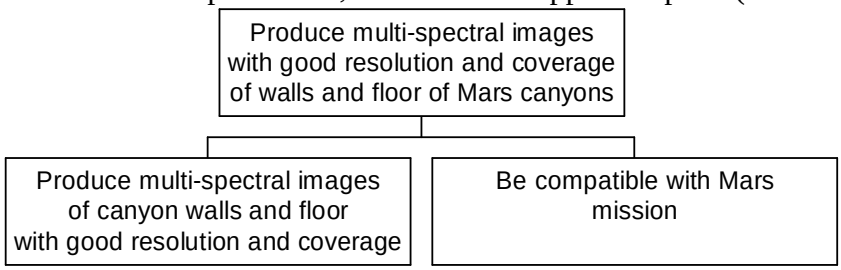
Delft University of Technology		
Course: **Systems Engineering & Technical Management Techniques (AE3-S01)**	Time: Location:	**9:00-12:00 hrs** **TBD**
Date: **Wednesday April 13, 2005**		
Write down your name, all initials and your study number on each of your sheets. Answer the questions in a short and concise manner. The length of the answer will not influence the grade. Give structured answers. You may NOT use a pencil to work out the assignments. The scrap paper cannot be part of the exam paper and you must take it with you afterwards. Note, that this exam is an individual test of your knowledge and understanding of the course material. No notes of any kind may be used during the exam, including data stored in a programmable calculator. You may answer the questions either in English or in Dutch, but you should used only one language for the exam. The exam consists of 6 assignments, for a total of 100 points		

Problem 1 Requirements Discovery for a MARS UAV mission (45 minutes, 25 points)

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 an Uninhabited Aerial Vehicle (UAV) to Mars and "deposit" it in the Mars atmosphere. The UAV will then fly through the Mars atmosphere and produce multi-spectral pictures of the floor and walls of a canyon.

1a Formulate a Mission Need Statement for the UAV mission.

You are requested to analyze the requirements on this UAV and its imaging 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).



Complete this Requirements Discovery Tree such that

1b It contains at least three levels of requirements,

1c It shows on at least two more places an example of the principle of dichotomy,

1d It shows both requirements derived from the description above and requirements obtained from your general knowledge of a mission to Mars.

1e What is the purpose of requirements discovery?

1f What type of tree is the Requirements Discovery Tree?

1g Which property of the Requirements Discovery Tree do you exploit?

1h How do you know for sure that your Requirements Discovery Tree is complete?

1i What is the next step in the requirements analysis process?

Problem 2 The Aerospace Market (35 minutes, 20 points)

2a Function, technology and customer are the three major elements (dimensions) of a market definition. Analyse the BA 609 tilt rotor product description given below and give a definition of the market(s) for this product based on the three major elements of a market definition.

2b Give a SWOT analysis of the product as found in a.

2c Give a definition of a supply chain and give a possible supply chain for the BA 609 based on data in the description below and your own imagination. Use text and a sketch to answer this question.

2d Is a supply chain a company or a product based view? Explain your answer.

2e Give a Space Market segmentation based on users (customers)

*The **BA609** is a civil tilt-rotor for the business market, combining turboprop cruise speed with the ability to take-off and land vertically like a helicopter. It is a completely new design, although the experience gained with the V-22 Osprey is of course heavily leveraged.*
Apart from the civil market, Bell is also targeting military roles for the 609. This could include a trainer for the V-22 Osprey in Marine Corps service. Also, Bell teamed with Lockheed to compete for the US Coast Guard Deepwater Program that would consider the 609 as a potential replacement for the USCG current fleet of helicopters and fixed-wing aircraft.
Besides Bell and Agusta, major suppliers for the BA609 include:

