CE2007
The 14th ISPE International Conference on
Concurrent Engineering
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Concurrent Engineering at ESA: from the Concurrent Design Facility (CDF) to a Distributed Virtual Facility

Massimo Bandecchi
Head of Concurrent Engineering section
& Concurrent Design Facility (CDF)
ESA/ESTEC – Noordwijk (NL)

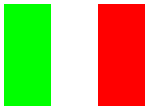
ESA: Europe in Space


Austria

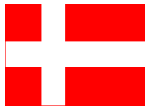

Ireland


Sweden


Belgium


Italy


Switzerland

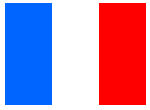

Denmark


Luxemburg


UK


Finland


Netherlands


France


Norway


Germany


Portugal


Greece


Spain

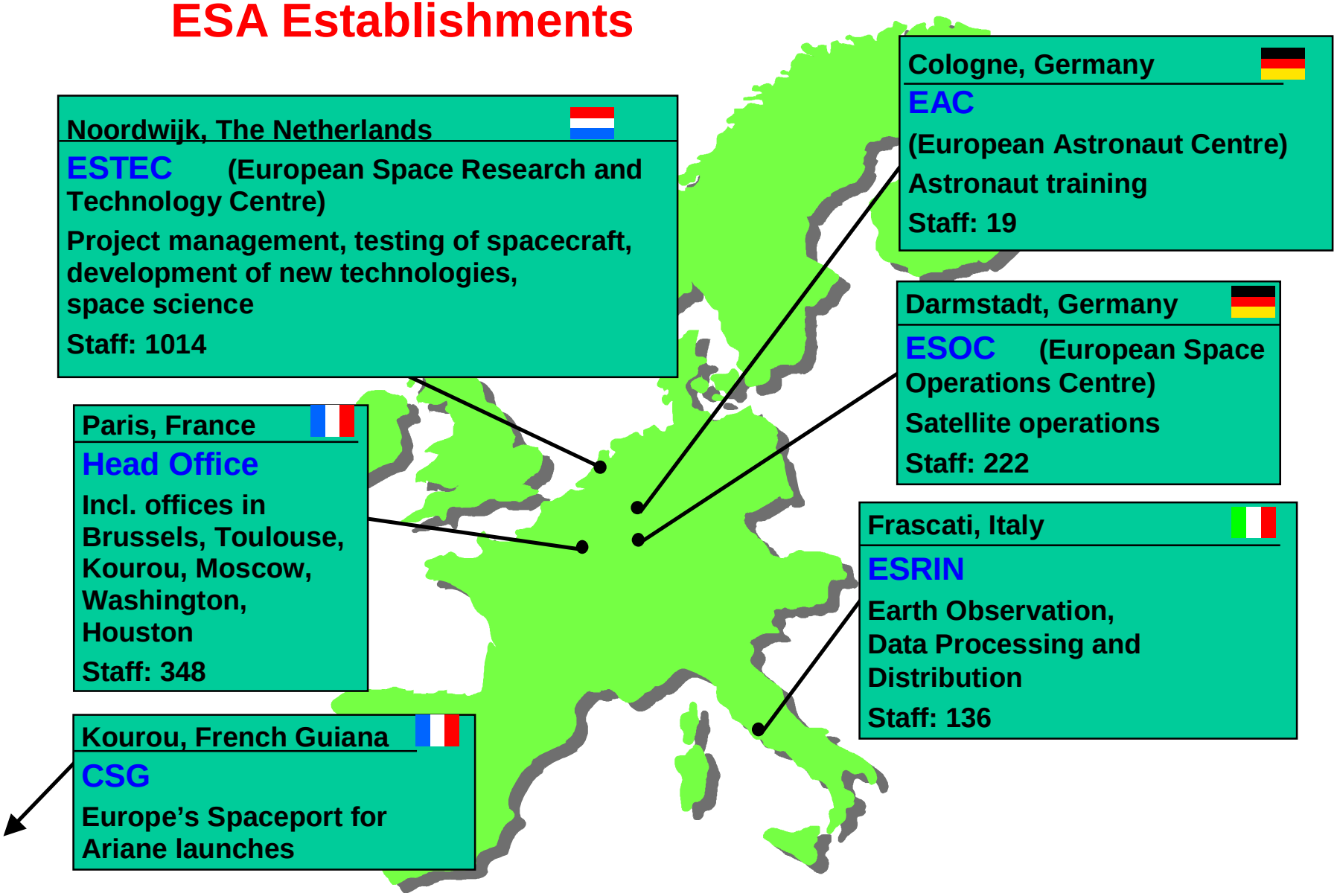
The European Space Agency was established in 1975

ESA replaced the former Eldo launcher and Esro satellite organisations, grouping the complete range of civilian space activities in a single agency

Luxemburg (16) and Greece (17) joined in 2004

Cooperation arrangement: Canada

ESA Establishments



Noordwijk, The Netherlands

ESTEC (European Space Research and Technology Centre)

Project management, testing of spacecraft, development of new technologies, space science

Staff: 1014

Cologne, Germany

EAC

(European Astronaut Centre)

Astronaut training

Staff: 19

Darmstadt, Germany

ESOC (European Space Operations Centre)

