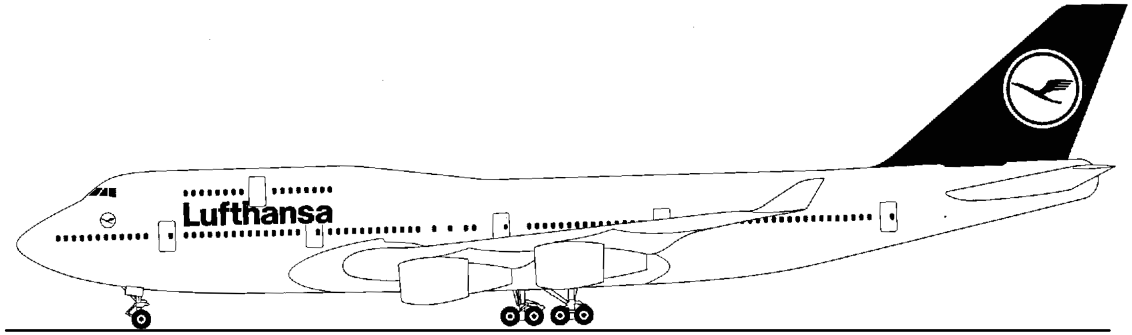
# Lufthansa
# Technical Training

## Training Manual
## B 747-400

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HYDRAULIC & FLIGHT CONTROL
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# ATA 22-00 AFDS HYDRAULIC & FLIGHT CONTROL

## HYDRAULIC & FLIGHT CONTROL SYS. OVERVIEW

### Hydraulic System Overview

The hydraulic power comes from four independent hydraulic systems. Each system gets power from an engine driven pump and a demand pump. System four also has an auxiliary pump for ground use.

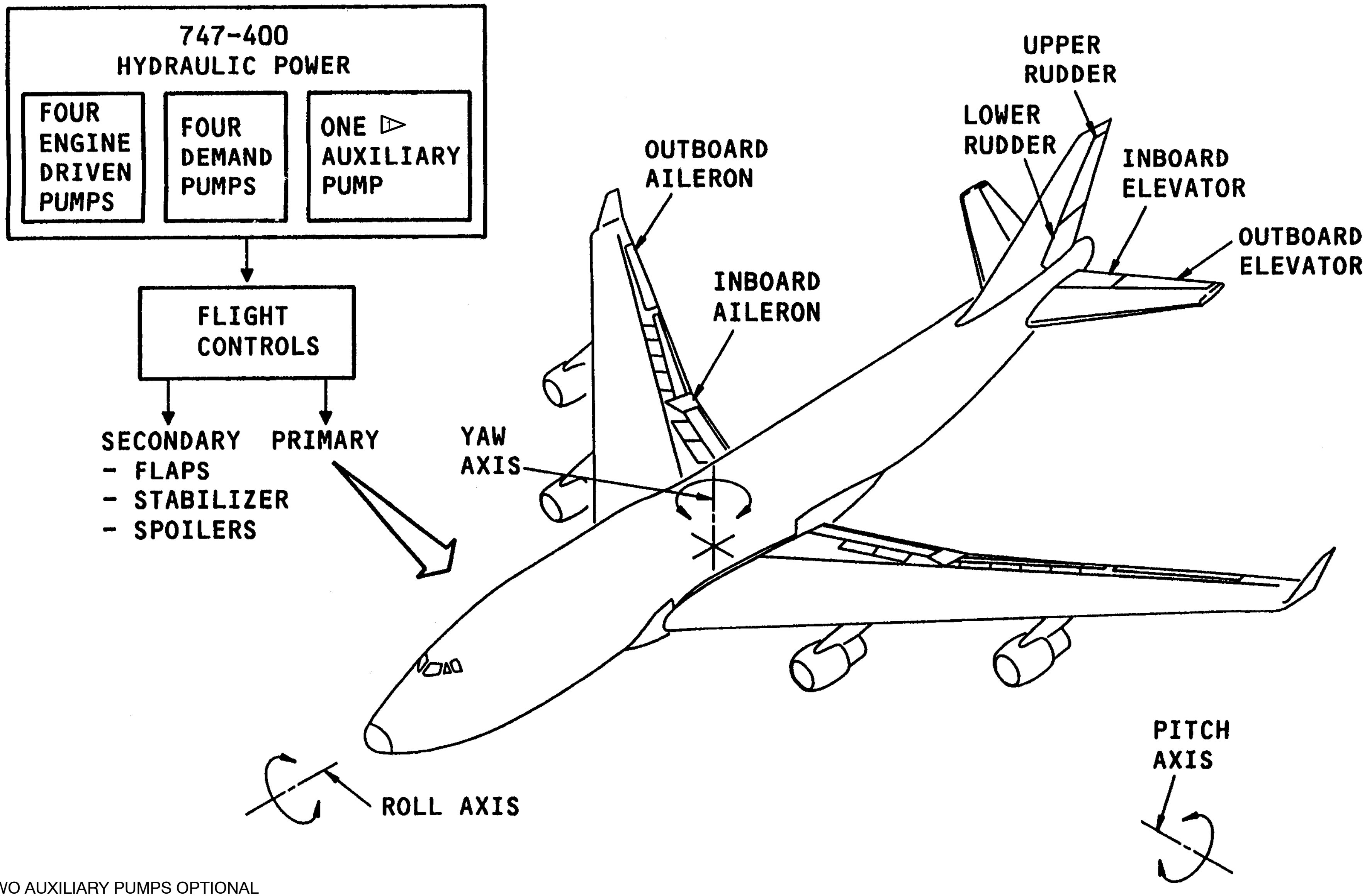
### Flight Control System Overview

The flight control system consists of a primary and secondary system. The primary flight controls are:

- Ailerons
- Rudders
- Elevators

The secondary flight controls are:

- Flaps
- Stabilizer
- Spoilers




1 TWO AUXILIARY PUMPS OPTIONAL

**Figure 1 Hydraulic & Flight Control System Overview**

## HYDRAULIC SYSTEM - INTRODUCTION

### Purpose

The purpose of the hydraulic system is to provide power for many mechanical functions. One of these functions is to move flight control systems and surfaces.

### General Description

The hydraulic system is divided into four independent systems. Each system provides power for flight controls. Each system has an independent pressurized reservoir, filters, pumps, valves and sensors. The rated system pressure is 3000 psi at no flow.

### Power Sources

Each system has an engine-driven pump (EDP) as its primary source of hydraulic power. System No. 1 and 4 have an airdriven pump (ADP) as a demand pump. System No. 2 and 3 have an AC motor-riven (ACMP) pump as a demand pump. -System No. 4 also has an auxiliary (AUX) ACMP which is used only to supply power to the brake system for ground handling. In addition, an external ground cart can be used to supply hydraulic power.

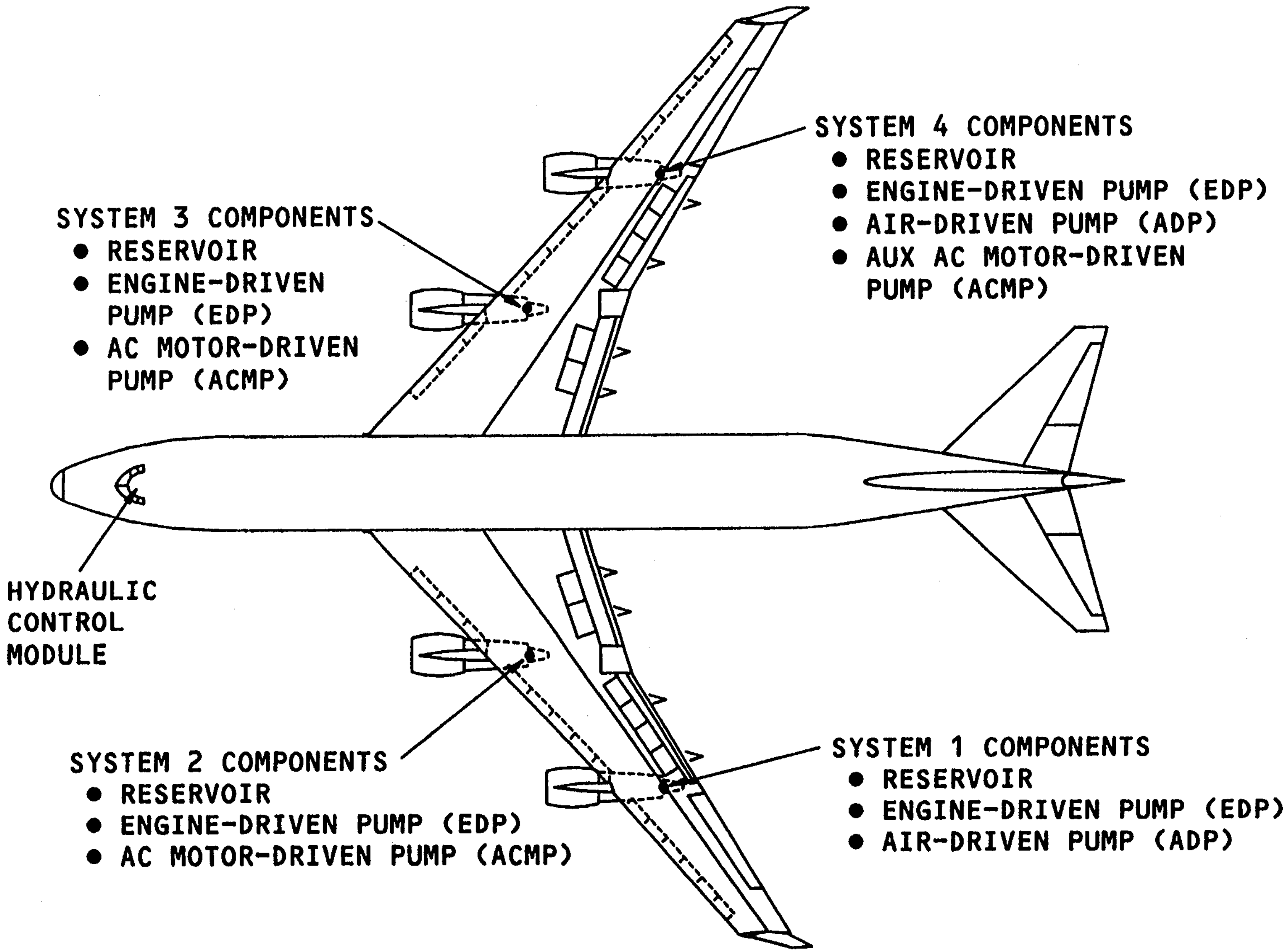



**Figure 2 Hydraulic System - Introduction**

## HYDRAULIC COMPONENT LOCATIONS FD

The hydraulic system components of interest are the hydraulic control module and the flight control shutoff panel. These are located in the flight deck.

