CHAPTER 9

AUTOMATIC CARRIER LANDING SYSTEM

The most demanding task facing a pilot is the landing of the aircraft on an aircraft carrier in rough seas. Landing an aircraft on a stationary land airstrip is hard enough. Add to that task the motion of the carrier in the water, the wave action, and the vortex of air caused by the island, and you can see the problems facing the pilot.

With the electronic technology of today, the carrier landing is made easier for the pilot. The automatic carrier landing system (ACLS) is a great aid to the pilot. This system, once engaged, provides the aircraft with the following capabilities:

- Data link roll commands are used to intercept and lock onto the landing pattern.

- Data link pitch commands establish the proper glide path.

- The autopilot provides warnings if the automatic carrier landing mode becomes uncoupled or is degraded.

This system does not guarantee a perfect landing, nothing can do that. What this system does do is to ensure that the pilot and aircraft have the best and safest possible approach and descent to the carrier deck and touchdown.

AUTOMATIC CARRIER LANDING SYSTEM COMPONENTS

Learning Objective: *Recognize systems, subsystems, and components used in the automatic carrier landing system.*

Although this system is used on the aircraft, some of the subsystems are located on the aircraft carrier. There is no ACLS “box” on the aircraft. This system uses parts of other systems already onboard the aircraft. Figure 9-1 shows how the ACLS components interface and the signal data.

AUTOMATIC FLIGHT CONTROL SYSTEM AN/ASW-42

The automatic flight control system (AFCS or autopilot) is located on the aircraft. This system provides the interface between the data link and the aircraft flight control surfaces. It is the system the pilot uses to select ACLS. The AFCS provides switching and signal conditioning, engage logic, command signal limiting, and failsafe interlocks. The failsafe interlocks are required to couple and process data link signals to the pitch and bank channels of the AFCS. Automatic synchronization is provided in all three axes.

DIGITAL DATA COMMUNICATION SET AN/ASW-25B

The digital data communication set (DDCS) receives the data link messages and signals, screens out invalid messages, and then sends the signals to the AFCS. The DDCS is located in the aircraft.

RECEIVING-DECODING GROUP AN/ARA-63

The receiving-decoding group (R-DG) determines the glide-path errors from the carrier’s instrument landing system radar. It also converts the data into signals for the pilot’s flight path cross pointers. The R-DG is used for airborne monitoring of Mode I approaches and for Mode II. All three modes (Mode I, Mode II, and Mode III) will be discussed later in this chapter.

INSTRUMENT LANDING SYSTEM AN/SPN-41

The instrument landing system (ILS radar) transmits the glide path pulse-coded Ku-band information from the carrier to the aircraft. This system is located on the carrier and uses two antennas. One antenna is used to transmit azimuth information, and the other transmits elevation information. Both signals are processed by the R-DG on the aircraft.

LANDING CONTROL CENTRAL SYSTEM AN/SPN-42

The landing control central system (tracking and comparison radar) (LCCS) transmits Ka-band signals from the carrier to the aircraft. The LCCS uses a conical scan antenna. This radar system tracks aircraft, and compares the aircraft position to the desired glide path. There are five shipboard subsystems included in this system. These subsystems are as follows:

1. Tracking pulse radar set (Ka band). This radar set locks on aircraft when the aircraft enters the acquisition gate. The system then tracks the aircraft in range, azimuth, and elevation until touchdown or waveoff.

