# Technical presentation

# Given at the United Nations Committee on the Peaceful Uses of Outer Space

# Scientific and Technical Subcommittee

## February 15th, 2011

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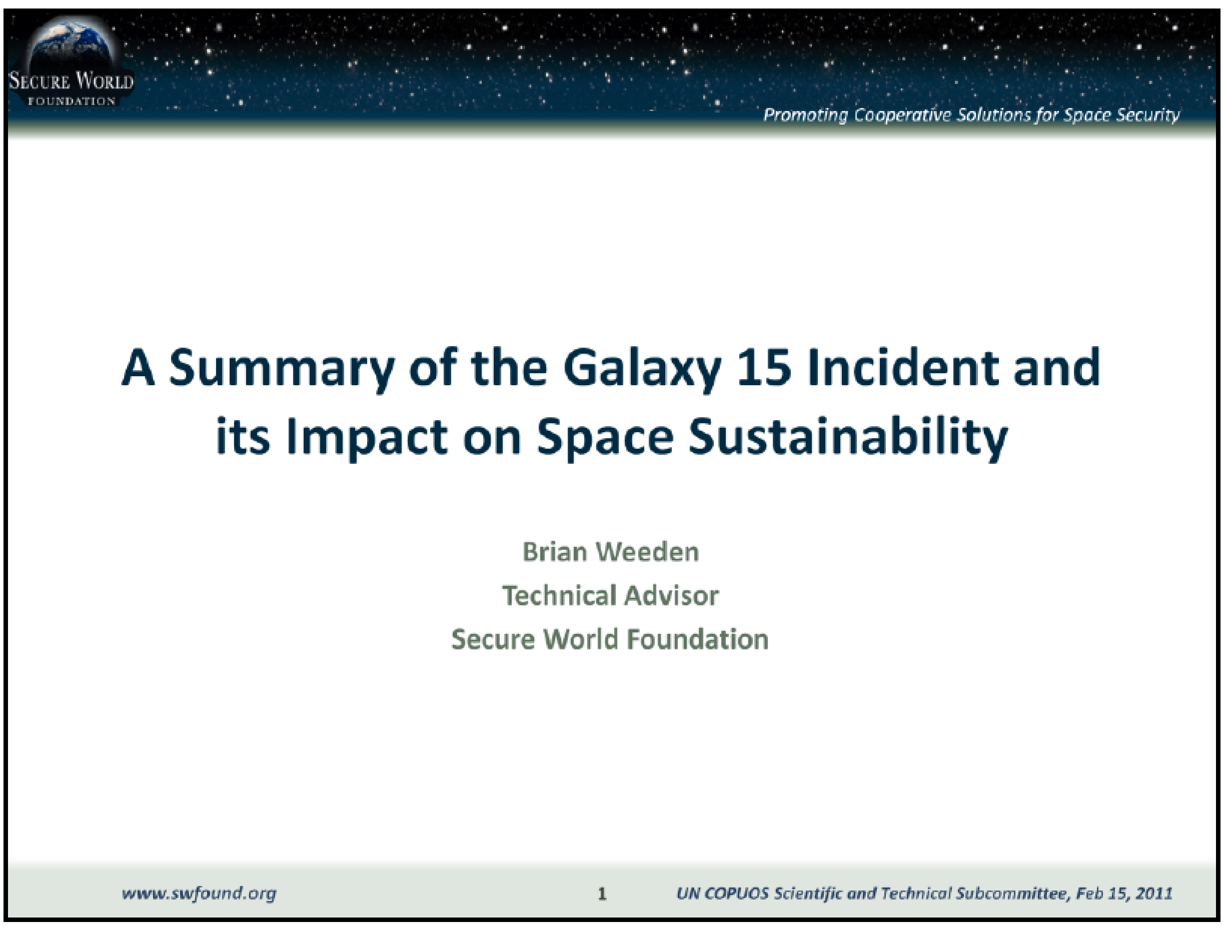
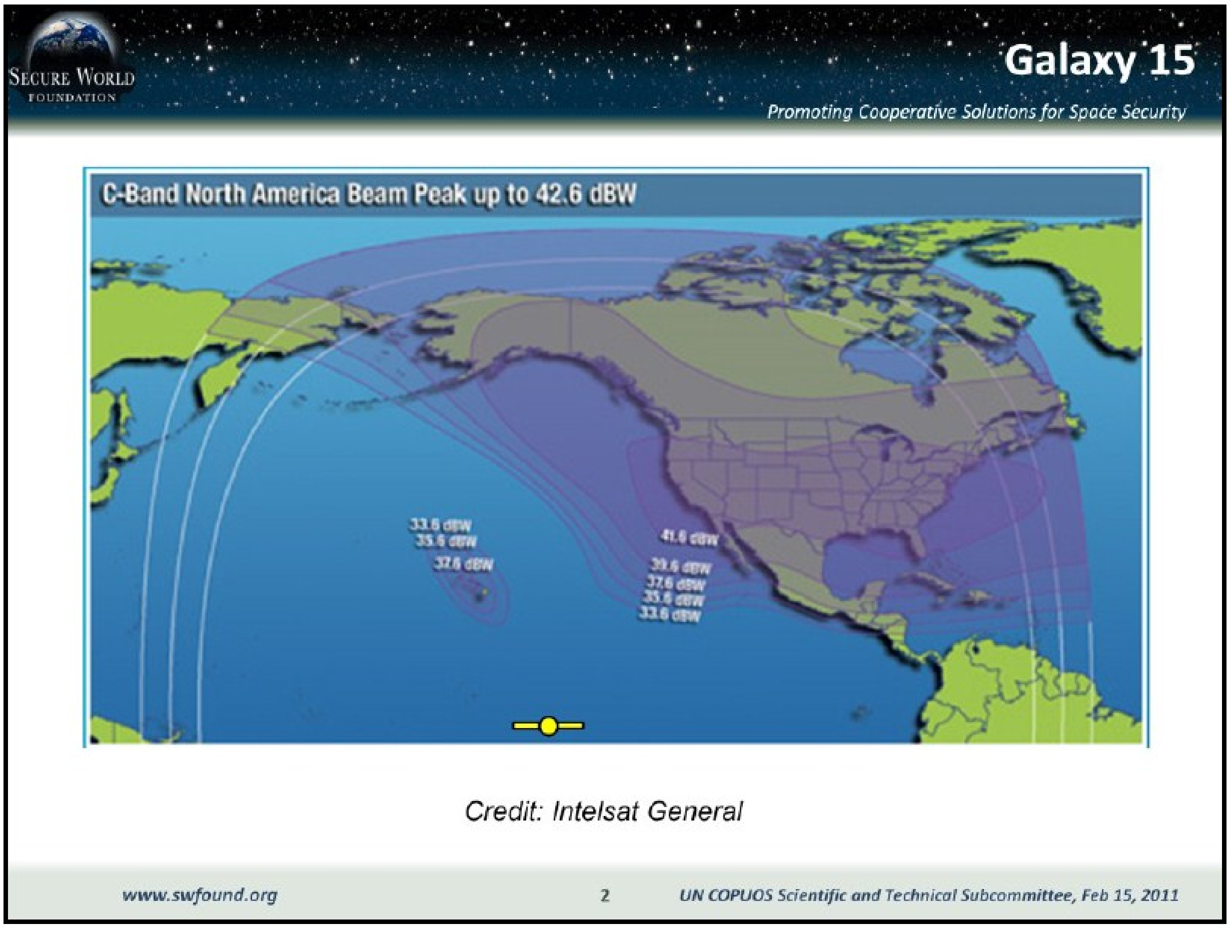
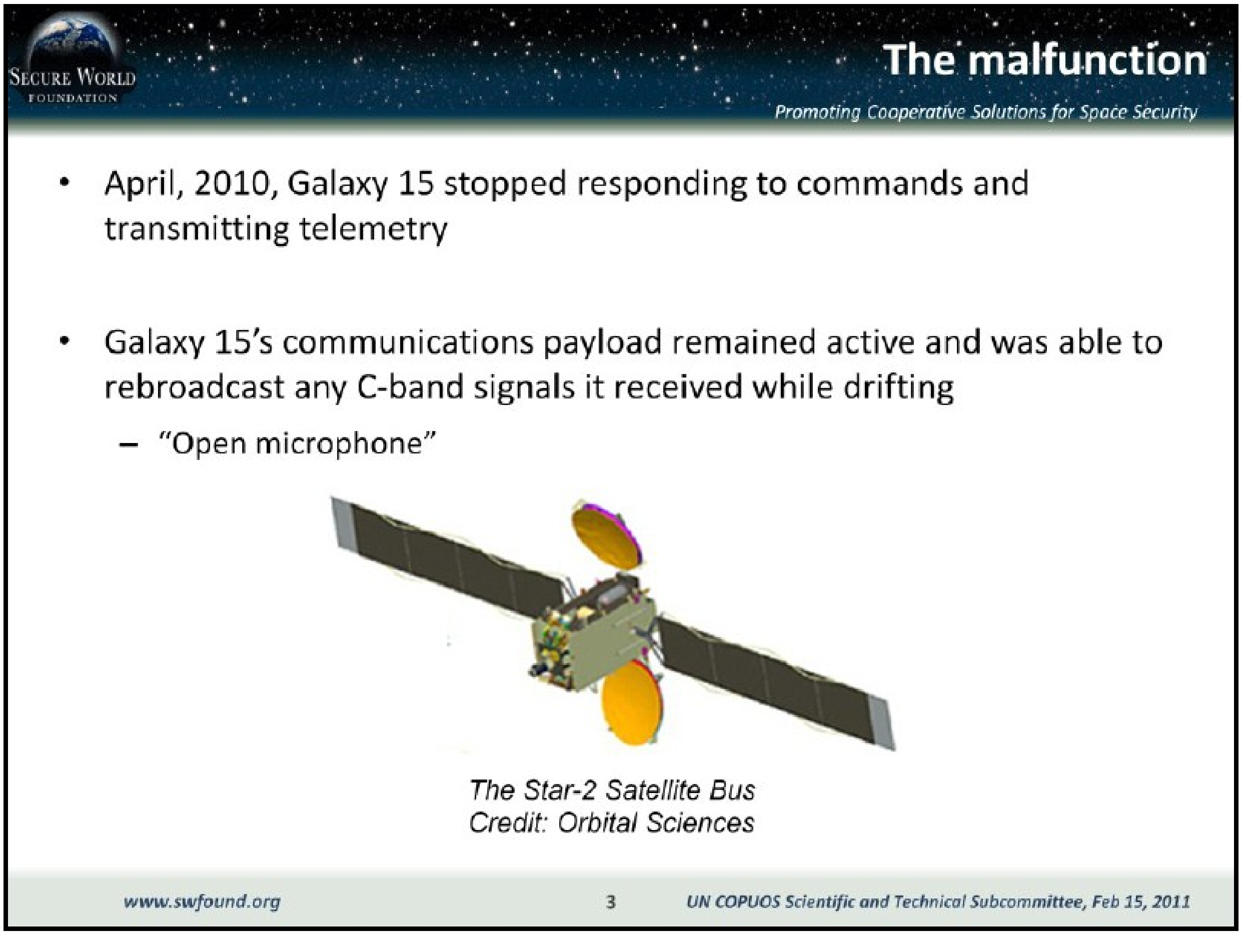
**Secure World Foundation**



