Space Project Management

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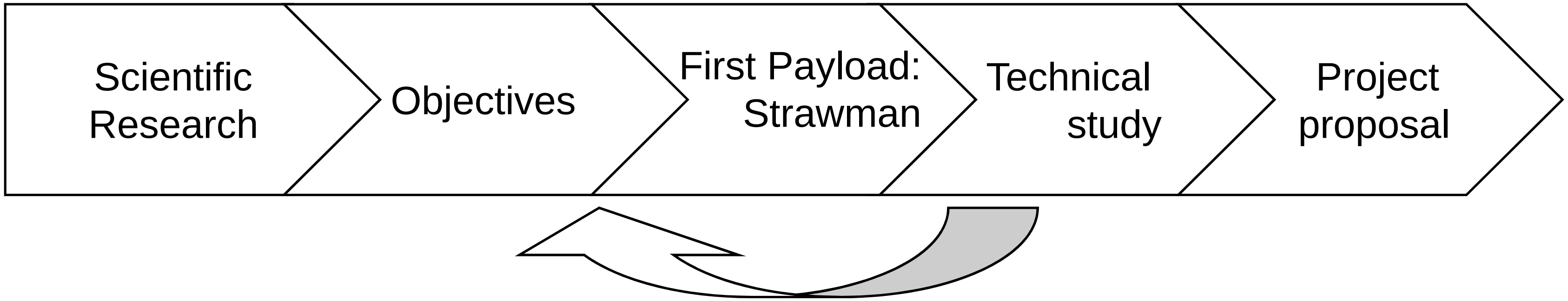
(Based on 2007 lectures by Petrus Hyvönen)

Outline

- Objectives and requirements
- Project management tools
- ESA project phases
- General comments

Mission Objectives

- The mission objectives define the goals and requirements of the mission
  - *To investigate Venus atmosphere and its coupling to the solar wind to understand the development of Venus atmosphere and hydrosphere*



(Note feedback all the way to the objectives)

Space Mission Analysis and Design Process

Typical Flow	Step		Section
	Define Objectives	A. Define broad objectives and constraints B. Estimate quantitative mission needs and requirements	1.3 1.4
	Characterize the Mission	C. Define alternative mission concepts D. Define alternative mission architectures E. Identify system drivers for each F. Characterize mission concepts and architectures	2.1 2.2 2.3 2.4
	Evaluate the Mission	G. Identify driving requirements H. Evaluate mission utility I. Define mission concept (baseline)	3.1 3.2 3.3
	Define Requirements	J. Define system requirements K. Allocate requirements to system elements	4.1 4.2-4.4

- Note that requirement is defining what is to be done, and not how
- Requirements are quantitative measurements of how well objectives are met

Top level mission requiremets

Top Level Mission Requirements

Functional <u>*Requirements*</u>	*Operational* <u>*Requirements*</u>	<u>*Constraints*</u>
Performance	Mission Duration	Cost
Coverage	Availability	Schedule
Responsiveness	Timeliness	Regulations
Secondary missions	Survivability	Political limits
	Data Distribution	Environment
	Data Content	External Interfaces
	Data Form	Development Constraints
	Data Format	Spacecraft Disposal

Project Management

Science objective vs Payload instrument matrix

Scientific Objective	Ion mass spectrometer	Ion and electron spectrometer	Plasma wave/lightning detector	Langmuir probe	Magnetometer	ENA spectrometer	Mass-resolving driftmeter	Near IR imaging spectrometer	UV/visible photometer	Sub-satellites	*Plasma sounder*	*Camera*
Venus atmosphere – solar wind interaction	X	X	X	X	X	X	X			X		
Direct measurement of escaping ions	X	X		X		X	X			X		
Water escape in the past	X	X										
Aurora		X	X	X					X			X
Acceleration processes	X	X	X	X	X	X	X			X		
Lightning			X						X			
Super-rotation	X	X			X		X	X				X
Greenhouse effect								X			X	
Dawn-dusk asymmetry	X	X		X		X	X			X		
Meso-scale properties										X		
Magnetic field					X							
Volcanic activity	X	X		X			X	X	X			
Kinetic effects of the solar radiation	X	X					X					