2. Stabilization group. This group translates the actual radar-derived position vector of the aircraft to a

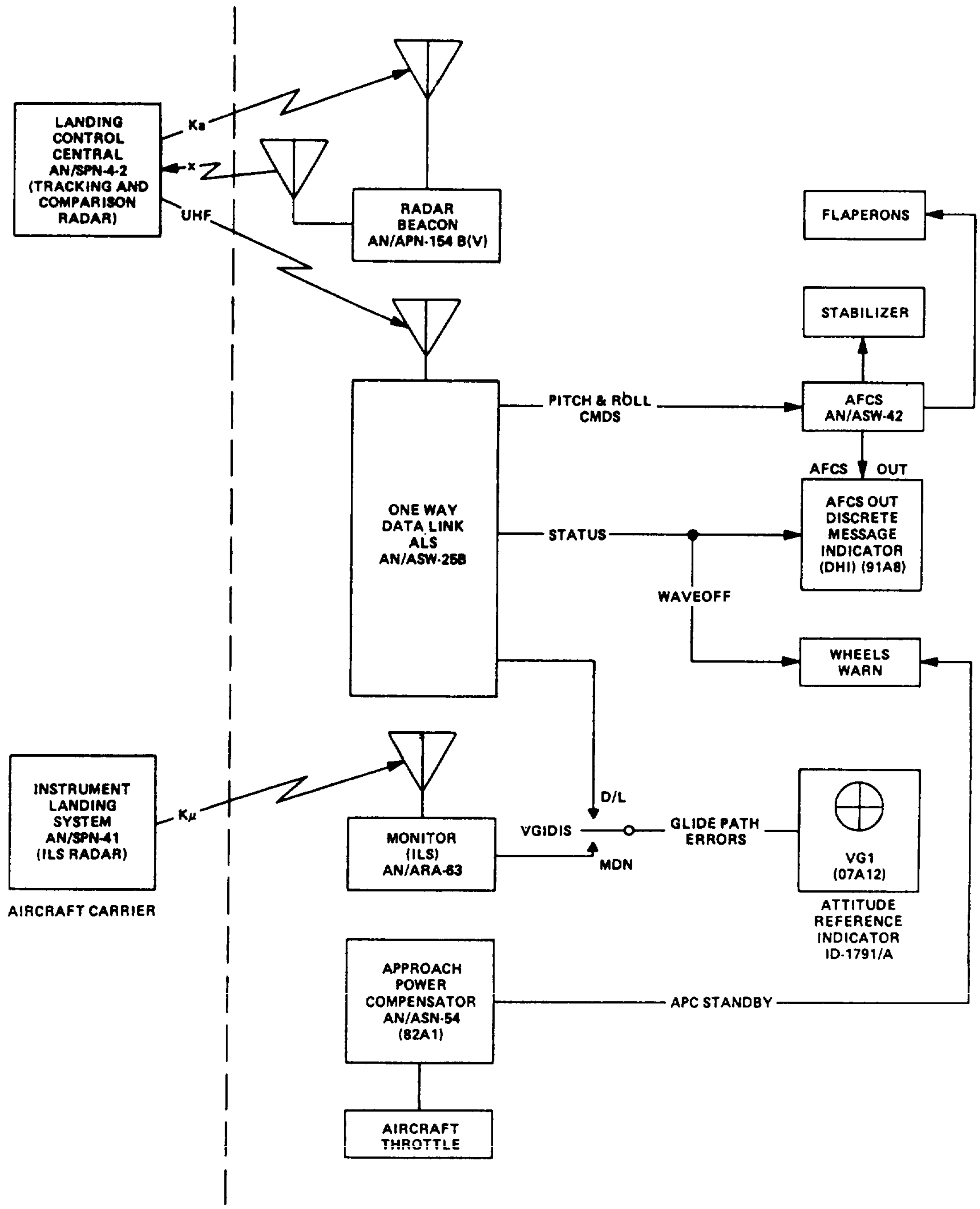

Figure 9-1.-Simplified block diagram of the ACLS system.

stabilized deck-coordinated system referenced to the touchdown point on the flight deck.

3. Digital computer. This is a general-purpose computer used to provide functions for radar data stabilization, data filtering, and computations required for control of the aircraft.

4. Data link monitor. This subsystem continuously checks data link transmissions for errors. If the messages do no check properly, the monitor will switch the system to either Mode II or Mode III, or will generate a waveoff signal.

5. Control console. This console monitors and controls the various functions of the landing system.

RADAR BEACON AN/APN-154B

The radar beacon is located on the aircraft and is used to receive the Ka-band signal interrogations from the LCC radar. The radar beacon then transmits X-band replies to the carrier to provide precise aircraft position data.

APPROACH POWER COMPENSATOR AN/ASN-54

The approach power compensator (APC) automatically adjusts throttles to maintain the angle-of-attack, and thus, the airspeed during aircraft landing approach. It can be used for all carrier landings and is required for Mode I approaches. For Mode II and Mode III approaches, the APC is optional. Data from the angle-of-attack transducer, normal accelerometer, and the stick/stabilizer position are used to control an electromechanical servo actuator. This servo actuator is coupled to the throttle linkage on the engine fuel control.

ATTITUDE REFERENCE INDICATOR ID-1791/A

The ID- 1791/A (VGI) is used to display the glide path errors from either the data link or monitor link on cross pointer needles. This indicator also determines and displays backup pitch and roll attitude, as well as displaying side-slip and turn rate.

