The 2nd Visionary Council
on the Moonshot Research and Development Program

Document 2

Overseas Trend of Research and Reference Cases

April 22, 2019

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Trend of Major Countries

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Trend of research and development

- Each country seeks to establish the framework where results of excellent research promptly lead to innovation to create markets before others and solve social challenges. Meanwhile, the trend to focus on the basic research has begun to surface.
- The development of information technology has resulted in the paradigm shift in research and development, and drastically accelerated technical innovation. Especially, the research and development in the category in relation to the national security is likely to be strongly promoted as the national strategy.
- Since the relationship between the science and technology and the society has reached the new stage (e.g. utilization of AI and biotechnology, etc.), the approach to Ethical, Legal and Social Issues (ELSI) and Responsible Research and Innovation (RRI), and the cooperation with social science become increasingly important.
- The approach where results of science and technology lead to the social value has been focused (e.g. expectation on Science, Technology and Innovation (STI) for Sustainable Development Goals (SDGs), increasing interest in the investment with ESG (Environmental, Social and Governance) criteria, etc.).
- Since now that innovation can't be made by only a single individual, organization, and country, therefore, the interdisciplinary, integrated and international cooperation beyond academic, industrial, and government institutions becomes the key to realize innovation.

America

Ensure predominance in "Industries of the Future"

- **Trend of planning national strategy in high technology and emerging research categories (4 future industries)**

  AI: Review "National Artificial Intelligence Research and Development Strategic Plan," and issue a new executive order of the "American AI Initiative"
  Quantum science: Announce "National Strategic Overview for Quantum Information Science," and enact "National Quantum Initiative Act"
  5G: "White House 5G Summit"
  Advanced Manufacturing: "National Strategic Plan for Advanced Manufacturing"
- **FY2020 "Research and Development Priority Areas"**
  - Governmental institutions **focus on basic research and applied research at the early stage**
  - R&D priority areas: National security, AI, quantum science, computing, connectivity and autonomy, manufacturing, space, energy control, innovation in medical treatment, agriculture
- **Department of Defense (DOD) focus on dual-use research**

  Massive investment in semiconductor devices & parts, AI, quantum science, mainly by DARPA (AI Next Campaign, and Electronics Resurgence Initiative)

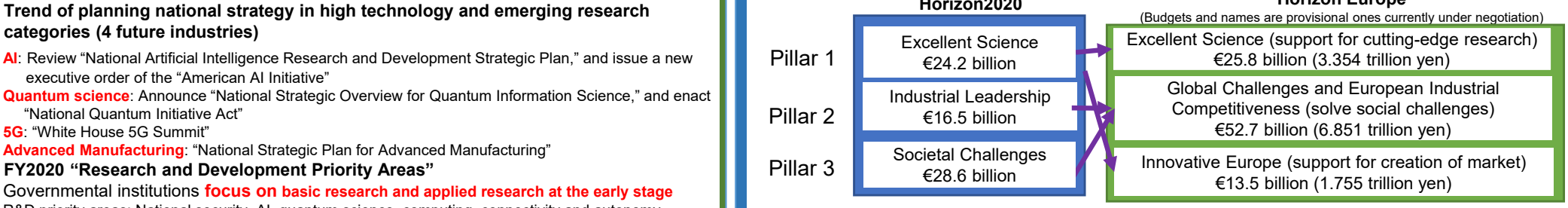
China

Aim to be the most innovative country in the world by 2050

- **Develop innovation systems**
  - Comprehensive support for basic research and innovative research, human resources development, formation of research center, etc.
  - Start "**China's Innovation-Driven Development Strategy and Prospects**" (from 2016 to 2030)
  - "1,000 Foreign Experts Introduction Plan" to enhance invitation of excellent human resources (including those who have foreign citizenship) from abroad (from 2008)
  - **Drastic reform of competitive research funding system** (from 2015 to 2017) for efficient support
- **Large-scale and intensive investment in strategic areas**
  - **"Made in China 2025"** (2015): Aim to achieve 70% in the rate of self-sufficiency of semiconductors and parts by 2025
  - **"AI2030"** (2017): Certify 5 companies as national next-generation AI platforms, and promote the development of joint research system in cooperation between the public and private sectors
  - **"The National Laboratory for Quantum Information Science" (investment of about 1 trillion yen), etc.**: Massive investment to lead the world

Europe

Action to formulate "Horizon Europe" (from 2021 to 2027) is fully in progress



- Pillar 1: **The support for cutting-edge research is continued and enhanced**, mainly by European Research Council (ERC) which has been highly acclaimed.
- Pillar 2: **Set plural interdisciplinary missions** to focus on the solution to specific challenges
- Pillar 3: Establish "European Innovation Council (EIC)" to **make rapid and disruptive innovation**
- "**Future and Emerging Technologies (FET) Flagships**" (from 2013) which is the support program for large-scale research at leading research centers is planned to be continued and enhanced.

