ASPECTS OF DISTRIBUTED CONCEPTUAL DESIGN SUPPORT

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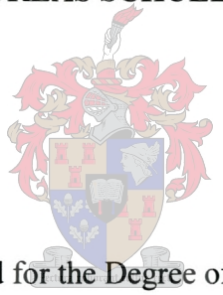

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Declaration

I, the undersigned, hereby declare that the work contained in this dissertation is my own original work and that I have not previously in its entirety or in part submitted it at any university for a degree.

Abstract

The findings of an investigation into the requirements of a support system for distributed conceptual design in small and medium enterprises are presented. Distributed conceptual design refers to the collaboration of spacially distributed design teams during the early stages of the product development process.

Three main elements of a support system were identified. The first element, 'Design Methodology', places a framework for specification development, functional analysis, concept generation and concept evaluation at the designers' disposal. It systematically guides the users through the different steps of the design process. These steps can be performed either alone, or together with other team members. The users are also aided in documenting their steps in order to allow the team members or designers of follow-up projects to understand the decisions made.

The second element, 'Communication and Information Transfer', co-ordinates the communication between the distributed designers and provides a platform for the exchange of design-related data, e.g. customer requirements, ideas, sketches, comments, and decisions. A case study was carried out to assess the use of various tools for communication and information transfer during synchronous and asynchronous collaboration. The case study is described and the results are presented and discussed.

Both elements make use of a support service providing various 'Input Devices for Conceptual Design', the third element of a support system. While standard tools such as mouse and keyboard meet the requirements of subsequent stages of the design process, they are often impractical in creating or annotating sketches. Various low-cost input devices were investigated.

A framework was developed to integrate the three elements into one support system. The 'Distributed Design Assistant', abbreviated as 'DiDeas', is an Internet-based system that allows simultaneous multi-user collaboration. A relational database is located on a central web-server and stores all design information entered into the system. The user interface was realized in the form of a collection of Microsoft Active Server Pages, which can be accessed platform-independently via a standard web-browser. The development of the database structure and of the user interface is

described in detail. A second case study was carried out to evaluate the Distributed Design Assistant. The case study is described and the results are presented and discussed.

The low-cost system has proven to be a very useful tool for distributed conceptual design. The Distributed Design Assistant systematically guides novice and experienced designers through the stages of specification development and conceptual design. It facilitates the easy collection and the fast exchange of a large amount of textual and graphical information during these stages. Although the system is relatively simple, compared to professional product data management systems used in later stages of the design process, it strongly enhances the productivity of designers and distributed design teams.

Keywords: Distributed Design, Conceptual Design, Systematic Product Development

Opsomming

Die bevindinge van 'n ondersoek na die behoeftes van 'n ondersteuningstelsel vir verspreide konsepsionele ontwerp in klein en medium ondernemings word aangebied. Verspreide konsepsionele ontwerp is die saamwerk van ruimtelik verspreide ontwerp spanne gedurende die aanvanklike fases van die produk ontwikkelingsproses.

Drie hoof elemente van 'n ondersteuningstelsel is geïdentifiseer. Die eerste element, 'Ontwerpmetodiek' stel 'n raamwerk vir spesifikasie ontwikkeling, funksionele analise, konsep generasie en konsep beoordeling tot beskikking van die ontwerpers. Dit lei die gebruikers stelselmatig deur die verskillende stappe van die ontwikkelingsproses. Die stappe kan of alleen of tesame met ander lede van die span uitgevoer word. Die gebruiker word ook ondersteun met die dokumentasie van die stappe sodat die lede of ontwerpers van opvolgprojekte die besluite wat gemaak is, kan begryp.

Die tweede element, 'Kommunikasie en Informasie Oordrag', koördineer die kommunikasie tussen die verspreide ontwerpers en bied 'n platvorm vir die uitruil van ontwerpinformasie, byvoorbeeld kliënte behoeftes, idees, sketse, kommentaar en besluite. 'n Gevallestudie is uitgevoer om die gebruik van verskeie gereedskapstukke vir kommunikasie en informasie-oordrag gedurende sinchrone en asinchrone samewerking te beoordeel. Die gevalle studie is beskryf en die resultate is bespreek.

Altwee elemente maak gebruik van 'n ondersteuningsdiens wat verskeie 'Invoergereedskap vir Konsepsionele Ontwerp' voorsien, die derde element van die ondersteuningstelsel. Terwyl standard gereedskap, byvoorbeeld 'n rekenaar muis en sleutelbord, die behoeftes van die latere ontwerpsfases bevredig, is hulle dikwels onprakties vir die maak van sketse en byskrifte. Verskeie laekoste invoergereedskap is ondersoek.

'n Raamwerk is ontwikkel om die drie elemente in een ondersteuningstelsel te integreer. Die 'Distributed Design Assistant', verkort 'DiDeas', is 'n Internet-gebaseerde stelsel wat sinchrone multi-gebruiker samewerking moontlik maak. 'n Gekoppelde databasis is op 'n sentrale webbediener geplaas en versamel al die ontwerpinformasie wat in die stelsel ingevoer is. Die gebruikerintervlak is geskep as 'n versameling van Microsoft Active Server Pages. Toegang tot die stelsel is onafhanklik van die rekenaar

bedryfstelsel en kan verkry word met 'n standard webblaaier. Die ontwikkeling van die databasisstruktuur en van die gebruikerintervlak is in detail beskryf. 'n Tweede gevallestudie is uitgevoer om die Distributed Design Assistant te beoordeel. Die gevallestudie is beskryf en die resultate is bespreek.

Die laekoste stelsel het homself bewys as 'n baie nuttige werktuig vir verspreide konsepsionele ontwerp. Die Distributed Design Assistant lei nuweling en ervare ontwerpers stelselmatig deur die spesifikasie ontwikkeling en konsepsionele ontwerp stappe. Dit fasiliteer die maklike versameling en die vinnige uitruil van 'n groot hoeveelheid teks en grafiese informasie gedurende hierdie stappe. Ofskoon die stelsel relatief eenvoudig is in vergelyking met professionele produkdata-bestuurstelsels, verhoog dit die produktiwiteit van ontwerpers en verspreide ontwerp spanne aansienlik.

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CHAPTER 1

INTRODUCTION

1.1 Distributed Conceptual Design

Product design and development has become a global process. Distributed product development offers a wide spectrum of new possibilities. Large companies can make use of resources at different company sites, in different countries. Small and medium size enterprises are enabled to exploit the know-how of experts from all over the world. These strategies result in reduced costs and lead-time, as well as in increased quality.

A challenge is to connect design teams worldwide, even those with different office hours (see Figure 1.1), and to support their communication and information transfer effectively.

GMT	+0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Stellenbosch	+2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	1	2
New York	-5	20	21	22	23	24	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Sydney	+10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	1	2	3	4	5	6	7	8	9	10

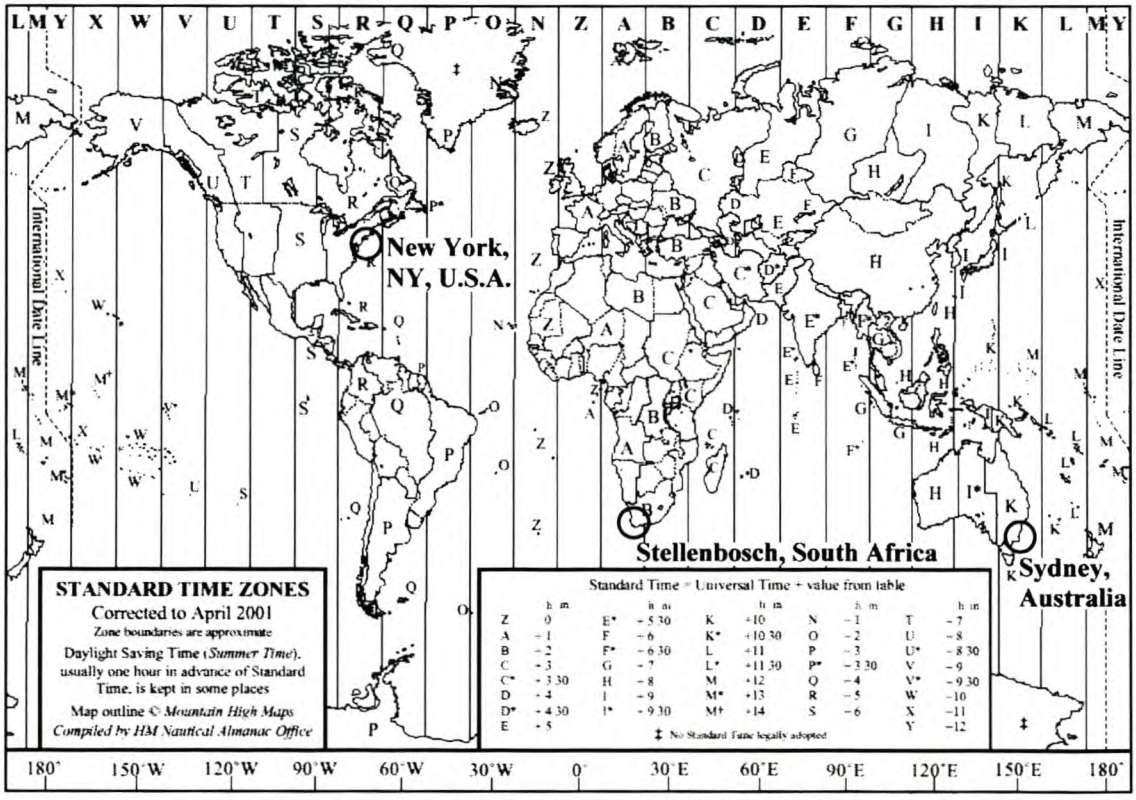


Figure 1.1: Office Hours around the World
[adapted from U.S. Naval Observatory Homepage, 2001]

While different office hours pose a problem for direct communication between the designers of a distributed team and the customer, they can also be used to make the most out of a 24-hour day, e.g. by forwarding a design project around the world, from one office-hour period to the next.

Anderl et al. [1999] have elaborated a number of characteristics, which are important for distributed product development processes, among others:

- number of partners
- location
- time
- language
- intensity of collaboration
- distribution of components
- number of interfaces
- tool compatibility
- compatibility of methods.

These characteristics are good indicators of the complexity of the setting up of a design project in a distributed environment.

Support systems for distributed design must ideally provide the same functionality and convenience that the designers are used to when working with their co-located colleagues. This applies specifically to the conceptual design phase, where designers need to share difficult-to-grasp design artefacts, such as ideas and sketches.

1.2 Motivation

Costs, performance, reliability, safety and environmental impact of a product are significantly influenced by the decisions made during conceptual design [Hsu and Liu, 2000]. This phase is often regarded the most important one of the entire design process. However, software support for methodical conceptual design has received only little attention, in contrast to the later stages of the design process, such as detailed design.

A recent empirical study on the influence of design procedures on the conceptualisation and rough embodiment design phases [Bender et al., 2001] indicates that a systematic and hierarchical approach of design methodology supports only very distinct sections of the design process, such as the concept evaluation. For designs steps with

predominantly associative and intuitive tasks, e.g. the development of concept variants, the strictly hierarchical strategies seem to be artificial and inappropriate.

The Internet, the world's largest network, provides an infrastructure for communication and information transfer not imaginable just a few years ago. It has dramatically changed distributed product development and it offers new possibilities for collaboration tools.

Based on the literature review (Chapter 2) the aims of the support system, henceforth referred to as the 'Distributed Design Assistant', will be given in Chapter 3.

1.3 Research Objectives

The main objective of this research project was to address the need for a system to support the early stages of distributed product development. Besides the thorough investigation of the requirements of such a system, the development of a framework to incorporate both methods and tools was strived for.

A support system that guides distributed designers through the design methodology of specification and concept development is expected to relieve the users of the problems associated with the hierarchical approach and the exchange of design information, thereby making more time available for the intuitive tasks.

Once the Distributed Design Assistant had been developed, each component of the framework was to be evaluated regarding their effectiveness.

1.4 Thesis Overview

Research carried out on the different fields related to distributed conceptual design is presented in the literature review in Chapter 2. The steps of the early phases of the design procedure are discussed in detail. An overview of various support systems is given. A strategy for design team composition and the implications of communication and information transfer in distributed teams are discussed.

In Chapter 3, the aims of a support system for distributed conceptual design are identified and described. Chapter 4 deals with the steps of the design methodology incorporated into the Distributed Design Assistant. The assessment of different tools for communication and information transfer in a case study and their implementation in the

DiDeas system are presented in Chapter 5. This is followed by an evaluation of different input devices for conceptual design in Chapter 6.

Chapter 7 describes the details of the implementation of the tools and methods discussed in Chapters 4, 5 and 6. This includes software and hardware considerations, aspects of the database structure, the user interface and an example project.

The Distributed Design Assistant was evaluated during a second case study. The results of this case study are presented and discussed in Chapter 8. In the final chapter, Chapter 9, the conclusions and a few suggestions for future work are made.

CHAPTER 2

REVIEW OF LITERATURE

2.1 Introduction

Distributed Conceptual Design includes a number of different aspects. In this section the main fields are described and recent research publications are discussed.

2.2 Methodical Specification and Concept Development

Different models of the design process have been developed since the early 1960s. The new Guideline VDI 2221 [VDI, 1993] can be applied to a number of design disciplines, such as mechanical engineering, precision engineering, software engineering and process engineering, although the focus seems to be on mechanical design process [Roozenburg and Eekels, 1995]. The general approach according to the VDI 2221 is illustrated in Figure 2.1.

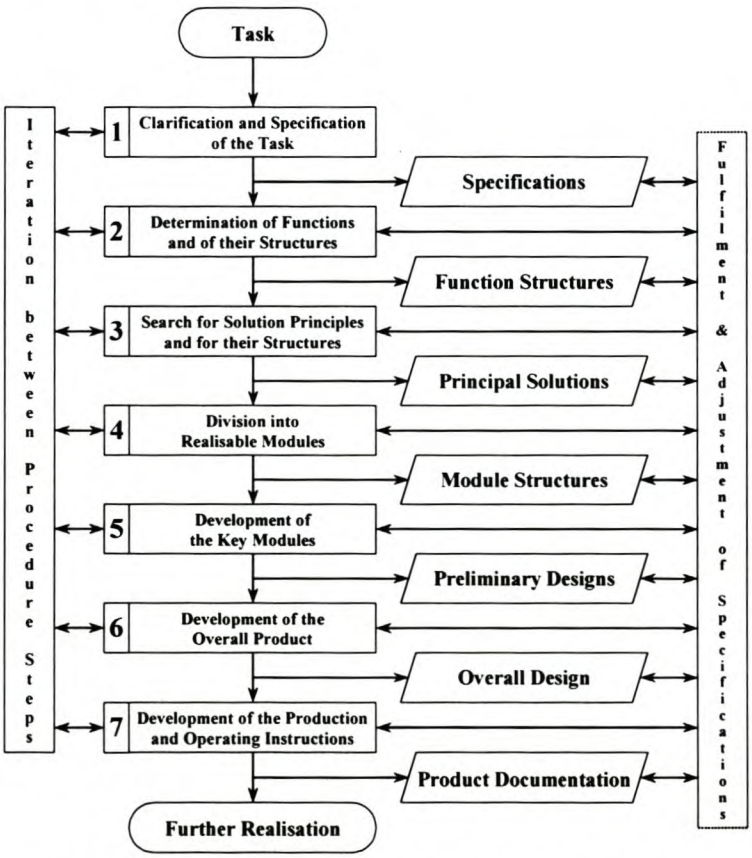


Figure 2.1: General Approach to Design [VDI, 1993]

Pahl and Beitz [1997] point out that the structure of the VDI guideline must not be seen as a prescription that designers have to follow word for word. Instead, the procedure has an iterative character, where some steps can be skipped and others are repeated. This flexibility corresponds to the design experience and is of great importance.

The design methodologies described by Pahl and Beitz [1997], Ullman [1997] and Hubka [1982] are more closely related to the mechanical design process.

2.2.1 Steps of the Early Stages of the Design Process

Pahl and Beitz [1997] give a detailed description of the steps involved in the first two phases of the design process, as illustrated in Figure 2.2.

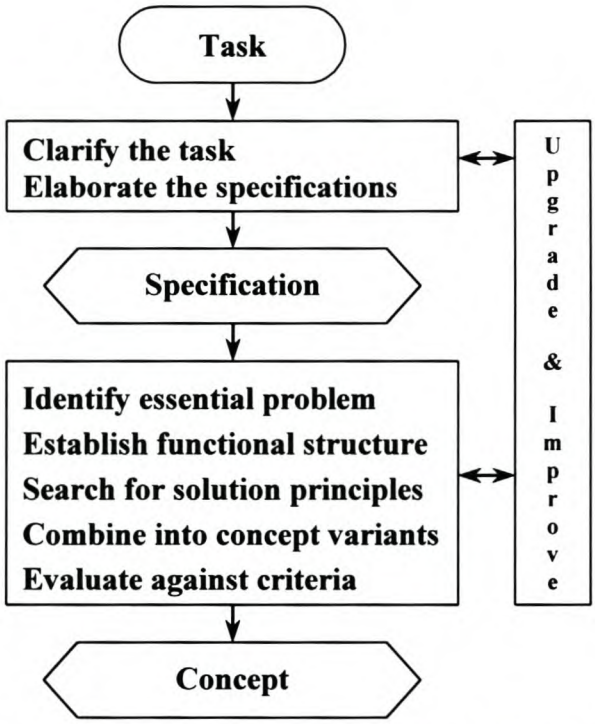


Figure 2.2: Early Steps of the Design Process [Pahl and Beitz, 1997]

2.2.2 Clarification of the Task

Two well-established strategies for the clarification of the task are presented.

Ullman's [1997] approach is based on the Quality Function Deployment (QFD) technique, which will be discussed in more detail in Section 2.2.3. He suggests the following eight steps for the specification development:

Step 1: Identify the customers.

Step 2: Determine the customers' requirements.

Step 3: Determine the relative importance of the requirements.

Step 4: Identify and evaluate the competition.

Step 5: Generate engineering specifications.

Step 6: Relate customers' requirements to engineering specifications.

Step 7: Identify relationship between engineering requirements.

Step 8: Set engineering targets.

Pahl and Beitz [1997] list four main steps for the specification development:

Step 1: Compile the requirements, including information on quality and quantity, and clearly specify 'Demands' and 'Wishes'. The wishes can be classified as wishes of 'major', 'medium' and 'minor' importance.

Step 2: Arrange the requirements in logical order, e.g. by defining the main objective and the main characteristics, identifiable sub-systems or categories.

Step 3: Distribute the requirements on forms to all project participants.

Step 4: Update the list of requirements with the feedback.

Both Ullman [1997] and Pahl and Beitz [1997] recommend the use of guidelines and checklists to ensure the completeness of the customer and engineering requirements.

2.2.3 Quality Function Deployment

Quality Function Deployment is a method for determining and recording the needs of the customer and their translation into design targets [Akao, 1990]. The main instrument of the method QFD is the 'House of Quality, which provides a large quantity of information in a very concise and well-organized form [Wood and Otto, 1998], as illustrated in Figure 2.3.

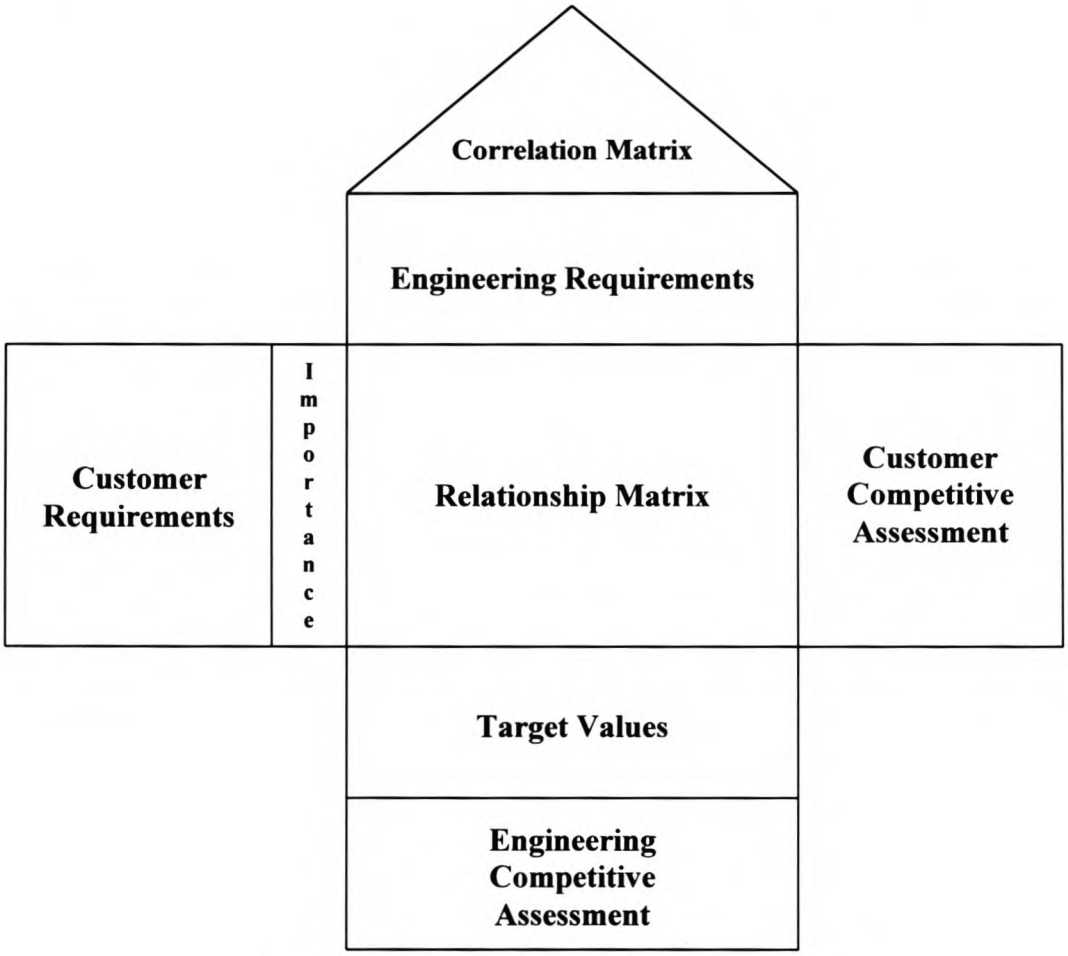


Figure 2.3: QFD-Matrix 'House of Quality'

Pahl and Beitz [1997] point out the advantages of QFD for the identification of critical functions and components. Rosenau and Moran [1993] emphasize its strength as a graphical planning and documentation system that greatly facilitates teamwork. Teamwork is also supported by stimulating and structuring multidisciplinary communication [Rozenburg and Eekels, 1995].

Ullman [1997] states that the QFD technique can be applied to all types of design problems. It will ensure that the design problem is well understood by all designers. While he recommends the method for all original design or redesign projects requiring new features, Suh [1990] argues that it is only useful for redesign, since new and innovative products must be defined 'solution-neutral'.

2.2.4 Functional Analysis

The development of a function structure of a product enables the designer to deal with a number of simple design problems instead of a single, more complex problem.

The procedure starts with the identification of the overall function, which depicts the essence of the design problem. It is a solution-neutral, abstract description of what the product must accomplish. The overall function is then broken down into sub-functions of lower complexity. These individual sub-functions can be combined into a function structure, which represents the overall function. Related functions or functions that might be satisfied with similar solutions can be grouped into logical units, a procedure known as 'functional packaging' [Blanchard and Fabrycky, 1997].

Three types of graphical illustration of the function structure are commonly used:

- the block diagram
- the logical flow diagram
- the hierarchical function tree.

2.2.4.1 Block Diagram

In a block diagram a single function can be represented by a 'black-box', in which the input in the form of energy, material and/or information is processed and transformed into the output, as illustrated in Figure 2.4.

Figure 2.4: Inputs and Outputs of a Function [adapted from Pahl and Beitz, 1997]

The complete function structure consists of the overall function and various levels of sub-functions, as shown in Figure 2.5.

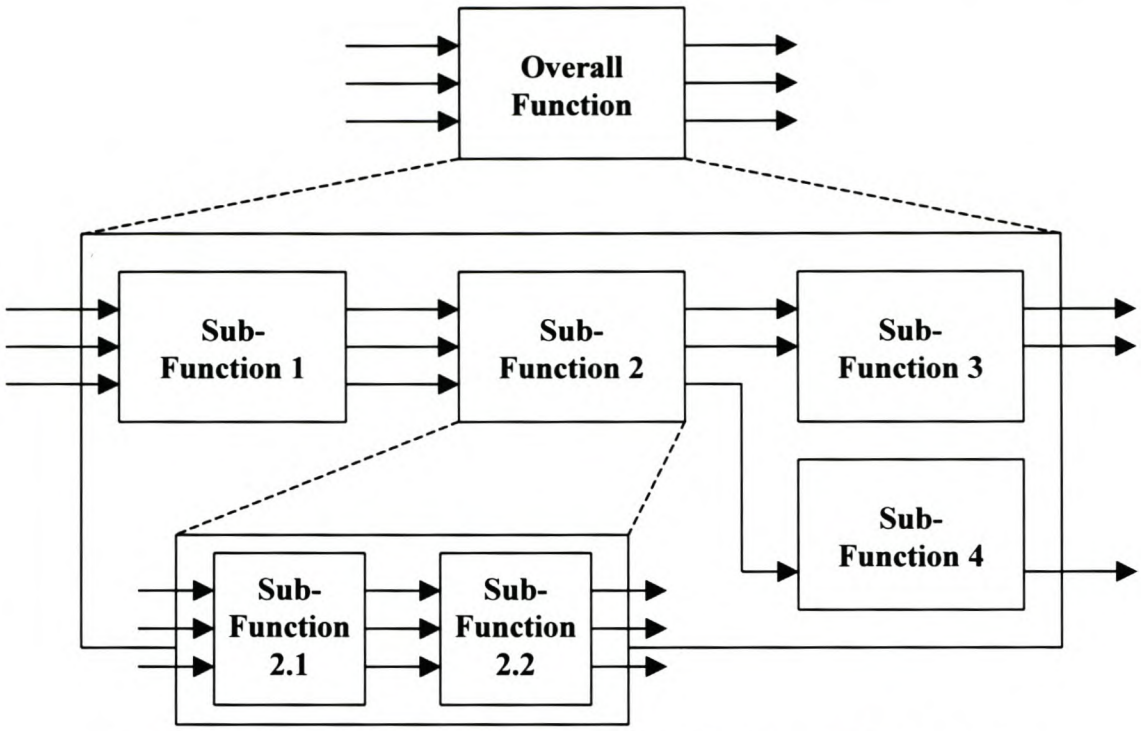


Figure 2.5: Function Structure with Overall Function and Sub-Functions [adapted from Pahl and Beitz, 1997]

The block diagram is the most complete representation of a function structure.

2.2.4.2 Logical Flow Diagram

The logical flow diagram is widely used in the fields of systems engineering and computer science, but can also be applied to the mechanical design process. Instead of boxes it uses symbols to represent logical functions, such as 'AND' and 'OR'.

2.2.4.3 Hierarchical Function Tree

The third illustration type is the hierarchical tree structure. Ullman [1997] states that a tree structure is often more effective for the representation of a function structure than a block diagram is. An example is shown in Figure 2.6.

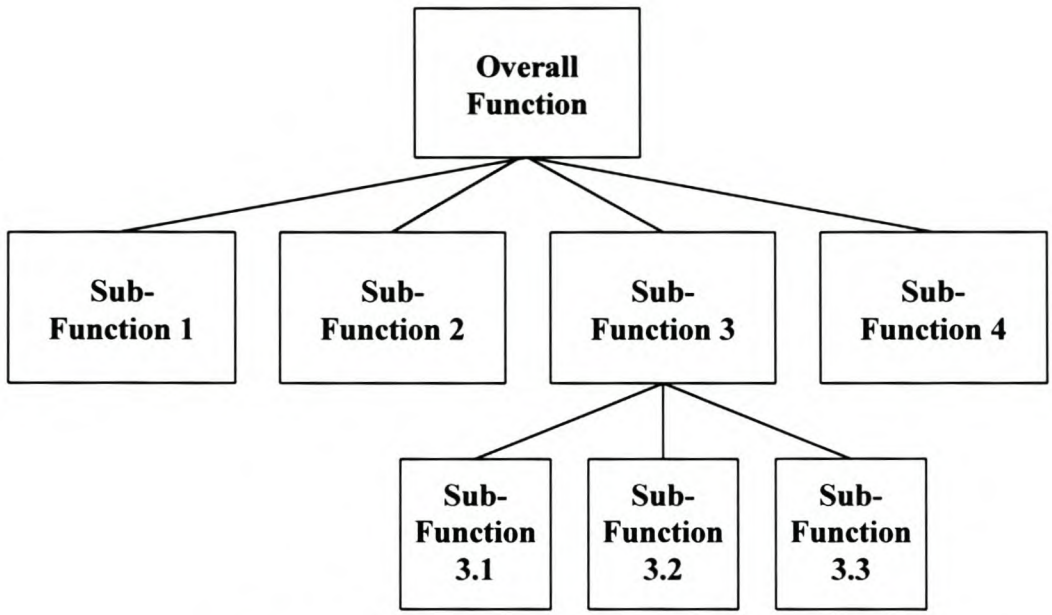


Figure 2.6: Hierarchical Function Structure

The hierarchical tree structure does not fully describe the function structure, but it allows for a better illustration of the different levels of decomposition than the block diagram does.

2.2.5 Search for Solution Principles

According to Pahl and Beitz [1997], there are three types of methods that can be applied to searching for possible solutions for the functions developed in the previous section:

2.2.5.1 Conventional Methods

Conventional methods include literature research, for instance in the form of a patent investigation, the study of natural systems ('Bionic') and analysis of technical systems, e.g. competitive products or older solutions for similar products.

2.2.5.2 Intuitive Methods

A solution is often created subconsciously, based on technical knowledge and experience of the designer, and emerges, triggered by an event, as a spontaneous idea. A purely intuitive approach has a number of disadvantages:

- good ideas cannot be created by force
- due to a lack of information new technologies or processes cannot reach the consciousness of the designer
- new solutions can be hindered by the designer's fixation on a solution.

Positive group-dynamic effects on intuitive problem solving have led to the development of a number of 'creativity techniques', such as 'Brainstorming' [Osborne, 1957] and 'Method 635' [Rohrbach, 1969], sometimes also called 'Brainwriting'.

2.2.5.3 Discursive Methods

Discursive methods support the conscious and systematic approach to problem solving.

They make use of, among others, catalogues of physical effects, machine elements, materials, etc., for the idea generation. Virtual marketplaces, such as the 'CompoNet' [Birkhofer, 1995], not only provide for comfortable access to online catalogue databases, but also aid the information exchange between designer and supplier, who can support the conceptual design process with expert know-how.

2.2.6 Development of Concepts

The systematic combination of the individual solutions for each sub-function developed in the previous section into complete concepts can best be realized by building a 'Morphological Matrix' [Zwicky, 1971], as illustrated in Figure 2.7.

Functions	**Possible Solution (PS)**				
Function 1	PS 1.1	**PS 1.2**	PS 1.3	PS 1.4	...
Function 2	**PS 2.1**	PS 2.2	**PS 2.3**	...	...
Function 3	PS 3.1	**PS 3.2**	**PS 3.3**	PS 3.4	...
...	...	...	...	...	...

Concepts:	**Concept I**	**Concept II**	**...**
	PS 1.1, PS 2.1, PS 3.2, ...	**PS 1.2, PS 2.3, PS 3.3, ...**	

Figure 2.7: Morphological Matrix

Some problems accompany the morphological matrix. If followed literally, the method creates a large (often too large) number of possible combinations. Furthermore, not all of these combinations make sense. Therefore, each combination of possible solutions should be checked for compatibility before considering it as a complete concept.

A third problem is the erroneous assumption that each function is independent and that each concept only satisfies one function. The 'functional packaging', discussed in Section 2.2.4, can help to minimize the number of components.

2.2.7 Evaluation of Concept Proposals

The evaluation process consists of two steps:

Step 1: concept screening (absolute comparison)

Step 2: concept evaluation (relative comparison).

The concept screening is intended to eliminate unsuitable concepts from the concept-pool. Pahl and Beitz [1997] list a number of criteria for the elimination process, which should take place after each step that generates proposals:

- compatible with the task
- fulfilling the demand of the specifications
- realizable in principle
- permissible in the expected cost structure.

The first two criteria allow for a 'go/no-go' decision. The evaluation regarding the other two criteria has often to be based on the designers experience or 'gut feel' [Ullman, 1997].

In the case of an unreasonable large number of remaining concepts, some concepts can be favoured above others for the following reasons:

- incorporation of direct safety measures or provision of positive ergonomics
- existing know-how, materials, manufacturing processes and positive patent situation.

The remaining concepts are scrutinized in more detail during the second step, which is the concept evaluation. The decision-matrix method or 'Pugh's method' is a simple and effective technique to determine the best concept, by scoring each concept relative to another in its ability to meet a set of criteria, based on the customer requirements. The engineering requirements can usually not be used, since most concepts are not refined enough at this early stage of the design process.

The decision-matrix is created from the criteria, their weight factors and the alternative concepts, as shown in Figure 2.8.

		Concepts			
Criteria	**Weight**	**I**	**II**	**III**	**...**
Criterion 1	Wt 1				
Criterion 2	Wt 2				
Criterion 3	Wt 3				
...	...				
Total +:					
Total -:					
Overall Total:					
Weighted Total:					

Figure 2.8: Decision-Matrix [Ullman, 1997]

Every designer selects his/her favoured concept as the datum and compares all other concepts to it for each of the criteria. A '+' (concept is better than the datum), 'S' (concept is equal to the datum) or '-' (concept is worse than the datum) is entered in the matrix for each concept and criterion. When all concepts are compared to the datum for each criterion, the scores are calculated.

- The 'Total +' score is the sum of all '+' marks of a concept.
- The 'Total –' score is the sum of all '-' marks of a concept.
- The 'Overall Total' score is the difference of the 'Total +' and the 'Total –' scores.
- The 'Weighted Total' score is the sum of each mark multiplied by the weight factor of the corresponding criterion (with '+'=1, 'S'=0 and '-'=-1).

The concept with the highest score is the 'best' concept regarding the selected criteria. If most concepts receive the same mark for a criterion, it might be necessary to re-examine the criterion, especially when it has a high weight factor. If the scores for some of the concept proposals are similar and no clear winner can be determined, the procedure can be repeated with the highest scoring concept as the new datum. It is also possible to use a finer scoring system, e.g. with seven levels instead of three.

Ullman [1997] states that the decision-matrix method is most effective if each team member completes the matrix independently and then the individual scores are

compared. It also makes it difficult for individual designers to push their own ideas, as is the case with other evaluation methods [Pugh, 1991].

2.2.8 Documentation of the Design Process

All steps of the design process discussed, i.e. specification development, functional analysis, concept generation and concept evaluation, produce documentation in the form of written descriptions and graphical representations. Blanchard and Fabrycky [1997] recommend formal design reviews, which provide a common baseline for all project personnel and a record of what design decisions were made, including the reasons for making them. Ullman [1997] advises to additionally keep diaries of the design process, so called 'design notebooks', which contain all sketches, notes and calculations that concern the design.

2.3 Support Systems for the Early Design Phase

In this section, recent developments of support systems for the early stages of the design process are discussed.

The Design Assistant [Schuster, 1997] is a single-user software tool for Microsoft Windows platforms, developed at Stellenbosch University, South Africa. A screenshot is shown in Figure 2.9.

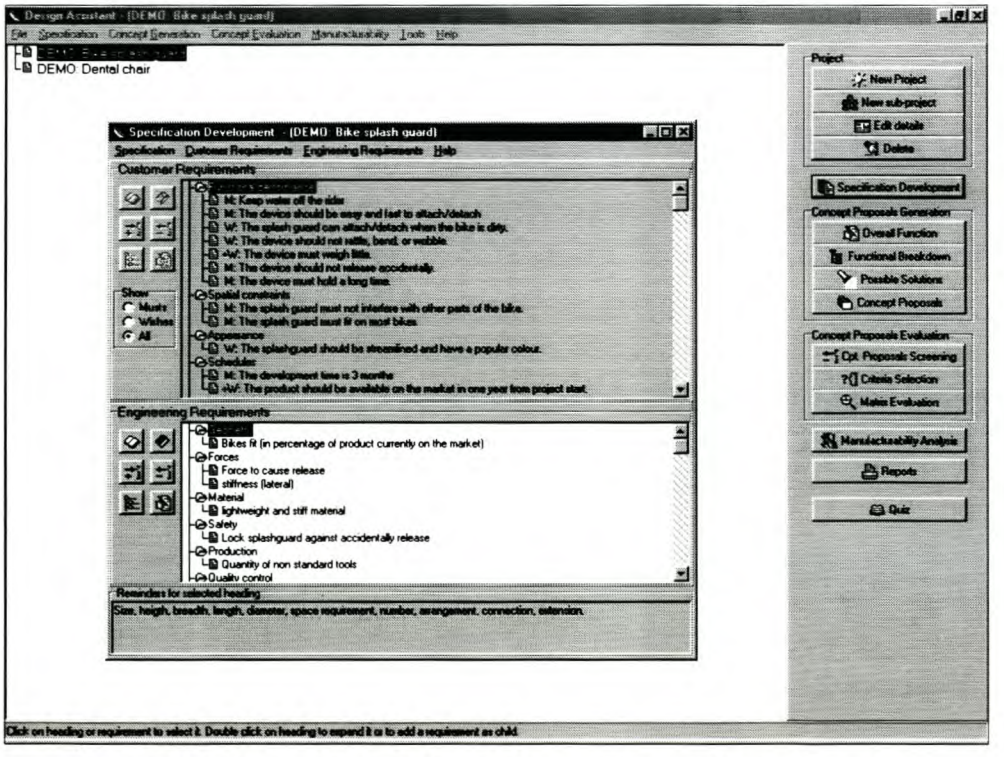


Figure 2.9: Screenshot of the 'Design Assistant' [Schuster, 1997]

The Design Assistant consists of two modules. The first module guides the designer through the specification development and the concept development phases, as described in Section 2.2. The second module is an application for manufacturability analysis, to estimate direct material cost and direct fabrication cost.

The specification and concept development section of the Design Assistant has adapted various elements of the design procedures described by Ullman [1997] and Pahl and Beitz [1997]. It provides special assistance, e.g. for the definition of the overall function and the generation of design reports.

However, the Design Assistant does not support spatially distributed users.

A similar system is described by Frankenberger [2001]. The Prosecco system also focuses on the early design phases, i.e. task clarification and concept development. A special feature of Prosecco is the collection of design information in so-called 'working-folders', which can be copied and taken as a basis for the documentation of new projects.

The framework developed by Huang and Mak [1999] is a web-based system to facilitate teamwork over Internet or Intranet. It provides a number of 'virtual consultants' for the functional analysis, morphological concept generation and concept assessment.

Both Prosecco [Frankenberger, 2001] and the system of Huang and Mak [1999] can automatically create a morphological matrix. This provides an overview of all possible solution variants. However, the morphological matrix generates a large number of solutions, which have to be analysed individually to find feasible concept designs. The Design Assistant [Schuster, 1997] does not automatically generate a morphological matrix. The designer rather builds concepts by selecting possible solutions from a tree-structure generated during the functional analysis.

A number of other Internet-based collaborative environments have been developed. They are predominantly designed for either the exchange of files or for the facilitation of communication, e.g. in the form of videoconferences. Examples of the first category are the 'Basic Support for Cooperative Work' (BSCW) system [Bentley et al., 1997] and the 'Collaborative Workbench' [Allen et al., 1999], while the 'CAIRO' system [Peña-Mora et al., 2000] represents the second group. Examples for mixed environments supporting communication and information transfer can be found in the form of Distance Education systems, such as 'WebCT' [WebCT Homepage, 2001] or

the 'Private Virtual Campus' [LearnLink Homepage, 2001]. However, none of the systems mentioned in this paragraph provide an integrated methodical approach to conceptual design.

The development of collaborative application frameworks is currently carried out, among others, at the National Institute of Standards and Technology (NIST). Their program on Distributed Collaborative Design (DisCollab) intends to integrate distributed designers and various point solution tools, i.e. tools addressing specific design problems, across the entire product life cycle [Parunak, 2000].

2.4 Design Team Composition

Teamwork is the key to productivity: "Teamwork is the cooperative effort of a group of individuals towards meeting a collective goal. Teamwork is achieved by defining the roles and responsibilities of the members of the team and then providing a climate that promotes the efficient operation of those roles and responsibilities" [Mendelson, 1998].

Researchers agree on a well-balanced diversity of the team members' personality characteristics as the main requirement for effective teams. Pahl and Beitz [1997] suggest the designers' field expertise as the primary reason for selecting team members. Ullman [1997] additionally recommends taking the designers' personal problem-solving styles into account. He lists eight roles, which, in an ideal team, are all cast by the individual team members: Coordinator, Creator, Resource-investigator, Shaper, Monitor-evaluator, Team worker, Implementer and Completer-finisher.

Wilde [1997] bases his methodology for team composition on the Myers-Briggs Type Indicator (MBTI). The MBTI is a questionnaire used for classifying people into personality categories, mainly in psychological and educational counselling. Wilde works with a 40-item questionnaire sampled from the MBTI, called 'Preference Questionnaire', and a mathematical model, to identify 18 possible 'Personality Types'. The technique has been successfully implemented into a graduate engineering design course [ME210 Homepage, 2001] at Stanford University, USA, and is regarded as a key factor for the top results obtained by ME210 students in the Lincoln Foundation Engineering Design Competition each year. A web-based system enables the designers to determine their own preferences for the various team roles and helps with the search for potential team mates [Wilde, 1999]. In the graphical representation, shown in Figure 2.10, each team role occupies an octant in one of the two domain maps, called the

'Judgement Domain' and the 'Perception Domain'. The center of each map is reserved for designers with no clear preference. A well-defined team will cover most fields of the two maps.

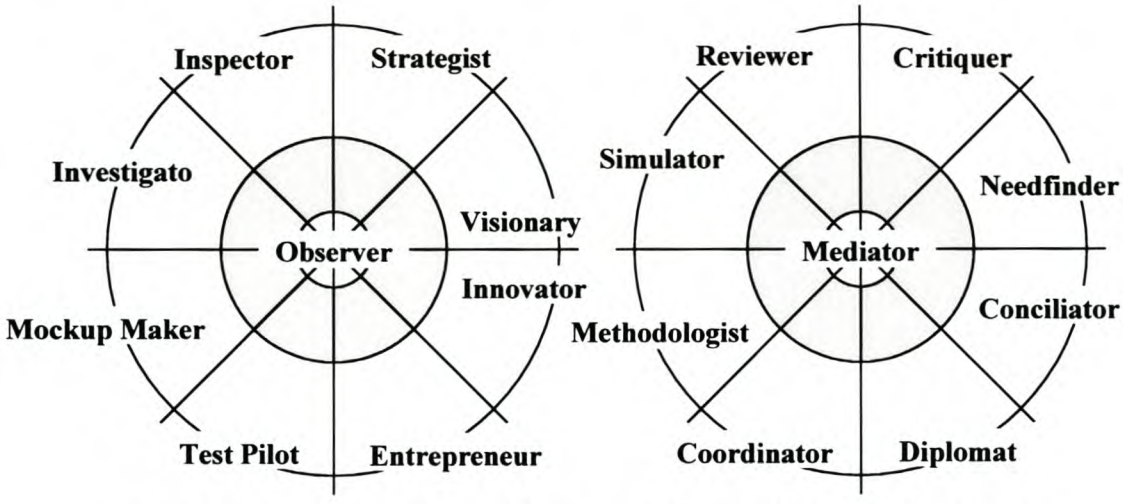


Figure 2.10: Perception and Judgement Domain Roles [Wilde, 1999]

An additional benefit of this method is the easy detection of functional gaps or overlaps, i.e. responsibilities not covered by any designer or assigned to more than one designer, which could cause problems during the design project.

2.5 Communication and Information Transfer

The results of a 1998 survey of 637 companies operating in the UK [Balbontin and Yazdani, 1999] indicate a clear priority for communication tools, followed by administrative tools, engineering design tools, Product Data Management (PDM) tools and Computer Supported Cooperative Work (CSCW) tools, as Information Technology (IT) applications supporting global product development. Although CSCW tools, such as electronic brainstorming software, take only one of the last places, the survey also shows that widely distributed teams use them twice as much as co-located teams.

Toye et al. [1994] investigated tools for the collaboration of distributed design teams within the SHARE project. They describe the tasks on which engineers spent the most time as follows: "gathering and organizing information; communicating with clients, suppliers and colleagues; negotiating tradeoffs; and using each others' services". The need for suitable communication and information transfer tools therefore becomes apparent.

When dealing with a number of different customers, communication with them is often limited to the standard tools and methods: personal meetings, telephone, fax, electronic mail and paper mail. Only in exceptional circumstances can videoconferencing be used. During embodiment and detailed design interaction in a distributed team relies mainly on the exchange of shared work by means of electronic files, e.g. CAD-files. Person-to-person communication is less important than the choice of the appropriate file format.

Fleischer and Liker [1997] scrutinized various collaboration technologies regarding their use in engineering design, as listed in Table 2.1. The 'Richness' refers to how much information can be transmitted between parties per unit of time.

Technology	**Richness**	**Best for**	
Formal written messages (paper or electronic mail)	low	⇐	one-way, low frequency
Shared databases	medium	⇐ ⇒	two-way asynchronous, low frequency
Personal written messages (paper or electronic mail)	medium	⇐ ⇒	two-way asynchronous, high frequency
Voice mail	medium	⇐ ⇒	two-way asynchronous, high frequency
Telephone	high	⇔	two-way synchronous, high frequency
Video conferences	high	⇔	two-way synchronous, low frequency
Face-to-face meetings (coming together from distant places)	very high	⇔	two-way synchronous, low frequency
Face-to-face meetings (collocation)	very high	⇔	two-way synchronous, high frequency

Table 2.1: Communication Technologies from Low to High Richness [adapted from Fleischer and Liker, 1997]

Karolak [1998] made a similar evaluation of communication tools. He adds that for effective communication, nonverbal indicators make it easier for the receiver to interpret the message's intent and for the sender to ascertain that the message was received and understood.

The communication needs during conceptual design differ from the ones relevant to other stages of the design process. Concept generation is a highly creative process, and part of it is to produce a large number of ideas [Ullman, 1997]. It is easy to share these

ideas with co-located designers, assuming there exists a well-established team. Over distances and without gestures, facial expressions, or just a piece of paper on which to sketch a rough draft, it becomes very difficult to exchange ideas between group members accurately and without misunderstandings.

Computer support for group creativity techniques, as discussed in Section 2.2.5, has proved its advantages. Holt [1996] came to the conclusion that, regarding the number of generated ideas, computer-aided brainstorming in a group is more effective than individual computer-aided brainstorming or group brainstorming without computer support. Combined with appropriate communication tools, these techniques can be valuable for the distributed designers.

CHAPTER 3

AIMS OF THE DISTRIBUTED DESIGN ASSISTANT

3.1 Introduction

During the specification development for the Distributed Design Assistant a list of 'Customer Requirements' was established. These requirements could be categorized as 'Musts', i.e. features that had to be fulfilled by the system, and 'Wishes', i.e. features that would provide additional benefits to the system. From these requirements the aims of the Distributed Design Assistant can be derived, as discussed in the following sections.

3.2 Requirements for a Distributed Conceptual Design Support System

An investigation into the requirements of a support system for distributed conceptual design was conducted, during which various tools for collaborative design and distance education were considered. Some systems, e.g. the framework of Huang and Mak [1999], focus on the implementation of methodical conceptual design in a distributed environment, but fail to provide a strategy for communication, information transfer and design-content input. Distance education environments, such as the Private Virtual Campus from LearnLink [LearnLink Homepage, 2001], on the other hand, offer a variety of tools for communication and information transfer in distributed groups. However, they do not provide the database functionality required to support a methodical design procedure.

Instead, a system of three segments, which complement one another and interact closely, is necessary [Schueller and Basson, 2001a]:

- The first segment is called 'Design Methodology', and has to place a methodology at the designers' disposal that guides them through the initial stages of the design process and provides a structured context for their communication. It should offer tools for the development of the design specifications and for the generation and evaluation of concepts.

- The second segment is called 'Communication and Information Transfer', and is required to co-ordinate communication between the distributed designers and to provide a platform for the exchange of design-related data.
- The third segment is called 'Input Devices for Conceptual Design', and should comprise the support for various input devices to aid the designers working with the first two segments.

The three segments of a distributed conceptual design support system and their interconnection are illustrated in Figure 3.1.

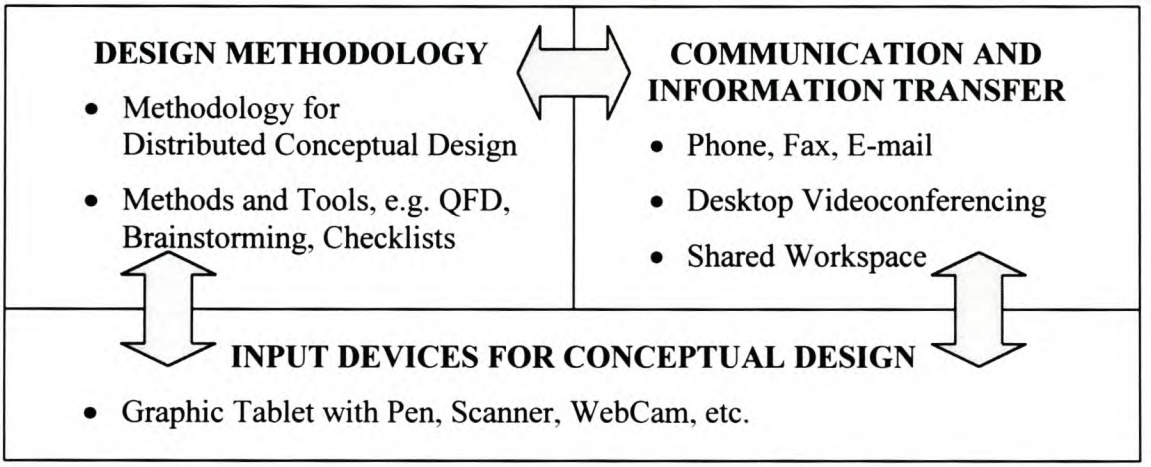


Figure 3.1: Main Segments of a Distributed Conceptual Design Support System

The segments will be discussed in detail in the Chapters 4, 5 and 6.

3.3 A Methodology for Distributed Conceptual Design

The design methodology presented covers the following stages: Specification Development, Functional Analysis and Concept Generation, Concept Selection and Concept Evaluation. An important aspect is the proper documentation of the design process throughout all stages, as illustrated in Figure 3.2.

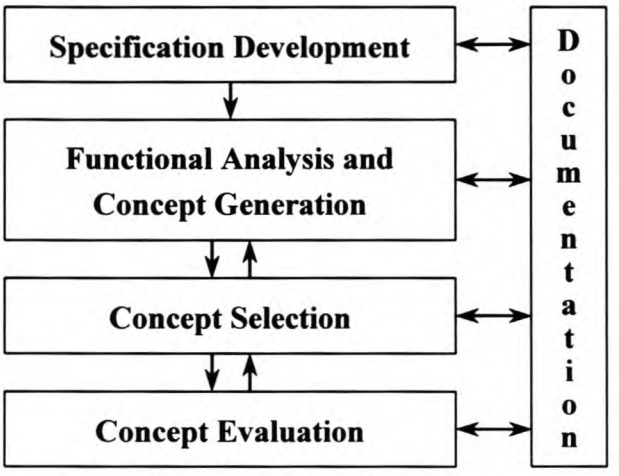


Figure 3.2: Documentation of the Design Process

A support system for distributed conceptual design must support all stages of the design procedure. The requirements for each stage are discussed in the following sections:

3.3.1 Specification Development

During the specification development phase the customer requirements are collected and translated into measurable engineering requirements. Usually not all team members meet with the client. However, all team members should be able to contribute to the list of customer requirements. The customer requirements should reflect the whole product life cycle, and therefore the input from all team members, often coming from different design disciplines, is important. Furthermore, the client often expects certain requirements, but does not specifically mention them. With the experience of a large number of designers, the risk of neglecting those requirements can be minimized.

The generation of engineering requirements should be supported by the system, e.g. through the Quality Function Deployment method.

All requirements should be presented in an organized way, e.g. sorted by importance. They should also be displayed in the same way to each team member, to avoid misunderstandings.

3.3.2 Functional Analysis and Concept Generation

The Distributed Design Assistant has to support the systematic generation and presentation of a functional structure. All team members must be able to participate in the functional decomposition and in the creation of possible solutions. A quick und intuitive procedure for information input can help to capture ideas before they slip the designer's mind. The concepts entered into the system must be shared amongst all

participants, in order to stimulate the creative idea generation process. As sketches play an important role during concept generation, the Distributed Design Assistant should support the exchange sketches in this phase.

3.3.3 Concept Selection

The DiDeas system must present the possible solutions in a way that allows for quick and logical selection of concepts. All designers should be able to make concept selections. The selected concepts should be visible to all users, to avoid the generation of duplicates and to stimulate the creation of new concept combinations.

3.3.4 Concept Evaluation

The concept evaluation has to be conducted in a fair and transparent way. All team members should able to evaluate the concepts individually, without being influenced by the other designers. The evaluation results should be presented in a way that supports their discussion.

3.3.5 Design Documentation

The documentation not only includes the writing of design reports, which should be encouraged through the use of the Distributed Design Assistant, but also the automatic capturing and storing of all design information entered into the system.

The Distributed Design Assistant should provide tools for writing both formal design reports and informal notes. However, not only the intentional data recording should be supported, but also the automatic capturing of information that is usually not archived, e.g. discarded concepts or the reasoning behind design decisions.

3.4 Communication and Information Transfer

The greatest disadvantage of distributed design is the restricted communication between the participating team members. Designers in a co-located environment can call for a meeting whenever necessary, but conferences in distributed design teams have to be planned more carefully. Considerations such as office hours in different time zones as well as the availability and suitability of communication tools, such as desktop-videoconferencing, have to be taken into account. With the continuous expansion and the increasing capacity of the World Wide Web, communication is no longer restricted to telephone, fax and postal mail. Traditional and modern communication means are complementary and should be supported by the Distributed Design Assistant.

The Distributed Design Assistant should provide for a large variety of communication tools, in order to cover all types of collaboration. The exchange of short messages and longer notes should be supported, including a notification system to actively inform the designer about incoming messages. It would be beneficial to capture the content of a conversation for later reference.

The DiDeas system should provide support for desktop-videoconferencing systems in the form of group-videoconferencing sessions, as well as for live image links to all participating designers.

Information transfer during the conceptual design stage differs from the later phases in content and frequency. The exchanged information consists to a large extent of sketches, ideas, mock-ups and other difficult to grasp objects. The quick and convenient distribution of various file types to one or more team members has to be supported.

3.5 Input Devices for Conceptual Design

Various input devices for conceptual design are discussed in Chapter 6. The Distributed Design Assistant has to support the capturing of design information using these devices and the processing of the data for distribution with the tools discussed in Chapter 5. However, this investigation focuses on low-cost tools suitable for small to medium size companies. 3D-scanners, e.g. used in reverse engineering, and Virtual Reality (VR) input devices, such as data gloves, are currently either too slow or too expensive.

3.6 Increased Productivity

The goal of a design support system is to increase a designer's productivity by reducing the time spent on a task and increasing the quality of the results. A design tool such as the Distributed Design Assistant should therefore encourage designers to apply a design methodology that can enhance productivity and, simultaneously, speed up the process of information gathering and distribution that a formal method requires.

Once the requirements for distributed collaborative work (see Section 3.2) are fulfilled, the advantages of distributed design, such as the use of company resources of know-how of experts from all over the world, can further increase the productivity.

3.7 Support for Different Design Scenarios

A large number of design projects are conducted with the team members residing in different time zones. The Distributed Design Assistant has to provide support for both synchronous and asynchronous collaboration environments.

Design teams as well as a single designer, the smallest possible design team, should benefit from the DiDeas system, although for a single user working on a design project, most of the communication and information transfer tools will be of minor importance.

3.8 The Distributed Design Assistant as a Teaching Aid

Another aim of the Distributed Design Assistant is the employment as a teaching aid, i.e. to impart the use of a systematic design procedure to novice designers, as well as to experienced designers with little or no knowledge of methodical design. Three scenarios are imaginable:

- individual design students
- co-located design student teams
- distance education students.

In design education the Distributed Design Assistant can be used to illustrate the design process as an additional or alternative medium to the traditional syllabus. Individual students can make use of the system to practice and deepen their acquired knowledge of methodical design. Teamwork, project coordination and communication can be taught in team-based design projects.

Students participating in a distance education program can work on joint tasks, which may have been difficult to realize in the past. Furthermore, cooperation between different educational institutions on mutual projects is possible.

3.9 User-Friendly Procedure and Interface

The Distributed Design Assistant will only be accepted and employed if the design procedure is intuitive and the user interface of the system attractive and user-friendly.

3.10 Summary

The aims of the Distributed Design Assistant can be summarised as follows:

- provision and support for the three main elements of a distributed conceptual design support system:
  - Design Methodology
  - Communication and Information Transfer
  - Input Devices for Conceptual Design
- increased productivity through increased design speed and quality
- support of different design scenarios, such as synchronous and asynchronous collaboration and single-user projects
- employment as a teaching aid in design education
- an intuitive design procedure and a user-friendly interface.

CHAPTER 4

DESIGN METHODOLOGY AND ITS IMPLEMENTATION IN THE DISTRIBUTED DESIGN ASSISTANT

4.1 Introduction

One of the main attributes of the Distributed Design Assistant is the systematic approach to the design process. The system guides the designers through the different steps of the design procedure and enables them to enter and display design information concurrently, but independently from another.

All elements of the design methodology and their implementation in the Distributed Design Assistant are explained in detail in the following sections. The sequence corresponds to the order in which they are encountered during a normal design project.

The implementation of the design methodology is closely tied to the user interface. The user interface aspects of the implementation are also discussed in this chapter.

4.2 The Main Window of the Distributed Design Assistant

The main window is divided into four areas, so-called 'frames', as seen in Figure 4.1.

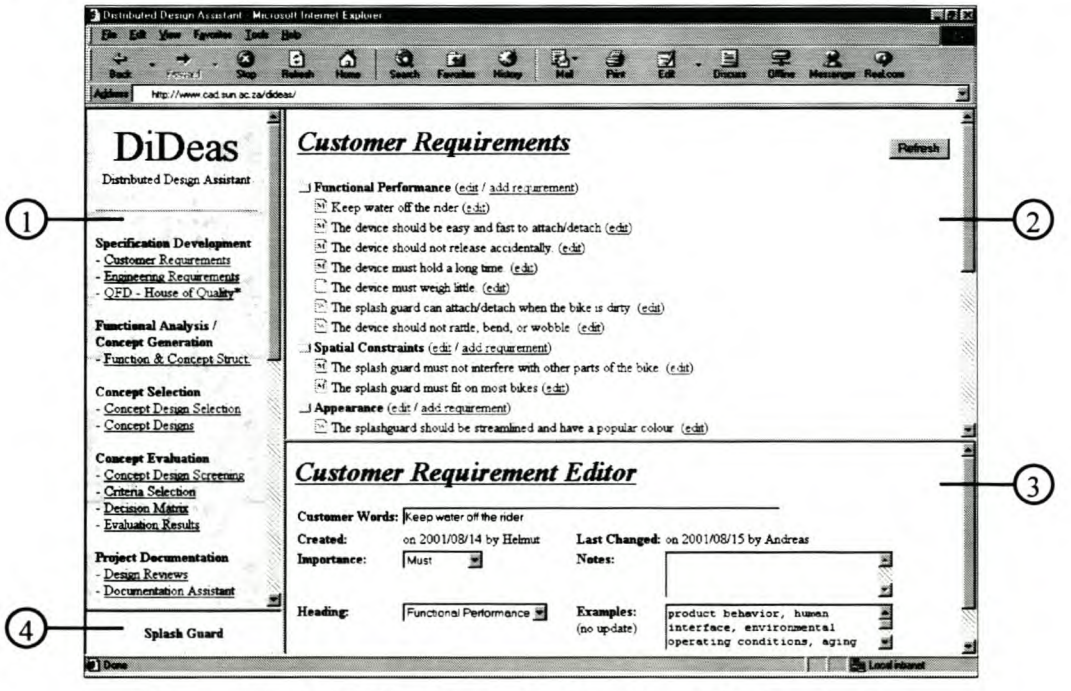


Figure 4.1: Main Window of the Distributed Design Assistant

The menu in the long frame on the left (1) provides hyperlinks to all elements of the Distributed Design Assistant, from the components of the methodical design procedure to the communication tools and the help file. The content and size of the two frames on the right (2 and 3) vary, depending on the feature selected in the menu. The small frame in the lower left-hand corner (4) serves two purposes. It displays the name of the present project and it informs the user of new 'Short Messages', similar to a pop-up of an e-mail or instant messaging program. Some features, e.g. the 'House of Quality' and the message board, are opened in separate windows.

All information entered into the Distributed Design Assistant is stored in the DiDeas database on the DiDeas web-server. The database structure will be discussed in detail in Chapter 7.4.

4.3 Specification Development

The first steps of the design procedure implemented in the Distributed Design Assistant are the collection of customer requirements and their translation into measurable engineering requirements. A 'House of Quality' supports this process.

4.3.1 Specification Development Methodology

The design process starts with an idea or a need for a new product or a product redesign, as expressed by a customer. The customer can be an external client and/or a department within a company. Since the development of the customer requirements usually does not involve the whole design team, the customer's words should be recorded as accurately as possible to avoid misunderstandings or misinterpretations by the different team members. A comprehensive compilation of the customer requirements is necessary. This helps to minimize the need for later enquiries, especially since distributed team members far from the customer's location may find it difficult to contact the client.

The customer requirement phase is followed by the engineering requirement phase, where the customer's words are translated into measurable engineering terms. Each team member can make contributions to both lists. Since group discussions cannot always take place, each entry can be annotated to inform the other team members of one's reasoning or to offer additional comments. During both steps, checklists can propose common requirements to guide the designers.

4.3.2 Implementation of the Customer Requirements

The customer requirements page of the Distributed Design Assistant lists all customer requirements for the current project. For clarity, the customer requirements are categorized, i.e. grouped under a number of headings. A new project does not contain any entries. Before adding the customer requirements, one or more requirement headings have to be created. In the requirement heading editor the heading name and a short description can be entered. Alternatively, standard headings can be selected from a list with typical customer requirement categories [Ullman, 1997; Schuster, 1997], as shown in Figure 4.2. This increases the speed of entering data and at the same time serves as a checklist for customer requirements still to be added.

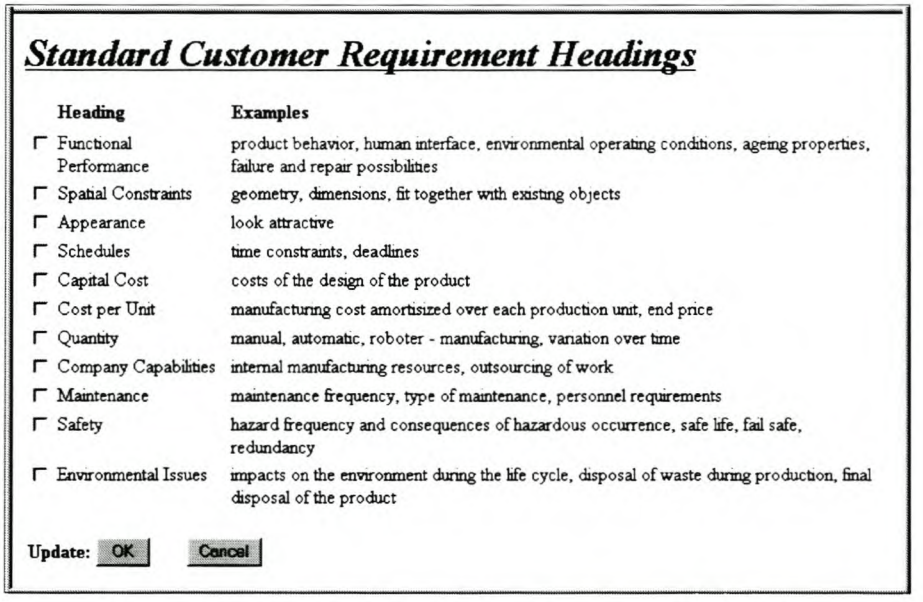


Figure 4.2: Standard Customer Requirement Headings

Once a heading is available, customer requirements can be added. This is done by entering the data in the customer requirement editor, as shown in Figure 4.3 (bottom).

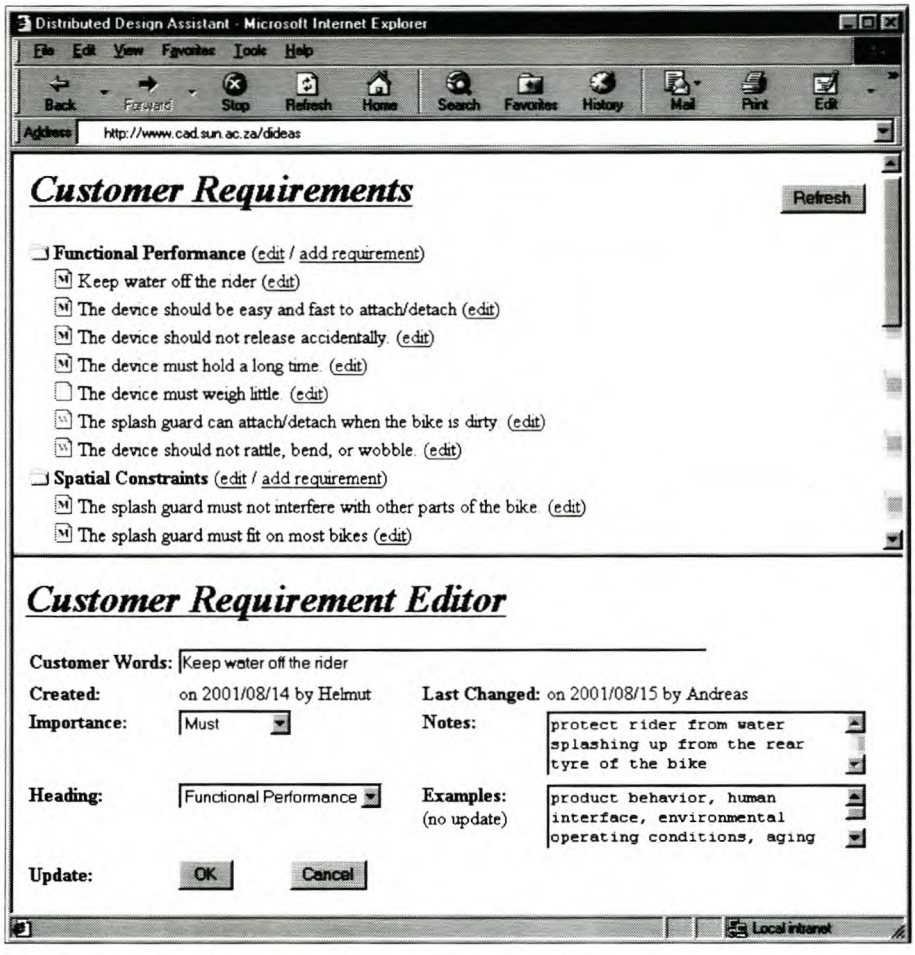


Figure 4.3: Customer Requirements and the Requirement Editor

The customer words are written down in the form of a short sentence, as close to the original customer description as possible. In this way misinterpretation can be kept to a minimum. In case the customer words require a more detailed explanation or the user wants to append personal comments, notes can be added. Some examples are given to guide the user.

The designers can also enter unspoken requirements, i.e. requirements that the customer may not have explicitly mentioned. These can be basic requirements, which are assumed functions of the product, and so-called 'wow-requirements', which were not mentioned by the customer because he/she did not expect them to be met in the product [Ullman, 1997].

Pahl and Beitz [1997] recommend a differentiation in 'Demands' and 'Wishes', as well as a classification of the wishes regarding their importance. This approach has been incorporated by providing a drop-down menu from which the user can select the relative importance of each customer requirement as 'Must', 'Major Wish' or 'Minor Wish'.

By clicking on the 'OK' button, the entered information will be added to the database. The new customer requirement can now be displayed in the customer requirement list. The entries are sorted according to the requirement heading and their relative importance. The importance is indicated by coloured icons; a red 'M' for a 'Must', a yellow 'W' for a 'Major Wish' and a green 'W' for a 'Minor Wish'.

Figure 4.3 (top) shows a part of the customer requirements list for the 'Splash Guard' project, including the hyperlinks for the addition and editing of requirements.

4.3.3 Implementation of the Engineering Requirements

The engineering requirements are entered and displayed in a similar way to the customer requirements. Before adding the engineering requirements, one or more requirement headings have to be created, using the requirement heading editor or the standard headings menu, as shown in Figure 4.4. The standard headings for the engineering requirements were adapted from Pahl and Beitz [1997] and Schuster [1997].

Standard Engineering Requirement Headings

Heading	Examples
☐ Geometry	size, height, breadth, length, diameter, space requirement, number, arrangement, connection, extension
☐ Kinematics	type of motion, direction of motion, velocity, acceleration
☐ Forces	direction of force, magnitude of force, frequency, weight, load, deformation, stiffness, elasticity, inertia forces, resonance
☐ Material	flow and transport of material, physical and chemical properties of the initial and final product, prescribed materials
☐ Energy	output, efficiency, loss, friction, ventilation, state, pressure, temperature, heating, cooling, supply, storage, capacity, conversion
☐ Safety	direct protection systems, operational and environmental safety, anticipated failure mode, employed failure criteria, incorporated failure avoidance strategies
☐ Ergonomics	man-machine relationship, type of operation, operating height, clearness of layout, sitting comfort, lighting, shape compatibility
☐ Production	factory limitations, possible dimensions, preferred production methods, means of production, achievable quality and tolerances, wastage
☐ Quality	control possibilities of testing and measuring, application of special regulations and standards
☐ Assembly	special regulations, installation, foundation
☐ Transport	limitations due to lifting gear, clearance, means of transport (height and weight), nature and conditions of despatch
☐ Operation	quietness, wear, special uses, marketing area, destination (eg sulphurous atmosphere, tropical conditions)
☐ Maintenance	servicing intervals, inspection, replacements and repair, painting, cleaning
☐ Costs	maximum permissible manufacturing costs, cost of tools, investment and depreciation
☐ Schedules	completion date of development, project planning and control, delivery date

Update: OK Cancel

Figure 4.4: Standard Engineering Requirement Headings

The engineering requirements are entered in the engineering requirement editor, which has a similar structure to the customer requirement editor (Figure 4.5 bottom).

