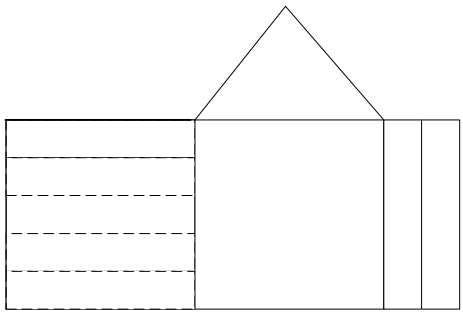
Delft University of Technology	
Course: **Systems Engineering & Technical Management Techniques (AE3-S01)**	Time: **14.00-17.00 hrs** Location: **Cornelis Drebbelweg 5**
Date: **Wednesday August 25, 2004**	
Write down your name, all initials and your study number on each of your sheets. Answer the questions 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 Quality Function Deployment (30 minutes, 16 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.



n. Are all elements present in the drawing? If not, produce a drawing containing all elements.

o. 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
H	Benchmark

p. What is noted down in the entry "benchmark"?

q. Which gradations are commonly used in the relationship entries?

r. Which gradations are used in the correlation entries?

s. Suppose there is a blank (empty) row in the relationship matrix. Which conclusion do you draw?

t. Suppose there is a blank (empty) column in the relationship matrix. What conclusion do you draw?

The QFD technique can be used to flow down user requirements to machine settings (that is: requirements how to set the machines producing a product) in a number of steps.

u. List these four steps and name each step.

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

h) Give an aircraft market segmentation based on customers
i) Give an aircraft market segmentation based on products
j) Function, technology and customer are the three major elements (dimensions) of a market definition. Analyse the Eclipse 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.
k) Give a SWOT analysis of the product as found in c.
l) Give a Space Market segmentation based on users (customers)
m) Give a definition of a supply chain and give an imaginary supply chain for the airframe of the Eclipse

Eclipse Aviation is creating a luxurious six-place, twin-turbofan aircraft that costs less than most used turboprops. It is more economical to own and operate than most of today's single engine pistons and all multi-engine pistons and turboprops. For those who don't want to pilot themselves, we anticipate that aircraft charter and air taxi services, complete with professional pilots, will typically be competitive with a full-fare airline ticket. The Eclipse 500 cruises at a brisk 375 knots and has a generous 1,280 nautical mile range with 4 occupants, NBAA IFR reserve (1,395 nm with 45-minute IFR reserve). A 41,000-foot ceiling avoids most severe weather and the 67-knot stall speed makes safe landings easier. Excellent performance at high altitudes and hot temperatures builds in an extra margin of safety. The Eclipse 500 will be certified for single-pilot operation to FAR Part 23.

The Eclipse 500 is engineered for safety. With near centreline thrust to increase control, and the reliability of twin PW610F turbofans, the Eclipse 500 is safer than piston engine and single-engine aircraft. Single engine performance offers a one-engine inoperative climb rate of 888 feet per minute (sea level, ISA).
Features such as fuel fully contained in the wing, bird-strike resistant windshields, and smart actuators that ensure symmetrical flaps deployment are also results of designed-in safety.
The Eclipse 500 features Avio to deliver pilot assistance through total aircraft integration. Avio decreases the pilot workload – extending the safety benefits of today's glass cockpits – by integrating most major aircraft systems.
In building the Eclipse 500, Eclipse Aviation is pioneering the use of innovative manufacturing processes that speed production and lower costs. Technologies such as friction stir welding which replaces more than sixty percent of the rivets on major aircraft assemblies, reduce assembly time drastically while producing superior joins on the aluminium aircraft.
The Eclipse 500 is an entirely new concept that puts high-performance jet ownership within reach for the first time.

Problem 3 Work Flow Diagram aircraft mechanical control system (30 minutes, 16 points)

You are requested to design an aircraft mechanical control system (ref. your second year project). To describe the activities which are required to execute that task, you have decide to produce a work flow diagram, capturing activities and the relations (inputs and outputs) of those activities. The project is to be executed in a group.

