

United States Army Warfighting Center
Fort Rucker, Alabama
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STUDENT HANDOUT

TITLE: CH-47D FLIGHT CONTROLS

FILE NUMBER: 011-2102-3

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CH-47D FLIGHT CONTROLS

STUDENT HANDOUT

TERMINAL LEARNING OBJECTIVE (TLO):

Action: Describe components, operational characteristics, functions, and limitations of the CH-47D Flight Controls.

Conditions: In a classroom, given a CH-47D Flight Controls Trainer and a student handout.

Standards: Correctly answer in writing, without reference, six of eight questions pertaining to components, operational characteristics, limitations, and functions of the CH-47D Flight Controls System, In Accordance With (IAW) TM 1-1520-240-10 and the student handout.

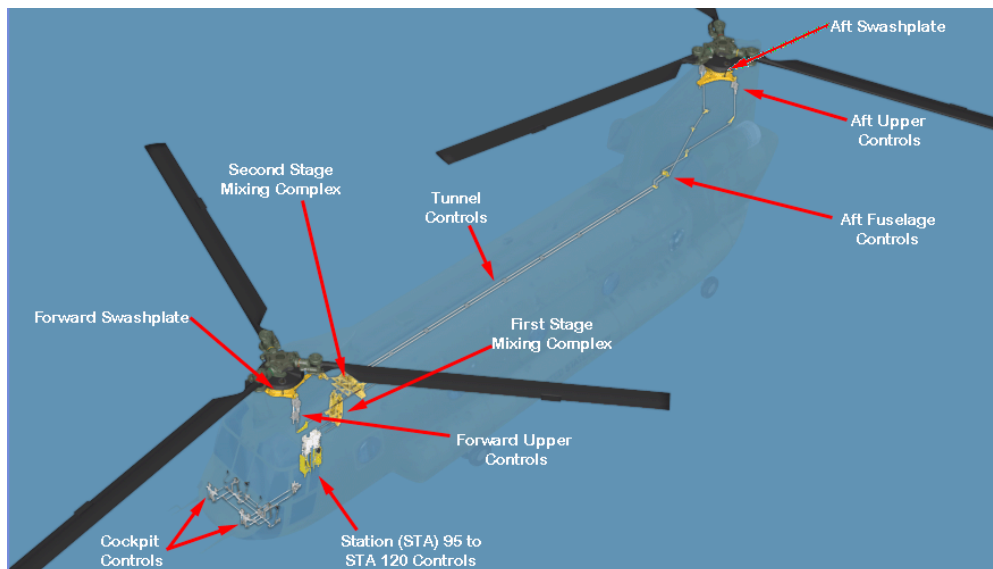
Safety Requirements: None.

Risk Assessment Level: Low.

Environmental Considerations: None.

Evaluation: Each student will be evaluated on this block of instruction during the first written examination. This will be a criterion type examination requiring a GO on each scored unit. You will have 90 minutes for the exam.

1. Learning Step/Activity 1-Describe operational characteristics, components, and limitations of the Flight Controls.

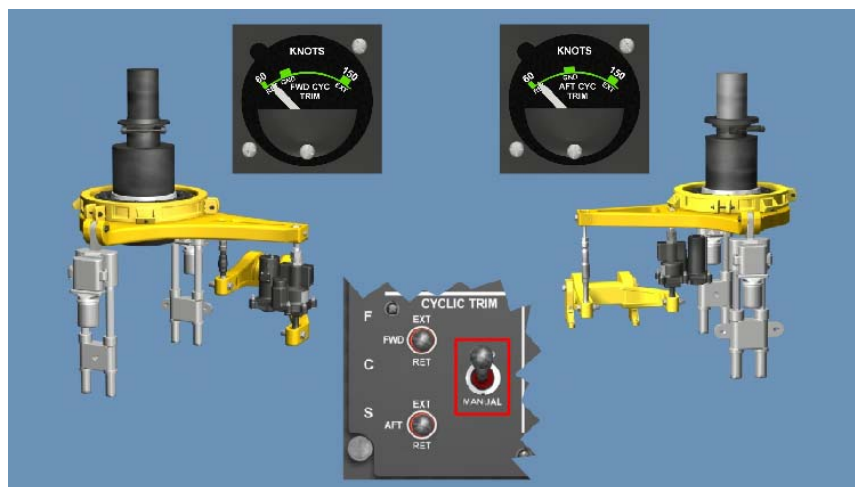


- a. Mechanical linkage between the cockpit and the rotary wing assemblies.
- b. Hydraulic actuators assist in the control movements.
- c. **The controls cannot be moved without hydraulic pressure.**



d. Preset transmission tilt (forward) of rotor discs.

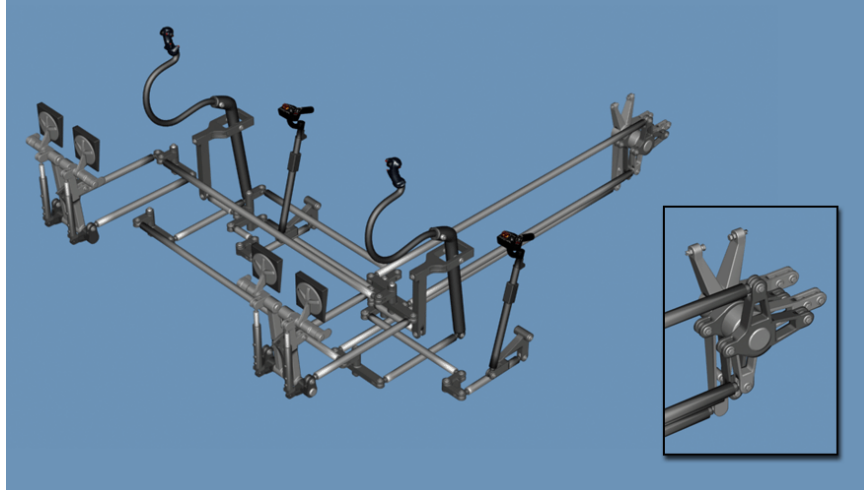
- (1) Forward transmission 9 degrees of forward tilt.
- (2) Aft transmission 4 degrees of forward tilt.
- (3) The propulsive force is directed forward by the transmission tilt.



e. Programmed cyclic tilt of rotor discs (forward/aft).

- (1) Provided by the Longitudinal Cyclic Trim (LCT) system which are electrical actuators attached to the swashplates.
- (2) Forward tilt increases as airspeed increases to minimize fuselage pitch attitude changes.
- (3) This directs the propulsive force more forward at higher airspeeds.
 - (a) Reduces blade flapping, stress on the aft vertical shaft, and fuselage angle of attack.
 - (b) Allows a higher velocity, not to exceed airspeed (VNE).

