Problem 1 - Requirements Discovery for a Mars formation flying mission (45 minutes, 24 points)

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<tr><th colspan="3">Delft University of Technology</th></tr>
<tr><td>Course: Systems Engineering & Technical Management Techniques (AE3-S01)</td><td>Time:
Location:</td><td>14:00-17:00</td></tr>
<tr><td colspan="3">Date: Friday July 6, 2007</td></tr>
<tr><td colspan="3">Write down your name, all initials and your study number on each of your sheets. Answer the questions in a short and concise manner. Lengthy answers will not influence the grade positively. Give structured answers. You may NOT use a pencil to work out the assignments. The scrap paper cannot be part of</td></tr>
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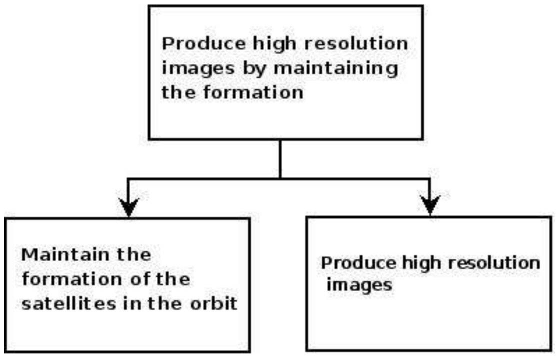
Up till now the surface of the planet Mars has been observed either from a large distance by satellites or from (very) close by means of Mars rovers. While satellites provide a very good overview of the area observed, the images lack detail, and for the pictures provided by the rovers the opposite is true. As a good compromise between these two observation platforms a mission is proposed that will bring two micro satellites to a low orbit around Mars in a formation flying configuration. The satellites will then orbit Mars and produce images through separated spacecraft interferometry.

a) Formulate a Mission Need Statement for the multi-satellite Mars interferometry mission.
b) You are requested to analyze the requirements on this mission and its instrument. To this purpose you construct a Requirements Discovery Tree. The top level of the tree has been split in two, more or less "opposite" parts (dichotomy).
c) Complete this Requirements Discovery Tree such that

   1. It contains at least three levels of requirements,
   2. It shows on at least two more places an example of the principle of dichotomy,
   3. It shows both requirements derived from the description above and requirements obtained from your general knowledge of a mission to Mars.



d) What is the purpose of requirements discovery?

e) What type of tree is the Requirements Discovery Tree?

f) Which property of the Requirements Discovery Tree do you exploit?

g) What is the next step in the requirements analysis process?

Problem 2 - Technical Risk Assessment (30 minutes, 19 points)

Consider the previous satellite mission. To generate sufficient power for the satellites and to keep them as small and light as possible (to reduce the cost of the mission), the solar panels of the spacecrafts can be composed of a recently developed thin film solar cells. The new solar cells are not space qualified yet but can generate much more energy comparing to available solar cells.

To evaluate the risks of such a design, a technique is often used in technical risk assessment which is called Risk Map and it is basically a two-dimensional matrix or table.

a) Which two “factors” determine the risk in a Risk Map?
b) How can you “mathematically” express risk?
c) Which technical aspect is often taken to estimate the frequency with which a risk may occur? Can you give at least four typical entries on the ordinal scale determining this frequency?
d) Which kind of events may be considered by the other factor determining the risk? Can you give at least three typical entries in the ordinal scale used for that axis of the Risk Map?
e) Draw a typical Risk Map. Where are the items with the highest risk located?
f) Indicate how you are going to mitigate the risks. Which two typical risk mitigation approaches may be taken? What is the result of each of these approaches?
g) In case of the mars mission: Which risk items or elements would you put as high risks where in the Risk Map and why?
h)

Problem 3 - The Aerospace Market (45 minutes, 24 points)

Markets can be defined along many different dimensions. For engineers it is often enough to use the following three dimensions: Customer, Function and Technology. Each of the dimensions can be segmented in many ways. Consider the Airbus A350 XWB:

