

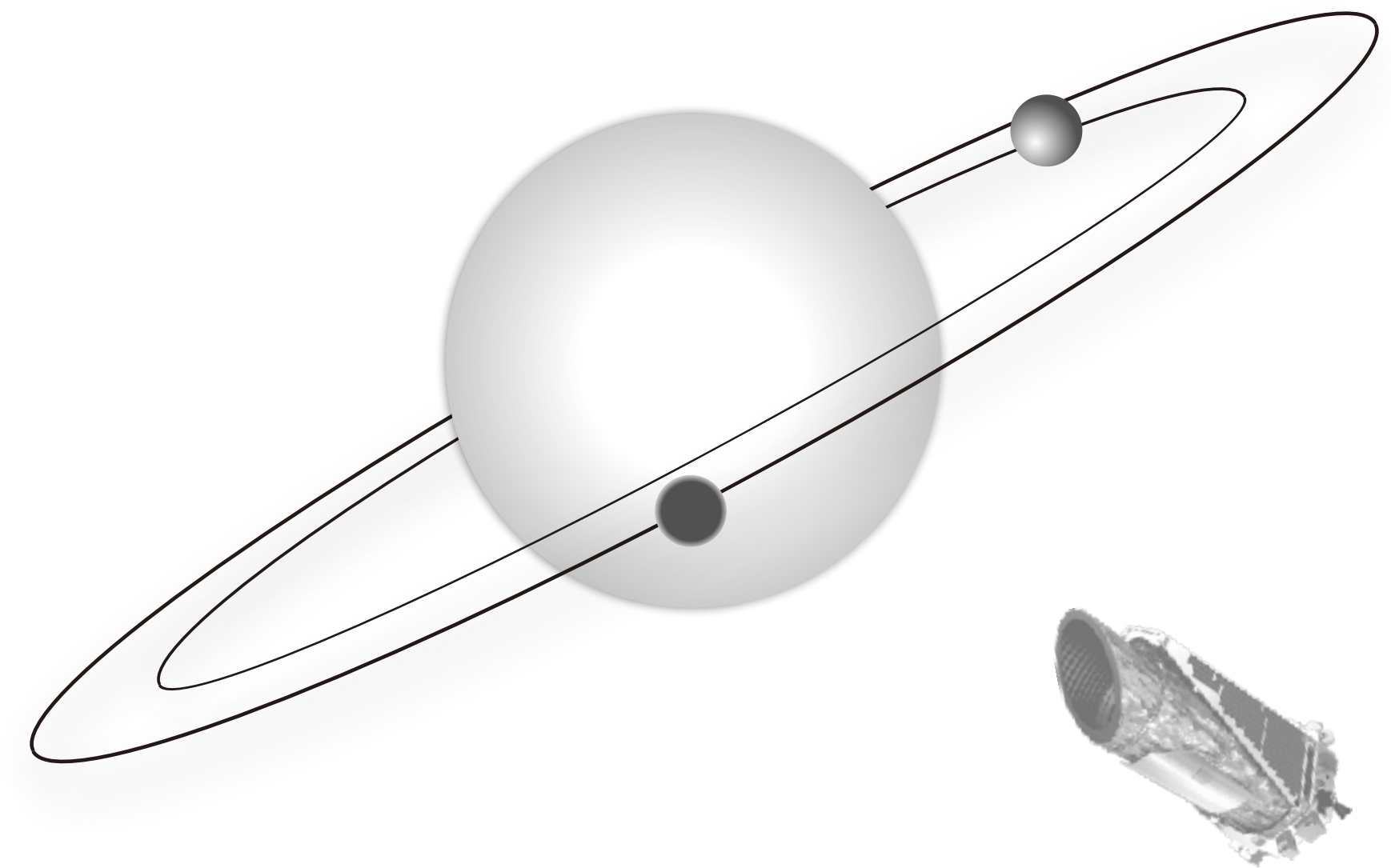
NAOJ Future Planning Symposium 2024: Science Roadmap of NAOJ

16:00-16:15, 5 Dec. (Day 3), 2024

Exoplanet Research Hub

Masahiro IKOMA

Division of Science, National Astronomical Observatory of Japan (NAOJ)

