Registration form (basic details)

1a Details of applicant

- Name, title(s):	Pieter C. Roos, Dr ir
- Male/female:	Male
- Address for correspondence:	University of Twente Faculty of Engineering Technology Water Engineering & Management P.O. Box 217, 7500 AE Enschede
- Preference for English correspondence:	No
- Telephone:	053-4895608
- Fax:	053-4895377
- E-mail:	p.c.roos@utwente.nl
- Website (optional):	www.wem.ctw.utwente.nl/organisatie/Medewerkers/Roos
- Doctorate (date):	3 September 2004
- Use of extension clause:	No

1b Title of research proposal Transient Dynamics in the Morphology of Coastal Seas (short title: TRANSIMORF)

1c Summary of research proposal (298 words plus five keywords)

The North Sea is a complex physical system. Water, sediment and the seabed interact according to nonlinear processes that are still only partly understood. These processes continuously affect the shape of the seabed, particularly causing the presence of various large-scale and dynamic seabed patterns: tidal sandbanks and sandwaves.

Besides a fascinating nonlinear system, the North Sea is of huge economical and societal importance. This inevitably leads to conflicts between activities (e.g., sand extraction/navigation dredging) and other interests (e.g., coastal safety). Herein, sandbank and sandwave dynamics are crucial. How these features respond to our intense activities in an environment that simultaneously experiences gradual changes (sea level rise) is unknown. Clearly, our insufficient understanding of large-scale pattern dynamics makes it hard to manage activities in the North Sea.

The proposed research aims at developing morphodynamic modeling tools that provide answers to these exigent questions concerning large-scale seabed patterns versus sea level rise and sand extraction. The very nature of these issues requires embracing the concept of *transient (morpho)dynamics:* the North Sea is continuously responding to abrupt and gradual changes in its environment. The project furthermore bridges a methodological gap in the field of morphodynamic modeling. So far, models particularly designed to study pattern dynamics (type A) have not been geared to deal with engineering problems, whereas engineering models (type B) have not been successful in describing pattern dynamics. The project will improve models of type A, in collaboration with modelers from engineering practice (type B, participating in the user group). Capturing nonlinear dynamics is essential; validation will be done using field data available from European projects and governmental agencies.

This project contributes to a sustainable policy regarding sand extraction in the North Sea. Moreover, it enables improvements in survey and dredging strategies that significantly reduce the cost of seabed maintenance.

Keywords: transient dynamics, nonlinear morphodynamics, large-scale seabed patterns, sea level rise, sand extraction

1d NWO council area **TW** (=STW) Technical Sciences

1e Host institution University of Twente (Faculty of Engineering Technology and Spearhead Institute IMPACT)

Research proposal

2 Description of the proposed research (1,998 words)

2a Research topic

Introduction
The seabed of the North Sea is neither flat nor static. Instead, it displays a variety of dynamic, rhythmic features, acting on different spatial and temporal scales. They are the result of the complex interplay between tides, waves and the sediment that shapes the seabed. The largest of these features are known as *tidal sandbanks* and *tidal sandwaves* (Fig.1) [Blondeaux, 2001; Dyer & Huntley, 1999]. Tidal sandbanks are typically tens of kilometers long, several kilometers wide and up to tens of meters high. Tidal sandwaves often occur in extensive patterns, characterized by wavelengths of 100-1000 m, heights of several m, and usually an asymmetrical cross-sectional shape (Fig.2).

Figure 1: Overview of large-scale seabed patterns in the Dutch part of the North Sea. Dark patches are tidal sandbanks, curly lines indicate sandwave fields. Source: Van Alphen & Damoiseaux [1989].

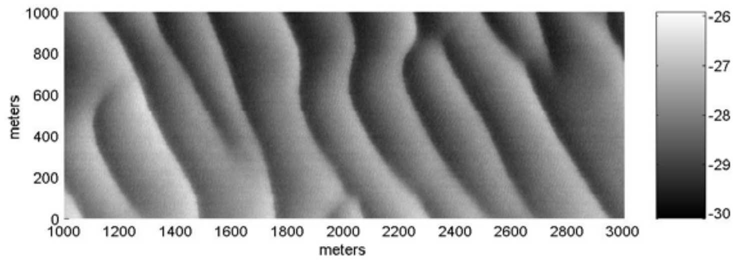

Figure 2: Bathymetric chart of a sandwave field in the North Sea, showing regular and irregular aspects (depth in m). Data from North Sea Directorate.

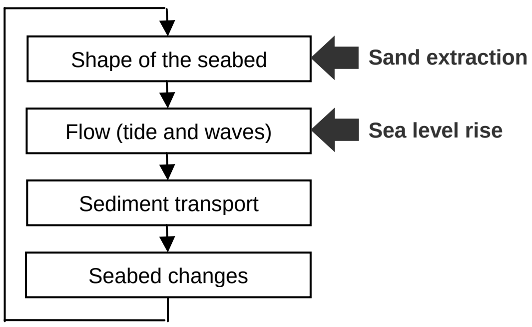

Figure 3: Morphological loop, including external factors like sand extraction and sea level rise (see text).

