External Calibration Activities

PAZ Mission CALVAL Centre

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OUTLINE

Introduction
   CALVAL In Flight Test Plan

External Calibration Activities
   Antenna Pointing Validation
   Antenna Pattern Validation
   Geometric Calibration
   Radiometric Calibration
   Polarimetric Calibration

Test Approaches. Tools and workspace
EXTERNAL CALIBRATION ACTIVITIES

Features to be Tested

- Antenna Pointing
- Antenna Pattern Verif.
- Geometric Calibration
- Radiometric Calibration
- Polarimetric Calibration

External Calibration

- Design of Test Cases
- Geometric Calibration
  - Elevation Pointing via Rain Forest DTs
  - Azimuth Pointing via Transponder
- Antenna Pattern:
  - Elevation Pattern verification
  - Azimuth Pattern verification
- Abs. and Relative Radiometric Accuracy
  - Absolute Calibration Factor
  - Absolute Radiometric Accuracy
  - Relative Radiometric Accuracy
- Radiometric Stability
- Channel Imbalance
- Channel Cross Talk
- Phase Pattern Validation
- Internal Delay Calibration
- Systematic Azimuth Shift

DT Start Time Characterization

DATA TAKE PLAN. POINT TARGET DEPLOYMENT

13 DTS OVER CORNER REFLECTOR PER CYCLE

Imaging Mode: Cycles 1-7
- HS-D: 1
- SM-S: 6
- SM-D: 4
- SL-D: 2

Imaging Mode: Cycles 8-10
- HS-D: 4
- SC: 2
- SL-S: 2
- SL-D: 2
DATA TAKE PLAN. RAINFOREST ACQUISITIONS

- 6 elevation notch Amazon
- 2 elevation notch Cameroon
- 4 ScanSAR
- 4 Strip dual
- 10 Strip single
ANTENNA POINTING VALIDATION

Elevation pointing with Distributed target with stable σ^0 acquisitions:

Antenna elevation pointing by imaging with elevation Notch.

8 planned DTs per Cycle
- 6 elevation notch Amazon
- 2 elevation notch Cameroon

Avoiding conflict with pattern verification data takes.
Only Tx Notch pattern.
Ascending and descending.
H and V.

Azimuth pointing by Azimuth notch pattern record with INTA ground receiver under development.
ANTENNA PATTERNS VALIDATION

PAZ Antenna reference pattern main purpose: reference patterns used and corrected by PAZ processor.

Will allow efficient instrument relative and absolute calibration:
  Reduce number of beams to be in-orbit verified.
  One calibration constant per mode and polarization approach.

Validation criteria defined to be consistent with relative and absolute radiometric accuracy requirements.

**Shape comparison** to comply with system relative radiometric accuracy

**Beam to beam gain variation** to comply with absolute radiometric accuracy:
  Gain variation respect average gain of full performance beams.
ANTENNA PATTERNS VALIDATION OVER DISTRIBUTED TARGETS

Elevation validation with distributed targets with stable $\sigma^0$ acquisitions:
Antenna elevation shape verification by DTs over rainforest.
Antenna peak gain to gain verification by DTs over rainforest.

First Cycle planned DTs
• 4 ScanSAR
• 4 Strip dual
• 10 Strip single

Second Cycle plan ongoing:
• Increase ScanSAR and Strip dual beams
• Reduce strip single

Beams measured in 2 cycles: Scan03-05-07-09
Strip04-08-13
StripNear05-Near13-Far21

Azimuth pattern shape validation with INTA Ground Receiver under development.
Antenna Patterns Validation over Distributed Targets

Tools and procedures tested with PAZ-TDX campaign Dataset

Strip Beam shape verification
StripNear07 HH-VV

Scan Beam shape and beam to beam gain verification
Scan08 HH

Long term Statistical analysis
A verification of the assumptions with respect to the antenna model accuracy is also made using corner reflector measurements.

**Elevation Antenna Pattern Beam Shape characterization.**
Characterization of absolute calibration factor in near, mid and far ranges within the swath. Standard deviation gives a relative radiometric accuracy value.

**Elevation Antenna Pattern Beam Gain characterization**
Gain offset applied in different beams is verified with mid-swath reflectors measured as a function of look angle.
RADIOMETRIC CALIBRATION

When Absolute Calibration factor can be considered independent of the position within the swath and the look angle used (radiometric budget compliant), following outputs can be extracted from all measurements over corner reflectors:

Absolute Calibration Factor = mean(absCalFactor)
Absolute Radiometric Accuracy = std(absCalFactor)
Relative Radiometric Accuracy = mean(std(absCalFactor)(per L1B))
Geometric Calibration

Pixel Localization Accuracy

Pixel Localization Accuracy
Range: -1.079 m
Azimuth: 0.0852 m

Pixel Localization Accuracy
Range: -32.917 m
Azimuth: 0.0852 m
Pixel Location Accuracy

Range Location:

Displacement = error_in_t * c/2

Error Characterization:
  Systematic delays induced by CE
  Polarization Channel
  Rx Bandwidth

Azimuth Localization:

Displacement = error_in_t * Vs

Error Characterization
  Systematic Azimuth Shift in time

*Pixel Location Accuracy* (Azimuth shift, Internal Delay, InternalDeltaDelay)
**Internal Delay:** Round trip difference from geometry slant range and from the Annotation SAR image slant range.

Internal Delay = $\tau_{\text{geometric}} - \tau_{\text{annotated}}$

**Azimuth Shift:** Radar time and Orbit time difference in azimuth.

Azimuth Shift = $t_{\text{annotatedGPS}} - t_{\text{orbitGPS}}$

**Pixel Localization Accuracy Along Track** [target; mean; std]:

$$(t_{\text{annotatedGPS}} - t_{\text{orbitGPS}}) \times v_{\text{sat}}$$

**Pixel Localization Accuracy Across Track** [target; mean; std]:

$$(\tau_{\text{geometric}} - \tau_{\text{annotated}}) \times c / 2$$
CALIBRATION OF POLARIMETRIC PAZ SAR DATA

- **Estimated Polarimetric Parameters**
  - Channel Imbalance (Amplitude and Phase)
  - Cross Talk

- **Tools**
  - **L1B Parameters Analysis Tool:** Statistical measurements results for all the L1B Products in LTDB which match the selected filter criteria.
  - **PolSAR analysis Tool:** Manual step by step analysis.

- **Data**
  - Dual-pol acquisitions containing corner reflectors and an active calibrator with different incidence angles from near to far range.
CALIBRATION OF POLARIMETRIC PAZ SAR DATA

Channel Imbalance

Cross Talk
WORKFLOW

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PAZ Mission

L1B PRODUCTS

LTDB

<query> CR products By ingestionTime

L1B PRODUCTS LIST

DTID

<create_workspace>

Analysis Workspace

CALIBRATION
POINT TARGETS
FILES

L1B Products

<copy>

L1B PRODUCTS

<xCAL file>

<xCAL params>

<xCAL params>

<xCAL file>

LTDB

<xCAL params>

LTDB

<create_workspace>

LTDB

<query> xCAL params

PROCESSING TOOL

AUXILIARY PRODUCT
UPDATE

ACTUAL INSTRUMENT
PARAMETER
L1B ANALYSIS TOOL
L1B ANALYSIS TOOL