THE DREDGE FLEET MONITORING SYSTEM (DFMS) AN INDUSTRY 4.0 COMPONENT

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ABSTRACT

Dredge fleet monitoring is not a new activity and in fact has been practiced by a vast majority of dredging companies, principals and other stake holders for decades. In the old days, a hand-written production log would suffice. In present days this has been replaced by latest available, modern, real time techniques within Industry 4.0 including connection to the World Wide Web. This enhances dredgers' intelligence as a guided and controlled working production platform. One of the latest developments in this area is the newly designed DFMS (Dredge Fleet Monitoring System). The system allows dredging contractors to follow their deployed fleet all over the world from their own office. Alternatively, tracking from anywhere in the world is feasible through VPN (Virtual Private Network) technology. Two recent developments, data on the dredger and mobile Internet communications are combined to provide detailed and near real-time insight of the actual dredging operation. The information involved in dredging shares some similarities with more ordinary vessel information such as location and fuel consumption. Dredge specific information like production and development of the DTM (Digital Terrain Map) are also provided through the DFMS. Demonstration of this technology has been installed on 3 cutterdredgers in the Middle East area with a required new PLC (Programmable Logical Controller) & SCADA (Supervisory Control & Data Acquisition) system. The DFMS can be set to an operator's personal preference within the built-in functionality as a freely configurable system. DFMS is designed as a web-based service. The Office module of the DFMS can be accessed from laptop computers as well as tablets and smartphones. Deployed dredgers are presented in top view on one or more layers of map content. One of the layers for example would be ECS (Electronic Chart Service) and automated pop-ups for more specific process. Another option could be tracking KPI (Key Performance Indicator) data. The goal is the collection and reporting of real-time data of the dredgers for each unique project. This information can be accessible as long as connectivity is available and internet is accessible.

Keywords: Industry 4.0, monitoring, KPI, Internet of Things, mobile data, real-time.

INTRODUCTION

Over the last 20 years many people, companies and even whole industries have changed at a rapid pace to adapt to the new technology available under the buzzwords "Industry 4.0" and "Internet of Things". For most people this is recognizable in our mobile phones with an array of functionality, to the extent that the word "phone" is an overly simplistic word for even one of the a microcomputer's applications. This ubiquitous tool now unavoidably combines our personal and business world. The dredging industry is no exception. The most important of those technology forces affecting the dredging industry, are currently perceived as:

- Security (incorporating data safety and integrity)
- Mobile (all information, anywhere, accessible for the people entitled)
- Cloud (unlimited logging of information, "big data")
- Internet of Things (interconnection of dredgers with other entities)

However, a brief historical review quickly reveals that most of this has already been around in the dredging industry for a longer time. Major game changers include the technical improvement in the ship to shore transmission and the

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rapid development of applications in the IT (Information Technology) world. This is much faster than the development of the hardware and software installation on a dredger. This difference in development speed is known as “Bimodal IT” or “2 speed IT” symbolized in Figure 1. The dredging world can apply this practical concept to develop IT policy and subsequential investments.

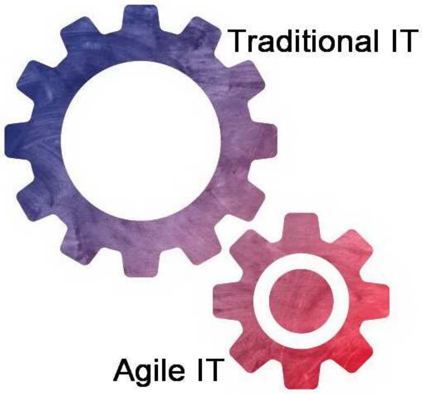

Figure 1. Bimodal IT.

In practical terms Bimodal IT for dredging can be compartmentalized into:

- Traditional IT as applied in the control, measurement, monitoring and automation systems on the dredger
- Agile IT where applications for monitoring and analytics are rapidly produced and changed, specific demands from pending dredging projects etc.

