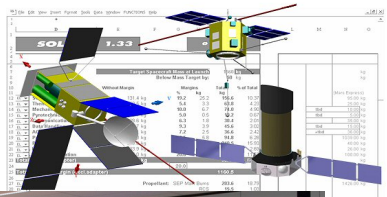
The ESA Concurrent Design Facility: Concurrent Engineering applied to space mission assessments

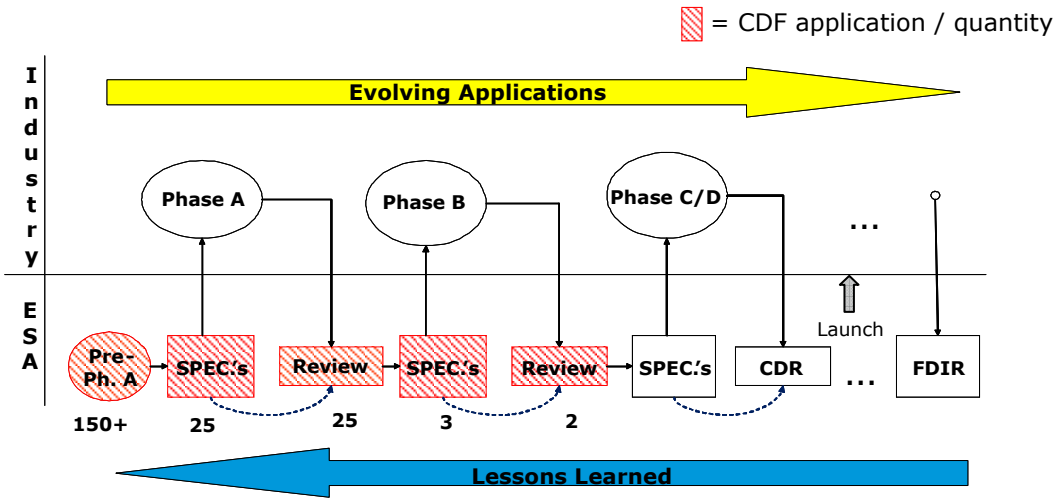


CDF
ESA/ESTEC
Noordwijk - NL

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
- The implementation started in Nov.1998, on an experimental basis with 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

The ESA project life-cycle

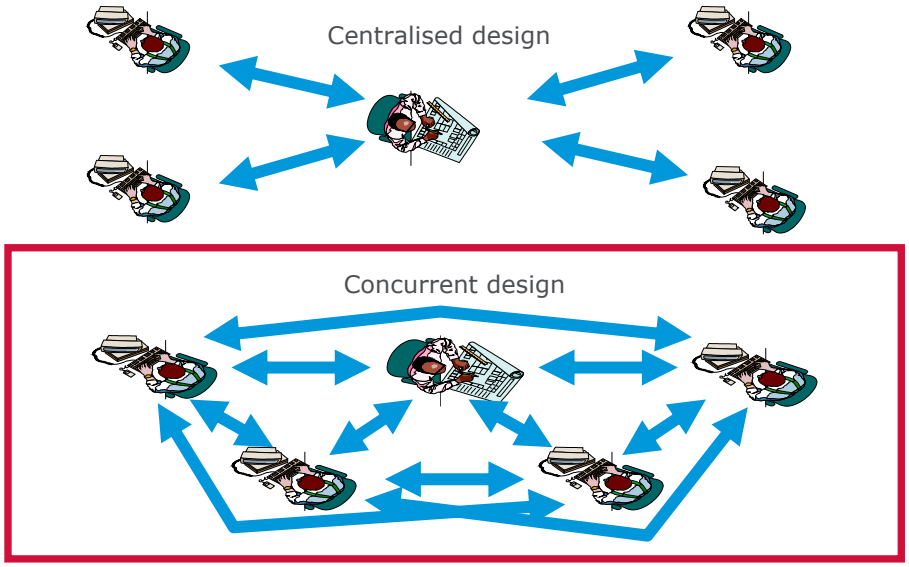


Why do we need Concurrent Engineering?

