Towards a framework for optimizing sea transportation – an integrated approach to planning, execution, and evaluation

by
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Optimization can be driven from different perspectives. Utilizing performance targets as a basis for driving optimization builds upon the idea that a coordinated approach, by co-producing actors within the ecosystem, is necessary to reach desired outcomes. Within MONALISA 2.0 there are ambitions to *increase* safety, *decrease* the negative impact on the environment, and *increase* operational efficiency of sea transportation. To reach the performance targets within these areas, different mechanisms need to be used. One of these mechanisms is to link execution to preceding long- and short term planning and the following acts of evaluation (see figure 1). The evaluations have the purpose of fine-tuning forthcoming planning, execution, and evaluation cycles and thereby stimulate a continuous learning on different levels in the system (c.f. e.g. PDCA-cycle according to Deming). Performance targets for the ecosystem would then inform and be the driver for what to pay attention to in planning, execution, and evaluation and thereby reach desired performance targets of the ecosystem.

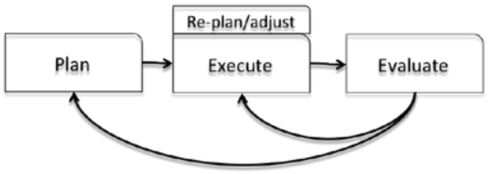

Figure 1: Integrated cycles of planning, execution, and evaluation as a driver for reaching performance targets

The different parts of the execution of the sea voyage form the basis for planning when and how to reach defined states (in execution). The execution of the sea voyage follows the stages from pre-departure (at port of origin) to arrival (at port of destination). Taking the scope of the sea voyage[1] as the point of departure, the execution of the sea voyage is broken into nine phases[2] (c.f. figure 2). The delimitation of each phase is based on spatial and time dimensions related to the sea voyage (from port to port) for the purpose of

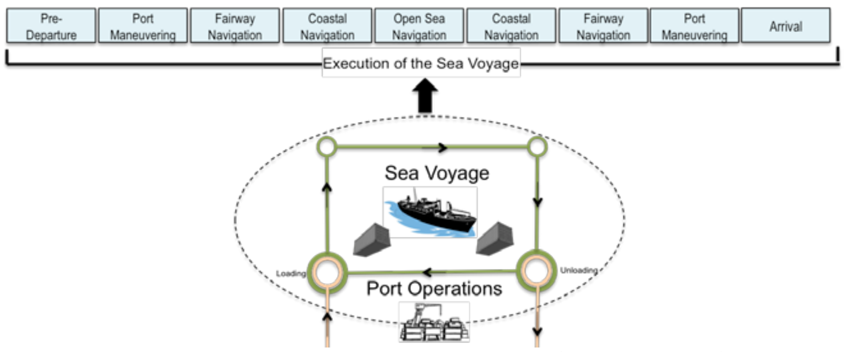

Figure 2: The nine phases of the sea voyage (from port to port)

[1] c.f. MONALISA 2.0 (2014) Identifying the Scope of Sea Traffic Management: The Interface to Ports Operations, Preliminary findings #01, MONALISA 2.0

[2] To our understanding there does not exist any common definition of the sea voyage as to be used in the development of Sea Traffic Management in accordance with the ambitions of MONALISA 2.0.

capturing the different logics of operations dependent on physical and time-based conditions. This means that actions prior to departure (including the turn-around process) will be covered by a stage of pre-departure, that different logics and conditions for the different stages (such as pre-departure, port manoeuvring, navigation in different types of areas (fairway, coastal, and open sea), and arrival at port) are to be covered. Execution includes all possible phases, where some phases might be excluded in a particular instance. The "turn-around process" in ports is covered by the phases of arrival and pre-departure.

