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DOCUMENT

ESA Generic Product Tree

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More extensive classification of the Ground Segment IV-B-4 Products	1	1	11/2010
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CHANGE RECORD

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1 INTRODUCTION

1.1 Objective of this Document

The objective of this document is to present the ESA Generic Product Tree (GPT), which provides a generic, structured and complete classification of space products.

The ESA Generic Product Tree presented herein may be subject to evolution and modification in time.

1.2 Historical Background

There already exist many Product Trees which aim to classify products. However, they vary from project to project depending on the mission type and contractor.
A need to have a generic structure to classify space products when carrying out a complete mapping of the industry capabilities has been identified by D/TEC.

To this end, a Generic Product Tree has been prepared by TEC-SGH in close coordination with technical experts from ESA Directorates.

The document was first distributed within ESA and externally to National Delegations and European Industry, as Technical Note in November 2010. In July 2011 has been updated for publication as ESA STM being the present issue (issue 1.1) the result of this update.

1.3 Objective and Structure of the ESA Generic Product Tree

The objective of the ESA Generic Product Tree is to provide a generic, structured and complete classification of all the products involved in space activities.

It will find particular use in databases collecting products and/or company information.

The Generic Product Tree is broken down into several levels. The number of levels depends on the product and therefore varies across the tree.

The first level of decomposition introduces 4 Segment Levels (SL):

(I) Launchers
(II) Satellites & Probes
(III) Orbital Transportation & Re-entry Systems
(IV) Ground Segment

Each Segment Level (SL) is further subdivided into Systems, which are then classified according to their integration level. For instance, Segment II "Satellites & Probes" has been classified as follows:

	Segment		**Systems**
II	**Satellites & Probes**	A	AOCS & GNC
		B	Electronics
		C	Materials
		D	Mechanisms
		E	On-board SW
		F	On-board Data Management

	Segment		Systems
		G	Optical Communication
		H	Parts
		I	Payloads/Instruments
		J	Power
		K	Propulsion
		L	RF / Microwave Communication (Platform and Payloads)
		M	System Engineering Software
		N	Structures
		O	Thermal Control
		P	Other

1.3.1 Nomenclature

In order to overcome the ambiguity related to the use of generic terms such as "equipment", "subsystem", etc., a definition of the nomenclature as it has been used within the Generic Product Tree is hereinafter reported:

Product: Generic term, which may refer to: Equipment, Building Blocks or Components & Parts. All products have been classified as one of the following:

- Equipment
- Building Blocks (BB)
- EEE Components, mechanical Parts and materials (C&P)

Where:

Equipment: Unit at high integration level performing a high-level function or set of functions.
In this perspective, a "Star tracker" can be considered as equipment but a charge-coupled device (CCD) detector cannot.

Building Blocks (BB): Unit at low integration level which must be utilised as part of a higher integration level to perform a high level function, allowing re-use without major non-recurrent system adaptations.
For example, a CCD detector can be considered a BB.

EEE Components, mechanical Parts and materials (C&P): Unit at the lowest integration level.

1.3.2 Colour code

A colour code is applied in order to offer a friendly and intuitive tree representation at Product decomposition level:

Products:
Equipment
Building Blocks (BB)
EEE Components, mechanical Parts and materials (C&P)

Depending on the product addressed, the classification granularity applied differs, as it is closely related to the supply chain of the specific Segment:

- Launchers: Equipment, BB and C&P
- Satellites & Probes: Equipment, BB and C&P

- Orbital Transportation & Re-entry Systems: Equipment and BB
- Ground Segment: Equipment

1.4 Product Classification Criteria

Products may be classified according to a variety of criteria, i.e. academic/functional classification, technology oriented, or mirroring, for instance, the specific internal organisational structure of a company.

The classification adopted for the ESA Generic Product Tree structures the products through a "Product Utilisation/Design point of view". According to this perspective, the sub-criteria applied are the following:

- Stand-alone/end-products with different integration levels (Equipment, BB, etc.) are classified according the System level they belong to.
  Examples:
  - Power Conditioning Equipment and Battery Charge Regulators BB → Power System
  - Thrusters Equipment and Fill & Vent valves C&P → Propulsion System

- BB and C&P common to more than one System are grouped together.
  Examples:
  - Mechanisms
  - EEE components

- For BB and C&P common to two or more Systems but not numerous enough to be grouped into a distinctive System, a "case by case" approach has been adopted:
The equipment is assigned to one system and a reference to the assigned system is then specified in the other system(s) under which it appears. This is the case of BB and C&P performing functions related to different systems, for which it is difficult to assign a "clearly identifiable and unique home".
  Examples:
  - Tanks BB: They appear under II-K-1.1-c, with a reference to "Structures" (II-N), where they are separated in two BB: "Pressure Tanks" (II-N-all.1-c) and "Propellant Tanks" (II-N-all.1-d).
  - CCD Detectors BB: It appears under II-A-1.1 "Sensors" and under II-G-1.1 for Optical Cameras, with the note **See AOCS&GNC*.