Upstream

Traditional IT is very recognizable aboard of the dredge fleet, by the desks on the bridge and the computer monitors for the operators. Many dredgers are designed and built for a full operational lifetime of at least 30 years. And during the design and building phase of the dredger only the proven technology of the moment was and still is applied, for obvious safety reasons. This is especially apparent for electronics because for many systems the average electronic platform lifetime is 7 to 12 years. The latest generation of dredging vessels have, like ordinary ships and manufacturing plants on land, become controlled and dependent on PLC (programmable Logic Controller) and SCADA (Supervisory Control and Data Acquisition) installations. By year 7 years and older, this phenomena will affect full operational availability of the dredger because of diminishing availability of spare parts and adequate services. In the dredging industry people are used to thinking in terms of improvement, upgrades, refurbishment and new technology to be installed due to the difference in lifetime of the dredger and electronics. Either new or old - dredgers in the year 2017, in general, have internet facilities aboard. A typical driver for data availability and information transformation has been the requirement for transparency of the dredging operations by the principals. Governmental and harbor authorities have always had a keen interest in the execution of dredging operations. This was initially started to check on economics of the operations and related contractual conditions between the principal and the dredging companies. Later on environmental compliance became an important factor. Most dredging contracts today incorporate clear contractual conditions how data is acquired, stored and delivered. The data of the dredger and operations can be seen as an upstream process to a virtual connection socket for various interested parties. The actual onboard processes could be described as “Edge Analytics”.

Edge Analytics

This is an approach to data collection and analysis in which an automated analytical computation is performed on data at a smart sensor or computational device onboard the dredger. The development of this kind of technology covers more than 30 years on board of dredgers - many times incorporated in the PLC / SCADA / Survey. It has applications in controllers for dredge pumps, draghead, etc. Nowadays the more advanced systems like DP/DT (Dynamic Positioning / Dynamic Tracking) together with A.I. (Artificial Intelligence) and the Dredge Advisory System for the operator become more and more involved with this “edge” part of data collection and analysis – (performed pre-storage) before the data is made available to external parties outside of the dredger or downstream of the dredge data transfer to on shore processing and storage.

Downstream and internet development incorporated

The data can be downloaded downstream and by users of the dredger's data once the data has departed the dredger's virtual socket via internet.. In this case we use exactly this kind of data to empower the DFMS to the extent that it can be viewed on mobile devices (smartphone and tablet). Another way to look at this is to see the dredger and dredging process as a data generator to be used on and off the dredger through internet. This is enabled by data transmission to shore and a virtual socket for users.

Connection to shore

The earliest artist impression of a dredger accessible over the internet by various users, as seen in Figure 2. originated around 2004. However, the lack of a safe, reliable and affordable connection from the dredger to the shore was perceived as a major limit for feasibility. Another shortcoming from the original concept was the idea to have data from the dredger transmitted only to shore, when in fact this has evolved into a bi-directional process. A good example is the transfer of survey data by transmission to and from the dredger. This achieves a possible cost saving by avoiding the Survey Department having to visit the dredger on a regular schedule. Early dredgers communications to off-site userswere through radio or high power custom-built WIFI connections which comprised of signal booster, special antennas and dedicated software to exchange the data automatically when in range.

