Technology Policy Applications and Challenges in Europe

International Space University
Master in Space Studies
Strasbourg, 3 March 2016

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Outline

- Introductory Message
- About Technology Policies
- Reminders
- ESA Policy and some technology Programmes
- European Technological non-dependence strategy
- EU Policy and some Technology Programmes
- A National example: CNES
- Challenges ahead

- Special thanks to Pieter DE SMET (DG GROW / EC), Gilles BELLAICHE (DIA / CNES) and Véronique PALATIN (DLA / CNES) for their help with some slides.

Message

- A Technology Policy (TP) is necessary to innovate, reach programmes objectives and deliver complex missions, reduce dependence vis-à-vis competitors, ensure autonomous decision making, maintain and gain leadership
- But it's a slow process, required to be pursued over a long period of time for achieving decisive pay-offs
- Political committment is key to success. Decision makers as well as legislators and regulators need to be exposed to understand technological processes and challenges
- R&D organisation, environment for innovation, and institutional rivalries, are still handicaping European efficiency
- Eurropean stakeholders need to step up their vision, ambition, coordination of means & funding to deliver innovative and competitive products & services to increasing demanding users in Europe as well as in the rest of the world

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Necessity of a technology Policy?

- TP not necessarily the panacea for guaranteed success
- Absolutely necessary, what do we need to…: Apollo, MIR, ISS, exploration of the solar system, space astronomy, High resolution EO, satcoms, launchers, ...
- Reaping the benefits of TPs, what can we do with… Existing ready-made parts or technological bricks: Space X, Planet Labs,, SkyBox Imaging. Plethora of apps using GNSS open signals,…

European TP Stakeholders

- Decision at a political level in EU Councils, ESA Councils, national ministers responsible for R&T and industry
- PPP with industry
- Dedicated multilateral actions involving R&D
- Industry initiatives
- organisations and / or industry, universities. SMEs very much involved

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Some Space funding figures

- In 2014: ~330 B$ space budgets and revenues, out of which:
  - 79 B$ space budgets, ~55 % for civil programmes, ~35 B$ for defence programmes
    - US: 43 B$ split into 20.5 B$ civil, 22.5 B$ defence, representing more than 54 % of world space budgets. ~64 % of world military space spending
    - Europe: 8.45 B€ total. ~1.23 B$ for defence space spending
  - The remaining 251 B$ address combined revenues from commercial space products and services, commercial infrastructure and support industries

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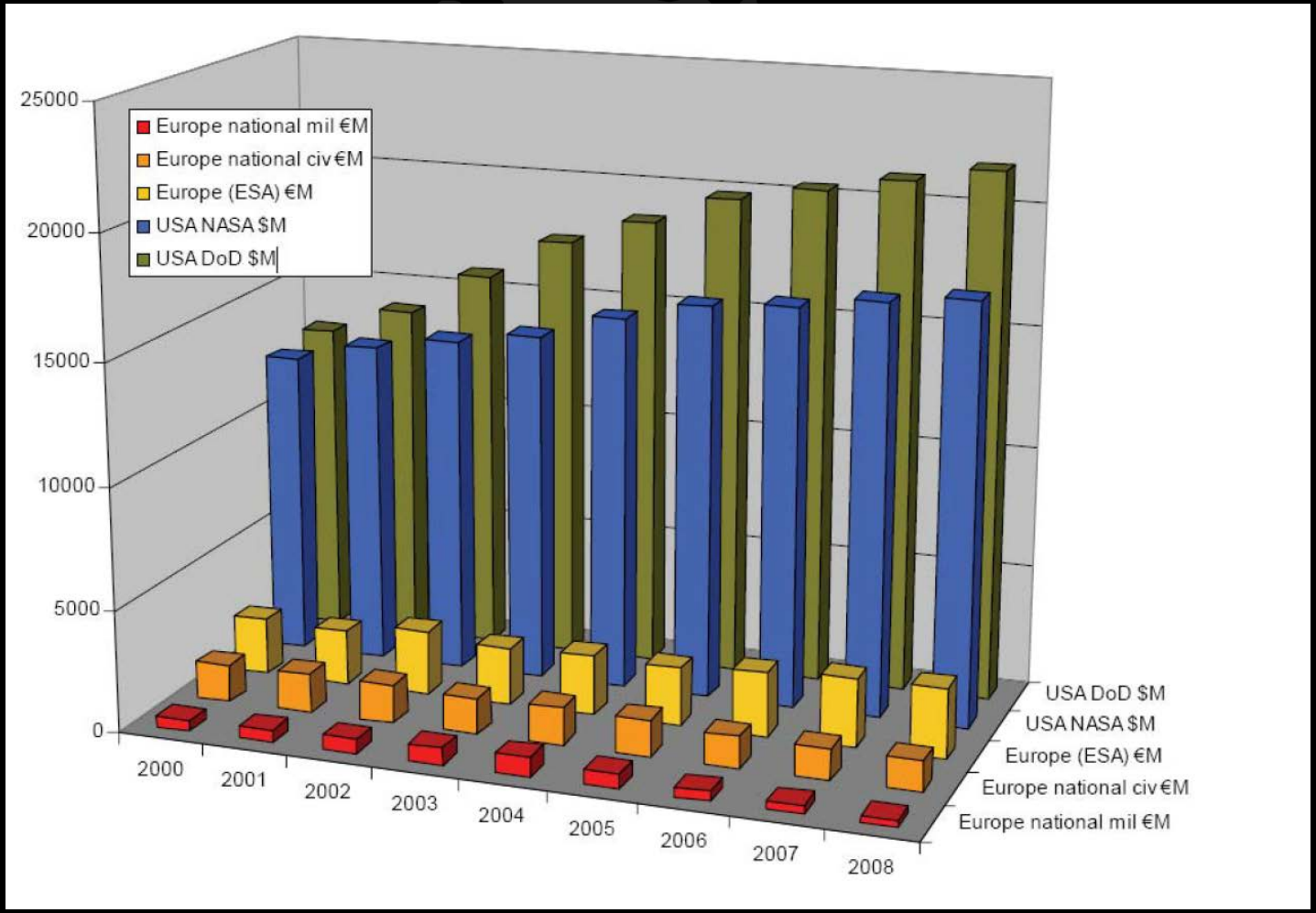
Europe and USA space activities funding



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Technology Readiness Levels (TRL)

Level	Definition	Explanation
TRL 1	Basic principles observed and reported	Lowest level of TRL. Scientific research begins to be translated into applied R&D
TRL 2	Technology concept and / or application formulated	Once basic principles are observed, practical applications can be invented and R&D started. Applications are speculative and may be unproven
TRL3	Analytical and experimental critical function and/or application formulated	Active R&D is initiated, including analytical / laboratory studies to validate predictions regarding the technology
TRL 4	Component and / or breadboard validation in lab environment	Basic technological components are integrated to establish they match and function together
TRL 5	Component and / or breadboard validation in relevant environment	Basic tech components integrated with reasonably supporting elements so they can be tested in a simulated environment
TRL6	System / subsystem model or prototype demo in relevant environment	A realistic model or prototype is tested in a relevant environment (ground or space)
TRL 7	System prototype demo in a space environment	A prototype system that is close to, or at, the planned operational system
TRL 8	Actual system completed and “flight qualified” through test and demo	In a real system, the technology has been proven to work in its final form under expected conditions (ground or space)
TRL 9	Real system “flight proven” through successful mission operations	The system incorporating the new technology in its final form has been used under actual mission conditions

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ESA Technology Policy and Management

- Guidelines for space technology policy and innovation policy given by ESA with participation of MS for a joint strategy
- User requirements: Mission needs, industry competitiveness and non dependence goals
- Planning and management →E2E process
- Programme formulation, funding, interface with Programme Boards →Programme directorate

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ESA E2E Process

- E2E technology policy goals:
  - Integrating different tech programmes within a common set of processes and goals
  - Securing appropriate funding at the right time
  - Leveraging and reinforcing technology harmonization & standardization
  - Setting a product policy
  - Setting a systematic monitoring and evaluation process of the technologies developed
  - Exploiting synergies with non-space sectors, promoting spin-in strategies

- E2E and its specific domains:
  - EO, science, human space flight & exploration, space transportation, telecoms, navigation, robotic exploration, generic technologies & techniques, security

- Two Key elements of the E2E process:
  - Technology Strategy and Long Term Plan (TSLTP)
  - Technology Monitoring and Evaluation (M&E)

ESA Specific Programmes 1 / 5

- Basic Technology Research Programme (TRP)
  - Mandatory programme covering TRL 1-3, disruptive innovation is a special priority
  - TRP, the only ESA programme that supports all Agency directorates addressing all technical disciplines
  - Structured around three domains: i) services, ii) technology, iii) cross-cutting
  - Allocates 1/3 of its efforts to generic technologies, including component design, spacecraft propulsion, power generation

ESA Specific Programmes 2 /5

- General Support Technology Programme, GSTP
  - Optional programme covering TRL 1-6, provides technologies for a wide range of new space programmes and supports industrial competitiveness
  - Aiming at providing a sufficiently high level of confidence in a technology development with a low risk factor
  - Typically GSTP-6 operates with ~ 350 M€ budget over 5 years
  - Programme structured under 4 elements
    - Support technology activities for projects and industry
    - Competitiveness
    - Technology flight opportunities
    - Precise formation flying demonstration

