

The Past, present, and Future of the Advanced Technology Center (ATC)

Masayuki Hirabayashi

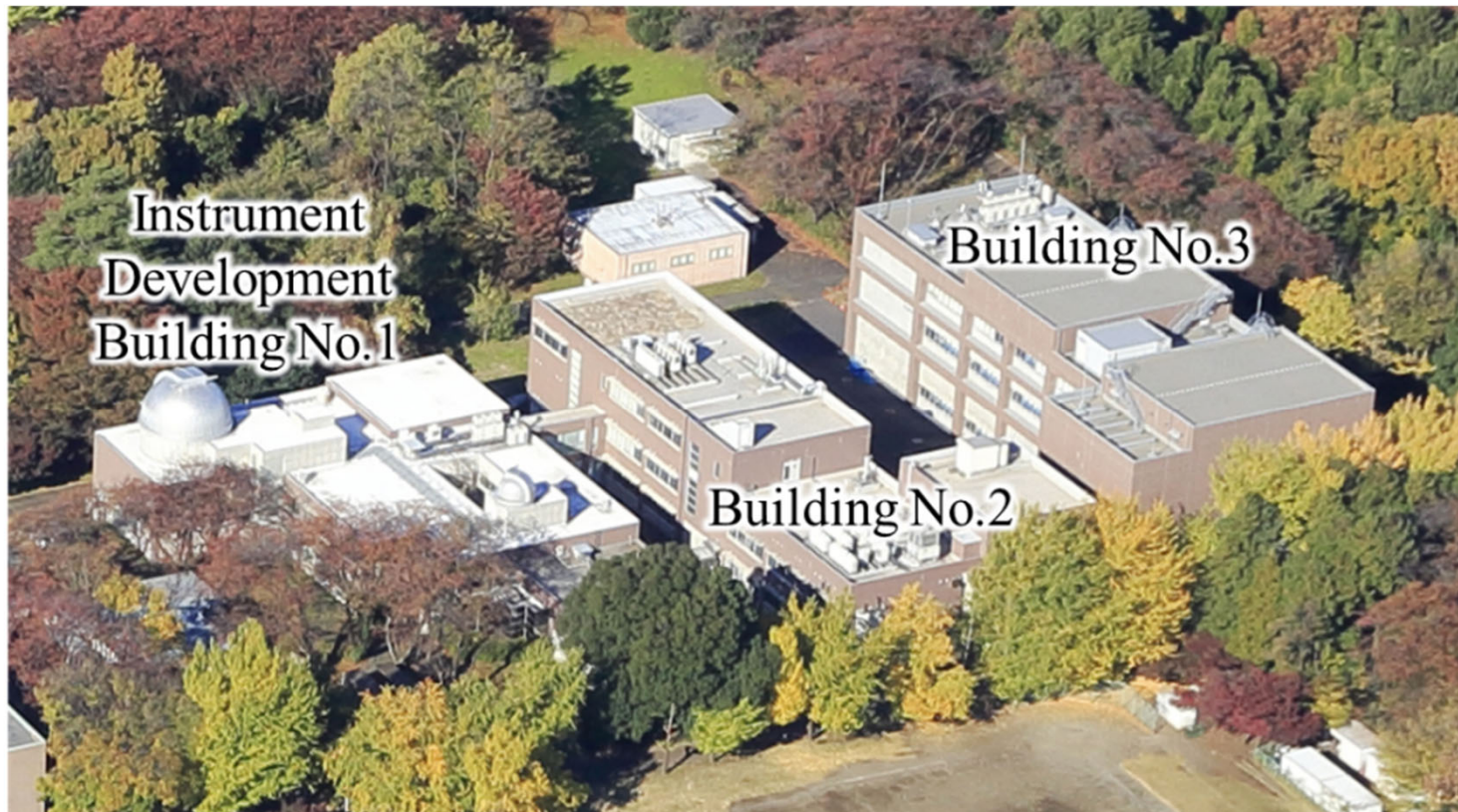
Advanced Technology Center
National Astronomical Observatory

December 8, 2022
NAOJ Future Planning Symposium 2022

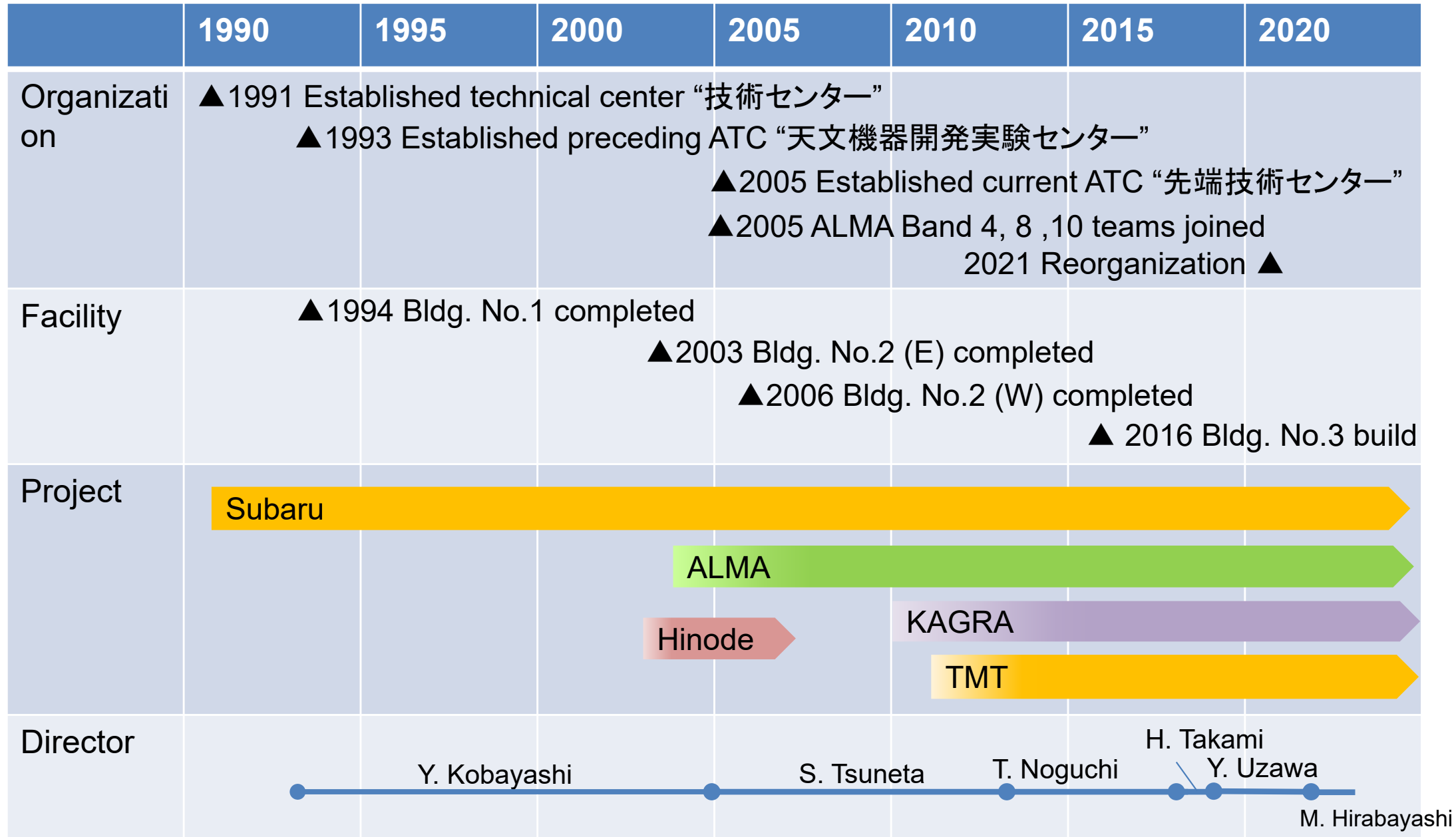
A brief overview of ATC

ATC is the center of instrument development for ground base and space telescopes at NAOJ. It covers Optical/IR and radio astronomy, as well as gravitational wave detection system.

Established in 1993 at NAOJ Mitaka campus initially for Subaru Telescope, ATC now covers ALMA, KAGRA, TMT, SOLAR-C, JASMINE, etc., and has now 53 employees (research, engineering, and support staff).



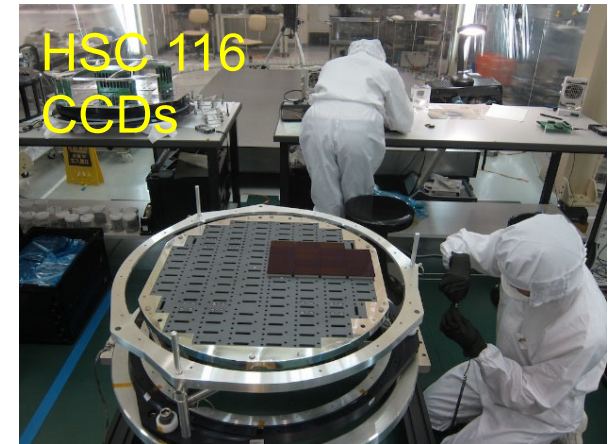
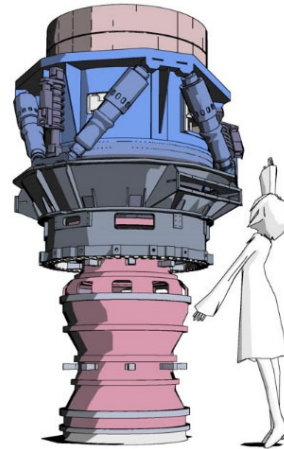
Brief history



Achievement

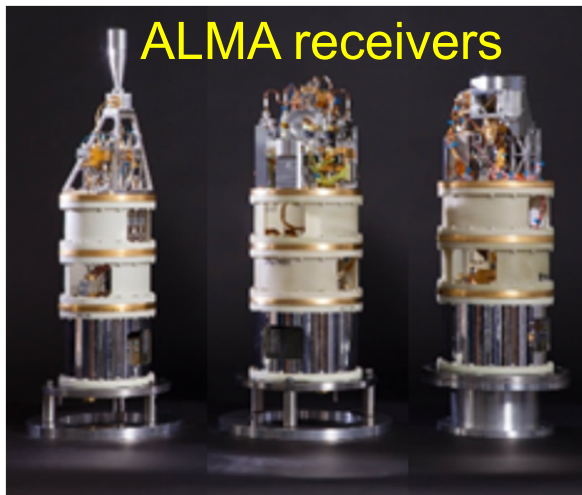
1) Instruments for Subaru Telescope:

Suprime-Cam (Prime focus camera), Adaptive optics, Hyper Suprime Cam (1.5 deg FOV prime focus camera for 8m telescope), etc



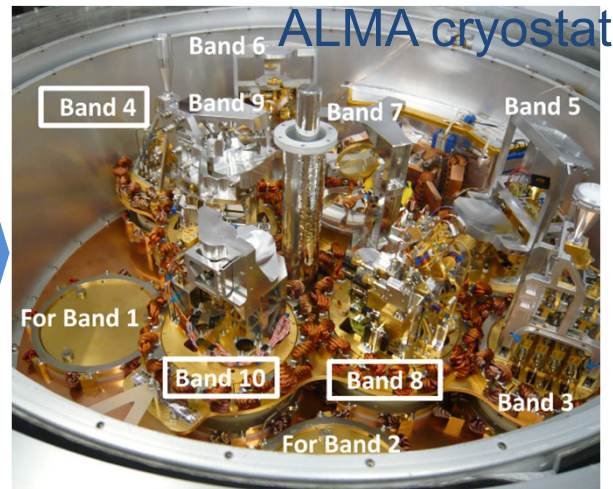
2) ALMA receivers:

Bands 4, 8, 10 receivers, 73 units for each band and 219 in total. Band 10 was the most challenging high frequency receiver for ALMA. ATC developed all the mixers and the systems in-house.



