



ESA ESOC
Robert-Bosch-Strasse 5
64293 Darmstadt
Germany

SK_AD02 - CR TO P3-SST-III ROBOTIC TELESCOPES DEMONSTRATION

Prepared by	ESA ESA
Document Type	Statement of Work
Reference	ESA-SSA-SST-SOW-0005-CR02
Issue/Revision	1.0
Date of Issue	25/03/2021
Status	Issued



APPROVAL

Title	SK_AD02 - CR to P3-SST-III Robotic Telescopes Demonstration		
Issue Number	1	Revision Number	0
Author	ESA	Date	25/03/2021
Approved By	Date of Approval		

CHANGE LOG

SK_AD02 - CR to P3-SST-III Robotic Telescopes Demonstration	Issue Nr	Revision Number	Date

CHANGE RECORD

Issue Number	1	Revision Number	0	
Reason for change	Date	Pages	Paragraph(s)	

DISTRIBUTION

Name/Organisational Unit



Table of Contents

1.1. Purpose and scope of the document.....	4
1.2. Overview of Slovak PECS activities	4
1.3. Objectives of the Activity	5
1.4. Applicable Documents.....	6
1.5. Reference Documents.....	6
2.1. Proposed Project Logic	8
2.2. Task 1: Interface Capacity With Robotic Telescopes	8
2.3. Task 2: Observation Campaigns for Network Capacity Demonstration.....	9
2.4. Task 3: Lessons learnt and identified gaps/shortcoming in Task-2	11

1. INTRODUCTION

1.1. Purpose and scope of the document

This document describes the activity to be executed and the deliverables required by the European Space Agency (referred as ESA or ‘the Agency’) for the SK_AD02 activity.

The objective of this activity is to prepare Slovak entities for efficient future participation in the ESA Space Safety Programme. This activity is intended to be placed as a Contract Change Notice to an on-going activity (P3-SS-III Robotic Telescopes Demonstration, Contract ref. 4000124438/18/D/MRP) with Iguassu Software Systems a.s. (CZ) for addition of work to be performed by a Slovak Subcontractor. This currently running activity is expected to be completed in the second quarter of 2021.

This document will become part of the contract and shall serve as an applicable document throughout the execution of the work (with possible amendments recorded during the Kick-Off meeting) and for external audit on the supplier(s).

The document is structured as follows:

- **Section 1** introduces the background and the main objectives of the work, and quotes applicable and reference documents (including applicable standards).
- **Section 2** defines the work to be performed under SK_AD02
- **Section 3** contains the requirements on deliverables, schedule and milestones.

1.2. Overview of Slovak PECS activities

Previous Slovak PECS activities have demonstrated a strong interest in and competency for Space Safety Programme (S2P) topics. Relevant work from the first period of the PECS Programme included:

- Development of a supporting optical sensor for high-area-to-mass-ratio objects cataloguing research (HAMROPTSEN) (TRL 3)
- Improvement of European capabilities for LEO objects tracking with optical passive sensors (TRL 3)
- Study of meteoroid composition by meteor spectroscopy and simulated ablation of meteorites (TRL 3)

- Slovak automated space surveillance and tracking optical system (TRL 4)

1.3. Objectives of the Activity

This activity specifically addresses technology developments for robotic telescopes for observation of space debris and will be directly complementary work, allowing for further progression of the development and providing a path for future cooperation with other ESA Member States, thereby addressing one of the recommendations of the end of period country report.

Extending the baseline of existing networking under this activity with Slovak sensors shall ensure compatibility with used and developing data exchange formats, protocols, and standards for applications in the domains of space debris and planetary defence. With such an extension and demonstration of the interaction with ESA's robotic test-bed telescopes, the capabilities of the Slovak entities will be increased. The activity shall also assess the capabilities to observe fragmentation events using existing ground-based sensors.

The activity shall:

- Formulate requirements for connecting the Slovak optical sensor infrastructure to existing robotic telescopes in Europe, also including, but not limited to, ESA's Test-bed Telescopes;
- Implement the required interface, by also adopting standardised data exchange formats;
- Propose and perform extensive testing for different areas of space safety, namely applications in space debris and planetary defence;
- Critically assess the obtained test results and establish a roadmap for closure of identified gaps in considering needs from a Slovak participation in ESA's Space Safety Programme.

1.4. Applicable Documents

Reference	Document Title	Reference
[AD-SoW2]	P3-SST-III Robotic Telescopes Demonstration	ESA-SSA-SST-SOW-0005

1.5. Reference Documents

Reference	Document Title	Reference
[RD-TDM]	Tracking Data Message	CCSDS 503.0-B-1 Blue Book . Issue 2. June 2020.
[RD-ODM]	Orbit Data Messages	CCSDS 502.0-B-2 Blue Book. Issue 2. November 2009.
[RD-ST70]	ECSS-E-ST-70c Space Engineering: Ground systems and operations	ECSS-E-ST-70C, 31 July 2008
[RD-IADC]	Light curves IADC format, Version 5, January 2014	Memo "Information exchange between WG1 and WG2"
[RD-MPC]	MPC format	https://www.minorplanetcenter.net/iau/info/OpticalObs.html
[RD-FITS]	Definition of the Flexible Image Transport System (FITS)	https://fits.gsfc.nasa.gov/standard40/fits_standard40aa-le.pdf

2. WORK TO BE PERFORMED

In order to achieve the previously stated objectives, the following tasks are foreseen in the present activity. Alternative suggestions can be made by the bidder as part of their proposal. However, for clarity it is requested that the naming convention offered below be applied as the starting point.

