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SYSTEMS GROUP CHAIRMAN'S FACTUAL REPORT
ATTACHMENT 4
ILS GENERAL DESCRIPTION

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(6 pages)

ATTACHMENT 4

Instrument Landing System (ILS)-System description

The ILS system consists of ground-based and airborne equipment. The airborne portion of the ILS system consists of a receiver or receivers with localizer, glideslope, and marker beacon functions; three antennas; a control unit; an indicator displaying localizer and glideslope deviation, and a set of marker beacon lights.

Ground facilities

An ILS facility consists of a localizer transmitter and antenna located at the far end of the instrument runway, a glideslope transmitter located at one side of the near end of the runway, and a set of marker beacon transmitters and antennas located along the approach course.

The glideslope antenna is capable of operating between 328.6 and 335.4 MHz, with the lowest assigned frequency at 329.15 MHz. The localizer operates between 108 and 112 MHz and the lowest assigned frequency is 108.1 MHz. The International Civil Aviation Organization (ICAO) specifies that the carrier is modulated at 47.5%.

The glideslope signal is radiated to produce two intersecting lobes, one above the other. The upper lobe is predominantly modulated at 90 Hz, while the lower lobe is predominately modulated at 150 Hz. On a line at 2.5-3.0° from the ground, the two audio signals are equal. This line of equal modulation defines the glideslope.

The localizer signal is similar except that the radiated lobes are side-by-side and directed along one side of the runway. The lobe to the left is predominantly modulated with 90 Hz, and the lobe to the right is predominantly modulated with 150 Hz. The two signals are equal along a line bisecting the extended center line of the runway. The line of equal modulation defines the localizer course.

ILS marker beacons operate on a fixed frequency of 75 MHz. The markers provide location along the glidepath and reference points for aircraft maneuvers. The locations of the markers are given in the approach procedures for each facility.

Airborne equipment

Receiver

Three receivers are used in ILS operation; a VHF localizer receiver, a UHF glideslope receiver, and a marker beacon receiver. Localizer and glideslope receivers are often contained within the same unit. The receiver contains all the necessary circuits for receiving, decoding, and computing the localizer and glideslope signals transmitted by the ground facilities.

If the information sent to the indicator is not valid or if there is a failure in the system, this fact would be displayed on the indicator by a warning flag or annunciator.

Controls

The control is usually the same used for the VOR system. The control selects a VHF localizer frequency which automatically selects the paired UHF glideslope frequency using a 2-of-5 binary, bridge tuning, or serial data word format.

ILS Indicators

ILS information can be displayed on several different types of indicators. These can include CDI's, HSI's, ADI's, and flight directors. These types of indicators show lateral deviation (localizer) and vertical deviation (glideslope) with respect o an aircraft symbol in the middle of the indicator. Also displayed on these indicators are pitch and roll functions, as well as steering command information as computed by flight director systems. Warning flags are displayed whenever the information supplying that function becomes unreliable.

A marker beacon visual indicator is usually a lamp installation that consists of three lamps (blue, amber, and white) which indicate the marker being flown over. Audio tones also indicate when the marker is being flown over.

Antenna

Three antennas are required for complete ILS operation. A horizontally polarized, omnidirectional antenna operating in the 108-112 MHz range is required for localizer operation. Typically the localizer receiver operates using the same antenna as the VOR navigation receiver. Glideslope operation requires a folded dipole antenna capable of receiving AM signals in the 329-335 MHz range. The marker beacon receiver typically uses a loop antenna operating at 75 MHz.

KOREAN AIR TESTS

Korean Air-ILS System Test Results

Following the Korean Air Flight 801 accident, Korean Air devised and performed a series of tests on various ILS receivers to determine the effects of extraneous signals on the ILS equipment. The NTSB, Boeing, and Rockwell Collins did not participate in the testing; however, the test methods and results were provided to all accident investigation parties.