ALMA receivers

2022-12-08



ALMA cryostat

NAOJ Future Planning Symposium 2022

3) Space programs

Hinode (Solar telescope 50 cm), CLASP (rocket launched Ly- α spectrograph)



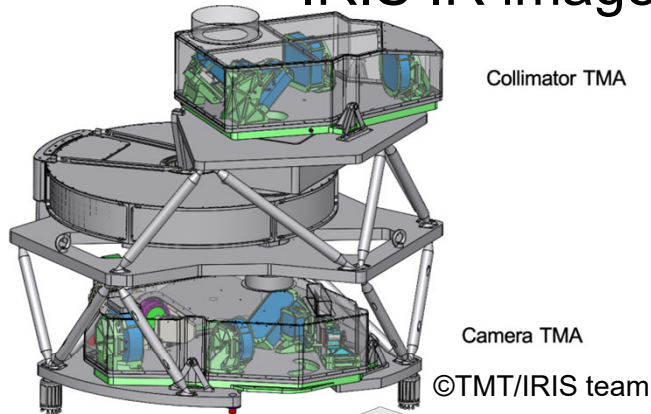
Hinode telescope

©JAXA

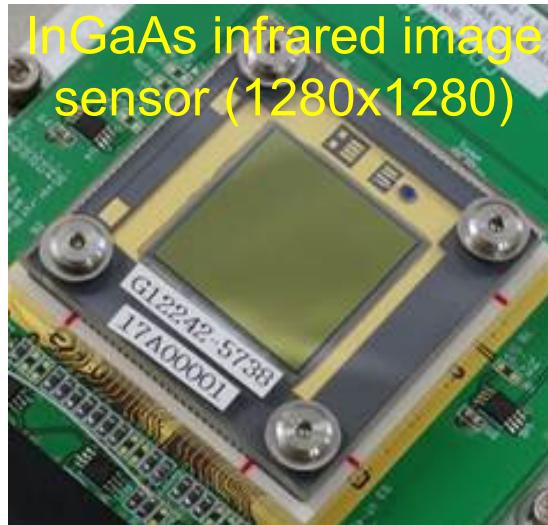
Current activities

- 1) **TMT instruments** IRIS (IR imager& spectrograph) imager development and WFOS
- 2) **KAGRA** gravitational wave telescope
- 3) **ALMA** future development: Band 1, Band 2, Wideband RF/IF, Multi-beam etc.
- 4) **Infrared detector**: InGaAs image sensor with low-noise CMOS readout circuit
- 5) **Space** programs, SOLAR-C, JASMINE

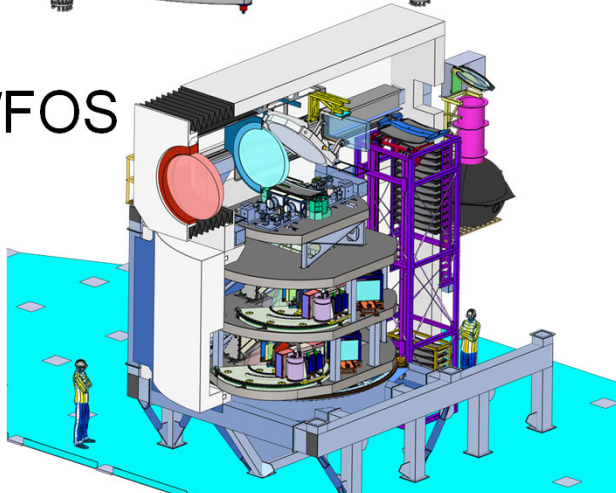
IRIS IR imager



InGaAs infrared image sensor (1280x1280)



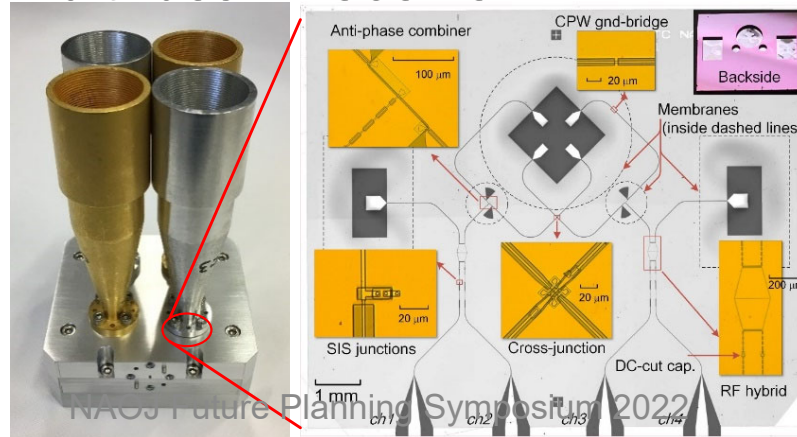
WFOS



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Courtesy: California
Institute of Technology

Multi-beam receiver



Missions

1. to support astronomical projects (ground and space) as a research and development center for advanced technologies (astronomical project support),
2. to pioneer internationally competitive technologies related to astronomy (development of new technologies), and
3. utilizing the above opportunities, to provide scientific activities and educational programs for undergraduate and graduate students, and young researchers and engineers (young scientist training).

from ATC-TD-001

Goals

1. (astronomical project support)

- (a) to support the technical development of NAOJ's ground-based telescope instruments, especially ALMA, Subaru, and TMT, and to successfully complete the development of these instruments;
- (b) to support the technical development of the instruments that NAOJ participates in the development, such as KAGRA, JASMINE mission system, and SOLAR-C_EUVST mission system, and to complete the development of these instruments successfully;
- (c) to support Japan's participation in astronomical missions and projects planned or carried out by domestic and foreign research institutes and space agencies such as JAXA, NASA, and ESA, and to provide instruments developed in cooperation with ATC for those missions;

from ATC-TD-001

Goals (cont'd)

2. (development of new technologies)

- (a) to initiate new technologies and conduct proof-of-concept of the technologies in line with the long-term roadmap of ground and space missions;
- (b) to develop observational instruments that can be provided to the actual environment required by each mission in accordance with the long-term roadmap of ground and space missions;

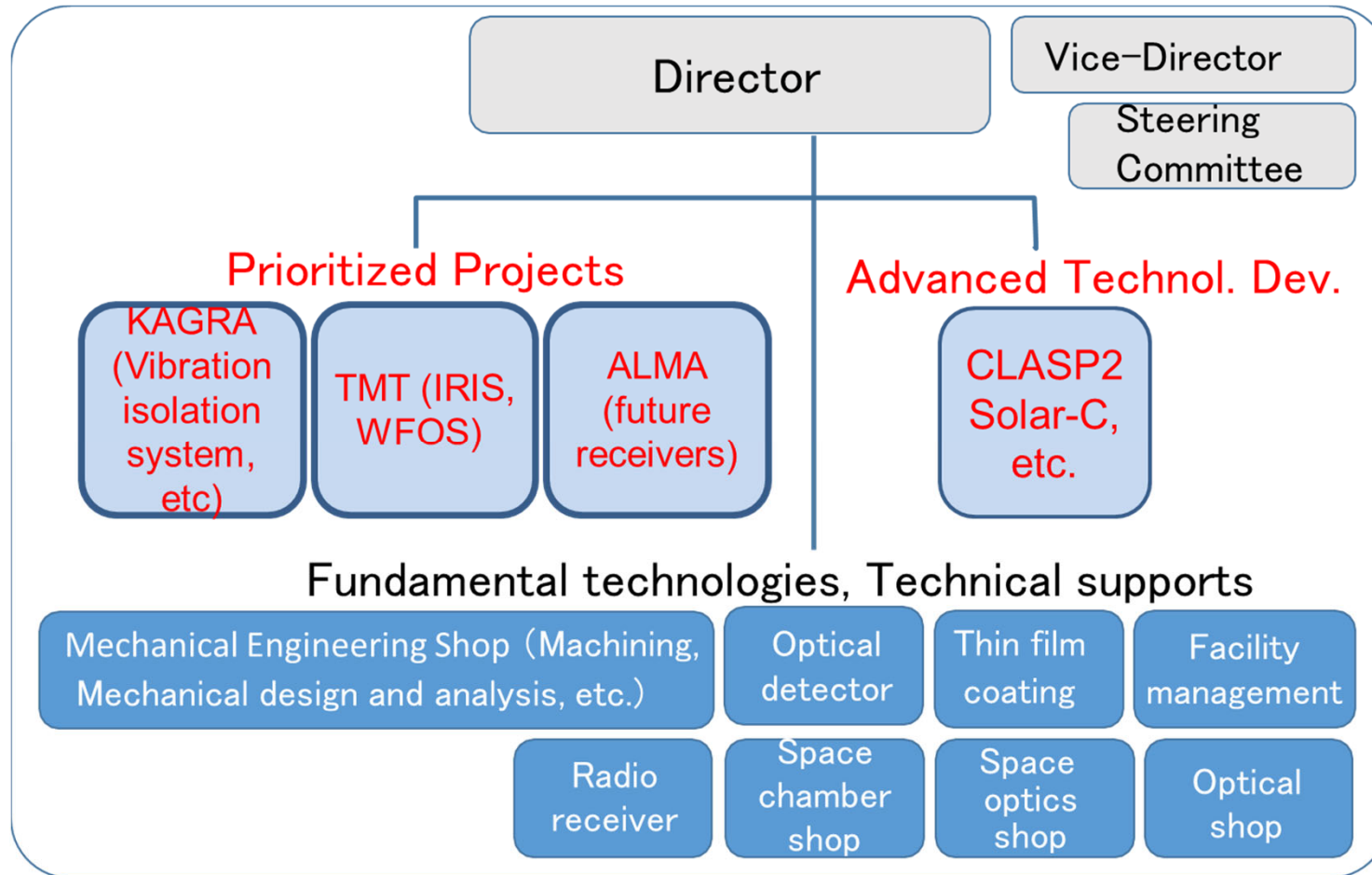
3. (young scientist training)

- (a) to educate undergraduate and graduate students, and young scientists and engineers to develop highly skilled young people;
- (b) to help provide and maintain opportunities for undergraduate and graduate students and young scientists and engineers to participate in international collaborations and build international networks;

from ATC-TD-001

Actions to achieve “Reorganization”

- Past organization structure (staff belonged to the projects)



Pros

- Acquire technologies from practical works
- Work as “one team” for achieving each project goal

Cons

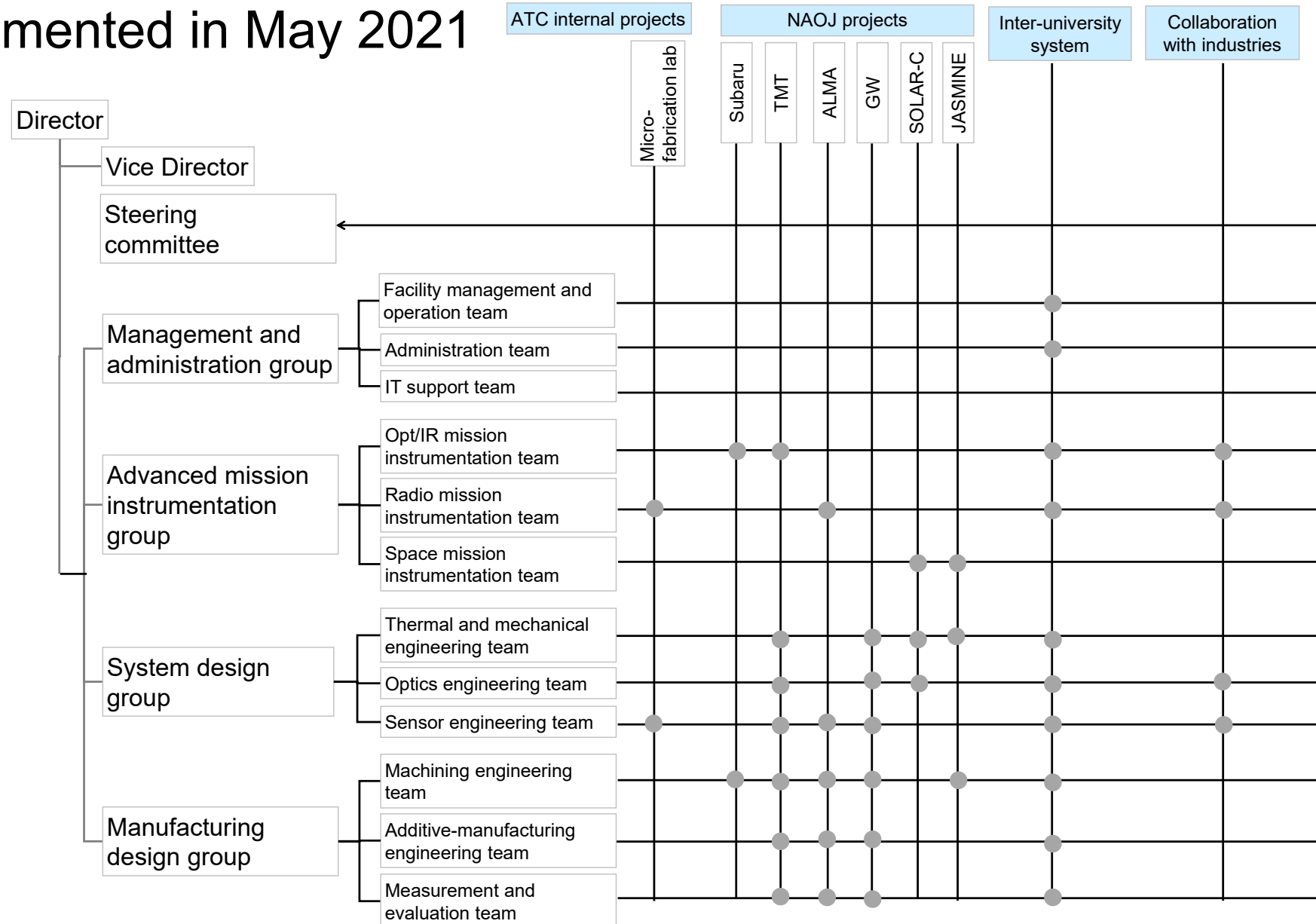
- Not necessarily improve skills of staff.
- No sharing technologies between projects even though they are similar

