Chapter 7 Mission Management

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7.1 Mission Management Overview

Mission Management is conceived by EUROCKOT to fulfil all the Customer's requirements to the greatest possible extent by undertaking the following activities:

- Management and planning of the entire mission integration process
- Definition and control of all payload/ launch vehicle interfaces
- Performance of mission design and mission analyses
- Provision of the launch vehicle with appropriate interfaces including the payload adapter and separation system
- Transport of the customer's spacecraft and support equipment from the Russian port-of-entry to EUROCKOT's facilities at the Plesetsk launch site
- Provision of appropriate payload preparation facilities within EUROCKOT's facilities at the Plesetsk launch site
- Management and performance of pre-launch operations and launch
- Performance of trajectory tracking and payload telemetry data reception, as required

7.2 Organisation and Responsibilities

EUROCKOT is responsible to the Customer for all commercial and technical activities within the launch contract. EUROCKOT implements this contract as the single prime contractor towards the Customer and as the Customer's sole industrial partner for all aspects of the law. EUROCKOT is a company governed by German law and offers all the legal safeguards provided by a Western company.

As a constituent company of EUROCKOT, Khrunichev State Research and Production Space Center (KSRC) of Russia provides the launch vehicle as well as the launch services and launch operations support through a sub-contract to the Russian Space Forces.

EUROCKOT's other parent company the European Aeronautic Defence and Space Company Space Transportation Division (EADS ST) which is located next door to EUROCKOT, offers support in engineering and commercial areas as necessary. The distribution of the relevant activities among EUROCKOT, KSRC and EADS ST is depicted in Figure 7-1.

For Mission Management, EUROCKOT has adopted a scheme (Figure 7-2) which has proven extremely successful in the past.

Customers conclude a launch services agreement (contract) directly with EUROCKOT launch services. EUROCKOT provides the single point of focus for the Customer through a designated Mission Manager. The Mission Manager is responsible for the management of all the launch service tasks. The Mission Manager has full programme authority and is responsible for all coordination required to implement the launch contract. The Mission Manager is responsible for ensuring that all payload launch requirements are met and is in continuous contact with the Customer from contract signature up to launch.

At the launch site, he/she acts as the day-to-day intermediary between the Customer and the launch site authorities for the purpose of satisfying the Customer's requirements. This includes responsibility for launch operations planning, procedures and launch execution. The launch decision is the responsibility of a Management Group consisting of the EUROCKOT Mission Manager and representatives of Khrunichev, the Customer and the launch site authorities.

The Mission Manager forms part of a team of experienced programme managers, mission managers and engineers who make up the nucleus of the EUROCKOT Technical Team. The Mission Manager reports to his/her respective programme manager as well to the Technical Director and the CEO. Within each individual project, the Mission Manager is supported by another member of the technical team, hence ensuring common standards and practices within EUROCKOT as well providing personnel redundancy. He/she is supported by other members of the EUROCKOT team to fulfil contractual obligations including the Contracts and Finance team which is responsible for all contractual, commercial and financial matters and the Sales team for public relations activities.

Within EUROCKOT, the Mission Manager represents the interests of the Customer; towards the Customer he represents the interests of EUROCKOT. The structure of the mission management organisation and its relationship to the customer and Khrunichev is shown in Figure 7-2.

