Technologies for European Non-Dependence and Competitiveness (Critical Space Technologies)

SPACE-10-TEC-2018

Guidance Document for

Horizon 2020 Work Programme 2018-2020"

Final

26/10/2017

This page is intentionally left blank.

Table of contents

1 OBJECTIVES

In 2016, The Commission-ESA-EDA Joint Task Force (JTF) ran another round of the non-dependence process to prepare a list of actions for Critical Space Technologies for European Non-Dependence for the time-frame of 2018-2020.

A consultation of European stakeholders allowed to gather feedback from Member States, Industry and SMEs. The JTF reviewed and consolidated the collected inputs.

This Action List for 2018-2020 document reflects the consensus on the Critical Space Technologies for European Strategic Non-Dependence – Actions for 2018/2020 which was reached with the delegates of the Commission, ESA and EDA during the European Non-Dependence Final Meeting held on 28 November 2016 in Noordwijk.

This document is an excerpt of the Action List for 2018-2020 document including the topics that will be addressed by the Work Programme H2020 Space 2018-2020.

2 DISTRIBUTION OF THE DOCUMENT

This document is made available to all proposers through the Horizon 2020 Participant Portal in support of the Horizon 2020 space calls (SPACE-TEC-xxx).

3 EUROPEAN NON-DEPENDENCE PROCESS IN 2016

The European Non-Dependence Process in 2016 followed the structure as defined here below:

European Non-Dependence Process in 2016

The process involved the following three main steps:

1. The first stage was the Mapping. This step involved all European actors (Commission, ESA, EDA, Research, Industry), to build a complete mapping of critical technologies for European Strategic Non-Dependence. It consisted of the following 3 steps:

   I. A *Draft Background Document* was prepared and distributed by Commission, ESA and EDA to all actors in the process (the Member States of EC, ESA, EDA, and Industry representatives), in April 2016.

   II. Industry comments were collected by Eurospace (and as appropriate by SME4Space). In this context, Eurospace involved both Eurospace and non-Eurospace members in its process. Expression of interest to be included in the process by Eurospace and SME4Space was expressed via the 3 organizations (Commission, ESA, EDA).

   III. The **Mapping Meeting** was held on the **19th September 2016** in ESTEC to discuss and complement the information in the *Draft Background Document.* Member State (MS) Delegations, Representatives from Industry, EDA, ESA and Commission were invited to contribute at the meeting. The Mapping Meeting was co-organised and co-chaired by Commission, ESA and EDA. In particular, contributors were asked to provide information on needs for critical space technologies for European Strategic Non-Dependence, relevant on-going developments in critical technology domains identified and strategic interests.

2. The next stage was the planning of the way ahead in the form of a *European Non-Dependence List of for 2018-2020* including recommendations for their implementation as appropriate);

   I. A *Draft European Non-Dependence List* for 2018-2020 was prepared by the three organisations, based on the information from the Background Document, and information gathered during the mapping meeting. It includes in addition recommendations on priorities and for implementation strategies. The *Draft European Non-Dependence List for 2018-2020* was delivered for review and comments to MS Delegations and Industry Representatives through Eurospace and SME4Space.

   II. Industry (via Eurospace/SME4Space) was invited to present comments to the *Draft European Non-Dependence List for 2018-2020* in a dedicated meeting with the Commission, ESA and EDA on 26 October 2016. The updated *Draft European Non-Dependence List for 2018-2020*, including Industry agreed comments, was distributed to MS Delegations in preparation for the Final Meeting.

   III. At the Final Meeting on the **28th of November 2016** in ESTEC, the proposed final *European Non-Dependence List for 2018-2020* was presented to the MS Delegations; the aim of the meeting was to arrive at an agreed *European Non-Dependence List for 2018-2020*, including implementation recommendations. After the Final meeting, the *European Non-Dependence List for 2018-2020* was updated (as necessary) to reflect the discussions and agreements of the Final Meeting.

   IV.I. The updated *European Non-Dependence List for 2018-2020* was sent to the MS Delegations for final review and comments. After implementing received comments the *European Non-Dependence List for 2018-2020* was then finalised.

   V. The final *European Non-Dependence List for 2018-2020* was distributed in January 2017 to all European stakeholders.

3. The *European Non-Dependence List for 2018-2020* with implementation recommendations will then be implemented in National and European Programmes. Tracking of the status of implementation will be performed yearly by Commission, EDA, ESA.

3.1 Definition of dependence

In the context of this document, it is important to recall the definitions of “Independence” and of “Non-Dependence”, namely:

- “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.

The aim of this action being undertaken by Commission, ESA and EDA is to contribute to ensuring European non-dependence.

In particular, the criteria used to evaluate if a technology can be included in the final list of actions will be:

1. Items shall be of low integration level, i.e. building blocks and components (System/sub-system assembly, methods are not included)
2. Items shall have a clearly identified function and performance target
3. Items shall be multi use and/or applications (i.e. not an enabling technology for a one shot use)
4. Items shall be not available from a European source and for which the unrestricted availability from non-European suppliers cannot be assured
5. Critical items for which no adequate or sufficient action is on going

3.2 Labels for Actions

- Title
- Item Description and Needed Action
- Estimated Initial TRL (according to ISO TRL definition)*
- Target TRL (according to ISO TRL definition)*
- Applicable Mission Class(es)**
- Industrial Non-Dependence Concern
- Delegations/Agencies voicing non-dependence concern
- Reference(s): In case this item was developed/ is related to a specific process e.g. Harmonisation Technology Dossier/Roadmap Reference, ESCC or other consultation process
- Remarks / Justifications
- Date of Entry of Item / Last Date of Change

* Ref: Standard ISO 16290 "Definition of Technology Readiness Levels (TRLs) and their criteria of assessment"

**Mission Classes: Earth Observation, Science Mission, Human Spaceflight, Space Transportation, Telecommunications, Navigation, Space Security, Robotic Exploration, Unmanned Aircraft Systems (UAS), Defence Applications

4 NON-DEPENDENCE ACTIONS

In this chapter the non-dependence actions selected for the Work Programme H2020 Space are shown.

