Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Level 2 Technology 2024

91360 Demonstrate understanding of redundancy and reliability in technological systems

EXEMPLAR

Merit

TOTAL 05

[redacted]

Demonstrate an understanding of the Redundancy and Reliability in technological systems

This report will discuss the use of reliability and redundancy within the [redacted] aircraft.

[redacted]

Redundancy

Redundancy refers to the addition or inclusion of extra components or systems that duplicate their functions, this includes backups so that the system can continue running if one system does not work or fails. Redundancy is important because it means that if a system fails then if it has redundancy it can still work.

Examples of Redundancy

- Emergency backup generators in a hospital
- Aeroplane engines have more power than needed, so if one fails the other can still fly the plane.
- Alternative lines for water mains so if part of it is cut then the water supply is not disrupted
- Cell towers for our phones overlap to reduce dead spots.

Forms of Redundancy

There are three forms of **redundancy**: **cold, warm, and hot redundancy**.

Cold redundancy is best suited to a system that is not time-critical, **cold redundancy** mostly relies on some form of human intervention like having to change the route of the water because it was ruptured would be an example of **cold redundancy.**

Warm redundancy is best suited to systems where response time is important but temporary outages are fine. An example of warmth would be a backup generator. If the power goes out, it takes a few seconds before kicking in and providing power. This is an example of **warm redundancy** as there is still a small period of outage.

Hot redundancy is when multiple systems are running at the same time so that if one goes down then there is no delay with a backup, suitable for systems that outage could be disastrous. An example of hot **redundancy** is air traffic control radar. There are multiple radar systems so if one is disrupted there is still a radar system. This is an example of **hot redundancy** radar systems running at the same time, and if there was no back up then the aircraft could collide.

Redundancy Systems On [redacted]

The following systems are the systems on the [redacted] that I will discuss,

- Auxiliary Power Unit (APU) which is responsible for power on the aircraft.
- Flight Controls Systems (FCS) which is responsible for controlling the aircraft.
- Engines responsible for proving thrust to move the aircraft

Redundancy Addressed In The [redacted]

Auxiliary Power Unit

The APU is designed to work in some of the most extreme conditions from -40° C to +40° C. This is because it provides electrical and manual power for all of the aircraft's systems. If the APU fails there is redundancy in the power generation system because there is another emergency system called a Ram Air Turbine (RAT) this is a small turbine that drops down under the fuselage to produce emergency power by using the aircraft's airspeed. This power produced is for the essential systems of the aircraft, like flight controls, hydraulic power and interments.

Flight control system

The flight control system (FCS) includes a fly-by-wire (FBW) system. Fly-by-wire has **redundancy** within it, as there are seven different flight computers running parallel to each other. These computers have **redundancy** because they are running hot, meaning that the flight computers are constantly checking each other and if there is any errors from one computer the other 6 will ignore it and take over the computing of the flight. These computers convert the pilots' inputs in the cockpit into electrical signals, which are sent to the various control surfaces, such as the ailerons, elevator, or rudder.

These surfaces then receive the data from the cockpit then depending on the signal received the flight computer will move the aircraft control surfaces needed to perform the action input by the pilot.

FBW because it is all done by computer means that the pilots are not getting fatigued as they are not having to use as much of their physical strength to control the aircraft. FBW also actively monitors the pilot's inputs to make sure that none of the inputs are going to endanger the flight or aircraft.

Engines

The [redacted] is equipped with 4 [redacted] or [redacted] which is a joint venture between [redacted] and [redacted] both engines having similar specifications. [redacted] put their engines through many tests both on the ground and in the air to ensure that they're **reliable**. The ground test aims to simulate flight conditions in a controlled environment. Once it has been tested on the ground [redacted]hen uses a heavily modified [redacted] to test the engines in a real flight environment.

[redacted] tests their engines in many ways before making it available for sale, these tests include altitude testing, weather testing and flight testing. The altitude test involves putting the engine in a chamber which then replicates some of the conditions from flying at sea level or at 40000 feet above sea level. How [redacted] weather tests their engines is they fire 800 gallons (3028.33 litres) of water per minute to make sure that the engines do not lose thrust while flying through heavy rain storms. The final test that [redacted] do is to put the engines on a modified 747 400 to test in real fight conditions. This test is to ensure that what engines will be safe and **reliable** on the aircraft that they will be used on.

Because the [redacted] has 4 engines this means that there is **redundancy**. This **redundancy** is because the [redacted] can in some circumstances fly with as little as one engine and still be able to land safely but it has to land as soon as it can. But if the [redacted] lost 2 engines over the ocean it still will be able to fly to its final destination without many problems.

<u>Maintenance</u>

An ex [redacted] aircraft technician who is a teacher at my college, [redacted] said that any engine on an aircraft had to be able to be replaced in one 8-hour shift. This is because for every hour that an [redacted] is not in the air or scheduled for a flight costs the airline 30,000 dollars. So when designing aircraft the engineers have to make sure that aircraft systems are made up of subsystems that can easily and efficiently be repaired or replaced to minimise the cost to the operating airline.

