AGENCE NATIONALE DE LA RECHERCHE

ANR

Work Programme 2017

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A. Context and objectives of Work Programme 2017

A-1) Context

The French National Research Agency (ANR) funds and promotes basic and applied research, technology transfer and academia-industry partnerships with the goal of promoting excellence at both the academic and technological levels by means of a rigorous selection process based on evaluation by peer review. ANR's mission also includes strengthening scientific cooperation at European and international levels by coordinating programmes to fit in with the European and international initiatives defined by the French Research Ministry and according to the priorities set out by the French Research Agency's international scientific strategy. The Agency also supports international consortia in partnership with other funding agencies in Europe and throughout the world.

Work Programme 2017 (WP 2017) is ANR's roadmap for the year to come. The Work Programme falls within the scope of the Strategic Agenda for Research and Transfer and Innovation "France Europe 2020"[1], elaborated in coordination with the European Framework Programme "Horizon 2020".
WP 2017 was also drafted in accordance with the National Research Strategy (SNR)[2], promulgated by the higher education and research law of 22 July 2013.
The SNR, in accordance with the Strategic Agenda, strives to *take up scientific, technological, environmental and societal challenges through the promotion of high-quality basic research.*

WP 2017's societal challenges section groups together French research priorities defined in the SNR text and takes into consideration contributions from the five national thematic Alliances of research organisations[3], those of the CNRS, and requests from the French Research Ministry, which coordinates interministerial initiatives between relevant ministries. The Work Programme was adopted on 29 June 2016 by the ANR Governing Board.

Work Programme 2017 lays out the main actions and calls for proposals launched by ANR for the 2017 financial year and gives ANR's research funding offering all-around visibility[4]. The Work Programme is directed toward all scientific communities as well as public and private stakeholders involved in French research, including small and medium-sized enterprises (SMEs) and very small enterprises.

[1] http://www.enseignementsup-recherche.gouv.fr/cid71873/france-europe-2020-l-agenda-strategique-pour-la-recherche-le-transfert-et-l-innovation.html

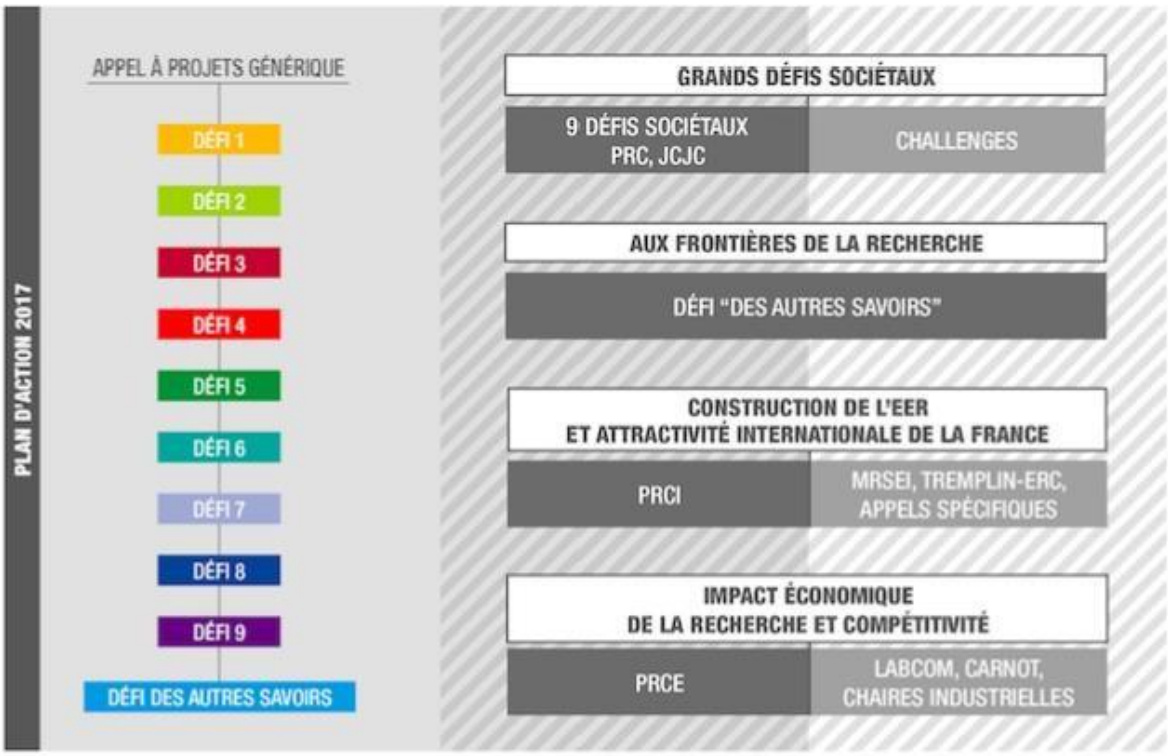
[2] http://www.enseignementsup-recherche.gouv.fr/cid78720/la-strategie-nationale-de-la-recherche-definit-les-grandes-priorites-de-la-definit-les-grandes-priorites-de-la-recherche-francaise.html

[3] Allenvi (Alliance in the field of research), ALLISTENE (alliance of science and digital technology), Ancre (National alliance for coordination of the research for energy), Athena (National alliance for social sciences and the humanities), Aviesan (National alliance for life sciences and healthcare sciences).

[4] ANR is placed under the authority of the French Ministry Higher Education and Research. Other relevant ministries include : agriculture, ecology, healthcare, industry, defence, foreign affairs, culture, national education.

A-2) Structure and objectives of Work Programme 2017

Work Programme 2017 (WP 2017) is divided into **four cross-cutting components**, each endowed with its own budget. Each component also has separate funding instruments, calls for proposals, and distinct programmes, shown in the graphic below. A generic call for proposals allows for the mutualising of a large number of each component's actions. A description of generic call submission procedures as well as the selection process can be found in the document.



Overview of Work Programme 2017 and its four components

(PRC: Collaborative Research Projects; JCJC: Young Researchers; PRCI: International Collaborative Research Projects; PRCE: Collaborative Research Projects involving Enterprises; MRSEI: Setting up European or International Scientific Networks;

The **funding instruments** offered by ANR are set out in section B of WP 2017. Submission and selection procedures are set out in the various calls for proposals including the Generic Call for Proposals (additional information to be posted from late August 2016). Each funding instrument has its own raison d'être, specific expected impacts, and distinct characteristics in terms of selection, follow-up and monitoring. The purpose of these funding instruments ranges from supporting collaborative research, instruments dedicated to individuals as well as other WP 2017 programmes and calls for proposals presented later on. At the time of project submission, researchers must choose which of these instruments will best serve their projects' needs and scientific objectives.

Work Programme 2017's four components are set out below and their corresponding strategic dimensions are highlighted.

1. "Major Societal Challenges" component

The French Research Ministry has requested that the French National Research Agency organise a significant portion of its Work Programme 2017 around **nine major societal challenges** spelled out in the "France-Europe 2020" Strategic Agenda (except for the space sector, under the authority of CNES), summarised in paragraphs D-1 to D-9, with thorough descriptions in paragraphs F-1 to F-9:

1. Efficient resource management and adaptation to climate change
2. Clean, secure and efficient energy
3. Industrial renewal
4. Life, health and well-being
5. Food security and demographic challenges
6. Sustainable mobility and urban systems
7. Information and communication society
8. Innovative, inclusive and adaptive societies
9. Freedom and security of Europe, its citizens and its residents

The "Major societal challenges" component groups basic knowledge acquisition and targeted, often applied research under one heading. This component is subject to the generic call for proposals and uses all available instruments (see section B for details) enabling funding of collaborative research projects in a national or international context (**PRC** and **PRCI** respectively) and possibly involving the business world (**PRCE**) or individual research projects coordinated by young researchers (**JCJC**).

2. "At the Frontiers of Research" component

This component introduces an additional challenge, known as the **"Other Knowledge" challenge** (see Section D-10), into the Generic Call for Proposals. The goal of this challenge is to give all scientific communities the opportunity to fund projects not falling within the scope of the nine societal challenges listed above. The funding instruments usable for this challenge are the same as those laid out in the "Major Societal Challenges" component (see section B).

3. "Building the European Research Area (ERA) and France's International Attractiveness" component

This component provides French researchers and teams with funding instruments aimed at increasing the influence and attractiveness of French research and contributing to the construction of the European Research Area (ERA). These instruments have been designed on a sector-by-sector basis for consistency with and complementary to the Horizon 2020 societal challenges. They foster the development of high-level international research partnerships, helping French teams assume leadership roles in European and international programmes.

The societal challenges making up Work Programme 2017 have strong European and international dimensions. Firstly, they have been designed on a sector-by-sector basis for consistency with and complementary to the Horizon 2020 societal challenges. Several of these challenges were designed with European programmes (e.g. ERA-NETs, JPIs, ERA-NET Cofund, etc.) and international programmes in mind (e.g. Belmont Forum, etc.). (sections C-6, C-7 and C-8).

The "Building the ERA and France's international attractiveness" component comprises the following Work Programme 2017 funding instruments, some of which are subject to a specific call for proposals:

- The "International Collaborative Research Projects " **(PRCI)** instrument aims to facilitate collaborative research with a second country through bilateral agreements (see sections Section B-1-3 for a description of this instrument; and table 1 for an overview of bilateral agreements.) This instrument is part of the Generic Call for Proposals.
- "Setting up European or International Scientific Networks " **(MRSEI)** aims to strengthen the position and influence of French research in European and international spheres. This instrument is subject to a specific call for proposals (see Section C-6).
- "Springboard-ERC" (T-ERC) aims to boost the success of French researchers applying for European Research Council (ERC) starting grants and consolidator grants. T-ERC works under a specific set of conditions, and is subject to a specific call for proposals (see section C-7).

In addition to these instruments, ANR is developing dedicated bilateral and multilateral calls in the framework of joint programming initiatives (JPIs), European instruments in the context of FP7 (ERA-NETs for instance) and Horizon 2020 (e.g. ERA-NETs Cofund) – as well as within the framework of other multinational initiatives dealing with global challenges (e.g. the Belmont Forum) (see section C-8 and table 2 for an overview of these specific calls for proposals).

4. "Economic impact of research and competitiveness" component

This component aims to facilitate partnerships with the business community and transfer findings made by public research into industrial applications. By strengthening cooperation and partnerships, the proposed initiatives enable value to be created from the results of public research, which also encourages R&D efforts among companies and prompts them to invent and innovate. Said initiatives are positioned in relation to an increasingly present theme of technological maturity whose integration is reinforced to varying degrees by such intersector partnerships. It has been remarked that in France specifically there is a low number of SMEs offering innovations in service or products with regard to the difficulties experienced engaging with the public research sector, justifying certain initiative's particular approach toward SMEs and intermediate-sized enterprises

To this end, ANR supports projects carried out in partnership with enterprises with a direct impact on the economy and competitiveness via the "**Collaborative Research Projects involving Enterprises**" (PRCE) instrument, accessible through the Generic Call for Proposals (see Section B-1-2).

In addition to the PRCE instrument, the component is also made up of the following specific programmes:

- **LabCom** creates and consolidates laboratories jointly established between a public research laboratory and small or medium-sized enterprises (SMEs) or intermediate-sized enterprises. Partnerships must be reinforced, strictly bilateral, and long-term so that the company may capitalise on innovative products derived from joint results generated in the LabCom. Technological maturity of projects is intermediate. (see Section C-2).
- **Industrial chairs**: For the establishment of chairs at public research facilities, in partnership with enterprises, funded jointly by said enterprises with ANR.

  This programme, which enables a laboratory to collaborate with one or several industrial partners, aims to strengthen the innovative and strategic research potential in priority areas for French industry for which technology readiness levels (TRLs) are still low (see section C-3).

- **Carnot Institutes** : Promoting the development of contractual research partnering public research structures and actors from the business world (see section C-4).

All of the above-mentioned initiatives are coordinated with academic research transfer structures, funded in particular under the Investments for the Future plan (a prominent example being the SATTs), but also with public structures close to the socio-economic sector. As was the case in the past, ANR's 2017 calls will be open to labelling by the competitiveness clusters.

A-3) Other funding opportunities, ANR partnerships and co-funding

By virtue of its mission as a project-based research funder, ANR establishes partnerships with other funders ("Partnerships and Cofunding" document) including:

- The National Solidarity Fund for Autonomy (CNSA),
- the Ministry of Defence (Defence Procurement Agency - DGA),
- The Ministry of Health (General Directorate for Care Provision, DGOS)
- The Ministry of Food, Agriculture, and Forests (MAAF),
- General Secretariat for Defence and National Security (SGDSN),
- APIS-GENE.

These particularly valuable partnerships provide research funding and co-funding [5] opportunities that complement the ANR's own operating budget, for either the generic call for proposals or specific calls for proposals. One example is the **Astrid** and **Astrid Maturation** programmes, implemented by ANR and funded by the DGA (see Section C-5).

Complementary funding through the Ministry of the Environment, Energy and the Sea (MEEM) may also be granted in addition to said partnerships.

Other public institutions also provide funding for project-based research and launch their own calls for proposals, e.g. the National Cancer Institute (Inca) and the National Agency for Research on HIV and Hepatitis A (ANRS). Such proposals and related projects are not supported by the French National Research Agency. The eligibility of projects submitted to ANR will therefore, irrespective of WP 2017 calls for proposals and falling within topics likely to receive funding by these organisations, be jointly decided upon by ANR alongside said bodies.

A-4) Procedures for submitting, evaluating and selecting projects

The submission, evaluation and selection procedures for projects are set out in the Generic Call for Proposals (AAPG) available online (late August 2016) on the ANR website. The instruments, challenge competitions, LabCom, Industrial Chairs, Carnot, MRSEI, Astrid Maturation and Springboard-ERC as well as the European and international calls (of the type ERA-NET or JPI) are subject to specific calls for proposals published on the ANR website. Applicants are advised to consult the calendars for these various calls on the ANR website.

[5] "Cofunding" means that part of the funding attributed to the project (based on the initial application) is provided by a partner of ANR. No additional funding is usually provided.

B. Generic Call for Proposals funding instruments

ANR's 2017 Generic Call for Proposals deploys a range of funding instruments for performing the roles assigned to it by French public research and innovation policy and addressing the needs of the project-based research community.

Funding instruments come under two categories, the characteristics and expected benefits of which are extremely important in project selection and monitoring:

- The **"collaborative research"** category proposes three instruments: "Collaborative Research Projects " **(PRC),** "Collaborative Research Projects involving Enterprises" **(PRCE)**, the " International Collaborative Research Projects **" (PRCI)**.
- The "**researcher**" category only includes the " Young researchers" **(JCJC)** instrument for the 2017 edition.

> Note: project grants for all funding instruments (PRC, PRCE, PRCI and JCJC) generally range from €50 k to €900 k, for a 24 to 48-month period, depending on the type of research proposed, the type of consortium and the number of partners involved, as well as the scientific goals of the project in question. The average cost of projects submitted and selected under AAPG 2016 will be available on the ANR website in September 2016.

B-1) Funding instruments dedicated to collaborative research

Collaborative projects[6] set out to achieve scientific results by pooling the skills and resources of various different public or private, national or international teams or research groups. By facilitating collaboration, grants awarded expedite proposed research. These instruments encourage research teams to work on projects for which collaboration provides added scientific value, either by making research possible, or by paving the way for more ambitious or higher quality results. Proposals for multidisciplinary research are welcome.

B-1-1) International Collaborative Research Projects (PRCI)

ANR works in collaboration with other countries' research funding agencies and signs agreements facilitating collaborations between teams from different countries. ANR establishes bilateral agreements both concerning precise themes and covering all ANR-funded research topics.

The objectives of these agreements include:

- Speeding up and developing French researchers' collaborations with top European and international research teams in key research fields,
- Fostering partnerships on topics of mutual interest with the potential to yield shared benefits with emerging countries,
- romoting the formation of elite international teams for the performance and sharing of top drawer research world-wide.

For partnerships centred around specific research areas, ANR and its partners strive to extend research over a two to three year period in order to strengthen collaborations and promote quality projects.

[6] The collaborative nature of a given project will be evaluated not only by the number of partners involved but by the value the proposed collaboration will create (in terms of scientific expertise and not just in administrative terms) as well as the opportunities to achieve scientific objectives that obtaining the grant will open up.

The funding instrument "International Collaborative Research Projects" (PRCI) is dedicated to collaborations established between at least one French partner eligible for ANR funding and at least one foreign partner eligible for funding from a foreign funding agency having signed a bilateral agreement with the ANR. **Robust synergy is expected between the two partners submitting a project together** implying **equal** involvement of French and foreign partners, and genuine involvement of scientific coordinators for projects in each respective country.

For Work Programme 2017, the countries concerned by these bilateral agreements are[7]:

- In Europe: Germany, Austria, Luxembourg, Switzerland.
- Internationally: Brazil, Canada, China, Hong Kong, Japan, Mexico, Singapore, Taiwan and Turkey.

B-1-2) Collaborative Research Projects involving Enterprises (PRCE)

The funding instrument "Collaborative Research Projects involving Enterprises" (PRCE) is dedicated to collaborations established between (public research laboratories and private companies **attempt to yield findings advantageous to both parties** by enabling public research facilities to address new research issues or address them differently, **and** by enabling companies to access high-level public research in order to improve their innovation capacities.

B-1-3) Collaborative Research Projects (PRC)

The "Collaborative Research Projects" (PRC) funding instrument is ANR's main funding instrument. It includes all forms of collaborations[8] not concerned by the PRCI and PRCE instruments.

B-2) Instrument dedicated to individuals

B-2-1) Young Researchers (JCJC)

The goal of the "Young Researchers" funding instrument is to prepare the new generation of young research talent to become leaders and pioneers in French scientific research. The instrument empowers young researchers and encourages them to adopt innovative approaches as they tackle scientific and technological bottlenecks.

JCJC allows young researchers to explore their own theme area, to assemble or consolidate a team, to develop their project-based research literacy and to unleash their innovative talents.

The instrument is also a springboard for young French researchers who, thanks to initial support from ANR, are given a leg up when it comes to submitting a project in response to calls from the European Research Council (ERC) in optimum conditions.

This individually-oriented instrument only provides for the funding of the young researcher's team.

[7] *see* table 1. List drafted at WP 2017's time of publication, likely to be supplemented or amended: applicants are invited to consult the ANR website. Country-specific annexes (available on the ANR Generic Call for Proposals webpage) lists eligible themes as well as specific submission and selection procedures. The annexes set out additional eligibility conditions for the Generic Call for Proposals and must therefore always be consulted prior to any submission to ANR or foreign partners.

[8] as indicated above, "collaborative" does not refer to the number of partners involved but the skills pooled to reach projects' objectives. Teams or multidisciplinary groups within the same structure are therefore allowed to propose projects eligible to be considered as collaborative.

C. Funding instruments subject to specific calls for proposals

Work Programme 2017 proposes various funding instruments, each with its own specific anticipated effects and distinct characteristics in terms of evaluation and monitoring. In this section, we describe funding instruments able to be used.
outside the scope of the generic call for proposals. These instruments' schedules are subject to specific programmes or calls for proposals whose calendars can be found on the Work Programme publication page of the ANR website.

"Major Societal Challenges" component

C-1) Challenge competitions

Certain societal challenges, focused on highly specific targets, justify prompting international teams developing competing approaches to contend with one another. The challenges select and fund several teams which have their respective approaches face off through a series of tests.

At the time of WP 2017's publication, two challenge competitions are likely to be launched in 2017:

- The **Malin Challenge competition** (mastering indoor localisation), at the interface between challenges 7 and 9 (see sections D-7 or D-9), conducted in partnership with the Defense Procurement Agency (DGA).
- The **Rose Challenge competition** (robotics in the service of Ecophyto: reducing pesticides in agriculture), backed by societal challenge 5 (see section D-5) alongside themes from societal challenge 7 (see section D-7), in partnership with the Department of Agriculture, Agri-Food, and Forests (MAAF) and the Ministry of the Environment, Energy and the Sea (MEEM).

Both challenge competitions will be subject to specific calls for proposals that will set their respective objectives and the type of tests considered. Applicants are advised to consult the relevant page on the ANR website.

"Economic impact of research and competitiveness" component

One of ANR's main missions is to encourage the transfer of findings made by public research into industrial applications. In addition to the "Collaborative Research Projects involving Enterprises " (PRCE) instrument in the Generic Call for Proposals, ANR features a series of programmes aimed at strengthening partnerships between research laboratories and private companies by means of various project-based research methods.

This cross-cutting component combines three programmes regulated by specific calls for proposals: ***LabCom***, ***Industrial Chairs*** and ***Carnot Institute***, as well as two programmes entirely funded by the French Defense Procurement Agency (DGA): **Astrid** and **Astrid Maturation**. Table 4 (annex E) summarises the main features of the component's ANR's "Economic impact of research and competitiveness" funding instruments. All of the following instruments call for the full participation of research organisation(s) and entreprise(s). Conditions for eligibility and details about expectations from proposals are set out in the respective calls for proposals.

C-2) LabCom

This programme supports the creation of joint research laboratories between public research bodies and SMEs or mid-cap companies and develops the potential of industrial partnerships and transfer already existing within academic research actors, particularly non-partnership-oriented actors. The aim of this programme is to help researchers to establish lasting bilateral partnerships with companies, especially SMEs and mid-cap companies, as these partnerships are crucial to the innovation process. The transfer of findings and know-how from public-funded research to smaller companies can be a robust driver of innovation, competitiveness and employment.

For this programme, open since 2013, ANR proposes that the public research laboratory grant a lump sum funding of €300 k. This gives researchers simplified set-up, expedited funding and greater flexibility in how grants are used. This programme has been continued for 2017, with rules and criteria similar to previous programming.

The 2017 LabCom programme will also offer an additional phase consisting of a "consolidator" grant. The consolidation phase will specifically concern previous Labcom-accredited laboratories for which financial returns from the exploitation of results are only presently sufficient to support said labs financially in the very short term.

C-3) Industrial Chairs

This programme is designed to mobilise resources to consolidate and strengthen French companies' competitiveness, pursuing a threefold objective[9].

- Enable teacher-researchers and internationally renowned researchers as well as French and foreign partners, whether or not they are internationally mobile, to work on an ambitious research programme of indisputable industrial scope and nature.
- Build and give structure to collaborative scientific research initiatives in priority areas and policy for public and private stakeholders involved in industrial relations via a strong and lasting partnership.
- Provide quality-committed training by making private actors' long-term vision, methodologies and experience available to doctoral or post-doctoral researchers in high-level public research laboratories.

This programme's main component is a call for proposals open to all research themes on topics defined jointly by an industrial chair's coordinating institution[10][10] and one or more partner enterprise(s). The project will be led by an eminent scientist and incumbent industrial chair holder, and jointly funded by ANR and the partner enterprise(s).

The selection process will be based on a single application document submitted by the host institution in close collaboration with the partner companies (which submit a letter of commitment upon submission of the proposal), along with the prospective holder of the industrial chair.

Funding will be provided for up to 48 months. ANR funding will be matched with funding from the private companies (liquid capital) and will be disbursed to the coordinating institution.

This initiative is subject to a specific call for proposals. Researchers are advised to consult the 2017 call for proposals calendar on ANR's website.

[9] or R&D activity in France.

[10] The coordinating institution must be a **research partner**: a public or assimilated partner whose main purpose is to carry out research, such as universities, French public scientific and technical research establishments (EPST), French cultural and professional public institutions (EPSCP), industrial or commercial public establishments (EPIC), and so on.

C-4) Carnot Institutes

Since 2006, the French Research Ministry has awarded the Carnot label to public research institutions whose main strategic focus is partnership-oriented research. In the interest of promoting and supporting cooperation between research institutions and private stakeholders, ANR makes an annual contribution (based on partnership revenues) to the Carnot Institutes. This contribution is used to develop scientific resources and for the professionalising of partnerships with the business world.

A commission of experts mainly from the business world; called Carnot Commission 3, has been tasked with proposing avenues of development for Carnot following the results of the first two Carnot phases. This commission has made a very positive assessment of the operation, considering that "this simple and empowering instrument, subject to regular retrospective evaluation, is a real success, strengthening links between public research and enterprises and accompanying institutes' development". This 10-year review has resulted in the extension of the programme under the Carnot 3 call.

In order to ensure effective leverage, the "Valorisation – Carnot Institutes" programme is allocated a budget under the Investments for the Future programme. Three calls[11] for proposals have been launched in this framework, one for specific initiatives related to SMEs, another for specific international undertakings and a third for structuring the offer in response to demand from economic sectors, especially small- and medium sized enterprises (SME) and mid-cap enterprises.

C-5) Astrid and Astrid Maturation

The **Astrid** (French acronym for "specific support for defence research and innovation") and **Astrid Maturation** programmes are entirely funded by the French Defence Procurement Agency (DGA) and are subject to specific calls for proposals managed by ANR. Applicants are advised to consult the call for proposal calendars and funding procedures posted on the ANR website.

- The Astrid programme strives to open up new research avenues on dual-interest themes (civil and military applications) with a view to probing into scientific and technical obstacles and encouraging potentially beneficial technological breakthroughs for defence and civil research, as well as industry.
- The ASTRID-Maturation programme promotes the application of scientific research carried out via other dual-use research funding instruments, the ASTRID programme in particular.

The cross-cutting dimensions of the ASTRID programmes cover a broad scientific spectrum encompassing dual-use research's most critical domains.

"Building the European Research Area (ERA) and France's International Attractiveneness" Component

Apart from International Collaborative Research Projects (PRCI; see section B-1-3), ANR's Generic Call for Proposal's main bilateral collaborative instrument; other types of European and international measures are planned in connection with Building the European Research Area (ERA) and international attractiveness components of Work Programme 2017:

- Setting up European or International Scientific Networks (**MRSEI**)
- Springboard-ERC (**T-ERC**)
- Specific European or international calls for proposals (**ERA-NETs, JPIs**, bi- or multilateral calls for proposals)

[11] See the relevant page on ANR's website: http://www.agence-nationale-recherche.fr/carnot

C-6) Setting up European or International Scientific Networks (MRSEI)

The objective of the **MRSEI** programme is to give French researchers more ready access to European and international funding programmes (Horizon 2020 in particular). Proposals submitted must necessarily be followed up by a submission/application to a European or international call for proposals.

The objective of this instrument is to reinforce France's scientific positioning by coordinating a proposal submitted to a large-scale European or international call for proposals. Proposals are expected to demonstrate the steps involved in constructing a scientific network on an internationally recognised level, on topics in any discipline, and to have a strategic, economic, technological or societal impact. The instrument does provide funding for research activities.

The **MRSEI** instrument will be subject to two specific calls in 2017. Prospective applicants are advised to regularly check back on the relevant ANR pages for updates.

For the **MRSEI** programme, ANR has taken measures to fast-track the decision-making process and the implementation of funding using simplified submission and peer selection performed by a single ad hoc committee not reliant on external peer reviewers.

The funding instrument's main features are: an ANR grant attributed to the MRSEI project coordinator: worth up to €50 k; Network: One French, European or international partner Funding: One single (French) partner funded; Duration: 18 months

C-7) Springboard ERC (T-ERC)

The “Springboard ERC” (**T-ERC**) funding instrument is part of the national strategy for fostering French research and technology and boosting France’s international scientific influence and attractiveness.

The aim of the T-ERC programme is to give French researchers the opportunity to submit a new application to a European Research Council (ERC) proposal to the "Starting Grant" or "Consolidator Grant” call while ensuring said researchers the very best chance of succeeding.

For the **T-ERC** programme, ANR has taken measures to fast-track the decision-making process and the implementation of funding using a simplified submission format based on application files previously sent to the ERC.

The programme T-ERC will be subject of a specific call in 2017. Prospective applicants are advised to regularly check back on the relevant ANR pages for updates.

The following are the funding instrument's main features: ANR grant attributed to the coordinator: Until the 150 k maximum; Coordinator: Only the coordinator of the project (Principal Investigator**)** will be funded / Duration: 18 months maximum

C-8) Specific calls for proposals in European or international collaboration

In connection with the various societal challenges, ANR has formed multilateral partnerships with its European counterparts in the framework of European initiatives such as **ERA-NETs, ERA-NET Cofunds, and Joint Programming Initiatives (JPIs)**. These initiatives are complementary to the framework programmes' other traditional collaborative projects. In this context, emphasis is placed on multi-year prioritisation of European activities and coordination between national and European measures. The precise manner in which these programmes complement one another is determined on a long-term, sector-by-sector basis. ERA-NETs, ERA-NET Cofunds and JPIs are subject to specific calls for proposals. Applicants are advised to consult individual calls for proposals on ANR's website.

In addition to the relationships with certain key agencies at the European level and international levels in the generic call (the PRCI instrument), ANR has developed specific relationships with major foreign funding agencies such as BMBF (Germany), DFG (Germany) and JST (Japan). It is in this context that initiatives on specific research topics are carried out either under bilateral partnerships (NSF in the US), or multilateral partnerships (Belmont Forum, the "CRCNS ORA" call). These initiatives are actualised through specific calls for proposals. Applicants are advised to consult the calendar for these calls for proposals on the ANR website.

Initiatives carried out in the framework of European Union programming may involve other such initiatives (ERA-NET Cofund/JPI calls) and involve multilateral initiatives such as those carried out by the Belmont Forum (Belmont Forum/JPI and ERA-NET Cofund/Belmont Forum calls).

D. Societal challenges and the Other knowledge challenge

The societal challenges set out in the National Research Strategy - France Europe 2020 (SNR[12]) are an integral part of ANR's Work Programme 2017, with the exception of the space sector, under the purview of the CNES. These challenges are complemented by the Work Programme's "Other Knowledge" challenge, designed to fund projects not falling directly within societal challenges' defined scope.

The challenges' scientific and technological scopes and their theme-based structure were defined in a collective, concerted manner with input from the National Research Strategy, the five national thematic Alliances[13], CNRS, requests made by the French Research Ministry[1414] (coordinates interministerial action between relevant ministries) and Scientific Challenge Advisory Boards featuring national and international experts as well as industrial and institutional representatives.

The nine societal challenges support thematic, multidisciplinary and integrative research on major societal issues. Following recommendations from the National Strategic Council for Research (CSR), each of these challenges covers fundamental research work in line with its objectives. These "knowledge bases" are listed as specific themes if they encompass entire challenges, or are given an introductory mention if they only make up one component of the themes concerned. In addition to its ability to provide opportunities to fund projects not directly covered by societal challenges, the "Other Knowledge challenge" promotes original interdisciplinary research and contributes to preserving the diversity of French research and providing a long-term vision of future challenges.

A summary of WP 2017's challenge objectives is provided below in the document entitled "Societal challenges in detail" which describes the issues at stake, the different types of projects targeted, themes touched upon, thematic overlaps and challenge-specific collaborations as well as the SNR priorities they serve. For each societal challenge, work conducted by the SNR has aided in determining the priority research areas set out in table 4 (annex). Project coordinators will be asked to specify whether or not their projects fit in with these priority areas at the time of submission. Research efforts falling under priority areas may be encouraged through preferential selection of registered pre-proposals.

[12] Research http://cache.media.enseignementsup-.gouv.fr/file/Strategie_recherche/26/9/strategie_national_research_397269.pdf

[13] Allenvi (Alliance for Environmental Research) allistene (Alliance for digital science and technologies), Athena (National alliance for social sciences and the humanities), Aviesan (National alliance for life sciences and healthcare sciences).

14 ANR is placed under the authority of the French Ministry Higher Education and Research

D-1) Challenge 1 – Efficient resource management and adaptation to climate change: Toward an understanding of global change 24

In light of world population growth and ever-increasing needs in terms of energy, raw materials, products and services, environmental changes are becoming an increasingly pressing matter at all levels, from individual landscapes to the planet as a whole (climate, biodiversity loss, soil degradation, pollution of air, fresh and marine waters, etc.).

This challenge is primarily directed at gaining insight into the mechanisms underlying these changes and their local and regional impacts on resources, human societies and human activities – particularly those that depend on ecosystem services. Addressing this challenge will require social, political and economic innovations to avoid or reduce impacts, compensate or restore environments, and adapt to new constraints and opportunities.

This challenge works within the framework of the European Research Area, notably through the Horizon 2020 programme "Climate Action, Environment, Resource Efficiency and Raw Materials", contributing to major international initiatives in the field. It should also be seen in the context of the COP21 agreement concluded in Paris in late 2015, the first ever worldwide climate agreement. Given systems' complexity, a wide variety of multi/inter/transdisciplinary projects is expected, as well as theme-dependent research ranging from academic research to partnerships with the private sector, public sector and communities.

Challenge 1 is structured around six themes (one of which is integrated), with particular attention given to projects concerning coastal areas (irrespective of their theme):

- Theme 1: Fundamental knowledge in relationship with the challenge (environments and biodiversity)
- Theme 2: Ecosystem dynamics to improve their sustainable management (*theme common to challenge 5*)
- Theme 3: Health-Environment, based on the One Health concept (*theme common to challenges 4 and 5*)
- Theme 4: Scientific and technological innovations to accompany the environmental transition
- Theme 5: Society in the face of environmental change
- Theme 6: Integrated approaches to territories' environmental development

In addition to the national generic call, challenge 1 will also receive support from a set of multilateral calls launched within the European framework (joint programming on climate, water, biodiversity, oceans, agriculture, and the Mediterranean) and via international frameworks (Belmont Forum, linking together G7 and emerging countries' agencies and the European Commission) in order to enhance the visibility and leadership of French research.

Work by the National Research Strategy has resulted in a list of five priority research areas for this challenge:

- Priority 1: Smart monitoring of the Earth system
- Priority 2: Sustainable management of natural resources
- Priority 3: Assessment and control of climate and environmental risk
- Priority 4: Eco- and biotechnologies to support the ecological transition
- Priority 5: The coastal areas as a natural laboratory

Project coordinators will be asked to specify whether their project fits in these priority areas at the time of submission, or where appropriate in other SNR priorities such as priority 15 (Sensors and instrumentation) or priority 20 (An integrated approach for production systems).

D-2) Challenge 2 – Clean, secure and efficient energy

Challenge 2 aims to enable ANR to mobilise top-notch scientific and technological expertise on the energy transition challenge in the context of the French “Factor 4" approach (pledged fourfold reduction of greenhouse gas emissions by 2050) as well as energy transition on a global scale:

Achieving this goal will mean promoting systemic, integrative and multidisciplinary approaches often demanded by energy issues (materials science, engineering sciences, Earth sciences, life sciences, mathematics, information and communication sciences, and social sciences and the humanities, etc.); it will also require supporting the exploration of radically new ideas and concepts which break away from existing paradigms through technological proofs of concept and even the preparation of experimental or integrated laboratory schemes making use of existing experimentation sites. The challenge's scope of intervention is limited to relatively upstream levels (Technology Readiness Level 1 to 5), acting in tandem with other R&D funding schemes positioned on phases which are more downstream at the national (ADEME, BPI France etc.) and European levels (Horizon 2020).

Challenge 2 is structured around the seven themes detailed in the annex below:

- Theme 1: Exploratory research and groundbreaking concepts
- Theme 2: Renewable energy production and energy harvesting
- Theme 3: Use of the underground for energy purposes
- Theme 4: Conversion of primary resources into fuels and platform molecules, carbon chemistry
- Theme 5: Storage, management and integration in renewable energy networks
- Theme 6: Energy efficiency of processes and systems
- Theme 7: Social sciences and humanities-based approaches to the energy transition

Apart from Theme 1, dedicated to the production of basic knowledge and groundbreaking concepts and theme 7 which brings together the contributions of social sciences and the humanities, the remaining themes cover energy issues from primary resource capture to end use, particularly in the industrial sector, including the conversion pathways between energy, storage and distribution vectors. Each theme supports research aimed at acquiring basic knowledge on the theme at hand.

The National Research Strategy has identified five priority research areas for this challenge:

- Priority 6: Dynamic management of energy systems
- Priority 7: Multiscale governance of new energy systems
- Priority 8: Energy efficiency
- Priority 9: Reducing dependency on strategic materials
- Priority 10: Fossil carbon substitutes for the energy and chemical sectors

Project coordinators will be asked to specify whether their projects fit in these priority areas at the time of their submission, or where appropriate in other SNR priorities such as Priority 2: sustainable management of natural resources, Priority 3: Assessing and controlling climate and environmental risks, Priority 4: Eco- and biotechnologies to support the ecological transition, Priority 14: Design of new materials) or priority 21: Biomass: from production to varied uses.

D-3) Challenge 3 – Industrial renewal

The research funded in this challenge is intended to prepare an industrial evolution which addresses: i) the need to implement sustainable competitiveness (with skills-appropriate jobs and efforts toward social cohesion); ii) wealth creation needs (by keeping consumption of resources to a minimum); iii) the challenges we face in the early 21st century, especially environmental: CO2 and water footprints, energy savings, reduction of pollution, elimination of toxic substances, saving natural resources, recycling...

French industry must progressively work towards clean and sustainable manufacturing, promoting a circular economy and remaining a step ahead of its competitors. Optimising human capital, the social role of industry, flexible production processes, adapting production processes to digital developments, as well as attractiveness and competitiveness are also key factors in industrial renewal. The goal of this challenge is to support research facilitating these changes in the medium to long term. This challenge concerns a variety of industrial fields (e.g. manufacturing industries, chemical industries, food industries, etc.) and very broad scientific disciplines (e.g. organisation of labour, labour law, ergonomics, industrial engineering, robotics, economics, physics, chemistry, mechanics, materials, process engineering etc.).

The goal of this challenge is to support research able to open new paths to technological innovation, without research necessarily being aimed directly at a particular innovation. Challenge 3 therefore supports studies on a broad technology readiness level (TRL) spectrum, ranging from fundamental research (TRL 1) broadly upstream of potential applications, to research that touches on industrial issues (TRL up to 4).

In connection with the National Research Strategy (SNR) and supplemented by the Scientific Advisory Board, changes aimed at clarifying thematic content and the interfaces between challenges, as well as better scientific consistency include for example merging “adapting work to industrial renewal” and “the factory of the future” from the previous edition into a single theme covering the human, organisational, and technological aspects of the factory of the future in a complementary and coherent manner.

The challenge is structured around four themes. These themes will also allow for an integrated assessment of research projects, from upstream research to future applications:

- Theme 1: The factory of the future: People, organisation, technologies
- Theme 2: Materials and processes
- Theme 3: Sustainable chemistry and related processes
- Theme 4: Nanomaterials and nanotechnologies for products of the future

The five priority research areas for this challenge are:

- Priority 11: The digital factory
- Theme 12: The green and people-friendly factory
- Priority 13: Flexible, human-centred manufacturing processes
- Theme 14: Design of new materials
- Theme 15: Sensors and instrumentation

Project coordinators will be asked to specify whether their projects fit in these priority areas at the time of submission, or if they fit into other SNR themes where appropriate such as Priority 4 : Eco- and biotechnologies to support the ecological transition, Priority 9 : Reducing dependency on strategic materials, Priority 10 : Fossil carbon substitutes for the energy and chemical sectors, Priority 21 : Biomass: from production to varied uses, and Priority 29: Human-machine cooperation.

D-4) Challenge 4 – Life, health and well-being

The "Life, health and well-being" challenge covers a wide research field. This major public policy challenge responds to the natural desire of human communities to optimise their health and well-being via the implementation of health policies.

The development of highly fundamental research on living mechanisms falls under for this challenge. Emerging knowledge in biology has had a high impact in several societal areas: health, which goes without saying, but also agriculture, economics and education. This challenge links together three key approaches: i) The first focuses on decoding the multiscale cellular, physiological, developmental and ageing mechanisms that take place in living organisms – this being an essential step towards understanding and diagnosing pathologies caused by malfunctions in these mechanisms. ii) The second aims to expand knowledge of pathological processes and to pave the way for risk reduction strategies, both at individual and community levels and for implementing compensation strategies. iii) The third pillar concerns public health and health -oriented social sciences

"Life, health and well-being" is therefore a challenge at the frontiers of knowledge offering a wealth of opportunities transferable to individuals and societies, but also a vector of innovation and economic growth for industrial sectors such as biotechnology, pharmaceuticals, diagnostics and medical devices.

Echoing work carried out in the National Research Strategy (SNR) and the AVIESAN Alliance, supplemented by the Scientific Challenge Advisory Board, WP 2017's Life, health, and well-being challenge is divided up into thirteen themes detailed in the annexes below, covering research projects from upstream stages through to future applications:

- Theme 1: Molecular study of biological systems, their dynamics, interactions and interconversions
- Theme 2: Decoding basic biological functions and their integration
- Theme 3: Research into systems and organs during normal and pathological function: physiology, physiopathology, ageing
- Theme 4: IT and digital systems, phenotyping, virtual organisms and pathologies, methodological, computer systems and statistical research to meet the conceptual needs of health research development.
- Theme 5: Genetics and genomics: genotype-phenotype relations, genome-environment interactions, epigenetics
- Theme 6: Microbiome and microbiota-host relations
- Theme 7: Exploration of the nervous system during normal and pathological function
- Theme 8: An integrated approach to immune responses
- Theme 9: Public health: French social inequalities in terms of health: preventive health care, primary care and social services (*common to challenge 8*)
- Theme 10: Translational health research
- Theme 11: Medical innovation, nanotechnologies, regenerative medicine, innovative therapies and vaccines
- Theme 12: Healthcare technologies
- Theme 13: Health-Environment, based on the One Health concept (*common to challenges 1 and 5*)

Work by the National Research Strategy has yielded a listing of five priority research areas for this challenge, including Priority 16: Multiscale analysis of the diversity and evolution of living organisms and Priority 17: Processing and collection of biological data.

D-5) Challenge 5 - Food security and demographic challenges, biological resources, sustainable exploitation of ecosystems and bio-economy

Food security means ensuring the global population access to a healthy and nutritional diet sufficient in quantity for everybody to meet their needs and food preferences. As highlighted by the broad international sustainable development commitments made in 2015 (Sustainable Development Goals - SDGs, Paris Climate Agreement), food security cannot be set apart from a set of interdependent sustainable development goals: reduction of inequality, access to energy and water, preservation of biodiversity and the fight against climate change.

Food systems and non-food use of biomass are at the core of the transformations necessary to cope with these global issues. Making said transformations sustainable involves both the reduction of the environmental footprint from land and marine bio-resource production and adapting production to global changes affecting climate, biodiversity, the world population, dietary practices and the globalisation of trade. All these factors exert growing amounts of pressure and damage on production systems. They generate increased health risks, with potential impacts on human health.

Challenge 5 calls for research, ranging from the most fundamental to the most finalised, for the production of disciplinary knowledge or stimulate innovation processes by systemic and cross-cutting approaches. It covers everything from biological resources, biomass and productive ecosystems to consumers in renewed systems: new bio-resources, new practices, new social organisations and new markets. A variety of scales and levels of organisation are concerned: From genes to individuals, to populations and finally, the ecosystem. These areas, complex and interlinked, draw from the life sciences, social sciences and humanities and matter sciences concerned with transforming biomass.

Challenge 5 is divided into six themes: a fundamental research theme concerning the whole field of investigation and five other more applied research themes.

- Theme 1: Fundamental knowledge for addressing challenge-related issues
- Theme 2: Animal biology, photosynthetic organisms and micro-organisms. Adaptation and input reduction
- Theme 3: Ecosystem dynamics to improve their sustainable management
- Theme 4: Health-Environment, based on the One Health concept (common to challenges 1 and 4)
- Theme 5: Food, healthy and sustainable food systems, world food security
- Theme 6: Bioeconomy: from production to the diverse uses of biomass

These six themes contribute directly to three National Research Strategy priority areas:

- Priority 19: Healthy and sustainable diet
- Priority 20: An integrated approach for production systems
- Priority 21: From production to diversified uses for biomass

Project coordinators will be asked at the time of submission to specify whether their projects fit under these priority areas, or where appropriate, under other SNR priority areas.

D-6) Challenge 6 – Sustainable mobility and urban systems

Research submitted under Challenge 6 should explore ways in which urban systems, transport, housing and their users are adapting to the need for sustainable development. The challenge particularly stresses integrated and systemic approaches enabling the interpretation of societal and environmental processes in their interactions. Mobility, habitat and more generally, coexistence should be considered in the light of environmental pressures, ecosystem services, reduction of nuisance factors and global changes. Without losing sight of vulnerabilities and potential inequalities, research should assess and improve the performance of buildings and transportation, as well as the organisation of urban systems promoting smooth, effective access to resources and services. Particular emphasis is given to advances made by today's digital society supporting, developing and promoting the use of sustainable transportation and smarter urban management while promoting sustainable and adaptable infrastructures and networks to meet the needs of existing and emerging economies. Governance procedures and the development of public policies that play a role in the management and development of urban systems must be analysed in light of said objectives.

Research undertaken in this framework must pursue several scientific objectives: i) constitute new bodies of knowledge focused on energy efficiency, environmental impacts and quality of use, for components (vehicles, buildings, etc.) and at different scales, examining the interactions between these criteria and scales; ii) develop phenomenon and data management modelling to support design, decision-making, and performance assessments, iii) explore how digital technologies can cause changes to mobility, housing and urban systems as well as user behaviour; iv) assist in developing a methodological and technological offering to build, design and renovate according to new energy and environmental requirements, but also more efficiently manage existing heritage and the various components of urban and transportation systems by actively involving the rider/user. V) take part in discussions and the development of innovative approaches to planning: *Nature based solutions, integrated cities*...

Challenge 6 is structured around five themes detailed in the annex below:

- Theme 1: Fundamental knowledge, exploratory research and groundbreaking concepts.
- Theme 2: Sustainable cities and territories
- Theme 3: Sustainable construction
- Theme 4: Clean, safe, connected, and automated vehicles
- Theme 5: Efficient networks and services

Work by the National Research Strategy has yielded a list of four priority research areas for this challenge:

- Theme 22: Urban observatories
- Theme 23: New conceptions of mobility
- Theme 24: Tools and technologies for sustainable cities
- Priority 25: The integration and resilience of infrastructures and urban networks

Project coordinators will be asked to specify whether their project fits in these priority areas or where appropriate in other SNR areas, especially Priority 3: Assessing and controlling climate and environmental risks, Priority 4: Eco and biotechnologies to support the ecological transition, priority 8: Energy efficiency, Priority 26: 5th generation infrastructure networks Priority 27: connected objects, Priority 28: Exploiting big data, and Priority 29: Human-machine cooperation.

D-7) Challenge 7 – Information and communication society

The "Information and communication society" challenge concerns the use of digital sciences and technologies for the benefit of society. The challenge features two main objectives: using digital technology for the benefit of society and designing and developing the digital technologies of the future through innovative concepts, methods and tools. Digital technology expertise is an increasingly strategic national issue affecting France's autonomy and competitiveness.

This challenge aims to mobilise France's national research network to address challenges affecting the digital societies. Proposals for research and development projects are expected to yield significant advances in areas of micro- and nano-electronics, IT, control, signal processing, and mathematics, which serve as a bedrock for digital sciences and technologies. Collaborative project proposals integrating a social sciences and humanities dimension are also expected to encompass joint research fields.

When possible, researchers are encouraged to take advantage of infrastructure and large, already-existing databases, and to promote their results via open access solutions. Researchers are also encouraged to coordinate their proposals with other national or international initiatives in the same fields (H2020, PIA, DGE, etc.).

Challenge 7 applies to the entire research and innovation chain, from the most fundamental research (mainly in theme 1 but also in other fundamental research areas connected to this theme) to the design and development of pre-industrial tools and methods. Challenge 7 is structured around eight themes detailed in the annex below:

- Theme 1: Foundations of digital sciences and technology
- Theme 2: The digital revolution: impacts on knowledge and culture *(joint research theme with Challenge 8)*
- Theme 3: Software sciences and technologies
- Theme 4: Interaction, robotics
- Theme 5: Data, knowledge, and big data - multimedia content
- Theme 6: Numerical simulation: from high-performance computing to big data
- Theme 7: Communication, processing and storage infrastructures
- Theme 8: Micro- and nanotechnologies for information and communication processing

Work by the National Research Strategy has yielded a list of five priority research areas for this challenge:

- Priority 26: 5th generation network infrastructures
- Priority 27: Connected objects
- Priority 28: Exploitation of big data
- Priority 29: Human-machine cooperation

Project coordinators will be asked to specify whether their projects fit in the above-listed priority areas at the time of submission, or when applicable in other SNR priority areas such as Priority 16: Multi-scale analysis of diversity and the way living things evolve, Priority 17: Processing and collection of biological data or Priority 32: Data availability and extraction of knowledge or Priority 33: Social, educational and cultural innovations.

D-8) Challenge 8 – Innovative, inclusive and adaptive societies

Challenge 8 is concerned with innovation, integration and adaptation processes. In addition to French society, societies from all cultural areas and periods are included. Social sciences and the humanities are encouraged to pursue cross-disciplinary approaches encompassing history, archaeology, arts and letters, philosophy, linguistics, anthropology, sociology, demography, geography, political science, religious studies, psychology and cognitive sciences, as well as law, economics and management.

All methods are accepted (in situ observation, interviews, textual analysis, experimentation, modelling...) as well as all sources (archives, corpora, data from surveys, administrative data, artistic or literary sources). Coordinators should inform the evaluators on these points, dedicating at least two dozen lines about them in submitted proposals.

When possible, researchers are encouraged to take advantage of infrastructure and large, already-existing databases, including international surveys recognised by the European roadmap for research infrastructures. Within the limits of existing financial resources, Challenge 8 may fund the conducting of surveys or the constitution of corpuses (texts, images, oral archives) on three conditions: 1) that they coincide with a research project ;2) that open data is provided 3/ that a mechanism exists for perpetuating said data.

