Spectrum Monitoring for ADS-B & MLAT

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What are the Issues on 1030/1090 MHz frequency band?

- 1030 MHz (SSR interrogation channel) and 1090 MHz (SSR reply channel)
  - **Used by multiple systems**: SSR, Airport / Wide Area Multilateration systems, ACAS/TCAS, IFF, ADS-B, TIS-B, and sometimes even DME crosstalk
- 1030 MHz Load: **Over-Interrogation**
  - can send XPNDR into permanent suppression → no XPNDR reply or broadcast
- 1090 MHz Load
  - Channel Access Method is "Aloha" (Ethernet: bandwidth used by >30% leads to packet collisions)
    - **Synchronous garbling** (synchronous replies),
    - **Fruit** – unsynchronized messages overlapping each other
    - **Stronger signals can destroy weaker signals**
  - Systems have limited "de-garbling capability" → loss of detection @ receiver

EASA Report-ED0.1-2014-ed04.00, December 3, 2014 stating in recommendation No. 3 that:

"**Member States ensure that the use of the 1030/1090 MHz frequency band is monitored and recorded**. ..."

EASA Recommendation: Monitor & Record Use of 1030/1090 MHz

- Determine Channel load
  - Number of Targets present
  - Number of signals on both channels
  - Characterize the signal mix by signal type (to identify the associated source)
  - Characterize the signal distribution in time and space
  - If possible, identify or even locate the source of any overload
  - Everywhere throughout operational airspace

» All the above is **very challenging or not feasible in full**

» **Essential if** surveillance capabilities are to be **expanded to drones**

Options to determine Channel load

1. Measure inside Aircraft
2. Measure on Ground
3. Simulate Radio Load
4. Record Interrogations and Replies using existing Surveillance Sensors
5. RF Analyzer Tool (Eurocontrol)

Options to determine Channel load

1. **Measure inside Aircraft**
   - Accurately reflects what this aircraft is exposed to while airborne (except when the aircraft transponder, its TCAS or its DME is transmitting itself)
   - Can only be measured while aircraft is operating (temporary spot check)
   - May miss specific events (Murphy's Law)
2. Measure on Ground
3. Simulate Radio Load
4. Record Interrogations and Replies using existing Surveillance Sensors
5. RF Analyzer Tool (Eurocontrol)

Options to determine Channel load

1. Measure inside Aircraft
2. **Measure on Ground**
   - Provides RF load as seen from the ground only
   - Can be monitored continuously – also detect individual peak events
   - No blanking/suppression due to TX activities
   - General long term also visible
   - If multiple receivers are used – determine position of signal source using TDOA
3. Simulate Radio Load
4. Record Interrogations and Replies using existing Surveillance Sensors
5. RF Analyzer Tool (Eurocontrol)

Options to determine Channel load

1. Measure inside Aircraft
2. Measure on Ground
3. **Simulate Radio Load**
   - Can be calibrated to match current measurements
   - Can consider all kinds of systems including military and experimental
   - Past and future scenarios can also be predicted
4. Record Interrogation Activities and Replies using Surveillance Sensors
5. RF Analyzer Tool (Eurocontrol)

Options to determine Channel load

1. Measure inside Aircraft
2. Measure on Ground
3. Simulate Radio Load
4. **Record Interrogations and Replies using existing Surveillance Sensors**
   - Can visualize effect of all interrogations
     (SSR: Sector avg. fruit level, WAM: all raw data received)
   - Can be used to precisely determine own contribution to spectrum load as transponder occupancy time
   - Misses other interrogation sources completely
5. RF Analyzer Tool (Eurocontrol)

Options to determine Channel load

1. Measure inside Aircraft
2. Measure on Ground
3. Simulate Radio Load
4. Record Interrogations and Replies using existing Surveillance Sensors
5. **RF Analyzer Tool (Eurocontrol)**
   - “Video recorder” logs the entire RF (I/Q) of both channels for some time
   - SW tool visualizes contents
   - Supports manual/semi-automated analysis of contents
   - Special training needed, time consuming
   - Can give full insight into specific cases and anomalies

How to…

Combination of Methods?

