Current ILS Operations and Lessons for the Future

Gerhard E. Berz, EUROCONTROL
Marcel Amherd, swiss49 ag
Juan Polymeris, SWISS International Air Lines

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Content

- Brief Introduction to ILS Sustainment (Localizer)
- Operational Flight Data Analysis using the EMS
- ILS Operations: Review of Approach Phases
  - Initial Approach – Entering ILS Coverage – ILS Capture & Tracking
- Lessons for the Future
ILS Localizer Challenges & Solutions

- Interference Mechanisms of Two Frequency Systems
  - Reflection and / or Diffraction from Static and / or Dynamic Objects

- Course → Course
  - Effect: Course scalloping

- Clearance → Course
  - Effect: Course bend

- Clearance → Clearance
  - Effect: Scalloping & possible false axis

Mitigation

Super Wide Aperture Arrays

Restricting Radiation

Often Results in States Needing to File Deviation from ICAO Annex 10 SARPs
Raised Coverage Localizer Concept

- Limit Clearance Radiation outside ±15 Degrees
  - Strong roll-off at 15°, but soft “shoulders” out to 35° to mask course sidelobes
  - Clearance Peak shifts inward from 12 to 7°
  - Mitigates typical “Hangar Reflectors” often found at 12 to 15°

- Consequence
  - Difficult / impossible to meet minimum field strength at 2000 ft HAT and 35°
  - However: low & far out coverage corners have limited operational significance
  - SARPs change: permit raising lower boundary up to defined maximum

- Benefits
  - More stable guidance signals where it matters (centerline and capture sectors)
  - No false axis in ±35° sectors, clean full scale deviations

- Goal
  - Enable ILS manufacturers and ANSP to implement ILS LOC that meets challenges by design (instead of accepting deviation from Annex 10)
Current Status

- One Localizer meeting proposed requirements in operation
  - ZRH ILS16 Cat III certified since November 2007
- ICAO NSP finalizing changes in coverage requirements
  - Possible agreement at Fall 2008 meeting
  - Lower coverage boundary height function of operational need (vertical use)
Flight Data Recording System ADAS & EMS
Aircraft Data Acquisition System & Event Measurement System

Data Acquisition + Management

Parameter Database

Maintenance Groundstation

ACARS (Aircraft Communication and Reporting System)

FDR

CVR

SWISS Datawarehouse (EMS System)

Data Analysis via Internet (secure)

Troubleshooting, Eng. Trend, Systems Maintenance

Flight Safety, Ops Engineering, Fuel Advisory, Performance, Planning
Supporting Operational Studies

- Check for Approach & IDENT
  - What the pilots do with ILS outside of coverage…
  - IDENT inside coverage and workload

- ILS Intercept and Capture
  - False capture issue and coverage

- ILS Tracking and Dynamic Multipath
Tuning of ILS (First Pilot Interest)

- First tuning usually in En-Route Phase
  - IDENT can be received well over 100NM out

- Pilots understand & expect that needles will be unreliable
  - Desired feature for some (‘needles alive”)

- IDENT check is normally done during Check for Approach
  - Around FL100
  - USUALLY well outside of coverage
Altitude 12000ft
- (Approach Brief)
- Approach Check
- IDENT Check
IDENT – What’s it for?

- Vital safety function especially at uncontrolled airfields
  - No IDENT = ILS signal shall not be used (ICAO Safety Campaign)
  - Confirmation of correct tuning of an operational facility

- Report “Established on Localizer” enables hand-back of NAV responsibility to Pilot and final descent on glidepath (FAP)
  - Good practice not to arm approach mode without IDENT
  - This “normal ops” function took some time to identify!

- In THEORY, Pilots would have to wait with IDENT until within coverage
  - Practice: Pilots want to get IDENT out of the way as early as possible to reduce high workload flight phase at localizer intercept
IDENT Study Approach

- Construct Worst-Case IDENT Scenario
  - If it had to be done within coverage
  - Determine if IDENT can be completed given workload

- Fleet Considerations
  - Focus on large air line operations
    - IDENT via PFD Display
  - Regional, Business and GA Fleet less critical:
    - Audio IDENT comes earlier than PFD
    - Higher dynamics correspond to aircraft capabilities (EMS Data, London City)
    - IDENT often also available via DME (ILS associated DME)
Worst Case Geometries & Timing

- Downwind Approach: close to LOC, many sidelobes
- Straight-In Approach: main signal lobe, time to acquire signal
- Most difficult are T-Approaches
  - least time b/w coverage & LOC intercept
- EMS shows distribution at 3 min to LOC Track Mode
  - 64% outside of coverage!
  - Analyzed “Shortest time to LOC track after crossing 35° line”
  - All flights have 120 seconds or more
  - From 15° line, 71% still have 120+ sec
  - 120 sec before LOC TRACK used as time window criteria
High Workload Approaches

- Workload highest if pilot busy keeping up with ATC instructions (short-cuts)
- High energy state / steep descent
  - EMS: “Excess Energy to Bleed” Warnings