DISCRETE MESSAGE INDICATOR 128AV66836

This indicator is located on the aircraft. It displays nine status indications from the one-way link system, autopilot, and the beacon radar.

WARNING INDEXER PANEL

Three warning lights on the warning indexer panel informs the pilot of the status of the approach power compensator, the status of the AFCS, and whether a waveoff has been initiated. The three indicators are the APC STBY, AFCS OUT, and the WAVEOFF indicators. The APC STBY will illuminate when the APC is in standby. The AFCS OUT will illuminate when the autopilot system is not operating properly. The WAVEOFF indicator will illuminate when a wave-off has been initiated. When either the AFCS OUT or the WAVEOFF indicators illuminate while in Mode I approach, the pilot is required to immediately take over control of the aircraft.

APPROACH INDEXER 1284V653-1

This unit is located on the aircraft. It provides an additional angle-of-attack in the pilot's field of view. This unit is used when flying cross pointers on a Mode II approach or when monitoring display on a Mode I approach.

PRINCIPLES OF OPERATION

Learning Objective: *Recognize the operating principles of the automatic carrier landing system.*

The all-weather combination AFCS/ACLS provides automatic, semiautomatic, or manual operation for aircraft carrier operations with minimum use of airborne electronic subsystems. The aircraft control commands are generated by shipboard computers so that the necessary pitch and bank signals can be received by the AFCS via the one-way data link system. This closed-loop operation between aircraft and carrier provides automatic control to touchdown. This system provides a final approach and landing for carrier-based aircraft during daylight or darkness, with minimum interference for conditions of severe weather and sea state, and no limitation due to low ceiling and visibility.

There are three modes of operation of the ACLS that can be selected by the pilot—Mode I, Mode II, and Mode III. Mode I is a fully automatic approach from entry point to touchdown on the flight deck. Mode II requires manual control of the aircraft. In this mode, the pilot controls the aircraft by observing cockpit displays. Mode III is manual pilot control with talkdown guidance by a shipboard controller that provides verbal information for pilot control to visual minimums. The pilot can use full Mode I capability with Mode II and Mode III as backups.

LANDING SEQUENCE

The landing sequence begins when the aircraft is at the marshaling point (fig. 9-2) under control of the carrier air traffic control center (CATCC). The sequence is in two phases: approach and descent. Flight from the marshaling point to the radar acquisition window is the approach phase. Flight from the radar window to touchdown is the descent phase. Transition from the approach phase to the descent phase is done with a minimum of switching operations to reduce pilot task loading.

MODE I LANDING OPERATION

Figure 9-3 shows the Mode I landing sequence. The sequence begins when the aircraft is at the marshaling point. Here the aircraft is held according

