ADOPTION OF SIMULATION TECHNIQUES FOR MASTERING LOGISTIC COMPLEXITY OF MAJOR CONSTRUCTION AND ENGINEERING PROJECTS

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ABSTRACT

Major construction and engineering projects pose high challenges at logistic planning, including numerous restrictions, risks and dynamic effects. Consequently many tasks cannot be effectively solved using conventional tools and methods. We propose an integrated planning procedure that adopts simulation techniques in order to consider the whole supply chain and incorporate operative processes as well as stochastic factors. These integrated planning principles have been applied successfully in the project Sochi 2014 and will be outlined here.

INTRODUCTION

Large public projects like construction of facilities for major sport events (e.g. Olympic Games, Soccer World Championship) are often characterized by specific sets of logistic problems that result from the complexity of the projects: often more than hundred constructions sites have to be managed simultaneously and enormous amounts of materials have to be supplied while infrastructure restrictions and physical locations (central location in the host-cities and regions) have to be taken into account. Furthermore, these projects are characterized by a heterogeneous partner landscape and dynamical and partly non-transparent interdependencies between project management and logistics.

However, planning activities in major construction and engineering projects focus primarily on project management and operative construction site logistics. These approaches often lack the necessary interfaces between project management and logistic layer. Additionally, there are a number of factors that make difficult the trade-off between logistic and planning layer: extensive planning tasks and specific challenges require new approaches and tools for solving the problems of strategic design and mid-term planning of the major projects; thereby considering dynamic restrictions and risks as well as later implementation and operative processes.

Though simulation is a proven approach for assessing logistics concepts, the subproject "simulation" is often badly integrated in the overall logistics planning. Up to the present time applications of simulation techniques in construction logistics have been limited to material flow problems of the on-site logistics. Typically conventional material flow simulation tools are applied here. Thus all information flow is neglected.

In contrast we propose an integrated logistics planning procedure, where we apply simulation techniques. This allows the holistic design of dynamic logistics networks including material and information flow processes.

In this paper we will first specify the logistic challenges in major construction and engineering projects in detail. Against this background we will outline our integrated approach. An application of this technique for the major construction and engineering project is consequently introduced in this paper.

LOGISTICS CHALLENGES IN MAJOR CONSTRUCTION AND ENGINEERING PROJECTS

Major public projects like Olympic Games, European Championship or World Exhibitions take place in well-established host cities or other well-known locations. This strategy poses the advantage of exploiting already existing infrastructures: both during the event itself (public transport, gastronomy, hotels etc.) and during construction period (existing storages, roads, transshipment facilities etc.). However, there is a downside to this strategy: most host cities and regions have grown historically and have not been planned to handle such amounts of additional logistics activity. Hence, extensive planning is needed to integrate new logistics concepts into existing and evolving infrastructure. Here a number of challenges arise.

Off-site logistic restrictions

Regarding off-site transportation capacities (inbound transportation channels), four main types of transportation modes can be distinguished: railway, ship

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(sea, inland water transports or combination), air cargo and road.
Road transport can be used for delivering construction materials and goods directly to material consumption points, thus combining off-site and on-site transports. All other transport modes require transshipment facilities in order to forward materials to consumption points.
Railway transports pose a number of restrictions for logistics operations: track capacities, train and railcar capacities, rail yard operational capacities and transshipment capacities.
Air-cargo transports are typically restricted by operational and transshipment capacities of the airport. Furthermore, due to the high costs of air-cargo operations, only a small part of material supplies can be carried by air.
Sea and inland water transports are cost-effective and capable of transporting high volumes of materials. However, ship transports are restricted by ship capacities, port yard capacities and port transshipment capacities. Both ship transports and railways have a lot of restrictions regarding infrastructure and bindings to particular supply chains in contrast to road transports that generally show high grade of supply chain flexibility and infrastructure availability.

Local logistic restrictions

The infrastructure of host cities is generally not suited for handling additional amounts of transports and thus has to be adapted or expanded in order to provide adequate logistic capacities. Furthermore, flawless operability of the city's public services during the construction period has to be assured in order to minimize negative effects for citizens.
Some logistic concepts target these specific restrictions, including strategies like strict separation of on-site and off-site logistics, outsourcing of off-site activities and storages from the host-city to its outskirts, providing high performance transportation channels (e.g. railways) from off-site areas to main construction sites (e.g. London 2012).