The actions are grouped by technology domains and are not necessarily in order of priority.

The code in bracket provides traceability with the List of Actions for 2015-2017.

The selection methodology

In the frame of the preparation of the H2020 Space WP 2018-2020, the Commission, with the ESA and the EDA, has established a methodology for the selection of the actions to be potentially funded through grants.

The selection is based upon the appraisal of the 43 actions from the List for 2018-2020 with respect to three main criteria:

- **Policy relevance:** adherence of the action with the "Space Strategy for Europe", adopted by the European Commission in 2016;

- **Programmatic fit:** suitability of the H2020 grants in implementing the action from a programmatic perspective, including budget, timeline and Technology Readiness Level;

- **Consistency with on-going or planned activities:** continuation potential complementarity with respect to past or on-going activities in EU or ESA and risk of duplication/overlapping with on-going or planned FP7/H2020 projects.

The three main criteria of equal importance are further broken down into a set of specific sub-criteria with associated metrics. With respect to the relevant metrics, each action will be ranked reflecting its level of compliance with the sub-criterion. For each main criterion, ranks of the relevant sub-criteria will be combined in accordance to predefined logics into an overall appraisal of the action. Filtering the actions with respect to the appraisal flags will result into the short list of selected actions. No weighting factors is be applied to neither the three main criteria nor their respective sub-criteria.

The selection is based on the information available on the Action List for 2018-2020 complemented by programmatic assumptions such as the rough order of magnitude of budget and time to completion required by each action, and technology status mapping information.

Standardisation

When addressing the qualification of electrical, electronic and electro-mechanical (EEE) components, applicants are invited to assume the standards developed by the European Space Component Coordination (ESCC).

4.1 Microelectronics and On-board Data Systems

4.1.1 JTF-2018/20-2 - ASICS for mixed signal processing [U11]

Description and needed Action	• Need to qualify export restriction free rad-hard mixed signal technologies • Establish development, verification and validation standards for derived mixed-signal IP cores • Establish an independent ASIC source in Europe based on a commercial (sustainable) process and radiation-hard-by-design libraries • Qualification of full supply chain (including assembling and test house, …) • Support European packaging of naked complex multi-pad dies and mixed ASIC testing capabilities • Ensure fair and non-discriminatory access to the IP for European companies.
Estimated Initial TRL:	4
Target TRL	7
Applicable Mission Class(es)	Earth Observation, Science Mission, Telecommunications, Navigation, Robotic Exploration, Defence Applications
Industrial Non-Dependence Concern	Industry consensus confirmed at the JTF convergence meeting (26 October 2016)
Delegations/Agencies voicing non-dependence concern on the item	Action approved by consensus at the Final Meeting of 28 November 2016
Reference(s):	"Microelectronics: ASIC and FPGA". European Space Technology Harmonisation Technical Dossier, 2016
Remarks / Justifications	• Increased demand for mixed signal ASICS in Telecommunications and scientific satellites. • Special market and interest in medium and high voltage applications. Increased interest for mega-constellations. Part of COMPET 1-2014 of Horizon 2020, the project SEPHY (space ethernet physical layer transceiver, target TRL6) is on-going. 1 running EDA project
Date of Entry / Last Date of Change	30-November-2016

4.1.2 *JTF-2018/20-3 - High Capacity FPGAs [U12]*

Description and needed Action	Validation of a high capacity Rad Hard Reprogrammable Field-Programmable Gate Array (FPGA) of European source ("BRAVE FPGA family") and development and validation of software tools. The family of BRAVE FPGAs will contain: - BRAVE FPGA- MEDIUM (0.5Mgates, 65nm) - BRAVE FPGA-LARGE (2Mgates, 65nm) - BRAVE FPGA-ULTRA (>10Mgates, 28nm) Depending on the actual FPGA case, different tasks are necessary. • Qualification of BRAVE FPGA-MEDIUM with LGA625 package • Qualification of BRAVE FPGA-LARGE in 2018 including packaging aspects to achieve competitiveness targets taking into account the ESCC constrains and market needs • FPGA alpha-use, debugging and dissemination: FPGA experimentation by first space end-users, migration of space-subsystems to make use of the new FPGA, Intellectual Property (IPs) implementation in the new FPGA, dissemination of the FPGA product • Tools: complement the FPGA tools of such a chip with capability to use higher abstraction-level design descriptions than RTL, extensions to recognise specialised optimally-implemented macros, extra testing and benchmarking of the design and programming tools • Industrialization of BRAVE FPGA-ULTRA, including foundry access (mask and wafers), functional and characterization testing • Qualification of BRAVE FPGA-ULTRA • Critical tests associated to complex packages • Support for ESCC evaluation and qualification tests The target European Space FPGA shall have a silicon proven architecture with the requirements indicated in the Remarks (please see remarks).
Estimated Initial TRL:	3-4
Target TRL	7
Applicable Mission Class(es)	Earth Observation, Science Mission, Human Spaceflight, Telecommunications, Navigation, Space Security, Robotic

