
Maintaining fouled submarine cables can be costly

KORN SRIRAWAN VIA SHUTTERSTOCK

Sea ice and iceberg dynamics are not easy to predict, but generally, as temperatures continue to rise, icebergs may calve more, but they will likely also melt faster

Arguably more problematic for coastal structures, rising sea temperatures mean rising sea levels. Structures, such as sea walls, will need to be higher – not just to take into account the shifting mean sea levels, but to account for the storm surges that may also be more intense as the climate continues to change.

Research, such as that by Dr Joan Pau Sierra of Universitat Politècnica de Catalunya BarcelonaTech and colleagues, suggests ports may also need to consider berthing area design. Their work showed how predicted sea-level rise under highly probable and worse projected climate scenarios could see berthing structures in the Balearic Islands suffering "huge increases of inoperability for berthing structures due to insufficient freeboard [the height of a dock above the sea surface]" by the end of the century.

The researchers highlight that adaptation is possible, but what action should be taken depends on the type of berthing structures. "In the case of piers, the more sustainable measure consists of the substitution of fixed piers by floating ones. In the case of docks, to prevent their inoperability, the easiest measure is the increase of their elevation, by adding a layer of concrete or units suitable for marine environments," they write.

Increasing and reducing a threat

While most potential impacts of sea temperature increases may mean rethinking engineering design to one extent or another, for those operating in polar regions, rising temperatures may increase and then reduce a threat – namely sea ice and iceberg impact.

Structures operating in the polar regions need to be designed to contend with sea ice and potentially iceberg impacts, which can result in vibrations that fatigue the structures, directly bend parts of a structure, move a structure or, in extreme cases, collapse a structure.

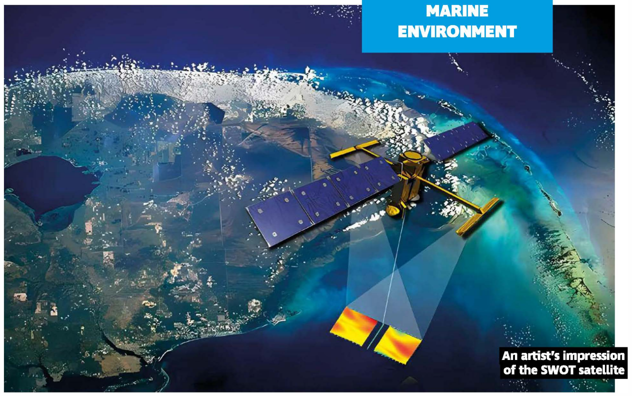
Sea ice and iceberg dynamics are not easy to predict, but generally, as temperatures continue to rise, icebergs may calve more, but they will likely also melt faster. In terms of sea ice, one study by Dr Yeon-Hee Kim of Pohang University of Science and Technology and colleagues suggests that an ice-free Arctic Ocean during September (when the sea ice extent usually reaches its minimum) is a real possibility. Other research indicates that the March extent – when sea ice has built up to the maximum – will be significantly reduced. Such changes will likely be accompanied by a more active, fragmented and dynamic sea ice regime that may present challenges for structures in the form of more loose, floating sea ice. This may include large, hard, strong, 'hummocked' ice structures which have built up over multiple years and are now able to move much more freely thanks to more open water.

While sea ice and icebergs may become more problematic in the short term, if climate change continues unabated and we continue to increase our greenhouse gas emissions as we are doing so currently, it is possible that in the long term, operators in some regions may see this particular threat declining, simply because the amount of ice becomes negligible. Should such a scenario bear fruit, "not designing for ice loading will probably only occur for some regions like the Baltic Sea later in the 21st century", Mawdsley notes.

While the prospect of not having to design for sea ice or iceberg impact sounds positive, operators should not be too overjoyed. Sea ice plays a crucial role in regulating ocean and air temperatures in the Arctic and Antarctic regions, as well as potentially disrupting ocean circulation and contributing to global temperature rises, exacerbating the climate crisis. ■

GROUND CONTROL TO MAJOR TIDES

Mapping the Earth's surface water levels from above


An artist's impression of the SWOT satellite

CNES

BY PAUL BELL

The Surface Water and Ocean Topography (SWOT) mission is a pioneering three-year Earth-orbiting satellite launched in December 2022 to map the Earth's surface water levels and assess freshwater resources in unprecedented detail.

The SWOT standard low-resolution products provide images of surface water levels globally, at 2km spatial resolution in two adjacent 60km swaths. SWOT high-resolution products are finer still, allowing rivers wider than 100m to be resolved over the Earth's landmasses and coastal areas at latitudes between 78° N and 78° S – to near-centimetric vertical accuracy. Existing nadir-pointing satellite altimeters flown for the past 30 years provide only single tracks of data at widely spaced intervals.

Over land, the objective is to monitor freshwater levels and their variability in lakes and rivers, with satellite revisits on average every 11 days. Over the ocean, as well as supporting research in tides and storm surges, subtle effects linked to ocean circulation are a key focus for scientists. Sea surface height anomalies – characterised by ocean height fluctuations of a metre or less over tens to hundreds of kilometres – are telltale signatures of large-scale ocean circulation and mesoscale eddies that drive ocean heat transport, ocean carbon uptake and vertical mixing.

SWOT's long journey into space began some two decades ago, when it was listed as one of 15 missions in the US 2007 National Research Council Decadal Survey of Earth science missions that NASA should implement in the subsequent decade. Eventually, a joint programme was initiated between space agencies in the US (NASA) and France (CNES) with co-funding from the Canadian Space Agency and the UK Space Agency.

SWOT in space

The spectacular night-time launch of a SpaceX Falcon 9 rocket from Vandenberg Space Force Base finally delivered SWOT into orbit on 16 December 2022.

The huge 2,000kg satellite flawlessly executed the complex unfolding of its 15m solar array and twin radar antennas, separated by a 10m boom shortly after launch.

Then followed a tense few months of engineering commissioning as the multitude of systems were each in turn powered up and tested. Finally, the revolutionary Ka-band Radar Interferometer (KaRIn) completed its 90-day calibration and validation phase (Cal/Val) in early July 2023.

SWOT adopted an initial orbit during the intensive Cal/Val phase that allowed a fixed set of 15 ground tracks to be scanned every day for 90 days. The Cal/Val phase delivered SWOT data to a multitude of ground-truth campaigns around the world, while providing unprecedented insight about the high variability of the ocean at daily and sub-daily timescales. In July 2023, SWOT moved to its science orbit to deliver global coverage every 21 days.

Early results... show that SWOT has already met its performance target for open ocean applications

The first SWOT data was distributed in autumn 2023 to the SWOT science team, made up of selected scientists and engineers from around the world. At the time of writing, activities focus on comparing and validating SWOT measurements with other data from in situ sensors, models and other satellites. Early results presented at the International Science Team conference in Toulouse in September 2023 show that SWOT has already met its performance target for open ocean applications, vastly exceeding the expected performance of the mission, and opening up large numbers of new applications – particularly in coastal, estuarine and sea ice environments. ■

Dr Paul Bell joined the National Oceanography Centre in Liverpool in 1992. He is leading the UK contribution to the global validation effort for SWOT, funded by the UK Space Agency and the UK Natural Environment Research Council.