PNOTS

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1. INTRODUCTION

1.1 OBJECT

The purpose of this document is the publication of the first Announcement of Opportunity of Scientific Exploitation of PAZ products, called Launch of the PAZ Science Phase.

This document presents the PAZ system, the characteristics of PAZ products and the types of requests available to the users as well as the Opportunity Announcement and its submission and execution procedure.

1.2 SCOPE

This document is addressed to all scientific users of the PAZ mission, being a public document.

2. REFERENCE DOCUMENTS

	Document	*Reference*	*Date*
RD-1	Commissioning Phase Report. Product Definition. Juan M. Cuerda, Jan-19	PAZ/INT/CALVAL/RPT/002	09/01/2019
RD-2	Resolución 420/38287/2018, de 8 de noviembre, de la Secretaría General Técnica, por la que se publica el Convenio entre el Instituto Nacional de Técnica Aeroespacial «Esteban Terradas» e Hisdesat Servicios Estratégicos, SA, para la realización de actividades científicas durante la misión del satélite Paz. Publicado en BOE viernes 23 de noviembre de 2018. Resolution 420/38287/2018, of November 8, of the General Technical Secretariat, publishing the Agreement between the National Institute of Aerospace Technology "Esteban Terradas" and Hisdesat Servicios Estratégicos, SA, for the realization of scientific activities during the mission of the Paz satellite. Published in BOE Friday, November 23, 2018.	BOE Núm. 283 Friday, November 23, 2018. Sec. III. Pág. 113917	23/11/2018

Table 1. Reference document

3. ACRONYMS

Acronym	*Meaning*
AO	Announcement of Opportunity
CEIT	Space Center INTA - Torrejón
CESAEROB	Center for Aerospace Observation Systems
DEM	Digital Elevation Model
EEC	Enhanced Ellipsoid Corrected
EULA	End User License Agreement
GEC	Geocoded Ellipsoid Corrected
HS	High Resolution Spotlight
HR	High Resolution
INTA	National Institute of Aerospace Technology
LEOP	Launch and Early Operations Phase
MGD	Multi Look Ground Range Detected
PNOTS	National Program for Earth Observation by Satellite
RD	Reference Document
RE	Radiometrically Enhanced
SAR	Synthetic Aperture Radar
SE	Spatially Enhanced
SM	Stripmap
SL	Spotlight
SSC	Single Look Slant Range Complex

4. PAZ MISSION

PAZ mission is the radar element of the National Program for Earth Observation by Satellite (PNOTS) for the development, operation and exploitation of space sensors for Earth observation by developing and operation of the observation satellites PAZ and INGENIO, with radar and optical payloads, respectively.

The space segment of PAZ mission is owned by Hisdesat Servicios Estratégicos S.A., also mission operator, and its main payload is a synthetic aperture radar (SAR) operating in X-band at 9.65GHz with up to 300Mhz of bandwidth and configurable operating modes from the ground segment.

The PAZ ground segment is property of INTA, responsible for its development and maintenance, and is deployed in three centers:

- The Space Center INTA - Torrejón (CEIT), where the systems that integrate the nominal operation center are located.
- The Defence Users Center, located in the Center for Aerospace Observation Systems (CESAEROB) of the Air Force.
- The Backup Center, containing the backup systems for the critical functions of flight operations, located in the Canary Space Center of INTA in Maspalomas (Canary Islands).

