

Concurrent Engineering of ESA's Future Space Missions in the CDF

Hans Peter de Koning (ESA)

60th Systems Architecture Study Group Meeting, 15 June 2017, ESA/ESTEC

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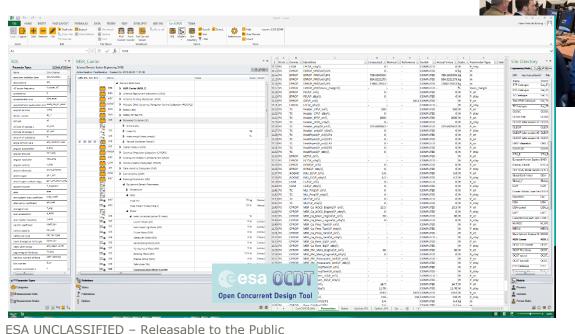


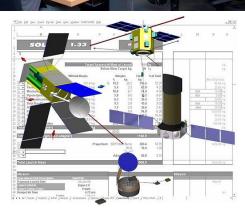
ESA Concurrent Design Facility (CDF)



Concurrent engineering /conceptual design of candidate ESA missions to establish feasibility, cost, risk, programmatics

10 to 20 studies per year





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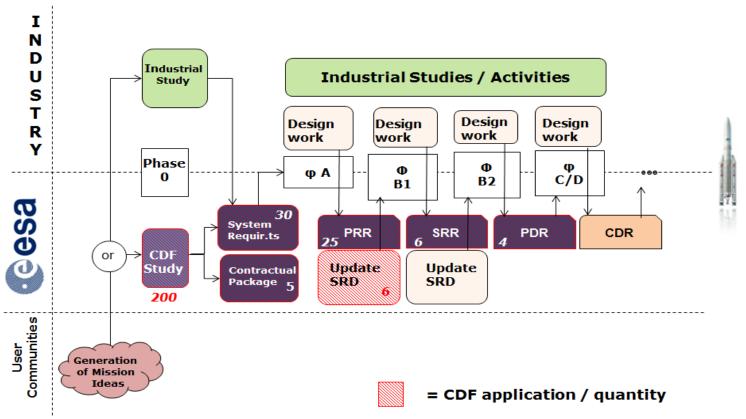






The ESA project life-cycle





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Slide 3







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CDF Studies performed since 1998

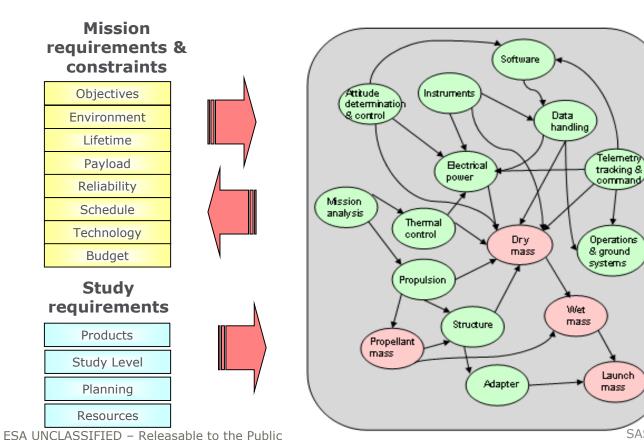


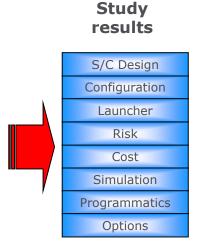


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Concurrent Engineering Process







Supported by integrated multi-disciplinary parametric model

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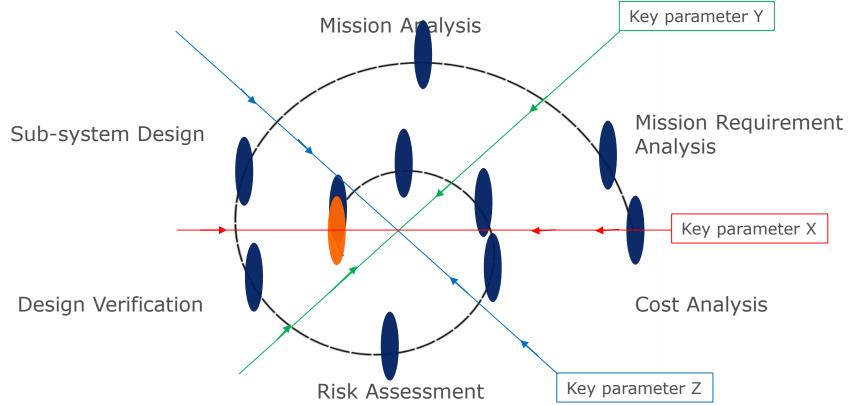