Besides intriguing manifestations of *nonlinear morphodynamics*[1], sandbanks and sandwaves are of considerable practical importance. Tidal sandbanks protect the coast from waves, act as nursery ground for fish and serve as a source of sand. The Kwinte Bank (Belgium), for example, is already extensively used for sand extraction, whereas the Zeeland Ridges (Netherlands) have been assigned as potential extraction locations. Maasvlakte II, the land reclamation for extending Rotterdam Mainport, requires 600 Mm^3 sand, strongly exceeding the amounts currently extracted (30 Mm^3/yr). The highly dynamic tidal sandwaves, with migration rates up to tens of meters per year, pose a hazard to offshore constructions, navigation, pipelines and telecommunication cables. A sustainable policy towards activities in the North Sea and coastal safety requires a better understanding of sandbank and sandwave dynamics.

Morphodynamic systems like the North Sea behave according to the so-called *morphological loop* (Fig.3). The shape of the seabed affects the flow, which determines the transport of sediments. In turn, the sediment transport controls the evolution of the seabed, thus closing the loop. However, this scheme is incomplete without recognizing several external factors (Fig.3). For example, repeated human intervention like large-scale sand extraction interferes

[1] *Morphodynamics* is the study of the evolution of seascapes/landscapes under influence of erosion and sedimentation.

directly with the seabed. The horizontal dimensions of sandpits are typically several km, similar to the spatial scales of sandbanks (and sandwave fields). Simultaneously, sea level rise [Douglas, 1995] poses a gradual change to the flow environment. The morphodynamic processes are generally so slow (decades to centuries), that the system is actually in a continuous stage of responding to the above changes. Even today the North Sea and Wadden Sea experience changes due to human intervention in the past, like the closure of the Southersea in 1932 and the Delta Works since 1958. Recognizing the importance of *transient dynamics*, the central theme of this proposal, is crucial when addressing both fundamental and engineering problems concerning the morphodynamics of coastal seas.

Relation to existing research
The concept of transient (morpho)dynamics takes the traditional approach of research on pattern dynamics to a higher level. Tidal sandbanks and tidal sandwaves, among other bed patterns[2], can be explained as *morphodynamic instabilities* of a flat seabed [Huthnance, 1982; Hulscher, 1996]. In other words, the morphological loop of Fig.3 contains a positive feedback mechanism by which a pattern of sandbanks or sandwaves tends to emerge. This instability process can be quantified and analyzed in so-called *idealized process-based models* that combine the essential physics with a simplified representation of the geometry. Such models commonly describe the evolution of a flat seabed into a final equilibrium:

(Traditionally:) flat seabed → onset of formation (linear stage) → finite amplitude growth (nonlinear stage) → equilibrium state(s) .

Herein, the linear stage is distinguished from a subsequent nonlinear stage[3], because the dynamics differ and, furthermore, modeling nonlinear dynamics requires more advanced solution techniques. There are three reasons why the above scheme is inadequate and should be modified to include *transient dynamics*.

1. From a mathematical-physical perspective, equilibrium states may not exist within a continuously changing environment.
2. Even if equilibrium states exist, they may never be reached. As the time scale of the autonomous dynamics is comparable to that of the external changes, the system is more likely to be in a continuous stage of responding to these changes. This congruence of temporal scales typically applies to sandbanks versus sea level rise, as well as to the repeated navigation dredging in sandwave fields.
3. Explaining the properties of sandbanks and sandwaves starting with a flat seabed ignores the dynamics of shifting from one (nontrivial) state to another.

Transient (morpho)dynamics has been the subject of earlier studies in different contexts. Using laboratory experiments, Hansen et al. [2001], studied the effect of an abrupt change in the forcing conditions over an initial, perfectly regular pattern of wave ripples. Such change may trigger transient dynamics towards a new pattern, involving typical three-dimensional pattern phenomena: bifurcations and other 'defects'. Another example is the wave-driven behaviour of coastline features as studied by Ashton et al. [2001], who furthermore recognize a similarity in temporal scales: internal dynamics versus sea level rise (though their model neglected sea level rise).

2b Approach
The key objective of this project is to tackle fundamental morphodynamic problems related to sea level rise and sand extraction. Hereto, nonlinear modeling tools will be developed that describe the transient dynamics of sandbanks and sandwaves. The proposed research method is *idealized, process-based modeling*. This is motivated by the transparency regarding the essential physics and the ability to perform sets of long-term simulations. The method has already proven successful in various morphodynamic studies, including the applicant's Ph.D. research.

Sandbanks and sandwaves show similarities that motivate a combined approach: both are large-scale morphodynamic instabilities that may co-exist. Yet the differences in physical mechanisms encourage a distinction between these features. For example, sandbank dynamics is driven by *horizontal* flow circulations, *sandwave* dynamics by vertical circulations. The requirement to describe the vertical structure of the flow in detail makes sandwave modeling computationally more complex. Because of the temporal scales (centuries for sandbanks, 1-10 years for

[2] Examples include river dunes, sand ripples under sea waves and channel-shoal patterns in estuaries.
[3] The terms *linear* and *nonlinear* indicate the model's linearity/nonlinearity in the 'bed amplitude': crest height divided by water depth.

sandwaves), the sandbank part of this project focuses on sea level rise and sand extraction, the sandwave part mainly on sand extraction/navigation dredging (see §2f).