Make UK the most innovative country in the world by "Industrial Strategy"

- Specify "Grand Challenges (**AI & data, ageing society, clean growth, and future of mobility**)"
- Establish UK Research and Innovation (UKRI) for the optimized and more efficient funding (2018)
- Intensive support for the category of quantum technology, by "National Quantum Technologies Programme" (from 2014)
- Intention to participate in Horizon Europe as an associate member, even after leaving the EU

Research leads to industrial achievement by "High-Tech Strategy 2025"

- Newly establish "**Agency of Dynamic Innovation**" to support for creation of innovation with higher impact, and "**Cybersecurity Agency**" to aim for innovation in the category of national security
- Intensive investment and human resources development in technological categories of **AI, quantum science, storage battery,** etc., which will be the core of future industry

Innovation policy led by President

- Establish "**Fund for Innovation and Industry**" and "**Defense Innovation Agency**", and develop the comprehensive support system to create innovation by utilizing technological capability of private companies
- Reorganization & scale-up of universities to enhance the research capability and the cooperation among regional research institutions

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作成者, 2019/05/09

Approach of EU Horizon 2020 (from 2014 to 2020)

Future Emerging Technologies (FET) Program

Provide appropriate support for research, and bring competition to science, in proportion to the scale of technology (3 types of FET Open, FET Proactive, and FET Flagships)

FET Open

- Support for research in its early stage to bring innovative new ideas
- From 50 to 60 projects in progress
- Up to €3 million (0.39 billion yen) per project for 3 years

FET Flagships

- Support for large-scale research at the leading research centers
- **€1 billion (130 billion yen) per research center for 10 years** *50% of cases are matching with various countries' government, local government, and companies, etc.
- 3 projects in progress (total 390 billion yen)
  - **Human brain (from 2013), graphene (from 2013), and quantum technology (from 2018)**
- **Newly inviting applications from the public in the following categories:**
  ICT and Connected Society
  Health and Life Sciences
  Energy, Environment and Climate change
  6 projects (as shown in the figure to the right) were selected as pilot projects.
  ⇒From March, each project team is provided with €1 million for a year. Up to 3 projects will be chosen to launch in 2021.
- At final round, about 25 world-famous experts will examine reports from each project team.

FET Proactive

- Support for interdisciplinary and exploratory research
- Average €5.9 million (0.77 billion yen) per project for 4 years
- Total 15 projects regarding 6 topics in progress
  6 topics are as follows: Artificial organs, tissues, cells and sub-cell structures
  Time
  Living technologies
  Socially interactive technologies
  Disruptive micro-energy and storage technologies
  Topological matter

Pilot projects	Details
Humane AI	Empower and expand human beings' potential by utilizing AI
RESTORE	Enhance clinical applicability of genetic and cellular therapy
LifeTime	Promote personalized medical treatment
Sunrise	Improve sunlight conversion efficiency by utilizing artificial photosynthesis
ENERGY-X	Improve sunlight conversion efficiency by utilizing catalysts, etc.
Time Machine	Digital search technology for Europe's historical archives

European Innovation Council (EIC) Pilot Program

- Start from 2018, prior to the establishment of EIC (an organization to be established in 2021, for the purpose of making rapid and disruptive innovation)
  (EIC: the pillar 3 in Horizon Europe)
- Support for mainly small and medium enterprises and start-up companies which have excellent technological capability, to create innovation
- In such framework, "**EIC Horizon Prizes**" supports **research and development which can contribute to solution to social challenges**
  (Only this program provides support for mainly researchers and innovators)

EIC Horizon Prizes

- Inviting applications from the public in 6 categories regarding social challenges
- Support research which can contribute to solution to challenges, regardless of conventional categories and sectors
- Support for leading researchers and innovators, etc.
  Total €40 million (5.2 billion yen) for 3 years

Social challenges in EIC Horizon Prizes	Budget (from 2018 to 2020)
1. Affordable High-Tech for Humanitarian Aid	€5 million (0.65 billion yen)
2. Fuel from the Sun, Artificial Photosynthesis	€5 million (0.65 billion yen)
3. Innovative Batteries for eVehicles	€10 million (1.3 billion yen)
4. Early Warning for Epidemics	€5 million (0.65 billion yen)
5. Blockchains for Social Good	€5 million (0.65 billion yen)
6. Low-Cost Space Launch	€10 million (1.3 billion yen)

Background of introduction of Mission-Oriented Research in Horizon Europe

Following Lamy Report where the importance of mission-oriented research was proposed, ESIR and RISE issued the more specific reports, in response to the request from Carlos Moedas, European Commissioner for Research, Science and Innovation. Following those reports, Mazzucato Report was issued, and it led to the proposal for Horizon Europe which introduced the concept of mission-oriented research.

