TanDEM-X: “Cutting Edge” Technology at DLR Oberpfaffenhofen

Launch of TanDEM-X

“**The successful launch** of the TanDEM-X satellite (TDX) signifies the importance of space research as a firm building block of our technological development program of Germany” said Parliamentary State Secretary of the Federal Ministry of Economics and Technology, Peter Hinze at the launch of TDX.

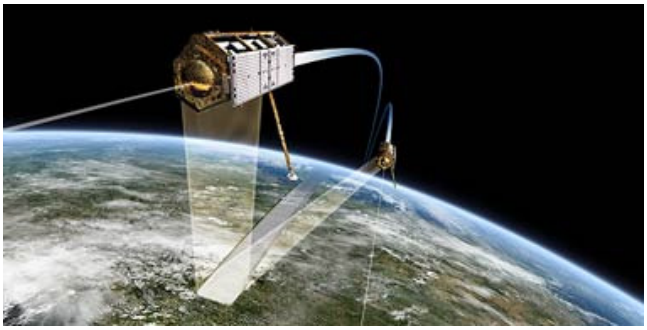
Germany's second Earth observation satellite, TanDEM-X, was launched as planned on 21 June 2010 at 04:14 Central European Summer Time (CEST, at 08:14 local time) from the Baikonur Cosmodrome in Kazakhstan. Atop a Russian Dnepr rocket, the satellite, weighing more than 1.3 tons and five metres in length, started its journey into orbit. At 4.45 CEST first signals were received via the ground stations Troll and O’Higgins in the Antarctic.

The German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt; DLR) manages the TanDEM-X mission (DEM-X = Digital Elevation Measurement using X-Band) now together with the TerraSAR (TSX) mission (first German Earth observation mission, launched on 15. June 2007) via its ground segment, and is responsible for mission operations and for generating and utilizing the scientific data. "TanDEM-X is a key German project and will provide us with a homogeneous 3D elevation model of the Earth which will be an indispensable aid for a great many scientific and commercial avenues of enquiry," said DLR Chairman Prof. Dr Johann-Dietrich Woerner at the launch event held in the German Space Operations Center (GSOC) at the DLR site in Oberpfaffenhofen. "This mission demonstrates Germany's expertise in satellite-based radar technology and is, in particular, the outcome of a consistent focus in the national space program. Also, TanDEM-X demonstrates a successful public-private partnership," stressed Prof. Woerner.

Public-private partnership

TanDEM-X is being run as a Public-Private Partnership (PPP) between the DLR and EADS/Astrium GmbH, with DLR funding coming from the German Ministry of Economics and Technology. Infoterra GmbH, a subsidiary of Astrium, is responsible for the commercial marketing of the TanDEM-X data. Astrium GmbH in Friedrichshafen built the satellite and is sharing the cost for its development and operation. The TanDEM-X mission cost amount to 165 million Euros. DLR’s share is 125 million Euros and the Astrium is contributing 40 million Euros.

TanDEM-X and its twin satellite, TerraSAR-X, will fly in formation



Together with its twin satellite TerraSAR-X, in space since June 2007, TanDEM-X will survey the entire land mass of the Earth from an altitude of 514 kilometers within three years.
"This will be the first time we will ever have had a globally standardized 3D digital elevation model of Earth, and with a measuring point density of 12 meters, it will be incredibly accurate," said Prof. Dr Alberto Moreira, Science Director of the TanDEM-X mission and Director of the DLR Microwaves and Radar Institute at Oberpfaffenhofen. Germany will be the first country ever to have a digital, three dimensional elevation model of Earth, making it a globally unique data product. This can be used in initiatives and programmes such as the ZKI (Center for Satellite-Assisted Crisis Information at DLR), GMES (Global Monitoring for Environment and Security) and GEOSS (Global Earth Observation System of Systems), and may also be incorporated in security-related cooperation treaties and agreements.

SpaceOps News (SoN) had the opportunity to talk to Dr. Martin Wickler (MW), Head of Satellite Mission Operations at DLR-GSOC:

SoN: TanDEM-X was launched exactly at equinox while TerraSAR-X was launched with a little offset to the equinox on 15. June 2007, what are the orbit peculiarities?
MW: Both satellites fly in a dusk-dawn orbit because of power supply considerations (optimized illumination of the solar array) and to be able to cover the Earth repeatedly from pole to pole. The TanDEM-X satellite will be maneuvered into very close vicinity (approx. 200 m) of TerraSAR-X to fly in formation to be able to take 3D profiles of the Earth. These manoeuvers will be performed in Oct 2010 finally.

SoN: It is possible for the first time to have a complete 3D model of the earth: Can new fields of applications be expected or will the 3D model just enhance the accuracy and the completeness?
MW: The TerraSAR-X and TanDEM-X measurements will be more accurate than those available so far and the total landmass of the Earth will be measured. So far only the SRTM-X/C mission provided equivalent data, however only between+-60 Deg because of the Shuttle’s orbital constraints. The accuracy will be increased by a factor of 5-10.
New applications are predictable, like for the DLR operated Center for Satellite-Assisted Crisis Information (ZKI) or for providing reference data for comparison before and after catastrophic events like floods or earthquakes.

