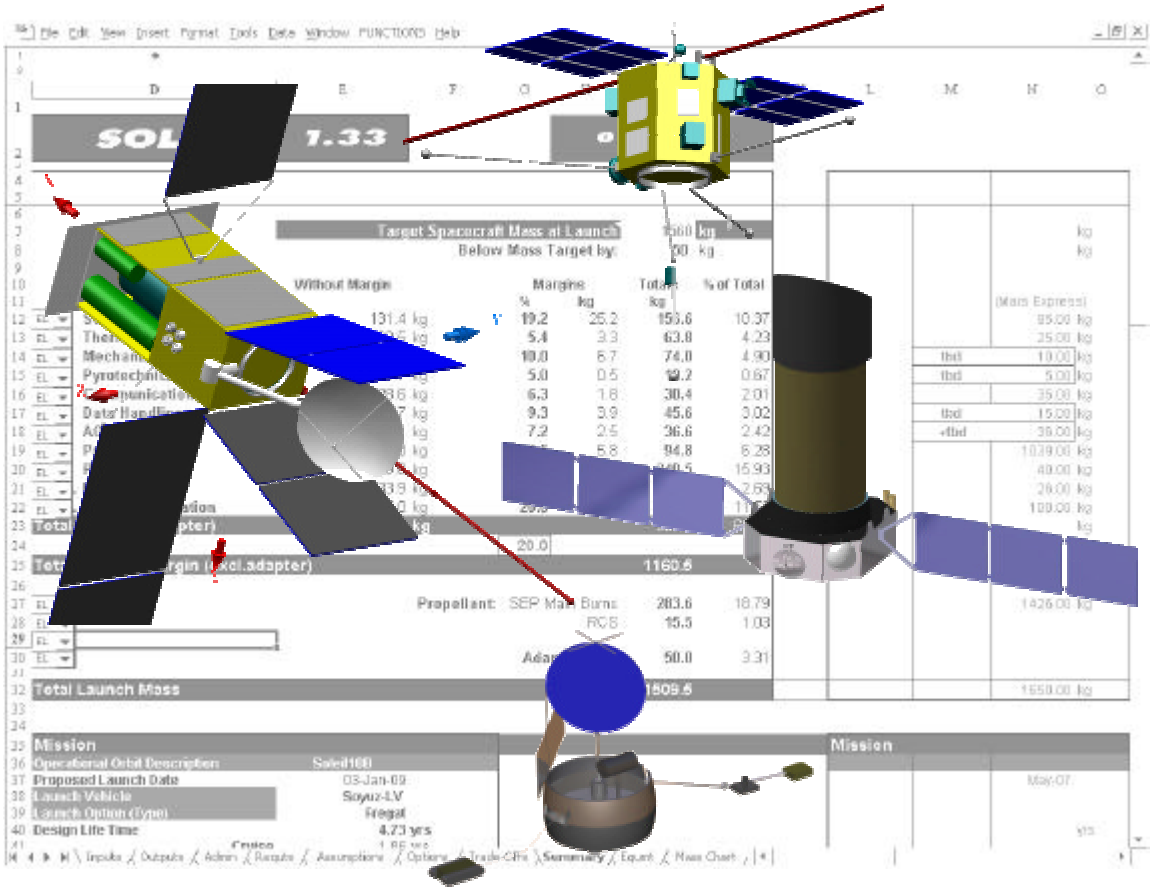
The evolution of the ESA Concurrent Design Facility (CDF)

