

CHAPTER 1**Air Temperature Measurement**

Introduction	1-1
Direct Reading Thermometer	1-3
Electrical Thermometer	1-3
Static Air Temperature Sensor	1-4
Total Air Temperature Probe	1-5

CHAPTER 2**Pitot-Static System**

Introduction	2-1
Pitot Tube	2-1
Static Source	2-2
Alternate Static Source	2-3
Combined Pitot-Static (Pressure) Head	2-4
Operating Problems	2-5
Pitot/Static System Errors	2-6

CHAPTER 3**Pressure Altimeter**

Introduction	3-1
Pressure Altitude	3-2
Density Altitude	3-2
The Simple Altimeter	3-2
Datum Sub-Scale Settings	3-3
The Sensitive Altimeter	3-4
Altimeter Displays	3-4
Design Errors	3-7
Errors due to Calibration	3-7
Blockages and Leakages	3-9
Servo Altimeters	3-9
Operation of a Servo-Altimeter	3-10
Servo-Altimeter Power Failure	3-11
Altitude Encoding	3-11
Advantages of Servo-Altimeters	3-11

CHAPTER 4**Vertical Speed Indicator**

Introduction	4-1
Principle of Operation	4-1
Operation of the VSI	4-2
Errors of the VSI	4-2
Lag	4-2
Instrument Error	4-2
Manoeuvre Induced Error	4-2
Faults of the VSI	4-2
Blockages	4-2
Breakage or leakage in the Static Line	4-2
Instantaneous Vertical Speed Indicator (IVSI)	4-2
Operation of the IVSI / ILVSI	4-3

CHAPTER 5

Airspeed Indicator

Introduction	5-1
Principle of the Airspeed Indicator (ASI)	5-1
Operation of a Simple ASI.....	5-1
Sensitive and Servo Airspeed Indicators.....	5-1
Calibration of the ASI	5-2
Colour Coding of the ASI	5-2
ASI Errors	5-3
ASI Faults	5-5
Calculation of CAS to TAS (up to 300 knots)	5-6

CHAPTER 6

Machmeter

Introduction	6-1
Critical Mach Number (M_{crit})	6-1
Principle of Operation.....	6-2
Machmeter Construction and Operation	6-4
Calibration.....	6-4
Errors	6-5
Blockages and Leakages	6-5
Accuracy	6-5
Serviceability Checks	6-5

CHAPTER 7

Mach Airspeed Indicator

Introduction	7-1
Display	7-1
V_{MO} Pointer	7-1
Driven Cursor.....	7-2
Bugs.....	7-2
Linkages.....	7-2
Errors	7-2

CHAPTER 8

Central Air Data Computer

Introduction	8-1
The Central Air Data Computer.....	8-1
Conversion of Sensing Pressures	8-2
Digital Air Data Computer	8-4

CHAPTER 9

Basic Magnetism

Introduction	9-1
Magnetic Properties	9-1
Fundamental Laws of Magnetism	9-3
Characteristics of Lines of Magnetic Flux	9-4
Magnetic Materials	9-5
Ferromagnetic	9-5
Paramagnetic	9-5
Diamagnetic	9-5
Permeability	9-6
Electromagnetism	9-6
An Electromagnet	9-7
Magnetic Moments	9-8
Period of Oscillation of a Suspended Magnet	9-8

CHAPTER 10

Terrestrial Magnetism

Introduction	10-1
Magnetic Dip	10-2
Earth's Total Magnetic Force	10-4
Examples	10-4
Magnetic Variation	10-5

CHAPTER 11

Aeroplane Magnetism

Introduction	11-1
Types of Aeroplane Magnetism	11-1
Components of Hard Iron Magnetism	11-2
Components of Soft Iron Magnetism	11-5
Determination of Deviation Coefficients	11-6
Minimum Deviation	11-7
Maximum Deviation	11-7
Joint Airworthiness Requirements (JAR) Limits	11-8
Compass Swinging	11-9
The Compass Swing Procedure	11-9
An Example of a Compass Swing	11-10
Deviation Compensation Devices	11-11

CHAPTER 12

Direct Reading Magnetic Compass

Introduction	12-1
Properties of a Direct Reading Compass	12-2
'E' Type Compass	12-3
Pre-flight Checks	12-4
Principle of a Pendulum	12-4
Acceleration Errors	12-4
Turning Errors	12-7

