Operational Results and Standardization Issues of Wide Area Multilateration Systems for Civil Air Traffic Control Purposes

Heinz Bartacek, Werner Langhans, Christian Scheiflinger, Bernhard Wolfmayr, Johann Zemsky
Austro Control GmbH

Helmut Schreiber
Graz, Univ. of Technology

ICNS Conference May 2-5, 2005

Agenda

- Wide Area Multilateration Systems
- Innsbruck TMA Situation
- Certification Methodology
- WAM Innsbruck System and Performance Tests
- Standardization Process & Issues
- Outlook and Conclusion

Wide Area Multilateration Systems

- WAM is a Cooperative, Independent Surveillance System
- Based on well known TDOA principle with multiple ground stations (with or without interrogator)
- Advantages
  - High update rate, no rotating antenna (comp. to SSR)
  - Lower lifecycle costs (comp. to SSR)
  - Independent from airborne navigation data and use of existing Mode A/C/S – transponders (beside others) (comp. to ADS-B)
- Disadvantages
  - Accuracy depends on time-synchronization
  - Many ground-sites needed (with reliable data-links), number depends strongly on topography

WAM System for Surveillance in Non-Radar Airspace

in the Terminal Area Innsbruck, Austria

austro CONTROL

Operational Results and Standardization Issues of
Wide Area Multilateration Systems for
Civil Air Traffic Control Purposes