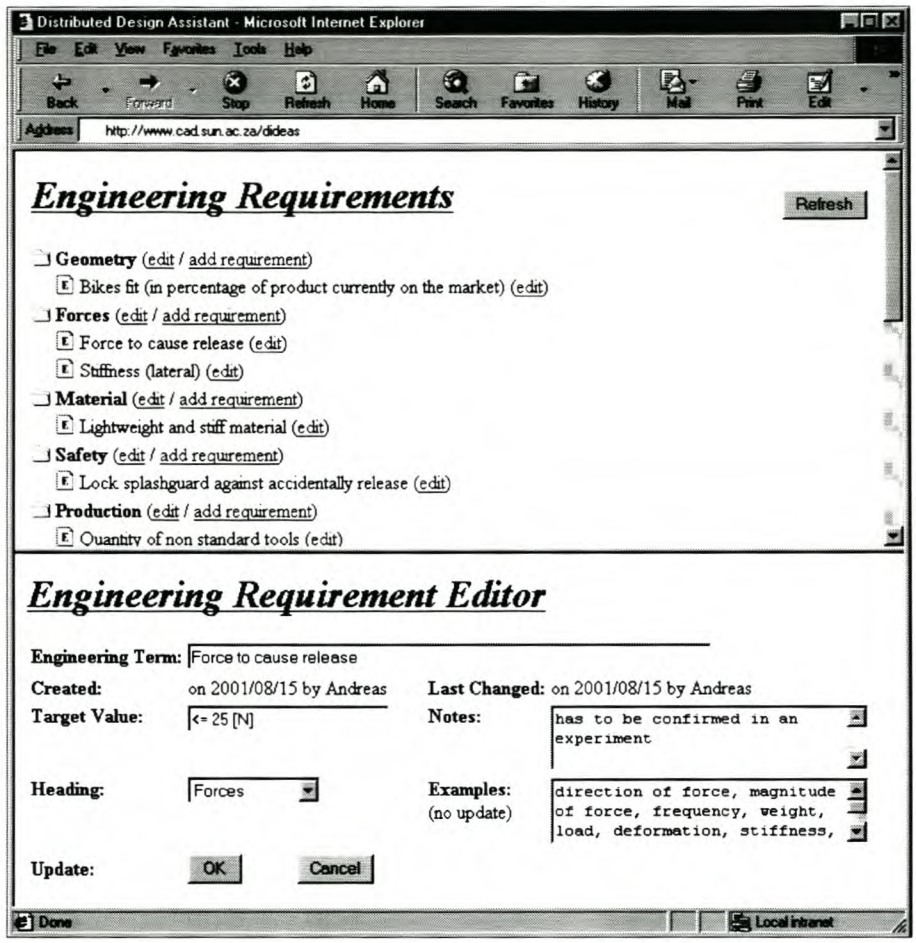


Figure 4.5: Engineering Requirements and the Requirement Editor

The engineering term for the requirement is recorded in the form of a short sentence, and additional information can be entered as notes. As with the customer requirements, some examples are given for guidance.

The target value should comprise a value and a unit, either as a nominal value, an upper or lower limit, or an interval.

By clicking on the 'OK' button, the entered information will be added to the database and the new engineering requirement will be displayed in the engineering requirement list, as shown in Figure 4.5 (top).

The designers can and should refresh the lists of customer requirements and engineering requirements regularly, in order to check their own entries, as well as to display the contributions of the team members. All customer and engineering requirements and customer and engineering requirement headings can be edited by anybody, at any time. This is important for dealing with inaccurate or duplicate entries. Duplicates are especially likely to appear when more than one designer are working on the

specification development simultaneously. In addition to the changeable requirement information, the requirement editor also displays when and by whom the entry was created and last modified.

4.3.4 Quality Function Deployment and the 'House of Quality'

For a distributed design environment the concept of QFD is particularly valuable because of its high information content and the comprehensible graphic representation in the form of the QFD-matrix 'House of Quality'. A properly developed 'House of Quality' can ensure the completeness of customer requirements and engineering requirements, and that the problem to be addressed is understood by all team members. The latter is a vital aspect, especially for a distributed design team.

4.3.5 Implementation of the 'House of Quality'

The 'House of Quality' was implemented in the DiDeas system in the form of an interaction matrix [Cross, 1994] or relationship matrix, as shown in Figure 4.6.

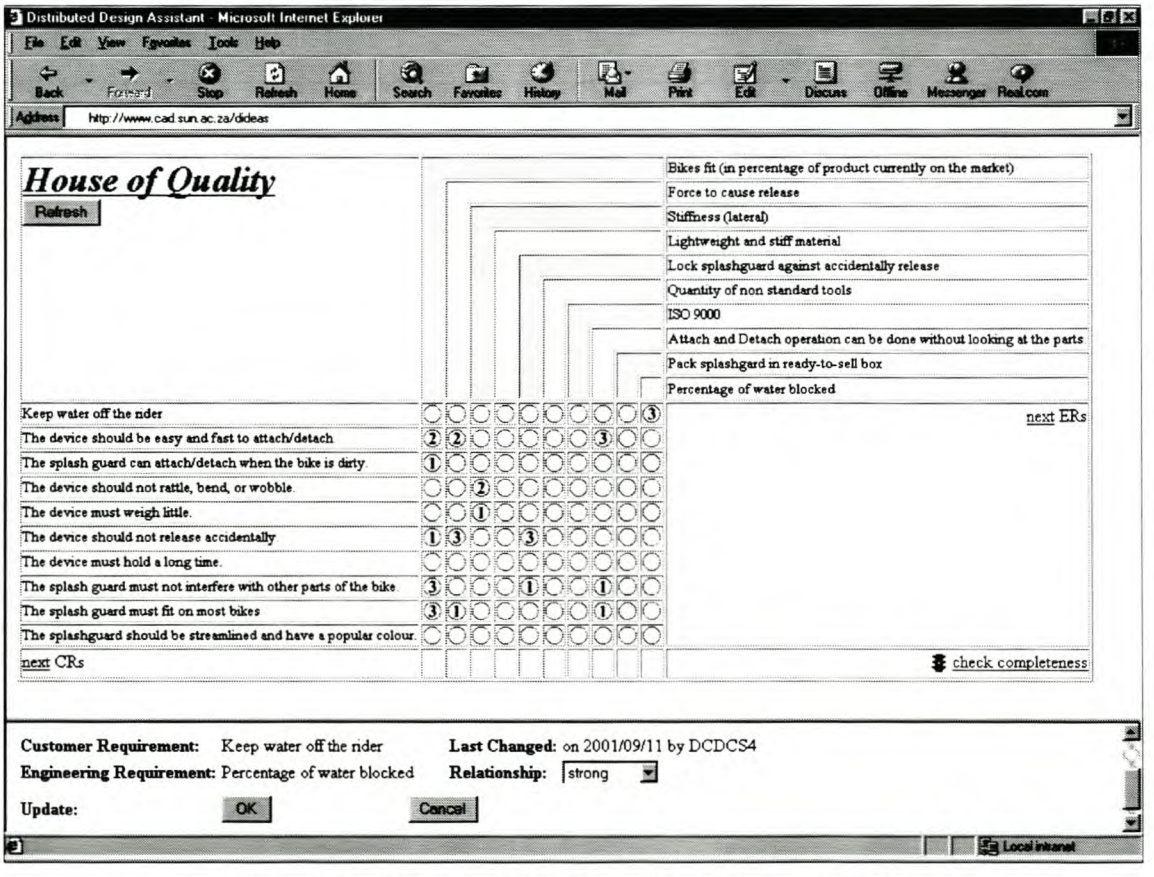


Figure 4.6: 'House of Quality' with Matrix and Editor

Due to its size, the matrix opens in a separate window. The customer requirements are located on the left, and the engineering requirements on the top of the matrix. Grey and

white indicator lines facilitate the tracing of the correct engineering requirement column. For clarity, only groups of ten requirements are shown, arranged in the same sequence as during their development in the previous sections. To move to the next or previous group of customer or engineering requirements, the designer clicks on the 'next' or 'prev.' hyperlinks below the group. Details on the data representation in the 'House of Quality' are discussed in Chapter 7.7.3.2.

To add or edit a relationship value between a customer requirement and an engineering requirement, the user clicks on the corresponding cell in the matrix. The editor in the bottom frame displays the two requirements and the user can select the strength of the relationship from the pull-down menu: 'weak' (1), 'medium' (2) or 'strong' (3). The fourth option is to delete an existing relationship ('no relation').

By clicking on the 'OK' button, the relationship value will be added to or deleted from the database. The relationship values can be edited by anybody, at any time. The designers can and should refresh the 'House of Quality' regularly, in order to check their own entries, as well as to display the contributions of the team members.

A hyperlink for a completeness check is located in the lower right-hand corner of the 'House of Quality'. The completeness check informs the designer about any unrelated customer or engineering requirement. In case an unrelated customer requirement cannot be linked to any of the engineering requirement (or vice versa), one can return to the previous section and add a new requirement. Although this method takes time to complete, it helps to understand the design problem and it ensures that each customer requirement is translated into a measurable engineering requirement.

4.4 Functional Analysis and Concept Generation

The second section of the Distributed Design Assistant's design procedure comprises the functional analysis and the concept generation.

4.4.1 Functional Analysis and Concept Generation Methodology

A number of traditional approaches to the functional analysis and the subsequent concept generation have been described in Chapter 2. However, the functional decomposition of a design problem into multiple levels of abstract functions and sub-functions before developing possible solutions does not reflect the common behaviour of a designer. Rather, the designer has the natural tendency to immediately think about

solution principles or concepts for each new sub-function. It is counter-productive to suppress this behaviour by prohibiting the solution finding process until the functions are completely refined.

A second problem encountered is the degree of abstraction necessary for the functional decomposition for many design tasks. Designers experience problems in defining functions specifically enough to describe the design problem but, at the same time, generally enough so as not to exclude any possible solution. A morphological matrix, as proposed by Pahl and Beitz [1997], can provide a large number of concepts proposals, which increases the chance for a perfect solution to be found among them. As stated earlier, many combinations of possible solutions will not be practical, e.g. because their components are incompatible. Nevertheless, they will be considered and evaluated, which is superfluous, time-consuming and expensive.

The proposed strategy for the Distributed Design Assistant differs from the traditional functional decomposition described by Pahl and Beitz [1997] and Ullman [1997]. It incorporates the designers' preference for early solution generation, as well as the combination of possible solutions to create a large concept pool. It consists of two steps.

The first step is the development of a number of alternative concepts to fulfil a given function. This step is identical to the search for possible solutions for the functions at the lowest level of function structure, as described in Chapter 2. A function and its alternative concepts, or solutions, are illustrated in Figure 4.7.

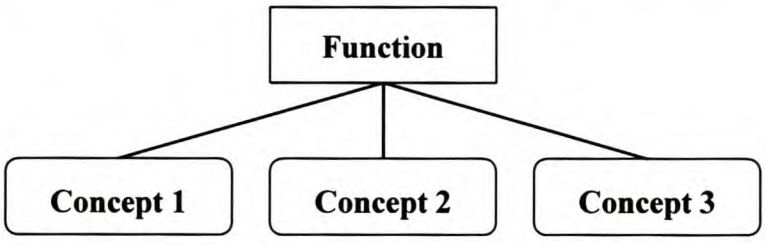


Figure 4.7: Function with its Alternative Concepts

The second step is the functional decomposition of each of these concepts into its determining functions, as shown in Figure 4.8.

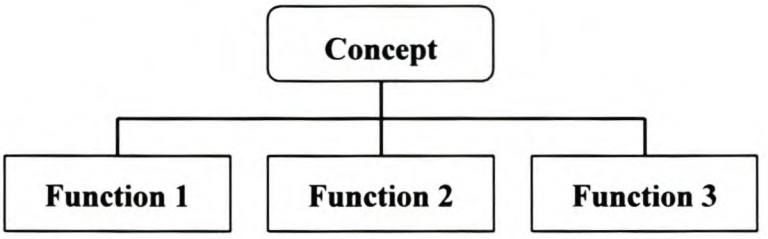


Figure 4.8: Concept with its determining Functions

The overall function of every concept is identical to the function that the concept is a solution to.

After the overall function for the design task has been established, concepts to fulfil this function are generated. These concepts can be very abstract at first, as long as they are distinguishable solutions for the overall function. Each concept is then treated as a new design task with an overall function that can be broken down into concepts and functions.

The two steps are iteratively repeated, until a satisfactory level of decomposition for each concept has been reached. The result is a hierarchical function-concept structure, as illustrated in Figure 4.9.

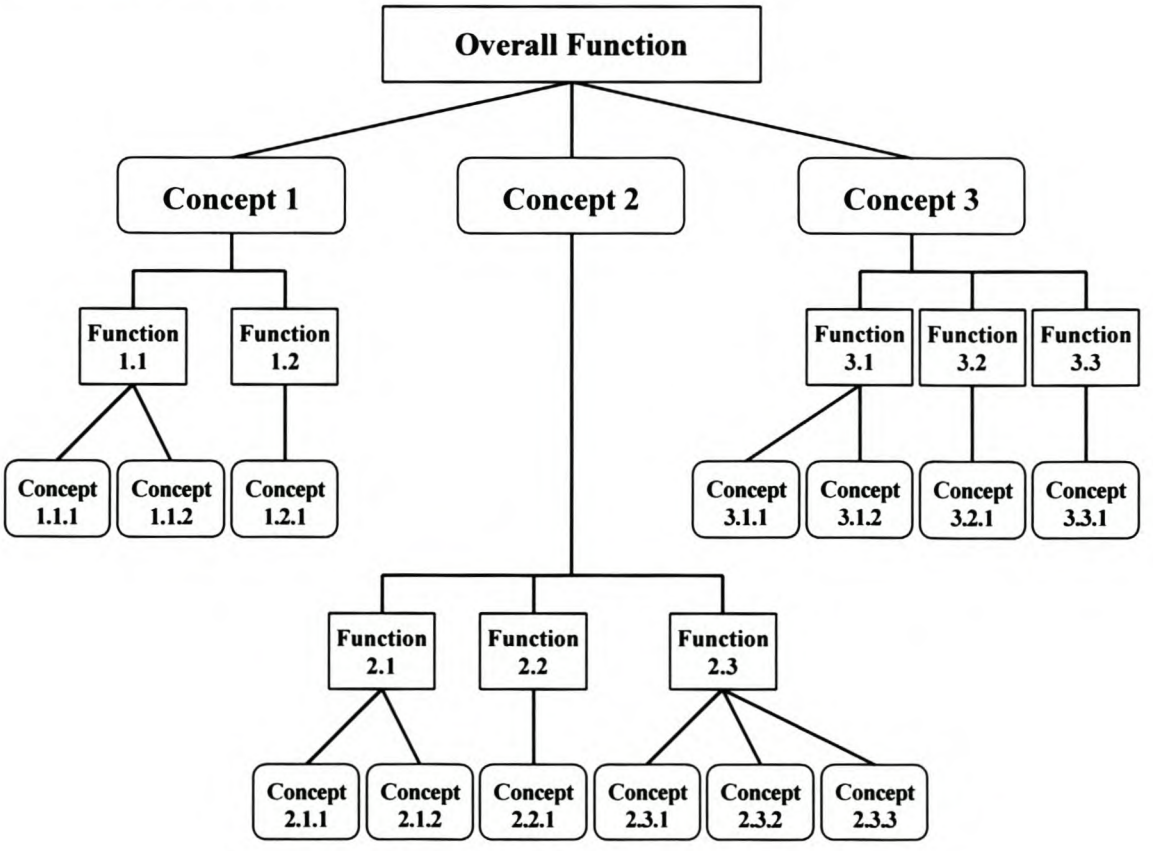


Figure 4.9: Hierarchical Function – Concept Structure

It is important to notice that the concepts of a function are alternatives to each other, while the functions of a concept are complementary.

For the branches of the function-concept structure, different levels of decomposition are possible, as illustrated in Figure 4.10.

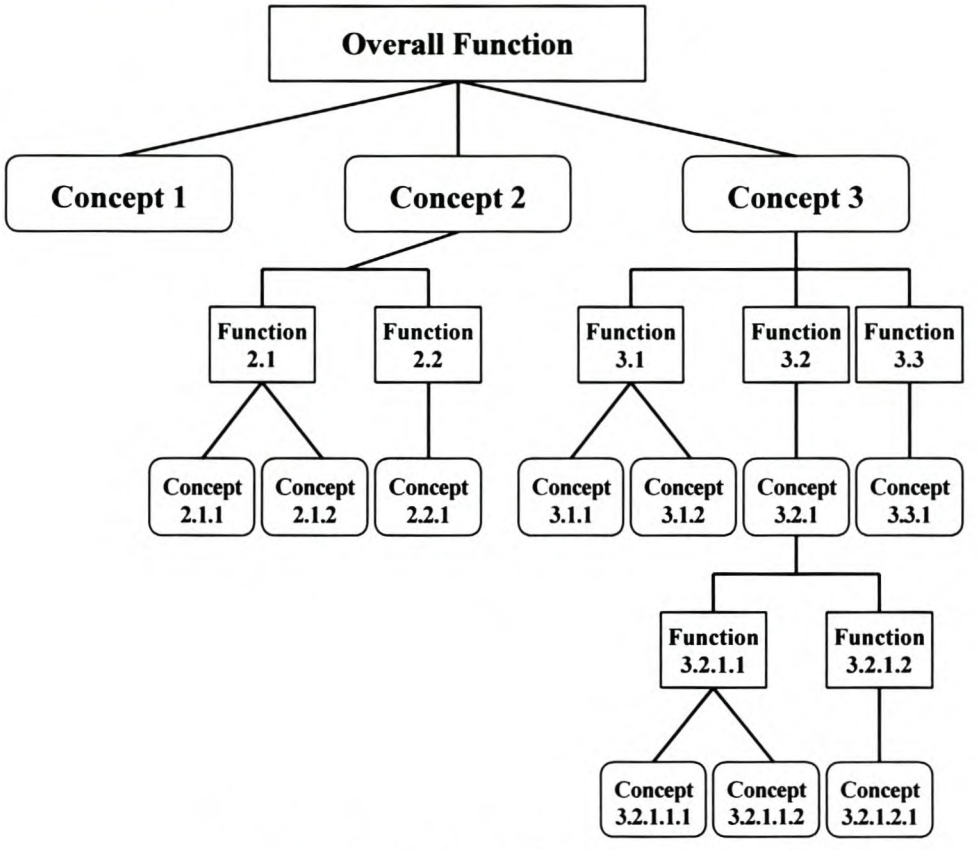


Figure 4.10: Different Levels of Decomposition

A concept with no further refinement, such as 'Concept 1' in the figure above, can indicate a concept already developed or a competitor's product.

4.4.2 Implementation of the Function and Concept Structure

The function and concept structure displays all functions and concepts for the current project as a tree structure. A new project does not contain any entries. As described in Section 4.4.1, the first step in developing the function and concept structure is the definition of the overall function. Figure 4.11 shows the overall function editor, where one designer describes the essential problem in a short sentence.

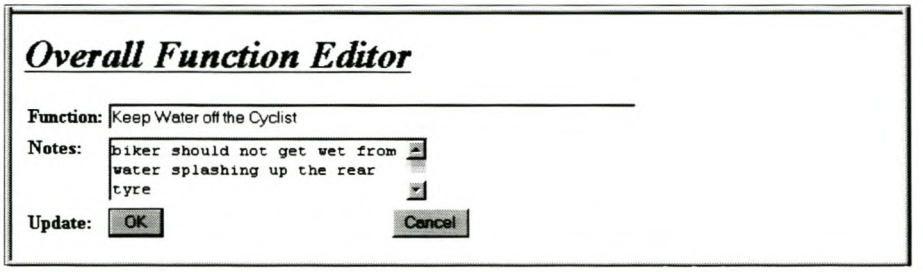


Figure 4.11: Overall Function Editor

The notes can contain details of the problem or a comment by the designer. It is also possible to add a description of the system boundaries and of the flow of energy, material and information.

Once the overall function has been created the main concepts can be generated and broken down into their individually determining functions. These steps of function and concept generation are repeated until a satisfactory level of decomposition is reached for each function-concept branch of the tree structure. Each function, including the overall function, has to have at least one concept, i.e. a solution to satisfy it.

Figure 4.12 shows a part of the function-concept structure for the 'Splash Guard' project.

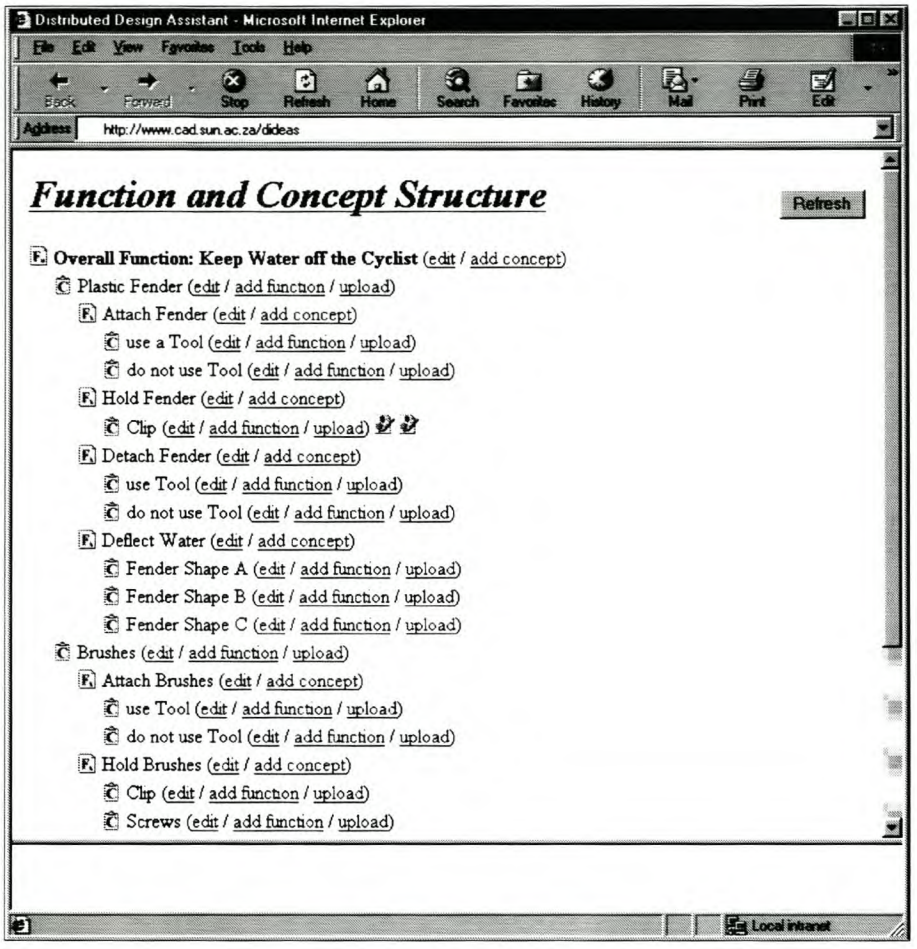


Figure 4.12: Function and Concept Structure

In the structure, functions are represented by a 'F_0' icon (overall function) or 'F_x' icons (other functions), and concepts by 'C' icons.

To add a new concept for a function, the user simply clicks the hyperlink 'add concept' behind the function and enters the concept information, i.e. a short concept description and some notes, if necessary. The concept editor is shown in Figure 4.13.

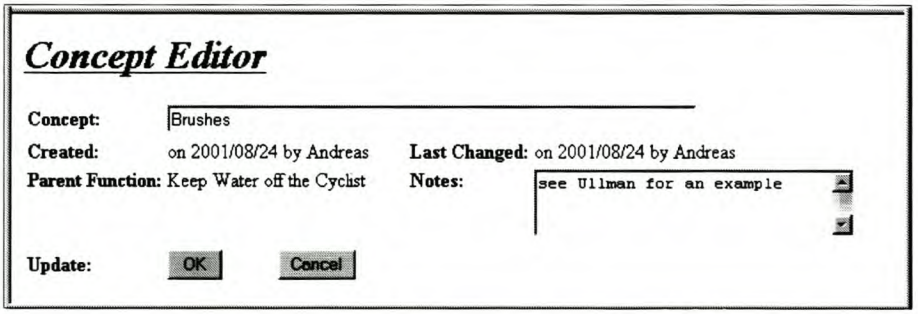


Figure 4.13: Concept Editor

To add a new function for a concept, the user clicks the hyperlink 'add function' behind the concept and enters the function information, i.e. a short function description and some notes, if necessary. The function editor is shown in Figure 4.14.

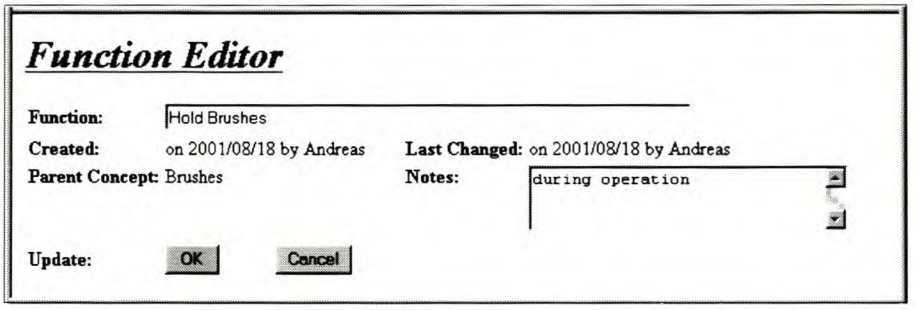


Figure 4.14: Function Editor

All functions and concepts can be edited by anybody at anytime. The same reasons as for the specification development apply. As with the customer and engineering requirements lists, the function-concept structure has to be refreshed by the designers at appropriate intervals.

A hyperlink for a completeness check is located at the end of the function-concept structure. The completeness check should be used before proceeding to the next step, the selection of concept designs. If any function of the function-concept structure is not satisfied by at least one concept, it will be indicated to the user. Otherwise a positive message is shown. If the design team decides to continue the procedure with an unsatisfied function, at least a 'dummy' concept has to be created to indicate the intent.

4.4.3 Concept Upload

Since 'a picture is as good as 1,000 words', a designer might want to append a sketch or an excerpt from a catalogue, to a concept, in order to share it with the fellow team members. The Distributed Design Assistant offers the possibility to attach information to the concepts of the function-concept structure in the form of files. The file format is not limited to images; all file types are permissible, such as pictures, text, movie clips and CAD files. To upload a file to the function-concept structure, the designer has to click on the 'upload' hyperlink behind the concept and specify the location of the desired file. This can be done by direct input into the text field or by browsing for the file on the user's computer or local area network, as shown in Figure 4.15.

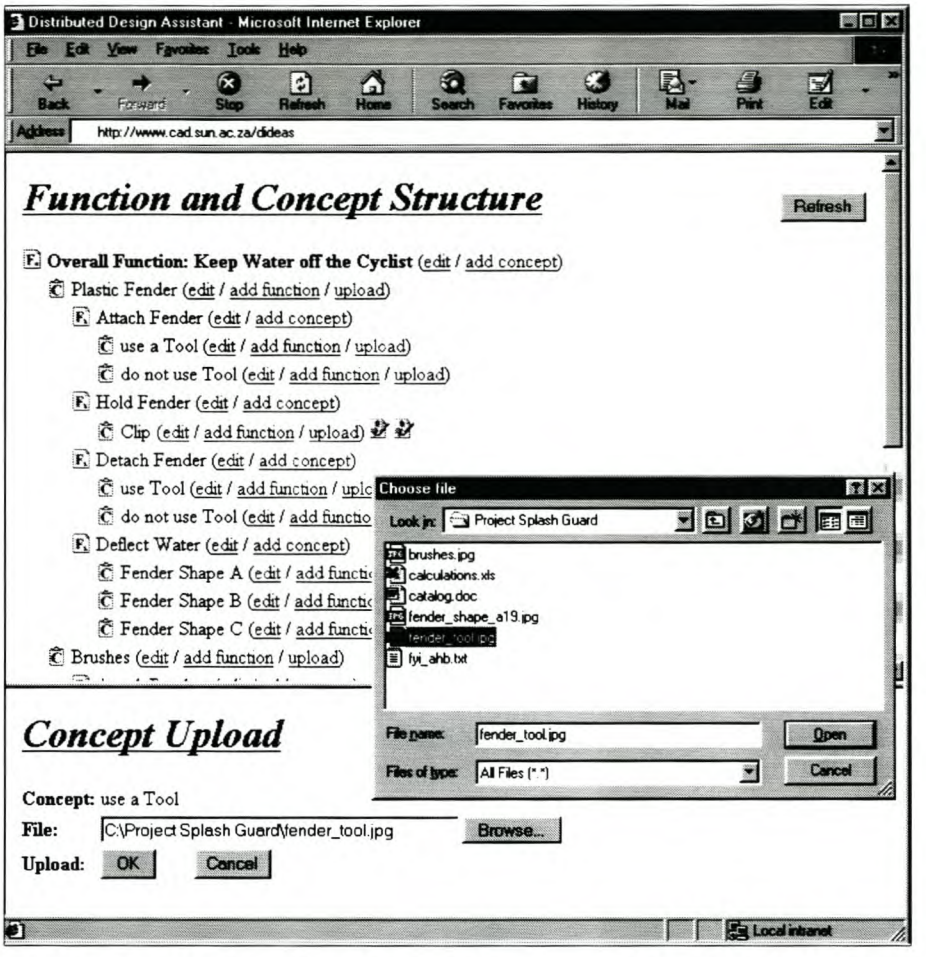


Figure 4.15: Function-Concept Structure and Concept-Upload

When the file is uploaded, an image icon is displayed behind the concept to indicate an attachment. Two concept attachments have already been uploaded for the concept 'Clip', as shown in the figure above. These icons are linked to the uploaded files, and by clicking on an icon the corresponding information will be displayed in a new web-browser window. In case the file format is unknown to the web-browser, e.g. an AutoCAD drawing, the user can download the file to his/her computer and open it using the proper application.

Figure 4.16 illustrates the display of a scanned and uploaded image file of a plastic clip [Ullman, 1997] in a new browser-window.

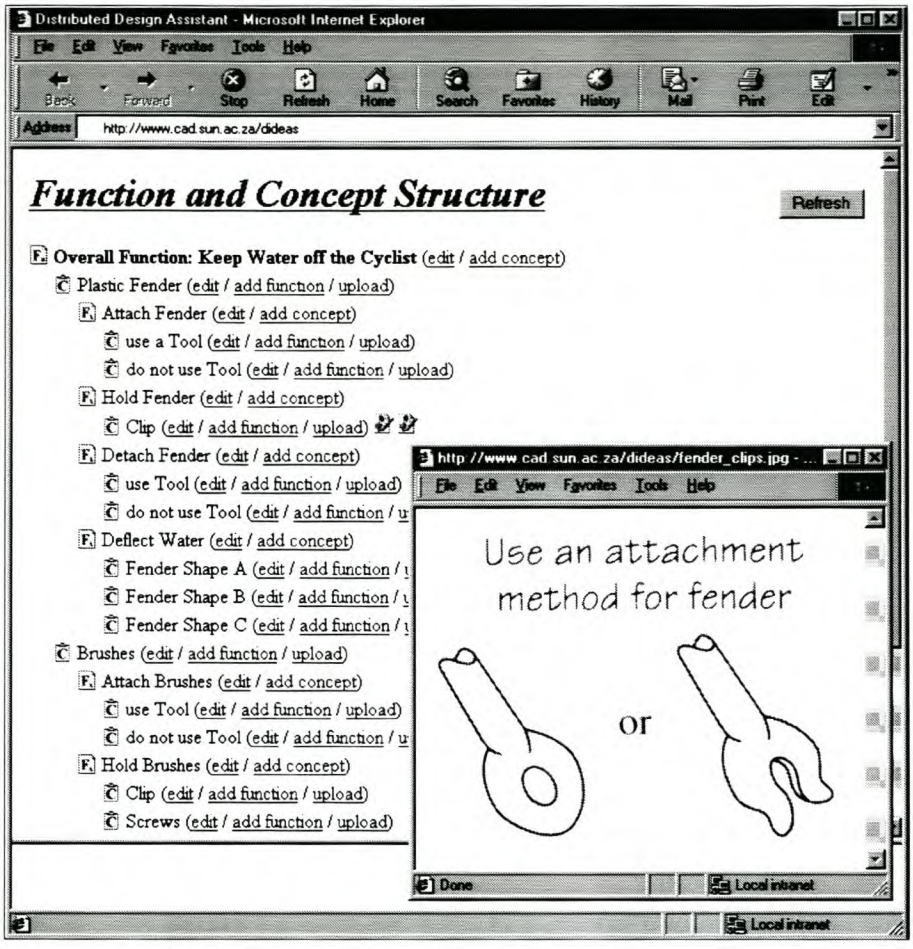


Figure 4.16: Display of a Concept Attachment in a new Browser-Window

Details about the technical aspects of the concept upload are given in Chapter 7.5.

4.5 Concept Selection

In the third phase of the design procedure the concept designs are selected.

4.5.1 Concept Selection Methodology

Once all functions of a branch of the function-concept structure are satisfied by at least one concept, the concept selection process can begin. For every function in the branch one concept has to be selected, as illustrated in Figure 4.17.

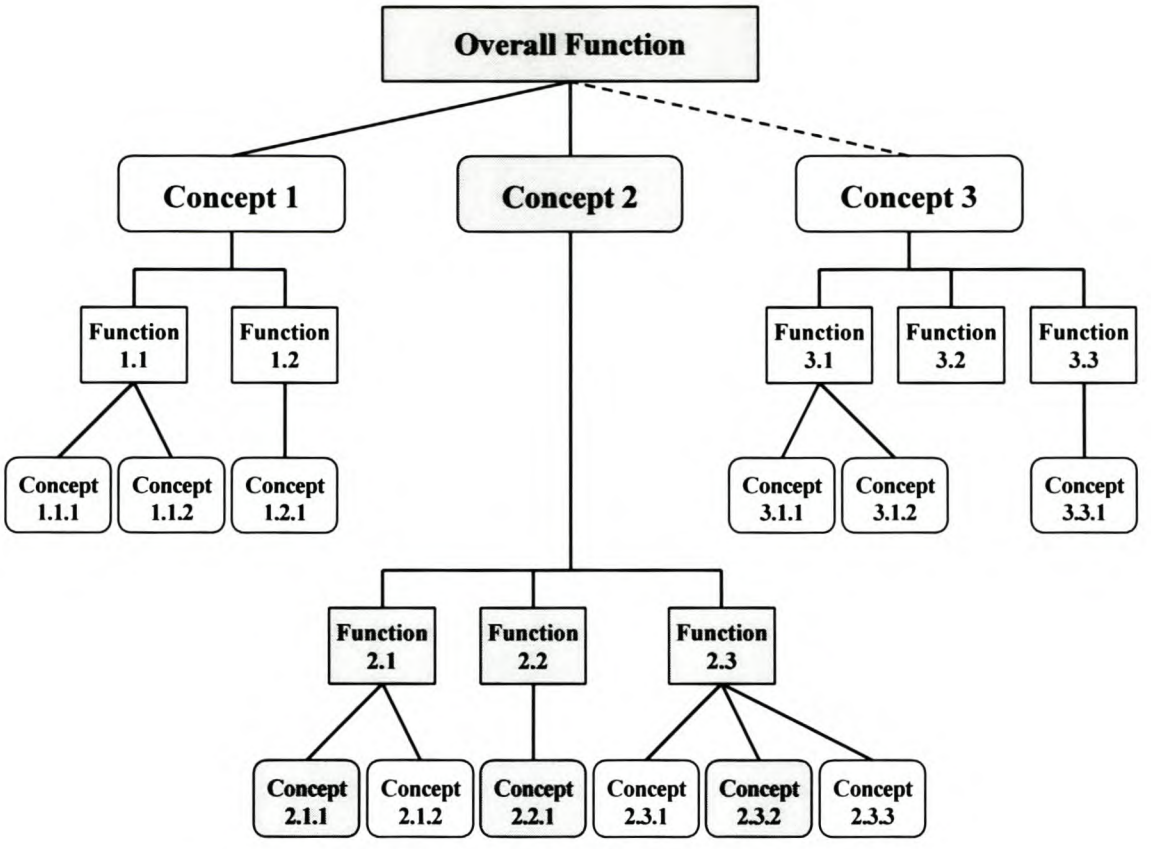


Figure 4.17: Concept Design Selection

By combining different concepts, a large number of different concept designs can be generated. Incomplete concepts, i.e. concepts with unsatisfied sub-functions, have to be excluded from the concept selection, like 'Concept 3' in the figure above, where the sub-function 'Function 3.2' of 'Concept 3' has no possible solution.

The described method minimizes the number of incompatible concepts, because a preliminary selection automatically takes place through the incorporation of concepts into the function-concept structure at an early stage. In other words, not every concept is automatically combined with all possible solutions of the other functions. This greatly reduces the effort for the concept evaluation.

4.5.2 Implementation of the Concept Design Selection

For the concept design selection a tree-structure similar to the function-concept structure is displayed, as shown in Figure 4.18. Since the function-concept structure has already been developed, no hyperlinks for adding, editing or uploading are necessary.

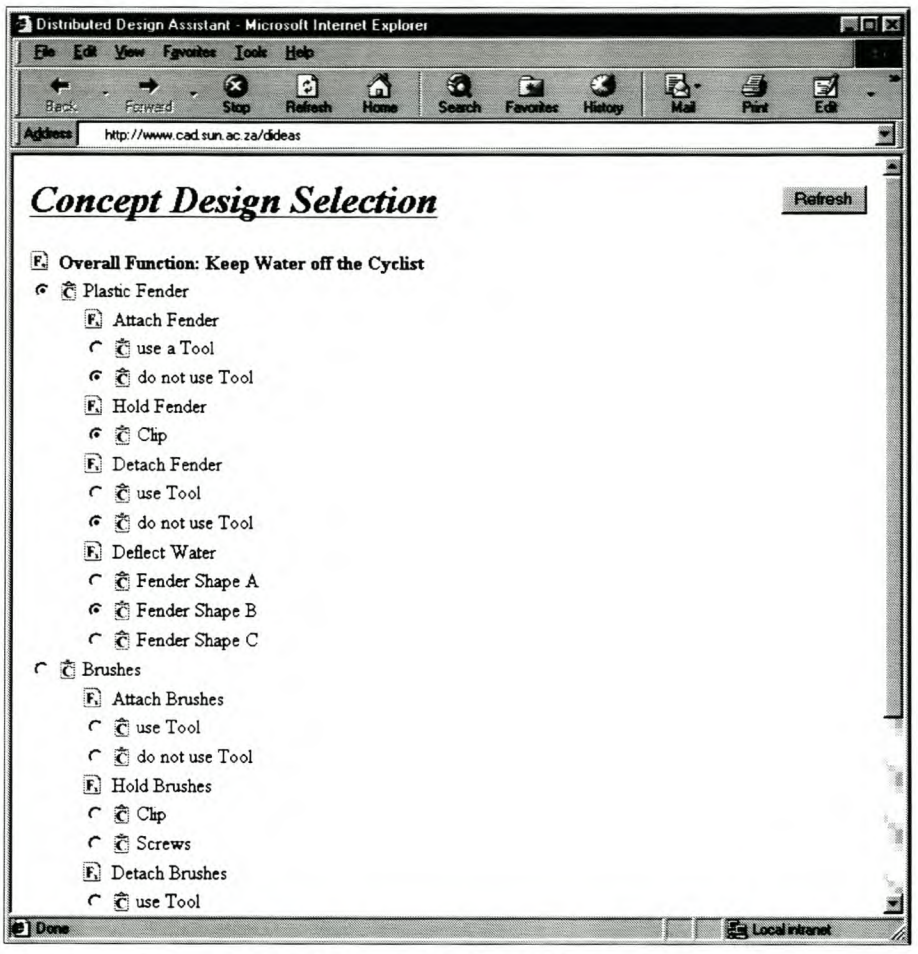


Figure 4.18: Concept Design Selection in DiDeas

The designers select concept designs by combining different sub-concepts of a main-concept. To do so, the user ticks the radio button in front of the desired concept. He/she starts with a main concept, i.e. a concept for the overall function, on the far left. Working one concept level at a time, from left to right, a concept for each function and sub-function of the main concept is selected. Within the concept group of one function only one concept can be chosen. If a function is only satisfied by one concept, this concept has to be picked. Figure 4.18 shows one possible complete selection of a concept design for the Splash Guard project.

At the bottom of the Concept Design Selection page a unique name for the new concept design must be entered, as shown in Figure 4.19.

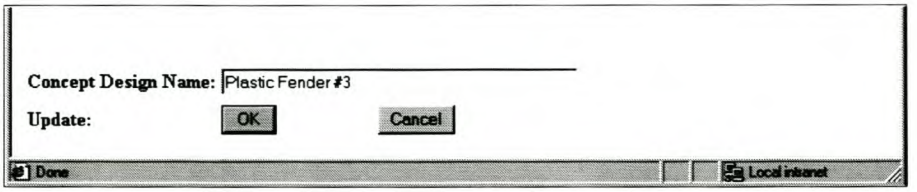


Figure 4.19: Naming of a Concept Design

By clicking on the 'OK' button, the selected concept design will be added to the database. The design team should agree on a convention for naming the concept designs, which is then followed by all team members. Possible standards are:

- user-name_number, e.g. 'andreas_1' or 'helmut_21'
- project-name_main-concept-number_number, e.g. 'splashguard_2_3'
- main-concept-name_number, e.g. 'fender_2' or 'brushes_5'.

Of course, numerous other conventions are imaginable.

The concept designs created in this manner cannot be checked automatically by the system regarding their completeness or feasibility. The Distributed Design Assistant can only record the concept designs, but not interpret them. However, it is possible to continue the design process with an incomplete concept design, if a designer intents to.

The concept designs page displays a table with all concept designs and some basic information, i.e. date and time the concept design was selected and the nickname of the responsible designer. By clicking on the concept design name, all functions and corresponding concepts of the particular concept design are shown, as illustrated in Figure 4.20.

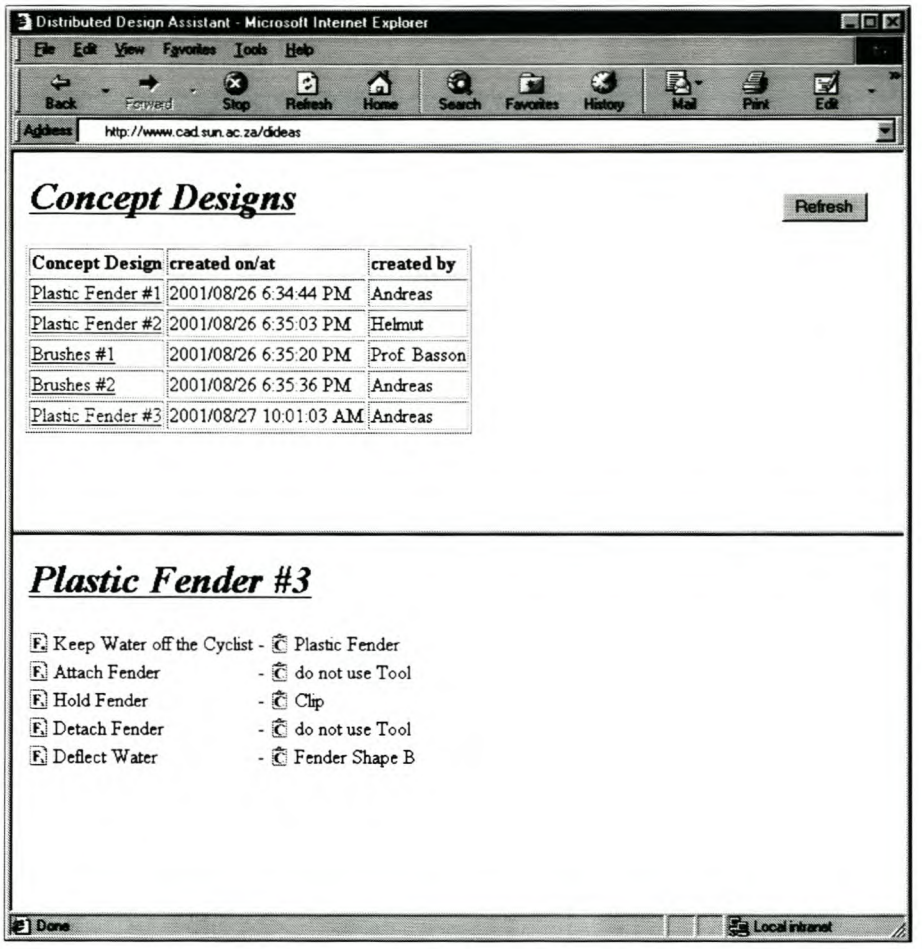


Figure 4.20: Table of Concept Designs and List of Functions and Concepts

4.6 Concept Evaluation

The fourth part of the design procedure of the Distributed Design Assistant is the evaluation of the generated concepts.

4.6.1 Concept Evaluation Methodology

The generated concept designs have to be evaluated in two steps:

Step 1: concept screening

Step 2: decision matrix.

The concept screening is intended to eliminate concepts that are not compatible with the overall function, are not realizable in principle, do not fulfil the specifications, or can be excluded from further evaluation for other reasons.

During the second step the remaining concept designs are compared with each other and evaluated against a number of criteria based on the design specifications, in order to determine the best concept. The decision matrix is most effective if performed

independently by the team members and the individual results are subsequently compared [Ullman, 1997]. In the case of disagreement between the designers, the decision matrix procedure can be repeated using refined concepts or adjusted criteria.

Both steps of the concept evaluation are described in detail in Chapter 2.

4.6.2 Implementation of the Concept Design Screening

Before comparing the concept designs, a rough concept design screening takes place. The intention is to eliminate those concepts from the evaluation process that do not comply with the customer requirements or engineering requirements and to reduce the number of potential winning concept designs to a more manageable number. In some cases it will not be possible to judge concept designs against all requirements, e.g. because not enough information is available during this early stage of the development process. Then the designers are allowed to base the screening on their 'gut feel' [Ullman, 1997]. Figure 4.21 shows the two frames of the concept design screening of the Distributed Design Assistant.

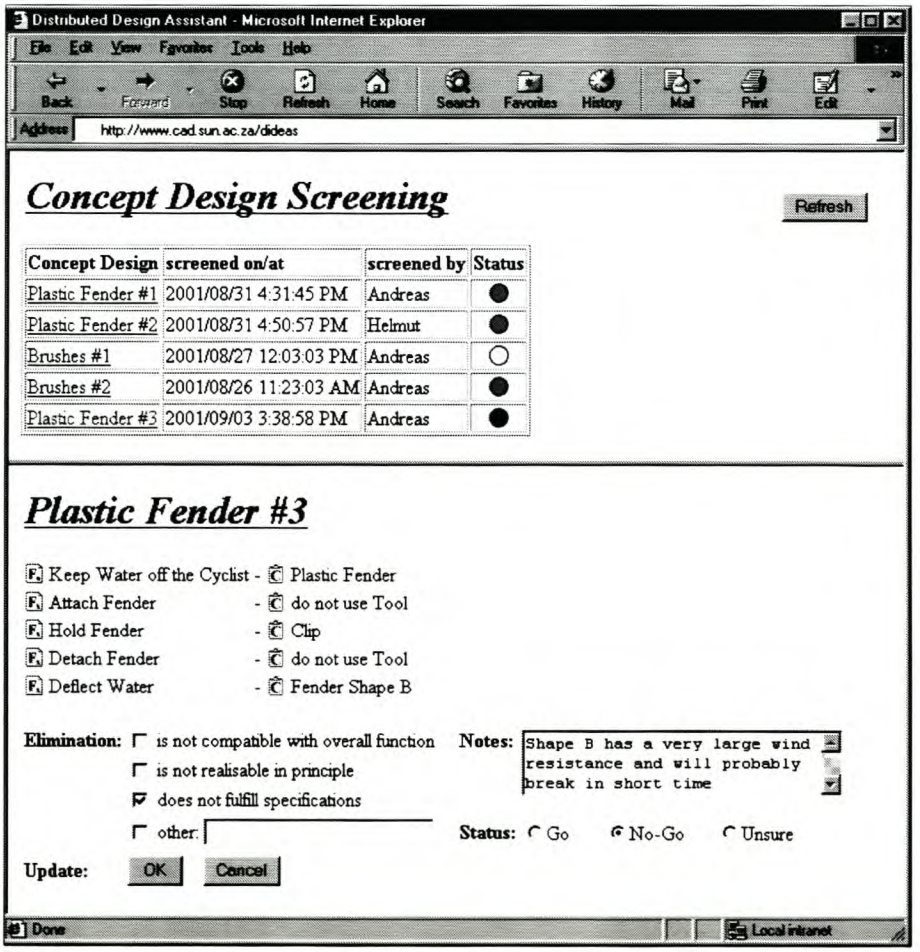


Figure 4.21: Concept Design Screening in DiDeas

In the top frame a table with all concept designs is displayed. The most important field of the table is the 'Status' field. A coloured dot indicates the status of the concept design as 'Go' (green), 'No-Go' (red) or 'Unsure' (yellow). Additionally, the date and time of the screening, as well as the nickname of the screening designer, are shown.

To screen a concept design, the user simply clicks on the concept design name. The functions and concepts of the concept design will be displayed in the bottom frame, together with the screening menu. The designer can select one or more of the pre-defined reasons for eliminating the concept design from the evaluation process:

- it is not compatible with the overall function
- it is not realisable in principle
- it does not fulfil the specifications.

An additional field is provided for other elimination reasons.

If only one of these items is ticked, the concept design will automatically receive the status 'No-Go'. Otherwise the user can decide on the status by selecting one of the three status radio-buttons. In case the designer is not convinced of either a positive or a negative judgement, he/she can choose the 'Unsure' status to indicate a decision. A notes field provides space for comments or additional information.

All concept design screenings can be edited by anybody at anytime and the frame with the screening results should be refreshed regularly.

Of all concept designs only the ones marked as 'Go' will be considered for evaluation in the decision matrix.

4.6.3 Implementation of the Decision Matrix

Each designer performs an individual evaluation of the concept designs using the decision matrix. This process can be divided into four steps.

4.6.3.1 Criteria Selection

The criteria are based on the customer and engineering requirements, and will be used to compare the alternative concept designs with each other. Figure 4.22 shows the two frames of the criteria selection.

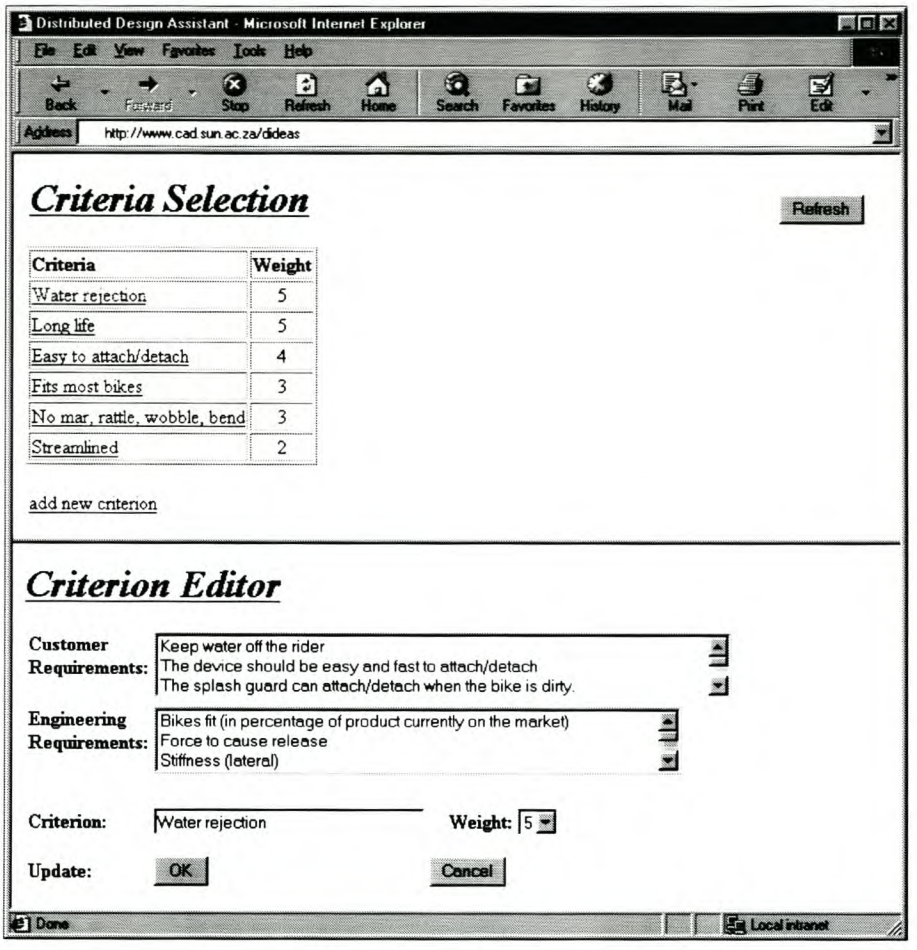


Figure 4.22: Criteria Selection in DiDeas

In the top frame all criteria and their corresponding weight factors are displayed. A new project does not contain any criteria. To add new criteria, the designer clicks on the 'add new criterion' hyperlink at the bottom of the criteria list. In the bottom frame the customer requirements and engineering requirements are shown, to guide the user in establishing new criteria. The criterion is entered as a short phrase and a weight factor between one and five is selected from the drop-down menu. The default value is three. By clicking on the 'OK' button, the entered criterion information will be added to the DiDeas database.

There is no limit to the number of criteria for the decision matrix. The team or team-manager has to decide when the criteria selection process is completed.

4.6.3.2 *Selection of a Datum Concept Design*

The designer selects a personal favourite as the 'datum', i.e. the concept design he/she regards as the best. All concept designs are listed in the datum selection frame, and the datum is selected by clicking on the concept design name.

4.6.3.3 *Individual Evaluation*

The next frame shows the decision matrix with the criteria and the weight on the left and the concept designs on top, represented by numbers. Figure 4.23 illustrates a decision matrix for the 'Splash Guard' project.

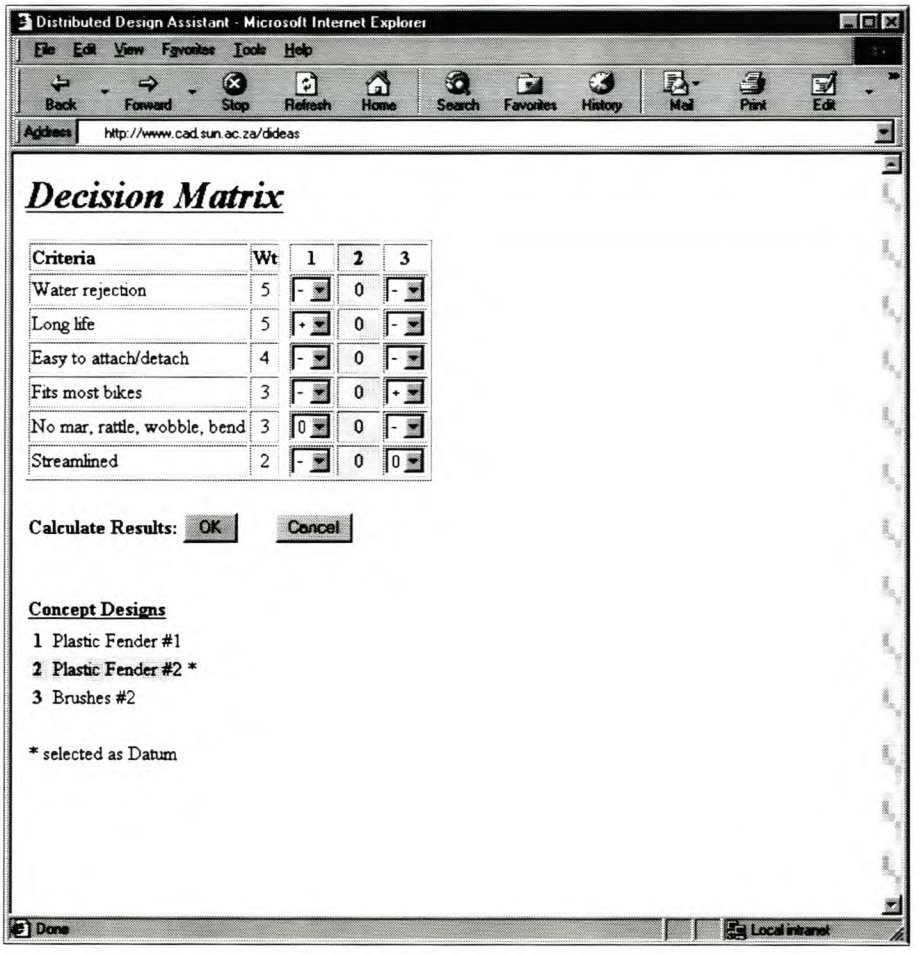


Figure 4.23: Individual Decision Matrix

For each criterion, the designer judges each concept design as either: better ('+') than, equal ('0') to, or worse ('-') than the datum. This is done by selecting the corresponding value from the drop-down menu in each cell. The values in all cells are preset to '0'. The cells of the datum column cannot be changed, as the datum cannot be compared with itself.

Once all concept designs are compared with the datum for every criterion, the personal decision matrix results can be calculated. Four scores are generated for each concept design:

- *Total* '+': the number of '+' scores
- *Total* '-': the number of '-' scores
- *Overall Total*: the difference between the number of '+' scores and the number of '-' scores
- *Weighted Total*: the sum of each score multiplied with the corresponding weight factor.

4.6.3.4 Combining Individual Evaluation Results

Finally the individual decision matrix results can be combined to produce the group results. The results for each user will be stored in the database, together with a code ('ControllID') for the concept designs and criteria incorporated in the decision matrix. In this way the adding up of user results with different numbers of concepts, different criteria and different weight factors, which would completely distort the group results, will be avoided.

4.6.4 Evaluation Results

The evaluation results are displayed in the two frames of the Evaluation Results page, as shown in Figure 4.24.

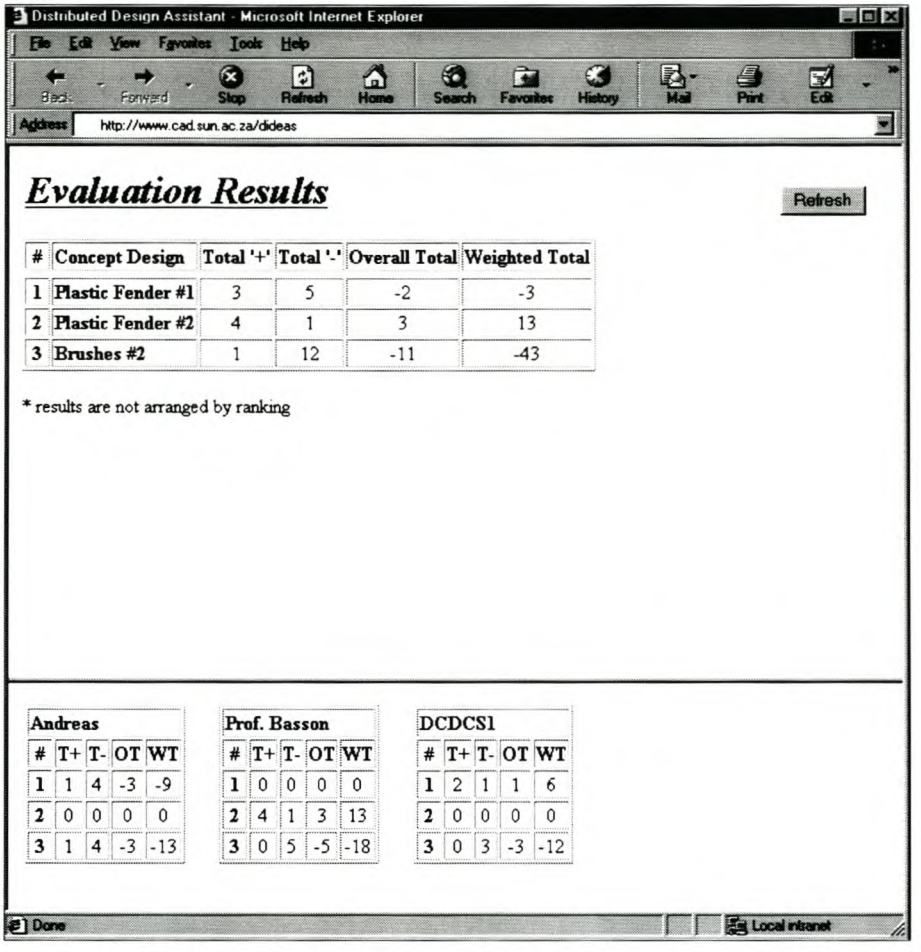


Figure 4.24: Combined and Individual Evaluation Results

In the top frame the combined evaluation results of all designers who have already completed the decision matrix are displayed. This identifies the winning concept design of the design team. In the bottom frame the individual results are shown. They are useful if there is disagreement between the designers or if no undisputed winner can be identified.

In this case the design team can add new criteria or edit the existing ones, e.g. by modifying the weight factors, and repeat the evaluation process until a clear winner can be determined.

4.7 Project Documentation

The Distributed Design Assistant offers two tools to support project documentation.

4.7.1 Design Reviews

Design reviews can be written by anybody, at any time. To create a new design review, the user can start the Design Review Editor by clicking in the 'New Design Review' hyperlink in the top frame of the design review window, as illustrated in Figure 4.25.

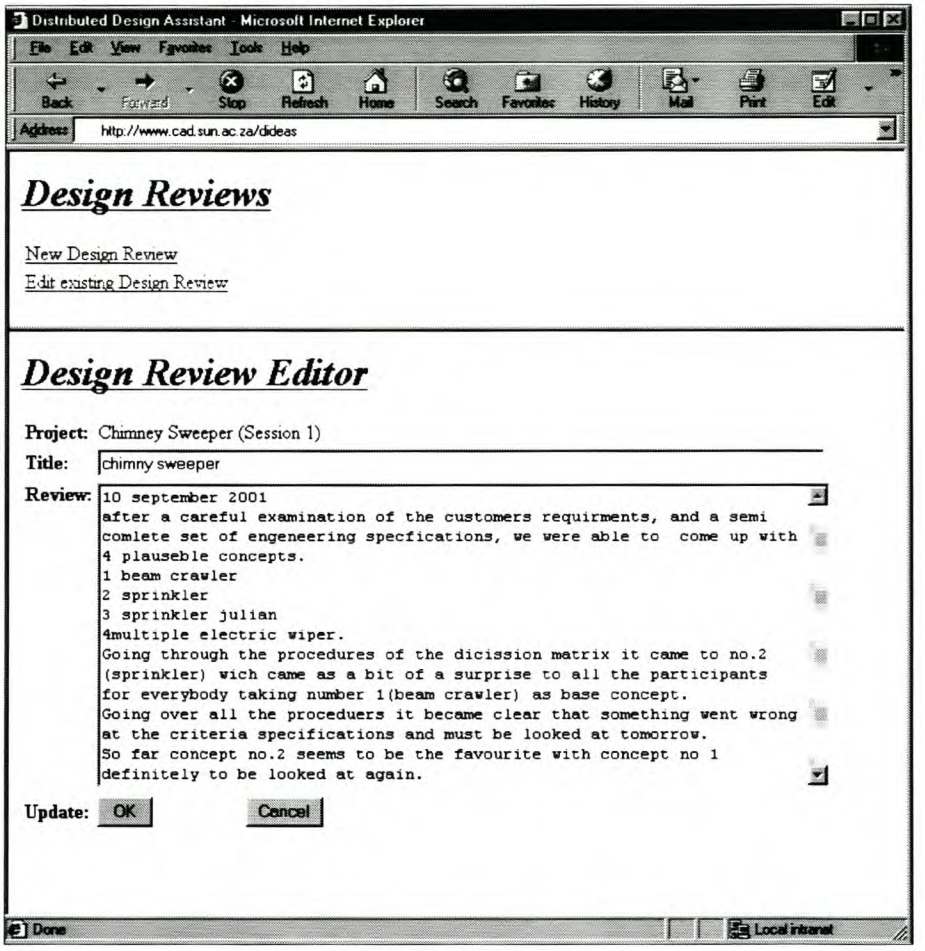


Figure 4.25: The Design Review Window of DiDeas

The new design review is linked to the current project. The user has to specify a title for the design review and can then add the review. By clicking on the 'OK' button, the entered information will be added to the DiDeas database.

To edit or view an existing design review, the designer clicks on the hyperlink 'Edit existing Design Review'. A list of all design reviews of the present project will be displayed, including information on when the review was changed last and by whom, as well as whether the design review is currently in use and by whom. A design review 'in use' cannot be accessed by another designer until the present user has finished working on it.

4.7.2 Documentation Assistant

The documentation assistant allows for printing of all elements of the design procedure discussed in the previous sections, from the list of customer requirements to the design reviews. Figure 4.26 shows the documentation assistant with the printable documents.

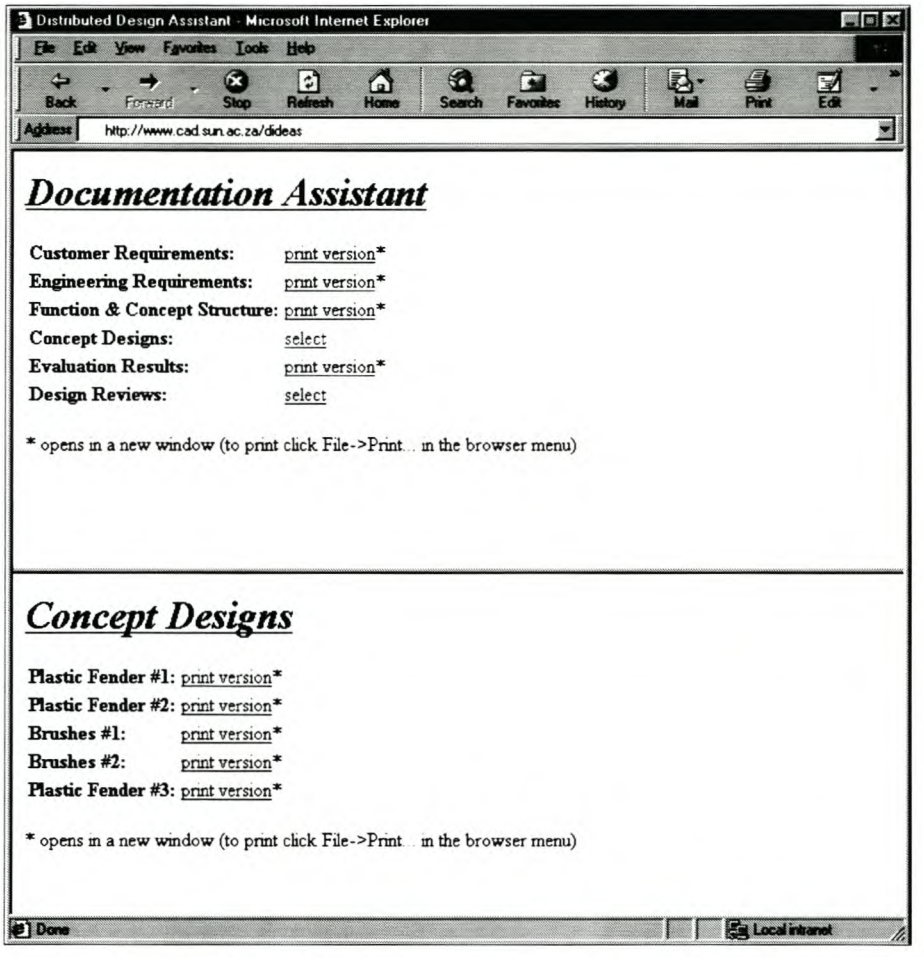


Figure 4.26: The Documentation Assistant of DiDeas

In the cases of the concept designs and design reviews, a list of available print versions is displayed for selection in the bottom frame.

The print version of a document consists of the same elements and has the same layout as the original page in the Distributed Design Assistant, but does not display any hyperlinks. Also the coloured icons used for the customer requirements are replaced by greyscale icons. The print version is displayed in a new browser window and can be printed directly from there via the print function of the web-browser.

CHAPTER 5

COMMUNICATION AND INFORMATION TRANSFER

5.1 Introduction

The elements of the design procedure were explained in Chapter 4. In this chapter the different communication tools for user interaction and the features for file transfer in distributed design teams are discussed.

A case study was carried out to assess the use of tools and applications used for synchronous and asynchronous collaboration during conceptual design. The results are presented and discussed.

The last part of the chapter describes the implementation of communication tools in the Distributed Design Assistant.

5.2 Tools for Communication and Information Transfer

Various tools for communication and information transfer have been investigated. They are described in the following sections.

5.2.1 Desktop-Videoconferencing

Videoconferencing technology substantially enhances communication in distributed teams. Not only does videoconferencing make the communication with one's counterpart more personal, it is also much more effective since non-verbal 'language', such as gestures and facial expressions, can be transmitted [Fetterman, 1996].

Professional videoconferencing studios allow design teams to access and share information of almost any type. They typically offer high-quality video images and control, directly or remotely, over various kinds of media input and output, such as paper and traditional whiteboards, PC/workstation data, and information on the Intranet and/or Internet. Disadvantages of professional systems are the high purchase costs or user fees (up to 100-150 US$ per hour), and the need for expensive high-speed connections, usually through telephone or satellite communication.

Desktop-videoconferencing is more suitable for small and medium size companies, since it is comparatively cheap, i.e. only the costs for a standard web-camera (<R1,000) and local telephone rates, and easy to implement. An example for a WebCam is the Logitech 'QuickCam', shown in Figure 5.1.

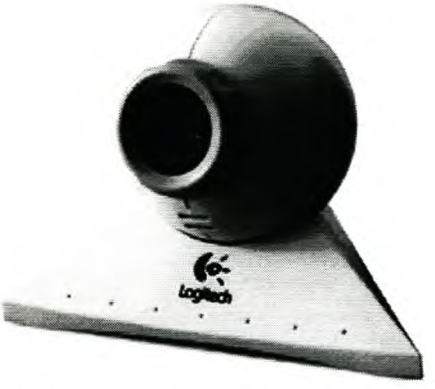


Figure 5.1: Logitech 'QuickCam' [Logitech Homepage, 2001]

Two desktop-videoconferencing applications were investigated:

- Microsoft NetMeeting
- CU-SeeMe from Cornell University.

Microsoft NetMeeting allows for several people to meet in a conference and to make use of its chat and shared whiteboard features, but the exchange of video images and audio is only possible between two participants at a time. CU-SeeMe, on the other hand, permits chat, video and audio in direct one-to-one meetings as well as in group-videoconferences via a central server. This so-called 'Reflector' receives data from each of the connected participants and distributes, or 'reflects', the data to all counterparts. Due to the increased data transfer, a reduced sound and video quality has to be accepted.

A permanent video connection enables distributed team members to check for the presence and activity of others, which leads to a 'heightened awareness of the activities of the team' [Poltrock and Engelbeck, 1999]. This experience can be enhanced by utilizing remotely controllable WebCams, as used for the 'Virtual in Person' (VIP) system at Stanford University [VIP Homepage, 2001].

An important aspect is the management of the videoconferences by experienced moderators, using pre-defined agendas and well-established group processes, as recommended by Boutellier et al. [1998].

5.2.2 Electronic Mail

Electronic mail (e-mail) has become one of the most popular communication tools. Reasons for this are its world-wide dissemination and ease of use. In distributed design e-mail can be employed both for communication and for information transfer in the form of attachments.

Especially during asynchronous collaboration, e.g. when team members reside in different time zones, e-mails present a convenient way of information exchange, since they wait in the electronic mailbox until collected by the recipient. It is not necessary to make any special arrangements, as required for videoconferencing.

5.2.3 Shared Workspace

As the amount of information and the number of team members increase, it becomes more and more inconvenient to distribute files by electronic mail. An alternative is to publish the information on a shared workspace system. The participating designers do not have to send each file to every team member that they assume will be interested in the information. Instead, the designers upload their data to a central shared workspace server where it can be accessed by other users. A professional example of such a shared workspace environment is the 'Basic Support for Cooperative Work' (BSCW) system developed by Bentley et al. [1997]. A screenshot is shown in Figure 5.2.

