THE STRATEGIC RESEARCH CLUSTER

IN-SPACE ELECTRICAL PROPULSION AND STATION KEEPING

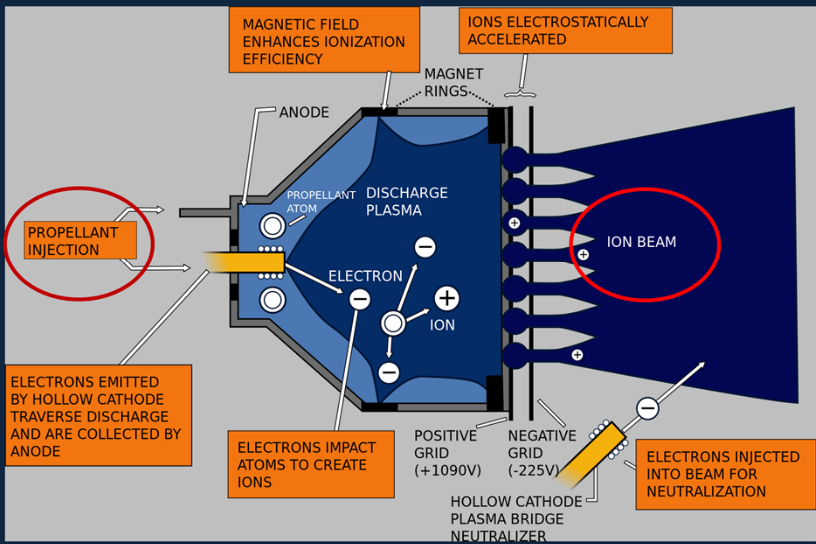
Briefing for potential applicants and evaluators of COMPET-3-2016

This video on the Strategic Research Cluster on “In-Space electrical propulsion and station keeping” serves as a briefing for potential evaluators and applicants.

With "Strategic Research Clusters" the European Commission introduced a new instrument into Horizon 2020. The idea of SRCs is to enable the European Commission to target mid-term to long-term objectives. This will not be done by creating large projects with great funding and long runtimes but by combining the results of different smaller projects, called "operational grants" to achieve a common goal. The coordination and interaction of these operational grants will be ensured by means of the Collaboration Agreement, a document which will connect all the SRC grantees including the Programme Support Activity, EPIC, beneficiaries. Summing this up we can define Strategic Research Clusters as "a coordinated effort of individual research and development grants that aim at producing a significant demonstration of a specific technology".

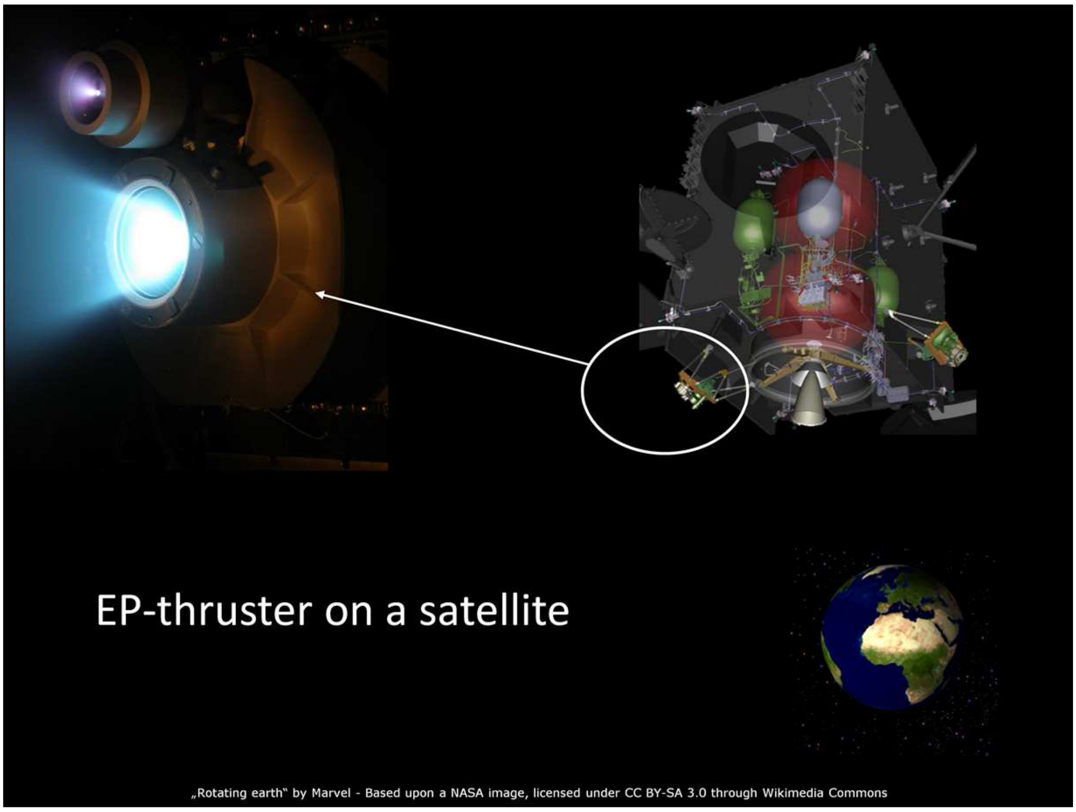
The SRC on "In-space Electrical Propulsion and station keeping" is part of the Horizon 2020 Space theme. As a first step to build up the SRC on Electric Propulsion, a call for proposals for the Programme Support Activity was issued in December 2013 as part of the first Work Programme for Space in Horizon 2020. In summer 2014 the proposal was selected and since 1st October of the same year the PSA "EPIC" is operating. EPIC stands for Electric Propulsion Innovation & Competitiveness. The next step for the SRC was the publishing of the call for proposals for the first Operational Grants on the Space Work Programme 2016-2017 under topic COMPET-3-2016. Before we take a closer look into the logic of the SRC on "In-space Electric Propulsion" and the technical details of the on-going call for proposals, let's learn about the idea, technology and applications of "Electric Propulsion"….

