Supporting
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ILS Forever?

Thoughts on ILS Sustainability and Strategic Aspects

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FOUNDING MEMBER OF sesar JOINT UNDERTAKING

NETWORK MANAGER

Early History – Initial Motivation

- Europe: Bad Weather
  - Reliable Schedules
  - UK Blind Landing Unit
- US: Passenger Comfort!
  - Most early airlines started with DC-3's

Courtesy of Ohio University Avionics Engineering Center

ILS History (first generation)

- 1947: ILS becomes a standard (ICAO Annex 10 applicable in 1950)
- 1950-ies: Improved ILS glide path antenna systems; more robust for high horizon and less need for levelled ground plane in front
- 1962: Capture effect introduced; the use of two-frequency systems reduced the effect of multipath both for localizer and glide path
- 1964: First CAT III automatic landing
- 1965: Wide aperture localizer antenna systems; more robust at airports with large buildings
- 1968: Use of log-periodic dipole antennas (LPDA) for localizer gave robustness against effects of ice and snow and more flexible installations
- 1974: introduction of 50kHz localizer channel spacing for increased number of channels

ILS History (second generation)

- 1970: Full transistorized transmitters and electronic amplitude modulators improved reliability
- 1972: Non-image glide path antenna systems; independent of levelled ground plane
- 1976: Optimized image-type glide path antenna system concepts to fit different terrains
- 1980: Remote Maintenance monitors
- 1980-2000: Use of new technologies and computer tools resulted in very stable and reliable ILS
- 2008: Localizer with raised / reduced clearance coverage for improved airport compatibility
- 2013: Ultra-wide Localizer antenna system; especially for airports with A380 services

Source: Alf Bakken & Thor Breien (Indra Navia and predecessor companies)

Reduced Clearance Coverage to Improve Airport Compatibility

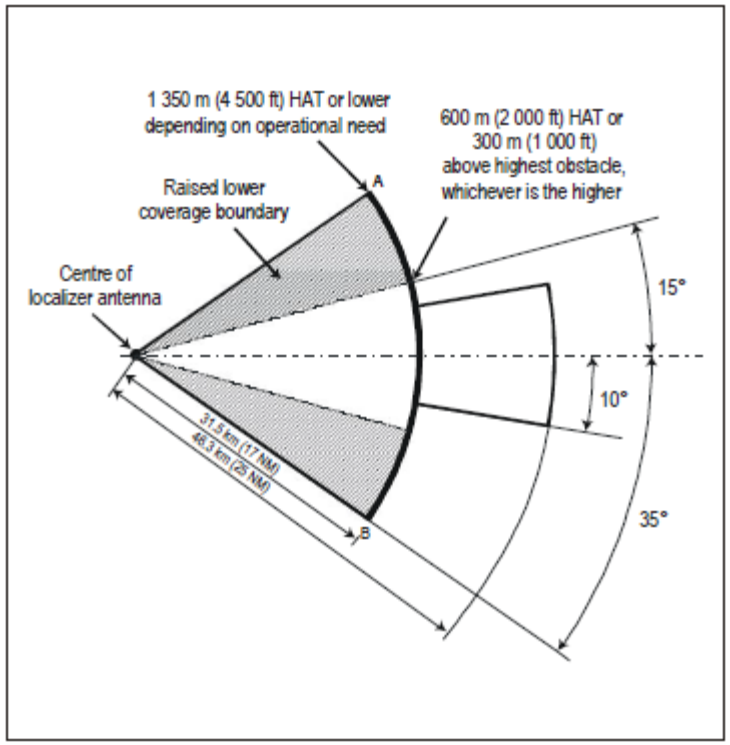


Figure C-7B. Reduced localizer coverage with respect to azimuth

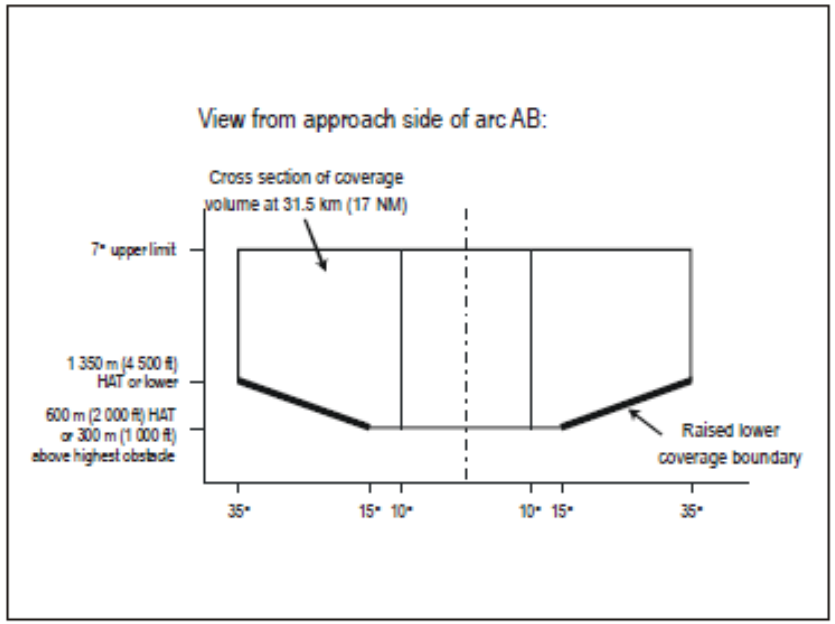


Figure C-8B. Reduced localizer coverage with respect to elevation

Figures from ICAO Annex 10, Volume I

Infrastructure for LVP: ILS Perspectives

- Both MLS and GBAS have been developed during the last 50+ years in large part due to concern about ILS sustainability
- Expectation was that ILS would eventually be replaced by a newer technology, not subject to limitations of ILS
- Meanwhile, ILS developments have resolved, to some extent, most concerns on ILS long term *technical* sustainability
- Recent GNSS RF Interference has created a renewed interest in terrestrial navigation infrastructure and complementary resilience
- Market for Cat III system remains small
  - Cat I market required for profitability

Climate Change and Low Visibility Operations

- A EUROCONTROL Navigation Steering Group ad-hoc group analyzed weather trends at several European airports over several years
  - No significant change could be detected in Low Visibility Conditions
  - Expect number of LVC hours to remain roughly constant
  - One surprise: Top 5 airports for LVC contain Porto and Lisbon in summer
    - LVC typically seen as a winter problem
- Shift in travel demand, away from business travel to more leisure travel makes summer the most important period for ATC demand
- Rise in significant weather in Europe creates more significant disruptions (winter storms or snow, summer thunderstorms) which get more attention
- Motivation to reduce LVC delays appears to have decreased (but used to be a major navigation topic some years ago!)