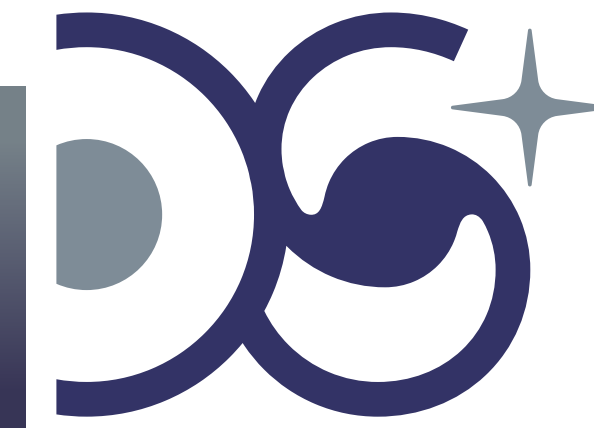


Science Goals

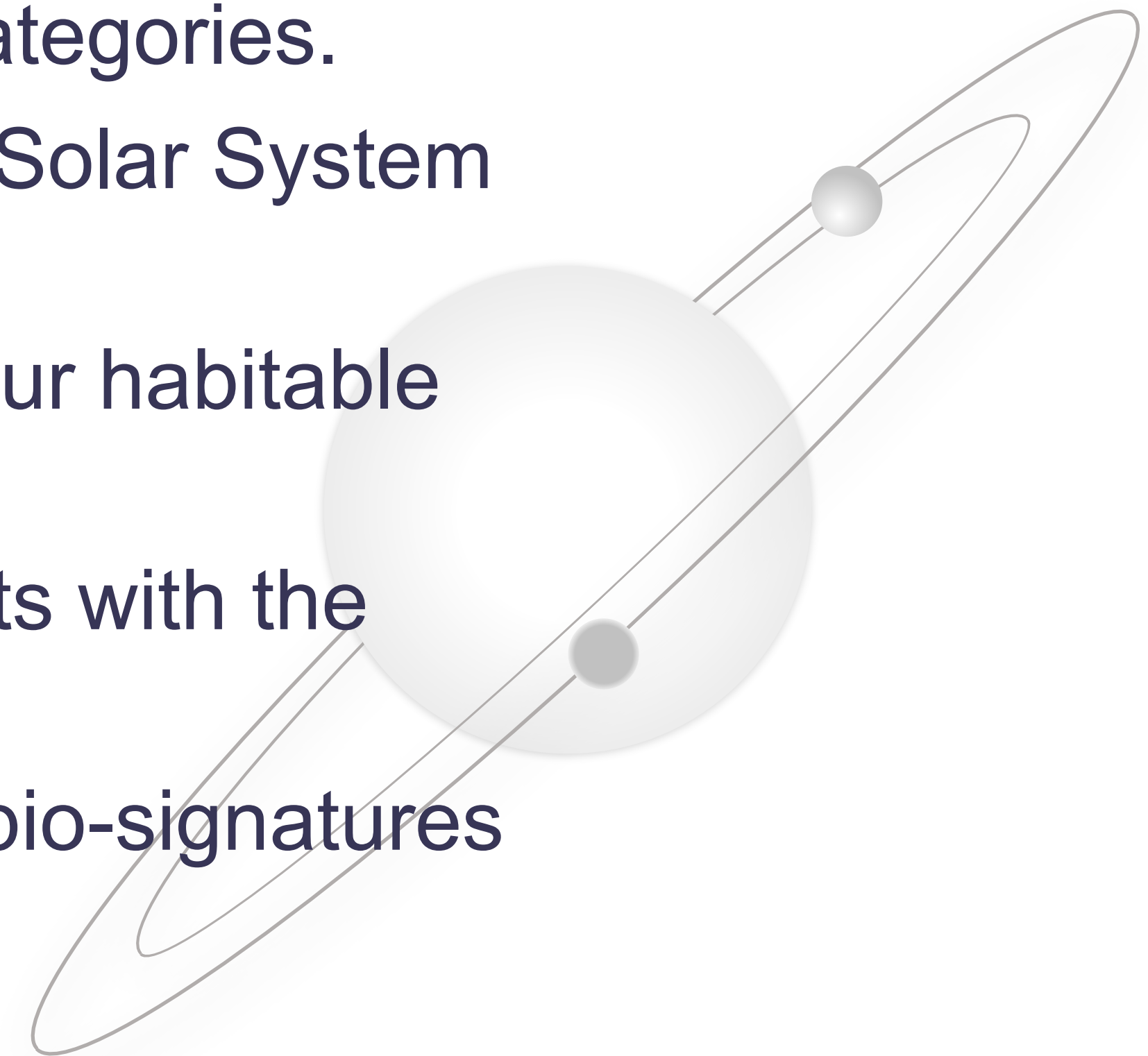
- Understanding the diversity of planetary systems and placing our Solar System in context.
- Uncovering the origin of Earth and the Solar System in the galactic context.
- Identifying exoplanets with habitable environments and potential signs of life.



Scientific Objectives



- **CENSUS** — Establish a comprehensive census of exoplanets across diverse stellar systems.
- **CHARACTERIZATION & TAXONOMY** — Characterize exoplanets to uncover their diversity and classify them into distinct categories.
- **ORIGINS** — Explore the formation and evolution of our Solar System and diverse planetary systems.
- **EARTH IN CONTEXT** — Develop a new perspective on our habitable planet Earth through comparative planetology.
- **HABITABLE WORLDS** — Search for Earth-like exoplanets with the potential to support life.
- **BIOSIGNATURES** — Lay the groundwork for identifying bio-signatures on exoplanets.





