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PERASPERA

EPIC

Strategic Research Clusters on Electric Propulsion and Space Robotics
General Information

EPIC and PERASPERA PSAs

Inés Alonso – ESA - EPIC Coordinator

National Space Info Day
Lisbon, 28 October 2015

These projects have received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 640199 and 640026.

Outline

- **H2020 Space Strategic Research Clusters : concept and composition**
  - PSA and Operational Grants
  - "Complementary" grants – Collaboration agreement

- **EPIC and PERASPERA PSAs**
  - Introduction
  - General work logic
  - From the roadmap to the 2016 SRC calls

H2020 Space SRC Concept and Composition (1/2)

- In the frame of Horizon 2020 Work Programme 2014, two Strategic Research clusters (SRC) were initiated in the fields of:
  - *In-Space electrical propulsion and station keeping*
  - *Space Robotics Technologies*
- A multi-annual structured approach is needed to achieve a long-term objective
- SRC implementation → **system of grants connected among them**:

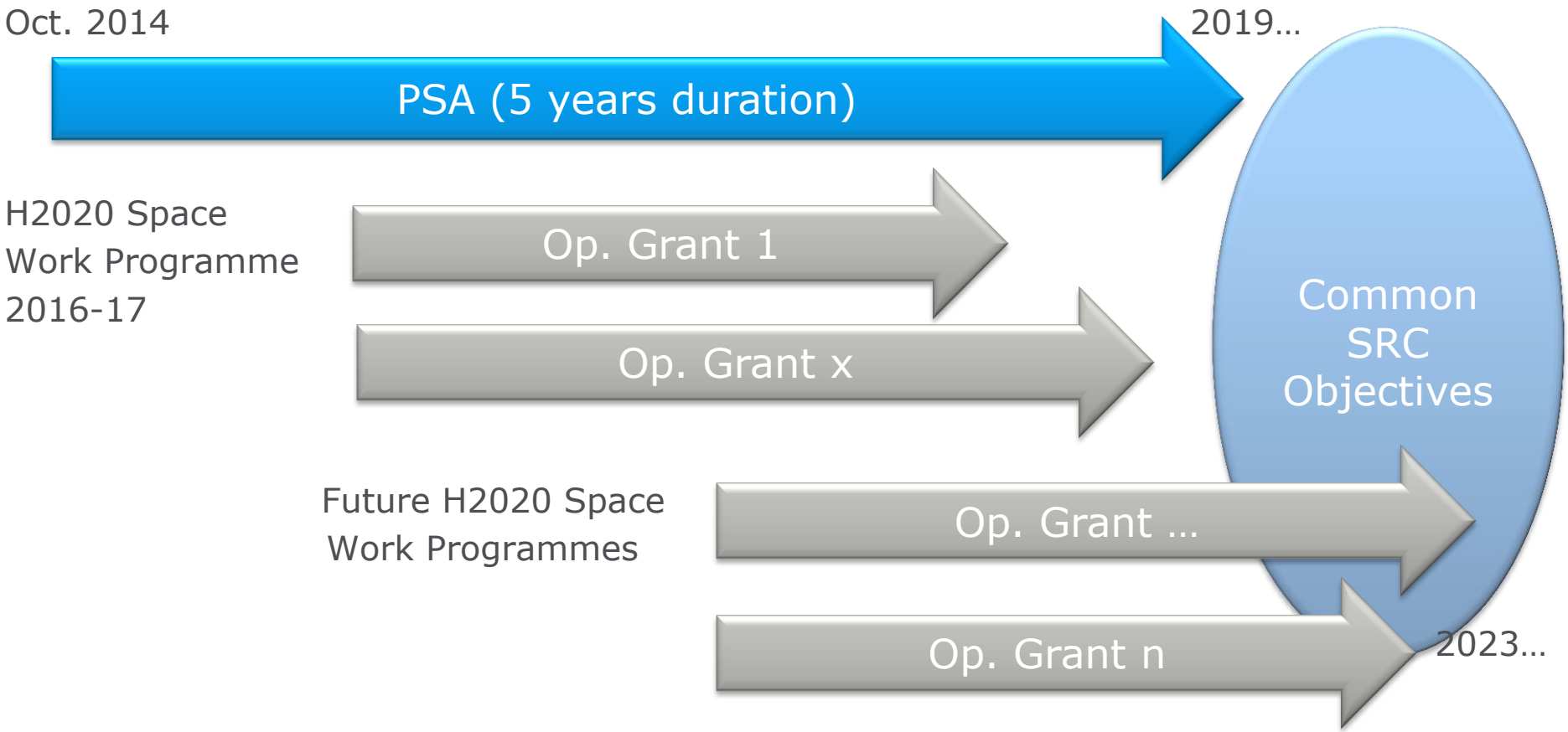
Programme Support Activity (PSA):
- Elaborates an SRC roadmap and implementation plan
- Provides advice to the Commission for the SRC calls documentation for Operational Grants
- Contributes to the assessment of progress and results of the Operational Grants
- Supports on the general SRC implementation

PSA is a Coordination and Support Action

Operational Grants (OG):
- Address the different technological challenges contained in the SRC roadmap
- Perform the necessary developments that, when put together, achieve the overall SRC objectives

Operational Grants can be:
- Research and Innovation Grants (100%)
- Innovation Grants (70%)

H2020 Space SRC Concept and Composition (2/2)



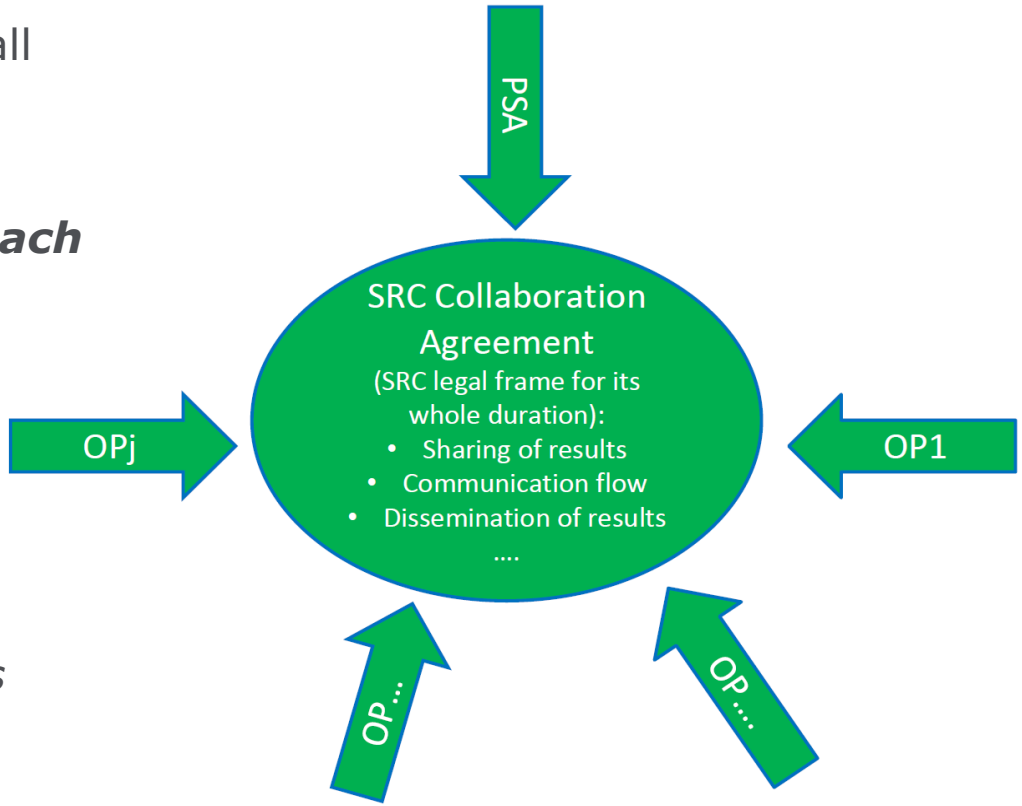
Within each SRC **the beneficiaries** of each awarded grant **will collaborate** for the **purposes of the cluster** with the beneficiaries of the other awarded grants.

