IRIDIUM 33 and COSMOS 2251: AN HISTORIC COLLISION

By Michael A. Earl

On June 16, 1993, a Russian satellite was launched from the Plesetsk Cosmodrome, 800 kilometres north of Moscow. Cosmos 2251 was a military communications satellite that served faithfully in this capacity until 1999 when it was deactivated and left a derelict spacecraft. It remained that way for nearly 10 years.

On September 14, 1997, an American satellite was launched from the Tyuratam Cosmodrome, 2,100 kilometres southeast of Moscow. Iridium 33 was a telecommunications satellite that was a part of the worldwide Iridium satellite telephone service. It faithfully served until the sudden end of its life nearly 12 years later.

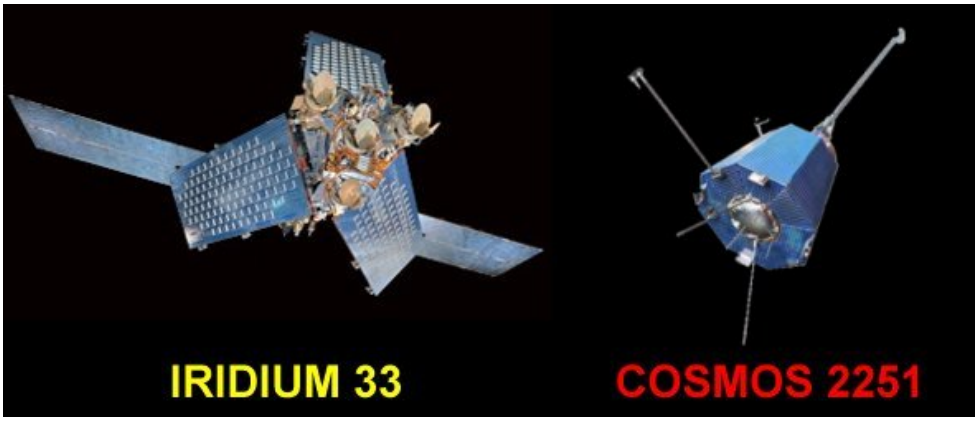

Figure 1: The American Iridium 33 and Russian Cosmos 2251 satellites.

At 11:56 a.m. EST February 10, 2009, the unthinkable happened. These two satellites made history by being the first fully intact payloads to collide. The satellites destroyed each other, leaving several hundred pieces of debris in its wake. This debris will be posing a major threat to other active satellites for several decades.

