Logistical challenges of avoiding collisions between satellites and sleighs

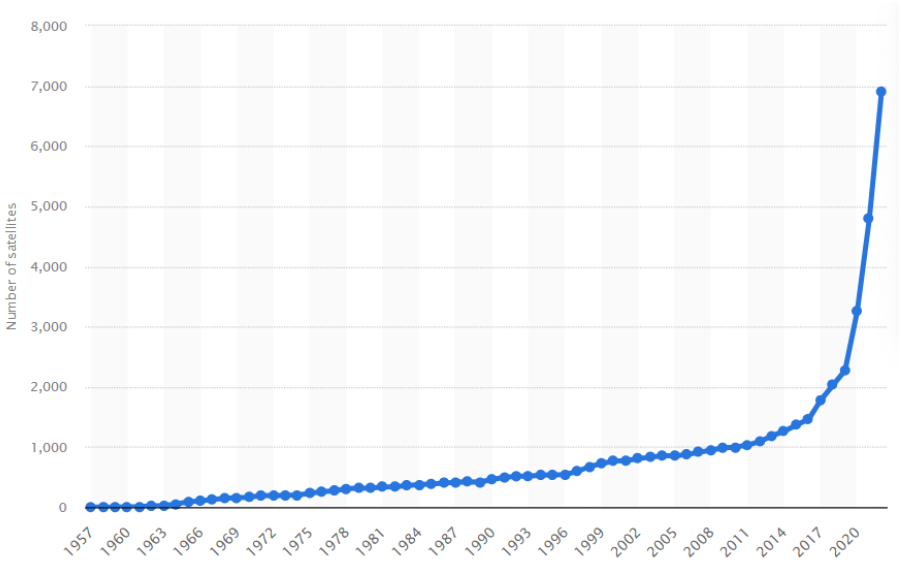
Briefing note | December 2023

As the festive season approaches, the activity at Northpole Oyj[1] has kicked into high gear, but in truth, the work began in earnest just before the summer. Whether in the traditional woodworking workshops or the more recent and snazzy electronics production chain, elf workers have been toiling 24/7 to ensure that no child's Christmas gets left behind.

There is one area of the preparations which has become more and more of a headache in the last few years: logistics. People may not think of it much, but the scope of delivery to children aged 0 to 14 has more than doubled since the middle of the last century[2] to now reach nearly 2 billion. With only 26 hours (accounting for time zones) in which to do his deliveries, every micro-second counts for Santa, which makes logistics a crucial challenge.

In recent years however, a new constraint has made itself felt that complicates matter even more – the launch of large numbers of low-earth orbit (LEO) satellites. Circling the earth at between 150 and 2,000 km, LEO satellites overlap widely with Santa's flight path. Their number has increased dramatically over the last decade, and these now make up over 85% of all active satellites.

Figure 1: Total number of active satellites by year[3]



[1] Incorporated in Finland, company number 15-03-0270
[2] See https://www.statista.com/statistics/678737/total-number-of-children-worldwide/
[3] Source: https://www.statista.com/statistics/897719/number-of-active-satellites-by-year/

In 2011, an in-depth analysis in The Atlantic[4] detailed some of the logistical challenges of Santa's deliveries. The article considered that only Christian children expected presents from Santa, but that is a reductive view of the world. According to World Population Review, most countries in the world celebrate Christmas[5], even if unofficially in many cases. It's safe to say that the number of children expecting a present is significantly higher than the 500,000 quoted by the Atlantic, if probably lower than the 2 billion cited above as 0 to 14 year old kids worldwide.

Irrespective of the precise number, logisticians the world around[6] agree that Santa's delivery speed is likely close to 16m km/h (15,937,500 to be exact), not counting the actual delivery time (on this particular point, Northpole Oyj is very quiet, suggesting some trade secret we are not privy to). At such speeds, the risk of collision is far from negligeable, and the increasing number of obstacles in Santa's orbit have turned into a bit of a head scratcher for the Christmas Company. Says Leo the Elf, head of logistics at Northpole Oyj, "If you look at space collisions any other night of the year, the details are already scary. So imagine the risks for Santa and for Christmas with such a fast vehicle navigating the same lanes."

Indeed, potential orbital collisions are not a rare occurrence. There are many times a day where satellites are in close proximity (several kilometres) of each other and it is necessary to take avoidance to prevent collisions with exiting satellites. For example, the European Space Agency's earth observation satellite recently had to manoeuvre to avoid colliding with a Starlink satellite[7].

The issue is compounded by the increasing prevalence of space debris which is becoming a major concern, with the near Earth space cluttered with some 36,500 pieces of space debris larger than 10 cm, about a million objects between 1 and 10 cm and considerably more less than 1 cm. To provide an example of the level of the problem, between 1 December 2020 and 30 November 2022 Space X's autonomous collision avoidance performed 26,037 manoeuvres – 12 moves on average for each satellite. Forbes quote there are 100 trillions of space debris[8], increasing all the time, meaning such manoeuvres are going to become more commonplace.

To avoid risk of collision Father Christmas needs to consider how well he knows the actual location of satellites where he will be flying, and have considered his manoeuvring capabilities and strategy to make his deliveries in the 26-hour window. This indicates the need for the sleigh to be fitted with autonomous avoidance, and Rudolph's red nose with sensors. Collision with even small pieces of debris could lead to damage to presents and injuries to reindeer.

So how does Northpole Oyj do it? It's hard to tell exactly, because they are a bit cagey about their technology solutions. More conventional businesses are increasingly relying on real-time orbital databases that can track data for thousands of space objects and analyse and visualise this data to minimise the risks of collision. It's not a stretch to imagine that Northpole would have commissioned, or even home-developed, such a solution to secure Christmas logistics. Rumours have recently floated of a new software solution called GPS (short for Generalised Present Security) installed at the Northpole HQ in Korvatunturi, Lapland. Could this be it?

While Northpole wants to reassure people that all is in good hands, and that this Christmas deliveries will be on time, individual households are also derisking by delaying Christmas. An increasing number of families in Europe are celebrating Christmas during the day of 25 December instead of their more traditional evening before[9], with some in Eastern Europe even pushing the date as far as 5 January. Let's hope that Santa's rumoured new technological solution combined with these mitigating delays will ensure that all goes smoothly this festive season, so that all can enjoy a Merry Christmas.

[4] See https://www.theatlantic.com/technology/archive/2011/12/santas-christmas-eve-workload-calculated/249844/
[5] See https://worldpopulationreview.com/country-rankings/countries-that-celebrate-christmas
[6] For example, see https://www.labmate-online.com/news/news-and-views/5/breaking-news/how-fast-does-santa-travel/32594#:~:text=In%20order%20to%20circle%20the,to%20get%20the%20job%20done
[7] See https://www.space.com/spacex-starlink-esa-satellite-collision-avoidance.html
[8] See https://www.forbes.com/sites/jamiecartereurope/2023/03/09/do-we-need-an-orbital-treaty-there-are-now-100-trillion-bits-of-space-junk-circling-our-planet-and-its-about-to-get-a-lot-worse/
[9] Other countries already had a traditional celebration on 25 December, and some families here are extending visits to 26 December instead.