-

Massimo Bandecchi
European Space Agency
ESTEC
The Netherlands



Europe in Space

Austria
Belgium
Denmark
Finland
France
Germany
Ireland

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

Portugal joined as 15th member state in 2000

Esro Satellites

Eldo Launchers

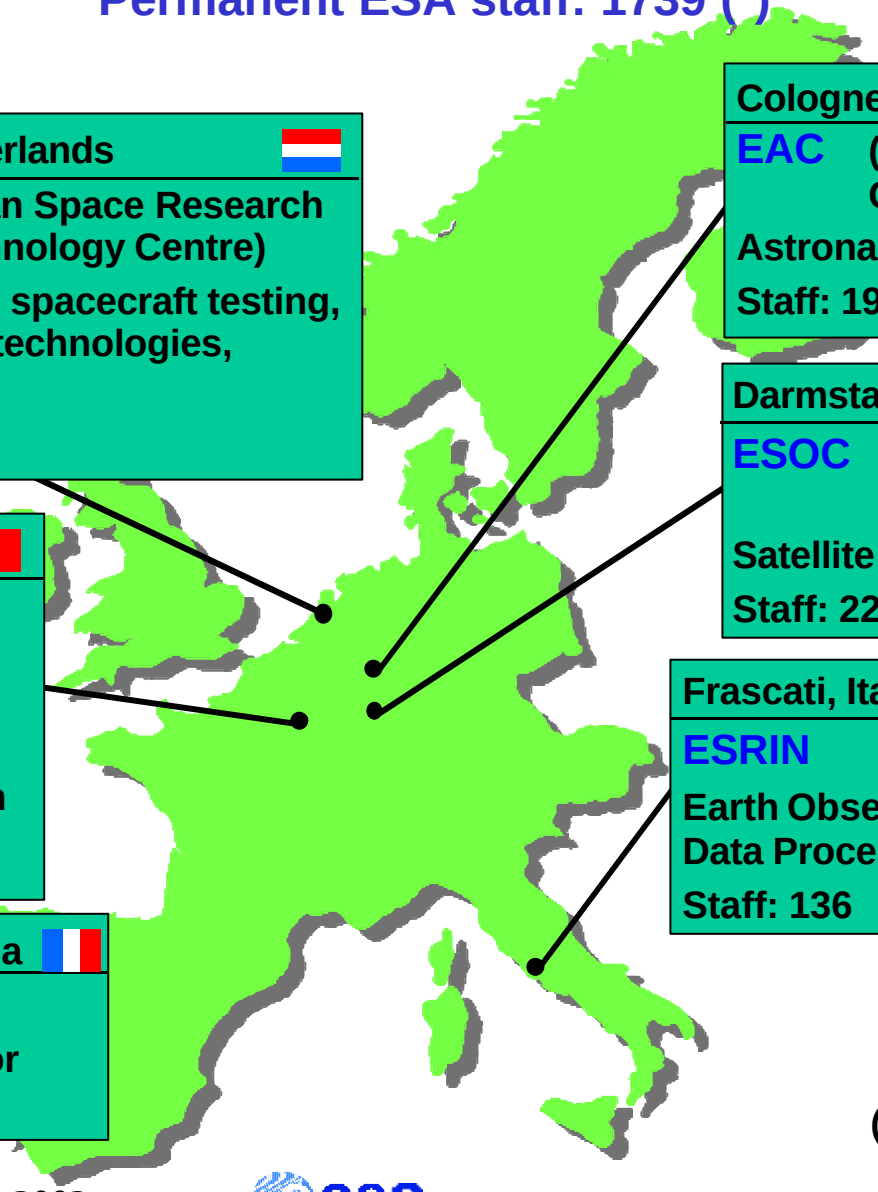
esa

Cooperation arrangement: Canada

Italy
Netherlands
Norway
Portugal
Spain
Sweden
Switzerland
United Kingdom

Establishments

Permanent ESA staff: 1739 (*)



Noordwijk, The Netherlands

ESTEC (European Space Research and Technology Centre)

Project management, spacecraft testing, 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

