Self-Evaluation of the Offshore Engineering Master of Science Degree Curriculum at the Delft University of Technology
CROHO 60178
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Preface

The MSc program Offshore Engineering started as an independent masters program in September 2004. The program was based on the interfaculty variant Offshore Engineering as it was part of the MSc program of Civil Engineering, Mechanical Engineering and Marine Technology and on the variant Dredging Engineering as it was part of Mechanical Engineering. The MSc program Offshore Engineering now covers all offshore activities that do not have the aim to transport goods or people (this is Marine Technology) and except fishery.

This report is the result of the effort of the joint staff of the MSc program Offshore Engineering, the educational committee, the exam committee and the people of the University Bureau. The first drafts were written by Walt Massie who put great effort in this, for which we wish to thank him. The report is completed under the responsibility of the educational director.

Dr.ir. S.A. Miedema
Educational Director Offshore Engineering
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1. Introduction

1.1. Initial Remarks

This section provides some general conventions to help the reader understand this document.

A lot of supporting information is included in appendices. These appendices are listed at the end of the Table of Contents. More "distant" supporting information is only included as a reference. Details of each of the references are given in appendix 1.1.

This document makes use of 'conventional' English names for Delft University of Technology study curricula in order to make this report more easily understood by those outside the university. Marine Technology - denoted by NA - is used here instead of Marine Technology for example. Appendix 1.2 includes the more common abbreviations used in this report along with their explanations.

The Offshore Engineering curriculum has participants instead of students. While this distinction may seem unimportant, it psychologically lowers the barrier between students and teachers thus stimulating an academic environment in which everyone - administrators, teachers and participants - seamlessly interacts as a single community of scholars.

1.2. Administrative Data

The Offshore Engineering Master of Science Degree curriculum is provided cooperatively by staff from Mechanical Engineering, Marine Technology, Civil Engineering and Petroleum Engineering. Civil Engineering serves as formal administrative base for this curriculum as this report is being written (2005).

The Offshore Engineering Master of Science Degree at the Delft University of Technology is registered in the Dutch Central Register of Higher Education (abbreviated as CROHO in Dutch) under number 60178.

1.3. Curriculum Definition and Background

1.3.1. Definition

Prof.dr.ir. J.H. Vugts provided the first more or less strict definition of offshore engineering for the Delft University of Technology in Mapping Out Offshore Technology; published in 1994. This document was internationally distributed to and acclaimed by industry. It initiated the modern development of what is now the Offshore Engineering curriculum being discussed here.

The current version of this definition (only a few words have been added and engineering has replaced technology since Vugts' original document) is as follows:

"Offshore Engineering is centered around three words:

- Engineering
- Applications
- Man-made structures (hardware)

"It also includes the five characteristics given below.

Offshore engineering concerns professional engineering. This is:

1. The systematic and responsible application of science and other organized knowledge for practical purposes, where the applications
2. Are situated at sea away from the coast, and
3. Are centered at a more or less localized area on, in, or under the sea, and where these applications deal with man-made structures (hardware) that
4. By design and method of construction are strongly influenced by the environmental conditions at the intended location, while accepting the natural circumstances and the state of the environment at the location as given facts, and
5. Serve for the exploitation of natural resources above, on, in or under the sea or for the support of a public utility."
"These five features are believed to be characteristic and exclusive; they distinguish offshore engineering from other fields of engineering. When each and all of these five characteristics are met, and only then, can one speak of offshore engineering as it applies to this curriculum."

In short, one can say that offshore engineers design fixed, floating and subsea structures and equipment (including pipelines and dredging equipment) for use on, in or under the sea at a more or less well-defined location.

1.3.2. Curriculum Background

Even though Delft University of Technology only began awarding Master of Science Degrees in Offshore Engineering from the first of September 2004, offshore engineering education has a history of more than a quarter century within the university. This section gives a brief historical overview.

The first course in offshore engineering within the Delft University of Technology was started about 1975. It was a broad multi-faculty survey of offshore technology - as it was then called - offered as a 4th or 5th year elective for most all engineering students.

Additional offshore courses developed with time so that with the advent of the 4-year curriculum in the early nineteen-eighties Civil Engineering introduced offshore technology as one of its separate specializations. Mechanical Engineering as well as Marine Technology did something similar in their curricula, but in a less formal way.

Vufts' Mapping out Offshore Technology document came when the reinstated 5-year curriculum was being planned in 1994. It led to a rather universal Offshore Engineering curriculum which filled the latter 2½ of the 5 years. In spite of its universal character, Civil Engineering and Petroleum Engineering were the only degree curricula to integrally include this curriculum. Both Mechanical Engineering and Marine Technology did provide teaching input and used some of its courses in their own offshore engineering programs.

The 2½-year curriculum was adapted and re-structured in order to fit it exclusively within a 2-year Master of Science time frame from the time the BSc - MSc curriculum structure was introduced in September 2002. Once again, Civil Engineering included offshore engineering as one of the specialties within its Master of Science curriculum; Mechanical Engineering as well as Marine Technology both continued their own more diffuse approaches to offshore engineering as well and continued to utilize some of the offshore engineering courses offered by others.

The decision to add Dredging Equipment Design as an accent area within offshore engineering - and to ultimately drop it from Mechanical Engineering - stimulated the establishment of the separate Master of Science Degree curriculum being evaluated here. One might say that this curriculum has been 'distilled' from all of the earlier curricula.

As of the 2004-2005 academic year the Design of Deep Sea Dredging Equipment has started within the Offshore Engineering MSc Degree curriculum even though Mechanical Engineering is still offering its own Dredging Equipment specialty. Since September of 2004 all new participants joining the Offshore Engineering MSc Degree curriculum are studying according to a uniform set of rules. Those who had already started on one of the earlier MSc (offshore) curricula may either complete their planned university student careers, or switch to the new curriculum.

It should be obvious from this historical overview that this report is being compiled for the first specific educational visitation for Offshore Engineering. Participation and enrollment data, etc. have been assembled for a longer period in order to be able to work with a more statistically representative sample.
1.4. Curriculum Relevance

1.4.1. The Market

Dutch engineering and construction firms have been active serving the offshore industry since even before oil and gas production started from the North Sea in the mid nineteen-sixties and the first offshore gas discovery was made in 1969. Indeed, the Dutch have played a part in much of the history of the offshore industry since the first platform was placed out of sight of land in 6 meters of water in the Gulf of Mexico in 1947. (This is generally recognized as the start of the offshore industry by the way.)

In 1998 and 1999 the Dutch Stichting Nederland Maritiem Land carried out a large-scale evaluation of the economic importance of 11 separate sectors of the Dutch Maritime Cluster of companies and agencies. Their relative importance is shown in the figure in terms of total (direct plus indirect) added value in relation to total employment provided. The original data can be found in Peeters (1999).

The offshore sector is the second largest sector - surpassed only by the sea harbor sector. Note that dredging equipment design and construction is not included in the offshore sector. Instead, it is a significantly smaller segment that is split between the shipbuilding sector (for the ships) and the maritime supply sector (for the special equipment such as pumps). The dredging sector in the figure relates to carrying out dredging work - typically supported by a branch of the Hydraulic Engineering MSc specialty within Civil Engineering. In the new MSc program Offshore Engineering everything offshore is covered that does not have the purpose to transport goods or people, since this is Marine Technology and except fishery, thus including Dredging in the program.

A later study carried out by the same foundation - van der Aa (2004) indicates that the offshore sector is the largest employer of professional level staff within the entire Dutch Maritime Cluster. About half of the (now) more than 35 000 employees have a university or sub-professional academic (Dutch HBO) background; they work for a total of roughly 400 companies. The companies require engineers from most disciplines, but they can use 30-40 multidisciplinary Offshore Engineers annually.

It might also be noted that the traditional offshore sector is often anti-cyclic in a macro-economic sense; high oil prices that often spark a general recession also usually stimulate offshore engineering activities and its employment. The dredging equipment design sector tends to be more conventionally cyclic, however.

The offshore industry is certainly not limited to the geographical boundaries of The Netherlands. Many Dutch companies operate internationally, an increasing number of participants come here from abroad to study and foreign employers are finding their way to Delft University of Technology to hire offshore engineering graduates as well.

1.4.2. Financial Support

An additional measure of relevance is the extent to which industry is willing to contribute to (the success of) the offshore engineering curriculum. Offshore engineering has enjoyed industrial support for more than 25 years in the form of 'free' coaching of participants completing theses in industry. Currently, more than 90% of the offshore engineering participants complete their theses via some form of industrial interaction. While many other Delft University of Technology students carry out industrial theses as well, the above percentage is high compared to what many other groups achieve.

As early as the late nineteen-nineties, Prof.dr.ir. Jan Vugts - then Professor of Offshore Engineering - successfully approached several Dutch industries to provide direct financial support - via cash contributions on a continuing
basis - earmarked for offshore engineering education, but without further restrictions. He succeeded in obtaining funding (50000 guilders at that time) from each of the following companies:

- ABB
- Heerema
- IHC

As far as is known, this was the first such earmarked educational contribution within the Delft University of Technology. In a stationary situation, the university funding of the program will be about € 900,000 annually with 30 graduates annually.

Since then, Prof.ir. Jan Meek has continued this practice of approaching industry for support. He has expanded the possibilities for this by also allowing companies to provide at least 12 hours of classroom instruction - including examinations, etc. - in lieu of a cash contribution. Support is currently received from:

- Allseas (teaching)
- Heerema (cash)
- IHC (cash)
- Intec/BP (teaching)
- Shell (cash)

In addition, many other companies provide more incidental support for thesis work or by sponsoring a field trip, to name just two examples. The curriculum described in this document would not be possible without this support. As will become obvious in later sections, the university offshore staff itself has neither the background breadth nor the physical capacity to provide the entire curriculum by themselves.

### 1.5. A Professional School

The Offshore Engineering Master of Science Degree curriculum has some special characteristics:

- Its curriculum combines scientific research with engineering practice to prepare its graduates for important industrial positions.
- Employers (industry in the case of offshore engineering) have influenced and agreed to the overall curriculum objectives and the route (via a Master of Science Degree) chosen to reach these.
- Industry actively supports the curriculum and its participants by:
  - Providing support in the form of guest lectures as well as participant coaching during industrial practice or thesis work, etc. This involves “invisible money” - costs which the industry absorbs directly.
  - Providing direct financial support via contributions earmarked for Offshore Engineering education. This involves “hard cash” - real money that flows to the university; this is quite unique.
- Curriculum performance - for both its staff and its participants - is measured in terms of results rather than effort. A consequence of this is that everyone is expected to deliver extra effort when the (academic) situation necessitates it. This means that both staff and participants will be treated as if they worked in industry and be judged by their results.

All of these are characteristics of a professional school in the same sense as the term is used in The United States to refer to schools of medicine or law.

### 1.6. Strengths and Weaknesses

The following strengths of the Offshore Engineering curriculum have been shown above:

- **S1a.** The Offshore Engineering curriculum serves a well-defined market.
- **S1b.** Its curriculum is relevant as witnessed by the earmarked financial support it receives from the industry it serves.
- **S1c.** The Offshore Engineering Master of Science curriculum is an academic and professional school - similar to schools of Law and Medicine in The United States - within the Delft University of Technology.

This chapter has revealed the following weakness:

- **W1a.** Offshore Engineering depends upon contributions from industry to provide its current teaching input. This is in fact a strength and a weakness, since it gives a perfect link with industry, but requires effort every year to organize this.
2. **Self-Evaluation Approach**

As has been mentioned before, Offshore Engineering is a new MSc program which started in September 2004. During the starting phase of the program most effort has been put into the contents of the program and organizing the curriculum.

To write this self evaluation report, the following activities have been carried out.

1. A study of the QANU instructions and guides.
2. Collecting the information from different sources.
3. Interviews with the main Offshore Companies regarding the goals of the program and their experience with graduates.
4. Interviews with students from the educational committee and from the ‘Dispuut Offshore Engineering’.
5. Interviews with teachers from the faculties involved.
6. Interviews with the staff of the university regarding the requirements for this self assessment.
7. Writing a first draft.
8. Discussing the first draft with the teachers and students involved.
9. Discussing the draft with the university staff and an other educational director (which is university policy).
10. Processing the comments, remarks and recommendations.
11. A final check regarding the QANU requirements of the self assessment.

The first two years (2004-2005 and 2005-2006), Civil Engineering carries out all the administrative tasks, while per September 2006 Mechanical Engineering will do this.

The first 9 steps have been carried out by Walt Massie, the former Curriculum Leader of Offshore Engineering, who retired in spring 2005. Per May 1st 2005, Sape Miedema was appointed Education Director and took over during step 9.
3. Organizational and Administrative Infrastructure

3.1. Introduction

This chapter describes the infrastructure supporting the Offshore Engineering MSc Degree curriculum. One must keep in mind that organizational formalities such as separate Education and Research Committees, etc. have only been required since Offshore Engineering achieved its separate MSc Degree status from September 2004.

Experience from the past indicates that the Offshore Engineering curriculum has functioned effectively with good leadership and a minimum of management overhead. The overall objective is to avoid the pitfall of most organizations - according to the management guru, Stephen Covey - of "over-management and under-leadership".

3.2. Organizational Structure

3.2.1. Overall Organization

The Offshore Engineering organizational and leadership structure is shown in the figure. Formally, primary responsibility for the Offshore Engineering Degree curriculum lies with Civil Engineering, but Mechanical Engineering and Marine Technology have been given a significant level of influence. In practice, the deans of the two faculties work together as a team, coordinating their leadership to the subgroup of Offshore Engineering teaching, research and administrative staff.

One will note from the figure that the Curriculum Leader plays an especially important role in this leadership structure. An agreement has been signed between the two faculties regarding the input of human resources and facilities and the division of the revenues.

3.2.2. Management Team

A management team including the most involved professors from each of the supporting faculties:

- Prof.ir. Jan Meek Civil Engineering (Educational director until 1-5-2005)
- Dr.ir. S.A. Miedema Mechanical Engineering (Educational director per 1-5-2005)
- W.W. Massie, MSc, P.E. Civil Engineering (Curriculum leader until 1-9-2004)
- Ir. G.H.G. Lagers Civil Engineering (Curriculum leader per 1-9-2004)
- Prof.dr.ir. Jo Pinkster Marine Technology
- Ir. H. Boonstra Marine Technology
- Prof.ir. Wim Vlasblom Mechanical Engineering

was already formed early in 2004. They helped the Curriculum Leader at that time, merge with Dredging Engineering to the Offshore Engineering curriculum. Much of their effort was devoted to administrative matters that were a consequence of the pending independent degree status of the curriculum.

This team continues to meet roughly once per month.

3.2.3. Formal Committees

The three committees shown in the figure above, have only been formed since the formal start of Offshore Engineering as a separate MSc Degree curriculum in September of 2004. The reader is reminded that the current MSc Degree curriculum was already well-defined early in 2004 by the Curriculum Leader working with the Management Team outlined in the previous subsection.
The **Education Committee** includes representatives from each of the three supporting faculties. The examination committee is facilitated by the administration of Civil Engineering (CiTG) until 01-09-2006 and after that by the administration of Mechanical Engineering (3mE). One or two meetings per academic year is sufficient for the Examination Committee to review and approve major curriculum changes and to officially decide about examinations. Further the committee handles matters according to the law and regulations.

Observe that there is a significant personnel overlap between the Education Committee above and the **Research Committee** presented here. This both streamlines operations and - along with the fact that the Curriculum Leader also attends the meetings - provides an optimum opportunity to link research plans to the educational curriculum. Note, by the way, that Dr. Miedema was well along on the formulation of an Offshore Engineering Research Program well before the new curriculum formally started on the first of September 2004. Although the Research Committee is involved with research and not education, the research results are used in the MSc courses where appropriate.

