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A DESIGN APPROACH FOR ASSET SUPPLY LOGISTICS

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ABSTRACT

In order to provide adequate logistics support for an oil & gas producing asset, onshore as well as offshore, a logistics support concept needs to be developed at an early stage in the opportunity realisation process. This logistic concept is eventually to define all personnel and material sources, discrete supply points including routings and hence infrastructure, and transportation equipment to address the requirements over the full lifetime of an asset. Typically, due to a vast amount of options for infrastructure (roads, ports, bases), the stochastic nature of impacting parameters, a distinct set of requirements for different phases in the lifetime - i.e. from development to abandonment - and the potentially changing business environment over time, finding an optimum integrated logistics solution is a difficult task without any system(atic) and/ or software support.

This subject matter led TU Delft and Shell E&P (Exploration & Production) to take a joint approach to develop a software tool that is to determine the optimum logistic concept for new developments in a new (greenfield) or existing business environment (brownfield). Objectives defined included to develop a generic tool for generating a number of alternative, but potentially optimum concepts for any given business environment. Secondly, objectives included the tool to evaluate all generated concepts using simulation techniques, assess performance by defined Key Performance Indicators (KPIs) and advise robustness of the concept to external stochastic variables (e.g. weather, delays in material supplies and people movements).

This paper presents the tool development and how to interactively generate of a set of feasible concepts and assess concepts' robustness by KPIs, which include operational cost, availability, operational safety and environmental impact.

INTRODUCTION

On a high level, the development of a new oil & gas producing asset follows three phases: design phase, construction phase and an operational phase. During the first phase, an in-dept analysis of the opportunity results in a comprehensive strategy for production and a design for associated infrastructure and processing plants. During the second phase, infrastructure and plants are constructed while an organisation is put into place to support both the project and the operations phase. During the third phase, the installations will start up production. The construction and operational phases both require logistic support, but the type of support may differ considerably: the construction phase generally is a relatively short period with high and irregular transportation volumes, whereas the logistic demand for the (typically much longer) operational phase shows a more constant pattern with lower logistics needs.

The logistic concept, providing logistic support during the construction and operational phase, is developed in the design phase of the opportunity development. It defines personnel and material sources, discrete supply points including routings and transportation equipment to address the requirements over the full lifetime of an asset. It also defines infrastructure, i.e. the locations of marine supply bases, air support bases and other land based facilities such as warehouses/ yards. Finally, the transport modes, types and sizes of transport equipment are determined and the routings and schedules for transportation are established.

Figure 1 shows an example of a brownfield development. Two offshore platforms are planned at predefined locations with a third one already producing. Existing and optional supply bases onshore and sources of material and personnel are indicated, as well as all possible transport connections. Obviously, choosing and opening any new base will have an effect in the cost evaluation whereby Capital expenditures (CAPEX) is discounted in time. Possible transport modes include road, air (rotary/ fixed wing), rail and sea.

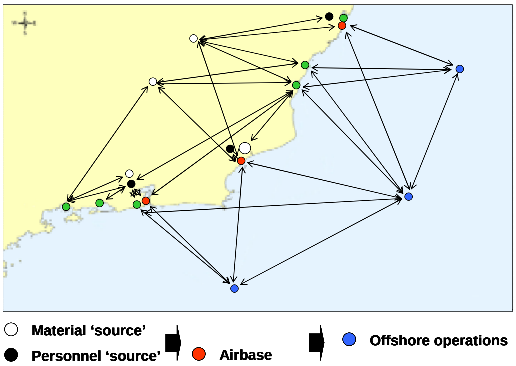

Figure 1: Example of brownfield development - planned platforms and possible locations of bases and sources with potential transport links

A logistic concept is defined as a sub set of the possible sources and basis. The quality of any concept is assessed using four KPI's being cost, robustness/ availability, transportation safety risk exposure and CO_2 emissions from transportation activities. Different transport modes have different contributions to KPI's. For example, helicopter transport and road transport incur higher transportation safety exposure than other modes. As the KPI's are essential for the development of the tool, they are discussed in more detail in the next section.

KEY PERFORMANCE INDICATORS

Cost

Each concept has a number of factors that add to the total cost of executing logistics. First, and in most cases main contributor, is cost associated with transport resources. Costs may be split up in Operating Expenditures (OPEX), a yearly contracting fee and a variable cost component, the latter depending on actual usage. A second contributor may be investment costs (CAPEX) to build or to bring existing facilities up to standards and the operational cost for providing services from the facility.

Robustness/ availability

Robustness indicates to what extend the supply of personnel and materials is resistant to disturbances in the logistic chain and actually reveals availability. Disturbances are for example bad weather conditions, equipment break down or irregularities in the external supply chains, consumption of materials or people movements. Robustness is expressed by a service rate. The service rate, at its turn, relates to the probability that an asset temporarily runs out of stock of one or more of its main supplies.