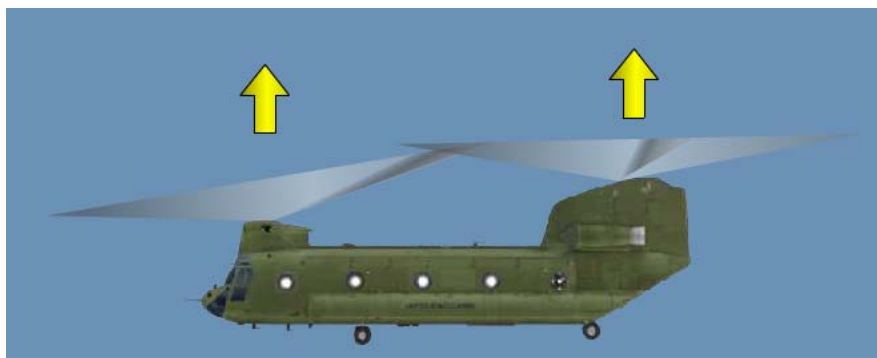
f. Four control axes are identified by the helicopter response to the control input.



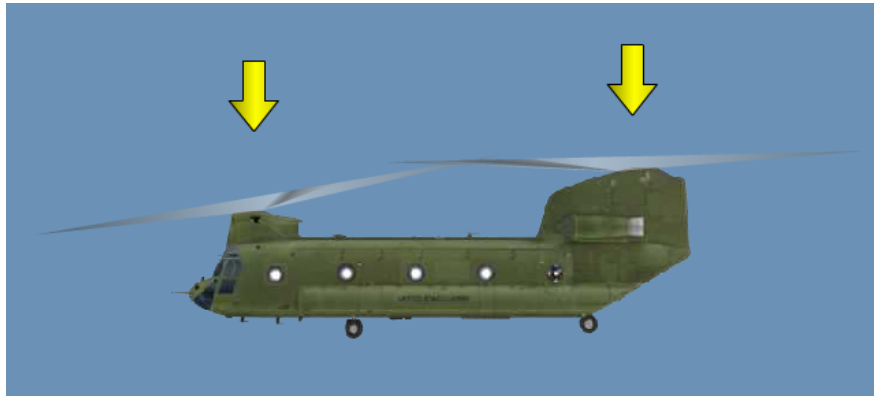
2. Learning Step/Activity 2—Describe components and operational characteristics of the Tandem Rotor.



- a. Thrust axis (thrust rod).
 - (1) Controls lift and propulsive force.
 - (2) The collective pitch angle of all six rotor blades is determined by the movement of the thrust rod.



- (a) Upward movement increases collective pitch in both rotors.



- (b) Downward movement decreases collective pitch in both rotors.
- (3) Vertical thrust (altitude) is controlled by the increase or decrease of the input.
- (4) Since both rotors turn in opposite directions, the torque effect is canceled.



- b. Pitch axis (forward and aft cyclic).
 - (1) Longitudinal control of tandem rotor helicopters is accomplished by differential thrust (collective pitch) of the forward and aft rotors creating pitch attitude changes of the fuselage about its lateral axis.
 - (a) Forward cyclic input decreases thrust (collective pitch) in the forward rotor system and increases thrust on the aft rotor system causing the aircraft to pitch nose down and increase airspeed.
 - (b) Aft cyclic input increases the thrust on the forward rotor and decreases thrust on the aft rotor system causing the aircraft to pitch nose up and decrease airspeed.
 - (2) This is called Differential Collective Pitch (DCP).



c. Roll axis (lateral cyclic).

- (1) Lateral control is accomplished by the lateral tilt of both rotor discs, which causes the fuselage to roll about its longitudinal axis.
- (2) Left cyclic tilts both rotor discs equally to the left.
- (3) Right cyclic tilts both rotor discs equally to the right.

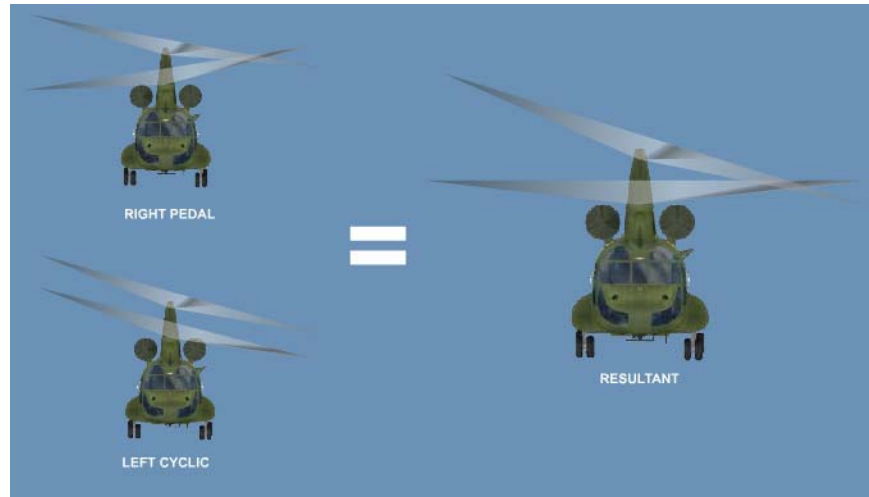


d. Yaw (directional pedals).

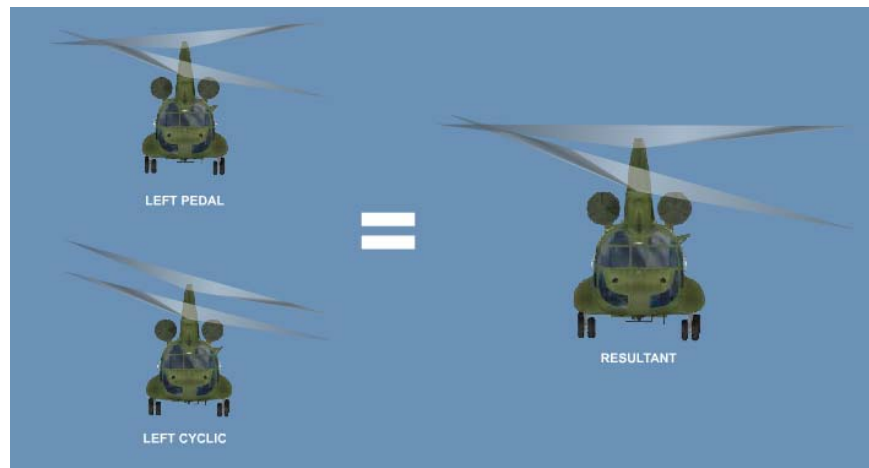
- (1) Directional control is accomplished by differential lateral tilting of both rotor discs, which causes the aircraft to turn about its vertical axis.
 - (a) Left pedal input causes a left tilt to the forward rotor disc and a right tilt to the aft rotor disc.
 - (b) Right pedal input causes the forward rotor disc to tilt right and the aft rotor disc to tilt left.

- (2) The coordinated use of lateral cyclic and directional pedals is necessary to maintain or change course heading in flight with Advanced Flight Control System (AFCS) off.

e. Hovering turns.



- (1) To turn around the forward rotor, coordinate pedal and cyclic in opposite directions. To turn around the center cargo hook, make only **pedal** input.