More recent ICAO Annex 10 ILS Milestones

- 2009, Amendment 84: Amend obsolete or ambiguous provisions for conventional navaids
  - Incorporates guidance on safety measures when testing ILS
  - Rejection of updated ILS critical and sensitive area examples (problem with more “honesty”)
- 2010, Amendment 85: Reduced localizer clearance
- 2016, Amendment 90: Marker Beacon / DME no longer “fixed” part of the ILS definition (replaced by “means” for glide path altitude check)
- 2018, Amendment 91: Updated ILS Critical and Sensitive Areas (CSA)
  - Vertical CSA dimension recognized, no further work
  - Many seem to apply example dimensions to different runways (without custom analysis)
- 2020, Amendment 92: ILS Facility Performance Categories (incl. glide path)
  - Some open issues remain, working on link to AWO Manual and AIP

ILS Critical and Sensitive Areas

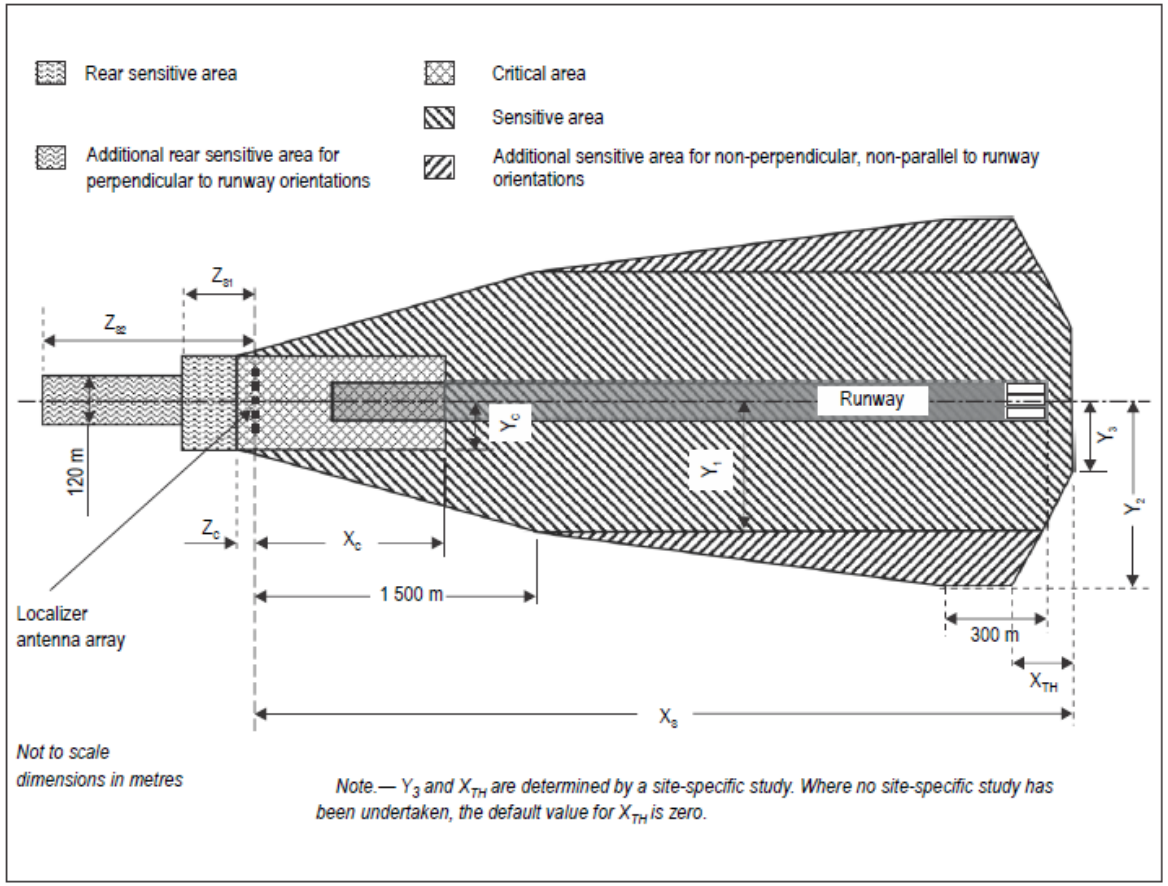


Figure C-3. Example of localizer critical and sensitive area dimensions (values in associated Table C-1 below)