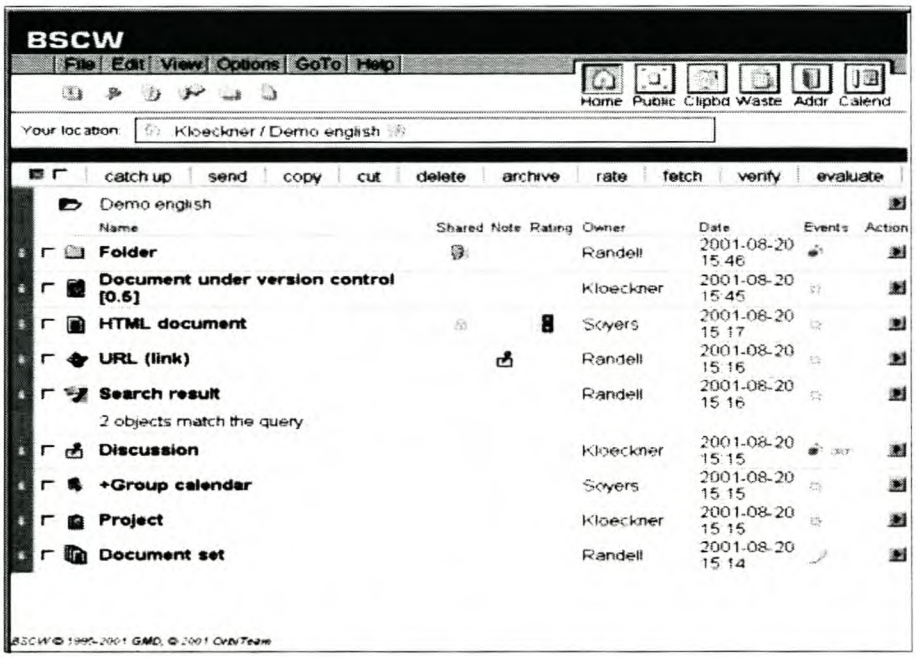


Figure 5.2: BSCW Shared Workspace System [BSCW Homepage, 2001]

In most cases a simple File Transfer Protocol (FTP) server is sufficient to provide file uploading and access.

An advantage of a shared workspace system over other tools for file exchange, e.g. as e-mail attachments, is the use of a standard web-browser to download and view files. In most cases the files do not have to be saved on the designer's computer and opened with another software program. Web-browsers like Microsoft Internet Explorer or Netscape Communicator support a variety of text and graphic formats. By using a Virtual Reality Modelling Language (VRML) plug-in, even 3D CAD-geometry can be exported from high-end CAD/CAM/CAE systems like I-DEAS Master Series from the Structural Dynamics Research Corporation (SDRC) and PRO/Engineer from the Parametric Technology Corporation (PTC), and visualized in the web-browser, as shown in Figure 5.3.

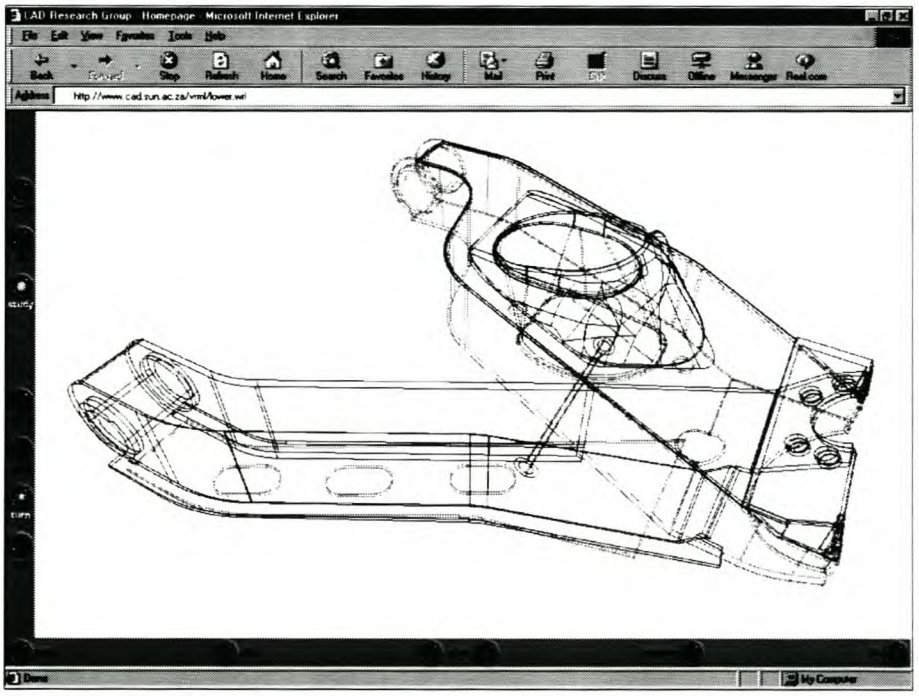


Figure 5.3: Virtual Reality Modeling Language (VRML) Model

The web-browser enables the user to zoom, pan, and rotate the model, as well as to play animations (e.g. a FEM simulation) and to display annotations. Equipped with sufficient computational power, one can explore 3D CAD-models and all attached information, such as hyperlinks to the World Wide Web, in a Virtual Reality environment. However, since the creation of CAD and VRML-files still requires significant effort, these tools are of rather limited value during the conceptual design stage.

5.3 Case Study on Synchronous and Asynchronous Collaboration in Distributed Conceptual Design

Synchronous collaboration takes place when the participants communicate with each other at the same time. It is characterised by immediate feedback, e.g. as in a face-to-face conversation. During asynchronous communication, on the other hand, a participant has to wait until the entire message, e.g. a fax page, has been transmitted and interpreted by the counterpart before a reply can be expected. This applies, for instance, to communication between team members in different time zones, when office hours do not overlap. In such a situation it is generally not possible to use telephone or videoconferencing. Hence messages are sent in the form of faxes or e-mails.

Table 5.1 illustrates these terms and provides some examples of collaboration in synchronous and asynchronous environments.

Place	**Time**	
	synchronous	**asynchronous**
co-located	group meeting	office workspace
distributed	videoconference	fax, e-mail

Table 5.1: Examples of Collaborative Communication

The following sections describe the main aspects of the setup, the evaluation and the results of the case study. The detailed results can be found in Appendix A.

5.3.1 Case Study Setup

The setup is an important aspect of a case study. The correct setup is critical for the validity of the results. The main aspects are described in the following sections.

5.3.1.1 Case Study Participants

A total of 21 undergraduate mechanical engineering students from Stellenbosch University participated in the case study. The students were divided into six teams of either three or four students per team, in mixed configurations of second and third year students. The group composition was restricted by the class schedules of the students. A team-building strategy based on their personality types could therefore not be implemented. The team leaders, or team managers, were chosen either because of their

more advanced design knowledge, as third year students in mixed teams, or because of previous experience with the communication tools used in the experiments.

5.3.1.2 Payment of the Case Study Participants

As gratification for their time and effort, all participating students were invited to a local restaurant for pizzas and refreshments. This get-together provided an opportunity for the author to give the students some feedback of the case study results and to receive additional comments on the project.

5.3.1.3 Case Study Environment

Five adjacent offices at the Department of Mechanical Engineering were used for the case study. Up to four offices accommodated one designer each, while in the last room the fax machine and the scanner were set up. The location of the offices in the immediate vicinity to each other provided the necessary spatial distribution of the designers and simultaneously allowed for close supervision by the case study supervisor. The proper functioning of the videotape recorders could be controlled, and technical problems with hardware and software could be dealt with immediately by the case study supervisor.

5.3.1.4 Fax Procedure Simulation

Since only one fax machine and one scanner were available, they had to be shared between the team members. The designers were instructed not to communicate details of the case study during chance encounters in the fax-scanner room.

The restriction to only one fax machine was necessary due to the limited number of telephone lines (four) available, which were to be used for telephone conversations only. The fax procedure was therefore simulated in the following way. To send a fax the designer had to make a copy using the copy function of the fax machine. He would then write the name or number of the addressee onto the fax and the fax would be delivered to the requested user by the case study supervisor. To send a fax to more than one designer, the steps had to be repeated. Since this procedure required as many steps and as much time as the real fax process, and the produced copy had the same characteristics as a real fax, it was considered an acceptable substitution.

5.3.1.5 *Scanner*

The software for the flatbed scanner was preset to 200dpi (dots per inch) and full colour. The users were advised to save all images in the JPEG file format. In doing so it was less likely that the designers would create files of inconveniently large file sizes, which could cause problems during their distribution as e-mail attachments or via the file upload to the shared workspace. Each scanner file was to be stored on the scanner computer and copied from there only to the computer of the scanning designer. From there the designer could distribute the file to his team mates. This procedure reflects the real scenario, since distributed designers usually do not have direct access to each other's computers.

5.3.1.6 *Computers, Operating Systems and Network*

All workplaces were equipped with similar hardware and software.

The computers ranged from Intel Pentium 150MHz to Intel Pentium III 500MHz with memory between 48MB and 128MB RAM and running under Microsoft Windows95 and Windows98 operating systems. The computers were connected via the Stellenbosch University Network, which is a 10Mbit/s Ethernet network.

5.3.1.7 *WebCams*

The four WebCams were of different brands, but all supporting the video resolutions of 160 x 120 pixels required by the videoconferencing software used in the case study. The cameras were placed on top of the computer monitor, facing the designer. Since the WebCams were not permanently attached, they could be moved around by the user. Movement was restricted only by the length of the camera cable. The WebCams were connected to the computers via the Universal Serial Bus (USB) and the parallel port.

5.3.1.8 *Graphic Tablets*

One designer of each team had a WACOM 'Graphire' graphic tablet with pen (see Figure 6.4) at his disposal. The system consists of the tablet with a sensitive area of approximately 127mm by 102mm (4"x5") and a pen with touch-sensitive tip. The pen can be used for sketching, handwriting and as a replacement for the computer mouse. Although no training with the graphic tablet could be provided prior to the case study, the participants were expected to get acquainted quickly with the system.

5.3.1.9 Shared Workspace

The shared workspace environment used in the case study was set up on a dedicated computer connected to the university's network. The web-server system 'Xitami' [Xitami Homepage, 2001] provided upload and download capability via FTP. Each designer could access the shared workspace either via the Windows Explorer or WS_FTP.

5.3.1.10 Software

The following software was installed on all computers:

- Pegasus Mail, for sending and receiving e-mails and attachments
- Microsoft NetMeeting, for one-to-one videoconferences
- CU-SeeMe, for group-videoconferences
- PaintShop Pro, for creating images with mouse and graphic tablet
- ACDSee, for viewing image files
- Microsoft Notepad, for simple word processing
- Microsoft Office, for advanced word processing and use of spreadsheets
- Microsoft Windows Explorer, for file management
- WS_FTP, for file upload to a shared workspace system
- Netscape Communicator, for viewing and downloading of files on the shared workspace system.

The following program was available to the graphic tablet users only:

- Painter Classic, for creating images, with mouse and graphic tablet (supports the pressure sensitive tip of the graphic tablet pen).

For easy access, links to all programs mentioned above were placed on the desktop.

5.3.2 Case Study Supervision

All sessions of the case study were supervised by the author.

5.3.3 Case Study Procedure

This section describes how the case study was carried out. Each session was to run in a similar fashion, in order to obtain comparable results. To avoid unnecessary repetition, the students were notified of problems experienced by previous groups.

5.3.3.1 Introductory Steps

Each session commenced with a short introduction to the project and of what was expected of the students. This was followed by an in-depth explanation of the hardware and software. Depending on the participant's level of experience with the hardware and software, the introduction took between 30 minutes and one hour.

5.3.3.2 Design Methodology

All designers had basic to intermediate knowledge of the design methodology recommended by Ullman [1997]. The participants were instructed to incorporate the following steps into their design procedure:

- recording of customer requirements
- translation into engineering requirements
- functional analysis, breakdown into sub-functions
- search for possible solutions for each sub-function
- generation of concepts from these solutions
- concept evaluation.

The steps were clarified to all participants and examples were given when necessary.

Due to time restrictions it was not possible to carry out all steps in full detail. Since the main focus of the experiments lay in the distribution of different types of design information, the participants were advised to shorten the functional analysis step in favour of the other steps. The output format of a functional analysis would have been predominantly text-based, and this type of information was to be exchanged in any case in other steps. A rough time frame was given to help ensure that the teams would complete both tasks within the allocated four hours.

5.3.3.3 *The Design Tasks*

The final step prior to the commencement of each part of the case study was the presentation and the discussion of the task. For this, the case study supervisor acted as the client or customer of the design team. During a 'fictitious' meeting all team members had the opportunity to ask questions. After this meeting, i.e. during the design session, the designers could not communicate directly with the client to clarify questions, but only through the team manager. This handicap was imposed on the design team to ensure that any customer requirements and design specification not discussed during the initial meeting would be distributed to all team members by the team manager. After this meeting the participants were placed in their offices and the design session commenced.

Each team had to fulfil two tasks: one for synchronous and one for asynchronous collaboration. Between the two tasks a short break for refreshments and the introduction of the second task took place. The design tasks had to be challenging, realistic, feasible in the time available and within the sphere of knowledge of the case study participants [Dorst, 1996].

The synchronous collaboration task was considered the larger, more complex task. It comprised the development of concepts for a new bicycle stand-lock-combination. A handout (see Figure 5.4) provided some examples of existing bicycle locks.

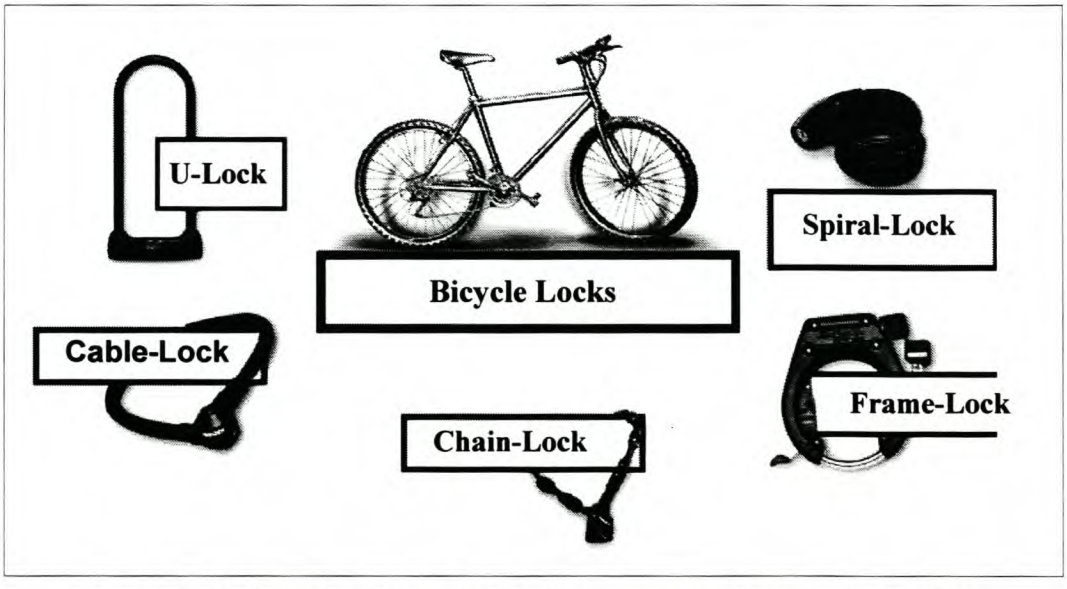


Figure 5.4: Handout 'Bicycle Locks' [from Trelock Homepage, 2001]

The main challenge was to secure all easily removable bicycle components, i.e. the wheels and the saddle.

This task was changed during the course of the case study, in order to identify possible interconnections between the task and the use of communication and information exchange tools. The other task for synchronous collaboration consisted of the development of concepts for a 'Lawnmower-Lift', i.e. a manoeuvrable platform for lifting and storing a lawnmower in a garage. The main challenge for this task was the incorporation of a locking system to hold the platform securely in an elevated position.

The second task each team had to work on was a smaller, shorter design exercise. It provided an insight into distributed idea generation and exchange in an asynchronous scenario. The task comprised the development of concepts for a re-usable teabag, with the emphasis on functioning principle and material selection. This task was not changed during the course of the case study.

5.3.4 Data Acquisition and Reduction

The actions of all 21 case study participants were recorded on videotape and analysed afterwards. All hand sketches and notes on 'scribble paper' as well as the files generated on the computers were collected and investigated. The tools and procedures used for the distribution were also scrutinised.

All e-mails exchanged, telephone calls made and desktop-videoconferences conducted during the case study were identified and categorised. Each telephone call and e-mail was marked as being one or more of the following types:

- 'design-related', if the designers discussed ideas or concepts
- 'communication and management related', if for instance a videoconference was arranged or the exchange of files was discussed.

This measure was used to investigate the communication pattern among the designers.

Short interviews were conducted with the participants during the break between the tasks and after the case study.

5.3.5 Case Study Results

The results of the case study on synchronous and asynchronous collaboration will be discussed in the following sections. Further observations are described by Schueller and Basson [2001a].

5.3.5.1 *Telephone*

The use of the telephone was only permitted during the first task, as it is a synchronous communication tool. About 70% of all phone calls made were communication and project management related, i.e. the designers arranged for videoconferences or inquired about the design procedure. It is most useful for these tasks because of the instant feedback. Only 30% of the phone calls could be linked to concept discussions. The average telephone conversation was only 50 seconds long.

5.3.5.2 *Desktop-Videoconferencing*

Two types of desktop-videoconferences could be clearly distinguished:

- Short conferences, on average 137 seconds long and between only two designers. They were mostly used to coordinate the design process, e.g. to discuss steps of the design procedure, to chat about the use of hardware and software, or to arrange other meetings. These videoconferences were mainly held in Microsoft NetMeeting, due to easier handling and better sound quality of the software.
- One long CU-SeeMe group-videoconference carried out by each design team. These conferences took up to 110 minutes. During the long videoconferences the individually generated concepts were presented by the responsible designers, and subsequently discussed and evaluated.

During two of the long group-videoconferences a number of individual person-to-person meetings took place with the rest of the team not actively participating. The designers only checked the video images on their computer monitors to determine whether a team member was available for a meeting, or not, e.g. because he/she was involved in another conversation or absent from the workplace.

Some designers tried to transmit sketches or short notes on paper via the WebCam, but were unsuccessful because of the low image quality of the cameras. Other objects, i.e. items related to the design task, were not transmitted.

5.3.5.3 *Electronic Mail*

The use of the electronic mail system was permissible during both design tasks. The number of e-mails sent increased dramatically during the second, asynchronous part of the case study, when e-mail took over the position of the telephone as a quick

information exchange medium. While the ratio of design related information to communication and project management related information remained the same for both tasks (synchronous 68% to 32% and asynchronous 69% to 31%) the number of e-mails did more than triple.

Various file types were sent as attachments:

- text files, generated in Microsoft Word or Notepad
- scribble papers, scanned and saved as image files
- image files, created using the mouse or the graphic tablet with pen.

While during the first tasks a total of 28 files were sent by e-mail (37.3% of all files exchanged), this number dropped to 5 during the second tasks (16.7%). Two groups did not use e-mail attachments at all during the second task, compared to one during the first task. The decline of attachments was explained by the growing preference for other distribution tools, such as the shared workspace environment and the fax in the course of the case study.

An interesting observation was the use of the e-mail system as a kind of textual intercom system, with designers typing short messages only into the subject-line of a message, leaving the e-mail body blank. In this way it was no longer necessary for the recipient to open the message, the designer rather read it like a message in a chat tool or a note on a bulletin board.

5.3.5.4 Fax

The fax is particularly useful for small design teams of only two to three designers. Furthermore, the possibility of making annotations directly on the fax and returning it to the sender within a few minutes can be an advantage. For larger groups, other input devices are more efficient, e.g. the scanning of paper sketches and the subsequent simultaneous distribution to many users as an e-mail attachment. The main disadvantages of a fax are the low quality in terms of colour depth and resolution, the time required for sending multiple faxes and finally the costs of sending long-distance faxes.

5.3.5.5 *Shared Workspace*

Of the files exchanged during the first task of the case study, 40% were uploaded to the shared workspace. Although the total number of distributed files decreased during the second task, for half of them the shared workspace system was used. Since the designers could access the files on the shared workspace in multiple ways, it was not possible to determine accurately if and how often a file was actually exchanged.

5.3.5.6 *Input Devices*

The input devices evaluated in the case study are discussed in Chapter 6.

5.4 Communication Tools Implemented in the Distributed Design Assistant

Based on the case study results, various tools for textual and visual communication have been developed and implemented in the Distributed Design Assistant. These include the 'Message Board', the 'Short Message' system and the 'Video Snapshots'.

5.4.1 Message Board

The message board of DiDeas is used to exchange textual information similar to a bulletin board. The message board opens in a separate window and can therefore remain open during an entire design session without interfering with the design procedure carried out in the main window. It consists of two frames, as shown in Figure 5.5.

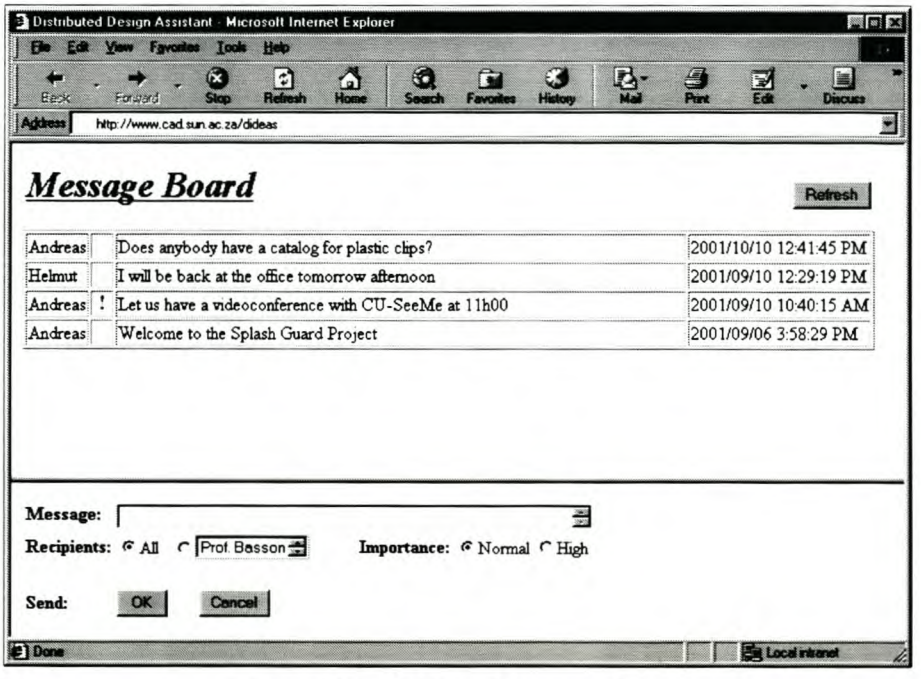


Figure 5.5: DiDeas Message Board

During the case study on synchronous and asynchronous collaboration a large number of designers communicated short messages in a very particular way, as mentioned in Section 5.3.5.3: the participants were typing messages in the subject line only, leaving the e-mail body blank.

The DiDeas message board allows for communication in a similar way and, since it is integrated into the system, all messages are saved in the database for future reference. In the top frame all messages sent by the user and all messages addressed to the user are listed with the most recent messages at the top of the list. In this way the designer does not have to scroll through the entire list to read the latest message. The information displayed comprises the sender of the message, a symbol indicating the importance of the message, the message itself, and the time and date when the message was sent. In the bottom frame the designer can create a new message. After the message text has been entered, the user can choose either all team members as recipients, or select individual team members from a list. The standard importance is 'Normal', but can be set to 'High'.

By clicking the 'OK' button, the entered message will be added to the database. With the next refresh it will be displayed in the message list. The list is updated automatically every 20 seconds, but the user can refresh the frame manually at any time.

5.4.2 Short Messages

The second text-based message system is termed 'Short Messages'. It was integrated into the DiDeas system because of the need for an active notification tool, in contrast to the passive message board. The short message system informs the user actively about incoming messages, while the message board has to be checked by the designer himself/herself to see whether new information has arrived. The system queries the database for new messages every five seconds and, on receipt of such, displays the hyperlink 'New Message!' in the small info frame in the bottom left corner of the main window, as shown in Figure 5.6.

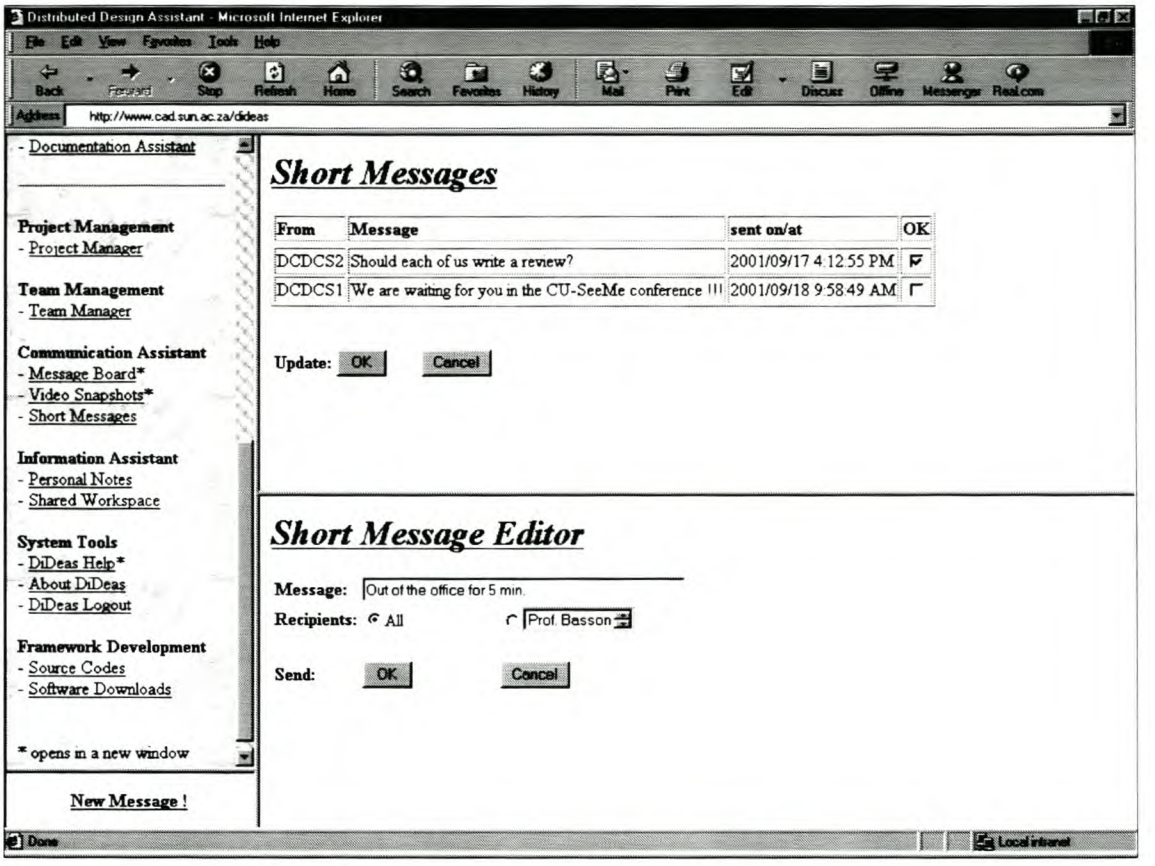


Figure 5.6: DiDeas Main Window with Short Message Info, Short Messages and Short Message Editor

The hyperlink 'New Message!' directs the user to the short message frame, with a list of all active short messages directed to him/her (Figure 5.6 top right). The list shows the sender, the message, and the time and date when the message was sent. If the designer acknowledges the message by ticking the checkbox next to the message, this message will not be displayed again. When the user checks all messages in the list, the notification in the info frame disappears as well.

To send a short message, the designer types the message in the editor and selects the project participants he/she wants to address the message to. By clicking the 'OK' button, the short message will be added to the database, and with the next automatic refresh of the recipient's info frame the notification will be displayed.

5.4.3 Video Snapshots

It was observed during the synchronous collaboration part of the case study that two of the six design teams conducted particularly long group-videoconferences. However, they did not communicate for most of the time, but rather used the video link to check what the other team members were doing. Before placing a phone call or starting a

discussion on the videoconferencing system the designers could check the availability of their counterparts. This practice corresponds with the recommendations by Poltrock and Engelbeck [1999] for an open video link between distributed workplaces, and led to the development of the video snapshots.

To provide a live image of themselves, the designers have to execute an image server program, e.g. WebCam2000, on their computers. The program serves live, still images from the video capture device connected to the computer, i.e. the WebCam, to the network. When a designer opens the video snapshots window, the system requests a new image every 20 seconds from the computers of all team members. If the team members have the WebCam2000 program running, their images will be displayed, as shown in Figure 5.7.

Figure 5.7: DiDeas Video Snapshots

Figure 5.7 shows the workplaces of the three team members via the video snapshots system. Two designers, Andreas and Charl, can be seen sitting in front of the camera, while the third designer, Liu, is currently not at his workplace. As with the DiDeas message board, the video snapshots are displayed in a separate window, which can remain open during the entire design session.

5.5 File Upload in DiDeas

There are two options for uploading files from the designer's computer or network to the DiDeas system.

5.5.1 File Upload for the Function-Concept Structure

The file upload for the function-concept structure is described in detail in Section 4.4.3.

5.5.2 File Upload for the DiDeas Shared Workspace

The second tool for file exchange is the DiDeas Shared Workspace. It functions as a 'drop zone', where designers can quickly store files of interest for the whole team. Personal experience and the positive results from the case study on synchronous and asynchronous collaboration led to the implementation of this feature into the Distributed Design Assistant. Since the DiDeas system is hosted on a web-server, files can be uploaded directly into a directory on this server. This provides two advantages:

- no external software has to be activated by the user, and
- additional information regarding the file and the user can be transmitted.

Figure 5.8 illustrates the DiDeas shared workspace.

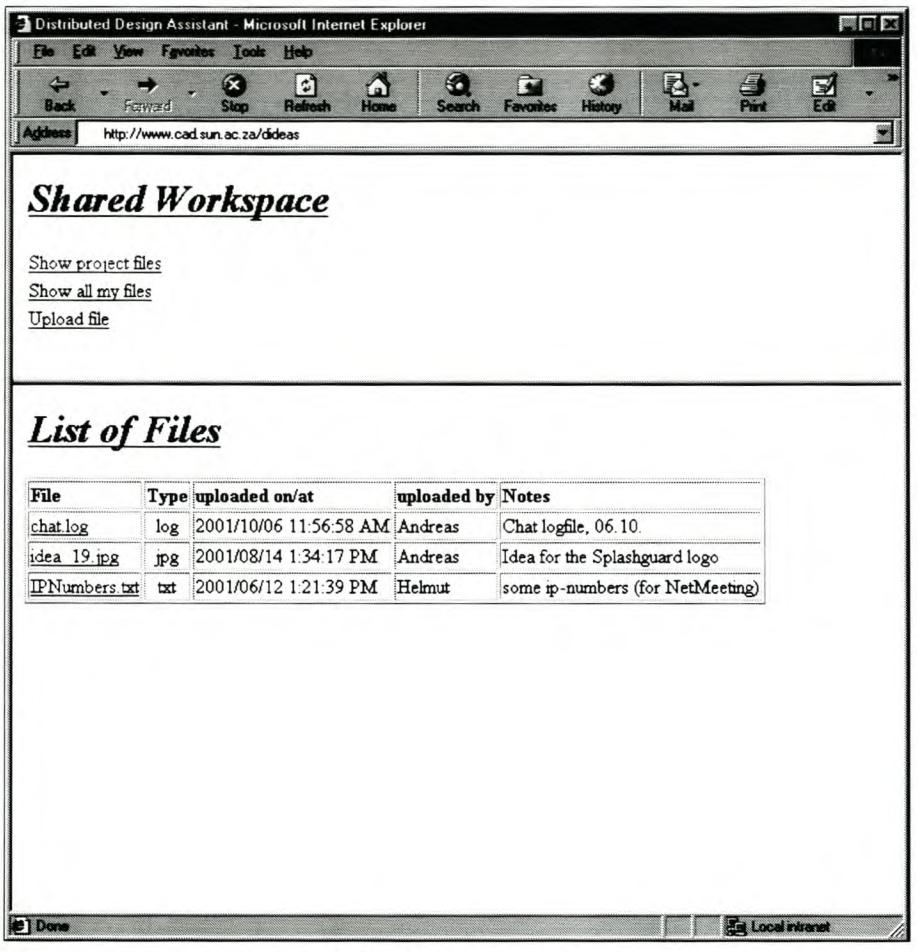


Figure 5.8: DiDeas Shared Workspace

The top frame offers three options to the user. He/she can display all files uploaded for the current project, i.e. files uploaded by all participating designers, as shown in the bottom frame. The second choice is to list the user's own uploaded files for all projects. In both cases the list contains information about when and by whom the file was uploaded, as well as a short description or comment. This additional information sets the DiDeas shared workspace apart from traditional shared workspace environments using a simple FTP upload without any direct possibility to attach or display file or user information.

The third hyperlink directs the user to the file upload, similar to the concept upload to the function-concept structure. The file upload frame is displayed in Figure 5.9.

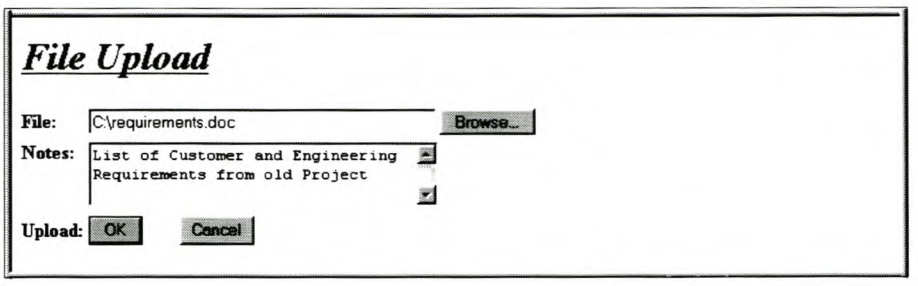


Figure 5.9: File Upload to the DiDeas Shared Workspace

The user can specify a file by location or via a browser. Furthermore, a comment or short description can be entered. By clicking the 'OK' button, the file will be uploaded to the web-server and the information added to the database. Details about the shared workspace implementation are given in Chapter 7.5.

5.6 Personal Notes

The personal notes are not intended for the exchange of information between designers, but rather serve as an information repository for each individual user. A personal note can only be viewed by the designer who created it. In this way the designers can collect ideas or comments in the DiDeas system without sharing them with the other team members. The user can assign a personal note to any of his/her projects, or keep it as a project independent note. The personal notes will be listed according to their project affiliation.

Figure 5.10 shows the list of personal notes for a particular designer in the top frame and the personal notes editor in the bottom frame.

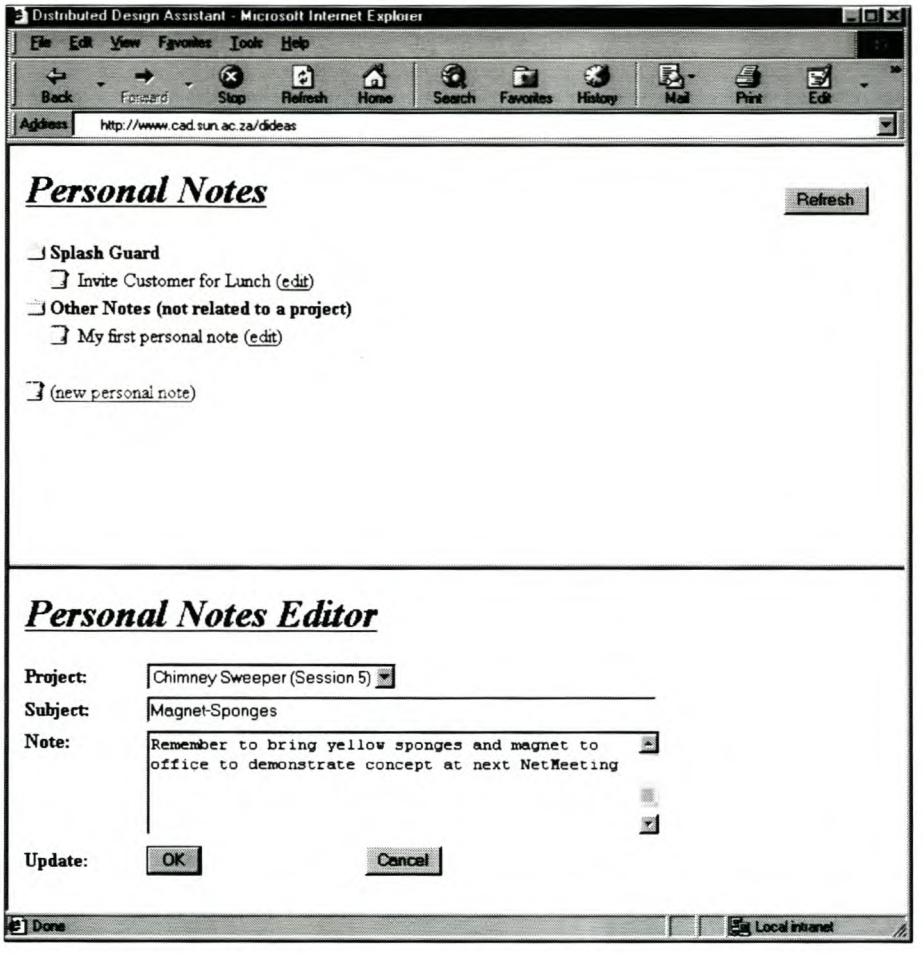


Figure 5.10: List of Personal Notes and Personal Notes Editor

After clicking on the 'new personal note' hyperlink at the end of the list of personal notes, the personal notes editor opens in the bottom frame. A project name or 'no project' can be selected from the drop-down menu. The subject line is entered, as well as the content of the note. By clicking the 'OK' button, the entered information will be added to the database.

5.7 Tools not implemented in the Distributed Design Assistant

Two of the communication and information transfer tools discussed in this chapter have not been integrated into the Distributed Design Assistant.

5.7.1 Desktop-Videoconferencing

It would have been desirable to automatically start a videoconference with one or more team members by clicking on a button or hyperlink in the DiDeas system. However, since both the investigated desktop-videoconferencing tools are independent software applications, a direct integration into the Distributed Design Assistant is not possible.

Also the execution of software outside the DiDeas system via ASP is impossible due to security reasons.

5.7.2 Electronic Mail

It is anticipated that the incorporation of e-mail into the DiDeas system will have a positive effect on the team performance, since the designers will not have to change between software anymore and all exchanged information becomes accessible via the Distributed Design Assistant. However, an e-mail system could not be implemented into the DiDeas system due to limitations of the web-server used for the development of the Distributed Design Assistant.

CHAPTER 6

INPUT DEVICES FOR CONCEPTUAL DESIGN

6.1 Introduction

Distributed conceptual design makes special demands on the input devices used. While standard tools, such as a mouse and a keyboard, meet the requirements of subsequent stages of the design process, e.g. CAD during the detailed design phase, they are often impractical in creating or annotating sketches.

The case study on synchronous and asynchronous collaboration (see Chapter 5.2) confirmed the advantages of pen-based sketch input, either by using a graphic tablet or by scanning a traditional pencil-paper-sketch, over standard input devices, such as the computer mouse. The main results are presented and discussed.

The investigation was limited to low-cost tools, suitable for small to medium enterprises.

6.2 Pen and Paper

The designers participating in the case study (see Chapter 5.2) clearly favoured pen-based sketching above the use of the computer-mouse. They created more than 120 paper sketches, but only utilized the computer mouse for a few sketches (an attempt is shown in Figure 6.1).

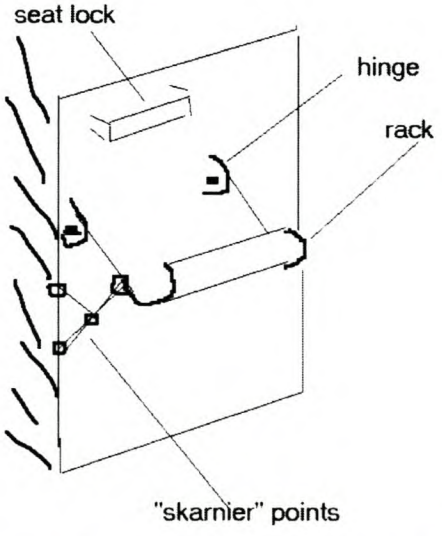


Figure 6.1: Sketch created by using the computer mouse

Drawings and sketches on paper can be faxed to team members, or scanned on a flatbed scanner and electronically distributed, e.g. as an e-mail attachment or via a shared workspace. A disadvantage is the need for an additional step to transform the paper sketch into an electronic file.

In the case study a large number of paper sketches were not shared with other team members. This indicates a lack of suitable tools and methods for distributing such data.

6.3 Graphic Tablet with Pen

Two input devices were tested by the author and during the case study. They combine the speed and ease of pen and paper with the comfort and productivity of a computer supported system.

The portable 'CrossPad' digitizer notepad from the CrossPen Computing Group, shown in Figure 6.2, allows the user to take notes and to make sketches on regular paper, while a digital copy of up to 80 pages is stored in the device for later transfer to and processing on a computer.

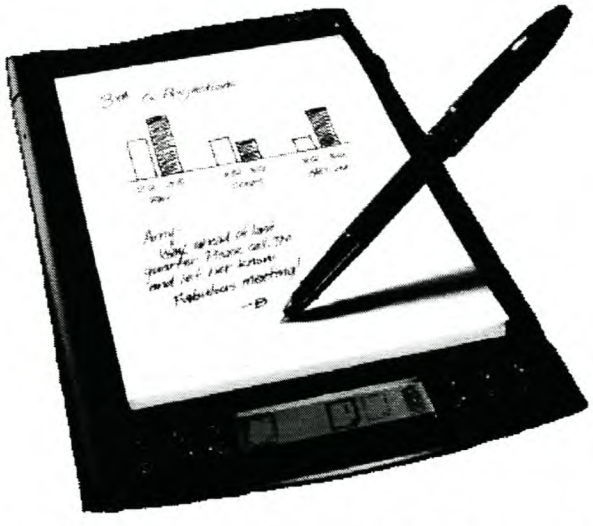


Figure 6.2: 'CrossPad' [CrossPen Homepage, 2000]

For two reasons the 'CrossPad' does not suit the requirements for idea generation during conceptual design. Firstly, it focuses on text input and handwriting recognition, and secondly, there is a lack of third-party applications for sketch manipulation. The 'CrossPad' has subsequently been discontinued, but similar products, such as the IBM 'TransNote' (see Figure 6.3), have emerged.

Figure 6.3: IBM 'TransNote' [IBM Homepage, 2001]

The second device investigated was the WACOM 'Graphire' graphic tablet with pen, a tool mainly used by graphic designers, e.g. for animated movies. Figure 6.4 shows the WACOM 'Graphire' graphic tablet with pen and mouse.

Figure 6.4: WACOM 'Graphire' Graphic Tablet [WACOM Homepage, 2001]

During the case study on synchronous and asynchronous communication, the benefits of the graphic tablet for distributed conceptual design were confirmed. With a little practice, the quality of the sketches was comparable to pencil sketches. It is even possible to combine graphic tablet annotations and pencil sketches, as illustrated in Figure 6.5.

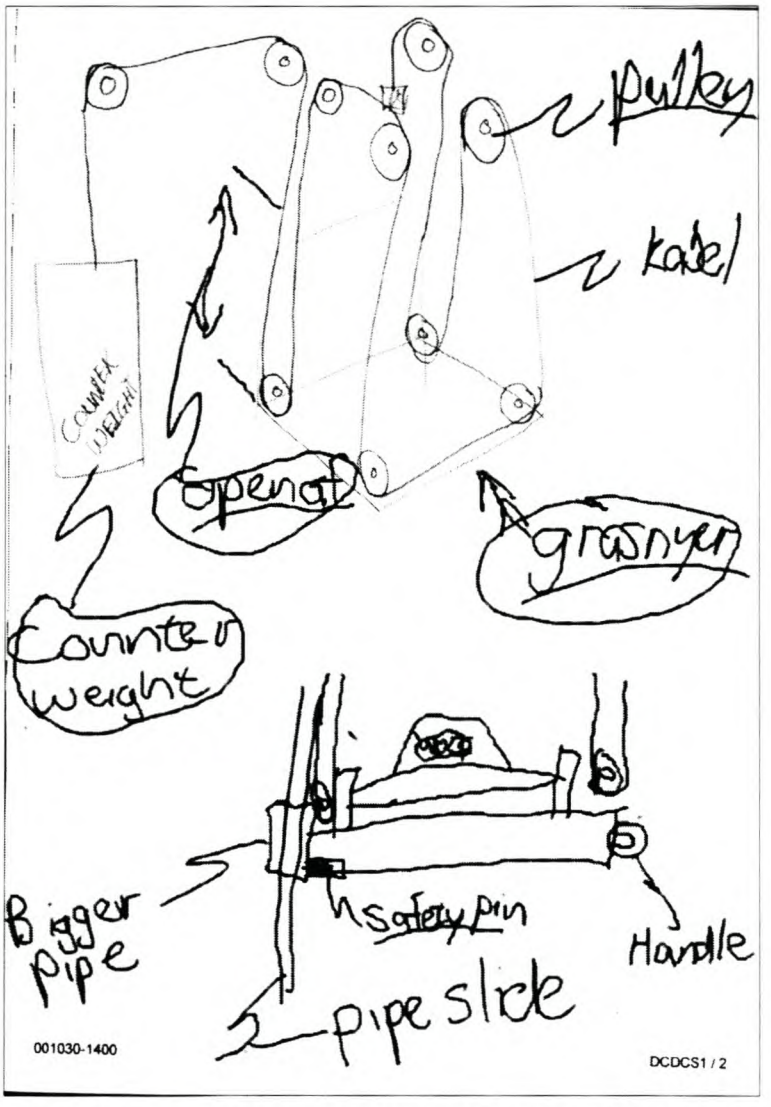


Figure 6.5: Sketch created by using Pen and Paper and the Graphic Tablet

The pen and paper sketch of a pulley system on scribble paper (Figure 6.5 top) was scanned and transmitted via e-mail. The recipient annotated the pulley system and added the sketch of the pipe-sliding mechanism (Figure 6.5 bottom) by using the 'Graphire' graphic tablet. A particularly helpful feature of the tablet is the pressure-sensitive tip, which, in contrast to the non-pressure-sensitive 'CrossPad', gives the sketches a 'natural look'.

6.4 Digital Camera and WebCam

Digital cameras and WebCams can also be used, apart from filming designers during a videoconference, to capture and transmit design information in the form of sketches, notes on white-boards, and three-dimensional mock-ups. Pictures from a videoconference between students located in the USA and Japan illustrate the

discussion of 3D objects (Figure 6.6) and a brainstorming session utilizing a traditional whiteboard (Figure 6.7).

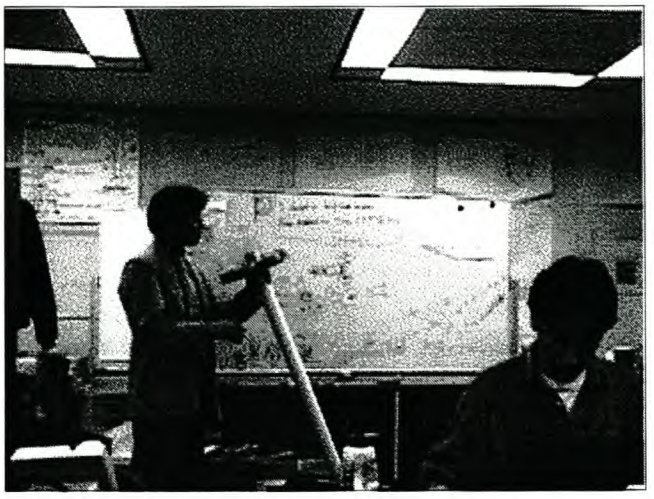


Figure 6.6: Mock-Up via WebCam

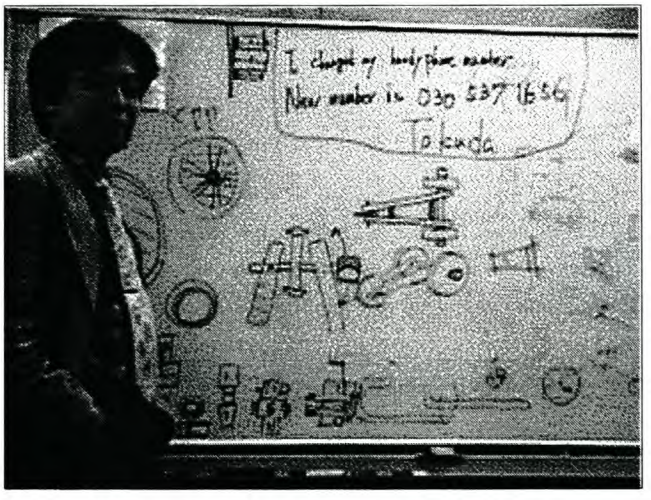


Figure 6.7: Whiteboard via WebCam

The videoconference took place during a design project, as part of the ME210 course [ME210 Homepage, 2001] at Stanford University, USA.

6.5 Electronic Whiteboard

Another device that can improve the quality of distributed design is an electronic whiteboard, such as the 'Mimio' system from Virtual Ink [Virtual Ink Homepage, 2001]. Sketches and text scribbled on this type of whiteboard, e.g. during a brainstorming session, can easily be captured and exchanged between team members.

CHAPTER 7

IMPLEMENTATION DETAILS

7.1 Introduction

The support of multiple, distributed designers, working on various design projects, makes high demands on the functionality of the system, on the management of users and projects, on the structure of the database, as well as on assisting the designers by the means of support tools and an intelligible user interface. These elements and their implementation are described in the following section.

7.2 Programming Languages

Two different programming language approaches were investigated for implementing the Distributed Design Assistant.

7.2.1 MIDAS and Borland C++ Builder

The Design Assistant [Schuster, 1997] was developed in Borland Delphi. Since the Design Assistant and the Distributed Design Assistant provide the same functionality for a number of their features and would therefore require a similar user interface and database control, the initial intention was to use the same, or a related, programming language, e.g. Borland C++ Builder. The main criterion for the selection of the programming language was its capability for simultaneous, distributed multi-user access to a database system over a network. Borland only offers this feature with its MIDAS (Multi-Tier Distributed Application Services) technology, which is included in the C++ Builder Enterprise Edition. Another criterion was the suitability of the Distributed Design Assistant for small to medium companies. However, each server hosting the DiDeas system and each client using it would require a separate license. A license for unlimited users is available for US$5,000 per server, i.e. for each company who wants to independently use the Distributed Design Assistant [Borland Homepage, 2001].

Furthermore, the platform independence is an important aspect in distributed design. Not every designer participating in a distributed project does necessarily work on computers with the same operating system. It would be not feasible to develop or compile the Distributed Design Assistant for different platforms

An additional reason for not choosing Borland C++ Builder for developing the DiDeas system was the price of the software (R12,199.99), which did not fit the research budget.

Therefore another development technology had to be found.

7.2.2 Microsoft Active Server Pages and HyperText Markup Language

Microsoft Active Server Pages (ASP) is a technology that combines HyperText Markup Language (HTML), server-side scripting and Component Object Model (COM) objects in order to create dynamic and interactive web applications.

Active Server Pages include HTML code and scripts written in script languages such as Visual Basic Script or Java Script. ASP allows for the access and manipulation of Open Database Connectivity (ODBC) compliant databases such as Microsoft Access and Oracle, residing on the web-server. The scripts are executed on the server, in contrast to client-side scripts such as JavaScript functions, often used for special effects or form validation.

7.2.2.1 The 2 Steps of HTML

The process of downloading and displaying a HTML page can be divided into two simple steps, as illustrated in Figure 7.1.

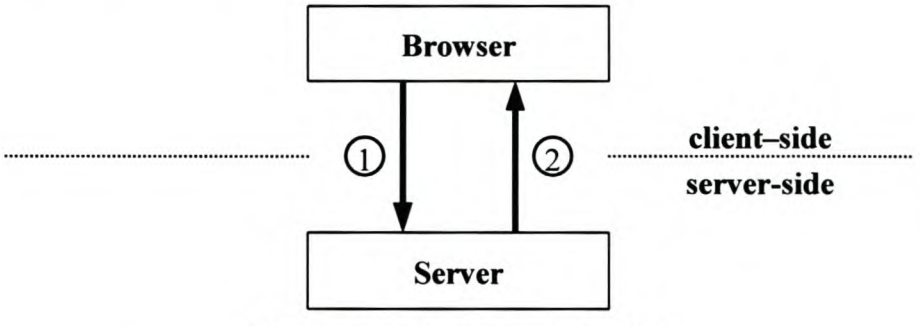


Figure 7.1: The 2 Steps of HTML

Step 1: The web-browser requests a HTML page from the server.

Step 2: The server returns the HTML code to the web-browser, where it is rendered and displayed.

A HTML page is static, i.e. only the content can be transmitted that has been written into the code of the HTML page. It cannot be modified dynamically by the user.

7.2.2.2 The 7 Steps of ASP

The process of displaying dynamic content, i.e. information the user can affect, via Active Server Pages, is more complex than with the HTML pages described in the previous section. It involves seven steps, as illustrated in Figure 7.2.

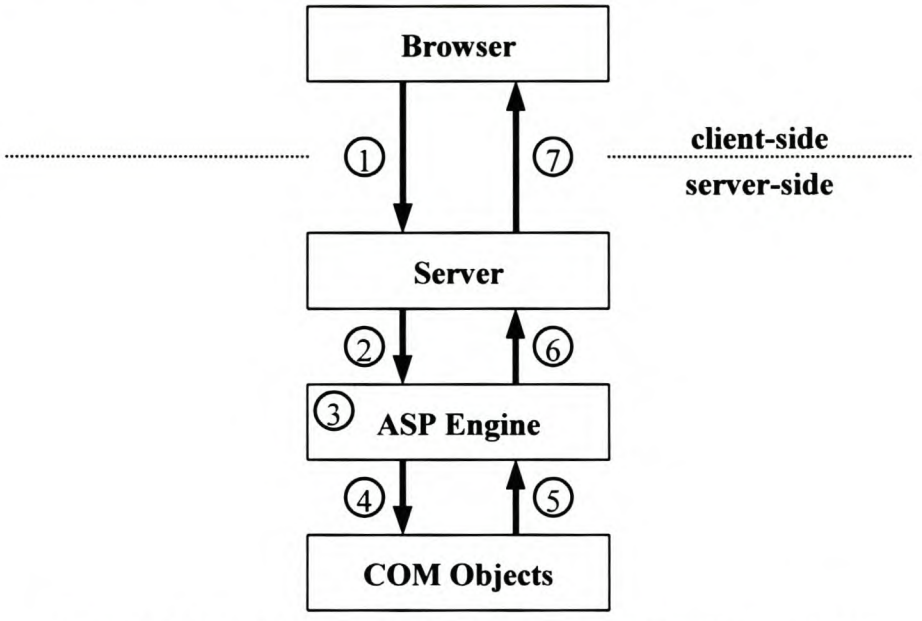


Figure 7.2: The 7 Steps of ASP [adapted from Kauffman, 1999]

Step 1: The web-browser requests an ASP page from the server.

Step 2: The server sends the requested ASP page to the ASP engine of the web-server.

Step 3: The ASP engine executes the server-side scripts contained in the ASP page.

Step 4: The ASP engine calls any COM objects, e.g. a connection to a database.

Step 5: The COM objects are executed.

Step 6: The ASP engine returns the generated HTML code to the server.

Step 7: The server returns the HTML code to the web-browser, where it is rendered and displayed.

7.2.2.3 Advantages and Disadvantages of ASP

Active Server Pages offers a number of benefits, but also contains some drawbacks, as described by Kauffman [1999]. The main advantages are:

+ Universal readability: the output created by Active Server Pages is usually pure HTML text and tags. HTML code, if compliant with the most recent

specifications laid down by the W3 consortium, can be interpreted by all web-browsers. This also means platform independence for the clients, since the HTML code is not operating-system specific, and web-browsers exist for almost all platforms.

+ Source code protection: only the results of the scripts contained in the ASP are returned to the user, but not the code of the ASP itself. This means that the user cannot see how the HTML code was generated nor download the Active Server Pages itself.

+ Easier coding and debugging: Active Server Pages can be written in a standard text editor, such as NotePad. More advanced editors are available, e.g. Microsoft FrontPage.

+ Innumerable resources: since Active Server Pages is a Microsoft product, it has attracted a vast number of programmers, testers, users and authors. Countless web sites are devoted to Active Server Pages and offer comprehensive support material.

The main disadvantages of Active Server Pages are:

- Multiple trips to the server: the server-side scripts are not downloaded, they remain on the server. For repeated operations, e.g. calculations, multiple requests have to be sent to the server and multiple results have to be sent back to the client. This causes increased traffic on the network and increased workload for the server.

- Costs for components: Although Active Server Pages is a free technology, commercial components, e.g. for e-mail applications or file transfer, are not free of charge.

- Limited server platform independence: ASP is a Microsoft solution for Microsoft operating systems. Additional commercial software is required to implement an ASP server on other platforms.

7.2.3 Structured Query Language

The Structured Query Language (SQL) allows the user to access and manipulate data in relational databases, such as Microsoft Access. The designers working with the

Distributed Design Assistant do not need to have any knowledge of SQL, since all SQL commands are generated by the scripts included in the ASP pages.

7.2.4 From User Input to HTML Output

The following section illustrates the process from data input by the user to the return of HTML code to display the data. The identical number of steps as in Section 6.2.2.2 is coincidental.

Step 1: The designer wants to add a new customer requirement. He/she requests the requirement editor by clicking on the corresponding hyperlink 'add requirement'.

Step 2: The server returns the HTML code for the requirement editor page to the web-browser, where it is rendered into the requirement editor page.

Step 3: The designer enters the customer words and requirement notes in the provided text fields, and selects the importance from the drop-down menu.

Step 4: By clicking the 'OK' button the entered information is sent to an ASP page specified in the source code of the requirement editor page. Attached to this information is hidden data about the designer (User ID) and the requirement heading of the new requirement (Heading ID). All data is transmitted within the Uniform Resource Identifier (URI, also known as Uniform Resource Locator or URL), the address of the ASP page. This looks as follows:

```
http://www.cad.sun.ac.za/dideas/req_insert.asp?UserID=1&HeadingID=27&Requirement=Text%20of%20Customer%20Words&ReqmntNotes=Text%20of%20Requirement%20Notes&Importance=3
```

The first part of the URL (http://www.cad.sun.ac.za/dideas/req_insert.asp) specifies the actual location of the ASP page. After the '?' and separated by a '&' the variable names and values are attached (UserID=1, HeadingID=27, etc).

Step 5: The script in the ASP page reads the variables and processes them according to the instructions. For adding a new customer requirement, a

connection to the database is established and a SQL-string to insert the new requirement is generated using the transmitted variables and additional data, e.g. the date. The SQL command is executed, and the database connection is closed again. The SQL string looks as follows:

```
INSERT INTO tblReqmntData (UserID, HeadingID,
Requirement, ReqmntNotes, Importance, CreateDate)
VALUES (1, 27, 'Text of Customer Words', 'Text of
Requirement Notes', 3, #01.05.2001#)
```

The date is determined by a command in the script code.

Step 6: The requirement is now stored as a new entry in the database. To display the requirements, the designer would click on the 'Refresh' button of the customer requirements page. The button is actually a hyperlink to an ASP page to display the customer requirements. After the request for this page the script is executed. The first step is to determine the IP address, a unique identification, of the requesting computer. After establishing a new connection to the database, the 'ProjectID' of the user related to the IP address is determined via SQL. Next, all customer requirement headings for the current project are selected from the database, and for each of the headings the related requirement information.

Step 7: At last the HTML code for displaying the customer requirements in an organized manner, including the requirement headings, the icons to represent the importance and all necessary hyperlinks to edit existing or to add new items, is generated and returned to the web-browser of the client. The web-browser finally renders the HTML code into the customer requirements list.

7.3 Hardware and Software Requirements

The hardware and software requirements for the Distributed Design Assistant can be divided into two categories: server requirements for the web-server computer and client requirements for a computer used as a client.

7.3.1 Server Requirements

The server to host the DiDeas system has to be a Microsoft Internet Information Server (IIS) or Personal Web Server (PWS). This restricts the operating system to Microsoft Windows (from Microsoft Windows95 upwards). Commercial software packages, e.g. 'Sun Chili!Soft ASP', make it possible to run Active Server Pages on a number of other platforms, such as Unix and Linux.

7.3.2 Client Requirements

The client computer is not restricted by the operating system. A network connection to the ASP and database server is necessary. This connection can be an Internet or intranet connection. The Distributed Design Assistant has been tested successfully on Microsoft Internet Explorer IE5.5 and Netscape Communicator 4.76. Other browsers compliant with the most recent HTML specifications laid down by the W3 consortium are expected to perform equally well.

7.4 Database Design

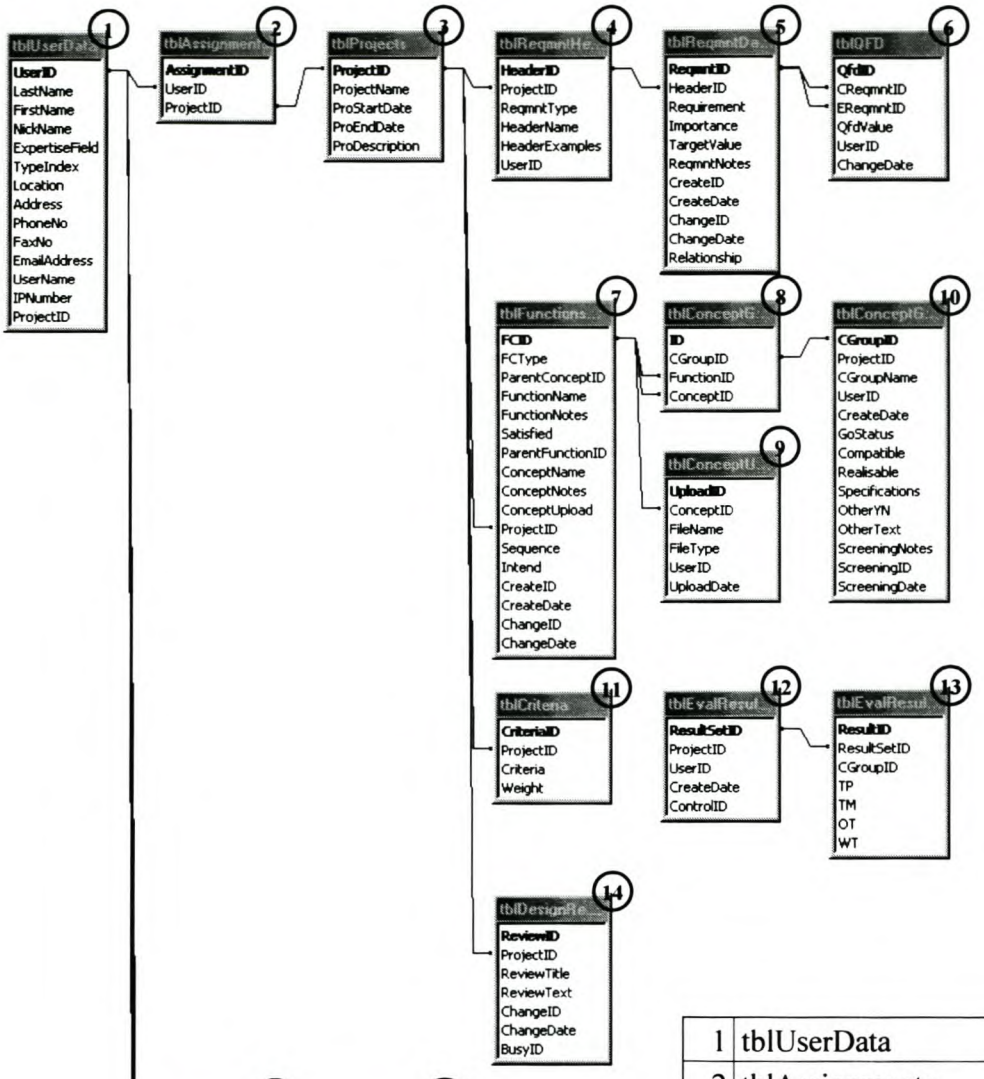
A relational database is the main component of the DiDeas system.

7.4.1 DiDeas Database Server

The web-server hosting the DiDeas system during development and evaluation was a Microsoft Internet Information Service 4 (IIS4), running on Microsoft Windows NT4 (Service Pack 6). The DiDeas database was a relational Microsoft Access2000 database.

7.4.2 Database Structure

The Microsoft Access2000 database of the Distributed Design Assistant consists of 19 tables, as shown in Figure 7.3.



1	tblUserData
2	tblAssignments
3	tblProjects
4	tblReqmntHeaders
5	tblReqmntData
6	tblQFD
7	tblFunctionsConcepts
8	tblConceptGroupItems
9	tblConceptUploads
10	tblConceptGroups
11	tblCriteria
12	tblEvalResultSets
13	tblEvalResultData
14	tblDesignReviews
15	tblMessages
16	tblMsgRecipients
17	tblSMS
18	tblPersonalNotes
19	tblSWorkspace

Figure 7.3: DiDeas Database Structure

The database of the Distributed Design Assistant is a relational database. All tables within the database share common attributes, which make it possible to link tables together. For example, the attribute ProjectID uniquely identifies one project. The definition of the project in terms of the project name, start and finish date, and a short description is done in the table tblProjects, as shown in Table 7.1.

ProjectID *	ProjectName	ProStartDate	ProEndDate	ProDescription
1	Dental Chair	01.04.01	31.12.01	Design and manufacture a dental chair that can handle a patient in a wheelchair, without requiring the patient to leave or adjust his chair at any time
2	Splash Guard	01.06.01	31.10.01	Rain Protection for Bike
3	Chimney Sweeper (S1)	10.09.01	10.09.01	Device to clean the glass collector of the Solar Chimney
4	Chimney Sweeper (S2)	11.09.01	11.09.01	Device to clean the glass collector of the Solar Chimney
5	Chimney Sweeper (S5)	17.09.01	17.09.01	Device to clean the glass collector of the Solar Chimney

Table 7.1: Project Information on the Table tblProjects

The ProjectID in the first column of Table 7.1 is a 'Primary Key', a unique identification number for each row of the table and therefore for each project of the DiDeas system. The primary key is indicated by an asterisk behind the attribute name. To ensure uniqueness, the data type 'AutoNumber' is selected for the primary key. Each new project is automatically assigned a new unique number, i.e. each number appears only once in this column.

To link project entities in other tables, e.g. in the table tblDesignReviews for the design reviews, to a project, it is not necessary to repeat all information for the project in this table. Instead, only the project identifier or primary key, i.e. the ProjectID, is used.

The attribute UserID appears in twelve other tables besides tblUserData. In some cases the attributes have different names, e.g. the attributes CreateID and ChangeID in the table tblReqmntData. Both these attributes contain UserIDs and can be linked to the UserIDs in the table tblUserData.

7.4.3 Generating the Function – Concept Structure

Of particular interest in terms of database design is the function-concept structure, which is displayed and modified during the functional analysis and concept generation, as well as displayed for the concept design selection. The structure consists of the overall function, alternative concepts and their determining functions. The level of decomposition has to be unlimited, even if in general practice only a few levels of the structure are to be used. This allows for complex systems to be analysed and to be broken down to the last component.

Two approaches have been identified to realize the function-concept structure.

The first approach for the layout of the database structure and the generation of the function-concept structure via ASP allows for separate database tables for functions and concepts. This has advantages in terms of the structure and the readability of the database tables. However, it would require additional tables to define the parent-child relationship for the functions and for the concepts. The position of each function and concept in the function-concept structure has to be calculated every time the user refreshes the displayed structure.

The second approach lists all functions and concepts in the same database table, together with their positions in the function-concept structure. An excerpt of the table tblFunctionsConcepts is shown in Table 7.2.

FCID *	FCType	ParentConceptID	FunctionName	ParentFunctionID	ConceptName	Sequence	Intend
1	F	0	Keep Water of the Cyclist			0	0
2	C			1	Plastic Fender	1	1
3	C			1	Brushes	14	1
4	F	2	Attach Fender			2	2
5	F	2	Hold Fender			5	2
6	F	2	Detach Fender			7	2
7	F	2	Deflect Water			10	2
8	F	3	Attach Brushes			15	2
9	F	3	Hold Brushes			18	2
10	F	3	Detach Brushes			21	2
11	F	3	Brush off Water			24	2
12	C			4	use a Tool	3	3
13	C			4	do not use Tool	4	3
14	C			5	Clip	6	3
15	C			7	Fender Shape A	11	3
16	C			6	use Tool	8	3
17	C			6	do not use Tool	9	3
18	C			8	use Tool	16	3
19	C			8	do not use Tool	17	3
20	C			9	Clip	19	3
21	C			9	Screws	20	3
22	C			11	2 Brushes	25	3
23	C			10	use Tool	22	3
24	C			10	do not use Tool	23	3
25	C			7	Fender Shape B	12	3
26	C			7	Fender Shape C	13	3
27	C			11	3 Brushes	26	3

Table 7.2: Database Table tblFunctionsConcepts (excerpt)

The attribute 'Sequence' specifies the vertical position or row in the function-concept structure. The sequence number is unique within a project. The attribute 'Intend' specifies the horizontal position, i.e. the level of decomposition. The value '0' for the sequence and intend is reserved for the overall functions. Odd intend values indicate a

concept and even values indicate a function. It is possible to read the data for the entire function-concept structure, including the position of each item, from the table tblFunctionsConcepts by using a single SQL-statement. The function-concept structure generated from the 27 entries displayed in Table 7.2 looks as follows:

Sequence	**Intend = 0**	**Intend = 1**	**Intend = 2**	**Intend = 3**
0	Keep Water of the Cyclist			
1		Plastic Fender		
2			Attach Fender	
3				use a Tool
4				do not use Tool
5			Hold Fender	
6				Clip
7			Detach Fender	
8				use Tool
9				do not use Tool
10			Deflect Water	
11				Fender Shape A
12				Fender Shape B
13				Fender Shape C
14		Brushes		
15			Attach Brushes	
16				use Tool
17				do not use Tool
18			Hold Brushes	
19				Clip
20				Screws
21			Detach Brushes	
22				use Tool
23				do not use Tool
24			Brush off Water	
25				2 Brushes
26				3 Brushes

Table 7.3: Function-Concept Structure created from tblFunctionsConcepts

To insert a new record, i.e. a function or concept, into the structure, its position is determined, the correct sequence number allocated and the sequence numbers for all following entities of the project are increased by one.

Since this approach does not require a re-calculation of all positions in the function-concept structure each time the structure is displayed, it is much faster than the first approach and has consequently been implemented into the Distributed Design Assistant.

The actual realization of the function-concept structure required a few additional SQL-statements for aesthetic reasons.

A detailed list of all database entities can be found in Appendix C.

7.5 File Upload

The possibility to upload files to the DiDeas web-server has been implemented in two segments of the Distributed Design Assistant: in the Function-Concept Structure, to attach a file to a concept, and in the Shared Workspace, to upload files to a location accessible by all team members.

To realize the file upload functionality, a third-party component was necessary. These components are often not very affordable and they usually require a registration at the web-server, which makes them cumbersome to work with during project development. A useful alternative became available with the Windows Script Component (WSC) 'MetaBuilders.FileUp.wsc' [Smith, 2001]. This component provides only the basic functionality for a file upload, i.e. the saving of a transmitted file on the web-server and the handling of a few file parameters. It does not need to be registered at the web-server, but can simply be placed in the desired upload directory.

7.6 Speed Comparison

The main factor contributing that determines the speed of the Distributed Design Assistant is the data transfer rate of the network that connects the participating designers and the database sever. The DiDeas system was tested extensively on the Stellenbosch University Network.

An additional test was conducted using an Intel Pentium II 300MHz notebook computer with a 56kByte modem for a remote connection. The notebook computer accessed the DiDeas system via an Internet Service Provider (ISP) and a regular telephone line.

Once the background images and icons were downloaded for the first time and cached, i.e. stored on the client-computer for faster loading, the normal operating speed on the notebook was indistinguishable from the speed on the desktop computers on the

Stellenbosch University Network. As expected, a noticeable decrease in speed on the notebook was detected during the uploading and downloading of files to and from the function-concept structure and the shared workspace system.

For both networks the upload of larger files, over 100kByte, did sometimes result in connection time outs, and the process had to be repeated.

7.7 User Interface

The user interface has to be functional and at the same time user-friendly. The main aspects of the user interface are discussed in the following sections.