- (2) To turn around the aft rotor, coordinate pedal and cyclic inputs in the same direction.

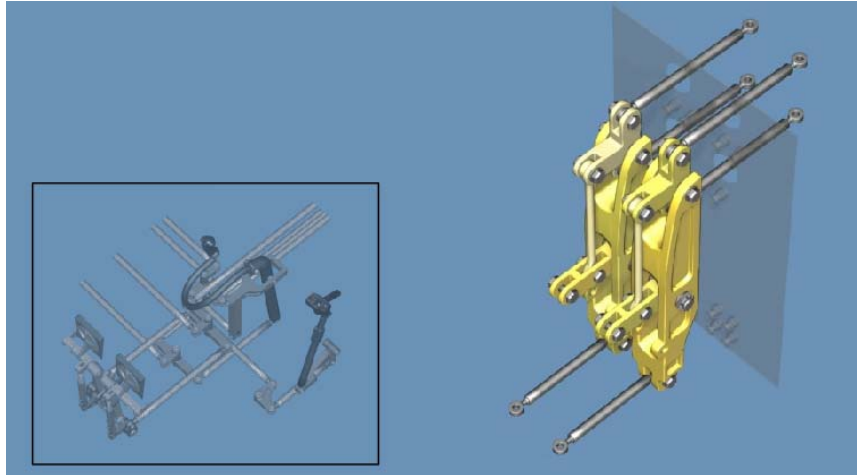


(3) To turn around the center cargo hook, make only **pedal** input.

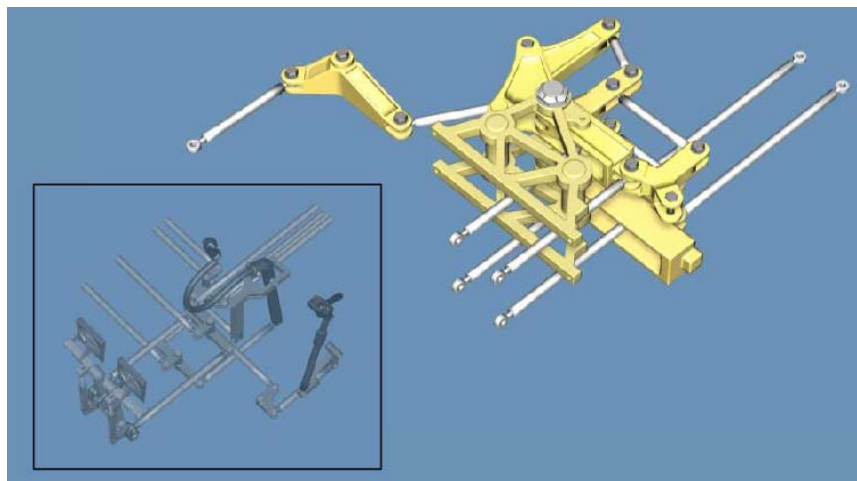
NOTE: The nose of the aircraft will always move in the direction of the pedal input.



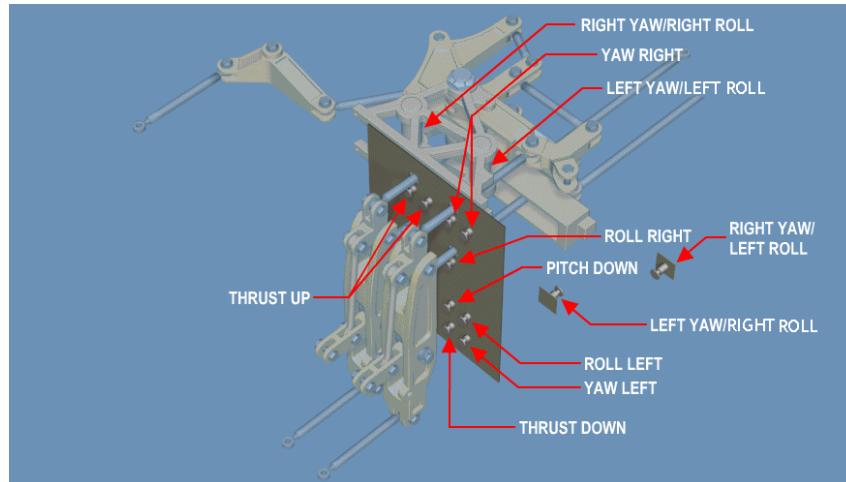
- f. Mixing units combine all control inputs into one integrated output to the upper dual boost actuators to move the swashplate.



- (1) First stage unit (two sections).
 - (a) One section mixes longitudinal cyclic (pitch) and thrust.
 - (b) One section mixes lateral cyclic (roll) and pedals (yaw).



- (2) Second stage unit. All inputs from the first stage unit are combined in the second stage unit.



- (3) Control stops.
- (4) During preflight, check for damaged components.

NOTE: During engine shutdown, position the pedals and cyclic at neutral and the thrust at ground detent.

OPERATOR'S MANUAL CAUTION: Critical flight control components can be damaged if thrust is not in ground detent, **Page 8-22.**

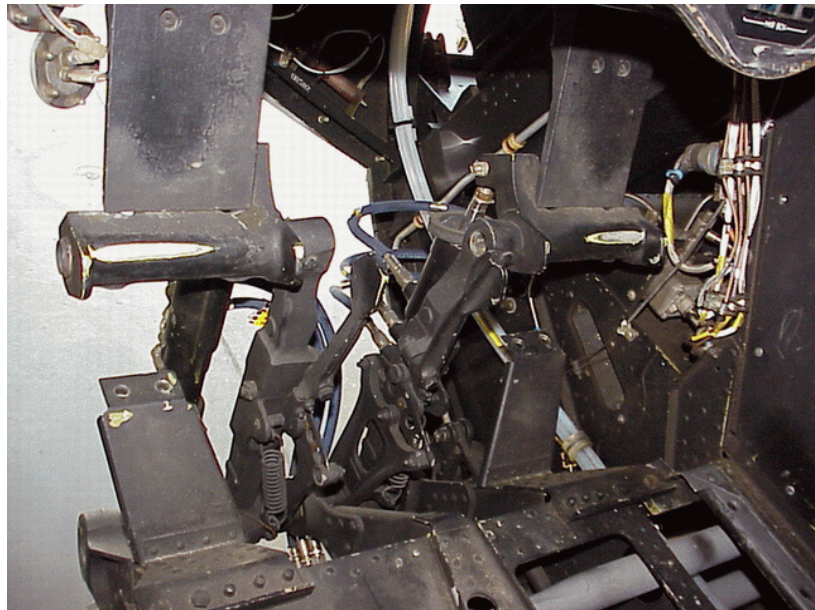
3. Learning Step/Activity 3–Describe flight and ground, Flight Control Limitations.



- a. During all ground operations, control movements are limited to prevent droop stop pounding.

