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swiss air navigation services ltd

GNSS in Switzerland: Status of Aviation Projects and Issues

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Overview

- GPS use in Switzerland – all modes
- Current Implementation Projects
  - SBAS
  - GBAS
- Regulatory Issues
  - Availability Considerations
- Spectrum Management
  - RFI Events
  - Resulting Strategies and Considerations
- Summary

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GPS use in Switzerland – all modes

- Geodesy
  - Dense reference station network (50+ stations)
  - RTK over cell phone link
  - Services provided by Swiss Federal Office of Topography
- Scientific Community
  - University of Berne (Precise Orbits)
  - Swiss Federal Institutes of Technology (Zurich and Lausanne)
    - Primarily geodesy, some sport training applications, some aviation
- Truck tolling
  - User fees based on mileage driven – LSVA (Lastwagen SchwerVerkehrs Abgabe)
- Recreational Use / Alpine Search and Rescue

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GPS use in Switzerland – continued

- Rail Applications – not known
  - Many tunnels
  - Already well developed signaling infrastructure
- Industry
  - Timing Standards (Galileo participation)
  - Chipset Integration (µblox)
- Aviation
  - Focus of this presentation
- Disclaimer
  - Overview may be incomplete

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GPS use in Switzerland: Aviation

- Skyguide is the Swiss Air Navigation Service Provider (ANSP)
  - Air Traffic Control and Management Services
    - One of Europe's most complex airspaces
  - Aeronautical Information Publications and Management
  - Communication, Navigation and Surveillance Infrastructure
  - Privatized Corporation
    - Stock owned 99% by Swiss Confederation
    - Permits private sector practices for hiring, acquisition, etc.
    - Military and Civil ATC under one roof
  - Skyguide ? Swiss International Air Lines
- Current Projects: SBAS (EGNOS) and GBAS
  - Currently no stand-alone GNSS other than B-RNAV (5NM)

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EGNOS Activities and Institutional Framework

- skyguide established cooperation with European Space Agency (ESA)
  - Bilateral agreement
  - Participation to EGNOS design reviews
  - Participation to performance monitoring team with ESA and other ANSP experts
- Skyguide is a founding member of ESSP (European Satellite Services Provider)
  - Together with other major European ANSP
  - Preparing to become the EGNOS operator
- Operational validation program for civil aviation
  - Coordinated by Eurocontrol
  - Operational Procedure Development
  - Validation of EGNOS Signal in Space in Swiss Airspace

EGNOS Infrastructure: Reference Station

- Hosting one of the 34 EGNOS RIMS (Ranging and Integrity Monitoring Station) at Zurich Airport Air Navigation Center
  - Equipment racks in emergency COM room

RIMS A Channel

- Installed 2002

- Supported first EGNOS Signal in Space in '03

RIMS B Channel

-Installed late '03

- Will support next SiS Phase

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EGNOS Demonstration in Sion

- Regional airport in challenging Swiss Alps environment
- Procedure motivated by limitations of current NAVAIDS
  - Significant terrain in missed approach / one engine out scenario
  - Requires very high cloud base minima
    - Low availability / diversions
  - No charter or scheduled operations possible despite market
  - Similar issues at a variety of Swiss regional airfields
- EGNOS demonstrated potential for new procedures
  - No GEO reception issues from terrain masking
  - GEO Elevation > 30°
- Challenges
  - Current obstacle clearance standards don't take full advantage of GNSS
  - Fall back options (Robustness of GNSS)

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EGNOS Demonstration in SION: Alpine Environment

Pilot: "Easy to fly but IMPRESSIVE"