### 3.2.4. Education Director

Generally in Civil Engineering (CiTG) only full Professors have been appointed as Education Director although not all faculties have such a restrictive policy. Prof.ir. Jan Meek - the only Professor of Offshore Engineering in the University - was the Education Director (as of the spring of 2004). Per 01-05-2005 Dr.ir. S.A. Miedema has been appointed. His position in the educational and examination committee are vacant and new members will be appointed. The Education Director as available for 0.2 fte (on average 1 day per week) in combination with having a Curriculum Leader.

Officially the Education Director is responsible for the MSc program in all its aspects. Since Offshore Engineering has a long history of having a Curriculum Leader, who in the past shaped the Offshore Curriculum and was responsible for the continuity of the variant, the tasks have been divided. The current Curriculum Leader will retire in 2007, while a new full-time professor will be appointed at 3mE in 2006. In this new situation there will probably be a new division of the tasks.

The old situation works well and since the program is in its starting phase and everything has to be carried out with a minimum of staff, major changes are avoided.

Now the Education Director is responsible for the overall view of the program, the accreditation, the contacts inside and outside the university and matters like quality control.

### 3.2.5. Curriculum Leader

The Curriculum Leader is the primary link between the curriculum administration and its participants. It has been felt from the beginning of the new 5-year curriculum that this person must be a full-time staff member in order to be optimally available for participant consultation. In addition, he must be dedicated to education and be familiar with the teaching team as well as the needs of the industry served. His tasks include the following:

1. Overall curriculum supervision. This involves the detailed scheduling as well as selecting (and sometimes even finding) teachers for all parts of the Offshore Engineering curriculum. It also includes the organization of class, course and curriculum (segment) evaluations.
2. Serves ex-officio on all thesis committees. In this function he helps assure that all participants are graded on a substantially equal basis. Along the way, he becomes aware of modern trends in and results of research carried out within thesis work. This helps him optimally carry out task 3.

3. Suggest curriculum improvements as part of a never-ending evolutionary process in which he strives to improve the curriculum while retaining its good qualities.

4. He meets periodically with each curriculum participant in order to help him or her with curriculum choices and other professional matters as necessary.

3.3. Administration

Direct administrative support for Offshore Engineering activities is provided by two part-time staff: Ms. Bokop and Ms. van Lijf (now Ms Baan). In addition, many of the administrative and technical staff within the relevant faculties on both sides of the Mekelweg provide incidental support as requested. This type of support ranges from classroom scheduling, administration of grades, assistance in the ship hydromechanics lab, help with budgeting and financial controls, etc.

The functionality of the offshore teaching team within Civil Engineering is currently (early 2005) hampered by the long-term sickness of Ms. van Lijf. Luckily, a (temporary) replacement for her arrived on 1 March (during 2005, Ms Baan was appointed and the problem was solved).

The more formal interfaculty nature of the Offshore Engineering Degree has exposed a few of the administrative weaknesses within the university. For example, the internal allocation of funds is done differently within different faculties. It has taken extra effort on the part of the Management Team to circumvent the difficulties that can result from this. For the time being, they have proposed a simple as well as pragmatic approach:

1. Each faculty funds its staff involved.
2. At the end of the year, any surplus or deficit within Offshore Engineering is subdivided with one third for each of the following:
   A. The Supervising Faculty (Civil Engineering in this case).
      Civil Engineering provides the bulk of the administrative support as well a couple of courses which are (also) used by Offshore Engineering participants.
   B. The Offshore team in Mechanical Engineering and Marine Technology.
      This team is larger than that in Civil Engineering and provides laboratory facilities as well.
   C. The Offshore team in Civil Engineering.
      This team provides a lot of education, and also funds guest teachers from outside the university.

This approach attempts to isolate the finances from the detailed teaching loads, thus avoiding overhead. It has been agreed that the above ratios may be revised based upon experience.

Additionally, Lee and Smith (1995) have found that a rigid bureaucratic administrative structure is not conducive to a student's progress through a modern community of scholars educational system Offshore Engineering is striving to implement.

3.4. Strengths and Weaknesses

3.4.1. Strengths

The following strength of the Offshore Engineering curriculum has been shown above:
S3.4a. The Offshore Engineering curriculum is management-efficient, because the limited number of staff members know each other well and all feel responsible for the success of the program. The management tasks are divided between the Education Director and the Curriculum Leader and in case one of them is temporary unavailable, the other can easily replace. This streamlines the curriculum management tasks significantly so that the small staff can devote relatively more effort to more productive and visible primary tasks: Education and research. This is documented further in chapter 4.

3.4.2. Weaknesses

The weaknesses exposed above by the Offshore Engineering curriculum can be summarized as follows:
W3.4a The central (policy-making) university administration apparently thinks too rigidly. It is apparently not yet capable of adapting to and accommodating academic activities - such as offshore engineering - that obviously cross current administrative boundaries (faculties).
4. Curriculum Details

4.1. Introduction

This chapter presents the bulk of the information about the content of Offshore Engineering MSc Degree curriculum. It inherently, therefore, includes much of the information upon which the self-evaluation is based.

Offshore Engineering strives to provide to be a student (team)-centered educational environment and to use tools and methods associated with this modern form of education:

- Flexible scheduling of classes and exams. These are often modified on the basis of a motivated consensus among the persons - staff as well as participants - involved.
- Just-in-time teaching (giving courses at the right moment as part of a project) and providing information at a moment when it is most needed by the participants. This is done especially in the Survey of Offshore Engineering Project.
- Having and honoring regularly-scheduled office hours for informal consultation.

All this is being done in a research-focused university environment in which education is teacher-centered and multi-faculty initiatives such as offshore engineering are hampered by a rigid and bureaucratic administration. See chapter 3.

Even though the Offshore Engineering MSc Degree curriculum only started in September of 2004, its curriculum has been undergoing development for more than a quarter of a century. Therefore, for the sake of completeness, to give a better impression of the on-going evolution of the curriculum, and to gain a larger statistical base, some parts of this chapter include information going back till the latter part of the nineteen-nineties.

4.2. Specification of a qualification profile in engineering (F1)

4.2.1. Position of Bachelor's and Master's Level

Universities educate in a high-level research environment. Therefore, mostly teaching is strongly interwoven with research. The teaching is carried out by staff who are research active and who disseminate advanced knowledge in their field. This is certainly true for the education at the master level; for basic education at the bachelors level, the didactic skills of the teaching staff are more important than their research activities.

The bachelor's level, achieved after a first study cycle of 3 academic years, is proof that fundamental knowledge and skills have been acquired. This allows the pursuit of most master studies in the fields of civil engineering, mechanical engineering and marine technology at any university, though for some combinations of specific bachelor and master programmes small bridging courses may be required.

Moreover, the bachelor level guarantees that the students' aptitudes indeed match the specific traits of the offshore engineering profession. They should be able to undertake theoretical/desktop work on an engineering basis in a supervised situation. 'Engineering' implies competence in design/synthesis beyond analytical skills. However, a true professional-level qualification for a university-trained engineer is only attained at the master's level in a particular subject like Offshore Engineering.

The master level ensures that the graduates will have experience of being involved in real research problems and methods and/or complex design activities. This results in attributes which make the students/graduates able to engage in industry, research, development, service, and management, and make them familiar with the latest developments in their field.

In the design, construction, management and maintenance of offshore engineering objects or systems both technical and non-technical (environmental, socio-economic, legal etc) aspects are of vital importance. Hence, appropriate offshore engineering requires high-level knowledge and skills both in the technical (construction) and some non-technical domains. Within five-year study programmes one cannot expect students to attain such a high level across the full range from construction skills to multidisciplinary approach of offshore systems and field development problems.

Therefore, the profiles which are described below should be understood in such a way that we consider it fully acceptable – if not inevitable – that a specific student who meets fully the "pure" technical qualifications, will meet the qualifications in the non-technical domains more generally and vice versa.

Consequently, an analogous consideration holds for the study programmes.
4.2.2. **The Bachelor’s level**

Although Offshore Engineering is an MSc program, a description of the generic BSc qualification profile gives an impression of the entrance level.

Students with a Bachelor diploma in Civil or Mechanical Engineering or Marine Technology will:

**A. General skills and attributes**

1. Have a consolidated body of scientific knowledge in the underlying theoretical disciplines and be able to deploy accurately established techniques of analysis and enquiry within these fields;
2. be thoroughly familiar with common methods and paradigms of scientifically based engineering activities, i.e. to:
   a) understand the role of formal models and results from the natural and relevant non-technical sciences in understanding and designing technical systems;
   b) be able to apply methods and techniques that they have acquired to integrate, review, consolidate, extend and apply their knowledge and understanding, to solve civil engineering problems and to carry out projects;
   c) be able to evaluate arguments, assumptions, abstract concepts and data, in order to make judgments and to contribute to solutions of complex issues.
3. Have an understanding at an introductory level of the most important research issues in their field of study and be aware of connections with other disciplines, and have the ability to describe and comment upon the implications;
4. be able to work in a team and in the context of larger projects;
5. be able to communicate information, ideas, problems, and solutions to both specialist and non-specialist audiences;
6. have awareness of possible ethical, safety, societal, environmental, aesthetic and economic implications of infrastructural interventions;
7. have the learning ability needed to undertake appropriate further training of a professional or academic nature;
8. have an appreciation of the uncertainty, ambiguity and limitations of knowledge.

**B. Skills and competences specific for a particular subject include:**

1. systematic understanding of key aspects of their field of study;
2. basic knowledge of methods in their field of study;
3. initial training in theoretical knowledge and methods in research and modelling;
4. basic knowledge of their field of study and the cohesion between the specific subject areas within that domain;
5. specific attitude and way of thinking expected in a particular subject;
6. awareness of connections with other disciplines.

4.2.3. **The Master’s level**

Students with a Master diploma in Offshore Engineering will meet the following qualifications, matching the Dublin descriptors:

**A. General skills and attributes**

1. **Analytical and Communication Skills**
   They will be able to apply their specific cognitive and intellectual skills in a multidisciplinary context for an externally required result. The graduates will be able
   1.1. to take engineering and technology questions from practice, understand the problems, formulate them and then communicate them to others;
   1.2. to analyse engineering and technology questions and formulate a solution;
   1.3. to understand and/or assess the impact of possible solutions on the life cycle of products, on sustainability and on environmental, socio-economic, legal etc. factors;
   1.4. to adequately report, both written and verbally, in appropriate (depending on the audience) language and terminology the results and work practices to persuade others about the benefits of new ideas and inventions;
   1.5. to communicate adequately in their native language and in English.

2. **Modelling, Creative and Synthesis Skills**
   The graduates will be creative and have intellectual skills to be able to work in all areas of their engineering field and cooperate with other disciplines.
   The graduates will have
2.1. insight into the basics of natural and relevant socio-economic sciences, and scientific method, such that they can study and understand their effects, in particular their application to engineering and technology and their potential to develop innovative solutions;

2.2. deductive skills, partly acquired through studies of e.g. mathematics, in order to analyse and lead to new knowledge, especially with view of new engineering methodologies;

2.3. a lateral way of thinking and be able to use abstraction, such that they can explore new paths to new solutions;

2.4. representative knowledge of their engineering and technology disciplines, methods, and tools, with an emphasis on mathematical, physical or socio-economic modelling and system approach. This includes the ability to design and conduct experiments, as well as to analyse and interpret data;

2.5. an operational understanding of system techniques, which may involve transformation of market-oriented needs in specified demands, followed by an adequate system configuration through an iterative application of function analysis, synthesis, optimisation, definition, construction, judging and evaluation.

**Engineering in Society**

The graduates will

3.1. understand their talents and choices as well as the effects of new developments and technologies on societal processes;

3.2. promote, through their actions, an understanding by society of the possibilities and results of their professional activities;

3.3. have awareness of possible safety implications of their work;

3.4. be aware of their overall responsibility for their work.;

3.5. be able to work in an international environment.

**Personal Development**

By attaining the Master’s in an engineering subject, the graduates will have developed the following:

4.1. independent gain and application of knowledge;

4.2. an independent and research study approach;

4.3. insight into complex decision-making processes;

4.4. insight into aspects of long-term development;

4.5. insight into the structure and functioning of companies through economic, company and legal management;

4.6. insight into the ethical aspects of the engineering profession;

4.7. work in a team and/or lead a team.

**B. Skills and competences specific for a particular subject include :**

1. required core knowledge and understanding in their field of study;

2. knowledge of methods and technical practice in their field of study;

3. training in theoretical knowledge and methods including modelling;

4. advanced knowledge of some areas in their field of study;

5. specific attitude and way of thinking expected in a particular subject;

6. awareness of connections with other disciplines and ability to engage in interdisciplinary work.

**4.2.4. The didactical philosophy (F10).**

For the development of education it is essential that goals, aims and objectives be formulated. Based on these goals aims and objectives, the educational program can be developed. It is herewith very important that the correct educational method is chosen, based on the character of the goals, aims and objectives. One can distinguish the following aspects:

1. Fundamental versus applied knowledge

2. Knowledge versus skills

3. Deductive versus inductive methods

4. Top-down versus bottom up

5. Methodology versus knowledge/skills

6. Long term versus short term knowledge

7. Reproducing versus generating

These aspects do not give a value judgment; after all, all aspects are important for a good functioning of the engineer in his working environment. It is however important to make a deliberate choice, in order to create critical, analytical, integrating problem solving engineers. The different aspects require different teaching methods. In general one can distinguish:

- Lectures, good for transferring long term fundamental knowledge, many times inductive, bottom up and resulting in reproduction of existing knowledge.

- Pre programmed practice, good for developing skills, many times reproducing.

- Problem based learning, good for learning applied knowledge, many times top down, deductive, learning a methodology. The learning aspect is more important then the result, open character.
• Project education, good for applying existing knowledge, many times top down, deductive, learning a methodology. The result is important, closed character.
• Assignment, like project education, but a more open character.

Since the learning methods and the capabilities of each student differ, the perfect teaching methodology does not exist. Choices can be made between inductive (bottom up) and deductive (top down) learning and between the means of implementation, like classical lectures and project or problem based education. Depending on the character of the knowledge or skills to be taught and on the capabilities of the student, there may be an optimum teaching method for the student in question.

The Offshore Engineering group of Delft University of Technology is convinced that the teaching system should be focused on the learning abilities of the student and not on the teaching abilities of the scientific staff. The teaching should be student-centered and the teaching staff should adapt itself to this principle.

The Offshore Engineering group of Delft University of Technology is also convinced that it is the aim of the education to focus on the knowledge and skills a student possesses at the time of graduation. This implies optimization of the curriculum as a whole and not sub-optimization of individual courses or projects.

This process of optimization also aims to obtain a high efficiency, a short average time between starting the study program and graduation and high motivation of the students.

Depending on the type of knowledge, inductive or deductive teaching methods or a combination of these have to be used. Theoretical knowledge requires that the student undergoes a process of growth and learns how to acquire profound knowledge. This usually requires the use of inductive methods, while the skills to put the knowledge to practical use can be acquired by following deductive methods.

Encyclopaedic technical and non-technical knowledge and skills can best be taught by deductive methods. It is not the aim of the academic engineer to memorise such information, but rather to be able to use his knowledge and experience in the context of tackling scientific, technical or social problems. This is also the case with non-technical knowledge and skills like economics, management, law, ethics, environmental issues and sustainability. These aspects of offshore engineering knowledge and skills should also be placed in the context of scientific, technical or social problems.