Lamy Report (issued In July 2017)
Report made by High-Level Expert Group in European Commission
→the importance of mission-oriented research was proposed

[Contents of proposal]
Establishment of missions of R&I to cope with global challenges is required. Then, we should call on researchers, innovators, and other stakeholders to realize missions.

ESIR Report (issued in December 2017)
Proposal for economic rationality of introduction of mission-oriented research

RISE Report (issued in February 2018)
Proposal for definition of missions, criteria for setting missions, importance of involvement of stakeholders, how the governance should be, etc.

Mazzucato Report (issued on February 22, 2018)
Report made by Mariana Mazzucato who was appointed as Special Advisor on Mission Driven Science and Innovation to Carlos Moedas, European Commissioner for Research, Science and Innovation.
→Strategic proposal for mission-oriented research and innovation in Horizon Europe.

[Important criteria for setting missions]
1. Dynamic and high impact with wide variety of social relation
2. Setting time limit to make targets clear and measurable
3. Ambitious but realistic research and innovation activities
4. Innovation beyond categories, sectors, stakeholders
5. Plural bottom-up solutions

Proposal for Horizon Europe
(announced on June 7, 2018)

ESIR: Expert group on the economic and societal impact of research and innovation
RISE: Research, innovation and science policy experts high level group

Contents of Proposals in RISE Report

- Set clear missions (targets) against social challenges
- Challenges are classified into the following 2 categories:
  Type A・・・There is a possibility to solve, and we can set the specific targets.
  (e.g. the Apollo program, development of vaccine of Ebola virus)
  Type B・・・It is difficult to define issues to be solved, because of complexity, and the solution is unknown.
  (e.g. eradication of cancers, the problem of immigrants)
- It is important to get all stakeholders including researchers, the industrial world, citizens, etc. participated in the discussion of missions.
- Strong leadership is required to enable the governance of many stakeholders (those who has been previously a cabinet minister and/or CEO is desirable as a responsible manager).

Challenges	Missions	Complimentary Measure
No household garbage	Completely recyclable packaging technology	・Regulations to encourage manufacturers to collect packaging ・Investment in recycle facilities by the public and private sectors
Server safe navigation	Innovative cybersecurity technology	・Training for utilization of cybertechnology ・Cultural and psychological approach to safety
Prevent water scarcity	New membrane technology	・Develop infrastructure for renewable energy ・Measure for decrease of water demand

Defense Advanced Research Projects Agency (DARPA)

Funding agency in Department of Defense (established in 1958) **Budget in FY2019: $3.43 billion (394.5 billion yen)**

- Focus on **the innovative research and development to meet the future needs of national defense**
- Discover and **provide support for high risk, high payoff research and ideas** to promote practical implementation
  (Composition ratio of distribution: about 70% for companies, and about 15% for universities)
- **Support for technical development which can be the basis of disruptive innovation** (successful examples: GPS, Internet, stealth technology, autonomous driving vehicles, robots to support for surgery, etc.)

Strategic focus areas

- Improvement of complex military systems – Modularization of weapons systems (e.g. positional information system which functions independently of satellite GPS, etc.)
- Control of huge data – Big data tools, cybersecurity, access and protection of network data
- Utilize biology as technology – Utilization of cutting-edge knowledge and technology in neurochemistry, immunology, and genetics
- Expand the cutting-edge areas of technology – Utilization of higher mathematics, new chemistry/process/material, quantum physics, etc.

Strong initiative

- "AI Next" Campaign ($2 billion for 5 years, equivalent to 230 billion yen)

  Development of AI system which can understand contexts and explain grounds for decision, for the purpose of bringing about cooperative relations between human beings and machines
  (e.g. correct understanding of huge and complex data, quick and appropriate decision making, accomplishment of missions by systems, etc., by machines)
- Electronics Resurgence Initiative (ERI) ($1.5 billion for 5 years, equivalent to 172.5 billion yen)

  Develop industrial infrastructure of safe and mechanized electronics to manufacture electronic devices for commercial and military purposes
  (manufacturing of special circuits in the domestic semiconductor industry, etc.)