Following the recommendations of the National Research Strategy (SNR), Athena Alliance and the Scientific Advisory Board for Challenge 8, the 2017 Edition strengthens and complements previously existing themes. Challenge 8 is structured around eight themes:

- Theme 1: Social innovation and risk
- Theme 2: Inequality, discrimination, migration, integration and radicalisation
- Theme 3: Changes in labour and employment, changing organisations
- Theme 4: Life-long education, cognitive skills, socialisation and training
- Theme 5: Cultures, creation and heritage
- Theme 6: The digital revolution and social change
- Theme 7: The digital revolution: our relationship with knowledge and culture (common to challenge 7: digital technologies and society)
- Theme 8: Public health *(joint theme with Challenge 4: Life, health and well-being)*

Each theme makes it possible to proportion fundamental research and applied research differently, with fundamental research defined here as conceptual issues, the development of a theoretical framework, construction of models and methods, as well as criticism of categories and data (construction, organisation, effects, scope and limits).

In addition, the project coordinators will be asked to specify at the time of submission whether their project fits into one of the priority research areas defined by the National Research Strategy for Challenge 8:

- Priority 30: Study of cultures and integration factors
- Priority 31: New innovation capacity indicators
- Priority 32: Data availability and extraction of knowledge
- Priority 33: Social, educational and cultural innovations

Project coordinators will be asked to specify whether their project fits into the above-listed priority areas at the time of submission, or where appropriate in other SNR priority areas such as Priority 28: Exploitation of big data. Coordinators may also declare that their proposed project does come under any priority areas.

D-9) Challenge 9 – Freedom and security of Europe, its citizens and its residents

The scope of Challenge 9 covers, but is not limited to, all research able to clarify the government's sovereign and non-sovereign security-related missions or delineate procedures for the protection of all critical infrastructure and even the role of public and private entities crucial for the proper functioning of the nation. These aspects must of course be consonant with the protection of fundamental rights.

All issues are to be considered against a backdrop of the accelerating deployment of new technologies, with consideration given to digital technologies which offer opportunities to citizens, administrations and businesses but also create new vulnerabilities. We must heed and address the increasingly intense mobility of people and flows (merchandise, capital, information and other data), regardless of the networks used.

All research involving the freedom and security of people in Europe have an in-depth reflection on risk as its starting point, in a context where security is associated with perception and risk management, as well as with social responsibilities and their impacts. Challenge 9 encourages research based on integrated approaches to managing risk both in physical spaces and in cyberspace. This ranges from the identification of threats and vulnerabilities to the management of consequences, as well as monitoring, prevention and protection mechanisms.

Many types of research can be used to address this challenge. **Fundamental or very upstream research** is necessary for the creation of a knowledge base. Whether or not their ultimate aims are technological in nature, research and innovation must often combine the natural and environmental sciences, digital sciences, engineering, and the whole of the humanities and social sciences **in one integrated approach.**

Challenge 9 is structured around five themes detailed in the annex below:

- Theme 1: Fundamental research related to the challenge
- Theme 2: Risks, management of crises of all types, resilience of systems
- Theme 3: Security of people and entities; fight against crime, terrorism and violent radicalisation
- Theme 4: Cybersecurity: freedom and security in cyberspace, securing information systems, fighting cybercrime and cyberterrorism
- Theme 5: Protecting vitally important infrastructures and networks, monitoring sovereign areas

Work by the National Research Strategy has yielded a list of three priority research areas for this challenge:

- Theme 39: Preventing and anticipating risks and threats
- Theme 40: An integrated approach to crisis management
- Theme 41: Resilience of security systems

Project coordinators will be asked to specify whether their project fit in these priority areas at the time of submission, or where appropriate in other SNR priorities.

D-10) "Other Knowledge" CHALLENGE

The Other Knowledge challenge was born out of the strong desire to give all the scientific communities continued funding opportunities for projects preparing our societies for the future through initiatives not falling within the immediate scope of the nine current societal challenges. The Other Knowledge challenge completes said challenges (which, it must be said, are highly receptive to basic research in their respective theme areas). Projects with a research topic covered by a societal challenge will be oriented, during evaluation, towards the appropriate challenge (after consultation of the Scientific Evaluation Panel concerned).

Research at the frontiers of knowledge

The Other Knowledge challenge is dedicated to research on topics aiming to advance knowledge and innovation, and giving researchers broad freedom of expression.

Such research should provide opportunities to create new tools, metrics, approaches, ideas, concepts and paradigms.

Frontier-expanding research is particularly valuable when one considers that society constructs its capacity to evolve and projects itself into the future based on the frontiers of knowledge in all their various forms. This thirst for progress, from the quest to understand the world around us and the laws that govern it, to the desire to come up with abstract concepts, will have major impacts on future decisions, far exceeding the bounds of initial queries.

On this basis, the Other Knowledge challenge supports basic research projects:

- mainly based on curiosity, observation, and creativity, whether or not they come under schools of thought;
- with bold ideas, risk-taking, and ground-breaking aspects;
- enabling a variety of initiatives and approaches;
- which provide an avenue for the development of integral approaches by combining inputs from different cultures and disciplines.

The scientific excellence of proposals is a decisive criterion, since the objective is to address questions falling outside the general framework or field of investigation peculiar to a given WP 2017 societal challenge.

Special fields of research

The Other Knowledge challenge offers funding opportunities across all scientific disciplines, but to varying degrees, since it strictly operates outside the perimeters of the societal challenges. Projects may involve fields that are well-recognised by the research communities, rare disciplines, or approaches based on original or relatively unexplored interdisciplinarities.

By way of illustration and in a non-exhaustive manner, this challenge gathers research projects in such broad fields as fundamental mathematics, condensed matter physics, subatomic physics, the sciences of the universe and the structure and history of the Earth. The challenge is to a lesser extent aimed at certain humanities, social sciences and theoretical chemistry themes not represented in the societal challenges.

The Other Knowledge challenge is also open to fundamental research in rare disciplines for which a paucity of researchers or waning interest could result in a loss of knowledge needed as new theoretical issues or practices arise.

The challenge is also about promoting original interdisciplinary research able to establish a new or rarely explored relationship between fields thought to be completely distinct. Research may employ a variety of approaches within these fields. Research projects could also enable the emergence and perpetuation of interdisciplinary themes with promising prospects for society.

E. Tables related to the Work Programme

Annex 1 Bilateral collaborations under Generic Call for Proposals 2016's International Collaborative Research Projects (PRCI)

(*table may be modified or extended based on ongoing negotiations. Applicants should consult ANR's website before submitting to ANR or foreign partner.)*

Countries (agencies)	Collaboration themes proposed by ANR in 2015 tbc upon agreement of the foreign agency	Challenges concerned
Brazil (FACEPE) *To be confirmed*	• ICT • Social sciences and humanities	Challenges 7, 8, and the Other Knowledge challenge
Brazil (FAPESP) *To be confirmed*	• ICT • Social sciences and humanities	Challenges 7, 8, and the Other Knowledge challenge
Canada (NSERC) *To be confirmed*	SPG Programme Environmental science and technologies, ICT, Manufacturing	Challenges 2, 3, 5, 6, and 7 ; Other knowledge challenge
China (NSFC) *To be confirmed*	• Water security in watershed (1) Water cycling in watershed and its response to global change (2) Impacts of human activities on water security in watershed, remediation and water management • **Scientific fields to be confirmed:** Green chemistry (recycling, reuse, remediation, chemistry bioresources, CO2 transformation), Materials (physical metallurgy), green ICT	Challenges 1, 2, 3, 4, and 7 ; Other knowledge challenge
Hong Kong (RGC) *To be confirmed*	All disciplinary fields funded by ANR and HK agency	Challenges 1,2, 3, 4, 5, 6, 7, 8 ; Other Knowledge challenge
Japan (MEXT/JST)	Generic technologies for operation in hostile environments under extreme condition: robotics including cobotics, remote operation, location, identification and mapping, image processing, observation systems, sensors, materials.	Challenges 3, 7
Mexico CONACYT *To be confirmed*	• Efficient resource management and adaptation to climate change • Food security and demographic challenges • Social sciences and humanities	Challenges 1, 5, 8, and the other-knowledge challenge

Taiwan (MOST) *To be confirmed*	All disciplinary fields funded by ANR and Taiwanese agency	Challenges 1,2, 3, 4, 5, 6, 7, 8 ; Other Knowledge Challenge
Turkey (TUBITAK) *To be confirmed*	• Marine geosciences • Seismic risks • Sustainable development of marine ecosystems • Social sciences and humanities • ICT • Energy	Challenges 1, 2, 7, 8 ; the Other Knowledge challenge
Singapore (NRF)	Materials, nanotechnologies, and nanosystems applied to societal challenges 2, 3, 6, 7: Clean, secure and efficient energy , Industrial renewal, Sustainable mobility and urban systems, Information and communication society	Challenges 2, 3, 6, and 7
Germany (DFG)	All disciplinary fields funded by ANR and DFG	All challenges, except Challenge 8
Austria (FWF) *To be confirmed*	All disciplinary fields funded by ANR and FWF	All challenges
Luxembourg (FNR) *To be confirmed*	All disciplinary fields funded by ANR and Luxembourg agency	All challenges
Switzerland (SNF) *To be confirmed*	All disciplinary fields funded by ANR and SNF	All challenges

Specific bilateral calls		
United States (NSF)	PIRE bilateral call: NSF Partnership for International Research and Education	Challenges 2, 3, and 7
Germany (DFG)	ANR DFG - social sciences and humanities thematic area (FRAL)	Challenge 8

Annex 2: Provisions for specific transnational projects in 2017

(The forecasts above are likely to evolve with the launch of European programmes. The following table is available on the ANR website and will receive routine updates; applicants are advised to consult the website regularly).

Call title	Societal challenge
MARTERA - JPI Ocean: Marine technologies	DEFSOC1
WATERWORKS 2017: water cycle	DEFSOC1
Transformation to sustainability - T2S	DEFSOC1,DEFSOC8
ERAMIN2: Primary resources	DEFSOC3
CoBioTech: Biotechnology for sustainable bio-based economy	DEFSOC3 and
EJP radioprotection CONCERT (not funded by ANR)	DEFSOC4
ERACoSysMed - medicine systems	DEFSOC4
ERA-CVD cardiovascular diseases	DEFSOC4
ERA-HDHL biomarkers in health/nutrition supporting JPI HDHL	DEFSOC4 and
HDHL-INTIMIC intestinal Microbiomics supporting JPI HDHL	DEFSOC4 and
E-Rare 3: Rare diseases	DEFSOC4
EuroNanoMed 3: Nanomedicine	DEFSOC4
Call supporting JPI JPND on neurodegenerative diseases	DEFSOC4
NEURON 3: Neurosciences	DEFSOC4
CRCNS: Computational neurosciences	DEFSOC4, DEFSOC7
Call supporting JPI AMR: Antimicrobial resistances	DEFSOC4 and
LEAP-AGRI (A long term EU-Africa research and innovation partnership on food and nutrition security and sustainable agriculture)	DEFSOC5
SUSFOOD 2: Sustainable Food Security – Resilient and resource-efficient value	DEFSOC5
ERA-CAPS "Europe-USA Call strengthening transnational research in the Molecular Plant Sciences"	DEFSOC5
Chist-ERA 2: Coordinated European research on long-term ICT challenges	DEFSOC7
QUANT-ERA: Quantum technologies	DEFSOC7
FLAG-ERA: FET Flagship	DEFSOC7,DEFSOC3 DEFSOC4
Call supporting JPI More Years Better Life	DEFSOC8

Annex 3: Partnerships and co-funding envisaged under Work Programme 2017

(all partnerships and co-funding may be amended or supplemented. *Applicants should consult ANR's website before submitting* projects to Generic Call for Proposals)

Partner	The main themes that can be concerned by of co-funding	Challenges and calls potentially concerned
CNSA The National Solidarity Fund for Autonomy	Topics related to ageing, autonomy, and quality of life	Challenges 4 and 8: AAPG
DGA The Defense Procurement Agency	Topics of dual civil and military interest (energy, global security, cybersecurity, etc.)	Challenges 2, 3, 7, and 9 AAPG and conflicts of interest, MALIN programmes Astrid and Astrid Maturation
DGOS General Directorate of Health Care Supply	Translational research in health (synergy fundamental research / clinical research)	Challenge 4: AAPG
MAAF The Ministry of Agriculture, Agri-Food, and Forests	Issues identified in the law of the future for Agriculture, Food and forests Of 13/10/2014 and in the work program for agro-ecological France, mainly in the framework of the plan Écophyto.	Challenge 5: AAPG Challenge ROSE
SGDSN General Secretariat for Defence and National Security	Global security and cybersecurity	Challenge 9: AAPG
APIS-GENE	Global efficiency in ruminant breeding (EGER)	Challenge 5: AAPG

Annex 4: Instruments of the "Economic impact of research and competitiveness" component

Instruments	Targeted enterpri	Nature of research projects	Funding procedures
PRCE instrument Generic Call for Projects	All enterprises except associations and	Collaborative research project with results sharing, without perpetuation beyond the project	ANR project partial funded by research organisations and enterprises
Labcom and Labcom-Consolidation- specific call for	VSE, SMB and mic-cap companies	Structure-giving research project carried out beyond ANR funding	ANR funding for research project only Mandatory contributions to project by enterprise
Industrial Chairs specific call for proposals	Intermediate or large-sized enterprises, or a consortium	A structure-giving academic research programme with support from enterprises, impacting higher education.	Partial funding from ANR of the research organisation alone, with funding matched by the enterprise allocated to the research organisation
Carnot specific programme	All enterprises	Research and findings benefiting companies	No project funding by ANR. The Carnot programme supports the scientific resourcing and professionalising of research organisations
Astrid DGA-specific programme led by ANR	Optional participation of any type of enterprise	Mixed research projects funded by DGA (including ASTRID Maturation)	Partial funding for the project by DGA through ANR and research organisations and businesses which may participate
Astrid Maturation DGA-specific programme led by ANR	All companies (with the participation of at least one SME)	Collaborative research project with sharing of results (following up on research funded by the Ministry of Defence, including Astrid) in which impact is followed by DGA	Partial funding for the project by DGA through ANR and research organisations and participating enterprises

Annex 5: Matching societal challenges/SNR (P: Principal; S: Secondary)

SNR	Title	Challenge 1	Challenge 2	Challenge 3	Challenge 4	Challenge 5	Challenge 6	Challenge 7	Challenge 8	Challenge 9
PRIORITY 1	Smart monitoring of the Earth system	P								
PRIORITY 2	Sustainable management of natural resources	P				S				
PRIORITY 3	Assessment and control of climate and environmental risk	P				S	S			
PRIORITY 4	Eco- and biotechnologies to support the ecological transition	P		S			S			
PRIORITY 5	The coastal areas as a natural laboratory	P								
PRIORITY 6	Dynamic management of energy systems		P							
PRIORITY 7	Multiscale governance of new energy systems		P							
PRIORITY 8	Energy efficiency		P				S			
PRIORITY 9	Reducing dependency on strategic materials		P	S						
PRIORITY 10	Fossil carbon substitutes for the energy and chemical sectors		P	S		S				
PRIORITY 11	The digital factory			P						
PRIORITY 12	The green and people-friendly factory			P						
PRIORITY 13	Flexible, human-centred manufacturing processes			P						
PRIORITY 14	Design of new materials		S	P						
PRIORITY 15	Sensors and instrumentation	S		P						
PRIORITY 16	multiscale analysis of the diversity and evolution of living organisms				P	S		S		
PRIORITY 17	Treatment and collection of biological data				P			S		
PRIORITY 18	National Centres of Excellence network for research and healthcare				P					
PRIORITY 19	Healthy and sustainable diet					P				
PRIORITY 20	An integrated approach for production systems	S				P				
PRIORITY 21	From production to the diverse uses of biomass		S			P				
PRIORITY 22	Urban observatories						P			
PRIORITY 23	New conceptions of mobility						P			
PRIORITY 24	Tools and technologies for sustainable cities						P			
PRIORITY 25	The integration and resilience of infrastructures and urban networks						P			
PRIORITY 26	5th generation of network infrastructures						S	P		
PRIORITY 27	Connected objects							P		
PRIORITY 28	Exploitation of big data							P	S	
PRIORITY 29	Man-machine collaboration			S			S	P		
PRIORITY 30	Study of cultures and integration factors								P	
PRIORITY 31	New innovation capacity indicators								P	
PRIORITY 32	Data availability and extraction of knowledge							S	P	
PRIORITY 33	Social, educational and cultural innovations							S	P	
PRIORITY 34	The Earth observation service chain	ANR WP not concerned								
PRIORITY 35	Compétitivité des secteurs des télécommunications et de la navigation	ANR WP not concerned								
PRIORITY 36	Critical components	ANR WP not concerned								
PRIORITY 37	Technologies for observing and exploring the universe	ANR WP not concerned								
PRIORITY 38	Defence and security of the territory	ANR WP not concerned								
PRIORITY 39	Preventing and anticipating risks and threats									P
PRIORITY 40	An integrated approach to crisis management									P
PRIORITY 41	Resilience of security systems									P

F. Societal challenges in detail

Introduction

Work Programme 2016 comprises nine of the ten societal challenges set out by the French National Research Strategy (SNR) **(see section G)**, along with an additional challenge known as the Other Knowledge challenge. The contents of the societal challenges were collectively and concertedly designed around France's 41 priority strategic research areas, laid out in the document entitled "National Research Strategy – France Europe 2020[15], which also incorporates contributions from the five national Alliances[16], the CNRS (French National Centre for Scientific Research), the concerned ministries[17] and the Scientific Challenge Advisory Boards, which bring together national and international experts, industry leaders and institutional representatives.

The challenges are open to fundamental, mission-oriented and applied research, cognitive research on basic mechanisms and research based on a number of high-priority topics:

- Societal challenge 1: Efficient resource management and adaptation to climate change
- Societal challenge 2: Clean, secure and efficient energy
- Societal challenge 3: Industrial renewal
- Societal challenge 4: Life, health and well-being
- Societal challenge 5: Food security and demographic challenges
- Societal challenge 6: Sustainable mobility and urban systems
- Societal challenge 7: Information and communication society
- Societal challenge 8: Innovative, inclusive and adaptive societies
- Societal challenge 9: Freedom and security of Europe, its citizens and its residents

Multidisciplinarity, cross-cutting research and interfaces

By combining the fundamental and applied aspects of particular fields and confront key societal issues, the challenges that make up the Work Programme show a high level of multidisciplinarity, calling for the integrated application of a diverse range of expertise and knowledge.

A significant number of research topics fall within more than one challenge. Most of these topics were identified during the mapping process carried out following the submission of pre-proposals to the 2014 and 2015 Generic Calls for Proposals. A non-exhaustive list of potential cross-disciplinary topics has been compiled in order to guide applicants as they pick the most appropriate challenge for their project:

- Projects coming under two or more challenges, depending on their individual focus, are indicated in the boxed text in the introductory section of each challenge concerned, complete with a listing of other applicable challenges (see the "Interfaces" section for each challenge);

[15] http://cache.media.enseignementsup-recherche.gouv.fr/file/Strategie_Recherche/26/9/strategie_nationale_recherche_397269.pdf

[16] AllEnvi (alliance for environmental research), Allistene (alliance for digital sciences and technologies), Athena (National alliance for social sciences and the humanities), Aviesan (National alliance for life sciences and healthcare sciences).

[17] ANR is placed under the authority of the French Ministry Higher Education and Research. Other relevant ministries include agriculture, ecology, healthcare, industry, defence, foreign affairs, culture, national education.

- Topics that should be addressed jointly by two or three societal challenges have been identified and are grouped together in the form of themes common to the challenges in question. These topics are as follows:
  - Health-Environment "One health": theme common to societal challenges 1, 4 and 5
  - Social inequalities in terms of health: preventive health care, primary care and social services (formerly called public health): theme common to societal challenges 4 and 8
  - Ecosystem dynamics: theme common to societal challenges 1 and 5
  - The digital revolution (our relationship with knowledge and culture): theme common to societal challenges 7 and 8
- other cross-disciplinary topics are likely to be addressed very broadly in most of the challenges, depending on research subjects
- These topics are given in detail below and are mentioned for reference purposes in the boxed introductory text (see challenges' "Interfaces" section).

Applicants are advised to read the concerned challenges in their entirety to gain a thorough understanding of their specific scope. Depending on the context or purpose of their research project, and in view of the societal questions addressed in each challenge, applicants alone are responsible for positioning their projects within the most appropriate challenge.

BIOECONOMIES & BIOTECHNOLOGY:

Depending on their field of study and application, biotechnology research projects should be submitted under Challenge 1, 2, 3, 4 or 5.

Biotechnology projects which are strictly dedicated to health applications should be submitted under Challenge 4.

Biotechnology projects targeting the production of advanced fuels fall within **Challenge 2**.

Biotechnology-related projects focusing on the use of bioresources for food or non-food applications, as well as projects related to the bioeconomy and circular economy and how these economies are integrated at the regional level fall within **Challenge 5.**

Projects targeting the optimisation or development of new bioprocesses for industrial applications, original products or molecules with high added value, should be submitted under **Challenge 3**.

Projects targeting the restoration of environmental media or the development of environmental sensors should be submitted under **Challenge 1.**

BIOLOGY:

Fundamental research aiming to decode the general mechanisms of living organisms but without targeted applications should be submitted under Challenge 4, and may relate to all clades; the same goes for upstream research on the development of generic research tools with a variety of potential uses. Research with potential applications for human societies, including over the long term, should also be submitted under Challenge 4.

Fundamental or applied research related to bioenergies – including research with long-term applications – should be submitted under Challenge 2; fundamental or applied research related to production ecosystems or food or non-food production should be submitted under Challenge 5. Projects focusing on biodiversity, ecology, evolution and the dynamics of non-human species and populations should be submitted under Challenge 1. Projects related to the management of biological risk situations and crisis management within the confines of bioterrorism (including specific detection systems) should be submitted under Challenge 9.

Elements of fundamental biology that do not explicitly fit into one of the societal challenges mentioned above should be submitted under the Other Knowledge challenge, along with a supporting argument.

SENSORS:

Sensors are covered by several of the challenges (**Challenge 1**, **Challenge 2, 3, 4**, **5, 7** or **Challenge 9**) but to different extents and in certain cases on specific aspects. Applicants are advised to consult notes and comments in the introductory section of each of the challenges concerned. Projects relating to sensors within a particular field of application (environment/climate, energy, health, food, industry, global security, etc.), from the proof of concept stage onwards, should be submitted under the most appropriate challenge.

For example, the design and development of gas sensors falls variously within Challenge 1 (environmental metrology) or Challenge 9 (chemical threats or explosives). Conversely, Challenge 2 does not cover projects related to gas sensors.

Challenge 3 covers projects related to the design and development of sensors for use in factories and products of the future and, more generally, online control and data acquisition systems (instrumented machines). In addition, projects addressing the performance (in terms of sensitivity, selectivity, etc.) of physical, chemical and biological sensors on a nanometric scale for factories and products of the future and, more generally, industrial metrology should be submitted under Challenge 3, except for those concerning CBRNE agents, which are addressed in Challenge 9, and environmental applications, addressed in Challenge 1.

Projects submitted under Challenge 7 shall address the design and manufacture of sensors as communicating, smart and/or autonomous objects. The creation of an infrastructure of networked sensors falls within the scope of Challenge 7 (applicants should note the thematic lines along which the various topics are divided within Challenge 7).

BIG DATA

Data is necessarily at the heart of research efforts across all disciplines and scientific challenges. Research projects relating to big data, simulation, modelling and high-performance computing may be relevant to any of the challenges. Pre-proposals addressing experimentation or the modelling of phenomena should be submitted under the corresponding societal challenge (urban systems, climate / environment, energy, industry, health, food, global security, etc.).

Pre-proposals involving interdisciplinary teams that use big data and/or high-performance computing fall within **Challenge 7** (Theme 6: "simulation: from high-performance computing to big data")

Pre-proposals addressing the collection and analysis of big data, knowledge extraction as an aid to understanding and forecasting, and decision support tools also fall within **Challenge 7** (Theme 5: Data, Knowledge and Big Data).

Pre-proposals focusing on the epistemological or cognitive issues involved in the use of big data fall within the joint theme common to **Challenges 7 and 8**.

ROBOTICS

Projects based on industrial robotics, irrespective of whether they relate to technological building blocks or complete solutions and whatever type of research they should propose (fundamental, industrial, experimental development), should be submitted under **Challenge 3** (Theme 2: The factory of the future).

Research projects relating to robotics within the framework of digital sciences, particularly cognitive robotics, control, and robot-robot or human-robot interactions fall within **Challenge 7** (Theme 4: Interaction, robotics, content).

If the scientific and technological basis for the robotic solution is not the priority focus of the research, robotic projects focusing on other specific fields of application (namely for climate and the environment, health, agriculture, transport or global security) should be submitted under the corresponding challenge – **Challenge 1**, **4, 5**, **6** or **9** respectively.

Challenge 1 : Efficient resource management and adaptation to climate change: Toward an understanding of global change

EUROPEAN AND INTERNATIONAL COLLABORATIONS

Challenge 1 is focused on climate and the environment, and calls for substantial European and international initiatives. The challenge is carried out under the ***European strategic joint programming framework*** *(JPIs climate, oceans, water, Facce/Agriculture, Urban Europe)* ***as well as its international counterpart*** *(Belmont Forum involving post-industrialised and emerging countries) in connection with mirror groups and set up by the French Research Ministry, involving concerned ministries, alliances and agencies. Implementation is based on three complementary instruments: i) multilateral projects involving at least three countries (****specific JPI or Belmont Forum calls****); ii) multilateral projects involving European Commission co-funding (specific* ***ERA-NET*** *call); iii) the international alignment of national projects via networking on targeted themes (generic call "****TAP****"/ Thematic Annual Programming).*

This multilateral dynamic is supplemented by ***bilateral projects focused on countries outside of previous joint programming*** *(generic PRCI call).*

The 2016/2017 topics given priority for international backing are detailed below and also given in tables 1 and 2 (appendix E) of the 2017 Work Programme. The following information aims to provide French teams with details of existing or forthcoming agreements between the ANR and its foreign counterparts that are designed to facilitate the formation of international projects and consortia. http://www.agence-nationale-recherche.fr.

INTERFACES

This challenge involves cross-cutting research topics relating to more than one challenge. *The other challenge(s) to which these topics relate is (are) indicated below, so that applicants may orient themselves towards the most appropriate challenge for their project. Applicants are strongly advised to read each related challenge in its entirety to gain a thorough understanding of its specific scope.*

For information concerning cross-cutting theme areas, most of which fall within the scope of multiple challenges (including Challenge 1), readers should refer to the paragraph entitled "**Multidisciplinarity, crossover and interfaces**" (pages 39-42) which covers the following fields: ***Big Data, Robotics, Sensors, Biology, Bioeconomics & Biotechnology.***

The following fields are also interfaced with Challenge 1:

Urban areas: Urban areas and urban ecology are fundamental to broader questions relating to global change and, in general, projects principally focused on the specifically urban aspects of an issue (adaptation to climate change, urban agriculture, etc.) are grouped together under **Challenge 6**. Projects that do not specifically address urban aspects should be submitted under the challenge that covering the other topic(s) addressed.

Telluric hazards: Geophysical and geodynamic processes serving as basic precursors of telluric hazards come under the **Other Knowledge** challenge.

Mineral resources, materials: The production of knowledge on mineral raw material deposits falls within the scope of Challenge 1. Projects pertaining to methods and technologies for the extraction, separation processing, and recycling of the materials used by energy technologies come under Challenge 3. All research concerning the use of mineral raw materials for energy purposes falls within the scope of Challenge 2.

Social systems and migration: The socio-political and legal dimensions of environmental migration fall within the scope of Challenge 8, as well as disasters that reveal social divides. The debate concerning the importance of climatic or environmental migration within migration as a whole falls within the scope of Challenge 8.

Paleoenvironments: projects with little or no relevance to the Anthropocene era fall within the scope of **the Other Knowledge challenge.**

Ecosystems and sustainable management: ***See Theme 2 (joint theme common to Challenge 5).*** **Health-Environment:** ***See topic 3 common to Challenges 4 and 5***

Health-Environment: ***See Theme 3 (joint theme common to Challenges 4 and 5).***

POTENTIAL CO-FUNDING[18] FOR PROJECTS SUBMITTED TO THIS CHALLENGE

Under the sub-theme "sustainable management and resilience of the territories with high environmental stake (particularly coastal)" in theme 6 of this challenge, some projects may be co-funded through the MEEM (Ministry of the environment, energy and the sea), if they are also relevant under the LGCC program (management and the impacts of climate change).

Introduction

In light of world population growth and ever-increasing needs in terms of energy, raw materials, products and services, environmental changes are becoming an increasingly pressing matter at all scales, from individual landscapes to the planet as a whole (climate, biodiversity loss, soil degradation, pollution of air, fresh and marine waters, etc.). The current era, dubbed the Anthropocene era, has brought with it the need for an integrated approach to managing both the environments and the development trajectories of human societies in all their diversity. Such an integrated management approach calls for an upstream understanding of the processes and mechanisms inherent to these complex systems.

Challenge 1 calls for the enhancement of fundamental knowledge about not only the processes responsible for changes but also gain insight into local or regional consequences of changes on resources, societies and human activities, particularly those that depend on ecosystem services (see the Millennium Ecosystem Assessment). This challenge also encourages social, political and technological innovations aimed at avoiding or reducing impacts, compensating or restoring environments and adapting to new constraints and opportunities. It contributes to a number of major international initiatives in the following fields (Geo, Future Earth, GFCS, IPCC, Ipbes, SDG, etc.) and is backed by international calls for proposals through the Belmont Forum.

Challenge 1 is set clearly within **the COP21 agreement concluded in Paris in late 2015**, the first ever worldwide climate agreement. Realisation about the threats to humans' well-being and the need to develop procedures for implementing the Paris Agreement raise questions about new research aimed at all Challenge 1 themes, for example:

i) Determine the climate sensitivity of the Earth system, including in its biological dimension, according to variations in radiation forcing and regional impacts of global warming for a wider range of scenarios.
ii) Develop methods for monitoring emissions.
iii) Expand the potential of relevant carbon sequestration in soils (in line with the "4 for 1000" initiative).

[18] Co-funding means that funding is partially allocated by ANR, with the remainder coming from one or several of the agency's co-

funder partners.

iv) Learn to aggregate heterogeneous INDCs (Intended Nationally Determined Contributions) and assess the socio-economic consequences.
v) Assess the risks associated with geo-engineering techniques.
vi) Develop innovative approaches for an effective and efficient implementation of public policies.
vii) Propose new modes of governance as well as new analyses in terms of justice, ethics and responsibility.

With regard to building the European Research Area (**ERA**) and enhancing its international profile, this challenge aims to encourage **French coordination of European projects** using the **MRSEI funding instrument** ("Setting up European or international scientific networks"), which is described in section C.7, in to hone in on the following calls:

- Calls under **Horizon 2020**, in particular themes falling within *Societal Challenge 5 "Climate action, environment, resource efficiency and raw materials"* and those of the European Research Council (ERC).

- calls under the **Joint Programming Initiatives** (JPI Climate, JPI Oceans, JPI Water, JPI FACCE) and associated ERA-NETs; applicants should consult the ANR website for details and up-to-date information regarding calls for proposals in which the agency has taken part.

Applications are invited across a broad range of scientific disciplines: social sciences and the humanities, environmental science, life and Earth sciences, engineering science and also IT and communications for a great number of numerical issues and, where applicable, disciplines within the healthcare field. Given systems' complexity, a wide variety of multidisciplinary projects is expected, as well as theme-dependent research ranging from academic research to partnerships with the private sector, public sector and civil society.

Work Programme 2017's Challenge 1 is divided into **6 themes** and **21 priorities**, ranging from fundamental research projects to projects with multiple applications contributing directly to the **Earth System** action programme (observation, forecasting, adaptation) and the following **5 priority research areas of the French National Research Strategy (SNR)**:

- priority 1: Smart monitoring of the Earth system,
- priority 2: Sustainable management of natural resources
- priority 3: Assessing and controlling climate and environmental risks
- priority 4: Eco and biotechnologies to support the ecological transition
- priority 5: The coastal areas as a natural laboratory

and, in a less prominent way, Priority 15: Sensors and instrumentation and Priority 20: An integrated approach to production systems.

In addition, cross-disciplinary approaches are relevant to five SNR topics needing to be addressed as a matter of urgency: i) exponential growth in the volume of digital data and how to exploit this data, ii) the key role of science and innovation in climate risk analysis and management, iii) the revolution in our understanding of the living world, iv) the need to develop innovative, effective healthcare, v) the importance of knowledge about cultures and humankind.

COASTAL AREAS – a 2016-2017 priority topic: special attention will be given to projects relating to coastal areas throughout this challenge, due to its direct alignment with SNR priorities.

Coastal areas are a natural laboratory housing a multitude of risks of both natural and human origin. They are impacted by issues of underground resources, primary biological resources, energy and transportation, urban development, land planning and tourism, and efforts to preserve natural and cultural heritage. France, including its overseas departments and territories, has the world's second largest coastline. Worldwide, 1.4 billion people live in coastal areas. The environmental, societal and economic dimensions of this topic should prompt action from a large diversity of communities interested in both inland and offshore.

Theme 1: Fundamental knowledge in relationship with the challenge (environments and biodiversity)

SNR strategic priority areas in Challenge 1 call for research on efficient resource management, required to understand the mechanisms governing the formation, function and evolution of environments and their biodiversity; this in turn will lead to enhanced anticipation of the impacts of exploitation and global change, with climate change as a top priority.

Functioning and evolution of climate, oceans and major cycles

Climate affects all compartments of the Earth system: the atmosphere, oceans, cryosphere, and continental surfaces in close interaction with the biosphere and human societies. At stake is the ability to better understand and represent the processes and better identify and reduce bias and uncertainties of models (gas-aerosols- clouds, circulations oceanic, marine biogeochemistry, flow drivers and dissipative mechanisms, non-linear or chaotic phenomena, nesting of scales and spaces, tele-connections, interfaces between environments, major cycles of water, carbon, nitrogen, and phosphorus...). It is also important to understand the mechanisms underlying climate sensitivity, in particular to identify cut-off points. Gaining a better understanding of uncertainty surrounding the sensitivity of the natural system and seeking to reduce by using observation data is crucial. The final aim is to quantify the regional impacts of climate change over a wide range of global average temperature increase from 1.5 °C to 4 °C (by 2100). System behaviour in the negative greenhouse gas phase must also be studied.

Studies are encouraged on the processes responsible for transfers of energy, matter and pollutants, etc., along coastlines and in coastal areas and their interfaces with deep-sea regions, continental areas and the atmosphere, in order to remove the obstacles and locks that hinder our ability to model these aspects of the Earth-sea continuum and their current and future responses to the pressures imposed by human activity.

Global warming, which is chaotic and marked by extreme events, leads us to raise questions about natural variability and the distinction between natural and anthropogenic signals (induced by gas and substance emissions). Studies are encouraged on i) the most recent millennia by the use of proxies and historical archives or ii) ancient periods for which analogues of rapid transition inform our interpretation of the current century's variabilities, extreme events and trends. Capitalising on large global re-analyses of the Earth system from the last decades or centuries is encouraged for a better understanding of modes of regional variability, associated extremes, and their predictability.

Scales ranging from season to decade, which are pivotal between seasonal forecasts and climate projections over a century, are crucial to decisions made concerning adaptation. In parallel, research on spatial downscaling in connection with the climate projections are expected to more accurately account for the heterogeneity of surface states and land use in drawing up proposals for adaptation. Studies are also encouraged on the methods of detection/attribution of climate change and in particular the occurrence of extreme past, present and future events; the examination of the effects of differentiated anthropogenic forcings (greenhouse gas emissions, aerosols, land uses etc.) also remains a challenge .

International alignment:

- Carbon sequestration in soils (TAP-SOIL)

Specific international calls:

- Closing the water cycle gap (JPI Water/Waterworks 2017)

Characterisation, dynamics and workings of the critical zone and the associated biosphere

The critical zone, which is the near-surface area of continent stretching from the lower atmosphere to aquifers, comprises a number of interdependent ecosystems made up of crucial resources: air, the visible and invisible biosphere, soil and surficial free water and groundwater. It performs a range of functions for these ecosystems: transfer of biotic and abiotic matter, biogeochemical cycles (C-N-P, etc.), etc. and numerous services: climate regulation (including greenhouse gas greenhouse effect and carbon sequestration), supply (food, fibers, wood, etc.), and preservation and renewal of resources (water, soil fertility and protection, biodiversity related to soil and water, etc.).

Resulting questions involve (i) biotic and abiotic actions and retroactions between soil, water, air, vegetation and other living organisms, (ii) the coupling of biogeochemical cycles of major, minor, trace and contaminant elements and (iii) transfer of energy and transport of materials (solid form, suspended, or in solution). Questions also arise about the formation and/or development of the components of the critical area (biodiversity, soil, aquifers, catchment areas, etc.) and the role of interfaces (ecotones, hyporheic areas, wetlands, coastal areas, etc.).

A particular effort should be made on the issue of transfer of spatial (connectivity, emergent properties, etc.) and temporal scales (time constants, scenario-building...). With this in mind, the development of new approaches, methods and technologies is encouraged to better identify and take into account the variability of the properties and functions of the critical zone's various components.

In terms of soils, research is required to identify the functional and taxonomic (or phylogenetic) importance of the biodiversity of soil organisms and to characterise and model the functioning of soil organisms and their role in the provision of ecosystem services (kinetics of pedogenesis or soil degradation, etc.) and ecosystem restoration.

Understanding the state and dynamics of hydro- and aquatic continental ecosystems must contribute to reducing hazards (floods, droughts) and risks (loss of physical, chemical, and/or environmental status).

By better defining components' response times and resiliencies in the face of disruptive elements, the issue is to identify, quantify, analyse and model the response of the critical zone to the multiple pressures of global change, be they linked to climate change, to changes in land use and/or other human activities, through a systemic and interdisciplinary approach heavily relying on observation and long-term experimentation.

International alignment:

- Carbon sequestration in soils (TAP-SOIL)

Specific international calls:

- Closing the water cycle gap (JPI Water/Waterworks 2017)

Investigating biodiversity, ecology, evolution and dynamics of species, populations and communities

France is currently seeking to renew its vision of biodiversity and the principles of action which enable its protection, its potential restoration and its sustainable use. However, despite centuries of discoveries, global biodiversity still remains largely misunderstood, even with challenges of all kinds (scientific, economic, public health, well-being, etc.) associated with knowing and understanding the processes and mechanisms governing its workings, which are inherently complex at different levels of organisation (genes, individuals, populations, communities, ecosystems) and are constantly evolving. It is therefore essential to intensify exploration of biodiversity's lesser-known branches, including those living in the wild in lightly or non-anthropised environments (on all levels, from genes to ecosystems), and the analysis of mechanisms that explain the origin, maintenance and development of biological diversity in all their dimensions, including functional, phenotypic and genetic, using the powerful conceptual framework provided by evolutionary biology and scientific ecology Basic research on biodiversity has to play a central role, without which the technical and technological research, including those on genetic resources (pharmacology, genes for improvement, etc.) will be unable to effectively and sustainably tackle societal challenges.

Expected research should provide knowledge about biodiversity, systematics, evolutionary history of organisms, especially in geographical areas and biodiversity-rich ecological systems, mechanisms as well as the interplay between ecological and evolutionary dynamics underlying genome divergence and convergence processes, species and populations.

Research is also being sought on species, populations and species groups dynamics in their ecosystem (emergence, extinction, colonisation, invasion, rapid or slow adaptive capacity, plasticity, etc.), and the evolution of behaviour (social, individual, reproductive strategies, etc.) in interaction with the environment (affecting or influenced by the environment). Particular attention will be paid to research leading directly or indirectly to a better understanding of vulnerability and organisms' responses to global change, including those which offer:

- to build on the long-term monitoring of populations or species in relation to the environment,
- to analyse the ability of organisms' responses to changes in their environment on an infra-specific scale,
- to address the long-term vitality of communities and populations, including the old periods where they may serve as a model for understanding current changes to the environment,
- to investigate a system's adaptation or development capacity based on ecological and phylogenetic taxonomic diversity.

Knowledge of mineral resources (underground and surface formations)

Mineral resources are crucial for industrial activity and the development of new technologies, particularly those relating to transportation and renewable energy resources (energy resources fall within Challenge 2). Even if optimised, recycling will not be sufficient to cover growing needs. Finding new resources, for example critical metals (Ge, REE, Li, etc.), and exploiting them in an environmentally friendly way

is increasingly difficult. A new paradigm is needed when it comes to potential terrestrial or marine deposits in their geological and environmental context, particularly in order to meet the needs of new industrial sectors.

New methods and technologies must be developed in order to shed light on the processes governing the origin of deposits and mineralisation, their spatial and temporal dynamics from the transfer of complex ore-forming fluids to structures favouring these accumulations, to successive deformations. These pathways are necessary to locate these resources and assess their potential and ensure early identification of potential obstacles to exploitation and/or impacts on natural environments, ecosystems and biodiversity (see theme 4).

Specific international calls:

- Primary mineral resources: exploration and extraction (ERAMIN-2)

Theme 2: Ecosystem dynamics to improve their sustainable management (joint theme with challenge 5).

This theme aims at better understanding how global changes – in particular climate change – will interact with the future of land and marine ecosystems across the whole spectrum, from natural systems or systems with low human activities to ecosystems of agricultural, forestry, fisheries or aquaculture importance. It also aims to draw up management and adaptation strategies in a variety of economic, social and cultural contexts. Thus, the issues are the sustainable development and management of ecosystems and resources, the impact of management methods on the environment and ecological services, and the complementarity between natural and productive ecosystems for all ecosystem services (supply, control of resources, common goods...). This cross-cutting topic is in line with the SNR (priorities 2, 3, 20 and 2 Action 2/Earth System programmes),

Specific international calls:

- Sustainable and multifunctional forestry (Sumforest)

Adaptation and sustainable management of ecosystems

Expected research on this topic should aim at better understanding the functions, development and resilience and adaptation capacity of land and marine ecosystems in terms of the interaction between species and between trophic levels, their functional biodiversity and their contribution to the major cycles (C-N-P, water). It is also important to understand the interactions, complementarities and interfaces between the different types of ecosystems.

This research will provide an insight into ecosystem evolution, adaptation, resilience and the capacity of ecosystems to provide multiple ecosystem services. They will facilitate ecological and agro-ecological transition through the design or the re-engineering of production systems based on a better knowledge of biotic interactions and functional ecology in order improve their sustainability.

Theme 2's objectives are more resilient and better use of renewable resources, with impacts expected at different levels: an improvement of environmental quality (water, soils, air), a mobilisation of biodiversity, including genetic resources, maintaining its evolutionary dynamics, and integrated management of production systems in the territories, landscapes, coastal and offshore areas.

Topics concerned include the management of resources and the maintenance of land and marine ecosystem services as well as transitions in agriculture, livestock systems, forestry, fishing and aquaculture towards integrated and sustainable productive systems: agro-ecological planning, ecophyto, sustainable forestry management, ecosystem approach to fisheries, sustainable aquaculture, etc. Research shall aim to provide a better understanding of:

- the adaptation dynamics of ecosystems in the face of climate change (including extreme events, amplified seasonalities) and environmental change; the functional role of biodiversity; its contribution to stability, resistance and resilience of ecosystems and associated ecosystem services;
- interactions and interfaces between production systems and systems with little human involvement; positive interactions between species with a view to improving the performance of production ecosystems; interactions between ecosystem services;
- Feedbacks between changes in biodiversity and ecosystem functioning and alteration of local, regional and global climate;
- The responses of the living systems with multiple simultaneous and/or successive forcings to build realistic evolution and sustainable management of ecosystems scenarios;
- The impacts of agroecosystems and various agricultural practices, aquaculture, fishing on the environmental changes;
- The alteration of marine or freshwater ecosystems with issues concerning of fisheries resources.

Research shall also include the necessary adaptation strategies for:

- controlling the impact of production activities on resources and environments, in particular on water resources and aquatic environments;
- sustainable management of production ecosystems on different spatial levels — from small plots of land to catchment areas: management and conservation of soils and their services, including in particular the functional role of organic matter, the integrated management of carbon, nitrogen, phosphorous and water cycles and the integrated and sustainable management of animal and plant health;
- The integration of production systems, land use, ecological infrastructure and protected areas to improve sustainability and performance.
- **Carbon sequestration** in soil, which is a priority objective for the "4 for 1000" initiative coordinated by France internationally (TAP SOIL).

International alignment:

• Carbon sequestration in soils (TAP-SOIL)

Evolution trajectories of ecosystems: Strategies and policies for supporting transitions

The transition of agroecological approaches to stimulate the transition of productive ecosystems towards greater sustainability involves the identification of innovative pathways and the implementation of a framework that encourages development through initiatives, strategies and policies. Research focusing in particular on the development and use of scenarios[18], with the ultimate goal of providing information to society and decision-makers for better targeting of management strategies and public policies, will be welcome. Research should also stimulate the innovation process for ecosystems, territories and product chains management. Supporting the transition towards more sustainable approaches involves:

- developing integrated models that combines socioeconomic, biotechnical and ecological aspects, and creating scenarios to predict the development and adaptation of ecosystems in response to global change;
- identifying barriers and drivers for action to facilitate agro-ecological transition on both a regional and a sectoral scale;
- gaining an understanding of the factors that influence actors' behaviours in the

[18] Research performed in this context is what provides the inputs for the group work of the Intergovernmental Panel on Climate Change (IPCC) and the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES).

face of change, whilst taking into account biotechnical and socioeconomic factors

- designing sustainable practices and integrated production systems in collaboration with stakeholders; analysing the learning processes of innovative stakeholders and designing new innovative pathways;
- development and evaluation of public policies for supporting transitions; these evaluation concern environmental performance and economic evaluation, social impacts, as well as the field of political sciences. Public policies concerned include biodiversity protection combining conventional regulatory instruments and incentive measures, and the integrated management of health risks via biomonitoring, biovigilance and biocontrol strategies.

Theme 3: Health-Environment- "One Health (joint theme with challenges 1, 4, and 5)

This theme is common to challenges 1, 4 and 5; projects submitted will be jointly evaluated. Theme 3 concerns the areas at the interface between these challenges, as well as particularly transdisciplinary approaches.

The “One Health” concept postulates that the epidemiological dynamics and actors’ incentives which determine the health of human and animal populations should be studied in their microbial, ecological, socio-economic and political contexts at the interface between human, animal and ecosystem health. The One Health approach provides a functional work environment for the integrated and interdisciplinary exploration of: 1) the effects of environmental factors on living species and human health, 2) the position of the environment among the various determinants of health, 3) the impact of multiple determinants on rare diseases, health and healthcare systems. They are supported by the concept of exposome and therefore entail a coherent analysis of emerging risks.

The study of how environmental factors affect living species or human health and the role of the environment among the various factors influencing health should focus on the impact of physical, chemical and biological contaminants by taking into account the various environments and levels of exposure. Research should also encompass interactions between the environment, animal health and human health, and the role of the environment in the mechanisms of emergence and re-emergence of disease mechanisms (ecology of health).

The issues at stake include the search for a better understanding of phenomena and mechanisms, the assessment of risks, and proposals for appropriate monitoring methods, countermeasures and policies. Cooperative initiatives are therefore expected between the different biological and medical science disciplines, environment and ecology, physical, chemical, mathematics and modelling, social sciences and humanities, etc.

Three sub-themes will be considered:

Environmental toxicology.

In environmental toxicology, encouraged approaches include pathways or networks of toxicity, systems biology, epigenetics and those targeting vulnerable stages in the life cycle of individuals, transgenerational effects, and effects of mixtures in particular in low doses, or key life-history traits for population dynamics in the environment. Particular emphasis will be placed on emerging contaminants and endocrine disruptors.

Contaminants, ecosystems and health[19]

This sub-theme focuses on the study of the transfer and toxicity of contaminants (including pharmaceutical contaminants), their metabolites, and transformation products in ecosystems, in human populations and the link between work and health.

Multi-disciplinary approaches are expected that: 1) explore the exposome concept, interactions between different contaminants and their possible cumulative effects; 2) model the transfers of contaminants in different media and networks, their repercussions in human and animal food chains, and their impacts on ecosystems and their component parts; 3) identify emerging risks and establish adequate systems of supervision, and analyse social risk assessment, debates and decision-making; 4) improve predictive capabilities through systemic approaches; 5) analyse the relationships between environmental change and chronic non-communicable and/or allergic illness; 6) include environmental, economic and social factors which determine or modulate exposures and vulnerabilities of human populations and involvement of social actors; 7) develop remedial approaches.

Environment, pathogens and emerging or re-emerging infectious diseases

This priority focuses on the dissemination of pathogens and infectious disease emergence mechanisms (human, plant or animal, including zoonoses) which can be conditioned by environmental factors (climate, biodiversity, land and resource use, etc.) in synergy with anthropogenic factors (agriculture, biodiversity, industry, urbanisation, mobility, demographic change, globalisation, social practices, etc.). It also concerns resistance to antibiotics, anti-parasitics, antifungals, insecticides, and biocides. Various pathogens are included (e.g. parasites, fungi, algae, bacteria, virus and non-conventional pathogens) as well as their products.

The objective is to support multidisciplinary research taking into account said pathogens' social and environmental dimensions in order to anticipate the risk of epidemics or pandemics, as well as develop prevention and proactive measures, and to fight against antimicrobial resistance and resistance to biocides in general. Particular attention will be paid to neglected infectious diseases as defined by the WHO.