It is worth noting that since the GPT will be mainly implemented in databases, the reference pointing to another field is transparent to the final users.

- For each Equipment/BB/C&P, a further classification is proposed in the "Description" column. The criteria and granularity of this further level of classification differs according to the related branches: in some cases, the classification is intuitive (e.g. AOCS), while in other cases it may be more complex, as multiple choices are possible (e.g. RF/Microwave Communication). In any case, a higher level of granularity of this further classification level is out of scope of the Generic Product Tree.
  Examples:
  - AOCS (II-A) → Sensors: Gyros / Accelerometers / Earth sensors / …
  - RF/Microwave Communication (II-L) → "Transmitters" can be classified by: Payload or Platform transmitters / Application (Near Earth application, Deep space application, Orbiter-Rover link, etc.) / Frequency band (X-band, S-band, etc.).

- The GPT focuses on branches and leaves corresponding to re-usable/customisable products; therefore, only in few cases mission-specific equipment is included.
  Example:
  - On-board Software elements often consist in mission-specific software embedded applications, which are extensively produced in-house.

2 ESA GENERIC PRODUCT TREE

2.1 Launchers

	Segment		Systems		Products: Equipment/Building Blocks/EEE Components, mechanical Parts and materials		Description
I	Launchers	A	Avionics	1	On-Board Computers	a	*See Software
				2	Data systems and I/F	a	Communication buses, harness, connectors, ...
				3	Power Storage, Conditioning and and Distribution - Equipment	a	Batteries
						b	Power conditioning and distribution units
				3.1	Power Storage, Conditioning and and Distribution - BB	a	Current and voltage sensors and limiters
						b	Heater Control
						c	Other
				4	GNC Units	a	IMU, IMU/GPS *See Software
				5	TT&C	a	Antennas, transmitters, receivers, transponders
				6	Safeguard Electrical Systems	a	Safe and arme devices, ...
				7	TVC control electronics	a	*See Software
				8	Others	a	Sequential units, ...
		B	Descent & Recovery	1	Descent	a	Parachutes
				2	Recovery	a	Beacon
		C	Electronics	1	EEE Components	a	Capacitors
						b	Connectors
						c	Crystals
						d	Discrete semiconductors (including diodes, transistors)
						e	Filters
						f	Fuses
						g	Magnetic components (e.g. Inductors, Transformers)
						h	Monolithic Microcircuits (including MMICs)
						i	Hybrid circuits
						j	Relays
						k	Resistors, heaters
						l	Surface acoustic wave devices
						m	Switches (including mechanical, thermal)
						n	Thermistors
						o	Wires and cables
						p	Optoelectronic Devices (including opto-couplers, LED, CCDs, displays, sensors)
						q	Passive Microwave Devices (including e.g. mixers, couplers, isolators and switches)
						r	Other
		D	Materials	1	Metallic		
				2	Non-metallic		
				3	Composite Materials	a	Reinforcement Material: Glass Fibres
						b	Reinforcement Material: Carbon Fibres
						c	Reinforcement Material: Aramid Fibres
						d	Reinforcement Material: Silicon Carbide, both Fibre and Particulate (SiC)
						e	Reinforcement Material: Alumina, both Fibre and Particulate (Al_2O_3)
						f	Reinforcement Material: New polymeric fibres
						g	Reinforcement Material: Others
						h	Matrix Structure: Epoxy
						i	Matrix Structure: Cyanate Ester
						j	Matrix Structure: Ceramic (SiC)
						k	Matrix Structure: Metal (Al, Ti, C)
						l	Matrix Structure: Others
		E	Mechanisms	1	Mechanisms - Units	a	Hold down and release
						b	Pyrotechnics
						c	Safety and Destruction Systems
						d	Stage/Payload Separation devices - not explosive (Clamp-bands, springs, ...)
						e	TVC Actuators
						f	Others

