Critical Space Technologies

for

European Strategic Non-Dependence

Actions for 2015/2017

V1.16

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1 OBJECTIVES

In 2014, The European Commission, ESA and EDA launched, a new round of the European Non-Dependence Process with a view to establishing a list of actions on critical space technologies for European non-dependence to be implemented in the time frame of 2015-2017.

A consultation of European stakeholders allowed to gather feed-back from Member States, Industry and SMEs. The Joint Task Force (JTF) reviewed and consolidated the collected inputs.

This document reflects the consensus on the Critical Space Technologies for European Strategic Non-Dependence - Actions for 2015/2017 which was reached with the delegates of the Commission, ESA and EDA during the European Non-Dependence meeting held on 13 February 2015 in Brussels.

2 DISTRIBUTION OF THE DOCUMENT

This document is made available to all three participating institutions, their member states, relevant Industry and SMEs.

3 THE 2014-2015 ROUND OF EUROPEAN NON-DEPENDENCE PROCESS

An overview of the overall 2014-2015 process can be found below in Figure 1.

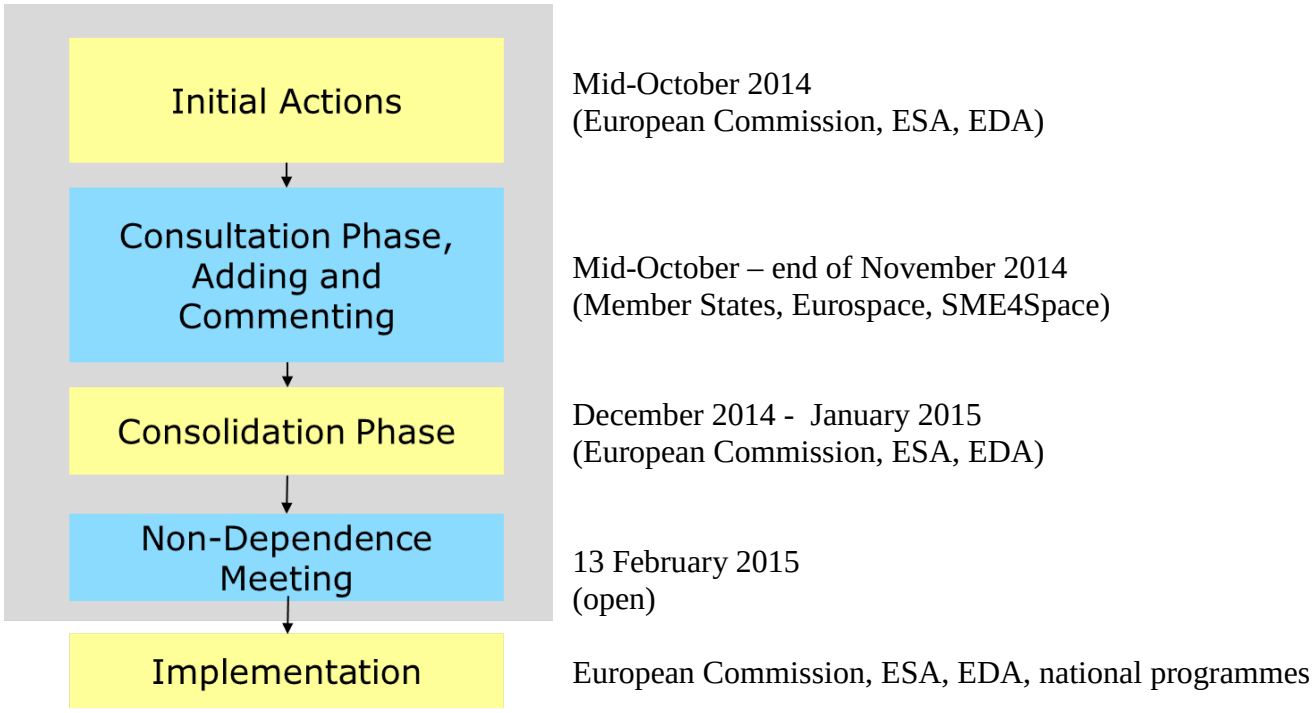

Figure 1 - European Non-Dependence Process in 2014-2015

Steps of the Process:

I. The original draft *Critical Space Technologies for European Strategic Non-Dependence - Actions for 2015/2017* was delivered for revision (updating/adding) suggestions to Member States (MS) and industry representatives.

II. Feedback on and additions to the draft *Actions for 2015-2017* were consolidated and distributed by the JTF to MS and industry representatives.

III. At the Non-Dependence Meeting, feedback from MS and industry representatives on the consolidated draft *Actions for 2015-2017* was recorded.

IV. The version of the *Actions for 2015-2017* emerging from the Non-Dependence Meeting was sent to MS representatives for final comments.

V. The final *Critical Space Technologies for European Strategic Non-Dependence - Actions for 2015/2017* is distributed to all European stakeholders.

VI. It is expected that the *Actions for 2015-2017* will then be implemented in national and European programmes. The Joint Task Force will work towards the establishment of monitoring and reporting mechanisms on the implementation of these actions.

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 identified actions is to contribute to ensuring European Non-dependence.

In particular, the criteria used to evaluate if a technology should be included in this action are:

1. Items shall be of low integration level, i.e. building blocks and components (System/sub-system assembly, methods and tools 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
- Target TRL
- Applicable Mission Class(es)*
- Order of Magnitude of numbers of restricted export licences in the last 10 years for this function**
- Order of Magnitude of numbers of units sold per year worldwide
- 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

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

** Export Licences (e.g. ITAR, EAR, …) (0, 1, >1, >10, >100, >1000, >> 1000) in the last 10 years. In case of change of export rules, a back projection can be done. Also if the current function is export controlled, these licence numbers can be used for next generation technology (e.g. GaN Power Mosfets can cite the export numbers of current Power MOSFETS).

4 NON-DEPENDENCE ACTIONS

In this chapter the non-dependence actions are shown.

The actions are not in order of priority.

4.1 U1 - Space qualification of low shock Non-Explosive Actuators (NEA)

Description and needed Action	Space qualification for non-explosive hold down and release actuators on-board a flight opportunity. This action principally refers to a hold down and release nut actuated by a non-explosive actuator. Current development activities have to be followed by flight opportunities to achieve flight heritage and subsequently access the commercial market with a full range (preload) of recurring products. The focus of the action is the development and qualification of flight hardware for this purpose, not the development of a specific In-Orbit Demonstration. The qualification of Hold Down & Release devices should not only concern the retaining capability versus the preload and the mechanical environment, but also the power consumption, the actuation resources i.e. input voltage, current and also the actuation time.
Estimated Initial TRL:	5
Target TRL	8
Applicable Mission Class(es)*	Target Application: especially Telecom, Science, Exploration and Navigation
Order of Magnitude of numbers of restricted export licences in the last 10 years for this function	>> 1000, approx. 10-30 in each satellite
Order of Magnitude of numbers of units sold per year worldwide	>1000
Industrial Non-Dependence Concern	Consensus confirmed at the Non-Dependence Meeting (13 February 2015)
Delegations/Agencies voicing non-dependence concern on the item	Consensus confirmed at the Non-Dependence Meeting (13 February 2015)
Reference(s):	
Remarks / Justifications	Part of COMPET 1-2014 of Horizon 2020 work programme for 2014 (1 project selected) Subject of 2015 Harmonisation effort (several on-going GSTP & ARTES funded activities). Note 1 (2015): The on-going ARTES and Horizon 2020 activities are based on different types of actuators i.e. fuse

	wire, SMA (Shape Memory Alloy) covering complementary application requirements in terms of pre-loading and actuation time response. Different application needs are therefore being addressed.
Date of Entry / Last Date of Change	1.9.2014