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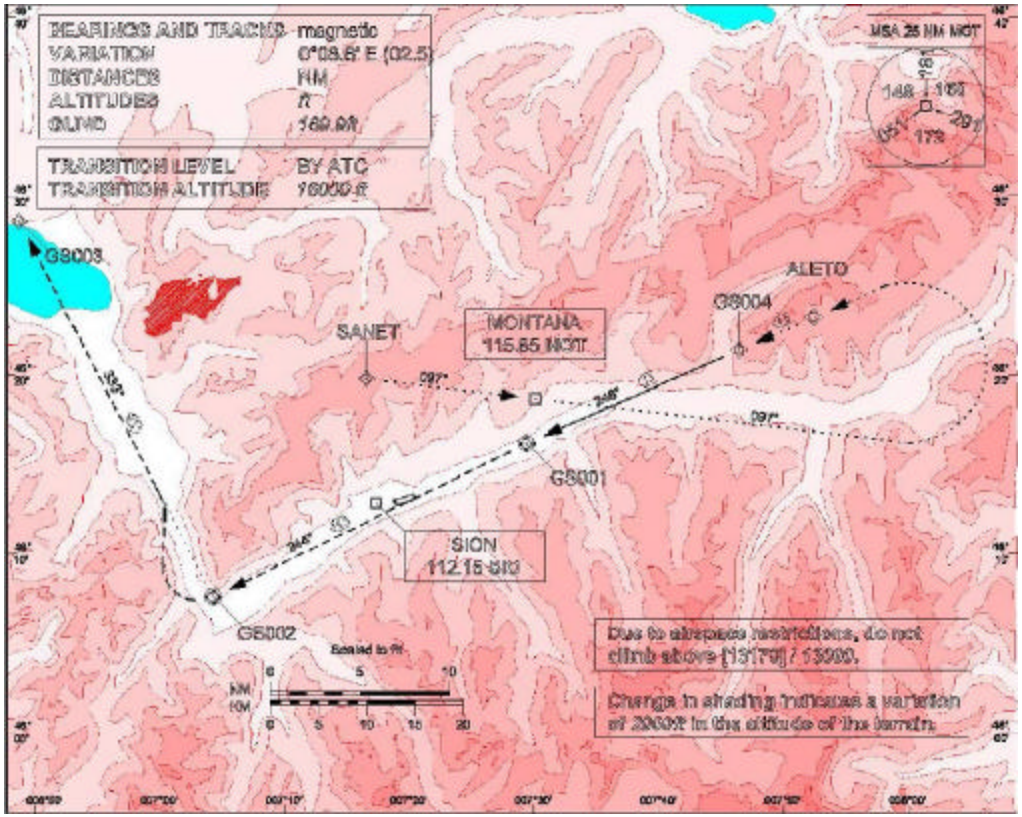
EGNOS Demonstration in SION: Procedure and Aircraft



Techn. Univ. Braunschweig

AENA (Spain) – Flight Inspection

Aerial Survey Aircraft by Swisstopo

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EGNOS and HEMS

- Helicopter Medical Emergency Service (HEMS) operator REGA
  - Todays operations only in Visual Meteorological Conditions
  - Clear Safety of Life Benefit / Access to medical care
- EGNOS is seen as the main navigation system
  - Low level IFR Routes
    - Connecting Hospitals / Regions / Operational Bases
    - Below Icing
  - Guided approaches to Helipads
- First demonstrations and studies currently ongoing
- Challenges
  - Provision of COM and Surveillance services at low altitudes
  - Separation from VFR traffic, especially in marginal VFR
  - Airspace redesign
  - Cost recovery for service provision

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EGNOS and HEMS

REGA Flight trials Lausanne – Nyon, April 2004

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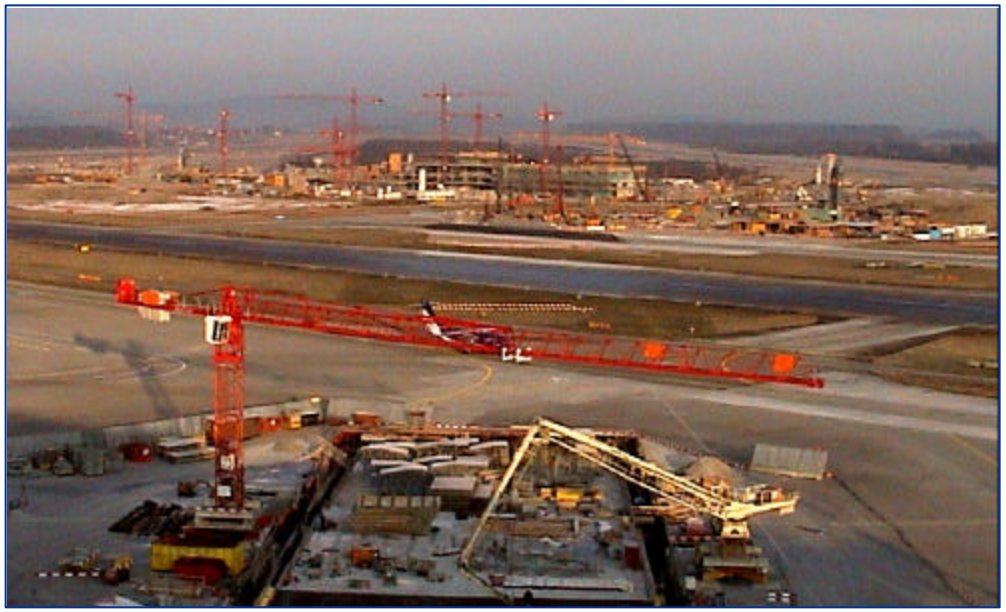
GBAS CAT I ZRH Project: Background

