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The Strategic Research Clusters on Space Electric Propulsion. A new instrument of the European Commission

EPIC Workshop in London on the 15-17 October 2017

EPIC PSA

EPIC project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 640199

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Content:

- Electrical Propulsion Strategic Research Cluster (SRC)
- EPIC Programme Support Activity
- SRC EPIC Roadmap
- SRC Grants Guidelines & Requirements
- SRC 2016 Call Grants
- SRC Next Steps

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Electrical Propulsion Strategic Research Cluster

What is a Strategic Research Cluster?

Implements multiannual strategic agendas in key research areas
Implemented through a system of interconnected grants:

“Programme Support Activity” (PSA): EPIC

- Prepares a roadmap and implementation plan for the whole SRC
- Advices the Commission on definition of calls for operational grants
- Facilitates and supervises the coordination of grants
- Assesses the evolution of operational grants in the SRC context

Several “Operational Grants": OGs

- Address different technological challenges identified in the roadmap.
- Separate projects but with obligation to coordinate/cooperate within the cluster
- The expected results of the individual grants would, when taken together, achieve the overall objective of the SRC.

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EPIC Programme Support Activity

EPIC = Electric Propulsion Innovation and Competitiveness

- EPIC (grant n. 640199) is the PSA project funded as part of the H2020 Space WP 2014+2019; 5+? years duration.
- EP SRC Challenge: to enable major advances in Electric Propulsion (EP) for in-space operations and transportation, in order to contribute to guarantee the leadership through competitiveness and non-dependence of European capabilities in electric propulsion at world level within the 2020-2030 timeframe, always in coherence with the existing and planned developments at national, commercial and ESA level.

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EPIC Programme Support Activity

EPIC Main tasks:

- Evaluation on the state of the art and needs of stakeholders
- Definition and refinement of SRC roadmap and master plan for implementation
- Definition of Call topics and related documents for H2020 Work Programmes for funding of SRC Operational Grants
- SRC Risk management
- Definition of the collaboration aspects between SRC grants, including the PSA
- Assessment of the progress and results of the Operational Grants, in the context of the SRC objectives
- Dissemination and education activities