4.2 U2 - Advanced thermal control systems

Description and needed Action	In-orbit demonstrations of two-phase heat transport systems need to be identified and funded to enable improved thermal performance in European satellite platforms and payloads.
Estimated Initial TRL:	5
Target TRL	8
Applicable Mission Class(es)*	Target Application: High power / heat rejection mission, and other thermally challenging missions especially: Telecom and dual use, Defence applications
Order of Magnitude of numbers of restricted export licences in the last 10 years for this function	> 1000
Order of Magnitude of numbers of units sold per year worldwide	> 1000
Industrial Non Dependence Concern	Consensus confirmed at the Non-Dependence Meeting (13 February 2015)
Delegations/Agencies voicing non-dependence concern on the item	Consensus confirmed at the Non-Dependence Meeting (13 February 2015)
Reference(s):	Harmonisation effort performed in 2009
Remarks / Justifications	In addition an in-orbit demonstration of a complete deployable radiator is urgently needed to increase maturity and acceptance level for potential users. Note 1 (2013): The proposed activities can also include the development of technologies and elements for such a flight demonstration. Note 2 (2013): In view of the evolution of technology and

	requirements, the activities could also be extended to include mechanically pumped (single-phase or two-phase) heat transport systems. Note 3 (2015): In view of the increase of dissipated power in intensive data processing boards, the activities could also be extended to Miniaturised heat transport solutions to be applied at board level (miniaturised heat pipes, micro-loop heat pipes) and to thermal connectors at equipment level. Note 4 (2015): Pending adequate technical maturity i.e. initial TRL of 5, magnetically coupled pumps could also be considered. Part of COMPET 1-2014 of Horizon 2020 work programme for 2014 (1 project selected). Ground qualification of a complete Deployable Radiator (with Loop Heat Pipes) is being performed under ESA ARTES-8. 1 potential EDA project in preparation
Date of Entry / Last Date of Change	1.9.2014

4.3 U3 - Propellant flow and distribution components for chemical propulsion

Description and needed Action	Development and qualification of alternatives for access restricted flow and distribution components, especially the pressure regulators, the mass flow controller and the isolation valve including miniaturization and, eventually, integration of two or more components.
Estimated Initial TRL:	4
Target TRL	6
Applicable Mission Class(es)*	All missions, especially Telecom and Science
Order of Magnitude of numbers of restricted export licences in the last 10 years for this function	>100
Order of Magnitude of numbers of units sold per year worldwide	>10

Industrial Non Dependence Concern	Consensus confirmed at the Non-Dependence Meeting (13 February 2015)
Delegations/Agencies voicing non-dependence concern on the item	Consensus confirmed at the Non-Dependence Meeting (13 February 2015)
Reference(s):	Harmonisation effort performed in 2012
Remarks / Justifications	1 project selected in FP7 Call 6 (2013)
Date of Entry / Last Date of Change	1.9.2014

4.4 U4 - Advanced materials and material technology for combustion chambers

Description and needed Action	– Availability of export licence free materials and coatings for space engines (TRL 6) – Ceramic chamber materials for advanced bi-propellant spacecraft engines (TRL 4) – Ceramic chamber for electric propulsion
Estimated Initial TRL:	TRL 2-4
Target TRL	See above
Applicable Mission Class(es)*	Earth Observation, Science Mission, Human Spaceflight, Space Transportation, Telecommunications, Navigation, Space Security, Robotic Exploration, Defence applications
Order of Magnitude of numbers of restricted export licences in the last 10 years for this function	>50
Order of Magnitude of numbers of units sold per year worldwide	>5
Industrial Non-Dependence Concern	Consensus confirmed at the Non-Dependence Meeting (13 February 2015)
Delegations/Agencies voicing non-dependence concern on the item	Consensus confirmed at the Non-Dependence Meeting (13 February 2015)
Reference(s):	
Remarks / Justifications	Part of COMPET 1-2015 of Horizon 2020 work programme for 2015 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	1.9.2014

4.5 U5 - Alternative to Hydrazine in Europe

Description and needed Action	Ensure the availability of a less toxic alternative to Hydrazine • Both ESA and Industry are now looking at future chemical propulsion subsystem design with the relevant impacts on component development. • In addition the impact of the REACH regulations on Hydrazine has the potential to affect the availability of European propulsion systems. The worst case scenario is that the use of Hydrazine will be restricted or prohibited in Europe in the mid-term. To address this issue, it is important to act: • to identify , with the support of ECHA, the proper acceptable CMR and SVHC levels of the non-hydrazine propellants, • to invest in non-hydrazine propellants , with the aim of replacing, at least, the hydrazine performances, • to invest in technologies, including the qualification of appropriate thrust chamber and catalyst combinations, and all other parts coming into contact with the fuel, as tank and its PMD / diaphragm / bladder, piping, valves, etc. • to invest in technologies, including the qualification of appropriate flight and ground systems components
Initial Estimated TRL:	4
Target TRL	8
Applicable Mission Class(es)*	Earth Observation, Science Mission, Human Spaceflight, Space Transportation, Telecommunications, Navigation, Space Security, Robotic Exploration, Defence applications.

Order of Magnitude of numbers of restricted export licences in the last 10 years for this function	0 t
Order of Magnitude of numbers of units sold per year	Hydrazine for European space use is in the order of 2-5 t a year
Industrial Non-Dependence Concern	
Delegations/Agencies voicing non-dependence concern on the item	Consensus confirmed at the Non-Dependence Meeting (13 February 2015)
Reference(s):	*Chemical Propulsion Harmonisation Dossier: Green Propulsion* 2012
Remarks / Justifications	*The text refers to hydrazine availability as a potential future issue. This could be misunderstood by the reader. The propellant may remain available from current sources (e.g. China) even if REACH prohibits use in Europe. The real issue is potential prohibition or restriction of hydrazine use in Europe.* Costs vary considerably depending on the programmatic decision taken, especially with respect to hydrazine-derived propellants. For development of alternatives to Hydrazine on spacecraft costs can be in range from 5 – 10 million € per thruster class per propellant (depending also on necessity to qualify the alternative propellant itself). On the other hand costs for replacement of hydrazine-derived launcher stages can easily reach the order of several hundred million Euro. Part of COMPET 1-2014 of Horizon 2020 work programme for 2014 (1 project selected)
Date of Entry / Last Date of Change	1.9.2014

4.6 *U6 - Fiber optic or photonics integrated technology Gyro based inertial measurement unit (IMU)*

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 High Accuracy applications requiring Navigation grade gyros (class 0.001 deg/h - ARW <5*10-3deg/√h - Scale factor residual<10 ppm)
Estimated Initial TRL:	4
Target TRL	≥ 6
Applicable Mission Class(es)*	Navigation, Science Missions, Earth Observation, Human Spaceflight, Robotic Exploration, potential Telecommunications, Launcher, UAS, Defence applications (tbc)
Order of Magnitude of numbers of restricted export licences in the last 10 years for this function	>100
Order of Magnitude of numbers of units sold per year worldwide	>50
Industrial Non-Dependence Concern	Consensus confirmed at the Non-Dependence Meeting (13 February 2015)
Delegations/Agencies voicing non-dependence concern on the item	Consensus confirmed at the Non-Dependence Meeting (13 February 2015)
Reference(s):	Subject of 2015 Harmonisation effort
Remarks / Justifications	The target TRL of 6 implies at least the development of an IMU Engineering Model. Part of COMPET 1-2015 of Horizon 2020 work programme for 2015
Date of Entry / Last Date of Change	1.9.2014

4.7 U7 - Power amplification: Travelling Wave Tube (TWT) materials

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.
Order of Magnitude of numbers of restricted export licences in the last 10 years for this function	Currently no export restrictions but single source
Order of Magnitude of numbers of units sold per year worldwide	>1000
Industrial Non-Dependence Concern	Consensus confirmed at the Non-Dependence Meeting (13 February 2015)
Delegations/Agencies voicing non-dependence concern on the item	Consensus confirmed at the Non-Dependence Meeting (13 February 2015)
Reference(s):	
Remarks / Justifications	Part of COMPET 1-2015 of Horizon 2020 work programme for 2015
Date of Entry / Last Date of Change	1.9.2014

4.8 U8 - Spacecraft charging analysis tool

Note: Given the current activities underway this item has been removed from the list. ESA considers that it is not necessary to continue to identify a spacecraft charging analysis tool as a missing critical technology, since many years of healthy investment by ESA has led to establishment of a tool (SPIS), and it is clear that the competence has now been established in Europe to avoid reliance on non-European tools, just as in similar domains (radiation analysis tools, thermal tools, etc.).