1. To overcome the communication gaps between the "designer" (who produces design information) and the "user" (who utilises the design information)

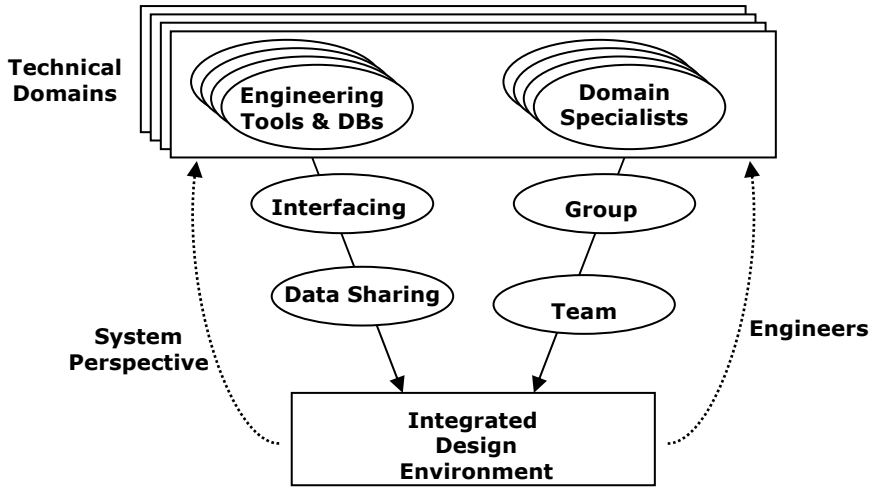
Sequential Design ("over-the-fence" approach)

Possible approaches to system design



CDF: the approach (Organisation dependent)

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



CDF: the achievements

Activities performed

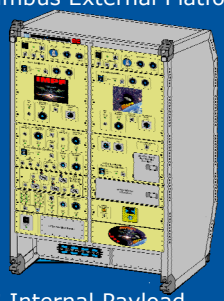
- 130+ (potential) future missions studied and designed internally at pre-Phase A, conceptual, system level
- 3 System of System studies and the integration of SoS software into the CDF
- 7 new launcher concept design
- 11 complex payload instrument design (IDA), incl. platform, system, mission
- 25 reviews of Industrial Phase A studies (internal + Industry) and Phase B
- 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

Payload & P/L accommodation

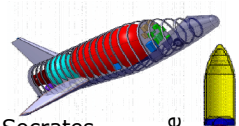
ROSITA instrument on Columbus External Platform



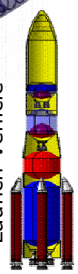
ISS Internal Payload – Science Requirements Definition