Satellite operations

Staff: 222

Paris, France

Head Office

Incl. offices in Brussels, Toulouse, Kourou, Moscow, Washington, Houston

Staff: 348

Frascati, Italy

ESRIN

Earth Observation, Data Processing and Distribution

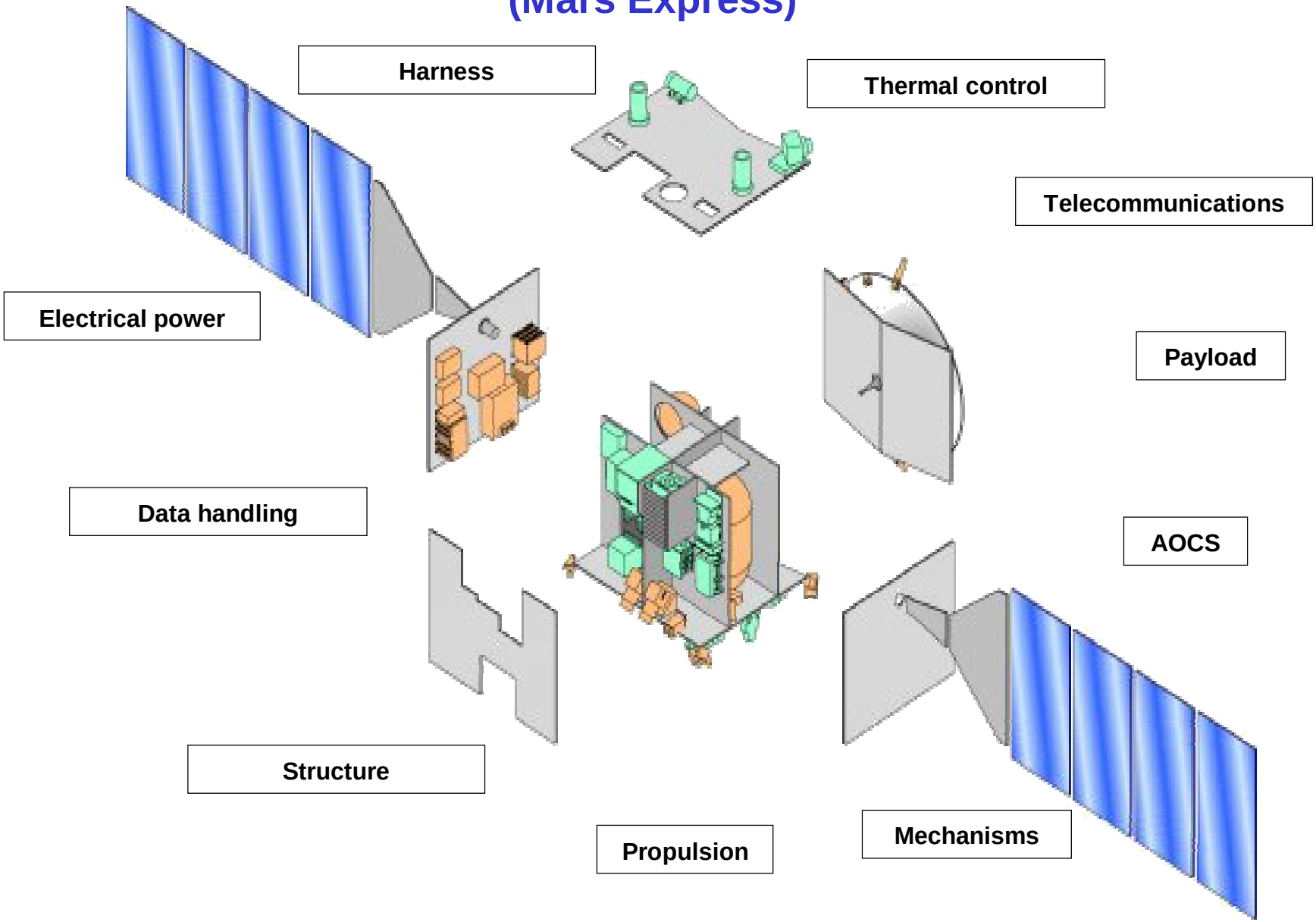
Staff: 136

Kourou, French Guiana

CSG

Europe's Spaceport for Ariane launches

What is a spacecraft system?
(Mars Express)



Space mission life cycle

Design and development

- Technology development
- Component procurement
- Manufacturing
- Assembly
- Verification & test

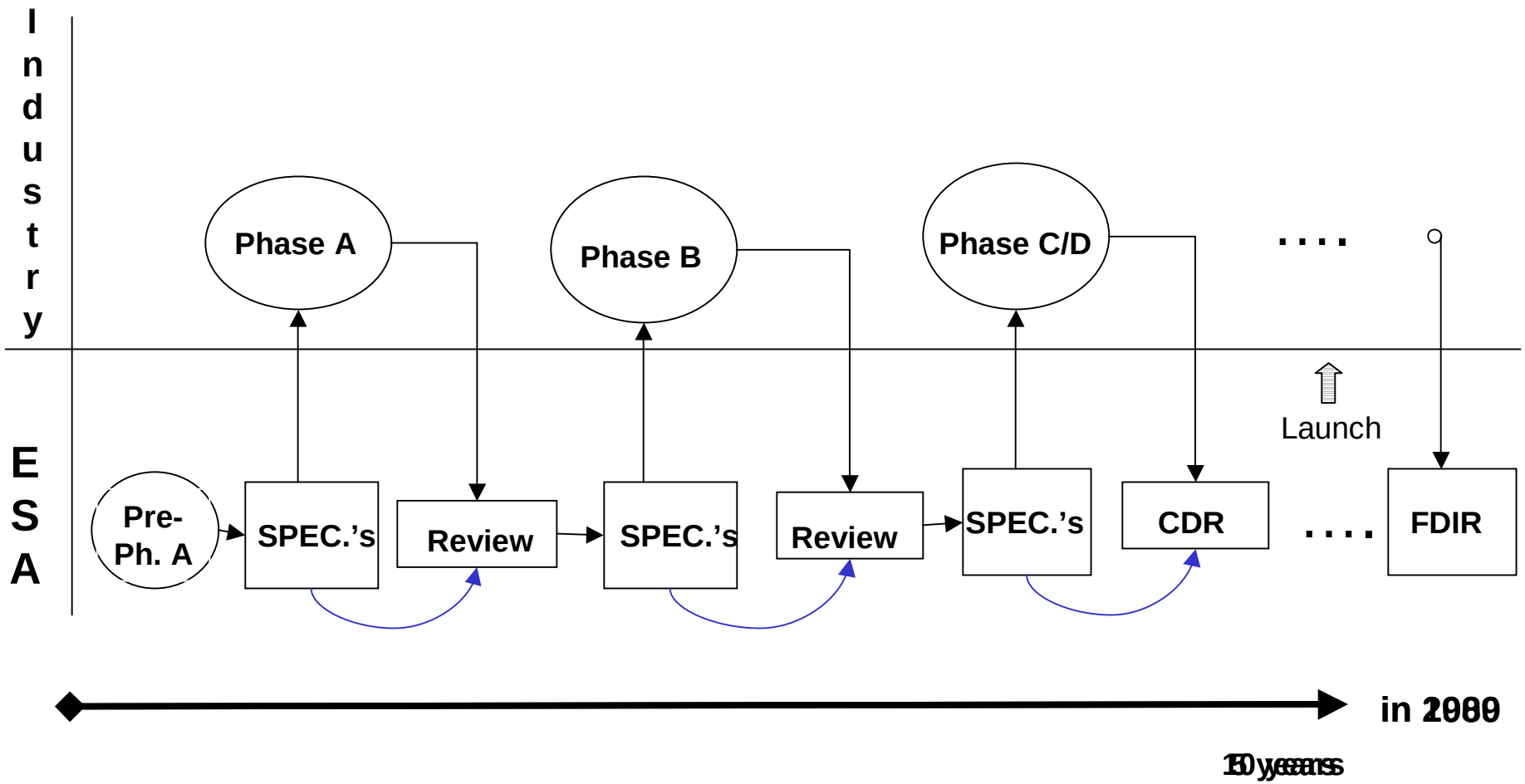
Special needs

- No mass production (EM & FM)
- No field service possible!
- Redundancy

Launch

Operations

ESA project life-cycle



CE: a definition

"Concurrent* Engineering is a systematic approach to integrated product development that emphasises the response to customer expectations. It embodies team values of cooperation, trust and sharing, in such a manner that decision making is by consensus, involving all perspectives in parallel, from the beginning of the product life-cycle."

* **collaborative co-operative collective**

simultaneous ….

CDF: what is it?

- **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**

- **Following the experience of using CE for the assessment of specific mission, the implementation of a permanent facility started in Nov.1998, on an experimental basis on initiative (and support) of the General Studies Programme (GSP)**

- **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: the achievements

Activities performed

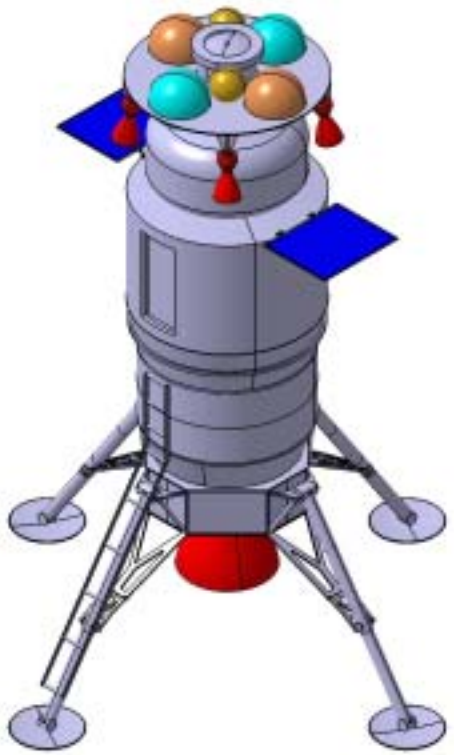
- **70+ (potential) future missions studied and designed internally at pre-Phase A, conceptual, system level**
- **3 new launcher concept design**
- **6 complex payload instrument design (IDA), incl. Platform, system, mission**
- **12 reviews of Industrial Phase A studies (internal + Industry)**
- **5 ISS on-board facilities/experiments accommodation studies; teaming with/supporting Industry in Phase A**
- **Joint studies with NASA/JPL/PDC-Team X (Distributed Concurrent Engineering), CNES CIC, Industry, Academia**
- **Anomaly investigation for later project phases**
- **Educational, training, promotion and standardisation activities**