4.3. Objectives (F2)

4.3.1. Introduction and Literature

The Offshore Engineering staff has developed a graphical means to show curriculum objectives. This so-called profile has been developed and documented in the literature over a period of about ten years. The initial form of this is given by Vugts (1994); the most recent developments can be found in Massie (2003b) and (2003c).

4.3.2. Curriculum Profile

A curriculum profile is a two-dimensional figure in which the intended level of intellectual development (represented vertically) is plotted as a function of an engineered object's life cycle step. The twelve horizontal steps quite straightforwardly depict (engineering) steps in an object's life cycle starting with defining the problem to be solved by the object and ending with its removal and re-cycling.

Each of the two vertical axes includes five levels that are a bit more abstract as well as important to the discussion in this report: The left axis is for knowledge while the parallel right-hand axis is for skill - defined here as one's ability to readily utilize associated knowledge. The scales used on these axes indicate one's level of intellectual development. These levels are - starting at the bottom:
• Undeveloped is the level of a student entering the university at the Bachelors level.
• Awareness implies that one can recognize a problem, but cannot solve it. This level cannot be applied to skill, by the way; this is why it is missing on the skill axis on the right in the figure.
• Routine describes one who can approach and solve commonly-occurring problems using well-established methods. It corresponds roughly with the highest level of technician programs such as the Dutch HBO education.
• Advanced implies that one can be somewhat original and innovative in solving well-defined as well as more unique problems.
• Superior is the highest level generally attainable with a university education alone. One can now solve large and complex problems - usually only within one's own specialty area, however.

A more detailed description of a curriculum profile can be found in appendix 4.1.

The profile for the Offshore Engineering Master of Science Degree curriculum at the Delft University of Technology is given in this figure.
A profile alone can be quite generic; it must be used in combination with a definition of the professional area to which it applies - Offshore Engineering in this case. This definition has been given in §1.3.1.

The expected Bachelors level in this figure is dictated by the background of the participants entering the Offshore Engineering curriculum. The Bachelors level assumed above corresponds to the highest level normally attained by technology program (Dutch HBO) graduates who also come to Delft for Masters Degrees. Even though such graduates typically take up to 30 credits (ECTS) of extra course work in Delft outside their Masters Degree program, these credits are utilized primarily to improve their overall background in mathematics and basic engineering sciences.

The curriculum profile offers two distinct advantages when designing a curriculum:
1. The profile is a simple image explaining to everyone - faculty as well as students or industry - just what the curriculum is out to achieve.
2. It focuses attention on what a curriculum is intended to achieve instead of on the courses needed to accomplish this. Faculty members, especially, are forced to think initially in terms of the whole rather than their own specific course.

4.3.3. International Educational Standard

The most widely used standard for engineering educational programs come from the Accreditation Board for Engineering and Technology (ABET) in The United States. The ABET standard - or set of criteria - have been developed more or less via a consensus among the various professional engineering societies in the USA. The American Society of Civil Engineers (ASCE) has a primary say in the ABET requirements for Civil Engineering as well as Ocean Engineering programs - both rather significant for the offshore engineering curriculum being discussed here. ASCE published a suggested modernization of the requirements (referred to as the Body of Knowledge or BoK) for both Civil Engineering professional recognition as well as university engineering curricula in January of 2004. This Body of Knowledge - with slight adaptations for Offshore Engineering - is taken as a standard. The ASCE criteria stipulate little in terms of technical content; ASCE does not wish to limit technical diversity between different universities. Instead, their criteria focus more on how a graduate is expected to work. Their (adapted) list includes the 18 items listed here.

ASCE Body of Knowledge Items (adapted for Offshore Engineering)
1. An ability to apply knowledge of science, mathematics and engineering.
2. An ability to design and conduct experiments as well as analyze their results.
3. An ability to design a system to meet desired needs.
4. An ability to be creative and innovative.
5. An ability to function in multi-disciplinary teams.
6. An ability to identify, formulate and solve engineering problems.
7. An understanding of professional and ethical responsibility.
8. An ability to communicate effectively.
10. Recognition of the need for, and an ability to engage in life-long learning.
11. Knowledge of contemporary issues.
12. An understanding of techniques, skills, and modern tools of engineering practice.
13. An ability to apply knowledge in a specialized area (such as offshore or even subsea engineering).
14. An understanding of the principles of project management.
15. An understanding of business fundamentals.
17. An understanding of the supervision, use and maintenance of constructed facilities.
18. An understanding of the role of a leader and leadership principles.

It should be explicitly noted that ASCE proposes that their requirements must be met in order to obtain professional registration as engineer in The United States. (This currently also requires 8 years of experience - including no more than 5 years credit for university education.)

It is shown in appendix 4.2 that the BoK items are inherent within the curriculum profile.

European universities use what is called the Dublin Descriptors to characterize their curricula, the qualification profile as described in chapter 4 is based on the Dublin Descriptors. It is shown in appendix 4.2 as well that these are inherent in the curriculum profile in combination with the BoK presented earlier in this chapter.

4.3.4. **Strengths**

Strengths:

- **S4.2a** The curriculum profile expresses curriculum objectives in an easily understandable way.
- **S4.2b** The curriculum profile concentrates initial attention on the curriculum as a whole and discourages premature attention for the individual courses within the curriculum.
- **S4.2c** There is a strong inherent relationship between a project's life-cycle and other modern curriculum criteria such as the ASCE Body of Knowledge or the Dublin Descriptors.

4.4. **The Curriculum (F6, F9)**

4.4.1. **Introduction**

Once the curriculum profile has been determined it has been found that the process of determining curriculum content - as well as its subdivision into individual courses - has been relatively straightforward. Initial attention to the curriculum as a whole appropriately delays attention for individual courses as long as possible. This section presents the courses making up the curriculum and demonstrates their relationship to the qualification profile as well as the BoK. Later parts of this section discuss other academic matters such as scheduling and study loads.

A summary of all Offshore Engineering courses has been included in appendix 4.3. This summary provides details for each course including:

- The course code and its title.
- The course credits as well as the accents (to be presented later in this section) for which the course is required.
- The teaching staff for the 2004-2005 academic year.
- The course objectives describe what a participant should be able to do (better) after successfully completing the course.
- The course description tells more about what the course provides to assist the participant in meeting the course objectives.
- The participant evaluation gives information about how the participant's attainment of the course objectives is evaluated.
4.4.2. Core (F3, F4)

The curriculum core listed in the table includes all those academic activities that can reasonably be considered relevant to all Offshore Engineering Master of Science Degree participants.

The Survey of Offshore Engineering Lectures at the beginning of the curriculum exposes participants to a broad series of topics to introduce Offshore Engineering’s many facets as well as place it in its larger professional perspective. The problem-driven project carried out in the second half of that same year forces teams of participants to integrate what they are learning in order to suggest and defend a development plan for an offshore oil and gas field. This project - usually carried out for an oil company client - exposes participants to many professional facets of their (future) work as well. Non-technical topics that are part of the project include:

- Effective teamwork
- Modern library use
- Professional ethics
- Project economics
- Project scheduling
- Schematization of complex problems
- Synthesis of sub-problem solutions
- Written and oral reporting

Each participant receives a copy of An Offshore Participant’s Survival Manual (Massie, 2002) in which many of these topics are discussed. Most topics are also treated in the course of the project work as well.

The technical background for this project comes from the earlier Survey of Offshore Engineering lectures as well as from other courses included in each participant’s program. The principle of just-in-time teaching is used here; the presentation of information is synchronized with the team’s need to know about a topic.

The Physical Oceanography and Waves course describes the marine environment in which one carries out offshore work. It is required for all who have not obtained a comparable knowledge from their BSc study. The Offshore Hydromechanics course treats - in quite some detail - how the marine environment interact with man-made structures placed on, in or under it as well as even its interaction with the sea bed. This latter course includes both theory and experiments carried out in the Ship Hydromechanics Lab. Participants often remark that this course is difficult as well as fun for them. Participants entering with a university BSc background in Marine Technology or Ocean Engineering usually participate in only parts of this course.

The Probabilistic Design course prepares participants (in a generic way) for Offshore Engineering design by showing how the statistical nature of ocean waves - from Oceanography and Waves - and thus the forces caused by them is responsibly used for design.

A course in Basic Soil Mechanics is required for everyone who has not had a soil mechanics course in his or her BSc curriculum.

All of these courses are applied in one way or another in each of the accent areas presented in the following section.

A thesis study lasting at least 6 months forms the capstone of the Offshore Engineering curriculum.

The offshore engineer must be prepared for a broad range of engineering duties in various engineering or related fields of interest. The final objectives have to ensure that the graduated offshore engineers possess the following attainments:

- A broad technical education
- Accessibility to a broad range of employment positions
- Sufficient flexibility in the professional career
- Ability to think critically and creatively
- Understanding of the context in which engineering is practised
- Good communication skills
- Ability to function in a team
- Curiosity and a desire for life-long learning
• Good problem solving capabilities
These qualities should ensure that they have access to a broad range of career openings. As previously stated in this chapter, the acquisition of good problem-solving abilities encompasses the other attainments that have been mentioned even if the types of problem are not restricted to engineering problems. It is the understanding of and the attitude behind the methodology applied to problem solving and not merely the knowledge, on which the reputation of the graduate of Delft (Offshore Engineering) is based. The academic knowledge has to be considered as one of the tools necessary to develop the problem solving capabilities to an academic level.

These objectives are especially acquired in the Survey of Offshore Engineering project and the thesis work. In these two projects the student has to be critical, analytical, create an overview on a complex technical problem and practice the problem solving capabilities. The assignments can be more scientific or design oriented, but always have to cover the state of the art of the scientific developments on the specific field of the assignment. Since each assignment is different, different fields of science are covered, but the scientific approach is more generic.

4.4.3. Accents, Sectors; Majors and Minors

4.4.3.1. Introduction
The Offshore Engineering curriculum includes four accents (or application areas):
• Bottom Founded Structures
• Deep Sea Dredging Equipment
• Floating Structures
• Subsea Engineering

These accent areas are somewhat related - in terms of application (as well as content - to be presented later in this section). Floating Structures and Subsea Engineering complement either or both of the other two accents. This can be visualized as shown in the figure. Since these latter accents serve 'both sides of the figure' it invites the definition of two sectors of accents:
• Deep Sea Dredging - grouped adjacent to Deep Sea Dredging Equipment.
• Energy - grouped around Bottom Founded Structures.

Each accent may be included in one's study program as either a major or a minor. A major includes all (or at least most) of the specific Offshore Engineering courses most relevant to the given accent. A minor - with fewer courses - provides only a minimum knowledge needed for limited accent area functionality.

Each participant must choose at least one of the four accent areas as major. In addition, he or she is normally expected to include either one additional major or two minors in his or her curriculum program. Each of the four accents is described a bit below.

4.4.3.2. Bottom Founded Structures
This is one of the oldest and the most developed of the original accent areas included in the Offshore Engineering curriculum. It includes the following list of courses in either its major or minor. The heart of this accent is obviously formed by the Bottom Founded Structures course taught during the second half of the first MSc year. The other courses provide desirable background supporting information.

The Bottom Founded Structures course is also a prerequisite for the elective on Offshore Wind Farm Design.

<table>
<thead>
<tr>
<th>Bottom Founded Structures</th>
<th>Major ECTS</th>
<th>Minor ECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Code</td>
<td>Course Title</td>
<td>ECTS</td>
</tr>
<tr>
<td>CT4140</td>
<td>Structural Dynamics</td>
<td>4</td>
</tr>
<tr>
<td>WB1480</td>
<td>Basic Finite Element Methods</td>
<td>2</td>
</tr>
<tr>
<td>OE4624</td>
<td>Offshore Soil Mechanics</td>
<td>3</td>
</tr>
<tr>
<td>OE4651</td>
<td>Bottom Founded Structures</td>
<td>6</td>
</tr>
<tr>
<td>Total Credits</td>
<td></td>
<td>15</td>
</tr>
</tbody>
</table>

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### 4.4.3.3. Deep Sea Dredging Equipment

The design of dredging equipment has been some form of specialty within Mechanical Engineering for more than thirty years. This has been partially transferred to the Offshore Engineering curriculum from September 2004; more complete integration (and elimination of the specialty within Mechanical Engineering) is planned for the 2005-2006 academic year.

This accent includes the courses given in the table. Its curriculum has undergone modifications to adapt it to its new academic environment. These include:

- Addition of a new course in Deep Sea Dredging to cover the increasing need to provide equipment for moving soil (both removing it and depositing it) in water depths of, say, more than 100 meters.
- Changing of the sequencing of some existing courses to even out the study load for Offshore Engineering participants choosing this accent.
- The summary course on Drive System Design Principles has been added to replace an earlier list of specific Mechanical Engineering courses. This makes this accent accessible to participants from all academic backgrounds.
- Inclusion of additional courses - Floating Structures and Dynamic Positioning - in order to broaden one's professional preparation.

### 4.4.3.4. Floating Structures

This is the second of the original accent areas within Offshore Engineering. It has an obvious affinity with Marine Technology and includes the courses given here. The accent culminates in the Floating Structures course that is supported by the more general courses in Structural Dynamics and in Basic Finite Elements. Offshore Moorings has been available in the curriculum from the start; Dynamic Positioning is a modern addition resulting from the offshore industry’s move to work in deeper and deeper water.

### 4.4.3.5. Subsea Engineering

Attention for Subsea Engineering within the offshore curriculum has increased over the past few years. It was included as a segment of a course on Marine Pipelines and Subsea Engineering from the (new) start of the five-year curriculum. The committee for the appointment of Prof. Meek found in 2000 that more attention for this area was justified. Subsea Engineering became a separate course - and study accent - with the introduction of the BSc - MSc curriculum structure in the fall of 2003. The accent currently utilizes the courses given here.

Subsea Engineering is the only accent area for which its flagship course is taught entirely by an expert from outside the university. Dr. John Preedy, who teaches several offshore engineering courses throughout the world,
Offshore Engineering

has developed and taught the subject for our university since even before subsea engineering became the separate course outlined above.

It should be obvious just from the table that this is the least developed of the four accent areas. This is recognized and will be picked up by appointing a new full professor in the 3mE faculty in 2006.

4.4.3.6. Additional Offshore Engineering Curriculum Elements

There are a few additional specific curriculum elements that are elective for any Offshore Engineering participant. These are listed in this section.

- The Offshore Wind Farm Design course forms the link between wind energy as well as offshore engineering research on the one hand and Offshore Engineering education on the other. Since the most practicable offshore wind farms use fixed rather than floating support structures, this course is the most popular with those participants who have chosen the Bottom Founded Structures accent.

- Industrial Practice is included as an elective (instead of a requirement) in the Offshore Engineering curriculum for two reasons:
  - It is impossible to reserve a curriculum quarter for this activity so that every participant can be required to include this without extending his or her total study duration to more than 2 years.
  - Most participants carry out their thesis work with industry. While an industrial experience is not exactly the same as a thesis, an industrial thesis does serve the same purpose of enhancing one's transition from being a university student to becoming a useful industrial professional.

  Credit can be given for an industrial practice period lasting from six to 10 weeks.
  Credit is not generally allowed for both Industrial Practice and a Multidisciplinary Exercise.

- A few participants choose to carry out a multidisciplinary exercise lasting eight weeks. Its purpose is to allow one to apply and integrate knowledge from (preferably) several Offshore Engineering courses in order to increase one's skill level (as defined in section 4.2.2. above). Occasionally participants carry out this work in industry, by the way.

4.4.3.7. Accent Remarks

The following two comments relate to the four accent areas just presented.