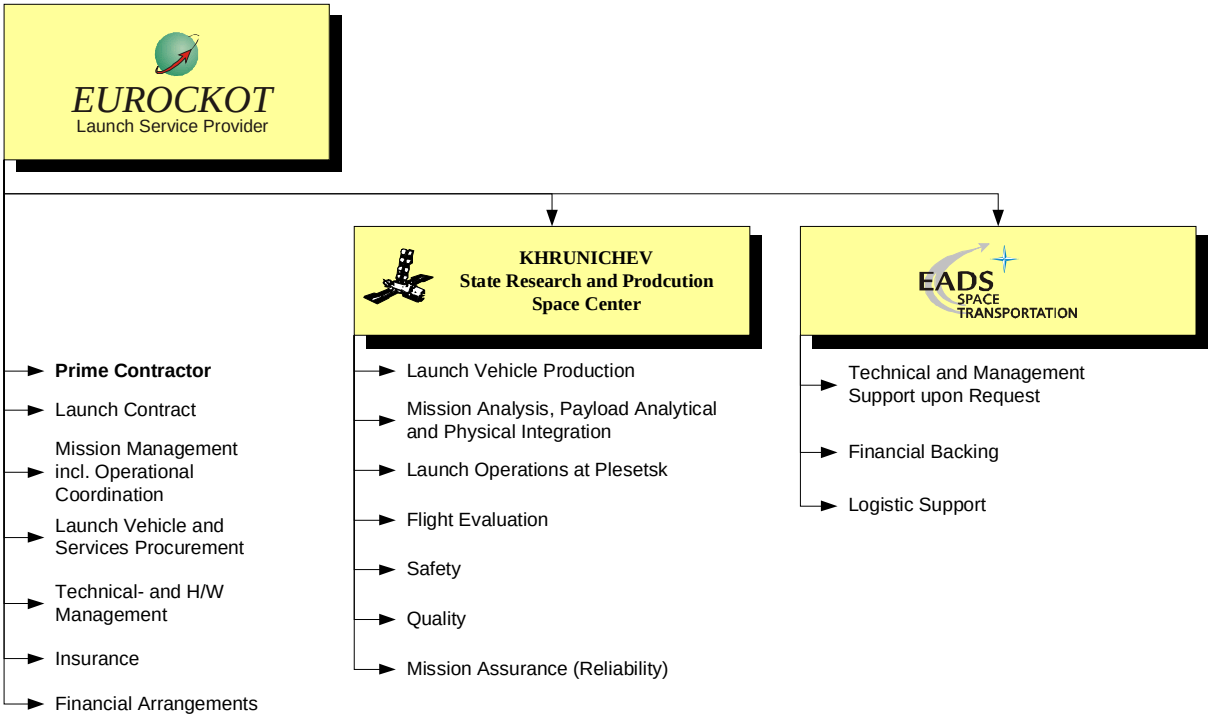

Figure 7-1: Industrial Organization of EUROCKOT and its Major Subcontractors

7.2.1 EUROCKOT Mission Responsibilities

EUROCKOT will manage all mission-related activities from first preliminary estimations before launch contract signature through post-launch evaluation and review with the emphasis on Customer satisfaction.

7.2.1.1 Mission Integration

EUROCKOT's mission integration responsibility includes the definition and control of the spacecraft to launch vehicle interfaces as well as the performance of the mission design and mission analyses (see Chapter 8 of this document). Initially a draft Interface Control Document (ICD) which contains the requirements and design solutions for the interfaces is established at the start of the mission integration phase. This is based upon customer responses to the questionnaire "preliminary mission design and mission analysis input data" as well as the Interface or Technical Requirements Document (IRD) which forms part of the technical annexes of the launch contract. This ICD is agreed and signed by all parties including EUROCKOT, Khrunichev, the Customer and the Spacecraft developer. Preliminary mission design and mission analyses are then performed versus the requirements contained within the ICD and presented in the Launch Vehicle Preliminary Design Review (PDR) for customer review and approval. After the PDR the ICD is updated and put under formal configuration control, with EUROCKOT responsible for maintenance and updating of this document. When the spacecraft design matures and the final spacecraft data is known the final mission design and mission analyses are then performed versus the requirements contained within the ICD and presented in the Launch Vehicle Critical Design Review (CDR) for customer review and approval.