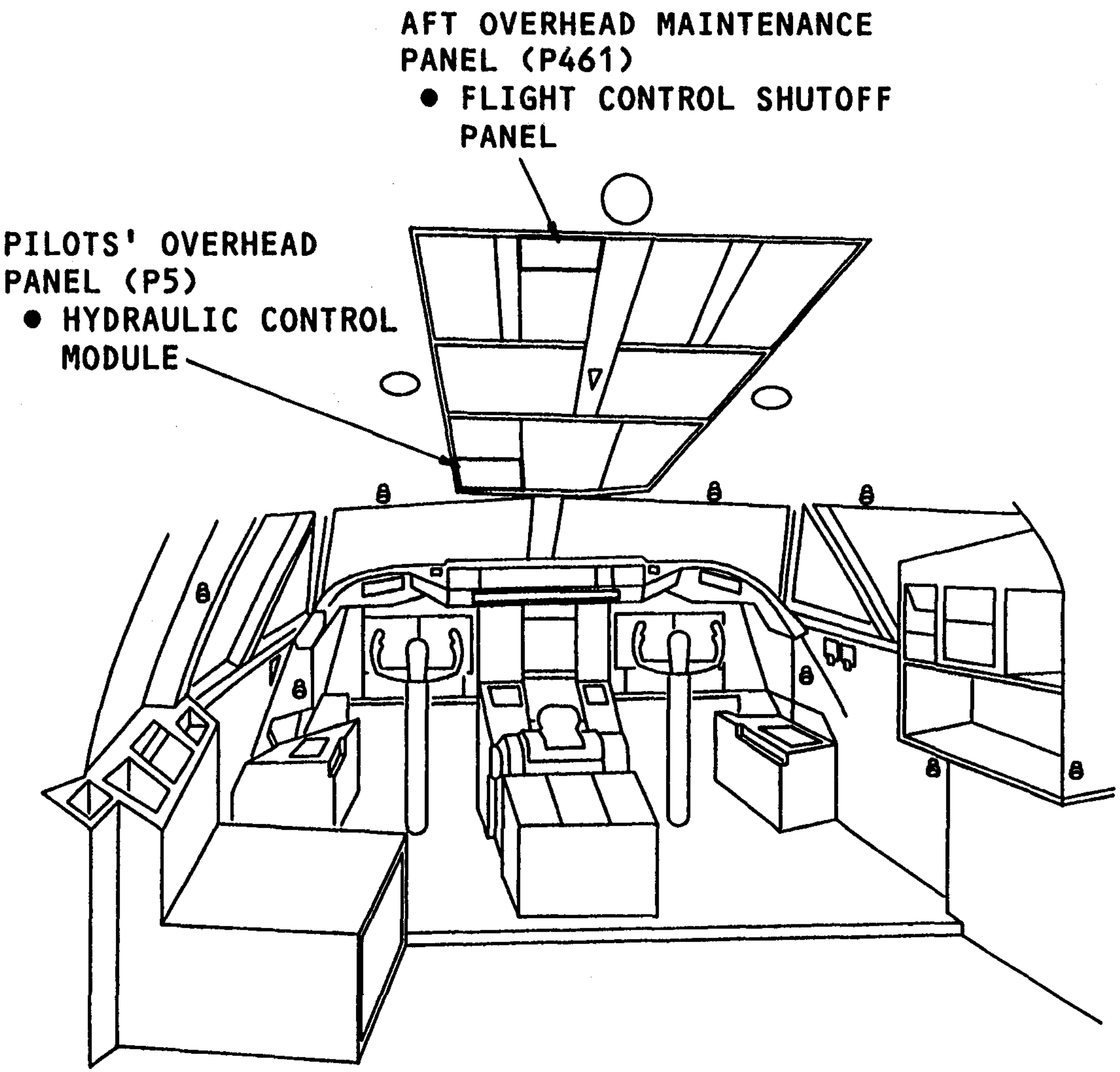



**Figure 3 Hydraulic Component Locations Flightdeck**

## HYDRAULIC SYSTEM - DISTRIBUTION -1

### General

The four hydraulic systems supply hydraulic power to many airplane systems. All systems which use hydraulic power are shown for reference. Only the primary flight control functions will be discussed in this section.

### Wing Shutoff Valves

The wing shutoff valves remove hydraulic power to the flight control components in the wing.

### Aileron Components

The left and right central lateral control packages (CLCPs) are dual actuators which receive power from two systems. The left and right autopilot servos in the CLCPs receive power from systems 3 and 2. The center lateral autopilot servo receives power from system 1.

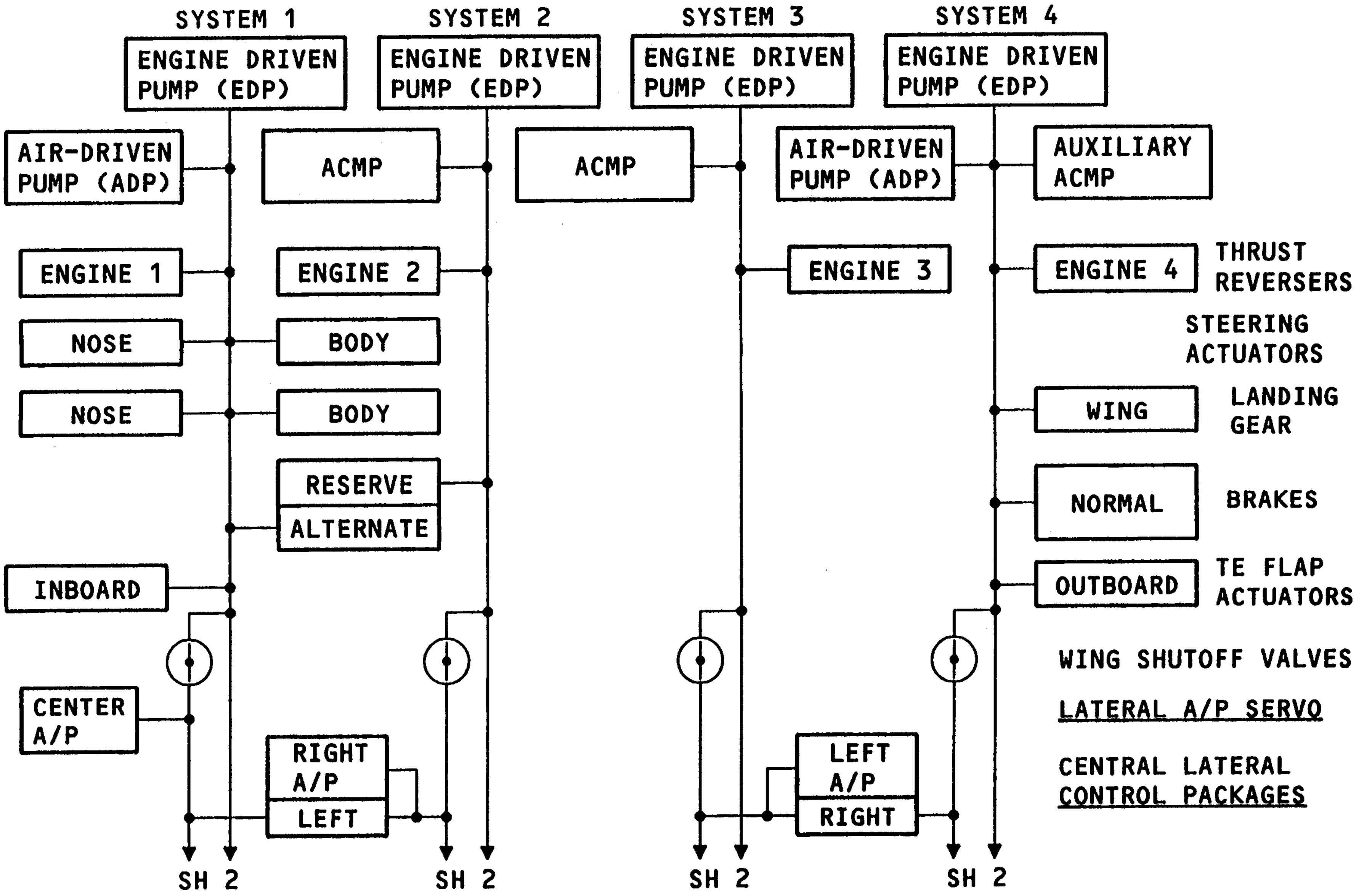



Figure 4 Hydraulic System - Distribution -1 (PW4056)

## HYDRAULIC SYSTEM - DISTRIBUTION - SHEET 2

**Aileron Components**

The aileron power control packages (PCPs) are dual actuators which receive power from two systems.

**Stabilizer Components**

The stabilizer trim control modules (STCMs) receive power from systems 2 and 3.

**Tail Shutoff Valves**

The tail shutoff valves remove hydraulic power from the flight control components in the tail area.

**Rudder Components**

The three autopilot rollout PCPs receive power from systems 1, 2, and 3. The rudder power control modules (PCMs) each receive power from two systems. The rudder PCMs supply the hydraulic control to the rudder actuators. The upper and lower yaw damper actuators in

the rudder PCMs receive power from systems 3 and 2.

**Elevator Components**

The inboard elevator PCPs are dual actuators which receive power from two systems. The outboard elevator PCPs receive power from systems 1 and 4. The three elevator autopilot servos receive power from systems 1, 2, and 3.

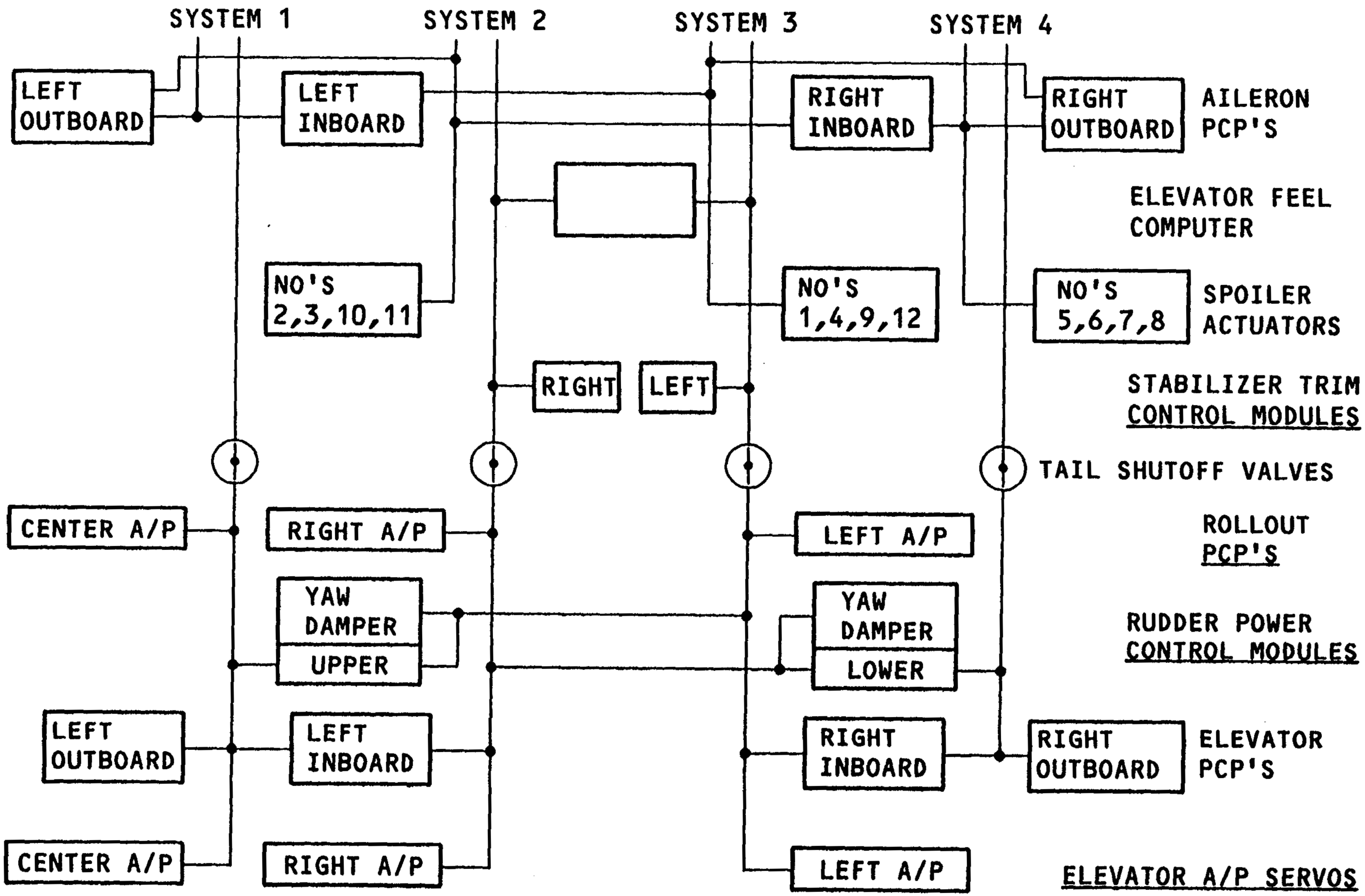



**Figure 5 Hydraulic System - Distribution - Sheet 2**

## HYDRAULIC CONTROL MODULE

### General

The hydraulic control module is on the P5 overhead panel. This module controls all four hydraulic systems and shows system faults and status.

