Green Propulsion.
State-of-art, prospectives and roadmap

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22/04/2015

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ESA Roadmap Summary – Approved Activity

Title	Crit.	Budget (kEuro)	Appr. Prog.	Pot. Prog.	Status/Remark	TRL		Date	
						Curr.	Targ.	Start	End
AIM A: Green mono-propellant development									
LMP-103S monopropellant qualification	H	1400		GSTP/ StrIn	Contract Prep. Proposal under TEB review.	5	6	2015	2016
Throughput Ext CCN2 - CDR Validation		499		TRP		4	5	2015	2015
ECAPS 1N thruster qulification		1900	GSTP		Myriade Evolution Focus.	5	6	2015	2016
200-300N class thruster development for A5 upper stage			A5 ME		Complete	3	3	2012	2012
200-300N class thruster development for A5 upper stage (H2O2 monopropellant HGRS Rocket engine development for A5ME SCATE applicatons up to CDR completion.)	H		A5ME/ StrIn		At PDR.	3	5	2012	2015
200-300N class thruster development for A5 upper stage		?			After CM - 2014	5	9	2015	2018
NOFBE Evaluation		300	ARTES		Contract Prep. 18 month duration.	2	3	2015	2016
HAN-based monopropellant assessment		350	TRP		In negotiation.	4	4	2015	2016
AIM B: Green bi-propellant development									
Hydrogen peroxide - kerosene 1N thruster development		570	GSTP		Implementation	3	4	2012	2014
400N class green bi-propellant thruster development (GRACE)	M	200		PNI	Implementation. Polish Initiatives (IoA)	1	6	2015	2018
AIM C: Green solid propulsion development									
Testing & performance of aluminium free solid propellant		400			Implementation	1	4	2014	2015
De-orbit motor engineering model manufacture & test		1300			In procurement preparation. Kick-off foreseen after 3rd quarter of activity C3a.	3	5	2015	2016
TVC system for solid propellant de-orbit motors		350			Contract Prep. Kick-off expected Sept 2014. Activity duration is 6 months. ESA Mechanisms lead.	1	3	2014	2015

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AIM D: Green hybrid & high performance propulsion development									
Development of hybrid propellant under the frame FLPP			FLPP		Implementation.	2	4	2010	2014
Development of hybrid propellant under the frame FLPP			FLPP		Rider to D1 contract. In implementation.			2013	2015
Development of hybrid propellant under the frame FLPP	M		FLPP		Approved by IPC. Amount depends on whether all country funding goes to this activity. Expect contract by Oct 2014	4	6	2014	2017
AIM E: Green propulsion system development									
H2O2 storability/compatibility verification	H	1000	GSTP		TEB held Feb 2015. ITT expected March/April 2015.	2	4	2015	2017
LMP-103S system/component qualification needs evaluation	H	200	TRP		In negotiation. This activity requires results from activity A1 tasks; therefore, start of activity will have to be postponed and activity duration will have to be extended to 1 year. Sept 2015 to Sept 2016	3	4	2015	2016
Environmentally friendly Hydrogen production		150	TRP		Activity kicked off Feb 2013. Activity completion foreseen by Summer 2014.			2013	2014

Uses of Standard Propellants for space applications

	Products	Uses
Monopropellant	1N Thrusters	Constellation satellites: GALILEO, GLOBALSTAR, IRIDIUM, etc Sentinel-1, -2, -3, Herschel-Planck, etc
	5N Thrusters	AEOLUS, Earthcare
	22N Thrusters	Herschel-Planck, EUCLID
	200N Thrusters	VEGA RACS
	400N Thrusters	Ariane 5 SCA, IXV, ExoMars
Bipropellant	10N Thrusters (MON/MMH)	Spacecraft Telecoms, MEX, VEX, GAIA, MSG, MTG, Solar Orbiter, Lisa Pathfinder
	22N Thrusters (MON/Hydrazine)	Bepi-Colombo
	200N Thrusters (MON/MMH)	ATV
	400N Thrusters (MON/MMH)	Spacecraft Telecoms, MEX, VEX, Lisa Pathfinder, MSG, MTG
	Several kN (MON/MMH or UDMH)	A5 upper stage (1 version) + VEGA & Soyuz Upper stage

Example of a high TRL green propulsion thruster

- 1N monopropellant thruster from ECAPS (based on LMP-103S)

	1st generation	2nd generation	3rd generation
Hydrazine 1N thruster State-of-art			
LMP-103S 1N thruster qualification	**Planned for 2016**		

1st generation	up to 20 kg of propellant throughput
2nd generation	up to 50 kg of propellant throughput
3rd generation	More than 75kg propellant throughput

ESA Roadmap Summary – Planned Activity

Title	Crit.	Budget (kEuro)	Appr. Prog.	Pot. Prog.	Status/Remark	TRL		Date	
						Curr.	Targ.	Start	End
AIM A: Green mono-propellant development									
H2O2 development (complementing FP7 activity)	M	1500		PNI	Contingent upon E1, ---	3	6	2014	2017
Monopropellant thruster scale up (e.g 5N class, 22N class)	M	10000		PNI	---	3	6	2014	2018
Alternate green monopropellant development	M	500		TRP	---	1	3	2014	2016
AIM B: Green bi-propellant development									
MON/MMH replacement with green bi-propellant	H	4000	GSTP		750k phase 1 proposed to delegation and in compendium as 2014 activity. Awaiting delegate indication of support. Activity duration is 24 months.	1	6	2015	2018
10-20N class green bi-propellant thruster development	H	5000	TRP		350k activity in the TRP work plan. Delegate support needed. Linked to B1.	1	6	2015	2018
Green bi-propellant apogee motor development	H	6000		GSTP	Delegate support needed. Linked to B1.	1	6	2015	2018
Alternate green bi-propellant development	M	700		TRP	---	1	4	2015	2017
200N class green bi-propellant thruster development	M	5000		PNI	---	1	6	2015	2018
AIM C: Green solid propulsion development									
Green solid propellant and assoc hardware development	H	1000		PNI	---	1	3	2015	2016
Green solid propellant and assoc hardware for spacecraft applications	M	2000		PNI	ARTES, GSTP.	1-2	4	2015	2018
AIM D: Green hybrid & high performance propulsion development									
Development of hybrid propellant 2 and associated hardware	M	1000		PNI	TRP, Launchers. ---	2	3	2015	2016
High performance green propellant development	M	2000		PNI	not necessarily a hybrid ---	1	4	2015	2017
High performance green propellant development	M	2000		PNI	not necessarily a hybrid ---	4	6	2017	2018
Green hybrid propellant and assoc hardware for spacecraft applications	M	2000		PNI	ARTES, GSTP.	1-2	4	2015	2017
AIM E: Green propulsion system development									
Key propulsion system hardware development /requal.	H	5000		PNI	500K GSTP Proposed. Duration is 8 months. In Clean Space Compendium 2014. This activity requires results from activity E2; therefore, foreseen kick off is postponed until 2016.	3	6	2016	2018
Additional propulsion system hardware development	L	5000		PNI	---	2	4	2014	2018

Communication