

MODULE 11A

FOR B1 CERTIFICATION

TURBINE AEROPLANE AERODYNAMICS, STRUCTURES AND SYSTEMS

**Aviation Maintenance Technician
Certification Series**



72413 U.S. Hwy 40
Tabernash, CO 80478-0270 USA

www.actechbooks.com

+1 970 726-5111

WELCOME

The publishers of this Aviation Maintenance Technician Certification Series welcome you to the world of aviation maintenance. As you move towards EASA certification, you are required to gain suitable knowledge and experience in your chosen area. Qualification on basic subjects for each aircraft maintenance license category or subcategory is accomplished in accordance with the following matrix. Where applicable, subjects are indicated by an "X" in the column below the license heading.

For other educational tools created to prepare candidates for licensure, contact Aircraft Technical Book Company.

We wish you good luck and success in your studies and in your aviation career!

REVISION LOG

VERSION	EFFECTIVE DATE	DESCRIPTION OF CHANGE
001	2015 10	Module Creation and Release
002	2016 01	Minor Revisions
003	2017 09	Format Update
003.1	2019 02	Added section on Pneumatic and Pressure Pumps in Sub-Module 16.
003.2	2019 05	Corrected incorrect answers in Sub-Module 20.

TURBINE AEROPLANE AERODYNAMICS, STRUCTURES AND SYSTEMS

Welcome	iii
Revision Log.....	iii
Forward.....	iv
Contents	xiii

SUB-MODULE 01 THEORY OF FLIGHT

Knowledge Requirements	1.1
Aeroplane Aerodynamics and Flight Controls	1.2
Primary Flight Control Surfaces.....	1.2
Operation and Effect of Roll Control Devices	1.3
Ailerons	1.3
Spoilers	1.4
Operation and Effect of Pitch Control Devices	1.5
Elevators	1.5
Stabilators	1.5
Variable Incidence Stabilizers.....	1.5
Canards	1.5
Operation and Effect of Yaw Control Devices	1.6
Rudders	1.6
Rudder Limiters	1.6
Secondary or Auxiliary Control Surfaces	1.7
Operation and Effect of Tabs	1.7
Trim Tabs	1.7
Balance Tabs	1.7
Servo Tabs.....	1.8
Anti-Servo/Anti-Balance Tabs.....	1.9
Spring Tabs	1.9
Aerodynamic Balance Panels	1.9
Mass Balance	1.9
Control Surface Bias	1.9
Flaps	1.10
Flaperons.....	1.12
Slats	1.12
Slots.....	1.12
Elevons and Ruddervators	1.13
Drag Inducing Devices	1.14
Spoilers	1.14
Speed Brakes.....	1.14
Boundary Layer Controls	1.14
Vortex Generators	1.14
Wing Fence	1.14
Stall Wedges	1.15
Sawtooth Leading Edge.....	1.15

Wingtip Vortices	1.15
Winglet	1.16
High Speed Flight	1.16
Speed of Sound	1.16
Mach Number, Subsonic, Transonic and	
Supersonic Flight	1.16
Shock Wave.....	1.17
Normal Shock Wave	1.17
Oblique Shock Wave	1.17
Expansion Wave.....	1.18
Critical Mach Number	1.18
Affects of Sweepback on Critical Mach Number.....	1.18
Compressibility Buffet	1.19
Aerodynamic Heating.....	1.19
Area Rule	1.20
Engine Intake Airflow of High Speed Aircraft	1.20
Questions	1.21
Answers	1.22

SUB-MODULE 02 AIRFRAME STRUCTURES-GEN. CONCEPTS

Knowledge Requirements	2.1
Airworthiness Requirements for Structural Strength..	2.2
Structural Classification	2.2
Primary Structure	2.2
Secondary Structure	2.2
Tertiary Structure	2.2
Damage Tolerant Concepts	2.2
Fail Safe	2.2
Safe Life.....	2.3
Damage Tolerance	2.3
Station Identification and Zonal Location Systems	2.3
Station Numbering	2.3
Zonal Identification System	2.4
Access and Inspection Panels	2.4
Structural Stresses	2.6
Hoop Stress	2.7
Metal Fatigue.....	2.7
Drainage and Ventilation Provisions	2.8
Drainage.....	2.8
Ventilation	2.8
System Installation Provisions	2.8
Lightening Strike Protection and Bonding	2.9
Construction Methods	2.10
Fuselage	2.10
Truss Type.....	2.10
Stressed Skin Fuselage	2.10

CONTENTS

Monocoque Type	2.10	Wing Spars	3.10
Semimonocoque Type.....	2.11	Wing Ribs	3.12
Beams Floor Structures	2.11	Wing Roots and Tips	3.12
Struts and Ties	2.12	Wing Skin	3.14
Methods of Skinning.....	2.12	Fuel Storage	3.15
Doublers	2.12	Attachments.....	3.16
Wing, Empennage and Engine Attachment	2.12	Landing Gear	3.16
Structure Assembly Techniques	2.14	Pylons	3.17
Anti-Corrosion Protection	2.17	Control Surfaces	3.18
Methods of Surface Protection	2.17	High Lift/Drag Devices.....	3.18
Anodizing	2.17	Stabilizers	3.18
Chromating.....	2.17	Construction	3.18
Cladding	2.18	Control Surface Attachment	3.18
Painting.....	2.18	Flight Control Surfaces	3.19
Surface Cleaning	2.18	Construction and Attachment	3.19
Exterior Aircraft Cleaning	2.18	Balancing	3.19
Alignment and Symmetry	2.19	Mass Balancing.....	3.19
Checking Dihedral	2.20	Aerodynamic Balancing	3.19
Checking Incidence	2.20	Nacelles/Pylons	3.19
Checking Fin Verticality.....	2.21	Construction	3.19
Checking Engine Alignment	2.21	Firewalls.....	3.19
Symmetry Check	2.21	Engine Mounts	3.19
Questions	2.23	Questions	3.21
Answers	2.24	Answers	3.22

SUB-MODULE 03

AIRFRAME STRUCTURES — AEROPLANES

Knowledge Requirements	3.1
Fuselage	3.2
Construction	3.2
Pressurization Sealing	3.2
Attachments.....	3.3
Wings	3.3
Stabilizers	3.3
Pylons	3.3
Undercarriage	3.3
Seat Installation	3.3
Cargo Loading System	3.4
Doors and Emergency Exits	3.5
Construction	3.5
Mechanisms	3.5
Operation and Safety Devices	3.6
Windows and Windscreen Attachment	3.6
Construction	3.6
Attachment	3.8
Wings	3.9
Construction	3.9

SUB-MODULE 04

AIR CONDITIONING AND CABIN PRESSURIZATION (ATA 21)

Knowledge Requirements	4.1
Air Supply.....	4.2
Sources of Supply Air	4.2
Bleed Air	4.2
APU	4.3
Ground Cart	4.3
Air Conditioning Systems	4.4
Air Cycle Air Conditioning	4.5
System Operation	4.5
Pneumatic System Supply.....	4.5
Component Operation	4.5
Pack Valve	4.5
Bleed Air Bypass	4.5
Primary Heat Exchanger	4.6
Refrigeration Turbine Unit or Air Cycle	
Machine and Secondary Heat Exchanger	4.7
Water Separator	4.8
Refrigeration Bypass Valve	4.8
Vapor Cycle Air Conditioning.....	4.11