4.9 U9 - Cost-effective high quality Ge-substrates and high performance, cost effective multi - junction solar cells for space applications

Description and needed Action	• The near term needs are 33% efficiency cell to be qualified at the latest in 2016 and in a next step for the 35% BOL/30% EOL cell in the 2020 time frame • Development and introduction of a quadruple junction solar cell for space (maybe even quintuple or sextuple) for which volume production is foreseen within 5 years. The main cell concepts under investigation are lattice matched quadruple-quintuple cells, lattice mismatched quadruple-sextuple cells, inversely grown quadruple-sextuple solar cells and quadruple solar cells realized by semiconductor bonding processes. • Cost-effective high quality Ge - substrates are required for present and next generation multi-junction solar cells in space. Requirements - For next generation solar cells: o Efficiency push to 35% BOL and 30% EOL o Reliability analysis - For Ge substrates: - Reduction of production costs at guaranteed high product quality - Adopt a proper life cycle assessment approach (LCA) to reduce environmental impact focussing on an effective recycling approach
Estimated Initial TRL:	2-4 (for next generation solar cells, depending on the concept)
Target TRL	5-6 (for next generation solar cells, depending on the concept)
Applicable Mission Class(es)*	Earth Observation, Science Mission, Human Spaceflight, Telecommunications, Navigation, Space Security, Robotic Exploration

Order of Magnitude of numbers of restricted export licences in the last 10 years for this function	NA, current generation European solar cells are used
Order of Magnitude of numbers of units sold per year worldwide	between 500,000 and 1,000,000 cells
Industrial Non-Dependence Concern	Consensus confirmed at the Non-Dependence Meeting (13 February 2015)
Delegations/Agencies voicing non-dependence concern on the item	Consensus confirmed at the Non-Dependence Meeting (13 February 2015)
Reference(s):	Subject of 2015 Harmonisation effort
Remarks / Justifications	For the time being the work horse solar cell for almost all European and many international satellite projects is the lattice-matched triple cell technology. This technology has reached the end of its evolution with the 3G30 and the CTJ30 solar cell whose qualifications are finalized at the moment. For the development, qualification and product introduction of the next generation multi-junction solar cell (efficiency up to 35% BOL and 30% EOL) a strong effort in a very competitive US-European market environment is needed, an effort comparable to the transition from silicon single junction solar cells to triple GaAs solar cells. Very significant investments are made in the US. 1 project running (FP7 Call 6 - 2013)
Date of Entry / Last Date of Change	1.9.2014

4.10 U10 - Digital Signal Processor (DSP) computers

Description and needed Action	Adaptation and radiation hardening of an existing DSP commercial device or suitable IP, prototyping and space qualification. Basic requirements for a next generation Space DSP include a theoretical processing power of at least 2 GFLOPS, hardware support of floating point data format, immunity against SEE and sufficient total dose hardness, deterministic operation for real time applications, high speed interfaces and built-in interfaces to typical DSP building blocks (ADC, DAC).
Estimated Initial TRL:	3-4
Target TRL	6
Applicable Mission Class(es)*	Earth Observation, Science Mission, Telecommunications, Defence applications
Order of Magnitude of numbers of restricted export licences in the last 10 years for this function	Up to several hundred (lack of NGDSP ASIC is partially compensated via large ITAR FPGAs)
Order of Magnitude of numbers of units sold per year worldwide	Up to several hundred (lack of NGDSP ASIC is partially compensated via large ITAR FPGAs)
Industrial Non-Dependence Concern	Consensus confirmed at the Non-Dependence Meeting (13 February 2015)
Delegations/Agencies voicing non-dependence concern on the item	Consensus confirmed at the Non-Dependence Meeting (13 February 2015)
Reference(s):	Reference documents: “Microelectronics: ASIC and FPGA”. European Space Technology Harmonisation Technical Dossier, Jan-2012
Remarks / Justifications	Investments in the order of ~10 M€ needed in total. 1 FP7 (6th call -2013) activity on-going.
Date of Entry / Last Date of Change	1.9.2014

4.11 U11 - ASICS for Mixed Signal Processing

Description and needed Action	• Need to qualify export restriction free rad-hard mixed signal technologies • Establish development, verification and validation standards for derived IP cores • Establish an independent ASIC source in Europe based on a commercial 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:	
Target TRL	7
Applicable Mission Class(es)*	Earth Observation, Science Mission, Telecommunications, Navigation, Robotic Exploration, Defence Applications
Order of Magnitude of numbers of restricted export licences in the last 10 years for this function	>100, significantly higher if FPGAs under are ITAR are included which are used for the same function
Order of Magnitude of numbers of units sold per year worldwide	> 1000
Industrial Non-Dependence Concern	Consensus confirmed at the Non-Dependence Meeting (13 February 2015)
Delegations/Agencies voicing non-dependence concern on the item	Consensus confirmed at the Non-Dependence Meeting (13 February 2015)
Reference(s):	
Remarks / Justifications	Increased demand for mixed signal ASICS in Telecommunications and scientific satellites. Also for medium and high voltage applications Part of COMPET 1-2014 of Horizon 2020 work programme for 2014 (1 project selected).). 1 running EDA project
Date of Entry / Last Date of Change	1.9.2014

4.12 U12 - High Capacity FPGAs

Description and needed Action	Validation of a high capacity Rad Hard Reprogrammable Field-Programmable Gate Array (FPGA) of European source and development and validation of software tools This includes in particular validation and FPGA product consolidation activities such as: • FPGA 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) migration to 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 • Critical tests associated to complex packages • Support for ESCC evaluation and qualification tests with a commercial view. The target European Space FPGA shall have a silicon proven architecture with the requirements indicated in the Remarks (please see remarks)
Estimated Initial TRL:	4
Target TRL	6
Applicable Mission Class(es)*	Earth Observation, Science Mission, Human Spaceflight, Telecommunications, Navigation, Space Security, Robotic Exploration, Defence Applications
Order of Magnitude of numbers of restricted export licences in the last 10 years for this function	>>1000
Order of Magnitude of numbers of units sold per year worldwide	>1000
Industrial Non-Dependence Concern	Consensus confirmed at the Non-Dependence Meeting (13 February 2015)
Delegations/Agencies	Consensus confirmed at the Non-Dependence Meeting (13

voicing non-dependence concern on the item	February 2015)
Reference(s):	Reference documents: “Microelectronics: ASIC and FPGA”. European Space Technology Harmonisation Technical Dossier, Jan-2012
Remarks / Justifications	The target European Space FPGA shall be part of a family of European FPGAs with at least two versions (0.8 Mgates and >1.5 Mgates) to address 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: ▪ It shall withstand a Total Ionising Dose (TID) up to 300 krad (Si) ▪ It shall be Latch-up immune for Linear Energy Transfer (LET) up-to 80 MeV/mg/cm^2. ▪ The sensitivity to Single Event Upsets (SEUs) shall be such that no additional radiation mitigation techniques should be done by the FPGA designer in the majority of space applications . ▪ The FPGA shall not have Single Event Failure Interrupts (SEFIs) due to radiation effects. • 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 product shall not be subject to Non-European export restrictions (98 % of the space FPGAs being used today in all European missions are now subject to ITAR/EAR export control), and be based as much as possible in European technology. 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). Part of COMPET 1-2015 of Horizon 2020 work programme for 2015. Part of ECSEL JU work programme for 2014. 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	1.9.2014

