

# **Flexibility in Early Stage Design of US Navy Ships: A Real Options Analysis**

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This thesis explores some design options for naval vessels and provides a framework for analyzing the benefit of these flexibilities. Future demands on Navy warships, such as new or changing missions and capabilities, are unknowns at the time of the ship's design. Therefore, ships often require costly engineering changes throughout their service life. These are expensive both fiscally – because the Navy pays for both engineering and installation work – and operationally – because either a warship cannot carry out a desired mission need or is carrying out a mission for which it was not initially designed. One method of addressing uncertainty in capital assets is by imbedding flexible options in their architecture. The thesis offers early stage design suggestions on flexibilities for naval platforms to incorporate pre-planned repeats of the platform with new or different missions. Then, the thesis uses a Real Options Analysis framework to evaluate the value of including these switching options in early stage design. The analysis uses the MIT Cost Model for early stage design to determine acquisition and life cycle costs. The model is modified to support this analysis by allowing a simulation of possible mission changes and their severity distributed stochastically over a realistic time horizon. Subsequently, the model calculates these affects on life cycle cost. The most important result is the value of the Real Options framework for evaluating these managerial options. This framework can extend to the subsystem level or to the system-of-systems level. In this application, the model predicts that, on average, a flexible platform should not only cost less to build, but also reduce maintenance and modernization costs by 35% per ship over its life cycle. Therefore, counter-intuitively, building a less-capable ship with the flexibility to expand capabilities or switch missions actually provides greater expected utility during its service life.

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