### Engine Driven Pump Control

The pushbutton switches at the bottom of the module are used to turn on and off the engine-driven pumps (EDPs)

The top half of the pushbutton has an ON light and the bottom half of the pushbutton has a PRESS indication which shows low EDP output pressure. When on, the hydraulic depressurization valve on the EDP is deenergized and the pump supplies pressure when the engine runs.

### Demand Pump Control

The demand pump control switches are above the EDP control switches. When the switch is off, the pump is off. When the switch is on, the demand pump runs continuously. When the switch is

in AUTO, the pump operates if the system pressure reduces due to system demand or if fuel is off to that engine.

For systems 1 and 4, the demand pump also operates with the switch in AUTO if the trailing edge flaps are in transit, or flap position is greater than zero and in the air.

System 4 has an auxiliary (AUX) ACMP controlled by this switch also. The auxiliary pump operates with the switch in the AUX position if:

- The airplane is on the ground and
- The EDP is not supplying system pressure

### Demand Pump Low-Pressure Indicator

The low-pressure indicators are a light above the demand pump control switches. This light shows low demand pump output pressure.

### System Fault Indicator

The system fault indicators are at the top of the hydraulic control module. This light comes on if:

- System pressure is low
- System temperature is high
- Hydraulic reservoir quantity is low

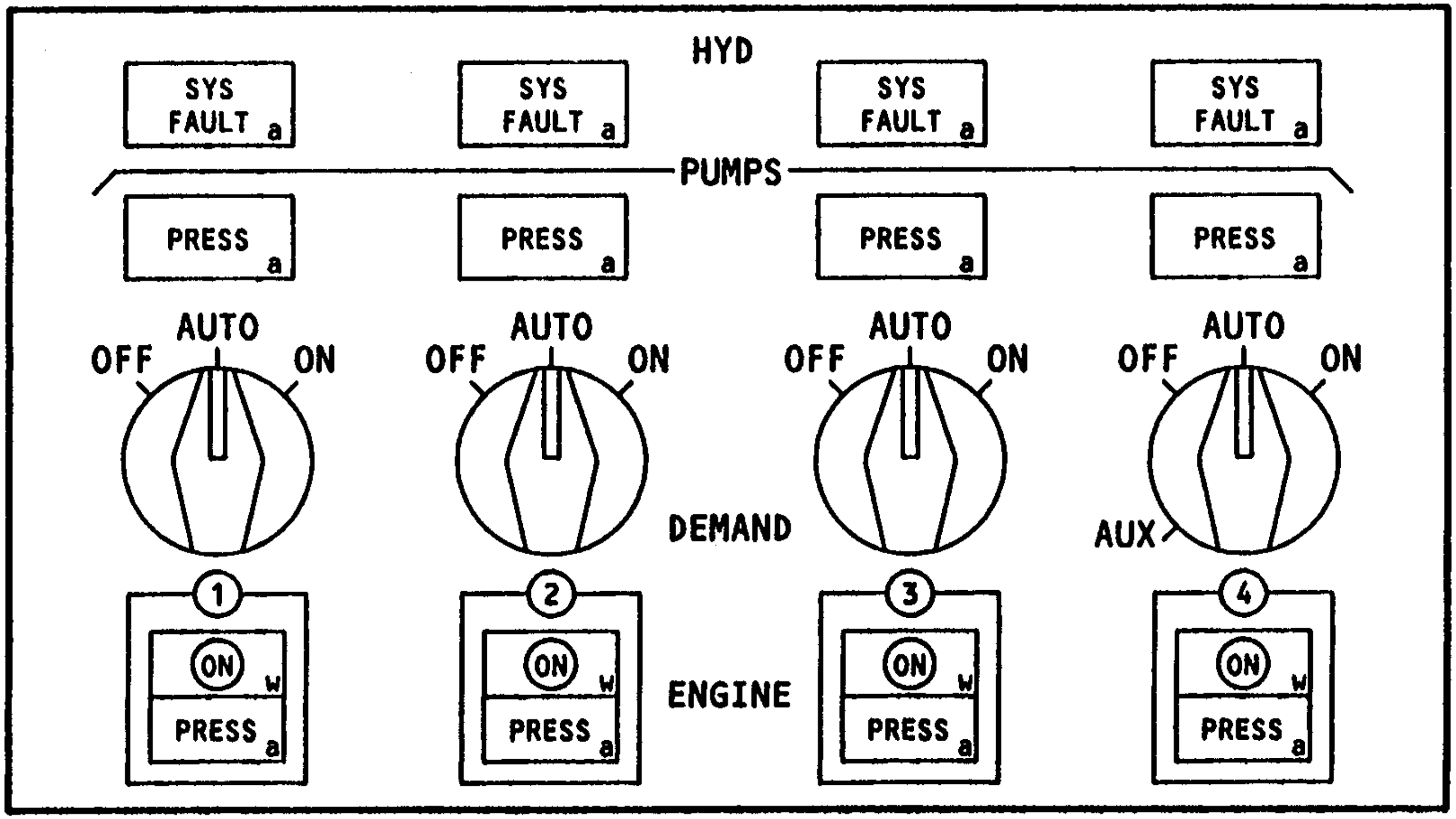



**Figure 6 Hydraulic Control Module**

## FLIGHT CONTROL SHUTOFF SWITCHES

**General**

The flight control shutoff switches operate hydraulic shutoff valves. The shutoff valves shut off parts of the flight control system for leak isolation or for maintenance activity when the system can not be completely shut off. The switches are on th34 P-461 maintenance panel.

**Opertaion**

For shut off, the flight controls are divided into the tal area and the wing area.

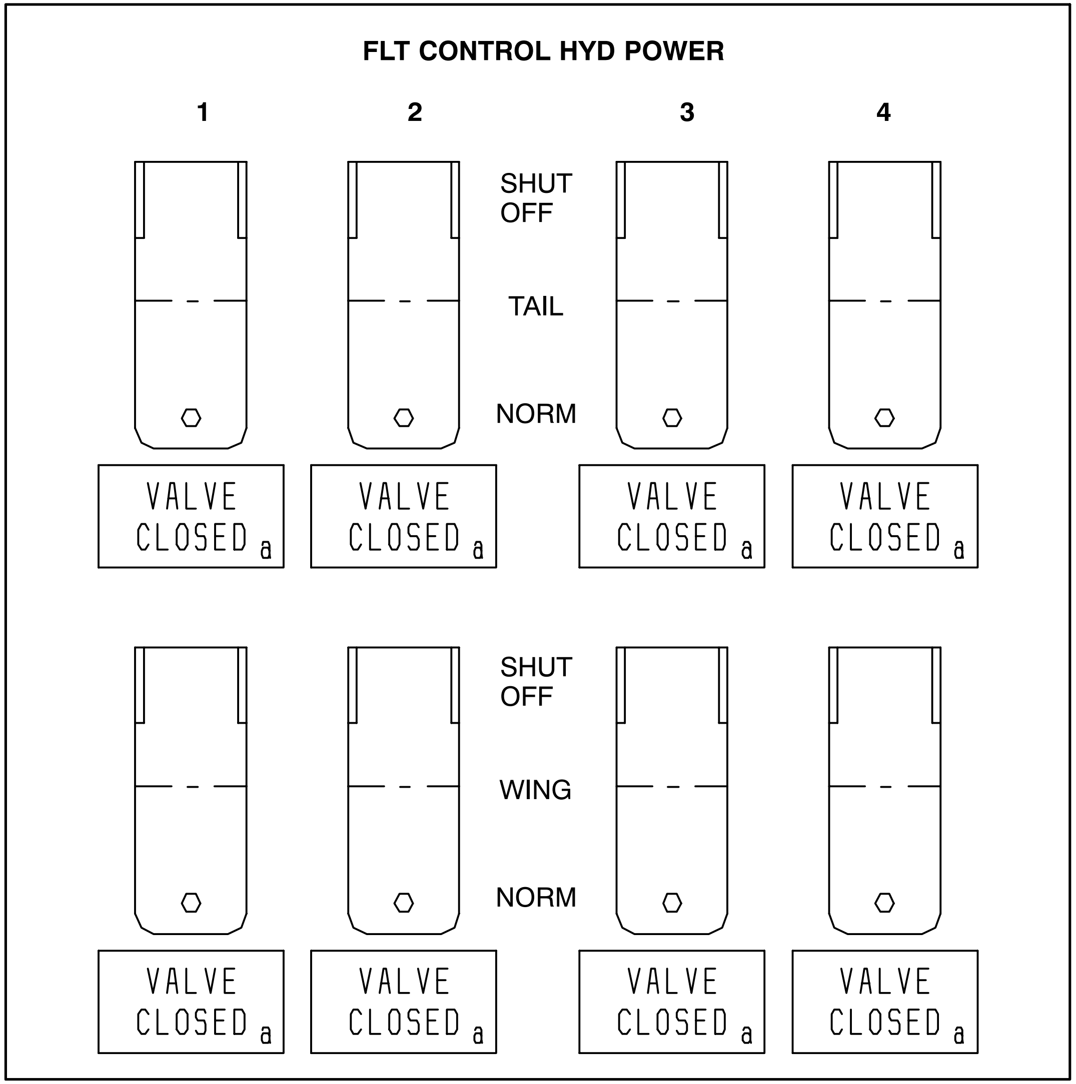



**Figure 7 Flight Control Shutoff Switches**

## HYDRAULIC POWER SOURCE - SYSTEMS 1 & 4

### General

System 1 and 4 are similar. They provide hydraulic power for airplane systems including flight controls.

### Reservoir

Each hydraulic system has a reservoir for fluid. The reservoir is pressurized by air from the pneumatic system to provide a positive pressure.

### Heat Exchanger

The heat exchanger cools the fluid returned from the casing drains of the hydraulic pumps. The heat exchangers are in the main fuel tanks 1 and 4. A minimum of 375 US gallons (2400 lbs) (1090 kgs) of fuel is required in these tanks for the heat exchanger to operate correctly.

### Temperature Sensor

The temperature of the fluid that enters the heat exchanger is monitored.

An overtemperature condition causes indications on EICAS and on the hydraulic control module.

### Fluid Quantitv Transmitter

The fluid level in each reservoir is monitored. A low-level *condition will* cause indications on EICAS and on the hydraulic control module.

### Enqine Driven Pump (EDP)

An EDP is installed on the engine. To turn off the EDP, a depressurizing valve solenoid is energized from the hydraulic control module. This decreases the pump output and closes the pump output valve. Fluid from the casing drain is then returned to the reservoir through the heat exchanger at a slower rate.

