COMMAND AND STAFF TRAINING INSTITUTE

BANGLADESH AIR FORCE

Individual Staff Studies Programme (ISSP)

PROFESSIONAL SUBJECT-2 : ENGINEERING
PHASE-16 : PART-II

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PHASE-16 : PART-II

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Revised by : **Gp Capt Md Shafiqul Alam, psc, GD(N)**
Wg Cdr Md Ashraful Islam, psc, Engg
Wg Cdr Sarker Ali Akbar, psc, Engg
Wg Cdr M Zahir Uddin, psc, Engg

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INTRODUCTION TO THE PHASE

Scope of the Phase

1. Phase-16 Note (Part-II, ISS) is a self-contained précis. It contains part of the following subjects:

a. Technical Management

b. Wing and Fuselage Construction

c. Airframe Limitations

d. Ground Resonance, Vortex Ring and Blade Sang

e. Communication System in BAF

f. Airborne Communication Systems

g. Radar Systems Used in BAF

h. Navigation System Used in BAF

j. Regulations Governing Inspection of Explosive

k. Red Card and Black List Procedure

l. Black Listing Procedure

m. Investigation Reporting of Armament Accident

n. Classification of Ammunition

p. Air Weapon Ranges

q. TOW Target System

r. Guide Missile Technology

s. General Sighting Theory and Harmonization of Aircraft Guns

t. Martin Baker Ejection Seat (MKBD 10D)

2. The syllabus has been so designed that you would be able to co-relate and implement (most cases) your knowledge in the profession field.

TASK-1
TECHNICAL MANAGEMENT

RECORDS, REPORTS AND ADMINISTRATION

Objective

1. Training. At the end of the task you should be able to:

a. Explain the activities of Records, Reports and Administration (RR&A)

b. Know the responsibilities of the records section of RR&A.

c. Explain the importance of the Reports and Administration Activity in centralized maintenance system.

RECORDS, REPORTS AND ADMINISTRATION

Introduction

1. The records, reports and administration (RR&A) activity in maintains historical records and files; prepares and submits maintenance reports; controls maintenance administrative procedures; prepares reports independently and as directed by OC maintenance wing. RR&A is the administrative Centre of the maintenance organization. In addition to processing and controlling essential historical data, it is the focal point for all correspondence and reporting.

Records

2. The records activity maintains historical and maintenance docu essential to the planning and scheduling of maintenance. It is on essential link in the processing of related forms connected wing technical order compliance and time change accessories. Files must be correct and legible at all times. Entries on maintenance documents must be promptly and correctly made in compliance with applicable TO/Publication. Responsibilities of this activity are enumerated below:

a. Maintain the historical records required for assigned equipment.

b. Maintain an individual jacket file for assigned equipment.

c. Ensure proper documentation of TCTO/bulletin and accessory change records as per the publication.

d. Scrutiny of F781, F201 and other documents and transferring/complying information in the appropriate log books/registers.

e. Forecasting replacements of life components of assigned equipments at least sic months in advance of their expiry date.

Reports and Administration Activity

3. This activity is responsible to :

a. Establish and control a central reporting and administration.

b. Maintain all correspondences and report files for OC Maintenance Wing except for special reference files maintained by each maintenance function.

c. Ensure proper distribution of all non-technical information and publication received.

d. Maintain an effective correspondence and reports suspense system.

e. Ensure publishing and distribution of maintenance orders, schedules, directions, procedures, reports, summaries etc.

f. Submit various returns to Air Headquarters in time.

<u>Consolidation Exercise - 1</u>

To consolidate your reading, answer the following questions :

Q1. Write the main points of the records, reports and administration (RR&A) activity.

Q2. State the responsibilities of the records section of RR&A.

Answers to Consolidation Exercise – 1

A1. Following are the records, reports and administration activity :

a. To maintain historical records and files.

b. To prepare and submit maintenance report.

c. To control maintenance administrative procedure.

d. To prepare reports independently and as directed by OC Maintenance Wing.

A2. Responsibilities of the records section of RR&A are to :

a. Maintain the historical records required for assigned equipment.

b. Maintain an individual jacket file for assigned equipment.

c. Ensure proper documentation of TCTO/bulletin and accessory change records as per the publication.

d. Scrutinize F781, F201 and other documents and trans-registers.

e. Forecast replacements of life components of assigned equipment at lease six months in advance of its expire dates.

QUALITY CONTROL

Objective

1. Training. At the end of the task you should be able to :

a. Explain the types of inspection carried out by the Inspectors of Quality Control

b. Know the responsibilities of Quality Control in respect of Functional Check Flights (FCFs).

c. Know the action taken by the Quality Control in implementing the TCTO/Bulletin.

QUALITY CONTROL

Introduction

1. Quality Control inspects to determine the quality of maintenance accomplished; supervises or performs all FCFs for assigned aircraft. The quality control supervisors must establish relationship with the individual maintenance supervisors which will ensure adequate corrective action on verbal as well as written discrepancy reports, The quality control supervisors will frequently check with each maintenance activity to determine whether inspection coverage is adequate, inspection reports are helpful, and inspectors are affording assistance to maintenance personnel.

Reports

2. To merit the confidence and active support of all maintenance activities, Quality Control must render complete, accurate, and impartial reports with sound recommendations which will air in the correction of discrepancies or irregularities.

Functional Check Flights

3. Supervise or perform all FCFs of both tactical and non-tactical aircraft in accordance with the prevailing directives. Brief each FCF crew prior to the flight. Accomplish FCF worksheets for each FCF Quality Control will conduct a formal de-brief of FCF crews when more detailed information is required than is normally available from the FCF reports.

Inspection

4. To determine the quality of maintenance throughout the maintenance complex following inspections will be performed by the quality inspection :

a. Accomplish inspection at critical stages of work during and upon completion of periodic inspection and unscheduled work on each aircraft/helicopter, aerospace ground equipment, vehicles etc.

b. Accomplish other inspections as desired by the OC Maintenance or other higher authorities.

c. Accomplish an inspection of in-process work and equipment at critical stages of work and upon completion of heavy or major field maintenance.

d. Accomplish each month, inspections on representative member of operationally ready items of equipment.

e. Review the adequacy of technical publications require for all the squadrons of maintenance activities.

f. Inspect the records jacket files for all items, maintained by the maintenance organization.

g. Inspect aircraft weight and balance records upon completion of modifications to ensure compliance with pertinent directives.

h. Inspect all maintenance activities at least once in six months for compliance with technical and management procedures, safety directives and rules of good house keeping.

j. Maintain a master maintenance file, information file, a current file of technical publications pertinent to the items maintained by the maintenance organization.

k. Prepare and submit, through locally established channels, a report on each inspection accomplished and maintain a file of corrective action endorsements.

l. Request assistance from the analysis activity in the identification and analysis of material and production deficiencies. Keep OC Maint Wg informed of material deficiency reports and unsatisfactory material conditions concerning assigned equipment.

m. Ensure that weight and balance check of assigned aircraft are carried out at the specified intervals.

Inspection Scheduling

5. Quality inspections will be scheduled jointly by the Quality Control and the Maintenance Control to ensure minimum disruption of the weekly and monthly schedules. The schedule will include a quality inspection of equipment upon completion of periodic maintenance.

Operationally Ready Inspection

6. Each month the Quality Control will inspect a representative member of ‘Operationally Ready’ items to determine the quality of maintenance being accomplished during other than periodic or heavy field maintenance. These inspections may be detailed for spot-check as determined by the Quality Control supervisors.

TCTO/Bulletin

7. Quality Control will monitor compliance of TCTO/Bulletins at all level of compliance and report to OC Maintenance Wing. Each incoming TCTO/Bulletin will be reviewed to determine its applicability to the equipment being maintained. An action copy of each TCTO/Bulletin affecting assigned equipment will be forwarded to supply and to RR&A and information copies to Material Control and Maintenance Control. The copy of TCTO/Bulletin furnished to supply will be forwarded with a cover letter requesting supply endorsement to the records activity with the number of spares affected by the TCTO/Bulletins. TCTO/Bulletin monitoring will :

a. Attend maintenance planning and scheduling meetings at which TCTOs are discussed.

b. Assist Material Control and the records activity in deterring the kit requirements.

c. Monitor accomplishment of modification directed in TCTO/Bulletin.

d. Attend the monthly supply/maintenance TCTO kit reconciliation meeting.

Publication Familiarization

8. A Procedure will be established by the quality control personnel to read and understand all pertinent incoming publications. Inspectors will determine during each scheduled inspection whether personnel in the maintenance activity are familiar with pertinent directives, whether they have ready access to the publications etc.

Master Work Card

9. Quality Control will establish and maintain a current master deck of inspection work cards for each type and model of item maintained by the maintenance organization. Periodically but not less frequently than 3 months, the work card decks in use will be checked against the master deck to ensure that complete, current inspection requirements are in use.

Fuel Handling Surveillance

10. Quality Control will exercise surveillance over fuel handling methods and procedures to ensure compliance with accepted safety standards and refueling/defueling procedure set forth in the applicable weapon system hand-books of maintenance instructions. It is intended that maintenance supervisors will ensure that fuel is not only dispensed in the best possible way observing safety regulations, but also that fuel placed abroad aero-space vehicle or ground equipment is clean and of prescribed type.

Consolidation Exercise – 2

To consolidate your reading, answer the following questions :

Q.1. What are the responsibilities of Quality Control in respect of Functional Check Flights (FCFs) ?

Q.2. Who will schedule the quality inspection ?

Q.3. How the publication can be familiarized to the quality control personnel ?

Answer to Consolidation Exercise – 2

A1. Quality Control supervises or performs all FCFs of both tactical and non-tactical aircraft in accordance with the prevailing directives. Quality Control also briefs each FCF crew prior to the flight and accomplishes FCF worksheets for each FCF.

A2. Quality inspections will be scheduled jointly by the Quality Control and the Maintenance Control to ensure minimum disruption of the weekly and monthly schedules.

A3. A procedure will be established by the Quality control personnel to read and understand all pertinent incoming publication. Inspectors will determine during each scheduled inspection whether personnel in the maintenance activity are familiar with pertinent directives and have ready access to the publications.

ACCESSORY REPLACEMENT AND REUSE PROCEDURE

Objective

1. Training. At the end of the task you should to be able to :

    a. Know the rules governing the accessory replacement and reuse.

    b. Explain the various classes of the accessories.

ACCESSORY REPLACEMENT AND REUSE PROCEDURE

Purpose

1. The purpose of this instruction is to define the Air force Policy concerning replacement and reuse of aircraft equipment and engine accessories for maximum utilization of aeronautical accessories.

Definition

2. **Accessories.** For the purpose of these replacement and ruse procedures term 'accessory' will be used to include accessories and components other than aircraft engines for which there is an established replacement internal in the manuals.

3. **Functional Test**. A functional test will normally be accomplished with accessories installed on the aircraft or equipment utilising auxiliary power units, ground powered test equipment, or engines as a source of power. However, a functional test may be accomplished either in the field maintenance shop or depot shop utilizing authorized test equipment.

4. **Through Inspection**. A through inspection will consist of an external inspection and disassembly to the extent authorised in applicable publications to determine the physical condition of the accessory.

Replacement of Accessories

5. Accessories, which are not listed in the inspection requirements manuals, are considered condition items. There will be periodically inspected and functionally tested as mentioned in he inspection manuals to determine their operational serviceability and will be replaced as and when necessary.

6. Accessories, which are listed in the inspection requirement manuals, will be considered due and will normally be replaced during post-flight or periodic inspection nearest to the replacement due time s indicated on the AFTO Form 781E. If the replacement is not made when due, the accessory will be carried on a red dash on the AFTO Form 781B. Such use of red dash symbol will be permitted to any post flight or periodic inspection which becomes due during the 60 days period after use of the red dash was stared or to the 60th day at which time grounding action will be required. At the expiration of this time limit, the symbol will be changed to a red X and replacement will be mandatory. Authorisation to use red dash will not prevent replacement of those time change accessories at the prescribed time interval when the maintenance officer considers the component an immediate safety hazard.

7. When an accessory has an established replacement interval and removed prior to the expiration of this interval for repair of compliance of bulletin the accessory will be subjected to reuse as governed by the following conditions:

   a. The accessories may be reused when the accumulated time on the accessory plus 100 hours does not exceed the replacement time specified in the inspection requirements manual.

   b. Accessories that are to be reused will be given a through inspection and functional test to determine operational serviceability. Accessories showing evidence of mal-function or impending mal-function will not be reused.

   c. When an accessory is re-installed, the time since new or last overhaul will be entered in the AFTO Form 781E.

8. Externally mounted engine accessories which are subjected to removal from the aircraft at the time of engine change will be handled as follows :

a. **Class A-1 and B-1 Accessories**. These accessories are externally mounted engine parts and components of reciprocating and turbojet engines respectively, which constitute a complete basic engine. These accessories will be returned with the engine to an overhaul facility when the engine is sent for overhaul.

b. **Class A-2 and B-2 Accessories**. These accessories are externally mounted engine components of reciprocating and turbojet engines respectively, which are not a part of the basic engine but are a part of the engine quick change power pack-up or engine build-up for which a replacement time is specified in the corresponding Inspection Manual. These items may be reused at the time of engine change if the accumulated time on the accessory plus 100 hours does not exceed the specified replacement time.

c. Externally mounted engine accessories which are not included in the above categories will be considered condition items and will be handled in accordance with para 5.

Field Maintenance Shop Procedure

9. All accessories removed from aircraft or equipment will be screened by the field maintenance shops to determine if they are serviceable or within the scope of field level repair. Screening will consist of through inspection and utilization of authorised test equipment and facilities to accomplish a comprehensive functional test.

10. Accessories determined to be beyond field level repair and those removed after expiration of their operating life for which repair facilities do not exist at the base will be tagged as R/D (Repairable at the Depot) and will be returned to supply sqn.

11. When an accessory is determined operationally serviceable or is made serviceable by minor repair and if it is not to be re-installed in the same aircraft from which removed, it is to be tagged as serviceable giving the following informations :

a. Scheduled Replacement Time ……………………………….

b. Previous Operating Time ……………………………………...

c. Remaining Operating Time ……………………………………

12. These items are to be kept as serviceable in the shop if it falls within the authorized pre-issue level, otherwise it is to be returned to Supply Sqn.

13. Depot Maintenance Procedure. Complete aircraft or equipment being processed through Depot for major maintenance/repair will have accessories replaced if it is indicated in the AFTO F-781E or in the inspection manuals.

Consolidation Exercise – 4

To consolidate your reading, answer the following questions :

Q1. Write short notes on the following terms :

a. Through Inspection.

b. Class A-1 and B-1 Accessories.

Q2. What action is to be taken, when an accessory is determined operational serviceable or is made serviceable by minor repair.

Answers to Consolidation Exercise – 4

A1. a. A through inspection will consist of an external inspection and disassembly to the extent authorized in applicable publications to determine the physical condition of the accessory.

b. Class A-1 and B-1 accessories are externally mounted engine parts and components of reciprocating and turbojet engines respectively, which constitute a complete basic engine, these accessories will be returned with the engine to an overhaul facility when the engine is sent for overhaul.

A2. Accessory is not to be re-installed in the same aircraft from which removed. It is to be tagged as serviceable by giving the following information:

a. Scheduled Replacement Time ………………………………

b. Previous Operating Time ……………………………………...

c. Remaining Operating Time ……………………………………

MT ADMINISTRATION IN BAF

Objective

1. Training. At the end of the task you would be able to :

    a. Explain how MT Establishment is made.

    b. Know the procedure followed in procurement of MT vehicles.

    c. Explain the purpose and use of F-658E and F-793.

    d. Know the action to be taken by a driver in case of MT accident.

    e. Know the rules governing the issue of driving license.

MT ADMINISTRATION IN BAF

MT Establishment

1. Establishment of MT vehicles, specialist vehicles, prime movers, bi-cycles etc are given in part III of the establishment document. Requirements of MT vehicles for various Base/Units and for the Air Headquarters are screened by the Air Headquarters for determining the scales. While determining the scale of MT vehicles, guidance is taken from the scales of other Air Forces, recommendations of specialist directorates, finding of work-study teams and Air Board decisions. There are then processed with the Ministry of Defence for inclusion in the establishment.

Procurement of MT Vehicles

2. MT vehicles are procured through tenders floated by DGDP after obtaining approval from the Ministry of Defence. After receiving in the country the vehicles are brought to No 212 MU for detailed inspection and raising of vehicles log books and inventories. Once these have been completed Air Headquarters is informed about the engine and chassis numbers of each vehicle for allotment of BA Number. Finally Air Headquarters (Dte of Sup) allots the vehicles to various Bases/Units as per the recommendation of Air Headquarters (Dte of Engg). The vehicles are then collected by the user Bases/Units from No 212 MU.

Maintenance Capabilities

3. At present first and second line servicing at MT vehicles are carried out by the Bases/Units. Third and fourth line servicing are carried out by No 212 MU. At present No 212 MU is not in a position to carry out all the maintenance work needed in a further line servicing. Some of the jobs of fourth line servicing are in hand to develop all the facilities in No 212 MU. So that the entries fourth line servicing can be carried out. Vehicles which are found beyond economical repair are disposed of through auction.

