**AIRCRAFT AND SPACE VEHICLES SPACE SYSTEMS AND OPERATIONS**

**Space Operations and Ground Support Working Group (WG3)**

**Orbital Debris Coordination Working Group (ODCWG)**

Minutes

Venue: British Standards Institute, Chiswick High Street, London, UK

Date: 28th to 29th October 2010

1. The meeting was called to order at 0930 on 28 October 2010. Dr. Finkleman welcomed participants, who introduced themselves. The attendance list is attached. The Chinese Delegation and half of the anticipated Russian Delegation were unable to attend because UK visas had not yet been granted. It is unfortunate to learn this on the date of the meeting, but it is not the fault of the delegates. We suggest that the convenor be responsible keeping track of visa status as meetings approach.

2. After a long delay due to Dr. Finkleman's lack of preparation and overhead projector issues.

3. We reviewed the program of work, noting several discrepancies in the latest N250. This was the basis for actions due. Minutes of the previous working group meeting served as an ad hoc agenda. There were no comments, additions, or deletions, and the minutes are adopted as presented. .

4. Dr. Finkleman presented the entire SC14 program of work as a convenors report.

5. We discussed work items in the following order.

5.1 16159: Space Systems - Launch pad and integration site - Analysis of failures: Mr. Tsukanov presented current status which included response to comments from NASA/KSFC, transmitted by Mr. Schultz. All comments but one were adjudicated. The final one, Section 7: Corrective and Preventive Actions is still in contention. Comments from submitted were at best unkind and offered no alternative. Mr. Tsukanov wishes to retain that section. Action: Adjudicate the difference through Mr. Schultz. WG recommendation is to move this work item to the next stage with the section in question with clarification to follow during the next version and vote.

5.2 24113: Orbital Debris Management: This work item is complete for publication. Publication was delayed because obvious editorial inconsistencies noted by Dr. Stokes were not transmitted to ISO in a timely manner. These appeared again in final proofs, which naturally had to be corrected. We hope that this work will actually have been published before the spring plenary.

Dr. Kato raised issues with the definition and employment of the probability calculations as described in an appendix. The formula for P(D|M) is at least ambiguous and can lead to probabilities greater than 100% when applied in the most obvious manner. These formulae were reflected in 24113 because the appear in 26872: Space systems - Disposal of satellites operating at geosynchronous altitude, authored by Dr. Ailor, et. al. At previous meetings consensus was that the same should be included in 24113 for consistency. Therefore, the clarification and guidance for employing the scheme rest with Dr. Ailor and his colleagues at the Aerospace Corporation.

Later in the meeting, Dr. Stokes reviewed issues and suggested revisions received since the work item was finalized for publication. We discussed when it might be appropriate to revise the document. At Dr. La Croix suggestion, it was agreed that none of the items would change the standard materially. The compendium of issues and comments will be maintained until the next mandatory review/revision milestone, three years from publication.

Action: Dr. Ailor to provide an unambiguous formula and definitions as well as examples of how this process is employed at the Aerospace Corporation.

5.3 26872: Space systems - Disposal of satellites operating at geosynchronous altitude: Dr. Ailor was not present. This item is mature and scheduled for publication. However, the interpretation of the rule that once a satellite is raised above the geostationary protected region it not return there for 100 years was again discussed. It was offered that this and low Earth orbit IADC disposal guidelines were guidelines, not laws, and that a degreed of uncertainty and judgement were inevitable.

Action: None

5.4 We next discussed the continuing work item for uniformity of terminology within SC14. The Ukrainian delegation was unable to attend, but Mr. Stryzak did notify us well in advance and submitted a brief report. Dr. LaCroix, having been designated to work with the Ukrainian delegation, beginning with his contributions to WG5 terminology, has communicated well with the Ukraine, but the existing data base of terms that have been employed inconsistently and the computer programs that screen documents against the ISO terminology compendium have not been provided.

Action: Ukrainian delegation to provide the database for Dr. LaCroix. Dr. Finkleman to facilitate.

5.5 CD 11233: Orbit Determination and Estimation: This item lapsed through lack of action by the Secretariat. Required documentation was provided to the Secretariat which lost it leading to cancellation. The item was reactivated by ISO. The documentation was reconstructed, and the document should pass into DIS by the May 2011 plenary.

Action: Dr. Finkleman to follow up with Secretariat.

5.6 Space systems-Far field analysis elements for Launch Vehicle/Spacecraft Separation (China) and Launch Collision Avoidance Support Plan (US). The Chinese delegation was not present, and no information was provided.

Action: Song Qiang to update status and indicate whether this item is sufficiently well justified for continuation.

