IMPLICATIONS OF A ZERO-DEBRIS APPROACH TO FUTURE SATCOM MISSION DESIGN (ARTES FP 1A.129) - EXPRO+
ESA EXPRESS PROCUREMENT [PLUS] – EXPRO [+]

ARTES Future Preparation 1A.129 – Implications of a Zero-Debris Approach to Future Satcom Mission Design

Prepared by	**ESA**
Reference	**1A. 129**
Issue	**1**
Revision	**0**
Date of Issue	**06/02/2025**
Status	**Approved**

Table of contents:

1 INTRODUCTION

1.1 Scope of the Document

This document describes the activity to be executed, and the deliverables required by the European Space Agency in relation to the activity "Implications of a Zero-Debris Approach to Future Satcom Mission Design" (Programme reference, 1A.129).

This document will be part of the Contract and shall serve as an applicable document throughout the execution of the work.

1.2 Reference Documents

The following documents can be consulted by the Contractor as they contain relevant information:

Reference	Version	Document Name	Link
ESSB-ST-U-007	1	ESA Space Debris Mitigation Requirements	https://technology.esa.int/upload/media/ESA-Space-Debris-Mitigation-Requirements-ESSB-ST-U-007-Issue1.pdf
ECSS-U-AS-10C	2	Space sustainability	https://ecss.nl/wp-content/uploads/2024/02/ECSS-U-AS-10C-Rev.2-(9February2024).pdf
JMR-003E (E)	1	Space debris mitigation standard	https://sma.jaxa.jp/TechDoc/Docs/E_JAXA-JMR-003E.pdf
ISO/TR 16158	2	Space systems — Avoiding collisions among orbiting objects	https://www.iso.org/standard/81695.html
SSC	2	Best Practices for the Sustainability of Space Operations	https://spacesafety.org/wp-content/uploads/2023/04/SSC_Best_Practices_for_Space_Operations_Sustainability_v29.pdf
ESSB-HB-U-002	2	ESSB-HB-U-002, iss.2, "ESA Space Debris Mitigation Compliance Verification Guidelines", 14/02/2023	https://sdup.esoc.esa.int/documents/download/ESSB-HB-U-002-Issue214February2023.pdf
ESSB-U-ST-004	1	ESSB-U-ST-004 issue 1, ESA Re-entry Safety Requirements, 04/12/2017	https://sdup.esoc.esa.int/documents/download/ESSB-ST-U-004-Issue14December2017.pdf
UN	Vienna, 2010	UN COPUOS Space Debris Mitigation Guidelines	**Error! Hyperlink reference not valid.**https://www.unoosa.org/pdf/publications/st_space_49E.pdf

IADC-02-01	2	IADC Space Debris Mitigation Guidelines	https://orbitaldebris.jsc.nasa.gov/library/iadc-space-debris-guidelines-revision-2.pdf
UN	Vienna, 2024	The "Space2030" Agenda: space as a driver of sustainable development	**Error! Hyperlink reference not valid.**https://www.unoosa.org/res/oosadoc/data/documents/2024/stspace/stspace88_0_html/st_space-088E.pdf
UN	Vienna, 2021	Guidelines for the long-term sustainability of outer space activities of the committee on the peaceful uses of outer space	https://www.unoosa.org/documents/pdf/PromotingSpaceSustainability/Publication_Final_English_June2021.pdf
ESPI	25 Sep. 2024	A Party for Everyone? Analysing International Efforts in Space Debris Mitigation	https://www.espi.or.at/reports/a-party-for-everyone-analysing-international-efforts-in-space-debris-mitigation/

1.3 Acronyms and Abbreviations

Acronym	Definition
ARTES	Advanced Research in Telecommunications Systems
GEO	Geostationary Earth Orbit
LEO	Low Earth Orbit
ESSB	ESA Standardization Steering Board
ECSS	European Cooperation for Space Standardization
SDM	Space debris mitigation

1.4 Key Terms

1. **Building Block:**
   - A fundamental component or element that can be integrated into a larger system or solution, providing specific functionalities.
2. **Design Drivers:**
   - Key factors and requirements that influence and guide the design and development of a system or product, such as performance, cost, and regulatory compliance.
3. **Cost/Benefit Analysis:**
   - A systematic approach to evaluating the financial implications of a decision or project by comparing the costs incurred to the benefits received.
4. **Compliance Gap:**
   - A discrepancy between current practices and the requirements set by regulations, standards, or guidelines that must be addressed to achieve compliance.
5. **Market Trends:**
   - Patterns and tendencies in the market that indicate the direction of growth, consumer preferences, and technological advancements.
6. **Technological Solutions:**
   - Innovative technologies and systems developed to address specific challenges and improve the efficiency, performance, and sustainability of satellite communications.

