High Tech as Collaps Prevention

Traffic Monitoring with Radar

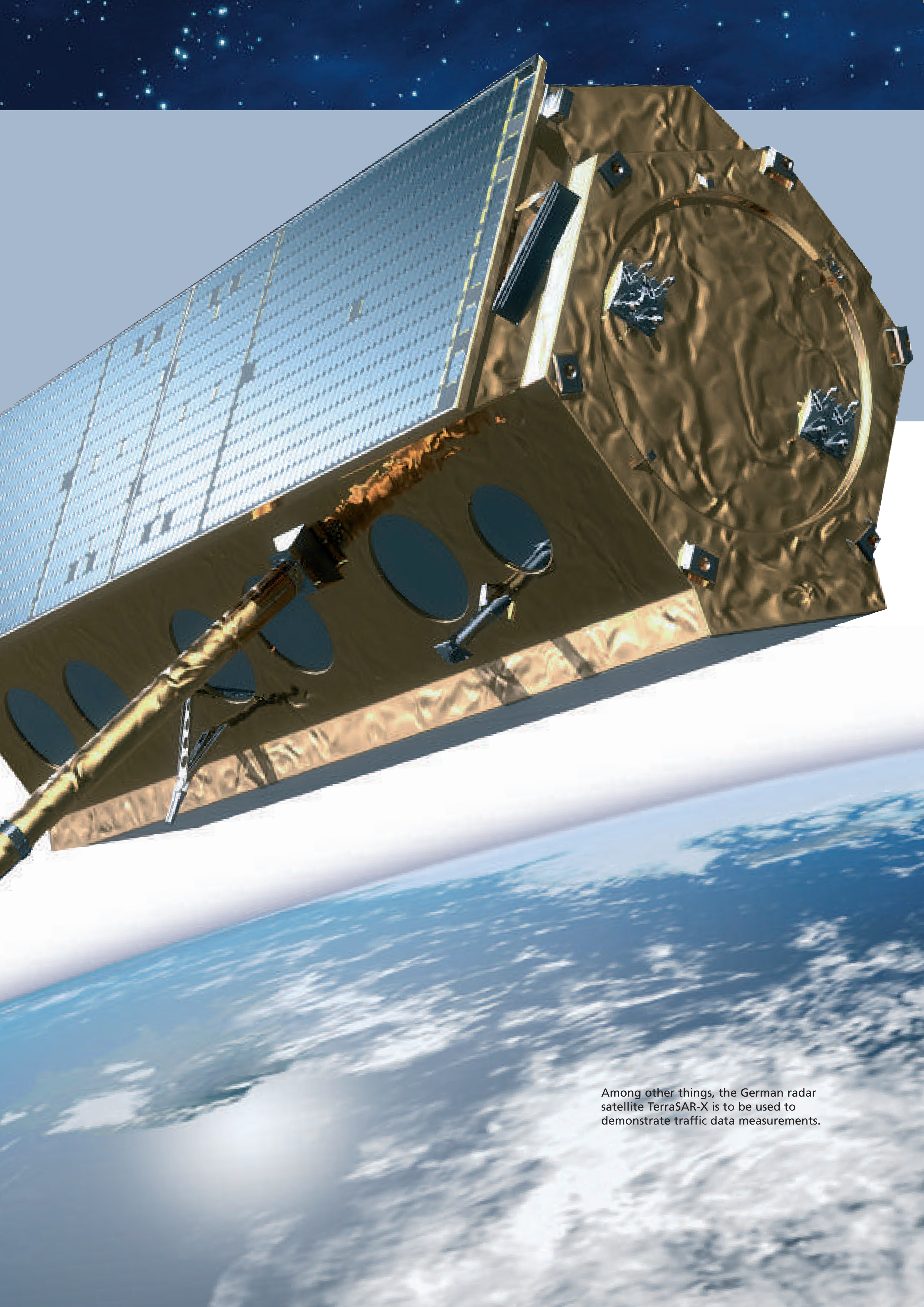
By Dr.-Ing. Karl-Heinz Bethke and Hartmut Runge

The word "infarct" is increasingly making the headlines and it is often not related to a medical diagnosis. Traffic, and primarily road traffic, is the issue at heart. While this may be a somewhat clumsy comparison, as is the case with all comparisons, the two references nevertheless have one factor in common: In order to be able to counter an impending infarct, the warning signs must be recognized in good time: bottlenecks, weaknesses in the overall system, capacity overloads. Monitoring the heart region in isolation will not suffice.