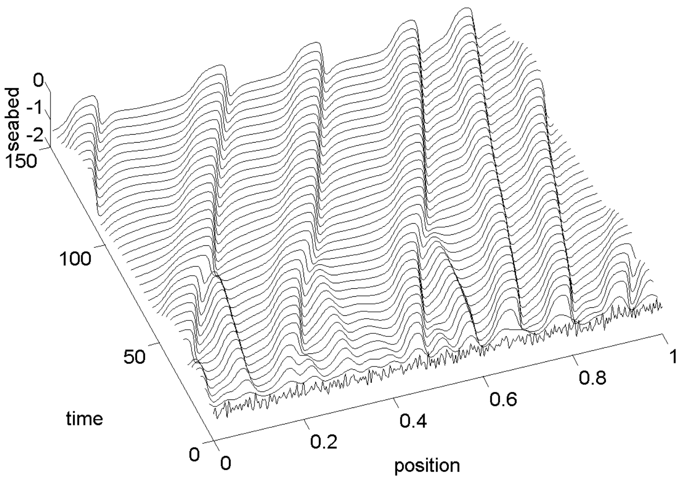

Figure 4: Example of a simulation with the sandbank pilot study. The graph shows one-dimensional seabed profiles z=-h(x), evolving in time (units of ~100 years). Tidal conditions are asymmetric, triggering bank migration from left to right; the initial profile is random. Clearly visible is the transient process of many sandbanks merging into a state with fewer banks. Neither sea level rise, nor human intervention is included.

Tidal sandbanks
A numerical pilot study by the applicant of a nonlinear sandbank model forms the starting point of the sandbank part of this project (Fig.4). The numerical code is able to describe patches of several sandbanks in a computationally efficient way. It thus extends earlier research by the applicant on equilibrium shapes of tidal sandbanks [Roos et al., 2004], which in turn was based on earlier work by Huthnance [1982] on the initial formation stage. The main steps are:

1. Refine the physics of the nonlinear sandbank model, mainly regarding the role of wind (waves). Measurement data from the Kwinte Bank (Belgium), gathered within the international *EUMARSAND*-project[4], are available for validation.
2. Investigate the fundamental properties of the sandbank system, e.g. the transient dynamics towards 'surviving modes' (Fig.4). This subject fits in with existing research on shoreface-connected ridges[5] [Calvete & De Swart, 2003; De Swart & Calvete, 2003].
3. Investigate practical issues concerning sandbanks. This requires implementation of sea level rise, the corresponding changes in flow conditions and human intervention (e.g. local sandpits in a *non-flat* bed). How does the system respond to these gradual and abrupt changes?
4. A crucial point is the validation of steps 2 and 3, which will be done using bathymetric data of the North Sea and geological information (e.g., for a hindcast).

Tidal sandwaves
The currently available model framework for tidal sandwaves is inadequate for studying transient dynamics. The applicant will select one from three future options that are the subject of ongoing research: (i) weakly nonlinear stability analysis (in collaboration with Blondeaux; see Besio et al. [2003]), (ii) strongly nonlinear numerical analysis [Van den Berg & Van Damme, 2004]. An alternative is (iii) a new semi-nonlinear approach combining linear hydrodynamics with nonlinear morphodynamics. The next steps are:

5. Investigate which of the three approaches above is most appropriate. Judgment criteria are: representation of the physics, computational efficiency (ability to deal with extensive sandwave fields) and the feasibility of incorporating sand extraction/dredging.
6. Investigate the autonomous evolution of sandwave fields. Such fields clearly display several aspects of pattern dynamics: regularities, but also bifurcations and other 'defects' (Fig.2). Data are available from the Netherlands Ministry of Public Works and the Netherlands Hydrographic Service (see user group; §2f).

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[4] *EUMARSAND* is an international training network for young EU-researchers, involving the applicant on behalf of UT. Central theme is the impact of sand extraction from coastal seas. Extensive data sets are available on the *Kwinte Bank*.

[5] *Shoreface-connected ridges* are of similar dimensions as tidal sandbanks, but occur in shallower regions near the coast. Though resembling that of sandbanks, the analysis involves different aspects: storm effects, shelf slope and coastline.

7. Investigate the response of a sandwave field, i.e. *a non-flat* bed, to sand extraction/navigation dredging. For data, see 6.
8. Compare the results for sandbanks and sandwaves, and interpret them on an aggregated level. This involves a comparison with general stability concepts [Van Saarloos, 2003] and may lead to heuristic models for pattern dynamics [Andersen et al., 2001].

2c Innovation

The innovation of this project is twofold.

First, the concept of *transient (morpho)dynamics* is novel. As pointed out earlier (§2a), most practical issues regarding North Sea morphology essentially deal with its transient dynamics. However, only the recent advances in the morphodynamic modeling of seabed patterns allow for a transient dynamics approach. So far, modeling efforts have been unable to perform long-term simulations while resolving the physics and spatial scales in sufficient detail.

Second, the project bridges a methodological gap in the field of morphodynamic modeling. So far, models particularly designed to study pattern dynamics (type A) have not been geared to deal with engineering problems, whereas engineering models (type B) have not been successful in describing pattern dynamics. The dynamic role of large-scale seabed patterns has been recognized only recently in the coastal engineering community [Tonnon et al., *submitted*]. In this project, models of type A will be developed and improved by allowing for less idealized geometries complexity and site-specific application, in close collaboration with modelers from engineering practice (type B, see user group; §2f).