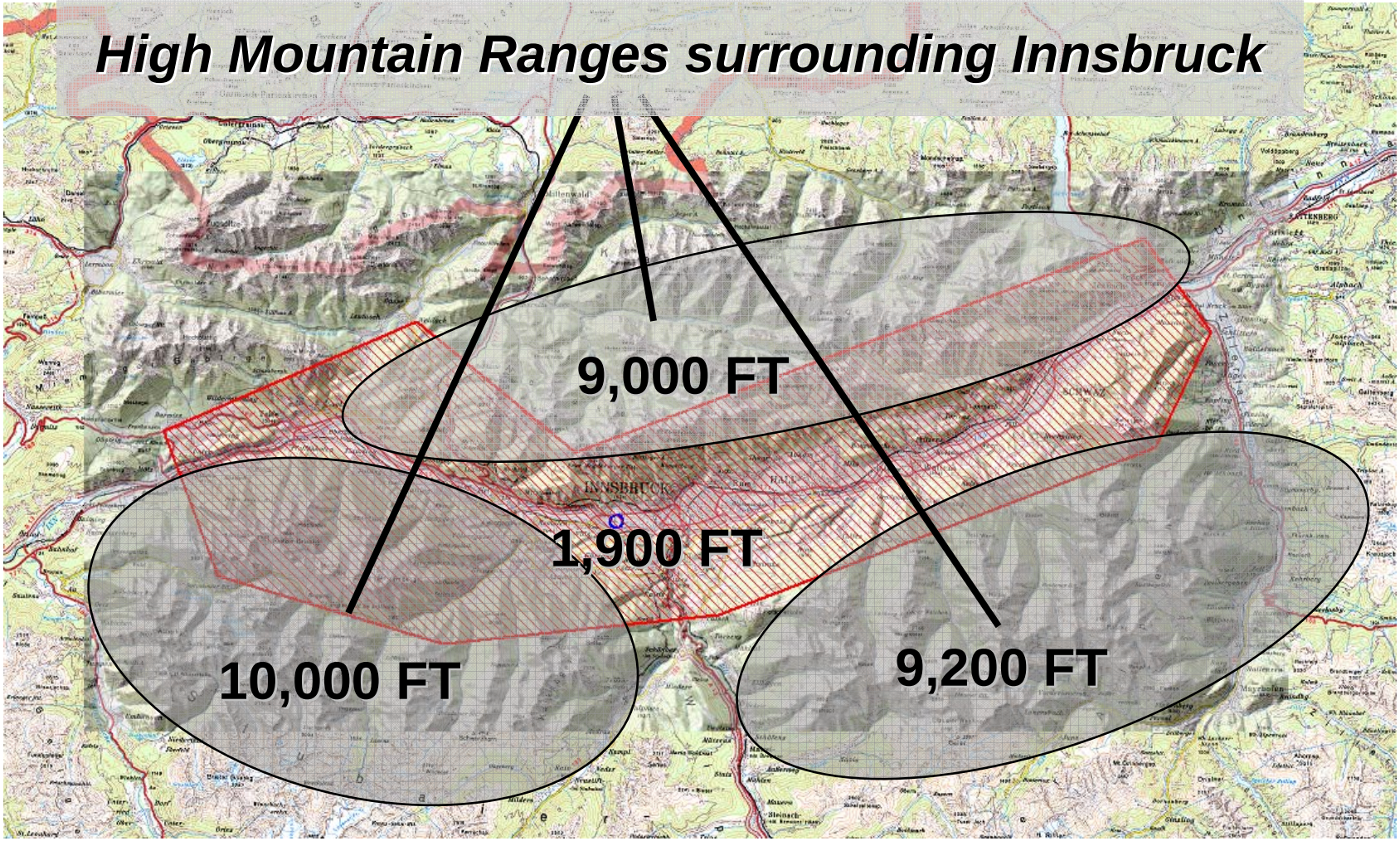
TUG

Situation in Innsbruck TMA

- **Difficult terrain situation : High mountains, narrow valley**
- **IFR Operational Situation**
  - **Strong traffic mix VFR-IFR-Gliders with an average of 200 movements per day, charter peaks 360+.**
  - **Surveillance coverage was at FL110 and above, only.**

Surveillance coverage required for TMA

Airport Innsbruck and WAM Coverage Area



Solution for Airport Innsbruck

- Two radar stations needed for coverage area!
- Radar solution would be highly expensive in terms of initial acquisition and Life Cycle Costs.
- Radar would be technically and politically difficult:
  - Radar coverage would be limited within mountainous region, multi path effects difficult to overcome
  - Radar requires additional environmental considerations for RF issues.

Solution for Austro Control is
WIDE AREA MULTILATERATION – combined with ADS-B

- Introduction of WAM and ADS-B
  - NUP & CRISTAL - projects

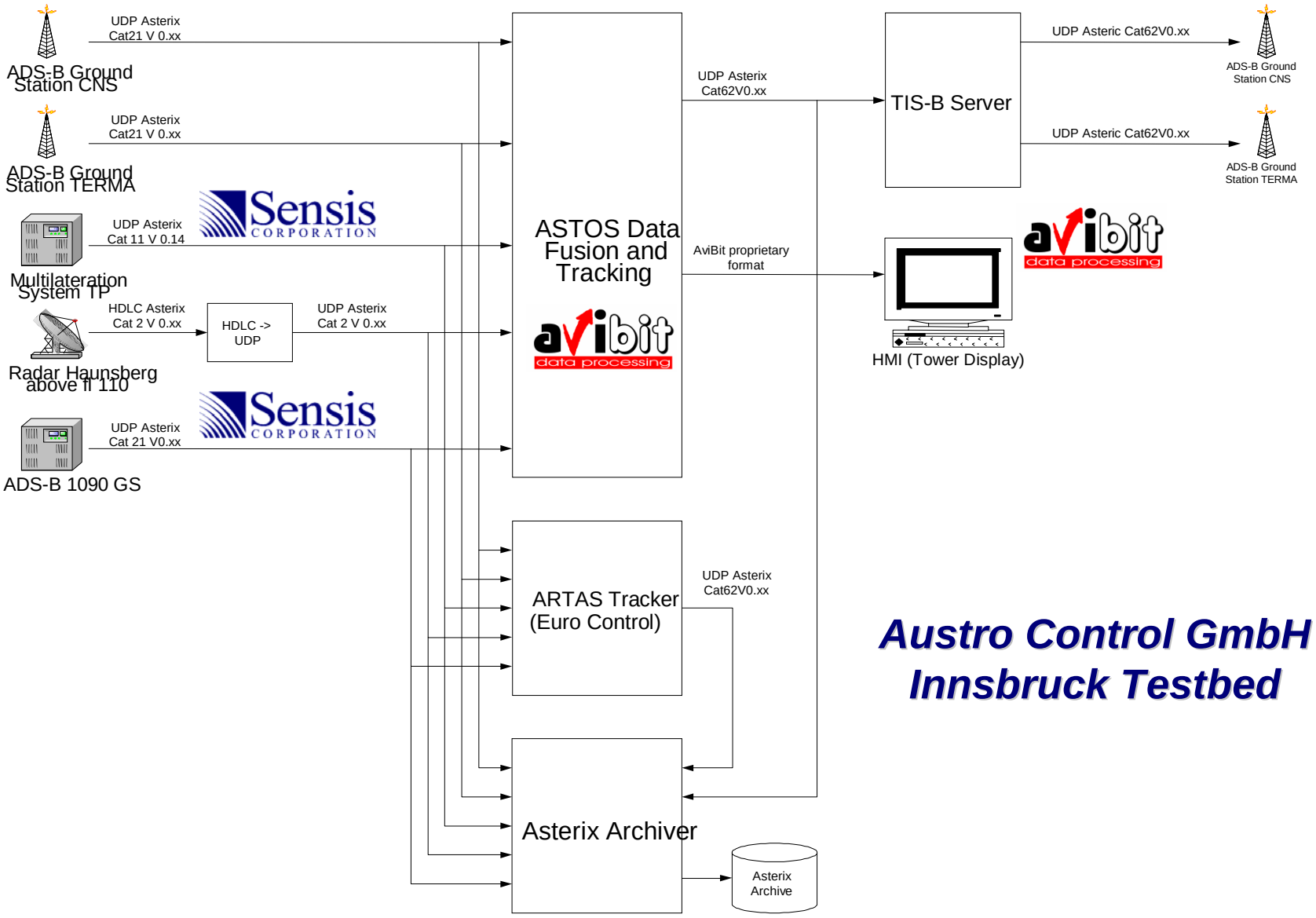
Certification Methodology

(based on ED-078A Process)

