The

Aviator's Handbook

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Qualified Flying Instructor
DGCA Designated Examiner

Fifth Edition

2025

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The Aviator's Handbook

First published in 2021
by Cdr Thomas Tom

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"This book is akin to a 'one stop shop', where 'rookies', as well as those aspiring for higher qualifications can find what they need".

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Director
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Wg Cdr S Chakravarty
Chief Ground Instructor
IGRUA

"The Aviator's Handbook is an easy to understand, interactive & is designed for aspiring aviators. A must-have in your Nav-bag!"

Hemant DP
Chief Executive Officer
Asia Pacific Flight Training

What this book is…

Dear aviator, if you are starting out in your aviation career or want to expand your professional horizons, or if a CPL/ATPL is your aim, then you will have no choice but to study from many excellent, but voluminous and expensive aviation books, such as:

- Oxford Aviation Academy Ground Training (14 volumes)
- FAA Handbooks for Aviation (multiple volumes)
- AP3456 - RAF Manual for Flying (14 volumes)
- Ground Studies for Pilots (6 volumes)
- ATPL 1000 Questions - Keith Williams (7 volumes)
- IAF Flight Instructor School précis (5 volumes)
- ICAO Annexes/Docs & many more…

You will have to read, study, make notes, and have it ready for revision before your exams. Who has the time for all this these days? This is where The Aviator's Handbook can help you. The contents of this book come from my personal studies and flying experience in the last 20 years, and are researched from all the books mentioned above.

This book has its humble beginning as my personal notes, which I meticulously made and maintained throughout my flying career. Through this book, I want to share with you my journey, what I learnt, and what you will need to study. As far as possible, I have avoided the use of technical jargon and complex formulae. In the course of making this handbook, I adhered to three guiding principles:

- Use a language as simple as possible.
- All topics should be fully covered.
- Each topic should not exceed one page.

This book will serve you as a strong foundation on your quest for knowledge. It is for people like you & me… the average pilot, the busy aviator, the CPL/ATPL aspirant. Use this book as an exam preparatory tool or as a quick reference handbook of aviation knowledge. I hope both experienced and inexperienced pilots will find their own use of this book. Rest assured, this book will save you a lot of time.

I wish you all blue skies, tailwinds and happy landings.

Cdr Thomas Tom
Kochi, 22 Feb 2020

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After all, we all are here to learn, aren't we?

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How can you benefit from this book?

Student Pilots aspiring for CPL/ATPL

This book encompasses the entire gamut of professional knowledge a budding aviator needs. It includes all the topics that will be taught to you during your initial pilot training, be it in the defence forces or civil aviation. It also covers the entire syllabus for CPL/ATPL exams. Carry this handbook to all your ground subject classes. Rather than making any notes yourself, you could tick-off the topics in this book as and when they are covered in your course. And as you come closer to your exam dates, you will soon realise - this book is your best friend.

Military Aviators

My colleagues, there is no question about it… you all are 'Top-Gun'. You have flown high, close to the edge of space, and have pulled countless 'g's. You have flown low over the vast blue oceans in radio silence to track enemy targets. You have flown deep into the endless deserts and jungles to rescue countless civilian lives by risking yours. But trust me. Civil aviation is a very different ball game, in a different arena, run by a different set of rules. Here, your knowledge of regulations, performance, air-conditioning & safety of passengers is more important than your ability to do a perfect 'upward-clover'. This book will help you reduce your burden while preparing for your ATPL exams, and align you faster with your new career, by adding to your existing knowledge.

Experienced Civil Pilots

You are the stalwarts of aviation. And experience, just like vintage wine, only gets better with age. However, age and memory do not always go hand-in-hand, and we need to keep revisiting our textbooks from time to time. This book is just what you need. It is a reference manual for aviation subjects and is an indispensable and invaluable encyclopaedia that deals with all aspects of aeronautical information. It will help you brush up on your facts and keep you at the top of your game, at all times.

Flight Instructors

My dear colleagues, you are the torch-bearers of this fine profession, and an enormous burden rests on your shoulders to impart quality training to your pupils. Each chapter in this book is laid out in an optimal sequence, allowing your students to progressively build from foundational to more complex topics. You may also use this book as a reference to set minimum standards of knowledge on each topic. As you prepare for your lecture, a quick read of that topic in this book will help refresh your memory. This book will also come in handy when you set a question paper for trainee pilots.

Dedicated to

My Parents. I am what I am, because of you.
My Wife. You are my anchor.
My Daughters. You are my happiness.
My Sister. This would not have been possible without you.

&

My Instructors. You had faith in me.
And most importantly, my Pupils.
I have learnt from you, more than you have from me.

Subjects

Flight is freedom in its purest form,
To dance with the clouds which follow a storm;
To roll and glide, to wheel and spin,
To feel the joy that swells within;
To leave the earth with its troubles and fly,
And know the warmth of a clear spring sky;
Then back to earth at the end of a day,
Released from the tensions which melted away.

Should my end come while I am in flight,
Whether brightest day or darkest night;
Spare me your pity and shrug off the pain,
Secure in the knowledge that I'd do it again;
For each of us is created to die,
And within me I know,
I was born to fly.

- Gary Claud Stokor

1

Air Regulations

Rules & regulations for flying

Contents

1.1 International Agreements

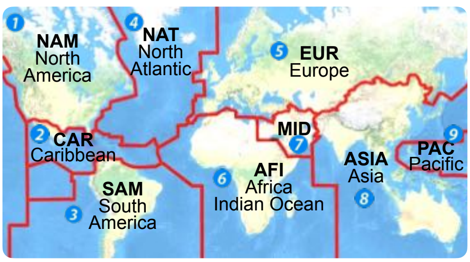
Introduction

The aviation industry, due to its peculiar nature of worldwide operations, is subject to extensive international rules and regulations. The need for a common worldwide set of rules, particularly for safety, was recognised early on. Many international conventions have been organised over the years. A few important ones are:

- **1929 Warsaw Convention:** It established operator liability, rules for delays, and compensations for loss of life, injury, baggage & freight.
- **1944 Chicago Convention:** It established the 'International Civil Aviation Organisation' (ICAO), as a UN agency.
- **1952 Rome Convention:** It laid down rules regarding damage caused by a foreign aircraft to third parties on the ground.
- **1963 Tokyo Convention:** It laid down rules regarding penal law, i.e. offences and acts committed on board an aircraft.
- **1970 Hague Convention:** It established rules concerning hijackers.
- **1971 Montreal Convention:** It laid down the authority of the 'Captain of aircraft' and rules against unlawful acts, i.e., destruction of aircraft in flight, destruction of nav-aids, etc.

ICAO International Civil Aviation Organisation

- ICAO was formed to encourage the safe & efficient development of international commercial aviation.
- Its HQ is at Montreal, Canada. Its 7 regional offices assist, maintain & implement air navigation plans of their respective 9 geographic regions.



1 2	Mexico City	NAM, CAR
3	Lima (Peru)	SAM
4 5	Paris (France)	NAT, EUR
6	Nairobi (Kenya)	East & South Africa
6	Dakar (Senegal)	West & Central Africa
7	Cairo (Egypt)	MID
8 9	Bangkok (Thailand)	ASIA, PAC

7 Geographic Regions and 9 Regional Offices

ICAO Assembly
(Consists of 193 contracting States. They meet once in 3 years)

Council
(Governing Body)
(Consists of 33 contracting States, elected by Assembly for a 3-year term)

Commissions & Committees
- Air Navigation Commission
- Air Transport Committee
- Legal Committee
- Finance Committee
- Committee of Unlawful Interference
- Personnel Committee
- Committee for joint support of air-navigation services

Secretariat
- Air Navigation Bureau
- Air Transport Bureau
- Technical Assistance Bureau
- Legal Bureau
- Administration & Services

1.1

Definitions

- **Contracting State:** Any State that is a party to the International Civil Aviation Convention, signed in Chicago on 7 December 1944.
- **Territorial Airspace:** Airspace bounded within a State's geographic boundary and extends unlimited vertically.
- **High Seas:** All the seas outside of a State's territorial sea.
- **Cabotage:** Transport of goods or passengers within one country (domestic services), by an aircraft registered in another country.
- **Annexes:** These are Standards & Recommended Practices (SARPs) on aviation procedures, finalised by the 'Air Navigation Commission' and adopted by ICAO. There are 19 Annexes.
- **PANS:** Annexes are 'technical' in nature and need further explanation, which are published as **'**PANS' (Procedure for Air Nav Services).
- **Docs:** Documents containing aviation procedures & recommendations that are not yet mature enough for inclusion in Annexes.

Important Obligation of Contracting States

- **National & International Law:** If a 'contracting state' has 'adopted' and 'ratified' Chicago Convention and ICAO rules, they are binding. They have to enforce Annexes (SARPs) in their territorial airspace, unless they notify ICAO the differences and publish it in their AIP within 60 days.

> **In India:** it is published in AIP section 1.7

- **Right to prosecute offenders**
  - **In the air:** State in whose airspace the offence was committed has the right to prosecute.
  - **Over land:** Rules of State above which aircraft is flying will apply.
  - **Over international waters:** International law will apply.
  - **Over high seas:** State where aircraft was registered will prosecute.
- **Search & Rescue:** All Contacting States must provide SAR facilities within its territory, maintain a high level of cooperation with adjacent states and must assist with SAR requests.
- **Cargo Restrictions:** No state shall carry 'munitions of war' above another State without its permission. Dangerous cargo, if carried, must be compliant as per Annex 18.
- **Searching of Aircraft:** Any contracting State has the right to search an aircraft of another contracting State on landing or before departure.

International Air Transit Agreements

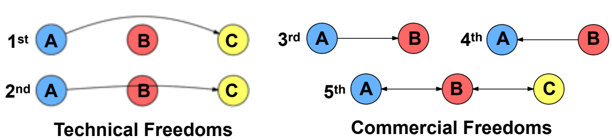
They are a set of rights granting a country's airline the right to enter & land in another country. They came about during the Chicago convention, as a result of concerns of smaller countries over the extent of commercial aviation domination asked by bigger countries (like the US).

Technical Freedoms

1st degree: Freedom to overfly another country.
2nd degree: Land in another country for technical requirements/fuelling.

Commercial Freedoms

3rd: Fly with passengers from their own country to another country.
4th: Pick up passengers from another country & drop them in own country.
5th: Pick up passengers from another country & drop in a third country.



Unofficially, there are 6th, 7th, 8th & 9th degrees of freedom too (combinations of these 5).

ICAO Annexes

Annex 1 Personnel Licensing	*Ch 1.5*
Annex 2 Rules of Air	*Ch 1.6*
Annex 3 Meteorological Services for Air Navigation	*Ch 10.26*
Annex 4 Aeronautical Charts	*Ch 8.6*
Annex 5 Units of Measurement	
Annex 6 Operation of Aircraft	*Ch 1.7, 2.1 - 4*
Part I - International Commercial Air Transport	
Part II - International General Aviation	
Part III - International Operations for Helicopters	
Annex 7 Nationality and Registration Marks	*Ch 1.4*
Annex 8 Airworthiness of Aircraft	*Ch 1.3*
Annex 9 Facilitation	*Ch 1.29*
Annex 10 Aeronautical Telecommunications Service	*Ch 1.22, 3.1*
Volume I - Radio Nav-aids	
Volume II - Communication Procedures	
Volume III - Communication Systems	
Volume IV - Surveillance Radar & ACAS	
Volume V - Aeronautical Frequency Utilisation	
Annex 11 Air Traffic Services	*Ch 1.15, 16, 17*
Annex 12 Search & Rescue	*Ch 1.30*
Annex 13 Aircraft Accident Investigation	*Ch 1.32*
Annex 14 Aerodromes	*Ch 1.21*
Volume I - Aerodrome Design & Operations	
Volume II - Heliports	
Annex 15 Aeronautical Information Service	*Ch 1.23*
Annex 16 Environmental Protection	
Volume I - Noise	
Volume II - Emissions	
Volume III - CO_2 Emission	
Volume IV - Carbon Offsetting	
Annex 17 Security - Unlawful Interference	*Ch 1.31, 2.24*
Annex 18 Safe Transport of Dangerous Goods by Air	*Ch 2.22*
Annex 19 Safety Management	

Important ICAO Docs

4444 PANS ATM - Air Traffic Management	*Ch 1.18 - 20, 8.5*
7030 Regional Supplementary Procedures	*Ch 2.8*
7333 Search and Rescue	*Ch 1.30*
8126 AIS Aeronautical Information Services Manual	*Ch 1,23*
8168 PANS OPS - Aircraft Operations (2 Parts)	*Ch 1.8 - 14, 2.9-10*
8400 PANS ABC - Abbreviations & Codes	*Ch 3.1*
9365 All Weather Operations	*Ch 2.7*
9432 Manual of Radio Telephony	*Ch 3.1 - 9*
9433 Interception of Civil Aircraft	*Ch 1.6*
9613 PBN Performance Based Navigation Manual	*Ch 1.25*
9756 Accident Incident Reporting	
9868 PANS TRG - Training	
9981 PANS AD - Aerodromes	*Ch 1.21*
10085 EDTO Extended Diversion Time Operations	*Ch 1.28*

There are around 260 Docs published by ICAO under various heads. Some of the important Docs are mentioned above.

1.1

Important Aviation Organisations & their functions

IATA International Air Transport Association
- It is an international organisation that lobbies for the interests of airline companies.

ECAC European Civil Aviation Conference
- It was established by ICAO in 1955 to institute standard aviation policies and a safe/sustainable air transport system in Europe.

EASA European Aviation Safety Agency
- It is the Aviation safety organisation in the European Union & represents civil aviation regulatory authorities of EU States. It was established in 2002.
- It took over functions of JAA for establishing common regulatory standards & procedures, licensing, etc.

JAA Joint Aviation Authorities
- It was a cooperation of aviation authorities in Europe.
- It was established in 1970 for common certification standards. It was disbanded in 2009 by EASA.
- Only the training organisation, JAA-TO, remains.

ITU International Telecom Union
- It is the oldest international organisation.
- It was established on 17 May 1865.
- It is now part of the UN, with HQ in Geneva.
- They set up standards for 'radio-frequency spectrum management'.
- Their main document is **ITU RR** (Radio Regulations).

DGCA Director General Civil Aviation
- It is the regulatory body for civil aviation in India.
- They issue CARs (Civil Aviation Requirements).
- They deal with**:**
  - Licensing of pilots & ATC controllers;
  - Registration of aircraft, Airworthiness;
  - Grant of Air Operator Certificate for operators;
  - Accident investigation;
  - Amendments to the Aircraft Act, Aircraft Rules, etc

AAI Airports Authority of India
- It was formed in 1995. They deal with**:**
  - Provision of ATS services in their aerodrome;
  - Provision of nav-aids, comm-aids;
  - Publishing AIPs, NOTAMs, PIBs;
  - Design, development and maintenance of aerodromes.

WPC Wireless Planning & Coordination (India)
- It was set up in 1962 under the Ministry of Communication to implement the policies of ITU.

1.2

National Law (India)

(Ref: 1934 Aircraft Act, 1937 Aircraft Rules)

1920 Indian Aircraft Rules: It mainly deals with rules regarding customs.

1934 Aircraft Act

It governs manufacture, operations, sale and import of aircraft. However, the Central Government can, by a 'Gazette', exempt anyone from this.

- Penalty for contravention of this Act**:** 2 years prison + Rs.10 lakh fine.
- These rules apply to**:**
  - Citizens of India, wherever they are;
  - Aircraft & passengers on an aircraft registered in India; and on and aircraft not registered in India but is currently flying over India;
  - Aircraft operated by a non-Indian, but his business is in India.
- Govt has the power to detain any a/c & has wreck & salvage rights.
- Penalty for slaughtering animals/depositing rubbish within 10 km of an aerodrome ARP**:** 3 years prison + Rs.10 lakh fine.

> In 2024, Bharatiya Vayuyan Vidheyak has been enacted to replace the Aircraft Act of 1934, marking a significant modernisation of India's aviation regulations.

1937 Aircraft Rules

It lays down regulations for civil aviation in India. Amendments to these rules are published by DGCA in AIC. Some important Aircraft Rules are**:**

- Crew must communicate with a boom-mic:
  - When receiving 'departure clearance',
  - When on the ground and the engines are running,
  - In air and the aircraft is below TA or 10000' (whichever is higher).
- **Prohibited Areas** shall not be overflown by any aircraft.
- **Supersonic flight** is not permitted in Indian airspace.
- **Climb-cruise** technique is not permitted in Indian airspace.
- **Aerobatics** is not permitted within 6 nm of an aerodrome & below 6000'
- **Formation flying** is not permitted for any civil aircraft in India.
- **Military a/c formation** must be within **.**5 nm laterally & 100' vertically. Formation must operate as a single unit for nav/position reporting. Separation between a/c in formation is the responsibility of flight leader.
- **Night Flying:** Any flying ½ hr after sunset to ½ hr before sunrise.
- **Succession of Command** of crew is to be published by the operator.
- **Radio:** No person will operate an aircraft radio without an RTR license.
- **Hangar:** Aircraft with fuel in their wings must be parked in a well-ventilated hangar certified with non-inflammable materials.

1954 Aircraft Public Health Rules

These are rules regarding health and safety in aviation.

- The PIC shall inform ATC at least 2 hrs before arrival if any person on board the aircraft is suffering from infectious/quarantinable disease.
- Disinfecting, if required, must be done at least 30 mins before landing.
- Dead bodies of yellow fever, plague or anthrax are not allowed on a/c. Other dead bodies are allowed if they are properly enclosed in a coffin.

1994 Rules on obstructions/demolition w.r.t. buildings around aerodromes.
2003 Rules on the carriage of dangerous goods
2011 Rules on Aircraft Security
2012 Rules regarding Aircraft Accident Investigation

1.3

Airworthiness

ICAO Annex 8 Part 3, Aircraft Act 1934

Introduction

Airworthiness certification is the process that ensures that an aircraft is designed, flight tested and manufactured as per stringent safety standards and is certified to be safe and fly-worthy. The Aviation Regulatory Organisation of the State where the aircraft is manufactured issues the 'Type Certificate' for a particular aircraft model and subsequent model variants (FAA USA for Boeing, EASA France for Airbus, etc.). Based on the Type Certificate, the State of registry, after a short 'compliance test', issues the Certificate of Airworthiness to individual aircraft once that aircraft gets its registration number.

Annex 6 deals with airworthiness standards needed for safe operations.

