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Fly by Wire Technology

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ABSTRACT-

The fly by wire technology shows the execution and evolution of airplane flight control systems. It also describes the development of airplane flight control systems and gives a survey of the principal phases of the flight control systems that assure the finding and execution of the fly-by wire system.The development of flight control systems, from human control with mechanical links to a wire-driven computer, is a remarkable representation of the development of aeronautical technologies.The fly-by-wire system constitutes a fast-forwarding in aircraft design, from mechanical linkage to large hydraulic actuators to computer-assisted fly-by-wire system.The use of the fly-by-wire system has generated huge satisfaction for the aircraft industry by lessening the weight of the flight control system, by creating multiple redundancy flight control systems, which increases the flight safety of all aircraft equipped with the fly-by-wire system. The passage from analog to digital is another fast-forwarding in the development of fly-by-wire systems.This system is built to very stringent dependability requirements both in terms of safety.

Keywords-Fly by wire, manoeuvres, fly by light.

INTRODUCTION

At the early stage of aviation, aircraft utilized cables and pulleys for controls also known as mechanical linkage. This cables and pulleys act as pull and push system to move the flight control's surfaces at the expense of the pilot's effort. By using the cables and pulleys, every forces act on the flight control surfaces are being transmitted to the cockpit control and felt directly by the pilots which they have to counter these forces using their own strength without any assistance. Early aircraft were lightweight and the aircraft can only fly at a slower speed thus aerodynamic force is not strong making it possible to manoeuvres the aircraft.

With new emerging technology and war at that time, air superiority has become an advantage. Aircraft needs to fly faster, carry more payload and strong. This is when hydraulic systems plays an important role in aircraft control system. By using hydraulic systems, aircraft can fly faster due to the pilot does not have to put extra effort to move the control surfaces with increasing aerodynamic forces.Hydro-mechanical control system is a system which mechanical linkages are connected to the hydraulic system. This system utilized cables, pulleys, and gears at the cockpit control and hydraulic system consist of pipes, reservoir, valves and pumps at the control surfaces. With hydro-mechanical system, the aerodynamic forces acting on the control surfaces are not felt by the pilots making it easy to controls.

II. TECHNOLOGY

POWERED FLIGHT CONTROLS:

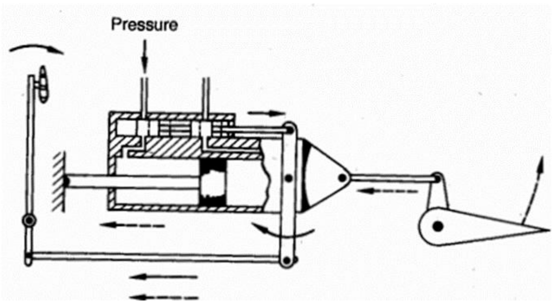

Fig 1: Powered Fight Control System

Figure shows the Powered flight controls are employed in high-performance aircraft, and are generally of two main types (a) power-assisted and (b) power-operated. The choice of either system for a particular type of aircraft is governed by the forces required to overcome the aerodynamic loads acting on the flight control surfaces. In basic form, however, bothsystems are similar in that a hydraulically-operated servo-control unit, consisting of a control valve and an actuating jack, is connected between the pilot's controls and relevant control surfaces. The major difference, apart from constructional features, is in the method 9f connecting actuating jacks to control surfaces. In a power-assisted system, the pilot's control is connected to the control surface, e.g. control column to elevators, via a control lever. When the pilot moves the control column to initiate a climb say, the control lever pivots about point 'X', and accordingly commences moving the elevators up.

At the same time, the control valve pistons are displaced and this allows oil from the hydraulic system to flow to the left-hand side of the actuating jack piston, the rod of which is secured to the aircraft's structure. The reaction of the pressure exerted on the piston causes the whole servo-unit, and control lever, to move to the left, and because of the greater control effort.

Trends in Fly By Wire Technology:

The F-8 Digital Fly-by-Wire (DFBW) flight test program intended to provide the technology for advanced control systems, giving aircraft enhanced performance and operational capability is addressed. A detailed analysis of the experimental system was performed to estimated the probabilities of two significant safety critical events: loss of primary flight control function, causing reversion to the analog bypass system, and loss of the aircraft due to failure of the electronic flight control system.The analysis covers appraisal of risks due to random equipment failure, generic faults in design of the system or its software, and induced failure due to external events. A unique diagrammatic technique was developed which details the combinatorial reliability equations for the entire system, promotes understanding of system failure characteristics, and identifies the most likely failure modes. The technique provides a systematic method of applying basic probability equations and is augmented by a computer program written in a modular fashion that duplicates the structure of these equations.

