GRIDDED ION ENGINE
STANDARIDISED ELECTRIC PROPULSION PLATFORMS
GIESEPP

24/10/2017, Madrid, Spain
Dr. Farid Infed
PART 1 – OBJECTIVES AND EXPECTED IMPACT

PART 2 – CONSORTIUM AND COMPETENCIES

PART 3 – GIESEPP CONCEPTS

PART 4 – ACTIVITIES AND SCHEDULE

PART 5 - DESIGN AND DEVELOPMENT CHALLENGES
01

OBJECTIVES AND EXPECTED IMPACT
GIESEPP – OBJECTIVES (1/2)

The aim of the GIESEPP program is to develop standardized Gridded Ion Engine Systems (GIESEPP), including Gridded Ion Engines (GIE), Power Processing Unit (PPU), Xenon Propellant Management System (XPMS) and Neutralizer Cathodes, to meet the future needs of the competitive GEO Telecoms, Navigation and LEO Constellation markets as well as for Space Transportation, Exploration and Interplanetary Missions. In particular our aims are to:

- Gain worldwide technology leadership in the fields of high Isp electric propulsion and Xenon fluid control systems and maintaining and securing European non-dependence
- Achieve a significant reduction of the EPS cost, targeting at least a 30% reduction of the current European products.
- Standardization of testing sequences and methods for significant cost reduction for the recurring phase
- Incrementally develop the European RIT-series and T-series GIE thrusters to improve performance (Dual Mode Functionality), share common interfaces and components (common Neutralizer) wherever possible, and drive down thruster costs
- Develop a PPU design that has the capability to drive either the T-series or the RIT-series thrusters, whilst driving down costs.
- Develop and implement an XPMS (Propellant Control) design that reduces complexity, mass and cost
- Assess and select an alternative propellant, and perform confidence tests using this propellant with breadboard model RIT-series and T-series GIE
GIESEPP – OBJECTIVES (2/2)

Develop, build and test the first European Plug and Play Gridded Ion Engine Standardized Electric Propulsion Platform (GIESEPP) to operate Ariane Group and QinetiQ Space ion engines.
IMPACT AND AMBITION

The competitive advantage of GIESEPP technology undermines the necessity of maintaining and further developing Gridded Ion technologies in Europe:

- The GIESEPP technology has unique design feature which provides high performance at low complexity
- The GIESEPP can deliver the highest Isp and will lead therefore to the highest mass saving, resulting in half xenon mass compared to other technologies, smaller tanks and lower operating pressure. It is the best solution for satellite station keeping.
- For EOR, GIESEPP ensures thanks to the Dual Mode capability of the thruster high thrust performance and therefore overcomes the disadvantage w.r.t. to other technologies.
- With increasing payload power, the RIT system advantages become more dominant. Therefore the GIESEPP technology has the highest growth potential.

<table>
<thead>
<tr>
<th>State of the Art (Pre GIESEPP)</th>
<th>Beyond State of the Art (Post GIESEPP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5k W EP systems for single GIE thruster types (T and RIT series)</td>
<td>EP system for transfer missions at 30% reduced cost and complexity for European competitiveness operating with no changes as plug and play for both QinetiQ and ASL thrusters</td>
</tr>
<tr>
<td>High PPU cost</td>
<td>High performance thrusters operating in dual mode at a large range of specific impulses (2500 – 6000 s) to close the gap in performance range</td>
</tr>
<tr>
<td>Isp either below 2000 or above 4000 s</td>
<td>Low cost EP system for small satellite mega constellation</td>
</tr>
<tr>
<td>Low TRL or Part obsolescence for low power GIE EP Systems</td>
<td>Commercial high power systems</td>
</tr>
<tr>
<td>Dingle unit production capacity for low and high power EP system</td>
<td>High production capability for low cost EP</td>
</tr>
<tr>
<td>No high power commercial solution for 20kW segment</td>
<td>Xe as standard propellant and additional alternative propellants</td>
</tr>
</tbody>
</table>
02
CONSORTIUM AND COMPETENCIES
CONSORTIUM AND COMPETENCIES

GIESEPP
Project Needs
and
Team Involvement

Satellite System Requirements
OHB

Thrusters
ArianeGroup / QinetiQ

System Engineering
ArianeGroup / QinetiQ

PPU
CRISA / Airbus DS

Alternative Propellants
University of Southampton

Analytical Design and Test Support
Mars Space

Testing
QinetiQ / ArianeGroup

Propellant Control
AST

German
English
Spanish
German
03
GIESEPP CONCEPTS
## MAIN REQUIREMENTS AND MISSION SCENARIOS
- **CONSIDERED PLATFORMS**

### 500 W class
- **LEO Constellations**
  - Small/Medium – 1-2 t class
  - Mega – 150-200 kg class
- **LEO EP Platform (500kg)**
- **SmallLEO EP Platform (50kg)**
- **GEO Station Keeping (8 Thrusters)**