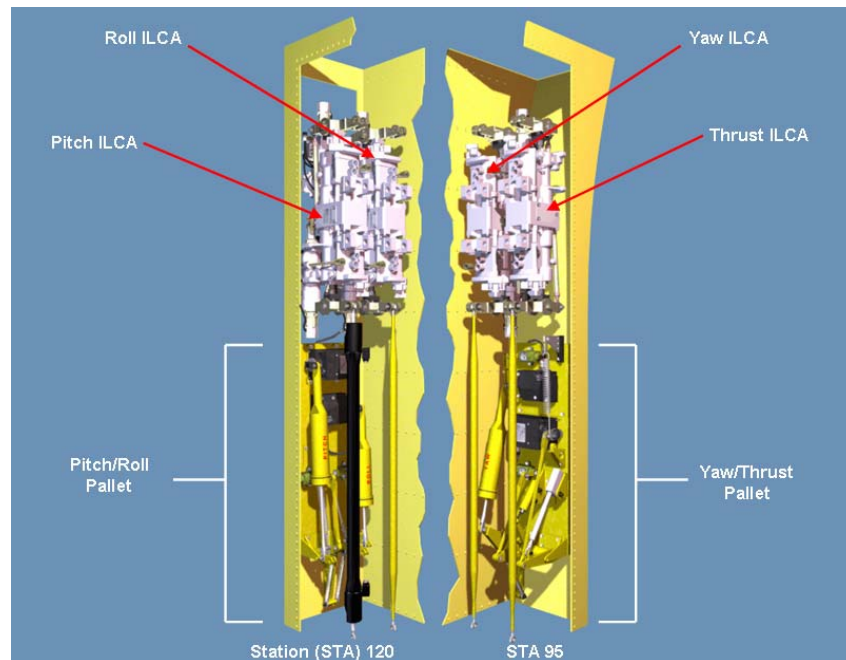


- (1) Thrust – not below the ground detent.
- (2) Aft cyclic – 2 inches.
- (3) Lateral cyclic – 1 inch.
- (4) Pedals – 3/4 inch.

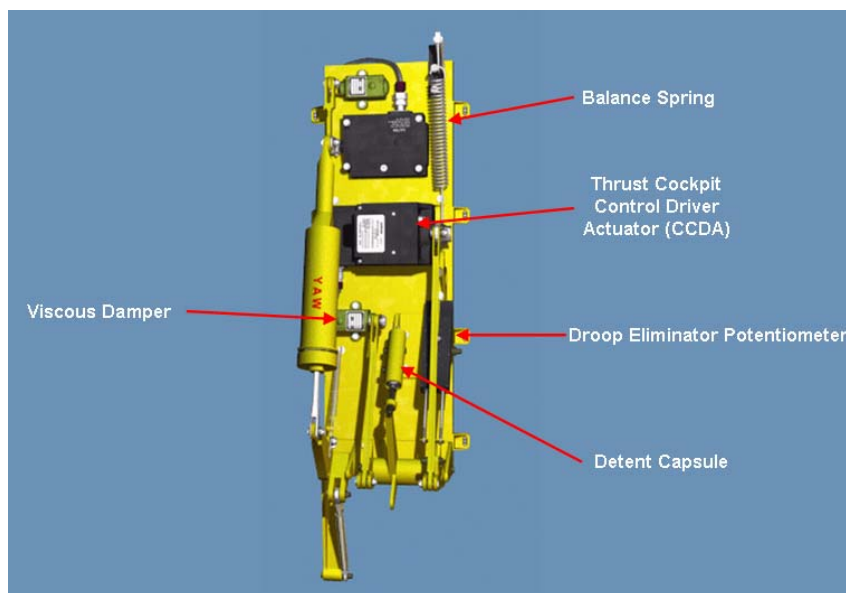


- b. Ensure that your left and right pedals are adjusted to corresponding positions prior to engine start.

4. Learning Step/Activity 4–Describe Flight Control Components.

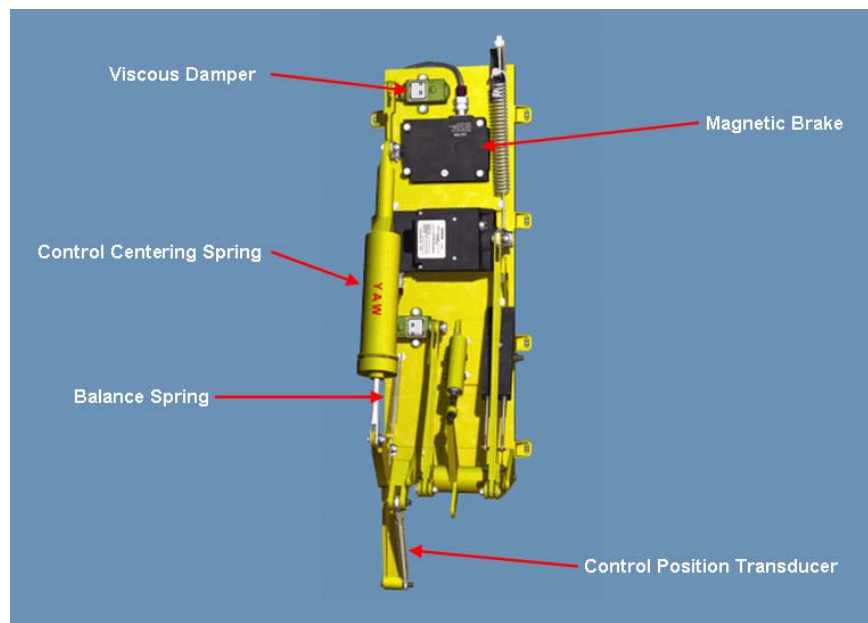


- a. Secondary controls are mounted on pallets to simplify maintenance.



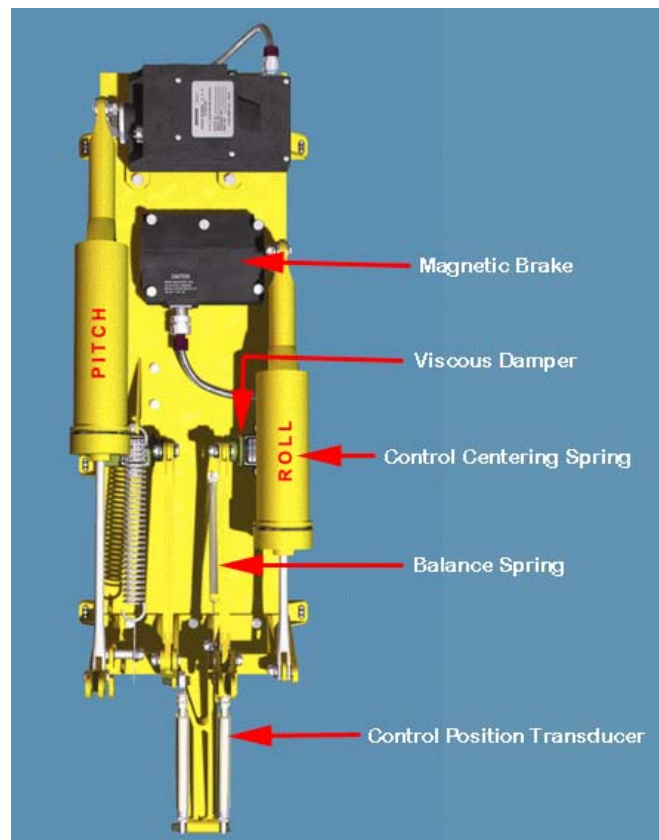
- b. Pallet at station 95 contains the following thrust axis components.
- (1) Viscous damper improves control feel by reducing control sensitivity.
 - (2) Droop eliminator potentiometer maintains a constant rotor rpm as thrust is changed.
 - (3) Detent capsule establishes a ground reference detent.