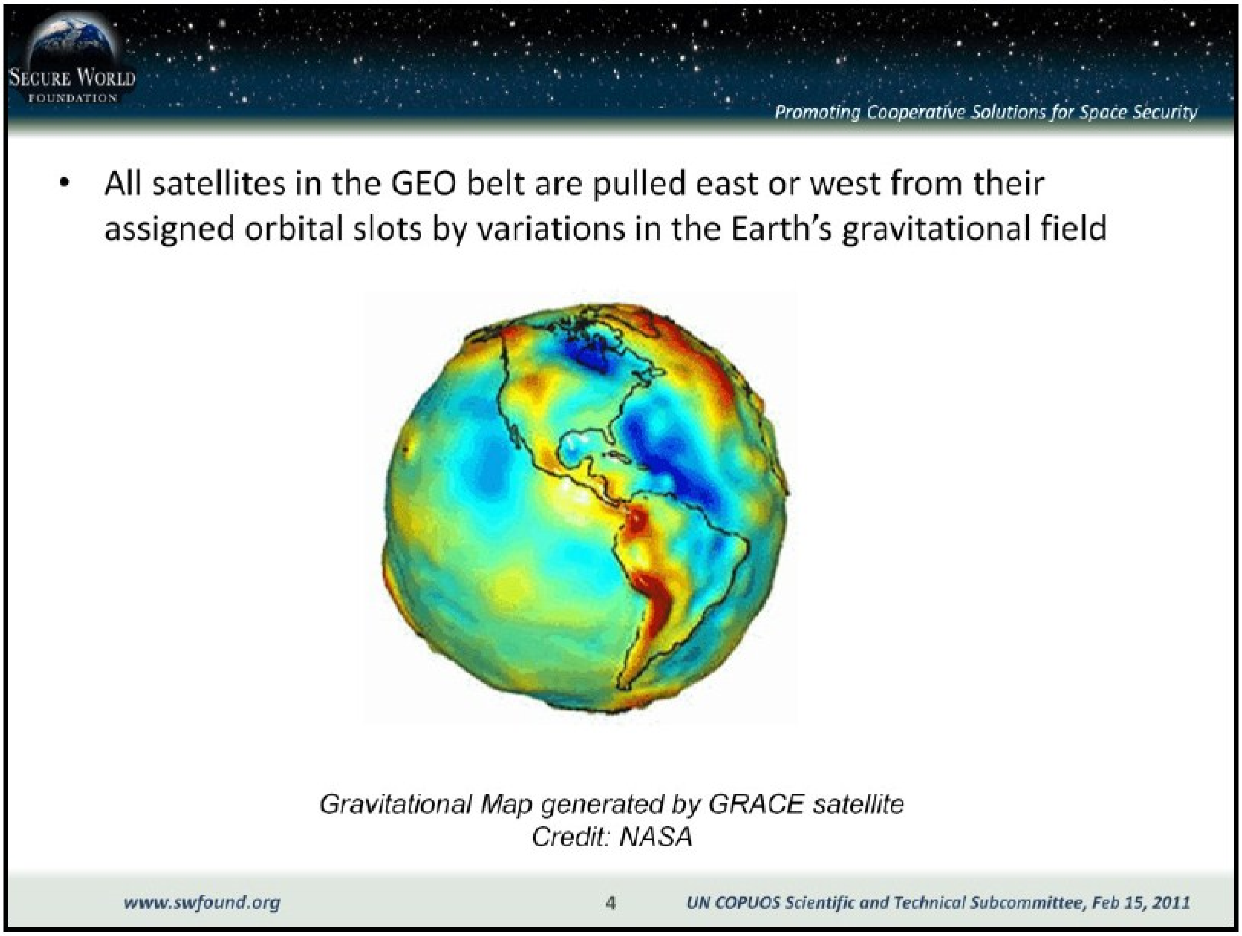
Thank you Mr. Chairman.  Distinguished delegates, it is my privilege to have the opportunity to speak to you today concerning a significant event from 2010 that touches on several of the agenda items being discussed by this esteemed Subcommittee.




In early April of 2010, one of the fifty geostationary satellites owned and operated by the commercial company Intelsat General experienced a malfunction in orbit.  At the time, the satellite, Galaxy 15, was located in its assigned orbital slot of 133 W longitude along the Equator, east of Hawaii.




