

**Space Situational Awareness:** *An analysis of threats, consequences and future solutions for Europe's security, safety and prosperity.*

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## Background

As Europeans, we rely on space-borne assets to support our daily lives. Even without thinking about it, the all-pervasive influence of services that we continually depend on hang on our ability to protect our link to Space.

This dependence on Space is both visible and submerged in many different areas. The apparent ones, such as our navigation systems and entertainment sources are in some way understood to derive from satellites orbiting above our heads. Others are more subtle and their benefits are less obvious, but by no means less important.

Space provides the following benefits to the security and prosperity of all Europeans:

- Navigation and door-to-door guidance through Global Navigation Signal Systems (GNSS) such as GPS and Galileo
- Accurate time keeping to ensure the integrity of banking systems and the secure transfer of funds between banking entities
- Internet access in rural communities
- HDTV entertainment broadcast
- Live news and sport coverage from around the globe
- Monitoring of crops and analysis of growing methods
- Disaster relief assistance through rapid imagery and ad-hoc communication networks for emergency services
- Maritime security and tracking of goods
- Military intelligence gathering and secure communications

This is not an extensive list, but provides a snapshot of some of the benefits that Space access is giving to all European citizens right now. As technology improves, additional services are added and our reliance increases.

## Space Surveillance

It is therefore apt that one finds a burgeoning need to monitor activity in Space. Without a situational awareness of all objects in orbit, we find ourselves trusting to luck that our services will remain uninterrupted. Without this awareness, we can compare the situation to someone trying drive a car without the benefits of sight, sound or touch. We do not know which lanes are busy or if traffic is approaching or from what direction, we just know that we have to move forward. With so much at stake, it is not surprising that some kind of solution to this sensory deprivation needs to be found.

The problem is compounded when you consider that satellites orbiting close to the Earth, such as the majority of imaging satellites, travel constantly at over 30,000 km/hr. Attempting to drive with traffic at that speed would be very challenging, but that is what Europe's satellites do at every minute of every day.

From this information comes another question – how much 'traffic' is in orbit. To answer this, one should realise that most of these orbital objects are the residue from man-made systems. They can be defunct satellites, nuts, bolts, fragments from explosions, results from 'anti-satellite' tests. The design of most operational satellites ensures that they can survive collisions with objects with a diameter of under one centimetre. The problem is that data generated by the European Space Agency indicates that there are *over 600,000* objects in orbit that have a diameter of one centimetre or over – and the number is growing all the time.

Figure 1, below, illustrates the current state around the Earth. Although this is an artist's impression, the position and densities of the orbits derive from actual data.

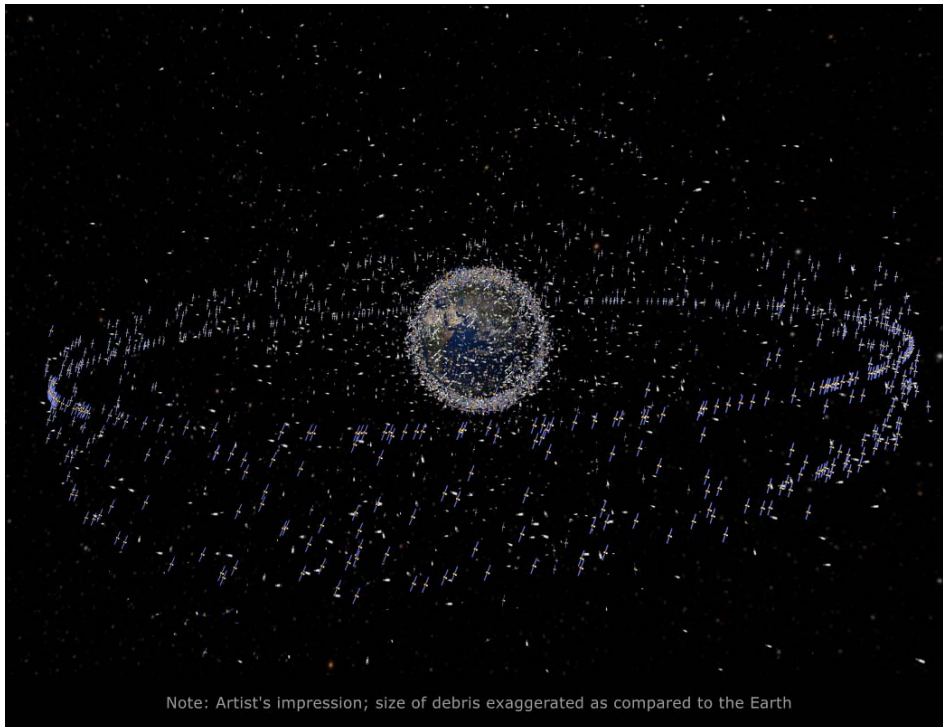


Figure 1: The current state of space

Now consider this: Europe has no autonomous capability to survey those objects that threaten its assets – the same assets supporting our agriculture, banking, entertainment, security forces, emergency services and defence forces. Research and development within European member states has provided us with the technical framework, but to date the deployment of this technology has not allowed us to create a true and independent picture of the actual situation.

Current analysis within Europe relies on data generously provided by the USA. Although this data gives a much clearer picture of the traffic in Space, it has certain flaws that preclude European satellite operators and owners to ensure that their spacecraft are protected. These flaws are:

- Only non-US military objects (both satellites and debris)
- No indicators on the precision or validity of the data
- Absence of any independent assessment of the accuracy of the data
- Large gaps within the reach of the data

Without a solution to these problems, the ability of the European community to protect its space-based infrastructure is impaired.

