IRIDE EAGLET-II LEOP: A New Operational Paradigm for Constellation Operations

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The increasing adoption of satellite constellations in LEO orbit is driving new operational challenges during the Launch and Early Orbit Phase (LEOP) that become increasingly critical. Thousands of satellites are sharing the Low Earth Orbit, elevating the importance of phasing strategies and collision mitigation, which are now central topics in mission design discussions.

This paper presents an operational case study of the LEOP for an 8-satellite (EAGLET-II) constellation within the IRIDE programme, operated by OHB Italia in its first mission hosted and controlled in the newly established proprietary Mission Control Center.

The paper will focus on pre-launch activities such as trainings, operational product preparation to monitor and control a constellation in its nominal and potential contingency modes, their validation and processes set-up covering all phases of the mission, from LEOP to Commissioning to Routine.

The operations execution strategy will be described according to the concept of operations, bringing light to the activities carried out during the LEOP, when the operations teams managed the constellation of eight satellites. The constellation was successfully guided to a nominal configuration through a total of approximately fifty ground contacts. The efficient operational strategy, combined with a fast-paced approach for anomaly management, allowed the beginning of Commissioning activities within an exceptionally short timeframe of less than three days.

Despite the significant results achieved, the LEOP was conducted by a relatively novice operations team that progressively developed and consolidated its expertise throughout the preparation phase and, most notably, during the execution of the initial on-orbit activities. As a direct consequence of the lessons learned during this first launch, the test and validation phases of the mission's future LEOP activities will be tuned to have a significant improvement. This paper presents and discusses the most critical of these lessons.

Keywords— LEOP, Constellation, IRIDE, EAGLET-II, Mission Control Center, Operations

I. CONTEXT

Over the past five years, the number of active satellites in orbit has increased from approximately 3,300 in 2020 to more than 11,500 in 2024, primarily driven by the deployment of large-scale LEO constellations. This rapid growth is expected

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to continue, with projections indicating up to 100,000 satellites in orbit by 2030.

The main factors that are driving this massive expansion are:

- Reduced access cost to the space
- High global demand about connectivity, earth observation and defense
- Redundancy and low latency
- Higher competition with new players all around the world.

The LEOP phase is becoming increasingly critical in this scenario for many reasons.
The high number of satellites, especially in Low Earth Orbit, is increasing the complexity of the operations, leading to a shorter time window available for operations, debris mitigation and collision avoidance, parallel operations with high workload and limited resources and more dependance on automatism.

The role of ground operational teams is, therefore, becoming more critical, as they provide the necessary expertise, flexibility, and oversight required to manage high-tempo, parallel, and risk-sensitive operations.

II. OBJECTIVES

This work shows a case study on the operation and management of a LEO Satellite Constellation that is made up of 8 satellites (EAGLET-II) and part of the IRIDE Program.

The main objectives of this contribution are:

- to describe the operational approach adopted for the management of this constellation;
- to outline the overall preparation and execution of the operations;
- to summarize the handling of anomalies and the key lessons learned from the LEOP.

The preparation phase included:

- definition of constellation-level operational strategies;
- mission control room setup (Main, Support, Special);
- planning of contact windows and mission activities;
- development and validation of flight and ground operational procedures.

Special emphasis was placed on pre-operational simulations, aimed at validating procedures and mitigating potential risks prior to execution.

During the execution phase:

- the satellites were operated by an integrated team (Flight, Ground, System, Management);
- Telemetries were evaluated to assess the status of the constellation
- Within the first three contacts for each satellite, LEOP might be declared as completed, and the satellites brought to a Mission nominal mode

The teams were trained to face several anomalies. The resolution of the anomalies was evaluated during the anomaly review boards *(ARBs)* where the teams involved had to assess the issue, trade – off the different resolution approaches and to take a decision to be able to continue the operations nominally without further impacts on the LEOP timeline.

The experience gained from this case study led to the identification of key lessons learned, providing valuable insights for the design and operation of future batches of this constellation.