	Exploration, Defence Applications
Industrial Non-Dependence Concern	Industry consensus confirmed at the JTF convergence meeting (26 October 2016)
Delegations/Agencies voicing non-dependence concern on the item	Action approved by consensus at the Final Meeting of 28 November 2016
Reference(s):	Reference documents: “Microelectronics: ASIC and FPGA”. European Space Technology Harmonisation Technical Dossier, 2016
Remarks / Justifications	These European Space FPGAs shall include the following architecture elements: • 4-input Look-Up Table (LUTs) • Internal memory • Digital Signal Processing hard-macros. • SERDES High Speed Serial Links. • Internal interconnection shall allow fast interconnect and allow a LUT density higher than 1.500 LUT/mm^2 (value for 65 nm technology not including radiation hardening) with a minimum capacity of 25000 LUTs and scalable to capacities higher than 100.000 LUTs in 65 nm technologies (including radiation hardening). The following requirements are needed: • The FPGA shall be radiation hardened. • The FPGA devices shall become available in space-qualified packages. • The FPGA product shall include the software tools that execute the typical digital microelectronics flow starting from a Register Transfer Level (RTL) description and system constraints (e.g. timing, capacitive loading) to ultimately generate the bit-stream necessary to program the FPGA with the desired functions. • In order to meet the FPGA capacity and performance requirements, the FPGA shall be implemented in a technology node (minimum feature size of the transistors) of 65 nm or smaller. • The FPGA shall be a European sourced free of non-European export control regulation product (98 % of the space FPGAs being used today in all European missions are now subject to export control). The requirements and characteristics mentioned above are derived after discussions in the framework of CTB / ESCC and other fora with Industry (customers), Vendors (technology

	suppliers, private funding) and Public Space Organizations and Agencies (institutional funding). The third products of the BRAVE FPGA family will scale up the capacity of equivalent ASIC-gates to >10Mgates (BRAVE-ULTRA) based on 28nm technology. Part of COMPET 1-2015 of Horizon 2020, the project VEGAS is on-going. The project will cover the ESCC Space Evaluation of BRAVE-MEDIUM. In addition, within the call COMPET 1-2016 of H2020, the project DAHLIA (Development of a Very High Performance microprocessor System on Chip (SoC) based on European 28nm FDSOI technology with multi-core ARM processors for real-time applications) was funded. Part of ECSEL JU work programme for 2014, it was founded the project DEMETER (focused on the development of BRAVE-ULTRA based on 28 nm technology. 1 running EDA project. Note 1 (2015): The target European Space FPGA should also address other high reliability markets.
Date of Entry / Last Date of Change	30-November-2016

4.1.3 *JTF-2018/20-5 - Very high performance microprocessors [U20]*

Description and needed Action	New generation rad-hard high performance microprocessors: - implemented in 65nm deep sub-micron technologies or smaller technology nodes - performance improvements of factor 5-10 over existing microprocessors and SOC's implemented in existing European technologies - development, validation, qualification of flight models of such performance and their application in space missions - Consolidation of SW ecosystem for the new microprocessors, including tools to exploit in an optimal way (processing speed, power consumption, and fault-tolerance) the multi-core nature of these devices.
Estimated Initial TRL:	4
Target TRL	> 6
Applicable Mission Class(es)	Earth Observation, Science Mission, Human Spaceflight, Space Transportation, Telecommunications, Navigation, Space Security, Robotic Exploration, Defence Applications
Industrial Non-Dependence Concern	Industry consensus expressed at the JTF convergence meeting (26 October 2016). However, Industry proposed on 18 November 2016 a new description / remarks text which was not accepted by ESA because it was deemed too technically specific.
Delegations/Agencies voicing non-dependence concern on the item	Action approved by consensus at the Final Meeting of 28 November 2016
Reference(s):	"Microelectronics: ASIC and FPGA". European Space Technology Harmonisation Technical Dossier, 2016
Remarks / Justifications	Currently Europe is leading in the development of the next generation high performance microprocessor, the GR740 based on four LEON4 cores; however the final step for creation of the space qualified Flight Models is still and urgently needed. H2020-COMPET-2016 contract under preparation (DSM 28nm). Part of H2020-COMPET-2014 of H2020, the project TCLS ARM FOR SPACE (Feasibility and Definition of a Triple Core Lockstep ARM System-on-Chip for Space Applications) is on-going. Note 1 (2015): To keep in mind that large and fast memory components are also needed to reach high performances with new microprocessors. Developments on-going in ESA.
Date of Entry / Last Date of Change	01-December--2016

4.1.4 *JTF-2018/20-8 - ASICS: 28nm Deep Sub-Micron (DSM) [U22b]*

Description and needed Action	○ Evaluation of next deep-submicron space ASIC technology to accomplish higher integration and performance using 28nm or smaller node, with very high speed serial links (HSSL), ADC and DAC IP to be used with it. ○ Development and characterization of radiation hardened ASIC libraries and ASIC design kit for space users. ○ Preparation of the ESCC qualification of a 28nm (or smaller node) space ASIC platform.
Estimated Initial TRL:	3
Target TRL	6
Applicable Mission Class(es)	Earth Observation, Science Mission, Human Spaceflight, Space Transportation, Telecommunications, Navigation, Space Security, Robotic Exploration, Defense applications
Industrial Non-Dependence Concern	Industry consensus confirmed on U22 (a+b) at the JTF convergence meeting (26 October 2016)
Delegations/Agencies voicing non-dependence concern on the item	Action proposed and approved by consensus at the Final Meeting of 28 November 2016
Reference(s):	"Microelectronics: ASIC and FPGA". European Space Technology Harmonisation Technical Dossier, 2016 and ESCC CTB roadmaps
Remarks / Justifications	• DSM processes require a high degree of focus on long term reliability and SEE process capability. Radiation and SEE hardened cells and libraries are required since SEE is effecting the overall performance reliability to a non-negligible extent. • Preliminary developments on 28nm are taking place as Part of ECSEL JU work programme for 2014 (DEMETER) • A generic 28nm (or smaller node) space digital ASIC platform will help with the development of other general use integrated circuits manufactured with the same Silicon process: BRAVE-Ultra FPGA (U12), microprocessors (U20), DSP(U10) or ultra-reprogrammable SoCs (N50)
Date of Entry / Last Date of Change	30-November-2016