Philosophy of the New Organization

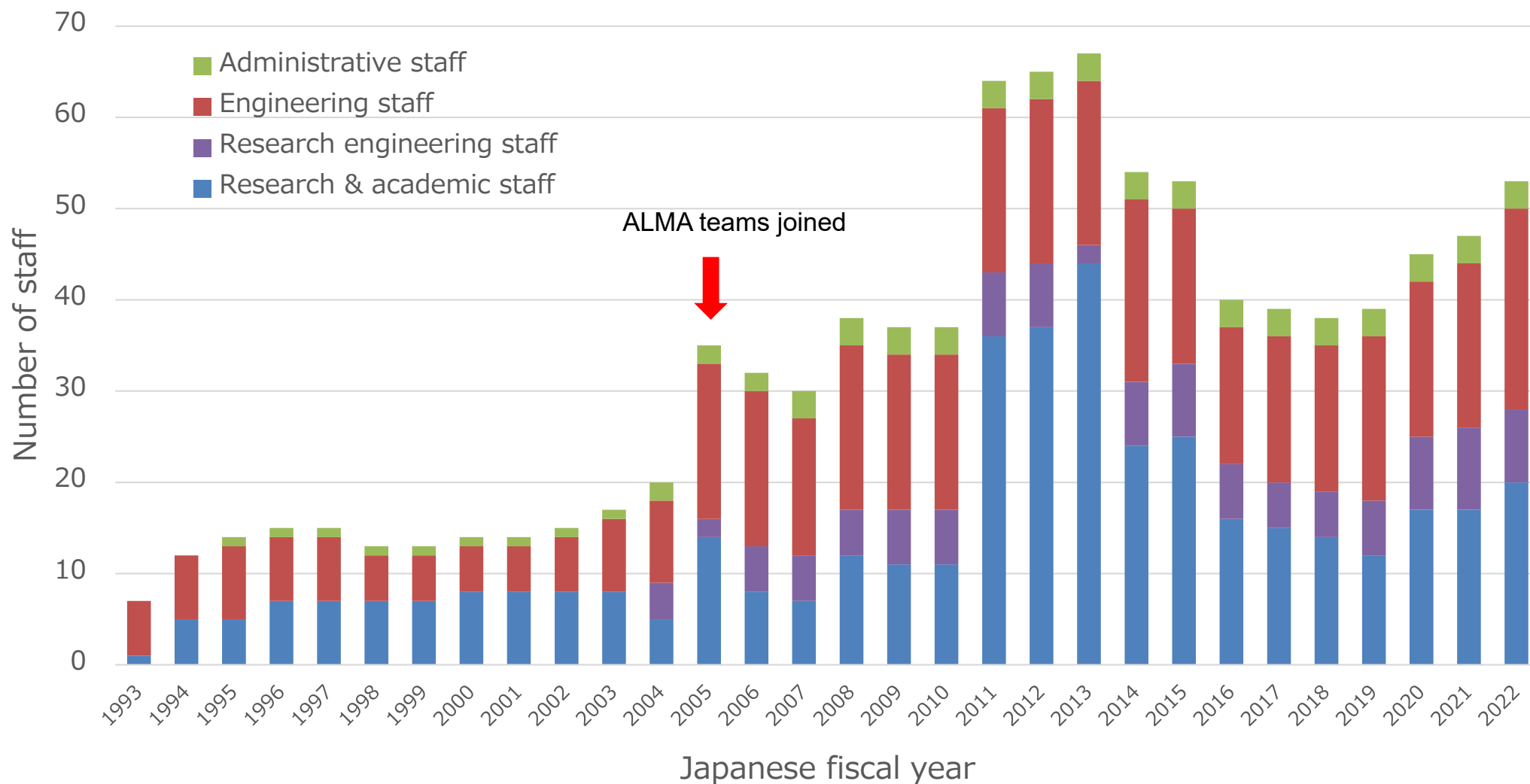
- To achieve project (mission) goals with limited personnel and budget,
 - It is necessary to share acquired technologies in each technical area, keep and develop them, and implement new technologies.
 - It is important to improve the skills of staff belonging to ATC, and a structure is needed to realize it
- In order to do so,
 - The technical areas are divided into the following four groups,
 - Management and Administration Group
 - Advanced Mission Instrumentation Group
 - System Design Group
 - Manufacturing Design Group
 - Teams are established within the groups to further subdivide technical areas

New Organization Structure

Implemented in May 2021

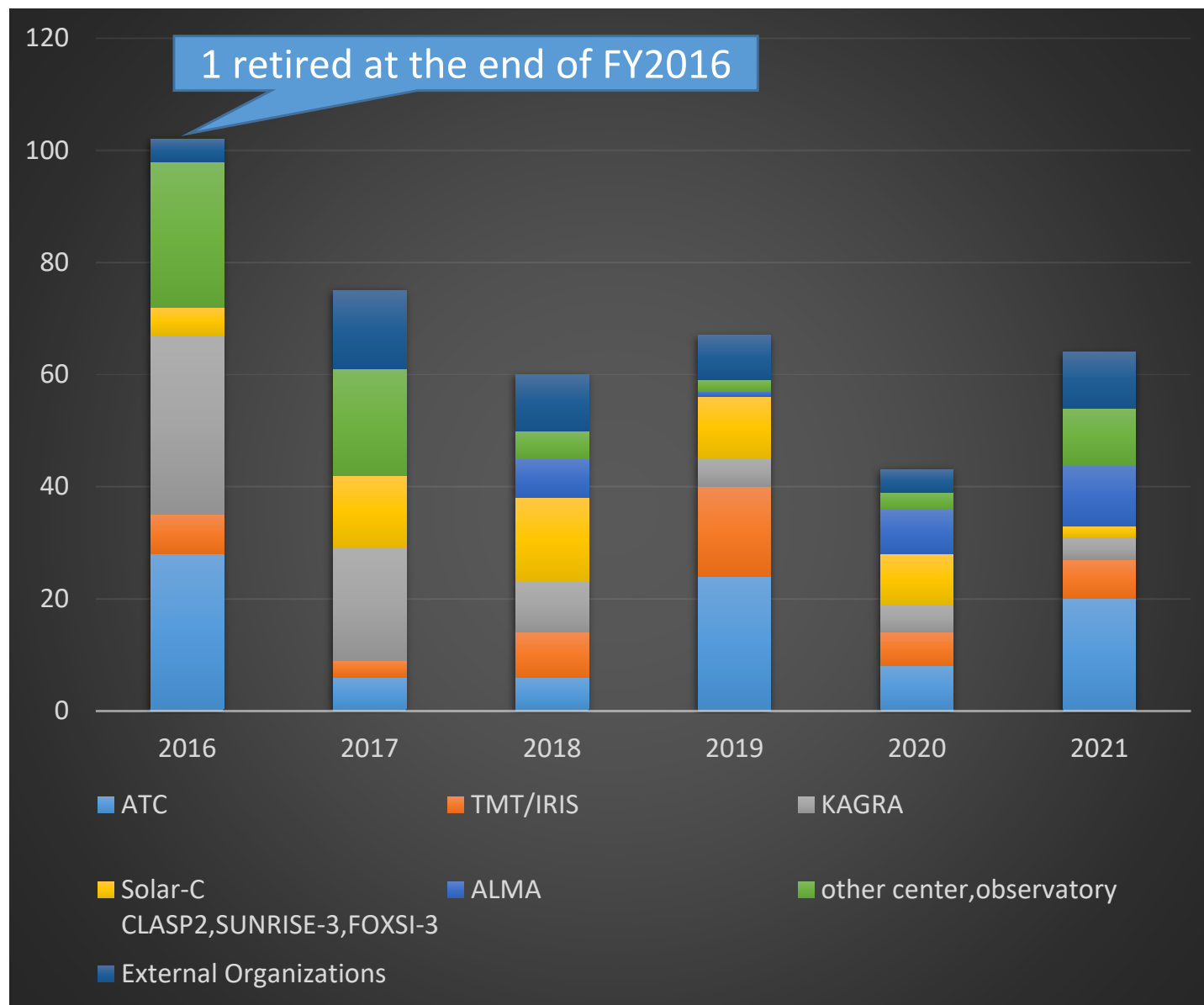


Number of Staff



ATC has been requesting NAOJ top management to hire necessary staff, resulted in increasing the number.

Number of work requests (Manufacturing)



- Main machines

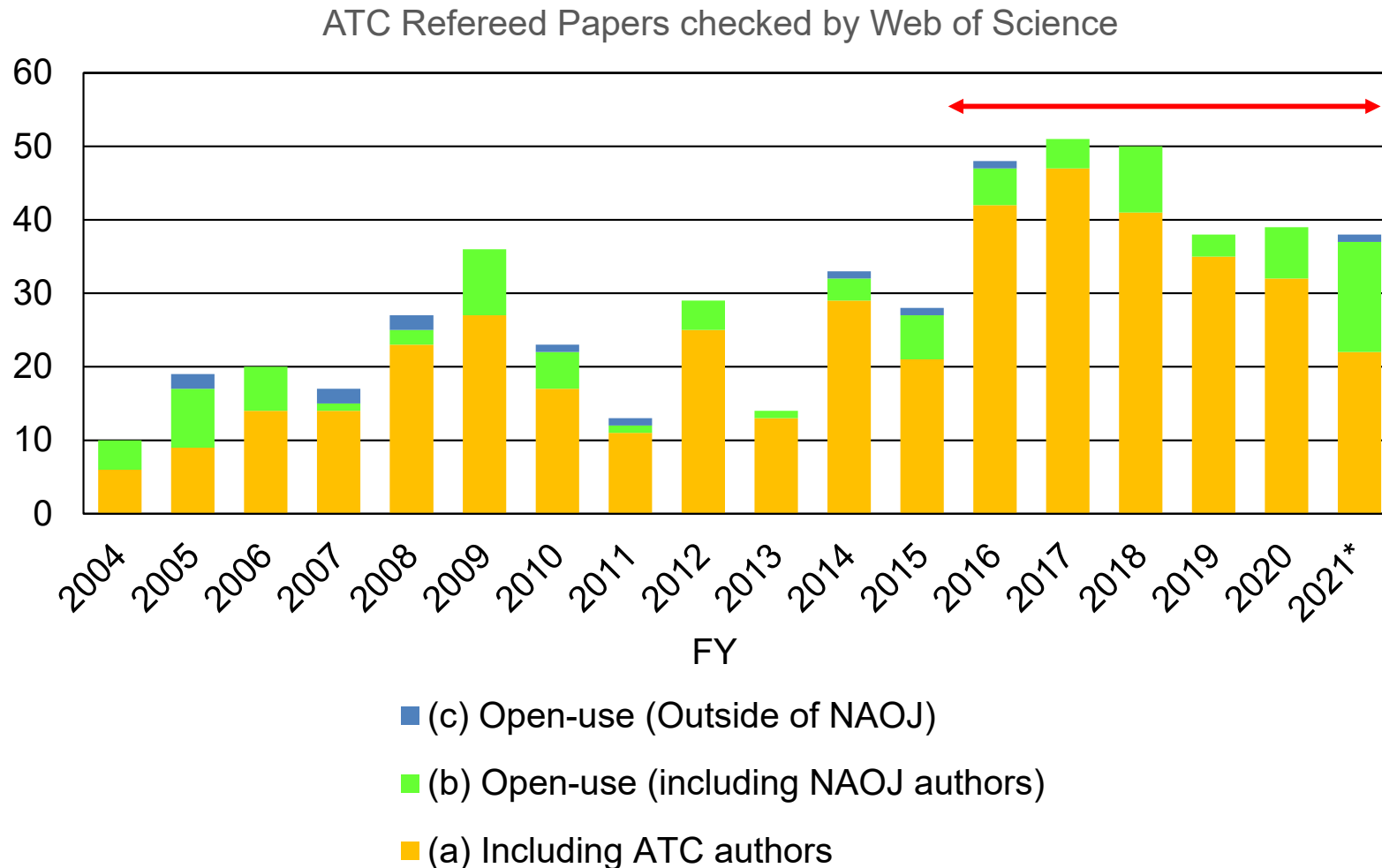


Two Wire-EDMs



5-axis machining center

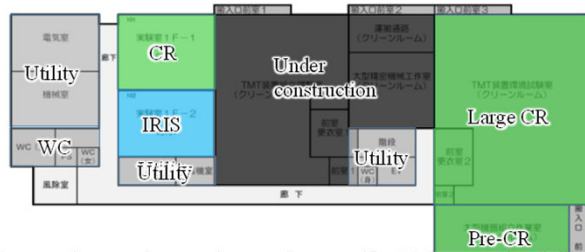
Number of papers (international journal)



In FY2016-2021, number of papers are more than the other terms.

