Future Development Plan of Sample return Capsule evolved on the basis of HAYABUSA SRC heritage

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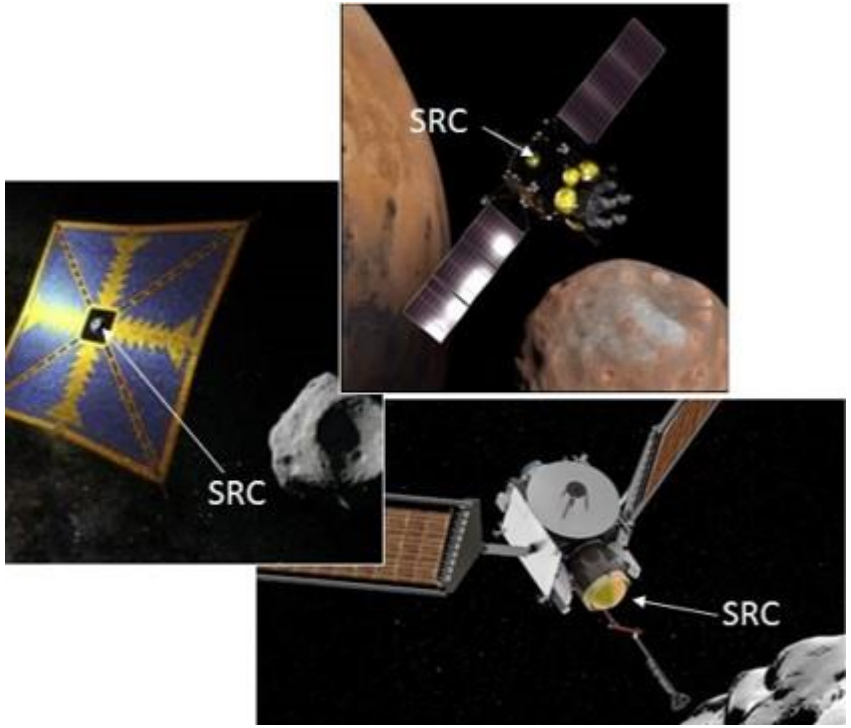

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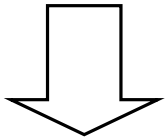
Background

- **Many planetary exploration missions are being conducted and proposed as future missions.**

  Ex. ROSETTA, DAWN, OSIRIS-REX, HAYABUSA2 , BepiColombo, MARS2020, EXOMARS, LUCY, PSYCHE, MMX, JUICE, DESTINY+, OKEANOS…..

- **Japan especially focuses on the sample return mission to deep space on the basis of HAYABUSA's heritage.**

  HAYABUSA→HAYABUSA2→Mars Moon Exploration(MMX)→Trojan exploration by solar power sail(OKEANOS), and Comet SR(CAESAR)



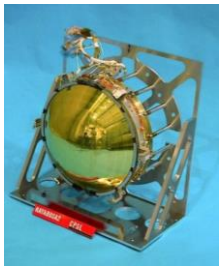
- **Enhancement of "sample return capsule" technology is indispensable to realize these advanced sample return mission.**

ISAS's Exploration strategy

HAYABUSA's Sample Return Capsule

- **Sample return capsule is one of key technologies and indispensable for sample return missions**

Japan has an outstanding heritage of sample return capsule technology which can survive in high speed reentry directly from interplanetary trajectory. That is "HAYABUSA" SRC.



HAYABUSA & HAYABUSA2 has an almost same sample return capsule.

*Diameter: 40cm
*Mass : 16kg
*Reentry speed :12km/s
*Heat shield can survive in severe aerodynamic heating with heat flux of 15MW/m^2.
*Heat shield is jettisoned during descent phase.
*HAYABUSA SRC could be recovered in a day after the reentry in Australia using beacon track system

Evolution from HAYABUSA SRC

Future sample return mission requests more advanced science achievements.