- *Aerazur: Fuel cell*
- *Fuji Heavy Industries: fuselage*
- *Lear Astronics: Flight control computers*
- *Lucas Aerospace: DC electric power systems*
- *Dowty Aerospace: Flight control actuators*
- *Messier-Dowty: Landing gear*
- *Rockwell Collins: Pro Line 21 avionics with a glass cockpit (three displays)*
- *Toray Composites: Composite material*
- *Howmet: Pylon support casing*
- *Pratt & Whitney Canada: PT6C engines*
- *Simula: Crashworthy seats*
- *Sully Produits Speciaux: Windows*
- *BF Goodrich Aerospace: Stand-by instrument system*
- *AMETEK Aerospace Systems: Nacelle interface unit*

General
Crew: 1 - 2
Passengers: 6 – 9 in executive or standard configuration
Baggage compartment: 1,4 cu m (50 cu ft)

Problem 3 Risk Map for an Extra Long Range version of an aircraft (25 minutes, 14 points)

You are developing an Extra Long Range version of an Airbus A340-300. To achieve this you introduce two modifications:

- A brand-new wing, using advanced smart materials to optimize the aerodynamic shape of the wing (*CL/CD* improvement 10% in cruise) and to save wing mass (10% mass saving on wing structure)
- A modified engine having a 15% better fuel consumption

Other aircraft structure and systems remain unchanged, but interfaces will have to be adapted to the new or modified elements.
To assess the technical risks present in this project you are asked to produce a (Technical) Risk Map and a Risk Mitigation Plan (what you are going to do to bring the risk back to acceptable proportions).

3a What is the list of elements/functions you want to include in the risk map?

3b How is risk defined and how do you represent it in a risk map?
3c Which steps (ordinal ranking list) will you use in the assessment of the probability of occurrence of "things going wrong"?
3d Which steps (ordinal ranking list) will you use in the assessment of the consequence when the risk occurs?
3e Plot the elements in a Risk Map with the highest risks in the top-right corner.
3f Define for the two top risk elements the risk mitigation measures you will take and explain how they are expected to change your risk map.

Problem 4 Design Concept Selection (30 minutes, 17 points)

You find yourself on an uninhabited island and you want to get home. You decide to build a multi-functional vehicle and you set yourself to the design and production of it. On the island you have trees with lianas, two old oil barrels, a lake with reed, a very old very leaky rowing boat and some wild goats and sheep.

4a Sketch a workflow diagram for your project and make a small planning.
4b Sketch a functional tree and a design option tree for your vehicle.
4c Is the design option tree an AND or an OR tree? Explain the difference
4d What is a trade-off process? Give a (rough) process flow diagram of the trade-off process
4e What are killer requirements and give two for the trade-off applied to your vehicle design.
4f Perform a trade-off for your design (use at least two criteria) and report your trade-off in a table.
4g Give the difference between ordinal and cardinal methods for design option selection.

Problem 5 Reliability of an Earth Observation instrument (20 minutes, 11 points)

An Earth Observation instrument is taking data from the Earth continuously. Mission duration is 10000 hours. The reliability R_I of the instrument is 0.7. The data are transferred to the ground station by means of a radio link (RF system). The failure rate of the RF system λ_{RF} is 0.0000693 failures per hour. You may assume an exponential distribution for both components.

5a Draw a reliability block diagram of the instrument including the RF system. Indicate failure rate and/or reliability in it.
5b What is the reliability of the total system?

5c What is the Mean Time Between Failure? Do you think the mission can be accomplished without failure?

The RF system is capable to transmit the data taken in 12 hours to the ground in a time span of 15 minutes.

5d How could you improve the reliability of the instrument, including RF system? Give at least two options.

5e If you would switch the RF system on during the minimum ground contact time of 15 minutes per 12 hours only, what does the overall reliability and MTBF of instrument and RF link become? What do you conclude?

Problem 6 Design for verification / design for production (25 minutes, 15 points)

6a The Space Design Process defines four methods for verification: Review of Design, Inspection, Analysis and Test. Describe all four of them in your own words.

6b Give three types of verification tests and give an example of their application.

6c Define the difference between qualification testing and acceptance testing

6d 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 both process types.

6e Give a definition of lean manufacturing and describe three types of waste that can be often identified in production lines.