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MAASVLAKTE 2: AN INNOVATIVE CONTRACTUAL AND SYSTEMS ENGINEERING APPROACH

ABSTRACT

The Port of Rotterdam Authority (PRA) awarded the Maasvlakte 2, Contract 1, to PUMA, a joint venture comprising dredging and marine contractors Boskalis and Van Oord. The PRA applied a "fit for purpose" format for this mega infrastructure Design Construct and Maintenance Contract (DCM), including an innovative Systems Engineering approach. The tender process and the Systems Engineering principles are described here. Also the benefits of the applied contractual approach are highlighted.

The authors acknowledge that the Port of Rotterdam Authority actually developed the described Tender procedures. Likewise they prescribed the application of the system-oriented approach to be complied with by all Tenderers. This article was first published in the *Proceedings of PIANC MMX,* 125th Anniversary PIANC, International Navigation Congress, Liverpool, May 2010 and is reprinted here in a slightly revised form with permission.

INTRODUCTION

On September 5, 2005 the Port of Rotterdam Authority (PRA) started a prequalification procedure to select suitable contractors for the Maasvlakte 2 project phase 1. The Maasvlakte 2 Contract 1 comprises 700 ha port areas, hard and soft defences of 11 km in total length, 530 ha of harbor basin, quay walls and infrastructure.

Three contractors were selected and the tender phase started in January 2006. The PRA decided to apply the Design Construct and Maintenance principle to this huge contract for obvious reasons:
- to incorporate construction expertise in the design process
- to avoid disputes between designer and contractor
- to make cost savings by having a design made by the contractor with the convenience of construction in mind

In February 2008 the contract was awarded to PUMA *(Projectorganisatie Uitbreiding MAasvlakte)* which consists of dredging and marine contractors Boskalis and Van Oord. The first container terminal is scheduled to be operational in 2013.

Above: The complexity of the mega infrastructure works at Maasvlakte 2 led the Port of Rotterdam Authority to apply a "fit for purpose" format for this Design Construct and Maintenance Contract (DCM), including an innovative Systems Engineering approach.

Innovative contract based on the use of Systems Engineering

The tender period for Maasvlakte 2 and in particular the award procedure is described in further detail in the following section. Important parts of the tender procedure were the design brief and instructions to tenderers. The design brief prescribed that the design should be based on a system-oriented approach, in other words Systems Engineering.

For several years now, both clients and contractors of large infrastructure projects in the Netherlands have been experimenting with innovative contracts based on the use of Systems Engineering. A shift in roles and tasks is taking place in the construction industry in the Netherlands. Clients are increasingly asking contractors to take on the responsibility for preparing designs at a much earlier stage.

The reason for introducing this method based on Systems Engineering is the political and social demand to reduce the involvement of the Dutch government and the need to involve the market sector to a greater extent and at an earlier stage in the design, construction and management of infrastructure. Another reason is the call for transparency and better process control.

Figure 1. Overview of Maasvlakte 2, Contract no.1.

Systems Engineering provides a method that identifies the roles and tasks of all parties involved with the lifecycle of public works and water management systems, from the planning stage to construction continuing to maintenance and even restoration, an approach that provides clear insight at any time into the decisions made during the process – even after the project's completion.

In line with Systems Engineering the design brief only comprised the functional requirements and the geometrical outline (layout) of the future Maasvlakte 2 port facility – the so-called programme of requirements.

This article discusses the innovative contractual approach, which includes the use of Systems Engineering. The resulting innovation in design and equipment is also described. The insight for both contractor and owner as generated by the implementation of Systems Engineering makes it easier to optimise the design when new options and new knowledge provide opportunities to reconsider and improve the design.
A good example is the partnering with the client resulting in an optimisation of the hard sea defence design which is described briefly in section on "Contract Award and Partnering".

TENDER PERIOD AND PROCEDURE

The PRA prescribed a step-by-step approach, leading to the final award of the contract as follows:

- Discussion phase — January–May 2006
- Offer phase — May–July 2006
- Negotiation phase — July 2006–Spring 2007
- BAFO phase — Spring–October 2007
- Award phase — From October 2007
- Contract award — 27 February 2008

Discussion phase

In this phase the tenderers discussed with the PRA: the project, the programme of requirements, the draft contract, the risks and other aspects excluding financial issues. The purpose of this phase was to enable the PRA to further clarify the project in order to enhance the tenderers' understanding. On the other hand, the tenderers were given the opportunity to verify their interpretation of the scope of works. The discussion phase was strictly structured. The input of the tenderer was critical. The PRA could order particular documents to be submitted for discussion, like the so-called requirements tree and verification matrix (RTVM).