Risk and uncertainties

Franke points to the following structure of risks for industrial plant engineering projects that are also valid for public construction projects (Franke 1987, pages 32-33):

- Risks resulting from quantities and efficiencies (processes, engineering, procurement, erection, tests and inspections),
- Risks resulting from dependencies (customer, suppliers, etc.),
- Scheduling risks,
- External influences (authorities, politics, market situation, etc.),
- Uncertainties as to payment and concerning liabilities (delay, penalty, etc.),
- Warranty risks.

Furthermore, there are two external influences that are especially important for major public projects: social-acceptability and sovereign risks. Social-acceptability risks refer to the likelihood that sponsors will meet opposition from local groups, economic-development agencies, and influential pressure groups. Sovereign risks in turn involve the likelihood that a government will decide to renegotiate contracts, concessions, or property rights (Miller 2001, page 439).
Other external, payment, liability and warranty risks are mostly out of sphere of the influence of logistics. Yet risks resulting from quantities, efficiencies, dependencies and scheduling risks are pivotal for logistics planning.

Ramp-up of facilities

It is obvious that many infrastructure facilities are not available for logistics operations from the first day of the project. They have to be built up or extended either before project's start or during construction time. Due to the extensive construction volumes and mostly tight time schedules it is essential to carry out sophisticated planning, taking into account overlaps between schedules of infrastructure projects and main construction objects. In other words, construction plans must match the ramp-up of transportation, transshipment and storage capacities.
Furthermore, especially in the beginning of the project's lifespan material flow focuses on bulk goods (crushed stones, gravel, cement etc.) changing to general cargo with overall project's advancement. Accordingly transshipment and storage capacities must be adjusted.

Operative restrictions and conditions

Strategic design and planning for major event and construction projects depend strongly on the later operative logistic concept. Processes included in the operative layer influence strategic design and mid-term planning and vice versa. However, these interdependencies are complex. A center for logistics coordination is crucial. Its main task is to integrate strategic, tactical and operative planning processes under consideration of scarce infrastructure capacities.
So, this covers a wide range of operational tasks, including organizational issues like fleet accreditation, supporting workflows or even coordination of centralized supplies (e.g. gravel, sand or concrete). Nevertheless strategic logistic design and planning need to focus on those operative processes which can be influenced to a great extend:

- order consolidation rules and lead times for inbound transport, differentiated both by material type and transport mode;
- dispatching rules for local transport;
- transport restrictions;
- material storage rules (which material groups are centrally stored and which are delivered directly to construction sites);
- storage call-off rules;

Waste disposal and environmental concerns

Major projects environmental issues come to the fore due to the strong public attention. Consequently the logistics design has to be analyzed in-depth to prevent or minimize negative implications on environment and populations. In context of construction or engineering projects waste and pollution are the most important environmental issues to be taken into account.

Sochi region is located in the very sensitive environmental area and many construction activities take place near nature protection areas. Therefore it is essential to evaluate waste flows and development of the waste disposal yards in order to assess influence of the construction activities n the environment.

AN INTEGRATED PLANNING AND EVALUATION APPROACH FOR LOGISTIC CONCEPTS

Logistics design and planning addresses the configuration of the logistics structure as well as the planning and allocation of processes and resources (Arnold 2008, page 3). It has to determine the cost-optimal and service demand satisfying structure and design of logistics networks (Kuhn and Hellingrath 2002, page 88). The objective is to identify, specify and validate recommended logistics structures including an optimal process and resource allocation. Typically all three aspects are strongly interconnected. Processes must be designed to comply with resources and network structure, resource concepts must be supported by reliable network structures.

Nevertheless effective logistics design requires the evaluation and validation of logistics performance and efficiency. Yet explication and interpretation of system behavior is difficult for complex logistics systems (Kuhn et al. 2010, page 1), especially as given in context of major construction and engineering projects. Logistics scenarios have become too complex to be handled without tools of advanced information technology providing transparency. The conclusion on the question which methodology to apply for assessing logistics concepts has to be drawn against the background that strategic network design is a task with high impact on subsequent planning and execution phases (Seidel et al. 2005, page 55). Considering the size and complexity of construction and engineering projects, mathematical models have been assessed as rather unsuitable to master all named challenges. And evaluation cannot stop at a highly aggregated level, but has to consider detailed logistics characteristics.

Nevertheless the possibility to rapidly model and evaluate, large scale networks represents a strong argument for the application of static analysis. Yet, in order to allow for thorough assessment in a dynamic environment the application of simulation techniques provides valuable capabilities. Therefore we strongly support the application of both methodologies to be prepared for the challenges at hand in major construction and engineering projects (see also Klingebiel and Seidel 2007):

In an early phase of logistics planning static analysis provides the possibility to rapidly design a large number of alternative models and to evaluate these by help of low granularity key performance indicators (KPI). The number of feasible and economically efficient models is being reduced drastically and a small group of alternatives remains. In the next step these alternatives can be assessed in detail by help of simulation techniques which then provides high granularity KPIs. Thus, the combination of both methodologies provides the potential for consistent and thorough assessment of logistics concepts.