Form - 658

4. F-658 is an application for duty journey and is to be submitted to the MT detail, duly filled in a least 24 hours in advance prior to the commencement of journey. On receipt of F-658, MT Sqn raises Form-658E and details the most suitable transport. The name of the driver is entered in F-658E. It is then approved by either OIC MT Sqn or by WOIC MT Ops Flt. But for outstation duties beyond 40 miles it is to be approved by either Base Commander or by OC Maint Wing. Both F-658 and F-658E are to be attached together. After completion of the journey, point-to-point journey is to be shown on the reverse of F-58E and it must be signed. COAS and PSOs of the rank of Air Commodore and above have the privilege of not indicating the nature of duty and point-to-point journey.

Form-793

5. F-793 is used for hiring service transport. AFI 21/49 gives detailed procedure about it. Air Force vehicles may be hired out to the following persons :

a. To parties of Air Force Officers for the purpose of recreation.

b. To the families of airmen for recreation.

c. To Air Force messes and sports teams for the purpose of recreation.

d. To officers and families of airmen for individual use provided there is no excessive work thrown on drivers or vehicles.

e. To military departments or military personnel provided that not military transport is available.

f. To civil government department and service employed civilian personnel provided that no civil transport is available in the town or area.

6. Service vehicles will be given on F-793 when the following conditions are fulfilled :

a. That there are no trains as public conveyances which could normally be made as a measure of economy.

b. That the person is not in possession of private motor vehicles. If the motor vehicle is unserviceable, production of a certificate to that effect to the commanding officer is necessary.

c. That the journey is over 2 miles (excluding return journey) and not more than 20 miles (excluding return journey).

d. Officers and families of airmen can avail two repayment runs in a month when they use it for individual purpose.

e. All repayment vehicles are to be driven by a service driver of MTO trade, who is not a member of that party and the vehicle is to have a serviceable speedometer.

7. The authority competent to section the hire of service transport is the Officer Commanding of the Base/Unit or OC Main Wing.

MT Accident Report

8. Common Causes of Accidents. These are over speeding, overtaking at high speeds, over fatigue or negligence on the part of the driver, non-compliance and disregard to high way codes, road conditions, condition of the vehicle etc.

9. Papers to be in Possession with the Driver. All personnel driving service transport must be in possession of the following documents :

a. A duly approved F-658E/793.

b. A current driving licence authorizing him to drive the particular type of vehicle.

c. Identity Card/Security Pass.

d. A blank form 446A and a blank sheet of paper.

10. Action by Driver. Following actions are to be taken by the driver in case of accident :

a. Immediately stop and complete front page of F-446A.

b. Make detailed sketch of the scene of the accident.

c. Make a complete note of damages.

d. Complete the accident slip on the front page of F-446A to hand over it to police officer or the person involved in the accident as the case may be.

e. Statement by the driver should be given out of hearing of all other civilian personnel.

f. The vehicle be re-driven only after through inspection as to its serviceability.

g. Inform Base/Unit or Orderly Officer.

h. Safeguard the vehicle and equipment.

j. Submit a full report to MTO.

Issue of Driving Licences

11. Issue of Driving License to Airmen : Airmen of the following trades are only authorized to drive Service Vehicles :

a. MTOs.

b. MT Fitters.

c. Ground Signalers.

d. Provost.

e. Ground Combaters.

12. Issue of Driving Licence to Officers F-1839. Driving license, F-1839, to officers is issued by the Air Headquarters. Applications are to be made to Air Headquarters in accordance with F-1839B for issue of F-1839 under the signature of Base/Unit commanders. The under mentioned officers are authorized to drive service vehicles and permits may be issued to them on application to Air Headquarters :

a. Senior officers who have been allotted vehicles under the terms of AFI 33/70.

b. Base/Unit Commanders.

c. Tech officers in charge of MT Sqn.

d. PM and other officers of Provost Branch.

e. Officers responsible for training drivers.

f. Any other officers who is recommended for issue of a driving licence by the Base/Unit Commander.

Consolidation Exercise - 6

To consolidated your reading, answer the following questions :

Q1. Explain briefly the procedure followed in the procurement of MT vehicles.

Q2. What are the documents to be in possession with the driver ?

Q3. Who are the officers authorize to drive service vehicles ?

Answer to Consolidation Exercise – 6

A1. MT vehicles are procured through tenders floated by DGDP after obtaining approval from the Ministry of Defence. After receiving in the country the vehicles are brought to No 21 MU, for detailed inspection and raising of vehicles' log books and inventories. Then Air HQ is informed about the engine and chassis numbers of each vehicle for allotment of BA Numbers. Finally Dte of Supply allots the vehicles to various Bases/Units as per the recommendation of Dte of Engg. The vehicles are then collected by the user Bases/Units from No 212 MU.

A2. The following documents must be in possession with the driver :

a. A duly approved F-658E/793.

b. A current driving licence authorizing him to drive the particular type of vehicle.

c. Identity Card/Security Pass.

d. A blank form 446A and a blank sheet of paper.

A3. The under mentioned officers are authorised to drive service vehicles :

a. Senior officers who have been allotted vehicles under the terms of AFI 33/70

b. Base/Unit Commanders.

c. Tech officers in charge of MT Sqn.

d. PM and other officers of Provost Branch.

e. Officers responsible for training drivers.

f. Any other officer who is recommended for issue of a driving licence by the Base/Unit Commanders.

TASK – 2

WING AND FUSELAGE CONSTRUCTION

Introduction

1. The few basic forces acting on an aircraft in flight, lift, weight, thrust, drag, all affect the construction of the aircraft structure. The designer has to ensure that the strength of the airframe exceeds the normal maximum operating loads imposed on it, by the required safety margin. These forces will very considerably throughout the flight envelope, and are dependent on such things as loading (g), airspeed, turbulence, movement of control surfaces, changes in configuration (Lowering of landing gear, etc) and landing.

2. In the early days of aircraft design, when the biplane configuration was used almost exclusively, the use of external wires and bracing struts enabled wing structures to be made which were extremely rigid compared with the weight and strength of the components. The wings and fuselages were built up from a light frame-work of wooden ribs, spars and formers covered with light fabric and doped. The wires and struts bracing the main planes formed what was, in effect, a large lattice girder; wires were also used to brace the tail plane and fin.

3. As the top speed of aircraft increased, so the shape and layout of the aircraft, and the materials used in its construction changed. The monoplane layout became universal, bringing with it the increased problems of designing a thin unbraced wing that was strong enough to resist the tension, compressive and twisting loads imposed upon it. Metal was used for formers, ribs and as an outer skin in place of the plywood and fabric of the earlier aircraft. The conflicting requirements of light weight and strength usually resulted in a compromise, and aluminum alloys are used extensively in medium speed, subsonic aircraft. With supersonic aircraft, the kinetic heating effect of prolonged supersonic flight can cause the light alloys to lose some of their strength; other materials, such as stainless steel, which is heavier, stronger and more expensive, have to be employed in the construction of aircraft designed for continuous supersonic flight.

Wing Construction

4. Spars. In order to resist the bending forces imposed on it, and ideal spar is given a certain depth. An example of this is an ordinary ruler, which will flex easily when loaded on the upper or lower surfaces, but is very stiff when a load is applied to the edge. Unfortunately, the modern wing is thin in cross-section, precluding the use of a deep spar. Two, three, or more spars are used in the wing to give the necessary strength. The spar usually consists of solid books at the top and bottom, connected by a thin plate web. Normally these are manufactured as separated items and riveted together, but some

spars are made in one piece from heavy forgings, machined to perfect shape.

5. Stressed – Skin. Although some light aircraft still have part of the airframe covered in fabric, most aircraft re metal clad. In subsonic aircraft, the wing skeleton of spars and ribs is cover with a light alloy skin. This is riveted to the framework and is designed to stiffen the wing, by taking some of the loads. This type of construction is known as “stressed-skin” and produces a relatively strong wing without too large a weight penalty. The wing can with stand twisting or torsion loads, and is usually strengthened by the addition of span-wise stringer to withstand the bending or flexure loadings.

6. Machined Skin. The faster an aircraft flies, the greater the rigidity of the structure is required. To achieve this, the stressed-skin of the slower aircraft is replaced by a machined skin. This consists of a skin that is manufactured from a solid billet of metal. The metal is milled away by machines so that in its final form the contour of the wing is very accurately reproduced, together with the necessary strengthening but tresses and ribs. Altogether up to 90% of the original metal with be cut away, leaving a structure that is extremely strong but light in weight. The panels so produced are joined together to form a rigid, strong wing.

7. Torsion-Boxes. In this form of construction the skin of the upper and lower surfaces of the wing joins the front and rear spars rigidly together in the form of a box. To the front is attached the leading edge and to the rear the aileron and flaps. To increase the load carrying capacity of the skin between the spars, it is common to corrugate it and then cover the corrugations with a thin sheet. This form of construction is much used and a variation of it, which has a number of spars, one behind the other, forming a series of boxes, appears particularly suited to aircraft with low aspect ratios.

8. D-Spar Construction. The front spar, which takes most of the bending load, is placed as near as possible to the point of maximum thickness of the wing, and the skin of the leading edge is rigidly attached to it to form a D-shaped tube, which takes nearly all the tensional stresses of the wing.

9. Control Surfaces. For speeds up to 300 – 350 kt fabric-covered ailerons built up on a spar and ribs are usually satisfactory. Higher speeds demand a rigidity that can only be obtained by a stressed-skin covering built up in much the same way as a D-spar wing. Additional stiffness can be obtained by employing longitudinal fluting of the skin (ie spaced corrugations); in this design most of the ribs can be eliminated.

10. Braced Wings. This design feature is used almost exclusively in small high wing aircraft. The bracing struts, running from the fuselage to a point about half-way along the wing, relieve the spars of much of their vertical load and anchor them in tension. The designer can therefore save weight in the wing, but because of the additional to aircraft with a low top speed.

Fuselage Construction

11. Fuselages present basically a simpler structural problem than wings. A fuselage is usually built up from a framework of frames or transverse members joined by longitudinal girder members or “stringers”, the whole framework being covered by stressed skin. The shape of the cross-section of the fuselage will vary with the job that the aircraft has to perform. Pressurized transport aircraft have circular cross-sections this has been found to be the most suitable shape to resist the differential pressures. Fighter aircraft have a cross-section of minimum area, the shape is determined by the engine it encloses and/or the radar, armament or other equipment carried. Light aircraft usually have a square fuselage; this being an easy and strong shape to construct.

12. Pressurization. The ideal shape for a pressure vessel is a sphere; passengers and freight are best carried in a box shape. In pressurized transport aircraft the designer combines these two shapes as much as possible and the pressure cabin is usually in the form of a circular tube with hemispherical ends. Basically, this structure is easy to construct from light alloys and the stresses induced by pressurization are not difficult to calculate. The problems of providing openings for doors, windows, etc are more difficult. Where cut-outs are made in the stress carrying skin, additional strengthening is required around the edges to provide a stress-path around the hole; strong rims alone are not sufficient, the loads must be gradually absorbed by the surrounding structure to prevent any sudden stress concentration that can lead to fatigue. The ideal shape for any opening in a pressure cylinder is an ellipse and many aircraft have their windows this shape. Elliptical door shapes are not so practicable from a loading aspect and the more usual shape is a rectangular door with rounded corners.

13. Sealing Problems. Ideally, a pressurized cabin should be air tight; in practice, leaks are kept to a minimum. Sealing must be effective under all conditions, including the structural flexing that occurs during flight, and the expansion and contraction caused by temperature variation. For hoods and doors the sealing medium normally used is an inflatable tube, fitted between the door/hood edge and the aircraft structure and cables passing out of the cabin must be adequately sealed against leakage, whilst allowing movement and self alignment with a minimum of friction.

Supersonic Aircraft Structures

14. To achieve stranger airframes the machined skin type of construction (para 6) can also be applied to most parts of the fuselage. However, for aircraft designed for prolonged flight at high supersonic speeds even stronger materials have to be used. Because of the kinetic heating effect at high Mach number, parts of the skin can be raised to over 120°C

at M2-0. At this temperature aluminum alloys lose 40% of their strength. Therefore, in order to retain acceptable strength and rigidity, large panels are made from a stainless steel honeycomb sandwich. This consists of a core, built up from thin strips of stainless steel in the form of a honeycomb, and brazed together. The completed core is then machined to the shape of the required panel and placed between ready shaped inner and outer skins, also of stainless steel. The whole is heated in an inert atmosphere until all the joints have been brazed together. This results in an extremely rigid and relatively light structure which will retain its strength at temperatures of around 260°C.

15. Complete airframes can be built up of the honeycomb sandwich paneling, pre-shaped as described in the previous paragraph, with extruded stainless steel boundary members, transverse struts and attachment points attached. Areas subjected to large stresses have the density of the core increased, and the skin thickened. The leading and trailing edges have a solid honeycomb core and the skin is of a honeycomb sandwich supported by welded stainless steel spars.

<u>“Safe – Life” and “Fail – Safe”</u>

16. In concluding this chapter, mention must be made of the structural concept of “safe – life” and “fail-safe”. A structure designed for a given safe life is one in which actual testing of similar structures has enable the designer to calculate the minimum flying hours before structure failure will occur. This figure is then the “safe-life” for the particular structure. A “fail-safe” structure is one in which, by duplicating primary structures, an alternative path is available for a load. Therefore, if one member fails, the remaining structure can carry the load for a limited time. In some cause this will involve and extra weight penalty, but often the stand by part can justify its existence by performing some separate task. An example of this is the window of a pressure obtain, which consists of two layers of glass wing a sandwich of dry air between. Normally the pressure differential is support by the inner layer, but should this fail then the outer layer can be made to take the load.

TASK – 3

AIRFRAME LIMITATIONS

Introduction

1. Except when landing, or manoeuvering on the ground, all loads on an aircraft structure are imposed aerodynamically in two ways, either as the result of a manoeuvre or because of an atmospheric disturbance (eg gusts). Limitations such as indicated speeds, much number, accelerations, weights, and CG positions, are imposed for reasons of safety. These usually depends on factors not related to the skill of the pilot. All airframe limitations are quoted in the Aircrew Manual for the type, and must not be exceed intentionally.

2. Limitations take into account the aircraft role, structure handling, and controllability, and are imposed only when they are essential. Disregard of limitations leads to damage and weakens the aircraft structure so that it may fail immediately or on some subsequent flight.

IAS Limitations

3. The air leads acting on the airframe depend principally upon dynamic pressure (the $\frac{1}{2}\ pV^2$ effect) and vary roughly as the square of the IAS. Thus at a certain speed the total load on some part of the airframe, usually the wings to tail structure, increases up to the safety limit. The strength of the tail structure is frequently the limiting factor because a considerable down load, produced by the elevators or tailplane, is required to keep the wings at the angle of attack necessary to produce the large amount of lift when manoeuvering at high.

4. A further consideration is that at high IAS the loads on the airframe may be great enough to cause aero-elastic distortion which could so alter the stability characteristic of the aircraft as to make its behavior unpredictable.

5. The maximum permissible IAS given as the service limitation in the Aircrew Manual is slightly lower than the design maximum IAS which is the highest figure for which the aircraft is stressed. The difference between the two gives the pilot a small safety margin. If the design maximum IAS were permitted, even the slightest inadvertent exceeding of it would almost certainly cause damage to the aircraft.

Mach Number Limitations

6. A Mach number limitations is usually imposed when violent compressibility buffot may lead to structural failure or when loss of control due to compressibility characteristics may cause the aircraft to exceed the structural limitation before control can be regained. Alternatively it may be necessary to impose a Mach number limitation in the early stages of an aircraft's service life because trails have not been completed to allow clearance to a higher Mach number. When a Mach number limitation is imposed it may imposed it may

be quoted as a definite figure such as 0.88M or as a special condition of flight eg when a nose-up trim change occurs.

7. On some aircraft mach number limitations are imposed at low altitudes, because even temporary or partial loss of control at the high accompanying IAS could quickly result in a dangerous situation; the larger aerodynamic and g loads set up by violent behavior, added to the already large leads imposed by the high IAS, might well be more than the airframe could absorb.

8. Each number limitations are also imposed whenever the addition of external stores has undesirable effects. For example, it is often found that externally-carried bombs cause Buffeting which is strong enough to damage the airframe. On the other hand, some drop tanks have no adverse effect and consequently no limit is set. Buffeting alone is rarely the cause of a limit being imposed, unless it is severe enough to fatigue the structure or affect control.

9. On aircraft with no Mach number limitation at, say heights about 25,000 ft it is not harmful to exceed the Mach number at which compressibility effects become marked even up to the point of imminent loss of control, or, for that matter, complete loss of control provides that vibration or buffeting is not severe; this is because the accompanying IAS is comparatively low and well below the maximum permissible. It will be found that the loss of control is temporary, there are no ill-effects, and control can be regained comparatively quickly before the IAS has increased up to or beyond its limiting value, provided of course that the correct recovery action has been taken.