- One will quickly observe that the above accent areas do not fit in a fixed curriculum structure. The number of credits for a major vary from 11 to 34 while those for a minor range from 4 to 12 - by a factor of at least three in both cases. This results from the fact that curriculum design has continually been driven by the educational needs of the industry and the curriculum participants instead of a rigidly defined curriculum structure.

- An attentive reader will discover that several courses are used by more than one accent area. As a result of this, there is at least some overlap between several of the majors and minors. Deep Sea Dredging Equipment Design is an extreme example of this: The major automatically includes minors in Floating Structures and in Subsea Engineering.

One who works out the accent combinations allowed by the 'rules' will discover that there are six possible combinations including two majors and twelve possible combinations of one major with two minors. Not all of these combinations are considered to be realistic from the point of view of one's study or professional preparation. It is expected that most participants will restrict their choices to combinations within either the energy or the dredging sector. This limits the number of combinations so that as a final result, it is expected that no more than ten accent combinations (five for each sector) will be popular.

4.4.4. Relation to the Profile

The course titles listed above are insufficient to determine exactly how the Offshore Engineering curriculum courses relate to specific profile life-cycle steps. The relation matrix shown below has been derived from the more detailed information provided for each course in appendix 4.3.

Remarks related to the Profile matrix:

- The courses are listed in three groups. The uppermost group is the core curriculum; every participant must have completed each of these (or equivalent) courses. Attainment of the relationships shown here is 'guaranteed' for each participant.

- Accent choices will require every participant to include at least two of the courses in the second group. Since all of these courses share quite similar links to the life-cycle steps, this attainment can also be effectively 'guaranteed'.

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• The remaining list includes courses that will not normally be included by every participant. While not all of the course relationships are identical, most include a significant technical competence core associated with solving sub-problems.
• The Survey of Offshore Engineering - Lectures together with Project - plays an instrumental role of itself in meeting the profile requirements.

By observing that in an overall sense the level of attention that each participant must spend each life-cycle step more or less corresponds to the level of attainment suggested by the profile presented in § 4.2.2, one can conclude that it is reasonable to expect most participants to meet the profile requirements as a result of their study.

4.4.5. Relation to the Qualification Profile and the Body of Knowledge (F5)

The comment at the beginning of the previous section is equally valid for this section.

The relationship matrix below has been compiled based upon more detailed course information and - since attention for some items is often subtle - even upon the author's knowledge about the specific teachers for each course.
Remarks related to the Body of Knowledge Matrix:

- The uppermost group of courses on the left is the core curriculum. Every participant must have completed each of these (or equivalent) courses. Attainment of the relationships shown here is ‘guaranteed’ for each participant.

- Accent choices will require every participant to include at least two of the courses in the second group. Since all of these courses share quite similar links to the Body of Knowledge, this attainment can also be effectively ‘guaranteed’.

- The remaining list includes courses that will not normally be included by every participant. While not all of the courses have identical relationships to the BoK, most include a significant technical competence core as evidenced by their generally strong relationship to BoK items 1, 6, 12 and 13.

- The Survey of Offshore Engineering - Lectures together with Project - plays an instrumental role of itself in meeting the BoK requirements.

In the same way as with the profile, one can conclude that it is reasonable to expect most participants to meet many BoK requirements as a result of their study. It must be remembered that more than just a university education is needed to attain all of the BoK requirements. For example, an engineering practice environment is probably more effective for developing project management or leadership qualities.

Even so, not everything is perfect. The matrix shows that the design and use of experiments is relatively weak. A university can be an excellent setting to carry out original experiments but most of the required experimental work within the Offshore Engineering curriculum consists of a few ‘standard tests’ - to determine hydromechanics coefficients for example - without the participants having to design the experiment or its equipment set-up.
There is a strong but not always obvious link between Offshore Engineering Education and Offshore Engineering Research. The link works in both ways in that a significant body of research is carried out during Offshore Engineering thesis work that is (also) coached by teaching staff who use these results in their teaching when appropriate and consistent with any thesis sponsoring agreements. Some MSc theses are linked to and support work being done by Offshore Engineering PhD candidates. Dissertation results are also used in courses when appropriate.

The current overall longer-term research program is included as appendix 4.4. Comparison of this with the curriculum courses from appendix 4.3 reveals a multitude of links between education and research.

Examples of such links can have many forms:
- The staff members have their own research assignments/projects and incorporate the results where appropriate in their courses.
- The entire Offshore Wind Energy course resulted from several years of research carried out jointly with the University's Institute for Wind Energy.
- PhD dissertation lab results about details of slurry transport in pipelines is included in the classroom explanation of head losses in such pipelines.
- Several exercises and theses over the years have been used to develop user-friendly software to assist participants completing offshore moorings design computations.
- Thesis participants have carried out detailed studies to support PhD research on the reeling of clad (bi-metal) pipelines.
- Attention for vortex-induced vibrations within the offshore hydromechanics course has been expanded as a result of increased industrial concern for this phenomenon and associated PhD research now being carried out.

A key element in the success of this linking is the desire on the part of the teaching staff to keep their courses up-to-date and in tune with industrial needs in order to optimize curriculum participants’ preparation for industrial practice.

### 4.4.7. Intended Course Sequencing

Curriculum design from a logistic point of view involves the delicate balance of the following five factors:
1. Participant study workload during each quarter.
2. The progressive development of necessary knowledge and skills.
3. Development of pre-requisite knowledge for optimum performance in later courses.
4. The realization that just-in-time teaching is more effective.
5. Fitting of all courses into a harmonious time scheme linked to teacher and classroom availability.

The results from this balancing exercise carried out each year by the Curriculum Leader have been discussed in the past with students and the Education Director. While this practice will certainly continue, the curriculum's Education and Examination Committees will review the result as well from now on.

Occasional attempts have been made to construct an overall 'flow diagram' or critical path schedule of the Offshore Engineering curriculum. Such diagrams quickly become too complex for overview functionality. Instead use has been made of a diagram essentially without links as shown on the following page.

Course sequencing in terms of factors two and three in the above list has traditionally been provided with lists associated courses in A Participant's Guide to the Offshore Engineering MSc Degree Curriculum. In spite of this, most teachers regularly find persons in their classroom who have not yet even attempted to master the published pre-requisite knowledge and skills. On the one hand, this situation is understandable for exchange students who want to accomplish as much as possible during their limited stay in Delft. On the other hand, 'regular' curriculum participants may just be too lazy to read the course details published in the Participant's Guide, or too poor planners to heed this information.

Since engineers may be more responsive to graphical information, a diagram showing important links is now

<table>
<thead>
<tr>
<th>Earlier BSc or MSc study</th>
<th>Primary Quarter</th>
<th>Next Quarter</th>
<th>Later Quarters</th>
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<tbody>
<tr>
<td>Expected Pre-requisites</td>
<td>Expected Co-require</td>
<td>Expected Pre-requisite for</td>
<td>Expected Pre-requisite for</td>
</tr>
<tr>
<td>Suggested Additional Pre-requisites</td>
<td>Suggested Additional Co-require</td>
<td>Suggested Pre-requisite for</td>
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Primary Course (first part) | Primary Course (latter part)
included along with each course's entry in appendix 4.3. It remains to be seen whether this will be more effective - when and if used in future editions of the Participant's Guide - in assuring proper preparation by regular participants in later curriculum courses.
The detailed planning of a participant's specific masters degree program is complicated by the fact that most of those who come from the Delft University of Technology bachelor's degree curricula start on their masters degree before fully completing their bachelor's study. This has two consequences:

- Participants must split their academic effort between their remaining BSc work and their Offshore Engineering study. The amount of time that they can allocate to Offshore Engineering usually varies from quarter to quarter too. This can cause difficulties with building up the required pre-requisite knowledge and skills.
- The detailed scheduling of necessary activities in the two curricula often overlaps so that participants cannot fully take part in their scheduled activities. This too, hinders academic progress.

A requirement that all Masters Degree participants have a Bachelors Degree before starting on their Masters Degree is the official TU Delft policy. Because, when the BSc MSc system was introduced, this would cause delays in the study progress, in the first years of the Offshore Engineering program was not to strict in applying this requirement.

### 4.4.8. Participant Study Load (F7)

#### 4.4.8.1. Overall Study Load

Study load - in terms of hours of work or credits per quarter - has already been mentioned in relation to scheduling in the previous section. The actual number of credits that any given participant includes in any given quarter depends upon a participant's:

- Choice of Offshore Engineering curriculum accents as well as elective courses.
- Remaining Bachelors Degree work to be completed (only for Delft University of Technology BSc candidates).
- Study tempo in relation to other time demands such as a part-time job, student management function or just plain intellectual capacity or study motivation.

Since there is no real control over these factors, it is only realistically possible to check the study load via the number of credits that are required for the core curriculum plus realistic combinations of accents. This has been done for ten relevant combinations. It is possible to combine two majors or one major with two minors, but only the combinations that make sense are mentioned in the table below.

Credit Load per Quarter for Realistic Accent Combinations

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<tr>
<th>Sector</th>
<th>Accent Combinations</th>
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The last three rows of this table deserve some explanation:

- The last row lists 120 credits, the minimum total number of credits needed for graduation.

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33
Offshore Engineering

- The third row from the bottom, Maximum Required credits, is the sum of all of the required credits listed in that table column. It is a maximum because no allowances have been made for participants who have already satisfied some requirements via their BSc background. For example, Delft University of Technology Mechanical Engineering students have already included a basic course in Finite Element Methods via their BSc experience.
- The middle of the three rows is the difference between the two rows just mentioned. Every participant is guaranteed this minimum number of electives; he or she may have more than this number depending upon whether he or she has met some Offshore Engineering requirements via his or her BSc curriculum.

Further, one will see from the table that:
- There are never more than 16 (the ideal norm is 15) required credits scheduled in any one quarter.
- There are never more than 30 (the ideal norm is 30) required credits in any one semester.
- There are never more than 60 (the ideal norm is 60) required credits in any one academic year.

The one credit overload for some participants during occasional quarters is considered to be acceptable.

The overall study load will be monitored by using curriculum reviews and discuss the results in the Educational Committee.

4.4.8.2. Study Load Peaks within Quarters

A more detailed facet of the study load on participants is the fluctuations in work load imposed by exercises, etc. that teams or individuals must prepare and submit during the progress of a course or term. Since it is usually ineffective to start on an exercise before one has accumulated at least some knowledge from a course, participants are often confronted by work peaks later in each quarter. On the one hand, it can be good training in professionalism for participants to mobilize the (extra) effort to meet such peak loads and to meet stringent deadlines. Sometimes the sharpest load peaks can be smoothed a bit via careful planning, but planning does not seem to be the forte of most participants - even though attention to work planning is given in the Survey of Offshore Engineering. On the other hand, the author knows from experience that there is often little freedom - from the teacher's side - to shift the time frame of course activities and deadlines very much either.

This problem can't be solved by planning one MSc program, since courses from other programs are used as well. This problem can be reduced by using 42 study weeks a year instead of 38 and using the extra weeks for project based courses. Meanwhile peak loads are monitored by the Education Director and the Curriculum Leader, since there is an almost daily contact with the students. If required solutions will be implemented either ad-hoc or structural.

4.4.9. Curriculum Entrants and Curriculum Capacity (F8)

4.4.9.1. Admission Requirements

In practice, more than 95% of the Offshore Engineering participants come from three design-oriented bachelors curricula: Civil Engineering, Mechanical Engineering or Marine Technology; see the table in § 4.3.9.2. (Adding the more recent Dredging Engineering specialists from Mechanical Engineering to this statistic will only increase the portion of design-oriented curriculum entrants.)

Indeed, the key element of a student's background for the Offshore Engineering curriculum is (generic) design experience within a sufficiently academic environment. This implies that his or her background in solid and fluid mechanics will also be good, since mechanics is utilized in design. Indeed, Bachelors students who ask about their electives are advised to include work on mechanics and design.

Note that no specific offshore engineering preparation is expected of entering participants from Civil and Mechanical Engineering or Marine Technology. This is done simply because most (international) Bachelors Degree curricula do not actively consider this field of application with their students. Of course, those with a Civil Engineering BSc background generally will have already had the equivalent of Basic Soil Mechanics; they need not repeat this in Offshore Engineering. Similarly, those coming from Marine Technology or Ocean Engineering generally will be exempt from part of the requirements for Oceanography and Waves as well as Offshore Hydromechanics. These courses can be considered compulsory elective courses.

Offshore Engineering participants are selected - to the extent possible - based upon their performance in areas of design and mechanics as well their motivation to venture into a new field of - for them - engineering application.

Delft University students, students from the TU Eindhoven and Twente and students from the IDEA League with a BSc in Civil or Mechanical Engineering or Marine Technology can enroll without additional courses, but the may have to do some elective course depending on their background.

Dutch students with another BSc can enroll depending on their BSc, but will have to do additional courses, for example students from Aerospace Engineering or Mining. The additional courses depend on the situation and are usually dedicated.
Other foreign students with a BSc in Civil, Mechanical or Ocean Engineering or Marine Technology can enroll. Students with other technical BSc degrees should contact the Education Director or Curriculum Leader to investigate the possibilities. Dutch HBO students in Civil or Mechanical Engineering or Marine Technology can enroll after finishing a 30 ECTS credit point deficiency program. Students from other technical HBO level programs should contact the Education Director or Curriculum Leader to investigate the possibilities.

### 4.4.9.2. Curriculum Capacity

On the one hand, the capacity of any university curriculum should bear some relationship to the needs of the employment market for its graduates. On the other hand, this market can be somewhat broader than the specific accent areas might indicate. Before the Deep Sea Dredging Equipment accent was added to the curriculum, the Offshore Industry's capacity to absorb new graduates was estimated to be between 15 and 25 per year. Given that:

- The above estimate has been good in practice over the years, and
- Some graduates choose to work outside the offshore industry, thus increasing the market, and
- That the Dredging Equipment group had 10-15 graduates per year,

then a reasonable capacity for the Offshore Engineering Curriculum should now be in the order of 30 participants per year. This capacity is nearly fully utilized in the 2004-2005 academic year; 25 participants - in four teams - are (spring 2005) working on an offshore oil field development project. (This participation is the best available indication of serious interest in an Offshore Engineering study.)

#### 4.4.10. Participant Progress Evaluation (F16, F17)

##### 4.4.10.1. Course-Level Progress

Participant progress through each curriculum course is evaluated as is indicated in appendix 4.3. The teachers are encouraged to include challenging questions on their examinations - independent of whether these are oral or written. Challenging here means that participants are required to apply what has been learned to a situation that has not been discussed directly in class. Examples of this include:

- Requiring each Survey of Offshore Engineering Project participant to 'run through' the design of a field development for an entirely different set of circumstances (which are unknown to the participant before the start) during an oral discussion with the curriculum leader and/or his or her coach.
- Asking Offshore Hydromechanics written quiz participants to quantitatively compare the force on a fixed offshore structure caused by a storm wave to that caused by a tsunami. (The Christmas 2004 tsunami

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<tr>
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| Gender                |      |      |      |      |      |         |         |         |
| Men                   | 12   | 12   | 20   | 9    | 21   | 17      | 22      | 134     |
| Women                 | 2    | 6    | 1    | 2    | 2    | 3       | 16      |
| Total:                | 14   | 18   | 21   | 11   | 21   | 19      | 25      | 150     |

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As of January 2005, a total of 37 participants are registered for Offshore Engineering with the university; this list includes the 10 starters mentioned above as well as six who have completed their academic work since 1 September 2004 and already have been awarded the Offshore Engineering Master of Science Degree diploma.