Some comments made by the tenderer concerning, for example, the draft contract and leading to contract changes, were possibly to be made public, i.e., had to be communicated with all tenderers (via tender instructions) to ensure equal treatment.
The same core team from PRA conducted the bilateral discussions between PRA and the various tenderers, to guarantee uniformity and transparency and thus equal treatment of the tenderers. Obviously the team leader of the tenderer's core team had to have full authorisation, to be confirmed in a letter at the start of the discussion phase.

Although outside the scope of this article, it is worthwhile mentioning that the PRA scheduled the various procedures to run simultaneously such as:

1. Tender process for construction of Maasvlakte 2,
2. Obtaining clients for the Port Areas and
3. Applying for main permits concerning partial planning, environment and compensation for the loss of natural assets.

The simultaneous running of these procedures was done to achieve early commencement of the project construction phase (see Figure 2).

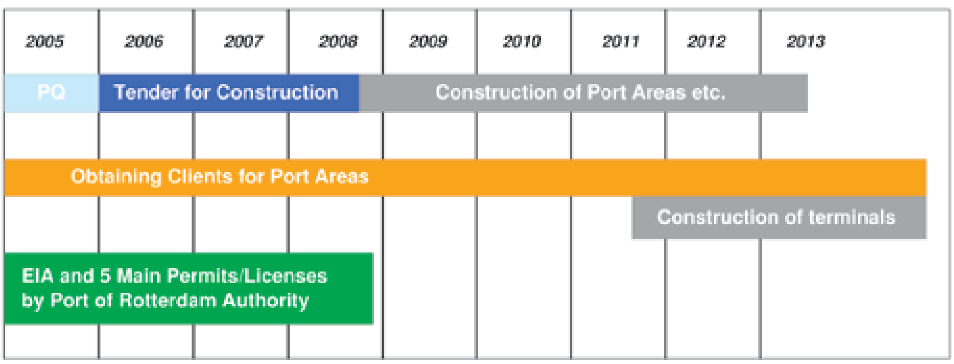

Figure 2. Project approach.

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graduated in 1998 with an MSc in Civil Engineering from Delft University of Technology, The Netherlands. In 1999 he joined Hydronamic Bv, Port & Waterway Engineers, Engineering Department Royal Boskalis Westminster as a project engineer, later working as desk manager in Singapore, project manager at Boskalis Offshore and as a senior project engineer. He is presently Head of Systems Engineering Department at PUMA.

Apart from achieving the earliest commencement of the works, this project approach also made it possible to achieve early mutual understanding between PRA and the contractor on the possible restrictions for contractors as (to be) attached to the main permits. Simultaneously scheduling tenders for construction and maintenance resulted in almost 3 years' acceleration compared to the traditional approach of first arranging permits before starting the tender phase.

It was also crucial for the financial feasibility to have firmly committed clients for part of the port areas before construction could commence.

Offer phase

This phase started after completion of the discussion phase. In this phase the tenderers prepared their offers and submitted their tender. The PRA ranked the offers on the basis of award criteria and award method, as described in the tender brief (see under "Contract Award and Partnering"). The offer phase was completed by sending invitations to two successful tenderers to enter the negotiation phase.

Negotiation phase

The PRA started to negotiate with the two tenderers who submitted the best offers. After this phase the BAFO phase started, in which the tenderers prepared their best-and-final offer (BAFO), followed by assessment and award by the PRA.

BAFO phase

The BAFO phase comprises four parts: General part, technical part, financial part and maintenance part.

In the tender procedure, and in particular in the discussion phase, system-oriented design played an important role (actually dictated by the client). Every tenderer had to further develop the programme of requirements as provided by the PRA with additional (sub) requirements based on the Systems Engineering method. In addition to the requirements, the contractor also had to describe which verification method(s) had to be applied. For this the so-called requirement tree and verification matrix (RTVM) was prepared. The RTVM provided proof that the solution designed (choices made by the tenderers) indeed fulfilled the programme of requirements as provided by the PRA. The tenderer had to submit the prepared RTVM as an integral part of the submission. The RTVM would become eventually part of the Contract to be awarded.

SYSTEMS ENGINEERING PRINCIPLES

The instructions in the design brief were an important part of the tender procedure and the innovation of the project.

The principles of Systems Engineering play an important role in this contract. Already during the tender period it was prescribed in the design brief that the design should be based on Systems Engineering. But what are the principles of Systems Engineering? What is Systems Engineering?

Numerous definitions of Systems Engineering can be given. The International Council on Systems Engineering (INCOSE) defines Systems Engineering as follows:

An interdisciplinary approach and means to enable the realization of successful systems. It focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, then proceeding with design synthesis and system validation while considering the complete problem.

The Dutch public works sector and the large infrastructure projects apply a more practical interpretation of Systems Engineering, which is more to the point and focuses on the best and feasible elements of Systems Engineering for such kind of projects.

The applied definition of Systems Engineering for large infrastructure projects

Systems Engineering is a systematic, structured and transparent way of handling technical and contractual information through all project phases. It helps create transparency and manage change and interfaces in the project.

