**NATIONAL TRANSPORTATION SAFETY BOARD**
Office of Aviation Safety
Washington, D.C. 20594

May 7, 2009

# Systems Group Chairman's Factual Report

DCA-09-MA-026

## A. ACCIDENT

| | |
|---|---|
| Operator: | US Airways |
| Location: | Hudson River |
| Date: | January 15, 2009 |
| Time: | 1530 Eastern Standard Time |
| Airplane: | Airbus Industrie A320-214, N106US |

## B. SYSTEMS GROUP

Chairman: Scott Warren
National Transportation Safety Board
Washington, D.C.

Member: Arnaud Desjardin
Bureau d'Enquetes et d'Analyse pour la sécurité de l'Aviation Civile
Aeroport du Bourget, France

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International Association of Machinists
Charlotte, NC

Member: Pete Dolf
US Airline Pilots Association
Charlotte, NC

Member: Christophe Duphil
Airbus SAS
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## C. SUMMARY

On January 15, 2009, about 1527 Eastern Standard Time, US Airways flight 1549, an Airbus A320-214, registration N106US, suffered bird ingestion into both engines, lost engine thrust, and landed in the Hudson River following take off from New York City's La Guardia Airport (LGA). The scheduled, domestic passenger flight, operated under the provisions of Title 14 CFR Part 121, was en route to Charlotte Douglas International Airport (CLT) in Charlotte, North Carolina. The 150 passengers and 5 crewmembers evacuated the aircraft successfully. One flight attendant and four passengers were seriously injured.

The Systems Group convened on January 15-20, 2009 in New York City, NY, to examine and document the aircraft.

## D. DETAILS OF THE INVESTIGATION

### 1.0 Flight Controls

The pitch trim system was examined, and the trim indications were noted from the indicating wheel in the cockpit, the index marks on the tail, and by measuring the trimmable horizontal stabilizer actuator (THSA). The pitch trim wheel in the cockpit indicated approximately 4.7 units aircraft nose up. The index marks on the tail indicated a position of 4.7 units aircraft nose up. The measurements of the THSA were 270 mm measured from the bottom of the ball screwjack to the top of the lower ballscrew stop (measurement X’ on figure 1). The length of the upper screw section of the THSA (measurement X on figure 1) could not be measured accurately, but was determined to be approximately 270 +/- 40 mm. According to Airbus documentation, these measurements correlated to a pitch trim position between 4.5 and 5 units aircraft nose up.

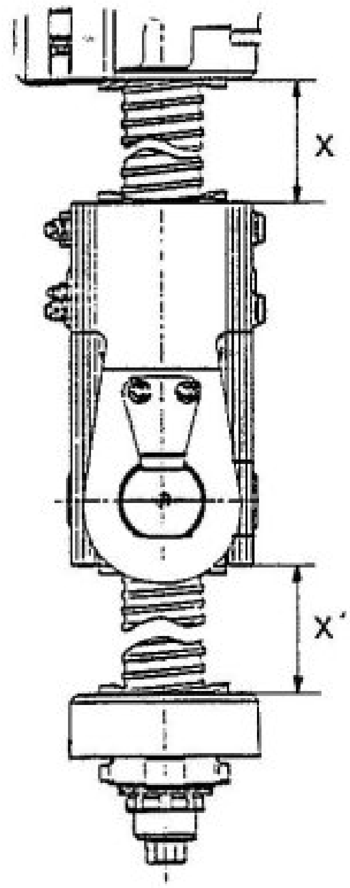


Figure 1
Trimmable Horizontal Stabilizer Actuator Measurement Locations

The left wing was examined, and an inboard section of the outboard flap was missing. The left inboard flap was badly damaged, while the remainder of the left outboard flap appeared to be only slightly damaged. The right wing was examined, and all sections of the flaps were present, but both the inboard and outboard flaps were bent out of their normal shape.