2d Plan of work

Time table

	Year 1				Year 2				Year 3			
Task	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1	×	×										
2		×	×	×								
3					×	×						
4					×	×	×					
5							×	×	×			
6								×	×	×		
7										×	×	×
8							×					×
Publ.				P1			P2	P3				P4,P5

Planned publications

P1: Finite amplitude sandbank model and fundamental system properties
P2: Case study Kwinte Bank (regarding sand extraction)
P3: Tidal sandbank dynamics and sea level rise
P4: Fundamental dynamics of sandwave *fields*
P5: Sandwave dynamics in response to sand extraction
The applicant will present his research at international conferences: ICCE'06, RCEM'07, ICCE'08.

National and international collaboration

- Prof.Dr S.J.M.H. Hulscher (process, modeling and applications),
- Dr R.M.J. van Damme (numerics),
- Prof.Dr A. Falqués, Dr D. Calvete and Dr H.E. De Swart (shoreface-connected ridges),
- Prof.Dr P. Blondeaux and Prof.Dr G. Vittori (physics/numerics of sandwave modeling),
- UT-Institute IMPACT: Prof.Dr E.W.C. van Groesen, Prof.Dr D. Lohse and Prof.Dr ir H.W.M. Hoeijmakers,
- Users (§2f),
- Netherlands Centre for Coastal Research (NCK).

Host institute

University of Twente, Faculty of Engineering Technology, Water Engineering & Management (WEM) group, Prof.Dr S.J.M.H. Hulscher (P.O.Box 217, 7500 AE Enschede, s.j.m.h.hulscher@utwente.nl, tel:053-4893546), part of UT-Spearhead Institute IMPACT.

2e literature references

Andersen, K. H., Chabanol, M.-L. & Van Hecke, M., Dynamical models for sand ripples beneath surface waves, *Phys. Rev. E*, **63**, 066308, doi:10.1103/PhysRevE.63.066308, 2001.

Ashton, A., Murray, A. B., & Arnoult, O., Formation of coastline features by large-scale instabilities induced by high-angle waves, *Nature*, **414**, 296-300, 2001.

Besio G., Blondeaux, P. & Frisina, P, A note on tidally generated sand waves, *J. Fluid Mech.*, **485**, 171-190, 2003.

Blondeaux, P., Mechanics of coastal forms, *Ann. Rev. Fluid Mech.*, **33**, 339-370, 2001.

Calvete, D. & De Swart, H. E., A nonlinear model study on the long-term behavior of shoreface-connected ridges, *J. Geophys. Res.*, **108**(C5), doi:10.1029/2001JC001091, 2003.

De Swart, H. E. & Calvete, D., Nonlinear response of shoreface-connected sand ridges to interventions, *Ocean Dyn.*, **53**(3), 270-277, 2003.

Douglas, B. C., Global sea level change: Determination and interpretation, *Rev. Geophys.*, **33**, 1425-1432.

Dyer, K. R. & Huntley, D. A., The origin, classification and modelling of sand banks and ridges, *Cont. Shelf Res.*, **19**, 1,285-1,330, 1999.

Hulscher, S. J. M. H., Tidal induced large-scale regular bed form patterns in a three-dimensional shallow water model, *J. Geophys. Res.*, **101**(C3), 20,727-20,744, 1996.

Huthnance, J. M., On one mechanism forming linear sand banks, *Est. Coast. Shelf Sci.*, **14**, 74-99, 1982.

Roos, P. C., Hulscher, S. J. M. H., Knaapen, M. A. F. & Van Damme, R. M. J., The cross-sectional shape of tidal sandbanks: Modeling and observations, *J. Geophys. Res.*, **109**, F02003, doi:10.1029/2003JF000070, 2004.

Tonnon, P.K., Van Rijn, L.C. & Walstra, D.J.R., The modelling of sand ridges on the shoreface, *submitted.*

Van Alphen, J. S. L. J. & Damoiseaux, M. A., A geomorphological map of the Dutch shoreface and adjacent part of the continental shelf, *Geol. Mijnbouw*, **68**, 434-444, 1989.

Van den Berg, J. & Van Damme, R. M. J., A simplified sand wave model. In: Hulscher, S.J.M.H., Garlan, T. & Idier, D. (Eds.), Marine Sandwave and River Dune Dynamics (pp. 284-288) Enschede: University of Twente (ISBN 2-11-088355-3), 2004.

Van Saarloos, W., Front propagation into unstable states, *Phys. Rep.*, **386**, 29-222, doi:10.1016/j.physrep.2003.08.001, 2003.

2f utilization paragraph

Problem statement and solutions

A typical problem in coastal seas like the North Sea is the conflict between economical and societal interests in an environment that furthermore displays (morpho)dynamic behavior. These *interests* deal with the variety of economical activities (navigation, fisheries, exploration/transport of hydrocarbons, telecommunication cables, sand extraction, dumping of waste material, and windmill farms) as well as societal values (ecology, coastal safety, recreation, military exercising). The *morphodynamics* of the North Sea is the dynamic behavior of the seabed in general, and that of tidal sandbanks and sandwaves in particular. Crucial is that the above interests interfere with each other and with the natural morphodynamics of the North Sea. However, our understanding of the dynamics of these large-scale patterns, both *autonomously* and *in interaction with these activities*, is insufficient. This poses a massive problem for coastal managers whose task it is to develop a sound and sustainable policy for the North Sea.