	Segment		Systems		Products: Equipment/Building Blocks/EEE Components, mechanical Parts and materials		Description
I	Launchers	F	Parts	1	Mechanical and Magnetic Parts	a	Connecting Parts (nuts, bolts, ...), Separating Parts (springs, cutters, ...), Spacing Parts, Bearing Parts, Control Parts (gears), etc.
						b	Magnetic Parts
						c	Other
		G	Propulsion	1	Liquid propulsion systems		
				1.1	Liquid propulsion systems - BB	a	Propellant Tanks *See Structures*
						b	Pressure Tanks *See Structures*
						c	Feeding system devices (feed lines, filters, valves, ...)
				2	Storable liquid engines		
				3	Cryogenic liquid engines		
				4	Hydrocarbon liquid engines		
				2/3/4.1	Liquid propulsion engines - BB	a	Combustion chambers
						b	Flow control and distribution devices (Pipes, Valves, Actuators, Filters, ...)
						c	Gas generators (gas generetor cycle engine)
						d	Nozzles
						e	Pre-burners (stage combustion cycle engine)
						f	Turbo-pumps
						g	Other
				5	Solid propulsion motors		
				5.1	Solid propulsion motors - BB	a	Motor Cases (metallic, composite)
						b	Thermal Protection
						c	Propellant Grain
						d	Igniters
						e	Nozzles
						f	Other
				6	Reaction and Attitude Control Systems		
				6.1	Reaction and Attitude Control Systems - BB	a	Thrusters
						b	Flow control and distribution devices
						c	Tanks *See Structures*
						d	Other
				7	Propulsion System SW	a	SW tools for propulsion system and engine design, analysis, simulation, etc.
		H	Software	1	Flight SW	a	On-Board computers
						b	Inertial Measurement Units (IMUs)
						c	Thrust-Vector Control (TVC)
						d	Other
				2	System Engineering SW (for operational Ground SW see Segment III)	a	Dependability, Safety and Quality Tools (RAMS, FMECA, ...)
						b	Mission Analysis tools (Trajectory computation; Propellant masses optimisation; Stage fall-down, Orbital modelling and simulation, ...)
						c	System Modelling & Simulation (Aerothermodynamic Tools for Design, Environment, ...)
						d	Other
		I	Structures	1	Stage structures	a	Intestages, skirts, thrust frame, ...
				2	Tanks		
				3	Propellant tanks		
				4	Pressure tanks		
				5	Fairing		
				6	Payload adapters		
				7	Other		
				1/2/3/4/5/6/7.1	Structures - BB	a	Structural joints, dampers, interfaces support, interface rings, ...
						b	Plates panels and bearing walls
						c	Other
				8	Structural Engineering SW	a	SW for Structures design, analysis, simulation, etc.
		J	Thermal Control	1	Thermal Protection		
				2	Heat storage and rejection		Coating and Insulation (surface thermal control)
				3	Heat pipes		
				4	Passive coolers		
				5	Thermal Engineering SW	a	SW for Thermal design, analysis, simulation, etc.
				6	Other	a	Ventilation piping and venting
				all.1	Thermal Control - BB	a	Heaters
						b	Temp. Sensors
						c	Heat flow control and distribution devices (Pipes, Valves, ...)
						d	Other

2.2 Satellites & Probes

	Segment		Systems		Products: Equipment/Building Blocks/EEE Components, mechanical Parts and materials		Description
II	Satellites & Probes	A	AOCS & GNC	1	Sensors	a	Accelerometers
						b	Earth Sensors
						c	Formation Flight specific sensors
						d	Gyros
						e	Inertial Mesurament Units (IMUs)
						f	Magnetometers
						g	Optical Navigation Units (including 3D cameras)
						h	Star Trackers
						i	Sun Sensors
						j	Other
				1.1	Sensors – BB	a	Detectors (APS, CCD, infrared detectors, ...)
						b	Electronics (proximity/ analog processing, digital conversion, etc.)
						c	Optical heads
						d	Other
				2	Actuators	a	Wheels (Momentum, Reaction)
						b	Control Moment Gyros
						c	Magnetorquers
						d	Reaction Control Systems (low-thrust)
						e	Other
				2.1	Actuators – BB	a	Actuators Electronics
						b	Actuators Mechanisms *See Mechanisms*
						c	Electrical motors *See Mechanisms*
						d	Other
				3	Guidance Navigation Control (GNC)	a	Radars, lidars, GNSS receivers
						b	Hybrid Navigation Units (IMU/GPS, ..)
						c	Other
				4	AOCS & GNC On Board SW	a	*See On Board Data Management*
				5	AOCS & GNC Eng. SW	a	SW for AOCS&GNC design, analysis, simulation, etc.
		B	Electronics	1	EEE Components	a	Capacitors
						b	Connectors
						c	Crystals
						d	Discrete semiconductors (including diodes, transistors)
						e	Filters
						f	Fuses
						g	Magnetic components (e.g. Inductors, Transformers)
						h	Monolithic Microcircuits (including MMICs)
						i	Hybrid circuits
						j	Relays
						k	Resistors, heaters
						l	Surface acoustic wave devices
						m	Switches (including mechanical, thermal)
						n	Thermistors
						o	Wires and cables
						p	Optoelectronic Devices (including opto-couplers, LED, CCDs, displays, sensors)
						q	Passive Microwave Devices (including for instance, mixers, couplers, isolators and switches)
						r	Other
		C	Materials	1	Metallic		
				2	Non-metallic		
				3	Composite Materials	a	Reinforcement Material: Glass Fibres
						b	Reinforcement Material: Carbon Fibres
						c	Reinforcement Material: Aramid Fibres
						d	Reinforcement Material: Silicon Carbide, both Fibre and Particulate (SiC)
						e	Reinforcement Material: Alumina, both Fibre and Particulate (Al_2O_3)
						f	Reinforcement Material: New polymeric fibres
						g	Reinforcement Material: Others
						h	Matrix Structure: Epoxy
						i	Matrix Structure: Cyanate Ester
						j	Matrix Structure: Ceramic (SiC)
						k	Matrix Structure: Metal (Al, Ti, C)
						l	Matrix Structure: Others