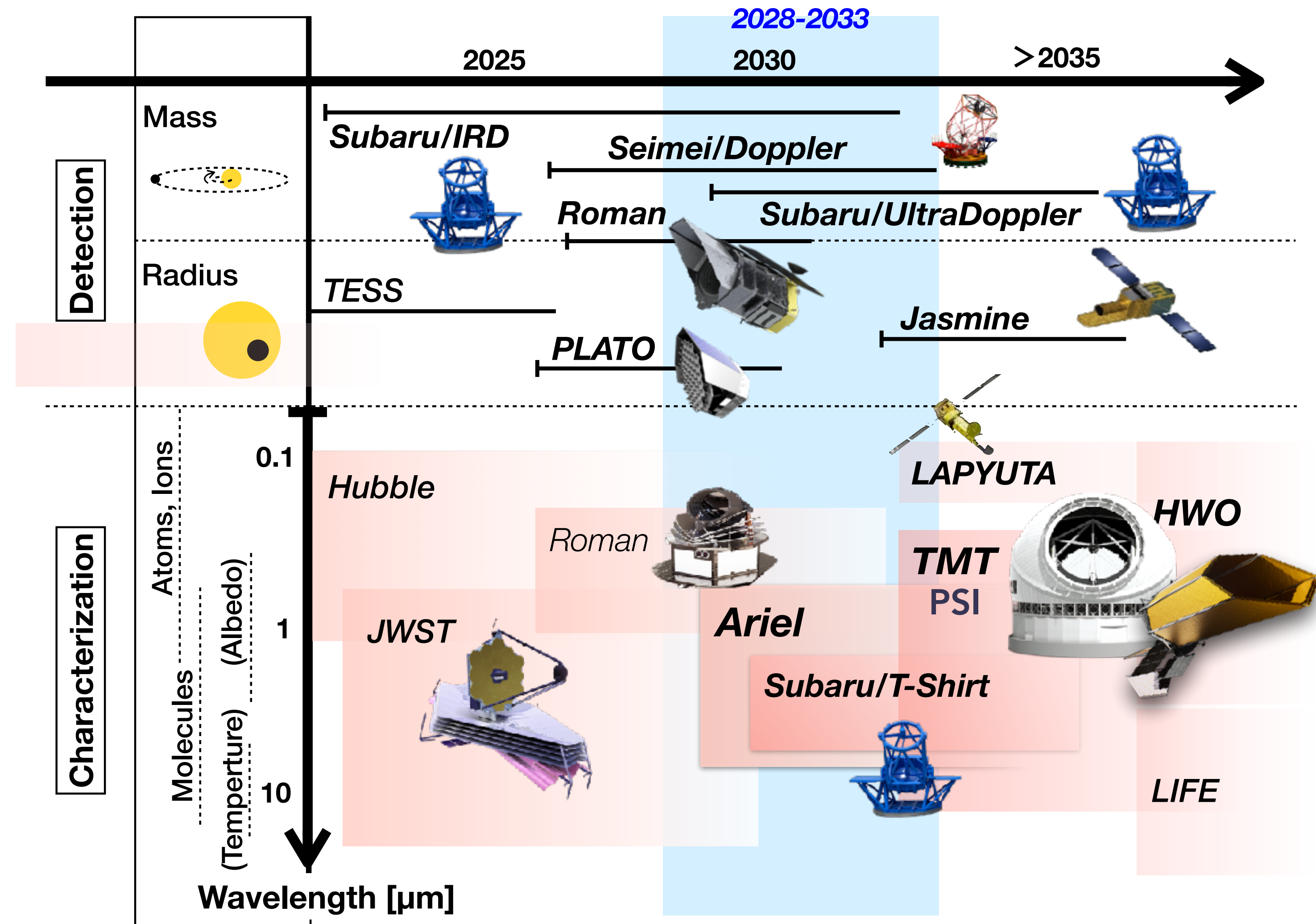
Instruments & Data

EXOPLANET DETECTION

- **Subaru-UltraDoppler & SEIMEI-SuperHRS:** High-dispersion Doppler velocimetry for detecting Earth-like planets around Sun-like stars
- **Roman (NASA):** Microlensing exoplanet survey for wide ranges of planetary mass and orbital period
- **JASMINE:** Transit survey for potentially habitable planets orbiting mid- to late-M stars

EXOPLANET CHARACTERIZATION

- **Ariel (ESA):** Atmospheric characterization for transiting exoplanets in the infra-red
- **Subaru-TSHIRTS:** High-dispersion characterization for transiting exoplanets in the infra-red
- **LAPYUTA:** Detection of escaping atmospheres of potentially habitable planets through transit observations in the UV
- **TMT-PSI:** Detection of bio-signatures of exoplanet atmospheres orbiting M stars
- **HWO:** Direct detection of bio-signatures of exoplanet atmospheres orbiting Sun-like stars



→ See individual Lols

Exoplanet Science Roadmap

Search for Second-Earths & Signs of Life

Detection of Potentially Habitable Planets

Subaru-UltraDoppler

SEIMEI-SuperHRS

JASMINE

Roman

PLATO

Census of Exoplanets

Exoplanet Research Hub

Atmospheric Characterization

Ariel (IR)