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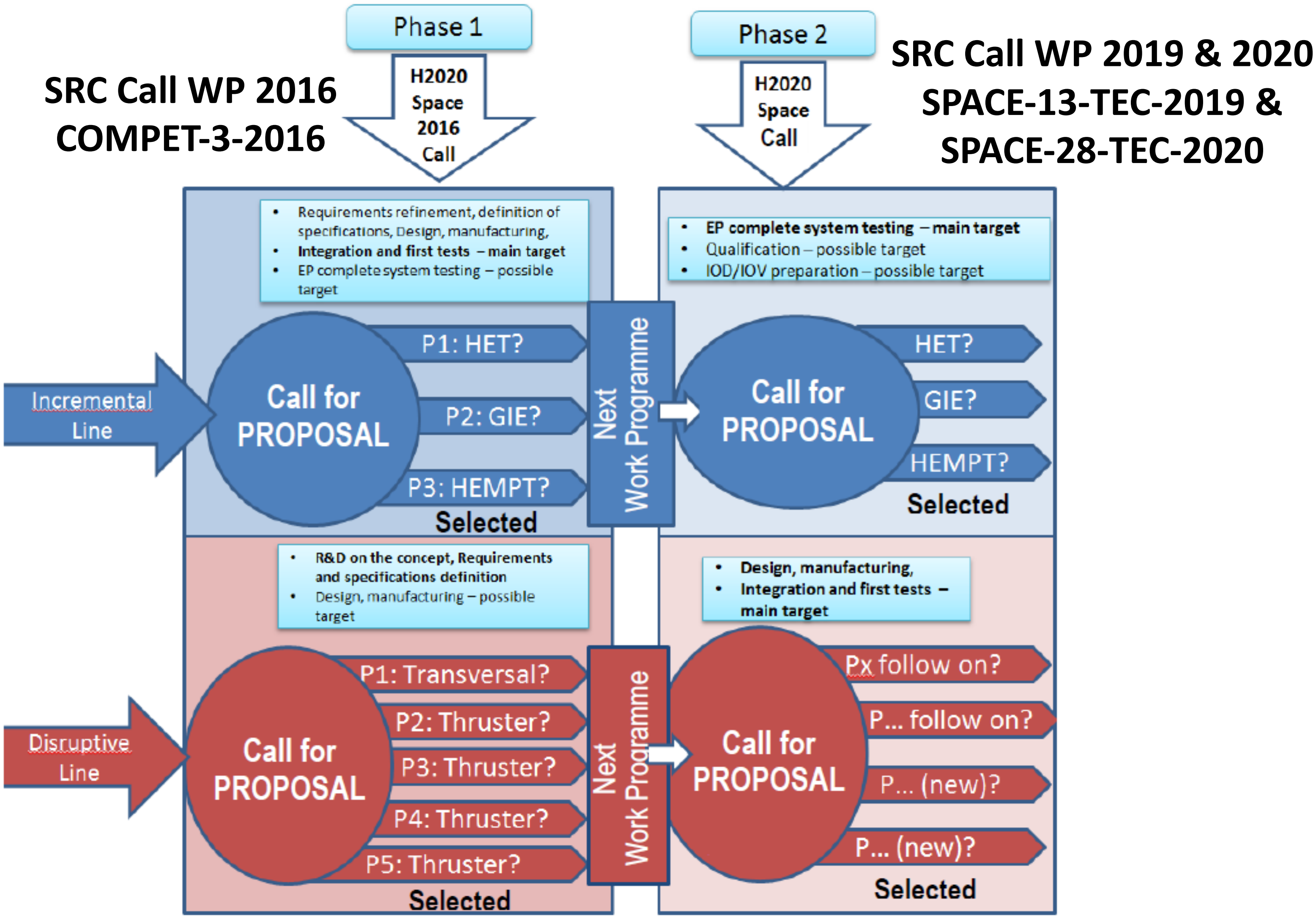
SRC EPIC Roadmap



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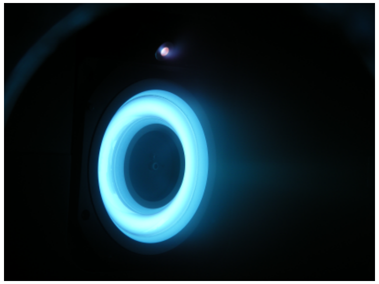
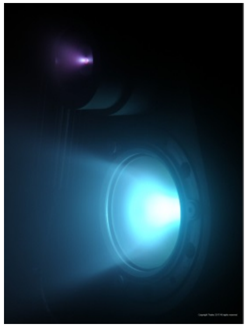
SRC EPIC Roadmap

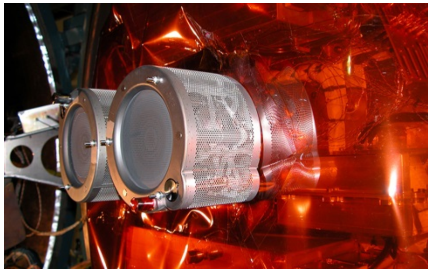
Incremental Technologies:

- The Incremental Technologies are the most mature technologies, i.e. the ones with high TRL and possibly with flight heritage, with the physical principal well understood, and with established performances in all of the relevant parameters: thrust (T), specific impulse (Isp), power/thrust ratio (P/T), total impulse, and lifetime.

- They are the Hall Effect Thruster (HET), the Gridded Ion Engines (GIE), and the High Efficiency Multistage Plasma Thrusters (HEMPT).







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SRC EPIC Roadmap

Disruptive Technologies:

- The Disruptive Technologies, are very promising EP thruster concepts or transversal EP technologies which could disrupt the propulsion sector by providing a radical improvement in performance and/or cost reduction, leading to become the preferred technology for certain applications; or enable new markets.