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Strawman Payload

- First payload that is used as a baseline in the design of the spacecraft
- Will be changed during a formal call
- Important to early get a design of the spacecraft and understand the requirements

Instruments	**kg**
Mass resolving ion spectrometer	5
Electron & ion spectrometer	2
Wave/lightning detector	2
Langmuir probe(s)	1
Magnetometer	0,5
ENA spectrometer	2,5
Driftmeter with mass resolution	3
Subsatellites	16
Subsatellite release/support system	3
Atmospheric instruments	
Near IR imaging spectrometer	10
UV/visible photometer	3
Radio science experiment	0
Total Mass:	**48 kg**

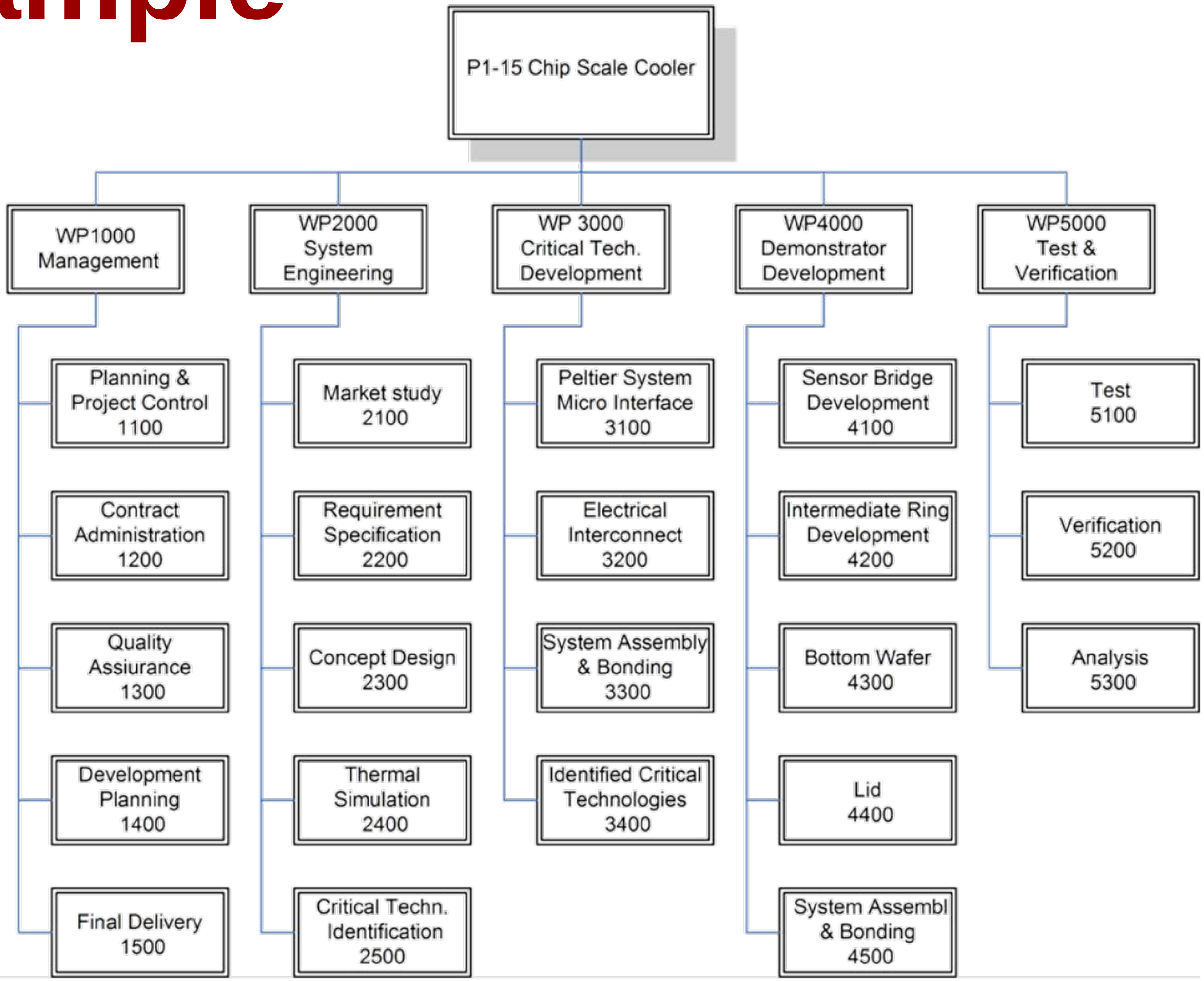
Project management tools

- Work breakdown structure
  - Total project work structured
- Gantt Chart
  - Work as a function of time with critical links
- Organizatinal chart
- Integrated models

Work package breakdown & Work package description

- On a large project, the work should be broken down into manageable subunits (work packages).
  - Tree structure ensures all work packages sum to 100% of task.
- A work package description:
  - is measurable and manageable in its scope
  - is allocated to only one manager
  - results in supply of products or documents
  - identifies all inputs and outputs, including interfaces with other tasks or WPs
  - clearly identifies planning constraints

Work package breakdown – example



Work package description – example

PROJECT:	CHIP SCALE COOLERS		**W.P. REF:** 1400
W.P. TITLE:	Development Planning		**SHEET 1 OF 1**
CONTRACTOR:			**ISSUE NO:** 1
MAJOR CONTST:	System Engineering		
START EVENT:	Kick-off	**PLANNED DATE:**	**ISSUE DATE:** 2006-09-21
END EVENT:	Final delivery	**PLANNED DATE:**	
W.P. MANAGER:	Petrus Hyvönen		

OBJECTIVES:

To establish and maintain development plans for the chip-scale cooler demonstrator

INPUT REQUIRED TO START:

- Kick-off or authorization to start
- Authorization to proceed with proposed objectives

TASKS INCLUDED:

- Establish the development plan for chip-scale coolers
- Maintain and update the development in a controlled way through the development process
- Compilation of test and verification plan

OUTPUT:

- Detailed development plan for chip-scale coolers
- Contribution to design reviews and final report

