

DEVELOPMENT OF ISO STANDARDS ADDRESSING MITIGATION OF ORBITAL DEBRIS

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ABSTRACT/RESUME

The International Organisation for Standardization (ISO)'s Technical Committee "Aircraft And Space Vehicles" Sub-Committee "Space Systems And Operations" (known as ISO TC20/SC14) is currently engaged in the development of standards to address implementation of measures associated with debris mitigation, as identified in recent international-level discussions. This activity is in response to recent international discussions, and interagency agreements on the need for mitigation of space debris.

The ISO TC20/SC14 Orbital Debris Co-ordination Working Group (ODCWG), set up in 2003, after initial ISO discussions on the need for development of standards on the topic of debris mitigation, is responsible for developing a plan for the preparation of standards on debris mitigation, and managing the preparation of those standards by the SC14 working groups. The tasks of the ODCWG also include establishing and maintaining external liaisons with a range of agencies involved in space debris mitigation

This paper provides an overview of the current status of the development of these standards, and the current and planned activities of the ODCWG, including liaisons with other organizations. Issues influencing the progress and direction of the ISO activity are discussed. Reference information on ISO TC20/SC14 and the development of ISO standards is also provided.

1. INTRODUCTION

Launch and operation of Earth orbiting satellites typically generates non-functioning objects. These objects may be launch vehicle stages, post-mission satellites, or objects generated by the break-up or degradation of operational or "dead" satellites. These objects are called space debris, or orbital debris. The presence of orbital debris has been identified as a potential hazard to operating satellites, and the growth of the orbital debris population a risk to future access and use of space.

Mitigation of space debris has been the focus of international discussions at the United Nations Committee for the Peaceful Uses of Outer Space (UN

COPUOS) and within the InterAgency Space Debris Co-ordination Committee (IADC). The IADC released their Space Debris Mitigation Guidelines in 2002, and an update of these guidelines is being considered, in parallel with dialogue with the UN COPUOS who have agreed to draft a high level mitigation document based on the IADC Space Debris Mitigation Guidelines.

The International Standards Organisation Technical Committee "Aircraft And Space Vehicles" Sub-Committee "Space Systems And Operations" (known as ISO TC20/SC14) is currently engaged in the development of standards to address implementation of measures associated with debris mitigation, as identified in recent international-level discussions. This activity is in response to recent international discussions, and interagency agreements, on the need for mitigation of space debris.

This paper provides an overview of the current status of the development of these standards, a summary of complementary international-level discussions, and the current and planned activities of the ODCWG, including the status of liaisons with external organisations associated with mitigation of orbital debris. Issues influencing the progress and direction of the ISO activity are discussed. Reference information on ISO TC20/SC14 and the development of ISO standards is also provided.

2. RECENT DISCUSSIONS ON MEASURES ASSOCIATED WITH DEBRIS MITIGATION

Discussion of the need for, and scope of, measures associated with the mitigation of debris (generation of, and effects of) has been carried out at an inter-governmental level (UN COPUOS). The scope, and nature, of the measures have also been discussed at interagency level (at the International Telecommunications Union (ITU), and within the Inter Agency Space Debris Co-ordination Committee (IADC), a federation of eleven space agencies, representing space-faring nations. The space agencies represented in the IADC defined an agreed set of high-level debris mitigation guidelines in 2002, and, at the time of this paper (2005), they are currently discussing updates to these guidelines, with a release of these updated guidelines in the near future.

These measures represent a vision statement and a goal to be achieved, and they are not requirements-driven (i.e. formulated as standards). The implementing agency can choose to limit the scope of its implementation of these measures at a national level, or tailor their implementation on a case-by-case basis to different missions. Some national space agencies have implemented standard practices, or standards, to expand, and define more clearly at national level, the scope of activities needed. If measures taken from the IADC guidelines are applied as part of national law, national licensing or regulation, or national implementation of international agreement on principles, they would generally be applicable to all space missions, covering space vehicles and space launchers.