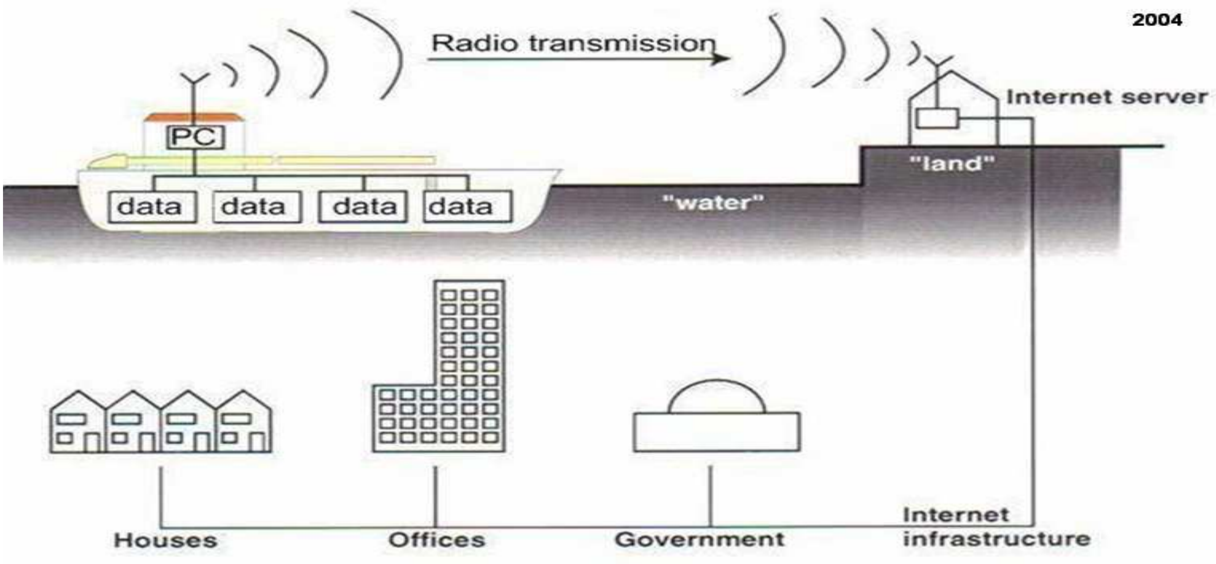

Figure 2. Artist impression 2004.

This range of about 1 Kilometer was accomplished at negligible data transmission costs. There was no thought given at that time yet to make this data available for all kinds of users. Organizations were simply not yet developed for this. Over time prices of satellite connections came down and very reasonably priced 4G bandwidth solution emerged. which generally provides near-shore coverage. Current state of the art is that real time connectivity is feasible and limitations like bandwidth and the size of data to be transported is improving all but disappearing soon for the most important applications. Unfortunately, we also know that with every improvement we see a rise in requirements because people recognize new possibilities. The vision for the next generation of connectivity between ship and shore is that this will be dominated by the development of applications to help principals and dredge management enhance operational efficiency and better scheduled maintenance and repairs, translating to more data ("Big Data"). In dredging, the typical key areas (beyond the dredging projects specific data) include features like remote maintenance, engine & fuel monitoring, delivery of electronic charts, weather data and even e-Learning services. Finally, in the overall data transmission today's dredging crew are demanding good communication connections to home. They expect access to social media and the Internet at sea as well as access to news, training and professional development. However, in the DFMS application we focus on the monitoring on shore of the dredging data of the dredger.

THE DREDGER'S CONNECTION SOCKET

With sufficient transmission bandwidth the dredger's data can be qualified as real-time for on shore use which is changing the dredging industry and the management of dredging projects. In short: we see the disappearance of "remote" dredging jobs where headquarters and principals receive the project results only at the end. This signals the rise of real-time quality control systems with full transparency and continuous real time involvement. This is enabled by safe real-time access to the data of the vessel as shown in Figure 3 - by either a common connection or a, more safe, VPN (Virtual Private Network).