4.13 U13 - Passive components

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 targeted include super capacitors, modular connectors, miniaturisation of DC/RF connectors, RF passive attenuators, coil transformers and lower size chip capacitors and resistors, heaters, coolers, Peltier Thermo Electric Cooling. – Qualifications of cable assemblies especially for high RF power, high voltage, high speed. Activities should follow the recommendations with regard to highest priority items from European Space Components Co-ordination (ESCC) via CTB.
Target TRL:	6
Estimated Initial TRL	4 (usually)
Applicable Mission Class(es)*	Earth Observation, Science Mission, Human Spaceflight, Space Transportation, Telecommunications, Navigation, Space Security, Robotic Exploration
Order of Magnitude of numbers of restricted export licences in the last 10 years for this function	>>1000
Order of Magnitude of numbers of units sold per year worldwide	>>1000
Industrial Non-Dependence Concern	Consensus confirmed at the Non-Dependence Meeting (13 February 2015)
Number of Delegations/Agencies voicing non-dependence concern on the item	Consensus confirmed at the Non-Dependence Meeting (13 February 2015)
Reference(s):	
Remarks / Justifications	
Date of Entry / Last Date of Change	1.9.2014

4.14 U14 - Active discrete power components

Description and needed Action	Development and qualification of active components (like diodes) assuring unrestricted availability of space qualified high reliability components in Europe – CMOS MOSFET transistors – GaN diodes & transistors – Power functions: POL, PWM, ICL, drivers (MOS) The recommendations from European Space Components Co-ordination (ESCC) via CTB will be taken into account.
Target TRL:	6
Estimated Initial TRL	4 (usually)
Applicable Mission Class(es)*	Earth Observation, Science Mission, Human Spaceflight, Space Transportation, Telecommunications, Navigation, Space Security, Robotic Exploration
Order of Magnitude of numbers of restricted export licences in the last 10 years for this function	>>1000
Order of Magnitude of numbers of units sold per year worldwide	>>1000
Industrial Concern	Consensus confirmed at the Non-Dependence Meeting (13 February 2015)
Number of Delegations/Agencies voicing non-dependence concern on the item	Consensus confirmed at the Non-Dependence Meeting (13 February 2015)
Reference(s):	See ESCC Dossier
Remarks / Justifications	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	1.9.2014

4.15 U15 - Photonics components

Description and needed Action	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. • 10 Gbps 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. Photonics components needed for future optical telecom payloads functions like: frequency generation, up/down conversion, local oscillator distribution and optical switching, and optical beam forming. In particular components such as: phase modulators, Er fibre amplifiers, large matrix optical switch, high dynamic range - high frequency detectors for optical RF links. Micro-photonic integration of active and passive components (phase and frequency modulation) for compact low phase noise RF frequency generation and control in the optical domain.
Target TRL:	7
Estimated Initial TRL	4
Applicable Mission Class(es)*	Earth Observation, Science Mission, Human Spaceflight, Space Transportation, Telecommunications, Navigation, Space

	Security, Robotic Exploration, Defence applications
Order of Magnitude of numbers of restricted export licences in the last 10 years for this function	N/A VCSEL based transceivers have not been used in any European space missions to date. SMOS has flown digital optical links, using FP lasers and at a lower data rate (100Mbps). COTS components were qualified for the SMOS mission - Modulight (Fin) lasers. AlphaSat and Proba V both have IODs of fibre optic communication links, using VCSEL transceiver from DAS Photonics (E). In both cases the data rate was limited to 100Mbps. Proba V IOD also contains high density COTS fibre optic cable assemblies.
Order of Magnitude of numbers of units sold per year worldwide	N/A Today optical solutions are not the base line for either Space Fibre or for Telecom digital processors, even though they have some significant advantages over the electrical technology. First Space Fibre prototypes have been sold in in the order of a few 10s. Future digital telecom processors could require over a 1000 optical links to support the internal data traffic which equates to 100s of optical modules per processor.
Industrial Concern	Consensus confirmed at the Non-Dependence Meeting (13 February 2015)
Delegations/Agencies voicing non-dependence concern on the item	Consensus confirmed at the Non-Dependence Meeting (13 February 2015)
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. 3 projects running (FP7 Call 6 - 2013) EDA projects: 1 on-going and 1 planned.
Date of Entry / Last Date of Change	1.9.2014

4.16 U16 - Space qualified GaN components and demonstrators

Description and needed Action	Qualify and demonstrate qualified GaN Technology . Development /Space evaluation / qualification of: – Higher frequency GaN HEMT technology for improvement of Noise performance and robust receiver operation and robust low-loss series and parallel switches for applications up to Ka Band – 2nd generation GaN technology (L-C band (0.5µm) and X-Ku band (0.25µm)). – GaN MISHFET & diodes – RF front-ends based on GaN technology – Robust GaN MMIC process (improved integrated passive components robustness) - High thermal dissipative packaging for GaN
Estimated Initial TRL:	5, if not stated differently
Target TRL	6, if not stated differently
Applicable Mission Class(es)*	Earth Observation, Science Mission, Human Spaceflight, Space Transportation, Telecommunications, Navigation, Space Security, Robotic Exploration, Defence Applications
Order of Magnitude of numbers of restricted export licences in the last 10 years for this function	<100 (in function, not yet in GaN)
Order of Magnitude of numbers of units sold per year worldwide	> 1000 (in function, not yet in GaN)
Industrial Non-Dependence Concern	Consensus confirmed at the Non-Dependence Meeting (13 February 2015)
Delegations/Agencies voicing non-dependence concern on the item	Consensus confirmed at the Non-Dependence Meeting (13 February 2015)
Reference(s):	For RF: Harmonisation Dossier ESA/IPC/THAG(2013)10 Critical RF Technologies: GaN & SiGe
Remarks / Justifications	1 EDA project on-going. 2 FP7 (6th call -2013) activities on-going. Note 1 (2015): Radiation resistant GaN components on GaN substrates could also be considered.
Date of Entry / Last Date of Change	1.9.2014

4.17 U17 - High density (up to 1000 pins and beyond) assemblies on PCB and PCBs

Description and needed Action	• A solution for high pin count assemblies (1000 pins and beyond) is needed. • 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. This action is for both Digital as well as Mixed ASIC packages
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
Order of Magnitude of numbers of restricted export licences in the last 10 years for this function	>10 (now increasing)
Order of Magnitude of numbers of units sold per year worldwide	50- 100
Industrial Non-Dependence Concern	Consensus confirmed at the Non-Dependence Meeting (13 February 2015)
Delegations/Agencies voicing non-dependence concern on the item	Consensus confirmed at the Non-Dependence Meeting (13 February 2015)
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	1.9.2014

4.18 U18 - Enhanced performance and space qualified detectors

Description and needed Action	High-performance CMOS image sensors (CIS) continue to be a requirement for future Earth Observation, Science and Astronomy missions with sensitivity from UV to VLWIR. In the infrared, a good base of European manufacturers is available and recent developments in NIR, SWIR and LWIR continue to improve the range of technologies on offer. However, it is clear that further progress is both necessary and possible in terms of improved performances and exploitation of different material systems. Large format arrays in the NIR and SWIR are essential for future missions as are longer wavelength detectors with lower dark currents. In the visible waveband (UV is also included here), CCDs continue to dominate due to their higher electro-optical performances. While this remains the case, it is not possible to fully exploit the inherent advantages on offer from CIS (lower power, faster readout, enhanced radiation tolerance, ease of interfacing…) and it is a high priority goal to meet this challenge. Two approaches are possible: 1. European design house coupled with non-European foundry 2. European design house coupled to European foundry Option 1 is likely to provide the best performance in the shorter term, but is only partial non-dependence and consequently subject to more external influences. Option 2 implies full European non-dependence and potentially better control over the processes. However, the European foundry landscape is currently changing and developments need to be targeted and controlled. This said, it is still considered a high priority to develop and support a stable, European CIS supply chain.
Estimated Initial TRL:	2-5
Target TRL	8
Applicable Mission Class(es)*	Earth Observation, Science Mission, Defence applications
Order of Magnitude of numbers of restricted export licences in the	50 - 200

last 10 years for this function	
Order of Magnitude of numbers of units sold per year worldwide	1000
Industrial Non-Dependence Concern	Consensus confirmed at the Non-Dependence Meeting (13 February 2015).
Delegations/Agencies voicing non-dependence concern on the item	Consensus confirmed at the Non-Dependence Meeting (13 February 2015)
Reference(s):	ESA Harmonisation 2015: Optical Sensors, visible range
Remarks / Justifications	High-performance image sensors (and not just in the infrared) are state-of-the-art for high-end applications and consequently subject to export control. EDA activity “High Resolution Imaging”.
Date of Entry / Last Date of Change	1.9.2014