4.1.5 JTF-2018/20-9 - Design and prototype of ultra-reprogrammable SoCs [N50]

Description and needed Action	Microprocessor/ DSP combined with an embedded FPGA in a monolithic single chip, in most advanced space ASIC technology available, and reusing existing IP.
Estimated Initial TRL	2
Target TRL	4
Applicable Mission Class(es)*	Earth Observation, Science Mission, Telecommunications, Navigation, Robotic Exploration, Unmanned Aircraft Systems (UAS), Defence Applications
Industrial Non-Dependence Concern	The preliminary Industry support which was stated at the JTF convergence meeting (26 October 2016), was not confirmed on 18 November 2016. Industry considers it, as low priority, when compared to other actions such as U10, U11 and U20.
Delegations/Agencies voicing non-dependence concern on the item	Action approved by consensus at the Final Meeting of 28 November 2016
Reference(s)	"On-Board Payload Data Processing" (OBPDP) and "Microelectronics ASIC & FPGA" European Space Technology Harmonisation Technical Dossier, 2016
Remarks / Justifications	Highly reconfigurable systems become more feasible with the availability of European based reprogrammable FPGAs. This allows modification of the unit depending on the mission phases, replacing several units by a single one which can be reconfigured accordingly. Combination of such a re-programmable FPGA with a Microprocessor/ DSP in a single chip follows the development currently seen in the commercial market (Xilinx Zync) and increases the integration density for future equipment. The needed IPs (BRAVE FPGA, Leon processor, Xentium DSP) are available
Date of Entry	30-November-2016

4.1.6 JTF-2018/20-11 - Design and Qualification of uController for Space application [N52]

Description and needed Action	Need to qualify an export-restricted-free rad-hard single-core microcontroller. Prototype (TRL 4) available end of 2017
Estimated Initial TRL	4
Target TRL	6-7
Applicable Mission Class(es)*	Earth Observation, Science Mission, Human Spaceflight, Space Transportation, Telecommunications, Navigation, Space Security, Robotic Exploration, Unmanned Aircraft Systems (UAS), Defence Applications
Industrial Non-Dependence Concern	Preliminary Industry support stated at the JTF convergence meeting (26 October 2016). Industry consensus confirmed on 18 November 2016
Delegations/Agencies voicing non-dependence concern on the item	Action approved by consensus at the Final Meeting of 28 November 2016
Reference(s)	"Data Systems and On-Board Computer" European Space Technology Harmonisation Technical Dossier, 2016
Remarks / Justifications	• Software based data acquisition/processing and simple control applications are widely used in many spacecraft subsystems. They allow implementing software based control architectures that provide a higher flexibility and autonomous capability versus hardware implementations. For these types of applications, where limited performances are requested to the processor, general purpose microprocessors are usually considered not compatible due to high power consumption, high pin count packages, need of external memories and peripherals. • Low-end microcontrollers are considered more attractive in many applications such as: propulsion system control, sensor bus control, robotics applications control, simple motor control, mechanism control, power control, particle detector instrumentation, radiation environment monitoring, thermal control, antenna pointing control, AOCS/GNC (Gyro, IMU, and MTM), RTU control
Date of Entry	30-November-2016

4.1.7 *JTF-2018/20-12 - Design and prototype of nvRAM for SPACE with Serial interface ((quad)-SPI) [N53]*

Description and needed Action	• Use of microcontrollers and FPGA in peripheral systems push for the availability of low-footprint, small size reliable NVRAMs • Availability of small-footprint NVRAM is already a problem for several MCU-based designs
Estimated Initial TRL	3
Target TRL	5
Applicable Mission Class(es)*	Earth Observation, Science Mission, Human Spaceflight, Space Transportation, Telecommunications, Navigation, Space Security, Robotic Exploration, Unmanned Aircraft Systems (UAS), Defence Applications
Industrial Non-Dependence Concern	No European device exists until the EC funded R2RAM project is finalised. Industry consensus confirmed at the JTF convergence meeting (26 October 2016). However, Industry support was put on hold on 18 November 2016 until the R2RAM project outcome is made available.
Delegations/Agencies voicing non-dependence concern on the item	Action approved by consensus at the Final Meeting of 28 November 2016
Reference(s)	"Data Systems and On-Board Computer" European Space Technology Harmonisation Technical Dossier, 2016
Remarks / Justifications	• Flexible storage for boot code, program code, vital preference data or logged data • Industry-standard SPI interface reduces pin count and simplifies routing • Easy migration and modularity: devices are all pin compatible and require only 4/5 pins to connect to MCU/FPGA for different sizes and with minor design changes. • Uniform block erase architecture simplifies wear levelling design and is ideal for embedded code and data storage • Monitoring of the outcome of the R2RAM activity funded by EC is recommended prior updating the status.
Date of Entry	30-November-2016

4.2 Space System Control

4.2.1 JTF-2018/20-14 - Fiber optic or photonics integrated technology Gyro based inertial measurement unit (IMU) [U6]

Description and needed Action	Ensure long term availability of an European cost effective fiber optic or photonics integrated technology gyroscope based IMU (with accelerometers). This activity targets the full range of FOG IMUs aiming at dependence and cost reduction by the introduction of COTS components.
Estimated Initial TRL:	4
Target TRL	≥ 6
Applicable Mission Class(es)	Navigation, Science Missions, Earth Observation, Human Spaceflight, Robotic Exploration, potentialTelecommunications, Launcher, UAS, Defence applications
Industrial Non-Dependence Concern	Industry consensus confirmed at the JTF convergence meeting (26 October 2016)
Delegations/Agencies voicing non-dependence concern on the item	Action approved by consensus at the Final Meeting of 28 November 2016
Reference(s):	Subject of 2015 Harmonisation effort
Remarks / Justifications	The target TRL of 6 implies at least the adaptation of an IMU Engineering Model. Part of COMPET 1-2015 of Horizon 2020 work programme for 2015
Date of Entry / Last Date of Change	30-November--2016

