DATA SHARING TO IMPROVE CLOSE APPROACH MONITORING AND SAFETY OF FLIGHT

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ABSTRACT

Individual satellite operators have done a good job of developing the internal protocols and procedures to ensure the safe operation of their fleets. However, data sharing among operators for close approach monitoring is conducted in an ad-hoc manner during relocations, and there is currently no standardized agreement among operators on the content, format, and distribution protocol for data sharing. Crowding in geostationary orbit, participation by new commercial actors, government interest in satellite constellations, and highly maneuverable spacecraft all suggest that satellite operators will need to begin a dialogue on standard communication protocols and procedure to improve situation awareness. We will give an overview of the current best practices among different operators for close approach monitoring and discuss the concept of an active data center to improve data sharing, conjunction monitoring, and avoidance among satellite operators. We will also report on the progress and lessons learned from a Data Center prototype conducted by several operators over a one year period.

1. INTRODUCTION

The commercial satellite industry has been providing essential services for almost as long as humans have been exploring space. Over the decades, this industry has played an active role in developing technology, worked collaboratively to set standards, and partnered with government to develop successful international regulatory regimes. Success in both commercial and government space programs has meant that new demands are being placed on the space environment. This has resulted in orbital crowding, an increase in space debris, and greater demand for limited frequency resources. The successful management of these issues in the future will require better cooperation between commercial entities and a strong partnership between government and industry.

Operating with only limited government oversight, commercial satellite operators have, over the years, developed their own internal protocols and procedures to ensure the safe operation of their fleets. Operators have also become adept at informal coordination and information exchange with adjacent operators. Nonetheless, increased utilization of the geostationary orbit by new commercial and governmental actors suggest that a review of current industry best practices for close approach monitoring might be in order. The purpose here is to examine the current state of data sharing in the commercial satellite industry and its relationship to safety of flight. In addition, this paper will explore new paradigms for easing communication between operators and between operators and governments.

2. COLLISION MONITORING TODAY

Most operators rely on the publicly available Two Line Elements (TLE) provided by the US government via the space-track.org website for close approach monitoring. There are drawbacks to this approach for close approach monitoring. TLE data do not have the required accuracy for credible collision detection. An operator relying on TLE data must increase the calculated collision margin to avoid potential close approaches. In most cases, threats identified using the basic TLE data are downgraded after coordination with other operators or further evaluation with more precise

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orbital data. In addition to the inaccuracies of the TLE data, these data also lack maneuver information. This limits the usefulness of the TLE for longer term predictions, since maneuver information is necessary to properly predict the ephemeris for active satellites. The lack of this data becomes increasingly problematic as more satellites employ ionic propulsion systems and are, essentially, constantly maneuvering.

A few satellite operators have signed special agreements with the US Air Force to receive supports from the US Joint Space Operations Center (JSpOC) for close approach support through the US Commercial and Foreign Entities (CFE) program (commonly referred to as the Form 1 Process). Generally this monitoring system follows a two tier model. The initial detection is based on TLE. Once a potential threat is identified the operator relies on JSpOC to validate the conjunctions detected via the TLE. Although helpful, it is cumbersome to rely on the Form 1 Process as an operational tool because it requires advance notice, which is often impossible in emergency situations. In addition, conjunction events often require close cooperation and interactive communication. Today, the Form 1 Process relies primarily on email as a method of communication and does not guarantee the rapid turnaround necessary in most cases.

Some operators routinely exchange orbital data with other satellite operators whose satellites are operating in adjacent control boxes. The exchanged data usually consist of the latest orbital information, near term maneuver plans, frequency information and contact information for further discussion. There is no single approved way to represent the position of an object in space. As a result, operators generally use different formats for their orbital position data depending on the software they use for flight operations. In addition, there is no one agreed protocol for sharing information and so coordinating operators must be prepared to accommodate the practices of other operators. To do this, operators must maintain redundant file transfer protocols and tools to convert and reformat information so that it can be input into the owner/operator's software systems for computing close approaches. Separate tools are therefore necessary to exchange data between different operators and indeed some operators write their own software tools for monitoring and predicting the close approach of other spacecraft.

Other operators contract out the close approach monitoring for whole or part of their fleet to third parties, e.g., the MIT Lincoln Laboratory supports these activities for some commercial operators through the cooperative research and development agreement (CRDA) program. Because MIT has direct access to the observations from the US Space Surveillance Network, their conjunction monitoring is based on high precision SP quality data. However, the monitoring is restricted to non-active passive space objects. This restriction is due to difficulties in detecting past maneuvers and predicting future maneuvers of active satellites and thus invalidates longer term close approach predictions.