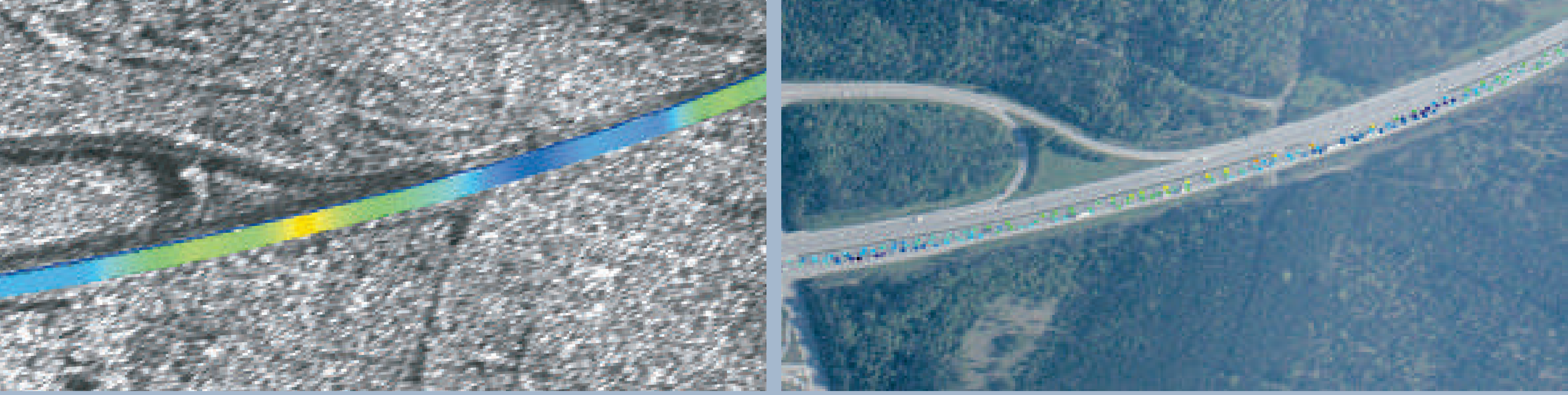
Information about traffic is generally obtained using permanently installed sensors (induction loops in the road surface) and cameras on bridges. However, wide-scale and seamless coverage of the road network is not possible using this approach. The picture of the actual traffic situation thus remains fuzzy, with signs of developing traffic jams failing to be identified. Things start getting dangerous when there is insufficient information for emergency rescue services regarding the navigability of the roads and when emergency services have problems in reaching the emergency site. Not to mention the unnecessary costs, loss of time, and carbon dioxide emissions that are created by traffic jams.

A promising solution exists in the use of "Floating-Car-Data," which, however, is not available everywhere. But a complete overview of traffic developments can only be obtained from high altitudes, in other words, with aircraft or satellites. DLR has access to both.

The catch is that as the height increases, the visual quality deteriorates. There is also the issue of traffic during the hours of darkness. Sensors that function in the visual optical field are dependent on sunlight. Infrared systems cease to work when it rains. Only radar technology can guarantee functionality in all environmental conditions, regardless of whether during the daytime or nighttime, with precipitation or heavy clouding. Radars work as active sensors and illuminate the scene with microwaves. The so-called Synthetic Aperture Radar (SAR) has established itself for large-scale and high-resolution images. This type of sensor is fitted on the DLR research aircraft Do 228 and on the German remote sensing satellite TerraSAR-X. Moving objects can be detected with a radar sensor and their direction and speed can be ascertained.



Among other things, the German radar satellite TerraSAR-X is to be used to demonstrate traffic data measurements.



Aircraft-supported traffic data measurements on the A96 near Munich using a radar (left) and camera (right)

The simultaneously recorded E-SAR radar data and series images of a digital camera reveal a traffic jam in front of a construction area during the morning rush hour. With the two systems, the exact length of the traffic jam was able to be ascertained at 1.3 kilometers and the traffic jam speed was recorded from the air. Although the radar and camera image exhibit different mapping geometries, it can be easily verified that the measurements tally with each other. The currently required time to pass through the traffic jam was able to be calculated from the radar data as 3 minutes and 53 seconds. In the image, an "accordion effect," which is typical of a traffic jam, can be identified: The speed of the vehicles, which can be read from the color coding, varies in a wave-like pattern.

By comparing with an earlier image ("Change Detection" process), it is even possible to map changes in the traffic infrastructure, for example, roads that have become impassable due to land slides or floods.