III. LEOP PREPARATION

The success of a satellite constellation mission relies on thorough and structured preparation across all operational phases, from launch to routine operations. However, particular emphasis must be placed on the Launch and Early Orbit Phase (LEOP), which is widely recognized as the most critical and time-constrained stage of the mission. During this phase, the satellites transition from a launch configuration to fully functional space systems, and any anomaly can have irreversible consequences on mission success. For the EAGLET II constellation as part of the IRIDE mission, this criticality is further amplified by the presence of eight satellites, which significantly increases operational complexity in terms of coordination, scheduling and ground segment resource management, especially during the early phases of orbit acquisition. As a result, the importance of rigorous and well-structured LEOP preparation becomes fundamental to mission success. This preparation is strongly driven by the generation and validation of a complete set of Flight Operations Procedures (FOPs), which represent the core operational reference for the entire LEOP and subsequent mission phases. The FOPs are developed to cover all expected nominal activities as well as a comprehensive range of contingency scenarios, ensuring that every critical spacecraft function is fully addressed in a structured and executable manner. The development of Flight Operations Procedures (FOPs) is grounded in a well-structured and strictly controlled Satellite Reference Database (SRDB). The SRDB plays a key role in configuration control and version traceability, ensuring that each FOP set remains fully compatible with a specific EAGLET II spacecrafts and ground segment software. Building upon this controlled baseline, the validation of FOPs for the EAGLET II mission is conducted through a functional simulator (FLATSAT) that reproduces the logical behavior of the spacecraft and its interfaces with the ground segment. The simulator is configured using the same SRDB instance associated with the target operational baseline, thereby guaranteeing consistency between procedure definitions, onboard configurations, and simulated system responses. The validation process is initiated by importing the relevant FOP set and associated configuration data into the MOC test which is the simulation environment. Each procedure is executed using this test environment, ensuring that command generation, uplink formatting, and telemetry processing are representative of operational conditions. The simulator processes telecommands in accordance with its internal subsystem models and returns telemetry reflecting the expected spacecraft state evolution.

Indeed, the validation activities process focuses on several key aspects. First, the correctness and completeness of command sequences are verified, including parameter ranges, execution order, and timing constraints. Second, telemetry monitoring points embedded within the procedures are assessed to ensure that all critical system states and transitions are observable and correctly interpreted. Third, the logical consistency between procedure steps and spacecraft behavior is evaluated, with particular attention to state-dependent operations and inter-subsystem dependencies. The simulator also supports timing analysis by reproducing execution latencies, command acknowledgment delays, and telemetry acquisition cycles. This allows validation of temporal constraints, including wait times, synchronization points, and timeout conditions defined within the procedures.

Moreover, all validation runs are systematically recorded, any discrepancies are classified according to their origin—procedure definition errors, inconsistencies in the SRDB, or limitations in the simulator models—and are tracked within a formal anomaly management process. An iterative correction cycle is then applied. Updated FOPs are revalidated against the same SRDB-controlled baseline to confirm issue resolution and to ensure that no regressions are introduced.

Through this methodology, all EAGLET II FOPs are operationally sound, resilient to anomalies, and fully aligned with the spacecraft and ground segment configuration prior to deployment in real mission environment.

Following the iterative validation cycle, a formal campaign of System Validation Tests (SVTs) is established to qualify the Flight Operations Procedures (FOPs) under representative operational conditions, with particular emphasis on those supporting the Launch and Early Orbit Phase (LEOP). For the EAGLET II mission, the SVT campaign is organized into three dedicated validation sessions, encompassing approximately three hundred FOPs. A subset of these procedures is allocated to LEOP-critical activities, reflecting the operational sensitivity, time constraints, and limited recovery margins that characterize this phase.

The first System Validation Test (SVT-1) session wass defined to verify core platform and ground segment functionalities that are essential for both LEOP and subsequent operational phases. The session focuses on the validation of Flight Operations Procedures (FOPs) associated with S-band communications, real-time and historical telemetry management, scheduler, onboard data handling, X-band communications, Attitude and Orbit Control System (AOCS) activities, and Automatic Identification System (AIS) data management.

The second System Validation Test session (SVT-2) shifted the focus toward FOPs related to power and thermal management, optical payload operations, propulsion activities, and selected anomaly handling scenarios.

The third System Validation Test session (SVT-3) completed the validation campaign by addressing the remaining mission scenarios. This latter session was dedicated to the validation of FOPs related to security operations, Patch & Dump activities, and Telemetry, Tracking and Command (TT&C) management.