The SRCs Collaboration Agreement

Work Programme text for both SRC call topics:

"*Grants awarded under **COMPET-3-2016-a** will be **complementary to each other** and complementary to grants awarded under sub-topic **COMPET-3-2016-b**; and vice versa.*

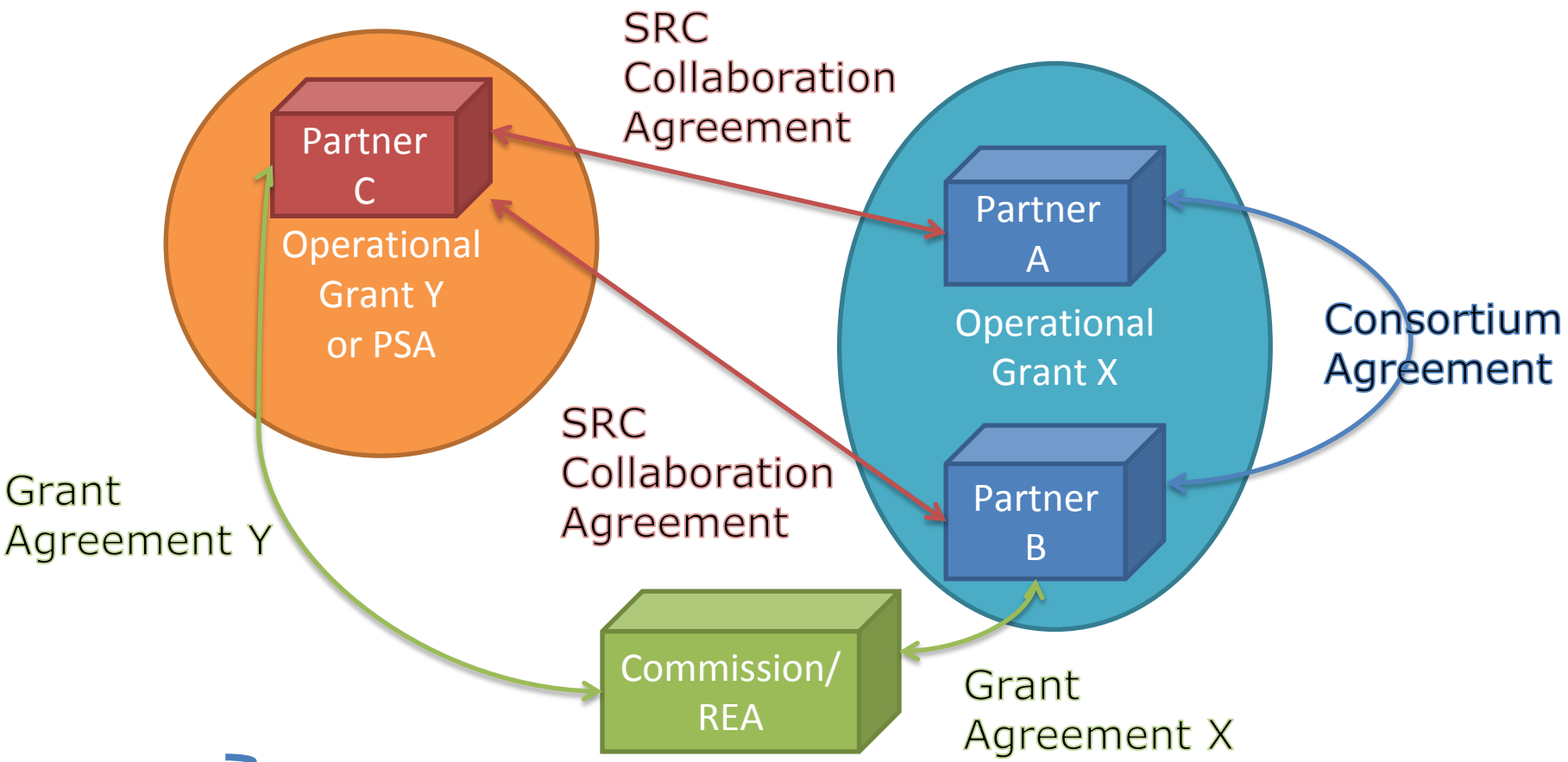
*In order to ensure a smooth and successful implementation of this Strategic Research Cluster (SRC), the beneficiaries of complementary grants ("complementary beneficiaries") shall conclude a written "**collaboration agreement**". The respective options of Article 2, Article 31.6 and Article 41.4 of the Model Grant Agreement will apply."*