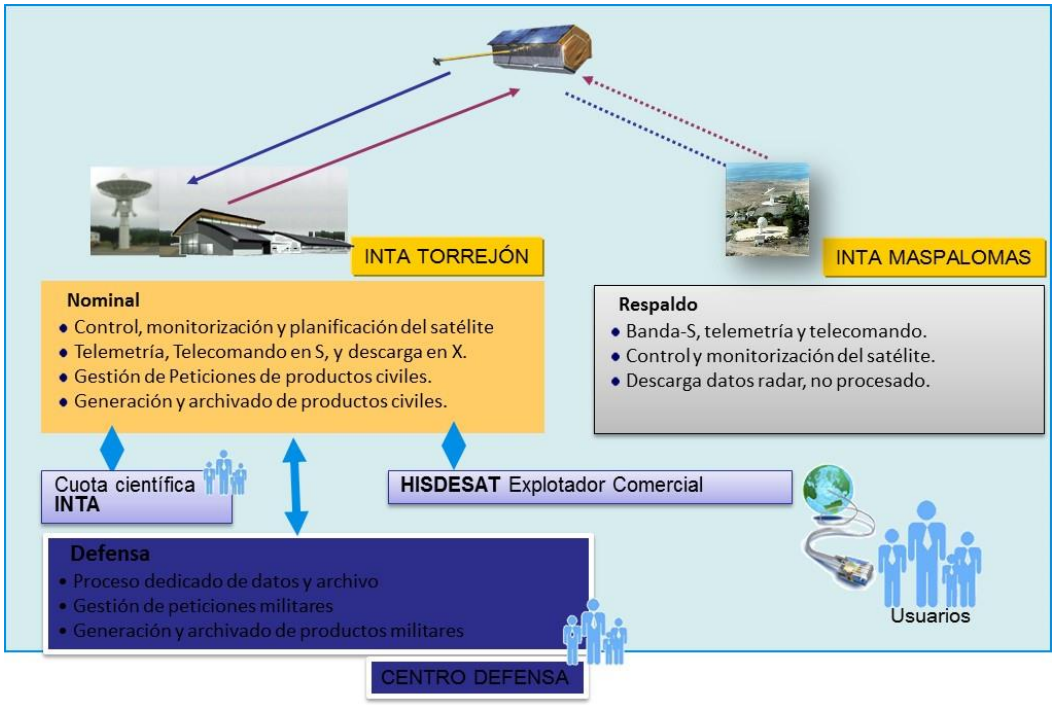

Figure 1. PAZ Ground Segment

The PAZ satellite was launched on February 22nd, 2018 from Vandenberg (California) onboard a Falcon 9 rocket. After the initial LEOP phase, the commissioning phase began on April 3rd, extending 5 months until September 6th, when the system was officially declared operational.

The operational declaration also implies the beginning of science activities of PAZ mission, responsibility of INTA.

4.1 ACQUISITION MODES

The versatility of PAZ system allows its operation in different acquisition modes that define the coverage and resolution of the resulting image products.

Currently, available PAZ imaging modes are:

- Stripmap: elevation and azimuth beams are fixed during the acquisition time. It provides a compromise between coverage and resolution.
- ScanSAR: an electronic antenna elevation steering is used to switch between swathes with different incidence angles to provide greater coverage with coarse resolution.
- Spotlight: this mode uses beam steering in azimuth direction to increase the illumination time, increasing the resolution at the expense of reducing the coverage of the product.
- High Resolution Spotlight: variant of Spotlight mode increasing the resolution.