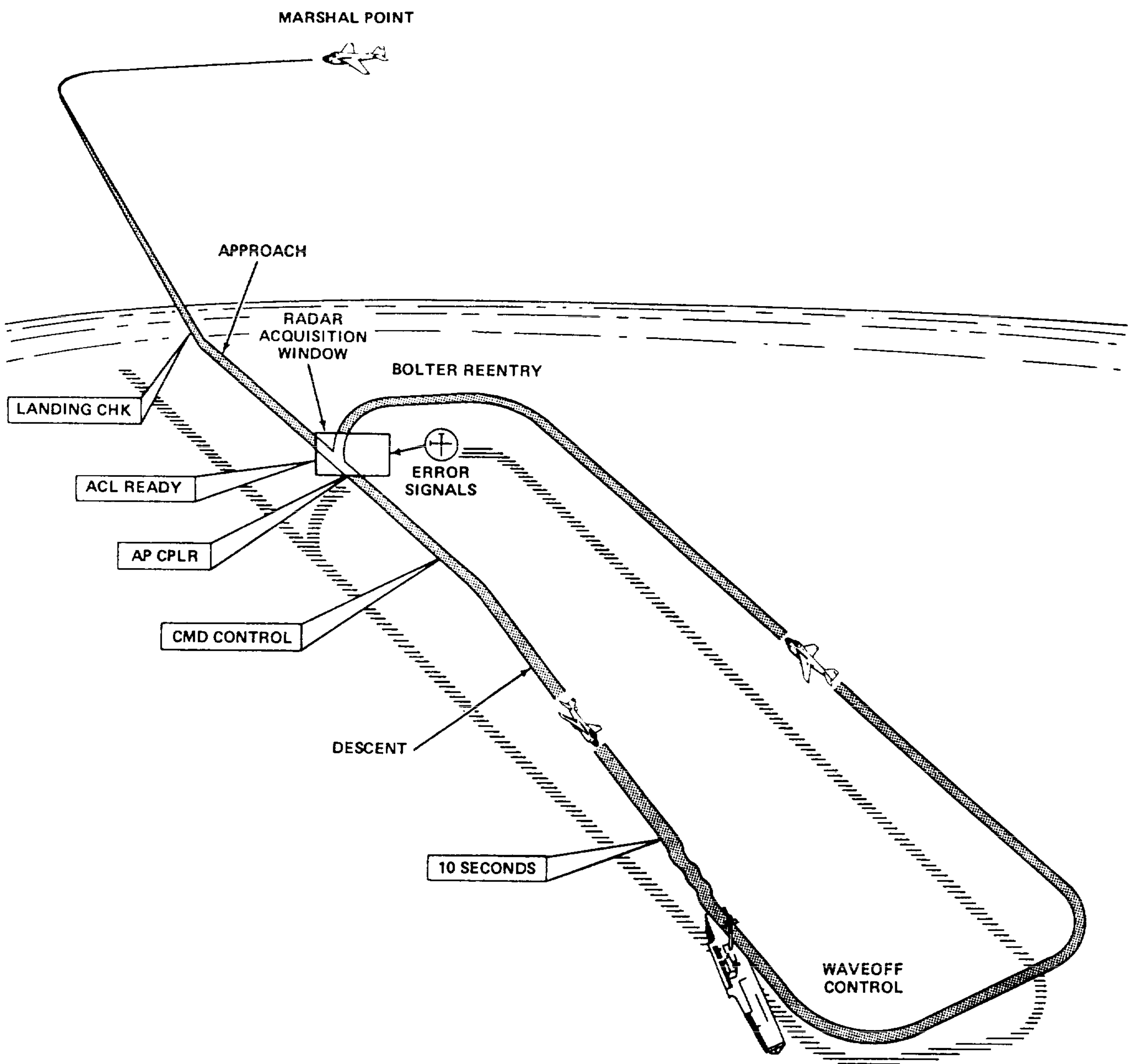

Figure 9-2.-Automatic carrier landing sequence.

