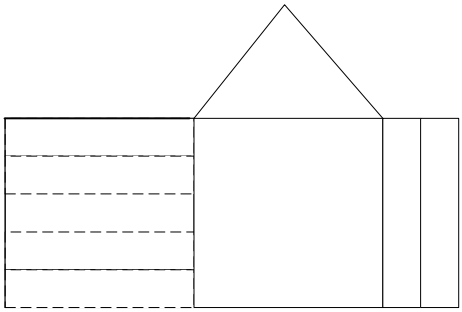
Delft University of Technology		
Course: **Systems Engineering & Technical Management Techniques (AE3-S01)**	Time: Location:	**14.00-17.00 hrs** **Kluyverweg 4-6**
Date: **Friday, 4 July 2008**		
Write down your name, all initials and your study number on each of your sheets. Answer the questions in 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		

Problem 1 Quality Function Deployment (30 minutes, 20 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.



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

c. What is noted down in the entry "benchmark"?
d. Which gradations are commonly used in the relationship entries?
e. Which gradations are used in the correlation entries?
f. Suppose there is a blank (empty) row in the relationship matrix. Which conclusion do you draw?

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

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 Diamond Aircraft D-Jet:

Your jet, within reach.

Owning a jet has historically required deep pockets, and flying one meant you had to be a professional pilot – until now. Like every aircraft in the Diamond family, the D-JET is designed for simplicity of operation, superb comfort, safety and of course, affordability.

The D-JET is not a scaled-down business jet. Rather, it‘s been designed from the ground up to be a Personal Light Jet suitable for both personal and business use. Step inside and you'll see a cockpit that's as spacious as it is simple. Make yourself comfortable in the leather pilot's seat, and marvel at the three-panel Garmin G1000 glass cockpit, great outward visibility, and controls and switches that are placed exactly where you want them.

Your accountant, insurance agent, and loved ones will all be as happy as you are with this purchase, thanks to Diamond's commitments to training and safety. Built with real aircraft components, the D-JET Simulator offers you a surprisingly 'true' flying experience that's not only safe, but also speeds your learning process by allowing you to stop, back up and do it again. Diamond is unique in general aviation in providing certified aircraft-specific simulators, which are accessible within Diamond Flight Centers and other training partner locations.

Spacious luxury and style.

While most very light jets are, well, very light and very small, the D-JET sets new standards for interior room and baggage space. The seating configuration is two plus three, with a rear-seat bench that comfortably accommodates three people, with Executive Class comfort for two. The unique seating arrangement offers more leg room than any comparable aircraft. Whether you're traveling for pleasure or business, the D-JET offers you the space and comfort you'd expect from an aircraft costing much more to acquire and operate. The D-JET's cockpit is nothing short of impressive, as we've paid careful attention to the ergonomic design of the interior. Many pilots will be surprised to find the D-JET as easy to fly as a highperformance single-engine piston, due to the D-JET's systems that reduce pilot workload. You'll marvel at the space in the cockpit and cabin. Even professional basketball and football players can sit comfortably in this aircraft, with its abundant head, shoulder and leg room. Unlike other very light jets, getting in and out of the cockpit is easy, thanks to the wide aisle between the seats and the leg room-enhancing cantilevered center console.

Cabin pressurization control is automatically maintained throughout the flight profile with a comfortable cabin altitude of 8,000 feet at FL250. The standard electrically driven vapor cycle air conditioning system allows you to pre-cool the aircraft prior to boarding and, once your trip is underway, ensures you and your passengers travel in comfort. Comfort and peace of mind also come from knowing the D-JET is more environmentally friendly than comparable aircraft with its single-engine fuel efficiency and acceptable sound levels.

Affordability.

Affordability is a word not of ten associated with jet ownership, but it is synonymous with the D-JET. It's not only affordable from an acquisition perspective, but more importantly from an operational one. The rugged composite airframe powered by the bulletproof Williams FJ33 engine
is a combination that will log many trouble-free hours. Of course, a single engine means that you have only one engine to maintain. And when it comes time for maintenance, the easy access to components and to the bottom-mounted engine will help keep these costs down.

Designed for Safety

We're proud of our industry-leading safety record – it's at the heart of the design of every aircraft we build. Like other Diamond airplanes, the D-JET employs active and passive safety systems. The D-JET also makes use of several redundant systems, such as dual power supplies. Its certified ceiling of 25,000 feet represents another important safety advantage. FL250 is a realistic altitude for most flights in terms of mission and ATC access. FL250 also offers some distinct operational advantages with respect to safety. Consider that a sudden depressurization at altitudes of 35,000 or 41,000 feet provides only seconds to react. At 25,000 feet, D-JET safely operates further from the edge of the envelope, ensuring that there's more time to recognize the problem and safely react to it.

a) Consider the civil transport aircraft market. Give a segmentation of the dimensions 'function' and 'customer'. The segmentation of the dimension 'function' should address the differences in the type/characteristics of 'transport' that can be performed with civil transport aircraft. The segmentation of the dimension 'customer' should address the differences between individuals that influence the aircraft design. Identify at least three segments for the dimension customer and three segments for the dimension function (transport).
b) Diamond addresses several technologies to improve the way the D-Jet aircraft performs with respect to its competitors. Analyze the text above and give at least three combinations of functions and technology that address the pilot and the passenger.
c) Explain the concept of 'supply chain'. Use the information on the D-Jet to illustrate your explanation.
d) Explain the difference between primary demand and derived demand.
e) Give two examples of secondary demand related to private jet aircraft

Problem 3 Technical Risk Assessment (30 minutes, 16 points)

Google Lunar X prize (GLXP) will be given to the first team which manages to safely land and operate a craft on the Moon's surface while complying with a set of rules and regulations set out by GLXP Foundation. Assume that you have designed a lander which carries the craft to the moon. Then the craft will be deployed from the lander and start moving on the surface of the moon and making pictures and transmits them back to the earth through the lander. You do not need to bring back the craft to the earth.
You have to assess the technical risks of this mission by using Risk Map.

a. Which two "factors" determine the risk in a Risk Map?
b. How can you "mathematically" express risk?

c. Which technical aspect is often taken to estimate the frequency with which a risk may occur? Can you give at least four typical entries on the ordinal scale determining this frequency?
d. Which kind of events may be considered by the other factor determining the risk? Can you give at least three typical entries in the ordinal scale used for that axis of the Risk Map?
e. Draw a typical Risk Map. Where are the items with the highest risk located?
f. Indicate how you are going to mitigate the risks. Which two typical risk mitigation approaches may be taken? What is the result of each of these approaches?
g. In case of the GLXP mission: Which risk items or elements would you put as high risks where in the Risk Map and why?

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

You want to develop a remotely piloted/highly autonomous aerial vehicle (RPV), including ground station that can be used to transport 2 passengers from city to city. The RPV must have a range of at least 350 km.

In the questions below the abbreviation RPV is used for the remotely piloted 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 RPV.
b. Give a requirements discovery tree for the RPV 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 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 MBTF of instrument and RF link become? What do you conclude?

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 verification 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.