AIAA
SP-016-1992

Special Project

Orbital Debris Mitigation Techniques:
Technical, Legal, and Economic Aspects

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**Prepared under the auspices of the
AIAA Standards Program and the
Technical Committee on the Legal Aspects of
Aeronautics and Astronautics**

Abstract

This AIAA Special Report addresses the minimization of the orbital debris hazard from an interdisciplinary perspective. It reviews a broad range of existing and proposed debris mitigation techniques and presents the results of an AIAA survey of industry and government. It discusses a number of important economic issues associated with orbital debris and provides a first-order economic assessment of the mitigation techniques. Finally, the report describes the existing regulatory framework and addresses several options for implementing those techniques, both nationally and internationally.

This report is not an AIAA Position Paper.

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Orbital debris mitigation techniques : technical, economic, and legal aspects / a special study of the American Institute of Aeronautics and Astronautics ; performed under the auspices of the Standards Program and the Technical Committee on the Legal Aspects of Aeronautics and Astronautics.
p. cm.
At head of title : Special Project Report
"AIAA SP-016-1992."
Includes bibliograpical references.
ISBN 1-56347-023-3 (pbk.)
1. Space debris I. American Institute of Aeronautics and Astronautics Standards Program Orbital Debris Study Group. II. American Institute of Aeronautics and Astronautics Technical Committee on the Legal Aspects of Aeronautics and Astronautics.
TL1499.072 1992
629.4--dc20 92-3610
CIP

Published by
American Institute of Aeronautics and Astronautics
370 L'Enfant Promenade, SW, Washington, DC 20024

Printed in the United States of America

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The Orbital Debris Study Group approved the document in November 1991.

The AIAA Standards Technical Council approved the document in January 1992.

Executive Summary

A scant 40 years ago, before the first launch of a man-made object into space, the idea of trash littering outer space as a result of human activities was difficult even to imagine. But trash in space, or more specifically, debris in Earth orbit, is no longer merely a conceptual problem. It is now the subject of intensive study and government policy-making, and a very real and growing threat to all space programs.

There are four general sources or classifications of orbital debris: discarded rocket bodies, inactive payloads, debris from the operation of spacecraft, and fragments caused by collisions or explosions. The mass, size, location, and distribution of this material varies over time and significant uncertainties remain in the accurate characterization of the problem, particularly with regard to debris that is smaller than 10 cm.

Despite these uncertainties, a general consensus has developed among space experts in all disciplines that in the absence of any efforts among the spacefaring nations to control the problem, orbital debris could severely restrict the use of some orbits within a few decades. All government reports and policy statements issued to date have consistently cited the need to minimize the growth of such debris, and the U. S. government has already made significant progress in researching and defining the problem.

In the view of the Study Group, what matters most about the orbital debris problem is not what we do not know, but what we do know. Although we may be relatively ignorant about the total number, size, and distribution of the debris, we know that it already poses a small, but growing threat of damage or destruction to our operational spacecraft. Although we may not know with certainty what the global launch rate will be in the coming years, we know that the hazard generally will continue to increase with every launch of a mission that does not prevent the creation of new pieces of debris. This report focuses on the most promising methods for minimizing that hazard from technical, economic, and legal perspectives.

TECHNICAL ASPECTS

As used in this report, "mitigation techniques" refer to a broad spectrum of debris minimization or reduction measures that may be implemented, either through hardware design or spacecraft operation. They include techniques for prevention of debris generation, spacecraft disposal or active removal, and protection of spacecraft through shielding or collision avoidance. Shielding and collision avoidance techniques are adaptive as well as mitigating; that is, they are used to improve spacecraft survivability in a worsening debris environment while also preventing the creation of more debris by protecting the spacecraft from collisions.

A comprehensive strategy for addressing the orbital debris problem requires consideration of both reactive adaptation measures and proactive mitigation techniques. This study focuses on the latter approach, however, because the Study Group considers this to be in more urgent need of attention.

The Study Group conducted a survey of industry and civil government agencies and organizations to obtain information on debris mitigation techniques as they relate to each debris class. For each class of debris, several specific mitigation techniques were provided as options. Survey respondents were asked to indicate which of the listed mitigation techniques they were already using or were considering for implementation. The following is a summary of the commonly practiced techniques and those favored by respondents for future implementation.