An example of a recent national-level regulation is the June 2004 new ruling by the US Federal Communication Commission (FCC), on the subject of mitigation of orbital debris (“Second Report and Order in the Matter of Mitigation of Orbital Debris”). Although launch vehicle activities in the US are licensed by the Federal Aviation Authority (FAA), the FCC authorises the launch and operation of U.S. spacecraft that are owned and operated by private companies and use radio frequencies. Other launches and frequencies are licensed by different US authorities and, for remote sensing satellites, remote sensing activities and post-mission disposal are authorised by the Commerce Department, NOAA. For non-US spacecraft, FCC authorizes commercial radio frequency operations in the U.S. through earth station licensing or market access rulings.

Future measures could also complement existing United Nations Treaties on the use of outer space (United Nations Treaty on Principles Governing the Activities of States in exploration and Use of Outer Space, including the Moon and other Celestial Bodies, January 1967 “Outer Space Treaty”; United Nations Convention on International Liability for Damage caused by Space Objects, 1972; the Principles relating to the Use of Nuclear Power Sources in Outer Space, 1992), noting that some treaties have not been signed by all space-faring nations.

In summary, recent agreements at international level have been signed on the types of measures that address the issue of debris mitigation. Within some countries, steps have been taken to codify elements of these agreements as part of national regulation or licensing activities, or to produce national-level standard practices, or standards, to complement the international agreements, and to assist with their use within that country.

3. RECENT AND PLANNED ACTIVITIES BY ISO ON THE DEVELOPMENT OF STANDARDS FOR ORBITAL DEBRIS MITIGATION

Recognising that mitigation of orbital space debris is an issue of international concern, and that a system of implementation standards was potentially required to implement mitigation measures, ISO TC20/SC14 has monitored progress in the development of mitigation guidelines by the IADC and national/regional agencies over the past few years.

At the eleventh annual plenary meeting (May 2001) of the ISO TC20/SC14 a resolution was unanimously agreed that, through the Chairman SC14, an approach would be made to the IADC to work together to define design areas in which SC14 can be of immediate assistance in progressing debris related standards.

At the twelfth annual plenary meeting (May 2002) of ISO TC20/SC14, the ISO experts concluded that a set of engineering design standards was required to enable implementation and verification of requirements derived from debris mitigation guidelines, and may also be required to improve the reliability and survivability of space systems in the debris environment. Both groups of standards should be developed through ISO TC20/SC14 as international standards. Resolutions were passed that ISO TC20/SC14 form an Ad-Hoc Space Debris Working Group, drawing on expertise from the member bodies, the working groups, ESA, and ECSS, to review the issues and advise the SC14 Chairman on priorities, options, and approaches to the development of engineering standards for debris mitigation. In May 2003, the formation of the Orbital Debris Co-ordination Working Group was agreed by the ISO TC20/SC14 Heads of Delegation at the TC20/SC14 annual plenary meeting.

As defined in their Terms of Reference, the tasks of the ODCWG include:

- developing a plan for the preparation of ISO standards addressing implementation of debris mitigation
- establishing and maintaining external liaisons with a range of agencies involved in space debris mitigation (e.g. IADC, UN COPUOS, IAA)
- developing and maintaining links within ISO TC20/SC14 with the working group convenors who are responsible for the development of the standards and with the TC20/SC14 Heads of Delegation

The TC20/SC14 Heads of Delegation:

- represent nine national standards bodies in total,
- vote on the initiation of each standards project, and its progress through the development standards to the production of an ISO International Standard, Technical Specification or Technical Report).

The ISO process to develop standards (as described in Annex A), supported by the general practice of commenting on drafts (informally throughout the development process, and formally, at designated voting stages), is used to identify areas of agreement and disagreement within the drafting team (consisting of individual technical experts, and national delegation representatives, nominated by the TC20/SC14 Heads of Delegation) preparing the standard, and at national level. The general principle of consensus (defined as absence of sustained opposition) is applied throughout the standards development process. Further information on the membership of TC20/SC14 and voting on the projects is given in Annex A.

The first draft of the ODCWG Programme of Work for the Development of Standards for Orbital Debris Mitigation (Debris Standards Plan) was released internally to ISO TC20/SC14 in October 2004, and included a preliminary analysis of the IADC guidelines to identify:

- internationally-agreed measures that could be translated into measurable and verifiable requirements in standards.
- topics noted in the IADC guidelines that might need standards for their implementation.