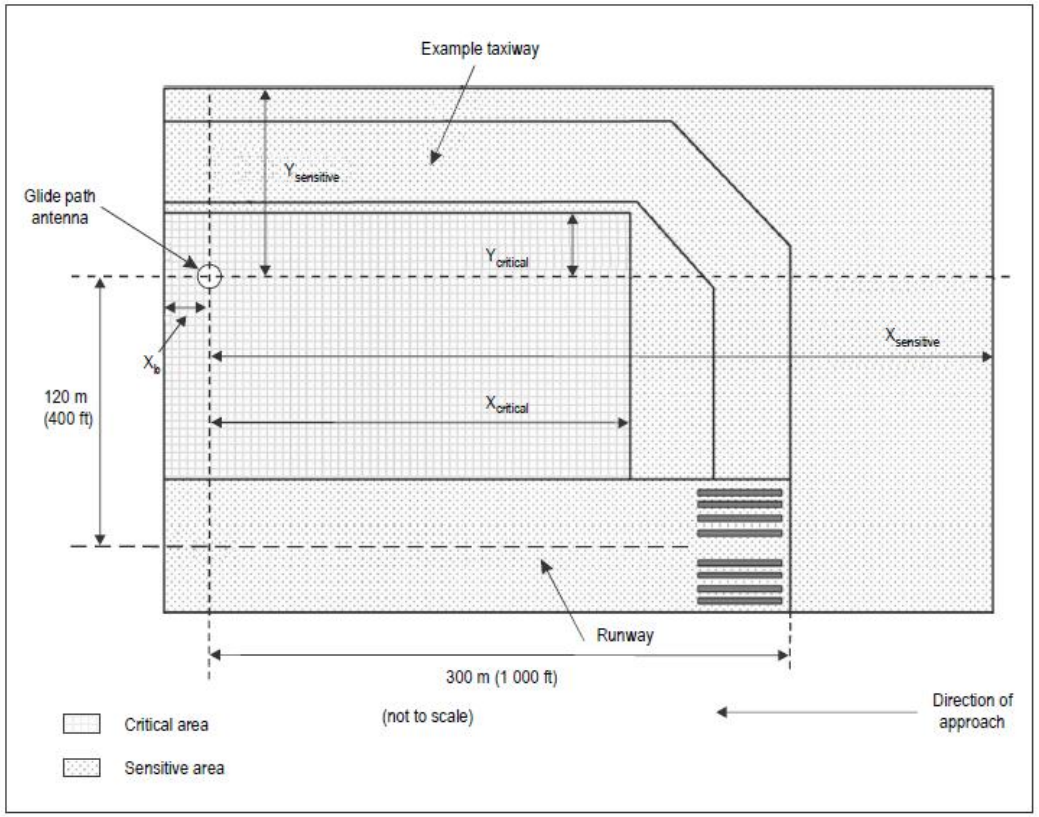


Figure C-4. Example of glide path critical and sensitive area dimensions (values in associated Table C-2A below)

Figures from ICAO Annex 10, Volume I

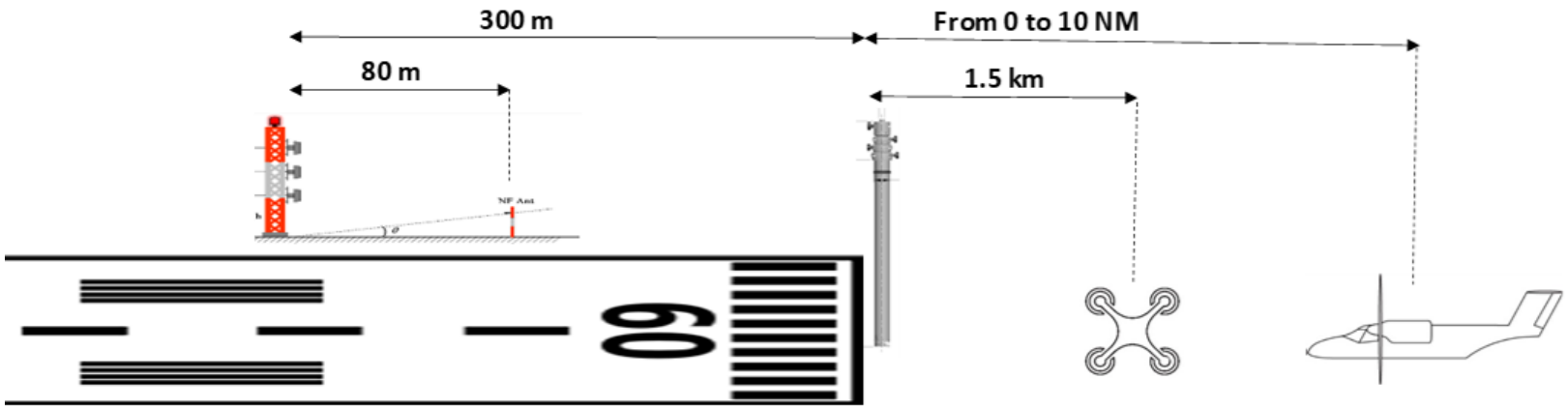
Current ILS Developments in ICAO NSP

- Reduction of ILS operations cost by reduction of flight inspection runs
  - Reduction from around 20+ down to as low as 3 runs in one State
  - Alternative / complement to inspection periodicity extension
  - Enabled by improved stability of ILS, improved maintenance & monitoring, modelling, site protection
  - DOC 8071 V1 guidance became available in spring 2026 (advance unedited version)
- Use of Drones in Flight Inspection
  - DOC 8071 V1 2018 Edition: Open Door Only
  - Reduction of flight inspection runs (as above): one State example where drone is key enabler
  - Two major categories:
    - Small multi-copter UAV as complement to ground maintenance, VLOS only, on or near airport. Starting to become relatively well established in industry
    - Larger fixed- or hybrid-wing drones, RPAS operating BVLOS. Still relatively new, experience limited to a few States / Suppliers
    - Recent NSP/8 Meeting agreed to create new job card to further update DOC8071

ILS Glide Path Safety

REF: ICAO NSP JWG10 WP24

- "Old" GP GND check: ≈20m mobile mast at threshold
  - Operationally intrusive, many ANSP do not do it
  - Measurement **inside** beam forming area
- Multi-copter Drone permits far field measurement
  - Faster, more accurate & more relevant than mast mx
- Antenna fault simulation and measurement validation
  - 2,5deg AZ turn of A3, -18cm of A2 vertical change
  - Barely seen by mast (OK), FULLY Out Of Tolerance in far field
  - **Mechanical stability of antenna elements is integrity relevant**



ILS Safety and Frangibility

- Jehu Air Accident, South Korea, Dec 2024
  - LOC Antenna Mast not adapted to non-standard height
  - Case not clearly covered in existing ICAO guidance
- ICAO ADOP Discussion
  - Concern on some structures which are declared to be frangible which are clearly not
  - Requested better guidance for testing / compliance
  - Need to respect trade off between need for frangibility and need for mast stability
- ICAO NSP Discussion
  - Need to ensure that safety investment is made in the right places
  - Concern about counterproductive shelter requirements