1.5 Background and Scope

1.5.1 Background

In the next three years there will be more satellites launched than in the past six decades combined. With this rapid increase in Earth orbiting missions, it is widely accepted that new, stricter guidelines on debris creation and mitigation are required to ensure that orbits are kept usable for generations to come.

ESA's own response to this challenge is the 'Zero Debris' philosophy which aims to stop the generation of debris from ESA missions by 2030. As a result, ESA recently updated the Satellite Debris Mitigation (SDM) requirements for its own missions, making them stricter and expanding the orbits they apply to. Whilst ESA's new approach recommends changes applicable to all orbits that telecom satellites currently operate in, and commercial operators have participated in workshops to help formulate the guidelines, they were created specifically with ESA-funded missions in mind.

Individual countries are also tightening requirements on debris generation as a necessity for launch authorisation and is expected that a 'Debris Mitigation Philosophy' of one form or another will become standard operating practice for all in the years to come. New standards will therefore likely emerge that recommend more stringent orbit decay times, collision avoidance capabilities, and the inclusion of design for removal technologies with variations seen between orbits. (For example, space debris proliferation in GEO due to a collision or an explosion is less likely than other orbits but would be extremely impactful for all operators in this region since any fragment would remain in orbit for centuries. Debris from collisions in LEO however, whilst significantly more likely following the proliferation of telecom constellations, would naturally decay from orbit much quicker).

In some instances, the design drivers for commercial satcom missions diverge from those of institutional projects. Some of the new recommendations will therefore likely prove to be too lenient for commercial needs, whereas others will be ill suited to constellations or mass-produced satellites, introducing unnecessary cost and suboptimal solutions for commercial missions. Implementing such approaches without due consideration could therefore put European satellite operators at a disadvantage compared to operators from other regions, possibly following guidelines written specifically with commercial satcom missions in mind. The new range of SDM measures therefore need to be assessed separately and specifically with the commercial satcom sector in mind. This is especially important for ensuring European based manufacturers and operators can retain and build a competitive advantage. For example, by having advance plans in place for any regulatory changes imposed by launching countries or being able to clean orbits they operate in quickly to allow safe space for a replacement satellite.

1.5.2 Activity Scope

The purpose of this activity is therefore to establish a view of space debris mitigation and removal requirements appropriate to the commercial satcom sector. The activity will assess the needs of satcom operators and manufacturers, both now and in the future, from a commercially sensitive perspective, to help ensure a viable and sustainable environment for operators to act in. The activities primary goals are to:

- Assess the impacts that each of the debris mitigation frameworks currently being developed would have if applied within the commercial satcom sector.
- Generate commercial-satcom specific SDM recommendations considering competitiveness and large-scale constellation operations from the outset.

All aspects of the satellite mission life cycle from design and manufacturing to launch, operations, and de-commissioning are to be considered. The envisaged approach is to:

- Review the full range of new SDM measures, techniques, and approaches, currently being studied and developed across the space sector.
- Conduct technical studies on commercial satcom mission elements that might be affected by the application of such new approaches.
- Identify the associated challenges created to the commercial satcom industry.
- Identify emerging technologies that may be applied, as well as companies that might benefit from opportunities such changes in approach might generate.
- Create satcom-specific recommendations for future missions, with a focus on large-scale LEO constellations.
- Make recommendations as to how industry can best coordinate to realise these changes in a competitive manner.

The activity shall consider all orbit types with a focus on constellations in LEO as these are at the highest risk.

The activity will consider solutions that have been used in the past as well as planned future or theoretical solutions.