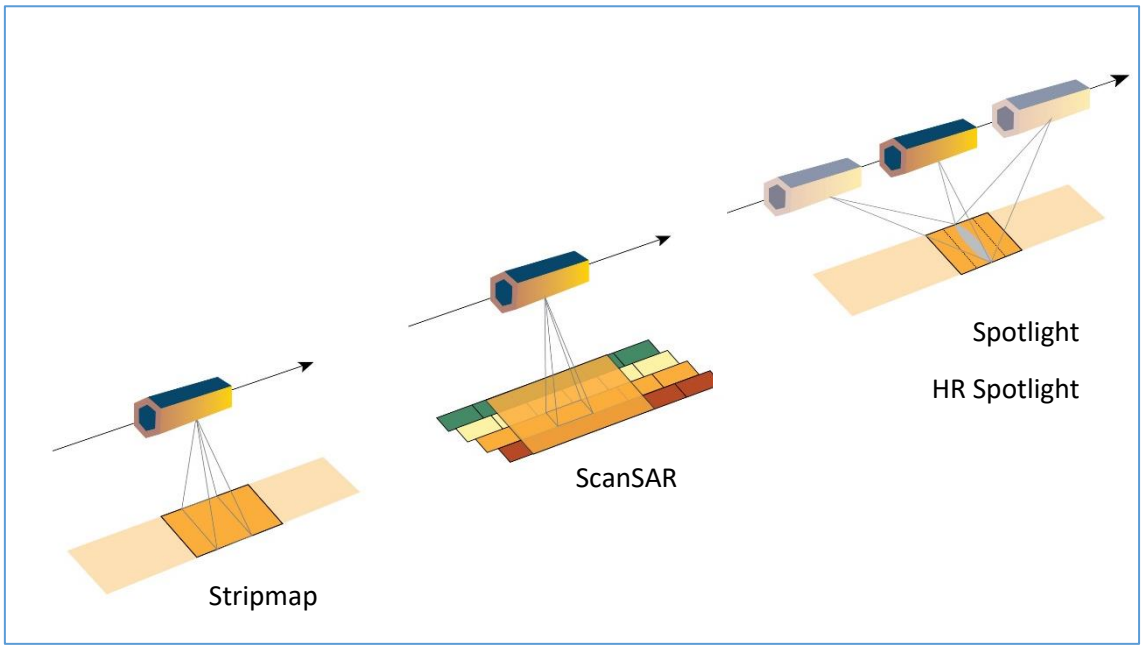

Figure 2. PAZ imaging modes

The raw data resulting from the acquisition is processed in the Ground Segment to obtain the basic PAZ products (or L1B level products) that will be delivered to the users. The performances of PAZ image products depend on the imaging mode as can be seen in Table 2.

Imaging Mode	Polarization		Standard Product Size[a] [Km]	Slant range resolution [b] [m]	Azimuth resolution[c] [m]	Incidence angles	Bandwidth [MHz]
Stripmap	Single	HH VV	30x50	1.76 / 1.1[c]	3.01	20-45º	100/150
	Dual	HH/VV HH/HV VV/VH	15x50	1.18	6.04	20-45º	150
ScanSAR	Single	HH VV	100x150	-	17.66	20-45º	150
Spotlight	Single	HH VV	10x10	1.18	1.46	20-55º	150
	Dual	HH/VV	10x10	1.17	3.10	20-55º	150
High Resolution Spotlight	Single	HH VV	10x5	0.60	1.05	20-55º	300
	Dual	HH/VV	10x5	1.17	2.16	20-55º	150

Table 2. PAZ image modes performances

[a] Km [Range x azimuth]

[b] SSC

[c] 100MHz /150MHZ.

4.2 PAZ BASIC PRODUCTS

4.2.1 L1B Products Processing Levels.

PAZ basic products are defined as four types of L1B level products, equivalent to those provided by the TerraSAR-X and TanDEM-X systems:

- Complex products.
    - SSC Products - *Single Look Slant Range Complex*. Product with image data in complex format, with amplitude and phase information. Not available for ScanSAR image acquisition.
- Detected products.
    - MGD Product - *Multi Look Ground Range Detected*. Product projected to ground with square resolution cells and speckle noise reduction.
    - GEC Product - *Geocoded Ellipsoid Corrected*. Product resampled and projected in the reference ellipsoid WGS84, using an average height.
    - EEC Product - *Enhanced Ellipsoid Corrected*. Orthorectified product, with DEM compensation of the distortions due to ground elevation.

In detected products (MGD, GEC and EEC) the user can also select a processing variant oriented to improve either ground resolution or radiometry:

- SE resolution variant - Spatially Enhanced. Variation to obtain the best ground square resolution in the field. Not available for ScanSAR.
- RE resolution variant - Radiometrically Enhanced. Variation for radiometric optimization, with additional speckle noise reduction.

Furthermore, Standard (Rapid) or Fine Precision (Scientific) orbit precisions can be selected for all basic products, achieving finer localization precision at the expense of the latency in the generation of the image product.

Orbit product	Orbit product precision (3D rms)	Image product latency
Rapid Orbit	2 m	≈ 24 hours after the satellitepass
Science Orbit	10 cm	≈ 3 days after the satellite pass

Table 3. Orbit products for PAZ product generation

4.3 USER REQUESTS

PAZ users can perform three types of system requests:

- Data acquisition requests:
    - This type of request implies the programming of the satellite to perform an acquisition with the characteristics desired by the user, including the area of interest and the time period in which the user demands the data acquisition to be executed, as well as the image mode (Stripmap, ScanSAR, Spotlight or High Resolution Spotlight) and the desired processing level (SSC, MGD, GEC or EEC).