The proposed research will develop new morphodynamic modeling tools that provide answers to the problems sketched above. More precisely, the practical issues in the North Sea essentially boil down to questions concerning the *transient dynamics* of these patterns, in response to both abrupt (repeated sand extraction) and gradual changes (sea level rise) in its environment.

The modeling tools give answers to the needs of the actors that are involved in the user group. Three fields of utilization can be identified.

1. The North Sea Directorate (Netherlands Ministry of Public Works) is responsible for the planning, licensing and management of activities in the North Sea. Where and how should these activities take place? And what kind of spatial safety margins should be imposed to avoid unwanted interference of activities? For example, what distance should be kept between a pipeline and a sand extraction area to minimize any unwanted interference? Should sand extraction from tidal sandbanks be permitted and – if yes – how? To answer these questions, the North Sea Directorate usually consult the National Institute for Coastal and Marine Management (RIKZ), who in turn may address other parties such as universities, governmental institutes and engineering consultants. Clearly, a thorough understanding of sandbank and sandwave dynamics is necessary to develop a sound and sustainable policy regarding activities in the North Sea.

2. The North Sea Directorate is also responsible for warranting the minimum depth in e.g. the IJ Channel and the Euro-Maas Channel. This task is essential to prevent e.g. oil-tankers from running aground. It requires repeated maintenance dredging, which is an expensive operation. As most of these navigation channels cross (highly dynamic) sandwave fields, particularly the sandwaves pose a hazard to navigation. Insight in the transient behavior of sandwaves in response to repeated dredging activities enables improvements in dredging strategies that will significantly reduce the cost of seabed maintenance.
3. The Netherlands Hydrographic Service is responsible for the production of nautical charts. To this end, they conduct repeated surveys of the Netherlands Continental Shelf, which are expensive undertakings. To ensure reliable charts, highly dynamic areas like sandwave fields require a higher resurvey frequency than static areas. Here a similar observation as in point 2 applies: this project enables improvements survey strategies, significantly reducing the cost of producing nautical charts.

Users (including their contact information)

ir R. Bijker	**Advanced Consultancy Romke Bijker** Tjeukemeerstraat 18, 8531 RM Lemmer, NL, romke.bijker@acrb.nl	**confirmed**
ir L.L. Dorst	**Netherlands Hydrographic Service** MPC 13 A, Badhuisweg 167, 2597 JN Den Haag, NL, ll.dorst@mindef.nl	**confirmed**
Dr J.P.M. Mulder	**National Institute for Coastal and Marine Management (RIKZ)** Ministry of Transport, Public Works and Water Management P.O.Box 20907, 2500 EX Den Haag, NL, J.P.M.Mulder@rikz.rws.minvenw.nl	**confirmed**
Dr ir A.A. Németh	**Witteveen+Bos** Van Twickelostraat 2, P.O.Box 233, 7400 AE Deventer, NL, A.Nemeth@witbo.nl	**confirmed**
Drs A. Stolk	**North Sea Directorate** Ministry of Transport, Public Works and Water Management Lange Kleiweg 34, P.O.Box 5807, 2280 HV Rijswijk, NL, a.stolk@dnz.rws.minvenw.nl	**confirmed**
Prof dr ir L.C. van Rijn & Ir D.J.R. Walstra	**WL|Delft Hydraulics** P.O. Box 177, 2600 MH Delft, NL, leo.vanrijn@wldelft.nl, walstra@wldelft.nl	**confirmed**

Implementation

The knowledge will be generated by the set-up and analysis of morphodynamic models for tidal sandbanks and tidal sandwaves. In addition, sites from which data (concerning bathymetry, hydrodynamics and/or sediment transport) are available, serve as case studies for both validation and application:

- The Kwinte Bank (Belgian Continental Shelf), which has been used for sand extraction and has been extensively monitored, e.g. within the *EUMARSAND* project (steps 1, 3 and 4 in §2b).
- Sandwave fields in the North Sea. Data sets are available from both the Netherlands Ministry of Public Works and the Netherlands Hydrographic Service, e.g. in the Euro-Maas channel (steps 6 and 7 in §2b).

Past performance

During his Ph.D. research, the applicant created his own user group[6] with delegates from engineering practice, government and governmental institutes. Their feedback has proven fruitful in several respects. The user group contributed in (i) clearly formulating the actually relevant practical issues, (ii) recognizing practical constraints (e.g., technical limitations of sand extraction, expected pit sizes and legislation), (iii) monitoring the ongoing development of these constraints throughout the project, and (iv) interpretation of the theoretical results and translating them into practical guidelines.

Contracts and Patents

Not applicable.

[6] Although the applicant's project was not funded by STW, the user group was organized according to the usual STW-standards, e.g. involving half-yearly meetings.