Theory of Refrigeration	4.11
Basic Vapor Cycle	4.12
Vapor Cycle Air Conditioning System Components ..	4.13
Refrigerant	4.13
Receiver Dryer	4.14
Expansion Valve.....	4.15
Evaporator	4.16
Compressor	4.16
Condenser	4.18
Service Valves.....	4.19
Vapor Cycle Air Conditioning Servicing Equipment	4.19
Manifold Set, Gauges, Hoses, and Fittings	4.20
Full Service Refrigerant Recovery, Recycling, Evacuation, and Recharging Units	4.21
Refrigerant Source	4.21
Vacuum Pumps	4.21
Leak Detectors.....	4.22
System Servicing	4.23
Visual Inspection	4.23
Leak Test	4.24
Performance Test	4.24
Feel Test	4.24
Purging The System.....	4.25
Checking Compressor Oil.....	4.25
Evacuating The System.....	4.25
Charging The System	4.26
Distribution Systems	4.26
Flow Control	4.27
Temperature Control.....	4.27
Humidity Control	4.28
Pressurization	4.30
Pressure of The Atmosphere	4.30
Temperature and Altitude	4.31
Pressurization Terms	4.32
Pressurization Systems	4.33
Control of Cabin Pressure	4.34
Pressurization Modes	4.34
Cabin Pressure Controllers	4.34
Control Valve (Outflow Valve)	4.35
Cabin Air Pressure Safety Valve Operation	4.37
Pressurization Indication.....	4.38
Pressurization Operation.....	4.38
Cabin Pressurization Troubleshooting.....	4.39
Safety and Warning Devices.....	4.39
Protection and Warning Devices	4.40
Questions	4.41
Answers	4.42

SUB-MODULE 05

INSTRUMENTS/AVIONIC SYSTEMS

Knowledge Requirements	5.1
Instrument Systems Introduction	5.2
Classifying Instruments.....	5.3
Flight Instruments	5.3
Engine Instruments	5.4
Navigation Instruments	5.4
Classification By Operating Principles.....	5.5
Pressure Measuring Instruments.....	5.5
Types of Pressure	5.8
Pressure Instruments	5.9
Engine Oil Pressure	5.9
Manifold Pressure	5.9
Engine Pressure Ratio (EPR)	5.10
Fuel Pressure	5.10
Hydraulic Pressure	5.11
Vacuum Pressure	5.12
Pressure Switches	5.12
Pitot Static Systems	5.13
Pitot Tubes and Static Vents.....	5.13
Air Data Computers (ADC) and Digital Air Data Computers (DADC)	5.15
Pitot Static Pressure Sensing Flight Instruments	5.17
Altimeters and Altitude	5.17
Vertical Speed Indicator.....	5.23
Airspeed Indicators	5.25
Remote-Sensing and Indication	5.27
Synchro Type Remote-Indicating Instruments ..	5.27
DC Selsyn Systems	5.28
AC Synchro Systems	5.28
Remote Indicating Fuel and Oil Pressure Gauges	5.30
Mechanical Movement Indicators.....	5.30
Tachometers	5.31
Mechanical Tachometers	5.31
Electric Tachometers	5.31
Synchroscope	5.33
Accelerometers	5.34
Stall Warning and Angle of Attack (AOA) Indicators	5.34
Temperature Measuring Instruments	5.37
Non-Electric Temperature Indicators	5.37
Electrical Temperature Measuring Indication....	5.38
Electrical Resistance Thermometer	5.38
Ratiometer Electrical Resistance Thermometers	5.39
Thermocouple Temperature Indicators	5.40
Turbine Gas Temperature Indicating Systems	5.41

CONTENTS

Total Air Temperature Measurement	5.43	VOR Navigation System.....	5.69
Direction Indicating Instruments	5.44	Automatic Direction Finder (ADF).....	5.72
Direct Indicating Magnetic Compass	5.44	Instrument Landing Systems (ILS)	5.75
Vertical Magnetic Compass.....	5.46	Localizer.....	5.76
Remote Indicating Compass	5.47	Glideslope.....	5.77
Remote Indicating Slaved Gyro Compass.....	5.47	Compass Locators	5.77
(Flux Gate Compass)	5.47	Marker Beacons	5.78
Solid State Magnetometers.....	5.49	Distance Measuring Equipment (DME)	5.79
Gyroscopic Instruments.....	5.49	Area Navigation (RNAV)	5.81
Sources of Power for Gyroscopic Instruments	5.49	Radar Beacon Transponder	5.81
Pressure Driven Gyroscopic Instrument Systems	5.50	Transponder Tests and Inspections	5.83
Electrically-Driven Gyroscopic Instrument Systems	5.50	Altitude Encoders	5.85
Principles of Gyroscopic Instruments	5.50	Collision Avoidance Systems	5.85
Mechanical Gyros	5.50	Traffic Collision Avoidance Systems (TCAS)	5.85
Solid State Gyros and Related Systems	5.52	ADS-B	5.87
Ring Laser Gyros (RLG)	5.52	Radio Altimeter	5.89
Microelectromechanical Based Attitude		Weather Radar	5.90
and Directional Systems (MEMS).....	5.53	Emergency Locator Transmitter (ELT).....	5.93
Attitude Heading and Reference Systems	5.54	Global Positioning System (GPS)	5.95
Common Gyroscopic Instruments	5.54	Wide Area Augmentation System (WAAS)	5.97
Vacuum-Driven Attitude Gyros.....	5.54	Inertial Navigation System (INS)/Inertial	
Electric Attitude Indicators	5.56	Reference System (IRS)	5.97
Gyroscopic Direction Indicator or		Comm./Navigation Avionics Installations	5.99
Directional Gyro (DG).....	5.56	Questions	5.101
Turn Coordinators	5.57	Answers	5.102
Turn-and-Slip Indicator	5.57		
Glass Cockpit.....	5.59		
Avionics Systems	5.60	SUB-MODULE 06	
AutoFlight	5.60	ELECTRICAL POWER (ATA 24)	
Basis for Autopilot Operation.....	5.61	Knowledge Requirements	6.1
Autopilot Components	5.61	Batteries	6.2
Sensing Elements.....	5.61	Primary Cell Batteries	6.2
Computer and Amplifier	5.61	Secondary Cell Batteries	6.2
Output Elements	5.61	Dry Charged (Flooded) Lead Acid Batteries	6.3
Command Elements	5.63	Valve-Regulated (Sealed) Lead-Acid	
Feedback or Follow up Element.....	5.63	Batteries (VRLA)	6.3
Autopilot Functions	5.64	Nickel Cadmium (NiCd) Batteries	6.3
Yaw Dampening.....	5.65	Lithium Ion Batteries	6.4
Automatic Flight Control System (AFCS)	5.65	Battery Installations and Operation.....	6.5
Flight Director Systems	5.65	AC Power Generation	6.6
Communications	5.67	AC Alternators	6.9
Very High Frequency (VHF) Radios.....	5.67	Alternator Drive	6.10
High Frequency Radios	5.68	AC Alternators Control Systems.....	6.12
Selective Calling (SELCAL)	5.68	DC Power Generation	6.13
Satellite Communication Systems (SATCOM)	5.68	Functions of Generator Control Systems	6.14
Service Interphone System	5.68	Voltage Regulation	6.15
Navigation Systems	5.69	Over voltage Protection	6.15
		Parallel Generator Operations	6.15

Over Excitation Protection.....	6.15	Cabin Layout	7.4
Differential Voltage.....	6.15	Equipment Layout	7.5
Reverse Current Sensing.....	6.15	Cabin Furnishing Installation	7.5
Generator Controls for High Output Generators....	6.15	Cabin Entertainment Equipment	7.6
Other Voltage Regulation	6.16	Galley Installation	7.6
Carbon Pile Regulators.....	6.16	Cargo Handling and Retention Equipment	7.7
Three Unit Regulators.....	6.17	Airstairs	7.8
DC Alternators and Controls	6.19	Questions	7.9
DC Alternators	6.19	Answers	7.10
DC Alternator Voltage Regulation	6.20		
Solid State Voltage Regulators.....	6.20		
Power Distribution	6.21		
Power Distribution on Small Multi-Engine Aircraft	6.21		
Power Distribution on Large Aircraft	6.23		
Split Bus Systems	6.23		
Parallel Bus Systems	6.25		
Split Parallel Systems	6.25		
Inverters, Transformers and Rectifiers.....	6.27		
Inverters	6.27		
Rotary Inverters	6.27		
Permanent Magnet Rotary Inverter	6.27		
Inductor Type Rotary Inverter.....	6.28		
Static Inverters	6.30		
Transformers	6.32		
Current Transformers	6.35		
Transformer Losses.....	6.35		
Power in Transformers	6.35		
Rectifiers	6.36		
Silicon Controlled Rectifiers	6.37		
Transformer Rectifiers.....	6.39		
Circuit Protection.....	6.39		
Current Limiting Devices	6.39		
Fuses.....	6.40		
Circuit Breakers	6.40		
Emergency Power Generation	6.41		
Standby Power	6.41		
External/Ground Power.....	6.41		
Questions	6.43		
Answers	6.44		

