AGENCE NATIONALE DE LA RECHERCHE
ANR

Work Programme 2016

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A. Context and objectives of Work Programme 2016

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. The 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 Ministry's international scientific strategy. ANR also supports international consortia in partnership with other funding agencies in Europe and throughout the world.

Work Programme 2016 (WP 2016) is ANR's roadmap for 2016. 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 2016 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.*

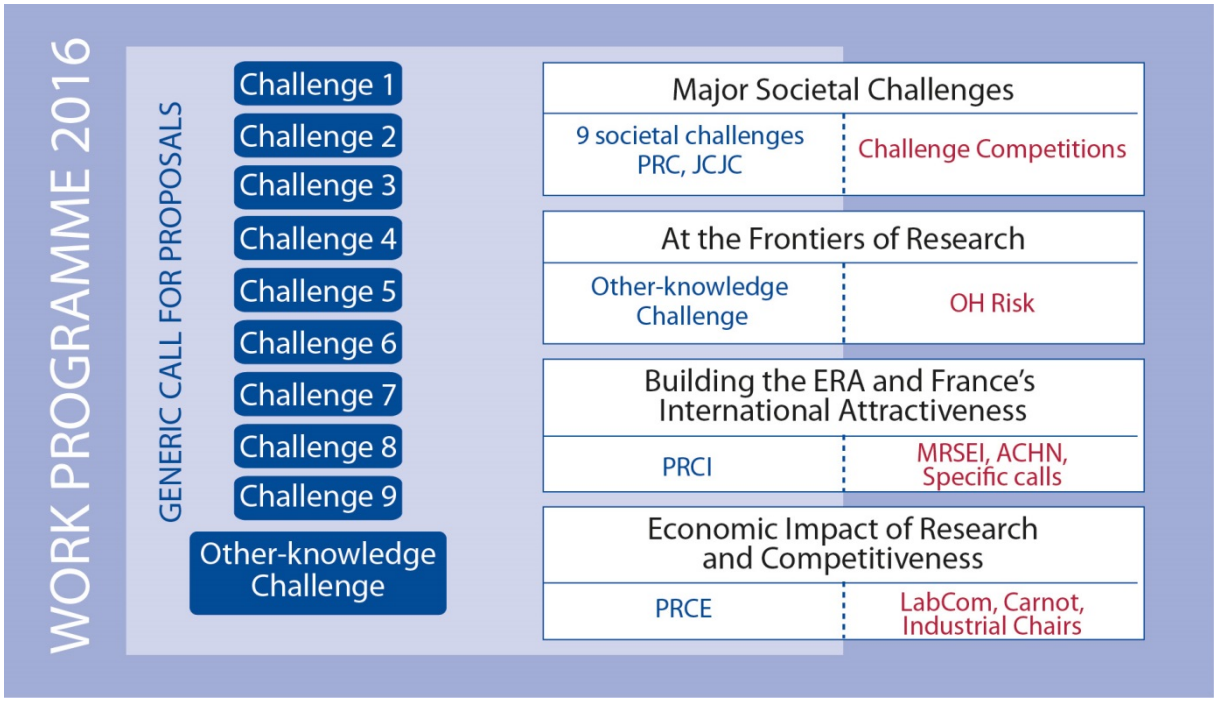
WP 2016's societal challenges section groups together French research priorities defined in the SNR text and takes into consideration contributions from the five national thematic Alliances[3] of research organisations, those of the CNRS, and requests from the French Research Ministry, which coordinates interministerial actions between relevant ministries[4]. The Work Programme is a single consolidated document, adopted on 18 June 2015 by the ANR Governing Board.

The 2016 Work Programme lays out the main actions and calls for proposals launched by ANR for the 2016 financial year and gives ANR's research funding offering all-around visibility. 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-recherche-francaise.html
[3] Allenvi (Alliance for environmental research), Allistene (Digital science and technology alliance), Ancre (National alliance for the energy research coordination), 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 of 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 2016

Work Programme 2016 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 the generic call can be found in a specific document detailing submission procedures and selection processes.



Overview of Work Programme 2016 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; ACHN: Hosting High-Level Researchers

Funding instruments provided by ANR are set out in section B of WP 2016. Submission and selection procedures are set out in the various calls for proposals, including the Generic Call for Proposals. Each funding instrument has its own raison d'être, specific expected impacts, and distinct characteristics in terms of selection and follow-up and monitoring. The purpose of these funding instruments ranges from supporting collaborative research, instruments dedicated to individuals as well as other WP 2016 programmes and calls 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 2016's **four components**, with its numerous strategic dimensions, are described below.

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 2016 around **nine major societal challenges** spelled out in the “France-Europe 2020” Strategic Agenda (except for the space sector, under the authority of CNES), described in paragraphs D-1 to D-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 that do not fall within the scope of the nine societal challenges listed above. This challenge aims to foster prospective or exploratory research with the potential to expand the frontiers of knowledge beyond that related to major societal challenges. The funding instruments usable for this challenge are the same as those for the "Major Societal Challenges" component (see section B).

As a complement to the Other-knowledge challenge, the “At the Frontiers of Research” component includes an additional instrument known as the **“OH Risk” programme**, fostering the emergence of high-risk scientific projects. This instrument is subject to a specific call for proposals (see section C-1*).*

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

This component provides French researchers and teams with funding instruments increasing the influence and attractiveness of French research and contributing to the construction of the European Research Area (ERA). These actions complement and give precision to those carried out under the Horizon 2020 programme. They encourage the development of high-level international research partnerships, helping French teams assume leadership roles in European and international programmes.

The challenges making up Work Programme 2016 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 thought up with European programmes (e.g. ERA-NETs, JPIs, ERA-NET Cofund, etc.) and international programmes in mind (e.g. Belmont Forum, etc.). Finally, bilateral agreements concluded within the context of the challenges between ANR and foreign agencies allow for the establishment of strategic partnerships or facilitate international collaboration in a borderless research area (see sections C-6, C-7 and C-8).

The "Building the ERA and France's international attractiveness" component comprises the following funding instruments in Work Programme 2016:

- "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 E-6).
- "Hosting High-Level Researchers" (**@RAction**) gives France the opportunity to host top non-French or expatriated French scientific researchers. This instrument is subject to a specific call for proposals (see section C-7).
    - The "International Collaborative Research Projects" (**PRCI**) instrument aims to facilitate collaborative research with a second country through bilateral agreements (for a description of this instrument, see section B-1-3; and document "Bilateral collaborations in the framework of generic call 2016: PRCI" for an overview of the bilateral agreements.) This instrument falls within the scope of the generic call for proposals.
- In addition to these instruments, ANR is developing specific **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 actions revolving around global challenges (e.g. the Belmont Forum) (see section C-8 and "Provisions for specific transnational calls for proposals in 2016" document).

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.

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 based on the following specific programmes:

- **LabCom**
  For the creation of joint research laboratories between public research institutions and SMEs or intermediate-sized enterprises (ETI in French) (see section C-2).
- **Industrial chairs**
  For the establishment of chairs at public research facilities, in partnership with enterprises, funded jointly by the latter and ANR (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).

This component also establishes relationships between ANR and competitiveness clusters in order to bring public research findings more in line with the needs of private industry. As was the case in the past, ANR's 2016 calls will be open to labelling by the 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 (See "Partnerships and Co-funding" document) including:

- the Ministry of Defence (Defence Procurement Agency - DGA),
- General Secretariat for Defence and National Security (SGDSN),
- The Ministry of Health (General Directorate for Care Provision, DGOS)
- The Ministry of Culture and Communication (MCC),
- The Ministry of Food, Agriculture, and Forests,
- APIS-GENE,
- The National Solidarity Fund for Autonomy (CNSA),
- The Research Foundation for Aeronautics and Space (FRAE),
- The National Institute for Agricultural Research (INRA),
- Muscular Dystrophy Canada (MDC).

These partnerships provide research funding opportunities that complement the ANR's[5] own funding budget for either the generic call for proposals or specific calls for proposals. Examples of such

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.

opportunities include the **Astrid** and **Astrid Maturation** programmes, implemented by ANR and funded by the DGA (see § C-5).

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). In the interest of efficiency, such proposals and related projects are not supported by the French National Research Agency. In the case of very early stage research within ANR's scope of action, researchers are advised to provide arguments[6] as to why they thought it appropriate to submit projects to the ANR generic call or to another ANR call rather than one launched by the above-listed organisations.

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

All PRC, PRCE, PRCI, or JCJC projects relating to major societal challenges or to the "Other-knowledge challenge" (sections B-2 and B-3 below) will be dealt with according to the submission, evaluation and selection procedures described in the **Generic Call for Proposals**. The general calendar for the generic call for proposals' evaluation and selection process is found on the ANR website and in the generic call text.

Additional procedures apply to **Work Programme 2016's other calls and programmes** (especially OH Risk, LabCom, Industrial Chairs, Carnot, Hosting High-Level Researchers, MRSEI, Astrid) and specific European and international calls (ERA-NETs, JPIs). These procedures are each set out in separate call for proposals documents. Applicants are advised to consult the calendars for 2016 calls on the ANR website.

B. Funding instruments for the generic call for proposals

Generic call for proposals 2016 gives access to a great number of funding instruments. Researchers will need to choose which of these instruments shall best serve the needs and scientific objectives of their project.

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 pertains to research work defined on the basis of a description of the objectives to be attained within a framework of predefined resources and deadlines. Three instruments are proposed, "**Collaborative Research Projects" (PRC), "Collaborative Research Projects involving Enterprises" (PRCE),** and **"International Collaborative Research Projects" (PRCI).**

- The "**researcher**" category pertains to support for work carried out by individuals within a research body, the goal being for researchers to gain, maintain or increase high-level

[6] Said arguments are to be incorporated in applicants' scientific pre-proposal description, and where applicable in the full proposals as well.

scientific visibility and expand the scientific influence of the laboratories hosting them. The following instrument belongs to the "**Young researchers**" **(JCJC)** category.

Note: project grants for all funding instruments (PRC, PRCE, PRCI and JCJC) generally range from €100 k to €800 k, for a 24 to 48 month period, depending on the type of consortium and the number of partners involved, as well as the scientific goals of the project in question.

B-1) Dedicated funding instruments for collaborative research

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

This is the main ANR funding instrument. Collaborative projects set out to achieve scientific results by pooling the skills and resources of various academic or public sector research teams. By facilitating collaboration, the grants expedite proposed research. This instrument encourages academic or public sector 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 work are welcome in this instrument category.

The reviewers involved in the project selection process will evaluate the collaborative nature of proposals submitted under this funding instrument. The collaborative nature of a given project will be evaluated not only based on the number of partners involved, but with consideration to the value the proposed partnership will create, and the opportunities that obtaining the grant in question will open up for the project. The project must be scientifically original in comparison to the scientific typical research performed by the teams or entities involved. A project entailing extremely advanced science may, in exceptional cases, be allowed to apply for a grant even if the project is only being proposed by a single team.

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

Collaborative projects conducted as partnerships 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 in a different way, and by enabling companies to access high-level public research in order to improve their innovation capacities.

Project reviewers will evaluate the relevance and soundness of this type of collaboration in proposals submitted under this funding instrument. The type of collaboration will not be evaluated solely on the involvement of research organisations and enterprises in the project per se, but on shared objectives in terms of competencies, opportunities, and interests generated by research performed. Companies' prospects of capitalising on project findings will be assessed on the same basis as research organisations' scientific prospects.

B-1-3) International Collaborative Research Projects (PRCI)

ANR works in collaboration with other countries' funding agencies and participates in agreements facilitating collaborations with teams from different countries. The ANR enters into bilateral

agreements on targeted topic areas; in other cases, such agreements encompass all of the research areas funded by the ANR. In such cases, each agency funds teams from its own respective countries.

The objectives of these agreements include:

- Speeding up and developing collaborations by French researchers 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
- Promoting 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.

The International Collaborative Research Projects (PRCI) instrument is mainly dedicated to bilateral collaborations. Robust synergy is expected among project partners, implying equal involvement of French and foreign partners and the naming of scientific coordinators for projects in each country. Projects may be either exclusively conducted by research organisation partners or via collaboration between such organisations and one or more enterprises.

Reviewers involved in the project selection process will examine the international character of proposals submitted under this funding instrument. The international character of a given project will not be appraised solely on involvement of partners from one or several countries, but also on balanced collaboration and the sharing of competencies; reviewers will also look at opportunities and common interests likely to create scientific value.

For Work Programme 2016, bilateral agreements concluded by ANR concern the following countries[7]:

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

Country-specific **annexes** set out eligible theme areas and specific submission and selection procedures which apply concurrently with procedures set out in the generic call for proposals. These country-specific annexes can be downloaded on the ANR website's generic call page. It is absolutely essential to consult the country-specific annexes containing information on the thematic and disciplinary fields covered by these bilateral partnerships and their conditions.

A "Lead Agency" agreement has been concluded with certain agencies. This type of agreement is based on transparency and mutual trust; the use made of it is a gauge of the ERA's construction. A

[7] See document "Bilateral collaborations in the framework of generic call 2016: PRCI": List last updated at the time of document's issuance, subject to change. Applicants are advised to regularly check the ANR website.

joint proposal is prepared by the teams and is submitted to the lead agency, responsible for peer review, evaluation and project selection. These transnational projects compete with national projects submitted to the agency conducting the evaluation. The partner agency has access to all information. Each agency funds its country's teams according to its own conditions and procedures.

For 2016, project submissions and applications in Germany, Austria, and Switzerland will be submitted and applied for through respective countries' agencies. ANR will receive and evaluate applications on behalf of funding agencies in Luxembourg (FNR) and Brazil (FAPESP). For collaborations with Canada, Mexico, Turkey, India, China, Singapore, Taiwan, Hong Kong, and Japan, projects are submitted to and evaluated by the two agencies in parallel. Candidates are required to indicate in their application that they have opted for the generic call for proposals' PRCI instrument. It is absolutely essential to consult the country-specific annexes containing the relevant application procedures for these bilateral partnerships.

Note: Outside the scope of such bilateral agreements, it is also possible to submit a proposal for a project involving collaboration with one or more foreign teams from any country desired. In this case, the foreign team(s) involved will be required to fund themselves using their own financial resources or national funding. In such cases, submitting an application under the generic call for proposals, the French researcher be required to use the PRC or PRCE instruments referred to above, and not the PRCI instrument, reserved solely for collaborative projects carried out under bilateral agreements between ANR and foreign agencies.

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 independently explore their own theme area, to assemble or consolidate a preliminary team, to acquire a project-based research culture and to unleash their innovative talents.

It 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.

The funding instrument is open to researchers having completed a doctoral thesis (or any degree or qualification corresponding to the international PhD) less than 10 years ago (see procedures in the generic call for proposals). There is no age limit. This instrument, intended for individuals, provides for the funding of the young researcher's team alone (not possible to fund partners and collaborations).

Reviewers called upon in the selection process for JCJC projects will reflect upon the merit and realistic viability of giving the young researcher full scientific autonomy. Reviewers will not confine their evaluation merely to verification that the scientific coordinator successfully defended his or her doctoral thesis, but will also look at the project's scientific objectives. Projects dealing with theme areas previously explored by their host laboratory do not fall *a priori* within this framework.

C. Funding instruments subject to specific calls for proposals

Work Programme 2016 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 are subject to specific programmes or calls for proposals whose calendars can be found on the Work Programme publication page of the ANR website.

"At the Frontiers of Research" component

C-1) OH Risk

Fostering creativity and risk taking for projects with high scientific potential is an objective present throughout Work Programme 2016 and which will be a part of all funding instruments' selection criteria.

A category has been set aside for very high-risk (albeit high-potential) projects requiring a dedicated instrument; selection criteria for such projects are highly specific. These are projects involving preliminary research necessary to demonstrate the feasibility of a new concept or develop a research area for which there is no real precedent in scientific literature. Funding for this proof of concept category is indispensable for getting bold, path-breaking research projects off the ground. These are seed projects which by their very nature do not lend themselves to selection based on traditional criteria of scientific excellence.

The selection process revolves around a single submission document which states:

- the idea being proposed, with a scientifically reasoned justification and a discussion of the likelihood that the project will be successful;
- A state of the art demonstrating either the absence of previous work or the ways in which the proposal breaks away from previous research;
- In the event of success, an impact assessment of breakthroughs in scientific knowledge, and/or technological developments, and/or potential economic benefits.

The programme will take the form of a contest based on specific criteria and procedures aimed at selecting a small number of proposals. Procedures and calendars will be posted on the agency's website.

"Economic Impact of Research and Competiveness" Component

One of ANR's main missions is to encourage the transfer of findings made by public research into industrial applications. In addition to collaborative academia-industry partnership projects (see section B-12 – Collaborative Research Projects involving Enterprises), the main industry-oriented instrument of the generic call for proposals, ANR provides a series of programmes aimed at strengthening partnerships between research laboratories and private companies by means of various project research methods.

This cross-cutting component combines three programmes regulated by specific calls for proposals:

- LabCom
- Industrial chairs
- Carnot Institutes

The table below gives a summary of ANR's main funding features for the "Economic impact of research and competitiveness" component. These instruments imply the full participation of research organisation(s) and entreprise(s). Conditions of eligibility and details about features are set out in respective calls for proposals (except Carnot).

Instruments	**Targeted companies**	**Nature of research projects**	**Funding procedures**
PRCE instrument Generic call for proposals	All enterprises	One-time collaborative research project non-extendable beyond initial running time	ANR partially funds research project carried out by organisations or enterprises
LabCom Specific call for proposals	VSEs, SMEs, and intermediate-sized enterprises	Structure-giving collaborative research programme beyond ANR funding deadlines	Partial funding from ANR of the research organisation alone. Enterprises are required to contribute to the project
Industrial chairs Specific call for proposals	Intermediate or large-sized enterprises, or a consortium of enterprises	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 See http://www.anr.fr/carnot	All enterprises	Research and findings benefiting companies	No project funding by ANR. The Carnot programme supports the scientific resourcing and professionalising of research organisations

C-2) LabCom

This programme supports the creation of joint research laboratories between public research bodies and SMEs or intermediate-size companies and develops the potential of industrial partnerships and

transfer existing in academic research actors, particularly in non-partnership-oriented actors. The aim of this programme is to help researchers to establish lasting bilateral partnerships with companies, especially SMEs and intermediate-sized enterprises, 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, the selection process is based on a simplified application and lump sum funding of €300 k for a public research laboratory, so as to expedite project set-up and allow for more rapid funding and greater flexibility in the use of the research grant.

This programme is subject to a specific call for proposals, whereby applications will be accepted on a continuous flow basis. Applicants are advised to consult the relevant page[8] on the ANR webpage.

C-3) Industrial chairs

The aim of this programme is threefold:

1. For public and private researchers involved in the Chair to conduct research in strategic priority areas via a strong and lasting partnership.
2. To provide quality-committed training by making the vision, methodologies and experience of private actors available to doctoral or post-doctoral researchers in high-level public research laboratories
3. To allow prominent French and foreign research-lecturers to deepen their expertise and spearhead pioneering research.

This programme involves a call for proposals in all research areas on research themes defined from the outset by the public research laboratory(ies) together with their private sector partner(s). The project will be led by an eminent scientist (future holder of the Chair), carried out in one or more public research laboratories, and jointly funded by ANR and the partner company(ies).

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

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 host institution.

This initiative is subject to a specific call for proposals. Researchers are advised to consult the calendar of 2016 calls for proposals on the ANR website.

C-4) Carnot institutes

Since 2006, the French Research Ministry has awarded the Carnot label to public research institutions, called "Carnot Institutes", whose main strategic focus is partnership-oriented research.

[8] http://www.agence-nationale-recherche.fr/financer-votre-projet/impact-de-la-recherche-et-competitivite/laboratoires-communs/

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.

In order to make the Carnot programme a success and ensure effective leverage, the "Valorisation – Carnot Institutes" programme is allocated a budget under the Investments for the Future programme. Three calls for proposals have been launched in this framework, one for specific initiatives related to SME, 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 intermediate-sized 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 posted on the ANR website.

- The Astrid programme pursues the opening of new research avenues on dual- interest themes. The goal is to explore scientific and technological obstacles and encourage potentially beneficial technological breakthroughs for defence, civil research and 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 field encompassing dual-use research's most critical domains.

"Building the European Research Area (ERA) and France's International Attractiveness" 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 2015:

- Setting up European or International Scientific Networks (**MRSEI**)
- Hosting High-Level Researchers (**ACHN**)
- Specific European or international calls for proposals (**ERA-NETs, JPIs**, bi- or multilateral calls for proposals)

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

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

The objective of this instrument is to reinforce France's scientific positioning, expressed through the coordination of a proposal submitted to a large-scale European or international call for projects. Proposals are expected to demonstrate actions needed to construct 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 not allow for the funding of research activities.

The "Setting up European or International Scientific Networks" (**MRSEI**) instrument will be subject to two specific calls in 2016. Prospective applicants are advised to regularly consult the relevant page on the ANR webpage. 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 relying on external peer reviewers.

Funding instrument's main features: ANR grant attributed to the coordinator: worth up to €50 k / Network: French and European or international partner(s) / Funding: a single (French) partner funded / Duration: 18 months

C-7) Hosting High-Level Researchers (ACHN)

Hosting High-Level Researchers (**ACHN**) dovetails with the national strategy for reinforcing research and French technology and increasing the international scientific influence and attractiveness of France.

ACHN strives to enhance the potential of innovative research and provide a long-term structure for new theme areas in French laboratories by capitalising on the highly generative skills of French and foreign researchers who have spent most of their post-doctoral careers outside of France.

The substantial funding associated with the ACHN programme and the host institution’s commitment (RPOs, university, etc.) are meant to ensure that each grant recipient benefits from excellent hosting and scientific integration in order to pursue research expected to have a major impact and form a research team.

This programme is intended for two different French and foreign researcher profiles: very high potential juniors and top-tier seniors. Junior candidates are those who have earned a doctorate 2 to 7 years after the closing date. Senior candidates are those who earned doctorate over seven years after this date. In both cases, candidates must have spent most of their scientific careers outside France. All candidates must be able to relocate to France on short notice.

Funding instrument's main features:
Maximum indicative ANR grant amount: €500 k for a junior candidate, €1 M for a senior candidate / Duration: 36 to 48 months

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-NETs Cofund,** and **Joint Programming Initiatives (JPIs)**. These initiatives are complementary to the framework programmes' other traditional collaborative projects. With this in mind, emphasis is placed on multi-year prioritisation of European activities and the coordination between national and European tools. The manner in which these programmes complement one another is determined on a long-term, sector-by-sector basis. ERA-NETs, ERA-NETs Cofund and JPIs activities are subject to specific calls for proposals. Applicants are advised to consult the calendars for these calls on the ANR website.

Several international agreements have similarly been concluded with major foreign funding agencies, either under **bilateral** partnerships (NSF in the US, JST in Japan, BMBF and DFG in Germany) or **global-scale multilateral** partnerships (SynBio multilateral initiative, Belmont Forum). These initiatives will launch specific calls for proposals. Applicants are advised to consult the calendar for these calls for proposals on the ANR website.

D. Societal challenges and the Other-knowledge challenge

The societal challenges defined in the National Research Strategy - France Europe 2020 (SNR[9]) are an integral part of ANR's Work Programme 2016, with the exception of the space sector, which comes under the purview of the CNES. These challenges are complemented by the Work Programme's "Other-Knowledge" challenge, designed for funding projects which do not fall directly within societal challenges' defined scope.

Scientific and technological scopes and the theme-based structure were defined in a collective, concerted manner with input from the National Research Strategy, the five national thematic Alliances[10], CNRS, requests made by the French Research Ministry (coordinates interministerial action between relevant ministries[11]) and Scientific Challenge Steering Committees featuring national and international experts as well as industrial and institutional representatives.

The nine societal challenges support thematic, multidisciplinary and integrative research revolving around major societal issues. Following recommendations from the National Strategic Council for Research, 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 providing 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 2016'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 to determine the priority research areas set out in the annex's table. Project coordinators will be asked to specify whether their project fits in these priority areas at the time of submission. Pre-proposals for research projects falling under these priority areas will be given preferential selection.

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

[10] Allenvi (Alliance for environmental research), Allistene (Digital science and technology alliance), Ancre (National alliance for the energy research coordination), Athena (National alliance for social sciences and the humanities), Aviesan (National alliance for life sciences and healthcare sciences).

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

D.1) CHALLENGE 1 – Efficient resource management and adaptation to climate change

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 landscape scale to global scale (climate, biodiversity erosion, soil degradation, air quality, freshwater and marine pollutions, 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. Given the complexity of the systems in question and depending on the particular topic, a wide variety of multi/inter/transdisciplinary projects is expected, ranging from academic research to partnerships with the private sector, public sector and civil society.

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: Understanding and anticipating environmental change
- Theme 2: Ecosystem dynamics to improve their sustainable management
- Theme 3: Health-Environment (health risks in the face of environmental change) (common to challenges 4 and 5)
- Theme 4: Scientific and technological innovations aimed at anticipating or remedying environmental risks
- Theme 5: Societies in the face of environmental change
- Theme 6: Integrated approaches to environmental development: toward more efficient solutions

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 the listing of five priority research areas covered by 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 to production systems).

D.2) CHALLENGE 2 – Clean, secure and efficient energy

This challenge will enable ANR to elicit top-notch scientific and technological expertise to tackle the energy transition challenge in the context of the French “Factor 4" approach (reduction of greenhouse gas emissions by a factor 4 by 2050) and, more generally, at world level.
Achieving this goal will mean promoting systemic, integrative and multidisciplinary approaches often required to address energy-related issues (sciences of matter, 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 radical and groundbreaking new ideas and concepts which break away from existing paradigms through the provision of technological proofs of concept, which may include developing laboratory experiments or the integration into existing experimental sites. This challenge's scope of intervention is limited to relatively upstream levels (Technology Readiness Levels 1 to 5), and complements other R&D funding aimed at more downstream phases, both at national level (ADEME, BPI France etc.) and European level (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 into energy grids
- 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 groundbreaking concepts and theme 7 with its strong focus on 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 interconversion of energy vectors, storage and distribution. Each theme includes research aimed at enhancing fundamental knowledge in the field concerned.

Work by the National Research Strategy has resulted in the listing of 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 14 (Design of new materials) or priority 21 (Biomass: from production to varied uses).

D.3) CHALLENGE 3 – Industrial renewal

Research funded through challenge 3, "Industrial renewal" is intended to prepare an industrial evolution which takes into account the following societal aspects:

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

French industry must progressively work towards domestic, sustainable manufacturing, promoting a circular economy in which it remains 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 aim of this challenge is to support research projects that will facilitate these developments in the medium to long term. This challenge concerns very broad industrial fields (manufacturing industries, chemical industries, agrifood industries, etc.) and scientific disciplines (organisation of labour, labour law, ergonomics, industrial engineering, robotics, economics, physics, chemistry, mechanics, materials, process engineering etc.).

In line with the European Union's Horizon 2020 programme for research and innovation, especially the "Industry Leadership" pillar and the "key enabling technologies" area (KET), challenge 3 supports research covering a wide range of TRLs (Technology Readiness Levels), ranging from fundamental research (TRL 1) well upstream of potential applications, to research that touches on industrial issues (up to TRL 4).

Echoing work carried out in the National Research Strategy (SNR) supplemented by the Scientific Challenge Steering Committee, themes have been clarified, the overlap between challenges delineated and better scientific consistency achieved. The challenge is structured around five themes. These themes will also allow for an integrated assessment of research projects, from upstream research to future applications:

- Theme 1: Adapting work to industrial renewal
- Theme 2: The factory of the future
- Theme 3: Materials and processes
- Theme 4: Sustainable chemistry, products, related processes
- Theme 5: Nanomaterials and nanotechnologies for products of the future

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

- Priority 11: The Digital factory
- Priority 12: The green and people-friendly factory
- Priority 13: Flexible, human-centred manufacturing processes
- Priority 14: Design of new materials
- Priority 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 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 Steering Committee**, WP 2016's Life, health, and well-being challenge is divided up into thirteen themes detailed in the annexes below supporting 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 and technological challenges 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 resulted in a list of three priority research areas for this challenge, including priority 16: Multiscale analysis of the diversity and evolution of living organisms and priority 17: Collecting and processing biological data.
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 priority research areas.