The malfunction was unusual in that it rendered the satellite unresponsive to commands from controllers on the ground while leaving its communications payload operational, with the ability to still retransmit C-Band signals that it received on its uplink transponders. It became in essence an "open microphone" in orbit.



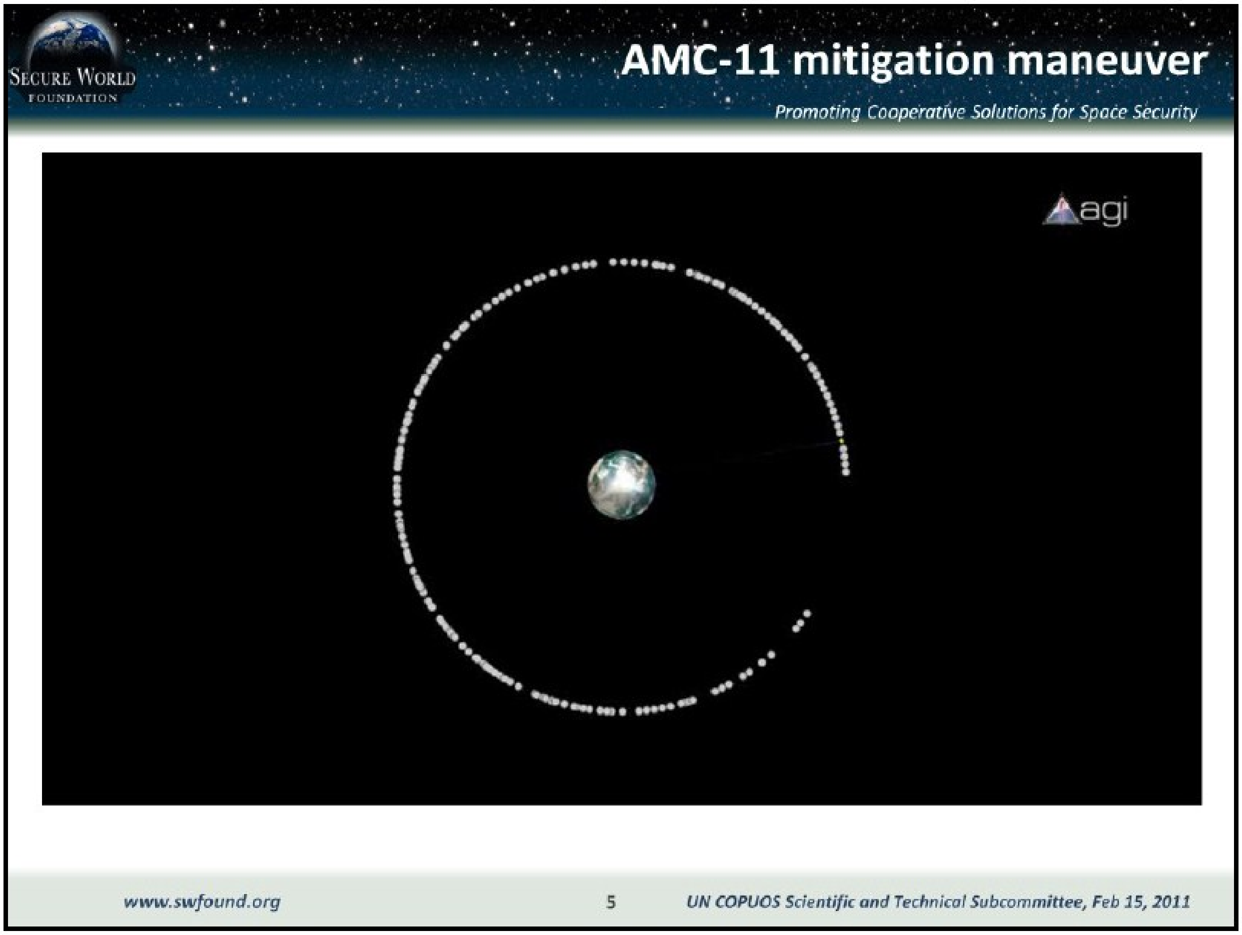

The loss of command and control over the satellite meant that ground operators could no longer perform the periodic station keeping maneuvers necessary to keep the satellite within its assigned orbital box. This image shows the variations in the Earth's gravitational field which cause orbital perturbations on objects in orbit. These perturbations caused Galaxy 15 to start slowly drifting eastward through the geostationary belt, and past the other active satellites located over the Americas. While there was a potential collision risk with these other satellites, the large size of Galaxy 15 and excellent space situational awareness in this region enabled Galaxy 15 to be easily tracked and warnings to be provided to other satellite operators. This greatly mitigated the physical interference issue.

The real concern from this situation was one of radio frequency interference. As Galaxy 15 drifted past other operational satellites, its still functional communications payload could pick up C-Band transmissions intended for these other satellites and retransmit them, potentially causing multi-path interference and service disruption.

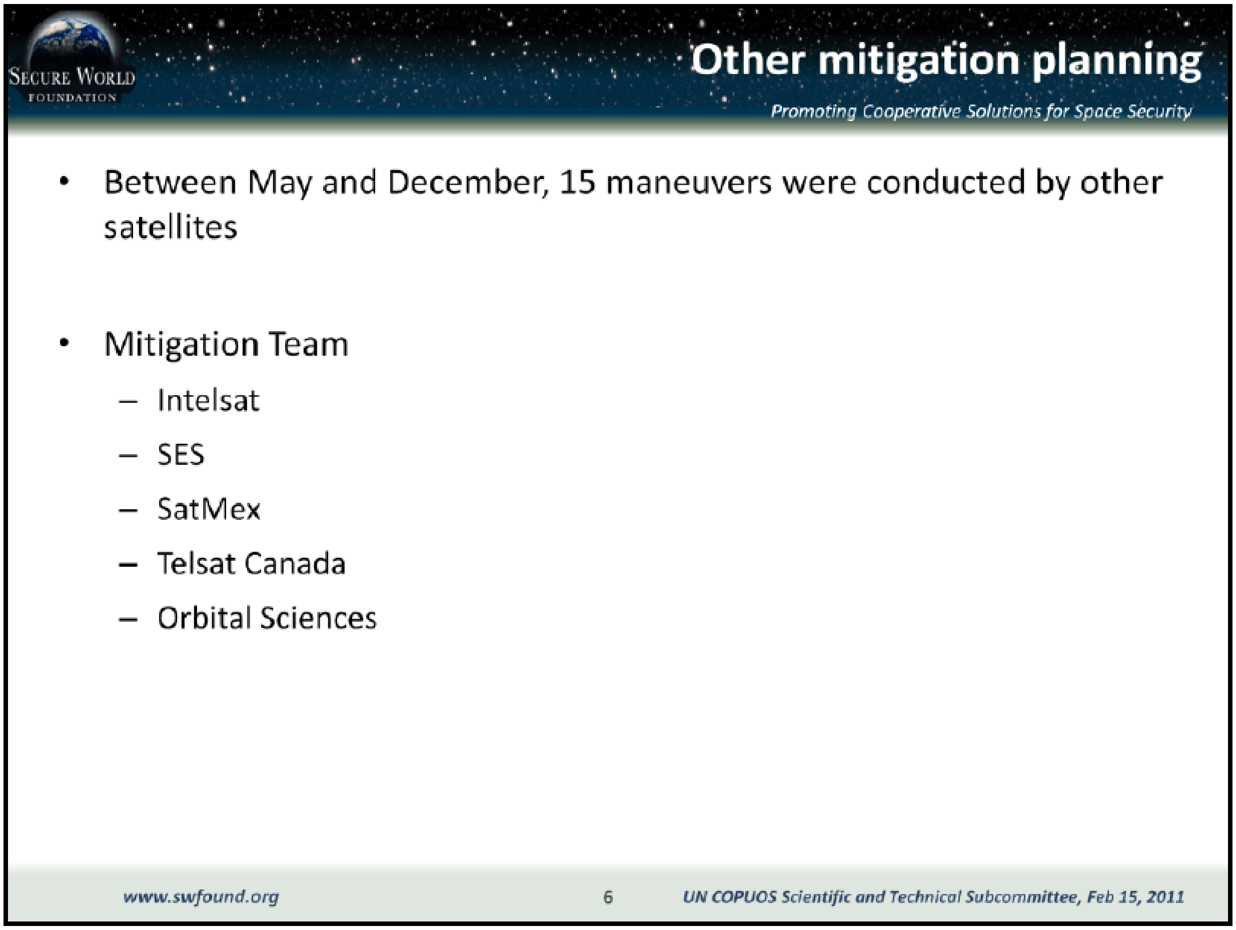
Galaxy 15's communication payload was powered by its solar panels, and as long as it could keep its panels pointed at the Sun and its transponders pointed at the Earth, known as "Earth lock", it presented a radio frequency interference threat. Eventually, without periodic commands from the ground, Galaxy 15's momentum wheels would saturate and it would be unable to maintain its attitude. Shortly thereafter, it should lose electrical power. However, the many unknowns in this situation made it extremely difficult to predict when the loss of power would happen.