- Ground Monitoring
- Airborne Monitoring
- Simulations

What is readily available for ground through recording Tool, real time Statistics, embedded Oscilloscope and Spectrum Analyzer:

- Spectrum load Measurement on ground
- Simultaneous recording 1030 and 1090 MHz
- Permanent Signal Extraction and Statistics
- Record Interrogations and Replies using existing Surveillance Sensors

Monitoring Application

- Continuous logging of extracted Mode S raw data (uplink and downlink)
  - Both channels synchronized
  - Both channels determine signal level
- 1090 ES ADS-B decoding
- Extracting number of targets (separately Mode S, ACAS and ADS-B)
- While Mode 1/2/3A/C replies and interrogations can be also detected by design, the false alarm rate is relatively high (hence the WAM system is using correlation to interrogation patterns)
- Future Applications
  - TDOA for Mode S Interrogators

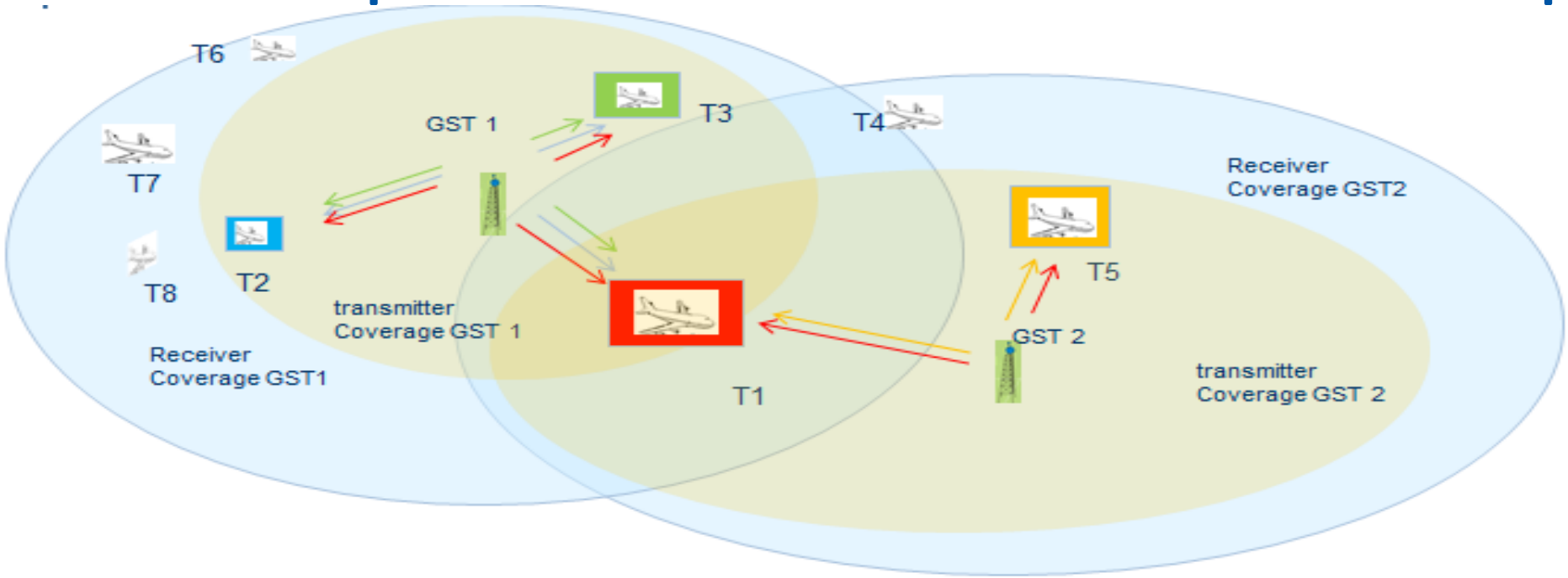
Other Features: Detect Transponder anomalies

- Erroneous data content
- Not replying to some interrogations
- Protocol Issues
- ADS-B issues
- ACAS/TCAS Issues

Thales tool : Evaluation Time of Occupancy

- Tool reads interrogation and reply logfiles and configuration data from a WAM system and estimates the transponder occupancy time generated by the WAM system for each transponder in coverage
- The tool considers
  - the actual interrogation activity (time, destination, interrogation type),
  - the actual position of all transponders in range,
  - the actual position and coverage of involved interrogators,
  - the tool estimates a worst case transponder occupancy time based on the maximum blocking times defined by ICAO ANNEX 10 Volume IV.