SUB-MODULE 07

EQUIPMENT AND FURNISHINGS (ATA 25)

Knowledge Requirements	7.1	Knowledge Requirements	8.1
Emergency Equipment Requirements	7.2	Introduction	8.2
Seats, Harnesses and Belts	7.3	Requirements for Fire To Occur	8.2
Seats	7.3	Classes of Fires	8.2
Seat Belts and Harnesses.....	7.3	Fire Zones	8.2
		Fire Prevention	8.3
		Fire Detection and Warning Systems	8.3
		Requirements for Overheat and Fire Detection Systems	8.3
		Thermal Switch Systems	8.4
		Thermocouple Systems	8.4
		Continuous Loop Systems.....	8.5
		Fenwal System.....	8.5
		Kidde System	8.5
		Sensing Element.....	8.6
		Combination Fire and Overheat Warning	8.6
		Temperature Trend Indication.....	8.6
		System Test.....	8.7
		Fault Indication	8.7
		Dual Loop Systems	8.7
		Automatic Self Interrogation.....	8.7
		Support Tube Mounted Sensing Elements	8.7
		Fire Detection Control Unit (Fire Detection Card)	8.8
		Pressure Type Sensor Responder Systems.....	8.8
		Pneumatic Continuous Loop Systems	8.8
		Averaging Function	8.8
		Discrete Function.....	8.8
		Smoke, Flame, and Carbon Monoxide Detection Systems	8.9
		Smoke Detectors	8.9
		Light Refraction Type	8.10
		Ionization Type	8.10
		Flame Detectors.....	8.10
		Carbon Monoxide Detectors.....	8.10
		Fire Extinguishing Systems	8.11
		Fire Extinguisher Agents	8.11
		Fixed Container Fire Extinguishing Systems.....	8.12

CONTENTS

Containers	8.13	Fly-By-Wire Control	9.11
Discharge Valves	8.13	Fly-By-Optics	9.12
Pressure Indication	8.14	Fly-By-Wireless	9.13
Two Way Check Valve	8.14	Artificial Feel	9.13
Discharge Indicators	8.14	Yaw Damper	9.13
Thermal Discharge Indicator (Red Disk)	8.14	Mach Trim	9.13
Normal Discharge Indicator (Yellow Disk) ..	8.14	Rudder Limiter	9.14
Fire Switch	8.14	Gust Lock Systems	9.14
Fixed Fire Protection: Cargo Compartments	8.15	Balancing and Rigging	9.14
Cargo Compartment Classification	8.15	Static Balance	9.15
Cargo Compartment Fire Protection and Warning	8.16	Dynamic Balance	9.15
Smoke Detector Systems	8.16	Rebalancing Procedures	9.15
Cargo Compartment Extinguishing System..	8.17	Rebalancing Methods	9.16
Fixed Fire Protection: Lavatories	8.17	Aircraft Rigging	9.17
Lavatory Smoke Detector and Warning Systems	8.18	Stall Protection/Warning Systems	9.17
Lavatory Fire Extinguisher Systems	8.19	Questions	9.19
Fire Detection System Maintenance	8.20	Answers	9.20
Fire Detection System Troubleshooting	8.21		
Fire Extinguisher System Maintenance	8.21	SUB-MODULE 10	
Container Pressure Check	8.21	FUEL SYSTEMS (ATA 28)	
Discharge Cartridges	8.22	Knowledge Requirements	10.1
Agent Containers	8.22	Basic Fuel System Requirements	10.2
Portable Fire Extinguishers	8.23	Fuel System Independence	10.2
Portable Extinguisher Types	8.23	Fuel System Lightning Protection	10.2
Questions	8.25	Fuel Flow	10.3
Answers	8.26	Flow Between Interconnected Tanks	10.3
		Unusable Fuel Supply	10.3
		Fuel System Hot Weather Operation	10.3
		Fuel Tanks	10.3
		Fuel Tank Tests	10.4
		Fuel Tank Installation	10.4
		Fuel Tank Expansion Space	10.4
		Fuel Tank Sump	10.4
		Fuel Tank Filler Connection	10.4
		Fuel Tank Vents	10.5
		Fuel Tank Outlet	10.5
		Pressure Fueling Systems	10.5
		Fuel Pumps	10.5
		Fuel System Lines and Fittings	10.5
		Other Fuel System Components	10.5
		Fuel Valves and Controls	10.6
		Fuel Strainer or Filter	10.6
		Aircraft Fuel System Layout	10.6
		Fuel Tanks	10.7
		Integral Fuel Tanks	10.7
		Bladder Fuel Tanks	10.8
		Fuel Supply Systems	10.10
SUB-MODULE 09			
FLIGHT CONTROLS (ATA 27)			
Knowledge Requirements	9.1		
Flight Controls (ATA 27)	9.2		
Primary Flight Controls	9.2		
Secondary Flight Controls	9.2		
Trim Controls	9.2		
Active Load Control	9.4		
High Lift Devices	9.5		
Lift Dump and Speed Brakes	9.5		
Control System Operation	9.6		
Mechanical Control	9.6		
Control Cables	9.6		
Push-Pull Tubes	9.8		
Bellcranks and Levers	9.9		
Jackscrews	9.9		
Torque Tubes	9.9		
Hydromechanical Control	9.9		
Electrical and Electronic Controls	9.10		
Pneumatic	9.11		

Fuel Feed	10.10	Surfactants.....	10.36
Cross-Feed and Transfer Systems	10.10	Microorganisms	10.36
Fuel Dumping, Venting and Draining	10.12	Foreign Fuel Contamination	10.37
Fuel System Drains	10.12	Detection of Contaminants.....	10.38
Fuel Vent Systems	10.12	Fuel Contamination Control.....	10.40
Fuel Jettisoning System	10.12	Questions	10.41
Fuel System Components.....	10.14	Answers	10.42
Fuel Lines and Fittings	10.14		
Fuel Valves	10.15	SUB-MODULE 11	
Manually-Operated Gate Valves	10.16	HYDRAULIC POWER (ATA 29)	
Motor Operated Valves.....	10.16	Knowledge Requirements	11.1
Solenoid-Operated Valves	10.16	Aircraft Hydraulic Power.....	11.2
Fuel Pumps	10.17	System Layout	11.2
Centrifugal Boost Pumps.....	10.17	Open-Center Hydraulic Systems	11.2
Ejector Pumps.....	10.18	Closed-Center Hydraulic Systems	11.3
Fuel Filters	10.19	Evolution of Hydraulic Systems	11.4
Fuel Indication and Warnings	10.21	Hydraulic Power Pack System	11.4
Fuel Quantity Indicating Systems.....	10.21	Modern High Performance Systems	11.4
Ratiometer Type	10.21	Hydraulic Fluid	11.5
Capacitance type.....	10.22	Properties	11.5
Mechanical Type.....	10.23	Viscosity	11.5
Fuel Flowmeters	10.23	Chemical Stability	11.6
Fuel Temperature Gauges	10.25	Flash Point	11.6
Fuel Heaters.....	10.25	Fire Point	11.6
Fuel Pressure Gauges.....	10.26	Types of Hydraulic Fluids	11.6
Pressure Warning Signal.....	10.26	Mineral-Based Fluids	11.7
Valve-In-Transit Indicator Lights	10.27	Polyalphaolefin-Based Fluids	11.7
Refueling and Defueling	10.28	Phosphate Ester-Based Fluid (Skydrol®)	11.7
Fueling.....	10.28	Intermixing of Fluids.....	11.7
Over-The-Wing Refueling	10.28	Compatibility With Aircraft Materials	11.7
Pressure Refueling	10.29	Hydraulic Fluid Contamination	11.8
Defueling	10.29	Contamination Check	11.8
Fire Hazards When Fueling or Defueling	10.30	Hydraulic Sampling Schedule	11.8
Longitudinal Balance Systems.....	10.30	Sampling Procedure	11.8
Fuel System Repair.....	10.31	Contamination Control.....	11.9
Troubleshoot The Fuel System	10.31	Filters	11.9
Location of Leaks and Defects	10.31	Hydraulic System Flushing	11.9
Fuel Leak Classification	10.31	Health and Handling	11.9
Replacement of Gaskets, Seals and Packings	10.31	Hydraulic Reservoirs and Accumulators	11.10
Fuel Tank Repair	10.32	Reservoirs.....	11.10
Integral Tanks.....	10.32	Non-Pressurized Reservoirs	11.10
Bladder Tanks	10.32	Pressurized Reservoirs	11.12
Fire Safety.....	10.34	Air-Pressurized Reservoirs	11.12
Fuel Servicing and Contamination	10.34	Fluid-Pressurized Reservoirs.....	11.13
Fuel and Fuel System Contaminants	10.34	Reservoir Servicing.....	11.14
Water.....	10.35	Accumulators	11.14
Solid Particle Contaminants.....	10.35	Types of Accumulators	11.15