- Promising EP thrusters are for example: Helicon Plasma Thrusters (HPT), Electron Cyclotron Resonance Thrusters (ECRT), Magneto Plasma Dynamic Thrusters (MPDT), Pulsed Plasma Thrusters (PPT), Field Emission Electric Propulsion thrusters (FEEP), etc.

- Transversal EP technologies are for example radical innovations in Power Processing Units (PPU), magnetic nozzles, alternative propellants, etc.

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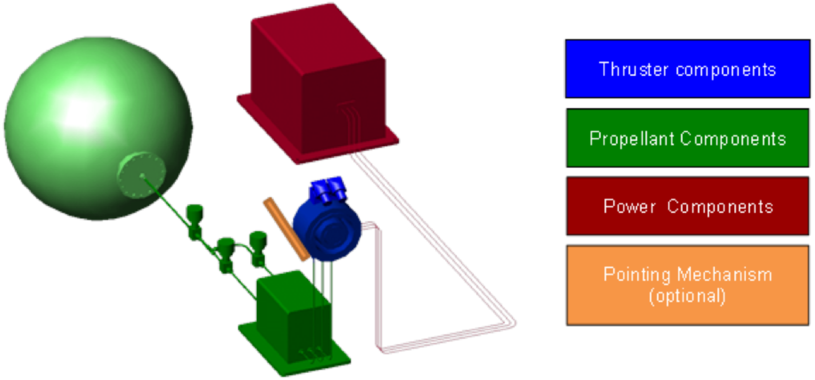
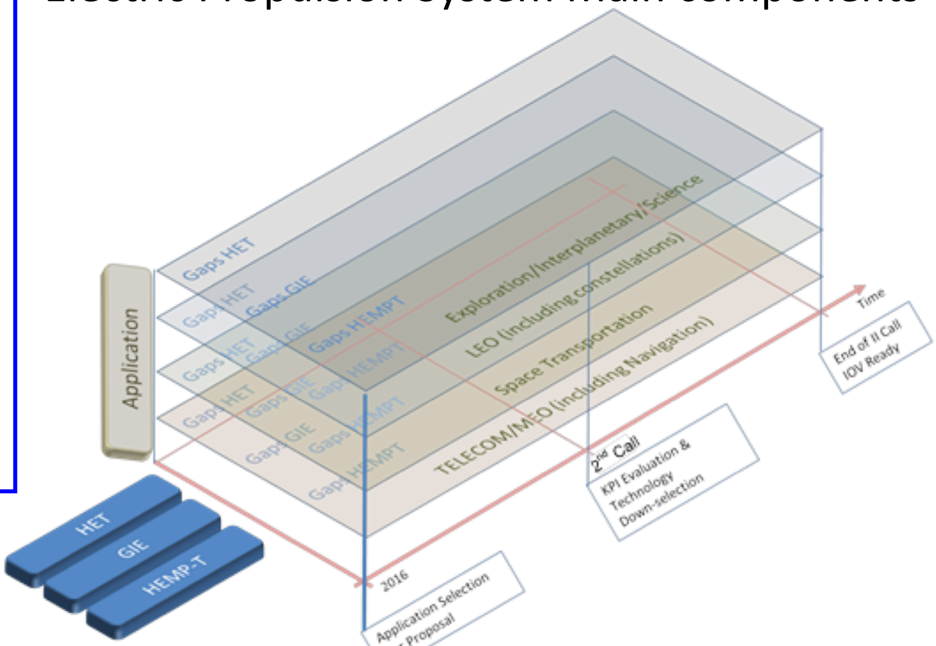
SRC Grants Guidelines & Requirements

GUIDELINES FOR STRATEGIC RESEARCH CLUSTER ON IN-SPACE ELECTRICAL PROPULSION AND STATION KEEPING HORIZON 2020 SPACE CALL 2016