- Processing requests:
    - This request allows to obtain a product with a specific processing level from a past acquisition existing in PAZ catalogue.
- Dissemination requests:
    - Request for an existing product in the mission catalogue.

5. PAZ SCIENTIFIC EXPLOITATION

The BOE of November 23, 2018 includes the Agreement between the National Institute of Aerospace Technology "Esteban Terradas" and Hisdesat Servicios Estratégicos, SA, for the realization of science activities during the mission of the satellite PAZ, starting on January 1st of 2019.

This Agreement includes the establishment of a quota for the use of the PAZ satellite of 5 daily acquisitions by INTA for its scientific use. All the acquisitions will be property of HISDESAT and a final use license will be provided to INTA. The distribution of images to third parties will include the License Agreement with the End User (EULA) that HISDESAT provides.

According to this Agreement, PAZ Scientific Exploitation is oriented to the implementation of a system for the use of PAZ image products with a scientific objective and the promotion of SAR technology and its applications to national and international entities dedicated to research.

The primary objectives of the scientific exploitation of PAZ are:

- Development of new methods, techniques and algorithms for the processing of L1B products and SAR calibration.
- Data fusion, considering image products from different spaceborne or airborne SAR sensors and images from optical sensors.
- Exploitation of product, such as:
    - Development of applications to expand the use of PAZ products, with special emphasis on those oriented to crisis management.
    - Use of the polarimetric and interferometric capabilities of PAZ.
    - Application of PAZ products to monitoring, including urban areas, land cover and vegetation and hydrological resources, among others.
    - Obtention of derived parameters from PAZ L1B products.

6. PAZ SCIENCE TEAM

PAZ science team (paz-ciencia) is the working team of INTA in charge of the promotion, coordination and execution of the scientific exploitation of PAZ. It is composed of scientists from PAZ Ground Segment and INTA PAZ Calibration and Validation group, as well as experts in Remote Sensing and Space Programs of INTA.

PAZ Science team tasks are:

- Prepare the scientific objectives of the PAZ mission.
- Promote the scientific use of PAZ, through the opportunity announcements, working groups and specific congresses.
- Prepare opportunity announcements and evaluation criteria.
- Receive the proposals, evaluate, send the result of the evaluation to the investigators.
- Introduce scientific requests in PAZ systems, follow up and deliver products to users.
- Receive and disseminate scientific studies, publication of summaries and results.

7. ANNOUNCEMENT OF OPPORTUNITY: LAUNCH OF PAZ SCIENCE PHASE

7.1 ANNOUNCEMENT OF OPPORTUNITY

According to RD-2, scientific exploitation of PAZ will be developed, generally, through the publication and execution of Opportunity Announcements.

This section, Announcement of Opportunity (AO): Launch of PAZ Science Phase, is the first call to use the PAZ image products with scientific objectives.

Interested investigators are invited to respond to the announcement by means of proposals that define the scientific work to be carried out. For those projects approved, they will receive the PAZ products of L1B level agreed according to the definition contained in the proposal.

This AO is defined as a general purpose one, with the main objective of bringing the PAZ products to the scientific community to carry out projects that match to the general objectives of scientific exploitation of PAZ. Because of that he objectives of the scientific proposals should be in line with the general objectives of the scientific activities of PAZ presented in section 5 of this document.

Research projects shall have a duration from 1 to 3 years. If justified, an extension of this period can be considered.

Likewise, Launch of PAZ Science AO also tries to present the research works to the entire scientific community, publishing the summaries and reports resulting from the execution of the AO projects, as well as related papers at INTA PAZ Science Activities website:

http://www.inta.es/WEB/paz-ciencia/en

The proposals shall identify the scientific purpose of the use of the PAZ products used, which will be provided at no cost. The working teams will have to have their own funding sources that allow the execution of the project during the entire duration of the project.

7.2 AO PROCEDURE

This section specifies the steps to be followed from the publication of the announcement of opportunity to its execution and completion. Along with each of the steps, the initiator of the activity is indicated, as well as the deadline for execution.