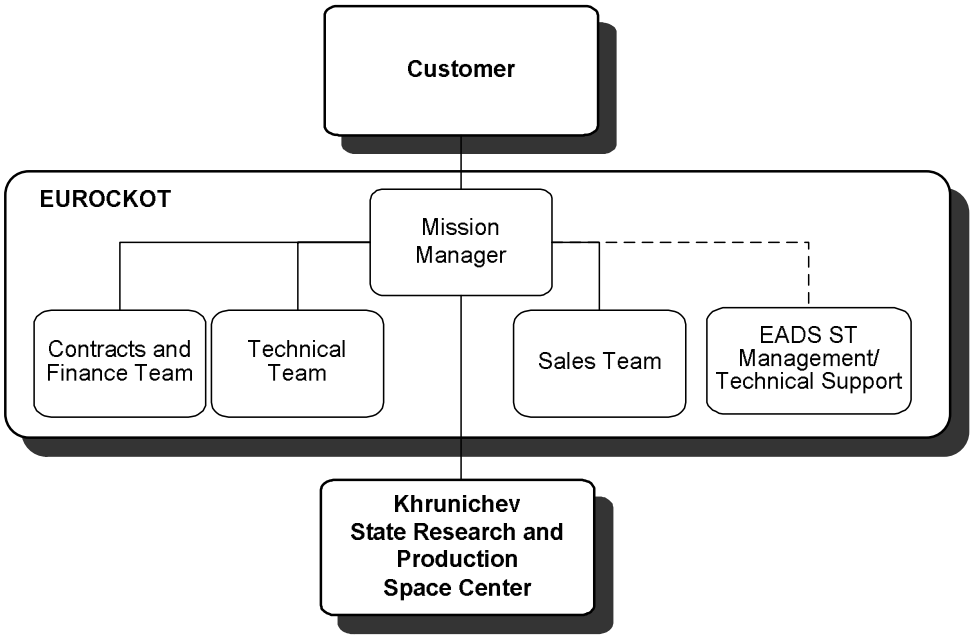

Figure 7-2: EUROCKOT Mission Management Organisation

The ICD is maintained under formal configuration control until launch. This document also includes relevant technical specifications relating to payload preparation facilities at the range.

7.2.1.2 Interface Design, Qualification and Verification

The design of the interface between the launch vehicle upper stage and the spacecraft, i.e. the payload adapter, attachment and separation system, is one of the first activities to be started after technical kick-off. In the majority of cases a mission-specific payload adapter design is usually adopted, due to the fact that even for similar designs there can still be small but significant differences between designs, e.g. connector type / layout, spring pusher location/ forces, band pre-tension, adapter geometry and height as well as different spacecraft mass properties etc. Hence in the cases where qualification by similarity is not applicable, a design and qualification process will be undertaken to cover these differences.

7.2.1.2.1 Design of the Payload Adapter

Compliance of the design with the Customer requirements stated in the ICD and with the environmental constraints is demonstrated in the PDR and CDR. A successful CDR signifies payload adapter design approval and the manufacturing go-ahead. If, on the other hand, design changes are necessary because of the CDR, this go-ahead is given when these design changes are successfully completed.

However, owing to time constraints, the procurement of long lead items and initiation of piece part manufacturing can start earlier. Like the necessary effort for qualification, this depends mainly on the degree of individuality of the payload adapter for each mission. Ideally, qualification and flight units are produced together. On the basis of the existence of a fully qualified launch vehicle including *Breeze*-KM upper stage and payload fairing, only the mission-specific interface has to be verified. Depending on the degree of individuality of the payload adapter as requested to fulfil specific spacecraft designs, a qualification test program will be set up.

7.2.1.2.2 Payload Adapter Qualification Test at KSRC

The qualification programme of the payload adapter will typically consist of some of the following test steps:

- Static Tests
- Dynamic Tests
- Spacecraft Separation Tests
- Fit Check with Payload Adapter (or optionally in case of low clearances to the payload fairing, a volume fit check with the fairing)

The tests are performed at the premises of KSRC in Moscow, Russia. The tests are performed using a *Breeze* Upper Stage Mechanical Interface Simulator together with a Spacecraft Mass Frequency Simulator Model (SC MFS). This SC MFS is a high fidelity reproduction of the spacecraft flight model electro-mechanical interfaces and also reproduces the major mass and dynamic properties of the spacecraft in-

cluding its fundamental frequencies. In case of low clearances between the spacecraft and payload fairing, an additional volume fit check, using a spacecraft volume simulator can also be undertaken as an option.