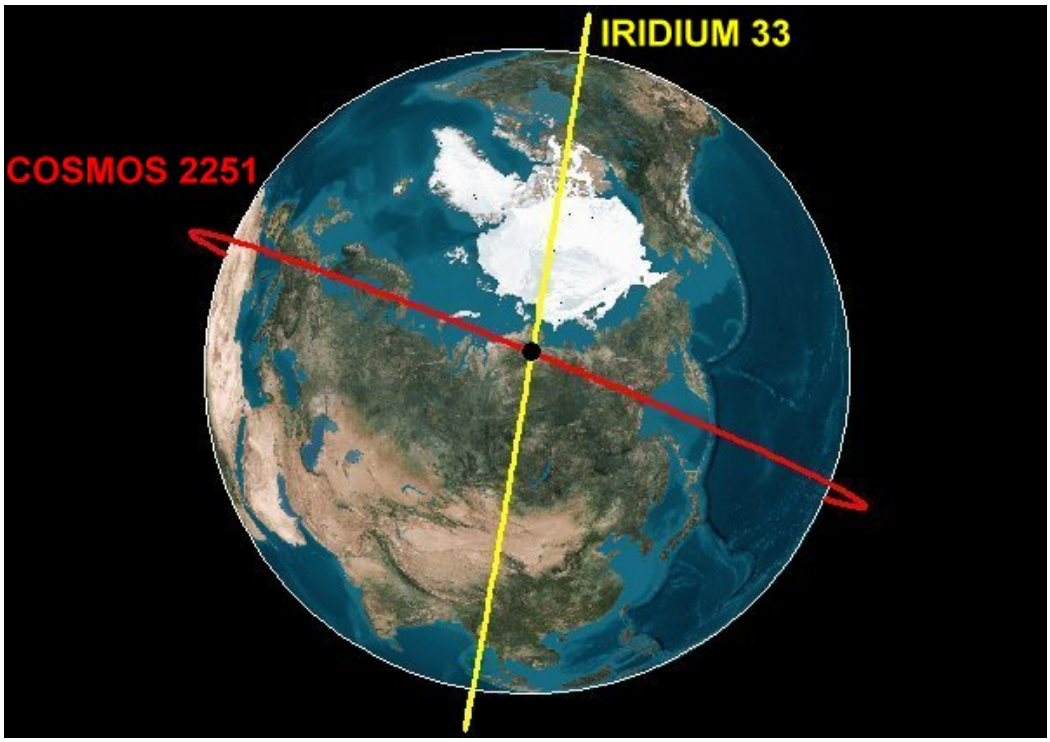

Figure 2: The orbits of Iridium 33 and Cosmos 2251 at the time of the collision, as viewed directly above the collision point (black dot). Earth and orbit imagery by Analytical Graphics Inc.

Iridium 33 (600 kilograms) and Cosmos 2251 (900 kilograms), collided at an angle of 103.3 degrees with a relative velocity of 9.2 kilometres per second. That's 33,000 kilometres per hour or 26 times the speed of sound.

The two satellites collided 788.6 kilometres directly above a point on the Earth 97.86 degrees east longitude and 72.51 degrees north latitude; the extreme north of Siberia.