Whilst the application of a ‘Zero Debris’ approach may have significant financial implications for both planned and future spacecraft operations, it is not the intention that these impacts be quantified under this activity. Instead, the investigation will provide an understanding of the nature and scope of potential changes in approach, generating a qualitative view of their likely commercial impact, and will generate information to assist individual operators to form an assessment of the financial impact on their own operations.

This activity may reveal the need to: advise licensing authorities and launcher manufacturers on the implications of a new approach, identify technology gaps and satcom-optimised opportunities the new measures might create, and develop corresponding technology roadmaps.

2 WORK TO BE PERFORMED

2.1 Work Logic

The work to be performed is divided in four main tasks:

- **Task 1: Understanding the Difference in New and Old Standards and their Impact.**
- **Task 2: Identification of Satcom driven requirements**
- **Task 3: Identify Technological Solutions & Their Commercial Impacts**
- **Task 4: Sensitivity Analysis and Recommendations for Improvement**

The Tasks must be executed sequentially. The Contractor is free to propose to the Agency a redistribution of activities through as deemed appropriate, as well as to propose additional tasks when considered necessary to the fulfilment of the study objectives.

Error! Reference source not found. shows the proposed timeline for the study, which includes deliverable reviews and Milestone Payment reviews.

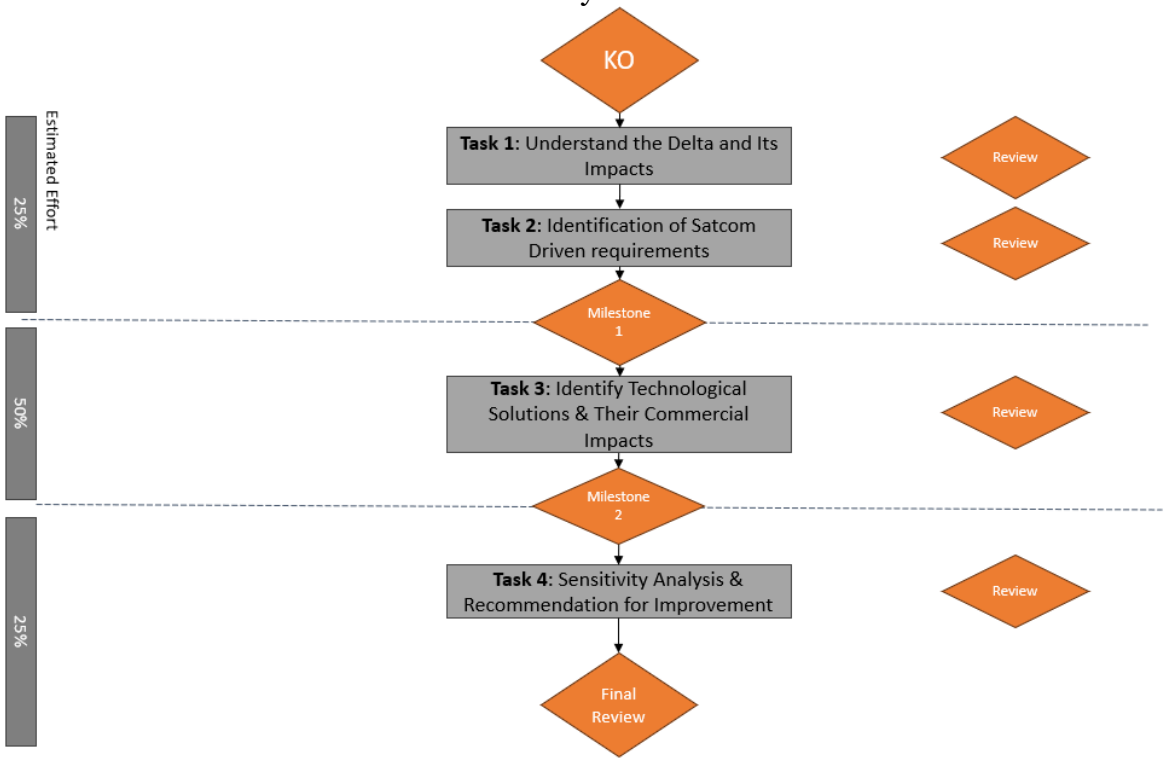

Figure 1: Proposed Activity Timeline

2.2 Tasks

This section defines the detailed requirements for the work to be performed by the Contractor.