PSA = Programme Support Activity

OP = Operational Project

Relationship between the beneficiaries of an SRC



A and C
B and C
} Complementary Beneficiaries

EPIC and PERASPERA PSAs: Introduction

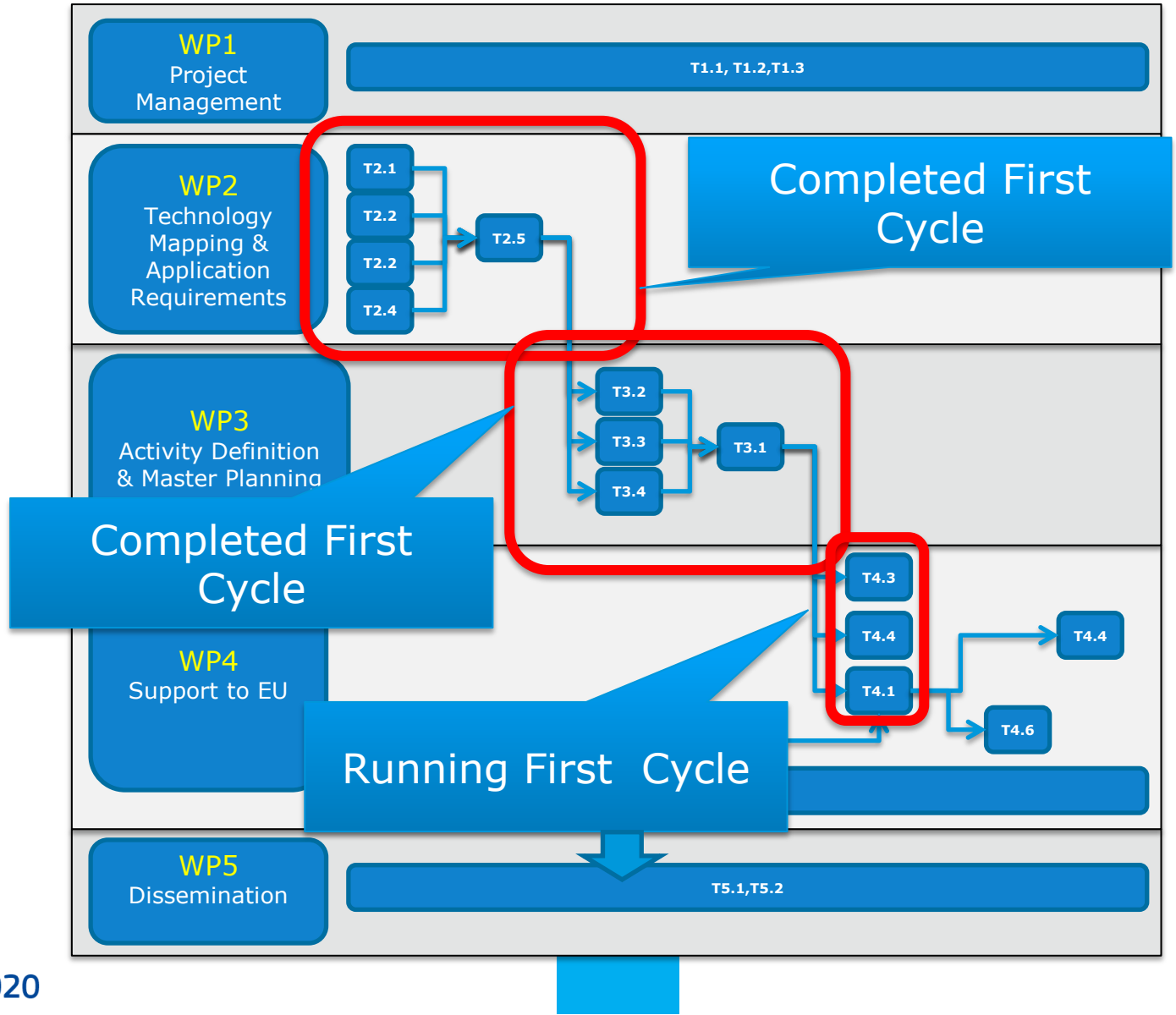
- **EPIC** (grant n. 640199) and **PERASPERA** (grant n.640026) are the PSA projects funded as part of the H2020 Space WP 2014.
- 5 years duration, starting October 2014.

- **EPIC = Electric Propulsion Innovation and Competitiveness**

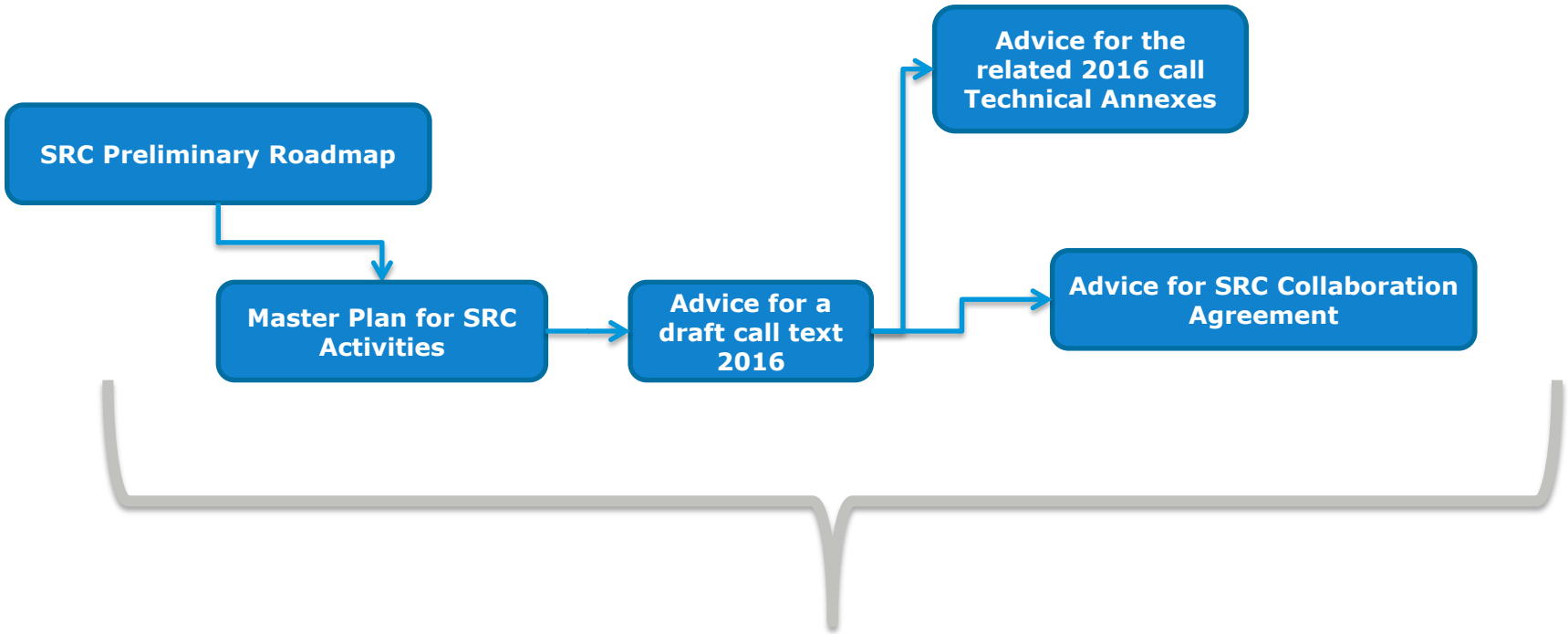
- **PERASPERA (AD ASTRA) = "Through Hardship to the Stars"**

- Most partners in both projects have been and are funding already through ESA or National Programmes more than substantial research and development in technology and space missions involving electric propulsion and space robotics.
- All partners are already since many years harmonising (together with all ESA member states) R&D in Technology through the **European Technology Harmonisation Advisory Group (THAG)** → roadmapping and consultation exercises.
- Knowledge, experience and expertise to support the H2020 SRCs.

EPIC and PERASPERA PSAs : general work logic



EPIC and PERASPERA: from the SRC roadmap to the 2016 SRC call



European Commission 2016 SRC call + call related documents

This process, together with a continuous monitoring of the state of the art and the assessment of the progress of the first SRC op. grants (2016 call), will be repeated for the subsequent SRC phases.