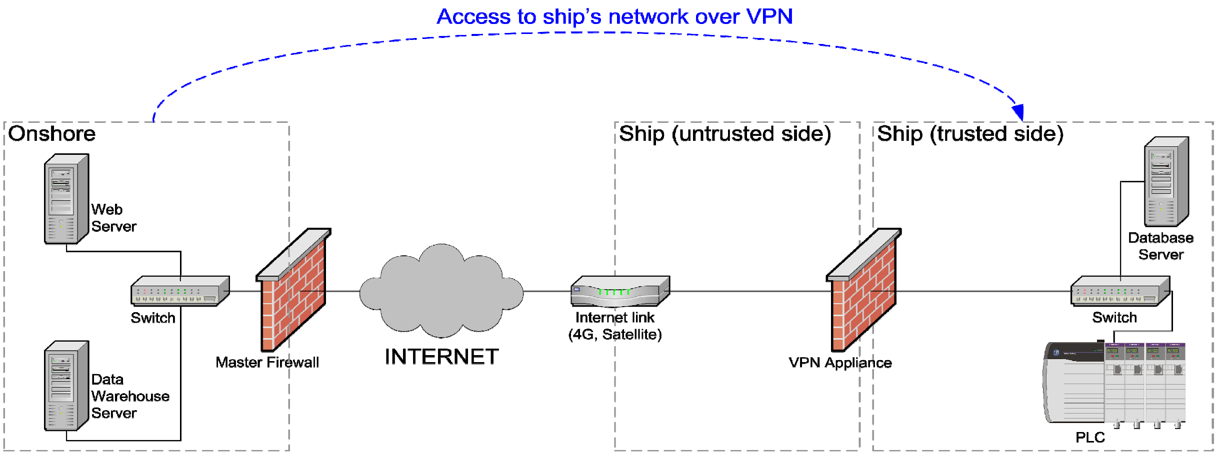

Figure 3. "IHC Connect" architecture.

Security and safety of the equipment and onboard systems require a rigorous review. The safety of the dredger should never be compromised by outside influences. Secondly, as previously discussed, there is a lot of data and there are multiple parties interested only in discrete parts. For these main reasons a system architecture is designed to create safe and discriminating access to dredger systems and data, for example:

- Service, like software upgrades
- Cloud, for big data logging
- Monitoring data of the dredger's operations and progress

Access can be managed from the dredger using the "Connect Management Center" (CMC) as shown in Figure 4. This proprietary system (or something similar) allows for user interface at the dredger and access control. The current IHC CMC is located in Sliedrecht but could also be a CMC on the premises of the dredging company or a third party like an internet access or cloud provider. Any choice of ownership and placement of a CMC system has advantages and disadvantages and the decision is up to the user.

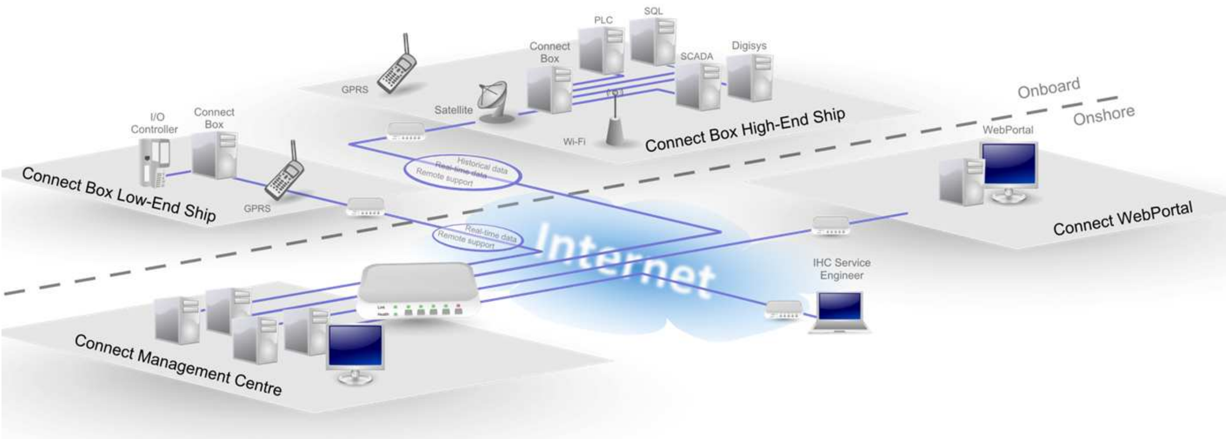

Figure 4. The big connection picture.

Security (switch)

Dredging is a competitive activity. Dredging contracts in general are tendered and the lowest and compliant bidder will –usually- win the contract. Dredging data and experience is valuable because dredged soil conditions as well as the dredger's equipment used vary and have their own best efficient working methods. Transparency to the principal is commonly required and accepted.

Figure 5. The switch on the dredger to allow access.

Full transparency to everyone (competition included), is unpopular like nearly all other industries. A currently installed feature on dredgers operating in more remote parts of the world is a hardware switch as shown in Figure 5. This allows data connection from the dredger to a supplier only possible when the switch on the dredger is "on". This could also be handled by software and "rights" to have access or not. However this switch remains living proof that a dredge contractor does not want outside influences to impact security and that they value operational data..