Integrated and multidisciplinary approaches are expected on:

1) pathogenic agents, their ecological niches (reservoirs and arthropod vectors), their persistence and development conditions and their spatio-temporal dynamics of transmission;
2) assessing the risk of inter-species transfer of pathogens;
3) The study of the relationship between pathogens, and interaction mechanisms between the different determining factors promoting the spread of pathogens;
4) modelling of emergence, dissemination, exhibition and elimination parameters (including through retrospective analyses and predictive ecology scenarios). The creation of geographical, environmental, climactic, biological, social, economic, demographic, epidemiological, clinical and health databases able to aid in establishing indicators for a predictive approach to evolving epidemics in health monitoring;
5) The control or monitoring methods compatible with human health and the environment: treatment, vaccination, surveillance, prevention policies, biological or vector blockers, emergency management...;

[19] This priority is part of the research priorities defined in IFRES (French Environment and Health Research Initiative) coordinated by the group "Inter-Alliances Allenvi-Aviesan-Athena".

6) bacterial or parasitic multi-resistance in order to identify the molecular and environmental factors involved in the spread of multi-resistances. The following topics are particularly encouraged: the impact of the host and its microbiota in the development of resistance to antibiotics in a pathological context; microbiota dynamics in normal and pathological conditions; The role of epistasia in the development of multi-resistances to anti-infectious agents and identifying at-risk areas and populations (eco-epidemiological approach);
7) The perception and behaviour of different actors towards risk, as well as alert, information and prevention capabilities, and treatment and control strategies. Methods for the design, formulation, implementation and evaluation of different policies and measures will also be studied.

International actions:
Certain projects falling under JPI-AMR (antimicrobial resistance) will be integrated with this theme in addition to certain IMI2 calls.

Theme 4: Scientific and technological innovations to support the ecological transition

Environmental topics address issues concerning the reduction of environmental impacts or aiding adaptation to environmental changes, in addition to remedial or preventive initiatives to mitigate associated risks. (The circular economy, associated with new industrial sectors, comes under Challenge 3.) In order to avoid, reduce or offset environmental risks, research should take into account the existing level of uncertainty surrounding knowledge of the environment and ecosystems. In theme 4, public-private partnerships are preferred around the priorities set out below.

Specific international calls:
- Closing the water cycle gap (JPI Water/Waterworks 2017)

Development of sensors for environmental monitoring (smart monitoring)

The heterogeneous nature of the environment undermines the benefits of conventional metrology and the effectiveness of many prevention and protection solutions. A new generation of sensors or sensor systems are awaited to power the observation and diagnostics systems.

Technological, digital, economic and methodological breakthroughs are expected, leading to cost reductions and greater miniaturisation, autonomy, reliability and ruggedness in sensors (progressing towards very low doses), the increase of data flows, in situ and continuous measurement, especially on complex matrices, a cocktail of organic contaminants, pollutants and invasive species, etc.

In this diversified innovation sector featuring numerous types of businesses, research is especially encouraged on technology transfers enabled by information and communication sciences and technologies (nanotechnologies, robots, drones, bio-mimetics, big data and crowdsourcing-related solutions), life sciences (biotechnology, bio-indicators and biomarkers including genetic markers), and geosciences (geophysics, geo-chemistry, remote sensing, and geostatistics). All environmental compartments are involved, e.g. water, sea, coastline, air (outside and inside), soils, forests with their biotic and abiotic components, applications in natural or impacted environments.

Specific international calls:
- Marine technologies (JPI oceans/marTERA)

Methods and tools for operational alert and environmental crisis services

In terms of forecasting, prevention and management of environmental alerts or crises, there is often a synergy or "cascade effect" in natural and/or human-induced risks[20].

We are particularly interested in methods and tools for providing services to combat these multiple risks, for all media, including modelling and data assimilation and visualisation tools. These advances should lead to real-time or almost real-time management of massive multi-source data, and include them in predictive models. The ultimate aim is to better assess impacts, identify the mechanisms and conditions for alerts, and manage risks and crises effectively.

Proposals should focus on integrated forecasting systems that can produce data and scenarios based on the possible causes of an emergency or catastrophe, a succession of pressures and/or simultaneous application are encouraged. Combinations of several different alert systems should draw upon a collaborative initiative between the stakeholders and users concerned. Depending on the field, forecasting systems shall study periods ranging from several days to several decades, for a variety of geographical areas, from single towns to entire regions. This shall include climate services in the broader sense and scenarios for societal adaptation and ecosystem resilience, but not climate predictability, which is covered by Theme 1 above.

Methods and technologies for sustainable remediation, environmental engineering and climate engineering

The priority in terms of remediation is to restore soil, (whether contaminated or more deeply degraded due to compaction, erosion, or loss of organic matter) sediment, biodiversity, water, water service, and climate engineering quality. The priority's objective is to advance the concept of curative treatment toward more systemic and sustainable remediation concepts (including assistance to self-repair ecosystems, solutions based on natural processes), and to implement integrated strategies concerning primary needs, while still meeting societal needs (air, water, energy, and land, as well as CO2 storage). The solution proposed must include a core methodology based on tools such as life-cycle analysis or other forms of cost-benefit analysis (e.g. use of secondary materials). The insertion of technology trains (biotechnology, genomics, nanotechnologies, coupling hydro-biogeochemistry, etc.) will be centred around the ability of materials or products to be recycled and lay the foundations for new engineering practices.

When it comes to polluted sites and soils, genuinely novel processes and/or treatment combinations with a positive environmental record must be developed (depending on subsequent uses and risks). Pedo-genetic engineering and soil reconstruction (technosoils) are considered to be directly in line with this approach.

In terms of water, priority shall be given to ground-breaking projects targeting the specific concept of units of supply and treatment of the future', including i) integration of particularly emerging pollutants and associated metabolites, ii) the recovery of raw materials derived from the effluents (phosphorus, nitrogen, metals, etc.), and increased energy output to achieve positive energy balances. The concept of decentralised treatment units (networks or cascade processes) may also be included.

In the marine environment field, the programme should help to i) develop new design and eco-design strategies for marine projects and infrastructure, integrate sustainable development, climate change (the rise in sea level) and proper environmental status, (ii) ecological restoration testing of workshop sites on different scales and characteristics (particularly sensitive and intertropical environments); and (iii) environmentally optimal compensatory measures based on an ecosystem strategy. Medium to long term monitoring solutions will need to be developed.

[20] Chronic and accidental pollution, allergenic, toxic products, eutrophication, species invasions, biodiversity erosion, flooding and high water levels, coastal erosion, land movement, eruptions, earthquakes, storms, fires, droughts, natural or induced low water levels, overuse of water, etc.

In the area of ecological engineering, priorities will be based on the development of solutions inspired by natural processes (e.g. infrastructure/green and blue belts, account taken of the resilience of degraded ecosystems, combating invasive species, the fight against the process of ecosystem simplification) and for preserving ecosystems in a good ecological condition whilst adapting them to natural or anthropised environments. Solutions offering monitoring protocols and existing networks integration will be given preference.

In the area of climate, greenhouse gases and 2030 emission reduction targets, the programme will endeavor to develop French climate engineering expertise (see www.arp-reagir.fr), in particular i) management of solar radiation and its often negative impacts, ii) the capture of atmospheric CO2 or oceanic CO2 sequestration. With respect to this last section, the following are welcome: a) “second intent” carbon sequestration solutions able to be grafted onto the existing industrial processes; b) “territorial” geo-engineering, however which must use soil to help improve local climatic conditions; and c) climate-oriented agriculture. For all of the techniques covered, a reflection on environmental, ethical and political dimensions is expected on the associated risk and on governance of solutions being considered (in an optionally international context).

Reducing and controlling the environmental impact of new economic sectors

Ecological transition is giving rise to new economic sectors (industrial, energy, agricultural, mining and storage activities), which are either completely new or the result of a shift within established industries. These new sectors are based on environmentally friendly exploitation of natural resources and, as such, present a low — or even positive environmental impact, whilst maximising socio-economic benefits (economic activity, employment, and quality of life) by drawing upon synergies. In this context, dedicated prevention research should be conducted to analyse and forestall the potential impact and any environmental risks (water, air, soil, underground, biodiversity, ecosystems, climate, etc.) and socio-economic risks so that specific recommendations can be drawn up concerning the economic sector in question to minimises environmental impact, for example:

- Develop bio- and geo-inspired processes (for production of raw materials, energy or materials for treatment or storage of carbon, energy, etc).
- Assess the territorial synergies with a view to increased efficiency of resource use (water, energy, raw materials, soil) by industrial ecology tools.
- impact and potential stress scenarios for these new sectors in terms of the environment, health and long-term trends;
- Propose methods and tools facilitating the development of these new sectors (planning, collaborative approaches.), particularly on the basis of advances in digital data (crowdsourcing, open data, big data).
- Anticipate and identify the key issues in impact monitoring and parallel monitoring of risks and benefits in these sectors on sectoral or territorial scales.
- while maximising socio-economic benefits.

Specific 2016/2017 international calls:
- Mineral primary resources: exploration and extraction (ERAMIN-2)

Theme 5: Society in the face of environmental change

Environmental impacts need to be mitigated by means of suitable development and governance modes. The task here is to explore the vulnerabilities and opportunities arising from environmental, social, political, cultural and economic change; the conditions under which various societies adapt to these constraints; and prospects for action. Technology and resource dimensions must be integrated. Projects may address different temporal and spatial scales, sectoral or multisectoral approaches and apply to different locales. Comparative analyses are welcome.

Policies and actors, actions and instruments

The management of problems depends as much on their acuity as on the way in which they are addressed by public and private stakeholders. A number of questions arise. Which actors have a structuring and disseminating effect on proposals? And to what effect, in terms of reconfiguring power relationships, coalitions, logic and action and spaces? Under which conditions do environment issues call for public action (justification, hierarchisation modes, knowledge, controversies, uncertainties, etc.)? Particular attention should be paid to interfaces between scientists and decision-makers.

Environmental policies and forms of action may be analysed according to their conception, content, implementation, and learning and cooperation patterns. Which instruments are used (consultation, incentivising, constraint, etc.)? How should research combine the various tools (technical standards, self-regulation, etc.)? What is the relevance of concepts of ecosystem, environmental or climate services?

There should be an exploration of the interrelationships between various policies (environment, health, agriculture, trade, industry, innovation, energy, etc.) and thought should be given to their alignment. The definition of a global adaptation objective in the Paris Agreement offers a new agenda for research. How can we evaluate these policies?

To what extent are regions centres of impulse? What role do different regional actors play, including cities? Should we not renew the way we support local initiatives? Research on evaluation tools and mechanisms favourable to collective action, whatever the geographical scale, are particularly encouraged.

Conflicts, cooperation, governance

Environmental changes can potentially lead to new geopolitical power relationships and conflicts. Conversely, certain confrontations may accentuate the effects of these changes. The interplay between developmental modes, the environment, vulnerability and international relations ought to be explored. What is the role of multilateralism? After the adoption of the global goals for sustainable development and the Paris agreement, what role can the United Nations and intergovernmental agencies play? Do they usher in a new understanding of the relationship between national sovereignty and international governance? What methods of cooperation and solidarity mechanisms can be implemented? Particular consideration should be given to the connections or interference between various topic areas and entities (UNFCCC, the Protocol on Ozone, The Biodiversity Convention, Global Sustainable Development Goals, WTO, IMF, etc.). What coordinating role do private actors, international organisations and judges play? Does the circulation of standards and stakeholders contribute to improving policies' consistency and effectiveness?

Societal vulnerabilities, resilience and adaptation

Climate change effects are forcing us to go beyond ad hoc approaches suited for a given hazard and develop cross-sectoral multi-hazard approaches, integrating new effects (thresholds, tipping points, or “dominos”). The concept of resilience allows for the qualification of capacities for resistance and adaptation of unequal societies. What economic, social, cultural factors enable us to adapt to sudden or gradual extreme events? What is the relationship between the objective and subjective perceptions of risks and vulnerabilities? What is the relationship between the social representations of risks and adaptation strategies? To what extent does political instability compromise environmental management? How do we remedy growing inequalities in adaptation and resilience capacity? How can vulnerabilities be mitigated?

The effectiveness of preventive policies is, in part, reliant upon the knowledge that individuals have of threats, probable consequences and their own vulnerability. How can the distance between scientific risk assessment, management policy and social perception be shortened?

Historical approaches assist in understanding these phenomena by analysing past dynamics. What role do people’s memory and knowledge play in different cultural settings? How can long-term factors be taken into account in light of temporalities arising from other spheres of life in society: finance, infrastructure, innovation, policy, lifestyles and so on? What are the most relevant liability, protection, insurance, and repair schemes? What factors influence the perception of risks? How much leeway do populations have? Research may cover vulnerable areas (intertropical and island, etc). An integrated approach to the long-term trajectories of socio-ecosystems is encouraged. The study of periods of cultural, environmental and climatic ruptures, as well as past disasters, must contribute to our understanding of the relationships between human societies and the environment. The various forms of cultural expression can be analysed from the point of view of their role in the collective memory, in representations of risks and disasters, visions of the future and of all possible worlds.

Production and consumption, innovation and growth

In order for sustainable development to be achieved, changes need to be effected through a multisectorial approach, in conjunction with management, production and consumption patterns. What options should be considered to promote solutions such as those envisaged in the Paris agreement, given constraints and determinisms? How can innovative stakeholders emerge? What dynamics are necessary to construct markets, new sectors, private investment, etc.? How can short chains and the circular economy be promoted in an integrated world economy? What are the barriers preventing the dissemination of innovative technologies? Which instruments will allow for the adaptation of production and consumption behaviours (certification, labelling, regulations, best practices, etc.) and forms of organisation and economic incentive? Technology can be looked at from the standpoints of objectives, forms of legitimisation, transfer modalities, and its relation with existing infrastructure. How should land management, environmental management and competitiveness be reconciled?

To what extent does economic growth and development take environmental changes into account? How do production and consumption patterns adapt the depletion of certain resources (incentives to develop new sources of growth, industrial policy, research, etc).

Justice and accountability

The issue of equity and environmental injustice warrants further exploration (unequal access to resources, common ownership of property by private stakeholders, differentiated environmental risks from a socio-economic point of view, including housing, localised pollution, etc.). How can needs for equity and solidarity be reconciled? What are the indicators of injustice (differentiated effects on health, for example)? The issue of equity can also be addressed in a longer perspective, taking into account future generations. What could then be the basis for "intergenerational democracy"?

Is it possible to mobilise the main principles of "distributive justice", accountability, moral and political philosophy to "legitimise" the apportionment of reduction efforts between countries? Can the ethics of responsibility derived from these principles be translated into concrete action?

Recognised in the Rio Declaration of 1992, the principle of "common but differentiated responsibilities" plays a central role in the climate system since it allows account to be taken of differences and injustice in the degree of adaptation and therefore resilience of countries to the risk of climate change. Even if its interpretation has been a constant source of blockages in international negotiations. Differentiation is an issue of justice and international equity — but also of efficiency. How does the construction by aggregation of national contributions relate to the issue of fair sharing of "burden"? Following the Paris Agreement, will the discussion on sharing responsibility be debated on the national stage?

Important issues such as the prevention and remedying of 'loss and damage' caused by climate change have been the subject of provisional compromises that cannot satisfy southern countries in any lasting way, including on the issue of climate migrants. What mechanisms should be used to ensure compensation for such damage? What vision of international solidarity does the agreement reflect? How can justice, equity, responsibility and the sovereignty of States be reconciled? The issue of equity conveyed by the principle of common but differentiated responsibilities arises at the national level, but also within states, in particular those from the south (where inequalities between urban and rural areas, for example) remains strong. More generally, and in a long term perspective, will this principle be sufficient to reduce climate injustice?

Certain topics under Theme 5 are also addressed within Challenge 8

Theme 6: Integrated approaches to territories' environmental development

Issues related to efficient resource management and adaptation to changes in human activities and climate cover several fields and research issues addressed in Themes 1 to 5 of the challenge. Ultimately, responses to ANR Challenge 1 must be found on the socio-ecosystems scale. The objective of Theme 6 is to promote integrated scientific approaches that focus on complex interactions between ecosystems and socio-economic systems.

This topic calls for multi-, inter- and transdisciplinary research in areas common to all five previous themes in Challenge 1, and with significant input from the social sciences and humanities communities. The identification and analysis of interactions between environments, usages and practices of actors based on integrated or systemic approaches make up the desired foundations for (i) addressing changes in behaviour and practices, resource management and territories, and (ii) anticipating, identifying, facilitating and amplifying transitions. Research should contribute to a greater adaptation and/or resilience of the socio-ecosystems faced with change.

Spatial or temporal multi-scale approaches explaining the internal interactions and forcings external to targeted socio-ecosystems subject to scientific inquiry are expected. Particular attention will be given to joint projects with socio-economic actors engaged as partners [21]. This may include short exploratory projects helping to build innovative consortia and large integrative projects on topics which have already been put forth.

Ecosystem services: evaluation, competition and arbitration

Ecosystem services, and environmental services as a whole cover many aspects, ranging from supply services[22] to environmental regulatory services[23] to immaterial and leisure services[24]. Their identification, evaluation, and the characterisation of their functions are parts of a growing research area driven by various national and international initiatives (International Convention on Biological Diversity, IPBES, Ministry of the environment, FRB, ADEME, etc.).

Projects are expected in particular on the analysis of synergies and competition between different ecosystem services, and the process of building compromises between stakeholders, particularly in the context of a discussion on the relevance of ecosystem services and their evaluation methodologies, value creation and compensation, as a tool of environmental policies.

These services may be analysed by environmental compartments taking into account the multiple functionalities offered and also limits to mono-service approaches. These issues may be covered where appropriate in retrospective studies on the identification process of such services.

International alignment concerning Generic Call 2017:
- Carbon sequestration in soils (TAP-SOIL)

Sustainable management and resiliency of territories of strategic environmental importance (including coastlines)

Sustainable development of territories requires a reduction or a mitigation of the cumulative environmental impacts of human activities just as much as it requires the adaptation of societies to increase their resilience. This implies assessing the potential of local and regional authorities for better management in the medium and long term, and an "intermediate" spatial scale (typically landscape scale or from the scale of a small basin to a large region, so from 1 to 100 000 km²). Similarly, retro-analyses may offer transposable avenues for adaptation and mitigation. Expected research will bring together researchers, local stakeholders in the socio-economic world and/or public policymakers around a shared problem and a common territory. Results may call on scenarios and modelling to inform planning methods and support local projects.

In this context, the preferred territories for 2017 are those which are particularly vulnerable and/or insufficiently studied:

- Coastal zones: from water catchment area to the sea, island territories, estuaries and deltas,
- Intertropical area, including overseas regions,
- Mediterranean area,
- Cities (for example: heat islands, role of plants, interaction between urban and environmental risks)

[21] associations, enterprises, communities, public managers, etc.
[22] food, fibres, valuable molecules, genetic resources, water, soil, energy, etc.
[23] climate, water cycle, biogeochemical cycles, natural barriers and risk reduction, etc.
[24] quality of the landscape, hunting and fisheries, spiritual, recreational benefits.

ANR and the Ministry of the Environment, Energy and the Sea (MEEM) have noted possible synergies within this sub-theme, which makes up a field of common interest between ANR and the GICC call (Management and Impacts of Climate Change) of MEEM. Projects in this field shall contribute to stimulating the incubation of innovative projects supporting public policies, redefining climate change adaptation policies and determining the conditions of their implementation in a context of ecological transition.

Researchers are advised to consult MEEM's GICC call for smaller projects corresponding to a complementary exploratory funding instrument.

An integrated chain for assessing risks, including natural hazards, vulnerabilities, and landscape impacts

Global changes affect the scale and scope of environmental risks to populations. The objective is to improve risk awareness and increase socio-ecosystem resilience. Climate forcing, mechanisms influencing hazards and the identification of exposed areas and the vulnerability of socio-economic actors are important factors when assessing environmental hazards.

Projects are expected on effects, including multi-hazard components, cascades, tipping points, interactions between natural, industrial and technological risks and feedback. This risk chain in geographically identified catchment areas should extend to issues of economic valuation as well as risk perception and representation.

The barriers identified prevent the study of complex processes in interaction with one another, their potential impacts, and modelling of these elements. Such an integrated assessment must enable innovative approaches in environmental risk prevention in all its components.

Challenge 2 : Clean, secure and efficient energy

EUROPEAN AND INTERNATIONAL COLLABORATIONS

This challenge falls within a specific European and international research development dynamic. The following information aims to provide French teams with details concerning existing or forthcoming agreements between ANR and its foreign counterparts. Said agreements aim to facilitate the formation of international projects and consortia.

The 2016/2017 topics prioritised for international backing are detailed below and also listed in annexes 1 and 2 of Work Programme 2017. Lists are subject to change, applicants who wish to conduct their projects at the European or international level should regularly consult the ANR website for more information on these partnerships and calls for proposals: http://www.agence-nationale-recherche.fr.

The following calls are particularly related to this challenge: • ERA-net Cofund CoBioTech • AAP NSF ANR PIRE programme (Partnerships for International Research and Education)

INTERFACES

Challenge 2 involves cross-cutting research topics relating to more than one challenge. *The other challenge(s) to which these topics relates is (are) indicated below, so that applicants may orient themselves towards the most appropriate challenge for their project. You are strongly advised to read each related challenge in its entirety to gain a thorough understanding of its specific scope.*

For information concerning cross-cutting theme areas, most of which fall within the scope of multiple challenges (including Challenge 2), readers should refer to the paragraph entitled "**Multidisciplinarity, cross-over and interfaces**" (pages 39-42) which covers the following fields: ***big data, robotics, sensors, biology, bioeconomy & biotechnology.***

The following fields also overlap with Challenge 2:

Environmental impacts: quantification of overall impacts (water needs, CO2 emissions…) of energy systems falls under **Challenge 1**; however, the design of energy technology with a lower environmental impact as well as research dedicated to management/prevention of hazards posed by new energy technologies falls under **Challenge 2**.

Mineral resources, materials: Gaining an understanding of mineral raw material deposits falls within the scope of Challenge 1. Projects pertaining to methods and technologies for the extraction, separation, processing, and recycling of the materials used by energy technologies come under Challenge 3. All research concerning the use of mineral raw materials for energy purposes falls within the scope of Challenge 2.

Biorefineries and bio-based platform molecules: Projects targeting the production of advanced fuels from bioresources, possibly jointly with platform molecules for the chemical industry under Challenge 2 – Theme 4, those used for the production of other bio-based products fall within Challenge 5. Projects relating to the manufacture of commodities or products functionalised from bio-based platform molecules or downstream from the vegetable chemistry sector (fine chemistry, specialty chemistry) are to be submitted under Challenge 3.

CO2 valorisation: Projects for producing synthetic fuels or platform molecules for chemistry (possibly jointly) from CO2 fall within Challenge 2.

Energy efficiency of buildings and transport: projects dealing with integrating energy components and systems (electrochemical accumulators, heat pumps, etc.) into buildings or transportation — and not on the design and the manufacture of these components, which fall within **Challenge 2** — the challenge must be submitted under **Challenge 6**. New combustion methods, the use of alternative fuels, including biofuels, and emission control systems primarily aimed at transport applications also fall within **Challenge 6**.

Smart grids: projects on intelligent energy networks fall within **Challenge 2** and **Challenge 7**, as long as they do not primarily relate to IT (algorithmics), big data management techniques or telecoms (communication protocols).

Protection of infrastructure and energy networks related to energy: research relating to the physical protection and digital infrastructure and networks linked to energy fall within **Challenge 9**.

Gas sensors: their design and development are subject either to the challenge 1 (Metrology for Environment) or industrial metrology (**Challenge 3**) or **Challenge 9** (chemical threat agents or explosives).

LED and OLED: their design and manufacture under **Challenge 3** and for electronic applications, **Challenge 7**.

POTENTIAL CO-FUNDING[26] FOR PROJECTS SUBMITTED TO THIS CHALLENGE

Projects submitted under this challenge may be co-funded by the DGA (the French Defense Procurement Agency).

Introduction

The **5 SNR priority areas** which principally concern ANR Work Programme 2017 **Challenge 2** are:

- Priority 6: Dynamic management of energy systems
- Priority 7: Multi-level governance of new energy systems
- Priority 8: Energy efficiency
- Priority 9: Reduced dependency on strategic materials
- Priority 10: Alternatives to fossil carbon for energy and chemical sectors

Challenge 2 is also concerned by SNR priority research areas no. 2 (sustainable management of natural resources), 3 (assessing and controlling climate and environmental risk), 4 (Eco and biotechnology to support the ecological transition), 14 (development of new materials) and 21 (from production to diversified uses of biomass).

This challenge will enable ANR to mobilise top-notch scientific and technological expertise to tackle the energy transition challenge in the context of the French “Factor 4" 2050 emission reduction pledge as well as energy transition on a global scale.

Challenge 2 is focused on six major objectives:

- Promotion of the **systemic, integrative** and generally **multidisciplinary** approaches often required when dealing with energy issues; though the social sciences and humanities have a specific theme (Theme 7), their capacity for interdisciplinary research calls for support for their deployment on the other, more technological themes within the challenge.

[26] Co-funding means that funding is partially allocated by ANR, with the remainder coming from one or several of the Agency's co-funder partners.

- Further mobilise all scientific disciplines able to yield basic knowledge of use in the energy transition, whether they belong to the material sciences, engineering sciences, earth sciences, life sciences, mathematics and information sciences and communication or social sciences and humanities; upstream research may be aligned with Theme 1, but must also correspond with thematic issues laid out in the challenge's other themes.
- Research creating and **exploring** radically new ideas and **concepts breaking with existing paradigms** are mainly expected within Theme 1.
- the design of **materials, methods and processes** useful for energy technologies; we are aiming to support a wide spectrum of projects on **energy-related materials**, ranging from research and design focusing on materials with useful properties for the target applications (electronic conduction, photonic conversion, the energy barrier, etc.) to their integration into functional systems; depending on the application in question, each of these projects should fall within one of the themes covered by the challenge;
- the provision of technological proofs of concept, which may include developing laboratory experiments or integration into existing experimental sites. This challenge's scope of intervention is nevertheless limited to relatively upstream levels (Technology Readiness Level 1 to 5), complementary to other R&D funding schemes positioned on phases which are more downstream at the national (ADEME, BPI France etc.) and European levels (Horizon 2020). However, project coordinators – including those whose projects are carried out at upstream research phases – are encouraged to reflect on usage constraints and conditions, lifespan, costs, reduced reliance on or recourse to substitutes for rare or toxic raw materials, etc.
- promoting the contribution of **social sciences and humanities** toward discussions on the energy transition and characterising the way in which societal choices are made through the deployment of energy technologies. Social sciences and humanities, through the plurality of their concepts and methods, are required to go beyond a sectoral approach to technologies and address the systemic dimension of innovation and their impacts.

Apart from Theme 1, dedicated to the production of basic knowledge and groundbreaking concepts and Theme 7 which aggregates contributions from social sciences and humanities' contributions, the remaining themes cover energy issues from primary resource capture to end use, particularly in the industrial sector, including conversion of energy vectors, storage and distribution. Each theme supports research aimed at acquiring basic knowledge on the theme at hand.

Theme 1: Exploratory research and groundbreaking concepts

Directed at producing basic knowledge and exploring groundbreaking concepts, Theme 1 also aims to attract new communities towards energy issues and foster new partnerships. It is cross-cutting with Challenge 2's other thematic areas.

Knowledge Base and fundamental research of interest for energy

Solving long-term energy challenges requires a basic knowledge foundation and consolidated scientific expertise, whether they involve the matter sciences (physics, chemistry, etc.), engineering (mechanical, thermal, processes), earth sciences, life sciences, mathematics and information sciences and communication (modelling, simulation, algorithmic trading, automatic control.) or social sciences and humanities.

Modelled on the DOE programme 'Basic Energy Sciences", this sub-theme aims to support upstream research guided by medium to long term applications in the field of energy (generation, conversion, transmission, storage, effectiveness, uses of energy), potentially constituting the foundations of future technology.

Interdisciplinary research is naturally encouraged, given the complex nature of the topics falling within the challenge.

However, basic research developments connected to Challenge 2 do not exclusively fall within this sub-theme: they must fall within the scope of another area if they aim to create new knowledge or solve problems in specific fields described in other thematic areas.

Groundbreaking concepts

As with other programmes' agencies (ARPA-E for DOE[25], EFRI for NSF, A- STEP High Risk for JST in Japan, FET – Future Emerging Technologies - of Horizon 2020…) this sub-theme aims to promote projects to explore **ideas and radically new approaches and groundbreaking** research alternative to more incremental and scientifically charted research directions. These changes can be introduced as part of the development of previously identified areas or create a new research field. This will include the proof of concept demonstrating the new idea's potential for an application in the field of energy.

Proposals must substantiate claims of a poor fit within research areas or better charted research concepts, with regard notably to scientific literature.

Theme 2: Renewable energy production and energy harvesting

In line with findings obtained by the SNR, researchers' attention must be drawn to the need to lower costs and increase conversion efficiencies of energy from renewable resources, facilitating the development of renewables and increasing their penetration rate in the energy mix (SNR Priority 6 — dynamic management of energy systems), and reduce or eliminate the use of strategic materials (rare earths, pt.) (SNR Priority 9 — reducing dependency on strategic materials)

Solar resources

In a single hour, the Earth receives an amount of energy from the sun equal to the planet's total annual consumption. Only 0.1% of this energy is used by photosynthesis to produce biomass, and human use accounts for another tiny fraction. There are three ways of converting these resources into energy vectors, and all three are ripe for development :

- direct electricity production, by photoelectric conversion; avenues for progress include the use of inorganic, organic or hybrid semiconductors for photovoltaic, where applicable combined in multijunction cells, solar concentration and very high yield concepts; the manufacturing technologies of modules is also included ;
- heat production, at low or high temperatures (**solar thermic** or **concentrated solar thermodynamic**) for direct heating and also for cooling, and even electricity or hydrogen production (water splitting using thermochemical cycles) ;

[25] http://science.energy.gov/bes/

- the **production** of fuels, either through **natural photosynthesis** to produce biomass dedicated mainly to energy applications[26] where a better understanding and improved "energy" yields in certain micro-organisms (production of lipids, sugars, hydrogen etc.) or by means of the bioinspired **photo-electrolysis**, possibly combined with the **photo-catalysis of CO2** (production of "**solar fuels**").

Other renewable sources (air, water) and energy harvesting

Other energy sources — aeraulic, hydraulic, heat, temperature gradient, pressure, vibration, organic waste, etc. — are offered by natural environments, as well as by certain human activities (waste heat, etc.), and the exploitation of these could lead to diversification and enrichment of the energy mix or the production of energy for targeted applications. Although a few technologies have already reached demonstration stage, a more efficient capture of these resources still requires research to pave the way for innovative, economically viable technologies over the medium and long term, both for renewable energy sources (**wind, hydraulic, marine energies**) and for the recovery and use of diffuse energies (energy harvesting): **biofuel cells, thermoelectricity, piezoelectricity**, etc.

Theme 3: Use of the underground for energy purposes

Even though it produces a significant part of our energy resources, the underground remains a little known and underexplored medium. Research is needed on both the extraction of key energy resources and the exploitation of its storage capacities. Said research must seek the acquisition of knowledge and the development of tools, methods (multi-scale modelling in particular) and technologies for using the underground and exploiting its resources which are competitive and have a low environmental impact and which have their place in the future energy mix.

Research based on and/or integrating the various components of earth sciences (geology, geophysics, geochemistry, geo-mechanics, geothermal) are necessary upstream, regardless of whether they focus on exploration, characterisation, design, construction, monitoring operations, closing exploitation sites, or storing different kinds of energy or CO2. Progress is expected both on geological characterisation (all scales: macroscopic and microscopic, account taken of heterogeneities), technical feasibility (behaviour diagrams, couplings, etc.), the yields and the long-term securing of extraction and storage apparatuses, involving research on monitoring sites and environmental risk management (monitoring strategies.). Research lies partly within a corpus sufficiently general enough to be useful for different energy uses in the underground and partly in connection with specific scientific questions around certain uses. The opening and integration of methods and approaches developed in other areas, inter alia, physical, chemical, thermal and mechanical applied to the earth and its specificities, can provide new insights making exploration worthwhile.

[26] See Theme 4 of this challenge to projects addressing one of the transformation pathways of biomass into biofuels or biomass fuels (and possibly platform molecules).

The logical, optimised and sustainable use of the underground will contribute to reaching certain objectives of the French energy transition law (LTECV) of 18 August 2015, consistent with the SNR (Priority 6). This concerns the reduction of GHG emissions, diversification of the energy mix, energy autonomy in the overseas departments via the reinforcement or development of new sectors and new uses including:

- **Geothermal energy** (low, medium and high temperatures) for heat/cold production and/or electricity extended to broader geographical areas (diversification of sources in exploitation) and its role in the processes of thermal storage (exploration, recovery of underground heat, reinjection of underground geothermal fluids, etc.).
- **Underground storage of CO2**: the characterisation of formations and deep aquifers, injectivity, capacity and containment of storage.
- Underground storage of energy:
    - **heat storage**: Though storages at low temperatures have already been developed, medium and high temperatures remain problematic;
    - **CAES;**
    - **hydrogen storage;**
    - **new concepts for underground storage.**
- Exploitation of **native hydrogen**.

Research may also concern maintaining the level of mature sectors in more environment-friendly conditions (in surface and depth exploitation):

- A safer **nuclear** sector through more secure storage of radioactive waste and
- 'responsible' exploitation of **hydrocarbons**: increased efficiency in terms of energy and resource consumption and the technologies involved throughout the oil chain and a reduced impact in terms of discharge;

Exploitation and use of the underground cannot be considered separately from overall energy systems and systemic impact. Projects shall propose interdisciplinary cooperation on the following:

- the relationship with other energy sources (hybridisation/combination/cogeneration) and various types of storage (hydraulic, for example)
- the organisation of actors (public, private) in collecting, sharing and data retention on energy resources in the underground, and provision of this data for collective management strategies
- alignment of mining, civil, environment and property law in order to adjust the legal frameworks for these resources' contemporary exploration/exploitation processes.
- the process of territorialisation, in particular, the arrangements for informing and deliberation over uncertainties (health, environment, water management, etc.).

The development of a cross-cutting knowledge base and methodologies for exploration and evaluation of the characteristics and potential of the underground with a view to storage or the extraction of energy resources will benefit all sectors. This is also the case for new digital technologies which are an essential contribution to geosciences and must be developed in two respects:

- high-performance computing for static and dynamic modelling of sub-surface systems
- new concepts, algorithms and methodological approaches to cope with increased volume and data flows (measured or calculated)

Theme 4: Conversion of primary resources into fuels and platform molecules, carbon chemistry

Hydrocarbons, bio-based or otherwise, still have a major long-term role to play in the future energy mix, both as long-term and high energy density means of storage, and as a source of carbon for the chemical industry. The principal challenge is to reduce the CO2 emissions generated by the production, conversion and use of these resources. This issue comes under SNR priority 10 – Fossil carbon substitutes for the energy and chemicals sectors.

In addition to **direct combustion** of fossil or bio-based (lignocellulosic biomass, organic waste, etc.) primary energy resources for heat or electricity production, or a mix of these (cogeneration), which will require a dual solution including **CO2 capture from stationary sources, there are two avenues to be explored for more efficient production of liquid or gas combustibles with low CO2 emissions (essentially biofuels) as well as for the supply of bio-based platform molecules (or synthons) of interest to the chemical industry:**

- **Physical-chemical and thermal processes**, which are the most mature technologies, and in which avenues of progress to separation processes, syngas purification for direct use or transformation into fuels and research into new catalysers for improving the efficiency of processes; the integration and energy optimisation of process chains should come under particular scrutiny;
- **Biological, biotechnical or biochemical processes** using **microorganisms** and/or **enzymes** to convert biomass into liquid or gas energy compounds and/or platform molecules. Characterisation of these ecosystems as well as synergies and communication between microorganisms calls for a special effort at the level of knowledge concerning them, and then subsequently control of their functions. These biological processes may in some cases be combined with chemical methods.

The conversion routes and **joint use of biomass** into energy, chemicals, materials and the concept of **bio-refinery** are important to consider.

In this context, the various pathways for **transformation/re-use of captured CO2, particularly fossil CO2 for hydrocarbon production,** and especially for use as a storage method for intermittent renewable energies and/or the supply of carbon molecules for chemicals applications should be explored and developed.

Research is particularly encouraged on the production of **synthetic hydrocarbons**, in particular for sectors without current alternatives to oil (auronautics, for example).

Theme 5: Dynamic management of energy systems: storage, networks, vectors

Many renewable energy sources are intermittent by their very nature, and their production is often more spatially distributed than conventional energy resources: We must work towards transporting and distributing them via **networks under optimal conditions, and providing energy storage solutions** that smooth the discrepancies between supply and demand. In addition, the development of onboard storage systems should reduce dependency of transport systems on fossil fuels (via cable channel, for example). These issues fall within the scope of SNR Priority 6 — Dynamic management of energy systems.

Hydrogen and fuel cells

Hydrogen has potential as a massive energy storage solution. It must, however, be produced without giving off CO2 emissions (by **electrolysis** or **water thermolysis** in particular). In parallel, research is required to develop **fuel cells and hydrogen storage solutions**, including upstream research on materials and structures suitable for solid hydrogen storage.

Energy storage

Although some types of storage are already mature, and others have major room for progress or even require further fundamental research before becoming viable solutions:

- storage in **electrochemical accumulators**, for stationary storage as well as onboard and mobile storage solutions, must see an improvement in energy density and specific power as well as reliability, safety and environmental performance, whilst also reducing costs; **super capacity storage** also requires research initiatives to improve energy density and safety;
- Other types of **storage required** for **massive storage of electricity or heat**;
- **New concepts for energy storage and management**, in conjunction with **self-production** and **self-consumption** and partial grid decoupling or via the addition of new functionalities to existing systems (for example electric vehicle batteries, domestic hot water tanks), may be explored.

Transport, distribution, management and consumption of energy

It is also important to work on tools and technologies that allow for a better integration of energy into grids as well as electricity management, both for stationary and onboard energy systems: electrical engineering, power electronics, electrical machinery (actuators and generators), which all rely very heavily on the design and use of very high performance materials (dielectric, magnetic and electromagnetic materials, etc.) in order to be efficient.

The development of more spatially distributed and intermittent energy sources and storage means calls for research on smart grids concepts at different spatial scales, in order to provide a real-time optimization of the energy system. To this end, research drawing mainly on information science and technologies are expected on:

- Management of networks, including spatial and temporal prediction of potential production of renewable energy and power; in that perspective, development issues, local consumption micro-grid (including self-consumption) and the design of flexible mode uses (e.g. in industrial processes), as well as erasable or loadable uses should be considered.
- Managing nuclear power stations load dynamics to compensate the intermittency of wind and solar power and reduce the need for electricity storage: this entails adapting reactors' driving systems and developing interruptible heat or hydrogen cogeneration methods.
- Safety (resilience and reliability) and safety by design[27].
- The interoperability of energy networks (electricity, different gases, heating, etc.).

[27] Research relating to the protection of infrastructure and networks linked to energy should be treated within the Challenge 9 'freedom and security of Europe, its citizens and its residents'.

Theme 6: Energy efficiency of processes and systems

Substantial energy savings and greater efficiency in energy use may be achieved through direct efforts targeting **specific processes within the manufacturing industry**[28] (reduction in energy requirements for existing production processes, and research into alternative processes that are more energy-efficient or with lower CO2 emissions) and **energy production** (improvement in conversion yields, loss reduction and energy recovery).

Equipment and auxiliary systems (pumps, heat and cooling production systems, ventilation, etc.) should also come under scrutiny. Research should take account of usage constraints (operation in extreme conditions, mechanical constraints, limiting fouling and corrosion, robustness, reliability, ease of use, rapid return on investment, etc.).

One of the key issues in energy efficiency is the development of methods of heat recovery, transportation and use (including **waste heat**), either using **thermodynamic devices** (heat exchangers, heat pumps, organic Rankine cycles.), or **involving materials** (PCM, heat absorbers, etc.).

These topics are in line with SNR Priority 8 — energy efficiency.

In addition to the need for greater energy efficiency, there should be a move towards energy decarbonisation based on an increased use of decarbonised electricity in industrial processes (for example, induction or microwave heating) and on the development and optimisation of **combustion** processes with lower greenhouse gas emissions, particularly those involving **CO2 capture** and **transport**.

Theme 7: Social Sciences and Humanities-based approaches to the energy transition

In addition to the essentially technical development needs outlined in the themes above, questions also arise in the field of social sciences and humanities, in line in particular with SNR priority 7 — multiscale governance of new energy systems and SNR priority 8 — energy efficiency. Indeed, developments expected in the new energy technologies are inseparable from the political, societal and environmental challenges issues they address. These challenges affect the size of these technologies at all stages of the innovation process, from their premises to large-scale deployments. The humanities and social sciences are approaching this set of combined dimensions with a renewed vision of technology, seen as an open, social and technical assembly consisting of multiple entities which are sometimes changing and unstable. This reflects the systemic nature of energy transition, changes in stakeholders, and the constant need to agree on what make up “priorities” and “values”.

Thanks to the variety of concepts and methods, social sciences and humanities (anthropology, planning, law, economics, psychology, geography, history, political science, sociology) may contribute to the analysis of many issues raised under Challenge 2, well beyond the expected disciplinary areas. This ability to work in an interdisciplinary way is structured around four themes detailed below: They all converge around a central objective: describe how the deployment of energy technology (past, present or future) involves societal dimensions (poverty, health, environment, landscape, etc.) at different scales, from the emergence of sociotechnical collectives to the choice of public policies, to major societal change (governance, markets, biodiversity).

[28] Under this challenge, only projects whose principal objective is to save energy and reduce CO2 emissions will be considered, projects concerning other challenges for industrial processes come under Challenge 3

The territories in the energy transition

The emergence of climate and energy policies that are more systemic and open to local initiatives causes the question of territories to shift. The objective of this priority is to understand the **emergence of new energy systems**, the **modalities of their relationship with existing socio-spatial organisations** and **the intensity of resulting recompositions**. Several themes are gaining attention: The role (lever or brakes) of **different socio-geographical heritages** on transition trajectories; the multi-scale governance of new energy systems and redefinition of the **energy policy** field, the process of building **new energy resources**, and re-distributive and catchment effects they can generate. These issues suggest international research opportunities in and outside Europe. France has called for the exploration of space solutions, in all their diversity, in response to the energy transition law for sustainable growth.

Demands, uses of energy

Efficiency policies and energy efficiency are powerful levers for the energy transition. However, the changing consumer **behaviour** and lifestyles are not a question of simple control. Beyond concepts like behaviour, which are sometimes normative, demand must be understood as relying on a systemic process crossing **social, cultural, political, historical dimensions** in a routine but perpetually renewed energy usage action. In particular, the aim is to analyse: the coordination between **social practices and management systems and access to energy** (domestic systems, socio-technical systems); the construction of demand and its transformations (demographic and societal trends and emergence of the consumer-producer-citizen, energy saving practices.); the role of **economic and non-economic instruments** and their use through public action (incentives — including non-financial incentives such as nudges, quotas or ecotaxes, etc.).

The energy transition, markets, regulation and governance

The questions raised the energy transition go well beyond Member States' energy policies. The governance of these policies is caught between several sides: **sectoral heritages** (oil, gas, nuclear and wind) in energy policy, international climate negotiations, the **renewal of the geopolitics of energy** (diversification of energy resources, major emerging countries), **liberalisation of energy markets**, and finally the **plethora of stakeholders** shaping public policies. The humanities and social sciences must, in all their diversity, analyse the ongoing process and the choices that lie ahead of us, as regards: **instruments** (fees, allowances, bonuses, exchangeable.), **market or network architectures** (rules, regulatory frameworks), business models and organisational sectors (vulnerabilities and resilience) to boost development and integration (equity, energy security) new forms of energy (intermittent, flexibility, storage); new offers (differentiated kWh) and forms of energy access (smart grids, distributed generation, solidarity between territories). The humanities and social sciences can help **assess these options** with regard to their capacity to achieve transition objectives as well as the social, economic, industrial, environmental challenges associated with them.

Construction of futures, forward studies, modelling

The last three decades have been marked by an increased use of long-term quantified **scenarios**, backed by **forward studies**, used in energy policymaking. These often complex interdisciplinary models have been developed to form a fully-fledged field of research and a social practice of constructing energy futures. Social sciences are called upon to contribute in this area in two ways. As participants in these "energy and economy" models, they are in charge of **better integrating the real dimensions** of foresight tools (e.g. actors, innovation processes characteristics, technology, technical and financing capital inertias...) in order to better **inform our assessments**, take into account a **wider range of challenges** (e.g. energy security, social impacts, etc.), put into perspective the objectives set and means granted by the French Energy Transition Law. They are also called to put into perspective **use models** and **scenarios** as **methods of constructing futures**. Research must therefore analyse these **models** and the **social worlds** that put them forth through social practices associated with them (fabrication, validation, movement, role and influence in the political processes, etc.).

Challenge 3 : Industrial Renewal

EUROPEAN AND INTERNATIONAL COLLABORATIONS

The 2016/2017 topics prioritised for international funding are detailed below as well as in annexes 1 and 2 of Work Programme 2017. The following information aims to provide French teams with details of existing or forthcoming agreements between ANR and its foreign counterparts that designed to facilitate the formation of international projects and consortia. *http://www.agence-nationale-recherche.fr.*

For this challenge, the calls are: *The ERANET Cobiotech JTC call, the ERANET Flag-era JTC call on graphene; The ERANET ERAMIN-II JTC call*

The partnerships established through bilateral agreements in connection with the Generic Call for Proposals are listed in annex 1; for this challenge, we would particularly mention: Germany; Austria; Switzerland; Luxembourg; Canada; Taiwan; Hong Kong; Singapore.

INTERFACES

This challenge involves cross-cutting research topics relating to more than one challenge. The other challenge(s) to which these topics relates is (are) indicated below, so that applicants may orient themselves towards the most adapted challenge for their project. Applicants are strongly advised to read each related challenge in its entirety to gain a thorough understanding of its specific scope.

For information concerning cross-cutting theme areas, most of which fall within the scope of multiple challenges (including Challenge 3), readers should refer to the paragraph entitled "**Multidisciplinarity, cross-over and interfaces**" (pages 39-42) which covers the following fields: ***Big Data, Robotics, Sensors, Biology, Bioeconomics & Biotechnology.***

The following fields also overlap with Challenge 3:

Biorefineries and bio-based platform molecules: the production of advanced fuels and/or platform molecules for the chemical industry using bioresources is covered by Theme 4 in **Challenge 2**. However, projects relating to the manufacture of commodities, high-added-value products or products functionalised using bio-based platform molecules, or downstream processes in phytochemistry (fine chemicals, speciality chemicals, etc.), should be submitted under **Challenge 3**. Research on the regional integration of biomass chains, on their environmental, social and economic impact on rural and local development and on competitiveness is covered by **Challenge 5**.

Mineral resources and materials: Gaining an understanding of mineral raw material deposits falls within the scope of **Challenge 1**. Projects pertaining to methods and technologies for the extraction, separation, processing, and recycling of the materials used by energy technologies come under **Challenge 3**. All research concerning the use of mineral raw materials for energy purposes fall within the scope of **Challenge 2**.

Adequate knowledge of human labour processes on the individual and socio-organisational levels will be necessary in order to design the factory of the future. Particularly relevant here are: 'New organisations of the production chain", "virtual factory", "industrial robotics" of theme 1, "factory of the future". These issues will require a collaborative effort between specialists in social sciences and humanities and technological sciences as production systems must be designed which incorporate or correct human dimensions and take into account users and their actual work. Research based on physiology, psychology, sociology, economics and ergonomics will help to develop alternatives to the idea that humans will adjust to technology or compensate for its defects.

However, “the changes in work and employment” and “Changes to organisations” in any industry sector and for any form of employment are covered in several sections of Theme 3 in Challenge 8:” The labour and employment market, employment policies, the organisation of work “;” Job quality, the role of work in society, at work, the emotional connection between work and health “;” men and women at work: the challenge of professional equality”

Energy: Functional materials for energy production and storage
(photovoltaic panels, batteries, etc.) are addressed in Challenge 2.

Molecules for energy (applications in electrochemistry, energy production, new molecular storage systems) are covered in **Challenge 2**. The **use of CO2** to produce molecules is addressed in **Challenge 2**.

Health: **Projects involving materials for medical use** (bio-compatible materials and biomaterials) are covered in **Challenge 4**. For projects concerning innovative nano-objects for health which might come under Theme 4 in **Challenge 3**, but if the focus of the research is mainly therapeutics, the projects should be submitted under **Challenge 4**.

Nanotechnologies: **Challenge 3** covers generic aspects concerning nanoparticles, nanomaterials and their assembly into products of the future. Projects regarding the manufacturing/design of nanomaterials with a view to their integration into components and/or devices for information and communication science and technology applications, or more broadly for electronics applications, should be submitted under the micro/nano theme in **Challenge 7**.

The design, synthesis, formulation and implementation of active materials for flexible, printable electronics fall within **Challenge 3**. However, the design, synthesis, formulation and implementation of devices for **flexible, printable electronics** fall within **Challenge 7**.

LED and OLED: their design and manufacture for energy-efficient **lighting** fall within Challenge 3 and for electronic applications, Challenge 7.

INTERFACES WITH DEFAS

Projects dealing with “catalytics” and its various components, whether the studies are fundamental, groundbreaking, upstream or closer to current applications fall within Challenge 3 and should mainly be submitted under Theme 3.

Projects dealing with “materials, intelligent materials and their characterisation” in their various components, whether the studies are fundamental, groundbreaking, upstream or closer to current applications fall within Challenge 3 and must be submitted in the corresponding theme.