Facilities

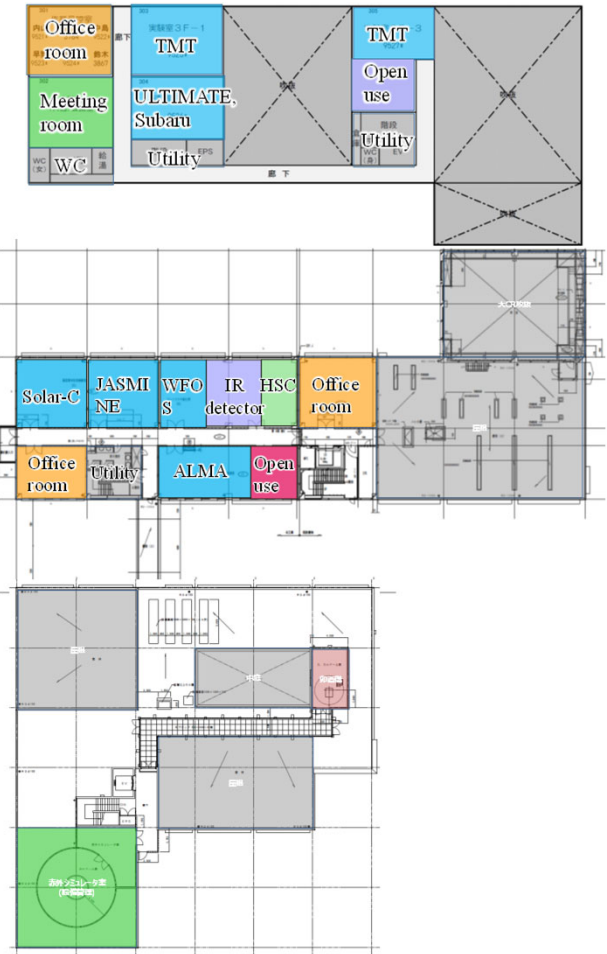
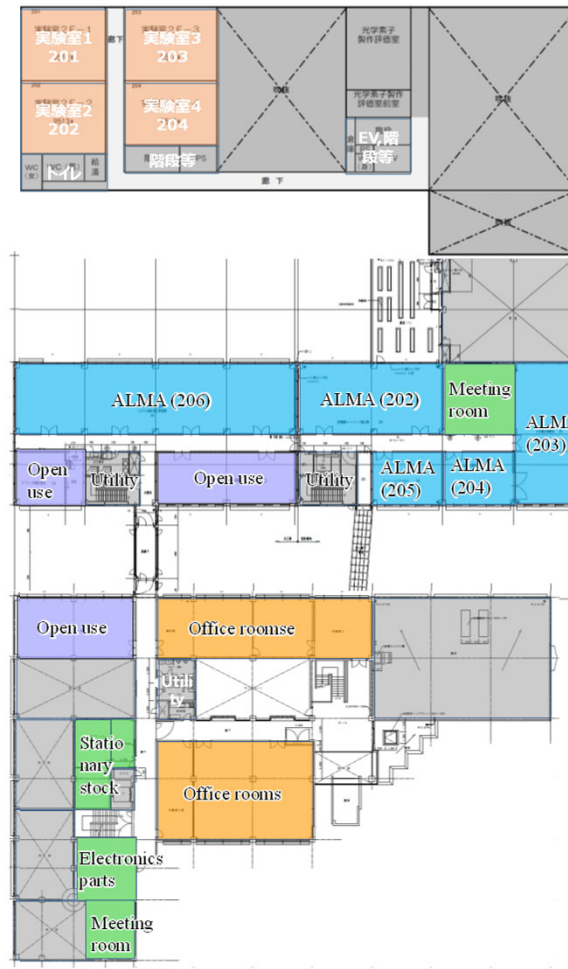
Bldg.3



Bldg.2



Bldg.1



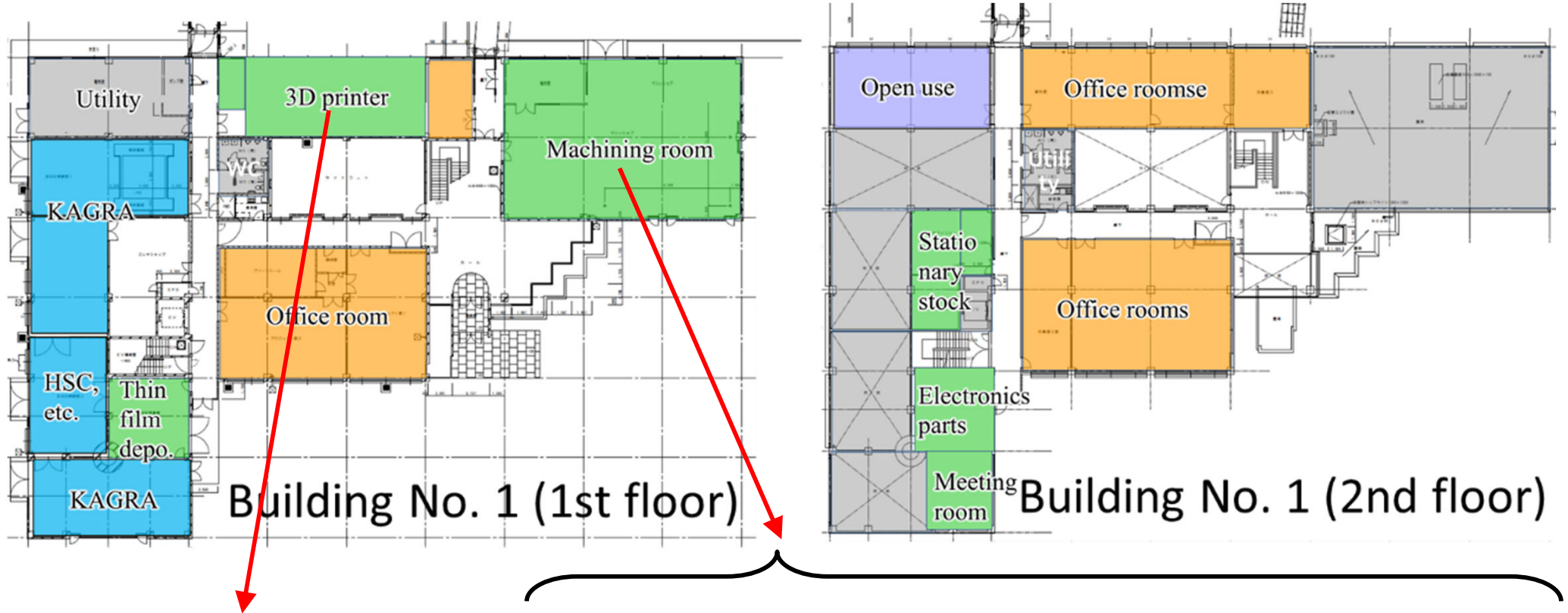
1st floor

2nd floor

3rd floor



Facilities (Building No.1)



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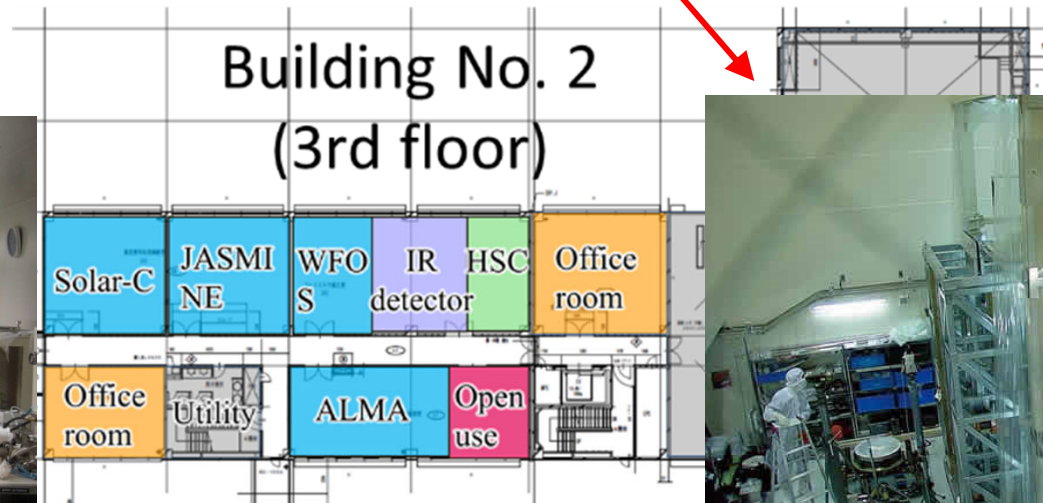
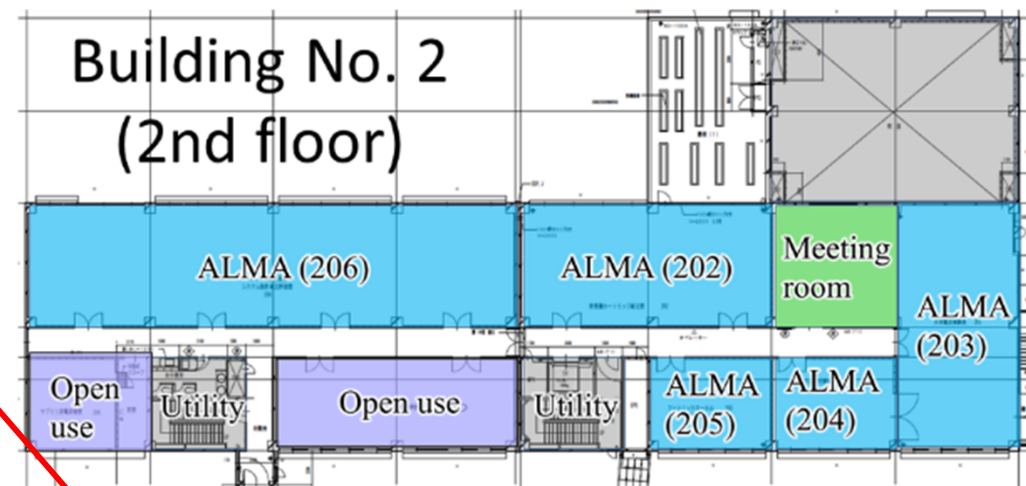
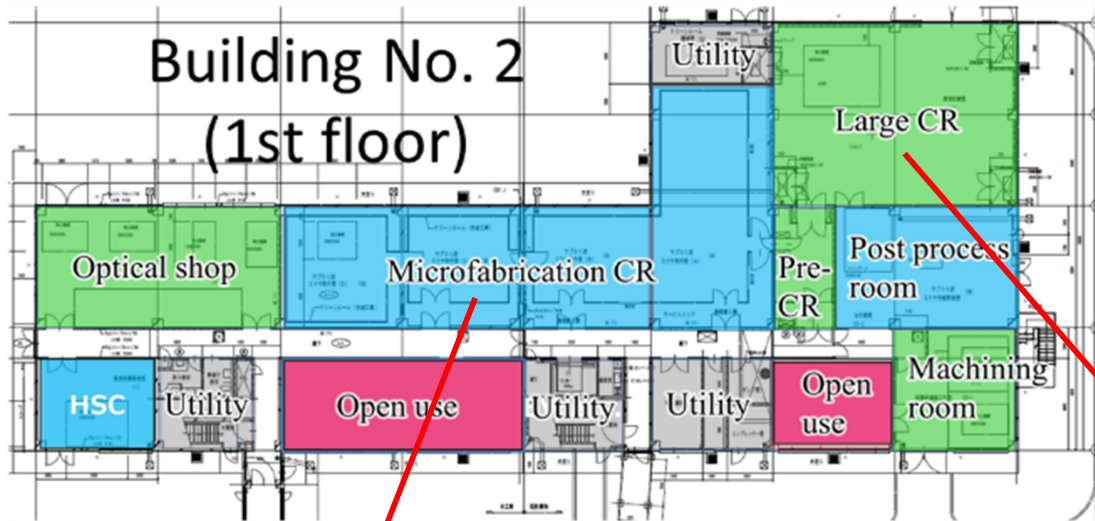