The flap positions were determined by taking measurements as specified in figure 2. The measurements are taken along the flap track beam between the flat of the "full retract" stop and the edge of the side roller of the flap carriage (measurement X on figure 2). These measurements were taken on tracks 2 and 3 of the right wing and were determined to be 358 and 361 mm respectively. According to Airbus documentation, these measurements correspond with flap position 2. Examination of the flap lever in the cockpit determined that the lever was in position 2. These measurements could not be taken on the left wing because these measurement points were not accessible. Qualitative examination determined that the flap positions on each side of the aircraft appeared to be the same.

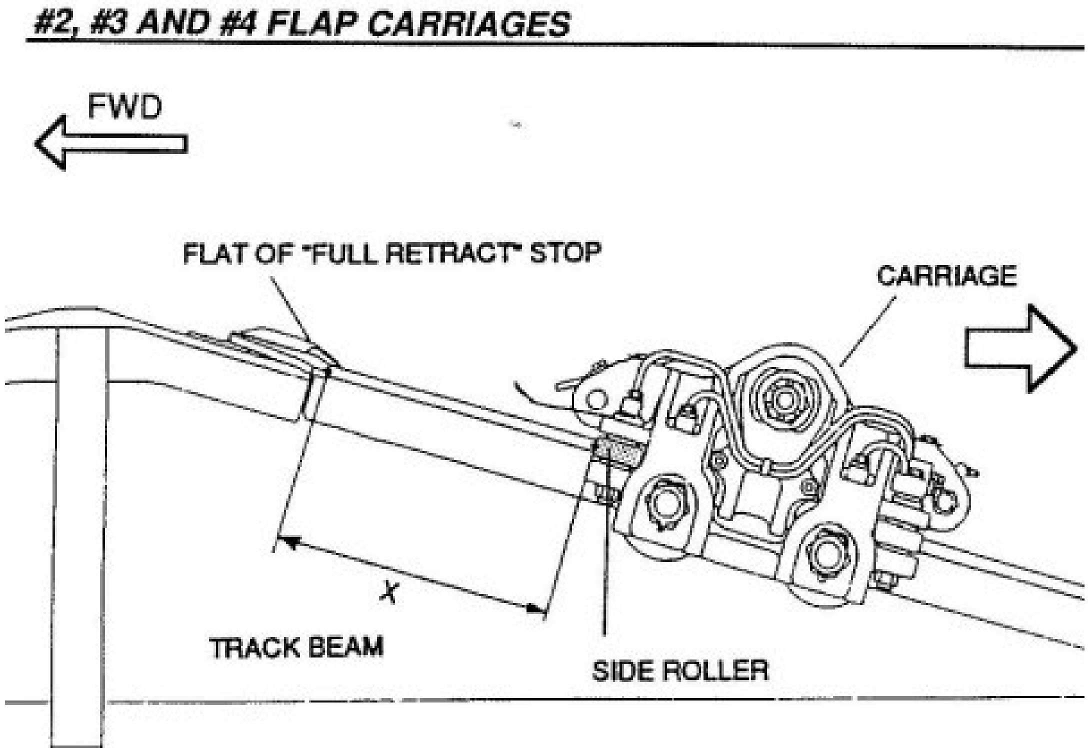


Figure 2
Flap Carriage Measurement Location

The slats on the left wing were present with the exception of slat panels 4 and 5. Numerous dents and cuts were present in many areas along the leading edge. The slats on the right wing were all present with numerous dents in many areas along the leading edge.

The slat positions were determined by taking measurements as called out in figure 3. The measurements are taken along the slat track beam between the stop and the roller of the slat (measurement Y in figure 3). These measurements were taken on tracks 5 and 6 of the left wing and were determined to be 234 and 236 mm respectively. According to Airbus documentation, these measurements correspond with slat configuration 2 or 3 (the slat positions do not change when the flap lever is moved from position 2 to position 3). These measurements were also taken on tracks 5, 6, and 7 of the right wing and were all determined to be 235 mm. According to Airbus documentation, this measurement also corresponds to slat configuration 2 or 3.

