Commercial efforts to manage the space environment

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The commercial satellite industry has billions of dollars of assets in space and relies on this unique environment for the development and growth of its business. As a result, safety and the sustainment of the space environment are two of the satellite industry's highest priorities. This paper provides an overview of industry efforts to coordinate space traffic control practices and to manage the growing problem of satellite radio frequency interference.

Background

The commercial satellite industry has been providing essential space 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 programmes 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 will require a strong partnership between government and industry and the careful, experience-based expansion of international law and diplomacy.

The satellite industry has never taken for granted the remarkable environment in which it works. Industry has invested heavily in technology and sought out the best and brightest minds to allow the full but sustainable exploitation of the space environment. Where problems have arisen, such as space debris or electronic interference, industry has taken the initiative to deploy new technologies and adopt new practices to minimize negative consequences.

Space traffic control

Since January 2007, Intelsat has relied on an in-house close-approach monitoring system to ensure the safety of its fleet of over 50 satellites. This system relies on information from the United States Joint Space Operations Center (JSpOC) to analyse potential close approaches between satellites. The basic information (the so-called two-line element or TLE data) used in this process is available through the US government's Space-Track.org web site. Space Track obtains satellite orbital data from the US Department of Defense and posts TLEs in near real time. It provides this data upon request to registered users. Intelsat routinely screens its satellites using the TLE data and, during special activities such as satellite relocations and transfer orbit missions, we also exchange data with other commercial

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and government operators whose satellites are near or adjacent to our satellites. The information exchanged usually consists of the latest location information, near-term manoeuvre plans, and frequency and contact information for further discussion.

There are drawbacks to the current close-approach monitoring process. In addition to a lack of agreed standards for TLE modelling, TLE data do not have the required accuracy for credible collision detection. An operator that is forced to rely on TLE data must increase the calculated collision margin to avoid potential close approaches. This wastes fuel and shortens the life of satellites and, in some cases, can introduce uncertainties that make space operations less safe. In most cases, threats identified using the basic TLE data are downgraded after coordination with other operators or further evaluation with more precise orbital data.

In addition to the inaccuracies of TLE data, they also lack reliable information on future satellite manoeuvres. This limits the usefulness of the TLE for longer-term predictions, since manoeuvre information is necessary to predict properly the orbital location of active satellites. Today, operators relying on chemical propulsion systems will manoeuvre about once every two weeks to maintain their orbital position. Accurately predicting the orbital location of a satellite will become more difficult as more satellites employ ionic propulsion systems and are, essentially, constantly manoeuvring.

The problem is rendered more complex by the fact that there is no single standard for representing the position of an object in space. Operators characterize the orbital position of their satellites differently depending on the software they use for flight operations. In addition, there is no one agreed protocol for sharing information, and coordinating operators must be prepared to accommodate the practices of other operators. To do this, separate tools are necessary to exchange data with each operator: operators must maintain redundant file transfer protocols and tools to convert and reformat information so that it is consistent with other owners' or operators' software systems for computing close approaches. Some operators write their own software tools for monitoring and predicting the close approach of other spacecraft, while others contract with third parties for this service. The magnitude of the effort to maintain space situational awareness grows quickly as the number of coordinating operators increases. However, operators are not in fact under any obligation to be able to track their satellites beyond the requirements of the relevant national or regional licensing authority, and many are not able or willing to participate in close-approach monitoring at all, due to lack of resources or capabilities.

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Because of the relatively imprecise nature of the TLE data, the US Air Force established the "Interim CFE Data/Analysis Redistribution Approval Process" (commonly referred to as the Form 1 Process) for granting operators access to information that goes beyond the basic TLEs. Through the Form 1 Process, operators can request additional information (the special perturbation, or SP, data) on specific close-approach situations (although this is less useful for low Earth orbit satellites since the assessment of miss probability changes rapidly). 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.

Data Center proposal

In response to the shortcomings of the current TLE-based CFE programme and the recognition that better inter-operator communication is desirable in and of itself, a number of commercial satellite operators have recently begun a broad dialogue on how best to ensure information-sharing within the satellite communication industry. One proposal currently being discussed in the international

operators' community is the Data Center. As conceptualized, the Data Center would be an interactive repository for commercial satellite orbit, manoeuvre and frequency information. Satellite operators would routinely deposit their fleet information with the Data Center and retrieve information from other member operators when necessary. The Data Center would allow operators to augment existing TLE data with precision orbit data and manoeuvre 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 in different formats;
- adopt common usage and definition of terminologies;
- develop common operational protocols for handling routine and emergency situations; and
- exchange operator personnel contact information and protocols in advance of need.

As the Data Center gains acceptance, it could perform additional functions, such as the close-approach monitoring tasks currently being conducted by the operators. In this phase, US government-provided TLE data could be augmented by the more precise data available from operators. This would improve the accuracy of the Center's conjunction monitoring and could provide a standardized way for operators to share information with governments. In the early stages, information on non-operational space objects would still need to be supplemented by TLE data from the Air Force CFE programme or other government programmes. US or other government support would still be required when precise information is needed to conduct avoidance manoeuvre planning.