Electric Propulsion System Main components



The Incremental line for the SRC on Electric Propulsion

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SRC Grants Guidelines & Requirements

Table 1.2
Hall Effect Thrusters (HET) EPS activities oriented to LEO applications

Description and needed Action	EP is one of the new revolutionary technologies at the moment in satellite markets. There are many developments in LEO systems and applications, and EP could play a significant role in this market. Hall Effect Thrusters (HET) EPS have good prospects for use in LEO, due to their power-to-thrust ratio allowing higher thrusts ... in LEO. Projects in this area shall aim at improving EPS p... recurrent indicative cost of the EPS. All HET proposals shall cover this activity and th... hereafter.	
Requirements		
• Target TRL at the end of the COMPET-3-2016 project	5-6	
• Target TRL at the end of the SRC (2023/2024) if the project were to continue	7-8	
• Cycles	TBD by proposers	Due to the eclipses, a large n... operation in LEO. Thus, the c... the impact that it has on perf... EPS. This number of cycles s... lifetime requirement of the pl... years)
• EPS Power	200-700 W	The EPS should demonstrate ... operated at low to medium p...
• *P/T*	< 16 W/mN	Low *P/T* ratio is needed in o... little power is available.
• *Isp*	> 1500 s	The EPS efficiency is import... LEO missions. The higher th... requirement is a trade-off of s...
• Innovative and cheaper PPU	Low cost and compact PPU	
• EPS Cost	< 200 k€ (indicative)	
Remarks	Compact, integrated and low mass system shall be...	

Table 2.1
Gridded Ion Engine (GIE) EPS activities oriented to Telecommunication / Navigation applications

Description and needed Action	EP is one of the new revolutionary technologies at the moment in satellite markets. For Telecommunications this is the main short-term commercial market for EP, with chemical propulsion as main competitor, and a fierce international competition. Gridded Ion Engines are one of the best options for this market at the moment due to their high *Isp*, which allows significant mass savings and allows lower launch costs. Projects in this area shall aim at improving this position in the mid-term and at being one step ahead for the future needs of the Telecom market, by substantially improving EPS performances and reducing cost... All GIE proposals shall cover this activity and the requireme... hereafter.	
Requirements		
• Target TRL at the end of the COMPET-3-2016 project	5-6	
• Target TRL at the end of the SRC (2023/2024) if the project were to continue	7-8	
• Dual mode	TBD by proposers	The EPS should be optimized to work in... for two different types of functions: EOR... minimise the time to final orbit; and SK... to minimize the propellant used in the in... the case of GIE, it is expected that the ef... will mainly aim to improve the thrust lev... adequate *P/T* ratio.
• EPS Power	> 5 kW for EOR mode > 3 kW for SK mode	The EPS should demonstrate power perf... the state of the art, justifying the specific... selected with an analysis of the medium... needs.
• *P/T*	~ 21.5 W/mN for EOR mode ~ 30 W/mN for SK mode	The time to orbit is a critical requiremen... operators and is fully dependent on the *P*...

Proposals based on sub-line	Application activities the proposals shall address	Application activities the proposals can choose to address	Applicable Tables
HET	• Telecommunnications / Navigation • LEO • Space Transportation / Exploration / Interplanetary		0 1.1 1.2 1.3
GIE	• Telecommunnications / Navigation • LEO	• Space Transportation / Exploration / Interplanetary • Science	0, 2.1, 2.2, 2.3 (optional), 2.4 (optional)
HEMPT	• Telecommunnications / Navigation • LEO	• Space Transportation / Exploration / Interplanetary • Science	0, 3.1, 3.2, 3.3 (optional), 3.4 (optional)

Table 3.4
Highly Efficient Multistage Plasma Thruster (HEMPT) EPS activities oriented to Science applications