Following the completion of the SVT campaign, a dedicated and intensive simulation campaign was conducted under highly realistic operational conditions. Given the criticality of LEOP, this campaign was designed to replicate the full operational timeline with strict adherence to real-time constraints, incorporating both nominal and contingency scenarios, as well as the operational dynamics associated with Flight Control Team (FCT) shift handovers. The campaign was structured as a series of continuous simulation runs, each reproducing the chronological sequence of LEOP activities from spacecraft separation through initial stabilization and early commissioning. The functional simulator was initialized with post-launch conditions including initial attitude states, power availability, communication visibility windows, and subsystem configurations. The MOC test environments were fully integrated, and all operations were conducted using the nominal control interfaces, ensuring procedural and environmental fidelity. Nominal scenario executions form the baseline of the simulation campaign. These runs validated the end-to-end execution of LEOP FOPs under expected conditions. Contingency scenarios are interleaved with nominal runs to assess the robustness of procedures and FCT reaction under degraded conditions. The simulation officers, via the functional simulator, introduced anomalies such as partial deployment events, unexpected attitude dynamics, communication interruptions, and inconsistent telemetry. Corresponding contingency FOPs were executed to apply recovery strategies and re-establish nominal configurations. These scenarios were designed to stress both procedural logic and Misssion control team coordination under time-critical conditions.

A key feature of the simulation campaign was the incorporation of FCT shift handovers, reflecting the continuous nature of LEOP activities. Simulation runs were structured to span multiple shifts, requiring formal handover processes between outgoing and incoming teams. Dedicated checklists for shift transition were validated, including status reporting, configuration verification, anomaly tracking, and transfer of situational awareness. The effectiveness of communication protocols and the completeness of handover documentation are critically assessed to ensure continuity of operations without loss of information or increased risk. The campaign also evaluated workload distribution and team interaction across functional roles, including spacecraft operations, ground systems, and subsystem specialists. Scenarios are designed to create periods of peak activity, requiring prioritization and coordination, as well as quieter phases where monitoring and preparation dominate. This allowed assessment of both procedural usability and human factors under realistic operational pressure. This intensive LEOP simulation campaign ensured that procedures, systems, FCT, ground and subsystem specialist teams are fully prepared to manage both expected and unforeseen conditions, while maintaining continuity across shift transitions in a real mission environment.

After the LEOP simulation campaign, a formal Dress Rehearsal (DR) campaign was conducted as the final validation step prior to launch. The objective of this campaign was to demonstrate the end-to-end operational readiness by executing the complete set of LEOP nominal flight operations procedures in a fully integrated and time-constrained environment, replicating as closely as possible the conditions of the real mission minutes following the separation from the launcher. The outcome of the Dress Rehearsal served as a primary input to the Operational Readiness Review (ORR). After the DR session, the MOC platform was frozen to avoid any misconfiguration prior to the launch date.

Evidences from the entire validation campaign, including SVTs, LEOP simulations, and the Dress Rehearsal, were presented and reviewed by our customer which is the European Space Agency team.

Key aspects evaluated during the ORR include:

- Completeness and validation status of all FOPs, with emphasis on LEOP procedures.
- Consistency and configuration control of the SRDB baseline.
- Performance and reliability of ground segment systems.
- Results of simulation campaigns, including anomaly resolution and regression validation.
- Readiness of Flight Control Team (FCT), including training, shift organization, and handover processes.

Successful completion of the ORR results in the formal declaration of Operational Readiness. This milestone confirms that all procedures, systems, and personnel are fully prepared to support the LEOP phase and subsequent mission operations. It represents the final authorization to proceed with launch and in-orbit operations, with a high level of confidence in the ability to execute all planned activities safely and effectively.

Prior to the launch date, an exstensive campaing of Data Flow Tests was planeed and exeucted with all the antennas available in the network of the selcted GSN provider. The main objective was the verification of the MOC-GSN connection. The campaign has been conducted analyzing:

- the TCs released from the MOC with respect to the data received by the antennas
- The TM data published on the antenna side and received on the MQTT channel at MOC level.

The DFTs were repeated with a subset of antennas on the launch day to exclude any issue at least for the first passes after deployment from the launcher.