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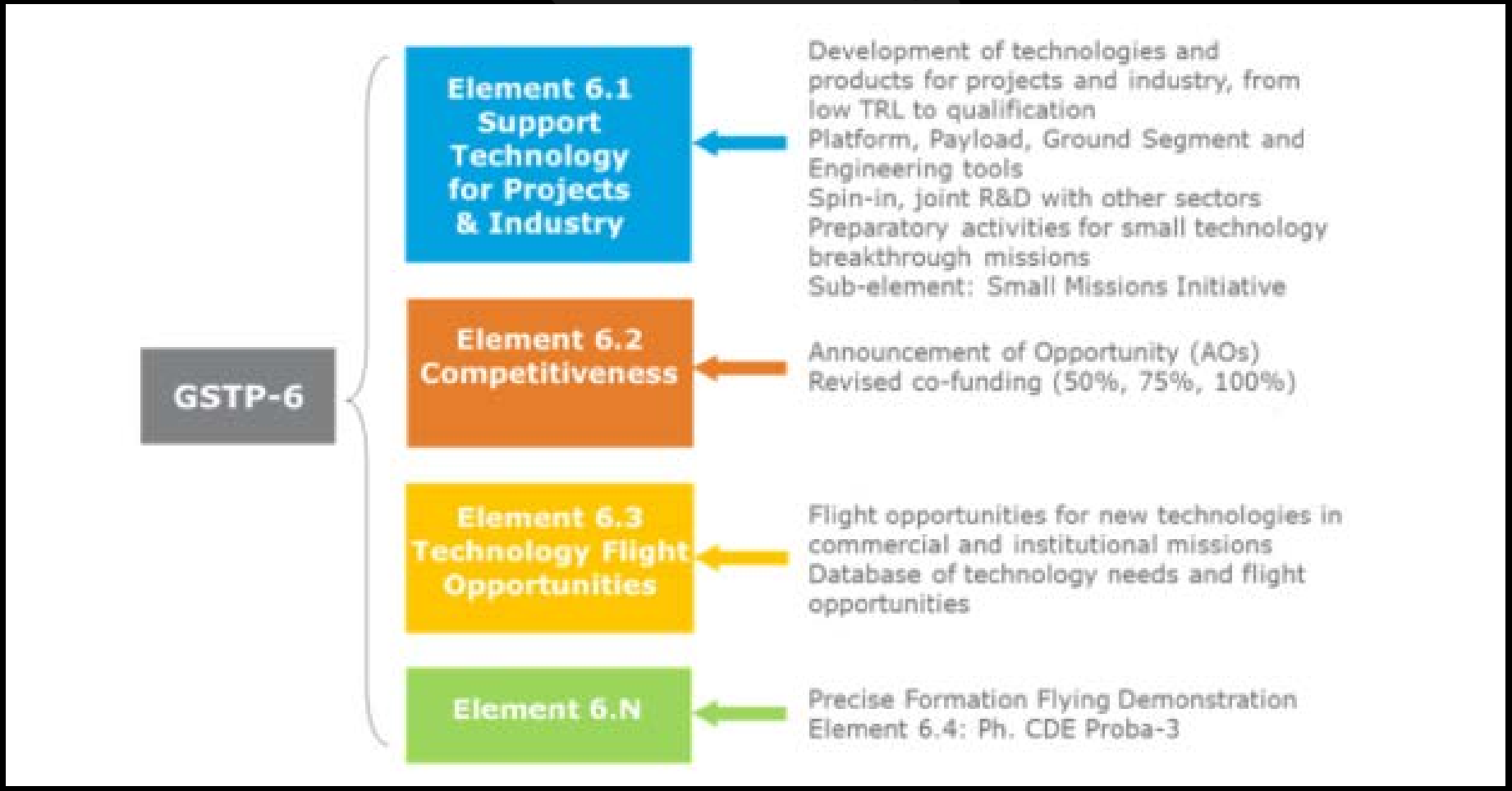
ESA GSTP-6 Elements (2012-2017)



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Example of a technology development under GSTP

THE THRUST VECTOR CONTROL SYSTEM OF THE ZEFIRO 23 ENGINE, PART OF THE VEGA LAUNCHER, WAS DEVELOPED UNDER GSTP

ESA Specific Programmes 3 / 5

- Advanced Research in Telecommunications Systems (ARTES) programme enables European and Canadian industry to explore, through research and development (R&D) activities, innovative concepts to produce leading-edge satcom products and services. ARTES offers varying degrees of support to projects with different levels of operational and commercial maturity.
- ARTES is made up of programme elements, including:
  - Future preparation (ARTES 1)
  - Competitiveness & Growth (previously ARTES 3-4 Products): development, qualification, and demonstration of products
  - Advanced Technology (previously ARTES 5 Technology): long-term technological development, based on ESA or satcom industry initiative
  - (EDRS) (previously ARTES 7 EDRS): development and implementation of an European Data Relay Satellite (EDRS) system
  - Large Platform Mission (LPM) (previously ARTES 8 Alphabus/Alphasat): development and deployment of Alphasat, the first unit of the Alphabus Platform jointly developed by Astrium and Thales Alenia Space. Launched in July 2013, Alphasat is operated by Inmarsat

ESA Specific Programmes 4 / 5

- Satellite communication for air traffic management (previously ARTES 10 Iris): satellite-based communication system to be part of an air traffic management system currently being developed under the SESAR programme of the EU, by Eurocontrol and the European Aeronautical community
- Small Geostationary Satellite (SGEO) (previously ARTES 11): small satcom platform capable of accommodating a wide range of commercial payloads and missions (TV broadcasting, multimedia applications, Internet access and mobile or fixed services in a wide range of frequency bands.
- Next Generation Platform (NEOSAT) (previously ARTES 14): "Next Generation Platform", in partnership with industry. Aimed at developing, and demonstrating in orbit, new satellite platform product lines for 3 to 6 tonnes geosat
- Integrated Applications Promotion (previously ARTES 20 IAP): development, implementation and pilot operations of Integrated Applications, requiring applications of space systems combining different types of satellites, such as satcoms, EO and navigation. E.g. secure transport systems for developing emergency / disaster management systems

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ESA Specific Programmes 5 / 5

- Satellite Automatic Identification System (SAT-AIS) (previously ARTES 21 SAT-AIS) The Automatic Identification System (AIS) is a short range coastal tracking system currently used on ships. It was developed to provide identification and position information to vessel and shore stations. Space-based, or SAT-AIS will provide AIS data via satellite, allowing for the detection of seafaring vessels equipped with AIS tracking devices
- ARTES 33 Partner is a new programme element to provide the satcom industry with an efficient framework to bring innovative products and systems into the marketplace through industry-generated PPPs.

TRLs within European Programmes

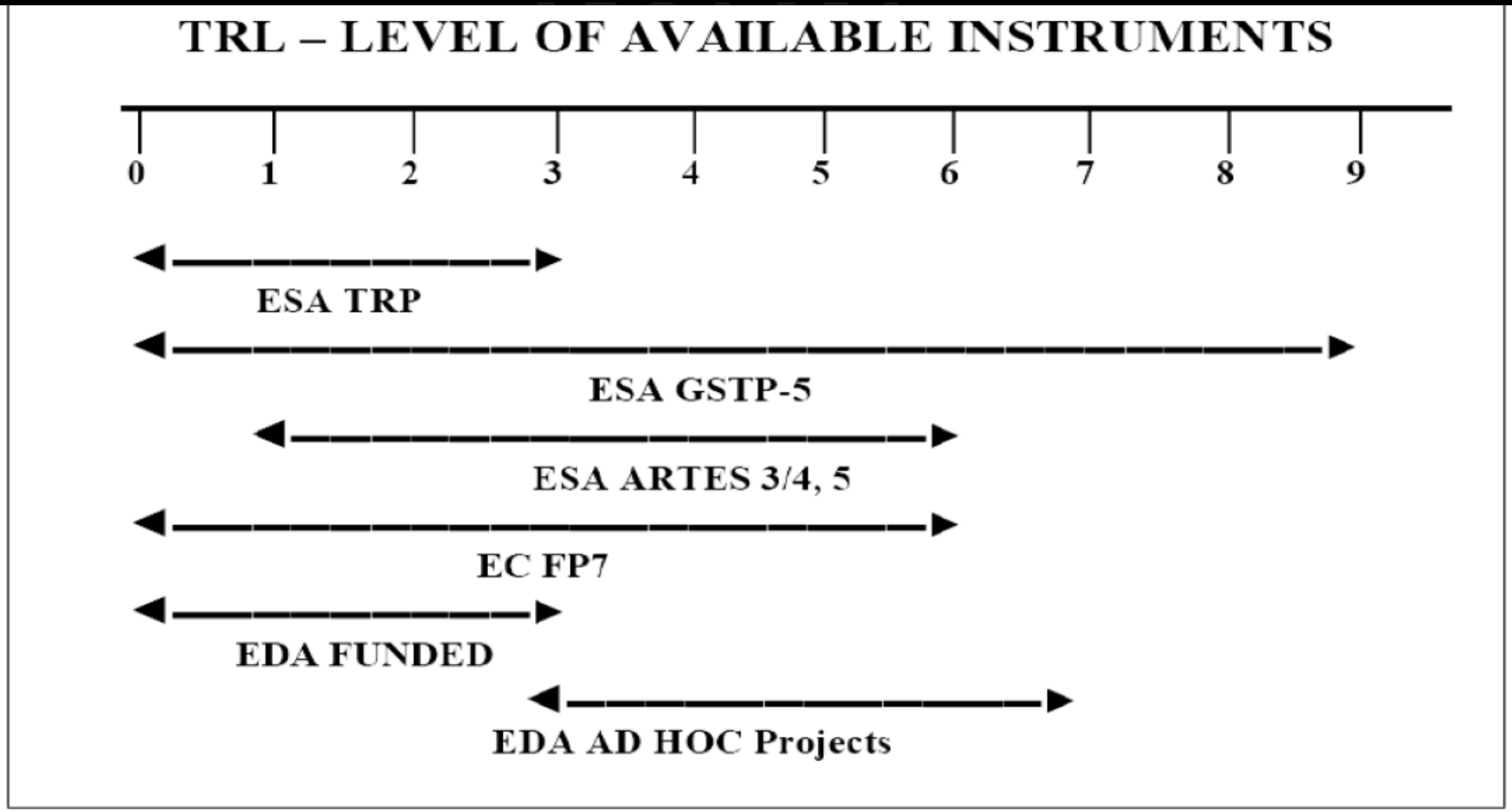

Fig. 4: TRL level within ESA, EDA and EC programmes. Figure from: FP7-Space: R&D activities in support of European microelectronics enabling technologies, presentation by Richard Gilmore, ESCONN Conference 2011, ESA/ESTEC, 15-17 March 2011