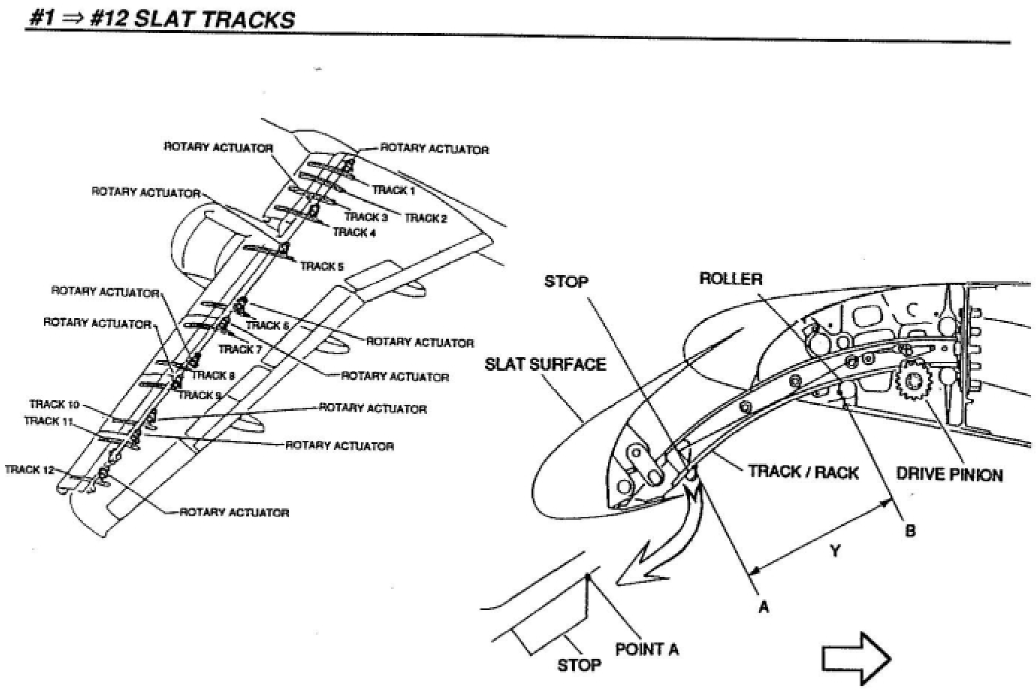


Figure 3
Slat Position Measurement Locations

## 1.1 Observations Regarding Other Aircraft Systems Items

After examining the aircraft, the following items were noted (the damage noted in this report was identified after several boats impacted the aircraft during the recovery operations and the aircraft was lifted out of the water onto a barge):

The outflow valve doors were separated from the outflow valve door actuator. A position for the outflow valve door could not be determined.

The ram air turbine (RAT) was noted to be in the extended position when the aircraft was lifted from the water. Both blades on the RAT were present, and no major deformation of the blades could be seen. The RAT was substantially damaged when the aircraft was placed on the barge.

The avionics cooling skin air inlet valve and skin air outlet valve were both found in the closed position.

The blue hydraulic system reservoir was located in its normal location, and one of its return lines was severed. The indicated fluid level was empty.

The tailcone, including the APU was broken off of the fuselage of the aircraft, and it was hanging from the rear of aircraft by the APU generator cables.

After the aircraft was lifted from the water and placed on the recovery barge, the following recording units and avionics boxes were removed from the aircraft:

Cockpit Voice Recorder (CVR)
Allied Signal
P/N: 980-6020-001
S/N: 2878
Date Code: 9908
Mod: 1, 2, 4, 5, 6, 7, 8, 9

Flight Data Recorder (FDR)
Honeywell
P/N: 980-4700-003
S/N: 7336
Date Code: 0106
Mods: 1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 15, 16, 17, 18

Enhanced Ground Proximity Warning System (EGPWS)
Honeywell
P/N: 965-10976-003-206 (mod 3)-206 (mod 2)
S/N: 7393
Mfg date: 0010
Mod Status: 1-11 inclusive

Data Management Unit (DMU)
SFIM Industries
P/N: ED45A300
S/N: 884
Date Code: 11/99
No Amendments

## 1.2 Cockpit Documentation

The cockpit switch and button positions were examined, and the following items were noted:

<u>CAPT/FO Instrument Panel</u>
PFD/ND's - Each knob was in the full bright position
Speakers - Off
Console/Floor – Off
A/Skid & N/W STRG – On

Landing Gear Lever – Up
Yellow Pressure Brake Triple Indicator – All indicators at zero psi

