

THE ON-ORBIT SERVICE AND ROBOTIC PLATFORM CONCEPT FOR NEW PLAYERS

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ABSTRACT

This paper discusses the on-orbit service and robotic platform concept for new players by analyzing the current state of the art for on-orbit service and planned robotic technology demonstration. To achieve robotic platform concept, the potential participation may exist and the several critical partnerships issues are remained such as service standardization of modular payloads installation through the dexterous tele or autonomous manipulation. By encouraging the partnership among the private companies and space agencies in several ways in the worldwide, robotic platform concept will be realized as functionally distributed platform in geo-stationary orbit step by step in the future.

1 INTRODUCTION

It is difficult to achieve the on-orbit service activity by one entity because versatile stakeholders are involved in the activity. The on-orbit service also requires the various technologies such as rendezvous and robotics. Moreover, there is an essential to deploy the global market in order to increase potential customers. Therefore, it is a key for the on-orbit service activity to establish the partnership among private sectors as well as space agencies. It may also be feasible to develop the relevant technologies collaboratively.

The geosynchronous platform is one of the well-known concepts in early stage of space development in the past to enable exchange and upgrade of mission payloads on orbit by robotic operation. By developing the robotic platform in geo-stationary orbit to enlarge new space players, new type of space business such as dedicated mission service may be rapidly deployed by non-space entities because they can utilize the platform resource without considering harsh environment adaptation.

The robotic platform needs to utilize the versatile on-orbit servicing technologies such as refueling, exchanging payload, inspecting/repairing and assembling/manufacturing as well as transporting payload with docking capability. The several on-orbit service such as life extension on geo-stationary communication satellite has been executed. The transportation opportunities maybe increase more and their cost becomes more reasonable in near future due to the emergent low-earth orbit constellation.

The following section discusses the partnership program in JAXA called J-SPARC (JAXA Space Innovation through Partnership and Co-creation), current status of on-orbit service activation, robotic geo-platform concept, load-map to establish the functionally distributed platform and associated challenges.

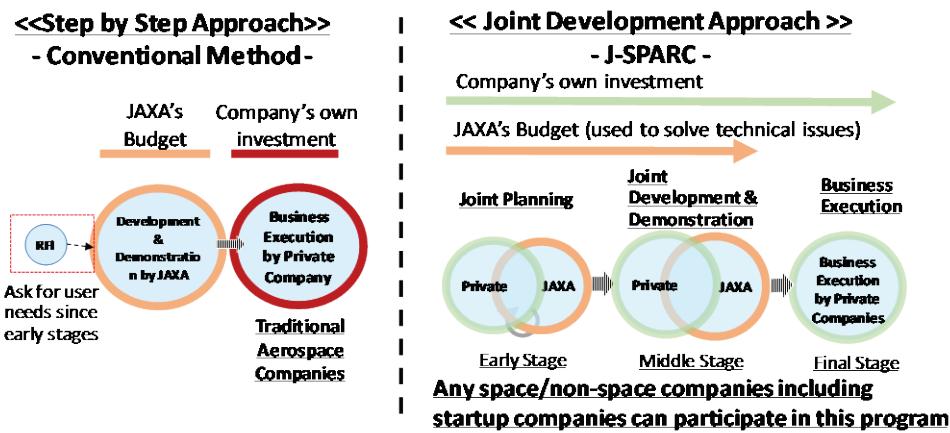


Figure 1: J-SPARC Development Approach.

2 JAXA J-SPARC PROGRAM

J-SPARC began with dialogues between JAXA and private enterprises seeking to launch space business. This is a new co-creation research and development program with the objective of creating space-related businesses based on new ideas with mutual commitment of both parties toward commercialization, joint consideration of business concepts, and technical development and demonstration with clear end results. The program has been implemented since May 2018 and approximately 20 projects are currently underway.



Figure 2: Main Business Themes of J-SPARC

As shown in Figure 1, the joint planning at early stage called “Concept co-creation study” based on business ideas and concepts, aims to formulate business plans targeted through activities such as market surveys and consideration of business concepts. The joint development and demonstration at middle stage called “Joint demonstration of business” based on business plans, targets commercialization based on

pre-commercialization activities such as joint feasibility studies, joint technical development and demonstrations. The on-orbit service activities are one of the major themes to focus on J-SPARC program as shown in Figure 2.