- Project Kick-Off in late 2000
- Partners
  - *Regulator* Federal Office for Civil Aviation
  - *Air Navigation Service Provider* skyguide
  - *User Airline* swiss international airlines, ltd.
  - *Airport Authority* unique zurich airport
  - Swiss Federal Institute of Technology ETHZ
- Triggering Events
  - ILS Cat III downgrades due to construction crane
  - ILS Sustainment **remains a critical issue**
- Following slide from official project presentation:

Future Developments

- **Risk**

  Due to the development of the airport and its environment the performance of the existing ILS may be jeopardized



- **Conclusion**

  New landing system technologies are required, e.g.

  - Installation & operation of an MLS for CAT III
  - Installation & approval of a GBAS CAT I

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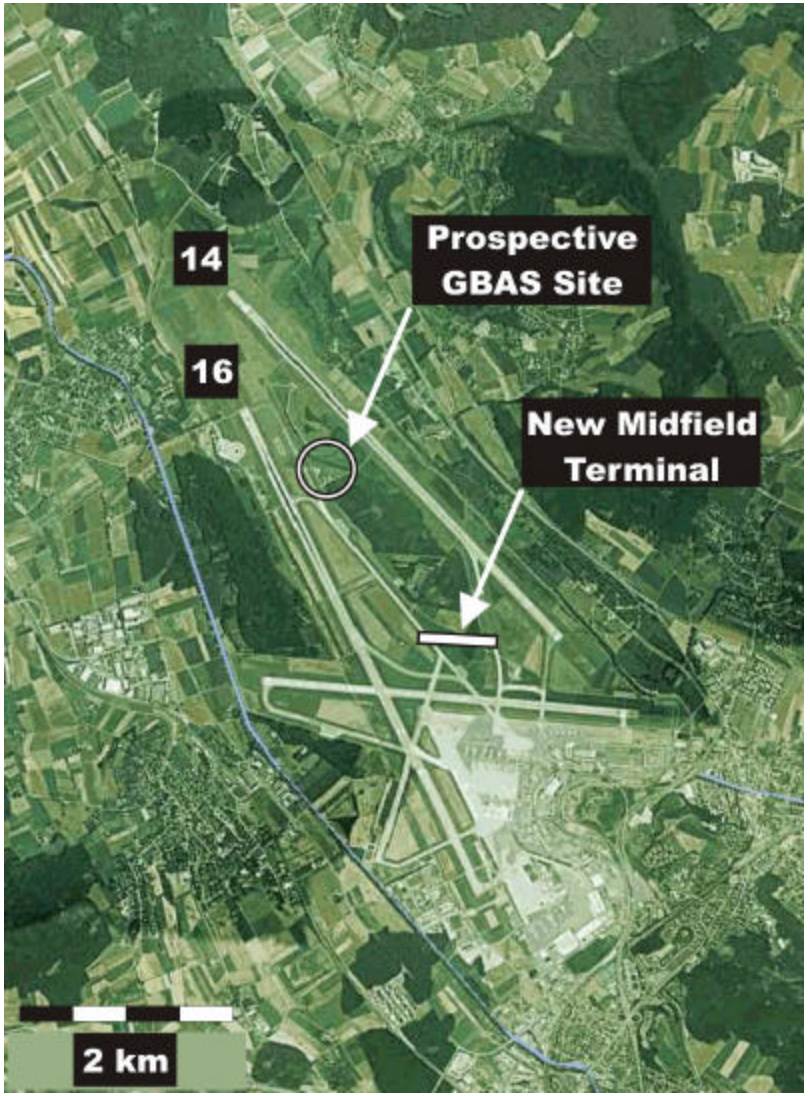
GBAS CAT I ZRH
Project Motivation

