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Redundancy and Reliability 2.7 - Airbus A380 by Ken Hendricks

Redundancy (engineering) – Having multiple components that can perform the same function, in case of a failure the system will be able to run without compromise of ability. This increases reliability as it provides a backup or "Plan B". Simple examples of redundancy can be seen in the human body which consists of two lungs where the body only needs one to survive. This is done to provide safety and caution in case one is faulty and doesn't work to its full capacity. Redundancy in technological systems is for the system to function unhindered in the event of a subsystem not working. This is done by having 2 or more subsystems that can perform the same job. This way redundancy increases the reliability of the system as it is less likely to fail.

When the system is designed, engineers decide how much redundancy to equip the system with, in events of subsystem failures. They must take into account the amount of reliability needed and the importance of the job being carried out- e.g. are people's lives at risk. They must find a balance to increase reliability by adding redundancy to the system but also keeping in mind production costs.

There are different forms of redundancy. The most common are DMR (double-mode redundancy) and TMR (Triple-mode redundancy). One provides 2 alternative pathways for a function while the other provides 3 respectively. This grants the system a high reliability, hence in case of a problem the system will carry on as before without being affected.

Reliability (engineering) - Reliability is the measure of how well a system can perform in different conditions and environments it faces. The system must fit its purpose and carry out the job in normal or even unexpected circumstances. Reliability in technological systems is achieved by using quality materials to design a product that are less likely to fail. It also means designing the product to use these materials in a reliable and efficient way that fits the purpose of the system.

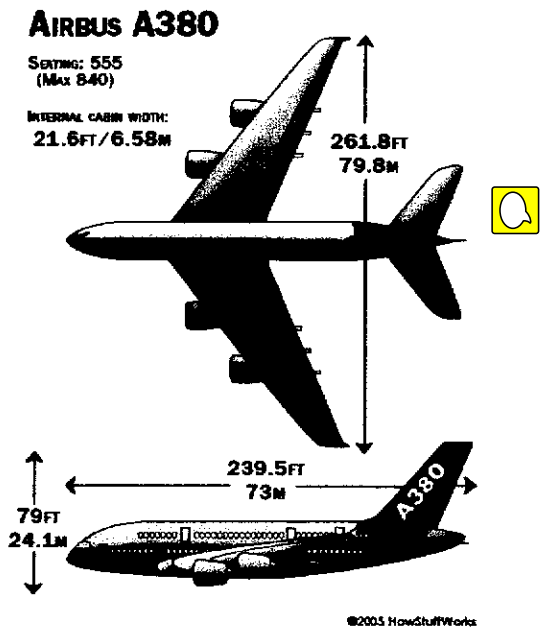
Commercial Aircrafts - Airbus A380

My project will focus on the redundancy and reliability of Avionics in the Airbus A380-800 jet. Commercial Air Transport is massive mode of transportation that connects the world in a matter of hours. People from all over the globe use air transport, to explore over the new horizons or return home. Companies like the ICAO (International Civil Aviation Organisation), other aviation governing bodies, manufacturers like Boeing or Airbus rely on aircrafts being safe, efficient and reliable in order to carry passengers thousands of feet in the air for thousands of miles. This project discusses the reliability and redundancy of passenger aircraft. Navigational, radar and electronic systems on a plane are nearly as important as wings. These key instruments are vital for a safe flight.

ABS

The Airbus 380 is the largest commercial passenger jet on the planet. It is able to carry 525 passengers in a 3 class configuration (first class, business and economy) and 853 in all economy class configurations for 15,700 kilometres at a cruising speed of Mach 0.85. The Airbus 380 uses state of the art technology while in flight.