### 1500 W class
- **GEO Station Keeping (3 Thrusters)**
- **LEO Constellations**
  - Small/Medium – 1-2 t class
- **In Orbit Servicing**
  - Refueling
  - Station Keeping
  - Debris Removal
- **Constellation Removal (tbd)**

### 5000 W class
- **GEO Communication**
  - SmallGEO (2-3 t)
  - Medium to Large GEO (4-6t)
- **MEO Navigation (2t)**

### 20000 W class
- **Space Tug**
  - Navigation Sats
  - GEO Sats
  - Moon Station
**GIESEPP CONCEPT – GIESEPP 1L/2L – 200-700 W - LEO**

- 1 x Thruster
- 1 x Power Processing Unit PPU 1L
- 1 x Electronic Pressure Regulator
- 1 x Flow Control Unit FCU
- For 2L RADICAL instead of FCU and EPR
- 1 x set of Harness, Filters and Sensors
GIESEPP CONCEPT – GIESEPP 1G – 5KW – MEO/GEO

- 1 x Thrusters
- 1 x Power Processing Unit PPU 1G 1
- 1 x Electronic Pressure Regulator
- 1 x Flow Control Units FCU
- 1 x set of Harness, Filters and Sensors
GIESEPP CONCEPT – GIESEPP 1G – 20KW – SPACE TRANSPORTATION, EXPLORATION AND INTERPLANETARY

- Clustering of GIESEPP 1G
- 1 x Thrusters
- 1 x Power Processing Unit PPU 1G 1
- 1 x Electronic Pressure Regulator
- 1 x Flow Control Units FCU
- 1 x set of Harness, Filters and Sensors
04 ACTIVITIES AND SCHEDULE
**ACTIVITIES AND SCHEDULE**

- **Phase 1:** Mission Scenarios, Platforms, Requirements and Gap Identification
- **Phase 2:** Electric Propulsion System Definition
- **Phase 3:** Electric Propulsion System Development and Cost Optimisation
- **Phase 4:** Build, Procure, Assemble and Prepare Standardised Tests
- **Phase 5:** Test and Analysis

---

**GISePP**

- M1: 01.01.2017
- M7: 18.07.2017
- M16: 17.04.2018
- M24: 18.07.2017
- M36: 17.04.2018
- M48: 17.04.2018

Project is fully in line with DOA w.r.t:
- Schedule
- Deliverables
- Costs
ACHIEVEMENTS BY TODAY

- Candidate platforms for 3 mission types: LEO/ GEO/Scientific
- System Requirements analysis, development needs and gap analysis
- Define and provide high lvl requirements for EPS for candidate platforms
- Thrusters requirements analysis: LEO: T5; GEO/Sci: Ring Cusp
- Thrusters requirements analysis: LEO: RIT10EVO; GEO/Sci: RIT2X-X
- PPU requirement analysis regarding high lvl system requirements
- EPR, FCU, RADICAL requirement analysis regarding high lvl system requirements.
- Alternative propellants assessment and impact analysis
- Common EPS concepts trade-offs
- Preliminary EPS definition (architecture): LEO, GEO, Scientific
- Preliminary Specifications for components: Thrusters, PPU, FCU, EPR, Harness, Sensors, Filters

Mission Scenarios, Platforms, Requirements and Gap Identification

- Define candidate platforms for 3 mission types: LEO / GEO / Scientific
- Define and provide high lvl requirements for EPS for candidate platforms
- Thrusters Requirements Analysis: LEO: T5 GEO/Scientific: Ring Cusp
- System Requirement analysis, development needs and gap analysis
- Preliminary EPS definition (architecture): LEO GEO Scientific
- Common EPS concepts trade-offs
- PPU requirement analysis regarding high lvl system requirements
- EPR, FCU, RADICAL requirement analysis regarding high lvl system requirements
- Alternative propellants assessment and impact analysis
- Preliminary Specifications for components: Thrusters, PPU, FCU, EPR, Harness, Sensors, Filters
- Improved Communication Strategy and Action Plan
- Concept Review
- Dissemination

Preliminary EPS (architecture): LEO, GEO, Scientific
- PPU, EPR, FCU, RADICAL: Refined Requirement analysis and development needs and gap analysis
- Communication Strategy and Action Plan
ACTIVITIES AND SCHEDULE – NEXT PHASE

2021 - 2022

GIESEPP FR – CDR Phase 2020-2021

CDR
Qualification Model Production
Lifetime Qual Campaign
Analytical Test Predictions
Environmental Qual Campaign
Functional & Performance Qual Campaign

Q1 2023 – Q3 2023

MRR
Proto-Flight Hardware Production
IRR
Proto-Flight Hardware MAI
TRR
Proto-Flight Hardware Acceptance Testing
PSR
Protoflight System Production

Q4 2023 – Q2 2024

Project Kick-Off
MRR
Flight Hardware Production
IRR
Flight Hardware MAI
TRR
Flight Hardware Acceptance Testing
PSR
Recurring System Production
DESIGN AND DEVELOPMENT CHALLENGES
### MAIN REQUIREMENTS AND MISSION SCENARIOS - DESIGN DRIVERS