Projects involving the development of ‘theoretical chemistry and modelling and calculation methods” as well as “upstream, theoretical and methodological developments in spectroscopy’ essentially fall within the scope of the Other Knowledge challenge.

POTENTIAL CO-FUNDING[31] FOR PROJECTS SUBMITTED TO THIS CHALLENGE

Projects submitted under this challenge may be co-funded by the DGA (the French Defense Procurement Agency).

[31] Co-funding means that funding is partially allocated by ANR, with the remainder coming from one or several of the Agency's co-funder partners.

Introduction

Following the strategic structure of the call for projects around major societal challenges decided by ANR, Challenge 3 was organised in keeping with National Research Strategy's (SNR) 4 priority research areas:

- Theme 1: The factory of the future: People, organisation, technologies
- Theme 2: Materials and processes
- Theme 3: Sustainable chemistry and related processes
- Theme 4: Nanomaterials and nanotechnologies for products of the future

These themes correspond to an integrated assessment of research projects, from upstream stages to future applications: The **5 SNR priority areas which principally concern ANR Work Programme 3** are:

- Priority 11: The digital factory
- Theme 12: The green and people-friendly factory
- Priority 13: Flexible, human-centred manufacturing processes
- Theme 14: Design of new materials
- Theme 15: Sensors and instrumentation

Projects submitted under Challenge 3 may also correspond, to a lesser degree, to the following priority areas[29].

The 4 themes are then clearly laid out in thematic areas corresponding to main subjects of research enabling **French research to focus on the broad topics to which the SNR has assigned priority status**[30]. Applicants should bear in mind that their choice of a main subject of research allows ANR to identify the best-placed scientific community to evaluate the project.

Research funded under this challenge should aim to pave the way for future industrial developments, taking into account:

- the need to establish sustainable competitiveness (with corresponding jobs and efforts towards social cohesion)
- The needs to create wealth (by minimising consumption of resources),
- The challenges facing us in the early 21st century, particularly in environmental terms: CO2 and water footprints, energy efficiency, reducing pollution, eliminating toxic substances, saving natural resources, recycling, etc.

French industry must progressively work towards clean and sustainable manufacturing, promoting a circular economy, and trying to remain one step ahead of its competitors. The optimisation of human capital, the social role of industry, the flexibility of production processes and the adaptation of these processes to digital developments, as well as attractiveness and competitiveness, are also key factors in industrial renewal.

The goal of this challenge is to support research facilitating these changes in the medium to long term. This challenge concerns a variety of **industrial fields** (e.g. manufacturing industries, chemical industries, food industries, etc.) and very broad **scientific disciplines** (e.g. organisation of labour, labour law, ergonomics, industrial engineering, robotics, economics, physics, chemistry, mechanics, materials, process engineering etc.).

[29] priority 4: Eco- and biotechnologies to support the ecological transition; Priority 9: Reducing dependency on strategic materials; Priority 10: Fossil carbon substitutes for the energy and chemical sectors; Priority 21: Biomass — from production to varied uses; Priority 29: Human-machine cooperation.

[30] The challenge contains 27 sub-themes and 29 main research subjects in the "catalytic systems" field under Theme3 Contains 3 main research subjects (see Generic Call for Proposals annexes)

All these disciplines produce acquired knowledge and technology promoting the emergence of disruptive innovation to renew industrial sectors sometimes located very upstream in value chains. The goal of this challenge is to support research able to open up new paths toward technological innovation, without research necessarily being aimed directly at a particular innovation. The objective is instead to seek new scientific results eventually enabling such innovation and spread upstream changes downstream on value chains.

Industrial renewal will therefore not only come about through direct support to existing industries (which is not the purpose of this challenge) but also through the capacity of research results sought by the challenge to provide these industries an opportunity to reinvent themselves as well as see new innovative industrial activities emerge.

The (r)evolutions through research expected under this challenge, whether through methods for designing, manufacturing, or assembling objects, in the industrial structure or the world of work, must be envisaged and designed as an upstream source to industrial renewal in the country, which will have to combine innovation, economics and response to the society's expectations (respect for the environment, employment and value creation, etc.).

Also, in line with the European Union's Horizon 2020 programme for research and innovation, particularly the "Industrial Leadership" pillar and the "key enabling technologies" area, Challenge 3 aims to support research covering a wide range of Technology Readiness Levels (TRLs), from fundamental research (TRL 1) well upstream of potential applications, to research that keys on industrial issues (up to TRL 4). Where relevant, a life-cycle analysis (or even a simplified life-cycle analysis) will be appreciated.

Reception of fundamental research projects:

The need to generate innovation at all stages of the value chain calls for research in the various disciplines implemented, low maturity if necessary, in order to create major breakthroughs. **The different theme will therefore consider fundamental or upstream projects meant to renew approaches in these areas in the medium or long term.**

Theme 1: The factory of the future: People, organisation, technologies

The factory of the future must fit into a challenging climate. It must respond to consumer demand for more personalised products, which requires a flexible and interactive relationship with supplier and subcontractor networks. It also has to optimise products by designing sustainable and high-quality products at competitive prices within a service-integrated chain. Furthermore, there are strong societal expectations regarding factories which are environmentally responsible, safe, and integrated into their environments.

Support and enhance the development of new digital or manufacturing technologies (IoT, big data, cloud computing, simulation, sensors and smart machinery, collaborative robots, additive manufacturing etc.) make up an initial major breakthrough theme for addressing production issues. As offer-based competitiveness becomes crucial, companies must innovate faster by cutting development time in response to a demand for customised and optimised products.

Promote a vision and a systemic organisation of the factory in its life cycle and value chain dimensions has emerged as a second disruption theme complementary to the previous one. The imperatives of flexibility require a more agile development process integrated into the life cycle of the product: the customer, acting upon the life cycle, interacts with the industrial system as a whole (design, manufacture, usage, recycling). The vision of the factory as a system is also based on the organisation of the relationship with suppliers (equipment, parts, services) which become major players in the value chain and the factory's overall performance.

People-focused factories is the third disruption theme. With men and women remaining at the centre of manufacturing operations in a more flexible work organisation, the scope for regulating labour, individually and collectively, may narrow. Another important breakthrough is needed to address production challenges while reducing the operator's cognitive and physical workload. New approaches to automation will be needed to compensate for limits or better capitalise on workers' experience. An information system must be designed for use as a tool for factory work; research must assess the benefits and risks of collaborative organisations (inside and outside the factory) made possible by the factory system. The quality of work relations and day-to-day management will contribute towards accountability, recognition and appreciation of actors. A sound knowledge of human labourer processes at the individual and organisational levels will therefore be needed to design the factory of the future.

Projects expected within the seven theme areas described below may come from different communities: engineering science, information and communication sciences and technologies, social sciences and humanities, etc. Cross-cutting projects taking into account technological aspects and human aspects are strongly encouraged as they are likely to provide significant disruptions in the design of future production systems. Finally, as with consideration for industrial purposes, consideration of upstream issues are at the core of the call's mission. Highly disruptive exploratory research projects (PRC) are particularly welcome.

People in new productive organisations

The design of the modern manufacturing system will be based on an optimal distribution of tasks between humans and machines, as well as on a more continuous adaptation of labour to workers' physical, sensory and cognitive capacities. An increasing number of questions will arise: how do we provide means for individual and collective regulation of activity? How can health and safety be integrated into concepts of production? New work organisations are emerging (e.g. networked companies), creating opportunities (e.g. work for companies on a project basis) and risks (e.g. fragmentation of collectives and responsibilities) which must be explored. Humans will be at the heart of factories, directing and deciding. But how can people be assisted when managing abnormal and unexpected situations crucial for the security of human-machine systems? Multiple layers of constraints on the manufacturing process and its dynamic nature imply the need to combine information in such a way that the operator remains in control of the system. Semantic representation of the industrial process is one possible approach. This consists of reporting relations and significant constraints into a system (e.g., from a production point of standpoint) on visual relations displayed, so that the system's normal and abnormal states can be kept track of easily.

The smart, connected, controlled factory

The factory of the future will be smart and connected. With the Internet of Things, the product takes on an active role in the factory: It bears the relevant data for the supply of its constituent parts and shows the traceability of its production. The connection with product and process design data makes it possible to adapt processes in real time, offering product flexibility and quality. The compilation, analysis and dissemination of information gathered on machinery, and product flow facilitate the operator and management chain's decisions, increasing operational efficiency (product quality, efficiency of installations). New technologies, such as enhanced people, also facilitate decision-making at the various production workstations: production, capacity, logistics, and maintenance. Lastly, the interconnection of systems between the factory, its suppliers and customers shortens processing time, reduces stocks and contribute to the agility of the industrial system. The factory of the future is expected to be a distributed and interconnected cyber-physical systems, including real-time processes, remote control, coordination and data exchanges. Cyber-security is an aspect which must be included from the factory of the future's design stage.

The virtual factory

The virtual factory must make it possible to anticipate changes. It requires true digital models with measurable performance. Innovative technologies for interaction between workers and the virtual factory to must enable the validation of new use scenarios. Advanced virtual and augmented-reality solutions, innovative design methods and process-product optimization, collaborative simulation techniques, and production reconfiguration mechanisms should be mastered to facilitate “first time right” design. The virtual factory must also improve the activities of engineering, production and maintenance teams in a more integrated and connected environment via business information systems. Training needs are identified for professions already working in the factory. The virtual factory will give rise to the creation of tools to rethink training and knowledge management. The multiple uses of augmented reality are capable of transforming the nature of work; it is important to anticipate their effects. For example, say that experiments are launched to equip the teams supplying spare parts to the factory with smart glasses. Does this situation have a positive impact on the workload (physical and cognitive) and regulation of activity?

Flexible and agile factory

Enterprises must (competitively) provide more personalised and complex products in mass markets but also in niche markets. Rapid renewal of products requires a design and industrialisation capacity incorporating management of diversity and services associated with products. There must therefore be opportunities for reconfiguration of the production system, reusing as best as possible sub-assemblies and customisable components, available means of production, with “plug & play” and systems engineering approaches. Possibilities for reconfiguration of the industrial organisation of development projects, and of production processes, are also needed. The agility dimension must be present in both the decision-making and operational process from the product, process, system or production unit design phase. These requirements also make it necessary to rethink peoples’ role in projects, taking into account interactions with engineering, industrialisation, production or maintenance teams, with consideration to developing their skills.

Green factory

Compliance with new rules and logistical cost increases are incentivising the contractor to devise more sustainable production systems integrating economic, environmental and societal impacts. These systems will form part of a circular economy and eco-design logic. innovation must be increased across the supply chain for processes that are less energy-intensive and which consume less matter. It is necessary to encourage the creation of industrial ecosystems which are optimised at the local level and in terms of energy production and consumption, consumption and material flows. With a view to cutting down on environmental footprint, ecodesign integrates the environment in the design of products and services throughout all stages of their life cycle (from design to recycling). In particular, the designing of the reverse logistics chain and efficient production systems dedicated to recycling and reuse of all or part of products raise many optimisation and industrial management issues.

Industrial robotics and multi-robot co-operative systems

Autonomous manufacturing robots are a key component of manufacturing and assembly. To allow greater flexibility, programming for rehabilitating different products or series could build on the use of learning techniques and advanced process control. The development of perception devices, efficient or innovative sensors or effecters is also of interest in improving robots’ suitability to tasks. The study of AGV-type robot fleets deployed in the workshop or warehouse for handling, or drones for aid coordinating cobot fleets for transportation and delivery, is also relevant. Several “factory of the future” topics concern operator-robot collaboration. Robotic collaborative islands, or robot COBOT/exoskeletons aim to reduce human labour costs: the robot must provide precision and endurance to activies in which humans distinguish themselves through expertise, judgment and decisionmaking. Reproducing sensory-motor skills in robots still remains a key challenge.

Sensor technology (sensory, perception) can increase the sensitivity and dexterity of the robot, and make it expressive. Can sensors be implemented for more natural interaction between robots, operators and working environments while making the latter safer? Finally, cobots learn by imitation; the operator is therefore able to format it for their own use.

New production and control technologies

The factory of the future will require that added value be controlled in all its dimensions on the technological level. Innovative technologies for production, assembly and in-process (or post-process) control provide high added value for customised products. Industrial developments requiring new scientific and technical proposals in technologies for monitoring and measurement are expected. Additive manufacturing represents a major shift in factory manufacturing: the gained ability to produce complex geometry objects improves their resistance, weight and environmental impact. Additive manufacturing still faces considerable scientific challenges and improving the overall equipment effectiveness of innovative manufacturing technologies is a major challenge. One of the current priorities of enterprises introducing new means of production is quality assurance. Monitoring using multiple measurements creates problems processing large volumes of data and extracting data for corrective measures or operator control assistance through new industrial processes. Research is sought which improves production efficiency through the integration of these new technologies.

Theme 2: Materials and processes

Materials (polymers, metals and alloys, composites, ceramics and glass, multi-material or hybrid, natural materials, etc.) and their interfaces and surfaces are strategic elements for industrial development and the competitiveness of enterprises, in particular for aspects related to resources, performance (in a very broad sense), or new functionalities. The performance and properties of these materials are an inseparable part of the pathways used to obtain them (preparation, shaping, assembly, etc.), efforts are being made to make them more efficient and environmentally friendly and compatible with regulations. This approach also applies to recycling. Amongst all of the materials and processes, metallurgy, (e.g. synthesis processes, numerical simulations, thermodynamics) polymer science, as well as studies on monitoring (instrumentation, measurements etc.) and online processes management are considered major challenges. The development of materials for use in extreme conditions (very high temperatures, severe mechanical stresses, high strain rates, highly corrosive environments, irradiation, etc.) is also encouraged.

Industrial developments benefit from the creation of innovative materials (multifunctional, adaptive), the design of new techniques for packaging, assembly, and reliable, efficient, economical processes able to be monitored and controlled in real time, while remaining flexible.

This theme seeks to promote upstream research projects demonstrating significant risk-taking. Project coordinators are invited to submit proposals which are innovative by the nature and/or function of the material, their preparation and implementation process, predictive tests... Incremental improvement of existing infrastructure is not the purpose of this challenge.

Projects must fall in line with the priority area traced out by the National Research Strategy (SNR) — development of new materials, sensors and instrumentation which are themselves consistent with the theme's main research subjects. In order to facilitate applicants' choice of research subject, a breakdown involving a reduced number of headings (compared to previous years) is proposed. For each case, a few indications and illustrations are provided, without being exhaustive.

Projects submitted covering recycling and substitution are encouraged to clarify their proposal's national positioning in relation to submission restrictions on this topic under the multilateral call to be launched by the multilateral ERANET Eramin-ii in 2017 involving ANR.

Functional inorganic materials

Inorganic materials (including ceramic materials and glasses) have many applications in our day-to-day lives, for example in the field of electronics, information storage, and energy conversion and storage... It is important to continue efforts in this field to seek new materials with functional or multi-purpose properties (thermal electric, magnetic, etc.). In this category, researchers may submit projects designed to develop new structures, new features, or projects whose purpose is to replace sensitive elements (scarcity, chemical risk, cost, etc.).

Approaches to modelling/simulation of material properties in relation to their structure or composition in order to improve understanding and control, must be encouraged.

Metallurgical science and engineering

Every disruptive development or change in the design or processing of metallic materials has an impact on the industrial sector because of the large number of fields in which metals are used: (e.g. the aeronautical, car, rail, construction and packaging industries, etc.). The development of innovative alloys is substantial challenge facing this field. Proposals shall concentrate on this need and will promote the use of base elements from recycling. They will be structured around a microstructure-property relationship approach and may involve the use of simulations (ab initio calculation methods, thermodynamics and kinetic coupling, simulation of the history of the microstructures). These approaches, strongly coupled with experimentation operating at the same scales as simulations, become powerful tools for shortening development time and replacing conventional empirical approaches, offering a major competitive asset to the industrial sector.

Functional polymeric, composite materials

In this sub-theme, research is sought which offers advances in the development of polymer-based materials with special properties (self-repairing, thermo-mechanical, antibacterial, anti-adhesive.) for specific applications (e.g., sensors, smart textiles, etc.).

Issues of industrial interest are still present, for example, in the field of composite resins in the form of polymerisations controlled at moderate temperatures, leading to compounds stable at high elevated temperatures, and cycle times which are significantly shorter than at present.

Surface and interface: functionalisation, surface treatment

Solid materials generally have a primary function that may be structural, for example, but they interact with the environment via their surface, or their coatings, if any. Surface treatments or thin film coatings are intended to confer new characteristics or functions in relation to the environment. The techniques used are varied and may also be coupled. Innovative approaches must be developed in this area, both by the proposed process and by the intended properties.

Assemblies

Processes for assembly (bonding, brazing, welding, riveting, etc.) are widely used in the industrial field, in particular multi-material architectures and complex structures. Problems related to interfacial heterogeneities (gradient in composition or microstructure, location of the phenomena under stress) which are inherent to the assembly process will also be addressed. Experimentation/simulation coupled approaches will be encouraged, as well as the development of original processes.

Implementation of materials

For the implementation of materials through processing or assembly, the objective is to match up materials' characteristics with the processes used to obtain them, especially those with recourse to simulation tools. The call covers all classes of materials, as well as hybrid materials. Additive manufacturing, a technique whose use will likely spread considerably in the coming years, is eligible under this theme.

Measurement methods and instrumentation

The increased quality and productivity of materials calls for improved monitoring of their implementation. This necessitates in particular the online monitoring of the characteristics of the materials produced, in order to adjust operating conditions in real time. To obtain this data, the development of online characterisations and diagnostics is crucial. Under this priority, projects will be selected which are innovative because of their detection technology or the modes of action on the process.

Theme 3: Sustainable chemistry and related processes

Sustainable chemistry and related processes are the essential foundations of an industry whose products are used by many industrial sectors. Any fundamental advance or groundbreaking concept in chemical syntheses, the choice of raw materials used, processes, etc., for which disruptive innovations can subsequently be developed, has a significant potential application for many industrial players. The sciences and technologies of synthesising, producing and processing molecules and materials are undergoing radical and increasing rapid changes. Chemistry must also meet the challenges of sustainable development and impacts on humans and the environment, which are at the forefront of its priorities. For this, it needs to accelerate the development of its practices to reduce its use of raw materials, energy and environmental costs (gaseous and liquid discharges, toxicological and ecotoxicological footprint...) while creating molecules and materials, macromolecules, supramolecular polymers or via supramolecular assemblies, etc.). Since said developments will require that raw materials be diversified, the advent of plant-based chemicals is necessarily part of the answer.

To which must be added an improved carbon fossil resource management, searching for alternative raw materials and developing waste recovery through recycling and cascading uses. This is also amplified by industrial biotechnology developments providing access to new families of platform molecules. The development of chemical manufacturing towards a 'circular' economy must be based on research and innovation in chemistry and process engineering techniques, combined with activation breakthroughs. Eco-design, cost-benefit analysis and life cycle analysis should to the greatest extent possible integrate into all levels of technological readiness, and be thought out so that data gathered is relevant with a view to industrial development.

Projects must therefore be centred on the research, development and implementation of processes leading to the current products, molecules, and materials, and new molecules and materials. Projects are expected to explore genuinely innovative solutions, supporting the future development of highly innovative and competitive chemical production. Projects shall cover all production phases, from the selection of raw materials, the development of the reaction pathway (the search for new activation methods, catalytic objects, "green" solvents, etc.) and to the associated process, including separation and purification stages if necessary. The development of safer and lower environmental impact processes, relying in particular on the concepts of intensification of (eco-efficient) processes are also encouraged within this theme. Targeted applications concern all the chemical sectors without exception. Applicants are reminded that theme areas coming under the Other Knowledge challenge are laid out at the beginning of Challenge 3.

In all the proposed topics, projects submitted in this priority area must be **experimental, theoretical, technological, industrial** in nature (processes), while striving for a **multi-disciplinary approach**. **Fundamental** research and **projects proposing innovative approaches** are expected. **Projects will build on experimental tools** (advanced preparation, characterisation and evaluation of physico-chemical and toxicological properties), but also on tools for simulation and modelling at different scales (from molecules to processes). Research will provide knowledge on the impacts of **analysing product life cycles**.

The integration of the environmental and societal concerns set out by the National Research Strategy, in particular "green, people-friendly factories", leads us to propose the following priorities with regard to main subjects of research:

New molecules, new reaction schemes and associated tools

This theme focuses on the conception of new molecules with novel properties in line with societal expectations.

Expected advances concern research on i) synthesis pathways, intermediaries and efficient functionalisation and protector groups, (ii) alternative solutions to the use of toxic substances, or leading to more environmentally friendly products or new, more targeted properties (e.g.: new therapeutic properties).

Innovations can involve new reaction schemes, as well as reactions, reagents and original implementations. Attention will also be given to innovation in the areas of detection, separation and the characterisation of said new molecules. The development of methods for the design and ex-ante assessment of reactivity properties alongside expected properties (*in silico* approach) will play a key role, in a context of increasing competition, plant safety and biological and environmental impacts.

Bio-based chemistry

Projects submitted within this topic are encouraged to clarify their proposal's national positioning in relation to submission restrictions on this topic under the multilateral call to be launched by the multilateral Eranet "Cobiotech" in 2017 involving ANR.

Bio-based chemistry projects should include obtaining molecules and innovative-property products, based on the processing of plant-derived raw materials as secondary flows of different biomass processing industries. The differentiation of properties will in particular enhance the specific character of molecule and material structures, macromolecules and bio-based polymers. For example, semisynthetic pathways from bio-based synthons and associated processes, control of functionality or the formation of composite by macromolecule association, particularly those from a controlled and non-integral biomass split, or the transformation or functionalisation of natural macromolecules.

Projects will also address the problems posed by the diversity and the inherent variability of these materials in seeking to reduce differences and the presence of flows of specific impurities able to contaminate catalysts, or by developing special methods of processing and non-fossil molecule functionalisation (e.g. carbohydrate and not hydrocarbons). An additional emphasis shall be placed on recycling issues, on the identification of new renewable raw materials taking into account available and exploitable deposits. This includes integrating cascading use possibilities and end-of-life-cycle recovery. Problems of characterisation, extraction, separation, and purification will also have to be considered. The specificites of these raw materials can also be problematic when it comes to modelling (representation of biomass); problems should be integrated during the development of efficient processes.

Catalytic systems

This domain covers three main research subjects: homogeneous and heterogeneous catalysis, multiple catalysis (and other catalytic systems). Catalysis is a key principle of sustainable chemistry and is at the heart of the major industrial challenges of tomorrow. Innovations concern both the development of new catalytic systems, regardless of type (uniform, heterogeneous, multiple) and the implementation of efficient systems for key reactions with efficient atom economy. Innovative formulations for more efficient and higher-performing catalytic complexes (selective catalytic chimio-, regio-, enantio-) are expected. This includes developing new homogeneous-based systems with unique properties (lambiphiles, redox, cooperative, etc.) or heterogeneous systems for which the interactions between the active, support and mixture phases shall be optimised. The contribution of catalytic systems combining several chemical or/and enzymatic principles will form a complementary theme. Projects may also cover the stability of catalytic systems including stringent reactive conditions (temperature, pH, etc.), the influence of impurities from envisaged substrates and effects of potentially present poisons, in particular to establish deactivation mechanisms and propose remedies. Progress is also expected in downstream technologies for recycling metal catalysts (metal and ligands) and that said technologies be homogeneous or heterogeneous or multiple. Special attention should be paid to the use of

non-toxic metals and/or ligands for which availability and cost are not sensitive criteria.

Specific and innovative implementation techniques are welcome, for maintaining highly reactive or unstable species, for instance (nanoparticles, intermediate degrees of oxidation), as are solvents which are not harmful to the environment.

All approaches (including kinetic in-situ characterisation, modelling, etc.) enabling improved knowledge of catalytic steps will be considered. Other forms of association (electro, photocatalysis activations, ultrasound, microwave, plasma) and the development of micro/nanoreactors constitute additional topics of interest.

White biotechnology, bio-inspired mechanisms and corresponding processes

Projects submitted within this topic are encouraged to clarify their proposal's national positioning in relation to submission restrictions on this topic under the multilateral call to be launched by the multilateral Eranet "Cobiotech" in 2017 involving ANR.

Biology and biotechnology are rapidly evolving due to the ramping up of research in the priority's title fields, the increased use of metabolic strain models, the targeted processing capacity of living organisms. This impressive progress makes it possible to imagine the substitution of an ever-increasing number of chemical production processes using biotechnological processes and the production of more complex molecules or macromolecules. These processes should be able to benefit from the increased modification capacity of micro-organisms, including by shortening development time: thus, bioinformatics, high-throughput screening, and databases are key elements in this process. The ability to use an increasing amount of food enzymes, extending all the way to non-natural enzymes, is not an important innovative factor.

Highly compatible with the use of renewable raw materials and used increasingly on fossil materials, industrial biotechnology (white biotechnology) should focus on the identification, development, implementation and optimisation of new, economically viable processes (enzymatic and fermentation processes, implementation of fermentative, implemening microbial consortium). This will require the definition of new metabolic pathways enabling access to original products, as well as necessary progress on specific process engineering and industrial biotechnologies (separation, etc.).

The processes and chemical synthesis pathways based on those performed by living organisms (enzyme catalysts inspired activation modes.) and translating them into new and industrialisable reaction schemes emphasising recycling of species may also be actively explored.

Application aspects, particularly in the industrial sector, for bio-remediation or bio-sensors or are also envisaged.

Chemistry and synthesis of polymers

The design of polymeric materials meeting social expectations will be achieved by developing synthesis methods and processes that use fewer raw materials and energy. This calls for the maximisation of yields, a drastic reduction in the quantities of solvents and secondary products used and a high purity.

Preference will be given to the use of biomass-derived monomers and oligomers or the recycling of end-of-life materials. Recovery of end-of-life polymeric materials will also entail the development of methods and effective processes for depolymerisation, controlled deterioration or modification/functionalisation. The proposal of chemistries allowing for both the synthesis and efficient recycling of polymers will be much appreciated. On the other hand, it would be highly desirable to develop effective routes for the synthesis of performance polymers enabling the use of materials under extreme conditions.

This priority also covers the design of new non-toxic monomers and oligomers, the functionalisation of natural polymers and precision macromolecular chemistry. Projects shall also explore ways to facilitate the building of chemistries with different polymers or biomimetic stimuli, or on which new methods of industrialisation will be based (additive manufacturing).

Supramolecular chemistry and molecular assemblies

The assembly of molecules by weak links plays a key role in the field of living organisms (macro, meso and molecular recognition enzyme-substrate receptors, molecular interactions) or for the design of “smart” materials (having properties or functions beyond those of their constituents, self-repair, regulation and/or autonomous adaptation, recognition and/or supramolecular catalysis).

This main research subject concerns in particular the production of synthons enabling supramolecular organisations through their self-assembling or self-organisation properties. It also includes the study of architectures or assemblies themselves, such as reversible or programmable molecular systems. Chemistry and associated structure-property relations will be addressed both from theoretical and application standpoints.

Efficient processes, intensified and new media

This theme concerns the identification of new methods to develop innovative, competitive and eco-efficient processes. These may include: i) the design of new processes, in particular those linked to special chemistries under development (novel, innovative modes of activation, intensified catalytic reactors, etc.), ii) the implementation of new technologies, processes and unit operations for obtaining environmental economic disruptions. This may be for example the miniaturisation of equipment, or effective reaction chains with a view to limiting the number of steps of a process or equipment used in the implementation process, (iii) the exploration of new media (new solvents, without solvent, new environmentally friendly media, etc.) and iv) recasting of existing methods to improve competitiveness and environmental efficiency through the implementation of innovative solutions: reduction of wastes, recycling, improvement of energy balance, coupling transfer, integration of discharges into the process economy.

Theme 4: Nanomaterials and nanotechnologies for the products of the future

The industry of the future will be based in part on multifunctional materials and integrated measurement and detection systems. These will be particularly effective because the integration of their assembly and functions at various scales (micro and macro) will be designed at the nanometric scale. This scale is still poorly controlled today in industrial processes. The development of these processes will require a series of crucial scientific and technological building blocks.

Applicants are invited to consider that the presence of objects or **specific nanoscale** phenomena in the final outcome of the project should be the main criteria for submission of the project under Theme 4, rather than under the chemistry or materials themes. Projects submitted under this topic should address generic scientific and technological hurdles and explain how they fit into knowledge and value chains. More applied projects should be submitted under the ad hoc challenge. The various hurdles that need to be overcome have been grouped into six categories in line with the priorities laid down in the SNR concerning the “design of new materials” and “sensors and instrumentation’.

Complex functional nano-objects

The first technological building block for products of the future is the mass production of nanomaterials (nanoparticles, nanotubes and nanowires, core-shells, etc.), which may be hybrid or composite. In the case of composite materials, the interface can itself be considered a nano-object study. The development of innovative materials for opto-electronics and flexible substrates must be regarded as an issue cutting across several possible approaches, (compatibility with living organisms, adaptation to the different forms of structures, visual communication etc.). Production patterns must integrate if possible eco-design provisions and ***safe by design*** objects. The durability and lifecycle of nanomaterials may also constitute subjects of research. Said nano-objects may present functional properties (mechanical, chemical, biological, thermal), enabling their use in materials with novel properties. Projects focusing on nanomaterials for electronics for spintronic and optical applications for information and communications should be submitted under Theme 8 of Challenge 7.

Management of interfaces at the nanoscale, functionalisation, interactions across interfaces

The second technological building block involves surface functionalisation at nanometric scale, including ultrathin films, and the modification of nano-objects which endow them with a functional purpose (chemical or biological reactivity, passivation, directed interaction between surfaces, adhesion, optical and magnetic properties, etc.). Dry and wet methods may be examined. Changes in the physical properties of surfaces such as their wettability, studies on the stability of liquid/solid or liquid/liquid interfaces, or fluid emulsions and polymer compounds, with stabilisation charges or reinforcement charges making up part of this approach.

Nano-object assemblies and 2D and 3D nano-structuration

The necessity to assemble or direct the self-assembly of nano-objects is an obstacle in obtaining bi or tri-dimensional functional materials. The development of processes for nanostructuring, shaping and controlling assemblies of objects (electrospinning, coatings, microfluidics, nanofluidics, rheology of nanopowders, etc.) is another building block in creating the capability to produce new (nanostructured) products; it therefore comes under this theme. In this context, the compatibility of nanomaterials with industrial processes may also constitute a subject of study.

Nano-objects and innovative nanomaterials for health

Fundamental knowledge acquired over the last twenty years in the physical chemistry of nanoparticles can be exploited to make new breakthroughs in terms of biotechnological applications. Projects must focus on the definition and study of innovative new families of multifunctional nano-objects (imaging, encapsulation/vectorisation of active ingredients (excluding cancer treatment applications). Research may consider upstream questions about mechanisms for training, stability, biocompatibility, release and visualisation.

Projects focusing on the in vivo demonstration of a therapeutic application should be submitted under Theme 11 of Challenge 4. Regardless of the hurdles targeted, projects focused on the fight against cancer, HIV/AIDS and viral hepatitis cannot be submitted under this challenge, as these topics are dealt with by the French National Cancer Institute (Inca) and the French National Agency for Research on AIDS and viral hepatitis (ANRS).

Innovative nanometric sensors

One of the priorities of the National Research Strategy (SNR) is the manufacture of innovative sensors for the factory of the future or as products in their own right. The design and use of sensors in which the sensitive part is micrometric in size (does not cover nano-structuring or nanometric-thickness surface functionalisation) for process monitoring comes under Theme 2 of Challenge 3. Under Theme 4, projects must focus on nanoscale improvements or breakthroughs potentially brought about by these sensors' performances in terms of detection (physical, chemical, biological) of sensitivity, specificity, resolution or action. The integration of nanosensors into materials may also be considered. But the design of sensors as components in the field of information and communication science and technology, as well as the management of their (autonomous and non-autonomous) power supply and their ability to communicate, should be submitted under Theme 8 of Challenge 7. The same problem issues under Challenge 1 for environmental monitoring, Challenge 5 for food security and Challenge 9 for security aspects.

Instrumentation, characterisation, in situ and in operando characterisation

The use of nanomaterials requires dedicated instruments to meet the needs for metrology and characterisation of nano-objects. Projects that focus on the development of instruments or instrumental methodology in this field will therefore be welcomed. Detection and counting of nano-objects in complex environments, fluid or solid, diluted or not, and associated methodologies are also challenges included in the brick. The coupling of technical analyses on the same object or the same point are part of the brick; The physical properties on which are based these instruments may be of any kind (Raman, SERS, LSPR, optical microscopy, super resolution principle, electronic microscopy, near field, acoustic, magnetic and thermal properties, etc.). *Operando* and even *in-situ* characterisation methods are of particular interest when the nanomaterials are used in functional devices.

One aim of this theme is to promote closer links between academic laboratories and companies, with the potential for technology transfer. **Projects may therefore be experimental, theoretical, technological, industrial and instrumental, and may include a fundamental knowledge acquisition dimension. Projects may focus on aspects that break new ground, as well as production steps making use of nanometrics for overcoming technological hurdles involving nanometric dimensions.** From a general standpoint, modelling and simulation aspects may be present in projects tackling previously defined obstacles or be covered in specific projects.

Projects dealing with Graphene and other 2d materials should demonstrate potential links with the European FET Flagship ‘Graphene’.

Challenge 4 : Life, health and well being

EUROPEAN AND INTERNATIONAL COLLABORATIONS

The 2016/2017 topics prioritised for international funding are detailed below as well as in annexes 1 and 2 of Work Programme 2017. The following information aims to provide French teams with details of existing or forthcoming agreements between ANR and its foreign counterparts. Said agreements aim to facilitate the formation of international projects and consortia.
http://www.agence-nationale-recherche.fr.

This challenge is particularly concerned by the following initiatives:

- The Franco-American call for proposals in computational neurosciences in connection with the "Collaborative Research in Computational Neuroscience" (CRCNS) programme, with the United States (NSF and NIH), Germany (BMBF) and Israel, in association with Challenge 7.
- ERANETs integrated into EU programming in FP7 or Horizon 2020.
- EuroNanoMed 3 - Nanomedicine,
- ERACoSysMed - Medicine systems,
- E-Rare 3 - Rare diseases,
- ERA-CVD - Cardiovascular diseases,
- ERA-HDHL supporting JPI HDHL - Biomarkers in health/nutrition,
- ERA-HDHL supporting JPI HDHL - Intestinal microbiomics,
- ERA-NET Cofund neuron3 — neurosciences,
- Calls for proposals under JPND neurodegenerative diseases
- FLAG-ERA (in line with the Human Brain Project),
- Call for proposals in the context of JPI AMR — antimicrobial resistance;

INTERFACES

Thematic overlap among challenges: For themes common to the various challenges or bearing similarities to themes under other challenges, coordinators are invited to submit under Challenge 4 when the project involves a significant amount of research in biology, physiology or physiopathology, develops applications to pathologies or when patients are involved.

Overlap between different themes within Challenge 4: For cases in which the project comes under different themes, coordinators are encouraged to submit under the most specific theme available: For example, Theme 3 for physiopathology of toxic or infectious external stresses lacking an environmental component; Theme 6 for the exploration of systems and bodies and their normal and pathological functioning; projects on synaptic plasticity in neurosciences, or lymphocyte biology in theme 6, etc.

POTENTIAL CO-FUNDING[34] FOR PROJECTS SUBMITTED TO THIS CHALLENGE

Some projects within this challenge may be co-funded by CNSA (National Solidarity Fund for Autonomy) or DGOS (Directorate-General for Healthcare Provision).

[34] Co-funding means that funding is partially allocated by ANR, with the remainder coming from one or several of the agency's co-funder partners.

Introduction

The “Life, health and well-being” challenge covers a broad field of research addressing citizens’ natural desire for well-being within the context of health policy optimisation. This initiative requires research to push back the boundaries of knowledge through the most advanced fundamental research on living mechanisms on a number of levels: molecular, cellular, tissue, systemic or organic levels. It calls for an integrative approach that brings together materials science, environmental sciences and humanities. Multiscale analyses of the diversity and evolution of living organisms should be carried out to identify, quantify and document the properties of living organisms as a whole, from molecules and basic biological functions to entire systems and populations. Projects aiming to contribute to our fundamental knowledge of Life Sciences may relate to any cladus, treated either as the primary focus of research, or as a model organism. These studies based on the diversity of experimental models will contribute in particular to the development of synthetic biology and systems biology. They will also be instrumental in creating new opportunities in industrial, environmental and medical fields.

Life and health sciences are constantly evolving and presenting new concepts, interdisciplinary exchanges and scientific, technological, health-related and socio-economic challenges. The unprecedented increase in data production resulting from this scrutiny of living organisms at all levels, as well as the cumulative benefits of multidisciplinary approaches, have revolutionised the field of human health. Biological approaches and concepts now draw upon fields as diverse as engineering, physics, chemistry, biomaterials, mathematics, IT, humanities, economics and social sciences, and in return enrich these disciplines with bioinspired technologies.

This particularly wide-ranging field of research must pay heed to the prevailing trend towards an increasingly ageing population and changes in lifestyle and social behaviour. These factors may encourage the development of diseases — such as nervous system diseases, metabolic or nutritional pathologies or infectious diseases — requiring the implementation of national measures.

“Life, health and well-being” offers enormous potential for pushing back the frontiers of knowledge and transferring resulting gains to individuals and society as a whole. This challenge is also a driver for innovation and economic growth within the biotechnology, pharmaceuticals, diagnostics and medical device sectors.

ANR Work Programme 2017’s “Life, health and well-being” challenge is divided into 13 themes. The challenge is structured around the eleven strategic priority areas laid out in the French National Research Strategy (SNR)’s “Health and well-being” challenge, in line with the recommendations of the French High Council for Research. It also contributes to four of the prioritised SNR action programmes: exponential growth in the volume of digital data and the exploitation of this data, the key role of science and innovation in climate risk analysis and management, the revolution in our understanding of the living world, and the need to develop innovative, effective healthcare.

ANR initiatives are intended to complement initiatives implemented by other national funding agencies. For example, ANR does not fund research on cancer, HIV/AIDS and viral hepatitis, which are already funded by the French National Cancer Institute (Inca), Cancer Plan and the French National Agency for Research on AIDS and viral hepatitis (ANRS). On these topics, projects in partnerships with industry (PRCE instrument) may nevertheless receive ANR funding, along with projects belonging to eligible topics submitted under the ERA-NET scheme. Clinical research projects should preferably be submitted under the hospital clinical research programme (PHRC), and research projects on health and care systems should be submitted under the research programme for the performance of the healthcare system (PREPS) run by the Directorate-General for healthcare within the French Ministry of Health (DGOS)

The “Life, health and well-being” challenge is based on three key approaches:

(i) The first approach focuses on decoding the living cell, physiology, developmental and ageing multi-scale mechanisms that take place in living organisms, which is an essential step towards understanding and diagnosing diseases caused by malfunctions in these mechanisms. Approaches should go beyond descriptive and observational processes, or genome sequencing, and seek to improve our understanding of intricate functional mechanisms.

(ii) The second approach aims to provide a better understanding of pathological processes and pave the way for risk reduction strategies, a holistic view that takes account of both the individual and the community as a whole, or the implementation of compensation strategies. This also involves approaches within the field of biomedical innovation: new biological biomarkers or innovations in the imaging of cells, tissues or organisms, new therapeutic targets and molecules, novel high-content, high-throughput screening methods, innovations in pharmaceuticals and pharmacology, regenerative and substitution biotherapies, biomaterials, and technological research in the field of e-health and telemedicine.

(iii) The third approach concerns public health and health-oriented social sciences covering all fields of application. It focuses on the causal chains of socio-economic, gender, environmental and cultural inequalities, on the impact of health shocks or chronic diseases on individuals and their environment, on social, economic and political dynamics relating to health innovations and the regulation of health-related activities, and on methodological research.

ANR shall also provide funding to certain international or European initiatives under Challenge 4.

In order to address the issues that make up the “Life, health and well-being” challenge and encourage the emergence of cross-disciplinary sectors, 13 scientific themes with strong cross-disciplinary and multidisciplinary linkage have been highlighted for funding in 2017. **Most of these areas are very open to fundamental research projects, for which a particular support may be implemented.**

In addition, the National Research Strategy has identified two priority areas for this challenge: Priority areas 16 — multiscale analysis of the diversity and evolution of living organisms and 17 — Biological data collecting and processing.

Theme 1: Molecular study of biological systems, their dynamics, interactions and interconversions

This theme seeks to characterise the biological mechanisms and molecular machinery involved in the functions and malfunctions of living systems. The aim is to understand, visualise and quantify the biochemical and physico-chemical processes enabling molecular components to work together in their cellular environment. Research under this theme shall draw upon a variety of fields — chemistry, physics, IT, genetics, biophysics, biochemistry, molecular and structural biology or imaging — with the aim of decoding and predicting the structure of biological macromolecules and their compounds, the dynamics of their interactions and their responses within cellular or subcellular systems.

This theme aims to shed light on biological challenges by using integrative structural biology approaches, to support and encourage novel technological developments for research, for example on single cells and molecules, novel strategies in emerging areas in structural biology, super-resolution microscopy, mass spectroscopy or “chemical biology”. This theme's research may also explore new experimental approaches aimed at living organisms, with possible applications in applied biology, in human health (probe, inhibitors, therapeutic or diagnostic-targeted molecules) or in biotechnology. The design of new biological systems (synthetic biology) is included in theme 1.

Theme 2: Decoding basic biological functions and their integration

This theme aims to provide an understanding of how bacterial, animal and plant cells are made up of groups of molecules and how they grow, multiply, differentiate themselves, die and are replaced, how they move in response to environmental stimuli, how they cooperate to form a multicellular organism, tissue or organ and how these mechanisms were established over the course of evolution. Support will be given to the emergence of new study models, in particular short life cycle models that can be reproduced in a laboratory setting. This initiative covers the study of self-renewal, differentiation and normal or pathological tissue remodelling in adult, foetal stem cells in all relevant species and models.

Theme 3: Research into systems and organs during normal and pathological function

This theme aims to improve

- The understanding of the hierarchical assembly of tissue, and organ components, underlying metabolic pathways, and the physiological properties generated by their interactions
- The understanding of these properties within entire organisms, and at the interface with the environment,
- The understanding of the mechanisms of their alteration in disease processes,
- The support of projects addressing all determinants (biological, behavioural, psychological and social), especially in the field of metabolic disorders and nutrition.

International initiatives: ERA-NET CVD projects, certain projects under ERA-NET EraCoSyMed and ERA-NET E-Rare 3 fall within this theme. Projects outside the JPI HDHL microbiota will be included under this theme.

Theme 4: IT and digital systems, methodological research, computer systems and statistical research to meet the conceptual and technological challenges of health research development, genotype-phenotype associations, organisms and virtual pathology

This theme concerns:

- Biostatistics, bioinformatics and biological modelling including the use of high-throughput biological data. Also covered are the collection of big and wide-ranging data, the processing and interpretation of such data as well as numerical simulation. The development of models and methods for comparison against actual data also falls within this theme.
- Bioinformatics and biostatistics tools in pre-clinical and clinical research, epidemiology, including impacts on health system organisation. Covered topics include the nosological breakdown of common diseases, attempts at understanding their physiopathology and an assessment of related medical interventions. This theme covers big data analysis, data interpretation, data use in decision-making, data exchange, data access, and the security and ethical dimensions of data management.
- Personalised, digital medicine, which includes using the above data to create virtual biomedicine (realistic anatomical, representational, functional and metabolic in silico simulations), which is then compared to data from physical, biological and medical procedures, thus combining health technologies with our understanding of living systems.

This theme covers research on the social dynamics and ethical issues linked to the above-mentioned types of biomedical innovation.

International initiatives: International initiatives: certain projects funded under CRCNS Computational neurosciences or EraNet EraCoSyMed may be considered as projects

Theme 5: Genetics and genomics: Organisation of genomes and genome environment interactions, regulation of gene expression, epigenetics, genotype-phenotype relations

Theme 5 seeks to provide an understanding of the genetic and epigenetic foundations of how various living organisms function as well as the genetic mechanisms and gene expression problems that give rise to human diseases.

- The aim of this theme is to characterise genome variability, the mechanisms responsible for genome integrity and faithful transmission of genetic information, the principles of genome organisation and evolution.
- Transcriptional, post-transcriptional and translational regulation/deregulation, analysis of genetic variation, particularly that of genomic regions targeted by epigenetic changes and the involvement of non-coding RNA and maturing processes, will be addressed by studies on cellular models, non-human species, (models or otherwise) or patient cohorts and control populations.

Theme 6: Microbiome and microbiota-host relations

Recent descriptions of new microbial strains, including those with viral nucleotide sequences and potential relationships between microbiota and diseases have laid down an initial knowledge base that now needs to be strengthened so as to provide an integrated view of the microbiome present in every human and animal organism.

Theme 6 aims to encourage interdisciplinary research in all 'omics' technologies, high-throughput research, bioinformatics analysis tools dedicated to under-represented molecules, software adapted to data collection and modelling to enhance knowledge of the molecular mechanisms involved in balance and adaptation strategies between microbial communities and their hosts (symbiosis) as well as microbiome functions and malfunctions and their impact on microbiomes (dysbiosis) and the organism as a whole.

Research on the connection between microbiota and pathogens, in particular on the impact of microbiomes on susceptibility to infections, will be encouraged. Issues involving micro-organism communities and their development will be addressed in this theme, including through modelling. Research shall particularly shed light on the role of the microbiome in antibiotic resistance. Lastly, the studies of the microbiome as a factor in the occurrence or predictive biomarker of mucosal inflammatory diseases or other diseases also come under this call theme.

Physiology projects focusing on nutrition, digestion, and digestive flora falling outside pathology should be submitted under Challenge 5.

International initiatives: Microbiota projects funded under initiatives undertaken by JPI Human infectious diseases (HDHL) will come under this theme.

Theme 7: Exploration of the nervous system during normal and pathological function

This theme covers three major research fields:

Understand the functioning of the nervous system and the sense organs: basic approaches

Theme 7 seeks to explain the logic of the hierarchical structure of thousands of molecular, cellular and tissue components within the nervous system and sense organs, how their dynamics and plasticity generate the nervous system's functional properties (e.g., the neural code). It is also important to understand the different levels of hierarchy and interactions specific to the functioning of the brain (e.g. neural networks, sets of networks, integrated actions) without which it is impossible to address high-level brain properties (e.g. sensory multi- integration and recognition of objects, decision-making, memory, behaviour, cognition), as well as aspects specific to the human brain, including the social dimension (e.g. self-awareness, an equity perspective, deliberate thought, language, relationships with others).

Mental health, psychiatry and addictions

This priority aims to support projects addressing the full range of expressions of mental health, psychiatry and addiction. Research should strive to understand the mechanisms as well as the biological and social determinants of these conditions in order to prevent and treat them.

This theme aims to encourage complementary aspects and synergies between fundamental research and preclinical, clinical and epidemiological research in the fields of social sciences and humanities and health technologies in the area of mental health, psychiatry, and addiction.

The epidemiology approach to health inequalities in mental health falls within Challenge 4's "Public health" theme, whereas their sociological or economic analyses (access to healthcare, medical insurance coverage, vulnerabilities, decisive equity and care provision) comes under Challenge 8; connected devices falling within Challenge 4, Theme 13.

Neurological diseases, diseases of the sensory organs, and research on neurodegenerative diseases

This area covers nervous system illnesses including cerebrovascular diseases and diseases of the sensory organs with the exception of neural aspects that are not covered by Theme 3. It will aim at understanding the mechanisms of these conditions to prevent and treat them.

This sub-theme aims to encourage complementarity and synergies between fundamental research and preclinical research, clinical research and epidemiology in the fields of social sciences and humanities and health technologies.

International initiatives: Initiatives under the ERA-NET Cofund "Neuron 3" (neurosciences), certain projects of the CRCNS initiative (computational neurocience) with the NSF-NIH (USA), BMBF (Germany) and Israel, as well as initiatives under the ERA-NET "FLAG-ERA" on the human brain project and initiatives centred on neurodegenerative diseases (JPND) and participation in the international CoEN network, will come under this theme.

Theme 8: An integrated approach to immune responses

Given the increasing impact of immune, inflammatory, allergic, and tolerance breakdown diseases, the aim of this theme is to characterise the molecular and cellular mechanisms involved in organism defences and inflammatory reactions during adaptive and innate responses, so as to compile a comprehensive analysis of the immune system in normal and pathological situations. Research defining the functional and molecular foundations involved in immune deficiencies, hyperimmune disease, vaccines to improve efficiency and prevent harmful organism immune responses are also encouraged. The development of new animal models to better understand the evolution of inflammatory auto-immune conditions and software supporting the modelling of responses is included in this call for proposals.

International initiatives: Some projects falling under the JPI-AMR (antimicrobial resistance) will be integrated in this theme.

Theme 9: French social inequalities in terms of health: preventive health care, primary care and social services (joint theme with Challenge 8, Theme 8)

Public health research straddles Challenge 4 “life, health and well-being” and Challenge 8 “innovative, inclusive and adaptive societies”. The ensuing projects will be evaluated by the same experts belonging to a single interdisciplinary committee. The objective is to promote cross-disciplinary research and enrich the discussion surrounding possible initiatives to address the main causes and manifestations of social inequalities and vulnerabilities related to health in France. An appropriate response from public authorities presupposes prior analysis of social, behavioural, psycho-social, economic and biological aspects in an effort to shed light on the effects of certain social determinants on health, and to identify the scale and type of phenomena that fall outside this analysis. This theme includes the development of health policy research as well as investigations into the effectiveness and equity of health services, and the link between health system and society. It has strong links with Challenge 8, Theme 2, which deals with projects centred on social sciences, humanities and societal aspects.