IMPACT facility inside an ISS rack

Advanced launchers



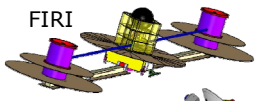
Socrates

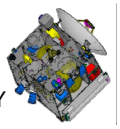


Heavy Lift Launch Vehicle

Telescopes and Technology

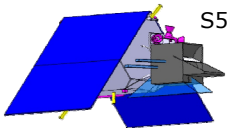
FIRI





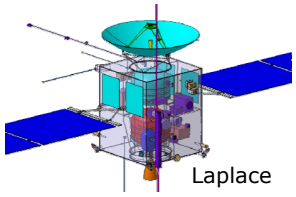
WiFLY

Diverse range of space missions



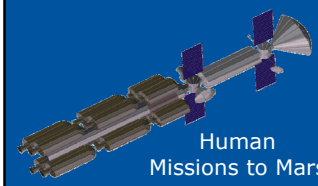
S5P

ExoMars

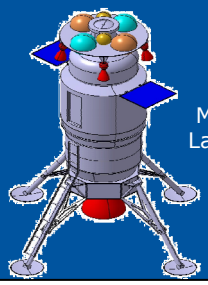


Laplace

Crewed vehicles for exploration preparation programme



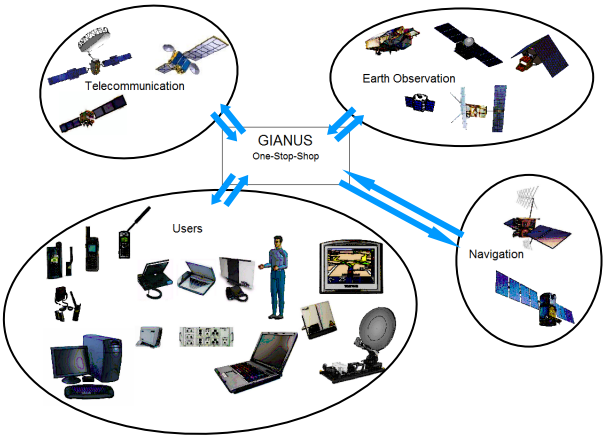
Human Missions to Mars

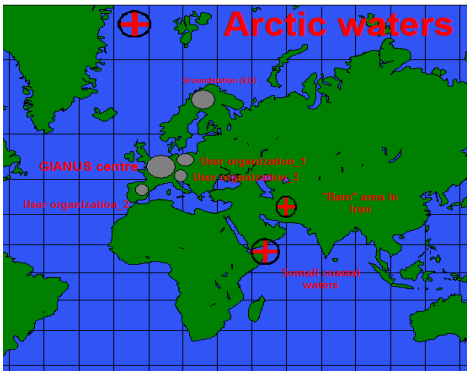


Moon Lander

New CDF application - System of Systems architecture Service oriented – Example: GIANUS

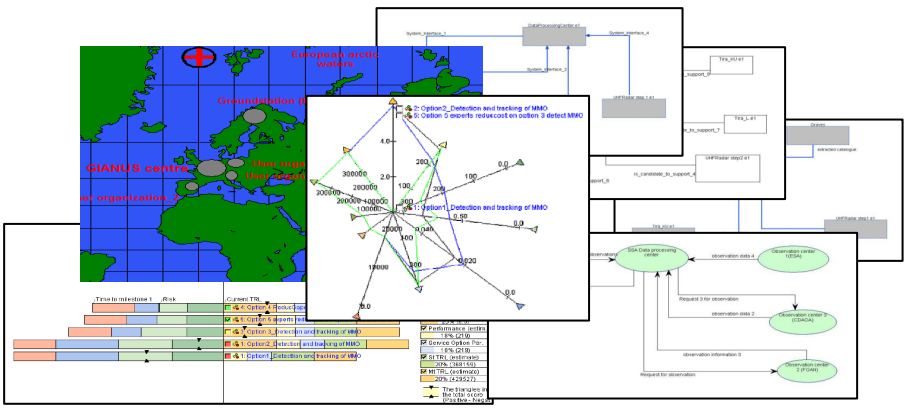
1. Architecture and integration of independent space assets and systems to provide a layer of global services (e.g. security)
2. Collaboration among ESA programme directorates and other Agencies
3. Support EU and national authorities dealing with Civil Crisis Management (ref. EC-EDA-ESA workshop - 16 Sep. 2009 - on Space for Security and Defence)