The European Space Agency is currently drafting the design of a system that will draw upon current national assets, such as radar, telescopes, computer systems and expertise. This design will also govern the scope of additional assets that are required to provide a clear, accurate and reliable picture of the near Earth environment.

The system has been designed with three main segments. These are:

- Space Surveillance and Tracking  
To produce an accurate and timely picture of all satellites and debris in Earth orbit.
- Space Weather  
Allow the dissemination of the actual Space environment around the Earth, including the effects of the Sun on satellites, power systems and gas pipelines.
- Near Earth Objects  
To monitor and track asteroids and comets in order to provide early warning of potential impacts with our planet.

Binding these segments is a common *governance and data policy*. This development will certify the integrity of the data produced, to ensure the appropriate handling of sensitive information and to guarantee a rapid dissemination of information to authorised parties.

### **Orbit Decay Prediction**

We can predict that most satellites will remain in orbit for many years, decades or even centuries. However, it is no surprise that the decay, or *re-entry* of satellite occurs on a regular basis. During satellite launches, the last or final stage of the launch vehicle will orbit the Earth briefly before decaying; safely burning up in the atmosphere.

However, there are occasions when the destruction of these objects is not completed by the heat of re-entry. Satellites which did not reach the correct orbit or satellites that have finally been snared by the drag caused by Earth's

atmosphere will often reach the ground with a very high terminal velocity – and hence a potentially destructive energy.



Figure 2: Ariane Fuel Tank after re-entry

There are two reasons why Europeans should be interesting in knowing when – and where – Space debris could potentially come back down to Earth. The first of this is for the obvious reason of protection of life and property. If a satellite is predicted to impact within or close to an urban area, the local security services should receive advance notification of this potential in order to be prepared for any eventuality.

The second reason is one of responsibility. Just as European satellite owners and operators are accountable for the damage their assets inflict in-orbit, they are also responsible for harm effected during re-entry. It is, therefore, Europe's responsibility to be able to predict re-entry events so as to minimise or mitigate any injury inflicted by European-owned assets.

The ability to provide accurate decay predictions relies on an accurate data set or catalogue of orbiting objects, in a very similar fashion to the detection of in-orbit collisions. In reality the sensors, infrastructure and data are almost identical, although the data is processed through specific software that then predicts the impact point.

For high precision predictions, it is also necessary to possess the ability to *image* objects in orbit. With an image, one can determine the attitude of the object and hence attempt to determine how it will react when encountering the denser regions of the atmosphere.

Certain European institutions possess this ability, as shown in Figure 3, below (from the TIRA radar in Wachtberg, Germany). Currently this is done on an experimental basis rather than for routine operations.

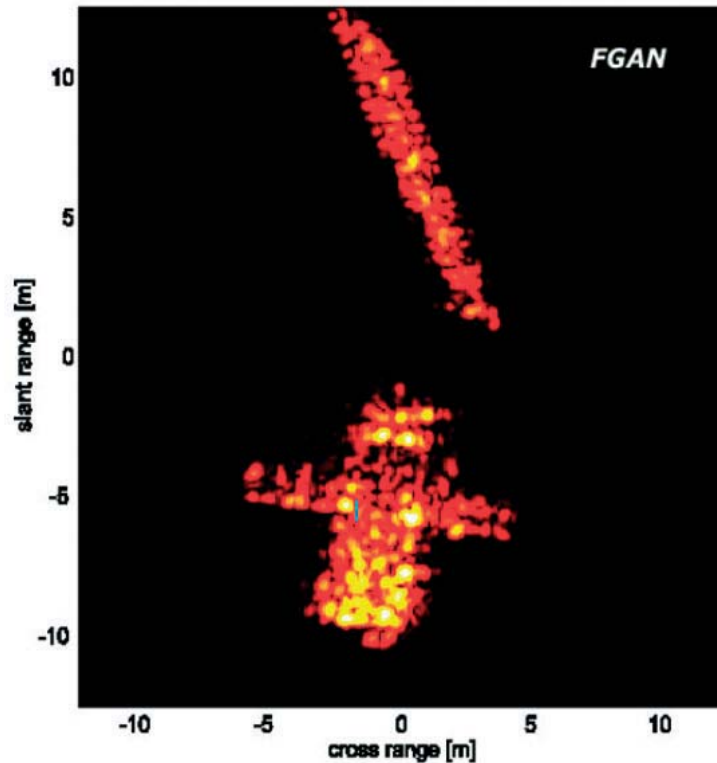


Figure 3: Image of Envisat taken by the TIRA radar

To ensure compliance with routine operational requirements, three main elements are required. The first of these is equipment that can be tasked with short notice to perform tracking of objects as they begin the decay. This is vital for accurate orbit predictions – especially as the conditions are changing rapidly when an object starts to feel to full effects of the atmosphere's drag.

The second is the ability to image an object as described above. Knowing the actual orientation of the re-entry subject has large effects on the accuracy of the decay prediction.

The final requirement is to have a system of governance and data management to ensure that the right people receive correct information in a timely fashion. Without a rapid warning of decay, the rest of the system loses its power to aid and assist governments, security services as well as the necessary emergency services.

## Summary

Space-borne assets play a vital part in the daily lives of European citizens. They help us work and play, trade and negotiate as well as ensure security within all member states.

Guarding these assets from threat has become an important requirement. The European Space Agency is working towards a system that will provide advance warning of threats, both to operational satellites as well as from the risk posed by uncontrolled de-orbit of Space debris.

Conducive to ensuring that the system will be both accurate and efficient is the need for a network of dedicated sensors, processing, expertise and governance. The Agency is dedicated to ensuring that all these factors are taken into account within both the initial services as well as the full operational system.