### Air-Driven PumD-(ADP)

The ADP receives air power from the pneumatic system. This pump is controlled by the hydraulic control module to be off, on continuously or on only when the system pressure reduces due to demand. This is why this pump is called a demand pump.

To operate this pump, the pneumatic system must have pressure and dc bus 1 or 4 must have power. Also, the HYD 1 DEMAND or HYD 4 DEMAND circuit breakers on P-7 must be closed.

### Auxiliarv AC Motor-Driven Pump (ACMP)

An auxiliary ACMP in system 4 provides hydraulic pressure for the brake system during ground handling. To provide electrical power to this pump, the airplane must be on the ground, the ground handling busses (ac and dc) must have power, the HYD PUMP AUX AC and HYD PUMP CONT AUX AC circuit breakers on P-7 must be closed, the demand pump and engine-driven pump pressure switches must sense a low-pressure condition and the No. 4 demand pump control switch must be in AUX.

### Pressure Transmitters

Sensors at the output of the pumps and in the system monitor the pressure. A lowpressure condition causes an indication on EICAS and on the hydraulic control module.

### Hvdraulic Suvplv Shutoff Valve

The hydraulic supply shutoff valve is closed when the fire handle for that engine on P-5 is pulled. This removes hydraulics from the engine area.

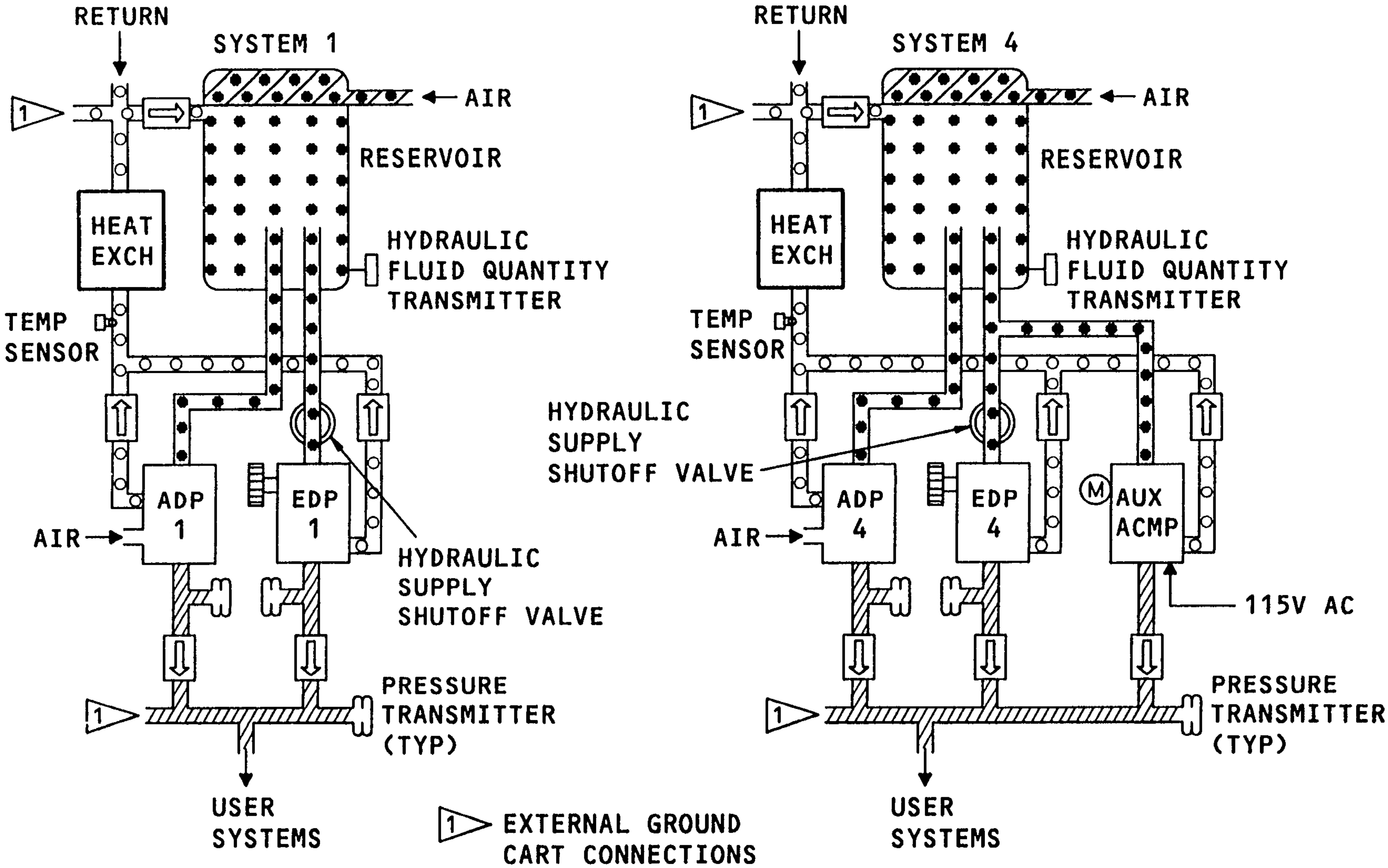



**Figure 8** Hydraulic Power Source- System 1 & 4

## HYDRAULIC POWER SOURCES SYSTEMS 2 & 3

### General

System 2 and 3 are similar to systems 1 and 4. only the differences will be discussed at this time.

### Heat Exchanger

A minimum of 805 US gallons (5200 lbs) (2366 kgs) of fuel is required in tanks 2 and 3 so that the heat exchangers can reduce fluid temperatures.

### AC Motor-Driven Pump (ACHP)

The ACMP receives power from 115v ac. This pump is controlled by the hydraulic control module to be off, on continuously or on only on demand. To supply electrical power to this pump, bus 2 or 3 (ac and dc) must have power and the HYD 2 DEMAND or HYD 3 DEMAND circuit breakers on P-7 must be closed.

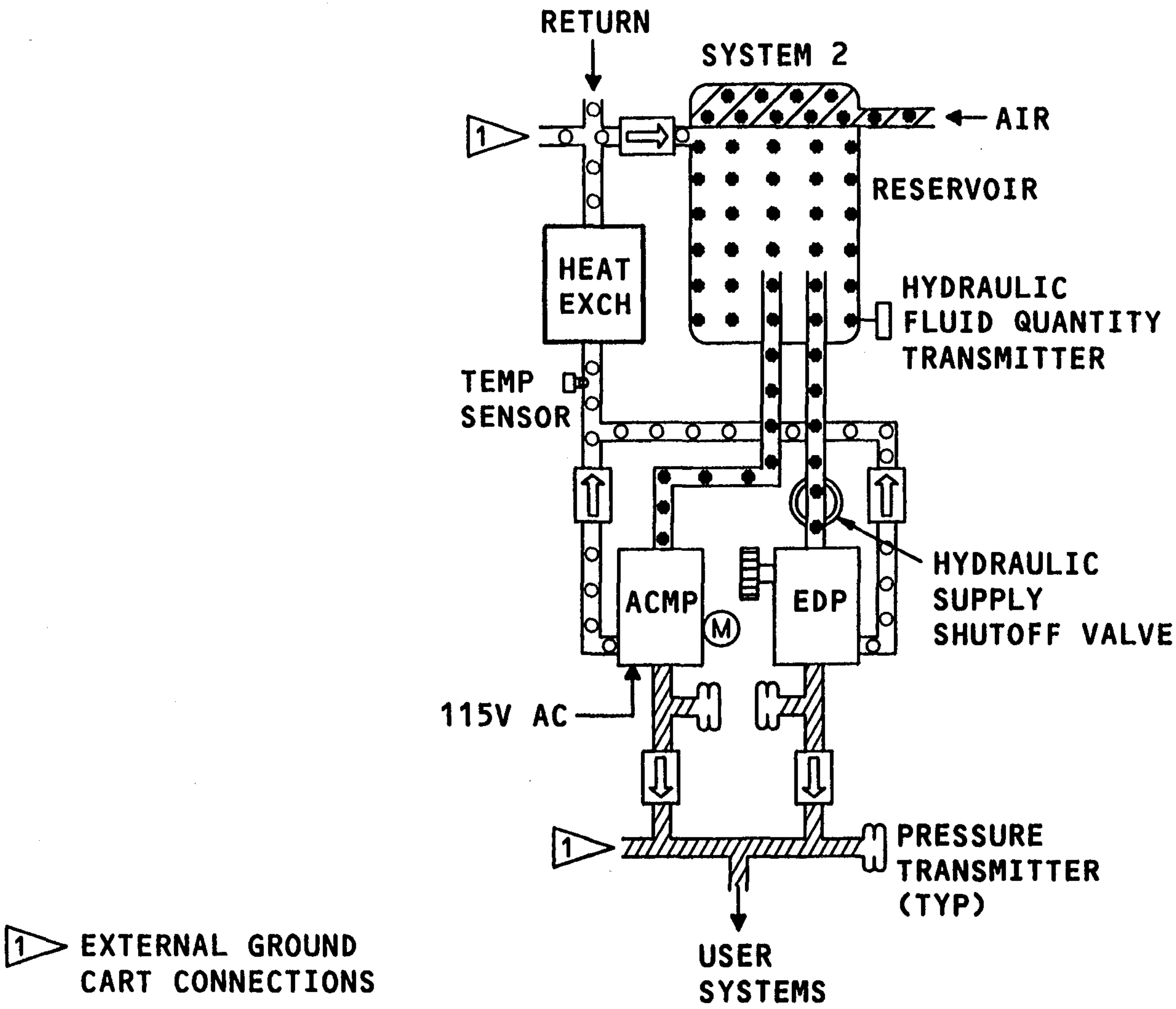



Figure 9 Hydraulic Power Sources Systems 2 & 3

## FLIGHT CONTROL SYSTEM (FCS) - INTRODUCTION

The flight control system has control surfaces to allow the flight crew to control the airplane in roll, pitch and yaw. All flight control surfaces are moved by hydraulic actuators or hydraulic power control packages. Included in this discussion of flight controls are the cables, quadrants, linkages and components for manual and autopilot control of the surfaces. The flight controls are divided into two groups:

- Primary flight controls: ailerons, elevators and rudders
- Secondary flight controls: spoilers, trailing edge flaps,  leading edge flaps and stabilizer

Only the primary flight controls will be discussed.