Until 2005, unavailability of qualified coaching staff has limited this project to a maximum of 21 participants, by the way. The table summarizes the participation in the field development project since 1997. It excludes Dredging Equipment Design students who have chosen to approach that study via a Mechanical Engineering Masters Degree path. Only 12 students have completed a 'pure' dredging equipment design program as part of the Offshore variant in the period covered by this table.

The group that is taking part in the 2005 project started in Offshore Engineering in September 2004. The fact that only 10 of this group of 25 are actually registered for Offshore Engineering is probably the result of automatism from the past; many will most likely switch to Offshore Engineering in the future.
occurred just after the most relevant classes had been completed for this year.) In this particular case, the average grade for this question (representing 40% of the total grade) was the same as the average for the entire exam.

These kinds of questions require participants to work at higher intellectual and thus higher curriculum profile levels. See Fedler and Brent (2004).

Generally, everyone successfully completes the intensively coached Survey of Offshore Engineering project and its evaluation discussion. However, some (new) participants underestimate the difficulty of and effort required by some Offshore Engineering courses. Apparently they are not yet accustomed to the professional school atmosphere (like working in a professional environment); this has an obvious temporary negative effect on their performance.

### 4.4.10.2. Curriculum-Level Progress

The curriculum leader has regularly-scheduled office hours and attempts to meet with each curriculum participant about twice per year to discuss the participant's curriculum choices, progress, and plans for the coming period. On average, these meetings occur spontaneously as participants drop in during his office hour. At the other extreme, a few fail to respond even after having been sent an e-mail invitation for a discussion. All of these discussions have a dual purpose:

1. They help the curriculum leader with the planning of coaching and other pending academic activities.
2. They confront each participant with his or her own progress, and in some cases lead to suggestions of ways to improve one's academic performance or optimize one's planning.

Even though this goes on, it is felt that each participant is primarily and individually responsible for his or her own study tempo and progress through the curriculum. Other factors that influence a participant's study tempo have already been mentioned.

### 4.4.11. Curriculum Developments

As will become obvious in section 4.6, the Offshore Engineering curriculum continues to undergo a continual evolution. Guided by the motto: "Keep that which is good, but strive to improve," the curriculum has undergone - usually small - changes each year since the first participants joined the modern Offshore Engineering curriculum in January of 1997.

Of the four curriculum accent areas:

1. Bottom Founded Structures
2. Deep Sea Dredging Equipment
3. Floating Structures
4. Subsea Engineering

the first three have a historical support basis within the university:
Bottom Founded Structures in Civil Engineering for hydromechanics, structural and geotechnical engineering and design.
Deep Sea Dredging Equipment in Mechanical Engineering for drive systems, slurry transport and pumps as well as the process of excavating soils and rock.
Floating Structures in Marine Technology for hydromechanics, ship layout, as well as structural design.

Subsea Engineering has never had a real base within the Delft University of Technology. Part of the reason for this is that it is the newest of the accent areas within the offshore industry. It received only cursory attention as part of another course in the Offshore Engineering curriculum until the fall of 2002. Even with the introduction of its own place in the curriculum, Subsea Engineering has had to be taught by a teacher who comes from England specifically to teach this course; there is too little overall expertise in this area within the Delft University of Technology, itself. (Of course there are many topic areas in Delft - such as control engineering - that can find challenging applications in Subsea Engineering; what is lacking is the overview and stimulating coordination.) To fill this vacuum, plans are being formulated (as of early 2005) to seek and appoint a full-time full Professor of Subsea Engineering to be stationed within Mechanical Engineering.

There is a plan to add an additional required core curriculum course on offshore structures. The objective of this course is to give all participants more depth of introduction to all sorts of offshore structures than can be achieved within the Survey of Offshore Engineering lectures.

It can be expected that the course in Drive System Design Principles will become a required course for both the Floating Structures as well as the Subsea Engineering Majors - in addition to its current status within the Deep Sea Dredging Equipment Design accent from the Fall of 2005. This is motivated by the need to use drive systems for both subsea work and for dynamic positioning systems on floating structures.
The addition of a Renewable Energy accent (initially as a minor only) to the Offshore Engineering curriculum has been suggested by the Education Committee. This accent would utilize existing courses on topics such as wind energy and offshore wind farms, but would also add a new course on wave and current energy conversion. On the one hand, this looks like an attempt to ‘return to the old ways of doing things’, but on the other hand, it can be a pragmatic suggestion given the extent of the personnel changes to be expected within the foreseeable future. The main reason is however that dredging in deeper waters is a logical development in the dredging industry.

4.4.12. Ways to judge the participants (F11)

A number of ways to judge the participants is used, sometimes in a combination of different ways. As described in the didactical philosophy, the participants need to have knowledge and skills, but more important a scientifical approach to problem solving. The approach or methodology is in fact more important then the specific problem the students have to solve. To judge the abilities of the participants, different methods are used:

- Written exams for the more theoretical courses
- Presentations and reports for courses with projects
- Reports and presentations for projects
- A report, presentation and an oral exam for the thesis

To ensure the quality and objectiveness, a small group of teachers is involved in judging the courses with projects, the projects and the thesis, so the result never depends on one teacher.

An analysis of the balance between the different methods of judging has to be carried out.

4.4.13. Strengths and Weaknesses

This section has yielded the following strengths:

S4.3a The curriculum is academic and both scientific and professional.
S4.3b The inclusion of accents and sectors within the curriculum helps to structure the course offerings - and as it is done here - without sacrificing educational objectives.
S4.3c The Subsea Engineering accent was added to the curriculum in the fall of 2002 in response to signals from the offshore industry.
S4.3d The Dredging Equipment Design program from Mechanical Engineering has been relatively easily absorbed within the Offshore Engineering curriculum as a fourth curriculum accent in the fall of 2004. It has been expanded to include Deep Sea Dredging Equipment as well.
S4.3e The Offshore Engineering curriculum more or less matches the profile set out for it. It also satisfies many of the Body of Knowledge requirements - keeping in mind that some of these can only be attained during one’s first years of professional practice.
S4.3f The Survey of Offshore Engineering (Lectures plus Project) exposes all curriculum participants to the breadth of Offshore Engineering in a very professional-like way while at the same time helping them to enhance what is called their ‘professional survival skills’.
S4.3g Research has been strongly linked to the curriculum. Two complete courses - Offshore Moorings and Offshore Wind Farm Design - are both products of research carried out by university staff and offshore engineering participants.
S4.3h The planned study load per quarter, semester or year is within reasonable limits - on the assumption that there is a correct relationship between credits and participant effort. (This will be discussed in § 4.7.3.)
S4.3i The curriculum as a whole is attracting a sufficient number of participants each year and is operating at near capacity.
S4.3j The curriculum evolves continuously from year to year. Past evolutions will be discussed in § 4.6.1. The proposal of a new accent in on Renewable Energy is proof that this process is continuing.
S4.3k A plan to strengthen the Subsea Engineering accent by appointing a new full-time professor is beginning to take shape early in 2005.

The following weaknesses have been found:

W4.3a The design and use of experiments within the Offshore Engineering Curriculum is relatively weak. The experiments used are too 'standard' and most participants have no opportunity to carry experimental work 'from scratch'. Given the expected closing of some lab facilities and the cost of maintaining remaining labs, it is unrealistic to expect this weakness to be alleviated. On the other hand, the Mechanical Engineering as well as the Marine Technology BSc curricula do require all students to carry out experiments or simulations as part of their BSc thesis work.
W4.3b Participant discipline when it comes to meeting course pre-requisite requirements is weak at best.
W4.3c Participant time planning is sometimes weak; they commonly have difficulty adjusting to peak loads and to meeting the associated deadlines within a given quarter. This is in spite of
attention to planning and time use effectiveness-enhancing methods discussed during the Survey of Offshore Engineering Project.

4.3d The Survey of Offshore Engineering Project is more difficult for participants who are unable to simultaneously take part in a significant number of other Offshore Engineering courses. Their attention for these other courses can be limited by a need to complete BSc curriculum requirements.

To solve these problems, a number of measures will be taken. Some courses like Drive System Design Principles and Offshore Moorings include research oriented assignments (per September 2005). The official entrance requirement of having completed the BSc will be used more strictly. Students will be assisted in making a proper planning more actively by the Curriculum Leader.

4.5. Staff (F12, F13, F14)

4.5.1. Personnel Overview

The tables below provide a total overview of the teaching and research associated with the Offshore Engineering Master of Science Degree curriculum. The first table gives a quick overview of the 12 teaching professionals by rank, etc.

The low percentage of PhD's can be explained by the fact that most staff members are specialized in the design and development and not in the fundamental research. It is still not very common to write a PhD thesis on a design although it is possible.

This is augmented by the second table that also includes university Offshore Engineering research staff as well as others with an indication of where they are based. (Not all of the teachers are from the university and the university staff also come from various faculties, etc.)

The curriculum derives its primary university support from 20 professional staff of which 12 provide the educational effort of 3.6 fte.

Each of the 32 others listed in this right-hand column of this second table devotes less than 0.1 fte to Offshore Engineering education. All contribute to classroom instruction - by providing only a few hours of lectures in an Offshore Engineering course or by providing a course primarily for others (such as Basic FEM) that is also utilized by the Offshore Engineering curriculum. Of the 32 persons in this group, 13 come from industry without including those who only coach industrial thesis work.

Offshore Engineering has traditionally made very effective use of its limited university staff resources. This has been achieved partially utilizing teaching activities originated for other groups as well as by placing the actual responsibility for 'running' the curriculum with its curriculum leader who maintains good contact with participants and staff about all sorts of academic matters. It remains to be seen to what extent formal requirements (and extra overhead) associated with the (new) Masters Degree status of Offshore Engineering will reduce this overall management effectiveness.

The supporting staff at the bottom of the latter table includes a student counselor, two subgroup secretaries and two other supporting staff members.

A complete list of names, along with research interests and efforts is provided in appendix 4.5. The distribution of teaching input among the core and curriculum accents is also indicated in that table.

Biographical outlines for the 12 earmarked teaching faculty are bundled in appendix 4.6.
Student-teacher ratio data is presented in chapter 4 after the total number of participants and their study tempo has been discussed.

### 4.5.2. Relation to Research

Eight PhD candidates provide much (6.8 of the 8.5 fte) of the (formal) research effort. One additional PhD candidate is on leave to England for the 2004-2005 academic year. More informally, a group of roughly 20 Masters Degree participants per year also delivers up to roughly 10 fte of research effort themselves. While these researchers are usually a bit less effective and their work is more diffusely spread over a number of industries, the value of this work for the Dutch economy as a whole must not be forgotten.

Research interests for the earmarked Offshore Engineering staff are listed in appendices 4.5 and 4.6. Thesis topics as well as the supporting industries for a number of recent graduates are listed in appendix 4.7. Many of the faculty research interests as well as a significant number of PhD dissertations as well as Masters thesis studies provide new information that the teachers 'recycle' into the curriculum via their courses.

Beside the PhD research projects, the staff members of Dredging and Shiphydromechanics also carry out research projects and incorporate the results in their courses where appropriate.

The new chair of Offshore Engineering in the 3mE faculty will also have research tasks. This will be more clear after appointing the new full professor.

### 4.5.3. Developments

As of early 2005 there is a plan to seek and appoint a full professor for subsea engineering to be based within Mechanical Engineering (3mE). Both those in the university and those from industry applaud this plan, but filling this position will not be easy:

- There are relatively few qualified persons in the world.
- The current Subsea Engineering teacher is too near his pension and has no interest in coming to Delft on a full-time basis.
- University salaries are meager compared to the industry.

The position could be made more attractive if provisions were also made for him or her to have a supporting staff of junior subsea engineering professionals as well. In the current plans there will be 2 vacancies for new staff members.

The administrators hope to have the new professor on-the-job by the end of 2005. His or her arrival along with appropriate staff can make it possible for the university to provide its own expertise - which now comes exclusively from industry - for both teaching and research within the Offshore Engineering curriculum’s Subsea Engineering Accent.

The current full-time Professor for Dredging Equipment Design will retire in 2006. The dredging industry will provide the fundings for a part-time professor to continue to lead education and research for the Dredging Design Accent within Offshore Engineering. The negotiations with the industry have started in November 2005.

The current full-time Professor for Ship Hydromechanics who leads the Ship Hydromechanics Lab within Marine Technology is scheduled to retire in 2006. Given the importance of this position for both the Offshore Engineering and Marine Technology curricula, current planning is to appoint a new full-time professor in this position. He or she can be expected to (continue to) support both curricula.

The current curriculum leader has indicated that he would like to retire in 2006 as well. Actions for his succession have been initiated as of the Spring of 2005.

In spite of the above plans-retirements, the more generalist core of the Offshore Engineering staff is still weak. Indeed, the other side of the staff effectiveness is the curriculum’s dependence upon only a very few key staff. More than 40% (1.5 fte) of the educational effort is provided by only two of the 12 earmarked teaching faculty.

Loss of either of these experienced persons can cause a precarious situation. By now, both of these persons are over 60 years of age, and one will be retiring in 2005. Prof. Vugts called attention to this in a letter to the Dean of Civil Engineering in the fall of 1999; see appendix 4.8. No structural solution to Prof. Vugts' problem has been proposed or implemented as yet. However within 3mE calculation have been made regarding the required human resources and this will result in 2 vacancies for scientific staff.

The distribution of staff effort over the core curriculum and the four curriculum accent areas has been shown in the latter table in § 4.5.1. The retirements as well as the planned new appointment for Subsea Engineering - already discussed above - are indicated in that table as well.
4.5.4. **Strengths and Weaknesses**

This section has yielded the following strengths:

- **S4.4a** The Offshore Engineering curriculum has traditionally made very effective use of its staff as well industry to provide both classroom teaching and thesis coaching.
- **S4.4b** There is a strong link between faculty as well as participant research and the educational program. The fact that most Masters thesis are carried out in industry strengthens the relevance of that work for the (primarily Dutch) economy as a whole.
- **S4.4c** Mechanical Engineering has responded to subsea engineering developments in industry by planning to add a new full-time professor of Subsea Engineering.

This section has also exposed some weaknesses as follows:

- **W4.4a** The academic staff supporting the Offshore Engineering curriculum is - as a group - too old. At least seven of its 12 earmarked university teaching staff are over 50 years old. At least three will be retiring by the end of 2006.
- **W4.4b** There is an imbalance in the allocation of teaching staff across the curriculum accents.

As mentioned above, appointing a new full professor and at least 2 scientific staff members should solve this problem.

4.6. **Facilities (F15)**

4.8.1. **Classrooms**

In 2002, Offshore Engineering partially funded the modernization of classroom 3.99 (shown in these photos) in the Civil Engineering building. The faculty provided some new floor covering, doors, a new ceiling and beamer were installed along with new lighting and electrical wiring. Offshore Engineering provided the electronic whiteboard and decorated the room with a series of appropriate photos. All in all, the classroom, with a normal capacity of about 35 to 40, was at the time the most modern in the Civil Engineering building. This room is located just down the hall from the offices of three primary Offshore Engineering teachers; this makes it especially easy for them to take demonstration and other teaching materials with them to the classroom.

A new modernization is taking place in January of 2005 - again paid for from external funds earmarked specifically for Offshore Engineering - to replace the electronic board with a special computer screen instead. This makes it possible for the speaker to face the audience while 'writing on the (computer screen) board' and - more importantly, the projection screen can be mounted higher so that it is more visible to those sitting toward the back of a more full classroom. This is especially important given the flat floor of the classroom and the larger groups of Offshore Engineering participants now using it.
In return for this investment, Offshore Engineering has been given first claim on the use of this room for its classes each year. (Others do use the room when it is not needed for Offshore Engineering.) Most of the Offshore Engineering courses are scheduled in this 'offshore' classroom. Most classes taught by the Dredging Lab staff are taught in the Mechanical Engineering building across the street; they prefer to work nearer to their offices, too.