	Segment		Systems		Products: Equipment/Building Blocks/EEE Components, mechanical Parts and materials		Description
II	**Satellites & Probes**	D	**Mechanisms**	1	Mechanisms	a	Deployment (SADM, SADE, ...)
						b	Hold Down and Release
						c	Instrument specific mechanisms
						d	Scanning
						e	Solar Array Drive Mechanisms (SADMs)
						f	Thrusters orientation (EPPM, ...)
						g	Other
				1.1	Mechanisms – BB	a	Sensors: Position sensors, Velocity, Acceleration, Stress, ...
						b	Motors: Brushed DC, Brushless DC, Piezo-electric, Stepper, Voice Coil, ...
						c	Other
				1.1.1	Mechanisms – C&P	a	Lubricant (dry, fluid), etc
						b	Motors C&P: Motor housing and shaft, Sliprings, ...
						c	* *See Mechanical Parts*
		E	**On-board SW**	1	Operating Systems		
				2	Libraries	a	Packet Utilization Standard
						b	Command Laws and Algorithms (See specific subsystem)
						c	Other
				3	Re-usable / customisable SW applications	a	File management systems, ...
				4	Other		
		F	**On-board Data Management**	1	On Board Data Management	a	Central Data Management Units (CDMU) or Satellite Management Units (SMU)
						b	Payload Data Handling Units
						c	Onboard Storage (Mass Memories, Safeguard Memories)
						d	Telemetry and Telecommand Units
						e	Reconfiguration Units
						f	Remote Terminal Units
						g	Other
				1.1	On Board Data Management – BB	a	General Purpose Microprocessors (ERC32, Leon 2)
						b	General Purpose Digital Signal Processors (e.g ADSP 21020, TMS320xx)
						c	Microcontrollers
						d	Dedicated Signal Processing Processors (e.g. FFT, Compression)
						e	General Purpose Programable Logic (PLD, FPGA)
						f	Rad Hard Memory
						g	High Density Memory Devices (e.g stacked SDRAM, FLASH)
						h	Onboard Communcation (MIL-STD-1553, CAN, SpW, Sensor Bus, Wireless)
						i	TM/TC (Formater, encryption)
						j	Other
		G	**Optical Communication**	1	Optical Comm.		Optical terminals
				1.1	Optical Comm – BB	a	Detectors **See AOCS&GNC*
						b	Electronics (elector-optic modules)
						c	Laser sources, modulators
						d	Telescopes
						e	Receivers
						f	Software
						g	Tracking, (fine) Pointing and Stabilization mechanisms
				1.1.1	Optical Comm – C&P	a	* *See Mechanical Parts*
		H	**Parts**	1	Mechanical, Optical and Magnetic parts	a	Connecting parts (nuts, bolts, etc), Separating parts (springs, cutters, etc), Spacing Parts, Bearing Parts, Control Parts (gears), ...
						b	Optical Parts (lenses, beam-splitters, ...)
						c	Magnetic Parts
						d	Other