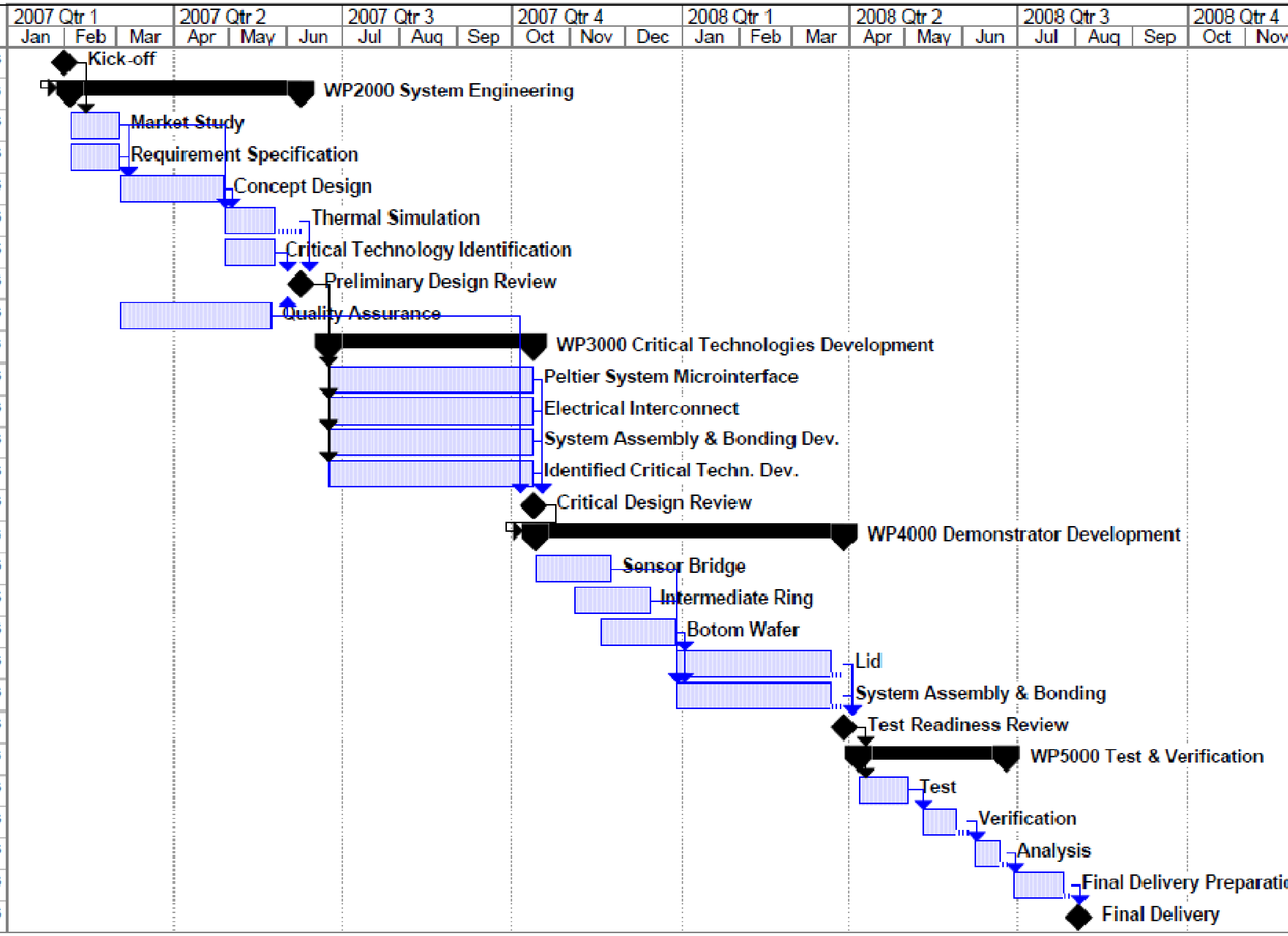
Schedule

As a minimum, the baseline schedule contains:

- key milestones
- descriptions of the activities
- start and finish dates of activities
- duration of activities
- identification of the critical path activities

Gantt Chart

ID	Task Name	Duration
1	Kick-off	0 days
2	**WP2000 System Engineering**	**90 days**
3	Market Study	20 days
4	Requirement Specification	20 days
5	Concept Design	40 days
6	Thermal Simulation	30 days
7	Critical Technology Identifi	20 days
8	Preliminary Design Review	0 days
9	Quality Assurance	58 days
10	**WP3000 Critical Technologies**	**80 days**
11	Peltier System Microinterfa	80 days
12	Electrical Interconnect	80 days
13	System Assembly & Bondi	80 days
14	Identified Critical Techn. D	80 days
15	Critical Design Review	0 days
16	**WP4000 Demonstrator Develo**	**120 days**
17	Sensor Bridge	30 days
18	Intermediate Ring	30 days
19	Botom Wafer	30 days
20	Lid	65 days
21	System Assembly & Bondi	65 days
22	Test Readiness Review	0 days
23	**WP5000 Test & Verification**	**57 days**
24	Test	20 days
25	Verification	17 days
26	Analysis	12 days
27	Final Delivery Preparation	22 days
28	Final Delivery	0 days

