DORIS signal integrity monitoring and control
DORIS signal integrity monitoring
What is it? (1)

- Reminder: DORIS system is based on accurate measurements of the Doppler shifts on a radiofrequency signal

- The signal:
  - Dual frequency: 401.25MHz; 2.03625GHz
  - Transmitted by DORIS ground stations
  - Received on-board satellites by DORIS instruments

- Besides the signal
  - Beacons transmit system data
  - Especially master beacons (broadcast upload)

⇒ Without a consistent ground beacon network the DORIS system cannot reach its full performance
DORIS signal integrity monitoring
What is it ? (2)

■ To ensure the capability of the Doris system to carry out its mission, we have to monitor and maintain the network availability and measurements quality
  => DORIS signal integrity monitoring

■ Doris involvement in missions and performance required are always increasing
  ⇒ This monitoring has become crucial

■ A DORIS integrity team has been in charge since 2005

■ 2 main parts of the work described today:
  ◦ Maintain beacon network availability and signal quality
  ◦ Check the consistency of information transmitted to instruments
DORIS beacon network monitoring

Daily monitoring
Weekly monitoring
Long term investigations
Objective:

- **Control the beacons’ status**
  - With respect to several parameters

- **Detect any major problem on the network**
  - Transmission interruption, signal degradation…

- **First investigations and actions**
  - Information request to host agency
  - Corrective action definition and application
DORIS beacon network global status

Permits to detect major defaults:
- Beacon transmitting erroneous data or in a non nominal mode
- Non received beacons
- Low power level beacons
DIODE navigator: first customer of DORIS signal
- Calculates a real time orbit sensitive to almost any perturbation

=> DIODE quality index used to detect noisy measurements
  - Unexpected peaks are analysed.
  - Once the default identified, corrective actions are defined and performed

Cibinong beacon example:
- 2 peaks observed at the beginning of March on Jason 2
- Default identified: USO anomaly (degraded stability)
- Beacon shut down, new beacon sent to replace it
DORIS beacon network monitoring

- Daily monitoring
- Weekly monitoring
- Long term investigations
Weekly monitoring

■ Objective:
  ▶ Identify trends or upcoming degradation
  ▶ Anticipate default in order to fix it before a strong impact

■ Crosscheck of several reception statistics calculated over the same 1 week period
DORIS instrument statistics

Statistics giving the network status from the instrument point of view
Based only on instrument telemetry data

allows:
- To check instruments programming and processing
- To detect upcoming transmission default (loss or quality degradation)

Measurements reception w.r.t. instrument programming

Quality of received measurements:
Measurements validity on the two channels
Ground processing statistics

Statistics (maps) giving the network status from ground processing’s point of view
Provide information about measurements quality
2 maps available:

- **MOE map**
  Beacons plotted function of the MOE results on their measurements

- **Technological map**
  Based on measurements quality w.r.t. technological criteria (consistency between the two channel, power level, transmission mode…)

### Réseau MOE
(semaine 27 : du 04/07/10 au 10/07/10)

### Réseau DORIS-DIODE
(semaine du 01/08/10 au 07/08/10)
Balance 1.1 et 2.0 sont toujours en blanc ou noir
Link budget analysis

**Principle**

- Power level measured on-board is compared to a theoretical power level
- Discrepancies are plotted as a function of elevation for each beacon

![Graph showing link budget analysis](image)
DORIS beacon network monitoring

Daily monitoring
Weekly monitoring
Long term investigations
Long term investigations (1)

■ **Objective:**
  - Evaluate Doris site quality

■ Quality analysed with respect to
  - Power level,
  - POE residuals

■ Analysis over a long period (at least 6 months of data)

■ Illustrated via geographic maps

■ Cf. article “Impact of DORIS Ground Antennas Environment on Their Radio Signal Quality”
P. Yaya and C. Tourain; Advances in Space Research Volume 45, Issue 12, 15 June 2010
Long term investigations (2)
Greenbelt example

Pylon disturbing DORIS signal

Power level attenuation

POE residuals

Pylon suppressed from DORIS antenna environment

2 GHz
DORIS system processing monitoring
Objective

- Besides radiofrequency signal, DORIS beacons transmit information
- Especially master beacons transmit broadcast uploads:
  - Station coordinates
  - Time links data

- These data are important for DORIS real-time processing and performance.
  - Error in these data can imply (slight) accuracy degradation of real-time products

=> Monitoring of DORIS instrument processing
  - To detect any impact of erroneous data
Software report monitoring

- Reports generated by the instrument and transmitted via DORIS telemetry
- “Instrument talking to us”

- Gives the status of both:
  - DORIS on-board software
  - DIODE software

- Operational monitoring allows us:
  - To follow the behaviour of software.
  - To detect inconsistency in data transmitted by the beacons
On-board time determination monitoring

- DIODE navigator performs a time tagging used for platform application and measurements dating
- Process based on time links data transmitted by master beacons
  ⇒ On board time tagging accuracy directly linked to the accuracy of these data
- Consistency of these data is essential

Before upload: Time link data accuracy assessment

After upload: onboard time tagging performance monitored operationally

Drift or jumps are tracked to readjust time links if needed
Summary

- Monitoring and analysis described previously were set:
  - To simplify and accelerate detection of defaults,
  - To identify possible improvements on the network.

- DORIS integrity team have now reached a high level of efficiency
  - Network availability: always over 75% since 2005 (mean 85%)
  - Reactivity: defaults are mostly detected and corrected before they impact users
  - Quality:
    - low-quality Doris stations are identified
    - some of them have already been improved in collaboration with installation and renovation team

- Work still on-going
  - Reactivity: remote control (Iridium) of DORIS beacon under deployment
  - DORIS site quality: continued effort to find quality factors and any source of improvement