- (4) Balance spring counteracts the downward imbalance of the thrust controls.
- (5) Thrust axis Cockpit Control Driver Actuator (CCDA).
 - (a) Thrust control magnetic brake.
 - 1) Holds the thrust rod in position selected by the pilot.
 - 2) Controlled by thrust control brake trigger switch on the thrust rod.
 - 3) Electrical power to release is supplied by the essential DC bus.
 - 4) Brake can be slipped with a force of 7 to 23 pounds.
 - 5) **Do not** slip the brake with altitude hold engaged.
 - 6) **Do not** enter forecast turbulence with an inoperative thrust brake (one that will not hold the thrust in position).
 - (b) Driver actuator.
 - 1) Controlled by the altitude hold functions of AFCS.
 - 2) Increase or decrease thrust to maintain a constant altitude.
 - 3) The thrust rod will move when the CCDA makes a control input.



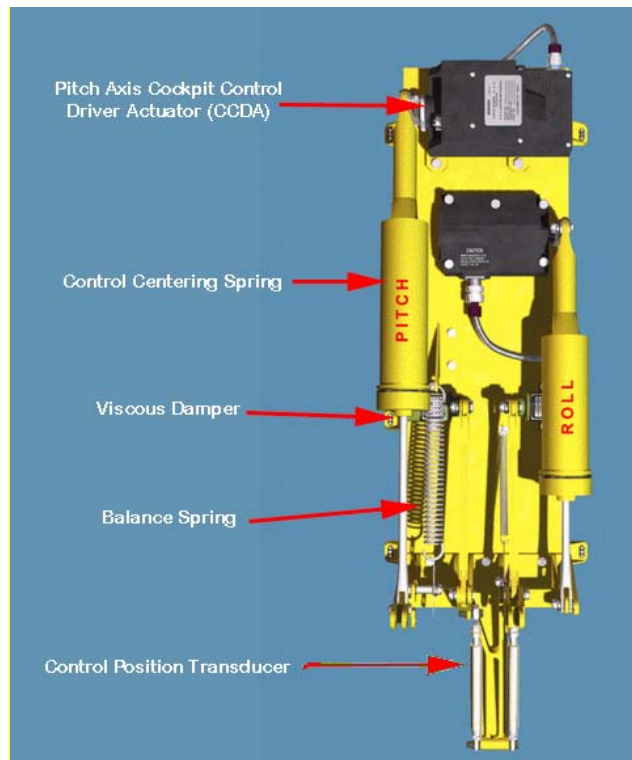
- c. Pallet at station 95 contains the following yaw axis (pedals) components.
 - (1) Force feel trim magnetic brake.
 - (a) Holds the controls in position.

- (b) Controlled by the CENTERING DEVICE RELEASE switch (press to release) on the cyclic.
 - (c) Electrical power to release is supplied by the 28 VDC switched battery bus through the control center circuit breaker on the No. 1 Power Distribution Panel (PDP).
- (2) Control centering spring.
 - (a) Provides a force feel when the control is moved with the brake locked.
 - (b) Assumes a new trimmed position when the brake is released.
- (3) Viscous damper provides a control feel when the control is moved while the magnetic brake is released.
- (4) Balance spring is installed to prevent pedal creep.
- (5) Control Position Transducer (CPT).
 - (a) Produces a position signal to AFCS.
 - (b) Tells AFCS when the pilot has induced the motion.



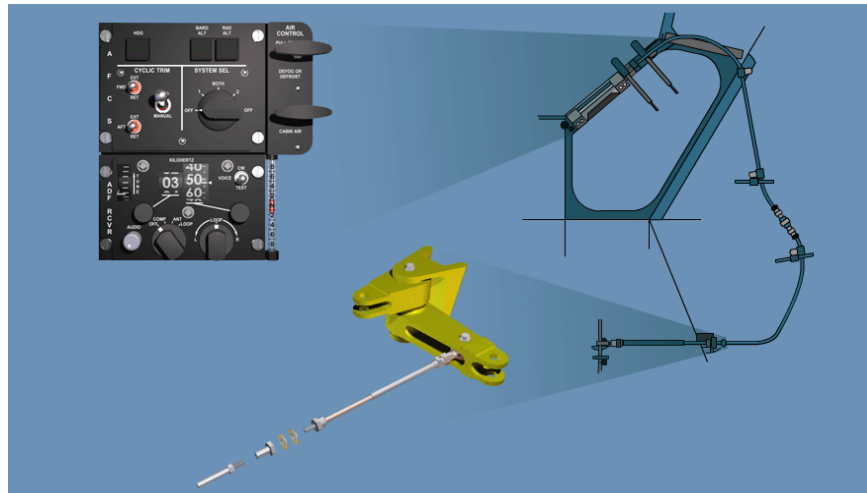
- d. The pallet at station 120 contains the following roll axis (lateral cyclic) components.

- (1) Control centering spring.
- (2) Magnetic brake.
- (3) Viscous damper.
- (4) Balance spring.
- (5) CPT.



- e. The pallet at station 120 contains the following pitch axis (forward and aft cyclic) components.
- (1) Control centering spring.
 - (2) Viscous damper.
 - (3) Balance spring.
 - (4) CPT.
 - (5) Pitch axis CCDA contains:
 - (a) Magnetic brake is released when the centering device release switch is pressed.
 - (b) Driver actuator.

- 1) Controlled by the AFCS trim switch on the cyclic (forward and aft movement).
- 2) The cyclic will move.



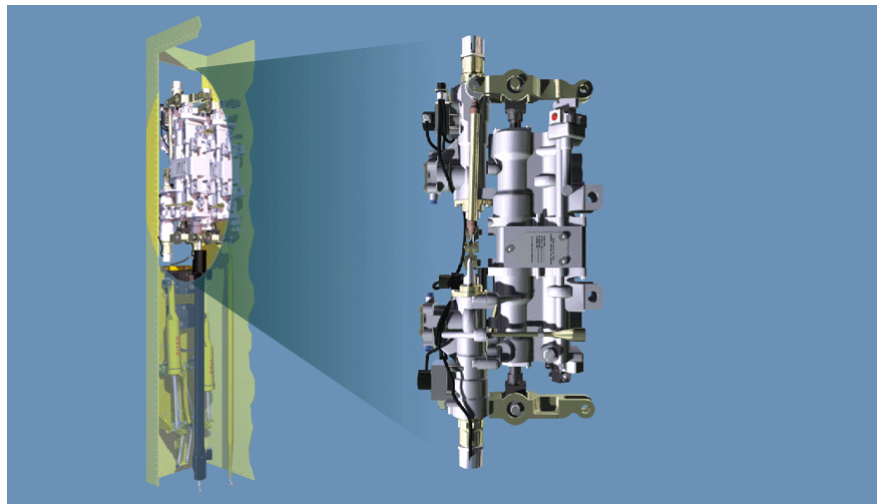
f. Cyclic stick position indicator.

