Environmental Life Cycle Criteria for Making Decisions about Green versus Toxic Propellant Selections

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Large uncertainties of performance and expense have been an on-going deterrent to serious consideration of less-toxic green propellants as alternatives to hydrazine for aerospace propulsion systems. Although candidate propellants may equal or even surpass the performance of current propellants, with environmental benefits that have been documented, life cycle trade analyses performed to date have not provided a sufficient business case for investment in such a significant infrastructural change.

These analyses have been incomplete - typically focused on broad cost, performance, and risk characteristics, and have not taken into account the comparative costs associated with the environmental impacts of the alternatives. Environmental life cycle costs must be included in the analyses in order to understand the true costs incurred.

This research defines a set of environmental components to serve as criteria in life cycle cost analyses for propellant selection decisions. Based upon information gathered during visits to facilities responsible for each phase of the propellant life cycle, a detailed compilation of the environmental life cycle processes and related costs was constructed, including manufacturing and storage; general safety considerations; site control and access; air monitoring; personal protective equipment (PPE); decontamination procedures; transportation by rail, sea, air, and public highway; operations and maintenance; and end of life disposal.

Lending credence to the significance of the identified costs, a case study approach was implemented as a way to examine these environmental cost factors using real data. The case study for this effort was the PRISMA mission, which provided a one-to-one comparison between the baseline hydrazine to a High Performance Green Propellant (HPGP) system. This case study revealed a significant reduction in costs (~$500K) during only one phase of the mission life cycle (a 2/3 reduction from the baseline hydrazine system). This analysis resulted in a sample model utilizing the significant cost factors previously identified that should be included in future total life cycle cost analyses.

These cost categories (broken into operational cost and capital cost) should be identified for both the baseline option and the alternative option over the expected life of the propellant. The methodology best suited for incorporation of these identified environmental costs for decision-making is a customized cost-benefit analysis (CBA). This research has indicated that the biggest environmental cost drivers over the life cycle of the propellant are facility operations and maintenance, end of life disposal, and transportation. The costs associated with health and human safety protection while operating with hazardous materials are major cost drivers for propellant selection and present significant direct, indirect, and capital costs over the life of the propellant. These costs are critical, and must be included in the analyses for informed decision-making.

When environmental costs are included in the analysis, one can potentially bridge the gap between traditional investment and return on investment models in a timeframe that can be acceptable to investment decision-makers.