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Strategic Research Cluster on Electric Propulsion

H2020 Space call text 2016 & related Guidelines document

I. Alonso – ESA - EPIC Coordinator

National Space Info Day
Lisbon, 28 October 2015

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

Outline

COMPET-3-2016: SRC - In-Space Electrical Propulsion and Station keeping

- **Call topic text:**
  - COMPET-3-2016-a Incremental technologies
  - COMPET-3-2016-b Disruptive technologies

- **Guidelines for the SRC in the H2020 Space call 2016 :**
  - High level SRC roadmap
  - Technical Annex for "Incremental technologies" projects
  - Technical Annex for "Disruptive technologies" projects

- **Important call topic related links**

- **Conclusions**

COMPET-3-2016 – An Introduction

COMPET-3-2016 SRC In Space Electrical Propulsion and Station Keeping

The challenge of this Strategic Research Cluster (SRC) is 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.

- This call topic is divided in two "sub-topics", addressing different Scope and Expected Impact
    - **COMPET-3-2016-a Incremental Technologies**
    - **COMPET-3-2016-b Disruptive Technologies**

COMPET-3-2016-a
Incremental Technologies

- **Incremental technologies** are those considered **mature enough** at the moment to allow for incremental steps **to enable capabilities** such as **dual mode, higher/lower power, Electric Orbit Raising (EOR)**, required by a number of **applications such as telecommunications, LEO / MEO missions, space science and exploration, space transportation** which the current systems (some of them qualified and some with flight heritage) are not able to provide.

- Proposals shall, therefore, enable incremental advances in the already known technologies for **Electric Propulsion systems based on**:
    1. **Hall Effect Thrusters (HET)**
    2. **Gridded Ion Engines (GIE)**
    3. **High Efficiency Multistage Plasma Thrusters (HEMPT)**

- A **maximum of one proposal per aforementioned technology** (1, 2, 3) will be selected, with the target of supporting all three technologies.

- Proposed requested contribution from the EU of **between**:
    1. **HET: EUR 7.5 and 11 million**
    2. **GIE: EUR 5.5 and 7.5 million**
    3. **HEMPT: EUR 4.5 and 5.5 million**

COMPET-3-2016-b
Disruptive Technologies (1/3)

- **A 'disruptive space technology'** is an **emerging technology** that disrupts the status quo of the space sector by **replacing the dominant technology** and provides a **radical improvement in performance** that is perceived as valuable by a customer or part of the market, or it **opens up new opportunities not possible with the incumbent technology**.

- If a disruptive technology can be identified early enough, **accelerating** the development of that technology would help sustain advances in performance.

- Emerging technologies that are potentially 'disruptive' often underperform compared to the dominant technology in early development phases – **the underlying physics may not be fully understood** for example and more R&D is required to properly ascertain performance attributes.

COMPET-3-2016-b
Disruptive Technologies (2/3)

- Proposals are expected on the areas of disruptive technologies for Electric Propulsion and for EP thrusters, that are currently at **low TRL (≤ 4) and not part of the incremental line (COMPET-3-2016-a)**.
  - **Indicatively and non-exhaustively, EP thrusters** based on concepts such as:
    - Helicon Plasma Thrusters (HPT),
    - Electron Cyclotron Resonance plasma thrusters (ECR),
    - Magneto Plasma Dynamic thrusters (MPD),
    - Pulsed Plasma Thrusters (PPT),
    - micro-propulsion electric thrusters, etc.
    - ……
  - **Transversal** relevant technologies for **disruptive electric propulsion systems**, such as, indicatively:
    - direct drive,
    - radical new PPU architectures,
    - dedicated spacecraft power system architectures and/or materials
    - ……..
- Proposals for disruptive technologies **shall NOT address incremental thruster technologies** (e.g. micro-GIE, etc.).

COMPET-3-2016-b
Disruptive Technologies (3/3)

- **A maximum of:**
  - **1 proposal** addressing **transversal** relevant technologies for disruptive Electric propulsion systems (not thrusters), **and**
  - **4 proposals** devoted to specific **disruptive EP thrusters**

  will be selected.
- Proposed requested contribution from the EU of between **EUR 1 and 1.5 million** per proposal.

COMPET-3-2016
Specific conditions for the call

Type of Action:

- COMPET-3-2016-a **Incremental** technologies → **Innovation Actions (IA)**
- COMPET-3-2016-b **Disruptive** technologies → **Research and Innovation Actions (RIA)**

Opening date(s), deadline(s), indicative budget(s):

- Opening: **10 Nov 2015**
- Deadline: **03 Mar 2016**
- indicative budget COMPET-3-2016-a (IA): **18 EUR million**
- indicative budget COMPET-3-2016-b (RIA): **5 EUR million**

Eligibility and admissibility conditions:

- No beneficiaries of grant agreement EPIC (640199) except **DLR research institutes**, **Eurospace** and **SME4Space VZW** will participate in consortia of proposals submitted under this call for proposals.
- Considering the nature and objectives of the actions, and in view of favouring wider competition and participation, the **European Space Agency will not participate in consortia** of proposals submitted under this call for proposals.

Collaboration Agreement – between "Complementary Grants"

Consortium agreement:

- Members of consortium are required to conclude a consortium agreement, in principle prior to the signature of the grant agreement.

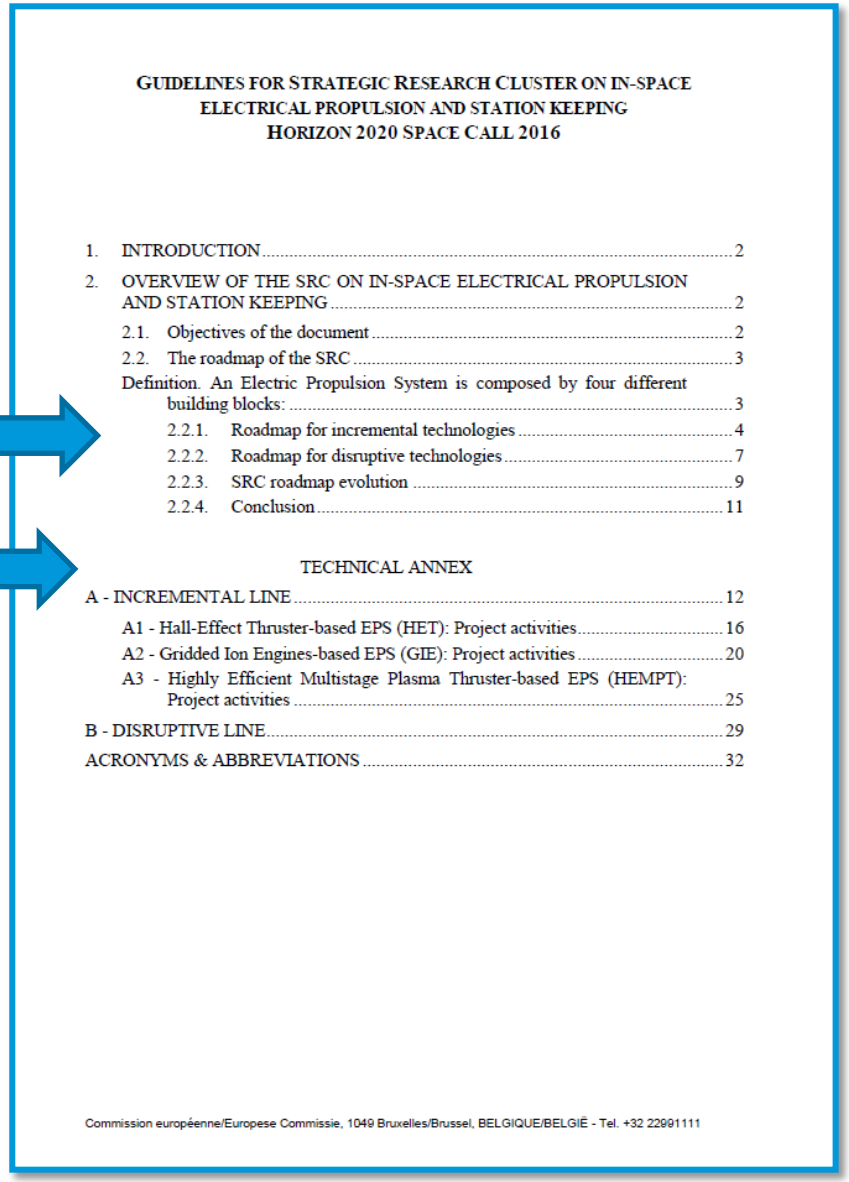
Guidelines for the SRC in the H2020 Space call 2016