The core elements of Systems Engineering are:
- Analysing and presenting the client's requirements in a systematic and structured way (identifying the problem and the project, specifying the requirements)
- Translating the client's requirements into products to be designed and built in a systematic, structured and transparent manner (Design & Construct process)
- Transparent verification of the specified requirements for the products designed and constructed (delivery of a suitable and accepted product)

Furthermore, Systems Engineering is being welcomed by more and more partners in large infrastructure projects in the Netherlands. This increases the need to define and agree on how to apply Systems Engineering in such projects. In other words: there is a need to collaborate on developing a language for the construction industry. It is important that the contracting authorities and the contractors work according to the same basic principles. This effort, in which PUMA actively took part, has resulted in the development of "Guideline Systems Engineering for Public Works and Water Management" [ref.1]. Based on this

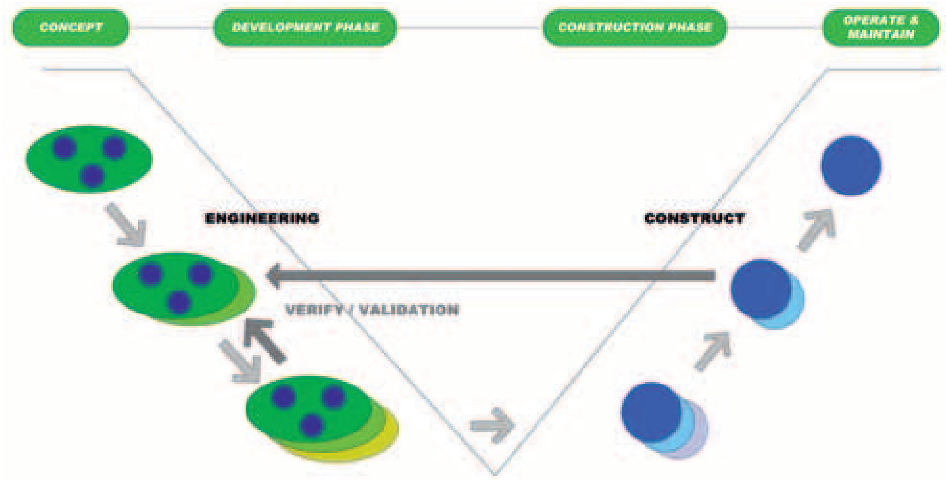

Figure 3. The Systems Engineering process throughout the lifecycle of the project.

effort and guideline the principles of Systems Engineering are defined as follows.

The main principles of Systems Engineering for a large infrastructure project

Systems Engineering focuses on the needs of the client or stakeholder throughout the lifecycle. The Systems Engineering process and the lifecycle has four main phases, namely:

- Concept programme of requirements (client and stakeholder requests)
- Development phase
- Construction phase
- Operation and maintenance

For the contractor the starting point is the development phase, which starts with the programme of requirements provided with the tender documents. In the programme of requirements the problem statement is described in so-called "functional requirements".

For example, "Traffic congestion between points A and B must be resolved". This problem statement is also referred to as the project's primary requirement. The Systems Engineering process subsequently proceeds to achieve that objective. The engineering process features requirements-driven design described as a basic principle. In order to work out the design in further detail, a number of requirements and/or sub-requirements that the system's solution is expected to meet are derived from the main requirements. This process is repeated until a design emerges that is suitable for construction.

Repeating the engineering process one level down means that the system is subdivided into smaller subsystems at a lower level of detail. This process is referred to as decomposition. The system is further decomposed at each lower level of detail in the engineering process until a level of detail is reached where the design is ready for construction.

By combining the engineering and construction processes in a single diagram, the V-model emerges which is often used in Systems Engineering. The process flow is also depicted in Figure 3, with a descending line representing the further detailing of the engineering process and an ascending line representing the construction process.

- The *concept phase* is carried out for the purpose of assessing new business opportunities and to develop temporary system requirements and feasible design solutions. The results consist of a feasibility assessment and a rough draft of the user requirements and solution-independent requirements specification. The final result is the programme of requirements (including as much as possible solution-independent system specifications) that form the start of the project.
- A system is developed during the *development phase* that meets the contracting authority's requirements and that can be produced, tested, evaluated and operated and maintained. The product of the development phase is a design for the entire system.
- The system is constructed and tested (verified and validated) during the *construction phase*.
- The *operation and maintenance phase* consists of the operation of the system and the provision of services within the targeted environment, and is designed to ensure that a consistent level of effectiveness is provided in relation to utilisation and business operations.

The engineering process is carried out for the first time during project execution by the contractor. This involves the concept, development and construction. Once the system is developed or even in operation it is possible to improve and renew the system. New options arise, allowing for improvement, and users have new or revised requirements. The engineering and construction processes are re-executed in order to produce a design based on the new option or renewed requirements. The renewal or improvement of a system can be repeated several times during the lifecycle of a system.