<u>g Limitation</u>

10. Limitations are based on the ultimate designed strength of the airframe. This obviously varies with the role of the aircraft. For example, a fighter aircraft may be designed to withstand g loads of up to 11g, at which stage structural failure is almost bound to occur. In order to give pilots a margin for error a safety factor of at least 1.5 is imposed, and a lower, but safe limit is given in the example quoted above the actual g limitation would stated as 7g. Thus, the aircraft could be flown safely with a loading of up to 7g without risk of damage; if the limit is inadvertently exceeded there is increasing risk of permanent deformation and failure. Similarly, but lower values are usually fixed for the maximum safe negative g.

11. Every type of aircraft is designed to fulfill certain duties and is stressed to carry out the loadings that its duty demands. At the same time the controls are designed, as far as possible, to keep the loading that the pilot can impose within the design limits; this is evident by the comparative heaviness of the controls of large aircraft, which have low g limits, and the lightness of those of a well-designed fighter.

12. The danger of overstressing the aircraft owing to excessive g is much greater at lower altitudes, because it is here that the highest loadings are most easily obtained. At higher altitudes the reduced lift due to compressibility effects, combined with the lower IAS obtainable, restricts to a comparatively low figure the maximum g that can be reached

before the aircraft stalls.

The Flight Envelope

13. The flight envelope is a graphical method of representing various limits imposed on an aircraft. The detailed construction of this diagram is covered in the chapter on Manoeuvres (Sec 1, Chap 13).

High Altitude Limitations

14. Aircraft designed to operate at very high altitudes and mach number may be severely restricted in terms of both IAS and mach number at low altitudes. For example an aircraft that cruises at 0.95M at 50,000 ft is flying at 250 knots IAS (540 knots TAS). An aircraft of this type might well be limited to 4000 knots TAS at sea level, or about 0.6M. If enough strength were built in to allow a higher IAS at low altitude the greater weight of structure would drastically curtail the more important high altitude performance. This type of aircraft, having a large reserve of power at low altitudes, would be capable of easily exceeding the IAS limitation it is the pilot's responsibility to see that this does not happen.

Flight in Turbulence

15. Turbulence air imposes g load on the airframe, the effect of which is proportions; to the IAS. If turbulent air is encountered when flying at high IAS, the air speed should be reduced to that recommended in the Aircrew Manual for safe flight in these conditions. speeds higher than the recommended figure may result in damage to the airframe, whereas lower speeds may lead to difficulty in control. AP3456, Vol F, Part 1 Sect 2, Chap 2 details the technique for flying through severe air turbulence and discuss the best speeds for different types of aircraft.

Prohibited Manoeuvres

16. The flying controls on aircraft enable the pilot to manoeuvre the aircraft into any altitudes; some of these altitudes may lead to dangerously high leadings and air speeds which the aircraft has not been designed to withstand. To protect the pilot and aircraft certain manoeuvres are prohibited.

Undercarriage and Flap Limiting Speeds

17. The speed limitations for the raising and lowering of the flaps and undercarriage arise from the limited strength of the components to withstand the air loads, or from the power of the operating mechanism. The limiting speed still applies with the service in the extended position unless the Aircrew Manual quotes a higher speed. Further, should the undercarriage or flaps be lowered at higher speeds the trim and stability of the aircraft may be markedly affected and the airframe overstressed. Unless the Aircrew Manual for the

type states that the flaps are designed to assist manoueuvres, they should not be used under conditions of loading appreciably greater than those of standby level flight. it should be noted that the figures quoted are limitations and are not recommended at the best speeds at which to perform these operations. The limiting speeds quoted for the operation of other items such as bomb doors, canopies and landing lamps, are imposed for similar reasons.

Weight Limitations

18. Weight limitations are imposed on all aircraft, the determining factors being the strength of the undercarriage, particularly for the landing case, and the loads that can be absorbed by the wings when manoeuvring at the maximum permissible g. On twin and multi-engine aircraft the performance on asymmetric power is sometimes criticals and exceeding the weight limitations may result in a serious drop in performance.

19. Aircrew Manuals often give more than one weight limitation, for example :

a. Maximum weight for take-off and gentle manoeuvres only, and a lower limit.
b. Maximum weight for all other permitted forms of flying, and a still lower limit.
c. Maximum weight for landing.

This means that at the highest weight the aircraft must be handled gently, moderate turns should be made and only small amounts off g imposed. Also, the IAS and mach number should be kept well within the limitations until the weight falls to the limit at which all forms of flying are permitted. This limits imposed for landing should be exceeded only when an emergency landing must be made and excess load cannot jettisoned. In this case every care must be taken to avoid large shock loads and the aircraft landed as gently as possible.

CG Limitations

20. Flying limitations include the most forward and most aft permissible position of the CG. This information is contained in the Aircraft Servicing Manual – Ground Handling and is also given in the Aircrew Manual in many cases. The aircraft should be flown at standard loadings at which the CG is within safe limits. Allowance should always be made for any shift of the CG as fuel is used or stores dropped.

21. Non – observance of CG limits can lead to instability at all speeds and to uncontrollable nose or tail – heaviness at low speeds, the latter because of the elevators reaching the limit of the movement. On aircraft which carry a large fuel load distributed at various positions in the fuselage and wings, the fuel should be used in the sequence given in the Aircrew Manual in the paragraphs dealing with management of the fuel system. If this is not done the position of the CG may move beyond its safe limits and control will be affected. For the same reason Aircrew manuals sometimes specify the disposition of the crew and passengers or the amount and position of ballast needed.

22. Aircraft may some times have occasion to carry non-standard loads and pilots must ensure that the disposition of those loads will keep the CG within its limits. If an aircraft has to carry a heavy, concentrated load which can only be secured well aft or well forward of the CG, the balance must be preserved by placing an equal weight on the other side of the CG position at an equal distance, or a lesser weight at a greater distance. In other words, the moment of the load must be balanced by an equal moment in the opposite direction.

Dangers of Exceeding Limitations

23. Exceeding flying limitations, in particular the maximum IAS limitations, the mach number limitation (if any), and the maximum g limitations, involves a risk of structural failure, and must be avoided unless operational necessity or an emergency make it essential for the pilot deliberately to take risks with his aircraft, balancing one risk against another. In all cases, if these limitations are exceeded, the facts must be reported after landing, giving details and the duration of the overstressing period. This is necessary so that the airframe can be checked for damage which, as stated earlier, might prove fatal in a later flight if not attended to, even though on this occasion the pilot had “got away with it”. On every occasion that overstress occurs some of the ability of the airframe to absorb high stresses is lost, and the strength of the structure and so the breaking load is reduced, perhaps to a very low figure. The early signs of an over stressed airframe are loose rivets and wrinkles in the skin, particularly at the wing roots and along the rear fuselage.

THERMAL AND PROPULSIVE EFFICIENCIES

Expression for Thermal Efficiency

1. In airbreathing power plant , the thermal efficiency (Σth) may be expressed as follows :

$$\Sigma th = \frac{\text{Gas power produced}}{\text{Fuel power used}}$$

Relative Velocities	V c	0	Vje .
Absolute Velocities	0	Va .	(Vje - Va)

$$\Sigma th = \frac{\frac{1}{2}m_a \quad V_{je}^2 - \frac{1}{2}m_a \quad V_a^2}{2 \text{ mf x calorific value}}$$

$$\Sigma th = \frac{m_a \quad (V_{je}^2 - V_a^2)}{2 \text{ mf x calorific value}}$$

Where m_a = the mass flow rate of air

m_f = the mass flow rate of fuel

V_a = Velocity of intake air (TAS)

Vje = effective velocity of jet efflux

Expression for Propulsive Efficiency

2. Using the same notation as in para 1, the propulsive efficiency (Σp) of an airbreathing powerplant may be expressed as follows :

$$\Sigma p = \frac{\text{Propulsive power produced}}{\text{Propulsive power produced} + \text{Kinetic power rejected}}$$

$$= \frac{m_a (V_{je} - V_a) \times V_a}{m_a (V_{je} - V_a) \times V_a + \frac{1}{2} m_a (V_{je}^2 - V_a^2)}$$

$$= \frac{m_a (V_{je} - V_a) \times V_a}{m_a (V_{je} - V_a) \times V_a + \frac{1}{2} m_a (V_{je} - V_a)(V_{je} + V_a)}$$

$$= \frac{V_a}{V_a + \frac{1}{2}(V_{je} + V_a)}$$

$$= \frac{2}{1 + \frac{V_{je}}{V_a}}$$

This expression is often named the Froude Efficiency. From this, it can be seem that the propulsive efficiency becomes unity when the velocity of the jet efflux is the same as the velocity of the air being admitted to the engine intake.

Propulsive Efficiency (%)

Fig-2 Effect of V_a / V_{je} ratio on propulsive Efficiency

TASK – 4

GROUND RESONANCE, VORTEX RING AND BLADE SAILING

Ground Resonance

1. Ground resonance can be defined as being a vibration of large amplitude resulting from a forced or self-induced vibration or a helicopter in contact with or resting upon the ground. The pilot will recognize ground resonance from a rocking motion or oscillation of the fuselage and, if early corrective action is not taken the amplitude can increase to the point where it will be uncontrollable and the helicopter will roll over.

2. Cause of Ground Resonance. The initial vibration which causes ground resonance can already be present in the rotor head before the helicopter comes into contact with the ground. Ideally the diso should have its centre of gravity over the centre of rotation, but if for any reason its position is displaced, a “wobble” will develop, the effect being similar to an unbalanced fly-wheel rotating at high speed. Ground resonance can also be induced by the undercarriage being in light contact with the ground particularly if the frequency of oscillation of the oleos and/ or tyres is in sympathy with the rotor head vibration.

a. Rotor Head Vibration. Rotor head vibration can be caused by :

(1) Blades of Unequal Weight or Balance. Blades should be correctly weighed and balanced during manufacture, but flight in icing conditions can cause imbalance due to the uneven accumulation of ice on the rotor blades. Moisture absorption or blade damage can also be a cause of imbalance.

(2) Faulty Drag Damper. With a three-bladed rotor system the blades should be equally spaced 120° apart. It a damper is sticking or is allowing uneven spacing of the blades, the centre of gravity of the rotor will be displaced away from the axis of rotation (Fig-1).

(3) Faulty Tracing. A rotor which is greatly out of track may set up an unbalanced condition which will be transmitted through the helicopter. This type of imbalance usually results in nothing more than a rough helicopter and a “beat” in the cyclic stick. However, if enough track imbalances exists, it is possible that a combination of factors may be encountered that would result in ground resonance being induced (Fig-2).

b. Fuselage Vibration. Fuselage vibration can be caused by :

(1) Miss-landing, aggravated by continuous lateral movement of the cyclic stick.

(2) A taxying take-off, or run-on landing, over rough or uneven ground.

(3) Incorrect or unequal tyre pressures; incorrect or unequal eleo pressures.

Additional operational could arise from troops deplaning from a helicopter hovering in light contact with the ground and falling against the undercarriage, or a wheel dropping into a hole or rut on landing.

3. Recovery Action. The more appropriate of the following actions must be taken :

a. Take-off immediately if take-off rotor rpm are available. Rotor rpm should always be maintained in the operating range until the final landing has been completed.

b. Shut down immediately if take-off Rrpm are not available, or if take-off is not practicable; ie lower pitch lever, reduce power, apply rotor brake and wheel brakes.

Vortex Ring

4. Although vortices are always present around the periphery of the rotor, under certain airflow conditions the vortices will intensify and coupled with a stall spreading outwards from the root end of the blade, result in a sudden loss of rotor thrust and a subsequent rapid loss of height. This condition is similar in some ways to stalling in a fixed-wing aircraft and when it occurs the helicopter is said to be in a state of vortex ring. This state can be entered from several in flight manoeuvres but the airflow conditions which give rise to its formation remain substantially the same in all cases. These conditions will only occur when one or all of the following are present :

a. The helicopter has an induced flow passing down through the disc, ie power flight.

b. There is an external airflow directly opposing the induced flow, is high rate of descent.

c. The indicated air speed is low. One flight manoeuvre from which vortex ring state can develop is when the helicopter enters a power-assisted descent with low or zero indicated air speed. The manner in which it can develop this manoeuvre is discussed below. Other manoeuvres where vortex ring can develop are :

d. As a result of applying power to recover from a low air speed autorotation without first increasing the air speed.

e. Allowing the helicopter to lose height during a harsh flare.

f. Downwind approach.

Development of Vortex Ring State

5. When the helicopter is hovering in still air (Fig-3) the direction of the relative airflow can be determined from the blades' speed of rotation and the induced flow, both of which will have their greatest value near the tip. Assuming that the ratio of rotational velocity to induced flow is constant throughout the length of the blade, then the direction of the relative airflow all along the blade will be the same, but, because of the twist or wash-out, the root end of the blade will have the greatest angle of attack (Fig 3 b and c).

6. Consider the effect the reducing collective pitch to commence a rate of descent (Fig -4a). When the descent is established a new airflow component will exist directly

opposing the induced flow which in turn will alter the direction of the relative airflow along the blade. If, at the root end of the blade, the airflow from rate of descent is equal to the induced flow, then the relative airflow will be in the plane of rotation, causing the angle of attack to increase (Fig 4c). In the area of the tip, the conflicting airflow outside and inside the disc will intensify the tip vortices, further increasing the induced flow (Fig 4b). If the increase in induced flow has the same value as the airflow from rate of descent, a change will take place in the direction of the airflow relative to the blade but, because the collective pitch has been lowered, the angle of attack in the area of the tip will have actually decreased (Fig 4b).

7. If the collective pitch lever is lowered further, the rate of descent will again increase (Fig 5a); the process will be repeated, and eventually a condition will be reached where the root end of the blade will reach its stalling angle (Fig 5c). At this stage, rotor thrust is decreasing both at the tip of the blade, due to the vortices, and at the root of the blade, because of its stalled condition, leaving an area in between to produce the rotor thrust necessary to balance the weight. Any further increase in rate of descent resulting form lowering the lever will further reduce the area of the blade that is effectively producing rotor thrust and, on a condition is reached where the rotor thrust becomes insufficient to balance the weight, then the rate of descent will rapidly increase, being as high as 6,000 rpm on some types of helicopter. Wind-tunnel experiments indicate that the vortices form and intensify in a most erratic manner, subjecting each blade inboard from the tip to large and sudden variations in angle of attack. Dissymmetry of rotor thrust occurs and the helicopter will pitch, roll and yaw to no set pattern, making control of the aircraft extremely difficult. In the full developed vortex ring state, raising the collective; pitch lever will only aggravate the condition and instead of checking the rate of descent, it will cause it to increase. The higher the all-up weight of the helicopter for a given rotor rpm, the higher the collective pitch setting necessary to maintain the hover at the given rotor rpm. Consequently, vortex ring state can occur at an earlier stage in a heavily-laden helicopter than it would in a lightly-laden one, under the same conditions.

<u>Vortex Ring State Symptoms and Recovery Action</u>

8. <u>Symptoms of the Vortex Ring State</u>. The onset of vortex ring state can be identified form the following symptoms :

a. Judder and stick shake.

b. Random yawing.

c. Rapid increase in rate of descent.

d. Cyclic stick less effective.

e. Random rolling and pitching.

Note : a. and b. can occur in turbulent conditions on a steep approach, therefore a cross-check should be made between air-speed and rate of descent to distinguish between turbulence and the onset of incipient vortex ring state.

9. Avoidance of Vortex State. The pilot should avoid situations likely to cause the vortex ring state, or, if this is impossible restrict the rate of descent to allow (200 rpm) when the airspeed is low (below 15 kt). This is because the most likely flight conditions occur when within 500 ft of the ground where recovery techniques are unlikely to be successful.

10. Recovery. To recover from a state of vortex ring, it is necessary to change the airflow conditions which are causing it. The commended method is to change the disc attitude to achieve forward flight, so that the induced flow no longer opposes the airflow from the rate of descent, and then wait until the air-speed has increase to a safe figure before increasing power. Another method of affecting recovery is to enter autorotation, but it may be impossible to prevent the over speeding and a full recovery will result in a considerable loss of height. The recommended recovery actions are :

a. Stick forward to tilt the rotor disc.

b. Pause-to gain forward speed above 20 kt.

c. Apply power.

Blade Sailing

11. A condition known as blade sailing can occur when the rotor is starting up or slowing down in strong wind conditions, particularly if the wind is gusting. With the helicopter facing into wind, the advancing blade experiences an increase in lift and will flap up excessively due to the low centrifugal force, reaching its maximum height to the front of the helicopter. As the blade progresses on the retreating side, it experiences a sudden loss of lift and will flap down rapidly, flex and reach its lowest position to the rear of the helicopter, ie over the tail cone. There is an extreme danger of the blade striking the tail cone at this stage. Due to the poor stick response and low Rrpm it is almost impossible to control blade sailing. The effect, however, can be minimized by displacing the stick forward and slightly into wind, or by facing the helicopter slightly out of wind so that the lowest point of the blades; path does not occur over the tail cone. Since this condition occurs at low Rrpm in strong wind conditions, it is adviseable to slow the rotor down quickly on shut-down by using the rotor brake. On start-up, the rotor rpm should be increase at a faster rate than normal.