Spin-off

- **Transfer of CDF know-how and software to national Agencies, Industry, Academia**

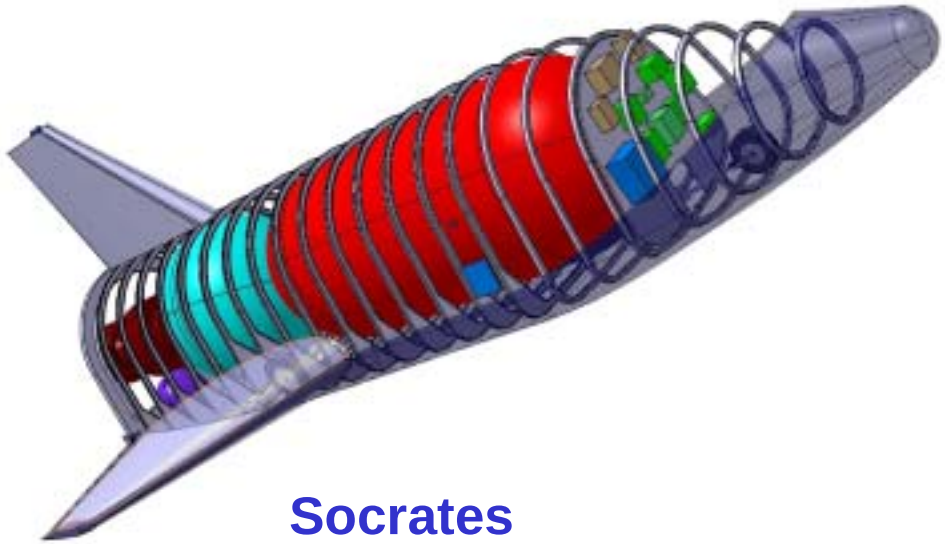
Design of manned vehicles for the exploration preparation programme