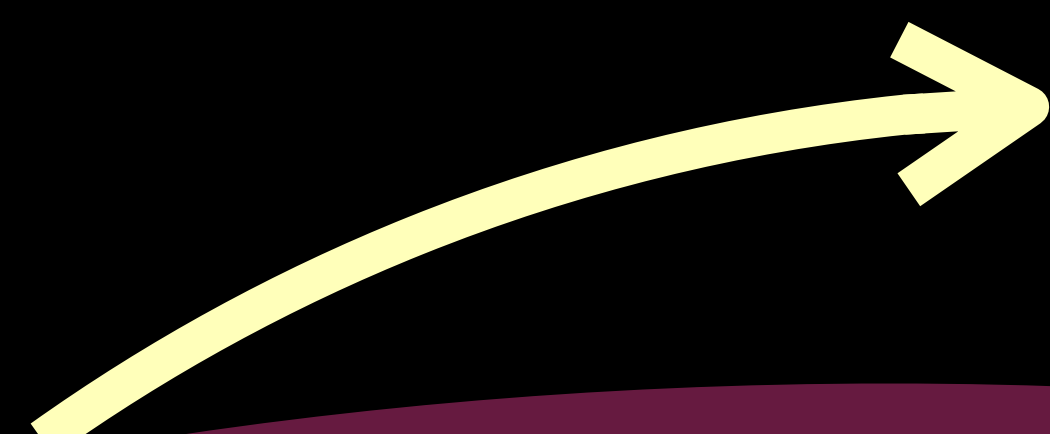
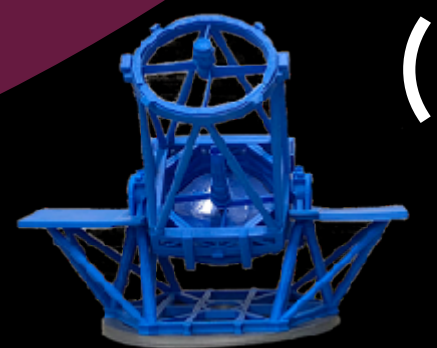
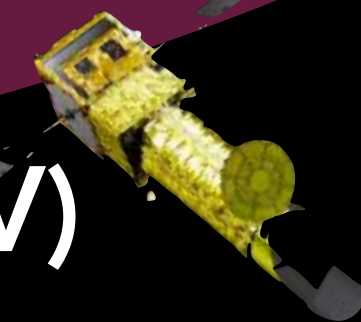
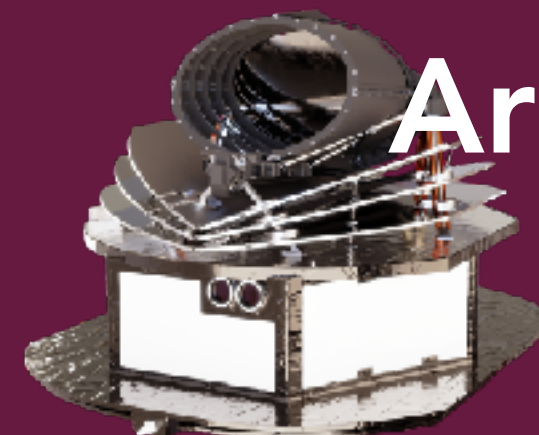
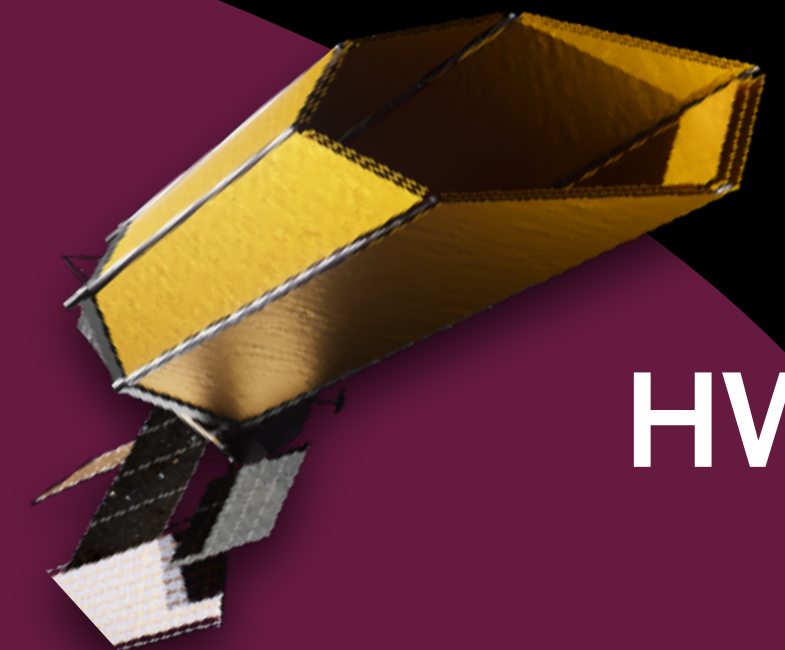
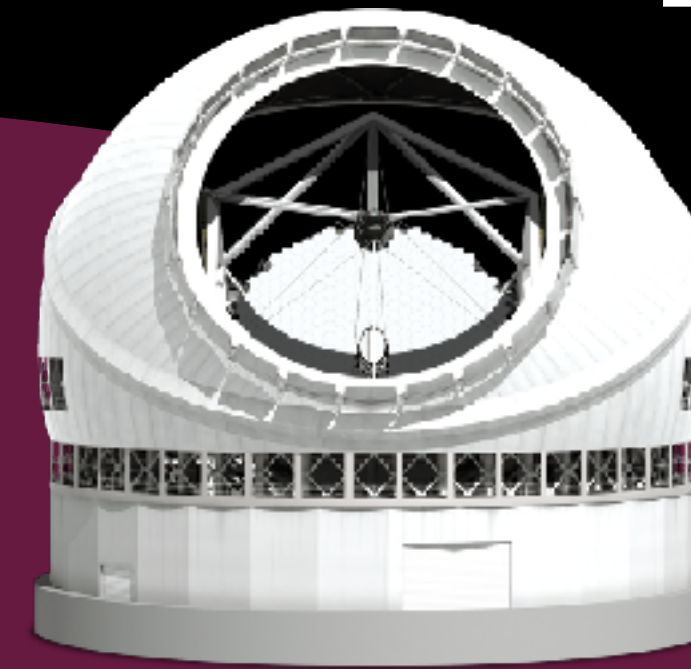
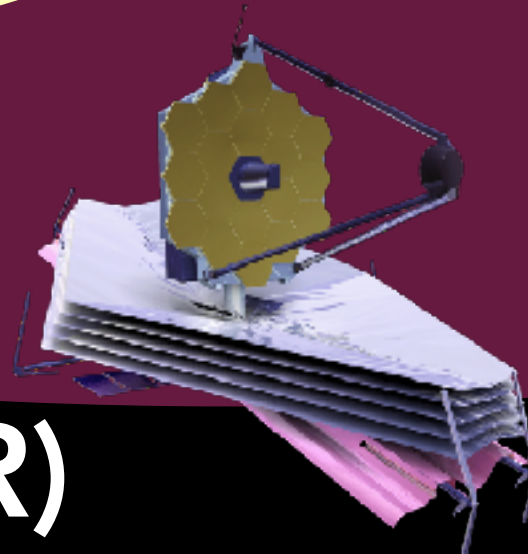
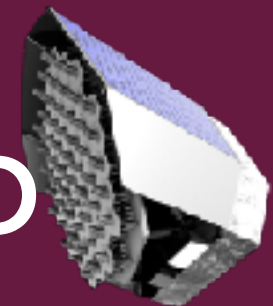
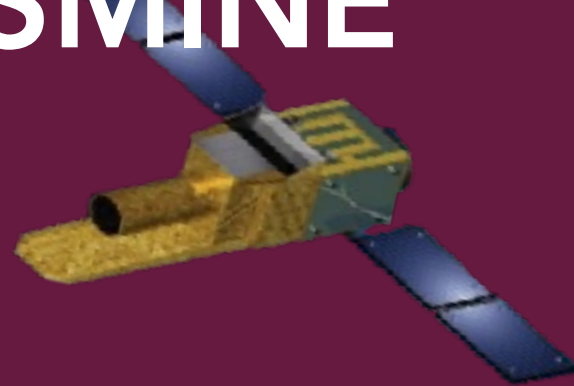
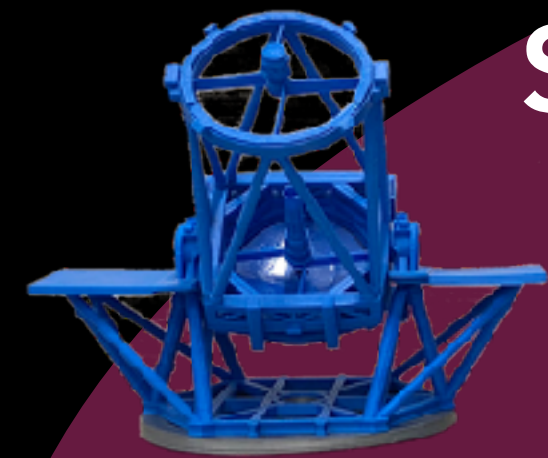
Subaru-TShirts (IR)

LAPYUTA (UV)