- (1) Located on the right side of the center console.
- (2) Indicates the forward and aft position of the cyclic stick.

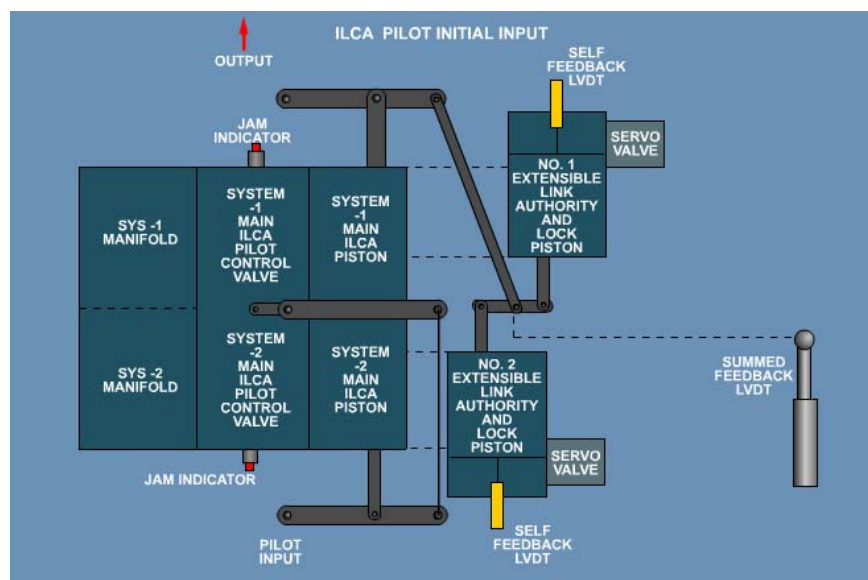


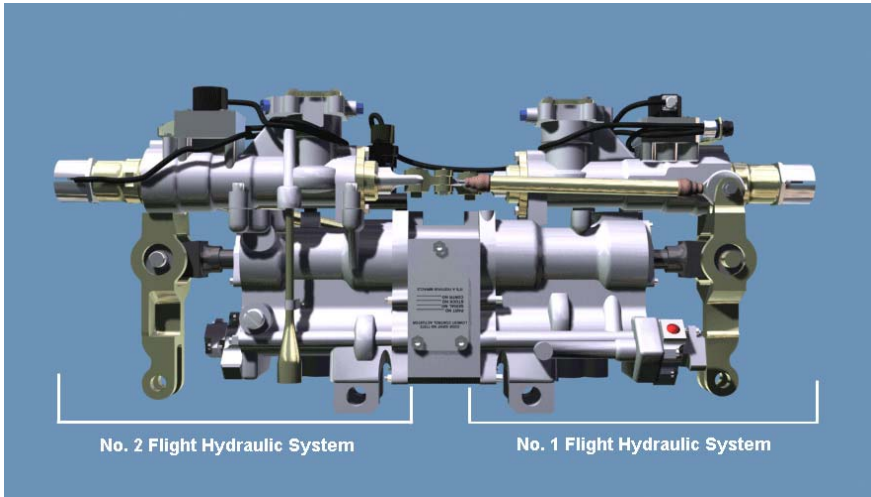
- (3) Check cyclic stick travel during the 'flight control travel and hydraulics' check.
 - (a) Forward – 7" minimum.
 - (b) Aft – 4" minimum.
 - (c) Slope operations.

OPERATOR'S MANUAL CAUTION: If the helicopter is parked on a slope greater than 4°, longitudinal stick travel may be restricted to less than 7 inches forward (up slope) or 4 inches aft (down slope).
Page 8-11.

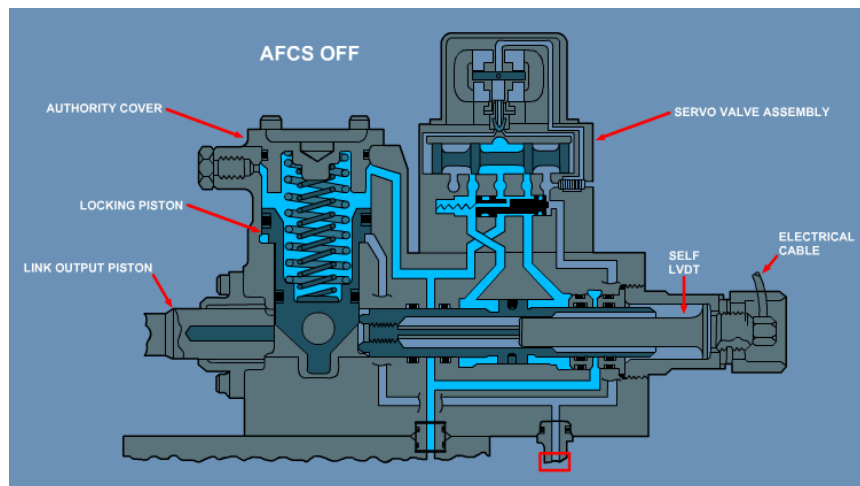
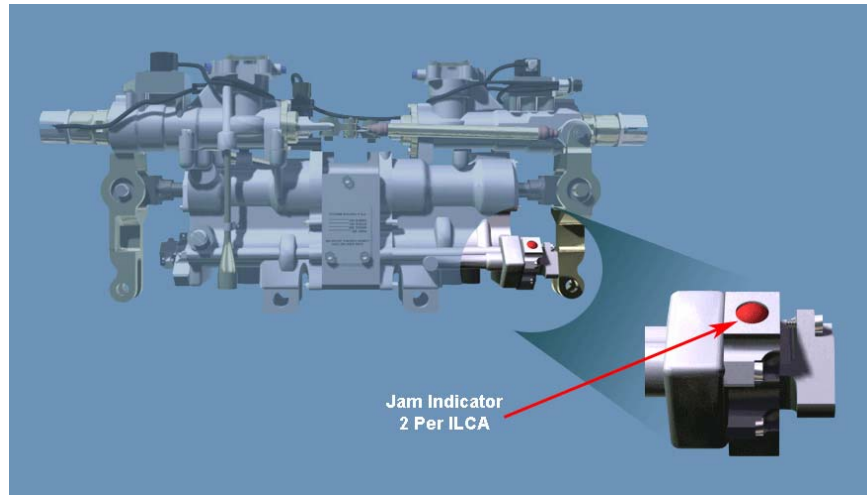


- g. Integrated Lower Control Actuators (ILCA). There are four ILCA's located in the flight controls closet. One each for pitch, roll, yaw, and thrust.