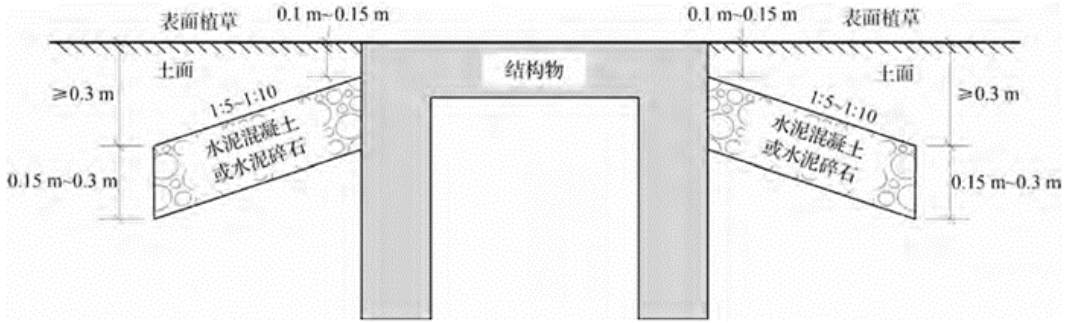


图 4.4.5-2　升降带平整范围内结构物的消除直立面措施示意图（一）

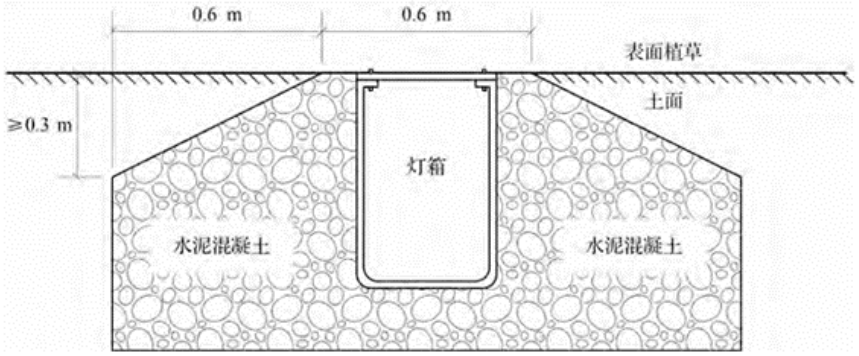
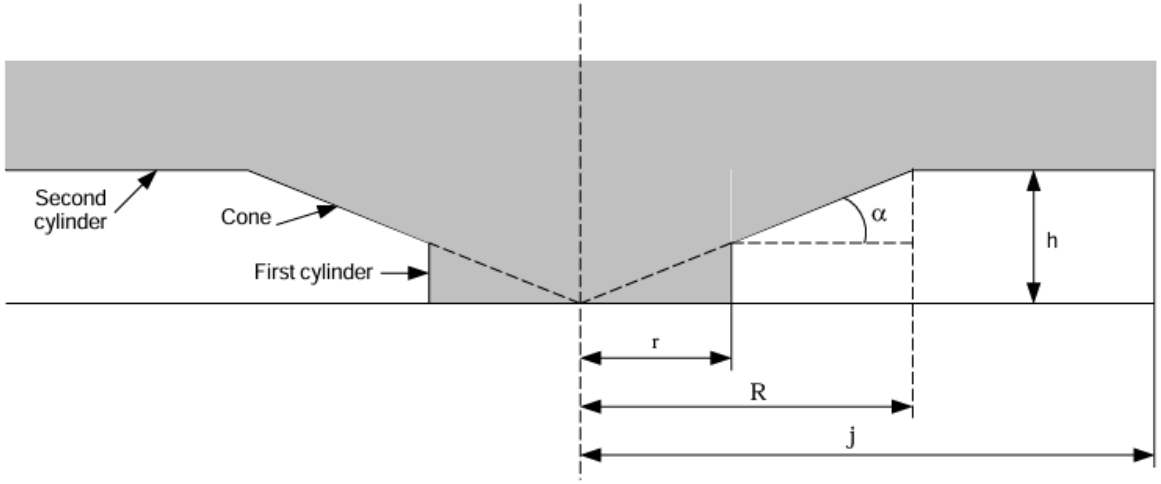


