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AIRFRAME AND SYSTEMS
CHAPTER 1: MODERN AIRCRAFT

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CONTENTS .... PAGE

INTRODUCTION

This chapter is included to update students with information relevant to modern large commercial aircraft design and operation. The system operating experiences gained so far on light training aircraft are quite different to the complex systems managements employed on large modern aircraft.

The content of this chapter is for student background information only and does not form part of the examinable material for this subject.

NEW TECHNOLOGIES

The mid 1980's saw the beginning of computer, digital and "glass cockpit" type technologies being applied in the construction of large multi-engined commercial and military aircraft. This has had a significant impact on the way modern aircraft systems are controlled and operated.

Typically an aircraft of this size, built prior to 1980 would be operated by three crewmembers, the third being a Flight Engineer or third Pilot. This was necessary due to the complexity and high workload required to operate and monitor the many analog type aircraft systems.

In today's modern aircraft, computer and computer assisted control of almost all systems has become the normal method of operation.

AIRFRAME SYSTEMS

Large modern commercial aircraft such as the Boeing 777 and the Airbus 340 employ multiple avionic and mechanically based aircraft systems. Based on the Training Curriculum this Student Guide will cover the systems commonly referred to as "Airframe Systems": they are;

1. Hydraulic Systems,
2. Pneumatic Systems,
3. Fuel Systems,
4. Ice and Rain Protection Systems,
5. Landing Gear and their Associated Systems, and
6. Emergency Systems and Equipment.

The fundamental principles and the components used within the systems listed above have not changed much from older types of aircraft however, a dramatic shift has occurred in the way the systems are managed and monitored. Additionally, new technologies, materials and design have dramatically improved the reliability of the components used.

SYSTEM RELIABILITY

Modern systems are much more reliable than in older aircraft due to improvement in materials and design. Additionally electronic system controls, rather than mechanical or analog, are much smaller and may be duplicated easily allowing multiple control redundancy to be applied.

SYSTEM REDUNDANCY

Most aircraft systems that require continuous monitoring and adjustment during flight such as air-conditioning, pressurization and fuel feed are now computer controlled, typically by two or more independent computers operating as master and standby or simultaneously. This means a much greater capability of the aircraft to dispatch on time and carry one inoperative system controller until rectification can be carried out.

Multiple hydraulic systems can now easily provide triple redundancy for primary flight controls eliminating the previous need for manual reversion or other methods of emergency control.

SYSTEM LOGIC

In older technology aircraft it was up to the crew to ensure that the aircraft and the systems were operated and maintained within the manufacturers limitations. Many of the individual systems had no cross communication and it was left to the crew to determine conflicting or damaging system operation.

Using computers for system control allows the manufacturer to ensure that components are activated or actuated at the times when they should and that they are disabled when operation would damage the system or violate a limitation. An example of this is the disabling of landing gear down if airspeed is greater than the extension limit.

It is important that the crew understand the logic of the system being operated as confusion regarding system serviceability may occur.

INTEGRATED SYSTEM COMMUNICATION ARCHITECTURE

Most modern aircraft now use an integrated central communication bus, typically called the 1553 Bus. This communication bus links all the aircraft systems in some way, either exercising full control or just monitoring positions or parameters.

All the individual system computers can access this common information from the 1553 Bus and ensure that normally disassociated systems do not conflict in operation.

An example of this is in the Airbus logic where the closing of air-conditioning ram air inlets automatically takes place during the takeoff roll to avoid ingestion of foreign objects. The air-conditioning controllers receive inputs of wheel speed and thrust setting.

ABBREVIATIONS AND ACRONYMS

Along with the increase in computer controlled management of systems has come the many and varied names that are used by different aircraft manufacturers to describe the computers or controlling devices. The trend has developed to refer to this equipment by abbreviation or acronym.

It is important that when using these new terms that the operator understands exactly what the term is referring to and the context of the situation. An example of this is the term “ELEV” which means Elevator or Elevation depending on context.

Two of the terms that will be used consistently within this Student Guide are as follows;

- EICAS – Engine Indicating and Crew Alerting System (Boeing)
- ECAM – Electronic Centralized Aircraft Monitoring (Airbus)

These systems present the aircraft's system operation to the crew in the form of electronic screen displays.

For general information a handout of the abbreviations and acronyms used by Boeing and Airbus is available from your Instructor.