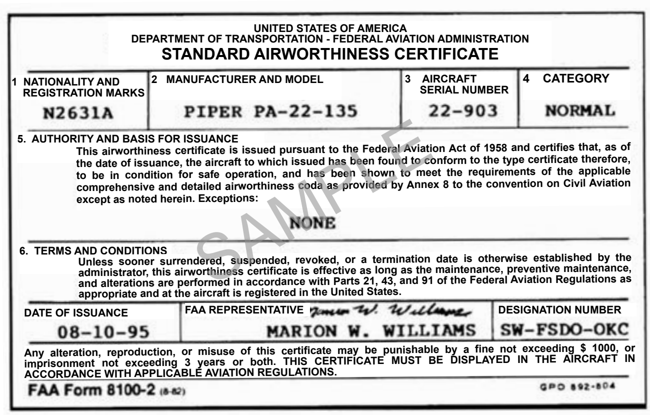
Annex 8 deals with airworthiness from an engineering point of view,

Applicability

'C of A' is applicable to all multi-engine aircraft with more than 5700 kgs intended for carriage of passengers, cargo, or mail.

Certificate of Airworthiness

- Type certificate ensures that the aircraft is developed & manufactured properly and is fit to fly. The country of the manufacturer has to ensure that aircraft standards are equal to or above that of ICAO regulations.
- Standard C of A form contains aircraft nationality, registration marks, designation of aircraft (e.g. Boeing 747-400) and its serial number.
- C of A is issued/renewed/cancelled by the State of registration. It is re-validated at periodic aircraft inspections, as per the rules of the State.
- C of A is applicable for the life of the aircraft, provided that all aircraft maintenance procedures are adhered to. If an aircraft is damaged, C of A will be re-issued only after repair and inspection.
- To ensure continued airworthiness, the State of Registry must ensure that the operators have a system for a continuing structural integrity programme, defect monitoring, record maintenance, and corrosion control, for all aircraft with AUW > 5700 kg.
- C of A must be displayed at the cabin or cockpit entrance, so that it is visible for all passengers and crew.
- The State may temporarily exempt C of A for a prototype aircraft.



UNITED STATES OF AMERICA
DEPARTMENT OF TRANSPORTATION - FEDERAL AVIATION ADMINISTRATION
STANDARD AIRWORTHINESS CERTIFICATE

1 NATIONALITY AND REGISTRATION MARKS	2 MANUFACTURER AND MODEL	3 AIRCRAFT SERIAL NUMBER	4 CATEGORY
N2631A	PIPER PA-22-135	22-903	NORMAL

5. AUTHORITY AND BASIS FOR ISSUANCE
This airworthiness certificate is issued pursuant to the Federal Aviation Act of 1958 and certifies that, as of the date of issuance, the aircraft to which issued has been found to conform to the type certificate therefore, to be in condition for safe operation, and has been shown to meet the requirements of the applicable comprehensive and detailed airworthiness coda as provided by Annex 8 to the convention on Civil Aviation except as noted herein. Exceptions:

NONE

6. TERMS AND CONDITIONS
Unless sooner surrendered, suspended, revoked, or a termination date is otherwise established by the administrator, this airworthiness certificate is effective as long as the maintenance, preventive maintenance, and alterations are performed in accordance with Parts 21, 43, and 91 of the Federal Aviation Regulations as appropriate and at the aircraft is registered in the United States.

DATE OF ISSUANCE	FAA REPRESENTATIVE	DESIGNATION NUMBER
08-10-95	MARION W. WILLIAMS	SW-FSDO-OKC

Any alteration, reproduction, or misuse of this certificate may be punishable by a fine not exceeding $ 1000, or imprisonment not exceeding 3 years or both. THIS CERTIFICATE MUST BE DISPLAYED IN THE AIRCRAFT IN ACCORDANCE WITH APPLICABLE AVIATION REGULATIONS.

FAA Form 8100-2 (8-82) GPO 892-804

SAMPLE

Sample Airworthiness Certificate

1.4

Aircraft Registration / Markings

ICAO Annex 7

Introduction

As per Annex 7, all aircraft must be registered in a State (like any vehicle) consisting of a Nationality mark + a Registration mark (separated by a 'hyphen'). However, the State may temporarily exempt registration (for prototype flights) or markings (for historic/military aircraft).

Certificate of Registration

- It is an official document certifying that the 'State of Registry' has registered the aircraft. It is valid until the destruction of the aircraft.
- No one shall fly an aircraft unless it is registered and nationality/ registration marks are painted on the aircraft. However, under special circumstances, they may be flown without it, with written permission from the regulatory agency. E.g., an experimental test flight aircraft.
- No aircraft registered in a State will fly outside that State unless it has a valid permit from the State regulatory agency.
- **Information contained in Certificate of Registration**
  - Manufacturer's designation
  - Year of manufacture
  - Nationality & registration marks
  - Serial number
  - Name & address of owner
  - Date of registration
  - If leased, the name of the lessee and lessor.

Nationality Mark

These are a group of letters/numbers selected from the 'International Radio Callsigns' allocated by ITU (International Telecom Union) to the State registry, who in turn sub-allots them to various State departments.

> **In India:** WPC is the State Registry that allots aircraft callsigns and nationality-marks to the DGCA.
> **Callsigns allotted by ITU to India**: ATA - AWZ, VTA - VWZ, 8TA - 8YZ.
> **Nationality mark allotted for Indian aircraft: VT** (civil) **VU** (military)

Registration Mark

They are assigned by the State registry to the aircraft. These could be any letters except the 5-letter codes from 'International Code of Symbols', or 3-letter 'Q Codes', or SOS / PAN / XXX / TTT.

Nationality and registration marks must be painted on the underside of wings (50 cm wide), between the wing/tail (30 cm wide) & on the tail (30 cm wide).

Common Mark

It is used by operators that are registered in more than one country. ITU allocates these codes to ICAO. e.g., 4YB is 'Arab Air Cargo' registered in Iraq and Jordan.

Classification of Aircraft

- **Heavier than Air**
  - Airplane, Helicopter *(Powered)*
  - Glider *(Non-powered)*
- **Lighter than Air**
  - Air Ship *(Powered)*
  - Ballon *(Non-powered)*

2

Op Procedures

Procedures for operating a safe flight

Contents

2.1

General Requirements

ICAO Annex 6

Introduction

'Operational Procedures' deal with aircraft operations in commercial air transport. Rules governing these are primarily given in Annex 6 (Part 1). Parts of Annex 6 are:

Part 1 - Aeroplane (International Commercial Air Transport)
Part 2 - Aeroplane (General Aviation)
Part 3 - Helicopters (International Commercial Air Transport)

Compliance with Law

Operators engaged in international operations must ensure that the aircraft and crew are conversant with and comply with the laws of the foreign State and the airspace the aircraft is flying in, as well as the laws of the State in which the aircraft is registered.

Common Language

Operators must ensure that the language used for verbal crew communication and the language used for writing the crew's duties in the 'Operations Manual' are the same.

Operational Control

Operator or a designated representative will have operational control of an aircraft (initiation, diversion, termination, etc.). This responsibility may only be delegated to the Commander (or PIC Pilot in Command).

Flight Safety and Accident Prevention

- The State has to establish 'Safety Programs' for all operators to:
  - Identify safety hazards.
  - Provide continuous monitoring of the safety levels achieved.
  - Ensure remedial actions to maintain minimum standards.
  - Make continuous improvements for the overall level of safety.
- A 'Flight Safety Documentation System' is to be established by operators. These documents should be published using standard phraseology and the crew must be notified of any amendments.
- A 'Flight Data Analysis Program' is to be maintained by the operator for all aircraft with AUW > 27000 kg as part of their safety program.

Maintenance Release

- Before a flight (after any maintenance work has been done), the PIC should check the aircraft documentation to confirm the airworthiness of the aircraft. He should check:
  - Identity of the maintenance organisation.
  - Date and time of maintenance.
  - Details of maintenance done, referenced to approved books.
  - Identity of the person signing the release.

Ditching

Ditching is an intentional attempt to land an aircraft over the sea/water surface because the aircraft cannot fly to the nearest land due to any emergency. To minimise this risk, no aircraft with pax > 30 is to fly 400 nm or 120 mins cruise flying time from the coast (whichever is less), unless the aircraft is EDTO compliant. *(See also: **2.21** OP > Ditching)*

Documents to be Carried Onboard

- Certificate of Registration *(original)*
- Certificate of Airworthiness *(original)*
- Air Operator Certificate *(original)*
- Noise Certificate *(original)*
- Aircraft Radio License *(original)*
- Aircraft Insurance
- Crew License *(original)*
- Journey Logbook
- Operator Manual

Additional Documents

- NOTAMs/Briefing material
- Passenger manifest
- Cargo manifest
- Flight plan
- Mass & Balance sheet
- Special pax list (Security)
- Any dangerous cargo
- Charts & Maps

Information to be Retained on Ground

- Copy of Flight Plan
- Relevant NOTAMs
- Aircraft technical and maintenance log
- Mass & Balance, Load distribution logs

Preservation and Production of Documents

- Operator is to ensure any document required by State inspectors is produced within a reasonable time.
- When required by State representatives, the Commander is to produce any document that is to be carried onboard.
- The operator must retain the original documents for the prescribed time period, even if he ceases to be the operator.
- Following an incident/accident, all CVR/FDR recordings must be retained for 60 days.

Authority of Commander, His Responsibilities & Flight Preparation

He is a designated pilot amongst the flight crew, who is a qualified PIC. He is the final authority as to the disposition and safety of the aircraft. He may delegate his duties to another pilot.

He is the representative of the 'State of registration' from the time he enters the aircraft till he leaves. All crew and passengers are to obey his lawful commands in respect to the safe conduct of a flight.

He is responsible for ensuring**:**

- Compliance of flight with rules of the air.
- Flight planning, awareness of weather.
- Progress of flight is as per MEL (Minimum Equipment List).
- Safety of all crew, passengers & aircraft while he is onboard.
- Carrying all relevant documents, manuals, charts (incl diversion), etc.
- Loading/Offloading of passenger and cargo.
- He can refuse to carry deportees/cargo in the interest of flight safety.
- Ensure aircraft CG & weight limitations are catered for.
- Ensuring CVR/FDR is not switched OFF, except in situations where CVR data needs to be saved and keeping it ON might over-write it.

Crew Responsibilities

They have to discharge their duties in accordance with the Operator Manual in the interest of passengers and flight safety. Any fault, malfunction or incident has to be reported to the commander.

Crew shall not perform duties on an aircraft if:

- They are under the influence of medication.
- They have consumed alcohol 12 hrs before duty cycle or if the blood alcohol content is more than 0.2 pro-mille.
- They know or suspects that he is fatigued.
- Following blood donation or scuba diving > 30 ft, for a period of 24 hrs.

Carriage of Persons

- Operator must ensure no stowaways/hidden-cargo are onboard.
- Operator must ensure that crew and passengers are carried only in authorised parts of an aircraft.
- Passengers will not allowed to share seats, except for infants.
- A Commander can permit temporary access to unauthorised parts of an aircraft if he deems it necessary for flight safety considerations.

Admission to Fight Deck

It is permitted only for operating Crew, State representatives for the conduct of their duty, and persons permitted to do so as per Operator Manual, at the discretion of the Commander.

Alcohol & Smoking

- No alcohol is to be consumed by the crew 12 hours before a flight.
- No alcohol must be served on domestic flights.
- Where the safety of passengers would be affected, no person under the influence of alcohol or drugs is permitted to board an aircraft.
- Smoking is not permitted on civil passenger aircraft.
- Smoking is permitted in a private aircraft if certified in its ‘Certificate of Airworthiness’. Signs must be displayed where & when smoking is prohibited/allowed. However, it is not permitted during take-off, landing or refuelling.

Portable Electronic Devices

Operator is to take all reasonable measures to prevent the use of PEDs onboard, which could adversely affect the functioning of aircraft system and equipment.

Lease of Aircraft

When an airline uses an aircraft owned by another company, it is called leasing. Types of leasing are:

- **Dry Lease:** Aircraft is operated under AOC of borrowing company.
- **Wet Lease:** Aircraft is operated under AOC of the leasing company.

Before each flight a pilot must make sure his bladder is empty and his fuel tanks are full.

2.2

Operator Certification & Ops Manual

AOC Air Operator Certificate

AOC is the authority for an operator to carry out commercial air transport operations. AOC is issued by the State's aviation governing agency, after ensuring the following:

- Operator must not have another AOC from another authority, unless otherwise specifically approved.
- All aircraft belonging to the operator must be airworthy certified, and maintained as per the manufacturer's guidelines.
- Operator must demonstrate safe operations & financial viability.
- Operator must ensure that planned destination and diversion aerodromes are of an acceptable safety standard.
- Operator's main base must be fully established with support facilities.
- Operators must exercise full operational control of all flights. The method by which this control is exercised must be included and approved in their Operations Manual.
- All administrative posts in the airline, as required by the State, are to be maintained by the operator, such as:
  - Flight Operations Manager
  - Maintenance System Manager
  - Ground Operations Manager
  - Crew Training Manager

Contents of AOC

- Name and address of the operator.
- Date of issue and validity.
- Description of type of operations allowed and area of operations.
- Registration markings of the aircraft.
- Area of operations.
- Any limitations imposed.
- Special aircraft approval, if any (RVSM, RNAV, ETOPS, etc.).

Suspension of AOC

Authorities can conduct periodic/random audits to ensure operator compliance with rules. AOC can be suspended if the State is convinced that safe operations cannot be continued.

Competence of Personnel

Operator is to ensure all personnel employed are trained, checked, and competent regarding the discharge of their duties.

Aircraft Maintenance

Operator is to ensure that all aircraft are maintained and inspected, and that proper records are maintained as per regulations and manufacturer instructions.

3

Communications

How pilots & ATC talk to each other

Contents

3.1

General Procedures

ICAO Annex 10 Vol II (Communication Procedures)
Doc 8400 Abbreviations & Codes

*(Must read: **1.6** REGS > Rules of the Air > Definitions)*
(Must read: Appendix A > Abbreviations)

Introduction

RT Phraseology has been carefully developed to provide maximum clarity and brevity while ensuring information is unambiguous. Using non-standard, ambiguous phrases could compromise to flight safety, especially in busy airspace with congested frequencies. However, when necessary during unique scenarios, plain-english language can be used on RT, but keeping it clear & concise.

Pronunciation of Letters & Numbers

Similar sounding alphabets can cause confusion, e.g. 'C' - 'V' or 'A' - '8'. To mitigate this, pronunciations on RT have been standardised.

Alphabets

A (Alfa)	AL-fah	**J** (Juliet)	JEW-li-ETT	**S** (Sierra)	see-AIR-rah
B (Bravo)	BRAH-voh	**K** (Kilo)	KEY-loh	**T** (Tango)	TANG-go
C (Charlie)	CHAR-lee	**L** (Lima)	LEE-mah	**U** (Uniform)	YOU-ni-form
D (Delta)	DELL-tah	**M** (Mike)	mike	**V** (Victor)	VIK-tah
E (Echo)	ECK-oh	**N** (November)	no-VEM-ber	**W** (Whiskey)	WISS-key
F (Foxtrot)	FOKS-trot	**O** (Oscar)	OSS-car	**X** (X ray)	ECKS-ray
G (Golf)	golf	**P** (Papa)	pah-PAH	**Y** (Yankee)	YANG-key
H (Hotel)	hoh-TEL	**Q** (Qubec)	keh-BECK	**Z** (Zulu)	ZOO-loo
I (India)	IN-dee-ah	**R** (Romeo)	ROW-me-oh		

Numbers

0 - ZE-RO	**1** - WUN	**2** - TOO	**3** - TREE	**4** - FOW er
5 - FIFE	**6** - SIX	**7** - SEV en	**8** - AIT	**9** - NIN er
Decimal Day-see-Mal		**Hundred** Hun-dred		**Thousand** Tou-sand

Numbers in 'hundreds' or 'thousands' used to describe the altitude of FLs are said as 'whole numbers'. Remaining FLs and terms like 'squawk code' or 'bearings' use 'single digit' pronunciations. E.g.:

FL 90	*Flight Level Niner Zero (Not Zero Niner Zero)*
FL 100	*Flight level One Hundred*
Altitude 800'	*Altitude Eight hundred feet*
Altitude 1600'	*Altitude One thousand six hundred feet*
Altitude 12000'	*Altitude One Two thousand feet*
Visibility 3000m	*Visibility Three thousand meters*
Visibility 6 km	*Visibility Six kilometres*
RVR 800 / 1500	*RVR Eight hundred / One thousand five hundred*
Heading 060	*Heading Zero Six Zero*
Wind 360 / 06	*Wind Three Six Zero degrees Zero Six Knots*
Runway 19	*Runway One Nine*
QNH 1010	*QUE ENN ECH One Zero One One*

The following words may be omitted while transmitting on RT, provided there is no ambiguity.
surface (when reporting surface winds)
degrees (when reporting headings)
visibility, *clouds*, *height* (when reporting Met)
hectopascals (when reporting QNH)

Frequencies

Use six digits, except where the last 2 digits of frequency are both zero, in which case only the 1st four digits are transmitted.

Fq 123.565	*Frequency One Two Three decimal Five Six Five*
Fq 124.7	*Frequency One Two Four decimal Seven*

Call Signs

All aeronautical fixed & mobile stations are to have their own callsigns.

Call Signs of ATS Units

Area Control Centre	*Control*
Radar (in general)	*Radar*
Approach control	*Approach*
Approach control radar arrivals	*Arrival*
Approach control radar departure	*Departure*
Aerodrome control	*Tower*
Surface movement control	*Ground*
Clearance delivery	*Delivery*
Precision approach radar	*Precision*
Direction finding station	*Homer*
Flight information service	*Information*
Apron control service	*Apron*
Company dispatch	*Dispatch*

First call by a pilot to an ATS should contain their name & callsign. Once contact is established, name may be omitted for further transmissions.

***Pilot**: Kochi Radar, this is Navy 237.*
***ATC:** Navy 235, go ahead*
***Pilot**: Radar, Navy 237, request descend.*

Call Signs of Aircraft

There are 3 types of aircraft callsigns**:**

Type A: Registration marks. It may be preceded by aircraft type.

Full: *VUBFT* **Abbreviated:** *VFT*
Full: *Boeing VUBFT* **Abbreviated:** *Boeing FT*

Type B: Operator Designator + last 4 chars of registration or flight ID

Full: *Air India UBFT* **Abbreviated:** *Air India FT*
Full: *Air India 719* **Abbreviated:** *-nil-*

Type C: Registration Number

Full: *Navy 237* **Abbreviated:** *-nil-*

First call by an ATC unit to an aircraft should contain their full callsign. Once contact is established, abbreviated call signs can be used.