Theme 10: Translational health research

This incentive initiatives in translational research is aimed at financing studies positioned downstream of exploratory research projects carried out in research laboratories, and upstream of clinical research projects supported by the Hospital Clinical Research Programme (PHRC) which is run by the Directorate-General for Healthcare Provision (DGOS). The objective is to fund collaborative research projects around scientific questions at the interface between fundamental and clinical research.

This theme focusing on translational research aims to break down the boundaries between upstream and downstream areas, particularly in terms of physiopathology. Project results should enable the formulation of new hypotheses to be tested in clinical research procedures. Applicants who wish to seek ANR-DGOS co-funding for their project within the framework of a joint action such as the ‘Translational Health Research Programme” (**PRTS**) should submit their project under this theme.

Theme 11: Medical innovation, nanotechnologies, regenerative medicine, innovative therapies and vaccines

This is a targeted initiative to fund applied biological and biomedical research projects. Funding may be assigned to two possible types of projects: (i) those with high innovation potential in terms of knowledge acquisition, design or technological maturity that will promote future industrial transfer; (ii) projects aiming to develop and transfer knowledge between industrial and academic partners in order to strengthen French competitiveness in the biomedical sector. This theme only concerns innovations in the research and validation of diagnostic methods (including the identification and validation of biomarkers, screening and prognosis), therapeutic targets and treatments, industrial application and production aspects.

Projects aiming to study the dynamics of biomedical innovation within healthcare may also be submitted under this theme.

International initiatives: Some projects falling under the JPI-AMR (antimicrobial resistances) shall be integrated into this theme.

Theme 12: Healthcare technologies

Engineering sciences, digital science and mathematics, in association with life and health sciences, are powerful tools for improving our quality of life in terms of healthcare and autonomy and can trigger medical advances. This theme includes technologies related to compensating for disability or loss of autonomy. Funding may be given to two possible types of projects: (i) those with high innovation potential in terms of knowledge acquisition, design or technological maturity designed to promote future industrial transfer; (ii) projects aiming to develop and transfer knowledge between industrial and academic partners in the field of health, in order to strengthen French competitiveness in the biomedical sector. Projects focusing on research tools for industrial development are also relevant to this theme. Projects studying the dynamics of technological innovation within healthcare may also be submitted under this theme.

Theme 13: Health-Environment- "One Health" (joint theme with challenges 1, 4, and 5)

Projects submitted under this theme, common to Societal Challenges 1, 4 and 5, shall be jointly assessed. Theme 13 concerns the transdisciplinary approaches at the interface between these challenges.

The One Health concept postulates that the epidemiological dynamics and actors' incentives which determine the health of human and animal populations should be studied in their microbial, ecological, socio-economic and political contexts at the interface between human, animal and ecosystem health. The "One Health" approach provides a functional work environment for the integrated and interdisciplinary exploration of: 1) the effects of environmental factors on living species and human health, 2) the position of the environment among the various determinants of health, 3) the impact of multiple determinants on rare diseases, health and healthcare systems. It is underpinned by the 'exposome' concept, and involves a coherent analysis of emerging risks.

The study of how environmental factors affect living species or human health and the role of the environment among the various factors influencing health should focus on the impact of physical, chemical and biological contaminants, by taking into account the various environments and levels of exposure. It should also encompass interactions between the environment, animal health and human health, and the role of the environment in the mechanisms of emergence and re-emergence of diseases (ecology of health).

The issues at stake include the quest for a better understanding of phenomena and mechanisms, the assessment of risks, proposals for appropriate monitoring methods, counter measures and policies. Cooperative initiatives are therefore expected between the different biological and medical science disciplines, environment and ecology, physical, chemical, mathematics and modelling, social sciences and humanities, etc.

Three sub-themes will be considered:

Environmental toxicology.

In environmental toxicology, the encouraged approaches are pathways or networks of toxicity, systems biology, epigenetics and those targeting vulnerable stages in the life cycle of individuals, transgenerational effects, and effects of mixtures in particular in low doses, or key life-history traits for population dynamics in the environment. Particular emphasis will be placed on emerging contaminants and endocrine disruptors.

Contaminants, ecosystems and health[31]

This sub-theme focuses on the study of transfer and toxicity of contaminants, their metabolites and transformation products, ecosystems, the health of human populations and the link between work and health.

Multidisciplinary approaches are expected to: 1) explore the concept of exposome, interactions between different contaminants and their possible cumulative effects; 2) model the transfers of contaminants in different media and trophic networks, their repercussions in human and animal food chains and their impacts on ecosystems and their component parts; 3) characterise emerging risks and establish adequate systems of supervision, analyse social risk assessment, processes in debates and decision-making; 4) improve predictive capabilities through systemic approaches; 5) analyse the relationships between environmental changes and chronic non-communicable and/or allergic illnesses; 6) include environmental, economic and social factors which determine or modulate exposures and vulnerabilities of human populations, the awareness of social partners; 7) develop remedial approaches.

Environment, pathogens and emerging or re-emerging infectious diseases

This priority covers the emergence mechanisms of infectious human, animal or plant diseases that may be triggered by environmental factors (climate, biodiversity, use of soil and resources, etc.) in synergy with human-induced factors (agriculture, livestock breeding, industry, urbanisation, transport, demographic changes, social practices, etc.). It also concerns resistance to antibiotics, anti-parasitic, antifungal, insecticides, and biocides. Various pathogens are included (e.g. parasites, fungi, algae, bacteria, viruses and non-conventional pathogens) as well as their products.

The objective is to support multidisciplinary research taking into account said pathogens' social and environmental dimensions in order to anticipate the epidemic or pandemic risks, as well as to develop prevention and proactive measures, and to fight against antibiotic resistance and resistance to biocides in general. Particular attention will be paid to neglected tropical infectious diseases as defined by the WHO.

Integrated and multidisciplinary approaches are expected to focus on: 1) pathogenic agents, their ecological niches (tanks and arthropod vectors), their persistence and development, spatial and temporal dynamics of transmission and the fate of pathogens in ecosystems; 2) risk assessment of inter-species transfer of pathogens; 3) the study of the relationship between pathogens, and interaction mechanisms between the different virulence determinants, and the dissemination of pathogens; 4) modelling parameters of emergence, distribution, exhibition or disposal (including through retrospective analyses and predictive ecology scenarios). The creation of geographical, environmental, climactic, biological, social, economic, demographic, epidemiological, clinical and health databases able to aid in establishing indicators for a predictive approach to evolving epidemics in health monitoring; 5) control or monitoring methods compatible with human health and the environment: treatment, vaccination, surveillance, prevention policies, vector control or biological, emergency management, etc.; 6) bacterial or parasitic multi-resistance in order to identify the molecular and environmental factors involved in the spread of multi-resistance. Other possible topics include: the impact of the host and its microbiota in the development of resistance to antibiotics in a pathological context; microbiota dynamics in normal and pathological conditions; The role of epistasia in the development of multi-resistances to anti-infectious agents and identifying at-risk areas and populations (eco-epidemiological approach); 7) the perception and behaviour of different actors towards risk, alerts, information and prevention, treatment and control strategies. Methods for the design, formulation, implementation and evaluation of different policies and measures will also be studied.

[31] This sub-theme is part of the research priorities defined in IFRES (French Environment and Health Research Initiative) coordinated by the group "Inter-Alliances Allenvi-Aviesan-Athena".

International initiatives: *Some projects falling under the JPI "AMR" (antimicrobial resistance) will be integrated with this theme, in addition to certain IMI2 call themes.*

Challenge 5 : Food security and demographic challenges, biological resources, sustainable exploitation of ecosystems and bio-economy

EUROPEAN AND INTERNATIONAL COLLABORATIONS

With a view to the construction of the European Research Area (ERA), Challenge 5 is based on a dynamic international programming. Priority will be given to multilateral actions supported by European initiatives (JPI) joint programmes involved in ERA-NETs opening additional funding from the European Commission. Bilateral cooperation for countries not covered by these initiatives.
The 2016/2017 topics that shall be given priority for international backing are detailed below and also given in tables 1 and 2 of the 2017 Work Programme. Since all lists are subject to change, applicants who wish to conduct their projects in a European or international context should routinely visit the ANR website to stay posted about these partnerships and calls for proposals. http://www.agence-nationale-recherche.fr/

Research networks: Challenge 5 aims to encourage French coordination of European projects using the MRSEI funding instrument ("setting up European or international scientific networks) described in section C.7, in order to target the following:

- The Horizon 2020 calls, in particular topics under Societal Challenge 2 "Food security, sustainable agriculture and forestry, marine, maritime and inland water research and the bioeconomy"' and those of the European Research Council (ERC);

- Calls for proposals under Joint Programming Initiatives (JPI Climate, JPI Oceans, JPI Water, JPI FACCE, JPI HDHD) and associated ERA-NETs and ERA-NET COFUNDs (e.g. ARIMNET) Applicants are advised to consult the call for proposal calendars posted on the ANR website.

INTERFACES

Challenge 5 involves cross-cutting research topics relating to more than one challenge. The other challenge(s) to which these topics relate is (are) indicated below, so that applicants may orient themselves towards the most relevant challenge for their project. Applicants are strongly advised to read each related challenge in its entirety to gain a thorough understanding of its specific scope.

For information concerning cross-cutting theme areas, most of which fall within the scope of multiple challenges (including **Challenge 5**), readers should refer to the paragraph entitled "**Multidisciplinarity, cross-over and interfaces**" (pages 39-42) which covers the following fields: ***Big Data, Robotics, Sensors, Biology, Bioeconomics & Biotechnology.***

The following fields are also interfaced with Challenge 5:

Nutrition biology (Theme 1): The themes of this area in connection with the human disease are treated within Challenge 4.

Dynamics of ecosystems to improve their sustainable management (Theme 3). This theme is common to Challenges 1 and 5.

Environment-health — "One health" (Theme 4): This theme is common to Challenges 1, 4 and 5.

Microbiomes (Theme 5): Projects on microbiomes and their interactions with food from production until their effects in the digestive tract come under Challenge 5; those relating to

Bioeconomy: specific technologies and systems approaches (Theme 6): Multipurpose and cascades approaches to bio-resource use in which the objective is not exclusively energy-focused fall under this theme. Biotechnology projects targeting mainly the production of advanced biofuels in biorefineries fall within Challenge 2; projects for the production of other bio-based products fall within the Challenge 5. Research on the regional integration of biomass chains, on their environmental, social and economic impact on rural and local development and on competitiveness is covered by this challenge.

POTENTIAL CO-FUNDING[36] FOR PROJECTS SUBMITTED TO THIS CHALLENGE

The involvement of the Ministries of Agriculture, Agri-food and Forestry (MAAF) and the Environment, Energy and the Sea (MEEM) in this challenge is one of the challenges identified in the law on the Future of Agriculture, Food and Forests of 13/10/2014 and in the Agri-environmental Plan for France. These Ministries may mobilise additional financial resources to support Challenge 5 projects dealing with these issues, primarily in the context of *Plan Ecophyto*.

ANR is also working in partnership with apis-gène on Challenge 5. This involvement comes under apis-gène' s Eger programme (focusing on global efficiency in ruminant breeding), which aims to identify drivers that improve the efficiency of ruminant feeding, reproduction, health and well-being and the quality of ruminant products through a better understanding of the underlying' genetic mechanisms and the diversity of geographical conditions and farming systems. In this context of improving efficiency and sustainability of farms, apis-gene will mobilise professional financial resources to support such research projects in public/private partnership.

CHALLENGES

Challenge rose — robotics in the service of Ecophyto: to reduce pesticides in agriculture. Agriculture's shift towards multiperformance will involve the implementation of new practices that may require the development of innovative agricultural equipment capable of limiting inputs and encourage the establishment of systems adapted to social, economic and environmental constraints. In connection with the launch of five sector programmes under plan Ecophyto with a strong operational R & D focus, solutions to reduce the cost and improve the use of plant protection products, agricultural and non-agricultural action will be subject to a dedicated 'challenge'. [The five programmes respectively cover biocontrol, agricultural equipment (including robotics) and personal protective equipment (PPE), varietal innovation and sustainable management of the flora weed alternative technical solutions in gardens, planted spaces and infrastructure). In line with the Innovation 2025 (FAO) — plan the development of technologies and tools in relation to digital must contribute to the objective of reducing pesticide use, taking into account the needs and constraints of farmers, pathways and challenges — environment. Challenges whose specific arrangements have yet to be determined in the coming months may be co-financed under Theme 2 of Plan Ecophyto, co-chaired by the French Ministries of Agriculture and of the Environment by mobilising other possible sources of funding, including from enterprise.

This challenge is also interfaced with the thematic areas of Challenge 7.

[36] Co-funding refers to the fact that the funding granted to any given project may come partly from the ANR and partly from one or more of the Agency's co-funding partners

Introduction

Challenge 5's thematic scope covers food safety, the sustainability of agro-ecosystems, forest, aquatic and freshwater ecosystems and the bioeconomy.

Food security means ensuring the world's population has access to healthy, balanced nutrition sufficient to satisfy its needs and food preferences. As highlighted by the broad international sustainable development commitments made in 2015 (Sustainable Development Goals - SDGs, Paris Climate Agreement), ensuring food security cannot be set apart from a set of interdependent sustainable development goals including reducing inequality, granting access to energy and water, and fostering biodiversity by fighting climate change.

Food and non-food systems using biomass are at the heart of the transformations needed to address these global challenges. Ensuring their sustainability involves both the reduction of the environmental footprints left by agricultural, forest, fisheries, aquaculture and animal production, as their ongoing adaptation to global changes: climate change and degradation of biodiversity, but also the expanding global population, changes in consumption patterns including food and the globalisation of trade. All of these factors exert growing amounts of pressure on production systems. greenhouse gas emissions, damage to soil, surface water, ground water and air quality, resource depletion, competition for usage. They generate increased health risks, and may have impacts on human health.

Challenge 5, directly aligned with commitments put forth by the Paris climate agreement and the SDGs, calls for research from the most fundamental to the most finalised to generate subject-specific knowledge and encourage systemic innovation processes and cross-cutting approaches. The challenge extends from biological resources, biomass and ecosystems to consumers in renewed productive systems: new bioresources, new practices, new social organisations and new markets. Different scales and levels of organisation are covered, from genes to individuals, to populations and finally, the ecosystem.

These areas, complex and interlinked, call on the life sciences, social sciences and humanities and matter sciences for processing of bioresources.

Expected research under Challenge 5 must yield fundamental subject-specific knowledge and stimulate processes of innovation through systemic and cross-cutting approaches.

Challenge 5 is divided into six themes, themselves split into sub-themes: a knowledge base covers the entire scope of the challenge and five mostly finalised research themes.

- Theme 1: Fundamental knowledge for addressing challenge-related issues
    - *Animal biology, photosynthetic organisms and microorganisms*
    - *Nutrition biology and food science*
    - *Understanding ecosystem dynamics to improve their sustainable management*
    - *Conceptual and methodological developments for the bioeconomy*
    - *Knowledge bases in social and economic sciences and humanities in connection with the challenge's themes*
- Theme 2: Animal biology, photosynthetic organisms and microorganisms
    - *Adaptation and input reduction*
- Theme 3: Ecosystem dynamics to improve their sustainable management
    - *Adaptation and sustainable management of ecosystems*
    - *Evolution trajectories of ecosystems: Strategies and policies for supporting transitions*
- Theme 4: Health-Environment- "One Health"
    - *Environmental toxicology*
    - *Contaminants, ecosystems and health*
    - *Environment, pathogenic and emerging or re-emerging infectious diseases*

- Theme 5: Food, healthy and sustainable food systems, world food security
    - *Changes in technology, processes, behaviours and policies for healthy and sustainable food*
    - *Global food security*
- Theme 6: Bioeconomy: specific technologies and systemic approaches
    - *The production and mobilisation of bioresources*
    - *Transforming bioresources (including biorefineries)*
    - *The externalities of the bioeconomy*
    - *Levers for developing the bioeconomy:*

These six themes contribute directly to three of the national research strategy's priority areas:

- Priority 19: Healthy and sustainable diet
- Priority 20: An integrated approach for production systems
- Priority 21: From production to diversified uses for biomass

Challenge 5 also contributes to the implementation of the ECOPHYTO system and Innovation 2025 (FAO) — and draws from orientation documents produced by the "Standing Committee on Agricultural Research" (DG Research, European Commission), especially as pertains to the bioeconomy.

Theme 1 - Fundamental knowledge for addressing challenge-related issues

Projects submitted under this priority will address, including in the very long term, questions raised in the introduction and challenges defined in one of the challenge's thematic areas (Themes 2, 3, 4, 5 and 6). No disciplinary field is excluded *a priori*. Interdisciplinary research is also expected, given the complex nature of the issues falling under this challenge. The following text illustrates particular objects and relevant basic research approaches within this challenge.

Animal biology, photosynthetic organisms and micro-organisms

Fundamental biology research is expected on **livestock or food-producing animals**, on **photosynthetic organisms of interest and dedicated models** and associated organisations (microorganisms, pests etc.).

Research may be part of a **continuum of levels** (genes, genome, molecule, cell, body, individual, population), investigating **all levels of regulation** (genomics, transiptomic, epigenetics, translational, post-translational, metabolic, physiological, etc.).

Methodological developments for data integration and modelling approaches may be relevant. Research will be able to draw on complementary approaches including systems biology, modelling and synthetic biology.

Eligible research topics include the genome, polymorphism, regulation of its expression on mechanisms and determinants for reproduction, development and growth of individuals or their responses to environmental constraints.

For animal biology, research may endeavor:

- to better understand the **construction of phenotypes**, including by comparing genotypes/phenotypes of neighboring species, and better combining the objectives of selection;
- explore the **mechanisms regulating compromises** between these different functions of interest (particularly between production and adaptation) and to develop **a systemic approach to interactions** (between genes, between individuals, and between animals and their environment).

Plant biology, research may endeavor:

- to explore the process of adapting photosynthetic organisms to environmental constraints (single or multiple abiotic stresses);
- To identify **metabolic networks**, genes involved and their regulation and signal transduction channels, including hormonal;
- study the **interactions between organisms**, whether they are positive (symbiosis, beneficial plant associations, microorganisms, etc.), negative (parasitism, pathogenicity, competition,etc.), bipartite or multi-party. ;
- to examine the **interrelationships** between abiotic environmental variations (deficiency/excess nutrients, drought, etc.) and development of favourable or unfavourable biotic interactions.

International call 2016/2017: Third ERA-CAPS "Europe-USA" call strengthening transnational research in the molecular plant sciences

Understanding ecosystem dynamics to improve their sustainable management

Encouraged research in this priority is aimed at the acquisition of fundamental knowledge, and comes under objectives of understanding ecosystems to improve their sustainable management (Theme 3, cross-cutting with Challenge 1).

Research in **soil biology, functional ecology, ecosystems, agronomy** and all fields of life sciences or social sciences and humanities to foster the long-term development of innovations in the fields of agro-ecology and sustainable management of productive ecosystems and their biological resources are particularly welcome under this theme. Research is ultimately expected to enable the implementation and functioning of complex multi-species biological communities at **different spatial scales** (from plots to landscapes) and **temporal scales** (from an annual cycle to long maturation of ecological services). Theme 1 also covers basic knowledge on **relationships between ecosystems, technical systems and societies at these different scales**. Furthermore, robotisation and the development of digital technology in the areas of agriculture, food and ecosystem management is a challenge which also calls for exploratory research interactions in mobilising fields focused on until-now underexplored **interdisciplinary interactions between the sciences of living organisms and digital social sciences.**

Nutrition biology and food science

Projects expected within this sub-theme may concern the following thematic fields, in particular:

- **Nutritional biology** (preventive nutrition and nutrigenetics, intestinal nutrient absorption mechanisms and interactions between microbiota and the digestive tract, human microbiota, regulating the energy balance, etc.);
- **Microbiology, virology, mycology, parasitology in food and water** (mechanisms of pathogenic microorganisms and the host-pathogenic relations of microorganisms, interactions in consortia on the basis of complex ecosystems under dynamic conditions, development of enzymes, selection pressures of adaptation and resistance, ('omics' technologies, genomics, proteomics, transcriptomic metabolomics) and phenotyping, hazard assessment and risk assessment);
  "omics" (genomics, transcriptomics, proteomics, metabolomics) and phenotyping, assessment of hazards and risk assessment, etc.)
- **Biophysicochemistry of the food matrix** (molecular mechanisms of interactions in complex biochemical environments in dynamic conditions, matter and heat transfer in complex biochemical ecosystems in dynamic conditions);
- **sensoriality** (neurobiological perception mechanisms, etc.)

Conceptual and methodological developments for the bioeconomy

addressing questions raised requires the following in particular :

- to explore and characterise **continental and marine biodiversity** for development of bio-resources of interest; at various levels, from the gene to entire organism. All Clades are concerned, including fungi, non-arable microorganisms, algae and insects;
- to accelerate **varietal innovation, clone and strain** technologies (genome editing, genomic selection and recombination metabolism in connection with functional genomics, high-throughput phenotyping, systems biology to synthetic biology) on lines based on the objectives of suitability for uses or processing or sustainability of solutions in an integrated vision of the systems;
- to study, explore and model the **metabolic pathways of complex biomolecules** (proteins, polysaccharides, fat, plant and microbial polyphenols, lignin, etc.) and to explore mechanisms of expression and regulation
- to study and/or model the structure/function relationships of biomolecules (especially with regard to wood and plant walls);
- **Develop digital tools for representation**, monitoring and decision support of complex systems, taking into account, in particular, interconnections between sectors, cascading use (including waste), the resilience of systems, evaluation and risk management, objectivising choice (such as biomass-process-product adequation);
- **Modelling the functioning of markets** for bioresources at different scales by integrating usages' and common projects' substitutabilities.

Knowledge bases in social, economic and humanities in connection with the challenge's themes

The topics covered by Themes 3, 4, 5, 6 of Challenge 5 are mainly draw on all the humanities and economic and social sciences. Horizontally to themes and questions raised in the introduction, a number of theme areas require research concerning the following, in particular:

- **The behaviour of actors** and of socio-ecosystems towards innovations and risk, the role of representations in beliefs and behaviour: behavioural economics, social psychology, anthropology, sociology, history, (as well as individual and collective behaviour);
- **The bioeconomy and food systems**, across all value chains or specific components (production, processing, distribution, consumption and uses), taking into account their links to territories, markets and companies;
- **Socio-technical systems and bioeconomy, including food systems, their long-term temporal dynamics**, and the conditions and role of innovation in transition pathways;
- **Dynamics of collective mobilisation**, both for the management of an ecosystem or jointly exploited resources in a training, innovation and change dynamic;
- **Public policies**: for their design, implementation and evaluation, including experimentation processes;
- **interactions between firms and the workings of markets**: Dynamic and anticipated market stabilisation instruments, forms of organisation, etc.
- The integrated modelling of biotechnical and social sciences at different spatial scales.

Theme 2 - Animal biology, photosynthetic organisms and microorganisms Adaptation and input reduction

Ensuring food security and biomaterials supply (wood, fibres, etc.) for a growing population in a context of global changes whilst mitigating the impacts of agricultural, forestry and fisheries activities on the climate and environment requires the development of productive living organisms, contributing to the threefold economic, environmental, and social performance, adapting to changes, and promoting biodiversity. Research must aim to:

- characterise and structure **genetic resources**, select more efficient varieties and breeds for usage of inputs (fertilisers, pesticides, water, etc.) or food, limiting environmental impacts (soil degradation, salinity, deterioration of water or air quality, carbon balance);
- promote diversity within and between breeds in animals, including cross-breeding for better efficiency, better resistance to diseases, greater robustness, resilience to environmental change and limiting environmental impacts (reduction of waste, reduction of methane emissions.);
- **define the necessary mitigation or adaptation characters needed for living organisms exploited in response to long-term global trends;**
- explore the **biodiversity** of species, varieties, alternatives and associated microbiota breeds adapted to local conditions or specific socio-economic contexts;
- integrate **varieties and breeds with novel characteristics** (animal and vegetable protein, sugars, fat, metabolites) in renewed productive systems (agroforestry, new husbandry systems, agroecology, aquaculture, etc.);
- These organisms and genetic resources will contribute to the development of **new or alternative production models** that are more suited to local conditions and fall within an ethical and sustainable framework giving consideration to sustainability and animal welfare wherever appropriate.

In order to optimise agricultural transition processes, species, breeds and varieties should be maintained, developed and tested in farming systems. Projects should aim to:

- improve methods for the preservation and exploitation of **genetic resources**, including through the implementation of **genomics selection** programmes;
- implement **translational biology** to transfer the knowledge accumulated from model species to living organisms, to exploited species or other exploitable species (lifting of methodological and conceptual barriers, for example by comparative biology or functional analysis tools for the development of modern selection tools, especially including epigenetic effects);
- optimise the **methods** for **transforming genomes**, their expression and their selection (reproduction, clonal propagation, polyploidisation, apomixis, gene editing, GMOs, etc.);
- **make use of modelling for a more integrative and predictive biology**

Theme 3 - Ecosystem dynamics to improve their sustainable management (joint theme with challenge 1)

This theme aims at better understanding how global changes — in particular climate change — will interact with the future of land and marine ecosystems across the whole spectrum, from **natural systems or systems with low human activities to ecosystems of agricultural, forestry, fisheries or aquaculture importance.** It also aims to draw up management and adaptation strategies in a variety of economic, social and cultural contexts. Thus, the issues are the sustainable development and management of ecosystems and resources, the impact of management methods on the environment and ecological services, and the complementarity between productive and natural ecosystems for all ecosystem services (supply of resources, regulation of the environment, common property, etc.).

Adaptation and sustainable management of ecosystems

Expected research on this topic should aim at better understanding **the functions, development and resilience and adaptation capacity of land and marine ecosystems** in terms of the interaction between species and between trophic levels, their functional biodiversity and their contribution to the major cycles (C-N-P-S, water). It is also important to understand the interactions, complementarities and interfaces between the different types of ecosystems.

This research will provide an insight into ecosystem evolution, adaptation, resilience and the capacity of ecosystems to provide multiple ecosystem services. They will facilitate ecological transition and agri-environmental aid in the design or the re-engineering of production systems based on a better knowledge of biotic interactions and functional ecology in order improve their sustainability. The objectives are more resilient and better use of renewable resources, with impacts expected at different levels: an improvement of environmental quality (water, soils, air), a mobilisation of biodiversity, including genetic resources, maintaining its evolutionary momentum, integrated management of production systems in the territories, landscapes, coastal and offshore areas.

This concerns the management of resources and the maintenance of land and marine ecosystem services as well as transitions in agriculture, livestock breeding, forestry, fishing and aquaculture towards integrated and sustainable productive systems: sustainable forestry management plan, agroecology, ecosystem approach to fisheries, sustainable aquaculture, etc. Research shall aim to provide a better understanding of:

- **the adaptation dynamics of ecosystems** in the face of climate change (including extreme events, amplified seasonalities) and environmental change; the functional role of biodiversity; its contribution to stability, resistance and resilience of ecosystems and associated ecosystem services;
- **Interaction and Interfaces** between production systems and systems with little human involvement; positive interaction between species with a view to improving the performance of production ecosystems; interaction between ecosystem services;
- **Feedbacks** between changes in biodiversity and ecosystem functioning and alteration of local, regional and global climate;
- The responses of the living systems with multiple simultaneous and/or successive forcings to build realistic evolution and sustainable management of ecosystems scenarios;
- The **impacts of agro-ecosystems** and various fishing, aquaculture, and agricultural practices on environmental changes;
- The deterioration of marine and aquatic ecosystems with implications for fisheries resources.

Research shall also cover the necessary adaptation strategies for :

- **controlling the impact of production activities** on resources and environments, in particular on water resources and aquatic environments;
- **sustainable management of production ecosystems** on different spatial levels — from small plots of land to catchment areas: management and conservation of soils and their services, including in particular the functional role of organic matter, the integrated management of carbon, nitrogen, phosphorous and water cycles and the integrated and sustainable management of animal and plant health;
- **The integration of production systems**, land use, ecological infrastructure and protected areas to improve sustainability and performance.
- **carbon sequestration** in soil, which is a priority objective for the initiative (related to the "4 for 1000" initiative coordinated by France internationally).

Evolution trajectories of ecosystems: Strategies and policies for supporting transitions

The use of agro-ecological approaches to stimulate the transition of productive ecosystems towards greater sustainability involves the identification of innovative pathways and the implementation of a framework that encourages development through actions, strategies and policies. Research focusing in particular on the development and use of scenarios[32] with the ultimate goal of providing information to society and decision-makers for better targeting of management strategies and public policies, will be welcomed. Research should also stimulate the innovation process for ecosystems, territories and sectors. Supporting the transition towards more sustainable trajectories involves:

- developing integrated models that combines socioeconomic, biotechnical and ecological aspects, and creating scenarios to predict the development and adaptation of ecosystems in response to global change;
- identifying barriers and drivers for action to facilitate agroecological transition, on both a regional and a sectoral scale;
- gaining an understanding of the factors that influence actors' behaviours in the face of change, whilst taking into account biotechnical and socioeconomic factors;
- designing sustainable practices and integrated production systems in collaboration with stakeholders; analysing the learning processes of stakeholders having demonstrated innovation in their own right and designing new innovative pathways;
- development and assessment of public policies for supporting transitions; these assessments concern environmental performance and economic assessment, and social impacts, as well as the field of political science assessment. Designing and assessing public policies to include biodiversity protection measures combining conventional regulatory measures and incentive measures, and the integrated management of health risks via biomonitoring, biovigilance and biocontrol strategies.

2016/2017 international calls for proposals: ERA-NET Cofund LeapAgri (a long term EU-Africa Research and Innovation Partnership on food and nutrition security and sustainable agriculture).

International alignment concerning Generic Call 2017: Carbon sequestration in soils (TAP-SOIL)

[32] Research performed in this context is what provides the inputs for the group work of the Intergovernmental Panel on Climate Change (IPCC) and the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES).

Theme 4: Health-Environment- "One Health (joint theme with Challenges 1, 4, and 5)

This theme is common to Challenges 1, 4 and 5; projects submitted will be jointly evaluated. Theme 4 concerns the areas at the interface between these challenges or particularly transdisciplinary approaches.

The One Health concept postulates that the epidemiological dynamics and actors' incentives, which determine the health of human and animal populations should be studied in their microbial, ecological, socio-economic and political contexts at the interface of human, animal and ecosystem health. The 'One Health' approach provides a functional work environment for integrated and interdisciplinary exploration of: 1) the effects of environmental factors on living species and on human health, 2) the position of the environment among the various determinants of health, 3) the impact of multiple determinants on rare diseases, health and healthcare systems. They are supported by the exposome concept and involve a coherent analysis of emerging risks.

The study of how environmental factors affect living species or human health and the role of the environment among the various factors influencing health should focus on the impact of physical, chemical and biological contaminants by taking into account the various environments and levels of exposure. It should also encompass interactions between the environment, animal health and human health, and the role of the environment in the mechanisms of emergence and re-emergence diseases (ecology of health).

The issues at stake include the quest for a better understanding of phenomena and mechanisms, the assessment of risks, and proposals for appropriate monitoring methods, counter measures and policies. Cooperation is therefore expected between the different disciplines of biological and medical sciences, environment and ecology, physical, chemical, mathematics and modelling, social sciences and humanities...

Three priorities will be considered:

Environmental toxicology.

In environmental toxicology, the encouraged approaches are pathways or networks of toxicity, systems biology, epigenetics and those targeting vulnerable stages in the life cycle of individuals, transgenerational effects, effects of mixtures in particular in low doses, or key life-history traits for population dynamics in the environment. Particular emphasis will be placed on emerging contaminants and endocrine disruptors.

Contaminants, ecosystems and health[33]

This sub-section focuses on the study of transfer and toxicity of contaminants, their metabolites and transformation products, ecosystems, the health of human populations and the link between work and health.

Multidisciplinary approaches are expected to: 1) explore the concept of exposome, interactions between different contaminants and their possible cumulative effects; 2) model the transfers of contaminants in different media and networks and their repercussions in human and animal food chains, and their impacts on ecosystems and their component parts; 3) characterise emerging risks and establish adequate systems of supervision, and analyse the social risk assessment, debates and decision-making; 4) improve predictive capabilities through systemic approaches; 5) analyse the relationships between environmental change and chronic non-communicable and/or allergic illness; 6) include environmental, economic and social factors which determine or modulate exposures and vulnerabilities of human populations, the mobilisation of social partners; 7) develop remedial approaches.

[33] This sub-theme is part of the research priorities defined in IFRES (French Environment and Health Research Initiative) coordinated by the group "Inter-Alliances Allenvi-Aviesan-Athena".

Environment, pathogens and emerging or re-emerging infectious diseases

This priority focuses on the dissemination of pathogens and infectious diseases emergence mechanisms (human, plant or animal, including zoonoses) which can be conditioned by environmental factors (climate, biodiversity, land and resource use, etc.) in synergy with anthropogenic factors (agriculture, livestock, industry, urbanisation, mobility, demographic change, globalisation, social practices, etc.). It also concerns resistance to antibiotics, anti-parasitic, antifungal, insecticides, and biocides. Various pathogens are included (e.g. parasites, fungi, algae, bacteria, viruses and pathogens, non-conventional) as well as their products.

The objective is to support multidisciplinary research taking into account said pathogens' social and environmental dimensions with a view to preparation for epidemic or pandemic risk, but also prevention and proactive measures, and to fight against antibiotic resistance and biocides generally. Particular attention will be paid to neglected infectious diseases within the meaning of the WHO.

Integrated and multidisciplinary approaches are expected on: 1) pathogenic agents, their ecological niches (basins and arthropod vectors), their persistence and development, spatial and temporal dynamics of transmission and the fate of pathogens in ecosystems; 2) risk assessment of inter-species transfer of pathogens; 3) the study of the relationship between pathogens, and mechanisms of interactions between the different virulence determinants, and the dissemination of pathogens; 4) modelling parameters of emergence, distribution, exhibition or disposal (including through retrospective analyses and predictive ecology scenarios). The establishment of databases, geographical, environmental and climactic, biological, social, economic, demographic, epidemiological, clinical and health, which could contribute to the definition of indicators for a predictive approach evolving epidemics in health monitoring; 5) the control or monitoring methods compatible with human health and the environment: treatment, vaccination, surveillance, prevention policies, vector control or biological, emergency management...; 6) the multi- bacterial resistance or parasitic to characterise the molecular and environmental factors involved in expanding towards multi-resistance. Other possible topics include: the impact of the host and its microbiota in the development of resistance to antibiotics in a pathological context; microbiota dynamics in normal and pathological conditions; the role of epistasia in the development of multi-resistances to anti-infectives and identifying at-risk areas and populations (eco-epidemiological approach);7) the perception and behaviour of different actors towards risk, the alert, information and prevention, treatment and control strategies. The arrangements for design, formulation, implementation and evaluation of different policies and measures will also be studied.

International initiatives: *Certain projects under JPI-AMR (antimicrobial resistance) will be integrated with this theme in addition to certain IMI2 programme themes.*

Theme 5 — Diet, healthy and sustainable food systems, global food security

Food, healthy and sustainable food systems, world food security, food systems at all levels, local, regional, national or international or whether they involve Western, emerging or developing countries — are facing global changes that question their sustainability. The aim of a more sustainable food system is to meet increasing food demand by developing effective production systems that use less natural resources, have a lower impact on the environment and on biodiversity, reduce losses and waste and promote waste recycling and a smaller carbon footprint. Food products should also **meet the health, nutrition, cultural, ethical needs and pleasure expectations of consumers**, **be accessible to all and favour health and well-being**. Lastly, the development of a sustainable food system is based on a resilient economic system that creates employment, shares value fairly between stakeholders and encourages national and regional development. It is also supported by public policies adapted.

Achieving these objectives requires changes in food systems, which in turn involves a change in practices, technologies and policies and which must be based on a better understanding of the underlying mechanisms of global food security on various levels. This theme addresses all the above dimensions related to food systems. Integrated approaches relating to the bioeconomy are addressed in theme 6.

Changes in technology, processes, behaviours and policies for healthy and sustainable food

This should cover **all practices**, from the **production and processing** of agricultural raw materials and water to **manufacture and distribution**, to **food consumption behaviour**. Food production companies should take into account the combined economic, social and ecological dimensions and produce food of a controlled quality (in terms of safety, sensory, nutritional and functional value) in an economic climate of increased competition, trade globalisation, raw material variability and price volatility. Opening up avenues of innovations is indispensable if undertakings are to meet the requirements of sustainable food systems. In addition, drivers for efficient public policies should be identified and proposed so as to facilitate consumer choices and behaviours in relation to sustainable food.

Research shall therefore focus on the structure of the food supply chain, in particular the food transformation stages (primary and secondary) and food formulation and conservation, and also on the analysis of consumer behaviour and the impact of behaviour on health and the environment, and on public policy implementation methods and enterprises' strategies.

Research in the form of multidisciplinary approaches on the following themes is particularly encouraged:

- **Innovative technologies and processes in food production**: process flexibility in line with the variability of raw materials; online operation and management; automation and robotisation of operations and biomechanical techniques to improve performance and reduce musculoskeletal disorders; cost control; tools for expert assessment and knowledge capitalisation.
- **Optimising raw materials and resources on an industrial scale**: exploiting biodiversity, reducing loss and consumption (water, energy, raw materials, packaging, etc.); Eco-design of production processes; environmentally friendly packaging that is active, functional, smart and user- friendly (ICTs, sensors, etc.); life cycle optimisation; by-product and waste recovery (circular economy).
- **Safety of the food chain**: pathogenic organisms (bacteria, viruses, parasites) and spoilage organisms; hazards (chemical and immunochemical neoformed compounds, contaminants, allergens); methods for hazard and risk assessment on an industrial or sectorial scale; improvements in food shelf life.
- **Interactions between food, microbiota and the food chain**: the control of food microbiota accompanying food processing will be sought in particular for the properties passed on to foods by microbiota introduced via food enzymes, and via the gut microbiome and its dynamics;

- **Social, cultural, economic and sensory determinants of food preferences, consumption practices and physical activities** aiming to facilitate a healthier and/or more environmentally friendly lifestyle. Priority shall be given to field experiments. Projects are encouraged which address how public policies operate to support these lifestyle changes.
- **Foods and diets for preventive nutrition**: Priority shall be given to projects relating to the elderly, new-borns, infants and vulnerable populations. Priority shall also be given to integrative biology approaches and projects focusing on multiple feeding-related determinants (safety, nutritional, sensory, social and economic).
- **Industrial strategies**: from competition and complementarity between the food industry, agro-industry and retailing; industrial strategies responding to public policies and regulations.
- **Social and economic organisation of food systems**: the capacity of sectors to integrate new qualitative constraints and generate productivity gains; regional dynamics and organisation of food systems; The sharing of value between sector actors; resilience and resistance to economic shocks in safety; impact analysis and drivers for public policies targeting food system actors (enterprises, consumers, and new actors etc.).

Global food security

Food security covers the four key dimensions set out by the FAO: (i) agricultural and food availability, both in qualitative and quantitative terms; (ii) food use and the nutritional status of populations; (iii) access to food in relation to vulnerability and poverty problems; (iv) stability of availability and access to food in a context of price and market uncertainties. An additional dimension should be added relating to food security policies and governance. These dimensions should now be (re)examined in the light of current global change (climate change, depletion of non-renewable natural resources, degradation of renewable natural resources, demographic change, energy transition, nutritional, socio-political, economic growth and increasing transition inequalities, etc.). Given that proposals can be viewed in a worldwide perspective or include the non-European or European contexts of emerging or developing countries, research shall concern in particular:

- **Quantitative/qualitative balance** between food demand and supply: modelling that includes the effects of global change at all levels on agricultural productivity and on the adaptation of production systems and technologies, taking into account land-use competition as well as the effects of nutritional transitions, the strategies of industrial organisations and public policies, urbanisation processes, risks and hazards (environmental, including climatic risks, agricultural market instability);
- **Public policies and governance of food security**: construction of public action, policies and instruments promoting food security governance at the different levels; organisations and food safety (regional or international); conditions for the emergence of food security policies; investments in the organisation of public or private markets and infrastructure;
- **the determinants of food access**: household food strategies, the links between activities, incomes and food access, food security in a climate of economic and political insecurity; the dietary situation and nutritional status of poor and/or vulnerable populations; innovative forms of organisation that facilitate supply security; local marketing circuits between farmers and consumers;
- **food transitions**: changes in the dietary patterns of populations as a result of changes in lifestyle, including economic growth, migration, urbanisation; impact of changes in food product supply, product characteristics and enterprise strategies on dietary patterns; health-related economic, social, and environmental impacts of nutritional transitions; public policy instruments that limit the detrimental effects of food transitions and that are adapted to economic, social and cultural contexts.

2016/2017 international calls for proposals: *ERA-NET-Cofund SUSFOOD 2:* Sustainable food production and consumption; JPI initiatives HDHL (healthy diet for healthy life).

Theme 6 - Bioeconomy: specific technologies and systemic approaches

The European Union defines the bioeconomy as “the sustainable production of renewable biological resources and their conversion, as well as food waste for humans or livestock, such as bio-based products including bioplastics, biofuels and energy. The bioeconomy encompasses the sectors of agriculture, forestry, fisheries, food, and pulp and paper. The SNR stresses that the challenge of developing the bioeconomy is addressing the scarcity of certain non-renewable natural resources, with the objective of more sustainable and environmentally friendly production.

This theme does not cover the very broad scope of these definitions; some topics are touched upon in other themes of the challenge (sustainable production methods under constraints, human diet, economic valuation of ecosystem services, etc.), it is more specifically open to **cross-cutting and/or systemic approaches**.

Challenges specific to the bioeconomy, and methods and technologies specifically or primarily related to this field, biotechnology and transformation processes, including in bio-refineries.

This theme includes **all bioresources** (cultivated, harvested, livestock, forestry, and waste) in **marine and continental** systems.

Research can make use of tools for modelling complex systems. Projects may explore the environmental, economic and social dimensions of planned developments, or incorporate two different levels of the value chain (production, primary processing, further processing, uses, cascading uses, closing cycles) and encompass all types of knowledge. Multidisciplinary projects are encouraged.

The production and mobilisation of bioresources

The scope of research encompasses, in particular:

- The design of **sustainable cultivation systems constrained by the use** of bio-resources (e.g. challenges of improving productivity in molecules of interest and reduction or elimination of undesirable secondary metabolites);
- **varietal selection** and development of economically, environmentally and socially efficient technical itineraries according to the principles of agroecology for new bioresources (including non-food crops, micro and macroalgae, insects, new tree species, phytoremediation, etc.); ;
- **Recovery of marginal or degraded areas**, change of use of agricultural lands and territories through the exploitation of new or traditional bioresources
- **modelling on the territory scale** of the availability of constrained bioresources (economic, environmental, economic and qualitative usage conflicts, etc.)
- The impact of the **energy transition** on primary production.

Transforming bioresources (including biorefineries)

Research projects may concern all bioresources, in particular new plant or animal proteins (food), and all insect biomolecules in food and non-food industries (bioactive products for animal or plant health, bio-based materials, platform molecules, etc.). Research topics shall include:

- the knowledge management of **adaptation measures to heterogeneity** (volumes, specifications, price.) of bio-resources and robustness of processes;
- **optimisation** (efficiency, effectiveness, sustainability, economic performance) **technologies and bioresource transformation processes**, including the development of sensors and monitoring instruments for processes, improving and diversifying extraction, fractionation, purification and functionalisation techniques, changes of scale (downscaling, including processing and biorefineries on the farm);

- the development, optimisation and **predictive modelling** of biosynthetic pathways of bioengineering (in vitro bioreactors, enzymatic processes in unconventional settings, couplings, metabolic engineering processes) for the production of molecules of interest.

Projects involving the two-step production and processing are expected, in order to shed light on:

- **robustness of the bioeconomy** depending on the energy source involved in systems of production and processing;
- the description and optimisation of cascades use (including the development of alternative uses of by-products and waste);
- **Securing/stabilisation of supplies** in their quantitative, qualitative, economic, technical and legal aspects, in terms of optimisation of logistic chains and organising collection and storage, etc.
- The **traceability of bioresources** in quantitative and qualitative terms, in particular for fractionation products.

The externalities of the bioeconomy, through the systematic inclusion of a "business as usual" model

The assessment of the social and environmental impact of developing the bioeconomy raises numerous methodological issues. Consideration must be given to:

- improving **tools for assessing and monitoring the environmental performanc**e of the bioeconomy and its different sectors (LCA, Ecology territorial model PEF, taking account of direct and indirect land-use changes, etc.);
- developing **methodologies to assess the social performance** of bioeconomic models, including the transition process;
- to examine the robustness of these methods in light of changes in the evaluation scale;
- to develop the **integration of environmental assessments with social and economic data;**
- to develop **methods of compilation and comparison of scenarios** for foresight and decision-making.

Levers for developing the bioeconomy:

Encouraging economic development implies working on:

- **The conditions for deploying the bioeconomy** throughout different regions, supporting reconversions related to external bioeconomy drivers (climate, etc.) or internal (food transitions, new sectors);
- **The role of local public policies**, particularly in terms of urban development planning/design of networks, green infrastructures, etc.), coordination of economic and social programming, training/interpretation policies, etc.
- **Legal brakes and levers** (examples: waste production, new marine bioresources) and societal (including the acceptability of regulations), especially in transition paths;
- **Incentive measures** (tax, insurance, organisational, financial bonus/malus) or market (labelling, certification, etc.), their effectiveness and their social and ethical issues;
- **the technical, organisational and economic conditions for the adoption of innovations** by economic actors, in particular cost-benefit analysis and the management of uncertainty and risks (health, environmental, economic.);

- **the public and private decision-making process** encouraging the integration of production/processing/company within a territory (including the management of positive and negative externalities); the identification and articulation of the administrative and geographical scales according to relevant issues (food security, inserting new cultures, biodiversity, supply biorefineries, involvement of stakeholders, multi-criteria analysis, identification of marginal land cultivation.);
- Coordination between new value chains and existing channels (culture, dialogue, logistics, exchange of information, industrial property); modelling of micro/macro coordination;
- The ethical and legal approach to the concept of a public/private property for the design or redesign of bioeconomy systems;
- Innovative forms of governance of sectors (including questions of shared value) and dialogue with society;
- decision support tools and analysis for public policies and industrial strategies.

International calls 2016/2017: *ERA-NET Cofund in biotechnology CoBioTech: Biotechnology for sustainable bio-based economy*

Challenge 6 : Mobility and sustainable urban systems

EUROPEAN AND INTERNATIONAL COOPERATION

The 2016/2017 topics prioritised for international backing are detailed below and also listed in annexes 1 and 2 of Work Programme 2017. Lists are subject to change, applicants who wish to conduct their projects at the European or international level should regularly consult the ANR website for more information on these partnerships and calls for proposals: http://www.agence-nationale-recherche.fr.

The following calls are particularly concerned by this challenge: ERA-NET Sustainable urbanisation (SU-ENGI), launched as part of JPI Urban Europe, which complements the national activities under Theme 1 of this challenge

INTERFACES

This challenge involves cross-cutting research topics relating to more than one challenge. *The other challenge(s) to which these topics relates is (are) indicated below, so that applicants may orient themselves towards the most appropriate challenge for their project. Applicants are strongly advised to read each related challenge in its entirety to gain a thorough understanding of its specific scope.*

For topics concerning cross-cutting theme areas, most of which fall within the scope of several challenges (including **Challenge 6**), readers should refer to the paragraph entitled "**Multidisciplinarity, cross-over and interfaces**" (pages 39-42) which covers the following fields: ***Big Data, Robotics, Sensors, Biology, Bioeconomics & Biotechnology.***

The following fields are also interfaced with Challenge 6:

In general, projects that mainly focus on the specifically urban aspects of an outcome (adaptation to climate change, urban agriculture, etc.) should be submitted under **Challenge 6**. Projects that do not specifically address urban aspects should be submitted under the challenge that covers the other research topic; for example, the development of an environmental technology not specifically related to the urban sector would fall within the scope of **Challenge 1**.

Research dedicated to the design, manufacture and study of physical and mechanical properties of materials for buildings or transport vehicles are dealt with in **Challenge 3**, taking into account the precise specifications for transport or building applications; the only projects that fall under **Challenge 6** are those focused on integration issues of these materials in transportation systems and buildings;

Research on batteries, charging infrastructure, fuel cells and on-board hydrogen storage, low- power electronics and high-efficiency electric machinery is covered in **Challenge 2**, taking into account the specific technical specifications for transport applications; projects concerning the integration of these technologies into vehicles come under **Challenge 6**.

Technical approaches to smart grids are addressed in **Challenge 2**, but the impact of their use on urban and transport systems falls within the scope of **Challenge 6**.

Projects that focus on the automation of vehicles for passenger and/or goods transport come under **Challenge 6**.

Projects concerning the development and use of powertrains for all modes of transportation fall under **Challenge 6.** Health issues are primarily handled in Challenges 4 and 8 but issues of exposure fall within Challenge 6 ;

Introduction

The scope and content of this challenge's themes are particularly focused on the work carried out for the French National Research Strategy's (SNR) "Mobilities and sustainable urban systems" working group, as well as input and remarks from the ANCRE and AllEnvi alliances. The four SNR priority areas that concern Challenge 6 of WP 2017 are as follows: i) Urban observatories, ii) New conceptions of mobility, iii) Tools and technologies for sustainable cities, iv) The integration and resilience of infrastructures and urban networks. Challenge 6 of ANR's 2016 WP is also concerned by at least five other priority areas (assessment and control of climate and environmental risk, eco- and biotechnologies to support the ecological transition, energy efficiency, fifth generation of network infrastructures and human-machine cooperation). Challenge 6 of WP 2017 also contributes to the five SNR action programmes needing to be addressed as a matter of urgency: i) exponential growth in the volume of digital data and how to exploit this data, (ii) the key role of science and innovation in climate risk analysis and management, (iii) the revolution in our understanding of the living world, (iv) the need to develop innovative, effective healthcare, (v) the importance of knowledge about cultures and humankind.

