Delft University of Technology
Date: **Friday February 3, 2006**

Problem 1 Requirements Analysis of an aircraft passenger seat (35 minutes, 19 points)

Quality Function Deployment, sometimes indicated with the term House of Quality because of its shape, is a method used for requirements analysis.

a. What is the primary function of the House of Quality tool?

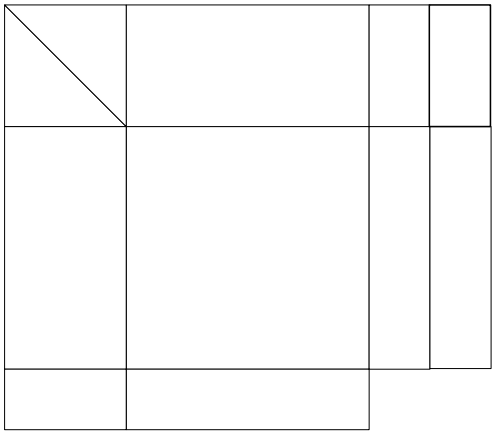
In a specific case of a requirements analysis for an aircraft passenger seat we find the requirement: *Enough leg room*. (**1**)

b. What kind of requirement is this?

Another requirement is: *Height of back*. (**2**)

c. What kind of requirement is this?

The picture below shows the appearance of the House of Quality.



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

e. Indicate in the picture where requirements **1** and **2** should be placed.

f. Place the letter indicating the House of Quality elements below in the correct location in the completed figure.

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

g. What is noted down in the entry “benchmark”?

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

i. Which gradations are used in the correlation entries?

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

k. 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.

l. List these four steps and name each step.

Problem 2 The Aerospace Market (30 minutes, 16 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 a supply chain and explain why the term supply tree or supply network would be more applicable.

e. Make a SWOT analysis of the product described below. Address functionality and technology and give two entries in each of the four boxes of the SWOT matrix.

A new aircraft category is emerging: the very light jet (VLJ)

The Eclipse 500 will be probably the first VLJs to enter the market. Below you find a short advertisement text of the company developing the eclipse:

The Eclipse 500 very light jet (VLJ)—the category of jet we created—is loaded with capability and functionality, yet is priced less than any other competitive jet and has the lowest operating cost per mile of any jet.

The Eclipse 500 has a maximum cruise speed of 375 knots, it can carry up to six occupants, and has a generous range of 1,280 nautical miles. A 41,000-foot ceiling avoids most severe weather, and this extraordinary jet gives you access to more than 10,000 airports in the U.S. We designed the Eclipse 500 to handle short runways, letting you get in and out of almost any airport in the United States. How? It starts with our low-weight design, low wing loading, large Fowler-type flaps and powerful PW610F turbofans. These design features result in the aircraft having excellent takeoff performance. On landing, the wing and flap design, and low weight also result in slower, safer approach speeds and short landing distances, and eliminate the need for costly thrust reversers and antiskid braking.

Problem 3 Interface Analysis (20 minutes, 10 points)

The N2 Chart is a tool used in relation to interfaces.

a. Make a simple drawing of a N2 Chart

b. What are the entries placed on the diagonal?

c. What is placed on the other places in the matrix? Which convention is used on these other places?

The tool can be used in (at least) three ways.

d. Give a one sentence description of each way the tool can be used.

e. Give a one sentence description when the tool is used in a project for each of these uses.

Problem 4 Design for verification / design for production (30 minutes, 18) points)

a. 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.

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

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.

   Give three examples of both for the development of a production line.

   Give three examples for the design engineering process.

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

Problem 5 Design for Satellite System Reliability (35 minutes, 22 points)

A satellite is in a low Earth orbit with an orbital period of 100 minutes and an eclipse duration of 40 minutes. Its operating lifetime is 4 years. Part of the equipment is only needed in eclipse (the Eclipse Equipment, **EE**), and is therefore only switched on during eclipse. You may assume, that switching functions are perfect (have a reliability equal to 1.0) and that equipment, that is switched off, does not degrade (has a reliability equal to 1.0 during the period it is switched off). The part of the satellite essential for the safety of the satellite, the Safety Equipment, **SE**, is hot redundant. The remaining part of the satellite, the Payload (**PL**) is not redundant for reasons of cost limitation.