4.19 U19 - High speed DAC-ADC based on European Technology

Description and needed Action	Current status:, the existing 10 & 12bit high speed ADC and 12bit DAC were developed and are successful products on the market. The 12-bit high speed DAC has even gained world leadership in the market and the 12-bit high speed ADC has world-class performance parameters. Future needs: - Fast, Low power Dual Channel ADC ; the next generation of European ADC (DUAL12b) has started development on BiCMOS process. - New DAC generation today not planned . Serial/deserial I/O are being considered (see also U21-Very high speed serial interfaces) - 1.5 Gsamples per Second target
Estimated Initial TRL:	2 (for next generation), >6 for current generation
Target TRL	6 (for next generation)
Applicable Mission Class(es)*	Navigation, Earth Observation, Telecommunications, Science Mission, Human Spaceflight, Space Transportation, Robotic Exploration, Defence Applications
Order of Magnitude of numbers of restricted export licences in the last 10 years for this function	500 – 1000 (before the European products became available)
Order of Magnitude of numbers of units sold per year worldwide	>100
Industrial Non-Dependence Concern	Consensus confirmed at the Non-Dependence Meeting (13 February 2015)
Delegations/Agencies voicing non-dependence concern on the item	Consensus confirmed at the Non-Dependence Meeting (13 February 2015)
Reference(s):	
Remarks / Justifications	Note 1 (2015): Additionally, photonic assisted ADC will be considered as a possible candidate to go beyond the limits of the current technology. This technology will be very useful for telecom digital payloads and digital antennas. EDA activities: on-going THIMS project, planned PICTURE project.
Date of Entry / Last Date of Change	1.9.2014

4.20 U20 - Very high performance microprocessors

Description and needed Action	Next Generation MicroProcessor (NGMP) is a 4 core LEON4 based microprocessor targeting the 1 GIPS (giga-instruction-per-second) performance range (http://microelectronics.esa.int/ngmp/). The development strongly relies on the 65 nm DSM developments (DSM libs, high pin count flip-chip packages) Functional (non rad-hard) prototypes are available, and the implementation on rad-hard 65 nm (DSM) technology is currently in progress (2014-2015). Needed actions are validation and qualification activities, e.g. via flight model development and user experience. For future generations of microprocessors, beyond the 65 nm, the development of more advanced DSM technologies will be necessary.
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
Order of Magnitude of numbers of restricted export licences in the last 10 years for this function	>10 (usage of Maxwell Power PC boards) Much larger, if ITAR restricted FPGAs would be counted, which are used as an alternative to high performance processors.
Order of Magnitude of numbers of units sold per year worldwide	>100. With an expected product life time of > 10 years, a total count of > 1000 flight parts is expected.
Industrial Non-Dependence Concern	Consensus confirmed at the Non-Dependence Meeting (13 February 2015)
Delegations/Agencies voicing non-dependence concern on the item	Consensus confirmed at the Non-Dependence Meeting (13 February 2015)
Reference(s):	Reference documents: “Microelectronics: ASIC and FPGA”. European Space Technology Harmonisation Technical Dossier, Jan-2012
Remarks / Justifications	Currently Europe is leading in the development of the next generation high performance microprocessor; however the final step of the space qualification is needed. 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	1.9.2014

4.21 U21 - Very high speed serial interfaces

Description and needed Action	Development/Industrialisation of an European high speed serial interface (serialiser/deserialiser) component based on Deep Sub Micron (DSM) technology and using Flip-Chip packaging, with a throughput >= 6,25 Gbps per line.
Estimated Initial TRL:	3
Target TRL	6
Applicable Mission Class(es)*	Earth Observation, Science Mission, Telecommunications, Defence applications
Order of Magnitude of numbers of restricted export licences in the last 10 years for this function	> 500 (esp. US TLK 2711, Wizardlink)
Order of Magnitude of numbers of units sold per year worldwide	> 100
Industrial Non-Dependence Concern	Consensus confirmed at the Non-Dependence Meeting (13 February 2015)
Delegations/Agencies voicing non-dependence concern on the item	Consensus confirmed at the Non-Dependence Meeting (13 February 2015)
Reference(s):	
Remarks / Justifications	Such a component would be a pilot example for European DSM technology, where the basic design needed for such a component are already developed in the DSM context. It would be a generation ahead with respect to the current non-European component. Note 1 (2015): An open standard for very high speed serial interfaces (SpaceFibre) will be standardised through ECSS in 2015. IP cores will be developed and be made available. The first activity towards the development of an corresponding interface chip for data rates up to 25Gbit/sec based on European Deep Sub-micron technology will be started in 2015 with TRP funding. The significant funding for the following steps to implement and qualify the corresponding devices is not yet secured.
Date of Entry / Last Date of Change	1.9.2014

4.22 U22 - ASICS: Deep Sub-Micron (DSM)

Description and needed Action	ESCC qualification of the 65 nm technology and first products, extended test vehicles and packaging aspects. In the 65 nm library it is necessary to include elements oriented to the development of Mixed Signal Multiprocessors System-on-Chip (MPSoC), such as Fast and Slow DACs and ADCs for data acquisition and housekeeping as well as analogue multiplexers or Network on Chip (NoC) modules.
Estimated Initial TRL:	5
Target TRL	≥6
Applicable Mission Class(es)*	Earth Observation, Science Mission, Human Spaceflight, Space Transportation, Telecommunications, Navigation, Space Security, Robotic Exploration, Defence applications
Order of Magnitude of numbers of restricted export licences in the last 10 years for this function	>>1000 (including FPGAs build in lower than 100nm processes)
Order of Magnitude of numbers of units sold per year worldwide	>>1000 (see e.g. FPGAs)
Industrial Non-Dependence Concern	Consensus confirmed at the Non-Dependence Meeting (13 February 2015)
Delegations/Agencies voicing non-dependence concern on the item	Consensus confirmed at the Non-Dependence Meeting (13 February 2015)
Reference(s):	
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. Part of ECSEL JU work programme for 2014.
Date of Entry / Last Date of Change	1.9.2014

4.23 U23 - Development of Large Deployable structures for Antennas

Description and needed Action	For the continuation of the developments in order to reach a relevant TRL as presented in the Roadmaps of Telecommunications Antennas and considering the strategic nature of the product and the need for non-dependence, immediate action to establish a viable programmatic road forward was done (see reference below). The next step is the qualification and the development of a flight model of an antenna >5 m. Due to the complexity of such structures, in particular the deployment and on orbit dynamics, flight demonstrations will be necessary at one point. The other technologies related to these antenna such as reflective surface net, deployment mechanisms, hold-down and pointing, RF and mechanical design methodologies are also of strategic interest.
Estimated Initial TRL:	3
Target TRL	8
Applicable Mission Class(es)*	Telecommunications, Earth Observation, Science mission, Defence applications
Order of Magnitude of numbers of restricted export licences in the last 10 years for this function	<10
Order of Magnitude of numbers of units sold per year worldwide	10 (definition > 4m)
Industrial Non-Dependence Concern	Consensus confirmed at the Non-Dependence Meeting (13 February 2015)
Delegations/Agencies voicing non-dependence concern on the item	Consensus confirmed at the Non-Dependence Meeting (13 February 2015)
Reference(s):	Large Reflector Antenna Working Group, Final Report, TEC-EEA/2010.595/CM CEAS Space Journal Vol 5 No 3-4 Dec 2013, Special Issue on Large Reflector Antennas.
Remarks / Justifications	The US has a quasi-monopoly in this field. Development of a 12 m aperture EQM can be estimated for about 15 MEuro Development of a 12 m aperture EQM and a 12 m PFM with deployable arm can be estimated for about 25 MEuro.