In order to ensure that processes within the phases of execution are realized in a safe, environmentally friendly, and operationally efficient way, these processes need to be preceded by long-, mid-, and short term planning. *The probability of reaching performance targets substantially increases through an integrated approach to planning, execution, and evaluation of the distributed co-production*. Ecosystem of this kind covers many actors co-producing value. One essential driver for such an integrated perspective is that these actors inform each other about when different states are expected to be, and are, reached in order to enable each actors' optimization of their performance. In order to ensure flexibility, since it is difficult or impossible to predict all situations that may occur, it is important to enable re-planning and/or adjustments during execution. In figure 3 these different stages of execution (of the sea voyage) are depicted and positioned in relation to planning and evaluation as discussed above.

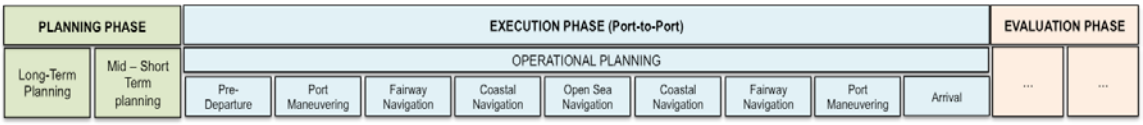

Figure 3: The different phases of Sea Voyages (inspired by the work of SESAR[3])

The purpose of bringing forward these phases is two-fold; 1) to provide a framework for describing the realization of one sea voyage – from long-term planning to evaluation – with all relevant data kept together with a unique voyage number, and 2) to provide a basis for managing multiple instances of sea voyages and thereby improve situational awareness (for the purpose of e.g. capacity management, collision avoidance etc.) that comes with STM. Such instances of situational awareness are the effect of each actor's provision of added value to the information-enabled Sea Traffic Management within an integrated and collaborative information-sharing environment. Returning to the necessity to look upon sea transportation integrated with other processes[1] the agreements and sharing of information related to the different phases of sea voyages in relation to e.g. port operations and other means of transportation becomes important to reaching performance targets for the multi-modal transportation system.

Following a sea voyage assignment issued by the ship owner and/or operator, each ship's voyage is planned in detail by the ship's crew, i.e. by or on the order of the Master, in line with normal standard procedures. In voyage and passage planning, the process begins with a plan at a strategic level and continues with an operational plan. The operational plan has to be updated due to the changes in the environmental conditions, such as for example wind, ice,

[3] c.f. SESAR Concept of Operations Step 1 Edition 01.00.00

visibility, sea state and traffic density. It is mainly in the Execution Phase, see Figure 3, that the Dynamic and Proactive Route (DPR) concept, developed in MONALISA 1 and in MONALISA 2.0 Sub activity 1.2, is applied affecting the operational planning. Both strategic and operational planning will include the following processes and steps:

- *Appraisal* - as the process of gathering relevant information for the passage, when a first assessment of the voyage is made;
- *Planning* - this stage involves the detailed planning of the passage from berth to berth;
- *Execution* - when the Estimated Time of Departure (ETD) and Estimated Time of Arrival (ETA) are known, the final tactics of the execution of the voyage can be applied[4]; and finally
- *Monitoring* - as the process of continuously monitoring that the ship is proceeding according to the plan/re-plan.

Should the ship receive new orders regarding a new destination, a new voyage plan needs to be created for the new part of the voyage. The ship should not proceed towards the new destination until a new plan has been established and approved by the Master.

Within sea transportation, much effort regarding collaborative sharing of information/reporting is made by giving information *when* different states (via statements of facts) have been reached (REF?). This is to compare with that planning builds on the idea that information is provided about estimates of when a certain state is to be reached. Planning in sea transportation is performed rather in isolation by each actor independent of others (REF?). Consequently sub-optimization becomes a non-stoppable reality as long as a collaborative approach to planning, execution, and evaluation based on patterns on information sharing does not exist.