With this integrated planning approach, simulation has gained significance besides analytical and optimizing methods. It is applied to validate pre-selected planning, control and material flow processes as well as structure and resource oriented concepts.

Nevertheless, simulation as a method needs to be strongly integrated in the well-known procedure of design and planning of logistics systems (Kuhn and Hellingrath 2002; Scheer 2002; Klingebiel 2009). This procedure starts with identification of strategic project objectives and related measurable key performance indicator and continues with a detailed analysis of current state processes and structures before identifying fields of actions and developing and evaluating to-be scenarios (see Figure 1). We note that three essential conditions need to be met (Kuhn et al. 2010):

- Assignment of simulation experts with know-how in the field of logistics planning
- Full integration of these simulation experts into the planning team
- Avoidance of budget distribution between planning and simulation in order to decide about the degree of detail in simulation without bias.

The general method for proceeding within the simulation step is separated into the phases of conceptual design, data preparation, modeling and verification, scenario evaluation, analysis and documentation (Klingebiel and Seidel 2006). This proven methodological approach is based on German industrial guidelines for simulation (VDI 2000; Rabe et al. 2008; Wenzel et al. 2007) and depicted in the Figure 1. In parallel to these steps the models, scenarios and results need to be continuously validated. This initiates back loops to previous steps to refine the model, model concept, or even the scope and objectives.

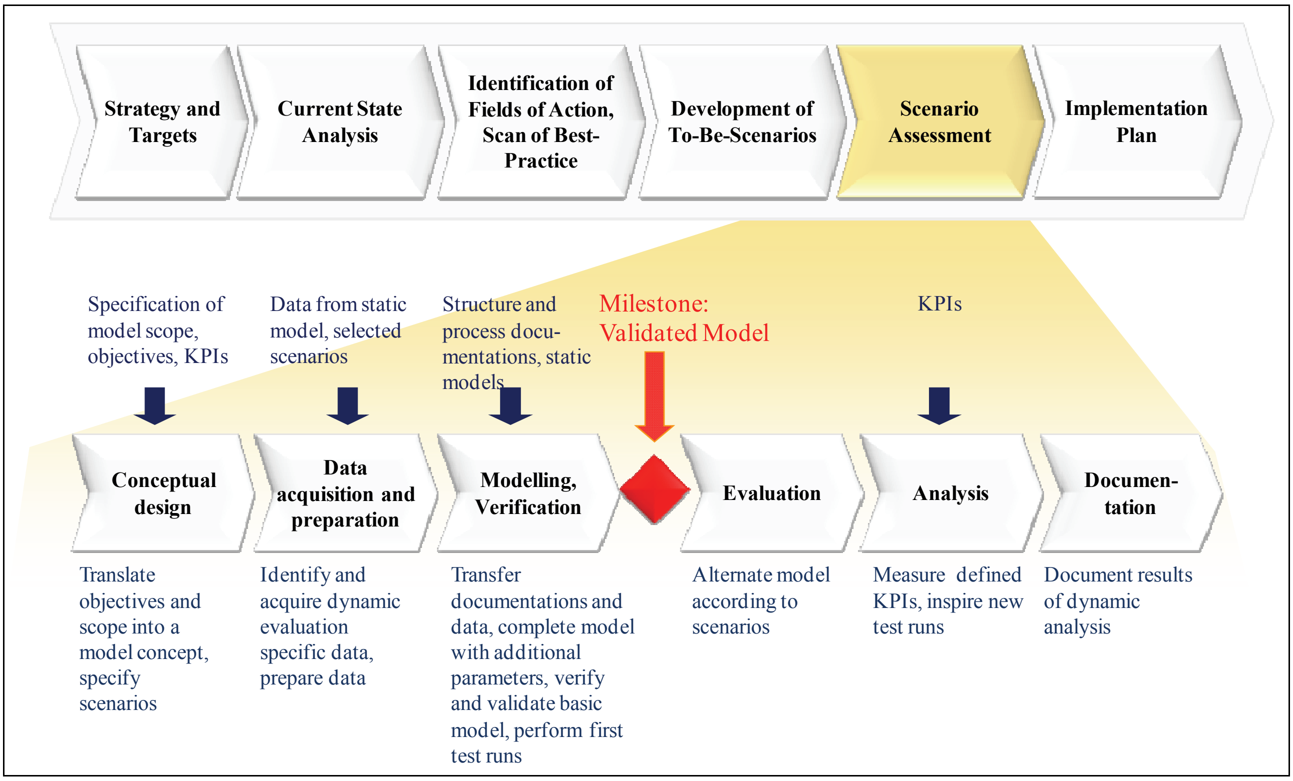

Figure 1: Methodological approach for simulation (Klingebiel 2006)

Conceptual design

During this phase a general overview of the evaluation model is developed which is in most parts related to the to-be model, but might vary in details - depending on the specifics of the applied evaluation tool.