	Note 1 (2015): Large deployable structures for Radar antenna could also be considered.
Date of Entry / Last Date of Change	1.9.2014

4.24 U24 - Low cost, solid green propellant formulations

Description and needed Action	Find and qualify competitive more environmentally friendly solid propellant formulations Ensure development of solid green propellants which will introduce application cost reduction and great care of natural environment and staff while simultaneously providing the same or similar efficiency as current propellants in use.
Estimated Initial TRL	
Target TRL	6
Applicable Mission Class(es)*	Earth Observation, Science Mission, Human Spaceflight, Space Transportation, Telecommunications, Navigation, Space Security, Robotic Exploration, Unmanned Aircraft Systems (UAS), Defence Applications
Order of Magnitude of numbers of restricted export licences in the last 10 years for this function	
Order of Magnitude of numbers of units sold per year	Green propellants for European space use (laboratory use) is in the order of 1-2t a year
Industrial Non-Dependence Concern	
Delegations/Agencies voicing non-dependence concern on the item	Some non-dependence concerns expressed during the European Non-Dependence meeting (13 February 2015)
Reference(s)	
Remarks / Justifications	
Date of Entry / Last Date of Change	January 2015

4.25 U25 - ASIC: Availability of IP Cores

Description and needed Action	Ensure access and compatibility (interfaces) of European public funded IP Cores for space – Ensure Coordination between Agencies, EC and on national level – Define a list of target IPs to be developed. These IPs should cover at least the IPs implementing the compression, encoding and communication standards. – Promote re-use of IP cores and ensure easy access to the licences – Manage IP cores data lifecycle – Maintenance and growth of European IP cores, which can be made available
Estimated Initial TRL:	n.a.
Target TRL	n.a.
Applicable Mission Class(es)*	Earth Observation, Science Mission, Human Spaceflight, Space Transportation, Telecommunications, Navigation, Space Security, Robotic Exploration
Order of Magnitude of numbers of restricted export licences in the last 10 years for this function	n.a.
Order of Magnitude of numbers of units sold per year worldwide	Currently ca 40 European licences a year
Industrial Non-Dependence Concern	Consensus confirmed at the Non-Dependence Meeting (13 February 2015)
Delegations/Agencies voicing non-dependence concern on the item	Consensus confirmed at the Non-Dependence Meeting (13 February 2015)
Reference(s):	
Remarks / Justifications	The Action takes into account support for IP implementation in all kind of applications IP Cores which are made available to the European space community need to be guaranteed to have been specified, verified validated and documented to a defined standard. An application lifecycle management approach could be helpful,

	both for hardware and software, in order to manage the knowledge related to the whole IP Cores life cycle, from the management of functional requirements and user's feedback during design and release of new IP Cores, to the licensing to third parties.
Date of Entry / Last Date of Change	1.9.2014

4.26 U26 - Space qualified carbon fibre and pre-impregnated material sources for launcher and satellite subsystems

Description and needed Action	Today, high performance carbon fibre materials are required in almost all space relevant applications, appearing in components in launchers and satellites. However, there are no European suppliers of high performance (e.g. high or intermediate modulus) carbon fibres, no capacity to perform new developments on the precursor and to supply high modulus intermediate products, such as reinforcement fabrics or specialised pre-impregnated materials. Therefore, dedicated development strategies need to be followed to enhance European capability with the aim to support the establishment of an innovative industry and supply chain, and, if economically viable, provide access to manufacturing slots.
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, Launcher vehicles
Order of Magnitude of numbers of restricted export licences in the last 10 years for this function	0
Order of Magnitude of numbers of units sold per year	1-10 t in Europe
Industrial Non-Dependence Concern	Consensus confirmed at the Non-Dependence Meeting (13 February 2015)
Delegations/Agencies voicing non-dependence concern on the item	Consensus confirmed at the Non-Dependence Meeting (13 February 2015)

Reference(s):	2014 Harmonisation Dossier: Composite Materials
Remarks / Justifications	In 2014 an European Harmonisation on this topic was undertaken, where the European needs and needed actions were identified and agreed on.
Date of Entry / Last Date of Change	1.9.2014

4.27 N27 – RF components

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.
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
Order of Magnitude of numbers of restricted export licences in the last 10 years for this function	
Order of Magnitude of numbers of units sold per year	
Industrial Non-Dependence Concern	Consensus confirmed at the Non-Dependence meeting (13 February 2015)
Delegations/Agencies voicing non-dependence concern on the item	Consensus confirmed at the Non-Dependence meeting (13 February 2015)
Reference(s)	

Remarks / Justifications	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	January 2015

4.28 N28- Non Dependence of materials and processes

Description and needed Action	The activity should aim to identify critical European materials and processes affected by the REACH regulations and aim towards green and sustainable long-term replacement solutions e.g. alternative materials for metallic anodizing and passivation, protective and hardener coatings free of Cr3+ Cr6+, etc. Space environment qualification is needed. Dependence is also to be identified outside the REACH domain through ITAR, e.g. the case of black Kapton.
Estimated Initial TRL	N.A
Target TRL	N.A
Applicable Mission Class(es)*	Earth Observation, Science Mission, Human Spaceflight, Space Transportation, Telecommunications, Navigation, Space Security, Robotic Exploration, Defence applications
Order of Magnitude of numbers of restricted export licences in the last 10 years for this function	
Order of Magnitude of numbers of units sold per year	
Industrial Non-Dependence Concern	Consensus expressed at the Non-Dependence meeting (13 February 2015)
Delegations/Agencies voicing non-dependence concern on the item	Consensus expressed at the Non-Dependence meeting (13 February 2015)
Reference(s)	

Remarks / Justifications	
Date of Entry / Last Date of Change	January 2015

4.29 N33- PROM (Programmable Read Only Memory)

Description and needed Action	Development and qualification of a Programmable Read Only Memory, PROM, assuring unrestricted availability of space qualified high reliability components in Europe
Estimated Initial TRL	
Target TRL	7
Applicable Mission Class(es)*	Earth Observation, Science Mission, Human Spaceflight, Space Transportation, Telecommunications, Navigation, Space Security, Robotic Exploration
Order of Magnitude of numbers of restricted export licences in the last 10 years for this function	>>1000
Order of Magnitude of numbers of units sold per year	>1000
Industrial Non-Dependence Concern	
Delegations/Agencies voicing non-dependence concern on the item	Some non-dependence concerns expressed during the European Non-Dependence meeting (13 February 2015).
Reference(s)	
Remarks / Justifications	PROMs (Programmable Read-Only Memory) are used in basically all kinds of devices containing processors.