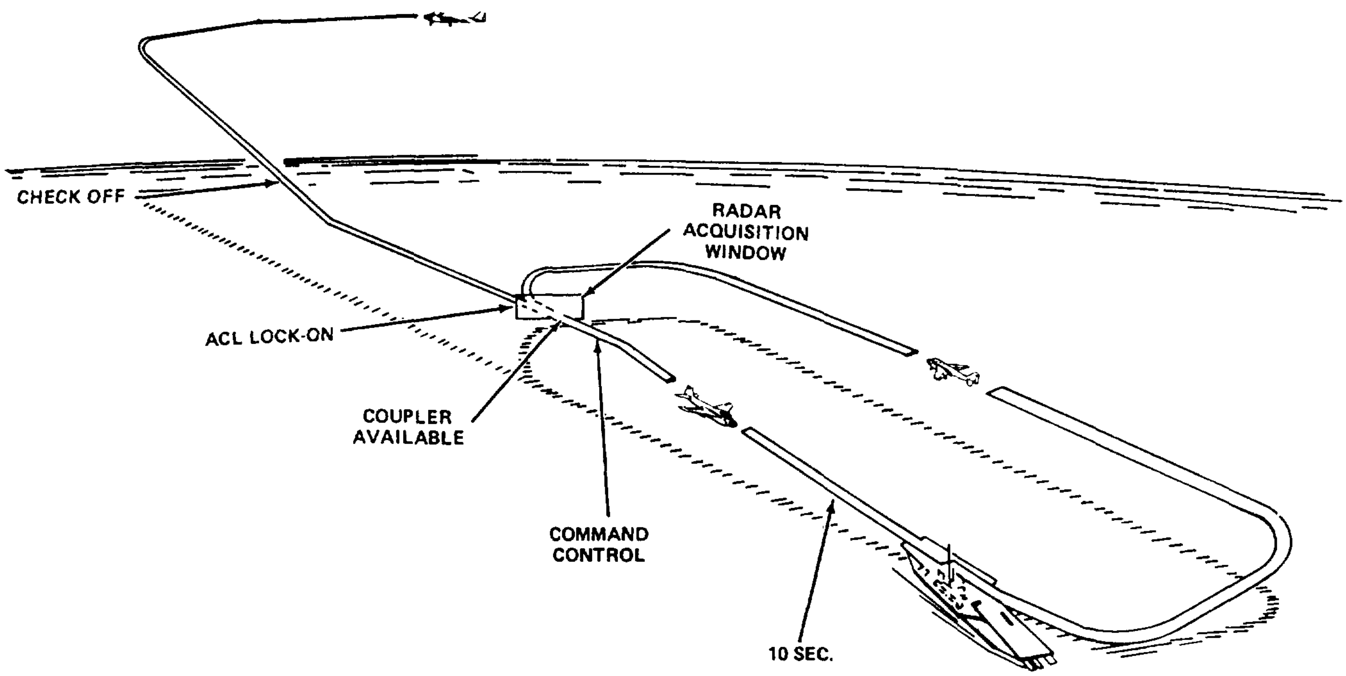

Figure 9-3.-Mode I landing sequence.

to fuel or safety status to determine landing priorities. It is here that the aircraft is assigned a data link channel for automatic landing. The pilot is cleared for approach when the LDG CHK indicator illuminates on the discrete message indicator. The pilot prepares for landing by ensuring the APC is in automatic and that all the other subsystems are on and operating.

As the aircraft continues its approach and passes through the acquisition radar window, the LCC radar acquires the aircraft, and the ACL RDY lamp lights on the discrete message indicator. The acquisition radar window is located approximately 4 miles astern of the ship. When the ACL RDY lamp lights, the CATCC system begins sending vertical and lateral error signals, which represent the actual displacement of the aircraft from the approach path. These signals are converted to a display on the VGI. At this time, the pilot requests the approach mode desired—Mode I for fully automatic touchdown.

The LCC system transmits a COUPLE discrete signal to the aircraft. This signal indicates that pitch and bank commands may be coupled to the autopilot. At this time, the pilot ensures that the APC is engaged; the landing gear, flaps, and speed brakes are extended; and the aircraft is near the approach speed with wings level. With the autopilot turned ON and in AUTO, the pilot then switches the ACL/OFF/PCD switch to ACL. This couples the data link to the autopilot. The pilot will then verbally acknowledge engagement of the autopilot. The ground command controller then sends the CMD CONT discrete signal to the aircraft. At this time, the system begins sending pitch and bank command signals to the aircraft. As the aircraft continues down the approach path, and at approximately 12.5 seconds from touchdown, the 10 SEC discrete message will be sent. This message informs the pilot that deck motion compensation is being added to the glide-path commands. Compensation is in the form of a slight increase or decrease in aircraft attitude as needed to adjust for the movement of the touchdown point in response to the carrier's movement. At 1.5 seconds from touchdown, the landing system freezes the pitch and bank commands, and the autopilot holds the aircraft attitude until touchdown.

SAFETY PROVISIONS

The automatic carrier landing system has many provisions to protect the pilot and the aircraft from human errors or equipment failures. The monitor link uses the ILS AN/SPN-41 to independently check the LCCS flight path progress. This allows the pilot to monitor position in relation to the safe glide path. When the aircraft exceeds the Mode I flight path control envelope boundaries, as shown in figures 9-4 and 9-5, the system ceases transmitting the COUPLE discrete signals. This turns off the lamp on the discrete message indicator and causes the autopilot to uncouple and revert to the STAB AUG mode. The aircraft can continue to approach the carrier, but the pilot must be in Mode II or III. If the flight path error increases to the point where a large maneuver is required of the aircraft to bring it back on course, the ground controller sends a wave-off message. This wave-off message totally disengages the carrier landing system, lights a WAVEOFF lamp on the discrete indicator, and allows the pilot to execute his wave-off routine.

Between 12.5 and 1.5 seconds from touchdown, the tracking and comparison radar sends a wave-off signal automatically if the aircraft exceeds the boundaries shown in figures 9-4 and 9-5. A manual wave-off signal may also be sent by the appropriate carrier personnel anytime the aircraft approach is considered unsafe.

The pilot can override the system at anytime after engaging the ACL mode by applying a control stick force of 10 pounds fore or aft (pitch), or 7 pounds laterally (roll). Either of these motions will uncouple the ACLS and automatically down mode the autopilot to the STAB AUG position. The pilot can continue the approach manually under Mode II, Mode III, ILS, or visually, or decide not to chose any of these and go around for another try.