Human Missions to Mars

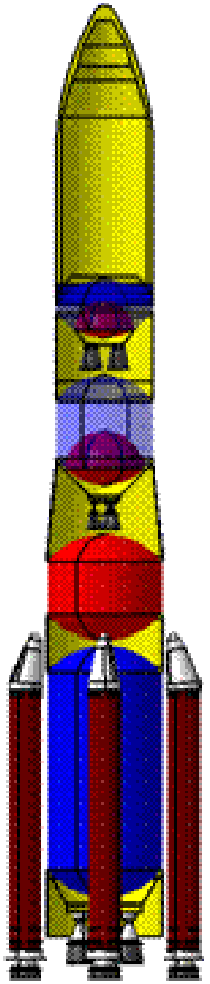


Moon Lander

Advanced launchers

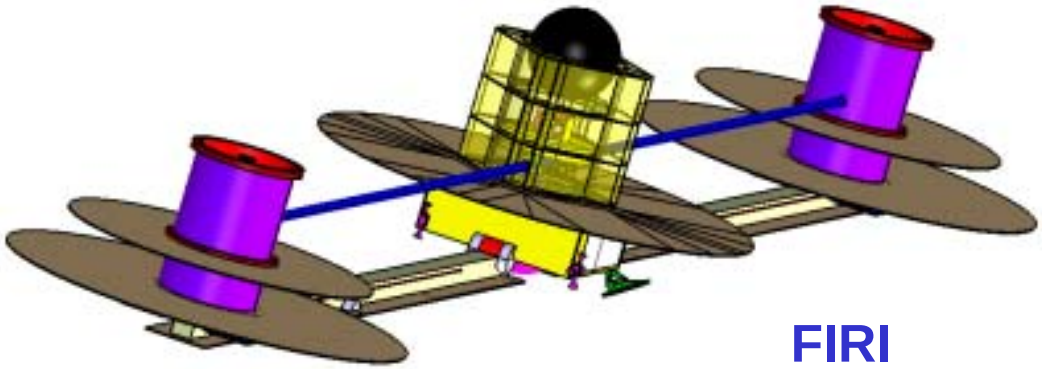


Socrates

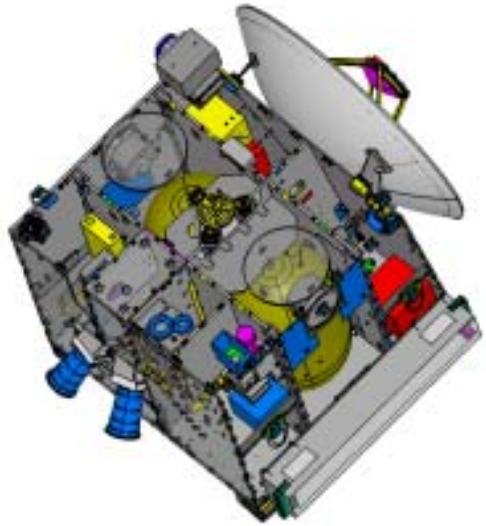


Heavy Lift Launch Vehicle

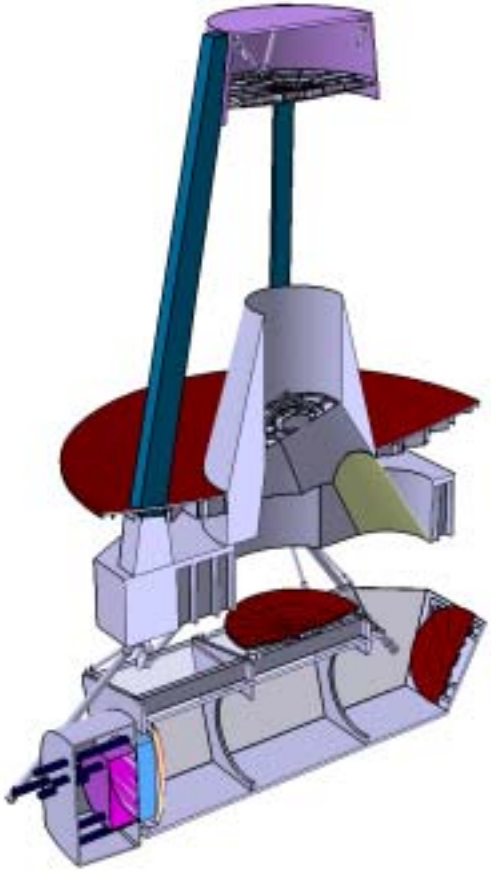
Telescopes and Technology



FIRI

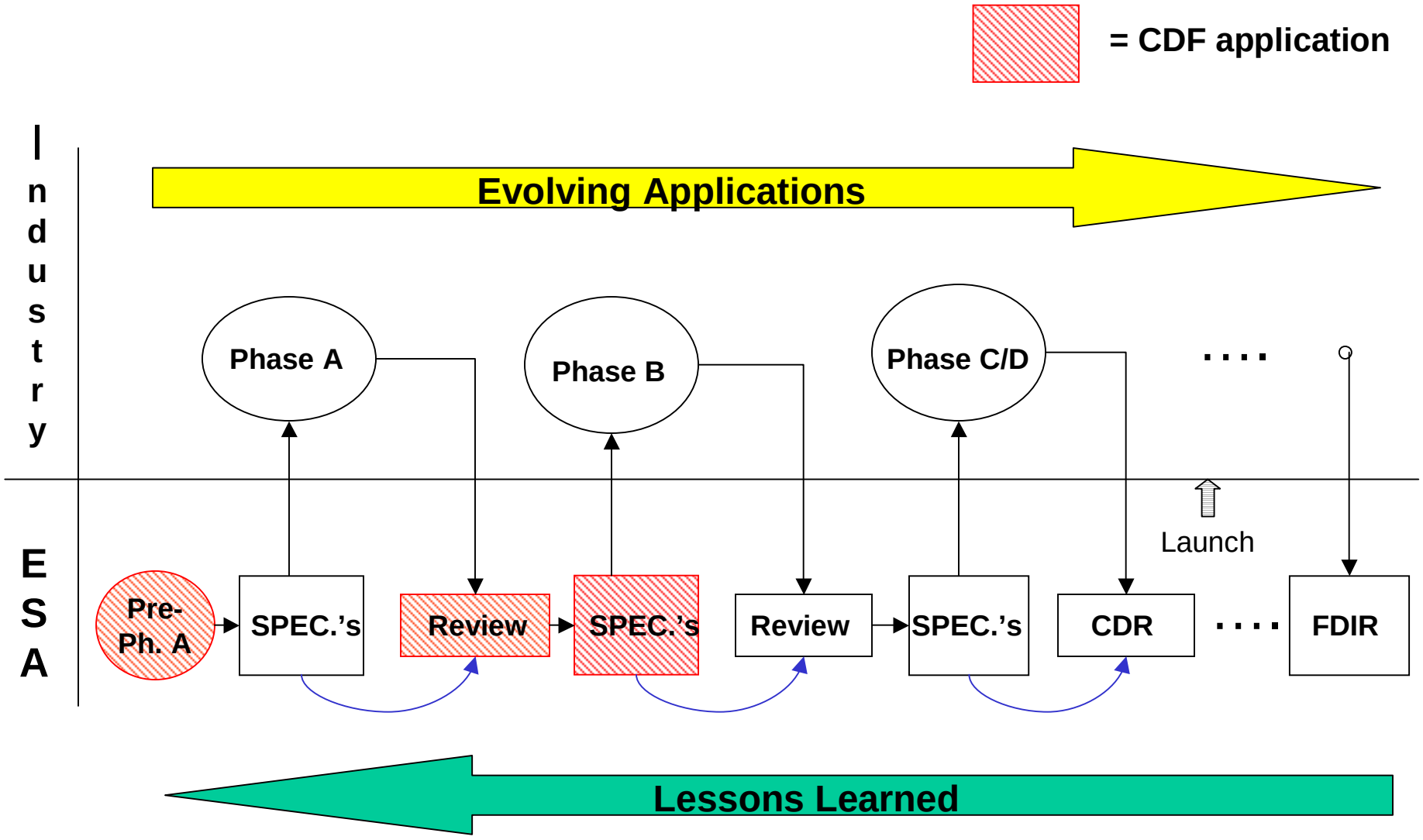


WiFLY



WFI Payload cutaway

The ESA project life-cycle

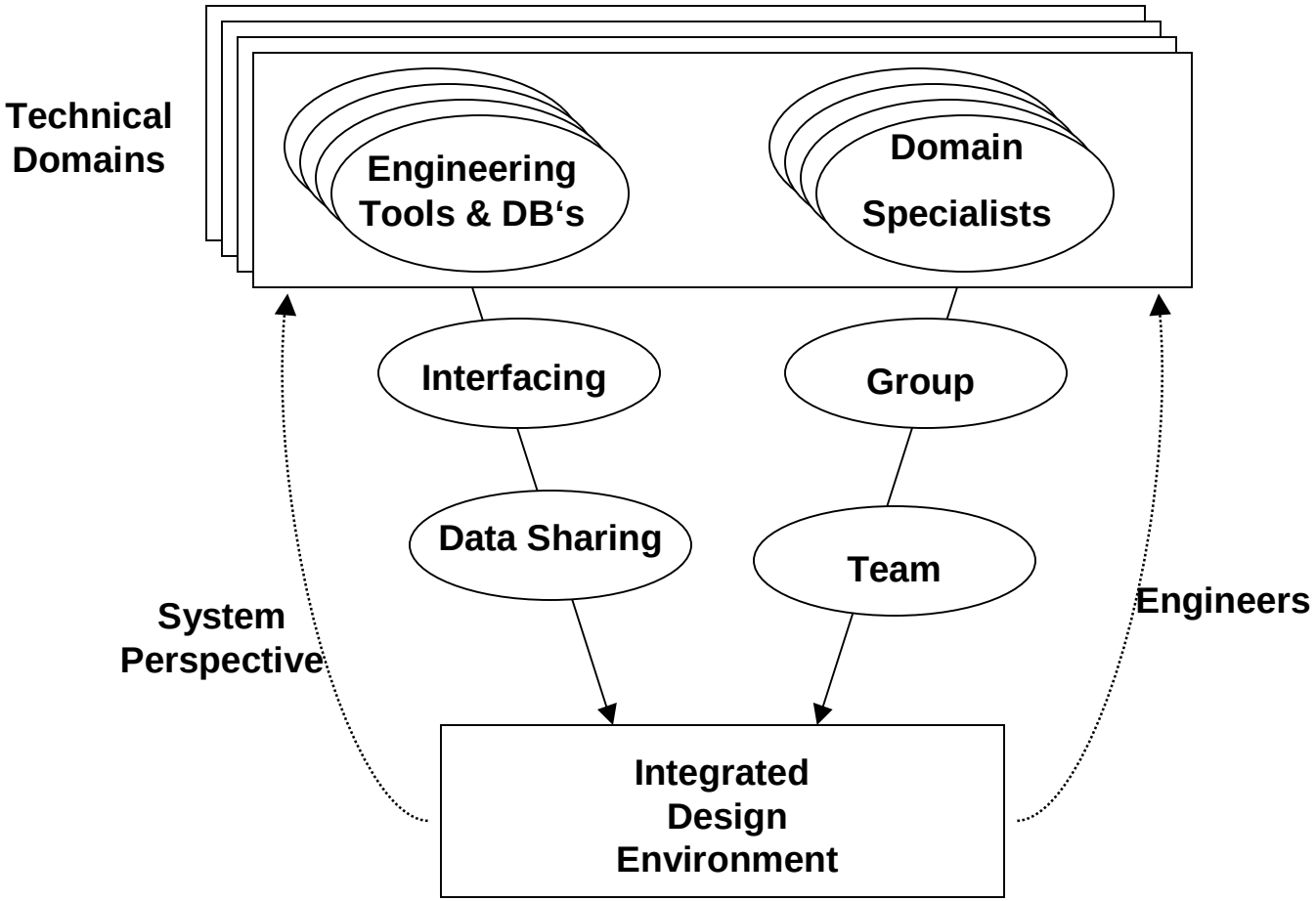


CDF: the 5 key elements

- **a process**
- **a multi-disciplinary team**
- **a facility**
- **an integrated design model**
- **a software and hardware infrastructure**

CDF: the approach
(Organisation dependent)

- **Re-organization of existing tools and human resources in a more effective (i.e. “concurrent”) way**