It should be noted at this point that Intelsat put forward a herculean effort to deal with the Galaxy 15 situation. During the first few weeks after the initial malfunction, Intelsat sent between 100,000 and 200,000 commands to Galaxy 15 in an attempt to regain control. Intelsat even tried transmitting exceptionally powerful broadcasts, in an attempt to overload Galaxy 15's communications payload. They were willing to cause irreparable damage to their own asset, which might still have been recovered, in the hope that it would mean fewer problems for others. Intelsat ceased these efforts to regain control of or turn off Galaxy 15 in May, but only because it was too close to another satellite to safely continue the transmissions.

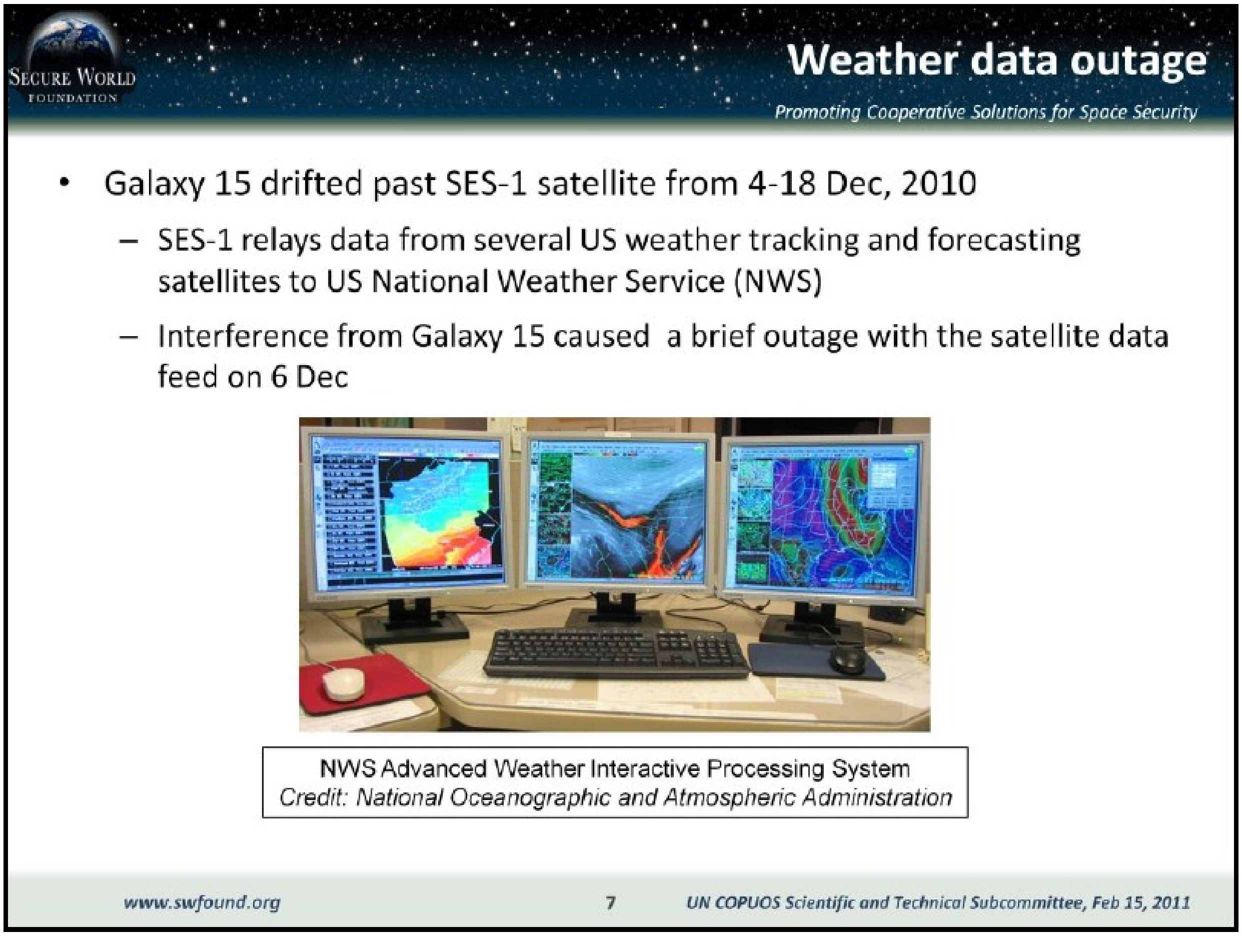
From the end of May to early June, Galaxy 15 drifted through the orbital box of the first operational satellite in its path, AMC-11, which is owned and operated by SES World Skies. Intelsat management and engineers worked closely with their counterparts at SES to develop a complex mitigation plan. As many customers as possible would be transferred from AMC-11 to other SES satellites. A maneuver scheme was also developed to minimize the chance of interference as Galaxy 15 passed in front of AMC-11. And those customers still using AMC-11 were directed to reduce their uplink transmissions to as low as five watts per channel to minimize any multi-path interference.