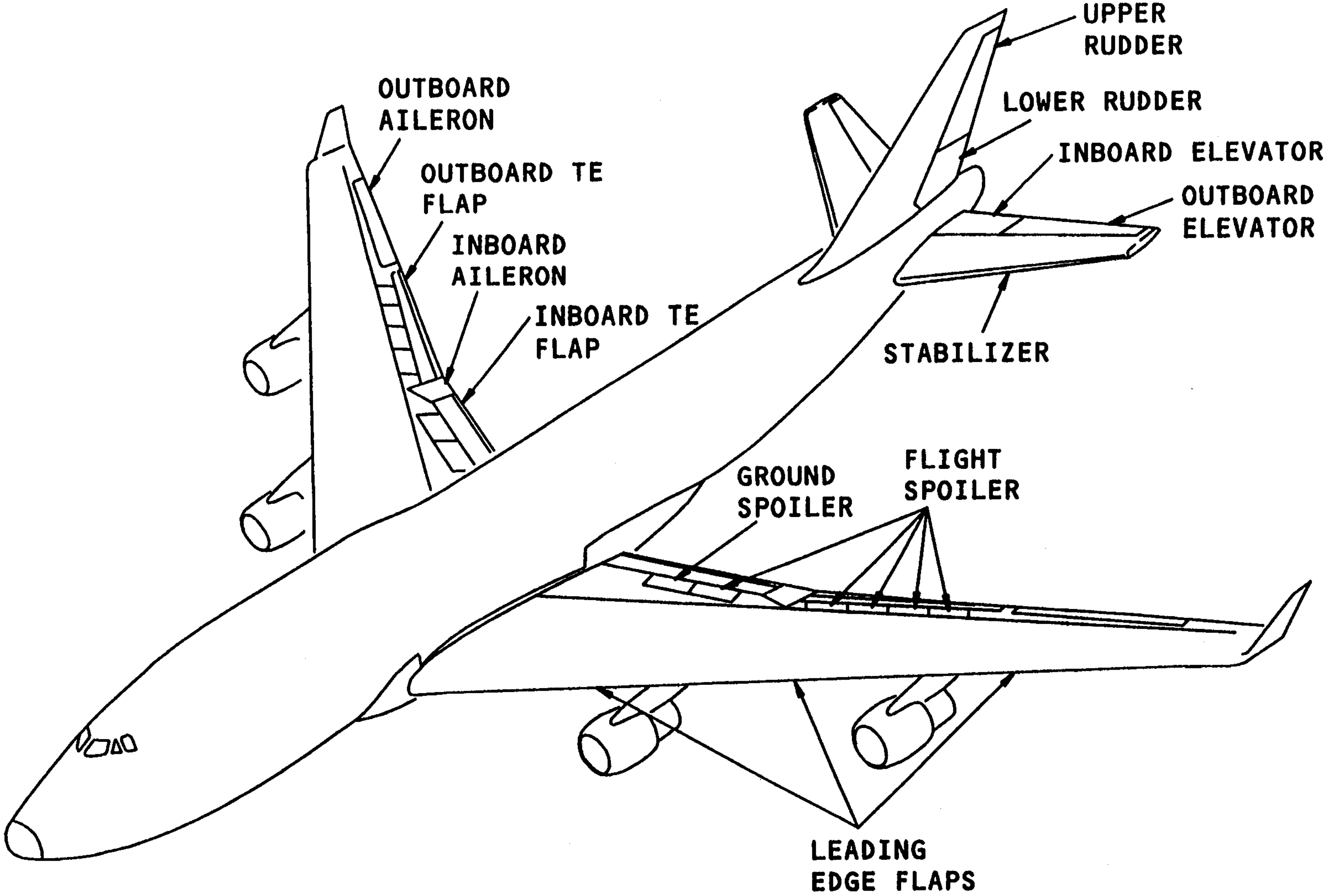



**Figure 10 Flight Control System - Introduction**

## FCS - COMPONENT LOCATIONS

The flight control system components which are of interest are:

- Rollout power control packages
- Elevator autopilot servos
- Central lateral control packages (CLCP)
- Lateral autopilot servo

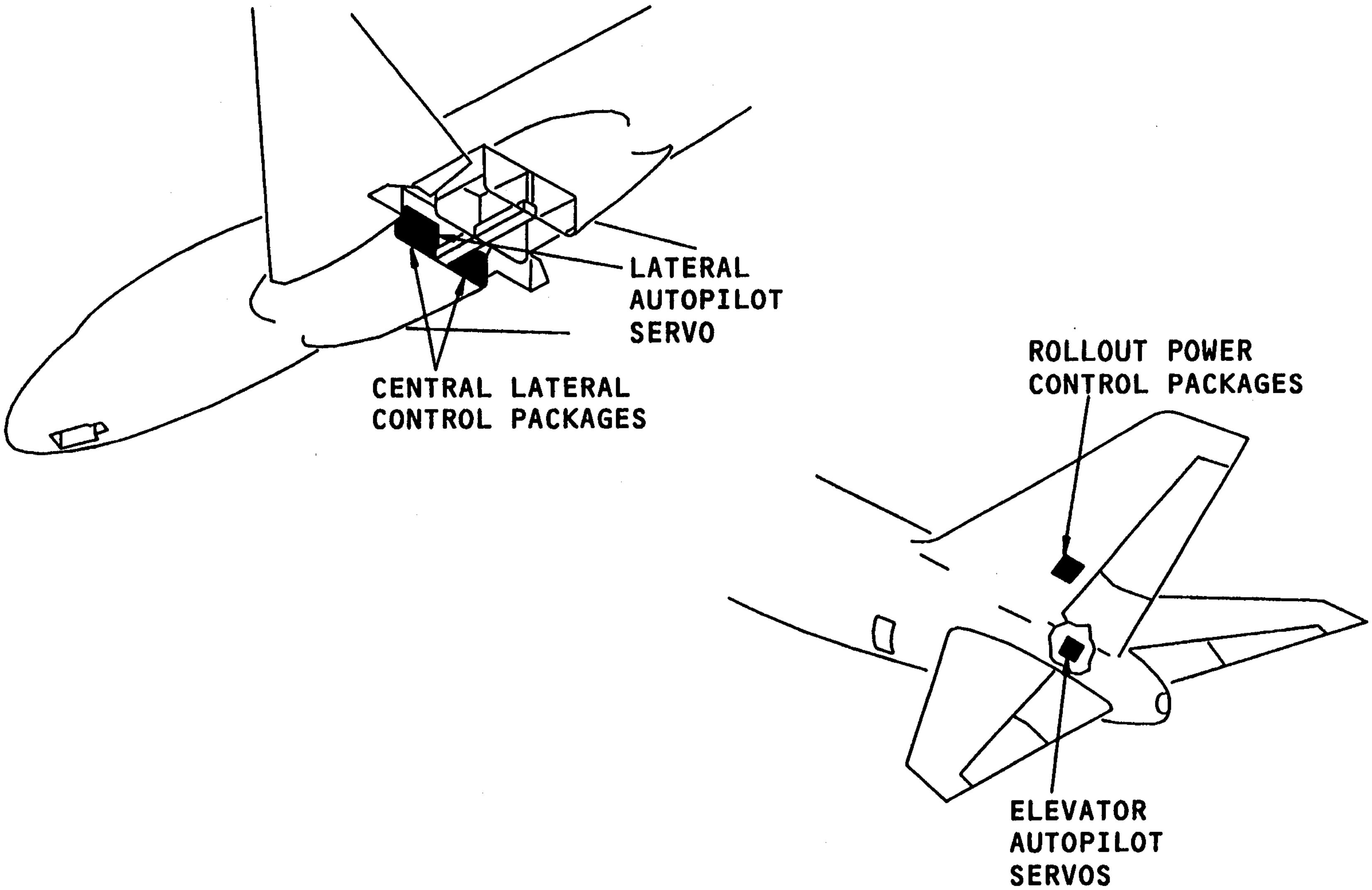



**Figure 11 Flight Control Component Locations**

## FCS - AILERON

### Manual Input

Control wheel input is transmitted to the trim and feel mechanism and to the central lateral control packages (CLCPs) through the left body cables. The CLCPs are connected together by the input limiter bus rod. The trim and feel mechanism provides artificial feel and centering as well as trim.

The CLCPs provide hydraulic boost to reduce the forces required to move the control cables. The output of the CLCPs provide the input to the aileron programmers.

The programmer output moves the input to the aileron power control packages with cables. Redundant control paths are provided by the right body cables, output limiter bus rod and the backdrive rod.

The inboard ailerons operate at all airspeeds. The outboard ailerons are used at low airspeeds or when flaps are extended. The aileron lockout mechanism is motor-operated and is controlled by the stabilizer trim/rudder ratio module (SRM).

### Autopilot Input

The autopilot input to the aileron control system is made through a lateral autopilot servo and servos which are part of each CLCP. These three servos are connected to the trim and feel mechanism. When the autopilot is engaged, the servos move the same point in the control system as the pilot input. The control wheel is also backdriven.

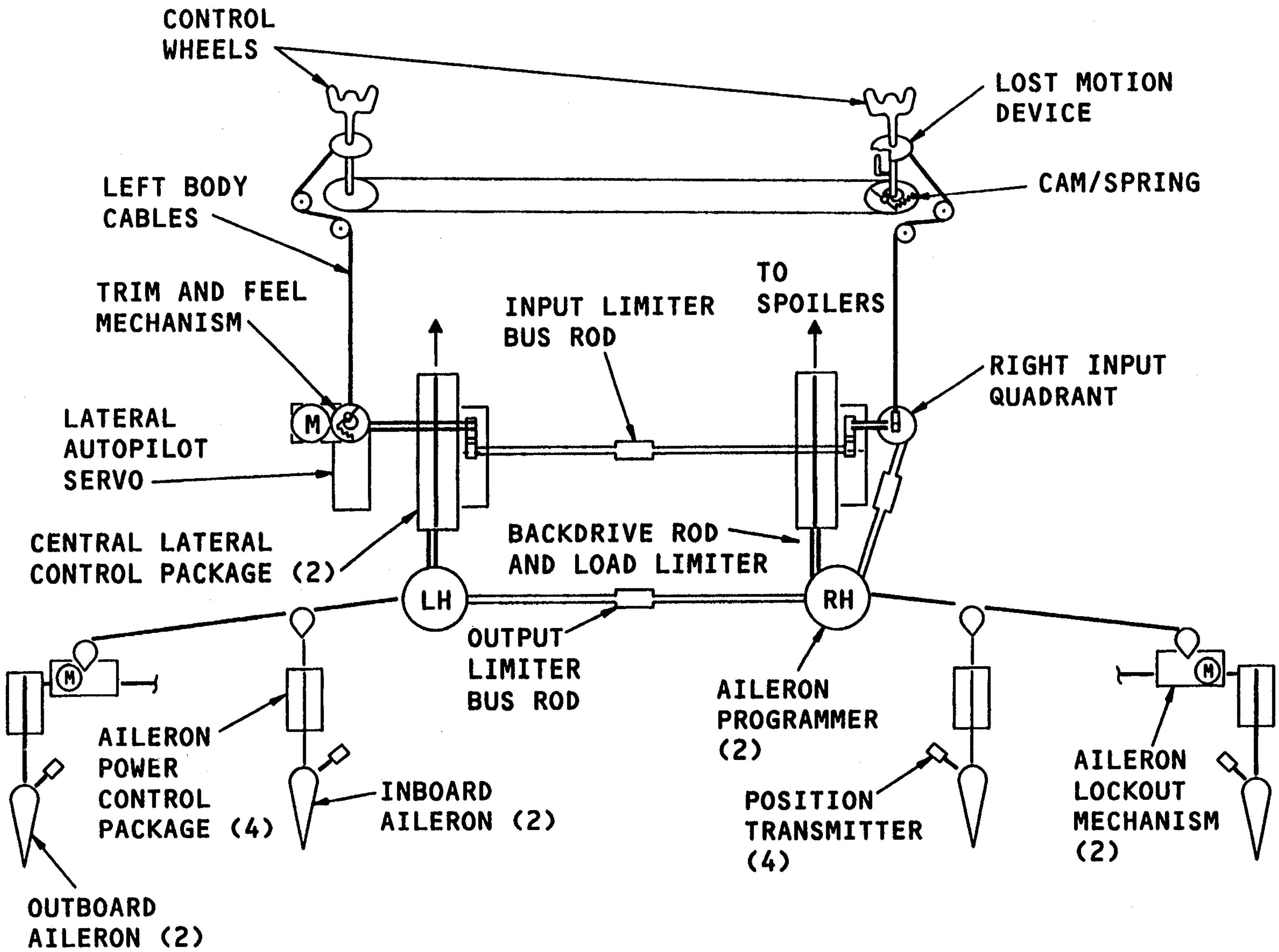



**Figure 12 Flight Control System - Aileron**

## FCS - AILERON AUTOPILOT COMPONENTS

### General

The autopilot components of the aileron control system are near the forward bulkhead of the wing gear wells.