Cost estimates

3a budget

	2006	2007	2008	2009	TOTAL
Staff costs: (in k€)					
Applicant	21	64	66	45	196
Support staff	-	-	-	-	-
Non staff costs: (k€)					
Equipment	2	-	-	-	2
Consumables	-	-	-	-	-
Travel and subsistence	-	3	3	4	10
Other	-	-	-	-	-
TOTAL	23	67	69	49	208

Note: The 'equipment cost' concerns the purchase of a laptop computer; the 'travel and subsistence' part covers the visits to international conferences (§2d).

3b Indicate the time (percentage of fte) you will spend on the research
1.0 fte (100%)

3c Intended starting date
1 September 2006.

3d requested additional grants?
No

Curriculum vitae

4a Personal details

Title(s), initial(s), first name, surname:	Dr ir P. C. (Pieter) Roos
Male/female:	Male
Date and place of birth:	24 March 1975, Bathmen, The Netherlands
Nationality:	Dutch
Birth country of parents:	Netherlands

4b Master's

University:	University of Twente, Faculty of Applied Mathematics
Date:	13 January 1999 ***(cum laude)***
Main subject:	dynamical systems, morphodynamic modeling of rivers

4c Doctorate

University:	University of Twente, Faculty of Engineering Technology
Date:	3 September 2004
Supervisors ('Promotores')	Prof.Dr S. J. M. H. Hulscher, Prof.Dr ir H. J. de Vriend
Title of thesis:	Seabed pattern dynamics and offshore sand extraction

4d Work experience since graduating

1 September 2004-date	Post-doc at Water Engineering & Management (WEM) Group, University of Twente, The Netherlands [full time, fixed term]. This involves the co-supervision of one Ph.D candidate (ir. L. L. Dorst, see 4h)
1 September 2000-1 September 2004	4 years Ph.D. Candidate at Water Engineering & Management (WEM), University of Twente, The Netherlands. [full time, fixed term]
1 July 2000-1 September 2000	2 month research stay at **Naval Postgraduate School, Monterey (California, US)**, study into hydrodynamics over wave-ripples. [full time, fixed term]
1 September 1999-1 July 2000	10 month research stay at the **Dipartimento di Ingegneria Ambientale, Università di Genova (Italy)**, study into the formation of three-dimensional wave-ripple patterns, supervised by Prof.Dr P. Blondeaux, EU-funded by scholarship from **NUFFIC Talentenprogramma**. [full time, fixed term]
May 1999-July 1999	2 month research position at the Faculty of Applied Mathematics, University of Twente; extending results of Master's project. [full time, fixed term]
January 1999-May 1999	3 month research stay at **Institut Teknologi Bandung (Indonesia)**, study into the coastal zone of Banda Aceh, in collaboration with Dr Salmawaty. [full time, fixed term]

4e Man-years of research

15 months	The applicant has been a post-doc for 15 months.

4f Brief summary of research over last five years (240 words)

During his Ph.D. work, Roos studied the interaction between large-scale seabed dynamics and human intervention, such as offshore sand extraction and gas-mining [Roos & Hulscher, 2002]. Applying both analytical and numerical modelling techniques, he developed and analyzed process-based morphodynamic models for sandbanks [Roos et al, 2004] and sandwaves [Roos et al., 2005]. The research perfectly fitted in the scope of the EU-project *HUMOR* (2001-2004, see 4g), which provided a fruitful international network. At a national level, a user group was formed around the research project, with delegates from engineering practice, governmental institutes and the government.

During his Ph.D. work, Roos clearly benefited from his earlier research stay in Genova (Italy, EU-funded by the NUFFIC Talentenprogramma), where he investigated the dynamics of three-dimensional wave-ripple patterns, under supervision of Prof.Dr P. Blondeaux. He thus became acquainted with morphodynamic modelling in general, and the powerful mathematical techniques like stability analysis in particular. The collaboration with Prof.Dr P. Blondeaux and co-workers has continued ever since, and it has led to several joint publications [Roos & Blondeaux, 2001; Roos et al., 2004; Roos et al., 2005]. Roos' current research activities include the co-supervision of the Ph.D. project by L. L. Dorst on the statistical analysis of seafloor surveys of offshore areas with sandwaves. The applicant enjoys the various aspects of research: analytical and numerical modelling, communication and collaboration with specialists and non-specialists, as well as writing journal papers and presenting his work at international conferences.

4g International activities

2004-date	Participation in international post-doc training network *EUMARSAND* (see Sections 2d and 2f), collaboration with Dr C. Brière.
2001-2004	Participation in EU-project *HUMOR*, on *HU*man interaction with large-scale *MOR*phological features (coordinator Prof.Dr M. A. Losada, University of Granada, Spain).
1999	Participation in MAST Course on *'Multiscale Coastal Dynamics: Fluxes and Predictions for the Physical Component'*, Barcelona (Spain).
1997	Five month practical training at **ABB Corporate Research, Baden (Switzerland)**, research into combustion processes within burners.

