Convergence of technologies, divergence of knowledge

by Fabrizio Bernardini

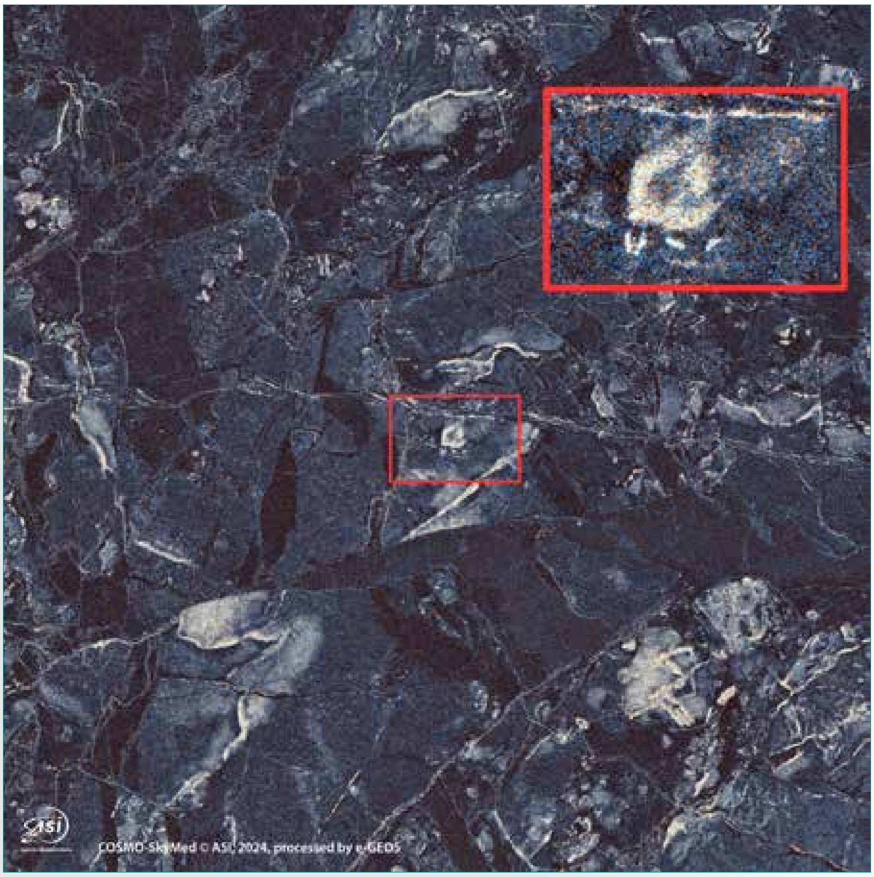
The convergence of meridian lines at the North Pole is a fitting metaphor for the convergence of technologies involved in the first success of the Transglobal Car Expedition, which reached the North Pole after a challenging journey across the frozen Arctic Sea, starting from the Canadian coast. The expedition is currently aiming to cross Africa, reach the South Pole and then return to New York via South America.

This modern expedition utilized four specially designed vehicles capable of withstanding not only the Arctic's harsh conditions but also the possibility of encountering open water, given that polar ice formations are no longer stable. This situation, one of the main and dramatic consequences of climate change, made the crossing even more difficult and dangerous.

However, the technological convergence we want to highlight is not limited to the vehicles and equipment, which, although modern, are ultimately rather conventional due to reasons of redundancy and maintainability. Instead, we want to discuss about the convergence of technologies made available today by satellite infrastructures, which many still do not understand how they continue to change our society. These are complex systems, often with applications unknown to most people, or only vaguely understood, on which we now depend extensively. The Transglobal Car Expedition, which reached the North Pole on the evening (European time) of April 7, highlighted several of these systems and our modern dependence on them.