Value

Data or "Big Data" is currently expressed as having 5 parameters: Volume, Velocity, Variety Veracity and Value. The DFMS focuses on value. Data in dredging should be considered a business asset. In doing so a company is more likely to develop a data strategy that will capture effective content in a re-usable format. It is also important to understand data sharing as a necessity. The 'on/off' switch in the previous discussion is not recommended for all dredgers and can at best be judged as a temporary solution is a certain sophistication of development. Whilst collecting masses of raw data has its merits, if you take time to consider who needs the information and why, it is possible to overcome the problems and costs inherent to disparate data sets. By standardizing meanings, values, and formatting you will better support cross-functional business usage. Standardized "packaging" of data also enables a move towards centralized cloud storage, greatly reducing the time spent for managing and searching information. It is, once in full operation, the connection between principal , contractor, people, processes and assets like a dredger.

DATA SELECTION

Now that we have all the dredging data anytime, everywhere, the obvious question is what to do with all this to make it usable information to enhance our job. This phase puts us in the world of Agile IT which if able to use and produce Apps to do precisely what we want and we all have our PC, Tablet, Phablet and Phone to work with it. In the particular situation of the DFMS we found the application theory by applying the "Theory of Constraints" principle to monitoring expensive dredging assets. This theory is about identifying a (temporary) constraint and applying a faster fix to improve productivity. Dredgers in general have relative high maintenance costs due to abrasive soil pumping and a rough environment of salty water and moving parts. Some of this translates to unexpected down time because of discovering certain things too late for standard maintenance cycles. The ability to "visualize" in real time how your dredging machines are operating allows you to react more quickly to situations because other people than just the operator are involved. Measuring what actually happens on the dredger allows you to fine tune your processes, all by using automatic and accurate tracking systems. Overall Equipment

Effectiveness (OEE) is the knowledge based interface that drives the dredgers monitoring process forward. Dredger data flowing to a DFMS will bring the following capabilities, as routed in Figure 6. to the users:

- Information: allows the user to see the productivity in real-time
- Knowledge: dashboard indicators are available for everyone involved with the dredger
- Understanding: identify and discuss problems faster
- Wisdom: increase OEE and efficiency.