Iterative Spiral Model





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Typical CDF Study



- Conducted in plenary sessions and "homework" in-between
 - Plenary work session in which all relevant space engineering domains participate
- > ~8 sessions per study 2 sessions per week 4 hours per session
- > Team leader coordinates "conductor of the orchestra"
- Customer (ESA-internal) participates actively
- Model driven
 - Using OCDT near-real-time concurrent, multi-disciplinary, parametric model
- Highly co-operative & interactive
- One or more design iterations per session cycles in the spiral model
- Identification of design options and trade-off for preferred solution



Sharing Information Between Disciplines



Getting the right version of the right information to the right team member at the right time ...

Ensuring consistent, complete, navigable, reviewable information ... while making a deadline

- Major challenges in all our projects
- Digital engineering / model based approaches show great promise ... but require a lot of interoperable standards and tools

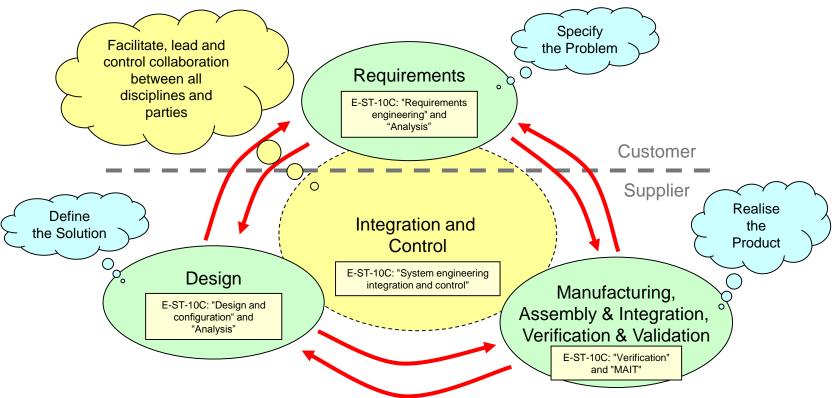






System Engineering according to ECSS-E-ST-10C

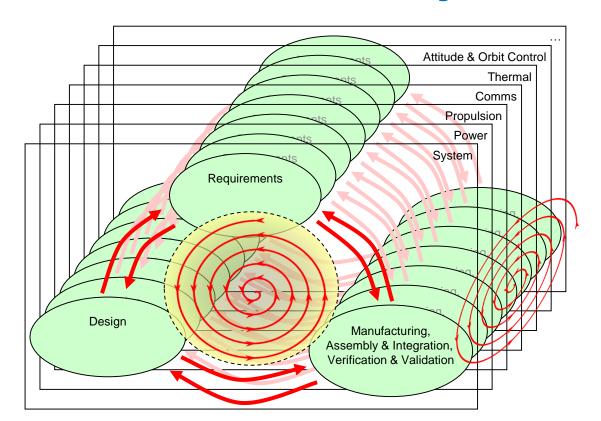




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ECSS-E-ST-10C: Iterative "Integration and Control"



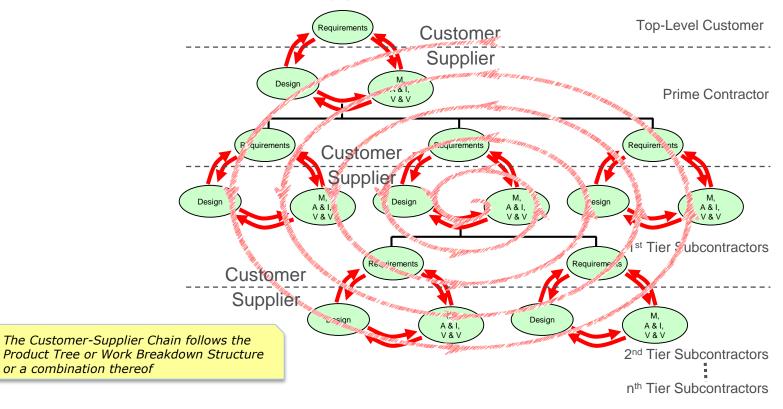


- Integration and Control
 - Concurrent in early phases
- Iterate between Requirements, Design, and MAIV&V
- > Iterate across Disciplines