4.3 Power

4.3.1 JTF-2018/20-16 - Active discrete power components [U14]

Description and needed Action	Development and qualification of active components (like diodes) assuring unrestricted availability of space qualified high reliability components in Europe: - MOSFET transistors - non-RF GaN and SiC diodes and transistors - Power functions: POL, PWM, ICL, drivers (MOS) - novel integrated Vacuum Microelectronics Devices (VMD) - other The recommendations from European Space Components Co-ordination (ESCC) via CTB will be taken into account.
Estimated Initial TRL	4 (usually)
Target TRL:	7
Applicable Mission Class(es)*	Earth Observation, Science Mission, Human Spaceflight, Space Transportation, Telecommunications, Navigation, Space Security, Robotic Exploration
Industrial Non-Dependence Concern	Industry consensus confirmed at the JTF convergence meeting (26 October 2016)
Number of Delegations/Agencies voicing non-dependence concern on the item	Action approved by consensus at the Final Meeting of 28 November 2016
Reference(s):	See ESCC Dossier
Remarks / Justifications	Evaluation of GaN switches for power application, in terms of performance at converter level, will be covered by the project GaNOMIC part of the Electrical Propulsion cluster COMPET 3-2016 founded by EC. However, within the frame of this project, non-European technology will also be evaluated considering its level of maturity. Numbers of restricted export licenses and number of units sold are the number of MOSFETs and Diodes with current technology. Note 1 (2015): GaN components could also be investigated. Note 2 (2015): High voltage applications could also be considered.
Date of Entry / Last Date of Change	30-November-2016

4.4 RF Payload System

4.4.1 JTF-2018/20-17 - Power amplification: Travelling Wave Tube (TWT) materials [U7]

Description and needed Action	Ensure unrestricted access to materials for TWT production • Export restriction free helix wire material needed. • Export restriction free dielectric materials: o material for helix support rods o insulation ceramic for high-power collectors Manufacturing alternatives to Aluminium tubes
Estimated Initial TRL:	Depending on material 3-5
Target TRL	≥ 6
Applicable Mission Class(es)	Earth Observation, Science Mission, Human Spaceflight, Space Transportation, Telecommunications, Navigation, Space Security, Robotic Exploration, Defence applications.
Industrial Non-Dependence Concern	Industry consensus confirmed at the JTF convergence meeting (26 October 2016)
Delegations/Agencies voicing non-dependence concern on the item	Action approved by consensus at the Final Meeting of 28 November 2016
Reference(s):	
Remarks / Justifications	Part of COMPET 1-2015 of Horizon 2020, the project ERFTM (export restriction free travelling wave tubes materials) is on-going. Target TRL 6.
Date of Entry / Last Date of Change	30-November-2016

4.4.2 *JTF-2018/20-18- RF components [N27]*

Description and needed Action	In any space mission high sophisticated semiconductor components for telecommunication such as PLLs, prescalers, power and low noise amplifiers are vital for reliable communication. Although there are very promising attempts in R&D for such components in Europe, almost all components are ordered from overseas. European industry and research facilities have the technological know-how and potential to supply the space community with components having equivalent or even better performance in comparison to its "overseas competitors" but still need R&D to come to market readiness of space qualified components. Activities will include RF components such as integer-N PLLs, voltage-controlled oscillators (i.e. VPAs), high performance MMIC Power Amplifiers, MMIC LNAs, among others.
Estimated Initial TRL	4
Target TRL	7
Applicable Mission Class(es)	Earth Observation, Science Mission, Human Spaceflight, Space Transportation, Telecommunications, Navigation, Space Security, Robotic Exploration, Defence applications
Industrial Non-Dependence Concern	Industry consensus confirmed at the JTF convergence meeting (26 October 2016)
Delegations/Agencies voicing non-dependence concern on the item	Action approved by consensus at the Final Meeting of 28 November 2016
Reference(s)	
Remarks / Justifications	For practical implementation reasons, it is recommended to split this item into separate comprehensive activities/projects. RF and Microwave RF components such as PLLs, power and low noise amplifiers are definitively needed as today only available from US with EAR Export license required. A qualified and European controlled source is vital for space end users.
Date of Entry / Last Date of Change	30-November--2016

4.5 EEE components

4.5.1 JTF-2018/20-19- Passive components [U13]

Description and needed Action	– Increase the number of freely accessible space qualified passive components, – European Space industry is still very reliant in most cases on single source suppliers and/or suppliers from outside of Europe (USA); – high voltage/ robust to high mechanical stress relays, ceramic capacitors, – New technologies required in Europe include HV relay, decoupling capacitors for Next generation FPGA, Multianode polymer Tantalum capacitors, HV cable assemblies for Electric Propulsion, modular connectors, miniaturisation of DC/RF connectors, RF passive attenuators, coil transformers and lower size chip capacitors and resistors, heaters, coolers, supercapacitors, L-band passive High Power components (e.g. filters, couplers, connectors, etc.) – Qualifications of cable assemblies especially for high RF power, high voltage, high speed. Where applicable, activities should follow the recommendations with regard to highest priority items from European Space Components Co-ordination (ESCC) via CTB.
Estimated Initial TRL	4(usually)
Target TRL:	7
Applicable Mission Class(es)*	Earth Observation, Science Mission, Human Spaceflight, Space Transportation, Telecommunications, Navigation, Space Security, Robotic Exploration
Industrial Non-Dependence Concern	Industry consensus confirmed at the JTF convergence meeting (26 October 2016)
Number of Delegations/Agencies voicing non-dependence concern on the item	Action approved by consensus at the Final Meeting of 28 November 2016
Reference(s):	

Remarks / Justifications	For practical implementation reasons, it is recommended to split this item into separate comprehensive activities/projects. Passive components requires continuous support and investment to expand the current portfolio available within Europe, as most passives for space cannot be replaced by terrestrial devices.
Date of Entry / Last Date of Change	30-November-2016

4.5.2 *JTF-2018/20-21 - High density (1000 pins and beyond) assembly capabilities and PCBs [U17]*