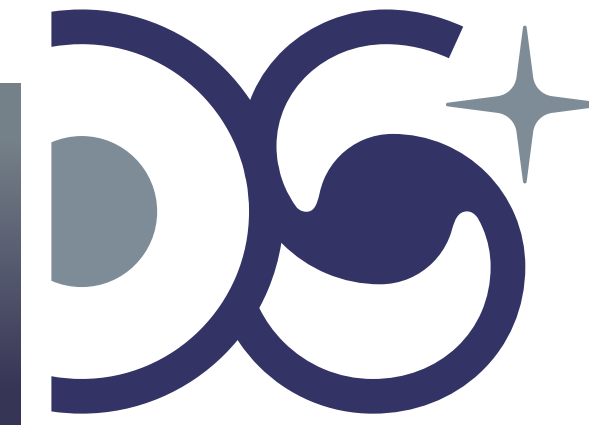
JWST (IR)

TMT-PSI

HWO



Science Investigations



- **4.1. Science investigation until 2033**

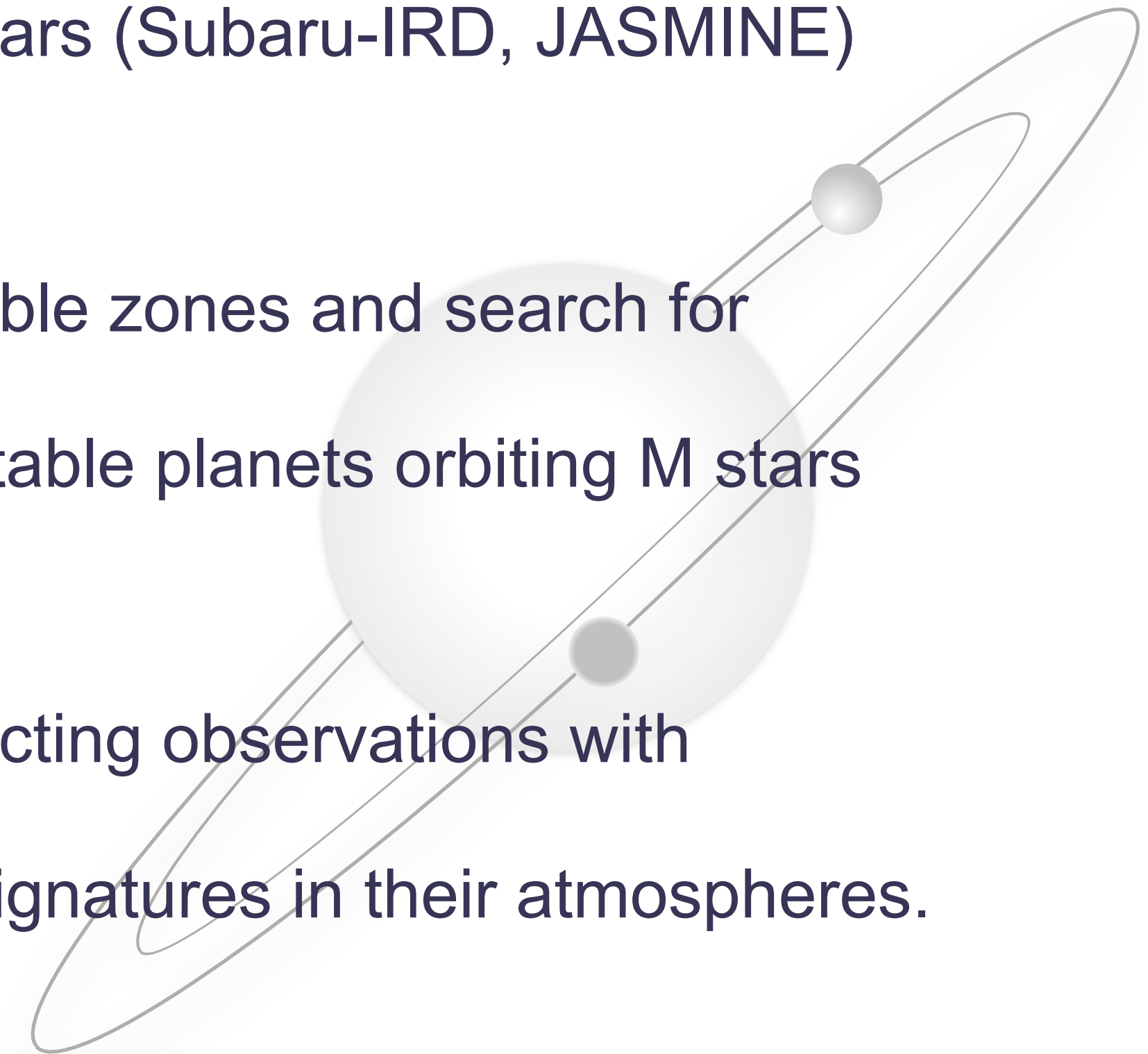
- Conduct a comprehensive census of exoplanets (Roman, PLATO).
- Characterize the atmospheres of super-Earths and larger exoplanets (JWST, Ariel, Subaru-TShirt).
- Discover Earth-class exoplanets in habitable zones around M stars (Subaru-IRD, JASMINE) and Sun-like stars (Subaru-UltraDoppler, Seimei-SuperHRS)

- **4.2. Science investigation beyond 2034**

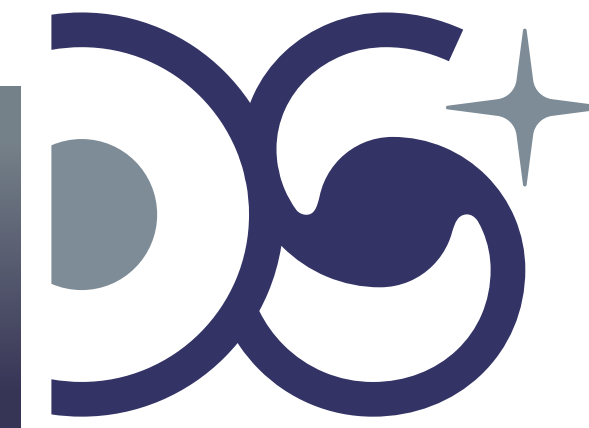
- Characterize the atmospheres of Earth-like exoplanets in habitable zones and search for potentially habitable terrestrial planets (LAPYUTA, HWO)
- Search for bio-signatures in the atmospheres of potentially habitable planets orbiting M stars (TMT) and G stars (HWO).