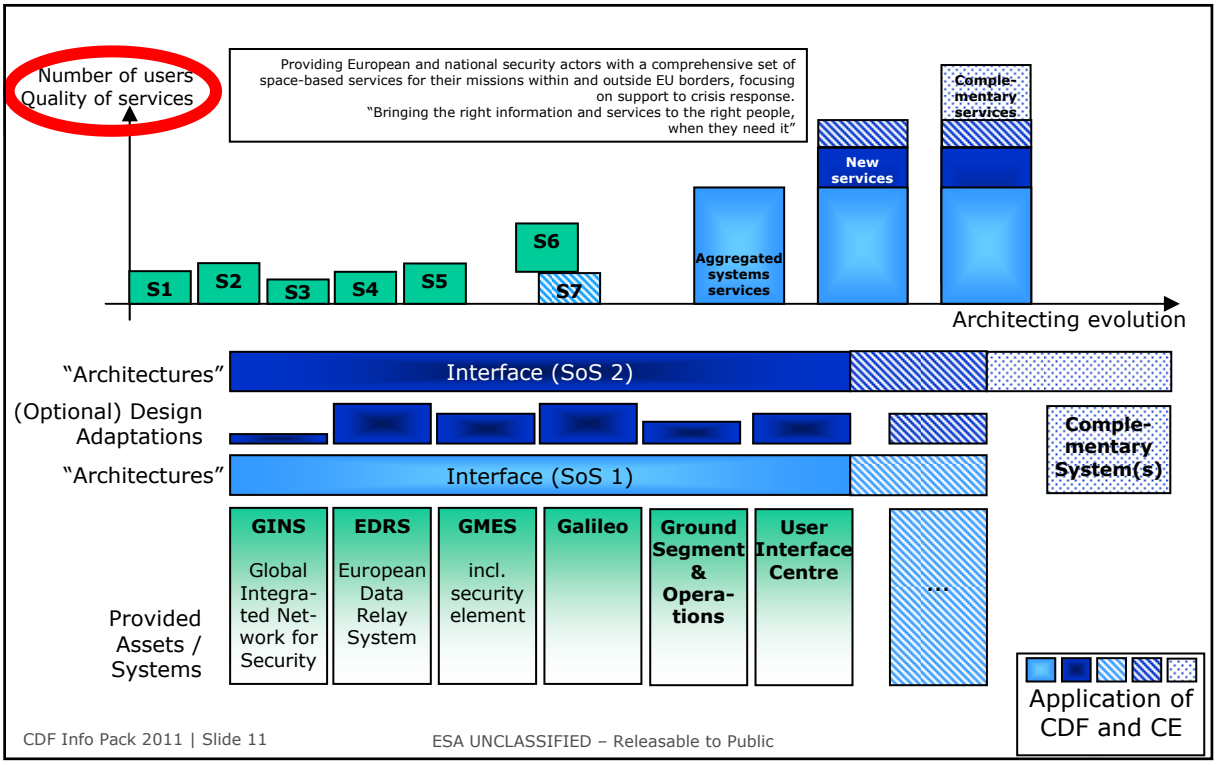




System of Systems – Architecture Activities

- Evaluated set of architectures (based on customer preferences/priorities)
- Identification of potential additional service(s)





Benefits

1. Performances (typical pre-Phase A study):
   a. Study duration (Design phase): 3-6 weeks (cp. 6-9 months!)
   b. Factor 4 reduction in time
   c. Factor 2 reduction in cost (for the Customer)
   d. Increased nr of studies per year, compatibly with max 2 parallel studies
2. Improvement in quality, providing quick, consistent and complete mission design, incl. technical feasibility, programmatics, risk, cost
3. Technical report becomes part of the specs for subsequent industrial activity, Cost report remains the ESA independent reference
4. Capitalisation of corporate knowledge for further reusability
5. CDF: an essential tool for the ESA Decision Making and Risk Management processes

Process elements

1. Conducted in sessions
    a. Plenary meeting where representatives of all space engineering domains participate from early phases (requirement analysis) to end of design (costing)
    b. 6 to 10 sessions / study — 4 hours / session
    bi-weekly frequency
    c. Team leader co-ordination
    d. Customer participation
2. Model driven
3. On-line design
4. Highly co-operative & interactive
5. Iterations
6. Design options comparison and trade-offs