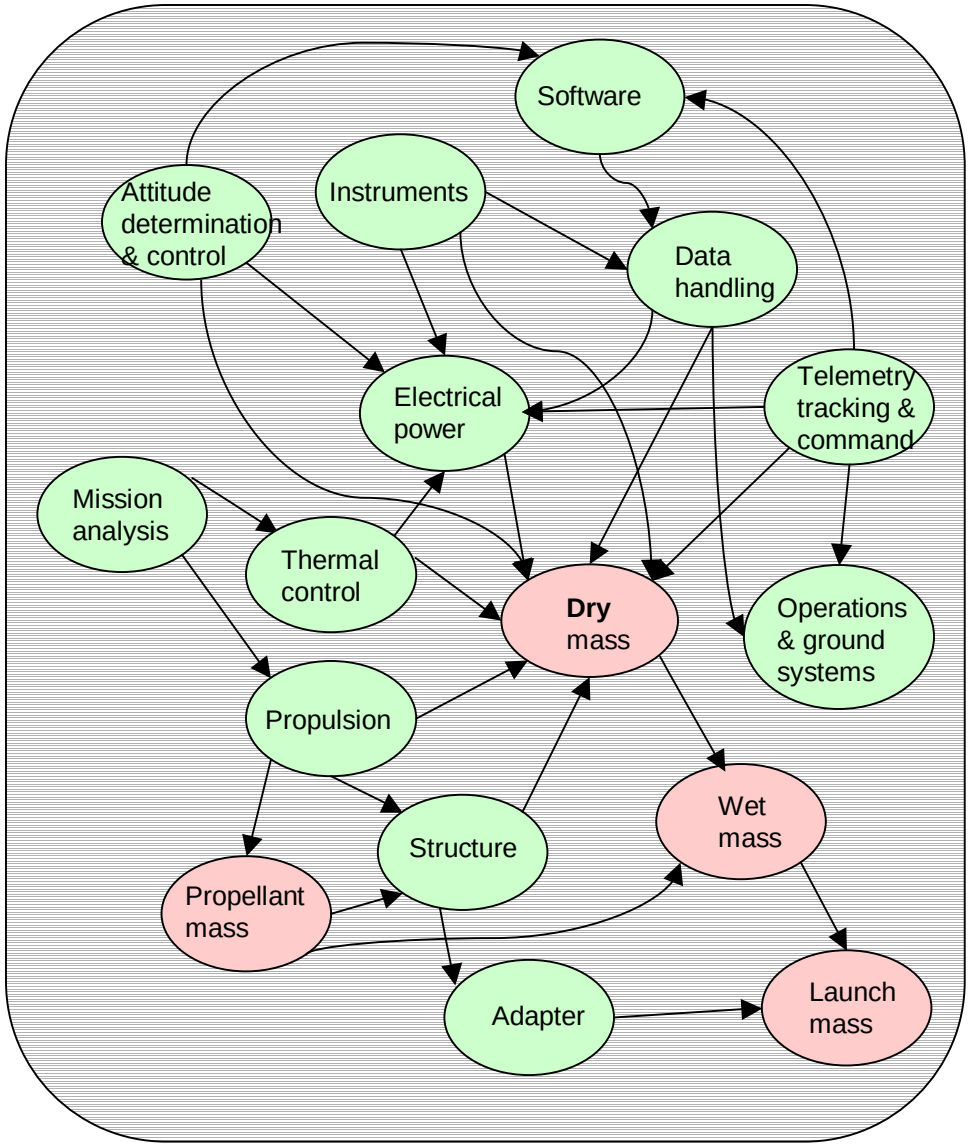
Design process

Mission requirements & constraints

- Objectives
- Environment
- Lifetime
- Payload
- Reliability
- Schedule
- Technology
- Budget