ECSS-E-ST-10C: "Integration and Control" Across the Customer-Supplier Chain





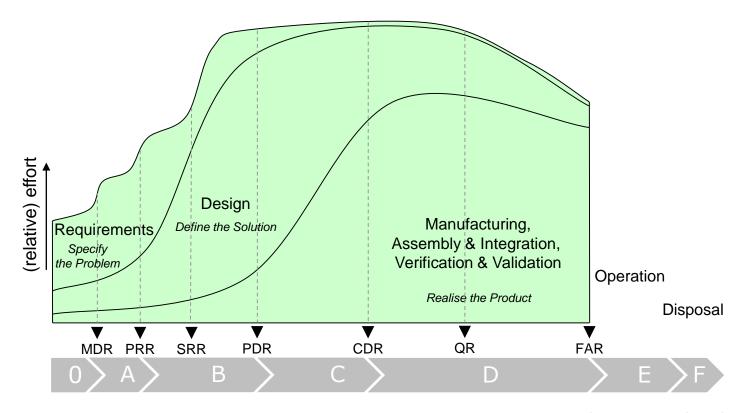
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or a combination thereof

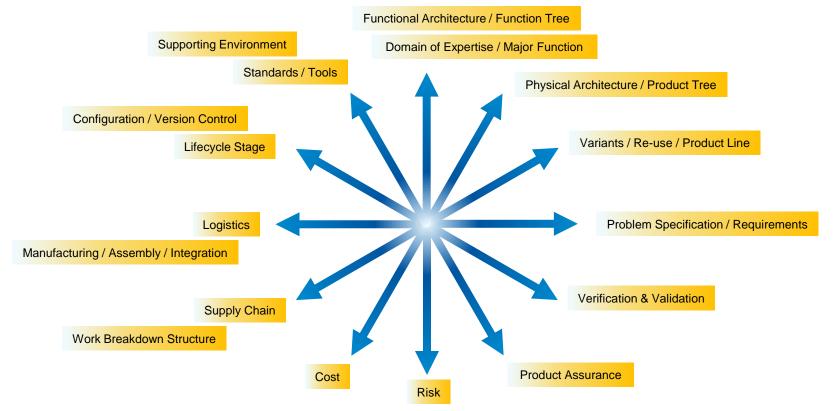
ECSS-E-ST-10C: "Integration and Control" Effort along the System Life-Cycle





A Huge Information Management / Knowledge Representation Exercise ... across many dimensions





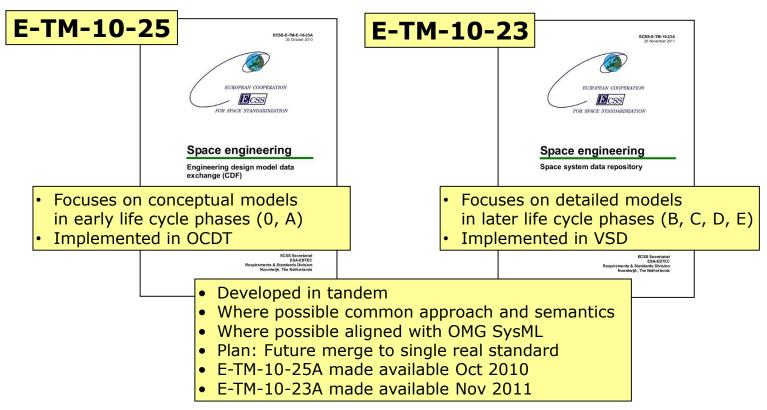
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ECSS Semantic Data Models in support of MBSE