Once the system is in operation it will require maintenance after a period of time. Maintenance and/or replacement keeps the system in such a condition that it continues to meet the originally specified requirements. The engineering and construction processes will have to be partially re-executed as part of the maintenance process. It should be noted here that repeating the engineering and construction processes once again does not mean that the entire process starts from scratch. When proper asset management practices are used, all the system information is still available. We repeat the engineering and construction process in order to, where necessary, adjust requirements, consider new options and variants and modify the design to accommodate the results of the changes.

Systems Engineering during the development phase

For a project like the Maasvlakte 2, the development phase is most important and most interesting from a Systems Engineering point of view. After all what will be constructed and operated is born in this phase. The physical solution of the system is shaped and becomes visible.

What are the Systems Engineering principles leading to the best solution for the system? In the development phase the engineering process is a generally applicable process. It consists of three sub-processes:

- Requirements analysis
- Structuring and allocation
- Design

These consecutive sub-processes form an iterative process leading to the solution with the agreed and acceptable level of detail. At the end of the process, the solution is specified and is compared to the specified requirements and solution space. This is the verification of the physical solution against requirements. In Figure 4 this process is presented together with the input and output. The scenario with respect to the input and output process is visualised and described below.

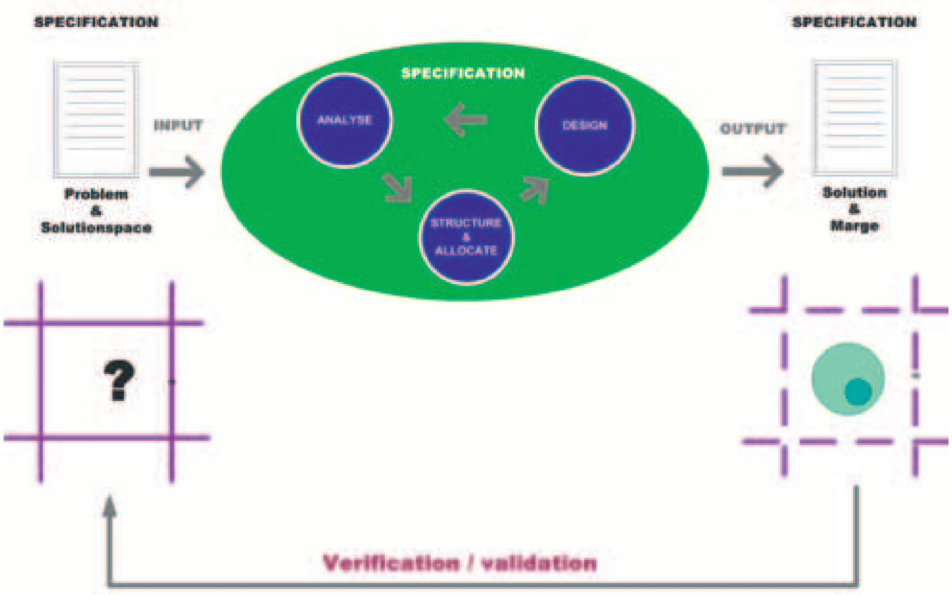

Figure 4. The engineering process.

The input into the engineering process is the output of the concept phase, the programme of requirements. This process always starts with a problem statement and the related need(s) of the client/contracting authority and other stakeholders. The input specification describes the problem statement and the solution space and is represented in Figure 4 as an empty box with a question mark. The output specification is the solution proposed or designed plus the margin (dependent on uncertainty and risk) and is represented in the figure as a circle. This specification of the solution is prepared by the contractor following the engineering process during the development phase. In other words: the solution-independent system of the client is transformed into a physical solution-based system by the contractor (Figure 5).

The verification/validation process takes place simultaneously. The result of this process is to prove that the solution plus its margin meet the requirements, in other words, the solution fits into the given solution space.

CONTRACT AWARD AND PARTNERING

Award criteria and assessment

The award was based not only on lowest price, but also on other aspects. Before being considered for ranking, the tenderer's bid had to comply with three so-called knockout criteria.

1. *Time criterion*
   The contractor shall be able to complete the work within 4 years and 10 months, including some intermediate milestones during the construction period.
2. *Technical criterion 1*
   The offer complies with the programme of requirements, to be checked by assessing the requirements and verification matrix. The tenderer does not submit a design, as traditionally done with technical description, drawings and design reports.
3. *Technical criterion 2*
   The design shall successfully pass physical and numerical model testing.

Only if the tenderer has passed all the above criteria will he/she be considered for ranking. The criteria for ranking are based on a mix of construction costs, time, maintenance costs and risks (contractual risk share). On top of that the tenderer could achieve bonuses (for ranking purpose only) when some critical parts are completed earlier than specified by the PRA; these are: date of completion of the recreation beach (latest date for completion June 1, 2012) and nautical access to the first container terminal (latest date April 1, 2012).