<table>
<thead>
<tr>
<th>High Level Requirements</th>
<th>Flexibility (Input &amp; Output)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Accuracy</td>
</tr>
<tr>
<td></td>
<td>Efficiency</td>
</tr>
<tr>
<td></td>
<td>Environmental Loads</td>
</tr>
<tr>
<td>Materials and Components</td>
<td>High Batch Numbers</td>
</tr>
<tr>
<td></td>
<td>(Industrial/MIL) Parts &amp; Processes</td>
</tr>
<tr>
<td></td>
<td>Tolerances</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>Complexity / Flexibility</td>
</tr>
<tr>
<td></td>
<td>ECSS &amp; GERD</td>
</tr>
<tr>
<td>Testing</td>
<td>In-house vs. Outsourcing</td>
</tr>
<tr>
<td></td>
<td>Cleanliness</td>
</tr>
<tr>
<td></td>
<td>Margin Philosophy</td>
</tr>
<tr>
<td>Verification Documentation</td>
<td></td>
</tr>
<tr>
<td>Meetings and Contract Discussion</td>
<td></td>
</tr>
<tr>
<td>Non Recurring Qualification</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Trust vs. Responsibility</td>
</tr>
<tr>
<td></td>
<td>High cost of TVAC and Structural Test</td>
</tr>
<tr>
<td></td>
<td>Life Time Qualification</td>
</tr>
<tr>
<td>Goal</td>
<td>Challenge</td>
</tr>
<tr>
<td>------</td>
<td>-----------</td>
</tr>
</tbody>
</table>
| PPU Cost Reduction for 1L/2L | Maintaining maximum communalities between PPU1G and PPU1L | • Ensure common architecture  
• Provide flexibility in bus input voltage variation | • Define steps in DDP for BB’s EM’s  
• Elaborate possibilities for further disruptive approaches w.r.t. GIE technology specifics |

- Increase impact and business case enlargement by targeting most possible LEO/New Space Platforms  
- Increase competitiveness to HET solutions

| | PPU1L shall be compatible with different EPS voltage inputs | Establish PPU architecture and electrical interfaces allowing wider range of voltage variation | Increase dissemination and communication with SAT primes to assess widest expected voltage variation |

- Ensure Plug and Play approach for cost reduction on S/C and EPS LvL  
- Ensure compatibility for potential need of cold gas systems

| | Provide electrical and fluidic interfaces among all GIESEPP components with highest commonalities among GIESEPP 1G/1L/2L and 1S  
• Smart control | • Identification and very close tracking of harness, thermal control, fluidic control, mechanical, electrical and telemetry I/F  
• Ensure adequate adapters if necessary for different thruster types | Define steps in DDP for BB’s EM’s |
## DESIGN AND DEVELOPMENT PLAN CHALLENGES

<table>
<thead>
<tr>
<th>Goal</th>
<th>Challenge</th>
<th>Solution</th>
<th>Risk Mitigation</th>
</tr>
</thead>
</table>
| Dual Mode for increasing competition w.r.t. HET | • Optimize simplified and robust thruster design to cope with different Thrust/Isp Modes  
• Provide PPU1G coping with higher voltage variation to ensure best dual mode functionality | • Acceptable range for voltage has been identified  
• Perform BB and EM test for verification and confirmation of solution approach | • Define steps in DDP for BB’s EM’s  
• Elaborate possibilities for further disruptive approaches for further voltage variation at high power modes for both thruster types |
| Mass reduction                            | • Optimize simplified and robust thruster and PPU design  
• Provide adequate shielding for acceptable life time                      | Mass drivers identified                                                                       | • Analytical assessments of life time vs mass reduction  
• Analytical assessments of performance loss w.r.t. load limitation                                                                                          |
## DESIGN AND DEVELOPMENT PLAN CHALLENGES

<table>
<thead>
<tr>
<th>Goal</th>
<th>Challenge</th>
<th>Solution</th>
<th>Risk Mitigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrialization for significant cost</td>
<td>• Provide robust design for high unit production</td>
<td>• Manufacturing sensitive parts identified</td>
<td>• Identification of production cost drivers</td>
</tr>
<tr>
<td>reduction</td>
<td>• Change design for introduction of faster and cheaper manufacturing process</td>
<td>• Focus on COTS parts for electronics</td>
<td>• Assess reliability vs. costs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Introduce adequate manufacturing processes</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Identification of production cost drivers</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Assess reliability vs. costs</td>
<td></td>
</tr>
<tr>
<td>Alternative Propellants for increasing</td>
<td>• Ensure full functionality of optimized EPS with applicable alternative</td>
<td>• Candidate propellants identified</td>
<td>• Increase analytical assessments for EPS impact</td>
</tr>
<tr>
<td>market impact</td>
<td>propellants</td>
<td>• Perform BB and EM test for verification and confirmation of solution approach</td>
<td>• Define in DDP BB and EM tests for fluidics and thrusters</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
THANK YOU!

www.giesepp.eu
www.giesepp.com

https://ec.europa.eu/programmes/horizon2020