HUMAN MACHINE INTERFACE (HMI)

With the change in cockpit configuration on large modern aircraft from three person to two person crews, many of the system control panels, previously located at the Flight Engineer position, have been significantly reduced in size for fitment into the overhead panel and centre console.

The size reduction has been made possible mainly due to the removal of the analog gauges and annunciator lights associated with each system.

SYSTEM PRESENTATIONS IN THE COCKPIT

Older type aircraft typically group individual system controls and indicators on one control panel complete with drawn lines depicting the flow or circuit relationship between switches and gauges. Also included on the panel are individual annunciators or warning lights to alert the operator of malfunctions occurring within the system. Often these warning lights will be repeated on the glareshield panels or a master annunciator panel.

Modern large commercial aircraft have significantly changed this presentation by eliminating almost all of the systems gauges, lights and flow lines from the control panel and presenting the information instead on a screen display or "system synoptic".

SYSTEM SYNOPTICS

The term synoptic is used to describe the system displays available to the crew on screens located on the centre instrument panel. The synoptic is a coloured graphical diagram depicting the system that has been requested. Refer to Figure 1-1 as an example of a hydraulic system synoptic. The diagram will display the system in real time operation including the valves, flows of fluid or electrical connection, and of course malfunctions.

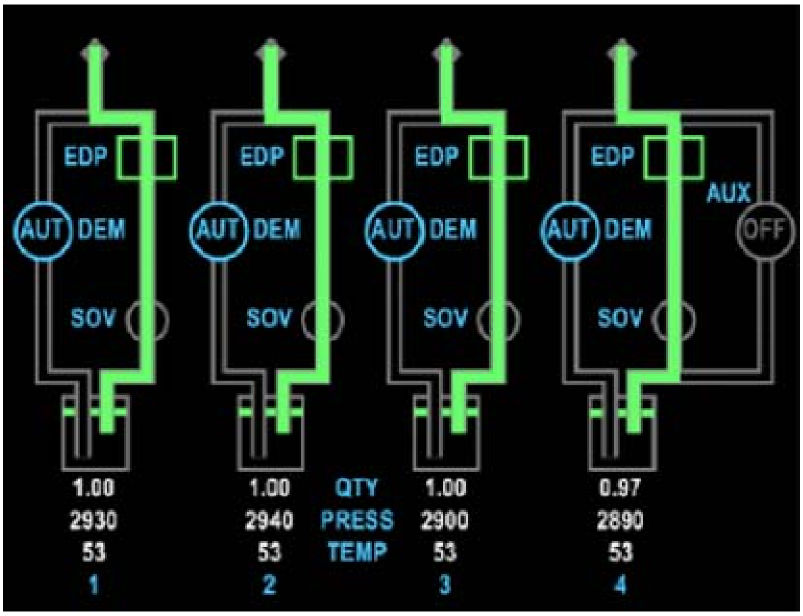

Figure 1-1 System Synoptic

Typically each system synoptic will appear on the screen automatically when the crew select an operation relating to that system, for example, when landing gear is selected, the GEAR synoptic will be shown.

The crew can also select any system synoptic at anytime via a small selection panel. Refer to Figure 1-2. Included on the panel is a selection called STATUS which brings the display back to a summary of all the systems which is the default or normal display for ECAM or EICAS.