SoN: Since TerraSAR-X was run under a PPP arrangement already: What is the experience with the commercial market and how is the interface with strategic demands outside Germany, i.e., what mechanisms exist to make sure the provided information is not “misused”?
MW: TerraSAR’s operator is GSOC, the marketing of the data is divided between DLR and the commercial company Infoterra, Germany (ITD), a subsidiary of EADS/Astrium. Data for scientific purposes are distributed by DLR, data for commercial purposes is marketed by ITD. The operations of the satellite as well as the distribution of the data is regulated by a German satellite data security law, the “Satelliten-Daten Sicherheits-Gesetz” (SatDSiG). That means the satellite operator has to make sure that all commands to the satellite can not be corrupted by a third parties and the data distribution units are forced by this law to make security checks on the trustworthiness of its customers. In some cases the data can be withheld for some days before

released.

SoN: A recent SpaceNews (Vol. 21, issue 24) issue is postulating a conflict between France and Germany with respect to technology developments of high-resolution optical Earth observation satellites (a French domain) and radar imaging satellites (a German domain) and a possible fusion of optical and radar pictures. Any comments from a TerraSAR-X, TanDEM-X point of view?
MW: This conflict is not relevant for TSX and TDX since both satellites deliver radar data for scientific and commercial purposes only.

SoN: How efficiency driven is the private/institutional interface between DLR and EADS? What are the contractual arrangements?
MW: The financial contribution shares of ITD are regulated in a memorandum for the execution of the project, the so called “Durchführungs-Vereinbarung”. The financial amounts IDT has to transfer to DLR depend on the quality, volume and timeliness of the data.

SoN: Any indications with respect to customer satisfaction from the TerraSAR-X experience so far?
MW: The total production chain from ordering of a data product, the mission planning/commanding efficiency of the satellite, the actual data taking and the data processing and delivery was recently investigated and evaluated by the National Geospatial-Intelligence Agency (NGA) in comparison with the performance of the Cosmo-Skymed and RadarSat satellites. TerraSAR-X was rated best.
The quality of the products as well as the service of the ground segment is decisive also for ITD: In specific urgent cases the system response time between ordering and delivery of a certain data take can be reduced to 3 hrs. In conclusion it could be said that the scientific users as well as the commercial clientèl is very satisfied with the provided quality and service.
The current planning of IDT is to finance the follow-on mission TSX-2 (planned for 2015) using the accumulated profit.

SoN: DLR has the unique advantage that the radar technology development group within the DLR Microwaves and Radar Institute as well as the image processing team (DLR-DFD) is on location – does this improve the operations efficiency as well?
MW: As mentioned before to have the end-to-end production chain on the premises is a unique feature. For operating the satellite it is very convenient to have the support of the instrument experts available on your fingertips. Especially during emergency situations a quick recovery can be guaranteed.

SoN: What kind of operational back-up provisions exist to guarantee continuous customer service?
MW: We have established different kinds of backups. All critical elements are one- or two-failure tolerant like data lines, antennas, command system, mission planning etc., each position of the operations team is covered by at least 4 resident experts and a catastrophic loss of the control center facility at Oberpfaffenhofen would be covered by a physically separate control center located at our antenna site at Weilheim, 50 km south of Oberpfaffenhofen.

SoN: If one of the two satellites would fail prematurely - does the project have a Plan-B?
MW: No, we expect both satellites to work during the entire mission period.