	European Space industry is on reliant on sources/suppliers outside of Europe (USA). Today not an ITAR product, but is still connected to certain export restrictions
Date of Entry / Last Date of Change	January 2015

4.30 N34 – Drivers for CAN (Controller Area Network) bus compliant with ISO (International Organisation for Standardisation)

Description and needed Action	Development and qualification of CAN bus drivers compliant with ISO, assuring unrestricted availability of space qualified high reliability components in Europe. CAN bus is being more frequently used and is foreseen to grow in usage increasing the need to have more sources available on the market, and unrestricted access
Estimated Initial TRL	
Target TRL	7
Applicable Mission Class(es)*	Earth Observation, Science Mission, Human Spaceflight, Space Transportation, Telecommunications, Navigation, Space Security, Robotic Exploration, Defence applications
Order of Magnitude of numbers of restricted export licences in the last 10 years for this function	>1000 CAN bus technology not widely used within European space missions to date, but will increase
Order of Magnitude of numbers of units sold per year	>100
Industrial Non-Dependence Concern	
Delegations/Agencies voicing non-dependence concern on the item	Some potential long-term non-dependence concerns expressed during the European Non-Dependence meeting (13 February 2015).
Reference(s)	

Remarks / Justifications	Usage of CAN bus technology is predicted to increase in many fields. An increase is also predicted for future space applications. Today, European Space industry is reliant on source/supplier outside of Europe (USA). ESA:This activity proposal is seen as only low priority as there exist already 2 US alternatives which are non ITAR and which fulfil our requirements. In addition an ESA IP core has been developed which can be implemented in a European technology platform (DARE).
Date of Entry / Last Date of Change	January 2015

4.31 N35- High pressure very light tank for space applications

Description and needed Action	Development and qualification of high pressure very light tanks for space applications.
Estimated Initial TRL	4
Target TRL	6
Applicable Mission Class(es)*	All Classes: Earth Observation, Science Mission, Human Spaceflight, Space Transportation, Telecommunications, Navigation, Space Security, Robotic Exploration, Unmanned Aircraft Systems (UAS), Defence Applications
Order of Magnitude of numbers of restricted export licences in the last 10 years for this function	
Order of Magnitude of numbers of units sold per year	
Industrial Non-Dependence Concern	Consensus expressed during the European Non-Dependence meeting (13 February 2015).
Delegations/Agencies voicing non-dependence concern on the item	Consensus expressed during the European Non-Dependence meeting (13 February 2015).
Reference(s)	The European Space Industry largely depends on US, Israel and a limited number of other non-European Countries. Access to Israel company (Raphael) products for some

	national companies has been very difficult on this topic. This key-component is very often a determinant factor for a go no-go decision on the real development of many innovative and also conventional Space programmes.
Remarks / Justifications	
Date of Entry / Last Date of Change	January 2015

4.32 N36- High Dose and High Speed SRAMS for Deep Space

Description and needed Action	SRAMs for space application are typically tailored for LEO (100krad) and GEO (300krad) but not for Deep Space Scientific Mission (e.g. JUICE) where TID required exceeds 1Mrad. Development of High Dose (TID >1Mrad) and High Speed (access time <20ns) for SRAM based products (Synchronous and Asynchronous SRAMs, High Speed CAMs and High Performance Cache memories) to be used as Stand Alone products or IP-core memory modules (Cache memories for core processors).
Estimated Initial TRL:	4
Target TRL	6-7
Applicable Mission Class(es)*	Science Mission (JUICE), Space Transportation, Robotic Exploration, Deep Space Mission, Long Term Mission
Order of Magnitude of numbers of restricted export licences in the last 10 years for this function	
Order of Magnitude of numbers of units sold per year	>100
Industrial Non-Dependence Concern	
Delegations/Agencies voicing non-dependence concern on the item	
Reference(s):	
Remarks / Justifications	ESA: ultra-rad hard (by process and transistor level design) high-speed SRAM (on and off-chip) actual and future needs should be studied more in depth during 2015 , with the help of

	the ESCC CTB Silicon WG experts, and with eventual support of the Microelectronics Harmonisation Dossier revision exercise. Today we rely on higher level mitigation techniques (error detection and correction codes, off-chip mitigation when errors are detected. New memory technology and architectures maybe attractive and help to reduce the mitigation overheads at higher levels. To be studied. Non-dependence and criticality are TBD.
Date of Entry / Last Date of Change	January 2015

4.33 N37- Alternative to MMH and UDMH

Description and needed Action	Hydrazine, N2H4, is widely used as monopropellant in space crafts and missiles. Hydrazine is however currently on the REACH list of chemicals of very high concern and might be banned in the future. This might adversely influence the European propulsion industry. Alternatives to monopropellant hydrazine are thus of interest and this is covered by action point **U5: Alternative to hydrazine in Europe**. Monomethylhydrazine, MMH, and unsymmetrical dimethylhydrazine (UDMH) are used in bipropellant engines. If hydrazine will be banned, MMH and UDMH might be next to follow. It is thus of importance for the European propulsion community to be proactive and prepare for what might come by developing alternatives to MMH and UDMH. It is therefore proposed to include a new action point concerning alternatives to MMH and UDMH.
Estimated Initial TRL	
Target TRL	
Applicable Mission Class(es)*	Earth Observation, Science Mission, Human Spaceflight, Space Transportation, Telecommunications, Navigation, Space Security, Robotic Exploration
Order of Magnitude of numbers of restricted export licences in the last 10 years for this function	
Order of Magnitude of numbers of units sold per	

year	
Industrial Non-Dependence Concern	
Delegations/Agencies voicing non-dependence concern on the item	Some long-term non-dependence concerns expressed during the European Non-Dependence meeting (13 February 2015).
Reference(s)	
Remarks / Justifications	
Date of Entry / Last Date of Change	January 2015

4.34 N41- Thermal insulation systems based on aerogels for Space environments with atmosphere

Description and needed Action	To further develop and qualify aerogels based thermal insulation systems for safety use in Space environments with atmosphere e.g. Mars. Although Aerogel is a promising material , more development work is needed to solve the particle shedding problems by e.g. packaging so as to meet the material cleanliness levels required for space qualification.
Estimated Initial TRL	3
Target TRL	6
Applicable Mission Class(es)*	Science Mission, Human Spaceflight, Unmanned Aircraft Systems (UAS), Space Transportation
Order of Magnitude of numbers of restricted export licences in the last 10 years for this function	
Order of Magnitude of numbers of units sold per year	
Industrial Non-Dependence Concern	
Delegations/Agencies	Some non-dependence concerns expressed during the

voicing non-dependence concern on the item	European Non-Dependence meeting (13 February 2015).
Reference(s)	
Remarks / Justifications	Considering the strategic nature of this product for future space exploration missions, and the need for non-dependence of Europe in the production of Aerogels with a potential spin-off for non-space applications, Actions are deemed necessary to complement the European studies on aerogels already performed in ESA ITI / TRP and EC FP7 programmes.
Date of Entry / Last Date of Change	January 2015

4.35 N42- New data compression systems for space instrumentation

Description and needed Action	Study, design and implement (as IP Cores, allowing software and hardware implementations) new high-performance data compression algorithms to cope with the large data sets generated by modern space instruments, including integrated encryption algorithms. Advanced and efficient data compression techniques should be designed, offering excellent ratios with a very low-energy consumption (or processor utilisation) on-board payload data processing systems. These techniques should be able to handle any kind of data generated by existing or planned detectors: generic data (generic lossless compression), grey scale images (lossless and lossy), multi-band or multi/hyperspectral images (lossless and lossy), etc. Integrated data encryption is recommended, in order to deliver a complete integrated system with compression and data encryption for more secure communication downlinks. An added value would be to develop as well the necessary ground-based tools, allowing operating directly on the compressed data, thus avoiding the processing and storage overhead caused by the decompression of the on-board algorithm.
Estimated Initial TRL	3
Target TRL	8
Applicable Mission	Earth Observation, Science Mission, Human Spaceflight, Space Transportation, Telecommunications, Navigation,

Class(es)*	Space Security, Robotic Exploration, Unmanned Aircraft Systems (UAS), Defence Applications
Order of Magnitude of numbers of restricted export licences in the last 10 years for this function	>100
Order of Magnitude of numbers of units sold per year	>100
Industrial Non-Dependence Concern	
Delegations/Agencies voicing non-dependence concern on the item	Limited non-dependence concerns expressed during the European Non-Dependence meeting (13 February 2015).
Reference(s)	
Remarks / Justifications	Current and future space missions generate increasingly large data volumes that space data compression algorithms cannot handle properly, often leading to too high requirements on the processing resources required on-board for the data compression, or too high requirements in the downlink. The Consultative Committee for Space Data Systems (CCSDS) recommendations are becoming obsolete and need a proper revision due to their weaknesses, such as degradation in the performance when the data to be compressed is not as envisaged (which is often the case due to new detectors with higher resolution, for example). Several alternative algorithms are available, but they need proper evaluation and testing in order to deliver a fully integrated data compression solution for space communications. Integrated data encryption would obviously provide an added value, as well as on-ground tools to work directly on the compressed data, thus delivering a complete product for efficient and secure space downlink systems.
Date of Entry / Last Date of Change	January 2015