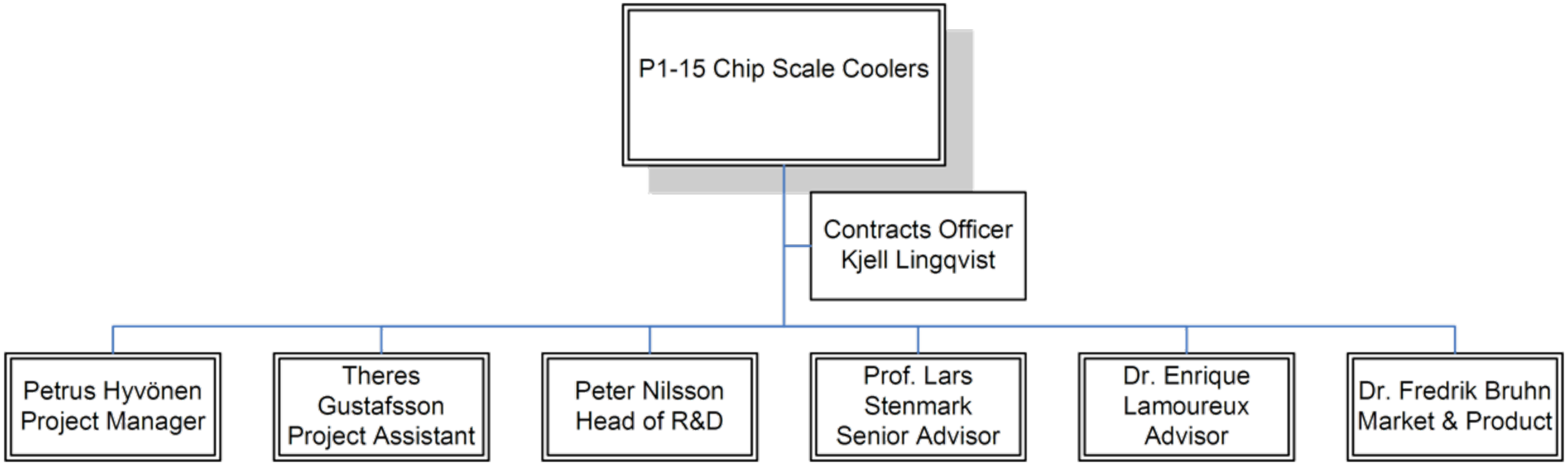


Project: P1-15 Gnatt.mpp
Date: 2006-09-07

Task
Split
Progress
Milestone
Summary
Project Summary
External Tasks
External Milestone
Deadline