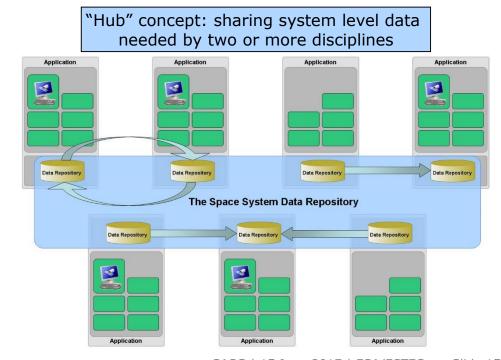




E-TM-10-23 & 25 Approach



- WGs realised early on: in order to ensure long term interoperability must create semantic conceptual data model i.e. the ontology approach
 - At the time (2006-2011) not yet the means nor expertise ...
 - ... Best effort with 'semantic' UML / Ecore models
 - Auto-generate implementation technology from conceptual data model – as much as possible
- Information sharing via "Hub": Space System Data Repository
 - Federation of data stores with adapters complying to semantic standard model
- Approach reconfirmed in 2014 Technical Harmonisation "System Data Repository"



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Patterns implemented in E-TM-10-25 (and OCDT)



- Ownership / responsibility by Domain of Expertise
 - "Domain of Expertise" is generalization of "Discipline"
- Unambiguous stable object identifiers UUIDs
- Separation of "Core Data Concepts" and "Reference Data"
 - Core Data Concepts are hard-coded in (generated) software implementation
 - * Reference Data is loaded at run-time and provides extension mechanism
- Rigorous formal model of Quantities, Units, Scales, Physical Dimensions
- Web Service with simple HTTP(S) REST API
 - Encapsulates persistent data store / hides implementation detail
 - Compatible with secure traversal of corporate firewalls











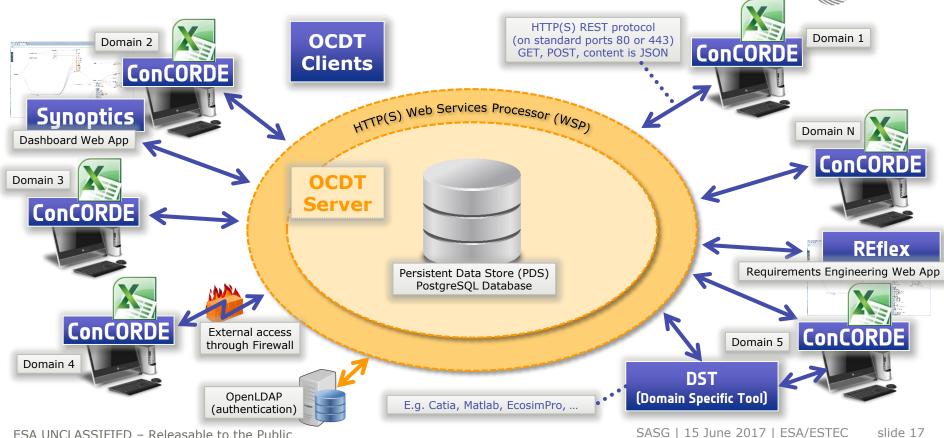






OCDT Architectural Overview

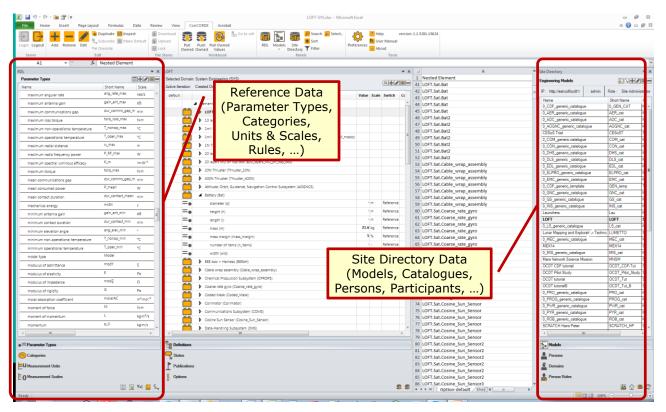
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European Space Agency

ConCORDE - Screenshots (1/2)