The LEOP activities have been carried out from the Mission Control Centre (MCC) located at OHB-I premises in Rome. The MCC have been developed to host IRIDE EAGLET-II LEOP, commissioning, and routine activities of all different batches composing the constellation of 24 EAGLET-2 satellites. The Mission Control Centre will expand to support additional missions for which OHB-I has and will be named responsible for the operations preparation and execution.
In the frame of the IRIDE EAGLET-II programme, the MCC provides secure operators access to the front-end interfaces of the MOC and of the operational tools necessary to prepare and executed all the related tasks. In the current configuration, the MCC foresees the following setup:

- Main Control Room (MCR)

The MCR is used as the primary control room for nominal operations. For the successive IRIDE EAGLET-II launches, it will serve as control room for LEOP activities. The MCC hosts a total of nine workstations assigned to different operational roles; however, they are interchangeable and not permanently bound to specific functions. In addition, one workstation dedicated to administrative purposes, equipped with a quad-monitor setup. The wall display system consists of two 65" screens and one central 43" display and are used to provide a high-level insight about the ongoing activities. In fact, those display the operational timeline with the details of the upcoming passes and a subset of telemetry data to monitor the data flow between MOC, ground antennas and the satellites.

- Support Control Room (SCR)

The SCR hosts the system engineering functions, with SYS personnel seated in this room to provide technical support to the operations team during both routine and critical operational phases. In such a room a total of seven workstations assigned to different system support roles; however, they are interchangeable and not permanently bound to specific functions. The wall screens in the SCR are managed directly by the support engineering team and might be used, if necessary, to display the same information as in the MCR.

- Special Operations Room (SOR)

The SOR is designed to support operational flexibility. During LEOP phases, it can be used to host routine operations, allowing the MCR to focus on launch and early orbit activities. During routine operations, the SOR is used to perform specific or intrusive activities on the constellation without impacting nominal operations in the MCR, such as onboard software updates, enhanced monitoring activities, collision risk analyses, and other specific operational activities that require isolation from nominal operations. In specific cases, it might also offer an ideal environment to host Anomaly Review Board (ARB) with the aim to avoid impacts to ongoing operations while the engineering teams focus on the technical analysis. In the SOR a total of four workstations assigned to different system support roles; however, they are interchangeable and not permanently bound to specific functions.

During the LEOP preparation, the MCC has hosted the simulation campaign, and its design has been further improved based on the lessons learned analysed at the end of each session.

Among the MCC functionalities, an important operational asset is the voice loop which is fundamental to ensure smooth and clear communication among the different teams involved in the operations execution. For the IRIDE EAGLET-II programme, OHB-I has adopted a cost effective solution during simulation and real time operations. Such a tool has been intensively tested prior and during the simulation campaign and has been considered a valuable support thanks to its high user configurability. In fact, it allows the generation of independent channels hosting the different OPS role. At each push-to-talk action, the operator needs to select the channel and therefore the OPS positions that will be able to listen to the message.

IV. LEOP EXECUTION

For OHB-Italia, managing for the first time the operations preparation for a satellite constellation (comprising 8 satellites with the first batch, 16 with the second, and 24 with the third) the first LEOP (Launch and Early Orbit Phase) represented a significant test of all prior work. Following multiple lift-off delays, which tested and validated the exceptional adaptability and responsiveness of the teams involved, operations were ready for the launch day.

The LEOP phase of a satellite is considered complete once the following conditions have been met: all primary subsystems are stabilized and under control; the solar arrays have been successfully deployed; correct transitions between spacecraft and AOCS operational modes have been verified, culminating in the nominal standby/nominal mission configuration; and secure, authenticated S-band communication has been established.

All these activities were executed across the first batch satellites following four Flight Operation Procedures (FOPs).

A. First Acquisition

The first contact procedure involves the initial telemetry acquisition via a blind acquisition, enabling periodic real-time telemetry generation. After the FCT verifies that the satellite and AOCS mode are in the expected configuration, historical telemetry recorded onboard from first power-on until the initial contact is downloaded and subsequently analyzed offline. Manual solar panel deployment is performed even if an automatic deployment sequence is present as a safety net. Upon confirmation that attitude telemetry is nominal and clearance is granted by the systems engineers, the FCT performs the first AOCS mode transition, enabling precise Sun vector measurements. The satellite then can autonomously execute out-of-visibility attitude transitions between NADIR pointing and Sun pointing based on orbital position. The first contact concludes with a request to download the onboard FDIR configuration.