The work to be performed is divided in four main tasks:

2.2.1 Task 1: Understanding the difference in new and old standards and their Impacts

Input: n/a
Task description: Compare new or pending debris mitigation standards against historic ones that may impact satcom spacecraft and identify changes to requirements. Analyse the technical impacts of these changes on different classes of satcom platforms, thereby identifying design drivers for the evolution of satcom platforms evolution.

Task List:

- Collect and review documentation on historic debris mitigation standards relevant to satcom spacecraft and include at a minimum the Applicable & Reference Documents.
- Gather information on suggestions for new debris mitigation requirements from government agencies and private companies that are operating in the domain of clean space. These should include space agencies, satellite operators and de-orbiting companies.
- Highlight potential changes in requirements, noting any major additions, modifications, or removals.
- Demonstrate the evolution of requirements and their implications for the satcom sector by providing compliance statements for each satcom orbit (i.e. LEO, MEO, GEO)
- Categorize satcom platforms into different classes.
- Document the technical specifications and operational characteristics of each class.

Deliverables:
TN1.1: Analysis of Delta Between New and Existing Debris Mitigation Standards.

2.2.2 Task 2: Identification of Satcom Driven requirements

Input: TN1.1
Task description: Recommend debris mitigation requirements based on commercial satcom needs. Achieve this by identifying operators needs from engagement with satcom operators, actors in the debris mitigation domain, and your own analysis of market trends.

Task List:

- Develop a questionnaire and interview guide to gather input from satcom operators and suppliers on their needs and concerns regarding debris mitigation requirements.
- Conduct interviews and surveys with satcom operators & suppliers to identify their specific needs and preferences.
- Engage with actors in the debris mitigation domain (e.g., regulatory bodies, environmental organizations, commercial service and technology providers) to gather insights on current and future trends in space debris management.
- Analyse market trends to identify commercial drivers and emerging technologies in the satcom sector.
- Review industry reports, market analyses, and competitive benchmarks to understand the commercial landscape and future projections.
- Consolidate the data from operator engagements and market trend analysis to identify key commercial needs related to debris mitigation.
- Prioritise these needs based on their potential impact on commercial viability and operational efficiency.
- Develop a set of additional debris mitigation best practices based on the identified commercial needs and gaps. Involve operators in the agreement of these suggested practices.

Deliverables:
TN2: Analysis & Recommendations for Satcom Centric Debris Mitigation Requirements

2.2.3 Task 3: Identify Technological Solutions & Their Commercial Impacts

Input: TN1.1, TN2
Task description: Assess the impacts and design drivers to identify technological solutions and building blocks to be developed. This should be achieved by examining the market for preexisting solutions, using case studies such as large GEO platforms and LEO constellations, and by proposing new solutions. Perform a qualitative assessment of the financial implications.

Task List:

- Assess the technical impacts of the new suggested requirements from Task 1 and Task 2 on each class of satcom platform. Consider factors such as design, materials, manufacturing processes, operational procedures, and end-of-life disposal. Display this in the form of a compliance matrix where it is clear which requirements impact which platform type and how it is impacted.
- Identify key design drivers influenced by the new requirements for each class of satcom platforms. Highlight critical factors such as durability, propulsion, power systems, and debris mitigation technologies.
- Analyse the market to identify existing technological solutions and building blocks that address the identified design drivers.
- Evaluate the maturity, availability, and performance of these solutions.
- Perform a gap analysis to identify gaps where existing solutions do not fully address the design drivers.
- Propose new technological solutions and building blocks to fill these gaps considering innovative technologies and emerging trends in the satcom industry.
- Evaluate the technical feasibility of each identified technological solution and building block including consideration of re-entry, system resilience (disposal, health monitoring, collision risk), mitigatory operation, and design for removal.
- Perform a qualitative assessment for the financial impacts. The analysis should identify Key Factors affecting financial aspects highlighting as minimum the impact level, the expected change and the risk level associated.
- Compare each solution and highlight the most viable solutions.