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Facilities (Building No.2)



SIS clean room equipment

1. Photolithography equipment



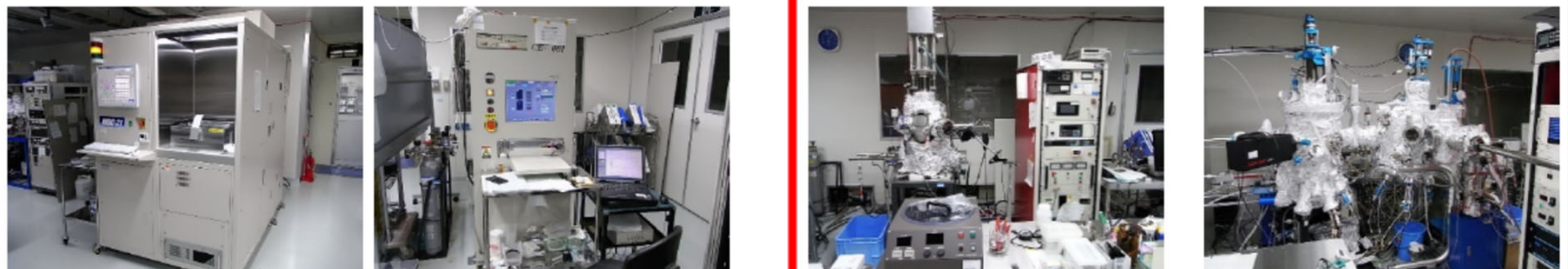
2. Measurement equipment



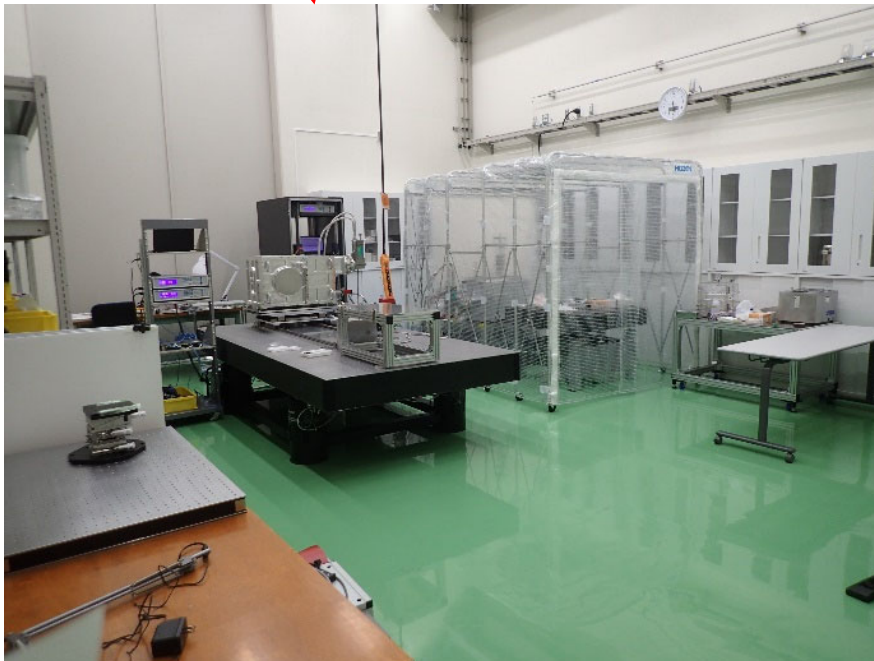
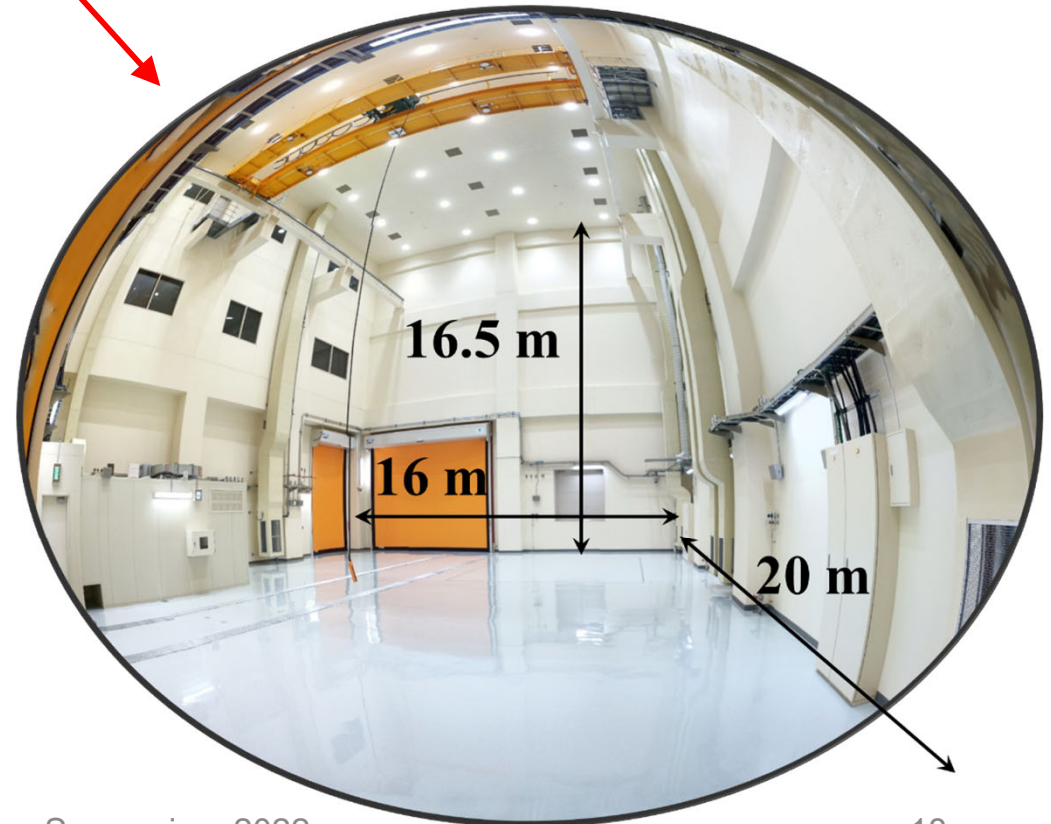
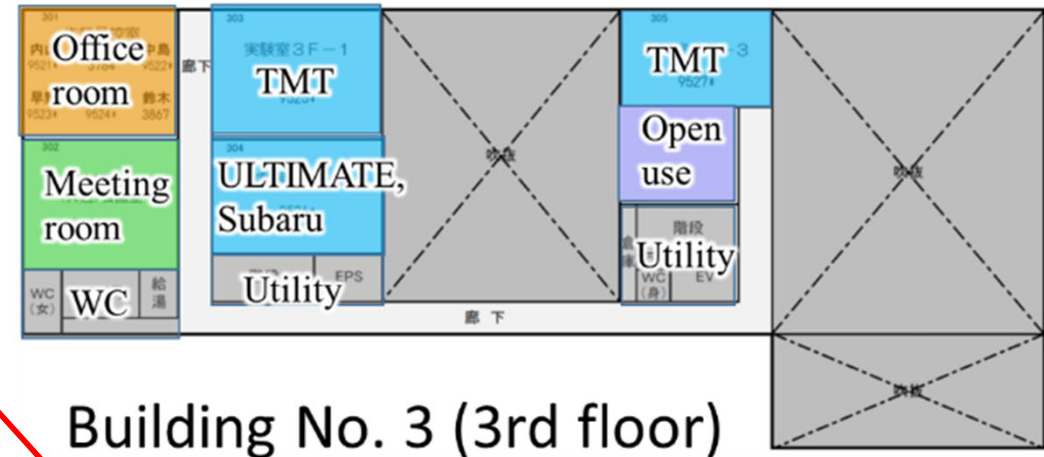
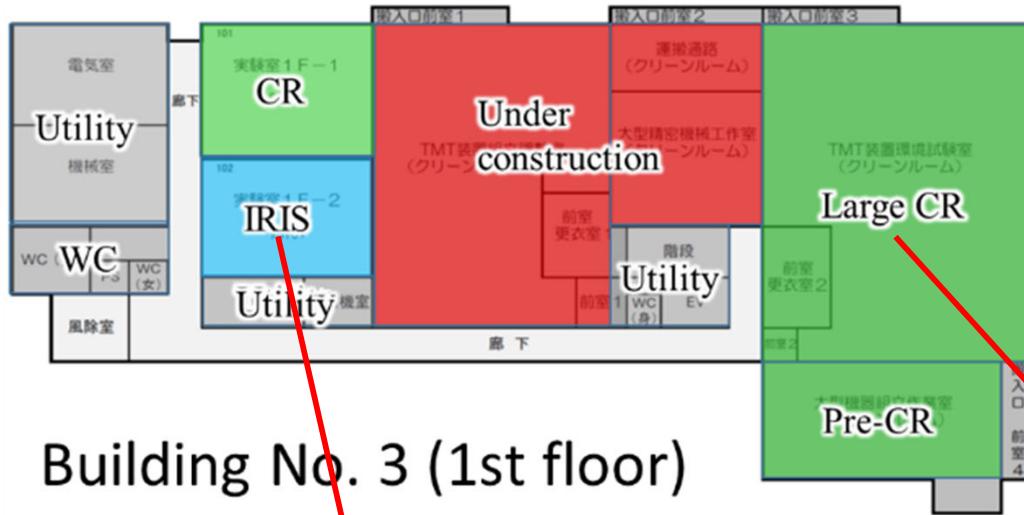
3. Thin-film deposition systems



4. Dry etching systems

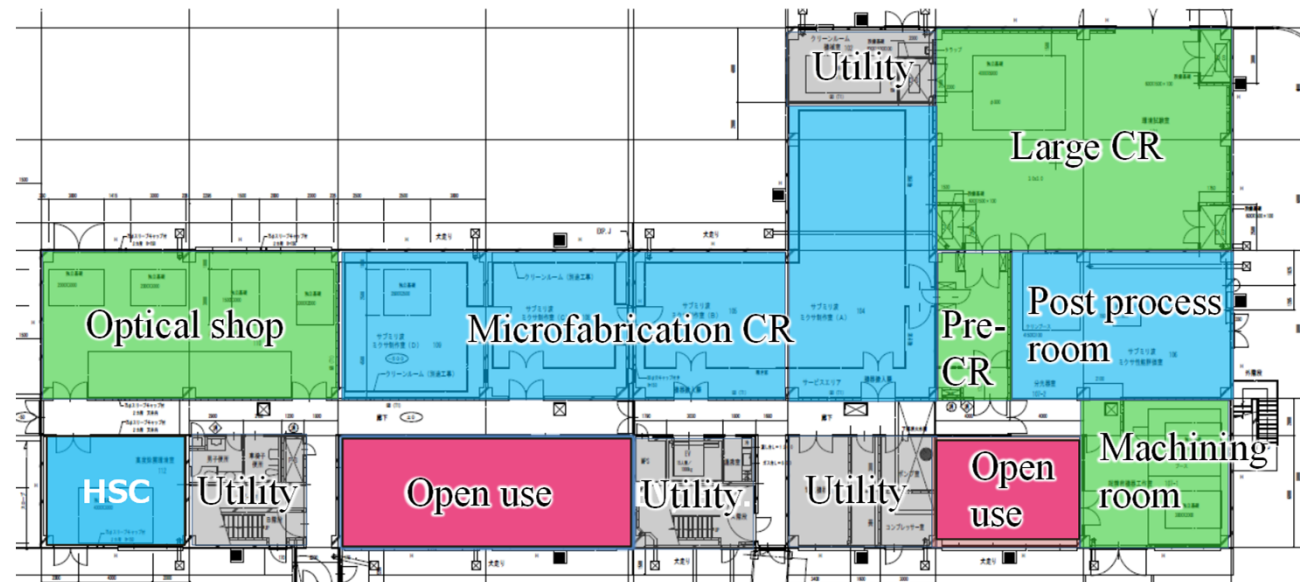


Facilities (Building No.3)