CONTENTS

SUB-MODULE 12

ICE AND RAIN PROTECTION (ATA 30)

System Operation.....	12.20	Emergency Extension Systems.....	13.19
De-Ice System for Turboprop Aircraft.....	12.22	Landing Gear Retraction Test	13.20
Inspection, Maintenance, and Troubleshooting of Rubber De-Icer Boot Systems	12.22	Indications and Warning	13.20
Operational Checks	12.22	Landing Gear Safety Devices	13.20
Adjustments	12.23	Ground Locks	13.21
Troubleshooting	12.24	Nose Wheel Centering	13.21
Inspection	12.26	Safety Switches	13.22
De-Ice Boot Maintenance	12.26	Proximity Sensors	13.22
Electrical De-Icing Systems	12.26	Air-Ground Sensing.....	13.24
Electric Propeller De-Ice	12.26	Steering.....	13.24
Electric Airfoil De-Ice Boots	12.26	Nose Wheel Steering.....	13.24
Hot Air De-Ice/De-Fog	12.26	Steering Damper.....	13.27
Chemical De-Ice Systems	12.27	Shimmy Dampers	13.27
Windshield Chemical De-Ice.....	12.27	Piston Type	13.27
Chemical Propeller De-Ice.....	12.28	Vane Type	13.28
Chemical Ground De-Icing of Aircraft.....	12.28	Non-Hydraulic Shimmy Damper.....	13.28
Frost Removal	12.29	Landing Gear System Maintenance	13.29
De-Icing Fluid	12.29	Landing Gear Rigging and Adjustment.....	13.29
Holdover Time (HOT)	12.29	Adjusting Landing Gear Latches.....	13.30
Critical Surfaces	12.29	Gear Door Clearances	13.30
Ice and Snow Removal.....	12.31	Drag and Side Brace Adjustment	13.31
Rain Control Systems.....	12.31	Aircraft Wheels	13.32
Windshield Wiper Systems	12.31	Wheel Construction	13.32
Chemical Rain Repellent	12.32	Inboard Wheel Half	13.33
Windshield Surface Seal Coating	12.33	Outboard Wheel Half	13.34
Pneumatic Rain Removal Systems	12.33	Wheel Inspection.....	13.35
Questions	12.35	on Aircraft Inspection	13.35
Answers	12.36	Proper Installation	13.35
		Axle Nut Torque	13.35
		Off Aircraft Wheel Inspection.....	13.36
		Loosening the Tire from the Wheel Rim	13.36
		Disassembly of the Wheel	13.36
		Cleaning the Wheel Assembly	13.37
		Inspection of the Wheel Halves	13.37
		Wheel Tie Bolt Inspection	13.37
		Key and Key Screw Inspection	13.37
		Fusible Plug Inspection	13.38
		Balance Weights.....	13.38
		Wheel Bearings.....	13.38
		Cleaning the Wheel Bearings	13.38
		Inspection of Wheel Bearings	13.38
		Bearing Handling and Lubrication	13.40
		Aircraft Brakes	13.42
		Types and Construction of Aircraft Brakes	13.42
		Single Disc Brakes	13.42
		Floating Disc Brakes.....	13.42
		Fixed Disc Brakes	13.43

SUB-MODULE 13

LANDING GEAR (ATA 32)

Knowledge Requirements	13.1
Landing Gear Construction.....	13.2
Landing Gear Configurations.....	13.2
Tail Wheel Type Landing Gear.....	13.3
Tandem Landing Gear	13.3
Tricycle Type Landing Gear	13.3
Fixed and Retractable Landing Gear	13.5
Landing Gear Alignment and Support	13.6
Alignment.....	13.7
Shock Absorbing	13.10
Shock Struts.....	13.10
Shock Strut Operation	13.13
Servicing Shock Struts	13.15
Bleeding Shock Struts.....	13.16
Extension and Retraction Systems: Normal	13.17

CONTENTS

Dual Disc Brakes	13.44	Chattering or Squealing	13.73
Multiple Disc Brakes	13.45	Aircraft Tires and Tubes	13.73
Segmented Rotor Disc Brakes	13.46	Tire Classification	13.73
Carbon Brakes.....	13.50	Types	13.73
Expander Tube Brakes	13.50	Ply Rating	13.75
Brake Actuating Systems.....	13.51	Tube Type or Tubeless	13.75
Independent Master Cylinders	13.51	Bias Ply or Radial	13.75
Boosted Brakes	13.53	Tire Construction	13.76
Power Brakes.....	13.54	Bead.....	13.76
Brake Control Valve/ Brake Metering Valve..	13.56	Carcass Plies	13.77
Emergency Brake Systems	13.57	Tread	13.77
Parking Brake	13.59	Sidewall.....	13.77
Brake Deboosters.....	13.59	Chine.....	13.78
Anti-Skid	13.61	Tire Inspection on The Aircraft	13.78
System Operation	13.61	Inflation.....	13.78
Wheel Speed Sensors	13.61	Tread Condition	13.79
Control Units	13.62	Tread Depth and Wear Pattern	13.79
Anti-Skid Control Valves	13.64	Tread Damage	13.81
Touch Down and Lock Wheel Protection.....	13.64	Sidewall Condition	13.83
Anti-Skid System Tests	13.65	Tire Removal	13.84
Ground Test	13.65	Tire Inspection Off Aircraft	13.85
Inflight Test.....	13.65	Tire Repair and Retreading	13.86
Anti-Skid System Maintenance	13.65	Tire Storage	13.86
Wheel Speed Sensor.....	13.65	Aircraft Tubes	13.87
Control Valve	13.65	Tube Construction and Selection	13.87
Control Unit	13.66	Tube Storage and Inspection	13.87
Auto Braking	13.66	Tube Tire Inspection	13.88
Brake Inspection and Service.....	13.66	Tire Mounting.....	13.88
on Aircraft Servicing.....	13.66	Tubeless Tires	13.88
Lining Wear	13.66	Tube Type Tires	13.90
Air In The Brake System	13.67	Tire Balancing	13.90
Bleeding Master Cylinder Brake Systems	13.68	Operation and Handling Tips.....	13.91
Bleeding Power Brake Systems.....	13.70	Taxiing	13.91
Fluid Quantity and Type	13.70	Braking and Pivoting	13.92
Inspection for Leaks	13.70	Landing Field and Hangar Floor Condition	13.92
Proper Bolt Torque	13.71	Takeoffs and Landings	13.92
Off Aircraft Brake Servicing and Maintenance	13.71	Hydroplaning	13.92
Bolt and Threaded Connections	13.71	Questions	13.95
Discs	13.71	Answers	13.96
Automatic Adjuster Pins.....	13.72		
Torque Tube	13.72		
Brake Housing and Piston Condition	13.72		
Seal Condition	13.72		
Replacement of Brake Linings	13.72		
Brake Malfunctions and Damage	13.72		
Overheating.....	13.73		
Dragging.....	13.73		

