



Moonshot Goal

“Realization of a society safe from the threat of extreme winds and rains by controlling and modifying the weather by 2050.”

Explanation of R&D Policies

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Agenda

- Overview of R&D concept
- Recruitment and selection policies, etc.
- Policy for the promotion of R&D

Moonshot Goal

“Realization of a society safe from the threat of extreme winds and rains by controlling and modifying the weather by 2050”

The vision of society and targets that are the aims of this Goal:

- By 2050, making it possible to intervene to change the timing, range and intensity of typhoons and extreme rains (including those that occur in linear precipitation zones), significantly reducing disaster damage and bringing a wide range of benefits to society.
- By 2030, demonstration on a computer that it is possible to reduce disaster damage by controlling typhoons and extreme rains (including those that occur in linear precipitation zones), using realistic intervention operations, and conduct experiments to verify these operations.

Direction of research and development

■ Area and field to promote challenging R&D

- Control methods that will yield great results from small disturbances, etc.

Constructing control theories

Developing control technologies/techniques that are socially, technically, and economically feasible

Improving the accuracy of predictions

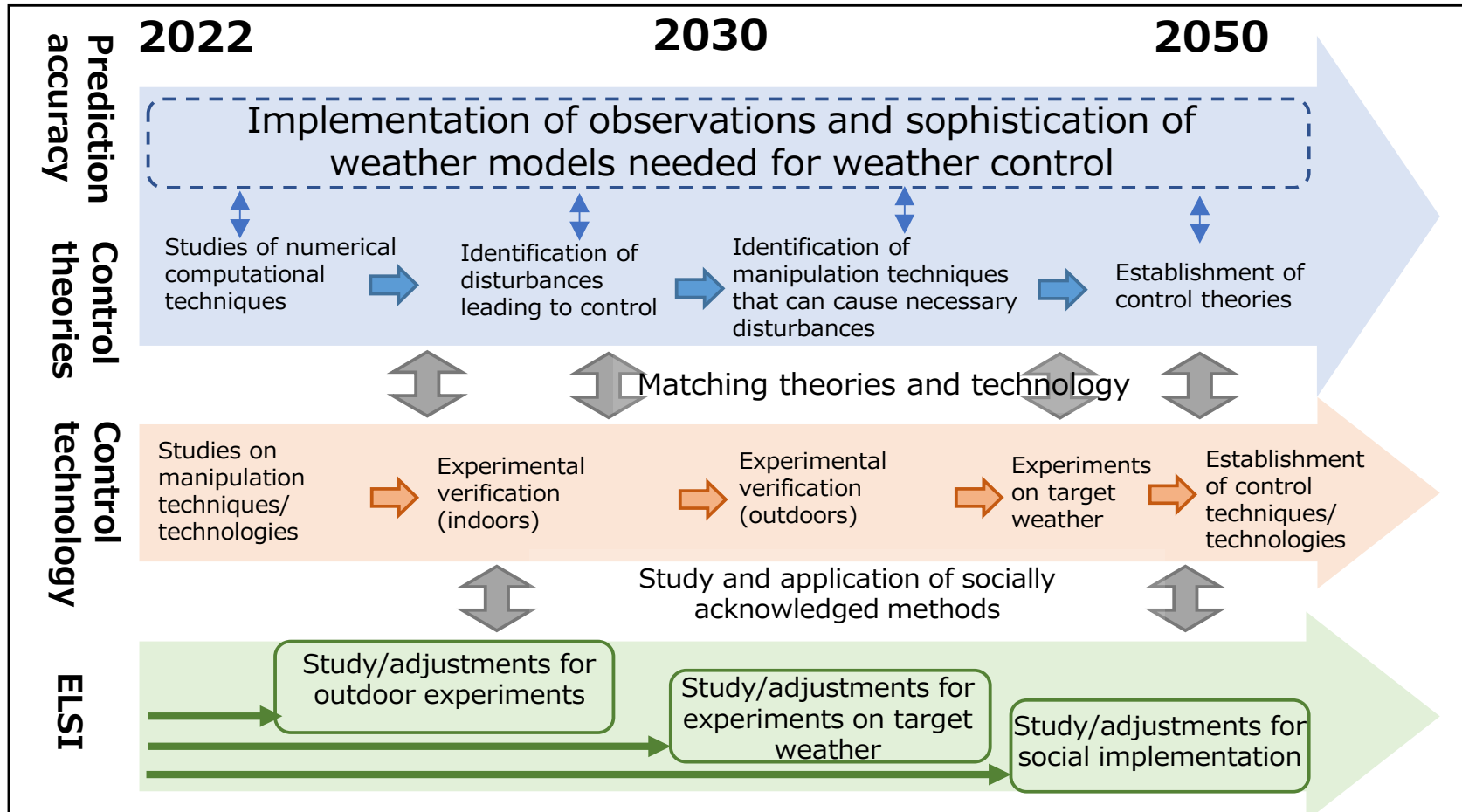
- Controlling the state of water vapor
- Controlling ground-surface/ocean-surface temperature
- Reducing wind energy, etc.