	Segment		Systems		Products: Equipment/Building Blocks/EEE Components, mechanical Parts and materials		Description
II	Satellites & Probes	I	Payloads / Instruments	1	RF and microwave Instruments	a	Altimeters
						b	Imaging Radars
						c	Microwave radiometers
						d	Microwave Telescopes
						e	Other (Scatterometers,..)
				2	InfraRed instruments	a	Telescopes, …
				3	Optical Instruments	a	Imaging radiometers
						b	Imaging spectrometers
						c	Infrared spectroscopy
						d	Lidars
						e	Passive sounders
						f	Optical Telescopes
				4	Other Instruments	a	Gradiometers, Plasma detectors, …
				all.1	Instruments – BB		
		J	Power	1	Generation: Solar Photovoltaic	a	Photovoltaic Assemblies
				1.1	Generation: Solar Photovoltaic – BB	a	Solar Cells Assemblies (SCA) with inter-connectors and coverglass
						b	Structural/mechanical (rigid honeycomb panels, flexible blankets, ...)
						c	Solar Cells
						d	Other
				1.1.1	Generation: Solar Photovoltaic – C&P	a	Substrates, cover-glass, coatings, adhesives, ...
						b	Other *See EEE Components
				2	Generation: Solar Thermal		
				3	Generation: Nuclear reactors	a	Radioisotope Thermoelectric Generators (RTGs)
						b	Other
				4	Generation: Tethered		
				5	Storage: Flywheels		
				6	Storage: Fuel cells		
				7	Storage: Batteries		
				8	Power Monitoring and Control	a	PCDUs, ...
				8.1	Power Monitoring and Control - BB	a	Batteries Charger/Discharger Regulators (BCR; BDR)
						b	Current and voltage sensors and limiters
						c	Heater Control
						d	Pyro Control
						e	Solar Array Regulator
						f	Other
				8.1.1	Power Monitoring and Control – C&P	a	*See EEE Components
				9	Power Eng. SW	a	SW for Power systems design, analysis, simulation, etc.
		K	Propulsion	1	Chemical Propulsion	a	Propellants
						b	Chemical Propulsion Systems
				1.1	Chemical Propulsion – BB	a	Combustion chambers
						b	Nozzles
						c	Tanks *See Structures
						d	Pumps
						e	Flow control and distribution devices (pipes, valves, actuators, filters, pressure transducers, pressure regulators)
						f	Other
				2	Chemical Propulsion Engineering SW	a	SW for Chemical propulsion design, analysis, simulation, etc
				3	Electric Propulsion	a	Electrostatic Propulsion Systems
						b	Electromagnetic Propulsion Systems
						c	Electrothermal Propulsion Systems
				3.1	Electric Propulsion – BB	a	Flow control and distribution devices (Fuel decent valves, pyro-valves, high and low pressure transducers, tubing, brackets, ...)
						b	Electric modules (Power Processing Unit, Power Supply and Control Unit, Actuator Drive Electron, Radio Frequency Generator, Electrical filter, ...)
						c	Thruster module (Plasma/Ion Thrusters), Xenon Flow Control Unit, … *For Thruster Pointing See Mechanisms
						d	PRE card for propellant management
						e	Other
				4	Electric Propulsion Engineering SW	a	SW for Electric propulsion design, analysis, simulation, etc.
				5	Solar sail		
				6	Cold gas propulsion		

	Segment		Systems		Products: Equipment/Building Blocks/EEE Components, mechanical Parts and materials		Description
II	**Satellites & Probes**	L	**RF / Microwave Communication (Platform and Payloads)**	1	Antennas	a	Omnidirectional, Helix, Horn, Parabolic, Phased Arrays / Platform vs Payload
				1.1	Antennas - BB	a	Feeds
						b	Antenna Towers and/or Reflectors
						c	Antenna mechanisms (Including control electronics) *See Mechanisms for: Hold down and release/Deployment and trim /Pointing
						d	Other
				2	Transmitters	a	X-band, S-Band, Ka band, … / Near Earth application, Deep space application, ... / Platform vs Payload
				3	Receivers	a	X-band, S-Band, Ka band, … / Near Earth application, Deep space application, ... / Platform vs Payload
						b	Navigation Receivers ***** *See AOCS & GNC* - Single-frequency (Platform/Low-end missions) - Multiple-frequency (Science mission/hig-end missions)
				4	Repeaters and Transceivers	a	Bent-pipe repeaters, regenarative transponders, ...
				2/3/4.1	Communication - BB (Antennas excluded)	a	Analog: RF front ends
						b	Analog: Signal amplifiers
						c	Analog: Power amplifiers (SSPA, TWTA, …)
						d	Analog: Clocks (integrated oscillators, time counters, …)
						e	Analog: Comparators (Frequency/Phase)
						f	Analog: Microwave generators
						g	Digital: Up/Down Converters
						h	Digital: Cryptographic, Digital Signal Processors
						i	Digital: Encoders/Decoders
						j	Digital: Frequency Synthesisers
						k	Digital: Routers (FDMA, …)
						l	Digital: Filters and Multiplexers
						m	Digital: Switching BB
						n	Other
				all.1.1	Communication Systems -	a	**See EEE Components*
				5	RF Comm. Eng. SW	a	SW for RF Comm. design, analysis, simulation, etc.
		M	**System Engineering Software**	1	Aerothermodynamic Tools for Design	a	Computational Fluid Dynamics (CFD)
						b	Hypersonic / high enthalpy facilities and plasma facilities
						c	Propulsion stands and rocket / jet interaction facilities
				2	Dependability, Safety and Quality tools	a	RAMS, FMECA, ...
						b	Other
				3	Environment Models and Computational Tools	a	Radiation belts, Solar energetic particles, Galactic cosmic rays, …
				4	System Modelling & Simulation	a	Dedicated simulation tools (on-board computer emulators, front-end equipment simulation, ...)
						b	Mission analysis tools (Orbital modelling and simulation)
						c	Modelling tools (Model development, Non real-time execution, Code generation, ...)
						d	Simulator executive tools (run-time environments)
						e	Other

