Development of the BIM based process for Dredging Works

R. Heikkilä[a], T. Leinonen[b], H. Paukkeri[c] and H. Virtanen[a]

[a]Construction Technology Research Center, University of Oulu, Finland
[b]Terramare Oy, Finland
[c]Meritaito Oy, Finland

E-mail: rauno.heikkila@oulu.fi, tapio.leinonen@boskalis.com, heikki.paukkeri@meritaito.fi, henvirtan@gmail.com

Abstract - Development of building information modelling for dredging process has been studied. In dredging area different 3-D guidance and control systems have been used already over 15 years. However, the information transfer process from early initial data acquirement phase through design and further to construction phase has suffered from information delivery gaps, undetermined modelling and information delivery methods. In the paper, a new specification for initial data modelling, BIM based design process and BIM based as-built measurement and quality control procedures are to be introduced. Most essential in the process model is to transfer the information, which is binding the parties. This will be done electrically using 3D information models throughout the total operation chain. An important result of the project is also the documentation of the current dredging work process in Finland that has not been done in the past. The new models were tested using Novapoint software as a BIM design tool and two different construction projects (Rauma and Helsinki, Finland) were used for the experiments. Future work will be also described.

Keywords - BIM, Automation, Dredging

1 Introduction

Dredging monitoring systems (DMS) have been widely used for a long time (more than 15 years). As well, survey methods and modelling applications are relatively advanced. The whole dredging project still needs improvement. There have been a lot of problems in split of work and communication. For example the official data transfer has been document-based and the electronic data provided has remained to be only unofficial additional information and thus not transferred and shared with the later work phases.

In the fairway and dredging projects ordered by Finnish Transport Agency, the undeveloped data transmission and data utilization are today aimed to be improved by applying and utilizing BIM (Building Information Modelling). BIM or Infra BIM on the area of civil engineering, means the whole of the parsed digital data of the product, in its whole life-cycle. In the model-based process, the current situation of the planning area is described in the initial model which becomes to the design model by adding the design data into it. The design model is edited to production model which is utilized in dredging monitoring systems. Furthermore, the as-designed model is compared to the as-built model, the measured data of the fairway is saved in the maintenance model, and the final situation of the fairway is described in the residual model.

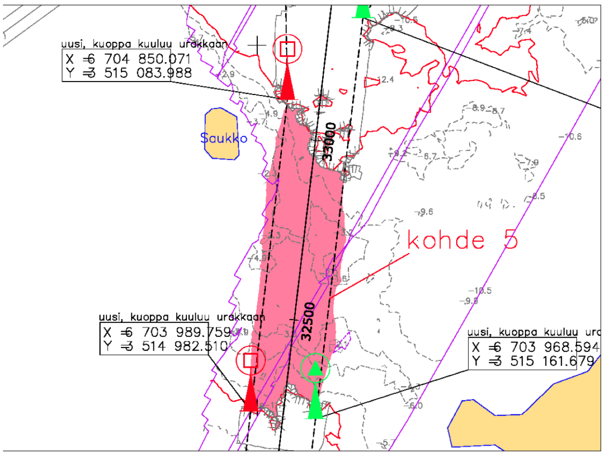

Figure 1. From planning to construction – current process: approximately 200 drawings in 5 folders (length about 10 km) and a map for background from the client, in DWG format. Bathymetry data is given to contractor in ASCII format.

The aim of the research project called Dredging BIM was to investigate and develop for dredging works a new process utilizing information modelling and automation, and to publish it for the whole branch along the instruction of the client. As the sub-purposes, the following tasks were set: to research the possibilities to develop the source data, to develop the construction planning by defining the construction model, to research the possibilities to develop the gathering of as-built information, utilizing information gathered by dredging monitoring systems, continuous sounding methods and barsweeping, and to develop the methods for digital data transfer utilizing open formats when possible.