In-Space Electric Propulsion



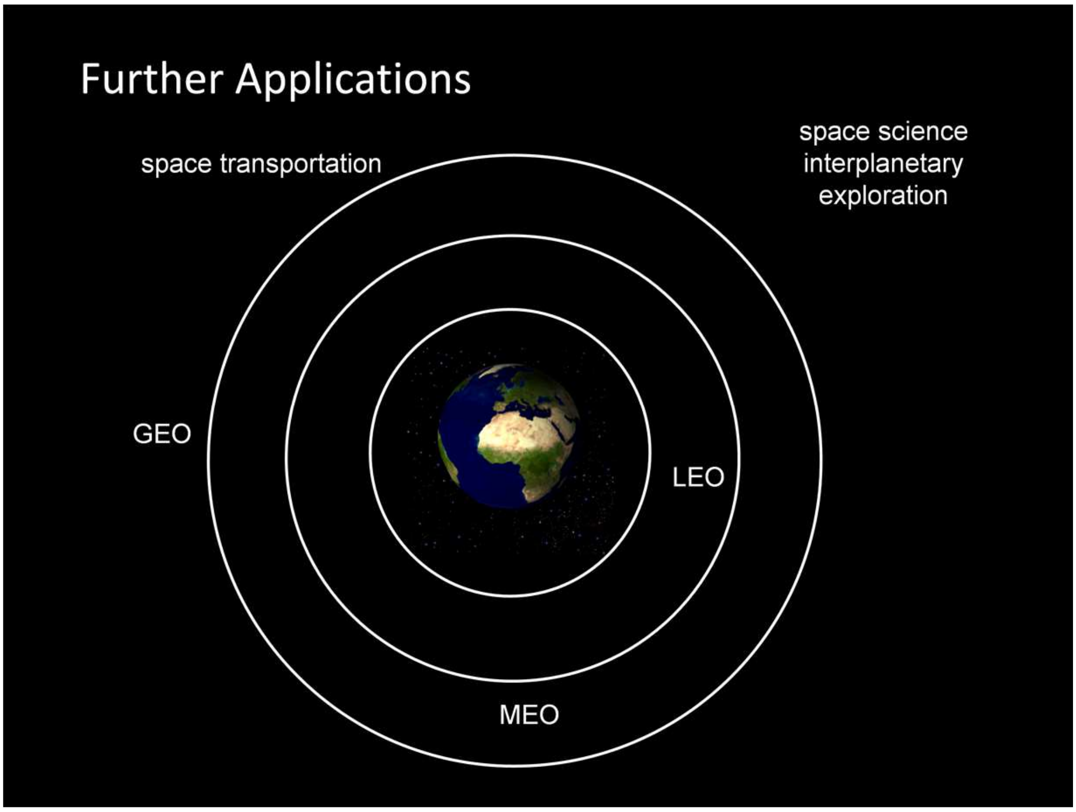
Example of a gridded electrostatic ion engine

Electric Propulsion makes use of electrical power to accelerate a propellant by different possible electrical and/or magnetic means. Compared to chemical thrusters, electric propulsion requires considerably less mass to accelerate a spacecraft. The propellant is ejected up to twenty times faster than from a conventional chemical thruster and thus delivers an up to twenty times higher impulse per unit of propellant mass. Therefore, the overall system can be much more mass-efficient, and satellites equipped with EP systems may either carry more payload or be launched with a less powerful and less expensive launcher.



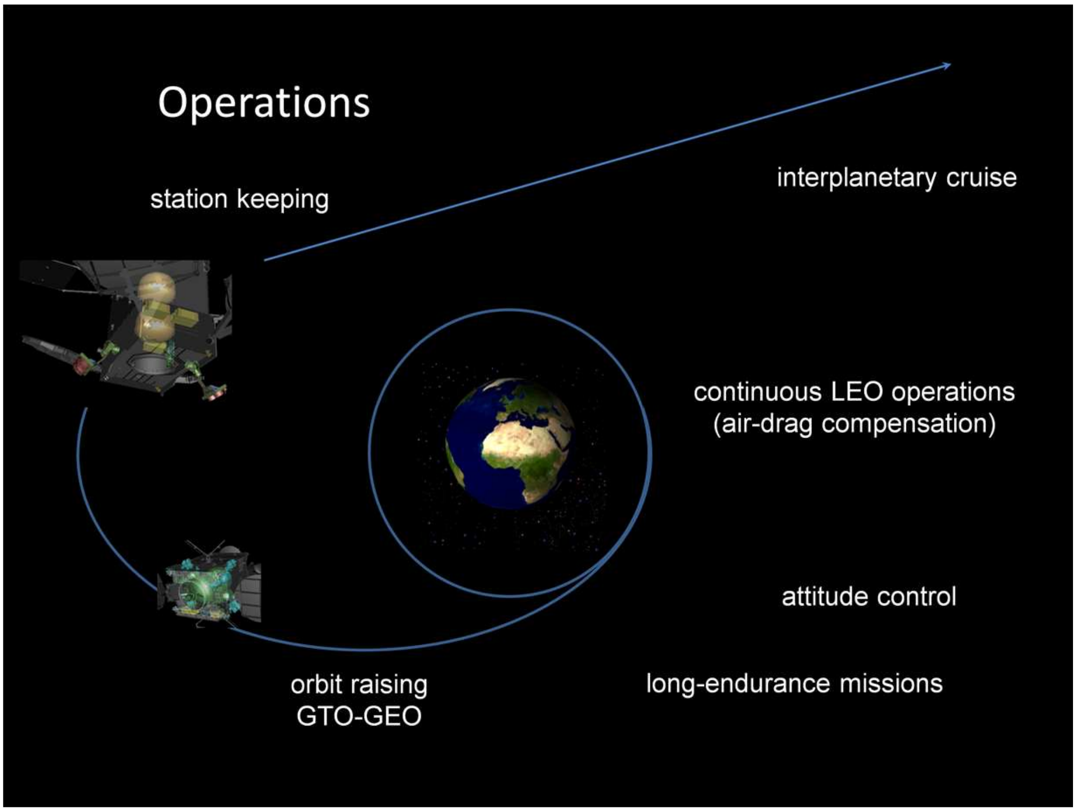
The animation shows an example of a communication satellite equipped with two different EP systems for North-South station keeping, two Hall Effect Thrusters (HET) and two High Efficiency Multistage Plasma Thrusters (HEMPT), of which one system is the primary propulsion system and the second one is redundant.