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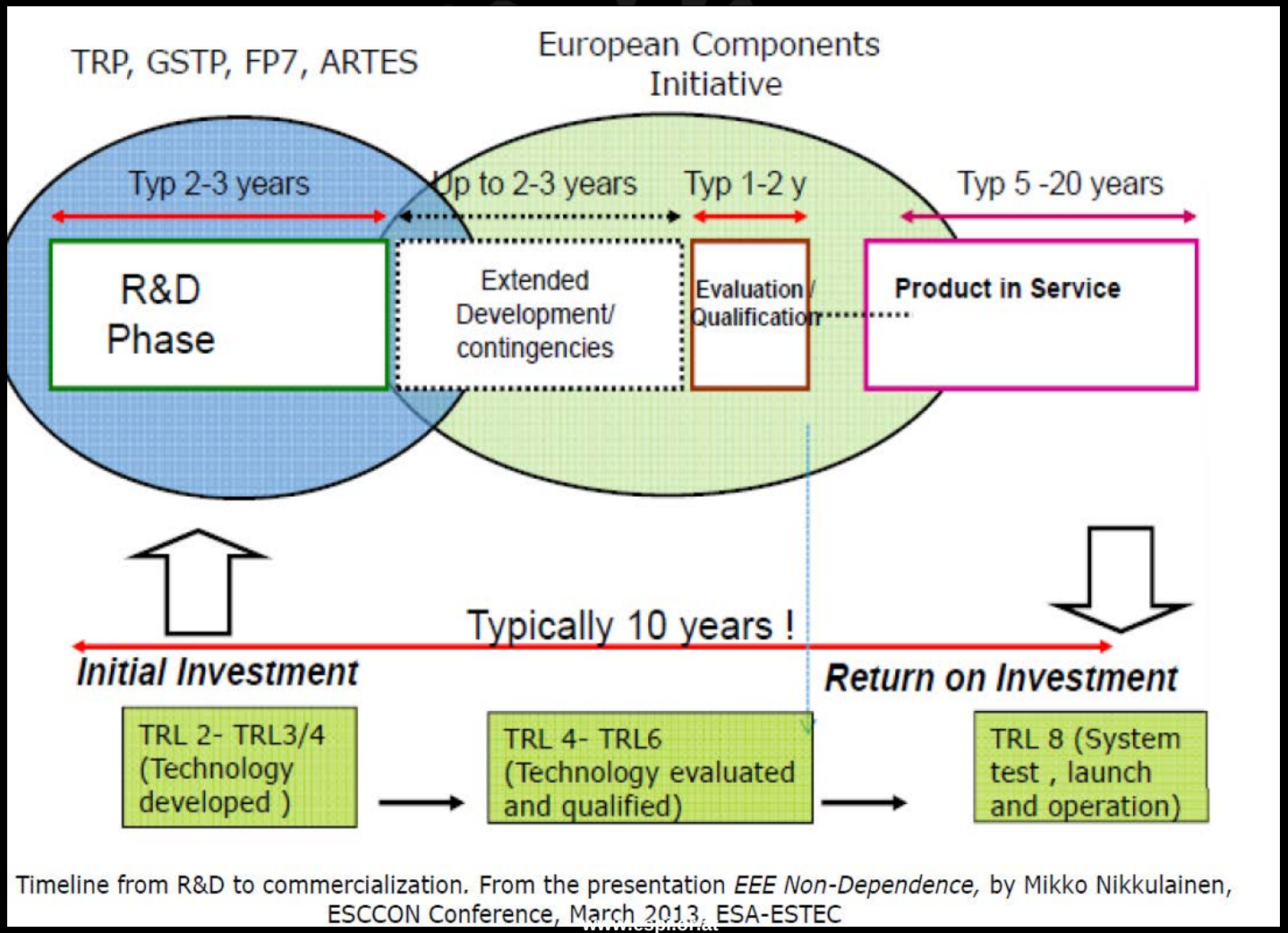
From R&D to Commercialization



Timeline from R&D to commercialization. From the presentation *EEE Non-Dependence,* by Mikko Nikkulainen, ESCCON Conference, March 2013, ESA-ESTEC

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The technology Harmonisation Process 1 / 2

- Harmonisation is an ESA-led process with participation of space agencies, EC, research institutes, operators & industry
- Overcoming fragmentation in an effective way through programmatic action for the establishing a European technological and industrial policy
- Objectives:
  - Fill strategic gaps
  - Consolidate European strategic capabilities
  - Achieve a coordinated & committed European Space Technology Policy
  - Ensure continuity and coherence between technology and industrial policy
- Focusing on:
  - Technology needs / gap filling
  - Mapping European capabilities, defining common roadmaps for future developments. The important role of the European Space Technology Requirements database (ESTER)
  - Identifying strategic areas for European independent capabilities
  - Creating frameworks of cooperation
  - Avoiding duplication & fragmentation

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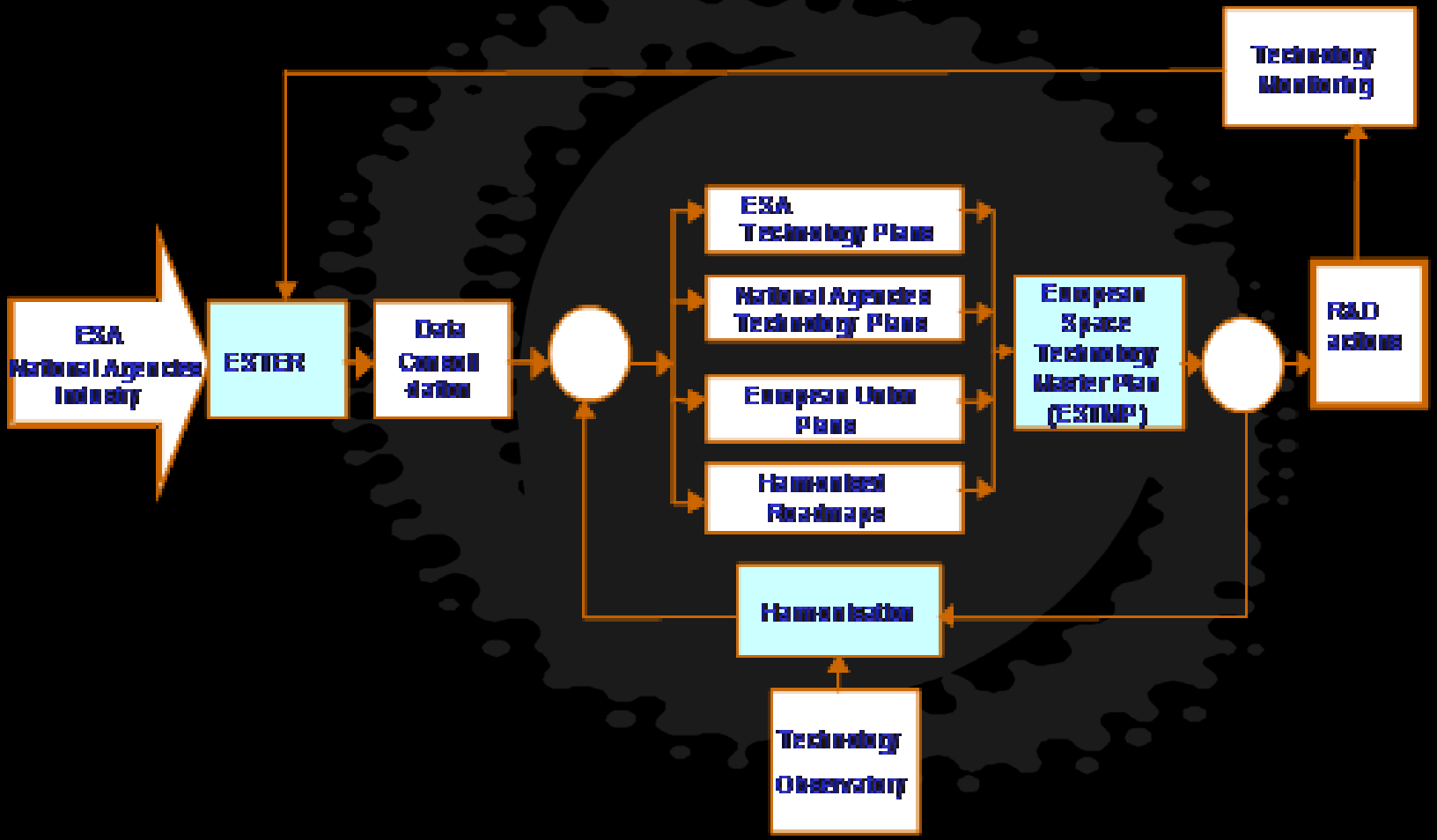
The Technology Harmonisation Process 2 / 2



Other European Space technology initiatives

- European Space Component Coordination (ESCC). Founding Act in October 2002 to develop cooperative actions to create a coherent system of qualification for electrical, electronic, electro-mechanical (EEE) components
- European Component Initiative (ECI) agreed in 2004 (ESA Council). Goal for non-dependence in EEE-components and parts types
- European Space Technology Platform (ESTP) established in 2003 by the European Council to strengthen the European Research Area.
- Objective: Foster collaborative research and long-term partnerships, bringing in space and non-space sectors, multiple use technologies and applications.
- EC-ESA-EDA Joint Task Force for European Technology Non-Dependence (ETnD) established in 2008. Focus on:
  - Key enabling technologies for space
  - Cost quantification
  - Differentiate from other European space technology initiatives. Be very specific.

