MARITIME VEHICLE ROUTING UNDER UNCERTAINTY: LNG SHIPPING AND OFFSHORE PIPELINE DAMAGE ASSESSMENT PROBLEMS

Jaeyoung Cho, Gino J. Lim, Seonjin Kim.

Department of Industrial Engineering
University of Houston, Houston, TX, 77204-4003
Tel: (713)743-7010, Email Address: jcho12@uh.edu

Maritime vehicle routing and scheduling problem has been studied extensively in the context of risk mitigation. This study discusses about two maritime vehicle routing problems and its mathematical frameworks considering environmental uncertainty.

The first problem considers to mitigate weather impacts to LNG production-inventory planning and LNG carriers' routes scheduling. This problem is formulated to two optimization models: a two-stage stochastic mixed integer programming model and a parametric optimization model. The first one maximizes the overall expected revenue while minimizing disruption cost which resulting from extreme weathers. The second one, a parametric optimization model attempts to reflect decision maker's preference on risks by varying the ratio of revenue to on-time delivery. Therefore, a decision maker can have a 'what-if analysis' to compare multiple options for the final planning decision. Stochastic production-inventory control constraints set is also developed which synchronizes production-inventory plan and LNG carrier routing schedule under weather disruption.

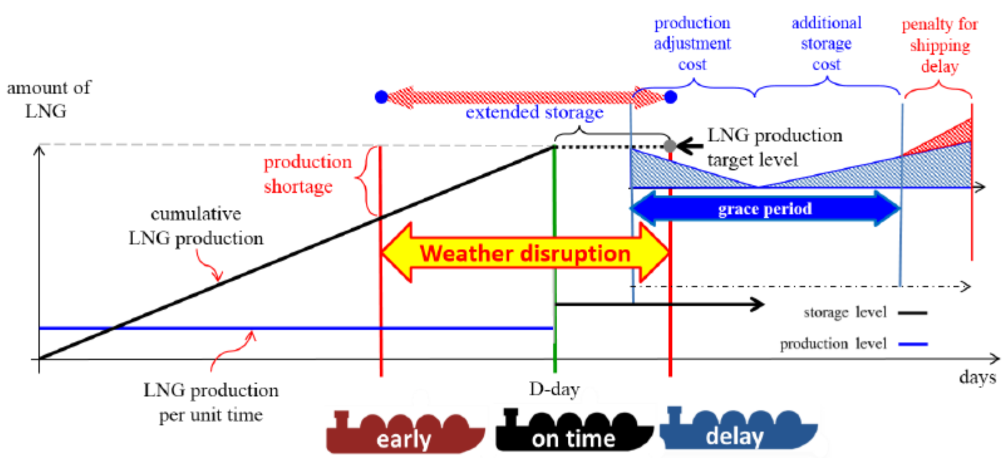

Fig. 1 A random extreme weather impacts to LNG production-inventory plan and LNG carrier routing schedule

The Second one, offshore pipeline damage assessment problem is to minimize overall inspection time by using multiple autonomous underwater vehicles (AUVs). In order to collect how/what might have caused pipeline damages by a weather disruption, multiple AUVs are pre-positioned at some selected underwater locations before the beginning of the extreme weather. Once the weather clears up, the pre-deployed AUVs start pipeline damage assessment. This problem is formulated as a two-phased multiple AUVs pre-positioning and routing model. The first phase problem is to determine optimum AUVs' pre-positioning locations considering maximum AUV operating distance and random weather impact. In the second phase, AUV paths are generated to scan the designated offshore pipeline networks while minimizing operating cost proportional to the number of pre-deployed AUVs.

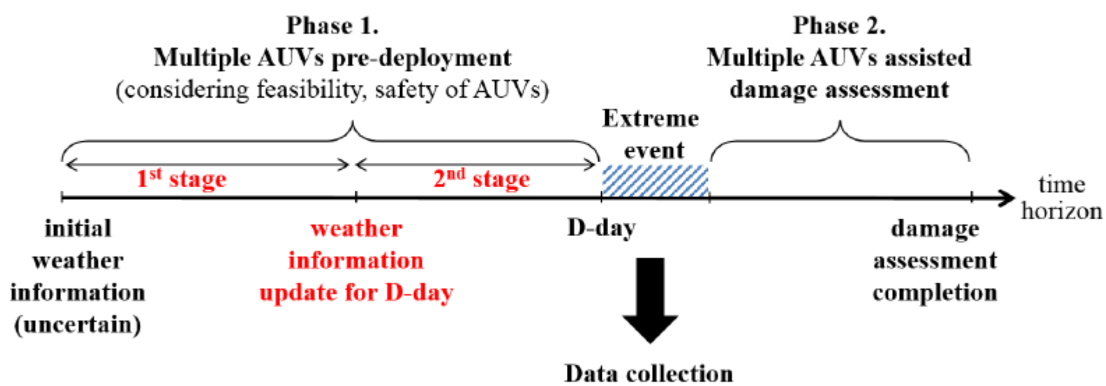

Fig. 2 Offshore pipeline network damage assessment over a planning horizon

As both models are NP-hard problems, we developed computational techniques, such as pre-processing algorithms, valid inequalities, and also utilized Lagrangian relaxation to generate a tighter bound for the objective functions. We presented computational results of both models which showing that a stochastic approach outperforms its deterministic counterparts, and analyzed the effectiveness of computational options.

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