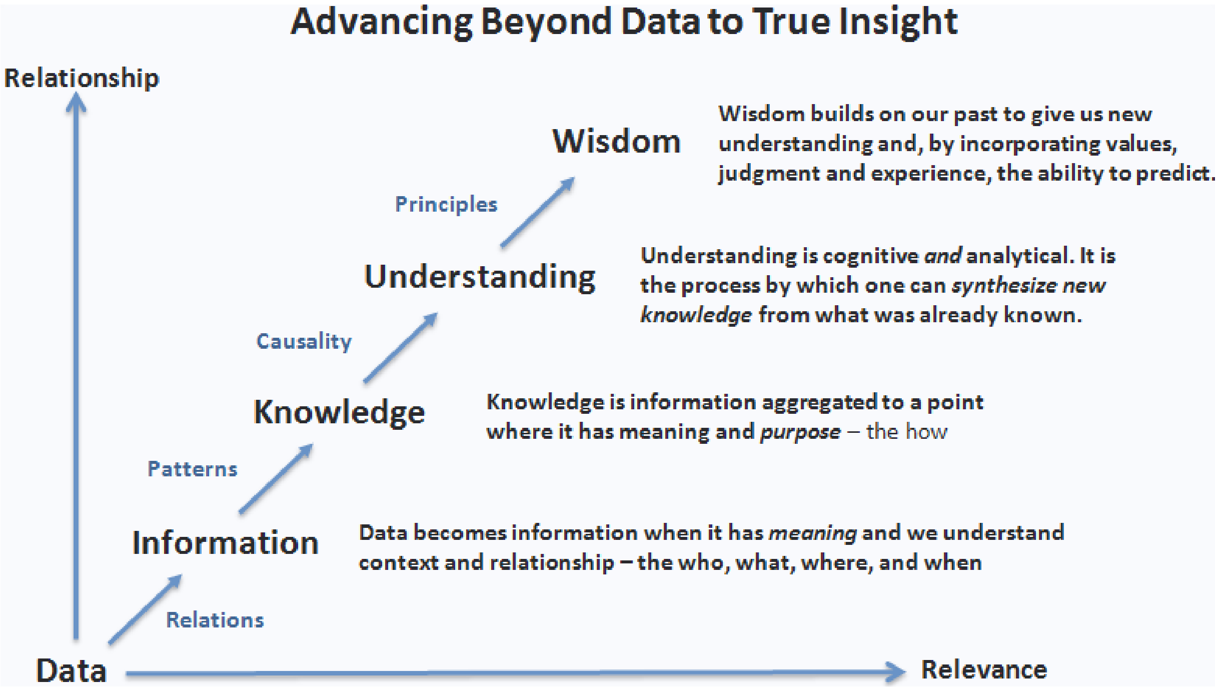

Figure 6. The path to better OEE.

The difference between dredgers and other vessels is dredgers have the process data, in addition to the ordinary data, like engine data and nautical data. It is therefore important to have knowledge of the dredging process to develop beneficial applications for dredging contractors and principals. A serious consideration also includes the fact that the world dredge fleet ranges from a fleet older than 40 years and hardly any process measurements to brand new state of the art dredgers with more than 1000 I/O (Inputs / Outputs). The latter is like the hopper dredge Magdalen in Figure 7. Most of Magdalen’s process data is in a central PLC / SCADA system and is therefore well prepared to accommodate a virtual socket and DFMS once the dredger is operational.

Figure 7. Under construction, hopperdredge Magdalen.

DFMS

The DFMS data is unique to each production environment and should consist of accurate utilization and efficiency figures, which would be theoretically available to all users. The various layers within the DFMS help to understand how efficient the dredger is actually working and utilize the data as fuel for further productivity improvements as well as estimating future jobs. From the positive approach "If you can measure it, then you can manage it." The design of DFMs started as top-down process with an analysis to determine what kind of primary information the management would like to see from the data of a cutter- or hopper dredger. The highest level, or first layer, is currently listed as:

- Uptime of the dredger
- Production
- Fuel consumption

In dredging production can have different forms or expression. It can be expressed as amount of: pumped material, transported material, Tons of Dry Solids (TDS) or a dredged or filled submerged area. This requires the DFMS tool to have great flexibility to accommodate all possible requirements. One applied method is using augmented pictures, comprising data from the dredger as well as a map layer from another source, like your own PC, as in Figure 8.