7.7.1 Main Window

The main window (see Figure 4.1) is divided into four areas, with the menu frame and the Short Message Information frame on the left and the two working frames on the right. This arrangement does not change throughout the course of the design project and the designer can get used to it quickly.

The layout of all working frames looks similar. A short heading identifies the page unambiguously. Pages with the purpose of listing database entries, e.g. the customer requirements or the function-concept structure, have a 'Refresh' button in the upper part of the frame. Pages where a user input is required, e.g. the engineering requirement editor, have an 'OK' button and a 'Cancel' button at the end of the form. In this way the functionality of a design element, even if new to the user, becomes natural quickly.

7.7.2 Separate Windows

Separate windows were chosen for the 'House of Quality', the 'Message Board', the 'Video Snapshots' and the 'DiDeas Help'.

For the 'House of Quality', the size of the matrix was most important. Only when the 'House of Quality' window was enlarged to its maximum size did it provide the optimum representation of the matrix. To implement it into the working area of the main window, a very small font would have been necessary, which would have a negative effect on the readability of the 'House of Quality'.

The three remaining windows are intended to support the designer throughout the project. It was considered too distracting for the user and too disturbing to the design process if the user had to leave the current step of the design process, then open for

instance the message board, check for new messages, and return to the same location of the design procedure every time he/she expected a message from other team members. Instead, separate windows were created which can be opened in addition to the main window, thereby not interrupting the flow of the design process.

7.7.3 Data Representation

Some elements of the design procedure require a more complex representation of the data. The tree-structures, used several times in the Distributed Design Assistant, and the QFD-matrix of the 'House of Quality' are described in detail in the following sections.

7.7.3.1 Tree-Structures

To provide a better overview, collapsible tree-structures were planned for the customer requirements and the engineering requirements, as well as the function-concept structure and the concept selection structure. However, since this is not a standard component of ASP, it would have required a very complex ASP code and an additional table system in the database to store the user's selection (collapsed or opened) for each level of every tree structure. This would have slowed down the display of the structure considerably. Therefore, it was decided against a collapsible tree-structure and in favour or a simple, non-collapsible tree-structure at this stage of the project. If fast and cheap ASP components become available, the situation should be re-evaluated.

7.7.3.2 QFD-Matrix

One objective of the implementation of the 'House of Quality' was to determine a suitable user interface for such a tool. The QFD-matrix of the Distributed Design Assistant is made up of the customer requirements on the vertical axis and the engineering requirements on the horizontal axis of the matrix.

One possible way of representing the QFD-matrix elements is shown in Figure 7.4.

	Engineering Requirements	Eng. Requirement 1	Eng. Requirement 2	Eng. Requirement 3	Eng. Requirement 4	Eng. Requirement 5	Eng. Requirement 6	Eng. Requirement 7	Eng. Requirement 8	Eng. Requirement 9	Eng. Requirement 10	...
Customer Requirements												
Cust. Requirement 1												
Cust. Requirement 2												
Cust. Requirement 3												
Cust. Requirement 4												
Cust. Requirement 5												
Cust. Requirement 6												
Cust. Requirement 7												
Cust. Requirement 8												
Cust. Requirement 9												
Cust. Requirement 10												
...												

Figure 7.4: 'House of Quality'-Matrix with Rotated Text

Since the engineering requirements are rotated by 90 degrees, it is theoretically possible to scroll the displayed area in all directions, i.e. to scroll left and right to see more engineering requirements, and up and down for more customer requirements. However, in this case the requirements would move out of the visible area when scrolling too far to the right or to the bottom, and it would become very difficult to enter the relationship values properly. This can be avoided by displaying only a limited number of requirements at the same time. By clicking on hyperlinks the designers are able to display the next or previous set of requirements.

The graphic capabilities of the HTML language do not allow for rotated text. Therefore both customer and engineering requirements had to be represented in vertical lists. Here also there is the danger of scrolling the requirements out of the visible area if too many requirements are displayed simultaneously. So the customer and engineering requirements were grouped into sets of requirements, as described above. Ten was identified as the optimum number for a standard screen resolution of 1024x768 pixels. The arrangement of the requirements in the QFD-matrix is illustrated in Figure 7.5.

											Engineering Requirements
											Eng. Requirement 1
											Eng. Requirement 2
											Eng. Requirement 3
											Eng. Requirement 4
											Eng. Requirement 5
											Eng. Requirement 6
											Eng. Requirement 7
											Eng. Requirement 8
											Eng. Requirement 9
											Eng. Requirement 10
Customer Requirements											*Next Set of ERs*
Cust. Requirement 1											
Cust. Requirement 2											
Cust. Requirement 3											
Cust. Requirement 4											
Cust. Requirement 5											
Cust. Requirement 6											
Cust. Requirement 7											
Cust. Requirement 8											
Cust. Requirement 9											
Cust. Requirement 10											
Next Set of CRs											

Figure 7.5: 'House of Quality'-Matrix with Horizontal Text and Hyperlinks

To guide the designer from an engineering requirement to the corresponding column of the matrix, a grid of shaded stripes with a 90-degree angle was included, as shown in the figure above.

7.7.3.3 Automatic versus Manual Page Refresh

Most of the dynamic pages of the Distributed Design Assistant, i.e. the web-pages with content that are modified by the designers or by actions of the designers, can be refreshed or updated manually. An exception is the 'Short Message Info' frame, which is updated automatically every five seconds. In this particular case user interaction is undesirable, because a manual refresh would be counterproductive to the notification system. Some pages, e.g. the message board, provide an automatic refresh in regular intervals and can additionally be updated manually. This strategy was chosen to keep the list of messages updated during normal operations, i.e. when the designer visits the

page only every once in a while. In the case of more intensive activity, e.g. when the message board is used for a chat, the user has the option to update the content more frequently.

7.8 User and Project Registration

Tools for user and project management were not required for the evaluation of the Distributed Design Assistant. Therefore, their implementation had a low priority. At the current stage all permanent user and project data stored in the database tables 'tblUserData', 'tblProjects' and 'tblAssignments' (see Appendix C for details) has to be entered via Microsoft Access2000.

7.9 DiDeas System Tools

A number of tools for the management of users and projects have been implemented into the Distributed Design Assistant. They will be described in the following sections.

7.9.1 User Login and Identification

Every designer who wants to use the Distributed Design Assistant has to be registered in the DiDeas database. To login into the system, a username is required, as shown in Figure 7.6. A password protection is not implemented at this time, but will be necessary for commercial use of the Distributed Design Assistant.

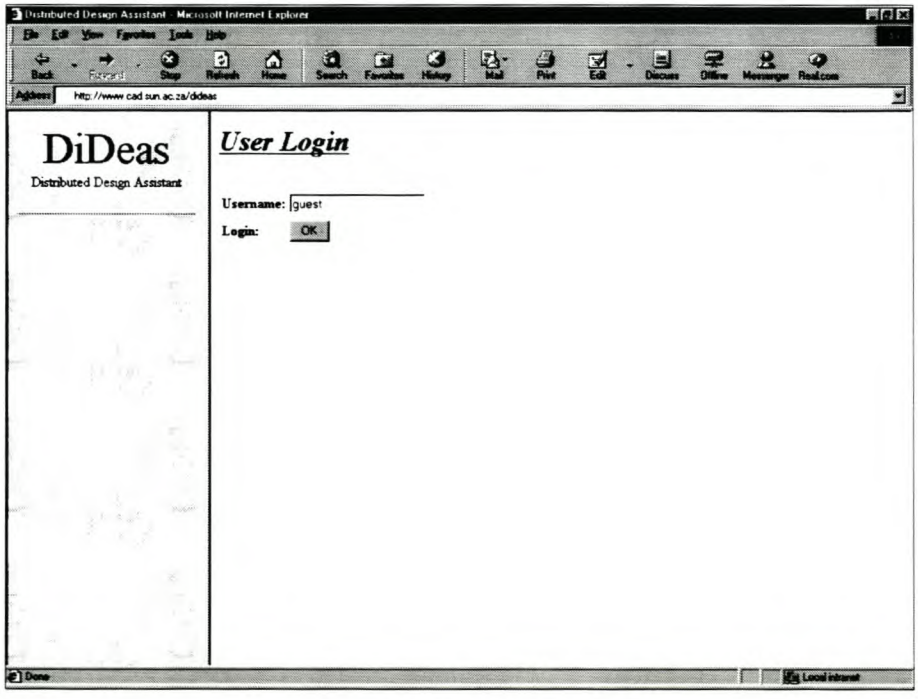


Figure 7.6: User Login

When the user is not logged in, no items are shown in the menu. During the login procedure the designer's computer IP address will be determined and written into the database. As long as the user is logged in to the DiDeas system, he/she will be listed in the database as an active user, working on the computer with the IP number stored in the database. If the designer forgets to log out after a session, he/she will still be listed as 'active', according to the database entry. When the designer logs in with the correct user name for the next design session, the IP number in the database will be updated.

A recurring check whether or not a user logged into the system is actually 'active' was considered too unreliable, since the designer could just have left the workplace for a certain period of time with the intention to return later.

The IP number is used to identify the user during the design process. Whenever the designer's name is required, e.g. for the creation of a new customer requirement or for a concept design screening, the IP number of the computer which sends the request is determined and compared with the IP numbers of the active users.

7.9.2 The Project Manager

Figure 7.7 shows the main window of the Distributed Design Assistant with the second half of the menu on the left and the two project manager frames on the right.

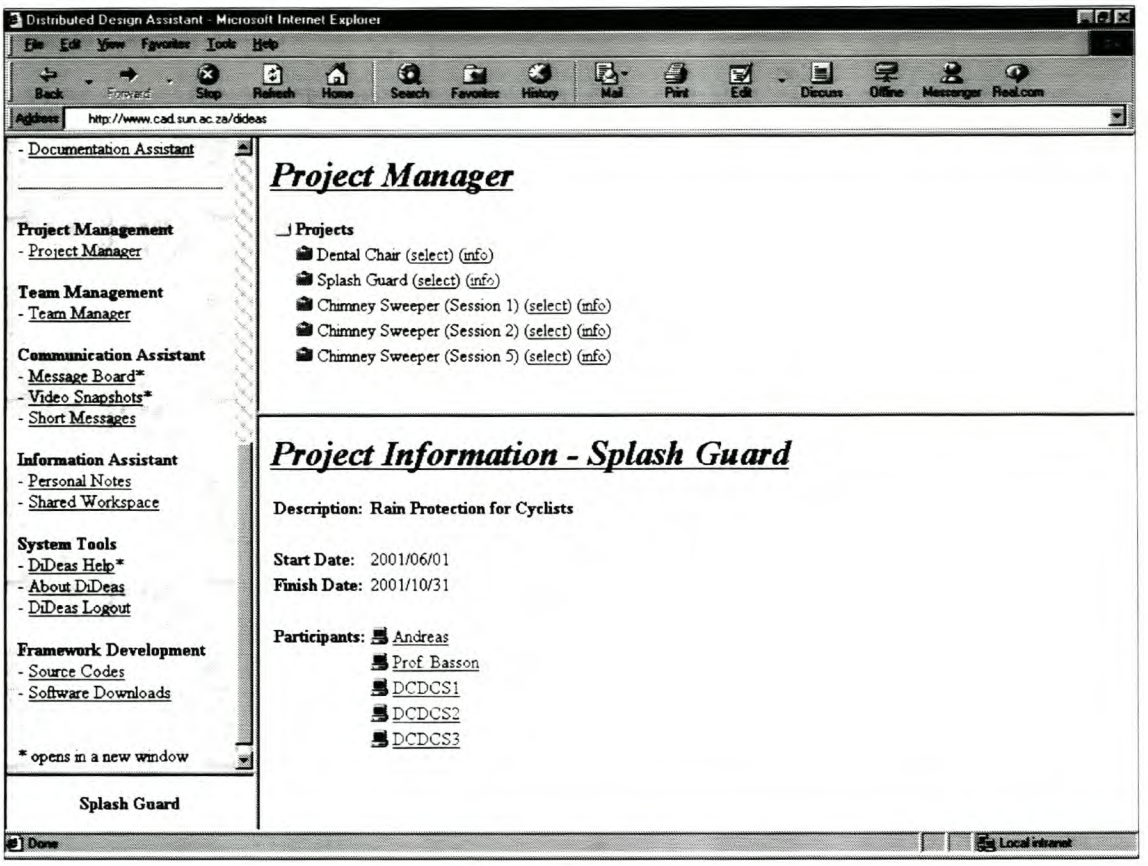


Figure 7.7: 2nd Part of the DiDeas Menu and Project Manager Frames

Every designer in the database is assigned to one or more projects. An exception is the guest account. A person logged in with the username 'guest' cannot participate in any project, but has limited access to some of the elements of the Distributed Design Assistant, e.g. the 'DiDeas Help' and 'About DiDeas pages', for information purposes.

In the project manager the user can select a project from the list of available projects, i.e. projects he/she is assigned to (Figure 7.7 top right). The designer can switch from one project to another at any time. This makes it easy to consult other projects for help regarding the use of the Distributed Design assistant, or to be inspired by previous cases.

The project information frame (Figure 7.7 bottom right) presents a short description of the project, start and finish date, as well as a list of all designers assigned to the project. The icon in front of the nickname of the user indicates whether he/she is currently logged into the system and working on the same project. The nickname provides a hyperlink to additional user information, as explained in the next section.

7.9.3 The Team Manager

The team manager lists all designers registered to the Distributed Design Assistant, as seen in Figure 7.8.

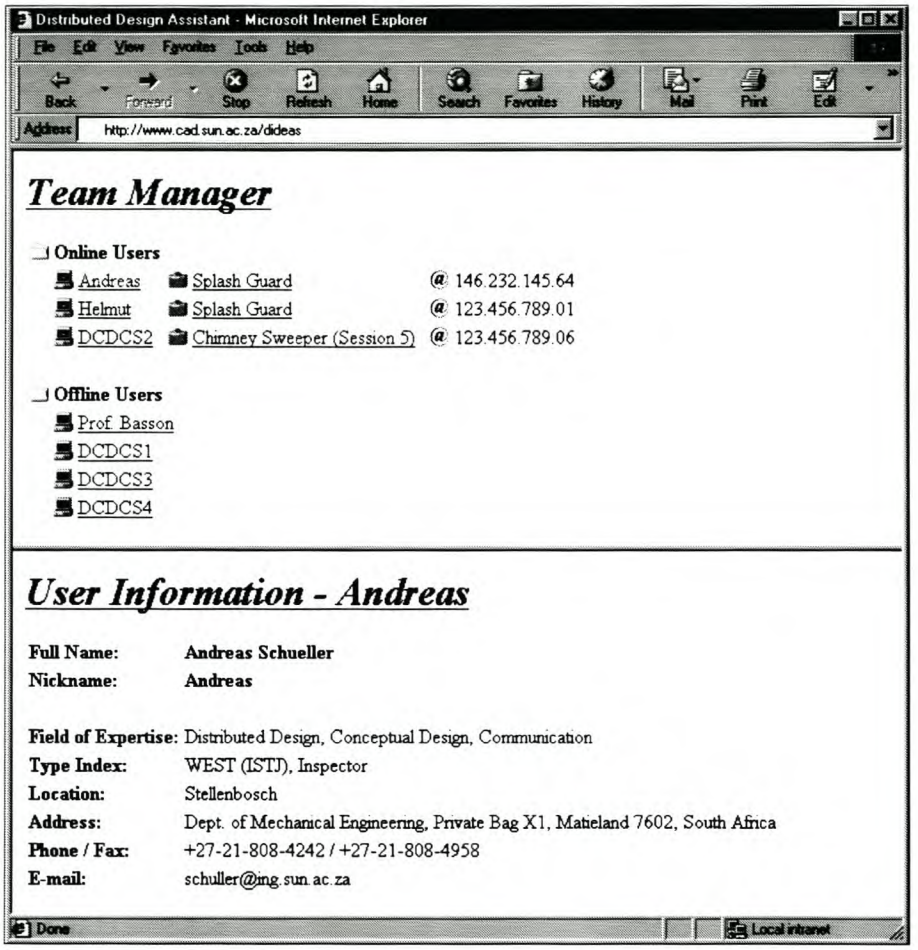


Figure 7.8: DiDeas Team Manager and User Information

For online users, i.e. designers logged into the DiDeas system, additional information in the form of the name of the project he/she is currently working on, and the IP number are shown. The IP number can be used for desktop videoconferencing via Microsoft NetMeeting and CU-SeeMe. For offline users just the nickname is displayed.

In both cases the nickname provides a hyperlink to additional user information. The user information frame displays the designer's full name and nickname, field of expertise, index for the Myers-Briggs Type Indicator, location, address, telephone and fax numbers, and the e-mail address. It can be accessed at any time during a project.

7.9.4 DiDeas Help

A help file was included in the Distributed Design Assistant to support the designers in quickly familiarizing themselves with all elements of the DiDeas system and to provide assistance, if required.

The DiDeas help window is divided into two frames, containing an index in the top frame and the help text in the bottom frame, as shown in Figure 7.9.

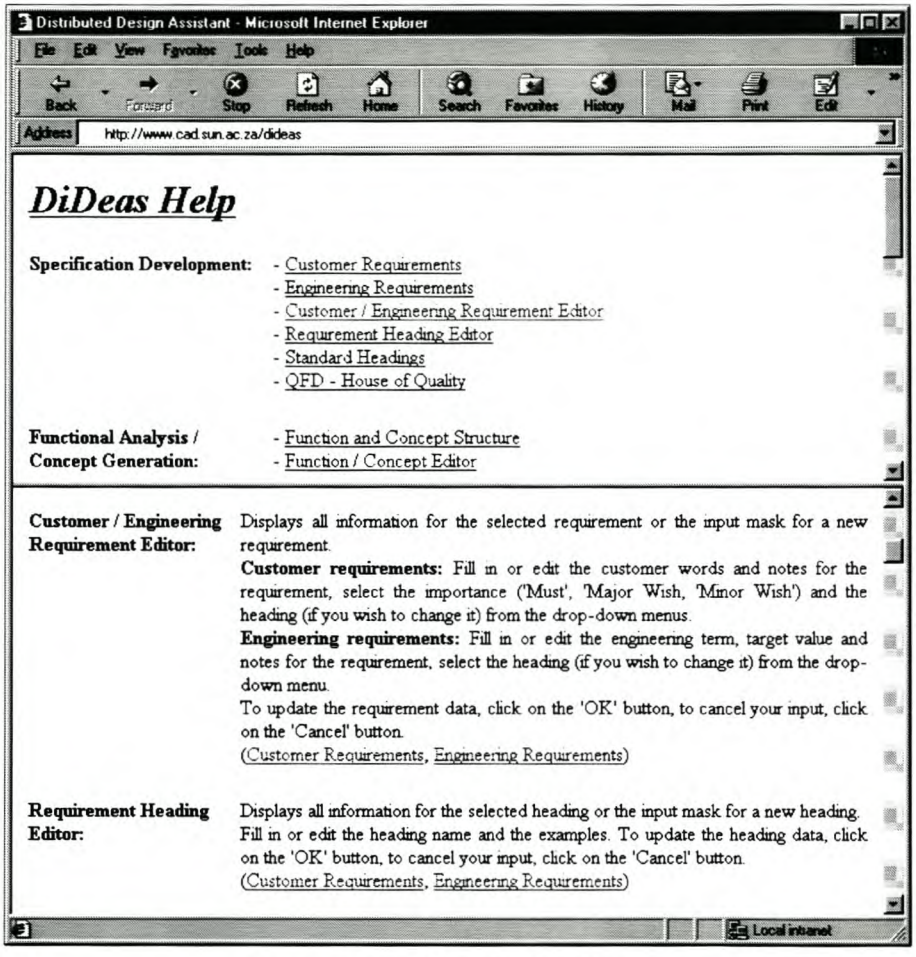


Figure 7.9: DiDeas Help System

By clicking on a hyperlink in the index, the corresponding help text section is shown in the bottom frame. Each section of the help text explains the purpose of the feature and the required user actions. Hyperlinks throughout the help text provide cross-references to related topics.

The DiDeas help system opens in a separate window and can therefore remain open to be easily accessible during the whole design task.

The complete DiDeas help can be found in Appendix D.

7.10 Example Project

It was considered helpful for the designers to implement an example project into the Distributed Design Assistant. This example project can be accessed by any user registered to the DiDeas system. The designers can use is as an introduction to the Distributed Design Assistant, and learn its functionality by browsing through the different elements of the design process integrated into the system.

More experienced designers would probably appreciate a fully developed design project, on which they could fall back for inspiration.

The 'Splash Guard', utilized by Ullman [1997] and Schuster [1997], was chosen as a suitable example. This was done for two reasons:

- the extensive database of Schuster [1997] could be used and easily complemented for employment in the Distributed Design Assistant, and
- a large number of designers are familiar with Ullman's [1997] design procedure and the examples he presented.

The number of projects a designer has access to and visits during the course of a design project can be beneficial to the quality of his/her designs. The lists of requirements developed for other tasks can facilitate the specification development for the current project, and browsing through a different function-concept structure can spark new ideas.

CHAPTER 8

EVALUATION OF THE DISTRIBUTED DESIGN ASSISTANT

8.1 Introduction

A second case study was carried out to evaluate the Distributed Design Assistant. The main objective was to determine whether or not the DiDeas system enhances the productivity of distributed design teams during the specification development and conceptual design stages. The work of a number of design teams using the Distributed Design Assistant was therefore compared to teams working without the DiDeas system.

The following section describes the main aspects of the setup, the evaluation and the results of the case study. The detailed results can be found in Appendix B.

8.2 Case Study Setup

The experience gained during the previous case study (see Chapter 5.3) was invaluable. Most aspects of the setup were adopted for the evaluation case study. Any divergence will be pointed out.

8.2.1 Case Study Participants

A total of 18 postgraduate and undergraduate mechanical engineering students with different levels of design education and experience participated in the case study. The students were recruited from Stellenbosch University, the University of Cape Town and the Cape Technikon. This was done in order to investigate the influence of different design methodology backgrounds. The students were divided into six groups of various configurations in terms of size, experience and software equipment, and each group was to work as a distributed design team during one session:

- Session 1: 3 undergraduate students, using DiDeas
- Session 2: 4 postgraduate students, using DiDeas
- Session 3: 3 undergraduate students, not using DiDeas
- Session 4: 1 postgraduate student, 1 undergraduate student, not using DiDeas

- Session 5: 3 undergraduate students from different universities, using DiDeas
- Session 6: 3 undergraduate students, not using DiDeas.

The group composition was again restricted by the class schedules of the students and a team-building strategy was not implemented. The team leaders for Session 4 and Session 5 were selected based on their higher level of design knowledge, for the other sessions the team leaders were picked at random from volunteering students.

8.2.2 Payment of the Case Study Participants

Again, all participants were invited to a local restaurant for pizzas and refreshments as a gratification for their time and effort. Feedback of the case study results was given and additional comments on the project were exchanged.

8.2.3 Case Study Environment

The environment was the same as in the case study on synchronous and asynchronous collaboration, utilizing five adjacent offices for up to four designers and the fax machine and scanner. The procedures for fax and scanner were identical to the ones implemented in the first case study (see Chapters 5.3.1.4 and 5.3.1.5).

8.2.4 Hardware and Software

All workplaces were equipped with similar hardware and software. However, the equipment differed from the one used in the previous case study.

8.2.4.1 Computers, Operating Systems and Network

The computers ranged from Intel Celeron 333MHz to AMD Athlon 1.3GHz with memory between 64MB and 512MB RAM. The operating system of four computers was Microsoft Windows98, while the fifth computer was running under Microsoft Windows2000. The graphic tablets and some of the WebCams, all of them connected to the computers via the Universal Serial Bus (USB), required Microsoft Windows98 or Windows2000. The computers were connected via the 10Mbit/s Ethernet network of Stellenbosch University.

8.2.4.2 WebCams

The same WebCams as in the previous case study were used (see Chapter 5.3.1.7).

8.2.4.3 Graphic Tablets

Due to the positive experiences made during the previous case study, each designer was provided with a WACOM 'Graphire' graphic tablet with pen (see Chapter 5.3.1.8).

8.2.4.4 Shared Workspace

A shared workspace environment (see Chapter 5.3.1.9) was set up for both DiDeas users and non-users. For the DiDeas users it provided an alternative to the file upload integrated into the Distributed Design Assistant.

8.2.4.5 Software

The following software was installed on all computers:

- Pegasus Mail, for sending and receiving e-mails and attachments
- Microsoft NetMeeting, for one-to-one videoconferences
- CU-SeeMe, for group-videoconferences
- PaintShop Pro, for creating images with mouse and graphic tablet
- Painter Classic, for creating images, with mouse and graphic tablet, supports the pressure sensitive tip of the graphic tablet pen
- ACDSee, for viewing image files
- Microsoft Notepad, for simple word processing
- Microsoft Word, for advanced word processing
- Microsoft Windows Explorer, for file management
- WS_FTP, for file upload to a shared workspace system
- Netscape Communicator, for viewing and downloading of files on the shared workspace system.

The following program was available to the DiDeas users only:

- Microsoft Internet Explorer, for accessing the DiDeas system.

The following program was available to the users working without DiDeas only:

- Microsoft Excel, for generating a 'House of Quality'.

For easy access, links to all programs mentioned above were placed on the desktop.

8.2.5 Case Study Supervision

All sessions of the case study were again supervised by the author.

8.3 Case Study Procedure

The procedure of the evaluation case study followed closely the procedure applied during the first case study (see Chapter 5.3.3). Any divergence will be pointed out.

8.3.1 Introductory Steps

Each session commences with a project and case study introduction and an in-depth explanation of the hardware and software. A comprehensive introduction prior to the case study was not possible due to time constraints.

8.3.2 Systematic Approach

All designers were required to follow a systematic design procedure. The participants using the Distributed Design Assistant were instructed to make use of all methodology features of system. The participants not using DiDeas received a list of steps which they were to follow as closely as possible:

- Specification Development
  - List of Customer Requirement
  - List of Engineering Requirements
  - QFD - House of Quality
- Functional Analysis / Concept Generation
  - Function - Concept Structure
- Concept Selection
  - List of Concept Designs
- Concept Evaluation
  - Concept Design Screening
  - List of Criteria for Decision Matrix
  - Decision Matrix
  - Evaluation Results
- Project Documentation
  - Short Design Review.

The steps were clarified to all participants and examples were given when necessary. The team manager was instructed to ensure that all items on the list were dealt with. A rough time frame was given to help ensure that the teams would complete the task within the allocated four hours.

8.3.3 The Design Task: A Solar Chimney Cleaning System

The final step prior to the commencement of the design part of the case study was again the presentation and the discussion of the task. The case study supervisor acted again as the client or customer of the design team. During the 'fictitious' meeting the client's technical drawings were handed out and the designers could ask questions.

Only a single task had to be performed. In this case, each team had to develop a number of concepts for a cleaning system for the Solar Chimney, a solar power plant currently under development by, among others, the Department of Mechanical Engineering at Stellenbosch University.

The Solar Chimney is made up of a circular glass collector under which heated air flows towards and through a central chimney. A turbine at the base of the chimney is used to produce electricity, as illustrated in Figure 8.1.

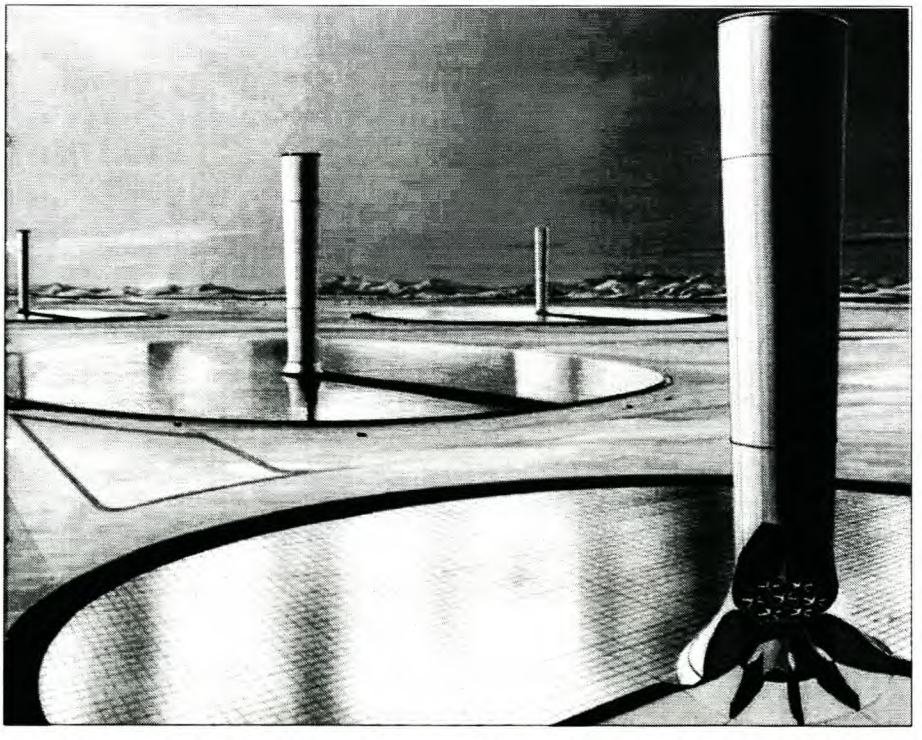


Figure 8.1: The Solar Chimney Power Plant [Schlaich, 1995]

The glass collector has a diameter of four kilometres and consists of approximately two million rectangular glass plates, hanging in steel frames positioned between ten and thirty meters above the ground. Various ideas for a cleaning system were imaginable, from a simple sprinkler system to remote-controlled vehicles moving on top of the collector field.

8.4 Data Acquisition and Reduction

As with the case study on synchronous and asynchronous collaboration, the actions of all case study participants were recorded on videotape and later analysed. The hand sketches and notes on 'scribble paper' as well as the files generated on the computers were collected and investigated. The tools and procedures used for the distribution were also scrutinised.

All e-mails exchanged, telephone calls made and desktop-videoconferences conducted during the case study were identified and categorised as being one or more of the following types:

- 'design-related', if the designers discussed ideas or concepts
- 'communication-related', if for instance a videoconference was arranged or the receipt of an e-mail with attachment was confirmed
- 'procedure-related', if steps of the design procedure were mentioned.

Furthermore, short interviews with the participants during the sessions and a questionnaire completed after the case study provided valuable insight into the personal experiences of the participants regarding the tools and strategies used.

8.5 Evaluation Results

The results of the case study are divided into the three main elements of a support system, i.e. design methodology, communication and information transfer, and input devices for conceptual design, as described in Chapter 3.2. Since the intention of the case study is the evaluation of the Distributed Design Assistant, the sections on communication and information transfer and on input devices for conceptual design will focus on the relation of these elements to the DiDeas system.

It was found that the different numbers of participants in the teams using the Distributed Design Assistant (10) and the teams not using the system (8) did not have an influence on the evaluation results. Spelling mistakes produced by the designers are not corrected.

Additional observations made by the case study supervisor are included.

8.5.1 Design Methodology

This section follows the design procedure elements listed in Chapter 4. For each step the results of the case study analysis are listed and commented on.

8.5.1.1 Customer Requirements and Engineering Requirements

The number of customer requirements and engineering requirements can be used as an indicator as to how well the designers thought the design task through. The requirement headings help the designers to organize the requirements and determine any missing information.

The DiDeas groups laid down a total of 49 customer and engineering requirements, compared to 29 by the non-DiDeas groups. Only one student of the non-DiDeas groups wrote down a single heading for the customer requirements, while the DiDeas users created a total of 19, all but two of which were selected from the standard requirement list. However, they failed to add any requirements to five of the engineering requirement headings, which can be interpreted as an intention or a reminder to create more requirements for these categories.

Figure 8.2 illustrates the number of customer and engineering requirement headings, and Figure 8.3 shows the number of the customer and engineering requirements.

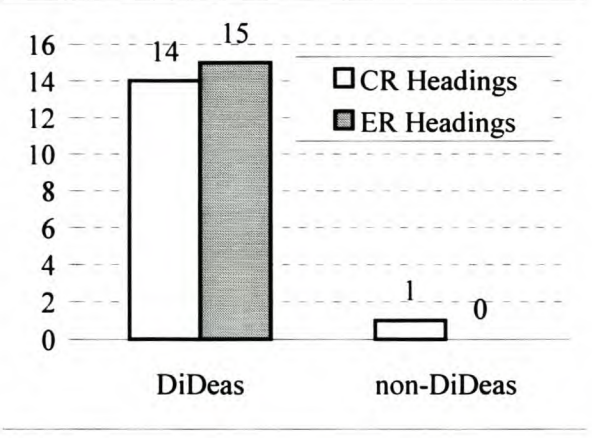


Figure 8.2: Customer and Engineering Requirement Headings

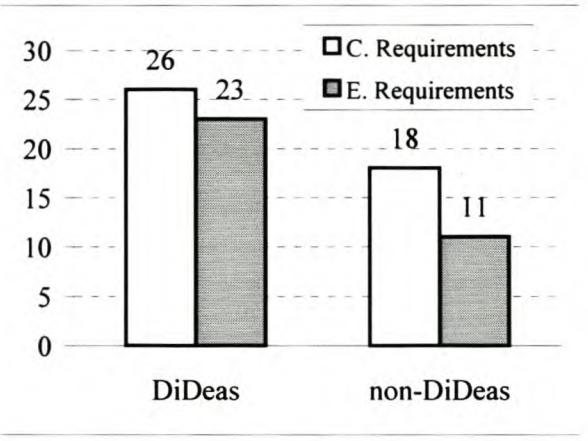


Figure 8.3: Customer and Engineering Requirements

All groups had difficulties in clearly distinguishing between customer requirements and engineering requirements. This issue has to be addressed in the future by providing explanatory notes and additional examples.

While every DiDeas user could enter the requirements personally into the system, the participants of the non-DiDeas groups had to transmit their ideas for the customer and the engineering requirement to the team-leader by e-mail, via the shared workspace, or in a videoconference. The team-leader had to categorize the requirements and check for duplicates or similar requirements. A few designers sent text files only labelled 'Specifications', with no clear classification, which created additional workload for the team-leader.

Duplicate entries were expected for the DiDeas groups, but only two items had to be deleted. It remains unclear as to whether these two entries were actually duplicates or just re-created in more suitable categories of the requirement lists.

8.5.1.2 QFD – 'House of Quality'

Each of the groups using the Distributed Design Assistant built a 'House of Quality'. Only two of the three non-DiDeas groups constructed 'Houses of Quality', one as a Microsoft Excel spreadsheet, the other one drawn on paper. While the DiDeas teams had no unrelated customer or engineering requirements, i.e. the 'Houses of Quality' were complete, one of the non-DiDeas teams could only set up an incomplete 'House of Quality', as shown in Figure 8.4.

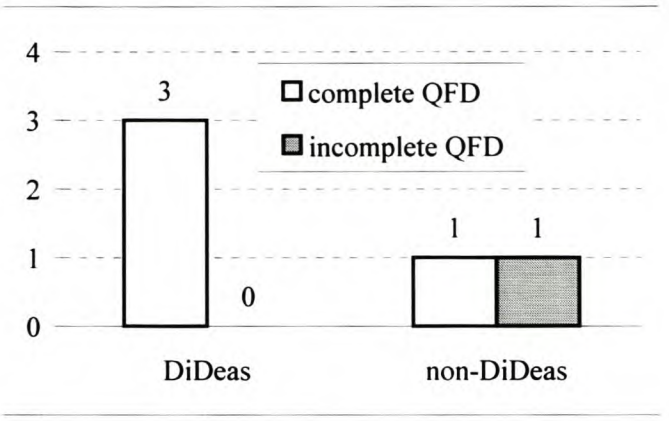


Figure 8.4: Completeness of the 'House of Quality'

The non-DiDeas group with the completed 'House of Quality' distributed the Excel file via the File Transfer Protocol (FTP), i.e. the shared workspace. All team members added and edited the QFD-matrix until everyone was satisfied. This practice indicates that the design task was tackled in a satisfactory manner. This was in contrast to the other non-DiDeas group, in which only the team-leader worked, unsuccessfully, on the 'House of Quality'.

Only the DiDeas users were asked, in the questionnaire, about their impressions regarding the QFD method and the 'House of Quality'. Four of the five students who answered to the question rated the 'House of Quality' as a useful tool that helped them to gain a better understanding of the design problem. Most of them stated that the restricted representation of the matrix on the screen was the main drawback of the DiDeas 'House of Quality'.

8.5.1.3 Functional Analysis, Concept Generation and Concept Design Selection

All three teams using the Distributed Design Assistant came up with a four-level function-concept structure consisting of a overall function, main concepts, sub-functions to the main concepts and sub-concepts to fulfil these sub-functions. The complete function-concept structure of Team #2 is shown as an example in Figure 8.5.

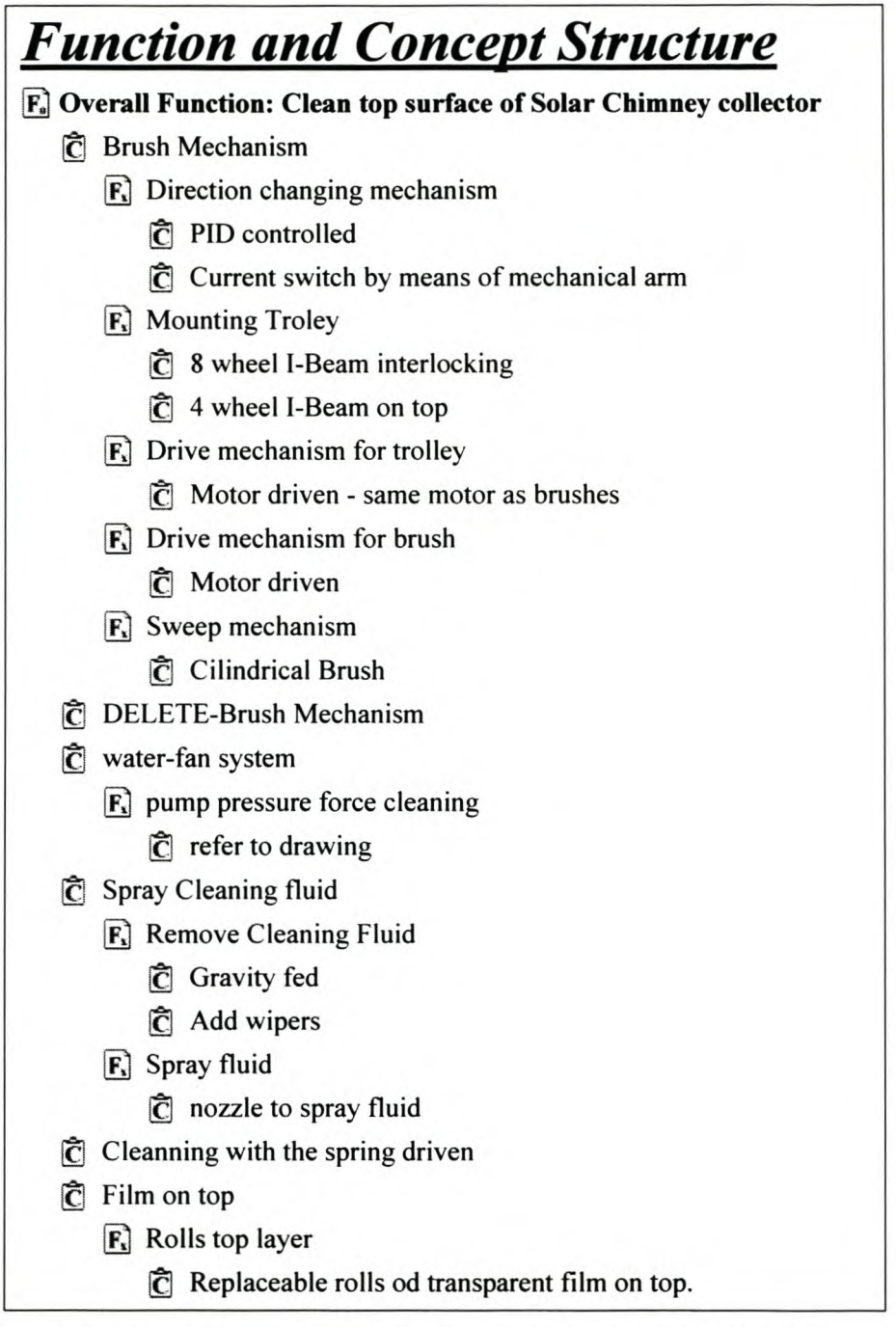


Figure 8.5: Example of a DiDeas Function-Concept Structure

All ten participants stated that the approach for function-concept structure used in the Distributed Design Assistant was intuitive to them.

A number of files were uploaded to the DiDeas web-server and attached to the concepts in the function-concept structure. Details will be discussed in Section 8.5.2.5.

The selection of concept designs in DiDeas did not cause any major problems for the students. In one case a duplicate of an existing concept was generated. On a few

occasions designers selected concepts from different, i.e. independent, branches of the function-concept structure. However, in most cases this was considered to be intentional, to combine various main concepts, e.g. a vehicle and a sprinkler system. It indicates that support for the cross-combination of concepts or for the copying of a whole branch of the function-concept structure into another could be a useful feature of the Distributed Design Assistant.

The three groups not using the DiDeas system applied different strategies to the functional analysis and concept generation. The first group broke down the overall function into three sub-function levels, as shown in Figure 8.6. All team members participated in the process via fax and a group-videoconference.

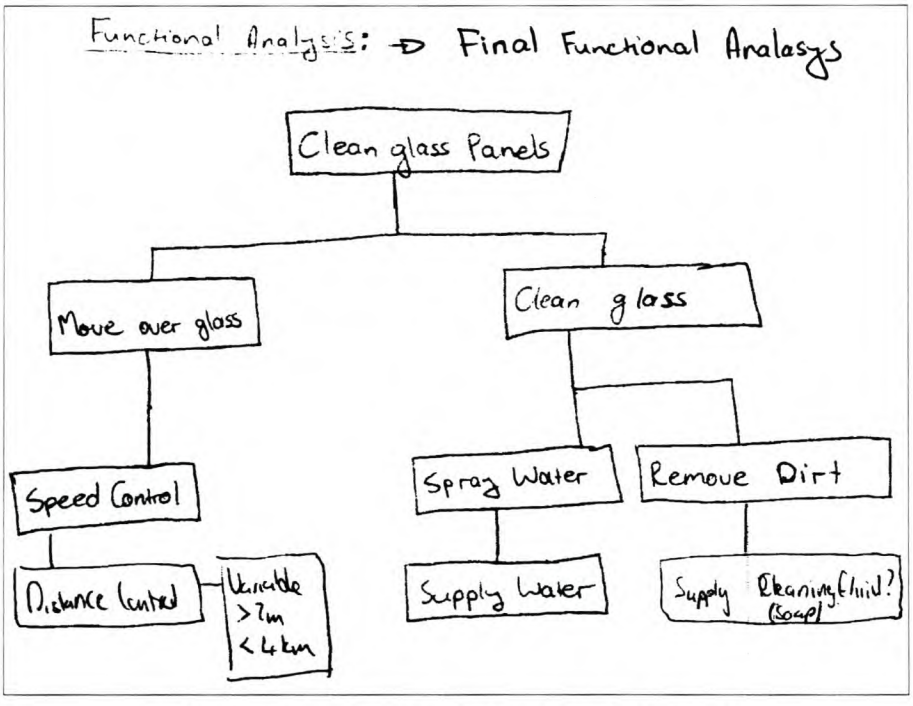


Figure 8.6: Functional Analysis of Team #3

However, the students did not develop multiple possible solutions for the low-level functions in Figure 8.6. Instead, each designer used this function structure to create a concept or two on his own. Only one designer in Team #3 created an additional small function-concept structure with two alternative concepts for one sub-function, as shown in Figure 8.7.

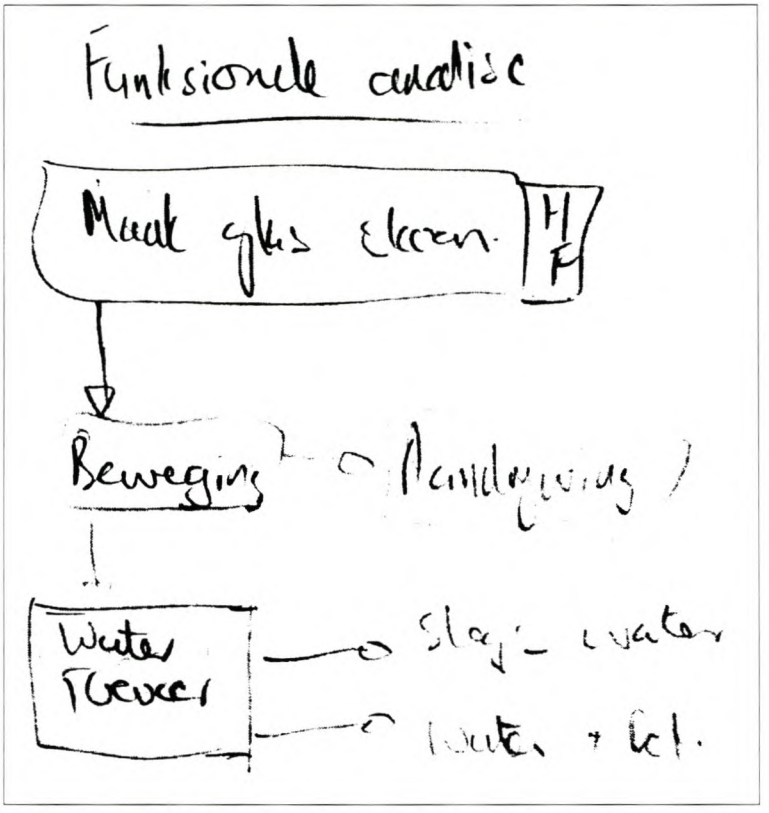


Figure 8.7: Additional Functional Analysis of Team #3

The concept designs of each team member were only exchanged for the concept evaluation, when a short chat discussion took place. It was, however, too late to get inspired by this discussion and to incorporate ideas into new concepts.

The second group consisted of only two designers. This fact allowed for a continuous Microsoft NetMeeting videoconference and the utilization of its shared whiteboard for the functional analysis and concept generation. It was possible for both students to work simultaneously on the same worksheet. First, they listed various concept ideas in a small tree-structure, as shown in Figure 8.8.

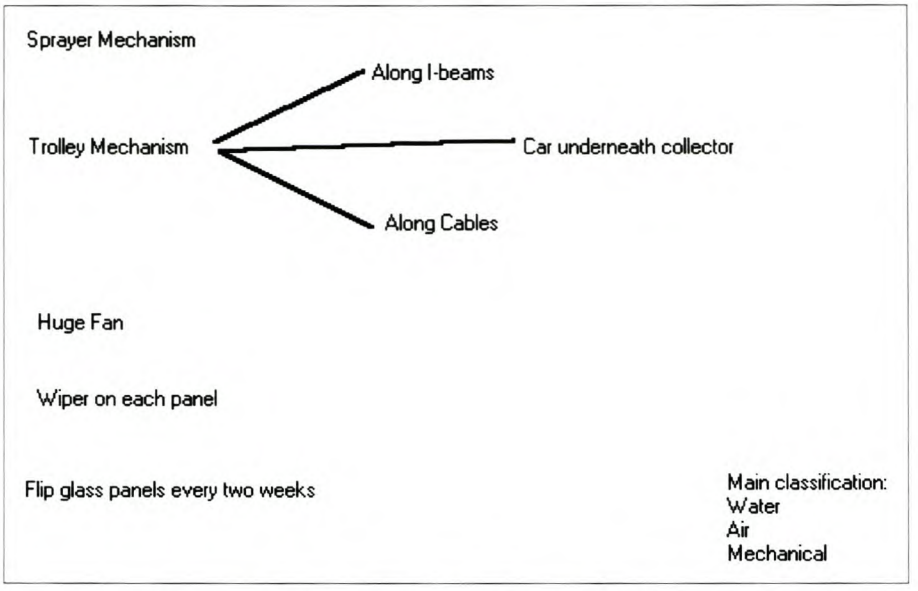


Figure 8.8: Concept Ideas Structure of Team #4

They then created a detailed function-concept structure for one of the concepts, referred to as 'Trolley Mechanism along I-beams', as displayed in Figure 8.9.

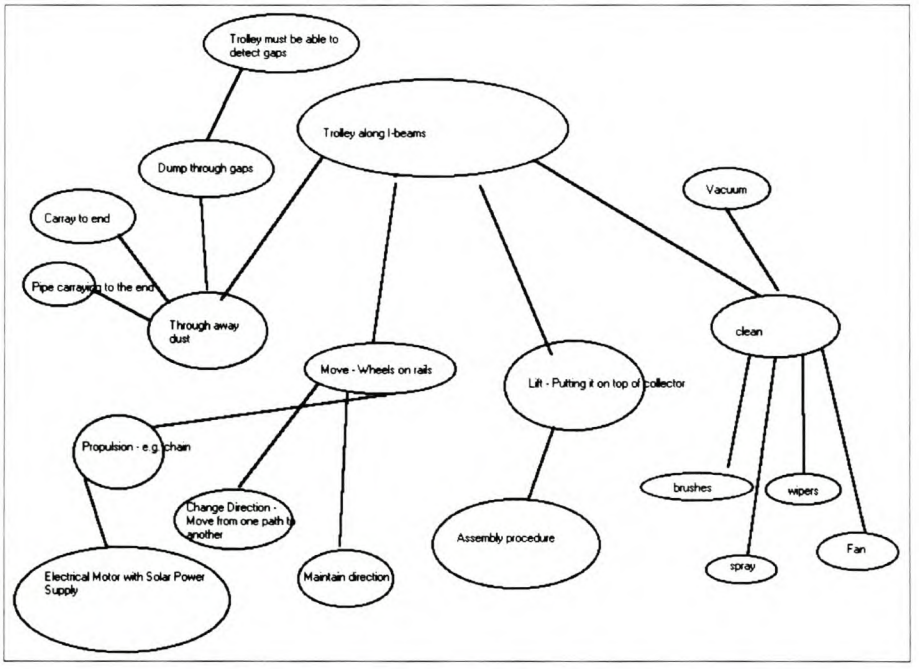


Figure 8.9: Function-Concept Structure of Team #4

By combining various solutions from this structure, three different concept designs were produced. For those, a number of detailed sketches were created and exchanged via the shared workspace system.

The third group without the support of the DiDeas system chose a different approach to the other two teams. Each team member spent a considerable amount of time

developing concepts individually. These concepts were subsequently exchanged via fax or as e-mail attachments and discussed in a number of telephone conversations. Since all concepts were based on a vehicle moving on top of the glass collector, it was possible to break down the different concepts and to build the following function-concept structure (Figure 8.10).

Movement:

Guidance:

- Rails placed on the I-beams
- Rails hanging from suspension cable supports

Motivation:

- Wheels powered by a hydraulic pump, using the water pressure.
- Mechanism at end of track pulling unit

Cleaning:

Dirt removal:

- Car wash type brushes on underside of unit
- High pressure water jets

Water source

- Tank on unit large enough for complete journey from one end to the next and be refilled before each journey starts.
- Refilling points along the way were unit stops and refills a smaller capacity tank.
- Pipe which drags along with unit supplying it with water – no tank

Power source for jet pumps, motors etc.

- Batteries
- Solar panels
- Sliding power connection to mains.

Turning around:

- Special high vehicle running on perimeter road, with mechanism for taking unit off one set of tracks, and placing it on the next set.
- Device running on a track around the outside perimeter at the height of the glass with the same mechanism.

Figure 8.10: Function-Concept Structure of Team #6

Each concept of the function-concept structure shown in Figure 8.10 was classified as either 'go' or 'no-go', and the remaining concepts (status 'go') were combined into two final concept designs.

One of the reasons for developing a function-concept structure, either according to the traditional design methodologies described in Chapter 2, or by applying the approach used for the Distributed Design Assistant, was the generation of a large number of practically feasible concept designs. The following table (Table 8.1) lists the number of

possible concept designs derived by combining the concepts, or possible solutions, from the function-concept structures of the different design teams.

	Team	Possible Concept Designs
DiDeas	#1	28
	#2	9
	#5	18
non DiDeas	#3	2
	#4	21
	#6	144

Table 8.1: Possible Number of Concept Designs per Team

The low number of possible concept designs for Team #3 resulted from the incomplete functional decomposition carried out by only one student. The high number for Team #6 can be explained by the relatively large number of possible solutions for each function of their functional analysis.

All design teams except Team #3 incorporated concepts into their function-concept structures at an early stage. Too few groups chose the traditional method for a functional decomposition, which made a comparison of the different strategies impossible.

However, it was demonstrated that the method for functional analysis and concept generation incorporated into the Distributed Design Assistant is successful, and that it can produce a large variety of alternative concept designs.

All DiDeas users answering the related questions in the questionnaire commented positively on the method they had employed for the functional analysis and concept generation.

8.5.1.4 Information Exchange during Concept Development

Of particular interest was the exchange of ideas in the form of sketches and notes during the concept generation. Two of the teams working with the Distributed Design Assistant made use of the concept upload feature. The groups uploaded only image files in the JPEG format, with the exception of one Microsoft Word document that also contained two images. The first group uploaded two files to the concept-function structure and one file to the DiDeas shared workspace, and the second group uploaded seven files to the concept-function structure. More details on the information exchange are included in Section 8.5.2.5.

8.5.1.5 Concept Evaluation

For the three teams supported by the Distributed Design Assistant, the first step of the Concept Evaluation was the screening of all generated concept designs. They did not experience any difficulties with the screening process of the DiDeas system. Most designers (nine out of ten) participated in the screening process, judging their own and their colleagues' concept designs. This was accompanied by a number of concept discussions via telephone and desktop-videoconferencing. However, one team missed a duplicate concept design, i.e. an identical combination of concepts, which consequently reached the decision matrix evaluation twice, where it made first and second place.

The design teams not using the Distributed Design Assistant followed very different concept evaluation procedures. Team #3 did not perform a concept screening, except for the designers themselves. They decided alone on whether to share a concept with the team, or not. The team manager collected all submitted concept designs, developed a number of criteria with weight factors by himself, and generated a decision matrix template in Microsoft Excel, as seen in Figure 8.11.

	Decision Matrix				
	Weight	Datum: Corne1	Marc1	Marc2	Pieter1
Criteria					
Will sufficiently clean glass	5	0			
Cost <= R100 000	3	0			
Withstand 100 deg	3	0			
Clean whole area in 2 weeks	3	0			
Not Break the Glass	4	0			
Not Interfere with the structure	3	0			
Easy to Maintain	2	0			
Legend					
Weight: 1 = not so important					
5 = very important criteria					
Comparison: -1= worst than datum concept					
0 = same as datum concept					
+1 = better than datum concept					
Concepts					
Marc1 = Trolley with nozzles and bucket for water and cleaning fluid					
Marc2 = Trolley and triggered nozzles on I-Beams					
Pieter1 = Trolley with resevoir					
Corne1 = Trolley with water hose on pulley					

Figure 8.11: Decision Matrix Template of Team #3

The template was uploaded to the shared workspace. Each team member downloaded the file, filled in the decision matrix, and uploaded the file under a new name, back to

the shared workspace. The team manager collected the files, combined the results and announced the winning concept.

The second non-DiDeas team (Team #6) to perform a decision matrix chose a different approach. During a CU-SeeMe group-videoconference the team developed the decision matrix in a joint effort. First, a number of criteria and weight factors were collected. Then the team-leader asked the group to judge their two concept designs regarding each criterion. A '1' or a '0' was placed in the decision matrix, indicating a positive or negative opinion of the whole group. The team-leader multiplied the '1's with the weight factors and added up the results to determine the winning concept design.

The two designers of the third non-DiDeas team did not use a decision matrix, but came to a mutual agreement during their videoconference. They first eliminated five of their seven concept designs by rating them as 'too expensive', 'impractical' or 'unsafe'. After a short discussion the concept with the 'most potential' was declared the winner. No individual or comparative evaluation took place.

Most designers who used the Distributed Design Assistant were surprised by the results of their individual decision matrix evaluations, as well as the final evaluation result, as illustrated in Figure 8.12.

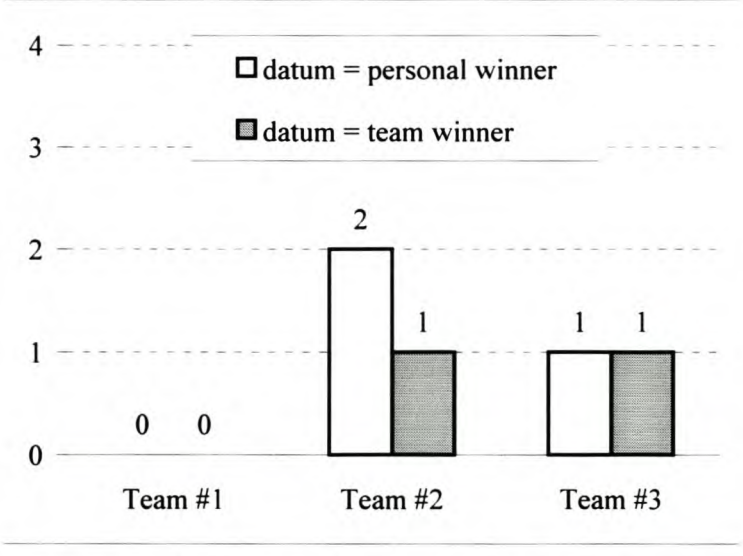


Figure 8.12: Datum Selection of the DiDeas Teams

All designers were required to select their personal favourite concept design as the datum for the decision matrix. Only three out of the ten participants were confirmed in their choice of the datum by their individual results, i.e. for seven designers their datum

selection was a bad choice, according to the decision matrix results. Only two designers could identify the winning concept design for their team with their selection of the datum. Team #1, in particular, was stunned by the completely unexpected results, as the team members had unanimously declared another than the winning concept design the best concept design. The problem, which consequently led to the surprise winners, was identified as an incomplete selection of criteria and weight factors. All designers later agreed that they should have spent more time and effort on this important phase of the design process.

The three non-DiDeas teams were not confronted with this particular problem, because they used a common datum selected by the team-leader (Team #3), they did not use a datum method (Team #6), or they did not use a decision matrix method (Team #4).

Table 8.2 lists the numbers of developed concept designs and the number of concepts designs for the final evaluation.

	Team	Developed Concept Designs	Evaluated Concept Designs
DiDeas	#1	13	4
	#2	7	4
	#5	6	2
	Total:	**26**	**10**
non DiDeas	#3	4	4
	#4	7	3
	#6	5	2
	Total:	**16**	**9**

Table 8.2: Created and Evaluated Concept Designs per Team

The teams using the Distributed Design Assistant created a total of 26 concept designs, compared to only 16 by the non-DiDeas users. No connection between the number of developed concept designs and the team size could be found.

8.5.1.6 Project Documentation

The final design documentation, i.e. a short design review with a description of the concepts and the winning concept design, was required. Two of the teams supported by the Distributed Design Assistant made use of the Design Report feature of DiDeas. The other four groups created the documentation in Microsoft Word. Of those, one group included a table with the evaluation results in their report. All groups used formatted text (bold and/or underlined). Although the latter is considered as not essential, the inclusion of objects such as tables or figures can be beneficial.

8.5.2 Communication and Information Transfer

In this section the results for the communication and information transfer are presented and discussed.

8.5.2.1 Telephone

The results of the analysis of the telephone calls did not provide much information regarding the Distributed Design Assistant. Only a small increase can be noticed in the proportion of communication-related telephone calls of the design teams without the DiDeas system, as shown in Table 8.3.

	Team	Calls	design-related	procedure-related	communication-related
DiDeas	#1	61	45.9 %	65.6 %	37.7 %
	#2	48	22.9 %	68.8 %	37.5 %
	#5	24	20.8 %	62.5 %	45.8 %
non DiDeas	#3	28	28.6 %	53.6 %	60.7 %
	#4	3	66.7 %	66.7 %	66.7 %
	#6	33	36.4 %	63.6 %	51.5 %

Table 8.3: Percentage of 'design-related', 'procedure-related' and 'communication-related' Conversations in the Telephone Calls

The telephone calls covered the full spectrum of topics one would expect in distributed conceptual design, i.e. from information about the design procedure, schedules, and hardware, to the discussion of concepts and final results.

8.5.2.2 Desktop-Videoconferencing

As in the case of the telephone calls, analysis of the desktop-videoconferences did not indicate any direct relation between this communication medium and the Distributed Design Assistant. However, a few interesting observations could be made.

All teams carried out long videoconferencing sessions, of between 34 minutes and over three hours. During this time the team members would start a conversation whenever they needed to and the desired counterpart was available. The video-link provided the means to check out the other's situation, i.e. to see whether the colleague was busy on the telephone or out of the office. In contrast to the previous case study on synchronous and asynchronous collaboration [Schueller and Basson, 2001b], only two short person-to-person videoconferences were conducted, to discuss the design procedure and schedule.

Except for the two-designer team (Team #4), all groups used the CU-SeeMe videoconferencing application to connect the team members during the long group meetings. Team #4 conducted a single Microsoft NetMeeting conference (3 hours 44 minutes) and used it to discuss design-related, procedure-related and communication-related matters, almost as in a co-located environment. While in CU-SeeMe a button has to be clicked to open a voice-channel, similar to a walkie-talkie, this is not necessary in Microsoft NetMeeting. The designers of Team #4 could communicate as in a normal person-to-person conversation. The shared whiteboard feature of Microsoft NetMeeting was particularly valuable for the two designers. Figure 8.13 shows the shared whiteboard window used for concept sketching and discussion.

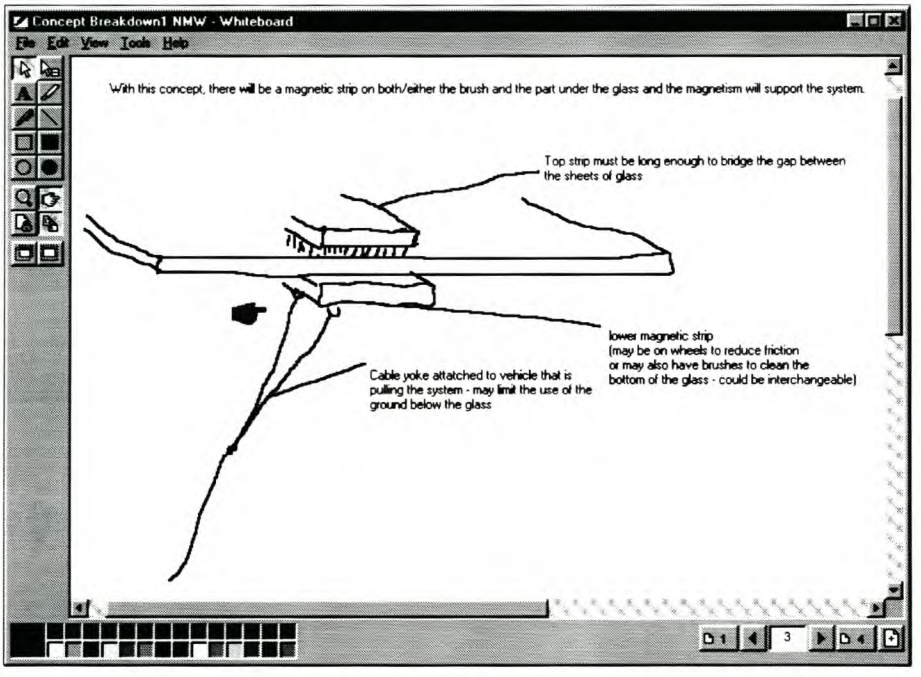


Figure 8.13: Concept Sketching and Discussion in Microsoft NetMeeting

The 'hand' icon allows the user to point out specifics of the sketch, since the mouse cursor cannot be seen by the other party.

All but one of the CU-SeeMe teams used the chat function of the videoconferencing software. This was mainly due to the fact that the voice quality was not comparable to a face-to-face conversation or telephone call. Most of the designers used a specific chat writing style with slang expressions, switched between English and Afrikaans, and did not no correct spelling mistakes.

A number of specific gestures, e.g. waving and the 'thumbs-up', could be observed, besides the normal facial expressions. Two designers held up small objects in front of

the camera, e.g. a water bottle or a little globe. Some students tried to transmit paper sketches via the desktop-videoconferencing system, as shown in Figure 8.14, but with little success, due to the low resolution of the camera. One student gave an 'OK-sign' to acknowledge a request made by another user via the voice system of CU-SeeMe. Another student illustrated a curve by moving his hand in front of the camera.

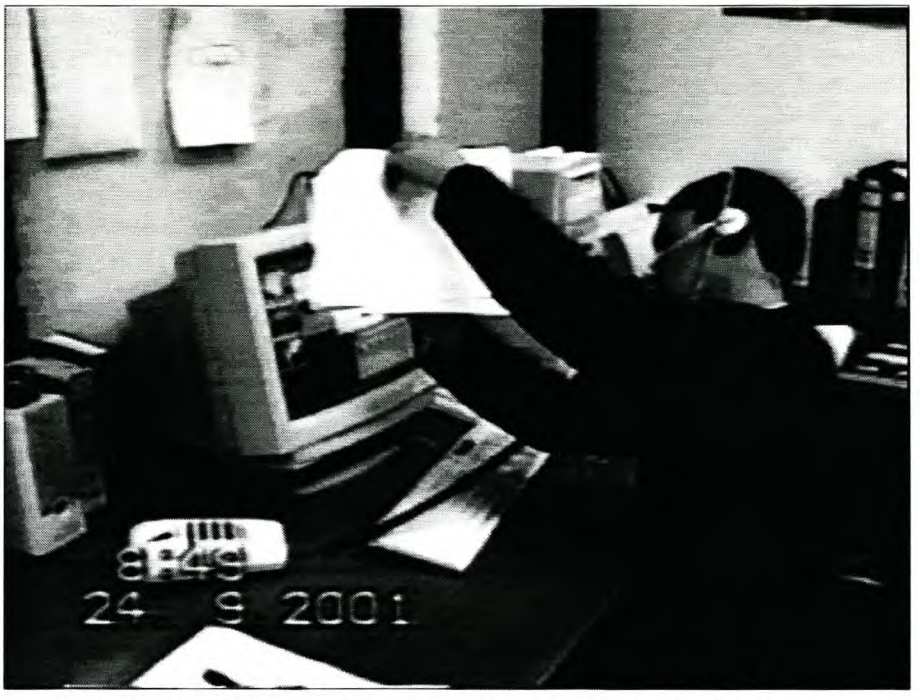


Figure 8.14: Attempt to transmit a Sketch via the WebCam

Only a few technical problems were experienced during one videoconferencing session. Apparently the Microsoft Windows2000 operating system does not fully support the CU-SeeMe software. This resulted in the total loss of the audio feature of CU-SeeMe. The student had to cope with the situation by conducting telephone calls and using the chat system.

8.5.2.3 Electronic Mail

The number of electronic mails and attachments sent by the DiDeas supported designers differed from those sent by the non-DiDeas users, as illustrated in Figure 8.15.

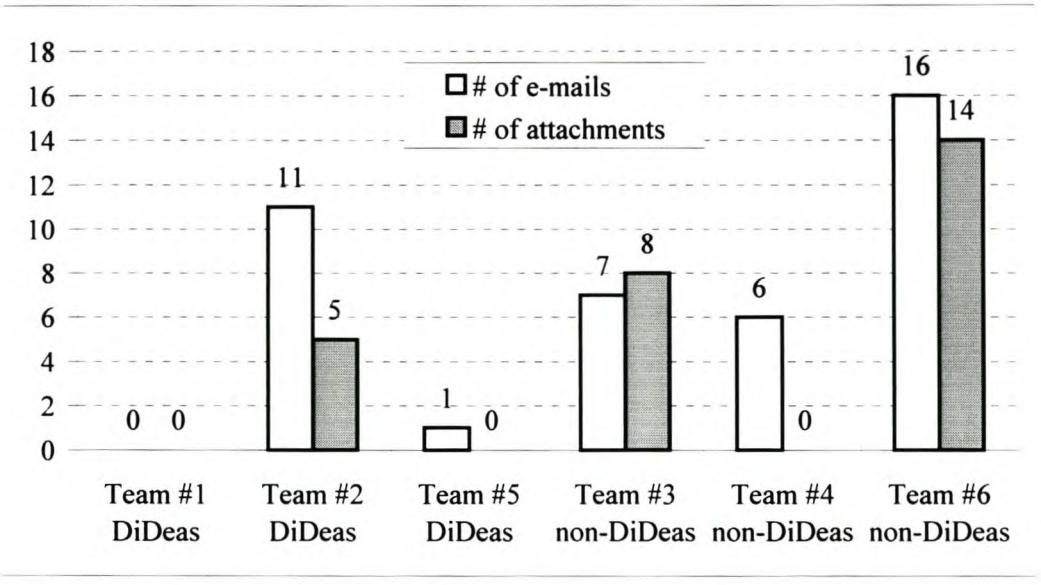


Figure 8.15: Numbers of exchanged E-Mails and Attachments

The DiDeas users sent less e-mails (12) and less attachments (5) than the designers without the support system (29 e-mails and 22 attachments).

More interesting than the number of e-mails was the content, as shown in Figure 8.16.

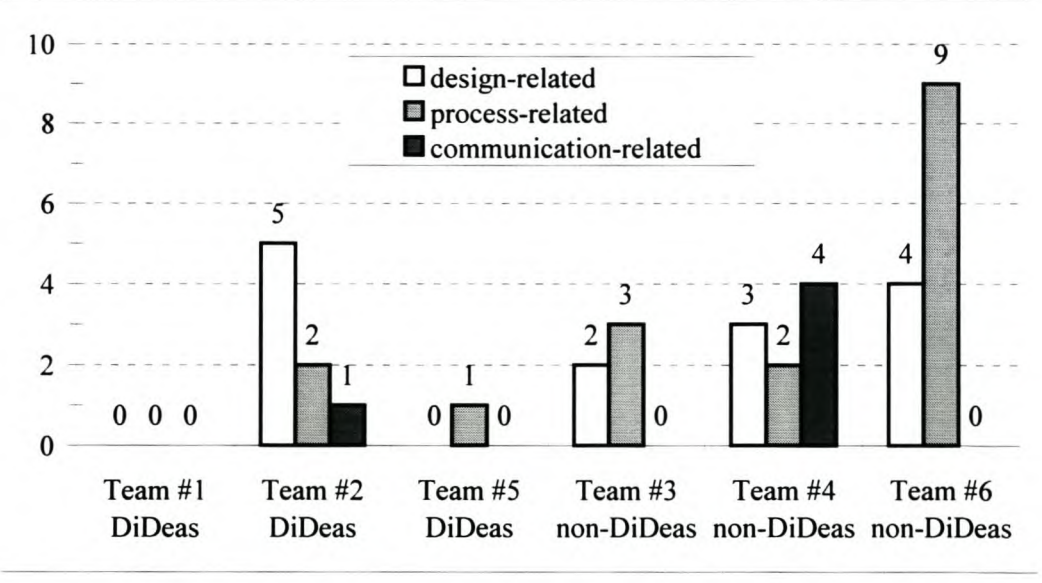


Figure 8.16: Numbers of 'design-related', 'procedure-related' and 'communication-related' E-Mail Content

In the groups supported by the Distributed Design Assistant the design-related content was predominant, at least for Team #2, in contrast to the non-DiDeas teams. In the case of the latter, a high design-related content, and an even higher procedure-related content could be observed. This indicates that the DiDeas users did not need to discuss the

design procedure as much as the unsupported team did, since the Distributed Design Assistant provides a clear and intuitive structure.

The relatively small numbers of electronic mails with communication-related content indicate that e-mail is not suitable to discuss the use of, or make arrangements for, other, faster communication tools.

The file types sent as e-mail attachments are shown in Table 8.4.

	Team	.jpg	.txt	.doc	.xls
DiDeas	#1	0	0	0	0
	#2	3	0	2	0
	#5	0	0	0	0
	Total:	**3**	**0**	**2**	**0**
non DiDeas	#3	6	2	0	0
	#4	0	0	0	0
	#6	2	3	6	3
	Total:	**8**	**5**	**6**	**3**

Table 8.4: File Types of E-Mail Attachments

For the non-DiDeas groups the transfer of text-based data was predominant.