TASK-5

COMMUNICATION SYSTEMS IN BAF

Introduction

1. Comm is one of the fastest growing technology and has become an integral part of human civilization. With the adv of comm, electronic and computer tech, the whole gamut that we call comm has increased its sphere in every area of any mil op. Today, comm has not only become an integral part of comd, but also associated with surv, guidance & cont of firepower & wpn to achieve dramatically increased level of accuracy. Without comm it is now imposs to think of any comd & con of any Armed Forces. The so called C^2I are ever increasing it its power and now people speak of C^4ISR - meaning comd, con, comm, computers, int, surveillance and reconnaissance. What started as drum beats & pigeons, now has come to tel radios, computers and mob which not only carr the voice & written msgs, but also data, charts and videos which was unthinkable only a few yrs back. The sphere of comm has expanded and integrated with computer technology so much, that people have now given it a new name - Info Technology of IT in short. Days are not far when btl and its fate will depend on IT alone.

Comm Sys of BAF

2. BAF, being technologically intensive arm of the defence forces, is more susceptible to the impact of changing scenario. BAF must have an efficient, rapid, secured and reliable comm sys, both on grd and in the air, as it deals with very high speed machines like cbt ac, msl and other wpn sys. To sp the flg op of cbt and all other ac, BAF also needs a reliable telecom net, radio, radar and sophisticated nav and landing aids, during peace and war. Every progressive air force of the world is thus cont upgrading & modernizing their comm eqpt & sys. BAF is no exception to accept the fact that up gradation & modernization of its own comm sys has to be a cont process to keep abreast with the tech adv of technology and meet the ever increasing need of the future. On the other hand, some of existing comm sys of BAF have become old and are not adequate to meet the reqr of BAF. So the need for replacement, up gradation and expansion of the existing comm sys has been felt since long. This chapter would discuss the present comm systems of BAF. Even though BAF maintains wide verities of eqpt and sys of comm range which incl comm, avionics, nav aids, radios, radar, computer, simulators and so on. But this chapter would only discuss about BAF Surface Comm and Air to Air/Grd Comm.

Existing Comm Sys Of BAF

3. In BAF, we have basically two broad kinds of comm sys i.e. Surface Comm and Air to Air/Grd Comm. The Surface and Air to Air/Grd Comm sys consist of the fol sys :

a. Surface Comm Sys

(1) Inter-Base Admin Comm Net.

(2) AD and Air Comd/Sp Comm Net.

(3) Comm Net with C&M(U).

(4) BAF PABXs.

(5) LOS Microwave Comm Sys.

(6) Mob Comm Sys.

(7) BAF Computer Net.

(8) Cypher Comm Sys.

(9) Intercom Sys.

(10) Fd Tel Exchs.

(11) Fax Comm.

(12) Auto Tel.

(13) Internet.

(14) Sat Tel and Civ Mob Phones.

b. Air to Air/Grd Comm Sys

(1) ATC Air to Grd Comm Net.

(2) AD Air to Grd Comm Net.

(3) Air to Air Comm Net.

Inter-Base Telecom Sys

4. The existing inter-base/unit telecom sys are basically long dstn comm net that are used to comm between bases and units for op, AD and admin purposes. These three nets are interactive and one takes precedence over the other depending on the sit. Except the AD Net, those comm sys fun from more as admin and trg comm net during peace time, while in war sit, the same sys would fun more as op net.

a. Admin Comm Net. The Admin Comm Net consists of a no of trunk, hot and point-to-point line connecting the PABX of BAF Comm (U) with PABXs of all Bases/ Units. All exchs are interlinked through BAF LOS and BTTB leases lines. The existing inter-base admin comm net consists of the fol comm lines :

(1) Trunk Lines.
(2) Hot Lines.
(3) PP Lines.
(4) Fax Comm.
(5) LAN/WAN through LOS.
(6) HF RT Comm.
(7) Cypher Comm
(8) PABX Exts.
(9) Sat Phone.
(10) Civ Auto Tel.
(11) Intercom Sys.

b. Comm with C&M(U). All BAF C&M(U) has one civ auto tel. The Units are also linked through HF having voice, fax and data comm facilities. Cypher comm is also aval through this HF link. One 10+100 line PABX with one CO line of Bogra T&T exch (no 73530) has already been instl at the new AD Unit, Bogra. One 10+100 lines digital PABX has also been instl at AD Unit, Moulivibazar. In the yr 2006, the LOS link has been extended upto S/Nagar and FIS, Bogra via Moulvi Bazar and Bogra radar sta respectively.

c. AD Comm Net. AD comm net is basically a perm set up, and all AD (U) and ADOC exclusively use this net to sp constant surveillance and con of our air space. This independent net, with its hub at ADOC, has been estb for AD purpose only. BAF provides nec comm incl the data comm facilities into the AD net of the country.

d. Air Comd and Sp Comm Net. BAF estb a separate comm net between ACOC, ASOC and Ops Rooms all op Bases/Units/dets to conduct ex and op activities of BAF. A good no of PP lines, data links, fax nconnections are instl temp for op/ex pd. This net is designated as Air Comd, Air Sp Comm as it connects all Bases/Units Ops Rooms with the Comd Ops cen and Air Sp Ops cen. This comm net is estb during ex and real emergency pd to run all ex and op of BAF. A typical Air Comd, Air Sp as well as Cont Comm Net, which are generally estb during ex. This net consists of the fol comm elms :

(1) Point to Point (PP) Line.

(2) HF Net.

(3) Data Comm through LAN/WAN.

(4) PABX Connections.

(5) FAX.

(6) Auto Tel.

(7) VHF AM/FM.

e. <u>Limitations</u>. An effective comm net is prerequisite for successful conduct of ex and real op. Besides the limitation of LOS and BTCL lines, we do not have any perm comm setup for our Air Comd and Sp Net. As such, every time we need to estb a new comm net prior to the commencement of each ex and op, disconnecting some admin comm setup and often makes it cumbersome both for Comm and op pers. Basically, a peace and war.

<u>BAF Tel Exch</u>

5. BAF has come a long way in the fd of telecom. Over the past yr all BTCL provided analogue PABX of BAF have been replaced with BAF owned digital PABX. The capacity, type/model and loc of BAF exchs and their replacement plan are shown below :

Ser No	Bases/Units	Type of Exchange	Date of Instl	Remarks/Replacement Plan
a.	Comm Unit	NEC, Japan 24E1 200+2000 line	2007-2008	-
b.	BAF KTL	50+500 Lines Digital PABX Model:HICOMK-372, Siemens (German)	Dec 1998	100+1000 lines Digital PABX of Comm(U) will be shifted to KTL
c.	BAF ZHR	Karel, Turkey 06E1, 60+600 line	2007-2008	-
d.	BAF ZHR	Karel, Turkey 06E1, 60+600 line	2007-2008	-
e.	BAF PKP	50+500 Lines Digital PABX Model: DS200 Karel, Turkey	Jan 06	In the yr 2016
f.	ADOC BAF	64+56 Lines Digital PABX Model: IOX1200, OKI(Japan)	Dec 98	In the yr 2008
g.	BRU	10+100 Lines Digital PABX Model: SX2000, Mitel (Canada)	May 2000	In the yr 2010
h.	C&M(U) S/Nagar	10+100 Lines Digital PABX Model: SX2000, Mitel (Canada)	May 2000	In the yr 2010
j.	Field Exch BSR	10+100 Lines Digital Field Exch, Model: PX24/100, Telesis, (Turkey)	Jun 2004	In the yr 2014
k.	Field Exch ZHR	10+100 Lines Digital Field Exch, Model: PX24/100, Telesis, (Turkey)	Jun 2004	In the yr 2014
l.	Field Exch MTR	10+100 Lines Digital Field Exch, Model: PX24/100, Telesis, (Turkey)	Jun 2004	In the yr 2014
m.	MRU	10+100 Lines Digital PABX Model: DS200, Karel, Turkey	Sep 2005	In the yr 2015

6. These high tech digital PABXs are being efficiently run by BAF pers, which was

major break through in BAF Comm Sys. This has increased our op efficiency and made us independent of BTCL. Exts of BAF PABXs have been connected to various office and residential users through BAF owned under grd cable net. While all BAF exch have been linked with each other with a no of Trunk/Hot lines through BAF LOS microwave and BTCL leased line.

BAF Under Grd Cable Net

7. Tel cable is an integral component of the tel comm sys. In each base, BAF has taken a no of BTCL junc lines connected through under grd tel cables. We have intercom exchs, Fd exch and LAN connections in each base that are also connected through under grd tel lines. With the increase of no of new BAF Instl, specially in Dhaka area, the no of tel subscribers have increased manifold. Accordingly, the reqr of under grd tel lines have increased proportionately.

Microwave (MW) /LOS Comm Sys

8. Microwave. BAF LOS MW was instl in 1988 with "Eagles Eye Project". It was primarily for AD Comm. But later on, all our ops and admin comm, which were connected through BTCL leased lines, have been estb ut BAF LOS MW chs. In 2003, these analog links have been replaced with the digital links with 'Falcon's Eye Project". Presently BAF is maintaining 11 repeater sta and 12 terminal ?sta of LOS comm, which are spread out all over Bangladesh. The existing MW comm links iwth capacity are shown below :

	Links	Capacity
a.	Comm (U) - BRU	8E1
b.	Comm (U) - MRU	8E1
c.	Comm (U) - PKP	8E1
d.	Comm (U) - MTR	16E1
e.	Comm (U) - ZHR Link via 74 Sqn	16E1
f.	Comm (U) - 71 Sqn Link	4E1
g.	Comm (U) - KTL Link	4E1
h.	Comm (U) - 203 MU Link	4E1
j.	MRU-Shamsernagar	4E1
k.	KTL-ZIA Tower Link	08 Channel

BAF LAN/WAN

9. Computers are the most amazing and fascinating invention of modern world. With a view to enhancing the efficiency of op, maint and admin act, BAF has been operating LAN/WAN since 2000. At present, more than 372 work sta are in use with the net. The LAN of all the bases was interconnected through the BAF MW links to form the BAF WAN. A fiber optic link has been estb between central Server room and LOS MW room at Comm (U) to enhance the speed of BAF LAN/WAN. The most effective application of those LAN/WAN is to use as a primary means of comm media and share info between bases/units, and enhance decision-making ability at each level and overall org efficiency of BAF.

Crypto Comm Sys

10. Reqr of a secure and reliable comm sys is essential to run any mil op. Keeping these aspects in mind, all secret msgs of BAF are transmitted after being encrypted by cypher trade pers. In this respect, C&E Dte keeps contact with the Depl of Cypher, MOD. The cypher sec of BA, BN and BAF has incorporated new eqpt, hardware and software. Over the last few yrs, there has been dev in op procedure, methods and means of comm of signal msgs. Now, we have computer and software for encryption/decryption, and software operated HF eqpt for wireless data comm of encrypted docus. The CODAN HF set with its integrated use with crypto machine can effectively be used in mode of comm i.e Voice, Data and Fax mode. The airmen recruited and working in the cypher trade are kept updated through imparting adequate trg on these new sys. The major eqpt and sys held t cypher sec of various bases and units re listed below:

a. Crypto Machine - Model HC-550; Qty-01 at each base.

b. Computer and crypto software for data comm at each base.

c. PC and HF (CODAN) set for voice and data comm at each base.

HF R/T Net

11. BAF uses HF comm net between ACOC and different bases and units through which voice, fax, computer data link can be estb reliably. The HF net is used as primary comm means with the C&M(U). Grd Radio Comm facilities and extended through HF R/T net for voice and Data Comm as per daily schedule of different Bases and Units. It also works as stand by sys with other bases particularly during ex. CODAN HF R/T sets - proc in the yr 1996, 97 have been found to be very reliable and effective. Later on, BAF has purchases the improved version of same brand HF RT set Model : NGT SR. During ex these sets have been tested over a pd of time. Due to their sat performance and reliability, BAF has gradually/phase-wise phased out or replaced the old aged eqpt to keep the HF net of BAF reliable. HF sets (CODAN/NGR SR) are reliably and effectively used by FAB and RAB during ex. The HF link or net ism also kept as stand by to our other primary comm. sys. BAF has already taken its AD units and ADOC under separate HF link/net. It may be mentioned

that the CODAN/NGR SR H/F sets have the fol op features :

a. Fax and data comm.

b. Auto link estb.

c. Remote con.

d. Scanning.

e. Preset chs.

f. Telephone Interfacing.

g. ID no recognition.

h. Voice/Data or fax transmitted through these sets, can't be intercepted by other sets op in the same freq.

i. These sets have a sys of using ID no to recognize each other.

12. CODAN HF sets can be used for the fol :

a. Main Comm Net between Comm (U) and all C&M (U) and detts.

b. Stand by Voice Comm Net between Comm (U) and all Bases/Units.

c. Main cypher Comm Net between Comm (U) and all Bases/Units.

d. Stand by ex Comm Net ACOC and all Bases Ops Rooms.

e. ATC Net between all ATC Ops Room.

Other Aval Field Comm Sys

13. Intercom. Almost every base, units an d sqns have been provided with intercom exch to facilitate inter comm among the users of those units. This is an addl sys to our PABX sys, which is extensively used for day-to-day activities. At present, BAF has at least 53 intercom sys of different capacities instl at different places.

14. Field Exch. We have been using Fd Tel Exchs in BAF as an addl and stand by sys to our PABXs and also to provide comm facilities at remote sites.

15. Auto Tel. BAF has taken a good no of junc lines and aujto tel connections from BTCL for all PABXs and for selected offices and residencies. At present, the no of junc, office and res auto tel in BAF are 150, 195 and 120 respectively.

16. Civ Mob Phone. BAF procured a no of civ mob phone both from Grameen and City Cell to provide telecom facilities to imp appts, and at remote sta particularly for use during ex. Some of those sets were also issued to BAF contingent for using in Congo msn.

17. Internet Facility. With a view to exploiting the resource of IT and maint comm with intl agencies, Broad band internet connection has been given at Air HQ hiring 786 kbps dedicated bandwidth from ISN ltd where 45 users have been connected. Under the same proj, broadband internet connection has also been given at BAF Offrs' residences at Tejgaon area. Beside those connections imp offices to the BAF KTL broadband internet

connections have been provided. BAF instl where there is no facilities to provide broadband internet connection, internet facilities have been provided to them through dial up sys.

18. FAX Comm. We have Fax net in all bases through our LOS as well as BTCL Chs. Fax comm are being used as the substitute of the TP CCT. To exchange msgs with Intl agencies we have total 03 ISD FAX instl at Comm(U) (Incoming-01 & outgoing-01) and COAS Sectt.

19. Interfacing with Army/Navy. To provide inter svc comm facilities among 3 svc a ltd no of interface connections have been estb among Army and Navy exchs. BAF Comm Unit has only 4 junc lines with BA and 01 with 01 with BN.

20. Air Defence Auto. With the introduction of Air Defence Auto sys, the efficiency of Air Defence has been increased. Nec comm ch have been provided for data transfer. The full op of Air Defence Auto Sys is satisfactory.

Air to Air/Grd Comm Sys of BAF

21. The Air to Air/Grd Comm Sys of BAF are directly associated with the air op to maintain comm between ac to ac and ac to grd. The main users of this net are aircrew, ATC controller and AD controllers. The Air to Air/Grd Comm Sys of BAF consists of 3 different nets and their limitations are described in the subsequent paras.

22. ATC Comm Net. The ATC net maintains comm with all BAF ac during flg with the help of VHF radios aval at all ATC tower and GCA radar. In addition, they also maintain comm from Rangamati Det, Rasulpur Firing Range and Halisahar Firing Range during op of BAF ac in those area. All ATC Towers and GCA radar have been equipped with a no of VHF and HF Radios. The HF comm are ut for long Dstn comm specially with AN-32, C-130 ac and some BAF hel. Since ATC Towers are jointly used with CAAB, they also use those CAAB's VHF R/T for controlling air traffic in the closed proximity of the air fd. However, the VHF R/T instl in various type of BAF ac are of different origins as those were originally fitted with the ac.

23. AD VHF Net. The AD VHF net is exclusively used with BAF ac during interception and trg flg. Each Radar sta is equipped with a no of VHF Radios of different origins. In addition, they also provide VHF R/T with the MOUs depl at different part of the country during ex and op to enhance the AD coverage of the country. AD radar controllers also use IFF sys to identify the friend and foe ac.

24. Limitations. The AD Air to Grd comm sys lacks secure means of comm and ESM facilities. Though some of the VHF R/T AD3400 and P862 fitted with F-7MB and Mig-29 ac, have encryption facilities, but those cannot be used with the grd sta due to non-aval of those provisions the grd R/T sets. The encryption provision of AD-3400 VHF/UHF radio aval in F-7 MB ac can fun in encryption mode only for air-to-air comm between F-7 MB ac.

25. Air to Air Comm Net. In BAF, only VHF radios are used in the Air to Air Comm Net. The Air to Air Comm Net is used to coord between aircrew during fmn flg. The Air to Air comm sys lacks secure means of comm and ESM facilities.