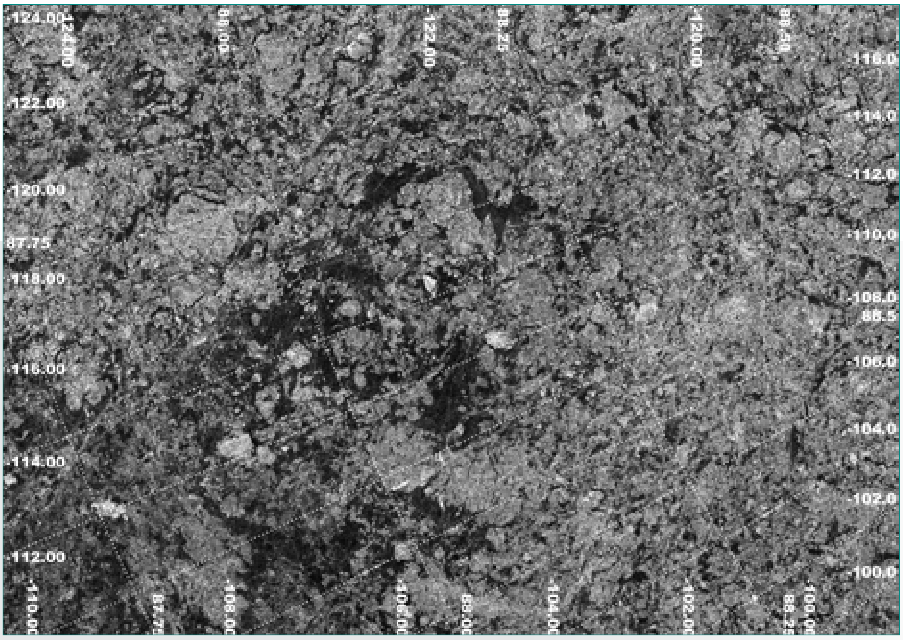
Let's start with the latest addition (for the expedition), namely the all-Italian satellite constellation called Cosmo-SkyMed, originally conceived by one of the fathers of Italian astronautics, engineer Giorgio Perrotta of the then Selenia Spazio, later Alenia Spazio, and now Thales Alenia Space, a true 'leader' in the field of space radars. Thanks to the collaboration with the Italian Space Agency, put into operation in mid-March, it was possible to regularly provide the expedition with SAR images (thus radar images with particular characteristics) in high resolution. These images allowed, during the highest risk due to the instability of the ice sheet, the safe daily definition of routes. The images were of such quality that they were even used as navigation maps inside the vehicles, not just to assess the ice conditions, an activity carried out by experts from the Alfred Wegener Institute (AWI) in Bremen. To assist the expedition with its progress, which was difficult to predict, the ability to tactically plan subsequent images just hours after their acquisition was also crucial. All this was possible thanks to the generous availability not only of the ASI managers but also of the operators of E-Geos, who manage the Cosmo-SkyMed system: they were all a determining factor in the success of this application

In addition to Cosmo-SkyMed, the expedition also used images from Sentinel-1B, a SAR satellite from the Copernicus system managed by ESA on behalf of the European Union. The radar images from this satellite could provide support only up to about 86 degrees North latitude and had a lower resolution than those of Cosmo-SkyMed, but they were still essential in deducing the movement and fragmentation of the ice, thus providing support in the initial phases of the crossing. Again, the kind availability of ESA and the Sentinel-1B mission team made this unique collaboration possible.
Information on the global state of Arctic ice, particularly thickness and fragmentation, was also obtained from measurement campaigns by the ESA Cryosat-2 satellite, which for years has been constantly mapping the state of ice and snow globally, confirming climate models and the consequences of dramatic changes underway.
Other satellite images, this time in the visible spectrum, were used from continuous campaigns conducted by NASA's MODIS satellite, which, like ESA, makes its data freely available to the community. These images were consulted as the situation became increasingly dangerous to understand the extent of ice fragmentation on a large scale. Being in the visible spectrum, they were only partially useful due to the difficulty of estimating reliefs and fractures, which is possible with radar images.
Of course, the expedition used modern satellite positioning systems like GPS/Navstar, Galileo, and Glonass as its primary navigation system, using both conventional receivers and professional navigators for this type of situation.



Italian COSMO-SkyMed satellite constellation collects images of vehicles parked at the northernmost point of the planet. Spotlight-2B mode (area 10km x 10km, spatial resolution 0.6m) acquired in dual polarisation (HH+HV). COSMO-SkyMed Second Generation Image © 2024 ASI. Processed by e-GEOS

Satellite positioning systems (GNSS) are another of those space systems we take for granted today, but which are


Sar image used to help TCGE navigation. COSMO-SkyMed Second Generation Image © 2024 ASI. Processed by e-GEOS

extremely complex, requiring dozens and dozens of vehicles and redundant control centers with specific functions for the continuous verification of system accuracy and positioning reliability. Space and time are the key elements of GNSS systems, and their use extends wherever spatial and temporal knowledge is needed. GNSS systems are used not only by our cell phones to guide us through traffic but also by the entire aviation and maritime world, in short, by any transport vehicle, and they also have many collateral applications, not least in the field of time synchronization (also essential in the digital communication systems we depend on).

In fact, communications are also involved. To stay in touch with the support team (spread across several nations), the expedition used various systems, all based on the Internet. Both messaging systems, like Telegram and WhatsApp, and direct access to the World Wide Web were used. They also used Google Drive to send high-resolution images to be used as maps, among other information; IoT technologies to receive scientific data from the expedition (automatically displayed on a dedicated website); and finally, Zoom for teleconferences when important decisions needed to be made or to celebrate the arrival at the North Pole in real-time.

All of this was made possible by a satellite constellation like Starlink, which provided virtually continuous communications throughout the journey, something absolutely unprecedented. This constellation offers communication performance once unimaginable, allowing the use of any available Internet service without any problems and without resorting to special technologies. As a backup, other portable satellite devices were also used, the kind we are used to seeing on boats or in other cases where the cellular network is not easily accessible. Starlink and Iridium are also complex satellite systems that require special ground infrastructures for their operation. For those living in densely populated areas, they are certainly not for everyday use, but for many, they are indispensable tools, especially when it comes to broadband Internet access. Not that satellite communications are new, being one of the first major applications of the space sector, born in 1957 with Sputnik 1. But to go from large geostationary telecommunications satellites (which also include applications like satellite television) to making a 'Zoom call' from the North Pole using Starlink as if it were an absolutely normal thing is something that, just a few years ago, would have been considered science fiction.