***ATC:** VUBFT, this is Kochi Radar*
***Pilot**: Kochi Radar, VUBFT, go ahead.*
***ATC**: VFT, descend to FL 60.*

Radio Check

'Radio Check' call is used to check transmission clarity between units. The receiving unit can reply with these standardised replies:

Perfectly readable	*Strength 5*	**Readable now & then**	*Strength 2*
Readable	*Strength 4*	**Unreadable**	*Strength 1*
Readable with difficulty	*Strength 3*		

***Pilot**: Kochi Radar, VUBFT, Radio Check.*
***ATC**: VFT, Kochi Radar, read you Strength 2.*

Time

Time is transmitted in 4-digit UTC. 2400 is midnight, 0001 is the next day. If there is no confusion, just the 2-digit minutes may be transmitted.

08 hrs 03 min 0803 *Time Zero Ait Zero Tree; or Zero Tree*

Categories of Messages

Types of messages have been grouped and is transmitted as per their priority. Sequence of priority is**:**

- **Distress:** Aircraft is being threatened by a serious imminent danger and needs immediate assistance. RT is prefixed with *'MayDay'* x 3
- **Urgency:** Safety of aircraft or a person on board is concerning, but not requiring immediate assistance. RT is prefixed with *'PanPan'* x 3.
- **DF Direction Finding:** RT related to DF messages given to aircraft
- **Flight Safety:** Messages regarding aircraft safety. e.g., ATC Clearances, ATC instructions, Radar vector calls, etc.
- **Meteorological Messages:** weather warnings/deterioration en route.
- **General Messages:** Other messages.

Standard Phrases

Whenever possible, standard phrases are used in RT, and each have a specific meaning. Use of these phrases helps with brevity & clarity.

Affirm	Yes
Approved	Permission for the proposed action is granted.
Break	I indicate the separation between portions of the message.
Break break	Indicates separation between messages for different a/c.
Cancel	Annul the previously transmitted clearance.
Check	Examine a system or procedure; no answer is expected.
Cleared	Authorised to proceed under the conditions specified.
Confirm	Have I; *or* did you correctly receive the following message.
Correct	That is correct.
Contact…	Establish radio contact with … *(fq)*.
Correction	An error has been made in transmission; correct version is...
Disregard	Ignore the previous transmission.
Go ahead	Proceed with your message.
I say again	I repeat for clarity or emphasis.
Maintain	Continue in accordance with the conditions specified.
Monitor…	Listen out on … *(fq)*.
Negative	NO; *or* permission not granted, *or* that is not correct.
Out	Transmissions has ended & no response is expected.
Over	My transmission has ended & I expect a response from you.
Read-back	Repeat all or specified parts back to me exactly as received.
Re-cleared	A change has been made, and this is your new clearance.
Report	Pass me the following information…
Request	I would like to know…; *or* I wish to obtain…
Roger	I have received all of your last transmission. Not to be used for a question that needs an answer in Affirm or negative.
Say again	Repeat all, or a part of your last transmission.
Standby	Wait, I will call you.
Unable	I cannot comply with your request/instruction/clearance.
Wilco	I understand your message and will comply.
Speak slower	Reduce your rate of speech.
How do you read	What is the readability of my transmission?
Acknowledge	Let me know if you have understood the message.

Types of Transmissions

- **Broadcast:** Information relating to air navigation of general nature, that is intended for all flights/ATS-units in that area.
- **Blind Transmission:** One station is transmitting, hoping that the intended station is receiving. This call is generally repeated. This situation may arise due to various reasons, e.g., receiver is not working.

__Pilot__: Kochi Radar, Navy 237, Transmitting Blind, on 123.5, … message.., I say again, - then repeat full call - …

Clearance & Conditional Clearance

Clearance is an approval for an aircraft to takeoff/fly under specific conditions, to ensure separation from all controlled flights. It will always have a clearance limit, the point to which that aircraft is granted air traffic control clearance. All clearances have to be read-back by a pilot.

Conditional Clearance allows an aircraft to execute the instruction only after another event has taken place.

- Conditional Clearance is only used when the aircraft concerned is seen by both pilot and controller. Aircraft or vehicle causing the condition shall be the first aircraft/vehicle to pass in front of the other aircraft concerned.
- The condition must relate to only one movement.
- Conditional clearance is given in the following order and must be read-back in full and in the same sequence as given:
    - Call sign;
    - The condition;
    - The clearance; and
    - Brief reiteration of the condition.

__ATC__: Navy 237, after landing Airbus 321, cross Runway 08, after.
__ATC__: Navy 237, behind landing Boeing 757, line up runway 27, behind.
__ATC__: Navy 237, after passing 4000 feet, fly heading 030.

Mandatory Read-back of Clearances

Some important instructions must be read-back to ATC, to check the accuracy of reception. Reading-back of clearances is vital for ensuring mutual understanding between the pilot and the controller of the intended plan for that aircraft.

- Whenever ATC says "cleared", the pilot must read-back the entire RT call in the same order given, suffixed with the aircraft call sign.
- If a pilot does not 'read-back', ATC will ask for it.
- Writing down the clearance by pilots before read-back is good airmanship. Ensure that all flight crew members listen to clearances when they are being transmitted.
- After read-back, listen & check for ATC confirmation of the read-back.

Clearances that must always be read-back by a pilot

- Taxi instructions
- Departure / Take-off clearance
- Airways / Route clearance
- Level / Heading / Speed instructions
- Approach / Landing clearance
- Enter runway / hold-short / cross / backtrack instructions
- Transition levels
- Frequency changes
- SSR instructions
- Altimeter settings
- Type of radar service

General Transmission Techniques

- Always keep in mind that when you transmit on RT, you represent yourself, your airline, and your country. Take pride in how you represent them.
- Always use a respectful, polite and professional tone. Remember that the ATC controller may be under as much stress as you are, if not more.
- Be aware that English may not be the mother tongue of the person receiving the message. Therefore, speak clearly and always use standard radiotelephony words and phrases.

- **Listen:** Before transmitting on a frequency, listen out if there is anyone else already transmitting. Do not interrupt unless it is urgent.
- **Voice:** Use normal voice and volume; speak clearly and enunciate. Rate of speech should be around '100 words per minute'.
- **Hesitation:** Avoid saying "umm.." "err..", etc., in your call. If you need more time to frame your reply, just say *"stand by"* and release PTT.
- **Microphone:** Don't adjust/touch the microphone/headset-mouthpiece while transmitting; it may distort the transmission.
- **Courtesies:** Use of courtesies (e.g. good morning) should be avoided.
- **Be precise:** Avoid clogging RT by transmitting unnecessary read backs or requests. Don't transmit more information than necessary. But if you do not understand any instructions given by the controller, do not hesitate to ask for clarification.
- **Inappropriate words:** The use of the word 'for' can cause confusion if it is interpreted as the number 'four'. Similarly, the word 'to' directly before a climb/descent or change of heading can be confused with 'two'**.** This can be avoided by using the mandatory words 'flight level' or 'heading' immediately before the numbers.
- **Patience:** Keep in mind that controllers may have additional tasks to accomplish prior to responding to your call. Wait at least 10 seconds before a second call is made.
- **Arguments:** Do not initiate or engage in arguments of any nature on RT. In case of a disagreement of any kind, briefly and politely make your point if you need to, and then revert to standard RT.
- **Abbreviation:** Some commonly used abbreviations are read out 'as-is' e.g., VOR is pronounced VOR and not Victor Oscar Romeo.

(See also: Appendix A > Transmitted as words)

- **PTT:** Do not depress PTT until ready to speak. Depress PTT fully before speaking and do not release it until the message is complete. One of the most irritating and potentially dangerous situations in RT is a 'stuck' PTT. Always ensure that PTT is released after the transmission.
- If the message is long, give frequent pauses by releasing PTT.
- A slight pause before and after numbers will assist in making them easier to understand.
- Controllers should not transmit to an aircraft during take-off, initial climb, last part of final approach or landing roll, unless necessary.
- The word "immediately" should only be used when immediate action is required for flight safety.

__ATC__: Navy 237, turn right heading 090, immediately.

4

Human Performance

Limitations of the human body & mind, during flight

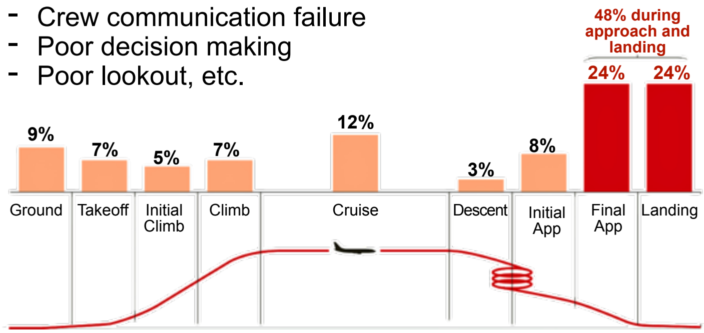
Contents

4.1

Human Performance Limitations

Aviation Accidents

- 73% of all aviation accidents are attributed to 'human factors'. Hence, a sound understanding of human performance and its limitations is vital for all aviators.
- Rate of a fatal aviation accident is approx 1 in every 1 million flights.
- Almost 50% of all accidents occur during approach and landing.
- **CFIT** Controlled Flight Into Terrain is the most common air accident.
- Most common factors of accidents include:
  - Lack of situational awareness
  - Crew communication failure
  - Poor decision making
  - Poor lookout, etc.



Aviation Accident - Stages of Flight

4.2

Atmosphere

Introduction

- Atmosphere extends upwards from the earth's surface, until 800 km.
- 50% of air is below 6 km, 75% below 10 km & 99% below 32 km.
- Approx 99% of all gases in the atmosphere are nitrogen & oxygen.
- Amount of water vapour in the atmosphere depends mainly on the temperature, and varies between 0.2% to 4%.
- **Composition of Atmosphere**

Nitrogen	78% by volume	75% by weight
Oxygen	21% by volume	23% by weight
Argon	0.93% by volume	1.3% by weight
CO_2	0.04% by volume	0.05% by weight

Effects of Increasing Altitude

- Relative proportions of these gases are constant till stratosphere.
- But, as altitude ↑, air density and pressure ↓.

  Density at Sea Level 1.225 Kg/m³

  Density at 36000' 0.365 Kg/m³ *(⅓ of sea level)*
- Thus, quantity of oxygen in a given volume of air is ⅓ as compared to sea level.

*(See also: **4.13** HP > Hypoxia)*

Oxygen Requirement for Aircrew

*(See also: **2.4** OP > Oxygen Requirements)*

- 12000' (4 km) upwards **:** Additional oxygen is required.
- 34000' (11 km) upwards **:** 100% oxygen is required.
- 41000' (14 km) upwards **:** Pressure breathing is essential.
- 63000' (20 km) upwards **: Ebulism** boiling of body fluids occur.
- 75000' (25 km) upwards **:** A sealed cabin is essential.

Nervous System

Human Brain

- Human brain is only 2% of the body weight but consumes 20% of its total energy needs.
- The brain can only deal with one conscious decision at a time.
- 70% of the information processed by the brain is from visual channel.
- **Visual Constancy:** It is the process of recognising familiar objects in unfamiliar conditions.
- **Expectancy** or **Perceptual Set:** To some extent, we perceive what we expect to perceive. Perception is a highly subjective process.
- Top-down processing use previous knowledge to modify mental model.
- Bottom-up processing use sensory info to start building a mental model

Nervous System - It consists of 3 parts**:**

CNS Central Nervous System

- It regulates all conscious and unconscious bodily processes.
- It consists of the brain and the spinal cord, which contains nerve cells that connect information flow between the brain and the body.

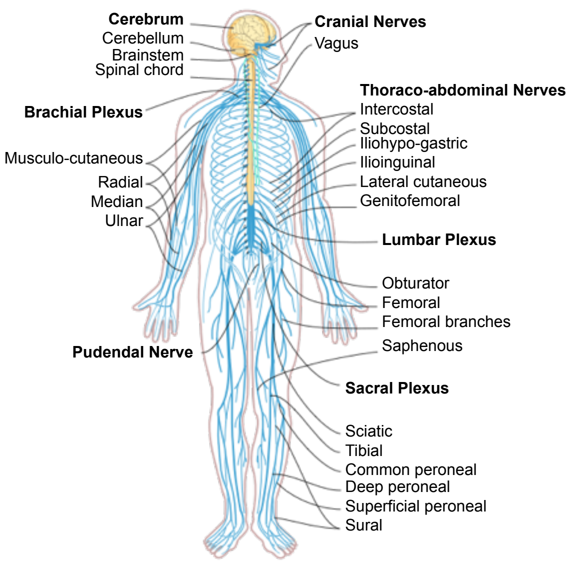
PNS Peripheral Nervous System

- It connects the CNS to all the muscles and organs of the body.
- It controls organs such as skin, blood vessels, muscles, etc.
- It also regulates all the reflex actions.

ANS Autonomous Nervous System

- It functions independently of CNS
- It is a part of PNS, and controls organs such as**:**

Heart	Stomach	Temperature	Urinary output
Intestines	Breathing	Bladder	Blood Pressure
Eyes	Sweating	Glands	Fight/Flight response



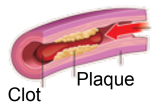
Human Nervous System

4.4

Circulatory System

The Heart

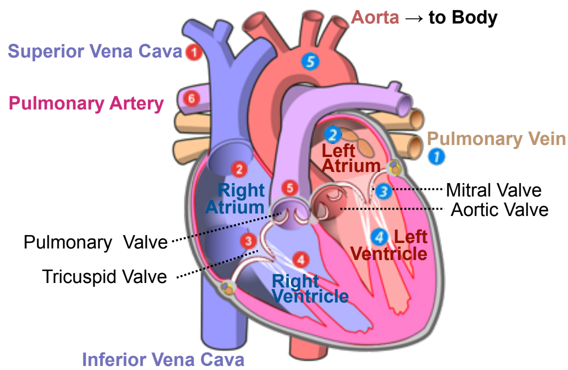
- Average adult resting heart rate is 72 bpm.
- Human heart pumps approximately 5 litres of blood every minute.
- **Blood Pressure:** Normal adult BP is 120*(systolic)* / 80*(diastolic)*.
- **Angina:** Chest pain or discomfort you feel when there is insufficient blood flow for the heart muscles to function, due to a blood clot or plaque buildup in the coronary artery.
- **Heart Attack:** Occurs when an Angina lasts long enough, causing permanent damage to heart muscles. Sometimes, a sudden over-whelming stress can also cause a heart attack.
- Causes of a heart attack**:** Diabetes, high BP, smoking, stress, drinking excessive alcohol, high-fat diet, lack of exercise, etc.



Blood flow obstructed in an artery

Heart Beat

- A heartbeat (systole) has two stages. First, the left & right Atria pump together, pushing blood to the left and right Ventricles through a valve. Then, the left & right Ventricles pump blood out of the heart.
- The heart muscles then relax (diastole), allowing blood to fill the left and right Atria before the heart beats again.
- Oxygenated blood from the Lungs is received through Pulmonary Vein ❶→ Left Atrium ❷→ Mitral Valve ❸→ Left Ventricle ❹→ Aorta ❺→ reaches all tissues & organs.
- Deoxygenated blood from the tissues & organs is received through Superior Vena Cava ❶→ Right Atrium ❷→ Tricuspid Valve ❸→ Right Ventricle ❹→ Pulmonary Valve ❺→ Pulmonary Artery ❻→ Lungs ❼



Blood

*(See also: **4.18** HP > Hypertension)*

- It contains Plasma, that carries all the nutrients, hormones & waste.
- **WBC White Blood Cells** produce antibodies that fight infections.
- **RBC Red blood cells** contain haemoglobin, which carries oxygen.
- **Platelets** assist in the blood clotting process during an injury.
- **Functions of the blood:**
  - Carry oxygen to and CO_2 from organs and tissues.
  - Transport nutrients and hormones that regulate body functions.
  - Help regulate body temperature.
- After donating blood, a 48-hour rest is mandatory.

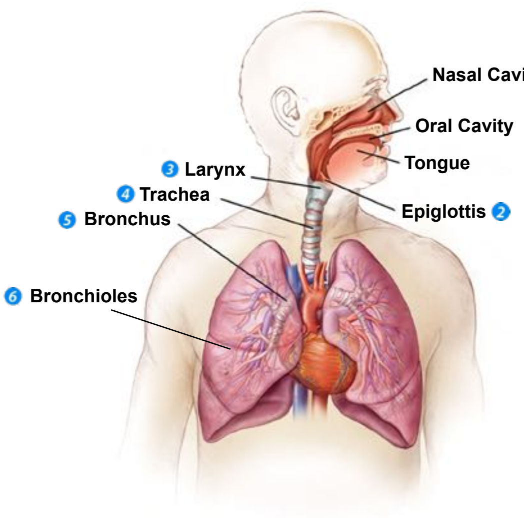
4.5

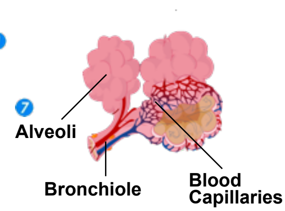
Respiratory System

The Lungs

- During inhalation, air passes through Nasal cavity ❶→ epiglottis ❷→ larynx ❸→ trachea ❹→ bronchus ❺→ bronchioles ❻→ alveoli.❼
- At an alveoli, oxygen transfuses through alveoli membrane & binds to the haemoglobin in the blood. Simultaneously, CO_2 gets released.

- External Respiration: Absorption of O_2 & excretion of CO_2 at the lungs.
- Internal Respiration: Absorption of O_2 & excretion of CO_2 at tissues.
- **Tidal Volume:** Normal respiration volume of lungs, ~ 500 ml.
- **Inspiratory Reserve Volume:** Additional volume that can be inhaled forcefully, ~ 3000 ml.
- **Expiratory Reserve Volume:** Excess volume of air that can be expelled by force breathing out, after tidal volume, ~ 1100 ml.
- **Residual Volume:** Minimum air that remains in lungs, come what may, ~ 1200 ml.
- Average adult breathing rate is 16 times a minute.
- Women have 25% less lung volume than men.
- Level of CO_2 in the blood controls the respiration rate.





- **Epiglottis** : A muscular flap that covers the trachea during swallowing so that food doesn't enter the lungs.
- **Larynx** : Vocal cords or Voice box.
- **Trachea** : Air passage to the lungs.
- **Bronchus** : Air passage that branches from trachea into the lungs.
- **Bronchioles** : Minor air passages.
- **Alveoli** : Tiny air sacs at the end of bronchioles.