5.7 16158: Space systems - Avoiding collisions with orbiting objects and Conjunction Assessment Message. Since the original intent remains, to provide information on diverse approaches to estimating the probability that a close approach between satellites (conjunction) will result in direct contact (collision), it was decided to retain this WG3 work item, which is currently assigned to Dr. Ailor. Dr. Finkleman reviewed the Conjunction Assessment Concept Paper prepared for a CCSDS Birds of a Feather group. It will also serve as the outline and justification for a corresponding SC14 joint work item. Dr. Finkleman requested of SC13 and SC14 convenors approval to pursue this jointly, as we did with Orbit Data Messages, now ISO 26900. Approval from SC14 leadership has been received, and SC13 is forthcoming. There was no further discussion or issues.

Action: NWIP to be circulated for implementation by the spring plenary.

5.8 New Work Item: Disposal of Orbital Launch Vehicle Stages. We puzzled over the status of this item, which is Dr. Ailor's responsibility. At the last meeting, action was assigned to Dr. Finkleman and Mr. Oltrogge to conduct analysis of what might be required to dispose of spent stages in geostationary transfer orbit. The analysis was conducted and included within a more comprehensive technical paper that was presented at the American Astronautical Society Meeting last August. Mr. Oltrogge reviewed the paper, which concluded that a perigee altitude of approximately 200 km was required for natural decay of a GTO within 25 years. Dr. Kato presented a historical analysis of stages that achieved orbit. Most remained in an orbit close to the vehicle they had placed in orbit. Some migrated to higher altitudes. Notably many Delta II boosters were in orbits with approximately 200 km perigees. His analyses, derived mainly from Space-Track data, demonstrated that disposal of stages in GTO was not current practice and that GTO objects required perigees less than 200 km to minimize interference with the LEO protected region. He recommended that avoiding interference with the GEO protected region was most important. Recent analysis conducted by Dr. Finkleman demonstrate that collisions between GTO and GEO objects would create the most threatening environment for geostationary satellites. These independent observations are fully consistent with each other.

Nonetheless, the practical feasibility of intentional, controlled deorbit of objects in GTO remains arguable. Consensus is that no further decision or comment is possible until there is a working draft.

Action: Dr. Ailor to produce a working draft to be distributed in time for members to examine it and be prepared for more substantial discussion at the next meeting.

5.9 16164: Space systems - Disposal of satellites operating in or crossing Low Earth Orbit: Andrew Cawthorne reviewed current status and summarized the content of the document. Comments thus far converge on the need for greater substance in the document so that value added was more apparent. Some elements of the document reflect similar clauses in the GEO disposal work item, for example, the requirement that if a LEO satellite were raised to an orbit above the LEO protected region it should not return to that region for 100 years. After discussion, the consensus was that this should not be difficult, since orbit lifetime increases rapidly for altitudes greater than about 500 km. Previous comments suggest a section on contingency planning should the intended disposal fail. The consensus was that deorbit planning should implicitly consider contingencies, and a separate section is not necessary. We discussed the desirability of representative examples of LEO disposal plans. We noted that there are many alternatives.

Action: Mr. Cawthorne to conceive a representative worked example.

5.10 New Work Item: Launch Support Package. Mr. Oltrogge presented a proposal for a launch support package that would include comprehensively information required to execute a launch mission. This includes post-deployment trajectories, planned maneuvers, sensor contact requirements, points of contact for each phase of the launch, and many other items. The group noted that we all operate in different ways. Some of these support needs are met with interface control documents or other formal working relationships, for example.

Action: Members to provide information on their individual launch support arrangements and documentation in order to determine if some or any of the provisions of the work item proposal are already covered in other ways and confirm the need for standardization if there is wide diversity or no provision.

5.11 Report of ECSS Space Debris Working Group: Mr. Lazare presented an excellent summary prepared by our colleague Dr. Roberto Destefanis, Thales-Alenia, Turin. ECSS has designated liaisons to each SC14 working group. Several debris related ISO standards have been accepted for confirmation as ECSS standards. Some were accepted in part. The presentation is attached.

Action: None

5.12 Informational report on time related work items. Dr. Finkleman summarized findings from examination of the ITU recommendation to eliminate the leap second from Universal Coordinated Time (UTC). The conclusion is that normative standards are required for appropriately qualified definitions of the various kinds of seconds (the fundamental time interval) and UTC (the civil time scale). In addition guidance is required either for properly implementing leap seconds or, if leap seconds are eliminated, transitioning efficiently the many systems that currently accommodate leap seconds.

Action: None.

5.12 16127: Prevention of Breakup of Unmanned Spacecraft. This is a WG1 project, but it was discussed because the current meeting is joint between WG3 and ODCWG. It was noted that many of the provisions were similar to those of WG3 and WG5 work items. The essence seems to be a failure mode and effects analysis specific for branches that would lead to breakup. This should perhaps be an element of the FMECA hierarchy required for any spacecraft.