The necessity and extent of each test depend mainly on spacecraft mass and stiffness properties, geometrical interfaces environment sensitivities etc.

To further verify correct attachment interface and integration feasibility, two additional means to confirm interface compatibility can be undertaken and are described in the following paragraphs.

7.2.1.2.3 Fit Check of FM Spacecraft with FM Payload Adapter

A fit check, preferably using the flight model spacecraft and the flight model payload adapter or an identical model thereof, is performed at the spacecraft manufacturer's premises, demonstrating that the mating and separation of mechanical and electrical joints comply with the ICD requirements. Depending on the customer's specific requirements a separation test involving ignition of the separation system pyrotechnics can be undertaken to verify shock levels at the spacecraft interface.

7.2.1.2.4 Master Gauge Interface Verification

A master gauge / drill template, produced by either the spacecraft contractor or EUROCKOT, ensures that the correct positions of the fixing points are achieved not only by compliance with the interface drawings but also by using the same, identical tool for applying them on the test and flight hardware. This is generally used for point attachment systems to ensure correct positioning of the interface points on the spacecraft for the separation system.

7.2.1.3 Configuration Control

Programme-specific configuration control and data management procedures begin immediately upon contract signature with EUROCKOT and cover all documents and data exchanged with the Customer. These documents are defined in Chapter 7.3. The overall programme configuration control of the launch vehicle and launch service is an extension of the KSRC Quality and Mission Assurance Plan. Data management is an integral part of this plan. A unique programme configuration control plan is prepared. This plan shows:

- Responsibilities for configuration management in each organisation
- Documentation subject to configuration management
- Change orders issued
- Orders processed
- The constitution of the joint change board

7.2.1.4 Launch Vehicle Procurement

EUROCKOT monitors the launch vehicle production progress according to the mission integration schedule, approves launch vehicle acceptance and is responsible for the specification and provision of the launch vehicle/spacecraft interfaces and, if applicable, adaptation of the fairing.

7.2.1.5 Spacecraft Preparation/ Launch Operations

EUROCKOT defines the launch operations for the launch site through the establishment of a Joint Operations Plan (JOP) for all joint activities with the customer. This includes all activities which involve support from EUROCKOT/ Khrunichev at the launch site, for example launch site support activities including fuelling support as well as combined operations of the launch vehicle and spacecraft. The plan defines the launch site organisation, joint operations, facilities, operational support, electrical check-out as well as launch day activities including go/no-go criteria. The Spacecraft Operation Plan (SOP) (see Section 7.2.2) provided by the Customer provides the inputs for this plan and will be adhered to. The joint operations plan is the working document used by EUROCKOT, the Customer and Khrunichev and its subcontractors to manage the launch campaign.

7.2.1.6 Post-Launch Activities

State vectors of the upper stage at burnout and of the satellite separation event will be provided as preliminary data approximately 30 minutes after separation and as detailed state vectors after one week. Two months after launch, EUROCKOT provides a Launch Evaluation Report (LER), showing the performance achieved and the behaviour of the launch vehicle. This report is based on processed launch vehicle telemetry and tracking data, as well as on spacecraft orbit data provided by the Customer.

7.2.1.7 Quality Assurance/ Mission Assurance

At KSRC the Deputy Director for Quality Assurance, reporting directly to the General Director, ensures and supervises compliance with all relevant requirements. Quality audits and procedures maintain rigorous adherence to all elements in the factory and launch site operations. Incoming materials and subcontractors are certified and continuously reviewed and inspected. A system of procedures which has proven its efficiency in the past assures detailed analysis of discrepancies as well as related dispositions and verification of their execution.