Carbon Monoxide Poisoning:

- Carbon monoxide is an odourless, colourless poison. It is a by-product of incomplete fuel combustion.
- Up to 10% of exhaust gases from an engine can be CO.
- Blood Haemoglobin has 250x more affinity with carbon monoxide than oxygen. Thus, when exposed to CO, blood hB gets saturated with it, and its oxygen-carrying capacity reduces drastically. The body tissues are starved of oxygen.
- **Symptoms of CO Poisoning:**
  Dizziness Headache Nausea Impaired Vision
- **Immediate Actions in case of CO Poisoning:**
  Turn off cabin heating, increase ventilation & use oxygen if available.

5

Instruments

Cockpit instrumentation

Contents

5.1

Instrument Design & Layout

Introduction

Pilots receive information about the state and performance of their aircraft through cockpit instruments. From a pilot's perspective, the main requirements for these instruments are:

- **Readability:** Information displayed must be easily readable.
- **Reliability:** Information displayed must be accurate.
- **Range:** Complete range of data required must be displayed.
- **Resolution:** No. of significant digits to which a value is measured.

If a small dial is used and the range required is high (e.g., ASI 0 to 500 kts), then there may not be sufficient resolution, to read speed clearly. Also, since instruments are calibrated for a particular speed, as the range increases, the accuracy of information at the extremities may reduce. In such cases, non-linear, or multi-pointer dials may be used.

Linear Dial
Distance between 20 - 40 kts is same as 120 - 140 kts

Non-Linear High Range Dial
Distance between 20 - 40 kts is more than 120 - 140 kts
Also, pointer travels beyond 360°

Multi Pointer
Long pointer covers 100s
Small pointer covers 1000s

Instrument Layout

The layout of the 'basic flight instruments' is standardised and is consistent in all aircraft. This standard layout is called the 'basic 6' and is always placed right in front of a pilot, ahead of the 'control yoke'.

Colour Coding

Standard colours are used on all instruments to represent 'limits'

- Green : Normal operating range
- Yellow : Cautionary range
- Red : Max limit / Unsafe range

5.2

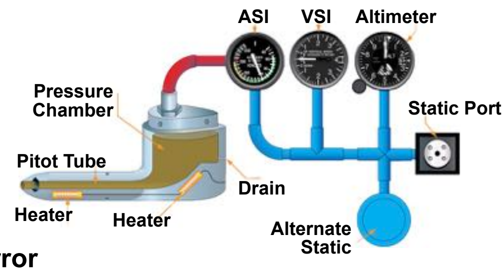
Pitot System

Principle of Pitot System

- Pitot system is a simple way to <u>measure static & dynamic pressure</u> on an aircraft, when flying. It is <u>used in ASI, VSI & Altimeter</u>.
- **Pitot Tube:** It is a tube fitted in front of an aircraft with its mouth open parallel to the airflow in normal flight attitude, to <u>sense dynamic pressure</u>. To do it correctly**:**
  - It must be positioned outside the boundary layer.
  - It should have de-icing provisions & drain holes.

Pitot Tube on an aircraft

- **Static Vent:** It is a simple vent placed on an airframe, with its mouth perpendicular to airflow, to <u>sense static air pressure</u>. No component of dynamic pressure should enter it.
- **Dynamic Pressure:** It is the air pressure acting on a moving aircraft's forward-facing parts, corresponding to ½ ρ v².
- **Static Pressure:** It is the air pressure at that altitude, denoted by 'S'.
- Total pressure inside a Pitot tube = Dynamic (½ ρ v²) + Static (S). or Dynamic pressure (Speed of aircraft) = Pitot - Static pressure.



***Pitot + Static** supplied to ASI & Machmeter*

***Only Static** Supplied to Altimeter & VSI*

Position Error

- Position Error occurs due to suction effect & turbulent airflow around the static vent. Thus, a static vent may not sense static pressure correctly. It is influenced by**:**
  - Position of pitot & static - Configuration**:** u/c, flaps, etc.
  - Angle of attack, Side Slip - Aircraft speed, shock waves.
- This can be reduced by careful design & positioning of static vents.
- 2 interconnected static vents on either side of the aircraft fuselage will also balance out errors caused by sideslipping or yawing.
- Position error is increased during 'Ground Effect'.
- When 'alternate static source' is used, position error may increase.
- It doesn't matter where Static vents are placed on an aircraft; as long as they sense static pressure correctly, instruments will read correctly.

Pitot/Static Blockage Errors

		ASI / Mach meter	VSI	Altimeter
Pitot	Block	Level: Indication freeze Climb: Over read Descend: Under read	*- No Effect -*	*- No Effect -*
	Leak	Under read		
Static	Block	Level: Correct Climb: Under read Descend: Over read	Read '0' through-out	Indication Freeze at that altitude
	Leak	Pressurised a/c: Under read Unpressurised a/c: Over read		Show pressurised cabin altitude

*(See also: **11.2** AD > Static, Dynamic Pressure)*

5.3

Altimeter

*(Must read: **1.27** REGS > Altimeter Setting Procedure)*

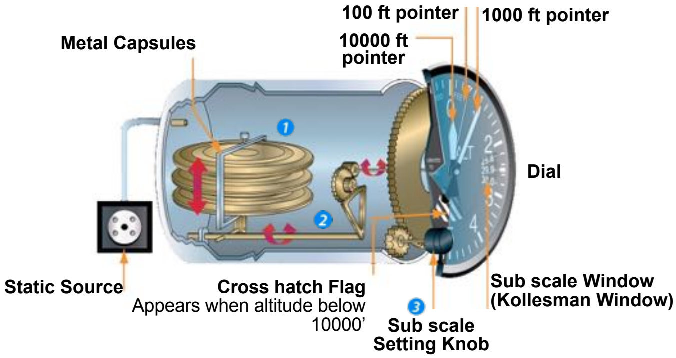
Introduction

- Altimeter is a simple instrument that senses atmospheric static air pressure (from Static vent) and displays it as altitude information. Higher the aircraft, lower the outside pressure, higher the altitude.
- All altimeters are calibrated to ISA temperature/pressure at MSL & ISA Lapse Rate. However, since pressure & temperature reduction rarely follow ISA Lapse Rate, and because there may be local pressure systems, altitude displayed may not always be accurate.
- However, since all altimeters are calibrated on the same datum, a safe vertical separation can be achieved between 2 aircraft maintaining the same altimeter setting (QNH/QNE).

> **Altimeter Calibration:** Altimeter is calibrated to give a linear presentation of the non-linear atmospheric pressure drop by the use of a variable magnification lever. Temperature compensation is also done by the use of a bimetal compensator connected to the linkage system.

Construction

- An altimeter consists of a thin corrugated partially-vacuum metal capsule ❶ ,which is prevented from collapsing by a spring leaf.
- Static pressure from the static vent is fed into the altimeter casing. Changes in static pressure cause the capsule to contract or expand. Mechanical linkages ❷ feed these movements to the altimeter dial.
- A bimetallic strip compensates for capsule movement caused by changes in temperature within the casing.
- To apply correction for local atmospheric pressure variations, every altimeter will have a QNH/QNE setting knob.❸ When QNH is set, the altimeter will read the elevation of the aircraft above the MSL. When QNE (1013) is set, it will read the Flight Level (Pressure Altitude).
- A small vibrating device is an altimeter ↓ friction effect in the linkages.
- An altimeter's sensitivity decreases above 60000’ due to the low pressure and density of the air at that altitude.
- A **Sensitive Altimeter** is one that has 2 or more pointers, as a single pointer is not accurate enough for the entire range. However, multi-pointer altimeters can be easily misread by a pilot.
- A **Servo-Assisted Altimeter** is even more accurate. Instead of mechanical linkages, a position-control servo and induction pickoff system controls pointer movements, virtually eliminating lag error.



Instruments

Errors in an Altimeter

Blockage Error

<table>
<tr><td>Pitot</td><td colspan="2">- No Effect -</td></tr>
<tr><td rowspan="2">Static</td><td>Block</td><td>Indication freeze</td></tr>
<tr><td>Leak</td><td>Show pressurised cabin altitude</td></tr>
</table>

**Partial static block causes lag in indication.*

Lag Error

- Occurs because capsule/linkage movement is not instantaneous.
- Altimeter under-reads during climb, over-reads during descent.
- This error can be eliminated by using servo altimeters.

Instrument Error

- Error due to manufacturing tolerances since a capsule under stress will have imperfect elastic properties.
- It causes delayed reading when leveling out from climb/descend.

Position/Pressure Error

- Due to interference of dynamic pressure at the static vent, an altimeter will under-read. It is caused because of 2 reasons:
  - Wrong positioning of the static vent. It is eliminated by placing 2 static vents, on opposite sides of the airframe.
  - **Manoeuvre Induced Error:** Caused by aircraft manoeuvres.

B
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T
B
Errors in Altimeter

Temperature Error *(High - Low - High error)*

- Cold air mass is denser than standard air. Thus, pressure levels are more closely spaced & pressure decreases more rapidly and altitude increases, which is sensed as even higher altitude. So when an aircraft is flying where the air is colder (higher density than ISA conditions), the altimeter will over-read.
- This error is '0' at sea level & increases with altitude.
- **Altimeter Cold Temperature Corrections** is used to correct this error**.** Altitude is corrected by +4% for every 10°C below standard ISA temp (till -15°C), as measured at the altimeter setting source.

Aerodrome temperature (°C)	*Height above the elevation of the altimeter setting source (feet)*													
	200	300	400	500	600	700	800	900	1 000	1 500	2 000	3 000	4 000	5 000
0	20	20	30	30	40	40	50	50	60	90	120	170	230	280
–10	20	30	40	50	60	70	80	90	100	150	200	290	390	490
–20	30	50	60	70	90	100	120	130	140	210	280	420	570	710
–30	40	60	80	100	120	140	150	170	190	280	380	570	760	950
–40	50	80	100	120	150	170	190	220	240	360	480	720	970	1 210
–50	60	90	120	150	180	210	240	270	300	450	590	890	1 190	1 500

Barometric Error *(High - Low - High error)*

- This error occurs if the actual atmospheric pressure differs from the QNH set on the altimeter sub-scale.
- When flying from a high-pressure area to a low-pressure area, the altimeter will over-read & actual aircraft altitude will be lower.
- The type of terrain below the aircraft can also cause this. Air sweeping around hills cause low pressure on the leeward side.

Altimeter Accuracy

During pre-flight checks, altimeters must be checked for accuracy by setting the QNH and verifying against aerodrome elevation. Indicated altitude must be within ±60'. Avoid tapping the altimeter glass.

Altimeter Accuracy Needed

± 60' (0 to 30000'), ± 80' (30000' to 50000')

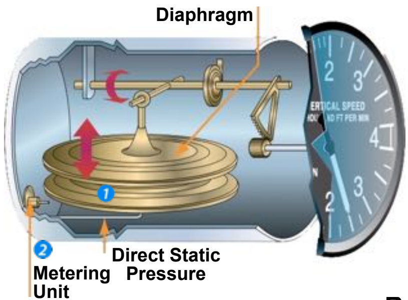
5.4

VSI Vertical Speed Indicator

Construction

- VSI displays the vertical speed of an aircraft by measuring the difference between the static pressure supplied into a capsule (1), inside the VSI and a delayed static pressure fed into the VSI case 4-6 seconds later, through a 'Capillary & Orifice' metering unit (2).
- Static changes with aircraft altitude & delayed static lag behind. By sensing the difference between them, vertical speed is measured.
- The delayed Static is fed into the VSI case by a 'capillary & orifice metering unit' to compensate for pressure & temperature variations.

> **Capillary & Orifice metering unit:** Airflow through a capillary is laminar and the orifice is turbulent. Also, Airflow through a capillary is directly proportional to temperature & inversely proportional through the orifice. So, pressure difference across the capillary ↑ with increase in altitude and temperature. The reverse is true for the orifice. Pressure difference across capillary ↓ with decrease in temperature. The reverse is true for the orifice. Thus, pressure & temperature variations are compensated.



Errors in a VSI

Blockage Error

Pitot	*- No Effect -*	
Static	Block	Read '0' throughout
	Leak	

B L I P Tr *Errors in VSI*

Lag, Instrument, Position/Pressure Error *(same as altimeter errors)*

Transonic Jump: VSI indicates a climb at transonic speeds, because of the lower pressure behind the formation of shock waves.

IVSI Instantaneous VSI

- IVSI consists of an accelerometer (a mass balanced by a spring) that responds immediately to departure from level flight.
- As soon as an aircraft climbs, inertia causes the mass to move, thus, moving the VSI needle. After a few seconds, this effect dies away, and the normal metering unit takes over.
- In IVSI, lag and manoeuvre induced errors are eliminated. However, instrument and position errors still persist.
- IVSI may be too sensitive and indications may fluctuate during turbulence or may show a climb during turns (bank > 40°)

On Ground	: Should read '0'
During Climb/Descend:	± 200 fpm between -20°C to +50°C, ± 300 fpm outside these temperatures

VSI Accuracy Needed

6

Radio & Nav-aids

Radio & navigation aids used for aircraft navigation

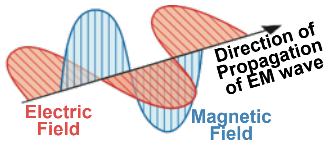
Contents

6.1

Properties of Radio (EM) Waves

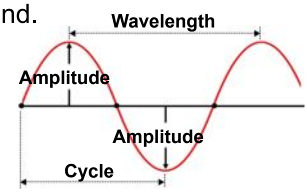
Introduction

- DC (Direct Current) when passed through a wire, causes a steady magnetic field at 90° around it.
- But when an AC (Alternating Current) is passed through a wire, it causes an alternating magnetic field around it.
  This is because, in AC, the electron flow is reversed many times a second. This creates an oscillating magnetic field, which results in a radio wave.



- Radio waves are EM waves (electromagnetic waves), where the electrical field is perpendicular to the magnetic field.
- In a given medium, radio waves always travel in a straight line, at a constant speed at 'c' - the speed of light (3 x 10^8 $^m/_s$)
- When travelling from one medium to another, it changes direction towards the denser medium (refraction).
- Speed of EM waves reduce in a denser medium.
- **Square Law:** To double the transmission range, the power of transmission has to be increased 4 times.

Cycle: One complete process of a waveform. 1 Cycle = 1 Hertz.
Amplitude: The maximum value a wave achieves in a cycle.
Wavelength (λ): Distance travelled by a wave, in 1 full cycle.
Frequency (f) Hz: No. of waves (cycles) per second.



f **c = Fq** (f) x **wavelength** (λ)

Q & A
Q. Fq is 121.5 MHz. Find wavelength.
Ans. λ = c/f => 3×10^8 **/** (121.5×10^6) = 2.47 m

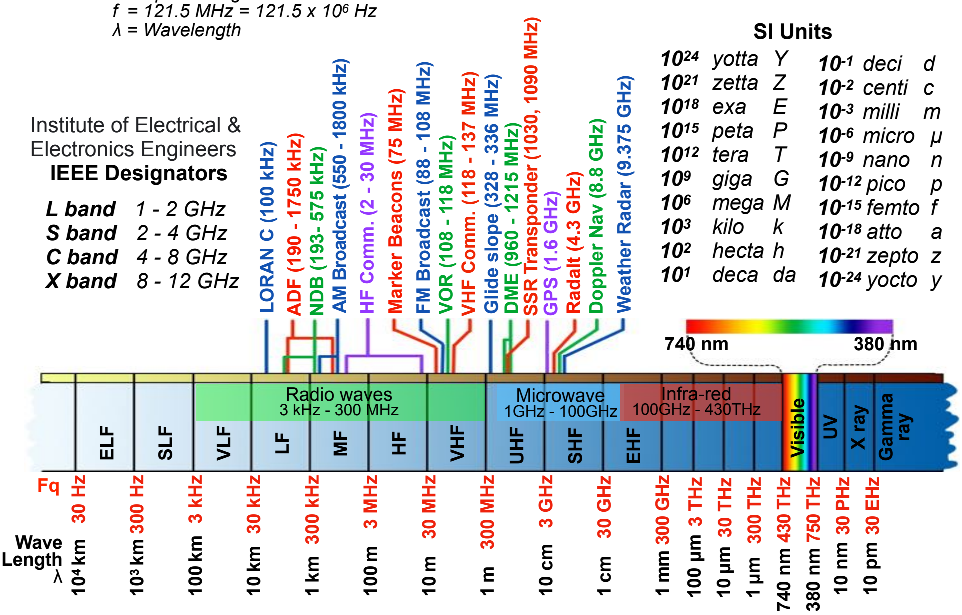
c = Speed of light = 3×10^8 m/s
f = 121.5 MHz = 121.5×10^6 Hz
λ = Wavelength

Institute of Electrical & Electronics Engineers
IEEE Designators

L band	*1 - 2 GHz*
S band	*2 - 4 GHz*
C band	*4 - 8 GHz*
X band	*8 - 12 GHz*

SI Units

10^{24}	*yotta*	*Y*	***10^{-1}***	*deci*	*d*
10^{21}	*zetta*	*Z*	***10^{-2}***	*centi*	*c*
10^{18}	*exa*	*E*	***10^{-3}***	*milli*	*m*
10^{15}	*peta*	*P*	***10^{-6}***	*micro*	*µ*
10^{12}	*tera*	*T*	***10^{-9}***	*nano*	*n*
10^{9}	*giga*	*G*	***10^{-12}***	*pico*	*p*
10^{6}	*mega*	*M*	***10^{-15}***	*femto*	*f*
10^{3}	*kilo*	*k*	***10^{-18}***	*atto*	*a*
10^{2}	*hecta*	*h*	***10^{-21}***	*zepto*	*z*
10^{1}	*deca*	*da*	***10^{-24}***	*yocto*	*y*

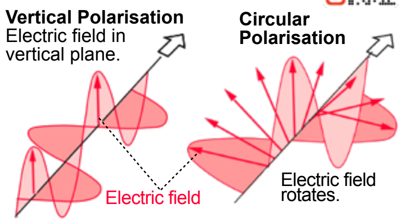


Radio Nav-aids

Polarisation

It is the plane of propagation of the 'electric field' in an EM wave.

Vertical Polarisation



- In this, electric field of the EM wave is in the vertical plane.
- Vertical polarisation needs a vertical antenna for reception.

Circular Polarisation

- In this, electric & magnetic fields spin around the axis of advance. It is generated by a 'helical antenna'.
- **Advantage:** In aviation radar systems, the polarisation circularity of reflections from the water drops present in precipitation is reversed and this can be eliminated, resulting in less clutter.
- In circular polarisation, if a dipole antenna is used, the orientation of the antenna is no more critical, e.g., Sat-comm antennae.

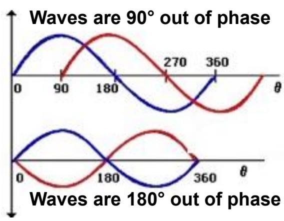
Polar Diagram: It is a line joining points of the same signal strength.

