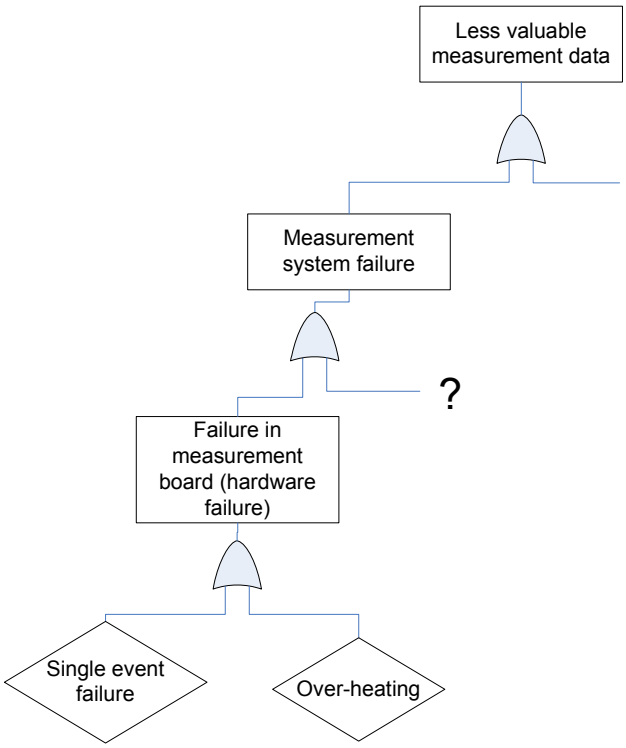
Delft University of Technology	
Course: **Systems Engineering & Technical Management Techniques (AE3-S01)**	Time: **09:00-12:00 (3 hours)** Location:
Date: **February 2, 2007**	
Write down your name, all initials and your study number on each of your sheets. Answer the questions in a short and concise 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 the exam paper and you must take it with you afterwards. Try to keep your answers to the point and concise. You may answer the questions in English or in Dutch. The exam consists of 6 assignments, for a total of 100 points	

Problem 1 Fault Analysis (30 minutes, 14 points)

Consider Delfi-C3 satellite case study of Problem 5.

a) To identifying the possible failure modes, which reduce the value of measurement data, try to use fault tree analysis (FTA). Draw the tree and evaluate at least three levels of faults that may reduce the value of the measured data. Your FTA should cover at least 10 more blocks. Try to use both AND and OR gates and relevant FTA symbols. You may use the following FTA and add your blocks to it.



b) Describe the difference of AND and OR in your FTA.

c) Indicate at least two cut-sets in your FTA. What is the relation of the number and size of the cut-sets with OR and AND gates?
d) How can you use FTA to increase the reliability of system?

Problem 2 The Aerospace Market (30 minutes, 20 points)

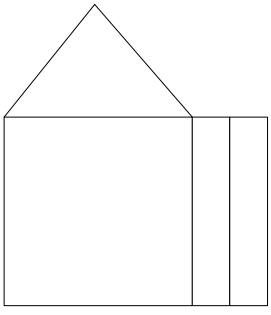
Markets can be defined along many different dimensions. For engineers it is often enough to use the following three dimensions: Customer, Function and Technology. Each of the dimensions can be segmented in many ways. Consider the Boeing Delta IV Rocket:

> *The Boeing Delta IV rocket is designed to provide reliable access to space for satellite launch customers. Delta IV blends advanced and proven technologies to launch medium- to heavy-size satellites. Delta IV rockets can accommodate single or multiple payloads on the same mission and can carry satellites weighing between 4,210 kg (9,285 lbs.) and 13,130 kg (28,950 lbs.) to geosynchronous transfer orbit (GTO). Delta IV rockets also can launch satellites to polar orbits, Sun-synchronous orbits, and the International Space Station orbit with the capability to lift over 23,000 kg (50,000 lbs.) to low-Earth orbit (LEO). The Delta IV family consists of five launch vehicle configurations based on the Boeing Common Booster Core (CBC) first stage with the Pratt & Whitney Rocketdyne RS-68 main engine. The Delta IV second stage uses the Pratt & Whitney RL10B-2 engine, with two sizes of expanded fuel and oxidizer tanks, depending on the vehicle configuration. Delta IV vehicles use four-meter (13.1-ft) and five-meter (16.7-ft) diameter second stages and payload fairings built by Boeing.*

a) Describe the functionality and the technology of the Boeing Delta IV.
b) The dimension 'customer' can be segmented in many ways. Give 3 segmentations for rockets in general and two specifically for the Boeing Delta IV rocket..
c) Explain the difference between primary demand and derived demand.
d) Give two examples of primary demand related to rockets and two related to satellites
e) Explain the concept of 'supply chain'. Use the information on the Boeing Delta IV rocket to illustrate your explanation.