- **Coordinated Requirements Determination**
  - **Operational Services and Environment Information Capture**
    - **⇒ OSED**
  - **Operational Safety Assessment (including OHA)**
  - **Operational Performance Assessment**
    - **⇒ Operational, Safety and Performance Requirements SPR**
  - **Interoperability Assessment**
- **Development and Qualification**
  - **Validation and operational acceptance**
- **Entry into Service**
  - **NOTAM issued on Nov 25, 2004**

Surveillance System Architecture Innsbruck

- **Innsbruck Testbed Components:**
  - **Sensors:**
    - Wide Area Multilateration Detection System (SENSIS MDS)
    - 1090 ES ADS-B (SENSIS MDS)
    - VDL Mode 4 ADS-B (CNS Systems)
    - Radar above FL110
    - Flight plan data
  - **Data processing**
    - ASTOS Datafusion and Tracking System (Avibit)
    - Parallel ARTAS Tracker v7.0 (for validation purposes)
    - TIS-B server
  - **ATCO Display**
    - ASD Display processor with HMI (ASTOS from Avibit)
  - **CDTI**
    - for vehicles and cockpit (Eurotelematic, CNS Systems)

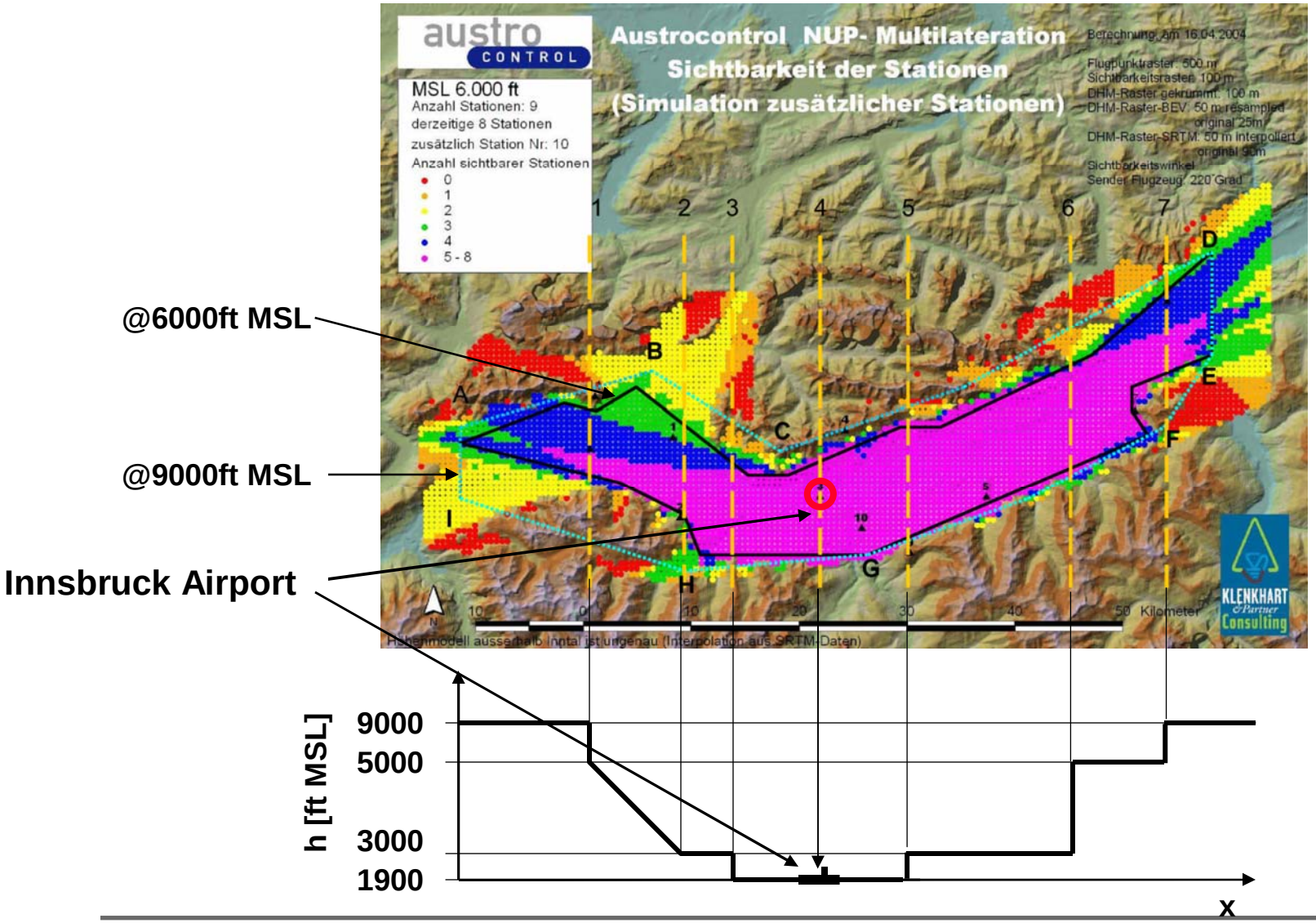


Austro Control GmbH
Innsbruck Testbed

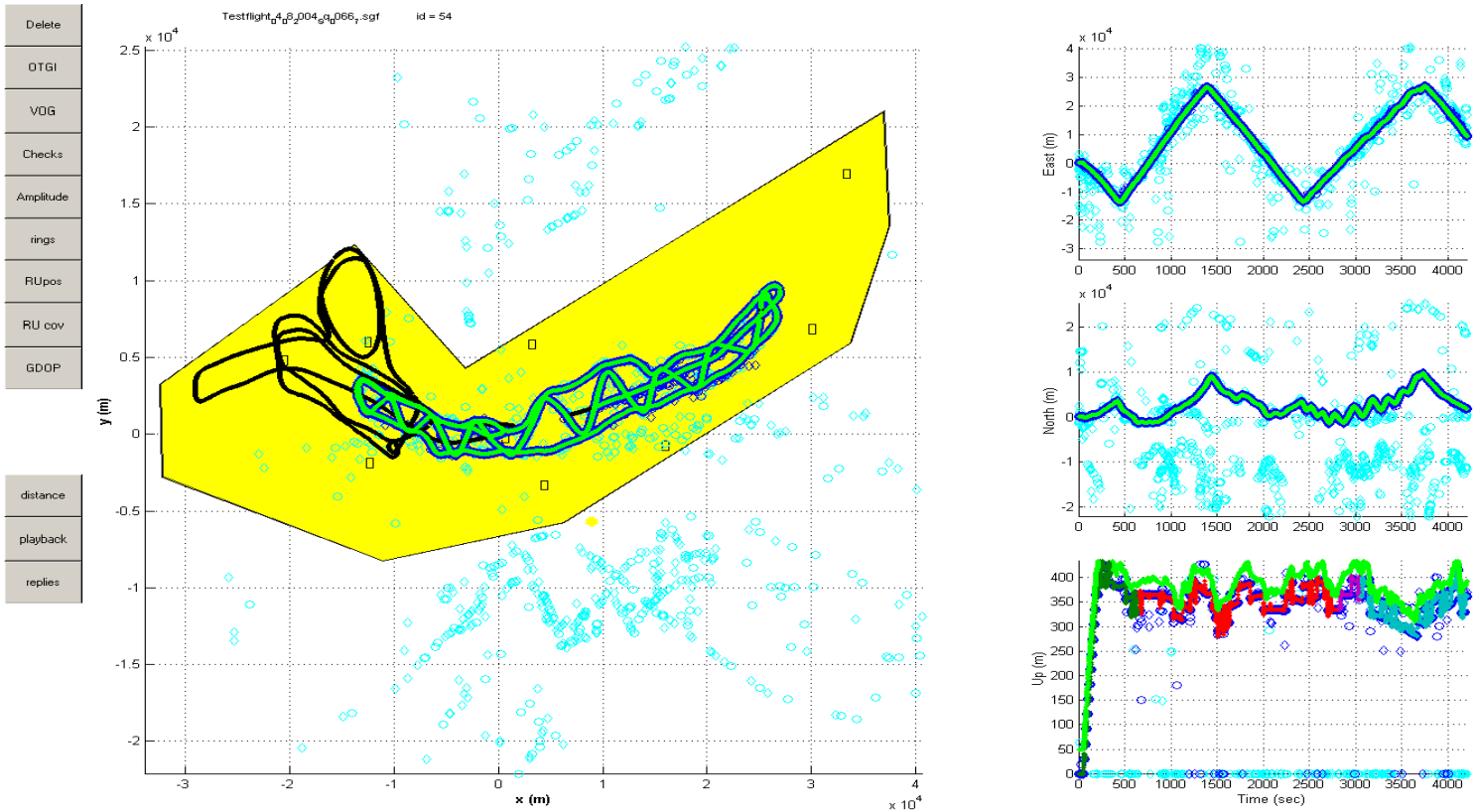
WAM Performance Testing

- **Flight Trials in three steps:**
  - **Nov 2003 (course tuning)**
  - **May 2004 (fine tuning)**
  - **August 2004 (final tuning)**
  - **November 2004 (additional flight tests)**
- **Main Tuning Criteria:**
  - **Coverage Area**
  - **Position Accuracy**
  - **Probability of Detection**
  - **Number of False Position Reports**
  - **Mode S and ATCRBS equally detectable**
- **Additional checks for:**
  - **N-1 Sensor Performance**
  - **Latency time**
  - **Resolution checks**
  - **Integrity**