### Installation

The left central lateral control package (CLCP) and the lateral autopilot servo are mounted to the vertical rigging beam in the left wing gear well. The right CLCP is in the right wing gear well. The CLCPs, lateral autopilot servo and the lateral control quadrants are connected together with control rods.

### Operation

The servos for aileron control are connected together. This is the same as the autopilot servos for all three axis. There are two reasons for this. First, it provides capability for any one autopilot channel to control the airplane's attitude. Second, it provides the method of multi-channel autopilot control known as mechanical voting. In mechanical voting, differences between the control from each autopilot channel are detected and resolved.

In the case of triple-channel operation, small differences are resolved by using the middle value of the three channels. If there is a large difference, the flight control computer for the channel which is different from the other two, disengages so the difference (assumed to be due to a failure) will not cause a problem.

In the case of dual-channel operation, small differences are resolved by using the smallest (or least) value of the two. If there is a large difference, it can not be determined which one is correct so both flight control computers disengage.

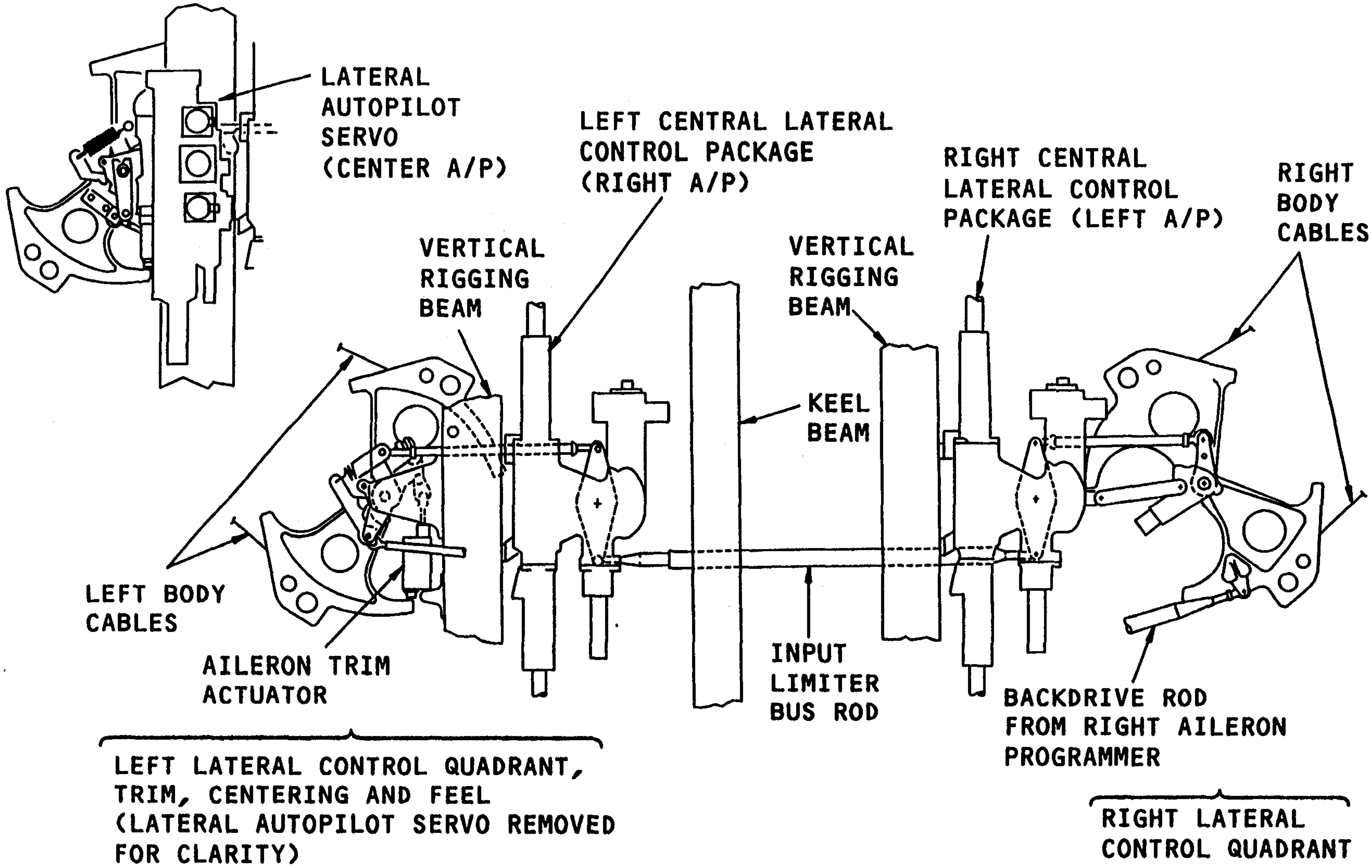



**Figure 13 Flight Control Aileron Autopilot Components**

## FCS - ELEVATOR

**Manual Input**

Control column input is transmitted to the aft quadrant through parallel cables. The feel unit is connected to the aft quadrant and it provides artificial feel and centering.

The inboard elevator power control packages receive the manual input from the aft quadrant. Movement of the inboard elevators moves the input to the outboard elevator power control packages through slave linkages.

**Autopilot Input**

The autopilot input to the elevator control system is made through elevator autopilot servos. These servos are connected to the aft quadrant. When the autopilot is engaged, the servos move the same point in the control system as the pilot input. The control column is backdriven also.

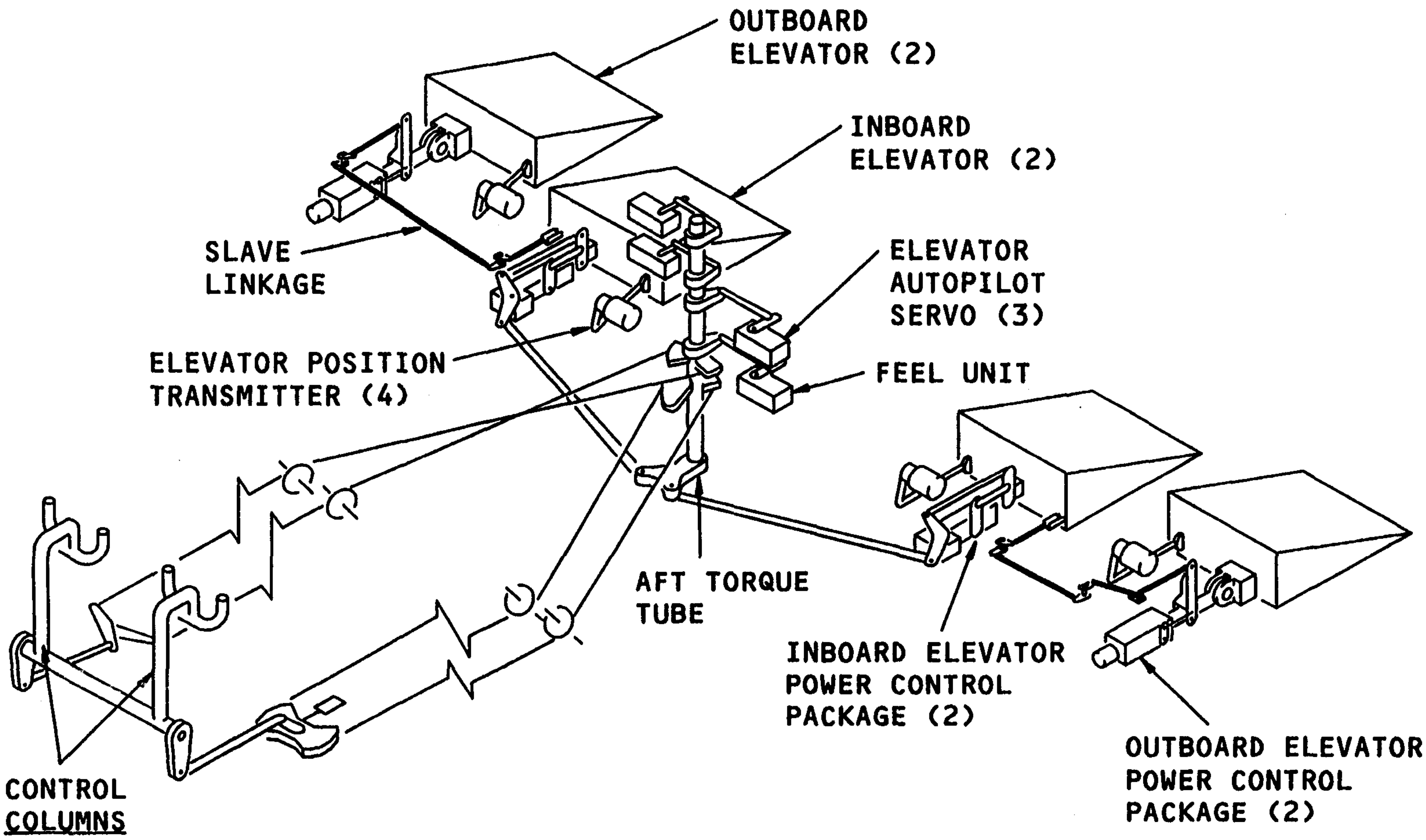



**Figure 14 Flight Control System - Elevator**

# FCS - ELEVATOR AUTOPILOT COMPONENTS

### General

The autopilot components of the elevator control system are in the tail cone at the middle of the horizontal stabilizer and forward of the auxiliary power unit.

### Installation

The elevator autopilot servos are mounted on the stabilizer hinge bulkhead at the top end of the aft torque tube. The left and right elevator servos are on the right of the torque tube. The center elevator servo is on the left.

The servos are connected to the flight control system with control rods. Access to the elevator autopilot components is through an access door on the bottom of the tail cone below the torque tube.

### Operation

The operation of the elevator autopilot servos is similar to that for the aileron system.

