The TerraSAR-X / PAZ Constellation: Operational Preparation

Katja Bach, Airbus Defence and Space, katja.bach@airbus.com, Germany
Hanjo Kahabka, Airbus Defense and Space, hanjo.kahabka@airbus.com, Germany
Fernando Cerezo, Hisdesat Servicios Estratégicos, fcerezo@hisdesat.es, Spain
Juan Ignacio Cicuendez Pérez, Hisdesat Servicios Estratégicos, jicicuendez@hisdesat.es, Spain

Abstract

The TerraSAR-X/PAZ Mission is a constellation formed by two independent missions. The operational TerraSAR-X Mission has been providing a wide range of products in various resolutions to commercial customers. It was joined by the PAZ Mission in early 2018; PAZ is currently in its commissioning phase. Together they will bring all the benefits of a true constellation to users: harmonized products and tasking/delivery procedures, higher revisit, joint direct receiving solutions. The mission is implemented by way of a partnership between industrial partners, namely Airbus Defence and Space, Germany and Hisdesat of Spain. It will cover a wide range of applications, ranging from Mapping, Change Detection & INSAR to Maritime, Intelligence and Emergency Applications. The TSX/PAZ mission is an excellent example of how two commercial partners work together, combining their assets for the benefit of the market and setting a new standard for the future WorldSAR constellation approach. This paper provides an introduction to the mission, an overview of the features and benefits of the constellation, and provides details of activities leading up to operational readiness.

1 Introduction

Airbus Defence and Space (ADS) and Hisdesat (HDS), the Spanish owner and operator of the PAZ radar satellite, have been working together to establish a constellation approach with TerraSAR-X and PAZ, enhancing a wide range of time-critical and data-intensive applications through shorter revisit times and increased data acquisition capacities. PAZ is a dual-use mission designed to meet operational requirements of both defence and civilian applications; it will be launched into the same orbit as the established TerraSAR-X Mission. For further information, please refer to [1].

With the TSX/PAZ Constellation, independent missions are working together for the benefit of users. The space and ground segments of each mission are operated independently while the commercial service segments of both missions are interconnected to provide combined product ordering and delivery. For Direct Receiving Station (DRS) Customers, upgrades to their existing stations are available to receive and process data from both missions. New customers can choose a DRS solution provided by either ADS or HDS; in any case, they can receive data from both missions.

The TSX/PAZ product portfolio consists of dedicated constellation modes for both missions, so users can seamlessly combine data from both missions, e.g. for the generation of InSAR stacks. Delivery of data is performed to the customer using the delivery mechanisms established for the respective mission. A joint pricing strategy exists, and invoicing for data from both missions is done by the partner that was approached by the user, either ADS or HDS.

By way of this constellation, the time from user request to delivery is significantly reduced for time-critical applications requiring rapid tasking, as the tasking is done for the satellite that has ‘first access’ over an area of interest. As a constellation, the mission covers a wide range of applications, ranging from Mapping, Change Detection & INSAR, Emergency Applications, Intelligence to Maritime [2], to name a few. Both missions also operate as Copernicus Contributing missions (CCM), providing data to Copernicus Users [3].

The constellation will enter commercial operations in 2018; it paves the way towards future generations of X-Band SAR Missions and ultimately, the WorldSAR Constellation.

2 Mission Setup

2.1 Constellation Orbit and Phasing

One of the objectives of the TSX/PAZ Mission from a market point of view is the ability to more quickly generate datastacks suitable for INSAR applications. Consequently, the PAZ satellite flies on the TerraSAR-X or-

bit, with an identical ground track, but a different phasing. The phasing of 98º anticlockwise from TerraSAR-X in the same orbital tube was selected because of the following benefits:

Interferometric revisit results in 4 and 7 days, so INSAR stacks can be built twice as fast than with one of the two missions alone;

The resulting timing between passes of TSX and PAZ over a ground receiving station varies between 26 and 69 minutes [4], thus allowing ground stations with only one antenna sufficient time between passes to set up the antenna in time to receive the second satellite. This is of particular relevance for Direct Receiving Customers.

This configuration results in a daily global revisit capability of the constellation (right and left looking mode).

2.2 Launch and Commissioning Phase

PAZ was launched into a near-polar, sun synchronous orbit on February 22, 2018 at 14:17 UTC on board a Falcon 9 from Vandenberg Air Force Base in California. by Hisdesat Subcontractor SpaceX. Launch and Early Orbit Phase (LEOP) under the responsibility of the Hisdesat Prime Contractor Airbus DS Spain was conducted by the German Aerospace Center (DLR) using the German Space Operations Center (GSOC) Facilities in Oberpfaffenhofen, Germany. The LEOP concluded nominally after a few days with a hand-over from DLR GSOC to the nominal ground control center at the National Institute for Aerospace Technology (INTA) of Spain,, located outside Madrid in the city of Torrejon. On March 8th, 2018, PAZ reached its final orbit location after a two-week orbit drifting phase. The SAR instrument was subsequently activated and the first acquisitions (Madrid and Barcelona) were commanded. On March 13th, the first PAZ image was successfully acquired, downlinked and processed, hence validating the tasking chain for the first time. The LEOP is followed by 3-6 months of in-orbit testing (IOT) of the spacecraft, the radar instrument, and further secondary payloads such as the AIS (automatic identification of ships) and the ROHP (radio occultation and heavy precipitation). The 'PAZ Only' commissioning phase of four months for spacecraft and ground segment will be followed by a TSX/PAZ Constellation commissioning phase of further three months during which several activities relevant for the constellation will take place: Enabling of the PAZ Ground Segment for the DRS Case, introduction of new modes Wide ScanSAR and Staring Spotlight and implementation of constellation harmonization measures.