The intensive use of 'their own' classroom by Offshore Engineering participants also reinforces the 'community of scholars' atmosphere mentioned in section 1.1. Everyone seems to share a pride in the room; its remains remarkably neater than several of the other classrooms in the building.

### 4.8.2. Participant Team Meeting Rooms

Several Offshore Engineering courses require participants to work in teams - of usually between 3 and 7 persons - outside of class time on various projects and exercises. The Survey of Offshore Engineering Project is the most striking example of such team work, but other courses such as Bottom Founded Structures, Offshore Wind Farm Design or Design of Dredging Equipment all include unscheduled team activities that cannot take place in the regular classroom. Unfortunately, the Civil Engineering group of buildings offers little space - other than a few areas with tables and chairs in open hallways - where teams can meet, converse and otherwise work together.

Since some of the Offshore Engineering participants have done their BSc study in Mechanical Engineering or Marine Technology, teams sometimes work in the building for Mechanical Engineering and Marine Technology. This building provides a myriad of open study places - often with computers and has special rooms for team work. Additionally, nearly all library study spaces are designed for individual rather than team use.

Offshore Engineering participant teams currently meet in a variety of other locations as well such as:

- One of the few meeting rooms in the Main Library.
- The Offshore Student Club offices in the Civil Engineering building.
- Any un-used classroom during a lunch break.
- Meeting facilities in other university buildings.
- Participant homes.

An ideal meeting room provides a comfortable working environment in a closed area so that sounds do not disturb others. Equipment should include a number of computers (or (wireless) internet connections for laptops), a whiteboard, etc. and possibly even a beamer for practicing presentations or giving a prepared talk in addition to adequate table space and comfortable chairs. A faculty team in Civil Engineering is currently (early 2005) working out the design criteria for good team meeting rooms for this building.

### 4.6.3. Offices and Material Infrastructure

Generally speaking, the teachers and those others who often have to work with individual or small groups of participants have their own personal offices within the Civil Engineering or the 3mE building. The offices for the most important teachers are located on the same floor as - and not too far away from - the 'offshore' classroom, room 3.99. All of these offices have tables and chairs, filing cabinets, desktop computers and internet connections. Even wireless internet is available in this part of the building, but as far as is known, only one of the offshore staff makes use of this.

Printing work is done either on a b/w laser printer in the secretary's office or for color work on a printer maintained by the Hydraulic Engineering team within Civil Engineering. Civil Engineering has recently implemented a plan to concentrate B/W document printing and copying at a more limited number of specific locations within the building. One objective is to provide better quality work with less management and maintenance. The negative side of this is that many users will have to walk farther to pick up their printed work and it will be more difficult to assure the confidentiality (when needed) of work being printed in such a public area.

Participants as well as staff can make use of general copying and binding facilities on the ground floor of the Civil Engineering building; they pay the usual fees for this. Participants working in industry - for example on a thesis - usually make use of the host industry's facilities as part of the industrial support they receive.

PhD candidates and some part-time staff such as a student assistant usually share office space. Each office user has his or her own computer and internet connection however.

One office is shared by Offshore Engineering MSc participants who must work within the university in order to utilize special facilities such as computer software or a lab.
The Offshore Engineering Student Club (or Dispuut Offshore Technologie (DOT) in Dutch) has the use of one office allocated to Offshore Engineering.

Civil Engineering is currently planning a significant reduction in the number of offices used, because of a university wide reorganization and limitation of the total number of buildings. It is now (early 2005) too early to determine how this will change the arrangements outlined above. In any case, it should be done with intelligence instead of policy. For example, the curriculum leader and the student counselor often have private meetings with participants. They must keep private offices in order to be able to continue to do this effectively.

Some individuals who do not need special facilities carry out their own work in one of the university libraries. Indeed, many offshore participants seem to be frequent users of the Civil Engineering faculty library.

Most course notes, and other participant materials are usually distributed via the Offshore Engineering office rather than the Civil Engineering faculty bookstore. This practice was adopted more than a decade ago so that participants would not - at that time - have to 'roam all over the campus' to accumulate course materials which at that time were sold from at least four different buildings. This also provides for sufficient distribution control; some teachers stipulate that their notes be distributed only to participants who are registered to take part in their class.

### 4.6.4. Ship Hydromechanics Laboratory

The small towing tank in the Ship Hydromechanics Lab is used by small teams of up to 6 participants for two half-day sessions as part of the Offshore Hydromechanics course.

Even though this tank is relatively small by commercial standards, it is still impressive for a university facility: The tank is 1.25 m deep, 2.75 m wide and 85 m long. Its towing carriage can travel at speeds up to 3 m/s in either direction. Regular as well as irregular waves can be generated at one end of the tank as well.

Participants spend one half-day observing - see the picture - vortex-induced vibrations (VIV) and determining the hydrodynamic interaction coefficients for a slender cylinder. During the other half-day they determine hydrodynamic coefficients for a larger, more ship-like structure. Both of these lab sessions have a strong 'exercise' component in that the test set-up and experimental procedures have already been determined for the participants beforehand.

### 4.6.5. Dredging Laboratory

All participants majoring in Dredging spend about three weeks in the Dredging Equipment Lab (see photo) working along with a research project that is then going on in that lab. Participant activities can be quite varied and range from sedimentation tests, hydraulic excavation of clay, sand-water flow through centrifugal pumps, velocity and concentration profiles in sand-water jets with high concentrations to research on radioactive concentration meters to more accurately measure concentration profiles in pipelines.
4.6.6. Library

4.6.6.1. Introduction

The attention given to modern library use within the Offshore Engineering curriculum core (see §4.3.2) makes a good and handy library facility important to the curriculum’s participants.

The Delft University of Technology Library is one of the larger engineering libraries in Europe. About 8,000 new titles are added within the university’s library system each year. The library is organized as a system of libraries within the university; there is a central or main library as well as a number of satellite libraries in other university buildings. The main library as well as its satellite facilities for Mechanical Engineering & Marine Technology as well as for Civil Engineering are discussed here.

4.6.6.2. Main Library

The Main Library’s open stack collection of recent books, etc. includes over 50,000 items. A much larger number of older works are kept in a closed-stack section. The main library provides a number of services for all of the satellites:

- Purchasing
- Cataloging - via a central electronic catalog.
- Virtual Knowledge Centers.
- 5,000 electronic journals available anywhere on campus.
- Preservation and storage of older books, etc.

In addition, the central library maintains a collection of about 2,500 printed periodicals; these are not loaned out. The building also provides about 800 individual study spaces; 200 of these are equipped with computers.

Opening hours

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4.6.6.3. Civil Engineering Library

The Civil Engineering Library maintains a modern collection of about 16,000 books and 300 periodicals. Older works ‘migrate’ almost automatically to the closed stacks of the Main Library. The Civil Engineering Library has been developing its map collection - including a respectable collection of marine charts (including some in electronic form) over the past years. Other significant map collections will be moved to the Civil Engineering library in 2005 as well. The photo shows part of the Civil Engineering Library during an examination period.

Books in this library are included in the university’s central catalog and are shelved according to the same subject classification system as is used in the Main Library.
The Civil Engineering library, located on the first floor of that building normally provides 60 individual study spaces. Of these, 16 are integrated study spaces with a PC and internet access. An additional ten PCs for various other purposes can be found here, too.

Because Offshore Engineering has 'grown up' in this faculty, it is not surprising that Offshore Engineering is prominently represented in its library. It has the largest satellite library collection of Offshore Engineering items in the university library catalog. About two thirds of the more than 900 items cataloged have been published more recently than 1990.

The university's Civil Engineering Virtual Knowledge Center includes a special section for Offshore Engineering (Offshore Technologie in Dutch).

4.6.4. Mechanical Engineering and Marine Technology Library

The combined Mechanical Engineering and Marine Technology library is being closed early in 2005, due to a university wide reorganisation. Its collection is being moved to the Main Library. Given the central role that a modern library (or resource center) plays - even today - in a modern community of scholars, this action is not conducive to a student-friendly atmosphere within this building. It weakens the support for all students and staff on the west side of the Mekelweg.

4.6.5. Offshore Engineering News

The Offshore Engineering News is a more or less monthly Newsletter edited and published by the Offshore Engineering Curriculum Leader. It typically publishes the latest information about such coming events as:
- Thesis presentations.
- Scheduled exams.
- The start of classes.
- DOT activities.
- Company recruiting visits.
- KIVI NIRIA Offshore Techniek group activities.

This was originally distributed by snail-mail. More recently it is routinely distributed via E-mail. The latest edition is also prominent on the Offshore Engineering website, www.offshore.tudelft.nl; earlier issues can be viewed there as well.

4.6.7. Information Technology Use

4.6.7.1. E-Mail

Offshore staff members have used E-mail for communications since soon after it was introduced within Delft University of Technology. This is now used routinely by both participants and staff. Just as has been the case with 'old-fashioned' junk mail, the increasing flood of E-mail encourages one not to read everything that comes along. A decreasing attentiveness for the content of the Offshore Engineering News is one negative result of this trend.

4.6.7.2. Website

Offshore Engineering currently (early 2005) has its own website (www.offshore.tudelft.nl) It was set up a few years ago as a means of communication with our own participants as well as the 'outside' world and to make it possible to have an online database of participant data that could be easily accessed.

Since the beginning, the website has been set up and maintained by student assistants. The lack of clear and complete programming documentation along with evolving database needs coupled to the continuing evolution of the curriculum have resulted a system that is often less than optimal in daily use.

A popular and reasonably dependable feature of the website is the online schedule of classes. Anyone can access this to determine when a particular course meets or what courses are being presented on any given hour, day, or week, etc. It is the Curriculum Leader's task to keep the information in this schedule up-to-date.

Other public website features include:
- Abstracts of completed thesis projects.
**Offshore Engineering News** and its archive.
Information on admissions, etc. for prospective participants.

In addition, the website also includes a password-protected segment in which the primary feature is database with addresses and the curriculum planning for each curriculum participant. Only a very select group of persons can access this part and even fewer can make changes to records in it. For example, any entry in a participants database record can be modified - new course choices added, for example - by the Curriculum Leader when he meets with the participant; see § 4.5.9.

A participant, on the other hand, may access only his or her own record and is allowed to change only certain entries in the database such as a phone number or E-mail address. Anyone who is not already known within the database is denied access to this entire protected portion of the site.

The DOT uses the same database and has access only to name and address data on everyone. They do have a segment for their own administration as well.

The Dredging Lab and the Dredging specialty within Mechanical Engineering continue to maintain its own website: www.dredgingengineering.com. This website gives information on the old Dredging curriculum and contains many downloads of lecture notes and scientific papers. This will ultimately have to be integrated into the offshore site to form a single main website.

The university administration has announced plans to streamline the structure - and possibly the content - of all of the websites associated with the university. Progress with this seems to be slower than was initially promised; it is not yet known what the consequences of this plan will be for the offshore website as described above.

### 4.6.7.3. Blackboard

Blackboard software is being used by a very significant and increasing number of teachers and courses within the Delft University of Technology to enhance communications with and among course participants. Several - but not all - of the Offshore Teaching staff make use of its features as well. Luckily, the non-users are a shrinking group as they leave the university - via pensioning or otherwise. Participants may be relying on Blackboard too much; at times it seems that in their eyes, 'if it ain't on Blackboard, it doesn't exist!'

### 4.6.7.4. Specialized Software

Several courses make use of specialized software to enhance the value of material taught or to avoid the 'slavery' of laborious computational procedures so that course participants can focus their attention on the analysis of the relationships between input and output instead of on the mechanics of computation procedures.

AQUA has recently become available in addition to the Delft University of Technology's own Delfrac software for carrying out various hydrodynamic computations associated with floating bodies in waves and currents. This software is made available to participants for educational purposes free of charge.

All participants use QUESTOR to carry out cost analyses of their field development concepts within the Survey of Offshore Engineering Project. This quickly identifies the primary cost drivers of their projects so that the participant teams can quickly zoom in on a purposeful economic optimization of their plan. Special free licenses for this software are provided by its supplier which are valid only for the duration of the project each year.

A series of students have developed special user-friendly software to carry out mooring design computations in the Offshore Moorings course. Although commercial software is available, this has generally been considered to be both too expensive and too cumbersome to use for student exercise work. The development work has been done by combining thesis work with exercises for elective courses in software development.

### 4.6.8. Participant Mentoring and Coaching

Participant mentoring and coaching has already been mentioned. It can be split into three phases depending on a person's position in the curriculum:

1. Initially, the curriculum leader (and, for participants coming from outside the Delft University of Technology, the general student counselor) screens applicants to determine their qualifications and motivations for choosing Offshore Engineering. An important discussion point for the university's own BSc candidates is the degree to which they have finished their BSc curriculum before they will start on their MSc study. Those who must still complete too many credits or essential supporting courses within their BSc curriculum are generally advised to wait a year before starting in Offshore Engineering. Offshore Engineering participants are
expected to have been awarded their Bachelors Degree before they complete the Survey of Offshore Engineering Project work at the end of their first Offshore Engineering MSc year. The fact that this 'rule' has not been strictly enforced has already led to some disappointments later in the curriculum. A few participants have not been able to receive an Offshore Engineering Diploma because they had not completed all of their course work by the time they held their final thesis presentation.

2. Once a person becomes an active curriculum participant, the curriculum leader meets with him or her to consult with, to hear about and assure the motivation for the chosen accents, majors and minors within the Offshore Engineering curriculum. Even so, the initiative for selecting elective courses lies with each participant. He or she must motivate these choices to the curriculum leader, however. The general study counselor remains available to advise individual participants about other more general academic or personal matters.

3. Once a participant has started on a thesis, he or she is coached by a team that includes at least three Delft University of Technology faculty members as well as any relevant industrial coaches. This team is formed as soon as the thesis topic has been sufficiently defined. The committee guides the thesis work and monitors the participant's completion of any other remaining curriculum requirements. The curriculum leader serves ex-officio in each of these committees. In this way, he maintains contact with each participant, but more importantly, he helps to assure that a uniform grading system is used to evaluate each thesis.

Completion and a public presentation of the participant's thesis work culminates his or her study; the Offshore Engineering Master of Science Degree diploma can then be awarded a few minutes after the completion of the public presentation.

4.6.9. Expected Developments

4.5.10.2. Introduction

One expected facilities development, the closure of the Mechanical Engineering and Marine Technology Library has already been mentioned.

There are other (potential) developments as well; these are outlined in separate sections below.

4.6.9.2. Dredging Lab

The entire Dredging Lab within the Delft University of Technology will be closed during 2005. As this is being written (in the Spring of 2005) negotiations are nearing their climax to:

- Move the slurry transport circuit to the new dredging lab within 3mE so that this will be maintained there and be available to Offshore Engineering staff and participants.
- Allow Offshore Engineering staff and participants to make use of an existing and much more modern dredging basin already present within WLDelft Hydraulics for educational and research purposes. The present older facility within Mechanical Engineering will simply be dismantled and discarded.

One objective of this change will be to allow Offshore Engineering students in the Dredging Accent to make use of a more modern and complete lab than can now be provided within the university. No curriculum changes are envisioned as a result of this change, by the way.