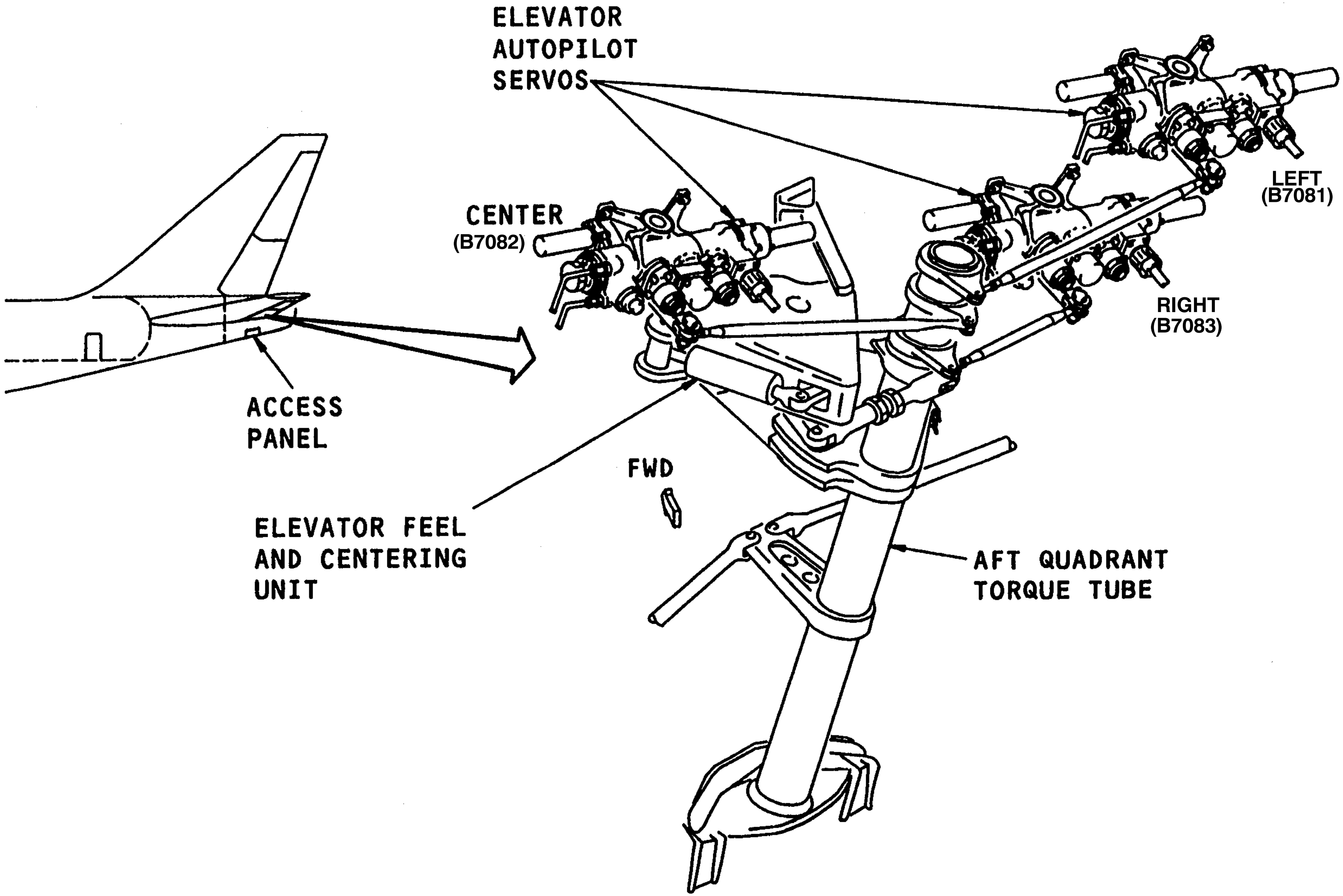



**Figure 15 Flight Control Elevator Autopilot Components**

## FCS - RUDDER

### Manual Input

Rudder pedal input is transmitted to the aft quadrant through cables. The feel and centering mechanism is connected to the aft quadrant. This feel and centering mechanism provides artificial feel and centering as well as trim.

The rudder pedal movement goes through the rudder ratio changers to the rudder power control modules (PCMs). The rudder PCMs supply control hydraulic pressure to the rudder actuators which move the rudder surface. There are three actuators on the upper rudder and two actuators on the lower rudder.

### Autopilot Input

The autopilot input to the rudder control system is made through rollout power control packages. These power control packages are connected to the feel and centering mechanism through the override mechanism. When the autopilot is engaged in rollout control, the rollout power control packages move the same point in the control system as the pilot input. The rudder pedals are backdriven.

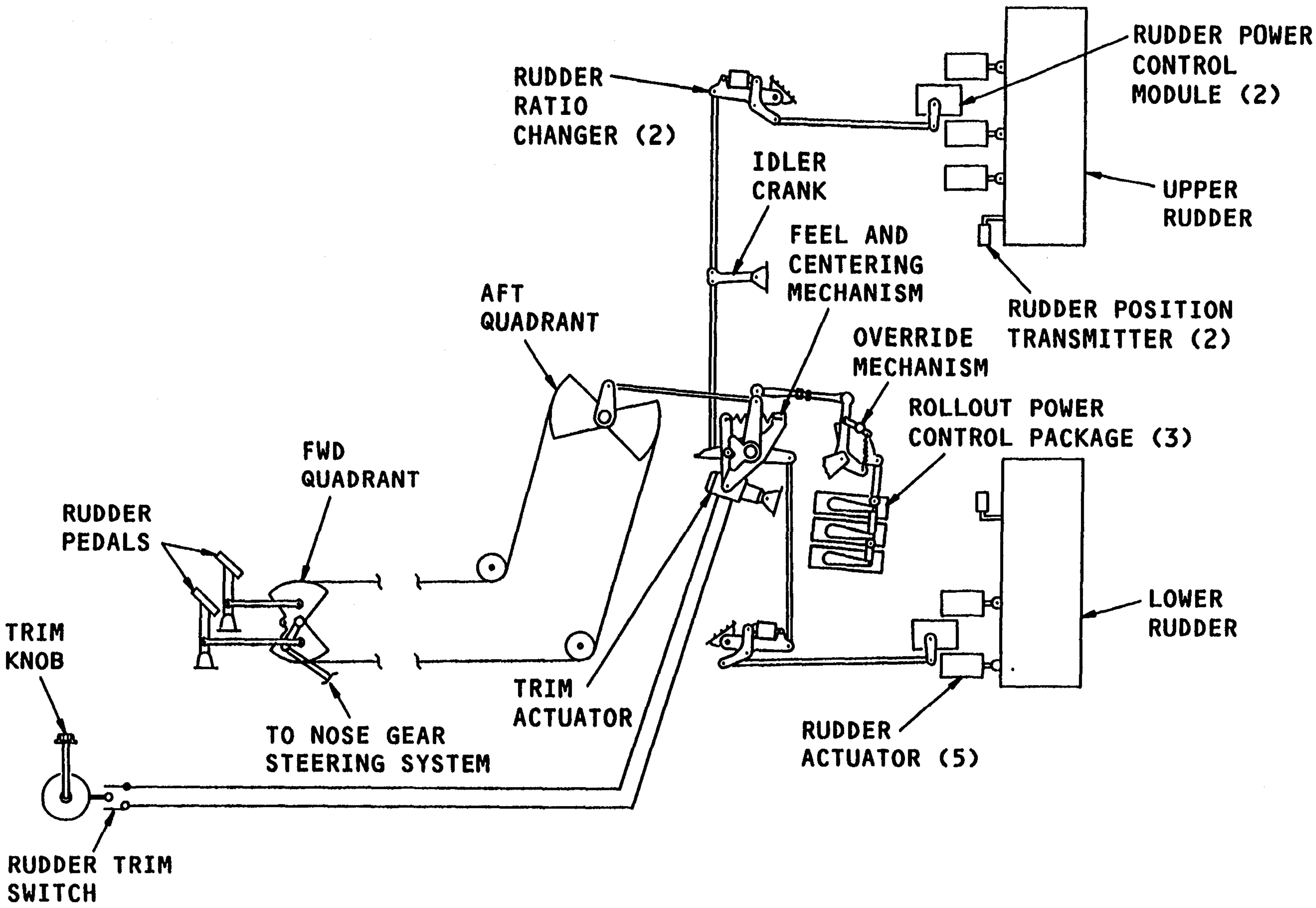



Figure 16 Flight Control System - Rudder

## FCS - RUDDER AUTOPILOT COMPONENTS

### General

The autopilot components of the rudder control system are in the vertical stabilizer, forward of the rudder hinge and aft of the rear spar.

### Installation

The three rollout power control packages are mounted to structure between the upper and lower rudders. They are connected to each other and to the override mechanism with connecting rods. The override mechanism is connected to the feel and centering mechanism.

Access to the rudder autopilot components is through access panels on both sides of the vertical stabilizer, between the upper and lower rudders.

### Operation

The operation of the rollout power control servos is similar to that of the servos for the aileron system.

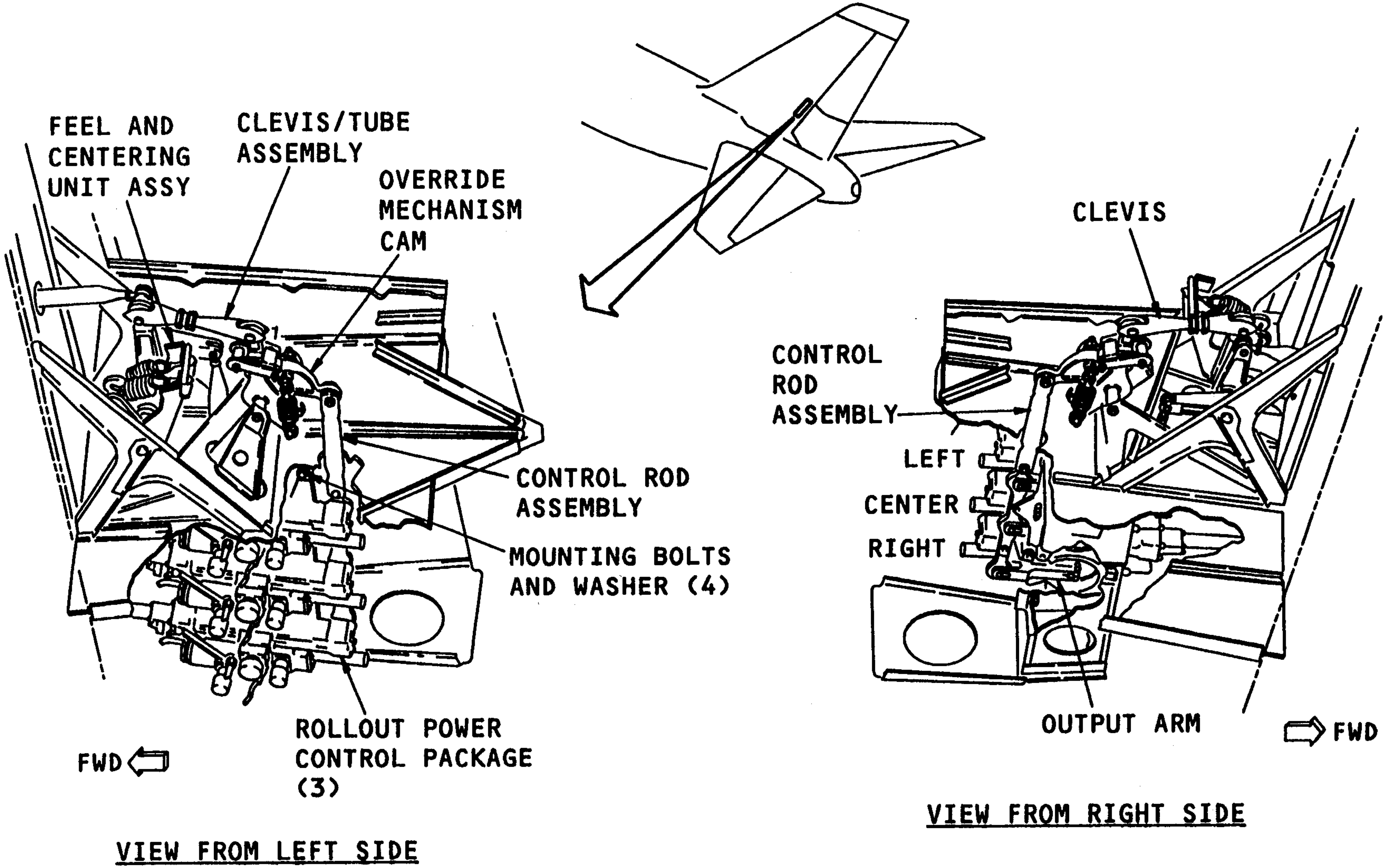



Figure 17 Flight Control Rudder Autopilot Components

## FCS - AUTOPILOT SERVO

**General**

There are two different types of autopilot servos. One type of servo is used in lateral control. The other type of servo is used for elevator and rollout control. However, both types of servos are similar. A drawing of both styles is shown below.