- Broadcast transmissions usually have a circular polar diagram.

Phase

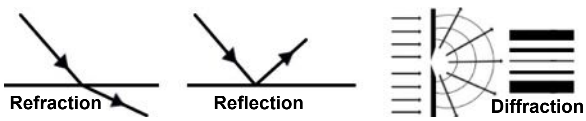
It is the instantaneous position of a particle in a wave.

Phase Difference: It is the angular difference between 2 signals or 2 corresponding points in a wave. To compare the phase, both the signals must have the same frequency.



Factors Affecting EM Wave Propagation

- **Refraction:** It is the phenomenon of change in speed, direction & wavelength of an EM wave when travelling from one medium to another, where it bends toward the denser medium. Frequency ↑ = refraction ↓.
- **Diffraction:** It is the bending of a wave around obstruction corners, producing a diffraction pattern. Frequency ↑ = diffraction ↓.



- **Fading:** Phenomena by which signal strength of skywaves (HF) reduces due to interference with itself (multi-path propagation) or due to fluctuations in the ionosphere. It usually happens during dawn/dusk, when transition of D, E & F ionisation layers are at max.
- **Attenuation/Absorption:** It is the gradual loss of signal strength as it travels outwards, as it is absorbed and scattered by air, dust, etc.
  - **Frequency:** Frequency ↑ = attenuation ↑.
  - **Depth of Penetration:** More penetration ↑ = attenuation ↑.
  - **Type of Surface:** Higher attenuation on land, less at sea.
  - **Polarisation:** Vertical polarisation has lesser attenuation.
- **Inverse Square Law:** As an EM wave travels 2x distance, its strength reduces to ¼.
- **Directivity:** If transmission is concentrated in a narrow beam, there will be an increase in range in that direction, but is unusable in other directions .

6.2

Propagation

Introduction

As far as aviation spectrum is concerned, EM propagation is of these types:

Propagation
- **Ground Wave** *(Non-Ionospheric)*
  - Surface Wave
  - Space Wave
- **Sky Wave** *(Ionospheric)*

Ground Wave

(Non-Ionospheric Propagation)

It occurs for fqs between 20 kHz - 50 MHz (upper VLF - lower VHF). (Used 20 kHz-2 MHz). It is of 2 types:

1. **Surface Wave**
   - These are waves that hug the surface of the earth due to the diffraction of waves moving along the earth's surface.
   - For a surface wave, frequency ↑ = range ↓. Power ↑ = range ↑.
   - Ranges are more over the sea.
   - Ranges of Vertically Polarised transmission are more.

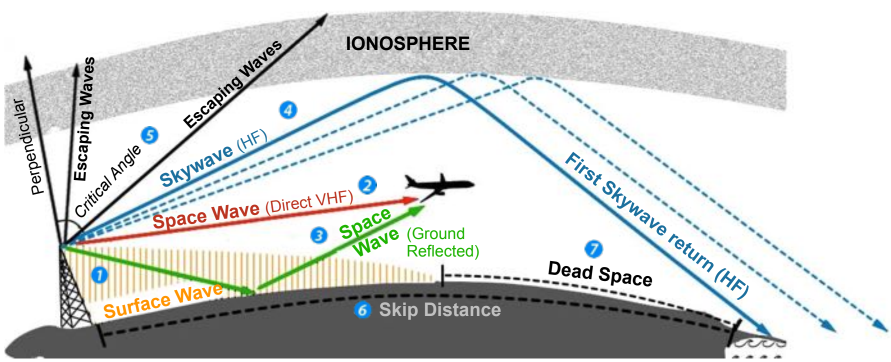
f **Range** (nm) = 2√Power watts (Land) *or* 3√Power (Sea)

2. **Space Wave**
   - At VHF and above, it is line of sight transmission. It is of 2 types:
   - 2 **Direct Wave**: These are frequencies with direct line of sight reception (VHF, UHF). Due to atmospheric refraction, VHF ranges are generally 7% more than the actual line of sight range.
   - 3 **Ground Reflected Wave**: Surface wave reflected off the ground.

f **Range** (nm) = 1.23 (√Tx (ft) + √RX (ft))

Super Refraction (Duct Propagation)
- It is a phenomenon in which VHF (30 MHz) & above experience a down-ward bend, increasing their range up to 40%.
- **Pre-conditions for Super-refraction**
  - Presence of an inversion layer - pronounced radiation cooling.
  - High pressure - causing subsidence.
  - Decrease in relative humidity with height.

Sub Refraction
- This phenomenon is rarer than 'super refraction' and causes a reduction in VHF ranges by up to 20%.
- Its pre-conditions are opposite to that of super refraction.

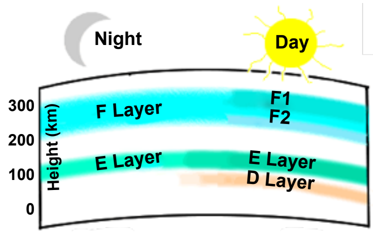


4 **Skywave** *(Ionospheric Propagation)*

- Skywave occurs at frequencies between 2 MHz - 30 MHz.
- Long-range HF communications take advantage of this.
- Solar radiation in UV & short-wavelength ionises the air molecules in the stratosphere and above, thus changing their refractive index. These ionisation layers cause radio waves to reflect back to earth, giving them excellent ranges.
- Because of varying intensity of solar radiation, multiple layers form, D, E, F1 & F2. At night, solar radiation stops. This causes D layer to disappear, E to move up, and F1 & F2 to combine. This increases the height of the ionisation layer, causing skip distance to increase. So, at night, HF fqs are decreased to reduce skip and maintain the same HF ranges.
- Ionisation layers are stable during day and night, but are very transient during dawn and dusk, causing communication fluctuations.
- Highest ionisation of atmosphere occurs at 1400 hrs.
- Ionisation levels will be:
  - higher in summers than winters.
  - higher towards equator.
- Solar flares can cause disruption in ionisation, & hence communication.

Ionisation Layers

D Layer	(50 - 100 km)
E Layer	(100 - 150 km)
F1, F2 layer	(200 - 250 km)



5 **Critical Angle:** Angle between a perpendicular to the transmitter and the 1st skywave return. Any angle less than critical angle will escape into space. Critical angle for 3 MHz = 0°, 30 MHz = 90°.

6 **Skip Distance:** Distance b/w transmitter & 1st skywave reception. Max skip distance (nm) = $1.43\sqrt{H}$ *(height of ionosphere in km)*

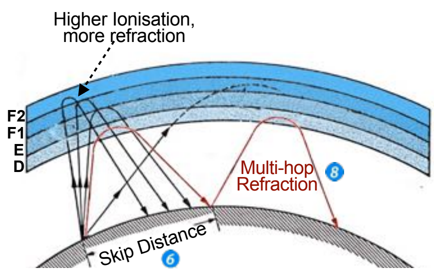
7 **Dead Space:** Distance between ground wave range & 1st skywave.

Skywave Ranges

- Refraction ranges of 1350 nm from the E-layer (at 125 km) and 2200 nm from F-layer (at 225 km) can be expected.

8 **Multi-hop Refraction**

Refracted skywave is reflected from the earth surface back to the ionosphere again. Ranges across to the other side of the earth sometimes occur.



Factors Affecting Skywave Ranges

- **Ionisation Intensity:** For a given frequency, higher the ionisation, the more the refraction, meaning refraction will take place at a smaller critical angle. Skip distance and dead space will decrease.
- **Frequency:** Fq ↑ = critical angle ↑, skip distance ↑, dead space ↑.
- **Layer Height:** Ionisation layer height ↑ = skip distance ↑, dead space ↑, range ↑.

11

Aerodynamics

The physics of how aircraft fly

Contents

Why / What is Aerodynamics?

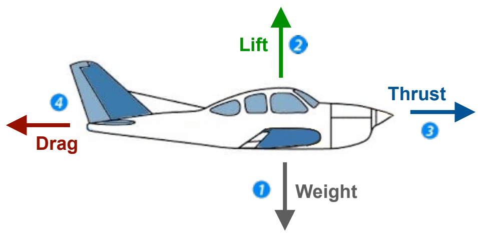
Aerodynamics is the study of the creation of 'Lift' and how to harness its power to make 'winged flight' possible.
In any aeroplane**:**

- Wings provide the Lift.
- Control surfaces (on the wing and tail) provide manoeuvrability.
- Engines provide the thrust needed to move forward.
- Tail plane provides stability.

In a nutshell,

1. An aircraft at rest only has weight (due to gravity) acting on it.
2. To fly, this weight has to be balanced by the same amount of Lift.
3. Lift is generated by the wings when the engine provides sufficient Thrust to move the aircraft forward.
4. As the aircraft moves forward, air resistance creates Drag.

- These forces are all interrelated. More Weight = more Lift needed = more Drag generated = more Thrust needed. And they always have to be balanced with control surfaces (ailerons, elevators, etc) to fly safely from A to B.
- Aircraft speed, air density, wing shape/size and many other factors also affect lift & drag production. That's why we study 'Aerodynamics'.



An aircraft designer uses the principles of aerodynamics to build an aircraft to obtain specific performance characteristics from it (e.g. is it a cargo aircraft? or is it a combat aircraft for which speed & agility are crucial? etc.). The position and shape of wings, engines and control surfaces can drastically alter aircraft performance & handling. Also, more efficiency in one area usually means performance degradation in another. For example, bigger wings mean more lift (more AUW), but it also means a wider/ runway requirement, and a slower operating speed.
Therefore, any aircraft design always involves a compromise between performance, efficiency, and the resources available to build it.

Aerodynamics is my favourite subject, right next to Meteorology. But before studying basic aerodynamics, we need to brush up on some terms and definitions used in physics.

Q: *How often do airplanes crash?*
A: *Just once.*

11.1

Terms & Definitions

Scalar : A quantity with only magnitude.
Vector : A quantity with both magnitude & direction.
Speed : Rate of change of distance with time (m/s). It is Scalar.
Velocity : Same as speed, but in a specified direction. It is a Vector.
Acceleration: Rate of change of velocity (m/s^2). It is a Vector.

Mass
- It is the quantity of matter contained in a body.
- ↑ Mass = ↑ force needed (in that direction) to move or stop a body.
- **Unit** Newton (kg) [M]

Weight
- Force with which mass is attracted to earth's centre (g = 9.81 m/s^2).
- **Unit** Newton (kg m/s^2) [MLT^{-2}]

Momentum
- It is the tendency of a body to continue in motion after being placed in motion. A 5 kg mass moving at 2 m/s has 10 kg m/s of momentum.
- If velocity is the same, a larger mass will have more momentum than a smaller mass. If velocity is 0, momentum is 0.
- **Unit** Newton-Second (kg m/s) [MLT^{-1}]

Inertia
- It is the reluctance of a body to change its state of equilibrium (rest/motion). It refers to both stationary and moving objects.
- It is a quality related to its mass (thus scalar) and not its velocity.
- Inertia should not be confused with momentum.
- **Unit** Moment of Inertia (kg m^2) [ML^2]

Force
- Force (a push or a pull) that changes momentum/state of rest or uniform motion of a body. Larger the Mass, more the Force required.
- **Unit** Newton (kg/s^2) [MT^{-2}]

Work
- Force is said to work on a body when it moves <u>along its line of action</u>. If the body does not move, no work is done.
- If force 100 N is used to move a mass of 10 kg or 100 kg for 10 m, the work done is the same. 1J = 1N moves a mass by 1m
- **Unit** - Joule (or newton-meter) (kg m) [ML]

Power
- It is the rate of doing work, or the rate at which a Force is displacing a mass (irrespective of the quantity of mass).
- **Unit** Watt (Joule/sec) (newton-meter/sec) (kg m/s) [MLT^{-1}]

f

W (weight) = **m** (mass) x **g** (gravity)
Momentum = **m** (mass) x **v** (velocity)
F (force) = **m** (mass) x **a** (acceleration)
W (work) = **F** (force) x **d** (displacement)

Power = $\frac{\text{F (force) x (Disp)}}{\text{t (time)}}$

M (mass) = $\frac{\text{W (weight)}}{\text{g (gravity)}}$

Q & A

Q. Mass 60000 Kg. Find the lift Force needed?
Ans. F = m x g F = 60000 x 9.81 = 588600 N

Q. 5000 N moves a mass by 1000 m in 2 mins. Find Work & Power.
Ans. Work = (F x d) W = (5000 x 1000) = 5000000 joules
Power = (F x d) / t F = (5000 x 1000) / 120 = 4167 Watts

Energy

- It is the capacity of a body to do work.
- Energy of a body is measured in the amount of work it can do.
- **Unit** - Joule *(same as work)*

Kinetic Energy: It is the energy stored in a body due to its motion.

Derivation

$v^2 = u^2 + 2as$ but, if a body starts from 0, then
$v^2 = 0 + 2as$
$v^2 = 2as \Rightarrow s = v^2 / 2a$........ *(1)*
but, KE = F (force) x s (distance) or
M x a x s. Substituting *(1)*,
KE = $M.a.v^2 / 2a$, or **KE = $Mv^2 / 2$**

u = initial velocity
v = final velocity
a = acceleration
s = distance

Potential Energy: It is the energy stored in a body due to its position.

Derivation

Energy = Force x Distance
PE = F x d => m x a x d but a = g (gravity)
PE = m x g x h d = h (height)

m = mass
d = distance
a = acceleration

Newton's Laws of Motion

1. A body will remain in rest or uniform motion in a straight line unless acted upon by an external force.
2. Rate of change of momentum is proportional to applied force and change of momentum takes place in the direction of applied force.
3. Action and reaction are equal and opposite.

Equations of Motion

Derivation

s = ut **v = u + at** ...*(1)*
s = average velocity x time = $\frac{(u + v)}{2}$ x t ...*(2)*
substituting v,
$s = \frac{(u + at + v)}{2} \times t$ or **$s = ut + \frac{1}{2} at^2$**
from (1), t = (v-u)/a. Substituting in *(2)*,
$s = \frac{(v + u)}{2} \times \frac{(v - u)}{a} \times t$ or **$v^2 = u^2 + 2as$**

u = initial velocity
v = final velocity
a = acceleration
s = distance
t = time

Gas Laws

1. **Boyle's Law:** Under constant temperature, the volume of a perfect gas is inversely proportional to its pressure. $P_1V_1 = P_1V_2$ *or* P is proportional to $^1/_V$ *or* PV = constant.
2. **Charles's Law:** If the pressure of a gas is constant, its volume will increase by $^1/_{273}$ per degree (°C) rise in temperature. $V_1/T_1 = V_2/T_2$
3. **Gay Lussac's Law:** If the volume is constant, then its pressure will increase by $^1/_{273}$ per degree (°C) rise in temperature. $P_1/T_1 = P_2/T_2$
4. **Avogadro's Law:** If the amount of gas in a container is increased, the volume increases. $V_1/n_1 = V_2/n_2$

Combining all 4, we get the Gas equation:

ƒ $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ or $\frac{PV}{T}$ = constant or **PV = nRT**

R = Gas constant
P = Pressure
V = Volume
T = Temperature

Laws of Fluid Pressure

1. In a fluid at rest, pressure at any point acts equally in all directions.
2. In a fluid at rest, pressure acts perpendicular to the surface with which the fluid is in contact with.
3. In a fluid at rest, the pressure increases with depth.

11.1

Motion Along a Curved Path

Angular Velocity (ω = v/r)

Derivation

ω = θ/t *(rate of change of θ with time)*
But, θ=s/r *(because S = r θ as per radian theory)*
Therefore, ω = s/r x 1/t or ω = s/t x 1/r but s/t = v
or ω = v x 1/r or ω = v/r

Angular Acceleration (v^2/r)

ω x v = v/r x v = $\mathbf{v^2/r}$

Centripetal Force ($F = Wv^2/r$)

F = m x a F = m x v^2/r
but m = w/g Therefore, $\mathbf{F = Wv^2/r}$

ω = Angular Velocity
m = Mass
v = Velocity
a = Acceleration
r = Radius
g = Gravity
I = Moment of Inertia
W = Weight

Moment
- The moment of a force about a point is the product of the force and the distance through which it acts. **Unit** Newton-Meter

Moment of Inertia ($I = mr^2$)
- It is the sum of the product of all moments for all particles in a rigid body rotating about an axis.

Angular Momentum (Iω)
- It is the Product of the 'moment of inertia' and its angular velocity.

Pressure
- Force exerted per unit area. (N/m^2) [$MT^{-2}L^{-2}$]
- **Unit** Pascal (Pa). 1 Pascal = 1 newton / $meter^2$
- It can also be expressed in Psi or 'in Hg' (inches mercury)

Density
- Mass per unit volume. (kg/m^3) [ML^{-3}]. **Unit** Kg

Viscosity
- It is the tendency to ↓ relative motion between adjacent fluid layers.
- **Unit** 'Coefficient of viscosity' (μ). (kg m/s) [$ML^{-1}T^{-1}$]
- In a **gas**, temperature ↑ = viscosity ↑ (due to ↑ collision b/w molecules).
- In the **atmosphere**, altitude ↑ = temperature ↓ = viscosity ↓ (till tropopause). In stratosphere, viscosity remains steady.
- In **liquid**, temperature ↑ = viscosity ↓ (due to ↓ cohesive forces).
- For air, viscosity (μ) = 1.79 x 10^{-5} kg m/s at ISA sea level.

Kinematic Viscosity
- It is an alternative way to measure the viscosity of gases.
- It is the ratio of the 'coefficient of viscosity' to its density ($^{\mu}/_{\rho}$).
- With ↑ in altitude, μ ↓. But ρ (density) ↓ more. So, as altitude ↑, kinematic viscosity ↑, even in the stratosphere.
- For air, Kinematic Viscosity ($^{\mu}/_{\rho}$) = 1.46 x 10^{-5} m^2/s at ISA sea level.

Other Definitions
- **Fluid:** A substance, either gaseous or liquid, that will conform to the shape of the container that holds it.
- **Friction:** A force resisting the relative motion between solid surfaces or fluid layers.
  - **Limiting (Static) Friction:** Friction before an object starts moving.
  - **Sliding (Kinetic) Friction:** Friction between moving/sliding objects. Sliding friction is less than static friction.
- **Isothermal:** Change in state, at a constant temperature.
- **Adiabatic:** Change with no heat exchange from surroundings.

13

Airframe

Construction & parts of an aircraft

Contents

13.1

Terms & Definitions

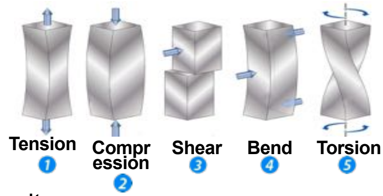
Aircraft: Any machine that can fly in the air (hot air balloon, helicopter, etc.)
Aeroplane: An aircraft that derives lift from fixed aerofoil surfaces.
Fuselage: An aircraft structure to provide space for the crew, cargo or pax.