CHAPTER 13**Remote Indicating Compass**

Introduction	13-1
RIC Architecture	13-1
Principle of a Flux Detector Element	13-1
Flux Detector Unit	13-4
Operation of the Remote Indicating Compass System	13-5
Gyroscope Element	13-8
Heading Indicator	13-8
Modes of Operation	13-9
Synchronising Indicators	13-9
Manual Synchronisation	13-10
Operation of an RIC in a Turn	13-10
Advantages of a Remote Indicating Gyro Magnetic Compass	13-11
Disadvantages of the Remote Indicating Gyro Magnetic Compass	13-11

CHAPTER 14**Gyroscopic Principles**

Introduction	14-1
Principle of Construction	14-2
Gyroscopic properties	14-2
Types of Gyroscopes	14-4
Power Sources for Gyroscopes	14-6
The Disadvantages and Advantages of Air Driven Gyros	14-7
The Disadvantages and Advantages of Electrically Driven Gyros	14-7
Gyro Wander	14-8
Horizontal Axis Gyro	14-8
Vertical Axis Gyro	14-10
Transport Wander	14-10
Examples of Gyro Wander	14-11

CHAPTER 15**Direction Indicator**

Introduction	15-1
Basic Description of the Direction Indicator	15-1
Operation of the Direction Indicator	15-2
Errors Associated with the Air Driven Direction Indicator	15-4
Use of the Direction Indicator (DI)	15-4
Advanced Use of the Direction Indicator	15-4
Sample Calculation	15-5

CHAPTER 16**Artificial Horizon**

Introduction	16-1
Air driven (Classic) Artificial Horizon	16-3
Construction.....	16-3
Operation	16-4
Erection System.....	16-5
Errors	16-6
Electrically Driven Artificial Horizon.....	16-7
Construction.....	16-7
Torque Motor and Levelling Switch System.....	16-8
Fast Erection.....	16-8
Errors	16-9
Remote Vertical Gyro.....	16-9
Standby Attitude Indicator.....	16-10

CHAPTER 17**Turn and Balance Indicator**

Introduction	17-1
Turn Indicator.....	17-1
Construction and Principle of Operation	17-1
Operation	17-3
Errors	17-4
Pre-flight Check	17-4
The Balance Indicator	17-4
Construction and Operation	17-4
Limitations and Errors	17-5
Pre-Flight Check	17-5
Electrically Driven Turn and Balance Indicators.....	17-5
Typical Indications on a Turn and Balance Indicator.....	17-6

CHAPTER 18**Turn Co-ordinator**

Introduction	18-1
Principle of Operation	18-2

CHAPTER 19**Inertial Navigation System**

Introduction	19-1
The Principle and Construction of an Accelerometer	19-1
Performance	19-3
Operation of a Gyro-Stabilised Platform.....	19-3
Setting-up Procedures	19-6
Levelling	19-6
Alignment	19-7
Levelling and Alignment	19-7
Corrections	19-7
Coriolis	19-8
Centripetal Acceleration	19-8
Wander Azimuth System.....	19-9
The Schuler Tuned Platform	19-9
Errors	19-11
The Advantages and Disadvantages of an INS.....	19-12
Mode Selector Panel.....	19-13
Control Display Unit	19-14

CHAPTER 20**Inertial Reference System**

Introduction	20-1
Description of the Strap-Down System	20-1
Solid State Gyros	20-2
Ring Laser Gyro	20-2
Fibre Optic Gyro	20-3
Advantages and Disadvantages of RLGs	20-3
Alignment of the Inertial Reference System	20-4
Performance	20-4
The Control, Display, and Output from an IRS	20-4
Description of a Typical IRS	20-5
IRS Transfer Switch	20-7
IRS Alignment	20-7
Loss of Alignment in Flight.....	20-7

CHAPTER 21**Radio Altimeter**

Introduction	21-1
The Radio Altimeter System	21-1
Principle of Operation of a Radio Altimeter	21-3
Performance and Accuracy of a Radio Altimeter.....	21-4
Errors Associated with a Radio Altimeter	21-4
Leakage Errors.....	21-4
Mushing Errors.....	21-4
The Advantages of a Radio Altimeter.....	21-5