D.5) CHALLENGE 5 – Food security and demographic challenges

World demographic growth is a major challenge for our societies' future, particularly in terms of food security and the various uses of biomass from renewable carbon. This challenge is set against a backdrop of changing dietary patterns, globalised production circuits, trade in raw materials and processed products, scarce resources, increasing climatic hazards and environmental concerns related to the exploitation of productive ecosystems. Within this context, challenge 5's objectives are the following:

- Innovate to boost economic, social and environmental performance
- Achieve food security in quantitative and qualitative terms

- Promote the regional bioeconomy

Challenge 5 is structured around five themes detailed in the annex below:

- Theme 1: Animal biology, plant biology, micro-organism biology, and adaptation to environmental change
- Theme 2: Ecosystem dynamics to improve their sustainable management
- Theme 3: Health-Environment (common to challenges 1 and 4)
- Theme 4: Food, healthy and sustainable food systems, world food security
- Theme 5: Bioeconomy: from production to the diverse uses of biomass

These themes concern the acquisition of fundamental and applied knowledge in biology, agricultural and ecological sciences, social sciences and the humanities, and the interfaces between these disciplines. Such themes involve systemic research initiatives demanding a high level of conceptualisation and the integration of data and knowledge from a variety of disciplines, relating to different organisation levels and spatial and temporal scales.

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

- Priority 19: Healthy and sustainable diet
- Priority 20: An integrated approach to production systems
- Priority 21: Biomass: from production to varied uses

Project coordinators will be asked to specify whether their project fits in these priority areas at the time of submission, or where applicable in other SNR priority areas such that priority 2 (Sustainable management of natural resources), priority 3 (Assessment and control of climate and environmental risk), priority 10 (Fossil carbon substitutes for the energy and chemical sectors) or priority 16 (Multiscale analysis of the diversity and evolution of living organisms).

D.6) CHALLENGE 6 – Sustainable mobility and urban systems

This societal challenge aims to explore the extent to which urban systems, buildings and transport can be transformed to embrace sustainable development. This requires developing increasingly integrated and systemic approaches in order to improve our understanding of physical, environmental, political and socio-cultural processes while highlighting any vulnerability. Urban areas lie at the intersection of issues concerning habitat, mobility and, more broadly, living together in society. Towns and cities, which account for 70% of Europe's energy consumption, also contribute greatly to the greenhouse effect and environmental pressures while also being sensitive to environmental damages and to the consequences of global change. Other major challenges include the performance of buildings and transport, the organisation of urban systems that encourage smooth, efficient access to resources and services, the emergence of digital society to support, develop and promote the use of sustainable transport and to provide more intelligent urban

management (the “smart city” concept), and the longetivity and adaptation of infrastructures and networks to meet existing and emerging needs.

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 methods for modelling phenomena to back design, decision-making, and performance assessments.
- Assist in developing a palette of methods and technologies that are 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.

The challenge 6 is structured around seven themes detailed the annex below:

- Theme 1: Sustainable urban systems
- Theme 2: From buildings to a sustainable built environment
- Theme 3: Clean, safe vehicles
- Theme 4: Efficient networks and services

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

- Priority 22: Urban observatories
- Priority 23: New conceptions of mobility
- Priority 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 priorities such as priority 3 (Assessment and control of climate and environmental risk), priority 4 (Eco- and biotechnologies to support the ecological transition), priority 8 (Energy efficiency), priority 26 (5th generation of network infrastructures) 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 has two main objectives: using digital technology for the benefit of society and designing and developing digital technologies of the future through innovative concepts, methods and tools. Mastering digital technology is therefore an increasingly strategic national issue affecting France's autonomy and competitiveness.

This challenge aims to mobilise the French research network to address challenges affecting digital societies. Proposals for research and development projects are expected to yield significant advances in areas of micro- and nano-electronics, IT and mathematics; subjects which serve as a bedrock for digital sciences and technologies. Collaborative project proposals integrating a social science 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 field (H2020, PIA, DGE, etc.).

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.

These are structured around eight themes:

- Theme 1: The digital revolution: our relationship with knowledge and culture (common to challenge 8)
- Theme 2: Foundations of digital sciences and technologies
- Theme 3: Software sciences and technologies
- Theme 4: Interaction, robotics, content
- Theme 5: Data, Knowledge and Big Data
- Theme 6: Numerical simulation: from high-performance computing to big data
- Theme 7: Infrastructures for communication, processing and storage
- Theme 8: Micro- and nanotechnologies for information and communication processing

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

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

Project coordinators will be asked to specify whether their projects fit in these priority areas at the time of submission, or when applicable in other SNR priority areas such as priority 16 (Multiscale analysis of the diversity and evolution of living organisms), priority 17 (Collecting and processing biological data) or priority 32 (Data availability and extraction of knowledge) or 33 (Social, educational and cultural innovations).

D.8) CHALLENGE 8 – Innovative, inclusive and adaptive societies

Challenge 8, "Innovative, inclusive and adaptive societies" encourages research focused on societies' ability to innovate, integrate and adapt. Going beyond French society, researchers are to study societies spanning every possible cultural area and open up their research across the humanities and social sciences, practising the most transdisciplinary approach possible, englobing: 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.

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, analysis of texts, statistical surveys, administrative data, 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.

When possible, researchers are encouraged to take advantage of infrastructure and large already-existing databases, including international longitudinal surveys recognised by the European roadmap for research infrastructures. 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 an instrument for perpetuating them.

In response to work by the SNR and the ATHENA Alliance with input from challenge 8's Scientific Challenge Steering Committee, the 2016 edition has undergone a massive overhaul. Novel theme areas have been introduced which are likely to interest new research communities. The challenge is structured around eight themes corresponding to an integrated assessment of research projects, from upstream stages to future applications:

- Theme 1: Social innovation and attitudes toward risks
- Theme 2: Inequalities, discrimination, 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)
- Theme 8: Public health (common to challenge 4)

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

- 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 in these priority areas at the time of submission, or where appropriate in other SNR priority areas such as priority 28 (Exploiting big data).

D.9) CHALLENGE 9 – Freedom and security of Europe, its citizens and its residents

This challenge covers but is not limited to any research which may contribute to the government's sovereign missions of security and protection, as well as the protection of infrastructures and public and private operators vital for the proper functioning of the nation. It also encompasses research on non-sovereign security issues concerning individuals or legal entities such as organisations and companies. All freedom and security issues are to be considered against a backdrop of the accelerating development of new technologies, particularly digital technologies, which offer opportunities to citizens, administrations and businesses but also create vulnerabilities. The increasingly dense movement of people, commodities (goods, energy, water, etc.), capital and information needs to be taken into consideration to ensure security for all, at all levels.

Research relating to the freedom and security of European citizens and residents requires an integrated approach to risk management both in physical space and in cyberspace. This ranges from the characterisation of threats and vulnerabilities to the management of consequences, as well surveillance, prevention and protection mechanisms.

This challenge invites proposals from all types of research: fundamental or highly upstream research is also important to build up a body of knowledge on which public policies and ambitious future projects can be based. In all cases, regardless of whether or not the aim of the project is technology-related, an integrated approach is often needed, in which scientific and technical disciplines that do not usually meet are brought together: natural and environmental sciences, computer sciences, engineering, and social sciences and humanities (analyses of individual and collective behaviour, public law, public policy analysis, ethics, geography, etc.).

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 cyberterrorism
- Theme 5: Protecting vitally important infrastructures and networks, monitoring sovereign areas

Research work by the National Research Strategy has resulted in the listing of three priority research areas for this challenge:

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

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.

D.10) "Other-Knowledge" CHALLENGE

The "Other-Knowledge challenge" complements the mechanisms dedicated to the nine major societal challenges, they themselves eligible for basic research in their clearly identified theme-based area.

There is a strong desire to uphold, for all the scientific communities, opportunities for funding projects to prepare our societies for the future through actions which do not fall in the immediate scope of the societal challenges from both a knowledge base and themes standpoint.

- **Research at the frontiers of knowledge**

The Other-Knowledge Challenge aims to encourage prospective or exploratory research with the potential to expand the frontiers of knowledge. Such research is particularly valuable when one considers that society constructs its capacity to evolve and project itself into the future based on these frontiers. This thirst for knowledge, from the quest to understand the world around us and the laws that govern it to the desire to develop abstractions, will have major impacts on future decisions far exceeding the bounds of initial queries.

This challenge supports scientific advances anchored (or not) within schools of thought and generated essentially from curiosity, observation, and creativity. The knowledge and know-how which form the core of this challenge's projects should also be a driver of discovery whose implications are not always foreseeable, but which are essential for anticipating change and addressing future societal issues.

The Other-Knowledge challenge also aims to promote advances over the long term, insofar as it has the power to usher in breakthroughs and new concepts and paradigms, certain of which will provide a source of applied or industrial development essential to France’s industrial renewal.

Lastly, the challenge may provide an avenue for the development of integral approaches such as the creation of new tools and generic methods or the integration of various inputs in a transdisciplinary research strategy. The impact of such wide potential approaches will not be immediately felt, but merit support rather for their intrinsic internal dynamics, even if they do not neatly fit into the nine societal challenges' priorities.

The objective of the Other-Knowledge challenge is to generate the additional dynamics necessary for the emergence of new scientific and technological ideas constituting a precious capital for the future. Proposals' scientific excellence is a decisive criterion, since the objective is to respond to questions falling outside the general framework or field of investigation peculiar to a given societal challenge.

- **Special fields of research**

The "Other-Knowledge challenge" provides funding opportunities for research at the frontiers of knowledge which do not fall under the Work Programme’s societal challenges. They may involve

well-recognised fields outside of these challenges and concern rare disciplines or original interdisciplinary themes containing previously unexplored dimensions.

By way of illustration and in a non-exhaustive manner, research at the frontiers of knowledge in areas such as astrophysics, fundamental physics, particle physics, the structure and history of the Earth, chemistry, certain fields in the humanities and social sciences, certain fundamental biology or fundamental mathematics domains may apply to this funding mechanism for projects lying beyond the scope of the major societal challenges.

The inclusion of rare disciplines which would not otherwise have been included in the new societal challenges stems from the need to use research to stimulate knowledge acquisition in understaffed sectors contributing to the scientific, cultural, societal and economic heritage of our country and to the understanding of movements in contemporary societies. This also concerns scientific disciplines, more specifically those for which waning interest may result in the loss of knowledge needed when new theoretical issues or practices arise; a problem which needs to be addressed.

This challenge is also about promoting original interdisciplinary research through curiosity, observation and creativity, thereby establishing a new rapport between fields thought to be completely distinct. Such research may employ a variety of approaches within these fields. The research projects could also potentially bring about the emergence and perpetuation of interdisciplinary, scientifically and/or socio-economically promising themes.

Project proposals for this challenge can employ all types of approaches, from the theoretical to the instrumental.

E. Annexes

List of corresponding challenges and SNR priorities

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	Collecting and processing 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 to production systems	S				P				
PRIORITY 21	Biomass: from production to varied uses		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	Exploiting big data							P	S	
PRIORITY 29	Human-machine cooperation			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	Competitiveness of the telecommunications and navigation sectors	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

(P: principal; S: secondary)

Priority research areas identified in the National Research Strategy (SNR), as related to the societal challenges set out in ANR's Work Programme 2016

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 / Assessment and control of climate and environmental risk

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. This priority is designed to document high-risk areas and assess the impacts of a hydro-climatic or hazardous toxicological event, to develop pre-operational forecasting services and validate new toxicological and ecotoxicological testing. 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 areas as a natural 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 / Multiscale governance of new energy systems

This priority sets out to examine the evolving needs of local, regional, national and European policies on the evolution of market regulation in order to design 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 / Fossil carbon substitutes for the 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 Green 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 (human-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 / Design of 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 / Multiscale analysis of the diversity and evolution of living organisms

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 / Collecting and processing 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. Particular emphasis will be placed on technological and medical innovation processes enabling data collection: development of diagnostic instrumentation, self-monitoring devices and sensors, and collecting sociological data...

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 to 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, 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 / Biomass: from production to varied uses

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 establishment 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 of network infrastructures

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 objects

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 / Exploiting big data

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 objects 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 / Human-machine cooperation

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 / Preventing and anticipating 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.

Work Programme 2016

Societal challenges in detail

Societal challenges in detail

Introduction

The 2016 Work Programme comprises nine of the ten societal challenges defined within the framework of the French National Research Strategy (SNR), along with an additional challenge known as "the Other-Knowledge Challenge". These challenges have been drawn up collectively and collaboratively around France's 41 priority strategic research areas, which are explained in the document entitled "National Research Strategy – France Europe 2020,[12] which also incorporates contributions from the five national Alliances,[13] the CNRS (French National Centre for Scientific Research), the ministries concerned[14] and the Scientific Challenge Steering Committees, 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**

[12] http://cache.media.enseignementsup-recherche.gouv.fr/file/Strategie_Recherche/26/9/strategie_nationale_recherche_397269.pdf
[13] AllEnvi (alliance for environmental research), Allistene (alliance for digital sciences and technologies), Ancre (alliance for energy research), Athena (alliance for humanities and social sciences) and Aviesan (alliance for life sciences and health)
[14] ANR is under the authority of the French Ministry of Research and Higher Education; other ministries concerned: Agriculture, Ecology, Health, Industry, Defence, Foreign Affairs, Culture, National Education

Multidisciplinarity, cross-cutting research and interfaces

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

A 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 in response 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 in the selection of the most appropriate challenge for their project:

- topics that may apply to two or more challenges, depending on their individual focus, are indicated in the boxed text in the introductory section of each challenge concerned, with a reference to any other applicable challenges (please see the "Interfaces" section for each challenge);

- topics that should be addressed jointly by two or three societal challenges have been identified and are grouped together in the form of themes that are common to the challenges in question. These topics are as follows:

    - Health-Environment: theme common to Societal Challenges 1, 4 and 5
    - 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 may be addressed very broadly in most of the challenges, depending on the specific research question. These topics are given in detail below and are mentioned for reference purposes in the boxed text in the introductory section of each challenge (please see the "Interfaces" section for each challenge).

Applicants are advised to read the challenges concerned 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, it is applicants' own responsibility to position their project within the most appropriate challenge.

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.

BIOECONOMICS & 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 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.**

SENSORS:

Sensors are covered by several of the challenges (**Challenges 1, 2, 3, 4, 5, 7** and **9**), each from a different standpoint depending on specific aspects. You are advised to consult the points made 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 corresponding challenge.

For example, design and development of gas sensors fall 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** (but note how the various topics are divided between the themes in 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 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: Digital 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 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 robot-human 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

EUROPEAN AND INTERNATIONAL COOPERATION:

This challenge focuses on climate and the environment, and calls for substantial international initiatives. Priority shall be given to multilateral initiatives backed by i) European Joint Programming Initiatives (JPIs) in conjunction with ERA-NET projects, giving rise to possible complementary funding from the European Commission; ii) the ***Belmont Forum****, which brings together the main agencies for funding global environmental research (including the European Commission) in post-industrialised countries and emerging economies (Brazil, China, India, South Africa, etc.).* ***Bilateral projects (International Collaborative Research Projects, or PRCIs)*** *are focused on non-European countries for this challenge.*

The 2015/2016 topics that shall be given priority for international backing are detailed below and also given in tables 1 and 2 (appendix E) *of the 2016 Work Programme. These lists are subject to change, and so applicants who wish to conduct their projects at European or international level should regularly consult the ANR website for more information on these partnerships and calls for proposals: www.anr.fr/en*

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. You are strongly advised to read each related challenge in its entirety, to gain thorough understanding of its specific scope.

For cross-cutting topics that present extensive overlap between several challenges (including **Challenge 1**), please refer to the paragraph entitled "**Multidisciplinarity, cross-cutting research and interfaces**" (on page 48), which covers the following fields: ***Big Data, Robotics, Sensors, Biology, Bioeconomics & Biotechnology.***

The following fields are also interfaced with Challenge 1:

Ecosystems and sustainable management: ***See Theme 2 (joint theme common to Challenge 5).***

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

Urban areas: Urban areas and urban ecology are fundamental to the wider questions relating to global change and, in general, projects that mainly focus on the specifically urban aspects of an issue (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 issue under study.

Environmental risks: Crisis management on an operational, organisational, logistical and economic level, amongst others, falls within the scope of **Challenge 9**. Natural risks and the possible origin of a crisis (hazard identification and relevant risk factors, monitoring tools and methods, etc.), forecasting systems, threat evaluation and alarm thresholds fall within the scope of **Challenge 1:** environmental health risks relating to contaminants and emerging pathogens come under *Theme 3*, alerts and operational services come under *Theme 4*, multi-risk approaches involving societal adaptation come under *Theme 5*, risk assessment – an integrated chain with major interdisciplinary relevance to social science and humanities – comes under *Theme 6*. Geophysical and geodynamic processes that are the basic precursors of telluric hazards come under **the Other-Knowledge Challenge.**

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.**

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.**

CO-FUNDING[15] POSSIBILITIES FOR PROJECTS WITHIN THIS CHALLENGE

(see table 3):

Some of the projects within this challenge may be co-funded by the French Research Foundation for Aeronautics and Space (FRAE) or the French National Institute for Agricultural Research (INRA).

[15] 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

Against the backdrop of a growing world population and an escalating demand for energy, raw materials, products and services, it has become increasingly urgent to address **environmental changes**, **from landscape scale to global scale** (climate, biodiversity erosion, soil degradation, air quality, freshwater and marine pollutions, etc.). The current era, dubbed the Anthropocene era, has brought with it the need for an **integrated approach to manage** both the **environments** and the **development** trajectories of human societies in all their diversity. Such an integrated management approach calls for an understanding of the processes and mechanisms inherent in these complex systems.

This challenge calls for the enhancement of current knowledge about not only the **processes** responsible for changes but also the local or regional **consequences** of changes on **resources**, **societies** and human activities, particularly those that depend on **ecosystem services** (see the Millennium Ecosystem Assessment[16]). This challenge also invites 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 this field (GEO, Future Earth, GFCS, IPCC, IPBES, SDG, etc.) and is backed by international calls for proposals through the Belmont Forum.

In line with the build-up of the European Research Area (**ERA**) and 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 order to target the following:

- calls for proposals under the **Horizon 2020** programme, in particular the topics within *Societal Challenge 5*, *"Climate action, environment, resource efficiency and raw materials"* and topics backed by the European Research Council (ERC);
- calls for proposals under **Joint Programming Initiatives** (JPI Climate, JPI Oceans, JPI Water, JPI FACCE) and associated ERA-NETs (e.g. BiodivERsA); applicants should consult the ANR website for details and up-to-date information regarding calls for proposals in which the agency is participating.

Applications are invited within a broad range of scientific disciplines: mathematics, social sciences and humanities, environmental science, life and Earth sciences, engineering science and also IT and communications for the many digital issues and, where applicable, disciplines within the field of health. Given the **complexity of the systems in question**, and depending on the particular topic, it is expected that there will be a large diversity of **multi-**, **inter-** or **trans-disciplinary** projects, from **academic** research to partnerships with stakeholders in the **private** and **public** sectors and **civil society**.

Challenge 1 of the 2016 ANR's Work Programme is divided into **6 themes** and **19 topics**, ranging from upstream research projects to projects with multiple applications contributing directly to the **Earth System** action programme (observation, forecasting, adaptation) and the **5 priority research areas of the French National Research Strategy (SNR)**:

[16] http://www.maweb.org/

- 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

and, on a secondary level, priority 15 (Sensors and instrumentation) and priority 20 (An integrated approach to production systems).

In addition, cross-disciplinary approaches are relevant to the **five SNR action programmes that need 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 priority for 2016: In line with the priority areas of the National Research Strategy, a particular attention will be given to projects relating to coastal areas in all themes of this challenge.

Coastal areas constitute a natural laboratory housing a multitude of risks of both natural and human origin, with aspects relating to underground resources, primary biological resources, energy and transport, urban development, land planning and tourism, and efforts to preserve the 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 working either on upper continental part or far offshore part. .

Theme 1: Understanding and anticipating environmental change

In line with the SNR strategic priority areas for Challenge 1, efficient resource management calls for an understanding of the mechanisms that govern the formation, function and evolution of environments and their biodiversity; this in turn will lead to enhanced anticipation of the impacts of resource exploitation and climate change.

Functioning and evolution of climate, oceans and major cycles

The climate domain touches upon all of the Earth System's compartments: the **atmosphere** and the **hydrosphere** (including the **oceans** and the **cryosphere**) closely interact with the geosphere, the biosphere and human societies. The challenge here is to gain a better understanding and representation of the relevant processes, and reduce model biases and uncertainties (gas-aerosols-clouds interactions, ocean circulation, marine biogeochemistry, flux drivers and dissipative mechanisms, non-linear or chaotic phenomena, scales and spaces interactions, tele-connections, interfaces between environmental compartments, global cycles of water, of carbon , of nitrogen, and so on).

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 **distinguishing** between **natural** and **anthropogenic** signals (induced by gas and substance emissions). Studies are encouraged on (i) the use of **proxies** and historical **chronicles** concerning the most **recent millennia**; or (ii) periods long ago where **analogues of rapid transition** help us to gain an understanding of 21st century variabilities and tendencies. Applicants are encouraged to take advantage of the major global **re-analyses** of the Earth System concerning recent decades and centuries, in order to gain greater insight into **regional** variability modes, the related **extremes**, and their **predictability**. The scales ranging from the **season** to the **decade**, which are pivotal between seasonal forecasts and climate projections over a century, are crucial to decision making concerning adaptation

2015/16 international calls for proposals: (i) Climate predictability and inter-regional linkages (JPI Climate and Belmont Forum)

Continental land areas: Critical zone and biosphere, in particular the invisible biosphere

The critical zone, which is the near-surface area of continent, covers the zone between the lower atmosphere and the unaltered lithosphere, and comprises a number of interdependent ecosystems made up of crucial resources: soil (s.l.), air, the visible and invisible biosphere, and surficial free water and groundwater. It provides a range of functions and services: climate regulation (including greenhouse gases), water supply and transfer and associated aspects, biogeochemical cycles (C-N-P, etc.), resources conservation and functions of these ecosystems (water, soil fertility and protection, biodiversity related to soil and water, etc.). Various questions arise here concerning biotic and abiotic interactions between soils, water, the atmosphere, plants and other living organisms, the coupling of biogeochemical cycles of major, minor and trace elements and contaminants, energy and matter transfers (transport of solids and of matter in suspension or in solution, etc.), the role of interfaces (ecotones, hyporheic areas, wetlands, coastal areas, etc.), the conservation of ecosystem services and the processes and scale of potential feedbacks. 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. Insight into how the critical zone functions is also crucial to gaining an understanding of the status and the dynamics of continental aquatic ecosystems, and will contribute towards actions to reduce certain hazards (floods, low water levels, drought, etc.) and limit vulnerability (ecological discontinuity, etc.). By improving response times and the resilience of ecosystems in the face of disruptive elements, the main stake is to identify, quantify, analyse and model critical zone responses to the multiple pressures of global changes relating to climate, land use patterns and other human activities. A functional and interdisciplinary approach is recommended over both the short and long

term, at different spatial scales, based particularly on long-term observation and experimentation mechanisms.

2016 International call for proposals: Biodiversity of soils and sediments (ERA-NET BIODIVERSA-3)

Evolution and dynamics of species and populations

It is hoped that research shall focus on the development of knowledge relating to the biological diversity, the systematic, history and evolutionary mechanisms of organisms, their genomes and their populations in natural systems, and the evolutionary relationships inherent in their phenotypic development.

Research is also invited on the dynamics of species, populations and groups of species within their ecosystems (emergence, extinction, colonisation, invasion, rapid or slow adaptive capacity, plasticity, etc.) and on behavioural evolution (social and individual behaviours, reproductive strategies, etc.) in interaction with the environment (in other words behaviours that influence or are influenced by environment). Research shall be prioritised to give a better understanding of responses to various pressures caused by global change and to other man-made or environmental pressures.

Lastly, it is hoped that research will lead to a better understanding of the adaptive and evolutionary capacity of a given system in relation to the taxonomic and phylogenetic diversity and the long- and short-term dynamics of land settlement, populations or species. These topics may include research on historic and prehistoric periods, where these may serve as a model for understanding current changes related with environmental or human origin global change.

Knowledge of mineral resources (underground and surface formations)

Mineral resources are indispensable for the development of **new technologies**, particularly those involving transportation and renewable energy (energy resources fall within the scope of challenge 2). Even if recycling is optimised, it will not be sufficient to meet the ever-increasing needs. Hence **finding** new resources and **exploiting** them while respecting the natural environment is increasingly difficult – for example critical metals (Ge, REE, Li, etc.). 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.
Understanding the **processes** governing the **origin** of deposits and mineralisation, their spatial and temporal dynamics from the transfer of complex ore-forming fluids to structures, and developing **methods and technologies** to shed light on the structures favouring these accumulations, are essential for **locating** these resources, **assessing** their potential, and **identifying** as early as possible potential **obstacles** to their exploitation or **impacts** on the natural environment, ecosystems and biodiversity (see also Theme 6).

Theme 2: Ecosystem dynamics to improve their sustainable management

(theme common to 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 productive and natural ecosystems for all ecosystem services.
This cross-disciplinary topic is in line with SNR priority areas 2, 3 and 20 and the Earth System programme, Action 2.

Functioning, 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 ecosystem.

This research will provide an insight into ecosystem evolution, adaptation, resilience and the capacity of ecosystems to provide multiple ecosystem services. It will also provide inspiration for the agroecological transition towards new, integrated and sustainable production systems based on ecological functioning that combine better efficiency, reduced emissions (water and soil quality, greenhouse gases and air quality), controlled management of the use of water and soil resources, stimulation and protection of biodiversity factors, carbon storage and integrated management of production systems, from landscape to regional scale. 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: agroecology plan, 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 and greater seasonal variability) and environmental change; the functional role of biodiversity; its contribution to the 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;
- the impacts of agroecosystems and various agricultural, aquaculture and fishing practices on environmental changes; the deterioration of marine or aquatic ecosystems with implications for fisheries resources.

Research shall also relate to 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 scales – from small plots of land to landscape scale or 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 infrastructures and protected areas to improve sustainability and performances.

2015/16 international call for proposals: i) Green infrastructures (ERA-NET BIODIVERSA-3)

The transition of ecosystems: Strategies and policies for supporting transitions

The use 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 via actions, strategies and policies. Research focusing in particular on the development and use of scenarios, 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 product chains management. Supporting the transition towards more sustainable approaches involves:

- developing integrated models that combine socioeconomic, biotechnical and ecological aspects, and creating scenarios to predict the development and adaptation of ecosystems in response to global change;
- identifying obstacles and drivers for action to facilitate agroecological transition, on both a regional and a sectoral scale;
- gaining an understanding of the factors that influence stakeholder behaviours in the face of change, whilst taking into account biotechnical and socioeconomic factors;
- designing integrated and sustainable practices and production systems in collaboration with stakeholders; analysing the learning processes of stakeholders who have demonstrated innovation in their own right and designing new innovative pathways;
- designing and assessing public policies to support transitions, including biodiversity protection measures combining conventional regulatory measures and incentive measures, and the integrated management of health risks via biomonitoring, biovigilance and biocontrol strategies.

2015/16 international call for proposals: Green infrastructures (BIODIVERSA)

Theme 3: Health-Environment: Health risks in the face of environmental change

(common to Challenges 4 and 5)

As part of an integrated approach, 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 impacts of physical, chemical and biological contaminants on ecosystems and on human health and take into account the various environments and levels of exposure (the exposome

concept). It should also encompass interactions between the environment, animal health and human health, in line with the One Health Initiative (www.onehealthinitiative.com), and the role of the environment in the mechanisms of emergence and re-emergence diseases.

The issues at stake include the quest for a better understanding of phenomena and mechanisms, the development of integrative approaches, an assessment of the risks, and proposals for appropriate surveillance methods, counter measures and policies. Cooperative initiatives incorporating different disciplines (biology, medicine, ecology, epidemiology, mathematics, environmental sciences, physics, chemistry, social sciences and humanities) are therefore welcomed.

Contaminants, ecosystems and health

This theme sub-section seeks to encourage investigations into the toxicity of contaminants (including pharmaceutical contaminants) and their metabolites and transformation products for ecosystems and the health of human populations (including via occupational exposure), amongst others the environmental spread of substances inducing resistance to anti-infectious agents. In terms of contaminants, multidisciplinary research approaches are invited for:

- studying the interactions, within the exposome concept, between various contaminants, their kinetics and dynamics in different media (air, water, soil) and organisms, and their potential cumulative effects (in combination with the toxicity of other contaminants, other environmental stresses, etc.);
- highlighting and describing different types of emerging risk: proposing appropriate surveillance systems (including in the work environment);
- analysing the social context in which risks may be assessed and in which discussion and decision-making processes may be undertaken;
- improving prediction capacities using systemic approaches for determining contaminant action mechanisms, assessing ecosystem and health risks and pinpointing vulnerable areas – including over the long term – within ecosystems and human populations, and improving our modelling capacity;
- understanding the environmental, economic and social factors that determine or influence exposure levels and vulnerabilities in ecosystems and human populations, action on the part of social stakeholders and the occurrence of crises and methods of correction and regulation;
- developing detoxification strategies and remedial approaches for dealing with hazards.