<u>Glare shield</u>

Capt – Altimeter Units Selector: InHg, Navigational mode selector: Arc, Navigational display range selector: 80nm, ADF/VOR selector: off
F/O - Altimeter Units Selector: InHg, Navigational mode selector: Arc, Navigational display range selector: 10nm, ADF/VOR selector: off
Alt Selector – 100'

<u>Pedestal</u>

Switching Panel: All selectors in the normal position
ECAM upper/lower screens: All knobs in the full bright position
Radio Management Panel (RMP) power switch Capt. & F/O: both on
THS: 4.7 up
Thrust Lever: L – Climb Detent, R- 1/8 inch aft of climb detent
Capt Audio Control Panel (ACP): Com 1 button - out, volume - 10 o'clock position. Interphone: out, volume - 2 o'clock position
Main flood light – Off, Integral – full bright, pedestal flood – off
Radar tilt: +5 degrees for both pilots, Capt - wx/turb position, windshear auto, control on Capt. F/O- wx position
Engine Masters – off
Ignition – IGN/START
F/O com - #1 button out, full loud volume
Transponder: auto, #2, alt on, tcas all position, TA/RA selected
Speedbrake handle in the retract position
Flap handle in position 2
Parking brake: off

<u>Overhead panel:</u>

Adirs: Displayed Information Selector – TK/GS, Displayed System Selector - SYS 3, System Mode Selectors - all in NAV
Evac panel: Capt position
FLT CTL: All in
GPWS: Unknown position (pushbutton does not change position when pushed, so the current state of the switch could not be determined)
Recorder Panel: Unknown (pushbutton does not change position when pushed, so the current state of the switch could not be determined)
Oxygen Panel: Unknown (pushbutton does not change position when pushed, so the current state of the switch could not be determined)
Wipers: Capt. & F/O: Off
Fire Panel: Eng 1&2: out, APU: in, agent buttons: unknown (pushbutton does not change position when pushed, so the current state of the switch could not be determined)

Hyd Panel: All buttons – in, except Elec pump
Fuel Panel: Unknown (pushbutton does not change position when pushed, so the current state of the switch could not be determined)
Electrical Panel: Unknown (pushbutton does not change position when pushed, so the current state of the switch could not be determined)
Air Conditioning: Pack flow- norm, Heat knobs (Left to Right) -10 o’clock, 11 o’clock, 11 o’clock, All buttons - in except APU bleed, Xbleed - Auto
Anti-ice: Wing button - out, engines and probe/window heat - unknown (pushbutton does not change position when pushed, so the current state of the switch could not be determined)
Cabin Press: Ldg elev - auto, cabin mode sel and ditching - unknown (pushbutton does not change position when pushed, so the current state of the switch could not be determined)
Lights: Strobe - auto, beacon - on, wing - on, Nav & Logo - on, runway turnoff - off, land - on, nose - off
APU: Master Switch - in, start - unknown (pushbutton does not change position when pushed, so the current state of the switch could not be determined)
Internal lights: overhead integral - full bright, icing & Stby compass - off, dome - off, annunciator - bright
Seatbelt: off, no smoking - on
Emerg exit: arm
#3 ACP: com 1 and PA buttons out
Flt Ctl panel above F/O: All in
Cargo heat: All in, temp @ 4’oclock position
Cargo smoke: unknown
Ventilation: all in
Eng man start: both out
All O2 masks stowed, Capt & F/O rudder pedals full left
Maintenance panel appears normal
F/O sliding window outer pane cracked

Circuit Breakers popped:
#1 & #2 HP FUEL SOV (2 breakers),
#1 & #2 ignition (1 breaker),
FADEC A EIU #2,
SEC #1 norm supply,
ELAC #1 norm supply,
slat/flap 1 position indicator,
LGCIU #1,
DMC #3 stby supply,
DMC #1 supply,
FWC #1 supply,
SDAC 26 vac sync #2 ac essential bus,
SDAC #1 supply,

CIDS director ess #1,
CIDS director ess #2,
MMR #1,
VOR #1,
F/O Flood,
GEN #1 off,
BTC #1 supply,
eng 1 FADEC B& EIU #1,
ECB supply

## 1.3 Electrical System Description

Two Integrated Drive Generators (IDG), one mounted on each engine, normally supply the aircraft electrical power in flight. These IDG's supply electrical power which is then distributed throughout the aircraft by electrical busses. An IDG will only supply electrical power when the engine core speed (N2) is high enough for the generator to work properly. The IDG is disconnected if N2 is lower than 54%.