Rigidity / Stiffness: It is the ratio of stress over strain (Young's Modulus).
Elastic Limit: Limit at which stress causes strain. When stress exceeds a body's elastic limit, a permanent 'set' happens. Upon the release of the load, the body will not return to its original shape.
Dynamic Load: Load that suddenly builds up. E.g. gust ↑ wing loading.
Static Load: Standard load on the airframe. E.g. aircraft weight on wheels.

Types of Loads

1. **Tension:** It is a stress that tries to stretch a body. It is calculated by dividing the load required to pull the body apart by its cross-section area. It is measured in Psi.
2. **Compression:** It is a stress that tries to crush a body. It shortens or squeezes aircraft parts. It is also measured in Psi.
3. **Shear:** It is a stress that resists the force trying to cause one layer to slide over another, e.g., loads on bolts, rivets.

Combination of Loads



4. **Bending Force:** Compression at the top, tension at the bottom.
5. **Torsion:** Twisting force, compression at one end and tension at the other. e.g., engine propeller rotation.

- **Stress:** A force acting on a body, per unit area.
- **Strain:** Deformation caused due to stress. It is a ratio: $\frac{\text{change in size}}{\text{original size}}$
- **Torsional Strength:** Strength of a body to resist twisting.

Load Limits

- **DLL Design Limit Load:** Maximum load an aircraft designer expects the airframe and components to experience. They are:

Normal category Aircraft	+2.5 g	-1.0 g
Utility category Aircraft	+4.4 g	-1.76 g
Aerobatic Category	+6.0 g	-3.0 g

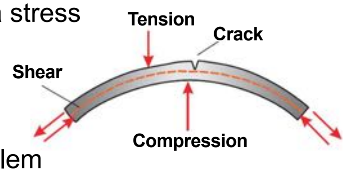
- **Proof Load:** (DLL x 1.125) During proof load, the aircraft structure must not suffer permanent deformation. Flight controls and systems should function normally.
- **DUL Design Ultimate Load:** (DLL x 1.5) Airframe deformation may occur, but the aircraft structure must withstand DUL without collapse.

Design Philosophies

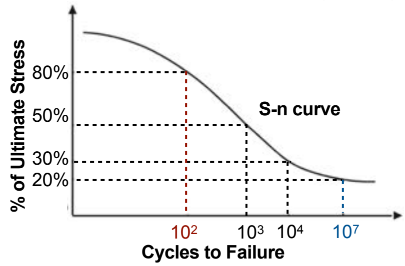
- **Safe Life:** In this, a structure is designed to survive a pre-determined number of flying hours, after which the component is replaced or overhauled. If a crack is found, the airframe is retired. This system is inefficient because predicting structure deterioration rate is difficult.
- **Fail Safe:** Structure retains adequate strength until planned inspections. They are damage tolerant, have redundant load path & crack arrest features. Component is replaced before its predicted life is reached.
- Aircraft designed for long distance should not be used for frequent short haul flights because lifetime of fatigue sensitive parts and load bearing members (landing gear, etc) has been designed accordingly.

Metal Fatigue

- Stress at which metal cracks is called Ultimate Stress. Fatigue cracks usually form where stress will be concentrated, e.g. on surface discontinuities, screw holes, joints, etc. Multiple ON/OFF loads below ultimate stress can also cause cumulative damage, which will eventually cause it to fail at a stress below its calculated ultimate stress.



- Fatigue life of commercial aircraft is based on its pressurisation cycle & not its landing cycle.
- Composite metals do not have this problem at stress levels less than 80% of their Ultimate Stress.
- **S-n Curve:** The 's-n curve' plots the no. of times different stress levels can be applied to the body before the structure collapses. E.g. 80% of Ultimate Stress applied 10^2 times can cause failure. But, 20% US has to be applied 10^7 (10 million) times for the same failure to occur.



Measures to Reduce Fatigue

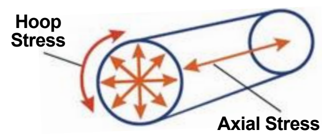
- Reduce roller-landing/takeoffs.
- Avoid turbulence.
- Avoid tight 'g' turns.
- Carry only fuel required for sortie.
- Minimise 'close formation' flying.

Stages of Fatigue Failure

- **Crack initiation:** Occurs along joints, rivet holes, sharp corners, etc
- **Crack moderation:** Crack conditions deteriorate due to corrosion.
- **Crack growth:** Once a crack reaches 1 mm, crack growth depends less on the condition that caused it and more on stress levels.
- Final fracture will occur when the crack reaches the critical crack length, at which point catastrophic failure will occur.

Stress in a Pressurised Aircraft

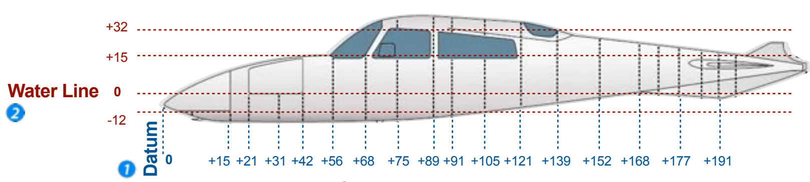
- **Axial Stress:** Longitudinal stress that tends to elongate a pressurised cabin
- **Hoop Stress:** Radial stress that tends to expand fuselage x-section



Station Numbers

1. Fuselage Station number is a fore-aft datum reference (usually measured as inches from the front tip of an aircraft) for locating components of an aircraft during inspections and maintenance.
2. Vertical stations are measured up or down from the 'Water Line'.

- Wing station numbers are referenced from the fuselage centreline.

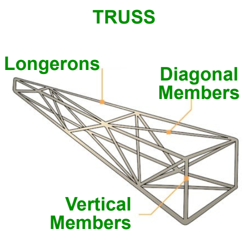


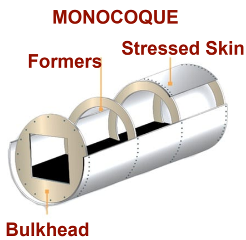
Station Numbering

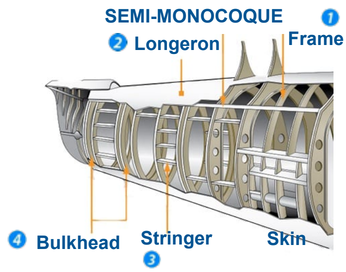
Airframe Construction

Fuselage Construction Methods

- **Truss** or **Framework:** In this, metal tubes are welded in triangular shapes called trusses. It is used in light / non-pressurised aircraft.
- **Monocoque:** In this method, all structural and aerodynamic loads are absorbed by the aircraft skin (also called stressed skin). It has light frames inside to give it shape. It can't tolerate dents/deformation.
- **Semi Monocoque:** In this, additional structures reinforce the aircraft skin & provide fuselage shape & form. More sturdy than Monocoque.







Parts of an Airframe

1. **Frames/Formers:** For vertical strengthening, to oppose hoop stress. It also gives shape to the fuselage.
2. **Longeron:** Beams that run fore-aft, to strengthen the airframe. They are often placed below the cabin floor, to take on bending loads.
3. **Stringer:** Additional longitudinal strengthening member.
4. **Bulkhead:** A solid frame (but may have doors through them. It gives shape to the fuselage and also takes some of the main loads.

- **Firewall:** Separates cabin from engine compartments, made using heat-resistant stainless steel or titanium alloy.
- **Cockpit Windscreen:** They are made of impact-resistant glass with shock-absorbing clear vinyl interlayers and rubber pressure seals. When flying at speed V_C (design cruise speed) at MSL (or 0.85 V_C at 8000 ft, whichever is higher), it must be capable of withstanding an impact with a bird weighing 2 kg, without penetrating it.
- **Passenger windows:** They are dual-layered; each layer is capable of withstanding entire cabin pressure by itself.
- **Doors:** All pressurised passenger aircraft doors are plug type, meaning, when closed, the cabin pressure seals the door in place, making it impossible to be opened in the air.

Wing Construction Methods

- **Bi-Plane:** Old design with 2 sets of wings, for speeds < 200 kts.
- **Braced:** It uses external braces to support the wings, e.g., Cessna.
- **Cantilever:** It uses thick spars in a wing to support all loads. Modern aircraft designs have cantilever wings. There are of 2 types**:**
  - **Mono Spar:** Only one spar is used. Ribs & bulkheads supply the necessary contour and shape for the wing.
  - **Multi Spar:** Uses more than 1 spar.

Bi-Plane

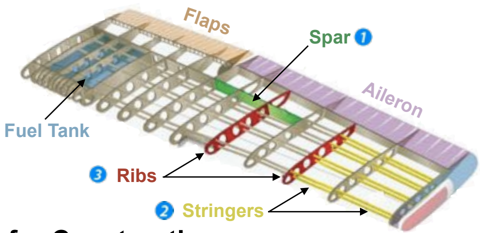
Braced

Cantilever

13.2

Parts of a Wing

- ❶ **Spar:** It is the principal span-wise load-bearing member in a wing, to withstand all vertical, bending and torsional loads.
- ❷ **Stringers:** They are span-wise add-on members to a spar, to prevent buckling and bending of the wing. It works by stiffening the skin and absorbing the longitudinal traction-compression stresses.
- ❸ **Ribs:** Transverse member, which supports skin, maintains its shape and supports the spars, stringers and skin against buckling. Holes in ribs reduce their weight and strengthens them.
- **Torsion Box:** A box formed between the front spar, rear spar, skin, ribs and stringers. It resists bending and twisting loads.



Materials Used for Construction

Materials are chosen for their particular properties w.r.t strength, wear, resistance, strength-to-weight ratio, fire resistance etc. Modern aircraft primarily uses aluminium alloys, due to their light weight and strength.

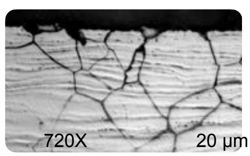
- **Duralumin:** An aluminium-copper alloy is used for all major parts. They are lightweight and have good fatigue resistance. However, it has poor corrosion resistance and is difficult to weld.
- **Titanium:** Used where strength & temperature resistance is required (firewalls). But it is expensive.
- **Steel:** Used where strength is vital at a penalty of weight.
- **Composites:** Used extensively for more lightly loaded structures.

Corrosion

- It is a slow degradation of material due to electrochemical action. When metal is exposed to air, it reacts with oxygen to form more stable compounds like oxides, carbonates or salts.
- Presence of moisture in the atmosphere (salt in coastal regions) or industrial pollution in the atmosphere accelerates corrosion.
- ❶ **Surface Corrosion:** These are the most harmless because they will be visible, and prompt remedial action can be taken.
- ❷ **Stress Corrosion:** Metal under stress corrodes rapidly, forming pits on the surface. Stress intensifies at these pits, forming cracks that extend under further stress, until failure occurs.
- ❸ **Inter-granular Corrosion:** This type of corrosion forms along the metal grain boundaries, penetrating into the metal core. It does not depend on oxygen, and is accelerated if the structure is under stress. This type is most dangerous as it goes undetected, till catastrophic failure occurs. Hairline cracks may be visible.

❶ Surface Corrosion

❷ Stress Corrosion



❸ Inter Granular

13.3

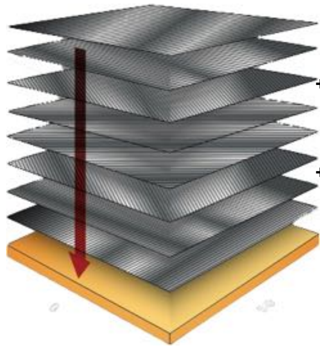
Composites

Introduction

- Composites are made by mixing a matrix (resin) with fibre. Matrix is the binder that transfers all the loads onto the fibre.
- Composites save weight & give additional strength to the airframe.
- Composites have different properties in different material directions.

Types of Composite Fibre Weaving:

- Unidirectional
- Multidirectional
- Woven
- Braided
- Stitched
- **Balanced Laminate:** Orientation of fibres are the same in each layer.
- **Symmetrical Laminate:** Among the layers of laminate sheets, the half above is a mirror image of the half below.



Types of Composites

- **Fibre:** It uses a fibre and a resin. (e.g. GRP uses glass fibre, carbon, boron and a resin).
- **Laminar:** It uses layers of materials, sandwiched between a matrix (e.g. plywood).
- **Particulate:** Powder/particles are embedded in a matrix (concrete).
- **Hybrid:** A combination of the above.

Advantages of Composites

- They are weight saving.
- Offer resistance to corrosion
- Durable and reliable.
- Low thermal expansion.
- Improved dent resistance.
- Directional tailoring/aero-elastic tailoring possible.

Disadvantages

- Absorption of moisture.
- Inferior resistance to lightning strike
- Thermal fatigue.
- Less impact resistance.
- Higher cost than metals.

Aeroelastic Tailoring

- It is a procedure for using custom-tailored composite structures to construct an airframe. In this, a material with the required strength and properties can be designed by adjusting the angular orientation of each fibre layer. This allows the material to twist in the desired direction when it is stretched or compressed.
- E.g., this eliminates problems of divergence in swept-wing aircraft.
- It also reduces CP movement and flutter in unswept/swept-wings.

***Q:** What do airplane builders say about their job?*
***A:** It's riveting.*

Formulae

Aerodynamics

Basics

Velocity	**v**	= **d** (distance) / **t** (time)	meter/sec	ft/sec
Acceleration	**a**	= **v** (velocity) / **t** (time)	meter/sec^2	ft/sec^2
Weight	**W**	= **m** (mass) x **g** (gravity)	kilo (Kg)	pounds (lb)
Density	**ρ**	= **m** (mass) / **V** (volume)	kg/m^3	pound $feet^3$ (lb/ft^3)
Momentum		= **m** (mass) x **v** (velocity)		
Force	**F**	= **m** (mass) x **a** (Accln)	newton (N)	pounds Force (lbf)
Work		= **F** (force) x **d** (disp.)	joules (N.m)	foot pound (ft lb)
Moment	**M**	= **F** (force) x **d** (disp.)	joules (N.m)	foot pound (ft lb)
Power	**P**	= **W** (work) / **t** (time)	watt (W)	
Pressure	**p**	= **F** (force) x **A** (area)	pascal (N/m^2)	pound $inch^2$ (lb/in^2)

Kinetic Energy = ½ **m** (mass) x **v** (velocity)^2 joules
Potential Energy = **m** (mass) x **g** (gravity) x **h** (ht) joules

Lift & Drag

Lift $= C_L \tfrac{1}{2} \rho V^2 S$
Drag $= C_D \tfrac{1}{2} \rho V^2 S$ $C_D = C_{DI} + C_{DP}$
Parasite Drag $D_P = \tfrac{1}{2} \rho V^2 C_{DP} S$
Induced Drag $D_I = \tfrac{1}{2} \rho V^2 C_{DI} S$

C_L Coeff of lift
C_D Coeff of drag
C_{DP} Coeff of parasite drag
C_{DI} Coeff of induced drag

Stall

$$V_{SB1} = V_{SB} \times \frac{\sqrt{W_{NEW}}}{\sqrt{W_{BASIC}}}$$ *(Weight)*

$$V_{SB1} = V_{SB} \times \sqrt{g}$$ *(Load factor)*

$$V_{SB1} = V_{SB} \times \frac{1}{\sqrt{\cos\theta}}$$ *(Bank angle)*

AoB 30° = V_{SB} x 1.07
AoB 45° = V_{SB} x 1.2
AoB 60° = V_{SB} x 1.41
AoB 75° = V_{SB} x 2

Load Factor = $^{Lift}/_{Weight}$ = $^{1}/_{\cos\theta}$

Aquaplaning

Takeoff (tyre rotating) $9\sqrt{Psi}$ or $34\sqrt{Kg/cm^2}$
Landing (tyre not rotating) $7.7\sqrt{Psi}$

Conversions

1 nm	= 6080 feet	**1 kg**	= 2.2 lbs	**1 bar**	= 100000 Pascal
1 nm	= 1852 m			**1 bar**	= 14.5 psi
1 km	= 3280 feet			**1 Atm**	= 14.7 psi
1 m	= 3.28 feet				
1 yard	= 3 feet				
1 foot	= 12 inches				
1 inch	= 2.54 cm				

Navigation

Time

Longitude east, UTC least *(LMT East to UTC = subtract time)*
Longitude west, UTC best *(LMT West to UTC = add time)*

360° Longitude = 24 hrs of time
15° Longitude = 60 mins of time
1° Longitude (60' arc) = 4 mins of time
1' Arc = 4 seconds of time

Projections

Departure = Change of Longitude x 60 x COS mean Latitude
Convergency = Change of Longitude x SIN mean Latitude
Conversion Angle = ½ Convergency

Magnetism

Variation East = Magnetic Least *(Mag Hdg is less than True hdg)*
Variation West = Magnetic Best *(Mag Hdg is more than True hdg)*
Deviation East = Compass Least *(Comp Hdg is less than Mag hdg)*
Deviation West = Magnetic Best *(Comp Hdg is more than Mag hdg)*

CDMVT: Compass heading + *(+E / -W)* **D**eviation = **M**agnetic heading
Magnetic heading + *(+E / -W)* **V**ariation = **T**rue heading

Coeff A = Deviation (N + NE + E + SE + S + SW + W + NW) / 8

Coeff B = $\frac{\text{Dev E - Dev W}}{2}$

Coeff C = $\frac{\text{Dev N - Dev S}}{2}$

Coeff B is due to Longitudinal Magnetic Component 'P'
Coeff C is due to Lateral Magnetic Component 'Q'
Coeff A is due to fixed mis-alignment, independent of hdg.