Environment and emerging and re-emerging diseases (One Health)

This sub-section covers the emergence mechanisms of infectious human, animal or plant diseases that may be triggered by environmental factors (climate, biodiversity, land use of soil and resources, etc.) in synergy with human-induced factors (agriculture, livestock breeding, industry, urbanisation, transport, demographic changes, social practices, etc.). The exploitation of resistance-inducing molecules (antibiotic use resulting in the emergence of multi-resistant bacteria, antivirals, antiparasitics, antifungals, insecticides, etc.) may also be taken into consideration. This area concerns various biological agents and their products (parasites, bacteria, viruses, fungi), including zoonotic agents.

We would be particularly interested in multidisciplinary and integrative approaches on the following themes:

- the origin of pathogenic agents, ecological niches (reservoirs, hosts and vectors), their development conditions and their spatio-temporal dynamics of transmission;
- interaction mechanisms between environmental, anthropic and social factors promoting virulence and dissemination of pathogenic agents, breaches of the species barrier, treatment resistance mechanisms;
- modelling of emergence, dissemination or exposure parameters, monitoring systems, matching of environmental, biological, social, population and health data with the aim of helping define relevant indicators for a predictive approach; identification of high-risk areas and populations;
- environmentally friendly and human health-beneficial methods and tools for fighting pathogens (vaccination, treatment, monitoring, prevention policies, crisis management, etc.).

Theme 4: Scientific and technological innovations aimed at anticipating or remedying environmental risks

Environmental issues centre around reducing 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, falls within the scope of 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. Preference shall be given in this theme to public-private partnerships that address the following priorities:

Development of sensors for environmental monitoring (smart monitoring)

Underestimating the heterogeneous nature of the environment undermines the benefit of conventional metrology and the effectiveness of a great many prevention and protection solutions. Taking this heterogeneity into account requires a new generation of monitoring systems or long-term diagnostic mechanisms.

It is hoped that there will be technological, digital, economic and methodological breakthroughs in this field, in terms of reduced costs, miniaturisation, improvements in sensor durability, autonomy and reliability, higher data flows, etc. Eco-design or green sensors approaches are encouraged.

In this diversified field of innovation involving numerous types of businesses, we are particularly expecting **technology transfers** that are enabled by information and communication sciences and technologies (robots, drones, nanotechnologies, bio-mimetics, big data and crowd sourcing related solutions), life sciences (biotechnology, bio-indicators and biomarkers), and the geo-sciences (geophysics, geo-chemistry, and remote sensing). When it comes to applications for natural or man-made environments, all environmental compartments are concerned: **water, sea, coast, interior and exterior air, soil** components and their biotic and abiotic components.

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 (pollution, eutrophisation, species invasions, biodiversity erosion, toxic products and allergens, floods and high water levels,

coastal erosion, ground movement, volcanic eruptions, earthquakes, storms, fires, droughts, natural or induced low water levels, over-exploitation of water, etc.).

We are particularly interested in methods and tools for providing operational services to combat these multiple risks, including modelling and data assimilation tools. These advances should lead to real-time or almost real-time management of massive multi-source data, and consequently to more accurate identification of the ways in which effective alert systems may be implemented.

Proposals should focus on integrated forecasting systems that can produce data and scenarios based on the possible causes of an emergency or catastrophe, and 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 relate to 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, but not climate predictability, which is covered by Theme 1 above.

2016/2017 European call for proposals: Climate Services (JPI Climate)

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

The priority in terms of remediation is to restore soil, sediment, biodiversity, water, water service, and climate engineering quality. The goal is to advance the concept of curative treatment toward more systemic and **sustainable remediation** concepts, and to implement integrated strategies concerning primary needs, while still meeting societal needs (air, water, energy, and land, as well as carbon sequestration and the like) The proposed solution should include a methodology based on tools such as life cycle analysis or other types of cost-benefit analysis.

Based on **ecological engineering tools** and **new eco-technologies** (e.g. biotechnology, including genomics, nanotechnology and nano-biotechnology, geophysics, hydro-bio-geochemistry), incorporating technology chains centring around the capacity of products to be recycled will lay down the foundations for **new forms of hands-on engineering**.

In the domain of **contaminated sites**, we encourage research on new processes and/or combinations of remediation measures with a **positive environmental balance sheet**, with the goal of establishing **pedo-genetic engineering practices** that are conducive to deployment in urban and/or de-industrialised areas.

In terms of water, priority shall be given to ground-breaking projects targeting the specific concept of putative experimental waste water treatment plant , combining i) the recovery of raw materials derived from the effluents and their relevant treatments, ii) an awareness of emerging pollutants and their metabolites and iii) increased energy efficiency. The concept of decentralised treatment plants (networks or cascade processes) may also be included.

In terms of **greenhouse effect**, the programme aims to develop French expertise in the field of **climate engineering** (see www.arp-reagir.fr) particularly concerning: (a) management of solar radiation and its (often negative) impacts; and (b) **capturing atmospheric or marine carbon.** In respect of this last section, the following are welcomed: (a) inventive "**second intention" carbon sequestration solutions**, which could be grafted onto the existing industrial processes; (b) **"territorial" geo-engineering**, or using soil to help improve local climatic conditions; and (c) **climate oriented agriculture**.

In the marine environment sector, the programme should help develop new design strategies for marine projects and infrastructures, integrating sustainable development, climate change (the rise in sea level) and the achievement of good ecological status. The approach should propose compensatory measures aiming at optimal environmental benefits based on an ecosystem strategy. Ports, industrial and brownfield port sites and coastal and offshore infrastructures provide opportunities to carry out environmental restoration or eco-design experiments (new projects) on a variety of different scales and in a broad range of "workshop" conditions.

Reducing and controlling the environmental impact of new economic sectors

Ecological transition gives 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 environmental and socio-economic benefits (economic activity and employment) 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.) that extend beyond the physical limits of the industrial activity,[17] so that specific recommendations can be drawn up concerning the economic sector in question to minimise environmental impact, for example:

- efficiency and sustainability factors for resources and the environments in which they are kept;
- stress and potential impact scenarios for these new sectors in terms of the environment, health and long-term trends;
- identification of the key issues in impact monitoring and parallel monitoring of risks and benefits.

2016 European call for proposals: Climate Services (JPI Climate)

Theme 5: Societies 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 collaboratively explore the following: the vulnerabilities and opportunities arising from environmental, social, political and economic changes; the conditions under which various societies adapt to these constraints; and the perspectives for action. Technological and

[17] Within any given challenge (Challenge 2, Challenge 3, etc.), environmentally friendly solutions are sought for the physical premises in which the activity is located.

energy implications should be taken into account. Projects may address various temporal and spatial levels depending on whether a sectorial, multi-sectorial, intersectorial and international approach is adopted.

Renewal of forms of action and instruments of intervention

The management of problems depends as much on their acuity as on the way in which that are addressed by public, private, social or economic stakeholders. A number of questions arise. Which problems have a structuring effect on discourse and proposals and disseminate these elements? And to what effect, in terms of reconfiguring power relationships, coalitions, action related thinking and spaces? Under which conditions do environment problems become public problems (justification and hierarchy-creating modes, knowledge production and dissemination modes, controversies in the face of uncertainties, etc.)?

Environmental policies and the forms of action may be analysed according to their elaboration modes, their content, their implementation, and learning and cooperation patterns. Which instruments are used (consultation, incitation, law, etc.)? How may the different tools be combined (command and control, contracts, technical standards, regulations, self-regulation, etc.)? There should be an exploration of the interrelationships between various policies (environment, health, agriculture, trade, industry, innovation, energy, etc.). Projects aimed at developing assessment tools and proposing mechanisms encouraging collective action will be particularly welcome.

Geopolitical aspects, forms of cooperation and international negotiations

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 may be explored, including how multilateralism fits into a more effective governance model, the implementation of possible cooperation and solidarity mechanisms, or how a successful balance may be achieved between national sovereignty and international governance. Particular consideration should be given to the connections or interference between various topic areas and entities (UNFCCC, WTO, IMF, etc.).

Societal vulnerability, capacity for resilience and adaptation

As a result of the effects of climate change, ad hoc approaches for a given hazard are being abandoned in favour of long-term development of multi-risk, inter-sectorial and integrative approaches that take the domino effect into account. The concept of resilience allows for the qualification of capacities for resistance and adaptation on the part of today's societies. What are the economic, social and cultural factors leading to adaptation to extreme or long-term events?

Historical approaches should promote an understanding of these phenomena. What role do memory and knowledge of people play in different cultural settings? How can long-term factors be taken into account in light of the temporalities arising from other spheres of life in society: finance, infrastructures, innovation, policy, lifestyles and so on? What factors influence the perception of risks

and how much room for manoeuvre do populations have? An integrated approach to the long-term trajectories of socio-ecosystems is encouraged. Retrospective analyses may contribute to an understanding of the process of settlement and the environmental consequences of changes in agricultural practices. The study of periods of cultural, environmental and climatic breakthroughs should contribute to our understanding of the relationships between human societies and the environment.

Management, production and consumption patterns; new growth modes

In order for sustainable development to be achieved, change needs to be effected through a multi–sectorial approach, in conjunction with management, production, and consumption modes. Which options should be envisaged, in light of the existing stakeholders? Which dynamics will allow for the development of markets, new industries and so on? Which instruments will allow for the adaptation of production and consumption behaviours (certification, labelling, regulations, good practices, etc.) and forms of economic organisations? How land management, environmental management and competitiveness should be reconciled? New investigations are required to look into the interplay between growth, development and growing scarcity of certain natural resources (new impetuses for growth, incentives for growth development in keeping with these objectives, the role of industrial policy). Projects may focus on topics including soil or water issues and how they are affected by climate change (in both quantitative and qualitative terms) within a context of growing demand from populations.

Theme 6: Integrated approaches to environmental development: toward more efficient solutions

Issues concerning efficient resource management and adaptation to climate and environmental change can only be addressed by taking into account the complex interactions between ecosystems and socio-economic systems.

This theme calls for multi-, inter- or transdisciplinary research in areas common to all five previous themes in Challenge 1, and with significant input from the social sciences and humanities community. Definition and analysis of the interactions between environments, uses, practices and stakeholders according to integrated or system-based approaches should provide the foundations for (i) addressing changes in practices, behaviours and resource and land management, and (ii) anticipating, detecting, facilitating and enhancing transitions. This research should contribute to adaptation and/or greater resilience on the part of socio-ecosystems in the face of change.

It is recommended that projects specify the various links within the targeted socio-ecosystems (feedback, synergies, antagonisms, etc.) and define any constraints and forcing mechanisms, even external forcing mechanisms. Spatial or temporal multiscale approaches are sought. Priority shall be given to projects drawn up in collaboration with stakeholder partners from the socio-economic sectors. Such projects may range from short, exploratory projects contributing to the formation of innovative consortia to extensive, integrative projects on well-developed issues.

2015/16 international calls for proposals: i) renewable energies, water resources and their connections for the Mediterranean region (ERA-NET ERANETMED), ii) The mountains as sentinels of change (Belmont Forum).

Ecosystem services: assessment, competition and arbitrage

Ecosystem services encompass many aspects, from supply services (food, fibres, useable compounds, genetic resources, etc.) to environmental regulation and self-maintenance services (climate, water, carbon, nutritional elements, oligo-elements, metals, etc.) and cultural services (landscape quality, hunting and fishing, psychological or recreational benefits, etc.). Identifying, quantifying and evaluating these elements (commercial and non-commercial values) is part of an expanding research field stimulated by a number of different national and international initiatives (IPBES, Ministry of Ecology, etc.).

We are expecting proposals in this field, in particular concerning the analysis of usage conflicts between various ecosystem services (e.g. biodiversity conservation versus carbon storage, energy resources versus cultural heritage, purification or buffer roles versus productivity, etc.), concerning the emerging process of compromise or trade-off mechanisms between the relevant stakeholders. Ecosystem services may be analysed, where applicable, by environmental domain (for example forests, aquatic environments, etc.), also taking into account any multifunctional aspects and the limitations of single-service approaches. Retrospective studies may also be carried out on the processes involved in the recognition of these services.

Sustainable management and resilience of land with high environmental stake (in particular coastal areas)

Sustainable land development requires a reduction in (or mitigation of) the cumulative environmental impacts of human activities and an effort of adaptation on the part of societies in order to increase resilience. This involves an assessment of an area's potentiality in terms of better medium- and long-term management on an "intermediate" spatial level (typically from landscape scale or the scale of small catchment basins to extensive regions, in other words covering between 1 and 100,000 km²). We are looking for projects that unite researchers, local socio-economic stakeholders and/or public policymakers around a shared problem in a common region. The resulting data may draw upon scenarios and models, and subsequently contribute towards developing planning and support methods for regional projects.

Within this framework, priority areas for 2016 are as follows:

- Coastal areas: sea drainage basins, estuaries and deltas, interfaces between continental, river and marine environments, coastal development, eutrophisation, etc.;
- Ultramarine regions, which are particularly exposed to global environmental changes;
- High-risk or environmentally sensitive continental l areas (in terms of pressure on resources, areas with several accumulated risks, protected areas, etc.);
- Developing countries, vulnerable areas and those with low adaptation capabilities;
- (Urban areas: please see Challenge 6).

2016 international call for proposals: The sustainability of global urbanisation (Belmont Forum & JPI Urban Europe)

An integrated chain for assessing risks, from natural hazards to landscape impacts

Global change has major impacts on the scale of natural disasters, in terms of intensity or geographical reach. The objective is to achieve better risk awareness and increased socio-ecosystem resilience. Climate drivers, physical mechanisms influencing hazards and the identification of exposed areas and their physical vulnerability or the vulnerability of their systems are important factors when assessing natural hazards. Induced effects such as multi-hazard components, cascade effects, the interaction between natural, industrial and technological risks and feedback (residual risk) should be taken into account in an increasingly detailed manner. This risk chain in geographically identified risk catchment areas should be addressed by multi-, cross- or interdisciplinary approaches, with sustained and extensive involvement with the social sciences and humanities community, particularly for questions involving the cost of risk and the community's perception of risk.

Stumbling blocks involve the inclusion of complex and interactive physical phenomena, as well as their potential impacts on the exposed goods and on modelling these elements in an integrated assessment initiative. Expected benefits centre around an improvement in decision-making tools used for preventing natural hazards, in particular for representative or highly sensitive risk areas.

CHALLENGE 2 – Clean, secure and efficient energy

EUROPEAN AND INTERNATIONAL COOPERATION:

This challenge is part of a European and international research promotion initiative. 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 consortiums.

The 2015/2016 topics that shall be given priority for international backing are detailed below and also given in tables 1 and 2 of the 2016 Work Programme. These lists are subject to change, and so applicants who wish to conduct their projects at European or international level should regularly consult the ANR website for more information on these partnerships and calls for proposals: www.anr.fr/en

The following actions are particularly relevant to this challenge: • ANR-JST (Japan) *"From molecular technology to functional materials"*; • ERA-NET MED.

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. You are strongly advised to read each related challenge in its entirety, to gain a thorough understanding of its specific scope.

For cross-cutting topics that present extensive overlap between several challenges (including **Challenge 2**), please refer to the paragraph entitled "**Multidiciplinarity, cross-cutting research and interfaces**" (on page 48), which covers the following fields: ***Big Data, Robotics, Sensors, Biology, Bioeconomics & Biotechnology.***

The following fields are also interfaced with Challenge 2:

Environmental impacts: quantification of the worldwide impacts (water requirements, CO_2 emissions, etc.) of energy systems falls within the scope of **Challenge 1;** however, the design of low environmental impact energy technologies and research focusing on the management and prevention of risks induced by new energy technologies fall within the scope of **Challenge 2.**

Mineral resources and materials: The production of knowledge on deposits of primary natural mineral resources falls within the scope of **Challenge 1**; projects relating to methods and technologies for extracting, separating, processing and recycling materials used in energy technologies fall within **Challenge 3**; however, all research relating to the use of raw mineral resources for applications in the energy sector fall within **Challenge 2**.

Nuclear energy: research on materials that are subjected to extreme conditions – such as those within the nuclear industry, for example – fall within the scope of the theme entitled "Materials and

processes", in **Challenge 3**. Questions relating to digital simulation are addressed under **Challenge 7.**

Biorefineries and bio-based platform molecules: projects relating to the production of advanced fuels using bioresources, where applicable in conjunction with platform molecules for the chemical industry, fall within the scope of Theme 4 of **Challenge 2**; projects relating to the production of other bio-based products fall within **Challenge 5**. However, projects relating to the manufacture of commodities or functionalised products using bio-based platform molecules, or to downstream processes in phytochemistry (fine chemicals, speciality chemicals, etc.), should be submitted under **Challenge 3.**

CO_2 re-use: Projects relating to the use of CO_2 to produce synthetic fuels or platform molecules for the chemical industry fall within the scope of **Challenge 2.**

Energy efficiency for buildings and transport systems: projects to introduce energy systems or components into buildings and transport systems (rechargeable batteries, heat pumps, etc.) – rather than projects focusing on the design and manufacture of these systems or components, which fall within **Challenge 2** – should be submitted under **Challenge 6**. New combustion methods, the use of new fuels – including biofuels – and pollution control systems targeting transport applications also fall within the scope of **Challenge 6.**

Smart grids: projects relating to intelligent energy networks fall within the scope of **Challenge 2** rather than Challenge 7 if their main focus is a subject other than IT (algorithmics, etc.), big data management or telecoms management (communication protocols).

The protection of energy networks and infrastructures: research relating to the physical and digital protection of energy infrastructures and networks falls within the scope of **Challenge 9.**

Gas sensors: the design and development of gas sensors fall variously within **Challenge 1** (environmental metrology), **Challenge 3** (industrial metrology) or **Challenge 9** (chemical or explosive threats).

LEDs and OLEDs: design and manufacture fall within **Challenge 3** and electronic applications within **Challenge 7.**

CO-FUNDING[18] POSSIBILITIES FOR THE PROJECTS WITHIN THIS CHALLENGE

(see table 3 of the 2016 Work Programme)

Some of the projects within this challenge may be co-funded by the French General Directorate for Armaments (DGA) or the French Research Foundation for Aeronautics and Space (FRAE).

[18] 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

The **5 priority areas in the French National Research Strategy (SNR)** with a high degree of relevance to **Challenge 2** of the 2016 ANR Work Programme are as follows:

- 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 chemicals sectors.

To a lesser degree, Challenge 2 also relates to SNR priority areas 14 (Design of new materials) and 21 (Biomass – from production to varied uses).
The ANR hopes that this challenge will elicit the very best scientific and technological expertise for meeting energy transition requirements both at national level, playing a part in creating the future energy mix under the terms of the "Factor 4" approach (reduction of greenhouse gas emissions by a factor of 4 by 2050) and, more generally, at world level.

There are five key objectives:

- the promotion of appropriate **systemic**, **integrative** and generally **multidisciplinary** approaches often required to address energy-related issues;
- the encouragement of greater involvement on the part of all scientific disciplines able to provide the requisite **fundamental knowledge** for this energy transition, including sciences of matter (physics, chemistry, etc.) engineering sciences (mechanical or chemical engineering, etc.), Earth sciences, life sciences, mathematics and information and communication sciences or social sciences and humanities; these upstream research projects should produce elements useful for the topics described in the themes of the challenge;
- the production and **exploration** of radical and **groundbreaking** new ideas that move away from existing thinking: Theme 1 focuses on this type of research;
- the design of **materials, methods and procedures** that should be 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.) up 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 the integration into existing experimental sites. The scope of action for this challenge is nevertheless limited to relatively upstream levels (Technology Readiness Levels 1 to 5), and complements other R&D funding mechanisms aimed at more downstream phases, both at national level (ADEME – the French Environment and Energy Management Agency, BPIFrance – a public investment bank, etc.) and European level (Horizon 2020). However, project coordinators – including those whose projects relate to 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.

Apart from Theme 1, which focuses on groundbreaking concepts, and Theme 7, which directly addresses the social sciences and humanities, the themes in this challenge cover energy issues from primary resource capture to end use, particularly in the industrial sector, including the interconversion of energy vectors, storage and distribution. Each theme includes research aimed at enhancing fundamental knowledge in the field concerned.

Theme 1: Exploratory research and groundbreaking concepts

This is a cross-cutting theme that interacts with all other themes of Challenge 2. Taking inspiration from programmes put in place by other agencies (the US DOE's ARPA-E programme, EFRI NSF, the High-Risk Challenge in the JST A-STEP programme, Future and Emerging Technologies under the Horizon 2020 programme, etc.), as well as upstream energy research programmes (the US DOE's Basic Energy Sciences programme, EPSRC's "Encouraging physical sciences research to meet energy needs" programme), it aims to encourage projects that explore radically new ideas or approaches and groundbreaking concepts that move away from more incremental and amply documented scientific research projects. These groundbreaking initiatives may fall within the scope of existing fields (the use of perovskites in solar panels, for example, constituted such a breakthrough in 2012) or create new research fields (an example being the introduction, ten years ago, of processes mimicking photosynthesis for the production of solar fuels). The aim, in particular, is to provide proofs of concept in terms of the potential for applying the new idea in the energy sector. Within this context, Theme 1 also aims to interest new communities in energy-related issues and encourage the formation of new partnerships.

Fundamental research relating to Challenge 2 is not exclusive to Theme 1: any research that aims to create new knowledge in existing sectors and scientific fields should be submitted under another theme. Proposals falling within Theme 1 should state how they are different from more amply documented research areas or concepts, and how they are positioned in relation to the scientific literature.

Theme 2: Renewable energy production and energy harvesting

In line with SNR conclusions, researchers' attention is drawn to the need for cost reduction and increased conversion yields for energy produced using renewable sources; these objectives will facilitate the development of renewable energy technologies and increase their penetration rate within the energy mix (SNR priority 6 – Dynamic management of energy systems). There is also a need for the reduction or even elimination of recourse to strategic materials (rare earth elements, Pt, etc.) within these technologies (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 its 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, where applicable combined in multijunction cells, solar concentration and very high yield concepts; solar photovoltaic panel manufacturing technologies are also welcomed;
- heat production, at low or high temperatures (**thermal solar or concentrated solar thermodynamic**) for direct heating and also for cooling, and even electricity or hydrogen production (water splitting using thermochemical cycles);
- the production of **combustibles**, either using natural **photosynthesis** to produce a biomass mainly for energy applications[19] requiring a better understanding and improvement of the "energy" yields of certain microorganisms (production of lipids, sugars, hydrogen, etc.), or using **bio-photoelectrolysis**, where applicable combined with CO_2 photocatalysis (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 some 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 some technologies have already reached demonstration stage, a more efficient capture of these resources still requires research, which will 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

Although it produces a major part of our current energy resources, the subsoil remains a little known and underexplored medium. Research is necessary relating both to the extraction of key energy resources and to the exploitation of its storage capacity, so that competitive, environmentally friendly tools, methods and technologies for exploiting underground resources may find a place in the future energy mix. Optimising exploration is a subject that involves all disciplines related to renewable and non-renewable underground energy resources.

Geothermal energy is a non-intermittent renewable energy source, and represents a high-potential option for high and low temperature applications, in both sedimentary basins and volcanic or magmatic systems. *In line with SNR priority 6, researchers' attention is drawn to the need for a reduction in the costs of geothermal energy in order to facilitate its integration into the energy mix.*

In terms of **non-renewable energies** (conventional or non-conventional hydrocarbons, gas hydrates, native hydrogen, etc.), advances are required for economically viable, environmentally friendly exploitation methods, for both surface and underground exploitation.

[19] See Key Area 4 of this challenge for projects relating to one of the ways of converting biomass into biofuels (or platform molecules).

There is still room for research aimed at developing underground **CO_2 storage** potential and also for **energy storage** (heat, hydrogen, compressed air, etc.). Underground energy storage is also in line with SNR priority 6.

Advances are required in terms of technical feasibility and long-term safety of storage and extraction mechanisms, which involves research into site monitoring and environmental risk management (monitoring strategies, etc.). The development of cross-disciplinary **base knowledge** and **methodologies for assessing the characteristics and capacities of the subsoil** in terms of storage or extraction of energy resources will be of benefit to all sectors.

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 storage means, and as a source of carbon for the chemical industry. The main concern is to reduce the CO_2 emissions generated by the production, conversion and use of these resources. This issue is in line with SNR priority 10 – Fossil carbon substitutes for the energy and chemicals sectors.

In addition to the **direct combustion** of fossil or bio-based primary energy resources (lignocellulosic biomass, organic waste, etc.) for heat or electricity production, or a mix of these (cogeneration), which will require a dual solution including **CO_2 capture from stationary sources,** there are two avenues to be explored for **more efficient production of liquid or gas combustibles with low CO_2 emissions (essentially biofuels) as well as for the supply of bio-based platform molecules (or synthons) to be used in the chemical industry**.

- **physical-chemical and thermal processes,** which are the most mature technologies, and in which avenues of progress relate to separation processes, syngas purification for direct use or conversion 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 or biochemical processes** using microorganisms and/or enzymes to convert biomass into liquid or gas energy compounds and/or platform molecules. These processes may in some cases be combined with chemical methods.

We are also interested in possible avenues for biomass recovery and conversion into energy, chemical products and materials (the **biorefinery** concept).
In this context, the various pathways for **conversion / re-use of CO_2, particularly captured fossil CO_2,** 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.

Theme 5: Storage, management and integration into energy grids

Many renewable energies 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 the dependency of transport systems on fossil fuels (via electrification, 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 should, however, be produced without CO_2 emissions (by water electrolysis or thermolysis in particular), using decarbonised energy sources. 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, others have major room for progress or even require further fundamental research before becoming viable solutions:

- storage in **batteries**, 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 disconnection from the grid or via the addition of new functionalities to existing systems (for example electric vehicle batteries, domestic hot water tanks), may be explored.

Energy transportation, distribution and management

It is also important to work on tools and technologies that allow for a better integration of energy into the grids and electricity management, both for stationary and onboard energy systems: **electrical engineering, power electronics, electrical machines** (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 increasingly temporally intermittent and spatially distributed energy sources and the associated storage solutions requires to work on the concept of **smart energy grids**, on different spatial scales, aimed at providing energy system optimisation in real time. For this, research on the following topics, particularly in association with information and communication sciences, is welcome:

- management of the grid, including space-time predictions of renewable energy production and energy demands; in this regard, consideration should be given to the development of micro-grids, local consumption (including self-consumption) and the design of flexible usage modes (in particular in industrial processes), 'interruptible' consumption or consumption smoothing solutions;

- the dynamics of load management in electro-nuclear energy production to give optimal compensation for the intermittence of solar energies and limit electricity storage requirements: this will necessitate adaptation of the system for managing reactors and the design of interruptible cogeneration modes for heat or hydrogen;
- network security (resilience and reliability) and intrinsic safety or safety by design;[20]
- the management of energy grids interconversion and interoperability (electricity, various gases, heat, etc.).

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**[21] within the manufacturing industry (reduction in energy requirements for existing production processes, or research into alternative processes that are more energy-efficient or have lower CO_2 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. This research should take account of usage constraints (operation in extreme conditions, mechanical constraints, limiting fouling and corrosion, reliability, robustness, 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, etc.) or **materials-based solutions** (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, the energy transition will manifest itself in combined changes in technologies, behaviours, governance modes, regional roles and the various coordination methods (including the market).
Initiatives and action programmes should be underpinned by an understanding of these changes and their socio-economic impacts. There will be a need to strengthen the capacity for dynamic integration of the socio-economic aspects linked to energy policy choices. These steps should avoid the pitfall of focusing exclusively on French operational methods and value systems when addressing

[20] Research relating to the protection of energy infrastructures and networks should be carried out under Challenge 9, "Freedom and security of Europe, its citizens and its residents".
[21] Only projects whose main objective is to save energy or to reduce CO_2 emissions fall within this challenge; projects that address questions surrounding other issues for industrial processes fall within Challenge 3.

issues – particularly industrial issues – that decisively transcend national borders. In this context, the dialogue between society and the sciences surrounding the transition would gain much from being placed in a historical perspective regarding previous transitions born out of resource constraints or innovations, and also from the points-of-view of legal experts, geographers, economists, sociologists, etc.