TASK-6

AIRBORNE COMMUNICATION SYSTEMS

a. Introduction.

b. Special Features of airborne communication system.

c. Airborne communication system used in BAF.

Introduction

1. There is a fundamental need for communication between aircrew and ground controller among the aircrew and between aircrew and passengers. External communication achieved by means of radiotelephone (R/T) link while internal communication (intercom or radio integrating system by wire opposed to wireless). Although intercom is not a radio system, it is included in this chapter because of its intimate relationship with the aircraft radio system. Voice recorders and in-flight entertainment system are also considered since they are usually the responsibility of the aircraft radio technician/engineer.

2. The audio integration system (AIS) complexity depends on the type of aircraft. A light aircraft system may provide two transmit/receive channels for dual VHF communication and receive only for dual VHF Nav, ADF DME and marker. Each receive channel has a speaker-off-phone switch while the microphone can be switched between VHF communication 1 and VHF communication 2. A multi-crew large airliner has very many more facilities.

Special Features Of Airborne Communication System

3. One should not forget the possible effects of non-radio systems and equipment when investigating reported defects. Poor bonding, broken static dischargers, open circuit suppression capacitors, low or inadequately filtered dc suppliers, low voltage or incorrect frequency ac, supplies, etc, will all give rise to symptoms which will be reported by the pilot as radio defects. Sometimes symptoms are only present when the aircraft is airborne and the system is subject to vibration, pressure and temperature changes, etc. One should mention the obvious hazard of loose articles; so obvious that many aircraft accidents have been caused in the past by carelessness. Tools and test equipment, including leads, must all be accounted for when a job is finished. A well-run store with signing-in and signing-out of equipment is an added safeguard to personal responsibility. Installation of equipment should be in accordance with the manufacture's instructions that will cover the following :

a. Weight of Units. Centre of gravity may be affected.

b. Current Drawn. Loading of supplies should be carefully considered and the correct choice of circuit breaker made.

c. Cooling. More than adequate clearance should be left and forced air-cooling employed if appropriate. Overheating is a major cause of failure.

d. Mounting. Anti-vibration mounts may be necessary which, if non-metallic, give rise to II need for bonding straps.

e. Cables. Length and type specified. Usually maximum length must be observed but in some cases particular lengths are necessary. Types of cable used must provide protection against interference and be able to handle current drawn or supplied. Current capabilities are reduced for cables in bunch.

f. Antenna. Approved positions for aviation authorities lay down particular types of antenna or particular types of aircraft. Strengthening of the structure around the antenna in the form of a doublers plate will probably be necessary. A ground plane is essential and must not be forgotten if the antenna is to be mounted on a non-conducting surface. If the antenna is movable. Adequate clearance should be left. Any alignment requirements must be met.

g. Interface. Compatibility with other systems/units must be ensured. Both impedance matching (including allowing for capacitive and inductive effects) and signal characteristics should be considered. Loading of outputs should be within limits. Particular care should be taken in deciding where synchro devices obtain their reference supplies. Programming pins for choice outputs and/or inputs must be correctly connected.

h. Compass. Safe distance 9 Radiation hazards.

Airborne Comm Sys used in BAF

4. In Airborne comm sys of BAF mainly HF and VHF comm. Sys are used.

VHF Communications

5. Principles of HF Comm. An aircraft VHF communication transceiver is comprised of either a single or double conversion superhetordyne receiver and an AM transmitter. A modern set provides 720 channels at 25 KHz spacing between 118 MHz and 135.975 MHz until or 60 channels with spacing 50 KHz. The mode of operation is single channel simplex (SCS), i.e. one frequency and one antenna for both receiver and transmitter. Communication by VHF is essentially line of sight' by direct (space) wave.

HF Communications

6. Principles. The use of HF (2-30 MHz) carriers for communication purposes greatly extends the range at which aircrew can establish contact with aeronautical Mobile service stations. This being so, we find that HF com. Systems are fitted to aircraft flying g routes which are, for some part of the flight, out of range of VHF service. Such aircraft obviously include public transport aircraft flying intercontinental routes. but there is also a market for general aviation aircraft.

7. The long range is achieved by use of sky wave, which are refracted by the ionosphere to such an extent, that they are bent sufficiently to return to earth. The HF ground wave surfers quite rapid attenuation with distance form the transmitter. Ionospheric attenuation also takes place, being greatest at the lower HF frequencies. A significant feature of long-range HF transmission is that it is subject to selective fading over narrow bandwidths (tens of cycles).

8. The current and future norm is to use single sideband (SSB) mode of operation for HF communications, although sets in service may have provision for compatible or normal AM, i.e. carrier and one or two sidebands being transmitted respectively. A feature of aircraft HF systems is that coverage of a wide and of RF and sue of a resonant antenna requires efficient antenna tuning arrangements which must operate automatically on changing channel in order to reduce the VSWR to an acceptable level.

TASK-7

RADAR SYSTEMS USED IN BAF

Introduction

1. Radar is an important part of air-defence system as well as the operation of offensive missiles and other weapons. In air defence it performs the functions of surveillance and weapon control. Surveillance includes target detection, target recognition, target tracking and designation to a weapon system. Bangladesh Air Force is providing surveillance, VVIP coverage, weather, support of distress aircraft and night flying coverage with the help of following radar :

a. TPS-63 (Low Looking Radar).

b. 1L-117 (Low Looking Radar).

c. AR-15 (Low Looking Radar).

d. GCA Radar.

e. Airborne Radar.

Different Features of 1L-117

2. Radar 1L-117 is mobile, low looking, S-band, long range, six channels, three dimensional, computerized search radar. It has high performance for determination of detected air targets in co-ordination with azimuth, slant range and height. This radar is capable to exercise detection and tracking either a single target or group targets as well as to carry 01 their IFF identification. Tracking of targets can be done manually or automatically through 360 degrees of radar site up to range of 350 km and altitude 17 km. Manually tracking of targets can be done on PPI console and in the computer monitor up to 200 targets. Automatic tracking up to 5 targets can be done trough - co-ordinates Extractor Unit (CEU).

Composition.

3. The 1L-11u radar is composed of the following components:

a. Transmitter - Receiver Cabin (TRC). The components of TRC are as follows :

(1) Transmitter - Receiver.

(2) MTI equipment cabinet.

(3) Control Cabinet.

(4) IFF equipment of MK-X system.

b. Set of Control Processing and Display Equipment (CPDE). The components of CPDE comprises are as follows :

(1) Control cabinet.

(2) Power supply cabinet.

(3) Three cabinets for processing and analogue display of radar data (PPI).

(4) Data extractor with maintenance display.

(5) The Operator Working Position (OWP) with roster scan display.

(6) Data recording and display working position (RWP) with roster display.

(7) Five sources of uninterruptible power supply (APC Back).

c. Set of power supply equipment. The set of power supply equipment comprises of :

(1) Main diesel-generator plant (P-135).

(2) Standby diesel plant (P-135).

(3) Uninterruptible power supply system.

(4) Two Converters.

(5) Set of cables.

Technical Characteristics

4. Transmitter.

a.	Average Power	:	Not less than 700W.
b.	Peak power CH-2, 3, 4, 5 & 6	:	800 KW
	CH-1	:	680 KW
c.	Duration of high frequency pulse envelope mode		
	SPARSE 1, 2	:	2, 4 to 3.1 us
	Mode FREQUENT	:	0.9 TO 1.2 us
d.	No of transmitter	:	Six

5. Receiver

a.	IF	:	30 ± 1 MHz
b.	Band Width of Channels	:	0.8 ± 0.15 MHz
c.	No of Receiver	:	Six
d.	Receiver Sensitivity	:	Not less than-87 dBm

6. <u>IFF Equipment MK-X System</u>

a. <u>Integrated Antenna System</u> :

(1)	Frequency Range Operation	:	1020 MHz 1100 MHz 'L' Band.
(2)	Polarization	:	Vertical
(3)	Azimuth beam width of interrogate Pattern.	:	Not greater that 3^o

b. <u>Transmitter</u> :

(1)	Output Frequency	:	1030 ± 0.2 MHz
(2)	PRF	:	300 - 375 Hz.
(3)	Pulses P1, P2 & P3 Duration	:	8 ± 0.1 us.
	Rise Time	:	Not greater than 0.1 us.
	Fall Time	:	Not greater than 0.2 us.
(4)	Time Interval Between RF Pulses Between P1 & P2	:	2 ± 0.15 us.
	Between P1 & P3 for different MK-X Modes of operation Mode 1	:	3 ± 0.01 us.
	Mode 2	:	5 ± 0.01 us.
	Mode 3/A	:	8 ± 0.01 us.
	Mode C	:	21 ± 0.01 us.
(5)	Pulse Width	:	1 ± 0.3 us.
(6)	Aerial Dimension (W X D X H)	:	284 X 310 X 24 cm.
(7)	Weight (Nominal)	:	15 KG.

c. <u>Receiver</u> :

(1)	Centre Carrier Frequency	:	1090 MHz (nominal).
(2)	Band Width	:	Not less than 5 MHz on either side of centre frequency.
(3)	Receiver Sensitivity	:	Not less than - 75 dBm.

d. MK - X Decoder :

(1) Mode : Four mode of operation e.g. 1, 2, 3/A & C. Mode C are used for civil aircraft.

(2) SPI Recognition :

Emergency : Code 7700 in mode 3/A.

Communication Failure : Code 7600 in mode 3/A.

Hijack : Code 7500 in mode 3/A.

Garble indication received condition provided on CU. : Whenever two reply codes in interleaved over lapped a garble indication.

e. Control Unit. This unit generates the following for PPI :

(1) F1 F2 Recognition (all aircraft) : Single pulse.

(2) Passive Code Match : Two pulse.

(3) SPI Recognition (civil/military) : Three pulse.

(4) Emergency (civil/military) : Four pulse and Communication failure.

(5) The video specification are :

(a) Amplitude : >3V into 75 ohm load.

(b) Pulse Width and Inter Pulse: 10 to 20 us selectable duration through a switch.

7. General Data

a. RCS (Radar Cross Sec) : $10m^2$

b. Target Detection

In Azimuth : 360^0

In Elevation : Up to 28^0

In Range : 350 KM.

c. Pulse Width : SPARSE 2.4, - 3.1 us FREQUENT 0.9 - 1.2, us

d. Azimuth Accuracy (Error) : 1^0

e.	Range Accuracy/Resolution		:	1000 meter.
f.	Height Accuracy (Error)		:	400 meter.
g.	Noise Factor		:	35 dB.
h.	Blind Angle		:	2 x target height.
j.	<u>Mode of Operation</u> :			
	(1)	Sparse Mode	:	350 ± 10 KM.
	(2)	Frequent Mode	:	120 ± 10 KM.
k.	Antenna Rotation		:	3 and 6 RPM.
l.	Antenna Shape		:	Parabolic.
m.	<u>Antenna Dimension</u>			
	(1)	Length	:	9.5 meter.
	(2)	Width	:	4.5 meter.
	(3)	Focal Length	:	2.5 meter.
	(4)	Reflector Size	:	9.7 x 3 meter.
	(5)	Antenna Tilt Angle	:	$\pm 4.6^0$ wrt the nominal position.
	<u>Power</u>			
	(1)	Power Supply Required	:	220V 50 Hz and 220V 400 Hz in three phases.
	(2)	Maximum power	:	$\geq$ 100 KW.
	(3)	Power Consumption of Tx	:	50 KW.
p.	<u>Radar Switch on Time</u>			
	(1)	Normal	:	$\geq$ 5 minutes.
	(2)	Emergency	:	$\geq$ 3 minutes.

q. <u>PPI Range Scale</u>

	(1)	Scale 1	:	100 km.
	(2)	Scale 2	:	250 km.
	(3)	Scale 1	:	360 km.
r.	Range Marks		:	10 km to 50 km.
s.	Azimuth Marks		:	5^0 and 30^0.
t.	<u>Beam with</u>			
	(1)	Vertical Plan	:	0^0 - 28^0.
	(2)	Horizontal Plan	:	$2^{0.}$
u.	Angle of Inclination between upper antenna and lower antenna		:	45^0.
v.	Operating frequency of six channels of magnetron oscillators :			
	(1)	Channel 1	:	2980 ± 15MHz.
	(2)	Channel 2	:	3100 ± 15MHz.
	(3)	Channel 3	:	2830 ± 15MHz.
	(4)	Channel 4	:	2860 ± 15MHz.
	(5)	Channel 5	:	3010 ± 15MHz.
	(6)	Channel 6	:	2710 ± 15MHz.
w.	Change of frequency in triggering mode		:	$\geq$ 0.5 MHz.
x.	Band Width		:	0.8 MHz.
y.	<u>PRF</u>			
	(1)	Sparse 1	:	375 Hz.
	(2)	Sparse 2	:	300 to 375 Hz with 6 period staggering.
	(3)	Frequent	:	800 to 1200 Hz with 18 period staggering.
z.	Target Tracking		:	Manual and auto.
	(1)	Manual	:	No of target available in PPI

(2) Auto : Up to 5 targets data in CEU

aa. Operating Temperature Range : 20^0 C to 55^0C,

ab. Storage Temperature Range : -40^0C to 70^0C,

ac. Humidity : Up to 100% RH.

Different Features of AN/TPS-63 Radar

8. The AN/TPS-63 radar set is a high performance, lightweight transportable two-dimensional tactical radar that automatically detects small, low flying objects in heavy ground clutter, dense rainfall, and electronic interference. This radar provides air surveillance in 3 selectable range of 80, 120 and 160 nautical miles with time shared display of IFF data. This radar set also contains a digital moving target indicator (DMII) circuit that provides high sub clutter visibility.

Technical Characteristics of AN/TPS-63 Radar

9. General Characteristics

a. Dimension and Weight : 8 feet wide by 10 feet long by 8 feet (Transport Mode) 4 inches high 7500.

b. Antenna Dimension : 18 feet wide by 16 feet high (Assembled).

c. Transportability. In the transport configuration, the Radar set consists of only shelter package. The shelter can be lifted form either side with a forklift truck. The shelter also has skids and may be towed along level ground for reasonable distances or can be mounted with wheeled mobilizers for the same purpose. The shelter can be transported by any of the following means. Helicopter, C-130 Cargo ac. government truck and trailer, Commercial truck, 40 foot railway car, transport ship or amphibious ship.

d. Set up Time : 1 hour (Four man team).

e. Tear Down Time : 1 hour (Four man team).

10. Performance Characteristics

a. Detection range : 0.5 to 80 or 120 or 160 nm.

b. Range Resolution : 0.1 nm.

c. Coverage : 0 to 40,000 feet.

11. Target Cross Section

a. 80 nm : 1 Square meter.

b.	120 nm	:	Square meter.
c.	160 nm	:	10 Square meter.
d.	Probability of Detection	:	90%.
e.	Elevation Angle	:	0.5 to 40 degrees.

12. <u>Transmitter Characteristics</u>

a.	Radiated Frequency	:	1.25 to 1.35 GHz 51 Channel.
b.	Type of Transmitter	:	Cross-Field Amplifier (CFA).

13. <u>PRF (Fixed or Staggered)</u>

a.	80 nm	:	750 PPS average (1333 us).
b.	120 nm	:	500 PPS average (2000 us).
c.	160 nm	:	375 PPS average (2667 us).
d.	Staggered PRF program	:	21-pulse sequence (anti-jamming)
e.	Peak Power	:	100 KW.

14. <u>Average Power</u>

a.	80 nm	:	3.2 or 1 KW.
b.	120 nm	:	2, 1.3 or 0.65 KW.
c.	160 nm	:	1.5, 1.0 or 0.5 KW.

15. <u>Pulse Width</u>

a.	Full Power	:	39 us, dual frequency (normal operation).
b.	Medium Power	:	26 us, single frequency.
c.	Low Power	:	13 us, single frequency.
d.	Pulse Encoding	:	Quadri-phase, 1 us bit interval.

16. <u>Antenna Characteristics</u>

a.	Type	:	Parabolic cylinder.
b.	Polarization	:	Vertical.
c.	Feed	:	Integral radar/IFF.
d.	Azimuth Beam Width	:	2.7 degrees.

e.	Rotation Rate	:	6, 7.5 12 or 15 rpm.
f.	Tilt	:	- 2 to + 5 degrees.
g.	Antenna Gain	:	Appx 32.5 dB.
h.	Elevation Angle	:	0^0 to 40^0

17. <u>IFF Subsystem Characteristics</u>

a.	Challenge Modes (with ISLS)	:	SIF modes 1, 2, 3/A, c.
b.	Effective Range	:	High Power 250 nm. Low Power 160 nm.
c.	Mode Selection (Optional)	:	Local and remote.
d.	Local Display	:	Passive decoded to PPI display(all modes); PPI diode window for active window for active decoding (all modes).
e.	Remote Outputs (Optional)	:	Composite video and mode identification.
f.	Tx Frequency	:	1030 MHz
g.	Rx Frequency	:	1090 MHz

18. <u>Technical Characteristics of AR-15 Radar</u>

<u>Transmitter</u>

a.	Type of Transmitter	:	Tunable air cooled magnetron.
b.	Power Output	:	600 (Peak), 420W (Mean).
c.	Frequency	:	2700 MHz to 2900 MHz (Low band). 2900 MHz to 3100 MHz (Hi band).
d.	Pulse width (PW)	:	1 usec (at 50% amplitude).
e.	Pulse Repetition Frequency (PRF)	:	700 PPS.

