

➤ SKA Engineering 2017
 “Collaborative Engineering for Megaprojects” session



ESA CDF

Concurrent Engineering applied to Space Mission Design

Massimo Bandecchi – ESA/ESTEC
 Rotterdam (NL), 15 June 2017

ESA UNCLASSIFIED – Releasable to the Public

- Over 50 years of experience
- 22 Member States
- Eight sites/facilities in Europe, about 2200 staff
- 5.2 billion Euro budget (2016)
- Over 80 satellites designed, tested and operated in flight






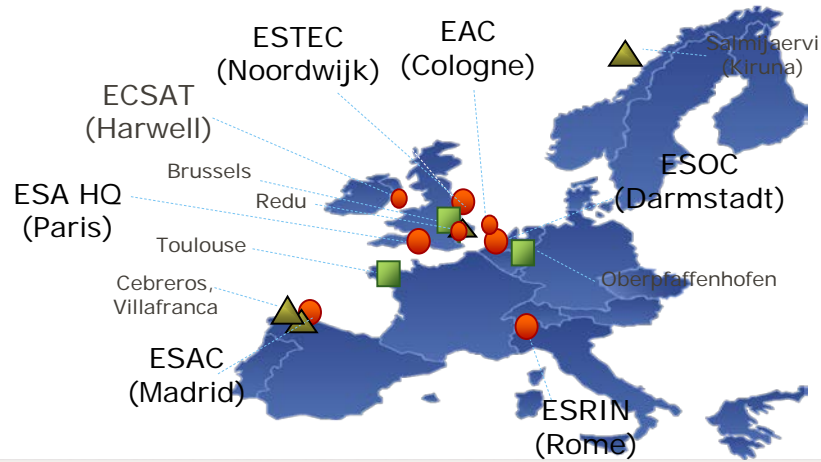
ESA has 22 Member States:
 20 states of the EU (AT, BE, CZ, DE, DK, EE, ES, FI, FR, IT, GR, HU, IE, LU, NL, PT, PL, RO, SE, UK) plus Norway and Switzerland.

Seven other EU states have Cooperation Agreements with ESA: Bulgaria, Cyprus, Latvia, Lithuania, Malta, Slovakia and Slovenia. Discussions are ongoing with Croatia.

Canada takes part in some programmes under a long-standing Cooperation Agreement.



-  ESA sites/facilities
-  Offices
-  ESA ground stations



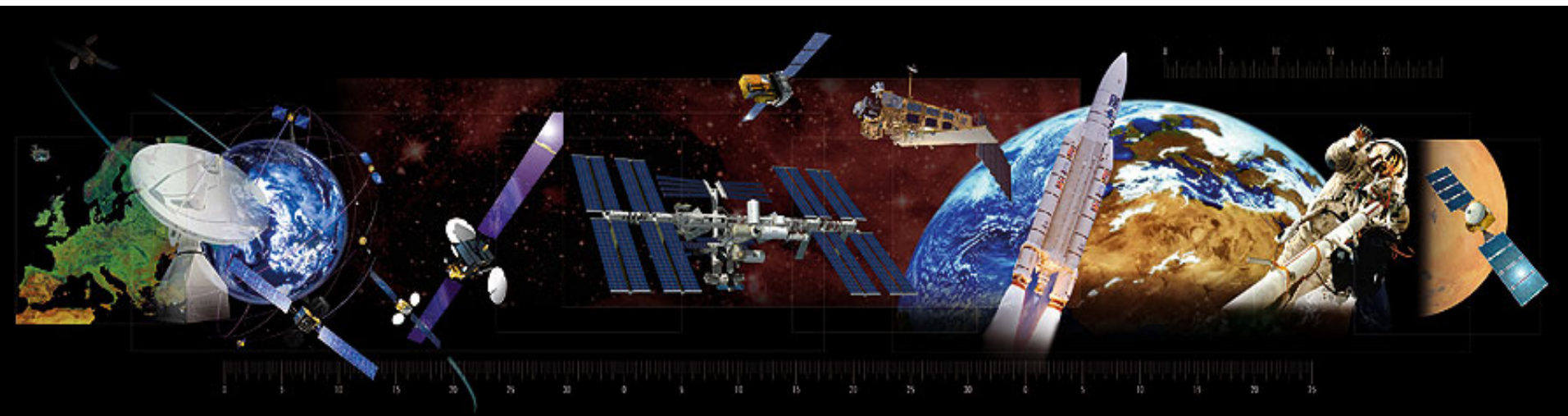
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ESA is one of the few space agencies in the world to combine responsibility in (nearly) all areas of space activity, including