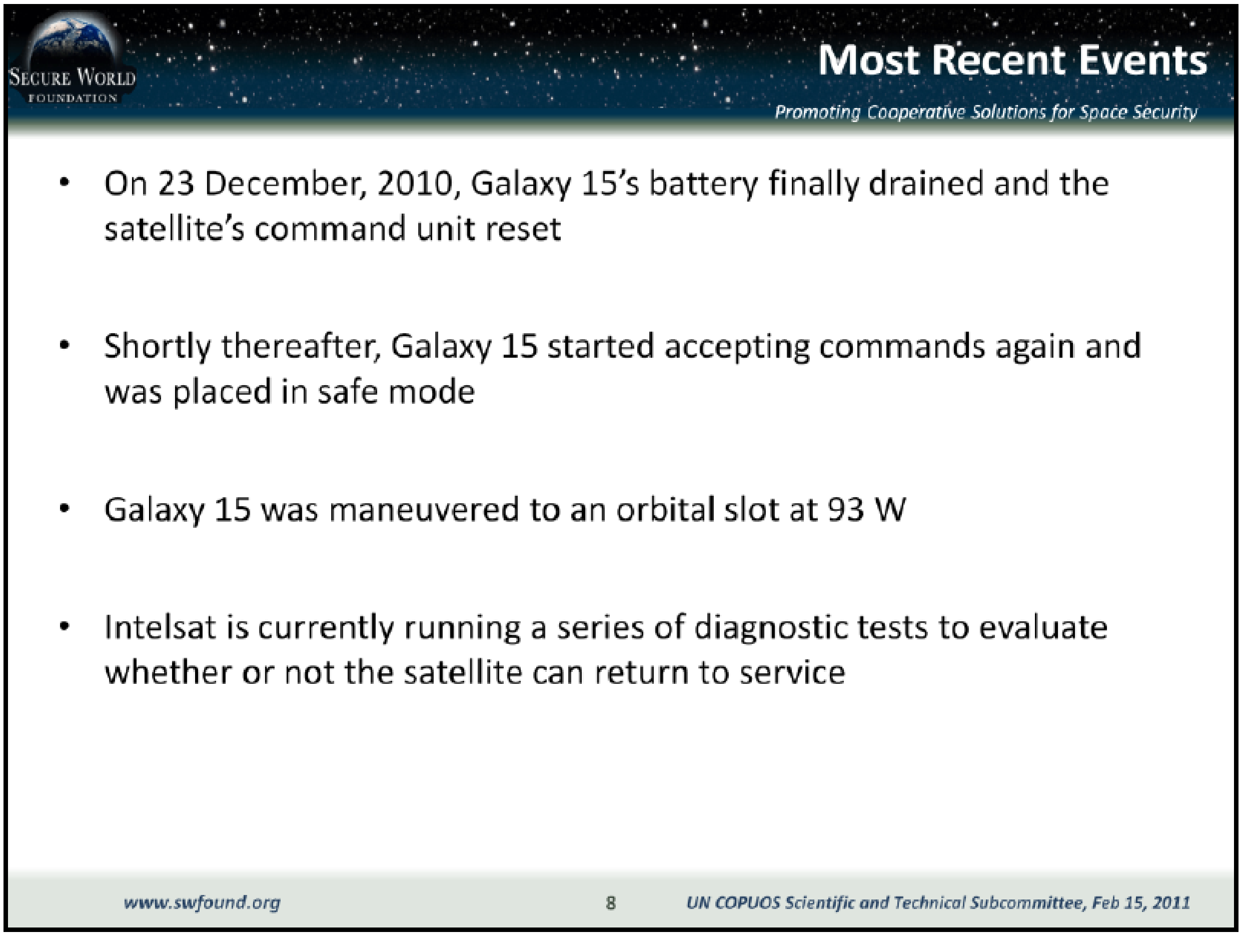

This video shows a computer simulation of the maneuver scheme. First, AMC-11 was maneuvered to the far eastern edge of its box as Galaxy 15 approached from the west. A second SES satellite, SES-1, was brought in from the west to act as a backup for AMC-11 if needed. During the middle of the night, while traffic was at a minimum, AMC-11 was quickly maneuvered around Galaxy 15 to the eastern edge of its box, and then slowly drifted back to the middle as Galaxy 15 exited the area. This plan worked, and there was no apparent interference or outage.



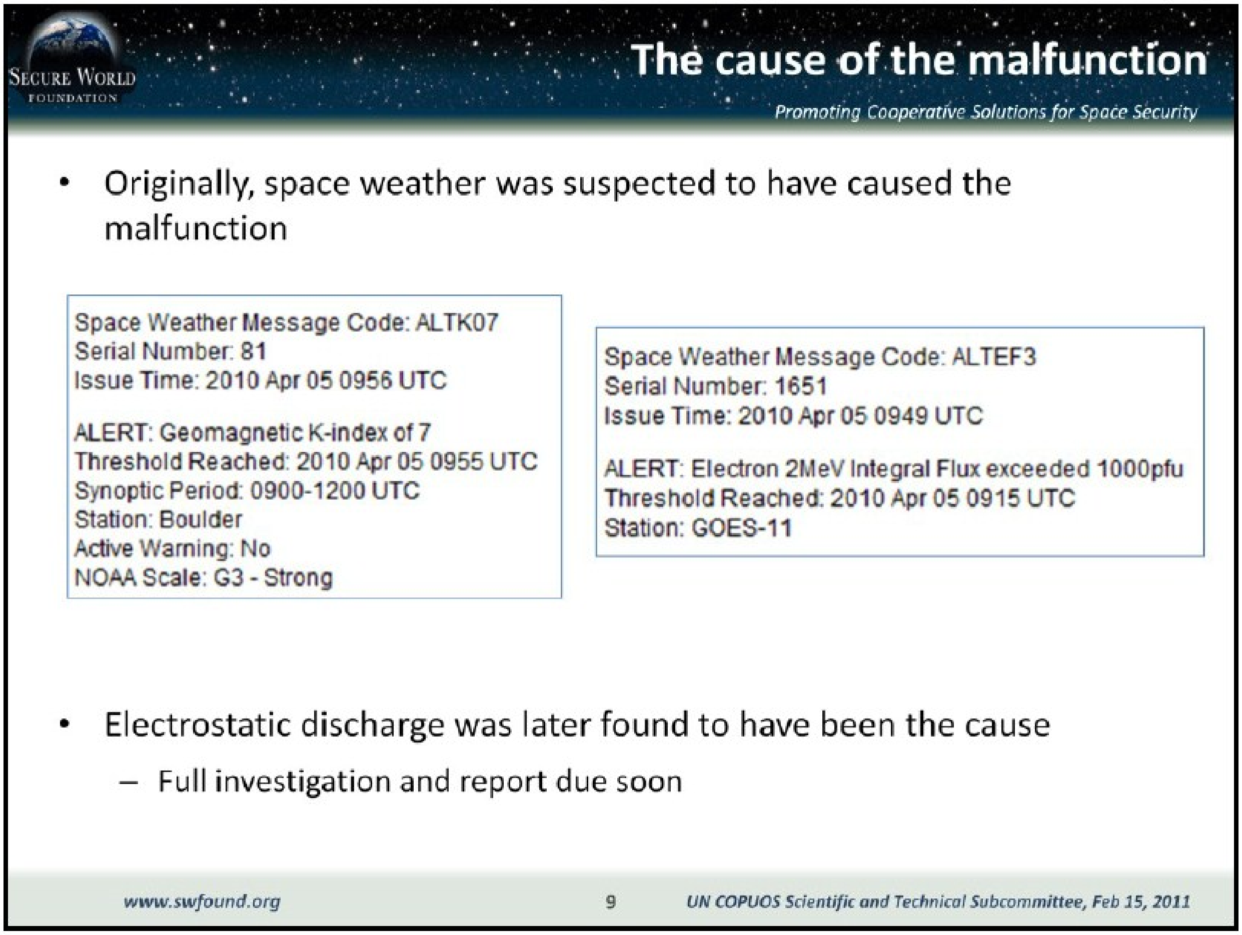

Over the next several months, Galaxy 15 would drift past several other operational satellites. In each case, Intelsat worked with other satellite operators to provide the most accurate information possible and in some cases to help develop similarly complex mitigation plans. The mitigation team included participants from Intelsat, SES, SatMex, Telsat Canada, and Orbital Sciences. In total, fifteen maneuvers were conducted to mitigate physical or radio frequency interference from Galaxy 15. Meanwhile, Intelsat continued its efforts to try and regain control of Galaxy 15 or render it harmless. It also worked with the satellite manufacturer to develop a software patch to prevent similar situations from happening to future Intelsat satellites.