Safety risk exposure in transportation

Around 50% of all incidents and fatalities in the Oil & Gas industry are logistics related, (Association of Oil and Gas Producers, 2005). In order to combine the risk of all transport movements that arise from a certain logistic concept, a unified risk measurement model has been used. Shell has recently conducted a study to scientifically determine the transport risk exposure and build a mathematical model to compare different transport scenarios for any part of the world (ref. Koornstra 2007).

Subject study uses a mathematical model that relates transport safety data from a number of countries with well-maintained transport accident records to their Gross National Income (GNI) to calculate a 'relative risk factor' for any other level of GNI.

$$Risk = R_m \times M_i \times M_j \times M_d$$

With:
R_m : Modal reference risk
M_i : Risk Multiplication factor GNI
M_j : Country GNI correction factors (wealthy but unsafe, or poor but safe countries)
M_d : Additional, mode specific correction factors

CO_2 Emission

This KPI addresses one of the environmental aspects of an opportunity development and its operation. Currently, there are no global legal requirements for monitoring or control of CO_2 emissions or other (greenhouse) gasses such as SO_2, NO_x. For European energy producing and industrial companies, some control is in place by the recently created CO_2 emission 'rights'. The right to discharge CO_2 has become as a tradable 'commodity', with a real and changing price. This legislation however does not include any vehicle, vessel or aircraft emission. As CO_2 emissions will very likely become an important issue for any near future E&P development, the tool also includes a KPI on emissions of transport movements.

CO_2 emission can be calculated for all vehicle, vessel and aircraft movements. The calculation is based on the total travelled distance multiplied by the specific fuel consumption for the mode of the transport. This results in the total fuel consumption per transport mode and will then be converted to an estimated CO_2 emission in kilograms. Fuel consumption data for land transportation are widely available. If the fuel consumption rate of a vehicle is known, CO_2 emissions can be calculated with a fair degree of accuracy by applying a fuel/ CO_2 conversion factor. For marine transportation, average emission factors can be derived from 'Service Contract on Ship Emissions', 2005, while for aviation, figures are used from the IPCC guidelines (2006).

DEVELOPMENT APPROACH

Cost, emission and safety risk can all be calculated for a static scenario. Robustness however, and hence

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availability, is influenced by stochastic parameters over time. For this reason, a second pass of evaluating concepts is done using simulation.

The starting point of any design case include locations of assets, personnel and material sources, supply bases and data available with respect to expected consumption personnel movement patterns. Further data needed is related to cost, transport risk and CO_2, and statistics for patterns of weather, material consumption and people movement.

Once data is available or estimated ('User Input') , steps to be made for an initial analysis are shown in Figure 2.

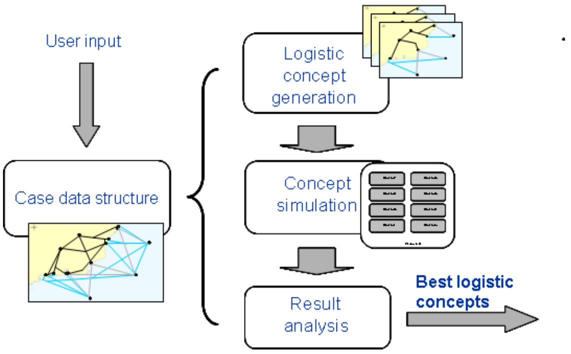

Figure 2: Steps in the logistic concept design process

Case data

The tool uses a common data base both for concept generation and for simulation. Figure 3 shows what type of data is required for the common data base; figure 4 zooms in on marine related data.