Description of work, in terms of goals and achievements, for the purpose of guiding **potential applicants** and **evaluation experts**.

High level SRC ROADMAP

TECHNICAL ANNEX

- Incremental line
- Disruptive line



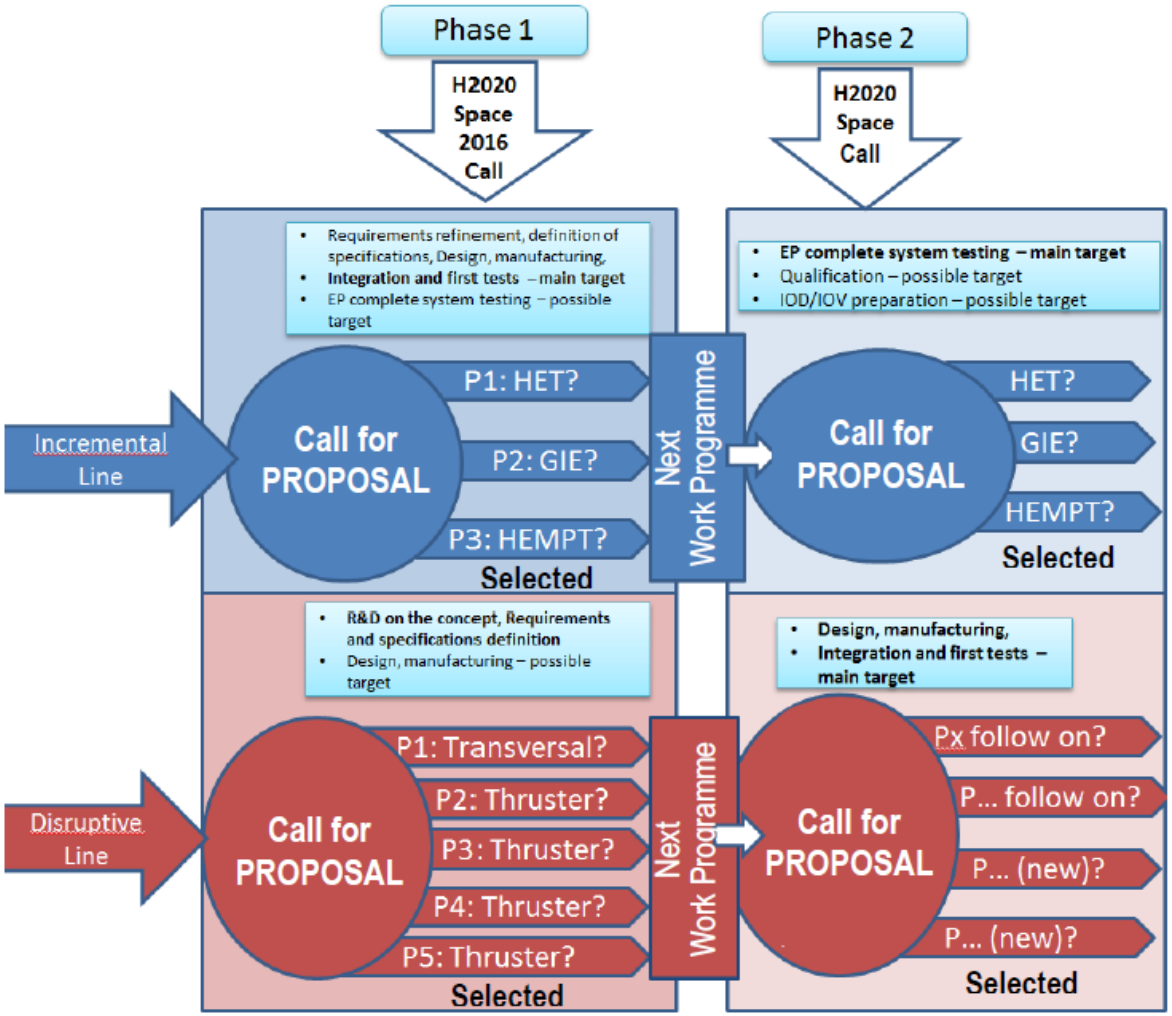
GUIDELINES FOR STRATEGIC RESEARCH CLUSTER ON IN-SPACE ELECTRICAL PROPULSION AND STATION KEEPING
HORIZON 2020 SPACE CALL 2016

Commission européenne/Europese Commissie, 1049 Bruxelles/Brussel, BELGIQUE/BELGIË - Tel. +32 22991111

2016 call Guidelines: High level SRC Roadmap (1/2)

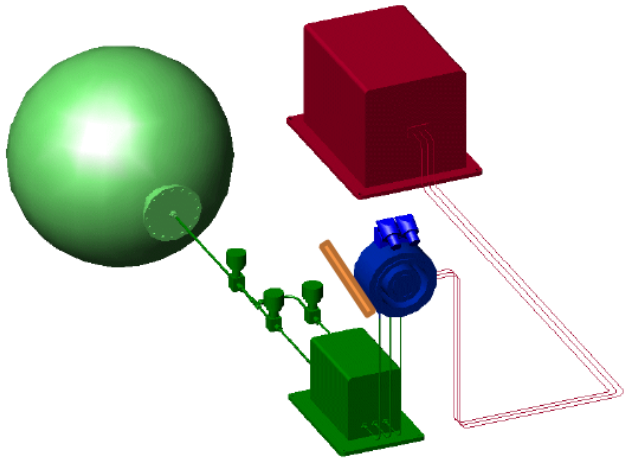
- Phase 2 objective: to support **the most promising technologies developed in Phase 1** towards higher TRLs, in order to, at the end of the Phase 2 projects, to achieve the SRC expectations and, potentially, be ready to prepare the chosen EP system(s) for a potential IOD/IOV.

- Phase 2 (future H2020 Space Call) aspects e.g. number of projects, continuation/establishment of new projects, expected funding, etc. **will remain OPEN** until the future Work Programmes are adopted, etc.