8.5.2.4 Fax

The fax was used to share ideas on 'scribble' paper. As illustrated in Figure 8.17, the teams with the support of the Distributed Design Assistant did not make as much use of it as the other three design teams did.

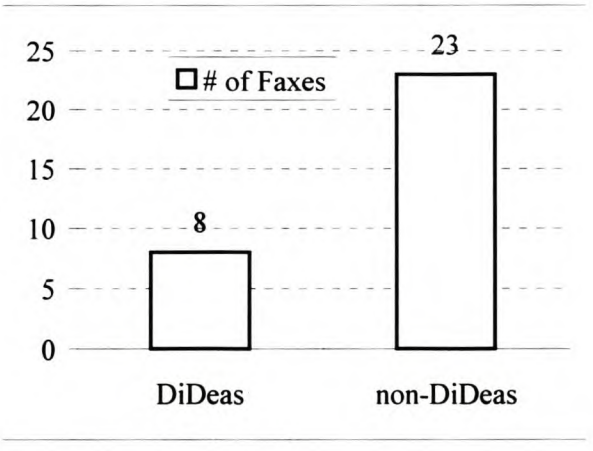


Figure 8.17: Numbers of Faxes

Here too, the transfer of text-based information was predominantly between the non-DiDeas teams, in contrast to the DiDeas users, as breakdown in Table 8.5 shows. The column 'Sketch or Drawing' lists sketches, from a few rough lines to detail views and

technical drawings handed out to the students with additional annotations in the form of sketches or notes. The next column shows 'scribble' paper with only a few words, e.g. the telephone numbers of the team members, and 'Concept Description' refers to longer text to describe for instance the functioning principle or materials used. The last two columns list tree structures used for the functional analysis and text describing elements of the design procedure.

	Team	Sketch or Drawing	A few Words	Concept Description	Tree Structure	Design Procedure
DiDeas	#1	4	4	0	0	0
	#2	0	0	0	0	0
	#5	4	2	2	0	0
	Total:	**8**	**6**	**2**	**0**	**0**
non DiDeas	#3	10	0	10	4	0
	#4	3	1	2	0	0
	#6	4	2	2	0	2
	Total:	**17**	**3**	**14**	**4**	**2**

Table 8.5: Content sent by Fax

A faxed page can contain multiple types of content. Only the column 'Sketch or Drawing' lists faxes with graphical content, the other columns indicate text.

8.5.2.5 File Upload

The third tool for information exchange was the file upload to the web-server. While DiDeas users had the choice between three applications, i.e. the file upload to the DiDeas function-concept structure, the file upload to the DiDeas shared workspace, and the file upload to an external web-server via FTP, the non-DiDeas teams could only use the last option. Table 8.6 illustrates the usage of the three tools.

	Team	DiDeas Concept Upload	DiDeas Shared Workspace	Shared Workspace (FTP)
DiDeas	#1	2	1	0
	#2	7	0	0
	#5	0	0	0
	Total:	**9**	**1**	**0**
non DiDeas	#3	-	-	6
	#4	-	-	6
	#6	-	-	0
	Total:	**-**	**-**	**12**

Table 8.6: File Upload to different Locations

Again, more expressive than the number of files, were the file types uploaded, as listed in Table 8.7.

	Team	.jpg	.txt	.doc	.xls
DiDeas	#1	3	0	0	0
	#2	6	0	1	0
	#5	0	0	0	0
	Total:	**9**	**0**	**1**	**0**
non DiDeas	#3	0	0	0	6
	#4	2	1	3	0
	#6	0	0	0	0
	Total:	**2**	**1**	**3**	**6**

Table 8.7: File Types of uploaded Files

In this case, there was a clear preference of the DiDeas groups for uploading image files, while the non-DiDeas teams used the shared workspace mainly for the exchange of text-based information.

8.5.2.6 DiDeas Message Board

Only one message was posted during the case study. A designer informed his team members that he would be absent from the office for a few minutes. The message board was not used for any other type of information, e.g. an agenda.

8.5.2.7 DiDeas Short Messages

The short message system was used by only one group for the exchange of three messages regarding the final design review. All messages were read and confirmed by the recipients. Although the number of messages is not very significant, the short response time (three minutes) of one student to read the message, to confirm it and to send a reply message, indicates the proper functioning of the system.

8.5.2.8 DiDeas Personal Notes

As anticipated, no personal notes were entered into the DiDeas system. The time allocated for completing the design task was most likely too short to think about personal, not project related things and record them in the Distributed Design Assistant.

8.5.2.9 DiDeas Video Snapshots

The video snapshot system was not well accepted by the case study participants. The students preferred the more flexible desktop-videoconferencing application CU-SeeMe, since it allowed for audio, video and chat, and it provided a live, continuous video link to check the activities of the other team members. A few students started the system, but

stopped it for the first videoconference and never restarted it. The requirement for a second application that cannot be run in parallel to other software utilizing the WebCam makes this tool too cumbersome to use.

8.5.3 Input Devices

In this section the utilization of different input devices is discussed.

8.5.3.1 Pen and Paper

Each designer was equipped with ten sheets of numbered 'scribble' paper, a pen and a pencil. None of the students made use of the option for additional paper.

The usage of pen and paper was a strong indicator of the value of the Distributed Design Assistant. The amount of notes, sketches and other information collected on paper by the non-DiDeas teams was exactly double the amount produced by the groups working with the Distributed Design Assistant, as illustrated in Table 8.8.

	Team	Annotated Drawing	Sketch and Text	Short Text	Matrix or Structure
DiDeas	#1	3	1	4	0
	#2	2	2	2	0
	#5	2	5	1	0
	Total:	**7**	**8**	**7**	**0**
non DiDeas	#3	1	12	6	2
	#4	1	4	3	0
	#6	4	5	3	3
	Total:	**6**	**21**	**12**	**5**

Table 8.8: Content of 'Scribble' Paper and Drawings

In Table 8.8, the column 'Annotated Drawing' lists the technical drawings handed out to the students, which were annotated in the form of sketches or notes. The next column shows the number of 'scribble' papers with concept sketches and descriptions, the column 'Short Text' lists 'scribble' papers with only a few words and the last column shows if a decision matrix or a function-concept structure was drawn.

Figure 8.18 illustrates how much of the 'scribble' paper information was actually exchanged, and by what means.

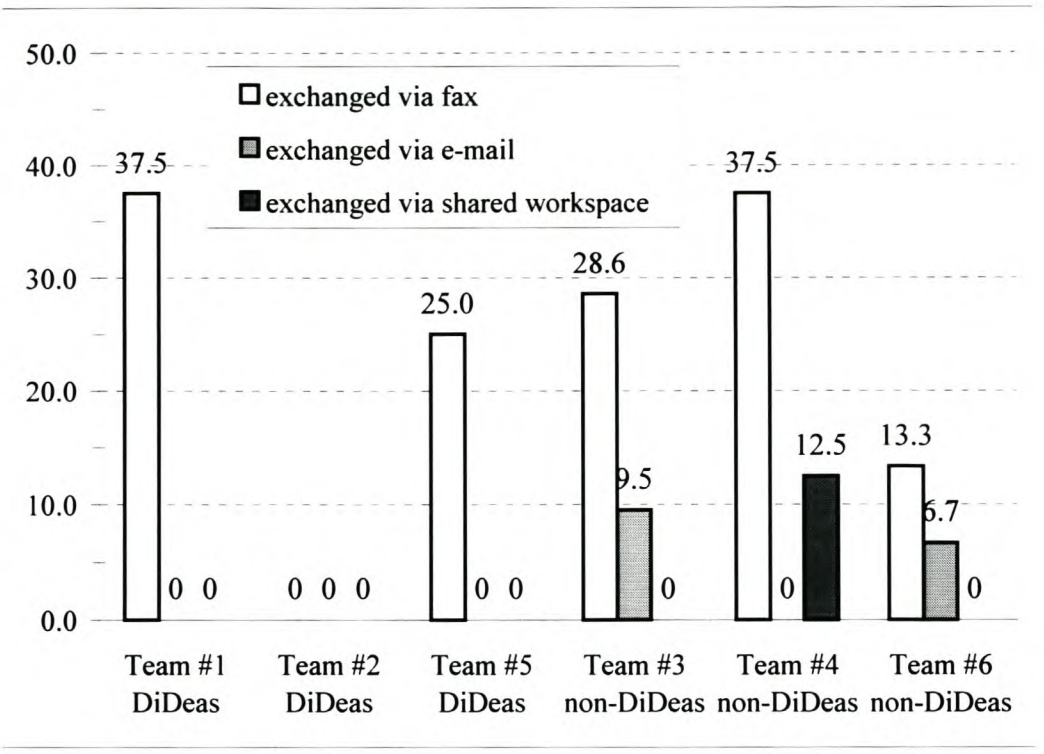


Figure 8.18: Types of 'Scribble' Paper Exchange (in %)

While the teams supported by the Distributed Design Assistant only faxed their paper-based sketches and notes to their colleagues, the non-DiDeas groups utilized many different, external tools, i.e. fax, electronic mail and the shared workspace. While the DiDeas teams transmitted only a total of 22.7% of their 'scribble' papers, the groups without DiDeas transmitted 34.1%.

The relatively low number of papers produced by the DiDeas teams indicates that a lot of information was directly entered into the Distributed Design Assistant and did not have to be exchanged by other means, thereby reducing the workload of the designers.

8.5.3.2 Graphic Tablet with Pen

80% of the DiDeas users and 75% of the non-DiDeas users worked with the graphic tablet. The number of sketches produced is illustrated in Figure 8.19.

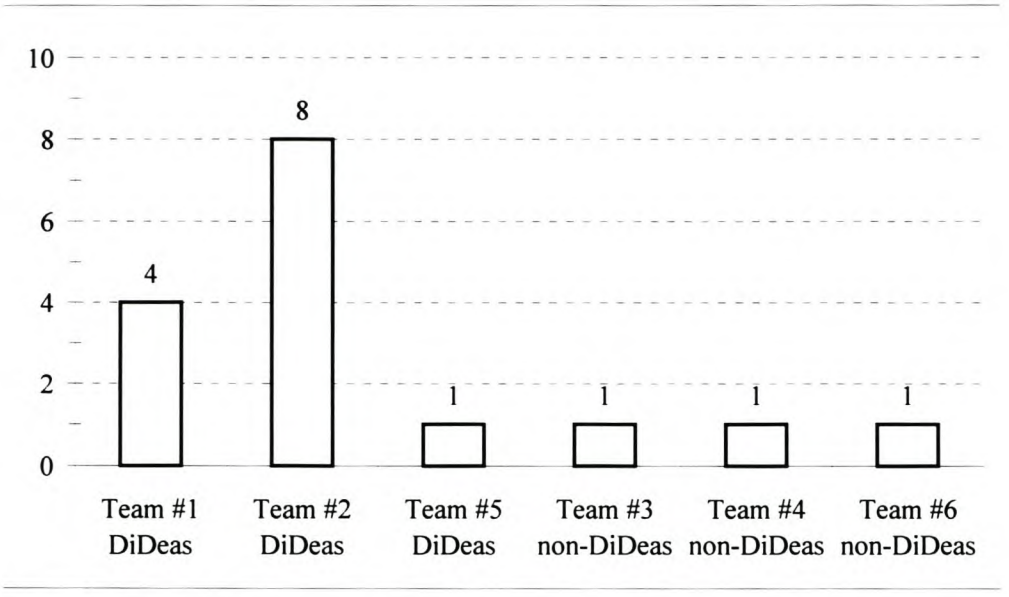


Figure 8.19: Number of 'Graphire' Graphic Tablet Sketches

Team #4 used the graphic tablet to create a sketch directly in the Microsoft NetMeeting shared whiteboard (Figure 8.13), while all other designers had to first make an image file that could be distributed via the tools described in Section 8.5.2. The action of Team #4 comes very close to working on one sketch during a co-located design session.

The means of file exchange for the 'Graphire' sketches are illustrated in Figure 8.20.

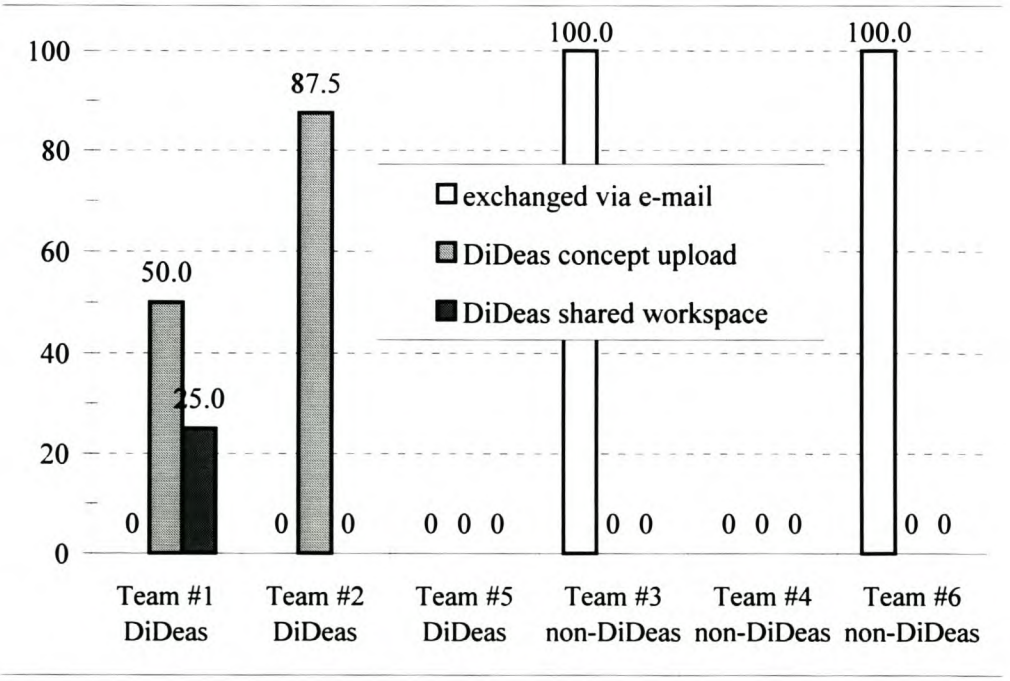


Figure 8.20: Types of Graphic Tablet Sketch Exchange (in %)

While the teams supported by the Distributed Design Assistant used only the DiDeas concept upload and the DiDeas shared workspace, the non-DiDeas groups preferred distribution in the form of e-mail attachments over the shared workspace via FTP.

The unanimous perception expressed in the questionnaire was that the graphic tablet is a very useful tool, but more practice is needed to improve the designers' skills. All participants stated that they currently prefer pen and paper, due to the higher speed of this medium. None of the participants used the computer mouse for sketch input.

8.5.3.3 Scanner

Drawings and 'scribble' papers were only scanned by the teams not using the Distributed Design Assistant, as shown in Figure 8.21.

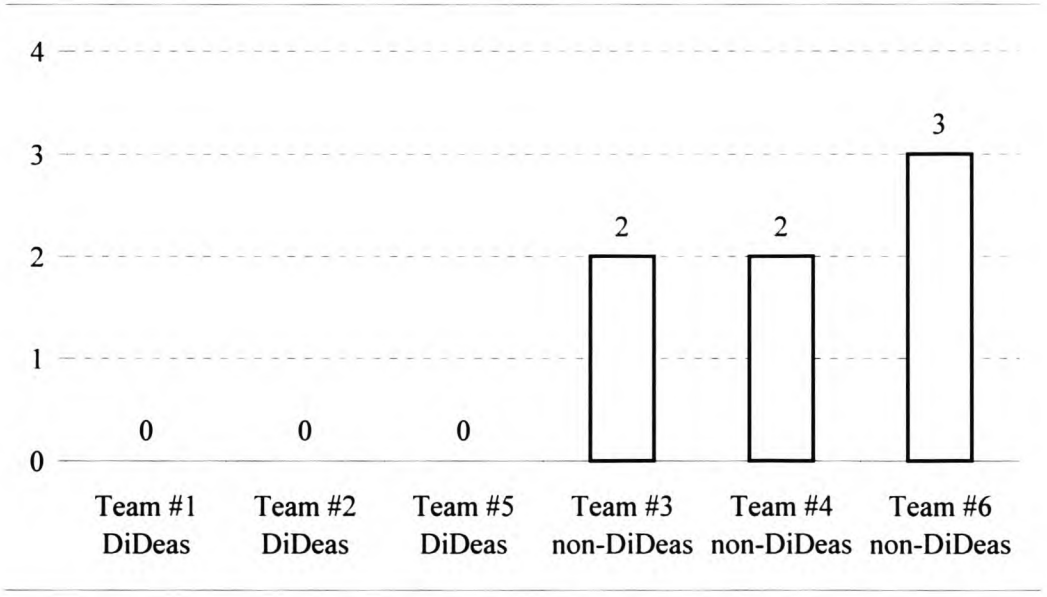


Figure 8.21: Usage of the Scanner

The DiDeas groups preferred the fax for the distribution of paper-based information, as explained in Section 8.5.3.1.

8.5.3.4 WebCams

A few attempts were made to transmit paper sketches via the WebCams, but no designer tried to use the WebCams to share 3D objects related to the design task with his colleagues (a few unrelated objects were put in front of the WebCams). Due to the low image quality required for transmitting audio and video, the WebCams are not suitable for detailed sketches or small objects. However, with faster networks or dedicated connections for videoconferencing, this medium could be utilized more extensively.

8.5.4 Additional Observations and Case Study Results

In this section, observations made by the case study supervisor and additional results from the questionnaire will be discussed.

8.5.4.1 The Role of the Team Manager

As in the case study on synchronous and asynchronous collaboration (see Chapter 5.3), the role of the team manager, or team leader, was, besides participation in the design task, the management of the project. This included the guidance of the team through the different stages of the design procedure, the coordination of the file exchange, the supervision of the videoconferences and the adherence to the given schedule.

Although it could not be confirmed by the results of the case study analysis, it appeared to the case study supervisor that the team leaders of the DiDeas-supported teams were more involved in the actual design process than the team managers of the unsupported teams. During the functional analysis and concept generation, in particular the team leaders supported by the Distributed Design Assistant seemed to have more time to help build the function-concept structure and to develop their own concepts than the other team managers did.

8.5.4.2 Asynchronous Collaboration

One designer of Team #2, which was using the DiDeas system, had to leave the case study temporarily. He missed about one hour of the session and could not participate in the functional analysis and most of the concept generation. However, when he returned to his workplace, he had no difficulties to quickly brief himself on the overall status of the project, to go through the function-concept structure and the already developed concept designs, and to catch up with his team mates by adding another complete concept design. This clearly indicates that the Distributed Design Assistant can also be used in asynchronous collaboration scenarios, i.e. when the designers do not work on a design task simultaneously. The Distributed Design Assistant allows a quick and comprehensive overview of the information entered into the system.

8.5.4.3 DiDeas Help and Example Project

None of the ten designers working with the Distributed Design Assistant made use of the DiDeas Help. They asked the case study supervisor for advice, or tried to solve the problem by looking at the example project. Most difficulties did not concern the operation of the Distributed Design Assistant, but rather the type of information requested for a specific step of the design procedure. A typical problem was the

distinction between customer requirements and engineering requirements. Half of the participants stated in the questionnaire that they switched between their design task and the example project. All of those designers agreed that the example project provided sufficient support.

8.5.4.4 Monitor Size and Resolution

It was expected that many participants would complain about the size of the computer monitor. A screen crammed with windows for desktop-videoconferencing and the DiDeas system is shown in Figure 8.22.

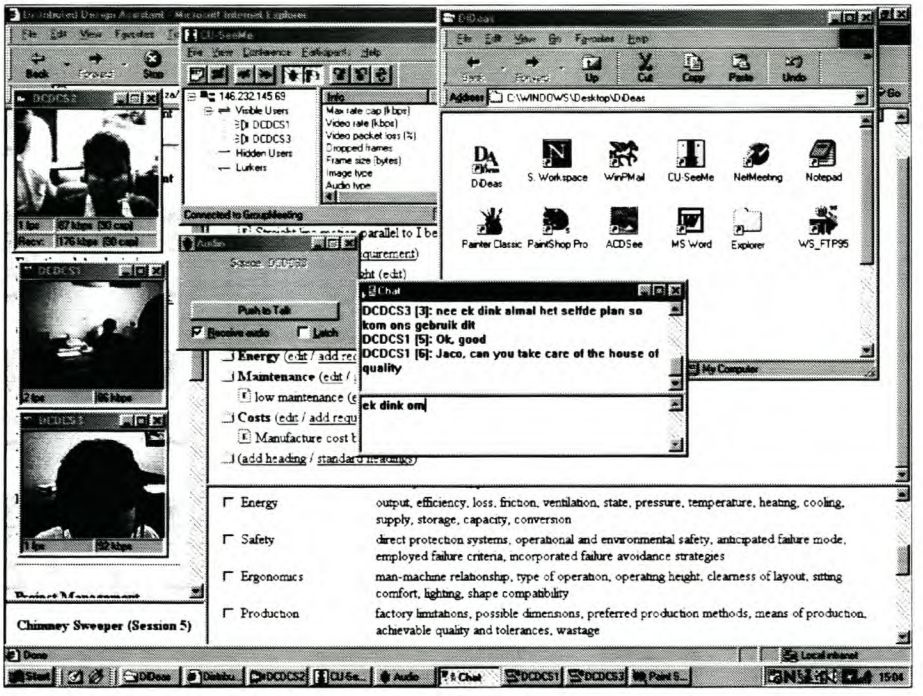


Figure 8.22: Crammed Computer Monitor

However, only three participants regarded the monitor size as insufficient. The problem was actually not the size of the monitor, but the amount of information presentable at any one time, determined by monitor size and resolution. One possible solution is the utilization of two monitors, one of which displays the web-browser windows for the Distributed Design Assistant and the other all applications for communication, sketch input and information transfer, as illustrated in Figure 8.23.

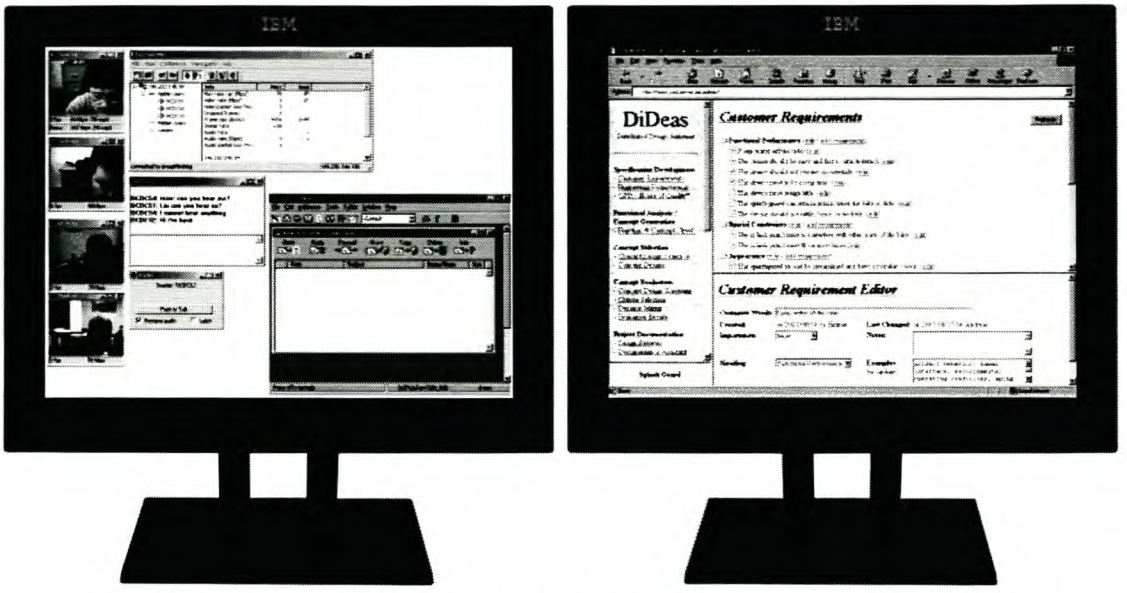


Figure 8.23: Utilization of two Computer Monitors

The display of information on multiple monitors is supported by various operating systems, among others Microsoft Windows98, Windows2000 and Windows XP.

8.5.4.5 Additional Communication and Input Devices

One participant proposed the incorporation of a telephone conference. The low quality of the audio function of the desktop-videoconference was probably the reason for this suggestion.

Three participants proposed the use of a digital camera as an additional input device. The reason for this request was most likely the low speed and resolution of the other input devices, such as the scanner and WebCam.

8.5.4.6 Problems Encountered

During the case study two students complained that data they had entered 'got lost'. While in the process of entering information in one frame, the designers had clicked on a hyperlink for another page. Before the data could be transmitted to the database, a page with new content was displayed and the previous information was erased.

Better introduction into the Distributed Design Assistant, as well as a reminder on the respective pages to update data regularly, will reduce the occurrence of this problem.

8.5.4.7 Comments and Suggestions made by the Participants

A few of the DiDeas users reported problems described as 'stalling' of the system, i.e. some pages of the Distributed Design Assistant took longer (up to about 30 seconds) to

load. Whether this problem is related to the network or the DiDeas server remains to be determined.

Some participants of both DiDeas supported and unsupported teams recommended that more time should be allocated for the case study: from a complete day to five days. This indicated that some students felt a strong time constraint and wished for more time for some or all steps of the design procedure. However, carrying out a case study with 18 participants over a few weeks was not realizable.

The response regarding the Distributed Design Assistant was positive; as one student expressed, 'a very good and quick way to do Ullman's design procedure.'

8.6 Summary

The Distributed Design Assistant was able to successfully impart the methodical design procedure described in Chapter 3 to the designers, even if they were not familiar with it.

During the specification development the DiDeas system aided the input of customer and engineering requirements. Since all team-members could enter requirements, the workload for the team leader was reduced. The use of standard headings for both types of requirements allowed for easy categorization, thereby improving the illustration of the requirements lists. It also helped to identify missing requirements.

The 'House of Quality' helped the designers to fully understand the design task. Most of the case study participants using the Distributed Design Assistant described the method as useful. Each DiDeas team developed a complete matrix and all team members could participate, in contrast to the groups without the DiDeas system. A more suitable strategy for displaying the QFD-matrix on a computer monitor remains to be developed.

The methodical approach to the function-concept structure was adopted by all teams. This is a clear indication of the preference of the designers to incorporate concepts at an early stage. Again, all team members of the DiDeas supported groups could enter information simultaneously, which enhanced productivity. The upload of concept sketches and descriptions directly to the function-concept structure of the Distributed Design Assistant was used successfully.

The teams supported by the DiDeas system developed more concepts than the unsupported teams, although duplicate concept designs were also generated. The evaluation process of the DiDeas teams was more systematic. However, due to

inaccurate criteria selection, the evaluation results calculated by the Distributed Design Assistant were inconclusive.

The communication tools implemented in the Distributed Design Assistant were not utilized to the expected extent. Due to being able to exchange design-related information via the DiDeas system, those teams produced far less paper-based information than the other groups. As a result, the use of external hardware and software applications for data exchange could be reduced.

The graphic tablet proved to be a very useful tool for sketch input and annotation, but the designers need practice with this before it will be favoured over pen and paper.

CHAPTER 9

CONCLUSIONS

9.1 Have the Aims been Achieved?

In Chapter 3 the aims of a support system for distributed conceptual design were identified. The three main elements of a support system, that is 'Design Methodology', 'Communication and Information Transfer' and 'Input Devices for Conceptual Design', were discussed. The design methodology described in Chapter 4, and various tools for communication and information transfer (see Chapter 5), were implemented in a low-cost, web-based support system, called 'Distributed Design Assistant'. A range of input devices for conceptual design were investigated and presented in Chapter 6.

Two case studies were carried out to assess collaboration tools and to evaluate the Distributed Design Assistant. The results of these case studies were discussed in Chapters 6 and 8. Regarding the provision and support for the three main elements of a distributed conceptual design support system, the following conclusions can be drawn.

The design methodology was successfully implemented and could support designers through all steps of the design procedure, from specification development to concept evaluation. The simultaneous input of design information into the DiDeas system by all team members greatly reduced the time for data collection. The systematic presentation of the gathered information, e.g. in the form of customer and engineering requirements and the 'House of Quality', led to a more comprehensive understanding of the design task. The integration of concepts at an early stage supported the functional analysis of the design task.

The quick information input minimizes self-judgement, which increases the chances for more radical concepts to be generated. The use of the Distributed Design Assistant also led to the development of a larger number of concept designs. A systematic concept evaluation was possible, although the results of the case study indicated the need for better criteria selection. With more time on hand for a real-life design project, the evaluation process could have been repeated and improved.

The communication tools implemented in the Distributed Design Assistant were not utilized during the case study as much as presumed before. This is expected to change in an asynchronous scenario, i.e. when the use of telephone and desktop-videoconferencing is restricted. Then the communication features of the DiDeas system could be of more value. The direct integration of electronic mail and desktop-videoconferencing into the Distributed Design Assistant was not feasible due to technical reasons.

The tools for information transfer, on the other hand, proved to be very useful, particularly the file upload to the function-concept structure.

As for the input devices supported by the Distributed Design Assistant, the graphic tablet was considered a very handy tool for sketch input and sketch annotation. The scanner was only used by the non-DiDeas teams during the case study. However, this could change during larger design projects with more time available.

Use of the Distributed Design Assistant led to a reduction in the amount of paper-based information and thereby the need for slow and inconvenient external hardware, such as the scanner, and software, e.g. the file upload to a shared workspace server via FTP.

The quick and extensive exchange of design information among all team members did enhance the productivity of the design teams. The systematic process of functional analysis, concept generation and concept selection led to a larger number of more comprehensively developed concept designs. This increases the chance for high quality concepts.

The Distributed Design Assistant can be used in synchronous and asynchronous collaboration scenarios. The assessment of the DiDeas features by the author also confirms the single-user capabilities of the system.

The Distributed Design Assistant was a suitable tool to teach the methodical approach to specification and concept development to both novice and experienced designers. During the case study, the use of the DiDeas system has shown the ability to extend the knowledge of design methodology through practical experience. It is expected that the system can be successfully integrated into formal design education.

The assessment of the design procedure and the user-interface by the case study participants was unanimously positive. Although the system is relatively simple, it is beneficial to designers and distributed design teams.

Hence, most aims of the Distributed Design Assistant, as set out, have been achieved. The research project is considered to be successful.

9.2 Recommendations for Future Work

Based on the case study results, a number of aspects that should be considered for future developments, to improve the Distributed Design Assistant, have been identified:

- incorporation of a team-formation strategy into the DiDeas system, e.g. based on the Myers-Briggs Type Indicator (MBTI), to optimise the team composition
- collapsible and expandable lists for customer and engineering requirements and a collapsible and expandable function-concept structure
- enhanced 'House of Quality' with better data input and display, including a correlation matrix, information on competitor's products, and a print option
- copying of elements of the function-concept structure, i.e. single functions and concepts or function-concept groups, to avoid repetitive input
- incorporation of a single-user or multi-user drawing tool, e.g. in the form of client-side scripts, to support sketch input and file upload to the DiDeas system
- incorporation of electronic mail into the Distributed Design Assistant, including the storage of e-mails in the DiDeas database for future reference
- enhanced help system that provides assistance directly at the feature in question, e.g. in the form of pop-ups
- export feature, to create reports and design reviews in Microsoft Word format and/or Adobe PDF
- evaluation of the Distributed Design Assistant in an industrial environment, over a larger period of time, and for a multi-national project.

CHAPTER 10

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APPENDIX A

CASE STUDY ON SYNCHRONOUS AND ASYNCHRONOUS COLLABORATION

A.1 Case Study Setup

Each participant received ten sheets of numbered scribble paper. To distinguish the sheets of scribble paper, each was labeled at the bottom with the following information:

- Date and time of the case study session
- User, e.g. DCDCS1 ('DCDCS1' is the login name of user #1)
- Paper number (1-10).

An example of the scribble paper is shown in Figure A.1.

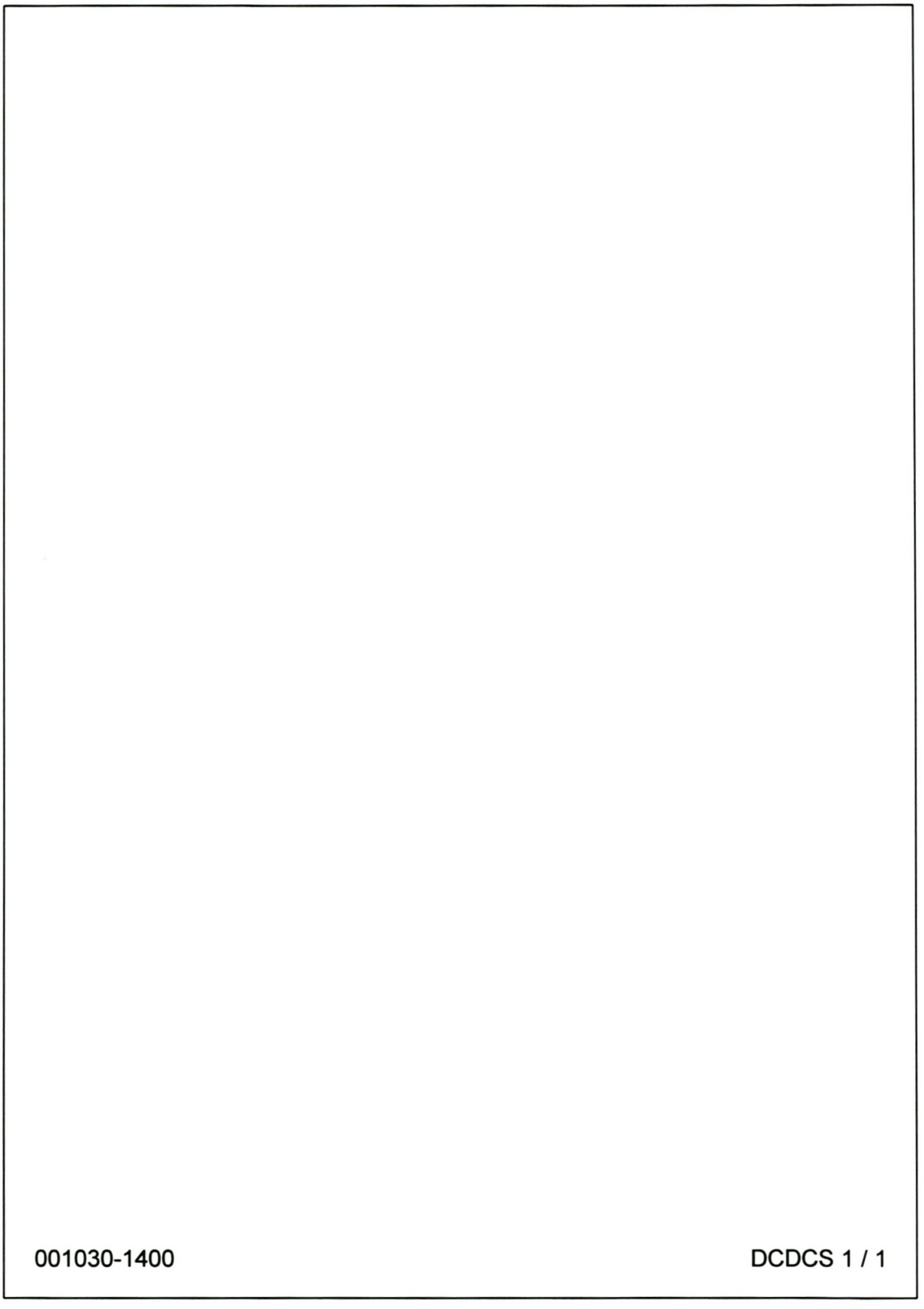

Figure A.1: Example of the Scribble Paper

A.2 Communication and Information Transfer Data

In this section the transcripts of the communication during the synchronous and asynchronous parts of the case study are listed. While the telephone and the desktop-videoconferencing could only be used during synchronous collaboration, electronic mail, fax, the scanner and the shared workspace could be used during both parts.

A.2.1 Telephone Calls

Each telephone call was analysed regarding the following criteria:

- Session: case study session
- CallID: unique ID for each telephone call identified
- From User: user who made the telephone call
- To User: user who received the telephone call
- Tape #: tape number, also identifies designer (tape #1 = designer #1)
- TapeStart: start time of the telephone call, as displayed on the video recorder
- TapeStop: stop time of the telephone call, as displayed on the video recorder
- Duration: duration of the telephone call (Duration = TapeStop – TapeStart)
- Type: type of the conversation (D = design-related, C = communication-related)
- Topics / Comments: topics of the conversation and/or comments by the author / case study supervisor.

The results are shown in Table A.1.

Session	CallID	From User	To User	Tape #	TapeStart	TapeStop	Duration	Type	Topics / Comments
s1	d2_p01_d1	d2	-	t1	0:03:25	0:03:58	0:00:33	D	Customer requirements, NotePad file
s1	d4_p01_d1	d4	-	t1	0:05:18	0:05:48	0:00:30	D	let's first begin with the customer requirements, … telephone numbers
s1	d3_p01_d1	d3	-	t1	0:08:34	0:09:13	0:00:39	D	just 5 minutes for the customer requirements
s1	d2_p02_d1	d2	-	t1	0:11:15	0:11:38	0:00:23	C	please open CU-SeeMe
s1	d3_p02_d1	d3	-	t1	0:54:05	0:55:47	0:01:42	C, D	discussion on a fax (?)
s1	d3_p04_d1	d3	-	t1	1:29:03	1:29:39	0:00:36	C	software problems at d3
s1	d2_p01_d1	-	d1	t2	0:02:46	0:03:19	0:00:33	D	Customer requirements, NotePad file
s1	d2_p02_d1	-	d1	t2	0:10:35	0:10:59	0:00:24	C	CU-SeeMe?
s1	d3_p03_d2	d3	-	t2	0:57:10	1:00:14	0:03:04	D	d2 explains one of her concepts (the one faxed?)
s1	d3_p01_d1	-	d1	t3	0:06:49	0:07:24	0:00:35	D	what are we doing with the customer requirements?
s1	d3_p02_d1	-	d1	t3	0:52:19	0:54:00	0:01:41	C, D	informs d1 about computer restart and discusses d2's concept (fax)
s1	d3_p03_d2	-	d2	t3	0:56:06	0:59:07	0:03:01	D	"can you explain the 'drawbridge' to me", d2 explains her design, then d3 explains his design
s1	d3_p04_d1	-	d1	t3	1:27:16	1:27:50	0:00:34	C	"my computer hangs"
s1	d4_p01_d1	-	d1	t4	0:02:40	0:03:10	0:00:30	D	"what are we supposed to do?"
s2	d1_p01_d2	-	d2	t1	0:04:05	0:04:21	0:00:16	D	can we work for 10 minutes on the customer requirements
s2	d1_p02_d3	-	d3	t1	0:04:29	0:04:50	0:00:21	D	can we work for 10 minutes on the customer requirements
s2	d1_p03_d4	-	d4	t1	0:04:57	0:05:29	0:00:32	D	can we work for 10 minutes on the customer requirements
s2	d1_p04_d2	-	d2	t1	0:08:05	0:08:18	0:00:13	D	when you have 5-6 concepts you can email them to me
s2	d3_p03_d1	d3	-	t1	0:10:01	0:10:28	0:00:27	C	I will email you that just now
s2	d3_p04_d1	d3	-	t1	0:13:41	0:14:18	0:00:37	C	Pegasus mail functionality
s2	d4_p02_d1	d4	-	t1	0:16:34	0:17:36	0:01:02	C	how to send /name files
s2	d4_p05_d1	d4	-	t1	0:22:47	0:23:38	0:00:51	C	CU-SeeMe session in 4min
s2	d1_p05_d2	-	d2	t1	0:28:51	0:28:59	0:00:08	D	how far are you?
s2	d1_p06_d3	-	d3	t1	0:29:10	0:29:54	0:00:44	D, C	how far are you? Cust.Req. are on ftp (all.doc)
s2	d1_p07_d4	-	d4	t1	0:30:00	0:30:34	0:00:34	D, C	how far are you? Cust.Req. are on ftp (all.doc)
s2	d1_p08_d3	-	d3	t1	0:31:43	0:32:20	0:00:37	C	can you see the file? It's now on ftp
s2	d1_p09_d2	-	d2	t1	0:32:26	0:32:33	0:00:07	C	can you see the file? It's now on ftp

Table A.1: Telephone Calls (1/11)

Session	CallID	From User	To User	Tape #	TapeStart	TapeStop	Duration	Type	Topics / Comments
s2	d4_p07_d1	d4	-	t1	0:36:09	0:36:58	0:00:49	D, C	all.doc, now concepts, then CU-SeeMe (schedule)
s2	d1_p10_d2	-	d2	t1	0:37:05	0:37:26	0:00:21	C	in 10min concept discussion in CU-SeeMe
s2	d1_p11_d3	-	d3	t1	0:37:31	0:37:51	0:00:20	C	in 10min concept discussion in CU-SeeMe
s2	d4_p08_d1	d4	-	t1	0:43:00	0:43:36	0:00:36	C	put it in this directory on ftp
s2	d1_p12_d4	-	d4	t1	0:44:49	0:45:35	0:00:46	C	do you have your concept on paper, lets have CU-SeeMe conference and hold paper in front of camera
s2	d1_p13_d4	-	d4	t1	0:49:12	0:49:19	0:00:07	C	email received? (not clear who)
s2	d4_p12_d1	d4	-	t1	0:56:11	0:56:26	0:00:15	C	we are waiting for the other two
s2	d1_p14_d4	-	d4	t1	0:56:42	0:56:47	0:00:05	C	log in to CU-SeeMe
s2	d4_p13_d1	d4	-	t1	1:00:53	1:01:09	0:00:16	C	still can't see you
s2	d1_p15_d2	-	d2	t1	1:03:54	1:04:28	0:00:34	D, C	what are you busy with, lets discuss with chat, fax your concept
s2	d1_p16_d4	-	d4	t1	1:04:45	1:05:30	0:00:45	D, C	fax your concept, then we discuss it via chat-line
s2	d1_p17_d3	-	d3	t1	1:13:35	1:14:22	0:00:47	D, C	lets begin discussing concepts and requirements
s2	d1_p18_d4	-	d4	t1	1:14:29	1:17:44	0:03:15	D, C	lets begin discussing concepts and requ., I can hold it in front of camera, lets use ftp
s2	d1_p19_d2	-	d2	t1	1:24:05	1:24:10	0:00:05	C	still busy?
s2	d1_p20_d3	-	d3	t1	1:24:15	1:24:25	0:00:10	C	d2 is still busy
s2	d1_p21_d4	-	d4	t1	1:24:31	1:24:52	0:00:21	C	d2 is still busy, once the files are on ftp we can discuss
s2	d4_p17_d1	d4	-	t1	1:25:48	1:26:01	0:00:13	C	I will have a look
s2	d4_p21_d1	d4	-	t1	1:31:19	1:32:25	0:01:06	C	how to use voice in CU-SeeMe (also via CU-SeeMe)
s2	d4_p23_d1	d4	-	t1	1:37:28	1:37:43	0:00:15	C	d4 informs AS on crash at d2
s2	d4_p24_d1	d4	-	t1	1:40:10	1:40:18	0:00:08	C	ok
s2	d1_p22_d2	-	d2	t1	1:41:10	1:41:30	0:00:20	D	how to discuss concepts
s2	d1_p23_d3	-	d3	t1	1:42:20	1:42:48	0:00:28	C	camera problems
s2	d1_p24_d3	-	d3	t1	1:42:53	1:43:20	0:00:27	C	visual problems
s2	d1_p25_d3	-	d3	t1	1:49:13	1:49:27	0:00:14	C	we are waiting for you, problems to connect
s2	d1_p26_d2	-	d2	t1	1:50:24	1:50:50	0:00:26	D, C	could you follow the discussion on CU-SeeMe
s2	d1_p27_d3	-	d3	t1	1:51:03	1:51:12	0:00:09	C	ok
s2	d3_p09_d1	d3	-	t1	1:51:58	1:52:22	0:00:24	C	can you see us, can you hear us
s2	d1_p28_d2	-	d2	t1	2:05:06	2:05:12	0:00:06	C	still busy?

Table A.1: Telephone Calls (2/11)

Session	CallID	From User	To User	Tape #	TapeStart	TapeStop	Duration	Type	Topics / Comments
s2	d1_p29_d3	-	d3	t1	2:07:47	2:13:26	0:05:39	C	d3 can't follow discussion, d1 tries to 'translate' (and holts phone receiver to speaker for d3 to listen)
s2	d4_p27_d1		-	t1	2:15:49	2:16:05	0:00:16	D	we go for concept 3.2
s2	d1_p01_d2	d1	-	t2	0:01:04	0:01:22	0:00:18	D	
s2	d2_p01_d3	-	d3	t2	0:04:29	0:04:58	0:00:29	C	email, ftp
s2	d1_p04_d2	d1	-	t2	0:05:05	0:05:18	0:00:13	D	email, ftp
s2	d3_p05_d2	d3	-	t2	0:12:45	0:13:25	0:00:40	C	start of a NetMeeting conference
s2	d4_p04_d2	d4	-	t2	0:18:40	0:19:40	0:01:00	D, C	cust. requirements, then concepts
s2	d1_p05_d2	d1	-	t2	0:25:50	0:26:02	0:00:12	D	ok
s2	d1_p09_d2	d1	-	t2	0:29:26	0:29:34	0:00:08	C	ok (ftp)
s2	d3_p06_d2	d3	-	t2	0:31:05	0:31:37	0:00:32	C	word doc, ftp
s2	d1_p10_d2	d1	-	t2	0:34:04	0:34:26	0:00:22	C	ok
s2	d4_p10_d2	d4	-	t2	0:42:40	0:44:09	0:01:29	D, C	tel-numbers
s2	d2_p02_d3	-	d3	t2	0:44:34	0:44:57	0:00:23	?	what are you doing?
s2	d2_p03_d3	-	d3	t2	0:53:12	0:55:22	0:02:10	C	connect groupmeeting, parallel to CU-SeeMe conference
s2	d1_p15_d2	d1	-	t2	1:00:53	1:01:29	0:00:36	D, C	no of concepts, on paper, fax it
s2	d3_p07_d2	d3	-	t2	1:14:47	1:15:58	0:01:11	C	where are the concepts? (only scanned, not distributed?)
s2	d4_p15_d2	d4	-	t2	1:19:59	1:20:10	0:00:11	C	ok
s2	d1_p19_d2	d1	-	t2	1:21:03	1:21:08	0:00:05	C	it's on its way
s2	d2_p04_d3	-	d3	t2	1:22:58	1:24:01	0:01:03	C	saved as jpeg, InternetExplorer/Netscape
s2	d4_p18_d2	d4	-	t2	1:24:41	1:25:38	0:00:57	C	files in shared on ftp
s2	d3_p08_d2	d3	-	t2	1:28:46	1:30:25	0:01:39	C	which button to press in CU-SeeMe for voice
s2	d4_p22_d2	d4	-	t2	1:33:09	1:33:33	0:00:24	C	error message
s2	d1_p22_d2	d1	-	t2	1:38:08	1:38:29	0:00:21	D	ok
s2	d3_p??_d2	d3	-	t2	1:39:07	1:39:47	0:00:40	C	my cam does not work anymore
s2	d1_p26_d2	d1	-	t2	1:47:22	1:47:50	0:00:28	D, C	yes, I just did
s2	d3_p10_d2	d3	-	t2	1:55:06	1:55:23	0:00:17	C	d3's computer is frozen
s2	d3_p11_d2	d3	-	t2	1:56:08	2:01:32	0:05:24	D, C	d2 holds his mic to the receiver for the others to hear d3, location of files, translating between d3 and rest of team (CU-SeeMe)
s2	d1_p28_d2	d1	-	t2	2:01:40	2:01:45	0:00:05	C	I'll do it now

Table A.1: Telephone Calls (3/11)

Session	CallID	From User	To User	Tape #	TapeStart	TapeStop	Duration	Type	Topics / Comments
s2	d3_p12_d2	d3	-	t2	2:03:30	2:03:34	0:00:04	C	I'm busy
s2	d3_p01_d2	-	d2	t3	0:00:20	0:00:37	0:00:17	C	webcam arrangement
s2	d3_p02_d4	-	d4	t3	0:01:06	0:01:12	0:00:06	?	?
s2	d1_p02_d3	d1	-	t3	0:02:47	0:03:10	0:00:23	D	word or email
s2	d2_p01_d3	d2	-	t3	0:05:47	0:06:18	0:00:31	C	word, then ftp
s2	d4_p01_d3	d4	-	t3	0:06:32	0:07:17	0:00:45	D	reads cust. Req., max 5min, then ftp, then video
s2	d3_p03_d1	-	d1	t3	0:08:21	0:08:48	0:00:27	C	everybody puts his cust.req. on ftp
s2	d3_p04_d1	-	d1	t3	0:12:03	0:12:37	0:00:34	C	how to send a message to all 4 users?, number of user in filename
s2	d3_p05_d2	-	d2	t3	0:14:05	0:14:44	0:00:39	C	lets have a NetMeeting conference, are your cust.req. on ftp?
s2	d4_p03_d3	d4	-	t3	0:19:17	0:19:50	0:00:33	D, C	?
s2	d1_p06_d3	d1	-	t3	0:27:28	0:28:14	0:00:46	C	where is it, on ftp? Shared, all.doc?
s2	d1_p08_d3	d1	-	t3	0:30:04	0:30:40	0:00:36	C	on shared, I see it
s2	d4_p06_d3	d4	-	t3	0:30:54	0:31:47	0:00:53	C	ftp, click refresh
s2	d3_p06_d2	-	d2	t3	0:32:26	0:32:47	0:00:21	C	all.doc
s2	d1_p11_d3	d1	-	t3	0:35:51	0:36:12	0:00:21	C	so we now meet in CU-SeeMe
s2	d4_p09_d3	d4	-	t3	0:42:14	0:42:32	0:00:18	D	ok
s2	d2_p02_d3	d2	-	t3	0:45:55	0:46:16	0:00:21	?	ok
s2	d4_p11_d3	d4	-	t3	0:49:26	0:54:28	0:05:02	C	contact, where are you?, problems with CU-SeeMe
s2	d2_p03_d3		-	t3	0:54:32	0:56:42	0:02:10	C	groupmeeting, ok, can you see me (waves hand)?, can you see concept (shows paper)?
s2	d1_p17_d3	d1	-	t3	1:11:54	1:12:40	0:00:46	D, C	it's on ftp, do you see it?
s2	d3_p07_d2	-	d2	t3	1:16:07	1:17:18	0:01:11	C	ftp, share? 2 concepts, save on ftp
s2	d4_p14_d3	d4	-	t3	1:17:40	1:18:55	0:01:15	C	did you get my fax, is fax on ftp? I can't see it
s2	d1_p20_d3	d1	-	t3	1:22:34	1:22:43	0:00:09	C	organised?
s2	d4_p16_d3	d4	-	t3	1:23:40	1:24:02	0:00:22	C	reads filenames on ftp
s2	d2_p04_d3	d2	-	t3	1:24:17	1:25:20	0:01:03	C	you have to refresh
s2	d4_p19_d3	d4	-	t3	1:27:05	1:28:28	0:01:23	D, C	concepts... (starts talking on video after call)
s2	d4_p20_d3	d4	-	t3	1:29:05	1:29:26	0:00:21	C	you do that
s2	d3_p08_d2	-	d2	t3	1:30:06	1:31:42	0:01:36	C	explains cu-seeme (voice function)

Table A.1: Telephone Calls (4/11)

Session	CallID	From User	To User	Tape #	TapeStart	TapeStop	Duration	Type	Topics / Comments
s2	-	-	-	-	1:39:00	1:45:30	-	-	no video
s2	d4_p26_d3	d4	-	t3	1:46:14	1:46:50	0:00:36	C	problem with cu-seeme conference
s2	d1_p27_d3	d1	-	t3	1:49:04	1:49:13	0:00:09	C	still trying to fix problem
s2	d3_p09_d1	-	d1	t3	1:50:00	1:50:24	0:00:24	C	informs others about computer crash
s2	d3_p10_d2	-	d2	t3	1:56:09	1:56:25	0:00:16	C	problems with software, I'll explain my concept just now
s2	d3_p11_d2	-		t3	1:57:11	2:02:58	0:05:47	C, D	video doesn't work, explains concept via phone
s2	d3_p12_d2	-	d2	t3	2:04:58	2:05:02	0:00:04	C	what are you doing? Ok
s2	d1_p29_d3	d1	-	t3	2:05:47	2:12:09	0:06:22	C	video doesn't work, discusses concepts over phone
s2	d3_p02_d4	?	-	t4	0:01:46	0:01:55	0:00:09	?	yes
s2	d1_p03_d4	d1	-	t4	0:03:58	0:04:30	0:00:32	D	yes, we can do that
s2	d4_p01_d3	-	d3	t4	0:07:15	0:07:59	0:00:44	D	what else are cust. req.?
s2	d4_p02_d1	-	d1	t4	0:15:37	0:16:39	0:01:02	C	informs d1 on uploaded file
s2	d4_p03_d3	-	d3	t4	0:19:59	0:20:32	0:00:33	C	how to handle files
s2	d4_p04_d2	-	d2	t4	0:20:42	0:21:40	0:00:58	D, C	first cust.req. then concepts, then upload
s2	d4_p05_d1	-	d1	t4	0:21:50	0:22:40	0:00:50	C	put files on server, asks d1 to send info to all,
s2	d1_p07_d4	d1	-	t4	0:29:01	0:29:38	0:00:37	D, C	I'm busy, ftp/shared
s2	d4_p06_d3	-	d3	t4	0:31:36	0:32:28	0:00:52	C	asks for location of files on ftp
s2	d4_p07_d1	-	d1	t4	0:35:11	0:36:00	0:00:49	D, C	not concepts, but cust.req.
s2	d4_p08_d1	-	d1	t4	0:42:05	0:42:39	0:00:34	C	location of files on ftp
s2	d4_p09_d3	-	d3	t4	0:42:55	0:43:14	0:00:19	D	how many concepts?
s2	d1_p12_d4	d1	-	t4	0:43:50	0:44:36	0:00:46	C	we can try, are your concepts ready
s2	d4_p10_d2	-	d2	t4	0:44:43	0:46:10	0:01:27	D, C	how many concepts? Filenames, explorer
s2	d1_p13_d4	d1	-	t4	0:48:12	0:48:21	0:00:09	C	just opening it now
s2	d4_p11_d3	-	d3	t4	0:50:08	0:55:10	0:05:02	C	CU-SeeMe, how to connect to d3
s2	d4_p12_d1	-	d1	t4	0:55:15	0:55:26	0:00:11	C	-
s2	d1_p14_d4	d1	-	t4	0:55:41	0:55:48	0:00:07	C	-
s2	d4_p13_d1	-	d1	t4	0:59:55	1:00:07	0:00:12	C	groupmeeting?
s2	d1_p16_d4	d1	-	t4	1:03:45	1:04:30	0:00:45	D, C	ftp, insists on file is there, goes to fax

Table A.1: Telephone Calls (5/11)

Session	CallID	From User	To User	Tape #	TapeStart	TapeStop	Duration	Type	Topics / Comments
s2	d1_p18_d4	d1	-	t4	1:13:29	1:16:46	0:03:17	D, C	how is it?, ftp-upload, how many concepts?
s2	d4_p14_d3	-	d3	t4	1:18:22	1:19:37	0:01:15	C	jpegs work, but psp-files not, files of ftp, concept same as others
s2	d4_p15_d2	-	d2	t4	1:22:00	1:22:12	0:00:12	C	jpegs work, but psp-files not, files of ftp, concept same as others
s2	d1_p21_d4	d1	-	t4	1:23:30	1:23:52	0:00:22	C	shared folder on ftp
s2	d4_p16_d3	-	d3	t4	1:24:21	1:24:42	0:00:21	C	checks filenames on ftp
s2	d4_p17_d1	-	d1	t4	1:24:49	1:25:04	0:00:15	C	where are your concepts?
s2	d4_p18_d2	-	d2	t4	1:26:42	1:27:39	0:00:57	C	can you see the concepts? Look at shared, 3 wheels?
s2	d4_p19_d3	-	d3	t4	1:27:46	1:29:10	0:01:24	D, C	can you see what I did?, concept discussion
s2	d4_p20_d3	-	d3	t4	1:29:47	1:30:09	0:00:22	C	push to talk (talks via phone and cu-seeme to d3)
s2	d4_p21_d1	-	d1	t4	1:30:19	1:31:28	0:01:09	C	look at cu-seeme menu, try that, can you hear us? You're too soft
s2	d4_p22_d2	-	d2	t4	1:35:11	1:35:34	0:00:23	C	flashbacks, comp problems
s2	d4_p23_d1	-	d1	t4	1:36:28	1:36:43	0:00:15	C	informs on d2's computer crash
s2	d4_p24_d1	-	d1	t4	1:39:11	1:39:18	0:00:07	C	?
s2	d4_p25_d3	-	d3	t4	1:40:30	1:41:05	0:00:35	?	? (during video-down-time of d3)
s2	d3_p??_d4	d3	-	t4	1:41:20	1:41:49	0:00:29	D	what's your concept, we begin with …
s2	d3_p??_d4	d3	-	t4	1:42:26	1:42:46	0:00:20	?	yes/no
s2	d4_p26_d3	-	d3	t4	1:47:14	1:47:49	0:00:35	C	problems
s2	d4_p27_d1	-	d1	t4	2:14:50	2:15:05	0:00:15	D	what do we do now?
s3	d1_p01_d2	-	d2	t1	0:04:47	0:05:50	0:01:03	C, D	have you opened NetMeeting?, starts NetMeeting session with d2
s3	d1_p02_d3	-	d3	t1	0:17:34	0:18:08	0:00:34	C, D	how is it going, you can use email, how are your customer requirements?
s3	d2_p03_d1	d2	-	t1	0:26:20	0:26:37	0:00:17	C	ok, should we then just work on paper and fax?
s3	d2_p04_d1	d2	-	t1	0:46:07	0:47:18	0:01:11	D	I was just faxing, if you lock it, maybe …; what other ideas do you have, have you heard anything from Rachel? calls d3 after this phonecall
s3	d1_p03_d3	-	d3	t1	0:47:46	0:48:19	0:00:33	D	organization of group discussion
s3	d1_p04_d3	-	d3	t1	1:10:35	1:11:01	0:00:26	C, D	I think we should finalize the concepts now, please go into CU-SeeMe, see you there
s3	d1_p05_d2	-	d2	t1	1:11:08	1:11:28	0:00:20	C, D	we will now have a groupmeeting in CU-SeeMe, discuss our concepts, maybe have some changes, see you there
s3	d3_p01_d1	d3	-	t1	1:17:03	1:17:19	0:00:16	C	I had to shut down the computer, see you now
s3	d2_p05_d1	d2	-	t1	1:31:34	1:32:00	0:00:26	C	I have to reset that thing
s3	d1_p06_d2	-	d2	t1	1:34:08	1:34:38	0:00:30	C	bloody technology, are you on or of? 5 minutes

Table A.1: Telephone Calls (6/11)

Session	CallID	From User	To User	Tape #	TapeStart	TapeStop	Duration	Type	Topics / Comments
s3	d1_p07_d3	-	d3	t1	1:38:01	1:38:30	0:00:29	C	have you got the fax yet? That's it, lets go over to the next one
s3	d1_p08_d2	-	d2	t1	1:38:38	1:38:57	0:00:19	C	looks good, I'll hire you, we are done
s3	d1_p01_d2	d1	-	t2	0:04:03	0:05:07	0:01:04	C, D	asks about further procedure and arranges to start NetMeeting conference
s3	d2_p01_d3	-	d3	t2	0:11:05	0:11:21	0:00:16	C	I started NetMeeting, can you do the same?; starts NetMeeting after phonecall
s3	d2_p02_d3	-	d3	t2	0:23:12	0:23:29	0:00:17	D	(I will send my concept now)?
s3	d2_p03_d1	-	d1	t2	0:25:40	0:25:56	0:00:16	C	I have to reboot my computer
s3	d2_p04_d1	-	d1	t2	0:45:27	0:46:36	0:01:09	D	… can't lock it …
s3	d1_p05_d2	d1	-	t2	1:09:53	1:10:20	0:00:27	C, D	CU-SeeMe, starts CU-SeeMe
s3	d2_p05_d1	-	d1	t2	1:30:54	1:31:17	0:00:23	C	problems with the computer, could you send me a fax that I have something in front of me
s3	d1_p06_d2	d1	-	t2	1:33:26	1:33:56	0:00:30	C	meeting? NetMeeting? Please send me a fax
s3	d1_p08_d2	d1	-	t2	1:37:55	1:38:20	0:00:25	C	no more conferences, are we done?
s3	d2_p01_d3	d2	-	t3	0:09:56	0:10:12	0:00:16	C	opens NetMeeting after call
s3	d1_p02_d3	d1	-	t3	0:15:42	0:16:17	0:00:35	C, D	he can't hear me, … I'm doing all in-between, I'll send it to you as soon as possible
s3	d2_p02_d3	d2	-	t3	0:22:00	0:22:19	0:00:19	D	ok, I'm sending you the rest of the customer requirements now
s3	d1_p03_d3	d1	-	t3	0:45:55	0:46:28	0:00:33	D	still drawing, have not looked at yours, will look at as soon as finished with mine
s3	d1_p04_d3	d1	-	t3	1:09:15	1:09:38	0:00:23	C, D	opens CU-SeeMe after call
s3	d3_p01_d1	-	d1	t3	1:15:12	1:15:27	0:00:15	C	are you going to log in, because we are waiting for you
s3	-	-	-	-	1:34:55	1:35:18	0:00:23	-	no video (picture and sound), possible connection to d1 (d3_02_01)
s3	d1_p07_d3	?	-	t3	1:36:09	1:36:38	0:00:29	D	yes, the fax is here with me now, what have we to do now
s4	d2_01_d1	d2	-	t1	0:03:09	0:03:18	0:00:09	D	yes, ok, bye-bye
s4	d3_02_d1	d3	-	t1	0:35:18	0:36:11	0:00:53	C, D	yes I got that; please use a numbering system for your concepts; the concept I understand except…; I'm still busy with it (is pointing to graphic on the screen)
s4	d3_03_d1	d3	-	t1	0:52:41	0:54:17	0:01:36	D	do you understand it, the pins will come in the circles, back is the same as the front, Nicola just phoned me, she thinks …, I think maybe one more
s4	d1_01_d2	-	d2	t1	0:54:57	0:56:30	0:01:33	C, D	I'm not sure if I understand you concept, how do you want to fasten the saddle? Ok, I understand it, another problem with his (d3) design is …, just refine you concept
s4	d1_02_d2	-	d2	t1	1:01:01	1:01:21	0:00:20	C, D	I just want you to have a NetMeeting conference with me so that you can explain your concept to me
s4	d1_03_d2	-	d2	t1	1:09:22	1:09:41	0:00:19	D	sorry to call, I had to convert a file … ACDSee
s4	d1_04_d3	-	d3	t1	1:09:54	1:10:04	0:00:10	C	CU-SeeMe videoconferencing session in one minute

Table A.1: Telephone Calls (7/11)

Session	CallID	From User	To User	Tape #	TapeStart	TapeStop	Duration	Type	Topics / Comments
s4	d1_05_d2	-	d2	t1	1:11:40	1:11:52	0:00:12	C	hi, can you see me, I can't see you
s4	d1_06_d2	-	d2	t1	1:15:25	1:15:41	0:00:16	C	cancel you connection with d3 and connect to Groupmeeting
s4	d1_07_d3	-	d3	t1	1:15:50	1:16:08	0:00:18	C	cancel you connection with d2 and connect to Groupmeeting
s4		d2	-	t1	1:17:05	1:17:13	0:00:08	C	is it ok goodbye
s4	d1_08_d2	-	d2	t1	1:21:42	1:21:51	0:00:09	C	how is it going? not well? Ok
s4	d1_03_d3	-	d3	t1	1:25:23	1:25:33	0:00:10	C	I think you went offline
s4	d2_01_d1	-	d1	t2	0:01:18	0:01:25	0:00:07	D	what are we starting with - ok, you just mailed me
s4	d3_01_d2	d3	-	t2	0:32:18	0:33:19	0:01:01	D	looking at image, can't really understand it, how to keep bike up the wall
s4	d1_01_d2	d1	-	t2	0:53:07	0:54:40	0:01:33	C, D	I just put the bar on, if you put it against the wall, … , did you get my email, if we can plug it against the wall like an ironing board
s4	d3_01_d2	-	d2	t3	0:33:10	0:34:10	0:01:00	C, D	did you get my mail, do you like it?, explains concept
s4	d3_02_d1	-	d1	t3	0:34:18	0:35:11	0:00:53	C, D	did you get my concept?, explains concept
s4	d3_03_d1	-	d1	t3	0:51:43	0:53:19	0:01:36	D	no not really, … padlocks, is it really necessary to have that middle one, should we have more concepts?
s4	d1_04_d3	d1	-	t3	1:08:54	1:09:07	0:00:13	C	allright
s4	d1_07_d3	d1	-	t3	1:14:50	1:15:10	0:00:20	C	I'm trying, I can see myself and d2
s4	d1_03_d3	d1	-	t3	1:24:24	1:24:38	0:00:14	C	ok, must I reset?
s4	-	-	-	-	1:33:36	1:33:53	0:00:17	-	no sound, no video
s5	d2_01_d1	d2	-	t1	0:04:11	0:04:41	0:00:30	D	just five minutes for the customers requirements, write it down, fax it, scan it, just that everyone has a hardcopy, yes you can do it on the computer
s5	d1_01_d2	-	d2	t1	0:11:25	0:11:48	0:00:23	C	did you get my fax, we shouldn't waste too much time with it
s5	d1_02_d3	-	d3	t1	0:11:55	0:12:21	0:00:26	C, D	did you get my fax, …
s5	d2_02_d1	d2	-	t1	0:17:44	0:18:15	0:00:31	C	just got your mail, haven't NetMeeting on, I'll switch NetMeeting on now
s5	d1_03_d3	-	d3	t1	0:20:19	0:21:21	0:01:02	C, D	how are your customer requirements going, that's not a concepts, we first do requirements, then 20min concept generation, then 20min concept evaluation, switch NetMeeting on for the concept evaluation
s5	d2_03_d1	d2	-	t1	0:45:12	0:45:54	0:00:42	C, D	I got your first concept, but change your labeling system for all your electronic files to 2concept1, 2 concept2, etc.
s5	d1_04_d3	-	d3	t1	0:46:01	0:47:09	0:01:08	C, D	label your electronic files 3concept1, 3concept2, etc, that all of us talk about the same file
s5	d1_05_d3	-	d3	t1	1:00:52	1:01:59	0:01:07	C	discusses ftp download of file
s5	d3_01_d1	d3	-	t1	1:03:53	1:04:50	0:00:57	D	let's now do concept evaluation, proposes sequence of files to be discussed
s5	d1_06_d2	-	d2	t1	1:06:08	1:07:30	0:01:22	C	copy all files to your computer, then open CU-SeeMe, make sure you have all your files accessible
s5	d1_07_d3	-	d3	t1	1:08:56	1:10:22	0:01:26	C	open CU-SeeMe, but close other programs first; then we are doing the evaluation, copy the files from the ftp-server to your harddrive

Table A.1: Telephone Calls (8/11)

Session	CallID	From User	To User	Tape #	TapeStart	TapeStop	Duration	Type	Topics / Comments
s5	d1_08_d2	-	d2	t1	1:16:25	1:17:40	0:01:15	C	explains how to connect to CU-SeeMe groupmeeting
s5	d1_09_d3	-	d3	t1	1:22:52	1:23:05	0:00:13	C	are you with us? What we are doing is … (hangs up)
s5	d3_02_d1	d3	-	t1	1:33:37	1:33:57	0:00:20	C	software problems, join us in the video-conference whenever you are ready, we will give you an update then
s5	d2_01_d1	-	d1	t2	0:02:33	0:03:04	0:00:31	D	… pencil and paper? …
s5	d1_01_d2	d1	-	t2	0:09:46	0:10:11	0:00:25	C	… sure
s5	d2_02_d1	-	d1	t2	0:16:06	0:16:36	0:00:30	C	NetMeeting says: not able to accept, are you on?
s5	d2_03_d1	-	d1	t2	0:43:34	0:44:16	0:00:42	C, D	that's what I have, ok
s5	d1_06_d2		-	t2	1:04:29	1:05:53	0:01:24	C	… ok, close NetMeeting, open CU-SeeMe
s5	d1_08_d2	d1	-	t2	1:14:47	1:16:02	0:01:15	C	must I close the window, groupmeeting ok, is yours switched on?
s5	d1_02_d3	d1	-	t3	0:11:05	0:11:33	0:00:28	C, D	…
s5	d1_03_d3	d1	-	t3	0:19:29	0:20:32	0:01:03	C, D	yes, I'll do that, NetMeeting
s5	d1_04_d3	d1	-	t3	0:45:12	0:46:20	0:01:08	C, D	I'm busy to mail to d2, I saved it as concept1, what are we doing now
s5	d1_05_d3	d1	-	t3	1:00:01	1:01:07	0:01:06	C	how to use WS_FTP, mine is 3concept1
s5	d3_01_d1	-	d1	t3	1:03:06	1:04:01	0:00:55	D	hydraulic …, has everybody a concept …, I have only one so far
s5	d1_07_d3	d1	-	t3	1:08:08	1:09:35	0:01:27	C	ftp/share, I don't see mine, share what? Ok, I get it
s5	d1_09_d3	-	d1	t3	1:22:03	1:22:12	0:00:09	C	I'm with you just now
s5	d3_02_d1	-	d1	t3	1:32:47	1:33:07	0:00:20	C	I'm off, ok
s6	d2_p02_d1	d2	-	t1	0:05:35	0:06:16	0:00:41	C, D	"got your mail, let's have a conference in 2 min in CU-SeeMe, then we can brainstorm what we have so far"
s6	d2_p03_d1	d2	-	t1	0:09:25	0:09:51	0:00:26	C	"we're just waiting for you to join"
s6	d1_p01_d4	-	d4	t1	0:11:12	0:11:53	0:00:41	C	invitation for CU-SeeMe conference and instructions how to start it
s6	d4_p01_d1	d4	-	t1	0:23:21	0:23:37	0:00:16	C	"great"
s6	d1_p02_p04	-	d4	t1	0:27:16	0:27:41	0:00:25	C	"got your fax, can't see, what's going on, it didn't come out clearly"
s6	d1_p03_p04	-	d4	t1	0:31:04	0:31:14	0:00:10	C	"fax is now much better"
s6	d4_p02_d1	d4	-	t1	0:42:07	0:42:45	0:00:38	C, D	how to proceed (open all concepts, have CU-SeeMe conference)
s6	d2_p04_d1	d2	-	t1	0:50:22	0:50:36	0:00:14	C	d1 talks about scanner problems, "we will wait for your stuff"
s6	d1_p04_p04	-	d4	t1	1:09:11	1:09:31	0:00:20	D	how to proceed (open all concepts and discuss, have CU-SeeMe conference)
s6	d1_p05_p04	-	d4	t1	1:12:06	1:12:53	0:00:47	C	"can you see what you are typing in the chat window? I can't see any typing"

Table A.1: Telephone Calls (9/11)

Session	CallID	From User	To User	Tape #	TapeStart	TapeStop	Duration	Type	Topics / Comments
s6	d4_p04_d1	d4	-	t1	1:13:37	1:13:50	0:00:13	C	"OK, no problem, just type something when you are ready"
s6	d4_p05_d1	d4	-	t1	1:16:29	1:16:42	0:00:13	C	"OK, excellent" (d4 is back online)
s6	d1_p06_d2	-	d2	t1	1:23:46	1:24:27	0:00:41	C	computer (video) problems with d2 (?)
s6	d2_p08_d1	d2	-	t1	1:25:35	1:36:16	0:10:41	C, D	'speedtyping' for d2
s6	d2_p01_d1	-	d1	t2	0:01:50	0:02:53	0:01:03	?	?
s6	d1_p??_d2	d1	-	t2	0:04:13	0:04:59	0:00:46	?	?
s6	d2_p02_d1	-	d1	t2	0:21:25	0:22:03	0:00:38	C, D	are we supposed to concepts just to you or to anybody?
s6	d2_p03_d1	-	d1	t2	0:25:15	0:25:40	0:00:25	C	have you started anything
s6	d2_p04_d1	-	d1	t2	1:05:42	1:05:54	0:00:12	C	?
s6	d2_p05_p03	-	d3	t2	1:21:45	1:21:59	0:00:14	C	are you going to join us? The CU-SeeMe thing
s6	d2_p06_p04	-	d4	t2	1:22:06	1:22:10	0:00:04	C	are you going to join us?
s6	d2_p07_p03		d3	t2	1:29:14	1:32:36	0:03:22	C, D	ahh, that looks professional, reads chat msgs, talks about ftp, types and reads chat msg
s6	d1_p06_d2	d1	-	t2	1:39:02	1:39:47	0:00:45	C	I can read your text, I'm typing now, can you read this, no, ok
s6	d2_p08_d1	-	d1	t2	1:40:54	1:51:35	0:10:41	C	?
s6	d3_p05_d2	d3	-	t2	1:52:34	1:53:14	0:00:40	C	I can see you, but you can't see me
s6	d3_p01_d4	-	d4	t3	0:28:52	0:29:07	0:00:15	C	let's see us in NetMeeting, no CU-SeeMe
s6	d3_p02_d4	-	d4	t3	0:51:09	0:52:01	0:00:52	C, D	(drawing in front of camera) can you see?
s6	d3_p03_d4	-	d4	t3	1:08:42	1:09:27	0:00:45	C	do you have NetMeeting open, explains how to do it
s6	d3_p04_d4	-	d4	t3	1:12:45	1:13:00	0:00:15	C	open NetMeeting
s6	d4_p03_p03	d4	-	t3	1:18:38	1:21:19	0:02:41	C	Netscape->Sharing
s6	d2_p05_p03	d2	-	t3	1:25:00	1:25:15	0:00:15	C	?
s6	d2_p07_p03	d2	-	t3	1:32:27	1:35:54	0:03:27	C, D	Thumbs up for the WebCam
s6	-	-	-	-	1:38:37	1:45:26	0:06:49		video malfunction (no video, no sound)
s6	d4_p07_d3	d4	-	t3	1:49:54	1:50:42	0:00:48	C	tests camera
s6	d3_p05_d2	-	d2	t3	1:55:33	1:56:13	0:00:40	C	what's going on
s6	d3_p01_d4	d3	-	t4	0:29:18	0:29:36	0:00:18	C	(open CU-SeeMe)
s6	d1_p01_d4	d1	-	t4	0:30:09	0:30:53	0:00:44	C	Reflector, where is that? OK

Table A.1: Telephone Calls (10/11)

Session	CallID	From User	To User	Tape #	TapeStart	TapeStop	Duration	Type	Topics / Comments
s6	d4_p01_d1	-	d1	t4	0:42:22	0:42:38	0:00:16	C	my system is down for a while
s6	d1_p02_p04	d1	-	t4	0:46:18	0:46:41	0:00:23	C	I'll fax it again
s6	d1_p03_p04	d1	-	t4	0:50:05	0:50:16	0:00:11	C	ok
s6	d3_p02_d4	d3	-	t4	0:51:35	0:52:29	0:00:54	C, D	is that a box with a bicycle in it?, aha
s6	d4_p02_d1	-	d1	t4	1:01:10	1:01:46	0:00:36	C, D	what should we have, one concept? Ok
s6	d3_p03_d4	d3	-	t4	1:09:08	1:09:54	0:00:46	C	is asked to open NetMeeting conference
s6	d3_p04_d4	d3	-	t4	1:13:11	1:13:30	0:00:19	C	?
s6	d4_p03_p03	-	d3	t4	1:19:07	1:21:45	0:02:38	C	Netscape, how to open default (d) page, one uses Netscape the other IE5
s6	d2_p06_p04	d2	-	t4	1:25:47	1:25:54	0:00:07	C	?
s6	d1_p04_p04	d1	-	t4	1:28:09	1:28:35	0:00:26	D	I am in but, I can't send video
s6	d1_p05_p04	d1	-	t4	1:31:05	1:31:55	0:00:50	C	I can see what you are typing …
s6	d4_p04_d1	-	d1	t4	1:32:38	1:32:52	0:00:14	C	I am experiencing some difficulties here
s6	d4_p05_d1	-	d1	t4	1:35:31	1:35:42	0:00:11	C	?
s6	d4_p07_d3	-	d3	t4	1:50:39	1:51:25	0:00:46	C	waar is die mense?