CHAPTER 22**Electronic Flight Instrument System**

Introduction	22-1
EFIS Architecture.....	22-1
Symbol Generator (SG)	22-2
Instrument Comparator Unit (ICU)	22-2
Compression Mode.....	22-2
Temperature Sensing Units	22-3
Mode Control Panels (MCP).....	22-3
Light Sensors.....	22-3
Attitude Director Indicator (ADI)	22-3
Radio Altitude.....	22-5
Decision Height.....	22-5
Localiser and Glide Slope Indication.....	22-5
The Horizontal Situation Indicator (HSI).....	22-5
Plan Mode.....	22-8
VOR and ILS Modes	22-8
EFIS/IRS Interface	22-10
Heading Reference Switch.....	22-11
HSI Symbology	22-11

CHAPTER 23**Flight Management System**

Introduction	23-1
The Flight Management Computer System.....	23-2
Command Display Unit	23-4
Control Panels	23-5
CDU and FMC Terminology	23-7
The Flight Management Computer Memory.....	23-9
General FMS Operation	23-11
Pre-Flight	23-12
Enroute	23-13
Lateral Navigation (LNAV)	23-13
Vertical Navigation (VNAV).....	23-14
Operational Notes	23-15
Fuel Monitoring	23-16
Flight Control and Management Summary.....	23-16

CHAPTER 24**Flight Director System**

Introduction	24-1
Flight Director Architecture.....	24-1
Flight Director Control Inputs	24-3
The Flight Director Computer (FDC)	24-4
Mode Control Unit	24-4
Flight Director Displays	24-4
Flight Director Modes of Operation	24-6
Attitude Mode.....	24-6
Heading	24-7
Altitude Hold.....	24-9
Localiser/VOR (LOC/VOR)	24-9
Glideslope (GS)	24-11
Go-Around (GA).....	24-12
Mode Annunciator.....	24-12
Operation of the Attitude Director Indicator	24-12
The Horizontal Situation Indicator (HSI) Flight Director Commands	24-14

CHAPTER 25**Automatic Flight Control System**

Introduction	25-1
Stability and Control Augmentation	25-1
Attitude Hold	25-1
Flight Control.....	25-1
Classification of an AFCS	25-2
Control Channels	25-2
Inner Loop Control (Stabilisation).....	25-2
Operation of an Inner Loop Pitch Stabilisation System	25-3
Outer Loop Control.....	25-4
Roll Modes	25-5
Pitch Modes	25-7
Combined Roll and Pitch Modes	25-8
Attitude Sensing	25-9
The AFCS Computer (Signal Processor)	25-10
Servomotor Actuators	25-11
Autopilot Terminology	25-12
Cross Coupling.....	25-14
ILS Coupling	25-14
VOR Coupling	25-15
Stability Problems	25-16
Yaw Damper	25-16
Mach Trim System	25-17
Automatic Pitch Trim Control	25-18
Interlocks.....	25-20
Synchronisation.....	25-20
Instinctive Cut Out.....	25-20

CHAPTER 26**Automatic Landing System**

Introduction	26-1
Basic Requirements for an Automatic Landing System	26-1
Automatic Landing System Terminology	26-2
Automatic Landing System Equipment Requirements	26-3
Automatic Approach, Flare, and Landing Sequence	26-4
Weather Minima	26-5
ICAO Categorisation for Low Visibility Landing Capabilities	26-5
The Fundamental Landing Requirement.....	26-6
System Reliability and Integrity	26-7

CHAPTER 27**Thrust Management Systems**

Introduction	27-1
Determining the Thrust Required	27-1
Calculation of Climb and Cruise Thrust.....	27-2
Cruising Methods	27-3
Electronic Engine Control (EEC)	27-3
Full Authority Digital Engine Control (FADEC)	27-3
Autothrottle (A/T).....	27-6
Thrust Lever Operation	27-7
Thrust Management via the Autothrottle	27-7
Thrust Management Computer (TMC)	27-8
Thrust Mode Select Panel (TMSP).....	27-8

CHAPTER 28**Central Warning System**

Introduction	28-1
Central Warning System Annunciator Panel	28-1
Aural Warnings	28-2