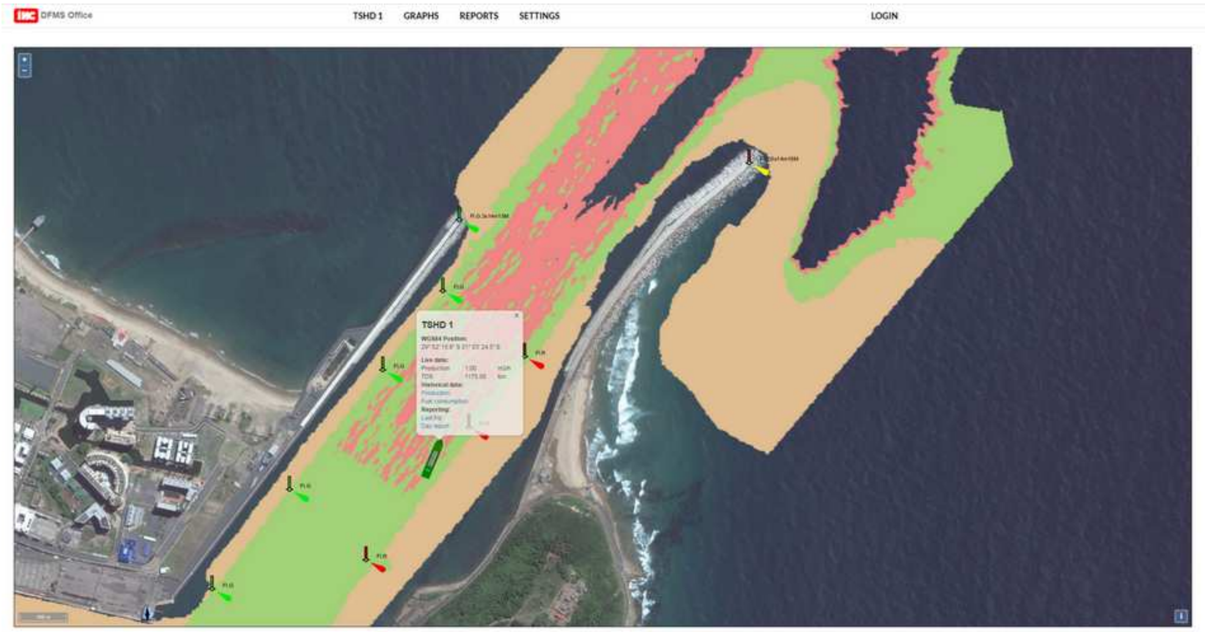

Figure 8. DFMS screenshot, as when applied on a PC.

DFMS is configurable. The user may configure it to any preference within the built-in functionality. As a web-based service, DFMS Office can be accessed from laptop computers as well as tablets and smartphones. This brings functional applications for site management personnel, who may use any of the means available. The system communicates with the PLC / SCADA presentation and automation platform installed on board. It supports WGS84 DXF overlays and can convert data from other geodesies. Dredgers in the project area are presented in top view on one or more layers of map content creating the augmented picture. Open-source as well as commercial map sources can be used. The dredger is presented in a reduced-colour dredge matrix indicating the progress of the dredging job, together with such things as upcoming dredging profiles, on-depth and over-depth profiles.

From this overview the user can 'zoom-in' to any to the DFMS system connected dredger in the working area. A user selected dredger can show by pop-ups the vessel name, its actual WGS84 position and live data. The previously mentioned top layer data like Production, TDS, fuel consumption, etc. can be accessed. Going deeper in the DFMS system, the second layer features such as historical data and reporting can be found by touch menus. Continuous data processing at predefined intervals can be obtained The top-layer data can be used for factual information, the on-demand feature for obtaining logged data for reports and graphs. This feature allows DFMS to quickly produce live data, accompanied by in time-delivery of ad hoc data if required. There is a great emphasis on the versatility of the DFMS and ease of use of every modern computer, Phone or Tablet as in Figure 9. The system is designed with the ability to work with every communication carrier, now and in the near future. The DFMS can be qualified as an Agile IT application with the ability to adapt to any applied Traditional IT platform on a cutter- or hopper dredger’s available data.