Description and needed Action	Science missions can have very specific propulsion requirements. Clear examples are the missions requiring micropropulsion with high controllability, for formation flying and high-accuracy orbit control. These missions also require continuous operation for extended periods of time, so they have in addition high *Isp* and long lifetime requirements. This activity is optional for HEMPT proposals.	
Requirements		
• Target TRL at the end of the COMPET-3-2016 project	4-5	
• Target TRL at the end of the SRC (2023/2024) if the project were to continue	6-7	
• Resolution	<1 μN	In low thrust range (<100 μN)
• Power	< 50 W	Low power levels are expected for micro-propulsion operation.
• Lifetime	> 6 years	Very long continuous operation
• *Isp*	> 1000 s	High *Isp* is needed, in order to support continuous operation for long periods. The higher the *Isp* the better, but this requirement is a trade-off of several performances.
• PPU	The PPU should be adapted to allow the large throttability voltage control needed to ensure high thrust resolution.	
Remarks	Large throttability (1:50) Very low noise	

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SRC 2016 Call Grants
CHEOPS

CHEOPS

Consortium for **H**all **E**ffect **O**rbital **P**ropulsion **S**ystem

- CHEOPS proposes to develop three different Hall Effect Thruster electric propulsion systems: a dual mode EPS for GEO applications, a low power for LEO applications and a >20 kW high thrust EPS for exploration applications.
- Each of these will be developed according to market needs and drivers applying incremental technology changes to existing EPS products.
- Development cover the elements: thruster, cathode, PPU and FMS.
- Objective is to reach at the end of CHEOPS Phase II (2023) the following:
  - TRL7-8 for dual mode and low power
  - TRL6 for high power HET EPS.
- The CHEOPS consortium is led by SAFRAN and is comprised of representatives of the biggest European Prime satellite makers, the full EPS supply chain and supported by academia.

CHEOPS project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730135

EPIC project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 640199

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SRC 2016 Call Grants CHEOPS

Partners:

- SAFRAN Aircraft Engines (France): project coordination, HET Dual Mode System for GEO/NAV and HET system for LEO.
- SITAEL (Italy): high power HET system for exploration and PPU in LEO.
- UNIVERSIDAD CARLOS III DE MADRID (Spain): modelling and transversal activities.
- Thales Alenia Space (Belgium): GEO dual mode PPU.
- BRADFORD (Netherlands): GEO dual mode FMS and LEO FMS.
- CHALMERS (Sweden): strategies for value creation and cost reduction.
- CNRS (France): modelling, testing and transversal activities.
- OHB (Germany), TAS (France), ADS (France): market analysis, key requirements and specifications elaboration.
- AST (Germany): HET system for exploration FMS
- SME4SPACE (Belgium): dissemination and web site
- DLR (Germany): GEO Dual Mode System MAIT

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SRC 2016 Call Grants
GIESEPP

GIESEPP

Gridded **I**on **E**ngine **S**tandardised **E**lectric **P**ropulsion **P**latforms.

- GIESEP proposes to develop, build and test to TRL5 the first European Plug and Play Gridded Ion Engine Standardized to operate ArianeGroup and QinetiQ Space ion engines in the 200-700W (LEO) and 5kW (GEO) domains.
- 5kW electric propulsion system will be designed to allow clustering for 20kW EP Systems for space transportation, exploration and interplanetary missions.
- Dual Mode functionality of the thrusters will be realized, whilst also offering a competitive higher thrust mode.
- Assessments alternative propellants.
- System standardization and the resulting solutions will provide highly cost competitive and innovative EP Systems for current and future satellite markets.
- The activity will also provide the roadmap to higher TRL by 2023-2024, providing a cost competitive EP Systems.