Problem 3 Quality Function Deployment (30 minutes, 18 points)

Quality Function Deployment is a technique to "translate" user requirements in product requirements. The graphical tool used to apply this technique is called "House of Quality" as the shape resembles a house. The drawing shows a number of elements normally contained in the tool.



h. The figure is not complete. Finish the drawing and then place the letter indicating the House of Quality elements below in the correct location in the figure.

A	User requirement; voice of the customer

B	Features
C	Relationship matrix
D	Requirements correlation matrix
E	Target value
F	Benchmark
G	Importance

i. What is noted down in the entry “benchmark”?
j. Which gradations are commonly used in the relationship entries?
k. Which gradations are used in the correlation entries?
l. Suppose there is a blank (empty) row in the relationship matrix. Which conclusion do you draw?
m. Suppose there is a blank (empty) column in the relationship matrix. What conclusion do you draw?

Problem 4 Design Concept Selection (30 minutes, 18 points)

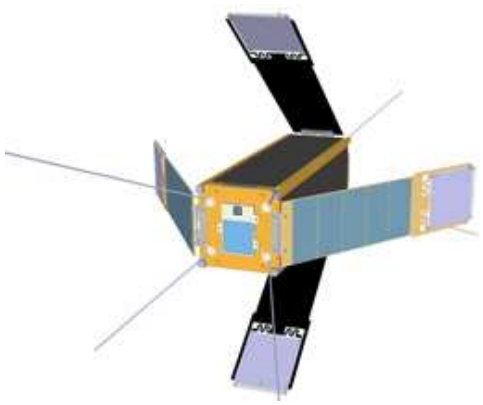
You want to develop an unmanned aerial vehicle (UAV) including ground station, that can be used by the fire brigade to survey areas (e.g. woods) that are prone to bush fires. The UAV must have an endurance of at least 3 hours, a range of 150 km and should be designed such that it is unlikely to become a source of bush fires itself in case of a crash.

In the questions below the abbreviation UAV is used for the unmanned aerial vehicle including ground station. Answer the questions with a proper combination of diagrams and descriptive text.

a. Give a functional flow diagram or a functional breakdown for your UAV.
b. Give a requirements discovery tree for the UAV and show/explain the relation between the requirements discovery tree and the functional breakdown.
c. Give design option trees for the three most important functions. Each option tree must at least have three levels.
d. Perform a trade-off for the options in your option three. Use at least two trade-off criteria; give weight factors for the trade-off criteria and report your trade-off in a table.
e. Give the difference between ordinal and cardinal methods for design option selection.

Problem 5 Interface Analysis (30 minutes, 15 points)

Delfi-C3 is a small size satellite. Its mission is to test some of the recently developed technologies in space. One of the payloads of the satellite is a measurement system that measures the performance of a new type of solar cell in low earth orbit. Receiving 8 data packets from the measurement device together with one packet of relevant



attitude information is required to evaluate the performance of the solar cell.
The satellite has an attitude measurement system and a passive magnetic control system with no feedback. It is very important to know the attitude of the satellite for the measurements. To get reliable and useful measurements it is necessary to make sure that the satellite is stabilized and de-tumbled (received data during tumbling is not useful or reliable).
There is no data storage on-board, and the communication link with the satellite is very limited in time and data-rate. The satellite has an on-board computer and deployable solar panels and antenna. There is no battery on-board the satellite.

a) How do you use a N2 chart as a systems engineering tool? (List at least two ways of using the chart).
b) Enlist at least 10 system functions of Delfi-C3 by considering the measurement system as the payload.
c) What do you put as the diagonal and off-diagonal entries in a N2 chart?
d) Fill the N2 chart with Delfi-C3 system functions.
e) Based on your N2 chart, specify those subgroups of functions which might be developed in parallel.

Problem 6 Design for verification / design for production / design recording (30 minutes, 15 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 verifications 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.