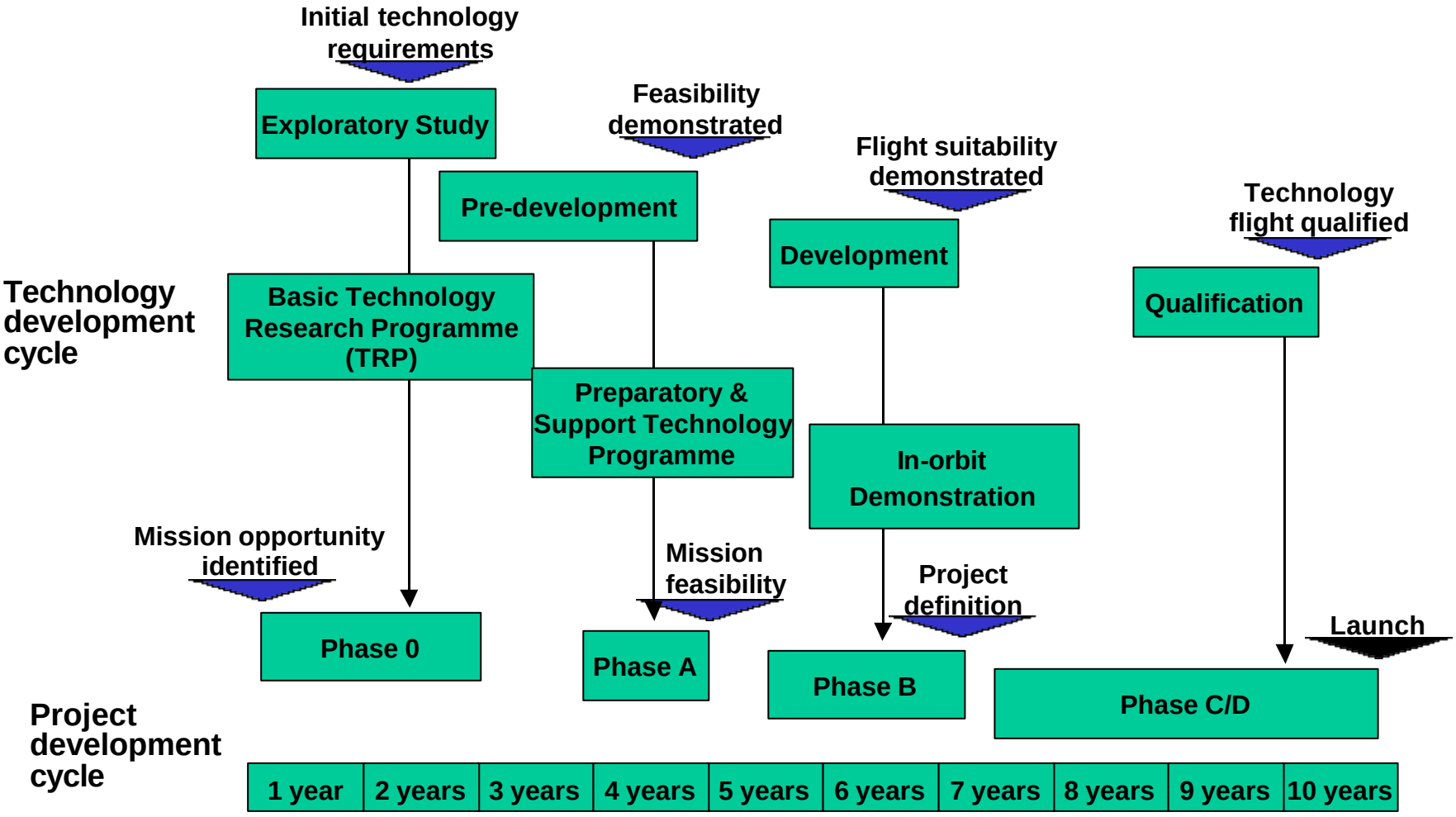
CSG

Europe's Spaceport for Ariane launches

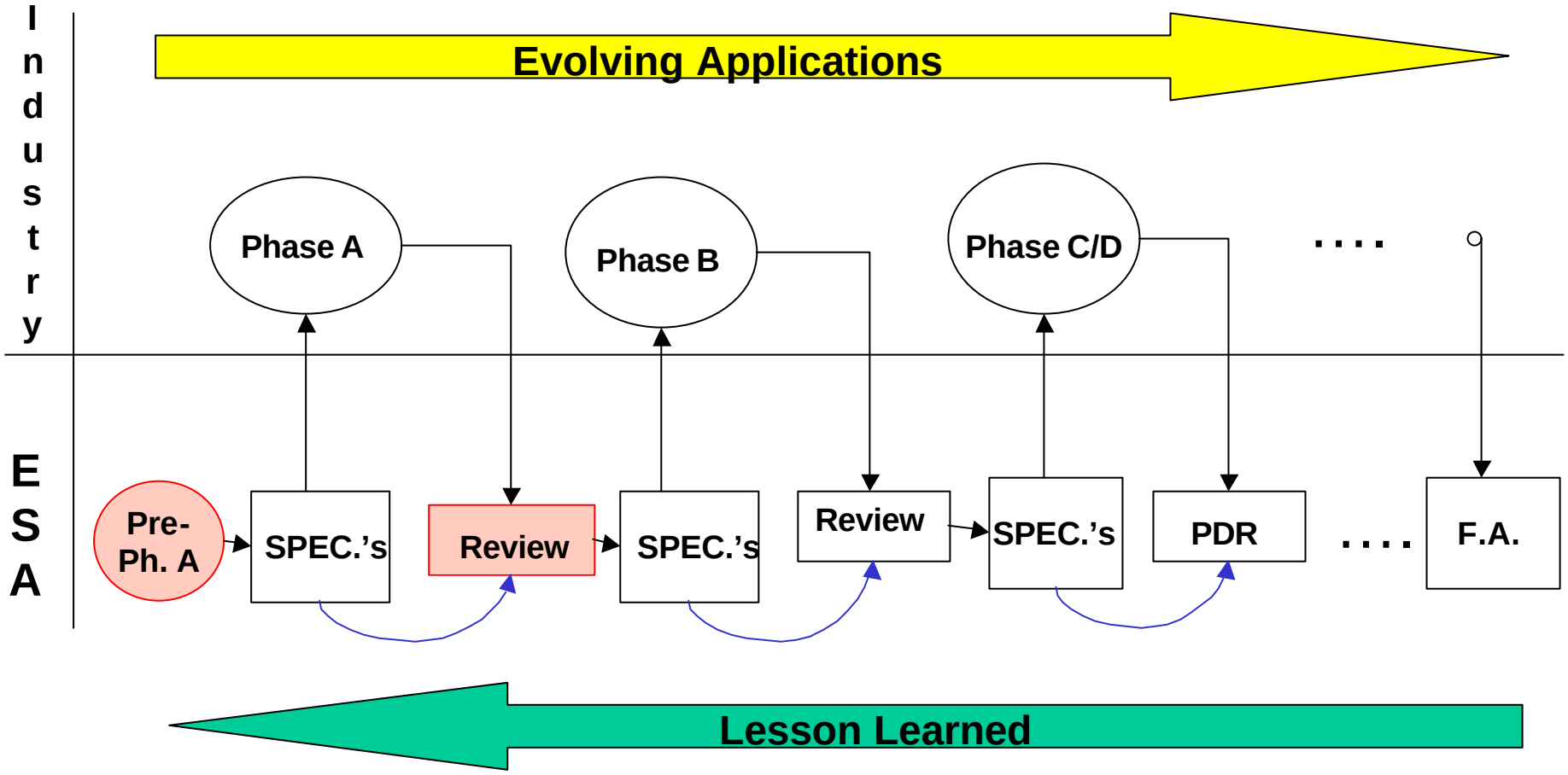
(*) Status: June 2001

Technology / Project Development Cycle

Phasing relationship



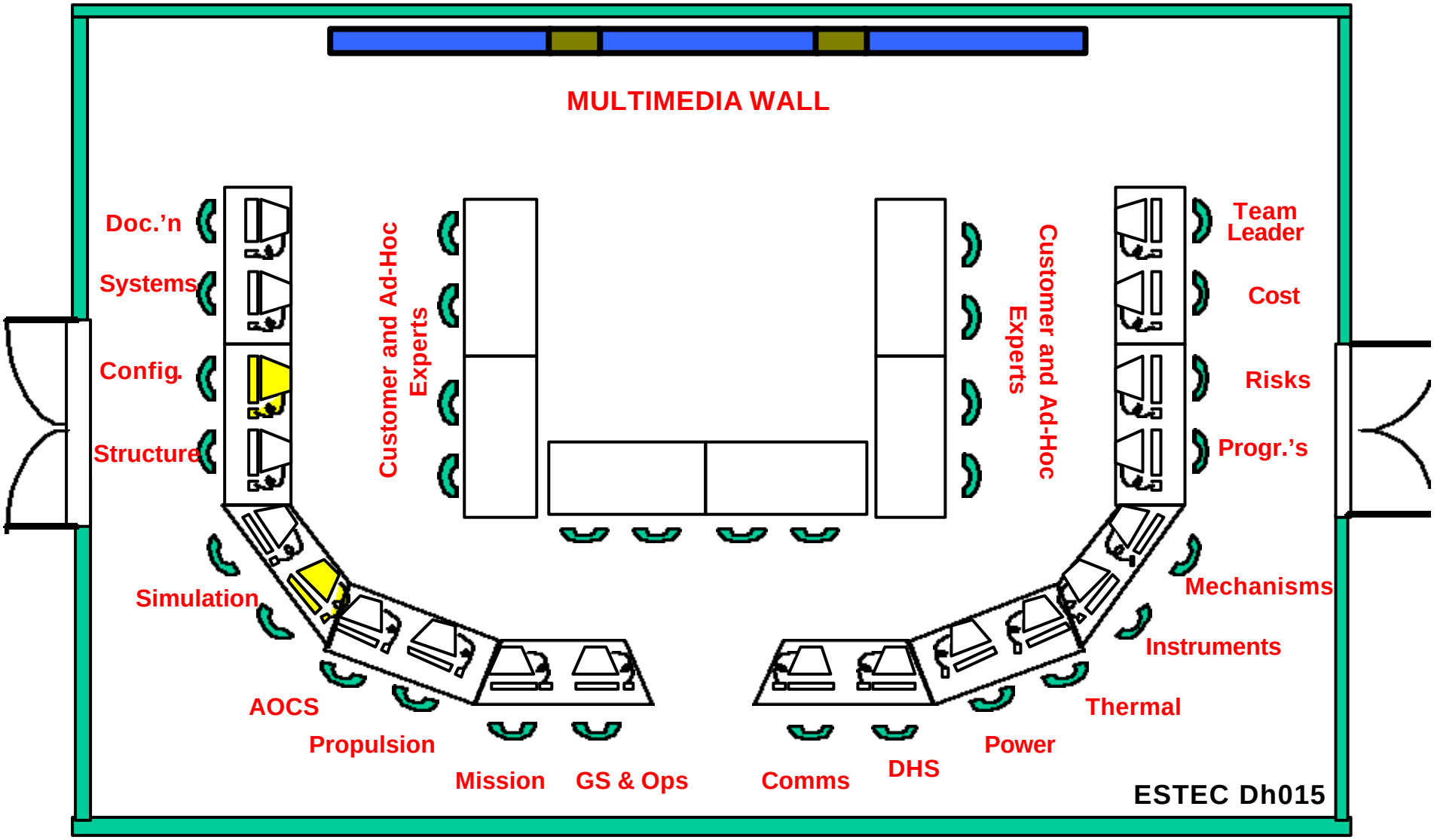
ESA Project Development Context



CDF: what is it?

- **An integrated design environment for interdisciplinary applications**
- **initially (Nov.1998) conceived for the assessment and conceptual design of future space missions (i.e. internal pre-phase A / level 0 studies)**
- **featuring:**
  - **team orientated (concurrent) collaborative engineering**
  - **integration of tools, project data, mission and system models**
  - **model driven, on-line, real-time design**
  - **co-operation, interaction, iterations**

The ESTEC CDF: layout



AOCS
14 15:05

14 15:16

CDF: status

- **The problem was not to recognise the paradigm shift, but to adapt it and make it accepted in our organisation … and culture - breakthrough !!!!**