You may assume a negative exponential distribution for all failure rates. Use the following reliability data:

- One set of Safety Equipment **SE**: Mean Time Between Failures $MTBF_{SE}$ = 100000 hours
- Payload **PL**: Failure rate λ_{PL} = 3.00 x 10^{-6} failures per hour
- Eclipse Equipment **EE**: Failure rate λ_{EE} = 1.44 x 10^{-6} failures per hour

a. Calculate total mission time t_{tot} in hours, total eclipse time over the mission t_e and total time the satellite is in sunlight t_s.

b. Calculate the reliability of one set of Safety Equipment R_{SE}, of the Payload R_{PL} and of the Eclipse Equipment R_{EE} for the periods each of these subsystems is active. What is the reliability for two hot redundant sets of Safety Equipment $R_{SE(par)}$ for the sunlit period?

c. Draw the reliability block diagram for the satellite, distinguishing the redundant, parallel equipment **SE**, the equipment not operational in eclipse **EE** and the payload **PL**.

d. If you have to evaluate the overall system reliability of the satellite, what is the order of evaluation of series reliabilities, parallel reliabilities, operational period and non-operational period?

e. Draw the block diagram you will use to evaluate the reliability during the period that all systems of the satellite are operational.

f. What is the total time the system is in this condition? Calculate the reliability for the period the satellite is in this condition.

g. Draw the block diagram you will use to evaluate the reliability during the period the satellite is in sunlight.

h. What is the total time the system is in this condition? Calculate the reliability R_s for the period the satellite is in this condition.

i. What is the total reliability of the satellite R_{tot} for the four-year mission duration? What is the Mean Time Between Failure for the satellite in that period? How does that compare to the total mission time?

Problem 6 Concurrent engineering and project management (30 minutes, 15 points)

a. Give a definition of concurrent engineering.

b. What is the driver behind the application of concurrent engineering?

c. What is meant with simultaneous involvement and simultaneous activities in the context of concurrent engineering? Give a definition and examples of both for the Formula Student project or any other project you want to use as an example.

d. Describe the three basic elements traded in a project planning.

e. Give the basic elements of a Gantt chart and draw one for a generic design project showing all basic elements of a planning.

Antwoorden

Question 1

a) Gevonden in Reader Part I, blz 6-10 (goed)
The House of Quality tool provides a fast way to translate customer requirements into specifications and systematically flow down the requirements to lower levels of design, parts, manufacturing and production.

b) Gevonden in Reader part I, blz 6-11 (goed)
Look at figure 6-10 to see that this is the voice of the customer, so it is a customer requirement.

c) Gevonden in Reader part I, blz 6-11 (goed)
Again look at figure 6-10, this is one of the features, so this is part of the technical parameters.

d) Gevonden in summary op blz 4 (goed)
The correlation between the technical parameters is missing, as well as the part to the right and the lower part of the figure as can be seen from the figure in the summary. Although this is a rather elaborate QFD. Lecture 3 #2 slide 21 shows a more concise QFD.

e) Gevonden in summary op blz 4 (goed)
From this we see that the customer requirement (1) should be most left, and the technical requirement/parameter (2) should be in the upper horizontal row.

f)

g)

h) Gevonden in Reader Part I, blz 6-13 (goed)
Gradations are strong, medium and weak, with numbers 9, 3 and 1.

i) Gevonden in Reader Part I, blz 6-13 (goed)
Gradations are strong positive, positive, negative, and strong negative.

j) Gevonden in Reader Part I, blz 6-13
Not really sure but I guess there is just no entry in the column “What”.

k) Gevonden in Reader Part I, blz 6-13
Again not really sure, but either the entry is empty or there is simply no relation at all.

l) Gevonden in de summary op blz 4/5 (goed)
House of Quality
- User requirements → Product requirements

Parts Deployment
- Product requirements → Technical requirements

Process Planning
- Technical requirements → Production requirements

Production Planning
Production requirements → Machine settings

Question 2

a) Gevonden in de Reader Part I, blz 2-9 (goed)
- Demographic factors (age, sex, income)
- Brand loyalty and switching patterns
- Attitudes toward product and competing brands
- Advertising media reading/viewing patterns
- “Psychograpghics” or “life-style” characteristics of consumer

b) Gevonden in summary op blz 6
Primary demand: total industry demand for a given product category
Derived demand:

c) Gevonden in de Reader part I, blz 3-30 (goed)
Aircraft:
- Passenger / cargo transport
- Reconnaissance / surveillance

Spacecraft:
- Communication
- Navigation
- Earth Observation

d) Gevonden in de summary op blz 5 en in Reader Part I blz 2-15 (goed)
A supply chain is a coordinated system of organizations, people, activities, information and resources involved in moving a product or service in physical or virtual manner from supplier to customer. The entities of a supply chain typically consist of manufacturers, service providers, distributors, sales channels and consumers (end customers). Supply chain activities transform raw materials and components into a finished product that is delivered to the end customer.
A supply chain is a special instance of a supply network in which raw materials, intermediate materials and finished goods are procured exclusively as products through a chain of processes that supply one another.
Because a supply chain is so complex and not as straightforward as shown in the picture (in the summary), each part of it can also be depicted as a tree of activities or people, so in reality a supply chain is more like a supply tree or a supply network.

e) Gevonden in summary op blz 6 en Reader Part I, blz 2-12/13
Strengths:
Weaknesses:
Opportunities:
Threats:

Question 3

a) Gevonden in summary op blz 3 (goed)
Look at the figure in the summary and the description that goes with it.

b) Gevonden in summary op blz 3 (goed)
The functions are placed on the diagonal of the N2-chart.

c) Gevonden in summary op blz 3 (incompleet?)
The convention is to put outputs on the horizontal, and inputs on the vertical sides of the diagram.

d) Gevonden in summary op blz 3 (goed)
- Identification of interfaces
- Grouping of functions (modularity)
- Documenting of interfaces

e)

Question 4

a) Gevonden in Reader Part II, blz 9-2 (goed)
Review of design: Establish by inspection of design documentation that the product answers the requirement.
Inspection: Establish by inspection of the product itself that it answers the requirement.
Analysis: Establish by mathematical or other analysis techniques that the product answers the requirement often in combination with tests to validate the mathematical model describing the product.
Test: Establish a test on (a representative model of) the product that it answers the requirement.

b) Gevonden in Reader Part II, blz 9-3 t/m 9-6 (goed)
Structural testing: Simulate the mechanical loads during handling, launch and in orbit operation. An example of application is acoustic load testing of rockets and rocket mounted items.
Thermal testing: Simulate the system under operational thermal conditions. An example of application is the thermal vacuum test to verify workmanship, using high temperatures some bad soldering joints in a structure can be exposed.
Integration testing: Done to find out if all system elements fit and work together. An example is the software test performed to check the correct functioning of software onboard the A380 on simulated hardware in a simulated environment.

c) Gevonden in Reader Part II, blz 9-5/6 (goed)
Acceptance testing: The flight model of each space vehicle or component of a space vehicle is subjected to an acceptance test. This test is a subset of all tests carried out on the product during its development. The conditions used are, however, more benign. The purpose is to establish correct workmanship and to show that the flight model performs equally well as the previous models tested.
Qualification testing: This can be of any type like structural, thermal or integration testing. Models are tested with a margin on top of the expected nominal conditions. It can be done on separate

models using an either structural, thermal, electrical or engineering model, or it can be done on one model only.

d) Gevonden in Lecture 10, slide 38 (goed)
Non-recurring costs in the development of a production line:
- Buying new machines
- Buying new tooling
- Building a new facility

Recurring costs in the development of a production line:
- Buying new material necessary
- Paying the labour hours of the employees
- Paying the energy bills for the machines and equipment

For the design engineering process:
- Paying the labour hours of the designers (recurring)
- Paying for a market analysis (recurring)
- Recording of the design process (recurring)

e) Gevonden in de summary, blz 19/20 (goed)
Lean manufacturing is a systematic approach to identifying and eliminating waste through continuous improvement by flowing the product at the pull of the customer in pursuit of perfection.
Three types of waste in production lines:
- Overproduction
- Waiting time
- Work in progress or inventory

Question 5

Question 6

a) Gevonden in de summary op blz 22 (goed)
Concurrent Engineering is the concurrent (simultaneous) running of separate phases during the product definition trajectory.

b) Gevonden in de summary op blz 22
Problems with bigger companies and larger projects are slow down of the process, ineffectiveness of communication and over-phasing of design process. CE can help to:
- Shorter lead time of the design process
- Deliver the quality the market asks for (aesthetics, functions, recyclability)
- Reduction of the integral product costs

c) Gevonden in Reader Part II, blz 14-3 en 14-4 (goed)
Simultaneous activities: several activities in separate phases within the process are running at the same time, without one waiting for the end results of another. Examples of this are the marketing and design phases: an aircraft is sold before the full scale development starts.
Simultaneous involvement: Knowledge of and experience with all facets of the lifecycle of the product should be considered as early in the design stage as possible. Examples of this are that customer and manufacturer work together during the design phase.

d) Gevonden in de summary, blz 24/25 (goed)

Develop the Work Breakdown Structure: A hierarchical breakdown of all work required to achieve the scope portion of the project objective. Consists of:

- Marketing
- Identification of all tasks
- Include tasks as planning the project, approval cycles, testing, printing, etc.
- Estimate the time each task will take (in hours, days, months or whatever is appropriate)
- Assign owners to the lowest level tasks
- Try to have only one owner per task Production

Develop the Schedule: This step employs a systematic process to generate a project schedule that is predictable and credible. It consists of:

- Marketing
- Identify all dependencies between tasks
- Make sure to check if new tasks have been identified after the WBS brainstorm
- Create a network diagram
- Assign work estimates to the lowest level tasks
- Review with the team estimates for longer or more ambiguous tasks
- Create a Gantt Chart (includes milestone definition and timing)

Develop Risk Management Plans: This step draws attention to project risks and the need to manage them, and consists of:

- Marketing
- Identify risks
- Prioritize risks
- Take actions to reduce the probability of risk
- Formulate contingency plans
- Decide who is responsible for managing risk

e) Gevonden in Lecture 13 slide 34