Organizational Chart

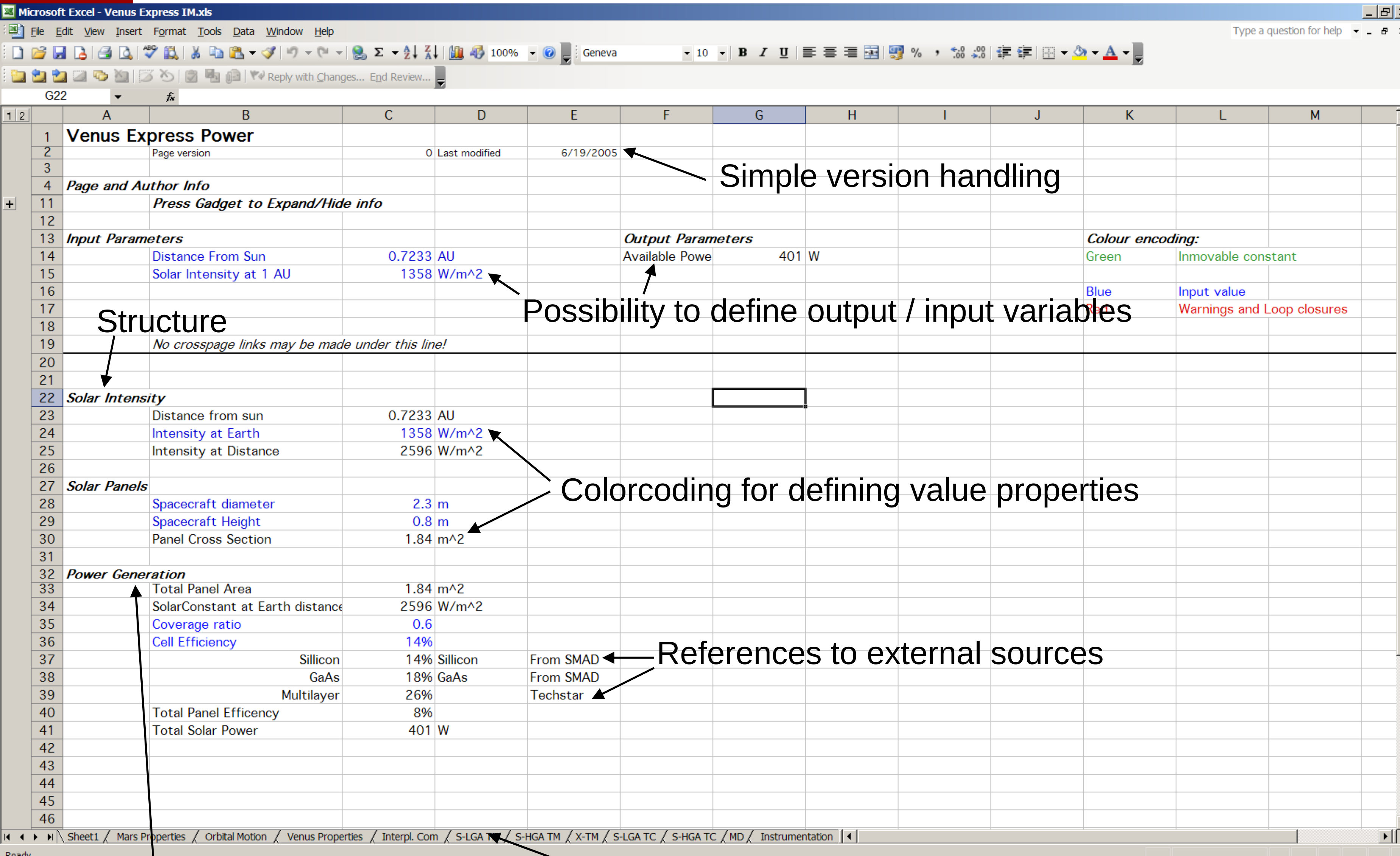
- Clear and unambiguous definition of individual roles, responsibilities and authority
- Both internal and external to the organization



Integrated Models & Concurrent engineering

- Concurrent engineering is a method to make early concept designs
  - ”Gather all in same room, have a boss, and make sure itall agrees in a semi-formal way”
- Tested by ESA, NASA and many universities with successful results at early project stages
- Integrated models are a central tool in this method
  - Collect and link calculations, values and other information
  - Enable all to access, modify and inspect
  - Uses COTS software – Excel
    - Commercial Off The Shelf