Expected research under Challenge 6 should explore ways in which urban systems, transport, housing and their users are adapting to the need for sustainable development. The challenge particularly seeks integrated and systemic approaches enabling the interpretation of societal and environmental processes in their interactions. Mobility, habitat and more generally coexistence must be weighed against environmental pressures as well as ecosystem services, reduction of nuisance factors and global changes. Research should, whilst taking into account vulnerabilities and potential inequality, assess and improve the performance of buildings and transportation, as well as the organisation of urban systems promoting smooth, effective access to resources and services. Particular emphasis is given to advancing the digital society in order to support, develop and promote the use of sustainable transport and manage smarter cities while promoting sustainability and the adaptation of infrastructures and networks to meet the needs of existing and emerging economies. Governance procedures and the development of public policies that play a role in the management, development and promotion of urban systems must be analysed in light of said objectives.

Research work developed in this framework must meet several scientific goals:

- Constitute new bodies of knowledge focused on energy efficiency, environmental impact and usability, for components (vehicles, buildings, etc.) and buildings on different scales, examining the interactions between these criteria and scales;
- Develop the modelling of phenomena and data management to back design, decision-making, and performance assessments.
- Exploring how digital technologies can cause changes to mobility, housing and urban systems as well as user behaviour;
- Assist in developing a palette of methods and technologies useful for designing, building, restoring and adapting to new energy and environmental requirements, but also more efficiently managing the existing heritage and the various components of urban and transport systems by actively involving users.
- take part in discussions and development of innovative planning: *Nature-based solutions, integrated cities*...

Theme 1: Fundamental knowledge, exploratory research and groundbreaking concepts.

Theme one, cutting across other themes, aims to produce **fundamental knowledge of use to the challenge** or enable the exploration **of radically new ideas and approaches and concepts breaking away from** more incremental research.

Basic or upstream research are indeed necessary to aid in the constitution of a knowledge base to serve as a reference point for preparing future technologies.

For example, contributions are sought:

- on conceptual approaches (sustainable cities concept, urban theory models, etc.)
- in sociology of socio-technical systems and dynamics of change
- in systems theory and optimisation
- in applied mathematics, advanced modelling, algorithmics, high-performance computing, and exploitation of big data
- in methods, tools and technologies for data collecting, exploration and mapping of urban and regional data
- adopting a variety of biomimetic or bio-inspired approaches, both for the development of new products as for the modelling of the urban metabolism and its environmental and energy footprint, or mobility management.
- on the interdisciplinary integration between the humanities and social sciences, engineering and the environment

For projects submitted under this theme, it is expected that research subjects, applications or purposes (even in the long term) be positioned in relation to at least one of the following themes and indicate how they can contribute on the issues described below.

The theme also aims to attract new communities and encourage new partnerships.

Theme 2: Sustainable cities and territories

The city is a complex, integrated system; acting more effectively on this system demands both targeted work on identified knowledge gaps and transdisciplinary and multi-sectorial integrated approaches to better improve understanding of its dynamic and action levers at different temporal and spatial scales. This challenge is in line with SNR priority 22 — Urban observatories.

Socio-spatial approaches to sustainability (mobility, development, practices)

Urban dynamics, **transitions** and interaction between short/long term and between local/global scales are still poorly understood, despite their key role in urban sustainability. The aim here is to improve our understanding of **the development factors affecting towns and cities** (growth, declining economic and social attractiveness, etc.), which can either consolidate however weaken urban systems and can also help boost the links between large cities, towns and areas of low density, raising the question of the location of people and economic activities (city centres, suburbs, rural areas, small or large conurbations, etc.). In this dynamic perspective, one should revisit the links between **urban forms, the organisation of urban fabric, the location of activities, transport and infrastructure services, mobility and environmental impact**. Research should inform the debates on **densification**, **compactness**, functional, social and generational **diversity**, **multipolarity**, etc., for the development of urban sustainability. With regard to phenomena for which the spatial scales and time scales are consequential and interlinked, the methodological challenge is a steep one. Even if modelling proves to be a promising path to develop, other methods (scenarios, international comparisons...) should still be developed or revisited.

The **practices of urban dwellers** are gradually changing, influenced in particular by **environmental issues** and the **appropriation of digital technology**. Other factors, such as economic crises are also contributing to these changes. However, gaps and inconsistencies persist even between more environmentally-centred perceptions and practices that are still often remain resource intensive. This is true for mobility practices, which are linked to housing choices, strategies for the siting of economic activities, and the configuration of transport networks. Identifying, understanding and managing the inherent tensions in the introduction of sustainable approaches to mobility, habitats, the use of public spaces, etc. constitute a research field in their own right.

Responding to questions of **well-being** and **quality of life**, research on urban sustainability calls upon a cross-section of research on changing urban lifestyles and the changing relationship between societies and their environment. It involves intersecting contributions from ecology, geography, history, sociology, psychology, anthropology, economics, law and political science.

Quality of the urban environment, ecosystemic services and optimising the use of urban resources

Towns and cities consume vast quantities of materials, food products and energy, some of which is released in the form of emissions into water, air and soil. It is becoming crucial to gain a better understanding of the processes involved in this **urban metabolism**. The underlying issues not only involve understanding, managing and controlling how towns and cities function, how they **interact with the biosphere** and their **effects on the environment and humans** (pollution, noise, conflicts over the use of space, etc.), as well as raise questions about future planning and action — closed-loop flows, symbiosis between urban, agricultural and industrial processes, short supply chains, urban sobriety, etc.

Issues of **urban environmental quality,** and those in connection with the health and welfare of people in particular, demand an adequate characterisation of people's multi-exposures to different types of **pollution** and **disturbances** (particles, noise, smells, dust, degraded landscapes), in all of the city's compartments (open, restricted, such as housing, urban transport.) — and their consequences.

Quality of life and environmental quality aspects must be tested in conjunction with technical developments, particularly in the field of energy.

Although we are starting to see improvements in our understanding of some of the roles played by **nature in towns and cities**, research to produce new knowledge on the workings of **biodiversity** and **urban social ecosystems**, including urban agriculture, is needed to form a solid basis for **urban ecological engineering**. These socialised, artificialised, 'natural' ecosystems provide a wide range of services, including provisioning, regulation and services of a social nature, amenities, and mitigation of environmental disturbances. It is becoming vital to develop ways of **assessing these ecosystem services**, in conjunction with the question of land use (assessment, environmental and social audits, contributing to adaptation to climate change, air and noise pollution, etc). It is also important to assess the balance between species, expected services related to ecosystems in question.

Finally, research will inform the relationship of double causality between the functioning and quality of urban ecosystems and **human well-being**. Three fields of investigation are to be considered: the value of non-market goods and services and their monetary appraisal, the role of quality and access to information in the value attributed to ecosystem goods and services by society; the social acceptability and participatory devices used in sustainable urban governance. In this respect, it will evaluate in particular the potential of resilience involved in maintaining a certain biodiversity both for the environment and the general quality of the ecosystem, and economic activity and human well-being. In this perspective, the resilience potential involved in maintaining a certain biodiversity both for the environment and the general quality of the ecosystem, as well as economic activity and human well-being may be assessed.

Research carried out may lead researchers to consider the relevance of human development indicators and their functionality.

The vulnerabilities and resilience of urban systems

Issues of urban **vulnerability** to sudden events (floods, effects of a heat wave, riots, etc.) or to gradual changes (slow impacts of climate change, an ageing population) and resilience need to be tackled in a systemic way. Research must first identify, describe and quantify the fragility of urban systems and develop approaches for assessing their overall vulnerability. One key outcome, in terms of both knowledge and operational requirements, is the development of resilience and adaptation strategies.

The issue of vulnerability and the resilience of urban systems shall take into account land and space use, their traditions and inertia, adaptability and reversibility capabilities, current and future conflicts over use (anthropisation, agricultural production versus the preservation of biodiversity...).

Attention will also be given to factors involving vulnerability, resilience of **economic dynamism, attractiveness** of urban systems and more generally of regions: type and range of activities, exposure to risks and dependence, promotion of a circular economy, hosting and accommodation of new businesses, tourism and cultural policy, etc.

Theme 3: Sustainable construction

This theme is concerned with SNR priority 24 — tools and technologies for sustainable cities.

From low-carbon buildings to complexes with low environmental impact

Targets for improving **energy efficiency in building stock** are extremely ambitious. However, research is still required on the appropriate spatial and temporal scales for "**positive energy**". **Building complexes** are a potential scale for integration that should be investigated in this respect.

At the same time, regulations in the building sector are set to replace obligations of means with obligations of results. Although this exchange should offer greater freedom of choice and encourage technical and architectural innovation, it will also require the development of methodologies and instruments for **physical measurement** (energy audits and performance monitoring). Several tools and **models for building design** are based on theories that undermine the new energy performance targets, particularly because previously neglected secondary phenomena are acquiring importance in this new context. It is important to review these tools for design, construction and renovation (digital mock-ups). They should address not only energy but also also issues related to health (air quality, noise etc.), comfort (multiphysics approaches, acoustics, lighting) and interactions and feedback mechanisms between technical systems and users. This will require a better understanding of **usability and use-values behaviours**, via a closer dialogue between social sciences and humanities and engineering, which will enable more accurate predictions to be made about buildings' actual performance. The aim is also to design building complexes that can be more easily appropriated and that are more robust in terms of performance when used for a wide range of purposes, firstly taking into account the habits and values of users. Finally, another important research field is **economic models** and the methods that should be used to encourage the dissemination and uptake of these innovations by both stakeholders in the building industry and users, particularly for the renewal sector.

Civil engineering, construction and sustainable management of built heritage and infrastructures

Moving beyond strictly energy-related issues, the **overall sustainability of built heritage** (buildings and infrastructures) remains a major challenge for sustainable development. The primary concern should be to improve knowledge about **ageing** mechanisms, performance losses and **risk of failure** of this heritage, as well as to suggest tools and methods for **monitoring, inspection, sizing and modelling**. New thought needs to be given to **construction, maintenance, planning**, inspection and management, prevention and protection against natural hazards, the materials that should be used, technologies for low-cost, high-performance **renovation/re-engineering** and high performance low-cost technologies, methods and tools unique to geotechnical engineering, techniques for intervention in buildings, transport infrastructures and networks, while keeping downtime to a minimum and factoring in possible resource variability over time, the potential impact of climate change and the entire life cycle.

Research is also encouraged to develop and structure data, methods and digital tools made for design, construction, the efficient and sustainable operation and maintenance of built heritage.

Special attention should be paid to the preservation and enhancement of cultural heritage cities, a source of differentiation and attractiveness.

Theme 4: Clean, safe, connected, and automated vehicles

This theme is in line with SNR priority 23 — new concepts of mobility.

Energy efficiency of vehicles: powertrains and general approaches

Reducing the environmental impact of transport is largely dependent on overcoming the scientific and technological hurdles that are preventing the widespread pillar introduction of vehicles (for private or commercial use or mass transportation) with low greenhouse gas emissions and local pollutants. This development will require **research efforts focused on high-efficiency powertrains with low emissions of pollutants**[34], pollution control systems, the use of **fuels emitting lower levels of greenhouse gases** than hydrocarbons from petroleum (including biofuels, gaseous fuels with high H/C ratio and hydrogen) in internal combustion engines, **vehicle connectors and hybridisation**, thermo-management, energy recovery and **on-board energy management** making use of opportunities offered by connectivity. Researchers must consider more comprehensive approaches such as **reducing vehicles' weight**[35] and improving their **aerodynamics** or **architecture** (especially for heavy vehicles), and more groundbreaking improvements generally.

Security, safety and adaptation of vehicles

Improving **road safety** (reducing the number and severity of accidents and their consequences) is an important issue. This will mean developing new types of vehicle better suited to demands and that are more **ergonomic** and **accessible**, stepping up the integration of technologies for passive and active vehicle safety. But knowledge in **accidentology** must also be expanded in order to craft more effective public policies in this field. Some issues should be further developed: the impacts of an ageing population, vulnerable road users, powered two-wheelers, driving distractions, the emergence of new means of transportation... The specificity of road safety in cities is to be taken into account in a new context marked by increase of "soft traffic", the diversification of modes of mobility and the increased complexity of managing public urban spaces.

[34] Projects which focus on combustion with essentially transport applications must be submitted within Challenge 6 and not another challenge.

[35] projects which focus on the design, manufacturing or study of materials' physical or Mechanical properties must be submitted under Challenge 3.

Driving aids, automation, connectivity and reliability

The development of **driving aids** and systems for communicating between vehicles and infrastructure, to the development of fully **automatic vehicles** fits in the context of improving **transportation efficiency** and safety (by road, rail, inland waterway, sea, air).

These developments can only have a real impact if the expectations and behaviours of users and drivers, together with vehicle usage constraints and interactions between varyingly automated vehicles and people (users and pedestrians alike), are taken into consideration. Interdisciplinary approaches between the humanities and the social sciences, psychology, sociology) and engineering sciences (ergonomics, robotics) are particularly encouraged under this theme.

Finally, the **reliability of built-in vehicle systems**, including electronics and information and communication technologies, must also be strengthened.

Theme 5: Networks and services

This outcome is in line with SNR priority 25 — the integration and resilience of infrastructures and urban networks.

Networks and services for transporting persons and goods

Research should contribute to rethinking **transport systems** as a whole, to make them more efficient as well as better suited to the mobility needs of people and goods. This should be based on information technologies, organising services that foster cooperation, pooling, multimodality and interoperability (particularly with the last mile), with optimised exploitation of transport infrastructure on real-time management of traffic and the organisation and involvement of transport operators. Though the user-client must be at the centre of concerns, it is also important for researchers to question the notion of need for mobility and how to strike a balance between supply and demand within financial limitations and adapt to economic and social contexts.

In such a general interest context, research must assess new combinations of **regulatory** measures, involving in particular, economics and psychology (“nudges”) able to optimise mobility for both passenger and freight transport. This means focusing on **behavioural patterns** as well as the **location** of households and activities. The aim is to reduce congestion in networks and environmental damage (noise, pollution, greenhouse gases, odours). The development and evaluation of **new services** based on a proper understanding of the dynamics of both developments in the mobility of persons in supplying households and companies must also contribute to these objectives: shared vehicles, service vehicles, soft modes... In the supply chains field, one cannot fail to notice the potentially significant gains in terms of resilience that the full implementation of **the physical internet** concept would create (based on the principle of creating a network of **logistics services** networks).

Resilient, fit-for-need urban networks and services

Towns and cities work on the basis of a pooling of networked **urban services** (sanitation, water, energy, waste, etc.). In addition to tools (inspection, maintenance and repair strategies, etc.) required for the ongoing sustainability of these **established networks**, attention should be paid to the development of these services and the production of new services that are better tailored to new constraints (energy efficiency, limited budgets, etc.) and emerging requirements (an ageing population, regional inequalities, etc.), and which take advantage of the development of information and communication technologies. Research should underpin the development of innovations in **urban engineering** that strengthen the resilience and **adaptive capacity** (or even reversibility) of networks, buildings and infrastructure to meet the needs of future generations and respond to a changing environment, particularly by adopting design/management approaches that are guided by use. Solutions that deliver continuous service, **even in degraded mode**, should be envisaged. Synergies and **inter-network** pooling, tailored to local conditions, and reduced multi-scale solutions should also be explored.

Smart cities, new uses and innovative services

Information technologies and communication have been increasing the efficiency and productivity of urban services for quite some time. The **smart city** concept goes one step further by contemplating these services through different organisational models that are more evenly distributed and immediate due to a greater digitisation of the technologies and networks producing and supplying these services. Considerable changes could be made with regard to implementation, exploitation, economics, engineering and logistics and more broadly speaking, regulation, behaviours, and governance. Major innovations are expected from such developments. For example, they could constitute key enablers in the transition toward more energy-efficient urban activities.

In addition, information and communication technologies enable the emergence of **new services**, e.g. in fields based on carrying goods and mobility of individuals, creating new channels for public information and action, possibly spurring them to help provide new services (collaborative economy) and changing their practices in many areas (consumption, mobility, participation in governance, etc.).

Truly multidisciplinary research issues identifying the impacts of a shift towards '**digital' cities** on the **practices** of urban dwellers and **urban metabolism** are expected.

Challenge 7 : Information and communication society

EUROPEAN AND INTERNATIONAL COLLABORATIONS

Challenge 7 is part of a dynamic for building the European research area and opening the French research at international level. *Research teams are invited to submit of international projects in the context of the Generic Call for Proposals (PRCI instrument) or international actions specific to the challenge.*

In order to facilitate the preparation of international proposals, a list of those actions planned or considered is given below and in annexes 1 and 2 of the present work programme. Since this list might evolve, researchers and interested parties are advised to consult the ANR website (menu "your project" / "ongoing calls for proposals").

• ERA-NET CHIST-ERA II (www.chistera.eu): European Coordinated Research on Long-term Challenges in Information and Communication Sciences & Technologies ERA-NET. A transnational call on two topics, "Lifelong Learning for Intelligent Systems" and "Visual Analytics for Decision Making under Uncertainty", is scheduled for publication in October 2016.

• ERA-NET FLAG-ERA (www.flagera.eu): The FET flagship ERA-NET. Partnership-based proposasl or those which may result in a partnership under one of the two FET Flagships — the Graphene Flagship and the Human Brain Project (HBP) — are invited to mention it via the submission interface. Partnership arrangements for both flagships can be found on their respective websites. In addition, a transnational call for proposals on both Flagships' topics (Graphene and HBP) is intended for publication year-end 2016, in connection with Challenges 3 and 4.

• ERA-NET QuantERA: QuantERA ERA-NET Cofund in quantum technologies. A call is scheduled for publication in January 2017.

• CRCNS: Collaborative Research in Computational Neuroscience. A transatlantic call is planned with the United States (NSF and NIH), Germany (BMBF) and Israel (BSF) in association with Challenge 4.

CHALLENGE COMPETITIONS

The "MALIN" challenge competition (mastering indoor positioning): A call for proposals in the field of the Indoor Positioning in critical situations launched in partnership with the French Defence Procurement Agency (DGA). MALIN deals with a topic thematically linked to Challenges 7 and 9.

The precise localisation of emergency intervention officials (civil security, firefighters, etc.), police and armed forces in a closed environment serves an operational function of great importance but which is difficult to fill in the absence of technologies adapted to technical demands (compactness, energy consumption, computing power, location, positional accuracy), technological demands (variety of sensors needed during missions) and environmental constraints (lack of or poor reception of GNSS signals...).

Currently, there are a multitude of indoor positioning systems that work in collaborative environments for "commercial" civil applications, using for example beacon-based technologies installed in buildings transmitting and receiving radio signals (GNSS, Wi-Fi, UWB, etc.). These systems do not meet civil and military localisation needs for operation in buildings in terms of both conditions of use and expected performance.

New solutions currently developed in research laboratories could meet these needs, but they are not mature enough to be industrialised. With technical maturity increasing, the DGA and ANR have designed a challenge dubbed "MALIN" (mastering indoor positioning).

The challenge will involve several teams whose proposed dual (civil/military) technology solutions will be evaluated through a series of three experiment campaigns.

The objective of the challenge is to foster progress in the field of 3D positioning in adverse indoor environment. Research must make it possible to: I) evaluate by comparison several architectures of technological solutions enabling the localisation in complex environments of different types of buildings, fields, basements, subways, mines, tunnels, etc. without the constant availability of GNSS signals (Global Navigation Satellite System); ii) to advance innovation in the field of the location of dismounted infantry soldiers for military applications and the agent of intervention for civilian applications; iii) to address the issue of indoor-outdoor transitions.

Certain of the challenge's themes are concerned by the **ROSE challenge competition** (see Challenge 5).

INTERFACES

This challenge involves cross-cutting research topics relating to more than one challenge. The other challenge(s) to which these topics relate is (are) indicated below, so that applicants may orient themselves towards the most appropriate challenge for their project. Applicants are strongly advised to read each related challenge in its entirety to gain a thorough understanding of its specific scope.

For information concerning cross-cutting areas, most of which fall within the scope of multiple challenges (including Challenge 7), readers should refer to the paragraph entitled "**Multidisciplinarity, cross-over and interfaces**" (pages 39-42) which covers the following fields: **Big Data, Robotics, Sensors, Biology, Bioeconomics & Biotechnology.**

The following field also overlaps with Challenge 7:

Cybersecurity, protection of information systems, cryptology and biometrics: Research projects on these topics, including highly upstream projects and proofs of cryptography algorithms, should be submitted under Challenge 9. However, if security is being researched as a software property or a communication infrastructure or calculation and the principal object of research is not security, proposals may be submitted under Challenge

POTENTIAL CO-FUNDING[41] FOR PROJECTS SUBMITTED TO THIS CHALLENGE

Projects submitted under this challenge may be co-funded by the DGA (the French Defence Procurement Agency).

Introduction

Digital science and technologies are now playing a vital part in major economic, social and human issues. Integrated circuits are omnipresent — in addition to being in computers and mobile phones, they can be found in a wide range of utility, domestic and leisure equipment. Connectivity of all these devices to different telecommunications networks, and ultimately to the internet, has become or is becoming the norm. The critical role played by information systems in the smooth operation of companies, institutions and major public infrastructure (transport, water, energy, etc.) raises questions relating to security and sovereignty.

[41] Co-funding means that funding is partially allocated by ANR, with the remainder coming from one or several of the Agency's co-funder partners.

Expertise in materials technology, software technology and network technology is therefore strategically more important than ever, both for our autonomy and our competitiveness. Several digital technologies now also play a major part in the practice of science: the processing of huge volumes of data in biology, physics, astrophysics and Earth observation and for use in social sciences and humanities research; high-performance computing for simulation in most disciplines; connected sensors for scientific observations, etc.

Progress in digital sciences and technologies is dependent on progress in micro- and nanoelectronics, IT and mathematics. To cover the various research fields and applications, researchers in this area need to foster close cooperation with all other disciplines and business sectors.

France has a high-quality research network in digital technologies, coordinated within the Allistene national research alliance. All the country's researchers also have a dense, reliable digital infrastructure at their disposal, provided by high-performance communication and computing network operators (RENATER and GENCI). Finally, France enjoys a high level of technical expertise in its industries and services, with prestigious international groups and thousands of first-rate SMEs and competitiveness clusters in the digital sector.

The "Information and communication society" Challenge focuses on how digital science and technologies can be harnessed by society, over and above the application of digital innovations within the various societal challenges in Work Programme 2017. This reflects a twofold priority: exploring how digital innovations can serve society, and designing digital technologies of the future through the development of concepts, methods and tools.

Challenge 7 applies to the entire research and innovation chain, from **the most fundamental research** to the **design and development** of pre-industrial tools and methods.

The challenge is divided into eight topics which tie in with the four French National Research Strategy (**SNR**) priority areas relating to Challenge 7 :

- Priority 26: 5th generation of network infrastructures
- Priority 27: Connected objects
- Priority 28: Exploitation of big data
- Priority 29: Man-machine collaboration

as well as the five SNR action programmes needing to be addressed as a matter of urgency (exponential growth in the volume of digital data and how to exploit this data; the key role of science and innovation in climate risk analysis and management; the revolution in our understanding of the living world as a result of the development of systems biology; the need to develop ever more innovative, effective healthcare; and the importance of knowledge about cultures and humankind).

Theme 1: Foundations of digital sciences and technology

This theme is geared towards fundamental research projects striving for excellence and new breakthroughs in the fields of computing, mathematics, and the science and engineering of systems and communications. Fundamental research should be strongly encouraged, as it serves as a vehicle for progress that can subsequently be used to promote and consolidate specific research leading to applications. Fundamental research expected in this theme must: (i) clearly be commensurate with Challenge 7, "Information and communication society" and (ii) should not be **explicitly** related to another theme in the challenge.

The following is a non-exhaustive guide to the fields in which fundamental research projects are welcome :

- **Mathematics and interactions**: the fundamental aspects of mathematical models and methods in a broad sense, in connection with the questions raised by digital science and technologies (particularly partial differential equations, control, optimisation, numerical analysis, probabilities and statistical methodologies, and also some aspects of fundamental mathematics, such as number theory).
- **Theoretical computer science**: fundamental aspects particularly associated with logic, computability, decidability, combinatorial analysis, formal methods, semantics, game theory and quantum computing.
- **automatic control**: fundamental aspects relating to control and observation, estimation and identification, systems theory and modelling, and control, optimisation and learning.
- **Signal processing:** fundamental aspects in statistical processing and signal detection/estimate, analysis and representation, information theory, and learning and optimisation.

Methodological projects including, but not limited to, the development of parsimonious, incremental, distributed, multimodal graphical models and co-design models with no direct application in the other themes in Challenge 7 will be welcomed in this theme.

Projects submitted should be related to the digital sphere but may also be directly linked to applications in areas such as biology, health, or the environment, etc.

Mathematical, statistical and computer models in these application areas has become essential for understanding the functioning systemic as well as the interaction networks implemented. Collaborative projects that will develop new conceptual approaches and methods (information systems, automatic control, signal processing, mathematics, statistics) to model these systems are also expected under this theme.

The projects on which they shine a light emphasise application areas but which are not intended to improve the existing methods must be proposed in the corresponding societal challenge (for example, Theme 4 of Challenge 4 for the "Digital and computer systems for biology").

Collaborative projects involving several fields in computing, mathematics, and the science and engineering of systems and communications, related to the key aspects of Challenge 7 “Information and communication society”, are also welcome in this theme.

Theme 2: The digital revolution: our relationship with knowledge and culture (common to Challenge 8)

This theme is common to Challenges 7 and 8. Projects submitted will be evaluated by a balanced joint committee whose evaluators will come from human and social sciences and digital sciences backgrounds.

- Projects must be proposed by an **interdisciplinary team or partnership** composed of both specialists from ICT and SSH;
Progress can relate to a single disciplinary scope (SHS or ICT) if it draws from **concepts or tools generated by recent advances** in the other field**.**

These two conditions are not administrative criteria governing eligibility, rather they are meant to explain an incentive to submit an interdisciplinary project. Joint action is not appropriate for projects which would lead to two unrelated sets of tasks in two different research fields (SHS, ICT).

The major topics in this theme are the following:

Education and training

Digital technology for education and training applies to all levels of schooling and types of training, classroom-based and distance learning, alone or in groups, in a national or international language, whether the need stems from an exacting professionalism or a will to learn. Ethical and legal issues, notably privacy, should not be neglected.

The digital revolution is expected to bring about progress, including the possibility of lifelong learning with a view to reducing the cognitive effects of ageing and disability, and narrow socio-economic and regional inequalities. The potential to transform educational and training systems is considerable, but this potential must be checked through controlled observation and the measuring its limits and prospects. To this end, projects should combine computer sciences and ICT with other disciplines such as psychology, linguistics, subject didactics, educational sciences, sociology and geography.

Learning with digital technology will enable us to benefit from both recent advances in digital techniques and cognitive sciences so that people can learn in optimal conditions. How can society create smart learning paths tailored to the needs of individual learners — (**adaptive learning**)? How can we track the progress of individual learners (**learning analytics**)? How do we improve long-term memory (**use of assessment as a learning method**)? How can we **assess** the solutions for mediated learning proposed ?

Such questions call for research on **modelling** learning, developing enhanced indicators, and considering the **role of communities** and networks in learning. It will also explore how digital technology can help to spread and maximise phenomena contributing to **life-long learning**. *For example, research shows that test-taking significantly improves long-term learning: taking a mid-term test increases students' long-term memory for test material whereas looking back over materials often results in better short-term retention. As digital technology makes it possible for generalised testing outside restrictive classroom learning settings, it may be useful to explore benefits for older adults or in work contexts.*

Digital learning has become essential both for getting by in everyday digital environments (**digital literacy**) and meeting the needs of qualified personnel in digital professions and trades that are "going digital". Emphasis will therefore be placed on training in numerical & data processing (in particular **computer coding**) from an early age, as well as the development of digital literacy among teachers. Questions arise concerning didactics: How do we teach about digital technology? Computer sciences and programming have become crucial to new programmes in education (primary, junior, and secondary schools). Project-based lessons should seek to identify and understand difficulties in the transmission, understanding and use of IT concepts.

To learn the digital era is to experience the effects of digital technologies on informational and cultural practices. The permanent availability promised by massive, nomadic and connected equipment changes values and behaviours. Research combining the study of digital practices with the other dimensions of social life are needed, in particular in the field of education, for cases in which educational institutions are based on organisational methods which may not be in line with social and cultural changes attributable to digital technology. Does the self-production of content, the ubiquity or extension of social networks democratise knowledge, culture and creation? Do they offset the drop-off in interest in reading by bringing about new forms of expression? The hopes placed in massively open online (**MOOCs**) and small private courses (**SPOCs**) deserve careful consideration. Research is needed to analyse experiments launched in Europe and abroad, their economic model and their ability to reach **target audiences**.

Creation and sharing of knowledge

Digital technologies directly affect **scientific practices,** including the definition of objects, observation and data collection, formalisation of assumptions and results, collective research, publication, etc. Research under this theme shall explore how new approaches enabled by digital data are leading many specialist fields to thoroughly overhaul their concepts and methods. Theoretical informatics as formal discourse on the conditions of knowledge, discourse analysis extended to controversies and arguments using techniques for searching textual content, or even the financial economy, with real-time data processing, are a few examples of epistemological issues.

We will also look to the competition or the complementarities between digital and paper writings, between the experimental and simulation, between the direct observation and researching using representations assembled from data, between the theoretical construction and exploitation of big data using statistical learning techniques. The use of big data raises important question concerning the effect of technological mediation for preparing and presenting data on understanding phenomena and researchers' intuition. **Epistemology, the cognitive sciences, ethics, the humanities and the social sciences** may be called upon for science and digital technology.

The very construction of knowledge itself may be the subject of research on recording, publishing and dissemination processes. More specifically regarding developments in the dissemination of technical and scientific information (IST), various issues should be examined including editorialisation and open access publications and valorisation of research data (notably through developing technologies for text and data mining). The establishment of new relationships among researchers and between experts and lay reader via freely available results (participative sciences, collaborative tools, platforms, etc.) is also part of these considerations.

Digital product tools that may in and of themselves constitute subjects of research. For example, a collaborative platform such as Wikipedia could serve as an observatory of contribution practices to the creation of shared knowledge. Research teams can contact Wikimedia Foundation France to obtain information.

Culture and heritage

Influenced by digital sciences and technologies, professionals and the general public are changing their relationships to objects in areas of heritage, culture and leisure.

Heritage objects: *Heritage objects (collections, sites, etc.) raise new challenges for acquisition, collection, processing, review, displaying, indexing, archiving, conservation and preservation (by incorporating the notion of quality data sources).*

Along with the humanities and the social sciences, digital sciences and technologies are heavily involved in research on **restoring and preserving 2D/ 3D and multimedia heritage.** Alongside social sciences and humanities, digital science and technologies are used in research to restore and preserve cultural heritage in 2D/3D and by using multimedia. Digital storage capacities are also increasing the number of documents with potential heritage value. How should new heritage objects be represented?

This priority does not concern the entire part of the data collection to be digitised (see Theme 6 under Challenge 8) but only data which raises **complex or unprecedented digitising problems**: frames sets, landscapes, objects, audiovisual documents, interactive data... The objective is to harmonise databases, as well as analyse and develop them while renewing **the design and processing of data**.

Project coordinators are encouraged to contact **TGIR Huma-Num** (very large digital infrastructure research for the humanities), which mobilises research networks seeking out best practices (geographical information systems, 3D reconstruction of monuments, texture analysis, etc.), an entity affiliated with **ERIC DARIAH** at the European level. This primarily concerns **museums** and audiovisual **archives** such as the **National Audiovisual Institute** (INA) which now provides researchers with: a wealth of data such that it requires close collaboration between researchers in SHS and those in digital science and technology; it offers an opportunity to update methods used for processing, annotation and indexing. The results of this research (annotations, enhancements, metadata, etc.) will be **freely available** and usable for other research. Researchers interested by this vast body of material should contact INA (http://dataset.ina.fr).

In view of the prospects raised by the digital revolution, museums are obliged **to rethink the way** they manage their collections. How should museums be made available to the public? How should they be organised and documented? Can the State apply its standards for labelling, inventory or classification to a material or immaterial heritage proposed by users? How should the relationship between **experts and non-experts** develop in this context?

Access to Heritage *The study of heritage tourists' practices calls for collaborations between ICT and SHS. New research techniques now make it possible to follow people closely as they visit museums, exhibitions, sites and cultural and artistic events, while noting their diverse characteristics (age, level of education, nationality, command of cultural codes, disabilities, etc.). Art therapy experiments will be given special consideration.*

Digital technologies integrated with local museums, their web portals and their mobile applications are revolutionising the **public's relationship with collections**. These technologies enable remote access and the exploration of virtual collections. Cultural mediation can therefore acquire a new dimension through individual and collective experiences, blending nomadic and immersive devices and mixed (augmented) reality. The same goes for **history of art and art education**, which is now enhanced with an interactive dimension (cyber museums). These new processes should be tested and, if possible, we should anticipate their future developments.

Theme 3: Software sciences and technologies

Software is a key component of digital systems, providing them with power, intelligence, flexibility, agility and durability. It enables sophistication and potentially limitless versatility, although it engenders a level of complexity that needs to be controlled by structuring and raising the level of abstraction, in terms of both design paradigms (languages, programming, software architectures, etc.) and execution (middleware and software platforms). Moreover, the production of reliable software, in terms of safety and security, is costly, hence the importance of ensuring the following properties: architecture principles, methods proven and automated design, validation and debugging.

This theme supports fundamental and mission-oriented research into software technologies, relating to software design and validation as well as to the software platforms required to implement software in all areas of application (from connected objects to large-scale systems).

The major topics in this theme are the following:

- **Software implementation platforms**: support for operating systems, virtualisation, embedded systems, distributed, memory management performance; specific middleware for different architecture principles (parallelism, distribution, real time, etc.).
- **Methods and tools for software design**: programming and specification languages, optimised compilation toward centralised or parallel architectures; specific computing models for parallelism, distribution, mobility, embedded and real-time systems; software design methods (design, model-based agile methods, etc.); software architectures and components.
- **Software validation**: methods and tools for programme analysis, verification and proof of properties (security and safety), auditing and optimisation of quantitative properties (time, energy, memory etc), testing and debugging, methods, software and hardware simulation methods, virtual prototyping.

Propositions related to execution platforms (at different scales) are of particular interest.

Project coordinators should position their project in relation to other national and European calls in the field and with regard to standardisation groups and alliances where relevant.

This theme is in line with SNR priority areas 26, 27, 28, and 29.

Theme 4: Interaction, robotics

We are currently experiencing a major technological shift which is amplifying our relationship with the physical and digital worlds, while enhancing and facilitating our interaction with our environment. This facilitation also involves the development of autonomous, highly interactive industrial robotics (Challenge 3, Theme 1) for professional, domestic and service purposes.

The following are Theme 4's major topics:

• **Human-machine interaction:** Interaction is based on multi-sensory interfaces combining contact, gestures, movement, speech, vision, and eye sensors, capturing the context and the psycho-physiology status of the user, leading to advances in wearable computing and technologies to augment or enhance humans (glasses and smart watches, implants or LCI for example). This includes research on information which is more valuable and more understandable for the user (professional or general public), based on personalised, synthetic and adaptive visualisations while incorporating images, virtual or enhanced to create immersive environments. This theme also addresses the issue of sensory-motor conflicts related to the use of virtual and augmented reality helmets.

Particular emphasis will be placed on the management of the cognitive load in order to continuously minimise the energy necessary for the operator to perform mental tasks, freeing up their creative faculties for other tasks involving continuous innovation, quality, or change management.

Expected research also includes the design and implementation of natural human-machine dialogue systems in their understanding and language generation dimensions (mono- or multimodal, including natural, oral or written), representation and inference of knowledge, modelling and automation of intelligent behaviour (particularly through reasoning patterns on mental states, the planning of communicative acts, possibly in combination with "physical" actions). Under this approach, in which dialogue is seen as a complex phenomenon derived from more primitive conduct, dialogue systems are seen as cognitive agents able to engage in advanced interactions with humans simultaneously to carry out other tasks. In this vein, and in connection with the sub-theme "autonomous and interactive robotics", proposals at the intersection of robotics and cognitive, intuitive communication-based human-robot interactions, which also address artificial intelligence issues, will be encouraged.

• **Autonomous and interactive robotics:** Robotics raises a series of highly diverse research questions related to the design and control of robots, the collection and interpretation of scenes, the planning and execution of 'move' and 'handle' actions, learning, and human-robot interaction. These questions are relevant to many application contexts with broad societal impact, such as manufacturing processes (the focus of Theme 1 of Challenge 3), hostile environments and assistance services. Robots may take on a variety of forms depending whether they are meant to serve industry or consumer purposes, ranging from humanoids to drones and including telepresence devices, off-road mobile robots, robot exoskeletons and manufacturing robots (see Theme 1 of Challenge 3). Innovative projects are encouraged it questions relating to operational autonomy, forecasting capabilities in relation to artificial intelligence, action planning and decision-making (autonomous or in conjunction with humans), multimodal physical and cognitive interaction with humans, cognitive architectures and learning capabilities, all of which are highly covered topics that also open up avenues for interdisciplinary research with the life sciences, social sciences and humanities.

Projects including ethical aspects are encouraged — in particular in an interdisciplinary approach — both in research ethics (see also themes 2, a joint them under Challenges 7 and 8 which deals with responsible research, ethics of use for compliance with ethical rules of implementation in application contexts and social interactions or ethics of systems, i.e. to the inclusion of moral rules and ethical behaviours in algorithms (artificial moral agents).

This theme is directly in line with SNR priority 29.

Theme 5: Data, knowledge, and big data - multimedia content

This theme is organised into three themes: the definition of processes and technologies enabling knowledge to emerge from data, the processing chain ranging from creating multimedia content to be used, and finally big data, with problems related to scaling, complexity, heterogeneity, speed, validity, veracity, protection, etc. Certain application areas may require a combination of two or three of these themes to produce concepts and original methods.

The expected proposals will contribute to the development of communities based on scientific data — data science — (scientific, economic and social areas) or involved in the creative and cultural industries. Research sought may directly relate to science and information technology and communication or in an interdisciplinary context involving IT experts, statisticians and digital humanities specialists. Projects should propose methods, techniques and algorithms to represent, store, index, annotate, and analyse data and contents to extract value-added knowledge relevant to the problem under consideration.

The major topics in this theme are the following:

• **From data to knowledge:** In this topic we will welcome research proposals that focus on establishing processes and technologies that can be used to extract knowledge from data, particularly in proposals on issues relating to semantic analysis, modelling, representation and the aggregation of knowledge. These processes involve complex processing chains that result in information products (rules, high-added-value behaviours, patterns, rare events, etc.) which increase the skill of users (experts, decision-makers or students) and enable them to formulate a rational decision. What makes these processes unique is that they can be used on incomplete, imprecise, or dynamic (temporal) data, and they can make use of probabilistic correlations and multimodal interaction. A key point is the use of statistics for the elimination of outliers which are probably aberrant, noisy or erroneous to extract individually unreliable, but generally correct data from raw data.

The knowledge produced is itself subjected to processes of representation, handling, combination and inference, so as to generate complex behaviours, particularly in situations of human-machine interaction.

The interest of big data is not only instructive analyses but also to help to determine the relevant activities to perform with relation to objectives pursued. To this end, the development of predictive models based on traditional knowledge is essential, enabling decision-makers in businesses and public authorities to consider possible options and their potential impacts.

• **Big data processing:** Processing large volumes of data has become a strategic field of major economic and societal importance. Whole swathes of the economy have emerged and been radically transformed through data management, which makes it possible to produce information or knowledge with high added value based on new economic models. The main challenges concern: volume and scaling up, variety of sources and heterogeneity of formats, and velocity of data flow. In the new economy, data becomes one of the main sources of wealth and opportunity to create added value and innovation. Other issues include intellectual property and data protection systems, in particular, security and confidentiality, communication methods, and monitoring how said data is exploited.

This theme is looking for innovative proposals concerning all or part of the data value chain: collection (particularly taking into account real-time flows); organisation into distributed databases or data lakes; storage; indexing, semantic analysis and automatic ontology construction; processes to increase variety: sourcing additional significant data (e.g. open data) and automatically generating additional variables (feature engineering, deep learning); Integration and cross-referencing from heterogeneous data sources; processing parallel requests and search engines for structured and unstructured data; factoring in personal data protection and security; advanced algorithms for large-scale, data mining and the analysis of unstructured data (text, image, audio, speech) or graphed data (social network analysis); restitution and visualisation of large volumes or networked data.

For the entire value chain, proposed techniques may make use of big data tools or offer innovative contributions using software. Data mining research may propose innovative contributions to open-source libraries. The data chains shall showcase the extraction mechanisms and structuring of knowledge in application areas with real implications (web, banking/insurance, distribution, health, connected objects, transport, environment, smart homes, agriculture, security, etc.). The availability of significant data sets should be specified in the proposal, with a timetable for data availability as the project progresses.

• **Processing of multimedia content:** this section addresses the entire digital content chain: creation, capture, production, editing, access, analysis, exchange, preservation, etc. It covers content for all media types: cinema, radio, TV, internet, video games, as well as the multimedia and multilingual aspects of documents. We expect research that supports collaborative, changing practices — collective and individual — associated with the creative, cultural, editorial and publishing industries, and which addresses new ways of writing, narrating, producing, disseminating and enhancing digital content, with the associated issues of usage and exploitation rights (digital watermarking and traceability). Finally, it is important to design technological solutions suited to new trends in content consumption in terms of mobility, multi-screen usage, browsing and dynamic discovery which take into account users' diversity.

By way of example, the French National Audiovisual Institute (INA) has decided to make a vast body of audiovisual archives available to interested research teams. This is an opportunity to develop and assess new mono- and multimodal methods for analysis, annotation and indexing. The results of this research should subsequently be made freely available for use in other research projects. For a precise, detailed description of the available archives, researchers should contact INA (http://dataset.ina.fr). Projects carried out by a highly interdisciplinary consortium of researchers in ICT/SSH should be submitted under the joint challenge 7/Challenge 8 theme (see Theme 2).

We would draw the attention of project coordinators to the fact that they should position their project, where appropriate, in relation to European initiatives and programmes, in particular the Big Data PPPs, and also in relation to the ICT-content topics in the Horizon 2020 Work Programme.

Fundamental research projects on processing 2D/3D images, video material, speech, music and audio material, as well as natural language processing (NLP) and sign language are expected in this theme.

This theme is in line with National Research Strategy priority areas 28 and 32.

Theme 6: Numerical simulation: from high-performance computing to big data

In many scientific fields (genomics, environmental science, climatology universe sciences, materials science, sociology, etc.) and technological and socio-economic fields (the high-tech, energy, pharmaceutical, manufacturing, digital, financial and service industries, etc.), the exploitation of large volumes of data and high-performance computing (HPC) have led to a data revolution. In this theme we expect interdisciplinary proposals involving computer scientists, analysts, mathematicians, statisticians, data scientists, etc.) which contribute to the emergence of an interdisciplinary community based around the fields of data science and computing. ANR is hoping to encourage groundbreaking approaches that harbour major potential for the integration of HPC with the processing of big data. This theme aims to tackle the following hurdles:

• Supercomputing: This topic involves designing and developing software solutions in synergy with areas of application in a bid to reconcile heterogeneous mass, hierarchical and parallelism (computing and network capacity, memory access, energy efficiency and fault tolerance. New approaches to modelling and numerical simulation methods are required to scale up algorithms and applications. the constraints imposed by hardware and data management must be integrated from these methods' design (co-design) stage. This research should be coordinated with European initiatives and projects, particularly those related to PPP, ETP, HPC, PRACE and the European Technology Platform HPC infrastructure. The best European hardware and software platforms should be chosen.

• Managing, analysing and exploiting the data deluge: The majority of scientific applications are confronted with a huge increase in the volume of data that they need to process. This could result in a potential change to the traditional data management workflow that involves saving data for subsequent analysis. Incorporating techniques and methods from the field of Big Data would seem to offer potential for resolving research issues related to the volume and complexity of the data to be processed — data either generated by or for use in (e.g. "generated by sensors) scientific computing. This concerns all aspects related to the processing of big data involved in simulation cycles: tools and methods of production, management, visualisation and computing. The data life cycle should be addressed in its entirety, and the question of integrating humans into the entire test cycle should also be explored. This theme involves the development of new mechanisms, metaphors, paradigms, algorithms, methods and tools.

This theme is directly in line with SNR priority 28.

Theme 7: Communication, processing and storage infrastructures

Infrastructures for communication, processing and storage are fundamental to the workings of our digital society: they play a key role in fields as varied and vital as knowledge sharing, the emergence of smart cities and smart transport, the widespread use of cashless transactions, energy optimisation, and big data processing in several fields (industry, environment, healthcare, etc.). The prospect of a proliferation of connected objects leading to a rise in the potentiality of innovative applications will require changes to networks to guarantee their connectivity and the introduction of new paradigms for communication and processing (potentially big) data.

Given the diversity of applications and the rate of change, building enabling, generic programmable and convergent infrastructures is key; generic in the sense that it seeks to avoid a silo infrastructure dedicated to one type of application. Such infrastructure, the basis of generic hardware solutions, is used with increasing frequency. Programmable to adapt in an agile manner to future changes which are difficult to predict. Converging in the sense that, within the network, historical segments (fixed/mobile, IP/transport/network, cloud computing/telecom) are merged in areas where the same infrastructural elements will support network functions, distribution of content, data processing, storage, interaction with the real world, etc.

These fixed or mobile infrastructures must be capable of achieving high levels of performance and efficiency, while being open and flexible so that they can be adjusted to meet the diverse, dynamic requirements of the various application categories (for example in terms of bandwidth, latency, processing capacity, mass storage capacity, and reliability).

The infrastructure to be deployed in industry must also be re-examined, including by taking account of sector-specific constraints and respective environments linked with networks of objects and integrating means of communication and self-organisation between the appropriate objects. Infrastructures must also be generic, programmable, and capable of adapting to the greatest extent possible of overcoming the constraints of various sectors of the industry of the future.

To meet these objectives, research projects are expected on the following themes:

• **High-speed communications infrastructure:** Solutions must be found to cope with continually growing demand for bandwidth. Current approaches in optics as well as radio are nearing the theoretical limits of transmission capacity and incremental improvements are not sufficient to absorb the demand in a durable manner; changes are necessary. Such an increase in the capacity of transmission systems and routing must be reconciled with reduced energy, elasticity, flexibility and the ability to adjust to demand dynamics.

• **Networks of objects:** The prospect of tens of billions of connected objects requires significant changes to networks. It is now recognised that new communication paradigms are needed. Systems should dynamically include increasingly distributed and heterogeneous equipment and devices, often “non-managed”, requiring a mobilisation of self-organisation approaches and interoperability management. Architecture and network interfaces must be redesigned to meet strong demands: Massive increase in the capacity of the control plan for the treatment of sporadic transmissions of a large number of objects, significant change in the traffic characteristics with the proliferation of communications from short bursts of data needing to be reconciled with the large video feeds also present in the network, objects with very limited power consumption to preserve battery life. At the same time, the necessity to ensure cost control, reliability, responsiveness and latency for certain applications.

• **HPC infrastructures and massive data processing:** HPC infrastructure must also evolve to meet the growing needs for data processing and storage. This will include improved performance from massively parallel computing nodes, system architectures able to integrate heterogeneous computation and storage technologies, performance (bandwidth, latency, congestion) networks of interconnections between nodes in transmission and routing/switching. Sequencing software, systems and operations management play a key role in effective and dynamic adaptability in the use of resources, whose heterogeneity must be managed. Energy efficiency is an important issue for the scaling-up of this equipment. Reliability and fault tolerance must be built in to solutions.

• **Network-Cloud Architecture:** Virtualisation enables the hosting of many network functions on cloud servers instead of dedicated telecoms equipment. Conversely, for performance reasons, in particular in terms of latency, there is a growing need to locate content and applications and proximity to the end-users on the periphery of the networks, giving rise to a cloud (edge cloud’ and ‘mobile cloud”). These new architectures require research on the best compromise between centralised and distributed approaches, on the dynamic optimisation of the placement of functions (network features, endpoints, applications), and on their orchestration. In this context, network architecture must itself be revised, with traditional access/metro/core segments losing their meaning. Operating system software encompassing network resources, storage, and spreadsheets with end-to-end management should be developed. Management, control, optimisation, monitoring, programmability networks, the cloud and systems

The complexity of infrastructure combined with the requirement of agility, optimising resources and strong guarantees of service require increased operational intelligence infrastructure at a high degree of automation.

"Software defined networks" must connect and schedule dynamically different applications and equipment to create slices of end-to-end virtual networks, optimised for different purposes. Particular emphasis on this call is placed on projects involving learning techniques for the purposes of infrastructure enablement, as well as projects including research on multilayer end-to-end security by design, including in Internet of objects and shared infrastructure by operators and multiple users.

• **Creation, deployment and optimisation of services:** The infrastructure of the future will be also be capable of supporting creation, deployment and agile optimisation of innovative services with a broad dynamic. The aim is to design operations systems that enable the automated, fast, and intuitive creation and orchestration of services. These systems must be able to ensure and manage service guarantees supported by heterogeneous infrastructures, thanks to an abstraction of various physical and virtual resources used.

• They must be able to build a knowledge map and contextualise service delivery in contexts adapted best to users and uses by making full use of the information available on the state of infrastructure and on users and their environment. New paradigms develop, resulting in new types of infrastructure; they should be consolidated and integrated. By way of example, we could cite the infrastructures natively integrating transactions (introduction of the "BLOCK chain" paradigm), making it possible to develop approaches by a variety of local markets and new business models.