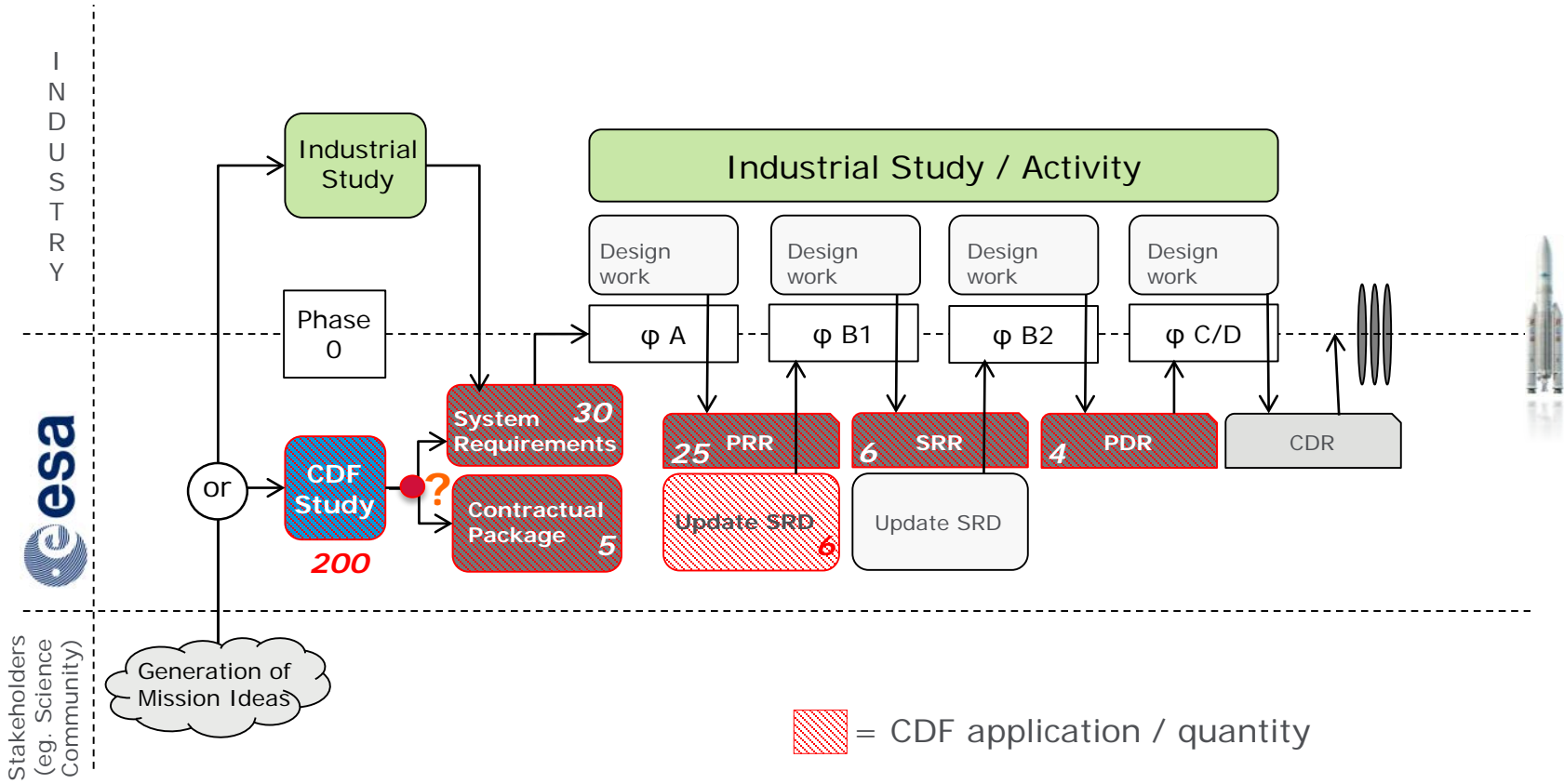


- Space science
- Human spaceflight
- Exploration
- Earth observation
- Launchers
- Navigation
- Telecommunications
- Technology
- Operations

* Space science is a **Mandatory programme**, all Member States contribute to it according to GNP. All other programmes are **Optional**, funded 'à la carte' by Participating States.

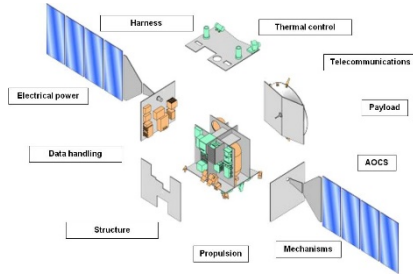


ESA Project life cycle - CDF record





CE for complex systems



Design (conceptual to DD)



Development / AIV



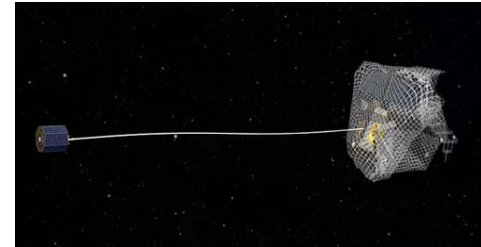
Launch



Ground segment



Operations



EoM Disposal

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Why do we need Concurrent Engineering?

Design phases: to overcome the communication gaps between the “designer” (who produces design information) and the “user” (who utilises the design information)

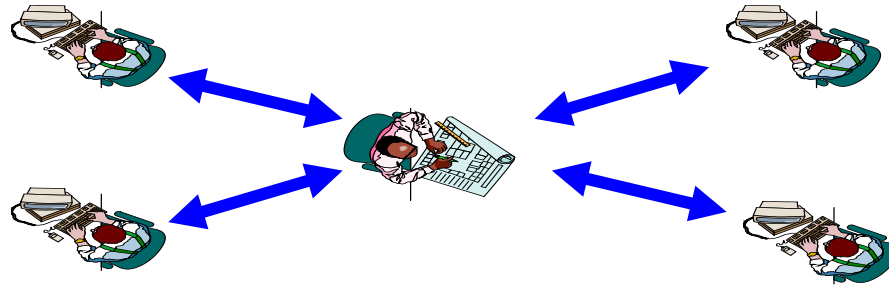
Sequential Design (“over-the-fence” approach)



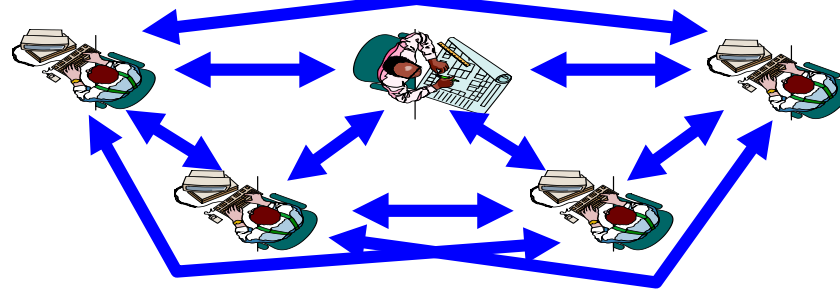
Development phase: to reduce the risk of engineering changes in later phases, which imply to halt the development and go back to the “drawing table”!