**Operation**

Flight control computers (FCCs) control the autopilot servos through the electrohydraulic servo valve (EHSV). The EHSV controls hydraulic pressure from one of the hydraulic systems to move the output crank.

The autopilot servo has three operating modes.

- Servo disengaged
- Servo armed
- Servo engaged

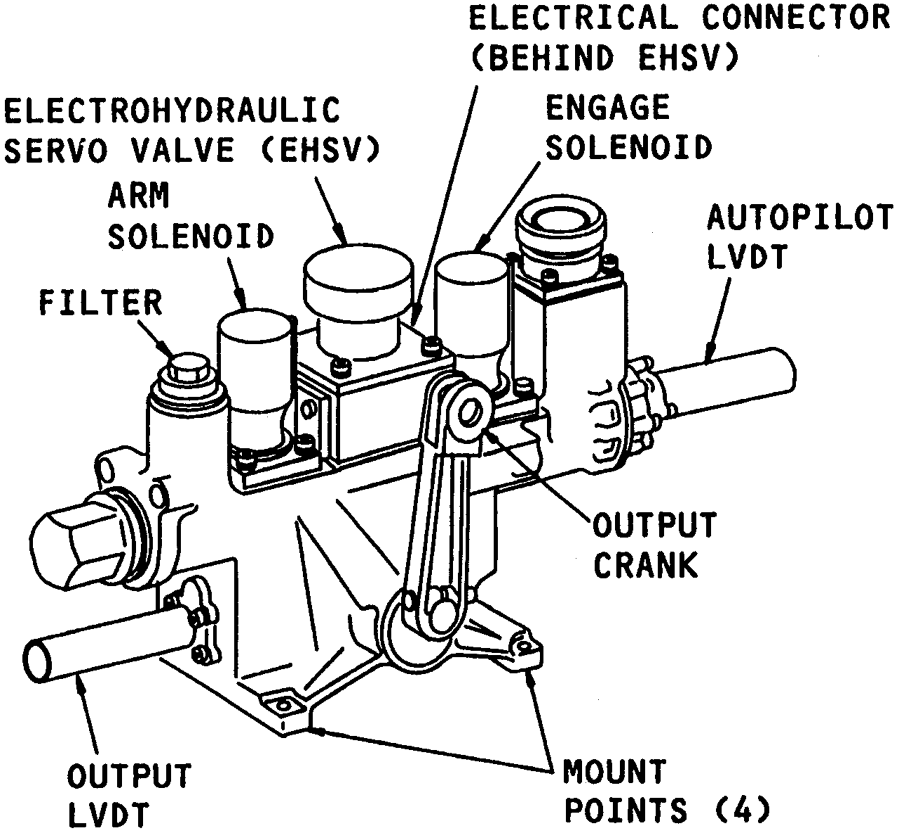
When the servo is disengaged, it is disconnected from linkage to the flight control surface. Any commands from the flight control computer to fly the airplane will not move a control surface.

In the arm mode, the autopilot servo position is synchronized to the flight control surface position.

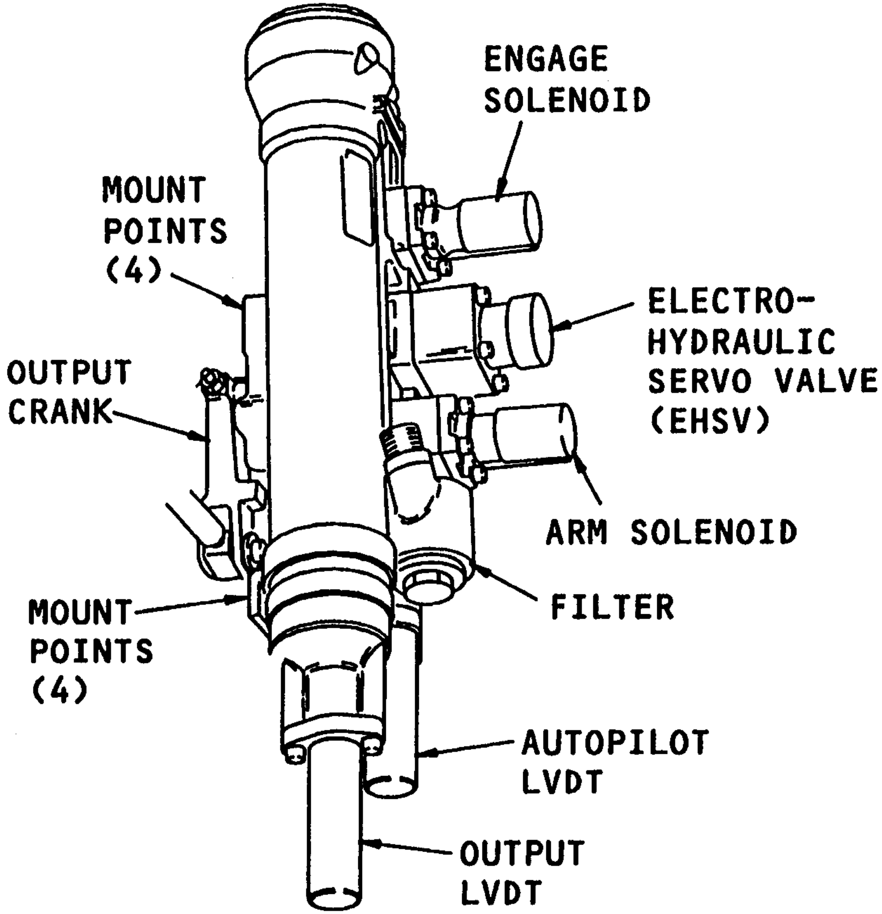
When the servo is engaged, the servo is connected to the flight control surface. Then the flight control computer flies the airplane with commands to the EHSV.

The arm/engage solenoid and the EHSV are LRUs and interchangeable with similar components on:

- STCM
- Yaw damper actuator
- CLCP
- Lateral A/P servo
- Elevator A/P servo
- Rollout power control package




ELEVATOR AUTOPILOT SERVO AND
ROLLOUT POWER CONTROL PACKAGE




LATERAL AUTOPILOT SERVO



**Figure 18 Flight Control System - Autopilot Servo**

# FCS - CENTRAL LATERAL CONTROL PACKAGE

**General**

The central lateral control package (CLCP) has two sections. They are an autopilot servo and a power boost.

**Operation**

The operation of the autopilot servo section of the CLCP is the same as for the autopilot servo. The power boost section provides a boost to change pilot control wheel movement to input for the aileron and spoiler systems.

The arm/engage solenoids and the EHSV are LRUs and interchangeable with similar components on:

- STCM
- Yaw damper actuator
- CLCP
- Lateral A/P servo
- Elevator A/P servo
- Rollout power control package

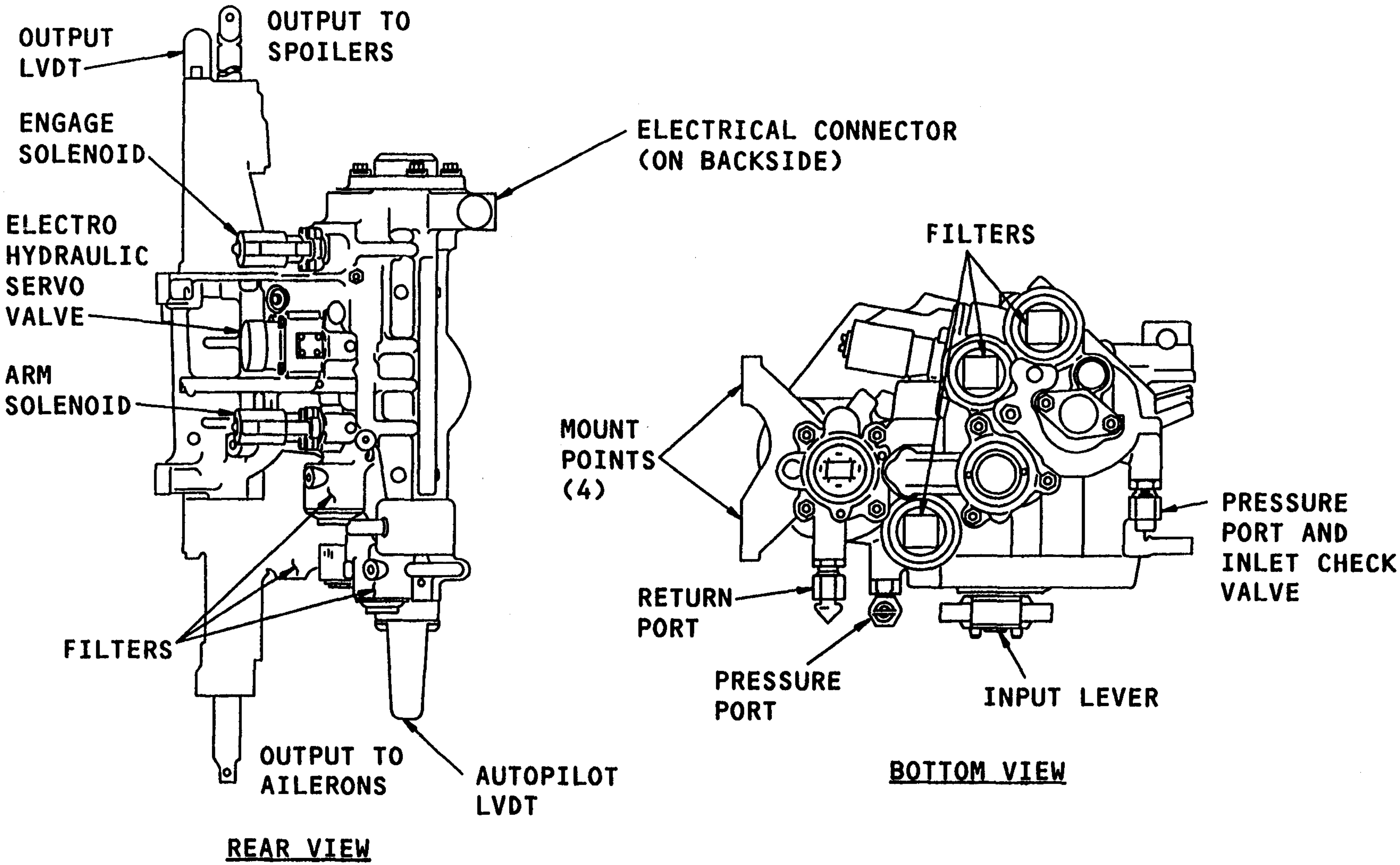



Figure 19 Flight Control Central Lateral Control Package

## HYD / FCS - ABBREVIATION/ACRONYM LIST

| | |
|---|---|
| ACMP | - AC MOTOR PUMP |
| ADP | - AIR DRIVEN PUMP |
| A/P | - AUTOPILOT |
| AUX | - AUXILIARY |
| CLCP | - CENTRAL LATERAL CONTROL PACKAGE |
| EDP | - ENGINE DRIVEN PUMP |
| EHSV | - ELECTROHYDRAULIC SERVO VALVE |
| ELEV | - ELEVATOR |
| FCC | - FLIGHT CONTROL COMPUTER |
| LVDT | - LINEAR VARIABLE DIFFERENTIAL TRANSFORMER |
| PCM | - POWER CONTROL MODULE |
| PCP | - POWER CONTROL PACKAGE |
| RDR | - RUDDER |
| SRM | - STABILIZER TRIM RUDDER RATIO MODULE |
| STCM | - STABILIZER TRIM CONTROL MODULE |
| TE | - TRAILING EDGE |
| VLV | - VALVE |

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