In addition to TerraSAR-X, DLR has the aircraft radar system E-SAR at its disposal and will soon have the new development F-SAR for demonstrating new technologies and applications for road traffic.

In both systems, the radar transmits laterally to the flight direction via its antenna. Depending on the flight altitude, the ground area covered measures several kilometers in width from the aircraft and up to several hundred kilometers in width from the satellite. The radiation which is reflected from the ground and from traffic vehicles is received by two to up to four antennae. They are located behind each other in the direction of flight and assigned to separate receiver chains. From the radar data, a two-dimensional image is created of a locally covered scene for each reception channel. The static image background can be eliminated by taking the difference between the different channels. This ensures that only the moving object is detected.

If there are more than two channels available, as is the case with F-SAR, the exact location of the vehicle can be ascertained in addition to the speed and the traffic on entire road networks can be depicted.

The newly developed radar F-SAR flies on a Dornier Do 228 and is an experimental SAR. The diverse settings options require a radar operator that operates the radar devices. The collected measurement data then need to be read and processed on the ground before it is made available for traffic analysis. As part of the DLR project ARGOS, the further development of hardware and software is being driven ahead so that fast data processing will be already enabled on-board and data can be transmitted from the aircraft to a ground station.

The Dornier Do 228 as a carrier platform for the F-SAR: The antenna system is attached in a radome under the tail of the aircraft.

The experiences here will then be used to develop a concept for a compact, lightweight and cost-effective radar sensor, which will be implemented in the medium-term in an operational system. The measurement data will then be able to be processed in real-time and transmitted to a control center. The system would then also be able to be used on small aircraft independent of the Do 228 or even on high-flying unmanned platforms such as so-called HALE aircraft (High Altitude Long Endurance) at an altitude of 20 kilometers.

New, high performance analysis processes are currently being developed. They will be designed to use the diverse technical possibilities that the F-SAR offers in order to achieve more precise results than have so far been possible. F-SAR will demonstrate what potential aircraft-carried SAR has for applications in transport and here, in particular, in crisis and catastrophe scenarios. On 15 June 2007, the German radar satellite TerraSAR-X was successfully launched. Just a few days later, the first high-resolution radar images were able to be analyzed.

F-SAR radar and operator in action on the Dornier Do 228

All results to date confirm the outstanding quality of the satellite and the ground segment developed at DLR. Although the satellite is still in the test phase for the standard modes, the first images have already been able to be made in a special mode for along-track interferometry (ATI). In this, moving objects, such as vehicles, can be detected and their speed measured. Unlike location-bound sensors on the ground, large-scale speed measurements are possible with the satellite procedure with a scene area of typically 1500 square kilometers. Through the high flight speed of the satellite, this area can be covered in just seven seconds.

As soon as the ATI imaging methods for traffic data collection with TerraSAR-X have been authorized for operation, the achievable precision and the detection rate will be investigated in detail through further experiments. The aim is to generate traffic parameters in virtually real-time for traffic information systems, for transport research, and emergency management. In addition to precise traffic jam lengths, travel times in congested traffic will also be ascertained on selected road sections. The system can cover the entire surface of the earth, making worldwide measurements possible. In central Europe, every area can be recorded almost daily, in Northern Europe even several times a day. Through a cooperation partnership with the Canadian space agency CSA the Radarsat-2 satellite can also be used, more than doubling the time coverage rate. Thanks to the installation of a traffic computer directly in the TerraSAR-X ground station in Neustrelitz, North of Berlin, it can be guaranteed that traffic information is available a short time after the satellite has flown over the area.

TerraSAR-X has been designed as a remote sensing satellite for a multitude of applications and was not specially developed for measuring traffic. It serves to demonstrate this new application. With the aid of the experiences gained, future radar satellites will be able to fulfill this task even better.

A large-scale overview of traffic developments will then be provided. State of the art radar technology, which is currently finding its way into traffic data collection, makes this possible. With the F-SAR, DLR has at its disposal a platform for developing entirely new radar concepts. With the TerraSAR-X satellite, traffic data can be gathered around the world for the first time in all weather conditions. The challenge for the future lies in developing lighter radar devices for high-flying stratospheric aircraft, which continually monitor traffic and road conditions over conurbations or catastrophe areas.

This would provide up-to-date, precise, and reliable traffic information that would make it easier for road users to decide whether to wait in the traffic jam, circumnavigate the traffic jam, change to public transport, or rather postpone the journey. Regardless of what course of preventative action is chosen, the risk of a traffic infarct can certainly be reduced.

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