Receiver

a.	Rx Noise Factor	:	Not greater than 4.5 dB.
b.	Intermediate Frequency (IF)	:	30 MHz.
c.	IF Bandwidth	:	1.2 MHz at - 3dB.
d.	Video Output	:	+ 3V Peak.
e.	Noise Level	:	3 V at the output.

Digital Moving Target Indicator (DMTI)

a.	Cancellation	:	Double Cancellation.
b.	Cancellation Ratio	:	33 dB.
c.	Range Gate	:	25 nm, 40 and 60 nm.
d.	Integrator Range	:	80 nm (displayed range).
e.	Clutter Gate	:	Within the MTI range.
f.	Input		
	(1) IF	:	30 MHz
	(2) IF Lock Pulse	:	250mV, 1 used, 50 ohm.
	(3) Video	:	Normal radar video (NRV).
	(4) MTI Start Pulse	:	-0.5 v, 1 usec, and 75 ohm.
g.	Output		
	(1) Delayed Normal Radar Video	:	1 or 2.
	(2) Gated MTI/ Normal Radar Video	:	1 or 2.

Displays

a.	Display range	:	80 nm.
b.	Display type	:	Plan position indicator (PPI)
c.	CRT diameter	:	406 mm (16").

<u>Aerial</u>

a.	Polarization	:	Variable form linear at 45^0 through elliptical to circular.
b.	Diversity Operation	:	2880 Mhz and 3095 MHz (Two Txs).
c.	Rotation Rate	:	15 rpm.
d.	Wind Speed	:	
	(1) Survival Stationary	:	120 nts gust.
	(2) Turning (Maximum)	:	70 nts.
e.	Gain	:	31 dB relative to isotropic radiator.
f.	Horizontal Beam Width	:	1.5^0 to half power point.
g.	Horizontal Aperture	:	488 cm (16').
h.	Vertical Aperture	:	198 cm (6.5').
j.	Mains	:	400 V ac, 50 Hz, 3 phase.

Note : Except aerial, all other mains supplier are 220 V ac, 50 Hz, single phase.

<u>Environmental Condition</u>

a.	External Equipment	:	-40^0C to + 55^0 C, relative humidity 0% to 100%.
		:	0^0C to + 40^0 C, relative humidity 5% to 90%.

<u>Coverage</u>

a.	Detection Range	:	90 nm.
b.	Range Resolution	:	500 ft.
c.	Azimuth Resolution	:	1^0
d.	Height	:	4500 ft
e.	Probability of Detection	:	80%
f.	Elevation Angle	:	0^0 to 40^0.
g.	Reflector	:	Parabolic reflector.
h.	Tilt	:	-1^0

Other Special Features

a. Range Marker : 2 nm, 5nm and 20 nm.

b. Range Scale : 5 nm, 10nm, 20 nm, 40 nm and 80nm.

c. Frequency Band : "S" band.

Different Types of Radar Used in BAF Aircraft

19. Different types of radar equipment are used in BAF aircraft and helicopters. Aircraft wise state of the radar equipments are shown in the subsequent paragraphs.

20. F-7 and FT-7 Aircraft

a. 956 Head Up Display (HUD). HUD is used to collect, store, process and display various flight parameters & weapon aiming parameters from different airborne avionics equipment and sensors.

b. 7M Ranging Radar. 7M Ranging Radar is used to measure the range and range rate of the target. The information is fed to the HUD for display.

c. LJ Radar Warning Receiver (RWR). The purpose of LJ-2 RxR is to warn the pilot about irradiated frequency coming 360^0 in azimuth and ± 30 in pitch.

d. SM-8AE Gun Sight. It is used to aim the target for accurate firing of weapon in the air or ground target and releasing the bomb in R drive.

e. 226 Radar Range Finder. 226 Radar Range finder is used to air the target and fire gun/rocket and missile in conjunction with the armament system.

21. AN-32 Aircraft

a. GROZA Radar. The PPOEA is designed to provide the radar presentation of the terrain and weather situation. The Radar solves the following problems :

a. Ground mapping to display terrain feature.

(2) Detection of atmospheric hazards such as thunderstorms zone, thick cumuliform cloud circuit.

(3) Measuring the drift angle.

a. Doppler Radar

(1) Model. ANCC 13, Manufactured : Russia, Drift angle = $\pm 45^0$, Ground Speed = 0.400KPH.

(2) Doppler Radar is designed to measure the ground speed, drift angle, drift speed and forward, backward distance.

22. A-5III Aircraft. 821 Gun Sight Radar in A-5III is used to solve the aiming problems of drive bombing, glad bombing, level flight bombing level flight delay 2" bombing air firming of gun and air to ground firing of Rocket and also to set the depression angle for bombing and the aiming angle for firing 68 mm rocket or lunching missile manually.

23. FT-6 Aircraft. LCF-3 Radar Range Filter in FT-6 aircraft is used to detect and tract the target and it also measure the distance form ac to target.

24. Bell-212 Helicopter. Weather Radar Model: Primus 700, manufactured by Honeywell, Inc, Arizona, USA is used in Bell-212 helicopter. Range of this radar is 300 nm and RF output is 10 KW. Primus 700 Weather Radar is a light weight X-band digital radar with alpha numeric designed for high resolution mapping and weather detection.

25. Mig-29 Aircraft. The following radar equipments are used in MIG-29 aircraft :

a. CEN-31 : Unified Indication System (UIS). UIS is intended for display of flight, navigational view and radar information for monitor.

b. A006/CRO-15M, Radiation Warning Receiver (RWR). RWR is intended to detect the radiation and to take the decision by the pilot to destroy the radiating target or over left the target to save own AC. It warns the pilot by audio and video signal.

c. CO-69M, ATC Transponder. It is used to control the air traffic in airfield area and during flight the ground control un it should receive the information about the AC altitude and AC board code n.

b. H0199, Radar and Fire Control System (RFCS). RFCS is designed for detection and destroying of the target in all weather conditions at day and night at ground sky or water surface.

e. 23C, Opto-Electronic Sighting System (OES). System 23c is designed for a round o'clock operation at all combat altitude against the land background, under the condition of optical visibility and active jamming.

f. CFO, IFF, Purpose. IFF is designed to identify whether it is friend or foe target with the transmission and reception of codes.

TASK-8
NAVIGATION SYSTEMS USED IN BAF

Introduction to Nav Aids Systems

1. Nav Aid system is an electronic aid to navigation. With this system it is possible to determine the bearing (direction in degrees with north as reference) and distance to a transmitting station from a remote point, to determine the landing path and slope to the run way and to know the exact position with reference to the earth or the transmitting station.

Ground Nav Aid Equipment

2. The Ground Nav Aid Equipments used in BAF are listed below :

Ser No	Name of Equipment	Model No
a.	Non Directional Beacon (NDB)	LWX100A, NX 2000BD and Dishary-II.
b.	VOR transmitter	
c.	VDF	AMPLUS-12 & PP- 022
d.	Glide Slope	
e.	Localizer	

Airborne Nav Aid Equipment

3. The Airborne Nav Aid equipments used in BAF are listed below :

Ser No	Name of Equipment	Model No
a.	Radio Compass	APK-9, APK-19, KDF-806, KDF-8000, WL-5, AN/ARN-6, APK-15M, WL-5A and WL-7.
b.	VOR/ILS	KYPCMII-70, KNR-634, NR2030B, ARN-127, VIR-31A and KYPCMII-2.
c.	Marker RxR	A-611, MII-3IIM, SX-6 and SX-6A.
d.	DME	CD-75, KDM-706, AN/ARN-154.
e.	GPS	GPS-90, 92, 150, 165, 165TSO, TNL-2000.
f.	Radio Altimeter	A-037, PB-5M, PB-5PM, WG-2A, 262, 265, WG-4.
g.	ELT	POINTER-3000, 3000-10, 7938II452.
h.	Homer	ZVG-2002, CHELTON-770-11, ZG-2.

Automatic Direction Finding

4. The system has been much developed since those early days and in particular its operation has been simplified. Within the band 100-2000 KHz (LF/MF) there are many broadcast stations and non-directional beacons (NDB) and aircraft today would have twin receivers which tuned two distinct stations or beacons, would automatically drive two pointers on an instrument called a radio magnetic indicator (RMI) so that each pointer gave the bearing of the corresponding station. The aircraft position is where the two directions intersect. Since such a system requires the minimum of pilot involvement the name radio compass has come to replace by automatic direction finder (ADF).

Working Principles

5. The Loop Antenna. The first requirement of any ADR is a directional antenna. Early loop antennas were able to be rotated first by hand and subsequently by motor, automatically. The obvious advantage of having no moving parts in the aircraft skin-mounted antenna has led to the universal use of a fixed loop and goino-meter in modern equipments, although some older types are still in service. The loop antenna consists of an orthogonal pair of coils would on a single flat ferrite core that concentrates the magnetic (H) field component of the e.m. wave radiated from a distant station. The plane of one coil is aligned with the aircraft longitudinal axis while the other is aligned with the lateral axis.

6. The current induced in each coil will depend on the direction of the magnetic field. When the plane of the loop is perpendicular to the direction of propagation, no voltage is induced in the loop since the lines of flux do not link with it. We now effectively have a rotating loop antenna in the form of the goino-meter rotor or search coil. As the rotor turns through 360^0 there will be two peak and two nulls of the voltage induced in it. The output of the rotor is the input to the ADF receiver which thus see the rotor as the antenna. Such an arrangement is known as a Bellini-Tosi system.

7. Since we are effectively backed with a rotating loop situation should consider the polar diagram of such an antenna, as we are interested in its directional properties.

8. This polarization error dictates that ADF should only be used with ground wave signals that in the LF/MF bands are useful for several hundred miles. However, they are contaminated by non-vertically polarized sky waves beyond, say, 200 m at 200 KHz and so at 1600 kz, the effect being much worse at night (night effect).

9. The Sense Antenna. The polar diagram of the loop that bearing of NDB will be given as one of two figures, 180^0 apart, since there are two nulls. In order to determine the correct bearing further information is needed and an omni-directional sense antenna provides this. In a vertically polarized field an antenna that is omni-directional in the horizontal plane should be of a type that is excited by the electric (E) field of the TEM wave i.e. a capacitance antenna. The output of such an antenna will vary with the instantaneous field strength while the output of a loop antenna varies as the instantaneous rate of change of field strength (Faraday's Law of induced EMF). As a consequence, regardless of the direction of the TEM wave the sense antenna r.f. output will be in phase quartered with respect to the search coil r.f. output. In order to sense the direction of the NDB the two antenna outputs must be combined in such a way as either to cancel or reinforce, and so either the sense or the loop signal must be phase shifted by 90^0.

10. A composite signal made up of the search coil output phase shifted by 90^0 and the

sense antenna output would appear as if it came from an antenna the polar diagram of which was the sum of those for the individual antennas. Now the figure-of-eight polar diagram for the loop can be thought of as being generated as we consider the output of a fixed search coil for various NDB bearings or the output of a rotating search coil for fixed NDB bearing, either way the separate halves of the figure-of-eight will be 180^0 out of phase. As a consequence the sense antenna polar diagram will add to the loop polar diagram for some bearings, and subtract for others. The resultant diagram is a cardio with only one null.

<u>VHF Omni Directional Range (VOR)</u>

11. The VOR system operates in the 108-118 MHz band with channels spaced at 50 KHz. This band is shared with ILS localizer the VOR being allocated to 160 of the 200 available channels. Of these 160 channels 120 are allocated to VOR stations intended for en route navigation while the other forty are for terminal VOR stations (TVOR). The output power of an en route station will be about 200 W providing a service up to 200 nautical miles, its frequency will be within the bank 112-118 MHz. A TVOR will have an output power of about 50 W providing a service of up to about 25 nautical miles; its frequency will be within the band 108-112 MHz, this being the part of the total band shared with ILS Localizer.

12. <u>Principles</u>. A simple analogy to VOR is given by imagining a lighthouse which emits an unidirectional pulse of light every time the beam is pointing due north. If the speed of rotation of the beam is known, a distant observer could record the time interval between seeing the omni directional flash and seeing the beam, and hence calculate the bearing of the lighthouse. In reality a VOR station radiates VHF energy modulated with a reference phase signal the omni directional light and a variable phase signal - the rotating beam. The bearing of the aircraft depends on the phase difference between reference and variable phases - time difference between light and beam.

13. The radiation from a conventional VOR (CVOR) station is a horizontally polarized VHF wave modulated as follows :

a. 30 Hz a.m. : the variable phase signal.

b. 9960 Hz a.m.: this is a sub carrier frequency, modulated at 30 Hz with a deviation of ± 480 HZ. The 30 Hz signal is the reference phase.

c. 1020 Hz AM identification signal keyed to provide Morse code identification at least three times each 30s. Where a VOR and DME are co-located the identification transmissions are synchronized.

d. Voice AM VOR system can be used as a ground-to-air communication channel as long as this does not interfere with its basic navigational function. The frequency range of the voice modulation is limited to 300-3000 Hz.

14. The 30 Hz variable phase is space modulated in that the necessary amplitude variation in the received signal at the aircraft is achieved by radiating a cardiod pattern rotating at 1800 RPM. The frequency modulated 9960 Hz sub-carrier amplitude modulates the RF at source before radiation. It is arranged that an aircraft due north of the beacon will receive variable and reference signals in phase, for an aircraft at X" magnetic bearing from the station the variable phase will lag the reference phase X".

15. The airborne equipment receives the composite signal radiated by the station to which the receiver is tuned. After detection filters separate the various modulating signals. The 30 Hz reference signal in phase compared with the variable signal, the difference, in phase giving the bearing from the station. The actual reading presented to the pilot is the bearing to the station rather than from, so if the difference in phase between variable and reference signal is 135^0 the 'to' bearing would be 135 + 180; 315^0.

16. If compass information (heading) is combined with the VOR derived bearing the relative bearing of the station can be presented to the pilot. Figure 4.4 illustrates that the relative bearing to the station is the difference between the magnetic bearing, to the station and the aircraft heading. An RMI is used to display the information. Such instruments are considered in Chapter 3. In this application the compass, as normal, drives the card so that the card reading at the lubber line is the aircraft heading. At the same time a pointer is driven to a position determined by the difference between the bearing to the station and the heading. A differential synchro or resolve is used to give the required angular difference.

17. The previous two paragraphs refer to 'automatic' VOR, so called since the pilot need do no more than switch on and tune in to an in-range station in order to obtain bearing information. 'Manual' VOR requires the pilot to select a particular radial on which he wants to position his aircraft. The actual radial on which the aircraft is flying is compared with the desired radial. If the two are different the appropriate fly-left or fly-right signals are derived and presented to the pilot.

18. A complication is that radial information depends only on the phase difference between modulating signals and is independent of heading; hence the fly-right or fly-left information may send the aircraft the 'Long way round". Further, when an aircraft is on course, i.e. the steering command is nulled; the aircraft may heading either toward or away from the station on the selected radial. A TO/FRFOM indication removes the ambiguity. With the aircraft heading, roughly, towards (away from) the station and the TO/FROM indicator indicating TO (FROM), the steering information gives the most direct path in order to intercept the selected radial.

19. If the reference phase ® is phase shifted by the selected course and then compared with the variable phase, a fly-fight indication will be given if R+C lags V, which if R + C leads V, the command will be fly-left. If we now add 180 to the phase-shifted reference phase we have R = C + 180 which will, on addition, either cancel V, partially or completely, in which case a TO indication will be given, or reinforce V, partially or completely, in which case a FROM indication will be given.

Doppler VOR (DVOR)

20. The use of CVOR leads to considerable site errors where the station is installed in the vicinity of obstructions or where aircraft are required to fly over mountainous terrain while using the station. The error is caused by multi-path reception due to reflections from the obstructions, and gives rise to course scalloping, roughness and/or bends when the aircraft is flown to follow steering commands. The terms used describing the course under these conditions refer to the nature of the departure from a straight-line course. DVOR is relatively insensitive to sitting reflects which would render CVOR unusable.

21. Although the method of modulation is completely different DVOR is compatible with CVOR in that airborne equipment will give the correct indications when used with stations of either type. In the DVOR the reference signal is 30 Hz a.m. while the variable signal is 30 Hz FM on a 9960 Hz sub-carrier. Since the roles of the a.m. and FM are reverse with respect to CVOR the variable phase is arranged to lead the reference phase by OX for an aircraft at XO magnetic bearing from the station of (CVOR).