3° G/S (data check)
Taskload Analysis

- Difference between Workload (mental) and Taskload (actions)
- EMS can only measure Taskload – used as indirect measure of workload
- Split into Pilot Flying PF / Pilot Non Flying PNF
  - Each action triggers an event of 5 seconds (takes into account some initiation and feedback time)
- Function of Autopilot (A320 peculiarity)
  - Not possible to fully extend speedbrakes with AP ON
  - PNF takes over all FMS / AP manipulations while PF hand-flies
  - PF looks idle due to absence of events, but is fully tasked
- Analyzed Flights with Fast Intercept Geometry & High Workload
Taskplot Example

- High Workload, Autopilot Off example
- Gear, flaps, speed brakes, VHF voice, FMS & Autopilot manipulations, etc...
- ASSUMPTION: If 30 sec task free window within 120 to LOC track, IDENT can be done
Results: Distribution of Task Free Windows

- Around 70% of flights meet the window criteria for either PF or PNF & AP on/off cases
  - As either pilot can do IDENT, cumulative probability is high
- Remaining most difficult cases reviewed by expert pilot
  - IDENT considered possible even in worst-worst cases
- But overall argument is a stretch!

(30 sec bins)
- Pilots need IDENT at check for approach near FL100
  - If pilots had to wait with IDENT until being inside, coverage requirements would be challenging to justify (would need to be larger)

- Not possible to remove this technical over-performance once pilots have gotten used to it!
  - Even if wrong IDENT is possible (co-channel / spectrum)

- High Workload caused by high energy state / ATC shortcut
  - Conversely, pilots aiming for low workload come in low on purpose (long-haul)
Supporting Operational Studies

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- ILS Tracking and Dynamic Multipath
Intercept Turn Initiation

- Course guidance is on the order of ±2° (FSD, function of runway length)
- DDM’s typically keep increasing up to ±4°
  - This system margin is intended to give installation flexibility to the ANSP
- Reliable intercept turn initiation without overshoot needs at least ±5°
  - More in strong tailwind situations
  - Has resulted in some avionics that make use of non-standardized region
  - Natural response to operator expectation, but leads to interoperability problems

Utilized by AFCS (up to ±4°)
Standardized Proportional Region

Problematic Scallops
False Capture Mitigation (Partial)

- Good practice to arm for LOC intercept as late as possible
  - Usually done near 5°
  - Conversely, late arming is a natural result of receiving ATC intercept clearance
Localizer Intercept Procedure

Interaction of PANS-OPS, Flight Ops & Vectoring…
ILS Capture Points

- Majority of Glide Path captures and significant portion of LOC capture occur well outside of formal coverage.
- OK because centerline coverage is usually best.

Distance from LOC capture to LDG RWY threshold:
- 25 NM (LOC)
- 10 NM (GP)
Intercept and Capture Lesson Summary

- Operational need for deviation guidance enabling reliable ILS intercept turn initiation is at least 5°
  - Pilot crews have gotten used to finding alternate means
    - RNAV or Airport VOR
    - Current interoperability issues (false capture) due to operational need

- Operational use of ILS has evolved
  - Advances in aircraft and associated aerodynamics, as well as ATC factors (vectoring practices) contribute to need for centerline guidance well outside of coverage ranges

- Advances in Continuous Descent Approach (CDA) Implementation
  - Will increase desire for far out captures (LOC and especially GP)
Supporting Operational Studies

- Check for Approach & IDENT
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- ILS Tracking and Dynamic Multipath
  - What level of deviations & disturbances is operationally relevant?
ILS Tracking - in Presence of Multipath

- Supports ongoing Critical & Sensitive Area (CSA) work

- Avionics have implemented additional filters to limit effect of transients (due to maneuvers on airport)
  - One OEM using 7 second window

- Loss of LOC tracking is very rare (go-around or other maneuver)
  - Prior to FAP (>> 7 NM to THR), significant maneuvers and recapture possible (operational reasons - flock of birds, etc. but extremely rare)
  - Roughly 1 or 2 in 300 go-around's can be attributed to ILS

- Transient deviation disturbance usually tolerable when visual
  - Go-around likely in Instrument Met Conditions
- Half dot deviation maxima is quite significant
  - Near 30µA SARPs tolerance
  - reasonable limit even if derived to limit displacement at DH/DA
- Events occur from 7 NM inward (5 sec example below)

![Half Dot (1/4 FSD, 37.5µA)]
Once aircraft is established on ILS, landing success highly likely
- ILS is a “minority cause” for rare approach interruptions and go-around’s
  - Many ILS operations each day ➔ pilots handle these cases regularly
  - Airline 1/4 dot go-around criteria reflects operational experience

Pilots are NOT expected to know about coverage volumes and associated implications
- ANSP notion of responsibility limit not relevant to pilot
- To pilot, avionics are to indicate any limitations

A signal will be used wherever it is received
- ANSP also has a desire to maximize utility of investment
- Pilots aware of limitations mostly from operational experience
- It can also be viewed as a detriment to safety to not use an available signal
Conclusions

- ILS is considered a standard of operational suitability
  - Does not mean that there isn’t room for improvement
  - New landing systems should try to alleviate current limitations (esp. coverage)
    - “ILS look-alike” includes the non-standardized features…!

- All such development requires an open dialogue between technical and operational communities

- EMS Essential to Provide Quantitative, Data-Driven Analysis
  - Large sample statistics ➔ global credibility
  - Provides filtering to enable expert analysis of small sample data
Questions?