Integrated or territorial approaches to the energy transition

Territorial approaches towards energy and, more generally, **integrated approaches towards local energy systems** and their interdependencies are encouraged in the context of this challenge. This in particular requires an exploration and redefinition of the technological and institutional interface between local and national links in creating "sustainable landscapes", the development of methods for analysing the role of local energy resources when defining regional policies and the integration of these resources in the local economic and social fabric; it also requires the creation of tools for local technical and economic forecasting associated with national transition scenarios.

Behaviours, uses and the roll-out of innovations

Shifts in **consumer behaviour** and lifestyle are of central importance to the energy transition, and go hand in hand with **the adoption and accepted roll-out of new technologies.** The following points are worthy of particular attention: non-financial incentives, or "nudges" aiming to control or reduce demand, the relationship between consumption patterns, flexible user behaviour and public policies (environmental taxes, quotas, etc.), the assimilation by citizens and end users of new energy technologies, conflicts and interactions between stakeholders around controversial energy technologies, social transformations linked to changing demand and the roll-out of technologies (solar, wind, etc.) that have a greater impact on the local landscape than conventional energy systems.

The economics of the energy transition, markets, regulation and governance

In the context of the energy transition, it is important that **economics, political sciences and the law** help to clarify the following aspects: the exploration of market architectures that reconcile market, supply security and decarbonisation policy; the definition of market rules and regulatory frameworks rendering intermittent producers accountable and taking advantage of storage flexibility; cost-benefit analysis relating to the development of intelligent networks and new products; market governance and rules at the interface between central and local levels; the spread of costs and long-term solidarity between regions; the macroeconomic consequences of the energy transition and the equality of energy access; questions concerning the vulnerability and resilience of manufacturing companies in the face of energy costs and availability; industrial strategies (both on a national and international level), economic and organisational models in the energy production, storage and management sectors.

Modelling and forecasting

Long-term energy and economic models must be improved by taking into account actual stakeholder behaviours, technological details, the variable results of R&D and industrial development, actual innovation processes and mechanisms that determine the speed of acquisition of new technologies, and inertia in terms of technical capital and funding opportunities. Research should also shed light upon multi-criteria assessments (including environmental assessments), by placing technologies in complete, systemic scenarios and no longer viewing them in isolation. These assessments should be based on new developments in terms of criteria choices and dynamic life cycle analysis, energy security and social impacts.

CHALLENGE 3 – Industrial renewal

EUROPEAN AND INTERNATIONAL COOPERATION:

The 2015/2016 topics that shall be given priority for international backing are detailed below and also given in tables 1 and 2 of the 2016 Work Programme. These lists are subject to change, and so applicants who wish to conduct their projects at European or international level should regularly consult the ANR website for more information on these partnerships and calls for proposals: www.anr.fr/en

For this challenge, the relevant calls are: ANR-JST 2016 bilateral call for proposals: Molecular Technology; FLAG-ERA Joint Transnational Call (JTC) (the four non-selected pilots, e.g. robotics)

The partnerships established through bilateral agreements in connection with the generic call for proposals are listed in table 1; for this challenge, we would particularly mention:
• Germany; Austria; Switzerland; Luxembourg
For the German Research Foundation (DFG), integrated research in science and materials engineering, combining digital simulation and experimentation, is encouraged.
• Canada
• Taiwan; Hong Kong; Singapore; India (engineering science).

INTERFACES:

This challenge involves cross-cutting research topics potentially relating to other challenges. 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. You are strongly advised to read each related challenge in its entirety, to gain a thorough understanding of its specific scope.

For cross-cutting topics that present extensive overlap between several challenges (including **Challenge 3**), please refer to the paragraph entitled "**Multidisciplinarity, cross-cutting research and interfaces**" (on page 48), which covers the following fields: ***Big Data, Robotics, Sensors, Biology, and Bioeconomics & Biotechnology.***

The following fields are also interfaced with Challenge 3:

The adaptation of work to the industrial renewal, from three perspectives – "the role of workers in the production system"; "adapting the way work is defined and managed"; and "new approaches to the production chain" in the factory of the future and in business networks – is covered by **Challenge 3**. But "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 market and employment, employment policies, the organisation of work"; "Job quality, the role of work in society, emotions at work, the connection between work and health"; "Men and women at work: the challenge of professional gender equality".

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**. But

projects relating to the manufacture of commodities, high-added-value products or functionalised products using bio-based platform molecules, or to 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: the production of knowledge on deposits of primary natural mineral resources falls within the scope of **Challenge 1**; projects relating to methods and technologies for extracting, separating, processing and recycling materials used in energy technologies fall within **Challenge 3**; however, all research relating to the use of raw mineral resources for applications in the energy sector fall within **Challenge 2**.

Energy: Functional materials for energy production and storage (photovoltaic panels, batteries, etc.) are addressed in **Challenge 2**. Structural materials for usage in severe conditions come under **Challenge 3**.

Molecules for energy (applications in electrochemistry, energy production, new molecular storage systems) are covered in **Challenge 2**. **The use of CO_2** to produce molecules is addressed in **Challenge 2**.

Health: Materials for medical use (biomaterials and biocompatible materials) are covered in **Challenge 4**. For projects concerning innovative nano-objects for health which might come under Theme 5, if the focus of the research is mainly therapeutics, the projects should be submitted under **Challenge 4**.

Nanotechnology: Challenge 3 covers generic aspects concerning nanoparticles, nanomaterials and their assembly into products of the future. Projects regarding the manufacture/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**.

LEDs and OLEDs for low-consumption **lighting** fall within the scope of **Challenge 3**. But the production of **basic organic or inorganic optoelectronic devices** (including LEDs and OLEDs) for optical communication is covered by **Challenge 7**.

CO-FUNDING[22] POSSIBILITIES FOR THE PROJECTS WITHIN THIS CHALLENGE

(see table 3 of the 2016 Work Programme)

Some of the projects within this challenge may be co-funded by the French General Directorate for Armaments (DGA) or the French Research Foundation for Aeronautics and Space (FRAE).

[22] 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

The **five priority areas of the French National Research Strategy (SNR) which mainly concern Challenge 3** of the ANR 2016 Work Programme are as follows:

- priority 11: The Digital factory,
- priority 12: The Green and people-friendly factory,
- priority 13: Flexible, human-centred manufacturing processes,
- priority 14: Design of new materials,
- priority 15: Sensors and instrumentation.

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

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 need to create wealth (by keeping resource consumption to a minimum),
- the challenges facing us in the early 21st century, particularly in environmental terms: CO_2 and water footprints, energy efficiency, reducing pollution, eliminating toxic substances, saving natural resources, recycling, etc.

French industry must gradually work towards domestic, sustainable manufacturing, promoting a circular economy in which it remains a 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 aim of this challenge is to support research projects that will facilitate these developments in the medium to long term. This challenge concerns very broad industrial fields (manufacturing industries, chemical industries, agrifood industries, etc.) and scientific disciplines (organisation of labour, labour law, ergonomics, industrial engineering, robotics, economics, physics, chemistry, mechanics, materials, process engineering, etc.).

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 TRLs (technology readiness levels), from fundamental research (TRL 1) well upstream of potential applications, to research that touches on industrial issues (up to TRL 4). Where relevant, a life-cycle analysis (even just a simplified life-cycle analysis) would be appreciated.

In keeping with the work carried out by the scientific steering committee for the French National Research Strategy (SNR), Challenge 3 is structured around five themes that demonstrate a comprehensive appreciation of research projects ranging from upstream research to future applications:

- Theme 1: Adapting work to industrial renewal
- Theme 2: The factory of the future

- Theme 3: Materials and processes
- Theme 4: Sustainable chemistry, products, related processes
- Theme 5: Nanomaterials and nanotechnologies for products of the future

Theme 1: Adapting work to industrial renewal

It has become increasingly clear that the renewal of industry will entail far-reaching changes to the industrial working environment. Although industry is not the only field in which technological innovation is changing long-held traditions, the very nature of industry places it in the unique position of combining the virtualisation offered by information technology with the continued existence of a significant tangible outcome resulting from each person's work via a process of collective production.

The aim of this theme is to focus on the specific issues that may arise in this industrial environment in connection with, or as a result of, these changes. Such issues may be triggered by these changes, or they may have existed previously but are now taking on new importance. They may become a differentiating factor, or a factor for success, if they are successfully managed and used. They must therefore be specifically analysed and understood in the context of the factory of the future, as envisaged in several themes within this challenge, as well as in the context of the entire ecosystem that will grow up among and around these "factories of the future". This involves taking into consideration the entire system created by the factory of the future as a producer of physical objects, and the role that all those involved play in this system.

The desired industrial renewal will both require and drive changes to the demands, rules and traditions that govern industry, and these changes will have a considerable impact on the nature and environment of the activity defined as "Work". These developments must be facilitated not only by adapting the physical and contractual framework governing work and by preparing individuals, but also by searching for a new meaning and value for work in these new production systems.

It is not yet possible to envisage and examine all potential future situations, but some can already be discerned and should be the focus of research so that preparations can be made for the benefit of everyone – society as a whole, and those involved both as individuals and within companies.

There is widespread agreement that the industrial world of the future will be "highly digital", or digitised, and connected. Tools will be highly "automated" in many fields, and will become smarter and quicker than humans. But it will be up to humans to ensure that tools remain flexible, responsive and adaptable. At the same time, it is likely that the "destructuring" of the creative process will continue apace, but that this in itself will lead to new possibilities for the cohesion and control of the production process.

Finally, we must bear in mind the assets and characteristics of today's industry, which give it a cohesive role in our society – the perception of a "shared" adventure and the existence of a solidarity which unites the entire process from creation to production – and make sure they remain a reality.

Against this backdrop, three topics emerge as priorities for research projects.

Humans as part of the system

People are already, and will remain, a key part of the production systems of the future. They have a detailed knowledge of the manufactured product, are able to understand and reconfigure complex systems, and provide high-level leadership by anticipating or reacting to needs. New technologies for capturing, summarising and providing information should help people, often working alone – whether with a role in the active process (which needs to be reliable and "punctual") or only called on in emergencies (to review the situation and react rapidly) – to act in an appropriate manner. These technologies will require new training and skills and also the adaptation of job profiles so that reactions and decisions have an optimal impact on the efficiency of the process with which humans are interacting. In any case, in an environment subject to excessive monitoring, the human-machine interface should help people in their tasks by providing not just a wealth of information but above all information that is relevant, comprehensible and discernible, to help them move from information to decision-making, while enabling them to develop a sense of responsibility and satisfaction at a job well done. In view of the aims of the factory of the future, this will require research to be carried out into both the physical organisation of the system and the role of the operator, as well as new ways of linking components in the system with operators.

Adapting the reality of work to the challenges of the factory of the future

New technologies have already resulted in the development of new ways of defining work, but they have also led to a more individualistic view of working in a company.

It is by no means clear whether these developments will encourage the broader transformations described above. Changes to the way jobs are defined have led to a greater emphasis on the results to be achieved, with people enjoying more autonomy in carrying out their work, but there is less focus on the individual and collective methods of achieving these results, bearing in mind the coordination and feedback required over the entire system.

Research is therefore needed on the very nature of the work required in industrial organisations, identifying what is actually achieved, the real responsibilities and room for autonomy in work, how these responsibilities and autonomy are assessed and recognised, and how the collective dimension of work is taken into account (e.g. whether job classifications and definitions take account of the realities of work in the factory of the future, whether coordination procedures enable the work achieved to be accounted for, and what training, appraisal, skills recognition and career development methods are used).
More broadly, how can we simultaneously encourage a development dynamic, the attractiveness of personal career management and the collective dimension of work in industry, which remains a cohesive factor in productive organisations? This is a key challenge for the successful renewal of the industrial sector.

New ways of organising the production chain

Networked companies, subcontracting and concurrent activity are concepts and situations that are being and will continue to be developed. New information technologies will also facilitate new and atypical ways of organising work.

In light of the challenges associated with industrial renewal, the focus should be not so much on broad changes to the organisational structures within companies, in a context of globalisation (see **Challenge 8**), as on the specific ways in which the production chain will be organised in the factory of the future, in other words on a production site.

Changes to the specific way companies are organised involve risks and opportunities that require analysis. Risks include the potential fragmentation of working communities and responsibilities, and social competition (see the discussions over the secondment of workers or "inpatriation" practices), while opportunities may arise for teams from several companies in a network to work together on a project basis, or for concurrent activity for larger projects.
The legal framework needs to be developed to include new technical possibilities which provide these fragmented organisational structures with the solidarity required, while respecting the work and responsibilities of those involved.

Theme 2: The factory of the future

This theme concerns the factory of the future in a broad sense, viewed as a system: from the most upstream supplier to the end client, the "technologies, human resources and organisations" components, along the entire product life cycle. This system, human-centred but mediated by the potential of digital technologies, must meet the expectations of customers, investors and society as a whole. It must offer quality products that meet market requirements as a result of a production system that performs to the highest possible standards, in which the labour dimension (working conditions, ergonomics, safety, skills, management, cooperation, etc.) plays a vital part. The production systems developed must incorporate new societal expectations in terms of sustainable development (especially the promotion of synergies between energy and materials in the local region) and also the safety and security of facilities. Projects will be welcomed in any one of the 5 topics outlined below. They should take account of both industrial dimensions and more upstream issues. Projects that break new ground are of particular interest.

A systems approach

The factory, in the sense of an "extended enterprise", is a complex system that includes various internal components (technologies, human resources and an organisational structure) which require a "systems engineering" approach. Design methods must involve interactions between these components and also with the environment (the customer and society in a broad sense). Designs should be developed with a view to the product life cycle, based on a circular production system. These new design methods also need to take account of related services, which are set to bring about fundamental changes in consumption patterns. The factory system should be integrated into its local ecosystem, in connection with a globalised logistics chain.

The virtual factory

The virtual factory should be designed to anticipate future developments in terms of technology, products and organisational structures, so as to achieve optimum industrial performance. It should

be based on digital models of reliable, measurable socio-technical or organisational systems. Innovative technologies for interaction between workers and the virtual factory should enable the validation of new usage scenarios. Advanced virtual- and augmented-reality solutions, innovative simulation and product process optimisation methods, simulation techniques for human-robot cooperation and production reconfiguration mechanisms that facilitate "right-first-time", efficient designs will also need to be used. This virtual factory should also offer faster, more effective training for those working in the factory within a connected environment.

The smart, connected, controlled factory

The factory of the future will be smart and connected. It will incorporate new technologies that increase the cognitive potential of human resources (enhancing human capabilities). Knowledge management will be a key factor in the success of the factory. The Internet of Things will mean that physical objects or "things" will have a part to play in controlling the factory. Factory management decisions will involve collecting information at the level of products or basic operations and using systems to process vast reams of data. The factory must be controlled in such a way that it operates safely and with a high degree of responsiveness. Control should involve all levels of decision-making, time frames and scopes (internally and with regard to the logistics chain). Finally, as with any system, cyber security is a vital aspect that must be integrated from the point of design.

The flexible and agile factory

Increasingly specific and exacting customer requirements are forcing companies to provide ever more complex, individualised products in an economic and competitive way, in both mass and niche markets. Product ranges are being renewed at ever more frequent intervals, meaning that production systems must be reconfigurable and involve optimised reuse of existing production methods, by means of "plug & play" approaches and also industrial organisation. This need for agility should be factored in from the point of design. These requirements, together with the increasing complexity of products, also mean that the human role in the factory should be reconsidered, taking into account interactions with operators and reflecting on how their skills can be developed to enable them to adapt to these permanent changes.

Factories based on production processes and methods

In the factory of the future, all aspects of added value will need to be managed, particularly at technological level. If factories are to fulfil new criteria for societal acceptance, they will require innovative manufacturing, assembly, implementation and measurement technologies that create high added value for the production of highly differentiated or even customised products. Additive manufacturing, which still has considerable scientific challenges to overcome, is leading to groundbreaking processes that simultaneously manufacture the final material, determine the geometry of the objects produced and integrate functions. This is having a direct impact on design and control methods, which need to develop and adapt to incorporate these technologies, and more broadly all innovative manufacturing technologies. The implementation of many of these technologies will require close cooperation between workers and advanced robotics solutions, and careful thought will need to be given to the coordination of this cooperation for all aspects of

performance. This will require advanced command and control technologies and implementation assistance technologies (e.g. cobotics and exoskeletons). Projects should examine how these new technologies will be incorporated into the factory of the future.

The factory of the future will only be possible with the development of new, groundbreaking concepts. Exploratory research projects which do not fit into any of the categories outlined above but are directly linked to the factory of the future will be particularly welcomed in this theme.

Theme 3: Materials and processes

Materials (metals, composites, polymers, glass, ceramics, hybrids, etc.) and their surfaces are strategic elements for industrial renewal and the competitiveness of firms, particularly with regard to resources, performance (in a broad sense) and new functionalities. The performance and properties of these materials are intimately linked to the methods used to obtain them (production, shaping, assembly, etc.), which are becoming more economical and environmentally friendly, with efforts also being made in terms of recycling. Within this series of materials and processes, metallurgy (e.g. production processes, simulations and thermodynamics), the science of polymers, and research into monitoring (instrumentation, measurement, etc.) and online process control are considered to be of major importance.
The aim of this theme is to promote upstream research projects that involve a significant degree of risk. The projects must fall within one of the topics outlined below, which are in line with the priority areas set out in the SNR:

Multi-materials, multifunctionality and processes

As a key factor in the materials of the future, multifunctionality should be seen in terms of “tailor-made materials” which can be obtained either by combining several materials according to a topological and structural organisation, potentially on several scales, so as to obtain all the desired features (mechanical, thermal, optical, etc.), or by directly designing polyfunctional materials. Research into innovative solid materials that combine several functional properties (electrical and magnetic properties for multiferroics, and electrical and thermal properties for composites, for example) comes under this theme.
Assembly processes (gluing, riveting, welding, brazing, etc.) are considered to be multi-material, multiscale processes. Issues relating to heterogeneous interfacial regions (microstructure gradients, localisation of phenomena under stress, etc.) will also be considered. We are looking for approaches that combine experimentation and simulation, as well as the development of innovative processes.

Bioinspired materials

In this topic, we will welcome new manufacturing methods for materials that use structuring models or processes similar to those used in nature (biomimetics) or the use of natural processes to control and direct the growth of new materials that consume less energy. Projects that focus on wood also come under this topic.
Biomaterials and biocompatible products will be considered under Challenge 4 (Health).

New types of chemistry for composite materials

The organic matrices used for composite structural materials make use of thermosetting matrices that are (mostly) derived from epoxy/amine resins. They require firing cycles at relatively high temperatures and the use of an autoclave. New types of chemistry are needed to obtain either materials that can be processed without an autoclave, with polymerisation temperatures between room temperature and 100°C so as to reduce the length of processing cycles and the related costs, or materials that can support constant high temperatures (up to 300°C) during in-service use, with industrially realistic processing.

Metallurgical science and engineering

Every development or breakthrough in the design or processing of metallic materials has an impact on the industrial sector because of the sheer number of fields in which metals are used (e.g. the aeronautical, automobile, rail, construction and packaging industries). Developing innovative alloys is a challenge in this field. Proposals should address this need. They should examine microstructure/property relationships, and may involve the use of simulations (*ab initio* calculation methods, the relationship between thermodynamics and kinetics, simulations of microstructure creation, etc.). These approaches, if closely combined with experimentation on the same scales as the simulations, will become powerful tools that can replace traditional empirical approaches, thereby shortening development time and providing the industrial sector with a major competitive advantage.

High-performance materials for severe conditions

The aim here is to develop a new generation of materials and related production processes that will lead to reliable performances and/or improved lifespans in extreme conditions (very high temperatures, high mechanical stress, high strain rate, highly corrosive environments, materials combining high performance and high recyclability, self-repair, etc.). Improved performances can be achieved by optimising compositions, meso-, micro- and nano-structuring, molecular and composite structures, and architectures. We are also interested in research into ageing and self-repair capabilities.

Substitutes for critical materials and recycling processes

The aim is partly to propose materials and related processes that can be used to replace other materials involving components that are increasingly depleted (or limited by geostrategic circumstances) or in the process of being banned; and also to encourage the use of natural and/or renewable materials that are intrinsically biodegradable and are processed using original methods, in particular environmentally friendly methods. This approach also involves efforts to identify innovative, environmentally friendly processes for the extraction or recycling of strategic metals and carbon-based composites.

Surfaces and interfaces: surface functionalisation and treatment

Solid materials generally have a primary function that may be structural, for example, but they interact with the environment via their surface. The aim of surface treatments or thin-film coatings is to give materials new characteristics or functionalities. Several different techniques are used, and they can also be combined. In this field we are looking for the development of approaches that show innovation either in the proposed functionalisation process or in the desired properties.

Material shaping

When it comes to material shaping, the aim is to establish a link between the specific features of the materials and the processes used to obtain them, particularly in simulation tools. Projects that focus on the links between processing techniques and the final properties of the material are of great interest. These shaping processes (which include additive manufacturing) may concern metals, polymers and/or ceramics.

Measurement and instrumentation methods

Production quality can only be increased by improving process control. This particularly involves online monitoring of the characteristics of manufactured materials, which can be used to make adjustments to operating conditions. Developing online (and real-time) characterisation and diagnostics is crucial for gathering real-time data. Projects of interest in this theme will involve breakthroughs in detection technology and potential corrective action for processes.

Digital and virtual materials

Creating virtual materials serves several purposes, such as being able to determine rapidly how textures and microstructures will influence the properties of the material and how microscopic defects will influence behaviour at macroscopic level, to predict how the material will degrade, and possibly even to certify parts. This approach speeds up material studies, but its reliability depends on whether the digital model is able to represent the structure, behaviour or phenomena under study. We are not looking for material behaviour studies that simulate materials using commercial software applications; but rather original modelling approaches designed to take into account the complexity of real materials.

Theme 4: Sustainable chemistry, products, related processes

The field of chemistry today needs to address the challenges of sustainable development and focus its priorities on people and environment. This will involve stepping up the development of practices to reduce consumption of raw materials, energy costs and environmental impact (gas and liquid emissions, ecotoxicology, etc.). These developments will require diversification of raw materials. The growth of phytochemistry is a key factor in tackling these challenges, alongside improved management of fossil carbon resources, the search for alternative raw materials and the development of waste recovery facilities via recycling and reuse systems. This development of the chemical industry to embrace a “circular” economy must be based on research and innovation

efforts in chemistry and process engineering, combined with ground-breaking activation techniques. Eco-design strategies, cost-benefit analyses and life-cycle analyses should be systematically and carefully incorporated at all levels of technological maturity so as to make sure that the acquired data are relevant for industrial development.

Projects on the investigation, development and implementation of new synthesis pathways that use fewer raw materials and less energy will be welcomed. They may address the entire value chain, from the selection of raw materials to the development of chemical pathways (research into new reactivities, catalysts, green solvents, etc.) and the related processes, if necessary also incorporating the downstream stages of separation and purification. Projects in this theme should also look at the development of safer processes with a reduced environmental impact, particularly based on concepts relating to process intensification (eco-efficient processes). There are potential applications in all chemical sectors, including pharmaceutical chemistry.

On the basis of the environmental and societal concerns laid down in the French National Research Strategy, in particular the priority “Green, citizen-based factories”, we have identified the following thematic priorities:

Economical, intensified processes

This part involves the development of technologies based on atom-efficient chemical processes (cascade, tandem, domino, multicomponent, one-pot reactions, etc.) and on innovative processes that use miniaturisation, microfluidics, transfer coupling, activation methods (microwaves, ultrasound, photochemistry, electrochemistry, non-thermal plasma, crushing, etc.), advanced simulation, process analysis and control, etc.

White biotechnology and bioinspired chemistry

This component focuses on the identification, development and optimisation of new bioprocesses (fermentation processes, implementation of microbial consortia, etc.) and new metabolic pathways that provide access to original products. Applications, particularly in the industrial field, for biosensors or bioremediation may also be explored. Projects submitted under this theme may be experimental, theoretical, technological or industrial (processes), but should favour a multidisciplinary approach. They may make use of experimental tools (for the preparation, the advanced characterisation and the evaluation of physical, chemical and toxicological properties) and also simulation tools at various levels (from molecule to process). Projects should explore applications in phytochemistry and also, more broadly, in organic chemistry.

New media, new molecules

The development of eco-friendly chemistry and related processes involves substituting traditional reactive media with less conventional media such as supercritical CO2, subcritical water, ionic liquids, eutectic solvents, colloidal media, bio-based solvents, etc. This usually requires upstream work for the effective implementation of these media, the analysis of their life cycle and recycling, and their separation, as well as research combining theory and experience that identifies specific reactivities obtained within them. Also of interest for this topic is the investigation of new molecules and

products with original properties that comply with societal expectations. We are looking for progress in the search for solutions to replace substances subject to authorisation in REACH, and for research that leads to products which are more environmentally friendly or demonstrate new, more targeted therapeutic properties. The development of methods for the design and prior assessment of the reactivity (in silico approach) of these new products will play a key role, given the increasing competition and requirements for secure installations and reduced biological and environmental impact. Research of interest may include screening for properties (QSPR and QSAR approaches) with a view to the development of predictive methods based on a molecular-level understanding of structure-property relationships and the chemical reactivity of products.

Supramolecular chemistry and assembly of molecules

Assembly of molecules using weak bonds is vital in the field of life sciences (living systems at meso- and macro-scale, molecular recognition, molecular receptors, enzyme-substrate interactions, etc.) or for designing smart materials. This thematic part particularly concerns the synthesis of mineral and organic supramolecular architectures with self-assembly or self-organisation properties, research into the architectures or assemblies themselves, and reversible or programmable molecular systems. The chemistry and associated structure-property relationships may be explored using a theoretical or applied approach, including colloidal chemistry, physical chemistry and enzyme chemistry.

Catalytic systems

Catalysis is an essential principle in sustainable chemistry and is central to the major industrial challenges of the future. Innovations of interest in this area concern multiple catalysis as well as homogeneous and heterogeneous catalysis.

Projects may particularly focus on combining different catalytic activities, based on research fields such as organocatalysis, dual catalysis (the combined effect of two chemical catalysts), hybrid catalysis (the combined effect of a biocatalyst and a chemical catalyst), tandem catalysis, multicatalysis, cooperative catalysis, enzyme catalysis, metalloenzymes and biocatalysis. Innovative catalytic complexes offering greater efficacy and stability, including in severe reaction conditions, will be welcomed. Progress in downstream technologies for catalyst recycling is also requested.

Projects based on homogeneous catalysis should focus on the search for new catalytic activities, but should also help undo the technological locks to the use of homogeneous catalysis in processes. This field concerns organometallic catalysis and catalysis in water or new media. The problem of catalyst recovery is one of the main issues to this type of catalysis. Projects that propose solutions, for example using biphasic homogeneous catalysis or supported homogeneous catalysis, or offer breakthroughs compared to conventional processes will also be welcome.

In the field of heterogeneous catalytic systems, we are looking for progress in terms of surface functionalisation and modification, supported heterogeneous catalysis, the design and development of nanocatalysts, electrocatalysts and photocatalysts and the development of micro- and nanoreactors. Research could focus on the stability of these catalytic systems and the selectivity of the reactions, which is often less well controlled than in homogeneous media. Finally, the behaviour of impurities in the proposed substrates, particularly bio-based substrates, should be taken into consideration in the study of the catalytic process.

Chemistry and bio-based polymers

This area involves research into how bio-based platform molecules (synthons), particularly from biorefineries or industrial biotechnology processes, can be transformed using chemical processes or a combination of chemical and biotechnological techniques into molecules with high added value, by means of an eco-friendly approach. Research into methods for obtaining naturally-occurring polymers and macromolecules is also of interest. These may include hemisynthesis using bio-based synthons and related processes, regulation of the functionality or formation of composites via the association of macromolecules, particularly those obtained from a controlled, partial fractionation of biomass, the recycling of synthetic or naturally occurring polymers, and the transformation or functionalisation of natural macromolecules.

Projects submitted under this theme may be experimental, theoretical, technological or industrial (processes), but should favour a multidisciplinary approach. They may make use of experimental tools (for preparation, advanced characterisation and the evaluation of physical, chemical and toxicological properties) and also simulation tools at various levels (from molecule to process).

Theme 5: Nanomaterials and nanotechnologies for 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 their functions at various scales (micro and macro) will be designed on a nanometric scale. Controlling industrial processes at nanometric scale remains a major challenge. The development of these processes will require a series of crucial scientific and technological building blocks. Projects submitted under this theme 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, nanowires, nanotubes, core-shells, etc.), which may be hybrid or composite, as well as innovative substrates for flexible optoelectronics, if possible using ecodesign and safe-by-design principles. The durability of nanomaterials may also be a subject for research. These nano-objects may have functional properties (mechanical, chemical, biological, thermal, etc.) which would potentially enable them to be used in materials with new properties. But projects focusing on nanomaterials for electronic, spintronic and optical applications for information and communications should be submitted under Theme 8 of Challenge 7.

