PROOF OF CONCEPT FOR DETUMBLING BY LASER ABLATION FOR ACTIVE DEBRIS REMOVAL:

EXECUTIVE SUMMARY

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The initial requirements for an Active Debris Removal laser ablation detumbling system, in terms of the forces which need to be applied to a debris target have been defined, and the potential advantages of laser ablation reviewed in comparison with other detumbling concepts.

The physics of laser ablation have been reviewed to define an optimal coupling between the incident light, and the momentum transferred to the target object. It has been demonstrated that the restrictions typically seen on laser spot size, due to the requirement for large focussing mirrors, do not apply to the close range operations proposed here. This opens the possibility of using commercially available lasers, although initial investigations suggest that those lasers currently available will only satisfy the basic requirements. Further, the investigation has suggested that the same laser system could be used for both the detumbling and de-orbiting of a target.

The state-of-the-art commercial systems are, however, not efficient enough and too massive to be competitive as a detumbling system. High power research diode pumped solid state laser systems currently reach the minimum requirement for efficiency and are close to being sufficiently light to be competitive. This, though, does not provide a direct technology spin-in, and significant work would be required to develop a bespoke system for an Active Debris Removal mission.

For a laser detumbling system to become genuinely competitive, the mass will need to be reduced, and the efficiency increased. A chemical thruster system with propellant is of the order of 30kg to detumble a large spacecraft, so with the advantages inherent in using lasers, a 50kg system would make an attractive alternative. Were this to be allied to an efficiency increase to 50%, which would reduce the waste heat by a factor of four, this would then become a highly competitive option.

Use of lasers at the current research level are most appropriate as both a de-orbiting and detumbling system, although further efficiency gains and mass savings are still needed to be truly competitive. The issues which need further work here are manner in which the chaser vehicle follows the target, as it also has to de-orbit, and ensuring that the re-entry casualty risk is acceptable. Each of these is a research area in itself.

Given the current rate of progress within the field, it is expected that laser systems will become more competitive for applications such as these. At the point that commercial 5J pulse diode pumped solid state laser systems become available that are approximately twice as efficient and half as massive as those currently on the market further investigations should be performed.