Deliverables:
TN3.1: Identification of Debris Mitigation Design Drivers for Satcom Satellites
TN3.2: Identification of most viable technical solutions

2.2.4 Task 4: Sensitivity Analysis & Recommendation for Improvement

Input: TN1.1, TN3.2
Task description: Calculate the sensitivity of the recommended technological solutions and building blocks to changes in key variables by performing a sensitivity analysis, highlighting the requirements of high impact to the commercial viability of the satcom sector. Make recommendations for changes to the debris mitigation requirements that have a positive commercial impact on the satcom sector without compromising sustainability goals.

Task List:

- Identify key variables that could impact the performance and commercial viability of the recommended technological solutions and building blocks (e.g., cost, market demand, regulatory changes, technological advancements).
- Identify how these variables are affected by the changed requirements.
- Develop a sensitivity analysis model to evaluate how changes in each requirement affect the recommended technological solutions and building blocks.
- Calculate the sensitivity of each solution and building block to variations in these key variables.
- Identify the requirements that have the highest impact on the commercial viability of the satcom sector.
- Evaluate the commercial implications of these high-impact variables on the satcom sector.
- Identify potential changes to the debris mitigation requirements that could enhance commercial viability without compromising environmental goals.
- Develop a set of recommendations for modifying debris mitigation requirements to benefit satcom operations respecting the underlying environmental goals.

Deliverables:
TN4: Sensitivity Analysis and Recommendation for Requirement Modification

3 REQUIREMENTS FOR MANAGEMENT, REPORTING, MEETINGS AND DELIVERABLES

The following are the requirements for Management, Reporting, Meetings and Deliverables applicable to the present activity.

3.1 Management

3.1.1 General

The Contractor shall implement effective and economical management for the project.

The Contractor's nominated Project Manager shall be responsible for the management, execution of the work to be performed and, in the case of a consortium, for the coordination and control of the consortium's work (including the submission of the deliverables to the Agency).

3.2 Reporting

3.2.1 Minutes of Meeting

The Contractor is responsible for the preparation and distribution of Minutes of Meetings held in connection with the Contract. Electronic versions shall be issued and distributed to all participants, to the Agency's Technical Officer and to the Agency's Contracts Officer not later than five (5) days after the meeting concerned.

The minutes shall clearly identify all agreements made and actions accepted at the meeting.

3.2.2 Bar-chart Schedule

The Contractor shall be responsible for maintaining the bar chart for work carried out under the Contract, as agreed with the Agency.

The Contractor shall present an up-to-date chart for review at all subsequent meetings, indicating the current status of the Contract activity (WP's completed, documents delivered, etc.).

3.2.3 Progress Reports

Every month, the Contractor shall provide a Progress Report in electronic format to the Agency's representatives, covering the activities carried out under the Contract. This report shall refer to the current activities shown on the latest issued bar-chart and shall give:

- Action items completed during the reporting period;
- Description of progress: actual vs schedule, milestones and events accomplished;
- Reasons for slippages and/or problem areas, if any, and corrective actions planned and/or taken, with revised completion date per activity;
- Events anticipated during the next reporting period (e.g. milestones reached);

- Milestone payment status.

3.2.4 Problem Notification

The Contractor shall notify the Agency's representatives (Technical Officer and Contracts Officer) of any problem likely to have a major effect on the time schedule of the work or to significantly impact the scope of the work to be performed.

3.2.5 Technical Documentation

As they become available and not later than the dates in the delivery plan, the Contractor shall submit for the Agency's approval Technical Notes, Task/WP Reports, etc.

Technical documentation to be discussed at a meeting with the Agency shall be submitted electronically two weeks prior to the meeting.

3.3 Meetings

A kick-off meeting shall take place by videoconference.

The following meetings shall be held under this contract:

Meeting	Where	When
Negotiation	By video or teleconference	Before contract signature
Kick-Off	By video or teleconference	Start of the activity
Review Meeting 1 (Technical)	By video or teleconference	At the end of Tasks 1
Review Meeting 2 (Technical)	By video or teleconference	At the end of Tasks 2
Milestone Signoff 1 (Programmatic)	By video or teleconference	At the end of Tasks 2
Review Meeting 3 (Technical)	By video or teleconference	At the end of Tasks 3
Milestone Signoff 2 (Programmatic)	By video or teleconference	At the end of Tasks 3
Review Meeting 4 (Technical)	By video or teleconference	At the end of Tasks 4
Final Review (Technical)	At ESTEC or teleconference	At the end of the Study
Project Closure (Programmatic)	By video or teleconference	Project Closure

In addition, separate Progress Meetings shall be held at approximately 2- to 3-monthly intervals, by videoconference, if no other Review Meetings have taken place within that period.

