SISTEMI ILS (INSTRUMENT LANDING SYSTEMS) E MLS (MICROWAVE LANDING SYSTEMS)
Poor Visibility Landings
Instrument Landing System
Instrument Landing System

- History of IFR landing procedures before development if ILS
- What’s it used for?
- How it works
- Why it’s so important
- Future plans for ILS system
History of IFR Landing Procedures

- Until the mid-1950’s, only visual landing procedures were possible
- 1958-First IFR landing system developed
- 1966-First ILS system developed and tested at Edwards AFB in Mojave, CA
- 1968-First ILS applications installed at major airports
- 1974-ILS systems mandated by FAA for at least two major runways at all Regional, and International Airports.
What It’s Used For

- Aid aircraft to a runway touchdown point in IFR conditions
- Aid larger aircraft (ex. Boeing 747, 777) to land on a designated runway touchdown point (VFR, IFR)
- Allow for use of new Autoland systems!

MD-80 aircraft taking off over Glide-Slope equipment
How does it work?

- VHF Frequency transmits radar signal and intensity data to ILS Signal Deciphering and Display Computer
- Localizer signal transmitted in direction opposite of runway to horizontally guide aircraft to touchdown point
- Glide-Slope signal transmitted at an angle of 7.5-10 degrees into sky to define vertical descent path to runway touchdown point
- On-board antenna system located in aircraft radome receives radar and VHF signals and sends it to on-board ILS computer
- Signal data is then displayed on instrument panel gauge which maps the directional, and descent path to the runway
Instrument Landing Systems (ILS) are designed to guide an aircraft in its final approach and landing.

Three distinct subsystems are used:
- Localiser,
- Glide Slope, and
- Markers.
ILS Components

- Localizer – indicates alignment w/ runway
- Glideslope – indicates correct descent path
- Outer Marker – Final Approach Fix
- Middle Marker – Missed Approach Point
Localiser

- Aids the pilot in lining up his/her aircraft in the proper azimuth approach to the runway.
- Consists of a group of transmitters and antennas positioned at the far end of the runway.
- The antenna radiation pattern has a $5^\circ$ beawidth, centred along the runway.
- The VHF frequencies used for the localise are in the range 108.1 to 111.9 MHz.
- The useful range of the system is about 40 km.
Localiser Plan

DIRECTION OF APPROACH
Localizer

Needle indicates direction of runway.
Centered Needle = Correct Alignment
Glide Slope

- Aids the pilot in making his/her approach at the proper elevation angle to the runway.
- Consists of a group of transmitters and antennas positioned beside the runway.
- The antenna radiation pattern has a 1° beamwidth, and elevated about 2.5° to 2.75° in the direction of approach.
- The VHF frequencies used for the glide slope are in the range 329.3 to 335.0 MHz.
- The useful range of the system is about 40 km.
The Signal Transmission System

Glide-Slope and Localizer Diagrams

Signal Tuning Box → Signal Amplifiers → Transmission Dish

Remote signal adjuster

Radio (VHF) Application

VHF Signal Processor → Signal Amplifiers
Glide Slope Plan

(top view)

(side view)

Direction of Approach

Runway

Localiser

Tx

90 Hz

150 Hz

5°

2.5° - 2.75°

1°

90 Hz

150 Hz

DIRECTION OF APPROACH
VHF Glide-Slope Antenna's
Frequency Arrangement
Glideslope

Needle indicates above/below glidepath.
Centered Needle = Correct Glidepath

Descent Cone
Correct Glidepath
Runway
Markers

- Markers are transmitters that radiate continuous narrow vertical radio beams.
- The carrier frequency is 75 MHz modulated by special tones.
- The first transmitter is modulated by a 400 Hz tone, located at 6 - 10 km from the end of the runway.
- The second transmitter is modulated by a 1300 Hz tone, located at 1 km from the end of the runway.
Markers Plan

Marker Tx
400 Hz
Carrier 75 MHz
1300 Hz
1 km
6 - 10 km

Runway (top view)

DIRECTION OF APPROACH
Outer/Middle Marker Beacons

● OM – Denotes beginning of final approach segment (Final Approach Fix).
● MM – Denotes Missed Approach Point (MAP)
  – Usually placed at decision height on glidepath.
  – “If you can’t see the runway yet, go around.”
● Represented by indicator lights with accompanying aural tone in cockpit.
Microwave Landing System
Introduction

- Microwave Landing System (MLS) was designed to handle the increase in air traffic volume and to satisfy the demand for all-weather landing facilities.
- Employs microwave frequencies (5 - 5.25 GHz band) rather than VHF.
- MLS provides better accuracy, ease of application, and automation. enables landing down to zero ground visibility.
- ICAO-approved replacement for the ILS system.
Architecture

● MLS consists of three subsystems:
  - Localiser,
  - Glide Slope, and
  - Flare.