SUB-MODULE 14

LIGHTS (ATA 33)

Knowledge Requirements	14.1
Aircraft Lighting Systems	14.2
Exterior Lights.....	14.2
Navigation/Position Lights	14.2
Anti-Collision Lights	14.2

Landing Lights	14.3
Taxi Lights	14.4
Wing Ice Inspection Lights	14.4
Interior Lights	14.5
Flight Deck/Control Cabin Lighting	14.5
Passenger Cabin Lights	14.5
Cargo Compartment Lighting	14.5
Emergency Lighting	14.6
Questions	14.7
Answers	14.8

SUB-MODULE 15 OXYGEN (ATA 35)

Knowledge Requirements	15.1
Oxygen and The Atmosphere.....	15.2
Human Respiration and Circulation	15.2
Sources of Oxygen	15.3
Oxygen Storage	15.4
Gaseous Oxygen Tanks	15.4
Chemical or Solid Oxygen	15.5
Onboard Oxygen Generating Systems (OBOGS) ..	15.6
Liquid Oxygen.....	15.6
Oxygen Charging.....	15.7
Oxygen Systems and Supply Regulation	15.9
Continuous-Flow Systems.....	15.9
System Layout: Cabin (Continuous Flow)	15.9
Demand-Flow Systems	15.11
Diluter-Demand	15.12
Pressure Demand	15.12
System Layout: Cockpit	15.12
Chemical Oxygen Systems	15.15
Electronic Pulse Demand Systems	15.15
LOX Systems.....	15.16
Oxygen System Distribution	15.16
Oxygen Indication and Warnings	15.17
Oxygen System Maintenance.....	15.19
Leak Testing Gaseous Oxygen Systems	15.19
Draining an Oxygen System	15.19
Purging an Oxygen System.....	15.19
Inspection of Masks and Hoses.....	15.20
Replacement of Tubing, Valves, and Fittings	15.21
Oxygen System Safety	15.21
Questions	15.23
Answers	15.24

SUB-MODULE 16

PNEUMATIC/VACUUM (ATA 36)

Knowledge Requirements	16.1
Vacuum Systems	16.2
System Layout	16.2
Cockpit	16.2
Cabin	16.2
Pneumatic Systems	16.2
High Pressure Systems	16.2
System Layout.....	16.3
Sources	16.3
Storage.....	16.4
Charging	16.4
Distribution.....	16.4
Supply Regulation.....	16.5
Emergency Back-Up Systems and Pneudraulics ..	16.5
Nitrogen Bottles.....	16.5
Gear Emergency Extension Cable and Handle ..	16.6
Dump Valve	16.6
Emergency Extension Sequence:	16.6
High Pressure Pneumatic PowerSystem Maint. ..	16.7
Medium Pressure Pneumatic Systems	16.7
System Layout.....	16.7
Sources	16.7
Storage.....	16.7
Pressure Control	16.8
Distribution.....	16.10
Pressure and Vacuum Pumps	16.11
Overview	16.11
Classification of Pumps	16.12
Types of Pumps.....	16.12
Vane Pump, Wet-Type and Dry-Type	16.12
Piston Pump	16.12
Centrifugal Impeller Pump	16.13
Turbine Engine Compressor	16.13
Roots Type Blower	16.14
Vacuum Pumps.....	16.14
Flight Deck Indications	16.15
Indications and Warnings	16.15
Interface With Other Systems.....	16.15
Questions	16.17
Answers	16.18

CONTENTS

SUB-MODULE 17

WATER/WASTE (ATA 38)

Knowledge Requirements	17.1
Water/Waste Systems.....	17.2
Layout	17.2
Supply.....	17.2
Distribution	17.2
Servicing	17.3
Draining.....	17.4
Toilet Systems.....	17.5
Flushing	17.6
Layout	17.6
Servicing	17.6
Corrosion Aspects	17.8
Questions	17.11
Answers	17.12

SUB-MODULE 18

ON BOARD MAINTENANCE SYSTEMS (ATA 45)

Knowledge Requirements	18.1
Introduction	18.2
Central Maintenance Computers.....	18.2
BITE.....	18.5
Data Loading Systems	18.6
Electronic Library System	18.7
Printing	18.7
Structure Monitoring	18.8
Questions	18.9
Answers	18.10

SUB-MODULE 19

INTEGRATED MODULAR AVIONICS (ATA 42)

Knowledge Requirements	19.1
Introduction	19.2
Integration of Avionics.....	19.2
Digital Data Bus Use Reduces Wiring	19.4
Core System	19.5
Network Components	19.6
777 AIMS	19.6
Questions	19.11
Answers	19.12

SUB-MODULE 20

CABIN SYSTEMS (ATA 44)

Knowledge Requirements	20.1
Introduction	20.2
Cabin Intercommunication Data System	20.2
Cabin Network Service	20.2
Cabin Core System.....	20.3
777 Cabin Services System	20.3
InFlight Entertainment (IFE)	20.4
External Communication System	20.5
Cabin Mass Memory System	20.5
Cabin Monitoring System	20.6
Miscellaneous Cabin Systems	20.6
Questions	20.7
Answers	20.8

SUB-MODULE 21

INFORMATION SYSTEMS (ATA 46)

Knowledge Requirements	21.1
Aircraft General Information Systems	21.2
Flight Deck Information System	21.2
777 Electronic Flight Bag	21.2
Maintenance Information System	21.3
Passenger Cabin Information System	21.4
Miscellaneous Information Systems	21.5
Questions	21.7
Answers	21.8
Acronym Index.....	A.1
Index	I.1

AEROPLANE AERODYNAMICS AND FLIGHT CONTROLS

The directional control of a fixed wing aircraft takes place around the lateral, longitudinal, and vertical axes by means of flight control surfaces designed to create movement about these axes. These control devices are hinged or movable surfaces through which the attitude of an aircraft is controlled during takeoff, flight, and landing. They are usually divided into two major groups: 1) primary or main flight control surfaces and 2) secondary or auxiliary control surfaces.

PRIMARY FLIGHT CONTROL SURFACES

The primary flight control surfaces on a fixed wing aircraft include: ailerons, elevators, and the rudder. The ailerons are attached to the trailing edge of both wings and when moved, rotate the aircraft around the longitudinal axis. The elevator is attached to the trailing edge of the horizontal stabilizer. When it is moved, it alters aircraft pitch, which is the attitude about the horizontal or lateral axis. The rudder is hinged to the trailing edge of the vertical stabilizer. When the rudder changes position, the aircraft rotates about the vertical axis (yaw). **Figure 1-1** shows the primary flight controls of a light aircraft and the movement they create relative to the three axes of flight.

Primary control surfaces are usually similar in construction to one another and vary only in size, shape, and methods of attachment. On aluminum light aircraft, their structure is often similar to an all metal wing. This is appropriate because the primary control surfaces are simply smaller aerodynamic devices. They are typically made from an aluminum alloy structure built around a single spar member or torque tube to which ribs are fitted and a skin is attached. The lightweight ribs are, in many cases, stamped out from flat aluminum sheet stock. Holes in the ribs lighten the assembly. An aluminum skin is attached with rivets. **Figure 1-2** illustrates this type of structure, which can be found on the primary control surfaces of light aircraft as well as on medium and heavy aircraft.

Primary control surfaces constructed from composite materials are also commonly used. These are found on many heavy and high performance aircraft, as well as gliders, homebuilt, and light sport aircraft. The weight and strength advantages over traditional construction can be significant. A wide variety of materials and

construction techniques are employed. **Figure 1-3** shows examples of aircraft that use composite technology on primary flight control surfaces. Note that the control surfaces of fabric covered aircraft often have fabric covered surfaces just as aluminum skinned (light) aircraft typically have all aluminum control surfaces. There is a critical need for primary control surfaces to be balanced so they do not vibrate or flutter in the wind.