Study requirements

- Products
- Study Level
- Planning
- Resources

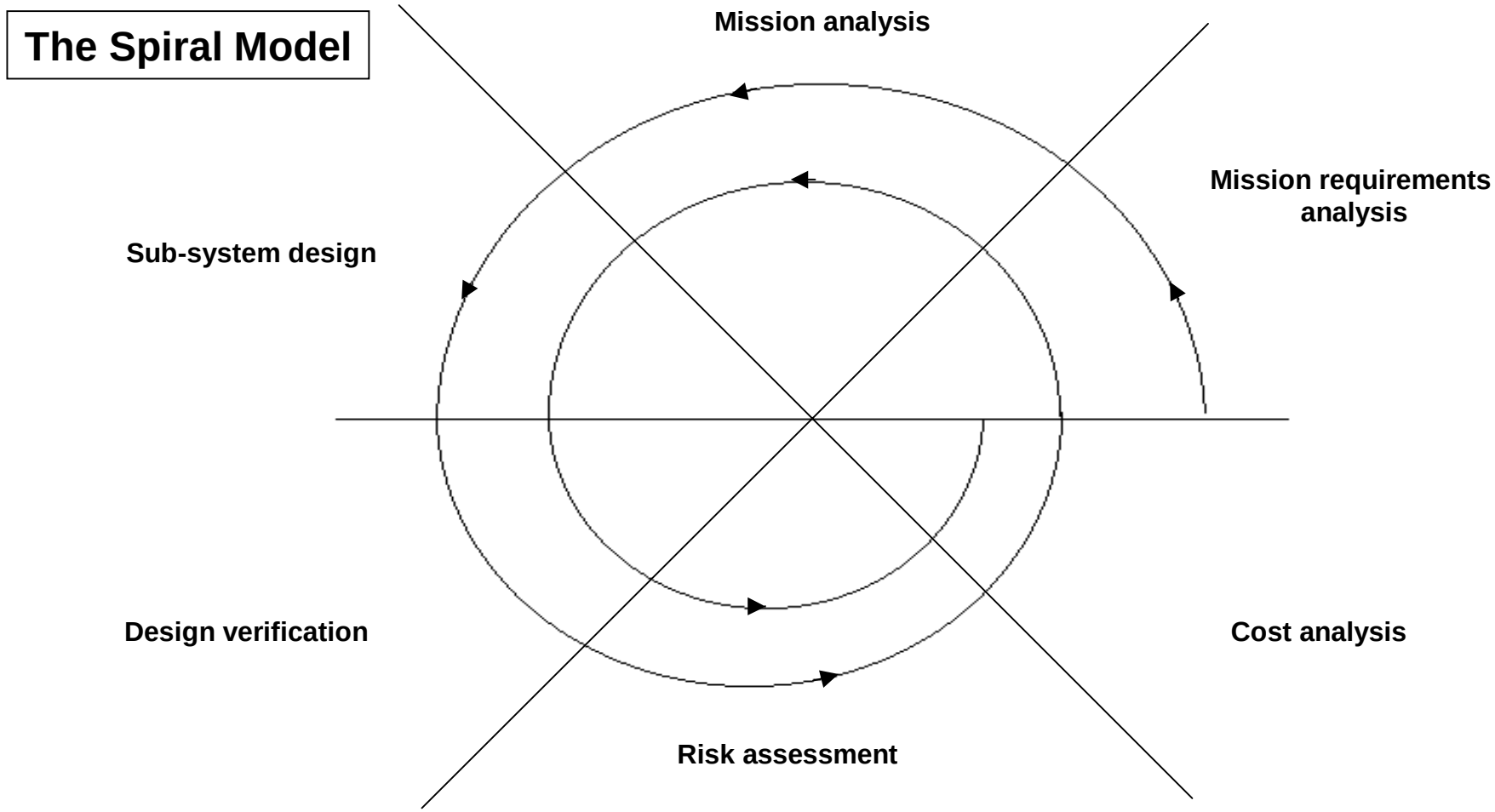


Study results

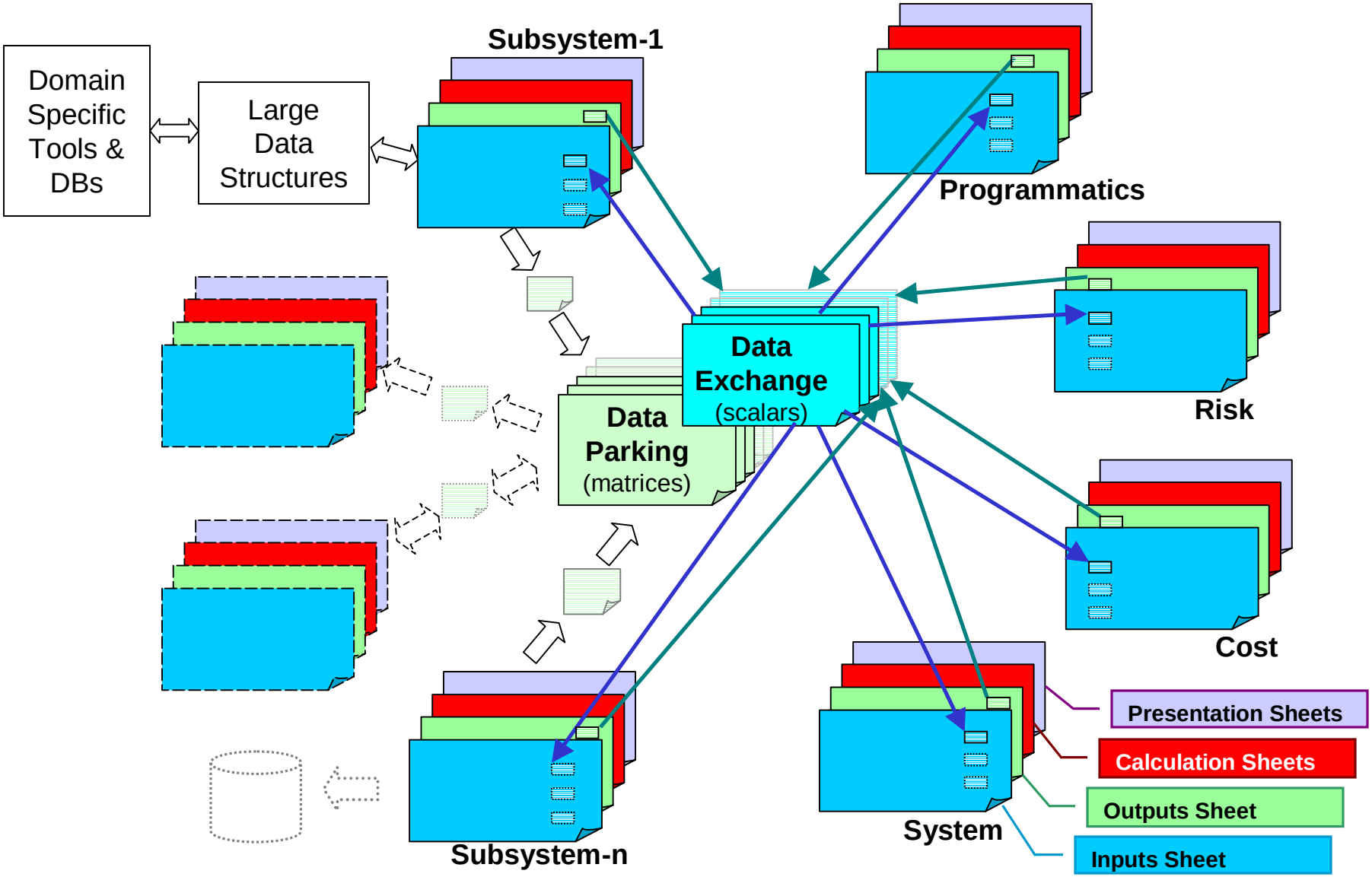
- S/C Design
- S/C Configuration
- Launcher
- Risk
- Cost
- Simulation
- Programmatics
- Options