4.6.9.3. Move the Offshore Engineering Base to Mechanical Engineering

Plans are being discussed to move the administrative base along with the General Staff for Offshore Engineering from Civil Engineering across the street to Mechanical Engineering. On the one hand, this is seen as a logical consequence of the planned appointment of the full-time full Professor of Subsea Engineering within Mechanical Engineering. Such a position can well become the focal point for at least Offshore Engineering research within the university. On the other hand, the Civil Engineering building now provides the best classroom as well as the best satellite library. Mechanical Engineering cannot match this at this time. It is not logical to move Offshore Engineering education across the street if its teaching facilities will be degraded by the move. The Dean of Mechanical Engineering is aware of this dilemma and is working to address and solve this problem.

4.6.9.4. Development of Team Study Areas in Civil Engineering

In December 2004 the Dean of Civil Engineering appointed two faculty members to lead a team to improve the academic environment within the Civil Engineering building. A study now nearing completion as a first step in the team's work (Massie, 2005) makes very obvious that the provision of work spaces for a large numbers of teams
will form an important part of this overall improvement. At least a few years will certainly pass before this can be realized, however.

4.6.9.5. **Strengths and Weaknesses**

The following facilities strengths have been revealed in section 4.5:

- **S4.5a** Offshore Engineering is fortunate to be able to make priority use of classroom 3.99 in the Civil Engineering building. This, most modern classroom in the building, is attractive for both teachers and participants and is located on the same floor as and a short distance from the offices of the most important teaching staff.

- **S4.5b** The Ship Hydromechanics Laboratory provides an excellent setting for participants to carry out some routine tests which significantly increase their understanding of material discussed in class.

- **S4.5c** The Civil Engineering Library is especially prepared to support the Offshore Engineering MSc Degree curriculum. Offshore Engineering is only more diffusely represented in the Mechanical Engineering and Marine Technology Library, which is being closed, anyway.

- **S4.5d** The Offshore Engineering Curriculum Leader plays an important role in participant mentoring. This keeps him in touch with the curriculum as a whole so that he can more effectively respond to needs and suggest improvements to lead the curriculum's on-going evolution.

- **S4.5e** The appointment of a qualified new Professor of Subsea Engineering to work within the Mechanical Engineering and Marine Technology building can do a lot to stimulate Offshore Engineering research input - especially from the more traditional Mechanical Engineering specialties.

- **S4.5f** Luckily Civil Engineering is starting to work on a plan to improve the academic environment within its complex of buildings. This will undoubtedly include the realization of a significant number of work rooms for student teams.

The following facilities weaknesses have been exposed in this section as well.

- **W4.5a** Neither of the supporting faculties - Civil Engineering nor Mechanical Engineering and Marine Technology - has a sufficient number of appropriate workspaces yet where teams of participants can meet to discuss and work together on a variety of exercises and projects.

- **W4.5b** Current planning to move the present Offshore Engineering core team - now based in the Civil Engineering building - across the street will implicitly move much of the curriculum and many students away from the excellent classroom and library which are now provided within Civil Engineering. This should not be undertaken before at least as good or better teaching and participant support facilities - see items S4.5a and S4.5c - can be made available within the Mechanical Engineering and Marine Technology building.

4.7. **Internal Quality Control (F17, F18)**

4.7.1. **Formal Internal Annual Curriculum Reviews**

Leaders of the Offshore Engineering curriculum have held annual (internal) curriculum reviews. This annual path has been chosen - instead of the sometimes more common quarterly reviews - primarily to (continue to) focus more attention on the curriculum as a whole.

The annual review procedure is described in appendix 4.9.

Each review resulted in suggestions for improving the curriculum as well as the individual courses that make it up. The general review results were distributed to all offshore engineering participants as well as to many of the curriculum teachers; these have been bundled in appendix 4.9 as well.

In addition, individual teachers were provided with the specific comments related to their own courses. Since some of these comments were sometimes sharp, it has not been deemed appropriate to distribute these details more widely.

Of course, it was the Curriculum Leader's and now the Education Directors task to (continue to) implement good suggestions and monitor the curriculum to check what happened as a result of them. In general this will first be discussed in the Educational Committee after which the Education Director or the Curriculum Leader will discuss improvements with the teacher in question.

Examples of suggestions and resulting actions in recent years include:

- Replacing an ineffective (industrial) teacher of the Subsea Engineering classes.
Offshore Engineering

- Reducing the Offshore Hydromechanics lab work requirements so that the total effort better matches the credit given.
- Survey of Offshore Engineering Project scheduling changes. This course has been very dynamic in that the structure of its content continually evolves following best industrial practices. Additionally, its scheduling is changed to accommodate - when possible - suggestions made by its participants each year.
- A university teacher has taken part in a special course so that he can present information more effectively in the classroom. This initiative resulted from repeated complaints from participants.
- One course has been entirely dropped from the curriculum - partially as a result of continued, but apparently unheeded, complaints about content and presentation.

The openness with which participants present and discuss their curriculum experiences has surprised some of the newer faculty attending the discussions.

The degree to which suggestions have been implemented has surprised many of the curriculum participants as well. Indeed, any evaluation system soon dies if suggestions do not lead to action and improvements.

4.7.2. Questionnaires

A series of printed paper questionnaires is being developed for the Offshore Engineering curriculum. The first version of these was used in the spring of 2004; the latest version was prepared in January of 2005. Each questionnaire targets a different evaluation objective as follows:

1. **Classroom teaching.** This most commonly used questionnaire evaluates a single classroom session given by a single teacher. Its feedback is intended to help him or her focus on ways to improve the course and its presentation to the audience.

2. **Course examination.** This is used to provide feedback about a specific course exam so that future exams can be brought more in line with the time available and important course objectives.

3. **Overall course review.** This questionnaire - usually distributed along with the exam questionnaire at the end of the course examination - focuses on the course as a whole. Participants can react to all course elements such as excursions and exercises as well as classes.

4. **First MSc year review.** This ‘forces’ attention for the curriculum as a whole. Information can be provided about course gaps or overlaps as well as the distribution of study effort.

5. **Exit review.** This exit questionnaire is normally completed shortly before each participant receives his or her diploma. It structures a review of his or her total experience in Delft while participating in the Offshore Engineering curriculum.

Samples of current (experimental) versions of each of the above questionnaires are given in appendix 4.10. These are based to some extent on a more extensive series of questionnaires presented by Al-Khafaji et.al. (2003).

Printed classroom or examination session questionnaires have been used in an effort to increase the response received. The response to internet-based questionnaires elsewhere in the university has generally been dismal at best. The method used in Offshore Engineering usually assures a very representative response, but requires a significant processing effort - especially for the multiple-choice questions. Luckily, the latter essay question answers on each questionnaire yielded a lot of insight themselves. In the latest questionnaire version a few key questions have been specially marked; a quick review can concentrate on the answers to those few questions.

A procedure for using these questionnaires is under development now.

4.7.3. Reactions from Industry (F19)

The Offshore Engineering curriculum now (early 2005) has no periodic and formal procedure for soliciting, obtaining or processing feedback from the industry served by its graduates. While Al-Khafaji et.al. (2003) did present questionnaires to get feedback from practicing graduates as well as their employers, these particular questionnaire forms have not - as yet - been implemented by Offshore Engineering in Delft.

There are two main reasons for this:

1. There is already a well-developed interaction between industry and the university curriculum. As indicated, 13 persons from outside the university already interact with participants in the classroom and with the university staff during coffee. A variable additional number of industrial staff is regularly in Delft as coach of an industrial thesis or as an industrial recruiter. The curriculum already has a very effective informal feedback system in operation. The external teachers and their courses are also subject to and participants in the use of the questionnaires.

2. The questionnaires are still somewhat of an experiment. It is most elegant to use our own participants to drive the further development process and ‘get the bugs out.’
4.7.4. Internal Evaluation and Evolution Procedures

Until Offshore Engineering became a separate Master of Science Degree curriculum in September 2004, curriculum changes were discussed quite informally within the curriculum’s community of scholars (participants as well as staff). Resulting suggestions for change were then presented and discussed within that same community before they were made known to authorities such as the Examination and Education Committees within Civil Engineering. They apparently approved the suggestions and arranged for their further processing; little more was ever heard.

Now that Offshore Engineering is a separate Master of Science Degree curriculum, its Curriculum Leader and Education Director will have to at least monitor the formal process of curriculum evolution more carefully. As of the time this is being written (February 2005) no formal curriculum evolution approvals have been needed; this text can only describe plans. It is envisioned that the initial curriculum evolution procedures will not change; the discussions and (informal) decisions within the community of scholars will remain intact as outlined above. (This is - in fact - the most primitive form of democracy.) From here, curriculum changes will be discussed - and hopefully approved, as appropriate - by the Examination and Education committees. From there, modifications will be forwarded to both Deans even though the formal top level decision is the responsibility of the Dean of Civil Engineering.

4.7.5. Strengths and Weaknesses

The following quality control strengths are apparent:

S4.6a The annual curriculum review has had surprising success. This is attributed to two factors:
1. Candid openness of all review participants.
2. Demonstrated utilization of suggestions made.

S4.6b The successful annual curriculum reviews have led to a continual but gradual Offshore Engineering curriculum evolution. The curriculum undergoes continual fine-tuning as all involved strive to improve its content and educational quality.

S4.6c Offshore Engineering is experimenting with a series of questionnaires in an attempt to gather more detailed information about the curriculum and its courses in a more systematic way.

S4.6d The large number of external professionals associated with the curriculum - either as teachers or thesis coaches - provides an extensive but informal external evaluation forum.

The last of the above strengths may be seen by some as a weakness:

W4.6a There is no formal structure now in place for gathering curriculum evaluation information from recent graduates or their employers; there is a very effective informal circuit that works well, however.

Since the Offshore Engineering program started in 2004, the graduates are registered and it is the intention to follow them during their careers. A procedure for gathering information is under development.

4.8. Results (F20, F21)

4.8.1. Resulting Level

4.8.1.1. Introduction

The resulting level of a curriculum is best measured based upon the successes of its graduates during the first years of their professional careers. Since the Offshore Engineering curriculum is so new it could be a bit premature to attempt to measure the level achieved in this absolute way. Even so, a few indications of level are available as discussed in the following subsections. Regarding the efficiency, Offshore Engineering attempts to have an efficiency between 95% and 100%. Since there is no Offshore Engineering BSc, the figures in the self evaluations of Civil and Mechanical Engineering and Marine Technology should be used. The few students who completely finished their BSc before enrolling in the MSc have proven that it is possible to carry out the program in the nominal time of 2 years. This is the target of the MSc program.

4.8.1.2. Use of Challenging Questions

The use of challenging questions to force participants to work at higher intellectual levels - as defined by Fedler and Brent (2004) - has already been mentioned. In the particular case reported there the participants’ average score on the challenging question was 7.2; identical to that for the examination as a whole.
4.8.1.3. Questionnaire Results

A very direct approach to measuring the level of intellectual development is to ask about it, via a questionnaire. One of the (earlier) experimental versions of the Exit Review Questionnaire has been used with six graduates. This is a very small and one-sided sample; all came from a Delft University of Technology Civil Engineering BSc background. This makes the general result only slightly indicative at best. Interesting results included:

- Five of the six had had a part-time job outside the university; one had been a student assistant.
- They spent between 2 and 4 years in the Offshore Curriculum; the average was 3.
- All six were moderately positive (score 4 out of 5) about their BSc preparation.
- Average scores on the questions related to their attainment of the curriculum profile and the Body of Knowledge (questions 23 through 38 on the exit questionnaire in appendix 4.10) was just over 4.2. The lowest average score on a single question in this series was just below 3.2 on question 37 relating to creativity.
- The respondents’ ranking of the general study facilities provided in the Civil Engineering building was below average with a ranking of 2.3. They ranked the Civil Engineering library and the building’s computer facilities somewhat higher, by the way.
- All six had done a thesis in industry.
- One ranked his industrial thesis coach with a 1 (poor) while four others gave him or her a 5 (excellent). The low score was not really motivated; the participant only indicated that he might have been better off with another thesis topic and probably another company.
- Their feelings about the best courses were somewhat mixed:
  - Bottom Founded Structures.
  - Offshore Hydromechanics (three of the six).
  - Survey of Offshore Engineering (lectures + project).
  - Thesis work.
- There were also feelings about the worst courses:
  - Finite Element Methods (2 of the six).
  - Dynamic Positioning.
  - Marine Engineering Geology (2 of the six).
  - Offshore Soil Mechanics.
- In general, they suggested that the curriculum be made more challenging as a way of improving it. One suggested replacing more exams with project work as a means of course evaluation.

Commentary on the above:

- One of the worst courses (above) has been dropped from all university curricula. Two of the others have been significantly modified since these graduates had participated in them.
- The suggestion to replace more exams with project work is very much in line with a lot of modern educational thinking. Participants are already aware of the possibilities offered by a community of scholars educational philosophy.

4.8.1.4. Thesis Review

A third way to check the level of a curriculum’s graduates is to review their theses. A list of those who have received diplomas in 2003 and 2004 is included as appendix 4.7 along with their thesis sponsors, thesis titles and thesis grades. A few statistics from that list are summarized in this table.

4.8.1.5. Interest from Recruiters

An indirect measure of the curriculum’s quality is that more and more companies: BP, IHC - SBM Incorporated and Shell routinely schedule recruiting visits to Delft specifically for potential Offshore Engineering graduates. Several of the 14 companies hosting Offshore Engineering thesis participants in 2003 and 2004 have employed recent graduates without a specific recruiting visit.

4.8.2. Participants and Study Tempo

As of January 2005, there were 37 participants in the Offshore Engineering curriculum who were also officially registered for the Offshore Engineering Masters Degree within the university. This can be seen in the table in § 4.3.9.2. That table also shows that only 11 of the 28 new participants in 2004 registered for Offshore Engineering. This leads one to suspect that about half of the new participants simply registered in their BSc faculty again. Many may have done this because they still had/have to finish their BSc curriculum; a few may have done this simply "automatically" without much thought.
Six of the 37 participants listed have already received their Master of Science Degree in Offshore Engineering. Indeed, some who joined the curriculum in 2002 and 2003, did this in the hope that the Masters Degree in Offshore Engineering would really start in September of 2004. The general policy, by the way, is that participants who had already started on the MSc Degree (as measured for Offshore Engineering by their completion of the Survey of Offshore Engineering Project) before 1 September 2004 have the option of completing a Masters Degree in the same field as their Bachelors Degree or (ultimately) switching to Offshore Engineering.

Statistics on study duration have been compiled using data from 60 participants who have graduated since the Offshore Engineering has had more-or-less its “own” curriculum - from February of 1997. It excludes, therefore, 12 who have completed the Dredging Engineering specialty in this same period within Mechanical Engineering and completely outside the realm of Offshore Engineering.

The curriculum duration was shortened from 2½ to 2 years starting in the fall 2002. To keep this change from distorting the data, study durations are expressed as a percentage of the nominal curriculum duration. One should note that these durations represent the total time spent within the Offshore Engineering curriculum. Most of the Dutch participants completed their BSc curriculum, and had some form of part-time job in this period as well. A smaller number took part in an additional study more or less simultaneously or served on a faculty committee or student club board for a year. On the other hand, some delays are simply the result of a participant’s own bad (or lack of) planning - in spite of the attention given to this in the Survey of Offshore Engineering Project. The average duration of 152% of the nominal time is therefore an inflation of the actual time spent on the Offshore Engineering Curriculum. An attempt to trace the historical development of the study tempo revealed only an erratic pattern with average study durations ranging from 141% (for ten participants who started in 2001) to 183% (for 8 participants who started a year earlier). These figures demonstrate how the relatively small number of graduates in each group makes the results erratic; further work will be done based upon the data in the table for all Offshore Engineering graduates given here.

