17th International Conference on Space Operations, Dubai, United Arab Emirates, 6 - 10 March 2023.

SpaceOps-2023, ID # 477

Management of Multi-Customer Operations In-Orbit

Hana Bird[a], Theodora Varelidi Strati[b]

[a] *In-Space Missions, Hampshire, UK,* hana.bird@in-space.co.uk
[b] *In-Space Missions, Hampshire, UK,* theodora.varelidistrati@in-space.co.uk

Abstract

In Space Missions' (ISM) first commercial rideshare CubeSat, Faraday-Phoenix was launched in June 2021. The ISM Operations team has been responsible for the planning, testing, and execution of payload activities throughout the mission. In this paper, we will discuss methods for coordination and prioritisation of payload operations across multiple customers with varying commercial goals. Furthermore, this paper will highlight how lessons learnt from Faraday-Pheonix will have a positive impact on future missions by guiding development of our reliable and resilient payload rideshare service.
Keywords: Rideshare, Customers, Communication, Service, Tasking, Payloads

Acronyms/Abbreviations

AOI: Area of Interest
ConOps: Concept of Operations
CDP: Client Data Portal
CSPS: Contact Schedule Planning System
ISM: In-Space Missions
LEO: Low Earth Orbit
SMT: Service Management Tool

1. Introduction

The Faraday Phoenix mission is a follow-on from In-Space Missions' (ISM) first commercial rideshare mission, Faraday-1. Faraday-1 was lost due to a launch failure, and so Faraday-Phoenix was designed in collaboration with the existing rideshare customers. In total, the turnaround from concept redesign to launch was nine months including integration, test and evaluation.

Faraday-Phoenix hosts six operational payloads. The Faraday-Phoenix model showcases the core of ISM's business model; offering sustainable and low-cost access to space by utilising flexible platforms to accommodate multiple payloads and mission partners. This approach encourages collaboration between different payload providers as well as optimisation of mission ConOps and operations design. A ride-share mission offers opportunities for technology demonstration, early service roll-out and acquisition of in-orbit flight heritage of new technologies to payload providers in Low Earth Orbit (LEO).

This paper will highlight the methods used and considerations made for handling the operations of multiple customer payloads hosted on a single platform. This will include the development of internal tools and how they are utilised throughout launch and early operations to further in-orbit operations.

2. Mission Requirements

The key requirement from a platform provider for a multi-customer mission is flexibility and reliability. These two items shape the derived requirements of the mission and supporting system design. They provide the focus on creating a system that employs a high level of automation both on the ground and in orbit, as well as systems that allow for proper capture and tracking of performance and metrics.

These key requirements make up the baseline of ISM's own standardised platform and operations design. The benefit of having standardised platforms is that they allow for a consistent product, simplifying operations and increasing reliability and quality. Payload requirements are captured at the initial 'Manifest' stage of the mission, where the process of matching a payload to one of the ISM platforms is begun. Requirements can then be shaped into the overall Concept of Operations of the payload, and as such, the mission as a whole. Some payload and customer level requirements may go on to form the Service Level Agreements, should the customer request that ISM be responsible for the operations of the mission. The payloads on-board Faraday-Phoenix have different use cases which translate to varying requirements (Table 1). This highlights the importance of managing customer expectations and communicating in advance of any expected impacts on the service.

Table 1. Key requirements that must be defined for the payloads and mission.

Requirements	**Description**
Payload Usage	Operational time of the payload. This varies based on the requested activities but there may be a significant difference between technology demonstrators and payloads in service which may require continuous operations.
Data Volume	Data to be downloaded daily or weekly. This affects the data budget and the number of ground station contacts that will need to be dedicated to downloading payload data.
Power Usage	Power draw of the payloads during different activities. This requirement determines whether payloads can be operated at the same time and the duration of activities.
Pointing mode	The ADCS mode to operate the payload, which can impact service for other payloads.

As expected for missions using a single platform to host multiple applications there is the challenge of conflicting needs between customers. Hosting on a standardised platform allows ISM to sell and operate a defined set of similar spacecraft with distinct operational cases between each type of platform. The mission specifications are made available to potential customers in order to best match the payload with the platform. The specifications are provided for both the physical platform for physical rideshare missions, but also for the service offerings for serviced and digital missions (i.e. where customer software is operated on ISM hardware).

3. Development of Internal Tools

The challenges of managing a multi-customer mission can be mitigated by bringing together all the customer management activities into one place. The ISM Service Management Tool (SMT) has been developed to provide this in an on-line tool. The SMT allows customers to transition through the entire mission lifetime in one place: manifestation of a payload; gathering requirements and developing ConOps allowing our internal team to best match the customer with a platform; in-orbit operations; keeping updated on payload performance; logging any issues or anomalies; and managing downtime of the platform for improvements and upgrades. This 'through life' approach encourages transparency and the development of heritage across a mission. A tool such as the SMT is critical for missions that hold multiple customers, to ensure that service levels are constantly being maintained and an open but tracked line of communication is established between the customer and the supplier. Metrics can be logged, and performance reported on, over the lifetime of the collaboration.