Organizational structure about 220 staff (including about 100 Program Managers (PM))

- Plural program managers belong to 6 technical offices
  ○Defense Sciences Office ○Strategic Technology Office
  ○Information Innovation Office ○Tactical Technology Office
  ○Microsystems Technology Office
  ○Biological Technologies Office
- Flat structure (Director – Office Director - PM)
- Appointment of PM
  PM is the staff with limited term (from 3 to 5 years,) and appointed through open recruitment
  DARPA seeks ambitious researchers and technical experts from universities, companies, governmental institutions, etc.
  25% of PM is replaced every year to introduce new ideas

Typical support system and characteristics of management

1) Funding distribution by the initiative of PM (grant method/contract method)

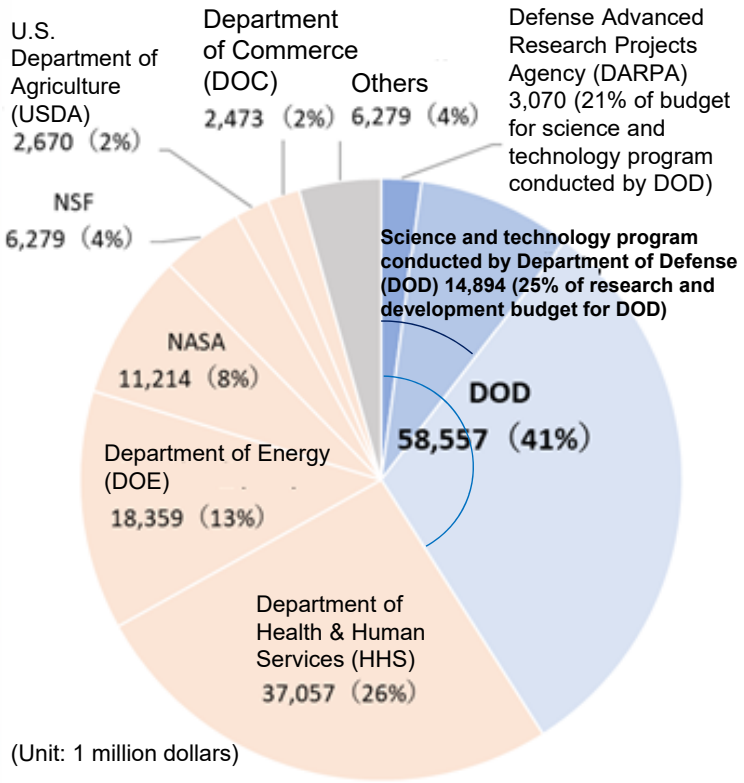
- PM has **a strong discretionary power** to plan, formulate, and implement programs
- Formulate programs with clear targets, and support them by providing several tens of millions of dollars from 3 to 5 years. Each program supports plural projects to improve the success rate.

2) Support for research and development (challenges) by prize method

- Grand Challenge (autonomous self-driving vehicles race), Launch Challenge (development of rocket to deliver payloads to low Earth orbit),etc.
- Aim to discover unexpected creative approaches, by setting only ambitious targets without preconceptions
- Not only the prize (from several to ten million dollars at maximum) but also demonstration of technological capability are incentives for participants.

Promote the support for wide variety and experimental research and development, by taking a risk to discover innovation, under the small-scale, flat and flexible organizational operation

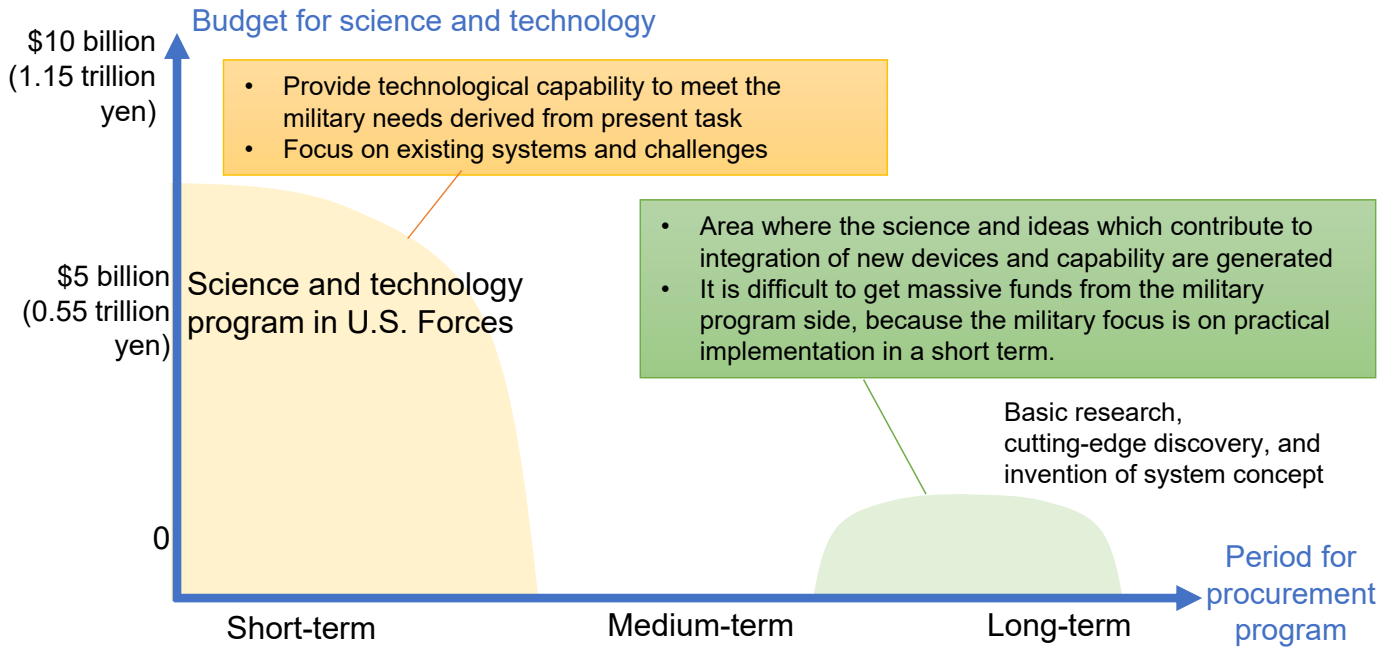
Defense Advanced Research Projects Agency (DARPA)