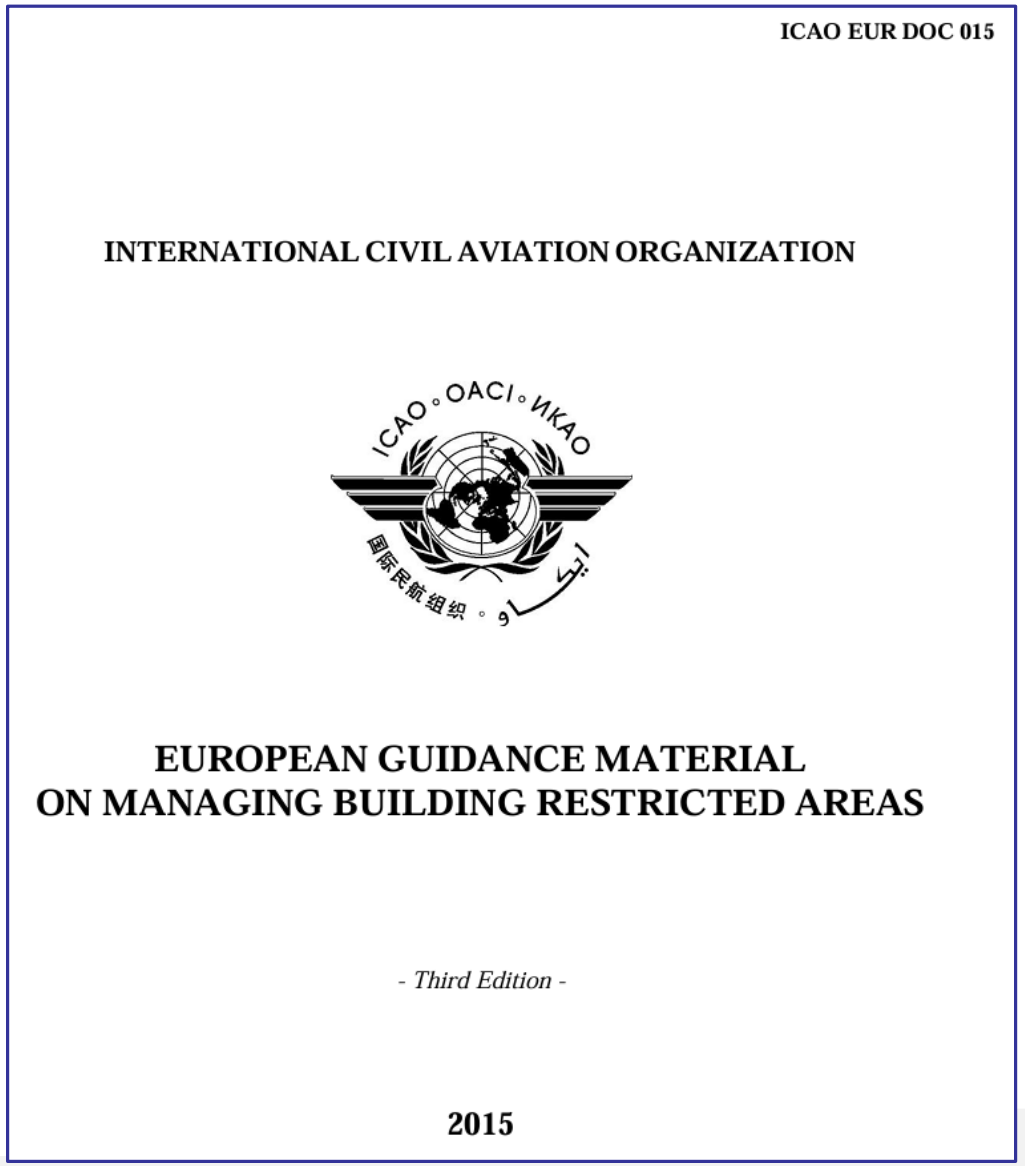
图 4.4.5-3　升降带平整范围内结构物的消除直立面措施示意图（二）

From email correspondence with NSP Panel Member China

ILS Site Safeguarding

- Land-Side & near airport areas generally subject to significant real estate development
- Protection area dimensions determine need for building reflection / diffraction expert assessment resources
  - Too conservative: ANSP gets flooded with resource intensive requests
  - Too optimistic: Difficult to “undo” building if it generates unacceptable signal disturbance




ICAO EUR DOC 015

INTERNATIONAL CIVIL AVIATION ORGANIZATION

EUROPEAN GUIDANCE MATERIAL
ON MANAGING BUILDING RESTRICTED AREAS

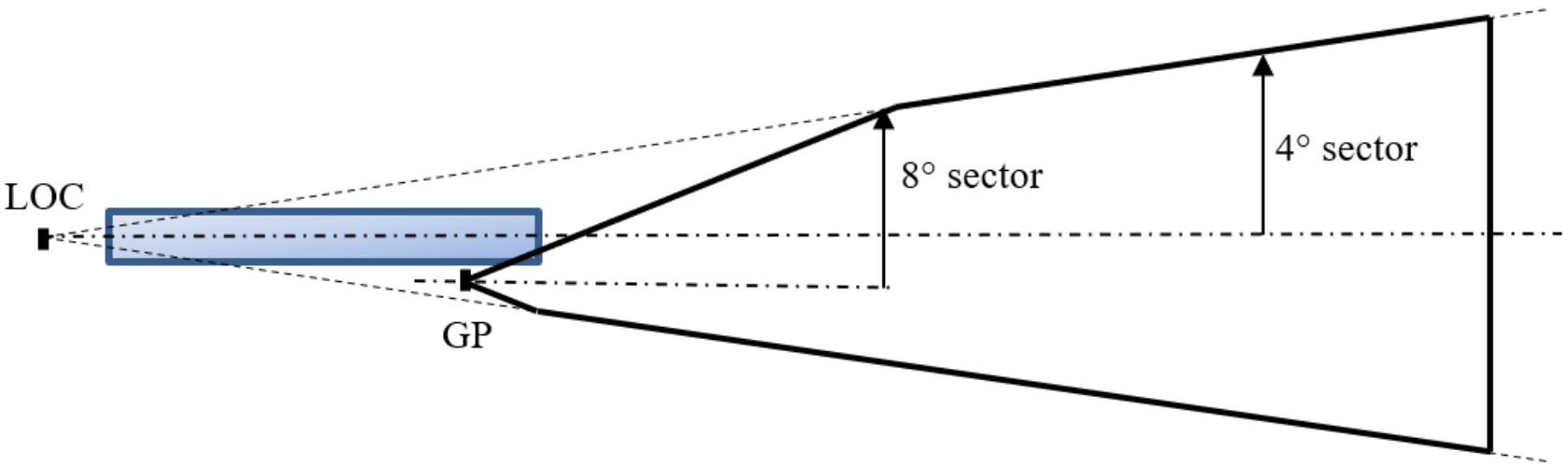
- Third Edition -

2015

Glide Path Optimization Potential: Unused

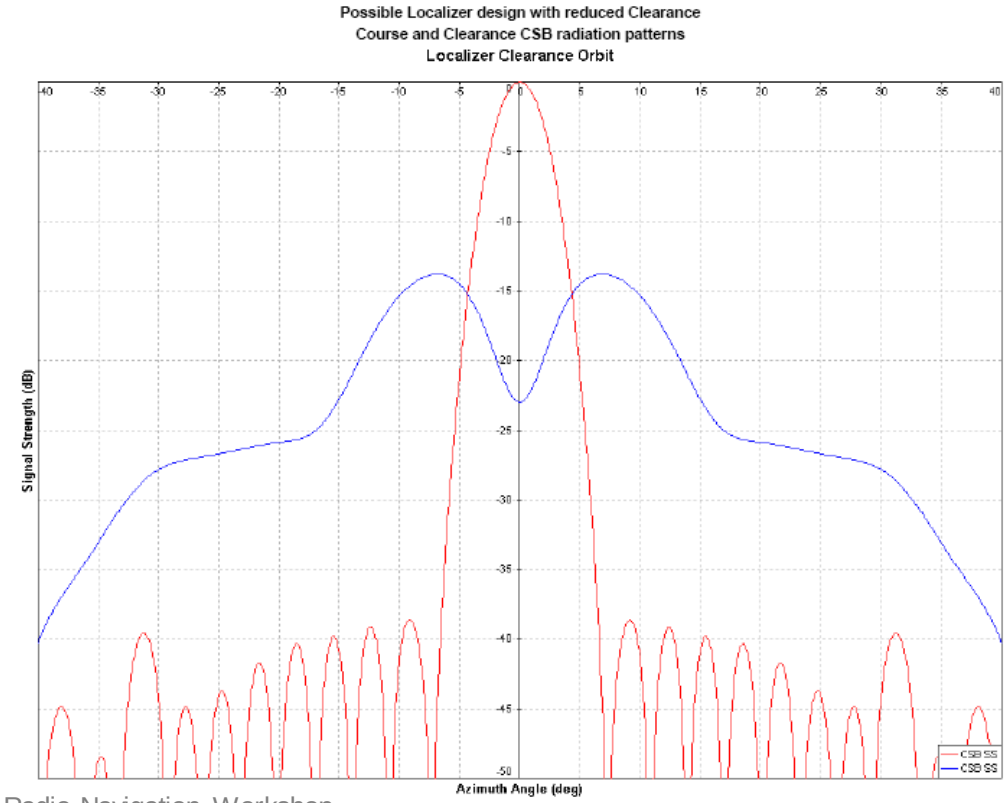
- Current ILS GP antenna elements are not optimized
  - UHF dipoles common in mobile telecom market = low cost
  - No OEM optimization interest due to cost sensitivity
- ± 8 degree coverage not necessary outside of Localizer course beam
  - Relaxed coverage requirement could alleviate various siting constraints
  - **Significant benefits only if GP mast is on same side as aircraft runway line up queue**