Indexation of cost is applicable and based on the tenderer's selection of proposed indices by the owner. The ranking has been made on Nett Present Value (NPV) per July 1, 2007. The NPV of the construction costs, calculated by the tenderer, was based on the financial format for payment as prescribed by the PRA (certificates) as well as the progress of the work (progress payments), mainly dictated by the construction programme of the tenderer.

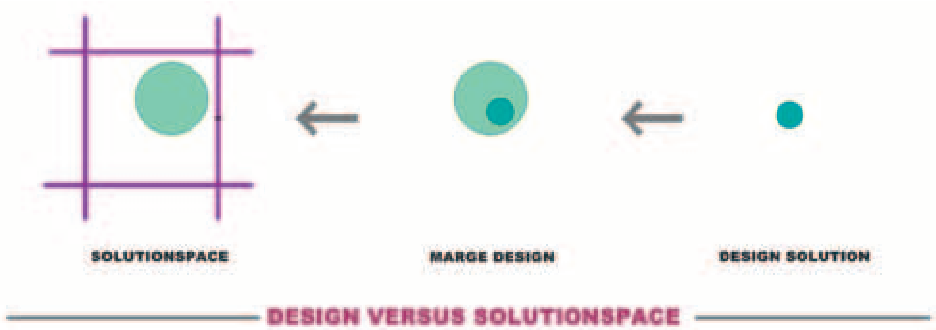

Figure 5. Physical solution-based system.

Partnering

The contract was awarded to PUMA, based on the submitted offer, and according to the above-mentioned award criteria, and assessment. During negotiations after the submission of the best and final offer, however, it became apparent that further optimisation of the hard sea defence was possible. This submitted design partly consisted of a cobble beach (length 1.3 km) (Figure 6) which could possibly be extended (with some modifications) to replace the more expensive remaining structure (length 2.2 km) (Figure 7) in whole or in part. The latter was a traditional S-shaped breakwater design with a primary armour layer of concrete cubes. The cobble beach design resulted in cost-savings but could require more maintenance. It was decided to include a partnering clause in the contract to jointly investigate the possibility of applying the cobble beach design of the hard sea defence and, if successful, to share the benefits equally. Partnering indeed appeared to be successful and led to cost savings design, both minimising investment as well as maintenance (Figure 8) replacing the cross sections as shown in Figures 6 and 7. This design again had to be completely tested in physical scale models before the final go-ahead for construction could be given by the PRA. The design of the sea defences is dealt with by G.L.A. Loman *et a.l.* [ref. 2] (Figure 9).

SYSTEMS ENGINEERING IN THE CONSTRUCTION PHASE

Systems Engineering is focused on the needs of the client or stakeholder throughout the lifecycle. In the first two phases, the concept and development phases, the solution of the system is developed based on and according to the Programme of requirements. The construction of the solution designed is the next phase. The challenge of the construction phase is illustrated in Figure 9. This schoolbook example shows the need for regular checks against the requirements and the client's needs. A good verification process is required throughout all phases of the project's lifecycle.

In order to be able to set up a good verification process, it is important to describe which verification method(s) are acceptable as early as when the requirements are prepared. For this the so-called Requirement Tree and Verification Matrix (RTVM) is prepared. In the RTVM all the requirements are listed together with the verification method. The contractor manages the RTVM in a transparent and traceable way such that the client is up to

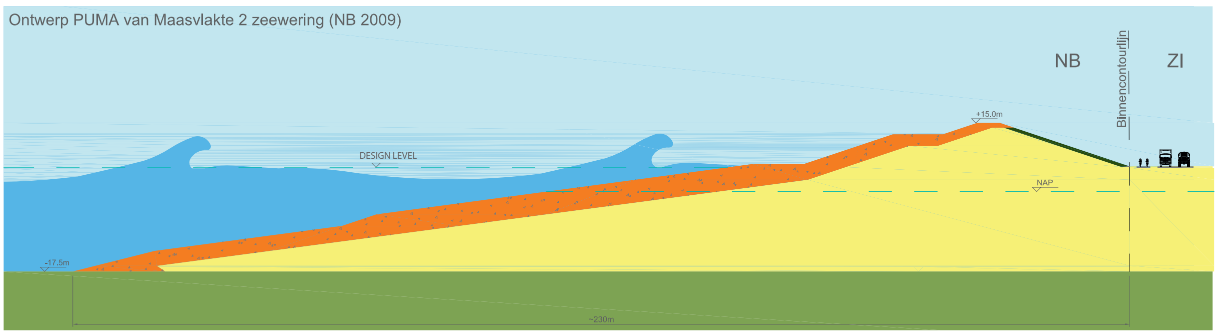

Figure 6. BAFO design, cobble beach, length 1.3 km.