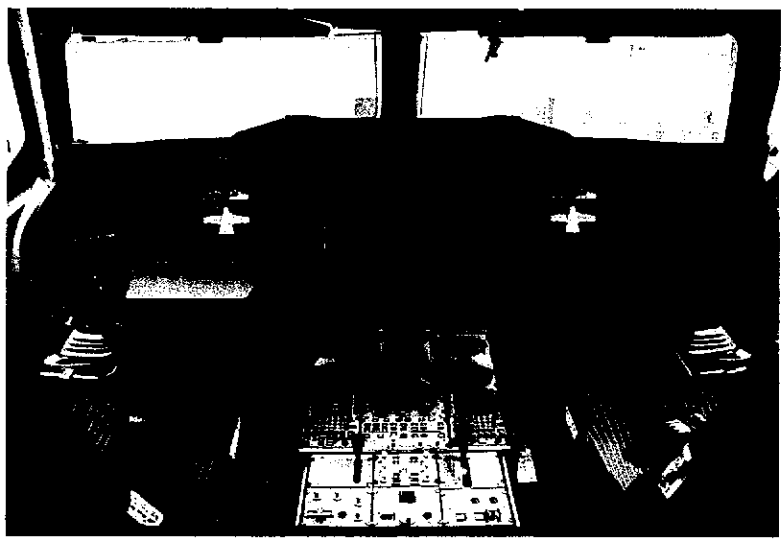
Importance of Redundancy and Reliability in an Airbus A380-800



This massive jet flies passengers all over the world, covering enormous distances non-stop. The aircraft is used by many airlines (262 orders in total) and is to withstand extreme weather conditions, and is tested for 47,500 life cycles of an airplane and has to do all of it with maintaining a perfect safety record. Aircraft safety is extremely important; there are no room for errors to occur or systems to fail thousands of feet high. Past air crashes have shown that very few passengers survive these disasters. A single fault can kill over 520 people at once. Reliability and redundancy of systems and components in an aircraft need very high. An aircraft contains many dangerous parts that could lead to disaster and fatalities, including highly flammable fuel being used to drive 4 Rolls-Royce Trent 900 or Engine Alliance GP7000 engines. For passengers and cabin-crew to be safe while flying, backup systems are put in place in case of any failure.

Airbus A380 Electric Power Systems Reliability and Redundancy

Electric Power for systems –

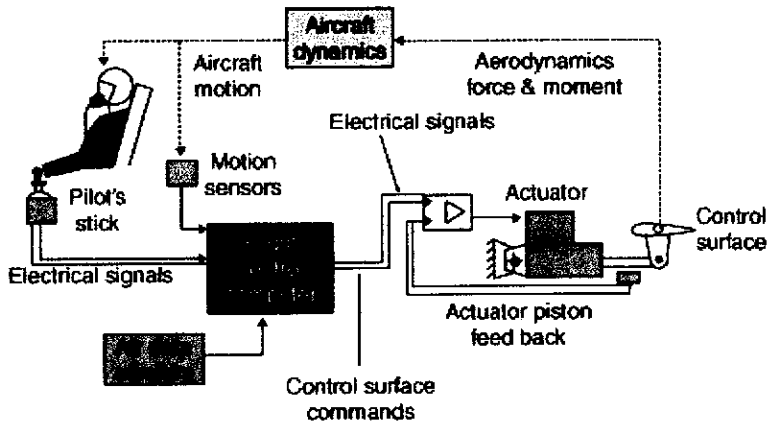


The A380 Avionics is high quality computer systems that help the pilot fly the aircraft. Electrical power is vital as most of the planes systems use it for navigation, communications and most importantly its avionics to keep the aircraft in the skies. With the modern use of computers to work the actuators, flaps, and hydraulic components, like Fly-by-wire etc, electrical power is even more important to run systems and computers. The aircraft must have multiple sources of power in case there is a failure. The primary source of power in the A380 is Generating Systems powered by the turbine engine, these generators store power in batteries for use in powering the computer systems. If engines were to blow out or a generator stopped working there needs to be another power source. The secondary