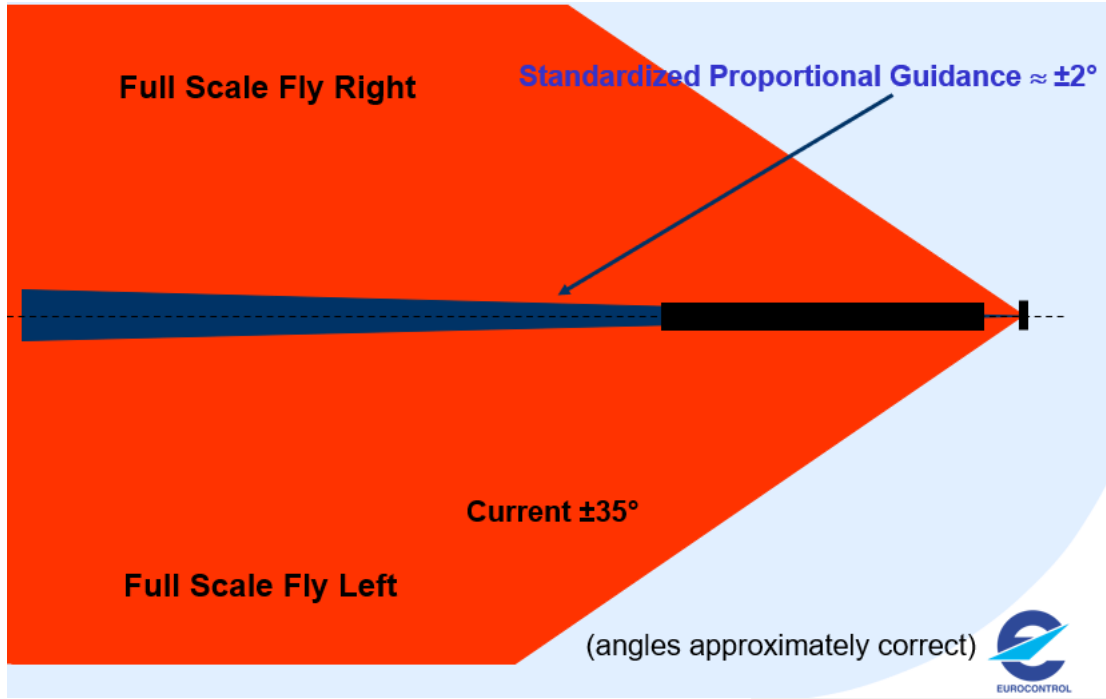
Watts Antenna Company
GP5 Wide Aperture Antenna
Minimizes Glide Path CSA



ILS Localizer Fundamental Issues: Mostly Solved

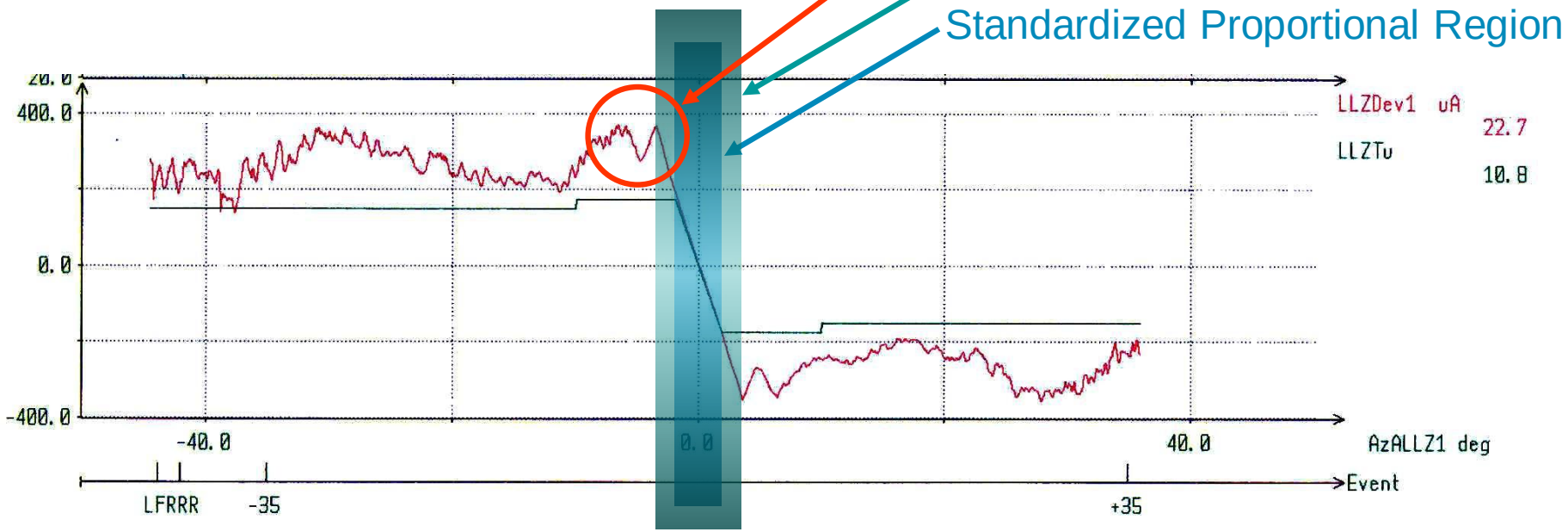
- ILS LOC composed of two RF signals: Course and Clearance
  - ACFT near RWY can cause Course➔Course Interference: *Narrow Beam using Ultrawide Aperture*
  - Buildings near RWY can cause Clearance➔Course Interference: *Reduced clearance option*
  - Course➔Clearance and Clearance➔Clearance often not in operationally relevant areas
  - Narrow beam comes at *expense of End of RWY Overlap (long roll-out problem)*