The use of EP systems for station keeping of geostationary communication satellites is well established.



The different applications which currently make use of Electric Propulsion or may make use of it in the future, are:

- LEO (for example, earth observation, earth science, constellations)
- MEO (navigation)
- GEO (telecommunications)
- Space transportation (launcher kick stages, space tugs)
- Space science, interplanetary missions and space exploration.

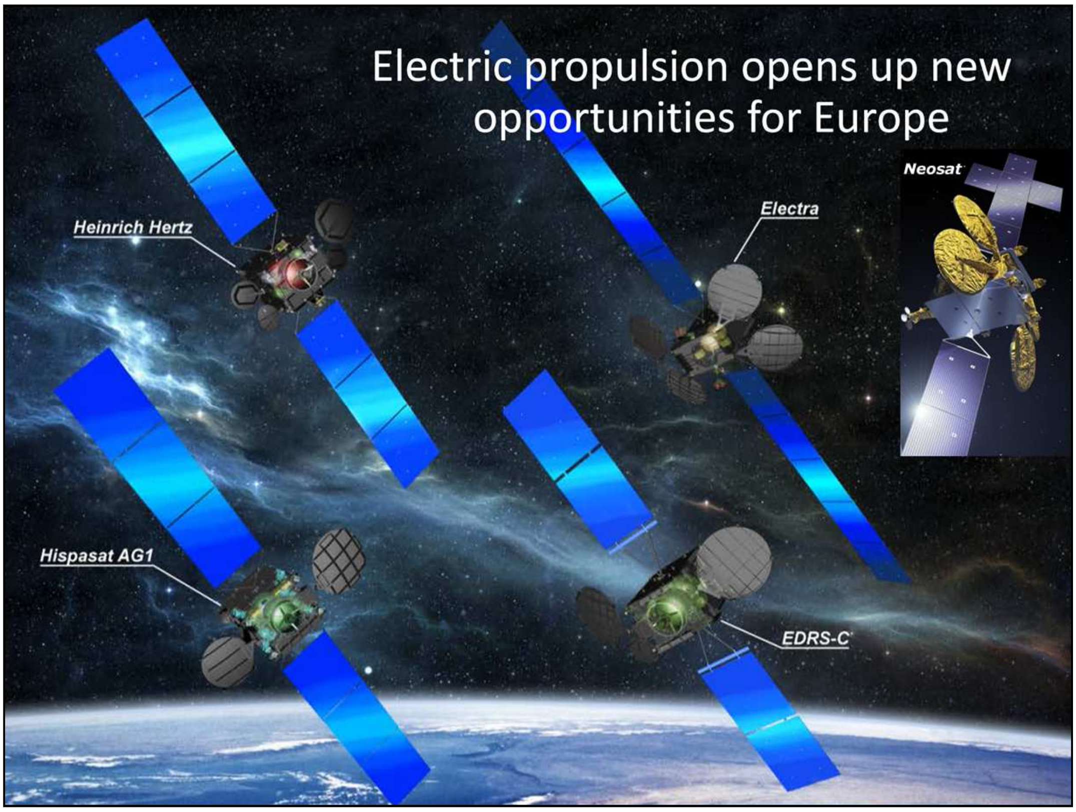


For these different types of missions and requirements, the technology is faced with operational challenges in order to be able to cope with different type of maneuvers, such as:

- continuous LEO operations (air-drag compensation)
- electric transfer from GTO to GEO
- station keeping
- interplanetary cruise
- extreme fine and agile attitude control
- long-endurance missions
- etc.

Major mass savings can be achieved, if EP systems are used for orbit raising. Due to their lower thrust, the transfer time is longer compared to chemical propulsion (several months instead of some weeks).

These applications span a very wide range of requirements. No single EP system may be optimum for all of these applications.