22. In a double sideband DVOR (DSV-DVOR) the carrier, fc, with 30 Hz (and identification) a.m. is radiated from an omni directional antenna. Two unpopulated RF sideband signals, one 9960 Hz above fc, the other 9960 Hz below fc 'are radiated from antennas diametrically opposite in a ring of about fifty antennas. These latter signals are commutated at 30 Hz anticlockwise around the ring of antennas. To a receiver, remote from the site, it appears as if the signal sources are approaching and receding, and hence the received signal suffers a Doppler shift. With a diameter 13.5 m and rotation speed of 30 rps the tangential speed at the periphery is n X 13.5 X 30 1272 Mps. At the centre frequency of the VHF band, 113 MHz, one cycle occupies approximately 2.65 m, thus the maximum Doppler shift is 1272/2.65 ± 480 Hz.

23. In the airborne receiver the sidebands mix with the carrier at f c to produce 9960 ± 480 Hz. Single sideband and alternate sideband DVOR are possible, but since they compromise the performance of the system they will not be discussed.

Instrument Landing System

24. The ICAO has defined three categories of visibility, the third of which is subdivided. All categories are defined in terms of run way visual range (RVR) an d, except Category III, decision height (DH), below which the pilot must have visual contact with the run way or abort the landing. The various V categories are defined in Table :

Category	DH	RVR
I	60m (200 ft)	800m (2600 ft)
II	30m (100 ft)	400m (1200 ft)
IIIA	--	200m (700 ft)
IIIB	--	30 m (150 ft)
IIIC	--	Zero

25. ICAS visibility categories standards are given in metres with approximate equivalents in feet (in parentheses). Sometimes categories IIIA and B are called "see to land' and 'see to taxi'.

26. The ILS equipment is categorized using the same Roman numerals and letters. According to its operational capabilities. Thus if the ILS facility is category ii, the pilot would be able to land the aircraft in conditions which corresponded to those quoted in Table 5.1. An Obvious extension of the idea of a pilot manually guiding the aircraft with no external visual reference is to have an autopilot that 'files' the aircraft in accordance with signals from the ILS (and other sensors including radio altimeter) i.e. automatic landing.

27. Principles. Directional radio beams, modulated so as to enable airborne equipment to identify the beam centres, define the correct approach path to a particular run way. In addition vertical directional beams provide spot checks of distance to go on the approach. The total system comprises three parts each with a transmitter on the ground and receiver and signal processor in the aircraft. Lateral steering is provided by the localizer for both front-course and back-course approaches; the glide-slope provides vertical steering for the front course only while market beacons give the distance checks.

28. Localizer. Forty channels are allocated at 50 KHz spacing in the band 108. 10-111.95 MHz using only those frequencies where the tenths of a megacycle count is odd; so, for example 108.10 and 108.15 MHz are localizer channels while 108.20 and 108.25 MHz are not. Those channels in the band not used for localizer are allocated to VOR. The coverage of the beacon will normally be as shown by the hatched parts but topographical features may dictate a restricted coverage whereby the ± 10^0 sector may be reduced to 18 nautical miles range.

29. The horizontally polarized radiated carrier is modulated by tones of 90 and 150 MHz such that an aircraft to the left of the extended center line will be in a region where the 90 Hz modulations predominates. Along the center line an airborne localizer receiver will receive the carrier modulated to a depth of 20 per cent by 'both 90 and 150 Hz tones. Deviation form the center line is given in DDM (difference in depth of modulation), i.e. the percentage modulation of the larger signal minus the percentage modulation of the smaller signal divided by 100.

30. The localizer course sector is defined as that sector in the horizontal plane containing the course line (extended centre line) and limited by the lines on which there is a DDM of 0.155. The change in DDM is linear for ± 105 m along the line perpendicular to the course line and passing through the ILS datum point on the run way threshold; these points 105 m from the course line lie on the 0.1555 DDM lines. The beacon is situated such that the above criterion is met and the course sector is less than 6^0. Outside the course sectors the DDEM is not less than 0.155.

31. The ICAO Annex 10 specification for the localizer-radiated pattern is more complicated than the description above indicates, in particular in the various tolerances for category I, II and III facilities; however we have covered the essential points for our purposes. The airborne equipment detects the 90 and 150 Hz tones and hence causes a deviation indicator to show a fly-left or fly-right command. Full-scale deflection is achieved when the DDM is 0.155. Provided the pilot flies to keep the command bar at zero, or the autopilot flies to keep the DDM zero, the aircraft will approach the run way threshold along the course line.

32. In addition to the 90 and 150 Hz tones the localizer carrier is modulated with an identification tone of 1020 Hz and possibly (exceptionally category III) voice modulation for ground-to-air communication. The identification of a beacon consists of two or three letters transmitted by keying the 1020 Hz tone so as to give a Morse code representation The identification is transmitted not less than six times per minute when the localizer is

operational.

33. Glideslope. Glideslope channels are in the UHF band, specifically 328.6- -335.4 MHz at 150 KHz spacing. Each of the forty frequencies allocated to the glideslope system is paired with a localizer frequency, the arrangement being that localizer and glideslope beacons serving the same runway will have frequencies taken from Table 5.2. Pilot selection of the required localizer frequency on the controller will cause both localizer and glideslope receivers to tune to the appropriate paired frequencies.

Table : :Localizer/glideslope frequency pairing (MHz)

108.10-334.70	108.55-329.75	109.10-331.40
108.15-334.55	108.70-330.50	109.15-331.25
108.30-334.10	108.75-329.35	109.30-332.00
108.35-333.95	108.90-329.30	109.35-331.85
108.50-329.90	109.95-329.15	

34. The principle of glideslope operation is similar to that of localizer in that the carrier is modulated with 90 and 150 Hz tones. Above the correct glide path the 90 Hz modulation predominates while on the correct glide path the DDM is zero, both tones giving a 40 percent depth of modulation. The rust stable null occurs at 50 which for a glide path of 3^0 is at 15^0. This is sufficiently different from the desired descent angle to create few problems; however to avoid confusion the glideslope beam should be 'captured' from below.

35. Once in the correct beam fly-up and fly down signals are indicated to the pilot in much the same way as with the localizer. Figure 5.3 illustrates a fly-up command of just over half-scale detection. The glideslope output is more sensitive than localizer in that typically a t^0 off the glide path will give full-scale deflection about 0.175 DDM compared with about $2t^0$ off the course line for full-scale deflection.

36. Marker Beacons. A marker beacon radiates directly upwards using a carrier frequency of 75 MHz. The modulating signal depends on the function of the marker. An airways, fan or 'Z' marker is a position aid for en-route navigation located on airways or at holding points. A such, it is not part of ILS. The carrier is modulated with a 3000 Hz signal that causes a white lamp to flash in the aircraft while station identification in Morse code is fed to the AIS.

37. The outer marker is normally located 4t miles from the runway threshold. The carrier is amplitude-modulated by 400 Hz keyed to give tow dashes per second which can be heard via the AIS and causes a blue (or purple) lamp to flash.

38. The middle marker is located 3500 ft from the runway threshold. The carrier is amplitude-modulated by 1300 Hz keyed to give a dot-dash pair 95 times per minute that can be heard via the AIS and causes and amber lamp to flash. The ILS marker beam widths are sufficiently wide in the plane perpendicular to the course line to cover.

Distance Measuring Equipment (DME)

39. Introduction. Distance measuring equipment (DME) is secondary radar pulsed ranging system operating in the band 978-1213 MHz. The origins of this equipment date back to the Rebecca-Eureka system developed in Britain during World War II. International Agreement on the characteristics of the current system was not reached until 1959 but since then implementation has been rapid.

40. The system provides slant range to a beacon at a fixed point on the ground. The difference between slant range and ground range, which is needed for navigation purposes, is small unless the aircraft is very high or close to the beacon. Figure 7.1 shows the relationship between slant range, ground range and height to be S2 = G2 + (H116080f) ignoring the curvature of the earth. To see the effect of this consider and error in range of 1 per cent, i.e. S = 1,01G. Substituting for G, rearranging and evaluating we have S- H1853 for a 1 per cent error. Thus at 30000 ft if the DME readout is greater than about 35 nautical miles the error is less than 1 per cent, while at 5000 ft greater than about 6 nautical miles readout will similarly give an error less than 1 per cent.

41. Giving range, DME alone can only be used for position fixing in a rho-rho scheme, three readings being needed to remove ambiguity. With the addition of bearing information, such as that derived from VOR, we have a rho-theta scheme; DME and VOR in fact provide the standard ICAO short-range navigation system. A DME beacon may readout while on an ILS, thus giving continuous slant range readout while on an ILS approach, such use of DME is limited at present.

42. TACAN is a military system that gives both range and bearing with respect t a fixed beacon. The ranging part of TACAN has the same characteristics as civil DME. There are, however, more channels available with TACAN since it utilizes and extended frequency rant of 962-1213 MHz. Thus a civil aircraft equipped with DME can obtain range measurement from a TACAN beacon provided the DME could be tuned to the operating frequency of the TACAN concerned. Many civil aircraft carry a DME that covers the full frequency range.

ATC Transponder

43. With the rapid build-up of international and domestic civil air transport since World War II, control of air traffic by means of primary surveillance radar (PSR) and procedures is not adequate to ensure safety in the air.

44. A PSR does not rely on the active co-operation of the target. Electromagnetic (EM) radiation is pulsed from a directional antenna on the ground. Provided they are not transparent to the wavelength used, targets in line with the radiation will effect energy back to the PSR. Measuring the time taken, and noting the direction of radiation find the range and bearing of the target. Display is by means of a plan position indicator (see Chapter 9). Such a system has the following disadvantages :

a. Sufficient energy must be radiated to ensure the minimum detectable level of energy is received by the p.s.r. after a round trip to a wanted target at the maximum range. Range is proportional to the 4th root of the radiated energy.

b. Targets other than aircraft will be displayed (clutter). This can be much reduced by used Doppler effect (see Chapter 10) to detect only to detect only targets.

c. Individual aircraft cannot be identified except by requested maneuver.

d. An aircraft's altitude is unknown unless separate height-finding radar is used. 5. No information link is set up.

d. No information link is set up.

45. Recognition of these disadvantages, in particular No.3 led to the development of a military secondary surveillance radar (SSR) known as identification friend or foe (IFF). With this system only specially equipped targets give a return to the ground. This system has since been further developed and extended to cover civil as well as military air traffic; the special equipment carried on the aircraft is the air traffic control (ATC) transponder.

46. Working Principles. Secondary surveillance radar forms part of the ATC radar surveillance system; the other part being PSR. Two antennas, one for PSR the other fro SSR, are mounted coaxially and rotate together, radiating directionally. The SSR itself is capable of giving range and bearing information and would thus appear to make PSR redundant; however we must allow for aircraft without ATC transponder fitted or a possible failure. The SSR transmitter radiates pulses of energy from a directional antenna. The direction and timing of the SSR transmission is synchronized with that of the PSR. An aircraft equipped with a transponder in the path of radiated energy will reply with specially coded pulsed RF provided it recognizes the interrogation as being valid. The aircraft antenna is omni directional.

47. The coded reply received by the ground is decoded and an appropriate indication given to the air traffic controller on PPI display. The reply will give information relating to identity, altitude or one of several emergency messages.

Radio Altimeter

48. The meaning of the terms aircraft altitude or height is complicated by the various references used from which the height can be measured. A barometric altimeter senses the static pressure at aircraft level and gives a reading dependent on the difference between this pressure and the pressure at some reference level. For aircraft flying above about 3000 ft, the reference of paramount importance is that level corresponding to a pressure of 1013.25 mbar (29.92 in.Hg), the so-called mean sea level. The other barometric references used are local sea level and airfield level. The pilot is able to set the reference level pressure at 1013.25 mbar, QNH (local sea level-regional) or QFE (airfield level),l the Q codes being used in communication with air traffic control (ATC).

49. Conversely the radio altimeter measures the height of the aircraft above the ground. If an aircraft is in level flight the barometric altimeter reading will be steady while the radio altimeter reading will be varying unless the aircraft is flying over sea of plain. It follows that radio altimeters are most useful when close to the ground, say below 2000 ft, and particularly so when landing provi9dng the final approach is over a flat surface. As a consequence, radio altimeters designed for use in civil aircraft are low-level systems, typical maximum ranges available being 5000, 2500 or even 500 ft in the case of use in automatic landing systems. Military aircraft can utilize high-level radio altimeters.

ELT

50. It is having in all aircraft, When an aircraft landed hard or falls to an accident the ELT then transmit the distress frequency that is 121.5 MHz with out put power 125 mw. By receiving this signal S/R (Search & Rescue) aircraft find out the spot. ELT operating presser is 50 gm and operating voltage is 9vDC with 500mA.

51. Changes in aircraft radio systems occur more a more frequently due to the improving state of the art. The first airborne radio equipments used thermionic devices, cat's whisker detectors and 1 parallel plate tuning capacitors; power, weight and size were restrictions on the development of such equipments. In the 1950s transistorized equipment began to appear although not completely transistorized, the RF stages being reluctant to succumb to solid state. Even now the thermionic, device is still with us in the shape of the magnetron and the CRT.

52. Transistorized equipment is of Course still marketed, but many of the transistors, diodes and resistors now appear on integrated circuits. The emergence of first small scale integration (881) the medium scale (M81) and now large scale integration (L81) of ever more components on one chip has revolutionized the design of air radio systems. In particular using LSI techniques to produce microprocessors opens up a whole new world.

53. The rate of development is the last decade or s. means that many aircraft fly with a range of technologies represented in their electronic system it is not inconceivable that an aircraft could be in service with a valve whether radar a transistorized ADF and an RNAV system employing a microprocessor, or some other combination which would make it a flying electronics museum. That happens and will continue to do so is the company accountant's choice not the engineer's or the pilot. The replacement or one system by another performing essentially the same function must be justified in terms of increased safety, increased reliability or an improvement in performance which allows flights to be made in conditions where previously the aircraft would have to be grounded.

54. The reluctance to replace an equipment that is performing adequately reduces the size of the market for the radio system manufacturer. Of course there is no problem with new aircraft that will have the latest proven equipment fitted. Paradoxically, the situation we have is that the aircraft fitted with equipment employing the latest state of the art are more likely to be in the general aviation category, since that market is very much bigger than that for commercial airliners.

55. Completely new systems do not appear very frequently, although when they do it is often because the improvement in the state of the art has it made the impossible. An airborne Omega r.t. receiver was not a viable proposition until the computer power and memory capacity necessary, could be economically made available in a box of reasonable size.

56. Systems such as VOR, DME, ILS, etc. require enormous capital investment and so once adopted on a large scale tend to last an extremely long time. During and immediately after World War II many airborne radio systems were developed but only a few survived; new systems developed since the 1950s have not been internationally agreed replacements for existing systems but provided competition for them. The microwave landing system (MLS) that will succeed ILS will be the first replacement system, as opposed to competing system, for decades.

The GPS

57. The GPS system consists of three pieces. There are the satellites that transmit the position information, there are the ground stations that are used to control the satellites and update the information, and finally there is the receiver that you purchased. It is the receiver that collects data from the satellites and computes its location anywhere in the world based on information it gets from the satellites. There is a poplar misconception that a GPS receiver somehow sends information to the satellites but this is not true, it only receives data. So, just how is it able to do computes its position?

58. Geometric View. Your GPS receiver uses an elaboration of a technique that is tried and true and used by navigator sand surveyors for centuries. Basically you use a known set of locations to compute your current location by taking fixes on the known sites. In the old days you took bearings (compass sightings) on existing locations and triangulated these on a chart to compute a fix on your location. Once your have a compass bearing you can draw a line through the known location and you know you are somewhere on that line. Do the same thing to a second point and the two lines will interest. This is your position. If you try a third point it should intersect at the same place the other two lines interest. Usually however, because of imprecise sightings, it intersects both lines at slightly different points thereby forming a small triangle. You are somewhere inside that triangle but don't know exactly where. If the triangle is small enough you consider it good enough, otherwise you need to take another sighting. Accuracy is determined primarily on your ability to get and plot an accurate bearing as well as the geometry of the known sites available. This means that if the sites are very close together you will get poorer results that if they are at some angular distance apart. What you would really like were two sites that were 90 degrees apart for best accuracy.

59. The GPS receiver uses a slightly different approach. It measures its distance from the satellites and uses this information to compute a six. How can it measure distance? Well it really measures the length of tie the signal takes to arrive at your location and then based on knowing that the signal moves at the speed of light it can compute the distance based on the travel time. However, un like the known sites of the olden days, these sites are moving. The solution to this problem is to have the satellite itself send enough information to calculate its current location relative to your receiver. Now, armed with the satellite location and the distance from the satellite we can expect that we are somewhere on a sphere that is described by the radius (distance) and centered at the satellite location.

60. By acquiring the same information from a second satellite we can compute a second sphere that cuts the first one at a plane. Now we know we are somewhere on the circle that is described by the intersection of the two spheres. If we acquire the same information from a third satellite we would notice that the new sphere would intersect the circle at only two points. If we know approximately where we are we can discard one of those points and we are left with our exact fix location in 3D space. Now, what would happen if we were to acquire the information from a fourth satellite? We should expect that it would show us to be at exactly the same point we just computed above. But what if it isn't ? Before we can answer that question we need a little more background.

