Payload Programme Cycle

This chapter provides an overview of the many preparatory activities that have to be completed by both the user and the Agency before the flight takes place.

Fig. 48 helps users to appreciate:
- outer circle A: the major programme phases that payloads generically undertake;
- circle B: a perspective of the corresponding hardware development phases;
- circle C: the generic evolution of the science objectives and aims;
- circle D: the Agency point-of-contact for users to address their programme technical and programmatic issues and concerns.

The inner circles are synchronised with the outer circle.

Payload Reviews and Planning Template

As part of the programme cycle, a number of reviews are planned in order for the Agency to determine payload progress and compliance with Columbus laboratory requirements. These reviews are:

- Preliminary Design Review (PDR), to demonstrate the payload functional requirements and compatibility of preliminary design with the Columbus carrier, ground physical and operations environments, payload integration schedule and initial payload data sets;

Fig. 48. Major payload programme phases.

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- Critical Design Review (CDR) to demonstrate the payload detailed design and compatibility with the Columbus Laboratory, and payload compatibility with the ground physical and operations;

- Preliminary Acceptance Review (PAR) to demonstrate the payload qualification/acceptance programme of the Flight Model (FM) and associated equipment prior to shipment to Columbus Laboratory compatibility testing;

- Final Acceptance Review (FAR) to demonstrate the completion of the qualification testing, the post-shipment checkout and the laboratory/payload interface compatibility verification;

- Safety Reviews (SRs) to demonstrate the progressive reporting of all payload hazard items, that their assessment and appropriate hazard controls have been implemented and hazard reports have been completed.

The Agency will provide support to payload users in the preparation of material for these reviews. The planning of these reviews and the major payload activities are shown in Fig. 49. The indicated schedule is typical for major complex payloads (Class 1 facility types). The major phases shown are detailed below.

**Flight Planning**

The first step in the programme cycle begins with entering payload information for evaluation and possible inclusion into the ESA-specific Partners Utilisation Plan (PUP). The information required is highlighted in Fig. 50.

All the ISS Partners regularly develop and maintain their PUPs for combination into the Consolidated Operations and Utilisation Plan (COUP). This COUP provides the ISS Operations and Utilisation Plan for the upcoming 5 years and includes the assignment of new payloads for flight in a specific year.

The payloads addressed in this chapter are complete rack facilities or complex instruments on an Express Pallet Adapter size; these are sometimes known as Class 1 or Facility Class payloads. Payloads 'embedded' in a facility (sometimes known as Class 2 payloads) have specific programme requirements and capabilities that are available directly from the facility-responsible developer. Their schedules are considerably shorter than for the Class 1 payloads, as are the drawer-type payloads to be accommodated in the EDR.
Once ESA has accepted a payload into its PUP, the Agency then prepares the Payload Interface Agreement (PIA) for agreement with the payload developer. The PIA and its Addendum detail the programmatic requirements, including roles and responsibilities as well as schedules and commitments for specific flights and on-orbit needs. Following signature of that agreement, the Agency initiates payload interface control documentation development. The major items of this documentation include:

- **Interface Control Document (ICD)**, which provides the controlled description of all the interfaces between the Station element and the payload.

- **Payload Verification Plan (PVP)**, which provides the controlled description of the ICD verification requirements and their traceability. For every ICD developed, there will be a corresponding PVP to be developed;

- **Payload Data Set (PDS) records**, which provide the controlled description of those data needed to integrate a payload into the physical and operational environment of the Station.

The Agency will undertake the development of this documentation together with the payload developer as part of its utilisation integration responsibility.

This documentation is regularly updated as the payload development proceeds and the payload assignment to a specific Increment approaches. The updating is generally synchronised with the various payload development reviews, where payload developers can expect to provide the majority of the review inputs.

The ESA Utilisation Manager provides the Agency point-of-contact during this starting phase.

Around 30 months before the year for flight, further detailed payload inputs enable ESA planners to evaluate the payload for a specific Increment within that year. An Increment is of about 3 months duration and basically reflects the period between two consecutive Shuttle visits.

Once the payload has been assigned to a specific Increment, then the ESA Payload Accommodation Manager (PAM) becomes the Agency point-of-contact and analytical integration can start. The PAM is responsible for the total Increment payload complement from this point on until the successful on-orbit activation of the payload has been accomplished.
During this step, the payload development model philosophy is established to ensure that adequate payload models are developed to support flight qualification, crew training and in-flight ground control operations.

The necessary tools required to support training will be consolidated at Laboratory level for a specific planning period. These tools, including training hardware and software as well as high-fidelity simulators, will support the training activities, for both flight and ground crews, that begin during this step and continue through the programme cycle.

**Analytical Integration**

The second step in the programme cycle begins with a provisional manifesting of a payload for inclusion in an Increment’s payload complement in the Columbus Laboratory or on its external accommodation site.