The FAA (Federal Aviation Administration) mandates many things to do with aircraft maintenance this is both for the safety of the aircraft and passengers as well as the function of the aircraft is **reliable**. One of the things mandated is that when maintenance is done it be done to the manufacturer maintenance manual, meaning that everything is done by the book and no mistakes can be made. The next thing mandated by the FAA is the use of scheduled maintenance ranging from daily pre-flight inspections to complete overhauls of aircraft systems.

The daily inspections are to try to find any damage to the outside of the aircraft. Then every 6 months or 750 operating flight hours, these inspections are perform small maintenance tasks this procedure is called A cheeks.

The next maintenance procedure is every 15 months, this is a more extensive look at various systems and components like the landing gear, engines, control surfaces, flight computers and other important systems for the operation of the aircraft, these implications are called B checks.

Following the B checks is a maintenance procedure that is done every 18000 flight hours for 3 years. This procedure normally takes the aircraft out of service for up to 7 days, this is because this maintenance produce goes extensively through the whole aircraft, including the structure and important systems, this is called the C checks.

The last maintenance procedure before the cycle begins is done every 36,000 or 6 years. This check can take 3 to 6 weeks to complete on the as it involves a complete overhaul of the aircraft. This ranges from replacing the landing gear, and engines and either overhauling or replacing. This is called the D check.
The engineers and the FAA came up with a maintenance schedule to ensure that the aircraft stays safe for everyone by being able to pick up problems early.

Reliability

Reliability in a technological system is the ability of the system components to perform the task they are designed to do in the time needed and under the conditions they are designed to work in.

How Reliability is Addressed In

The engineers when designing the made it **reliable** by using state-of-the-art materials and technology, extensive testing and continued self-checking by the flight computers. The state-of-the-art material used is a thin but really strong composite of aluminium and fibreglass called GLARE. GLARE is derived from Glass reinforced laminate, normally composed of thin layers of aluminium and interspersed with a mix of fibres and glass all being joined together with epoxy.

The GLARE material makes up 16% of the airframe of the this means that the airframe is 30% lighter than what it would be if it were made fully out of aluminium. GLARE has a higher tensile strength than traditional aluminium alloys the tensile h

strength of the aluminium used on the [redacted] is 70 KSI (70000 PSI) and the tensile strength of GLARE is 80 KSI (80000 PSI). this means that GLARE is both lighter and stronger as well as lighter. GLARE is also more tolerant of damage compared to aluminium because when damaged the fiberglass in the GLARE can bridge the gap caused by the damage making sure that the damage does not spread. This made the [redacted] more **reliable** because it means that the A380 requires less maintenance of the fuselage resulting in less downtime and more money for the airline and making the [redacted] more **reliable**.

The reason that the engineers used this GLARE material on the [redacted] is that if traditional aircraft materials were used this would make the aircraft heavy, with more weight come a larger wing span to create enough lift. Another reason the [redacted] needed to be lighter was because then it would use less fuel and be able to fly further. If the wing span was too wide then it would make it hard to maneuver the [redacted] around busy international airports. This meant the engineers had to test different composites of materials. This testing involved launching frozen chickens at take-off speed at the different materials to simulate a bird strike. The chicken went straight through thin alloys, but GLARE rebounded the chicken with minimal damage.

References

Picture of [redacted]
https://www.kdcresource.com/insights-events/airbus-to-cease-production-of-the-a380/

1.https://www.airbus.com/sites/g/files/jlcbta136/files/2021-11/Airbus-Aircraft-AC-A380.pdf

2.https://www.automationit.com/blog/79-cold-warm-and-hot-redundancy-determining-how-much-you-need

3.https://www.pprune.org/tech-log/628319-how-much-does-go-around-a380-cost-airline.html

4. https://www.compositesworld.com/cdn/cms/hpc-0902-a380feature-dalebrosius.pdf

5.https://www.rolls-royce.com/media/our-stories/discover/2020/how-to-test-a-jet-engine-power-of-trent.aspx#:~:text=But%20we%20also%20test%20our,and%20monitor%20how%20it%20behaves.

6. https://www.geaerospace.com/

Merit

Subject: Technology

Standard: 91360

Total score: 05

Q	Grade score	Marker commentary
One	M5	The importance of reliability and redundancy (R&R) is clearly explained using an aircraft as the technological system. Redundancy within at least 2 systems is explained in detail, as are the decisions about why the redundancy was addressed in the development of the technological system. Reliability was also explained but the detail about why it was addressed in the development of the systems was weak. The candidate could have developed the explanation on why reliability was addressed by giving examples and possible scenarios if it wasn't addressed well in the design / development phase of the system.