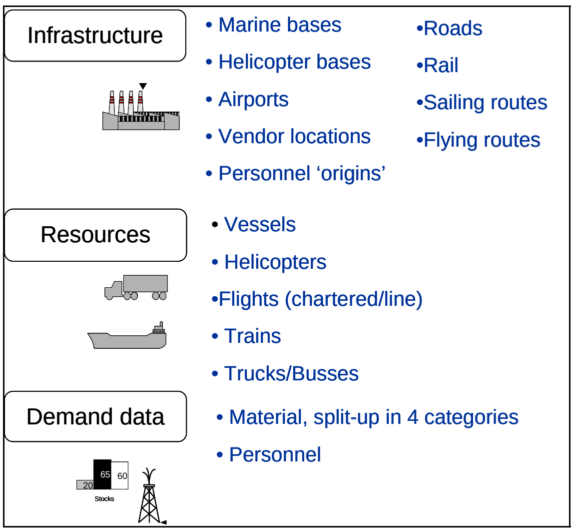

Figure 3: General data needed for concept design

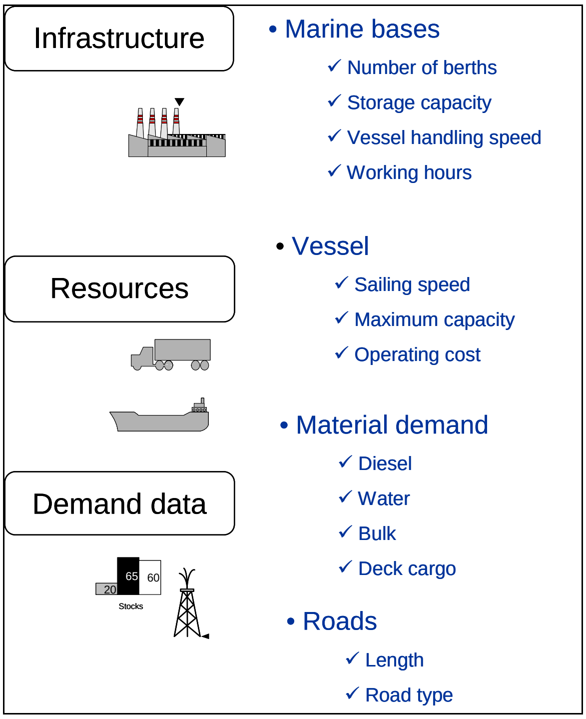

Figure 4: Specific case data relating to marine operations

Generating feasible logistic concepts

An interactive design approach has been selected for generating the initial set of potential concepts. The prime reasons for choosing an interactive approach are that 1) the professional logistics user can work with a set of *relevant* local data and logic other than having a tool generate non-feasible options and 2) the tool cannot be designed such that it will converge to feasible options without placing too many constraints. As such, the user support consists of an object oriented data base and tools to easily define and evaluate concepts and subsequently simulate them to take stochastic influences into account.

To choose the type and number of resources needed for a certain supply scenario at this stage, the user must at least get a preliminary insight in the degree to which the assigned resources are suitable for the task. The main parameters needed are the resources' capacity, the frequencies and quantities of the material orders and the travelling distances in the region. In practice these parameters are all interconnected: the total supply capacity of a resource over time is the result of the number of trips possible multiplied by loading capacity per trip. The number of trips is a function of the length of a (set of) routes, travelling speed and turnaround times. The eventual occupation rate is determined by the ordered quantities and frequencies of the calls, which in turn are dependant on the material requirement and the storage capacity of the assets. Because of the interconnection, without any constraints the matter becomes a circular reference and unsolvable.

Different techniques are known to get by with this issue. The closest resolution in operations research terms of a 'Resource Routing Problem' is the 'Travelling Salesman Problem' with vehicle capacity constraints (Charikar et al. 1998). This problem however has the limitation that it calculates the solution for a static problem and also does not include the assets' capacity. Another technique to solve the issue is also known as the *unbalanced transhipment problem* (Wayne Winston, 2003).

Although both techniques would provide a part of the solution, it has been concluded that these types of mathematical approaches would, in this particular development, constrain the objective of developing a generic tool or would require unacceptable simplifications of the system.

Therefore, it is argued here that a simulation based approach will provide best functionality and flexibility to the user. A method has been developed as an extension of a 'relay based' approach based on simulation of traffic in a network (Veeke, H.P.M., Ottjes, J.A., 1999). To aid the user in the process of selection a set of feasible logistic concepts, for each initial concept, the algorithm can determine the optimum routes, while respecting all capacity constraints. The expert user must determine the call-off frequency of all Assets in the field, combined with the Assets' stock capacity and demand over time, which results in the quantity needed per call. The algorithm uses the call quantities and the limited capacity of the resource to find the shortest route(s) to serve all Assets. A solution may comprise of a set of routes, with multiple intermediate visits to the source point to re-supply the resource. The user can now review and accept or decline the proposed routes, but also put in routes manually.

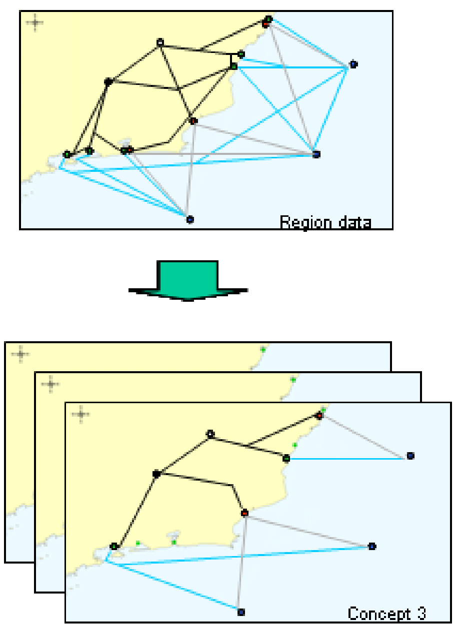

Figure 5: Set of feasible logistic concepts, constructed by assigning sources and supply bases to assets

At this stage, with the definition of routes, the call-off frequencies and quantities, it is now possible to statically compare effectiveness of the assigned resources.