Development of a framework for the development of orbital debris mitigation standards is made more difficult by the task of predicting the scope and impact on the ISO activity of the anticipated near-future changes in international agreements on debris mitigation, whether the changes are predicted at the IADC (changes to existing agreements) or at UN COPUOS level (possibility of new agreements on debris mitigation). However, the debris mitigation measures within the IADC guidelines are divided into the following four topics and it is not anticipated that there will be any major changes to these overarching themes:

- Limit debris during normal operations
- Minimise the potential for on-orbit break-ups
- Post-mission disposal
- Prevention of on-orbit collisions

As of April 2005, two standards projects have been agreed at ISO level and Working Drafts (WD) have been prepared and reviewed:

- ISOWD23339. Unmanned spacecraft remaining useable propellant mass estimation
- ISOWD24113. Space Systems – Orbital Debris – Part 1: Routes to compliance and management for debris mitigation

As of April 2005, four Work Item Proposals (NWIP) are in active development on the following topics:

- Orbital Conjunction Assessment Data and Information Exchange: Common Data Format for Collision Avoidance
- Launch Window Estimation and Collision Safety Verification
- Re-entry Safety Control for Unmanned Spacecraft & Launch Vehicle Orbital Stages
- Disposal of Satellites Operating at Geosynchronous Altitude

As of April 2005, some additional topics are under preliminary consideration as potential New Work Item Proposals:

- Process Based Implementation of Meteoroid and Debris Environmental Models (outline of proposal planned for review in May 2005)
- Selection of Satellite Surface Coatings and Materials
- Spacecraft Functionality And Reliability (Calculations) Under Debris Impact
- Standard Techniques for Limiting Re-contact of Released Items with Spacecraft (or Orbital Stages)
- Standards for Stage Separation Devices to Minimise Creation of Space Debris
- Determining Orbit Lifetime For Orbiting Objects (Intersecting The LEO Region)
- Disposal of Satellites Operating in the LEO Protected Region

Both the projects in active development and those under preliminary consideration will be reviewed in the run up to, and at the next ISO TC20/SC14 Plenary meeting (May 2005) meeting, and may be put forward for vote as new projects (in 2005, or later) following that review. Note that titles, and the scope inferred by these titles, of the proposed projects may change. Other topics may also be developed for consideration at this meeting.

Following agreement at the next ISO plenary, in May 2005, the next version of the ODCWG Programme of

Work for the Development of Standards for Orbital Debris Mitigation (Debris Standards Plan) is planned for release, and elements of this plan are planned for release on the public part of the TC20/SC14 website.

The ISO TC20/SC14 website is accessed via the ISO standards portal. To reach it, access this link (<http://isotc.iso.org/isotcportal/index.html>), then click on "TC 20 Aircraft and space vehicles", then on SC 14 "Space systems and operations" to access the public parts of the site, and to contact the ISO TC20/SC14 secretary with any general enquiries). ISO TC20/SC14 members access material (e.g. draft standards in development, minutes of meetings etc) via the members-only site (password and login system). Note that no material will be available on the public part of the site before the middle of 2005.

Since 2001, dialogue has continued between ISO TC20/SC14 and the IADC. Recent proposals by ISO for a Category A liaison between ISO and IADC are under consideration. Other existing external liaisons (as described in Annex A) have been evaluated and steps made towards involving organisations in the ISO debris standards activity.

4. ISSUES INFLUENCING THE ISO ACTIVITY

A number of issues are influencing the development of standards for mitigation of orbital debris. One issue external to ISO TC20/SC14 is the changing (or evolving) situation on international agreements (including ongoing discussions within IADC and UN COPUOS). Understanding the nature of international agreements is important because ISO wish to base their activity on broad international consensus. Some questions currently:

- How are national practices agreed ?
- What is the national policy of signatories with respect to implementation of IADC guidelines, or related mitigation guideline activities, at national level ?