Description and needed Action	High density assemblies significantly reduces the device footprint allowing more components to be mounted on the same size of PCB. • High dissipation devices, high density packaging technologies. • There is an urgent need to develop the thermount replacements as thermount is obsolete and soon no longer available • European solution for high pin count assemblies (1000 pins and beyond) is required to support DSM, high density ASICs/FPGAs, flip chip technology etc. • In addition a reliable and qualified solution for column attached packaging is needed. • A solution for large non-hermetic packages is needed. • To secure an European pool of PCB manufacturers and critical PCB base material suppliers for strategic dual-use applications. • European qualified assembly house • High Density Interconnection PCB technology (HDI) This action is for both Digital as well as Mixed ASIC packages.
Estimated Initial TRL:	4
Target TRL	7
Applicable Mission Class(es)	Earth Observation, Science Mission, Human Spaceflight, Space Transportation, Telecommunications, Navigation, Space Security, Robotic Exploration, Defence Applications
Industrial Non-Dependence Concern	Industry consensus confirmed at the JTF convergence meeting (26 October 2016)
Delegations/Agencies voicing non-dependence concern on the item	Action approved by consensus at the Final Meeting of 28 November 2016
Reference(s):	
Remarks / Justifications	Part of COMPET 1-2014 of Horizon 2020 work programme for 2014 (no project selected). Note 1 (2015): It is recommended to promote European coordination between civil and military industrial end-users.
Date of Entry / Last Date of Change	30-November--2016

4.5.3 *JTF-2018/20-22 – High Temperature Packaging [N49]*

Description and needed Action	Thermal management of high power semiconductors and very advanced components to ensure performance and reliability.
	– Specifically thermal management in space components where the efficient cooling of semiconductors is a key issue in order to be able to minimize volume and weight of electronics
	– A low junction temperature by an efficient dissipation of heat in order to ensure a long life and reliability of components.
	– Specific problematic are GaN RF and Power and SiC discrete components but other technologies may also be covered under this new element
	– Actions needed can cover
	    – assembly (die mounting) materials and techniques,
	    – Enhanced thermal dissipation materials to be used as package baseplate or substrates like for example graphite material or AlN, -Diamond composites, etc
	– Packaged components reporting techniques.

Estimated Initial TRL	3-4
Target TRL	7
Applicable Mission Class(es)*	Earth Observation, Science Mission, Human Spaceflight, Space Transportation, Telecommunications, Navigation, Space Security, Robotic Exploration, Defence Applications
Industrial Non-Dependence Concern	Preliminary Industry support stated at the JTF convergence meeting (26 October 2016). Final Industry support confirmed on 18 November 2016.
Delegations/Agencies voicing non-dependence concern on the item	Action approved by consensus at the Final Meeting of 28 November 2016
Reference(s)	
Remarks / Justifications	Components based on GaN start to be commercially available but with assembly and packaging techniques that are not always demonstrated as being suitable for space applications.

	SiC components are already used in ESA project with specific requirements, but it is urgent to improve high temperature materials and packaging techniques if we want to make optimum use of these new technologies. Improved high thermal conductivity / heat dissipating packages are required. There have been several European developments using Cu/Diamond/AlN, etc. The key issue is the commercial viability of the solutions. A European source of packages has to be competitive with Japan (Kyocera) or USA, Schott packages made in Europe are available for some power devices Today, commercial materials/packages are available from Japan or US only and European R&D. Concerning Japan, packages/materials have no strong restriction so far. One project (AGAPAC) was funded by EC within the call FP7-SPACE-2007-1. The project ended in 2012 and produced preliminary results in the advanced packaging for GaN in space applications.
Date of Entry	30-November-2016

4.6 Software

4.6.1 JTF-2018/20-23 - SW tool: Automatic Generation of code [N64]

Description and needed Action	Develop an European solution of Software Tool suite (including environment tool: model editor, simulator, model verification tool) for "Automatic Generation of Code" from existing non-European mathematical and simulation tools "MathWorks - Matlab and Simulink", and if possible in addition compatible with the European tool.
Estimated Initial TRL:	4
Target TRL	6/7 for an operational certified tool
Applicable Mission Class(es)	Earth Observations, Space Science, Exploration, Telecom, Navigation, Human Space Flight, Launchers and Operations
Industrial Non-Dependence Concern	Industry consensus confirmed at the JTF convergence meeting (26 October 2016). Most of codes generated automatically from these tools are critical SW.
Delegations/Agencies voicing non-dependence concern on the item	Action approved by consensus at the Final Meeting of 28 November 2016
Reference(s):	
Remarks / Justifications	Two qualities are important for automatic code generation of critical embedded software: 1) the knowledge of how the code is generated, and therefore the visibility within the code generator 2) the possibility to qualify the code generator to save the cost of validation of the generated code. These qualities are more difficult to achieve with non-European commercial tools than e.g. open source European tools. As an example, previous European projects have allowed the development of a prototype open source code generator (QGen) that needs to be pushed to a qualified product that would support significantly the autonomy of European stakeholders industry and agencies. It would allow European companies to establish themselves at the centre of a new ecosystem created around a new generation of tools called "model compilers", which are essential elements to the more and more expanding model based engineering.
Date of Entry / Last Date of Change	30-November-2016

4.7 Optics and Optoelectronics

4.7.1 JTF-2018/20-28 - Photonics components [U15]

Description and needed Action	DIGITAL PHOTONIC PAYLOADS
	Development and qualification of high data rate, high density optical links for future space missions to take advantage of the mass and AIT advantages that optical fibres and optical communications offer.
	• 10Gbps(>20 Gbps as target goal) optical emitter/receiver. This can be separated into three different packaging concepts.
	  – SpaceFibre module: Hermetic duplex transceiver such as would be interesting for SpaceFibre networks.
	  – Hermetic multichannel transceivers (4 channel transmit, 4 channel receive)
	  – Hermetic parallel optics simplex modules, either 12 channel TX or 12 channel RX modules.
	The challenge for developing these components for space remain:
	  – Radiation hard driver electronics
	  – Hermetic fibre feed through technology for parallel optic modules (12 fibres/module)
	• Space qualified optical cables and connector assemblies for multifibre cables (12 channels). The cable assemblies include; optical fibre, jacket, connectors and mating adapter assemblies. Different approaches required for inside and outside equipment boxes.
	In addition a “photonic sampler” which can be used as part of an Electro-Photonic ADC can be used to down-convert an RF signal to baseband (similar to frequency converter of Microwave Payloads)
	