<Key requests>
1) Samples from deeper space
2) Larger amount of samples
3) Keep samples in low temperature

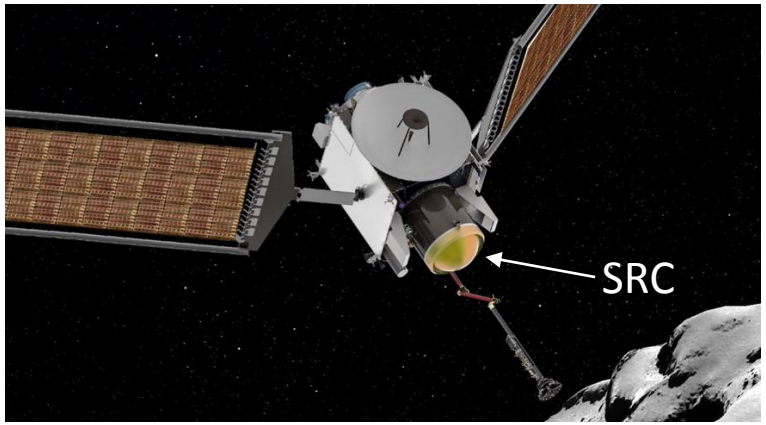
<Requirement to sample return capsule >
1) Survive in higher entry speed
2) Scale-up to install a large sample container
3) Precise thermal prediction and control.
4) Quick recovery.

Future Sample Return Mission

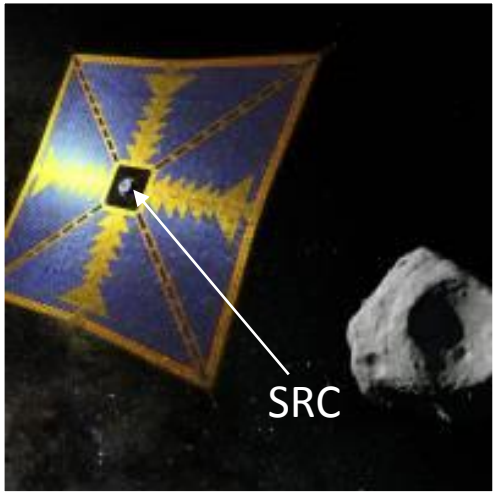
Several sample return missions from small body in solar system are already planned and discussed concretely as future planetary exploration missions, MMX, CAESAR, OKEANOS.

MMX
(Mars Moon Exploration)

CAESAR (Comet Astrobiology Exploration Sample return)