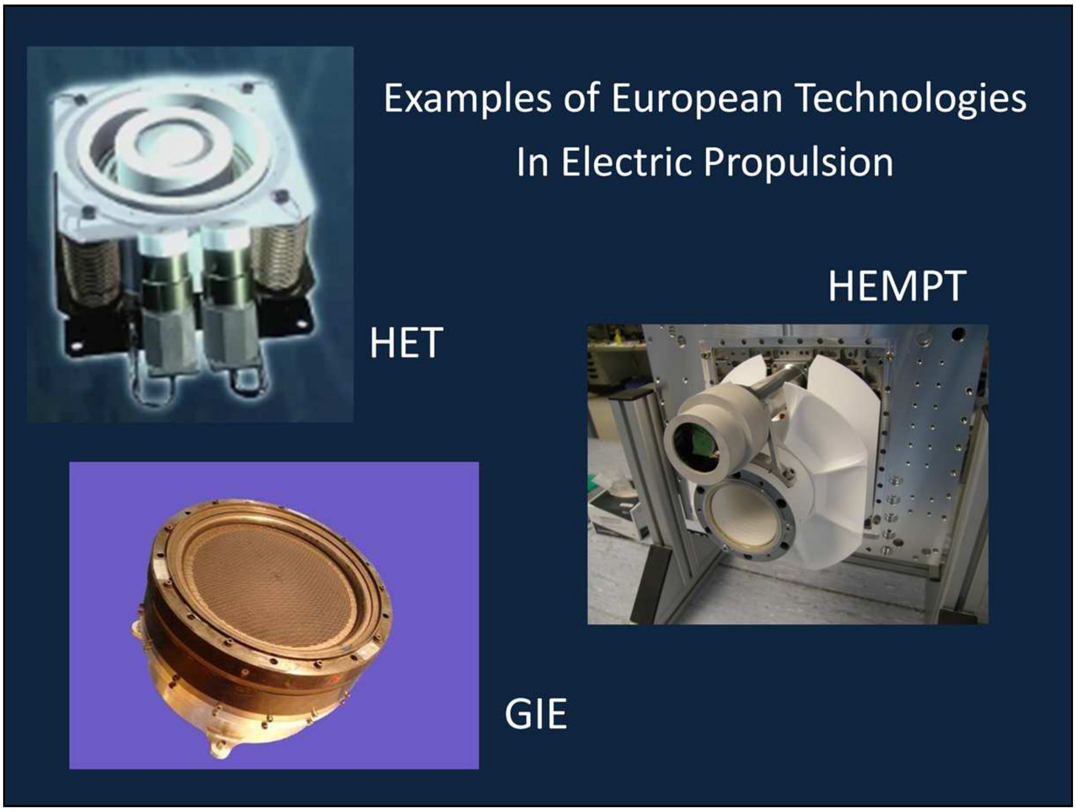


The “All-electric” satellites, which use EP for both orbit raising and station keeping, are not a vision anymore and in the coming decades they may take an increasing share of the commercial communication satellite market.

This slide shows a number of European satellites under construction. Of these, Electra and Neosat are all-electric satellites; the other ones are hybrid satellites. High-thrust power units that could accomplish the orbit transfer electrically are in great demand. At the same time, also simple, reliable and cost-efficient EP-systems for application in satellite constellations could suit the future market.

The repartition of the worldwide EP-market will be determined in the coming years.

European players are working on promising technologies, which could be transformed into marketable EP-systems to achieve commercial success.

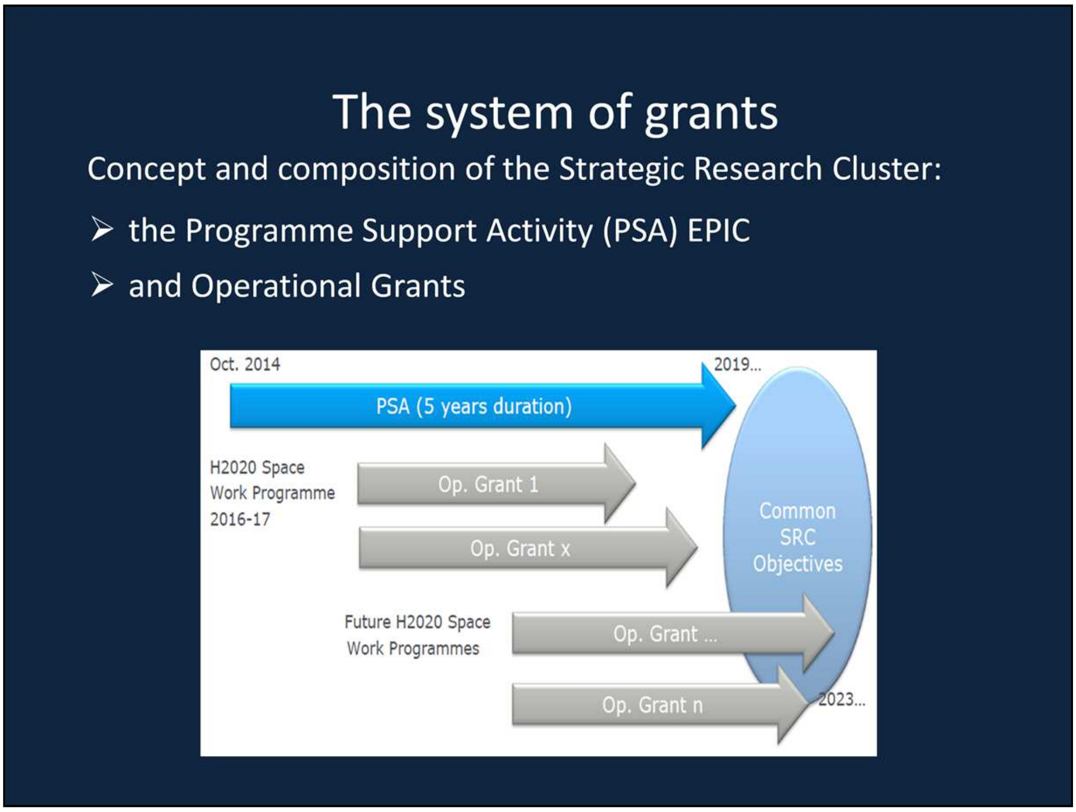


In Europe, developments have been carried out in all the different areas of electric propulsion over the last four decades.