Performed to manufacturer's instructions, balancing usually consists of assuring that the center of gravity of

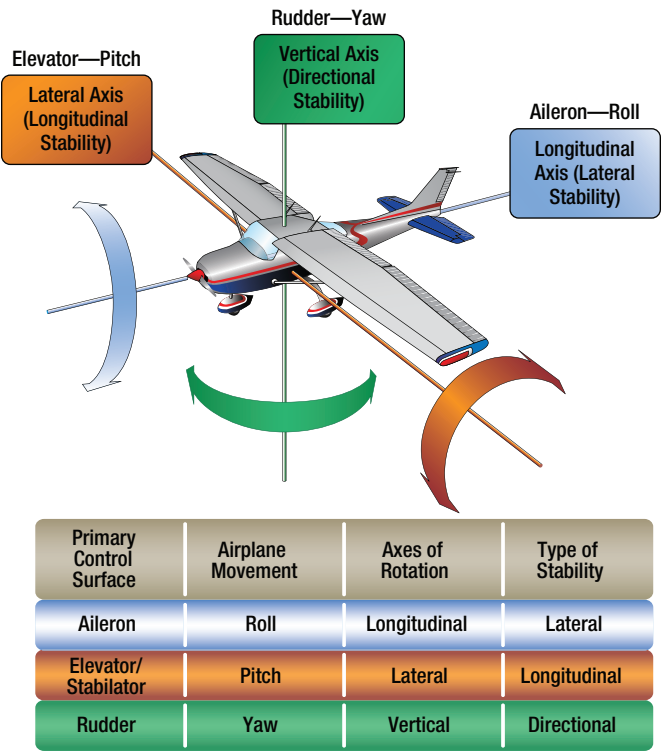


Figure 1-1. Flight control surfaces move the aircraft around the three axes of flight.

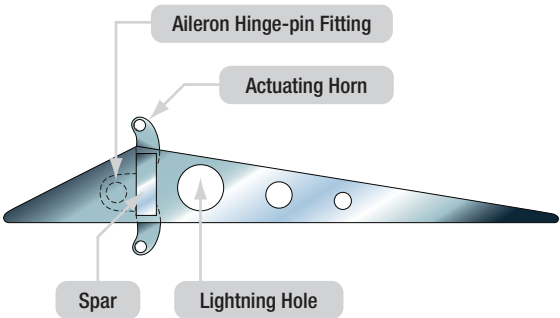


Figure 1-2. Typical structure of an aluminum flight control surface.

a particular device is at or forward of the hinge point. Failure to properly balance a control surface could lead to catastrophic failure. **Figure 1-4** illustrates several aileron configurations with their hinge points well aft of the leading edge. This is a common design feature used to prevent flutter.

OPERATION AND EFFECT OF ROLL CONTROL DEVICES

AILERONS

Ailerons are the primary flight control surfaces that move the aircraft about the longitudinal axis. In other words, movement of the ailerons in flight causes the aircraft to roll. Ailerons are usually located on the

outboard trailing edge of each of the wings. They are built into the wing and are calculated as part of the wing's surface area. **Figure 1-5** shows aileron locations on various wing tip designs.

Ailerons are controlled by a side to side motion of the control stick in the cockpit or a rotation of the control yoke. When the aileron on one wing deflects down, the aileron on the opposite wing deflects upward. This amplifies the movement of the aircraft around the longitudinal axis. On the wing on which the aileron trailing edge moves downward, camber is increased and lift is increased. Conversely, on the other wing, the raised aileron decreases lift. (**Figure 1-6**) The result is a sensitive response to the control input to roll the aircraft.

The pilot's request for aileron movement and roll are transmitted from the cockpit to the actual control surface in a variety of ways depending on the aircraft. A system of control cables and pulleys, push pull tubes, hydraulics, electric, or a combination of these can be employed. (**Figure 1-7**)



Figure 1-3. Composite control surfaces and some of the many aircraft that utilize them.

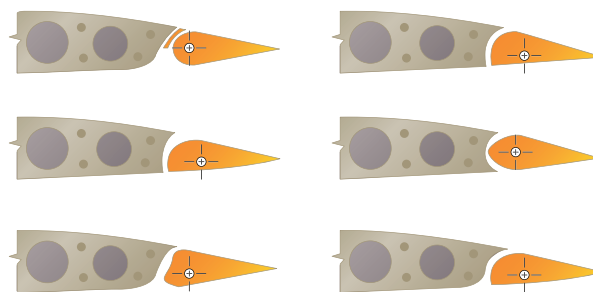


Figure 1-4. Aileron hinge locations are very close to but aft of the center of gravity to prevent flutter.

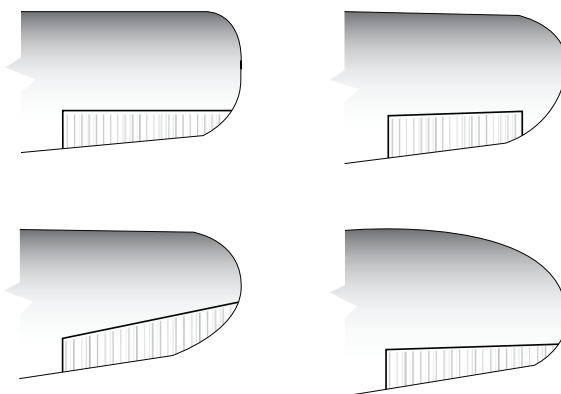


Figure 1-5. Aileron location on various wings.

Simple, light aircraft usually do not have hydraulic or electric fly by wire aileron control. These are found on heavy and high performance aircraft. Large aircraft and some high performance aircraft may also have a second set of ailerons located inboard on the trailing edge of the wings. These are part of a complex system of primary and secondary control surfaces used to provide lateral control and stability in flight. At low speeds, the ailerons may be augmented by the use of flaps and spoilers. At high speeds, only inboard aileron deflection is required to roll the aircraft while the other control surfaces are locked out or remain stationary. **Figure 1-8** illustrates the location of the typical flight control surfaces found on a transport category aircraft.

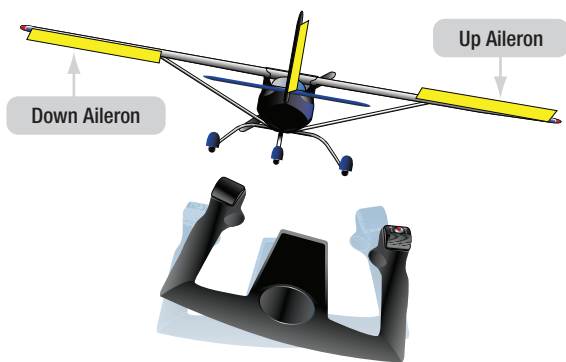


Figure 1-6. Differential aileron control movement. When one aileron is moved down, the aileron on the opposite wing is deflected upward.

SPOILERS

A spoiler is a device found on the upper surface of many heavy and high performance aircraft. It is stowed flush to the wing's upper surface. When deployed, it raises up into the airstream and disrupts the laminar airflow of the wing, thus reducing lift.

Spoilers are made with similar construction materials and techniques as the other flight control surfaces on the aircraft. Often, they are honeycomb core flat panels. At low speeds, spoilers are rigged to operate when the ailerons operate to assist with the lateral movement and

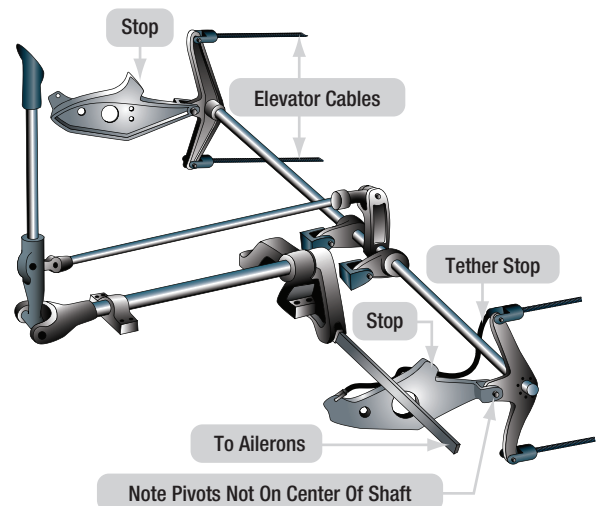


Figure 1-7. Transferring control surface inputs from the cockpit.