Conceptual model of mission & spacecraft design process

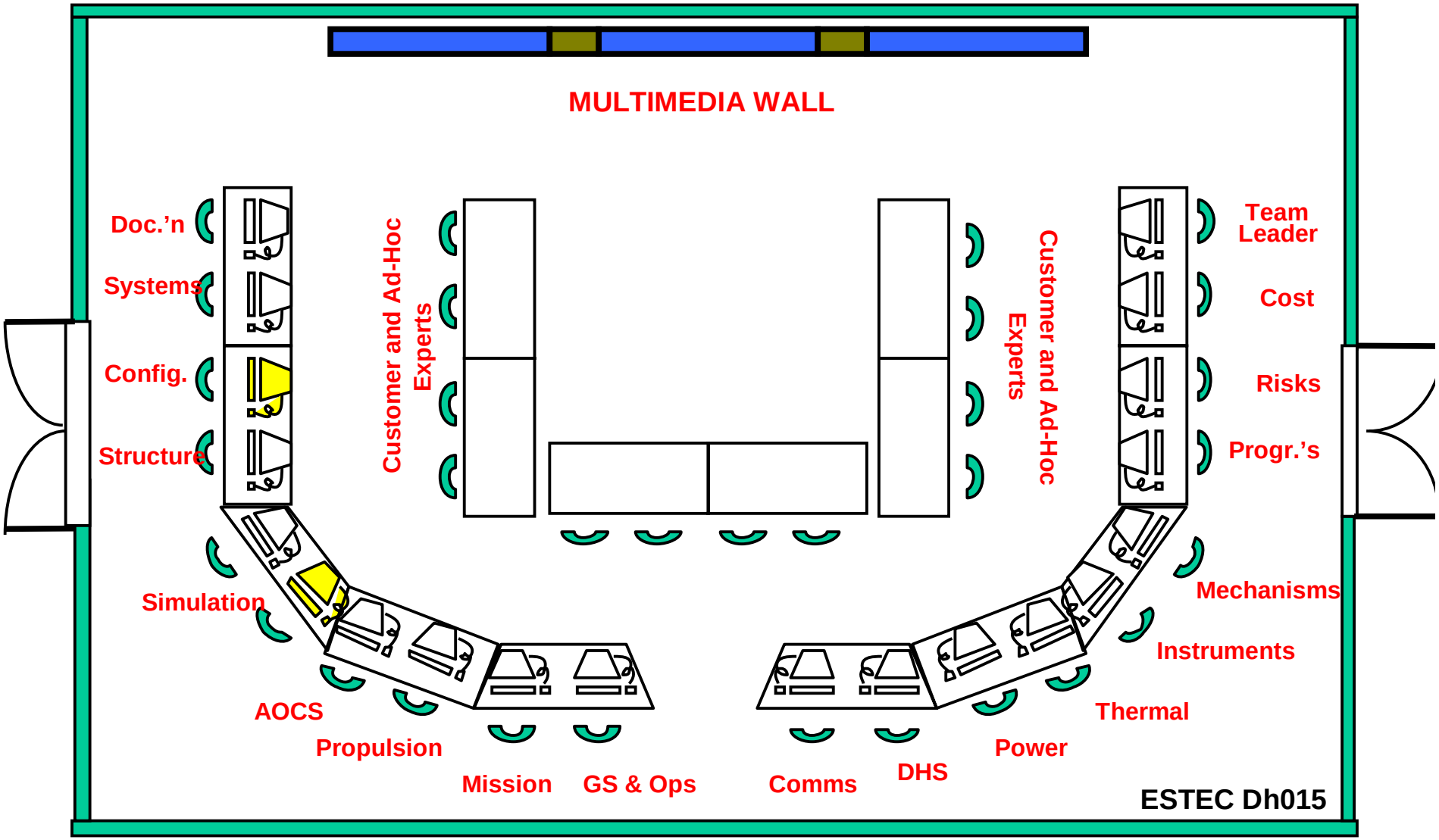
CE: iterative process



Integrated Design Model



CDF layout

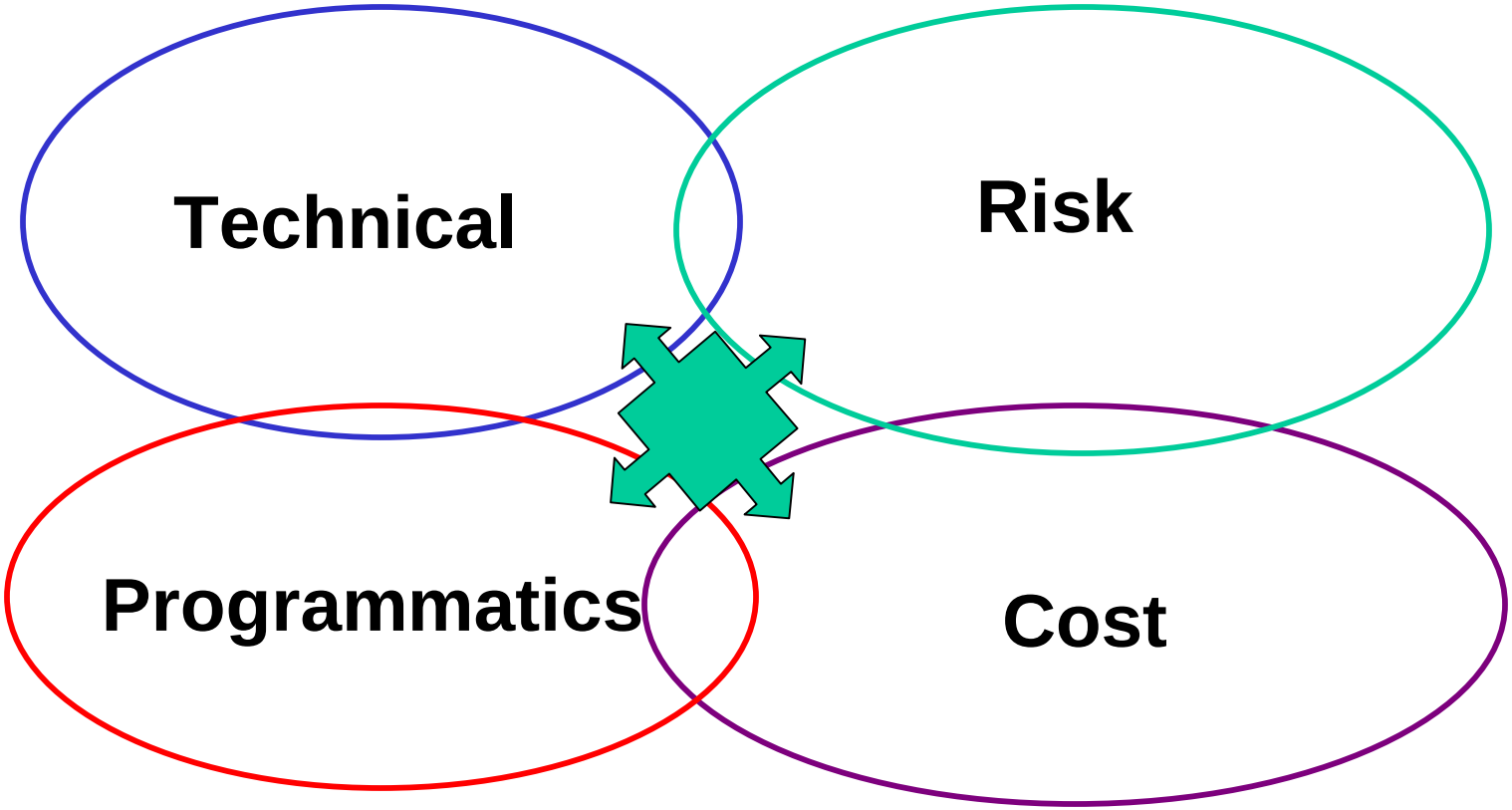

MULTIMEDIA WALL
Doc.'n
Systems
Config.
Structure
Customer and Ad-Hoc Experts
Customer and Ad-Hoc Experts
Team Leader
Cost
Risks
Progr.'s
Simulation
Mechanisms
Instruments
Thermal
Power
DHS
Comms
AOCS
Propulsion
Mission
GS & Ops
ESTEC Dh015

A CDF design session

Process elements

- **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 co-ordination**
  - **customer participation**
- **Model driven**
- **On-line design**
- **Highly co-operative & interactive**
- **Iterations**
- **Design options comparison and trade-offs**

Space mission feasibility



Benefits

- **Performances (typical pre-Phase A study):**
  - **Study duration (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**
- **Improvement in quality, providing quick, consistent and complete mission design, incl. technical feasibility, programmatics, risk, cost**
- **Technical report becomes part of the specs for subsequent industrial activity, Cost report remains the ESA independent reference**
- **Capitalisation of corporate knowledge for further reusability**
- **CDF: an essential tool for the ESA Decision Making and Risk Management processes**

Concurrent design centres for space in the world

	Facility name	since
> NASA:		
▪ **NASA/JPL**	**PDC (Project Design Center)**	**1996**
▪ **Every NASA site is (getting) equipped with a CE facility…**		
▪ **NASA/JPL**	**Mission System Design Center**	**2000**
> US Aerospace industries:		
▪ **Aerospace Corp. (US)**	**CDC (Concept Design Center)**	**1995**
▪ **Lockheed Martin (US)**	**CEE ….**	
▪ **TRW**	**….**	
> European Space Agencies and Industries:		
▪ **EADS ASTRIUM**	**SDO (Satellite Design Office (D))**	**1999**
▪ **CNES**	**CIC**	***2005***
▪ **ASI**	**CEF**	***2007***
▪ ***DLR***	***CDF***	***2008***
> Australia:		
▪ **Victorian Space Science Education Centre**		**2005**

