

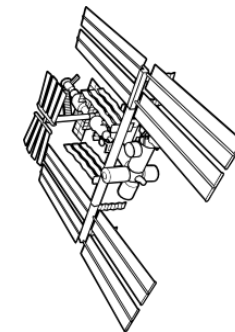
Advanced Manufacturing Cross-Cutting Initiative

Dr. Tommaso Ghidini
Head of the Materials and Processes Section

May 2017

Background and Objective

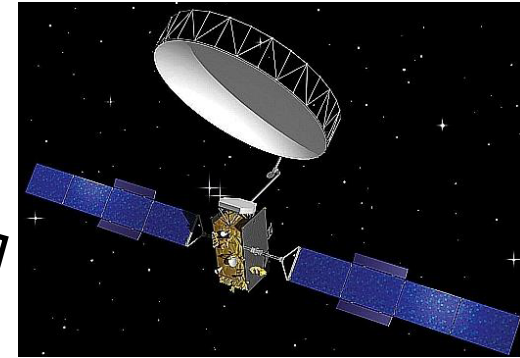
- Advanced Manufacturing (AM) for Space Applications Cross Cutting initiative has the following objectives:
 - Revitalize and consolidate the European leadership in advanced materials and manufacturing for space applications
 - Profit of the ideal opportunities in Europe to spin-in the digital manufacturing technologies and Industry 4.0 to space
 - Identify and qualify new manufacturing technologies for space applications enabling:
 - ✓ Design freedom
 - ✓ Performance improvement
 - ✓ Costs reduction
 - ✓ Lead time reduction (from concept to manufacturing)
 - Create new high-performance Space products by actively reducing the limitations imposed by the traditional manufacturing processes/concepts
 - Maximize European Space industry competitiveness



Space
Products

European Harmonisation Roadmap on Additive Manufacturing for Space

- Roadmap proposes about 30 types of parts (AIM A)
- Roadmap proposes technology developments (Aims B to F)
- **Roadmap endorsed by the IPC**



Aim A

- Aim B: Design
- Aim C: Material supply
- Aim D: Processing
- Aim E: Post processing
- Aim F: Qualification
- Aim G: Standardisation

End-to-end AM process

Terrestrial AM

- More than **700 experts** /stake holders involved
- **26 countries** represented
- **390 companies** represented
- **62 new members** joined the roadmap space community
- Available for everyone in Europe
- => Eurospace

Advanced Manufacturing TRP Workplan 2016-2017



ID#	Activity	Budget
T224-004QT	Demonstration of an Additive Manufactured Metallic Optical Bench	1000
T524-502QT	Development of cathode assemblies for Hall Effect Thrusters and Gridded Ion Engines for Electrical Propulsion systems	500
T724-504QT	ESA Additive Manufacturing Benchmarking Centre	900
T724-508QT	Curing on demand polymerisation by switchable stimulus	350
T724-505QT	Acceptance and Verification Criteria of AM Components	700
T707-502EE	Additive Manufacturing for Frequency and polarization Selective Surfaces	450
T720-502MS	Thin-Ply-Laminate Composite Structures	450



GSTP-6 Element 1 Compendium of Potential Activities Advanced Manufacturing



- Initial set of Advanced Manufacturing technologies identified following an extensive technical and programmatic coordination work with ESA as well industrial end-users
- The resulting THAG Roadmaps for Additive Manufacturing and Composites Materials used to establish the GSTP-6 Element 1 Compendium of Potential Advanced Manufacturing activities (Reference TEC-T/2015-013/NP)
- Compendium presented to the Delegations of the GSTP-6 Participating States and their Industries in November 2015