Alternative approaches to system design

Centralised Design



Concurrent Design



- The ESTEC Concurrent Design Facility is an **Integrated Design Environment (IDE)** available to all ESA programmes for interdisciplinary and inter-directorate applications, based on Concurrent Engineering methodology
- the implementation started in **Nov.1998**, on experimental basis
- initially conceived for the **assessment** and the **conceptual design** of future space missions, i.e. **internal pre-phase A / feasibility studies**
- featuring:
 - **team** orientated concurrent engineering
 - **integration** of tools, project data, mission and system models
 - **simultaneous participation of all mission domains**, incl. Programmatics/AIV, Operations, Cost Engineering, Risk Analysis, CAD, Simulation

CDF infrastructure evolution



Nov. 1998...



...2000-2007...



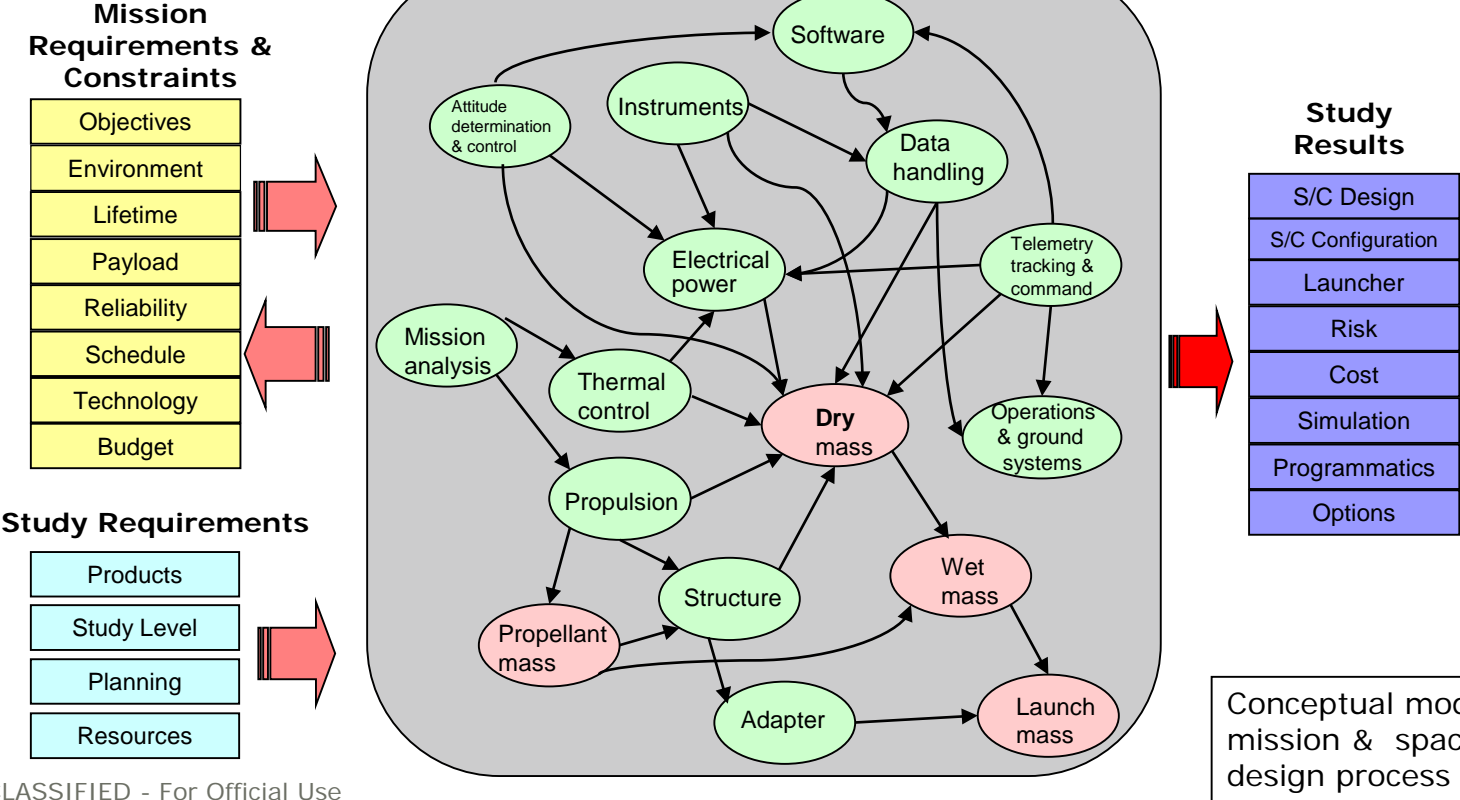
since 2008...