	MICROWAVE PHOTONIC PAYLOAD
	Photonics components needed for future photonic telecom payloads as well for RF Earth Observation photonic functions like: Frequency Generation, up/down Frequency Conversion, Local Oscillator Distribution, Optical Switching, programmable photonic processors, Optical Beam Forming/Steering, Photonic RF filtering.
	In particular components such as: Optical Modulators,

	Optical Fibre Amplifiers, Optical Switch (of low and high port count), High dynamic range - High frequency detectors for optical RF links. In addition, Micro-photonic integration of active and passive components for compact low phase noise RF frequency generation and conversion in the optical domain as well as beam-forming should be pursued.
Estimated Initial TRL	4
Target TRL:	7
Applicable Mission Class(es)	Telecommunications, Earth Observation, Science Mission, Human Spaceflight, Space Transportation, Navigation, Space Security, Robotic Exploration, Defence applications
Industrial Concern	Industry consensus confirmed at the JTF convergence meeting (26 October 2016)
Delegations/Agencies voicing non-dependence concern on the item	Action approved by consensus at the Final Meeting of 28 November 2016
Reference(s):	
Remarks / Justifications	High speed optical links are a high priority across all missions. There is a high interest to fly an IOD of a payload with optical interconnection plane by around 2018. Part of FP7 Call 6 – 2013, 3 projects are on-going. Specifically, HIPPO (High-power optical components and modules: high power lasers at 1550nm, photonics crystal fibres, HP passives, HP optical fibers amplifiers with target TRL 5), BEACON (Scalable & Low-Power Microwave Photonics for Flexible Terabit Telecom Payloads & High-speed Coherent Inter-satellite Links with target TRL 4) and MERLIN (Multi-gigabit optical inter-connectivity). EDA projects: 1 on-going and 1 planned.
Date of Entry / Last Date of Change	30-November-2016

4.7.2 JTF-2018/20-31 - Advanced Laser Crystals for High Power Space applications [N63]

Description and needed Action	Presently space laser missions for Earth Observation, such as ADM or Earth Care, as well as for Space Science, such as LISA (future L1 mission, to follow-up Lisa Pathfinder) or Planetary exploration and Navigation, are based on Nd:YAG laser technology. This technology can meet both high power/energy and low power/energy applications needs (for high power, high energy applications, Northrop Grumman (US) practically is the sole provider of Nd:YAG crystals, mostly in slab forms for high power/energy). Nd:YAG laser technology, operating in the infrared @ about 1 micron, suffers from low electrical efficiency, which require complex cooling systems and adequate high power laser-diode pumping to achieve the required output energies at the specific operating wavelengths. Emerging laser technology such as that based on Alexandrite crystal is very promising alternative and is presently being investigated at ESA as potential YAG replacement in view of the intrinsic higher efficiency, superior thermo- mechanical properties, shorter operating wavelengths, tunability and overall superior performance. ESA is pioneering the use of this technology and a number of activities have been or are presently running in the various technology programmes. To ensure adequate technology readiness and independence from the US market in this critical emerging area, this proposal is brought forward to develop this technology for space. The establishment of a European source for high-quality, custom-tailored laser crystals is of interest in the context of on-going developments of laser instruments for various space applications. Priority should be given to the advancement of laser materials such as Ho:YLF and alexandrite, which are being considered for active sensing missions targeting the measurement of atmospheric CO2 at 2 microns and vegetation monitoring at around 750 nm, respectively. The laser crystal development should go along with the enhancement of high damage threshold coatings for the crystal optical surfaces.
Estimated Initial TRL	4
Target TRL	6-7
Applicable Mission	Earth Observations, Space Science, Telecom, Navigation

Class(es)*	
Industrial Non-Dependence Concern	To avoid export restriction issues and ensure long term availability of this technology, it is proposed to introduce an activity item to cover a fully European development of high quality, high power Alexandrite crystals for space applications. Industry consensus confirmed on 18 November 2016
Delegations/Agencies voicing non-dependence concern on the item	Action approved by consensus at the Final Meeting of 28 November 2016
Reference(s)	Relevant ESA TRP projects/contracts on development of Alexandrite laser for space applications + TRP contract T117-504MM
Remarks / Justifications	Development effort of 2 Meuro required from TRL 4 to 6 in 3 years with demonstrator. Basic laser crystal technology is mainly controlled by US and Chinese manufacturers. One project (BRITESPACE) was funded by the EC, within the call FP7-SPACE-2012-1, related to semiconductor laser source for CO2 measurements. The project ended on Feb 2016, providing preliminary outcomes.
Date of Entry	30-November-2016

*Mission Classes: Earth Observation, Science Mission, Human Spaceflight, Space Transportation, Telecommunications, Navigation, Space Security, Robotic Exploration, Unmanned Aircraft Systems (UAS), Defence Applications