A 335 MHz test signal (ILS frequency of 110.3 MHz), -90dBmw, 120 Hz modulation at 100% was applied to the ILS receiver under test while the glide slope indicator and flag were monitored for movement. ***Reference Figure 1 of block diagrams for test setup*** The following results were noted:

Receiver	**Glide Slope indicator deviation**	**Flag**
51RV-5B	-58 mV	out of view
51RV-1	-5 mV (centered)	out of view
51RV-2B	-58 mV	out of view (at 270mV)
ILS-70	-1.01 V	out of view
RIA-32A	n/a	in view
ILS-700 series	n/a	NCD (no computed data)

The test was repeated with the same results using a radio transmitter powered by a full wave rectified DC with the oscillator frequency set at 83.75 MHz (one fourth of 335 MHz). ***Reference Figure 2 of block diagrams for test setup.***

The test was repeated on an airplane on the ground with 120 Hz pulsating current feeding the RF signal generator. ***Reference Figure 3 of block diagrams for test setup*** The indications recorded were:

VOR tuned to 115.3 MHz, course set as 063: NAV capture
NAV tuned to 110.3 MHz: LOC, GS flag out of view
LOC Center, GS 0.8 Dot up
FD Green NAV, White GS

Rockwell Collins response to Korean Air Tests

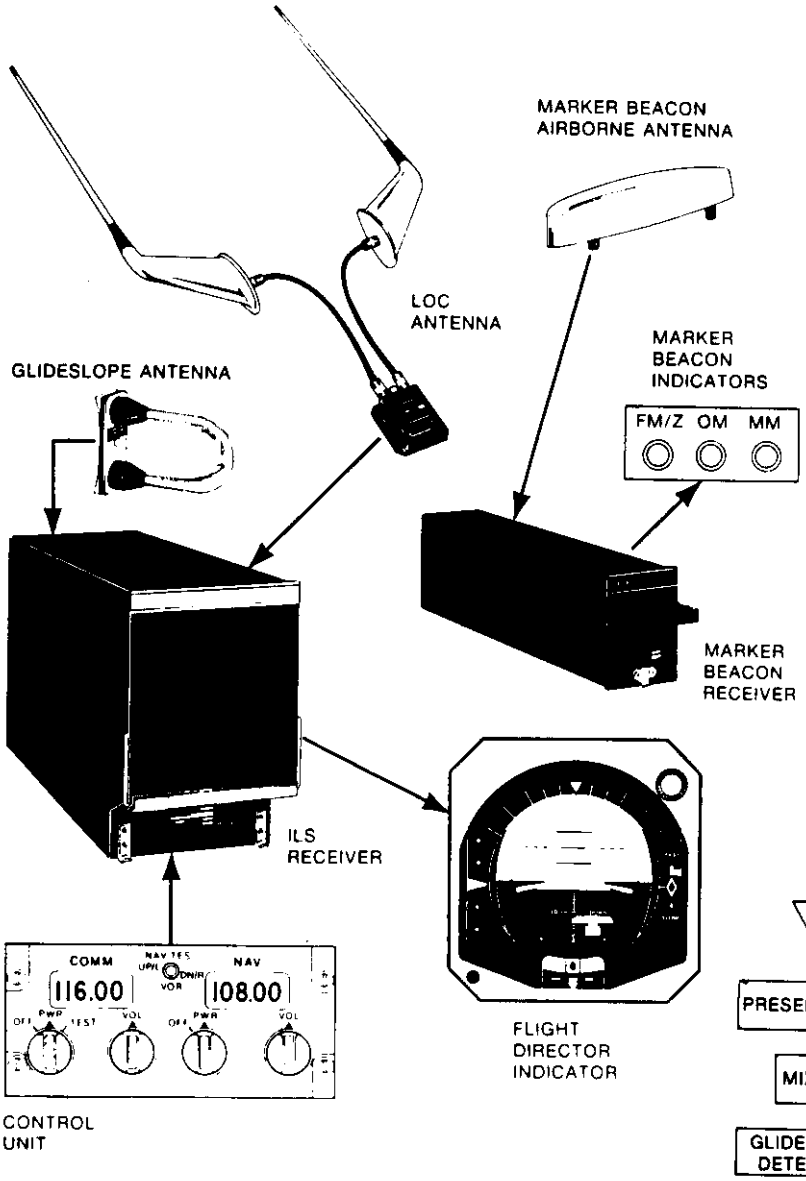
Rockwell Collins technical specialists evaluated the performance of the 51-RV5(B) according to the test defined by Korean Air and responded in a 19 December 1997 letter from Mr. R.A. Patterson to Mr. S. R. Cho of Korean Air:

> ...findings are similar to those of KAL; the receiver response to a single 120 Hz tone, 100 percent modulation at 335.0 MHz is an out of view flag. However this is consistent with the standards to which the product was designed and qualified.
>
> The ILS Glide Slope receiver function of the 51-RV5(B) complies with RTCA DO-132A which specifies warning flag operation for no tone, reduced tone

