Delft University of Technology
Course: **Systems Engineering & Technical**   Time: **9:00- 12:00 hrs** **Management Techniques (AE3-S01)**   Location:
Date: **Friday, January 2009**
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 Systems Engineering Principles**

a) Explain the difference between a Project Objective Statement and a Mission Need Statement
b) Describe the relation of the FFD, the FBS and the LOR to the Mission Need Statement
c) Describe the relation of the WFD, the WBS and the Gantt Chart to the Project Objective Statement
d) Decsribe the elements of the Gantt Chart and draw a simple Gantt Chart illustrating your answer

Problem 2 Market Analysis

a) It is often convenient to segment a market along three lines. Give a short description of these three lines
b) Give a market segmentation along the three lines mentioned in a) for micro-aerial vehicles. Assume the following (fictitious) definition for these vehicles:
   a. Fitting in a box of 500x500x500 millimeters
   b. Lighter than 4 kg
   c. Ceiling of at least 200m
   d. Capable of flying remotely controlled and autonomous
c) Another tool that can help you to better understand the customer is Quality Function Deployment.
   a. Describe the elements of the House of Quality, illustrate your answer with a sketch of a house of quality
   b. How does the House of Quality quantifies the customer's voice?
   c. Where do the design sensitivities (the influence of a design choice on the quality of the design as experienced by the customer) show up in the House of Quality?
   d. Is the House of Quality an objective tool? If not, where do you suspect subjective information? If yes, why do you think the tool is objective?

Problem 3 Design Verification

Proper Design Verification is obtained through verification material that is: 1) Relevant, 2) complete, 3) sufficiently objective

a) Describe why <u>traceability</u> is important for design verification?
b) How does a <u>compliance matrix</u> contributes to the verification process?
c) What is the relation between the LOR and the compliance matrix?

d) Name at least 4 <u>Means of Compliance</u> finding (for example Design Review) and explain what is acutually is.
e) Give an example for each of the Means of Compliance in your answer to d) in the context of a communication satellite design verification

For problem 4, 5 and 6 consider the following mission description:

FAST mission is a formation flying mission composed of a spacecraft pair which will allow a synoptic evaluation of global aerosol data and altitude profiles of the cryosphere with two cooperating microsatellites, FAST-D and FAST-T, flying in formation in 2011. The mission's scientific payload will consist of two spectropolarimeters and two altimeters. The spectropolarimeters will be used for the detection and characterization of aerosols in the Earth's atmosphere with one instrument on each spacecraft. To determine cryospheric height profiles, a laser altimeter will be flown on FAST-D and a radar altimeter on FAST-T. The satellites should log the payloads data and transmit it to ground station for analysis. To satisfy the measurement requirements of the payloads and also high speed ground-station communication, Attitude Determination and Control System (ADCS) of the satellite should be able to provide a precision of better than 1 degree. Also it is important to keep the satellites in the formation (900km along-track distance), therefore the satellites should be able to communicate and regulate their positions in orbit.

Problem 4 – Functions and design options [22 points]

a) Provide a mission need statement for the above mission.
b) Enlist 6 killer requirements for this formation flying mission.
c) Enlist 10 functions of one of the satellites (either FAST-D or FAST-T).
d) Select 4 out of 10 identified functions and draw a design option tree for each one. Each design option tree should consist at least 3 levels and 8 blocks.

Problem 5 – Interfaces and N2 Chart [12 points]

a. What is the purpose of drawing a N2 Chart as a system Engineering tool?

b. What are the entries placed on the diagonal?

c. What is placed on the other places in the matrix?

d. Fill the N2 chart with the 10 functions which you identified in Problem 4.

e. Use the N2 chart and describe how the functions are related. Show the connections between at least 6 functions.

Problem 6 - Risk map [16 points]

a) Describe the concept of a Risk Map as a System Engineering tool.

b) Which steps (ordinal ranking list) will you use in the assessment of the probability of occurrence of "things going wrong"?

c) Which steps (ordinal ranking list) will you use in the assessment of the consequence when the risk occurs?

For the 10 functions which you identified in the problem 4:

d) Plot a Risk Map and place those 10 functions with the highest risks in the top-right corner.
e) 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.