The final presentation shall take place to a public audience, within twelve (12) months of Contract closure. During the course of the activity the Agency will decide on the format for the final presentation (e.g. dedicated meeting, conference, specific event)..

Additional meeting may be requested either by the Agency or the Contractor.

With due notice to the Contractor the Agency reserves the right to invite Third Parties to meetings to facilitate information exchange.

For each meeting the Contractor shall propose an agenda in electronic form and shall compile and distribute material of any presentation given at the meeting. Should the

Contractor wish to invite Third Party(ies) to meetings, the prior approval of the Agency shall be sought.

3.4 Deliverable Items

In addition to the documents to be delivered according to section 4.2 here above, the following items shall also be delivered.

The draft version of the documentation shall be sent to the Agency's Technical Officer in electronic format not later than two (2) weeks before the documentation is to be presented.

All documents shall bear the appropriate copyright notice. In all cases, this shall include the title, ESA Contract number, deliverable number, date, status (draft), version and/or revision number. The information shall be repeated consistently in the header or footer of every page.

Documentation

Doc ID	Title	Definition	Milestone	e-copy to DMS
DMS (Data Management System) address: **tecdms@esa.int**. (or others as applicable for other ESA Directorate) Please note that all finalised (i.e. reviewed and approved by ESA in their final version) documents resulting from a technology Contract shall be electronically sent by the Contractor to D/TEC's Data Management System (DMS) using the e-mail address tecdms@esa.int. This applies not only to the final documentation such as the Final Report or Summary Report but to all approved output documents (TNs, Progress Reports, etc.).				
TN1	Technical Note TN1		end of Task 2	yes
TN2	Technical Note TN2		end of Task 2	yes
TN3.1	Technical Note TN3.1		end of Task 3	yes
TN3.2	Technical Note TN3.2		end of Task 3	yes
TN4	Technical Note TN4		end of Task 4	yes
TDP	Technical Data Package (**)	*TDP consists of the final versions of all approved technical documents, delivered during the execution of the activity.*	Final Review	yes
SR	*Summary Report*	*SR summarises the findings of the Contract concisely and, informatively. The SR shall be approximately twenty (20) pages or six thousand (6000) words.* *Note: The Agency may request the Contractor to produce the SR in the form of a paper suitable for publishing in a technical journal.*	*Final Review*	yes
ESR	Executive Summary Report (**)	*ESR concisely summarises the findings of the Contract. It shall be suitable for non-experts in the field and should also be appropriate for publication. For this reason, it shall not exceed five (5) pages of text and ten (10) pages in total (one thousand five hundred (1500) to*	Final Review	yes

		three thousand (3000) words).		
FR	Final Report (**)	*The FR shall provide a complete description of all the work done during the activity and shall be self-standing, not requiring to be read in conjunction with reports previously issued. It shall cover the whole scope of the activity, i.e. a comprehensive introduction of the context, a description of the programme of work and report on the activities performed and the main results achieved.* *The FR is a mandatory deliverable, due upon completion of the work performed under the Contract. For the avoidance of doubt, "completion of the work performed under the Contract" shall mean the finalisation of a series of tasks as defined in a self-contained Statement of Work.*	Final Review	yes
FP	Final Presentation (**)		Final Review	yes
PWP	Project Web Page (**)	Project Web Page in MS Word for Windows® template, to be delivered to the ESA Technical Officer with copy to the ESA Contracts Officer	Final Review	yes
CCD	Contract Closure Documentation (**)	*The CCD is a deliverable due at the end of the Contract. Work performed under Contract Change Notices adding new tasks with respect to the original Contract*	Contract Closure	yes

		shall require separate CCD.		

(**) Final Deliverable Documents

4 SCHEDULE

4.1 Duration

The duration of the work shall not exceed **12 months** from kick-off to the end of the activity (delivery of Final Report).