Data acquisition and preparation

Usually evaluation of concept feasibility requires more complex model data; hence the to-be model must be completed with additional data. So the next step comprises the identification of this data as well as the acquisition and preparation of it for application.

Modeling and verification

In the step 'modeling and verification' an evaluation model is built. The model provides the basis for the analysis of specified alternatives and scenarios of the to-be model. Thus it has to first be verified against semantic and syntactic failures. This comprises a check of whether the to-be model concept has been transferred correctly into the evaluation model concept and the model environment, i.e. whether the functionalities of the evaluation methods and supporting tool environment were applied as defined by the model concept.
In addition to this formal verification the validation of input data, evaluation model and results is an important step. Validation comprises the examination of the correspondence between the model, results and reality. By iterative validation we need to assure that the behavior of the model replicates reality in a sufficient way.

Because the model abstracts and idealizes reality, usually not every behavior can be studied in the model itself. Hence continuous validation requires the specification of expected results and associated accuracy beforehand. The model is verified against this tolerance framework. In many cases the evaluation models replicate stochastic effects parameterized by distributions. The characteristics of a distribution are replicated best when many random samples are executed. Consequently it is often necessary to execute a high number of test runs within the validation phase to gain reliable insight into the model's behavior. The outcomes of these test runs have to be discussed with industry experts.

Computation and simulation

In the next phase alternative scenarios are defined. The evaluation model is altered as specified and outcomes computed or simulated. Often the outcomes of one run cause new questions and thus scenarios. Thus evaluation is often executed in systematic trials where previous results inspire new test runs.

Analysis

The results of the test runs are measured by the previously defined KPIs. Thus the resultant data, which often comprises of basic measures, is aggregated to key performance indicators. Most evaluation methods and tool environments provide interfaces to external analysis tools that allow for specific and individual processing of result data.

Documentation

In the documentation phase the evaluation results are summarized and prepared for the interpretation and discussion. As this documentation constitutes the basic information source for the later decision which concepts to apply, in reality a clean and accurate analysis of results is necessary here.

Consequently, this integrated logistics planning approach and the underlying, clear procedure model give us the guideline for the logistics planning process within the context of major construction and engineering projects. Within several projects the application of this basic procedure has proven its efficiency. In the following we outline the benefits of this integrated approach as well as the valuable insights given by simulation-based evaluation for the project Sochi 2014.

THE APPLICATION OF A SIMULATION-BASED LOGISTICS DESIGN PROCESS FOR CONSTRUCTION LOGISTICS

The city of Sochi holds the Olympic Winter Games 2014. Sochi is located in the remote area of Krasnodar Krai (federal subject of Russian Federation) and is badly connected to the main road network. Though Great Sochi area has a length of 145 km, many of the 180 Olympic construction objects are distributed in the densely populated city of Sochi, in its proximity or in the mountain area Krasnaya Pollyanna. The existing logistics infrastructure is scarce and even not satisfactory for the current city's needs, especially in summer tourists additionally strain the infrastructure.

Consequently the project focus was to support the development of a logistics strategy in form of an integrated package of activities aimed to ensure construction of transport infrastructure, terminals and storage facilities from 2008 till 2012. As corresponding logistics activities would heavily affect local population a sophisticated transport strategy during construction had highest priority. Subtasks of our work have been the review and analysis of the given infrastructure under estimated goods movement within Sochi region from 2008 till 2012, the identification of existing risks and possible bottlenecks as well as the development of a concept for the freight logistics control.

Based on our experience in other major construction projects, specifications obtained from our local partners and visit in Sochi, we carried out the detailed analysis of given structures and processes so that major fields of action could be identified. In a next step the scenarios for inbound logistics have been developed. Based on geographical and logistics data a network model was designed that allowed the identification of optimal distribution channels and site locations.

It was one of the most important aspects within this project to evaluate the impact on the regional infrastructure. Consequently, logistics processes and information flows have been specified by help of an holistic simulation model of Sochi's logistics system for the construction of the Olympic facilities.