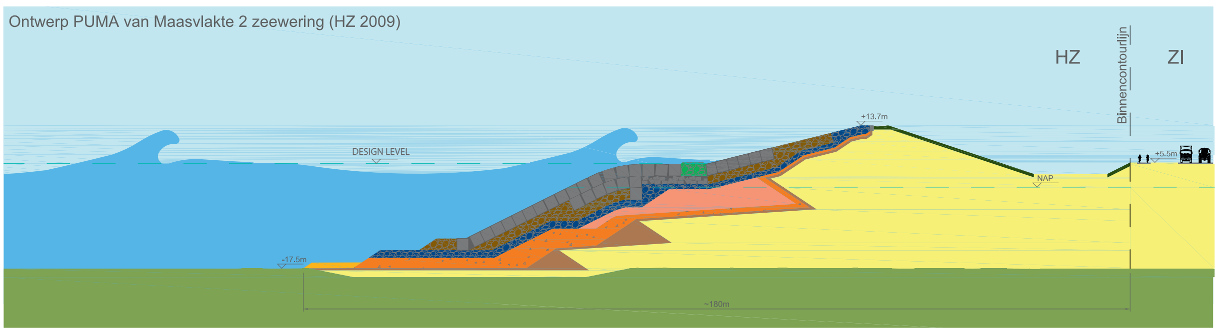

Figure 7. BAFO design, hard sea defence, length 2.2 km.

Figure 8. Partnering result: cobble beach and dune with concrete cube reef, length 3.5 km.

date with the verification process during the execution of the project. For the Maasvlakte 2 project, PUMA manages and administers the RTVM in a web-based environment. The client can log in and look into the RTVM whenever he/she wants and wherever he/she is.

Contractor and client

The responsibilities of the contractor and client overlap. The client's responsibilities focus on formulating specific requirements that the designs must meet and on monitoring these requirements during the design and construction process, while the contractor's responsibilities are to develop a design/solution meeting the specific requirements and verify that these requirements are met during the construction phase. In other words the client and the contractor have the same objective with respect to the monitoring of requirements during the construction phase: Monitoring and gathering proof that a properly constructed system is built that meets the client's requirements. Obviously the verification process plays a key role in meeting the objectives. Verification provides proof that something is constructed according to specified requirements.

Scheduling and planning verification will be essential (Figure 9). In principle verification of the requirements will take place during every phase of the project. Each discipline, the engineering department, the work preparation department and operations, will contribute to the verification process. Each discipline will be responsible for the verification effort to be executed during the phase for which it is responsible. The verification effort per phase and discipline are made transparent and traceable by the use of the RTVM. The RTVM database is managed and administered in a web-based software tool. This keeps both the contractor and client up to date and aware of the verification process. In other words they are aware of the quality of the work and the constructed product with respect to the requirements during the lifecycle of the project.

Figure 10. Trailing suction hopper dredgers of the PUMA partners at work on Maasvlakte 2.

Integral project management

The verification process is a key issue for project management. Hence project management efforts and tools should be applied to actively follow up on the objective to monitor and gather proof.

Project management (together with Systems Engineering) frequently uses breakdown structures:

- The *System Breakdown Structure (SBS) and the specification breakdown structure.* The system breakdown structure (SBS) represents the decomposition of the system in a hierarchical way. The requirements, interfaces and preconditions are grouped and allocated to the components of the SBS.
- The *Work Breakdown Structure (WBS)* contains all the activities that must be executed for a project. The WBS is an important tool for managing projects.

These structures support the top-down approach used in complex systems and help manage the complexity of a system. A good system breakdown improves manageability. The work breakdown structure is of central importance to project monitoring and control. Risks, time and money are linked to the work breakdown structure (Figure 10).

At the start of the construction phase the WBSs are prepared. The WBSs are used to manage the available resources and interfaces between separate activities. In addition, for each activity or group of activities in the WBS, requirements are allocated and managed as such. For the construction phase of Maasvlakte 2 a number of WBSs were prepared for the entire system and in more detail for different subsystems. In the WBS the activities that must be executed are listed and grouped so that the hierarchy and the relation between the (key) activities are visible. Based on the WBSs, the management appoints special task forces. Each task force consists of

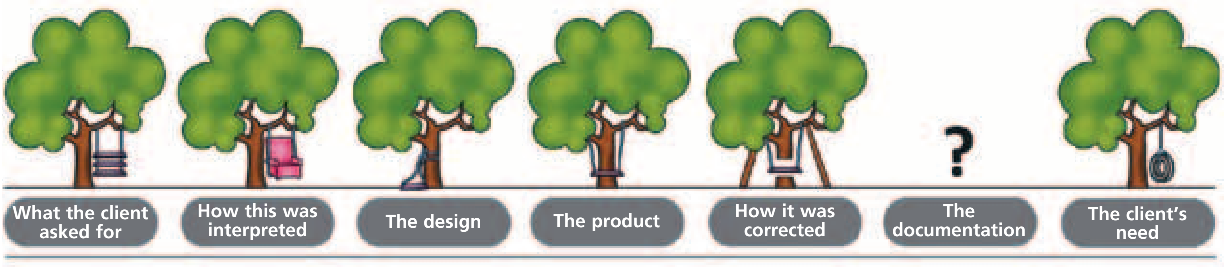

Figure 9. 'The Swing", the necessity for regular checks and verifications.