Over time, the magnitude of the efforts to maintain "space situational awareness" will grow quickly as the number of coordinating operators increases. Unfortunately, many operators are not able or willing to participate in close approach monitoring due to lack of resources or capabilities.

3. DATA CENTER PROPOSAL

In response to the shortcomings of the current TLE-based CFE program and the recognition that better inter-operator communication is desirable in and of itself, satellite operators have recently begun a broad dialogue on how to best ensure information sharing within the satellite communication industry. One proposal currently being discussed in the international operators' community is the creation of a "Data Center". As conceptualized, the Data Center would be an interactive repository for commercial satellite orbital, maneuver and frequency information. Satellite operators would routinely deposit their fleet information into the Data Center and retrieve information from other member operators when necessary. The Data Center would allow operators to augment existing Two Line Element (TLE) data with precision orbit data and maneuver plans from the operator's fleets. The Data Center would also:

- Perform data conversion and reformatting tasks allowing operators to share orbital element and/or ephemeris data received in different formats
- Standardize data quality and covariance calibration for those operators providing data
- Adopt common usage and definition of terminologies
- Develop common operational procedures for handling routine and emergency situations
- Exchange operator personnel contact information and protocols in advance of need
- Encourage participation in conjunction monitoring by providing resources and support to other operators

If the Data Center were to gain acceptance, it could perform additional functions, such as the close approach monitoring tasks currently being conducted

by the operators. In the early phase, US Government provided TLE data could be augmented by the more precise data available from the operators. This would improve the accuracy of the Center's conjunction monitoring and could provide a standardized way for operators to share information with the US Government and other governments. Two key goals of the Data Center are firstly, to seek access to the higher precision SP TLE data from the US Government and secondly, to gain access to third party data sources (such as optical tracking data) from different private and government agencies and international organizations to enable higher accuracy and more reliable conjunction analysis. To this end, two data sharing workshops attended by different satellite operators were conducted in 2008; one in Washington DC (February 2008) and one in Ottawa, Canada (Dec 2008) to promote this idea and lay the foundations for creating such an operational Data Center.

4. DATA CENTER PROTOTYPE

A prototype active Data Center was established to study the feasibility of such an approach following the workshop held in February 2008. Owner/operators including Intelsat, Inmarsat, Telesat, Echostar, SES, and others participated in this workshop. All of the operators present agreed on the need to simplify the data exchange process in order to minimize the risks to safety of flight and on the importance of creating a common Data Center. The operators agreed to work on a prototype Data Center as a proof of concept to improve coordination for conjunction monitoring. The Center for Space Standards and Innovation (CSSI) agreed to work with the operators to develop such a prototype. As a result, SOCRATES-GEO was developed to facilitate this process**.**

Once initiated, the prototype Data Center expanded quickly and today, 7 operators are regularly contributing data for over 115 satellites. The participating operators receive daily close approach alerts when the miss-distances and conjunction probabilities cross certain thresholds. There is also a daily neighborhood watch report issued showing the projected separations of satellites that are flying in adjacent control boxes. The participating operators provide their ephemeris data in the reference frames and time systems generated by their flight software and the Data Center performs the transformation and reformatting into a common reference frame for close approach analysis. This greatly reduces the burden on individual operators and thus encourages participation. A strict data policy has been put in place to ensure privacy of the data. The Data Center is not allowed to redistribute any of the data received from owner/operators without the approval of the owners of the data. While there is still significant work left to refine the data processing, the initial results from the Data Center are very promising. Another owner/operators workshop is planned to discuss both the technical issues and the formal organizational structure of the future operational Data Center.

5. SUMMARY

In summary, the principal goal of the Data Center is to promote safety in space operations by encouraging coordination and communication among commercial operators. The Data Center could also serve as a means to facilitate communication between commercial operators and governments. Details on the implementation of the Data Center, services to be provided, usage policies, structure of the organization and by-laws have yet to be determined and would require agreements with the member operators at the creation the organization. The development of a Data Center could provide new visibility and awareness of the geostationary orbit allowing all satellites to be flown in a safer manner and reducing the likelihood of satellite collisions in space.

Within the next decade, many more countries will gain the ability to exploit space for commercial, scientific and governmental purposes. It is essential that the world's governments provide leadership on space management issues today in order to protect the space activities of tomorrow. Bad decisions and short-term thinking will create problems that will last for generations. Wise decisions and the careful nurturing of our precious space resource will ensure that the tremendous benefits from the peaceful use and exploration of outer space are enjoyed by those who follow in our footsteps in the decades to come.