- Publication of the AO (INTA). [18.02.2019]
- Proposals submission. (Principal Investigator). [Deadline 03.June.2019]
    - An email confirming the reception of the proposal will be sent to the PI email (INTA).
- Evaluation of Proposals (INTA) [Deadline 15.July.2019]
    - Period of error correction of errors of the proposals (if needed, interaction INTA-Principal Investigator)
    - Approval of the Proposals-
        - A confirmation mail notifying the approval of the proposal together with the instructions to sign the license of use will be sent to the Principal Investigator (INTA).
        - Signature of the license of use (Principal Investigator).
- Execution of the scientific project for approved proposals
    - Insertion of the approved acquisitions in the PAZ Ground Segment. Delivery of the resulting products (INTA). [According to date of acquisition of the products]
    - Delivery of the project progress report (Principal Investigator). [In a semester basis after the proposal approval]
    - Submission of publications (Principal Investigator). [Throughout the execution of the project]
    - Delivery of the final project report (Principal Investigator). [Start of the project + 12/36 months]
- Declaration of the End of the Development of the project. [Start of the project + 12/36 months]. The establishment of an extension may be agreed to continue with the project.

7.2.1 Presentation of proposals and evaluation

- Proposals that respond to an Opportunity Announcement will be sent to INTA via PAZ-Science Activities website (http://www.inta.es/WEB/paz-ciencia/en/announcement-of-opportunity) or by email to paz_ciencia@inta.es in the terms established in section 7.2.
- All proposals received within the period identified in the announcement will be evaluated by the scientific committee of PAZ. The result of the evaluation may be:
    - **Approval**. It means the start of the project, with the signing of the license agreement with the end user (EULA), which confirms:

- The intention to execute the project.
- The availability of funding to carry out the project.
- The work team that will work on the project, including their CVs.
- Acceptance of the terms and conditions to receive the data.
- Acceptance of the quantity of products to be provided and the method of delivery.
- Acceptance of publishing results.
- Acceptance of the use of the data according to the terms and conditions stipulated in the use agreement.

If necessary, specific agreements may be established between INTA and the institution.

- **Denial**. In case the proposal does not meet the evaluation criteria.
- **Rectification of errors of the proposal**. In this case INTA will communicate to the Principal Investigator the information needed and a re-evaluation will be performed.

7.2.2 Procedure selection

- The INTA science team will review all the proposals received in response to each announcement of opportunity. The support of specialists may be required.
- The purpose of the review is to evaluate the proposals technically to ensure that they fulfil the selection criteria:
  - Proposals meet to the objectives of the scientific Exploitation of PAZ.
  - The investigators do not have a commercial purpose.
  - The projects manifest an innovative nature.
  - It is established a work plan and working team clear and convenient to achieve the project objectives.
  - The proposals define viable datatake acquisitions, not having conflicts with commercial or national security interests.

7.2.2.1 Proposals Template

Proposals may be prepared in Spanish or English, in Word or pdf format.

The proposals must contain the sections required in Table 4. The omission of the required information may imply the non-approval of the proposal. The scientific team may request the correction of errors after the reception of the proposal.

1. Identification of the project
• Title of the project. • Scientific objective (150 words). Summary formulation of the project objective. • Description of the geographic area of interest in which the acquisition (s) of data takes is required. (It is a geographical identifier of the area of interest: for example, the coast of Cádiz). • Duration of the project (12-36 months).
2. Project description

• Executive summary (500 words), including the objectives of the research work, main points and milestones (It would be published on the web portal of scientific activities)
• Description of the research team, identifying:
  • The Principal Investigator (including contact e-mail) and other members, including CV and structure of the organization.
  • Financing source, which ensures the viability and execution of the project.
• Definition of the contribution of the project to the objectives of the scientific mission PAZ.
• Definition of expected results and publications.
• Definition of the project duration. Identification of the expected delivery dates of progress and final reports.
• Initial description of the image products requested, including:
  • Justification of the number of products requested
  • Detailed definition of the area of interest (specific coordinates), time range of the acquisition.
  • Justification of temporary limitations related to the acquisition period (for example, the need for the acquisition to be made in a specific season of the year or the need for a data collection to be acquired with certain periodicity).