Integrated Model Example



Simple version handling

Possibility to define output / input variables

Structure

Colorcoding for defining value properties

References to external sources

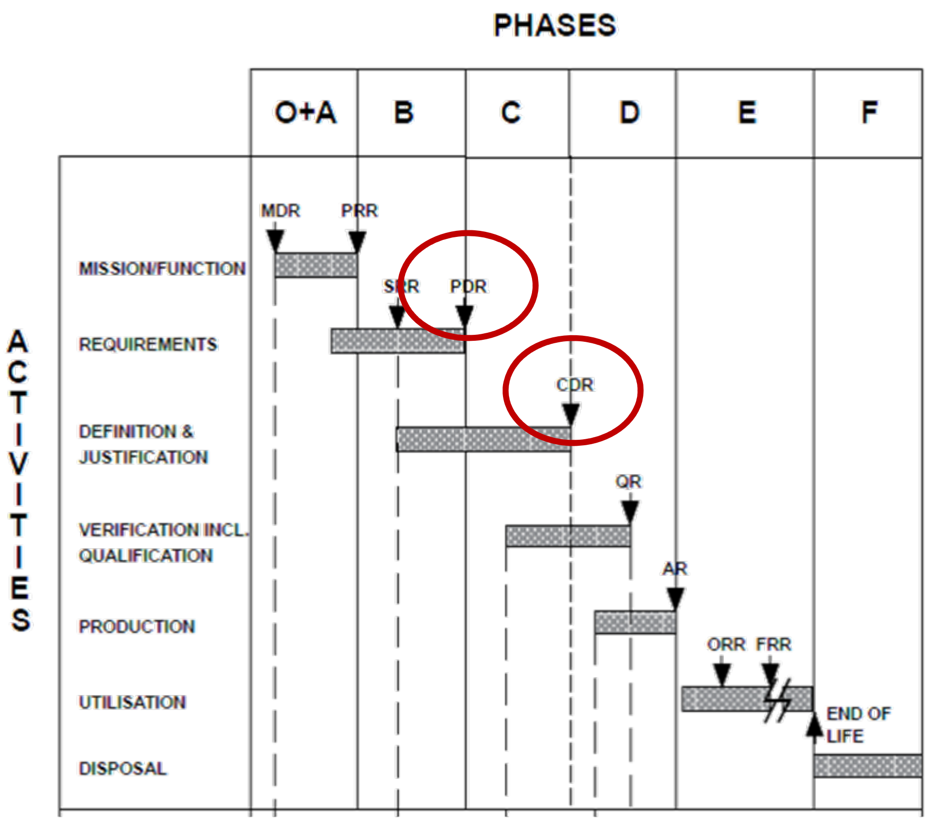
Reusability

Tabs for different subsystems

Cost estimation

- Cost estimation needs to rely on good knowledge or good assumptions
  - Use previous missions and make a range of what seems reasonable
- Parametric model exists for common types of spacecraft
  - The applicability of these can be discussed
  - SMAD has a simple model for small satellite cost estimation

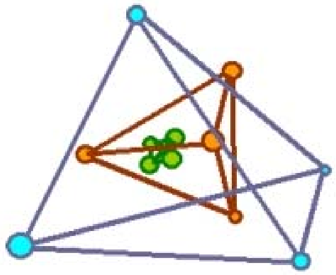
Project phases – ESA project



NOTE
AR = Acceptance Review
CDR = Critical Design Review
FRR = Flight Readiness Review
MDR = Mission Definition Review
ORR = Operational Readiness Review
PDR = Preliminary Design Review
PRR = Preliminary Requirements Review
QR = Qualification Review
SRR = System Requirements Review
WBS = Work Breakdown Structure

- A phase is a group of activities
  - advances a project from one milestone to another
  - often ended by a formal review that confirms if the work has been done follows the requirements

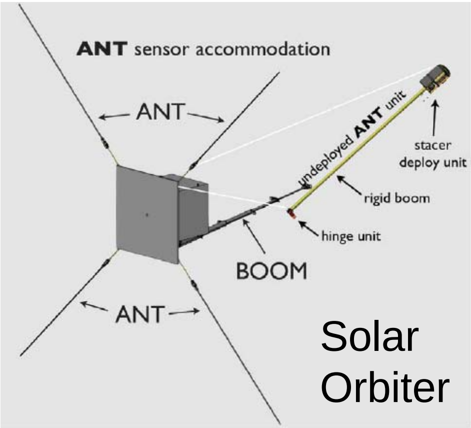
Phase 0: Mission Analysis and Needs Identification



- (NASA terminology: pre-phase A)
- Identification and characterization
- Expected performance
- Assessment of operating constraints
  - in particular: physical and operational environment,
- Identification of possible system concepts
- preliminary assessment of project management data (organization, costs, schedules)
- End result: specification of the mission concept

- At the end of phase 0, a Mission Definition Review (MDR) can take place
  - (NASA terminology: Mission Concept Review, MCR)