Internal to ISO, another issue is that a number of different opinions have been expressed on the following topics:

- Approaches to the development of standards
- Content of the standards
- Requirements used in the standards

These inputs may be influenced by the existing debris mitigation approaches at policy level within each country. In general, standards do not represent national law or national policy (unless implemented as such) and general custom and practice is that standards are

used as part of the specification between customer and supplier. (This may include tailoring of the requirements, or other aspects, of the standard).

Further detail on these three issues is provided below.

Approaches to development of the standards. Two complementary approaches are in use to support the development of the ISO standards on topics related to debris mitigation. Initially, it was proposed that these standards could be organised in a standards framework (all standards fit in together in an interconnecting system) and that this, and a plan for the preparation of the standards, should be written and agreed before any work started.

This approach was tried at first, but it was found to be difficult, particularly for topics where there was little industry best practice experience of implementing debris mitigation in that area.

As part of the assessment of each debris mitigation topic, as identified in the review of the IADC debris mitigation guidelines, it was found that, for some topics, the feasibility of developing standards for implementing some debris mitigation measures is currently limited by the lack of existing industry "best practice" and/or technically mature methods/data to input to the standard. Each requirement associated with debris mitigation - whether stated in the standard or derived (on a project basis) as a result of implementing a process defined in a standard – must be measurable and verifiable.

To help work through this, the normal ISO process for preparing proposals for vote is being used. Where a first draft of a proposal for a debris standards project can be prepared (adequate technical understanding), it is drafted, and reviewed. Drafts are put through the normal ISO vote process, which ensures that standards are written when they are ready to be written and a market need is present. The framework is being iterated with the material developed as part of the pre-vote outline drafting process.

Content of the standards. As part of the preparation and review of outlines for consideration for vote, two approaches have been apparent in the submissions to date from ISO WG members:

- Use of policy-type language - "should do this", "make best efforts" – and what is written in the standard does not necessarily need to be implemented. Text is interpreted via tailoring
- Use of requirements-type language - "must do this", "verify compliance" – and what is written in the standard must be implemented to show

compliance with the requirements in the standard. Requirements in standard are modified by contract (“tailoring”)

ISO allows for different levels of text within a standard ("shall", "should", or "may"), but a standard must be based on measurable and verifiable requirements ("shall"), supported by recommendations where appropriate ("should", "may"). Text is clarified and improved as part of the normal standards preparation process.

Requirements used in the standards. Designers and operators of space systems require measurable and verifiable requirements to be stated in a standard, or defined for a particular project as a result of a process defined in a standard.

One approach to implementing debris mitigation is that agencies (whether acting as licensing authorities or responsible authorities, involved in the purchase of a space system) define debris mitigation requirements and do not specify detail of how the satellite should be built or operated. In practice, agencies currently provide a more complex set of information in guideline form, including recommendations on constraints on the technical solution and operation. It is sometimes indicated that the relevant agencies wish to be involved in checking/monitoring the design and operation of the s/c through the lifecycle. This type of approach needs to be addressed in the content of the standards being developed.

A review of existing debris mitigation has also identified two types of guideline text, which might form the basis for requirements in a standard:

- Requirement to assess debris generation (“audit”) e.g. Determine objects released as part of normal operations
- Requirement to limit debris generation (“mitigate”) e.g. Total object-time product for objects > 1 mm must be less than 100 object-years per mission. Lifetime of each object must be less than 25 years in orbit

Both types of requirements are linked with a reporting requirement i.e. relevant information must be presented as part of debris mitigation plan. Definition of requirements represents an ongoing task for the ISO project teams leading the development of the standards.

5. SUMMARY

International discussions on the measures needed to address mitigation of orbital debris have led to the publication of a number of guidelines, and further discussion is planned by a number of international

bodies. To address the need for standards to implement debris mitigation, ISO TC20/SC14 has formed a dedicated Working Group, the ODCWG, which is charged with developing and updating a plan for the preparation of these standards (using existing TC20/SC14 working groups, and existing practices for preparation of the standards), and to co-ordinate external liaisons with other parties involved in debris mitigation. As of April 2005, two projects have been started, and a number more are under consideration.

6. ANNEX A (REFERENCE INFORMATION)

The ISO Space Systems and Operations Sub-Committee (ISO TC20/SC14) was established in 1993.