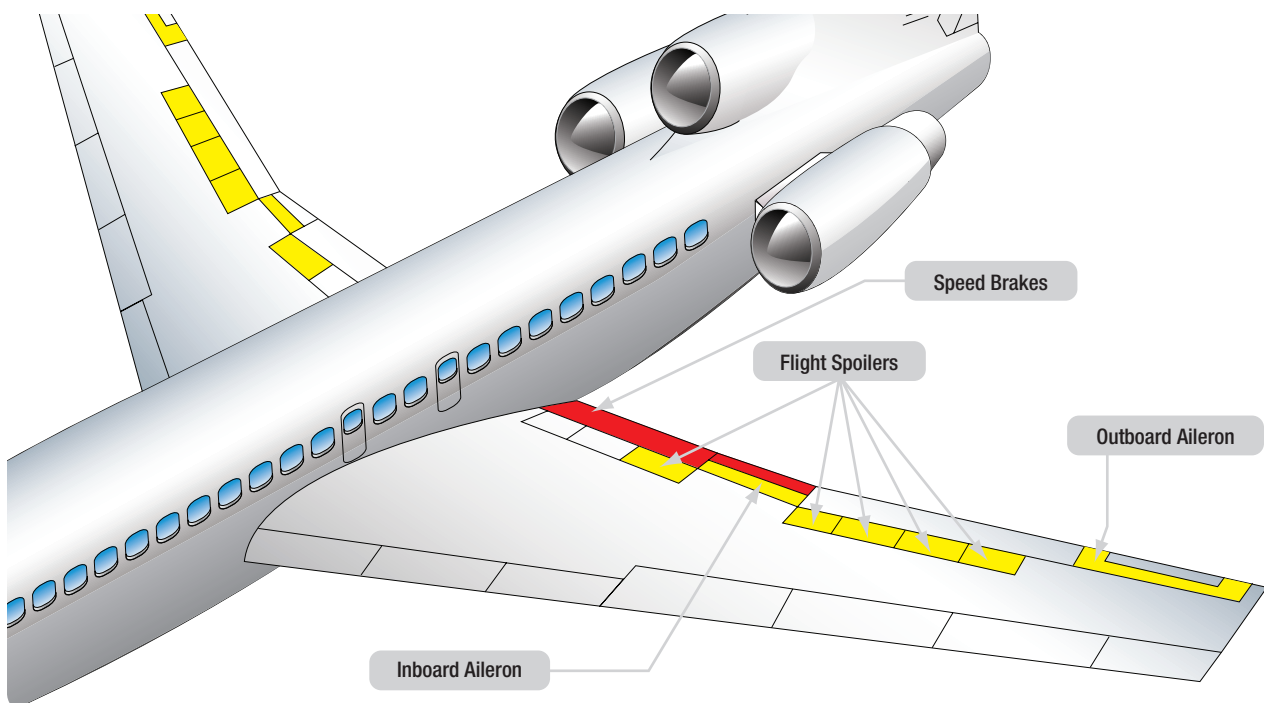


Figure 1-8. Typical flight control surfaces on a transport category aircraft.

stability of the aircraft. On the wing where the aileron is moved up, the spoilers also raise thus amplifying the reduction of lift on that wing. (*Figure 1-9*)

On the wing with downward aileron deflection, the spoilers remain stowed. As the speed of the aircraft increases, the ailerons become more effective and the spoiler interconnect disengages. Note that spoilers are also used in as drag inducing devices.

OPERATION AND EFFECT OF PITCH CONTROL DEVICES

ELEVATORS

The elevator is the primary flight control surface that moves the aircraft around the horizontal or lateral axis. This causes the nose of the aircraft to pitch up or down. The elevator is hinged to the trailing edge of the horizontal stabilizer and typically spans most or all of its width. It is controlled in the cockpit by pushing or pulling the control yoke forward or aft.

Light aircraft use a system of control cables and pulleys or push pull tubes to transfer cockpit inputs to the movement of the elevator. High performance and large aircraft typically employ more complex systems. Hydraulic power is commonly used to move the elevator on these aircraft. On aircraft equipped with fly by wire controls, a combination of electrical and hydraulic power is used.

STABILATORS

A movable horizontal tail section, called a stabilator, is a control surface that combines the action of both the horizontal stabilizer and the elevator. (*Figure 1-10*) Basically, a stabilator is a horizontal stabilizer that can also be rotated about the horizontal axis to affect the pitch of the aircraft.

VARIABLE INCIDENCE STABILIZERS

A variable incidence stabilizer refers to any horizontal stabilizer in which the angle of incidence of the horizontal stabilizer is adjustable. Thus, a stabilator is a variable incidence horizontal stabilizer. Various mechanisms and operating rigging are available. Most large aircraft use a motorized jackscrew to alter the position of the stabilizer often energized by the trim tab switch on the control yoke. The reason for a stabilator or any horizontal stabilizer variable incidence device is to minimize drag when trimming the aircraft in flight. Deflection of the elevator via the use of a trim tab causes drag and requires a relatively



Figure 1-9. Spoilers deployed upon landing a transport category aircraft.



Figure 1-10. A stabilator and index marks on a transport category aircraft.

large elevator on large aircraft to achieve all desired trim settings. By varying the angle of the horizontal stabilizer to adjust pitch, less drag is created and elevator size and deflection may be reduced. (*Figure 1-11*)

CANARDS

A canard utilizes the concept of two lifting surfaces. It functions as a horizontal stabilizer located in front of the main wings. In effect, the canard is an airfoil similar to the horizontal surface on a conventional aft tail design.

The difference is that the canard actually creates lift and holds the nose up, as opposed to the aft tail design which exerts downward force on the tail to prevent the nose from rotating downward. (*Figure 1-12*)

The canard design dates back to the pioneer days of aviation, most notably used on the Wright Flyer. Recently, the canard configuration has regained popularity and is appearing on newer aircraft. Canard designs include two types, one with a horizontal surface of about the same size as a normal aft tail design, and the other with a surface of the same approximate size and airfoil shape of the aft mounted wing known as a tandem wing configuration. Theoretically, the canard is considered more efficient because using the horizontal surface to help lift the weight of the aircraft should result in less drag for a given amount of lift.

OPERATION AND EFFECT OF YAW CONTROL DEVICES

RUDDERS

The rudder is the primary control surface that causes an aircraft to yaw or move about the vertical axis. This provides directional control and thus points the nose of the aircraft in the direction desired. Most aircraft have a single rudder hinged to the trailing edge of the vertical stabilizer. It is controlled by a pair of foot operated rudder pedals in the cockpit. When the right pedal is pushed forward, it deflects the rudder to the right which moves the nose of the aircraft to the right. The left pedal is rigged to simultaneously move aft. When the left pedal is pushed forward, the nose of the aircraft moves to the left.

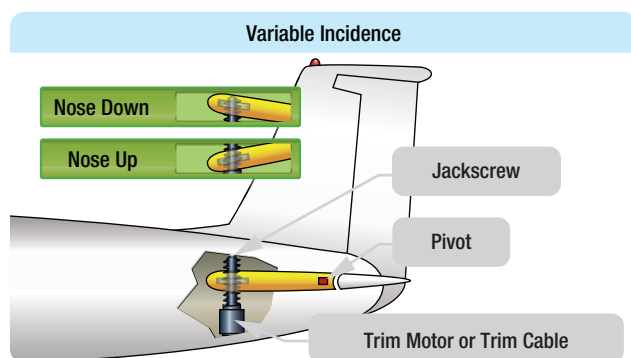


Figure 1-11. Some airplanes, including most jet transports, use an variable stabilizer to provide the required pitch trim forces.

As with the other primary flight controls, the transfer of the movement of the cockpit controls to the rudder varies with the complexity of the aircraft. Many aircraft incorporate the directional movement of the nose or tail wheel into the rudder control system for ground operation. This allows the operator to steer the aircraft with the rudder pedals during taxi when the airspeed is not high enough for the control surfaces to be effective. Some large aircraft have a split rudder arrangement. This is actually two rudders, one above the other. At low speeds, both rudders deflect in the same direction when the pedals are pushed. At higher speeds, one of the rudders becomes inoperative as the deflection of a single rudder is aerodynamically sufficient to maneuver the aircraft.