	Segment		Systems		Products: Equipment/Building Blocks/EEE Components, mechanical Parts and materials		Description
II	Satellites & Probes	N	Structures	1	Satellite Bus		
				2	Primary Structures		
				3	Secondary Structures		
				4	Folded structures		
				5	Space structures with changing geometries	a	Deployable Structures, Adaptive Trusses, ...
				6	Optical bench structures	a	Cases, supporting rings, ...
				7	Inflatable space structures		
				all.1	Structures - BB	a	Central tubes, Bars and rods, …
						b	Plates panels and bearing walls
						c	Pressure tanks (pressure-fed cycle engines)
						d	Propellant tanks
						e	Rings
						f	Structural joints
						g	Struts, Inserts, Fasteners , …
						h	Other
				8	Struct. Eng. SW	a	SW for Structure design, analysis, simulation, etc.
				all.1.1	Structures - C&P	a	** See Parts*
		O	Thermal Control	1	Thermal Protection for atmospheric entry	a	Ablative systems products, Reusable systems products
				2	Heat storage and rejection	a	Coating and insulation
						b	Radiators
						c	Thermal Capacitors
						d	Other
				3	Heat Transport	a	Constance Conductance Heat Pipes (CCHPs)
						b	Variable Conductance Heat Pipes (VCHPs)
						c	Heat Pipe Diodes (HPDs)
						d	Mini/Micro Heat Pipes
						e	High Temperature Heat Pipes
						f	Other HPs
						g	High temperature CPL/LHP (Capillary Pumped Loop/Loop Heat Pipe)
						h	Low temperature CPL/LHP (Capillary Pumped Loop/Loop Heat Pipe)
						i	Mini CPL/LHP (Capillary Pumped Loop/Loop Heat Pipe)
						j	Other Capillary Driven Loops
						k	Mechanical Pump Driven Loops (MPDL) - Single and two-phase loops
				4	Cryogenic and Refrigeration	a	Peltiers
						b	Cryostats
						c	Stirling, Pulse Tube, J. Thomson
						d	Reverse turbo Bryton coolers
						e	Microcooling
						f	Sub-kelvin coolers (He-sorption pump coolers, Dilution coolers, ...)
						g	Adiabatic de-magnetisation refrigerator, NIS chip cooler, ...)
						h	Other
				5	Thermal Engineering SW	a	SW for Thermal design, analysis, simulation, etc.
				all.1	Thermal control - BB	a	Cryostat components, cryogenic tanks, cryogenic rupture discs, liquid Helium valves, ...
						b	Cold plates
						c	Flow control and transfer components
						d	Heaters, Thermistors, Thermostats, ...
						e	Pumps
						f	TPL Evaporators, condensers, reservoirs, …
						g	Temp. sensors
						h	Other
				all.1.1	Thermal control - C&P	a	Coatings (black paints, sulphuric oxidation, aluminium, gold, ...)
						b	Conductive compounds (graphite-silicon sheets, ...)
						c	Insulators and refractive materials (MLI, ...)
						d	Other
		P	Other				