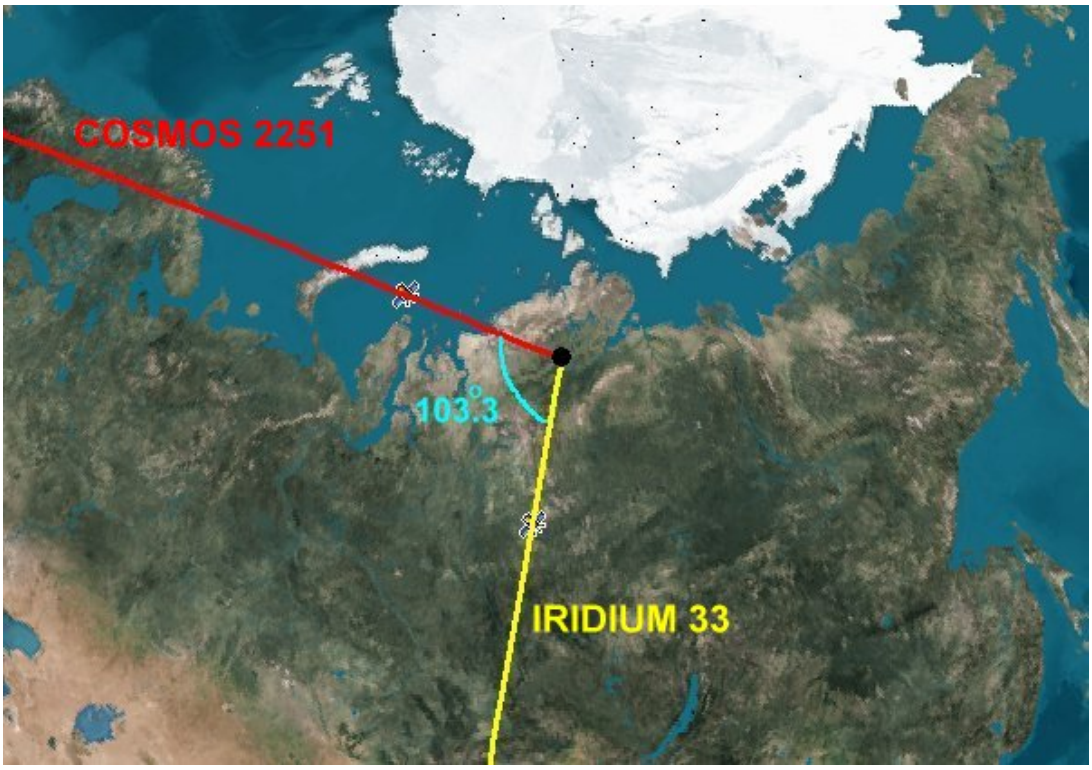

Figure 3: The collision angle of Iridium 33 and Cosmos 2251 as viewed from directly above the collision point, denoted by the black dot. Earth and orbit imagery by Analytical Graphics Inc.

Shortly after the collision, accusations flew from all directions. Iridium stated that “it had no advance warning of the impending collision”. A Pentagon spokesman stated that "We did not predict this collision," and "There are limits on your ability to track and compute every piece of orbiting man made object." A Russian technology expert had stated, “The U.S. side might have been unaware of, or had ignored, the possibility of the two satellites smashing into each other”. This is not surprising behaviour, given such an unprecedented event.

This is somewhat reminiscent of an elementary school, in which something has been accidentally broken and nobody wants to admit they had any part in it. The first kid is saying, “Don’t look at me, I should have been told that my toy was in danger”. The second kid is saying, “Don’t look at me, I don’t have eyes in the back of my head.” Finally, the third kid is saying, “Don’t look at me, I was just minding my own business, but those two should have known better.”

The damage to Iridium’s 66 satellite infrastructure was minimal. After the loss of Iridium 33, the Iridium company immediately moved one of its orbiting spares to take

Iridium 33's place. Regular service was restored in a matter of a few days. The damage to the orbital vicinity of the collision might be more severe, as up to 1,000 pieces of debris from the collision will be orbiting for several decades, threatening other functioning satellites, including the remaining functioning Iridium payloads.