7.2.1.8 Safety Provisions

EUROCKOT will provide the single focal point for all system and range safety matters. The Customer will provide the necessary data as described in Chapters 9 and 12 to enable EUROCKOT to obtain spacecraft safety approval for the launch campaign.

7.2.1.9 Risk Management

Risk management by EUROCKOT covers the following risk in particular:

Political Risk: The EUROCKOT programme is part of the German-Russian space cooperation agreement, backed by high level guarantees from the German and Russian Governments, explicitly including the Russian Space Agency and the Space Forces.

Commercial Risk: EADS ST and the German Federal Government are financial backers for all required funding.

Technical Risk: The *Rockot* launch vehicle is fully operational. The first two stages (SS-19) undergo extensive tests (DPA / test firing) on a yearly basis. The commercial *Rockot* configuration, including *Breeze*-KM and the large payload fairing, was successfully flight-qualified for the first time in May 2000. Co-production of *Breeze*-KM and *Breeze*-M (Proton) ensures programme continuity.

Launch Risk: Launchers which are held in stock for rapid replenishment ensure short reaction launches in the case of satellite problems and immediate re-launch in the case of launch failure after completion of a failure investigation. In the unlikely event of a launch failure, a contingency plan previously reviewed and tailored to the specific mission would control the total process providing a failure action list from data review, through anomaly identification and the setting up of analysis and review boards, up to final explanation and corrective action dispositions.

Almost 1500 launches from Plesetsk combined with the PROTON experience of KSRC and the ARIANE experience of EADS ST further reduce technical risks for the Customer.

7.2.1.10 Technology Transfer/ Security

EUROCKOT is committed to meeting government and Customer-imposed requirements concerning technology transfer issues and the physical security of the spacecraft, its support equipment and associated documentation during the mission integration process and the launch campaign. For this purpose, the mission integration process and launch site activities conducted by EUROCKOT, for instance all technical interchange meetings (TIM), data transfer from the spacecraft contractor, e.g. drawings and mathematical models, and activities at the launch site will be governed by the EUROCKOT security plan EPL-0001.

For the majority of spacecraft contractors the plan will be based to a large extent on US requirements issued by the Office of the Secretary of Defense Threat Reduction Agency (DTRA).

For spacecraft coming under DTRA jurisdiction, special measures will be taken to meet these requirements. In the case of technology transfer issues, it is recommended that a Technical Assistance Agreement (TAA) with DTRA be concluded very early on in the programme to allow for technical interchanges between the spacecraft contractor and the launch service companies, e.g. EUROCKOT, KSRC and their subcontractors. Physical security of the spacecraft, of its associated support hardware and of documentation at the launch site is assured by physical barriers such as controlled entry doors, round-the-clock guarding of the hardware by security guards and agreed procedures.

7.2.2 Customer Mission Responsibilities

The Customer is required to designate a Payload Mission Manager who will be the single point of contact for the Mission Manager at EUROCKOT. Early in the contract implementation process, the Customer is requested to provide responses to a questionnaire "preliminary mission design and mission analysis input data" which covers the following aspects:

- Required mission characteristics
- Spacecraft characteristics (dimensional, electrical, thermal, environ-mental, etc.)
- Spacecraft launch preparations requirements

Early in the mission analysis process, the Customer submits a payload development and test plan to meet the *Rockot* environmental conditions. Additionally, the Customer has to provide several spacecraft software models, especially for integrated structural and thermal analyses (see Chapter 8 and Section 12.2). During the Mission Design and Mission Analysis process, the Customer is requested to submit environment test results (see Section 12.4). The Customer attends the Preliminary and Final Mission Analysis Reviews which are undertaken as part of the Launch Vehicle Preliminary and Critical Design Reviews.

As an input to the planning of the Joint Operations Plan (JOP) the Customer will issue the Spacecraft Operations Plan (SOP). For the operational activities at the range, the Customer will provide procedures for the various operations on the spacecraft for safety examination by the range authority (see Section 12.5).