B. Second Acquisition

During the second contact, following the blind acquisition, if the satellite is in a nominal configuration, FCT, with systems engineers' approval, transition the satellite to a target-pointing attitude, aligning antennas toward the ground station to optimize data download. A return to nominal attitude is pre-scheduled onboard a few seconds after loss-of-signal (LOS) to ensure automatic and safe management of out-of-visibility attitude changes.

C. Third Acquisition

The third contact procedure transitions the satellite from the initial operational mode (used for onboard configuration changes) to the nominal mission mode, preparing it for operational activities such as AIS acquisition,payload-specific modes and orbital maneuvers. Following a blind acquisition to establish the communication link, FCT, with systems engineers' approval, transition the satellite to target attitude while scheduling a future return to the mission nominalprofile. Historical telemetry download is initiated, and AOCS parameters are adjusted for higher performance. Despite the scheduled return to nominal, the operator performs a real-time mission nominal-standby/target transition to monitor satellite behavior and intervene if necessary.

D. LEOP Nominal Contact

This procedure is executed during nominal contacts throughout the LEOP, following a specific procedure, until the phase is closed for the satellite. It involves blind acquisition, activation of periodic real-time telemetry download, transition to target-pointing attitude, and retrieval of historical telemetry recorded during out-of-visibility periods.

E. Flight Dynamics activities

Flight Dynamics Activities in LEOP resulted in carrying out four sequential macro-activities:

- Updated Pre-launch OPM (P-OPM) processing
- Post Launch OPM (L-OPM) processing
- Acquisitions of each satellite
- Satellite Identification and insertion in SATCAT

Shortly before the launch, the launch provider is forwarding to its customers an OPM - Orbit Parameter Message, i.e. a txt message providing information about foreseen release time and State Vector at release time for all the satellites that have been launched. This message allows operators to evaluate the expected orbit and generate the requested product (TLE) by the Ground Station provider to track the satellites. This message is sent several times during the pre-launch phase, whenever there is a change in launch date due to several different reasons, or there is a change in the release orbit, most of time due to avoid conjunction with other satellites already tracked by the conjunction assessment provider (Space-track).
For the sake of the FDS activities description, we refer to P-OPM (Pre-launch OPM) for all the messages that are provided by Space-X before the lift-off, while the one OPM provided after the satellites release will be referred to as L-OPM (Post Launch).

In the first part of the Updated Pre-launch OPM (P-OPM), processing the FDS engineer (hereafter FDE) evaluates the orbital parameters of the satellites. While there is interest in individual orbits, it is also important to take into account the relative configuration of the various satellites of the constellation. Therefore, the scripts involved in this process extract the following data:

- drift in terms of Argument of Latitude (AOL)
- Keplerian parameter evolution
- release state in different frames
- relative position
- release altitude at equator

Moreover, considering the available Ground Stations for the mission, a Contact table is generated: this is a list of “passes”, i.e. time intervals when satellites are in visibility of the antennas. After that, making use of the Mission Operation Centre, the FDE produces the Two-Line-Elements, that is a data format encoding a list of orbital elements of the satellite at given epoch. This is the message that the Ground Stations provider is requesting to perform its propagation and generate the control law for antennas to track the satellites when above the GS site geographic horizon (i.e. the satellite is in visibility of the antenna).

Post Launch OPM (L-OPM) processing is the second phase of LEOP FDS Operations. It basically consists in re-executing the evaluations performed during previous activity on the L-OPM, received after the satellites deployment from Space-track. FDE compares the orbit of the satellites with the one obtained from P-OPM: even though there is no change in the orbit (eccentricity, Semi-major axis, inclination) and in the satellite formation, this processing may show a drift in the AOL that leads to a drift in the Acquisitions of Signal (i.e. the start of the Contact table visibility windows), hereafter AOS, of the Antennas wrt what is reported in the Contact Table defined pre-launch. Ground Station Antennas have the capability to establish a link with satellite during a pass in the presence of a little orbit error. According to this margin, after the L-OPM processing, new TLE are forwarded to GS antenna provider before the first acquisition in case Contact Table for each satellite is shifted by more than 30 seconds after 12 hours from release time wrt the one generated processing P-OPM.