The project assignment describes three major phases: A first phase, meant to become familiar with the subject and to study typical implementations, a second phase, in which you will make the design of the control system, choosing the best option from several candidate solutions, and a third phase, where the details of the system are designed.

a. Make a work flow diagram of the preparatory activities, required to plan the project and to identify the activities for the second and third phase. Try to limit yourself to a maximum of ten activities.
b. Make a work flow diagram for the second phase of the project, with specific emphasis on structuring the selection process of the preferred design. Indicate where important reviews with your (internal or external) customer shall be located, and which decisions are to be taken on these reviews. Try to limit yourself to a maximum of ten activities.
c. Finally, make a work flow diagram for the last phase of the project. Try to limit yourself to a maximum of ten activities.
d. Draw the work breakdown structure for your project.

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

q. You are on an inhabited island and you want to get home. You have decided to build a vehicle and you set yourself to the design 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. Sketch a functional tree and a design option tree for this vehicle.
r. Is the design option tree an AND or an OR tree? Explain the difference
s. What is a trade-off process? Give a (rough) process flow diagram of the trade-off process
t. What are killer requirements and give two for the trade-off applied to your vehicle design.
u. Perform a trade-off for your design (use at least two criteria) and report your trade-off in a table.
v. Give the difference between ordinal and cardinal methods for design option selection.

Problem 5 Unusual Technical Performance Measurement parameters (30 minutes, 16 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).
- A modified engine having a 10% better fuel consumption.

The application of smart materials requires additional structure and actuators, which leads to an increase in wing structure mass of 24%. Other aircraft structure and systems remain unchanged.

a) Determine the maximum possible range extension based on the following characteristics of the existing aircraft.
   - Take-off weight of 271000 kg, of which 93000 kg fuel,
   - Wing structure mass 17720 kg,
   - Range 13300 km.

   Use the Breguet equation for the cruise range:

$$R_{cr} = \frac{V}{SFC}\frac{C_L}{C_D}\ln\frac{W_0}{W_1}$$

   where *V* is cruise speed in km/hr, *SFC* specific fuel consumption in Newton fuel weight per hour per Newton thrust, *W0* initial cruise weight and *W1 = W0 – Wfuel; V* remains unchanged, as well as *W0*; the other parameters change. You may assume the aircraft empty weight to be equal to *W1* and the take-off weight to be equal to *W0*. You may also assume that the additional fuel is accommodated without extra weight penalty.

b) Compute the maximum range extension you can guarantee to your customer, taking into account the mass contingencies from the table below and assuming a contingency of 15% on the fuel consumption and of 25% on the *CL/CD* improvement (very novel technology).

	Contingency (%)									
						Electronic boxes/ components				
Design Maturity	Structure	Mechanisms	Wire/cable	Batteries	Thermal control	0-5 kg	5-15 kg	>15 kg	Optical	Actuator
Conceptual estimate (based on sketches, descriptions, experience or finite element model)	20	20	25	20	20	20	15	10	20	20
Layout calculation (equivalent to major modifications of existing H/W or soft mockup)	15	15	20	15	15	15	10	5	15	15
Pre-released drawings (equivalent to minor modification or hard mockup engineering model)	5	5	10	10	10	10	5	5	5	5
Released drawing	3	3	5	5	5	10	5	5	3	3
Specification (vendor/subcontractors)	5	5	5	5	5	5	5	5	5	5
Actual measurement qualification hardware	1	1	1	1	1	1	1	1	1	1
Actual measurement flight hardware	0	0	0	0	0	0	0	0	0	0

c) Would you advise to apply both modifications? If so, why? If not, why not?

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

z. 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.

aa. Give three types of verifications tests and give an example of their application.

bb. Define the difference between qualification testing and acceptance testing

cc. 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.

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