2.3 Orbital Transportation & Re-entry Systems

	Segment		Systems		Products: Equipment/Building Blocks		Description
III	Orbital Transportation & Re-entry Systems	A	Descent & Recovery	1	Descent	a	Parachutes
				2	Recovery	a	Homing Beacon, ...
		B	GNC	1	Sensors	a	Rendezvous, Gyros, Sun Sensors, …
				2	GNSS receivers	a	GPS receivers
				3	Actuators		
		C	Environment and Crew Life Support (ECLS)	1	ECLS	a	Pressure, air, water, lighting systems, ...
						b	Video/Audio
						c	Crew Support Items (IVA suit, food storage, ...)
						d	Other
		D	Mechanisms	1	Mechanisms	a	Deployment
						b	Docking (including visual video target, visual ranging cues, ...) and Docking separation; Interface Sealing Mechanism (ISM), Hatch door
						c	Module Separation devices
						d	Safety and Destruction Systems
						e	SADM and SADE
						f	Umbelical retraction
						g	Other
				1.1	Mechanisms – BB	a	Sensors: Position sensors, Velocity, Acceleration, Stress, ...
						b	Motors: Brushed DC, Brushless DC, Piezo-electric, Stepper, ...
						c	Other
		E	On Board Data Mangement	1	On Board Data Management (HW and SW)	a	Central Data Management Units (CDMU)
						b	On Board Storage (Mass Memories, Safeguard Memories)
						c	Telemetry and Telecommand Units
						d	Propulsion drive electronics
						e	Other (Sequential Units, …)
				1.1	On Board Data Management - BB	a	Processors and controllers (communication processor, data processing, ...)
						b	Programmable logics (FPGA, PLD)
						c	TM/TC (Formatter, encryption)
						d	On Board Communcation (MIL-STD-1553, CAN, ...)
						e	Other
		F	Power	1	Generation: Solar Photovoltaic	a	Photovoltaic Assemblies
				1.1	Generation: Solar Photovoltaic – BB	a	Solar Cells Assemblies (SCA) with inter-connectors and cover-glass
						b	Structural/mechanical (rigid honeycomb panels, flexible blankets, ...)
						c	Solar Cells
						d	Other
				2	Power Storage	a	Batteries
				3	Power Monitoring and Control	a	PCDU, ...
				3.1	Power Monitoring and Control - BB	a	Current and voltage sensors and limiters, ...
						b	Other
		G	Propulsion and Reboost	1	Chemical Propulsion	a	Propellants
						b	Propulsion System
				1.1	Chemical Propulsion Systems – BB	a	Combustion chambers
						b	Nozzles
						c	Tanks *See Structures
						d	Pumps
						e	Flow control and distribution devices (pipes, valves, actuators, filters, pressure transducers, pressure regulators)
						f	Other
				2	Chemical Propulsion Engineering SW	a	SW for electric propulsion design, analysis, simulation, etc.

	Segment		Systems		Products: Equipment/Building Blocks		Description
III	Orbital Transportation & Re-entry Systems	H	RF Communication	1	Antennas	a	GPS Antenna+H30, S-band Antenna, ...
				2	TX, RX, Repeaters and Transceivers		
				2.1	TX, RX, Repeaters and Transceivers - BB	a	Power amplifiers (SSPA, ...)
						b	Signal Amplifiers
						c	Up/Down Converters, ...
						d	Other
		I	Software	1	Flight SW		
				2	System Engineering SW (for Ground SW see Segment III)	a	Dependability, Safety and Quality tools (RAMS, ...)
						b	Mission Analysis Tools (Trajectory computation, Propellant masses optimisation, Orbital modelling & simulation, …)
						c	System Modelling & Simulation (Aerothermodynamic Tools for Design, Environment, ...)
						d	Other
		J	Structures	1	Avionics Bay	a	Including rings, shell elements, …
				2	Modules structures	a	Cargo, Separation and distancing, Launch Escape System, Re-entry Module, ...
				3	Tanks	a	Pressure Tanks
						b	Propellant Tanks
				4	Other		
				all. 1	Structures - BB	a	Structural joints, dampers, interfaces support, …
						b	Adapters
						c	Plates panels and bearing walls
						d	Other
				5	Structure Eng. SW	a	SW for Structures design, analysis, simulation, etc.
		K	Thermal Control	1	Thermal Protection for atmospheric entry	a	Ablative Systems products, Reusable Systems products
				2	Heat storage and rejection	a	Coating and insulation (MLI)
						b	Radiators
						c	Other
				3	Heat pipes		
				4	Other		
				1to 4.1	Thermal Control - BB	a	Heaters, Thermistors, Thermostats, ...
						b	Temp. Sensors
						c	Heat flow control and distribution devices (Pipes, Valves, ...)
						d	Other
				5	Thermal Eng.SW	a	SW for Thermal design, analysis, simulation, etc.