If the information stored in the data link is not updated within any 2-second period after the first receipt of glide-path error data, a TILT discrete signal is transmitted and displayed on the discrete indicator. This causes the autopilot to disconnect from the

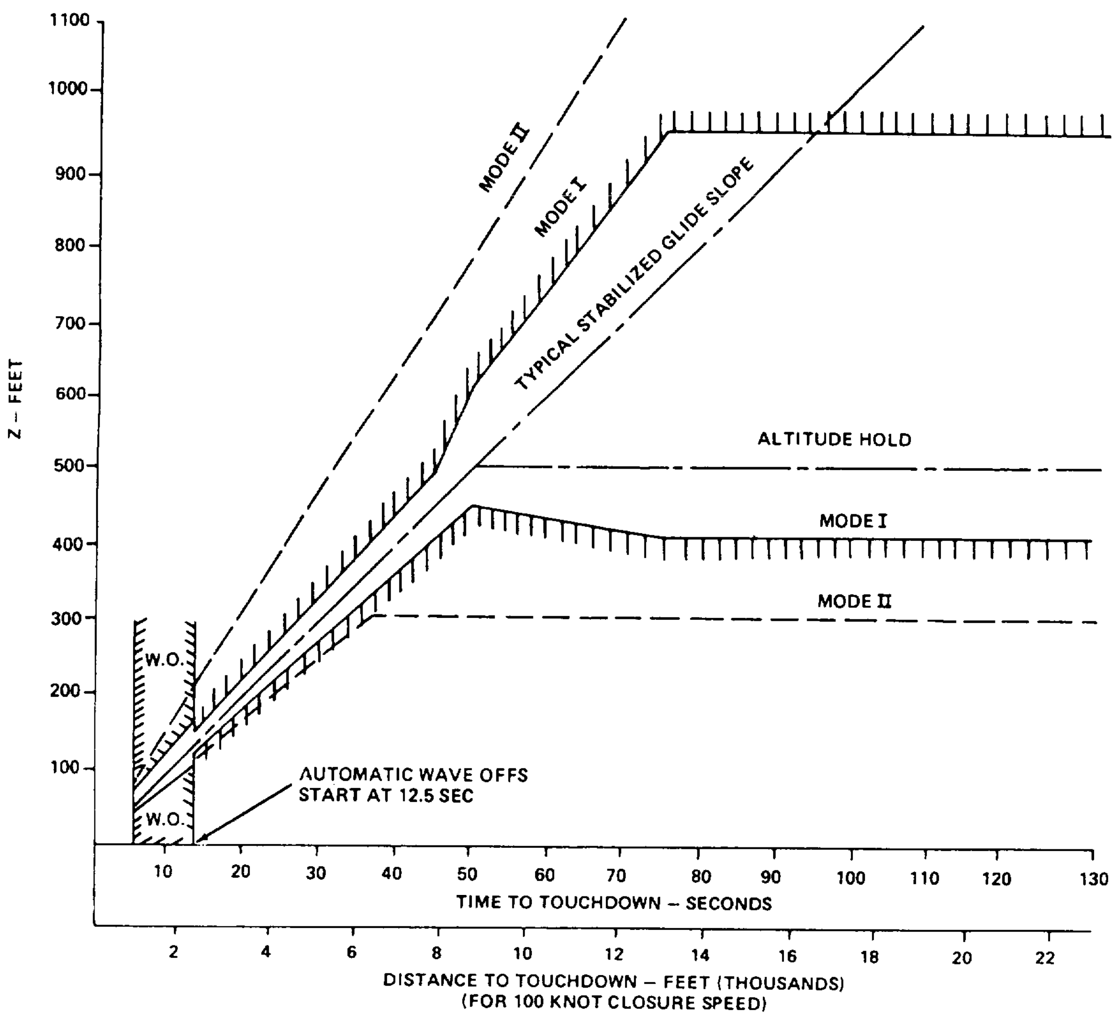

Figure 9-4.-Vertical flight path control and automatic wave-off boundaries.