Horizontal and Vertical Coverage Area



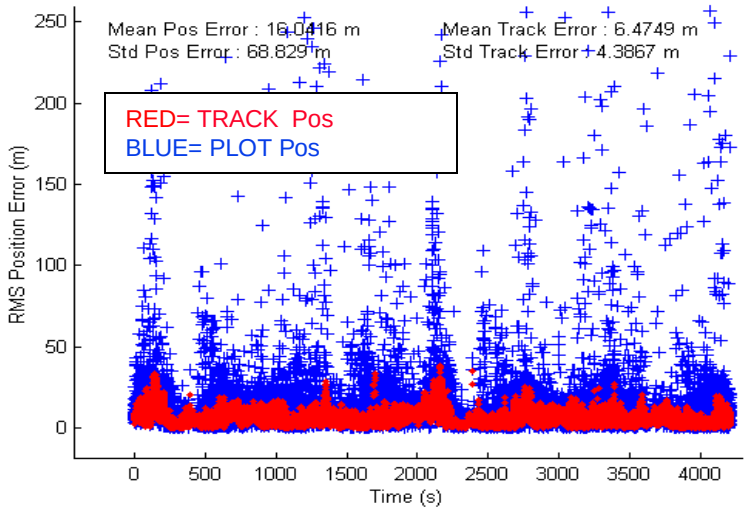
Analysis Example - Lower Coverage Limit Test (1)

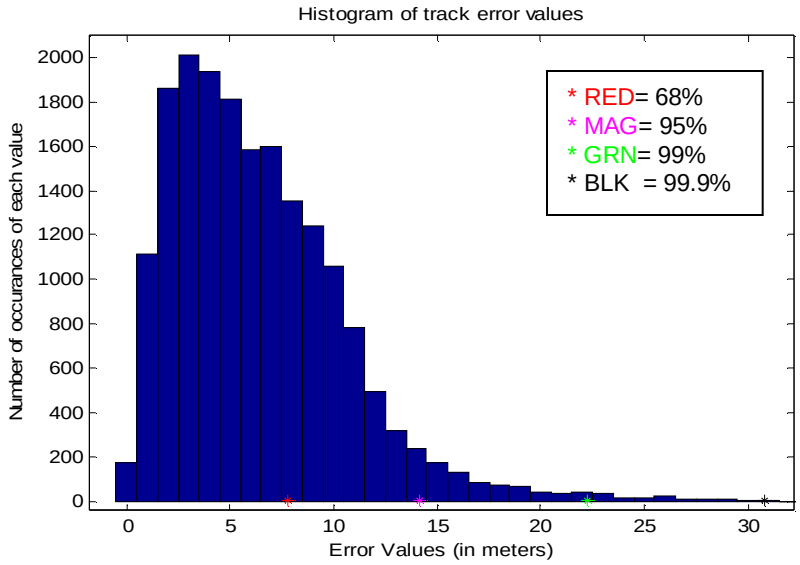


- This ATCRBS target traverses the required coverage volume, but is at a much lower altitude than the typical targets of interest for the Innsbruck MDS system. This target passed over the coverage volume at an altitude of approximately 1,300 feet. While inside the required coverage boundaries, this target track is updated on average 1.6 times per second. Total time of this flight segment is approximately 4054 seconds. Only the green colored position reports have been analyzed hereafter.

Example - Lower Coverage Limit Test (2)

- Coverage Area: Lower Boundary
- Position Accuracy:





Example - Lower Coverage Limit Test (3)

- **Position Accuracy:**
  - **Better than 15m@>95%**

Error Threshold [m]	Pos reports [count]	percent [%]	Track reports [count]	percent [%]
5.0	5920	32.14	7979	43.32
15.0	14663	79.62	**17669**	**95.94**
30.0	**17213**	**93.46**	**18393**	**99.87**
70.0	**17998**	**97.72**	**18417**	**100.00**
100.0	**18111**	**98.34**	**18417**	**100.00**
200.0	**18279**	**99.25**	**18417**	**100.00**
300.0	**18327**	**99.51**	**18417**	**100.00**