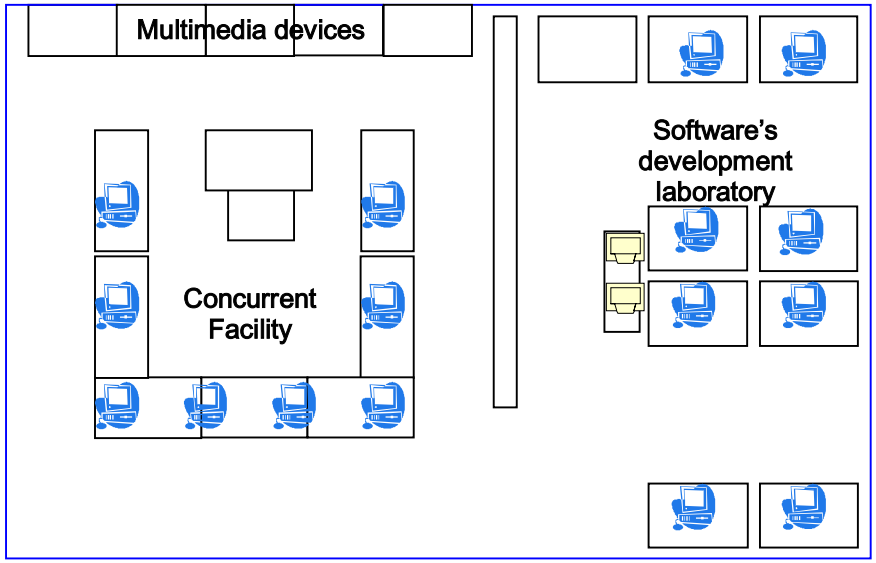
ESA partners using CDF Core-IDM

CNES – CIC

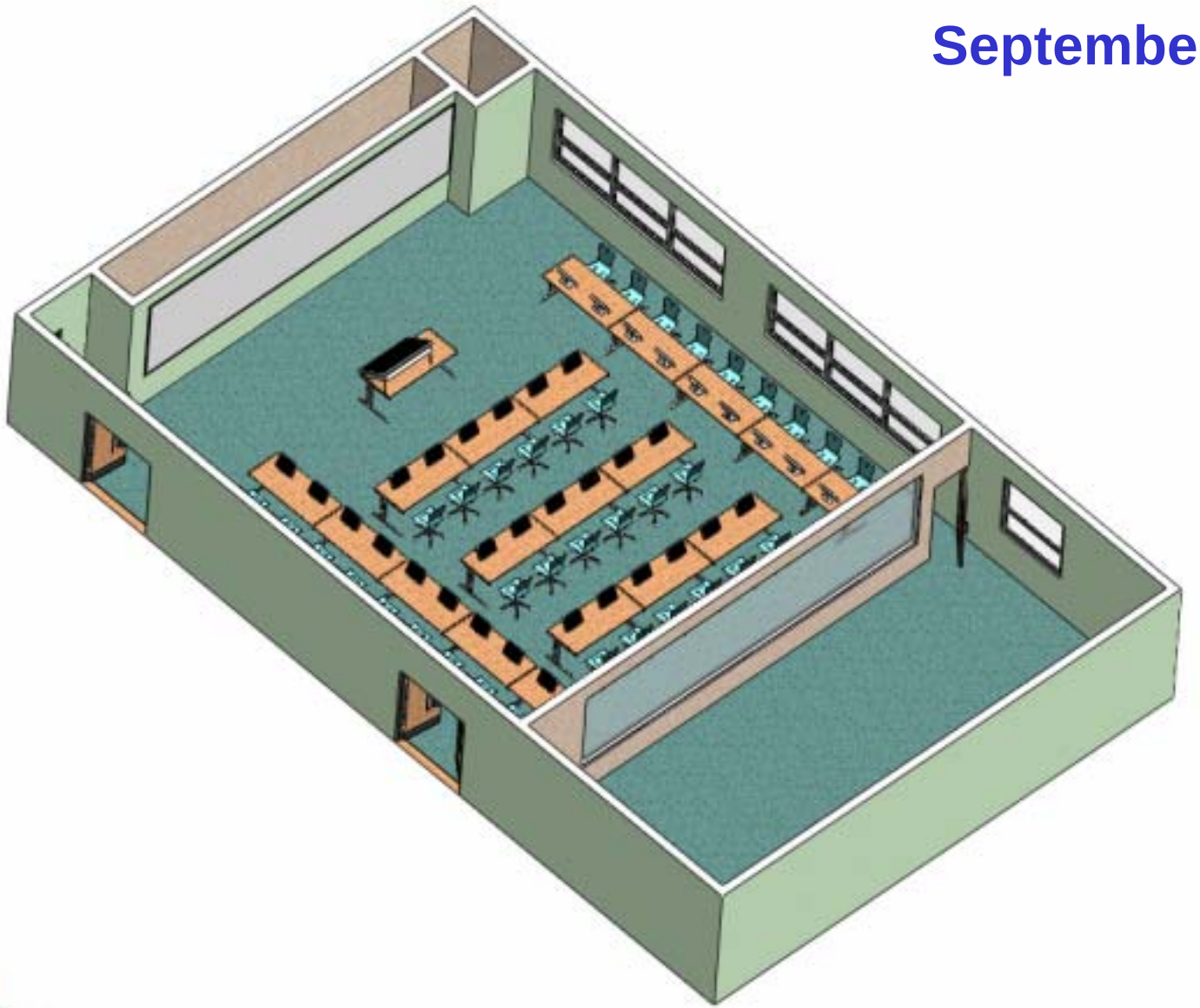
EADS ASTRIUM (D) - SDO (Satellite Design Office)

Alenia (Turin) - CDF

Layout



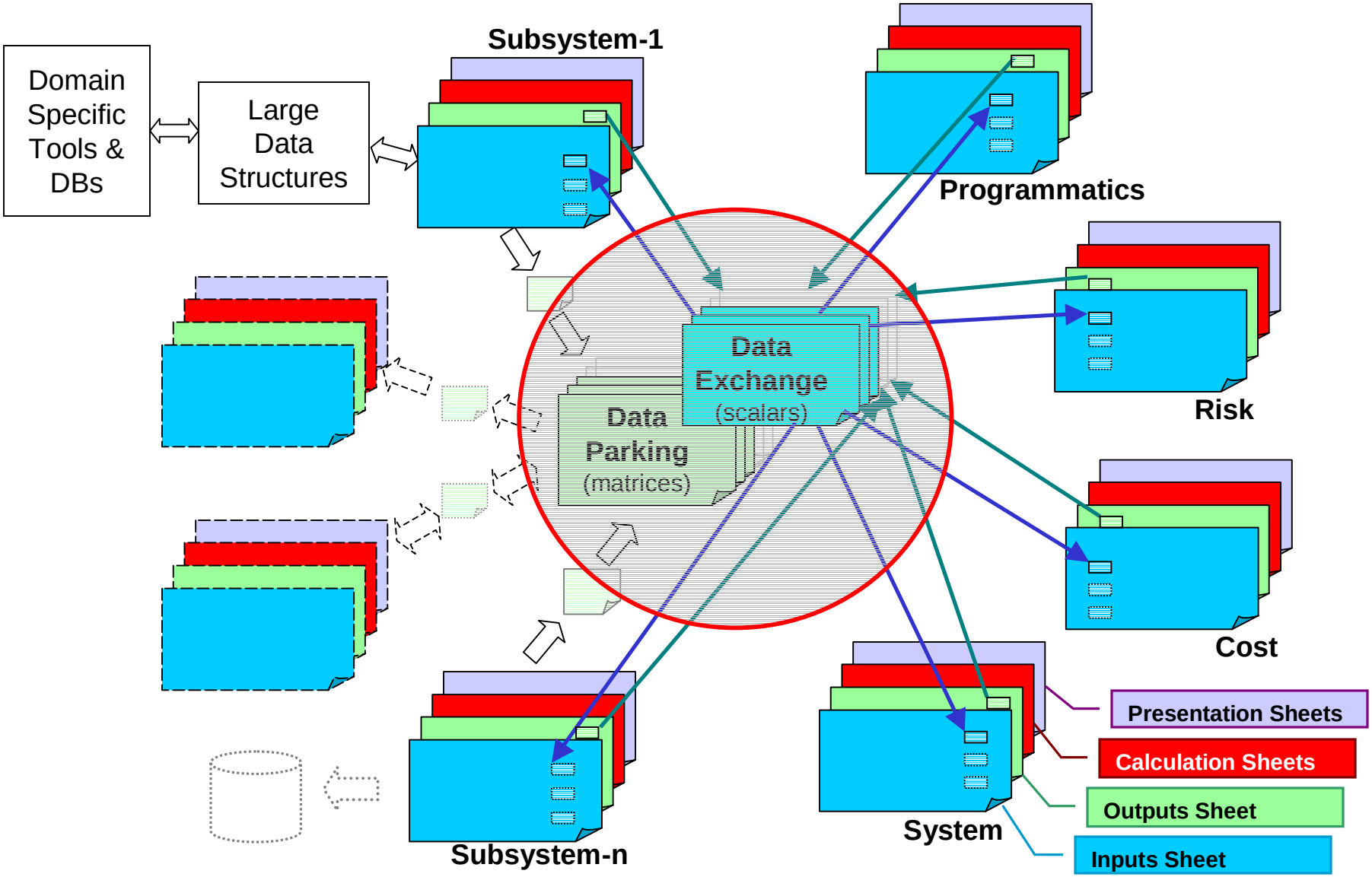
New CDF
September 2007



Enabling Factors
Our lesson learned (some hints)

- Convince the parties involved; each one should get added value(s) from the new approach:
  - Specialist engineers (involvement end-to-end)
  - Management (business case, ROI)
  - Customer (provide a better “driver’s seat”)
- Computer and model based (or aided) design: not necessarily a complicated ICT infrastructure
- Parametric design model
- No radical change in tools and data, to start with, but concentrate on new approach, creation of the team
- Right at the first time (especially for space…)
- “Standardised flexibility” or “flexible standard” (part of the systematic approach, i.e. the references)
- Radical change in mentality and attitude required from all stakeholders
- …

Integrated Design Model



The steps to the Distributed Virtual Facility

- **Promotion of concurrent design methods among the European partners, Industry and Academia**
- **Standardisation of the Data Model derived from the CDF Integrated Design Model - creation of a 'product' IDM based on open standards, but only the "core" part of it**
- **Distribution of the product IDM (core) to European space industry and partners as Community Software**
- **Assessment of the GRID technology and infrastructure as the enabler for the creation of Distributed Concurrent Design and a Virtual Concurrent Facility**
- **Assessment of expansion of CE technologies over all project-phases**
- **…**

The vision


common processes
standards
enabling technologies
compatible infrastructures

Further information

provided on CDF Web site:

http://www.esa.int/cdf