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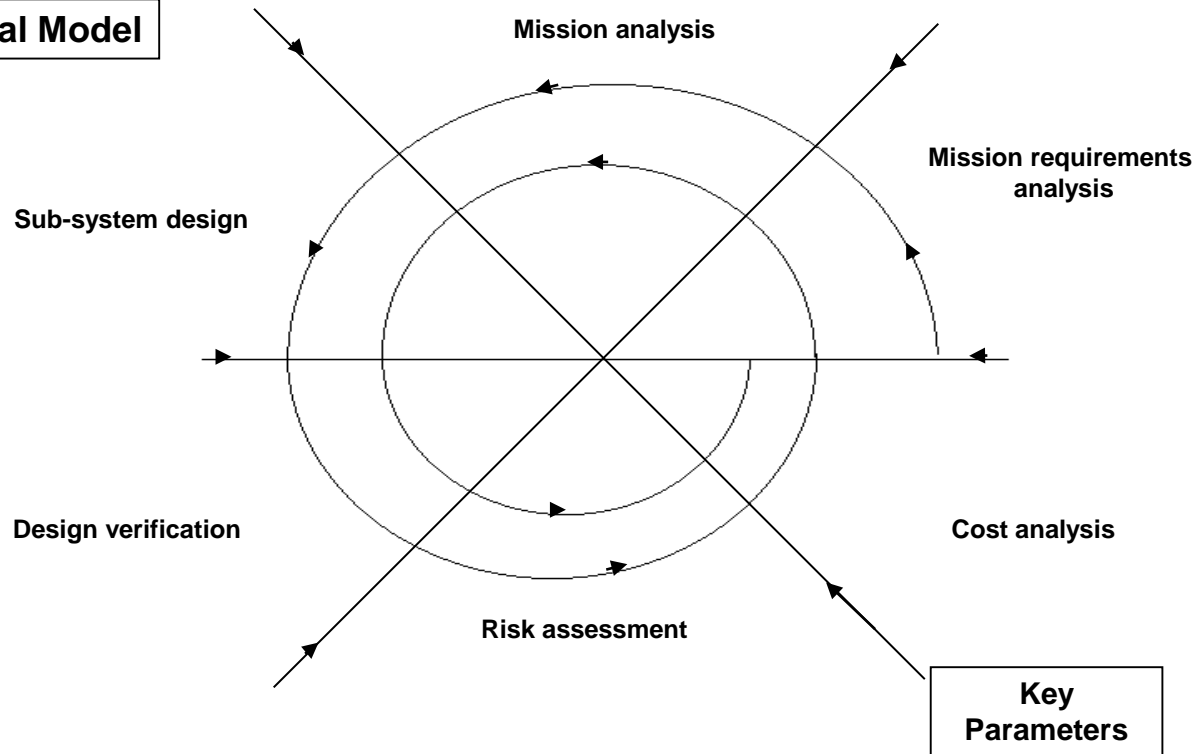
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Design is an interactive process