2 Methods

A new BIM based process model (Fig. 1) has been developed for dredging works and industry. In the process model, special initial information model is created based on 3D underwater surveys and other investigations. The initial information model will be transferred to designer. The design of new waterway will be performed using specialized modelling method, which creates a design model. For production purposes a specified production model will be transferred and utilized in the dredging automation systems used. During the production, specific as-built models based on measured data will be created, and transferred to the utilization in maintenance of the waterways and further in the control of water traffic. As-built and maintenance models are based on real measured data. During the operation and maintenance period continuous 3D control surveys will be performed, these survey results are further saved to the maintenance model.

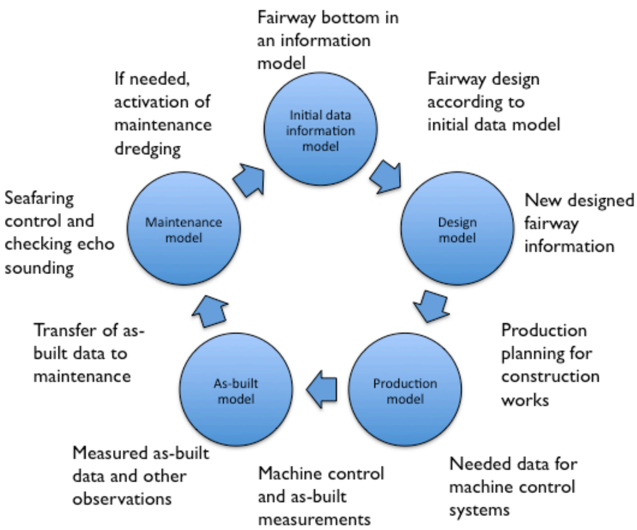

Figure 2. New BIM based model for dredging works.

One of the purposes of this first study was to develop the specification of the as-designed model for dredging, of which the usability was found out by processing and modelling the data of Rauma fairway. Moreover, the possibilities to utilize and develop the source data of dredging, the open format data transmission with IM (LandXML-based InfraModel) and infraBIM guidelines, were studied. The work focused on the phases of construction design and construction of the fairway.

Finnish InfraBIM guidelines were applied on the modelling of the source data of Rauma fairway. Details from the view of fairways were developed for the specification of these guidelines. The development work of the specification in the as-designed model was based on the InfraBIM guidelines on the as-designed modelling of roads and highways. Also, the dredging contractors were listened in order to gather the information for the development work. The as-designed model contained definitions for the digital data needed for dredging works, including fairway model, bathymetric and subsurface data, boulders and pits for buoy weights.

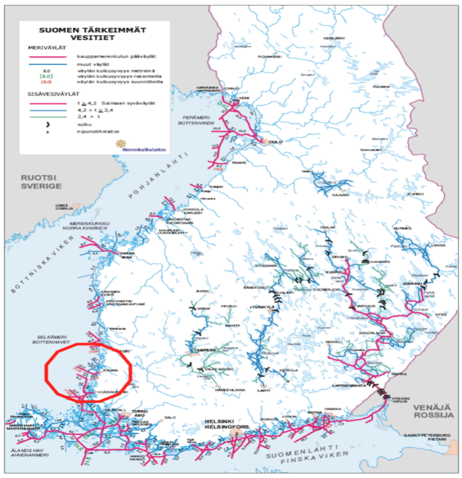

Figure 3. Rauma dredging project was selected as a pilot project for the experiments (The 4th largest port in Finland, deepening the current 7,5 m/10 m fairway to 12 m, costs app. 14 million EUR, estimated benefits app. 33 million EUR (30 years, 5%).

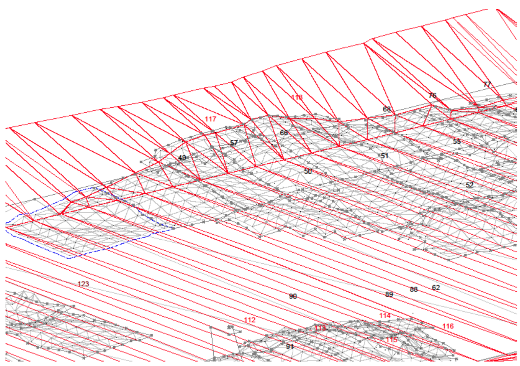

Figure 4. Production model – current process done by contractor. The contractor creates the 3D model:

edge lines, slopes, slope inclinations, buoy pits, triangulation in correct way, triangulation into matrix, crane monitoring system (three matrixes).