During all project steps the simulation experts shadowed the logistics planner and have been integrated in the planning team. With this concept the benefits of adopting simulation techniques could be fully exploited. It was possible to choose the right level of abstraction according to the beforehand named challenges and expectations.

We applied the simulation environment OTD-NET which has been developed by Fraunhofer Institute of Material Flow and Logistics in Dortmund, Germany (Wagenitz 2007). OTD-NET introduces a holistic approach for modelling and simulation of complex production and logistics networks. It delivers in-depth insights into information and material flows, stock levels, stability of the network, boundary conditions and restrictions.

Heart of OTD-NET is the discrete event simulation of business processes. The developed hybrid approach visualizes processes by aid of UML (Unified Modeling Language) and implements these in an object-oriented programming language (C# and partly C++). The analysis module provides reporting functionalities by an adequate processing of simulation data into multidimensional data structures including condensed data for online analytical processing (OLAP). Thus OTD-NET supports the diversity as well as the complexity of factors inherent in this type of project. However, specific challenges that have been described above have influenced the individual project steps immensely. In the following paragraphs a detailed insight into the simulation model is given.

Model Conception

Material inbound channels serve as source of material deliveries for the about 180 Olympic construction projects within Sochi region. We incorporated 33 basic types of goods and materials into the model (e.g. crushed stone, building steel or electrical equipment). The sources, i.e. inbound channels, can be distinguished into railway freight yards, sea ports and truck delivery channels. The model concept incorporates the essential information for inbound channels: connection to the transportation network of Sochi region, throughput and transshipment capacities. Especially the last two have been characterized as scenario data as they are subject to planning.

It was identified that for the aspired evaluations it was possible to cluster the sinks, i.e. the 180 Olympic construction sites, into 26 sub-clusters. Each sub-cluster incorporates several construction objects (stadiums, hotels etc.) as planned in the Olympic construction program which may be consolidated due to geographical aspects and logistic needs. Furthermore, we introduced waste yards as additional material consumption points to mirror the ecological challenges at hand.

Besides sinks and sources, distribution channels are the fundamental objects of the model concept. They are described by a number of parameters: transportation times, transport constraints, scheduling behavior. Within the transport network we also designed central storage points which are capable of buffering materials. This is necessary as material demand and material supply may not always be optimally synchronized due to the infrastructure and transport restrictions named before.

Figure 2 illustrates the resulting model concept showing construction site sub-clusters (yellow), distribution channels (arrows), inbound channels (green) and storage capacities (orange).