3 ON ORBIT SERVICE ACTIVITIES

JAXA including formerly called NASDA own the heritages regarding to on-orbit service since 90' as shown in Figure 3. ETS-VII (Engineering Test Satellite No.7) launched in 1997 have demonstrated the rendezvous docking to cooperative satellite on orbit automatically and the teleoperation of a space robot from the ground remotely by exchanging ORU (Orbital Replacement Unit). As for the practical application, 10m-length JEM (Japanese Experimental Module) Kibo robot arm have been in operation since 2008 to exchange experimental payloads and to deploy cube satellites into orbit. HTV (H-II Transfer Vehicle) Kounotori was successfully have been launched nine times since 2009 to deliver 6-ton cargo to ISS each time. Currently the project called CRD2 (Commercial Removal of Debris Demonstration) regarding to active debris removal has started to demonstrate the removal mission and their associated technologies for approach and removal of the upper stage of the rocket body by 2025.

The on-orbit service activities have studied and performed not only at JAXA but also at other space related agencies including RSGS program by DAPRA and Restore-L mission with SPIDER technology demonstration by NASA. For the activities under private sectors, Northrop Grumman have successfully

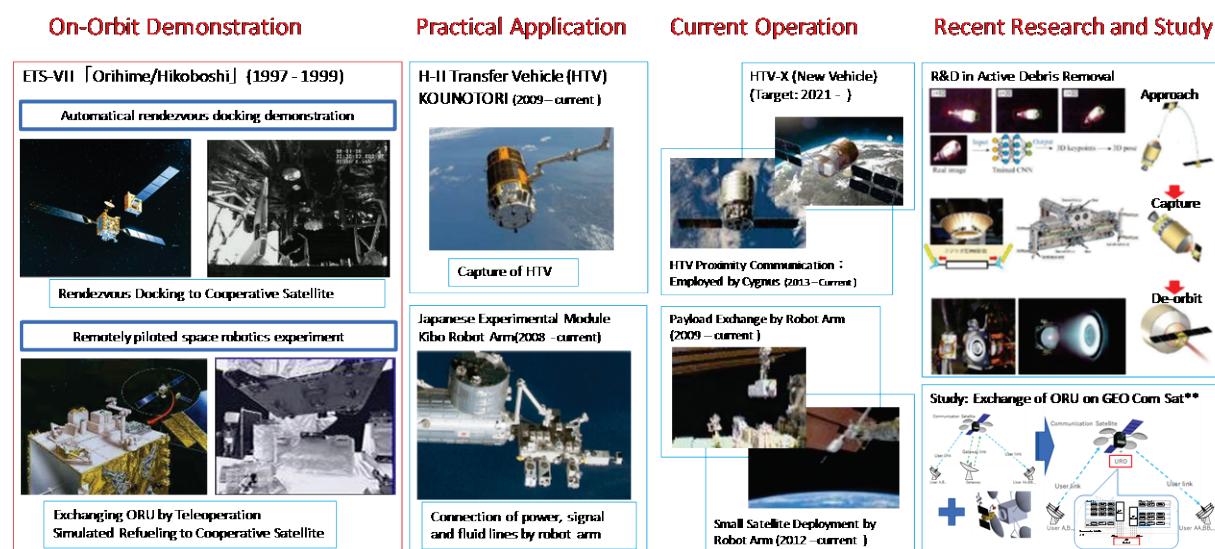


Figure 3: JAXA On-orbit Servicing Heritages

achieved the docking to Intelsat communication satellite for life extension by MEV (Mission Extension Vehicle) in 2020, and MEV-2 was launched in August 2020. Astroscale also announced on June 2020 to enter the GEO satellite life extension market while GITAI announced on September 2020 to plan the technical demonstration for space robotics inside the Bishop airlock attached to ISS. The on-orbit servicing activities will become more realistic toward the practical application.