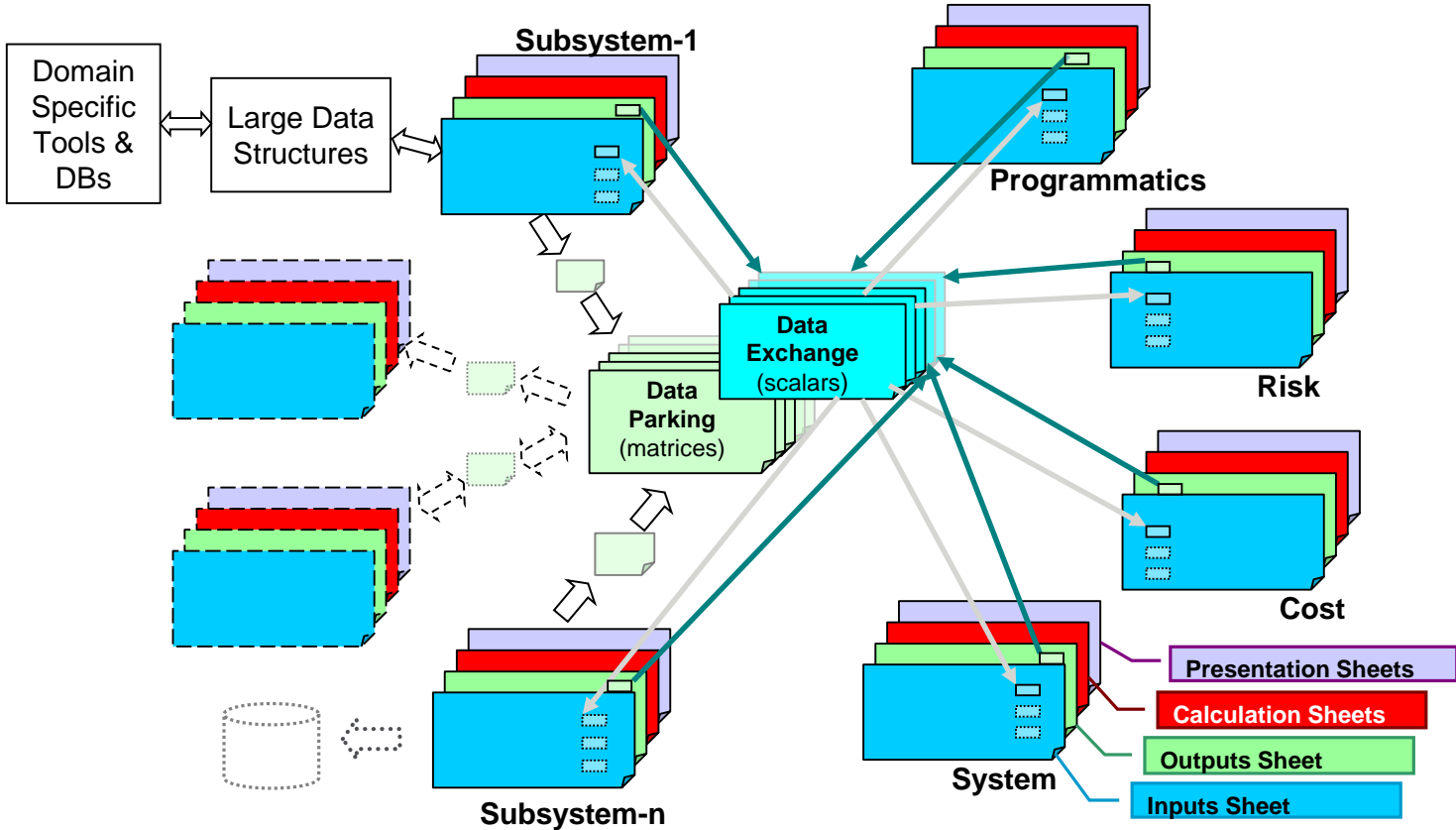


CE is an iterative process

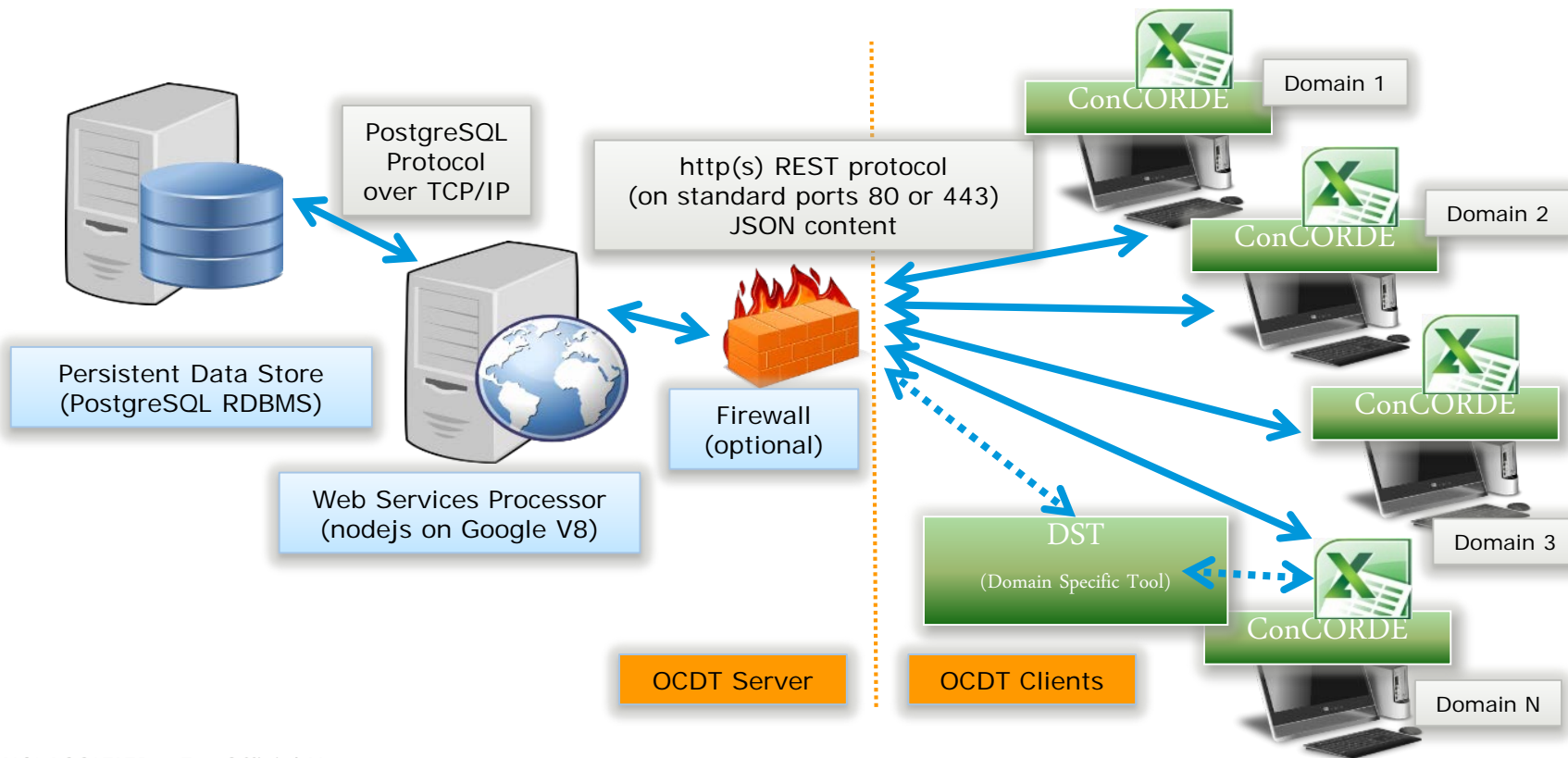
The Spiral Model



CE is Model Based – what is a model? e.g. IDM

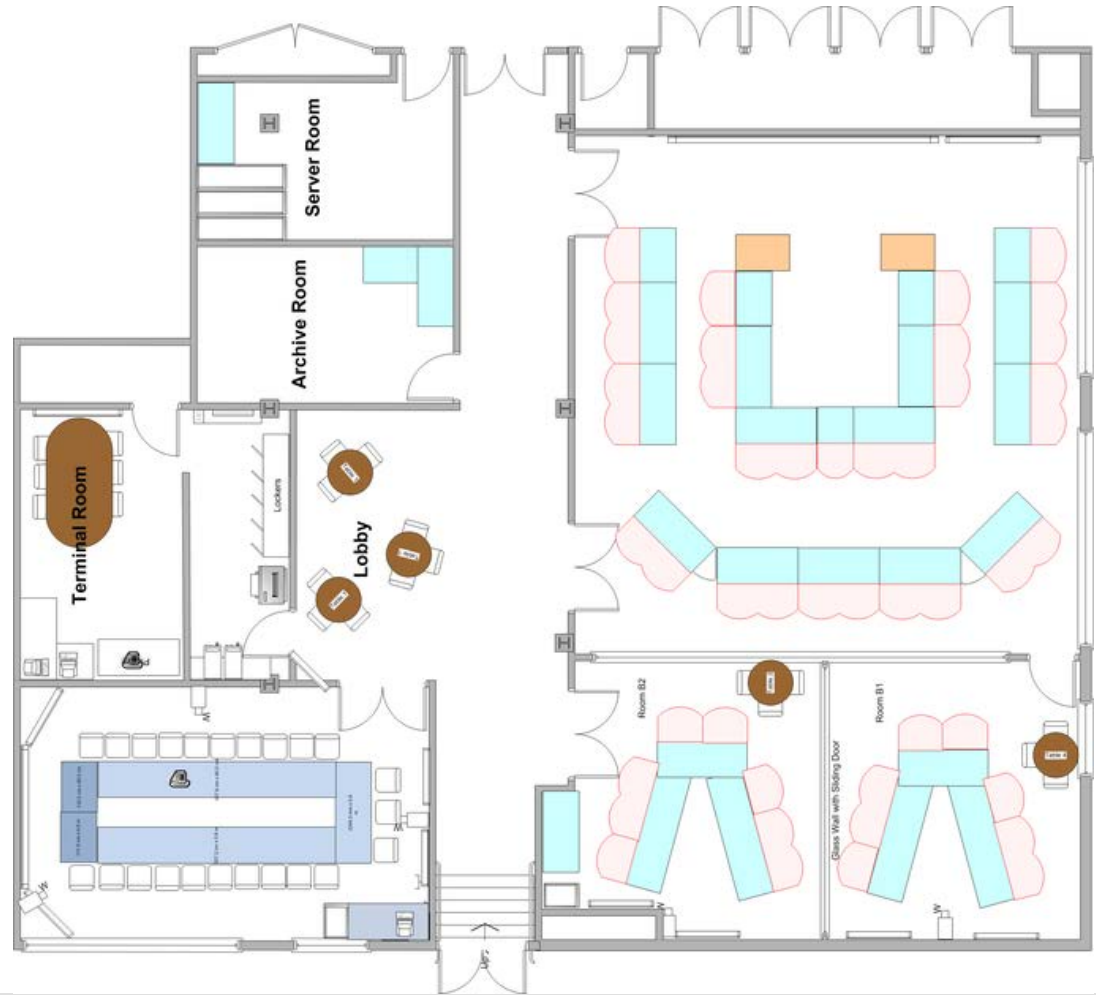


ESA-CDF new current model: Open Concurrent Design Tool (OCDT)



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CDF: the layout



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CDF room A



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CD enabling IT, design technology and tools



New design technologies are used to foster efficient cross-disciplinary analysis, experimentation, and representation of new product designs, e.g.:

- **three-dimensional (3-D) computer-aided design (CAD)**
- **simulation**
- **digital mock-up**
- **rapid prototyping (RP)**
- **stereo projection.**

Their 3-D rendering:

- **allows the expert to interpret design features,**
- **improving communication,**
- **reducing misunderstandings,**
- **helping to find solutions**

For CE to be successful, information and interpretation “asymmetries” among the experts must be avoided, whenever possible