The auxiliary power unit (APU) drives a third (auxiliary) generator (APU GEN), which can replace the electrical power normally supplied by either main generator (GEN 1 or GEN 2). Each of these 3 generators can supply the AC BUS 1, AC ESS BUS and AC BUS 2. An electrical schematic is attached as figure 4.

The ram air turbine (RAT) is in a compartment in the left belly fairing, forward of the main landing-gear compartment. It extends automatically when there is a total failure of AC busbars 1XP and 2XP. The crew can operate it from the flight compartment if necessary. The RAT supplies hydraulic power to the Blue hydraulic system. If there is an electrical failure, the RAT also supplies the controlled speed motor generator (CSM/G) which gives electrical power to the aircraft.

The RAT actuator allows for the deployment and retraction of the RAT. For the RAT retraction, the RAT actuator is hydraulically supplied. During the retraction sequence, a spring is compressed, and the RAT moves from the fully deployed position to the completely retracted (locked) position. The RAT retraction is initiated from the RAT stow panel located on the fuselage (there is no way to stow the RAT from the cockpit).

For the RAT extension, or if for any reason the retraction sequence is aborted, the RAT is designed to deploy to its fully extended (locked) position. The extension power is provided by the spring force. The RAT is designed such that it is never supposed to be in an intermediate position except during RAT travel from one position to the other.

The deployment is triggered by 2 separate solenoids supplied by the manual deployment pushbuttons in the cockpit or by the automatic deployment logic. The RAT automatic deployment logic is designed so that the RAT will automatically deploy if all of the aircraft's AC power (from AC Bus 1 and AC Bus 2) is lost when the aircraft speed is higher than 100 kt. In that condition, the batteries provide the electrical power to supply the deploy solenoid of the RAT actuator. The solenoid then unlocks the actuator, and the RAT deploys as a result of the spring force.