4.2 Milestones

The following milestones shall apply:

Milestone	Where	When
Negotiation	By video or teleconference	Before contract signature
Kick-Off	By video or teleconference	Start of the activity
Milestone Signoff 1	By video or teleconference	At the end of Tasks 2
Milestone Signoff 2	By video or teleconference	At the end of Tasks 3
Project Closure	By video or teleconference	Project Closure

4.3 Reviews

The following reviews shall be held:

4.3.1 Task 1 Review

- Date: End of Task 1
- Location: By video or teleconference
- Input: Task 1
- Description: Review of Task 1 deliverables
- Output: ESA approval of Task 1 deliverables

4.3.2 Task 2 Review

- Date: End of Task 2
- Location: By video or teleconference
- Input: Task 2

- Description: Review of Task 2 deliverables
- Output: ESA approval of Task 2 deliverables

4.3.3 Task 3 Review

- Date: End of Task 3
- Location: By video or teleconference
- Input: Task 3
- Description: Review of Task 3 deliverables
- Output: ESA approval of Task 3 deliverables

4.3.4 Task 4 Review

- Date: End of Task 4
- Location: By video or teleconference
- Input: Task 4
- Description: Review of Task 4 deliverables
- Output: ESA approval of Task 4 deliverables

ANNEX A. LAYOUT FOR CONTRACT CLOSURE DOCUMENTATION

(v2018-10)

Contract Closure Documentation
for
ESA Contract No. 4000XXXXXX/xx/XX/XXX/xxx
"[Title of Activity]",
hereinafter referred as the "Contract"

Section 1 – Parties, Contract Duration and Financial Information

Contractor		[CONTRACTOR NAME AND COUNTRY]
Subcontractor(s) *(state if not applicable)*		[NAME AND COUNTRY]
Contract Duration *(insert the dates agreed for kick-off and end of Contract)*		**From**: **To**:
Total Contract Price (*including all CCNs, Work Orders, Call of Orders*) and Total Contract Value *(in case of co-funding; state if not applicable)*		**EUR** EUR
Broken down as follows:	**Original Contract Price** and original Contract Value (*in case of co-funding; state if not applicable*)	**XXX EUR (XXX EUR)** EUR
	CCN x to n **Work Order x to n** **Call-Off Order x to n**	**EUR** in total **EUR** in total **EUR** in total

Section 2 – Recapitulation of Deliverable Items

2.1 Items deliverable under the Contract

If any of the columns do not apply to the item in question, please indicate "n/a".

Table 2.1.1 - Items deliverable according to the Statement of Work and Article 2 of the Contract

Type	Ref. No.	Name / Title	Description	Replacement Value (EUR)/ Other	Location [1]	Property of	Rights granted / Specific IPR Conditions [2]
Documentation							
Hardware							
Software			*(Delivery in Object code / Source code?)*				
Other							

Table 2.1.2 – Items deliverable under Article 7 of the Contract (*if applicable*)

The Contractor, after agreement with the Agency with respect to the disposal/transfer of Inventory Items/Fixed Assets under the Contract, shall submit the Inventory/Fixed Asset Record as attachment to the CCD. For each Item/Fixed Asset, the information as requested by Appendix 3 to the Contract shall be provided in the Record.

Table 2.1.3 – Customer Furnished Items and Items made available by the Agency

There was no Customer Furnished Items or Items made available by the Agency.

[1] *In case the item is not delivered to ESA, please indicate the location of the deliverable and the reason for non-delivery (e.g. loan agreement, waiver, future delivery, etc.)*
[2] *e.g. IPR constraints, deliverable containing proprietary background information (see also Table 2.1.3 below)*

Table 2.1.4 - Background information used and delivered under the Contract (see Article 6.3 of the Contract)

The following background information has been incorporated in the deliverable(s):

Proprietary Information (*title, description*)	**Owner** (*Contractor / Subcontractor(s)/ Third Party(ies*)	**Affected deliverable** (*which documents, hardware, software, etc.*)	**Description impact on ESA's rights to the deliverable ([3])**	**Other comments**

[3] *if not explicitly stated otherwise, the contractual stipulations shall prevail in case of conflict with the description provided in this table*

Section 3 – Statement on Intellectual Property Rights generated under the Contract

In accordance with the provisions of the Contract ..... [Contract Number], ... [Company] hereby certifies both on its own behalf and that of its consortium/Subcontractor(s), that no Intellectual Property Right(s) (as defined in the Contract, under the section 'Definitions') has(ve) been generated in the course of or resulting from work undertaken for the purpose of this Contract.