CD is on-line, real time, highly interactive design



Approach:

- Multidisciplinary
- Holistic
- Systematic
- Centralized
- focus on Customer expectations
- ...



Methodology:

- iterative presentations
- debate
- consensus
- system awareness
- ...

- Conducted in sessions
 - plenary meeting where representatives of all space engineering domains participate from early phases (requirement analysis) to end of design (costing)
 - 6 to 10 session / study, 4 hour / session, bi-weekly frequency
 - **team leader (or facilitator)** co-ordination
 - **customer participation**
- Model driven
- On-line design
- **Highly co-operative & interactive**
- Iterations
- Design options comparison and trade-offs

CDF dynamics – Centralised architecture

Process:

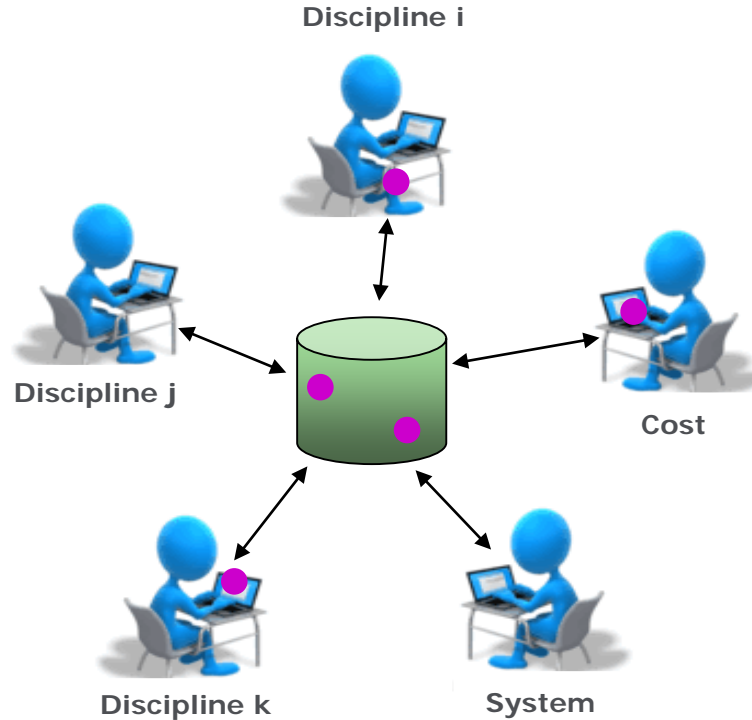
- Specialist “k” performs an estimate and shares data in CR
- Data is available to other specialists
- Each specialist can use this data to perform calculations and share the results

...

- x. System makes budgets
- y. Overall process iterates

...