A safety review based on three safety submissions (Phases I, II and III) and the Spacecraft Safety Certifcate provided by the Customer or Spacecraft Contractor must also be completed during the launch preparation phase. A Phase I Safety Submission is expected at the start of the contract phase. For details, see Chapter 9 and Section 12.3.

Hardware models which have to be provided, especially a spacecraft mass frequency simulator model and, if necessary, the volume fit check dummy, which are described in sections 7.2.1.2 and 12.7. In general, all items to be provided by the Customer such as documents, software and hardware models are summarised in Chapter 12 of this document.

7.3 Reviews and Documentation

Within each phase of the launch service implementation there are various activities and milestones planned to enable successful fulfilment of the contract. These activities include regular meetings with the Customer and Spacecraft Contractor and also the generation of documents and analyses for review and approval. The activities are coordinated by the EUROCKOT Mission Manager at the start of the contract.

Typically EUROCKOT tries to distribute meetings approximately evenly between the customer's sites (customer and spacecraft contractor) and EUROCKOT / Khrunichev sites. Generally to have easy access to specialists the main mission design/ mission analysis reviews, namely the Preliminary Design Review PDR and the Critical Design Review CDR are held at Khrunichev's premises in Moscow. Other technical interchange meetings and reviews can be held at other locations including the customer site depending on the specific purpose. A summary of reviews and their typical allocation within the mission schedule is given in Table 7-1.

The aim is, where possible, to combine some of these meetings and reviews in order to optimise the time and cost involved for all parties. An overall summary of documents to be supplied by EUROCKOT and the Customer, as well as their typical release dates is given in Section 7.4.

Meetings / Reviews Schedule	Date
Contract signature meeting	L - 18 months
Technical Kick-off meeting/ IRD Review	L - 18 months
Launch Vehicle to Spacecraft System Requirements Review + ICD Outline	L - 17 months
ICD Review (draft issue)	L - 16 months
Launch Vehicle to Spacecraft Preliminary Design Review incorporating the Preliminary Mission Design and Analyses	L - 13 months
ICD Review (issue 1)	L- 12 months
Spacecraft Operations Plan/ Joint Operations Plan Review	As necessary, combined with other meetings
Technical Interchange Meetings	As necessary, combined with other meetings
Safety Reviews (phases I, II and III)	As necessary, combined with other meetings
Launch Vehicle to Spacecraft Critical Design Review incorporating the Final Mission Design and Analyses	L - 8 months
ICD Review (issue 2)	L - 8 months
Design Qualification Review	L - 5 months
ICD Review (final issue)	L - 5 months
Campaign Preparation Status meeting	L - 4 months
Spacecraft Shipment Readiness Review	To be agreed
Launch Readiness Review (LRR)/ State Commission	L - 3 days
Launch quick-look assessment meeting	L + 1 day
Launch Evaluation Review Meeting	L + 2 months

Table 7-1: Typical Launch Services Reviews and Meetings

7.3.1 EUROCKOT Documents

The main documents to be established by EUROCKOT are summarised below:

Interface Control Document L - 16 to 5 months

The ICD is the document that guarantees, to the spacecraft Customer and to EUROCKOT, the technical definition and control of all interfaces between the launch system and the payload composite. In addition, the ICD is intended to establish the operational requirements for a launch campaign. The document will be updated regularly with inputs from the Customer and updated by the EUROCKOT-assigned Mission Manager in agreement with all parties. The ICD is a living document, being constantly updated to reflect the latest status of the launch services. A typical ICD structure is depicted in Table 7-2.