The experience gained in digital fly-by-wire technology through a flight test program being conducted by the NASA Dryden Flight Research Center in an F-8C aircraft is described. The system requirements are outlined, along with the requirements for flight qualification. The system is described, including the hardware components, the aircraft installation, and the system operation. The flight qualification experience is emphasized. The qualification process included the theoretical validation of the basic design, laboratory testing of the hardware and software elements, systems level testing, and flight testing.

Automatic Landing System:

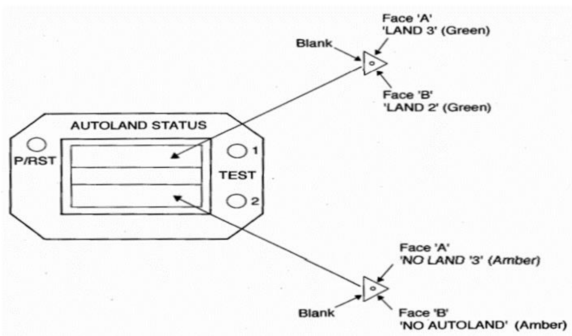

Fig 2 : Automatic Landing System

Figure above shows the profile of an automatic approach, flare and landing sequence is based on a system that utilizes triple digital flight control computer channels, allowing for redundancy to operate in the fail operational and fail passive conditions already defined. Depending upon the number of channels that are armed and engaged, the system performs what are termed a 'LAND 2' status or 'LAND 3' status autoland. Thus, 'LAND 2' signifies there is dual redundancy of engaged flight control computers, sensors and servos (fail passive operation) while 'LAND 3' signifies there is a full dual redundancy of engaged flight control computers, sensors and servos (fail passive operation) while 'LAND 3' signifies triple redundancy of power sources, engaged flight control computers, sensors and servos fail operational. The indicator is of the dual prismatic display type; the upper display indicates the actual autoland capability of the AFCS, while the lower display indicates the degradation from 'LAND 3' capability. Each triangular shaped prism is actuated by electro-magnetic coils so that the faces of the prisms display the relevant status information as shown. Two test switches are provided; number l rotates this upper and lower display faces 'A' into view and number 2 switch rotates the 'B' faces into view. A reset switch (P/RST) can be used to clear the lower display.

Pitch and Roll Control System:

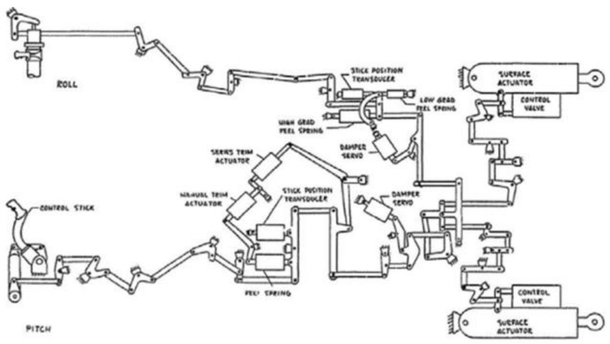

Fig 3 : Pitch and Roll Control System

Figure shows fly-by-wire system is a computer driven system that reads the pilot control inputs, various parameters such as the airspeed, the altitude and the angle-of-attack and orders the displacements of flight control surfaces such that the airplane remains within its designated flight envelope. The flight control computer evaluates electrical signals via pilot control and sensor input and sends electrical signals to actuate the adequate control surface such that to obtain the desired airplane orientation. The flight control computer evaluates electrical signals via pilot control and sensor input and sends electrical signals to actuate the adequate control surface such that to obtain the desired airplane orientation.

The introduction of FBW to an aircraft could simply provide a computer link between the pilot's controls and the control surfaces; in other words, a movement of the pilot's controls would cause a corresponding and proportionate movement of the control surfaces. Such a level of development would provide the weight savings promised by FBW but would do little to improve the handling of the aircraft, and would not advance the technology very far towards allowing aircraft with relaxed stability to be flown. Such an FBW system is often called an 'Active Control' system because the control system itself is more than a passive conveyor of instructions.