2016 call Guidelines: High level SRC Roadmap (2/2)

- For the projects to be developed within the H2020 SRC, the Electric Propulsion System (EPS) **does not** include:
  - the thrust orientation mechanisms
  - the tanks
  - The spacecraft power generation and distribution subsystem



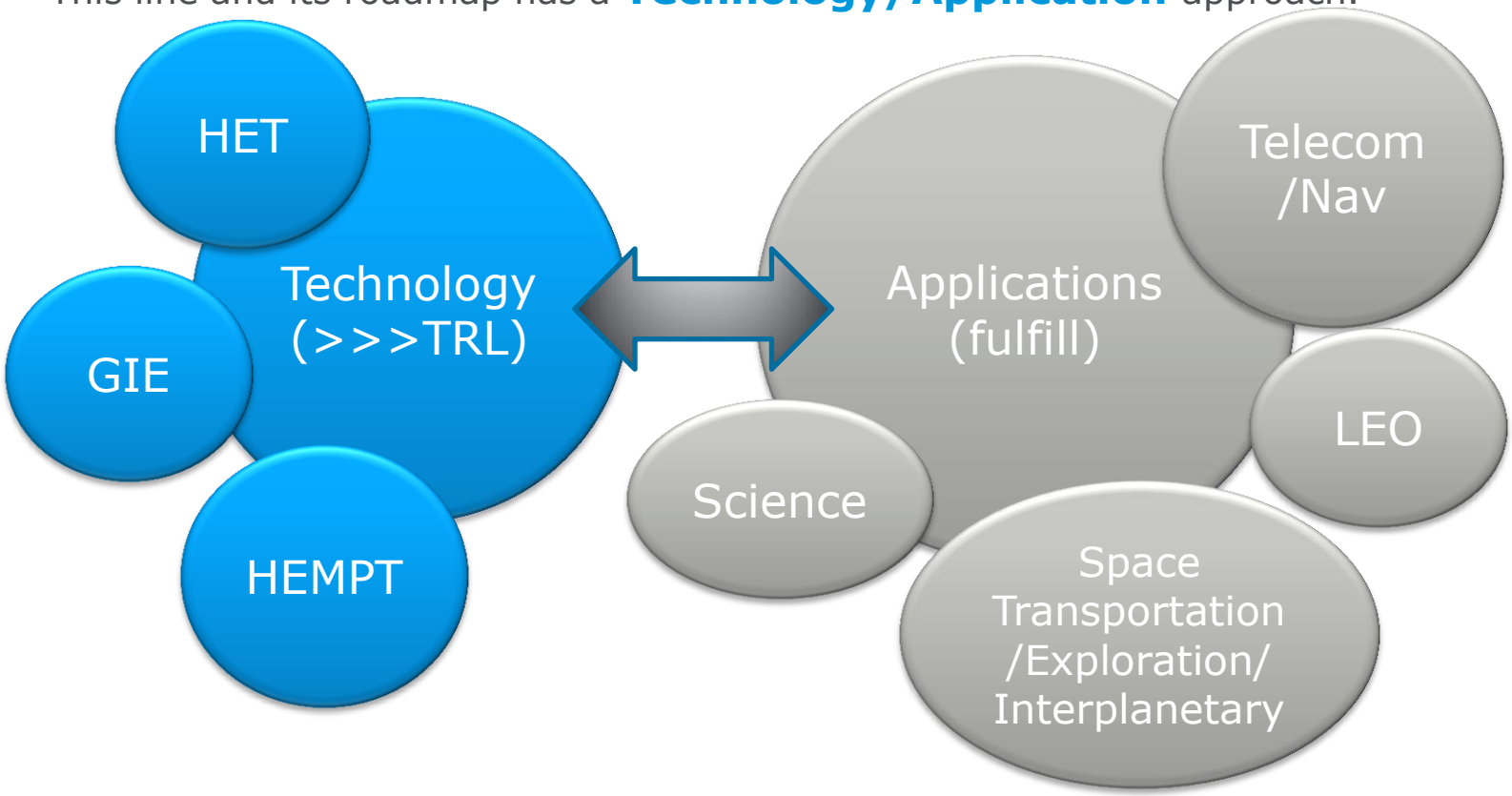
- "**EPS**" as used in the H2020 SRC documentation is composed of **the thruster, cathode (where applicable), PPU and fluidic management system only** → Specially important for Incremental line proposals.

- **Common aspects to all thruster-based systems are:**
  - Alternative/non-conventional propellants
  - High power testing facilities and diagnostics
  - EPS testing methods – standardisation of EP testing

These common lines are not meant to be separate projects. **All projects should take these common topics into account and propose solutions.**

2016 call Guidelines: Technical Annex Incremental Line (1/7)

- It provides additional information in order to **clarify what is expected from the proposals** to be submitted in response to **COMPET-3-2016-a**.
- This line and its roadmap has a **Technology/Application** approach.



2016 call Guidelines: Technical Annex Incremental Line (2/7)

ACTIVITIES = topic areas + their assigned requirements

→ to be covered by the proposals

→ each activity has a reference table depicting its requirements.

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)

2016 call Guidelines: Technical Annex Incremental Line (3/7)

Table 0 All incremental technologies (HET/GIE/HEMPT) activities	
Description and needed Action	The Electric Propulsion Systems (EPS) based on (HET/GIE/HEMPT) are considered mature enough at the moment to allow for incremental steps through this SRC aiming at enabling capabilities like operating at dual mode, higher/lower power, Electric Orbit Raising (EOR)/Station Keeping (SK), etc., required by a number of applications and markets, which the current systems, some of them qualified and others with flight heritage, are not able to provide. The main action needed is to improve the current state of the art performances specified and reduce the cost of the EPS, in order to satisfy the medium and future needs of different markets. The projects shall cover the development, validation (including testing) of the EPS. The EPS development and validation (including testing) shall be done following the relevant ECSS Standards, and testing shall be performed in a relevant environment.
Reference(s)	• Relevant ECSS Standards (www.ecss.nl) for the different elements of the EPS (i.e.: ECSS-E-ST-35C-Rev.1 – Propulsion general requirements, ECSS-E-ST-35-01C - Liquid and electric propulsion for spacecraft, , ECSS-E-ST-10-03C - Testing) and for the relevant milestone documentation (ECSS-E-ST-10C) • Proposers are invited to consult other EPIC public documentation available under www.epic-src.eu (EPIC website)
Proposals indicative content	• Proposals shall present an adequate approach addressing the relevant applications to be covered in a balanced way including all aspects and equipment of the EPS (thruster, cathode, PPU and fluidic management system). • Proposed developments shall include modelling/simulation and testing of each equipment in the subsystem as well as of the EPS. • Proposals shall include an initial work package dedicated to the requirements derivation based on the targeted application, as well as an analysis of the different classes of missions and EP system impacts on the satellite and the potential missions. The derivation of EPS specific requirements from the targeted application needs shall be included, taking into account the considerations described in the tables for each technology and application. Regarding the system impacts, thermal dissipation, plasma effects, electromagnetic interaction or any other effects shall be taken into account including considerations on integration of the EP system into the SC. • Proposals shall go beyond the present state of the art and, preferably, the expected state of the art at the time of completion if alternative technologies are being developed outside Europe. • Proposals shall demonstrate the readiness and interest to carry the developments further on through future calls of this SRC, by including a long-term plan for the developments to reach the TRL targeted in the EPIC

TABLE 0 is **applicable to and common to all the proposals focused on Incremental Technologies** (HET/GIE/HEMPT), independently of the targeted application.