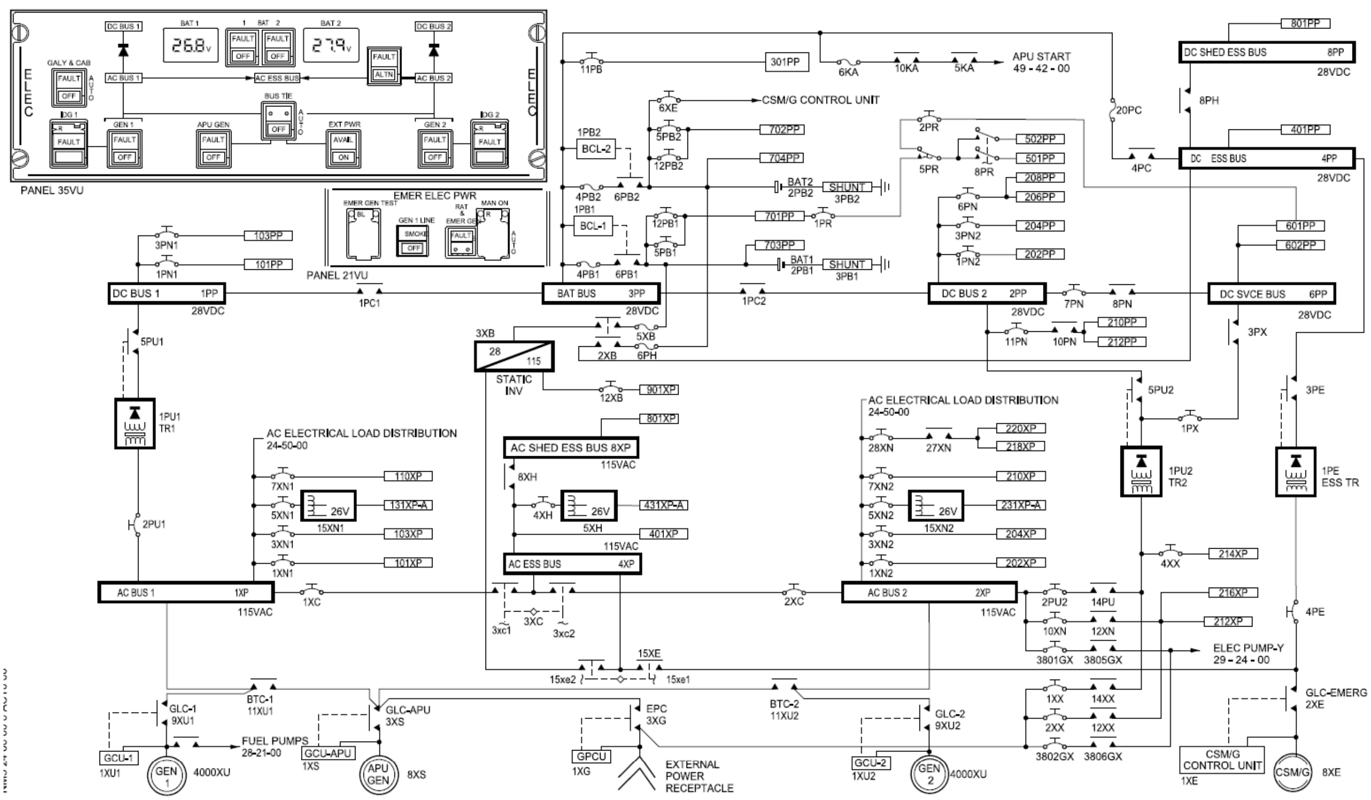


Figure 4

Electrical Power Distribution Schematic

## 1.4 Hydraulic System Description

The aircraft has three main hydraulic systems. They are identified as the Green, Blue and Yellow systems. Together they supply hydraulic power at 3000 psi (206 bar) to the main power users. These include the flight controls, landing gear, cargo doors, brakes and thrust reversers. Services which are not used during flight (cargo doors, brakes, landing gear and nosewheel steering) are isolated from the main supply.

The three systems are not hydraulically connected. Where possible they are kept apart to minimize the effect of an engine or tire burst, or other damage. There are no hydraulic lines in the passenger cabin or flight compartment.

The three systems are each pressurized by one main pump (see figure 5). The Green system pump is connected to the left engine and the Yellow system pump is connected to the right engine. The Green and Yellow pumps supply hydraulic power when their engine operates. The electric pump of the Blue system starts automatically when any one of the engines is operating. The three system main pumps are usually set to operate permanently. If necessary (because of a system fault, or for servicing), the pumps can be set to off from the flight compartment.

Most of the components of the systems are in the three hydraulic compartments. The Green system components are in the main landing gear compartment. The Yellow system components are in the hydraulic compartment in the right belly fairing. The Blue system components are in the hydraulic compartment in the left belly fairing. The two hydraulic compartments (Blue and Yellow) are forward of the main landing-gear compartment.

The power transfer unit (PTU) of the Green/Yellow system is in the main landing gear compartment. It can operate in two directions, Green to Yellow, or Yellow to Green. There is no hydraulic fluid transferred between the two hydraulic systems during PTU operation, and it is used to pressurize one system from another if required. The PTU operates automatically when there is a difference in pressure between the two systems of 500 psi (35 bar). The PTU is permanently available, but can be set to off from the flight compartment if necessary. There is a quick-release self-sealing coupling which isolates the PTU to stop one system pressurizing the other during servicing.

The Yellow electric pump is in the Yellow hydraulic compartment. It supplies the Yellow main system with hydraulic power when necessary (failure of the engine or engine pump). It is set to on from the flight compartment. It also starts when the aircraft is on the ground and a selection is made to operate the cargo doors. The hand pump of the Yellow system is on the Yellow ground service panel. It is used to operate the cargo doors if no electric power is available.

The engine driven hydraulic pumps are driven by the engine core (N2). These pumps are able to supply hydraulic pressure as long as the engine is running, even if N2 is lower than 54%. As a general rule, the lower the N2 is, the lower the hydraulic flow that can be delivered by the engine driven hydraulic pumps.