power source is called the Auxiliary Power Unit (APU) a fuel-burning turbine engine, these acts as a back up to any shortage in electrical power. APU's are normally used to start engines or to run cabin electronics or hydraulic equipment when the engines aren't running. But can also be used as backup power when hydraulic or engine generators fail, providing power to electrical instruments. The third source of power to provide the computers is the RAT (Ram Air Turbine). RAT is only used in a extremely serious emergency when no electrical power is generated by the engine generators or APU. The RAT is a small turbine hidden into the fuselage, wing or in the lower part of the engine in the A380. It is deployed manually or automatically when complete loss of power is detected. The RAT generates power by the airstream produced by the speed of the aircraft. The Airbus A380 has 2 RATs, each 1.63cm wide, that are connected to an electric generator or hydraulic pump. The A380 can control all hydraulic and electronic systems through the APU and RAT. This is the only commercial jet that can do so. This is an example of Triple-mode Redundancy and makes the aircraft electrical power systems very reliable because of them being unlikely to fail and if so have multiple backup options.

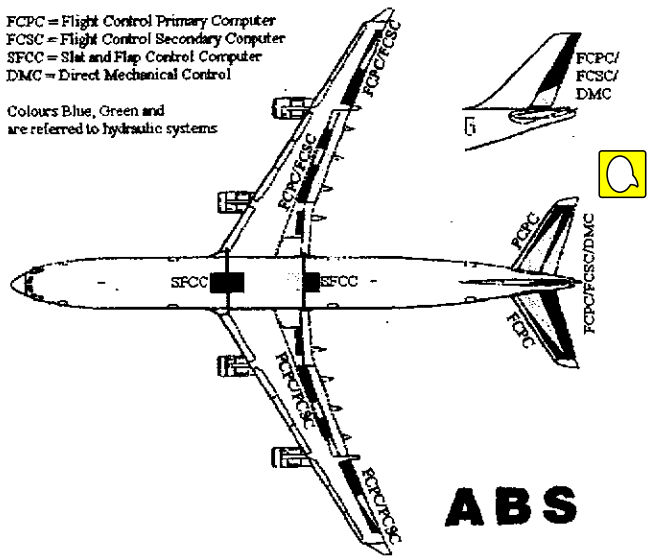
Fly-by-Wire technology Redundancy and reliability –

The A380 uses mostly electronic instruments and wiring to control the aircraft. Manual controls like hydraulic/pressure systems are now being made redundant on aircrafts and even new cars. This is due to their large weight and because of their higher chance of error compared to electronic systems. These new systems are called Fly-by-wire, where movement of flight controls are converted to electronic signals used to move the actuators. This new technology has been installed to backup primary hydraulic actuators in an event of failure. Fly-by-wire also automatically reacts to stabilize the aircraft when in need. The Airbus A380 is the first commercial jet that fully uses this technology, as it is much quicker in responding to commands and doesn't put physical strain on pilots like manual controls do in events of failure of systems. The A380 uses a Integrated Modular Avionics (IMA) architecture system, first used in jet fighters like the F-22 Raptor, as it provides quicker responses to the actuators and more precision flight ideal for air-air combat.



How Fly-By-Wire Works?

Fly-by-wire works like a simple Analog to Digital conversion. When a controls or sidesticks in the aircraft cockpit is moved an analog signal is sent to a computer via multiple channels (wires) to ensure that the signal reaches the computer. The A380 uses a triplex system (3 channels used). Once the computer receives the signal, it is then processed through multiple calculations to find the average signal type



of the 3 channels. The computer then converts these 3 signals to digital signals and adds one more channel. Now a quadruplex channel is sent to the actuators to control thrust, aileron and avionics. A signal is also sent back through the computer to the display screens of the cockpit to indicate to the pilots the position of each actuator.