Section 4 – Output from / Achievements under the Contract

4.1 Technology Readiness Level (TRL)

Indicate the TRL of the technology developed under the Contract using the classification given below (for additional information on definitions, please refer to ECSS-E-AS-11C):

Initial TRL	Planned TRL as activity outcome	Actual TRL at end of activity

1	Basic principles observed and reported
2	Technology concept and/ or application formulated
3	Analytical and experimental critical function and/ or characteristic proof of concept
4	Component and /or breadboard validation in laboratory environment
5	Component and /or breadboard critical function verification in a relevant environment
6	Model demonstrating the critical functions of the element in a relevant environment
7	Model demonstrating the element performance for the operational environment
8	Actual system completed and accepted for flight 'flight qualified'
9	Actual system 'flight proven' through successful mission operations

Note: The TRL shall be assessed by ESA. The Agency's responsible Technical Officer shall verify TRLs 1-4 while TRLs 5-9 shall be assessed through an ESA-internal formal procedure.

4.2 Achievements and Technology Domain

.....
Provide a concise description (max two hundred (200) words) of the achievements of the Contract and its explicit outcome (including main performances achieved): please refer to the final documentation (e.g. Final Report).

Please indicate the Technology Domain (TD 1 to 25) of the development (*please tick off*):

	1	On-Board Data Systems		14	Life & Physical Sciences
	2	Space System Software		15	Mechanisms & Tribology
	3	Spacecraft Electrical Power		16	Optics
	4	Spacecraft Environment & Effects		17	Optoelectronics
	5	Space System Control		18	Aerothermodynamics
	6	RF Payload and Systems		19	Propulsion
	7	Electromagnetic Technologies and Techniques		20	Structures & Pyrotechnics
	8	System Design & Verification		21	Thermal
	9	Mission Operations and Ground Data Systems		22	Environmental Control Life Support
	10	Flight Dynamics and GNSS		23	EEE Components and Quality
	11	Space Debris		24	Materials and Processes
	12	Ground Station System & Networking		25	Quality, Dependability and Safety
	13	Automation, Telepresence & Robotics			

4.3 Application of the Output/Achievements

Please tick off as appropriate:

☐ Possible use in programme:

.....
Please indicate the service domain (see table) relevant to a possible application

	1	Earth Observation
	2	Science
	3	Human Spaceflight and Exploration
	4	Space Transportation
	5	Telecommunications
	6	Navigation
	7	Generic Technologies and Techniques
	8	Security
	9	Robotic Exploration

☐ Actual use in programme:

.....
Please describe the specific programme and application or mission for which the output of this Contract is or will be used.

4.4 Further Steps/Expected Duration

Please tick off as appropriate:

☐ No further development envisaged.

☐ Further development needed:

.....
Please describe further development activities needed, if any, to reach TRL 5/6 including an estimate of the expected duration and cost.

4.5 Potential Non-Space Applications

.....
Describe any potential non-space applications or products that may benefit from the technology that has been developed. Emphasize potential markets and customers where known.

.....
Describe the principle features of technology that would be required in a technology demonstrator for any identified non-space application. Include an estimate of the resources in time and money that would be required.

The above statements provided in the various sections of this "Layout for Contract Closure Documentation" for ESA Contract No. **4000xxxxxx/xx/XX/XXX/xxx *[insert the corresponding contract number*]** have been made after due verifications. The Contractor furthermore certifies that all its obligations with regard to Fixed Assets, if any, have been fulfilled. If required by ESA, an updated version shall be provided for incorporating amendments requested by ESA.	
Name of Contractor: *[insert Contractor name]*	
Authorised signatory: *[insert Authorised signatory full name]*	*[signature of the Authorised signatory*]
Date: [insert date]	