

EUROPEAN SPACE AGENCY

ROBOTIC EXPLORATION

TECHNOLOGY PLAN

Addendum to March 2013 Programme of Work 2009-2014

This document is an addendum to the March 2013 Programme of Work and includes new activities in the Exploration Technology Programme (ETP, funded by MREP-2) that are supporting the implementation of ESA's Robotic Exploration Programme from 2009-2014.

**This document is provided for information only and is subject to future updates.
May 2013**

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1. Background and Scope

This document is an addendum to the Mars Robotic Exploration Preparation-2 Technology Development Plan (TDP) that was approved in March 2013 (ESA/IPC(2013)57). The TDP contains the description of the technology development activities (TDAs) required for the technological preparation of the Mars Robotic Exploration Programme 2 (MREP 2) and planned to be initiated in 2013.

This addendum addresses two additional activities to be started in 2013, one for the Harwell Robotics and Autonomy Facility (HRAF) architecture development including a pilot project and the second for the continuation of the High Thrust Engine development. The second MREP-2 work plan for defining 2014 activities will be produced in November 2013.

New Activities seeking approval for 2013-2015

Prog.	IPC Appr.	ESA Ref.	Activity Title	Budget 2013	Budget 2014	Budget 2015	PP	C'try	SW Clause	Remarks
ETP	IPC	E908-001FP	Harwell Robotics Autonomy Facility (HRAF) - Pilot project 1	1200	0	0	DN/C	UK	N/A	
ETP	IPC	E919-012MP	Design, development testing and generic qualification of a High Thrust Apogee Engine (HTAE)	2000	0	2300	DN/C	UK	N/A	Phase 2a (2000k), Phase 2b (2300k)
Total Budget:				3200	0	2300				

Harwell Robotics Autonomy Facility (HRAF) - Pilot project 1					
Programme:	ETP		Reference:	E908-001FP	
Title:	Harwell Robotics Autonomy Facility (HRAF) - Pilot project 1				
Total Budget:	1200				
Objectives					
<p>The objective is to implement the HRAF core infrastructure and demonstrate, through a pilot project, the value of the facility for the validation of autonomous systems and technologies. This activity is the first in a long-term programme and is funded by the ESA MREP-2 programme and supported by UKSA.</p>					
Description					
<p>The development of complex autonomous robotic systems will be critical for future planetary exploration missions. At a minimum, elements of the MSR mission such as Sample Fetch Rover, landing with high precision (and hazard avoidance), autonomous sampling and sample transfer or sample container rendezvous and capture will all require ECSS level-3 autonomy and higher. Although the related technology developments are progressing strongly within Europe, there remains a lack of critical infrastructure to allow validation, verification and integration of autonomy components at the mission level.</p> <p>The aim of this activity is to setup a facility that supports the validation of autonomous systems and associated technologies to enable the TRL of technologies to be raised, confidence in performance to be gained, cost estimates to be more credible, and eventually missions to be validated. These will require the use of specialist test facilities including mock planetary surfaces, software-based simulation environments and physical field trials in representative environments to provide ground truth.</p> <p>The aim of this activity is:</p> <p>Phase 1:</p> <ul style="list-style-type: none"> - Define underlying requirements (including prime, academic and Agency input) - Validation Process Definition - Define the architecture of the facility (S/W, H/W environment, tools...) <p>Phase 2:</p> <ul style="list-style-type: none"> - Start of Component Engineering - Integration of core infrastructure elements (including maturation of the EAGLE software tool) - Prepare and execute a pilot project <p>The activity is split into 2 phases: Phases 1 ends with a PDR. A successful PDR is the prerequisite for the execution of phase 2.</p> <p>The pilot project will be based on and use results and data from the SEEKER activity and EAGLE simulator development (ESA C21286(2007)).</p>					
Deliverables					
Documentation					
Software (Middleware components)					
EAGLE update					
Current TRL:	1	Target TRL:	3	Application Need/Date:	2015
Application Mission:	MSR, Photoprint, Inspire & various		Contract Duration:	12	
S/W Clause:	N/A		Reference to ESTER	N/A	
Consistency with Harmonisation Roadmap and conclusion:					

Design, development testing and generic qualification of a High Thrust Apogee Engine (HTAE)					
Programme:	ETP		Reference:	E919-012MP	
Title:	Design, development testing and generic qualification of a High Thrust Apogee Engine (HTAE)				
Total Budget:	4300				
Objectives					
This activity will continue the development, to a generic qualification level, of a High Thrust Apogee Engine for the Robotic Exploration Programme.					
Description					
<p>The MREP-funded Combustion chamber and Injection technology development activity, was a first phase aimed at defining a high thrust apogee engine (HTAE) that was a specific fit to Agency requirements for planetary missions and orbit insertion. The HTAE phase 1 targets an ITAR-free design and examines high performance injector design and cost effective high temperature materials developments. The definition of a flow control valve was also included to complete the equipment definition. The phase 1 activity will conclude in 2013 with a Intermediate PDR (I-PDR) for the injector, chamber and valve.</p> <p>The follow on Phase 2, which is the subject of this activity proposal, is intended to proceed following a successful close-out of the I-PDR, and is aimed at:</p> <ul style="list-style-type: none"> - Completion of design Definition <ul style="list-style-type: none"> o Final loop of injector, chamber and valve development testing as identified in Phase 1B will be performed to finalise injector down-selection for the design of the HTAE including any further optimisations identified. o PDR - Detailed design <ul style="list-style-type: none"> o CDR - Generic Qualification <ul style="list-style-type: none"> o Manufacture of EM (generic qualification) batch 2 test hardware o Process qualification for injectors, chamber manufacture and if relevant, chamber material coating process o HTAE Valve development activity - design and manufacture of a qualification model for engine qualification program o Qualification program of engine(s) to TBC specification (generic qualification requirements) <p>The Phase 2 will be split into two parts, Phase 2a and Phase 2b as shown below:</p> <ul style="list-style-type: none"> - Phase 2a (2000kEuros) starting 2013 for a duration of 24 months until CDR - Phase 2b (2300kEuros) starting 2015 for a duration of 18 months until completion 					
Deliverables					
Documentation, development models, engineering model engine and valve assemblies.					
Current TRL:	3	Target TRL:	5/6	Application Need/Date:	2016
Application Mission:	INSPIRE, Photoprint, MSRO and other future Mars missions		Contract Duration:	42	
S/W Clause:	N/A		Reference to ESTER	N/A	
Consistency with Harmonisation Roadmap and conclusion:					

**Justification for Proposed Tendering Procedure: DN/C
Industrial Policy Committee**

ESA Reference	Title	Firm Fixed Price (Keuro)	Proposed Bidder
E908-001FP	Harwell Robotics Autonomy Facility (HRAF) - Pilot project 1	1200	SCISYS (UK)

Justification:

This activity builds on the developments already done by SCISYS on rover field trials (SEEKER activity) and the EAGLE software tool (for Entry, Descent and Landing).

**Justification for Proposed Tendering Procedure: DN/C
Industrial Policy Committee**

ESA Reference	Title	Firm Fixed Price (Keuro)	Proposed Bidder
E919-012MP	Design, development testing and generic qualification of a High Thrust Apogee Engine (HTAE)	4300	MOOG (UK)

Justification:

This activity is a follow-on to the running ETP Phase 1 activity "Combustion chamber and injection technology development" which is currently being led by MOOG.