At the moment the most promising technologies for Europe, from the mature type of thrusters, are based on the Hall Effect Thruster, the Gridded Ion Engine and the Highly Efficient Multistage Plasma Thruster.

The European Commission acknowledged the relevance of EP-technology and has an objective: “To contribute to guarantee the leadership of European capabilities in electric propulsion at world level within the 2020-2030 timeframe”.

The Strategic Research Cluster offers an unique opportunity to carry out coordinated research and development activities of high impact and consistency paving the way for this objective.



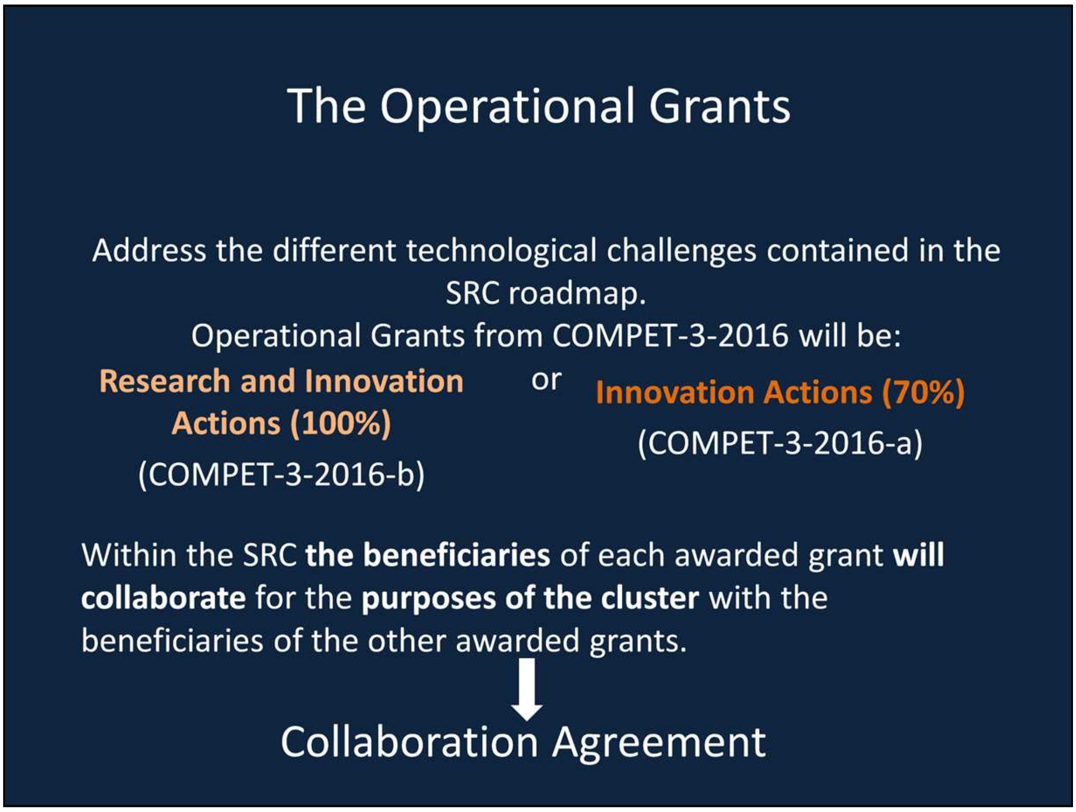
The SRC will be implemented through a system of grants that consists of a Programme Support Activity (PSA), and of the Operational grants (OGs).

The objective of this system of grants is that the expected results of each individual grant can be combined to achieve the overall objective of the SRC.

At the moment it is foreseen that there will be two rounds of operational grants in H2020.

The European Space Agency is the project coordinator of EPIC, and several National Agencies and two space industrial associations are partners in the consortium.

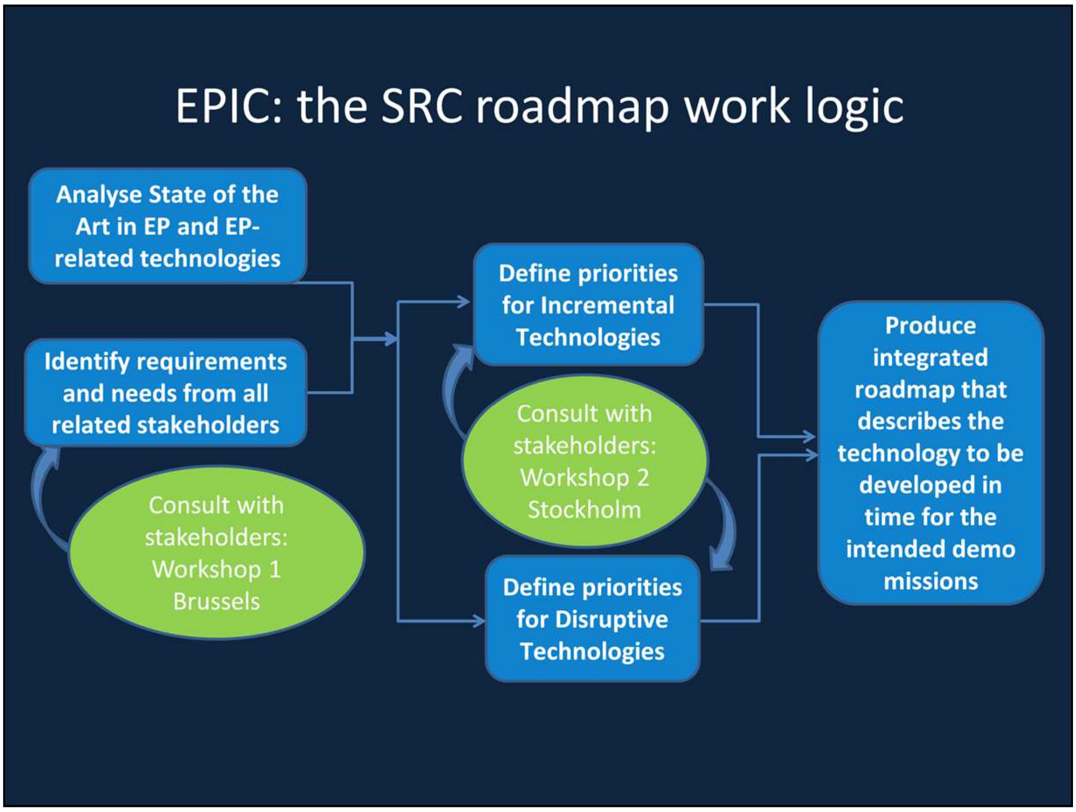
The main role of the PSA is to elaborate a roadmap and an implementation plan for the whole SRC, to provide advice to the European Commission for the description of the operational grants, as well as to assess the results of the OGs with respect to the roadmap, in order to check if they are compatible and expected to achieve the SRC objectives. The roadmap describes a plan for implementation in H2020 to increase European competitiveness in electric propulsion.