- Deepening understanding of weather
- Making weather models more sophisticated
- Integrating global and local simulations
- Estimating wide-ranging outcomes and effects, etc.

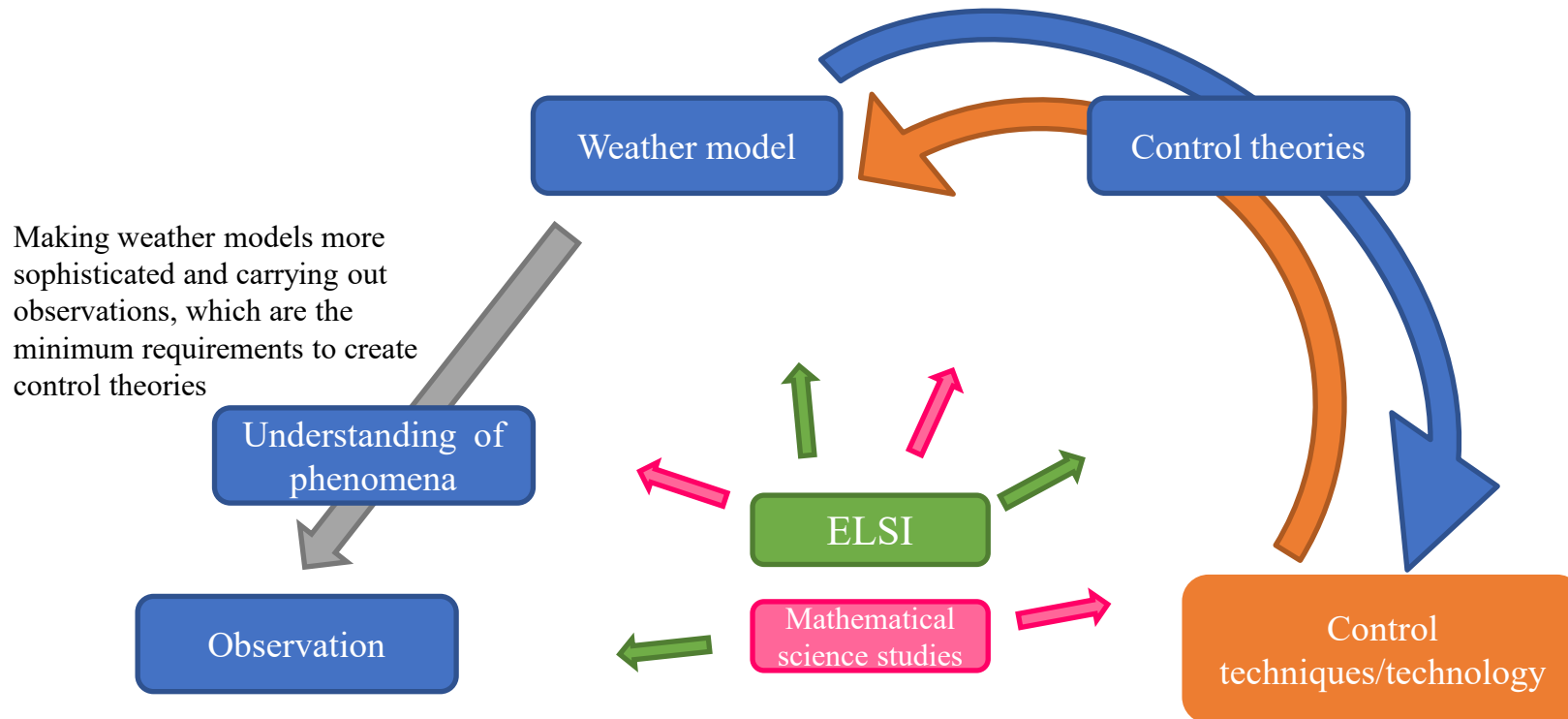
ELSI

- Ethical issues
- Legal issues
- Social issues, etc.

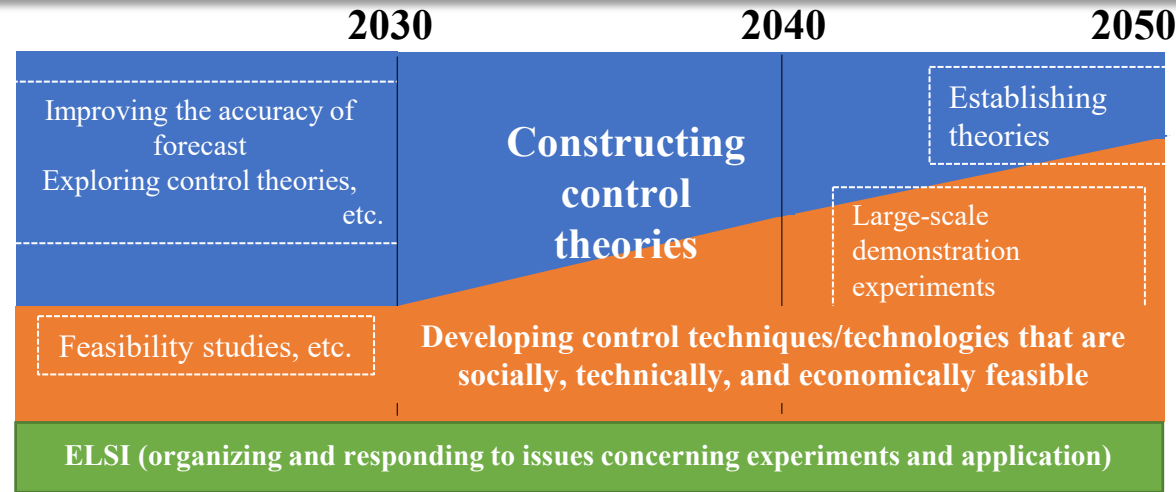
Overview of R&D progress



- Important point is to approach this from two sides: the **meteorological approach**, which works to realize weather control from weather models, and from an **engineering approach**, which works to realize weather control from control techniques and technologies, and to explore a wide range of possibilities while matching and integrating both sides.



- In addition to **Mathematical science studies** that will contribute to weather control, it is essential that this R&D integrates with research on Ethical, Legal, and Social Issues (**ELSI**) as it progresses.