2.4 Ground Segment

	Segment		System		Products: Equipment		Description
IV	Ground Segment	A	Mission Operations	1	Control Centre general equipment	a	Workstations, video signal distribution systems, wall screens, ...
				2	Mission Control	a	TM/TC, Planning & Scheduling, ...
						b	Satellite and Ground Segment Simulators (e.g. simsat, eurosim, etc.)
						c	Flight Dynamics Systems and Mission Analysis
						d	Operational Support (POD, GNSS, DDOR, ...)
						e	Engineering Support (GS S/W dev. and maintenance, ...)
				3	Operations Execution	a	Configuration management, FOP tools, On-board resource checker, ...
				4	Other		
		B	Ground Station	1	Antennas	a	Structure & Thermal, Servo / Mechanics, Reflectors, feeds and diplexers, Antenna Control Units (ACUs), Drive Systems, ...
				2	RF equipment	a	Transmitter and Receiver assemblies, Frequency converters, ...
				3	Baseband equipment	a	Telemetry and Telecommand equipment, Tracking, Ranging and Doppler measurement equipment, CODECS, ...
				4	F&T equipment	a	Quartz clocks
						b	Rubidium clocks
						c	Caesium clocks
						d	H-Masers
						e	Saphire Oscillators
						f	Atomic Fountains
						g	Optical Clocks (cold atoms, laser diodes, optical cavities,...)
						h	Test equipment
						i	GPS Receivers
						j	Time Generation and Synchronisation equipment
						k	Distribution Amplifiers
						l	Frequency Combs
						m	Frequency Dissemination equipment
						n	Other
				5	Ground Station Monitoring & Control		
		C	Ground Segment Network (or Ground Comm. sub-net)			a	Interface Equipment (NDIU), ...
		D	User Operations			a	Instrument management, Data analysis, PI equipment, etc.
		E	Development and Construction of Space Segment	1	Assembly Integration and Test	a	Electrical Ground Support Equipment (EGSE) and Special Check Out Equipment (SCOE)
						b	Mechanical Ground Support Equipment (MGSE) (Containers, stands, handling equipment, mechanical integration tools, protection devices)
						c	Optical Ground Support Equipment
						d	RF Suitcase
						e	Other
				2	General Support	a	Laboratories equipment (spectrum analysers, power meters, ...)
						b	Other
		F	Launcher specific Ground Segment				

3 APPENDIX: LIST OF ACRONYMS

A

- ACU Antenna Control Unit
- ADSP Analog Devices – Digital Signal Processor
- AOCS Attitude and Orbit Control Systems
- APS Active Pixel Sensor

B

- BB Building Block
- BCR Battery Charger Regulator
- BDR Battery Discharger Regulator

C

- CAN Controller Area Network
- CCD Charge – Coupled Device
- CCHP Constance Conductance Heat Pipe
- CDMU Central Data Management Unit
- CFD Computational Fluid Dynamics
- CPL Capillary Pumped Loop
- C&P Components & Parts

D

- DC Direct Current
- DDOR Delta Differential On-way Range

E

- ECLS Environment and Crew Life Support
- EEE Electrical, Electronic and Electromechanical
- EGSE Electrical Ground Support Equipment
- EPPM Electric Propulsion Pointing Mechanisms
- ERC32 Embedded Real-time Computer 32-bit

F

- FDMA Frequency Division Multiple Access
- FFT Fast Fourier Transform
- FMECA Failure Mode, Effects and Criticality Analysis
- FOP Follow-up Observing Program
- FPGA Field – Programmable Gate Array
- F&T Frequency & Time

G

- GNC Guidance, Navigation and Control
- GNSS Global Navigation Satellite System
- GPS Global Positioning System
- GPT Generic Product Tree

H

- HP Heat Pipe
- HPD Heat Pipe Diode

I

- IMU Inertial Measurement Unit
- ISM Interface Sealing Mechanism
- IVA Intra – Vehicular Activity

L

- LED Light – Emitting Diode
- LHP Loop Heat Pipe

M

- MGSE Mechanical Ground Support Equipment
- MIL-STD Military Standard
- MLI Multi – Layer Insulation
- MMIC Monolithic Microwave Integrated Circuit
- MPDL Mechanical Pump Driven Loop

N

- NDIU Network Data Interface Unit
- NIS Normal metal/Insulator/Superconductor

P

- PCDU Power Conditioning and Distribution Unit
- PI Portable Interface
- PLD Programmable Logic Device
- PRE Pressure Regulation Electronics

R

- RAMS Reliability, Availability, Maintainability and Safety
- RF Radio Frequency
- RTG Radioisotope Thermoelectric Generator

S

- SADE Solar Array Drive Electronics
- SADM Solar Array Drive Mechanisms
- SCA Solar Cells Assembly
- SCOE Special Check Out Equipment
- SDRAM Synchronous Dynamic Random Access Memory
- SMU Satellite Management Unit
- SpW Space Wire
- SSPA Solid State Power Amplifier
- SW Software

T

- TM/TC Telemetry/Telecommand
- TN Technical Note
- TPL Two – Phase Loop
- TT&C Telemetry, Tracking & Command
- TVC Thrust – Vector Control
- TWTA Travelling Wave Tube Amplifier
- TX/RX Transmitter/Receiver

V

- VCHP Variable Conductance Heat Pipe