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The European Space Component Coordination (ESCC) Structure

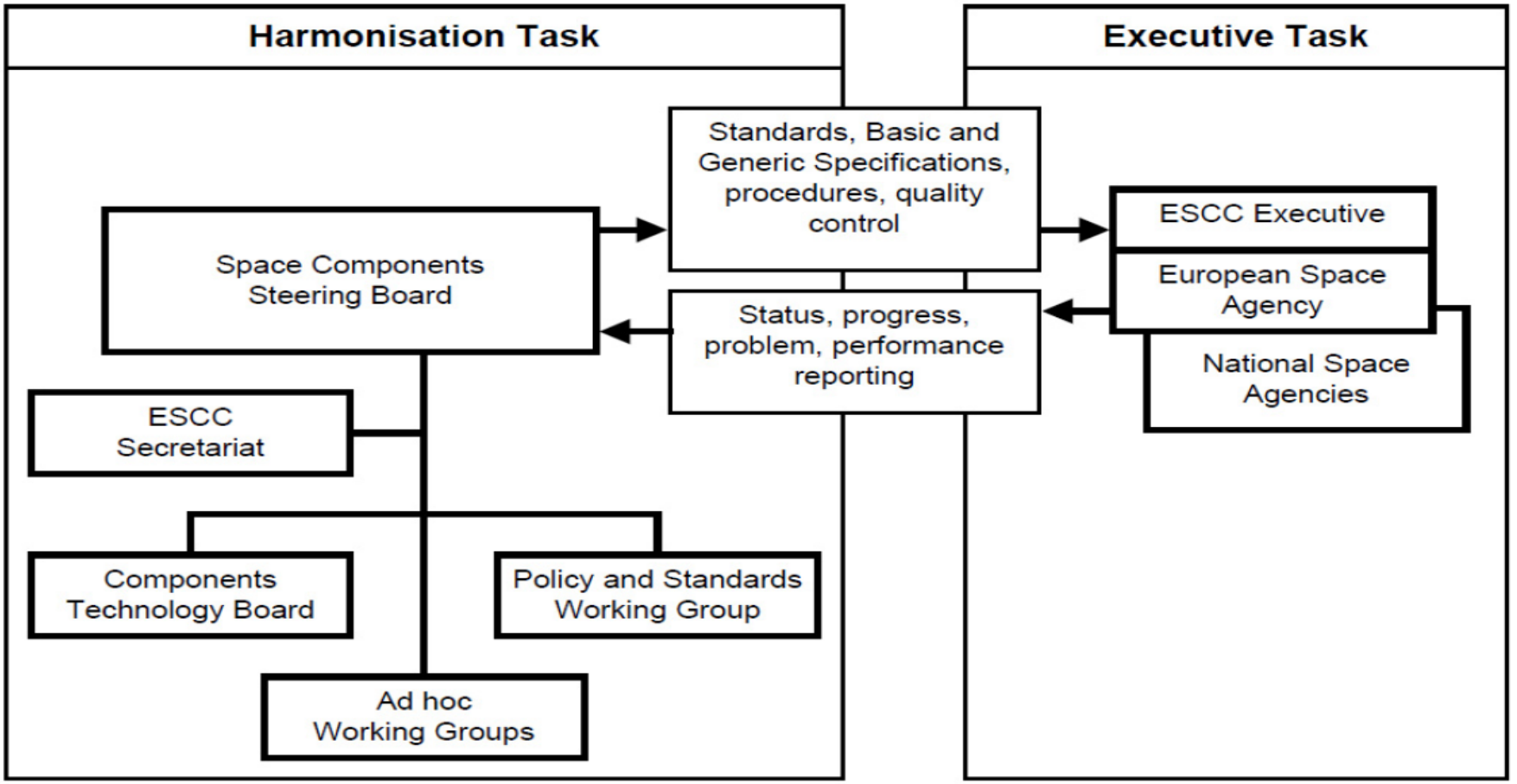

Fig. 7: The ESCC structure: Harmonisation Task and Executive Task. From *Charter of the European Space Components Coordination*, ESCC 00000, Issue 1, October 200

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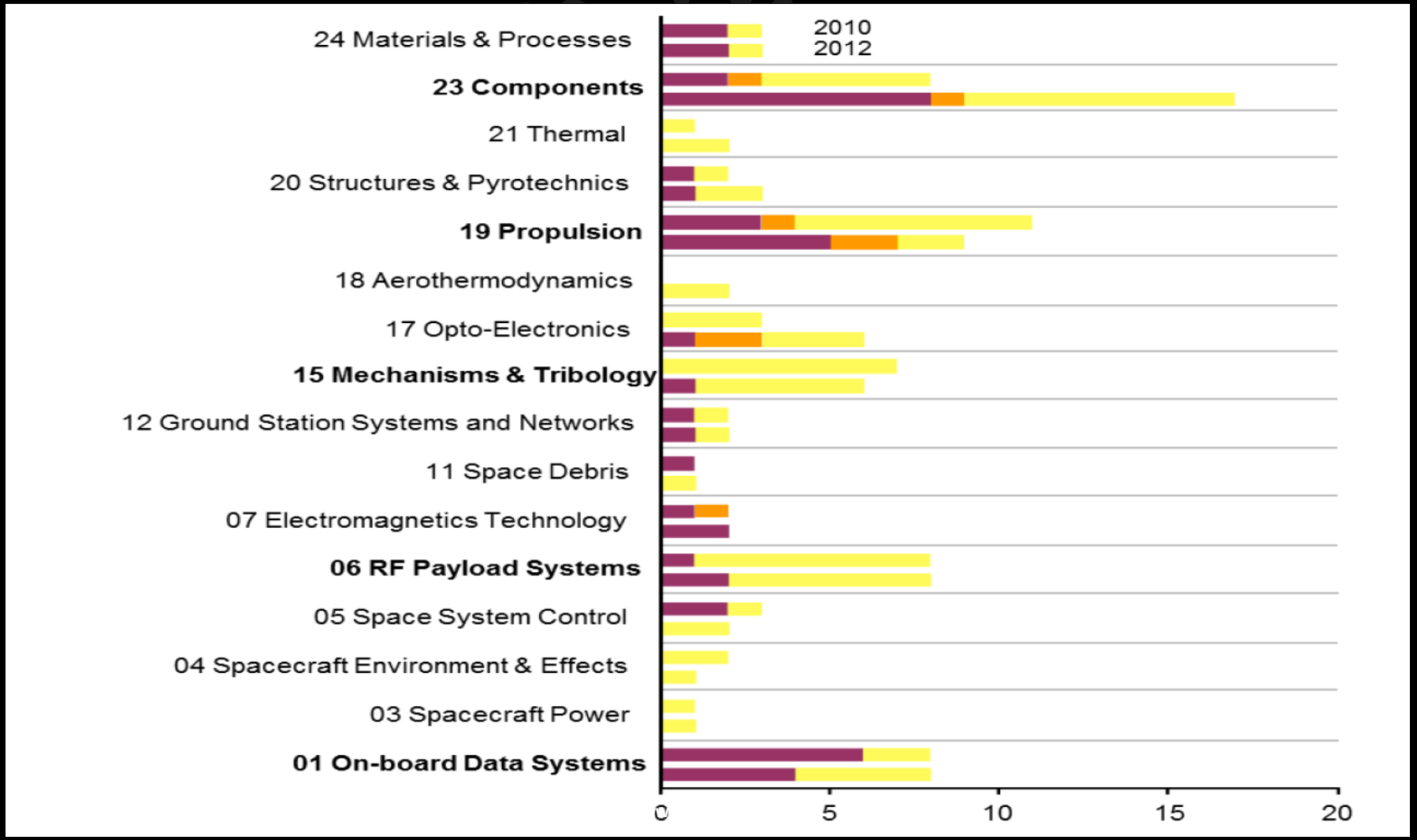
Technology Items for the Highest Critical Level (3)