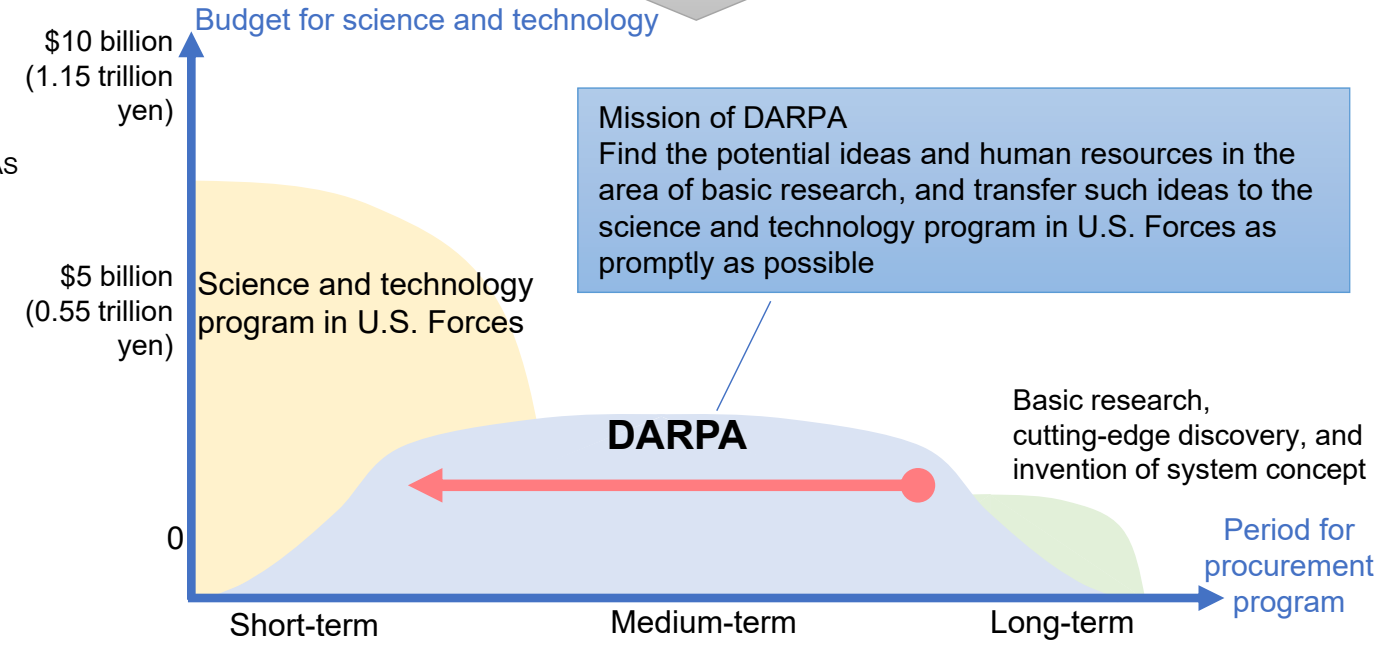


United States federal budget for research and development (on the basis of budget authority in FY2018)

*Compiled by CRDS, on the basis of statistics of AAAS

- About 40% of approximately $143 billion (about 16.4 trillion yen) which was the total federal budget for research and development was spent for DOD.
- About 25% of the research and development budget for DOD was spent for science and technology program.
- About 20% of budget for science and technology program was spent for DARPA.