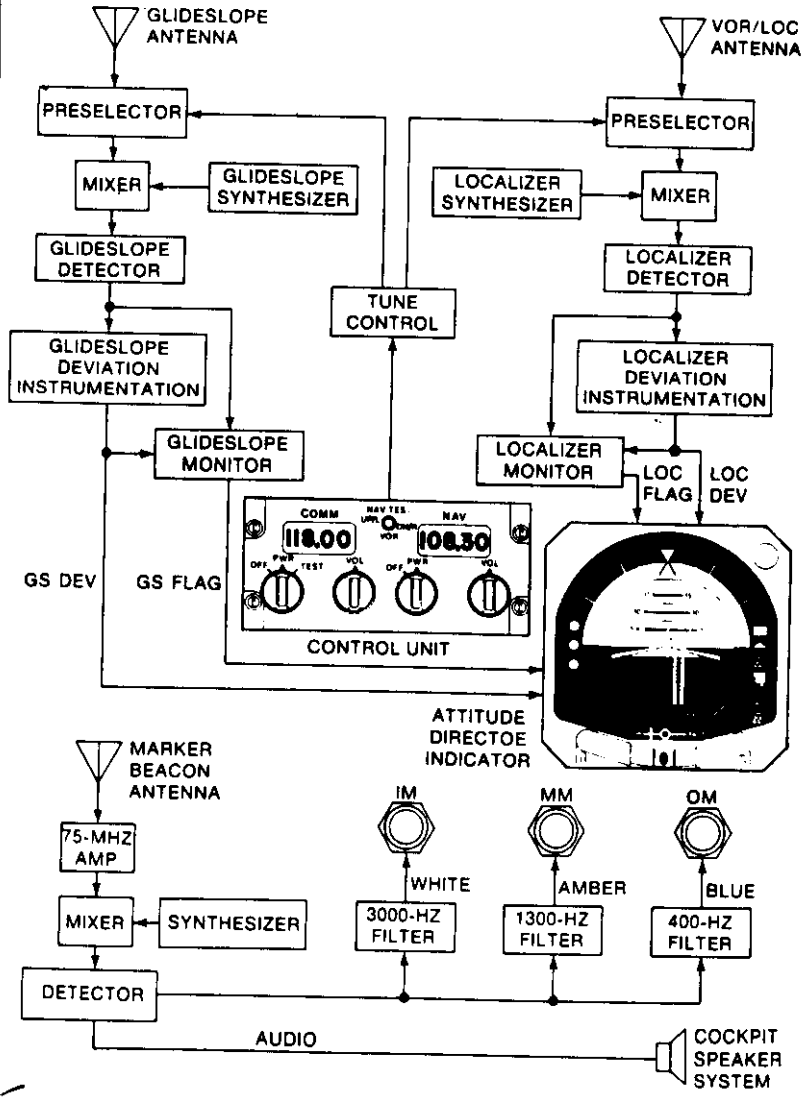
modulation, and loss of tone. These specify that the warning flag shall be in view when one tone (90 or 150 Hz) is maintained at the normal 40 percent level and the other is reduced to zero. The 51-RV5(B) complies with this specification.

ICAO Annex 10 Appendix 3 provides specifications for ILS transmitter stations. This specification stipulates, that for Glide Slope signals, the depth of modulation of the radio frequency carrier at each of the 90 and 150 Hz shall be approximately 47.5 percent. Limits are set at 45 and 50 percent "in order to achieve the maximum benefit from the airborne receiver flag alarm system."

The 51-RV5(B) implementation employs resistive/capacitive networks filters to detect 90 and 150 Hz tones. When the carrier signal is greatly over modulated, it is possible to couple sufficient energy through these filters to cause the alarm flag to move out of view. The test procedure defined by Korean Air represents a condition outside the specifications for either the transmitter or the receiver.