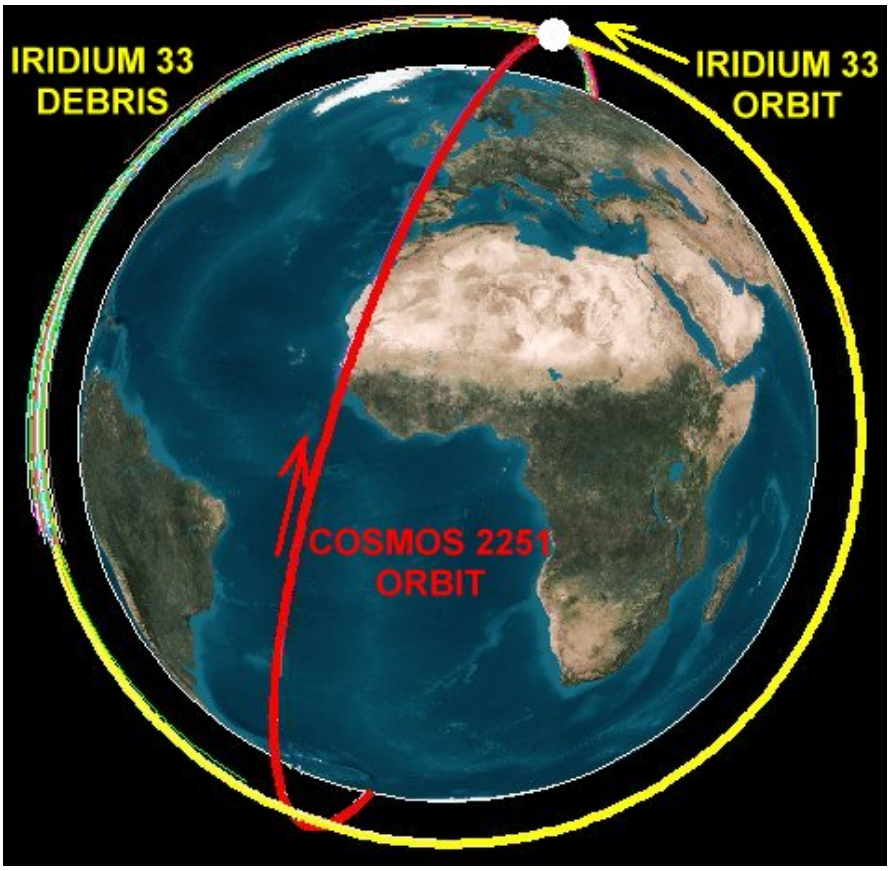

Figure 4: 153 pieces of Iridium 33 debris are plotted to 35 minutes after the collision. Notice how the debris spreads out after the collision. The collision point is denoted by the white dot. Earth and orbit imagery by Analytical Graphics Inc.

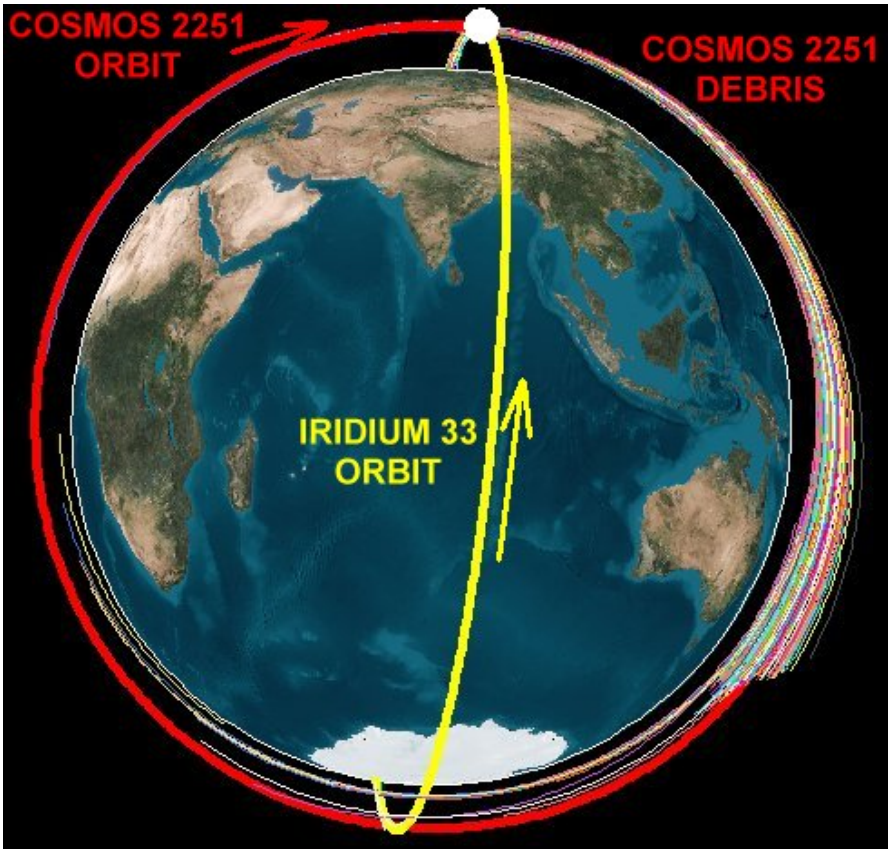

Figure 5: 354 pieces of Cosmos 2251 debris are plotted to 35 minutes after the collision. Notice how the debris seems to spread out more than the Iridium 33 debris. Earth and orbit imagery by Analytical Graphics Inc.