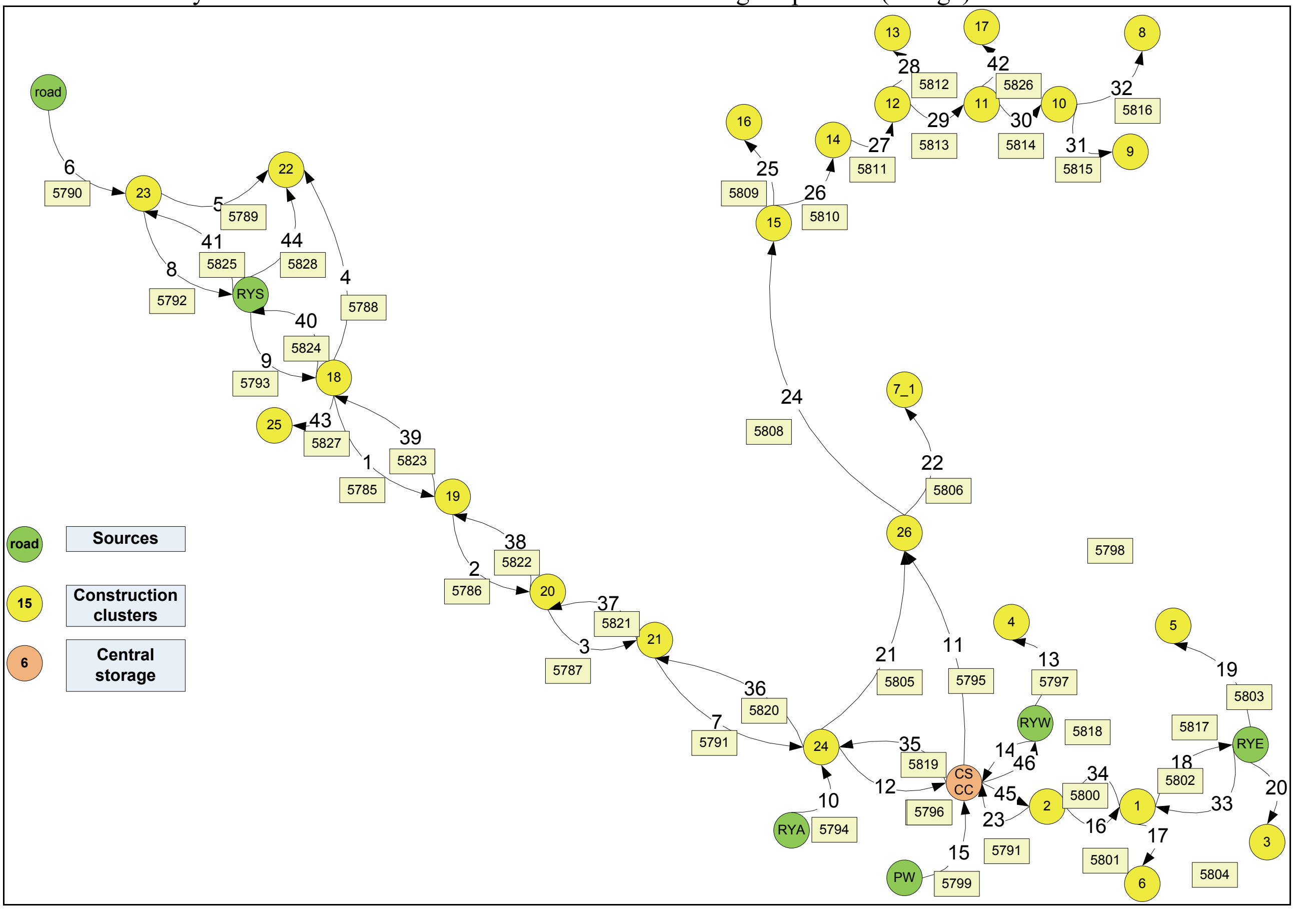

Figure 2: Graphical representation of the simulation model for Sochi 2014

Data acquisition

Due to the specific conditions of this project, data acquisition has been divided into two steps – preparation of a basic model and scenario-dependent input data for the simulation.

The first dataset comprises mainly the structural data, i.e. location of sinks and sources, transportation network specification, material types. The transportation network data has been specified by help of a geo-data database which was provided by the project partners. As seen in Figure 2, transportation channels have been implemented either in both directions or in one direction (for one-way roads).

The second dataset is much more dynamic und individually configurable. It comprises comprising material needs by material type for every sub-cluster (sinks), sourcing restrictions and dispatching rules.

In order to generate data for the second dataset, truck loads based on the material needs of the construction sites have been specified and allocated to specific inbound channels. The assumption was made that material delivery into Sochi region will correspond to the needs of the construction sites. However, a lot of restrictions and other conditions had to be taken into account during generation of truck loads, especially concerning truck profiles: 30 tons for bulk materials within main construction sites, 20 tons trucks for bulk materials outside construction sites, and 16 tons for general cargo.

Ramping-up of transshipment capacities is a crucial restriction in the beginning phase of construction works. As already mentioned, many infrastructure objects, like ports and rail freight yards are being brought into service over a specific period of time: for example in the first year only two port piers and 30% of rail freight yard are available for operations. Several other capacities are also being taken gradually into service. These limitations needed to be individually specified and integrated into the simulation model for ports, and rail freight yards. Additionally to the transshipment capacities there are also limitations concerning track capacities of the railways that must be taken into account during generation of the loads (separately for

bulk and general cargo). The user can individually define scenarios for extending such capacities.
The introduction of material groups allowed it to easily evaluate the simulation results. In this context scenario parameters comprise the allocation of individual material types to material groups (bulk, general cargo or cement).
Furthermore, priority rules for material sourcing of materials for individual construction sub-clusters need to be specified. For example, these rules define which construction materials are supplied by use of which transport modes and/or transshipment point.
In order to integrate realistic material flow behavior it is necessary to consolidate transport and supply orders. In this context lead time restrictions had to be introduced into the model: For example, these lead time restrictions specify to what extent materials may be delivered earlier into the demand region (In other words: if a transport mode has free capacities, a certain amount of material might be delivered a given time period before demand). These restrictions also apply to construction site supplies. Of course, all lead time restrictions influence inventory levels: relaxing inbound lead time restrictions can lead to increasing inventories at central storage points; in contrast, relaxing lead time restrictions for construction site supplies may lead to a reduction of these inventories, but inventory levels at the construction sites will build up.