- Primary: Sustainment of ZRH Precision Approach Capabilities
  - Strategy
    - Introduction on current ILS RWY
    - Later, CAT III (main benefit)
  - Full flexibility with design of final approach paths (Glide Path Angle, Threshold)
- Safety: Approaches with lateral AND VERTICAL guidance to ALL runways
- Future: GBAS Advanced Capabilities
  - Require corresponding Operational Developments

Zurich Airport 5th Expansion (completed)

GBAS Status and Plans

- Skyguide is small ANSP
  - GNSS requires significant technical resources and expertise
  - Cooperations Essential: EUROCAE, Eurocontrol, European ANSP, FAA, etc.
- GBAS Implementation Mature
  - Siting Criteria Development
  - RFI Study and Frequency Assignment
  - Environmental Impact Study
  - Civil Works Approval
  - Call for Tenders issues in anticipation of certified ground facility
- Revised phased acquisition strategy
  - In lockstep with FAA
  - European certification difficult
    - Institutional Framework missing
    - Some Galileo Local Element involvement



Phase 1: Recording Equipment

- Installation of 2 MLA and Receivers
  - MLA Base Height up to 13 m (43 ft)
  - Plus one L1/L2 Receiver (Iono)
  - **No** below earth construction
    - Foundation / Shelter / Cable Ducts
- Record and Analyze
  - Multipath over seasonal variation
  - Availability
  - Anomalies and other studies
- Main purpose
  - Reduction of period required between technical and operational approval
- Realization Spring 2005 (TBC)
  - Recording until at least 2007

2 GNSS REFERENCE RECEIVERS

DVD RECORDERS

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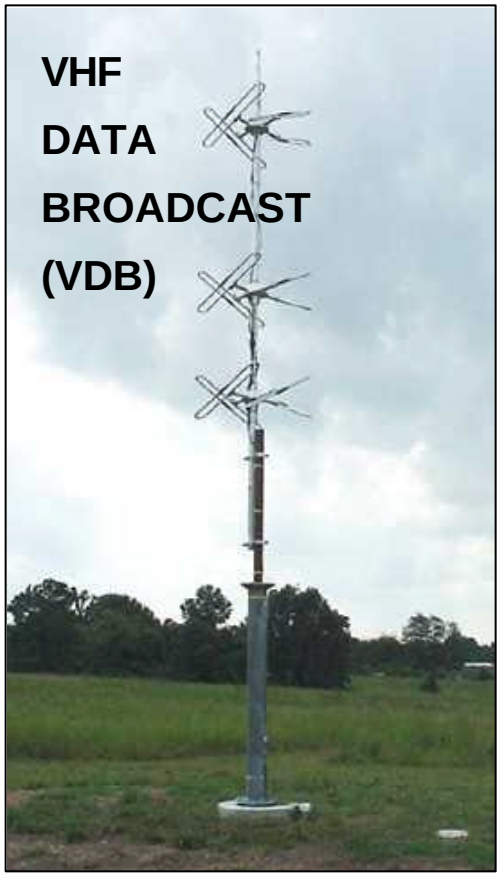
Phase 2 (Option): VDB Transmitter

- Installation of VDB Antenna, Transmitter and PC
  - Transmitting dummy data only
- Coverage Volume Analysis (Field Strength)
  - In parallel with Flight Inspection ILS / VOR
  - Flight Inspection Aircraft (FCS) already equipped
- Installation planned in 2006
- Phase 1 and 2 permit optimization of antenna locations
  - Data for technical exchanges with partners
  - Reduction of installation risks
    - Due to airport peculiarities
    - E.g., environmental protection zone