At the first acquisition of each satellite an Orbit Determination (OD) is carried out if satellite ADCS (Attitude Determination Control System) GPS is already active and provides correct TM. In case of contingency, it is also possible to extract TM from OBC (On-Board Computer) GPS to execute the OD. After convergence of the Orbit Determination algorithm the FDE make use of the orbit propagation derived from OD to generate the Sequence of Events (SOE) of all the satellites: this is list of events including contact table, satellite eclipse, node passes, etc… that are to be shared to all the LEOP team for different purposes. The last part of this phase is the generation of FDS products. During LEOP, since the maneuver phase is forbidden due to an agreement with the launch provider for the safety of the entire satellite fleet carried by launcher, the only FDS product to be generated in addition to the TLE is the Orbit Ephemeris Message (OEM). It is a standard message (defined by CCSDS 502.0-B-3 - ORBIT DATA MESSAGES) that specifies the position and velocity of a single object at multiple epochs. This file is used by the conjunction assessment provider, Space-track, both to:

- Compare the orbit of our satellite with orbits of a list of catalogued satellites (whose orbit is both derived from tracking observation and/or from other object forwarded ephemeris, if the object is active) and perform the conjunction assessment, i.e. evaluate if these objects minimum relative distance and probability of collision (evaluated by means of covariance matrix) exceeds some thresholds, defining different warning level. Exceeding these thresholds leads to the creation and provision to satellite operators of Conjunction Data Message (CDM), a test message containing information about the Time of Closest approach (TCA) between two objects, conjunction geometry and positional data of both the object at TCA, probability of collision (PoC) at TCA and satellite operators contact information (if provided to Space-track) to allow the management of maneuver to reduce the miss distance and/or the PoC.

- Identify our satellites and insert them in the Satellite Catalog (SATCAT), the list described in the previous bullet.

Satellite Identification and insertion in SATCAT is a process that can last up to one month when on board the launcher there are hundreds of satellites, because after the deployment these tiny objects are really close each other and the tracking antennas of the North American Defense (NORAD) are not capable of distinguish single objects in this “cloud” of satellites. Therefore, it is necessary to wait for the natural drift of satellites to start identifying them. The satellite identification brings to the assignment by Space-track of a NORAD ID for the satellite, which is simply the uniquely sequential number of the newest object inserted in the Satellite Catalog, the list of tracked objects for which every day the squadrons of the North American Defense perform the conjunction assessment (CA) and Collision Avoidance (COLA) services. This ID is used by the satellite operator to mark the shared satellite products for the remaining operative life with Space-track and other customers. Indeed, this number is also used in TLE message, shared with the Ground Stations provider. However, as described before, there is the need of sharing information also before the identification process is completed. To this aim, shortly before the launch date, Space-Track assigns to all the satellite a temporary norad ID (also called 9-digit Norad ID to be distinguished from the official NORAD ID that is a 9-digit number). This is used by the FDS team to share OEM with Space-track. After some days or weeks from the launch, Space-track provides several CDMs between your object (still marked by 9-digit number) and one catalogued object (having the official NORAD ID) but unassigned. This means that the two objects in the CDM are actually the same object and that the satellite operator can “claim” the official Norad ID for its satellite. After that, the satellite is officially part of the SATCAT, leading to the end of identification process and LEOP operation for the FDS team.

V. LEOP ANOMALIES OPERATIONAL MANAGEMENT

During the first batch of EAGLET II LEOP phase, as expected for a newlylaunched constellation anomalies were observed. All were detected and handled by the on-console teams with the avaialbe procedures and following the established processes.

Upon identification of all these anomalies, a structured and decision-making process is initiated to find and apply a recovery solution. The process is organized into two sequential phases: the Pre-Anomaly Review Board (Pre-ARB) and the Anomaly Review Board (ARB) phase.

The Pre-ARB phase effectively functions as an internal Anomaly Review Board prior to the formal ARB.