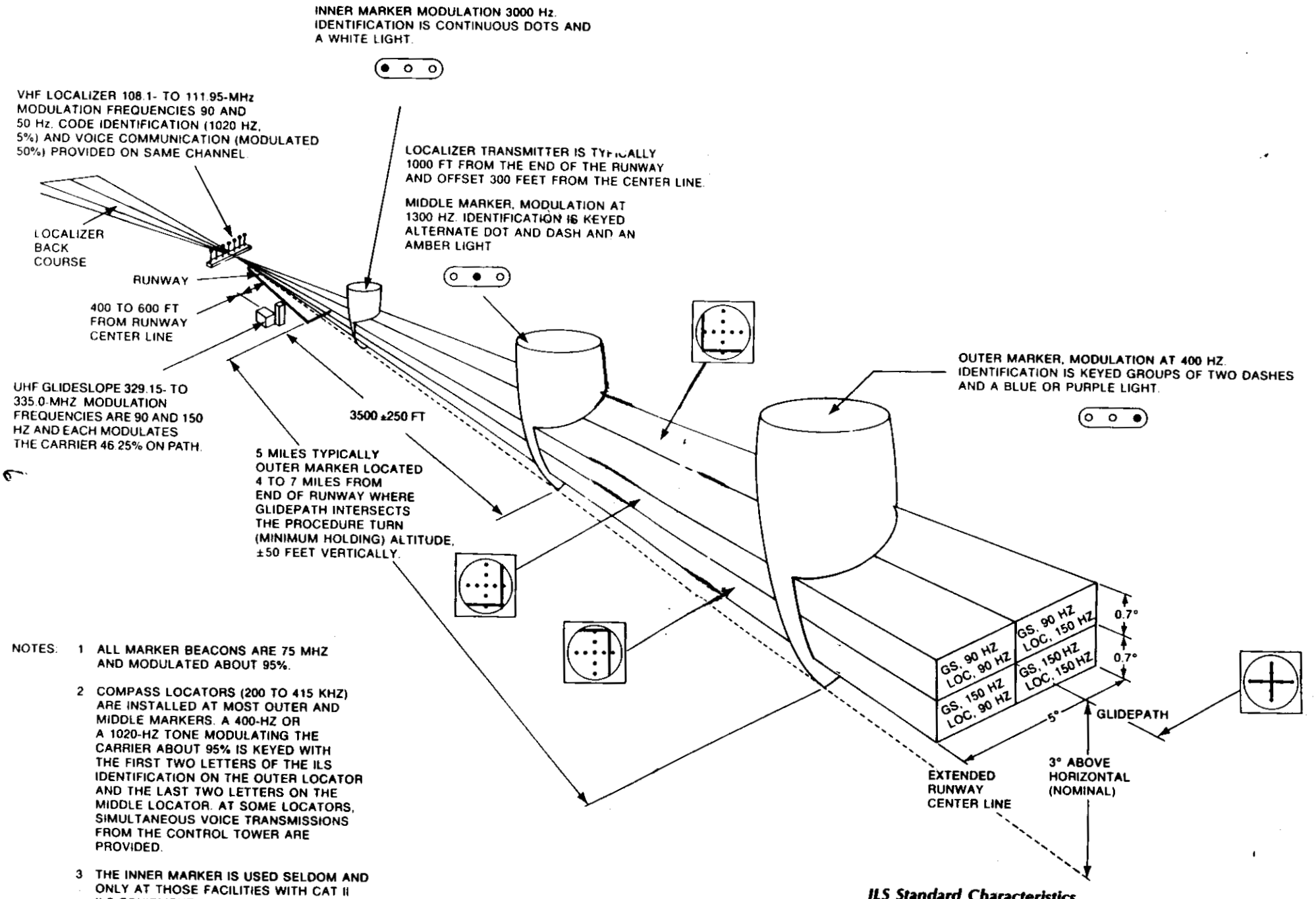


ILS System



ILS Block Diagram

ILS System description and Figures provided by:
Collins Air Transport Division
Rockwell International Corporation
Cedar Rapids, Iowa



NOTES:

1. ALL MARKER BEACONS ARE 75 MHZ AND MODULATED ABOUT 95%.
2. COMPASS LOCATORS (200 TO 415 KHZ) ARE INSTALLED AT MOST OUTER AND MIDDLE MARKERS. A 400-HZ OR A 1020-HZ TONE MODULATING THE CARRIER ABOUT 95% IS KEYED WITH THE FIRST TWO LETTERS OF THE ILS IDENTIFICATION ON THE OUTER LOCATOR AND THE LAST TWO LETTERS ON THE MIDDLE LOCATOR. AT SOME LOCATORS, SIMULTANEOUS VOICE TRANSMISSIONS FROM THE CONTROL TOWER ARE PROVIDED.
3. THE INNER MARKER IS USED SELDOM AND ONLY AT THOSE FACILITIES WITH CAT II ILS EQUIPMENT.

ILS Standard Characteristics