As for other dangers, it may seem trivial but is no less important to remember the role of satellite meteorology services and ground meteorological centers that continuously develop new forecasts for different categories of users. This is also one of the first satellite applications, but today the availability of meteorological images (not only in the visible spectrum but also in other bands) is taken for granted

Cryosat satellite. CREDIT ESA – P. Carril

Transglobal Car Expedition team at North Pole

without understanding the complexity of the vehicles involved. And to these vehicles, we must add those that collect further essential data for weather forecasting models, such as those on atmospheric humidity, particulate matter, aerosols, and high-altitude winds. A fleet of satellites is always in constant observation.

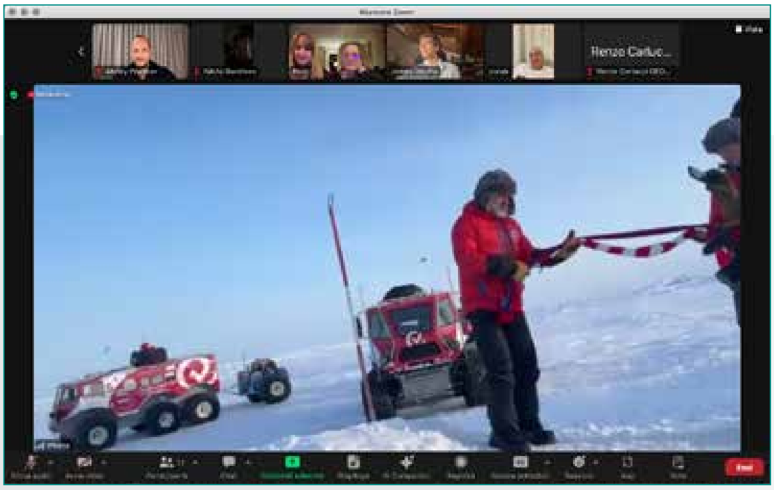
In short, all these satellite technologies—from SAR radars (individual for repeated campaigns, in constellations for high-resolution images with a quick response time), to scientific satellites like Cryosat-2, to those for conventional imaging and remote sensing like MODIS, and then positioning satellites (in the various available constellations), those for instant communications with small user terminals (Starlink or Iridium), and meteorological ones—converge together in the success of a modern enterprise like this one. What better context than this to remind us how much modern society depends on satellite infrastructures? Some still ask what the point is of going into space, as if this were a sector still to be explored, to be investigated... and it is true that there is much to explore, but at the same time, space is home to so many essential infrastructures with economic returns in some cases that can only be underestimated. And there are no alternatives: these services are only possible if delivered from space or based on vehicles orbiting our planet. Every investment made in the space sector returns enormously multiplied, just like when investing in essential infrastructures, such as those made in the aeronautical sector (does anyone still question its utility?) and more generally for any other transport infrastructure. Even the jobs generated by the use of space infrastructures are enormous compared to the jobs used to build these infrastructures.

If there is something that really does not work well in today's society, it is the knowledge gap that exists between those who create new technologies and the systems based on them, and those who use them in various applications (or enjoy the benefits offered), often without even knowing how they work. This gap is also expressed in the absolute ignorance of how satellite systems work, meaning basic knowledge, which should now be part of general culture in the modern world.

The cultural problem exists primarily in schools (but it is not the fault of the school) where they no longer explain how things work, or the reason behind many technical/scientific explanations that are imparted. There is much talk about STEM courses when the principles (i.e., the answers to certain 'whys') underlying the experiences in these courses are not at all clear, thus lacking a connection between experience and external reality. Even in universities, many technical students increasingly accept the notions received passively without making that leap in knowledge necessary for a true understanding of the role of science and technology, including its historical evolution.

Screenshot of GPS when reached North Pole

This then prevents the leap in knowledge needed for a true general vision of the whole. A vision that would be indispensable for understanding what choices to make for one's future.
If for the transpolar expedition the convergence of satellite technologies was essential, from a social perspective, unfortunately, we see not convergence but divergence, as society increasingly distances itself from understanding technology, its usefulness, and even its potential dangers. Another example of this divergence is the absurd discussions around so-called 'artificial intelligence,' which is another reflection of the daily 'cultural gap.' These are all discussions based on ignorance of the fundamental principles underlying the technologies used, driven by opportunistic opinions or incompetent commentators.
The cultural divergence in the technological sector, including satellite technology, is worse than the 'digital divide,' worse than 'fake news'; it is the reason why a nation loses the ability to control its own future.
If we truly want to continue on this path, we must invest in technical and scientific culture, in basic research, in university and industrial research and development activities, and in proper education on the history of technology. Science and technology, much like satellite infrastructure and its applications, are two sides of the same coin—a coin that only a few nations can proudly claim.



Zoom meeting snapshot with the team

Starlink antenna on TGCE veichles

KEYWORDS
Transglobal car expedition; satellite infrastructures; technologies

ABSTRACT
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