Model Configuration

Dispatching rules are the main instrument that allows replication of operative processes in the OTD-NET environment but it depends on demand data or patterns. Yet, in the early stage of the project information about later material demands is given in low level of detail (monthly and quarterly data after 2009). Consequently, it is hard to reproduce realistic demand behavior of the construction sites.
One option to process this demand data is to uniformly distribute the given, rough data to gain daily demands. This results in steady demand profiles that don't correspond to any real demand situation, which is typically characterized by heterogeneous patterns. One solution for this problem is the introduction of stochastic variance for demand profiles if more precise data concerning operative level is not yet available. Such variance (e.g. normal distribution) would imitate realistic demand, delivery and transportation data patterns. But all these approximations of simulation parameters for sources, distributions channels and sinks must be chosen carefully and agreed with all partners.
Additionally to these demand patterns, custom dispatching rules defined how material call-offs from the central storages occur and which materials are delivered directly to the construction sites, i.e. do not pass central storage points.
Additionally, detailed information for all external transport modes is needed, though this iss mostly not available within strategic planning. A typical mistake is to assume that external transport modes and transshipment facilities are used uniformly and operated at full capacity: These assumptions do not correspond to realistic behavior. Especially in case of maritime transports a closer examination of general cargo supplies is necessary. Unlike bulk materials, general cargo is a highly specialized good and cannot be sourced flexibly from other countries using standard supply chains.

Model Evaluation

The main questions that were effectively answered by application of this simulation model focused on the utilization of transportation channels, utilization of transshipment points, development of inventory levels (including waste yards), number of trucks that are required for stable operations in the region and the influence of the operative concepts on the overall logistics concept. These KPIs have been critical for both dimensioning of transshipment infrastructure and shaping of transport strategy.
The utilization of all inbound transshipment points (ports, rail yards) is essential for ensuring a continuous material flow into the region during the construction phase. Our conceptual work focused here on the dimensioning of capacities (differentiated by different types of material handling) as well as on optimizing of multimodal transshipment facilities. Simulation could provide an accurate evaluation of the inbound material flow under consideration of different restrictions, e.g. track limitation for rail transports. Figure 3 illustrates an exemplary resulting utilization profile of one of the rail yards (in number of transports per month).

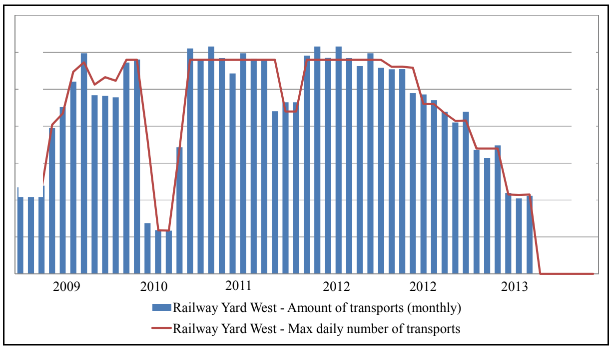

Figure 3: Utilization of the Rail Yard West

However, inbound transportation channels must not necessarily be transshipment points. Figure 4 shows the utilization profile of one of the inbound channels that was specified as a standby channel in case other inbound channels (rail and sea transports) are fully utilized. This channel represents a windy and dangerous coastal road. Any transports on this road should be avoided, so that utilization of this transportation channel was considered as a lack of main transportation or transshipment capacities.

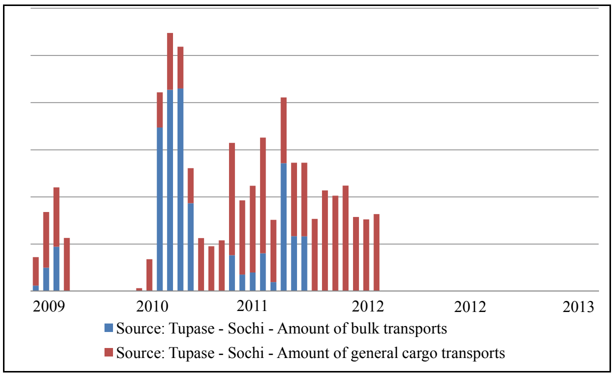

Figure 4: Number of transports on the road Tuapse – Sochi

Simulation has revealed that in several scenarios the road would have been heavily used for bulk cargo during the first half of the construction period (2010-2011) and furthermore for considerable amounts of general cargo in the year 2009 (see Figure 4). It was concluded that main transshipment points are not ready to handle sufficient amount of incoming materials (due to incremental ramp-up of the facilities). Consequently, alternative scenarios for bringing transshipment facilities into service had to be taken in consideration and corresponding measures for ensuring secure transports on that specific road were introduced in parallel.