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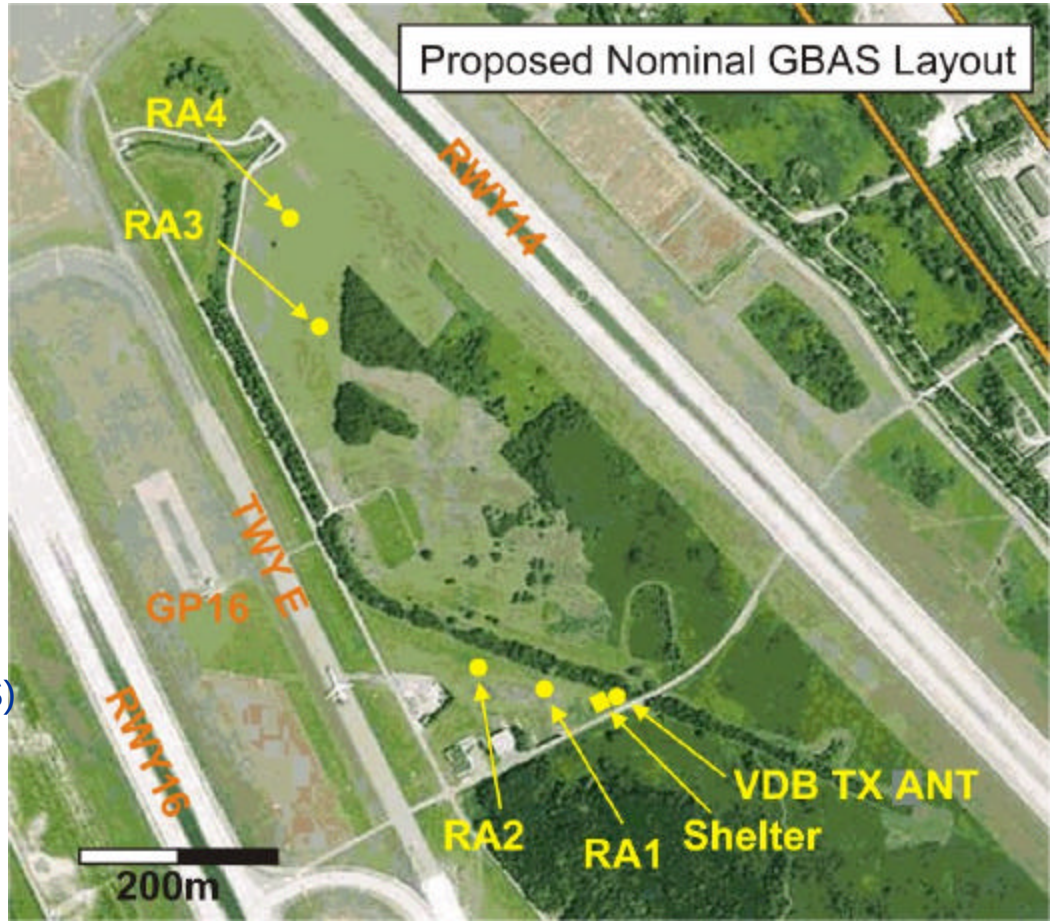
Phase 3 (Option): Full Installation GBAS

- Installation of remaining components
  - Processing Equipment
  - Remaining Antennae
  - Foundation and Shelter
  - ATC Interfaces
- Full ATM Integration
  - Procedures
  - Training, etc.
  - Preparations ongoing
- Installation 2007 (TBC)
  - Requires certified ground station
  - Desire to support Airbus Trials (SWISS)
    - Honeywell MMR
- Operational Cat I Approval 2008 (TBC)



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GBAS Project Summary and Implications

- Most critical issue is availability of certified ground equipment
  - Need to maintain industry and service provider support base
  - Fielding of CAT I capability makes a lot of sense
    - Fully develop operational concepts to take advantage of system capabilities
      - Requires statistically relevant operational data
    - Validate technical assumptions to assist CAT III development

- End state CAT III Systems will most likely be dual frequency (L5 / E5)
  - Need to preserve viable single frequency fall back mode
    - Justifies limited CAT I deployment
  - Dual systems required for robustness of service
    - User equipment transition is long – forward fit is 12 years plus
    - Need to achieve CAT III end state in a single step
      - Ideally, Galileo and GPS at the same time

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Regulatory Issues

- In order to issue an approval, regulator needs to be able to understand:
  - The technology itself
  - Failure modes and required mitigations
  - Operational concepts and service levels
  - Processes to define airspace requirements
    - ICAO SARPs define *ranges* for continuity and availability
- Consequently, documentation needs to be as complete and clear as possible
  - IFMEA and similar efforts are greatly appreciated
- Nominal and minimum performance need to be at appropriate relative levels
  - Example: Availability