4h Other academic activities

2005	Teaching Master's course 'Mathematical Tools for Civil Engineers': course material, oral lectures, practice hours and written examination.
2005	Design of case study for NCK Summer School, a 2 week training course for young scientists in coastal research (NCK=Netherlands Centre of Coastal Research).
2005	Presentation at NCK theme day on offshore sand extraction, involving researchers and coastal managers from both The Netherlands and Belgium.
2005	Supervision of R. M. van Dam's practical training at the University of Miami (Florida, US), who won the 2005 scholarship of the Netherlands-Florida Scholarship Foundation.
2005	Supervision of S. C. P. Buyck's B.Sc. project at Universidad Nacional Autonóma de México (UNAM, Mexico City, Mexico).
2004-date	Co-supervision of ir L. L. Dorst, Ph.D. candidate at the University of Twente, employed by the Netherlands Hydrographic Survey (The Hague, The Netherlands).
2004	Designing workshop on sand extraction within EU-project *HUMOR*, held during the 29th International Conference on Coastal Engineering, Lisbon, Portugal, September 2004.
2004	Presenting lecture on large-scale offshore seabed morphology at Tutorial Course during international ECUA'2004 conference on underwater acoustics (Delft, The Netherlands)
2003	Co-organizing course Technical Writing & Editing at University of Twente, in collaboration with Peterborough Technical Communications (UK).
2002-date	Refereeing manuscripts for several international journals: *Journal of Fluid Mechanics*, *Journal of Geophysical Research* and *Continental Shelf Research.*
2001-date	Supervision of several M.Sc. projects: ir H. H. van der Veen on large-scale offshore windmill farms, ir R. Wemmenhove on grain size sorting over tidal sandbanks, T. J. Hoffman on tidal sandbanks and sea level rise, W. Ottevanger (Applied Mathematics) on numerical river modeling, and I. Wientjes on tidal sandwaves.
2001-date	Teaching Master's courses 'Marine Dynamics I and II': oral lectures, practice hours and written/oral examination.
2001	Teaching within Master's course 'Seminar on Morphology': design and supervision of individual assignments on downstream fining in rivers and the morphodynamic modelling of sandpits.
1999	Participation in *'Week voor Wiskunde en Industrie'*, Leiden University.

4i Scholarships and prizes

1999-2000	EU-funded **Hfl 20.000**,- scholarship of **NUFFIC Talentenprogramma**, 10 month research stay at Università di Genova (Italy), study into the formation of three-dimensional wave-ripple patterns, supervised by Prof.Dr P. Blondeaux, and hosted by Prof.Dr G. Seminara.

List of publications

International refereed journals

Impact factors (taken from the 2003 Journal Citation Reports):

Reviews of Geophysics	Impact Factor 9.226, ranked #1 of 52 titles in *Geochemistry and Geophysics,*
Journal of Geophysical Research	Impact Factor 2.922, ranked #7 out of 128 in *Multidisciplinary Geosciences,*
Journal of Fluid Mechanics	Impact Factor 1.811, #6 out of 21 in *Physics, fluids & plasmas,* #5 out of 105 in *Mechanics,*
Continental Shelf Research	Impact Factor 1.191, ranked #16 out of 41 in *Oceanography.*

S **Roos, P. C.**, Blondeaux, P., Hulscher, S. J. M. H. & Vittori, G., Linear evolution of sandwave packets, *J. Geophys. Res.*, doi:10.1029/2004JF000196, 2005.

S **Roos, P. C.**, Hulscher, S. J. M. H., Knaapen, M. A. F. & Van Damme, R. M. J., The cross-sectional shape of tidal sandbanks: Modeling and observations, *J. Geophys. Res.*, **109**, F02003, doi:10.1029/2003JF000070, 2004.

S **Roos, P. C.** & Hulscher, S. J. M. H. Large-scale seabed dynamics in offshore morphology: modeling human intervention, *Rev. Geophys.*, **41**(2), 1010, doi:10.1029/2002RG000120, 2003.

Roos, P. C. & Hulscher, S. J. M. H. Formation of offshore tidal sand banks triggered by a gasmined bed subsidence, *Cont. Shelf Res.*, **22**, 2807-2918, 2002.

Roos, P. C. & Blondeaux, P. Sand ripples under sea waves. Part 4. Tile ripple formation, *J. Fluid Mech.*, **447**, 227-246, 2001.

Books, or contributions to books

Németh, A. A., Blondeaux, P., Hulscher, S. J. M. H., Besio, G., **Roos, P. C.**, Vittori, G., Knaapen, M. A. F., Brocchini, M., Van der Veen, H. H. & Idier, D., Models of offshore sand waves and sand banks and their applications, in (eds.): Losada, M. A. & Baquerizo, A., *HUman interaction with large scale MORphological features*, Real Academia de Ingenieria, Madrid, pp. 53-73, 2004.

Vittori, G., Blondeaux, P., Hulscher, S. J. M. H., Piqueret, M., **Roos, P. C.**, Potential use of sand waves and sand banks for sand mining, in (eds.): Van Rijn, L. C., Soulsby, R. L., Hoekstra, P. & Davies, A. G., Sandpit. Sand transport and morphology of offshore mining pits, Aqua Publications, Netherlands, pp. K.1-11.

Other

Dissertation

S **Roos, P. C.**, *Seabed Pattern Dynamics and Offshore Sand Extraction*, Ph.D. thesis, University of Twente, The Netherlands, ISBN 90-365-2067-3, 2004.