- **Probability of Detection: Pd=99,84%**

- **Height Measurement:**
  - **Better than 50m@>85%**

Error Threshold [m]	Pos reports [count]	percent [%]	Track reports [count]	percent [%]
25.0	2054	11.15	1931	10.48
50.0	**15720**	**85.36**	**15815**	**85.87**
100.0	**18392**	**99.86**	**18417**	**100.00**
150.0	**18397**	**99.89**	**18417**	**100.00**
250.0	**18399**	**99.90**	**18417**	**100.00**
500.0	**18417**	**100.00**	**18417**	**100.00**

Overall Performance WAM Sensor

- **Test conditions:**
  - **approx. 80.000 target reports,**
  - **flying ATCRBS and Mode S transponders throughout the coverage area**
  - **flying special maneuvers,**
  - **flying close above terrain and**
  - **flying an aircraft – aircraft proximity of approx. 50m (!resolution test!)**

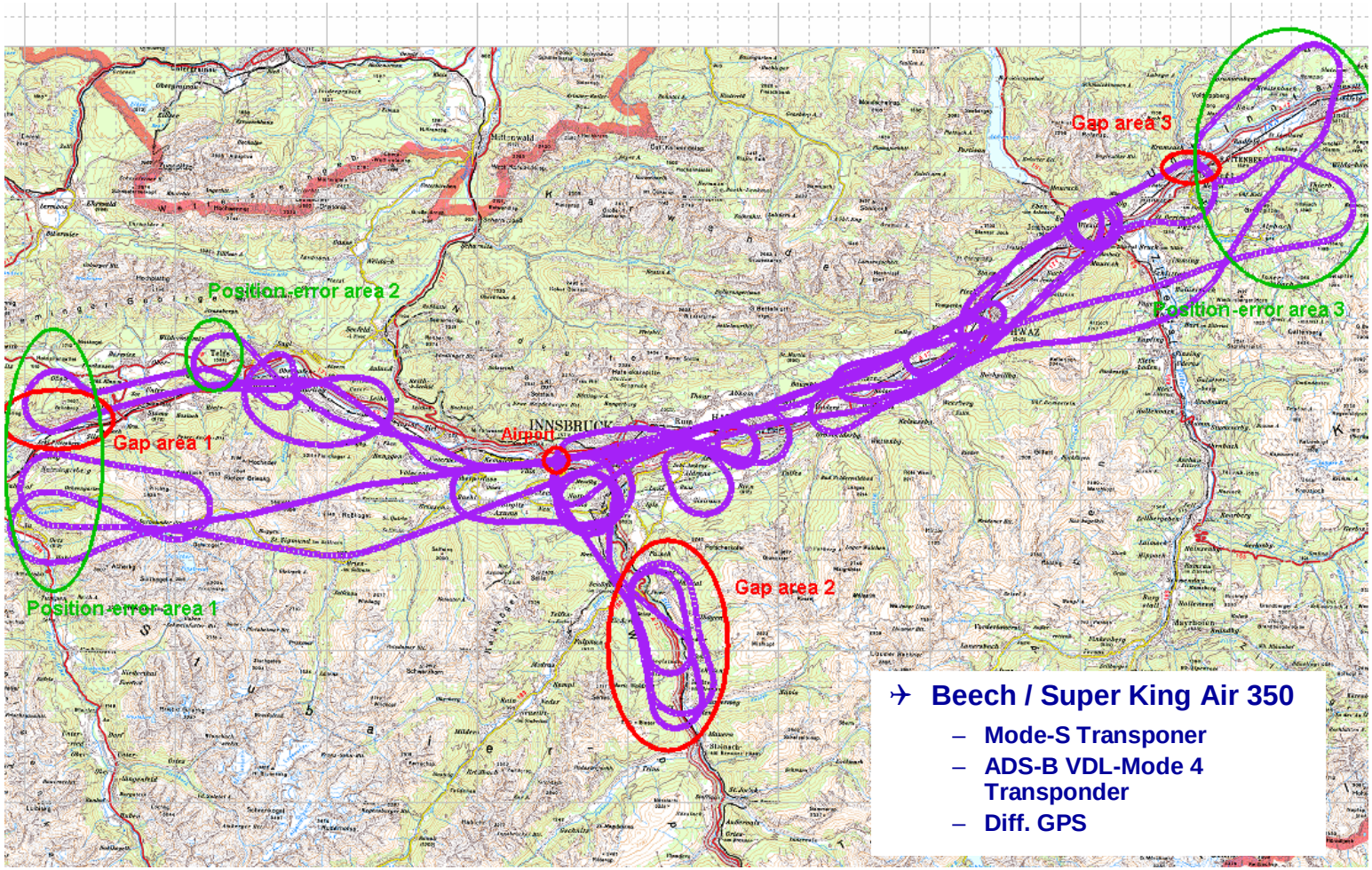
- **Position Accuracy:**
  - **Better than 30m: >93% ; Better than 70m: >99%**