Figure 5: Road Tuapse – Sochi

One could state that an evaluation of the total number of transports during a certain time period can easily be carried by static assessment. Yet, calculating the number of trucks simultaneously used in the system, i.e. average number of trucks at the same time on one road during a specific day) is a challenging tasks that demands consideration of many factors, e.g. operational handling parameters at the transshipment facilities. Only dynamic assessment, i.e. simulation in this case, can evaluate measures like

- maximum amount of trucks on the road;
- the maximum and average travel time in one transport channel per month;

Especially, maximum amount of trucks on the road is an important indicator for the feasibility of an operative concept that also allows the dimensioning of transportation fleets.

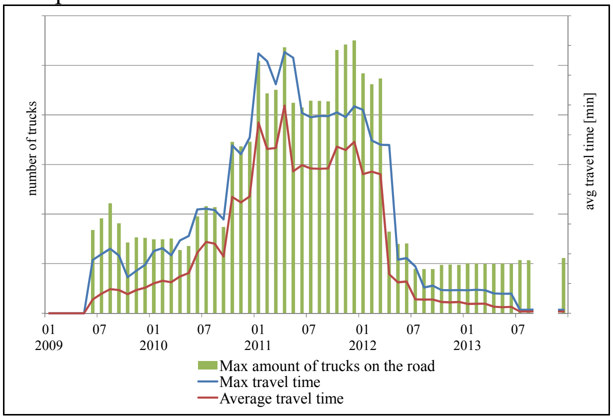

Figure 6: Key indicators for transport channels

Another key question focused on the the utilization of storage capacities. A storage concept comprises many operative concepts, i.e. order consolidation rules, dispatching rules, direct/indirect transports ratio. Applying simulation techniques made it easy to evaluate for example call-offs from the central storage, differentiated by trucks weights (see Figure 7). In combination with other measures like goods receipts, inventory levels and turnover we gained a detailed insight into the anticipatable utilization of a specific storage capacity under a given scenario. For example material call-offs illustrates the intensity of stock usage and are consulted for dimensioning of queuing areas. Furthermore, only simulation allowed assessing the implications of dynamic risk factors like delivery time fluctuations. Consequently, adequate strategies for preventing critical situations have been developed.

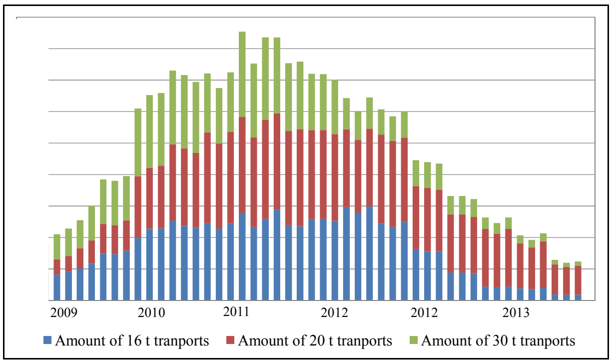

Figure 7: Material call-offs from central storage

CONCLUSION AND PROSPECTS

In this paper we presented an integrated logistics planning approach which focuses on dynamic evaluation of logistic concepts for construction and engineering projects. Key success factor is the integration of simulation experts into the logistics planning team and a close contact to the project management which allows for the avoidance of any friction losses. Any improper coordination between planning and evaluation can bee averted in advance.

Furthermore, by integration of simulation experts and their tools early in the planning process valuable insights can be revealed for the planning team.

The simulation expert may perceive early the restrictions and necessities of simulation. The simulation model itself is always designed around this knowledge: All available planning information is integrated but the level of detail is chosen carefully. So first simulations on a rough level typically abstract from stochastic influences and detailed dispatching rules, but already allow assessing dynamic influences.

This integrated approach has been applied successfully for a number of projects. For the presented project Sochi-2014 it delivered valuable insights concerning the practical application of simulation techniques for logistic planning of major construction and engineering projects. It has been agreed that methods and tools conventionally applied within these types of projects could not provide the adequate support for the challenges at hand, discussed above in this paper. The integrated simulation study provided guidance for the development of a sustainable logistic concept for the Sochi region and brought substantial value for dimensioning of both infrastructure facilities and operational processes.

Considering the high complexity, multiple restrictions and interdependencies in this logistics network, it is essential to continue this support for the operative work within the planned logistics centers. The prospective task is to apply similar simulation techniques for controlling of later material flow during the construction period itself. The benefits that arise by continuously applying the same procedures, methods, tools and experts from strategic to operative planning is highly mispriced today. To prove this is within focus of our future work.

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