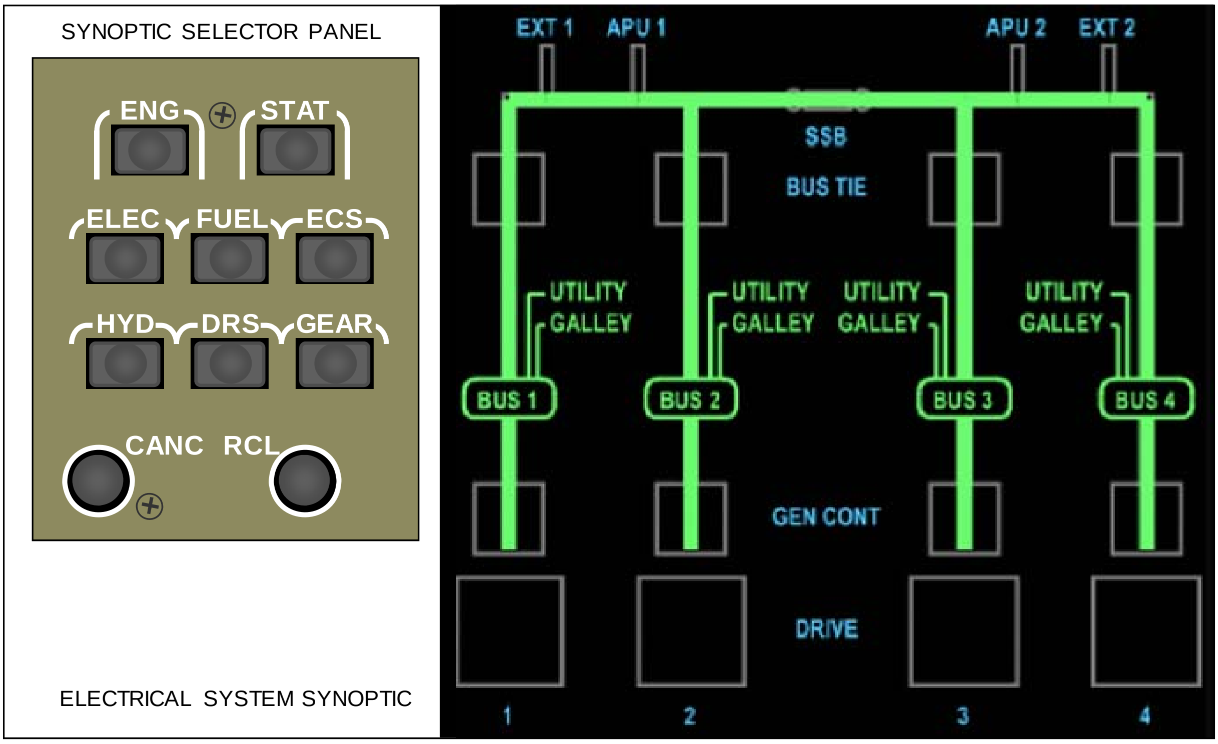

Figure 1-2 Selection of Synoptics

ECAM OR EICAS NORMAL DISPLAYS

The ECAM/EICAS displays information on two CRT or LCD screens which represent the primary and secondary displays. Refer to Figure 1-3. The uppermost screen (primary) details primary engine information and current status of major equipment such as landing gear and flaps. It also is the point where alerts are annunciated to the crew.