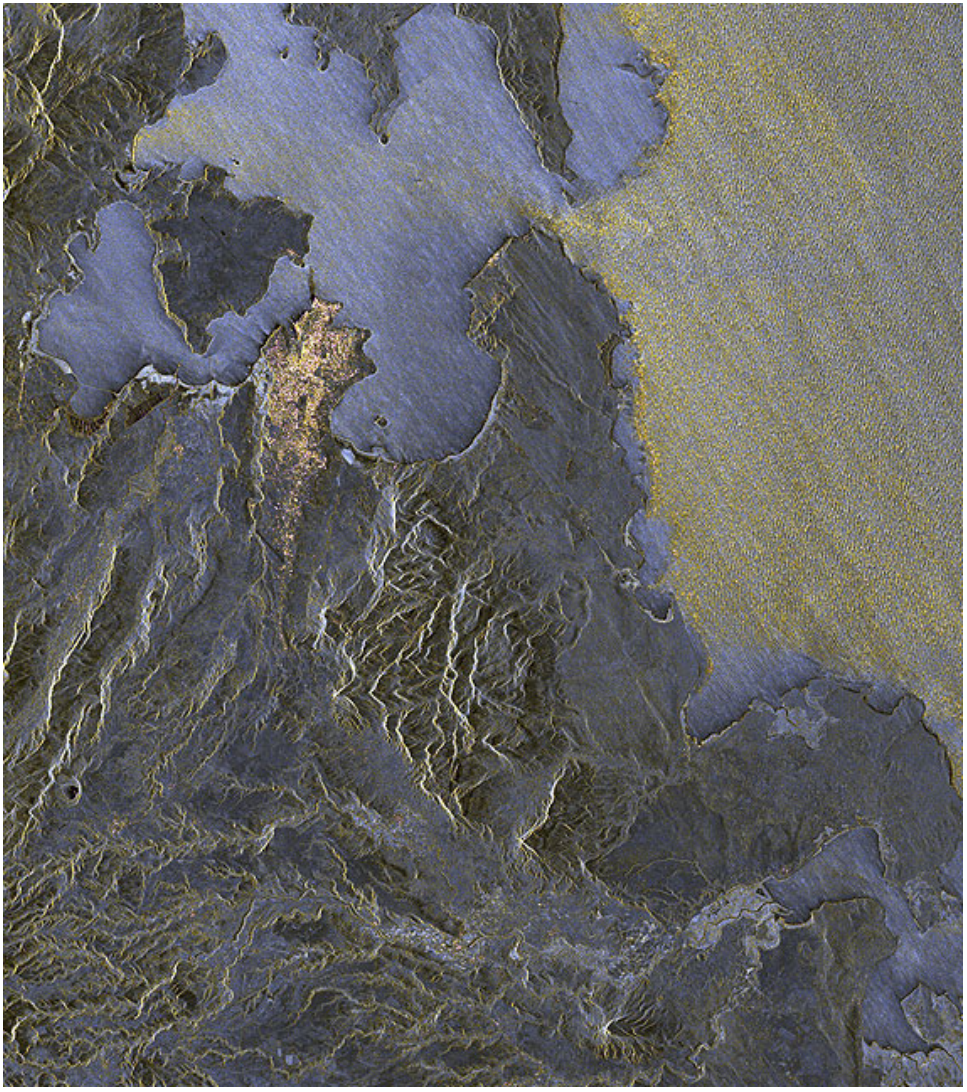
SoN: The German Ministry of Economics and Technology promised in a press release after the TanDEM-X launch that it would support the national satellite radar research program without any financial reductions despite it might be forced to reduce or freeze the ESA contributions because of the global financial crisis. What is the next development step to stay ahead of the technological and economic competition?
MW: There are a couple of activities which will be followed up in the future. For the commercial sector ITD has the obligation to continue the TerraSAR-X satellite series using its own revenue in case the radar market proves to be commercially successful (TSX-2) according to the PPP agreements.
The next generation of radar satellites will implement a technological quantum leap: The key word is HRWS (High Resolution, Wide Swath), i.e., the combination of highest possible resolution with a wider swath by applying the concept of “digital beam-forming”. Those activities are driven by the DLR-Agency.
A further improvement idea is move TanDEM-X to the L-Band (TanDEM-L). To discuss the possible advantages and applications realizing this idea would be outside the scope of this interview. The biggest challenge would be the spacecraft design (large antennas) and the handling of the enormous data volume. With this concept the total landmass could be charted within one week, while TanDEM-X needs approximately one year.

SoN: In conclusion could you tell us what the challenges for GSOC are to operate TerraSAR-X and TanDEM-X satellites?
MW: We have to face three challenges. Naturally the biggest challenge is flying the two spacecraft in the desired formation side by side with only 200 m apart which has never been realized before. The design features we have implemented onboard the spacecraft side and on the ground will allow us to complete the various formations within three years.
Another challenge is mission planning. To explain the situation: Only 10% of the time within a certain formation can be used for data takes, because this is the only time within a helix (i.e., within the intertwined orbits) where both satellites are flying right-looking side by side. The rest of the time will be used to take separate measurements, i.e., two separate missions for two satellites have to be planned, where each satellite can perform up to 500 data takes per day. Both missions are operated at GSOC within the so called multi-mission-environment, i.e., all Earth observation missions are operated by the same operations personnel. This concept yields very good financial synergies, however requires a very high flexibility within the team, vast relevant operational know-how and absolute dedication to the job of each team member.

As a result of this, the first TanDEM-X picture could be taken in record time on 24. June 2010 as verification of the instrumentation (picture see below), the first 3D pictures using TerraSAR and TanDEM-X data will be generated in October 2010 as part of the commissioning phase.

Madagaskar as seen from space

Even the ups and downs of the waves in the Indian Ocean – coloured pale yellow on the image – are charted by TanDEM-X as it flies over at a speed of seven kilometres per second. The change in the waves at the entrance to the Diego Suarez Bay is clearly visible. The water in the bay itself, on the shore of which the provincial capital, Antsiranana, can be recognised, is very flat – in contrast to the undulating ocean – and reflects the radar signals from TanDEM-X more uniformly. The area of valleys to the south drains the volcanic cone of Ambre-Bobaomby into the Indian Ocean.



TanDEM-X first image from space (Madagaskar): see more

Dr. Wickler, SpaceOps News wants to thank you for providing this inside information for the space operations community on this very successful project and good luck for the future projects TSX-2 and TanDEM-L .

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