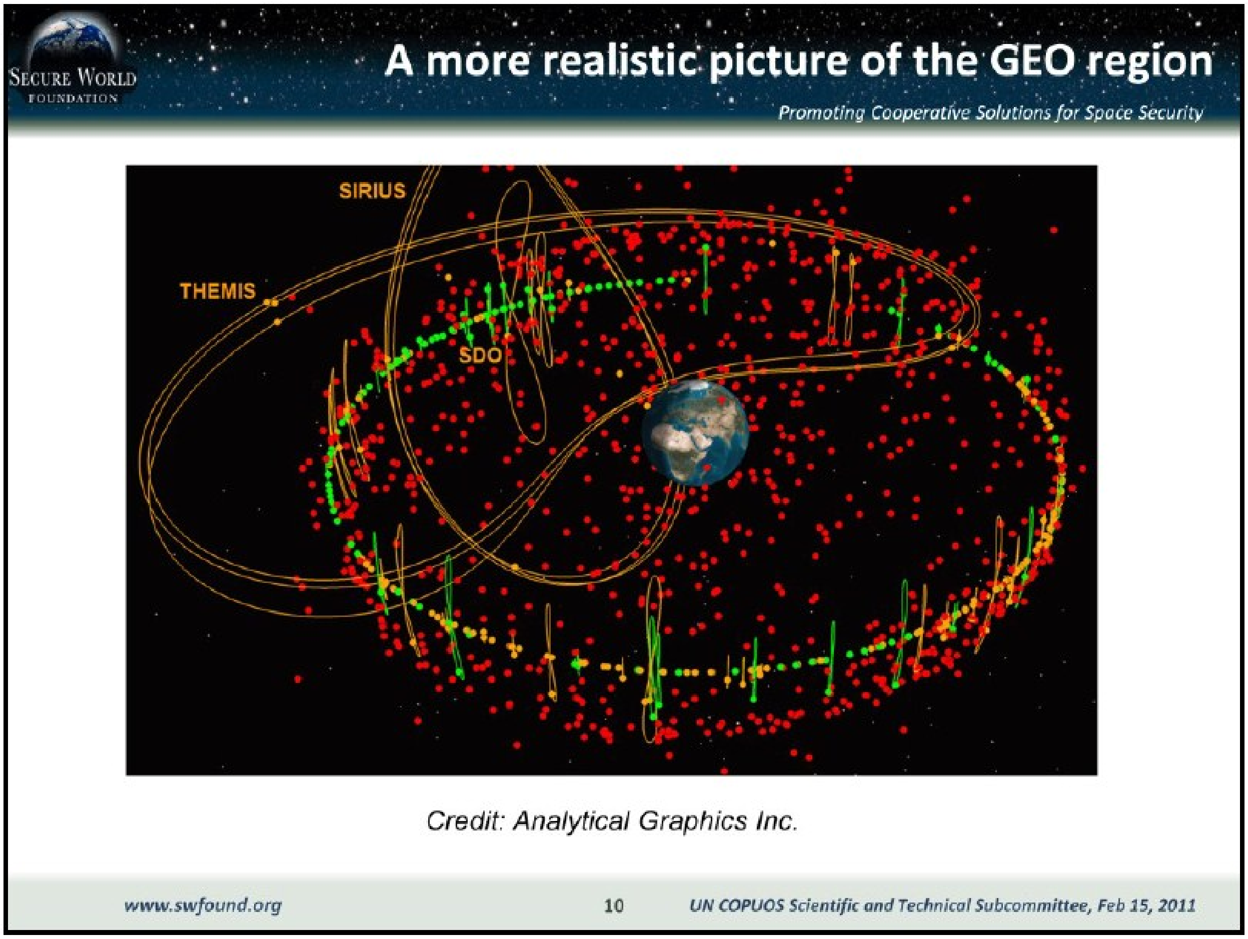

The only known radio frequency interference incident occurred in early December, as Galaxy 15 drifted past a satellite used to relay information collected by weather satellites to the U. S. National Oceanographic and Atmospheric Administration's ground processing stations, causing a minor service interruption.



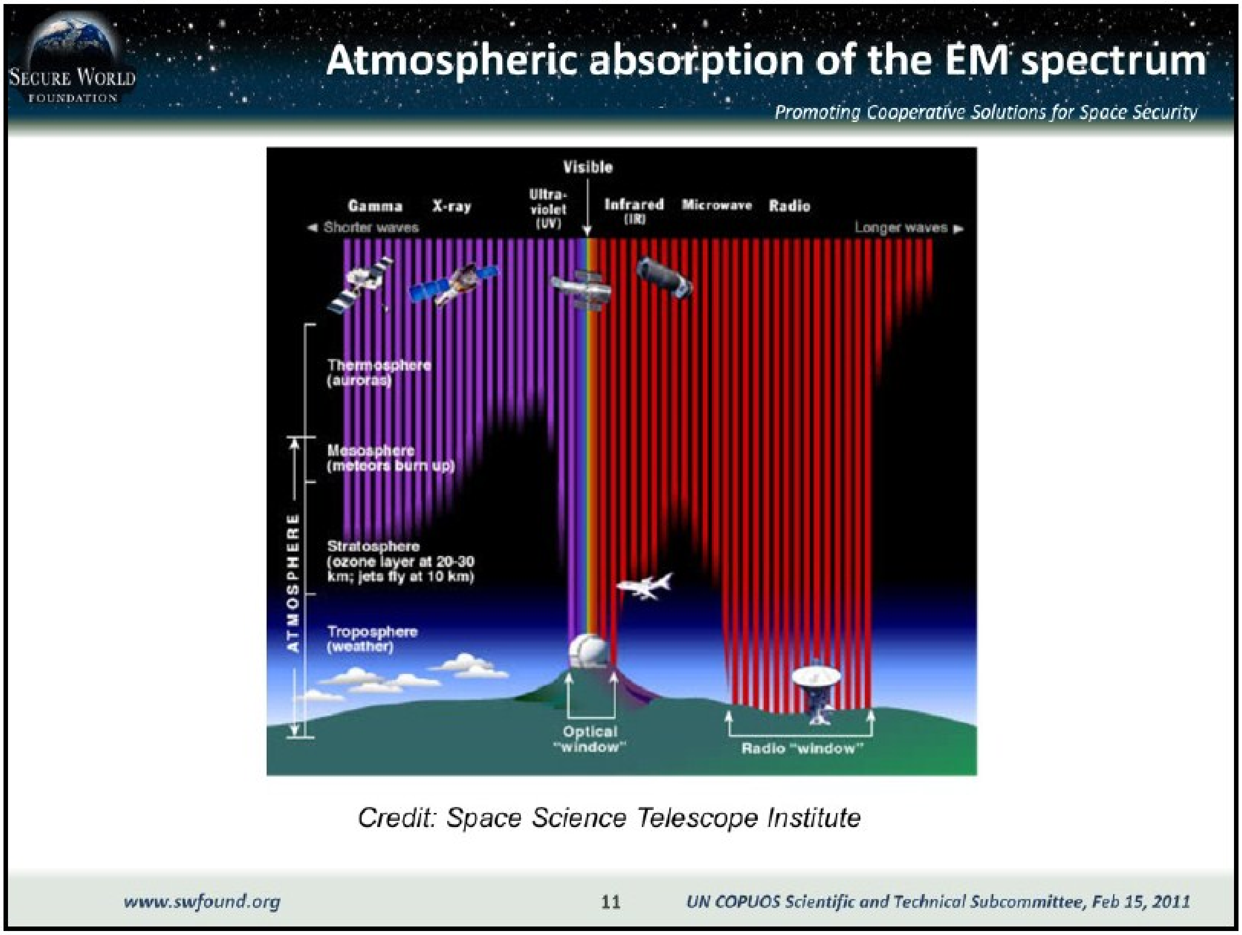

Thankfully, this story has a happy ending. In late December, just before Christmas, Galaxy 15 finally lost Earth lock and its batteries fully drained. This caused the satellite to perform a software restart, and restored its ability to receive commands from the ground. Intelsat resumed control, placed the communications payload in safe mode, and maneuvered Galaxy 15 to an orbital slot at 93 W for a full systems checkout. As of today, it appears that the satellite will be able to return to its original duties.