Regulatory Issues: Availability

- Taken from current Draft
  - RTCA LAAS MASPS
  - Availability Appendix
  - Histogram of all combinations of 22
  - Over 24 hours
- Corresponds to 99.71% Availability
  - Seems pretty good
- HOWEVER
  - Multiple short outages are very different from todays NAVAIDs
  - Approach ATC has no mechanisms to deal with short term outages
  - System performance is **completely unacceptable** even for low traffic airfield

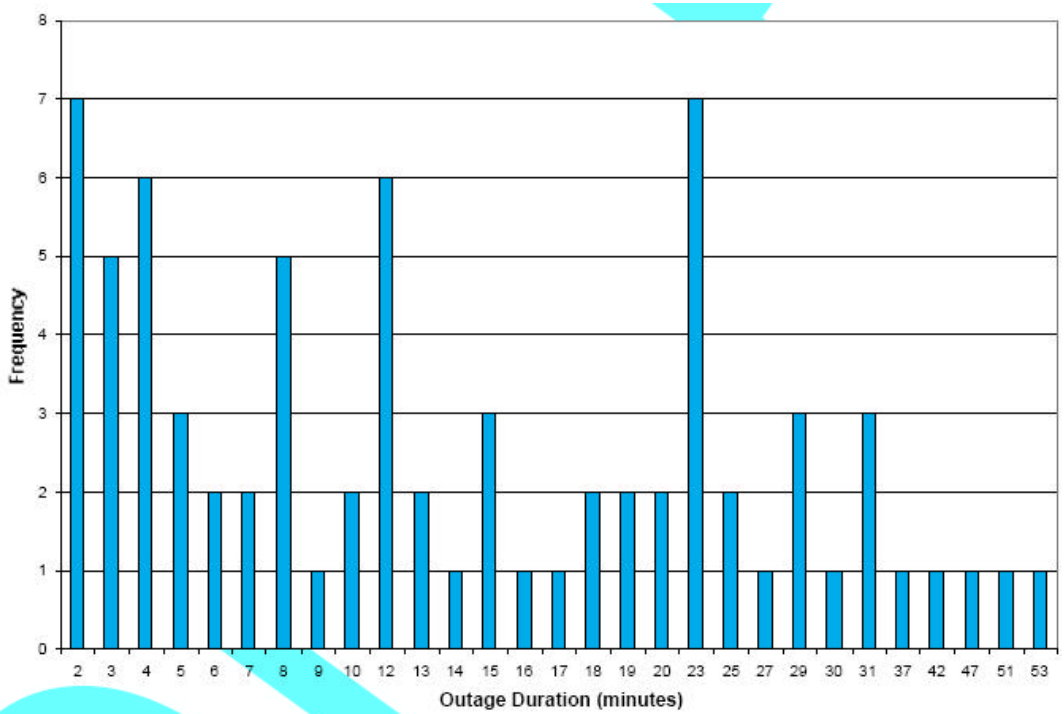

Figure F-1 Outage Duration For GSL C at Seattle Given 22 Satellites

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Regulatory Issues: Availability

- Concept of meaningful degraded modes needs to be developed
  - COM and NAV are traditionally ON or OFF
  - Multi-radar tracking contains degraded mode with defined action
    - If a radar goes out, separation is increased
  - "*Some* of your users *may* have an availability problem" does not cut it
    - Controller needs to know exactly what to do with the information
    - Otherwise, just declare service unavailable – negating benefits
- Operational Approval needs to take into account nominally achieved performance
  - 22SV constellation unrealistic today
  - Implies conditional approval dependent on monitoring
  - Long term service availability at risk
- Would be much easier to have a constellation definition based on todays performance
  - Ideally, comparable to Galileo

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Last but not least: Spectrum Issues