Figure 5. Operator user interface for 3D dredging work (University of Oulu, Terramare Oy).

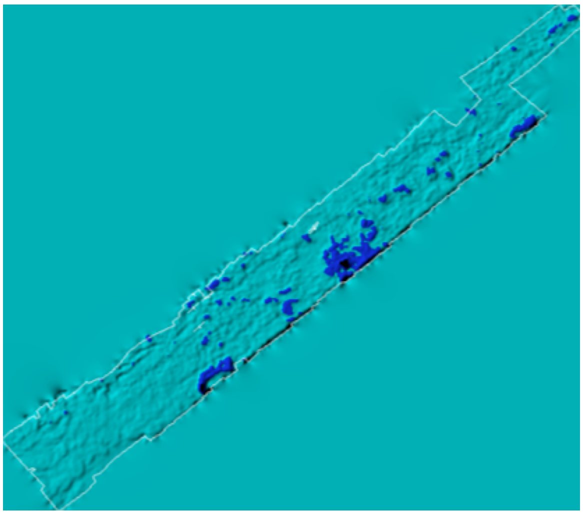

Figure 6. Example of measured (echo sounding) 3D as-built model (University of Oulu).

3 Results

Concerning the source data of dredging and planning works, needs for the development its coverage, the utilization of the measurements and the modelling of investigations were found. Also the development of dredging monitoring systems is needed for commissioning the model-based process and the IM-based data transmission. Also, the specification of the Inframodel format was still insufficient unambiguous, which turned out as the computer applications processed the Inframodel data differently. The ensemble of the source data of the dredging process and its usability, quality and manageability is estimated to be improved in the future by processing and aggregating the data in the model-based way.

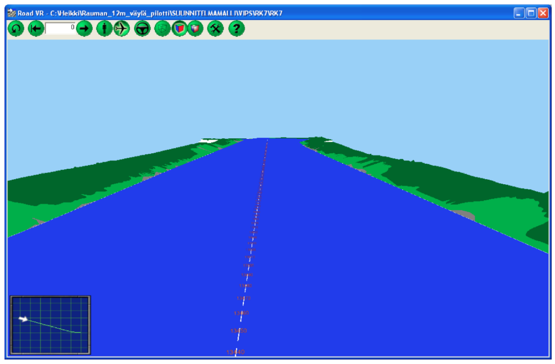

Figure 7. A scene to the waterway model in the design software (Novapoint). The sweep level (blue surface), the rock cuts (grey) and the soil cuts (light green) of the waterway were modelled.

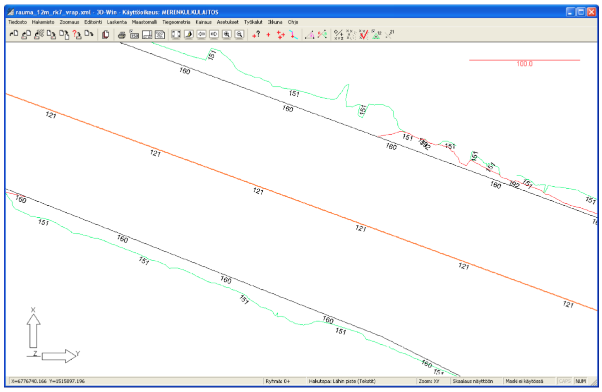

Figure 8. A scene to the as-designed string line model using 3D-Win software. The file was imported using open Inframodel format.