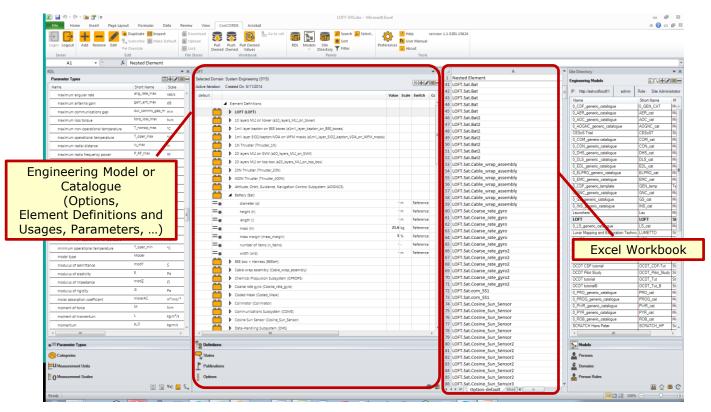


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ConCORDE - Screenshots (2/2)





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OCDT Domain Specific Tool Integrations

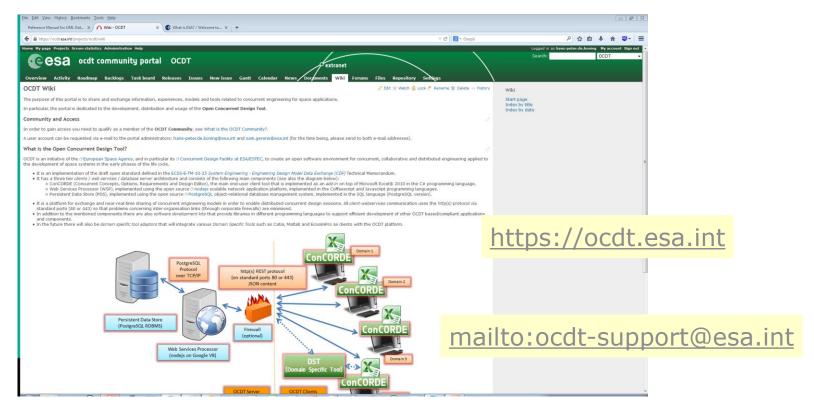


- Quick integrations via Excel worksheets for simple analysis / simulation capabilities
- Synoptics web app providing life study dashboard
- Catia v5 bi-directional interface for 3D Configuration in CDF studies
 - Basic geometric shapes and coordinate transformations
 - Catia computes centre-of-gravity and moments-of-inertia
 - Currently alpha version full operational release expected summer 2017
- Bi-directional SysML / UPDM interface (MagicDraw / ESA-AF) to support System-of-Systems Architectures
 - Alpha version developed in CESoS activity (2014)
- Life Cycle Assessment tool OPERA (in support of CleanSat)
 - Expected operational release summer 2017
- Matlab interface by University of Madrid
 - Alpha version demonstrated in SECESA 2016
- Requirements Engineering DOORS via RegIF, and SysML (MagicDraw)
 - In progress in Flexible Wiki-based Requirements Engineering activity: REflex
 - Expected operational release summer 2017
- Handover to VSD successfully prototyped, connection with e.g. MARVL in future
- Plans for Capella, EcosimPro, Thermal via STEP-TAS, maturing SysML and Matlab interfaces, Ground Segment Engineering ...



OCDT Community Portal





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slide 21



























Conclusions & Outlook



- Experiences with E-TM-10-25 / OCDT show that "Multi-Disciplinary Hub" based on semantic conceptual data model starts to work
 - For Phase 0 / A / B type data
 - Feature requests / improvements collected on OCDT Portal Backlog
- Good reasons to continue with pragmatic incremental approach
 - Not forgetting long term goals
 - ❖ Feed back lessons learned into further ESA, ECSS and OMG SysML v2
- OMG SysML version 2 looks like taking same approach
 - * REST-like services API will become part of the standard
 - Will most probably get much cleaner / ontology like meta-model allowing for Hub capability
 - Major emphasis on usability and reducing the learning curve
 - RPF expected Dec 2017 Standard and implementation around 2019 / 2020
- Continue and deepen semantic modelling approaches based on formal logic, semantic web technology (RDF/OWL/Open Linked Data, FBM) including automated reasoning
- Continue operations in ESA CDF and with ESA partners in industry and academia







SECESA conference (bi-annual, community forum)





Systems and Concurrent Engineering for Space Applications

Universidad Politecnica de Madrid 5-7 October 2016, Madrid, Spain http://esaconferencebureau.com/2016-events/16c11/

Next:
University of Strathclyde,
24-26 September 2018, Strathclyde, UK

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