The 2016 Operational Grants shall address different technological challenges identified in the roadmap.

The instruments used will be “Research and Innovation Actions with up to 100% funding and Innovation Actions with up to 70% funding.

Within the SRC the beneficiaries of each awarded grant are deemed to collaborate for the purposes of the cluster with the beneficiaries of the other awarded grants. In order to ensure a smooth and successful implementation of this Strategic Research Cluster (SRC), the beneficiaries of complementary grants (which will be called "complementary beneficiaries") shall conclude a written "Collaboration agreement" prior to signing their Grant Agreement. The template for the Collaboration Agreement has been prepared by EPIC and published on the EPIC website for all applicants to get familiar with it.



The SRC roadmap work logic is shown in the following scheme.

First, the State of Art in EP and EP technologies were analysed by the PSA. At the same time, requirements and needs from all stakeholders were identified. This was performed in the first EPIC Workshop in Brussels in November 2014.

The second step was the prioritisation of the EP technologies. This exercise was again performed in contact with the interested stakeholders, in the frame of the second EPIC Workshop in Stockholm in February 2015.

This work logic produced the integrated roadmap that describes the technology to be developed through the H2020 SRC.

Summary of the State of the Art

The technology mapping of EP in Europe has been performed by the PSA and complemented in Brussels WS, Nov. 2014.

Thrusters

- Three technologies targeting the commercial market are available with TRL ranging from 7 to 9.
- Technologies with lower TRL are being developed mainly in European universities or research institutes.

EP System

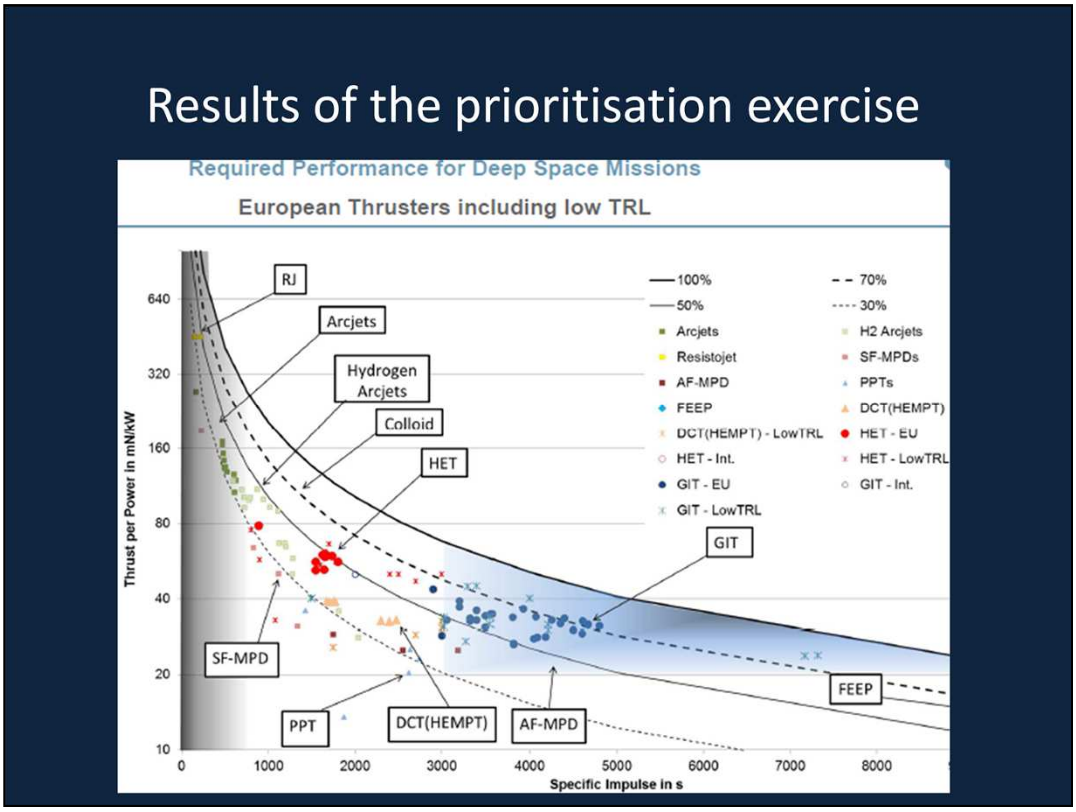
- Consisting of a thruster, in most cases a neutraliser, a power processing unit PPU and a fluidic management system for propellant supply.
- Dependence from non-European suppliers.