The Pre-ARB is composed by the SOM, the Mission Manager, the Engineering Support Team Leader and the GOM. The Pre-ARB session is convened following anomaly detection and discussions are structured starting with review of telemetry, event chronology, and system behavior to establish a common understanding of the occurred anomaly. Then, an impact evaluation is performed to determine the consequences of the anomaly first at spacecraft level, as regards the degradation of functionality and overall system integrity, then, at constellation level considering potential for common-cause effects, or replication across other units. Next, an assessment of risk is developed, considering recurrence under current or foreseeable conditions, escalation paths and worst-case scenarios and impact on mission continuity. Based on the whole discussion and the available data evidence a preliminary anomaly resolution strategy is outlined. This latter includes configuration adjustments, additional data acquisition and diagnostic actions, controlled commanding sequences or contact the unit supplier for support.

Following the Pre-ARB internal consolidation, the Anomaly Review Board (ARB) is formally convened as the authoritative decision-making body for anomaly resolution including the customer, represented by the European Space Agency team. The ARB operates on validating the technical conclusions developed during the Pre-ARB phase and reaching a substantiated decision. Indeed, the SOM presents the results of the Pre-ARB activities, including detailed anomaly description and reconstructed timeline, the root cause and contributing factors, impact on spacecraft safety, mission lifetime, eventually implications for the remaining constellation units and the recovery strategy. Based on all these informations the customer decision is reached after the anomaly resolution plan is approved, including the implementation steps and operational constraints.

Following formal approval by the ARB, the anomaly resolution strategy is translated into an implementation plan and depending on the nature of the anomaly and the selected recovery strategy, the approved resolution plan may be implemented through pre-existing, validated contingency procedures or a dedicated sequence of telecommands.

All implementation actions, whether based on contingency procedures or dedicated telecommands, are formalized through a Change Configuration Request (CCR). The CCR ensures full traceability, technical justification, and governance of any modification to the operational baseline. Prior to execution, the CCR undergoes a formal review and approval cycle and only once CCR is formally approved is also authorized for implementation by the FCT. Following implementation, a dedicated verification phase is conducted to confirm the effectiveness of the corrective actions. Results are documented and fed back into the anomaly tracking process, contributing to closure or further refinement if required.

VI. RESULTS AND LESSON LEARNED

The execution of the first Launch and Early Orbit Phase (LEOP) represented a critical milestone for the mission and the company, marking the transition from launch vehicle separation to the establishment of a stable and fully operational on-orbit configuration and the first mission fully under OHB Italia command and control from its own Mission Control Center. This phase was particularly challenging due to the limited number of resources (being balanced via the overall mission budget), low prior operational experience, and the inherent complexity of managing multiple subsystems under time-constrained conditions.
To mitigate these constraints, a preparation strategy centered on extensive simulation campaigns, Mission Operations Center (MOC) testing, and systematic front-loading of lessons across all subsystems was adopted. This chapter analyzes the benefits of this approach, its impact on schedule, resource utilization, and reliability, and concludes with recommendations derived from both the first LEOP and subsequent operational improvements.

A. Benefits of the Adopted Approach

A key pillar of mission readiness was the execution of an extensive simulation campaign. These simulations were designed to replicate nominal and contingency scenarios with high fidelity, enabling operators and subsystem engineers to:

- Develop procedural familiarity under realistic time constraints and environment
- Validate operational timelines and command sequences
- Identify interface inconsistencies between subsystems
- Improve coordination between Flight Control Team, Flight Dynamics, Ground Segment, and System Engineering Team.

The simulations went beyond standard validation exercises, functioning as iterative learning cycles. Each session generated actionable feedback, which was systematically incorporated into updated procedures and operational concepts.
Prior to the to simulation activities, rigorous MOC testing ensured that ground infrastructure, software tools, and communication chains were fully operational. This included:

- End-to-end validation of telemetry and telecommand links via SVTs (System Validation Tests) having one Flight Model in the loop. Four of such tests were conducted, lasting a total of 3 weeks.
- Verification of redundancy chains and failover mechanisms

This approach significantly reduced the risk of ground segment anomalies during LEOP, ensuring that potential points of failure were identified and mitigated before launch.

An important strategic decision was enforcing lessons learned across all segments prior to LEOP execution. Rather than deferring improvements to post-operational reviews, insights from simulations and testing were immediately discussed, disseminated and implemented.
This resulted in:

- Early harmonization of segment interfaces
- Increased procedural consistency across teams
- Reduction of ambiguity in roles and responsibilities
- Enhanced situational awareness during operations

The proactive integration of lessons learned contributed to a more resilient and adaptive operational framework.