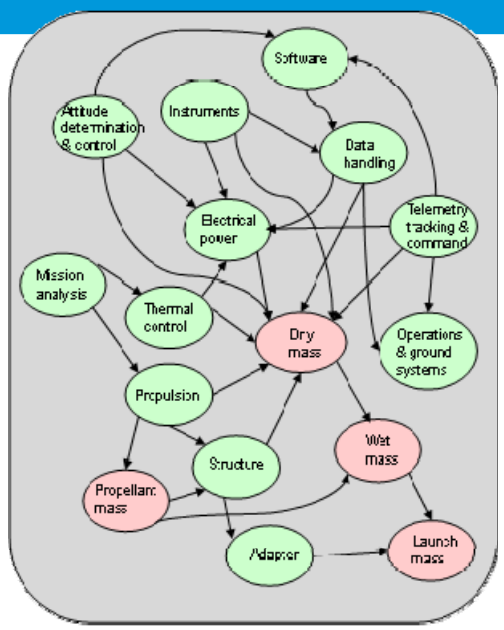
Design process

Mission requirements & constraints

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

Study requirements

- Products
- Study Level
- Planning
- Resources

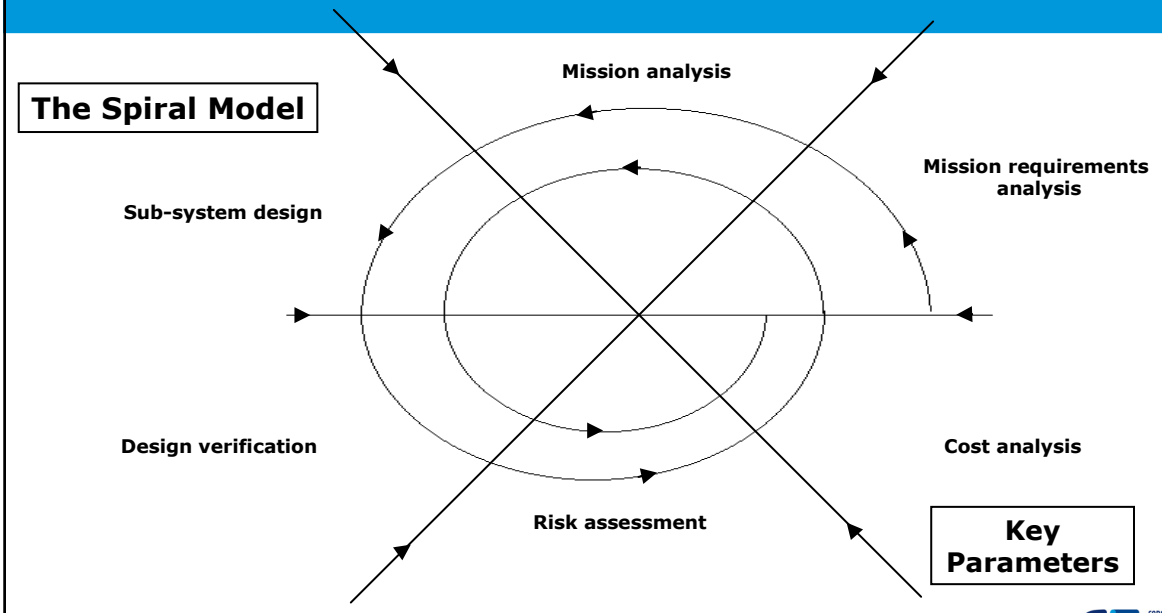


Study results

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

Conceptual model of mission & spacecraft design process

CE: iterative process



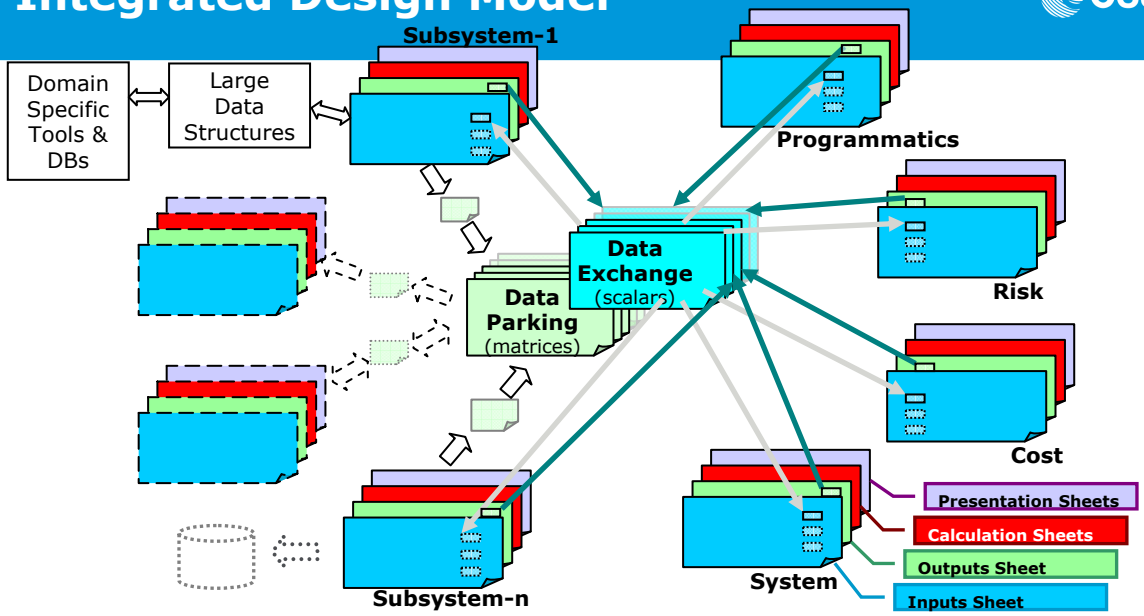
CDF: Integrated Design Model (*)