Each payload is analysed in sufficient detail to ensure individual payload compatibility with other Columbus Laboratory payloads as well as with the Columbus Laboratory systems.

The analytical integration is shown in Fig. 51. The Agency undertakes the analytical integration function as part of its utilisation integration responsibility. Should incompatibilities be established during this process, then the Agency will require the payload user to develop and establish a solution that ensures compatibility.

**Physical Checkout**

The third step in the programme cycle starts off with the user completing payload development. That means, for example, that the payload checkout has been completed in readiness for Columbus Laboratory compatibility verification.

The compatibility verification is accomplished through the Rack Level Test Facility (RLTF) for rack payloads or, for external payloads, through the Suitcase Test Equipment (STEP) capability.
The RLTF is an integration and test environment that provides a high-fidelity emulation of the resource interfaces between an ISPR and the Columbus Laboratory. This capability provides the opportunity for payload developers to complete payload verification and acceptance. The STEP provides an equivalent capability for external payloads.

The Agency leads the physical checkout function as part of its utilisation integration responsibility. The payload user is expected to support this activity and ensure that the payload is working according to the agreed baseline.

Following the successful completion of verification and acceptance activities, the Payload Accommodation Manager (PAM) accepts and certifies the payload for flight readiness, and subsequently delivers the qualified payload to the launch integration process.

Launch Integration
The fourth step in the programme cycle begins with the delivery of the qualified payload to the launch integrator by the PAM.

For the Columbus Laboratory launch complement, the Columbus Prime contractor represents the launch integrator and performs the actual integration of the payload racks into the laboratory. The launch complement payloads will be tested in their on-orbit locations to verify power-up and checkout. This is followed by a short mission sequence test to verify simultaneous payload operations. After completion of all tests, the Columbus laboratory is then delivered to the Space Shuttle launch site for Orbiter integration and launch.

For post-Columbus Laboratory launch payload racks, as well as for all Columbus Laboratory launch complement mid-deck stowage items and external payloads, the launch integrator is represented by the NASA Payload Mission Integrator (PMI) team. The PMI team will receive the payload items from the PAM at the Shuttle launch site. The PMI will integrate the Mid-Deck Lockers and payload supply items into the Mini Pressurised Logistics Module (MPLM) or on to the unpressurised payload cargo carrier.

On-Orbit Operations
The fifth step in the programme cycle begins with the arrival of the payload at the ISS, where it is transferred into its Columbus Laboratory on-orbit location. After physical integration, a short activation checkout is then performed to verify payload readiness for on-orbit user operations.

Up until the successful accomplishment of payload activation, the PAM is the user’s primary point of contact with the ISS programme. After successful payload activation, the Payload Operations Manager becomes the European point of contact.

On-orbit operations cover a wide variety of aspects and include nominal operations to accomplish the payload's mission objectives as well as any nominal servicing and maintenance that may be
needed to ensure the continued well-being of the payload’s equipment. The payload users, located at their local USOC or UHB, will be able to monitor and interactively control their experiment operations based upon the data received through the ground communications.

At the completion of the payload’s on-orbit operations, it is shut down and transferred from the ISS to the returning Shuttle. All mission samples and specimens are transferred to Shuttle mid-deck or MPLM stowage for return to Earth, or to the ATV for controlled destructive reentry.

**Landing De-Integration**
The sixth step in the programme cycle begins with the delivery of the payload to the point-of-contact by the NASA PMI after de-integration from the Shuttle and/or MPLM.

The point-of-contact performs a local checkout of the payload and follows this up with the transportation preparation and shipment of all payload items to the payload developer site.

In parallel with these transportation activities, the User Support and Operations Center (USOC) provides a complete history of all the payload’s telemetry/telecommanding history to the payload user in an electronic form.

**Payload Return**
The last step in the programme cycle begins with the delivery of the payload equipment, including the complete history of electronic data products, to the payload user. The payload users are expected to make a detailed examination of their equipment and data, and subsequently prepare both their ‘lessons learned’ and scientific results. The ‘lessons learned’ will be consolidated at Columbus Laboratory level with the goal of identifying whether system issues need to be addressed in pursuit of improving payload control and support functions.

This last activity of payload return marks the end of the payload’s utilisation for that campaign.

**Safety**
The role of safety and product assurance is continuously active from the beginning through to the completion of a payload’s engagement in the ISS programme. All ground and flight segment equipment and operations are regularly assessed for hazardous situations that could endanger the crew, other payloads, ground team, etc. Regular safety reviews are organised within the programme cycle, when all the hazards and hazard controls are addressed. The successful completion of these reviews plays a very significant role in the eventual certification of flight readiness for a payload.

**Smaller Payloads**
Essentially the same kind of steps will have to be followed by smaller Class 2 payloads but in a simplified and shortened schedule. It is the objective of the Programme to offer rapid access for less small and complex payloads.