Management of interfaces at nano-scale, functionalisation, interaction between interfaces

The second technological building block involves surface functionalisation at nanometric scale, including thin films, and the modification of nano-objects, giving them a functional purpose (chemical or biological reactivity, passivation, directed interaction between surfaces, adherence, optical and magnetic properties, etc.). Dry and wet methods may be examined.

Assemblies of nano-objects and 2D and 3D nanostructuring

Assembling or directing the self-assembly of these nano-objects to obtain bi- or tri-dimensional functional materials represents a challenge. 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, and it therefore comes under this theme. To this end, research might also examine the compatibility of nanomaterials and the potential solutions they offer with industrial processes.

Nanoparticles with innovative healthcare applications

The 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 should focus on defining and investigating new, innovative classes of multifunctional nano-objects (imaging, encapsulation of active ingredients, vectorisation, etc.). They may examine upstream questions about mechanisms for formation, 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 addressed, projects that focus on the fight against cancer, HIV/AIDS and viral hepatitis may not be submitted under this challenge, as these topics are covered 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 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 (without nano-structuring or nanometric-thickness surface functionalisation) for process monitoring comes under Theme 3 of Challenge 3. Projects submitted under this Theme 5 should focus on the improvements or breakthroughs that the nanometric scale can make to the performance of these sensors in terms of detection (physical, chemical or biological), sensitivity, specificity 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 or non-autonomous) power supply and their ability to communicate, should be considered under Theme 8 of Challenge 7. The same issue for environmental monitoring is covered by Challenge 1 and 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 instrumentation to meet metrology and characterisation needs for nano-objects. Projects that focus on the development of instruments or instrumental methodology in this field will therefore be welcomed. These instruments may be developed using any physical properties (Raman, SERS, LSPR, optical microscopy, electronics, near-field techniques, acoustics, magnetic and thermal properties, etc.). In situ or even in operando characterisation methods are of particular interest when the nanomaterials are used in functional devices. The use of optical superresolution to provide imaging capabilities will also be welcome. Finally, we are also interested in projects focusing on the detection capabilities offered by nanoparticles that could serve as a basis for the development of new instruments for process measurement and control.

One aim of this theme is to encourage 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 knowledge acquisition dimension. Projects may focus on aspects that break new ground, as well as production stages that involve overcoming technological hurdles relating to nanometrics. In general terms, modelling and simulation aspects may be included in projects that address any of the hurdles set out above or may be the focus of specific projects.

Projects dealing with graphene and other 2D materials should demonstrate potential links with the European “Graphene” FET Flagship.

CHALLENGE 4 – Life, health and well-being

EUROPEAN AND INTERNATIONAL COOPERATION:

The 2015/2016 topics that shall be given priority for international backing are detailed below and also given in tables 1 and 2 of the 2016 Work Programme. These lists are subject to change, and so applicants who wish to conduct their projects at European or international level should regularly consult the ANR website for more information on these partnerships and calls for proposals: www.anr.fr/en

The following actions are particularly relevant to this challenge:

- Bilateral or multilateral calls on specific topics with a defined schedule:
• Franco-American call for proposals relating to computational neuroscience 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.
• Quadrilateral call for proposals relating to synthetic biology.

- ERA-NET projects that are part of the 7th European FPRTD or Horizon 2020
• EuroNanoMed II – Nanomedicine,
• ERA-NET CVD – Cardiovascular disease,
• ERA-NET Cofund Neuron 3 – neurosciences,
• FLAG-ERA (in association with the Human Brain Project),
• Infect-ERA – Human infectious diseases,
• E- Rare 3 – Rare diseases,
• JPND / ERA-NET Cofund – research into neurodegenerative diseases
• CoEN initiative (Centres of Excellence in Neurogenerative diseases) • E-Rare 3 – Rare diseases
• ERA-NET to support JPIA MR – antimicrobial resistance;
• EJP Radioprotection,
• ERA-NET to support JPI HDHL – Biomarkers in nutrition and Health (BioNH),
• ERA-NET Sustainable Livestock Production, including Animal Health (in association with Challenge 5).

- Joint programming initiatives:
• JPI – AMR Antimicrobial resistance,
• JPND – Joint programme for neurodegenerative disease research,
• JPI HDHL – Healthy Diet for a Healthy Life, interfaced with 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 relevant 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 cross-cutting topics that present extensive overlap between several challenges (including Challenge 4), please refer to the paragraph entitled "**Multidiciplinarity, cross-cutting research and interfaces**" (on page 48), which covers the following fields: ***Big Data, Robotics, Sensors, Biology, Bioeconomics & Biotechnology.***

The following fields are also interfaced with Challenge 4:

Public health issues have strong links with **Challenge 8** and will benefit from joint expertise. Medical or epidemiological approaches to health inequalities fall within **Challenge 4,** but the sociological or economic analysis of these inequalities (access to care, insurance cover, vulnerabilities and determinants of social capital and intergenerational links) fall within **Challenge 8.**

CBRN threats and crisis management: research relating to the management of CBRN (Chemical, Biological, Radiological and Nuclear) agents or to operational, organisational, logistical or economic aspects of crisis management in the face of these threats or environmental risks falls within **Challenge 9.**

Overlaps between themes: if a project is potentially common to more than one theme, applicants should choose the theme corresponding most closely to the project: for example, antibiotic resistance mechanisms fall within "Environment and emerging or re-emerging infectious diseases", synaptic plasticity falls within "Neurosciences", lymphocyte biology falls within Theme 6, etc.

CO-FUNDING[23] POSSIBILITIES FOR THE PROJECTS WITHIN THIS CHALLENGE

(see table 3 of the 2016 Work Programme)

Some of the projects within this challenge may be co-funded by the French National Solidarity Fund for Autonomy (CNSA), Directorate-General for Healthcare within the French Ministry of Health (DGOS) or Muscular Dystrophy Canada (MDC).

[23] 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

The “Life, health and well-being” challenge covers a wide research field, and aims to respond to the natural desire of human communities to optimise their health and well-being via the implementation of health policies. This initiative requires us to push back the boundaries of knowledge via 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 sciences of matter, environmental sciences and humanities. Multiscale analysis 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 the generic knowledge base may relate to any clade deemed to be a primary focus of research or 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 should take account of the prevailing trend towards an increasingly ageing population and changes in lifestyle and social behaviour. These factors may encourage the development of pathologies – such as nervous system impairment, 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 learning and transferring the resulting knowledge 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 appliances sectors.

The “Life, health and well-being” challenge of the ANR 2016 Work Programme is divided into 13 themes. It is built around the eleven strategic priority areas proposed in the “health and well-being” challenge of the French National Research Strategy (SNR), in line with the recommendations of the French High Council for Research. It also contributes to four of the SNR action programmes that need 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, and the need to develop innovative, effective healthcare.

ANR initiatives are intended to complement actions implemented by other national funding agencies. For example, the ANR does not propose to fund research into cancer, HIV/AIDS and viral hepatitis, which are already funded by the French National Cancer Institute (INCa), *Plan Cancer* and the French

National Agency for Research on AIDS and Viral Hepatitis (ANRS). Projects in these fields but in partnerships with industry may nevertheless receive backing from the ANR, along with projects on admissible 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 multiscale cellular, physiological, developmental and ageing mechanisms that take place in living organisms, which is an essential stage in understanding and diagnosing pathologies caused by malfunctions in these mechanisms. Approaches should go beyond descriptive and observational processes and the sequencing of genomes and seek to improve our understanding of intricate functional mechanisms.
(ii) The second approach aims to provide a better understanding of pathological processes and to 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 cell, tissue or organism imaging, new therapeutic targets and molecules, novel high-throughput, high-content screening methods, innovations in pharmaceuticals and pharmacology, regenerative and substitution biotherapies, biomaterials, and technological research in the field of e-health and remote medicine.
(iii) The third approach concerns public health and social health sciences. It focuses on the causal chains of socio-economic, gender, environmental or cultural inequalities, the impact of health shocks or chronic disease on individuals or their environment, social, economic and political dynamics relating to health innovations and the regulation of health-related activities, and methodological research in all fields of application.

The ANR shall also provide funding to certain international or European initiatives under Challenge 4. In the scientific fields concerned by these initiatives, funding and incentives to form international partnerships shall be based on the expectation of a reasonable balance between national and international initiatives in the field in question.

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 themes with strong cross-disciplinary or multidisciplinary links have been highlighted for funding in 2016.

In addition, the SNR programme has identified two priority areas for this challenge: priority areas 16 – Multiscale analysis of the diversity and evolution of living organisms and 17 – Collecting and processing biological data.

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 will draw upon a variety of fields – chemistry, physics, IT, genetics, molecular, cell and structural biology, imaging – with the aim of decoding and predicting the architecture of biological macromolecules and their compounds, the dynamics of their interactions and their responses within cellular or subcellular systems. This theme particularly aims to support and encourage new technological developments in research, such as approaches towards single cells or molecules, original strategies in emerging fields in structural biology, super resolution microscopy, mass spectrometry or chemical biology. It involves analysis of protein or nucleoprotein compounds and their functions, as well as new experimental approaches targeting living organisms with possible applications in functional biology and human health or biotechnology. It includes the design of new biological systems (synthetic biology).

International initiatives: some projects falling within the framework of the Quadrilateral Synbio (Synthetic Biology) agreement shall be considered as belonging to this theme.

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, 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 or embryonic stem cells in all relevant species and models.

Theme 3: Research into systems and organs during normal and pathological function: physiology, physiopathology, ageing

This theme aims to improve understanding of the hierarchical assembly of tissue and organ components, how their properties are generated by their interactions and how deterioration or malfunction in one or more components cause pathologies. These pathologies may stem from a number of causes, including intrinsic factors, (genetic, epigenetic or aspects to do with ageing), extrinsic factors (nutrition, microbiota, infections, drugs, contaminants) or socio-behavioural factors, amongst others.

This initiative aims to support projects addressing all biological and social determinants, in particular – but not exclusively – in the field of metabolic pathologies and nutrition.

In environmental toxicology, biological approaches are encouraged focusing on toxicity pathways and networks, systems biology, epigenetics and investigations into vulnerable life cycle phases in individuals (foetus, puberty), transgenerational effects, the effects of toxic cocktails – particularly at low doses – or key life history characteristics in the dynamics of populations within the environment. Endocrine disruptors are of particular interest.

International initiatives: ERA-NET CVD projects and some projects within the framework of ERA-NET E-Rare 3 fall within this theme. Projects within the framework of ERA-NET Infect-ERA shall also be considered as belonging to this theme.

Theme 4: IT and digital systems, phenotyping, virtual organisms and pathologies, methodological, computer systems and statistical research to meet the conceptual and technological challenges of health research development

This theme involves:

- Bioinformatics, biostatistics and biological modelling tools, preclinical and clinical research, epidemiology including the use of high-throughput biological data and how it affects health system organisation. It requires a nosological breakdown of common diseases, an understanding of their physiopathology and an assessment of related medical interventions. This theme covers intensive and wide-ranging data collection, big data processing, data interpretation, digital simulation, data use in decision-making, data exchange, data access, and the security and ethical dimensions of data management. The development of models and methods for comparison against actual data also falls within this theme.
- Personalised, digital medicine, which includes using the above data to create representational virtual biomedicine (anatomical, functional and metabolic *in silico* simulations), which is then compared against data gathered from patients using physical biological and medical procedures, thus combining health technologies with the understanding of living systems. This includes taking into account the social dynamics and ethical issues surrounding the emergence and implementation of this type of biomedical innovation.
- The impact of these technical developments on patient relations and patient behaviour.

International initiatives: some projects funded within the framework of the CRCNS programme (computational neurosciences) may be considered as projects belonging to this theme.

Theme 5: Genetics and genomics: genotype-phenotype relations, genome-environment interactions, epigenetics

The aim of this theme is to characterise genome variability, the mechanisms responsible for genome integrity, the faithful transmission of genetic information, the principles of genome organisation and evolution and the control of genome expression. It seeks to provide an understanding of the genetic and epigenetic foundations of how various living organisms function and the genetic mechanisms and gene expression problems that give rise to human diseases. Cell models, non-human species (models or otherwise) or patient cohorts and control populations shall be used for the study of

genetic variations, and in particular the study of genomic regions targeted by epigenetic modifications, gene expression regulation mechanisms, non-coding RNA involvement and RNA maturation processes.

Theme 6: Microbiome and microbiota-host relations

Recent descriptions of new microbial strains and potential relations between microbiota and pathologies have laid down an initial knowledge base that now needs to be strengthened so as to arrive at an integrated view of the microbiome present in each human and animal organism. The aim is to encourage interdisciplinary research in all "omics", high-throughput research and modelling to enhance knowledge of the molecular mechanisms involved in balance and adaptation strategies between microbial communities and their hosts as well as microbiome functions and malfunctions and their impact on the organism generally. Research is also encouraged on susceptibility to infection, resistance to antibiotics in pathological cases and predictive biomarkers for inflammatory mucous membrane diseases.

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

International initiatives: some projects within the framework of ERA-NET Infect-ERA (human infectious diseases) shall be considered as belonging to this theme.

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

This theme covers three major research fields:

Neurosciences, fundamental approaches to nervous system function

This branch 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 (for example neural code), as well as aspects specific to the human or animal brain in its social dimension (multimodal sensory aspects, memory, behaviours, object and action recognition, conscience, thought, language, relationships with others, etc.).

Mental health, psychiatry and addiction

This theme sub-section aims to support projects addressing the full range of expressions and biological and social determinants of mental health, psychiatry and addiction. A medical or epidemiological approach to inequalities in the field of mental health falls within the theme of public health in Challenge 4, but sociological or economic analysis of these inequalities (access to healthcare, insurance cover, vulnerabilities, determinants relating to social capital and care provision) falls within Challenge 8; associated mechanisms fall within Challenge 4, Theme 13.

International initiatives: projects related to ERA-NET Cofund Neuron 3 (Neurosciences) shall be considered as projects belonging to these two sub-sections, as well as certain projects proposed to the CRCNS programme (computational neurosciences), with NSF-NIH (USA), BMBF (Germany) and Israel, and initiatives related to ERA-NET FLAG-ERA and the Human Brain Project.

Neurology, neuropathologies and research initiatives on neurodegenerative diseases

This theme also covers aspects related to understanding the mechanisms and development of nervous system pathologies, particularly sensory organ pathologies and cerebrovascular pathologies. Within the field of neurodegenerative diseases this theme aims to encourage complementary aspects and synergies between fundamental research and preclinical, clinical, epidemiological, social sciences and humanities and health technology research that will foster research into a number of neurodegenerative diseases. Projects should aim to enrich research into the various neurodegenerative diseases (NDDs) and provide a deeper understanding of NDDs via the analysis of their physiopathological mechanisms.

International initiatives: initiatives under the JPND (neurodegenerative diseases) programme and the CoEN initiative will be considered as belonging to this theme.

Theme 8: An integrated approach to immune responses

In the face of the increasing incidence of immune and inflammatory pathologies, 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. Funding shall also be given to projects aiming to diagnose immune deficiencies, improve vaccination efficacy and protect the organism from harmful immune responses.

International initiatives: some projects within the framework of JPI-AMR (antimicrobial resistance) fall within this theme.

Theme 9: Public health: French social inequalities in terms of health: preventive health care, primary care and social services

(theme common to Challenge 8)

Public health research straddles Challenge 4 ("Life, health and well-being") and Challenge 8 ("Innovative, inclusive and adaptive societies"). Relevant projects shall be assessed by a single, interdisciplinary panel of experts. 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.*

The objective is to encourage cross-disciplinary research and enrich the discussion surrounding possible initiatives to address the main causes and manifestations of social inequalities or vulnerabilities related to health in France. An appropriate response from the public authorities presupposes prior analysis of social, behavioural, psychosocial, economic and biological aspects in an effort to shed light upon the effects of certain social determinants on health, or 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 around social sciences, humanities and societal aspects.

Theme 10: Translational health research

Incentive initiatives in translational research are aimed at financing studies positioned downstream of the exploratory projects carried out in research laboratories and upstream of clinical projects backed by the Hospital Clinical Research Programme (PHRC) run by the Directorate-General for Health within the French Ministry of Health (DGOS). The objective is to fund collaborative projects around scientific questions positioned at the interface between fundamental and clinical research. This theme focusing on translational research aims to erase the boundaries between upstream and downstream areas, particularly in terms of physiopathological aspects. Project results should enable the formulation of new hypotheses for testing 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 mission-oriented biological and biomedical research projects. Funding may be given to two possible types of projects: (i) projects with high innovation potential in terms of knowledge acquisition, design or technological maturation that will promote 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. This field concerns only innovations addressing health via research and validation of diagnostic methods (including the identification and validation of biomarkers, screening and prognosis), therapeutic targets and treatments, and industrial application and production aspects. Projects to study the dynamics of biomedical innovation within healthcare may be submitted under this theme.

International initiatives: initiatives related to ERA-NET EuroNanoMed II (nanomedicine) will fall within this theme.

Theme 12: Healthcare technologies

Engineering sciences, digital sciences and mathematics, in association with life and health sciences, are powerful tools for transforming quality of life in terms of healthcare and autonomy, and play a decisive role in medical advances. The field includes technologies related to compensating for disability or loss of autonomy. Funding may be given to two possible types of projects: (i) projects with high innovation potential in terms of knowledge acquisition, design or technological maturation that will promote 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 to study the dynamics of technological innovation within healthcare may also be submitted under this theme.

Theme 13: Health-Environment, based on the One Health concept

(theme common to Challenges 1, 4 and 5)

Projects submitted under this theme, which is common to Challenges 1, 4 and 5, shall be jointly assessed. This theme concerns fields at the interface between challenges, or approaches that are particularly cross-disciplinary. It aims to encourage research throwing light upon the interactions between environment and health, in particular in connection with the behaviours and risk factors associated with living conditions.

The study of interactions between environment and human health requires strong links to be forged between biology and the fields of human, animal and plant health, chemistry, ecology, ecotoxicology, evolution, and social sciences and humanities. Lying at the heart of these studies is an understanding of the relationship between human health, the health of all living species and efficient ecosystem function. This concept is recognised internationally under the title “One Health”. It is underpinned by the exposome notion, and involves a coherent analysis of emerging risks.

Two sub-sections shall be considered within this theme:

Contaminants, ecosystems and health

This sub-section focuses on a number of areas of study, including the toxicity of contaminants, their metabolites and transformation products, ecosystems and the health of human populations and the link between work and health. Multidisciplinary approaches are welcomed for: 1) studying the notion of the exposome, the interactions between various contaminants and their potential cumulative effects; 2) characterising emerging risks and establishing adequate risk monitoring systems, as well as analysing the social context in which risks may be assessed and in which discussion and decision-making processes may be undertaken; 3) improving prediction capacities using system approaches; 4) understanding the environmental, economic and social factors that determine or influence exposure levels and vulnerabilities in human populations and that provoke action on the part of social stakeholders; 5) developing corrective approaches.

The environment and emerging or re-emerging infectious diseases

For Challenge 4, insofar as humans are the focus of the project, the aim is to fund multidisciplinary research that takes account of the social and environmental aspects of zoonotic infectious diseases with a view to be prepared for an epidemic or possibly a pandemic, and also with a view to prevention and anticipation, and to contribute to the fight against resistance to anti-infective agents. This sub-section aims to enhance our knowledge of environmental factors – of both human and non-human origin – in the emergence or re-emergence of diseases (human, animal and in particular zoonotic) or the appearance of resistance to anti-infective agents. We would be particularly interested in multidisciplinary and integrative approaches on the following themes:

- the origin and detection of pathogenic agents, their ecological niches (reservoirs and vectors), development conditions and the spatio-temporal dynamics of their transmission;
- information on pathogenic agents in themselves and the host-pathogen relationship;
- interaction mechanisms between environmental, anthropic and social factors promoting virulence and dissemination of pathogenic agents;
- modelling emergence, spread or exposure parameters, including the construction of databases or monitoring systems combining environmental, climatic, biological, social, economic, demographic and health data that could contribute to the definition of indicators for a predictive approach to the spread of epidemics as part of a health monitoring strategy;
- the identification of at-risk regions and populations, societal aspects and public health;
- environmentally friendly and human health-beneficial methods and tools for fighting pathogens (vaccination, treatment, monitoring, prevention policies, crisis management, etc.).
- management of resistance, including the improvement of rapid resistance detection and diagnostic tools.

CHALLENGE 5 – Food security and demographic challenges

EUROPEAN AND INTERNATIONAL COOPERATION:

This challenge is also based on international programming initiatives. Priority shall be given to multilateral initiatives backed by European joint programming initiatives (JPIs) in conjunction with ERA-NET projects, giving rise to possible complementary funding from the European Commission. Bilateral cooperation involves countries not covered by these initiatives.

The 2015/2016 topics that shall be given priority for international backing are detailed below and also given in tables 1 and 2 of the 2016 Work Programme. These lists are subject to change, and so applicants who wish to conduct their projects at European or international level should regularly consult the ANR website for more information on these partnerships and calls for proposals: www.anr.fr/en.

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. You are strongly advised to read each related challenge in its entirety, to gain a thorough understanding of its specific scope.

For cross-cutting topics that present extensive overlap between several challenges (including **Challenge 5**), please refer to the paragraph entitled "**Multidisciplinarity, cross-cutting research and interfaces**" (on page 48), which covers the following fields: ***Big Data, Robotics, Sensors, Biology, Bioeconomics & Biotechnology.***

The following fields are also interfaced with Challenge 5:

Ecosystems dynamics to improve their sustainable management (Theme 2): this theme is common to Challenges 1 and 5.
Health-Environment (Theme 3): this theme is common to Challenges 1, 4 and 5.
Microbiomes (Theme 4): projects relating to food and its interactions with microbiomes – from food production to the effect of food on the digestive system – should be submitted under Challenge 5; all projects relating to human diseases should be submitted under Challenge 4.
The varied uses of biomass (Theme 5): if the focus of the project is not specifically energy related, approaches to the varied uses of biomass fall within this theme. Biotechnology projects focusing on the production of advanced fuels in biorefineries fall within Challenge 2, and those focusing on the production of other bio-based products fall within Challenge 5. Research focusing on the territorial integration of biomass-using chains, and the associated environmental, social and economic impacts on rural or local development and on competitiveness fall within this challenge.

CO-FUNDING[24] POSSIBILITIES FOR PROJECTS WITHIN THIS CHALLENGE

(see table 3 of the 2016 Work Programme)

Within the framework of the 2016 generic call for proposals, the ANR is working in collaboration with the French Ministry of Agriculture, Agrifood and Forestry (MAAF). The MAAF's involvement concerns the key issues identified in the *Loi d'avenir* of Agriculture, Food and Forestry of 13th October 2014, and is also in line with the French agroecological plan (including the Ecophyto plan), which targets research and innovation fields falling within the scope of Challenge 5. The MAAF is therefore likely to allocate additional funding to projects that specifically address these issues.

The ANR is also working in partnership with Apis-Gène within the context of Challenge 5. This involvement falls within the framework of Apis-Gène's EGER programme (focusing on global efficiency in ruminant breeding), which aims to identify drivers that improve the efficiency of ruminant nutrition, reproduction, health and well-being and the quality of ruminant products via a better understanding of the underlying genetic mechanisms and an acknowledgement of the diversity of geographical conditions and farming systems. Apis-Gène shall allocate funding in a public-private partnership arrangement to support such research projects.

Introduction

World demographic growth brings with it key issues for the future of our societies, particularly in terms of food security and the various uses of biomass from renewable carbon. It should be seen in a context of changing dietary patterns, the globalisation of production circuits, trade in raw materials or processed products, the scarcity of resources, increasing climatic hazards and environmental concerns relating to the exploitation of productive ecosystems.

Three avenues of research emerge within this context:

- **Innovation for the triple economic, social and environmental performance of productive ecosystems.** The aim is to develop biological resources and production systems that contribute to improving this performance. In this context, a key issue is the sustainable management of agricultural, forest, fisheries or aquaculture ecosystems and of their interactions with natural and semi-natural ecosystems, as well as the sustainable management of associated ecosystem services. Of equal importance is management of the relationship between the environment and the health of populations and communities that live within these systems.
- **Ensuring food security in both quantitative and qualitative terms,** which involves feeding the planet "healthily, fairly and sustainably". Food systems (production, processing, trade, retailing, consumption) should be developed with this aim in mind. Innovations should include new raw materials and associated manufacturing processes, and also provide support for actors' behaviour change in terms of consumption practices, eco-design and reductions in loss and waste.
- **Promoting the regional bioeconomy.** Via the integrated design of systems to produce, convert and use biomass at territorial level, sustainable exploration and exploitation of the

[24] 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.

diversity of water- or land-based living organisms for food and non-food use must be developed, in a context of ecological transition and circular economy at regional level.

In line with these priority areas, Challenge 5 is divided into five themes, which focus on the acquisition of both fundamental and applied knowledge in biology, agricultural and ecological sciences, social sciences and humanities or the interfaces between these disciplines. These themes call for systemic research initiatives demanding a high level of conceptualisation and the integration of data and knowledge from a variety of disciplines, relating to different organisation levels and spatial and temporal scales,

- Theme 1: Animal biology, plant biology, micro-organism biology, and adaptation to environmental change
- Theme 2: Ecosystem dynamics to improve their sustainable management
- Theme 3: Health-Environment
- Theme 4: Food, healthy and sustainable food systems, world food security
- Theme 5: Bioeconomy: from production to the diverse uses of biomass

These five themes are directly relevant to three of the priority areas of the French National Research Strategy (SNR):

- priority 19: Healthy and sustainable diet,
- priority 20: An integrated approach to production systems,
- priority 21: Biomass – from production to varied uses

and, to a lesser extent, to other SNR priority areas, such as priorities 2 (Sustainable management of natural resources), 3 (Assessment and control of climate and environmental risk), 10 (Fossil carbon substitutes for the energy and chemical sectors) or 16 (Multiscale analysis of the diversity and evolution of living organisms).

Theme 1: Animal biology, plant biology, micro-organism biology, and adaptation to environmental change

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 demands:

- the development of productive living organisms that contribute to the triple benefit of improving economic, social and environmental performance and that are adapted to global changes whilst at the same time encouraging biodiversity;
- the improvement of genetic resources for enhancing efficiency of inputs (fertilisers, pesticides, water, etc.) and limiting environmental impacts (soil depletion, salinity, the degradation of water resources, carbon footprint).

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.

Targeting this improvement in performance requires complementary approaches in biochemistry, physiology, genomics, genetics, epigenetics, modelling, bioinformatics, etc., in order to:

- shed light upon **the mechanisms and determinisms** underlying **development, growth, reproduction, production and adaptive plasticity** in animal, plant and microbial species;
- decipher **the mechanisms and determinisms underlying interactions between organisms** – positive (symbiosis, beneficial partnerships, etc.) and/or negative (parasitism, pathogenicity, etc.). Proposals should focus on specific interactions but should also aim at deciphering the generic mechanisms. The cross relationship between environmental variations (nutrient deficiency or excess, drought, etc.) and the development of favourable and unfavourable biotic interactions is of particular interest here.
- determine **characteristics required by living resources to adapt or to mitigate long-term global changes**, and to explore the biodiversity for alternative species which are adapted to local conditions or specific socio-economic contexts. The determinism and expression mechanisms of these characteristics will then be studied in order to fit in with renewed production systems (agroforestry, new livestock breeding systems, agroecology, aquaculture, etc.).

In order to optimise agricultural transition processes, species, breeds and varieties should be maintained, developed and tested in farming systems, in particular: (i) to improve methods for preserving and exploiting genetic resources; (ii) to experiment so as to determine whether **knowledge gained using model species is transferable** to living resources (overcoming methodological or conceptual hurdles, for example in comparative biology or in functional analysis tools, or developing cutting-edge selection tools, integrating epigenetic regulation in particular); (iii) to optimise **breeding methods**, gene expression, regulation and selection (reproduction, clonal multiplication, polyploidisation, apomixis, transformation, etc.); (iv) to use **modelling** for **more integrative and predictive biology**.

Approaches to systems biology and synthetic biology fall within this theme, as well as the use of "omic" tools. This entire research area falls within a continuum of scale from molecules right up to cells, organs, individuals and systems biology.