CHAPTER 29**Altitude Alerting System**

Introduction	29-1
Altitude Alerting System Operation	29-1

CHAPTER 30**Ground Proximity Warning System**

Introduction	30-1
GPWS System Architecture	30-1
GPWS Modes	30-2
Warning System	30-3
GPWS Control Panel	30-4
Discretionary Response	30-5
Warning Inhibition	30-6
The Reporting of GPWS Events	30-6
Operation of the GPWS	30-6
Mode 1	30-6
Mode 2	30-7
Mode 3	30-8
Mode 4	30-8
Mode 5	30-10
Mode 7	30-10
Joint Aviation Requirements	30-11

CHAPTER 31**Traffic Collision Avoidance System**

Introduction	31-1
TCAS I	31-1
TCAS II	31-1
TCAS III	31-1
Aeroplane Installation	31-2
Operation of TCAS II	31-4
TCAS Aural Warnings	31-4
Information Display	31-5
Resolution Advisory / Vertical Speed Indicator (RA / VSI)	31-7
TCAS Control Panel	31-8
Operating Restrictions	31-8

CHAPTER 32**Mach/Airspeed Warning System**

Introduction	32-1
System Architecture and Operation	32-1
Maximum Operating Airspeed Schedule	32-2

CHAPTER 33**Stall Warning**

Introduction	33-1
Light Aeroplane Stall Warning Device	33-1
Transport Category Aeroplane Stall Warning Device	33-2

CHAPTER 34**Recording Devices**

Introduction	34-1
Flight Data Recorder (FDR) Requirements	34-1
FDR Design	34-3
Cockpit Voice Recorder (CVR) Requirements	34-3
CVR Design	34-4

CHAPTER 35**General Engine Instrumentation**

Introduction	35-1
Piston Engines	35-1
Turbo Propeller Engines	35-2
Gas Turbine Engines	35-2

CHAPTER 36**Pressure and Temperature Sensors**

Introduction	36-1
Pressure Measurement	36-1
Temperature Measurement	36-3

CHAPTER 37**Pressure and Temperature Indicators**

Introduction	37-1
Pressure Indicators	37-1
Manifold Pressure (MAP)	37-1
Engine Pressure Ratio (EPR)	37-1
Fuel and Oil Pressures	37-3
Temperature Indicators	37-3
Cylinder Head Pressure	37-3
Exhaust Gas Temperature	37-3
Fuel and Oil Temperatures	37-4

CHAPTER 38**RPM Indicators and Propeller Synchroniser Systems**

Introduction	38-1
Tachometers	38-1
Magnetic Drag Tachometer.....	38-1
Tacho-Generator and Indicator System	38-2
Tachometer Probe and Indicator System.....	38-3
Propeller Auxiliary Systems	38-6
Synchronisation System	38-6
Synchrophasing System	38-7
Operation of a Synchrophasing System.....	38-8

CHAPTER 39**Engine Torque Measurement**

Introduction	39-1
Torque Meter	39-1
Negative Torque Sensing	39-3

CHAPTER 40**Vibration Monitoring**

Introduction	40-1
Vibration Monitoring System	40-2

CHAPTER 41**Fuel Gauge**

Introduction	41-1
Measurement of Fuel Quantity.....	41-1
Float Type	41-1
Ratio Metre Type Fuel Gauge.....	41-2
Capacitance Type of Fuel Gauge	41-2
Fuel Totaliser	41-5
Fuel Flow	41-5

CHAPTER 42**EICAS**

Introduction	42-1
EICAS Architecture	42-1
Engine Displays	42-2
Crew Alerting	42-3
Warnings (Level A)	42-3
Cautions (Level B)	42-4
Advisories (Level C).....	42-4
Master Warning/Caution Light.....	42-4
Inhibits	42-4
Display Messages	42-4
Status	42-6
Maintenance	42-7
EICAS Failure Modes	42-7

CHAPTER 43**ECAM**

Introduction	43-1
Engine / Warning (E/W) CRT Display	43-2
The System / Status (S/S) CRT Display.....	43-3
ECAM System Architecture.....	43-3
Flight Warning Computers (FWCS).....	43-4
Display management Computers (DMC)	43-4
System Data Acquisition Concentrators (SDAC).....	43-4
ECAM Control Panel (ECP)	43-4
Attention Getters	43-5
ECAM System Failure.....	43-6
Failure Categorisation	43-6
System Operation	43-6