Task-1 Interface Capacity With Robotic Telescopes

Task-1.1 Identification of robotic telescopes in Europe

Task -1.2 Interface assessment of identified robotic telescopes in Task-1.1

Task -1.3 Interfaces implementation

Task-2 Observation Campaigns for Network Capacity Demonstration

Task-2.1 Space Debris Monitoring (SDM)

- Demonstrate capacity for fragmentations/break up events detection
- Demonstrate Light curves acquisition capacity
- Demonstrate the network performance by means of coordinated campaigns aiming at observing same targets from different sensors
- Demonstrate Stare and Chase capacity improving the performance of the proof of concept (Improvement of European capabilities for LEO objects tracking with optical passive sensors)

Task-2.2 NEO observations

- Demonstrate NEO observational capabilities in Slovakia
 - Submit images to NEOCC
 - Submit astrometry of objects to MPC
(NB: Ensure that all Slovak stations participating in the activity have an MPC observatory code. If not, they shall apply for one)
- Perform observations of artificial satellite in heliocentric orbits for entire duration of the contract
 - Submit images to NEOCC
 - Perform data analysis of images taken
 - Submit astrometry of objects to NEOCC
- Perform a comprehensive low elongation survey, complementary to the one performed with the Test-bed Telescope by ESA in order to test its observational capabilities
 - Submit images to NEOCC
 - Perform data analysis of images taken
 - Submit astrometry of objects to MPC

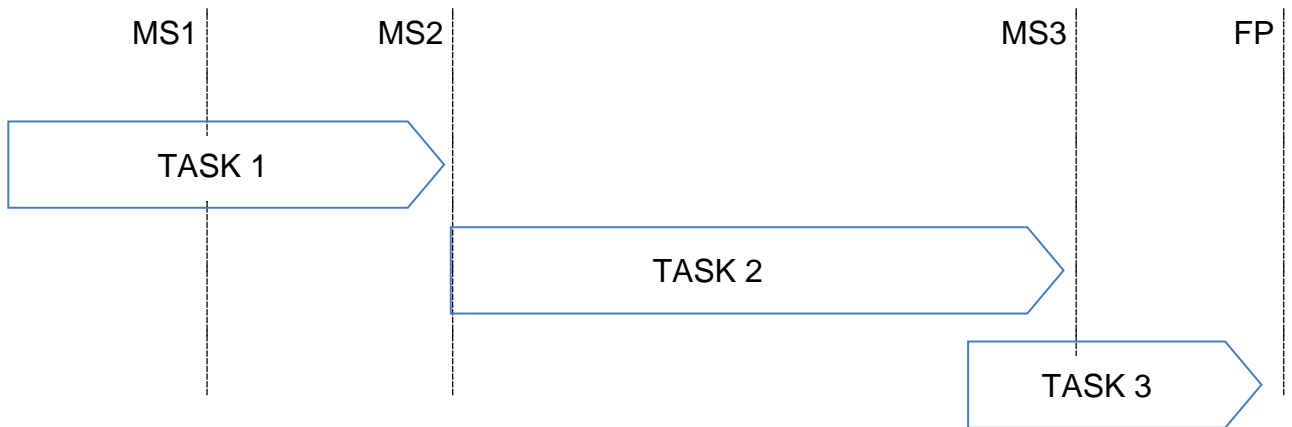
Task-3 Lessons learnt and identified gaps/shortcomings in Task-2

Task-3.1 Collect and analyse of the test results from Task-2

Task-3.2 Roadmap for closure identified gaps in Task-3.1

2.1. Proposed Project Logic

Figure below illustrates the logic behind the work and the scheduling of the tasks over the project period of 12 months. The duration of each period is described in last section of the present document.



2.2. Task 1: Interface Capacity With Robotic Telescopes

This task aims to develop an understanding of different robotic sensors existing across Europe and to formulate and implement the requirements needed for connecting the Slovak optical sensor infrastructure to them, following recommended standardise formats. During the survey exercise ESA’s Test-bed Telescopes shall be considered.

Req. Id.	Description
T1-001	Perform a survey to identify existing robotic telescopes in Europe with space debris and NEO monitoring capacity. NB: The use of ESA Test-Bed Telescopes shall be considered
T1-002	Review the suitability of state-of-the-art sensor technologies for their suitability for the SDM/NEO application
T1-003	Review the interfaces required to be established to ensure network capacity among the sensors.