Table A.1: Telephone Calls (11/11)

A.2.2 Desktop-Videoconferencing

Each desktop-videoconference was analysed regarding the following criteria:

- Session: case study session
- Users: users participating in the conference
- Initiator: user who initiated the conference
- Tape #: tape number, also identifies designer (tape #1 = designer #1)
- TapeStart: start time of the conference, as displayed on the video recorder
- TapeStop: stop time of the conference, as displayed on the video recorder
- Duration: duration of the conference (Duration = TapeStop – TapeStart)
- Program: software used (C = CU-SeeMe, N = Microsoft NetMeeting)
- Chat: chat used during the videoconference (x = yes)
- Voice: verbal communication used during the videoconference (x = yes)
- Gestures: gestures made during the videoconference (x = yes)
- Topics / Comments: topics of the conference and/or comments by the author / case study supervisor.

The results are shown in Table A.2.

Session	Users	Initiator	Tape #	TapeStart	TapeStop	Duration	Program	Chat	Voice	Gestures	Topics / Comments
s1	d1d2	d1	t1	0:11:42	0:13:18	0:01:36	C	x		x	arranged by email, tells d2 to connect to groupmeeting
s1	d1d2d3d4	?	t1	0:13:35	1:59:33	1:45:58	C	x	x	x	cust.req., concept discussion, big final discussion
s1	d1d2	d1	t2	0:11:07	0:12:37	0:01:30	C	x		x	no talking
s1	d1d2d3d4	?	t2	0:12:50	1:59:15	1:46:25	C	x	x	x	cust.req., concept discussion, big final discussion
s1	d1d2d3d4	?	t3	0:10:52	1:58:08	1:47:16	C	x	x	x	cust.req., concept discussion, big final discussion
s1	d1d2d3d4	?	t4	0:09:57	1:57:10	1:47:13	C	x	x	x	cust.req., concept discussion, big final discussion
s2	d1d2d3d4	d1	t1	0:54:59	2:16:01	1:21:02	C	x	x	x	d1, d3 hold papers in front of camera, later discussion of concepts via audio, everybody describes his concept, questions, d1 asks each for best concept voice only later
s2	d2d3	d3	t2	0:13:52	0:14:50	0:00:58	N	x		x	volume settings incorrect
s2	d2d3	d3	t2	0:16:17	0:17:54	0:01:37	N		x	x	discuss, how to tackle the task (scan, fax)
s2	d1d2d3d4	d1	t2	0:51:51	2:12:27	1:20:36	C	x		x	d2d3 talk via phone, try to hold paper in camera
s2	d2d3	d3	t3	0:15:14	0:16:12	0:00:58	N	x	x	x	can you hear me?
s2	d2d3	d3	t3	0:17:43	0:19:10	0:01:27	N		x	x	did you get cust.req? what now?
s2	d1d2d3d4	d1	t3	0:54:49	?	?	C	x		x	starts parallel to phonecall, shows multiple papers, funny hand sign
s2	d1d2d3d4	d1	t3	1:52:10	1:55:55	0:03:45	C				problems, cu-seeme crashes a few times
s2	d3d4	d3	t4	0:50:41	0:55:05	0:04:24	C	x		x	connects to d3 only, who is in v1CUd1d2d3d4
s2	d1d2d3d4	d1	t4	1:00:26	2:14:00	1:13:34	C	x	x	x	now in right meeting, sees 'customer' in d1 room, wants to talk to him all 3 concepts next to each other during discussion
s3	d1d2	d1	t1	0:05:49	0:06:56	0:01:07	N		x	x	lets mail concepts, lets discuss later
s3	d1d2	d1	t1	0:20:38	0:23:43	0:03:05	N	x	x	x	mic problems, d1 shows scribble sheet
s3	d1d2	d1	t1	0:25:19	0:25:52	0:00:33	N		x	x	d1 has difficulties to understand
s3	d1d2d3	d2	t1	1:12:34	1:15:09	0:02:35	C		x	x	only d2 and d3 can see/hear each other
s3	d1d2d3	d2	t1	1:18:34	1:37:00	0:18:26	C		x	x	joins previous conference, concept presentation by each user, comments on others, 'look at files in shared ftp', problems with rif-format, final concept to be generated from discussion

Table A.2: Desktop-Videoconferencing (1/2)

Session	Users	Initiator	Tape #	TapeStart	TapeStop	Duration	Program	Chat	Voice	Gestures	Topics / Comments
s3	d1d2d3	d2	t3	1:10:35	1:37:00	0:26:25	C	x	x	x	
s4	d1d2	d2	t1	1:02:36	1:05:06	0:02:30	N		x	x	arrange meeting in CU-SeeMe
s4	d1d2d3	d1	t1	1:16:18	1:21:40	0:05:22	C	x	x	x	concept discussion and evaluation, d2's computer crashed
s4	d1d2d3	d1	t1	1:24:02	1:54:06	0:30:04	C		x	x	explaining and discussing concepts, evaluation (pros/cons) via chat and audio
s4	d1d2	d2	t2	1:00:47	1:03:15	0:02:28	N		x	x	holds paper in front of camera, arrange meeting in CU-SeeMe
s4	d2d3	d2	t2	1:09:29	1:14:10	0:04:41	C	x		x	
s4	d1d2d3	d1	t2	1:14:25	1:15:05	0:00:40	C		x		crashes immediately
s4	d1d2d3	d1	t2	1:22:21	1:26:00	0:03:39	C		x	x	return to previous videoconference, holds paper in front of camera, camera crashes
s4	d1d2d3	d1	t2	1:26:22	1:52:30	0:26:08	C	x	x	x	return to previous vid.conf., holds paper in front of camera again, sends as fax, concept discussion (explains her concept)
s4	d2d3	d2	t3	1:12:16	1:14:59	0:02:43	C	x		x	
s4	d1d2d3	d1	t3	1:15:26	1:20:40	0:05:14	C		x	x	paper in camera
s4	d1d2d3	d1	t3	1:26:46	1:53:11	0:26:25	C	x	x	x	concept discussion and evaluation, proposes chat for evaluation, paper in camera
s5	d1d2	d2	t1	0:21:44	0:23:38	0:01:54	N		x	x	schedule discussion (what we do when), d2 shows concept in camera, but it's too bright
s5	d1d2	d2	t1	0:57:33	1:00:24	0:02:51	N		x	x	d1 sends mail, checks mail, some confusion on file names, can't see mail attachment, wants to have NetMeeting with everybody, d2 tells him that's not possible
s5	d1d2	d2	t1	1:11:11	1:15:25	0:04:14	C	x	x	x	d1 doesn't activate microphone, takes long to realize problem, no design discussion, both cancel session to connect to groupmeeting
s5	d1d2d3	?	t1	1:19:30	1:50:01	0:30:31	C	x	x	x	concept discussion
s5	d2d3	d2	t2	0:47:17	0:48:56	0:01:39	N		x	x	d2 is looking at one sketch, talking about pulley-system, where is the pulley-system located
s5	d1d2	d2	t2	0:56:05	0:58:44	0:02:39	N		x	x	talks about cellphone (?), you want me to scan it again?, CU-SeeMe - ok
s5	d2d3	d3	t2	1:00:43	1:01:04	0:00:21	N		x	x	... ok
s5	d1d2	d2	t2	1:09:31	1:13:43	0:04:12	C	x	x	x	I can see you, but I can't hear you, speak to me via the chat, write down if you can hear me, now I can hear you, no, I just clicked a button to record all the time, (burps), ok
s5	d1d2d3	?	t2	1:17:49	1:48:18	0:30:29	C	x	x	x	moet ons engels praat, haha? Ok sounds good
s5	d2d3	d2	t3	0:48:03	0:49:42	0:01:39	N		x	x	pulley-system, I have a hand-mechanism, I'm still busy, I'll fax it to you, how do I close this now?
s5	d2d3	d3	t3	1:01:33	1:01:52	0:00:19	N		x	x	I have my concept on the ftp-site
s5	d1d2d3	?	t3	1:19:36	1:49:12	0:29:36	C	x	x	x	software problems, has to restart CU-SeeMe at 1:32:30, no video-signals from d1 and d2 for the rest of the session
s6	d1d2d3d4	d2	t2	0:11:07	2:01:53	1:50:46	C	x	x	x	only one (long) videoconference

Table A.2: Desktop-Videoconferencing (2/2)

A.2.3 Electronic Mail

Each e-mail was analysed regarding the following criteria:

- Session: case study session
- User: user who sent the e-mail
- Recipients: users who received the e-mail
- Time: time, when the e-mail was sent
- Subject: subject of the e-mail
- Type: type of the conversation (D = design-related, C = communication-related)
- Attachment: file names of attachments
- Format: format or page number of the attachments
- Comments: comments by the author / case study supervisor.

The results for the synchronous part of the case study are shown in Table A.3, for the asynchronous part in Table A.4.

Session	User	Recipients	Time	Subject	Type	Attachment	Format	Comments
s1	d1	d2, d3, d4	10h21	changes in the ip number	C	Tel_IP_Numbers.txt	text	wrong ip-numbers, new numbers in the attachment
s1	d2	d1, d3, d4	10h33	specs	D	Specifications.txt	text	9 customer requirements, doesn't really know what to do with it
s1	d1	d2, d3, d4	10h35	conferance	C	-	-	asks for a CU-SeeMe converence at 10h35
s1	d2	d1	10h36	Re: conferance	C	-	-	waiting for start of video-conference
s1	d3	d4	11h06	pictures	D	hgdjygj.psp, Image2.psp	mouse	pictures of a bicycle and something like a frame, sketched on the computer with a mouse
s1	d3	d2	11h07	pictures	D	hgdjygj.psp, Image2.psp	mouse	pictures of a bicycle and something like a frame, sketched on the computer with a mouse
s1	d2	d3	11h10	Re: pictures	D	-	-	dcdcs2 can recognise the bike, but not the other sketch
s1	d2	d1, d3, d4	11h24	another concept	D	Andrew Concept.jpg	p2/3a	2nd concept of dcdcs2
s1	d1	d2, d3, d4	11h31	meeting	C	-	-	asks for a CU-SeeMe meeting as soon as possible
s1	d2	d1, d3, d4	11h34	oh yes	-	Schumacher rules.jpg	p2/4a	funny drawing on formula-one, not project related
s1	d3	d2	11h57	so waze up	C	-	-	ask what's going on
s1	d2	d3	11h58	Re: so waze up	C	-	-	tells him that the camera isn't working properly
s2	d1	d2, d3, d4	15h17	-	C	-	-	put your number in front of all file names for ftp upload
s2	d3	-	15h34	-	-	-	-	mail deliv. error - wrong e-mail address
s2	d3	d4	15h35	k	C	-	-	load it to your computer and open it in word
s2	d1	d2, d3, d4	15h48	om 15:53 moet ons almal in CU-SEEME in lock	C	-	-	lock ito CU-SeeMe at 15:53
s2	d1	d2	16h19	is dit moontlik om jou tekeninge op ftp te sit	C	-	-	ftp you drawings
s3	d2	d1, d3	15h06	customer requirements	D	-	-	customer req.
s3	d1	d2, d3	15h10	-	D	Cutomer requirments.txt	-	customer req.
s3	d1	d2	15h14	Re: customer requirements	D	-	-	congrats d2 to good idea, what does d2 think about d1's?
s3	d3	d1, d2	15h22	Re: (Fwd) customer requirements	D	-	-	aggrees with cust. Req. and adds more
s3	d3	d1, d2	15h50	concept	D	3Image1.jpg, 3Image2.jpg	mouse	explains concepts
s3	d2	d3	15h54	concept comment	D	-	-	concept comment, will send fax shortly
s3	d3	d1	15h59	concept 2	D	-	-	material
s3	d3	d1, d2	16h06	lock	D	3Image3.pg.jpg	mouse	lock for security
s3	d2	d1	16h07	more ideas	D	2conc.jpg	p2/2a	more ideas
s4	d1	d2, d3	10h10	User Requirements	D	-	-	please send user req. as you see them

Table A.3: Electronic Mail, Synchronous Collaboration (1/3)

Session	User	Recipients	Time	Subject	Type	Attachment	Format	Comments
s4	d2	d1	10h18	customer requirements	D	requirements.txt	text	some customer req.
s4	d1	d2, d3	10h18	Request for data	D	-	-	here are my cust req, please send yours
s4	d1	d2, d3	10h20	sorry	C	userreq#1.txt	text	attachment that should be sent by prev. mail
s4	d2	d1	10h22	requirements	C	-	-	didn't get your req.
s4	d1	d2	10h23	Re: requirements	D	userreq#1.txt	text	sends cust req again
s4	d3	d1, d2	10h24	requirements	D	3 req.txt	text	2 cost. req.
s4	d2	d1	10h26	Re: sorry	D	-	-	adds cust. Req.
s4	d2	d1	10h29	how is it going	D	-	-	what's the final list of cust. Req.
s4	d1	d2, d3	10h29	-	D	-	-	will send complete list of req in 2 min, start with concepts
s4	d1	d2, d3	10h33	Groups requirements	D	userreqgroup.txt	text	combined requ.
s4	d3	d1, d2	10h40	3 concept 1	D	Image2.psp	mouse	concept of bike hanging on wall
s4	d3	d1, d2	10h48	concept refined	D	3concept2.psp	mouse	similar to 1st concept, but now horizontal
s4	d2	d1	10h57	just a comment	D	-	-	comment on d1's concept
s4	d3	d2	11h07	re your concept	D	-	-	stolen wheels
s4	d2	d1	11h09	concept	D	concept2.psp	mouse	'skarnier'-sketch
s4	d2	d3	11h13	concept2	D	concept2.psp	mouse	the ironing board thingy
s5	d2	d1	15h15	-	D	-	-	list of customer req.
s5	d3	d1	15h16	massa?	D	-	-	weight of mower
s5	d1	d3	15h18	Re: massa?	D	-	-	weight of mower
s5	d2	d1	15h26	concepts	D	2concept1.jpg	mouse	-
s5	d1	d2	15h28	Re: concepts	D	-	-	let's begin
s5	d2	d1	15h33	More	D	2concept2.jpg	mouse	some more
s5	d3	d1	15h33	hoe gaan grassnyer vasgehou word	D	-	-	keep mower on platform
s5	d1	d3	15h34	Re: hoe gaan grassnyer vasgehou word	D	-	-	both options
s5	d2	d3	15h35	-	D	-	-	you like my ideas?
s5	d1	d2, d3	15h39	concept1	D	1,concept1.JPG	e-pen	this is concept1, please save
s5	d1	d2	15h42	plse send concept again	C	-	-	-
s5	d1	d2, d3	15h43	please send concept	C, D	-	-	please send concept, mark as 3concept1 etc

Table A.3: Electronic Mail, Synchronous Collaboration (2/3)

Session	User	Recipients	Time	Subject	Type	Attachment	Format	Comments
s5	d3	d1	15h43	watter tipe aandrywings beskikbaar	D	-	-	power sources
s5	d2	d1	15h43	More concepts	D	2concept2.jpg, 2concept3.jpg	mouse	hydraulic lift
s5	d3	d1	15h44	Re: please send concept	D	-	-	have no concept yet
s5	d3	d2	15h46	Re:	D	-	-	ideas about hydraulics
s5	d2	d1	15h54	pully-counterweight	D	-	-	good idea, suggestions
s5	d1	d2, d3	15h58	-	D	1concept2.JPG	e-pen	-
s5	d2	d1	15h59	-	D	2concept2.jpg, 2concept3.jpg, 2concept4.jpg	mouse	-
s5	d3	d2	16h08	verward	D	-	-	questions to concept
s5	d3	d1	16h17	-	C	-	-	asks for 'groupmeeting' (cu-seeme)
s6	d1	d2, d3, d4	15h18	-	C	tel_ip.txt	text	list of telephone and ip numbers
s6	d1	d2, d3, d4	15h23	Start 1	C	-	-	request for CU-SeeMe meeting
s6	d3	d1, d2, d4	15h35	RAK	C	-	-	how does the chat function work
s6	d4	d1	15h35	requirements	D	require.txt	text	list of requirements
s6	d4	d3	15h36	Re: RAK	C	-	-	I think you cannot hear me
s6	d2	d1	15h47	requirements.	D	-	-	list of requirements
s6	d2	d3	15h48	Re: RAK	C	-	-	short reply
s6	d3	d4	15h48	Re: RAK	C	-	-	Reply: I also cannot hear you
s6	d3	d1, d2, d4	15h51	CONCEPTS	D	3requirements.jpg	p3/1a	sketch with 4 concepts/ideas and a few customer requirements
s6	d4	d1, d2, d3	16h22	wiekus se konsepte	D	?	?	link to paintshop image
s6	d4	d1	16h24		D	image4.jpg	p4/1a	concept sketch (3 sketches and some text)
s6	d4	d1, d2, d3	16h39	wiekus se konsepte	D	image4.jpg	p4/1a	concept sketch (3 sketches and some text)
s6	d1	d2, d3, d4	16h49	SID SE KONSEPTE	D	pulleycons.jpg	p1/2a	handsketch of pulley system with grahic tablet sketches and annotations
s6	d3	d2	17h00	gerhard se konsepte	D	3requirements.jpg	p3/1a	sketch with 4 concepts/ideas and a few customer requirements

Table A.3: Electronic Mail, Synchronous Collaboration (3/3)

Session	User	Recipients	Time	Subject	Type	Attachment	Format	Comments
s1	d2	d1, d3, d4	12h36	lets go puppies	-	-	-	comment on f1-drawing
s1	d4	d3	12h40	question	D	-	-	asks for word translation (sif = sieve)
s1	d2	d1, d3, d4	12h44	concept	C	-	-	announcement of concept on shared folder soon
s1	d1	d2, d3, d4	12h46	jacques concept	D	jac_con.JPG	e-pen	description of his concept, file created with graphic tablet
s1	d2	d1, d3, d4	12h51	andrew concept	C, D	Andrew Concept (tea).jpg	p2/6a	short description of some of his concept's features
s1	d4	d1	12h52	re-useable teaholder	C	-	-	announcement of concept send by fax soon
s1	d1	d2, d3, d4	12h52		D	-	-	asks everybody to create email with comments on other's concepts
s1	d1	d4	12h54	Re: re-useable teaholder	D	-	-	congratulates dcdcs4 to good concept (almost same as his)
s1	d2	d3, d4	12h58	concept	C	-	-	"where are you, where is your concept?"
s1	d3	d1, d2, d4	12h58	concept	C	-	-	says he has shared his concepts
s1	d3	d2	12h59	concept	C	-	-	says he has shared his concepts
s1	d2	d1, d3, d4	13h01	comments on all	D	-	-	comments on all other concepts
s1	d2	d1	13h02	that all?	C	-	-	asks if that's all
s1	d1	?	13h05	comments	D	-	-	comments on other's concepts
s1	d4	d2	13h05	feedback	D	-	-	comment on dcdcs2's concept
s1	d1	d3, d4	13h06	finished	C	-	-	announces end of session
s1	d1	d2	13h07	Re: that all?	D	-	-	asks for comments
s1	d3	d1, d2, d4	13h07	comments	D	-	-	very short comments on other' concepts
s2	d2	d1, d3, d4	17h33	2cocepts	D	-	-	concept description, sketch will follow later
s2	d1	d2, d3, d4	17h34	-	D	-	-	10 min for design, fax, discussion each
s2	d3	d1, d2, d4	17h34	suggestion	D	-	-	suggestion for group work: ftp concepts, download, decide what and why, feedback to d1
s2	d4	d1, d2, d3	17h35	4 konsep	D	-	-	describes his concept (no copy to d3)
s2	d3	-	17h38	-	-	-	-	mail delivery error - wrong e-mail address (did you all get this?")
s2	d4	d1	17h39	org	C	-	-	how should we distribute our concepts? Please decide and advise
s2	d1	d2, d3, d4	17h44	-	D	-	-	let's fax all concepts to everybody, time schedule
s2	d3	d1	17h44	Re:	C	-	-	ok, got it
s2	d4	d1, d2,d3	17h46	4 Konsep 2	D	-	-	describes second concept (no copy to d3)
s2	d4	d1	17h46	Re:	C	-	-	I can't send concepts by fax (misunderstood task), my email is sufficient

Table A.4: Electronic Mail, Asynchronous Collaboration (1/10)

Session	User	Recipients	Time	Subject	Type	Attachment	Format	Comments
s2	d3	d1, d2, d4	17h47	ons moet vinniger maak	C	-	-	we have to hurry
s2	d3	d1, d2, d4	17h48	-	D	-	-	I have the following concepts, I'm waiting for d1's concept
s2	d4	-	17h49	'?'	-	-	-	not received by anyone (did you get mine?)
s2	d2	d1, d3, d4	17h51	evalueering	D	-	-	my idea is the best
s2	d3	d2	17h52	Phone call: max	-	-	-	phone call for you
s2	d3	d2	17h52	Re: evalueering	D	-	-	I agree with your first part of your message, but not with the second
s2	d4	d1	17h53	'?'	C	-	-	where is your concept?
s2	d3	d1, d2, d4	17h54	sdfh	C	-	-	let's do it
s2	d3	d1, d2, d4	17h54	-	D	-	-	I like d2's idea, let's go for it
s2	d1	d2, d3, d4	17h55	het julle vra oor my kone	D	-	-	any questions for the customer?
s2	d4	d1	17h55	wat?	D	-	-	I don't understand your sketch
s2	d2	d1, d3, d4	17h56	-	D	-	-	my idea ...
s2	d3	d1	17h57	Re: het julle vra oor my kone	D	-	-	comments on d1's concept
s2	d3	d1, d2, d4	17h58	-	D	-	-	tries to convince the others of concept #2
s2	d4	d1, d2, d3	17h58	aandag	D	-	-	I take control ! Send me your choice of concept and reasoning
s2	d3	d2, d4	17h59	-	C	-	-	I don't get feedback from you
s2	d3	d2	17h59	Re:	D	-	-	you are wrong
s2	d3	d2, d4	18h00	Re: aandag	D	-	-	I'm for d2's design because of the reasons I just gave
s2	d4	d3	18h00	laat weet	C	-	-	did you get this message?
s2	d2	d1, d3, d4	18h01	redes	D	-	-	this is a good idea
s2	d3	d2	18h01	-	?	-	-	?
s2	d3	d4	18h01	Re: Laat weet	C	-	-	sdfgsdfgsd received
s2	d1	d2, d3, d4	18h02	stuur vir my twee redes hoekom julle dink watter konsep is die b	D	-	-	what's the best concept?
s2	d3	d2	18h02	Re: redes	-	-	-	private
s2	d3	d2	18h02	-	?	-	-	?
s2	d4	d2	18h02	Re: redes	D	-	-	that's no good reason
s2	d1	d2, d3, d4	18h03	ek wag vir julle se redes ons het 2 minute oor,	D	-	-	I'm waiting, 2 min left

Table A.4: Electronic Mail, Asynchronous Collaboration (2/10)

Session	User	Recipients	Time	Subject	Type	Attachment	Format	Comments
s2	d4	d1	18h03	Re: stuur vir my twee redes hoekom julle dink watter konsep is d	C	-	-	I took control. Don't write comment in subject line
s2	d3	d4	18h04	Re: aandag	D	-	-	is everything settled?
s2	d4	d3	18h04	Re: aandag	D	-	-	better reasons please
s2	d2	d1, d3, d4	18h05	-	C	-	-	
s2	d3	d1	18h05	Re: ek wag vir julle se redes ons het 2 minute oor,	D	-	-	reasons for voting for concept #2
s2	d4	d3	18h05	hang aan	C	-	-	just waiting for the others
s2	d1	d4	18h06	-	D	-	-	hate to tell, but I need your reasons
s2	d3	d4	18h06	Re: hang aan	C	-	-	hurry
s2	d3	d2	18h06	Re:	-	-	-	private
s2	d4	d2	18h06	Re:	-	-	-	private
s2	d1	d3	18h07	Re: stuur vir my twee redes hoekom julle dink watter konsep is d	D	-	-	yes
s2	d3	d1	18h07	Re: stuur vir my twee redes hoekom julle dink watter konsep is d	D	-	-	did you get my reasons?
s2	d4	d1	18h07	Re:	-	-	-	private
s2	d1	d4	18h08	-	C	-	-	let's meet at my office
s2	d3	d2	18h08	Re:	-	-	-	pizza
s2	d3	d2	18h08	Re:	-	-	-	private
s2	d4	d2	18h08	Re:	-	-	-	let's go home
s2	d1	d2, d3	18h09	stuur vir my jou redes asseblief	D	-	-	write me your reasoning
s2	d3	d2	18h09	Re:	C	-	-	have to press the button all the time
s2	d3	d2	18h09	Re:	C	-	-	I haven't received so much mail in such short time
s2	d4	d1	18h10	'?'	C	-	-	what's going on?
s2	d3	d1, d2, d4	18h11	-	D	-	-	we selected concept #2
s2	d2	d1, d3, d4	18h12	-	D	-	-	my concept is the best - simple, looks good
s2	d3	d4	18h12	Re:	-	-	-	private
s2	d3	d4	18h12	Re:	-	-	-	private

Table A.4: Electronic Mail, Asynchronous Collaboration (3/10)

Session	User	Recipients	Time	Subject	Type	Attachment	Format	Comments
s2	d4	d3	18h12	Re:	-	-	-	private
s2	d3	d4	18h13	Re:	-	-	-	private
s2	d3	d2	18h13	Re:	D	-	-	no
s2	d4	d3	18h13	Re:	D	-	-	we go for #2
s2	d1	d2, d3	18h14	gaan ons almal op no 2se ontwerp ,ja of nee	D	-	-	are we going for the design of no2
s2	d3	d1, d2, d4	18h14	-	D	-	-	that's it
s2	d3	d1, d2, d4	18h14	-	D	-	-	no. 2 is elected, unanimously
s2	d2	d1, d3, d4	18h15	-	-	-	-	private, like d3's attitude
s2	d3	d1	18h15	Re: gaan ons almal op no 2se ontwerp ,ja of nee	D	-	-	yes
s2	d4	d1	18h15	Snap cap	D	-	-	we go for Snap cap
s2	d2	d1, d3, d4	18h16	JA	C	-	-	
s2	d3	d1, d2, d4	18h16	-	D	-	-	let's go
s2	d1	d2, d3, d4	18h17	ons is klaar bye bye	C	-	-	bye
s3	d2	d3	17h01	1st conc	D	2T-bag1.jpg	p2/4a	thanks for fax, here's my 1st concept
s3	d2	d1	17h02	1st concepts	D	2T-bag1.jpg	p2/4a	here's my 1st concept
s3	d2	d1	17h07	reply	D	-	-	questions to d1's concept
s3	d2	d3	17h08	opinion	D	-	-	what do you think of d1's concept?
s3	d3	d1, d2	17h10	Note	D	-	-	material
s3	d1	d2	17h12	Re: reply	D	-	-	size and material discussion
s3	d2	d3	17h12	Re: Note reply	D	-	-	suggestion
s3	d1	d3	17h14	Re: note	D	-	-	good idea, other idea suggested
s3	d2	d1	17h14	Re: reply	D	-	-	suggestion
s3	d3	d1, d2	17h16	Ideas	D	-	-	comments on the other's concepts
s3	d2	d1	17h17	stiff handle	D	-	-	suggestion
s3	d3	d1	17h19	Re: Note	D	-	-	flex cable
s3	d2	d3	17h21	Re: Ideas comment	D	-	-	comments on design
s3	d2	d1	17h24	concept 2 comment	D	-	-	I don't understand your concept, looks like mine
s3	d1	d2, d3	17h24	7 minuts to go	C, D	-	-	which concept will work best?, time in subject

Table A.4: Electronic Mail, Asynchronous Collaboration (4/10)

Session	User	Recipients	Time	Subject	Type	Attachment	Format	Comments
s3	d2	d1	17h25	Re: 7 minuts to go	D	-	-	comments on design
s3	d3	d1	17h25	-	D	-	-	comments on concept
s3	d1	d2	17h27	Re: reply	D	-	-	suggests idea
s3	d3	d1	17h27	Re: 7 minuts to go	D	-	-	comments on concept
s3	d2	d1	17h28	final decision	D	-	-	have you decided yet?
s3	d3	d1, d2	17h29	Final	D	-	-	what are we taking?
s3	d1	d2, d3	17h29	Re: Ideas	D	-	-	plastic as material
s3	d2	d1	17h29	Re: reply	D	-	-	I'm happy
s3	d2	d3	17h31	Re: Final	D	-	-	answers question
s3	d3	d1	17h31	Re: Ideas	D	-	-	coffee mugs
s3	d3	d2	17h32	Re: Final	D	-	-	fine
s3	d1	d3	17h34	Re: 7 minuts to go	D	-	-	wire mesh doesn't loose tea
s3	d1	d3	17h35	Re: Final	D	-	-	the final concept is ...
s4	d1	d2, d3	12h13	Teabags	D	-	-	good luck and work hard
s4	d2	d1, d3	12h17	teabag materials	D	-	-	materials
s4	d1	d2, d3	12h20	Re: teabag materials	D	-	-	look at ftp for image5.jpg, think materials
s4	d3	d1, d2	12h20	3's 1st concept	D	3tea bag1.psp	mouse	colorful teabag
s4	d1	d3	12h22	Re: 3's 1st concept	D, C	-	-	good idea, check my ftp
s4	d3	d1, d2	12h25	materials	D	-	-	different material options
s4	d2	d3	12h27	teeeeeeeea!	C	-	-	check my concept on ftp
s4	d2	d1	12h28	tea!	D, C	-	-	check out concept in ftp
s4	d3	d1	12h28	Re: 3's 1st concept	D, C	-	-	nice idea, glad you use the scanner
s4	d1	d2, d3	12h32	Teabags	D	-	-	comments on concepts of others
s4	d3	d2	12h32	Re: teeeeeeeea!	C	-	-	problems, your picture looks incomplete
s4	d2	d3	12h34	huh?	C	-	-	no problems with d1 receiving my files
s4	d1	d2	12h35	teabag	D	-	-	material
s4	d1	d3	12h36	teabag	D	-	-	have you seen d2's?
s4	d3	d2	12h36	Re: huh?	C	-	-	got it now

Table A.4: Electronic Mail, Asynchronous Collaboration (5/10)

Session	User	Recipients	Time	Subject	Type	Attachment	Format	Comments
s4	d2	d1	12h37	T	D	-	-	comments on design
s4	d3	d1	12h37	Re: teabag	D	-	-	evaluate concepts now?
s4	d1	d2, d3	12h40	T	D	-	-	let's start evaluating
s4	d2	d3	12h40	zipper	D	-	-	suggestions
s4	d1	d2, d3	12h43	T	D	-	-	I like d2's best, because ...
s4	d2	d1	12h46	tea	D	-	-	comments on design
s4	d1	d2	12h48	Re: tea	D	-	-	material
s4	d2	d3	12h48	tada	D	-	-	sealing, materials
s4	d3	d1, d2	12h48	concepts	D	-	-	critique on solid teabag, proposes bag-like teabag
s4	d3	d2	12h50	Re: tada	D	-	-	teabags don't maintain shape
s4	d1	d2, d3	12h51	Ball	D	-	-	size of ball
s4	d2	d3	12h52	rigid or not?	D	-	-	materials
s4	d3	d1	12h52	Re: T	D	-	-	damaging cup?
s4	d1	d3	12h55	Re: T	D	-	-	design details
s4	d2	d3	12h55	ttasjdaktea	D	-	-	comments on better tea brewing
s4	d2	d1	12h56	ttasjdaktea	D	-	-	comments on better tea brewing
s4	d3	d1, d2	12h56	balls!	D	-	-	so you like the balls idea
s4	d1	d3	12h57	Re: balls!	D	-	-	-
s4	d1	d2, d3	12h58	endgame	C	-	-	2 more mins
s4	d1	d3	12h58	Re: T	D	-	-	simple question
s4	d2	d3	12h58	Re: balls!	D	-	-	have we left the zipper idea?
s4	d3	d1	12h58	Re: T	D	-	-	why the effort?
s4	d3	d2	12h58	Re: ttasjdaktea	D	-	-	why the ball?
s4	d3	d2	12h59	Re: balls!	D	-	-	answer about zipper idea
s4	d1	d2, d3	13h00	Coffee	C	-	-	over
s4	d2	d3	13h00	Re: ttasjdaktea	D	-	-	yuppy status of stainless steel
s5	d3	d1, d2	17h03	voorstel vir "files"	C	-	-	naming of files
s5	d1	d3	17h04	Re: voorstel vir "files"	C	-	-	agrees to file name convention

Table A.4: Electronic Mail, Asynchronous Collaboration (6/10)

Session	User	Recipients	Time	Subject	Type	Attachment	Format	Comments
s5	d1	d2d3	17h05	1teabag1	D	teabag1.JPG	e-pen	drawing
s5	d3	d2	17h05	-	C	-	-	did you get my concept?
s5	d2	d1	17h08	2teabag1	C	-	-	info is on ftp
s5	d2	d3	17h09	2teabag1	C	-	-	info is on ftp
s5	d1	d2d3	17h10	-	D	-	-	how to rate the concepts
s5	d2	d1	17h12	tea	D	-	-	my concept is almost like yours
s5	d1	d2	17h13	Re: tea	C	-	-	can't find your ftp file
s5	d2	d1	17h16	tea	C	-	-	are we going to share all info on ftp?
s5	d3	d1, d2	17h16	3teabag1	C	-	-	3teabag3 is on ftp
s5	d1	d3	17h19	het jy al n konsep	D	-	-	-
s5	d2	d3	17h19	tee	C	-	-	can you scan it?
s5	d3	d1, d2	17h19	hoeveel konsepte elk	D	-	-	how many concepts do you have?
s5	d2	d3	17h20	Re: hoeveel konsepte elk	-	-	-	-
s5	d3	d1	17h20	Re: het jy al n konsep	C	-	-	my concept is on ftp
s5	d1	d3	17h21	Re: hoeveel konsepte elk	D	-	-	1
s5	d3	d2	17h23	Re: tee	C	-	-	ignore 1st concept, look for 2nd on ftp
s5	d2	d3	17h24	Re: tee	-	-	-	-
s5	d3	d1, d2	17h24	3teabag2	C	-	-	ignore 1st concept, look for 2nd
s5	d3	d2	17h25	Re: tee	C	-	-	filename is 3teabag2
s5	d3	d1, d2	17h27	-	D	-	-	do we need more concepts?
s5	d1	d3	17h28	Re:	D	-	-	no
s5	d1	d2d3	17h32	vote	D	-	-	rate all concepts available on ftp
s5	d3	d1, d2	17h34	evaluering	D	-	-	comments and +/- to each concept
s5	d3	d1	17h36	vote	D	-	-	vote x/10 for each concept
s5	d2	d1	17h38	rating	D	-	-	rating x/10 for 4 concepts
s5	d3	d2	17h38	2teabag2	D	-	-	comments on mesh design
s5	d3	d1	17h41	vote	D	-	-	top vote is 2teabag2
s5	d2	d3	17h42	Re: 2teabag2	D	-	-	inlet valve

Table A.4: Electronic Mail, Asynchronous Collaboration (7/10)

Session	User	Recipients	Time	Subject	Type	Attachment	Format	Comments
s5	d3	d1	17h44	besluite neem	D	-	-	asks for final vote
s5	d1	d2d3	17h46	finished, meet at copyroom	C	-	-	-
s6	d1	d2, d3, d4	17h28	skedule	D	-	-	schedule for 2nd task: 10min concepts, 15 min e-mail discussion, 5 min choose concept
s6	d4	d1, d2, d3	17h36	wiekus se konsepte	C	-	-	I'll put it on the ftp
s6	d3	d1, d2, d4	17h38	teesak	C	-	-	I've put a concept on the ftp-server
s6	d1	d2, d3, d4	17h41	sid se konsepte	C	-	-	look on the ftp, hurry
s6	d4	d1, d2, d3	17h43	wiekus	C	-	-	my concept is on ftp, look under d4
s6	d1	d2, d3, d4	17h48	sid se konsepte	C	-	-	my concept is on ftp, sidkonsep.jpg
s6	d2	d1	17h48	teesakkie consepte	D	-	-	mix of customer/engineering requirements and written concept descriptions
s6	d3	d1	17h48		C	-	-	can't find your concept on the ftp, mine is tee3
s6	d4	d2	17h50	'?'	C	-	-	have you all sent?
s6	d3	d4	17h54	konsep-tee	D	-	-	I like your concept
s6	d4	d1	17h54		D	-	-	do we have to do more concepts?
s6	d1	d2, d3, d4	17h56	Sid se	D	-	-	we have to start the discussion now
s6	d4	d3	17h57	thanx	D	-	-	your concept is the same as mine ...
s6	d3	d1	17h58	Re: Sid se(bespreking	D	-	-	my concept is like d4's, understand
s6	d4	d2	17h58	lesley	C	-	-	nothing received yet
s6	d4	d1, d2, d3	17h58	wiekus sê	C	-	-	I don't agree with d1, it might not fit all cups
s6	d3	d4	17h59	Re: thanx	D	-	-	yes, but my concept has ...
s6	d2	d4	18h00	Re: wiekus	C	-	-	my concept is now there, have a look
s6	d2	d4	18h01	Re: ?	C	-	-	look on the ftp for the file tee-beursie
s6	d2	d1	18h01	Re: sid se konsepte	C	-	-	look on the ftp for the file tee-beursie
s6	d3	d1, d2, d4	18h01	Re: wiekus sê	D	-	-	d1's 2n concept is a plunger
s6	d2	d1	18h02	Re: Sid se	D	-	-	okay
s6	d3	d1	18h02		D	-	-	do we have a concept from d2?
s6	d4	d3	18h02	Re: thanx	D	-	-	exactly
s6	d4	d3	18h02	Re: wiekus sê	D	-	-	it will work, but not for all cups
s6	d1	d2, d3, d4	18h02		D	-	-	look at all concepts and write down some pros and cons

Table A.4: Electronic Mail, Asynchronous Collaboration (8/10)

Session	User	Recipients	Time	Subject	Type	Attachment	Format	Comments
s6	d4	d1, d2, d3	18h04	hmm	C	-	-	send your comments to everybody, even if discussing only one concept
s6	d4	d1, d2, d3	18h05	lesley sn	D	-	-	how long will it last compared to metal?
s6	d4	d1, d2, d3	18h06	lesley sn	D	-	-	I like it, it's simple and cheap
s6	d3	d1, d2, d4	18h08		C	-	-	I don't have d2's concept
s6	d4	d3	18h09	Re:	C	-	-	it's on the ftp, tee-beursie
s6	d2	d3	18h10	Re: wiekus sê	D	-	-	thoughts about material (temperature, poisoness)
s6	d2	d4	18h10	Re: lesley sn	D	-	-	pros and cons on a concepts
s6	d4	d2	18h11	Re: lesley sn	C, D	-	-	thoughts about material, send your mail to everybody
s6	d2	d3	18h13	Re:	D	-	-	look at the ftp for tee-beursie, thoughts about material (temperature, poisoness)
s6	d2	d1	18h14	Re:	D	-	-	thoughts about material (temperature, poisoness)
s6	d3	d1, d2, d4	18h14	pro's con's	D	-	-	one comment/sentence only for each design
s6	d3	d2	18h15	Re:	C	-	-	got it, thanks
s6	d4	d1, d2, d3	18h15	gerhard	C	-	-	I can't see your 2nd concept
s6	d1	d2, d3, d4	18h16	sid se	D	-	-	proposes/instructs an evaluation system (+ or - or 0)
s6	d3	d1, d2, d4	18h18	Re: gerhard	D	-	-	description of the concept that d4 can't find
s6	d4	d1, d2, d3	18h18	evaluate	D	-	-	gives short comments on each concept
s6	d3	d1, d2, d4	18h19	Re: evaluate	D	-	-	just agrees to d4's 'evaluation'
s6	d4	d3	18h19	Re: gerhard	C	-	-	when I open the file I can't see anything, but I get the idea
s6	d4	d3	18h20	Re: evaluate	C	-	-	GO GERHARD
s6	d3	d1, d2, d4	18h22	evaluasie	D	-	-	+,-,0 for the 5 concepts
s6	d4	d1, d2, d3	18h22	punte	D	-	-	points for the 5 concepts
s6	d3	d4	18h23	Re: gerhard	C	-	-	I think not everybody has received my 2nd concept
s6	d4	d1, d2, d3	18h24	evaluate 2	D	-	-	+,-,0 for the 5 concepts
s6	d2	d1, d3, d4	18h25	Re: evaluate	D	-	-	+ and - for 4 concepts, short reasoning for one decision
s6	d4	d3	18h25	Re: gerhard	C	-	-	I also can't see it, it's not a jpeg
s6	d3	d1, d2, d4	18h26		D	-	-	ok, what now?
s6	d3	d1, d2, d4	18h28	Re: evaluate	C, D	-	-	short reply to d2's comment, what are we doing after the session is finished
s6	d4	d2	18h28	Re: evaluate	D	-	-	rubber or wood handle

Table A.4: Electronic Mail, Asynchronous Collaboration (9/10)

Session	User	Recipients	Time	Subject	Type	Attachment	Format	Comments
s6	d4	d1, d2, d3	18h29	aanvulling	D	-	-	we have to have a wooden or rubber handle on some of the concepts
s6	d2	d1, d3, d4	18h30	Re: evaluate	D	-	-	handle is a good idea
s6	d4	d3	18h30	Re: evaluate	D	-	-	proposes handle variations
s6	d2	d1, d3, d4	18h32		D	-	-	it can work
s6	d3	d1, d2, d4	18h32	Re: aanvulling	D	-	-	concerns about other products with this design
s6	d4	d1, d2, d3	18h33	Re: aanvulling	-	-	-	my mother has one like this (did not arrive in time)
s6	d1	d2, d3, d4	18h34	finaal	C, D	-	-	declares the winner (most points) and asks to meet in the coffee-room
s6	d3	d1	18h34		D	-	-	are you going to process the evaluation?

Table A.4: Electronic Mail, Asynchronous Collaboration (10/10)

A.2.4 Fax Usage

Every usage of the fax was analysed regarding the following criteria:

- Session: case study session
- User: user who sent the fax
- Recipients: users who received the fax
- Time: time when the fax was sent
- Page: page that was faxed (p1/2 = scribble paper page #2 of designer #1)
- Content: content of the faxed page
- Comments: comments by the author / case study supervisor.

The results for the synchronous part of the case study are shown in Table A.5, for the asynchronous part in Table A.6.

Session	User	Recipients	Time	Page	Content	Comments
s1	d4	d1	10h55	p4/0b	sketch (top/front)	first fax too light, d4 had to redraw darker and fax again
s2	d4	d1, d2, d3	16h09	p4/2a	sketches (2 concepts) with long descriptions	
s2	d2	d1	16h15	p2/2a	sketch	
s2	d2	d1	16h15	p2/3a	sketch	
s2	d2	d1	16h15	p2/4a	sketch	
s3	d2	d1, d3	15h32	p2/1a	sketch with description	
s3	d1	d2, d3	15h43	p1/2a	sketch (assembly) with description	
s3	d1	d2, d3	15h53	p1/3a	sketch with description	
s3	d2	d3	15h55	p2/2a	sketches (2 concepts) with description	only to d3, develops/refines d1's concept !!!
s3	d2	d1, d3	16h30	p2/3a	sketch with short description	
s4	d2	d1, d3	10h40	p2/2a	sketch with description	
s4	d1	d2, d3	10h55	p1/3a	sketch (top/front)	
s4	d2	d1, d3	11h40	p2/4a	sketch (front/side) no text	
s5	d1	d2, d3	15h06	p1/2a	customer requirements	includes comments for idea generation
s5	d3	d1, d2	15h24	p3/3a	client specifications	
s6	d2	d1, d3, d4	16h02	p2/2b	sketch with description	
s6	d3	d2	16h30	p2/2b	modifications of fax received	made changes directly on the fax received and sent it back to d2

Table A.5: Fax Usage, Synchronous Collaboration

Session	User	Recipients	Time	Page	Content	Comments
s1	d4	d1, d2, d3	12h45	p4/1b	sketch (assembly)	
s2	d3	d1, d2, d4	17h39	p3/3a	sketches (2 concepts)	sent a blank page first
s2	d2	d1, d3, d4	17h45	p2/5a	sketches (2 concepts)	
s2	d1	d2, d3, d4	17h50	p1/6a	sketches (3 concepts)	
s3	d3	d1, d2	16h55	p3/3b	sketch with description and pros	
s3	d1	d2, d3	17h05	p1/5a	sketch (assembly) with description and pros	
s3	d1	d2, d3	17h20	p1/6a	sketch with description	
s4	-	-	-	-	-	no fax
s5	d1	d2, d3	17h25	p1/6a	pros and cons of 3 concepts (+/-)	
s5	d2	d1, d3	17h35	p2/3a	sketch with description	
s5	d1	d2, d3	17h42	p1/8a	total points and results for 4 concepts	
s6	-	-	-	-	-	no fax

Table A.6: Fax Usage, Asynchronous Collaboration

A.2.5 Scanner Usage

Every usage of the scanner was analysed regarding the following criteria:

- Session: case study session
- User: user who used the scanner
- Time: time when the scanner file was created
- Page: page that was scanned (p3/6 = scribble paper page #6 of designer #3)
- FileName: name and extension of the created file
- Distribution: means of distributing the file
- Content: content of the scanned page
- Comments: comments by the author / case study supervisor.

The results for the synchronous part of the case study are shown in Table A.7, for the asynchronous part in Table A.8.

Session	User	Time	Page	FileName	Distribution	Content	Comments
s1	d2	11h03	p2/2a	Specs(andrew).jpg	ftp	sketch (top/side)	to all directories on ftp
s1	d4	11h13	p4/0b	Image4.jpg	ftp	sketch (top/front)	
s1	d1	11h18	p1/4a	1- jacques concept.jpg	ftp	sketch (top/iso)	
s1	d2	11h21	p2/3a	Andrew Concept.jpg	ftp, e-mail	sketch (iso/detail)	
s1	d2	11h30	p2/4a	Schumacher rules.jpg	ftp, e-mail	private	
s1	d3	11h38	p3/2a	Image8.jpg	ftp	sketch (top/side/front)	
s2	d3	15h27	p3/1a	3concept.jpg	ftp	assembly	
s2	d4	15h38	p4/2a	4concepts.jpg	ftp	2 concepts + text	
s2	d3	16h06	p3/2a	3concept2.jpg	ftp	sketch (top/side) + text	
s2	d2	16h10	p2/2a	2con1.psp	ftp, e-mail	sketch	
s2	d2	16h11	p2/4a	2con2.psp	ftp	sketch	
s2	d2	16h12	p2/3a	2con2.psp	ftp	sketch	
s3	d2	16h00	p2/2a	2conc.jpg	no ftp	3 small sketches + text	
s4	-	-	-	-	-	-	no scans
s5	d3	15h55	p3/3b	3konsep1.jpg	ftp	sketch (side/detail) + text	
s6	d3	15h44	p3/1a	3requirements.jpg	e-mail	4 small concepts + text	incl. customer requirements
s6	d4	16h15	p4/1a	Image4.jpg	e-mail	assembly	
s6	d1	16h22	p1/2a	pulleycons.jpg	e-mail	sketch	later modified by d1 using e-pen

Table A.7: Scanner Usage, Synchronous Collaboration

Session	User	Time	Page	FileName	Distribution	Content	Comments
s1	d2	12h46	p2/6a	Andrew Concept (tea).jpg	ftp, e-mail	sketch (top/side)	
s1	d3	12h54	p3/4a	Image10.jpg	ftp	2 small sketches	
s2	-	-	-	-	-	-	no scans
s3	d2	16h58	p2/4a	2T-bag1.jpg	e-mail	assembly	
s4	d1	12h16	p1/5a	Image5.jpg	ftp	sketch	
s4	d2	12h25	p2/5a	concept2.jpg	ftp	2 sketches + text	
s5	d2	17h04	p2/2a	2conceptee1.jpg	ftp	sketch (open/close)	
s5	d3	17h13	p3/5b	3teabag1.jpg	ftp	assembly + lots of text	scanned upside down
s5	d3	17h21	p3/5b	3teabag2.jpg	ftp	assembly + lots of text	same page, now correct view
s6	d3	17h34	p3/3a	3tee.jpg	ftp	sketch (front/side) + text	
s6	d1	17h39	p1/3a	sidkonsep.jpg	ftp	2 concepts	ftp from own workplace
s6	d4	17h41	p4/3a	case2.jpg	ftp	2 concepts (1 open/close)	
s6	d3	17h51	p3/4a	gerhardk2.psp	ftp	sketch (in use)	
s6	d2	17h57	p2/4a	Tee-beursie .jpg	ftp	4 sketches (how to use)	

Table A.8: Scanner Usage, Asynchronous Collaboration

A.2.6 Shared Workspace Usage

All files uploaded to the shared workspace were analysed regarding the following criteria:

- Session: case study session
- User: user who uploaded the file
- FileName: file name and file extension of the uploaded file
- Format: format or page number of the uploaded file
- Comments: comments by the author / case study supervisor.

The results for the synchronous part of the case study are shown in Table A.9, for the asynchronous part in Table A.10.

Session	User	FileName	Format	Comments
s1	d1	1- jacques concept.jpg	scan	
s1	d2	Specs(andrew).jpg	scan	
s1	d2	Andrew Concept.jpg	scan	
s1	d2	Schumacher rules.jpg	scan	private
s1	d3	Image8.jpg	scan	
s1	d4	Image4.jpg	scan	
s2	d1	1concept1.JPG	e-pen	
s2	d1	all.doc	text	all cust.req. combined
s2	d2	Customer requirements.doc	text	customer requirements
s2	d2	2con1.jpg	scan	
s2	d2	2con3.jpg	scan	
s2	d2	2con2.jpg	scan	
s2	d3	3cust requirements.doc	text	customer requirements
s2	d3	3concept.jpg	scan	
s2	d3	3concept2.jpg	scan	
s2	d4	4Customer requirements.doc	text	customer requirements
s2	d4	4Customer requirements.doc	text	customer requirements
s2	d4	4concepts.jpg	scan	
s3	d1	1Concept4.JPG	e-pen	
s3	d1	1concept4.RIF	e-pen	cannot be opened by others
s3	d1	1concept1.RIF	e-pen	cannot be opened by others
s4	d2	$wpm057a.jpg	mouse	same as concept2.psp, but not concept2.jpg
s4	d2	Image1.psp	mouse	pre-state of concept2.psp
s5	d1	1.concept1.JPG	e-pen	
s5	d1	1concept2.JPG	e-pen	
s5	d2	2.concept1.JPG	mouse	
s5	d2	2concept2.JPG	mouse	
s5	d2	2concept3.jpg	mouse	same as 2concept2.JPG
s5	d2	2concept4.jpg	mouse	
s5	d3	3konsep1.jpg	scan	
s6	-	-	-	no shared workspace usage

Table A.9: Shared Workspace Usage, Synchronous Collaboration

Session	User	FileName	Format	Comments
s1	d2	Andrew Concept (tea).jpg	scan	
s1	d3	1.doc	text	concept description
s1	d3	Image10.jpg	scan	
s2	-	-	-	no shared workspace usage
s3	-	-	-	no shared workspace usage
s4	d1	Image5.jpg	scan	
s4	d2	concept2.jpg	scan	
s4	d3	3tea bag1.psp	mouse	
s5	d1	teabag1.JPG	e-pen	
s5	d2	2conceptee1.jpg	scan	
s5	d3	3teabag1.jpg	scan	
s5	d3	3teabag2.jpg	scan	3teabag1.jpg upside down (now correct)
s6	d1	sidkonsep.jpg	scan	
s6	d2	Tee-beursie .jpg	scan	
s6	d3	3tee.jpg	scan	
s6	d3	gerhardk2.psp	scan	
s6	d4	case2.jpg	scan	

Table A.10: Shared Workspace Usage, Asynchronous Collaboration

APPENDIX B

DIDEAS EVALUATION CASE STUDY

B.1 Case Study Setup

Each participant received a set of technical drawings of the glass collector of the Solar Chimney, as well as ten sheets of numbered scribble paper. To distinguish the sheets of scribble paper, each was labeled at the bottom with the following information:

- Session
- User, e.g. DCDCS1 ('DCDCS1' is the login name of user #1)
- Paper number (1-10).

The technical drawings are shown in Figures B.1 to B.5, an example of the scribble paper is shown in Figure B.6.

B.1.1 Technical Drawings

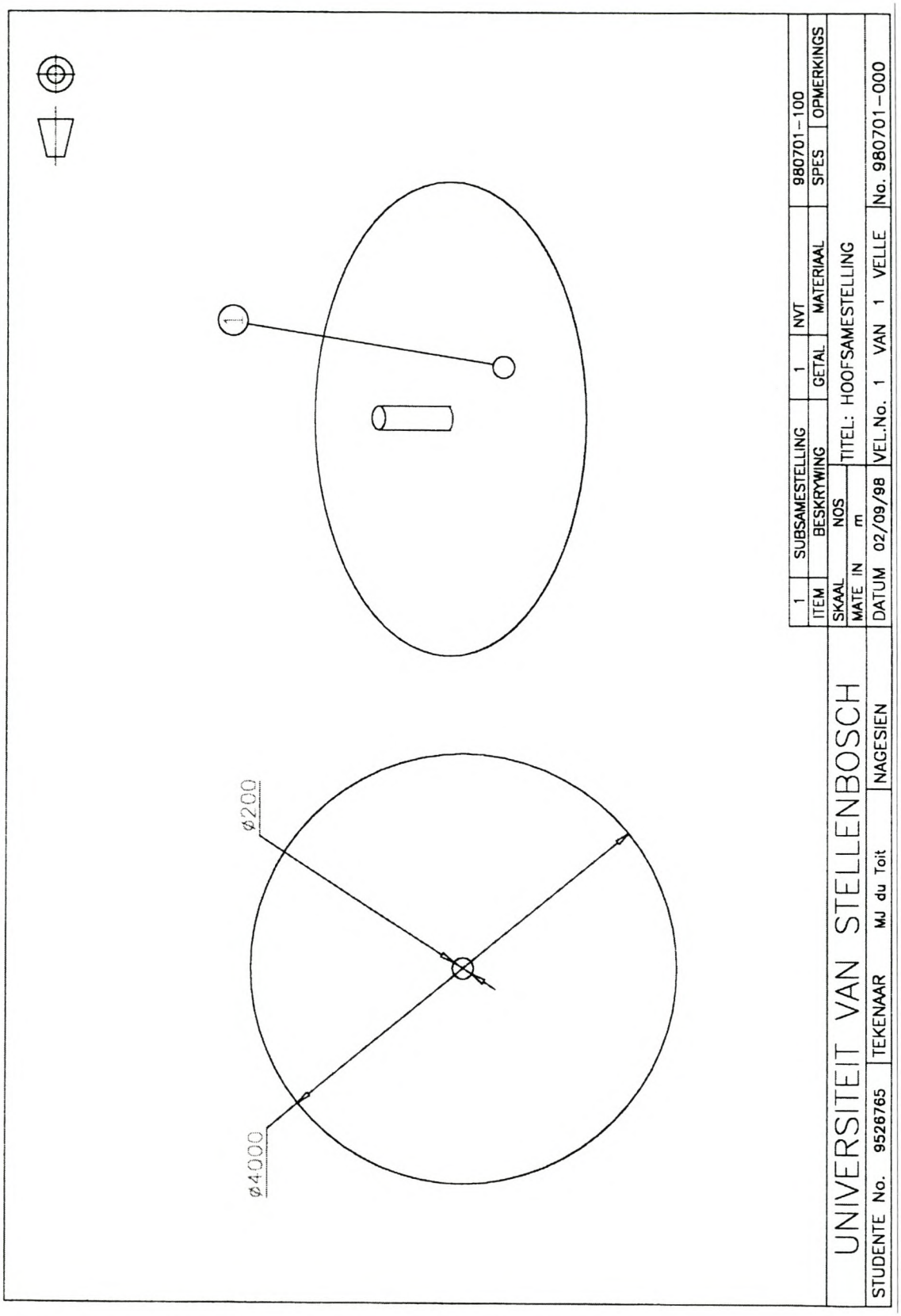

Figure B.1: Solar Chimney Collector, Technical Drawing #1 [Roux et al., 1998]

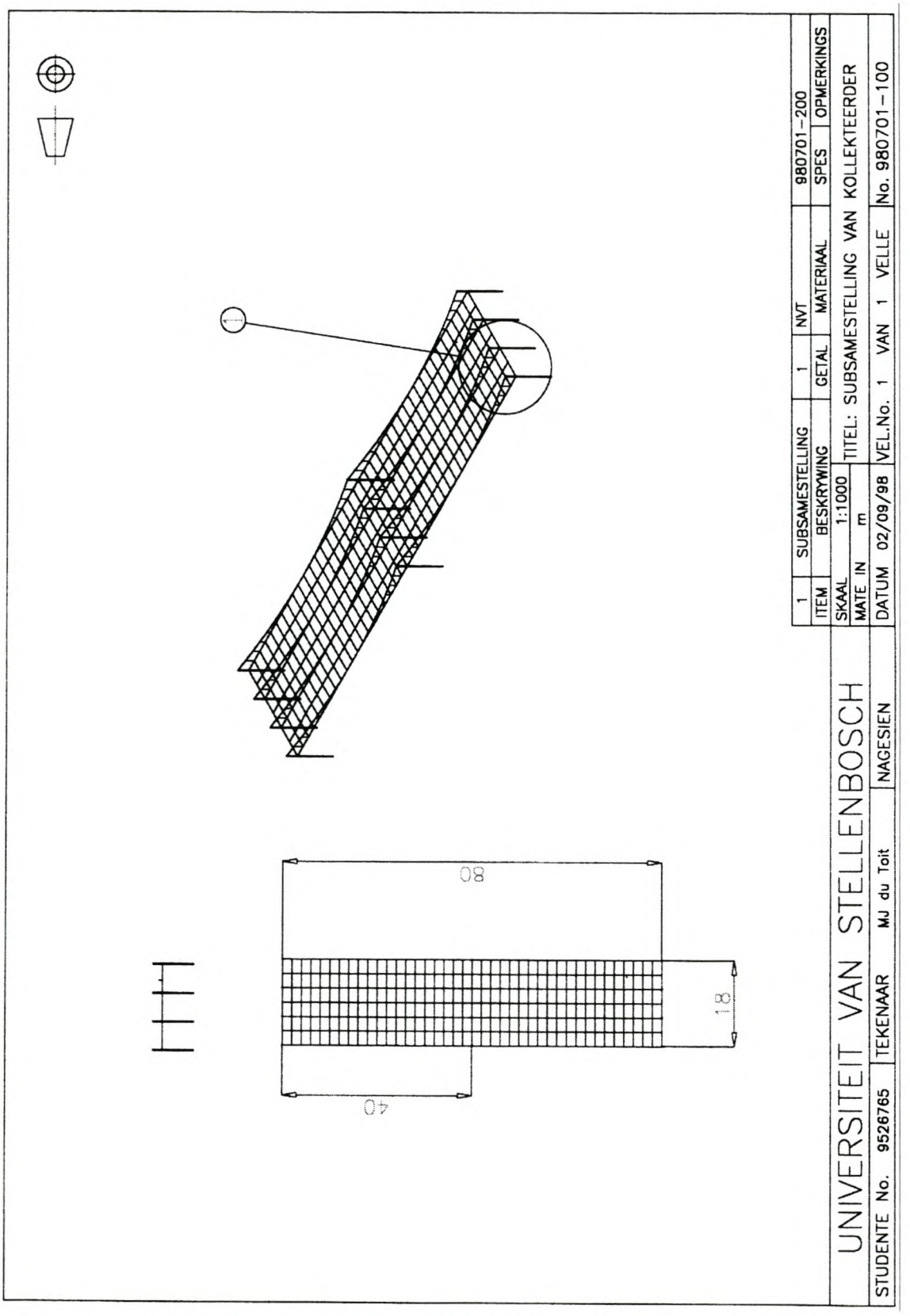

Figure B.2: Solar Chimney Collector, Technical Drawing #2 [Roux et al., 1998]

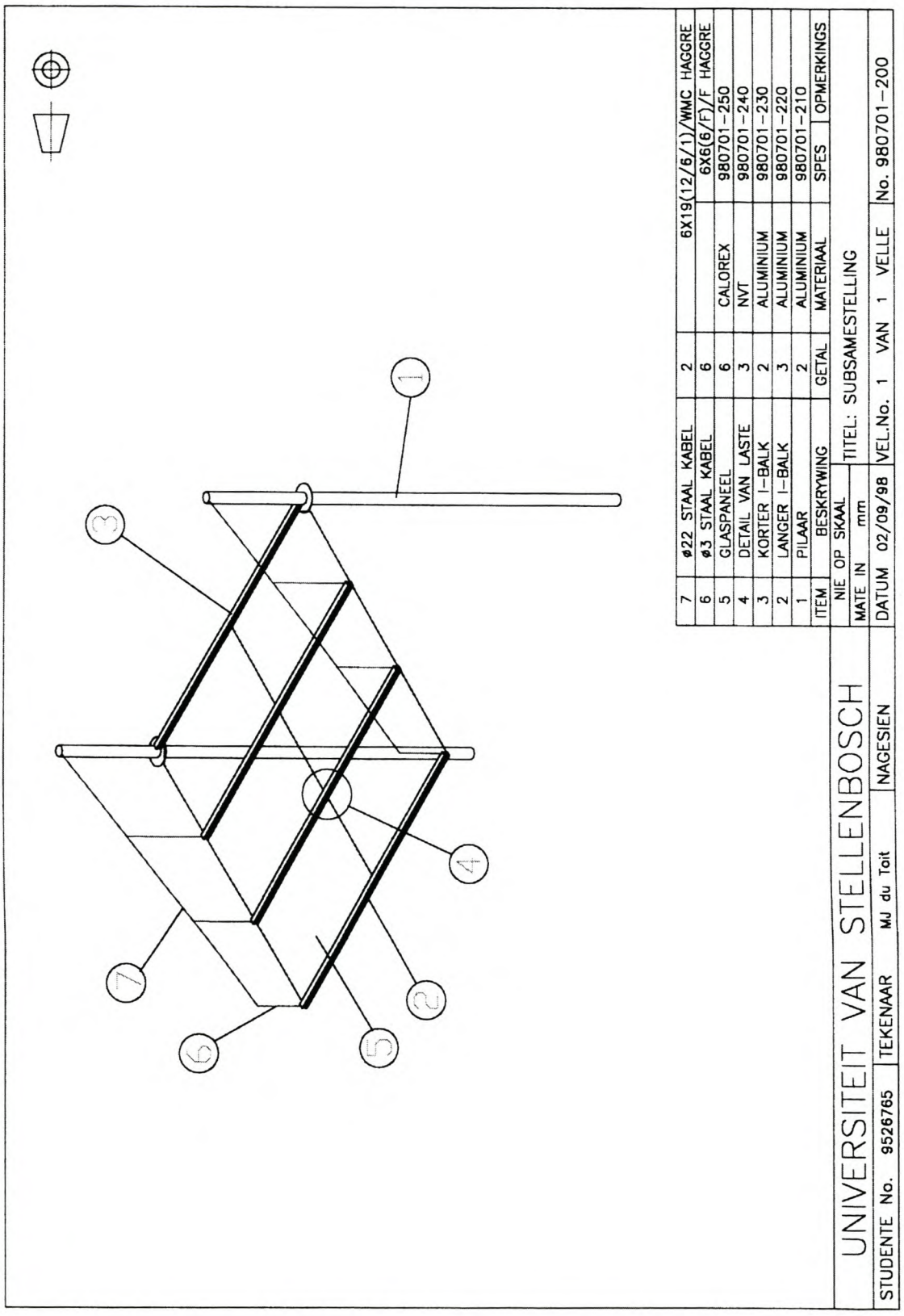

Figure B.3: Solar Chimney Collector, Technical Drawing #3 [Roux et al., 1998]

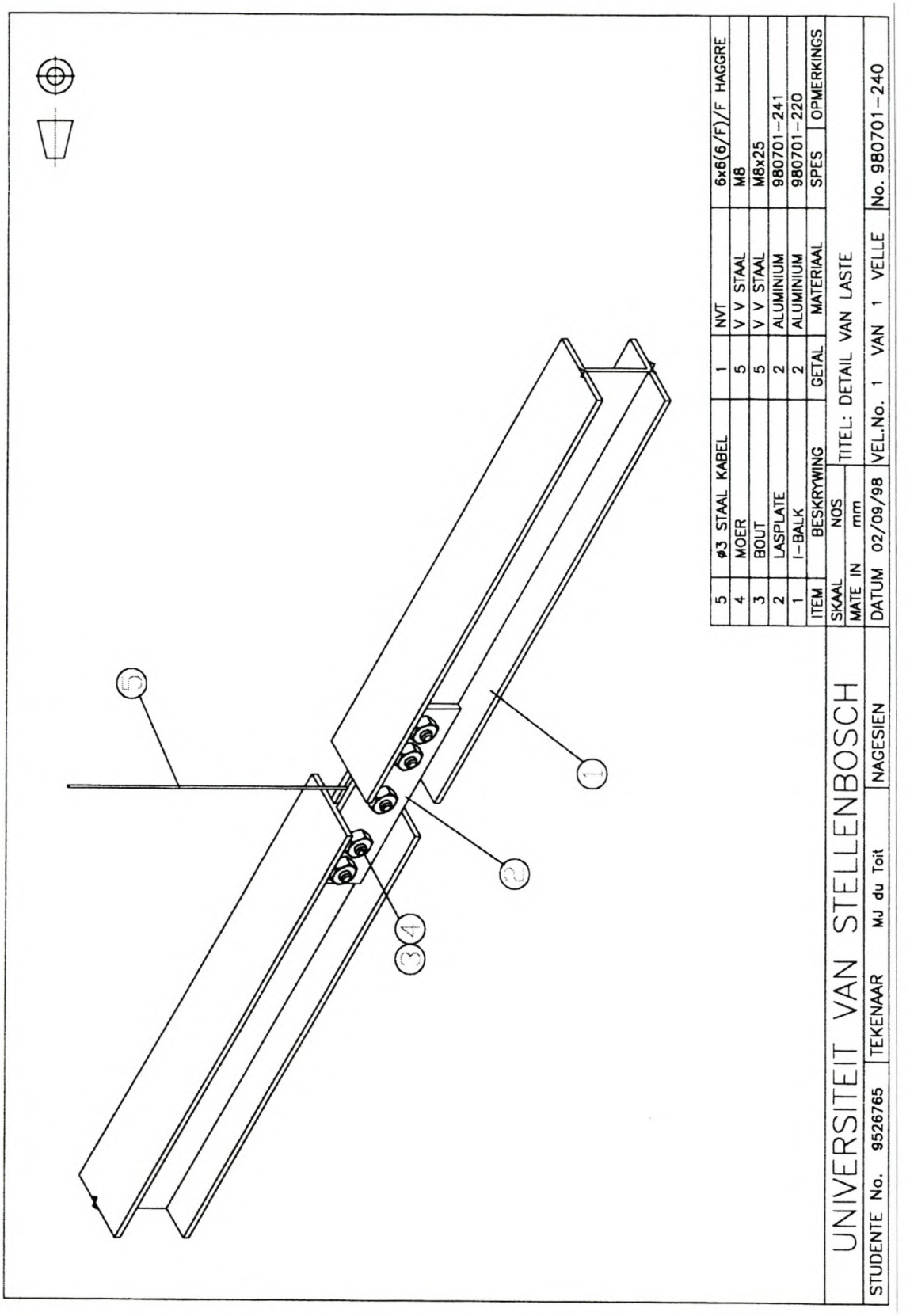

Figure B.4: Solar Chimney Collector, Technical Drawing #4 [Roux et al., 1998]

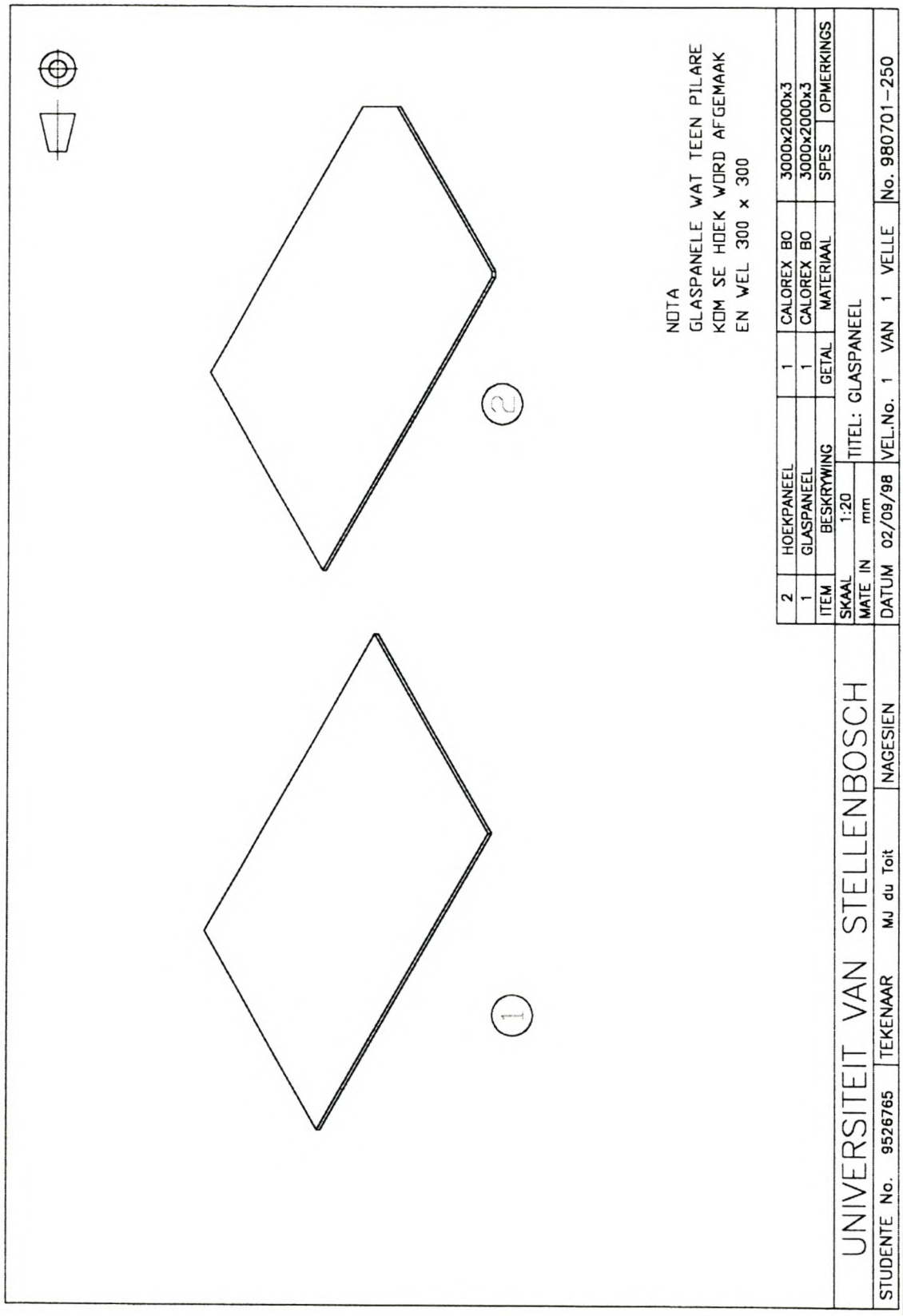

Figure B.5: Solar Chimney Collector, Technical Drawing #5 [Roux et al., 1998]

B.1.2 Scribble Paper

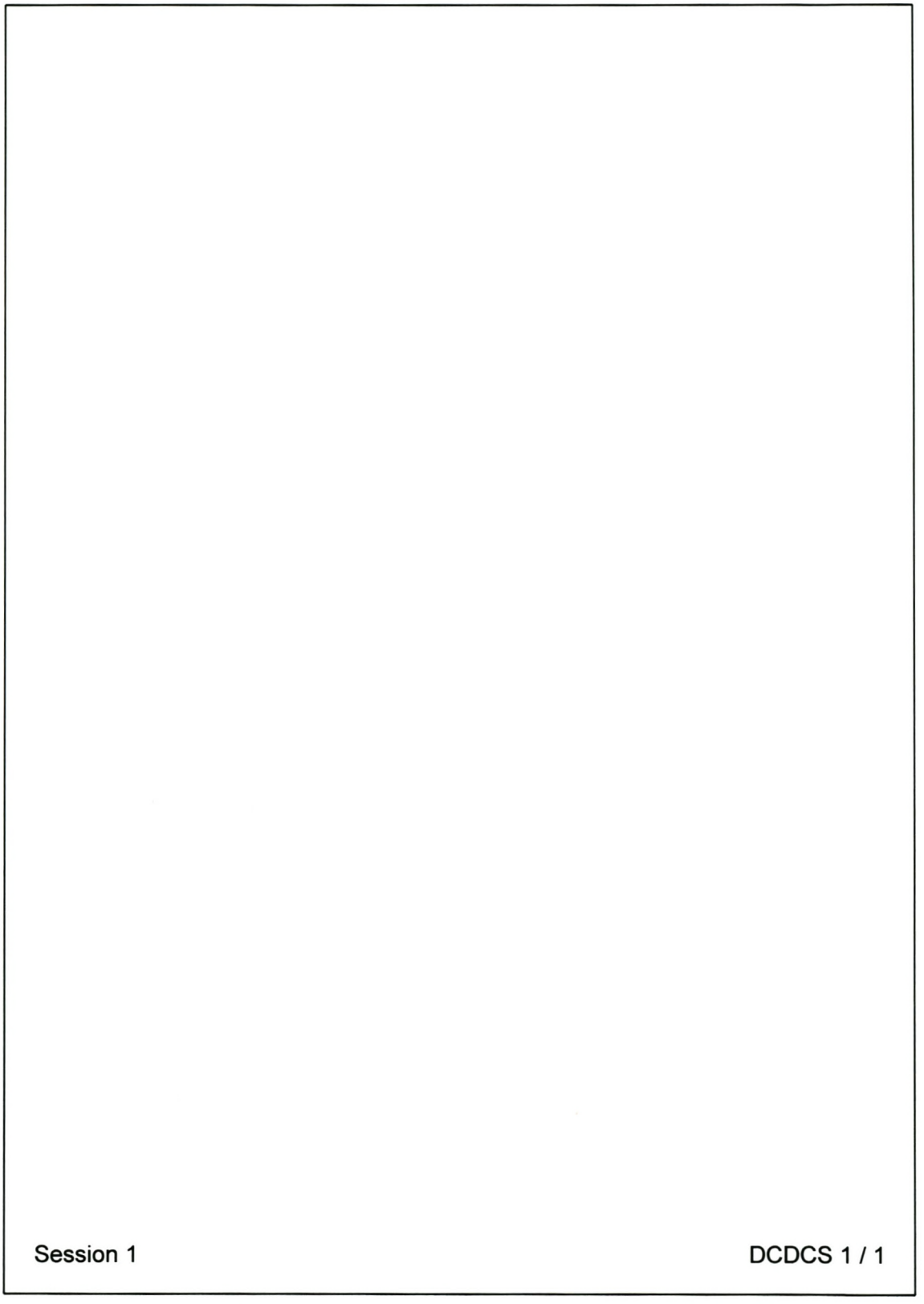

Figure B.6: Example of the Scribble Paper

B.2 Communication and Information Transfer Data

In this section the transcripts of the communication, i.e. telephone, electronic mail and desktop-videoconferencing, are listed. Furthermore, data collected for the usage of information transfer tools during the case study is presented. This includes: fax usage, scanner usage, graphic tablet usage and data on usage of the shared workspace via FTP.