As stated above, **a lot of the gains of MONALISA 2.0 would be reached by being more efficient in integrated and collaborative planning, execution, and evaluation. The framework provided in figure 3 is appropriate to use for both exploring the current situation (as-is), i.e. how it works today in each of the phases, and a desired future situation (to-be), i.e. how it would work in each of the phases in order to reach desired outcomes.** The framework would thus bring attention to e.g. how planning (by different actors in the ecosystem) is performed today. The framework would also bring attention towards how planning would need to be performed and integrated in order to reach the desired states with as little deviation as possible between

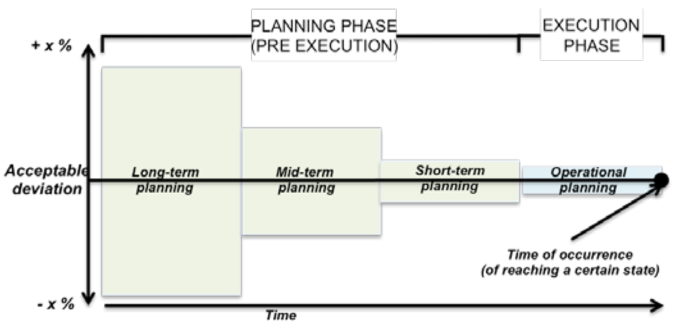

Figure 4: The funnel: Acceptable deviation between estimate and actual occurrence (in different time slots)

[4] In the navigation process, it is defined that it is in the Execution Phase that you put time on your route and check UKC at relevant passages. Even if you have a target ETA early in the planning stage you often know quite late the exact time of departure. It is also during this phase that the tactics and the briefing of the bridge team is performed. This should not be mixed up with the Monitoring Phase that is maybe what you normally mean with execution.

the estimate and the actual outcome.

In figure 3 different time perspectives related to planning are indicated (long-term, mid-term, short-term, and operational). These are the expressions of different planning focuses governed by the time of the planning being performed in relation to the time of execution[5]. As an example, one essential performance metric for the efficient transport system is punctuality. Punctuality is an expression for a desire to reach a non-existent (or small) deviation between an estimate (ETx) and an actual occurrence (ATx))[6]. This requires a high integration between planning, execution, and evaluation, where different actors need to be enabled to provide estimates at different checkpoints as well as reports on when reaching the different checkpoints.

Different planning horizons are associated with different levels of tolerance for deviation between the estimated and actually reached state (the outcome) as depicted in figure 4. The deviation should be diminishing with time; the closer to the Execution Phase the smaller the tolerance for deviation should be, until the actual moment of occurrence is reached for a certain state. This allows for planning process with different time horizons (i.e. long-term, mid-term, and short-term planning) to be performed optimally, based on the information about the interval of the outcome (e.g. a time span of when reaching a certain state).

The target concept of MONALISA 2.0 will define essential checkpoints, i.e. milestones that require confirmed estimates and/or re-planning. These will be defined as a consequence of what performance targets there are to be reached. It should be explored further whether the funnels for different estimates and different processes could be related to each other and thereby enable the integration of different planning processes. To exemplify, a funnel of when port operations are to be finalized matched with a funnel of when the vessel is to be berthed.

To conclude, it is strongly believed that reaching the success of MONALISA 2.0 builds upon that co-producing actors make efforts in sharing information about the desires of reaching different states as well as providing reports on when the different states are reached. States to relate to should be agreed by the co-producing actor founded in the definition of the ecosystem's performance targets. It is also essential that deviations are reported as early as possible, with the goal of as little (or non-existent) deviation as possible between the plan of reaching a certain state and the actual outcome of that state.

Subsequent evaluation processes open up for a continuous refinement and development of the performance targets. It is essential that evaluation processes become a vehicle for a successful and meaningful realization of the intentions of Sea Traffic Management for sustainable sea transportation. Evaluation has an important role in ensuring that the levels of the performance targets are accurate.

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[5] c.f. e.g. project management, when detailed planning is necessary for closely related actions are necessary while more overall planning is allowed for actions to be performed further away (in time)

[6] c.f. Lind M., Haraldson S., Holmberg P-E., Karlsson M., Peterson A., Hägg M. (2014) Punctuality as performance metrics for efficient transportation systems, Submitted to ITS World Congress

*** This paper describes preliminary findings within the MONALISA 2.0-project. They are not the final findings which will be part of the project deliverables. We encourage readers to send feedback and comments on this paper! ***