ISO TC20/SC14 consists of national delegations, usually represented by the national standards bodies of that country. The following countries are Permanent (P-) Members, who have the right to vote on standards: Brazil, Canada, China, France, Germany, Italy, Japan, Russia, UK, USA and the Ukraine.

In addition a number of countries are non-voting members (Argentina, India, Poland, Slovakia, South Korea, Spain, Sweden), and others are potential members (Australia, Austria, Belgium, Netherlands).

ISO TC20/SC14 also has a number of liaison arrangements with external organisations.

The organisations with Category A Liaisons (two way exchange of documents) to ISO TC20/SC14 are:

- Consultative Committee for Space Data Systems (CCSDS)
- European Cooperation for Space Standardization (ECSS)
- European Space Agency (ESA)
- International Academy of Astronautics (IAA).

Those with Category B liaisons (one way exchange of documents) are:

- Committee on Space Research (COSPAR)
- International Aerospace Quality Group (IAQG)
- United Nations Committee on Peaceful Uses of Outer Space (UN COPUOS).

As of 2005, ISO TC20/SC14 is composed of seven working groups (WG), preparing International Standards (IS) on the following space systems and operations topics:

- WG1: Design engineering
- WG2: Interfaces, integration, and test

- WG3: Operations and ground support
- WG4: Space environments (natural and artificial)
- WG5: Program management
- WG6: Materials and processes
- ODCWG: Orbital debris co-ordination.

Development of ISO standards follows a clear process and set timelines (Table 1), and the P-members vote on the standards at four stages. Information on the voting majority required for each standard is also shown in Table 1. Note that the published documents are reviewed according to set time limits. Some types of publications must be converted to International Standards within a set time frame, or withdrawn (e.g. Technical Specifications).

In addition to International Standards (IS), TC20/SC14 also develops Technical Specifications (TS) and Technical Reports (TR). ISO now also allows for the preparation of Publicly Available Specifications (PAS) and Industry Technical Agreements (established as an output of a workshop) but these have not yet been used within TC20/SC14.

Participation in the development of ISO TC20/SC14 standards is welcomed. Further information on ISO TC20/SC14 is available from the ISO TC20/SC14 secretary (contact via the ISO TC20/SC14 website), or from the authors of this paper.

Table 1. Summary of Approval Requirements for ISO Standards

<i>Stages</i>	<i>International Standard</i>	<i>Technical Specification (when proposed as a new project)</i>	<i>Publicly Available Specification</i>	<i>Technical Report</i>
Proposal stage (Preparation of New Work Item Proposal (NWIP), ends with acceptance of new project, following submission for vote on the NWIP)				
<i>Adoption of proposal for new deliverable</i>	Proposal achieves required value on the SVAT scale (Standards Value Assessment Tool) Simple majority of P-members of the committee 5-P members participating 5 experts named			N/A
<i>Adoption for proposal for amendment or revision or transformation of deliverable</i>	Proposal achieves required value on the SVAT scale (Standards Value Assessment Tool) Simple majority of P-members of the committee agree to the proposal 5-P members participating			N/A
Preparatory stage (Preparation of Working Draft (WD), ends with acceptance of registration of Committee Draft (CD), following circulation of final version of the WD)				
<i>Acceptance of WD for circulation as CD</i>	Not defined – determined by the committee secretary in conjunction with the committee			
Committee Stage (Preparation of Committee Draft (CD), ends with acceptance of registration of Draft International Standard (DIS), following vote on the CD)				
<i>Acceptance of CD for submission as DIS</i>	Consensus, or, support from 2/3 of the P-members voting	Support from 2/3 of the P-members voting	Simple majority of P-members of the committee	
Enquiry stage (Preparation of Draft International Standard (DIS), ends with acceptance of registration of Final Draft International Standard (FDIS), following vote on the DIS)				
<i>Acceptance for submission as FDIS</i>	2/3 of P-members positive; no more than 1/4 votes negative	N/A		
Approval stage (Ends with approval to publish the FDIS as International Standard (IS))				
<i>Agreement to publish</i>	As for enquiry stage	N/A		