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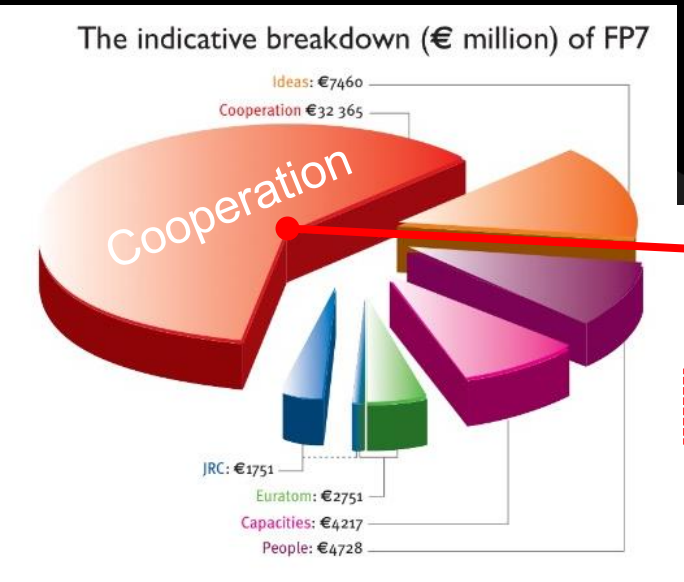
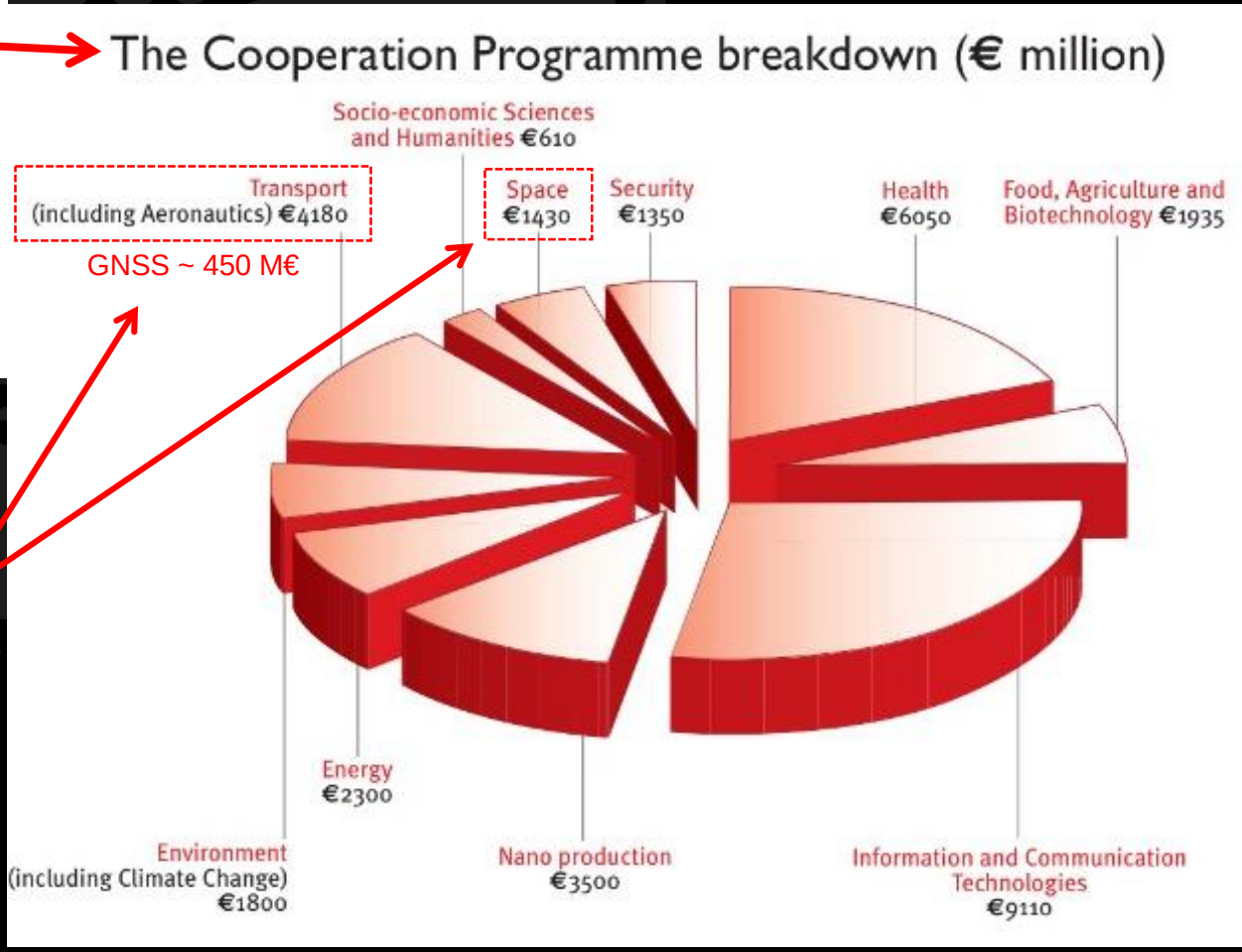


FP7 → 53.272 M€

Space in FP7
~ 1.900 M€
(3.6%)



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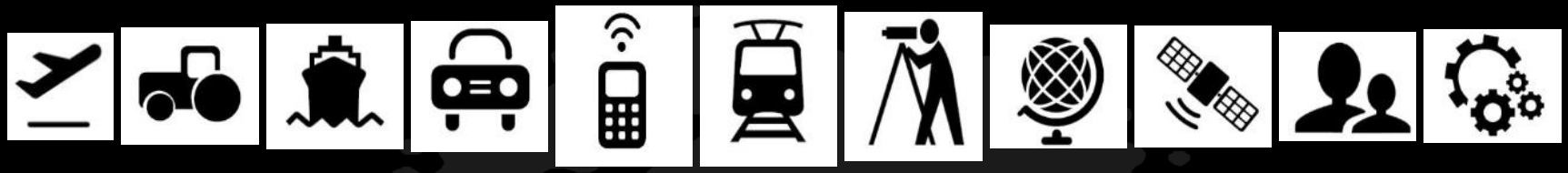
RTD GNSS projects in FP7/FP6



Aviation Agriculture Maritime Road LBS Rail Surveying/Mapping Education, innovation and support
Precision, professional and scientific applications PRS Infrastructure & evolution

GNSS research under FP7

- FP7 supported R&D and innovation on GNSS in 'Transport' theme
- FP7 GNSS applications R&D programme was €66.5 million
- A total of 86 projects were selected for funding out of a total of 299 proposals

GNSS research under FP6

- GALILEO R&D activities under its ‘Aeronautics and Space' thematic priority (2002-2006)
- Earmarked €100 million for GALILEO R&D activities under its ‘Aeronautics and Space' thematic priority (69 projects)

Further information available in
http://www.gsa.europa.eu/r-d/gnss-project-portfolio

Type of participant in FP7/Space projects

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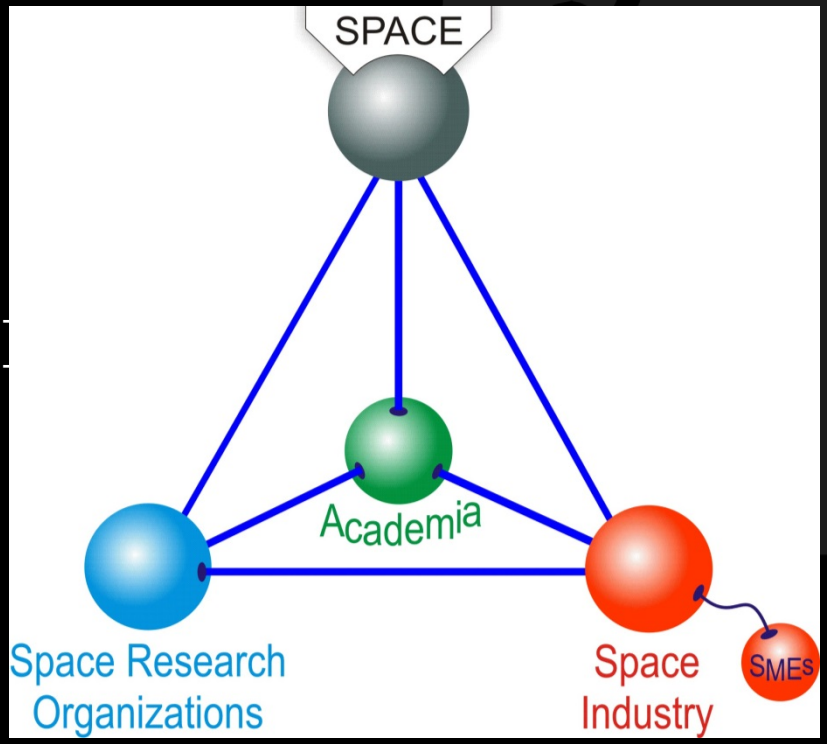
Space Technology
(€197 million)
- 24 % Universities
- 33 % Research Organizations
- 43 % Industry



Science
(€66 million)
- 50 % Universities
- 40 % Research Organisations
- 7 % Industry
- 2 % Public Administration
- 1 % Others

GMES services and applications
(€369 million)
- 16 % Universities
- 45 % Research Organizations
- 27 % Industry
- 10 % Public Administration
- 2 % Others

% EU Contribution

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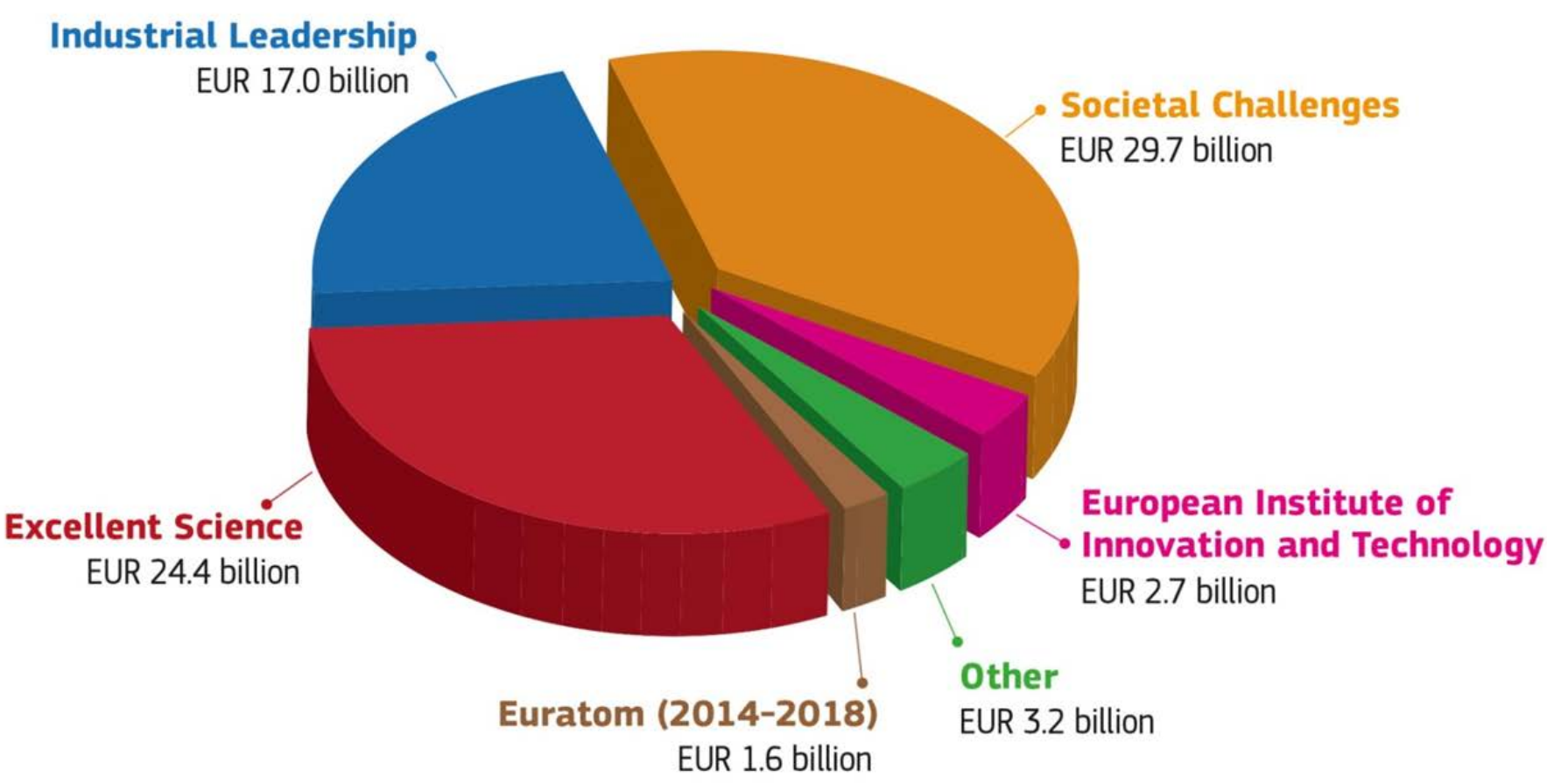
Horizon 2020