- **4.3. Threshold Science**

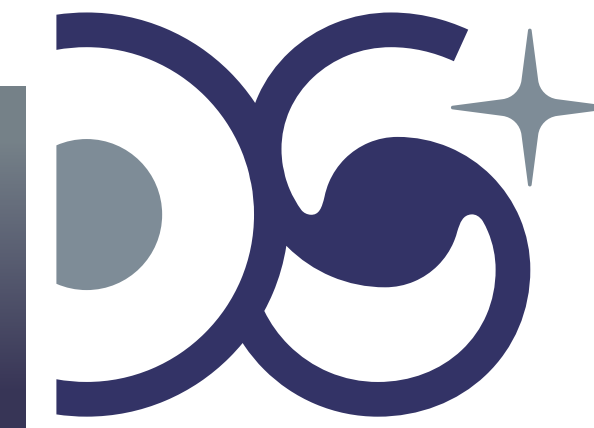
- Explore the diversity of planets and their atmospheres by connecting observations with theoretical understanding.
- Lay the groundwork for searching for “second-Earths” and bio-signatures in their atmospheres.



Originality & International Competitiveness



- **Unique Integration of Ground-based Observation and Space Missions**
 - NAOJ has the unique capability to integrate observations from its ground-based facilities, such as the Subaru and TMT, with data from multiple space missions involving Japanese researchers, such as Roman, Ariel, JASMINE, LAPYUTA, and HWO. This synergy allows for unparalleled contributions to exoplanet science.
- **Leadership in Data Integration and Cutting-edge Theoretical Research**
 - Leading theoretical researchers who excel in synthesizing diverse observational datasets to drive cutting-edge science. Integrating theory and observation ensures that NAOJ remains at the forefront of exoplanet research.
- **Collaboration between Astronomy and Earth & Planetary Sciences**
 - NAOJ fosters collaboration between astronomy and Earth & planetary sciences, with a particular focus on habitable planet research. This interdisciplinary approach places NAOJ in a globally leading position in the search for habitable worlds and the understanding of planetary habitability.



Current Status

EXOPLANET DETECTION

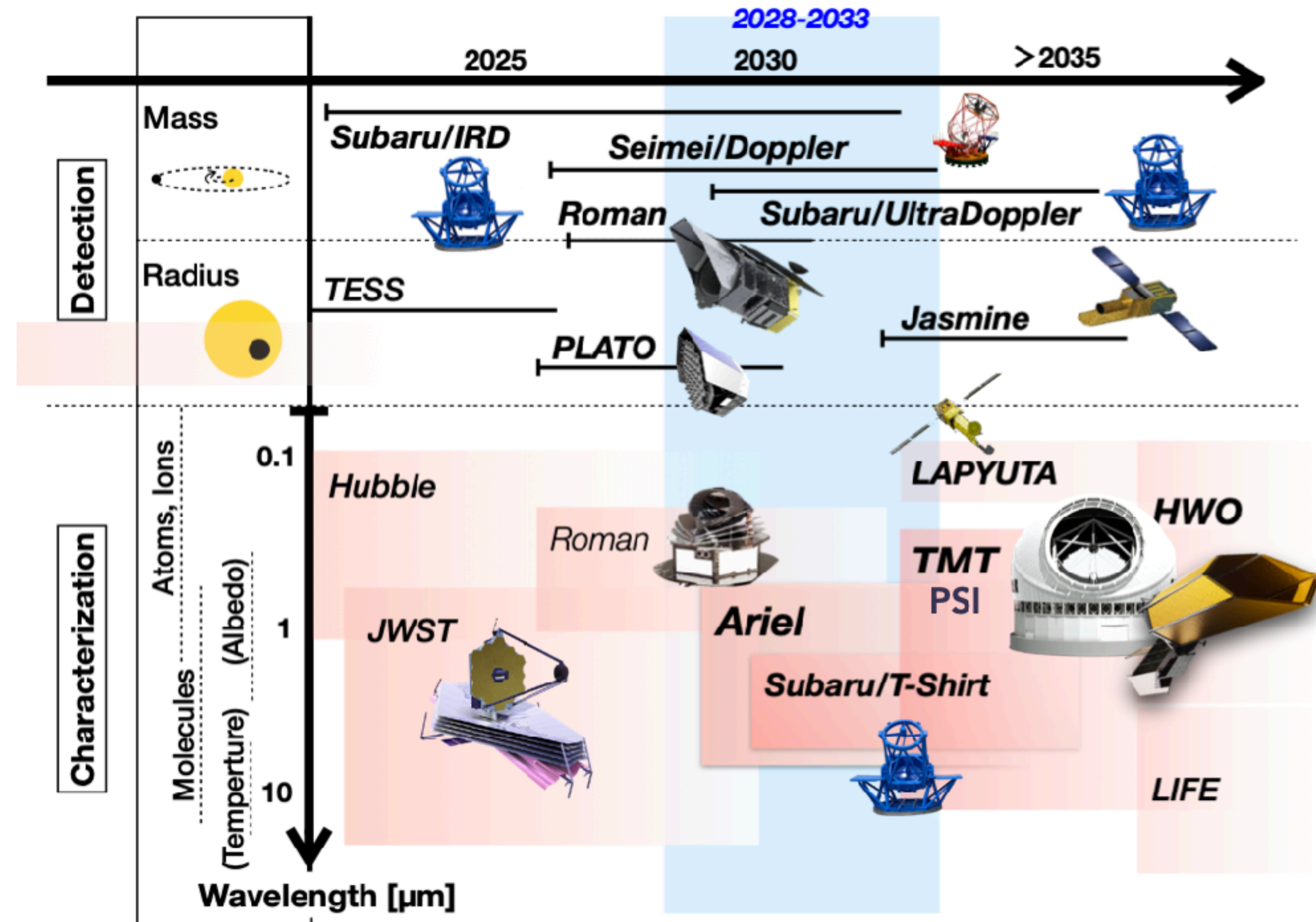
- Subaru-UltraDoppler & SEIMEI-SuperHRS: Concept study phase
- Roman (NASA): Implementation phase, scheduled for launch in 2027
- JASMINE: Pre-mission definition phase