At Manifest stage, the incoming customer will be assigned an ISM account holder, who they can liaise with via the SMT throughout the development of the mission. All interactions are logged, including internal notes taken by the account holder or relevant engineers. This means that decisions can be logged in real-time and referred to when required.

During the in-orbit operations phase of the mission, the SMT is used to ensure transparency between the Operations Engineers and the customers on the status of their payload as it progresses through commissioning. Issues that are raised through the ticketing system, hosted on the SMT, can be tracked by those who are assigned to the project and responded to as appropriate, as well as being logged against the defined Service Levels. This encourages the project team to ensure that decisions on the mission are always being made with the customer in mind.

The Contact Schedule Planning System (CSPS) was developed to optimise the mission planning, as well as automate many of the background activities that go into mission management. The CSPS links the tasking portal to the rest of the ground segment planning, handling on-board schedule generation, as well as ground contact co-ordination. It uses a RestAPI to link into the designated Ground Segment provider. This interface is used by most major service providers, and so allows for an agnostic system and better flexibility depending on customer requirements. Additional rules can be factored into the planning system; for example, if a customer contract requires a minimum data latency that requires specific ground contacts, this can be configured.

The Client Data Portal (CDP) is our central area for all payload functions and data transfers. Whilst the SMT centres on communication, transparency and exchange of information, the CDP is used for tasking of each payload and collection of data directly from the satellite. The CDP was developed with the key functionality of being scalable. The tool allows for flexibility for both the customer and the operators by managing the tasking of individual payloads up to whole constellations. This way a mission can be built up from a pathfinder to a whole constellation, encouraging further cooperation with existing customers.

Payload Tasking requests are submitted using date/time indicators and duration. This is then taken through the whole ground chain, arbitrated against the pre-defined criteria, usually agreed in the Payload concept of operations, and then confirmed/rejected based on spacecraft availability. The pre-defined criteria could be the length of time taken for a payload data capture, or the transfer time between the payload and the data store. The current design allows for tasking to be re-configured easily; furthermore, pre-defined settings can be changed within this tool and stored for later use. Payload taskings are logged, and metrics used to ensure that the operations and general spacecraft health and performance are tracked and available to the customer. This is another inherent function of the CDP, allowing easy and traceable access to satellite data, both from the payload and the platform.

The safety of the satellite and inherently the payload is also factored into the design of the CDP. This is essential when managing multiple payloads across a single platform. As the payload development and ConOps development progresses in the Manifestation stage of the mission, boundaries are set around Payload operations to ensure that the system is always able to maintain suitable conditions across the platform (i.e. battery depth of discharge). This will be managed by the System engineers at design phase, ensuring that the platform is capable of conducting the required payload operations. Once in orbit, the Operations engineers' responsibility lies in implementing any changes needed to the system as a result of successful completion of the platform and payload commissioning.

As the functionality and complexity of the tool develops, there will be additional capability of tasking against an Area of Interest (AOI). Further improvements to the system analysis of the spacecraft will also be included in this development to allow for increased levels of real-time safety checking.

4. Multi-Payload Operations

Initial discussions are key to understanding how the different payload providers plan to use the ISM rideshare service and how to best adapt the operations tools to the different requirements. Power and thermal analysis become critical for these discussions. A system model has been developed to perform power and data analysis based on the mission and payload ConOps. The system model has been expanded as live data from the spacecraft became available and different platform and payload activities were executed in orbit during commissioning phase. In turn this fed into the operational constraints and provided a better definition of what a 'Day in the Life' would be for Faraday-Phoenix during nominal operations.

Daily planning is required from the Operations team in coordination with Systems engineering and Service Delivery team. As described in Section 3, communications with the customer are handled through the Service Management Tool. This is checked daily by the operators to address any tickets raised by the customer and update any ongoing investigations for the customer's awareness. The customer and operators' interaction with the portal is outlined in Fig. 1.