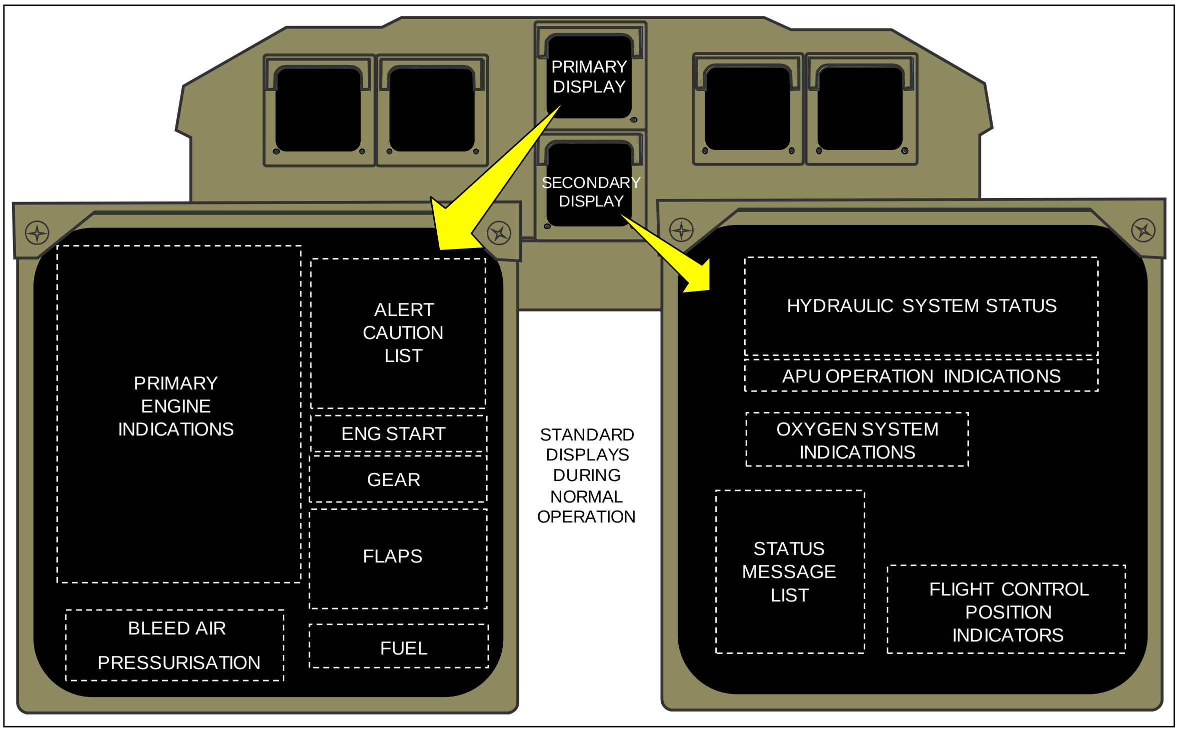

Figure 1-3 Primary and Secondary Displays

This screen always displays this information all of the time. The lower screen has a normal or default display as shown in Figure 1-3 but is able to display the multiple system synoptics as mentioned.

USE OF COLOUR IN DISPLAYS

The use of colour to indicate a degree of importance has been used in aircraft indications for many years and this has been continued in the ECAM/EICAS screen displays. The following table list the common uses of colour in older and more modern aircraft. Refer to Figure 1-4.

OLDER AIRCRAFT			
ANNUNCIATOR LIGHTS	**COLOUR**	**MEANING AND TYPICAL USES**	**OTHER INDICATIONS**
WARNING	RED	A very serious problem, take action immediately, e.g.; Engine Fire, Cargo Fire, Landing Gear unsafe	BELL OR HORN LIGHTS REPEATED ON FRONT PANELS
CAUTION	AMBER	A problem is present, refer to the checklist to resolve the issue. e.g.; generator failure, low hydraulic pressure	LIGHTS REPEATED ON FRONT PANELS
NORMAL	GREEN	Normal operation of a system that you have selected. e.g.; engine anti-ice is on, the valve is travelling to the selected position	NONE
GROUND ASSOCIATED	WHITE	A ground service has been plugged in and is available for use, Ground Electrical Power	NONE
MODERN AIRCRAFT			
SYNOPTIC DISPLAYS	**COLOUR**	**MEANING AND TYPICAL USES**	**OTHER INDICATIONS**
WARNING	RED	A very serious problem, take action immediately, e.g.; Engine Fire, Cargo Fire, Landing Gear unsafe	YES CONTINUOUS REPETITIVE CHIME OR VOICE
CAUTION	AMBER	A problem is present, refer to the checklist to resolve the issue. e.g.; generator failure, low hydraulic pressure, a valve does not match the switch position	YES SINGLE CHIME
NORMAL	GREEN	Normal operation of a system that you have selected. e.g.; engine anti-ice is on, hydraulic flow line, electrical flow line, and Reminder or Memo messages	NONE
OFF	NO COLOUR	The valve is not selected or there is no flow between components in the system	NONE
STANDBY	BLUE	The valve or pump you have selected on is standing by and will be activated by the computer at the appropriate time, and Aircraft or system limitations	NONE
MAGENTA	MAGENTA	Fuel jettison flow lines	NONE
GROUND ASSOCIATED	WHITE	A maintenance activity or related issue is present e.g.; APU needs oil refill, APU is inoperative for flight - MEL	NONE

Figure 1-4 Annunciator and Synoptic Display Colours

USE OF AURAL ALERTS AND WARNINGS

The use of sounds to alert the crew of a problem have been in use for many years but were typically limited to a bell, horn or chime which would quite often be used for a number of different system alerts. The operator had to know how many systems used the chime as their alert and find the problem by elimination. The first type of equipment to use voice recordings was the Ground Proximity Warning Systems (GPWS) with commands such as PULL UP, DON'T SINK, TOO LOW GEAR etc.

Modern aircraft have refined the use of different sounds and spoken voice recordings to specifically alert the crew to more and more particular issues. Refer to the table below for some examples of aural alerts.