Plotting

QTE = QDR ± variation
QDR = QDM ± 180°

True Bearing = Relative Bearing + True Heading
Subtract 360 if answer more than 360

Scale

RF Representative Fraction = **CL** Chart Length / **ED** Earth Distance

Scale at Lat = Scale at Equator x SEC Lat

$$\frac{\text{Scale at A}}{\text{Scale at B}} = \frac{\text{SEC Lat A}}{\text{SEC Lat B}} \qquad \frac{\text{Distance at A}}{\text{Distance at B}} = \frac{\text{SEC Lat A}}{\text{SEC Lat B}}$$

Climb / Descent / Turn

Climb Gradient = $\frac{\text{ROC}}{\text{TAS } (kts)}$

Climb Angle = $\frac{\text{ROC } (fpm)}{\text{TAS } (kts)} \times 0.6$

ROC *(fpm)* = $\frac{\text{Climb grd} \times \text{TAS} (kts)}{100}$

Radius of Turn = $\frac{V^2 (m/s)}{g \tan\theta}$ m; *or* $\frac{V^2 (TAS)}{11.26 \tan\theta}$ ft; *or* $\frac{\text{GS } (TAS)}{100}$ nm *(diameter)*

Rate of Turn = $\frac{1091 \times \tan\theta}{V\ (TAS)}$ °/sec

Angle of Bank *(rate 1 turn)* = $\frac{\text{TAS}}{10} + 7$

Time to Climb *(sec)* = $\frac{\text{Ht Diff } (ft) \times 60}{\text{ROC } (fpm)}$

Dist to Climb *(nm)* = $\frac{\text{Ht Diff } (ft) \times \text{GS } (kts)}{\text{ROC } (fpm) \times 60}$

Temperature

SAT* = TAT* - Ram rise $(^{TAS}/_{87})^2$
SAT# = TAT# / (1 + 0.2 x M^2 x K_R)

TAT Total Air Temp = Indicated Air Temp
SAT Static Air Temp = Outside Air Temp
M = Mach no. R = Recovery factor

°Celsius = $^5/_9$ x (°F - 32)
°Fahrenheit = $^9/_5$ x (°C + 32)
°Kelvin = °C + 273

** Temperature in °C*
 # Temperature in °K

Abbreviations

Doc 8400 Abbreviations & Codes

A-RNP	Advanced RNP
A/c*	Aircraft
A/d*	Aerodrome
AAD	Assigned Altitude Deviation
ABAS	Air-based Augmentation System
AC	Alternating Current
AC	Aerodynamic Centre
ACARS	Aircraft Communication Addressing & Reporting System
ACAS	Airborne Collision Avoidance System
ACC	Area Control Centre
ACN	Aircraft Classification Number
AD*	Aerodynamic
ADC	Air Defence Clearance
ADF	Automatic Direction Finder
Addl*	Additional
ADIZ	Air Defence Identification Zone
ADR	Advisory Route
ADS	Automatic Dependent Surveillance
ADS-B	ADS-Broadcast
ADS-C	ADS-Contract
ADS-R	ADS-Re-broadcast
AEM	Approach Equipment Minima
AFSRA	Aeronautical Fixed Service Routing Area
AFTM	Air Traffic Flow Management
AFTN	Aeronautical Fixed Telecom Network
AIC	Aeronautical Information Circulars
AIP	Aeronautical Information Publication
AIS	Aerodrome Information Service
AIRAC	Aeronautical Info Regulation & Control
AIREP	Air Report
AIRMET	Airmen's Meteorological Report
AIRPORX	Air Proximity Report
ALERFA	Alert Phase
ALS	Approach Lighting System
Alt*	Altitude
AMHS	Air Traffic Services Message Handling Services
AMO	Aerodrome Meteorological Office
AMS	Aeronautical Meteorological Station
AoA	Angle of Attack
AOC	Air Operator Certificate
AOM	Aerodrome Operating Minima
APAPI	Abbreviated PAPI
APG	Adverse Pressure Gradient
Appch*	Approach
APU	Auxiliary Power Unit
ARFOR	Area Forecast
ARP	Aerodrome Reference Point
ASDAR	Aircraft to Satellite Data Relay
ASE	Altimeter System Error
ASR	Air Surveillance Radar
ATA	Actual Time of Arrival
ATD	Actual Time of Departure
ATIR	Air Traffic Incident Report
ATIS	Automated Terminal Info Service
ATM	Aerodynamic Twisting Moment
ATPL	Airline Transport Pilot License
ATZ	Aerodrome Traffic Zone
AUW	All Up Weight
AVGAS	Aviation Gasoline
AVTUR	Aviation Turbine Fuel
AWO	All weather Operations
AWY	Airway
B-RNAV	Basic RNAV
b/w*	Between
BCN	Beacon
BDC	Bottom Dead Centre
BFO	Beat Frequency Oscillator
BHP	Brake Horse Power
BL	Boundary Layer
BPCU	Barometric Pressure Control Unit
BVOR	Broadcast VOR
Calc	Calculation
CANPA	Constant Angle Non-precision Approach
CAS	Calibrated Air Speed
CAT	Clear Air Turbulence
CAVOK	Cloud & Visibility OK
CB	Circuit Breaker
C_D	Coefficient of Drag
CDFA	Continuous Descend Final Approach
CDI	Course Deviation Selector
CDR	Conditional Routes
CF	Cold Front
CG	Centre of Gravity
Char*	Character
CHT	Cylinder Head Temperature
C_L	Coefficient of Lift
CIDIN	Common ICAO Data Interchange Network
CMC	Crew Member Card
CMR	Cautionary Meteorological Report
CMV	Converted Meteorological Visibility
CP	Critical Point
CP	Centre of Pressure
CPDLC	Controller Pilot Data Link Communication
CPL	Commercial Pilot Licence
CSU	Constant Speed Unit
CTA	Control Area
CTM	Centrifugal Twisting Moment
CTR	Control Zone
CVOR	Conventional VOR
CVR	Cockpit Voice Recorder
CVSM	Conventional Vertical Separation Minima
CW	Continuous Wave
DA	Decision Altitude
DALR	Dry Adiabatic Lapse Rate
D-ATIS	Datalink ATIS
DC	Direct Current
DDA	Derived Decision Altitude
DER	Departure End of Runway
Dist*	Distance
DISTRESFA	Distress Phase
DME	Distance Measuring Equipment

DOC Designated Operational Coverage
DP Dew Point
DPLR Dew Point Lapse Rate
DR Dead Reckoning
DSB Double Side Band
DVOR Doppler VOR
EADI Electronic Attitude Indicator
EAS Equivalent Air Speed
EASA European Aviation Safety Agency
EAT Estimated Approach Time
ECAC European Civil Aviation Conference
ECAM Electronic Centralised Aircraft Monitoring
ECZ Equatorial Convergence Zone
EDTO Extended Diversion Time Ops
EET Estimated Elapsed Time
EFIS Electronic Flight Instrumentation System
EGPWS Enhanced Ground Proximity Warning System
EGNOS European Geostationary Nav Overlay Service
EGT Exhaust Gas Temperature
EHSI Electronic Horizontal Situation Indicator
EICAS Engine Indicating & Crew Alerting System
ELAC Elevator Aileron Computer
ELBA Emergency Locator Beacon - A/c
ELR Environmental Lapse Rate
ELT Emergency Locator Transmitter
EMF Electro-motive Force
ENSO El-Nino Southern Oscillations
EOBT Estimated Off-Block Time
EPR Engine Pressure Ratio
Eqpt Equipment
ESHP Equivalent Shaft Horse Power
Estd* Established
ESWL Equivalent Single Wheel Loading
ETA Estimated Time of Arrival
ETD Estimated Time of Departure
ETOPS Extended Twin Engine Operation
FADEC Full Authority Digital Engine Control
FAF Final Approach Fix
FANS Future Air Navigation Systems
FCU Fuel Control Unit
FDE Fault Detection & Exclusion
FDR Fight Data Recorder
FIC Flight Information Centre
FIR Flight Information Region
FIS Flight Information Service
FIS-B Flight Info Service Broadcast
FL Flight Level
FMCW Frequency Modulated Continuous wave
FMS Flight Management System
FPL Flight Plan
Fq* Frequency
FSII Fuel System Icing Inhibitor
GAGAN GPS & Geostationary Augmentation System
GBAS Ground Based Augmentation Sys
GC Great Circle
GCA Ground Controlled Approach
GDOP Geometric Dilution of Position
GFC Gross Fuel Consumption
GLS GBAS Landing System
GLONASS Global Orbiting Sat Nav System
GMT Greenwich Mean Time
GNSS Global Navigation Satellite System
GPS Global Positioning System
GPWS Ground Proximity Warning System
GP Glide Path
Grnd* Ground
GRF Global Reporting Format
GRP Glass Reinforced Plastic
HAPI Helicopter Approach Path Indicator
Hdg Heading
HEIU High Energy Ignition Unit
HF High Frequency
HIALS High Intensity Approach Lights
HMR Humidity Mixing Ratio
HP High Pressure
HSI Horizontal Situation Indicator
HST High Speed Taxiway
Ht Height
I/b* Inbound
IAF Initial Approach Fix
IAS Indicated Air Speed
IATA International Air Transport Association
IDL International Date Line
IF Intermediate Approach Fix
IFR Instrument Flight Rules
IGV Inlet Guide Vanes
IHP Indicated Horse Power
ILS Instrument Landing System
IMC Instrument Meteorological Conditions
INCERFA Uncertainty Phase
Info* Information
Inop* Inoperative
INS Inertial Navigation System
IR Infrared
IRS Inertial Reference System
IRU Inertial Reference Unit
ITCZ Inter Tropical Convergence Zone
ITU International Telecom Union
IVSI Instantaneous VSI
JAA Joint Aviation Authorities
JPT Jet Pipe Temperature
KE Kinetic Energy
LAAS Local Area Augmentation System
LACFT Large Aircraft
LADGPS Local Area Differential GPS
LCN Load Classification Number
Ldg* Landing
LDIN Sequenced Flashing Lead-in Lights
LE Leading Edge
LF Low Frequency
LMT Local Mean Time
LNAV Lateral Navigation
LORAN Long Range Navigation
LP Low Pressure
LRC Long Range Cruise
LSB Lower Sideband
LSS Local Speed of Sound

Lts* Lights
LUT Local User Terminal
Lvl Level
LVP Low Visibility Procedures
LVTO Low Visibility Takeoff
MAA Max Allowed Altitude
MABH Min Approach Break-off Height
MAC Mean Aerodynamic Chord
Mach. No Mach Number
MALS Medium Intensity Approach Lights
MAP Manifold Absolute Pressure
MAPt Missed Approach Point
MBPU Minimum Burner Pressure Unit
MCC Mission Control Centre
M_{CRIT} Critical Mach No
MDA Minimum Descend Altitude
M_{DET} Detachment Mach No
MEA Minimum Enroute Altitude
MEHT Minimum Eye Height Over Threshold
MEL Minimum Equipment List
METAR Aviation Routine Weather Report
M_{FS} Free-stream mach No
Min* Minimum
MIST Met Info Standard Terminal
M_L Local Mach Number
MLS Microwave Landing System
MMEL Master Minimum Equipment List
MNPS Minimum Navigation Performance Specification
MOC Minimum Obstacle Clearance
MOCA Minimum Obstacle Clearance Altitude
MORA Minimum Off-Route Altitude
MSA Minimum Safe Altitude
MSAS Multifunctional Transport Satellite Based Augmentation System
MSLPC Mean Sea Level Pressure Chart
MUF Maximum Usable Frequency
MVFR Marginal Visual Flight Rules
MWARA Major World Air Route Area
NAM Nautical Air Mile
NAT HLA North Atlantic High Level Airspace
Nav* Navigation
NDB Non-Directional Beacon
NGM Nautical Ground Mile
NGV Nose Guide Vanes
NOSIG No Significant Change
NOTAM Notice to Airmen/Air missions
NPA Non Precision Approach
NPR Noise Preferential Routes
NSC No Significant Clouds
NTZ No Transgression Zone
o/b* Outbound
o/h* Overhead
OAT Outside Air Temperature
OBS Omni-bearing Selector
Obstn* Obstruction
OCA Obstruction Clearance Altitude
OCA Oceanic Control Area
ODALS Omni-directional Approach Lighting System
OGV Outlet Guide Vanes
OSG Overspeed Governor
OPMET Operational Met Information
OPS Operations
OUF Optimum Usable Frequency
P-RAIM Predictive RAIM
P-RNAV Precision RNAV
PA Precision Approach
PA Pressure Altitude
PANS Procedure for Air Nav Services
PAPI Precision Approach Path Indicator
PAR Precision Approach Radar
Pax* Passenger
PBN Performance Based Navigation
PCN Pavement Classification Number
PCTL Pre-computed Time Legs
PE Potential Energy
PF Pilot Flying
PGD Procedure Design Gradient
PGF Pressure Gradient Force
PIB Pre-flight Information Bulletin
PIC Pilot in Command
PLASI Pulsating VASI
PM Pilot Monitoring
PNF Pilot Non Flying
Posn* Position
PPL Private Pilot License
PPS Precision Positioning Service
PRF Pulse Recurrence Frequency
PRI Pulse Recurrence Interval
PRP Pulse Recurrence Period
PSR Point of Safe Return
PSR Primary Surveillance Radar
Pt* Point
Q Codes Page 14, 443
RA Resolution Advisory
RAAS Runway Awareness & Advisory Sys
RAF Relative Airflow
RAIL Runway Alignment Indicator Lights
RAIM Remote Autonomous Integrity Monitoring
RAS Rectified Air Speed
RAWIN Radar Wind Sounding
RCC Regional Co-ordination Centre
RCLS Touchdown Zone Lights
RCR Runway Condition Report
R_{CRIT} Critical Reynolds Number
RDARA Regional & Domestic Air Route Area
REDL Runway Edge Lights
REIL Runway End Identifier Lights
REM Rapid Eye Movement (Sleep)
Restd* Restricted
RH Relative Humidity
RL Rhumb Line
RLG Ring Laser Gyro
RLLS Runway Lead-in Lights
RMS Root Mean Square
RNAV Area Navigation
RNP Required Navigation Performance
ROFOR Route Forecast
ROP Runway Overrun Protection
ROW Runway Overrun Warning
RPL Repetitive Flight Plan
RSA Route Safety Altitude

RVR	Runway Visual Range
RVSM	Reduced Vertical Separation Minima
RVV	Runway Visibility Value
SALR	Saturated Adiabatic Lapse Rate
SAR	Specific Air Range
SAR	Synthetic Aperture Radar
SARP	Stds & Recommended Practices
SAT	Static Air Temperature
SATCOM	Satellite Communication
SBAS	Satellite Based Augmentation Sys.
SE*	Single Engine
SEC	Spoiler Elevator Computer
SELCAL	Selective Calling
SFC	Specific Fuel Consumption
SFL	Sequenced Flashing Lights
SID	Standard Instrument Departure
SIGMET	Significant Met. Information
SIGWX	Significant Weather Chart
SIWL	Single Isolated Wheel Loading
SLOP	Strategic Lateral Offset Procedure
SMR	Saturation Mixing Ratio
SNOWTAM	Snow NOTAM
SPECI	Aviation Selected Special Weather Report
SP	Safeguard Procedures
SPI	Special Position Ident
SPL	Student Pilot Licence
SPS	Standard Positioning Service
SRA	Surveillance Radar Approach
SSR	Secondary Surveillance Radar
STAR	Standard Terminal Arrival Route
STC	Sensitivity Time Control
SUA	Special Use Airspace
SVFR	Special Visual Flight Rules
SVR	Slant Visibility Range
SW	Shock Wave
SWD	Super-cooled Water Drops
T/o*	Takeoff
TA	Transition Altitude
TA	Traffic Advisory
TACAN	Tactical Air Navigation
TAD	Terrain Awareness Display
TAF	Terminal Aerodrome Forecast
TAS	True Air Speed
TAT	True Air Temperature
TCA	Terminal Control Area
TCAS	Traffic Collision Avoidance Sys.
TCF	Terrain Clearance Floor
TDC	Top Dead Centre
TDZ	Touchdown Zone
TDZL	Runway Centreline Lights
TE	Trailing Edge
TEMPO	Temporarily
TET	Turbine Entry Temperature
TGT	Turbine Gas Temperature
TIT	Turbine Inlet Temperature
THP	Thrust Horse Power
TIS-B	Traffic Information Service Broadcast
TL	Transition Level
TLS	Transponder Landing System
TMA	Terminal Manoeuvre Area
TP	Transition Point
TR	Total Reaction
TRCV	Tri Colour VASI
TRS	Tropical Revolving Storm
TRA	Temporary Reserved Area
TSA	Temporary Segregated Area
TSI	Turn & Slip Indicator
TVE	Total Vertical Error
TVOR	Terminal VOR
Tx*	Transmission
u/c*	Undercarriage
UAT	Universal Access Transceiver
UHF	Ultra High Frequency
UIR	Upper Information Region
ULRF	Ultra Long Range Flights
UPR	User Preferred Routes
UPRT	Upset Prevention & Recovery Training
USB	Upper Sideband
UTC	Co-ordinated Universal Time
VASI	Visual Approach Slope Indicator
VDF	VHF Direction Finding
VFR	Visual Flight Rules
VHF	Very High Frequency
Vis	Visibility
VM(C)	Visual Manoeuvring (Circling)
VMC	Visual Meteorological Conditions
VNAV	Vertical Navigation
VOR	VHF Omnidirectional Ranging
VORTAC	VOR + TACAN
VOT	Test VOR
VRB	Variable
VSI	Vertical Speed Indicator
VSTOL	Vertical / Short takeoff or landing
VOLMET	Met Information for Aircraft in Flight
WAAS	Wide Area Augmentation System
WAFS	World Area Forecast System
WD	Western Disturbance
WF	Warm Front
WMO	World Meteorological Organisation
MWO	Meteorological Watch Office
WAT	Weight Altitude Temperature
WILCO	Will Comply
WP*	Way Point
WPC	Wireless Planning Commission
WS	Wind Shear
Wt*	Weight

↑	Increase / Higher / More
↓	Decrease / Lower / Less
||	Parallel
⊥	Perpendicular

* Non standard abbreviation

Performance Terms

BEM	Basic Empty Mass	**MSLM**	Max Structural Landing Mass
EM	Empty Mass	**PLTOM**	Performance Limited Takeoff Mass
DOM	Dry Operating Mass	**PLLM**	Performance Limited Landing Mass
TOF	Takeoff Fuel	**RTOM**	Regulated Takeoff Mass
TL	Traffic Load	**RLM**	Regulated Landing Mass
UL	Useful Load	**TORR**	Takeoff Run Required
OM	Operating Mass	**TODR**	Takeoff Distance Required
ZFM	Zero Fuel Mass	**ASDR**	Acceleration Stop Distance Required
TOM	Takeoff Mass	**LDR**	Landing Distance Required
LM	Landing Mass	**TORA**	Takeoff Run Available
MZFM	Max Zero Fuel Mass	**TODA**	Takeoff Distance Available
MSTM	Max Structural Taxi Mass	**ASDA**	Acceleration Stop Distance Available
MSTOM	Max Structural Takeoff Mass	**LDA**	Landing Distance Available