This theme is directly in line with National Research Strategy priority areas 26, 27 and indirectly with priority areas 28 of 90.

Theme 8: Micro- and nanotechnologies for information and communication processing

Progress and breakthroughs in the field of information and communication science and technology are partly based on improving the performance of devices for processing or transferring information. These devices need to fulfil application challenges such as energy efficiency, the compactness and resilience of systems, connected objects, human-machine cooperation but also enable the emergence of secure systems for the operation of large amounts of data (components of the National Research Strategy).

Theme 8 covers the key generic technologies of electronics and photonics for information and communication, the question of integrating devices into systems, and the exploration of new paradigms possibly involving controlling quantum properties or bio-inspiration. Projects should address well-identified scientific and technological hurdles and should aim to demonstrate either improvements in performance or breakthroughs compared with existing knowledge. They will fit into any of the three areas described below.

Projects targeting predominantly or exclusively theoretical or digital approaches (simulation and/or design of components, materials, processes, complex systems) but also generic methodologies (design, testing, metrology), or the study of reliability, the characterisation of advanced materials or performance of nanodevices or basic components, are fully legitimate. They will be listed in one of the following areas, in line with the subjects discussed.

• **Micro and nanostructured materials for incorporating into components: development-manufacturing-processes:** This topic covers the basic technological brick essential for future innovations, made up of micro- and nanostructured materials from semiconductors (IV-IV, III/V, II-VI/nitrides) or other materials for electronics and photonics to materials for spintronics. It also covers the manufacturing processes of metamaterials and man-made materials.

This theme specifically concerns the development of materials, or basic studies of nanometric objects with a view to integrating them into components and devices.

Projects involving research into solid materials and their properties fall within the scope of Theme 3 of Challenge 3, whereas projects focused on materials for flexible electronics come under theme 4 of Challenge 3 if possibilities for integration are not explored.

• **Basic components and devices:** This topic concerns projects that aim to achieve basic functions for micro- and nanoelectronics, spintronics and quantum optics, non-linear optics near-field opitcs, wavefront treatment, milimetric and THz plasmonics and techniques, organic/nanophotonics, flexible electronics and optoelectronics. It also covers alternative methods such as quantic and neuromorphic technologies.

In this theme, and for projects which particularly focus on micro- and nano-scale integration, objectives such as the development of optical sources, optical fibres and new components for optics may also be considered.

• **Waves — architectures — integration — circuits:** Projects under this theme either fully or partly address the inclusion of devices or components: 3D integration, heterogeneous integration, alternative architectures (bio-inspired, neuromorphic, etc.).

Research should address a hurdle (or problem) associated with photodetection and related imagers; architectures and technologies related to the integration of optics into systems; micro- and nanosystems; circuits and systems for communications (optics, RF, etc.); and sensors as connected, smart and/or autonomous objects.

Projects that explore other issues/questions relating to sensors should be submitted either under Theme 7 of Challenge 7 (if the aim is to create an infrastructure of networked sensors), Theme 4 of Challenge 3 (if the research objectives are the physical, chemical and biological properties of physical nanosensors, etc.).

Additional Information: Projects in this theme may be mono-disciplinary, multidisciplinary or interdisciplinary. They may propose experimental and/or instrumental developments, adopt an integrative approach by encouraging the transfer of technology to business, or opt for more fundamental research that addresses challenges in information and communication science and technology. Digital simulation, modelling and theory may be included in mainly experimental projects or be the focus of specific projects.

Project coordinators in the field of European FET Flagship Initiatives 'Graphene' and 'Human Brain Project', and those addressing the challenges emerging from the European initiative on quantum technologies, are invited to present the potential links with these initiatives.

This theme is in line with SNR priority areas 26, 27, 28, and 29.

Challenge 8 : Innovative, inclusive and adaptive societies

EUROPEAN AND INTERNATIONAL COLLABORATIONS

This challenge is part of a process of developing European and international research.

The 2016/2017 topics prioritised for international backing are detailed below and also listed in annexes 1 and 2 of Work Programme 2017. As lists are subject to change, applicants who wish to conduct their projects at the European or international level should regularly consult the ANR website for more information on these partnerships and calls for proposals: http://www.agence-nationale-recherche.fr.

INTERFACES

The other challenge (s) to which these topics relates is (are) indicated below, so that applicants may orient themselves towards the most under challenge for their project. Applicants are strongly advised to read each related challenge in its entirety to gain a thorough understanding of its specific scope.

For the social sciences and humanities field, the ATHENA Alliance and CNRS have endorsed the principle of jointly handling certain themes via two challenges. They have asked that joint projects put forward in this context be presented accordingly and evaluated by peer reviewers in both areas. These themes can also be found in theme 7, Digital Revolution: education and heritage (drafted jointly with Challenge 7) and Theme 8, Public health (with Challenge 4).

In addition, Theme 3 of this challenge addresses changes in labour and organisations across all sectors, but “humans’ role in the factory of the future" falls under Theme 1 of Challenge 3 (industrial renewal).

Violent radicalisation is covered in theme 2 of this challenge. Issues concerning protection techniques and national security (detecting subtle signs of radicalisation, intelligence, cyber-security, the protection of persons, securing public places and buildings), as well as substantive issues on balancing security with freedom (legal aspects, role of law enforcement, civic engagement, etc. shall however be reserved for Challenge 9 ("freedom and security of citizens ... ")).

POTENTIAL CO-FUNDING[43] FOR PROJECTS SUBMITTED TO THIS CHALLENGE

Some of the projects within this challenge may be co-funded by CNSA (National Solidarity Fund for Autonomy)

Introduction

Challenge 8 encourages research focused on societies' ability to innovate, integrate and adapt. In addition to French society, it looks for societies of all cultural areas and from all periods. All of the social sciences and humanities are concerned: **history, archaeology, arts and letters, philosophy, linguistics, anthropology, sociology, demography, geography, political science, religious studies, psychology and cognitive sciences,** as well as **law, economics and management.**

[43] Co-funding means that funding is partially allocated by ANR, with the remainder coming from one or several of the agency's co-funder partners.

The **National Research Strategy** (SNR) has set out four priorities for challenge 8:1) cultures and integration factors; 2) new wellness indicators and the ability to innovate; 3) the availability of data and extracting knowledge ; 4) social, educational and cultural innovations. Challenge 8 is also concerned by two cross-challenge topics: the importance of knowledge on cultures and humans and creating value from digital data.

In response to recommendations by the SNR and the ATHENA Alliance with input from Challenge 8's Scientific Advisory Board, new themes have been added to the 2017 edition. Challenge 8 is divided up into five themes:

- Theme 1: Social innovation and risk
- Theme 2: Inequality, discrimination, migration, integration and radicalisation
- Theme 3: Changes in labour and employment, changing organisations
- Theme 4: Life-long education, cognitive skills, socialisation and training
- Theme 5: Cultures, creation and heritage
- Theme 6: The digital revolution and social change
- Theme 7: The digital revolution: our relationship with knowledge and culture (joint theme with to Challenge 7)
- Theme 8: Public health (joint research area with challenge 4).

Taking into account the "fundamental research" in the challenge 8

Generic Call 2017 is open to a wide range of projects from a variety of disciplines, including **basic research.** Basic research is present in every Challenge 8 theme, including empirical research bringing about a significant leap forward in knowledge, irrespective of applications. As regards topics raised by Challenge 8; fundamental research not only covers conceptual issues, the development of a theoretical framework or the construction of models and methods, but also critical reflection on the formation of categories and their effects and, more generally, the focus on the establishment and organisation of data, their scope and their limits.

Sources and methods, research infrastructures, data collection, constructing a corpus

Projects submitted in this challenge may apply a variety of methods: in situ observation, interviews, experiments, modelling, simulations, the compiling and use of archives and corpora, textual analysis, statistical surveys, administrative data, and artistic or literary sources. Applicants are advised to inform evaluators about the sources and methods used by devoting at least a page of the pre-proposal to them.

Researchers are encouraged to take advantage when possible of the large databases at their disposal. In the area of international longitudinal surveys recognised by the European roadmap for research infrastructures, mention should be made of SHARE-ERIC (health, ageing, retirement in 20 countries), European Social Survey (mindsets and attitudes in 21 countries), Generations & Gender (demographic behaviours, intergenerational bonds, 15 countries). The CESSDA (the 13-country European network of data banks for research) a very large survey data archive (including those in France by the PROGEDO TGIR Quetelet network). Large-scale cohorts can accommodate projects of diverse natures, such as Elfe, the longitudinal study on childhood themes drawing on epidemiology and the social sciences. Researchers in the humanities may (in France) call upon the technical support of the Réseau national des Maisons des sciences de l'Homme and TGIR Huma-Num (a very large research infrastructure for the digital humanities), part of the European DARIAH consortium.

Within the limits of existing financial resources, Challenge 8 may partly fund the conducting of surveys or the constitution of corpuses (texts, images, oral archives) on three conditions: 1/ that they coincide with a research project ; 2/ that open data be provided 3/ that there is a mechanism for perpetuating them.

Theme 1: Social innovation and risk

Innovation factors, innovative design, intellectual property

Our societies are caught in a double bind; they must at once protect against risks affecting the environment, health, food, privacy, and social ties while conversely curbing risk aversion to unleash innovation capacity. The objective will be to analyse **multiple forms of innovation and attitudes towards risk in societies and cultures**, risky behaviours and the demand for security, the recourse to precautionary principle and the development of entrepreneurship and creativity. In this context, though shall be given to the evolution of welfare, insurance systems and financial hedging.

At this theme's core are **innovation trajectories**, **ground-breaking innovations**, creative **design,** and experiments in **frugal innovation** looking to innovate better with less. What is the best way to organise, what dynamics should actors have, and what kind of **ecosystem** is best at fostering the emergence, dissemination and appropriation of innovation? Researchers will take a close look at innovation trajectories: should innovation be open, concerted, competitive, cooperative, random, or methodical? What are the heuristic advantages of methods such as serendipity, the examination of counter-examples, learning from past failures, counterfactual scenarios, and the lifting of legal barriers? Are new ideas born in response to **urgent needs** (time and cost constraints, the will to survive, ecological threat), or **prosperity** (demographic bonus, size of the domestic market, educational background, free competition, private sponsors)? Yet another critical issue: how does one explain the **hegemony of the United States and Far East countries in terms of technological innovation**?

Capitalising on innovations raises complex questions. How can we protect innovation without exhausting its sources? In terms of **intellectual property,** not everything can be patented: ideas, theories, learning methods, training concepts, software, and human gene sequences in many cases can not be patented because the innovations behind them go beyond mere inventions.

This theme's areas of application include habitats, cities, transportation, industrial production and the green economy, socio-cultural questions relating to environmental and climate change, such as the frugality of systems and programmes.

Challenges 1, 3, and 6 were created to host technology-oriented projects dealing with just such research areas. These projects may very well play a central role in the "Innovative societies" challenge if projects are centred on the innovation process itself and set out to cast light on its social, economic, cultural, and organisational dimensions. Artistic creation is discussed below in Theme 5.

Social innovation, political innovation, participatory democracy, the right to experiment

In addition to enterprises, intermediary and non-profit actors engage in **social innovation** to address environmental and social needs (isolation, social exclusion) and experience new uses, such as virtual communities. We will consider enterprises and collectives in which **communities of practice** are emerging that pool together knowledge and expertise. These actors **question scientific expertise** and seek out new relationships with researchers. Although the French constitution recognises local communities' **right to experiment**, attempts to generalise local innovations still nevertheless come up against the principle of equality; Researchers will try to identify legal obstacles.

Experiments in **participatory democracy** raise real questions. How does participatory democracy resolve the question of representation and spokespersons when locally elected officials are involved? What role do **referendums** play in our democracies? What are the challenges facing participatory democracy in order to secure legitimacy in the different spheres of action (economy, environment, urban planning, education, control of technical progress, etc.)?

The development of **participatory science**, also called "participatory research" or "citizen Sciences" (see the February 2016 Houllier report), becomes in itself an object of research for sociology and history of science, political science, life sciences, educational sciences : diversity of actors and objects, links between scientific rigour and *crowdsourcing* (mobilisation of a wealth of private initiatives on the same subject), publication and dissemination methods, paternity issues and recognition of discoveries, governance, funding, possible applications for teaching in schools, etc.

Social, political, religious, and scientific movements

Research on the drivers of social innovation must be understood in a broad sense. Throughout history, path-breaking individuals and groups have challenged the established order and imagined **new ways of living and doing things**, as well as **new belief and thought systems:** Utopians, heretics, prophets, artists, inventors, pioneers, exiles, migrants...

Over the past centuries, quite a few **innovative social movements** have cropped up (mutual learning, social economy, trade unionism, cooperative movements, mutual companies, free media, popular science writings, etc.) as well as **religious and humanitarian movements**. We will study their growth, organisational models, their social basis, their successes, failures, and their staying power.

Social movements based on demographic and family changes

One of the most prominent social innovations was the evolution of **demographic behaviours and family structures**: new contraceptive methods in the 20th century, the decrease in child mortality, longer life expectancy, the **extension of the principle** of equality (children's rights, reproductive rights, women's empowerment, rights of sexual minorities). What are their **vectors**: social movements, the medical community, public authorities, international organisations (WHO, UNFPA), private foundations, local initiatives? What **legal, economic or social** effects do they have? Thought shall be given to **the great debates** on diversity in family forms, termination of pregnancy (abortion), gestational surrogacy and end-of-life issues. Research on these themes necessarily concern people of all ages from all parts of the world.

From rhetoric to nudges: scope and the limits of persuasion techniques

How do we rally minds to innovation? Since conventional methods have largely proven insufficient (violence, legal constraints, pedagogy, financial incentives), many theories have explored the path of **persuasion**. Notable examples date back to antiquity and include rhetoric, governing passions, crowd psychology, charisma, propaganda, submission to authority, the illusion of free choice, informal logic and theories about conditioning, communication and undue influence, just to name a few. Extensive literature whose prevailing currents rarely overlap and for which there exists no compendium or overview. The latest addition to the list is the theory of nudges; nudges change behaviour at little cost and do not require coercion or a high level of willpower or calculation. Situated at the crossroads of the **psychology of cognitive bias** and behavioural economics, this model applies to any domain in which people try to influence individual choices, including health, the environment, shopping, saving money, voting, and charitable giving. Where does the border lie between persuasion and manipulation? What role does individual responsibility play?

Experiments and assessments are expected on this theme.

Reminder: The themes addressed in this component are open to ‘basic research’ as defined above in the introduction to Challenge 8.

Theme 2 : Inequality, discrimination, migration, integration and radicalisation

Socio-economic inequalities, inequalities among nations, innovation and inequality, health inequality

The **widening of inequalities** is a barrier to social integration. Projects in this theme will study the logic of withdrawal or **exclusion** on both ends of the social scale, the gap between **objective and perceived inequalities** and the reasons why some inequalities tend to be accepted and others not. Though research shall analyse long-term **income and heritage inequality**, other factors weigh on **wage inequality** across a single generation**:** The valuation and evaluation of activities, how they are compensated, and career management. Though social and matrimonial mobility are long-studied topics, the role of institutions and networks (including digital) as vectors of social mobility is less known. Other possible themes include dynamics of **segregation** (including residential mobility as a factor in curbing isolation), the link between social and **spatial inequalities** and, on a different scale, the inequalities **within and among different nations, without forgetting the emerging theme of climate inequalities**. All questions with a descriptive dimension must be accompanied by an explicative dimension. Attention should be paid to the principles of justice underlying the reflection on inequalities.

[N.B.: projects addressing health inequalities are to be submitted in theme 8, whether geographical, economic, social, cultural or gender inequalities (access to health care, insurance coverage, doctor-patient relationship, relationship to the body...)].

New socio-economic indicators of well-being and integration

To measure performance inequalities on an international scale, the economic and social sciences place emphasis on development and well-being indicators combining health status, education levels, death rate, economic performance (GDP, unemployment, productivity, concentration of wealth) and more recently gender inequality. Though the **human development index** (HDI) is the most famous indicator, other sectors are also affected: governance, democracy, trust, social capital, prosperity, security, added value of public services... Such indicators measure case-by-case **innovation capacity, the strength of civic and social engagements** as well as **well-being** and **happiness** metrics (such as the OECD's *Better Life Index*).

Researchers will consider whether these new indicators break with **the history of indexes in the social sciences**, if their dissemination contributes to inequality or rather bridges it, if the publication of **high-performer lists** (schools, universities, hospitals, publications etc.) casts light on or biases private and public choices. Comparative studies and experiments are welcome for all these subjects.

International migration: factors of migration, migration policies

Europe is an **immigration** continent. One out of four persons living in France is an immigrant (**first generation**) or was born in France to at least one immigrant parent (**second generation**). Most of the neighbouring countries are in the same situation. We will analyse migration in terms of transnational circulation and settlement, placing emphasis on a diversity of **factors and reasons for migration**: work, family reunification, marriage, studies, refuge, retirement, health, safety and freedom... These topics will be examined in the field with special emphasis given to the nature and real magnitude of **environmental migration**.

Research will of course shine a light on the summer 2015 **refugee crisis.** How should it be placed against the overall evolution of migration? What has it revealed about divisions in host societies, both between countries and within each country? Research can be conducted in departure and arrival areas, or even both at the same time.

One wide-spanning and multifaceted subject is the history of **migration policies**, straddling economic logic, law concepts (ratification of international conventions) and the will to exercise sovereign control over right of residence. Related issues include visa policy, the processing of asylum claims, integration contracts, and policies for accessing citizenship. The European debates on the Geneva Convention, the Dublin agreements, and the Schengen Area fit within this ensemble as well as the active and sometimes desperate strategies of those seeking to immigrate. Recent events can be used to measure the **costs** and **benefits** of opening or closure of borders in economic, social, and policy terms. Comparing the current experience with similar experiences from the twentieth century should be instructive.

Apart from students, France lets in few **skilled immigrants**. Who decides when it comes to recruiting economic migrants? The State? Employers? What are the criteria and effects of their immigration? Researchers will compare "point systems" to candidate selection based on human capital, listing “shortage occupation” professions and determining the country's economic needs. Is a purely economic migration entailing settlement conceivable?

Other themes must be further explored: **expatriations** (little known), the effects of brain drain versus brain gain, the intensity of **returns** or remigrations toward other countries, **transnational** circulation, mixed marriages and dual nationality, but also the long history of **forced** and **semi-forced** migration. All of these issues may be addressed from both national and international standpoints. They could also be extended to include **historical or pre-historic** migration, which throughout history has both divided and united peoples in motion.

Research into the causes and consequences of international migration is not limited to those destined for Europe.**South-south** immigration and immigration systems in **other parts of the world** (Gulf countries, China/Russia, Southeast Asia, the Indian Ocean, Latin America, Pacific ...), to be conducted if possible with researchers from participating countries.

Refugee integration of migrants

Nothing is more hotly debated that the issue of migrants' integration, particularly when they come from the **Muslim world** (Maghreb, Middle East, sub-Saharan Africa). The **concept of integration** remains crucial to measuring access to employment opportunities and goods and services; the concept demands comparative studies on a European scale. Public statistics surveys now contain information on **parents' country of birth and nationality.** Some surveys ask for **religious affiliation**, allowing for the separate consideration of how origins and religion have impacted immigrants' lives and those of their children. It becomes possible to estimate the weight of these factors in the **social, economic and cultural inclusion** of migrants and their descendants.

Integration does not occur at the same pace in all areas, creating discrepancies whose extent and impacts must be gauged. Inclusion also depends on the degree of integration in the host society. Degrees of integration will distinguish the legal requirements **imposed on individuals** (language proficiency, respect for laws, ability to provide for one's family) and indicators of **collective and probabilistic values** (rate of mixed marriages, rate of home ownership, religious practices, volunteering, voting participation, etc.), which provoke debate.

The complex issue (due to the available data) that is **the effects of geographic concentration** of immigration on the integration of migrants also fits comes under this heading.

Once again, the issue of integration is not specific to Europe. Comparative studies with the Southern countries or other groups of countries (Japan, the Gulf countries, former Soviet republics ...) are still poorly developed and will be welcome.

Discrimination

The concept of integration becomes devoid of meaning if, when **skills or situations** are held equal, discrimination blocks access to employment, training, promotion, housing and services. However, research has made very uneven progress concerning the various **illicit selection criteria** set out in the French penal code: age, sex, physical appearance, nationality, origins, trade union affiliation or political, religion, surname, state of health, disability, pregnancy, identity or sexual orientation, place of residence... The **accumulation of forms of discrimination**, often invoked, remains largely neglected. One question worth clarifying is the link between the subjective experience of discrimination and objective realities; this requires that researchers closely track and observe pathways to education, jobs and housing.

Discrimination cannot be abstractly postulated; it must be proven through **specially-designed methods**: CV testing, longitudinal monitoring of careers, explicit or implicit prejudice measurement methods. Discrimination may also be direct, **indirect or systemic** and arise from interactions between people or be crystallised through the partitioning of urban spaces and workplaces. **Statistical discrimination**, as defined by economists Arrow and Phelps, is driven by risk aversion; in other words, rejecting someone on the basis that their physical appearance supposed belongs to a “risk” category (e.g. the risk of pregnancy or other deduced dangers).

Researchers wishing to conduct projects measuring discrimination should get in touch with **private companies or government**. How do these entities use the methodological guide published in 2012 by the CNIL and human rights defenders on "measuring diversity"? Researchers will test **practical solutions** for recruiting based on skills and talent and getting away from old clichés, adapting tests, and creating a dedicated anti-discrimination position within organisations, etc.

violent radicalisation

Generic Call 2014 stressed the urgency with which **identitarian closure** must be analysed. It called upon researchers to draw inspiration from the Peace and CVE (Countering violent extremism) studies to better understand logics of **violent radicalisation**. The Generic Call cited the example of "The Online Recruitment of Young Jihadists". The January 2015 attacks in Paris and Montrouge as well as Paris in November 2015 and Brussels in March 2016 confirmed the call’s timeliness: men and women have been killed for their ideas, jobs, religions, or simply their lifestyle.

Over the past two years, French researchers have discussed violent radicalisation quite extensively in forums open to all disciplines, and the very controversial issue of its link with immigration. These debates are yet to be converted into interdisciplinary research projects testing assumptions and new methods heeding conducted research abroad. **Sociologists, political scientists, lawyers, philosophers, historians, linguists, anthropologists, demographers, economists, psychologists** and also experts in **literature** and **exegeses** can contribute by studying how **radicalisation** works (psychological and social vulnerability, generation gaps), **methods** (online recruitment, social networks, "swarm" organisation, manipulation techniques, conversions), actors (age, gender, habitat, origins), **arguments** (hero worship, the primacy of divine will over the principle of equality, legitimation of violence, dehumanising of the enemy, anti-Semitism); a central issue being to identify the conditions and mechanisms that drive those who go through with radical acts.

Research likely to **inform public action** on prevention, "de-radicalisation" and protection programmes are welcome. Whether causal factors identified are social, religious, political or psychological; research on violent radicalisation will be sensitive to data quality and the validation of assumptions (including the power of social networks).

Old and new parallels with other politically or religiously-motivated waves of attacks deserve to be looked into. Researchers shall not elude the difficulties Islam has traditionally had tolerating the **free examination of sacred texts** and differing interpretations with the potential to marginalise radical theses; they shall also study geopolitics in the Near and Middle East (civil wars, military interventions, disintegration of states).

Researchers are also invited to take a more broad interest in **all forms of radicalisation, not necessarily religious** sectarian, revolutionary or otherwise. The comparative study of violent phenomena around the world and throughout history may include terrorist groups as well as institutionalised and global organisations, their channels of funding, their access to communications technologies, their propaganda efforts, as well as counter-propaganda proposals (*Counter-narrative*) in the media and, more generally, new collective artistic forms.

[projects on protection techniques should be submitted under Challenge 9, "Freedom and security..."] .

Reminder: The themes addressed in this component are open to 'basic research' as defined above in the introduction to Challenge 8.

Theme 3: Changes in labour and employment, changing organisations

Labour and employment remain research **priorities**, regardless of sector (agriculture, services, craft trades, industry, public service, tertiary sector, creation). All forms of employment are concerned: salaried and non-salaried, fixed-term or permanent, formal or informal, free or forced, on-site or at-home - keeping in mind that these shifting categories are each affected by unique historical and comparative factors. Many disciplines are concerned: **Economics, management, law, sociology, political science, anthropology, history, psychology, ergonomics**...

The labour market and employment, employment policies, the organisation of work

Innovative projects are expected on the **functioning of the labour and employment markets**, the transformations of unemployment and how we support the jobless, the complexity of professional career paths, as well as recruitment and promotion methods. **Employment policies** (experiments, measurements, evaluations) are to be dealt with from this perspective, whether they advocate deregulation, intervention, protecting existing jobs or creating new ones. It is necessary to **go beyond a merely descriptive approach** (already covered by public statistics) and strive to set out explanatory and forward-looking models.

Employment and work issues should be put in context: technological change, business networks, economic constraints, new relationships with clients and contract givers, work relationships (representation, negotiation, agreements, etc.). Research on the **division of labour** will be pursued (between companies, nations), and on its **regulation** (flexible or standardised, hard or soft), its **measurement** (duration, performance, intensity, tedium), its evaluation (setting objectives, traceability, audits), its remuneration (collective or individual, seniority or merit, job or service), its fragmentation (intermittently, multi-activity), and its **management** system (anonymous or custom, technocratic or participatory, etc.).

Organisational changes can be studied at several levels: 1/ New forms of management and *reporting* (integrated software packages, roadmaps); 2/ restructuring and outsourcing phenomena brought about by conceptions of the companies' legal and accounting standards; 3/ the organisation of firms into networks and sub-contracting chains with their effects on labour relations and labour law *(see theme 1 of Challenge 3 for these phenomena's equivalents in the purely industrial sphere)*.

Job quality, the role of work in society, emotions at work, the connection between work and health

Researchers will look at ideas on **job quality** (content, aims, recognition, over- or under-qualification, loss or acquisition of knowledge, real/assigned work, forums for discussion on job quality and standards, the requirement to perform better for lower pay). **How work is viewed by society** remains a topical subject; how can the work world be reconciled with **non-work** domains (recreation, volunteering, retirement) with consideration to time periods and cultures? What conditions must be present in order to find fulfilment **in the work we do and see work as a creative commitment on the part of the employee**?

Our **attitudes towards work** can be regarded from psychological, social, cognitive, institutional, clinical and historical dimensions; according to gender and social group. **Emotions at work** (pleasure, boredom, pride, anger, compassion, humour, etc.) are a rapidly expanding research domain. Studies shall take a look at prescribed or proscribed emotions when dealing with the public, patients or colleagues, and tension and personal concerns caused by respecting managerial imperatives, the experience of "dirty jobs" (handling of waste, personal care, treatment of corpses etc.) or with the ambivalence of HRMs when faced with emotions (both denied and exploited at times).

This document will look later on at the relationship between **work and health** (occupational exposure, muscular strain injuries, accidents, wear-and-tear). The concept of **stress** or **psychosocial risks** is oft discussed; does it refer to employees' inability to meet the requirements of the organisation or to the organisation's inability to provide them with the necessary means? Researchers will peer into health fluctuations at work (as well as **health during unemployment**) accounting for risk factors, labour relations, union resources, know-how, practices and representations as well as technical, sanitary and legal standards. Special attention should be given to objectifying hardships and pathologies (context, actors, knowledge, and controversies).

Men and women at work: the challenge of professional gender equality

Though **the balance between family and work life has long been the concern of lawmakers**, **gender equality** has been neglected and outright ignored, with women subjected to increasing pressure due an accumulation of duties. Research on **social time** should be centred on technical, legal, fiscal, political and other solutions able to thwart **male domination**.

The main obstacles in this regard are well known. Men fail to do their fair share of housework and parenting, while social norms still exert pressure on women to undertake work that is reputed to be altruistic or selfless – but which is often undervalued (education, healthcare, jobs in cultural institutions or the service sector). There is an urgent need to **assess solutions** implemented by Scandinavian countries, such as male parental leave and quotas for women sitting on governing boards. How are companies really working to reduce gender inequality?

Reminder: The themes addressed in this component are open to ‘basic research’ as defined above in the introduction to Challenge 8.

Theme 4: Life-long education, cognitive skills, socialisation and training

Cognitive capacities during life's various age periods

Longer life expectancy and the growing diversity of career paths has renewed discussions on education, training and learning. The challenge is to give everyone the **ability to learn and receive on-going training** based on a sound knowledge base. Without overlooking the effects of work's social organisation discussed in the previous theme, such studies could be used to analyse and alleviate stress caused by an accumulation of constraints, requirements and needs to change or retrain.

A significant proportion is therefore firstly dedicated to basic research. Researchers are expected to produce models and experiments based on fundamental aspects of cognitive psychology (in the diversity of the process that it covers), cognitive neuroscience and linguistic and emotional psychology. Researchers will focus on the mechanisms linking **sensory and motor** skills and **cognitive, emotional and language development** to various environmental elements: family, social, school, and emotional. All ages are studied, from early childhood to old age. A major challenge for the study of the cognitive functions in children or adolescents suffering from pathologies (neuropsychological disorders, pervasive developmental disorders, psychiatric conditions etc.). The study of cognitive functions in the aged is a major challenge; elderly populations cope with cognitive and/or motor pathologies and must prolong their autonomy so that they can enjoy interacting with family and friends for a long time.

Innovative teaching methods

With regard to **fundamental knowledge**, France has obtained worrying results in **PISA surveys** of 15-year-old pupils in mathematics, writing comprehension and the sciences. France is the OECD country in which social origin bears most heavily on inequalities at school; this also applies to universities. Subsequently, many adults struggle to handle oral and written information essential for everyday living and work situations.

To improve the acquisition of basic skills, promote fluency in languages and digital tools and give or restore the pleasure of learning, we must overhaul our educational tools to better reflect how people learn and acquire skills. The focus will be on developing, testing, and validating teaching methods **adapted to a wide range of publics** (age, experience, previous achievements, social environment, responsiveness and emotional fulfilment, etc.). These pedagogical innovations will rely on new information and communication technologies; the degree to which they will change the transmission of knowledge and aid in palliating disease and physical and mental handicaps will be verified. Since asking whether new technologies improve skills is controversial, researchers will investigate the scope and limits of the skills-based approach and the exploration of more holistic models that take into account **cognitive psychology**, **behavioural theories** and **sociology of interactions** and test them in soundly constructed protocols.

New levers for combating educational failure

Factors affecting the achievement gap in school are well-known and studied by several disciplines, but their respective weight and interactions are less known: **Dealing with sensory, motor or cognitive handicaps** and **gifted children**; providing **incentives** to learn versus **withdrawal or hostility**; the **influence of educational institutions** on performance (the effects had by social class, discipline, teaching staff, neighbourhood) ; the influence of genre and its representations on the **choice of studies and success by discipline, family choices** (public/private divide, school map, selective languages, "top-scoring" schools, etc.).

The research community has every reason to engage cross-discipline studies for **fresh thought processes on these questions.** What place should individual initiatives be given in school systems? Can failure be decreased by valuing all forms of intelligence and skills? Can France rethink its system **of student orientation** by substituting its current negative selection system with positive incentives, like in certain foreign countries? Are implicit incentives and volunteering applicable to the world of school? How do we train teachers and guidance staff accordingly?

Combating educational failure

The watchwords of yore (discovery of new concepts *in situ*, learning to express oneself orally, combining academic training and vocational training, "learning how to learn") will remain hollow slogans if we never back them up with **real-life experience**. The nagging question remains why **innovations in teaching methods** have so much trouble going beyond experiments and small-time initiatives and gaining wide recognition. Evaluating these innovations is a major challenge.

Such questions are taking on crucial importance to both ends of the school curriculum. Little is still known about the **effects of pre-elementary schooling** from age two, but recent development of cohorts of children (starting with the Elfe cohort) should enable us to deal with the question methodically. The **dropout rate** and the number of **students leaving without a diploma,** as well as the French aversion toward **apprenticeship training** are areas in dire need of meaningful research. We have yet to elucidate contributing factors and make progress in the search for remedies. **Social psychology**, which analyses the role of dynamics and groups in success or failure, may be of use here.

Changes in higher education

Higher education remains an undeveloped research field. In the case of France, a divide separates universities (which themselves may differ greatly from one to the next) from prestigious *grandes écoles* and other *grands établissements*; The massifying of higher education has been accompanied by an increase in student diversity, including growing internationalisation. In addition, **difficulties recruiting** (drop in staffing in some branches, high dropout rate); **organisational problems** (autonomy, campus policies, insertion in innovation clusters); increased **international pressure** (global leaders, dominance of English, tendency of the "European research area" to widen gaps between countries instead of bridging them). Though reforms have been implemented to combat under-achievement, there have been few real innovations in research on organisational and pedagogical practices. There is an urgent need to methodically study these complex and shifting realities, if possible through a **comparative and prospective approach** laying a bright new path for the education and research system.

Reminder: The themes addressed in this component are open to 'basic research' as defined above in the introduction to Challenge 8.

Theme 5: Cultures, creation and heritage

An interdisciplinary approach to cultures and religion

The study of cultures, creation and heritage sheds light on societies' diversity, the transformations of cultural, economic and political practices, as well as mechanisms of integration, adaptation and innovation. **The social sciences and humanities** are invited in their entirety: Archaeology, art history, language, history, geography, philosophy, anthropology, sociology, law, economics, political science, cognitive science, as well as musicology, arts, architecture, design, archive, the study of religious faith.

The emergence of cultures and their manifestations (written, oral, audible or visual material), dissemination and transformation can be addressed from a synchronic or diachronic perspective, from **prehistory to modern times** spanning **all cultural areas**. Research will focus on individuals or groups, on artistic, philosophical or literary currents, and the movement of concepts and ideas. They may be carried out under the angle of archaeology, connected or comparative history studies, archival studies, genetic editing, as well as global studies and cultural studies.

Researchers shall put emphasis on religion in its historical and cultural diversity; formation, transmission and use of sacred texts, rites and beliefs, revivals and conversions, educational or worship-based institutions or networks, relations between sacred and profane art, the place of religion in public spaces, the role of religious identity as a force of division and consensus. The specific case of France should be placed in a comparative or historical approach fostered by empirical data, heedful of other possible configurations of the relationship between society and religion.

Prehistory and history of cultural and cognitive phenomena, fate of languages

The diffusion of cultures can be studied in a long-term vision embracing prehistory. The development of bipedalism, the making of tools, the acquisition of languages, learning, the development of communication systems, the expression of emotions, social and gender-based divisions of labour, creative activity; all of these phenomena and cognitive mechanisms interact with the environment and make reference to a **long history** of adaptation and creation from prehistoric times to the present.

Languages are an integral part of cultural heritage; the European Union intends to foster this heritage by supporting foreign language learning. However, Europeans' **language skills** have only moved backward, with the exception of English. Regional languages are fading, knowledge of Latin and Greek has declined, immigrant languages are confined to use at home; what are the costs and impacts of these phenomena? Though research on **endangered languages** is still necessary (90 percent of them are set to die out before the end of the century), we must also reflect upon the social contexts and policies which help or harm them. The discussion should also extend to computer languages and their connection with natural languages.

Creation, works and creators

Research shall observe the process of creating new works (cognitive, social, economic) throughout all eras. Researchers must also study creative processes by studying the works' **origins** (artistic, literary, musical, theatrical, film, TV, videogames), their **reception** and their **interpretation**. Research will give a privileged place to texts, works and **authors**, their career paths and networks. **New corpora** may be established in a monographic or prosopography approach (single author or a population of authors). Other areas to be studied are the circulation of works, models and ideas between the arts and cultural areas, the migration of forms, their processing and their hybridisation. It will also look into the actions that may induce or trigger the works (educational, divisive ideological positions).

Far from exhausted, **the study of the relation between emotion and creation**, among artists and the general public will benefit from the joint efforts of SHS and neurosciences. Projects in visual studies or sound studies, interdisciplinary by nature, are expected, as well as projects involving artists and researchers, to understand the process of creating or artistic devices in the various fields of contemporary creativity.

Other dimensions may be addressed; the study of **techniques** (tools and media) and their transformations, the role of the senses in creation (sight, hearing, touch), collective art forms, the role of academic institutions and the market, the synergy between artistic creation and technical innovation, renewing practices, as well as the **economy for and laws concerning creation** (public and private support, cultural industries, copyright, etc.). These dimensions can all be considered in terms of innovation: updating of techniques and practices, marginal expressions, the decisive role of performance and gender relations. Researchers will look into how the **arts are taught**, the transmission of practices, and interpretations and interplay in current and historical perspectives.

Transformations of cultural and heritage policies

In projects able to bring together researchers and professionals, the study of the process of heritage and usage shall identify the **social and political challenge posed by heritage**, identity claims to which it is subjected and the role of public and private or parapublic actors. Substantive issues shall not be eluded: What do we call "heritage" (the terms set forth in the official heritage creation and indigenous languages are not always identical)? Researchers will study what constitutes heritage and whether it is tangible or intangible (sites, landscapes, customs, works, figures). They will evaluate the attractiveness of heritage abroad and its contribution to countries' economies, tourism, and the promotion of regions. Research will cover **cultural landscapes, heritage museums, organisations and companies**, as well as the **history of museums and their audiences**. Digital documentation of heritage will be given its rightful place in the form of GIS or written, oral, visual, and audio-visual archive corpuses, explicitly created for research purposes. The study of **heritage endangered** by armed conflicts, vandalism, environmental changes, demographic pressure or tourism opens up broad search fields. Now the challenge is research on new ways of **safeguarding** it(3D simulations, storytelling, appropriation by populations). International and transdisciplinary collaborations in this area are strongly urged.

Heritage and its conservation also lend themselves to **projects with private partners** combining social sciences and the humanities and **materials science**. Researchers can also study the transformation of urban, industrial, landscaping and religious heritage, its promotion and “de-patrimonialising". The study of **cultural policies** and their history (classification, labelling, preservation, financing, management, but also cultural, intercultural and artistic education and mediation policies) should inform the respective role of international organisations, States and local authorities, as well as occasional tensions with local actors. **History and heritage of cultural administrations and public policies** should also be given consideration.

Reminder: The themes addressed in this component are open to ‘basic research’ as defined above in the introduction to Challenge 8.

Theme 6: The digital revolution and social change

Projects submitted under this theme will analyse the impact of the digital revolution on society without analysing digitalisation from a technical standpoint. Digital joint projects in the social sciences and humanities are to be submitted to the joint initiative provided for this purpose.

Effects of digital technologies on the economy, trades, and national sovereignty

Digital technology changes our relationship to the territorial realm and alters frontiers between work and private life as well as experts and amateurs. Tele-work, instant access to services and the virtual extension of reality are forms of progress that raise hopes of unprecedented **gains in productivity**. Unfortunately, the economic growth rate of the best-equipped countries has not kept pace. This is called **Solow's paradox**, and French research must continue to contribute to this debate.

The rise of digital technology has shaken up a number of **trades** (postal workers, taxis, publishers, booksellers, journalists, translators, etc.). "Creative" or irreversible destruction? What conclusions can be deduced from the dematerialisation of services in terms of qualifications and jobs? **The expatriation of individual data and the digital tools which process them** is such that the intermediation services between states and citizens are in the process of being transferred overseas, including tax data. What are the strengths and weaknesses of Europe's digital industry **when compared to North American and Asian** competition? Are regulatory bodies and legal instruments (computer laws and freedoms, the Hadopi Creation and Internet Law, French Intelligence Bill, etc.) capable of taking up the challenge launched by the American internet giants and the mass collection of personal data for monitoring or marketing purposes?

Lawyers, economists, political scientists, and sociologists are invited to launch innovative projects on this transfer, which raises substantive questions on internet governance (ICANN, cross-border istf 3WP, etc.) and involves the sovereignty of the European States.

Effects of digital technologies on cultural practices and teaching, MOOCs and SPOCs

Researchers should bring studies on the effects **of digital technologies on cultural practices** up to date. To what extent does the self-production of content, the ubiquity of recorded music or the extension of social networks **democratise knowledge, culture and creation**? Do they offset the now dated drop-off in interest in reading by bringing about new forms of expression? It may be valuable to compare data from the French Ministry of Culture on the diversification of practices with the PISA surveys on the ability of young people from underprivileged backgrounds to handle everyday writing tasks.

The effects of digital technologies on behaviours; legal dimensions and the ethics of digital technology

The **impact of digital technology on behaviour** is ambivalent, since the internet can act as both a problem and a solution (ex: plagiarism and its detection). Have video games changed our **cognitive capacities** or exacerbated or channelled **violence**? Is sitting in front of a screen more socially isolating than being absorbed in a book? Have social networks kept their promises? The **ethical issues raised by digital technology** also need to be addressed. An unwritten social contract ensures everyone the right to sign up; but then service providers turn around and **note users' interests, record their data** and determine **their profile to** be sold off to third parties. How can we guarantee the **right to be dereferenced** considering the small number of cases handled by the CNIL compared to the great mass of requests handled by Google? Does the internet giants' stranglehold on individual data affect European states' room for manoeuvring?

The transition from demographic data or administrative data to big data

This priority is part of the cross-cutting big data theme present in most of the challenges, starting with Challenge 7. *It is treated here from a humanities and social sciences perspective and through the criteria laid out by Challenge 8.*

We call big data digital data sets too large to be processed with micro-computing tools only. This data is **deemed** exhaustive and *ipso facto* representative without drawing samples, because they would cover the totality of the real world connected in the way that maps are co-extensive with pieces of land. The object of this theme is to **study,** from an SHS standpoint, the social and scientific implications of switching from conventional data to mass data, but also the possible alternatives offered by small data or self-service data.

The *UK Data Forum* launched by the Economic and Social Research Council emphasized the already massive character of **demographic data**: civil registry data and censuses are exhaustive *big data* sources. The University of Minnesota's **IPUMS database** brings together 238 censuses from around the world. There are 300 demographic and health surveys (**DHS**) in the world. By adapting the British typology, one can list and analyse the **big data of interest to research in the social sciences:**

- Civil status: births, marriages, civil unions, deaths ;
- Universal case management files: voting, taxes, passports, social security…
- Specialized files: individual, educational, hospital, legal data...
- Commercial transactions: credit cards, cash registers ;
- Tracking internet users: queries, downloads, social networks, blogs ;
- Telemetry data: cameras, road traffic sensors, GPS data ;
- Satellite images ;
- The collection and analysis of learning processes (learning analytics) associated with MOOCs ;
- Radio and television archives (developed and maintained in France by the INA or French National Audiovisual Institute).

The archive contains a potential gold mine of data for social sciences research. Serious questions have also been raised about the lack of **transparency** during their setup, the **complexity** of their architecture, and doubts about their real **coverage**. Are they durable enough to ensure the sustainability of TV series? Are there enough qualified researchers to process this data and unleash their research potential?

To do this, there is a strong need for **cooperation** between managing administrations, statistics institutions, *big data* specialists and control instances (CNIS, CNIL, ethics committees). The researchers will not lead this cooperation but may define its scientific and organisational requirements and carry out necessary experiments. It is necessary to **take stock of French and foreign experience**s in the matter and speculate on the transposition of practices from one country to another (technical, legal, cultural problems). One major challenge is methodically identifying **data of public interest with strong research potential**.

Scientific exploitation of *big data* by social sciences and the humanities entails the removal of certain barriers. The first is the inadequacy of **theories for modelling the interactions and networks** which structure social interactions. Researchers should ask what kind of people continually frequent the same people and places? Who discusses with whom? Who trusts who? Who helps who? Questions revolving around duration: which people do we see the most regularly? How are relationships rebuilt or diversified over time?

The second obstacle is the lack of **data** visualisation software capable of exploiting the laws of synoptic perception, making out field lines, picking up on odd cases or outliers without impoverishing data; this can help with decision-making. Taking up such challenges requires an alliance of humanities and social sciences disciplines (sociology, economics, cognitive psychology, geography, management sciences etc.) with a strong expertise in "semiology of graphics" and mathematical and computer networks.

Beyond these challenges, critical issues arise. When *big Data goes unregulated,*what are the **risks to privacy, security** - or even **dignity**, when children and minors are involved? Under what conditions do we disseminate information (open, anonymised, private)? Which entities are given access (State, individual, private sector…)? What is the connection with other public or private data (for example, commercial access , "security" data)? How do such issues affect entire sectors' values as public services (healthcare, education, justice) as well as the value of the internet as a public service? How do international treaties as TAFTA come into play? What about public policy comparisons in this area?

Researchers shall also shed light on the growth of **individual and collective knowledge thanks to *Big Data.*** Nothing is preventing the decision making and behavioral sciences to integrate "common good" criteria" based on social utility, environmental responsibility and well-being, by analyzing both the cooperative and competitive sides of
inclusive behavior, t on social networking, through *crowdsourcing* or the increasing power of actors to interpret the signs and intentions of others..

Reminder: The themes addressed in this component are open to 'basic research' as defined above in the introduction to Challenge 8.

Theme 7 : The Digital Revolution and its interaction knowledge and culture *(Joint theme with challenge 7)*

This theme is common with Challenges 7 and 8. Projects submitted will be evaluated by a balanced joint committee whose evaluators will come from both human and social sciences and digital sciences backgrounds.

- *Projects must be proposed by **an interdisciplinary team or partnership**, composed of both specialists from computer sciences or ICT and SSH researchers;*
- *Progress can relate to a single disciplinary scope (SSH or ICT) if they draw from concepts or tools generated by recent advances in the other field**.***
- *These two conditions are not administrative criteria governing eligibility, but are rather meant to provide an incentive to submit an interdisciplinary project. Joint action is not appropriate for projects which would lead to two unrelated sets of tasks in two different research fields (SSH, ICT).*
- *Since SHS-digital joint programming cannot encapsulate all of the themes under each challenge, it will focus on three of the National Research Strategy's flagship themes:*
  - *The digital revolution and new relationships knowledge: Education and training,*
  - *Creating and sharing knowledge in the digital age,*
  - *Digital revolution and e-heritage: research on heritage, audiovisual archives, and the digital arts.*

Education and training

Digital technology for education and training applies to all levels of schooling and types of training, classroom-based and distance learning, alone or in groups, in a national or international language, whether the need stems from an exacting professionalism or a will to learn. Ethical and legal issues, notably privacy, should not be neglected.

The digital revolution is expected to bring about progress, including the possibility of lifelong learning with a view to reducing the cognitive effects of ageing and disability, and narrow socio-economic and regional inequalities. The potential to transform educational and training systems is considerable, but this potential must be checked through controlled observation and the measuring its limits and prospects. To this end, projects should combine computer sciences and ICT with other disciplines such as psychology, linguistics, subject didactics, educational sciences, sociology and geography.

Learning with digital technology will enable us to benefit from both recent advances in digital techniques and cognitive sciences so that people can learn in optimal conditions. How can society create smart learning paths tailored to the needs of individual learners — (**adaptive learning**)? How can we track the progress of individual learners (**learning analytics**)? How do we improve long-term memory (**use of assessment as a learning method**)? How can we **assess** the solutions for mediated learning proposed?

Such questions call for research on **modelling** learning, developing enhanced indicators, and considering the **role of communities** and networks in learning. It will also explore how digital technology can help to spread and maximise phenomena contributing to **life-long learning**. *For example, research shows that test-taking significantly improves long-term learning: taking a mid-term test increases students' long-term memory for test material whereas looking back over materials often results in better short-term retention. As digital technology makes it possible for generalised testing outside restrictive classroom learning settings, it may be useful to explore benefits for older adults or in work contexts.*

Digital learning has become essential both for getting by in everyday digital environments (**digital literacy**) and meeting the needs of qualified personnel in digital professions and trades that are "going digital". Emphasis will therefore be placed on training in numerical & data processing (in particular **computer coding**) from an early age, as well as the development of digital literacy among teachers. Questions arise concerning didactics: How do we teach about digital technology? Computer sciences and programming have become crucial to new programmes in education (primary, junior, and secondary schools). Project-based lessons should seek to identify and understand difficulties in the transmission, understanding and use of IT concepts.

To learn the digital era is to experience the effects of digital technologies on informational and cultural practices. The permanent availability promised by massive, nomadic and connected equipment changes values and behaviours. Research combining the study of digital practices with the other dimensions of social life are needed, in particular in the field of education, for cases in which educational institutions are based on organisational methods which may not be in line with social and cultural changes attributable to digital technology. Does the self-production of content, the ubiquity or extension of social networks democratise knowledge, culture and creation? Do they offset the drop-off in interest in reading by bringing about new forms of expression? The hopes placed in massively open online (**MOOCs**) and courses for (**SPOCs**) deserve careful consideration. Research is needed to analyse experiments launched in Europe and abroad, their economic model and their ability to reach **target audiences**.

Creation and sharing of knowledge

Digital technologies directly affect **scientific practices,** including the definition of objects, observation and data collection, formalisation of assumptions and results, collective research, publication, etc. Research under this theme shall explore how new approaches enabled by digital data are leading many specialist fields to thoroughly overhaul their concepts and methods. Theoretical informatics as formal discourse on the conditions of knowledge, discourse analysis extended to controversies and arguments using techniques for searching textual content, or even the financial economy, with real-time data processing, are a few examples of epistemological issues.

We will also look to the competition or the complementaries between digital and paper writings, between the experimental and simulation, between the direct observation and researching using representations assembled from data, between the theoretical construction and exploitation of big data using statistical learning techniques. The use of big data raises important question concerning the effect of technological mediation for preparing and presenting data on understanding phenomena and researchers' intuition. **Epistemology, the cognitive sciences, ethics, the humanities and the social sciences** may be called upon for science and digital technology.