4.36 N43- High Temperature alloys

Description and needed Action	High temperature alloys and its composites for use over 1500ºC ➢ Few materials providers in Europe and few alloys space qualified ➢ Potential use in propulsion parts, hot parts and thermal protection structures in the evolution of launchers. Europe needs to find alternatives to alloy PM1000
Estimated Initial TRL	3
Target TRL	9
Applicable Mission Class(es)*	Future Launchers Preparatory Programme (FLPP) / Next Generation Launchers (NGL) / Defence applications
Order of Magnitude of numbers of restricted export licences in the last 10 years for this function	
Order of Magnitude of numbers of units sold per year	1Tn
Industrial Non-Dependence Concern	
Delegations/Agencies voicing non-dependence concern on the item	
Reference(s)	
Remarks / Justifications	Evolution of launchers. Resistance to extreme environment. Note 1 (2015): PM1000 was an alloy developed by Plansee (Austria) and was taken from the market due to negative business case. ESA: Given the targeted long-term applications, the proposed action is considered with a low level of priority.
Date of Entry / Last Date of Change	January 2015

4.37 N45- High conductive adhesives

Description and needed Action	To develop and qualify space conductive adhesives
Estimated Initial TRL	3 to 4
Target TRL	9
Applicable Mission Class(es)*	Earth Observation, Science Mission, Human Spaceflight, Space Transportation, Telecommunications, Navigation, Space Security, Robotic Exploration, Unmanned Aircraft Systems (UAS), Defence Applications
Order of Magnitude of numbers of restricted export licences in the last 10 years for this function	
Order of Magnitude of numbers of units sold per year	
Industrial Non-Dependence Concern	Consensus expressed during the European Non-Dependence meeting (13 February 2015).
Delegations/Agencies voicing non-dependence concern on the item	Consensus expressed during the European Non-Dependence meeting (13 February 2015).
Reference(s)	
Remarks / Justifications	There is no European supplier for space conductive adhesives
Date of Entry / Last Date of Change	January 2015

4.38 N46- Metal Matrix Composites

Description and needed Action	Titanium and intermetallic composites
Estimated Initial TRL	4
Target TRL	9
Applicable Mission	Future Launchers Preparatory Programme (FLPP) / Next

Class(es)*	Generation Launchers (NGL)
Order of Magnitude of numbers of restricted export licences in the last 10 years for this function	
Order of Magnitude of numbers of units sold per year	1Tn
Industrial Non-Dependence Concern	
Delegations/Agencies voicing non-dependence concern on the item	
Reference(s)	
Remarks / Justifications	Note 1 (2015): There is a very limited number of suppliers of titanium and intermetallic composites In Europe. The alloys are provided by USA and the fibres are coming from Japanese IP sources. The Titanium matrix composites have been proven for space structural parts, replacing Ti alloy thanks to higher toughness and temperature resistance. ESA: Given the targeted long-term applications, the proposed action is considered with a low level of priority.
Date of Entry / Last Date of Change	January 2015

4.39 N48- Composite cryo-tank technologies

Description and needed Action	To further develop composite cryogenic tank technologies including both structural and thermal insulation aspects.
Estimated Initial TRL	3-4 for LH2
Target TRL	At least 6 for LH2 and LOX
Applicable Mission Class(es)*	Mainly space transportation, although satellite applications cannot be excluded
Order of Magnitude of numbers of restricted export licences in the last 10 years for this function	
Order of Magnitude of	Zero for the moment, but USA competitors are qualifying

numbers of units sold per year	large composite LH2 cryotanks, gaining a competitive advantage
Industrial Non-Dependence Concern	Consensus expressed during the European Non-Dependence meeting (13 February 2015).
Delegations/Agencies voicing non-dependence concern on the item	*Several non*-dependence concerns expressed during the European Non-Dependence Meeting (13 February 2015).
Reference(s)	ESA 2014 Harmonisation dossier (Composite materials)
Remarks / Justifications	This capacity does not exist in Europe (only preliminary developments under ESA FLPP programme).
Date of Entry / Last Date of Change	January 2015

5 APPENDIX A: TABLE OF ACRONYMS AND ABBREVIATIONS

A/D	Analogue/Digital
ADC	Analogue Digital Converter
AOCS	Altitude Orbit Control System
ARTES	ESA Advanced Research In Telecommunication Systems Programme
ARW	Angle Random Walk
ASI	Agenzia Spaziale Italiana
ASIC	Application Specific Integrated Circuit
BOL	Beginning Of Life
CAN	Controller Area Network
CCSDS	Consultative Committee for Space Data Systems
CIS	CMOS imaging sensor
CMOS	Complementary Metal Oxide Semiconductor
CMR	Carcinogenic, Mutagenic or toxic to Reproduction
CNC	CapTech National Coordinators (CNC)
CNES	Centre National d'Etudes Spatiales
COM	European Commission
COTS	Commercial Off-The-Shelf
CPL	Capillary Pumped Loop
CTB	ESCC Components Technology Board
DAC	Digital Analogue Converter
DLR	Deutsches Zentrum für Luft- und Raumfahrt
DSM	Deep Sub-Micron
DSP	Digital Signal Processor
EAR	Export Administration Regulations
ECSS	European Cooperation for Space Standardization
ECHA	European Chemicals Agency

ECI	European Component Initiative
EDA	European Defence Agency
EEE	Electrical, Electronic and Electromechanical
EOL	End Of Life
EQM	Engineering Qualification Model
ESA	European Space Agency
ESCC	European Space Components Coordination
ESP	European Space Policy
ESSS	European Space Surveillance System
ESTER	European Space Technology Requirements Document
FLPP	ESA Future Launchers Preparatory Programme
FOG	Fiber Optic Gyro
FPGA	Field Programmable Gate Array
GaAs	Gallium Arsenide
GaN	Gallium Nitride
GFLOPS	Giga Floating Operations Per Second
GIPS	Giga Instructions per Second
Gsps	Giga samples per second
GSTP	ESA General Support Technology Programme
HEMT	High-Electron-Mobility Transistor
HSSL	High Speed Serial Link
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

JTF	Joint-Task-Force
LCA	Life Cycle Assessment
LH2	Liquid Hydrogen
LHP	Loop Heat Pipe
LNA	Low Noise Amplifier
LO	Local Oscillator
LOX	Liquid Oxygen
MEMS	Micro-Electro-Mechanical Systems
MISHFET	Metal Insulator Semiconductor Heterostructure Field Effect Transistor
MMH	Monomethylhydrazine
MMIC	Monolithic Microwave Integrated Circuit
MON	Mixed Oxides of Nitrogen
MOSFET	Metal-Oxide-Semiconductor Field Effect Transistor
MPSoC	Multiprocessors System-on-Chip
MS	Member States
NEA	Non-Explosive Actuator
NLG	Next Generation Launcher
NoC	Network on Chip
PCB	Printed Circuit Board
PFM	Proto-Flight Model
PLL	Phase-Lock-Loop
PMD	Propellant Management Device

PROM	Programmable Read Only Memory
RAD hard	Radiation hard
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
RF	Radio-Frequency
SAR	Synthetic Aperture Radar
SEE	Single-Event Effects
SiGe	Silicon Germanium
SMA	Shape Memory Alloy
SME	Small and Medium-sized enterprise
SRAM	Static Random-Access Memory
SVHC	Substance of Very High Concern
TD	Technology Domain
THAG	ESA Technology Harmonisation Advisory Group
TPS	Thermal Protection Systems
TRL	Technology Readiness Level
TRT	Technology Readiness Target
TRP	ESA Basic Technology Research Programme Research Programme
TWT	Travelling Wave Tube
UAS	Unmanned Aircraft Systems
UDMH	Unsymmetrical dimethylhydrazine
VCSEL	Vertical-Cavity Surface Emitting Laser