4 ROBOTIC GEO PLATFORM CONCEPT

The robotic platform as illustrated in Figure 4 is one of the well-known concepts to enlarge new space players and space business. The new type of space business such as the dedicated mission service by installing the payload may be rapidly deployed because they can utilize the robotic platform resource such as the power of the payload, the communication to the ground and the orbital station keeping.

The platform may be realized by technology maturation on step by step through development and investment, and it might become a new infrastructure on orbit in addition to the conventional infrastructure such as launch vehicles and satellites. There are a lot of opportunities for partnership to create new space business under robotic platform in the future.

The robotic platform could be realized in any orbits such as sun synchronous orbit, however, the

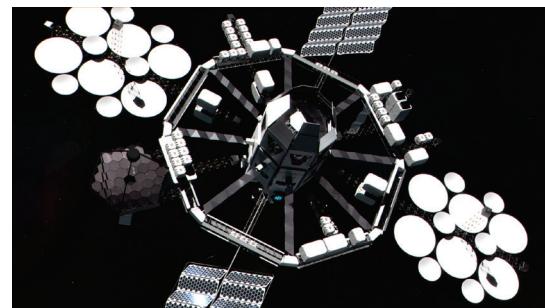


Figure 4: Robotic Platform Concept

geo-platform possesses several advantages over other platforms as follows.

- Frequent GEO transportation opportunities by cost effective rideshare
- High servicing technological readiness by realistic life extension on GEO
- Continuous direct communication to the ground under real-time robotic manipulation operation
- Software defined GEO satellite development toward potential on-orbit exchange of mission payloads in future

It is difficult to establish large scaled platform for short period of time due to huge investment required even if the realistic necessary technologies are matured. One possible way to realize the platform is to

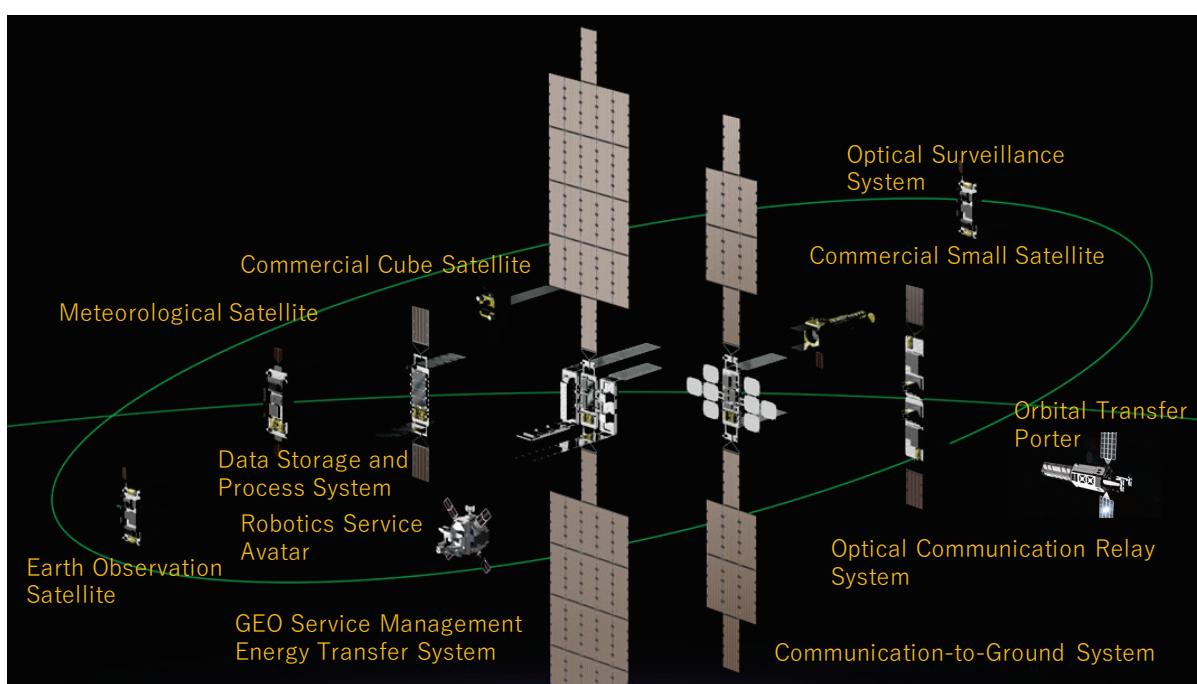


Figure 5: Distributed Platform in GEO

rely on the recent satellite technologies especially small satellites in geo-stationary orbit. Each functional system of the platform could consist of the several small satellites. The functional system become the part of the infrastructure to support the mission dedicated satellites as shown in Figure 5.