In preparation

Besio, G., Blondeaux, P., Brocchini, M., Hulscher, S. J. M. H., Idier, D., Knaapen, M. A. F., Németh, A. A., **Roos, P. C.** & Vittori, G.,The morphodynamics of tidal sand waves: a model overview, *submitted.*

Brière, C., **Roos, P. C.**, Garel, E. & Hulscher, S. J. M. H., Modelling the morphodynamic effects of sand extraction from the Kwinte Bank, *submitted.*

Dorst, L. L., **Roos, P. C.**, & Hulscher, S. J. M. H., The estimation of parameters for sea floor dynamics in surveys of sand wave areas, *submitted.*

Roos, P. C., Wemmenhove, R., Hulscher, S. J. M. H. Hoeijmakers, H. W. M. & Kruyt, N. P., Modeling the effect of graded sediment on the dynamics of offshore tidal sandbanks, *submitted.*.

Roos, P. C., Hulscher, S. J. M. H. & De Vriend, H. J., Modelling the morphodynamic effects of different design options for offshore sandpits, *in preparation.*

Van der Veen, H. H., Hulscher, S. J. M. H. & **Roos, P. C.**, Morphological effects of offshore windmill parks subject to tidal flow, *in preparation.*

Proceedings

Ribberink, J. S., **Roos, P. C.** & Hulscher, S. J. M. H., Morphodynamics of trenches and pits under the influence of currents and waves, to appear in Proc. Coastal Dynamics 2005 (April, 2005), Barcelona, 2005.

Roos, P. C., Blondeaux, P., Hulscher, S. J. M. H. & Vittori, G., Linear evolution of sand wave packets and relevance to offshore sand extraction, , In: McKee-Smith, J. (Ed.), *ICCE2004. 29th International Conference on Coastal*

Engineering, Lisbon, Portugal, pp. 2484-2492, 2005.

Roos, P. C. & Hulscher, S. J. M. H., Modelling the morphodynamic effects of different design options for offshore sandpits, In: Hulscher, S. J. M. H., Garlan, T. & Idier, D. (Eds.), *MARID 2004. 2nd International Workshop on Marine Sandwave and River Dune Dynamics*, University of Twente, April 2004.

Roos, P. C., Hulscher & S. J. M. H. & Van Damme, R. M. J., Finite amplitude tidal sandbanks. One-dimensional equilibrium profiles. In: McKee-Smith, J. (Ed.), *ICCE2002. 28th International Conference on Coastal Engineering*, Cardiff, UK, pp. 2800-2812, 2003.

Peters, B. G. T. M., Hulscher, S. J. M. H. & **Roos, P. C.**, Large-scale sand extraction offshore: interacting between model and decision process. In Lechuga, A. (Ed.), *FOMAR Congreso International Cienca y Technologia Marina, Oceans III Millennium, 2001.*

Roos, P. C., Hulscher, S. J. M. H., Peters, B. G. T. M. & Németh, A. A., A simple morphodynamic model for sand banks and large-scale sand pits subject to asymmetrical tides. In: Ikeda, S. (Ed.), *RCEM 2001, 2nd IAHR symposium on River, Coastal and Estuarine Morphodynamics*, pp. 91-100, 2001.

Internal reports

Roos, P. C., Morphodynamic effects of offshore sand extraction. Literature review. CE&M res. rep. 2004-002/WEM-001, Civil Engineering (CTW), University of Twente, 20 pp., 2004.

Roos, P. C., Van Beckum, F. P. H. & Van Groesen, E. W. C., Cross-sectional river shapes: A variational discharge-resistance formulation, Research Report, University of Twente, 1999.

Roos, P. C., Sediment transport and variational modelling of erodible river beds, Master's thesis, Applied Mathematics, University of Twente, January 1999.

Abstracts

Roos, P. C., Finite amplitude modeling of tidal sandbanks: evolution of wavelength and response to sand extraction, abstract #1545, accepted for oral presentation at *30th International Conference on Coastal Engineering*, San Diego, 2006.

Roos, P. C. & Hulscher, S. J. M. H., Sand extraction from tidal sandbanks, In *NCK-days 2005. Book of Abstracts*, pp. 29, 2005.

Roos, P. C., Blondeaux, P., Hulscher, S. J. M. H. & Vittori, G., Sandwave formation triggered by a dredged trench or pit, In Teixeira, A. T. (Ed.) *ICCE2004. 29th International Conference on Coastal Engineering. Abstracts*, paper #84, 2004.

Roos, P. C., Large scale sand extraction in the North Sea: A 'zand win-win'situation? In *Programma NCK dagen 2003*, p.10, 2003.

Roos, P. C. & Hulscher, S. J. M. H., Sand extraction and finite amplitude tidal sandbanks, In Burchard, H., Gardeike, B., Grabemann, I. & Kappenberg, J. (Eds.), *PECS 02. 11th biennial conference on physics of estuaries and coastal seas. Extended abstracts*. pp. 314-317, 2002.

Roos, P. C. & Hulscher, S. J. M. H., Finite amplitude tidal sandbanks, In Allsop, N. W. H. (Ed.), *ICCE2002. 28th International Conference on Coastal Engineering. Abstracts*, paper #207, 2002.

Roos, P. C., Local sand bank pattern formation due to human interventions at the sea bed, In *Programma NCK dagen 2001*, 2001.

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