Approach Lighting System

ALS	Approach Lighting System	**HIALS**	High Intensity Approach Lts
ALSF	ALS with Sequence Flashing Lts	**MALS**	Medium Int Approach Lts
REDL	Runway Edge Lts	**MALSF**	Medium Int Approach Lts with SFL
REIL	Runway End Identifier Lts	**MALSR**	Medium Int Approach Lts with RAIL
RAIL	Runway Alignment Indicator Lts	**SALS**	Short Approach Lts System
RLLS	Runway Lead-in Lts	**SALSF**	Short Approach Lts System with SFL
SLF	Sequenced Flashing Lts	**SSALS**	Simplified Short Approach Lts System
LDIN	Sequenced Flashing Lead-in Lts	**SSALF**	Simplified Short Approach Lts with SFL
ODALS	Omni-directional Appch Lts Sys	**SSALR**	Simplified Short Approach Lts with RAIL

Aerodrome Watch-Hours

H24	Continuous Ops	**HJ**	Sunrise to sunset	**SR**	Sunrise
HX	Irregular Ops	**HN**	Night hours	**SS**	Sunset
O/R	Open on request	**O/T**	Other times	**HS**	For scheduled operators
PNR	Prior notice reqd	**PPR**	Prior permission reqd	**HO**	As per Ops requirement

Weather Descriptors

Weather	Precipitation	Obscuration	Other
MI Shallow *(*Mince)*	**DZ** Drizzle	**FG** Fog	**SQ** Squall
BC Patches *(*Banc)*	**RA** Rain	**HZ** Haze	**FU** Funnel Cloud
SH Shower	**SN** Snow	**DU** Dust	**PO** Dust Devils
TS Thunder Storm	**SG** Snow Grain	**DS** Dust Storm	*(*Poussiere)*
FZ Freezing	**IC** Ice Crystal	**SA** Sand	
PR Partial	**PL** Ice Pellets	**SS** Sand Storm	**-** *Light Activity*
RE Recent	**UP** Unknown Precip.	**VA** Volcanic Ash	**+** *Heavy*
VC Vicinity	**PY** Spray	**BR** Mist *(*Brume)*	
BL Blowing (>2m ht)	**GR** Hail *(*Grele)*	**FU** Smoke *(*Fumee)*	* French Words
DR Low Drift (<2m ht)	**GS** Small Hail *(*Gresil)*		

SH, TS only used with RA, SN, PL, GS, GR
FZ only used with FG, DZ, RA
MI, BC, PR only used with FG
BL, DR only used with DU, SA, RA

Cloud Descriptors

Low Clouds		Medium Clouds	High Clouds
SC Strato Cumulous	**ST** Stratus	**AS** Alto Stratus	**CC** Cirro Cumulous
CU Cumulous	**NS** Nimbo Stratus	**AC** Alto Cumulous	**CS** Cirro Stratus
CB Cumulo Nimbus	**TCU** Towering Cumulous		**CI** Cirrus

Abbreviations Transmitted as Spoken Words in RT

E.g. ADIZ is transmitted as Ay-Diz

ACARS
ACAS
ADIZ
AIREP
AIRMET
ALERFA
APAPI
ATIS
AVGAS
BARO-VNAV
CAVOK
CIDIN
D-ATIS
DISTREFA
EFIS
EGNOS
ELBA
GAGAN
GBAS
GLONASS
IDENT
INCERFA
INFO
LNAV
LORAN
MET
METAR
MSAS
NOSIG
NOTAM
OPS
OPMET
PAPI
PROB
RAIM
RNAV
SATCOM
SELCAL
SBAS
SID
SIGMET
SNOWTAM
SPECI
STAR
TACAN
TAF
TCAS
TEMPO
VNAV
VOLMET
VASI
VORTAC
WAAS
WILCO

Abbreviations Transmitted as Letters in RT

E.g. ADF is transmitted as Ay-Di-Eff

ACC
ADF
ADS-B/C
AFTN
ATA
ATC
ATD
AFTN
ATC
CB
CPDLC
DME
ETA
ETD
FIR
FMS
GCA
GLS
GNSS
GPS
GPWS
HF
IFR
ILS
IMC
MLS
NDB
NTZ
PAR
PSR
QDM
QFE
QNH
RNP
RVSM
RVR
SAR
SSR
TMA
UHF
UIR
UTC
VFR
VHF
VIP
VMC
VOR

Q Codes

Q codes were originally used in the olden days as brevity codes to facilitate communication during aircraft HF transmission. They were transmitted in the Morse Code.

QAA - QNZ are reserved for Aeronautical use
QOA - QQZ are reserved for Maritime use
QRA - QUZ are reserved for Common use

QAB	May I have clearance from ... (*place*) to ... (*place*) at flight level/altitude... ?
QAF	Will you advise me when you are at ... (*place*)?
QAH	What is your height above ... (*datum*)?
QAI	What is the essential traffic with respect to my aircraft?
QAK	Is there any risk of collision?
QAL	Are you going to land at ... (*place*)?
QAM	What is the latest available meteorological observation for ... (*place*)?
QAN	What is the surface wind direction and speed at ... (*place*)?
QAO	What is the wind direction in degrees TRUE and speed at ... (*position)*
QAP	Shall I listen for you on ... Fq?
QAQ	Am I near a prohibited, restricted or danger area?
QAR	May I stop listening on the watch frequency for ... minutes?
QAU	Where may I jettison fuel?
QAY	Will you advise me when you pass ... (*place*)?
QAZ	Are you experiencing communication difficulties through flying in a storm?
QBA	What is the horizontal visibility at ... (*place*)?
QBB	What is the amount, type and height of cloud base?
QBC	Report meteorological conditions as observed from your aircraft.
QBD	How much fuel have you remaining?
QBF	Are you flying in the cloud?
QBG	Are you flying above the cloud?
QBH	Are you flying below the cloud?
QBI	Is flight under IFR compulsory at ... (*place*) [*or* from ... to ... (*place*)]?
QBJ	What is the amount, type and height above ... (*datum*) of the top of the cloud
QBK	Are you flying with no cloud in your vicinity?
QBM	Has ... sent any messages to me?
QBN	Are you flying between two layers of a cloud?
QBO	What is the nearest aerodrome at which flight under VFR is permissible?
QBP	Are you flying in and out of the cloud?
QBT	What is the runway visual range at ... (*place*)?
QBV	Have you reached flight level/altitude ... [*or* ... (*area or place*)]?
QBX	Have you left ... flight level/altitude ... [*or* ... (*area or place*)]?
QBZ	Report your flying conditions in relation to clouds.
QCA	May I change my flight level/altitude from … *(place)* to ... *(place)* ?
QCE	When may I expect approach clearance?
QCH	May I taxi to ... (*place*)?
QCX	What is your complete call sign?
QDB	Have you sent a message ... to ... ?
QDF	What is your D-Value at ... (*position*)?
QDL	Do you intend to ask me for a series of bearings?
QDM	Will you indicate the magnetic heading for me to steer towards you?
QDP	Will you accept control (*or* responsibility) of ... for now?
QDR	What is my magnetic bearing from you?
QDT	Are you flying in visual meteorological conditions?
QDV	Are you flying in a flight visibility of less than ... (*figures and units*)?
QEA	May I cross the runway ahead of me?
QEB	May I turn at the intersection?
QEC	May I make a 180-degree turn and return down the runway?
QED	Shall I follow the pilot vehicle?
QEF	Have I reached my parking area?
QEG	May I leave the parking area?
QEH	May I move to the holding position for runway number ... ?
QEJ	May I assume position for take-off?
QEK	Are you ready for immediate take-off?
QEL	May I take-off (and make a ... hand turn after take-off)?
QEM	What is the condition of the landing surface at ... (*place*)?
QEN	Shall I hold my position?
QEO	Shall I clear the runway (*or* landing area)?
QES	Is a right-hand circuit in force at ... (*place*)?

QFA	What is the meteorological forecast for ... (place)?
QFC	What is the amount, the type and the height above ... (*datum*) of cloud base?
QFD	Is the ... visual beacon [at ... (*place*)] in operation?
QFE	What should I set on the sub-scale, to indicate its height above a/d elevation?
QFF	What is the present atmospheric pressure converted to MSL?
QFG	Am I overhead?
QFH	May I descend below the clouds?
QFI	Are the aerodrome lights lit?
QFL	Will you send up pyrotechnical lights?
QFM	What flight level/altitude ... should I maintain?
QFO	May I land immediately?
QFP	Will you give me the latest information concerning ... facility [at ... (*place*)]?
QFQ	Are the approach and runway lights lit?
QFR	Does my landing gear appear damaged?
QFS	Is the radio facility at ... (*place*) in operation?
QFT	Between what heights above ... (*datum*) has ice formation been observed?
QFU	What is the magnetic direction (*or* number) of the runway to be used?
QFV	Are the floodlights switched on?
QFW	What is the length of the runway in use in ... (*units*)?
QFY	Please report the present meteorological landing conditions at ... (*place*).
QFZ	What is the aerodrome meteorological forecast for ... (*place*) for the period?
QGD	Are there on my track any obstructions whose elevation exceeds my altitude?
QGE	What is my distance to your station?
QGH	May I land using ... (*procedure or facility*)?
QGK	What track should I make good?
QGL	May I enter the ... (*control area or zone*) at ... (*place*)?
QGN	May I be cleared to land at ... (*place*)?
QGP	What is my number for landing?
QGQ	May I hold at ... (*place*)?
QGV	Do you see me?
QGW	Does my landing gear appear to be down and in place?
QHE	Will you inform me when you are on ... leg of approach?
QHG	May I enter the traffic circuit at flight level/altitude ...?
QHH	Are you making an emergency landing?
QHI	Are you…waterborne? o*r* on land?
QHQ	May I make a ... approach at ... (*place*)?
QHZ	Shall I circle the aerodrome (*or* go around)?
QIC	May I establish communication with ... radio station on ... kHz (*or* ... MHz)?
QIF	What frequency is …*(unit)* using?
QJA	Is my ...mark and space reversed?
QJB	Will you use … radio/cable/telegraph?
QJC	Will you check your … transmitter/antenna?
QJD	Am I transmitting … in letters/figures?
QJE	Is my frequency shift … too wide/narrow/correct?
QJG	Shall I revert to automatic relay?
QJH	Shall I run… my test tape/sentence?
QJI	Will you transmit a continuous ... mark/space?
QJK	Are you receiving ... a continuous mark/space?
QKF	May I be relieved at ... *(hours)*?
QKG	Will relief happen when ... (*identification*) established contact with survivors?
QKH	Report details of the parallel sweep (track) search being (*or* to be) conducted?
QKO	What other units are taking part in the operation…?
QKP	Which pattern of search is being followed?
QLB	Will you monitor ... station and report regarding range, quality, etc.?
QLH	Will you use simultaneous keying on ... frequency and ... frequency?
QLV	Is the ... radio facility still required?
QMI	Report the vertical distribution of cloud at ... (*position*) from your aircraft.
QMU	What is the surface temperature & dew-point at ... (*place*)?
QMW	At ... (*position)*, **what is the zero Celsius isotherm's flight level(s)**?
QMX	What is the air temperature at ... (*posn)* (at ... hours) at flight level/altitude ...?
QMZ	Have you any amendments to the flight forecast in respect of section of route?
QNE	What will altimeter give on landing at ... (*place*) of my sub-scale set to 1013?
QNH	What should I set on the sub-scale, to indicate airfield elevation?
QNI	Between what heights above ... (*datum*) has turbulence been observed, at…?
QNT	What is the maximum speed of the surface wind at ... (*place*)?
QNY	: What is the present weather and intensity at ... (*place)?*
QTE	What is my TRUE bearing from you?
QUJ	What is my TRUE bearing to you?

Index

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Bibliography / Image Source

The author acknowledges that the following books were referenced during the creation of this book.

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1 .	33	Marshalling Signals	© Transport Canada

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Subject 3 Communications

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Subject 4 Human Performance & Limitations

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4 .	5	Lungs	Krames Staywell
4 .	9	G Forces	© Vladimir Kvrgic
4 .	11	Runway Illusions	John Albrecht, Allen J. Parmet, M.D
4 .	11	Black-hole Approach	Pilotgetaways.com, Dale Wilson

Subject 5 Instruments

Books Instrumentation (Oxford Aviation Academy Ground Training 5)
Instruments (Ground Studies for Pilots 3)
ATPL 1000 Questions - Instruments (Keith Williams)
Airplane Flying Handbook - FAA
Instruments (FIS Précis)

Images	Chapter	Description	Source
5 .	6	Mach Meter	1stevensken.wixsite.com
5 .	10	Drift/Topple	Courtesy K Haroon, theairlinepilot.com
5 .	17	INS, RLG	Courtesy K Haroon, theairlinepilot.com
5 .	18	Oil Pressure Meter	Rolls Royce
5 .	19	Tacho Probe	Rolls Royce
5 .	26	GPWS	Honeywell EGPWS Guide

Subject 6 Radio & Nav-aids

Books Radio Navigation (Oxford Aviation Academy Ground Training 11)
Radio Aids (Ground Studies for Pilots 1)
ATPL 1000 Questions - Radio Navigation (Keith Williams)
Radio & Nav-aids (FIS Précis)

Images	Chapter	Description	Source
6 .	1	Polarisation	hyperphysics.phy-astr.gsu.edu
6 .	10	MLS	woottonbridgeiow.org.uk
6 .	22	Hyperbolic Navigation	Smithsonian Institute, Bruce Morser

Subject 7 Navigation

Books General Navigation (Oxford Aviation Academy Ground Training 10)
Navigation (Ground Studies for Pilots 1)
ATPL 1000 Questions - General Navigation (Keith Williams)
Navigation (FIS Précis)

Images	Chapter	Description	Source
7 .	1	Heavenly Bodies	© Adam Mosely, Cambridge University
7 .	3	Time	timetemperature.com
7 .	3	Latitudes & Longitudes	NOAA
7 .	5	Great Circle/Rhumb Line	esri.com
7 .	8	Magnets	Courtesy Spencer Sutton
7 .	11	Projection Light Source	geography.hunter.cuny.edu
7 .	11	Projection Methods	GNU Sutton 2009, An Introduction to GIS
7 .	11, 12	Azimuthal, Conic, Cylindrical	USGS National Atlas
7 .	12,13	Mercator, Lambert's, Conic	Encyclopaedia Britannica

Subject 8 Flight Planning & Monitoring

Books Flight Planning & Monitoring (Oxford Aviation Academy Ground Training 7)

Images	Chapter	Description	Source
8 .	6, 7	Chart Legend	Jeppesen Glossary
8 .	7	Approach Plan / Profile View	Indoavis Doc No: INDOAVIS.UG.0I/III

Subject 9 Mass & Balance, Performance

Books Mass Balance Performance (Oxford Aviation Academy Ground Training 6)
ATPL 1000 Questions - Performance, Mass & Balance (Keith Williams)

Subject 10 Meteorology

Books Meteorology (Oxford Aviation Academy Ground Training 9)
Meteorology (Ground Studies for Pilots 4)
Aviation Meteorology (Gp Capt IC Joshi)
Meteorology (FIS Précis)

Images	Chapter	Description	Source
10 .	4	Conduction/Convection	NOAA
10 .	4	Insolation	NASA
10 .	4	Inversion	stream1.cmatc.cn
10 .	8	Buys Ballot's Law	Credit David Babb
10 .	8	Local Winds	© Pearson Prentice Hall 2005
10 .	9	Mountain Wave	tadpolewebworks.com
10 .	11	Cloud formation	© Thomson Higher Education 2007
10 .	11	Types of Clouds	© Thomson Higher Education 2007
10 .	12	Precipitation	Source : KOAA News
10 .	13	Life cycle of a CB Cell	bom.gov.au
10 .	15	Air masses	NASA
10 .	16	Fronts	© Thomson Higher Education 2007
10 .	18	Cyclone X-section	CCL Kelvinsong
10 .	19	Jet Streams	NOAA
10 .	20	General Circulation	© The Atmosphere, Lutgens & Tarbuck
10 .	23	Contrails	airservicesaustralia.com
10 .	24	Satellite Images	allmetsat.com

Subject 11 Aerodynamics

Books Principles of Flight (Oxford Aviation Academy Ground Training 13)
ATPL 1000 Questions - Principles of Flight (Keith Williams)
Airplane Flying Handbook - FAA
Aerodynamics (FIS Précis)
Flight Without Formulae (AC Kermode)
RAF Manual for Flying (AP3456)

Images	Chapter	Description	Source
11 .	8	Pitch up	Courtesy K Haroon, theairlinepilot.com
11 .	9	Spin Convention	FIS Précis - Aerodynamics
11 .	13	Dihedral, Sweepback	avstop.com
11 .	14	Flight Controls	CCL Robert Hilbrich
11 .	15	Sonic Boom	CCL Chabacano
11 .	24	Flame-out Circuit Pattern	FAA

Subject 12 Engines

Books Aircraft General Knowledge (Oxford Aviation Ground Training 4 Engines)
ATPL 1000 Questions - Aircraft General Knowledge (Keith Williams)
Airplane Flying Handbook - FAA
Engines (FIS Précis)

Images	Chapter	Description	Source
12 .	1	Otto Cycle	Courtesy Shounak Bhattacharjee
12 .	1	2 Stroke Engine	cycleworld.com
12 .	10	Jet Engine	CCL Emoscopes
12 .	10	Jet Engine	CCL Jeff Dahl
12 .	11	Bypass Engines	CCL K Aainsqatsi
12 .	12	Turboshaft Engine	CCL Mliu 92
12 .	15	Pitot Intakes	CCL Flanker
12 .	15	Variable Intake	Courtesy Gordon
12 .	16	Centrifugal Compressor	CCL Emoscopes
12 .	17	Combustion Chamber	Courtesy Rolls Royce
12 .	20	Thrust Reverser	© Prude University
12 .	25	Concorde Reheat	Stephen Sausmarez, Heritage Concorde
12 .	29	Ramjet, Scramjet	CCL Cryonic07, CCL Luke490

Subject 13 Airframe

Books Aircraft General Knowledge (Oxford Aviation Academy Ground Training 2)
ATPL 1000 Questions - Aircraft General Knowledge (Keith Williams)
Airframe (FIS Précis)

Images	Chapter	Description	Source
13 .	4	Hydraulic System	Courtesy Integrated Publishing
13 .	5	Wheel Configurations	Courtesy Raymer 2006
13 .	6	Tyre	Yokohama Tyres
13 .	7	Pneumatic Oleo	Courtesy Moses Dhilip Kumar

Subject 14 Electrics

Books Aircraft General Knowledge (Oxford Aviation Ground Training 3 Electrics)
ATPL 1000 Questions - Aircraft General Knowledge (Keith Williams)

Images	Chapter	Description	Source
14 .	8	AC Generator	electricalacademia.com
14 .	11	Transformer	CCL BillC

To All That Fly

May God grant you blue skies aloft,
With winds of calm by land,
As you play on the outskirts of heaven,
On the fragile wings of man.

- John D. Duvall