The communication system to the ground may play important role of the ground communication for the mission dedicated satellites. The data storage and process system could provide the service of the data storage and processing to the mission dedicated satellites. The power management system could also manage the comprehensive of GEO service and transfer the energy to the mission dedicated satellites.

5 LOADMAP AND CHALLENGES

The first step toward the functionally distributed platform is the creation of the new market of the used on-orbit satellite business. The digital GEO satellite whose mission can be configured by software on orbit may be continuously utilized after first mission by switching to the second mission. It becomes important to identify the health status of the used satellite on orbit as the part of on-orbit servicing through the telemetry status and/or optical surveillance of the used satellite. The slot relocation and life extension capability could be an option for on-orbit service. In order to perform feasible life extension servicing, it

might require providing multiple satellite services by one serving vehicle.

The second step is the upgrade and/or the append of geo-stationary satellites payload on orbit by on-orbit service technologies. To facilitate feasible service, the satellite payload must become modular design so that the upgrade and additional performance can be reasonably achieved by state-of-art technologies on space robotics. The satellite bus may become standardized or establish the interface port in order to correspond modular payload design.

The final step is the payload capacity improvement at geo-stationary satellite where the resources for the mission dedicated satellite can be provided from the neighborhood servicing system. The crowd of servicing vehicles will independently participate in the functionally distributed GEO platform to support the power, communication and data processing in addition to the conventional satellite services such as the life extension and the upgrade. The servicing vehicle itself might be configured by modular payload design.

The mission dedicated satellite such as observation, communication and navigation with minimum bus could receive the support from the crowd of servicing so that the payload capacity is significantly improved against the similar satellite sizing. The payload of the mission dedicated satellite can be upgraded or