GSTP-6 Element 1 Compendium of Potential Activities

Advanced Manufacturing



GSTP-6 Reference	Title	Budget(K€)
Materials Processing		
G61A-001QT	Low Cost Manufacturing of Engineering Ceramic Materials for Space Applications	400
G61A-002MS	3D Weaving processes for realisation of near net shaped hardware	500
G61A-003QT	Extended pot life resins for out of autoclave processing for large and complex part	600
G61A-004QT	Novel Low temperature curing resins for enhanced out of autoclave processing for large and complex space composites structure	1,200
G61A-005MS	Integrated Optical Fibres in Launcher and Spacecraft Composite Structures	500
G61A-006QT	Powder Metallurgy Based Materials for High Wear Resistance, High Hardness and High Temperature	600
G61A-007MS	Manufacturing of Interfaces for Thermo-Plastic Structures	400
Surface Engineering		
G61A-008QT	Low cost/low temperature functional ceramic coating	500
Shaping		
G61A-009MS	3D Honeycomb for curved structure manufacturing	600
G61A-010MS	Lattice Structures for Launchers and Spacecraft Produced with Automatic CFRP Processes	900
G61A-011QT	Advanced Forming Technologies for Complex Shapes	1,500
G61A-018QT	Additive Manufacturing Powder Material Supply Chain: Verification and Validation	1,000
G61A-019QT	Advanced aluminium alloys tailored for Additive Manufacturing space applications, targeting high end structural spacecraft parts	900
G61A-020QT	Development of large 3D printed structures: tank shells joined by FSW for ultimate cost reduction	2,500
G61A-021QT	Primary Structures made by Additive Manufacturing	1,200

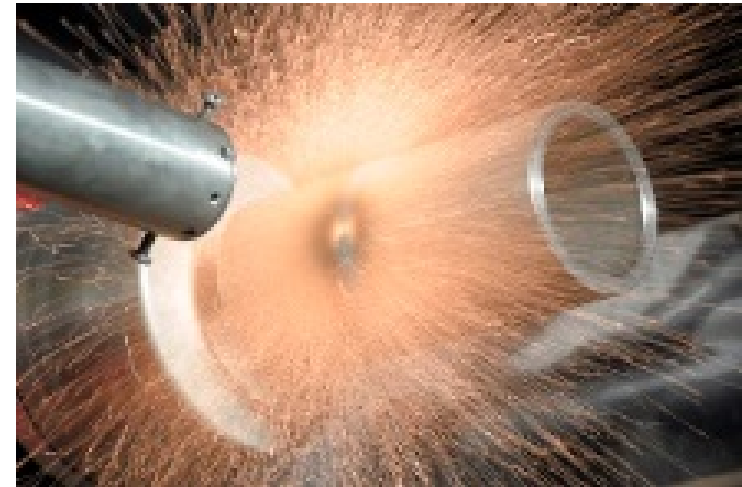
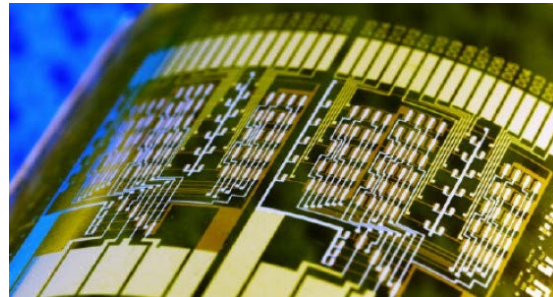
More information:
www.emits.esa.int

G61A-022QT	Enhanced contamination control for Additive Manufacturing	500
G61A-023QT	Development of a manufacturing process for large polymer structures for spacecraft applications: high strength electrical and/or thermally conductive polymers for Additive Manufacturing	700
G61A-024QT	Integrated recycling and manufacturing process for on planet manufacturing using polymers materials	700
G61A-025MS	Development of Design Methods for AM including CAD Design / FEM analysis / Manufacturing features	900
G61A-026MP	Additive Manufacture of In-space Engine chambers	2,000
G61A-027MS	Development of embedded thermal functions in structural parts using 3D printing	900
G61A-028QT	Development of a gradient sized mesh for cryocooler by Additive Manufacturing	1,000
G61A-029ET	Development of one single part integrating waveguide filter, bends, couplers, supporting structures made by Additive Manufacturing -	1,000
G61A-031MM	Development of thermally ultra-high stable compact grating spectrometer mirrors via Additive Manufacturing	500
G61A-032MM	Development of low areal density Aluminium alloy mirrors using Additive Manufacturing	400
G61A-033MS	Development of a Compliant Mechanism Based on Additive Manufacturing	500
G61A-034MS	Development of shock absorbing protection made of crushable materials (lattice / cellular structure) using Additive Manufacturing	600
G61A-035ET	Evaluation and consolidation of Additive Manufacturing processes and materials for the manufacturing of RF hardware	1,000
Joining		
G61A-012QT	Dissimilar transition joints for Aluminium demisable structures	400
G61A-013QT	Surface Nano-Texturing of Metals for Adhesive Bonding Improvement in Metal/CFRP and Metal/Metal Structural Joining.	600
Assembly		
G61A-014MS	Integral Manufacturing of Full CFRP Sandwich Structures for Optical Benches	700
G61A-015MS	Manufacturing of Large Friction Stir Welded Structures for Satellites and Launchers Applications	1,200
G61A-016QT	Rigid-flex PCB interconnections	900
G61A-017QT	High Density PCB assemblies	1,800
Total		29,600