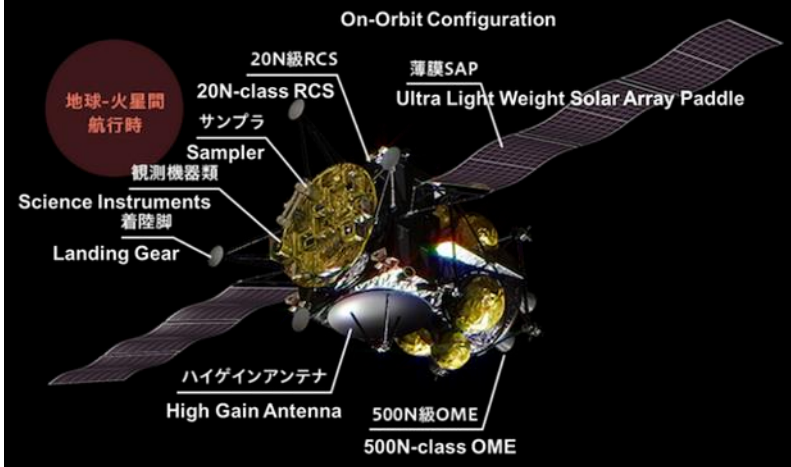


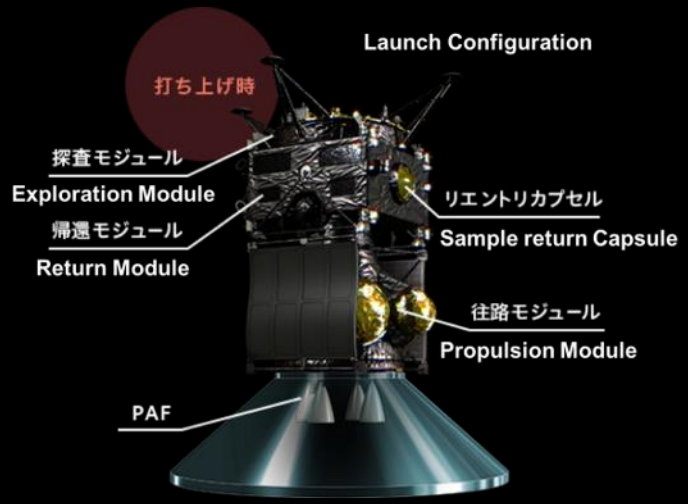
OKEANOS (Outsized Kitecraft for Exploration and AstroNautics in the Outer Solar system)



JAXA will develop sample return capsules for these missions in order to meet each mission requirements.

MMX (Mars Moons Exploration)





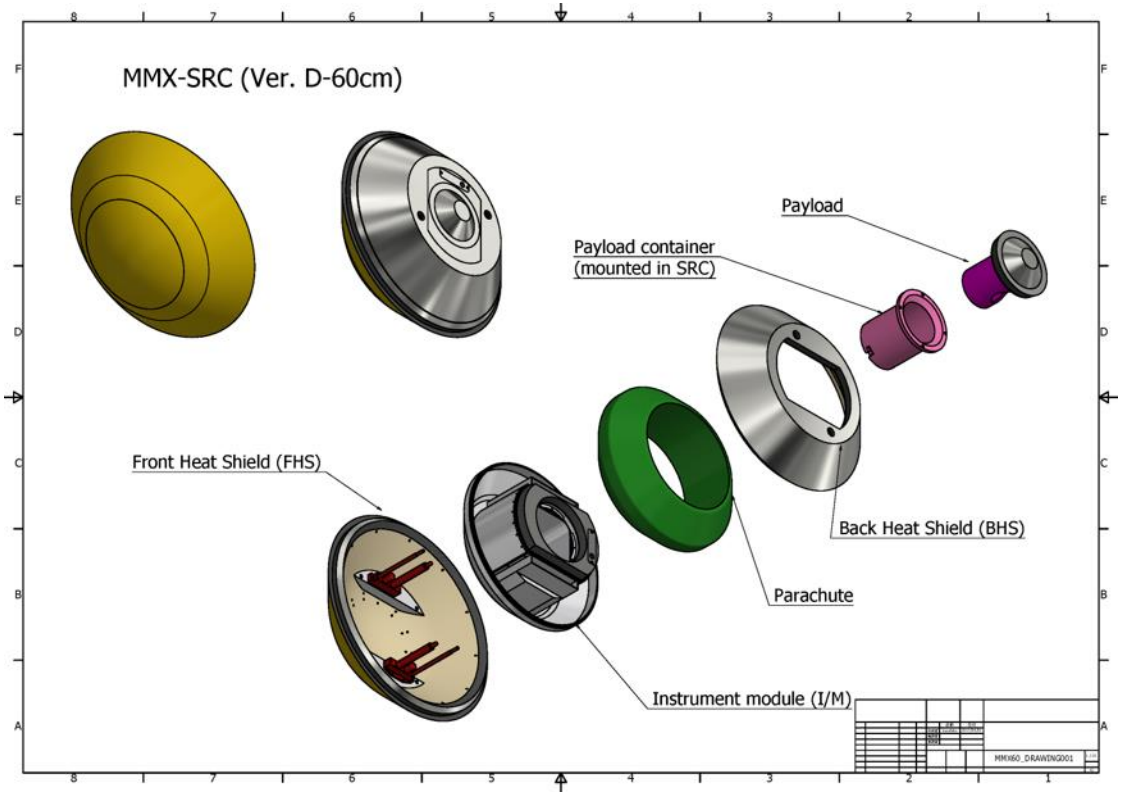
ISAS/JAXA plan to launch the spacecraft in early 2020s. **In order to retrieve the samples,** the spacecraft will need to complete a roundtrip to Mars, circle around the moon and land on its surface.

MMX will acquire samples from Phobos in several times. So, a large amount of samples have to be carried to the Earth and a large size container is necessary.
SRC has to be scaled-up from HAYABUSA SRC to install its samples and sample containers in SRC.

