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EXECUTIVE SUMMARY

The System Engineering that goes into any shipping vessel construction requires an intricate network that starts from parts procurement to the various agencies that participate in the construction of the main parts, the timely delivery of the main parts and the appropriate placement of those parts to create the finished product vessel. The Royal Thai Navy (RTN) is in the planning process of constructing three more Offshore Patrol Vessels (OPVs) in where the seriousness of a timely construction of the vessels is detrimental to the operations of the RTN.

PROBLEM STATEMENT

Due to the cost being of detriment to the construction of the OPVs, it is important to identify the network and understand any vulnerability the RTN may face. These vulnerabilities may be affected for many reasons, to include: if anyone wished to sabotage their efforts by delaying or halting construction, any political or economical problems in other parts of the world that may impede on the procurement of parts, or any type of disasters that halt procurement from affected contractors. The RTN has a list of contractors where various main parts for their construction efforts may be constructed and provided from. In this project, these proposed contractors represent 10 countries. Roughly forty percent of construction efforts are accomplished by the RTN, leaving the dependency to the multitude of contractors. A main factor in the network is the associated inner-network of part placement which requires that the successor to any and all predecessors be achieved within constrained time limits.

DATA SOURCES

All nodes and arc data was acquired from representatives of the RTN. For reasons of confidentiality, some of the procurement agencies have been either magically created or remain very vague. For reasons of security and confidentiality, costs associated with various aspects of the ship construction are also magically created in the data.

ASSUMPTIONS

Many of the contractors will have more cost associated with them but may serve as good alternatives when some of the major procurement nodes are eliminated.

ANALYSIS OF DATA

A breakdown of the data identified 22 nodes representing the major tasks necessary to build an OPV. Of the 22 nodes, 8 of them require all or most work done by a specialized contractor. The newly created nodes representing the contractors, which in this project were limited to 3 possible contractor options for each of the original 8 nodes representing the major tasks that required contractors, add to a total of 46 nodes for this project. Since most of the main jobs identified in this problem could be done in parallel, a closer analysis of the problem was developed via a project management spreadsheet modeling the critical path method. This analysis, which was done on only the nodes representing the main parts of the ship, identified that 4 nodes must be completed before the node representing the releasing of the vessel into the water. The following 13 nodes, inclusive of their predecessors, need to be done before the nodes representing testing could be started. This resulted in the creation of a plot which pinpointed the latest possible start time of any project as well as the project duration in order to create a flow of events. The spreadsheet modeling was also used to confirm and identify job timeline specifications, with a resulting job completion time of 917 days, which was used to create a cost estimate. This became our benchmark for proposed job completion cost while the added contractor option nodes served as a means to achieve a much smaller cost of the overall job.[i] The newfound flow was then ran in a GAMS shortest path interdiction model with each necessary node flowing into each other based on latest start times with the added emphasis on the identified necessary predecessor/successor relationships. The contractor options were added into the graph, identified by arcs spawning from the immediate predecessor of the node in which the contracting is associated with. This allows our flow to identify a shortest path which helps identify which contractors would minimize the amount of cost from our proposed problem. This is optimally achieved by pushing 0 flow from all

arcs except those arcs associated to a contractor node, whereas the amount of cost shaved off the project through the utilization of the specific contractor was the corresponding flow identified on these arcs. A delay of 100 million (M) dollars was added to the model in order to penalize the model for allowing any interdicted contractors.

RESULTS

Running the shortest path algorithm allowed us to identify the 8 contractors that would minimize the amount of cost for the building of the OPV, identified in the model as 35.7M dollars shaved off the proposed 91.7M, resulting in a total cost of 56M. 4 countries were represented in this shortest path and it could further be assumed that these countries are detrimental to maximizing the surpassing of the timely goal involved in this project. This model allowed up to 3 interdictions, where the third interdiction results in 'no path' along with a 100M dollar penalty to allow for the possible halt and re-assessment of the project towards completion. Running the model with 1 interdiction resulted in a savings loss of 35M with a contractor from Thailand being interdicted and resulting in a less desirable contractor from India for the node representing the task of Piping. With 2 interdictions in place, the model only shaved off 26.7M from the proposed project goal as the algorithm identified the interdiction of 2 arcs that both represented the 76mm Gun System node and leaving the least desirable contractor for the entire model when solely emphasizing on a cost-based scenario. After the above-mentioned achievements in this project, we proposed a more realistic scenario by manipulating our code to only interdict on arcs related to a specific country. The result to these interdictions showed that the only countries that affected the model were those 4 identified from the zero interdiction shortest path algorithm. Of the 4 countries, the most detrimental one to lose contractors from was the United States.

DISCUSSION

Representatives from the Royal Thai Navy are interested in this project as a planning consideration for their future expansion of 3 OPVs. Although much of the contractor data was vague and

make believe it does stress operational considerations on possible preliminary planning simulations that could be used to identify possible weaknesses in RTNs future projects. In this project we tried to capture a more realistic approach to the problem by taking out an entire country to show a shift in overall cost. This analysis could be further expanded to add completion time or look at the interdiction of multiple countries. Therefore, this small project of networking could lead to cost and time savings for the Royal Thai Navy and can be further expanded for any form of construction project where contractors are involved as an option.

[i] NOTE: The contractor times associated with the data in this project were magically created.