2016 multilateral call for proposals in France, Germany, Portugal, Spain: Plant genomics and adaptation to global change (PLANT KBBE)

Theme 2: Ecosystem dynamics to improve their sustainable management

This theme is common to Challenges 1 and 5. The intention is to encourage an integrated ecosystems approach to promote the agro-ecological transition of production systems. Interdisciplinary projects that integrate ecological sciences, agricultural and biological sciences, social sciences and humanities are encouraged. Proposals submitted under this theme shall be assessed by a mixed and representative panel of experts from agricultural sciences, ecological sciences, social sciences and humanities.

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 to develop food and non-food productions, including all ecosystem services.

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 ecosystem.

This research will provide an insight into ecosystem evolution, adaptation, resilience and the capacity of ecosystems to provide multiple ecosystem services. It will also provide inspiration for the agro-ecological transition towards new, integrated and sustainable production systems based on ecological functioning that combine better efficiency, reduced emissions (water and soil quality, greenhouse gases and air quality), controlled management of the use of water and soil resources, stimulation and protection of biodiversity factors, carbon storage and integrated management of production systems, from landscape to regional scale. 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: agro-ecology plan, 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) and environmental change; the functional role of biodiversity; its contribution to the 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;
- the impacts of agroecosystems and various agricultural, aquaculture and fishing practices on environmental changes; the deterioration of marine or aquatic ecosystems with implications for fisheries resources.

Research shall also relate to 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 scales – from small plots of land to landscape scale or 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 infrastructures and protected areas to improve sustainability and performances.

The transition of ecosystems, and strategies and policies for supporting transition

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 via actions, strategies and policies. Research focusing in particular on the development and use of scenarios, 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 products chains management. Supporting the transition towards more sustainable trajectories involves:

- developing integrated models that combine socioeconomic, biotechnical and ecological aspects, and creating scenarios to predict the development and adaptation of ecosystems in response to global change;
- identifying obstacles 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 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 who have demonstrated innovation in their own right and designing new innovative pathways;
- designing and assessing public policies: policies to support the agro-ecological transition; biodiversity protection measures combining conventional regulatory measures and incentive measures; the integrated management of health risks via biomonitoring, biovigilance and biocontrol strategies.

2015/16 international calls for proposals: i) Green infrastructures (ERA-NET BIODIVERSA-3); ii) Sustainable livestock production (JPI FACCE) (in association with Challenge 4); iii) Sustainable exploitation of marine resources (ERA-NET Cofund COFASP); iv) Mediterranean agriculture (ERA-NET ARIMNet)

Theme 3: Health-Environment

Theme 3 is common to Challenges 1, 4 and 5. This theme aims to encourage integrated, multidisciplinary projects, and it is hoped that it will attract integrative initiatives. Studies on the ecotoxicological impacts of substances used and produced by production chains fall within this theme. This theme comprises two sub-sections: projects shall be assessed by two corresponding sub-committees.

An integrated approach to the study of how environmental factors affect living species or human

health and the role of the environment among the various factors influencing health are among the priorities of the National Research Strategy (SNR), and are relevant to Challenges 1, 4 and 5. This theme concerns the impacts of physical, chemical and biological contaminants on ecosystems and human health and should take into account differences in environments and levels of exposure (the exposome concept). It also encompasses interactions between the environment, animal health and human health, in line with the One Health Initiative,[25] and the role of the environment in the mechanisms of emerging and re-emerging diseases.
Cooperative initiatives incorporating different disciplines (biology, medicine, ecology, epidemiology, mathematics, environmental sciences, physics, chemistry, social sciences and humanities) are therefore welcomed within this theme. The issues at stake include the quest for a better understanding of phenomena and mechanisms, the development of integrative approaches, an assessment of the risks, and proposals for appropriate surveillance methods, counter measures and policies.

Contaminants, ecosystems and health

This theme sub-section seeks to encourage investigations into the toxicity of contaminants (including pharmaceutical contaminants) and their metabolites and transformation products for ecosystems and the health of human populations (including via occupational exposure), amongst others the environmental spread of substances inducing resistance to anti-infectious agents. In terms of contaminants, multidisciplinary research approaches are invited for:

- studying the interactions, within the exposome concept, between various contaminants, their kinetics and dynamics in different media (air, water, soil) and organisms, and their potential cumulative effects (in combination with the toxicity of other contaminants, other environmental stresses, etc.);
- highlighting and describing different types of emerging risk: proposing appropriate surveillance systems (including in the work environment);
- analysing the social context in which risks may be assessed and in which discussion and decision-making processes may be undertaken;
- improving prediction capacities using system approaches for determining contaminant action mechanisms, assessing ecosystem and health risks and pinpointing vulnerable areas – including over the long term – within ecosystems and human populations, and improving our modelling capacity;
- understanding the environmental, economic and social factors that determine or influence exposure levels and vulnerabilities in ecosystems and human populations, action on the part of social stakeholders and the occurrence of crises and methods of correction and regulation;
- developing detoxification strategies and remedial approaches for dealing with hazards.

The environment and emerging and re-emerging diseases (One Health)

This sub-section covers the emergence mechanisms of infectious human, animal or plant diseases that may be triggered by environmental factors (climate, biodiversity, the use of soil and resources, etc.) in conjunction with human-induced factors (agriculture, livestock breeding, industry,

[25] http://www.onehealthinitiative.com/

urbanisation, transport, demographic changes, social practices, etc.). The exploitation of resistance-inducing molecules (antibiotic use resulting in the emergence of multi-resistant bacteria, antivirals, antiparasitics, antifungals, insecticides, etc.) may also be taken into consideration. This area concerns various biological agents and their products (parasites, bacteria, viruses, fungi), including zoonotic agents. We would be particularly interested in multidisciplinary and integrative approaches on the following themes:

- the origin of pathogenic agents, ecological niches (reservoirs, hosts and vectors), development conditions and the spatio-temporal dynamics of transmission;
- interaction mechanisms between environmental, anthropic and social factors promoting virulence and dissemination of pathogenic agents, breaches of the species barrier, treatment resistance mechanisms;
- modelling of emergence, dissemination or exposure parameters, monitoring systems, matching of environmental, biological, social, population and health data with the aim of helping define indicators for a predictive approach; identification of high-risk areas and populations;
- environmentally friendly and human health-beneficial methods and tools for fighting pathogens (vaccination, treatment, monitoring, prevention policies, crisis management, etc.).

Theme 4: Food, healthy and sustainable food systems, world food security

Food systems at all levels – whether 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 wastes and encourage waste recycling and a smaller carbon footprint. Food products should also meet the nutritional needs and pleasure expectations of consumers and 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 should also be supported by appropriate public policies.

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 5.

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

This development should concern on one hand all the processes from production and processing of raw agricultural and aquatic materials to food production and retailing and on the other hand consumers' behaviours. 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. It is crucial to open up avenues of innovation so that companies may respond to the demands 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 processing stages (primary and secondary) and food formulation, and also on an analysis of consumer behaviour and the impacts of this behaviour on health and the environment, and on public policy implementation methods and enterprises' strategies.

- **Innovative technologies and processes in food production:** process flexibility in line with the variability of raw materials; online operation and management; automation or robotisation of operations and biomechanical techniques to improve performances 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, intelligent and user-friendly (ICT, sensors, etc.); life cycle optimisation; by-product and waste valorisation (circular economy).
- **Safety of the food chain:** pathogenic organisms (bacteria, viruses, parasites) and spoilage organisms; chemical and immunochemical hazards (neoformed compounds, contaminants, allergens); methods for hazard and risk assessment on an industrial or sectorial scale; improvements in food shelf life.
- **Interactions between foods, microbiomes and the food chain**: projects addressing the control of food microbiomes during food processing, and in particular the properties passed on to foods by these microbiomes, as well as the effects of microbiota introduced into the intestinal microbiome via foods are expected.
- **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. We expect projects addressing how public policies operate to support these lifestyle changes.
- **Foods and diets that encourage 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 (sensory, nutritional, safety, social and economic).
- **Industrial strategies:** competition and complementarity issues between the food industry, agro-industry and retailing; industrial strategies to answer 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 sectors' actors; resilience and resistance to economic or safety shocks; impact analysis and drivers for public policies targeting food system actors (enterprises, consumers, etc.).

World food security

Food security covers the four key dimensions defined 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 and nutritional transitions, energy transition, socio-political transitions, economic growth and inequalities' increase, etc.). Given that proposals may integrate a global vision or take place in European or extra-European contexts (emerging or developing countries), research shall particularly focus on:

- 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 (climatic risks, agricultural market instability);
- **public policies** and **food security governance**: the formation of public action, policies and governance instruments to encourage food security at different levels; organisations and mechanisms aiming at food security (on a regional or international level); the conditions in which food security policies emerge; investment in the organisation of public or private markets and infrastructures;
- **the determinants of food access:** household food strategies, the link 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, migrations, urbanisation; impacts of changes in food product supply, product characteristics and enterprises strategies on dietary patterns; economic, social, health-related 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.

Theme 5: Bioeconomy: biomass – from production to the diverse uses of biomass

The bioeconomy assumes a systemic approach of the production, processing and marketing of a variety of bio-based products (foods, materials, energy, molecules, etc.) and also water recycling and waste recovery. It falls within a circular economy logic. It calls for a holistic approach of value chains and complementarities between the actors involved in these chains at territorial level, bringing together rural, peri-urban and urban stakeholders. It leads to a revitalisation of biomass uses via the exploration of biomass diversity, the design of sustainable technological and biological processes and the development of biotechnologies including synthetic biology.

Applications focusing exclusively on human nutrition shall be considered under Theme 4 of this challenge.

Biotechnologies and processes for bioresource conversion

The aim is to develop and optimise bioresource use – both food-related and non-food-related – particularly by defining and implementing methods relating to biotechnologies and transformation processes, and particularly within biorefineries. This issue demands research in fundamental biology at different scale, from the single gene to the organism. The development of methods based on genomics and post-genomics, as well as systems biology and synthetic biology, falls within this theme. It is also important to manage physical, chemical and biological transformation mechanisms, and combinations of these, that confer properties to food or non-food products.

Research in this theme should have the following aims:

- exploring continental and marine biodiversity using biochemistry, physico-chemistry, biology or genomics in order to develop bioresources that are adapted to new climatic, social, economic or demographic factors;
- developing generic technologies based on genomics and post-genomics as well as systems biology (up to modelling) or synthetic biology for promoting new bioresources;
- studying the metabolic pathways and the regulations of the production of valuable biomolecules and optimising these pathways and their yield in organisms (models or otherwise);
- developing various biological engineering systems for the production of biomolecules by microbes, plants or animals;
- developing biotechnological and/or chemical approaches to optimise extraction, refining, fractionation and functionalisation for biomass recovery, the properties of bio-based molecules and the closing of N, P and K cycles;
- enhancing expertise and design capabilities of processes to convert renewable resources.

For the last two items listed, projects should be governed by an assessment of targeted sustainability criteria (greenhouse gases, energy, value chain, etc.), in accordance with the aims of the proposal.

Research projects may concern all biomolecules, in particular new plant or animal food proteins (insects), and all biomolecules in food and non-food industries (bioactive products for animal or plant health, bio-based materials, platform molecules, etc.). Fields of investigation include physical, biochemical or chemical technologies, enzymology (liquid or solid phase) and biotechnologies. Research may be carried out from the gene to the entire organism, and fall within fundamental biology or synthetic biology up to proof of concept, based in particular on LCA and cost-benefit analyses.

Bioeconomy – a circular economy: integration into rural, peri-urban and urban areas

A systemic approach implies to design integrated, multiple-use production systems at regional level in the agricultural, forestry, halieutic and algae sectors. These systems are characterised by the cascading effects, waste sorting and recycling, conversion and refining of biomass in general, consumption at different levels (urban, regional, national, worldwide, north-south); these systems also aim to save and recycle the water used in all processing phases. This initiative falls within a context of globalisation of bio-based product markets. Research within social sciences on the

integration at various regional levels of biomass sectors and uses is also strongly encouraged within this theme.

Research, which may be based on modelling tools for complex systems, shall be focused on:

- **assessment of** (i) the most relevant **environmental impacts** to be anticipated for the technological change(s) proposed (carbon, resources, soils, water and biodiversity), ii) **social impacts**, (iii) **economic impacts**, iv) **impacts on rural or local development** (the sharing of added value, marketing channels, etc.) and (v) **impacts** on **competitiveness**;
- **studies on the balance between available resources and process optimisation** for combinations of resources in production systems at regional level, taking advantage of soil diversity and including the redevelopment of activities in order to adapt to global change (climate, energy, water depletion, nutritional status) or in the case of soils unsuitable for food production or recreational use;
- **assessment of the economic, environmental and social performance of innovative forms of organisation and governance** within companies, sectors and value chains, that systemically combine different resources and products; this assessment shall in particular focus on territorial scenarios (production or consumption area), in order to inform public policies of the regional impacts over timescales that cover several decades; these tools will also cover issues related to the involvement of various regional stakeholders in designing these models and scenarios;
- **the development of analysis and decision-making tools** for public and private sector policies and strategies (technology transfers, innovation policies, intelligent regional specialisation strategies, production diversification in line with the French agroecology plan, etc.).

2015/16 international call for proposals: Sustainable and resilient agriculture for food and non-food systems (JPI FACCE SURPLUS)

CHALLENGE 6 – Mobility and sustainable urban systems

EUROPEAN AND INTERNATIONAL COOPERATION:

The 2015/2016 topics that shall be given priority for international backing are detailed below and also given in tables 1 and 2 of the 2016 Work Programme. These lists are subject to change, and so applicants who wish to conduct their projects at European or international level should regularly consult the ANR website for more information on these partnerships and calls for proposals: www.anr.fr/en

The following calls are particularly related to this challenge: ERA-NET Cofund on Smart Urban Futures (ENSUF), launched as part of the JPI Urban Europe, which complements the national activities covered by Theme 1 of this challenge.

INTERFACES:

This challenge involves cross-cutting research topics potentially relating to other challenges. 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. You are strongly advised to read each related challenge in its entirety, to gain a thorough understanding of its specific scope.

For cross-cutting topics that present extensive overlap between several challenges (including **Challenge 6**), please refer to the paragraph entitled "**Multidisciplinarity, cross-cutting research and interfaces**" (on page 48), which covers the following fields: ***Big Data, Robotics, Sensors, Biology, and Bioeconomics & Biotechnology.***

The following fields are also interfaced with Challenge 6:

- in general, projects that mainly focus on the specifically urban aspects of an issue (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 issue under study; for example, the development of an environmental technology that does not specifically relate to the urban sector falls within the scope of **Challenge 1**;
- however, projects that specifically address questions on segregation and inequalities, even if they adopt spatialised approaches traditionally associated with the urban sector, fall within **Challenge 8**;
- research on batteries, charging infrastructures, fuel cells and on-board hydrogen storage, low-power electronics and high-efficiency electric machines 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**;
- new combustion methods and the use of new fuels for any form of transport fall within **Challenge 6** if they examine the application or use of these fuels for a drive system.

CO-FUNDING[26] POSSIBILITIES FOR THE PROJECTS WITHIN THIS CHALLENGE

(see table 3 of the 2016 Work Programme)

Some of the projects within this challenge may be co-funded by the French Research Foundation for Aeronautics and Space (FRAE).

Introduction

The scope and content of the thematic themes in this challenge take particularly into account the work carried out for the French National Research Strategy (SNR) by the "Mobilities and sustainable urban systems" working group, and inputs and remarks from the ANCRE and AllEnvi alliances. The **four priority areas in the SNR that concern Challenge 6** of the ANR 2016 Work Programme 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 the ANR 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 the ANR 2016 WP also contributes to the **five SNR action programmes** that need 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.

The aim of this challenge is to explore the extent to which urban systems, buildings and transport can be transformed to embrace sustainable development. This will require more integrated, systemic approaches that improve our understanding of physical, environmental, political and socio-cultural processes while highlighting any vulnerabilities. Urban areas are at the intersection of issues relating to habitat, mobility and, more broadly, living together in society. Towns and cities represent 70% of Europe's energy consumption; while they contribute significantly to the greenhouse effect and environmental pressures, they are also sensitive to environmental damages and to the consequences of global change. The other main challenges facing towns and cities involve the performance of buildings and transport, the organisation of urban systems that encourage smooth, efficient access to resources and services, the emergence of digital society to support, develop and promote the use of sustainable transport and to provide more intelligent urban management (the "smart city" concept), and the longevity and adaptation of infrastructures and networks to meet existing and emerging needs.

Research conducted on these topics should meet various scientific objectives:

- It should create new knowledge on energy efficiency, environmental impact and usability (comfort, air quality, noise, safety, etc.), for components such as vehicles (for land, sea and air) and buildings, on different scales (building complexes, districts, towns/cities, networks of towns/cities, etc.), while also investigating the interactions between these criteria and scales;
- It should develop methods for modelling phenomena as an aid to design, decision-making and performance assessment;

[26] 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.

- It should help to develop a palette of methods and technologies that are useful for designing, building, restoring and adapting to new energy and environmental requirements and emerging, alternative uses of the existing assets and managing the various components of urban and transport systems more effectively, in particular by involving users.

Theme 1: Sustainable urban systems

Since towns and cities are complex systems, it is vital to develop integrated approaches (multi-sector and cross-disciplinary) in order to improve our understanding of the dynamics of urban systems on different spatial and temporal scales. This challenge is in line with SNR priority 22 – Urban observatories.

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

Urban dynamics, transitions and interactions 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, decline, economic and social attractiveness, etc.), which can either consolidate or weaken urban systems and can also help boost the links between large cities, towns and countryside, raising the question of the location of populations and economic activities (city centres, suburbs, rural areas, small or large conurbations, etc.). In this 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, on functional, social and generational diversity, on multipolarity, etc., for the development of urban sustainability. **Modelling** is an approach that should be developed in this respect.

The practices of urban dwellers are gradually changing, influenced in particular by an "environmentalisation" of images and perceptions. Other factors, such as economic crises and the development of online services, are also contributing to these changes. But there remain discrepancies, even contradictions, between more environmentally-centred perceptions and the practices that are still often resource intensive. This is true for mobility practices, which are linked to housing choices, to strategies for the siting of economic activities, and to 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.

Research on urban sustainability touches on issues of well-being and quality of life, requiring a convergence of work on changing urban **lifestyles** and the changing relationship between societies and their environment. It involves contributions from a variety of disciplines, including geography, history, sociology, anthropology, psychology, 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 in the water, air and soil. It is becoming crucial to establish 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 **harmful effect** on the environment (pollution, noise, etc.), but also raise questions about future planning and action – closed-loop flows, symbiosis between urban, agricultural and industrial processes, short supply chains, conflicts over the use of space, etc.

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 urban social ecosystems, including urban agriculture, is needed to form a solid basis for urban ecological engineering. These artificialised, socialised "natural" ecosystems provide a wide range of services, including provisioning, regulation and services of a social nature. It is becoming crucial to develop ways of assessing these ecosystem services, in conjunction with the question of land use (environmental and social audits, contributing to adaptations to climate change, etc.).

The vulnerabilities and resilience of urban systems

This topic is in line with SNR priority 25 – The integration and resilience of infrastructures and urban networks. Cutting across these two topics, the question of **urban vulnerability** to unexpected events (floods, heatwaves, riots, etc.) or gradual change (the slow impact of climate change, an ageing population, etc.) and the issue of **resilience** should be addressed from a systemic perspective. The aim is firstly to quantify the weaknesses of urban systems, and secondly to develop approaches that can be used to provide a broad assessment of their vulnerability. One key issue, in terms of both knowledge and operational requirements, is the development of resilience and adaptation strategies.

Theme 2: From buildings to a sustainable built environment

This theme corresponds with SNR priority 24 – Tools and technologies for sustainable cities.

From buildings to positive-energy complexes with low environmental impact

The targets for improving energy efficiency in building stock are extremely ambitious. By 2020, any new buildings must achieve a positive energy balance. 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 construction industry are set to replace obligations of means with obligations of results. Although this change 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 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, realisation and renovation. They should address not only energy issues but also issues related to health (**air quality**, etc.), comfort (multiphysics approaches) and the interactions and feedback mechanisms between technical systems and users. This will require a better understanding of behaviours, usability and use-values via a closer dialogue between social sciences and humanities and engineering, which will enable more accurate predictions to be made about the actual performance of buildings. The aim is also to design buildings that can be more easily appropriated and 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 assimilation 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, loss of performance and risk of failure of this heritage, as well as to propose tools for monitoring, inspection and modelling. New thought needs to be given to construction, maintenance, inspection and management solutions, the materials that should be used, technologies for low-cost, high-performance renovation/re-engineering, and 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.

Theme 3: Clean, safe vehicles

This theme is in line with SNR priority 23 – New conceptions 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 introduction of vehicles (for private or commercial use or for mass transportation) with low greenhouse gas emissions. This development will require research efforts that are mainly focused on high-efficiency **powertrains** with low emissions of pollutants,[27] **pollution control systems**, the use of fuels that emit lower levels of greenhouse gases than the hydrocarbons from petroleum (including biofuels[28]) in **internal combustion engines**, vehicle **electrification and hybridisation**, **energy recovery and on-board energy management**, as well as **more comprehensive approaches** such as **reducing the weight** or improving the **aerodynamics** of vehicles. Research projects may address issues ranging from the improvement of simulation models and laboratory experiments with the aim of overcoming scientific

[27] Projects relating to combustion which mainly focus on transport applications should be submitted under Challenge 6, and not under another challenge.
[28] Manufacturing processes for biofuels are covered in Challenge 2, but their potential from a transport perspective (efficiency and pollution) is addressed in Challenge 6.

hurdles, to the production of demonstrators that can be used to investigate more technological drivers in the field of land, sea and air transport.

Security, safety, advanced driver assistance systems, transport automation, reliability

Alongside the efforts deployed to reduce the energy impact of transport, issues relating to security, safety and overall efficiency should not be neglected. This will mean developing new types of vehicle that are better suited to demand and are more accessible and ergonomic (particularly for people with reduced mobility), stepping up the integration of technologies for passive and active vehicle safety so as to reduce mortality and boost safety, and developing **advanced driver assistance systems** and systems for communication between vehicles and the infrastructure. The development of **fully automated vehicles** is closely linked with efforts to improve safety and efficiency. But the **reliability** of the systems integrated into vehicles, particularly electronics and information and communication technologies, also needs to be taken into consideration. These developments can only have a real impact if the expectations and behaviours of users and drivers, together with vehicle usage constraints, are taken into account.

Theme 4: Efficient networks and services

This issue is in line with SNR priority 25 – The integration and resilience of infrastructures and urban networks.

Transport networks and services

In addition to research on vehicles, a new approach needs to be taken to transport systems as a whole, so as to make them more efficient and also better suited to the needs and simultaneous developments of urban systems, making use of technologies that facilitate multimodality and interoperability, the optimised use of transport infrastructures of any sort, and real-time **traffic management** involving constant monitoring and increased exchanges of information, with the aim of reducing congestion for passenger and goods transport at all spatial scales (urban, rural, inter-urban, etc.). The development of **transport services**, based on a thorough understanding of the dynamics of mobility and **logistics**, should also contribute to the achievement of this objective.

Resilient urban networks and services that meet requirements

Towns and cities work on the basis of a pooling of networked urban services (sanitation, water, waste, etc.). As well as the 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, 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, constructions and infrastructures to meet the needs of future generations and respond to a changing environment, particularly by adopting design/management approaches that are guided by usage. Solutions that deliver continuous service, even in degraded mode, should be envisaged. Synergies between networks, “tailored” solutions that

reflect local conditions and small-scale solutions should also be examined.

Smart cities, new usages and innovative services

So far, information and communication technologies have often merely served to support and increase the efficiency and productivity of existing services and organisations, without challenging the way they actually work. But these technologies should also become key drivers for the development of services and the organisation of less energy-intensive urban activities (remote activity, teleworking, remote sharing, etc.). We are particularly looking for innovative solutions that combine technologies with new concepts of services (implementation, use, economic models, engineering and logistics) and other non-technological activities (information channels, regulatory aspects, governance, obstacles, expected impact on behaviour, etc.). The contributions that information and communication technologies and smart networks can make to the productivity of towns, cities and urban services should be the focus of multidisciplinary research, as should the impact of the smart city on the habits of urban dwellers and the urban metabolism.

CHALLENGE 7 – Information and communication society

EUROPEAN AND INTERNATIONAL COOPERATION:

This challenge is part of a European and international research promotion initiative. 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 consortiums.

The 2015/2016 topics that shall be given priority for international backing are detailed below and also given in tables 1 and 2 of the 2016 Work Programme. These lists are subject to change, and so applicants who wish to conduct their projects at European or international level should regularly consult the ANR website for more information on these partnerships and calls for proposals: www.anr.fr/en

The following calls are particularly related to this challenge:

• 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 the following two topics is set to be published in October 2015:

- "Security and Privacy in Internet of Things" (topic linked to Theme 7 of Challenge 7 and to Challenge 9);
- "Terahertz Band for Next-Generation Mobile Communication Systems" (topic linked to Theme 8 of Challenge 7).

• ERA-NET FLAG-ERA (www.flagera.eu): "The FET Flagship ERA-NET".

Projects submitted under the generic call for which a partnership is envisaged in connection with one of the two Flagships – the Graphene Flagship and the Human Brain Project (HBP) – should indicate this via the submission interface. Information about the mechanisms for partnering with both of these Flagships can be found on their respective websites. A transnational call on some of the topics in the four Flagship Pilots (FuturICT, Guardian Angels, ITFoM/ITFoC and RoboCom) is also planned (Themes 6 and 8).

• CRCNS: A call for proposals in the area of computational neuroscience is planned 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 4.

INTERFACES:

This challenge involves cross-cutting research topics potentially relating to other challenges. 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. You are strongly advised to read each related challenge in its entirety, to gain a thorough understanding of its specific scope.

For cross-cutting topics that present extensive overlap between several challenges (including **Challenge 7**), please refer to the paragraph entitled "**Multidisciplinarity, cross-cutting research and interfaces**" (on page 48), which covers the following fields: ***Big Data, Robotics, Sensors, Biology, and Bioeconomics & Biotechnology.***

The following field is also interfaced with Challenge 7:

Cyber security, protection of information systems, cryptology and biometrics:
Research projects on these topics, including highly upstream projects and proofs of cryptographic algorithms, should be submitted under Challenge 9. But proposals which examine security as a property of a software application or of a communications or computing infrastructure, where the main focus of the research is not security, may be submitted under the themes of Challenge 7.

CO-FUNDING[29] POSSIBILITIES FOR THE PROJECTS WITHIN THIS CHALLENGE

(see table 3 of the 2016 Work Programme)

Some of the projects within this challenge may be co-funded by the French General Directorate for Armaments (DGA) or the French Research Foundation for Aeronautics and Space (FRAE).

Introduction

Digital sciences and technologies are now playing a vital part in major economic, social and human issues. Integrated circuits are everywhere – as well as in computers and mobile phones, they can be found in a wide range of utility, domestic and leisure equipment. The 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 infrastructures (transport, water, energy, etc.) raises questions relating to security and sovereignty. Expertise in materials technology, software technology and network technology is therefore strategically more important than ever, both for our autonomy and for 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, as well as in social sciences and humanities research; high-performance computing for simulation in most disciplines; connected objects 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 all 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 sciences and technologies can be harnessed by society, over and above the application of digital innovations to the various societal challenges in the 2016 Work Programme. This reflects a twofold priority:

[29] 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.

exploring how digital innovations can serve society, and designing digital technologies of the future through the development of concepts, methods and tools.

This challenge is geared towards the entire innovation chain, from the most fundamental research to the design and development of pre-industrial prototypes for tools and methods.

The challenge is divided into 8 themes, which are in line with the **four priority areas in the French National Research Strategy (SNR)** that relate to **Challenge 7**:

- priority 26: 5th generation of network infrastructures,
- priority 27: Connected objects,
- priority 28: Exploiting big data,
- priority 29: Human-machine cooperation

as well as the five action programmes in the SNR that need 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: The digital revolution: our relationship with knowledge and culture

(theme common to Challenge 8 – Theme 7)

This theme is common to Challenges 7 and 8. Projects submitted under the joint theme will be assessed by a joint, balanced committee, with experts from either social sciences and humanities (SSH), digital science, or both fields. The projects should:

- be proposed by an **interdisciplinary team or partnership**, composed of both specialists from computer sciences or ICT and SSH researchers;
- aim to achieve **a breakthrough in ICT together with a breakthrough in SSH**.