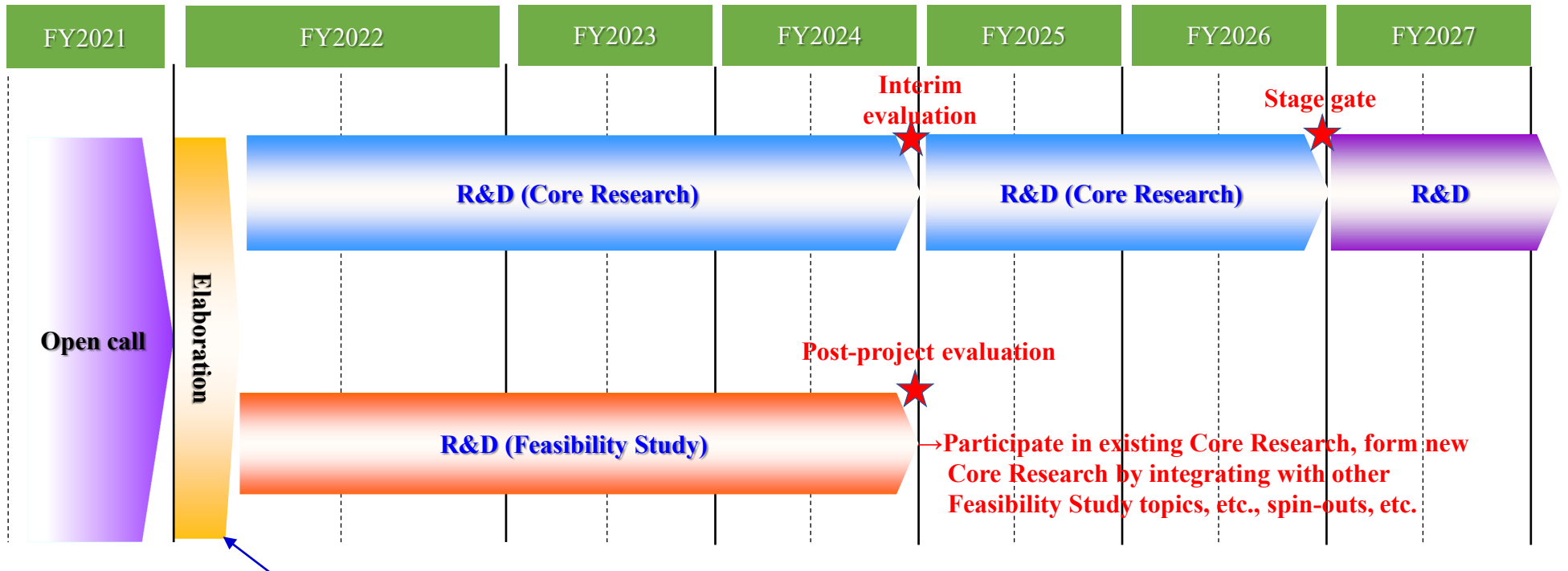


- Initially, this Goal's main aim is to carry out studies using computational equipment, as well as to explore feasible control techniques/technologies and resolve ELSI. Notably, outdoor experiments **are only possible** if researchers have established organizational and resolution methods for any effects and **the PD has judged that the experiment is feasible for the overall Goal** from the perspective of ELSI, etc.
- Transparency of R&D is the key** to gain the understanding of citizens and society, and projects will carry out close information exchanges between researchers and research communities around the world while sharing R&D outcomes with the general public.
- The Goal aims for **new disaster prevention and reduction integrated with human activities** in accordance with the stage of weather control realized. For example, the assumption is that weather control will be achieved little by little, and the aim is to derive optimal solutions from strategies that can adopt the possible weather control and human activities (evacuation, etc.) at that stage and then put them to use.
- Importance will also be placed on spin-offs**, for example making use of research outcomes to make weather predictions more precise.

R&D implementation policies (1)

Types of research in R&D implementation (see page 11 for details)

- **Core Research**
R&D project aiming to achieve the Moonshot Goal with your scenario, a grand design that leads to the goal's achievement by backcasting from your vision of an ideal 2050 society.
- **Feasibility Study**
R&D project that contributes to the Moonshot Goal, without a scenario that leads to its achievement.



Key research elements when implementing R&D

● Meteorological approach

R&D carried out to achieve weather control from weather models, including what kind of weather manipulation is effective for weather control. (The following are examples of R&D items that comprehensively tackle this)

- Exploring the relationship between manipulation and weather modification using weather simulations
- Exploring manipulation technology and techniques that could potentially cause the target weather modification
- Making weather models more sophisticated and carrying out observations, which are the minimum requirements for weather control
- Estimating the effects that will occur when the hypothesized weather modification is carried out (including economic aspects), etc.

