Advanced Propulsion

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EXECUTIVE SUMMARY

JASON studied high specific impulse propulsion systems for in-space orbital maneuvers of satellites. Existing and emerging electric propulsion systems were surveyed, and several advanced solar electric arrays were studied. The combination of these technologies was shown to significantly reduce the launch costs of several DoD satellites, and the potential increase in on-orbit power could be used to increase the operating performance, maneuvering capabilities, and resilience of future satellites.

JASON was impressed by the potential impact of advanced electric propulsion systems and recommends further research and development to support military satellite needs. Furthermore, detailed studies of fully integrated all-electric satellites should be performed to assess the potential improvements in on-orbit performance and the reduction in launch costs. Such a study should consider the advantages of greatly increased on-orbit power enabled by large low-mass solar arrays.

JASON was briefed on four possible approaches for producing thrust without expelling a propellant. Briefers presented experimental data that they interpreted as demonstrating non-zero thrust forces that could be used to propel a spacecraft. If the proposed propellent-less thruster concepts were proven to be valid, they would have to defy the basic laws of physics stating that there can be no net thrust unless there is a momentum flux through a control volume surrounding the device.

Several quantum mechanical explanations were proposed by the briefers, but JASON is unconvinced that these arguments can explain the data or have any validity. Thus, JASON focused on understanding the available data and the numerical calculations used to analyze the proposed thruster performance. All ex-

perimental configurations are complicated, with many possible uncertainties and the potential for mis-interpreting the measurements. JASON has identified several possible physical phenomena that could lead to spurious results, and has significant concerns with many aspects of the experiments claiming propellant-less propulsion; generally they are not sufficiently controlled and do not produce unequivocal results.

JASON notes that if a laboratory experiment shows a displacement of a component of a device, that does not imply that useful thrust forces are generated. For example, a diamagnetic material will float above a strong magnet, indicating that a force is generated without a propellant. However, no momentum flux crosses a control volume around the system, and therefore no net thrust can be generated. Thus, it would not be possible to propel a spacecraft with this effect.

JASON considered the numerical simulations that were used to bolster the claims of non-zero thrust for two of the proposed devices. It was found that these calculations suffer from a combination of incorrect boundary conditions, lack of grid resolution, and erroneous evaluation of the Maxwell Stress Tensor. Thus, they are not valid. JASON was able to analyze two sets of calculations in considerable detail to show the origin of the miscalculation. In addition, this report provides a general theorem that the detailed summing of electromagnetic forces within a closed cavity must average to zero over a cycle and thus can yield no net thrust.

JASON assesses that the unconventional concepts presented have no utility for in-space propulsion, given the uncertainties in the experiments and the fact that the operating principles defy the laws of physics.