AURAL ALERT	SITUATION	DURATION OF SOUND	SILENCING THE ALERT
CONTINUOUS REPETITIVE CHIME	ANY WARNINGS (RED)	CONTINUOUS	PRESS MASTER WARNING LIGHT
SINGLE CHIME	ANY CAUTIONS (AMBER)	0.5 SECS	PRESS MASTER CAUTION LIGHT
CAVALRY CHARGE MUSIC	AUTOPILOT DISCONNECTED BY PILOT	1.5 SECS	
	AUTOPILOT DISCONNECTED DUE TO FAILURE	PERMANENT	PRESS MASTER WARNING LIGHT
CLICK	LANDING CAPABILITY CHANGED	0.5 SECS	
CRICKET AND voice callout STALL	STALL	PERMANENT	
BUZZER	CALL FROM THE CABIN CREW	3 SECS	
	EMERGENCY CALL FROM THE CABIN CREW	3 SECS REPEATING	
	CALL FROM THE GROUND CREW	AS LONG AS THE CALLER PRESSES THE BUTTON	
	CALL FROM COMPANY OPERATIONS	CONTINUOUS	PRESS MASTER WARNING LIGHT
“C “ MUSIC CHORD	ALTITUDE ALERT	CONTINUOUS	SET NEW ALTITUDE
voice callout HEIGHTS 2500 500 40 20 10	WHEN BELOW 2500 FT	STATED ONCE	
voice callout WINDSHEAR	WINDSHEAR DETECTED	REPEATED 3 TIMES	
voice callout PRIORITY LEFT OR PRIORITY RIGHT	WHEN AUTOPILOT IS DISCONNECTED	1 SEC	
voice callout RETARD	THRUST LEVER NOT AT IDLE FOR LANDING	CONTINUOUS	RETARD THRUST
voice callout TCAS TRAFFIC TRAFFIC CLIMB CLIMB DESCEND DESCEND	TRAFFIC CONFLICTION	CONTINUOUS	NO LONGER CONFLICTING
voice callout SPEED, SPEED, SPEED	CURRENT THRUST IS NOT SUFFICIENT TO MAINTAIN A POSITIVE FLIGHT PATH	EVERY 5 SECS UNTIL THRUST IS INCREASED	INCREASE THRUST
voice callout DUAL INPUT	BOTH SIDESTICKS MOVED SIMULTANEOUSLY	EVERY 5 SECS	ONE STICK DEACTIVATED

Figure 1-5 Aural Alerts used by Airbus Aircraft

AIRCRAFT OPERATING MANUALS

The Flight Manual has long been the manual used by the crew to correctly and legally fly the aircraft in accordance with the manufacturer's recommendations and limitations. On very large aircraft with multiple systems and procedures, the Flight Manual can be quite large and difficult to read easily in emergency situations. The trend has developed to divide the book into readable parts and call them Flight Crew Operating Manuals (FCOM).

FLIGHT CREW OPERATING MANUALS (FCOMS)

FCOMs usually contain the following groups of information;

1. **FCOM Volume 1 - Systems Description.** A description of all the systems, their components and operation. It will include block and circuit diagrams, cautions and warning alerts and expected indications for the crew.
2. **FCOM Volume 2 - Performance.** A description and use of all parameters associated with the performance of the aircraft and engines beginning at Weight and Balance and including Takeoff, Climb, Cruise and Landing performance.
3. **FCOM Volume 3 - Flight Operations.** The normal procedures and limitations involved with the operation of the aircraft including refuelling, external and internal pre-flights, crew responsibilities, company policy and route operations.

Supplementary checklists and manuals that have originated from the Flight Manual also form part of the flight crew operating manuals system. They are;

4. **Quick Reference Handbook (QRH).** Designed as a small "quick grab" indexed handbook of checklists containing all the Emergency Procedures applicable to the aircraft such as Engine Fire, Cargo Fire, Loss of Electrical System, Loss of Hydraulic System etc.
5. **Minimum Equipment List (MEL).** Aircraft may fly with certain equipment unserviceable for a period of time provided any considerations or limitations are followed. The MEL lists the equipment of the aircraft that must be serviceable, the equipment that may be unserviceable and provides the authority to dispatch legally.
6. **Configuration Deviation List (CDL).** Aircraft may fly in a configuration deviating from normal for the purpose of returning to home base for rectification. An example would be a missing panel or winglet. The CDL lists the equipment allowed and provides the authority.

All of these manuals are carried in the cockpit for reference at any time by the crew.

THE MAINTENANCE PERSPECTIVE

With older types of aircraft maintenance engineers have to rely on the crews description of any system problems encountered during the flight. Reported unserviceabilities would quite often be ground checked by maintenance to confirm the problem and find the faulty equipment.

The same computer control of systems that has been discussed already also has the advantage of being able to monitor and save individual system operating parameters into memory. Maintenance engineers can access this information, read fault codes and review operation. Additionally, serious system fault codes are transmitted automatically from the aircraft to company ground stations providing advance warning of rectification required on arrival.

SUMMARY

As stated at the beginning, none of this information is examinable as most of this is learnt when training on a particular aircraft type, however this information is relevant as it details what the student should expect when managing the systems of modern large aircraft.