- z. Final design done, all information available in CR



Central Repository (CR)



“Data”

- **Performances:**
(for typical pre-Phase A study)
 - **Study duration** (Prel. design phase): 3-6 weeks (cp. 6-9 months!)
 - Factor 4 **reduction in time**
 - Factor 2 **reduction in cost** (for the Customer)
 - **Increased nr of studies** per year, compatibly with max 2 parallel studies
- **Quality improvement**, providing quick, consistent and complete mission design, incl. technical feasibility, risk, programmatics, cost
- Technical **report becomes part of the specs** for industrial activity
Note: Cost report remains the ESA independent reference
- Capitalisation of **corporate knowledge** for further reusability
- **Requirement consolidation**

(for typical pre-Phase A study)

- **Quality improvement**, providing quick, consistent and complete mission design, incl. technical feasibility, risk, programmatics, cost
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Note: Cost report remains the ESA independent reference
- Capitalisation of **corporate knowledge** for further reusability
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- CDF: an essential **tool to support ESA Decision Making & Risk Management** processes

Concurrent Design Centres in European Space Sector

United Kingdom

- CDF at **Univ. of Strathclyde**, Glasgow
- SDO at **Airbus/Astrium**, Stevenage
- CDF at **Univ. of Southampton**, Southampton
- CDF at **Harwell Institute**, Oxford

The Netherlands

- CDF at **ESA/ESTEC**, Noordwijk

Germany

- CEF at **DLR**, Bremen
- SDO at **Airbus DS**, Friedrichshafen

France

- CDF at **ISU**, Strasbourg
- PASO at **CNES**, Toulouse
- SDO at **Airbus DS**, Toulouse
- CDF at **Thales Alenia Space**, Cannes

Switzerland

- CDF at **EPFL**, Lausanne

Portugal

- CDF at **Univ. Técnica de Lisboa**, Lisbon

Italy

- COSE at **Thales Alenia Space**, Torino
- ISDEC at **Thales Alenia Space**, Roma
- CDF at **La Sapienza Univ.**, Roma
- CEF at **ASI**, Roma

Legend:
Agency
Industry
University

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➤ Thanks for your attention!

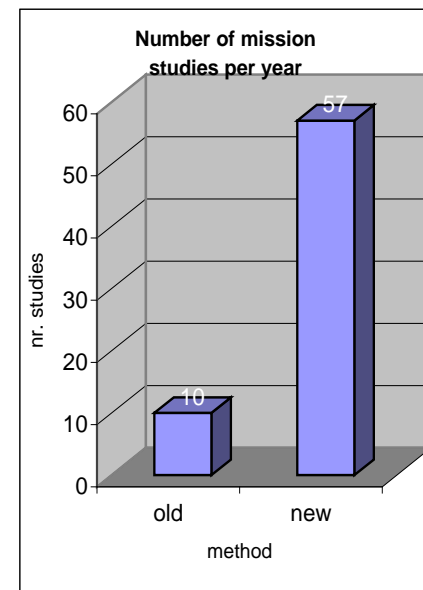
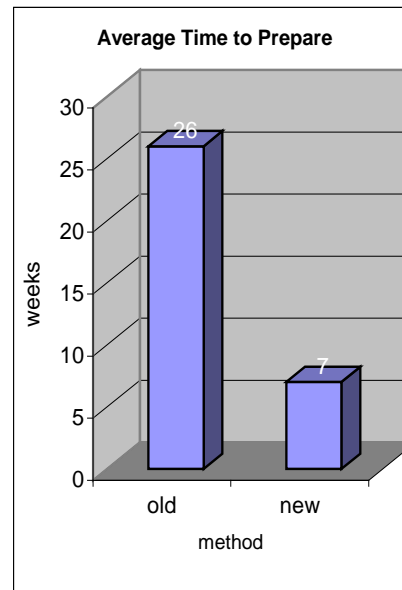
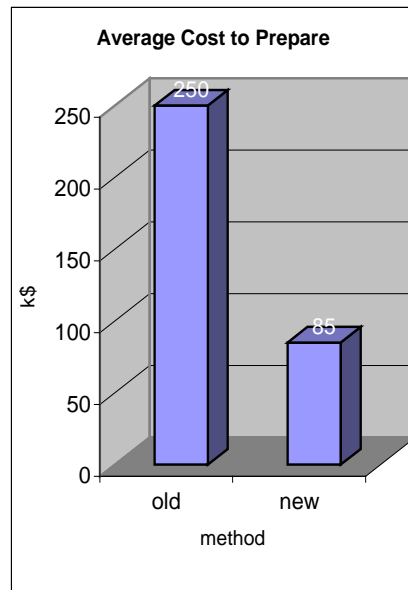
➤ Any Question?



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www.esa.int/cdf

CE: performances (source: NASA/JPL)