GIESEPP project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730002

EPIC project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 640199

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SRC 2016 Call Grants
GIESEPP

Partners:

- ArianeGroup GmbH (Germany): Coordinator, system engineering, thrusters and testing
- QinetiQ (United Kingdom): System engineering, thrusters and testing
- OHB System (Germany): Satellite system requirements
- CRISA (Spain) and Airbus Defense and Space (Germany): PPUs
- Advanced Space Technologies (Germany): Propellant control
- Mars Space (United Kingdom): Analytical design and test support
- University of Southampton (United Kingdom): Alternative propellants

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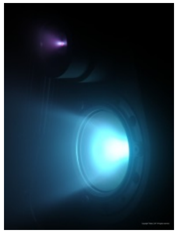
SRC 2016 Call Grants
HEMPT-NG



HEMPT-NG

High **E**fficiency **M**ultistage **P**lasma **T**hruster **N**ext **G**eneration

- HEMPT-NG will develop an integrated EP system based on (Highly Efficient Multistage Plasma Thruster) , including the fluidic management system, and the power processing unit.
- HEMPT-NG will offer an ideal EP System for LEO application up to 700 W and for Telecom/Navigation application up 5 kW. The HEMPT technology offers: No discharge channel erosion leading to higher lifetimes of the thruster; Acceleration voltages enabling a high specific Impulse (Isp) leading to a drastic reduction of propellant consumption; Unique large range of thrust offer enormous flexibility; Minimal complexity of concept providing an excellent basis for economic competitiveness.

HEMPT-NG project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 730020

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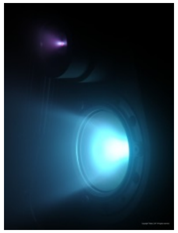
SRC 2016 Call Grants
HEMPT-NG



Partners:

- HEMPT-NG consortium is led by Thales Deutschland GmbH (Germany), Coordinator and responsible for thruster equipment and integrated EP Systems.
- European industrial partners are: Thales Alenia Space (France, Belgium, Germany and UK), OHB System (Germany), Airbus Defense and Space (Germany) and Aerospazio Tecnologie (Italy), who bring their expertise in spacecraft mission studies, equipment development and testing capacities.
- The University of Greifswald (Germany) will provide plasma simulation to support the thrusters developed.

HEMPT-NG project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730020

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SRC 2016 Call Grants
GANOMIC

GANOMIC

GaN in **O**ne **M**odule **I**ntegrated **C**onverter for EP systems

- The consortium plans to build a highly integrated PPU to globally reduce the cost of EP systems.
- GaNOMIC activities propose focus on the PPU "heart" studying a disruptive power converter beyond the state of the art combining innovative technologies such as GaN digital control, adaptive filtering and embedded packaging.
- The Consortium plans to demonstrate the selected technologies by means of a 7.5 kW power converter to be tested.
- Improvements are expected in cost, mass and volume targeting part list reduction (by 3), converter efficiency (98%) and optimized thermal characteristics (200°C).
- Technical basis for future Direct Drive configurations and to "distributed" configurations where the PPU can be eliminated.

GANOMIC project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730038

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SRC 2016 Call Grants
GANOMIC

Partners:

- Safran Electronics & Defense (France) participation to GANOMICS will be overall and technical management of the consortium.
- SITAEL (Italy) participation to GANOMICS will be focused on the integration and testing of the breadboard developed within the project
- Ampère laboratory (France): The staff included in the project works in the Energy Department which main focus is the integration of power systems
- SAFRAN (Technology Center) (France):virtual prototyping of power assemblies
- Technische Universität Berlin (TUB) (Germany): research and development in the area of microelectronic packaging and system miniaturization technologies
- UMI-LN2 (France) contributes to provide technical support around GaN Switch integration and PCB embedding & packaging.