1. Introduction
2. Mission Requirements
3. Mechanical and Electrical Interfaces
4. Mechanical Loads and Environments
4.1 Flight Loads
4.2 Ground Loads
4.3 Thermal
4.4 Cleanliness
4.5 EMC
5. Preparation Facilities
5.1 General Requirements
5.2 Communication
6. Verification Matrix

Table 7-2: Typical ICD Structure

Preliminary Design Review Data Package L-14 months

The results of the Preliminary Mission Design and the Analyses are documented in the preliminary design review data package. This includes:

- Payload Accommodation Design including Mission-Specific Equipment and Interfaces
- Trajectory and Mission Sequence
- Spacecraft Separation Analysis
- Ground and Flight Thermal Environment
- Dynamic Coupled Loads Analysis/ Loads
- Cleanliness
- Measurement System
- Telemetry
- Radio Frequency Compatibility
- Electrical
- Pre-launch Support and Operations
- Reliability
- Social Services
- Communication Infrastructure
- Security
- Transportation

Critical Design Review Data Package L - 9 months

The results of the Final Mission Design and Analyses are documented in the critical design review data package. This includes:

- Payload Accommodation Design including Mission-Specific Equipment and Interfaces
- Trajectory and Mission Sequence
- Spacecraft Separation Analysis
- Ground and Flight Thermal Environment
- Dynamic Coupled Loads Analysis/ Loads
- Cleanliness
- Measurement System
- Telemetry
- Radio Frequency Compatibility
- Electrical
- Pre-launch Support and Operations
- Reliability
- Social Services

- Communication Infrastructure
- Security
- Transportation

Joint Operations Plan	L - 13 months

The JOP covers all joint operations involving EUROCKOT, Khrunichev and its subcontractors and the customer, such as joint activities where launch site support is needed like spacecraft fuelling as well as combined operations of the launch vehicle and spacecraft from the beginning of encapsulation to lift-off. The JOP also includes the agreed go/ no-go criteria for launch.

Note: Specific spacecraft operations are the responsibility of the Customer (SOP).

Safety Reply, Phases I; II; III	L – 17; 11; 4 months

Contents:

- Assessment of Customer Safety Submissions
- Description of spacecraft systems and classification of hazardous systems
- Development of List of Hazards and reports on analysis of these hazards
- Verification of SC design compliance with the standards of either the country of origin or ESA
- Safety constraints tailored to dedicated spacecraft
- Verification of spacecraft design compliance with EUROCKOT Safety Handbook EHB0004 and establishment of reports on non-compliance with these provisions
- Specific verification guidelines

Please refer to Chapter 9.

Launch Evaluation Report	L + 2 months

Contents:

- Launch vehicle performance based on telemetry and tracking data
- Launch vehicle behaviour
- Launch vehicle/spacecraft interface aspects including launch environment

7.3.2 Customer Documents

The documents to be provided by the Customer are described in detail in Chapter 12 of this User's Guide; they are summarised in Table 7-3.

Documents to be Provided	Date (typically)	
	Preliminary	Final
Interface Requirements Document (IRD)	L - 18 months	
Safety Submission (Phase I, II, III)	I: L-18 months II:L-12 months	III:L- 6 months
SC Safety Certificate	L – 12 months	III: L – 5 months
SC Flight Readiness Certificate	L – 6 months	L – 5 months
Flight Readiness Data Package	L – 6 months	L – 5 months
Spacecraft Mechanical Environment Test Plan	L - 16 months	
Spacecraft Dynamic Model (Preliminary)	L - 16 months	L - 11 months
Spacecraft Thermal Model (Preliminary)	L - 16 months	L - 11 months
Response to Questionnaire: Input to Mission Design and Mission Analysis	L - 16 months	L - 11 months
Spacecraft Operations Plan	L - 11 months	
Spacecraft Mechanical Environment Qualification Test Results	L - 8 months	
Spacecraft Acceptance Test Results	L - 8 months	
Final Spacecraft Mass Properties	L - 7 days	
Orbital Tracking Operation Report	L + 2 weeks	

Table 7-3 Documents to be Supplied by the Customer

7.4 Overall Mission Schedule

Overall mission planning is designed to provide the Customer with a reasonably short lead-time of 18 months from contract signature to launch, while still allowing for thorough technical preparation, in particular through mission analysis. If a repeat launch for a similar spacecraft and comparable orbit characteristics is requested by the Customer, lead-times of 15 months should be achievable and would be the subject of specific agreements.