1. Model each domain (e.g. s/s) design
2. Share data between domain models
3. Interface with domain specific tools
4. Provide user visibility

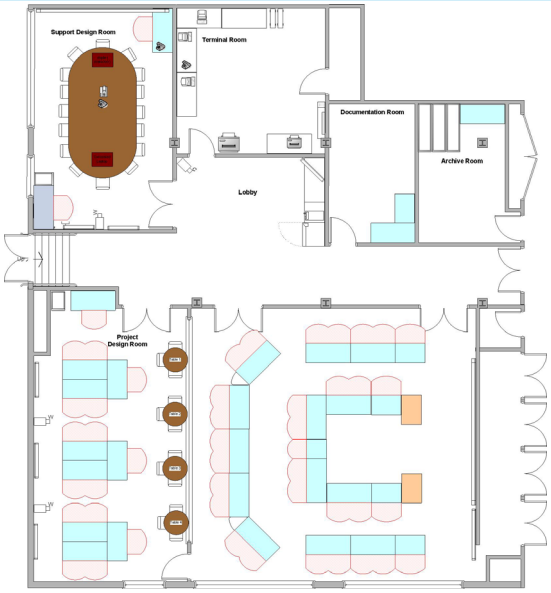
Use spreadsheets (MS Excel®)

(*) shall be replaced by OCDS (Open Concurrent Design Server) in the course of 2012