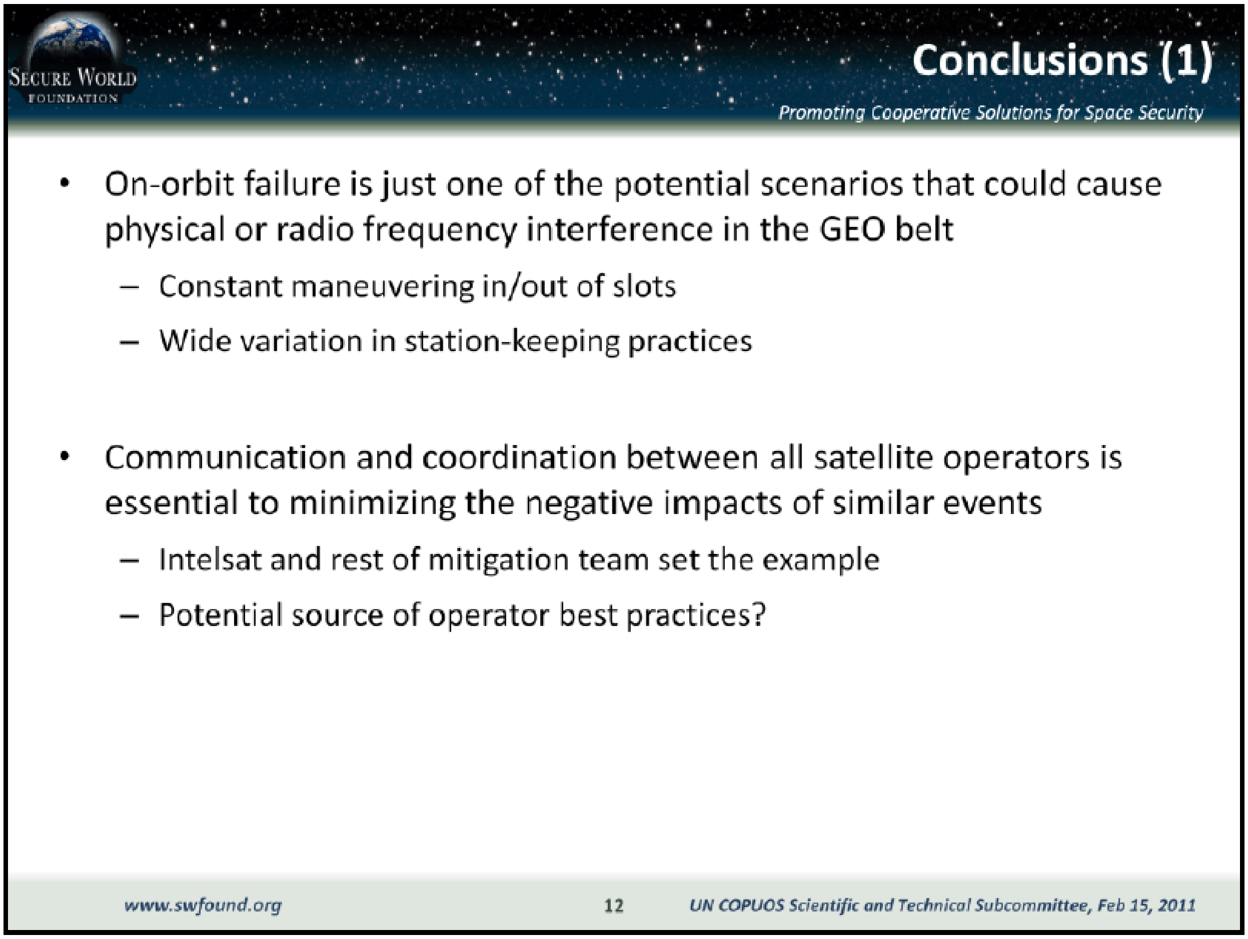

It should also be noted that at the time the malfunction occurred in April, it was believed that space weather could have played a role. On the day of the failure, the U.S. Government's Space Weather Prediction Center had released a space weather advisory bulletin detailing significant solar activity. However, after recovering the spacecraft, Intelsat announced that a failure review board had concluded that the malfunction was caused by an electrostatic discharge event, and that the solar activity did not play any role.




The events surrounding Galaxy 15 touch on several issues of importance to this Subcommittee. The long-term sustainability of outer space is crucial to humanity's ability to continue to derive socioeconomic benefits from in the future. The geostationary belt is a critical region of Earth orbit, and is actually a much more complex environment than the simple ring of satellites that is sometimes shown. This image shows the approximately four hundred operational satellites in the region in green and yellow, and approximately eight hundred currently tracked debris objects in red. Another one to two thousand debris objects are known to exist but are not currently tracked on a routine basis. And although a collision in the geostationary belt is unlikely, any collision or explosion in GEO could have much more severe, long-lasting consequences than a similar event in low Earth orbit, such as the Iridium-Cosmos collision in 2009.