T1-004	Define the sensor interfacing requirements for the identified sensors and Slovak ones.
T1-005	Implement the identified interface requirements to guarantee maximum efficiency when exploiting the network capacity during the observation campaign phase.
T1-006	Propose standardisation of sensor interfacing with SDM/NEO observation systems

OUTPUTS

- Detailed Technical Note (TN) listing the identified robotic telescopes in Europe, including location and sensor characteristic (such as, e.g., detector type, mount type, performances).
- Interface Control Document (ICD) compiling the identified interfaces of the selected sensors and the Slovak assets to determine the interfaces to be further developed.
- TN addressing the interface requirements and prototype identified to be implemented to exploit the benefits of interconnections between the sensors.
- TN compiling the standardisation proposal for any sensor interfacing with SDM/NEO observation systems.

2.3. Task 2: Observation Campaigns for Network Capacity Demonstration

This task aims at exploiting the network among the identified sensors in Task 1, distinguishing between Space Debris and NEO needs. Following requirements address the objective of the different observation campaigns that the bidder needs to perform.

Req. Id.	Description
T2-001	Space Debris Observation Campaign 1: Among the identified sensors in Task 1, the contractor shall demonstrate fragmentations / Break up events detection capacity. The data product generated shall be detection lists and shall be delivered to the ESA data archive via FTP.
T2-002	Space Debris Observation Campaign 2: Among the identified sensors in Task 1, the contractor shall demonstrate light curves acquisition capacity.



	<p>The data product generated shall be light curves in IADC format [RD-IADC], and derived products like the rotational period and delivered to the ESA data archive via FTP.</p>
T2-003	<p>Space Debris Observation Campaign 3:</p> <p>Among the identified sensors in Task 1, the contractor shall demonstrate the network performance by means of coordinated campaigns aiming at observing same targets from different sites.</p> <p>The data product generated shall be CCSDS TDM in both ASCII and XML format [RD-TDM] and delivered to the ESA data archive via FTP.</p>
T2-004	<p>Space Debris Observation Campaign 4:</p> <p>The contractor shall demonstrate operational level of the proof of concept stare and chase.</p> <p>The data product generated shall be CCSDS TDM in both ASCII and XML format [RD-TDM] and delivered to the ESA data archive via FTP.</p>
T2-005	<p>NEO Observation Campaign 1:</p> <p>Among the identified list of sensors in TASK1, the contractor shall demonstrate NEO observational capabilities in Slovakia. MPC observatory code is required, otherwise the contractor shall apply for it.</p> <p>The data product generated shall follow FITS standard [RD-FITS], and images shall be submitted to NEOCC and astrometry of observed objects submitted to MPC [RD-MPC].</p>
T2-006	<p>NEO Observation Campaign 2:</p> <p>Among the identified list of sensors in TASK1, the contractor shall perform observations of artificial objects in non-Earth bound orbits and perform data analysis of the images.</p> <p>The data products generated shall follow FITS standard [RD-FITS], and images shall be submitted to NEOCC and astrometry of observed objects submitted to MPC [RD-MPC].</p>
T2-007	<p>NEO Observation Campaign 3:</p> <p>Among the identified list of sensors in TASK1, the contractor shall perform a comprehensive low elongation survey, complemented to the one performed with the TBT, and perform data analysis of the images.</p> <p>The data product generated shall follow FITS standard [RD-FITS], and images shall be submitted to NEOCC and astrometry of observed objects submitted to MPC [RD-MPC].</p>

OUTPUTS



- Observation campaign plans (one for SD and one for NEO) covering all observation campaigns described above. A comprehensive allocation of the time to fulfil all the requirements for each type of observation campaigns needs to be agree beforehand with the Agency.
- Observation campaigns reports and data analysis
- Images and derived output data

2.4. Task 3: Lessons learnt and identified gaps/shortcoming in Task-2

This task aims at collecting the lessons learnt along the exercise of the different observation campaigns, and identifying the steps to be followed in the future to cover gaps as to enable for direct Slovak participation in European and international collaborations, and in particular in ESA’s Space Safety programme in the future.

The following subtasks have been identified:

Task-3.1 Collect and analyse of the test results from Task-2

Task-3.2 Roadmap and costing for closure of identified gaps in Task-3.1

OUTPUTS

- TN compiling identified gaps, criticality analysis and offering a future roadmap to solve them.

3. DELIVERABLES AND MILESTONES

Code	Title	Milestone
DOC-001	TN compiling list of sensors, description form, ICDs, availability	MA1(draft)/MS2
DOC-002	SSR, ICD	MS1(draft)/MS2
DOC-003	Standardisation proposal for sensor interfacing with SDM/NEO observation systems	MS2(draft)/FP
DOC-003	SST Observation Campaign Plan	MS2
DOC-004	NEO Observation Campaign Plan	MS2



DOC-005	SST Observation Campaign Report	MS3
DOC-006	NEO Observation Campaign Report	MS3
DOC-007	Gaps/Shortcoming criticality analysis and roadmap	FP

Milestone	Description	Events Timeline
KO	Kick-Off	T0
MS1	Sensor availability Review	T0+1m
MS2	Observation Campaign Readiness Review	T0+2m
MS3	Observation Campaign Review	T0+10m
FP	Final Presentation	T0+12m (payment)