Integrated Design Model



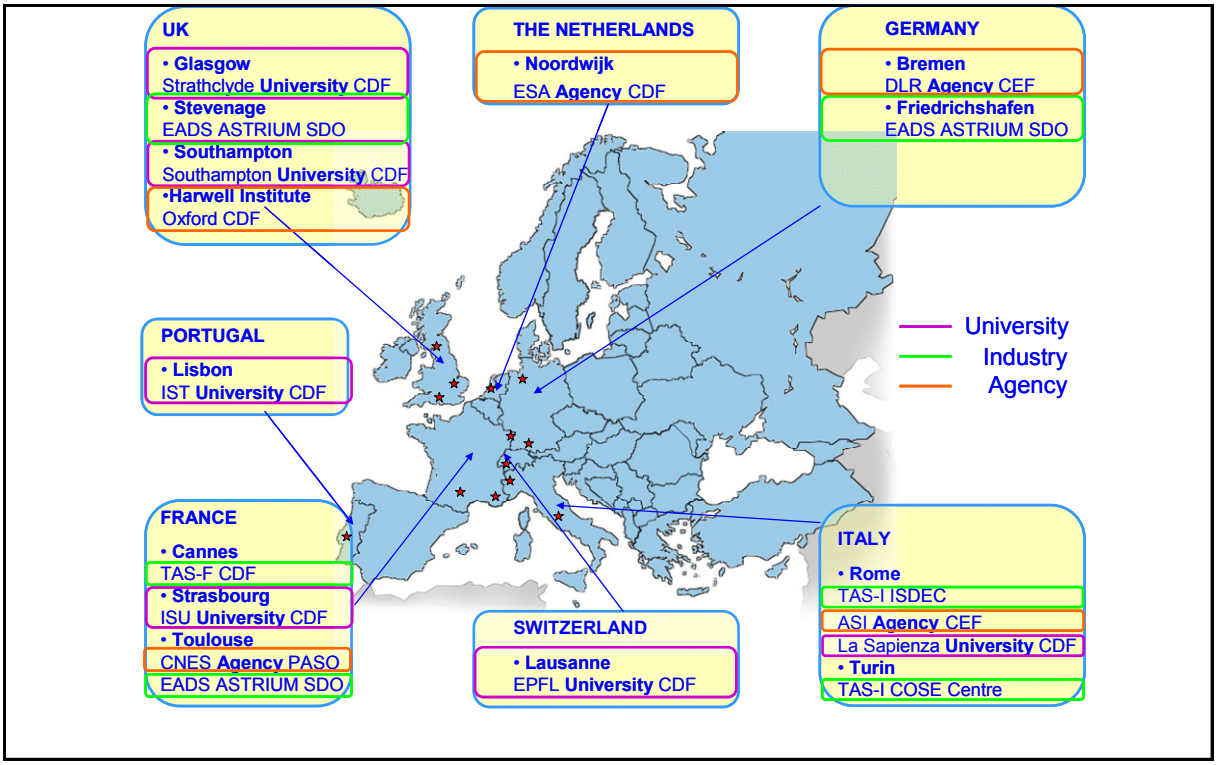
CDF layout



A CDF design session

Room A

Room B



CDF: the team

1. Team of ESA specialists (senior and junior!)
2. Technical disciplines ('CDF positions') selected for Phase 0 studies (according to ESA organisation):

Systems
Instruments
Mission analysis
Propulsion
Attitude and Orbit Control
Structures/Configuration
Mechanisms/Pyros
Thermal
Power
Command and Data Handling
Communications
Ground Systems & Operations
Simulation
Programmatics
Risk Assessment
Cost Analysis

Black: sub-system level
Blue: system level
Red: based on hi-end tools

Note: Instrument design activities have specialised teams with disciplines such as Receiver, Optics etc.

CDF: SW infrastructure (1/3)

General tools

FUNCTION	TOOLS USED
System modelling	MS Excel spreadsheets
Documentation storage and archive	Terminal Server (TSE)
Project documentation	MS Word
Electronic communication within the team	Lotus Notes
Storage for all data	iSCSI SAW
Remote audio/visual communication	Video-conferencing and WEB EX
Application Deployment	Citrix XenApp6 Application Streaming & Hyper=V Virtual Servers

CDF: SW infrastructure (2/3)

Domain specific tools

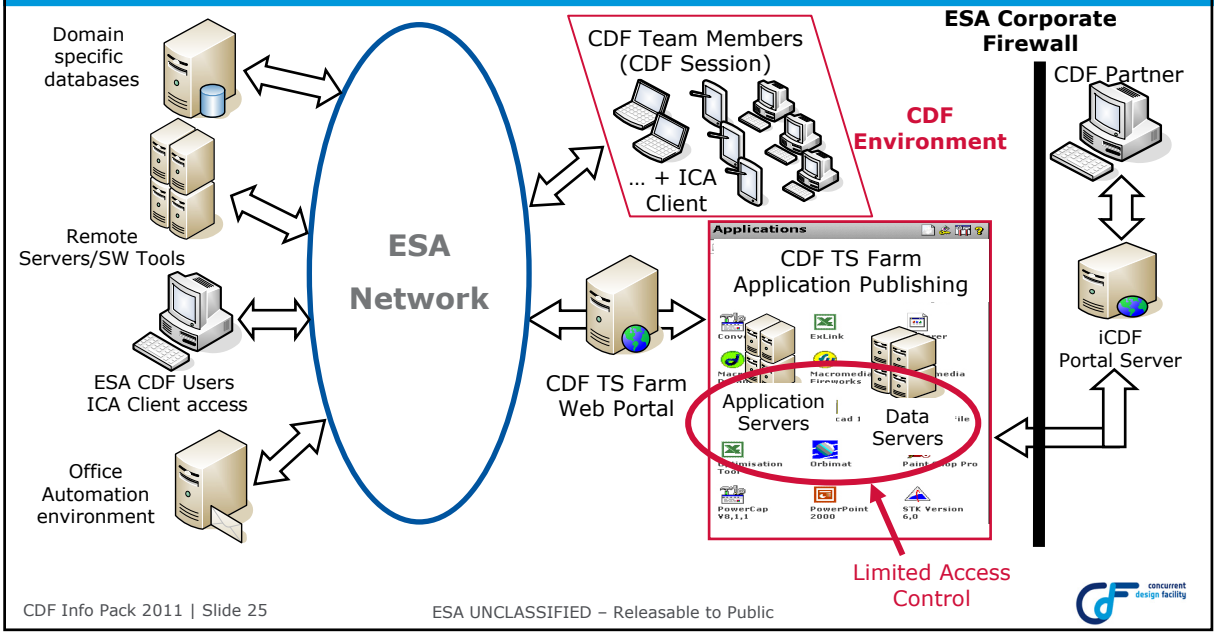
DOMAIN	TOOLS USED
System of Systems	IBM System Architect and Focal Point
Requirements Management	IBM DOORS
Software and System Modelling	MagicDraw, Teamwork Server, Cameo Altova
AOCS	Matrix X, Matlab
Communications	STK
Cost Modelling and Estimation	CEDRE, Small Satellite Cost Model, RACE Model, TIW-O, TIW-D, PRICE
Instruments	MathCAD