MMX-SRC

The sample return capsule for MMX is being developed with the same design concept of HAYABUSA SRC. However it needs **scale-up up to 60cm diameter and 41kg.** To meet its mission requirement, the performance of some components including, parachute deployment mechanism, heat shield and parachute is enhanced.

- Diameter: 60cm
- Mass : 41kg
- Reentry speed :12km/s
- Same design concept as HAYABUSA-SRC
- Front heat shield is same material as HAYABUSA SRC.
- Parachute system is same as HAYABUSA SRC.



CAESAR (Comet Astrobiology Exploration Sample Return)

- CAESAR (Comet Astrobiology Exploration Sample Return) is the international and worldwide collaboration project and is one of the finalist missions for NASA 4th New Frontiers Program. CAESAR team is lead by Prof. Steven Squyres in Cornell University and consists of NASA-GSFC, NASA-JSC, Orbital ATK, Honeybee, ESA, JAXA, etc.

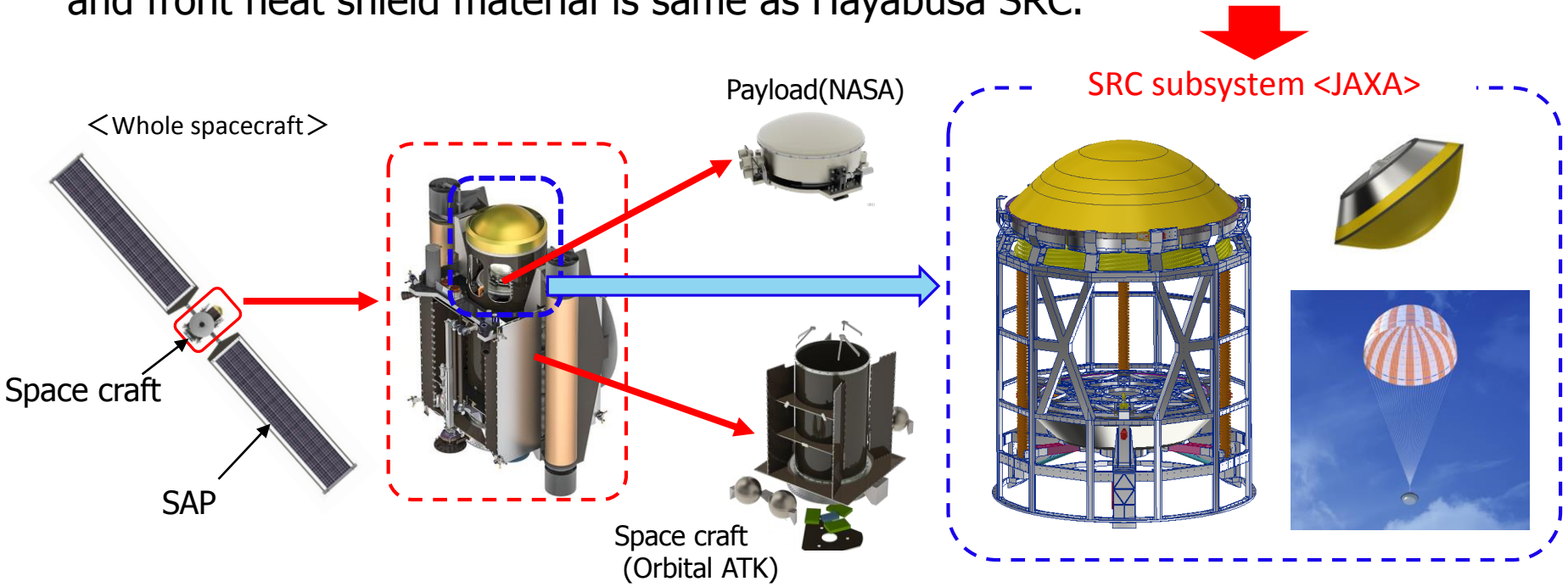
- CAESAR is a ultimately challenging and significant mission for the planetary exploration. CAESAR will return samples including not only non-volatiles, but also volatiles, from nucleus of comet 67P/ Churyumov-Gerasimenko. We expect that the origin of the solar system will be uncovered with thorough analyses of these samples by updated facilities in the future, when CAESAR returns in 2038.