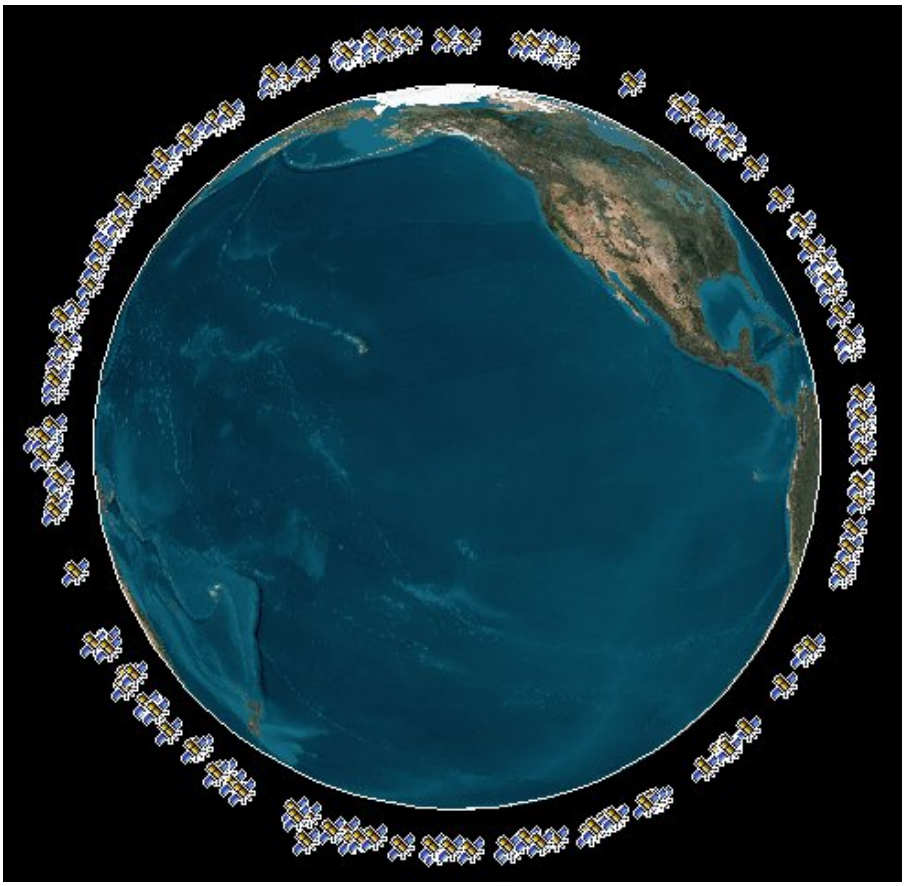

Figure 6: 153 known pieces of debris from the Iridium 33 satellite are shown here at 00:00 UTC March 6, 2009. There are likely many more pieces of debris to be found. Satellites are not to scale. Earth and orbit imagery by Analytical Graphics Inc.