B.2.1 Telephone Calls

Each telephone call was analysed regarding the following criteria:

- Session: case study session (the Distributed Design Assistant was used in sessions 1, 2 and 5)
- CallID: unique number for each telephone call identified
- CallID 2: corresponding telephone call identified on another tape
- From User: user who made the telephone call
- To User: user who received the telephone call
- RealTime: approximate time, identified on the clock at the workplace
- Tape #: tape number, also identifies designer (tape #1 = designer #1)
- TapeStart: start time of the telephone call, as displayed on the video recorder
- TapeStop: stop time of the telephone call, as displayed on the video recorder
- Duration: duration of the telephone call (Duration = TapeStop – TapeStart)
- Topics: topics of the conversation
- Design-R.: design-related conversation (x = yes)
- Procedure-R.: DiDeas or procedure-related conversation (x = yes)
- Comm.-R.: communication-related conversation (x = yes)
- Comments: comments by the author / case study supervisor.

The results are shown in Table B.1.

Session	CallID	CallID 2	From User	To User	RealTime	Tape #	TapeStart	TapeStop	Duration	Topics	Design-R.	Procedure-R.	Comm.-R.	Comments
s1	101	301	d1	d3	14h12	t1	0:03:32	0:04:34	0:01:02	d3 has problems to log into DiDeas		x		wanted to speak to d2, got numbers from DiDeas TeamManager or Project Manager
s1	102	201	d1	d2	14h15	t1	0:05:44	0:06:23	0:00:39	write down CRs, fax or email me	x		x	
s1	103	302	d1	d3	14h15	t1	0:06:35	0:08:11	0:01:36	write down CRs, email me, write important ones in uppercase d3 proposes to use DiDeas	x	x		d1 cant see him on TeamManager (has to refresh)
s1	104	202	d1	d2	14h20	t1	0:10:57	0:12:05	0:01:08	use DiDeas to put in CRs, explains how to add		x		d1 will edit CR if necessary
s1	105	203	d2	d1	14h25	t1	0:13:46	0:14:51	0:01:05	CR Maintenance (# of operators)		x		advice how to use CRs
s1	106	204	d1	d2	14h26	t1	0:16:08	0:17:38	0:01:30	how to delete CRs, d1 will change wrong CR, next step ERs		x		
s1	107	303	d1	d3	14h28	t1	0:17:48	0:18:43	0:00:55	are you done with CRs? Think about size of cables, lets start with ERs	x	x		
s1	108	205	d2	d1	14h32	t1	0:23:44	0:25:17	0:01:33	it doesn't really matter, lets think about HoQ, start sketching		x		
s1	109	304	d1	d3	14h35	t1	0:26:00	0:27:35	0:01:35	discussion remote control and other ERs, we are not worrying about maintenance, etc, we must go on, lets think about QFD	x			
s1	110	305	d3	d1	14h38	t1	0:29:18	0:30:10	0:00:52	discussing CR-ER relations, what's ER, what's concept		x		
s1	111	206	d1	d2	14h42	t1	0:30:52	0:32:26	0:01:34	QFD - CRs don't add up to ERs, they don't fit, what can we do? Need to change ERs		x		
s1	112	306	d3	d1	14h43	t1	0:32:58	0:35:07	0:02:09	we are looking at QFD now, I do the changes, send me fax, what should I ask him?	x	x	x	QFD and questions for the client
s1	113	307	d3	d1	14h46	t1	0:38:51	0:39:14	0:00:23	explain it to me quickly, where is the fax	x		x	fax didn't arrive yet
s1	114	309	d1	d3	14h49	t1	0:41:10	0:43:09	0:01:59	got fax, discussing fax (projections, how to read drawing), is QFD done		x	x	questing for client about tech. Drawings
s1	115	208	d1	d2	14h52	t1	0:43:19	0:43:50	0:00:31	go on to functional analysis, I ask him		x		
s1	116	310	d3	d1	14h48	t1	0:48:12	0:50:16	0:02:04	bird droppings, discuss air-concept, I'll ask client, how to add functions in DiDeas, discuss fax	x	x	x	
s1	117	311	d3	d1	15h02	t1	0:53:56	0:54:29	0:00:33	sand blast, carry on with ideas, anything	x			
s1	118	209	d2	d1	15h03	t1	0:54:51	0:56:30	0:01:39	sand blast, don't you think its gonna work, anything, we evaluate later, think about it, then videoconference in 2 minutes, use CU-SeeMe	x		x	
s1	119	312	d1	d3	15h06	t1	0:56:37	0:57:11	0:00:34	any more ideas, lets use CU-SeeMe (call it I-See-U-See) in 1 minute			x	
s1	120	313	d3	d1	15h16	t1	1:07:45	1:08:51	0:01:06	Problems with the Function-Concept structure		x		difference between concepts and concept designs
s1	121	210	d1	d2	15h26	t1	1:14:19	1:16:04	0:01:45	explains cf-structure, can't we use sub-concepts?		x		
s1	122	314	d1	d3	15h28	t1	1:16:11	1:17:28	0:01:17	what are you doing? We have to go deeper into the cf structure, discuss robot-concept	x	x		
s1	123	211	d1	d2	15h29	t1	1:18:17	1:19:30	0:01:13	can you elaborate on you actuators? Cables, pressure, ... draw it and fax/send it	x		x	doesn't understand item in cf-structure, has to phone for clarification

Table B.1: Telephone Calls (1/18)

Session	CallID	CallID 2	From User	To User	RealTime	Tape #	TapeStart	TapeStop	Duration	Topics	Design-R.	Procedure-R.	Comm.-R.	Comments
s1	124	316	d3	d1	15h33	t1	1:25:02	1:25:59	0:00:57	sprinkler system, water pressure, he is drawing that	x			
s1	125	213	d1	d2	15h35	t1	1:26:04	1:26:32	0:00:28	save the drawing for later, rather put in and expand your ideas		x		...in DiDeas
s1	126	317	d3	d1	15h42	t1	1:29:37	1:31:53	0:02:16	look at completeness, is it going through? How to edit		x		how to handle duplicate entries
s1	127	320	d3	d1	15h46	t1	1:36:57	1:39:10	0:02:13	explains how to select concepts and concept designs		x		
s1	128	216	d1	d2	15h52	t1	1:43:46	1:45:58	0:02:12	what are you doing? Add on the list, but not only sub-functions. Rather select concept designs		x		
s1	129	321	d1	d3	16h00	t1	1:52:16	1:53:01	0:00:45	what are you doing? Screening? Let's have a conference after the screening		x	x	
s1	130	217	d1	d2	16h01	t1	1:53:09	1:54:25	0:01:16	Are you at concept selection? Go to concept screening, after that we have a little conference		x	x	
s1	131	322	d1	d3	16h03	t1	1:54:43	1:55:42	0:00:59	D2 added some more functions. Everybody is doing their own screening?!?		x		
s1	132	323	d3	d1	16h14	t1	2:04:28	2:05:10	0:00:42	Ok, there is enough water, I'll ask him just now	x			Question for the client
s1	133	220	d2	d1	16h21	t1	2:10:47	2:13:16	0:02:29	We don't have to use water, just put that in the system. Let's have a conference, I'll bring the up and then we discuss it.	x	x	x	Also proposes that everybody prints the concepts, but then hesitates.
s1	134	326	d1	d3	16h23	t1	2:13:20	2:14:58	0:01:38	sandblaster - we talk about it in the chatroom, after that decision matrix - let's discuss it in the conference	x		x	
s1	135	221	d1	d2	16h31	t1	2:21:40	2:22:54	0:01:14	can you hear me (at videoconference), which was your 'green' idea? Did you draw it?	x		x	
s1	136	327	d1	d3	16h41	t1	2:30:47	2:31:55	0:01:08	(pause) look at example case for criteria, we only do the 4 concepts we have now	x	x		
s1	137	222	d1	d2	16h42	t1	2:33:44	2:35:00	0:01:16	What are you doing? Go to criteria selection and old example, then we do the matrix		x		
s1	138	328	d1	d3	16h51	t1	2:41:21	2:41:40	0:00:19	What are you doing, maybe phone Gill and tell him to start with the Decision Matrix		x	x	
s1	139	223	d1	d2	16h51	t1	2:42:48	2:43:24	0:00:36	Did you write ... in the Decision Matrix, What's that, I don't understand.	x	x		
s1	140	330	d3	d1	16h56	t1	2:46:45	2:48:08	0:01:23	Question for client regarding sprinkler-system. How could you design without knowing. Press calculate and wait for us.	x	x		
s1	141	226	d1	d2	17h00	t1	2:50:14	2:51:33	0:01:19	Are you done? How did you know about my sprinkler system, is your matrix complete?	x	x	x	problem: datum is not winner for all designers
s1	142	227	d2	d1	17h01	t1	2:52:43	2:52:58	0:00:15	Funny results, I'll phone you back.	x		x	
s1	143	333	d1	d3	17h04	t1	2:55:45	2:56:48	0:01:03	What are you doing? Strange result. We are out of time. I'll write the report.	x	x		
s1	144	230	d2	d1	17h12	t1	3:02:54	3:03:03	0:00:09		?			
s1	145	335	d1	d3	17h21	t1	3:13:22	3:13:41	0:00:19	Are you reading the design, someone is busy reading it.		x		
s1	146	231	d1	d2	17h22	t1	3:13:50	3:14:02	0:00:12	Are you reading, you can add something and fix spelling mistakes		x		

Table B.1: Telephone Calls (2/18)

Session	CallID	CallID 2	From User	To User	RealTime	Tape #	TapeStart	TapeStop	Duration	Topics	Design-R.	Procedure-R.	Comm.-R.	Comments
s1	147	336	d3	d1	17h24	t1	3:14:24	3:14:40	0:00:16	After Andrew has read it you can read it		x		
s1	148	232	d2	d1	17h27	t1	3:16:32	3:16:50	0:00:18	Are you done, phone Arthur and tell him		x	x	
s1	149	338	d3	d1	17h29	t1	3:19:01	3:19:32	0:00:31	Switch off that I can read it, tell Gill to meet in the coffee room		x	x	
s1	201	102	d1	d2	14h16	t2	0:04:59	0:05:42	0:00:43	On paper?	x			
s1	202	104	d1	d2	14h20	t2	0:10:13	0:11:23	0:01:10	I'll try, Engineering Requirements		x		
s1	203	105	d2	d1	14h23	t2	0:13:02	0:14:08	0:01:06	Low number of operators	x	x		
s1	204	106	d1	d2	14h25	t2	0:15:24	0:16:55	0:01:31	They are related, I'll do that, what subject		x		
s1	205	108	d2	d1	14h33	t2	0:23:00	0:24:33	0:01:33	Window wiper, sprinkler	x			
s1	206	111	d1	d2	14h40	t2	0:30:06	0:31:45	0:01:39	Maintenance, I'll do that		x		
s1	207	308	d3	d2	14h50	t2	0:39:43	0:40:00	0:00:17	Ok	?			
s1	208	115	d1	d2	14h53	t2	0:42:34	0:43:07	0:00:33	Concepts, ok	?			
s1	209	118	d2	d1	15h04	t2	0:54:07	0:55:47	0:01:40	Who's idea was that? The more ideas… I go for the window wiper, CU-SeeMe?	x	x	x	
s1	210	121	d1	d2	15h24	t2	1:13:35	1:15:21	0:01:46	Directing the jet.	x			
s1	211	123	d1	d2	15h28	t2	1:17:32	1:18:48	0:01:16	Rapid pinion arrangement, I have a drawing here, I'll mail it to you	x		x	
s1	212	315	d3	d2	15h33	t2	1:22:41	1:23:05	0:00:24	Actuator, I'm busy drawing	x			
s1	213	125	d1	d2	15h35	t2	1:25:19	1:25:47	0:00:28	Ok, I speak to him			x	
s1	214	318	d3	d2	15h42	t2	1:32:25	1:33:48	0:01:23	I sent the drawing as attachment			x	
s1	215	319	d2	d3	15h44	t2	1:34:16	1:35:26	0:01:10	Driving up and down, sliding back and forward	x			
s1	216	128	d1	d2	15h53	t2	1:43:00	1:45:17	0:02:17	Isn't that the same … then we start choosing	x	x		
s1	217	130	d1	d2	16h02	t2	1:52:23	1:53:41	0:01:18	I added two subfunctions, I have done 2 concepts designs, rubber ball, mostly functions	x	x		
s1	218	324	d2	d3	16h15	t2	2:04:37	2:05:43	0:01:06	You say the scraping system works good, use rubber	x			
s1	219	325	d2	d3	16h19	t2	2:08:36	2:09:44	0:01:08	I'll check with Gill	x		x	
s1	220	133	d2	d1	16h20	t2	2:10:02	2:12:30	0:02:28	Water, get rid of sand blaster idea, high pressure air	x			
s1	221	135	d1	d2	16h31	t2	2:20:52	2:22:12	0:01:20	I did this now, electric wiper, hydraulic cylinders	x	x		
s1	222	137	d1	d2	16h43	t2	2:32:58	2:34:22	0:01:24	OK, the matrix		x		
s1	223	139	d1	d2	16h51	t2	2:40:59	2:41:28	0:00:29	Doing the criteria, decision matrix, now		x		
s1	224	329	d3	d2	16h52	t2	2:42:00	2:42:40	0:00:40	Yes, I'm doing, mustn't damage glass		x		

Table B.1: Telephone Calls (3/18)

Session	CallID	CallID 2	From User	To User	RealTime	Tape #	TapeStart	TapeStop	Duration	Topics	Design-R.	Procedure-R.	Comm.-R.	Comments
s1	225	331	d3	d2	16h58	t2	2:47:46	2:48:07	0:00:21	Decision matrix		x		
s1	226	141	d1	d2	17h00	t2	2:49:28	2:50:49	0:01:21	Evaluation results, looks like		x		
s1	227	142	d2	d1	17h02	t2	2:51:49	2:52:14	0:00:25	It doesn't actually...				
s1	228	332	d3	d2	17h03	t2	2:53:26	2:54:53	0:01:27	Sprinkler system, I'll try again	x			
s1	229	334	d3	d2	17h06	t2	2:56:10	2:56:29	0:00:19		?			
s1	230	144	d2	d1	17h12	t2	3:02:09	3:02:20	0:00:11	What's going on there?			x	
s1	231	146	d1	d2	17h23	t2	3:13:03	3:13:18	0:00:15	spelling mistakes		x		
s1	232	148	d2	d1	17h26	t2	3:15:48	3:16:05	0:00:17	...Arthur...				
s1	233	337	d2	d3	17h26	t2	3:16:18	3:17:13	0:00:55	Are you looking at? It's up				problems with design review access
s1	234	339	d3	d2	17h29	t2	3:19:00	3:19:06	0:00:06	Coffee room			x	
s1	301	101	d1	d3	14h13	t3	0:02:08	0:03:10	0:01:02	I must be logged on, as DCDCS3		x		
s1	302	103	d1	d3	14h16	t3	0:05:12	0:06:50	0:01:38	I'm on, go to team manager to see online users, ok I'll write it down or rather type it in to CR, Specification Development right at the top, then I'll call you back	x	x	x	
s1	303	107	d1	d3	14h27	t3	0:16:24	0:17:21	0:00:57	Go to CR and press the refresh button. I put in most of the functional performance, just put in something on the constraints	x	x		
s1	304	109	d1	d3	14h36	t3	0:24:37	0:26:13	0:01:36	Just refresh yours (maintenance, maximum weight) I'm putting it in now, must have been Gill. QFD, Are you phoning Gill?	x	x	x	
s1	305	110	d3	d1	14h39	t3	0:27:56	0:28:48	0:00:52	Is it just me or do you also think that CRs and ERs are not going very well together? Ask Gill what he thinks.	x	x	x	QFD
s1	306	112	d3	d1	14h43	t3	0:31:37	0:33:44	0:02:07	I'll send you a fax. Problems with the drawings. Have you spoken to Gill? Discussing CRs/ERs. Where is Maintenance? Are you going to do it, then do it	x	x	x	Leaves to send fax
s1	307	113	d3	d1	14h48	t3	0:37:29	0:37:50	0:00:21	Did you get the fax? Bye			x	
s1	308	207	d3	d2	14h50	t3	0:39:05	0:39:22	0:00:17	Did you fill in the numbers in the House of Quality, I didn't know who did it?		x		
s1	309	114	d1	d3	14h51	t3	0:39:45	0:41:46	0:02:01	Listen to me. Do you have the pictures in front of you? Are the arrows I draw in the same direction? Ask him (the guy). Then we move to functional analysis. We need some conceptual thinking. Make sure with Gill we are going in the same direction.		x	x	
s1	310	116	d3	d1	14h58	t3	0:46:51	0:48:52	0:02:01	I want to know: Do we necessarily have to use water or can we use something like air, because you're out in the dessert? Yes, I'm in, add functions, go to project manager. Two arrows going in the same direction. Speak to you later.	x	x	x	
s1	311	117	d3	d1	15h04	t3	0:52:32	0:53:04	0:00:32	What is sand blast? Ok	x			

Table B.1: Telephone Calls (4/18)

Session	CallID	CallID 2	From User	To User	RealTime	Tape #	TapeStart	TapeStop	Duration	Topics	Design-R.	Procedure-R.	Comm.-R.	Comments
s1	312	119	d1	d3	15h06	t3	0:55:13	0:55:48	0:00:35	Ok Talk to Gill			x	
s1	313	120	d3	d1	15h17	t3	1:06:23	1:07:27	0:01:04	Before we go on we have to put in subconcepts for all functions, otherwise we can't go on. Click on check completeness. Call Gill	x	x	x	
s1	314	122	d1	d3	15h26	t3	1:14:52	1:16:07	0:01:15	What's going on? I did that, go to side-car/edit, read my note. It's just to have something there so that we can go on	x	x		
s1	315	212	d3	d2	15h33	t3	1:22:03	1:22:25	0:00:22	Do you have a subconcept for the actuator?	x	x		
s1	316	124	d3	d1	15h35	t3	1:23:40	1:24:34	0:00:54	Have you got a subconcept for the Propulsion, I could see you put it in. Ok there it is. He shouldn't draw but fill in, so that we can go on. Tell him.	x	x	x	
s1	317	126	d3	d1	15h39	t3	1:28:14	1:30:33	0:02:19	Can we go on now? If you go to concept design selection, there you vote… Each one of us does his own concepts now.		x		Explains concept design selection process
s1	318	214	d3	d2	15h43	t3	1:31:50	1:33:04	0:01:14	Did you put in the multi-window-wiper and squeegee? Can you send me the drawing? Is that back at FC structure?	x	x		Downloads concept sketch from FC structure
s1	319	215	d2	d3	15h45	t3	1:33:36	1:34:44	0:01:08	I was thinking…is the rack one of the beams? I have a similar, fax it to you and Julian, then we talk.	x	x	x	Downloads other concept sketch
s1	320	127	d3	d1	15h47	t3	1:35:34	1:37:45	0:02:11	When can we start discussing the concepts? I'll tell Gill… Back to functional analysis, he attached 2 drawings, look at the right one, I have similar idea. Call him and tell same as me.	x	x	x	
s1	321	129	d1	d3	16h01	t3	1:50:51	1:51:38	0:00:47	I'm busy with the concept design screen. You should draw. …definitively, to see which is the best concept	x	x		
s1	322	131	d1	d3	16h04	t3	1:53:18	1:54:19	0:01:01	Where? I'm not gonna do it. Then we compare it to the …	?			
s1	323	132	d3	d1	16h14	t3	2:03:05	2:03:45	0:00:40	Water, ask the customer, limited supply. Let me know	x			
s1	324	218	d2	d3	16h15	t3	2:03:57	2:05:05	0:01:08	Semi-desert area, scraping system, thin glass will break. Ok, change it back, gut feeling	x			
s1	325	219	d2	d3	16h19	t3	2:07:55	2:09:04	0:01:09	Do you think it will work? Were to get water from? Direct air up and use it. Call him and call me back.	x		x	
s1	326	134	d1	d3	16h23	t3	2:11:54	2:13:33	0:01:39	Looking at concept design screening, waiting. Just the 4 green ones, how do we get them to the decision matrix? Meet in the chat room.		x	x	
s1	327	136	d1	d3	16h40	t3	2:29:20	2:30:32	0:01:12	Very difficult, not working at all. We have to go on with the 4 …			x	
s1	328	138	d1	d3	16h51	t3	2:39:57	2:40:16	0:00:19	I'm busy with the decision matrix.		x		
s1	329	224	d3	d2	16h51	t3	2:40:21	2:40:47	0:00:26	What are you doing? Don't do too much, start with the decision matrix, we have enough criteria		x		
s1	330	140	d3	d1	16h56	t3	2:45:21	2:46:45	0:01:24	What to do after decision matrix? Go back to screening, look at description. I call Gill.		x	x	

Table B.1: Telephone Calls (5/18)

Session	CallID	CallID 2	From User	To User	RealTime	Tape #	TapeStart	TapeStop	Duration	Topics	Design-R.	Procedure-R.	Comm.-R.	Comments
s1	331	225	d3	d2	16h58	t3	2:47:08	2:47:28	0:00:20	What are you doing? When finished, give us a call.		x	x	
s1	332	228	d3	d2	17h04	t3	2:52:48	2:54:10	0:01:22	Are you finished? Call Julian. Problem: Criteria selection for wired results. We keep it for today.		x		
s1	333	143	d3	d1	17h05	t3	2:54:23	2:55:24	0:01:01	We spoke about the results. I call Gill to tell him you are busy with it.	x	x	x	
s1	334	229	d3	d2	17h07	t3	2:55:32	2:55:48	0:00:16	Julien is writing the report.		x	x	
s1	335	145	d1	d3	17h23	t3	3:11:56	3:12:18	0:00:22	Design reviews…		x		
s1	336	147	d3	d1	17h24	t3	3:12:59	3:13:15	0:00:16	Reading the report? Let me know.		x	x	
s1	337	233	d2	d3	17h27	t3	3:15:39	3:16:32	0:00:53	Can't see design review. It's still in use by you. Ok, there it is		x		
s1	338	149	d3	d1	17h29	t3	3:17:37	3:18:08	0:00:31	I read it through, I like it.		x		
s1	339	234	d3	d2	17h29	t3	3:18:22	3:18:27	0:00:05	Let's meet in the coffee room.			x	
s2	101	401	d4	d1	14h26	t1	0:17:13	0:17:47	0:00:34	On your own, discuss later, eg via NetMeeting or email		x	x	
s2	102	201	d1	d2	14h27	t1	0:17:56	0:18:39	0:00:43	You edited 1 thing already, you are fine.		x		
s2	103	301	d1	d3	14h27	t1	0:18:51	0:20:41	0:01:50	Work on CRs, very creative, question for the client		x		
s2	104	302	d3	d1	14h29	t1	0:21:34	0:22:24	0:00:50	That would be engineering requirements		x		
s2	105	304	d3	d1	14h43	t1	0:35:12	0:35:58	0:00:46	Enough with CR and ER, please cont. with the QFD		x		
s2	106	203	d1	d2	14h44	t1	0:36:10	0:36:30	0:00:20	Enough with CR and ER, please cont. with the QFD. You have already 1 entry, great		x		
s2	107	402	d1	d4	14h45	t1	0:36:39	0:36:57	0:00:18	We decided to move on, QFD		x		
s2	108	204	d2	d1	14h50	t1	0:44:29	0:44:37	0:00:08	Ok		x		(d2 has to leave)
s2	109	305	d3	d1	14h51	t1	0:45:03	0:45:54	0:00:51	More or less complete, I think we can move on. Cleaning top of glass, ok		x		discuss overall function?
s2	110	306	d3	d1	14h54	t1	0:47:29	0:48:15	0:00:46	Question regarding suspension (drawing2), ok go on	x			
s2	111	403	d1	d4	14h55	t1	0:48:30	0:48:48	0:00:18	House of Quality is defined, let's move on		x		
s2	112	307	d1	d3	15h00	t1	0:54:27	0:54:36	0:00:09	Technical Problem, where is Supervisor?	-	-	-	asks for assistance from CS supervisor, how to save attachments
s2	113	404	d1	d4	15h03	t1	0:56:57	0:57:35	0:00:38	Nice concept, please upload it to the function-concept structure. Did you mail it to the others? Please do so.	x	x	x	
s2	114	308	d1	d3	15h05	t1	0:57:56	1:00:33	0:02:37	Is your concept automated? Question for client	x			
s2	115	309	d1	d3	15h13	t1	1:04:04	1:07:26	0:03:22	We need more concepts than just one. I got something, no my is completely different. I don't get the 16-wheel … Good Idea	x	x		

Table B.1: Telephone Calls (6/18)

Session	CallID	CallID 2	From User	To User	RealTime	Tape #	TapeStart	TapeStop	Duration	Topics	Design-R.	Procedure-R.	Comm.-R.	Comments
s2	116	311	d1	d3	15h28	t1	1:20:11	1:23:04	0:02:53	Did you get my mail? Concept-Function structure not enough, look at my structure. FC-structure is not complete, I'll contact D4		x	x	
s2	117	406	d1	d4	15h32	t1	1:23:13	1:24:00	0:00:47	Add concept to your function in FC structure, it's not complete. Just say eg 'refer to sketch', just to have something. Then we can go to the next step	x	x		
s2	118	312	d3	d1	15h33	t1	1:24:48	1:25:14	0:00:26	Please repeat, ok.	x			
s2	119	313	d3	d1	15h39	t1	1:30:07	1:34:32	0:04:25	Concept design selection, explains how to select (build) a concept design. Don't do duplicate concepts. As soon as you are finished, we can go on to the next step. I'll phone D4		x	x	
s2	120	407	d1	d4	15h43	t1	1:34:40	1:34:50	0:00:10	5min break	-	-	-	CS supervisor request
s2	121	314	d1	d3	15h43	t1	1:35:00	1:35:14	0:00:14	5min break	-	-	-	CS supervisor request
s2	122	315	d1	d3	15h53	t1	1:46:13	1:47:34	0:01:21	CU-SeeMe, ok, is d4 up and running, I don't see anybody. How to make a groupmeeting connection			x	
s2	123	205	d2	d1	15h55	t1	1:47:43	1:49:27	0:01:44	You are back, ok. Explains what team did the last 30mins and what to do next. We now start a video conference for the concept design screening		x	x	D2 was out of office for some time
s2	124	316	d1	d3	15h58	t1	1:50:39	1:50:47	0:00:08	Tech. Problem, where is Supervisor?	-	-	-	supervisor assistance, how to speak in CU-SeeMe
s2	125	207	d2	d1	16h06	t1	1:58:47	1:58:59	0:00:12	Ok, no problem.		x		
s2	126	210	d1	d2	16h15	t1	2:08:31	2:09:21	0:00:50	Are you still busy developing concepts? Are you happy with the concept design screening? Not pissed? We need to continue		x		
s2	127	408	d1	d4	16h16	t1	2:09:35	2:10:06	0:00:31	Go to concept selection and criteria selection		x		
s2	128	211	d2	d1	16h22	t1	2:15:37	2:16:32	0:00:55	Problems with video, can only hear d2 and d3, need to inform d4 by other means. You are welcome to put in 2 or 3 more		x	x	
s2	129	409	d1	d4	16h26	t1	2:17:35	2:18:04	0:00:29	Did you get the chat message that we go to next step. If something important happens I will phone, otherwise keep an eye on the chat. Next step decision matrix		x	x	
s2	130	320	d3	d1	16h29	t1	2:20:11	2:21:12	0:01:01	Decision matrix, concept...	x	x		
s2	131	410	d1	d4	16h34	t1	2:25:14	2:25:33	0:00:19	How far are you with the decision matrix? Let me know when you're finished		x	x	
s2	132	321	d3	d1	16h35	t1	2:26:07	2:29:25	0:03:18	Concepts, sort of, close. I'm the boss, I'm allowed to do that. PaintshopPro problems. Let's continue, I'll inform the others	x	x	x	
s2	133	411	d1	d4	16h37	t1	2:29:36	2:29:50	0:00:14	Let's continue		x		
s2	134	412	d4	d1	16h44	t1	2:35:48	2:38:07	0:02:19	Message? I completely disagree, managers don't write reports, haha. Are you happy with the results from the decision matrix? Should we do it again? ... Now we have to do the design review, I'll tell the others		x	x	

Table B.1: Telephone Calls (7/18)

Session	CallID	CallID 2	From User	To User	RealTime	Tape #	TapeStart	TapeStop	Duration	Topics	Design-R.	Procedure-R.	Comm.-R.	Comments
s2	135	212	d2	d1	16h48	t1	2:41:29	2:43:34	0:02:05	Everybody should write a bit about their concept, Word or Notepad	x	x		
s2	136	322	d1	d3	16h49	t1	2:43:44	2:45:41	0:01:57	Write 2 lines about your concept and evaluation process. Word, then mail it to me. Evaluation process failed		x	x	
s2	137	413	d1	d4	16h54	t1	2:46:15	2:47:06	0:00:51	Please give me 2 line description of your concept and the selection process. Just what you think. Send it to me as an attachment in Word		x	x	
s2	138	213	d1	d2	16h55	t1	2:47:14	2:47:26	0:00:12	Can you email it to me?			x	
s2	139	414	d4	d1	16h58	t1	2:50:11	2:50:22	0:00:11	Yes I did, perfect			x	
s2	140	323	d1	d3	16h58	t1	2:50:37	2:51:41	0:01:04	What is the company? Good idea. … Solution		x		
s2	141	215	d2	d1	17h00	t1	2:53:19	2:53:44	0:00:25	Ok, I did receive			x	
s2	142	216	d1	d2	17h01	t1	2:55:03	2:55:13	0:00:10	Ok			x	
s2	201	102	d1	d2	14h26	t2	0:05:13	0:05:55	0:00:42	Going well, missing my coffee. I already edited 3. Have to leave soon.		x		
s2	202	303	d2	d3	14h37	t2	0:16:07	0:16:21	0:00:14	(you got mine? Ok)		x		
s2	203	106	d1	d2	14h44	t2	0:23:26	0:23:47	0:00:21	House of Quality, just started		x		
s2	204	108	d2	d1	14h52	t2	0:31:47	0:31:55	0:00:08	Have to leave now		x		returns at 15h55
s2	205	123	d2	d1	15h56	t2	1:34:59	1:36:40	0:01:41	I'm back. No concepts at this stage? I'll start CU-SeeMe		x	x	
s2	206	317	d2	d3	16h00	t2	1:39:44	1:40:22	0:00:38	Problems with CU-SeeMe, d3 explains how to use			x	
s2	207	125	d2	d1	16h07	t2	1:45:40	1:45:50	0:00:10	Decision Matrix		x		
s2	208	318	d2	d3	16h08	t2	1:47:02	1:47:30	0:00:28	How to do concept selection?		x		
s2	209	319	d3	d2	16h10	t2	1:48:44	1:49:02	0:00:18	Ok, I'll do a drawing		x		
s2	210	126	d1	d2	16h16	t2	1:55:22	1:56:11	0:00:49	Did only one. So many icons, I'm lost. … no problem		x		
s2	211	128	d2	d1	16h24	t2	2:02:30	2:03:20	0:00:50	Lost communication? 6 criteria, should be enough for the exercise. I type it in the chat so that everybody can see it		x	x	
s2	212	135	d2	d1	16h49	t2	2:28:16	2:30:19	0:02:03	System doesn't work. Save it in my directory. Do it in Word	x	x		
s2	213	138	d1	d2	16h55	t2	2:33:59	2:34:10	0:00:11	I'll email it to you			x	
s2	214	324	d3	d2	17h00	t2	2:38:32	2:38:50	0:00:18	Grammar check		x		
s2	215	141	d2	d1	17h01	t2	2:40:05	2:40:29	0:00:24	Did you receive my email?			x	
s2	216	142	d1	d2	17h03	t2	2:41:47	2:41:59	0:00:12	Decision.doc or something			x	

Table B.1: Telephone Calls (8/18)

Session	CallID	CallID 2	From User	To User	RealTime	Tape #	TapeStart	TapeStop	Duration	Topics	Design-R.	Procedure-R.	Comm.-R.	Comments
s2	301	103	d1	d3	14h27	t3	0:08:58	0:10:49	0:01:51	I'm already drawing, already developed a concept. Ok, CRs and ERs. Is the project going? Question for the customer, temperature on top. Phone you later		x	x	
s2	302	104	d3	d1	14h30	t3	0:11:43	0:12:32	0:00:49	Where do we add constraints (geometry)?		x		
s2	303	202	d2	d3	14h37	t3	0:18:58	0:19:14	0:00:16	Ok, IE		x		
s2	304	105	d3	d1	14h43	t3	0:25:21	0:26:07	0:00:46	How far is the project? So we can, I can start with the House of Quality?		x		
s2	305	109	d3	d1	14h53	t3	0:35:12	0:36:03	0:00:51	QFD is full, can we go to Functional Analysis. Do you, as Project Manager, put in the overall function?		x		
s2	306	110	d3	d1	14h56	t3	0:37:38	0:38:24	0:00:46	Drawing... That's not another concept? I-beam	x			
s2	307	112	d1	d3	15h03	t3	0:44:35	0:44:45	0:00:10	On his way	-	-	-	
s2	308	114	d1	d3	15h06	t3	0:48:04	0:50:42	0:02:38	Automated, 4x4, adding, looking at the pictures, from 1 I-beam to the other, trolley. I think we talk about the same.	x	x		
s2	309	115	d1	d3	15h13	t3	0:54:13	0:57:34	0:03:21	I have done 1, are you doing the rest? I put the file ... Variation, just the basic concept, terrible picture next to the ... 4 wheels on I-beam support platform, triangle, sideview	x		x	
s2	310	405	d4	d3	15h17	t3	0:58:50	1:00:33	0:01:43	It basically moves ... explains his concept. I know, terrible drawing, I know what it is, I will update it	x			
s2	311	116	d1	d3	15h29	t3	1:10:19	1:13:14	0:02:55	Mail, add more, yes I did. Concept ... we have now 1-2-3		x	x	
s2	312	118	d3	d1	15h33	t3	1:14:58	1:15:23	0:00:25	DC motor, direction changing	x			
s2	313	119	d3	d1	15h38	t3	1:20:18	1:24:39	0:04:21	Are we already at the concept selection stage? Concept designs, ok. I have to select one at select concepts first, I see. I'll obviously select mine. I can put in another one, just to have 2. How to select concept designs? Are we already going to the next stage? Now?		x		
s2	314	121	d1	d3	15h43	t3	1:25:08	1:25:22	0:00:14	Break for cookies	-	-	-	
s2	315	122	d1	d3	15h55	t3	1:36:16	1:37:38	0:01:22	Open CU-SeeMe. Where are we now, screening, ok, Explains how to connect		x	x	
s2	316	124	d1	d3	15h59	t3	1:40:43	1:40:51	0:00:08	Outside	-	-	-	
s2	317	206	d2	d3	16h01	t3	1:42:31	1:43:11	0:00:40	We started CU-SeeMe, how to start it and connect			x	
s2	318	208	d2	d3	16h09	t3	1:50:15	1:50:44	0:00:29	Concept screening, go/nogo		x		
s2	319	209	d3	d2	16h10	t3	1:51:58	1:52:16	0:00:18	Your concept, are you still busy? I would like to ...	x			
s2	320	130	d3	d1	16h29	t3	2:10:15	2:11:17	0:01:02	Where are we now, I finished my decision matrix.	x	x		
s2	321	132	d3	d1	16h34	t3	2:16:13	2:19:29	0:03:16	Isn't concept 3 and 4 the same - close to. 400x400 (size of images). CU-SeeMe, press talk	x	x	x	
s2	322	136	d1	d3	16h52	t3	2:33:47	2:35:46	0:01:59	I'll try. Can you access the database? It probably failed because...		x	x	

Table B.1: Telephone Calls (9/18)

Session	CallID	CallID 2	From User	To User	RealTime	Tape #	TapeStart	TapeStop	Duration	Topics	Design-R.	Procedure-R.	Comm.-R.	Comments
s2	323	140	d1	d3	16h59	t3	2:40:41	2:41:46	0:01:05	Tomorrow's solutions. Doc-file, brief description, email		x	x	
s2	324	214	d3	d2	17h00	t3	2:41:53	2:42:10	0:00:17	Did you write…		x		
s2	401	101	d4	d1	14h29	t4	0:06:21	0:06:53	0:00:32	Should everybody edit the CRs, or are we doing it through you?		x		
s2	402	107	d1	d4	14h48	t4	0:25:45	0:26:03	0:00:18	Ok, I'll start with ERs now		x		
s2	403	111	d1	d4	15h00	t4	0:37:37	0:37:56	0:00:19	I just got an idea. Should I send it by email?			x	
s2	404	113	d1	d4	15h09	t4	0:46:04	0:46:42	0:00:38	I saved it to FTP … Ok I'll do that			x	
s2	405	310	d4	d3	15h20	t4	0:57:51	0:59:32	0:01:41	Saw your idea, how do you want to change direction?	x			
s2	406	117	d1	d4	15h35	t4	1:12:19	1:13:08	0:00:49	I'll add some functions	x	x		
s2	407	120	d1	d4	15h46	t4	1:23:47	1:23:57	0:00:10	5min, ok	-	-	-	
s2	408	127	d1	d4	?	t4	1:58:41	1:59:14	0:00:33	Yes, finished. I already added one.		x		
s2	409	129	d1	d4	?	t4	2:06:41	2:07:11	0:00:30	Not yet, email?			x	
s2	410	131	d1	d4	?	t4	2:14:21	2:14:40	0:00:19	Still 3, almost finished. Ok I'll send a message		x	x	
s2	411	133	d1	d4	?	t4	2:18:43	2:18:57	0:00:14	Ok		x		
s2	412	134	d4	d1	?	t4	2:24:56	2:27:15	0:02:19	Did you see the message? You are the manager. I don't think mine is the best. Do we do it again? Design review, go to that one.	x	x		
s2	413	137	d1	d4	?	t4	2:35:21	2:36:13	0:00:52	Just a small hole. Can't edit the design review. I'll do that now		x		
s2	414	139	d4	d1	?	t4	2:39:20	2:39:28	0:00:08	Did you receive my email? Is that what you wanted?			x	
s3	101	201	d1	d2	13h32	t1	0:03:40	0:04:07	0:00:27	Send me email with customer requirements and I'll put the 3 of us together. Open CU-SeeMe		x	x	
s3	102	202	d1	d2	13h38	t1	0:09:55	0:10:27	0:00:32	Telephone numbers			x	
s3	103	301	d1	d3	13h39	t1	0:11:05	0:11:54	0:00:49	Telephone numbers, mail me your customer requirements, I'll put them together		x	x	
s3	104	302	d3	d1	13h45	t1	0:17:20	0:17:42	0:00:22	Correct	x			
s3	105	203	d1	d2	13h50	t1	0:21:41	0:22:35	0:00:54	What are you doing? CU-SeeMe, I don't see you			x	
s3	106	303	d1	d3	13h59	t1	0:29:02	0:29:16	0:00:14	Connect with CU-SeeMe to Groupmeeting			x	
s3	107	204	d1	d2	14h08	t1	0:37:26	0:38:05	0:00:39	Check the shared workspace for Excel sheet with CRs and ERs. Add it to the Excel sheet in the shared workspace, phone me when finished.		x	x	
s3	108	304	d1	d3	14h11	t1	0:40:20	0:41:10	0:00:50	What are you doing? Look at shared workspace for Excel file. Download when Marc is finished, Then we do functional analysis.		x	x	

Table B.1: Telephone Calls (10/18)

Session	CallID	CallID 2	From User	To User	RealTime	Tape #	TapeStart	TapeStop	Duration	Topics	Design-R.	Procedure-R.	Comm.-R.	Comments
s3	109	205	d2	d1	14h22	t1	0:50:39			call taken at other phone (copy room)	?			
s3	110	305	d1	d3	14h23	t1	0:52:49	0:53:14	0:00:25	Did you get my fax? If you make changes then fax it back. Check the Excel sheet on the shared workspace.			x	
s3	111	207	d2	d1	14h31	t1	1:01:21	1:02:10	0:00:49	Ok, generate concepts and then put them together. Then fax your final 2 concepts to me		x	x	
s3	112	307	d1	d3	14h34	t1	1:04:20	1:04:56	0:00:36	Got your fax. Generate concepts, sketch concepts then fax		x	x	
s3	113	308	d1	d3	14h44	t1	1:13:15	1:13:40	0:00:25	I made a QFD House of Quality and put it on the shared workspace. Let me know if you make changes		x	x	need to get informed about changes on documents on the shared workspace
s3	114	208	d1	d2	14h44	t1	1:13:48	1:14:33	0:00:45	Look at QFD Excel sheet, let me know if you make changes. Just your 2 final concepts.		x	x	
s3	115	309	d3	d1	14h48	t1	1:16:59	1:17:51	0:00:52	Ok	?			
s3	116	310	d3	d1	15h00	t1	1:31:15	1:31:52	0:00:37	Same problem, shouldn't be a problem	x			
s3	117	210	d2	d1	15h15	t1	1:44:29	1:46:06	0:01:37	Email - I'll check.			x	looks at sketch
s3	118	212	d1	d2	15h59	t1	2:29:34	2:29:54	0:00:20	Do you have concepts?		x		
s3	119	213	d1	d2	16h11	t1	2:39:46	2:40:13	0:00:27	What are you doing, I'm still waiting for Pieter's concepts.		x		
s3	120	313	d1	d3	16h12	t1	2:40:35	2:40:54	0:00:19	Ok	?			
s3	121	214	d2	d1	16h26	t1	2:51:39	2:51:56	0:00:17	Got yours, it's on its way		x		
s3	122	314	d3	d1	16h29	t1	2:58:28	2:59:40	0:01:12	I'm busy with it. I made a decision matrix, we decide on a datum. Download it from SW, fill it in, save it with your name, I will combine all		x	x	
s3	123	215	d2	d1	16h31	t1	3:00:58	3:01:56	0:00:58	Have you looked at Pieter's concept? I'll put the decision matrix on the SW, ... That should give us the best concept.		x	x	
s3	124	216	d2	d1	16h49	t1	3:19:07	3:19:45	0:00:38	Or electric motor, ok	x			
s3	201	101	d1	d2	13h35	t2	0:01:11	0:01:38	0:00:27	Requirements, give me 5min		x		
s3	202	102	d1	d2	13h41	t2	0:07:25	0:07:59	0:00:34	Telephone numbers, are you connected to CU-SeeMe, I'll connect now			x	
s3	203	105	d1	d2	13h53	t2	0:19:12	0:20:06	0:00:54	Are you discussing concepts, how to start CU-SeeMe, chat, I don't see you		x	x	
s3	204	107	d1	d2	14h09	t2	0:34:56	0:35:37	0:00:41	Write it up in Excel, Eng. Requirements, then give you 10min, Excel-sheet in shared workspace		x	x	
s3	205	109	d2	d1	14h22	t2	0:48:11	0:49:18	0:01:07	I copied it and saved it under the same filename. I put up some question marks at points where I have questions for the client. Waiting for fax.			x	
s3	206	306	d2	d3	14h30	t2	0:56:16	0:58:01	0:01:45	Just got the functional analysis from d1. What else can you add? Water, washing... There is not much to add. I'll phone d1.	x	x	x	

Table B.1: Telephone Calls (11/18)

Session	CallID	CallID 2	From User	To User	RealTime	Tape #	TapeStart	TapeStop	Duration	Topics	Design-R.	Procedure-R.	Comm.-R.	Comments
s3	207	111	d2	d1	14h33	t2	0:58:52	0:59:40	0:00:48	I don't know what else to add, can we go to the next step. Add concepts to each of these functions. Speed control, water, …	x	x		
s3	208	114	d1	d2	14h45	t2	1:11:17	1:12:00	0:00:43	Just got … I'll give you a call. Concepts I made...		x	x	
s3	209	311	d2	d3	15h11	t2	1:37:36	1:38:47	0:01:11	Got my email? Electric motor	x		x	
s3	210	117	d2	d1	15h16	t2	1:41:52	1:43:28	0:01:36	Got my email? What it basically says… Electric power, talk about concepts, choose the best for cleaning the glass, then come back and look into powering the thing. The one doesn't affect the other. Maybe organize a videoconference. Ill phone d3	x	x	x	
s3	211	312	d2	d3	15h18	t2	1:43:56	1:44:02	0:00:06	Go to CU-SeeMe			x	
s3	212	118	d1	d2	16h01	t2	2:17:39	2:17:59	0:00:20	Faxed it.			x	
s3	213	119	d1	d2	16h11	t2	2:27:50	2:28:16	0:00:26	I'm doing some more motor concepts. I don't know where he sent them. I'll call him.	x		x	
s3	214	121	d2	d1	16h23	t2	2:39:44	2:40:00	0:00:16	Where are the concepts? Are you looking at it? Did you get Pieter's?			x	
s3	215	123	d2	d1	16h32	t2	2:49:02	2:49:59	0:00:57	Which one, no I didn't look at this one. Want to talk about it now?	x			
s3	216	124	d2	d1	16h50	t2	3:07:09	3:07:46	0:00:37	The decision matrix, does it contain a pulley system? Both use electric systems	x	x		
s3	217	315	d2	d3	16h54	t2	3:10:58	3:11:04	0:00:06	Go to CU-SeeMe			x	
s3	301	103	d1	d3	13h43	t3	0:06:05	0:06:45	0:00:40	Telephone numbers			x	
s3	302	104	d3	d1	13h49	t3	0:12:21	0:12:42	0:00:21	Length?	x			
s3	303	106	d1	d3	14h01	t3	0:24:03	0:24:16	0:00:13	CU-SeeMe			x	
s3	304	108	d1	d3	14h12	t3	0:35:21	0:36:12	0:00:51	QFD, ok, ok		x		
s3	305	109	d1	d3	14h25	t3	0:47:50	0:48:15	0:00:25	Functional Analysis, ok, ok		x		
s3	306	206	d2	d3	14h30	t3	0:53:46	0:55:30	0:01:44	It's just what it does, speed control, water. We should only add to Corne's functional analysis, but it's very much complete	x	x		
s3	307	112	d1	d3	14h36	t3	0:59:20	0:59:58	0:00:38	Sketch concept		x		
s3	308	113	d1	d3	14h45	t3	1:08:16	1:08:42	0:00:26	QFD, ok		x		
s3	309	115	d3	d1	14h49	t3	1:12:01	1:12:52	0:00:51	I added to the QFD. 2m beams. Will continue with concepts	x	x		
s3	310	116	d3	d1	15h03	t3	1:26:18	1:26:53	0:00:35	Cloudy…cooling…	x			
s3	311	209	d2	d3	15h12	t3	1:35:15	1:36:25	0:01:10	Reply to it. JPG. Only the two main functions	x	x	x	
s3	312	211	d2	d3	15h18	t3	1:41:35	1:41:41	0:00:06	Ok	?			
s3	313	120	d1	d3	16h12	t3	2:35:30	2:35:50	0:00:20	I'm busy with my concepts, ok. I'll fax it to you		x	x	

Table B.1: Telephone Calls (12/18)

Session	CallID	CallID 2	From User	To User	RealTime	Tape #	TapeStart	TapeStop	Duration	Topics	Design-R.	Procedure-R.	Comm.-R.	Comments
s3	314	122	d3	d1	16h30	t3	2:53:24	2:54:37	0:01:13	Did you get my concept? How do we proceed, ok, Excel file on SW		x	x	
s3	315	217	d2	d3	16h55	t3	3:17:50	3:18:00	0:00:10	Ok			x	
s4	101	201	d1	d2	11h45	t1	1:17:06	1:17:21	0:00:15	Can you hear me?			x	Problems with the microphone and mouse
s4	102	202	d1	d2	13h25	t1	2:53:57	2:55:19	0:01:22	Time schedule, design something to move the trolley around, then short evaluation … shared workspace	x	x	x	
s4	103	203	d1	d2	14h12	t1	3:41:54	3:51:20	0:09:26	Read the word doc. I'll write, I'll have it open on my computer	x	x		D2 dictates for the final report
s4	201	101	d1	d2	11h48	t2	1:09:15	1:09:32	0:00:17	I switched off my microphone			x	
s4	202	102	d1	d2	13h25	t2	2:45:17	2:46:40	0:01:23	We can't do everything anyway, let me check email	x	x	x	
s4	203	103	d1	d2	14h13	t2	3:33:13	3:42:38	0:09:25	Lot of echoes. Seems pretty complete. Should I make a separate doc for concept 2?	x	x		
s5	101	301	d1	d3	14h22	t1	0:08:12	0:08:22	0:00:10	Log onto NetMeeting			x	
s5	102	201	d2	d1	14h30	t1	0:14:59	0:15:15	0:00:16	DiDeas		x		
s5	103	302	d3	d1	14h35	t1	0:21:37	0:21:56	0:00:19	Ok	?			
s5	104	202	d1	d2	14h37	t1	0:23:22	0:25:23	0:02:01	Jaco has finished his conceptual design. He is going to DiDeas to start with customer requirements. How far are you? Should each do his own CR or should we do it together? D3 is doing CRs, I'll look into ERs, you can look into both.		x		No idea of Ullman's specification development
s5	105	304	d3	d1	14h48	t1	0:36:02	0:36:30	0:00:28	NetMeeting or what, ok conference, I'll phone him			x	
s5	106	204	d1	d2	14h52	t1	0:39:43	0:40:02	0:00:19	Are you connected to CU-SeeMe, can you see me?			x	Problems to log in
s5	107	205	d1	d2	14h53	t1	0:40:46	0:41:17	0:00:31	Explains how to connect, Tell d3			x	
s5	108	206	d1	d2	15h16	t1	1:01:57	1:03:12	0:01:15	How far are you? We have basically chooses a water-cleaner, now we can select sub-things. We break it down, eg what concepts a sprinkler involves	x	x		
s5	109	305	d1	d3	15h17	t1	1:03:33	1:04:09	0:00:36	Just want to see how far you are. Great. Once you finished with QFD you can join us at the function concept structure		x		
s5	110	207	d1	d2	15h28	t1	1:11:52	1:12:11	0:00:19	I think we have enough for the function concept structure		x		
s5	111	306	d1	d3	15h30	t1	1:15:52	1:16:15	0:00:23	Just to see how far you are. I'll speak to d2, then we move on.		x	x	
s5	112	208	d1	d2	15h31	t1	1:16:45	1:17:00	0:00:15	We move on to the concept design selection		x		
s5	113	307	d1	d3	15h40	t1	1:25:10	1:25:48	0:00:38	We move on to the screening process. Ok		x		
s5	114	310	d3	d1	15h45	t1	1:31:10	1:33:34	0:02:24	Yes, good idea … I-beam … too long. Call d2 and tell him what we just discussed	x		x	
s5	115	312	d3	d1	15h56	t1	1:42:34	1:44:22	0:01:48	Screening, I think we keep Sprinkler1 and Sprinkler2. Now we go to criteria selection	x	x		

Table B.1: Telephone Calls (13/18)

Session	CallID	CallID 2	From User	To User	RealTime	Tape #	TapeStart	TapeStop	Duration	Topics	Design-R.	Procedure-R.	Comm.-R.	Comments
s5	116	212	d1	d2	16h06	t1	1:50:38	1:50:57	0:00:19	Enough criteria selection - 6. Phone Jaco to move to next section.		x	x	
s5	117	214	d2	d1	16h19	t1	2:03:13	2:04:10	0:00:57	1 final document, probably best if I do it, you send me info. Phone him and tell him what we discussed		x	x	
s5	118	315	d1	d3	16h26	t1	2:10:22	2:10:35	0:00:13	Everything OK. Tell Jaco.		x	x	
s5	201	102	d2	d1	14h30	t2	0:11:30	0:11:46	0:00:16	Are you logged onto the system?		x		
s5	202	104	d1	d2	14h39	t2	0:19:51	0:21:53	0:02:02	Concept design. Only had a look through the requirements. Better to do the requirements, then start with the design. Just uploaded some requirements. Maybe 1 goes into CR, 1 into ER, the check others. Refresh now and then.		x		
s5	203	303	d3	d2	14h51	t2	0:32:01	0:32:27	0:00:26	Ok			x	
s5	204	106	d1	d2	14h55	t2	0:36:12	0:36:34	0:00:22	I don't know			x	Problems to start CU-SeeMe video session
s5	205	107	d1	d2	14h56	t2	0:37:25	0:37:47	0:00:22	Can see Jaco now.			x	
s5	206	108	d1	d2	15h17	t2	0:58:25	0:59:42	0:01:17	Reading over it, not sure how to do the function-concept structure. How do we go on from here?		x		
s5	207	110	d1	d2	15h27	t2	1:08:24	1:08:40	0:00:16	Just want to finish, then we can carry on		x		
s5	208	112	d1	d2	15h32	t2	1:13:15	1:13:29	0:00:14	I'm finished now. OK, excellent		x		
s5	209	308	d3	d2	15h41	t2	1:22:23	1:22:43	0:00:20	Ok, great.				
s5	210	309	d3	d2	15h46	t2	1:26:50	1:27:30	0:00:40	Sprinkler … sketch … faxed, I'm #2	x		x	wrong user
s5	211	311	d3	d2	15h54	t2	1:35:22	1:38:56	0:03:34	2nd option, water, distilled water. The sprinkler I'm working on …no moving parts. Sprinkler#1 and Sprinkler#2, ok.	x			
s5	212	116	d1	d2	16h06	t2	1:47:07	1:47:27	0:00:20	1,2,6, ok, that's fine		x		
s5	213	313	d2	d3	16h06	t2	1:47:42	1:48:04	0:00:22	We are moving to next step.		x		
s5	214	117	d2	d1	16h18	t2	1:59:19	2:00:12	0:00:53	Got your short message, but it seems to be incomplete, something cut off. Perfect, or is it just slow?		x	x	
s5	215	314	d2	d3	16h20	t2	2:00:25	2:00:55	0:00:30	What are you doing? Computer problems. Final report		x	x	
s5	301	101	d1	d3	14h24	t3	0:02:26	0:02:36	0:00:10	Alright			x	opens NetMeeting
s5	302	103	d3	d1	14h37	t3	0:15:53	0:16:10	0:00:17	I have my concepts. I'll start with specification development, CR and ER, and then meet you there (DiDeas)		x		
s5	303	203	d3	d2	14h51	t3	0:29:46	0:30:10	0:00:24	Open CU-SeeMe … Concepts … ERs and CRs, see you on CU-SeeMe		x	x	
s5	304	105	d3	d1	14h52	t3	0:30:17	0:30:43	0:00:26	Let's go CU-SeeMe, then all of us can log in. Then have a look at each other's concepts		x	x	

Table B.1: Telephone Calls (14/18)

Session	CallID	CallID 2	From User	To User	RealTime	Tape #	TapeStart	TapeStop	Duration	Topics	Design-R.	Procedure-R.	Comm.-R.	Comments
s5	305	109	d1	d3	15h19	t3	0:57:47	0:58:22	0:00:35	QFD - it's a bit difficult to make the relations		x		
s5	306	111	d1	d3	15h31	t3	1:09:55	1:10:30	0:00:35	Finished QFD-House of Quality. I'm also looking what you guys did with the function concept structure. I think we only should do the last 2 types of cleaning…	x	x		
s5	307	113	d1	d3	15h41	t3	1:19:22	1:20:04	0:00:42	Had a crash. Best to fax me concepts, sketch what you have in mind. Better to visualize. I'll call him		x	x	
s5	308	209	d3	d2	15h42	t3	1:20:10	1:20:28	0:00:18	Fax me your concepts, to me and d1. Then I'll fax mine to you guys.		x	x	
s5	309	210	d3	d2	15h46	t3	1:24:35	1:25:15	0:00:40	Normal water…dcdcs3…fax	x		x	
s5	310	114	d3	d1	15h47	t3	1:25:25	1:27:48	0:02:23	Got your sketch…water comes in, brushes, good idea	x			
s5	311	211	d3	d2	15h55	t3	1:33:07	1:36:41	0:03:34	(discuss concept), sprinkler1, sprinkler2	x			
s5	312	115	d3	d1	15h59	t3	1:36:49	1:38:35	0:01:46	better to have sprinkler system than moving system, soapy water, names for concept designs, what's your idea	x	x		
s5	313	213	d2	d3	16h07	t3	1:45:25	1:45:50	0:00:25	criteria selection, decision matrix				
s5	314	215	d2	d3	16h20	t3	1:58:34	1:59:05	0:00:31	See you then…				
s5	315	118	d1	d3	16h26	t3	2:04:36	2:04:49	0:00:13	Ok		x	x	
s6	101	201	d1	d2	09h12	t1	0:06:20	0:06:37	0:00:17	Let's start with CU-SeeMe			x	
s6	102	301	d1	d3	09h12	t1	0:06:49	0:06:59	0:00:10	Please open CU-SeeMe			x	
s6	103	302	d1	d3	09h18	t1	0:12:47	0:13:34	0:00:47	Join us at the CU-SeeMe conference. Why don't we see you? Anything else for CRs (reads all CRs)?		x	x	
s6	104	303	d3	d1	09h20	t1	0:14:49	0:15:04	0:00:15	Excellent	?			
s6	105	305	d1	d3	09h25	t1	0:17:57	0:18:19	0:00:22	Engineering Specifications, brainstorm		x		
s6	106	203	d1	d2	09h26	t1	0:18:34	0:18:54	0:00:20	We finished CRs, did you send me mail?		x	x	
s6	107	204	d1	d2	09h30	t1	0:24:15	0:25:33	0:01:18	Where are your ERs, explains what it is. Same direction. Some ERs are only necessary for certain concepts (eg height of vehicle only if it moves under the cables). Email me.	x	x	x	
s6	108	306	d1	d3	09h31	t1	0:25:40	0:26:37	0:00:57	Do you have something for me? Where did you get this? Mail me lists of CRs and ERs.		x	x	
s6	109	307	d3	d1	09h34	t1	0:29:39	0:31:09	0:01:30	Did you email it to d2 as well? Do it please. I'm sitting here with 3 different versions. What are we doing with the QFD - Excel?		x	x	
s6	110	205	d1	d2	09h36	t1	0:31:42	0:31:52	0:00:10	You sent me a bad email.			x	
s6	111	308	d3	d1	09h42	t1	0:36:59	0:38:52	0:01:53	I'm drawing up a QFD. Basically 3 on each side (reads ERs and CRs). How does that sound? Go on with concepts. Call d2 and organize with him		x	x	

Table B.1: Telephone Calls (15/18)

Session	CallID	CallID 2	From User	To User	RealTime	Tape #	TapeStart	TapeStop	Duration	Topics	Design-R.	Procedure-R.	Comm.-R.	Comments
s6	112	310	d3	d1	10h06	t1	0:59:37	1:02:26	0:02:49	Received my concept? Let me explain...(explains concept) ... it's brilliant. Haven't received anything from you, would like to see your concepts. Then we break it down	x	x	x	
s6	113	207	d1	d2	10h08	t1	1:02:38	1:03:08	0:00:30	I want you to submit one concept. Then we break it down. How are you going to send it?		x	x	
s6	114	311	d1	d3	10h15	t1	1:09:38	1:10:05	0:00:27	Problems? Would like to start breaking concepts down. Break it down and give it to me		x		
s6	115	208	d1	d2	10h15	t1	1:10:13	1:14:22	0:04:09	Let's break your robot down, roller system, tracks, motion, method of washing, tank. Let's stay with this method., then we can combine with other concepts. Did you get my carwash concept (explains his concept)? Skip 1st concept. Take best of all 2 concepts.	x	x		
s6	116	312	d1	d3	10h23	t1	1:17:51	1:19:22	0:01:31	I see 2 pictures, but nothing else. How does it clean?	x			different methods/strategies, slight conflict about method, d1's method differs from Ullman
s6	117	313	d3	d1	10h43	t1	1:37:40	1:39:13	0:01:33	Got it. We now do the go/nogo screening, I already put something up in Excel. Then we do the Decision matrix for the 2 final concepts (explains criteria).		x	x	
s6	118	314	d1	d3	10h46	t1	1:41:10	1:41:24	0:00:14	Got your email twice			x	
s6	119	209	d1	d2	10h46	t1	1:41:36	1:42:47	0:01:11	Next steps: go/nogo screening, make 2 full concepts, evaluate them in the decision matrix. Think about criteria, give them to me, what is important for the evaluation		x	x	
s6	120	316	d3	d1	10h50	t1	1:46:43	1:50:34	0:03:51	We are going to pick the subconcepts ... (writes down and discusses solutions) ...	x	x		
s6	121	318	d1	d3	11h00	t1	1:55:50	1:56:00	0:00:10	We start with the go/nogo screening.		x		
s6	122	320	d1	d3	11h02	t1	1:59:33	1:59:58	0:00:25	Put on your headphones. Doesn't work? Chat?			x	
s6	123	321	d3	d1	11h13	t1	2:06:16	2:06:45	0:00:29	I don't like it, I have a veto right, haha. Ok	x			
s6	124	213	d1	d2	11h18	t1	2:12:18	2:13:48	0:01:30	You did break up. What did you say (discusses concept)? ... Ok, I'll speak to d3	x		x	
s6	125	322	d3	d1	11h20	t1	2:14:47	2:20:32	0:05:45	Can't you hear me? We want 2 concepts. ... Where do you get power? Some things are really absurd. Discussing concepts ... Ok, I'll speak to d2. Do you have some drafts?	x	x	x	
s6	126	323	d3	d1	11h35	t1	2:29:39	2:30:48	0:01:09	Like flexible rubber ... I've got 2 concepts, will send them by email, please send me your decision matrix	x	x	x	
s6	127	214	d1	d2	11h36	t1	2:30:58	2:31:55	0:00:57	Please send me your decision matrix. Give it a weight of 1,3or9, then give it a point of 1or0 and then multiply it. Then we evaluate the 2 concepts against it		x		no clue of Ullman
s6	128	218	d2	d1	11h50	t1	2:45:30	2:46:46	0:01:16	Explains concept because of bad voice connection in CU-SeeMe. We are using the decision matrix with the two concepts I compiled from all solutions	x	x		
s6	201	101	d1	d2	09h12	t2	0:06:43	0:07:03	0:00:20	Ok			x	
s6	202	304	d2	d3	09h21	t2	0:15:45	0:16:26	0:00:41	CU-SeeMe can't see you, ok. I'll send it			x	

Table B.1: Telephone Calls (16/18)

Session	CallID	CallID 2	From User	To User	RealTime	Tape #	TapeStart	TapeStop	Duration	Topics	Design-R.	Procedure-R.	Comm.-R.	Comments
s6	203	106	d1	d2	09h24	t2	0:18:58	0:19:22	0:00:24	I just send email with the CRs		x	x	
s6	204	107	d1	d2	09h30	t2	0:24:38	0:25:59	0:01:21	What exactly are the Engineering Requirements? … measurable… coming up		x	x	
s6	205	110	d1	d2	09h37	t2	0:32:07	0:32:17	0:00:10	Coming up.			x	
s6	206	309	d3	d2	09h45	t2	0:39:24	0:45:39	0:06:15	Is there a way that I can talk to you via CU-SeeMe, talk to the group? Are we now going into concepts and subconcepts? Sketchpad…Sprayer-system, little robot? Send sketches? #? Drawing #4, like this? Rail system, like a train. Type a concept	x	x	x	
s6	207	113	d1	d2	10h08	t2	1:03:00	1:03:33	0:00:33	Concepts? Yes, I'll send you an email and attachment.		x	x	
s6	208	115	d1	d2	10h16	t2	1:10:37	1:14:48	0:04:11	Like a caterpillar, drive train, squeegee, normal sprayer for the water and robot just for cleaning, let me check (the fax). The decision matrix? Ok I'll do that.	x	x		
s6	209	119	d1	d2	10h47	t2	1:41:59	1:43:10	0:01:11	What we should evaluate…		x		
s6	210	315	d2	d3	10h50	t2	1:44:47	1:46:32	0:01:45	Did you receive my email? Basically what it says is… (concept description) concerned about water to carry on a robot. It's just another concept, not the final	x		x	
s6	211	317	d3	d2	10h58	t2	1:52:51	1:55:26	0:02:35	I'm working on that… What do you think is important, amount of cleaning per day? … I'm just gonna talk to d1 (talks to d1 via CU-SeeMe)		x		
s6	212	319	d2	d3	11h02	t2	1:56:37	1:57:35	0:00:58	What did he say? Criteria		x		
s6	213	124	d1	d2	11h18	t2	2:12:34	2:13:47	0:01:13	Gets new tank with water at certain points … mailing	x			
s6	214	127	d1	d2	11h37	t2	2:30:52	2:31:53	0:01:01	Ok, as soon as possible. We still need the decision matrix at the end. How much does it count?		x		
s6	215	128	d2	d1	11h51	t2	2:45:30	2:46:45	0:01:15	2 concepts, spraying is clear, but for power we have a number of concepts, where we still have to decide … final concept, ok	x			
s6	301	102	d1	d3	09h13	t3	0:05:14	0:05:29	0:00:15	Yes			x	
s6	302	103	d1	d3	09h19	t3	0:11:13	0:12:03	0:00:50	…		x	x	
s6	303	104	d3	d1	09h21	t3	0:13:17	0:13:35	0:00:18	Problems with CU-SeeMe (no image)			x	
s6	304	202	d2	d3	09h22	t3	0:13:47	0:14:29	0:00:42	You should be able to see me now, number of glass plates	x		x	
s6	305	105	d1	d3	09h24	t3	0:16:23	0:16:48	0:00:25	…	?			
s6	306	108	d1	d3	09h32	t3	0:24:05	0:25:06	0:01:01	Cust.Req. are too defined. Eng. Requ. (what is the difference?) 2000000 glass plates		x		
s6	307	109	d3	d1	09h36	t3	0:28:04	0:29:38	0:01:34	You look cute, haha. Listen, … Maybe you should destroy ….	?			
s6	308	111	d3	d1	09h43	t3	0:35:27	0:37:20	0:01:53	Ullman, functions, subfunctions. Rather design 3 concepts and break them into subconcepts		x		

Table B.1: Telephone Calls (17/18)

Session	CallID	CallID 2	From User	To User	RealTime	Tape #	TapeStart	TapeStop	Duration	Topics	Design-R.	Procedure-R.	Comm.-R.	Comments
s6	309	206	d3	d2	09h45	t3	0:37:28	0:43:42	0:06:14	d1 is doing QFD, so we should go on with concepts. Either Ullman's way, or choosing a concept and break it down. Do you have the sketch in front of you? Let's sketch it … I-Beams, Glass panels, suspension cables, rubber thing that runs on it	x	x		
s6	310	112	d3	d1	10h06	t3	0:58:06	1:00:55	0:02:49	Maybe soap. Suggestion: each of us gives you one concept within the next 5min, I'll send mine as an attachment, then we break it down	x	x	x	
s6	311	311	d1	d3	10h16	t3	1:08:05	1:08:33	0:00:28	Start breaking down concepts.		x		
s6	312	116	d1	d3	10h24	t3	1:16:18	1:17:49	0:01:31	What's the concept, … different ways to move the system	x			
s6	313	117	d3	d1	10h44	t3	1:36:10	1:37:45	0:01:35	Are you going to put all 3 of our concepts into 1?		x		
s6	314	118	d1	d3	10h48	t3	1:39:37	1:39:53	0:00:16	Ok			x	
s6	315	210	d2	d3	10h51	t3	1:42:48	1:44:35	0:01:47	2000000 … Why don't we put all in one list and then do the screening?	x	x		
s6	316	120	d3	d1	10h53	t3	1:45:11	1:49:02	0:03:51	… if you put glass in … I-beams … performance … concept for water, concept for dirt removal, … break it up	x	x		
s6	317	211	d3	d2	10h59	t3	1:50:55	1:53:29	0:02:34	What are you doing at the moment?, Discusses criteria		x		
s6	318	121	d1	d3	11h02	t3	1:54:18	1:54:29	0:00:11	Send us all a copy of that document		x	x	
s6	319	212	d2	d3	11h03	t3	1:55:06	1:55:47	0:00:41	Time… Sent a copy of …step by step, lets discuss		x		
s6	320	122	d1	d3	11h06	t3	1:58:00	1:58:29	0:00:29	If it doesn't work… more yes than no			x	
s6	321	123	d3	d1	11h13	t3	2:04:45	2:05:14	0:00:29	Democratic society… finished	x			
s6	322	125	d3	d1	11h21	t3	2:13:18	2:19:01	0:05:43	You can't have that, 4 tanks maximum. What's the story of the electric guide rail, is that for power? Solarpower, controls. Wasting time now. Pre-programmed remote control, you can just pull it. That's just for the movement. Time is running out.	x	x		disagreement on strategy to follow for concept selection/evaluation addresses both team members (1 on phone, 1 on CU-SeeMe)
s6	323	126	d3	d1	11h36	t3	2:28:08	2:29:17	0:01:09	ok, I see. 2 concepts?				