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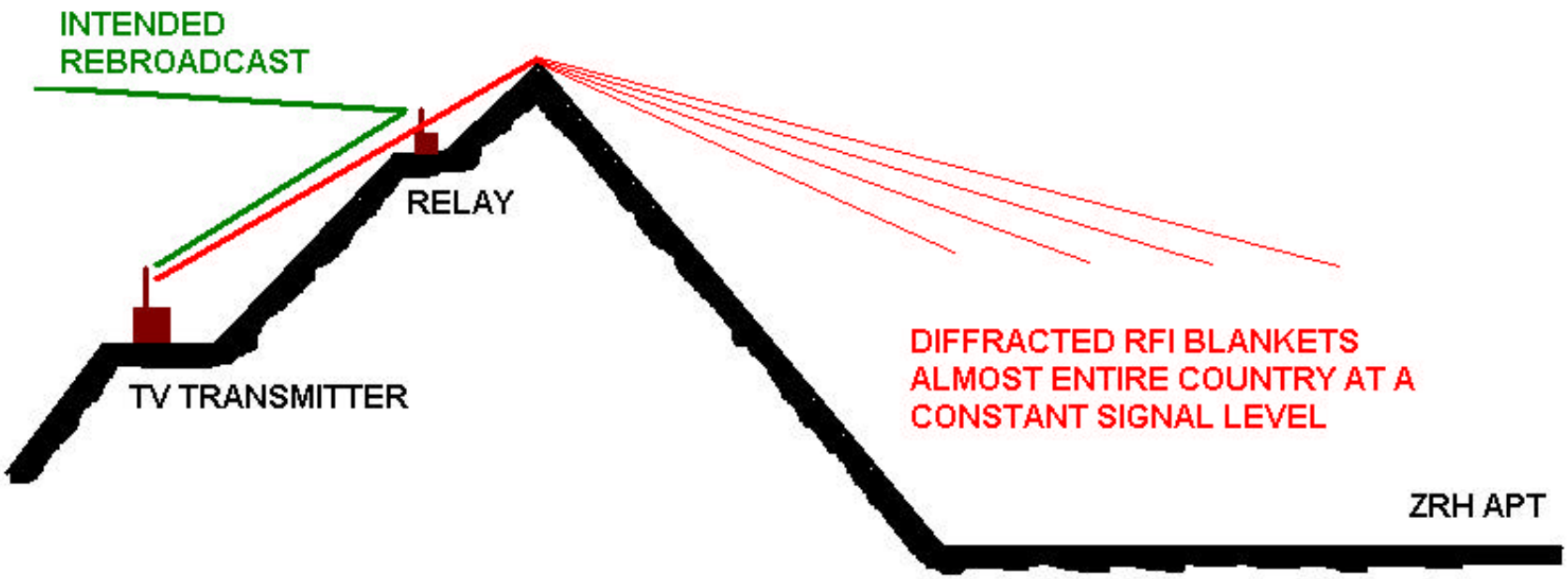
Interesting RFI Example

- TV Station broadcasting RFI directly on L1
- Link to relay diffracts off alpine ridge
- Causes RFI level slightly above ICAO interference mask at ZRH Airport
  - Source about 200km away
- Impacts only nearby VFR Operations, no IFR impact
  - Range of Detectability >> Range of Vulnerability



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Spectrum Management Implications

- RFI has been present since at least 2002
- Source is located in a neighboring state
  - State to state RFI resolution process is SLOW
    - And sometimes EXTREMELY slow
    - More severe examples with GNSS and even Radar exist
  - GNSS needs to be able to tolerate such RFI
    - Support Inertial Integration (ICAO ANC11 Recommendation)
    - Again underlines need for system robustness
- As reliance on GNSS increases, associated RFI detection and localization capabilities and processes need to keep up
  - Coordination in Switzerland being developed (slowly)

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Spectrum Mangement Considerations

- Vulnerability Issues
  - Needs to be taken seriously
  - Going overboard can be harmful as well
    - Overdrawn requirements can negate important safety benefits
    - Needs to draw on systematic data collection – many RFI events turn out to be receiver or user problems
- Proliferation of Non-Aviation GPS use can be Beneficial
  - Example: TV transmitters using GPS time for synchronization
- Need to ensure that Non-Aviation users don't have motivation to interfere
  - Truck tolling (LSVA): Truckers have contemplated jamming and spoofing GPS to avoid charges
    - Wheel sensor makes tampering obvious
    - thus no point in messing with GPS
  - Most such candidate applications are government controlled systems
  - Can significantly reduce probability of intentional RFI

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Summary

- GNSS holds significant benefits for Aviation (really!!)

- Implementation must overcome several challenges
  - Robust dual system / dual frequency system architecture
  - Operational Development
    - Airspace, Procedures
  - Institutional Issues, Certification
    - Clear and open documentation of core system attributes
  - "Minimum" Constellation Limitations / Viable Availability
  - Realistic Spectrum Management and RFI Monitoring

- Thank you for your attention!
  - Further questions: gerhard.berz@skyguide.ch