HORIZON 2020 BUDGET (in current prices)

€ 79 billion from 2014 to 2020



2013 figures

Horizon 2020 Priorities

Industrial leadership

Priority 2 – Industrial leadership

•Leadership in enabling and industrial technologies (LEIT)

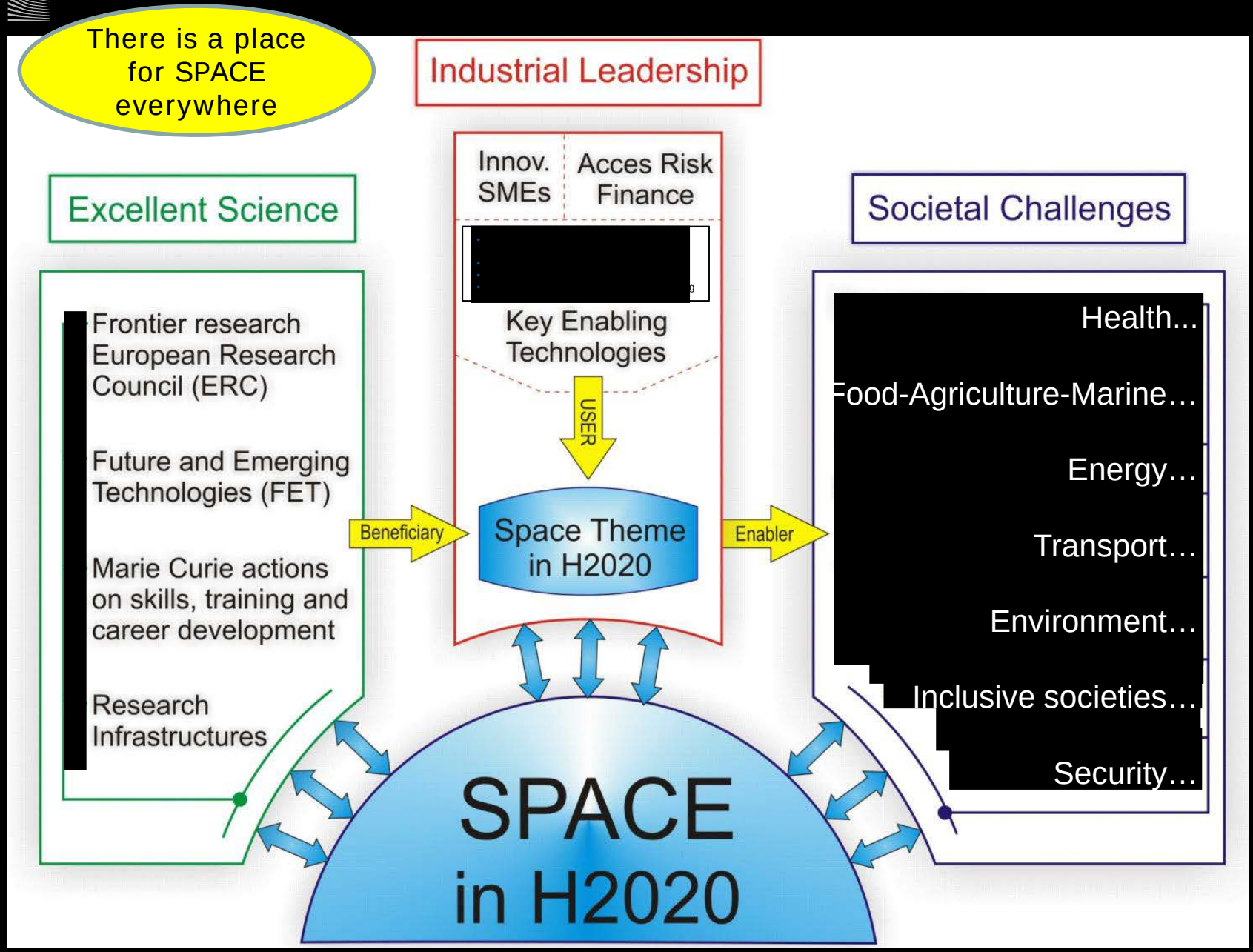
- Information and Communication Technologies (ICT)
- Nanotechnologies
- Biotechnology
- Advanced manufacturing and Processing
- **Space**

•Access to risk finance

•Innovation in SMEs

Why?

- Strategic investments in key technologies(e.g. advanced manufacturing, micro-electronics) underpin innovation across existing and emerging sectors
- Europe needs to attract more private investment in research and innovation
- Europe needs more innovative small and medium-sized enterprises (SMEs) to create growth and jobs


There is a place for SPACE everywhere
Industrial Leadership
Innov. SMEs
Acces Risk Finance
Excellent Science
Societal Challenges
Frontier research European Research Council (ERC)
Future and Emerging Technologies (FET)
Marie Curie actions on skills, training and career development
Research Infrastructures
Key Enabling Technologies
USER
Beneficiary
Space Theme in H2020
Enabler
Health...
Food-Agriculture-Marine…
Energy…
Transport…
Environment…
Inclusive societies…
Security…
SPACE in H2020

ESPI
European Space Policy Institute

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H2020 Space building blocks

Satellite Navigation (Galileo and EGNOS)	Earth Observation (Copernicus)	Competitiveness of the European Space sector	Protection of the European Space Assets
Applications	Applications	Technologies for European non-dependence and competitiveness	Space Surveilance and Tracking
EGNSS evolution	Data	Independent access to space	Space Weather, Space Debris, Near Earth objects
	Copernicus evolution	Space Science and Exploration	

Bottom-up engagement of SMEs in space R&D (SME Instrument)

Fast Track to Innovation pilot

ESPI
European Space Policy Institute

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Horizon 2020 Space WP 2016-17 structure

EGNSS
Galileo & EGNOS applications and infrastructure

Calls for proposals:
- EGNSS applications

Other actions:
- Evolution of EGNSS infrastucture, mission and services

EO
Earth Observation applications and services

Calls for proposals:
- EO downstream applications
- Evolution of Copernicus services
- EO "big data" shift

COMPET
Competitiveness of the European Space sector: Tecnology and Science

(incl. Space Weather)

Calls for proposals:
- Critical space technologies
- Strategic research clusters
- EO & SatCom technologies
- Science and Exploration
- Space Weather
- Space Portal
- Technology transfer

Other actions:
- ESA Engineering support
- Horizon prize on low-cost access to space

SST
Space Surveillance and Tracking support framework

Other actions:
- Contribution to the SST support framework
- Improving the performance of SST at European level

SME Instrument

Fast Track to Innovation 'pilot'

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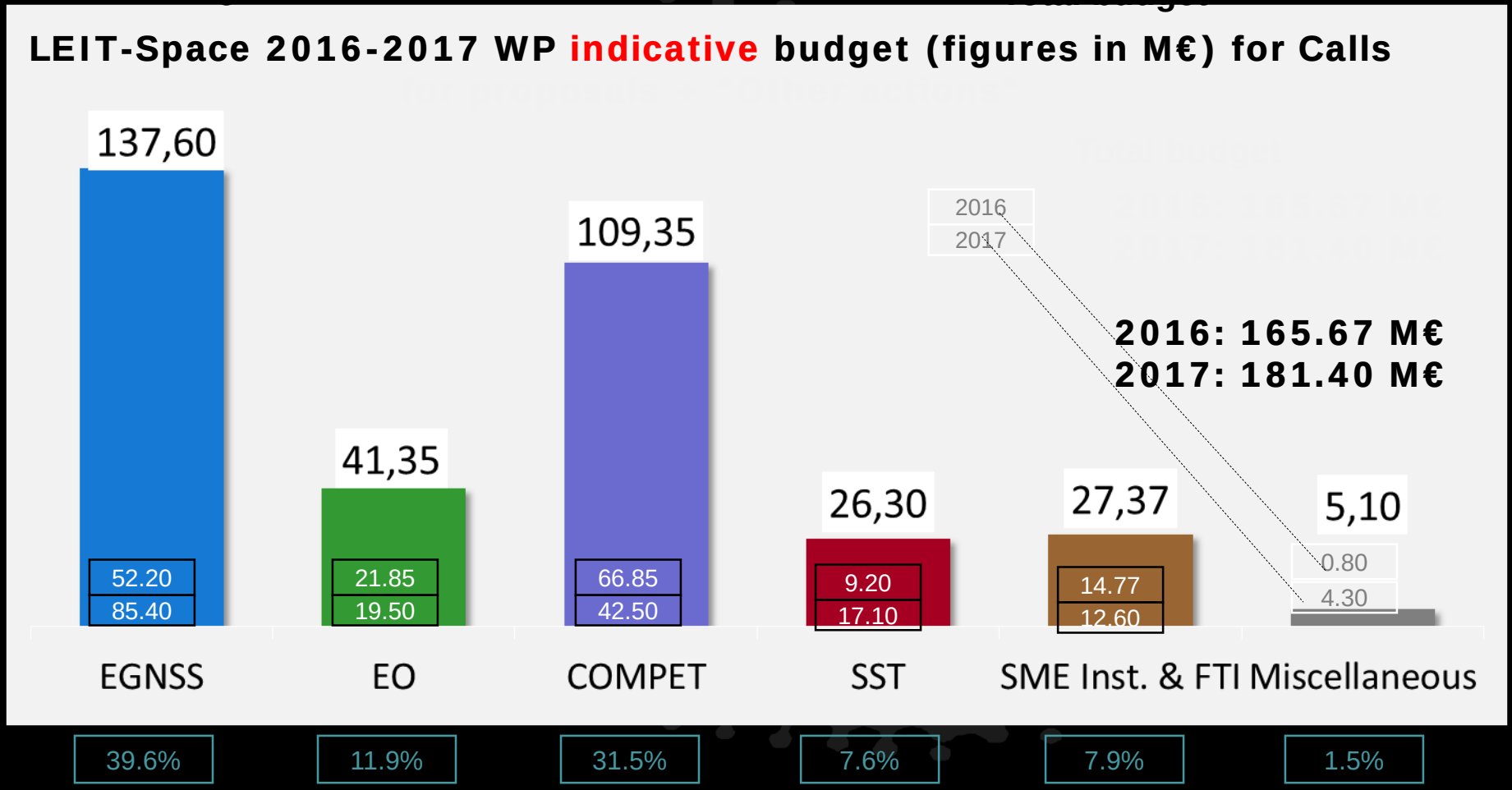
WP 2016-2017 Indicative budget