- **Probability of Detection:**
  - **Pd=98,2% (=target report update gaps <2s)**

- **False Alarm Rate and Integrity indication:**
  - **No report with an error >300m was generated lasting for more than 5s, even with one sensor off.**

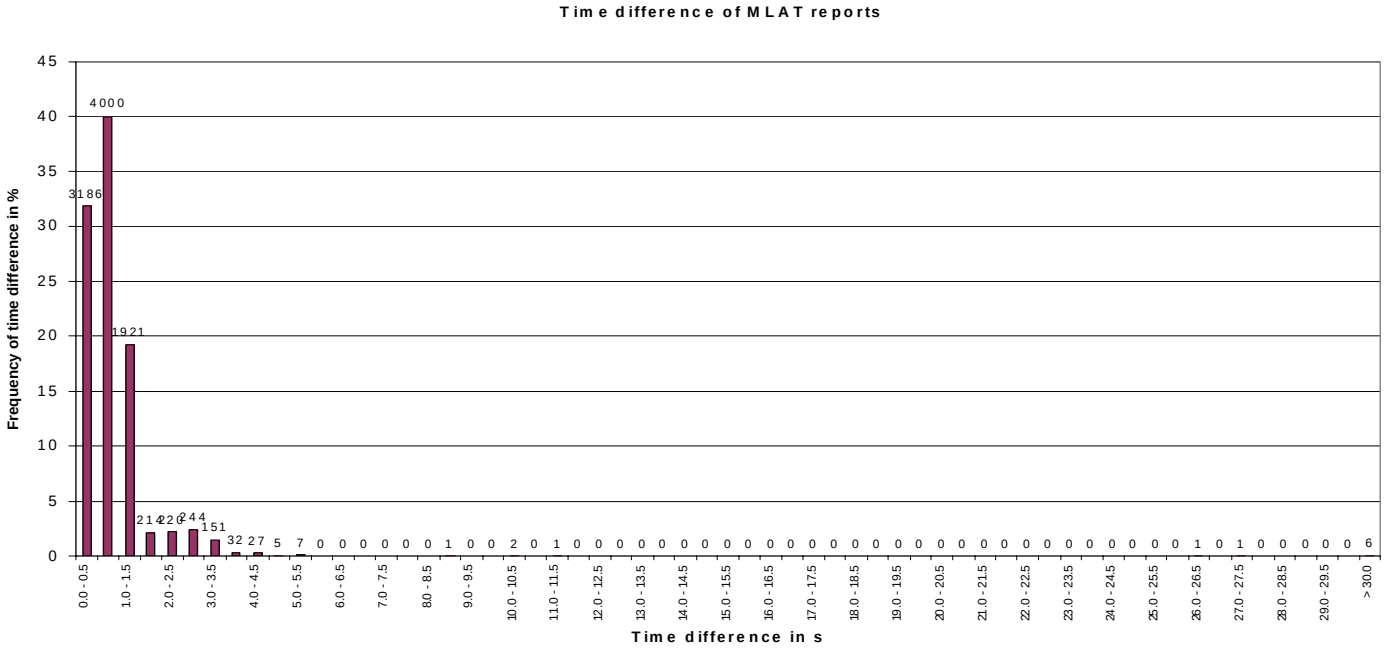
- **System Latency Time:**
  - **t_latency < 500ms**

Testflight on 25.11.2004



Analysis Results (November 04)