The mission schedule of a typical mission with an 18-month lead-time is depicted in Figure 7-3. Nevertheless, the mission-specific schedule will be established during the mission kick-off meeting. It will address in particular the spacecraft development and qualification schedule as well as other Customer wishes. The launch campaign schedule itself is described in Chapter 10.

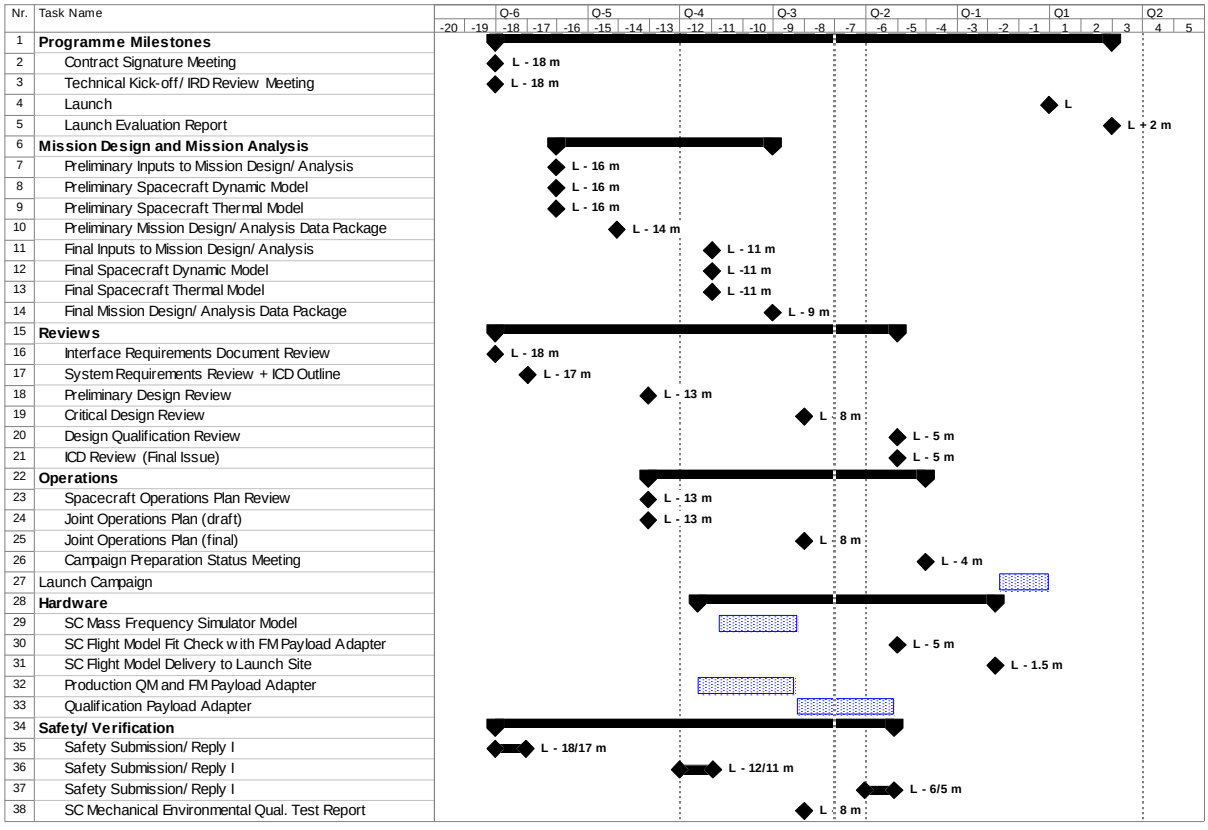

Figure 7-3: Typical Mission Schedule