*Edited and processed by CRDS, on the basis of "Bridging The Gap Powered By Ideas" issued by DARPA (2005)

Approach of Advanced Research Projects Agency - Energy (ARPA-E) and National Science Foundation (NSF)

Advanced Research Projects Agency - Energy (ARPA-E)

- ARPA-E was stablished and modeled after DARPA. ARPA-E provides financial support for the research which has difficulty to get funding from the industrial world because of its high risk, high payoff feature, for the purpose of development of innovative energy technology. The budget in FY2019 is approximately $0.37 billion (42.55 billion yen).
- Various interdisciplinary programs are provided in each area of “electricity generation and delivery”, “energy efficiency”, and “energy for transportation.”

[Examples of programs starting from 2019]	DIFFRENCIATE: Utilize machine learning tools in energy technology development process
	ATRANTIS: Development of floating offshore wind turbine which has great power generation efficiency by utilization of computer tools

National Science Foundation (NSF) “10 Big Ideas for Future NSF Investments”

- Research Areas (⇒Research Ideas) and approaches (⇒Realized Ideas) set by NSF for future investment.

The budget is prepared from FY2019. **The related budget in FY2019 is $0.343 billion (39.4 billion yen).**
*It accounts for 4.2% of $8.1 billion (928.6 billion yen) which is the total budget for NSF.

Research Ideas	Budget in FY2019	
	Budget for Areas	+Convergence Accelerator
Harnessing Data for 21st Century Science and Engineering	$30 million (3.45 billion yen)	+$30 million
The Future of Work at the Human-Technology Frontier	$30 million (3.45 billion yen)	+$30 million
Windows on the Universe: The Era of Multi-messenger Astrophysics	$30 million (3.45 billion yen)	
The Quantum Leap: Leading the Next Quantum Revolution	$30 million (3.45 billion yen)	
Understanding the Rules of Life: Predicting Phenotype	$30 million (3.45 billion yen)	
Navigating the New Arctic	$30 million (3.45 billion yen)	

Realized Ideas	Budget in FY2019
Growing Convergent Research at NSF	$16 million (1.84 billion yen)
NSF INCLUDES: Enhancing Science and Engineering through Diversity	$20 million (2.3 billion yen)
Mid-scale Research Infrastructure	$60 million (6.9 billion yen)
NSF 2026 for long-term support for innovative program development	$6.5 million (0.748 billion yen)

“NSF 2026 Idea Machine” which invites suggestion of the next set of “Big Ideas” from the public will be promoted in FY2019.

Convergence Accelerator promoted by NSF

- It is a new approach regarding “Big Ideas,” and NSF is proactively involved in the team building and the project promotion to get innovative results from high risk research. Its management system is modeled after that of DARPA. The budget in FY2019 is $60 million (6.9 billion yen).

Process of support

Phase 0 Team Building
- Building of teams which consist of various categories and sectors (e.g. industrial, academic, government institution, NPO, etc.) through workshop, etc.

Screening of documents

Phase 1 Generate Ideas
- Organize the group consisting of about 20 teams, and conduct the incubation program for about 6 months
- Delve into ideas through discussion and practice
- PO evaluate the progress every week

Screening of presentation

Phase 2 Start Research
- The chosen teams are provided with several millions of dollars as research expenses.
- Evaluation of progress once or twice a year

Examine results

The prize is awarded for the team with especially excellent results.

[e.g. themes in 2019 for invitation of application] Open knowledge network/AI and future jobs/National talent ecosystem
[Scale of support] Phase 1: Up to $1 million (0.115 billion yen) per case for 9 months tal number of cases is 50
Phase 2: Up to $5 million (0.575 billion yen) per case for 2 years

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作成者, 2019/05/09

Reference Cases in America and Europe

National Science Foundation (in America) “10 Big Ideas for Future NSF Investments”

Understanding the Rules of Life: Predicting Phenotype

Unravel the phenotype resulting from a complex interaction of genetics and the environment in biological organisms

The Future of Work at the Human-Technology Frontier

Creation of technologies that can collaborate with humans to enrich their lives in the workplaces of the future, and provide workforce in response to change of workstyle

Windows on the Universe: The Era of Multi-messenger Astrophysics

Answer the mystery of universe, such as how the universe began and why it is accelerating, from various information resources including electromagnetic radiation, neutrinos, and gravitational waves

Navigating the New Arctic

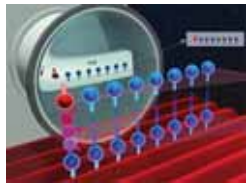
Following the rapid loss of Arctic sea ice because of the global warming, seek new access to the Arctic’s natural resources such as fossil fuels,
minerals, and new fisheries

Harnessing Data for 21st Century Science and Engineering

Develop a cohesive and national scale approach to huge research data infrastructure, and train the next generation of data scientists capable of working effectively with such data