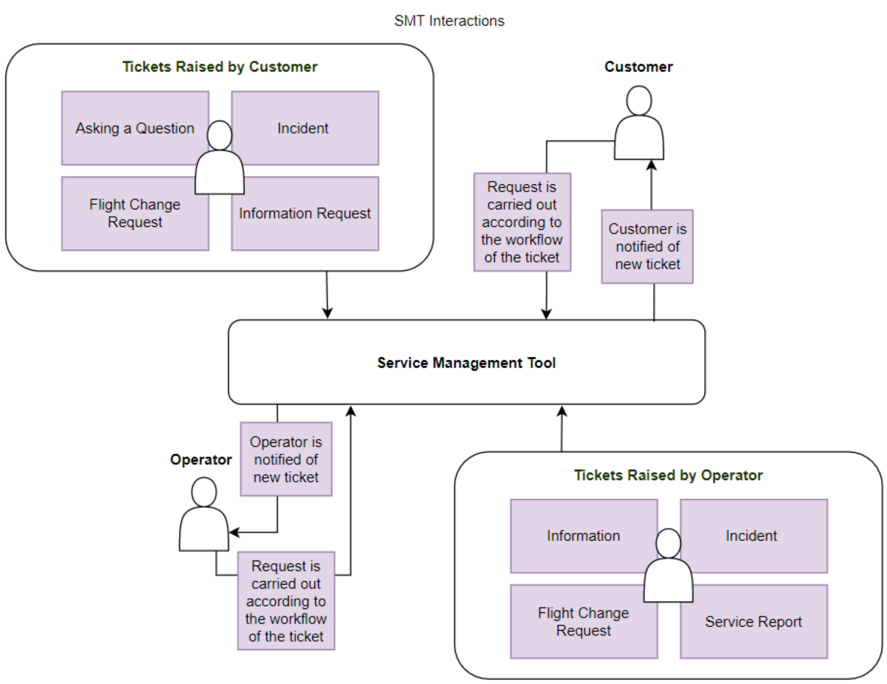

Fig. 1. Customer Journey through the SMT.

A significant task is to manage the various and sometimes conflicting requirements of the customers. Some of the criteria for prioritising certain customer activities are:

- Current power and thermal profile of the spacecraft

- Spacecraft Availability
- Impact on other payloads
- Service Levels that need to be met for each customer
- Opportunity to exercise the specific tasking request which mainly depends on ground station contacts availability

Tasking conflict resolution is also handled by the CSPS and currently operates on a first come, first served basis with the option of operator intervention following a fair-use policy. This model will be expanded for future ride-share missions with the goal of operating on the basis of a fully automated chain. Therefore, logic will be introduced to the tool to take into account the contractual service levels.

5. Lessons Learned

Initially, it was a challenge to find the right balance between personalised communication methods and utilising the functionality of the management tools. As the mission operations developed, routines were established to better maintain communication with payload customers. A key lesson learnt from this experience was to initiate the use of the tools as early in the mission as possible. This allows both operators and the customers to familiarise with the tools and highlight any areas of possible improvement to the flow of communication. The transition from early phases of the mission to nominal operations becomes much smoother as a result.

Throughout the commissioning campaign of the Faraday-Phoenix mission, the inclusion of the customers at each phase was critical. During these periods of the mission, at LEOP and in commissioning, it became imperative to ensure that the customers were kept up to date with progress. This inclusion allowed an open communication format, and resulted in customers who had a better understanding of the mission and its challenges. Weekly reports were sent out through the Service Portal to ensure that all customers were informed at the same level on the progress of the scheduled activities. In addition, weekly/bi-weekly meetings were scheduled (as needed) in order to maintain customer relationships and understand better any issues/concerns on their side.

Templates and procedures around customer management were also developed, to standardise communications and maintain consistency even in periods of rapidly changing schedules and plans. These templates and procedures were then utilised on other missions and will be developed into our standard process. It quickly became evident how important it is to plan and create these templates for different scenarios. This significantly decreases the time to inform customers of any anomalies and changes to the operations plan.

Another key lesson from this mission has been the importance of managing customer expectations. Maintenance operations and debugging activities are likely to occur at various points throughout the mission and, especially during the commissioning phase, they may result to outages in service. Planning these activities in advance (if possible) and more importantly informing the customer of the expected duration and the impact it will have on their service is very beneficial to them.

6. Conclusion

As ISM's first spacecraft in orbit, Faraday-Phoenix has offered the opportunity to better understand the challenges of managing multiple payloads in-orbit and to further develop ISM's operations philosophy. Being a ride-share mission, different tools have been designed on a mission and payload agnostic basis in order to provide a flexible and reliable service. The main functions of the tools are to facilitate communication with the customer, submit payload tasking requests, and allow for conflict resolution. Further work is being undertaken to implement the lessons learnt for future missions and to improve the user-experience by adding more capabilities to the existing tools.

The ISM rideshare service promotes the sustainable use of space by minimising the number of launches, reducing the carbon footprint due to reduced manufacturing, and offering an opportunity for upgrading software and therefore extending the use of different payloads. The latter will be further expanded with the next ISM ride-share mission, Faraday-Dragon, focusing on the Asia-Pacific region. Further work will be targeted at managing multiple missions with an infrastructure that can be reprogrammed and upgraded in orbit pushing further the limits of payload operations.