The technology mapping of EP in Europe has been performed by EPIC and presented in a dedicated workshop in Brussels in November 2014. The presentations and workshop report are available on the EPIC Website.

Many EP technologies are available in Europe and some are in advanced development stages or have already flight heritage. On the thruster side, three technologies targeting the commercial market are available with TRL ranging from 7 to 9.

Thruster technologies with lower TRL or targeting less market-oriented applications, such as space science, are being developed in Europe as well, many of them by universities or research institutes.

An EP system is composed of a thruster, accompanied in most cases by a neutraliser, a power processing unit or PPU, and a fluidic management system for propellant supply. All of these subsystems have been successfully developed in Europe, but in many cases components need to be integrated from non-European suppliers, and some of these are subject to trade restrictions. As of today no commercially viable European EP system could be built without non-European parts.



EPIC has taken a technology versus application based approach in order to arrive at a prioritisation of the thruster technologies to be further developed through the SRC.

The most mature technologies targeting the commercial market, HET, GIE, and HEMPT, are found to have individual profiles and offer slightly different responses to the different application requirements.

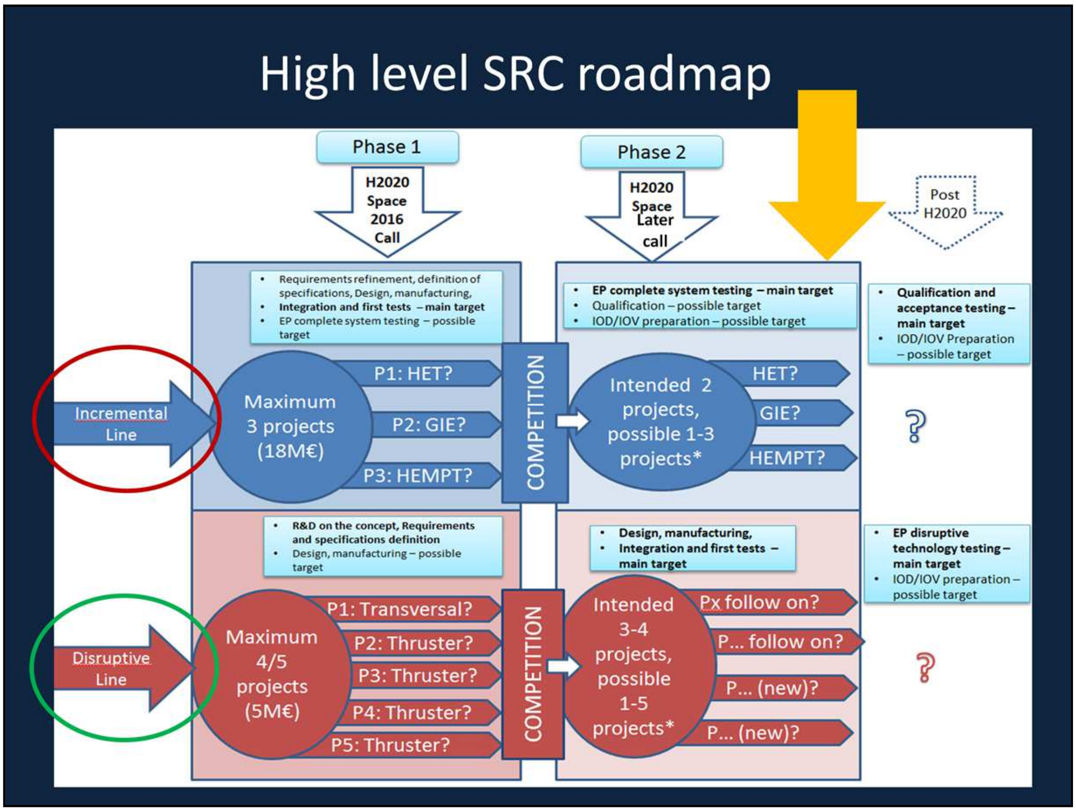
For station keeping the HET currently seem to be a bit at the low end of required specific impulse, nevertheless they are currently the most used EP systems for this purpose.

In the orbit raising case GIE thrusters are at the moment slightly below the range of desired thrust-to-power ratio, but the full EP satellites now operational are using GIE for orbit transfer.

HEMP thrusters are deemed to perform between HET and GIE, but have no flight heritage yet.

So, all three mature technologies have the potential to serve the commercial market, but need to develop individually in one or other direction for future success.

Deep space missions are an example of commercially less attractive applications, but a number of thruster technologies of presently lower TRL may strive to develop into this regime, or likewise towards Earth observation or other applications. In the case of these technologies, which may not yet have been able to show their full potential, a prioritisation can be done only very cautiously.



The roadmap developed by EPIC builds on the prioritisation results and is structured along two lines comprising two successive phases.

In Phase 1 of the Incremental Technologies line, the EP systems based on the three identified thruster technologies will have to be developed and advanced. In the disruptive technologies line, the first phase foresees that only the thruster will be brought to higher TRLs. In both cases requirements shall be satisfied, which are derived from application scenarios. Additionally, in the disruptive line possible funding of a transversal technology is proposed.

Phase 2 foresees the continuation of the two lines. Aspects as the number of projects, continuation or establishment of new projects, expected funding, etc. will remain open until the progress of the operational grants has been assessed. The objective for this second phase is to support the more promising technologies developed in Phase 1 towards higher TRLs, in order to live up to the SRC expectations and be ready to prepare the chosen EP system or systems for a potential In-orbit demonstration.