The Quantum Leap: Leading the Next Quantum Revolution

Research on quantum physics which is essential to implement the quantum computer as the next quantum revolution into technologies that will benefit the society and consumers



https://www.nsf.gov/news/special_reports/big_ideas/

EIC Horizon Prizes in Europe

Affordable High-Tech for Humanitarian Aid

Develop innovative solution which can be implemented in humanitarian aid for developing countries

Fuel from the Sun, Artificial Photosynthesis

Establish the artificial photosynthesis system which can generate fuel

Innovative Batteries for eVehicles

Develop innovative battery solution to electric vehicles, by utilizing material which is easily available and sustainable

Early Warning for Epidemics

Develop the epidemic early warning system which can be implemented in developing countries, to aim for monitoring, prediction, and prevention of outbreak

Blockchains for Social Good

Develop efficient and effective solution to social challenges, by utilizing the technology used in blockchain

Low-Cost Space Launch

Following the estimated increase of future demand for satellite data, develop the optical microsatellite to be launched into Low-Earth Orbit

https://ec.europa.eu/research/eic/index.cfm?pg=prizes

Case of UK

Industrial Strategy Challenge Fund (ISCF)

- Specify 4 “Grand Challenges” in “Industrial Strategy” as focus areas where UK can lead global technological innovation
- Set ambitious “Missions” in each Grand Challenge
- Industrial Strategy Challenge Fund (ISCF) provides financial support to solve social and industrial challenges which arise in each Grand Challenge
- Support for interdisciplinary joint research and development conducted by companies and leading researchers is provided. Since this program is modeled after DARPA, a project director is appointed in each challenge.
- The invitation of application of challenge from the public has made 3 times since 2017. Regarding approved challenges, the government is expected to make the budget which totals £3 billion (441 billion yen), and the same scale investment from the private companies is requested.

Grand Challenge
AI and data economy
Aging society
Clean growth
Future of mobility

The version of invitation of application	Name of Challenge	Scale of Budget
The 1st series approved in 2017	Faraday battery challenge	£0.246 billion (36.16 billion yen)
	Leading-edge healthcare	£0.181 billion (26.61 billion yen)
	National Satellite Test Facility	£99 million (14.55 billion yen)
	Robots for a safer world	£93 million (13.67 billion yen)
	Driverless cars	£38 million (5.59 billion yen)
	Manufacturing and future materials	£26 million (3.82 billion yen)
	Total	**£0.683 billion (about 100 billion yen)**

Case of Germany

Establishment of “Agency of Dynamic Innovation” A15

- Though gradual innovation in Germany has gotten results, but it is difficult to say that disruptive innovation to create new business models has been brought about by Germany.
- All top 10 companies ranked by market values in the world are American or Chinese companies.
- The venture capital market in Germany and Europe is comparatively weak, compared to America.
- The proposal for the necessity of innovation support program such as DARPA was made.
- In “the Innovation Dialogue,” Managing Director of Max Planck Institute A14 a proposal on this issue to the German Chancellor Angela Merkel.
- The coalition agreement (in March 2018) included the establishment of Agency of Dynamic Innovation. The research and development innovation policy “High-Tech Strategy 2025 (in September 2019)” also stipulated the establishment of this new agency.

Organization	Incorporated organization (GmbH in German abbreviation) under the jurisdiction of Federal Ministry of Education and research (BMBF in German abbreviation)
Total amount of grant	€1 billion (130 billion yen) for 10 years
Purpose	・Solve specific challenges for development into products or services by innovative technology ・Create unprecedented products and services in the market ・Create dynamic innovation which adds value to Germany ・Themes and areas have not been decided yet.
Management	Strong authority for the innovation manager
4 phases in implementation	1. Invitation of suggestion of ideas 2. Funding 3. Transfer hub 4. International cooperation
Criteria for adoption	• Clearly define social challenges • Development into the market in 3 to 6 years • Market analysis (why hasn’t the technology been realized in the market?)
Evaluation	Evaluation team by external experts

(Summary from material of BMBF in 2018: Details will be announced in the summer of 2019)

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作成者, 2019/05/09

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作成者, 2019/05/09

Summary of Famous Reference Cases

Creation of basic technology in the next generation

FET Flagships
Total €3 billion (390 billion yen) for 10 years
€1 billion (130 billion yen) x 3 projects
(Human brain, graphene, and quantum technology)

- Support for large-scale research at the leading research centers
- The example of 20 challenges in progress in the category of quantum technology
  iqClock €10 million (1.3 billion yen) for 4 years
  Development of optical clock by utilizing quantum technology

FET Proactive
Total €88.5 million (11.55 billion yen) for 4 years
Average €5.9 million (0.77 billion yen) x 15 projects