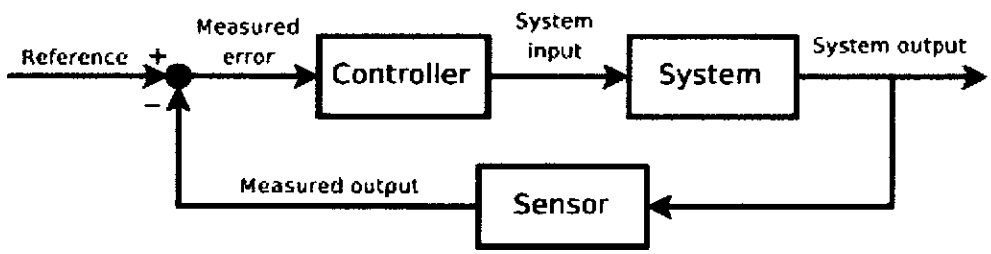
Automatic Stability Control

The use of fly-by-wire systems in the A380 also enables the aircraft to perform tasks itself without input from the pilots. Auto Stability controls work by sensors being installed on the aircraft to sense movement changes in pitch, roll and yaw. These sensors send signals to the computer, which then initiates automatic movement of actuators to counter the movement and thus stabilizing the aircraft.

This system increases the reliability and redundancy of flying and safety overall. There are multiple computers in the A380 that all send signals to manage the fly-by-wire system. In case any computer is damaged, crashed or facing technical difficulties, it is automatically overruled by the other computers. This provides much more redundancy and reliability as if there is any failure in a computer it is either re-booted or kicked from the decision making process. This also reduces human error as humans aren't involved in making this decision, as a result it will always be precise and accurate, making the aircraft safer to fly. The A380 prevents loss of signals by sending/receiving multiple signals to the computer or actuators. FBW systems can automatically respond to changes in aerodynamic conditions by changing the positions of the surfaces of the plane.

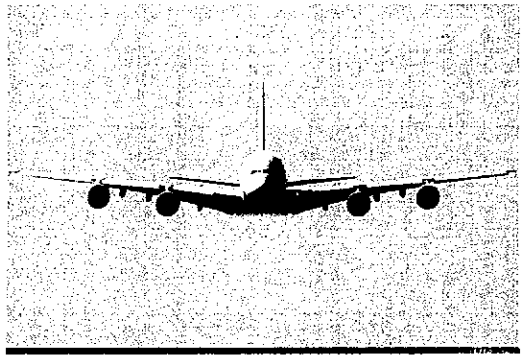
FBW systems increase reliability as they require less maintenance compared to mechanical and hydraulic systems that require frequent maintenance. This increases reliability because the aircraft doesn't need to be checked for damages or faults that frequently as they are less likely to happen. This makes the plane safer and more reliable.

FBW also decreases the overall weight of the aircraft as there are less mechanical components/subsystems to fly the aircraft and is instead controlled by much lighter computers. This decrease in weight means there is less stress on the aircraft frame as the natural stability is increased. Stability surfaces like tail fin and tail wings can be made smaller to stabilize the plane, thus furthermore decreasing weight. The removal of mechanical mechanisms makes the plane safer and more reliable as computers have fewer problems than mechanical systems. Decreasing the weight also reduces fuel consumption and increases economy.

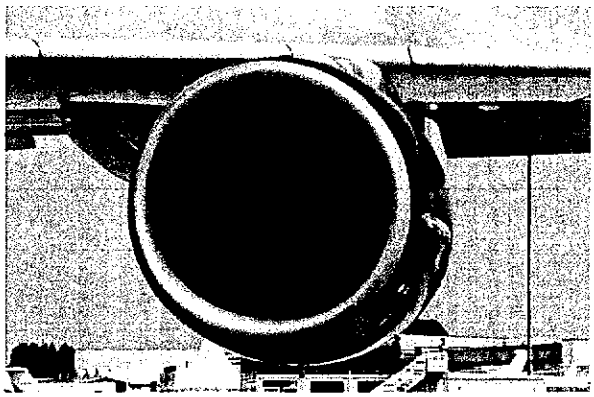


Airbus A380 Engines Reliability and Redundancy

The Airbus A380 is equipped with four Turbofan engines, two on each wing. The engines are an extremely important subsystem for the aircraft as they provide all the thrust power needed for it to fly. The A380 is available with two types of engines, the Rolls-Royce Trent 900 or the Engine Alliance GP7000.