- **The CDF has become a functioning, operational and accepted component of the ESA in-house mission design assessment process.**
- **The CDF has become a reference design centre for ESA internal design applications and developments, space (and non-space) European industry, national space agencies and academia.**

CDF: application highlights

- **Conceptual design: pre-phase A feasibility assessment, Phase C requirements change, payload requirements development - mature**
- **Industrial Phase A/B review - Model data exchange: preliminary**
- **Remote collaboration: Joint ESA-JPL Phase A design sessions, industrial proposal evaluation and feed-back – in development**
- **Stand-alone tool / Single designer approach: educational demonstration and student design tool – in development**

CDF: achievements (1/2)

Project Phase Improvements

- **Pre-phase A:**
  - **radical reduction of duration, up to 6 months to 4 - 6 weeks *depending on system complexity, i.e. single satellite to multiple elements***
  - **improved mutual customer and system engineering team confidence through understanding of engineering, programme and cost constraints and requirements consequences**

- **Payload requirements development:**
  - **radical duration reduction in time scale (2 weeks to 1 day) and manpower**
  - **improved science and engineering team mutual understanding**

CDF: achievements (2/2)

Project Phase Improvements

- **Industrial Phase A Review:**
  - **up to 50% reduction of duration in time scale and manpower**
  - **ability to check relaxation and added requirements in real-time**
  - **improvement in confidence in design and requirements**

- **Phase B/C requirements change:**
  - **ability to test radical programme or cost driven changes**
  - **fast turn-around**
  - **confidence boost in requirements validation or fast generation of quantitative system design, programme and financial consequences**

CDF: current trends

- **consolidation and improvement of method and infrastructure**
- **investigation of new fields of space applications**
- **assessment of application to later phases of the project cycle**