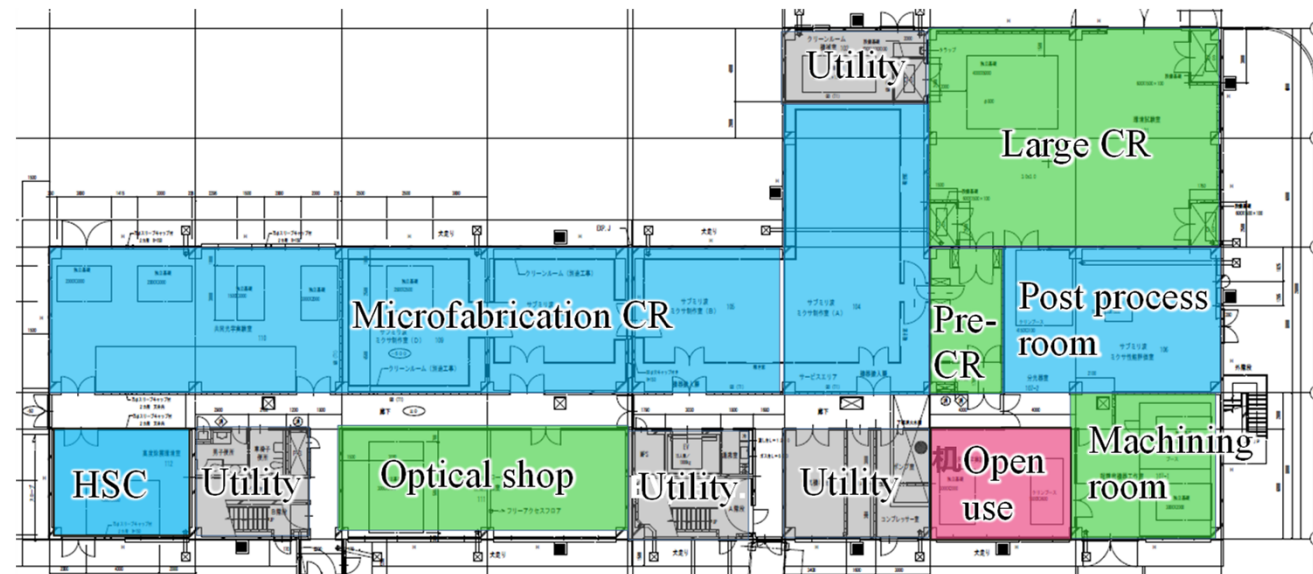


Expansion of SIS clean room

Past



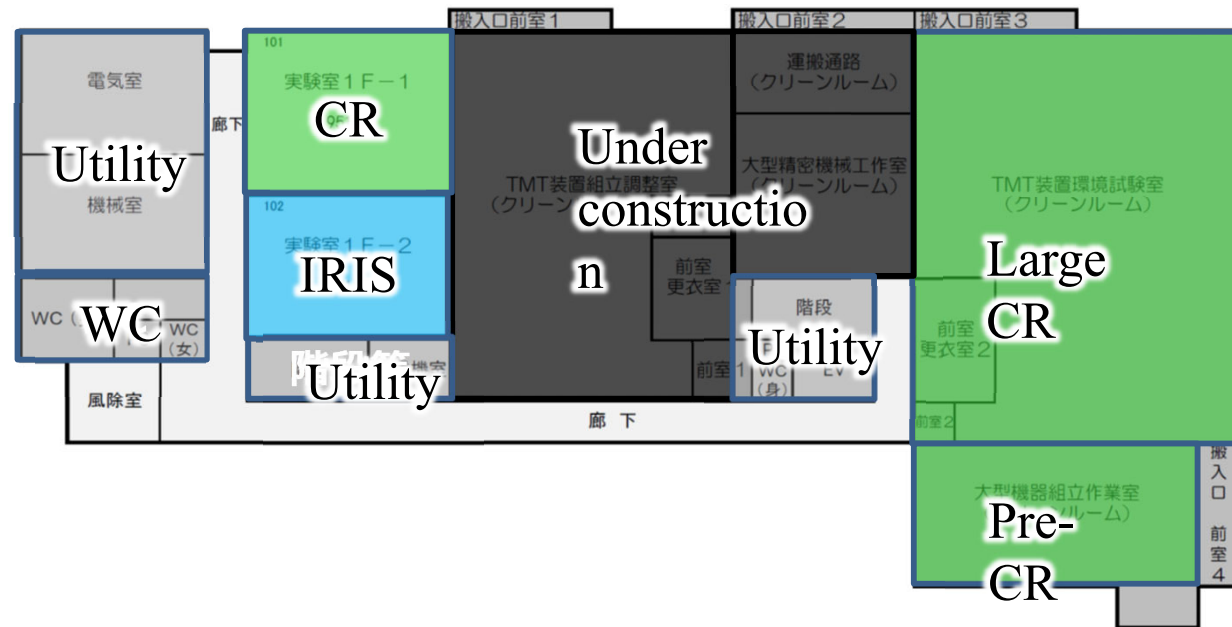
Next year
(budgeted)



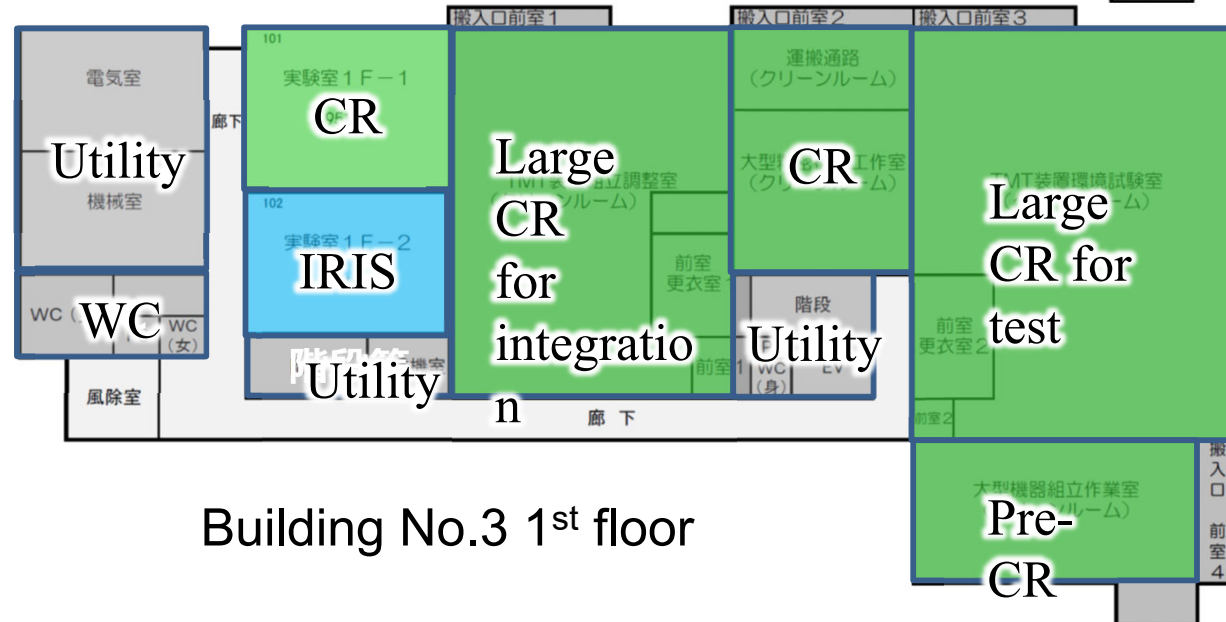
Building No.2 1st floor

Construction of Large CR

Current



Future
(requesting budget)

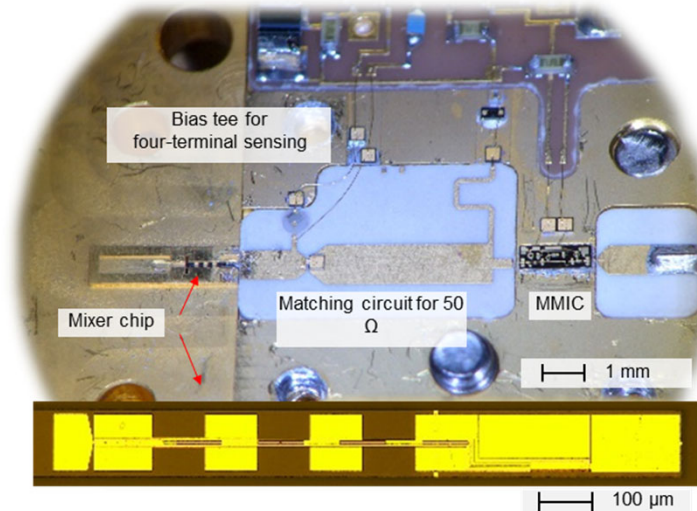


Building No.3 1st floor

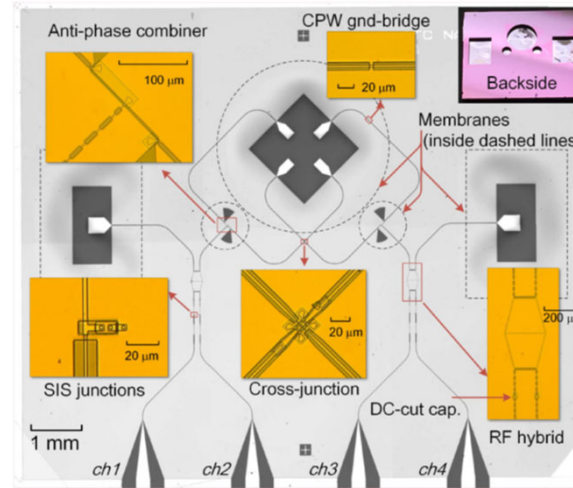
Promising technology 1

- Radio-wave field

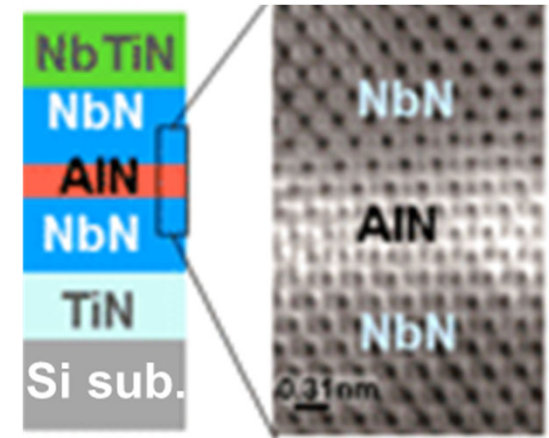
- Direction of technology development: wideband, multibeam, high frequency



Wide RF/IF SIS mixer by
T. Kojima



SIS mixer IC for multi-beam
by W. Shan & S. Ezaki



Epitaxial NbN SIS junctions
by K. Makise

- Superconducting device fabrication technology is essential.