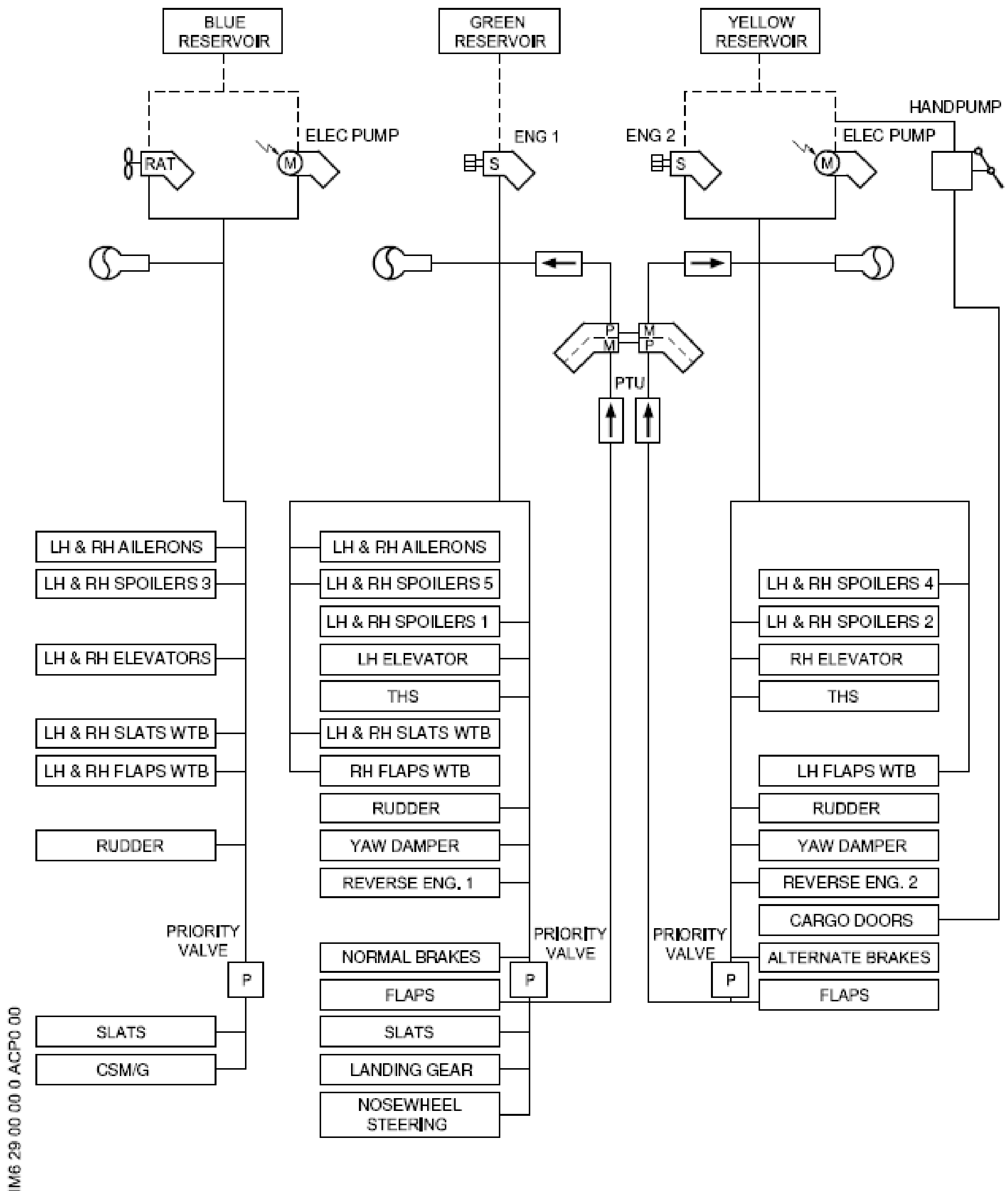


Figure 5
Hydraulic System Schematic

Scott Warren
Lead Aerospace Engineer