3. Definition of the PAZ products required
For each requested product: • Identification of the datatake acquisition characteristics:

○ Area of interest, coordinates (latitude / longitude) of the center of the scene or coordinates of the polygon of interest. ○ Range of dates of interest. As far as possible, the demand for specific dates will be avoided, with the indication of months or range of months of interest being preferable. ○ Imaging mode (SM / SC / SL / HS) ○ Satellite path (ascendant / descendent / indifferent) ○ Polarization • Single (HH / HV / VV) • Dual (HHVV / HHHV / VVVH) ○ Incidence angle (Full performance / 15º-60º) • Processing options: ○ Geometric correction (SSC / MGD / GEC / ECC) ○ Resolution type for detected products (SE / RE) ○ Orbit Type (Rapid o Scientific)

Table 4. Proposal template

7.2.3 Scientific Project Execution

Once the approval of the proposal has been communicated, the principal investigator will proceed to sign the user license, starting the execution of the project begins.

- INTA will publish in the PAZ Science Activities website the executive summaries of the approved projects.
- INTA will prepare and submit in PAZ Ground Segment the acquisition requests defined in the approved proposal.
    - The scientific user will be informed of the date in which each requested datatake collection will be acquired. In the event that the acquisition interferes with the commercial requests or security objectives of the mission, an alternative date will be provided.
    - The resulting PAZ products will be disseminated to the Principal Investigator via ftp (TBC) or an alternative procedure.
    - The principal investigator will send INTA the progress and final report (a progress report every six months)
    - Progress and final reports will be published on the PAZ Science Activities website.

- The publications made in the framework of the scientific project will be sent to INTA for its knowledge.

Once the scientific project is completed, its continuation can be considered through an Extension of the Project or by means of responding to a new AO. PAZ products shall not be used once the project is finished.

7.2.3.1 Progress and final report template

The Principal Investigator shall prepare and submit to PAZ Science the semestral progress report and the final report.

The reports may be prepared in Spanish or English, in word or pdf format, and must contain, at least, the sections required in Table 5. Progress and final report template

<table>
<tr><td>1. Report identification</td></tr>
<tr><td>• Tittle of the project.
• Principal Investigator.
• Type of report (progress / final).</td></tr>
<tr><td>2. Summary (1000 words)</td></tr>
<tr><td>•</td></tr>
<tr><td>3. Description of PAZ products used (1000 words)</td></tr>
<tr><td>•</td></tr>
<tr><td>4. Detailed information (12000 words)</td></tr>
<tr><td>5. Resulting images of the executed project (JPG, TIFF, PDF format)</td></tr>
<tr><td></td></tr>
<tr><td>6. Publications (Resulting publications at the report delivery date. They will be attached to the report).
<table><tr><th>Publication tittle</th><th>Filename</th></tr><tr><td></td><td></td></tr></table></td></tr>
</table>

Table 5. Progress and final report template

8. CONTACT

For any question related to the Opportunity Announcement or to the process of delivering proposals, evaluation and execution of science projects, you can contact with PAZ science coordinator:

María José González Bonilla

INTA. Instituto Nacional de Técnica Aeroespacial.

Carretera de Ajalvir km 4, 28850, Torrejón de Ardoz, Madrid.

Email: paz_ciencia@inta.es

Phone: 91 520 17 04

ANEXO A. PARAMETERS PAZ ACQUISITION REQUESTS

- Localization. Area of Interest definition (Country, Region, City, ...)
- Central Coordinates expressed in Latitude /Longitude (decimal degrees).
- Desired acquisition dates range.
- Imaging Mode: Stripmap, ScanSAR, Spotlight, High Resolution Spotlight (also Staring Spotlight and Wide Beam ScanSAR when available).
- Polarization
    - Single: HH, VV
    - Dual: HH/VV, VV/VH, HH/HV
- Flight direction
    - Ascending or Descending Orbit Direction
- Processing Level:
    - SSC
    - MGD
    - GEC
    - EEC
    - EEC con GIM
- Processing Variant:
    - Radiometrically Enhanced (RE)
    - Spatially Enhanced (SE)
- Orbit Type:
    - Rapid Orbit
    - Scientific Orbit