It is noteworthy that three of the four fastest participants in this table had come to Delft from a foreign country to take part in the Offshore Engineering curriculum. These people had already completed their Bachelors degrees, did not have part-time jobs and did not serve on committees. Some even had a visa limiting the total duration of their stay in The Netherlands. The message from this is that with good planning and concerted effort, one can complete a Masters Degree in Offshore Engineering in two calendar years, within the standard quality.

### 4.8.3. Effort for Credit

The participant effort invested in the Offshore Engineering curriculum was discussed in the 2000 evaluation; see appendix 4.9.3. The conclusion was that the study effort for Offshore Engineering courses was quite consistent with the standards and the earned credit; courses required - on the average - an effort consistent with these. Since several complained that they worked much harder than their colleagues in other Delft University of Technology Civil Engineering specialties, one can conclude that those other curricula were apparently too "light". More recently, some participants with a Mechanical Engineering BSc background have remarked that the Offshore Engineering curriculum seems much "lighter" than their BSc experience had been.

### 4.8.4. Student-Teacher Ratio

Student - teacher ratios are commonly determined by dividing the total number of students by the total number (fte) of staff allocated to teaching. Determining a representative student-teacher ratio is not simply the straightforward division of two readily available numbers in the case of Offshore Engineering. Data on the 'student side' is polluted by:
- Those who register early - before starting on the curriculum.
- Students from other curricula who choose one or a few offshore engineering courses as electives.
- Participants who join and participate in the curriculum for a while but leave before finishing.

---

**Overall Study Duration Statistics while in Offshore Engineering**

<table>
<thead>
<tr>
<th>% Nominal Duration</th>
<th>No.</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>90-99</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>100-109</td>
<td>3</td>
<td>Foreign BSc</td>
</tr>
<tr>
<td>110-119</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>120-129</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>130-139</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>140-149</td>
<td>2</td>
<td>Includes best CE grad. 2003-2004</td>
</tr>
<tr>
<td>150-159</td>
<td>10</td>
<td>Includes one MSc in Scotland.</td>
</tr>
<tr>
<td>160-169</td>
<td>12</td>
<td>2 Sigma limit</td>
</tr>
<tr>
<td>170-179</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>180-189</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>190-199</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>200-209</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>210-219</td>
<td>2</td>
<td>Includes one BSc from Erasmus U.</td>
</tr>
<tr>
<td>220-229</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>230-239</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>240-249</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>250-259</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td>60</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**
- Average: 152%
- Standard Deviation: 31%
- Median: 158%
- Mode: 165%
- Includes time for to finish BSc curriculum.
- Includes other simultaneous studies.
- Includes delays till CE diploma awards ceremony.
- Includes part-time jobs; committees or boards.

Revised 05 02 08
The 'teacher side' of the equation is equally hard to define in this case:

- Work done by industrial and guest teachers as well as industrial thesis coaches is not recorded; an attempt has been made to discount this in the computation below. It is questionable whether this should be discounted; several of the industrial teachers receive monetary compensation from the Offshore Engineering budget.
- Nineteen other university teachers each provide a small splinter (<0.1 fte - see § 4.4.1) of teaching input that is not recorded as such.
- Teachers for courses 'bought' from other curricula are not included the quantitative effort data. This has been discounted on the student side as well, however.
- The current curriculum leader only joined the offshore engineering team in the summer of 2004. The Dredging Engineering staff has been included in Offshore Engineering since September of 2004 even though many of the participants in the dredging classes are from outside the Offshore Engineering curriculum. These have been discounted in the computation below.
- Faculty members from outside Offshore Engineering provide their expertise to appropriate thesis coaching teams. This effect has been estimated in the computation.
- Most participants choose elective courses from outside the curriculum.

All of the above considerations make it difficult to make a very accurate computation of the student - teacher ratio. Instead, a more indirect approach has been chosen as given in this table. First, neither the staff from the Dredging group nor the students in the credits taught by each group have been estimated per curriculum accent. The enrollments also include a small margin for others taking Offshore Engineering courses as electives.

The product of enrollment and credits is accumulated on the right. The sums at the bottom of each column are then converted to participant fte by dividing by 120, the number of credits in one's Masters Degree program. The table indicates a grand total of about 18.7 fte participants per year. Given that participants also include elective courses from outside the Offshore Engineering curriculum, this result is roughly confirmed by the data, it shows that about 20 participants per year join the curriculum. Since participants take an average of just over three years - 152% of two years - to finish their curriculum activities, planning should be based on a total of about 60 active participants in the curriculum at any one time. (These are fte participants; the actual number of persons is higher.) The table above shows that the Offshore Engineering teaching team provides about 60% of the teaching so that their efforts should be compared to about 36 participants on the 'student side' of the ratio. In addition, this same staff also provides about one third of the coaching for six of the eight PhD candidates listed in appendix 4.5.

The 'teacher side' of the ratio is must be corrected as outlined above, too. The 3.6 fte for teaching now available, is modified based on the first of the detailed tables in appendix 4.5. Professor Meek spent more time on education up through 2004; his appointment was reduced in January of 2005. The Dredging Engineering staff should not be included as indicated above and the fact that Ir. Lagers only joined the team in July of 2004 must be discounted as well. This brings the 'teacher side' of the ratio to 1.9 fte.

Putting the above numbers together yields an overall student-teacher ratio (STR) of 20 participants per fte
teaching within the Offshore Engineering curriculum.

An analysis of data published by the ASEE and others has been used to provide a comparison basis for the above result. The results of this work - presented in appendix 4.11 - show a significant relationship between the percentage of BSc students in a curriculum and the STR. The figure shows the results as well as the linear regression line fitted to the US data. The current data for Offshore Engineering is also indicated in red on this graph. Older data from the 1999 self-evaluation of Civil Engineering in in Delft yields a STR of 18 for the curriculum as a whole at that time (before there was a BSc - MSc distinction).

The above value of 20 participants per fte teaching for Offshore Engineering in Delft is high by all measures. This confirms the historical efficiency (or systematic overload) of its teachers; see also appendix 4.8.

The myriad of pending staff changes as well as the total uncertainty about the number of new participants that the Deep Sea Dredging accent may attract, makes predictions about the future development of the STR too speculative to include here. On the other hand, there is currently little reason to expect the STR value to decrease significantly unless systematic action is initiated.

### 4.8.5. Strengths and Weaknesses

This section has revealed the following strengths:

**S4.7a** Various indications show that the Offshore Engineering curriculum attains a very attractive professional level:
- In one written test, participants did as well on a special challenging question as they did on the examination as a whole.
- The limited results from an exit review questionnaire for new graduates indicates this.
- More and more industrial recruiters are visiting Delft for the specific purpose of meeting with Offshore Engineering participants.
- Industry supports a record percentage of offshore engineering theses. This is also a form of recruiting.

**S4.7b** Young Offshore Engineering graduates rate the Civil Engineering library as well as the computer facilities within the building as one of its strong points.

**S4.7c** Foreign participants demonstrate that it is possible to complete the Offshore Engineering curriculum within a nominal two years with a concerted effort. The statistics on study duration have been polluted with other - often necessary - activities not directly related to a participant's study.

The following weaknesses have been revealed:

**W4.7a** The (limited number of) exit questionnaire respondents ranked the general study facilities within Civil Engineering lower than they did the library and computer facilities within the same building.

**W4.7b** Improved and realistic study planning by each participant would reduce the total time spent within the Offshore Engineering curriculum.

**W4.7c** The Offshore Engineering student-teacher ratio of 20 is high compared to US universities where - especially for graduate programs such as this one - the ratio should be nearer to 10.

**W4.7d** The administration has done little with Prof. Vugts' suggestions for improving the educational support for Offshore Engineering made in his letter to the Dean of Civil Engineering dated 25 August 1999; see appendix 4.8.

### 4.9. International Positioning

#### 4.9.1. Contacts and Current Position

On the one hand, one can find - via the internet - a significant number of universities worldwide that at least claim to offer Offshore or Ocean Engineering. While not all have been evaluated in detail, many:
- Offer only one or a few courses rather than a purpose-built degree curriculum.
- Target a different maritime cluster sector (§ 1.4.1) such as fishing.
- Target sub-academic participants such as equipment operators.

Our closest colleagues internationally have been and continue to be:
- Imperial College of Science Technology and Medicine (IC) in London, England.
- Massachusetts Institute of Technology (MIT) in Cambridge, Massachusetts, USA.
- Norwegian Institute of Science and Technology (NIST) in Trondheim, Norway.
- Texas A&M University (TAMU) in College Station, Texas, USA.
- HoHai University in Nanjing and ChangZhou, China.
The first of these is one of the three other universities in the European IDEA League.

The first three in the above list formed - with the Delft University of Technology - a consortium that sponsored and arranged periodic International Conferences on the Behavior of Offshore Structures (BOSS) between 1976 and 1997.

There have been contacts with TAMU for both dredging equipment design and offshore engineering for at least 15 years. These contacts have led to joint participation in symposia, etc. as well as to a very modest flow of Delft students to take courses associated with similar studies at TAMU as well as other Texas universities associated with TAMU's Offshore Technology Research Center.

While Offshore Engineering keywords can be found on the IC website, their activities are apparently limited to specialized research carried out by a couple of the Civil Engineering faculty members there. Indeed, the Delft University of Technology has no real colleagues within the IDEA League for Offshore Engineering education.

Contacts at MIT and TAMU have been primarily with staff from their Ocean Engineering curricula. Ocean Engineering at MIT has included a strong environmental and fisheries component as well as research on autonomous underwater vehicles. Until a new Professor of Subsea Engineering is functioning in Delft, one can say that there is little need for stronger MIT contacts for the sake of Offshore Engineering.

The TAMU has an Ocean Engineering curriculum at the BSc, MSc and PhD levels. It has traditionally included Coastal Engineering (part of Hydraulic Engineering within Civil Engineering in Delft) as well as Dredging Technology. In recent years, their curriculum has evolved to better serve the Offshore Industry; they have apparently learned a lot about curricula from Delft.

Cooperation with He Hai University has been centered on Dredging Technology. Both their Professor of Dredging Technology as well as several of his staff have had study and research experience in Delft.

Two recent Delft University of Technology Offshore Engineering graduates have become Offshore Engineering PhD candidates at the NIST. Other Delft Offshore Engineering participants have occasionally spent a semester at NIST in the past - especially in the period that the BOSS Conferences were being organized.

An ever-increasing number of potential foreign students - primarily from Africa and Asia are inquiring about and applying for admission to the Delft Offshore Engineering Master of Science Degree curriculum. While often only a small group of them actually matriculate to Delft - possibly for financial reasons, the number of foreign students actually taking part in the Offshore Engineering curriculum - either completely or for a semester - is increasing. So far, only one student from the IDEA League has come to Delft for Offshore Engineering; he did this on a one-semester exchange.

4.9.2. Possible Developments

The fact that The Delft University of Technology is closing its Dredging Laboratory and that:
- TAMU has recently built a new Coastal and Dredging Engineering Laboratory, and
- HoHai University in Changzhou also has a modern dredging lab

forms an open invitation for stronger cooperation - at least on the research side. On the other hand, industrial political and confidentiality worries may prevent such an idealistic international approach. These 'extra' influences are beyond the control of the Delft University of Technology and its Offshore Engineering team, however.

In addition, bilateral consultations between Delft and NIST are currently going on with an objective of strengthening educational ties. This may result in some form of joint curriculum in the future.

The Delft University of Technology can and should do more to publicize its unique Offshore Engineering Master of Science Degree curriculum within the IDEA League especially, but also in the rest of Europe and The United States.

4.9.3. Strengths and Weaknesses

This section has revealed the following strengths:

S4.8a The Delft University of Technology Offshore Engineering MSc curriculum occupies a quite unique position in the world. The university should publicize this to its advantage.

S4.8b Current negotiations with the NIST can lead to a new phase of Offshore Engineering cooperation initiated with the BOSS Conferences in 1976.

S4.8c The facts that:
A new Coastal Engineering and Dredging Lab has been built at TAMU.
The Delft University of Technology Dredging Lab is being closed.
The TAMU Ocean Engineering curriculum is becoming more and more comparable to the Offshore Engineering curriculum in Delft.

can provide an extra impulse for educational and research cooperation between the two universities.

The following weakness has been found:

W4.8a Industrial political and confidentiality concerns may thwart international cooperation for dredging research. The university can do little about this.
5. **Summary of Strengths and Weaknesses**

5.1. **Introduction**

Strengths and weaknesses have been listed in many sections of the earlier chapters - immediately following the text revealing them. These have been bundled for reference purposes in Appendix 5.1. Their numbering system includes the chapter section in which they were originally stated; this can make it easier to refer back to the supporting information if desired. One change has been made here, however: Weaknesses which are attributable primarily to factors outside the Offshore Engineering team are printed in italic text.

A few more general strengths and weaknesses are listed in section 5.2.

5.2. **Overall Strengths and Weaknesses**

The Offshore Engineering MSc curriculum is a student-friendly, professional and academic curriculum in a research-focused and teacher-centered university. It is especially strong in that it:

- Meets a well-defined industrial need.
- Has been designed starting with that need in mind.
- Has a well-defined curriculum profile.
- Generally meets this profile and an associated Body of Knowledge standard.
- Has appropriately sequenced courses and course activities in harmony with a just-in-time teaching model.
- Provides a progressive intellectual development via its sequence of courses.
- Does its best to create a community of scholars teaching and learning atmosphere.
- Is strongly, but sometimes indirectly (via thesis work), linked to high-level and academic as well as industrially relevant research.
- Has operated with a minimum of overhead. Attention has been focused on the products - education and research - instead.
- Has operated with a minimum of earmarked teaching staff.
- Is the only (or one of a few) Delft University of Technology curriculum receiving direct industrial financial support earmarked for Offshore Engineering education.
- Requires a participant effort commensurate with the credits earned and the published university norms.
- Evolves continuously to continue to optimally meet industrial needs. This involves both fine-tuning the curriculum as well as appointing new staff such as the proposed Professor of Subsea Engineering.
- Has usually attracted a near-capacity number of new and generally highly motivated participants each year.

The Offshore Engineering MSc curriculum suffers from the following university weakness:

- The university's administrative structure is not yet adapted to accommodate activities - such as Offshore Engineering - that obviously cross faculty boundaries. Its typically rigid and bureaucratic structure is counterproductive to a modern and broad 'community of scholars' educational atmosphere.

Closer to home, the Offshore Engineering MSc curriculum itself is weak in that:

- Its university teaching team (12 persons representing 3.6 fte for education) is too small and (on average) too old. Four of its key staff (2.2 fte) are over 60 years of age; three (1.4 fte) will retire before the end of 2006. The only remedy for this is to finance and appoint more new and younger but experienced staff.
- Participants are weak in planning and setting priorities. This results in un-necessarily long study durations for some. While more attention to project planning could be given to this in the curriculum, it could remain ineffective; planning weakness may have deeper cultural roots in The Netherlands.
- MSc study planning would be made simpler for students coming from Delft University of Technology BSc curricula if they were required to have finished their BSc work before starting on their MSc study. This is a common requirement in many other universities, by the way.
- Only a very few participants gain - by chance via a thesis involving this - a good background in the design, execution, processing and reporting of experiments. Given the systematic and structural reduction in laboratory facilities now going on in universities, it is doubtful that this can be improved.
6. References


Anon. (2001): [Projectteam curriculumherziening Civiele Techniek: Vugts, Massie, Touw] Samen een stap verder Stepping Stones to the future; Faculty of Civil Engineering, Delft University of Technology; August. Report plus Appendices, 65 + 99 pp. Note: The main part of this report is in Dutch; some of the appendices - including those most relevant to this report are in English.


