Round Table 1

KEY PAYLOAD TECHNOLOGY TRENDS FOR COMPETITIVENESS IN APPLICATIONS
Key payload technology trends for competitiveness in applications - areas covered

- The focus of this roadmap is to identify **key payload system needs** in three main applications areas
  - Telecommunications, Earth observation, Navigation
- Most technology proposals are relevant to payload technologies
- The roadmap also includes
  - System and architecture activities (mission driven)
  - Data chain aspects
  - Specific ground system and networks activities
- The current maturity level of most of the proposals is between 3 and 4
  - These are areas where operational requirements are paramount, with higher requirements on maturity
  - TRL 6 can be achieved relatively fast

- Key technology areas
  - Telecommunications
    - Electromagnetic Technologies and Techniques
    - RF Systems, Payloads and Technologies
    - Onboard data system
    - Optical technologies
    - Models & Tools
    - Ground Station Systems and Networks
  - Earth Observation
    - Active optical instruments
    - Passive optical instruments
    - Radar systems
    - Supporting technologies for EO
  - Navigation
    - Clocks and signal generation
    - System & Architecture
Key payload technology trends for competitiveness in applications

**TRL start**

**TRL end**

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**Navigation**

- 1
- 2
- 3
- 4
- 5

**Earth Observation**

- 1
- 2
- 3
- 4
- 5

**Telecommunications**

- 1
- 2
- 3
- 4
- 5

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Key technology drivers and challenges

- **Key Competitiveness drivers**
  - Data challenge
    - Onboard data handling/processing
    - Data rate, throughput, big data...
    - Data integrity and security
  - Mission enablers
    - Spectrum power and flexibility
    - Large antennas
  - Cost and mass reduction

- **Key Policy drivers and Challenges**
  - EU initiatives (in EO and Nav mostly) are strong policy drivers
  - Critical dependence situations (particularly in EO)

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Key technology areas

- Key technology areas by application

- Key technology areas by current maturity level
Round Table 2

KEY SYSTEM AND TECHNOLOGY TRENDS FOR THE SPACECRAFT BUS
Key system and technology trends for the spacecraft bus
Areas covered by RT2

- The focus of this roadmap is to identify **key spacecraft platform system needs**:
  - Most of the roadmap is looking at propulsion system needs.
    - Some activities are synergetic with Launcher upper stage and are included as well.
  - Technologies for the spacecraft bus are strongly driven by international competition
    - Mass and cost reduction trends
    - Full electric spacecraft (large and small)
    - Power system requirements
    - Thermal system requirements
  - Technologies for the spacecraft bus are challenged by critical dependence and REACH-related issues
- The current maturity level of most of the proposals is rather evenly distributed between TRLs 2, 3 and 4.
  - Bridging the TRL gap can be challenging as well

- **Key technology Areas**
  - **Propulsion system**
    - Advanced Propulsion
    - Chemical Propulsion Technologies
    - Electric Propulsion Technologies
    - Mechanisms
    - Supporting Propulsion Technologies and Tools
  - **Launcher**
    - Propulsion
    - Space system control
  - **Materials and mechanisms**
    - Thermal
  - **Avionics**
    - Onboard data system
    - Optics
    - Space system control
  - **Power system**
    - Spacecraft electrical power
  - **EEE Components and Quality**
  - **Ground systems**
    - System Design & Verification
Key system and technology trends for the spacecraft bus

**TRL start**

**TRL end**

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Key system and technology trends for the spacecraft bus
Technology drivers and challenges

- **Key Competitiveness drivers**
  - Propulsion challenges
    - Electric propulsion (and power system related issues)
    - Chemical propulsion
  - Cost and mass reduction

- **Risk factors affecting the roadmap**
  - Critical path
  - Critical dependence

- **Policy drivers**
  - Cleanspace
  - EU KETs
  - EU initiatives

[Graphs showing innovation challenges, critical path, critical dependence, clean space, EU critical materials, EU KET’s, EU initiatives]
Key system and technology trends for the spacecraft bus technology aims

- Key technology aims by technology group

- Key technology aims by current maturity level
Round Table 3

KEY TRENDS FOR INNOVATION AND BREAKTHROUGH
Key trends for innovation and breakthrough
Areas covered by RT3

- The focus of this roadmap is to identify key innovation trends
  - The roadmap focuses on activities at low maturity and/or potentially game changing and breakthrough
- The Roadmap addresses a wide variety of technology areas, but some areas raise very high interest
  - New materials and processes,
  - New manufacturing techniques
  - New instruments
  - Emerging needs for robotics and crew exploration
  - New concepts and new architectures
- The current maturity level of most of the proposals is usually low (TRL 2).
  - These are generally activities in evaluation phase.
  - Target TRL is often 6
- This round table has strong synergies with EU Key Enabling Technologies

Key technology Areas
- Materials and mechanisms
  - Advanced Manufacturing
  - Advanced and smart materials & functions, composite supply chain, REACH compliance
  - Smart Materials
- Launcher
  - Advanced launcher architecture, system improvement, design and modeling tools
  - Advanced materials & functions, Composite materials, lightweight metal, REACH compliance
  - Lean/Clean manufacturing
  - Re-usable systems, propulsion building blocks, green propellants
  - REACH compliance/mitigation
  - System
- Protection of Space Assets
  - Debris monitoring, environment models
  - Debris mitigation End of life solutions
- Navigation
  - Signal precision, time measurement
- Science
  - Detection chain improvement, large & distributed instruments
- Exploration and human presence in space
  - Breakthrough solutions for exploration
  - Crew performance and security enablers
- EEE Components and Quality
  - High power, high voltage, high temperature, High speed
Key trends for innovation and breakthrough