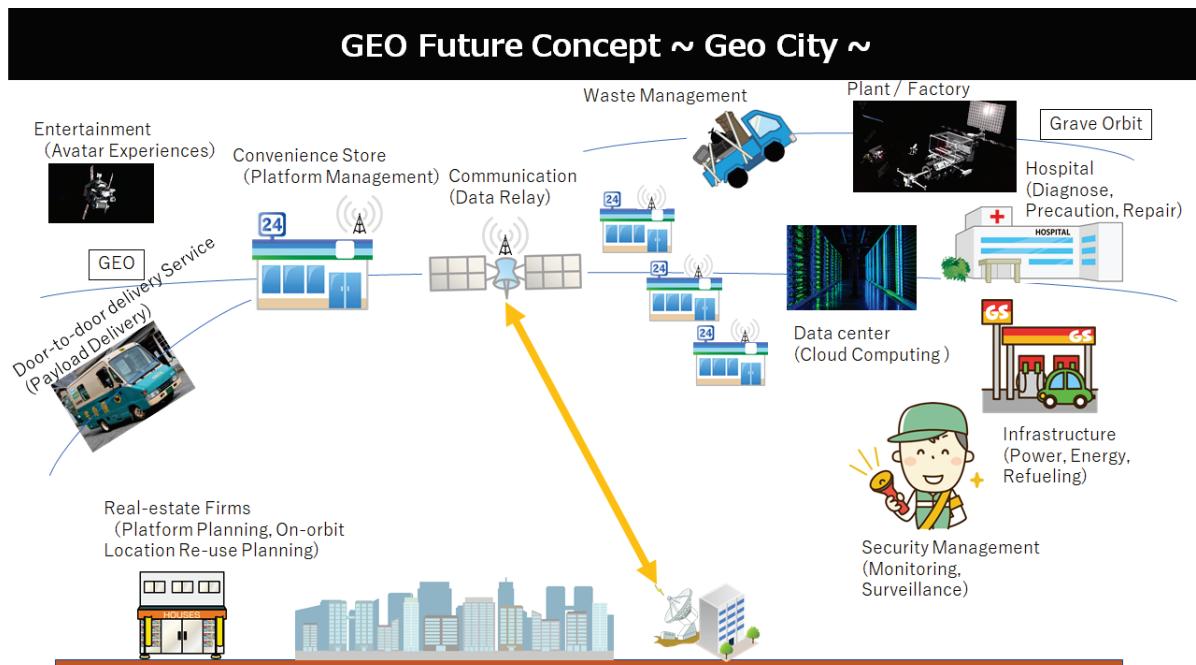


Figure 6: Partnership Opportunities on Platform

replaced by the on-orbit servicing at the second usage.

There are a lot of potential partnership opportunities in the distributed geo-platform and on-orbit services. The platform business may grow like the similarity of the terrestrial business as shown in Figure 6 and become geo-ecosystem in the future including entertainment and waste management as shown in Figure 7. The robotic platform, which may become new infrastructure in GEO, could even disrupt conventional launch/satellite services.

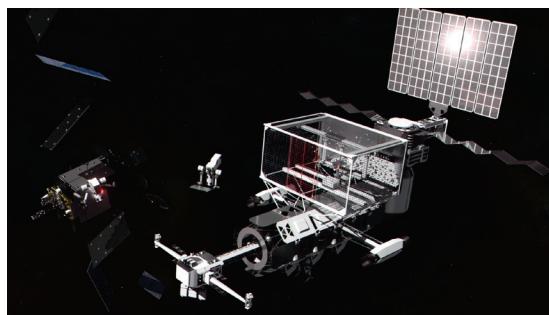


Figure 7: Concept Image of Recycling Plant

The following challenges are identified to need to overcome to realize the functionally distributed GEO platform.

■ Health monitoring and prediction of mission life

In order to utilize the used satellite in orbit, it is needed to estimate the health status of the satellite. It may be useful to predict the remaining mission life. The such technologies are needed to consider at the earlier phase by using telemetry and orbital surveillance.

■ Modular design and interface for payload

In order to exchange and upgrade the payload of the satellite in orbit, it is much easier and economically feasible if the modular design and/or the standardized interface applied to the satellite. The servicing manipulator can exchange the payload on the satellite with periodic operation if the attached interfaces are the same as others.

■ Partnership opportunities in global manner

In order to deploy platform services in global, it is necessary that the new partnership opportunities are created between private sectors as business side and space agencies as technology side.

6 CONCLUSION

The on-orbit service and robotic platform concept for new players are discussed by analyzing the current state of the art for on-orbit service and planned robotic technology demonstration. To achieve robotic platform concept step-by-step, the functionally distributed geo-stationary platform might be one way by utilizing the opportunities of the used satellite.

The potential participation may exist and the several critical partnerships issues are remained such as prediction of mission life and modular design including standardization service through the dexterous tele or autonomous manipulation.

References

- [1] J-SPARC (JAXA Space Innovation through Partnership and Co-creation) , at: <https://aerospacebiz.jaxa.jp/solution/j-sparc/>
- [2] CRD2 (Commercial Removal of Debris Demonstration) for ADR (Active Debris Removal): , at: <http://www.kenkai.jaxa.jp/research/crd2/crd2.html>
- [3] J. Davis, J. Mayberry and J. Penn, "On-orbit Servicing: Inspection, Repair, Refuel, Upgrade, and Assembly of Satellites in Space", Aerospace Corporation, April 2019,
- [4] "NASA Funds Demonstration of Assembly and Manufacturing in Space", PR 20-009, Feb 1, 2020, at: <https://www.nasa.gov/press-release/nasa-funds-demonstration-of-assembly-and-manufacturing-in-space>
- [5] "Astroscale U.S. Enters the GEO Satellite Life Extension Market", June 3, 2020, at: <https://astroscale.com/astroscale-u-s-enters-the-geo-satellite-life-extension-market/>
- [6] "GITAI & JAXA partner to co-create a business concept for the world's first Space Robot Business", September 14, 2020, at: <https://gitai.tech/en/2020/09/14/gitai-jaxa-partner-to-co-create-a-business-concept-for-the-worlds-first-space-robot-business/>