● Mathematical science studies

Mathematical science studies that will contribute to the achievement of this Goal.

(Areas with a notable relevance are the assumed fields and keywords: nonlinear dynamical systems theory/complex systems, control theories (optimal control theory, chaos control, etc.), uncertainty quantification (probability analysis, statistical analysis), data science, numerical analysis, mathematical modeling, discrete mathematics, algebra (representation theory, computational algebraic statistics, etc.), geometry (optimal transport, topographical data analysis, etc.), and mathematical analysis (nonlinear partial differential equations, etc.))

● Engineering approach

R&D carried out to achieve weather control from control techniques/technology, including which manipulation methods are actually feasible for use on the weather. (The following are examples of R&D items that comprehensively tackle this)

- Identifying manipulations that will cause atmospheric disturbances and confirming their feasibility through experiments
- Confirming effectiveness through simulations of weather modification using manipulations
- Calculating the necessary funds, etc. for these manipulations and carrying out a cost-benefit calculation, etc.

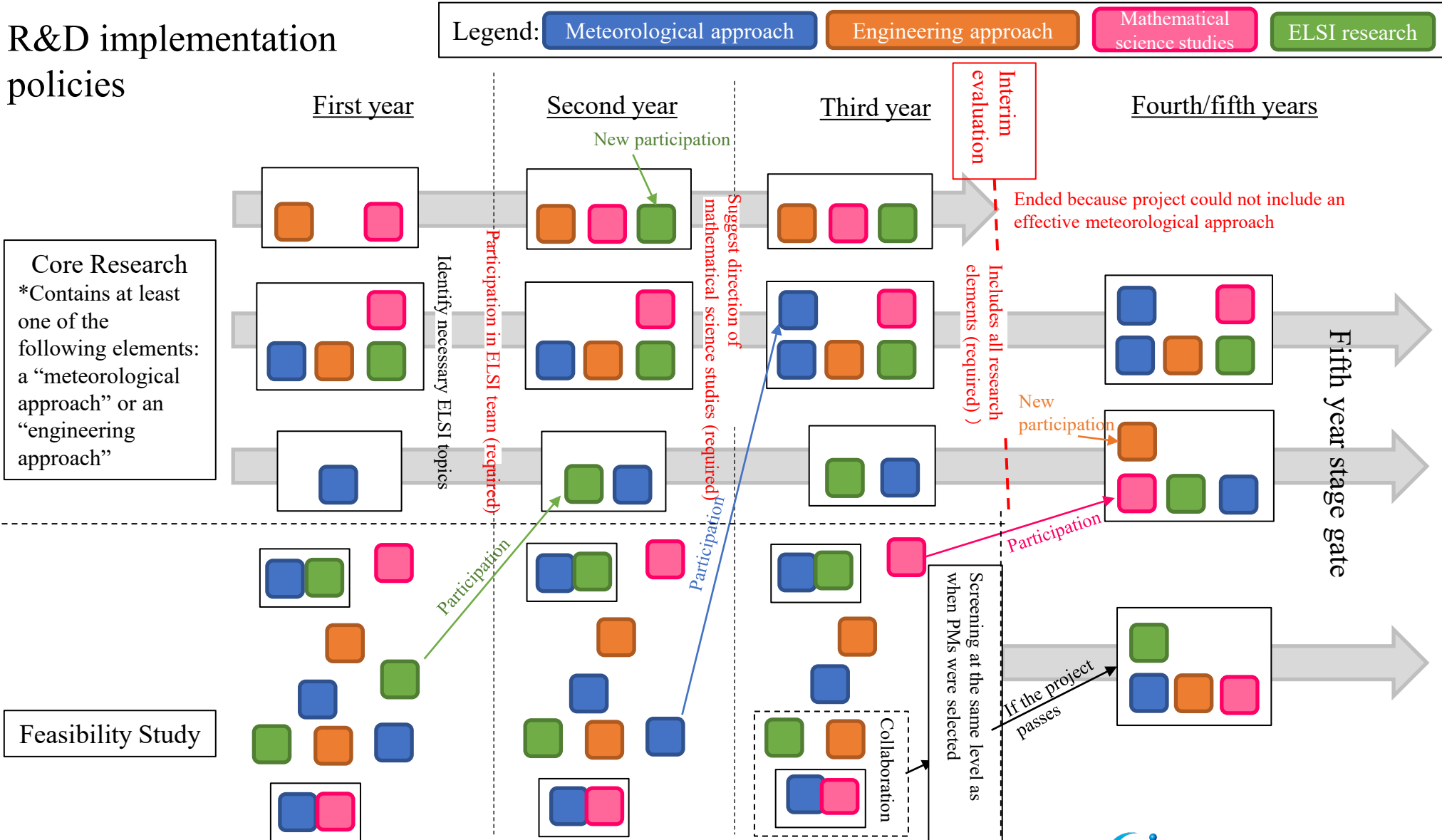
● ELSI research

R&D connected to ethical, legal, and social issues that should be resolved in order to carry out weather control experiments and social implementation. ELSI research that will contribute to the achievement of this Goal.

- Ethical issues such as how far weather manipulation should go
- Legal issues such as research rules for carrying out experiments and consensus building in Japan and overseas
- Social issues such as social acceptance and the presentation of solution strategies, etc.

R&D implementation policies (3)

R&D implementation policies



*This is a conceptual diagram, and does not reflect the actual number/ratio of research projects that will be adopted and implemented

	1) Core Research	2) Feasibility Study
Requirements	<ul style="list-style-type: none"> ● R&D project aiming to achieve the Moonshot Goal with your scenario, a grand design that leads to the goal's achievement by backcasting from your vision of an ideal 2050 society. ● Contains at least one of the following elements: a “meteorological approach” or an “engineering approach” 	<ul style="list-style-type: none"> ● Contains at least one of the following R&D elements: a “meteorological approach,” an “engineering approach,” “ELSI research,” or “mathematical science studies”