a representative of the design/engineering department, work preparation department and of operations. Together with the appointment the project management can provide the task force with useful (background) information such as the project vision/objectives/uncertainties and success criteria for the specific activity. This methodology assures the management of the project in an integral and controlled way. In addition typical design and construct problems – interface problems between design/engineering and operations – can be foreseen earlier, controlled and minimised.

RESULTING BENEFITS OF APPLIED CONTRACTUAL APPROACH

Quality management

A mutual benefit for contractor and client is well-monitored and controlled project execution throughout the project organisation and the systems lifecycle to ensure that requirements are consistently met. In other words: good quality management (Figure 11).

Quality management plays a key role in being able to guarantee the quality of a product, service or process. Quality management serves to standardise and formalise processes. An important component of quality management is the use of quality assurance. This method imposes requirements in terms of the way in which client and contractors communicate with each other in relation to the verification process. It is important to find a quality system with a quality assurance function that addresses all the processes used during the execution of this innovation in Systems Engineering based projects. The challenge for the large infrastructure project is to collectively agree on a suitable quality management system. Only then will it be possible to account for quality, and consequently effectiveness and efficiency. For the Maasvlakte 2 project a custom-made quality management system was developed. In short this custom-made quality system focused on quality control in line with the verification process of Systems Engineering and was based on ISO 9001.

Transparent and traceable process

It is often said that the difference between traditional engineering and Systems Engineering is that Systems Engineering is (more) transparent and traceable. The core element in Systems Engineering is the explicit documentation of information, something that in the traditional process flow usually only takes place within the heads of those involved. The main benefits of the transparency and traceability of the Systems Engineering process are:

- Preventing errors and the cost of failure – open communication and transfer of the documented information between parties and from one phase in the construction process to another
- Project managers, as well as clients, have an insight into the status of quality and progress during the project
- Changes and new options can be dealt with more easily. The traceability of requirements makes it easy to determine the impact of scope or configuration changes.

To elaborate on the latter benefit: During the execution of a large infrastructure project new options, optimisation and/or improvements of the design present themselves. The Systems Engineering process, especially the traceability of requirements, makes it fairly easy to deal with such opportunities. The impact of the changes can be determined. Analysing of the effect created by the change (or new option) on the requirements and the quality of the system/product can be done more systematically.