This Constellation commissioning will also verify the capability of the Constellation Service Segments on both sides such that either ADS or HDS can submit orders to any satellite TSX/TDX or PAZ from their respective Ordering System.

2.3 Operational Considerations

A series of measures have been taken to align and harmonize between both missions, to allow a customer experience fully in line with a true constellation. They are described in more detail in the following chapters.

2.3.1 Constellation Modes and Imagery Products

As the TerraSAR-X Mission is already operational, the PAZ space- and ground segments have undergone an update of beam configurations and parameters for image commanding and antenna configurations to align imaging modes and thus enable consistent constellation imaging operations. Additional modes that were introduced to the TerraSAR-X Mission during operations are also added to the PAZ Mission (Staring Spotlight and Wide ScanSAR Modes) to extend the list of available constellation mode [4].

Furthermore, both TerraSAR-X and PAZ imagery products will have harmonized product structure and delivery formats and quality standards.

Both companies have also agreed to market the products at the same commercial price list and present one harmonized face to the customer through their respective commercial ordering systems.

2.3.2 Ordering and Tasking

The constellation operations are implemented by way of interconnectivity of commercial user segments, while the missions remain completely independent from one another: Mission Operations for TerraSAR-X remain in Germany, with the main receiving station Neustrelitz; the PAZ Mission is controlled from and downlinked to Torrejon as main receiving station. The commercial ground segments of both missions will be connected by means of electronic interfaces for data ordering, and the customer service teams of both organizations are closely coordinating everyday operations, aligning their policies and operational timing. The constellation features two planning runs per day and per mission, and the commercial order deadlines (2 per day) for both missions have been harmonized for the benefit of the customers. Despite all harmonization measures, transparency in terms of which satellite acquires a particular image is ensured for the customer. Also, the continuation of existing customer relationships can be ensured, as order

handling and invoicing responsibility remains with the partner originally contacted.

2.3.3 Delivery

A harmonized data delivery mechanism has been specifically developed for the constellation. Standard Customers (meaning those without their own direct receiving stations) will be informed of a data delivery via a delivery notification containing a link for download; depending on whether the delivery contains TerraSAR-X or PAZ data, the link actually points to a physically different customer delivery point. While seamless from a customer point of view, this method was established to avoid copying data from one physical location to the other before customer delivery, thus avoiding a potential time delay in delivery. Both push and pull mechanisms will be available for the customer.

In summary, the 'constellation experience' manifests itself in a way that first, an existing TerraSAR-X customer will be able to continue using all established ways of ordering (e.g. email, using the TerraSAR-X order workstation) and secondly, the Hisdesat user segment will also offer an harmonized entry point to the constellation for customers. With the start of commercial constellation operations, any proposals and deliveries will potentially contain scenes from both missions.

2.3.4 Direct Access Solutions

Customers requiring near real time access will have the option of owning a joint direct access solution for quick access to data from both missions. Part of Airbus Defence and Space's portfolio includes a multi-mission infrastructure which can seamlessly integrate both radar and optical sensors in one processing, value-adding and distribution environment. This multimission infrastructure has the capability to process TerraSAR-X, TanDEM-X, SPOT and Pleiades satellites and after successful constellation commissioning will also be capable to receive and process PAZ data. Likewise, Hisdesat will offer its own multi-mission terminal to jointly receive and process data from both TSX and PAZ satellites, including also an exploitation environment for value added products.

Both solutions enable direct receiving customers to directly process data from both missions in their local infrastructure. The data can be decrypted immediately after reception and is processed to L1B Products, giving the benefit of a very short delivery time for data received over their local area of interest. As the joint Processor implemented in DRS is developed by DLR, a consistent product quality can be ensured.

Encrypted systems in both missions assure only the customer who orders the product can receive it, decrypt it and process it to obtain the product, no other Direct Receiving Station owner can process although their coverage cones intersect.

A copy of the TerraSAR-X and PAZ mission data accessed by customers via the multimission direct access capability would be repatriated to the respective ground segments.

3 Conclusions

The TSX/PAZ constellation is the blue print of a first of its kind coordinated constellation concept amongst X-Band SAR satellites. In principle, it can be expanded to include additional SAR Missions towards a WorldSAR Constellation. It provides more value for customers, and is unique in the industry for Earth observation in terms of new and innovative ways of collaboration and constellations.

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References

[1] Fernando Cerezo: *PAZ and TerraSAR-X constellation, innovation through international cooperation*, Special Invited Session, 11th European Conference on Synthetic Aperture Radar (EUSAR), Hamburg, Germany 2016.

[2] Wolfgang Koppe et al.: *Benefits of TerraSAR-X – PAZ Constellation for Maritime Surveillance.* Proceedings of the 10th European Conference on Synthetic Aperture Radar (EUSAR), Berlin, Germany 2014.

[3] Katja Bach et al.: *TerraSAR Advancements & Next Generation Mission Capabilities supporting GMES/Copernicus.* Proceedings of 'ESA Living Planet Symposium', Edinburgh, UK, 2013.

[4] Sahil Suri et al.: *TerraSAR-PAZ Constellation: Collaboration, Innovation and a Blue Print for the Future*. Proceedings of the International Aeronautical Conference, Toronto, Canada 2014.