NASA-SP-610S Definition of System Hierarchy

• System
  – Segment
    • Element
      – Subsystem
        » Assembly
          • Subassembly
          • Part
Program Phases:

Project Life Cycle for Major Systems

- Pre-Phase A (advanced studies)
- Phase A (feasibility)
- Phase B (detailed definition)
- Phase C (design guidelines)
- Phase D (development guidelines)
- Phase E (mission operations and data analysis)

"find a suitable project"
Phase A (feasibility)

"find a worthwhile project"

Phase A—Preliminary Analysis

**Purpose:** To determine the feasibility and desirability of a suggested new major system and its compatibility with NASA’s strategic plans.

**Major Activities and their Products:**
- Prepare Mission Needs Statement
- Develop top-level requirements
- Develop corresponding evaluation criteria/metrics
- Identify alternative operations and logistics concepts
- Identify project constraints and system boundaries
- Consider alternative design concepts, including: feasibility and risk studies, cost and schedule estimates, and advanced technology requirements
- Demonstrate that credible, feasible design(s) exist
- Acquire systems engineering tools and models
- Initiate environmental impact studies
- Prepare Project Definition Plan for Phase B

**Information Baselined:**
(nothing)

**Control Gates:**
- Mission Definition Review
- Preliminary Non-Advocate Review
- Preliminary Program/Project Approval Review

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Phase A (feasibility)

"find a worthwhile project"

**Figure 20.1** Phase A system engineering flow diagram
Phase B (detailed definition)

“define the project and establish a preliminary design”

Phase C (design guidelines)

“complete the system design”
Phase D (development guidelines)

“build, integrate, and verify the system, and prepare for operations”

Phase E (mission operations and data analysis)

“operate the system, and dispose of it properly”
Overview of Space Project Cycle:

**V Diagram**

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<th>Project Initiation</th>
<th>Preliminary Engineering</th>
<th>Plans, Specs and Estimates</th>
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<td>Systems Engineering Management Plan Framework</td>
<td>Concept of Operations</td>
<td>System Requirements</td>
<td>Subsystem Requirements Project Arch (HLD)</td>
<td>Component Level Design (Detailed)</td>
<td>Software Coding Hardware Fabrication</td>
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System Engineering Techniques

![System Engineering Techniques Diagram]

*Figure 26.2. System engineering boundaries. (Figure reproduced from [1] by permission of ESA on behalf of the ECSS members)*
Expansion/Translation of Top-Level Requirements

Orbit Options for Astronomy Missions
Design Drivers

Tradeoffs


System Mass and Power Budgets

Concurrent Engineering

Figure 20.5 Alternative approaches to space system design
“Waterfall” vs. Concurrent Design

NASA JPL Team X

http://jplteamx.jpl.nasa.gov/
European Space Agency Concurrent Design Approach

Figure 20.7 The ESA approach to the creation of an Integrated Design Environment

http://www.esa.int/Our_Activities/Space_Engineering_Technology/CDF

Process

Figure 20.8 Conceptual model of the mission and spacecraft design process. The ovals represent the disciplines, the boxes represent aggregated key parameters, the arrows are interactions and data exchange. Each discipline contributes, directly or indirectly to the definition of the main mission parameters (or key parameters)
Spiral Model of the Design Process

![Spiral Model Diagram]

Figure 20.9 Iterative process: Spiral Model representation. In the example, point T is the target value of key parameter A.

Design/Development Team

**Integrated Product Development Teams**

The detailed evaluation of product and process feasibility and the identification of significant uncertainties (system risks) must be done by experts from a variety of disciplines. An approach that has been found effective is to establish teams for the development of the product with representatives from all of the disciplines and processes that will eventually be involved. These integrated product development teams often have multidisciplinary (technical and business) members. Technical personnel are needed to ensure that issues such as producibility, verifiability, deployability, supportability, trainability, operability, and disposability are all considered in the design. In addition, business (e.g., procurement) representatives are added to the team as the need arises. Continuity of support from these specialty discipline organizations throughout the system life-cycle is highly desirable, though team composition and leadership can be expected to change as the system progresses from phase to phase.
Design Process Model

Figure 20.10 The CDF Integrated Design Model (IDM)

ESA Concurrent Design Facility
Hardware/Software Infrastructure for Concurrent Design

Benefits of Using Concurrent Design

- Reduced design time
- Reduced errors
- Increased quality
- Project management visibility
- Top-level change control
- Knowledge of how modules interface
Case Study: CRYOSAT

- CryoSat-1 failed to reach orbit
- CryoSat-2 launched April 2010

Mission Characteristics

- CryoSat-2's mission: study the Earth's polar ice caps, measuring and looking for variation in the thickness of the ice.

- Primary instruments:
  - SIRAL-2, the SAR/Interferometric Radar Altimeters, which use radar to determine and monitor the spacecraft's altitude in order to measure the elevation of the ice. Two SIRAL instruments are installed aboard CryoSat-2.
  - Doppler Orbit and Radio Positioning Integration by Satellite, or DORIS, is used to calculate precisely the spacecraft's orbit. An array of retroreflectors allow measurements to verify the orbital data provided by DORIS.

- Launch and Early Orbit Phase operations: April 2010

- The spacecraft underwent six months of on-orbit testing and commissioning.
Precision Measurements from Space

http://emits.sso.esa.int/emits-doc/ESRIN/7158/CryoSat-PHB-17apr2012.pdf

Designing the System

http://emits.sso.esa.int/emits-doc/ESRIN/7158/CryoSat-PHB-17apr2012.pdf
Payload: Re-use and Innovation

What Makes It Tick?

Putting It Together

http://www.esa.int/Our_Activities/Observing_the_Earth/CryoSat/Entry_2_CryoSat-2_undergoes_surgery

CryoSat Launch

Separation of CryoSat from Dnepr 3rd Stage
Next Time:
Product Assurance