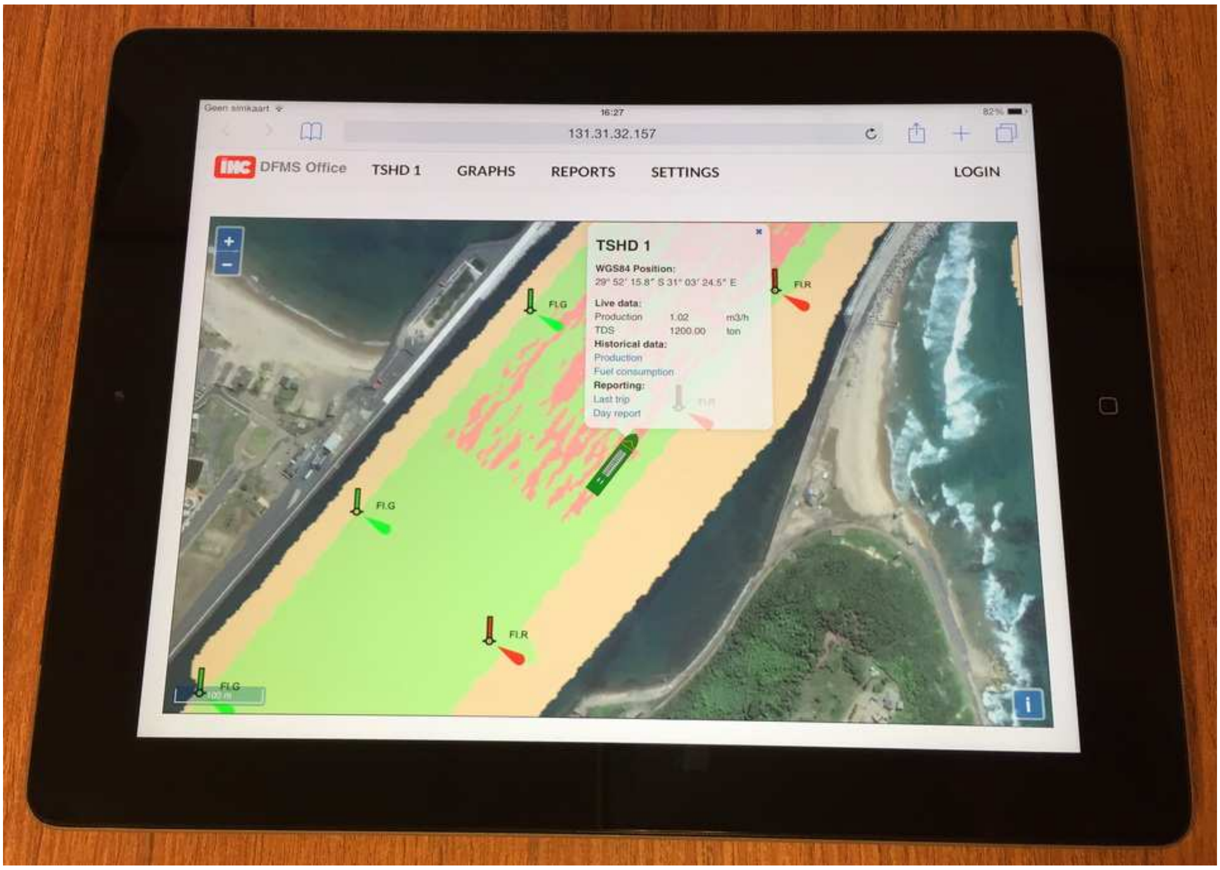

Figure 9. DFMS screenshot, as when applied on a Tablet.

Further layers

Currently only the most commonly known data and information is processed and translated to the DFMS platform, mainly focussed on dredge operations. The system has the potential to provide deep insights in the ongoing dredging job, the health of the equipment, and the possibility to adapt to contingencies during the dredging process. With type of 3D information, anything on the dredger, when it is part of the data in the dredgers network aboard is accessible. This data could be the calculated Tons of Dry Solid on a hopper dredge to the vacuum of a submersible pump, or the hydraulic pressure for the spud system on a cutter dredger. The first line of development after the introduction of the DFMS is we also see an old term, related to Overall Equipment Effectiveness (OEE) re-emerge, primarily geared to maintenance: Total Productive Maintenance (TPM). This OEE and TPM terms originate from the Japanese industry some decades ago. In the total operational cost of a dredger the maintenance cost can still take about 15 to 25 % of this costs. Although maintenance is an emphasis, all this new Information Technology provides several new avenues to evaluate known challenges and provide better efficiency due to the new transparency. Another area of interest will be for sure anything related to survey information, soil conditions and real time job progress. The dredger, as a piece of equipment that can dig, transport and dump a certain amount of underwater laying soil in a certain time, will remain a challenging working machine, this time to translate her many aspects to useful and everywhere operational apps.

CONCLUSIONS

The DFMS is a ground breaking step to provide increased personal visibility on intricate performance factors of a dredger. This function can be performed completely remotely from the dredge location and from anywhere access to a cloud service (and priority access) is available. The dredger can now be viewed as part of Internet of Things by the data users. Over time more applications will be developed within the DFMS and provide full monitoring of the dredger as an autonomous machine, as defined in Industry 4.0 while performing the dredging tasks. Similar to self-driving cars, we may eventually see a nearly self-driving dredge.

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