A prototype active Data Center was established to study the feasibility of such an approach following workshops of the major commercial owners/operators held in February 2008 in Washington, DC and December 2008 in Ottawa. A majority of the operators present agreed on the need to simplify the data exchange process to minimize risk for safety of flight and on the importance of creating a common Data Center. The operators agreed to work on the prototype Data Center as a proof-of-concept to improve coordination for conjunction monitoring. This prototype is a virtual centre, currently funded by the Center for Space Standards and Innovation (a research arm of Analytical Graphics, Inc.).

The prototype Data Center expanded quickly and today seven operators are participating and regularly contributing data from over 120 satellites in geostationary orbit. The participating operators receive daily close-approach alerts when the miss distances and conjunction probabilities fall below certain thresholds and a daily neighbourhood watch report showing the projected separations of satellites that are flying in an adjacent control box (geostationary satellites are generally required to remain in a "box" in space). The participating operators provide their ephemeris data in the reference frames and time systems generated in their flight software and the Data Center performs the transformation and reformatting to a common frame for close-approach analysis. This greatly simplifies efforts and reduces the burden on individual operators, thus encouraging participation. Given that the Data Center supports the exchange of satellite information, much of which is proprietary, a strict policy has been put in place to ensure privacy of the data. The Data Center is not allowed to redistribute the data received from the owners/operators to non-members without the approval of the owners of the data. While there is significant work remaining to refine the process, the initial results from the Data Center prototype are very promising.

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 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 ultimately require agreement among the member operators.

The development of a Data Center could provide new visibility and awareness of the geostationary orbit, allow all satellites to be flown in a safer manner and reduce the likelihood of an accidental international incident in space.

The Satellite Operators' Radio Frequency Interference Initiative

In addition to the Data Center, a number of satellite operators, including Arabsat, Asiasat, Eutelsat, Hispasat, Inmarsat, Intelsat, JSAT, SatMex, SES and Telesat, are already working together on a project called The Satellite Operators' Radio Frequency Interference (RFI) Initiative. This initiative is intended to respond to the concerns expressed by satellite customers regarding the increase in incidents of satellite radio frequency interference and the impact that these incidents have had on the quality of commercial satellite services.

Radio frequency interference is an electromagnetic disturbance that interrupts, obstructs or degrades the performance of electronic equipment. Each year, there are thousands of reported incidents of satellite radio frequency interference, which can originate with the satellite or with the Earth-based terminal, and be caused by faults in equipment, the proximity of equipment (both in space and on Earth), and problems with the transfer mechanism of the signal. Over the years, satellite operators have developed informal agreements and deployed new technologies to attempt to address interference. However, these informal agreements have not kept pace with the growth of the problem: the combination of more satellites in the sky and more terminals on the ground is raising new operational challenges.

As a result of the growth of the commercial industry, and the corresponding increase in demand for new orbital locations, global regulators have had to decrease the physical separation between satellites. This has increased the problem of adjacent satellite interference. As the number of satellites has increased, there has been a corresponding proliferation of ground terminals. And as the terminal industry has grown, new suppliers have entered the market, and it has been difficult to monitor the quality of some products. Furthermore, in today's marketplace there is a demand for smaller and mobile terminals. These classes of terminal require increased uplink power, which in turn increases the likelihood of interference. Finally, rapid industry growth has made access to training more difficult for some new operators. Industry records clearly indicate that "operator error" remains one of the most significant causes of satellite interference, but there are no regulated, internationally consistent education requirements for operators.

Concern over these issues motivated a number of satellite operators to launch the Satellite Interference Initiative (SII). This initiative is focused on accomplishing three major objectives.

- Support standardized training/certification: training is an essential element of good satellite operations. With the expansion of the industry and the increase in competition, the industry's commitment to training its antenna installers and uplinkers has wavered. The initiative is in its early stages, and currently dialogue is limited to the like-minded operators that are working together on SII. Participating operators seek to gain support for standardized training and, where appropriate, certification programmes to ensure compliance with industry best practices.
- Endorse "carrier identification" technology for terminals: carrier identification (ID) technology would help to identify malfunctioning or poorly maintained equipment by embedding information such as location, contact details and equipment data within the satellite signal. For the carrier ID initiative to be successful, antenna manufacturers would have to include the technology as a standard feature in their equipment. As part of the

Satellite Interference Initiative, satellite operators will be contacting major manufacturers to try to build a consensus on the inclusion of this technology.

- Building data sharing among satellite operators: as with the Data Center initiative for position location, the Satellite Interference Initiative seeks to formalize, standardize and, where possible, automate the process of sharing information about interference events. To identify the source of an interference event, operators need to know a number of elements such as precise satellite location and configuration information and known uplink sources (often referred to as reference emitters). These data could be included in a radio frequency interference database and routinely shared as part of an interference alert network.

Within the next decade, many more countries will gain the ability to exploit space for commercial, scientific and governmental purposes. Commercial satellite operators have taken the lead on building tools for space management, while it has been more difficult for governments to take concerted action. In the future, perhaps there will be commercial and governmental space management systems, both sharing information to ensure a safe and sustainable space environment. Programmes such as the space traffic Data Center and the Satellite Interference Initiative will become essential tools for managing our increasingly complex world. It is essential that industry and government work together to 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 persist 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.