Advanced Manufacturing - Facts

- **181 EOIs summing up to 115 M€** received in total
 - Materials processing: 24
 - Surface engineering: 3
 - Shaping: 122
 - Joining: 11
 - Assembly: 21
- **46 companies from 15 countries** provided EOIs and feedback



TEC-MSP 2016/7 R&D Programme

GSTP Advanced Manufacturing Compendium



ID#	Activity	Budget (k€)	Committed Support
G61A-005MS	Integrated Optical Fibres in Launcher and Spacecraft Composite Structures	500	500 (PL)
G61A-006MS	Powder Metallurgy Based Materials for High Wear Resistance, High Hardness and High Temperature	600	600 (BE), 600 (DE), 600(UK)
G61A-009MS	3D Honeycomb for curved structure manufacturing	600	600 (LU)
G61A-011MS	Advanced Forming Technologies for Complex Shapes	3000	1500 (BE), 1150 (DE), 750 (UK), 180 (PT)
G61A-018MS	Additive Manufacturing Powder Material Supply Chain: Verification and Validation	1000	400 (IE), 750 (UK), 700 (SE), 1000 (BE), 1000 (DE)
G61A-021MS	Primary Structures made by Additive Manufacturing	1200	1000 (LU), 1200 (BE), 600 (UK)
G61A-025MS	Development of Design Methods for AM including CAD Design / FEM analysis / Manufacturing features	900	900 (BE), 900 (DE)
G61A-033MS	Development of a Compliant Mechanism Based on Additive Manufacturing	500	500 (UK), 500 (BE), 500 (DE), 450 (LU), 500 (CH)
G61A-019MS	Advanced aluminum alloys tailored for Additive Manufacturing space applications, targeting high end structural spacecraft parts	900	800 (LU)
G61A-026MP	Additive Manufacture of In-space Engine chambers	2000	1450 (LU)
G61A-036MS	Assessing the use of Advanced Manufacturing to improve and expand space hardware capabilities	5000	2000 (DE), 1000 (BE), 500 (AT)
G61A-032MM	Development of low aerial density Aluminum alloys mirrors using Additive Manufacturing	400	400 (BE)
G61A-017QT	High Density PCB Assemblies	1800	1800 (BE)
G61A-019QT	Advanced Aluminum alloys tailored for Additive Manufacturing space applications, targeting high end structural parts	900	900 (BE), 800 (LU)
G61A-027MS	Development of embedded thermal functions in structural parts using 3D printing	900	900 (BE), 900 (D)
			28230 k€



Harwell Advanced Manufacturing Laboratory



- ESA Harwell Advanced Manufacturing Test Services
- Complementing the existing TEC-MS network of external facility
- Pre-screening of advanced materials and manufacturing processes towards space flight qualification
- ALM capabilities available



ESA Additive Manufacturing (AM) Benchmarking Center - UK



- **Additive Manufacturing** of hardware for space applications => **small, medium and large parts**
- Services to be **offered to ESA Projects/ESA Directorates** allowing access to state-of-the-art 3D Printing capabilities (metallic/non-metallic)
- Services to **offered to industry to mature their AM products** and process understanding
- Characterization of AM powders and produced materials
- Post processing of AM parts
- Failure investigation/re-manufacture of parts
- Comparison of AM machines
- Publication of a **European Newsletter** with all results generated by the Centre
- **Consolidate European leadership on AM**



ESA UNCLASSIFIED - For Official Use



Status of the AM ECSS Proposal

1. **AIM G of the Roadmap:** Develop the required normative framework for AM made hardware (ECSS)
2. **Motivation:**
 - An ECSS standard is required which shall establish the processing and quality assurance requirements for space parts produced by Additive Manufacturing
 - Profiting of existing international standards (e.g. ISO, ASTM) for AM
3. **Status:**
 - In agreement with the ECSS TA a WG has been established
 - WG activity completed
 - **ECSS WG recommended to be started in Q4 2016**



ASTM F42



ISO/TC 261



Thank you for your attention!

Would you like to know more?

Contact: Tommaso.Ghidini@esa.int