The very construction of knowledge itself may be the subject of research on recording, publishing and dissemination processes. More specifically regarding developments in the dissemination of technical and scientific information (IST), various issues should be examined including editorialisation and open access publications and valorisation of research data (notably through developing technologies for text and data mining). The establishment of new relationships among researchers and between experts and lay reader via freely available results (participative sciences, collaborative tools, platforms, etc.) is also part of these considerations.

Digital product tools that may in and of themselves constitute subjects of research. For example, a collaborative platform such as Wikipedia could serve as an observatory of contribution practices to the creation of shared knowledge. Research teams can contact Wikimedia Foundation France to obtain information.

Culture and heritage

Influenced by digital sciences and technologies, professionals and the general public are changing their relationships to objects in areas of heritage, culture and leisure.

Heritage objects: *Heritage objects (collections, sites, etc.) raise new challenges for acquisition, collection, processing, review, displaying, indexing, archiving, conservation and preservation (by incorporating the notion of quality data sources).*

Along with the humanities and the social sciences, digital sciences and technologies are heavily involved in research on **restoring and preserving 2D/ 3D and multimedia heritage.** Alongside social sciences and humanities, digital science and technologies are used in research to restore and preserve cultural heritage in 2D/3D and by using multimedia. Digital storage capacities are also increasing the number of documents with potential heritage value. How should new heritage objects be represented?

This priority does not concern the entire part of the data collection to be digitised (see Theme 6 under Challenge 8) but only data which raises **complex or unprecedented digitising problems**: frames sets, landscapes, objects, audiovisual documents, interactive data... The objective is to harmonise databases, as well as analyse and develop them while renewing **the design and processing of data**.

Project coordinators are encouraged to contact **TGIR Huma-Num** (very large digital infrastructure research for the humanities), which mobilises research networks seeking out best practices (geographical information systems, 3D reconstruction of monuments, texture analysis, etc.), an entity affiliated with **ERIC DARIAH** at the European level. This primarily concerns **museums** and audiovisual **archives** such as the **National Audiovisual Institute** (INA) which now provides researchers with: a wealth of data such that it requires close collaboration between researchers in SHS and those in digital science and technology; it offers an opportunity to update methods used for processing, annotation and indexing. The results of this research (annotations, enhancements, metadata, etc.) will be **freely available** and usable for other research. Researchers interested by this vast body of material should contact INA (http://dataset.ina.fr).

In view of the prospects raised by the digital revolution, museums are obliged **to rethink the way** they manage their collections. How should museums be made available to the public? How should they be organised and documented? Can the State apply its standards for labelling, inventory or classification to a material or immaterial heritage proposed by users? How should the relationship between **experts and non-experts** develop in this context?

Access to Heritage *The study of heritage tourists' practices calls for collaborations between ICT and SHS. New research techniques now make it possible to follow people closely as they visit museums, exhibitions, sites and cultural and artistic events, while noting their diverse characteristics (age, level of education, nationality, command of cultural codes, disabilities, etc.). Art therapy experiments will be given special consideration.*

Digital technologies integrated with local museums, their web portals and their mobile applications are revolutionising the **public's relationship with collections**. These technologies enable remote access and the exploration of virtual collections. Cultural mediation can therefore acquire a new dimension through individual and collective experiences, blending nomadic and immersive devices and mixed (augmented) reality. The same goes for **history of art and art education**, which is now enhanced with an interactive dimension (cyber museums). These new processes should be tested and, if possible, we should anticipate their future developments.

Reminder: The themes addressed in this component are open to 'basic research' as defined above in the introduction to Challenge 8.

Theme 8: Public health (common to challenge 4)

Health Inequalities: causal chains, public policies, databases

In this approach, which considers dialogue as a complex phenomenon derived from more primitive behaviour, dialogue systems are seen as cognitive agents capable of engaging in advanced interactions with humans while completing other tasks. In this vein, and in connection with the theme priority “Autonomous and interactive robotics”, proposals at the intersection of cognitive, communication-based robotics and intuitive human-robot interactions, which also address artificial intelligence issues, will be encouraged. As in 2016, project evaluation will be undertaken by a single ANR interdisciplinary evaluation panel within a single interdisciplinary committee.

According to the World Health Organisation, public health research should identify the following:

- the complex causal chains giving rise to pathological and physiopathological mechanisms and variations in morbidity and mortality resulting from socio-economic, gender, environmental and cultural inequalities;
- the processes by which health shocks or chronic pathologies may exacerbate socio-economic inequalities;
- the part played by the health and protection services in the fight against these factors

Other objectives include:

- sorting out the interactions between the different kinds of determinants: genetic, environmental, social, behavioural and those linked to the healthcare system;
- Delineating and evaluating the interventions able to reduce health inequalities and vulnerabilities;
- Measuring the ability of public policy to improve efficiency and equity in healthcare, social protection and healthcare insurance systems.

These manifold objectives call for an **interdisciplinary approach** combining social sciences and the humanities with cognitive, biological or medical sciences. Giving consideration to both qualitative upstream or downstream developments as well as new data collected, researchers are encouraged to make use of existing **large databases** and cohorts, whether they are focused on general population or specific illnesses.

Themes

The themes covered are far-reaching: normal and abnormal **ageing** (dementia, Alzheimer’s, Parkinson’s disease, etc.), **polypathologies**, **mental health** and behavioural disorders, developmental disorders (autism spectrum disorders, **addictions**, etc.) and psychoactive substances, **handicaps** and restriction on work and social participation in life. This definition includes **links to environment and health** and the design, evaluation and dissemination of **biomedical innovations**. Also included are advances in the biological sciences and medical techniques improving therapies as well as the prediction and diagnosis of diseases and their risk factors, and the transfer of these approaches to the social sector's biomedical modes of action. Another important theme: **cognitive behavioural therapy** with a view to “personalised medicine and care”.

The **welfare of elderly persons and children who are dependent** and/or suffering from serious illness, without overlooking their caregivers (family and skilled or unskilled staff) is critical and goes hand in hand with the success of health and caregiving policies. Consideration may also be given to the implementation and evaluation of **specific training for caregivers** (especially when it comes to relatives or unskilled staff).

It may be relevant to explore the tensions between, on the one hand, **policies targeting vulnerable groups** excluded from access to healthcare and social services or having low social capital, and **more comprehensive policies against inequality and discrimination** throughout the whole population.

The rise of “**shopping around**” for health and social services, due to increasing levels of

education and access to public information should be looked into; It could contribute to user social movements and calls for greater sharing of information and decisions. New practices including the **self-informing of patients** challenges information policies implemented by practitioners and public authorities. New practices also call into question **health monitoring policies**.

Lastly, research shall examine the **diversification of care practices** ('soft' medicine self-treatment, etc.), which goes hand in hand with demands for quality of service, the degree to which reception in care facilities is attentive and welcoming and the bond between patients and caregivers and between practitioners and users.

If the health aspect is predominant in the research project, the **impact of the employment situation and working conditions on health** are to be submitted under this theme, rather than Challenge 8's "Work" theme.

Research may also cover the health of migrants and health in prisons, homeless, etc. — in general, the link between **health, poverty or vulnerability,** bearing in mind that the concept of '**vulnerability**' can have a wide variety of applications: life's critical age periods, lack of status, socio-geographical margins, exposure to environmental hazards, potentially traumatic individual or collective events. Relevant topics are numerous: economic, social, political, environmental; the situation of developing countries is also covered.

The ethical, legal and philosophical dimensions of public health

Public health research cannot ignore the **principles of justice which govern access to care** (public or otherwise) and come into conflict with economic and social realities: regions' uneven resources, varying ability to mobilise personal networks and information systems, reliance on parallel medicine, coverage and cost sharing (insurance, mutual societies, special regimes, CMU, AME), prioritising of actions between patient categories (according to generation, rarity or frequency of illness, unequal chances of survival, etc.), without overlooking **dilemmas** related to the beginning and end-of-life, emergencies or crises.

Throughout this research, the study of **perceptions** and **representations** is essential (as evidenced by the increasing refusal of vaccination or compliance issues) and calls for an objective analysis of **debate and controversy** in public health matters.

Reminder: the themes addressed in this component are open to 'basic research' as defined above in the introduction to Challenge 8.

Challenge 9 : Freedom and security of Europe, its citizens and its residents

EUROPEAN AND INTERNATIONAL COLLABORATIONS

The 2016/2017 topics prioritised for international backing are detailed below and also listed in annexes 1 and 2 of Work Programme 2017. Lists are subject to change, applicants who wish to conduct their projects at the European or international level should regularly consult the ANR website for more information on these partnerships and calls for proposals: http://www.agence-nationale-recherche.fr.

CHALLENGE COMPETITIONS

The "Malin" challenge competition (mastering indoor localisation): A call for proposals in the field of the Indoor Localisation in critical situations launched in partnership with the French Defence Procurement Agency (DGA). Malin deals with a topic thematically linked to Challenges 7 and 9.

The precise localisation of emergency intervention officials (civil security, firefighters, etc.), police and armed forces in a closed environment serves an operational function of great importance but which is difficult to fill in the absence of technologies adapted to technical demands (compactness, energy consumption, computing power, location, positional accuracy), technological demands (variety of sensors needed during missions) and environmental constraints (lack of or poor reception of GNSS signals...).

Currently, there are a multitude of indoor positioning systems that work in collaborative environments for "commercial" civil applications, using for example beacon-based technologies installed in buildings transmitting and receiving radio signals (GNSS, Wi-Fi, UWB, etc.). These systems do not meet civil and military localisation needs for operation in buildings in terms of both conditions of use and expected performance.
New solutions being lab tested could go some way to meeting these needs, but they are not mature enough to be industrialised. With technical maturity increasing, the DGA and ANR have came up with a challenge dubbed "Malin" (mastering indoor localisation).

This challenge will be contested by several teams whose proposed dual (civil/military) technology solutions will be evaluated in demonstrations spread over 3 years.

The objective of the challenge is to make progress in the field of localisation of obstructive indoor environment. Research must make it possible to: I) evaluate by comparison several architectures of technological solutions enabling the localisation in complex environments of different types of buildings, fields, basements, metros, mines, tunnels, etc. without the constant availability of Gnss signals (global Navigation satellite system); ii) to advance innovation in the field of the location of the autumn infantryman for military applications and the agent of intervention for civil applications; iii) to address the issue of indoor-outdoor transitions.

INTERFACES

This challenge involves cross-cutting research topics relating to more than one challenge. The other challenge(s) to which these topics relate is (are) indicated below, so that applicants may orient themselves towards the most relevant challenge for their project. Applicants are strongly advised to read each related challenge in its entirety to gain a thorough understanding of its specific scope.

For information concerning cross-cutting theme areas, most of which fall within the scope of multiple challenges (including Challenge 9), readers should refer to the paragraph entitled "**Multidisciplinarity, cross-over and interfaces**" (pages 39-42) covering the following fields: ***Big Data, Robotics, Sensors, Biology, Bioeconomics & Biotechnology.***

The following fields are also interfaced with Challenge 9:

Cybersecurity, protection of information systems, cryptology and biometrics: Research projects on these topics, including highly upstream projects and proofs of cryptography algorithms, should be submitted under Challenge 9. However, security and operational reliability as properties of a software application or a communications or computing infrastructure, if research focuses on specification, verification, validation or demonstration methods, may be addressed in Themes 3 or 7 of Challenge 7 .

Violent radicalisation: violent radicalisation as the more general issue of social integration falls under Challenge 8.

Crisis management (whatever the origin of the crisis) on an operational, organisational, logistical and economic level, amongst others, falls within the scope of Challenge 9.

Natural risks and the potential origins of a crisis (characterisation of unknowns and risk factors, tools and methods for observation, etc.), forecasting systems, assessment of threats and alert thresholds, etc., fall within Challenge 1.

With regard to **biological risks**, Challenge 9 only covers the management of risk situations and the management of biological crises strictly related to bioterrorism (including specific detection systems). See the "Biology" section in the paragraph entitled "Multidisciplinarity, cross-sector research and interfaces" for guidance on other aspects.

Research projects on **industrial risk** management only fall within Challenge 9 if their applications or conclusions cut across several thematic challenges.

Research in the area of **risk management associated with urban and transport infrastructures** which addresses general topics involving security, but which is not entirely focused on the issue of security, falls within the scope of Challenge 6 .

POTENTIAL CO-FUNDING[36] FOR PROJECTS SUBMITTED TO THIS CHALLENGE

Projects submitted under this challenge may be co-funded by the DGA (the French Defense Procurement Agency) or the General Secretariat for Defence and National Security (SGDSN)

Introduction

Research on the freedom and security of European citizens and residents and more generally of people living in the European Union requires an integrated approach to risk management in both physical space and cyberspace. This ranges from the characterisation of threats and vulnerabilities development of prevention and protection mechanisms for property and persons, to crisis management. Research must also analyse legal instruments, including the exercise of individual rights and freedoms. The scope of this challenge covers but is not limited to, all research (regardless of disciplinary lines and multidisciplinary research disciplines-) able to contribute to clarifying the government's sovereign and non-sovereign security-related missions, to the definition of protection procedures of all critical infrastructure and even the role of public and private entities crucial for the proper functioning of the nation. Of course, these aspects cannot be divorced from a firm guarantee of fundamental rights[45].

[36] Co-funding means that funding is partially allocated by ANR, with the remainder coming from one or several of the agency's co-funder partners.

All issues are to be considered against a backdrop of the accelerating deployment of new technologies, with consideration given to digital technologies, which offer opportunities to citizens, administrations and businesses but also create new vulnerabilities. We must heed and address the increasingly intense traffic of people and flows (merchandise, capital, information and other data), regardless of the networks used.

Any research involving the freedom and security of people in Europe must be based on an in-depth reflection on risk, in a context where security is associated with perception and risk management, as well as with social responsibilities and their impacts. Challenge 9 focuses on the **challenges and consequences** for entities and institutions responsible for security, professionals in at-risk jobs and populations regardless of the **risks envisaged**, whether natural (including pandemics) or man-made (intentional or not).

This challenge therefore addresses crisis management, whatever the origins and dimensions of the crisis may be (human, technical, organisational, etc.). Research will therefore necessarily borrow from sociological, economic or legal views as well as technological research. Researchers will also look at peoples' security and the fight against terrorism and crime, emergency assistance and human protection, and the multiple procedures for searching for and determining the admissibility of evidence. Research is also expected on the protection of vital infrastructures and networks as well as the protection of sea, land and air spaces and their borders. All of these aspects imply a need to respect personal privacy, the protection of human dignity, and especially personal data protection in a potentially intrusive technology environment.

All of the above-mentioned topics relating to freedom and security are to be considered both in natural and digital environments (commonly referred to as cybersecurity) and in an integrated approach in which a security system necessarily combines both environments. Ensuring cybersecurity for Europe and for its citizens and residents will require solutions derived from multidisciplinary research. Given the nature of the issues covered in this challenge, particular attention should be paid in all themes to compliance with legal and ethical requirements[37].

Many types of research could be mobilised to address this challenge. Whether the end goal is technological or not, research and innovation must become synonymous and mutually integrated, until scientific and technical fields feed into each other naturally. **Fundamental or very upstream research** is necessary for the creation of a knowledge base. Whether or not their aims are technological, research and innovation must often bring together natural and environmental sciences, digital sciences, engineering, and the whole of the humanities and social sciences **in one integrated approach**. In all projects for which it is relevant, the involvement of end-users, regulatory authorities[38] or operators[39] is encouraged, as is the consideration of needs expressed by the French security industry[40] and other vital sectors (particularly energy, water treatment, transport, etc.).

[37] Article 1 of Law No 78-17 of 6 January 1978 on data processing, data files and individual liberties. General Data Protection Regulation — 2016 — Regulation (EU) 2016/679 of the European Parliament and of the Council of 17 April 2016 on the protection of individuals with regard to the processing of personal data and on the free movement of such data and repealing Directive 95/46/EC (General Data Protection Regulation), OJEU L 119/1 of 4 May 2016.

[38] regulatory authority: authority imposing rules, standards, and guidelines for security.

[39] operator: public or private organisation, producing goods or services and which must ensure the safety of its users, customers, employees, citizens and the environment.

[40] especially orientations of the Joint Committee for the Security Sector (cofis, www.cofis.fr)

This challenge is divided up into five themes:

1. Fundamental research related to the challenge
2. Risks, management of crises of all types, resilience of systems
3. Security of people and entities; fight against crime, terrorism and violent radicalisation
4. Cybersecurity: freedom and security in cyberspace, securing information systems, fighting cybercrime and cyberterrorism
5. Protecting vitally important infrastructures and networks, monitoring sovereign areas

The main research applications in this challenge are defined according to the end users of the research and concern all of the challenge's themes except Theme1, for which the main application is the creation of new knowledge.

- Public policies, standards, the legal and societal framework
- Preparing and equipping people and organisations; understanding individual and collective behaviour
- Technology, equipment, systems, sensors
- Information and communication systems
- Methods and organisations

The three priority areas of the French National Research Strategy (SNR) which concern Challenge 9 of the ANR 2016 Work Programme are as follows:

- Theme 39: Preventing and anticipating risks and threats
- Theme 40: An integrated approach to crisis management
- Theme 41: Resilience of security systems

Theme 1: Fundamental research related to the challenge

Theme 1 is about fundamental or highly upstream research (TRL 1 to 2 for technological research) and the development of a body of knowledge relevant. Projects whose primary aim is not a direct application in a field covered by the other themes are welcome under Theme 1.

We are interested here in the frontiers of knowledge, understanding phenomena, concepts and tools, creativity and social change regarding security. Prospective high-risk research able to introduce technological breakthroughs or deliver a high level of innovation are a priority target of this theme, especially at a fundamental level.

For projects submitted under this theme, it is still expected that research subjects, applications or purposes (even in the long-term) be clearly positioned in relation to at least one of the challenge's more application-oriented themes (2 through 5). No disciplinary fields are excluded, provided this requirement is met. Interdisciplinary research is naturally expected, given the complex nature of the issues which may fall under this challenge.

Exploratory research is also encouraged to develop strategies or technologies that will enable efficient leverage of the interdependence between digital and physical environments in order to process the stream of information available and to derive the relevant knowledge for surveillance systems, protection and decision assistance.

Fundamental research is encouraged in the following three major thematic areas (the examples given are indicative, and do not in any way purport to be exhaustive):

- Humanities and social sciences-based research is strongly encouraged and innovative proposals for the human element of security is expected. In particular academic research in this area with impacts on public policies, on possible developments and changes in collective and individual human behaviour, or the investigation of new terrains, are encouraged;

- digital science, including their most upstream and forward-looking components, also have a central role to play in this area, particularly in the broad discussion on security;

- Lastly, sciences and technologies other than ICT lie at the core of prevention, surveillance, crisis management and resilience topics. Proposals for technological breakthroughs and new concepts of employment are particularly encouraged.

Theme 2: Risks, management of crises of all types, resilience of systems

The challenge here is to propose approaches, or testing on specific cases, methods and tools, to better diagnose and understand threatening situations, account for whistleblowers, identify attempts to influence and to anticipate, and prevent and manage crises and their consequences.

Knowledge and anticipation of risks and threats

Attention will be paid here to sociotechnical, technical, or organisational **systems** which, if disrupted, could threaten the safety of persons and property or bring about a crisis. The challenge is that of integrating security issues at all stages of life systems, from the design stage to decommissioning, and in all aspects (technical, human, organisational, legal, etc.) and at all levels (local, national, European or international) for emerging technologies.

Research should **propose methodologies, methods of organisation and decision support tools**, including those based on models or big data analysis, etc.). A major effort will be focused on taking account of human and organisational factors. Researchers may also make use of analyses derived from social psychology and behavioural sciences or propose methodological studies and tools to assess the legal and economic impact of implementing security solutions. It will also look into the legal process of standards development. Approaches addressing security and dependability as well as business continuity systems are also encouraged.

An integrated approach to crisis management

The goal is to prevent crises and, when crises hit, minimise their impact and duration. Research must be concerned with the preparation and equipment of persons and organisations responsible for responding from its start, from detecting warning signs to restoring normalcy (resilience), as well as the information, participation and feedback from stakeholders and the public.

Research shall focus on systems and information-sharing and decision support processes used for feedback and possible inquiries. This concerns inter alia the development of modelling and simulation of critical events, the capacity to acquire and process data hybrids and multilateral sources in real time for the development of decision support tools based on a risk assessment of threats and vulnerabilities, with appropriate human/system interaction. The use of “serious games” may be considered for modelling crises and training relevant personnel.

This theme also covers how best to handle those affected by crisis, whether as victims or information relays, especially through social networks. It also covers crisis communication with the general public and authorities, information dissemination and transparency, the organisation of collaborative vigilance processes, situation monitoring, rescue, evacuation and intervention.

System resilience, restoring normalcy and analysing feedback

Here we are interested in the conduct and management of the end-of-crisis, post-crisis and consequences. Dealing with the remaining problems that crop up or persist after the crisis has ended and whose effects are foreseeable in the longer term. Researchers may for example propose studies on the state of emergency in France.

In the relatively short term, there are logistical challenges, but also challenges accompanying and monitoring individuals affected by disaster from a health, social, psychological, legal or financial standpoint: displaced and separated persons and trauma victims count among these. Concerning the medium to long term, research will look at the development of methods and tools for feedback analysis, studies on disasters and their implementation in order to understand, prevent, manage or mitigate a number of effects had by future crises.

While the inclusion of resilience in the conception of a system able to set off a crisis is part of anticipation, the implementation of this resilience presents its own difficulties, particularly in the context of complex interconnected systems. Tools such as network theory and the analysis of processes of decentralisation may be called upon, especially for advance evaluation of socio-technical systems' resilience against different types of crisis risks. The comparison of the proposed measures with those made in other countries will be an asset to better assess their applicability.

Even when risks of crisis have not been anticipated, prevention of risks within a technical or sociotechnical system requires a holistic approach combining several approaches, for instance insurance implications. This is particularly the case where the introduction of a new technology is likely to generate new vulnerabilities in a system deemed to be safe.

For example, in the agro-food sector, several points merit specific research developing tools for: more efficient control of lorries, providers and visitors in the access to industrial sites, better tracking of transport flows (surveillance, tracking, protection, etc.), to ensure the authenticity and integrity of commodities and the traceability of goods.

Theme 3: Security of people and entities; fight against crime, terrorism and violent radicalisation

Theme 3 focuses on the fight against anything that could undermine the security of persons, property and organisations.

Freedom and security of people, protection of rights

This topic deals with the safeguarding of security and the fundamental rights and freedoms of persons in the face of risks. It also covers the provision of emergency assistance and the preparation and equipping of individuals and organisations involved in risk prevention and in restoring safe conditions, particularly the protection of first responders.

It also encourages the analysis and design of new tools for combining the strength of the technology to secure anonymity in accordance with legal principles (processing large volumes of data and/or highly heterogeneous data).

The fight against violent radicalisation processes

We are interested here in all mechanisms that can be used to prevent, monitor, analyse and counteract the violent radicalisation of individuals or groups. Typical applications include the analysis of social, cultural and geopolitical contexts favouring trajectories of radicalisation, analysis of discourse and rationale, strategies and policies of prevention and de-radicalisation. The aim is to develop general methods for the detection of potentially at-risk or extreme behaviours including the perception and analysis of weak signals, in accordance with fundamental rights and freedoms. All types of radicalisation leading to violent action are to be taken into consideration.

Research will aim to improve the prevention of potentially dangerous behaviours, increase the protection of persons, develop the capacity of players and identify unknown vulnerabilities, unidentified risk factors, weak signals, and emerging risks. It may also offer to develop tools to detect emerging rare events or signals in data streams, and so on.

Fight against crime and terrorism

This topic concerns the fight against terrorist activities (including the use of CBRNE[4150] weapons), petty crime or organised crime. It also involves the identification and protection of leads and clues for administrative purposes and the admissibility of evidence in judicial investigations.

Research will be directed towards the gathering and processing of clues and pieces of evidence found on crime scene investigation to on-site investigation resources able to access all electronic platforms on the spot, even if encrypted, the development of stand-alone and unmanned systems, technology for border controls or reliable and fast identity checks to automate checks and verification process without necessarily systematising it, analysis and monitoring of social networks and the deep web. Research could also address hidden analysis of financial flows and detect low signals, perform semantic and linguistic analyses of speech, detect and monitor IP addresses, and correlate ephemeral multi digital data sources (audio, video, location, SMS, metadata, etc.).

Research should enable threats to be assessed and their impacts (in all areas) to be analysed. The identification and prevention of risks and threats also covers new surveillance and alert techniques. Interactions with citizens such as calls to witness or info bulletins. Projects may focus on the detection of weak signals in a stream of big data, behavioural analysis, the processing of web content (social networks, video surveillance, clues about movements, open source data or legally accessible to public authorities) while respecting individual rights and freedoms.

Given the risks that counterfeit food, medicines, tobacco and other everyday consumer goods represent for people safety (in terms of food and health, etc.), methods to guarantee the traceability of everyday consumer goods are also among the solutions that should be developed in this theme.

Tackling the challenges associated with the fight against crime and terrorism will require the **development of research on the organisation and workings of police forces (equipment)**. Research is also needed on public policies for surveillance and protection and their legislative consequences. Research on **methods that can be used to identify** and pursue perpetrators and on ways of repairing or compensating for damage to individuals and equipment are also welcomed.

Theme 4: Cybersecurity: freedom and security in cyberspace, securing information systems, fighting cyberterrorism

This theme mainly focuses on the risks, threats and vulnerabilities stemming from the addiction to digital technologies in our highly interconnected societies. Research involving encryption, virology, authentication, biometrics, information systems security, as well as law, economics, behavioural sciences, and sociology are welcome...

[41] nuclear, bacteriological, chemical and explosive.

The protection of information devices and systems

The aim here is to propose innovative approaches that protect information systems and all devices used to produce, process and store sensitive information. These proposals aim to ensure the protection of citizens, institutions, infrastructures, networks and tangible and intangible assets. The scope of research may range from the security of basic (including cryptographic) components to the security policies of a system of interconnected systems, the protection of digital data, and lastly human and organisational factors. It will also focus on cybersecurity instruments for E-government (administrative procedures, personal devices such as health insurance card or identity card, etc.), and e-democracy (electronic voting)[42]. Security technologies for the components and systems of the Internet of Things or for securing clouds should also be considered.

Where relevant, we will welcome transparent solutions, for example the use of verifiable open-source applications, in order to boost trust and reduce vulnerabilities by pooling expertise.

Projects may focus on initiatives that raise awareness and offer multidisciplinary for those involved in cybersecurity, as well as on tools to help master security solutions.

Cybersecurity of infrastructures, physical networks and equipment

The increasing proportion of digital technologies in the operation of physical systems, equipment, infrastructures and networks (transport, energy, etc.) is creating new vulnerabilities. The risk here is not simply data theft, but the alteration of software or the insertion of inaccurate information that may lead to critical situations. This risk is even greater as a result of interconnections with optimisation mechanisms in areas such as the energy transition (smart meters) or the circular economy (connected objects).

Areas of interest therefore include characterising and assessing the impact of risk scenarios or threats using digital resources; and methods for the design of secure systems that contribute to the widespread adoption of a systematic approach accounting for security and privacy from the design stage, particularly for SCADA-type industrial control systems or connected, piloted or autonomous vehicles that may interact with infrastructures or networks.

Fight against cybercrime and cyberterrorism

The focus here is on the fight against the use of digital technologies for illegal activities or activities which jeopardise the proper functioning of European and national institutions and authorities, entities and individuals. We are looking for research and solutions to combat the rise of offences and attacks either targeted directly against information and communication systems. Research should enable threats to be assessed and their impacts to be analysed. It will address the methods, means and tools for combating criminal or terrorist activities. Projects may include the detection of low signals in a stream of big data, behavioural analysis, the processing of web content (social networks, classified advertising sites, etc.), virology, the fight against malware..., whilst complying with applicable ethical and legal rules. Research on the computer attack topics may be considered, especially in social sciences and humanities and in full compliance with existing legal prohibitions.

Fight against violence and radicalisation in cyberspace

The anonymity of the web sometimes gives rise to behaviour, which, although not strictly classified as terrorism or crime, is still considered to be contrary to law and ethics. Research may be conducted into methods to combat this behaviour, which may be perpetrated by small groups acting alone in cyberspace. Given the international nature of the internet, scope for action is limited; however, efforts can be made to identify prevention methods – either technical solutions or initiatives to raise awareness – which promote ethical behaviour on the

[42] Regulation (EU) No 910/2014 of the European Parliament and of the Council of 23 July 2014 on electronic identification and trust services for electronic transactions in the internal market and repealing Directive 1999/93/EC — entry into force on 1 July 2016. JOUE L 257/73 of 28 August 2014.

internet.

Protection of rights and fundamental freedoms in cyberspace

Research should contribute to developing a framework of trust in services which will enable private and public companies and organisations to innovate and offer products and services that meet the needs of consumers and society as a whole. This framework of trust must also integrate ethical and legal challenges in all research projects dealing with security (ethical evaluation, implementing privacy by design) as well as research projects dedicated to empowering citizens (information, management and control).

Research combining knowledge and technological knowledge of social sciences and humanities on how to make sure that users remain at the heart of the system and retain control over their data and their exchanges (data decentralisation, encryption, anonymisation techniques, tools for data control and portability, etc.) will be particularly encouraged.

Theme 5: Protecting vitally important infrastructures and networks, monitoring sovereign areas

Protecting vitally important infrastructures and networks

The vulnerability of critical infrastructures and networks has greatly expanded under the combined effect of the increase in destructive capacity, the proliferation of potential targets, media coverage of attacks and ageing of protection systems. It is therefore important to provide a global security response organised around a precise and forward-looking assessment of threats and their consequences, vulnerabilities and measures to be implemented.

This topic mainly concerns reducing the vulnerability of critical infrastructures and physical networks (as well as related services), particularly in areas of energy, water supply, transport and telecommunications. Interdependencies between these infrastructures and with other infrastructures, particularly to improve the prevention and management of successive disasters (domino effect), are also of interest. This theme also concerns research on restricted sites and the combination of natural and technological hazards (natech).

The aim is to anticipate threats and to propose research concerning the prevention of risk situations and protection against the consequences of such situations. The management of crises resulting from the occurrence of such situations falls within Theme 2.

Research projects may involve characterising and assessing the effects of risk scenarios or threats, as well as designing protection against all types of risks and threats.

Safety must be integrated at the design stage. The development of safe and smart buildings may therefore be a valuable response. Security systems should be designed in a proactive approach to match threat level or an infrastructure's age. Potential target groups must be understood in the broad sense and include tangible, intangible and human assets. Finally, the adapting of legal and normative foundations linked to current and future security challenges must also enhance the research performed within this theme.

Regardless of which site concerned, the security requirements are unchanged: It is important to monitor, locate and protect people and property in real-world and digital environments. The two go hand-in-hand. If these are the most common needs, it is appropriate to consider the infrastructure environment to simplify solutions for the sake of balancing out technical means, human resources and doctrines. In particular, certain operational needs deserve special attention: active or passive protection against attack; identifying persons and overseeing the exercise of rights granted in order to detect abnormal or fraudulent behaviours; detection, tracking and monitoring of cooperative and uncooperative individuals in a controlled zone (closed or extended) to detect abnormal or dangerous behaviour and help to anticipate reactions; the detection of explosive materials and illicit devices during the construction and operation of infrastructure; optimising access controls to (sensitive sites, borders, etc.) by expediting them whilst maintaining detection quality level; security of supplies indispensable for critical sites; recording of supervision data centres for judicial control; the development of tools for every kind of solution, assessing its own level of protection and security and

conducting impact studies (on an event or a change); constant remote supervision by automatic means (analysis of images, scenes or movements) or remote-controlled means (robots), analysis of natural, technological and human risk and their combination must be a special area of research projects able to provide preventive responses.

Maritime, land and air surveillance

This topic involves assessing threats and managing the security of flows of humans, tangible goods (the logistics chain) and **intangible goods on sea, on land and in the air, and via interconnections between these different spaces**; as well as tools to improve the monitoring and traceability of personnel movements within different areas, in compliance with applicable legal regulations (particularly with regard to privacy and public information).

Topics such as the fight against all forms of trafficking, piracy and other illegal activities are included. Research may cover technological questions (all types of sensors including spatial and associated algorithms, correlation of events, intervention methods, etc.) and/or questions relating to social sciences and the humanities (law, political science and management, etc.). Particular attention will be paid to geopolitical and regulatory developments at the national, European and international levels.

Specific needs concerning the security conditions of airport hubs, particularly links with its environment (including intermodal connections). Comprehensive studies taking into account passengers, checked and carry-on luggage and accompanying persons are necessary. These studies will define the technological needs for addressing smart border and invisible security concepts.

Concerning the expression of needs specific to maritime space, a number of points deserve specific research in developing tools to: i) a more extensive, agile, and sophisticated surveillance of maritime spaces; ii) automatic or semi-automatic identification: suspicious behaviour in ports and near offshore vessels and infrastructure; suspicious objects on a ship or lost on the sea floor; ships acting suspiciously; (iii) a more appropriate check of crews and passengers when boarding ships or at port; (iv) a more precise and swifter check of goods on arrival in port; (v) more efficient monitoring of the inside of containers on arrival in port.

It is also important to: (i) prevent attackers from boarding vessels and stay safe if attackers are on board; ii) to protect against fragmentation bombs and suicide bombers, protect against and neutralise hostile swimmers; (iii) to better protect underwater cable telecommunications.

G. Annex: Description of the priority research areas identified in the National Research Strategy (SNR), as related to the societal challenges set out in ANR WP 2017

Challenge 1
Efficient resource management and adaptation to climate change

PRIORITY 1 / Smart monitoring of the Earth system

Monitoring of the Earth system is expected to intensify with the implementation of innovative and sustainable instruments (infrastructure, sensors, models, large amounts of data) to increase knowledge about how the Earth system works, enabling the development of services geared toward industry and public policy (including real-time climate information and environmental data). New instruments for observation and experimentation will be integrated in the European and/or international networks. These instruments will be deployed on the ground, placed on-board oceanographic and air fleets, in satellite infrastructures, and even on new types of fleets being developed (drones etc.).

PRIORITY 2 / Sustainable management of natural resources

The study of natural resources must go beyond discipline-restricted "silo thinking" action on ecosystems, biodiversity, water, soil, subsoil resources, and territories if we are to develop a more comprehensive overall vision. Research must be reinforced with regard to the cost-benefit analysis of exploiting resources, integrating impacts on economic activity and employment, such as effects on health, the environment and biodiversity. This priority is tasked with setting up an up-to-date national inventory of "critical" mineral and energy resources, with an overview of their availability, uses and potential conflicts over use.

PRIORITY 3 / Assessing and controlling climate and environmental risks

Climate disruption associated with the densification of land use and growing populations have rendered current predictions of climate and environmental disturbances inadequate for assessing and controlling risk; there is a need to strengthen our understanding of these disturbances through research accounting for natural, technological and industrial hazards. It will also be necessary to consider ecosystems' adaptability and analyse the economic impact of their decline.

PRIORITY 4 / Eco- and biotechnologies to support the ecological transition

Research on eco- and biotechnology should be encouraged in order to further develop industries with little environmental impact (low use of resources, improved efficiency, curative technologies). In particular, life cycle analyses will serve as a rough methodological basis, enabling a greater focus on specific ecosystem and management issues.

PRIORITY 5 / The coastal "laboratory"

Coastal areas provide a natural laboratory and are host to myriad natural and man-made risks, with issues linked to subsoil resources, primary biological resources, energy and transport, the development of urban planning, land-use planning and tourism, and the preservation of natural and cultural heritage. More specifically, this priority was created to support information collection and the construction of modelling and scenario-building tools on the land-sea continuum to conduct research on how these different risks interact with one another.

Challenge 2
Clean, secure and efficient energy

PRIORITY 6 / Dynamic management of energy systems

Increasingly numerous, both diversified and localised renewable energy sources require effective and dynamic methods for integrating these energies in distribution networks using technical solutions for an optimal combination of often irregular 'low-carbon' energy sources with programmable electricity sources. This implies the development of different energy vectors, storage and conversion technologies, as well as safe and smart energy grids allowing the distribution of electricity at the local level, for example transport via the major European networks.

PRIORITY 7 / Multi-level governance of new energy systems

This priority sets out to examine the evolving needs of local, territorial, national and European policies on the evolution of market regulation in order to design an effective and equitable governance which gives just consideration to a growing number of small-scale producers. To this end, it will be necessary to work on optimising interfaces between the different scales, from local to global. Governance models will analyse energy management at territorial levels and reconcile it with management at the national level; analyses must include costs associated with energy systems and anticipate impacts on businesses and private individuals.

PRIORITY 8 / Energy efficiency

Research and innovation efforts must be pursued to reduce energy needs in the domains of construction, transport and production systems. To be effective, the solutions developed must combine several innovative technologies (new insulations, heat recovery, optimisation of engines, smart meters etc.), changing actors' behaviours and introducing collective logical and incentive mechanisms and providing for their dissemination.

PRIORITY 9 / Reducing dependency on strategic materials

Reducing energy systems' need and use of strategic materials requires the setting up of a thought process on the chain connecting extraction, use, and recycling. Skills and expertise must be channelled into these three components to support the emergence of a sustainable sector (production methods, clean and innovative recycling). This will involve studying materials' behaviours under multiple stresses, seeking out substitute materials, and optimising yields and service life.

PRIORITY 10 / Alternatives to fossil carbon for energy and chemical sectors

The production of biofuels and applications derived from bio-based chemistry are in early stages of development. If these alternative development sectors are to become sustainable, we will have to break away from field-specific thinking and regard chemical processes and biofuels rather in terms of concurrent applications, the scales (local or otherwise) at which the resource and the products are used and manipulated, the conditions for obtaining them, possibilities of recycling, and the existence of other substitute materials.

Challenge 3
Industrial renewal

PRIORITY 11 / The Digital factory

The use of digital tools in industry has generated major efficiency gains applicable to engineering design, controlling production mechanisms, making information sharing smoother, and more. The idea is to maintain momentum by conducting research on digital technology to improve factories' operation effectiveness and interactions with external partners, potentially including the end customers. These research efforts will need to be integrated into an overall vision of the production process in order to ensure a coherent and collaborative chain from the design phases to the finished product.

PRIORITY 12 / The Eco-friendly and people-friendly factory

In a world where resources (energy, raw material, water, air, soil etc.) are scarce and increasingly costly, the factory of the future must be economical and responsible. The aim of research will be to come up with integrated industrial systems for managing energy, raw materials and risks. These systems will adhere to circular economy and eco-design philosophies by saving raw materials, recycling and reusing waste materials for other purposes, and finding substitute materials for unsustainable resources.

PRIORITY 13 / Flexible, human-centred manufacturing processes

This priority sets out to invent and deploy large-scale flexible manufacturing models suited to the needs of customers, as well as simple and user-friendly production control systems (man-machine cooperation, industrial cobotics). This new field must bring together researchers in the engineering sciences and social sciences and the humanities to devise user-friendly production systems.

PRIORITY 14 / Designing new materials

The products of the future will be more complex and mix several materials endowing final products with unique advantages (lightness, conductivity, resistance, hardness etc.). Combinations of basic components are becoming increasingly diverse. The forming and implementation processes of multi-materials (assembly technologies, additive manufacturing, powders, surface treatments, etc.) therefore pose a major challenge. It will also be necessary to classify these new materials, validate them and assess their tolerance to damage and ageing.

PRIORITY 15 / Sensors and instrumentation

There can be no smart machines or products without reliable fine physical measurements at acceptable economic costs. This priority will support the instrumentation and metrology sectors, in which France is a trail-blazer, to meet industry's new innovative needs. Research will mainly focus on designing and producing micro-sensors, integrating them into materials and processes, as well as imagining and developing systems for high-performance collection and processing of collected data.

Challenge 4
Life, health and well-being

PRIORITY 16 / Multi-scale analysis of diversity and the way living things evolve

This priority revolves around identifying, quantifying and formalising the properties of all living organisms at different scales (from molecules to populations) by calling upon mathematics, physics, chemistry, computer science and human and social sciences. The challenge is to study elementary biological functions as well as these functions at different levels of integration within biological systems. Studies relying on the diversity of experimental models will specifically benefit to the development of synthetic and systems biology and will help open up new pathways in industrial, environmental and medical fields.

PRIORITY 17 / Processing and collection of biological data

The treatment of large masses of data has become essential for research in biology and medicine; such research is based on an increasingly integrated and systemic approach. The aim will therefore be to foster the development of platforms for the collection of biological data and imaging, the constitution of patient cohorts and the opening of administrative databases to research. A special effort will be focuses on the process of technological innovation and medical which allow the data collection: Development of instrumentation for the diagnosis, devices and sensors for monitoring, data collection sociological studies;…

PRIORITY 18 / National Centres of Excellence network for research and healthcare

The network's primary mission will be to increase the quality and attractiveness of clinical research and the number of tests carried out in France via improved coordination between centres cooperating with industrial partners in a simplified regulatory context better adapted to the methodological developments and more favourable to innovation.

Challenge 5
Food security and demographic challenges

PRIORITY 19 / Healthy and sustainable diet

Fundamental knowledge on the human diet will need to be revisited in light of studies on human microbiota involved in digestion. Knowledge about how these microbes decompose food into molecules able to be absorbed by the body will in effect change the way we view the link between populations' health and their diets. This will be achieved by pursuing research aimed at understanding these microbe populations and developing new technologies (metagenomics, metabolomics) to explore their functions and subsequently measure and monitor the nutritional status of the human being. To enable sustainable food production, we will have to re-evaluate food's processing, storage, and supply chain from the perspective of their energy consumption; energy- consuming transformation and storage processes will need to be improved and alternative processes found.

PRIORITY 20 / An integrated approach for production systems

Industry, research laboratories and groups of farmers are behind multiple technological and organisational innovations, though these approaches are strongly compartmentalised by sector (livestock, plants, agricultural mechanics). It is necessary to develop an integrated approach for production systems, using the evaluation of their grouping in a global instrumented system to identify the constraints, benefits and risks of these innovations, as well as possible synergies. In addition, the agroecology remains largely inventing: In addition, agroecology has yet to come into its own as a field; we must strive to better understand and measure what ecosystems can contribute to production systems and how to use them without creating unbalances. These studies will be based on experimentation, observation and comparative approaches. Predictive biology will also be broadly solicited and work will be conducted at the scale of the individual, the plot, the herd and the farm, but also at the territorial level in systemic approaches. It will be necessary to design multi-criteria assessment tools for the various system sustainability and transaction cost systems.

PRIORITY 21 / From production to diversified uses for biomass

Optimising the total usage of biomass according to its many possible transformations (food, materials, energy) in particular by avoiding competition with usage for food purposes is an issue central to the development of the bioeconomy. It is necessary to develop an integrated vision based on novel tools for modelling complex systems. These tools enable society to evaluate actors' incentives, the functioning of ecosystems and interactions, and implement subsequent policy decisions. Research will also be focused on reassessing technological and biological processes in this framework, especially for processing food, overcoming technological and scientific obstacles related to bio-refining and, finally, developing concepts, methods and tools for use in synthetic biology.

Challenge 6
Mobility and sustainable urban systems

PRIORITY 22 / Urban observatories

To complement existing databases and data from international comparative studies and surveys, this priority sets out to develop observatories to provide information on the urban built environment as well as systems as well as flows of energy, materials and people in urban settings. These observatories will promote interdisciplinary approaches to mobilise all actors concerned with diagnostics, modelling and forecast scenarios. Observatories will also assess urban integration into regional and international systems to evaluate public policies and test new solutions invented.

PRIORITY 23 / New conceptions of mobility

The aim will be to devise new ways to move around combining various means of transportation relying on technological and organisational innovation. This objective breaks down into two research domains. The first is the design of new innovative vehicles with smaller environmental footprints (mini-vehicles, electric aircraft, and unmanned aerial vehicles, also known as “drones”) and multiple uses based on new concepts for automation, increased delegation, as well as connectivity and traffic management. The second is the production of technology or organisational breakthroughs in response to the "last mile" problem and change the point of view of the actors involved in establishing shared systems such as carpooling, car-sharing, and transport interfacing.

PRIORITY 24 / Tools and technologies for sustainable cities

It will be necessary to fit out contracting authorities with measuring instruments and digital design tools for low environmental footprint urban systems, not on the scale of individual buildings, but of entire neighbourhoods. In addition, innovation efforts must be maintained if technologies and tools are to optimise buildings' energy and environmental efficiency; this applies for example to heat pumps, cooling production systems, new insulation materials, waste disposal systems and indoor air and water quality control, etc.

PRIORITY 25 / The integration and resilience of infrastructures and urban networks

To optimise their implementation and usage, it is necessary to develop those concepts and tools enabling an integrated vision of the various urban networks (water, gas, electricity, telecommunications and transport) as early as the design phase. This priority also sets out to develop solutions for adaptation and resilience to unforeseen technical, social and climate risks.

Challenge 7
Information and communication society

PRIORITY 26 / 5th generation infrastructure networks

One of the foremost twenty-first century digital challenges is overcoming scientific and technical obstacles and developing the 5th generation of network infrastructures; this will be especially important for Europe. Beyond mobility, this generation of digital infrastructure will bring about the large-scale deployment of the Internet of things, the digital basis for smart cities, smart roads, and new energy systems... Updating infrastructure is a challenge both economically and from a sovereignty standpoint.

PRIORITY 27 / Connected devices

The connected object revolution requires research about hardware, for example involving very low consumption electronics or the field of communication protocols, as well as software, particularly embedded software and distributed software architectures. Research concerning data protection issues will also be developed in order to foster user trust in digital space.

PRIORITY 28 / Exploitation of big data Alain-approved©

Research on the means of collection, storage and processing of large masses of data will be fostered. The main issues relating to the diversification of devices and networks for data collecting, the development of algorithms performing smart mining of very large masses of unstructured data (sometimes remotely) and the optimisation of the material means of calculation necessary to these algorithms (high performance computing architectures, with particular emphasis on optimising energy consumption).

PRIORITY 29 / Man-machine collaboration

This priority area will revisit the ways in which men and machines interact from the standpoint of natural behaviour and human progress in autonomous machine operations and decision-making. In order to develop a genuine collaboration between humans and machines, research on self-learning processes between humans and machines must be expanded, with machine capable of adapting to the unpredictable aspects of operators' behaviour, with development of a greater interactional richness for "smart" automation.

Challenge 8
Innovative, inclusive and adaptive societies

PRIORITY 30 / Study of cultures and integration factors

In a globalised world, public authorities and businesses have a vital need to know and understand the diversity of cultures, both in their historic depth, languages and religions, their societal and institutional structures and the ways in which they interact and evolve. Among other issues, it is essential to analyse factors of social cohesion, economic development and well-being, focusing in particular on the roles and the forms taken on by acceptance and risk aversion. A special importance will be given to research mechanisms to understand levers to act on to allow our society to offer the best integration framework to fight against inequalities and promote economic development.

PRIORITY 31 / New innovation capacity indicators

Determining the fundamental basis by which societies innovate requires the development of new indicators for scientific activity and innovation. The priority will attempt to determine the capacity of education to capitalise on initiatives, demonstrate a sense of experimentation and creativity, and identify the most effective models for transmitting tacit knowledge. To do this, it is necessary to study both individual behaviours in response to risks and social attitudes vis-à-vis progress, research and science, and also representations of risk and the roles played by education systems, in particular the stigmatising of failure. This work should build on existing large infrastructures in the social sciences such as the European Social Survey (ESS), to study the mechanisms that underpin confidence in the future and the ability to project into the future.

PRIORITY 32 / Data availability and extraction of knowledge

Large masses of data and associated questions constitute a new and centrally important field which has assumed a strong interdisciplinarity with Information and Communication Sciences and Technologies. Research will focus on how to extract knowledge from non-hierarchical information flows. Emphasis will be placed on the creation and enrichment of open European databases for working on large cohorts and drawing comparisons.

PRIORITY 33 / Social, educational and cultural innovations

The study of social, educational and cultural innovations constitutes a new field facilitating the adaptation of the entire population to social transformations. In particular, it will be necessary to develop new methodologies presenting a rigorous comparative dimension and new frames of reference to assess social progress and account for subjective variables such as well-being. Dedicated national and transnational infrastructures, such as SHARE (Survey of Health, Ageing and Retirement in Europe) or ESS (European social survey)-type surveys will need to be developed. Research will focus on thematic areas such as innovative teaching devices or social representations, their dynamics and their dissemination.

Challenge 9
Freedom and security of Europe, its citizens and its residents

PRIORITY 39 / Prevention and anticipation of risks and threats

Security issues must be taken into account when designing physical or digital systems, particularly for the sizing of infrastructure and networks. Since human beings are at the core of these systems, it will be essential to study individual and collective behaviour in the face of risk, but also determine the principles for establishing rules and preventive standards which are both effective and respect public rights and freedoms.

PRIORITY 40 / An integrated approach to crisis management

Crisis management is tasked with integrating all information on critical events, their likely evolution, actors' response capacity, and so on. In order for this management to be effective, it will need to develop the modelling and simulation of critical phenomena (natural or human-made events), the capacity to acquire and process hybrid and multi-source data in real time in order to pinpoint relevant information and develop decision-making tools based on a hazard assessment and appropriate human/machine interactions.

PRIORITY 41 / Resilience of security systems

It will be necessary to develop scientific foundations and methodologies for analysis of interconnected complex systems' resilience including security systems and to integrate resilience processes starting at the design phase. Research will be based in particular on network theory, the analysis of decentralised processes, and coordination mechanisms; it will also set out to develop approaches and tools to aid in the design of resilient devices (fault tolerance, sabotage, and degradation) as well as methodologies for still underused ex post analyses.