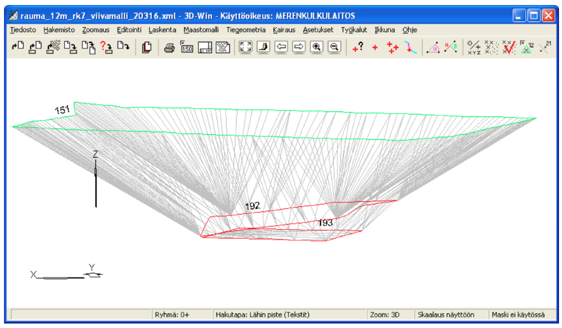

Figure 9. A scene to the as-designed model (3D-Win software).

In the machine monitoring test the production (as-planned) definition was detected functional. Machine monitoring worked flawlessly as planned. The need for improvement was though detected in the naming of the conveyable files. In the original production definition the production data meant all the data needed for execution. To clarify naming in the future it's suggested that production model only consists of the structural surfaces of the fairway or harbour. The rest of the model-based and other materials should be named as production material.

It was detected that when naming the as-built model the same rules should be followed as when naming the as-planned model. In road and railway construction (as well as in building sector) as-built model is at this moment defined as a design model which is corrected with the design mistakes. At the dredging industry this is not accurate and overall as-built model is defined as the actualized seafloor model detected by Multibeam or other acoustic surveying. The as built materials should consists of as-built model, detected soil type information, boulder information, the locations of blasted areas, experiential information and other files. The maintenance material is needed when keeping up the fairways and as start-up information for later dredging works in the same area. Maintenance information consists of the seafloor model detected by Multibeam or other acoustic surveying, soil type information, boulder information, the locations of blasted areas and experiential information.

Advanced dredging contractors are able to use their existing systems and know-how for utilizing information models proficiently and effectively. The subscribers' needs and opportunities in the model-based execution should be developed further for example using a suitable cloud service. At this moment it's not easy to storage the information models needed by the maintenance in the current data registries of the subscriber.

When comparing to the traditional design process, BIM based design needs a little bit more modelling work. In addition of the surface models every single pit should be modelled including also feature classified information. In the dredging process used in Finland these types of surface models have been used in design process for the needs of the volume calculations and to create cross-sections as a part of traditional design process. By developing more accurate specifications and guidelines for modelling methods, the quality of design models as well as the accuracy of design work can be improved.

The open LandXML standard and the Finnish extension Inframodel (IM) are quite unknown among the dredging industry in Finland and worldwide. To enable and facilitate the change and move to the new BIM-based process, more efforts should be aimed to the information communication between BIM developers and dredging industry.

In this work, suggestions were given to improve the source data of dredging projects and the data transmission. By increasing the amount of low-frequent soundings and the soil interpretations made of them, with utilizing the other investigations and already in the early phases of the projects, the source data will be improved. As well, the MBES data is to utilize also for habitat mapping in order to improve the soil co-interpretations. Also, the IM-specification and its usability will be improved by changing the cross section parameters of the fairways and by adding the definition for point objects, such as boulders, with feature data in the definition.

4 Conclusions

A new unique Infra BIM based process model has been developed and documented for dredging works and industry. The process model can further be utilized worldwide after some additional tests. Most essential in the process model is to transfer the information, which is binding the parties. This will be done electrically using 3D information models throughout the total operation chain. An important result of the project is also the documentation of the current dredging work process in Finland that has not been done in the past.

In addition, detailed modelling specifications as well as the nomenclature and numbering of part models have been developed. Also an extension for the next open inframodel schema has been suggested adding the needed parts and features to the schema from the dredging side.

The new Dredging BIM process model has been practically tested, but not yet in the whole scope of the purpose. New experiments will be needed for the feasibility evaluation and additional development of the inframodel extension part as well as in as-built and maintenance models. In that way confidence will be created to ensure that all necessary information is transferred in different project phases. For the wide continuation development and utilization, a common development and piloting plan would be valuable.

Open information transfer using the newest Inframodel extension will be a new challenge also for dredging industry. The saving and transferring of measured information needs to be studied more due to the typical extent of measurement data and information content. The transferring of production model to dredging monitoring systems needs software development and programming work from the industry. The final form and production of maintenance information model needs to be focused with more precision.

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