Figure 5 illustrates the step of generating logistic concepts, all having a sub set of all possible road, air and sea connections.

The generation of each concept consists of the following steps:

- **Infrastructure:**
  - – Choose location of Marine bases
  - – Choose location of Helicopter bases
  - ➢ This has to be done 'manually' by the expert user
- **Routes over land, sea and air:**
  - – Find routes for Personnel
  - – Find routes for Materials
  - ➢ Optimising routes is supported by the tool
- **Resources:**
  - – Find Number & Type of Vessel needed
  - – Find Number & Type of Helicopter needed
  - ➢ This is an iterative process using the results of the routing step

Selecting the final concept using simulation

To this stage, all calculations have been carried out for a static situation, so without any stochastic influences. One of the important features of the simulation routine of the tool however is the ability to model stochastic influences in order to assess the concept's robustness. This simulation routine, which incorporates reorder policies, safety stocks and priority ordering, is used to find the final concept, determined by its KPIs.

To demonstrate working with the tool, figure 6 and 7 show the results of simulation runs of a (simple) logistic concept in which stock level fluctuations of an asset are plotted against time. Figure 6 shows output whereby the simulations were performed on irregularities in the consumption pattern of the platform. Initially, intolerable out of stock situations occur in the platform stock levels ('initial scenario'), but by varying the set points for reorder stock levels of both asset and supply base, the situation is reached which satisfies the asset requirements ('best case scenario').

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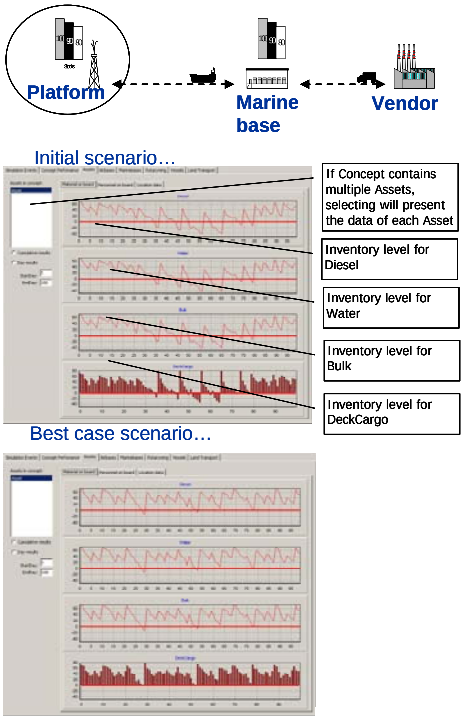

Figure 6: Initial and best case output of stock levels of a platform

Another simulation is subsequently performed adding stochastic weather conditions. As a result, both the marine base and the asset are unavailable for some 50 days, distributed over each year. The results in the inventory levels are shown Figure 7.

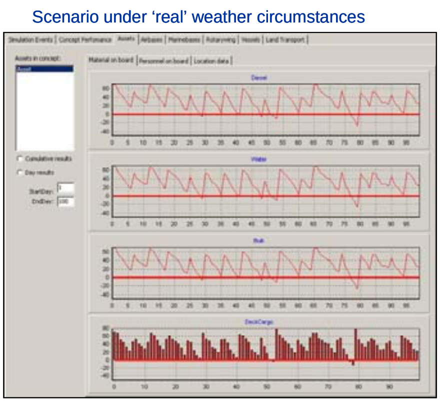

Figure 7: Best case of Figure 6 including realistic weather conditions

Apparently, the weather influence now is strong enough to make this concept trip up (i.e. 'negative' stock). A analogous simulation set up can be applied for personnel movements whereby insufficient transport capacity will result in long 'queues' of personnel waiting to either board or leave the asset.

By performing experiments with several concepts, the design team gains 'experience' with this specific case. The model can now be used to simulate and improve concepts, and to explore the dynamics and sensitivity of the particular case. The final concept is selected on the base of a weighed combination of the KPI's. The weighing factors are case specific.

CONCLUSIONS

In this paper a design approach and prototype tool are discussed that support logistics concepts generation, at an early stage, for different stages of an E&P development. The best concept can be selected from a number of initial concepts on the basis of four key performance indicators. The objective to automatically generate potentially optimum concepts has not been met yet as the initial concepts still have to be build by expert users. The tool however does support that task with a comprehensive case data base and functionality to optimise supply operations. The desired optimisation aspect of the objective needs further attention. The essence of the work up till now is that the initial static models of the concepts can be automatically converted into simulation models to determine the robustness, of each concept as a function of internal and external stochastic influences. A simple example is given to explain the way of working with the tool.

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