SRC Guidelines - Technical Annexes

Incremental line ***COMPET-3-2016a***

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

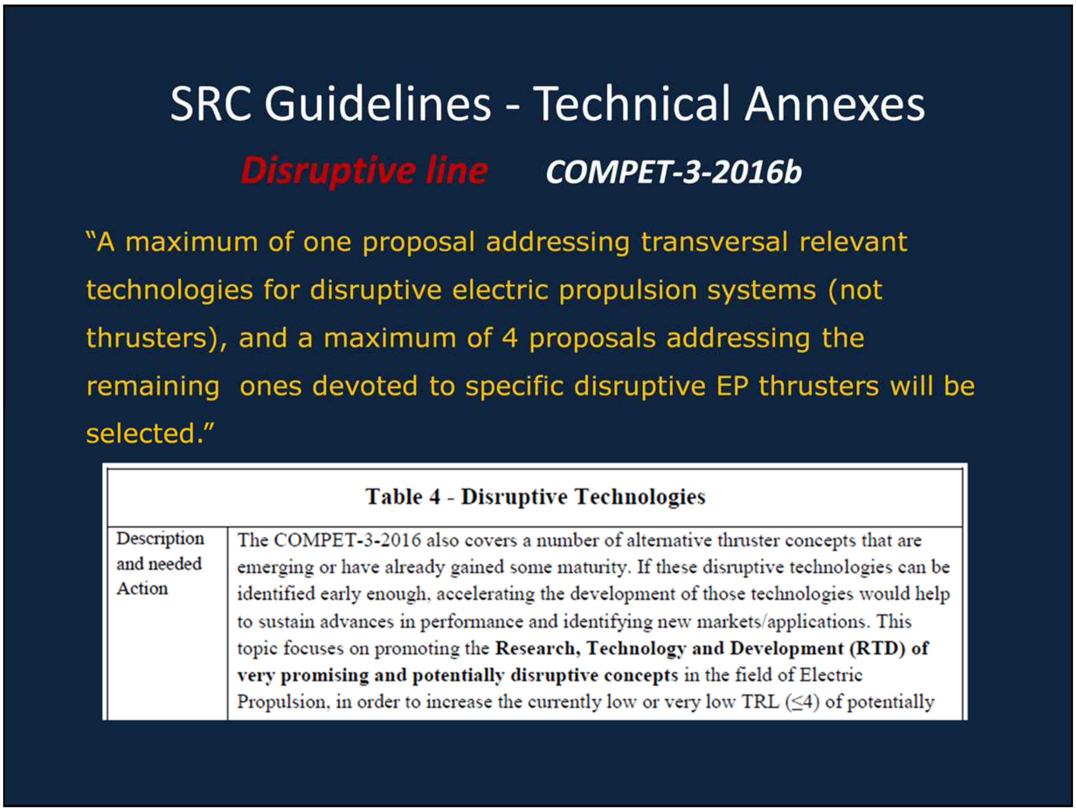
The Technical Annexes of the SRC Guidelines document describe the expected individual activities for each project. This document complements the call text and should be used as a guideline by applicants and evaluators, since it depicts what is necessary to accomplish the first phase of the SRC roadmap.

In the incremental line, the mature technologies HET, GIE, and HEMPT shall be further developed to satisfy the requirements of future applications, the objective being to support all three of them through the first phase of the SRC, funding allowing. However, in order not to dilute the effort by spreading the funds over too many projects, only one proposal per technology shall be selected.

The application activities which shall be addressed , are described in the Technical Annex, with tables detailing the requirements.

Here the three incremental technologies are given different application scopes and associated requirements, such as TRL. As a consequence, the Commission proposes to apply different funding ranges to the three incremental technologies, which take into account the assumed importance of the technology and the relative difficulty of the individual tasks.

The overall budget is, however, not of sufficient volume to support all technologies if they ask for a EU contribution at the upper end of their funding range. The justification of the requested amount shall therefore be critically assessed, keeping in mind the overall budget.



The sub-call topic COMPET-3-2016-b, Disruptive EP technologies, foresees funding of maximum four proposals for disruptive EP thrusters and maximum one proposal for transversal technology (to the EP system). For example, a subsystem of an EP System, like a radically innovative PPU which would enable a much more cost-efficient EPS, or any other idea or technology which could change the whole picture.

The thruster technologies mentioned in the roadmap, which are under development in Europe and elsewhere, are not meant to be exclusively eligible, but are meant to be known examples of what could be considered disruptive. In the field of disruptive technologies new ideas are encouraged, as long as the proposals can demonstrate a disruptive potential of the technology in question.

The Disruptive proposals are not meant to cover a specific application like the Incremental ones, because the scope of their expected disruption is not known. Enabling new applications or current applications with better performance parameters than the well-established technologies would be considered a disruption.

Electric propulsion comprises a wide field of technologies and applications, and the topic is very competitive. The EPIC Programme Support Activity has invested a lot of effort to define specific tasks in both the incremental and the disruptive line. Without the full understanding of these tasks it would be difficult to arrive to a balanced view of the SRC as a whole and to a reasonable and justified evaluation of the individual operational project proposals. Both the call topic text within the 2016 H2020 Work Programme as well as the Guidelines Document deserve in-depth reading.

Further EPIC documents on web

1st EPIC workshop
http://www.epic2014.eu/presentations/

EPIC website
http://epic-src.eu/

List of EPIC public documents
http://epic-src.eu/?page_id=113

Related links
http://epic-src.eu/?page_id=82

Thank you for your attention

Information has been collected and made available by EPIC. This includes background information on electric propulsion, workshop presentations, and some of the EPIC deliverables available to the public.

Evaluators are encouraged to consult as many of these documents as may deem helpful for the understanding of the topic, the work and the objectives of the Electric Propulsion SRC.