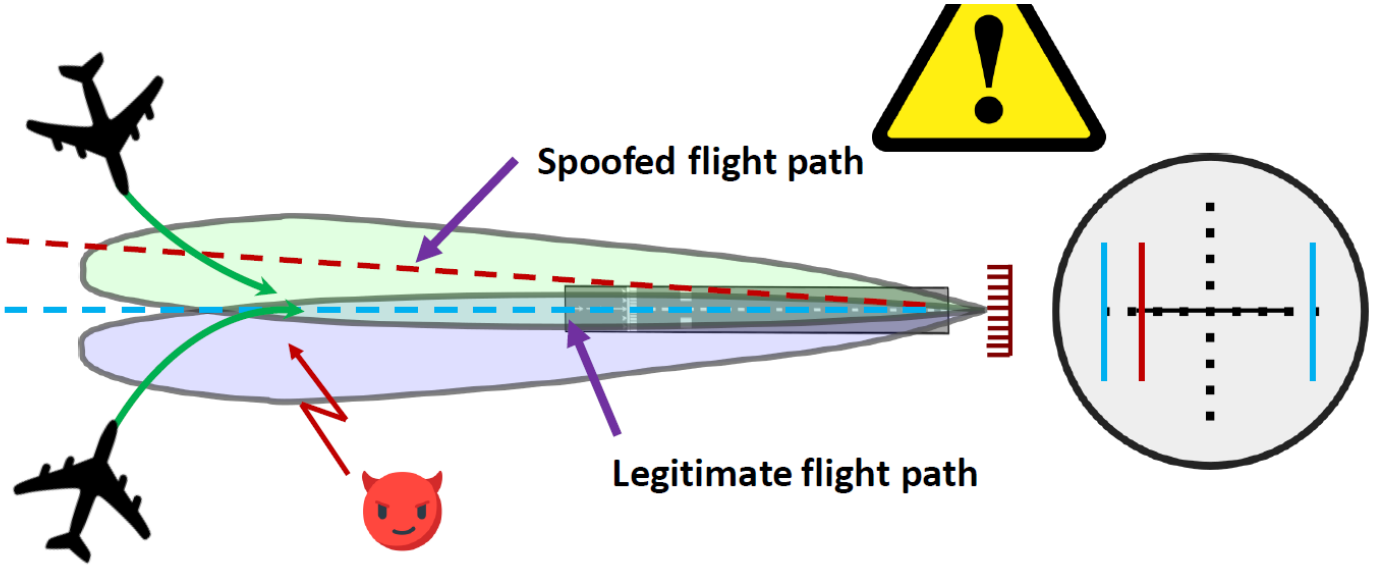
ILS Capture Issues – Need to retain awareness

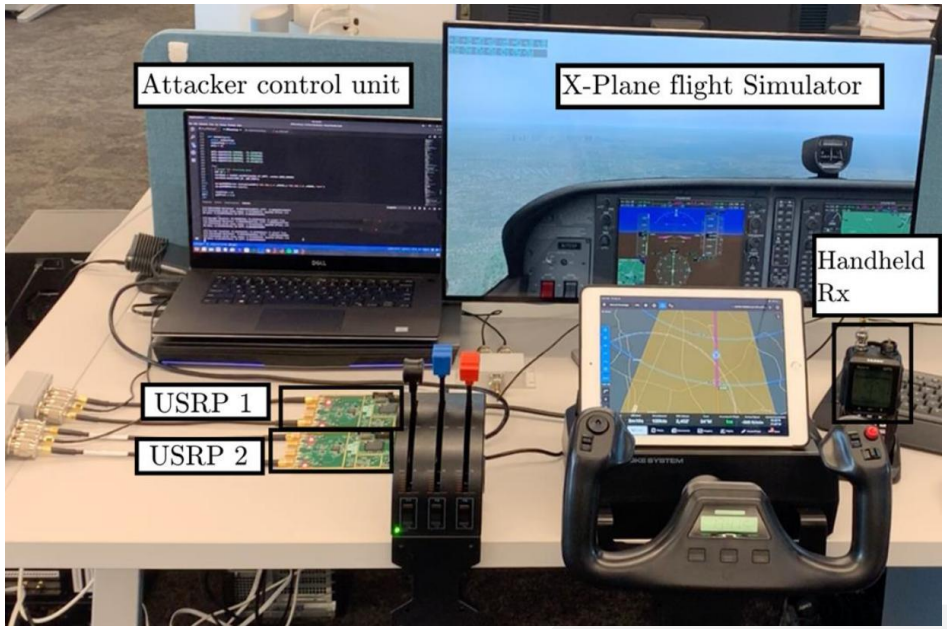
- Main LOC course beam is too narrow compared to operational need
  - Overshoot especially in tailwind situations
- Many pilots like to arm AFCS for LOC capture early
  - Outside of +/-35 degree clearance sector: false capture possible
- GP null (6°) or image (9°) can cause issues (rare)



ILS Spoofing?

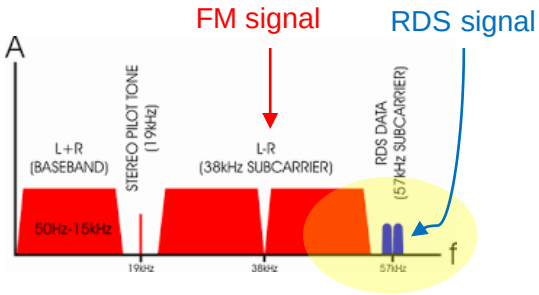
- Topic has not received much attention as far as we know
  - NSP JWG7 IP11, Northeastern University: Demonstrated Spoofing Attack in Flight Simulator
  - Relatively simple setup subject to a number of limitations
- Analog signals provide some rudimentary protection (need to satisfy SDM)
  - But introducing any security capabilities will remain very difficult
  - Effective countermeasures would likely require complementary integration