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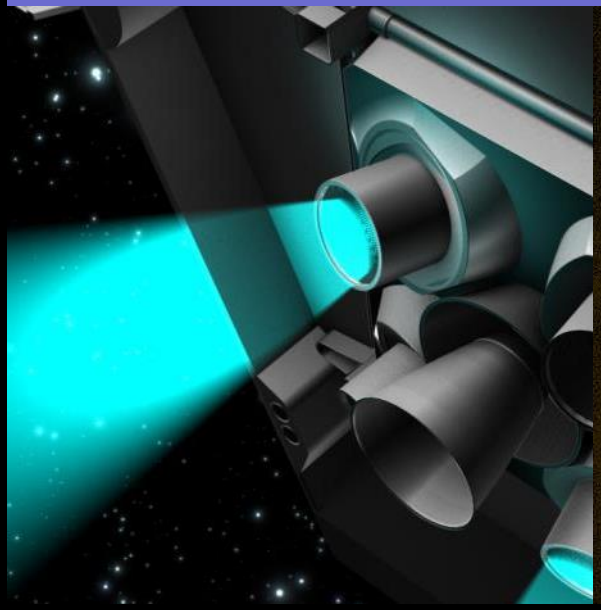
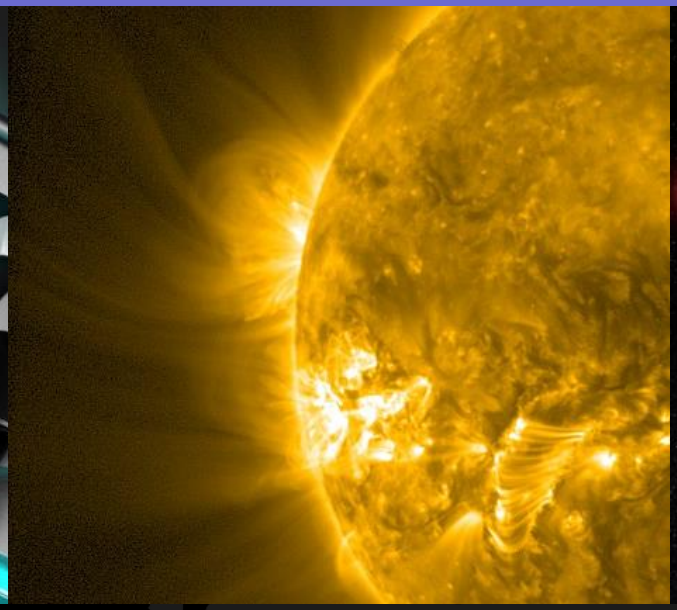
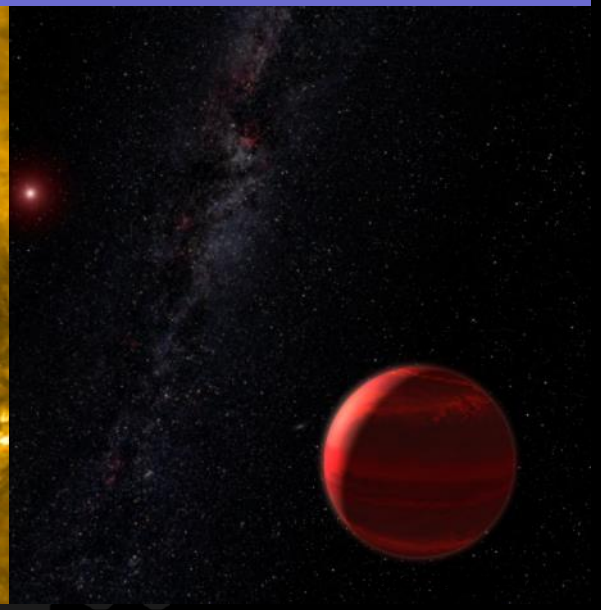
2016 call topics

Competitiveness of the European Space Sector Technology and Science

Indicative budget: 65.85 M€

Deadline: 3 March 2016

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Competitiveness of European Space Sector

COMPET-1-2016

Technologies for European non-dependence and competitiveness

Activities shall address technologies identified on the Joint EC-ESA-EDA Task Force list of Actions 2015-17

- *U14 - Active discrete power components*
- *U18 - Enhanced performance and space qualified detectors*
- *U19 - High speed DAC-ADC based on European technology*
- *U20 - Very high performance microprocessors*
- *U22 - ASICS: Deep Sub-Micron (DSM)*
- *N27 - RF components*

Reccomended project size
Indicative budget
Type of action

14,85 M€

Innovation Actions

The aim of identified actions is to contribute to ensuring European Non-dependence:

- "Independence" would imply that all needed space technologies are developed in Europe.
- "Non-dependence" refers to the possibility for **Europe to have free, unrestricted access** to any required space technology.

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Competitiveness of European Space Sector

COMPET-2-2016

Maturing satellite communication technologies

Reccomended project size
Indicative budget
Type of action

7 M€

The aim of this topic is to demonstrate, in a relevant environment, technologies, systems and sub-systems for satellite communications…

Proposals that demonstrate technologies targeting TRL 6 are welcome, … [and] *are sought with relevance for space in the following fields*:

- Advanced communication technologies…
  … preparing satellite networking in the Terabit-throughput… including optical / RF…
- Photonics technology…
- Active antennas building blocks…
- Flexible repeater…
- Reconfigurable coverages…
- New generation of waveforms and related protocols…
- End to end system enablers…

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Competitiveness of European Space Sector

	Reccomended project size *Indicative budget* *Type of action*
COMPET-3-2016-a **In-Space electrical propulsion (EP) and station keeping - Incremental Technologies** *Proposals shall enable incremental advances in technologies for Electric Propulsion systems based on:* *1 - Hall Effect Thrusters (HET)* *2 - Gridded Ion Engines (GIE)* *3 - High Efficiency Multistage Plasma Thrusters (HEMPT)*	18 M€
COMPET-3-2016-b **In-Space electrical propulsion (EP) and station keeping - Disruptive Technologies** *Proposals on potentially disruptive concepts in of EP which in the long term could change the landscape, addressing:* •*Transversal technologies for disruptive EP systems (not thrusters) → Maximum 1 proposal* •*Technologies devoted to specific disruptive EP thrusters* *Maximum 4 proposals*	5 M€

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Competitiveness of European Space Sector

Reccomended project size
Indicative budget
Type of action

COMPET-4-2016

Space robotics technologies

Proposals shall address one of the following six specific robotic building blocks:

a) *Space Robot Control Operating System*

b) *Autonomy framework Time/Space/Resources planning and scheduling*

c) *Common data fusion framework*

d) *Inspection Sensor Suite*

e) *Modular interfaces for Robotic handling of Payloads*

f) *Validation Platforms and Field Tests*

18 M€

Competitiveness of European Space Sector

Reccomended project size
Indicative budget
Type of action

COMPET-5-2016

Scientific instrumentation

Scientific instrumentation is understood in this context as mission payloads that perform scientific tasks

Proposals may cover different stages of development of scientific instrumentation from concepts, to breadboarding and prototype demonstration.

Proposals are particularly welcome that develop novel and advanced technologies, such as new sensors and other sub-systems that may be used in scientific instrumentation

Projects should address planned and future European scientific and exploration missions, as well as collaboration in the context of third country missions as a European contribution to global efforts.