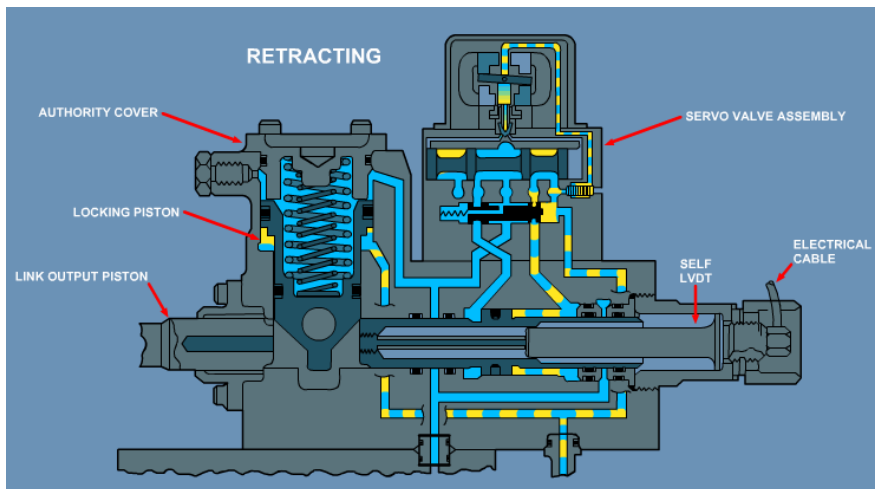
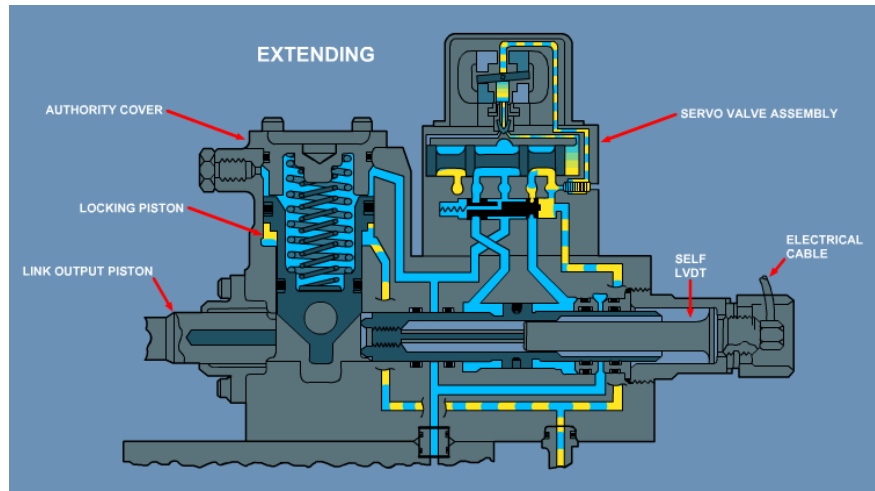


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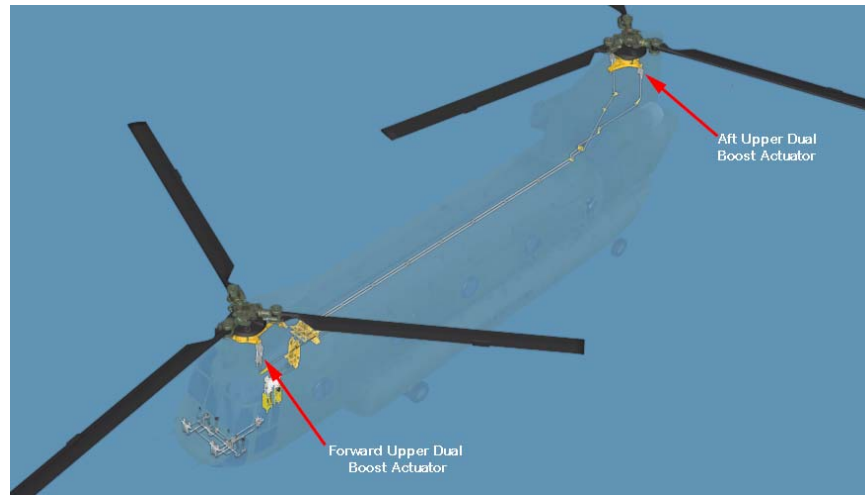


- (3) Extensible link section of the pitch, roll, and yaw ILCA's.
- (a) Converts AFCS electrical signals into a hydraulic input to the flight controls.
 - (b) Mechanically re-centers and locks when the AFCS is off.
 - (c) Upper link is controlled by the No.1 AFCS.
 - (d) Lower link is controlled by the No.2 AFCS.
 - (e) Linear Variable Differential Transducers (LVDT).
 - 1) Provides a feedback signal to the AFCS relative to the extensible link position.
 - 2) This signal is used to cancel (null) the AFCS command signal.
 - 3) Each extensible link has its own LVDT.
 - 4) The summing link has a dual LVDT for total signal to both AFCS.

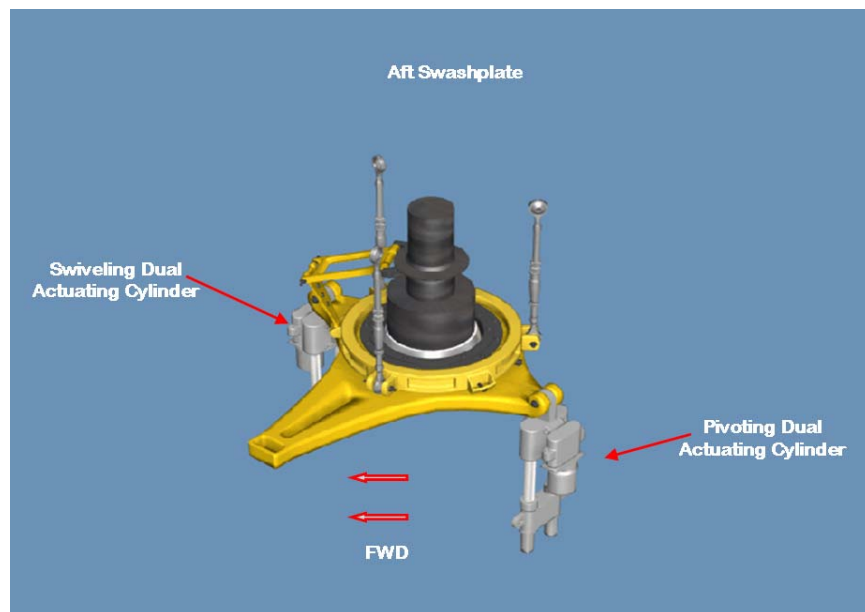
- (f) During dual AFCS operation, each extensible link provides 100% of the total required control input.
- (g) During single AFCS operation, the extensible link of the operating AFCS provides 200% of the total required control input based on the fixed pivot point.