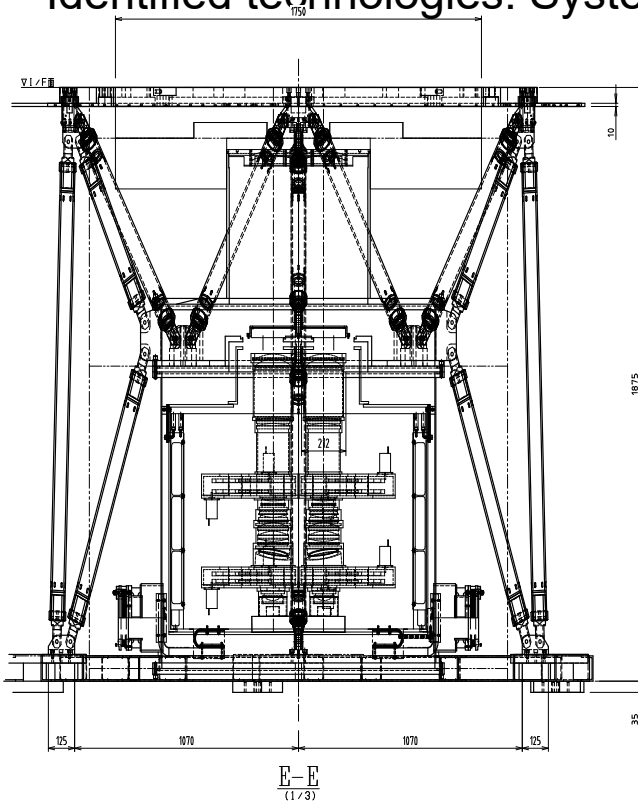


Two associate professors and one research engineer have been successfully hired.

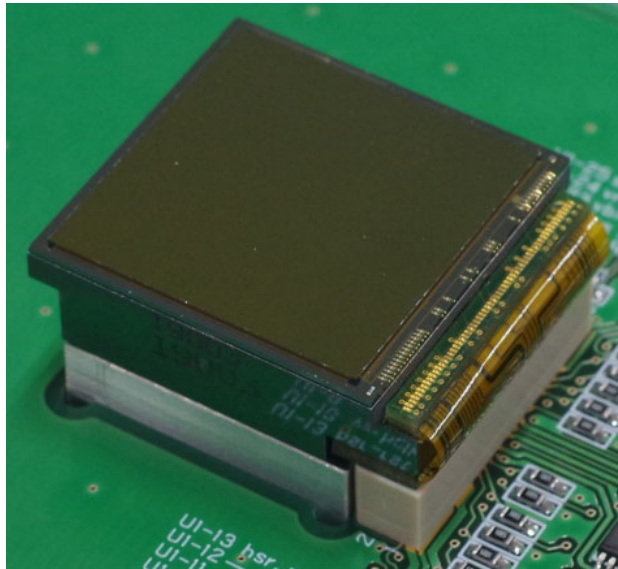
Promising technology 2

•Optical and IR field

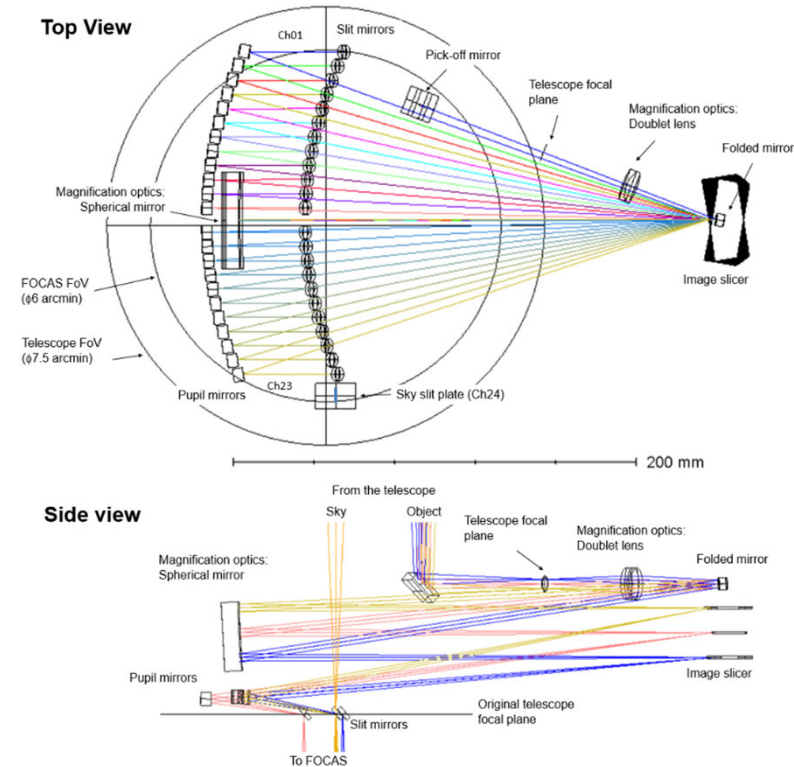
- Direction of technology development: high sensitivity, high resolution, wide field of view, spectroscopy, but impossible to cover everything at ATC
- Identified technologies: System integration, detector, IFU, optical design, adaptive optics



Wide Field Imager for ULTIMATE Subaru / design led by K. Motohara



InGaAs infrared image sensor (1280x1280) developed by H. Nakaya



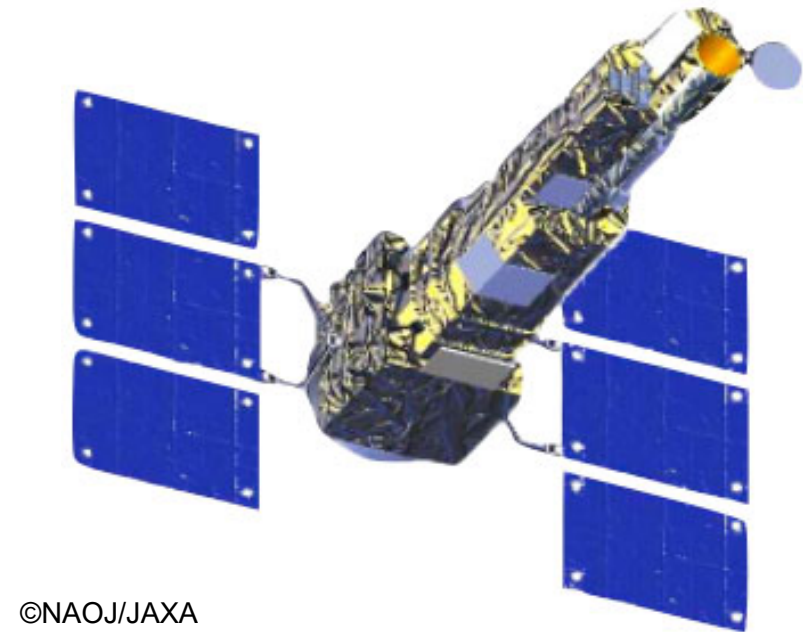
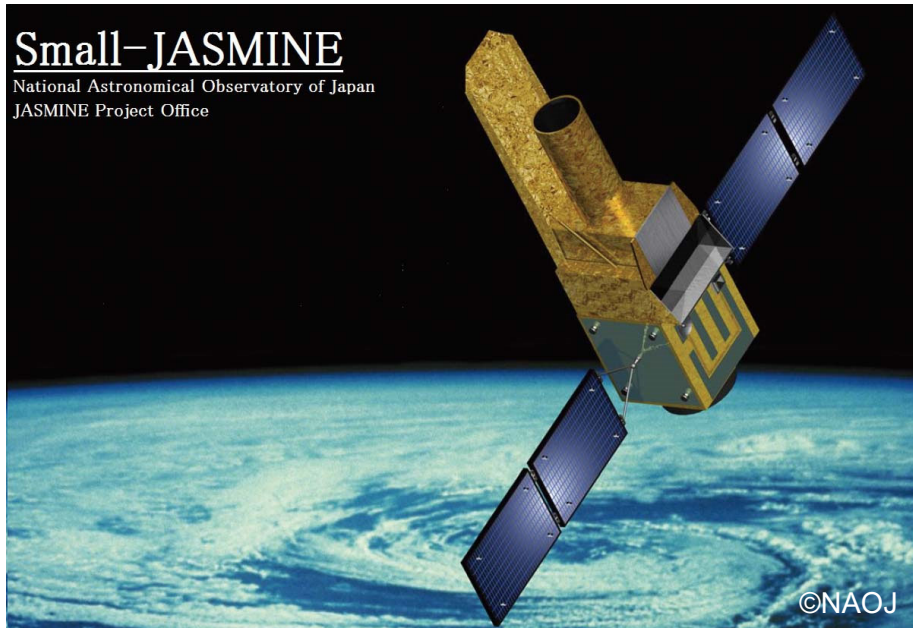
FOCAS IFU designed by S. Ozaki, T. Tsuzuki et al.

One professor, one associate professor, two senior lecturers, and one research engineer have been successfully hired.

Promising technology 3

- Space mission filed

- Direction of technology development: to participate in future international large space mission
- There are JASMINE and SOLAR-C projects to obtain necessary fundamental technologies



SOLAR-C

To ensure the success of the projects, two professors and one senior specialist have been successfully hired.

Evaluation of ATC engineering technologies

	Item	SRON (71 persons)	UK ATC (~75 persons)	ATC (54 persons)	Evaluation
Capability of developing instrument	Mechanical design	Yes	Yes	Yes	Fair
	Mechanical production	Yes	Yes	Yes	Fair
	Electrical design	Yes Both analog and digital	Yes	No Few staff	Needs improvement
	Electrical production	Yes	Yes	No Outsourcing	Needs improvement
	Optical design	No Designed by project members?	Yes	Yes Few staff	Good
	Software design	Yes Included in electrical design	Yes	No Designed by project members or ADC	Needs improvement
	Systems engineering	Yes	Yes	No Designed by project members	Needs improvement
	Safety and product assurance	Yes (6 persons) Rich in experiences	No	Yes Engineering Promotion Office is preparing	Needs improvement
Experience	Spaceborne instrument	Rich	Herschel/SPIRE, WST/MIRI etc.	SOLAR-B	Needs improvement
	Large ground-based instrument	Not so rich	Rich	Rich	Good

Outsourcing

Outsourcing

Outsourcing

Strength: Close communication between Mechanical/Optical designs and Mechanical production teams.

Weakness: Electrical engineering, systems engineering, spaceborne instrument

Recommendations in external evaluation

- External evaluation was held in March 2022
- Committee member: M. Hidaka (AIST), N. Iyomoto (Kyushu Univ.), N. Kuno (Univ. of Tsukuba), A. Lee (UCB), A. Moore (ANU), T. Shimizu (ISAS), W. Wild (CTA Obs.)

Recommendation from the committee	Action plan of ATC
ATC experiences a shortage of staff particularly in two main areas: maintenance and servicing of the clean room , and too few engineering staff in the area of electrical engineering . To maintain and strengthen the world-leading role of the ATC, the panel recommends considering improvements in these two areas of staff shortage .	Hiring engineering staff for clean room maintenance. Hiring a professor and a research engineer of electrical engineering.
Considering that good systems engineering is a key element in handling technically complex instrumentation, the committee encourages the ATC and NAOJ to consider establishing and strengthening a common system engineering effort within ATC .	OJT in projects. Participate in SE training course. (11 people from ATC in 2022) Hiring research and academic staff in systems engineering.