EXOPLANET CHARACTERIZATION

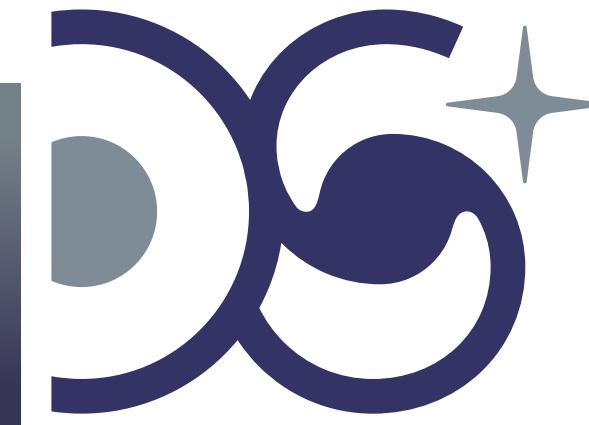
- Ariel (ESA): Implementation phase, scheduled for launch in 2029
- Subaru-TSHIRTS: Concept study phase
- LAPYUTA: Feasibility study phase before down-selection
- TMT-PSI: Concept design phase
- HWO: Concept study phase

EXOPLANET MODELLING

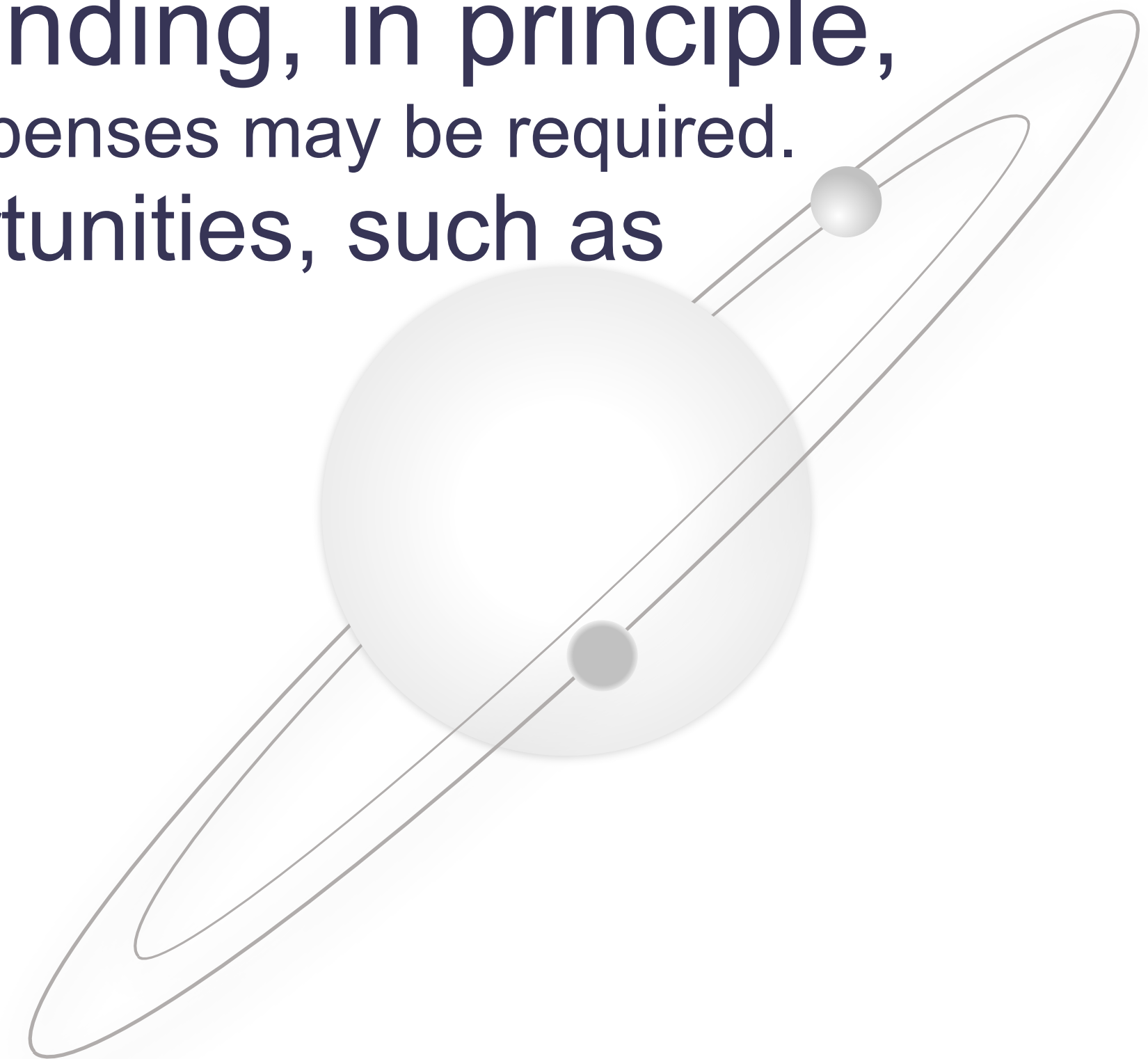
- Prototype models and frameworks developed