**PDC/Team X performances using CE
applied to future mission studies**



CNES – CIC
Inauguration Nov. 2005

DLR (Bremen) CEF
Inauguration 8 Dec. 2008





ASI CEF

First implementation: 13 July 2008

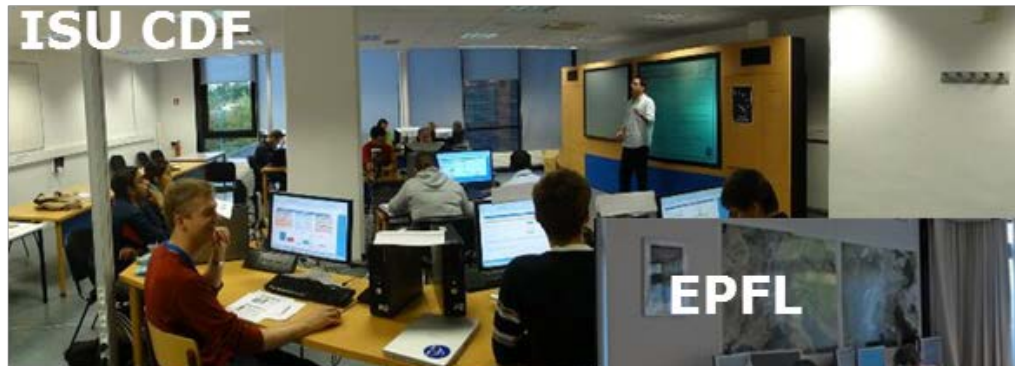
New facility inaugurated: 25 Nov. 2013



TAS-I & F (Torino, Roma, Cannes) - CDF



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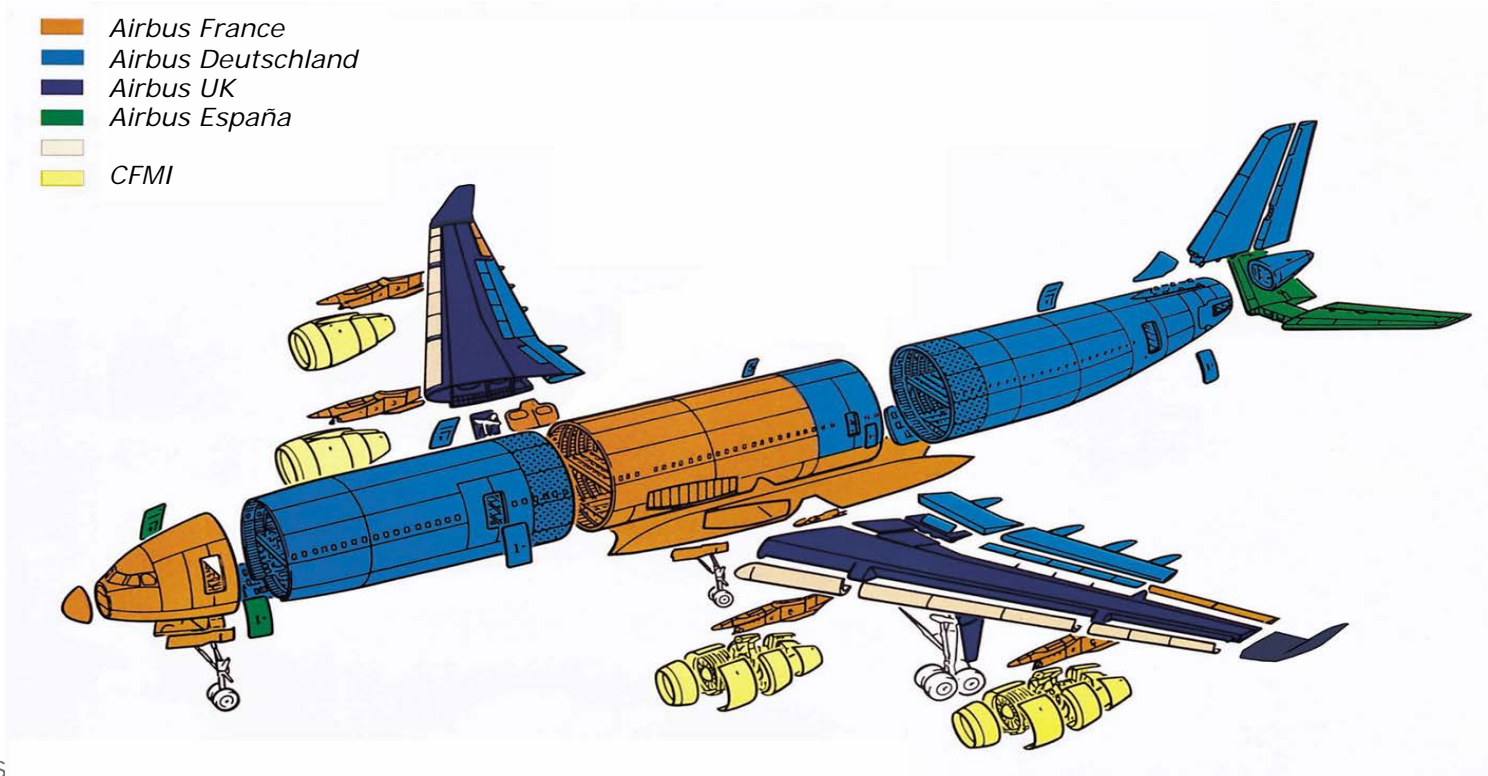
Melbourne
Australia



Victorian Space Science
Education Centre
(VSSEC)

AirBus: Production work sharing A340

(courtesy Airbus Industrie)



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AirBus: Systems Development Process & Collaborative Eng.ing

(courtesy Airbus Industrie)



- Systems are **complex** (hardware, software, loadable software, Interfaces)
Increasing trend of SIS (Software Intensive Systems)
- Each system is communicating with other systems → **Interface Management**
Inter-system communication is rapidly increasing
- The systems organisation is wide spread over different sites
- More intense **Systems suppliers** involvement
- Compatibility and continuity of models along the life-cycle (both directions)

Need to adapt **processes** and **way of working**

- Focus on complete **aircraft** product as a whole
- Work **interdisciplinary and transnational**
- Early definition and **validation** of systems architecture
- Ensure support for Collaborative Engineering by proven and committed **standards** at company level and compatible with international standards and requirements
- Early identification of **interfaces & risks**. All systems, structures,...
- Maintain competence and experience to control as Establish extended enterprise and **Architect and Integrator**

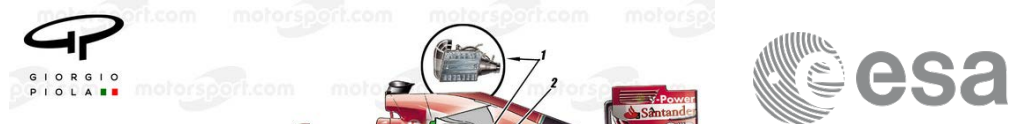
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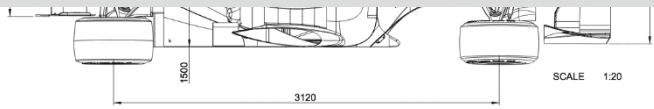
Ferrari F1 – race car design

(courtesy: Ferrari Scuderia Corse)



16
CONSTRUCTOR
TITLES

15
DRIVER
TITLES



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