- Support for interdisciplinary and exploratory research
- Total 15 projects regarding 6 topics in progress
(6 topics are as follows: Artificial organs, tissues, cells and sub-cell structures, Time, Living technologies, Socially interactive technologies, Disruptive micro-energy and storage technologies, Topological matter)
- [Examples]
  TOCHA: The next-generation topological device and architecture
  POTION: Innovative odour delivery system
  HARVESTORE: Harvest and storage of energy

FET Open
Total €0.15 billion (19.5 billion yen) for 3 years
Up to €3 million (0.39 billion yen) x 50 to 60 projects

- Support for research in its early stage to bring innovative new ideas
- [Examples]
  GOAL-Robots: Research on autonomous learning robots
  NanOQTech: Basic research on light quantum technology
  SC-square: Basic research on information security

Creation of core technology for clear purposes

DARPA: Funding distribution on the initiative of PM
Annual budget $3.43 billion (394.5 billion yen) in 2019
Average: Several tens of millions of dollars
(about 1 to 2 billion yen) x about 250 programs

- PM who has a strong discretionary power promotes clear targets
- [Example] Competency recognition machine learning (from 2018)
  Development of machine learning system which enables machines to evaluate self-performance under the dynamic situation, and explain it to human beings simply
- [Example] Bioelectronics for tissue regeneration (from 2018)
  Development of bioelectronics to trace the status of wound on a real-time basis, and optimize repair and regeneration of tissue

DARPA: Prize method
From several to ten million dollars at maximum (1.15 billion yen) per project

- Aim to discover unexpected creative approaches, by setting only ambitious targets
- [Example] $1 million (0.11 billion yen) for Grand Challenge 2004
  $2 million (0.22 billion yen) for Grand Challenge 2005
  Autonomous self-driving vehicles long-distance race in a desert
- [Example] $10 million (1.1 billion yen) for Launch Challenge 2018
  Competition of capability to deliver payloads to low Earth orbit by launching a rocket in a short-term, without any prior information about payloads and a launch site

ARPA-E: Funding distribution on the initiative of PD
Annual budget $0.37 billion (42.55 billion yen) in 2019
Average: Several tens of millions of dollars
(about 1 to 2 billion yen) x about 40 programs

- PD who has a strong discretionary power promotes clear targets
  (PD at ARPA-E is equivalent to PM at DARPA)
- [Example] DIFFRENCIATE (from 2019)
Utilize machine learning tools in energy technology development process

Technology fusion to solve social challenges

Industrial Strategy Challenge Fund (ISCF)
Total £3 billion (441 billion yen)
as the total budget for approved challenges

- 4 Grand Challenges (AI & data economy, ageing society, clean growth, and future of mobility) to solve social and industrial challenges
- Since this program is modeled after DARPA, a project director is appointed in each challenge.
- Support for interdisciplinary joint research and development conducted by researchers and private companies

NSF "10 Big Ideas for Future NSF Investments" NSF Annual budget $0.343 billion (39.4 billion yen) in 2019

- Research Areas and approaches set by NSF for future investment
- Areas: Data revolution, Human-Technology Frontier, Windows on the Universe, the Quantum Leap, Understanding the Rules of Life, the New Arctic

NSF Convergence Accelerator
Annual budget $60 million (6.9 billion yen) in 2019
(included in 10 Big Ideas)

- It is a new approach regarding "10 Big Ideas," and NSF is proactively involved in the team building and the project promotion to get innovative results from high risk research.
- Areas: Data revolution, Human-Technology Frontier

EIC Horizon Prizes
Total €40 million (5.2 billion yen) for 3 years

- Inviting applications from the public in 6 categories regarding social challenges (Affordable High-Tech for Humanitarian Aid, Fuel from the Sun, Artificial Photosynthesis, Innovative Batteries for eVehicles, Early Warning for Epidemics, Blockchains for Social Good, Low-Cost Space Launch)
- Support research which can contribute to solution to challenges, regardless of conventional categories and sectors
- Support for leading researchers and innovators, etc.

Strategic promotion of basic research model

Provide appropriate support in proportion to the scale of basic research

1. Support for research in its early stage to bring innovative new ideas
2. Support for interdisciplinary and exploratory research
3. Formation of strategic research center, and massive investment

Technological breakthrough model

Set clear targets to be achieved, and specify technological challenges which must be solved to achieve targets. In DARPA and ARPA-E, wide variety of plural projects are conducted to improve the success rate.

Solution to social challenges model

Interdisciplinary and cross-sectional themes to solve social challenges are set.
Make an approach to solve social challenges by mission-oriented research, and joint research between industrial and academic institutions, while attracting investment from private companies.