Table B.1: Telephone Calls (18/18)

B.2.2 Desktop-Videoconferencing

Each desktop-videoconference was analysed regarding the following criteria:

- Session: case study session (the Distributed Design Assistant was used in sessions 1, 2 and 5)
- Users: users participating in the conference
- Initiator: user who initiated the conference
- RealTime: approximate time, identified on the clock at the workplace
- Tape #: tape number, also identifies designer (tape #1 = designer #1)
- TapeStart: start time of the conference, as displayed on the video recorder
- TapeStop: stop time of the conference, as displayed on the video recorder
- Duration: duration of the conference (Duration = TapeStop – TapeStart)
- Program: software used (C = CU-SeeMe, N = Microsoft NetMeeting)
- Design-R.: design-related conversation (x = yes)
- Procedure-R.: DiDeas or procedure-related conversation (x = yes)
- Comm.-R.: communication-related conversation (x = yes)
- Chat: chat used during the videoconference (x = yes)
- Voice: verbal communication used during the videoconference (x = yes)
- Whiteboard: shared whiteboard used (Microsoft NetMeeting only, x = yes)
- Gestures: gestures made during the videoconference (x = yes)
- Topics: topics of the conversation
- Comments: comments by the author / case study supervisor.

The results are shown in Table B.2.

Session	Users	Initiator	RealTime	Tape #	TapeStart	TapeStop	Duration	Program	Design-R.	Procedure-R.	Comm.-R.	Chat	Voice	Whiteboard	Gestures	Topics	Comments
s1	d1, d3, d2	d1	15h08	t1	0:58:52			C	x		x	x	x		wave, funny hand movement	how to select criteria (look at example case)	problems with usage (how to make connection) and static, long break where video is open but users do other things
s1	d1, d3, d2	d1	15h10	t2	0:59:24			C	x			x	x		hold paper into camera		
s1	d1, d3, d2	d1	15h09	t3	0:57:33	3:18:41	2:21:08	C	x		x	x	x		laughter, stupid sign	Where is Gill? Shouldn't we print each concept so that everybody has a copy in front of him? Concept discussion of faxed concept, I'll keep talking, write in chat if you want to interrupt.	
s2	d1, d3, d4, d2	d3	15h58	t1	1:49:16	3:10:00	1:20:44	C	x	x	x	x	x		Wave to fellow team members to draw attention	What is project status? ... Ok, continue with that. Who can hear me? Doing a sketch, but struggling with graphic tablet Boss here, can we go to criteria selection. Are you happy with the go/nogo screening - ok then go to the next step no more criteria? Then let's go to next level These 2 concepts are almost the same Funny results, all have different opinion. What do we do next? Do we discard 1 concept and start over, or... Look at the results, not very uniform, we all disagree on the results. We have a winner, we will go on with that. Who will write the report?	Problems with sound/volume/frozen image. Restarts CU-SeeMe
s2	d1, d3, d4, d2	d3	16h01	t2	1:40:11	2:41:36	1:01:25	C	x	x	x	x	x		Wave hello dance (sitting in chair)	Struggling with the graphic tablet I can see the criteria	joins video conference after returning often re-arranges video windows
s2	d1, d3, d4, d2	d3	15h57	t3	1:38:15	2:46:25	1:08:10	C	x	x	x	x	x			Can anybody hear me? What is the project status? I'm done with my selection Problems with CU-SeeMe? Restart it Are we doing the criteria in collaboration or each by himself? How many do we need? I think we have a winner, let's go with that.	
s2	d1, d3, d4, d2	d3	?	t4	1:38:37	2:45:00	1:06:23	C				x			wave		no sound
s3	d1, d2, d3	d1	13h57	t1	0:24:17	0:27:56	0:03:39	C				x	x		Thumbs-Up		

Table B.2: Desktop-Videoconferencing (1/4)

Session	Users	Initiator	RealTime	Tape #	TapeStart	TapeStop	Duration	Program	Design-R.	Procedure-R.	Comm.-R.	Chat	Voice	Whiteboard	Gestures	Topics	Comments
s3	d1, d2, d3	d1	13h58	t1	0:28:17	3:41:30	3:13:13	C	x	x	x	x	x			Send me your CRs. Bad voice, rather chat. Let's create concepts for moving and cleaning and choose the 2 best of each. Let's fax our concepts in 10 min and have another conference to discuss Did you read what we wrote on the chatline? Final results, Marc's concept is best (hahaha)	
s3	d1, d2, d3	d1	13h56	t2	0:21:54			C				x			wave hello, wave goodbye after chat session	use chat rather than voice	first only direct connection to d1, then new connection to Groupmeeting
s3	d1, d2, d3	d1	15h18	t2	1:34:48	3:28:00	1:53:12	C		x	x		x			Discuss strategy how to select best concept. Lets meet in 10min again.	
s3	d1, d2, d3	d1	14h01	t3	0:24:37			C				x					same session. Session always open (all logged in to groupmeeting) but only use it from time to time
s3	d1, d2, d3	d1	15h19	t3	1:42:38	1:45:00	0:02:22	C	x	x			x			refilling reservoir	Are we working in a group to develop concepts?
s3	d1, d2, d3	d1	16h55	t3	3:18:16	3:34:39	0:16:23	C				x	x				
s4	d1, d2	d2	10h30	t1	0:00:00	3:51:45	3:51:45	N	x	x	x		x	x	Holds paper into cam	Discussion of procedure, Customer Requirements, Specifications File upload to the shared workspace Let's start with 1 concept, break it down, and the move to another concept (explains functional analysis strategy), let's use the whiteboard Functional Analysis (concept on top, break down into functions) Updated files back to shared workspace, KS downloads to check Discuss different concepts, screening (expensive, stupid, ...) I'll draw something and send you a fax Discuss drawings and procedure How to scan and copy files from scanner, location of files Select concepts for final evaluation Discuss final report	Whole design task done using NetMeeting as primary communication media Talking while writing or sketching, almost like working co-located (just without direct contact)

Table B.2: Desktop-Videoconferencing (2/4)

Session	Users	Initiator	RealTime	Tape #	TapeStart	TapeStop	Duration	Program	Design-R.	Procedure-R.	Comm.-R.	Chat	Voice	Whiteboard	Gestures	Topics	Comments
s4	d1, d2	d2	10h39	t2	0:00:00	3:44:05	3:44:05	N	x	x	x		x	x	Hand movement to illustrate a curve Holds paper into cam		Didn't see file on shared workspace (has to refresh)
s5	d1, d2	d1	14h20	t1	0:05:30	0:07:07	0:01:37	N		x			x			next couple of minutes get some ideas down on paper	videoconference established by AS for demo and then kept open
s5	d1, d3	d1	14h23	t1	0:08:58			N		x			x			next 10min get some ideas down on paper, do some stuff for yourself … ok, then we work with DiDeas system	voice too low, some tests to set time
s5	d1, d3, d2	d3	14h57	t1	0:42:12			C				x	x				voice problems, rather use chat
s5	d1, d2	d1	14h21	t2	0:02:12			N					x				
s5	d1, d3, d2	d3	14h56	t2	0:36:58			C				x					
s5	d1, d3, d2	d3	15h54	t2	1:35:22	2:09:40	0:34:18	C				x					
s5	d1, d3	d1	14h25	t3	0:03:12	0:05:13	0:02:01	N					x			develop some concepts. Adjust the sound (explains how to). Lets meet in 10min time to swap concepts	
s5	d1, d3, d2	d3	14h58	t3	0:35:44	crash		C	x	x	x	x	x			I tell you my concept, then you can think about it and give feedback.	Had problems to log in (didn't press connect)
s5	d1, d3, d2	d3	16h21	t3	1:59:26	1:59:36	0:00:10	C									only checks for others
s6	d1, d2, d3	d1	09h14	t1	0:08:45	3:04:15	2:55:30	C	x	x			x		L-sign Thumbs-up d1 sees other user phone him quick thumbs-up after request by team mate (via CU-SeeMe voice) if email was received	Customer Requirements, yes did you get your list? What would you add? Let's move to ERs. What are Engineering Requirements again? Put CRs into measurable ERs. D1 instructs d2 and d3 to go on with concepts. I have faxed you one of my concepts. Let's start with the go/nogo screening. Reads concepts, ask others for comments on go or nogo. Reads subconcepts/solutions and gives his opinion, then asks for others opinions. Explains concepts discussed by phone with d3. We are going for … (lists solutions). What do you think? Problems with one concepts. d1 makes suggestion 1/0 for entry in decision matrix, asks others to comment	first 1-1 connection between d1-d2 only d1 puts vote for go/nogo into Excel. Has to verify every decision a couple of times. D3 has to phone d1, because voice in CU-SeeMe is too bad 1 user is bored (yeah, whatever) d1 fills in decision matrix, makes suggestion, others almost all the time just agree (no real individual evaluation)

Table B.2: Desktop-Videoconferencing (3/4)

Session	Users	Initiator	RealTime	Tape #	TapeStart	TapeStop	Duration	Program	Design-R.	Procedure-R.	Comm.-R.	Chat	Voice	Whiteboard	Gestures	Topics	Comments
s6	d1, d2, d3	d1	09h14	t2	0:09:16	3:04:00	2:54:44	C	x	x			x		Holds paper into camera during phone call moves camera to lower position, makes wave movement with hand turns cam to monitor to show video image on screen to others holds globe on Corne's table into camera (no special reason)	Cust. Requirements, Concept discussion, problems with other concepts (glass too thin)	
s6	d1, d2, d3	d1	09h15	t3	0:06:45	3:00:05	2:53:20	C	x	x			x		Holds water bottle into camera turns camera upside down (for fun) funny hand movement, moves cam to his mouth	Customer Requirements, concept discussion	puts 2 windows of other users in the middle of the screen during final discussion

Table B.2: Desktop-Videoconferencing (4/4)

B.2.3 Electronic Mail

Each e-mail was analysed regarding the following criteria:

- Session: case study session (the Distributed Design Assistant was used in sessions 1, 2 and 5)
- User: user who sent the e-mail
- Recipients: users who received the e-mail
- Time: time, when e-mail was sent
- Subject: subject of the e-mail
- Content: summary of the e-mail text
- Attachment: file names of attachments
- Comments: comments by the author / case study supervisor.

The results are shown in Table B.3.

Session	User	Recipients	Time	Subject	Content	Attachment	Comments
s1	-	-	-	-	-	-	no emails
s2	d4	d1	14h59	idea1	short concept description	Liu_idea1.JPG	
s2	d4	d2, d3	15h08	idea	I have an idea	Liu_idea1.JPG	
s2	d1	d2, d3, d4	15h23	More concepts	add more concepts to the functions		
s2	d4	d1	15h44	finish time manage	procedure question?		proposed ways to reply (phone or DiDeas SMS)
s2	d3	d1	15h54	Re: More concepts	lets cuseeme		
s2	d4	d1	16h58	report	concept description for report		
s2	d3	d1	17h00	-		Brush Mechanism.doc	detailed concept description incl. 2 e-pen sketches; comments on failed decision process
s2	d2	d1	17h02	Decision		Concept decision.doc	
s3	d3	d1	13h55	spesifikasie		klient behoeftes_spes.txt	client and product specifications
s3	d3	d2	14h06	customer req.	some misunderstanding	klient behoeftes_spes.txt	client and product specifications
s3	d2	d1, d3	15h10	-	idea to use concepts for more than one function	C1_base.JPG	e-pen sketch of car-wash system
s3	d3	d1, d2	16h25	konsep1	short description of concept	koncept1a_3.jpg; koncept1b_3.jpg	2 scans (sketches and text) of reservoir concept; dcdcs3/3, dcdcs3/6
s3	d3	d1	16h50	dm	decision matrix and concept ideas		some questions, some ideas
s4	d1	d2	12h49	Concept Screening	word file with concept selection on shared workspace		
s4	d1	d2	12h50	Testing	just a test		
s4	d2	d1	12h52	Re: Concept Screening	working on sketches with e-pen		
s4	d1	d2	13h02	Magnetic Car Concept	saved sketch 'Magnetic Car Concept.jpg' on shared workspace		
s4	d1	d2	13h23	Ideas for turning the trolley around	saved word doc 'Turning the trolley around.doc' on shared workspace		
s4	d1	d2	13h53	Concept 1	saved word doc 'concept 1.doc' on shared workspace		
s5	d2	d1	16h28	final hand-in	remember to print everything		
s6	d2	d1	09h26	-	customer requirements	no2 Customer REquirements.txt	
s6	d3	d1	09h36	Requirements	customer and engineering requirements		
s6	d2	d1	09h36	engineering rec	engineering requirements	No2 Engineering Requirements.txt	

Table B.3: Electronic Mail (1/2)

Session	User	Recipients	Time	Subject	Content	Attachment	Comments
s6	d2	d1	09h37	No2 engineering rec	engineering requirements		problems with wrong email address, re-forwarded
s6	d2	d1	09h40	engineering requirements	engineering requirements	No2 Engineering Requirements.txt	
s6	d2	d1	10h15	Concept from 2	concept sketch of rover	conceptno2.JPG	
s6	d3	d1, d2	10h22	Concept 3	short concept description and 2 scans of frames/rails	Main Concept 3.doc	
s6	d3	d1, d2	10h45	Conceptual breakdown of concept 3	functional analysis / solutions for movement, cleaning and turning around of a concept	Conceptual breakdown of concept 3.doc	
s6	d3	d1, d2	10h49	Breakdown	functional analysis / solutions for movement, cleaning and turning around of a concept	Conceptual breakdown of concept 3.doc	same as above
s6	d2	d3	10h50	Evaluation of concepts	3 concept descriptions with comments, suggestions, sketch of outside sprayer, sketch of squeegee car	Evaluation.jpg	same as Image2.jpg (scanner)
s6	d1	d2, d3	11h05	-	Functional breakdown + solutions with evaluations (+)	stop.xls	
s6	d2	d1	11h44	ConceptEVALsheetNO2	as requested, stop.xls filled in and added (criteria/weight for decision matrix)	No2 Concept Eval.xls	

Table B.3: Electronic Mail (2/2)

B.2.4 Fax Usage

Every usage of the fax was analysed regarding the following criteria:

- Session: case study session (the Distributed Design Assistant was used in sessions 1, 2 and 5)
- User: user who sent the fax
- Recipients: users who received the fax
- Time: time when the fax was sent
- Page: page that was faxed (p1/2 = scribble paper page #2 of designer #1)
- Content: content of the faxed page
- Comments: comments by the author / case study supervisor.

The results are shown in Table B.4.

Session	User	Recipients	Time	Page	Content	Comments
s1	d3	d1	14h45	Technical drawing #2	Question on glass row orientation	
s1	d3	d1	14h47	Technical drawing #3	Question on glass row orientation	
s1	d2	d1, d2	16h29	p3/2	Concept sketches	car-wash concept
s2	-	-	-	-	-	no faxes
s3	d1	d2, d3	14h24	p1/2	Functional Analysis	
s3	d3	d1	14h34	p1/2	added to functional analysis	
s3	d1	d2	14h38	p1/2	renamed final functional analysis	same as fax from d3 to d1
s3	d1	d2, d3	15h38	p1/5	2 sketches for trolley system	some annotations
s3	d1	d2, d3	15h38	p1/6	sketch of wiper + textual description	long text
s3	d2	d1, d3	15h45	p2/5	3 sketches for bucket/roller system + text	
s3	d2	d1, d3	15h45	p2/6	text + sketch for sprinkler/trolley system	
s3	d2	d1, d3	16h15	p2/7	3 motor concepts (text + 1 sketch)	sketch hard to identify
s4	d1	d2	11h39	p1/2	concept sketch + description	
s4	d2	d1	12h36	p2/1	detail sketch for trolley system	
s4	d1	d2	13h23	p1/5	sketch for trolley turn-around system	
s5	d1	d2, d3	15h45	p1/1	sketch of trolley with hose	fax almost not recognizable
s5	d2	d1, d3	15h48	p2/3	sketches of 2 sprinkler systems	
s6	d1	d2, d3	09h10	Design procedure list	design procedure for everybody	
s6	d1	d2, d3	09h55	p1/3	concept sketch of jet system for forward motion	sketch hard to identify
s6	d1	d2, d3	10h10	p1/4	sketch for car-wash system, some annotations	

Table B.4: Fax Usage

B.2.5 Scanner Usage

Every usage of the scanner was analysed regarding the following criteria:

- Session: case study session (the Distributed Design Assistant was used in sessions 1, 2 and 5)
- User: user who used the scanner
- Time: time when the scanner file was created
- Page: page that was scanned (p3/6 = scribble paper page #6 of designer #3)
- FileName: name and extension of the created file
- Content: content of the scanned page
- Comments: comments by the author / case study supervisor.

The results are shown in Table B.5.

Session	User	Time	Page	FileName	Content	Comments
s1	-	-	-	-	-	no scans
s2	-	-	-	-	-	no scans
s3	d3	15h50	p3/3	koncept1a_3.jpg	complete concept (1 sketch, descriptions of diff. sub-systems)	
s3	d3	16h20	p3/6	koncept1b_3.jpg	sketch of sub-system, description of concept	
s4	d2	12h55	p1/3	Magnetic Car Cancept.jpg	sketch of car with extendible arm (magnetic system)	'L. da Vinci'
s4	d1	13h21	p2/1	trolley system top view.jpg	sketch of concept detail	scanned only 1 sketch out of 2 on the page
s5	-	-	-	-	-	no scans
s6	d3	09h53	Technical drawing #3	DCDCS3_scan1.jpg	location of rails in drawing	
s6	d3	09h56	Technical drawing #2	DCDCS3_scan2.jpg	location of washing unit in drawing	
s6	d2	10h40	p2/2	Image2.jpg	3 concept descriptions with comments, suggestions, sketch of outside sprayer, sketch of squeegee car	

Table B.5: Scanner Usage

B.2.6 Graphic Tablet Usage

All usage of the graphic tablets was analysed regarding the following criteria:

- Session: case study session (the Distributed Design Assistant was used in sessions 1, 2 and 5)
- User: user who created a file using a graphic tablet
- Time: time when the scanner file was created
- FileName: name and extension of the created file
- Content: content of the created file
- Comments: comments by the author / case study supervisor.

The results are shown in Table B.6.

Session	User	Time	FileName	Content	Comments
s1	d2	15h09	winwiper 1a.JPG	motor-wiper-system	
s1	d2	15h44	rack&pinion.JPG	rack-pinion-motor-battery-system	colors, comp-annotations
s1	d2	16h02	hydraulic scraper.JPG	hydraulic cylinders and wiper	
s1	d2	17h12	andrew final.JPG	pneumatic cylinder and wiper	colors, hand-annotations
s1	d3	17h53	Untitled-1.RIF		just a test
s2	d3	14h26	wheel consept.JPG	wheels in the I-beam	
s2	d4	14h56	Liu_idea1.JPG	water, wind and pipes	b/w, comp-annotations
s2	d3	15h02	side_view.JPG	lawn-mower concept	color, hand-annotations, first saved as .RIF
s2	d4	15h15	Liu_idea2.JPG	spring-loaded rollers	color, comp-annotations, complex with detail sketch
s2	d3		3d-brush.jpg	pre-sketch for 3d-brush_2.JPG	
s2	d3	15h17	3d-brush_2.JPG	brushes, motor, gears, wheels	color, hand-annotations
s2	d3	15h38	direction_switch.JPG	electric switch	color, hand-annotations
s2	d2	?	film.jpg	film that rolls on glass when dirty	b/w, hand-annotations
s3	d2	?	mark_concept1.JPG	remote controlled car-wash roller	b/w, hand-annotations
s4	d2	14h24	test drawing concept 1.jpg	sketch	pre-sketch for trolley system top view.jpg?
s5	d1	14h37	Ian1.jpg	3 lines, concept description of sprinkler running in I-beams by water pressure	
s5	d2	15h08	Image1.psp		just a test
s6	d2	10h12	conceptno2.JPG	sketch of rover concept	b/w, hand-annotations

Table B.6: Graphic Tablet Usage

B.2.7 Shared Workspace (FTP) Usage

All files uploaded to the shared workspace via the File Transfer Protocol were analysed regarding the following criteria:

- Session: case study session (the Distributed Design Assistant was used in sessions 1, 2 and 5)
- User: user who uploaded the file
- Time: time when the file was uploaded ('?' indicates a missing log-file)
- FileName: file name and file extension of the uploaded file
- Content: content of the uploaded file
- Comments: comments by the author / case study supervisor.

The results are shown in Table B.7.

Session	User	Time	FileName	Content	Comments
s1	-	-	-	-	no ftp
s2	-	-	-	-	no ftp
s3	d1	?	QFD.xls	hoq templare	just crs and ers
s3	?	?	QFD_weights.xls	hoq with filled matrix	
s3	d2	?	QFD_weights_1.xls	hoq with filled matrix	added values in red
s3	d1	?	QFD_FINAL.xls	final hoq	
s3	d1	?	Desicion Matrix.xls	decision matrix template	
s3	d3	?	Desicion Matrix3.xls	decision matrix d3	
s4	d2	10h48	specs.txt	9 CRs	multiple uploads
s4	d1	?	Magnetic Car Cancept.jpg	sketch of car with extendible arm (magnetic system)	p1/3
s4	d1	?	Turnign the trolley around.doc	2 ideas to turn trolley	spelling mistake
s4	d2	13h32	trolley system top view.jpg	sketch of concept detail	p2/1
s4	d1	?	Concept 1.doc	final description of 2 concepts	
s4	d1	?	Concept screening.doc	list of concepts, short descriptions	
s5	-	-	-	-	no ftp
s6	-	-	-	-	no ftp

Table B.7: Shared Workspace (FTP) Usage

B.3 Distributed Design Assistant Data

In this section the results from the analysis of the DiDeas database is presented.

B.3.1 Customer Requirements

Each customer requirement entry was analysed regarding the following criteria:

- Session: case study session
- S-Heading: number of standard customer requirement headings
- U-Headings: number of user-defined customer requirement headings
- Requirements: number of customer requirements
- Deletes: number of customer requirements marked 'delete'
- Comments: comments by the author and / or case study supervisor.

The results are shown in Table B.8.

Session	S-Headings	U-Headings	Requirements	Deletes	Comments
s1	3	0	10	2	1 CR under wrong heading, 1 heading was more a CR
s2	3	2	9	0	
s5	6	0	7	0	

Table B.8: DiDeas Customer Requirements

B.3.2 Engineering Requirements

Each engineering requirement entry was analysed regarding the following criteria:

- Session: case study session
- S-Heading: number of standard engineering requirement headings
- U-Headings: number of user-defined engineering requirement headings
- Requirements: number of engineering requirements
- Deletes: number of engineering requirements marked 'delete'
- Comments: comments by the author and / or case study supervisor.

The results are shown in Table B.9.

Session	S-Headings	U-Headings	Requirements	Deletes	Comments
s1	7	0	6	0	3 empty headings
s2	4	1	8	0	
s5	8	0	9	0	2 empty headings

Table B.9: DiDeas Engineering Requirements

B.3.3 QFD – 'House of Quality'

Each 'House of Quality' entry was analysed regarding the following criteria:

- Session: case study session
- Relations: number of relations made between customer and engineering requirements out of number of possible relations
- Comments: comments by the author and / or case study supervisor.

The results are shown in Table B.10.

Session	Relations	Comments
s1	16/60	deleted CR not related, otherwise complete QFD
s2	13/72	complete QFD
s5	12/63	complete QFD

Table B.10: QFD – 'House of Quality'

B.3.4 Function-Concept Structure

Each function-concept structure entry was analysed regarding the following criteria:

- Session: case study session
- Overall Function: entered overall function
- Concepts 1: number of alternative concepts for the overall function
- Functions 1: number of functions to determine 'Concepts 1'
- Concepts 2: number of alternative concepts for 'Functions 1'
- Deletes: number of functions and concepts marked 'delete'
- Uploads: number of files uploaded to the function-concept structure
- Comments: comments by the author and / or case study supervisor.

The results are shown in Table B.11.

Session	Overall Function	Concepts 1	Functions 1	Concepts 2	Deletes	Uploads	Comments
s1	clean glass plates	7	6	17	2	2	some single concepts and functions
s2	Clean top surface of Solar Chimney collector	5	9	12	1	7	some single concepts and functions
s5	Clean glass	2	5	11	1	0	each function at least 2 concepts, no singles

Table B.11: Function-Concept Structure

B.3.5 Concept Designs

Each generated concept design was analysed regarding the following criteria:

- Session: case study session
- Concept Designs: number of concept designs generated
- Go: number of concept designs with status 'Go' for the concept design screening
- No-Go: number of concept designs with status 'No-Go' for the concept design screening
- Unsure: number of concept designs with status 'Unsure' for the concept design screening
- Comments: comments by the author and / or case study supervisor.

The results are shown in Table B.12.

Session	Concept Designs	Go	No-Go	Unsure	Comments
s1	13	4	2	7	
s2	7	4	3	0	
s5	6	2	2	2	

Table B.12: Concept Designs

B.3.6 Concept Evaluation

Each concept evaluation procedure was analysed regarding the following criteria:

- Session: case study session
- Comments: comments by the author and / or case study supervisor.

The results are shown in Table B.13.

Session	Criteria	Comments
s1	9	all 3 users selected same datum, but got different winner through decision matrix
s2	8	different datums, nobody's datum became personal winner, 1 user responsible for overall winner
s5	7	only 1 user's datum became overall winner (1pt difference), others got non-datum as winner due to decision matrix

Table B.13: Concept Evaluation

B.3.7 DiDeas Short Messages

Each DiDeas Short Message was analysed regarding the following criteria:

- Session: case study session
- User: user who sent the short message
- Recipients: users who received the short message
- Time: time when the short message was sent
- Content: content of the short message
- Comments: comments by the author and / or case study supervisor.

The results are shown in Table B.14.

Session	User	Recipients	Time	Content	Comments
s1	-	-	-	-	no sms
s2	-	-	-	-	no sms
s5	d2	d1, d3	16h12	Should each of us write a review	
s5	d1	d2, d3	16h15	Ok	
s5	d1	d2, d3	16h16	it is probably best if I do it as Andreas only wan	message field was too short to hold complete message

Table B.14: DiDeas Short Messages

B.3.8 DiDeas Message Board

Each message board entry was analysed regarding the following criteria:

- Session: case study session
- User: user who wrote the message
- Recipients: users who received the short message
- Time: time when the short message was sent
- Importance: importance selected for the message
- Content: content of the message
- Comments: comments by the author and / or case study supervisor.

The results are shown in Table B.15.

Session	User	Recipients	Time	Importance	Content	Comments
s1	d2	d1, d3	16h22	high	going to toilet	
s2	-	-	-	-	-	no messages
s5	-	-	-	-	-	no messages

Table B.15: DiDeas Message Board

B.4 Questionnaires

Each participant was requested to fill in a questionnaire directly after the case study. Three different types of questions were used:

- Yes/No questions: the students had to tick off the 'yes'-option or the 'no'-option
- ABC questions: the student had to tick off one or more letters corresponding to items in a list of options, e.g. for different software used during the case study
- Text questions: the student was asked to write a few sentences, e.g. describing how the team collected the customer requirements

The first two types of questions could additionally be answered with a few words.

The questionnaires and the results are listed in the following sections.

B.4.1 Questionnaire for Designers using the DiDeas System

Design Methodology

1) Did your team compile customer requirements? yes no

1a) If yes, was the number of importance categories (Must, Major Wish, Minor Wish) sufficient? yes no

2) Did your team develop engineering requirements? yes no

3) Did your team develop a House of Quality? yes no

3a) If yes, how useful did you personally find it?

3b) If yes, how could the House of Quality be better presented (monitor, printer, save as, etc)?

4) Is the function-concept structure intuitive? yes no

5) Which other structure for the functional analysis/concept generation is possible?

6) Which structure do you prefer?

7) How did you personally develop different concepts?

8) Did you develop concepts together as a team? yes no

8a) If yes, how did your team develop concepts together?

9) Did you personally upload concepts? yes no

10) Did you personally download any concepts created by other team members? yes no

11) Did the decision matrix help to find the best concept design? yes no

11a) Which other evaluation methods could be used (indicate you preference)?

12) How did your team create the final project documentation?

Communication and Information Transfer

13) Did you personally use the telephone? yes no

14) Did you personally use the fax? yes no

15) Did you personally use e-mail? yes no

15a) If yes, did you send attachments? yes no

16) Did you personally use desktop videoconferencing? yes no

16a) If yes, did you make use of a) video, b) audio, c) chat, d) shared whiteboard? a b c d

17) Did you personally use the shared workspace (WS_FTP)? yes no

17a) If yes, did you create your own folder? yes no

18) Did you personally use the DiDeas shared workspace? yes no

19) Did you personally use a specific file name convention for your electronic files? yes no

19a) If yes, which system did you use and did the whole team use it?

20) Did you use the DiDeas personal notes? yes no

21) Did you personally experience problems with duplicate filenames? yes no

22) Did you personally use the printer? yes no

22a) If yes, what for?

Input Devices for Conceptual Design

23) Did you personally use the graphic tablet? yes no

23a) If yes, do you think it is useful, why or why not?

23b) If yes, do you prefer pen/paper sketches or electronic sketches, and why?

24) Did you personally use the scanner? yes no

25) Did you personally use the WebCam to transmit images of artefacts (sketches, objects, etc.)? yes no

26) What other input devices could be useful?

DiDeas System

27) What Does "DiDeas" stand for?

28) Did you personally use the help file? yes no

29) Did you experience problems with the system? yes no

29a) If yes, please describe the problems.

Environment

30) Did you have problems with the basic computer functions (operating system, copy/paste, etc.)? yes no

Options for questions 31-33): a) Internet Explorer b) Netscape, c) Pegasus Mail, d) CU-SeeMe, e) NetMeeting, f) Windows Explorer, g) WS_FTP, h) Painter Classic, i) PaintShop Pro, j) ACDSee, k) MS Word, l) NotePad

31) Which of the above programs did you personally use? a b c d e f g h i j k l

32) Which of the above programs did you personally use before? a b c d e f g h i j k l

33) Would you have preferred a longer software introduction? yes no

33a) If yes, for which of the above programs? a b c d e f g h i j k l

34) Did you miss any other software and/or hardware? yes no

34a) If yes, which software and/or hardware did you miss?

35) Did you find the size of the monitor sufficient (in terms of amount of information displayed)? yes no

36) Did you miss anything at your workplace (what and why)?

37) Did you find the task (Solar Chimney Sweeper) too demanding? yes no

38) Comments on the case study, necessary improvements, etc.:

Miscellaneous

39) Which of the following program(s) did you use to view images? a) Internet Explorer, b) Netscape, c) Painter Classic, d) PaintShop Pro, e) ACDSee

40) Do you think knowledge of Ullman's design procedure was helpful? yes no

41) Did you switch between the example task and the design task? yes no

41a) If yes, was the example task sufficient? yes no

B.4.2 Questionnaire Results for Designers using the DiDeas System

The questionnaire results for designers using the DiDeas system are listed in Table B.16.

Question	Yes	No	Answer / Comments
1	10	0	
1a	7	2	
2	10	0	
3	10	0	
3a	-	-	- Quite useful, however, our inexperience got us a bit muddled. - Gave me an idea of what was going on. - I like the idea of a house of quality, but I do not think that the form it is in works. - Visually compare. - Very useful, to give a better understanding of the problem. - This was not my department. - Wasn't quite involved with that part of the project. - Not highly effective, I probably need more training.
3b	-	-	- Perhaps if it could be printed, or somehow displayed in it's entirety. - Full screen application. - Printer. - The monitor was a bit small, so it is difficult to work with a big House of Quality and get a good oversight. - Fill in the numbers directly on the screen and update once only. - It would be helpful if the lines always line up, e.g. (sketch) and not only at certain window settings.
4	10	0	
5	-	-	- The one in Ullman, where no concepts are generated before function development is complete. - Ullman. - Maybe the structure could just be expandable/collapsible to facilitate easier viewing. With lots of concepts the screen gets a bit full. - Tree view.
6	-	-	- This one is fine. - DiDeas. - This one: it is sometimes difficult to separate concepts and functions. - List. - I found the function-concept one very good.
7	-	-	- Started with an idea and identified what systems/sub-systems was needed and developed them. - Concepts came as system progressed. - From experience. - Look at the basic functions, then find the simplest solution for that function. Next these ideas are combined. - On paper first, and then used telephones to swap concepts. - I considered the design requirements as well as the limitations. - Just by keeping the ideas as simple as possible. - Think idea, think hardware, link to criteria, evaluate
8	5	5	- to an extend.
8a	-	-	- We used bits and pieces of each-others ideas. - Telephone communications and faxes. - Telephonically mainly as well as fax and chat. - By discussing basic advantages / disadvantages via netmeeting and phone.
9	8	2	
10	7	2	
11	6	4	- We messed up. - We did not have correct criterium.

Table B.16: Questionnaire Results for Designers using the DiDeas System (1/3)

Question	Yes	No	Answer / Comments
11a	-	-	- I don't think it is a matter of finding another method. I believe that your matrix failed due to a lack of good criteria. - Graphic methods.
12	-	-	- Leader made writeup, others □mended. - Project-Manager completed the original and the other members edited. - We talked about it and wrote a report. - All info was sent to the project manager and he typed it up. - Written by each person, organized by the team leader. - Each member compiled a short paragraph about his own developed concepts. These were then mailed to the team manager, who then compiled the final report. - Project manager wrote it. - We all had the same ideas, so the team leader was left to put them to paper. - The team leader finalised the final documentation. - All typed brief summary of own concept. Project leader typed combined report.
13	10	0	
14	3	7	
15	6	4	
15a	3	3	
16	10	0	
16a	-	-	a: 9, b: 7, c: 10, d: 1
17	1	9	
17a	0	1	
18	7	3	
19	1	9	
19a	-	-	- It was similar to the basic method of operation (descriptive).
20	1	8	
21	0	9	- I didn't experience any problems, but had to rename a file to be able to upload it. I wanted to replace it with a newer version.
22	5	5	
22a	-	-	- Hard-copies of functional decomposition, engineering requirements, customer requirements. - To print documents. - To print the final report. - To print the design review.
23	8	2	
23a	-	-	- Very useful; almost like sketching with pencil & paper. - Absolutely. Drawing becomes much easier/possible. I think this is the reason I did not use the fax. - Easy to draw and change. - Very useful, just takes a while to get used to. - Very useful for drawings and to exchange concepts. - Yes, but took a little to get used to. - Yes, can be very useful, but I'm not used to it yet. - Useful, but I need practice!
23b	-	-	- I like pen/paper sketches (personal preference). - Pen/paper. Although the tablet works extremely well it is not at the stage of replacing pen and paper. Maybe because I am used to pen and paper. - Pen/paper for complex one, e-sketches for simple. - Paper sketches are difficult / tedious to scan. - Pen/paper personally, much quicker. - Prefer pen/paper. - Pen/paper faster to generate, but given practise both equal.
24	0	9	
25	1	9	- Resolution a bit small for that.

Table B.16: Questionnaire Results for Designers using the DiDeas System (2/3)

Question	Yes	No	Answer / Comments
26	-	-	- Digital Cam. - Digital camera.
27	-	-	- Design-something-or other. - Don't know. - D... Design Assistant. - Distribute Design Assistant. - Distributed Design Assistant. - Distributed Design Assistance. - Direct Design Assistant or Direct Design Assistant. - D... Design Assistant. - Distributed Design Assistant.
28	0	10	
29	5	5	
29a	-	-	- With a slow network sometimes (yes). - The network stalled at times, making progress impossible. - It was difficult to edit the system. - Occasionally it took a while to read and bring up the next page. - It seemed to have shortened a message sent to me via short message service. - Network down!
30	0	10	
31	-	-	a: 6, b: 1, c: 6, d: 9, e: 5, f: 6, g: 1, h: 5, i: 5, j: 4, k: 4, l: 4
32	-	-	a: 8, b: 7, c: 9, d: 1, e: 1, f: 9, g: 2, h: 0, i: 5, j: 6, k: 9, l: 9
33	4	6	
33a	-	-	a: 0, b: 0, c: 1, d: 1, e: 1, f: 0, g: 2, h: 1, i: 0, j: 1, k: 0, l: 0 - No ones specifically, just like some more experience.
34	4	6	
34a	-	-	- Popup. - Outlook / Outlook express. - AutoCad. - AutoCad.
35	9	2	- At least 17" or more preferred.
36	2	7	- A bigger desk. My desk got very cluttered with all the hardware and papers used in the exercise. - A radio!
37	2	8	- For the time allowed.
38	-	-	- It was a lot of fun, and DiDeas definitely works well. However, people with more experience would be able to make better use than us. - Should have made the whole study a full day event in order to give more time to explore both the problem and the software. Thought the study very interesting. - Good experience. The video conferencing gave us trouble. - That's quite fine. - Very good and quick way to do Ullman's design procedure. - I found the program easy to follow and quick to learn. In the beginning it seemed daunting, but as soon as I got underway, it became simple and logical. - Very interesting though not technical enough. - Maybe would be good to try and do it, say over 5 days. Still 1 team, but they work when they have time, and arrange set meetings etc.
39	-	-	a: 6, b: 0, c: 1, d: 1, e: 3 - Would have used ACDSee if I had downloaded any images.
40	8	1	- Yes, would have been lost without background. - I do not have any knowledge of Ullman.
41	5	5	
41a	5	0	

Table B.16: Questionnaire Results for Designers using the DiDeas System (3/3)

B.4.3 Questionnaire for Designers not using the DiDeas System

Design Methodology

1) Did your team compile customer requirements? yes no

1a) If yes, how did you compile customer requirements?

2) Did your team develop engineering requirements? yes no

3) Did your team develop a House of Quality? yes no

3a) If yes, how useful did you personally find it?

4) Did your team do a functional analysis? yes no

4a) If yes, how did you do the functional analysis?

5) How did you personally develop different concepts?

6) Did you develop concepts together as a team? yes no

7) How did your team evaluate the concepts?

8) How did your team settle on the best concept?

9) How did your team create the final project documentation?

Communication and Information Transfer

10) Did you personally use the telephone? yes no

11) Did you personally use the fax? yes no

12) Did you personally use e-mail? yes no

12a) If yes, did you send attachments? yes no

13) Did you personally use desktop videoconferencing? yes no

13a) If yes, did you make use of a) video, b) audio, c) chat, d) shared whiteboard? a b c d

14) Did you personally use the shared workspace? yes no

14a) If yes, did you create your own folder? yes no

15) Did you personally use a specific file name convention for your electronic files? yes no

15a) If yes, which system did you use and did the whole team use it?

16) Did you personally experience problems with duplicate filenames? yes no

17) Did you personally use the printer? yes no

17a) If yes, what for?

Input Devices for Conceptual Design

18) Did you personally use the graphic tablet? yes no

18a) If yes, do you think it is useful, why or why not?

18b) If yes, do you prefer pen/paper sketches or electronic sketches, and why?

19) Did you personally use the scanner? yes no

20) Did you personally use the WebCam to transmit images of artefacts (sketches, objects, etc.)? yes no

21) What other input devices could be useful?

Environment

22) Did you have problems with the basic computer functions (operating system, copy/paste)? yes no

Options for questions 23-25): a) Netscape, b) Pegasus Mail, c) CU-SeeMe, d) NetMeeting, e) Windows Explorer, f) WS_FTP, g) Painter Classic, h) PaintShop Pro, i) ACDSee, j) MS Word, k) NotePad, l) MS Excel

23) Which of the following programs did you personally use? a b c d e f g h i j k l

24) Which of the above programs did you personally use before? a b c d e f g h i j k l

25) Would you have preferred a longer software introduction? yes no

25a) If yes, for which of the above programs? a b c d e f g h i j k l

26) Did you miss any other software and/or hardware? yes no

26a) If yes, which software and/or hardware did you miss?

27) Did you find the size of the monitor sufficient (in terms of amount of information displayed)? yes no

28) Did you miss anything at your workplace (what and why)?

29) Did you find the task (Solar Chimney Sweeper) too demanding? yes no

30) Comments on the case study, necessary improvements, etc.:

Miscellaneous

31) Which of the following program(s) did you use to view images? a) Internet Explorer, b) Netscape, c) Painter Classic, d) PaintShop Pro, e) ACDSee

32) Do you think knowledge of Ullman's design procedure was helpful? yes no

B.4.4 Questionnaire Results for Designers not using the DiDeas System

The questionnaire results for designers not using the DiDeas system are listed in Table B.17.

Question	Yes	No	Answer / Comments
1	8	0	
1a	-	-	- Video conferencing, shared workspace. - E-mail, shared workspace. - Shared workspace, video conf. - Wrote a few things in notepad during a netmeeting session. - We wrote the requirements out in a list format. - Each member compiled into one list. - Team members input compiled into one list. - Each member made up a list and then compiled all lists.
2	6	2	
3	6	2	
3a	-	-	- Not very useful. - I don't think these things are very useful. - Not much. - Not much. - Did not use it.
4	6	2	
4a	-	-	- Fax, edited faxed back. - Leader created it, faxed it, and we added to it. - Fax - edit/added - fax back. - Sketches in Netmeeting session. - We thought of one concept and determined the subfunctions from that. - Yes, only verbally.
5	-	-	- Compiled according to functional blocks and joined most appropriate concepts into one. - Notes then sketches. - From functional analysis. - Yes, paper sketches from functional Analysis. - I thought of 3 different things to clean glass and then thought of concepts relating to each. - Own ideas, whole mechanism refining subsystems. - What can move between cables on huge surface. Looked at street washer, floorwasher, carwashes. - Creative thought, and discussion with other members.
6	5	3	
7	-	-	- Decision matrix. - Via a decision matrix. - Decision matrix (each on his own). - Vote during netmeeting / telephone. - We talked using videoconferencing about pros/cons of our ideas and used a whiteboard to assist us. - Go/NoGo Screening. - Concept Matrix. - Go-nogo screening and decision matrix.
8	-	-	- Discussion per videoconference. - Via decision matrix. - Decision matrix - via video conf. - Yes. - Comparison of pros/cons. - Decision Matrix. - Best concept for each subfunction: Movement and Washing. - Decision matrix results.

Table B.17: Questionnaire Results for Designers not using the DiDeas System (1/3)

Question	Yes	No	Answer / Comments
9	-	-	- Team manager. - Ask the leader. - Team manager. - MS Word – telephone discussion. - Created a word document and then discussed it by telephone. - Word. - The team leader compiled it.
10	8	0	
11	6	2	
12	7	1	
12a	5	2	
13	8	0	
13a	-	-	a: 7, b: 7, c: 3, d: 1
14	5	3	- Don't know how. Will use if know how to use.
14a	1	4	
15	3	4	
15a	-	-	- One name combined with member-number. - Included 'No2' from DCDCS2 in all files in own directory. All graphics in JPG format, because files are small, many programs can open JPG. - DCDCS3_Scan1.jpg / No.
16	0	8	
17	3	5	- Oops, what printer?
17a	-	-	- Printing of a scanner file. - Print images/notes to view, instead of on the computer. - Printing functional analysis developed in shared whiteboard. - Printing summary.
18	6	2	- tried to.
18a	-	-	- Yes, for sketching purposes, invaluable. - Yes, as soon as used to it. Quickly, accurate. - Yes, but it will take a while to get used to. - I need more practice to make it useful. - Yes, but not used to it. Can see it's value. - Difficult to get used to so quickly.
18b	-	-	- No, easier to sketch on paper. - Paper+Pencil, more used to. - Paper is best, it is what I am used to. - I prefer pen/paper at present, because I am more comfortable with them. - Paper sketch is faster with more detail. - At moment pen and paper. If used to shared workspace will be faster. - Pen/paper – quicker.
19	5	3	
20	2	6	
21	-	-	- Simultaneous conferencing over phone. - Maybe digital camera.
22	0	8	
23	-	-	a: 3, b: 8, c: 6, d: 3, e: 7, f: 5, g: 3, h: 7, I: 4, j: 8, k: 4, l: 6
24	-	-	a: 7, b: 8, c: 4, d: 2, e: 7, f: 4, g: 2, h: 6, I: 5, j: 8, k: 8, l: 8
25	1	7	
25a	-	-	- Shared workspace.
26	2	6	

Table B.17: Questionnaire Results for Designers not using the DiDeas System (2/3)

Question	Yes	No	Answer / Comments
26a	-	-	- Calculator. - Calculator.
27	7	1	- Two monitors would be better. - Would sacrifice video for better audio.
28	2	4	- Printer. - Hand calculator. - Eraser was provided. - Nothing, except milk for my coffee! - Videocamera for handdrawing. - An attractive secretary.
29	0	8	
30	-	-	- It was fun - thanks for introducing me to the technology! - Better voice communication would be helpful. The time allocated is actually a bit short, but it would be hard to find people prepared to spend the necessary time.
31	-	-	a: 0, b: 0, c: 1, d: 4, e: 3
32	6	0	

Table B.17: Questionnaire Results for Designers not using the DiDeas System (3/3)

APPENDIX C

DIDEAS DATABASE ENTITIES

C.1 Introduction

The following tables list all fields of the DiDeas database. The first column shows the field names. An asterisk (*) in this column indicates the primary key, i.e. a field of the type 'AutoNumber', which uniquely identifies each row of the table. The data types are shown in the second column, and short descriptions for each field are presented in the third column.

C.2 User Information

The table tblUserData contains information about all users registered to the system.

Field Name	Data Type	Description
UserID *	AutoNumber	Unique user identification
LastName	Text	Last name of the user
FirstName	Text	First name of the user
NickName	Text	Nickname of the user
ExpertiseField	Text	Description of the user's fields of expertise
TypeIndex	Text	Myers-Briggs Type Indicator
Location	Text	Location of the user
Address	Text	Postal address
PhoneNo	Text	Phone number (incl. country and area codes)
FaxNo	Text	Fax number (incl. country and area codes)
EmailAddress	Text	E-mail address
UserName	Text	Unique user name
IPNumber	Text	IP number of the computer the user is working on, updated at login to DiDeas
ProjectID	Number	Project ID of the project the user is currently working on

Table C.1: tblUserData

The table tblAssignments holds the projects each user is registered to work on.

Field Name	Data Type	Description
AssignmentID *	AutoNumber	Unique assignment ID
UserID	Number	User ID
ProjectID	Number	ID of the project the user is assigned to

Table C.2: tblAssignments

C.3 Project Information

The table tblProjects contains all projects of DiDeas and the project information.

Field Name	Data Type	Description
ProjectID *	AutoNumber	Unique project ID
ProjectName	Text	Name of the project
ProStartDate	Date/Time	Start date of the project
ProEndDate	Date/Time	Finish date of the project
ProDescription	Memo	Short project description

Table C.3: tblProjects

C.4 Specification Development Data

The table tblReqmntHeaders contains the headings for the customer requirements and engineering requirements.

Field Name	Data Type	Description
HeaderID *	AutoNumber	Unique heading ID
ProjectID	Number	Project ID
ReqmntType	Text	CR=Customer Req., ER=Engineering Req.
HeaderName	Text	Name of the heading
HeaderExamples	Text	Example requirements
UserID	Number	User ID of user who created heading

Table C.4: tblReqmntHeaders

The table tblReqmntData lists all engineering requirements and customer requirements.

Field Name	**Data Type**	**Description**
ReqmntID *	AutoNumber	Unique requirement ID
HeaderID	Number	Heading ID of the requirement's heading
Requirement	Text	Customer words or engineering term
Importance	Text	Importance value (only for customer requirements)
TargetValue	Text	Target value (only for engineering requirements)
ReqmntNotes	Memo	Description or comment
CreateID	Number	User ID of user who created the requirement
CreateDate	Date/Time	Date and time when the requirement was created
ChangeID	Number	User ID of user who last changed the requirement
ChangeDate	Date/Time	Date and time when the requirement was last changed
Relationship	Yes/No	Does a QFD relationship value exist?

Table C.5: tblReqmntData

The table tblQFD contains the relationship values for the customer requirements and engineering requirements used in the 'House of Quality'.

Field Name	**Data Type**	**Description**
QfdID *	AutoNumber	Unique ID for the CR/ER relationship
CReqmntID	Number	ID of the customer requirement
EReqmntID	Number	ID of the engineering requirement
QfdValue	Number	Relationship value (1, 2 or 3)
UserID	Number	User ID of user who last changed the relationship value
ChangeDate	Date/Time	Date and time when the value was last changed

Table C.6: tblQFD

C.5 Functional Analysis and Concept Generation Data

The table tblFunctionsConcepts contains all functions and concepts.

Field Name	Data Type	Description
FCID *	AutoNumber	Unique ID for the function or concept
FCType	Text	F=Function, C=Concept
ParentConceptID	Number	ID of the function's parent concept (only for functions)
FunctionName	Text	Name of the function (only for functions)
FunctionNotes	Memo	Description or comment (only for functions)
Satisfied	Yes/No	Is the function satisfied by at least one concept? (only for functions)
ParentFunctionID	Number	ID of the concept's parent function (only for concepts)
ConceptName	Text	Name of the concept (only for concepts)
ConceptNotes	Memo	Description or comment (only for concepts)
ConceptUpload	Yes/No	Have any files been uploaded for the concept? (only for concepts)
ProjectID	Number	Project ID
Sequence	Number	Position (vertical) in the function-concept structure, unique within a project
Intend	Number	Position (horizontal) in the function-concept structure
CreateID	Number	User ID of user who created the function or concept
CreateDate	Date/Time	Date when the function or concept was created
ChangeID	Number	User ID of user who last changed the function or concept
ChangeDate	Date/Time	Date when the function or concept was last changed

Table C.7: tblFunctionsConcepts

The table tblConceptGroups lists the created concept designs and the parameters from the concept screening.

Field Name	Data Type	Description
CGroupID *	AutoNumber	Unique concept design ID
ProjectID	Number	Project ID
CGroupName	Text	Name of the concept design
UserID	Number	User ID of the user who created the concept design
CreateDate	Date/Time	Date and time when the concept design was created
GoStatus	Text	Go-status of the concept design (go, nogo or unsure)
Compatible	Yes/No	Is the concept design compatible to the overall function? (yes=incompatible)
Realisable	Yes/No	Is the concept design realizable in principal? (yes=not realizable)
Specifications	Yes/No	Does the concept design fulfil the specifications? (yes=does not fulfil specs.)
OtherYN	Yes/No	Are there other reasons for elimination?
OtherText	Text	Other reasons for elimination
ScreeningNotes	Memo	Description or comment
ScreeningID	Number	User ID of the user who performed the screening
ScreeningDate	Date/Time	Date and time when the concept designs

Table C.8: tblConceptGroups

The table tblConceptGroupItems contains the functions and the selected concepts of the concept designs.

Field Name	Data Type	Description
ID *	AutoNumber	Unique ID, not used
CGroupID	Number	Concept design ID
FunctionID	Number	Function ID
ConceptID	Number	Concept ID

Table C.9: tblConceptGroupItems

The table tblConceptUploads lists the files uploaded for the concepts in the function-concept structure.

Field Name	Data Type	Description
UploadID *	AutoNumber	Unique ID for an uploaded file
ConceptID	Number	Concept ID
FileName	Text	Name of the uploaded file
FileType	Text	File type of the uploaded file
UserID	Number	User ID of the user who uploaded the file
UploadDate	Date/Time	Date and time when the file was uploaded

Table C.10: tblConceptUploads

C.6 Concept Evaluation Data

The table tblCriteria lists all criteria and their weight factors

Field Name	Data Type	Description
CriteriaID *	AutoNumber	Unique criteria ID
ProjectID	Number	Project ID
Criteria	Text	Name or description of the criterion
Weight	Number	Weight factor of the criterion

Table C.11: tblCriteria

The table tblEvalResultSets lists the individual result sets. A result set is created when a user completes a decision matrix.

Field Name	Data Type	Description
ResultSetID *	AutoNumber	Unique result set ID
ProjectID	Number	Project ID
UserID	Number	User ID of the user who completed the decision matrix
CreateDate	Date/Time	Date and time when the decision matrix was completed
ControlID	Text	Code created from evaluated concept designs (CGroupIDs) and criteria used (CriteriaIDs) to avoid the adding up of incompatible individual evaluation results

Table C.12: tblEvalResultSets

The table tblEvalResultData contains the individual decision matrix results for each concept design evaluated. All concept designs evaluated in the same decision matrix have the same ResultSetID.

Field Name	Data Type	Description
ResultID *	AutoNumber	Unique result ID
ResultSetID	Number	Result set ID
CGroupID	Number	Concept design ID
TP	Number	Total number of '+'
TM	Number	Total number of '-'
OT	Number	Overall total (difference between TP and TM)
WT	Number	Weighted total

Table C.13: tblEvalResultData

C.7 Project Documentation Data

The table tblDesignReviews hold the design reviews.

Field Name	Data Type	Description
ReviewID *	AutoNumber	Unique design review ID
ProjectID	Number	Project ID
ReviewTitle	Text	Title of the design review
ReviewText	Memo	Design review text
ChangeID	Number	User ID of the user who last changed the design review
ChangeDate	Date/Time	Date when the design review was last changed
BusyID	Number	User ID of user who is currently editing or viewing the design review

Table C.14: tblDesignReviews

C.8 Communication Data

The table tblMessages contains all messages created for the DiDeas Message Board.

Field Name	Data Type	Description
MsgID *	AutoNumber	Unique Message ID
SenderID	Number	User ID of the message sender
ProjectID	Number	Project ID
MsgDate	Date/Time	Date and time when the message was sent
Message	Memo	Message text
Importance	Number	Importance of the message (0=normal, 1=high)

Table C.15: tblMessages

The table tblMsgRecipients lists all recipients for each message of the Message Board.

Field Name	Data Type	Description
ID *	AutoNumber	Unique ID, not used
MsgID	Number	Message ID
RecipientID	Number	User ID of the recipient

Table C.16: tblMsgRecipients

The table tblSMS contains all active short messages of the DiDeas Sort Messages.

Field Name	Data Type	Description
SMSID *	AutoNumber	Unique short message ID
SenderID	Number	User ID of the sender
ReceiverID	Number	User ID of the recipient
ProjectID	Number	Project ID
SMSMessage	Memo	Message text
SMSDate	Date/Time	Date and Time when the message was sent

Table C.17: tblSMS

C.9 Information Transfer Data

The table tblPersonalNotes contains the personal notes stored in the DiDeas system.

Field Name	Data Type	Description
NoteID *	AutoNumber	Unique personal note ID
UserID	Number	User ID
ProjectID	Number	Project ID
NoteDate	Date/Time	Date and time when the note was created
NoteSubject	Text	Subject or heading of the note
NoteText	Memo	Note text

Table C.18: tblPersonalNotes

The table tblSWorkspace contains information on the files uploaded to the shared workspace system of the Distributed Design Assistant, but not the files themselves.

Field Name	**Data Type**	**Description**
SWUploadID *	AutoNumber	Unique ID for the uploaded file
UserID	Number	User ID of the user who uploaded the file
ProjectID	Number	Project ID
FileName	Text	Name of the file
FileType	Text	Type of the file
FileNotes	Memo	Description or comment
UploadDate	Date/Time	Date and time when the file was uploaded

Table C.19: tblSWorkspace

APPENDIX D

DIDEAS HELP FILE

D.1 Introduction

The following section shows the DiDeas help file, as it appears in the web-browser. The paragraphs in the help text can be accessed via the corresponding hyperlinks listed in the help index. Hyperlinks within the help text provide cross-references to related topics. Hyperlinks of the index and the help text are indicated by underlined text.

D.2 DiDeas Help Index

Specification Development:

Customer Requirements
Engineering Requirements
Customer / Engineering Requirement Editor
Requirement Heading Editor
Standard Headings
QFD - House of Quality

Functional Analysis / Concept Generation:

Function and Concept Structure
Function / Concept Editor

Concept Selection:

Concept Design Selection
Concept Designs

Concept Evaluation:

Concept Design Screening
Criteria Selection
Decision Matrix
Evaluation Results

Project Documentation:

Design Reviews
Documentation Assistant

Project Management:

Project Manager

Team Management:

Team Manager

Communication Assistant:

Message Board
Video Snapshots
Short Messages

Information Assistant:

Personal Notes
Shared Workspace

System Tools:

DiDeas Help
About DiDeas
DiDeas Logout

D.3 DiDeas Help Text

Customer Requirements:

Displays all customer requirements, sorted by heading and importance.
To refresh the list of customer requirements, click on the 'Refresh' button.
To add a new heading, click on the link 'add heading' or on the link 'standard headings'.
To edit an existing heading, click on the link 'edit' next to the heading.
To add a new requirement, click on the link 'add requirement' next to the heading.
To edit an existing requirement, click on the link 'edit' next to the requirement.
NB: Select a project before working on the customer requirements.
(Requirement Editor, Requirement Heading Editor, Standard Headings)

Engineering Requirements:

Displays all engineering requirements, sorted by heading.
To refresh the list of engineering requirements, click on the 'Refresh' button.
To add a new heading, click on the link 'add heading' or on the link 'standard headings'.
To edit an existing heading, click on the link 'edit' next to the heading.
To add a new requirement, click on the link 'add requirement' next to the heading.
To edit an existing requirement, click on the link 'edit' next to the requirement.
NB: Select a project before working on the engineering requirements.
(Requirement Editor, Requirement Heading Editor, Standard Headings)

Customer / Engineering Requirement Editor:

Displays all information for the selected requirement or the input mask for a new requirement.
Customer requirements: Fill in or edit the customer words and notes for the requirement, select the importance ('Must', 'Major Wish, 'Minor Wish') and the heading (if you wish to change it) from the drop-down menus.
Engineering requirements: Fill in or edit the engineering term, target value and notes for the requirement, select the heading (if you wish to change it) from the drop-down menu.
To update the requirement data, click on the 'OK' button, to cancel your input, click on the 'Cancel' button.
(Customer Requirements, Engineering Requirements)

Requirement Heading Editor:

Displays all information for the selected heading or the input mask for a new heading.
Fill in or edit the heading name and the examples. To update the heading data, click on the 'OK' button, to cancel your input, click on the 'Cancel' button.
(Customer Requirements, Engineering Requirements)

Standard Headings:

Displays a set of standard headings for customer requirements or engineering requirements.
To select one or more heading(s), click on the corresponding check-box. To update the selected heading(s), click on the 'OK' button, to cancel your selection, click on the 'Cancel' button.
(Customer Requirements, Engineering Requirements)

QFD - House of Quality:

Displays the customer requirements - engineering requirements relationship matrix.
To refresh the House of Quality, click on the 'Refresh' button.
To add a new relationship strength value or to edit an existing one, click on the corresponding cell of matrix and select the value from the drop-down menu in the bottom window. To update the value, click on the 'OK' button, to cancel your input, click on the 'Cancel' button.
To display the next or previous set of ten customer requirements or engineering requirements, click on the 'next' or 'prev.' link under the corresponding requirement list.
To check for completeness, i.e. each customer requirement is related to at least one engineering requirement (and vice versa), click on the 'check completeness' link.
NB: Create customer requirements and engineering requirements before working on the House of Quality.
(Customer Requirements, Engineering Requirements)

Function and Concept Structure:

Displays the function and concept structure.
To refresh the function and concept structure, click on the 'Refresh' button.
To edit an existing function or concept, click on the link 'edit' next to the function or concept.
To add a new concept, click on the link 'add concept' next to the function.
To add a new function, click on the link 'add function' next to the concept.
To check for completeness, i.e. each function is satisfied by at least one concept, click on the 'check completeness' link at the end of the list.
NB: Select a project before working on the function and concept structure.
(Function / Concept Editor)

Function / Concept Editor:

Displays all information for the selected function / concept or the input mask for a new function / concept.
Functions: Fill in or edit the function and notes.
Concepts: Fill in or edit the concept and notes.
To update the function / concept data, click on the 'OK' button, to cancel your input, click on the 'Cancel' button.
(Function and Concept Structure)

Concept Design Selection:

Displays the function-concept structure.
To refresh the function-concept structure, click on the 'Refresh' button.
To create a new concept design, select the concepts by clicking on the corresponding radio button and provide a concept design name. To update the selected concept design, click on the 'OK' button, to cancel your selection, click on the 'Cancel' button.
NB: Create the functions and concepts structure before selecting concept designs.
(Function and Concept Structure)

Concept Designs:

Displays a list of all concept designs.
To refresh the list, click on the 'Refresh' button.
To display the functions and corresponding concepts of a concept design, click on the concept design name link.
(Concept Design Selection)

Concept Design Screening:

Displays a list of all concept designs, including the Go-NoGo status.
To screen a concept design and to display its functions and corresponding concepts, click on the concept design name link.
To eliminate the concept design from the evaluation process, click on the check-box(es) for one or more elimination reasons. If none of the provided elimination reasons applies, another reason can be entered.
Fill in or edit the screening notes and select the correct Go-NoGo status by clicking on the corresponding radio button.
To update the concept design screening, click on the 'OK' button, to cancel your input, click on the 'Cancel' button.
(Concept Design Selection, Concept Designs)

Criteria Selection:

Displays a list of evaluation criteria and the associated weight.
To refresh the list, click on the 'Refresh' button.
To edit an existing criterion, click on the criterion name link.
To add a new criterion, click on the link 'add new criterion' at the end of the list.
Fill in or edit the criterion and select the weight factor from the drop-down menu. Customer requirements and engineering requirements are displayed as a guidance.
To update the criterion, click on the 'OK' button, to cancel your input, click on the 'Cancel' button.
(Customer Requirements, Engineering Requirements, Decision Matrix)

Decision Matrix:

Datum Selection: Displays a list of all concept designs with a Go status. To select a concept design as a datum, click on the 'select as datum' link next to the concept design.
Decision Matrix: Displays the decision matrix, including the criteria, weight factors and concept designs. The concept designs are numbered, the numbering key is located below the decision matrix. The column for the datum concept design is colored grey and cannot be edited.
To mark a concept design for a particular criterion, select the rating ('+': concept design meets criterion better than datum, '0': concept design meets criterion as well as datum,'-': concept design meets criterion worse than datum) from the drop-down menu.
To calculate the results, click on the 'OK' button, to cancel your input, click on the 'Cancel' button.
Decision Matrix Results: Displays the decision matrix results, based on your decision matrix evaluation.
To combine the results with the results of the other team members, click on the 'OK' button, to return to the decision matrix for a new evaluation, click on the 'Cancel' button.
(Criteria Selection, Evaluation Results)

Evaluation Results:

Displays the combined evaluation results in the top window and the individual results in the window below ('T+': Total '+', 'T-': Total '-', 'OT': Overall Total, 'WT': Weighted Total.
To refresh the evaluation results, click on the 'Refresh' button.
NB: Only the last evaluation of each user for the current set of concepts designs (Go status = 'Go') is taken into account.
(Decision Matrix)

Design Reviews:

To create a new design review, click on the 'New Design Review' link.
To edit an existing design review, click on the 'Edit existing Design Review' link. A list of design reviews will be displayed in the window below. Select a design review by clicking on the design review name link. If the design review is in use, the nickname of the relevant user is displayed in the design review list and only this user can access the design review.
Fill in or edit the title and review. To update the design review, click on the 'OK' button, to cancel your input, click on the 'Cancel' button.
NB: Do not proceed directly to another menu item when finished with the design review. Instead always click on the 'OK' button or the 'Cancel' button to properly close the design review. Otherwise no other user will be able to access the design review.

Documentation Assistant:

Displays a list of documents available for printing.
To print a document, click on the corresponding 'print version' link next to the document.
To print a concept design, click on the 'select' link. A list of concept designs available for printing will be displayed in the window below. Click on the 'print version' link next to the particular concept design.
NB: The print version of the document contains no hyperlinks (e.g. 'edit' or 'select') and all icons (e.g. for customer requirements) are greyscale. The document will be displayed in a new browser window without frames and can be printed by clicking on File->Print... in the browser menu.
(Customer Requirements, Engineering Requirements, Function and Concept Structure, Concept Designs, Evaluation Results, Design Reviews)

Project Manager:

Displays a list of all projects you are assigned to.
To select a project as the work project, click on the 'select' link. The selected project will be displayed in the info window below the main menu (with a delay of a few seconds).
To display the project information for a particular project, click on the project name link. The project information will be displayed in the window below.

Team Manager:

Displays a list of all online users, including the project and IP number. The second list shows all offline users.
To display the user information of a particular user, click on the nickname link. To display the project information for a particular project, click on the project name link. The user information and the project information will be displayed in the window below.

Message Board:

Displays a list of all messages sent by you and sent to you.
To refresh the list of messages, click on the 'Refresh' button.
The list of messages is automatically updated every 20 seconds.
To create a message, fill in the message field.
Select all team members as recipients by clicking on the 'All' radio button. To select only some team members as recipients, click on the other radio button and choose one or more team members from the drop-down menu.
To select the importance of the message, click on the Normal' or 'High' radio button.
To send the message, click on the 'OK' button, to cancel your input, click on the 'Cancel' button.
NB: Select a project before sending messages.

Video Snapshots:

Displays live pictures of all online team members.
To refresh the live pictures, click on the 'Refresh' button.
The pictures are automatically updated every 20 seconds.
NB: The program 'WebCam2000' must be running in order to send a live image.
NB: Before starting a videoconferencing application (e.g. CU-SeeMe) the program 'WebCam2000' must be closed, and vice versa!
NB: Select a project before displaying the video snapshots.

Short Messages:

To create a short message, fill in the message field.
Select all team members as recipients by clicking on the 'All' radio button. To select only some team members as recipients, click on the other radio button and choose one or more team members from the drop-down menu.
To send the short message, click on the 'OK' button, to cancel your input, click on the 'Cancel' button.
When a short message arrives for you, you will be notified by the phrase 'New Message !' displayed in the info window below the main menu.
To view the short message(s), click on the 'New Message !' link. A list of all short messages will be displayed. To acknowledge a short message, click on the corresponding check-box. To update the short messages, click on the 'OK' button, to cancel your selection, click on the 'Cancel' button.
NB: Select a project before sending short messages.

Personal Notes:

Displays a list of your personal notes, sorted by project and date.
To refresh the list, click on the 'Refresh' button.
To add a new personal note, click on the link 'new personal note' at the end of the list.
To edit an existing personal note, click on the link 'edit' next to the personal note.
Fill in or edit the subject and the note and select the project (if you wish to change it) from the drop-down menu.
To update the personal notes, click on the 'OK' button, to cancel your input, click on the 'Cancel' button.

Shared Workspace:

To list all files uploaded for the current project, click 'Show project files'.
To list all files you have uploaded, click 'Show all my files'.
To upload a file, click 'Upload file'. Specify the file location or browse your computer. Files can be annotated with a note. To upload the selected file, click on the 'OK' button, to cancel the upload, click on the 'Cancel' button.
NB: Since all files are uploaded to the same directory, duplicate file names are not permissible.

DiDeas Help:

This file.
Select a topic from the index in the top window and read the explanation in the window below.

About DiDeas:

A short description of the framework and some links to related sites.

DiDeas Logout:

Please logout from the DiDeas system after each session.