The new Airbus A350 has to become a competitor to the larger Boeing 777 as well as the Boeing 787.The A350 will have a fuselage cross-section wider than the existing Airbus wide body standard. Airbus refers to this as "XWB" or "Xtra Wide Body" and states that from the point of view of a seated passenger, the cabin is 5 inches wider at eye level than the competing Boeing 787. The A350 fuselage will have a constant cross-section from door 1 to door 4, unlike previous Airbus aircraft with the "Airbus taper". The fuselage is to be ovoid rather than circular. All A350 XWB passenger models will have a range of at least 8,000 nautical miles.
The aircraft will have a cruising speed of approximately Mach 0.85, similar to the Boeing 787 or Boeing 747, and Airbus claims that its maintenance costs will be 10% lower than for the 787. The A350 will have a common cockpit with the Airbus A380. The A350 is to have large windows and will be pressurised to 6,000 feet or lower with a cabin air humidity of at least 20%. Airbus has signed a contract with BMW to have them develop an interior concept.
The A350 features composite wings, rear fuselage and fuselage skin (with aluminium ribs), new engines, new landing gear and many new systems compared to the A330. It builds on the technologies developed for A380 and has a similar cockpit layout. 52% of the aircraft will be made out of composites, 20% Al/Al-Li, 14% titanium, 7% steel and 7% the balance. This compares to the 787, which consists of 50% composites, 20% Aluminium, 15% titanium, 10% steel and 5% the balance.
For the engines Airbus has confirmed that they will retain a full bleed air system on their engines, rather than the bleed less configuration used on the 787. Rolls-Royce has agreed with Airbus to supply a new variant of the Trent engine for the A350 XWB, currently called the Trent XWB, which will have a static thrust of 75000-95000 lbf.

Model	A350-800	A350-900	A350-1000
Cockpit Crew	Two		
Passengers	270 3-class 312 2-class	314 3-class 366 2-class	350 3-class 412 2-class
Length	198 ft 6 in (60.5 m)	219 ft 3 in (66.8 m)	242 ft 3 in (73.8 m)
Wingspan	209 ft 10 in (64 m)		
Wing Sweep back	35°		
Height	55 ft 5 in (16.9 m)		
Cabin Width	19 ft 4 in (5.90 m)		
Cargo Capacity	26 LD3	36 LD3	44 LD3
Max. Take-off Weight	40,000 lb (245,000 kg	580,000 lb (265,000 kg)	650,000 lb (295,000 kg)
Cruise Speed	.85 Mach (561 mph at 40,000 ft)		

Maximum Cruise Speed	.89 Mach (587 mph at 40,000 ft)		
Range, Loaded	,300 nm (15,400 km)	8,100 nm (15,000 km)	8,000 nm (14,800 km)
Max. Fuel		,682 US gal (150,000 L	
Service Ceiling	43,000 ft (13,100 m)		
Engines (2×)	RR Trent XWB		
Max. Thrust	75,000 lbf	87,000 lbf	95,000 lbf

a) Consider the civil transport aircraft market. Give a segmentation of the dimensions ‘function’ and ‘customer’. The segmentation of the dimension ‘function’ should address the differences in the type/characteristics of ‘transport’ that can be performed with civil transport aircraft. The segmentation of the dimension ‘customer’ should address the differences between airlines that influence the aircraft design. Identify at least three segments for the dimension customer and three segments for the dimension function (transport).

b) Airbus addresses several technologies to improve the way the A350 aircraft performs with respect to its competitors. Some of these improvements directly address the passenger, others the airline. Analyze the text above and give at least three combinations of functions and technology that address passenger and/or airline.

   Note: in this case the functions to describe are derived functions (derived from the top level function ‘transport’ addressed in the previous question).

c) Explain the concept of ‘supply chain’. Use the information on the A350 XWB to illustrate your explanation.

d) Explain the difference between primary demand and derived demand.

e) Give two examples of secondary demand related to passenger transport aircraft

Problem 4 - Interface Analysis (30 minutes, 15 points)

Analyze the interfaces of an ironing system with at least the following elements

- Steam iron
- Ironing board
- Electrical network
- User

    1. What is the Mission Need Statement for this system?
    2. Is this system complete? Give a rationale for your answer.
    3. Name the primary functions of each of these elements, also for additional elements you may need to complete your system.

4. Draw a N^2 chart and identify the interfaces between the elements by putting a cross in the squares where an interface is present.

Problem 5 - Design for verification / design for production / design recording (30 minutes, 18 points)

a) The Space Design Process defines four methods for verification: Design Review, Inspection, Analysis and Test. Describe all four of them in your own words. Give clear and relevant answers describing 'Design Review' as 'Review of the Design' is not considered a relevant answer.
b) Give three types of verification tests and give an example of their application during the development of a satellite.
c) Define the difference between qualification testing and acceptance testing
d) For the cost estimate of a new product it is common use to distinguish between non-recurring cost and recurring cost. These two types of cost are related to non-recurring and recurring processes in product development. Give a definition and at least three examples of each of the two process types.
e) Traceability and configuration control are very important aspects of quality assurance in the aerospace industry.
   Explain how document templates support traceability of design information and how they support configuration control.