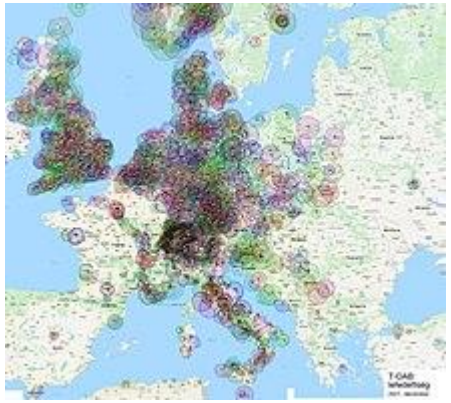




VHF Spectrum Adjacent Band Compatibility

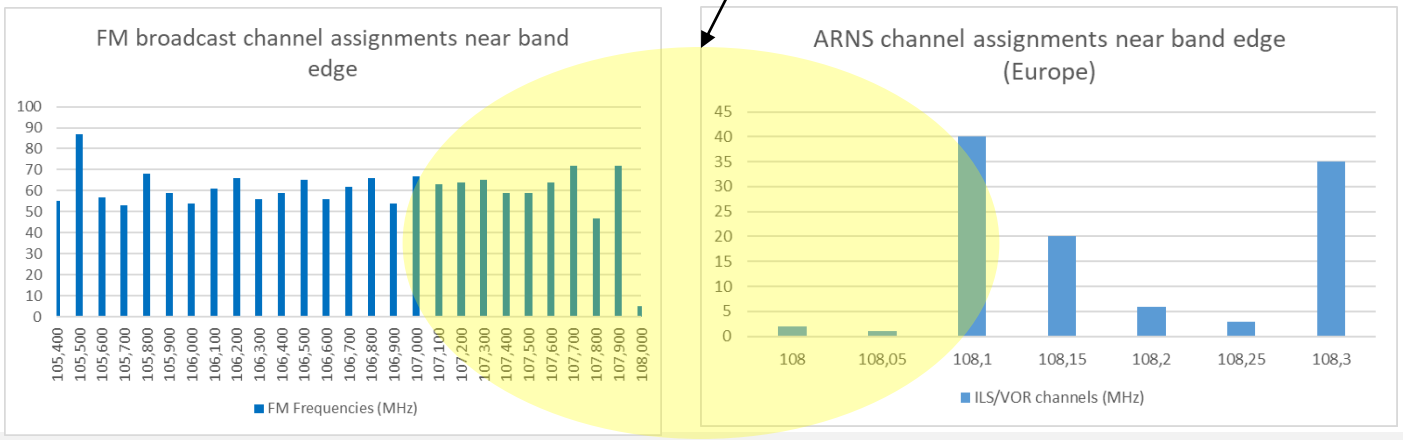
- US Broadcasters increasing digital sideband power (FCC NPRM)
  - Europe uses RDS in legacy FM band
  - Digital Audio Broadcast (DAB) deployment in different bands
  - FM compatibility criteria in ITU Recommendations were never updated
  - Normally aviation requires positive proof that operation is safe, not just an absence of reported problems
  - ***Nobody in European aviation seems to have any motivation to continue to positively ensure adjacent band compatibility***





DAB migration in Europe

FM/RDS signals and ILS-VOR signals assignments are extremely close and in some cases co-channel



Summary and Further Thoughts

- ILS is stable and mature in its third equipment generation
  - ILS has modernized and moved to digital equipment
    - However, ILS innovation has slowed down
  - Limited appetite to exploit remaining optimization potential

- Main ILS sustainment concern today is about:
  - Maintenance of engineering expertise (especially RF simulation tools)
  - Attraction of ATSEP
  - Reduction of maintenance versus logistic support capability
  - Viability of flight inspection: need sufficient routine, currency and experience
  - A very niche product in a small market (Cat I market carries Cat II/III market)

- ILS flyability benefits from advanced avionics
  - Pilots today express concern about having to fly a “raw data ILS approach”
  - Avionics have variety of anomaly mitigations, but these are not known to ANSP

Summary of ILS Weaknesses

- Operations: Typically longer line up segment compared to RNP Approach
  - Intercept from below causes inefficient level off segment (CDO)
- ILS Capture Issues
  - Annex 10 compliant LOC signal in space can still cause problems for some avionics
  - Intercept from above increases potential to capture false glide slope
- ILS Critical and Sensitive Area Management / Complexity
  - Requires advanced simulation tools for a very specialized application
  - Vertical dimension not well understood
  - New aircraft types could challenge current assumptions
- ILS Glide Path has no IDENT
- RF and Cyber Robustness will remain limited
  - Known issue of sporadic E(s) layer propagation (Japan)
- Outdated (aircraft receiver MOPS) and non-existent (ground facility MOPS) Standards
- Service outage during ILS renewal & false guidance signals during testing plus long time needed for Cat III integrity / continuity demonstration
- Engineering & ATSEP resources: no longer an attractive career choice
- Installation can be impossible depending on site

Summary of ILS Opportunities

- Main industry focus is reduction of life cycle cost
  - Remote and data-driven diagnostics could reduce need for on-site ATSEPs
- Drone-based flight inspection can improve safety and reduce operations cost
  - Drone to replace measurement van for runway centerline check?
- Further optimization of Low Visibility Operations?
- ILS Facility Classification, PB-AOM and Autoland
- Subjects which need equipment upgrades
  - Update of avionics standards to resolve capture issues?
  - Explore “Complementary PNT” for ILS-based final approach?
    - Use GNSS when available to protect against false captures?
    - Use GNSS / FMS to help ensure capture turn initiation with base leg tailwind?
      - However, this could also introduce new GNSS RFI cascading effects

RECOMMENDATIONS

- To responsibly sustain “ILS Forever”, the following needs to be addressed:
  - Expertise and staffing sustainability
  - Flight inspection sustainability
  - Market sustainability (watch manufacturer consolidation)
  - Security concerns should be investigated and possibly mitigated
  - Aeronautical VHF (and UHF?) Spectrum Strategy
  - Evaluation of need for exploiting remaining optimization potential
    - Especially Glide Path but also
    - Reduction of alignment segment to limit drawbacks compared to RNP approaches
    - LVO optimization for advanced ILS (CSA smaller than OFZ)?
  - Accept ILS and SBAS / GBAS as complementary systems for approach and landing

- ILS limitations need to be accepted
  - Inherent limitations remain, including LVO capacity limitations
  - ILS remains one system per runway end with significant civil works required