Recommendations in external evaluation (cont'd)

Recommendation from the committee	Action plan of ATC
The ATC plays a very important role in the education of undergraduate and graduate students . The number of accepted students increased in 2021 by the efforts of ATC staff, and the committee encourages the ATC to continue this effort .	Enhance publicity of “open-facility program, joint R&D program”.
There have been no students at SOKENDAI in the last few years. The committee encourages the ATC to more proactively and aggressively advertise to undergraduate students the opportunities at ATC . ATC could also increase the number of master students in engineering disciplines.	Enhance publicity of ATC at the guidance of Sokendai. Raise the profile of ATC academic staff in Sokendai. General PR activity. (ex. renewal of HP)

Report of the External Evaluation Committee (EEC) for the NAOJ Advanced Technology Center, May 2022

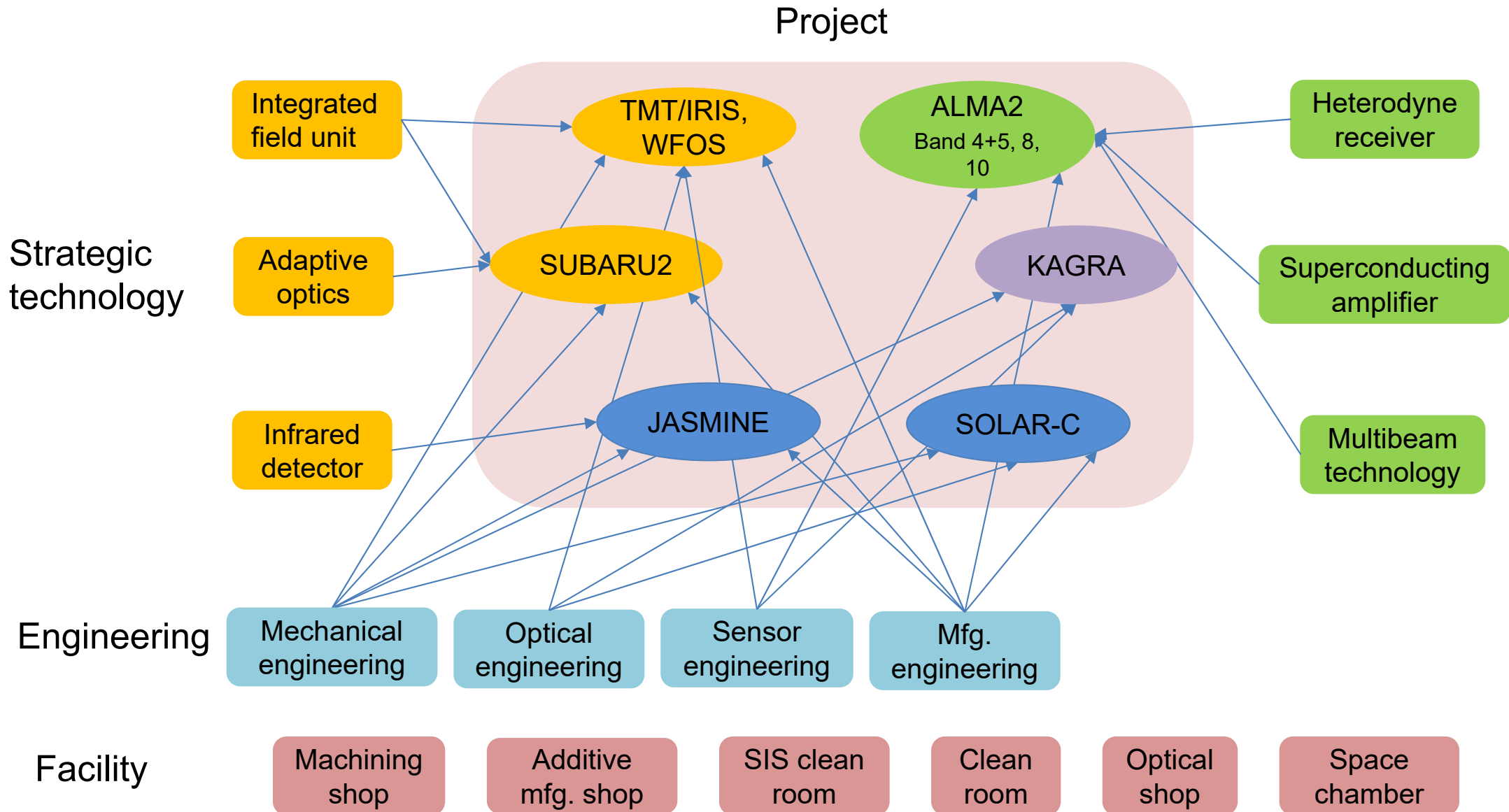
Strengthening organizational competence (plan)

- Improve organizational competence as a group of engineers, in addition to working on projects.
 - Formulate and implement a training plan within the ATC.
 - Shift from staffing to projects to receiving “contracted” jobs from projects
 - Provide opportunities to acquire skills through secondment to external organizations (JAXA, SRON, KEK, etc.)
- Create a mechanism to provide quantitative feedback on ATC resource consumption to projects
 - Billing, work-hour reporting, etc.

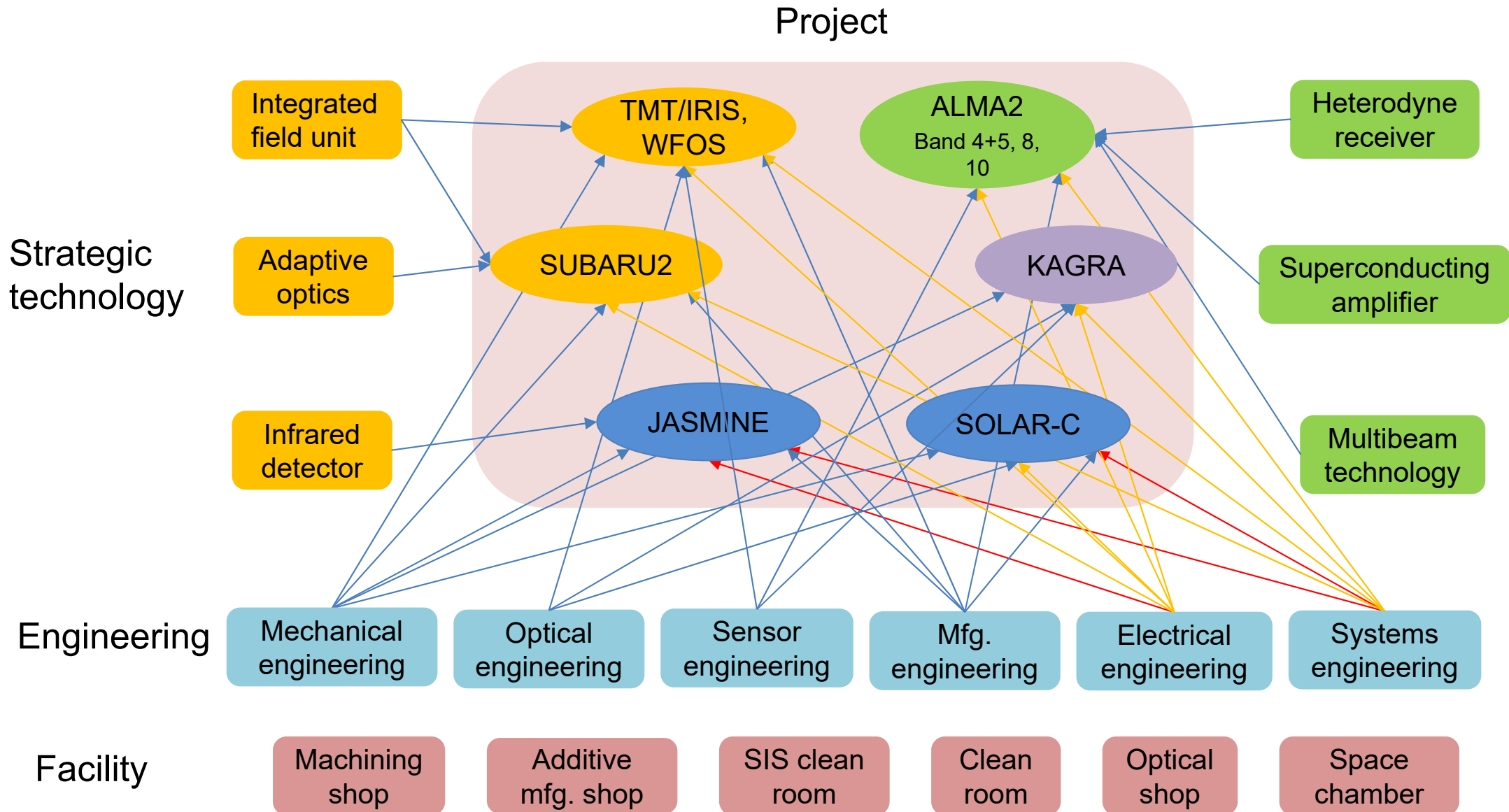
Strengthening organizational competence (plan)

- Create a mechanism to discover future ATC human resources through its role as an Inter-University Research Institution.
 - Currently, acceptance of students who aspire to become engineers in the future is low
 - Increase opportunities for engineering students to experience ATC's design and manufacturing by introducing an internship system for engineering students, etc.
- Create a culture of taking on difficult challenges
 - Since the difficulty level of assignments is not taken into account in performance evaluation, there is few incentives to set challenging assignments
 - Create a system that identifies assignments with high difficulty and evaluates efforts even if the level of achievement is low.

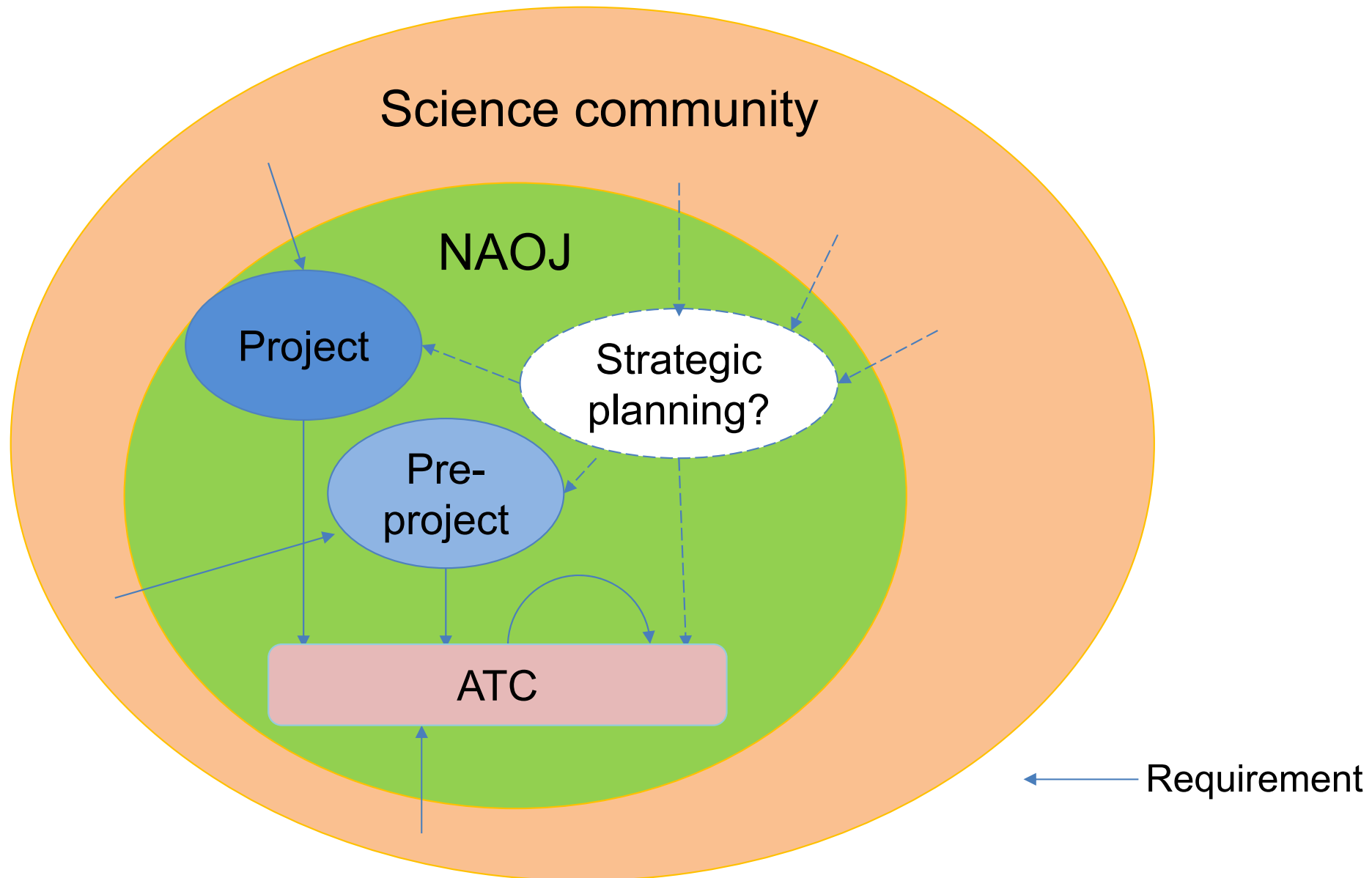
Technology map



Technology map



How to make a strategic roadmap?



Summary

- ATC has been technologically contributing to the success of projects in NAOJ
- In order to develop future technologies for the astronomical community, ATC is improving
 - facility capability
 - human resources
 - organizational competence
- Strategic planning based on the requirements of the astronomical community is essential to make a long-term technology roadmap