RUDDER LIMITERS

In flight, most large aircraft oscillate slightly from side to side. Yaw dampener units automatically detect this movement and send signals to the hydraulic power control unit (PCU) that moves the rudder so that it can correct for these yaw oscillations. Similarly, rudders are known to deflect without being commanded to do so by the flight crew. Again, the yaw dampener is designed to correct the fluctuations by signaling the PCU. However, too large of an involuntary deflection to a rudder can cause a loss of control of the aircraft.

A rudder limiter is fitted to many aircraft to prevent any more than a few degrees of involuntary motion of the rudder. Essentially, it limits the movement unless it is commanded from the flight deck.



Figure 1-12. The Piaggio P180 includes a variable-sweep canard design, which provides longitudinal stability about the lateral axis.

SECONDARY OR AUXILIARY CONTROL SURFACES

There are several secondary or auxiliary flight control surfaces. Their names, locations, and functions of those for most large aircraft are listed in *Figure 1-13*.

OPERATION AND EFFECT OF TABS

TRIM TABS

The force of the air against a control surface during the high speed of flight can make it difficult to move and hold that control surface in the deflected position. A control surface might also be too sensitive for similar reasons. Several different tabs are used to aid with these types of problems. The table in *Figure 1-14* summarizes the various tabs and their uses. While in flight, it is desirable for the pilot to be able to take his or her hands and feet off of the controls and have the aircraft maintain its flight condition.

Trims tabs are designed to allow this. Most trim tabs are small movable surfaces located on the trailing edge of a primary flight control surface. A small movement of the tab in the direction opposite of the direction the flight control surface is deflected, causing air to strike the tab, in turn producing a force that aids in maintaining the flight control surface in the desired position. Through

linkage set from the cockpit, the tab can be positioned so that it is actually holding the control surface in position rather than the pilot. Therefore, elevator tabs are used to maintain the speed of the aircraft since they assist in maintaining the selected pitch. Rudder tabs can be set to hold yaw in check and maintain heading. Aileron tabs can help keep the wings level.

Occasionally, a simple light aircraft may have a stationary metal plate attached to the trailing edge of a primary flight control, usually the rudder. This is also a trim tab as shown in *Figure 1-15*. It can be bent slightly on the ground to trim the aircraft in flight to a hands off condition when flying straight and level. The correct amount of bend can be determined only by flying the aircraft after an adjustment. Note that a small amount of bending is usually sufficient.

BALANCE TABS

The aerodynamic phenomenon of moving a trim tab in one direction to cause the control surface to experience a force moving in the opposite direction is exactly what occurs with the use of balance tabs. (*Figure 1-16*) Often, it is difficult to move a primary control surface due to

Secondary/Auxiliary Flight Control Surfaces		
Name	Location	Function
Flaps	Inboard trailing edge of wings	Extends the camber of the wing for greater lift and slower flight. Allows control at low speeds for short field takeoffs and landings.
Trim Tabs	Trailing edge of primary flight control surfaces	Reduces the force needed to move a primary control surface.
Balance Tabs	Trailing edge of primary flight control surfaces	Reduces the force needed to move a primary control surface.
Anti-balance Tabs	Trailing edge of primary flight control surfaces	Increases feel and effectiveness of primary control surface.
Servo Tabs	Trailing edge of primary flight control surfaces	Assists or provides the force for moving a primary flight control.
Spoilers	Upper and/or trailing edge of wing	Decreases (spoils) lift. Can augment aileron function.
Slats	Mid to outboard leading edge of wing	Extends the camber of the wing for greater lift and slower flight. Allows control at low speeds for short field takeoffs and landings.
Slots	Outer leading edge of wing forward of ailerons	Directs air over upper surface of wing during high angle of attack. Lowers stall speed and provides control during slow flight.
Leading Edge Flap	Inboard leading edge of wing	Extends the camber of the wing for greater lift and slower flight. Allows control at low speeds for short field takeoffs and landings.

NOTE: An aircraft may possess none, one, or a combination of the above control surfaces.

Figure 1-13. Secondary or auxiliary control surfaces and respective locations for larger aircraft.

Flight Control Tabs			
Type	Direction of Motion (in relation to control surface)	Activation	Effect
Trim	Opposite	Set by pilot from cockpit. Uses independent linkage.	Statically balances the aircraft in flight. Allows “hands off” maintenance of flight condition.
Balance	Opposite	Moves when pilot moves control surface. Coupled to control surface linkage.	Aids pilot in overcoming the force needed to move the control surface.
Servo	Opposite	Directly linked to flight control input device. Can be primary or back-up means of control.	Aerodynamically positions control surfaces that require too much force to move manually.
Anti-balance or Anti-servo	Same	Directly linked to flight control input device.	Increases force needed by pilot to change flight control position. De-sensitizes flight controls.
Spring	Opposite	Located in line of direct linkage to servo tab. Spring assists when control forces become too high in high-speed flight.	Enables moving control surface when forces are high. Inactive during slow flight.

Figure 1-14. Various tabs and their uses.

its surface area and the speed of the air rushing over it. Deflecting a balance tab hinged at the trailing edge of the control surface in the opposite direction of the desired control surface movement causes a force to position the surface in the proper direction with reduced force to do so. Balance tabs are usually linked directly to the control surface linkage so that they move automatically when there is an input for control surface movement. They also can double as trim tabs, if adjustable on the flight deck.

SERVO TABS

A servo tab is similar to a balance tab in location and effect, but it is designed to operate the primary flight control surface, not just reduce the force needed to do so. It is usually used as a means to back up the primary control of the flight control surfaces. (*Figure 1-17*)

On heavy aircraft, large control surfaces require too much force to be moved manually and are usually deflected out of the neutral position by hydraulic actuators. These power control units are signaled via a system of hydraulic valves connected to the yoke and rudder pedals.

On fly by wire aircraft, the hydraulic actuators that move the flight control surfaces are signaled by electric input. In the case of hydraulic system failure(s), manual linkage to a servo tab can be used to deflect it. This, in turn, provides an aerodynamic force that moves the primary control surface.

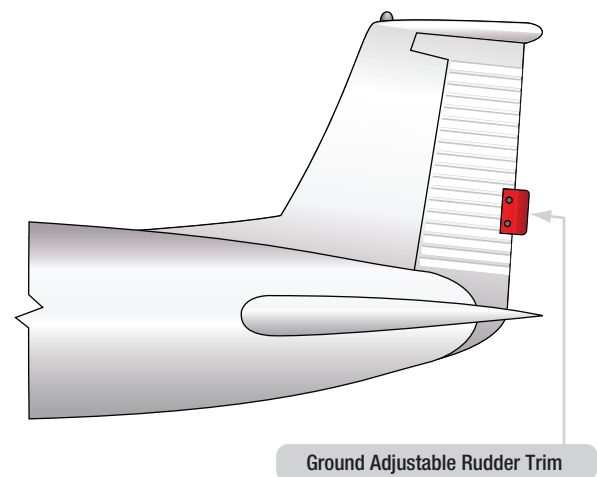


Figure 1-15. Example of a trim tab.

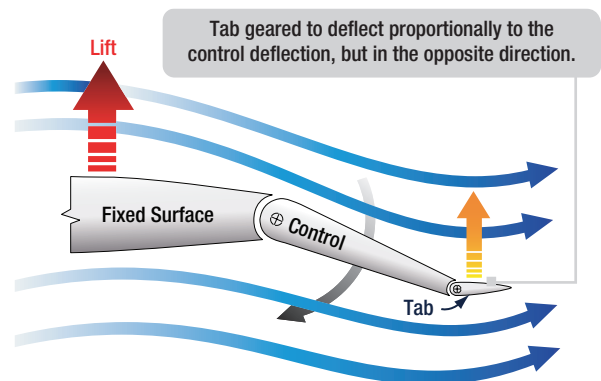


Figure 1-16. Balance tabs assist with forces needed to position control surfaces.