Implementation period	In principle, 5 years	As long as is necessary, up to 3 years
R&D funds (direct cost)	<p>Projects that focus on both approaches Up to 1.2 billion yen per PM (600 million yen for years 1–3 and 600 million yen for years 4–5)</p> <p>Projects that focus on one approach Up to 900 million yen per PM (300 million yen for years 1–3 and 600 million yen for years 4–5)</p>	Approximation: within 50 million yen per PM (total for three years)
Other	<ul style="list-style-type: none"> ▪ In addition to setting individual milestones, projects will also need to achieve the following common milestones. <ol style="list-style-type: none"> By the end of the first year, researchers should detail the requirements for studies to help resolve ELSI, and teams and/or experts will participate to carry out the necessary ELSI research during the research period. By the end of the second year, researchers should present the direction for mathematical science studies to make weather models more sophisticated By the end of the third year, research teams who use both meteorological and engineering approaches, and necessary mathematical science studies / ELSI research teams or R&D groups that include all experts will be formed 	<ul style="list-style-type: none"> ▪ We anticipate that researchers will participate in existing Core Research using their research outcomes and contribute to the achievement of the Goal, form a new Core Research group by combining with other Feasibility Studies, etc. and aim to achieve the Goal in this way,* or take other action. <p>*It will only be possible to accelerate R&D after three years if, after forming a Core Research group, the researchers accept and pass a screening on the same level as the PM selections.</p>

1 Industry-academia-government collaboration

We expect the progress of the R&D to have **a ripple effect, developing applications and yielding results that can contribute to various industries**, rather than just fostering research outcomes to achieve the 2050 Goal. Consequently, we require researchers to engage in proactive activities that allow private companies, governmental organizations, and other cooperative organizations to participate in the project.

2 International collaboration

To realize weather control, we expect researchers to constantly grasp R&D trends in Japan as well as overseas, and, if necessary, to carry out R&D while actively collaborating with foreign institutions. In addition, we require researchers to **engage in proactive activities that will allow international understanding and cooperation** for each project to enable social implementation.