- → Development + validation (including testing)
- → Relevant ECSS standards
- → Modelling/simulation + testing of each equipment and of the EPS
- → Work package on requirements derivation, classes of missions and system impact
- → Work package on Long-term plan and business plan.
- → Recurring cost reduction: clear expectations and methodology
- → No duplications with other developments → go beyond state of the art !!
- → Attention to deliverables expected

2016 call Guidelines: Technical Annex Incremental Line (4/7)

Table 1.1 Hall Effect Thrusters (HET) 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. In the case of Telecommunications, this is the main short-term commercial market for EP, with chemical propulsion as main competitor, and a fierce international competition. Hall Effect Thrusters (HET) EPS are the preferred option for this market at the moment due to their flight heritage and the acceptable Electric Orbit Raising (EOR) time. Activities in this area shall aim at consolidating 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 of the EPS. All HET proposals shall cover this activity and the requirements specified hereafter.	
Requirements		
• Target TRL[2] 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	250-800 V	The EPS should be optimized to work in two different points for two different types of functions: EOR mode with high thrust to minimise the time to final orbit; and SK mode with high efficiency to minimize the propellant used during the in-orbit operations.
• EPS Power	> 5 kW for EOR mode > 3 kW for SK mode	The EPS should demonstrate power performances beyond the state of the art, justifying the specific power performance selected with an analysis of the medium to long term market needs.
• *P/T*	~ 14 W/mN for EOR mode ~ 19 W/mN for SK mode	The time to orbit is a critical requirement from satellite operators and is fully dependent on the *P/T* ratio.
• *Isp*	> 1500 s for EOR mode > 2000 s for SK mode	The EPS efficiency in orbit operations is a critical requirement from satellite operators to optimize the mass of the propellant. The higher the *Isp* the better, but this requirement is a trade-off of several performance parameters. The *Isp* should be increased from the current state of the art, in order to make HET systems more competitive for SK utilisations.
• Innovative and cheaper PPU	The EPS should propose innovative and cheaper PPUs (addressing complexity vs. indicative cost), covering: industrialisation (reduction of number of EEE components, simplification of HV design, etc.), high power (high voltage (HV) modules in parallel, thermal coupling, etc.), in-orbit reconfiguration and modularity, etc. An asset would be a complementary study of alternative simplified PPU concepts for general orbit transfer application using direct input from spacecraft solar power systems.	
• Recurring Cost reduction	30% of the present EPS cost (indicative)	

TABLES 1.1, 2.1, 3.1 applicable to **Telecommunication / Navigation activities** for the three types of thrusters (HET, GIE, HEMPT) respectively

- → **Telecommunication** is the main short-term commercial market for EP
- → Obligatory activity for the 3 types of thrusters
- → Dual mode: EPS optimisation
- → Power performances beyond state of art
- → Attention to decreasing recurring costs
- → Innovative and cheaper PPU (complexity vs cost)

2016 call Guidelines: Technical Annex Incremental Line (5/7)

Table 2.2 Gridded Ion Engine (GIE) 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. Gridded Ion Engines have good prospects for use in LEO, due to the mass savings they can offer due to their high *Isp*. They have already demonstrated good performances in some LEO applications, such as drag compensation. Projects in this area shall aim at improving EPS performances and reducing the recurrent cost of the EPS. All GIE proposals shall cover this activity and the requirements specified hereafter.	
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	
• Cycles	TBD by proposers	Due to the eclipses, a large number of cycles are needed for operation in LEO. Thus, the design shall take into account the impact that it has on performances and lifetime of the EPS. This number of cycles shall be compliant with the lifetime requirement of the platforms (currently around 5 years).
• Power	200-700W	The EPS should demonstrate useful performances when operated at low to medium power levels.
• *P/T*	~ 25 (W/mN)	Low *P/T* ratios are needed in order to obtain useful Thrust when little power is available.
• *Isp*	> 3500 (s)	The EPS efficiency may be less important for the often mass-limited LEO missions than a high *Isp*. The higher the *Isp* the better, but this requirement is a trade-off of several performance parameters.
• Innovative and cheaper PPU	Low complexity PPU	
• EPS Cost	< 200 k€ (indicative)	
Remarks	Compact and low mass integrated system	

TABLES 1.2, 2.2, 3.2 applicable to **LEO activities** for the three types of thrusters (HET, GIE, HEMPT) respectively

- **LEO constellations** as possible future commercial market for EP
- Obligatory activity for the 3 types of thrusters
- Design taking into account eclipses
- Compact, integrated, low mass EPS
- Low cost and compact PPU
- EPS cost < 200 k€

2016 call Guidelines: Technical Annex Incremental Line (6/7)

Table 3.3 Highly Efficient Multistage Plasma Thruster (HEMPT) EPS activities oriented to Space Transportation/Exploration/Interplanetary applications		
Description and needed Action	EP is one of the new revolutionary technologies at the moment in satellite markets. The specific characteristics of EP enable new types of missions and applications, in particular in Transportation, Exploration and Interplanetary Missions. In order to improve the competitiveness of HEMPT systems within Interplanetary, Space Transportation and Exploration missions, the performances of existing systems must be improved. 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	
• Power	> 20 kW	The EPS should demonstrate power performances beyond the state of the art, justifying the specific power performance selected with an analysis of the medium to long term market needs. High power will be needed to develop the high thrust needed for some of the applications.
• *P/T* (for EOR)	< 26 (W/mN)	In order to reach the adequate Thrust levels for these types of missions, the *P/T* must be low enough. The activities must be aimed at improving the *P/T* ratio.
• *Isp* (for SK)	>3000 (s)	High *Isp* needed to achieve the large delta-V needed for these missions with a propellant mass compatible with launcher performance. The higher the *Isp* the better, but this requirement is a trade-off of several performance parameters. The *Isp* should be increased from the current state of the art.
• Innovative and cheaper PPU	High power PPU able to provide 20 kW to the thruster	
Remarks	Clustering of lower power EPS could be considered.	