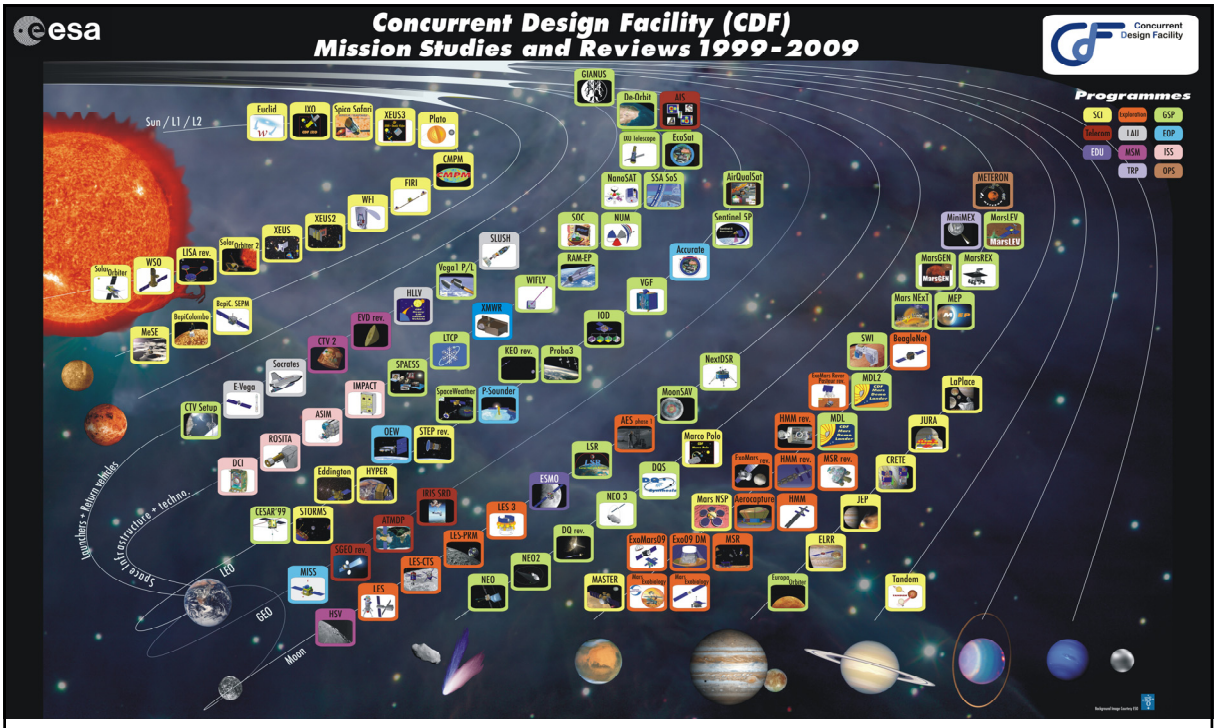
CDF: SW infrastructure (3/3)

Domain specific tools

DOMAIN	TOOLS USED
Mission Analysis	STK, ORION, Swing-by calculator, ATOS
Mission Simulation and Visualisation	EUROSIM
Power	PowerCAP
Programmatics	MS Project
Risk	Ceris, MS Access, Matlab
Structural design, Configuration, Accommodation	CATIA, PATRAN, NASTRAN, SimDesigner
Thermal	ThermXL – TCDT (Thermal Concept Design Tool)
Multibody Simulations	DCAP, Adams, MECANO, SimPACK

CDF HW Architecture





Further information

Provided on the CDF Web site:

http://www.esa.int/cdf