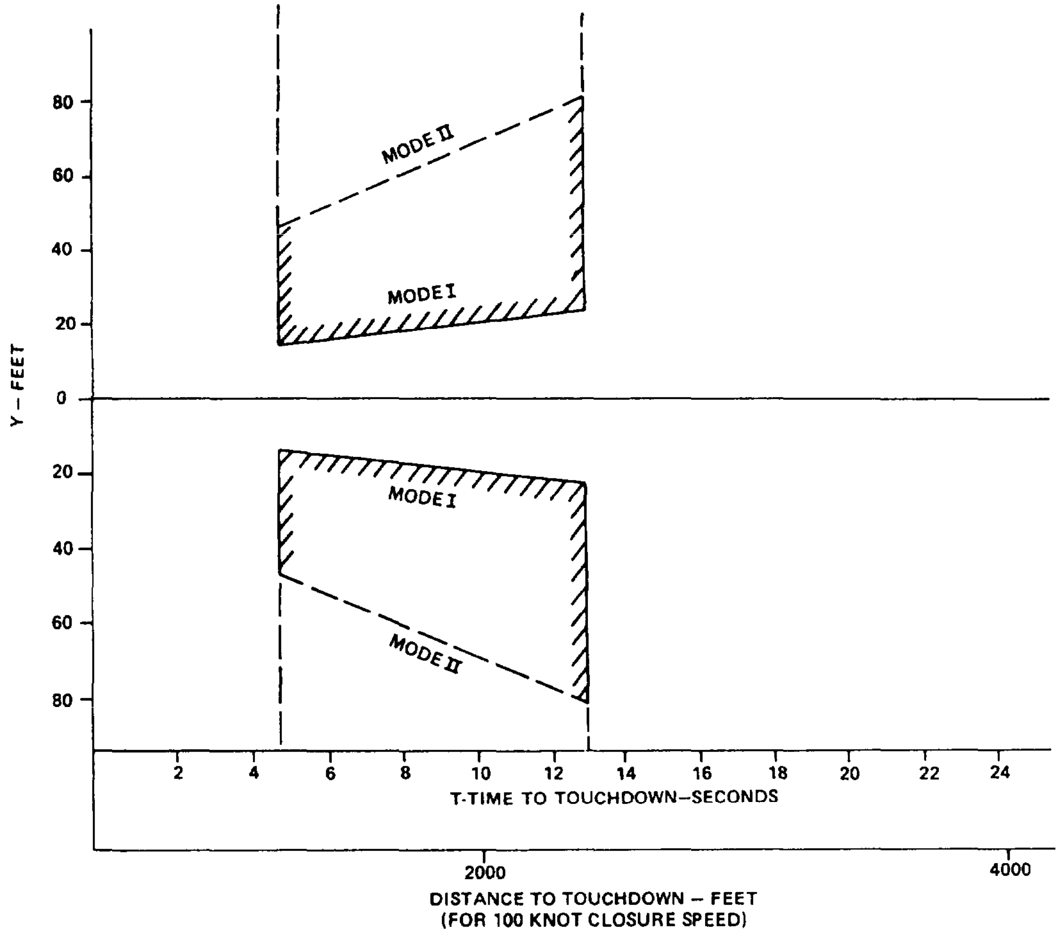

Figure 9-5.-Lateral automatic wave-off boundaries.

ACLS and revert back to STAB AUG. Whenever the autopilot disconnects from the ACL mode, the AFCS OUT indicator (on the discrete indicator) lights for 20 seconds, and then goes out.

If the pilot is monitoring glide path errors from the data link on the VGI cross pointers and a display of a TILT or WAVEOFF discrete signal appears, the cross pointers will drive out of view. There is no effect on the cross pointers, from these discretes, if the monitor link is being used. If the monitor link is being used for glide-path error display and the received RF signal is lost, the cross pointers are driven to a fly-up, fly-right indication. This will alert the pilot to take corrective action. If the monitor link is turned off or if primary power is lost, the cross pointers are driven out of view. When the radar beacon is being interrogated and is transmitting a replay in the ACLS mode, the BCN ON lamp (on the discrete indicator) lights, informing the pilot that the beacon is operating. When power to the VGI is removed or interrupted, a warning flag is immediately displayed on the indicator. All of these functions guard against any system malfunctions that may endanger the pilot or the aircraft.

REVIEW QUESTIONS

Q1. *True or False. The ACLS is a self-contained system located completely on the aircraft.*

Q2. *What are the three modes of operation of the ACLS?*

Q3. *At what point in the sequence does the LCC radar acquire the aircraft?*

Q4. *If the autopilot decouples from the ACL mode of operation, does the pilot have to initiate wave-off procedures?*