Delft University of Technology	
Course: **Systems Engineering & Technical Management Techniques (AE3-S01)**	Time: **14.00-17.00 hrs** Location: **TBD**
Date: **Monday August 29, 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. Try to keep your answers to the point and concise. You may answer the questions in English or in Dutch. The exam consists of 5 assignments, for a total of 100 points	

Problem 1 Functional analysis (45 minutes, 25 points)

Currently there is much interest to use Uninhabited Aerial Vehicles (UAV's) for surveillance tasks linked to threats to vulnerable objects like harbors and large industrial plants. You are requested to perform a functional analysis for such a vehicle with the following mission need statement.

> "To perform autonomous aerial surveillance (with the possibility of manual control interaction) for at least five hours of a remote area on a distance of 50 km and with a surface of 5 by 5 km at a speed between 0 and 100 km per hour and to transmit stereo pictures of the scene to the mobile remote base station with very limited take-off and landing possibilities."

You are requested to produce two functional flow diagrams (FFD's): The first one from an operational viewpoint is based on the criterion time, the second one is analyzing the data flow from the object to be observed until the display of the object image and underlying "housekeeping" data at the remote base station.

a. Give a list of 6 to 10 likely technical characteristics of the UAV.
b. Draw the operational functional flow diagram starting from the preparation of the UAV for flight at the remote base station and ending at the recovery after mission completion at that same location. Limit yourself to one level. Indicate in the diagram, when essential safety checks are useful. Indicate also, at which places in the FFD you would introduce manual interaction.
c. Draw the data functional flow diagram. Make a distinction between the autonomous flight, when only telemetry data are transferred from UAV to base station and the case when manual control interaction with the operator on the base station takes place. Indicate in the flow diagram what is the character of the data transferred (e.g. photons from the image, electromagnetic waves, etc.)
d. Indicate which functions you consider to be most critical. Give a rationale.

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

a. Markets can be defined along many different dimensions. A useful definition in three dimensions of supply and demand side together is given by: customer, function and technology. The dimension 'customer' can be segmented in many ways. Give 4 possible segmentations
b. Explain the difference between primary demand and derived demand.

c. Give two examples of primary demand related to aircraft and two related to spacecraft
d. Explain the concept of supply chain and explain why the term supply tree or supply network would be more applicable.
e. Make a SWOT analysis of the product shown below. Address functionality and technology and give two entries in each of the four boxes of the SWOT matrix.

*The **BA609** is a civil tiltrotor 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/Agusta is also targeting military roles for the 609. This could include a trainer for the V-22 Osprey in Marine Corps service. Also, Bell/Agusta 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 Interface Analysis (40 minutes, 22 points)

An Earth Observation (EO) satellite is broken down in the following components and/or subsystems:

- Infra-red camera (payload)
- Structure subsystem
- Electrical power subsystem
- Thermal subsystem
- Data handling subsystem (including computer)
- Communication subsystem
- Attitude and Orbit Control subsystem

Elements interacting with the satellite are:

- The space environment
- The launcher
- The subject (in this case the Earth)
- The ground station

You are requested to do an interface analysis for the satellite and its components. To this purpose you are using a N2-chart, a square matrix with length and width equal to the number of elements between which the interfaces are analysed.

a. What is the dimension of the N2-chart for the EO satellite?
b. Place the elements in the N2-chart. Define and explain the conventions used to place the elements and to indicate the interfaces between the elements.
c. One interaction or interface between two functions is that the satellite structure provides structural support to the visual image camera. Indicate this interface in the N2-chart with the word "structurally supports" and draw a circle around it.
d. Complete the N2 chart for the other interfaces. Use terms as "provides power", "points", "sends photons", "provides attitude reference", etc. You are expected to identify at least twelve ***different*** interfaces.
e. A method to increase overview is to collapse make functions, elements, components or subsystems into higher level functions, elements or systems. If you would do that for the elements of this EO satellite and the elements around it, which elements would you take together? Which name(s) would you give to these higher level element(s)? Motivate your answer.

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

You want to develop a micro unmanned aerial vehicle (MUAV), including ground station, that can be used by the fire brigade to inspect, indoor, factories and companies after explosions or accidents involving poisonous gases.

k. Give a functional breakdown for your micro aerial vehicle
l. Give a requirements discovery tree for the MUAV and show/explain the relation to the functional breakdown.
m. Give design option trees for the three most important functions. Each option tree must at least have three levels.
n. Is the design option tree an AND or an OR tree? Explain the difference
o. Perform a trade-off for your design (use at least two criteria) and report your trade-off in a table.
p. Give the difference between ordinal and cardinal methods for design option selection.

Problem 5 Design for verification / design for production (30 minutes, 15 points)

u. 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.
v. Give three types of verifications tests and give an example of their application.
w. Define the difference between qualification testing and acceptance testing
x. 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.
y. Give a definition of lean manufacturing and describe three types of waste that can be often identified in production lines.