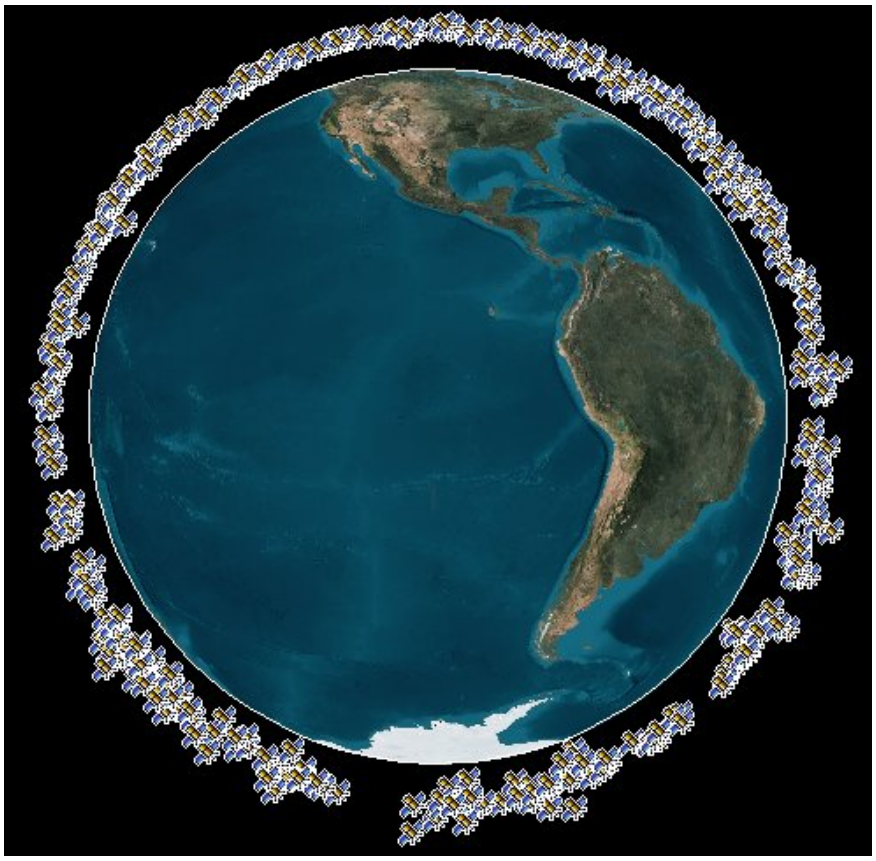

Figure 7: 354 known pieces of debris from the Cosmos 2251 satellite are shown here at 00:00 UTC March 6, 2009. There are likely many more pieces of debris to be found. Satellites are not to scale. Earth and orbit imagery by Analytical Graphics Inc.

Currently, our known satellite population contains 13,000 to 19,000 objects, depending on which press release you read. Imagine trying to determine all the potential collisions 24 hours a day, 7 days a week! With each new satellite launch, the number of satellites grows, thereby increasing the probability of collision. Despite enormous efforts to prevent this type of satellite mishap and the often stated “improbability” of collision, two full size satellites still managed to collide. Maybe the attitude that prevailed until now was: “Until a collision actually happens, it is impossible”.

The problem inevitably comes down to who had too little responsibility and who had assumed too much responsibility with respect to conducting regular tracking of debris, producing collision reports and especially investigating the liability of collisions. You might imply from the respective press releases that Iridium is assuming too little responsibility, NORAD is assuming too much responsibility and Russia is assuming very

little to no responsibility. If true, is this the right balance of responsibilities for the current circumstances?

Hindsight being 20/20, many have been saying that this collision could have been avoided. Unfortunately, that does not help Iridium 33. Yes, the collision could have been avoided, but it wasn't. Now is the time to figure out why, not dwell on something that has already happened and cannot be reversed.

CASTOR's wide field camera was able to detect both Iridium 33 and Cosmos 2251 during its "Sputnik 50th Anniversary Bonanza" in 2007. The question I have is why should two large satellites so easily detectable be so easily overlooked as far as a collision is concerned? Was the calculated probability of two fully intact payloads colliding much smaller than that of a piece of debris hitting a payload?

Collision probability reports are everywhere, but they obviously did nothing to help Iridium 33. The best method of protecting our active satellites is not only to calculate collision probabilities, but to track all detectable satellites as accurately and as frequently as possible. The aforementioned Pentagon statements suggest that this is no longer being done as frequently as required.