B. Time, Resources, and Reliability

The first LEOP was conducted under significant constraints in terms of human resources and operational experience. The limited size of the operations team required individuals to assume multiple roles, increasing workload and cognitive pressure.
Additionally, the relatively low level of prior LEOP experience introduced uncertainties in:

- Decision-making under time-critical conditions
- Anomaly recognition and classification
- Execution of contingency procedures

Despite these challenges, the preparatory activities helped partially offset the experience gap by providing structured exposure to realistic scenarios.

The iterative nature of the preparation and execution phases led to the identification and implementation of a substantial number of lessons learned (LL):

- More than 50 LL were identified and implemented in parallel to the simulation campaign, effectively enforcing an agile approach to operations preparation.
- More than 30 additional LL, across all the teams, were captured and applied after the first LEOP execution.

These lessons spanned multiple domains, including:

- Procedure (both Flight and Ground) optimization
- Ground Segment configuration, including interactions and planning with the Ground Station Network provider.
- Timing and sequencing of critical operations

While the high number of lessons learned reflects initial inefficiencies, it also demonstrates the effectiveness of the feedback loop in rapidly improving operational maturity.

C. Schedule

From a schedule perspective, the first LEOP required conservative timelines to accommodate uncertainties and ensure safe execution. This resulted in:

- Extended operational windows
- Increased reliance on manual validation steps. Several Configuration Change request had to be developed and implemented deviating for the nominal timeline.

However, this conservative approach contributed positively to mission reliability. Key achievements included:

- Successful spacecraft acquisition and stabilization
- Safe deployment and initialization of subsystems achieved in 24h
- Effective handling of minor anomalies without escalation, leading to a LEOP end declaration within 48h.

The emphasis on robustness over speed proved appropriate for a first-time operation under constrained conditions.

D. Process Optimization and Standardization

The experience gained during the first LEOP enabled significant process improvements, which were fully leveraged during the second LEOP. Key optimizations included:

- Streamlining of Flight Operations Procedures (FOPs)
- Refinement of Ground Operations Procedures (GOPs)
- Reduction of redundant steps and manual checks
- Improved synchronization between teams

These enhancements resulted in a more efficient and predictable operational flow.
A major lesson learned was the importance of continuity between pre-launch preparation and in-orbit execution. For the second LEOP:

- Procedures were validated earlier and more extensively
- Simulation scenarios were better aligned with actual mission profiles, relying on the experienced matured in the first LEOP.
- Team segregation: Teams were splitted in such a way to cover Commissioning activities of the already flying satellites and the LEOP of the second batch of satellites.

This end-to-end optimization reduced uncertainties and improved execution confidence.

The cumulative effect of these improvements was a dramatic increase in operational efficiency. The second LEOP achieved:

- Overall Completion in less than 30 hours
- Successful management of 8 satellites within a highly compressed timeline, having to manage both the LEOP satellites and the already flying satellites undergoing commissioning.

This represents a significant advancement compared to the first LEOP, demonstrating the value of iterative learning and systematic process refinement.

VII. CONCLUSIONS

The first LEOP execution served as both a validation of the mission architecture and a paradigm for operational maturity within OHB Italia. Despite all limitations and constraints, the adoption of a simulation-driven and lesson-oriented approach enabled a reliable and successful outcome.
The large number of lessons learned highlights the complexity of early operations but also underlines the effectiveness of continuous improvement mechanisms similar to an agile development. The transition to a highly optimized second LEOP demonstrates that investments in preparation, standardization, and feedback integration can yield substantial gains in efficiency and performance.
Future missions, in particular future “firsts” are strongly encouraged to adopt similar strategies, with particular emphasis on early validation, cross-segment integration, and iterative refinement of operational processes.

VIII. ACKNOWLEDGMENT

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IRIDE Stands as one of the most prominent European space programs in the fields of Earth observation. Its realization is set to occur in Italy trough the Government’s initiative, leveraging resources from the National Recovery and Resilience Plan (PNRR) supplemented by the funds of the National Supplementary Plan (PNC). IRIDE is a satellite system which is expected to be operational by June 2026, under the coordination of the ESA-European Space Agency, with the involvement of the ASI-Italian Space Agency.