● The Localiser and Glide Slope subsystems serve the same purpose as in ILS.

● The Flare provides information on the actual height of the aircraft above the plane of the runway.
The angle $\theta$ made by the aircraft and the runway at the point where the flare transmitter is situated is measured.

The distance $d$ between the flare transmitter and the runway is known.

The height is calculated using the equation:

$$h = d \tan \theta$$
Aircraft Height Measurement

\[ h = d \tan \theta \]
Operation

- The system is based on Time-Reference Scanning Beams (TRSB), referenced to the runway, that enables an aircraft to determine precise azimuth and elevation angles.

- The angular position is made by measurement of the time intervals between the TO and FRO azimuth antenna beam scan (typically +/- 60°) and UP and DOWN scan (typically 0° - 30°) of the elevation antenna pattern.
Time Reference Scanning Beam

- Time Reference Scanning Beam
- Localiser
- Runway
- (top view)
- DIRECTION OF APPROACH
- $\phi$
- $\theta$
- $\alpha$
- $\phi$
- $\theta$
- A
- B
- Localiser Tx
- (top view)
The angles $\theta$ (or $\alpha$) are calculated using the equation:

$$\theta = \phi \left[ 1 - \frac{D \Delta t}{\Delta \theta} \right]$$

$\Delta t$ is the time difference between pulses and $T$ is the scanning period from A to B and back to A.
Approach Plates
Non-Precision Approaches

- When glideslope is unavailable, pilots may still make a localizer-only approach.
- In lieu of glideslope, pilot uses step-down fixes printed in approach plate to descend.
VOR / DME

- VOR: bearing of aircraft to radio station
- DME: distance from aircraft to radio station
- VOR and DME are usually collocated, providing pilot with bearing and distance.
VHF Frequency Data Transmitter
Aircraft On-board Receiving System
Where Is The Ground Equipment Housed?

ILS Ground Equipment Shed
ILS Approach Plate (chart)

- Localizer path
- Glide-Slope Path
Input To System

- Pilot selects VHF frequency on board the aircraft to track the ILS
- ILS technician in control tower adjusts ILS signals as necessary (radar application only)
Why Is It So Important?

- Allows for IFR Landings
- Greatly increases airport efficiency in inclement weather, or in heavy aircraft operations
- Compatible with new Autopilot systems with Autoland capabilities
- Helps pilots land larger aircraft at unfamiliar airports
The Future of ILS

- Satellite Landing Systems (SLS) using GPS data to define Glide-slope and Localizer paths to runways
- Microwave Landing Systems (MLS): Operate in same principle as radar ILS, but at stronger signals
- IPLS (Instrument Pattern and Landing System) which maps landing corridor, and airport landing patterns
- Demise of radar ILS
- Certification of all ILS applications for Class 3 Autoland capabilities
Today’s landing systems

- The Instrument Landing System (ILS)
  - Concept adopted by ICAO in 1948
  - Cat IIIb autoland (zero visibility) since 1974
  - Currently used precision landing system worldwide
  - Proven technology
  - Limitations regarding siting, operational flexibility, number of available channels, susceptibility to interference from FM radio stations
Today’s landing systems

- The Microwave Landing System (MLS)
  - More flexibility, more channels, reduced siting requirements, reduced susceptibility to interference
  - Was scheduled to have replaced ILS worldwide in 1998
  - ICAO changed mandate in 1995 due to GPS euphoria
  - At present only installed at a few airports
GNSS: A potential alternative?

- Can GNSS replace ILS Cat I, II and III?
  - Required accuracy was demonstrated both in the U.S. and Europe during 1993 and 1994 using local differential corrections
  - At many U.S. airports WAAS does not provide a position accuracy that meets ILS Cat I requirements
  - Vulnerability to intentional interference is still a major issue
  - LAAS is needed for accuracy and integrity
  - In 1995, LAAS Cat I was expected to be available in 1998
GNSS: A potential alternative?

- Can GNSS replace ILS Cat I, II and III?
  - In January 2004 the FAA halted LAAS developments. After having spent $200M, no LAAS Cat I is available yet.
  - In the U.S. recently 150 new ILS Cat I systems have been acquired and another 150 are expected soon.
  - No credible timeline for the implementation of a satellite based Cat IIIb landing capability exists today.
New functions needing a GNSS sensor

- **Enhanced approach guidance**
  - Along more complex paths towards the final straight segment (noise abatement, terrain/obstacle clearance)
  - In locations where no other precision guidance is available (reduction of ALA/CFIT)

- **Surface navigation and guidance support**
  - No other on-board position sensor provides the required accuracy