Method and Infrastructure Improvements

Since last year:

- **Domain specific tool upgrade:**
  - **new mission analysis tools**
  - **new Risk assessment tools**
  - **new Cost estimate tools**
- **“System of systems” modelling**
- **System trades methods and tools**
- **Prototyping of advanced model DB (Oracle based)**
- **Design process modelling (state flow, fuzzy logic)**

New Fields of Space Applications

- **Scientific exploration missions (need to integrate new models, e.g. environmental)**
- **Advanced Concept Missions, e.g. new scientific payload concept (need for new design models)**
- **nano-satellite design: change in spacecraft modelling and “sub-system” approach**
- **Instrument/payload conceptual design**
- **Verification of new technologies at mission/system level**
- **System evaluation of advantages/disadvantages of certain technology programmes**
- **Verify and support development decisions**

Application to Later Phases of Project Cycle

- **Application to phase B, C/D taking into account ESA's role in the project development (e.g. project reviews)**
- **Adapting the same principles to the more complex scenario**
- ***Concurrent* and *collaborative* have to become also *Distributed*, *i.e.* not only "across technical disciplines" but also "across companies and organisations"**
- **Integration/interface of tools and databases used in Industry and in the Agency**
- **Essential element: standardisation of project data**
- **CDF as one of the components of the ESA "Virtual Spacecraft Design" activity**

ESA “Virtual Spacecraft Design” status

- **No major deliverable since Miro’s presentation at the NDP2001 workshop last year**
- **A lot of effort in pulling together the different (sub) domains within ESA to make this new R&D technical domain "System Design and Verification" a reality supported by everybody**
- **Number of significant events:**
  - **Innovation workshop in Copenhagen in Sept. 2001 with the delegations where the theme "Increasing Development Cost-Efficiency" was presented**
  - **As a result of that the "Spacecraft Virtual Design" activity has been approved and will be launched later this year**
- **Consultations with prime industry (Astrium, Alenia) have taken place, with others (Alcatel, EADS) are being planned**
- **The 1st ESA workshop on “Space System Design, Verification & AIT”, held on 13-14 June, represents an important milestone**

Distribution Enabling Technologies

- **Distribution means:**
  - **Integration of people, data and tools in spite the separation of these assets**
  - **Team access to distributed models, tools and simulations**
  - **virtual collocation**
- **Distribution implies communication. Here trends are:**
  - **Web based technologies ---> possibly GRID (?!)**
- **CDF represented in the ESA/GRID initiative with 3 pilot projects to investigate the GRID potentials for:**
  - **Distributed Concurrent Development**
  - **Distributed Design Support**
  - **Distributed Design Tools**

CDF: lines of evolution and research

"Where we should spend time to save time"

Concepts and Technology

- **Archiving of Systems and Design by spacecraft characteristics for future system architecture trade-off application to differing system drivers and criteria (plug-and-play set of elements)**
- **Introduction of modular platforms and subsystems application in upcoming feasibility studies and current project re-assessments**
- **Capture, formalisation and <u>systematic</u> exploitation of lesson-learned <u>throughout</u> project cycle (up to in-flight fault analysis results)**
- **Requirements management based on heritage models throughout project phases**

Improved Design Frameworks and Collaboration

- **Progressive introduction of “design-orientated” (hi-end) discipline tools in early phases and conceptual design**
- **Design verification in later project phases by merging standard ESA and industry recommended design tools and databases with the CDF environment (*how to merge w/o imposing a standard model)***
- **First steps in using CDF models as a “standard” technique across agency and industrial partners *(no standard in creativity or ways or working, but only in information exchange)***

Product Data Exchange

- **Open Standards (STEP AP's, SC4, XML, …) implementation for technical data exchange**

  (ref. NASA-ESA workshop on Aerospace Product Data Exchange, ESTEC, April 9-12, 2002)
- **ESA, space agencies, industrial partners application of same data model for design reviews and later project phase requirements evaluation**
- **Interfaces between different agency and industrial concurrent and collaborative environments and tools**

Standards Application

- **ECSS and ISO validation across the CDF for model methods and tools application for partner data exchange and collaborative working.**

Other ideas

- **Proposal for the creation of a Network of Excellence for Concurrent Engineering to promote:**
  - **a wider use of CE**
  - **cross-fertilisation among all centres**
  - **coordinated research of methods, tools, standards**