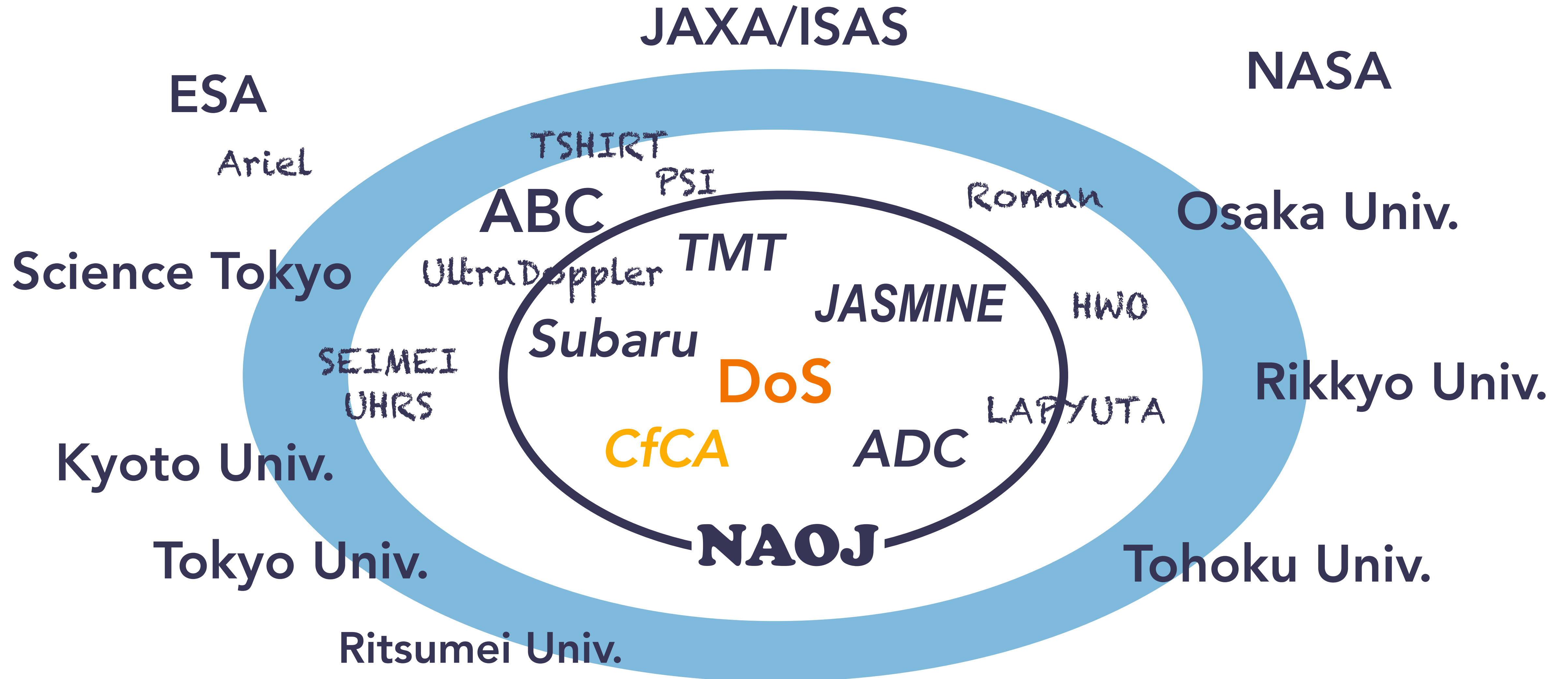
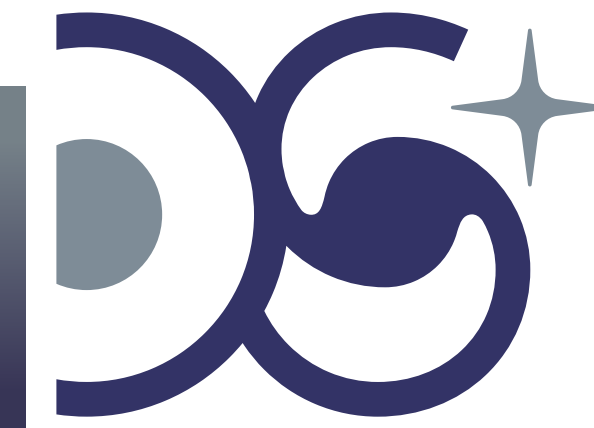
Cost Assessments, Budget Line & Status



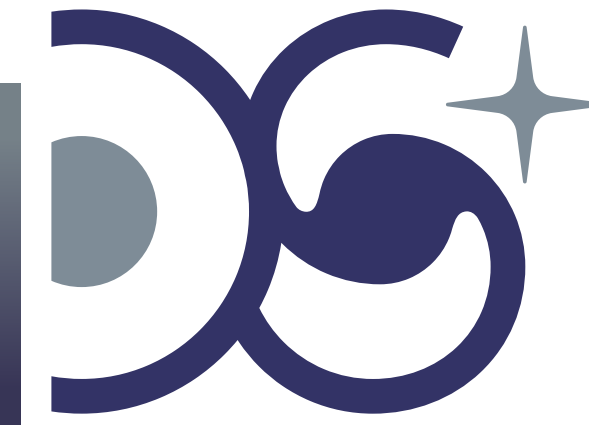
- A few project scientists at the level of assistant professors and research fellows are required (~20MJPY/yr)
- Costs will be covered through external funding, in principle, except in unavoidable circumstances where management expenses may be required.
 - Applying for large-scale external funding opportunities, such as KAKENHI and others.



Project Organization



10. Why NAOJ?



Why is an exoplanet research hub needed in NAOJ?

- **A Key Area in Astronomy**

- Exoplanet research is a pivotal field in astronomy, propelling future flagship programs such as the TMT and HWO, while addressing fundamental questions about habitable worlds and the existence of life.

- **Interdisciplinary Nature**

- Exoplanet research is inherently interdisciplinary, requiring expertise in astronomy, planetary science, atmospheric science, chemistry, and even biology. NAOJ serves as a vital hub for integrating diverse disciplines into a cohesive framework.

- **Maximizing Data from Ground and Space Facilities**

- Various instruments are under development or planned for Subaru and TMT, enhancing observational capabilities for exoplanet research.
- Many Japanese researchers actively contribute to space missions, such as Roman, Ariel, Jasmine, LAPYUTA, and HWO.
- NAOJ is uniquely positioned as a hub for synthesizing these diverse datasets, facilitating efficient collaboration and driving innovative discoveries.

- **Fostering Diverse Human Resources**

- Exoplanet research requires advanced observational techniques and theoretical modeling, making essential cultivating a new generation of researchers with diverse expertise. NAOJ provides an ideal environment for fostering researchers who can lead interdisciplinary and international collaborations.

- **Global Leadership in Exoplanet Research**

- NAOJ is well-positioned to take a leading role in global exoplanet research, leveraging its facilities, expertise, and collaborations to drive scientific progress.