Thales tool : Principles for Evaluation “Time of Occupancy”

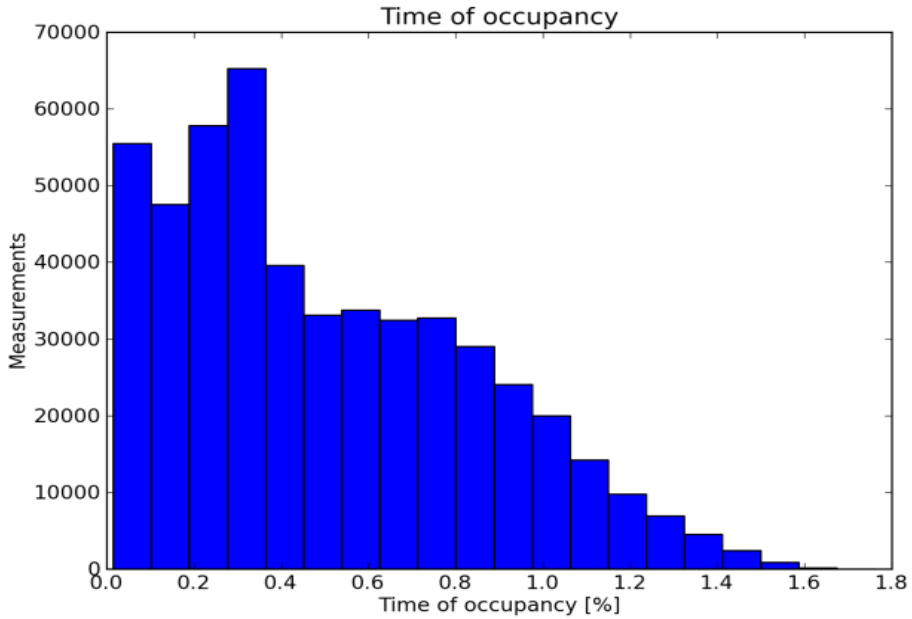


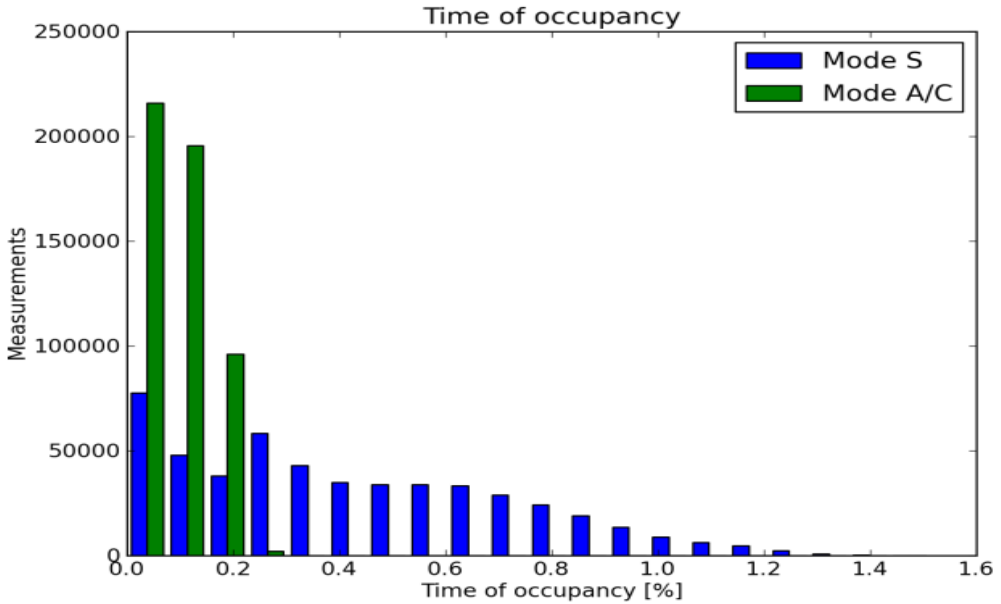
- Target T1 is inside Transmitters GST1 and GST2 coverage.
- Target T1 receives roll call interrogations from T1, T2 ,T3 and T5

An estimation of „Time of Occupancy“ for one target for the overall system is the sum of time of occupancy for each TX.

Thales tool : Output for “Time of Occupancy”

- Showing the distribution of transponder occupancy times (averaged across a 10s interval) for all targets during the entire configurable measurement period
- Capable to aggregate transponder occupancy time generated by other WAM and MLAT systems in pre-defined input format





THANK YOU