C* Control Algorithm:

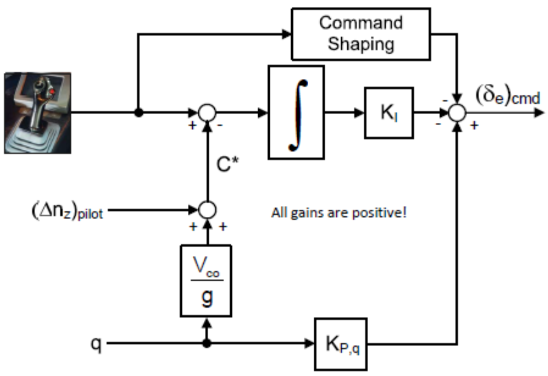

Figure 4 : C* Control Algorithm

Figure above shows the the linear combination of pitch rate and vertical load factor signals. C = (Dnz)pilot +Vcog q. where (Dnz)pilot is the vertical load factor at the pilot’s location, q is the pitch rate , Vco is the so called "crossover" airspeed and g being the gravity constant. The "crossover" airspeed is the airspeed at which the signals Vco g q and (Dnz)pilot are equally weighted (Vco 240kt). The criterion asserts that pilots use the pitch rate in the low speed regime and the vertical load factor in the high speed regime as main control cues. The airplane’s handling qualities are satisfactory when the C quantity falls within certain boundaries.

III. LITERATURE SURVEY

Ake Norberg et al.[1] discussed relevant to the study of monocopter stability is the stability of maple seeds in autorotation. His qualitative directional stability analysis was expanded into a quantitative analysis for monocopters.

McCutchen et al.[2] discussed a qualitative description of monocopter stability, and a brief description of how control of the vehicle could be effected using an under-slung fuselage. McCutchen makes the leap to say that future technology could make free-flying controlled monocopters possible.

IV. ADVANTAGES

- Reduced weight,Improved reliability, damage tolerance.
- The protection software included in Flight-Envelope automatically prevent any unsafe actions of pilots and help them to stabilize the airplane.
- FBW ensures suppression of air disturbance and as a consequence reduces the fatigue loads and increases the comfort of passengers.
- FBW ensures an optimized trim setting and as a consequence, drag reduction.
- FBW ensures an easier interfacing to other automatic flight control systems and to autopilot.

V.APPLICATIONS

- FBW in the general sense of computer-configured controls, where a computer system is interposed between the operator and the final control actuators or surfaces. This modifies the manual inputs of the pilot in accordance with control parameters.

- The fly-by-wire computers act to stabilise the aircraft and adjust the flying characteristics without the pilot's involvement.

VI. RESULT DISCUSSION

On a typical aeroplane, a set of mechanical parts acts as a conduit for the pilot's commands to reach the actuators. Additionally, computers are altering how the pilot perceives the controls, and computers used for autopilot are capable of commanding the servo actuators that move the entire mechanical control chain.All of the Airbus A320, A330, and A340 flight control surfaces are electrically and hydraulically operated. The aircraft is controlled using the side-sticks in pitch, roll, and (indirectly) yaw through turn coordination. The flight control systems translate the pilot inputs into surface movements that result in the required alteration of the flight path. The flight control computers receive commands from the autopilot computers when in autopilot mode. In this regard, the autopilot consists of two computers, whereas the flying controls consist of five to seven.

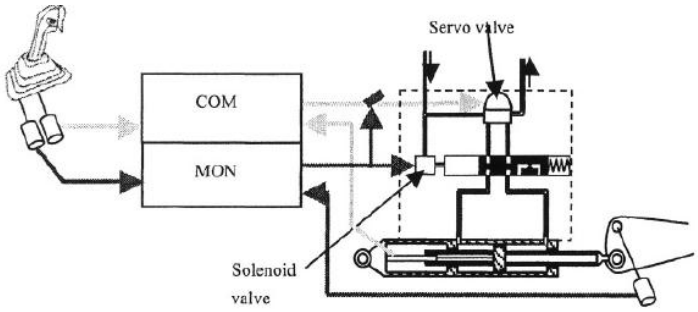

Fig 5 : Computer monitoring architecture

Fig 6 :Air bus A320 using fly by wire

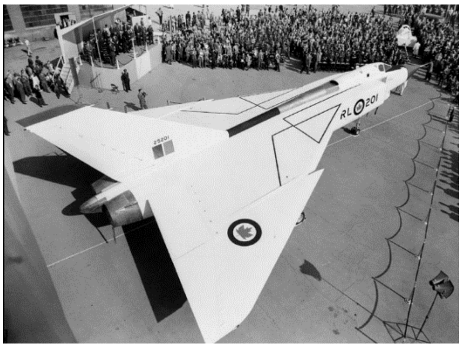

Fig 7 : First aircraft flown by fly by wire

Fig 8 :NASA F8 Crusader by fly by wire

VI. CONCLUSION

Using of fly-by-wire flight control systems has created huge benefits for the aerospace industry, reducing the weight of the flight control system, creating multi-redundant flight control systems which ultimately increases the flight safety for all airplane equipped with flyby-wire systems. The leap from analogue fly-by-wire to digital fly-by-wire is another great step forward in the evolution process of fly-by-wire systems. The present generation airplane is equipped with FBW systems, but in future the new design will migrate to the fly-by-light system for airplane control system.

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