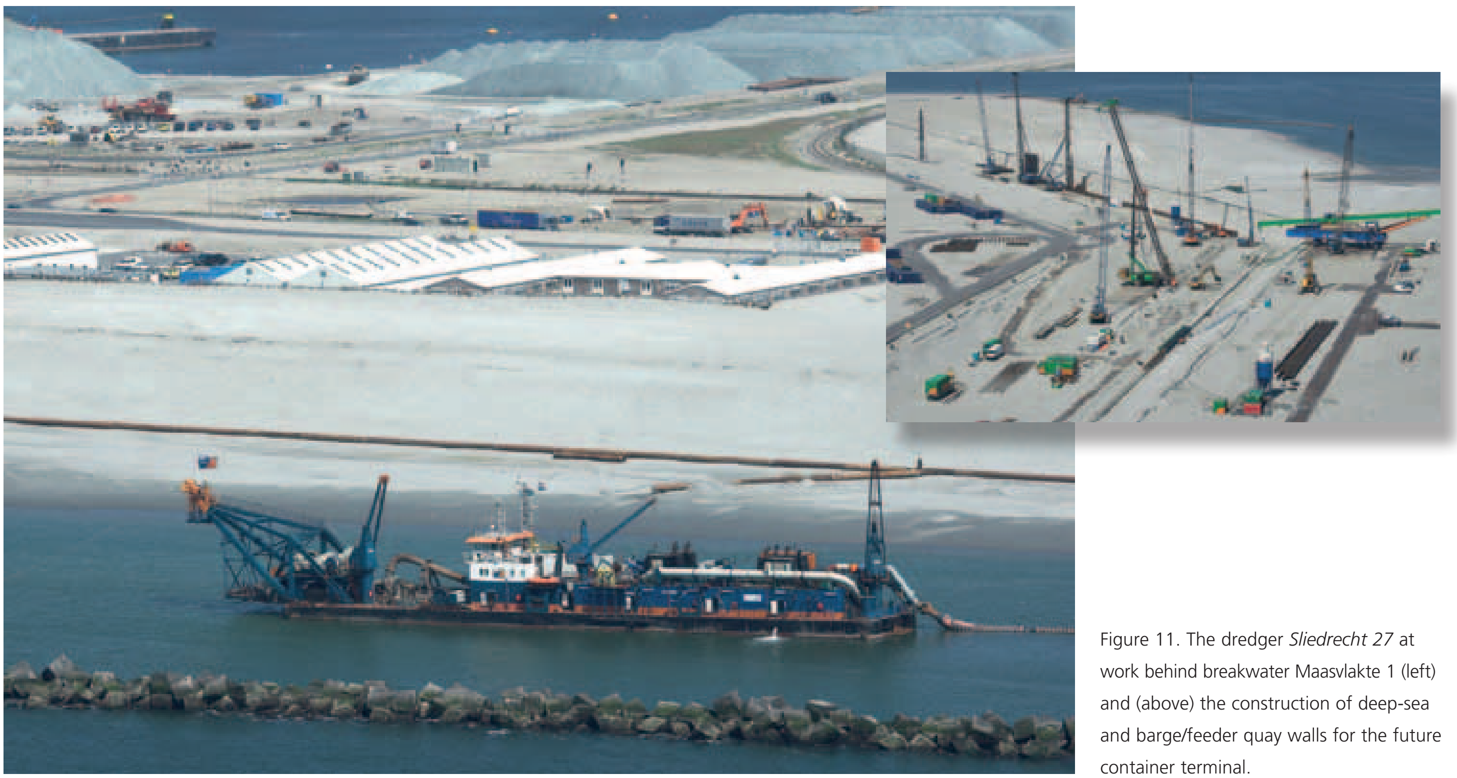

Figure 11. The dredger *Sliedrecht 27* at work behind breakwater Maasvlakte 1 (left) and (above) the construction of deep-sea and barge/feeder quay walls for the future container terminal.

Figure 12. Drawing (above) of the Blockbuster, and right, an aerial view. The Blockbuster was designed to place the 40 tonne concrete blocks in front of the hard sea defence.

In other words: which requirements have to be replaced or rephrased? Which have not been affected by the change? Is it still in accordance with the primary or the main functional requirement of this specific part of the system? Based on such an analysis the client and contractor can make well-considered decisions. An example of this, and underlining this benefit, is the "partnering result", a new optimised design for the hard sea defence as described above in the section "Partnering".

Innovative design and equipment

The Design Construct Maintenance Contract format indeed allowed the contractor to develop the design of the sea defence so that it makes optimal use of existing construction expertise and actual knowledge of the equipment and materials available. For further elaboration of that design see [ref.2]. As a result of the fact that the hard sea defence was designed in a systematic, structured and transparent manner it was much easier to achieve mutual agreement on the improved (partnering) design. Indeed the new option, which arose from discussions in the award phase (see discussion above), did not necessitate the entire design process to start from scratch, but had to be partially re-executed, i.e., only those parts which had an effect on relevant specific requirements. The transparency provided by the system-oriented approach appeared to be essential to arrive at the agreement on the innovative partnering result between Client and Contractor. Because of the volatile wave climate of the North Sea, it was decided to use as little floating equipment as possible for the construction of the hard defence. For installation of the concrete cubes (each weighing 40 tonnes) a special innovative crane was developed and constructed (Figure 12). This so-called Blockbuster is able to install the blocks (including the clamp for hoisting, weighing 50 tonnes) at 63 m from the centre of the undercarriage.

REFERENCES

[1] Leidraad voor Systems Engineering binnen de GWW-sector versie 2.0 (in Dutch) dated 27 November 2009. - Guideline Systems Engineering for Public Works and Water Management Second edition (English translation of original version, minor changes made to the Original version of April 2007), dated May 2008. - For the latest edition and information on these documents go to website http://www.leidraadse.nl

[2] Loman, G.J.A., Markvoort, J.W. and Onderwater, M. (2010). "Design of the sea defences for Maasvlakte 2". *Proceedings of PIANC MMX,* 125th Anniversary PIANC, International Navigation Congress, Liverpool, UK. May 10-14, 2010.

CONCLUSIONS

The Port of Rotterdam will be expanding into the North Sea. The realisation of the Maasvlakte 2 entails the creation of a new world-class port and industrial area. The selected Contract format, Design Construct and Maintenance Contract (DCM), and the system-orientated approach resulted in a "value for money product" for the following reasons:

- Construction experience was efficiently incorporated in the design process.
- Disputes between Designer and Contractor were avoided.
- Cost savings were achieved as a result of the Contractor making the design with the convenience of construction in mind.

The option for possible savings in the design of the hard sea defence, which became apparent in the Award Phase was successfully implemented via an additional Partnering Clause in the finally awarded Contract. The Partnering resulting in a new design of the hard sea defence was in particular successful as a result of the applied system-oriented approach (Systems Engineering). The inherent mutual transparency created through this approach was a key factor in reaching agreement between Client and Contractor.