TABLES 1.3, 2.3, 3.3 applicable to **Space Transportation/Exploration/Interplanetary** for the three types of thrusters (HET, GIE, HEMPT) respectively

- → Obligatory activity for the HET proposals
- → Optional activity for the GIE and HEMPT proposals
- → Very high power EPS (> 20kW), including high power PPU
- → High Isp , Low enough P/T
- → Clustering could be considered

2016 call Guidelines: Technical Annex Incremental Line (7/7)

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	

TABLES 2.4, 3.4 applicable to **Science** activities for GIE, HEMPT-based type of thrusters, respectively

- → Optional activity for GIE and HEMPT proposals
- → Micro-propulsion operation
- → Very long continuous operation
- → Large throttability, with adapted PPU
- → Very low noise

2016 call Guidelines: Technical Annex Disruptive Line (1/2)

- It provides additional information in order to **clarify what is expected from the proposals** to be submitted in response to **COMPET-3-2016-b**.
- This line and its roadmap focuses on promoting the **Research Technology and Development** of very promising and **potentially disruptive concepts** in the field of EP, with a focus on innovative EP thrusters.
- The disruption of the EP sector, could be provoked if these concepts are able to:
  - Provide a radical improvement in one or more performance attributes, perceived as more valuable than those of mature and well established (incremental) technologies, leading into becoming a preferred technology for certain applications/markets in the future.
  - Enable new applications/markets not possible with the existing technologies.

- This section for the disruptive line is composed by one table **(TABLE 4)** providing **guidance** for the proposals to be submitted and **requirements** for the technologies or concepts to be developed.

2016 call Guidelines: Technical Annex Disruptive Line (2/2)

Table 4 - Disruptive Technologies	
Description and needed Action	The COMPET-3-2016 also covers a number of alternative thruster concepts that are emerging or have already gained some maturity. If these disruptive technologies can be identified early enough, accelerating the development of those technologies would help to sustain advances in performance and identifying new markets/applications. This topic focuses on promoting the **Research, Technology and Development (RTD) of very promising and potentially disruptive concepts** in the field of Electric Propulsion, in order to increase the currently low or very low TRL (≤4) of potentially breakthrough concepts which in the long term could change the EP landscape. **Electric Propulsion thrusters** currently at low TRL (≤4) and not part of the Incremental line of this SRC, shall be the main focus of this line. Proposals are expected for concepts such as HPT, ECR, MPD, PPT, micropropulsion or other innovative thruster concepts not identified here. The activities proposed shall include modelling, development and testing beyond the current state of the art in order to: • Understand fundamental physical processes and their impact on performance. • Improve current thruster performances (thrust, specific impulse, power/thrust ratio, magnetic thrust vectoring, throttability, efficiency, lifetime, noise, etc.). • Progress the development of associated cathodes/neutralisers, if applicable to a thruster. • Investigate alternative propellants to Xenon and/or non-conventional propellants, understood as gases constituting the atmosphere of a planet, such as oxygen, nitrogen and combinations in the case of the Earth, with consideration to potential applications. • Further analyse the impact of the thruster on the whole EP system. It is important to acknowledge that there might be other elements in the EP system, aside from the thruster, with the ability to provoke a radical disruption. For example, new Power Processing Unit (PPU) concepts or architectures could substantially decrease the overall cost of the system. It is therefore also important and expected that proposals explore the potential for breakthrough innovation of **Transversal Disruptive EP system concepts**, such as: direct drive, radically new PPU architectures and dedicated spacecraft power system architectures and/or materials; hybrid solutions to drive different types of EP thrusters, highly innovative magnetic nozzles, modeling/design and simulation tools or testing techniques, or any other new concept belonging to the Transversal Disruptive EP system concepts category not specifically mentioned here. Proposals for thrusters in the Disruptive line should not be based on HET, GIE or HEMPT technologies.
References	• Relevant ECSS Standards (www.ecss.nl) for the different elements of the EPS (i.e.: ECSS-E-ST-35C Rev.1 – Propulsion General Requirements, ECSS-E-ST-35-01C - Liquid and electric propulsion for spacecraft, ECSS-E-ST-10-03C - Testing) and for the relevant milestone documentation (ECSS-E-ST-10C). • Proposers are invited to consult other EPIC public documentation available under www.epic-src.eu (EPIC website)

TABLE 4 (extract on left): applicable to and obligatory for **all proposals** on the Disruptive line

- → Concepts at TRL ≤ 4
- → Modelling, development and testing
- → Relevant ECSS standards
- → Requirements analysis
- → Long-term development plan and business plan.
- → Validation plan, including milestones and one or more validation methods → to verify how:
  - the concept meets the disruptive definition,
  - the development targets are being met, and
  - the landscape disruption shall take place in the future.
- → No duplications with other developments → go beyond state of the art !!
- → Attention to deliverables expected

HORIZON 2020

Important call topic related links

Call Topic Text, included in the Horizon 2020 Work Programme 2016-2017 Space:

- http://ec.europa.eu/research/participants/data/ref/h2020/wp/2016_2017/main/h2020-wp1617-leit-space_en.pdf

Guidelines document for the SRC 2016 call – in the Participant Portal:

- http://ec.europa.eu/research/participants/portal/doc/call/h2020/compet-3-2016-a/1682607-src_guidelines_in_space_electric_propulsion_(compet-3-2016)_en.pdf/

Grants Manual - Section on: Proposal submission and evaluation:

- http://ec.europa.eu/research/participants/data/ref/h2020/grants_manual/pse/h2020-guide-pse_en.pdf

Horizon 2020 Work Programme 2016 – 2017 Space / General Annexes:

- http://ec.europa.eu/research/participants/portal/desktop/en/funding/reference_docs.html#h2020-work-programmes-2016-17

EPIC PSA:

- www.epic-src.eu (apologies, still under construction):
  - all additional EPIC-produced documentation of interest for the 2016 call, including the "SRC Collaboration Agreement" will be available here at call opening.
- www.esa.int/Our_Activities/Space_Engineering_Technology/EPIC_Electric_Propulsion_Innovation_and_Competitiveness

Conclusions

- The **SRC** is a **system of connected grants with common high level objectives**, to be reached when the results of all the grants are put together.
- **EPIC and PERASPERA** are the Programme Support Activities (PSAs) that, between others:
  - have produced the SRC roadmap to be implemented through the Operational Grants.
  - will follow the SRC implementation, monitor the state of the art and redefine the roadmap and subsequent SRC phases (calls) as necessary.

- All beneficiaries within one SRC are "**complementary**" beneficiaries, including the PSA, and as such their interactions are regulated through the **SRC Collaboration Agreement**.

- The Commission has published the **H2020 Space Work Programme 2016-2017,** containing the SRC call topics **COMPET-3-2016 (a & b) and COMPET-4-2016,** together with their **Guidelines** document.
  - These two documents are essential for potential proposers and expert evaluators

- Projects are expected to be funded on both the Incremental and Disruptive line (COMPET-3-2016-a & b), in order to implement the first phase of the Electric Propulsion SRC.

- The **Guidelines** document contains additional information in order to clarify:
  - what the SRC roadmap looks like at the moment
  - what is expected from the proposals/projects on the Incremental and Disruptive line.

- The Technical Annex for Incremental and Disruptive shall be respected in order to build successful proposals targeting the SRC objectives.

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Many thanks for your attention

For more information on Horizon 2020 Space, please refer to:
https://ec.europa.eu/programmes/horizon2020/en/h2020-section/space

For more information on the EPIC PSA activities, please refer to:
www.epic-src.eu

www.esa.int/Our_Activities/Space_Engineering_Technology/EPIC_Electric_Propulsion_Innovation_and_Competitiveness

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