- JAXA participated the CAESAR team in 2015 and plays an important roles in CAESAR mission, that is, development of SRC subsystem which is indispensable to realize the CAESAR mission.

- The CAESAR SRC is required to install a large payload and keep a payload in low temperature until recovery.

CAESAR-SRC

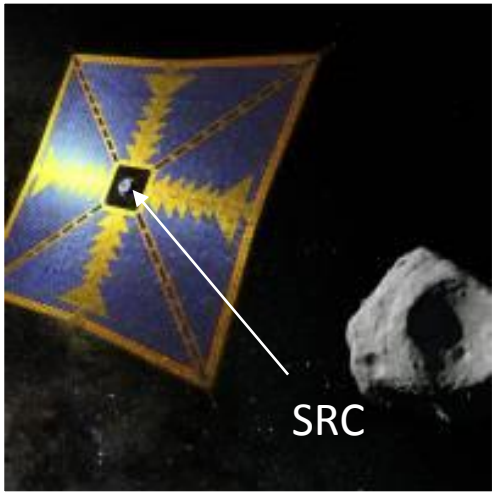
- The conceptual design of SRC was already carried out by utilizing the Hayabusa SRC heritage as much as possible. Aerodynamic shape is similar to Hayabusa SRC and front heat shield material is same as Hayabusa SRC.



CAESAR-SRC design is modified from HAYABUSA SRC in order to meet the mission requirements of CAESAR. For example, two stage parachute system is adopted to realize a safe deceleration and an integration of onboard devices including the payload system is modified from HAYABUSA SRC to keep samples in low temperature.

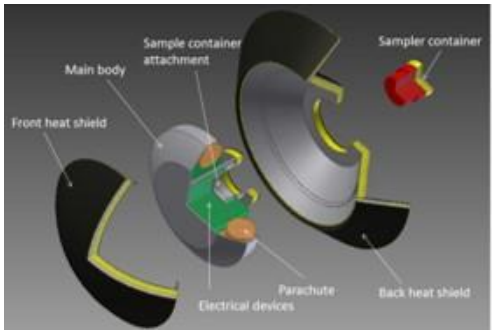
Toward OKEANOS

OKEANOS (Outsized Kitecraft for Exploration and AstroNautics in the Outer Solar system) is the trojan asteroid exploration mission using solar power sail technology. In OKEANOS mission, the sample return from trojan asteroid is also discussed as option plan.

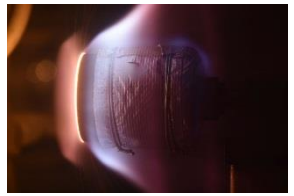


Requirements to OKEANOS's sample return capsule are very advanced.

*Mass allocation : 20kg
*Entry speed : 14.5km/s
*Sample temperature : as low as possible.



Drastic change from Hayabusa SRC is necessary to meet its requirements, including a development of low-mass heat shield material and investigation on the new aerodynamic shape. Additionally, understanding of hyper high speed aerodynamics and gas dynamics is necessary.



Summary (Line-up of sample return capsule)

We have developed a various type and size sample return capsule to meet the planned sample return mission on the basis of the Hayabusa SRC.
It sample return capsule technology will contribute to flexible and attractive solar system exploration mission in the future.

HAYABUSA-SRC
Launch：2003, 2012
SRC Diameter：40cm
SRC system mass ：20kg
Entry speed ：12km/s
Sample temp ：80degC

MMX-SRC
Launch ：2024 (Plan)
SRC Diameter ：60cm
SRC system mass ：50kg
Entry speed ：12km/s
Sample temp ：80degC

CAESAR-SRC
Launch ：2024 (Plan)
SRC Diameter ：more than 1m
SRC System mass ： more than 200kg
Entry speed ：12km/s
Sample temp ： as low as possible

OKEANOS-SRC
Launch ：2020's (plan)
SRC Diameter ：60cm?
SRC System mass ：20kg
Entry speed ：14.5km/s
Sample temp ：20degC (target)