These two conditions are not administrative criteria governing eligibility for the generic call, but they will be taken into account for the evaluation of the selection criteria mentioned in the call for proposals.
It follows that the digitisation of a literary, archival, archaeological or socio-demographic corpus, even if it is a highly resource-consuming task, is not a relevant topic under this joint initiative. Similarly, projects that focus on digitisation, encryption or parallel computing techniques, and for which SSH data is used only for the purposes of illustration, are not suitable for this joint theme. Nor are projects in which both types of research are conducted as two disconnected series of tasks. Projects of this type should be submitted under themes of either Challenge 7 or Challenge 8, and not under the joint theme.

Introduction

Our relationship with knowledge and culture, in the context of what is commonly referred to as the "digital revolution", raises numerous research questions at the intersection of the "Information and communication society" and "Innovative, inclusive and adaptive societies" challenges.

The accessibility to digital resources by everyone, everywhere (participatory encyclopaedias, MOOCs, cyber museums, etc.) is only the tip of the iceberg of the fundamental changes in our relationship with knowledge that are examined under this theme. The actual focus is on the far-reaching effects on education and training, on scientific research and the sharing of developing knowledge practices, and on new relationships with heritage.

Education and training

The use of digital technologies for education and **training** can be of interest at **all levels of education** and for **all types of training**, whether classroom or distance learning, alone or as a group, in a national or international language, for a professional requirement or for the sheer pleasure of learning.
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 narrowing **socio-economic and regional inequalities**. Widespread access to quality training could go hand in hand with methods that are tailored to individual needs. Digital technologies have a huge potential to transform the education and training systems, but their benefit should be measured via controlled observations; the scope and limits, constraints and prospects should be evaluated. To this end, projects should combine **computer sciences and ICT** with other disciplines such as **psychology, subject didactics, linguistics, educational sciences, sociology and geography.**
Particular attention should be paid to digital and computer training, particularly from a very young age (learning **computer coding**), as well as to the development of digital literacy in teachers in order to meet the need for qualified staff in ICT-related business. Finally, **ethical and legal aspects** should be considered with regard to the use of learning data, particularly at primary school, and the issue of privacy rights.

Applicants are also invited to consult Theme 6 of Challenge 8, which deals with education and training from a pure SSH perspective, including the economic and social model of MOOCs.

Knowledge creation and sharing

Digital technologies directly affect the **production of scientific knowledge:** the definition of objects, formalisation and transmission. The fields of **epistemology, ethics, humanities and social sciences** can contribute together with computer sciences and ICT to these digital studies. Research may focus on how the processing of digital data is leading many specialist fields to thoroughly review their concepts and methods. Examples include **linguistics** with new possibilities for language processing using big data, **theoretical computer science** as a formal discourse on conditions for knowledge, **discourse analysis** extended to debates and arguments via the extensive recording of written and spoken words, and **financial economics** with real-time data processing. The very process of

knowledge production can become the focus of research on procedures for recording, editing and sharing and on the role of computer simulation.

The establishment of **new relationships between researchers** and **between experts and non-experts** via freely available results (open science, collaborative tools, platforms, etc.) is also part of these considerations.

The use of big data raises the important question of the growing importance of technological mediation for data preparation and presentation. The impact on the understanding of the underlying phenomena and on researchers' intuition should be examined so that human cognitive mechanisms can be assisted without becoming biased.

Heritage management and access methods

Digital sciences and technologies are changing how professionals and the general public relate to objects in the fields of heritage, culture and leisure.

- Heritage management

We are facing **new issues relating to access, conservation, preservation and management** in relation to collections and sites. Alongside social sciences and humanities, digital sciences and technologies are used in research **to restore and to 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 can we make sure that the content is correctly edited and remains comprehensible?

This section of the joint theme does not concern the digitisation of data collections (for this see Theme 6 of Challenge 8) but solely those which raise **complex or unusual digitisation problems**: building complexes, landscapes, audiovisual documents, interactive data, etc. The aim is to harmonise, analyse and exploit databases by adopting a new approach to **data design and processing**.

Project coordinators are encouraged to contact **Huma-Num** (the very large research infrastructure for digital humanities), which leverages networks of researchers looking to establish best practices (geographic information systems, 3D reconstructions of monuments, texture analysis, etc.). Huma-Num is affiliated at the European level to the **DARIAH ERIC**. This research primarily concerns **museums** and **audiovisual archives**, such as those that the **French National Audiovisual Institute** (INA) now makes available for researchers. This mine of data requires close cooperation between researchers in SSH and researchers in ICT; it represents an opportunity to update the methods used for processing, annotation and indexing. The results of this research (annotations, enhancements, metadata, etc.) should 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 they be made available to the public? How should they be organised and documented? Can the State apply its standards for labelling, inventories and

classification to tangible and intangible heritage proposed by users? How should the relationship between **experts and non-experts** develop in this context?

- Access to heritage

Investigating the practices of visitors to heritage sites requires researchers in ICT and SSH to work closely together. 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.). Research into art therapy will be of particular interest.

The use of digital technologies in museums or on their web portals or mobile applications is revolutionising the **public's relationship with museum collections**. These technologies enable remote access and the exploration of virtual collections. This can offer a new dimension to cultural outreach via individual or shared experiences, combining nomadic and immersive devices and mixed and augmented reality. The same is true for **history of art and art teaching**, 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.

This theme is in line with SNR priority areas 27 and 33.

Theme 2: Foundations of digital sciences and technologies

This theme is geared towards fundamental research projects aiming 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 in this theme should be:

- fully in line with Challenge 7, "Information and communication society";
- and should not **explicitly** relate to another theme in the challenge.

The following is a non-exhaustive guide to the fields in which fundamental research projects will be welcomed:

- **Mathematics and interactions**: the fundamental aspects of mathematical models and methods in a broad sense, in connection with the challenges 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 signal processing and detection/estimation, 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 or health.

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" –, will also be welcomed in this theme.

This theme is in line with SNR priority areas 16 and 17.

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 (languages, programming paradigms, software architectures, etc.) and execution (middleware and software platforms). Producing software that performs safely and reliably is expensive; this makes it very important to develop proven, automated methods for 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 execution platforms**: operating systems, support for virtualisation, embedded systems, memory management, distributed execution; specific middleware for different architecture principles (parallelism, distribution, real time, etc.).

- **Methods and tools for software design**: programming and specification languages, optimised compilation to centralised or parallel architectures; specific computing models for parallelism, distribution, mobility, embedded and real-time systems; software engineering and design methods (model-based design, agile methods, etc.); software architectures and components.

- **Software validation:** methods and tools for program analysis, verification and proof of properties (security and safety), verification and optimisation of quantitative properties (time, memory, energy, etc.), testing and debugging methods, software and hardware simulation methods, virtual prototyping.

Proposals related to execution platforms (at different scales) are of particular interest.

We would draw the attention of project coordinators to the fact that they 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 27.

Theme 4: Interaction, robotics, content

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 robotics, for professional, domestic and service purposes. This theme targets research into cyber-physical environments and interfaces, investigating the entire chain of digital content by means of an approach that encourages convergence among all creative industries.

- **Human-machine interaction:** interaction is based on multi-sensory interfaces combining contacts, gestures, movements, speech, vision, eye sensors and detection of the context and psychophysiological state of the user, and can lead to wearable computing and to technologies that augment or extend human capabilities (smart glasses or watches, implants or brain-machine interfaces, for example). This includes research into how to present more useful, comprehensible information to users – professionals or the general public – based on synthetic, custom, adaptive visualisation, incorporating images and virtual or augmented reality to create immersive environments.

- We will welcome research that aims to improve interaction with the digital world, to design new interactive objects and services, and to create better tools for systems development – a major challenge which requires the integration of user diversity (varying ages, motor, sensory and cognitive disabilities) from the starting point of design and the taking into account of the interdisciplinary dimension of human-machine interaction in the entire digital product creation sector.

  Research of interest also includes the design and implementation of natural dialogue systems for human-machine interaction, particularly the aspects of language understanding and generation (mono- or multimodal, including natural, oral and written language), knowledge representation and inference, modelling and automation of intelligent behaviour (through models of reasoning on mental states and planning models for communicative processes, potentially combined with "physical" action). In this approach, in which dialogue is considered 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 sub-section "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.

- **Autonomous and interactive robotics:** robotics raises a series of highly diverse research questions related to the design and control of robots, the perception 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 2 of Challenge 3), hostile environments and assistance services. Robots may take on a variety of forms depending on their purpose, ranging from humanoids to drones and including mobile off-road devices, telepresence robots, exoskeletons and manufacturing robots (see Theme 2 of Challenge 3). Innovative projects are encouraged on 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 relevant topics that also open up avenues for interdisciplinary research with the disciplines of Life Sciences and Social Sciences and Humanities.

- **Content processing:** this section addresses the entire chain of digital content: creation, capture, production, editing, access, analysis, exchange, preservation, etc. It covers content for all media types: cinema, radio, TV, web, video games, as well as the multimedia and multilingual aspects of documents. We expect research that supports changing practices – collaborative, 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 questions 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 the diversity of users.
Fundamental research into processing 2D/3D images, video material, speech, music and audio material, as well as natural language processing (NLP) and sign language, is part of this theme.

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 consortium of researchers in ICT/SSH should be submitted under the joint Challenge 7/Challenge 8 theme (see Theme 1).

We would draw the attention of project coordinators to the fact that they should position their project, where appropriate, in relation to forthcoming European initiatives and programmes due to be launched in late 2015, in particular the SPARC PPP and the Big Data PPP, and also in relation to the ICT-Content and ICT-Robotics and autonomous systems topics in the Horizon 2020 Work Programme.

This theme is in line with SNR priority 29.

Theme 5: Data, Knowledge and Big Data

This theme is divided into two main topics: establishing processes that can be used to derive knowledge from data, and in the context of big data, all questions related to scaling up these processes. Proposals welcomed in this theme will contribute to the development of the Data Science

community, involving computer scientists and statisticians, by proposing methods, techniques and algorithms for representing, storing and analysing data and extracting knowledge with added value.

- **From data to knowledge:** In this topic we will welcome research proposals that focus on establishing processes that can be used to derive knowledge from data, particularly relevant proposals on questions relating to semantic analysis, modelling, representation and aggregation of knowledge. These processes involve complex processing chains that result in high-added-value information products (rules, behaviours, patterns, rare events, etc.) which increase the skill of users (experts, decision-makers or students) or enable them to develop 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 interactions. 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.

- **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 or have been radically transformed via data management, which makes it possible to produce information or knowledge with high added value. The main challenges (or 3 Vs) concern: Volume and scaling up, Variety of sources and heterogeneity of formats, and Velocity of data flow.
This theme expects 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, large-scale algorithms for data mining and the analysis of unstructured data (text, image, speech or audio) or graph 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 free software. Data mining research may propose innovative contributions to the main open-source libraries. Data processing chains will illustrate mechanisms for extracting and structuring knowledge in areas of application with real implications (web, banking/insurance, distribution, health, connected objects, transport, environment, home automation, 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.

This theme is in line with SNR priority 28.

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. The 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:

- **High-performance computing**: this topic involves designing and developing software solutions in synergy with areas of application in a bid to reconcile massive, hierarchical and heterogeneous 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 associated with equipment and data management should be incorporated into these methods right from the design phase (co-design). This research should be coordinated with European initiatives and projects, particularly those related to the ETP4HPC PPP European Technology Platform and the PRACE HPC infrastructures. 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 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 simulation cycle should also be explored. This theme involves the development of new mechanisms, metaphors, paradigms, algorithms, methods and tools.

This theme is in line with SNR priority 28.

Theme 7: Infrastructures for communication, processing and storage

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 momentum of change, it is vital to develop generic, programmable and convergent infrastructures: generic in that we should aim to avoid isolated infrastructures geared to just one type of application, and we should also develop infrastructures

that are increasingly based on generic hardware solutions; programmable so that they can be adapted using an agile approach to comply with future, often unanticipated, developments; convergent in that, within the network, traditional divisions (individual/general, fixed/mobile, IP/transport, networks within/between data centres) are merged and the same elements in the infrastructure will support network functions, content distribution, data processing, storage, real-world interactions, etc. These elements combine communication and computing technologies and are distributed both in current data centres and operator points of presence, and also in gateways between the real and the digital world, often embedded in connected objects.

These fixed or mobile infrastructures must be capable of achieving high levels of performance and efficiency, while being open and agile 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, reliability, and self-organisation to meet new needs automatically).

These objectives present three broad categories of technological hurdles to the research community:

- Issues regarding **scaling up** in various dimensions. Data flow requirements are constantly on the rise, both in fixed and mobile access networks and in metropolitan area and core networks. Forecasts suggest that there will be more than 70 billion connected objects by the year 2020, and even if these figures are open to discussion, it is now widely accepted that new communication models are needed. Increasingly large and heterogeneous volumes of data will need to be processed, sometimes with severe time constraints. Systems will have to dynamically integrate increasingly distributed and often unmanaged equipment and devices. All these requirements should be met while maintaining economically and environmentally acceptable levels of energy consumption.

- A **far-reaching change to the architecture and operation** of infrastructures.

Convergence and agility involve virtualising various functions (telecommunications, computing, storage, content distribution, application functions, etc.), harmonising control methods in computing and telecommunications, and increasing the programmability, automation and openness of networks and computing equipment. Themes that need to be addressed include questions relating to architecture optimisation; compromises between centralised and distributed approaches to data, computing and control; optimisation of the placement of resources and functions; and optimisation of the deployment and orchestration of end-to-end services.

- Some applications using these infrastructures, for example in the fields of healthcare, transport or the handling of “sovereign data”, can be highly critical. It is therefore crucial to create infrastructures that are robust in terms of **reliability, fault resilience, security and methods for protecting personal information.** These aspects take on a particular importance and complexity because these infrastructures will be shared, used and managed by several operators.

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 projects, in particular those associated with the NetWorld2020 European Technology Platform and the 5G Infrastructure PPP, the HPC PPP and the Cloud Computing theme in the Horizon 2020 Work Programme.

This theme is in line with SNR priority areas 26, 27 and 28.

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 must overcome application-related challenges such as energy efficiency and system resilience, resulting in the emergence of safe systems for the exploitation of large volumes of data, connected objects and human-machine cooperation (elements in the SNR).

This theme covers the key generic technologies of electronics and photonics for information and communications, the question of integrating devices into systems, and the exploration of new paradigms, which may involve controlling quantum properties or bioinspired approaches. Projects should address well-identified scientific and technological hurdles and should aim to demonstrate either real improvements in performance or breakthroughs compared with existing technologies. Target areas are grouped into four topics:

- **Micro- and nanostructured materials for integration into components: development, manufacturing and processes**: this topic covers the basic technological building block that is essential to future innovation, namely micro- and nanostructured materials ranging from semiconductors (IV/III-V / II-VI / Nitride) or other materials for electronics and photonics to materials for spintronics. It also covers the production processes for artificial materials and metamaterials.

This topic specifically concerns materials developed for integration into components and devices, or with a view to fundamental research into nanometric objects. Projects involving research into solid materials and their properties fall within the scope of Theme 3 of Challenge 3, while projects on materials for flexible electronics that do not examine integration possibilities come under Theme 5 of Challenge 3.

- **Basic components and devices:** this topic concerns projects that aim to achieve basic functions for micro- and nanoelectronics, spintronics, quantum or non-linear optics, near-field optics, wavefront treatment, millimetre and THz techniques, plasmonics and nanophotonics, organic/flexible electronics and optoelectronics, and quantum information. It covers alternative methods such as neuromorphic components. In this topic, 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 in this topic should focus entirely or partly on the integration of devices and components: 3D integration, heterogeneous integration and alternative architectures (bioinspired, neuromorphic, etc.). They should address a hurdle or issue 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), or Theme 5 of Challenge 3 (if the research objectives are the physical, chemical and biological properties of physical nanosensors, etc.).

- **Design – Simulation – Characterisation – Instrumentation:** this topic concerns projects that address issues related to digital approaches (the simulation and/or design of components, materials, processes and complex systems) and/or generic methodological approaches (design, testing, metrology, etc.). Research into reliability, the advanced characterisation of materials and the performance of nanodevices or basic components also falls within the scope of this topic.

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 stick to more fundamental research that addresses issues in information and communication science and technology. Digital simulation, modelling and theory may be included in mainly experimental projects or may be the focus of specific projects.

Coordinators of projects in fields related to one of the European FET Flagship initiatives (Graphene or the Human Brain Project) should indicate any potential links with these initiatives.

This theme is in line with SNR priority areas 27 and 28.

CHALLENGE 8 – Innovative, inclusive and adaptive societies

EUROPEAN AND INTERNATIONAL COLLABORATION

The 2015/2016 topics that shall be given priority for international backing are detailed below and also given in tables 1 and 2 of the 2016 Work Programme. These lists are subject to change, and so applicants who wish to conduct their projects at European or international level should regularly consult the ANR website for more information on these partnerships and calls for proposals: www.anr.fr/en

INTERFACES

This challenge involves cross-cutting research topics potentially relating to other challenges. 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. You are strongly advised to read each related challenge in its entirety, to gain a thorough understanding of its specific scope.

For cross-cutting topics that present extensive overlap between several challenges (**including Challenge 8**), please refer to the paragraph entitled "**Multidisciplinarity, cross-cutting research and interfaces**" (on page 48), which covers the following fields: **Big Data, Robotics, Sensors, Biology, and Bioeconomics & Biotechnology.**

Challenge 8's other interfaces covers the following themes:

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, **the digital revolution: our relationship with knowledge and culture** (common to challenge 7) and theme 8, **Public health** (to challenge 4).
In addition, theme 3 of this challenge addresses **Changes in labour and organisations**, across all sectors, but "the role of humans in the factory of the future" falls under theme 1 in challenge 3 (Industrial renewal).
Violent radicalisation is covered in theme 2 of this challenge. Challenge 9 (Freedom and security) will take on issues concerning protection techniques (e.g. detecting weak signals of radicalisation).

POTENTIAL CO-FUNDING[30] FOR PROJECT SUBMITTED TO THIS CHALLENGE

See table 3

For this challenge, certain projects may be co-funded by the French Ministry of culture and communication or the CNSA (National Solidarity Fund for Autonomy)

[30] 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

Challenge 8 encourages research focused on societies' ability to innovate, integrate and adapt. In addition to concerning **French society**, the challenges addresses societies from **all cultural areas**, with pertinence across the humanities and social sciences; challenge 8 researchers will strive to adopt the most transdisciplinary approach possible, with pertinent field including: **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**.

The National Research Strategy (SNR) has set out four priorities 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.

Challenge 8 also addresses two inter-challenge topics: the importance of knowledge about cultures and mankind and capitalising on digital data.

In response to **recommendations by the SNR and the ATHENA Alliance with input from challenge 8**'s Scientific Steering Committee, the 2016 edition has undergone a massive overhaul. Novel theme areas have been introduced which are likely to interest new research communities. Challenge 8 is divided up into five areas:

- Theme 1: Social innovation and attitudes toward risks
- Theme 2: Inequalities, discrimination, 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 research area with Challenge 7)*
- Theme 8: Public health (*joint research area with challenge 4)*.

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, training and use of archives and corpora, analysis of texts, statistical surveys, administrative data, artistic or literary sources. Applicants are advised to inform evaluators about the **sources and methods** used by devoting **at least one page of their 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 documented in France by the Quetelet network). Large-scale cohorts can accommodate projects of diverse nature, 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 established funding limits, challenge 8 may partly **fund the conducting of surveys** or **the constitution of corpora** (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 attitudes toward risks

Innovation factors, innovative design, intellectual property

Our societies are caught in a double bind; they must at once protect against risks affecting 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 implementation of precautionary principle and the development of entrepreneurship and creativity. In this context, researchers will give thought 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, will to survive, ecological threat), or **prosperity** (demographic bonus, size of 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 do you protect innovation and prevent from exhausting its sources? In terms of **intellectual property,** not everything can be patented: ideas, theories, learning methods, training concepts, software, and human gene sequences are in many cases not patentable 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**.
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 process of innovation itself and set out to cast light on its social, economic and organisational dimensions. Artistic creation is treated 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 where **communities of practice** are emerging which pool their 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. Why has participatory democracy been deemed a more legitimate approach for dealing with environment issues than for dealing with urban planning? How does participatory democracy resolve the question of representation and spokespersons when locally elected officials are involved? What role do our democracies give to **referendums** and other forms of consultation advocated by the French National Public Debate Commission?

Research on the key drivers of social innovation should 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 etc.) as well as **religious and humanitarian movements**, or their opposite, xenophobic movements. Researchers will study their growth, organisational models, 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 will 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 *a priori* concern people of all ages from all parts of the world.

From rhetoric to nudges: scope and 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 because they work using cognitive bias (ex: when the sadness you feel about losing something is proportionately greater to the enjoyment you get from possessing it). 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.** Experiments and evaluations on the topic are expected, without losing sight of the connection between *nudges* and other "engaging" techniques.

Gentle persuasion raises **political and ethical issues.** Where does the border lie between persuasion and manipulation? What role does individual responsibility play? Does free will exist in the absence of informed consent? Can we eliminate cognitive bias without introducing new biases? Can a public action rally citizens to an innovation of general interest democratically without law-making or imparting knowledge through instruction?

Theme 2: Inequalities, discrimination, integration and radicalisation

Socio-economic inequalities, inequalities among nations, innovation and inequalities, health inequalities

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. We will analyse long-term **income and heritage inequality**. Within the time horizon of one generation, other factors also bear on **wage inequality**, such as how we develop and evaluate job sectors, remuneration methods and career management. Though social and matrimonial mobility are long-studied topics, the role of institutions and networks 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**. Questions related to **concepts of justice**, including the question of spatial justice will also be covered.

Projects dealing with geographical and social-influenced **health inequalities** apply to this theme (access to healthcare, the doctor-patient relationship, insurance coverage) *[other **public health**-oriented projects will be submitted to theme 8 which is shared with challenge 4).*

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 indicators of development and well-being 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 phenomena are also of use: 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**). Researchers 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, safety and freedom... These topics will be examined in the field with special emphasis given to the nature and magnitude of **environmental and climate migration**.

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.

Apart from students, France lets in few **skilled immigrants**. Who is responsible for recruiting economic migrants, the State or employers? What are the criteria and effects of their immigration? Researchers will compare "point systems" to candidate selection based on human capital, identifying shortage occupations professions and determining the country's economic needs. Is a purely economic migration which does not entail settlement conceivable?

Other themes need to be explored: expatriations (little known), the effects of *brain drain*, 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 can 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.

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.

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 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 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 for barriers to access, 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, is driven by risk aversion; in other words, rejecting someone on the basis of his/her supposed belonging 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: interdisciplinary call for proposals

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 have confirmed the relevance of this call; men and women have been murdered for their ideas, jobs and religion. However, since immigrants and children of immigrants played the roles of victim, killer and hero, studying the incident as a research topic concerns the whole of society.

French research on violent radicalisation has yet to gain real visibility. There is an urgent need to develop such research. **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 propel those who go through with radical acts.

Old and new parallels with other politically or religiously-motivated waves of attacks in European countries deserve to be looked into. Researchers shall not elude the hard time Islam has traditionally had tolerating the **free examination of sacred texts** and differing interpretations with the potential to marginalise radical theses; they will also study **geopolitics** in the Near and Middle East (civil wars, military interventions, disintegration of states).

Researchers are encouraged to draw from **foreign work** on violent radicalisation and jihadism *[research on protection techniques are however reserved for challenge 9, Freedom and security]*. They will seek to **inform public action** on prevention programmes, de-radicalisation and protection, including reporting by family and friends. 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.

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 define explanatory and forward-looking models.

Employment and labour issues are to be dissected in **context**: technological change, business networks, economic constraints, new relationships with clients, 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/ phenomena of restructuring and outsourcing 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, 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 carry out and conceive 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; men and women are not subject to the same expectations. **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; do they 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 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 have long been the concern of lawmakers, professional 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 counteract **male dominance**.

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?

Theme 4: Life-long education, cognitive skills, socialisation and training

Cognitive capacities during life's various age periods

Lifetime employment in a single sector is no longer an option. Longer life expectancy and the growing diversity of career paths have 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 and requirements.

Researchers are expected to produce models and experiments based on fundamental aspects of **cognitive psychology, 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.** 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 mediocre 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 **teaching methods adapted to a wide range of audiences** (age, experience, previous achievements, social environment, responsiveness and emotional fulfilment, etc.). These pedagogical innovations will rely on new information and communication technologies which radically change the transmission of knowledge and could even aid in overcoming disease and physical and mental handicaps.

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 institution**s on performance (effects of social class, discipline, of teaching staff, neighbourhood) ; **choice of families** (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 volunteer-based soft incentives or nudges applicable to the world of school?

Combating educational failure through early education and teaching innovation

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.

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. S**ocial 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***; universities act as a social safety net in a context of massive youth unemployment. Higher education is experiencing **difficulties recruiting** (drop in staffing in some branches, high dropout rate, rise in international students); **organisational problems** (laying off teaching faculty for the benefit of presidencies, costs related to 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). 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.

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. **All of the humanities and social sciences are** encouraged to participate: archaeology, history, geography, linguistics, literary studies, philosophy, anthropology, sociology, law, economics, political science, cognitive sciences, as well as disciplines such as art history, musicology, archival science, architecture, design, religious studies.

The emergence of cultures and their manifestations (material, written, oral or visual), 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.

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.

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? The strong resurgence of long-dominated languages is exceptional (Catalan, Basque, Lithuanian etc.). Though research on **endangered languages** is still necessary (90 percent of them are set to die out before the end of the century), it is not enough to study them before they disappear; we must also reflect upon the social contexts and policies which help or harm them.

Creation, works and creators

Researchers must also study creative processes by studying the **creation** of works (artistic, literary, musical, theatrical, film, TV, videogames), their **reception** and their **interpretation**. Research will give a privileged place to works and **authors**, their career paths and networks. **New corpora** may be established, in a monographic or prosopographical approach. 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 social sciences, humanities and neurosciences.

Other dimensions may be addressed; the study of **techniques** (tools and media) and their transformations, the synergy between artistic creation and technical innovation, **renewing** practices, marginal forms of expression, the role of the arts with regard to academic institutions and markets as well as **economics of creation and laws concerning creation** (public and private support, cultural industries, copyright, etc.). With performance art playing a decisive role in these processes, researchers will look into how the **arts are taught**, the transmission of practices, and interpretations and interplay in current and historical perspectives.

Transformations of heritage and cultural policies

The study of the process of heritage and usage will 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. 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. In this perspective, attention will focus on the **heritage of museums, organisations and enterprises,** the history of **museums and their audiences,** their contribution to tourism and promoting territories.

Heritage and its preservation lend themselves to **projects with private partners** combining **social sciences and 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** (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.

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/social sciences and humanities joint projects are to be submitted to the joint action provided for this purpose.

Effects of digital technologies on the economy, occupations, 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 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 and marketing purposes? **Lawyers, economists, political scientists, and sociologists** are encouraged to launch innovative projects on this new set of issues affecting the sovereignty of 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 hopes placed in massively open online courses (**MOOC**) and more recently small private online courses (**SPOC**) also deserve careful examination. A MIT study points to the low rate of success: Only 5 percent of those enrolled in certified MOOCs complete cycles (more adults than students). Unlike their US counterparts, French universities do not have the financial resources to launch MOOCs.

Research is needed to analyse experiments with MOOCs launched in Europe and abroad, their economic model and their ability to reach **target audiences**.

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 after that, service providers **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 forgotten** 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 in the way that maps are co-extensive with pieces of land. The object of this theme is to **study, from the standpoint of social sciences and humanities, the social and scientific implications of switching from conventional data to big 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;
- Radio and television archives (developed and maintained in France by the INA or French National Audiovisual Institute whose 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 setting up, the **complexity** of their architecture, and doubts about their real **coverage**. Are they durable enough to

ensure the continuity of the 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 whom? 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.

Theme 7: The digital revolution: our relationship with knowledge and culture

(theme common to Challenge 8 – Theme 7)

This theme is jointly applicable to Challenges 7 and 8. Projects submitted under the joint theme will be assessed by a joint, balanced committee, with experts from either social sciences and humanities (SSH), digital science, or both fields. The projects should:

- be proposed by an **interdisciplinary team or partnership**, composed of both digital specialists and SSH researchers;
- aim to achieve **a breakthrough in digital science as a result of a breakthrough in SSH, and vice versa**.

These two conditions are not administrative criteria governing eligibility for the generic call, but they will be examined in the light of the selection criteria mentioned in the call for proposals.
The digitisation of a literary, archival, archaeological or socio-demographic corpus, although it is a highly demanding task, is therefore not sufficient for the submission of a project under this joint initiative. Similarly, projects based on digitisation, encryption or parallel computing techniques, in which SSH data is used only for the purposes of illustration, are not suitable for this joint theme. Nor are projects in which both types of research are conducted as two disconnected series of tasks.