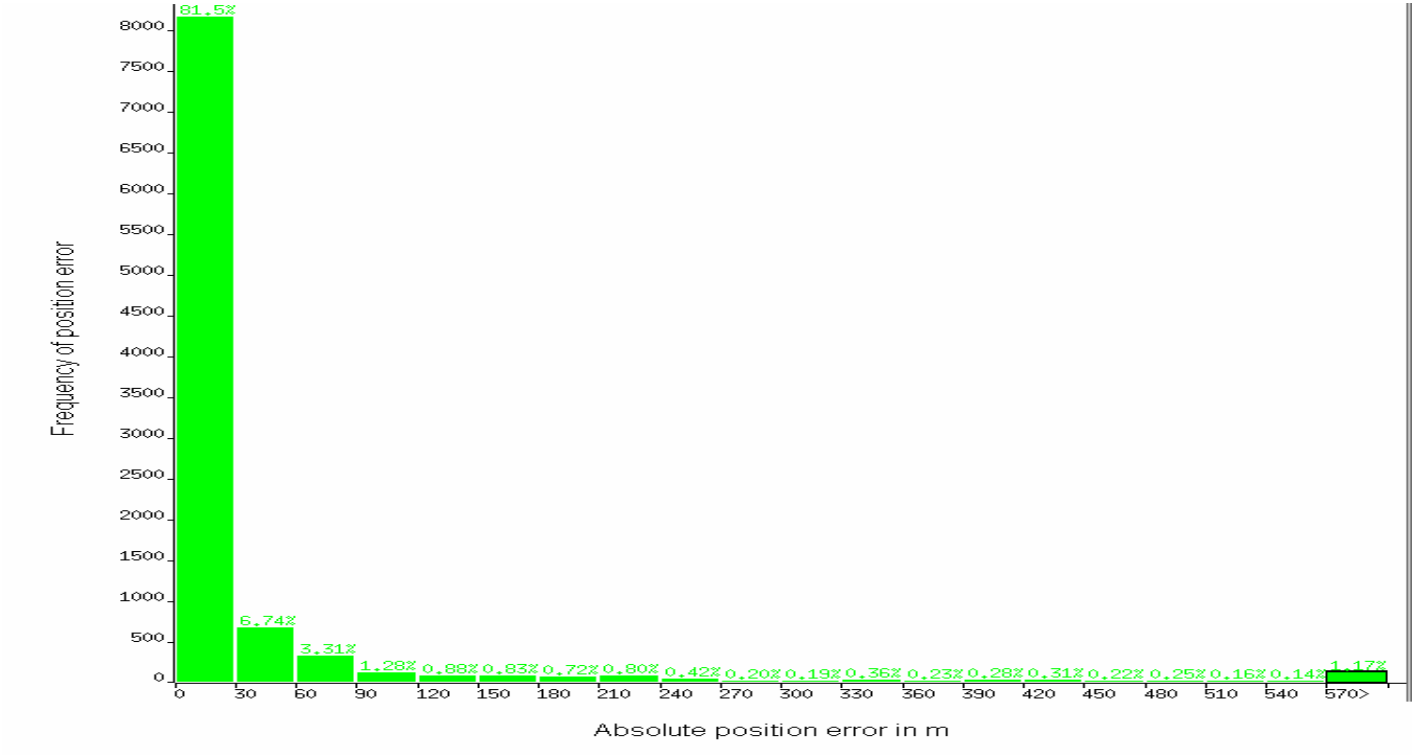
✈ Missing Plot Analysis



- **99.49 % of consecutive target reports are within 4 s**
- **All large gaps are outside the coverage volume**

Analysis Results (November 04)

✈ Accuracy Analysis



- Large errors are all outside the coverage area or below the lower coverage limit
- After removing these outliers : 13.26 m mean error, 22.40 m rms error

Standardization Process and Issues

- **Development of EUROCONTROL Surveillance Standard for WAM**
  - **WAM seen as "radar-like" services**
  - **Based on comparative assessment with:**
    EUROCONTROL Standard Document for Radar Surveillance in En-Route Airspace and Major Terminal Areas
- **Development of ASTERIX Category 20 for all type of Multilateration data by EUROCONTROL**
- **ICAO SASP and SCRSP activities**
- **EUROCAE WG70 : Development of Technical Specifications for WAM**

Standardization Process and Issues

- **New View on Availability required:**
  - **Time of service/equipment unavailability isn't a safety factor only, but is a**
    - safety factor during the first 10-15 minutes, until the conventional procedure is reestablished (depending on the airspace complexity and current demand),
    - cost factor, since capacity will decrease, but equipment maintenance staff presence can be reduced,
    - airport-accessibility factor

➔ **Distinguish parameters: availability, MTBCF, accessibility**

Outlook for WAM

- **Future Projects on WAM in Europe:**
  - **CEWAM, Central European Wide Area Multilateration**

    DFS, Skyguide and Austro Control are cooperating for a feasibility study to cover an area from Zurich to Salzburg and from Nurnberg to Innsbruck (400x700km approx.)
    - Technical feasibility
    - Cost-Benefit Calculation
    - Deployment scenarios with multiple vendors in mixed terrain (mountainous to flat)

  - **Many other countries/regions have already shown interest in WAM activities**

Outlook for WAM in Austria

- **Additional projects scheduled in Austro Control**
  - **Integration of WAM Sensors into the Surveillance Data Processing and Distribution System.**
  - **Expand WAM from Vienna Airport into the TMA.**
  - **Expand into the rest of Austria and surrounding areas with partner ANSPs**
- **Work with partners towards International Standardization of WAM (Eurocontrol MLAT Taskforce, EUROCAE WG-70, ICAO)**
- **WAM Hardware will be used for ADS-B in high density airspace and at airports in a complementary way.**
- **WAM reduces surveillance costs for Austro Control and provides improved accuracy and overall performance.**

Thank you

for your attention !