Phase A: Feasibility



Finalize needs expressed in phase 0 and propose solutions

- Quantify and characterise critical elements for technical and economic suitability
  - explore various possible system concepts
  - compare these concepts against the needs
    - determine levels of uncertainty and risks
  - estimate the technical and industrial feasibility,
- Identify constraints:
  - costs, schedules, organisation, utilisation (operations, implementation, maintenance),
- At the end of the phase A, the Preliminary Requirements Review (PRR) is conducted
  - (NASA terminology: Mission Definition Review, MDR)

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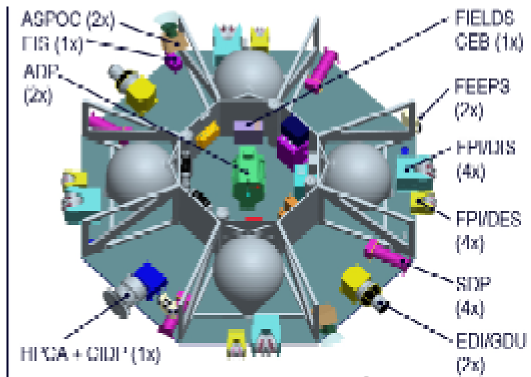
Phase B: Preliminary Definition (Project and Product)

- Select technical solutions for system concept selected in phase A
  - acquire a precise and coherent definition (performance levels, costs, schedules) at every level
- System Requirements Review (SRR)
  - Initial identification of ‘Make or buy’ alternatives
- Confirm feasibility of the recommended solution
- At the end of phase B:
  - Preliminary Design Review

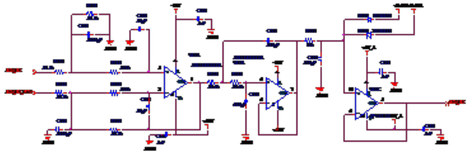


MMS

Phase C: Detailed Definition

- Detailed study of phase B solution
  - production of representative elements
  - detailed definition of system and components
- Allows a definitive ‘make or buy’ decision
- Allows confirmation of the test and qualification setup
- Allows preparation of phase E activities.

At the end of this phase, the Critical Design Review (CDR) is conducted.



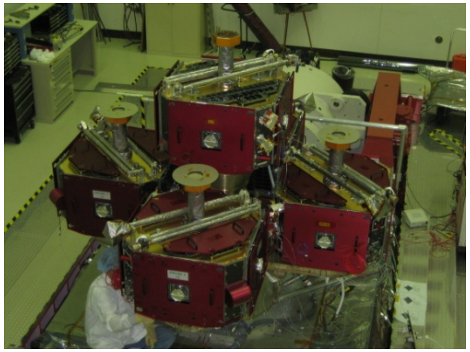
Phase D: Production/Ground Qualification Testing

Phase D is the end of the system development.

- Ground qualification testing verifies:
  - technical conformity of the components against the requirements (**design qualification**)
  - aptitude to be used operationally (**operational qualification)**
  - identification of the functional and operational margins.

Phase D ends with the Acceptance Review (AR)

Phases C and D are usually inseparable



Phase E: Utilisation

- Launch campaign, launch and in-flight acceptance of space elements
- Operation and maintenance of the system, feedback.
- Can be divided into two sub-phases:
  - E1: test and commissioning
  - E2: utilisation

This course

- Designing to a pre-phase 0 level
  - Don’t need, e.g., detailed circuit diagram of electronics
  - Do need to demonstrate that the system <u>could</u> be built, and what it would be able to do if it were built
- Get organized!
  - Define roles and responsibilities
  - Have a plan for how to meet deadlines
  - Don’t get too far ahead of yourselves

This course

- ”Phases”
  - Gathering questions
    - Meeting with experts: week of April 21
  - Preliminary strawman payload
    - Draft chapters May 16
  - Iterating
    - making into a consistent story
    - Making ”sellable”

End of the lectures
(Next: learning by doing)

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