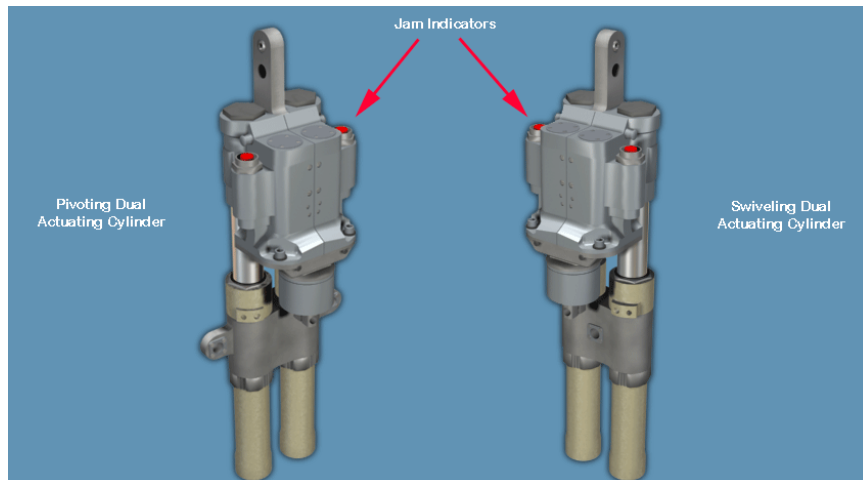
h. Upper dual boost actuators.



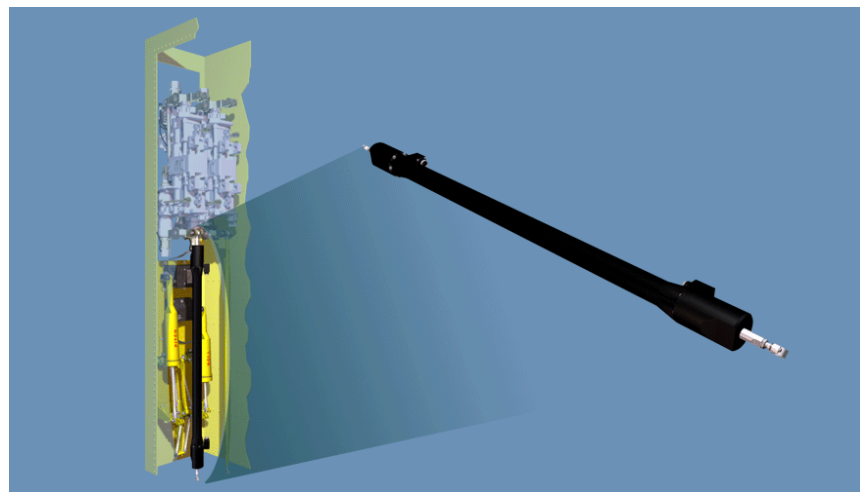
(1) Two located below each swashplate.



- (2) Hydraulically moves the swashplate.
- (3) One piston is powered by the No.1 flight control hydraulic system.
- (4) One piston is powered by the No. 2 flight control hydraulic system.



- (5) Separate control valves with jam indicators.



- i. Differential Airspeed Hold Actuators (DASH).
 - (1) Located in the pitch axis in the controls closet.
 - (2) Upper actuator – No.1 AFCS.
 - (3) Lower actuator – No.2 AFCS.
 - (4) Provides AFCS control inputs for:
 - (a) Airspeed hold.
 - (b) Pitch attitude hold.
 - (c) Positive stick gradient.

Appendix C - Practical Exercises and Solutions

CH-47D FLIGHT CONTROLS

PRACTICAL EXERCISE

NOTE: This practical exercise covers the instruction you received in this handout. Completion is optional, but strongly encouraged!

1. How will the rotor discs react to a right pedal input?
2. How will the rotor discs react to a right cyclic input?
3. How is the collective pitch in the forward and aft rotors affected when the cyclic is moved forward?
4. What control movements must be made for a hovering turn about:-
 - a. Center hook?
 - b. Forward rotor?
 - c. Aft rotor?
5. How must the flight controls be positioned prior to removal of hydraulic pressure?
6. Give names for the following abbreviations for flight control components – AFCS, DASH, ILCA, CCDA, LVDT and CPT.
7. Which aircraft system causes the extensible link portion of the ILCA's to make control inputs?
8. What is the minimum allowable forward and aft cyclic stick travel during the controls check?
9. What are the control limitations for ground operations?
 - a. Thrust.
 - b. Lateral cyclic.
 - c. Aft cyclic.
 - d. Pedals.
10. Should you enter forecast turbulence with an inoperative thrust brake?
11. What environmental flight condition shall be avoided when the thrust brake is inoperative?

12. Which control axes have magnetic brakes that are released when the centering device release switch is pressed?
13. Why is it important to have the left and right pedals adjusted to the same holes prior to engine start?
14. How may forward and aft cyclic travel be affected during the controls check if the aircraft has been parked on a slope?
15. What are the functions of the boost portion of the ILCA?
 -
 -
16. What is the function of the AFCS extensible link portion of the ILCA?
17. How will the forward and aft rotor discs react when the cyclic is moved left?
18. What are the two parts of the #1 Pitch ILCA?
19. Should you slip the thrust brake during your controls check?
20. Pulling the cyclic aft increases pitch in the forward blades and decrease pitch in aft blades, this is an example of?
21. What component improves control feel by reducing control sensitivity?

CH-47D FLIGHT CONTROLS

PRACTICAL EXERCISE SOLUTIONS

1. Forward rotor disc tilts right and the aft disc tilts left.
2. Both rotor disc tilt to the right.
3. Pitch is decreased on the forward rotor and increased on the aft rotor.
4.
 - a. Pedal only.
 - b. Right pedal and left cyclic or left pedal and right cyclic.
 - c. Pedal and cyclic in same direction.
5. Thrust at ground detent, and pedals and cyclic at neutral.
6. AFCS – Advanced Flight Control System, DASH – Differential Airspeed Hold CPT – Control Position Transducer, ILCA – Integrated Lower Control Actuator, CCDA – Cockpit Controlled Driver Actuator , LVDT – Linear Variable Differential Transducer
7. AFCS
8. Forward 7 inches, aft 4 inches.
9.
 - a. Not below ground detent.
 - b. 1 inch.
 - c. 2 inches.
 - d. 3/4 inch.
10. No.
11. MODERATE or STRONGER TURBULENCE
12. Pitch, roll, and yaw.
13. To prevent droop stop pounding.
14. Stick travel may be restricted to less than 7" Fwd or 4" Aft.
15. Provides hydraulic assist and Prevents control feedback.
16. Provides AFCS control input.
17. Both Tilt Left
18. Boost portion, and extensible link portion
19. No.
20. DCP (Differential Collective Pitch).
21. Viscous Damper