3 M€

Innovation Actions

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A National Programme: R&T at CNES 1/ 5

- Two areas of interest:
  - Orbital systems: ~20 M€ / year on a national basis (CNES, R&T institutes, universities, companies);

    ~40-50 M€ / year → ESA programmes
  - Launchers: ~12 M€ / year; 4 M€ / year → ESA programmes. Usually matching funds coming from industry. Now progressively moving to low TRLs, high risk, leaving TRL 3-6 to industry. In addition, participation in demonstrator programmes

A National Programme: R&T at CNES 2 / 5

- A / Orbital Systems: 9 areas of interest

1. Earth observation: HR/VHR imagery, radiometric imagery, atmospheric probes, radar altimetry, image information extraction, Added value ICT
2. Positioning, navigation and timing (PNT): time-frequency for new generation systems, performance improvement, preparing infrastructures for future GNSS
3. Microtechnologies & environment: participation to the European prgramme on microsystems & microtechnologies, components hardening, innovative assembly technologies
4. Platforms: GEO sats (electric propulsion & end of life), LEO sats (design for demise, controlled re-entry, lifetime extension, reduction of development time), stratospheric balloons (structures, payloads), common technologies addressing a broad range of platforms

A National Programme: R&T at CNES 3 / 5

5. Science of the universe: Priority given to innovative technologies necessary for mission success
   - New instrument concepts and associated technology bricks,
   - Adaptation for operating in hostile environment

   The following domains are addressed: Fundamnetal physics, astronomy-astrophysics, planetology, solar physics and ionized media, science in microgravity, and exobiology
6. In flight / ground systems: Ground segment operation control, systems engineering, simulation and in-flight softwares, navigation, guidance and control (NGC)
7. Generic techniques and technologies: Radio-frequency & optics techniques (new antennas, RF components,…), SV techniques (structures, power, thermal engineering, software,…), materials

A National Programme: R&T at CNES 4 / 5

8. Telecommunications: reduction of mass, electric consumption, cost of the payload, lower cost of the transmitted bit, compress satellite development time, better digital-optical integration in for payloads. This addresses fix and mobile telecoms, generic technologies, hybridization of space and terrestrial infrastructures
9. Demonstrators and strategic components:
   - Demonstrators: Bring technologies to TRL 7, if possible up to orbit validation (IOV): 3D micro camera, 10W optical amplifier, on-board compatible multi-GNSS receptors, …
   - Strategic components: activities selected in line with the priorities of the Components Technology Board (CTB) of the European Space Component Coordination (ESCC). Harmonised with ESA European Component Initiative (ECI). For instance: Deep sub-micron chips, power MOSFETS transistors, …

A National Programme: R&T at CNES 5 / 5

- B / Launchers: Structured around 3 main objectives & 6 domains
- R&T in launcher field in Europe is conducted by several independant actors : space agencies, research centres, industrial companies. This approach can be very fruitful to help the emergence of new solutions but it must be coordinated to avoid waste of energy and public money.
- CNES R&T is conducted with partners in a cooperative spirit (12 M€ / year)
  - Research centres, University, Schools
  - Industrial actors
  - Medium or small size Companies leader in their activity
- Partnership means active role in choice of activity, and logic of work , but also participation in budget covering, and valorisation rights.
- Cooperative spirit means that work plan and results are organised and shared in multilateral groups with operators from the different European countries.

INTRODUCTION TO FUTUR PLANIFICATION METHODOLOGY

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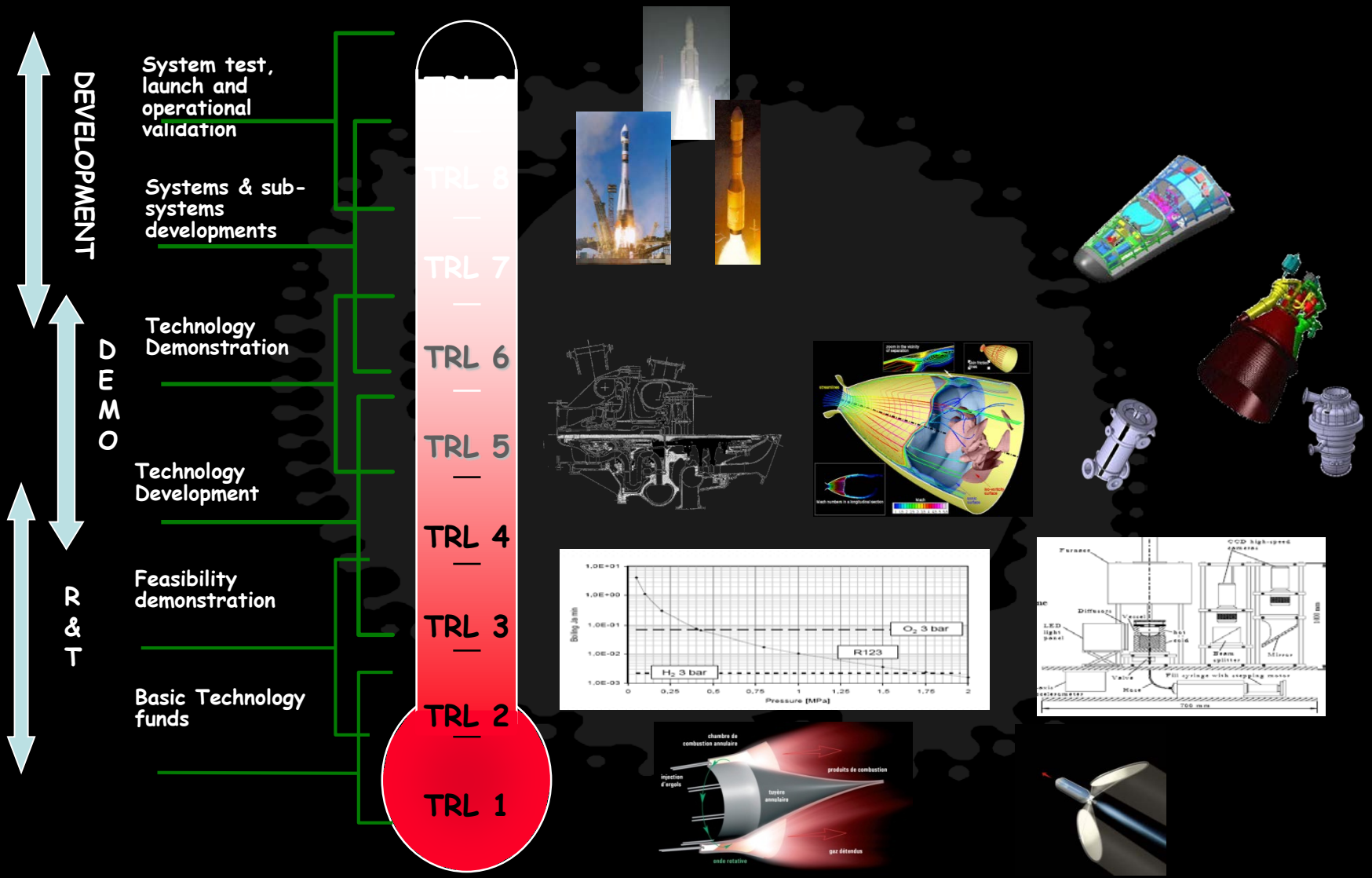
03/03/2016

TRL, R&T, DEMONSTRATORS AND SYSTEM RELATIONSHIP



ESPI
European Space Policy Institute

Luncher R&T Programme

STRUCTURED AROUND 3 MAIN OBJECTIVES

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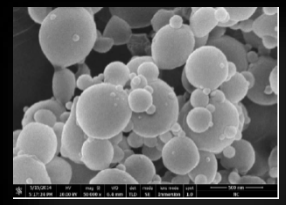
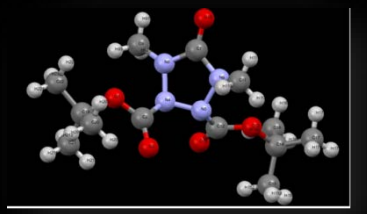
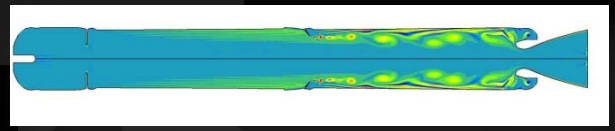
R&T

Innovation & Techno Disruption
New manuterials, manufacturing process, wireless sensors, new propellant, innovative control algorithms….

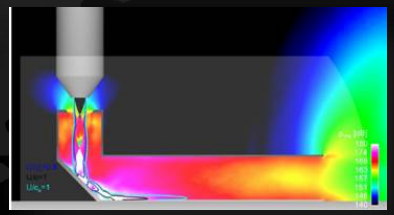




Complex phenomenae understanding
Pressure oscillation, combustion HF instability, acoustics & blastwave, stage reentry and fragmentation…..



Simulation & Numerical testing
Improvement of simulation capacity in all technical fields
Implementation High Performance Computing



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Launchers R&T Programme

STRUCTURED AROUND 6 DOMAINS

- Liquid propulsion
- Solid propulsion
- Mechanical structures
- Environmental behviour
- Avionics and software
- Guidance / Navigation / Control

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Outline

- Introductory Message
- About Technology Policies
- Reminders
- ESA Policy and some technology Programmes
- European Technological non-dependence strategy
- EU Policy and some Technology Programmes
- A National example: CNES
- Challenges ahead

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Challenges ahead

- In line with long-term European space strategy, need to improve methodology to define commonly agreed technology priorities
- Reducing technology dependence should be n° 1 priority: objective to reduce satellite US-made components significantly below 50 %
- Fund allocation to be revisited in two directions:
  1. A European Space Technology Fund (ESTF), pooling together contributions from EU, EDA, ESA, national and industry
  2. A European DARPA for space, EU and multilateral funding
- Legal, regulatory and fiscal environment more favourable to hi-tech SMES's and start-ups
- Preparing technology bricks for a major exploration programme (NASA analog), or preparing a major European-led exploration programme requiring innovative (disruptive) technologies?

Thank you!

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Some reading material

- European Technological Non-Dependence in Space, Letizia Caito, ESPI Report 51, September 2015, http://www.espi.or.at/Studies/reports
- Space and the Processes of Innovation, Christina Giannoppa, Peter Hulsroj, Arne Lahcen, Nunzia Paradiso, ESPI Report 43, July 2012, http://www.espi.or.at/Studies/reports
- Key enabling Technologies and Open Innovation, Christina Giannopapa, ESPI Report 24, July 2010, http://www.espi.or.at/Studies/reports
- Yearbook on Space Policy 2014: The Governance of Space, Edited by Cenan Al-Ekabi, Blandina Baranes, Peter Hulsroj, Arne Lahcen, Springer Verlag Wien 2016
- European Autonomy in Space, Edited by Cenan Al Ekabi, Springer International Publishing Switzerland 2015
- ESA and EC websites for technology policy and related programmes