Action: Deferred until outcome of the very recent WG1 meeting in Brazil are known. There were no Japanese representatives in Brazil as best we could determine.

Respectfully Submitted:

David Finkleman

Convenor and Recorder, TC20/SC14/WG3

Hedley Stokes

Deputy Convenor, ODCWG

ATTENDANCE

Akira Kato, Japan

Anton Spivak, Russia

EvgenyTsukanov, Russia

Bruno Lazare, France (CNES)

Andre LaCroix, Germany (DLR)

Akahoshi, Japan

John Davey. UK (ODWG)

Hedley Stokes, UK

David Finkleman, USA

Daniel Oltrogge, USA

Dominique ….., Astrium

………………. , Japan**ATTACHMENTS**

CONJUNCTION SUMMARY MESSAGE

Duane Bird, United States Strategic Command

Denise Kaya, United States Air Force Space Command

David Finkleman, Center for Space Standards and Innovation

William Ailor, Aerospace Corporation

Daniel Oltrogge, Center for Space Standards and Innovation

ABSTRACT:

This Concept Paper proposes developing Consultative Committee for Space Data Systems (CCSDS) standards for warning spacecraft of estimated close approaches to other spacecraft or debris and to guide maneuvers that mitigate the risk of catastrophic collision. Recommendations will address aspects that require standardization in order to enable consistent warning and mitigation by agencies employing diverse conjunction assessment techniques. The Paper recommends the allocation of proposed work to CCSDS Areas.

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INTRODUCTION:

CCSDS Concept Papers are working documents of the CCSDS, its Areas, and its Working Groups. They have no official status, but they are the vehicle for presenting technical matters to CCSDS and enabling authorization of official work 8tems. They are valid for a maximum of nine months and may be updated, replaced, or rendered obsolete by other documents at any time. This Concept Paper is intended for presentation at the CCSDS Fall Meetings, scheduled 26 Oct – 2 Nov 2010 at the British Standards Institute, London, UK.

CONJUNCTION ASSESSMENT:

Conjunction assessment is the process of predicting approaches between spacecraft within a specified close approach threshold and estimating the probability of collision given proximity within the established threshold.

Spacecraft operators may be civil, commercial, or military. Their spacecraft are controlled, orbits determined, and maneuvers executed in many different ways. Some of these operational categories have reasonable knowledge of the orbits and state of others. Some have no such awareness. All need to be informed of close approaches that occur without prior coordination. The work item proposed will establish the mechanism for communicating any operator's perception of an uncoordinated close approach to the involved parties and others that might be affected if there were a collision.

The process of orbit determination and propagation is described in texts[[1]](#footnote-1) and standards[[2]](#footnote-2). There is no universally optimal technique for orbit determination or propagation. Different orbit classes, satellites, and missions require different techniques. Mission owners and operators work for greatest convenience in different reference frames, coordinate systems, and temporal references. As long as their data is provided in a commonly understood format with the fullness of essential metadata, all may operate as they wish. The CCSDS Orbit Data Message standard describes the process and formalism for such exchanges[[3]](#footnote-3).

ADVANTAGES OF STANDARDIZATION

Techniques for conjunction assessment are as diverse as orbit determination and propagation schemes. Diversity leads to diverse outcomes. Vallado and other have documented the differences among outcomes using different orbit determination and propagation schemes[[4]](#footnote-4) so that users can explain the diversity of outcomes and compensate for these differences. There is no such comparison of conjunction assessment techniques. The community must pursue this urgently because different conjunction assessment techniques will certainly lead to Type 1 and Type 2 errors among the techniques. Some will perceive conjunctions that others do not perceive. When two approaches perceive the same conjunctions, they are still likely to estimate different epochs for conjunctions, different close approach distances, and different probabilities of physical collision.

The intent of this work item is to develop a comprehensive set of essential elements of data and metadata for as many conjunction assessment approaches as can be assimilated within a schedule sufficiently short that conjunction warning collaboration can be established as quickly as possible.

PROPOSED FORMATS AND DOCUMENTS

Description of CSM, SDC notifications, JAXA approaches, ESA approaches, etc.

Recommendation for a standard format applicable to all

RECOMMENDATIONS

1. Vallado, Astrodynamics and Applications [↑](#footnote-ref-1)
2. AIAA Standard XXXX, Astrodynamics Best Practices and Test Cases,… [↑](#footnote-ref-2)
3. ODM Blue Book [↑](#footnote-ref-3)
4. Vallado AAS Copper Mountain Paper [↑](#footnote-ref-4)