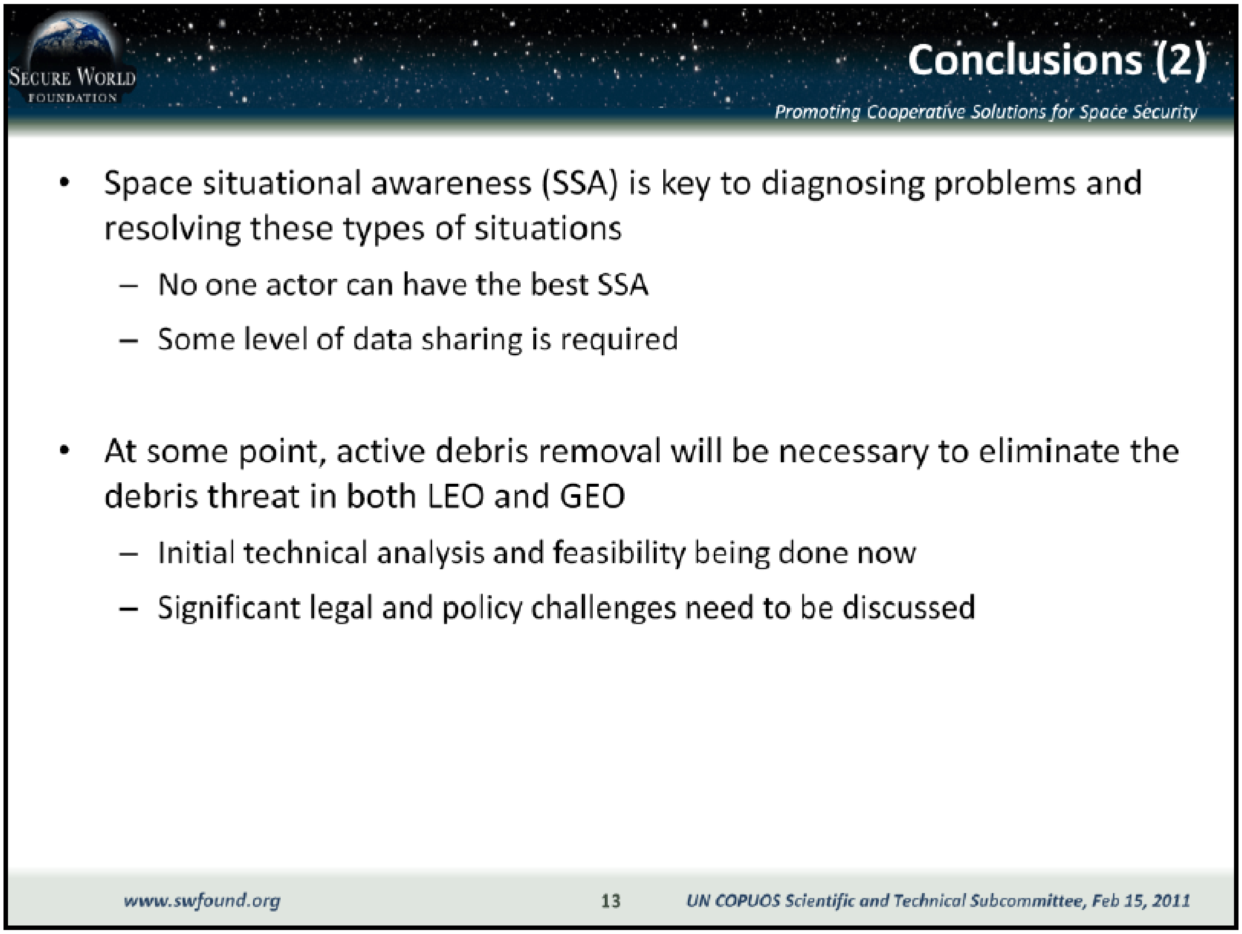



However, as serious as a physical interference could be, it is far more likely, that radio frequency interference events will occur again. This is partly the fault of physics. There is only one electromagnetic spectrum, and within that spectrum only two narrow regions which are suitable for communicating between space and the ground, the radio window and the optical window, as shown in this diagram. Until laser communication technology becomes more mature, all communication to and from satellites must occur within the radio portion of the spectrum and the realities of engineering and technology mean many satellites operate on the same or similar frequencies.




Although the situation that left Galaxy 15 adrift with a functional payload was unusual, there are other situations which could cause similar radio frequency hazards. Satellites in the geostationary belt are constantly maneuvering as new ones are launched into space, old ones are retired to the graveyard orbits, and satellites are moved from one operational slot to another. Thus, the issues involving potential radio frequency interference are just as important as the issues of physical interference.

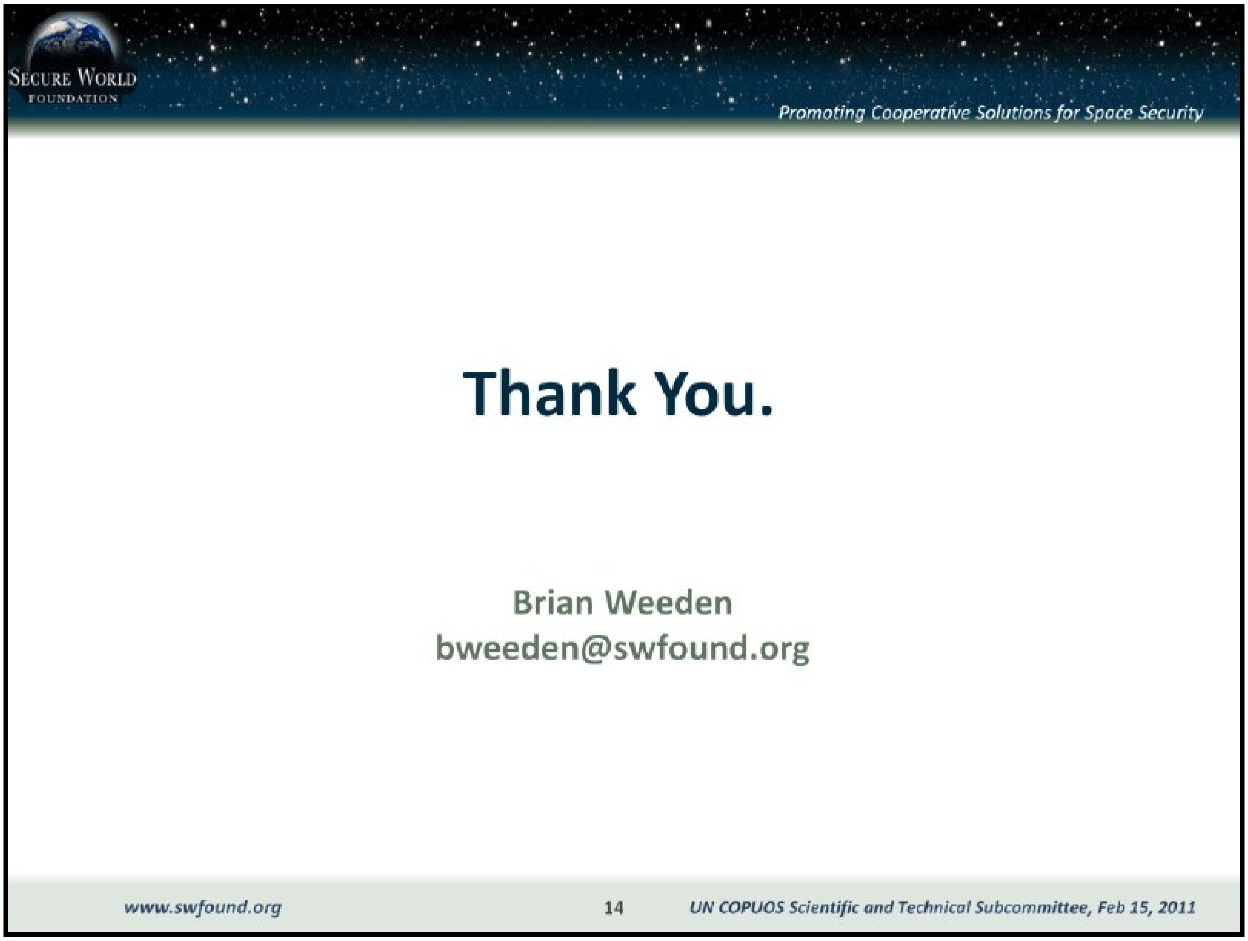
There is no evidence that Intelsat was in any way at fault in what happened with Galaxy 15, and on the contrary Intelsat should be commended for their actions in responding to this unfortunate event. Intelsat and the rest of the mitigation group worked relentlessly to communicate and coordinate with other satellite operators, many of whom were direct competitors, to ensure that Galaxy 15 had a minimal impact on activities in the geostationary belt. The Galaxy 15 situation should be examined further for potential best practices that could be incorporated into the Working Group on the Long-Term Sustainability of Outer Space Activities.




The mitigation plans and maneuvers needed to deal with Galaxy 15 were only made possible by excellent space situational awareness. The incident happened in a region of the globe with excellent sensor coverage, mainly as a result of the mechanical tracking radars and optical telescopes the U.S. military operates in North America. Other regions of the world are not as well covered. More importantly, it was the communication and sharing of data between Intelsat, the United States government, and other satellite operators which turned this into a success story. No single space actor can achieve good SSA by themselves – by definition it requires at least some data sharing among space actors.

Finally, we should consider what would have happened had Intelsat not been able to recover control of Galaxy 15. Without maneuvering control, Galaxy 15 would have joined the other 45 large pieces of debris stuck in the gravitational “trough”, librating back and forth over the Americas for centuries.

An on-orbit failure which turns an operational satellite into a piece of debris in the active geostationary belt is not a rare event.  Each year, one or more satellites experience a malfunction which prevents the operator from re-orbiting it to the disposal region.  Although not a pressing matter at this point in time, the only way to eliminate these debris objects as a threat is through some sort of active debris removal.  Active debris removal is currently a topic of interest among the technical community, and is at an early stage of development. Nevertheless, modeling done by NASA and other space agencies indicates that active debris removal will be necessary at some point to ensure the long-term sustainability of space activities, especially in low Earth orbit.  Active debris removal poses significant legal and policy questions, and these must be dealt with in conjunction with the technical analyses.




In summary, Secure World Foundation would like to reiterate the importance of the Galaxy 15 event and its relationship to the work of this Subcommittee as it discusses the agenda items on space debris, geostationary orbit, and the long-term sustainability of outer space activities. We believe this event is a significant source for lessons learned and best practices from which all space actors can learn more about both the potential threats to space operations and how they can be handled in a cooperative manner. Mr. Chairman, thank you for this opportunity, and I invite any questions at this time.