Projects of this type should be submitted under either Challenge 7 or Challenge 8, and not under the joint theme.

Introduction

In light of what is commonly referred to as the "digital revolution", the issue of our relationship with knowledge and culture has been identified as raising numerous research questions at the intersection of the "Information and communication society" and "Innovative, inclusive and adaptive societies" challenges. The aim is to create a dialogue that links social sciences and humanities with digital sciences and technologies, so as to help us understand, anticipate, support and direct the effects of this digital revolution on our societies.

This topic examines the fundamental changes in our relationship with knowledge, which have been summed up rather hastily by the idea of accessibility to digital resources by everyone, everywhere (participatory encyclopaedias, MOOCs, cyber museums, etc.), but which are nevertheless having far-reaching effects on education and training, on scientific research practices and the sharing of developing knowledge, and on new relationships with heritage.

Education and training

The use of digital technologies for education and **training** applies to **all levels of education** and **all types of training**, whether classroom or distance learning, alone or as a group, in a national or international language, for a professional requirement or simply for the pleasure of learning.
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 narrowing **socio-economic and regional inequalities**. Widespread access to quality training could go hand in hand with methods that are tailored to individual needs. There is huge potential for using digital technologies to transform systems for education and training, but the impact should be evaluated via controlled observations, and the scope and limits, constraints and prospects should be measured. To this end, projects should combine **digital sciences and technologies** with other disciplines such as **psychology, subject didactics, linguistics, educational science, sociology and geography.**
Particular attention should be paid to digital and computer training, particularly from a very young age (learning **computer coding**), as well as to the development of digital literacy in teachers in order to meet the need for qualified staff in digital professions. Finally, **ethical and legal aspects** should be considered with regard to the use of learning data, particularly at primary school, and the issue of privacy rights.

Applicants are also invited to consult above Theme 6 of Challenge 8, which deals with education and training from an SSH perspective, including the economic and social model of MOOCs.

Knowledge creation and sharing

Digital technologies directly affect the **creation of scientific knowledge:** the definition of objects, formalisation and transmission. The fields of **epistemology, ethics, humanities and social sciences** can be examined from the viewpoint of digital sciences and technologies. Research may focus on

how the processing of digital data is leading many specialist fields to thoroughly review their concepts and methods. Examples include **linguistics** with new possibilities for language processing using big data, **theoretical computer science** as a formal discourse on conditions for knowledge, **discourse analysis** extended to debates and arguments via the extensive recording of written and spoken words, and **financial economics** with real-time data processing. The very process of **knowledge building** can become the focus of research on procedures for recording, editing and sharing and on the role of computer simulation.

The establishment of **new relationships between researchers** and **between experts and non-experts** via freely available results (open science, collaborative tools, platforms, etc.) is also part of these considerations.
The use of big data raises the important question of the growing importance of technological mechanisms for data preparation and presentation. The impact on our understanding of phenomena and on researchers' intuition should be examined so that human cognitive mechanisms can be assisted without becoming biased.

Heritage management and access methods

Digital sciences and technologies are changing how professionals and the general public relate to objects in the fields of heritage, culture and leisure.

- *Heritage management*

We are facing **new issues relating to access, conservation, preservation and management** in relation to collections and sites. Alongside social sciences and humanities, digital sciences and technologies are used in research into the use of **2D/3D and multimedia approaches to restoration and preservation**. Digital storage capacities are also increasing the number of documents with potential heritage value. How can we make sure that the content is correctly edited and remains comprehensible?

This section of the joint theme does not concern the digitisation of all data collections (for this see Theme 6 of Challenge 8) but solely those which raise **complex or unusual digitisation problems**: building complexes, landscapes, audiovisual documents, interactive data, etc. The aim is to harmonise, analyse and exploit databases by adopting a new approach to **data design and processing**.

Project coordinators are encouraged to contact **Huma-Num** (a very large research infrastructure in the field of digital humanities), which leverages networks of researchers looking to establish best practices (geographic information systems, 3D reconstructions of monuments, texture analysis, etc.). Huma-Num is affiliated at European level to the **DARIAH ERIC**. This research primarily concerns **museums** and **audiovisual archives**, such as those that the **French National Audiovisual Institute** (INA) now makes available for researchers. This mine of data requires close cooperation between researchers in SSH and researchers in digital sciences and technologies; it represents an opportunity to update the 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 they be made available to the public? How should they be organised and documented? Can the state apply its standards for labelling, inventories and classification to tangible and intangible heritage proposed by users? How should the relationship between **experts and non-experts** develop in this context?

- *Access to heritage*

Investigating the practices of visitors to heritage sites requires researchers in information and communication science and technology and SSH to work closely together. 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.). Research into art therapy will be of particular interest.

The use of digital technologies in museums or on their web portals or mobile applications is revolutionising the **public's relationship with museum collections**. These technologies enable remote access and the exploration of virtual collections. This can offer a new dimension to cultural outreach via individual or shared experiences, combining nomadic and immersive devices and mixed and augmented reality. The same is true for **history of art and art teaching**, which now includes an interactive dimension (cyber museums). These new processes should be tested and, if possible, forecasts should be made concerning their future developments.

Theme 8: Public health

(theme common to Challenge 4)

Health Inequalities: causal chains, public policies, databases

Research on public health lies at the crossroads between challenge 4 ("Life, health, well-being") and challenge 8 ("Innovative, integrative and adaptive"). The ensuing projects will be evaluated by a single evaluation panel within a single interdisciplinary committee. For space reasons, the text that follows has been condensed and modified for challenge 4.

Public health research is concerned with health inequalities (morbidity and mortality) and the **causal chains** linking them to socio-economic, environmental or gender inequalities. Such research must also assess the efficiency and equity of **public policies** as well as **that of health and insurance systems in** interventions designed to reduce health inequalities and vulnerability factors.
These objectives require an **interdisciplinary approach** combining the human and social sciences with biological or medical sciences. Giving consideration to both upstream or downstream qualitative studies, researchers are encouraged to make use of existing **databases** and **cohorts,** whether they target the general population or specific illnesses.

Broad themes are covered: ageing, multi-morbidity, mental health, addictions, disabilities, limits on social activity, but also environment/health links and dissemination of biomedical innovations. A central issue is the well-being of the elderly and dependent individuals or people suffering from

severe illness, as well as that of caregivers (family and professionals). The analysis of public debates on these issues can also fuel research projects.

[In contrast, projects on the implications of employment and working conditions on health are to be submitted in challenge 8's Work theme]

Principles of justice and socio-economic constraints; public health's ethical dimension

Public health research cannot ignore the **socio-economic and space constraints** which influence access to healthcare and challenge **principles of justice**: unequal availability of land, variable capacity of persons to use networks and information systems, alternative medicine, coverage and cost sharing (insurance, mutual societies, special regimes, CMU, AME). What are the criteria used to determine **priority patients**: rarity or frequency of diseases, unequal chances of survival, emergencies or waiting lists? Dilemmas about the **beginning and end of life must also be resolved**.

Throughout this research, the study of **perceptions** and **representations** is essential, as evidenced by the increasing rejection of vaccination, issues relating to over-prescription and observance, decisions made between doctors and the "expert patients", doubts about the medical benefit of commonly used drugs, etc. These issues require an objective analysis of **debates and controversies** on public health issues. Researchers will assess the capacity of public policy to implement sleep and alert mechanisms on public health subjects and disseminate information to populations. We enquire about the reasons for the frequent discrepancy between public health campaigns and the public's response.

CHALLENGE 9 – Freedom and security of Europe, its citizens and its residents

EUROPEAN AND INTERNATIONAL COOPERATION:

The 2015/2016 topics that shall be given priority for international backing are detailed below and also given in tables 1 and 2 of the 2016 Work Programme. These lists are subject to change, and so applicants who wish to conduct their projects at European or international level should regularly consult the ANR website for more information on these partnerships and calls for proposals: www.anr.fr/en

The following calls are particularly related to this challenge: **Franco-German call**: Selected topic – "Urban Security". **ERA-NET CHIST-ERA call**: Selected topic – "Security and Privacy in Internet of Things".

INTERFACES:

This challenge involves cross-cutting research topics potentially relating to other challenges. 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. You are strongly advised to read each related challenge in its entirety, to gain a thorough understanding of its specific scope.

For cross-cutting topics that present extensive overlap between several challenges (including **Challenge 9**), please refer to the paragraph entitled "**Multidisciplinarity, cross-cutting research and interfaces**" (on page 48), which covers the following fields: ***Big Data, Robotics, Sensors, Biology, and 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 cryptographic 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 the research focuses on specification, verification, validation or demonstration methods, may be addressed in Themes 3 or 7 of **Challenge 7**.
Violent radicalisation: Techniques to detect and fight violent radicalisation fall within the scope of Challenge 9. Violent radicalisation within the more general context of social integration and individual radicalisation processes come under Challenge 8.

The operational, organisational, logistical, economic, etc. aspects of **crisis management**, regardless of the origins of the crisis, come under **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** that addresses general questions involving security, but is not entirely focused on the issue of security, falls within the scope of **Challenge 6**.

CO-FUNDING[31] POSSIBILITIES FOR THE PROJECTS WITHIN THIS CHALLENGE

(see table 3 of the 2016 Work Programme)

Some of the projects within this challenge may be co-funded by the French General Directorate for Armaments (DGA), the French Research Foundation for Aeronautics and Space (FRAE) or the French General Secretariat for Defence and National Security (SGDSN).

Introduction

Research on the freedom and security of European citizens and residents requires an integrated approach to risk management in both physical space and cyberspace. This ranges from the characterisation of threats and vulnerabilities to the management of the consequences of a crisis, accident, incident or attack, and includes surveillance, prevention and protection mechanisms. The scope of this challenge covers, but is not limited to, any research (in any disciplines and including multidisciplinary research) that may contribute to the government's sovereign missions of security and protection, as well as the protection of infrastructures and public and private operators that are vital for the proper functioning of the nation. It also covers research on non-sovereign security issues concerning individuals or legal entities such as organisations or companies.

All questions relating to security should be examined in the context of rapid spread of new technologies, particularly digital technologies, which, as well as offering opportunities for citizens, authorities and companies, also create vulnerabilities. The increasingly dense movement of people, commodities (goods, energy, water, etc.), capital and information needs to be taken into consideration if we are to ensure security for all, at all levels.

[31] 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.

It is impossible to conduct research on security without considering the question of risks, in a context in which security is increasingly associated with the perception and management of risks and with social and human responsibilities. This challenge looks at **the challenges and consequences** for organisations in charge of security, and also the consequences of **all types of risk** – whether natural or man-made, intentional or unintentional – on all those involved.[32] Analyses proposed under this challenge should not be based on a purely technical and/or organisational view of risks, but should also consider the specific risk culture within each organisation involved, the involvement of citizens in security processes, and the need to protect rights and freedoms.
Therefore, topics of interest to this challenge include the management of crises of all origins (natural, technological or human), and from all points of view (human, technical, organisational, etc.). It also looks at the security of people 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. The challenge also covers the protection of vital infrastructures and networks, as well as air, sea and land surveillance. All these questions relating to freedom and security should be examined both in the physical and social world and in the digital world (cybersecurity), which has also its own set of problems and challenges regarding the protection of information systems, data and internet users. Ensuring cybersecurity for Europe and for its citizens and residents will require solutions derived from complex, multidisciplinary research (e.g. integrating developments in cryptology and virology into secure, privacy-compliant solutions). Given the nature of the issues covered in this challenge, particular attention should be paid in all the themes to **compliance with legal and ethical requirements**.

This challenge invites proposals from all types of research: **fundamental or highly upstream research** is also important to build up a body of knowledge on which public policies and ambitious future projects can be based. In all cases, regardless of whether or not the aim of the project is technology-related, an **integrated approach** is often needed, in which scientific and technical disciplines that do not usually meet are brought together: natural and environmental sciences, computer sciences, engineering, and social sciences and humanities (analyses of individual and collective behaviour, public law, public policy analysis, ethics, geography, etc.). By way of example, the list of key technologies for 2020 identified by the French General Directorate for Enterprise illustrates the wide range of technical objects of interest, identifying in the area of security: autonomous robots and drones, the intelligent use of big data, secure and reliable embedded and distributed systems, behavioural analysis, secure communication and strong authentication. While some building blocks for these technologies fall within the scope of Challenge 7, their specialisation to meet security requirements and their integration into security systems (including human and organisational aspects) come under Challenge 9, as do the societal impacts of these systems. For all projects where relevant, the involvement of end-users, regulatory authorities or operators[33] is encouraged, as is the consideration of needs expressed by the French security industry and other vital sectors (particularly energy, water treatment, transport, etc.).

[32] It should be noted that each societal challenge involves the characterisation of its own specific risks and the implementation of effective initiatives that take into account the interests of all individuals and groups affected.
[33] Operator: a public or private organisation which produces goods or services and which, in this capacity, is responsible for the safety of its users, customers, staff and citizens and of the environment.
Regulatory authority: an authority that issues rules, standards and guidelines relating to security.

This challenge is divided into five themes, which may overlap on some topics:

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 cyberterrorism
5. Protecting vitally important infrastructures and networks, monitoring sovereign areas

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 for the challenge. Projects whose primary aim is not a direct application in a field covered by the other themes are welcomed under Theme 1.
Theme 2 aims to encourage research about crises, from crisis prevention to the return to normality. The term “crisis” should be understood here in the strict sense: the occurrence of a large-scale disruptive event of natural, technological or human origin. Broader meanings (“the 1930s crisis”, “the crisis of civilisation”) are not covered here.
Themes 3 and 4 concern the security of people, legal entities, groups and societies as a whole. In Theme 3, the emphasis is placed on security in the physical space, while in Theme 4 the focus is security in cyberspace.
Theme 5 is aimed more specifically at the physical and digital protection of vitally important infrastructures and networks. It also covers the surveillance of sovereign areas.

The main research applications in this challenge are identified in relation to the end users of the research and concern all the themes in the challenge apart from Theme 1 (which is aimed at building up 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:

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

Theme 1: Fundamental research related to the challenge

For projects submitted under this theme, the research objectives, applications and ultimate aims (even in the long term) should be clearly positioned in relation to at least one of the more application-based themes (2 to 5) of the challenge. All disciplines are accepted in principle, as long as this condition is respected. Social sciences and humanities are strongly encouraged. Interdisciplinary research is naturally welcomed, given the complex nature of the questions raised by this challenge.

Theme 2: Risks, management of crises of all types, resilience of systems

The aim of this theme is to propose approaches, methods and tools, firstly to improve our understanding of risk situations and secondly to anticipate, prevent and manage crises and their consequences. Priority should be given to large-scale crises in terms of their impact on society, whether as a result of their immediate effects or because of their long-term consequences on people or on political and social organisations. Crises on a more local scale may be considered if the related research results could be relevant for use in a broader context than the situation under study.

Preventing and anticipating risks and threats

This topic involves technical and socio-technical systems which, if disrupted, may generate a crisis that should be avoided or whose scale should be limited. The aim is to incorporate security issues at all stages in the life cycle of systems, from design to dismantling, considering all aspects (technical, human, organisational, legal, etc.) and taking into account applicable frameworks (national, European or international).
NB: Detailed analyses of criminal or terrorist threats fall within the scope of Theme 3 for physical threats or Theme 4 for digital threats. The characterisation of environmental, biological, industrial and health risks is addressed within the relevant challenges.

The focus here is on methodologies, organisational methods and decision-making tools, including those based on models and on the analysis of big data (weak signals, consideration of invisible factors or neglected phenomena, etc.). Considerable efforts should be made to investigate human factors, which may either contribute to risk prevention or aggravate the level of risk. This could involve, for instance, social psychology or behavioural analysis.

Methodological studies and tools that could be used to assess the legal and economic impact in terms of cost-saving thanks to avoided failures and/or improvements in efficiency (direct or indirect) as a result of the introduction of security solutions could be proposed.

Different ways of modelling crises, the use of big data for decision-making (policy analytics), and the integration into processes of redesigned indicators and in particular of human and social factors could be investigated. Research could also explore the legal processes involved in developing standards.

Approaches that guarantee the reliable operation of interconnected systems are also encouraged. The aim is to ensure that the introduction of equipment, devices or practices does not generate

major risks as a result of their interactions with the technical or socio-technical environment into which they are integrated.

An integrated approach to crisis management

When a crisis occurs, the aim is to minimise its impact and its length. We will therefore welcome research on preparing and equipping people and organisations responsible for responding to crises as soon as they occur, from the detection of warning signals to resolution (return to normality).

Systems for information sharing and decision support are also of particular interest, for real-time crisis management and also to record data that can be used for *ex-post* analysis and any subsequent enquiries. Emphasis could be placed on modelling probable developments – such as domino effects – and factoring in the reaction capabilities of those involved. Effective crisis management involves the development of techniques to model and simulate critical phenomena (natural or man-made events), the capability to acquire and process hybrid, multi-source data in real time to extract relevant information, and the development of decision support tools based on an assessment of threats and vulnerabilities, equipped with an appropriate human-system interaction. The use of "serious games" may be considered as support for crisis modelling and for the training of the staff involved.

The people involved in crises, whether as victims or as information relays (in particular via social networks), are also of interest for this topic, as well as the communication to the public in a crisis, the dissemination and transparency of information, and the organisation and collaborative processes of aid, evacuation or intervention.

The resilience of systems, return to normality and ex-post analysis

This topic is about the management of the end of a crisis, the post-crisis period and the consequences. The aim is to address less urgent or critical problems which have foreseeable effects in different time-scales.

In the relative short term, logistical challenges may arise, as well as the need to support and monitor those involved in disasters from a psychological, health, social, legal or financial viewpoint: those who have experienced displacement, separation or trauma.

For the medium- to long-term, projects should examine the development of methods and tools for *ex-post* analysis (of crises that have been resolved or avoided), as well as disaster studies and the way such research can be implemented to prevent the occurrence of other crises, or at least to lessen some of their effects.

While the incorporation of a capacity for resilience when designing systems of which the failure has the potential to generate a crisis is part of the anticipation topic, the implementation of such resilience often raises its own difficulties, particularly within *complex interconnected systems*. Tools such as network theory and the analysis of decentralised processes may be used in this area.

Theme 3: Security of people and entities; fight against crime, terrorism and violent radicalisation

This theme focuses on anything that may jeopardise the physical security of people, goods or organisations. Although security in the digital sphere (cyberspace) is the focus of Theme 4, the projects submitted under this theme can include cybersecurity aspects (from a technological and/or legal viewpoint).

The main topics of interest are:

- the conditions required to guarantee freedom and security for people and entities (secure societies);
- equipping security forces and first responders.

Freedom and security, protection of individual rights

This topic covers any research related to the preservation of security and of rights and fundamental freedoms in case of risks caused by vulnerability or negligence rather than by malice.

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.

The involvement of individuals in their own protection and the protection of others, and the improvement of the security of people living in urban areas are also of interest. People security may also be considered in terms of methods employed by communities and societies themselves for their protection, ranging from citizen participation (public debates) to the organisation of safety procedures and the social acceptability of these procedures, as well as questions relating to transparency and simplification of public action.

Fight against violent radicalisation processes

NB: Violent radicalisation within the more general context of social integration comes under Challenge 8.

This topic concerns any methods to prevent, monitor, analyse and combat violent radicalisation among individuals or groups of individuals. These may include analysis of the social and cultural contexts that promote radicalisation, analysis of discourse and arguments, and strategies and policies for prevention and de-radicalisation: motives for radicalisation (vulnerability), procedures (online recruitment) and the conditions that lead to radical action being committed. The aim is to develop general methods to detect hazardous behaviour or extreme behaviour, for example using the perception and analysis of weak signals, while respecting rights and fundamental freedoms (including privacy) and avoiding stigmatisation.

All types of radicalisation that lead to violent actions in our society should be considered. Research should not be restricted to religious extremism; political radicalisation or desperate situations that

can also lead to radical action, particularly in professional contexts, should also be taken into account. Examples may include sabotage of sensitive sites, workplace suicides that cause serious accidents, etc.

Research will be encouraged on the following topics: improving the prevention of potentially dangerous behaviour and the protection of individuals; increasing the ability to detect unknown vulnerabilities, non-identified risk factors, weak signals and emerging risks; developing tools to detect rare events and emerging signals in a stream of data.

Fight against crime and terrorism

This topic concerns not only the fight against terrorist activities (including the use of CBRNE weapons) and serious crime (which may be organised transnationally), but also questions related to petty crime, delinquency and counterfeiting, and questions related to the search for evidence (forensics) and the admissibility of evidence in enquiries.

Research should enable threats to be assessed and their impacts (macro-economic, material, legal, etc.) to be analysed. The prevention and identification of risks and threats also covers new surveillance and warning techniques. Projects may focus on the detection of weak signals in a big data flow, behavioural analysis, and the processing of content (speech, video surveillance, tracked movements, open source data) – while being careful to protect rights and fundamental freedoms, including privacy, when gathering information (anonymisation or pseudonymisation of the information collected, protection against correlation attacks).

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, protection, preparation and organisation). 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, in full compliance with standards and without jeopardising rights and fundamental freedoms, and research on ways of repairing or compensating for damage to individuals and equipment are also welcomed.

Safety and security of technical and socio-technical systems

Even if there is no anticipated risk of crisis, preventing risks within a technical or socio-technical system may require a comprehensive, multi-faceted operational approach. This is particularly true for cases in which the introduction of a new technology may generate new vulnerabilities in a system that was thought to be safe.

The development of rigorous techniques for identifying and characterising risks and assessing their consequences, as an aid to public policies, is therefore of particular interest.

Theme 4: Cybersecurity: freedom and security in cyberspace, securing information systems, fighting cyberterrorism

This theme particularly focuses on security in cyberspace, in other words the risks, threats and vulnerabilities associated with dependence on digital technologies in our highly interconnected societies. Research into cryptology, biometrics, authentication, virology and information systems security therefore falls within the scope of this theme, as does research into the related legal frameworks. The focus on digital issues here does not rule out the inclusion of aspects relating to physical security or material development in the projects submitted under this theme.

The protection of information devices and systems

The aim here is to propose innovative technical and legal approaches that meet the need to protect information systems and all mechanisms used to convey sensitive information. These proposals should aim to offer protection for the public, institutions, infrastructures, networks and tangible or intangible heritage, while respecting individual rights and fundamental freedoms, particularly privacy. The scope of research may range from cryptographic components to the security policies of a system of interconnected systems and the protection of digital data, without neglecting human and organisational factors. Research on the cybersecurity of tools for e-democracy (electronic voting, administrative procedures, personal devices such as social security cards or digital identity, etc.) will also be welcomed. 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.

Since information systems security depends to a large extent on users, projects may focus on initiatives that **raise awareness** and offer **multidisciplinary training** for those involved in cybersecurity, as well as on tools to help master security solutions.

Cybersecurity of infrastructures, physical networks and equipment

NB: The protection of vitally important physical infrastructures and networks, including cyber protection, is covered in Theme 5.

The growing role 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). The aim is to achieve a balance, particularly in financial terms but also in terms of usage conditions, between fully safe operation that complies with applicable legal regulations, and fully optimised operation.

Areas of interest therefore include characterising and assessing the impact of risk scenarios or threats using digital means; and methods for the design of secure systems that contribute to the widespread adoption of a systematic “security by design” and “privacy by design” approach, particularly for SCADA-type industrial control systems or connected, piloted or autonomous vehicles that may interact with infrastructures or networks.

The “cyber” dimension of the risk or threat should not obscure the role of individuals and organisations. While errors, negligence and malicious acts are risk factors that should be taken into account, compliance with well understood procedures, vigilance and initiative serve as a safeguard that should also be taken into consideration in a socio-technical systems approach.

Fight against cybercrime and cyberterrorism

The focus here is the fight against the use of digital technologies for illegal activities or activities which jeopardise 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 or which make use of these systems to carry out or boost more traditional criminal activities.

Research should enable threats to be assessed and their impacts (macro-economic, material, legal, etc.) to be analysed. It should also examine the methods, resources and tools that may be used to fight against criminal or terrorist activities associated with information technology. Projects may focus on the detection of weak signals in a stream of big data, behavioural analysis, the processing of web content (social networks, advertising websites, etc.), and regulations governing consultations and the provision of legal information, while respecting individual rights and freedoms. Research may also look into tools and methods for forensic investigation and the detection of threats and risks. This topic also covers digital virology and the fight against malware.

Fight against violence and radicalisation in cyberspace

The anonymity of the web sometimes gives rise to questionable behaviour, which, although not strictly classified as terrorism or crime, is still considered to be an unacceptable demonstration of violence. Examples may include organised barrages of comments that violate human dignity on blogs or social networks, which can have deep and lasting effects on victims. Without seeking to restrict freedom of expression, research may be conducted into methods to combat this behaviour, which may be perpetrated by small groups acting solely 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 internet. IT countermeasures may also be considered to neutralise the resources of attackers, while remaining within legal boundaries and legal protection systems may be proposed.

Protection of privacy and other rights and fundamental freedoms in cyberspace

Some aspects of public protection can lead to new forms of invasion of privacy. More broadly, the digital environment depends on complex information infrastructures which private stakeholders have developed for their own needs, in which data, particularly data about individuals (personal data), takes on the role of "elementary particles". Practices used to monitor and target individuals are therefore widespread in the digital sphere. Even if the aim of these practices appears at first glance to be harmless (marketing, targeted advertising, etc.), they seem to reflect the increasingly widespread use of more or less aggressive methods for monitoring individual behaviour and habits. The fact that these methods enable the development of extraordinarily innovative goods and services, which meet both individual and collective requirements, should not obscure the importance of respecting individual rights and freedoms (such as the right to "informational self-determination"). Without the development of mechanisms for transparency, control and compliance with legal rights, the digital environment is at risk of losing the trust of its users.

Research should contribute to the development of 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 should also enable public services to fulfil their missions within the legal framework, while giving citizens the opportunity to exert public control over these activities, and without moving towards a surveillance society.

Research on how to make sure that users – whether consumers or service and content providers – 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.

Achieving these objectives will require a new generation of hybrid or pragmatic research, which combines technological expertise with social and practical knowledge (in the fields of sociology, law, politics, etc.). Compatibility with the national and European legal frameworks for the protection of personal data (including regulations relating to the concept of "privacy by design") should be demonstrated.

The notion of freedom also involves the ability to decide, and therefore the public's right to information and training. Freedom means protecting people in vulnerable situations, which entails the development and application of standards on minimum levels of human security in cyberspace.

Theme 5: Protecting vitally important infrastructures and networks, monitoring sovereign areas

NB: The safe operation of complex interconnected systems is addressed in Theme 3; cyber protection in general is addressed in Theme 4.

Protecting vitally important infrastructures and networks

This topic mainly concerns the improvement of the security of critical infrastructures and physical networks (as well as related services), particularly in the areas of energy, water supply, transport and

telecommunications, through the protection against vulnerabilities. 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 topic also concerns research into sensitive facilities and combined natural and technological ("natech") risks, as well as the protection of restricted areas, in particular for airport security (tools to improve the monitoring and traceability of staff movements in different areas, in compliance with applicable legal regulations).

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: detection of individuals with malicious intent, perimeter protection; protection against CBRNE threats (understanding, assessment, remote detection, identification, physical and organisational protection, decontamination); the development of methods for designing secure infrastructures that can withstand all nature of aggressions, based on the use of predictive physical models (models that simulate effects, models for structural resistance, outages, failures, sabotage, external or internal attacks); the cybersecurity (particularly at the design stage) of infrastructures and connected/smart critical networks, contributing to the widespread adoption of a systematic "security by design" approach by taking into account people as both risk factors and risk-prevention agents.

These approaches may make use of technologies such as innovative materials (e.g. self-decontaminating materials), integrated, smart sensors which respect freedoms and rights (for applications including video protection), methods for modelling, supervision and control (physical and digital), and the integration of systems for monitoring purposes. At a systems level, the development of innovative architectures for ERPs in the area of security, which offer virtualisation of physical security functions and a harmonised approach to logical and physical security policies, could be examined, in particular by involving security operators.

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 spaces; as well as tools to improve the monitoring and traceability of staff movements within different areas, in compliance with applicable legal regulations (particularly with regard to privacy and information of the public).

Topics such as the fight against all forms of trafficking, piracy and other illegal activities are included. Research may cover technological questions (sensors, correlation of events, intervention methods, etc.) and/or questions relating to social sciences and humanities (law, political science, etc.). Particular attention will be paid to geopolitical and regulatory developments at national, European and international level.