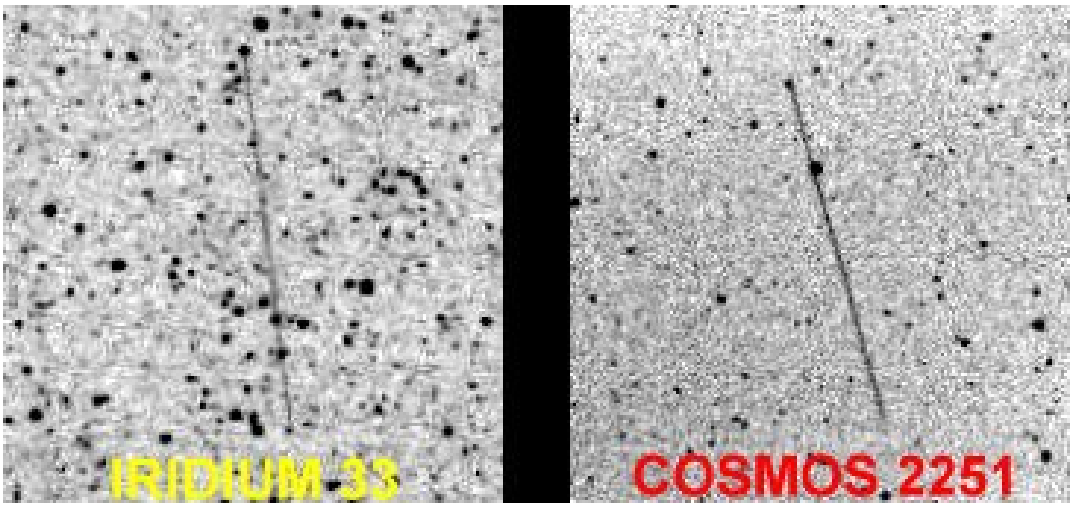

Figure 8: Negative cropped CASTOR images of Iridium 33 and Cosmos 2251. Iridium 33 was detected at 00:20:47.481 UTC February 11, 2007 (nearly two years before the collision). Cosmos 2251 was detected at 01:54:16.495 UTC on April 20, 2007. Iridium 33 was 783km in altitude and Cosmos 2251 was 785km in altitude, respectively.

Using orbit elements from both satellites, I had determined that the minimum predicted distance between Iridium 33 and Cosmos 2251 at the time of the collision was 830 metres, much smaller than the 5 kilometre threshold that NORAD uses for its collision reports.

Currently, there are two strategies to reduce the probability of satellite collision:

1) Constant vigilance over the entire satellite population. This would involve spending larger amounts of money to increase the tracking frequency and accuracy of all detectable satellites orbiting the Earth; and/or

2) Debris removal and disposal. This would involve spending even larger amounts of money to design, implement and launch specialized satellites that would capture and de-orbit derelict satellites.

Strategy #2 has never been implemented in all 51+ years we have been launching satellites. However, several satellites, including SkyLab and MIR, were deliberately de-orbited. The Chinese used an anti-satellite missile to destroy a Fengyun 1C weather satellite in 2007. One year later, the American classified USA 129 satellite was destroyed the same way. With the Pentagon's admission that the U.S. military cannot possibly know the whereabouts of all satellites at all times, strategy #1 is now cast into some doubt.

What NORAD has been doing over the past 51+ years is nothing short of phenomenal. It has been actively tracking the vast majority of satellites and producing collision avoidance reports for satellite companies; warning them of potential collisions. The hardworking men and women likely received little or no praise preventing collisions before this collision occurred, but get most of the blame (from Iridium, the Russians and possibly the Pentagon) afterward. A fair question to ask would be: How many satellite collisions have been <u>prevented</u> because of NORAD's efforts?

Several days after the collision, a chance fireball was spotted over Texas and Oklahoma. Many believed that it was a piece of the collision debris. Although the object in question was eventually proven to be a meteor, the event shows that many were still very much focused on the collision's after-effects.

There are currently no international laws regarding satellite traffic control in place; especially when collision liability is concerned. The long-held belief that throwing satellites into "wide open space" is a harmless exercise is now gone forever. What will be replacing it?

Maybe one day the satellite industry will begin acting as its own satellite traffic controlling body. This move could serve to offload responsibility, stress and blame from

NORAD as well as focus the satellite industry to produce more accurate satellite tracking data and collision avoidance strategies. Meanwhile, NORAD can spend more time on its “high priority” satellites and dealing with potential security threats. Would NORAD agree to offload a portion of its satellite tracking responsibilities to private industry?

The science of satellite tracking has officially entered a new phase in its evolution. No matter what chain of events led to the collision, warning signs had certainly been missed. This oversight led to the destruction of an expensive piece of space hardware. Whoever takes the blame will ultimately decide what happens next.

Iridium 33 and Cosmos 2251 will always be part of the CASTOR Satellite Catalogue as #0237 and #0534 respectively. The catalogue now has two disturbing additional amendments: “destroyed by collision at 11:56 a.m. EST February 10, 2009”. In the realm of the satellites, this date should never be forgotten.