TRL start

TRL end

EEE Components and Quality
Materials and mechanisms
Launcher
Protection of Space Assets
Human Presence in Space
Exploration
Science
Navigation

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Key trends for innovation and breakthrough
Technology drivers and challenges

- **Key Competitiveness drivers**
  - Innovation challenges
    - Advanced materials and functions
  - Design and manufacturing
    - Advanced manufacturing
    - Models, tools, engineering solutions
  - Mission enablers
    - Adressing new challenges in payloads and instruments (clocks, high power, thermal control, cryos)
  - Cost and mass reduction

- **Risk factors affecting the roadmap**
  - Critical dependence
    - Mostly due to dependence on source materials and on models and tools

- **Policy drivers underlying**
  - This roadmap is strongly moving a stronger Europe regarding KETs
  - Cleanspace also appears as an important driver
    - Debris reduction/mitigation approaches
    - REACH compliance
Key trends for innovation and breakthrough technology aims

- Key technology groups by service domain

- Key technology aims by dependence level (3=critical)
Key trends for innovation and breakthrough
The KETs Roadmap

- KETs driven activities by Domain

- KETs driven activities by Aim

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Round Table 4

KEY TRENDS FOR THE DATA CHALLENGE
The Data Challenge
Areas covered by RT4

- The focus of this roadmap is to identify **key technology developments to support the Data Challenge**
  - The roadmap is driven by growing requirements on the data chain, associated to the growth in data quantity and quality across many applications
    - Mostly Telecommunications and Earth Observation
    - Also relevant to Navigation, Science and Launcher
  - The data chain involves
    - Data Processing (on board and on ground)
    - Data Conversion
    - Storage
    - Transmission (space to ground - fixed/mobile terminals, LEO to GEO etc.)
    - Data security and integrity aspects (incl. cryptography)
- The Roadmap addresses a wide variety of technology areas,
  - The main focus (half of the activities) is associated to EEE components for on board data handling/processing
    - The data challenge has high relevance to the work performed at ESCC/CTB level
  - The Ground segment (mission/user segment) also plays a critical role in the data challenge
    - System architecture and ground/space trade offs are essential elements of appreciation
  - Activities for data downlink, with particular relevance to Earth Observation missions are considered as well.
- The current maturity level of most of the proposals is usually low to medium (TRL 2, 3 and 4).
  - Target TRL is usually 6 for evaluation prior IOD/IOV if relevant

- Key technology Areas
  - **EEE components**
    - Digital and Analogue Devices and Technologies
    - Hybrids and Micropackaging
    - Optoelectronic Active and Passive Components
    - Passive Components
    - Power components
    - Printed Circuit Board Technologies
    - RF Microwave and Millimetre Wave Components
    - Silicon-Based Components
  - **Telecommunications**
    - Electromagnetic Technologies and Techniques
    - RF Systems, Payloads and Technologies
    - Onboard data system
    - Optical technologies
    - Models & Tools
    - Ground Station Systems and Networks
  - **Earth Observation**
    - Active optical instruments
    - Radar systems
    - Supporting technologies for EO
  - **Navigation**
    - Clocks and signal generation
    - System & Architecture
  - **Science**
    - Data handling
  - **Launcher**
    - System performance

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The data challenge

**TRL start**

**TRL end**

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The Data Challenge

- Key Competitiveness drivers
  - The Data challenge is a major competitiveness driver in the Eurospace RDT priorities list, and has been identified as such across the whole set of priorities
  - Activities in this roadmap are also relevant to:
    - Mission enabling technologies
    - Cost and mass reduction strategies
    - Design and manufacturing challenges
    - Innovation (low TRL and breakthrough)

- Risk factors affecting the roadmap
  - Critical dependence
    - EEE components are a well identified area of dependence situations
  - Critical path
    - Most dependence items are sourced in the US, and are available without restrictions to US competitors
    - Europe shall bridge the gap to restore its competitiveness at global level
  - Policy drivers underlying
    - This roadmap has direct links with applications in the EU initiatives domains (EO and NAV)
    - It has also relevance to EU KETs

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The Data Challenge technology areas

- **EEE components by family & dependence level (3=critical)**
  - Digital and Analogue Devices and Technologies
  - Hybrids and Micropackaging
  - Optoelectronic Active and Passive Components
  - Passive Components
  - Power components
  - Printed Circuit Board Technologies
  - RF Microwave and Millimetre Wave Components
  - Silicon-Based Components

- **Other technology areas in the Data Challenge by service domain**
  - Avionics
  - Data handling
  - Electromagnetic Technologies and RF Systems, Payloads and Mission ground segment
  - Onboard data system
  - Optical technologies
  - Models & Tools
  - Ground Station Systems and Active optical instruments
  - Radar systems
  - Supporting technologies for EO
  - Clocks and signal generation
  - System & Architecture
  - System Design & Verification
  - System performance