The Rolls-Royce Trent 900 outputs a maximum power output of 70,000-80,000 lbf each (310-360kN of thrust), while the Engine Alliance GP7000 outputs a maximum of 81, 500 lbf each (363kN of thrust). Both engines are well suited for the use in the A380. The engines are a component that must show good reliability and redundancy as this is an extremely important aspect of the aircraft. Failure of engines could lead to fatal crashes and the loss of lives and the aircraft.



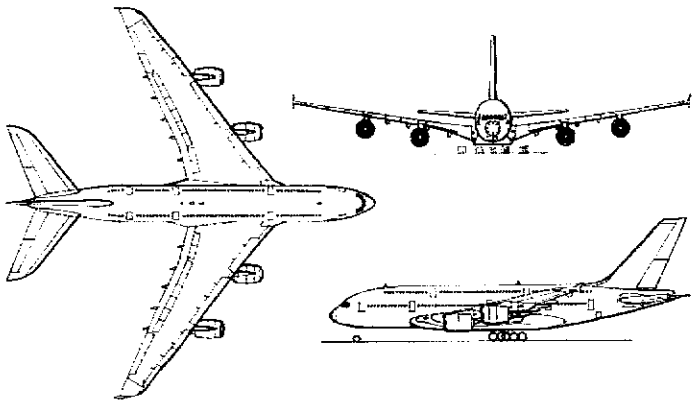
Rolls-Royce Trent 900

Redundancy- In case of all four engine failures, which is unlikely to ever happen but should still be taken into account, the aircraft can fly over 150 miles from a normal cruise altitude of 36,000 ft. If 3 engines were to fail, the aircraft would become a long-range glider and could glide for about 400 miles approximately, depending on atmospheric conditions and weather. If two engines were to fail the A380 would be able to cruise for much longer and most likely reach its destination. With one engine failure, the A380 would carry on flying with no disruption only less thrust power. This means that the redundancy of each engine is high because the A380 can fly without all four engines, making it extremely safe.

Reliability- Engine reliability is very high in the A380 as it uses top quality materials for each engine to lower the risk of failures to an almost minuscule value. The engines are made using titanium blades and feature internal cooling systems for them to run smoothly. The engines also have thrust reversers on the two inboard engines to increase braking power. The two outboard engines do not have thrust reversers due to the debris picked up during landing. These thrust reversers are electrically controlled making them more reliable than their hydraulic equivalents and also save weight. The engines of an A380 are extremely

reliable and exceed requirements needed for normal flying. They can cope with many engine failures and also have a very long life span. The engines can also be changed easily if damaged, not effecting the plane in anyway.

The engines increase the reliability and redundancy of the A380 making it a safer commercial airliner to travel on.