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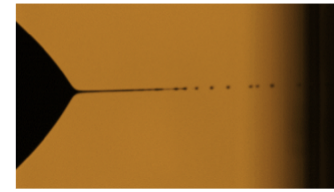
SRC 2016 Call Grants
HIPERLOC-EP



HIPERLOC-EP

- The HiperLoc-EP project aim to use a novel approach to develop an Electrospray Colloid Electric Propulsion System (ECEPS).
- The project seeks to develop a disruptive electric propulsion technology that provides a high performance EP system a cost that is at least one order of magnitude lower than today. A High Performance Low Cost Electric Propulsion system would enhance the functionality, performance and the value of many micro/nanosatellite missions in the future.
- The objectives include identifying the performance requirements, enhancing the TRL for an ECEPS system, and understanding key processes in order to determine the optimal way to operate an ECEPS.
- The HiperLoc-EP system is anticipated to operate at an efficiency of 50% at an Isp of up to 2500s. The cost target for HiperLoc-EP is to be attractive to constellations of small satellites, CubeSats and nanosatellites.

HIPERLOC-EP project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730075

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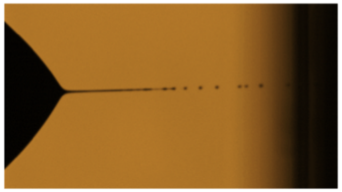
SRC 2016 Call Grants
HIPERLOC-EP



Partners:

- Queen Mary Univ. of London (United Kingdom) (Coordinator) provides the leading understanding and expertise in Europe of electrospray processes and systems.
- SystematIC (Netherlands) is a IC design house with focus on analog and mixed signal integrated circuit. Has delivered power supply and control circuitry to the Delphi C3 nanosatellite.
- Airbus Defense & Space (United Kingdom) Europe's leading satellite prime contractors and a recognized expert within the field of electric propulsion and as a user of such systems.
- NanoSpace AB (Sweden), has expertise in miniaturized propulsion systems and was among the first to fly a propulsion system onboard a CubeSat in 2015.

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MINOTOR
Magnetic nozzle thruster with electron cyclotron resonance

SRC 2016 Call Grants MINOTOR

MINOTOR

Magnet**I**c **NO**zzle thruster with elec**T**ron cycl**O**tron **R**esonance

- MINOTOR’s strategic objective is to demonstrate the feasibility of the ECRA (Electron Cyclotron Resonance Accelerator) technology as a disruptive game-changer in electric propulsion, and to prepare roadmaps paving future´s way.
- The main objective of the project is to bring the ECRA technology from TRL3 to TRL4/5, in order to demonstrate its potential in a large range of thrust levels.
- ECRA is a cathodeless thruster with magnetic nozzle, allowing thrust vectoring. It has a significant advantage in terms of global system cost and reliability compared to mature technologies. It is also scalable and can potentially be considered for all electric propulsion applications, from microsatellites to space tugs.

MINOTOR project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 730028

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MINOTOR
Magnetic nozzle thruster with electron cyclotron resonance

SRC 2016 Call Grants
MINOTOR

Partners:

- ONERA (France). Coordinator, and in charge of most experimental investigations of the thruster configuration.
- University Carlos III de Madrid (Spain) will develop the codes and implement the numerical modeling of the thruster.
- Thales Microelectronics (France) will demonstrate a high efficiency microwave generator technology.
- Universitaet Giessen (Germany) will conduct the higher power tests (1 kW) and the erosion test on the 200 W prototype.
- Thales Alenia Space Belgium SA (Belgium) will investigate the impact of the ECRA technology on the PPU architecture and cost.
- Safran Aircraft Engines (France) will provide expertise in electric propulsion thruster production and performance.
- L-up (France) will help on the project management.

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SRC Next Steps

- Assessment of the progress and results of the ongoing Operational Grants.
- Update the SRC EPIC roadmap and master plan.
- Preparation of the second phase of the SRC EPIC roadmap: SRC 2019 Call topic (SPACE-13-TEC-2019) and SRC 2020 Call topic (SPACE-28-TEC-2020).
- Dissemination and educational activities.
- EPIC Workshops: London (United Kingdom) on 2018, and Noordwijk (Netherlands) on 2019.
- EPIC Lecture Series in concurrence with the next EPIC Workshops.

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