4.8 Propulsion

4.8.1 JTF-2018/20-33 - Advanced materials and material technology for combustion chambers [U4]

Description and needed Action	– Availability of export licence free materials and coatings for space engines (TRL 7). Mature process for Pt/Rh nozzle processes. – Ceramic chamber materials for advanced bi-propellant spacecraft engines (TRL 4) – Extend functional grading activities to cover also combustion chamber transition joints – Ceramic chamber for electric propulsion – Ceramic and ceramic/metal composite chamber materials for high temperature applications
Estimated Initial TRL:	2
Target TRL	4-7
Applicable Mission Class(es)	Earth Observation, Science Mission, Human Spaceflight, Space Transportation, Telecommunications, Navigation, Space Security, Robotic Exploration, Defence applications
Industrial Non-Dependence Concern	Industry consensus confirmed at the JTF convergence meeting (26 October 2016)
Delegations/Agencies voicing non-dependence concern on the item	Action approved by consensus at the Final Meeting of 28 November 2016
Reference(s):	
Remarks / Justifications	Part of COMPET 1-2015 of Horizon 2020 work programme for 2015. However, no projects were funded. Note (2015): As far as chemical propulsion is concerned, this activity is to address the current generation of spacecraft engine combustion chambers (i.e. MON/MMH) engines. It is not intended primarily to consider potential green propellants currently. There is an interest in considering materials for green propellants but note that the general H202 compatibility study (ESA GSTP) needs to be completed before a definite answer is available to the long term storage (and hence suitability) of H202.
Date of Entry / Last Date of Change	30-November-2016

5 APPENDIX A: TABLE OF ACRONYMS AND ABBREVIATIONS

AD	Analogue-to-digital
ADC	Analogue Digital Converter
AIT	Assembly, Integration & Test
AOCS	Altitude Orbit Control System
ARM	Asteroid Removal Mission
ARTES	ESA Advanced Research In Telecommunication Systems Programme
ARW	Angle Random Walk
ASIC	Application Specific Integrated Circuit
BiCMOS	Combination of Bipolar and CMOS technology
BOL	Beginning Of Life
CCD	Change-coupled Device
CIS	CMOS imaging sensor
CMOS	Complementary Metal Oxide Semiconductor
CMR	Carcinogenic, Mutagenic or toxic to Reproduction
CNC	CapTech National Coordinators (CNC)
CS	Compressive Sensing
CTB	ESCC Components Technology Board
DA	Digital-to-analogue
DAC	Digital Analogue Converter
DC	Direct Current
DIAL	Differential Absorption Lidar
DPR	Deployable Radiators
DSM	Deep Sub-Micron
DSP	Digital Signal Processor
EAR	Export Administration Regulations
ECSEL	Electronics Components and Systems for European Leadership
ECSS	European Cooperation for Space Standardization

ECHA	European Chemicals Agency
EDA	European Defence Agency
EOL	End Of Life
EQM	Engineering Qualification Model
ESA	European Space Agency
ESCC	European Space Components Coordination
FLPP	ESA Future Launchers Preparatory Programme
FOG	Fiber Optic Gyro
FPGA	Field Programmable Gate Array
GaAs	Gallium Arsenide
GaN	Gallium Nitride
GEO	Geostationary Orbit
GFLOPS	Giga Floating Operations Per Second
GNC	Guidance, Navigation & Control
GPP	General Purpose Processor
GPU	Graphic Processor Unit
Gsps	Giga samples per second
GSTP	ESA General Support Technology Programme
GTO	Geostationary Transfer Orbit
HEMT	High-Electron-Mobility Transistor
HET	Hall Effect Thruster
HSSL	High Speed Serial Link
HV	High Voltage
ICL	Integrated Current Limiter
I/F	Interface
I/O	Input/Output
IMU	Inertial Measurement Unit
IOD	In Obit Demonstration
IP	Internet Protocol
IPC	ESA Industry Policy Committee
IR	Infrared

ITAR	International Traffic in Arms Regulation
ITI	Innovation Triangle Initiative
JTF	Joint-Task-Force
JU	Joint Undertaking
LCA	Life Cycle Assessment
LEO	Low Earth Orbit
LNA	Low Noise Amplifier
LH2	Liquid Hydrogen
LNA	Low Noise Amplifier
LO	Local Oscillator
LOX	Liquid Oxygen
LUT	Look-up Table
LWIR	Long-Wave Infrared
MCU	Microcontroller Unit
MISHFET	Metal Insulator Semiconductor Heterostructure Field Effect Transistor
MMH	Monomethylhydrazine
MMIC	Monolithic Microwave Integrated Circuit
MON	Mixed Oxides of Nitrogen
MOS	Metal-Oxide-Semiconductor
MOSFET	Metal-Oxide-Semiconductor Field Effect Transistor
MS	Member States
MTM	Magnetometer
Nd:YAG	Neodymium-doped Yttrium Aluminium Garnet
NEA	Non-Explosive Actuator
NIR	Near Infrared
NoC	Network on Chip
NRZ, NRTZ	Non-return-to-zero
NVRAM	Non-Volatile Random-Access Memory
PCB	Printed Circuit Board
PFM	Proto-Flight Model
PLL	Phase-Lock-Loop
PMD	Propellant Management Device
POL	Point-of-load

PWM	Pulse-width modulator
R&D	Research and Development
RAD hard	Radiation hard
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
RF	Radio-Frequency
RTL	Regional Transfer Level
RTU	Remote Terminal Unit
SEE	Single-Event Effects
SEFI	Single Event Failure Interrupts
SERDES	Serializer/Deserializer
SEU	Single Event Upset
SiC	Silicon Carbide
SiGe	Silicon Germanium
SMA	Shape Memory Alloy
SME	Small and Medium-sized enterprise
SOC	System on Chip
SPI	Serial Peripheral Interface
SpW	Space Wire
S-PwL	Space-PowerLink
SVHC	Substance of Very High Concern
SW	Software
SWIR	Short Wavelength Infrared
TEC	Thermoelectric Cooler
THAG	ESA Technology Harmonisation Advisory Group
TID	Total Ionising Dose
TRL	Technology Readiness Level
TRP	ESA Basic Technology Research Programme Research Programme
TWT	Travelling Wave Tube
UAS	Unmanned Aircraft Systems
UDMH	Unsymmetrical dimethylhydrazine
UV	Ultraviolet
VMD	Vacuum Microelectronics Device
VLWIR	Very Long Wavelength Infrared