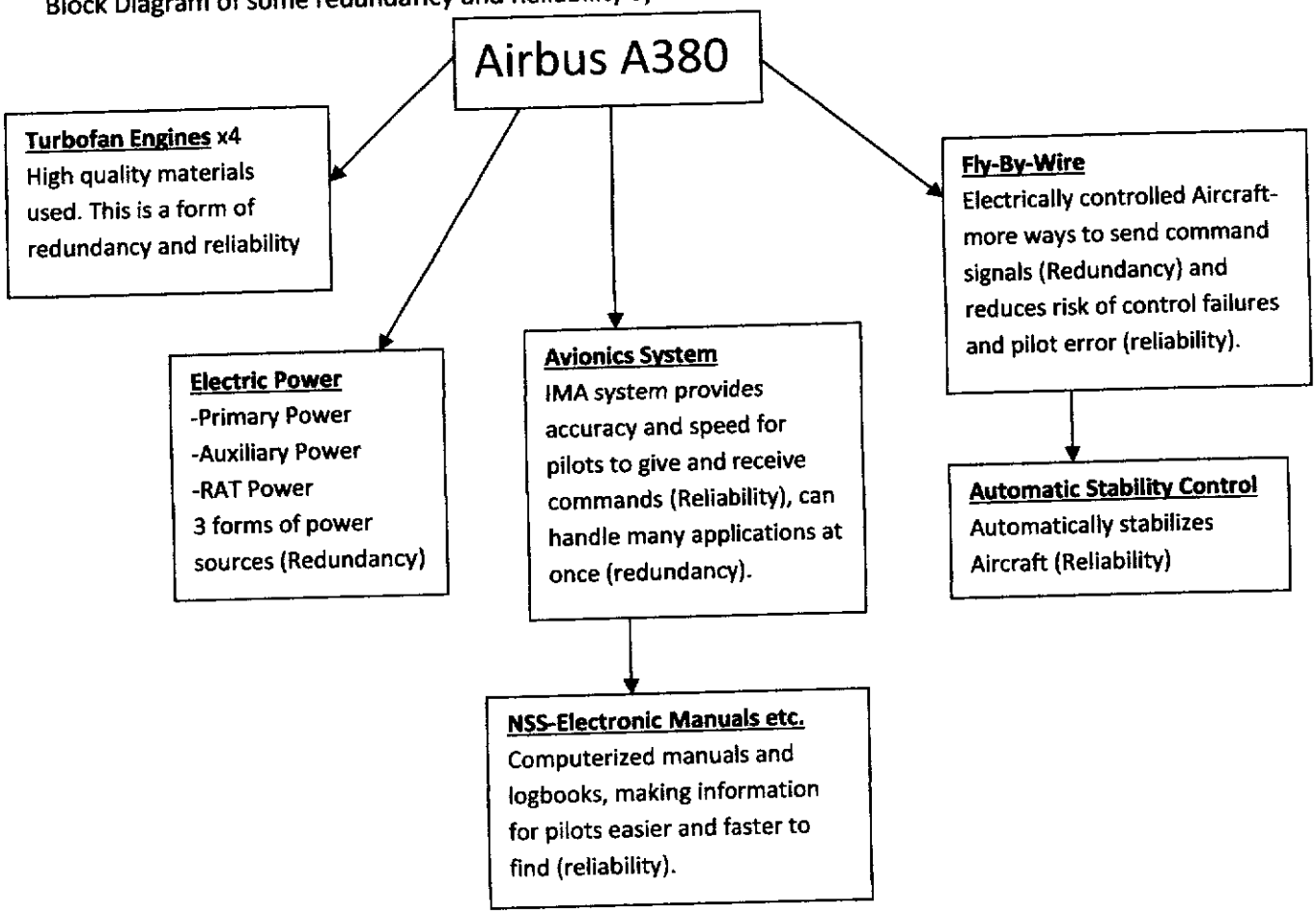
Airbus A380 Avionics and Instruments

The A380 is a top of the line aircraft that must have the best quality materials and technology to ensure safe and efficient flight. Avionics of an aircraft include communication, navigation, display panels and many more electrical systems used to run different tasks on board. The avionics of an aircraft are extremely important as they are responsible for almost all systems to run smoothly. The cockpit of the aircraft is mainly the location of all avionic equipment like control, monitoring, communication, navigation, weather and other equipment.

The A380's avionics management system is Integrated Modular Avionics (IMA) architecture, also used in jet fighters. This system supports different applications at once and provides all the information needed for the pilots. The A380 has 8 LCD displays to show data and information needed by the pilots. They also include QWERTY keyboards and tracking balls to make navigating the system easier. The system also includes Network Systems Server (NSS) to replace all flight manuals and logbooks formally used in a cockpit in case of emergency. This is an electronic library that makes it very easy for pilots to search and find information and help when in need.

This IMA technology used in the A380 increases reliability of the whole aircraft. This system controls the aircraft with high accuracy and speed. It monitors and helps pilots know exactly what is happening in and around the aircraft at all times. This system maintains constant contact with ground control and also identifies itself if a problem is found and then indicates to the pilot. This makes this avionics system very reliable as it makes the airliner safer and easier to fly. This system can do many tasks at once and if encountered with a problem, the system automatically tries to fix it or will work to replace it. This increase redundancy of the aircraft and also makes it very reliable.

Block Diagram of some redundancy and Reliability systems in the Airbus A380



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