61. A more basic question is, " How does the GPS know the travel time so that it can compute the distance? The satellite sends the current time along with the message so the GPS can subtract its knowledge of the current time from the satellite time in the message (which is the time that the signal started its descent) and use this to compute the difference. For this to work the time in your GPS must be pretty accurate-to a precision of well under a microsecond. The satellite itself has an atomic clock to keep the time very precisely, but your unit is probably not big enough nor expensive enough to have an atomic clock built in, so your clock is likely to be in error! For this reason our assumptions about the distance calculation are likely to have considerable error and the fourth satellite fix will reveal this to us. However, if we assume the error is caused by an error in our clock then we can adjust our clock a little and recomputed all 4 fixes, continuing to do this iteratively until the error disappears! We will then have a good position fix and as a side effect we will also have the correct tie to about 200 nanoseconds or so. One of the applications of GPS technology is to provide the correct time even when we don't care about position.

62. Maintaining the fix means that we need to continuously recalculate the information based on the moving satellites. Once we have a number of fixes we can derive much more information that just location data. For example, GPS can compute the travel direction (compass heading) by comparing current location to previous location. Similarly the GPS can keep track of travel distance, compute speed, record travel time and other valuable data.

63. This view is simplified. In addition to the data already mentioned the unit uses Doppler data from the moving satellites, almanac data to figure out the approximate positions of all the satellites, and ephemeris data download directly from the satellite that can be used to compute its position in the sky. Similar to the geometry problem we had in the order system of taking bearings on fixed sites, the satellite geometry has a significant effect in the accuracy of our final position. A unit less number representing this geometry is called Dillution Of Position, DOP and is used by the GPS in determining which of the satellites available represents the best ones to use. The smaller the number to better the geometry.

64. Mathematical View. Another way to understand the operation of a GPS system is to look at the math that goes into calculating a position. From Pythagoras we have :

$$Prs + T + Es = \text{sqrt}\,\{(X - Xs)^2 + (Y - Ys)^2\ (Z - Zs)^2\}$$

Where X, Y, Z are the positions we are trying to find a T is the time error at the receiver.

The terms Xs, Ys, Zs are the satellite positions that can be calculated from ephemeris information sent from each satellite. The Es term is a lump sum of all the modeling errors considered by the GPS. These include such things as troposphere and ionosphere errors, clock errors from the satellite and any other error the GPS receivers thinks is significant enough to model. Prs is the approximate (pseudo range) distance from the receiver to the satellite. Since we can calculate the pseudo range and satellite positions independently and we can factor in modeling in formation from hardcode date we are left with four unknown, X, Y, ZA, and T. Therefore we need 4 equations to solve for the 4 unknowns. Mathematically this is a standard least squares problem. One approach is to use guesses of our current position to calculate delta's from what we would expect and then iterate towards a converged solution. This is the reason that the unit requires an estimate of our current location to compute our position. Once we have the delta's down to an acceptable level we have a solution.

65. In actual practice a Germen/receiver calculates a set of equations with 7 unknowns. In addition to the 3 positions and time they have added the Doppler data dx, dy, and dz which represents the relative speed between the satellite and the receiver. These terms are needed because our solution is based on moving objects and dx and dy can be used as part of the receiver velocity calculation (dz is discarded). Four equations will compute a full 3D solution but new 12 channel Germin units can use additional satellites to perform an over determined solution that will offer more accuracy. older multiplex units pick the best 4 satellites based on their DOP. As satellites move out of view or get blocked from the receivers view by buildings, trees, and other objects the receiver will switch to other satellites to maintain a location fix. If the number of tracked satellites drops to three then a 3D solution is n o longer possible and the receiver will use the last available altitude and compute a 2 D fix for horizontal position.

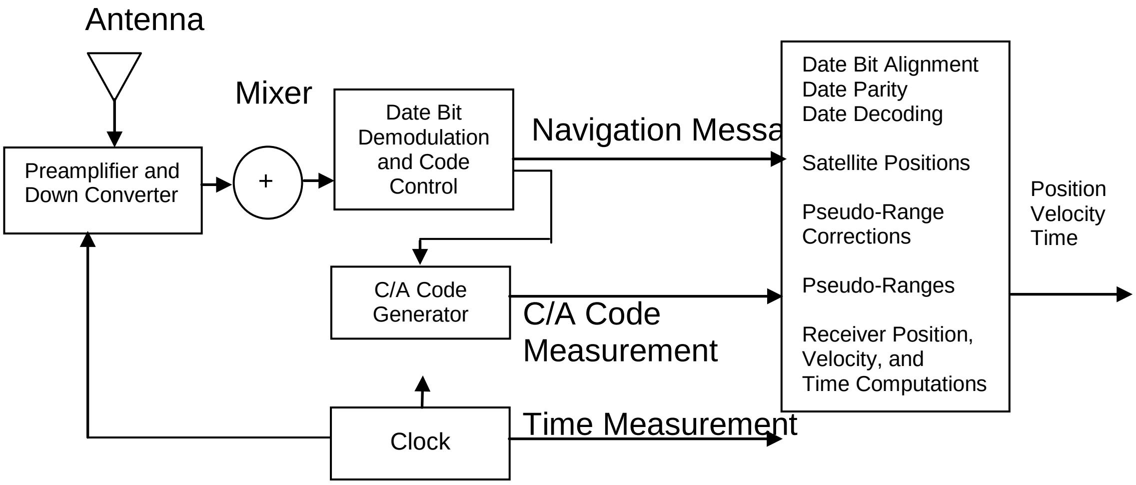
<u>The Other Two Elements of the GPS System</u>

66. In addition to the receiver we must have a set of satellites in the sky and a method of updating the data in each satellite. There are full time land based sites that monitor the various satellites, which are often referred to as Space Vehicles, SV's. These land based sites back the health of the SV's, check how closed they are to their optimum orbits, check the clock accuracy, and send adjustments as needed. The land based sites are located a precisely known positions so that they can verify the operation of the satellites.

67. The satellites are traveling around the world 11,000 nautical miles high in carefully controlled orbits at a speed that means they will make a complete orbit twice a day. Each orbits takes 11 hours and 58 minutes, so like the stars they will seem to drift 4 minutes a day. The complete constellation consists of a minimum of 21 SV's and 3 working spares. Currently there are 27 total satellites in the sky and it is possible that there could be as many as 31 or 32. There are 6 orbits with multiple satellites in each orbit as depicted in the drawing at the top of the page. Each orbit is inclined 55 degree from the equator and thus there are no orbits that go directly over the poles, but certainly a great many orbits can be seen from the poles or

anywhere else on the earth. The goal of the system is to always provide at least 4 satellites somewhere in the visible sky. In practice there are usually many more than this, sometimes as many as 1?

68. Each satellite contains a supply of fuel and small servo engines so that it can be move in orbit to correct for positioning errors. With update control from the ground units it can maintain an essentially circular orbit around the earth. It also contains a receiver to get update information, a transmitter to send information to the GPS receiver, an antenna array
to magnify the weak transmitter signal, several atomic clocks to accurately know the time, control hardware, and photoelectric cells to power everything.



Simplified GPS Receiver Block Diagram

The steps involved in calculating a position are :

a. Sync with an available satellite and download the navigation information.

b. Convert the messages to internal format for calculation. These include clock information, ionosphere data, and ephemeris (orbit) data.

c. Calculate the exact satellite position. This will include both the elevation and azimuth data so we can apply troposphere-modeling corrections that are dependent on how far above the horizon the satellite is.

d. Calculate the pseudo-range data and then correct for ionosphere and other modeling errors. (Note that consumer units may not compensate for ionosphere or tropospheric errors.

e. Repeat these steps for each available satellite. On a Germin we will initially attempt to find 3 SV's starting directly overhead and compute a 2D fix using the previous fix altitude (or data input by the user).

f. Correct the SV position for earth's rotation based on the time it takes for the signal traversal using the pseudo range data. (If the internal clock is close this can be done once, otherwise it will have to be repeated after the receiver position is (computed).

g. Correct using differential if available. (This may have to be done after the initial position is computed as part of the refinement step if the internal clock isn't accurate.) If the differential station is near the GPS receiver it will be able to skip the corrections for modeling errors since this is part of the correction data available. Using GPS corrections leads to accuracy considerably beyond the capability of a standard receiver.

h. Calculate the initial receiver position as described in the prior section.

j. Convert the data based on whatever datum and grid system you have chosen and display the answer on the position page. Altitude is also corrected for geoids height prior to display.

k. Add in the leap seconds and time offset from UTC time to the computed time data and converts it for display.

l. Refine the position based on additional satellites and the correct tie to.

TASK-9

REGULATIONS GOVERNING INSPECTION OF EXPLOSIVE

1. Annual Inspection of Explosives. All explosives held in the Bangladesh Air Force, whatever their condition, whether approved service explosives or those in the experimental stage, whether held in main store, in ready use buildings, in explosive preparation buildings, in aircraft or in aircraft equipment, are to be submitted for inspection annually. Annual inspections are to be done in accordance with the agreed programme. At ammunition supply depots, the annual inspection is to be done in accordance with a programme agreed between the stock holder and the concerned quality assurance inspector, designed to ensure the all stocks are inspected annually in the most economical manner.

2. Special Inspection. In addition to annual inspections, special inspections are to be carried out when the circumstances justify such action. When the stock holder or user requires a special inspection, or when he agrees with an inspector's recommendation that one be done, he is to raise and submit inspection forms in accordance with part-3 leaflets G2&G3.

3. Stores Not Installed. Enter the relevant information against Bases, serial No (Which should include the Base Monogram and year), "Canopy No" and period of Account", Delete "Annuals/Specials/lntermediate" as appropriate, ignore "Voucher No", and "Held for" unless the owner is be stated. In cot 1, delete the numbers, and insert against each lot/date (not group) entered on the form item numbers, starting at No 1 on each form.

4. In Cols 2-4 and 6 enter the details of each group once only, below this, enter in Col 5 in consecutive order the lot numbers/work dates (SAA, day, month and year plus any suffix letters) contained in the group.

5. In col *7* enter the designation of the packages outer and inner if applicable, and the number or rounds per effective package containing the stores eg:

a. 30mm ammunition - 220X36 rds.

b. Cartridges Signal 26mm - 2 X130 Rds.

c. Cartridges seat Ejection sets Part No. MEEU-62749-1 1X12 sets.

6. In cols 8-10 against the relevant lot/date enter as appropriate.

a. In col 8 the quantity of sealed stock.

b. In col 9 the quantity of opened stock (see 3, leaflet).

c. In col 10 any stock held other than serviceable.

d. !n col 17 a brief statement to explain any entry in col 10 eg RCTS/72, local RC/F1022FS/N

7. Inspection Details. In col 12 enter the number of packages/ rounds inspected against the lots/ dates from which the sample has been taken. If the previous inspection history shows that an adequate sample form the group has already been inspected, enter VS indicating that while no sample has on this occasion been drawn the visual condition of the group as stored is satisfactory.

8. Proof Details. In col 13 enter the number of rounds selected for proof against the lots/ dates from which the sample has been taken, deducting these quantities from the quantities submitted. For other than local proof enter a danger (+) in both cols 12, and 17, and in the latter quote the concerned proof center and the relevant F3811A serial number,

9. Sentences. In cols 14-16 as appropriate, enter against the lots/ dates the quantities as sentenced. In col 17 enter remarks to support entries in cols 18 giving brief details, for eg down-grading and specifying any special storage or handling requirement arising.

TASK-10

RED CARD AND BLACK LIST PROCEDURE

1. This order lays down the procedure for red carding and black listing of explosives held in the BAF.

Suspension of Red Card Procedure

2. Introduction. In order to standardize suspension or red card procedure in the service, instructions as described in the order are issued for the guidance of, and implementation by, the personnel concerned with the job. The red card is the procedure whereby all explosives suspected of being inefficient and dangerous or those whose condition is unknown are clearly marked. If necessary they are to be segregated and recorded. The explosives which fall under the category of inefficient are those which are classified as unserviceable, repairable, unclassified and under inspection, investigation and proof tests. The stores are recorded in the Red Card Register (BAF F-3861) and Red Card (BAF F-2884) which are used for identification of red carded stores and bears the reasons and authority for red carding.

Occasion of Red Carding

3. The red card procedure is to be used when :

a. Issue or use of stock has been temporarily banned by Air Headquarters.

b. Stocks are defected or suspected for any reason and fall under the classification of 'U/S', 'R' and 'U/C'.

c. Stock have been certified by inspector as unsafe for use, but safe for normal handling and storage.

d. Stores are recovered after an accident involved in a trial. explosives are held for use on red card forms (BAF)

Authority of Red Carding

4. The following are authorized to impose red card restriction :

a. Air Headquarter (DA&W),

b. Armt QC Inspector of explosives.

c. Base armament officer.

Notification of Red Card or Suspension Procedure

5. Unless it is within the knowledge of Air Headquarters all units are immediately to intimate Air Headquarters by signal the red card action taken. The signal is to be addressed to Air Headquarters, attention DA&W and to furnish the information under the following code :

a. Section and reference number or stock number.

b. Nomenclature.

c. Maker or filler.

d. Date of manufacture cf filling.

e. Maker or filler lot number.

f. Reasons for red carding.

g. Special handling instructions if there are any.

Responsibility of Air Headquarters

6. DA&W is Responsible of the Fol:

a. Transmitting of red card instructions to all units used by the BAF.

b. Forwarding results of investigation, inspection and proof of explosives.

c. Circulating to all units the results of investigation in order to lift the restrictions imposed by red carding.

d. Maintaining a record of red card explosives.

Responsibility of Units

7. Responsibility of Units are fol:

a. Maintaining a red card register which is to record all red card instructions issued and received, together with the action taken thereon. The card register is to be compiled as follows:

(!) It is to be made up of BAF F-3861, and divided into sections for each type of store (as described in AP 3149).

(2) Each section is to contain separate sub-section for each individual stores, in which the red carding of all marks of that stores is to be recorded.

b. Identifying red carded items by the appropriate BAF Form 2884. The cards are to be placed on the stocks immediately red carding instructions are received, or as soon as red card action is required to be taken locally. Stocks are to be converted to appropriate classifications by F-21.

c. Taking red card action on explosives stores as laid down in paras 3 and 4, in addition to F 1022 or UR action should this be necessary.

d. Demanding necessary replacements of stores which have been declared U/S in the normal manner,

e. Endorsing the red card register and listing red card restriction from stores on receipt of instructions. On cancellation of red card action the stores are to be converted to their proper classification (F-21 action}.

f. The lot register maintained on the base for explosives to be endorsed in pencil, accordingly till its final classification is determined.

Removing Red Card Restriction *(Or* Release from Suspension)

8. The restriction imposed by red card action is to be cancelled under the following condition only :

a. On Air Headquarters instructions.

b. When stocks have been sentenced serviceable by quality control inspector of explosives.

c. When disposal action has been taken on stock concerned.

d. Shortage of stock necessitates continued use, provided it is safe for continued use.

e. When the explosives is subject of F-1022 or UR action and authority for its use is given a minimum of 10 items or in the case of SAA 200 rounds is normally to be retained for subsequent investigation or inspection or inspection by the quality control inspector of explosives.

Duration of Red Card or Suspension Restriction

9. Red Card restrictions will not normally remain in force for more than 12 months. If at the end of that time the restriction is not lifted by Air Headquarters DA&W may be informed accordingly.

Submission of Return

10. A red card return no RCN 743 is to be submitted quarterly to Air Headquarters (DA&W) in respect of stocks affected on each station.

TASK-11

BLACK LISTING PROCEDURE

Introduction

1. Black list is the procedure where by a record is maintained of all lots of their ultimate disposal or destruction. All concerned are to take the following action.

Authority for Black Listing

2. It is to be imposed by :

a. AP 3149, as and when amended by the issue of amendment list or consolidated black list (BAF).

b. Air Headquarters (DA&W).

Method of Recording

3. It is to be recorded as follows :

a. Black List Register. It is maintained to record black listed explosives at units and Bases._It consists of a number of sections, each of which includes explosives of similar nature. Each section is sub-divided into sub-section dealing with individual explosives stores, and the black listing of different number and mark of each item is to be recorded under their respective Sec/Ref or stock number. Each section is indexed for easy reference.

b. AP 3149. On receipt of a consolidated black list AP 3149 is to be amended by cutting out the amendments and posting them on to the appropriate CBL. Addenda sheets, are to be inserted behind printed sub-section sheets.

Method of Notification

4. It will be notified as follows :

a. By a signal from Air Headquarters which will give the following information :

(1) Section and reference number or stock number.
(2) Nomenclature.
(3) Maker or filler.
(4) Date manufacture of filling.
(5) Makers or filler's lot number.
(6) Reason for black listing.
(7) Disposal instruction and special handling instruction.

b. By consolidated black list to AP 3149 (BAF).

Method of Applying Black List Action

5. When stores are black listed, a Red Card (F-2884) with a black cross superimposed on it, is to be placed on the appropriate item; when the item concerned is already subject to red card action a black cross is to be superimposed on the existing red card. Black listed stores are to be converted to "unserviceable" on F-21 the black list confirmation being quoted as the authority and stock records are to be adjusted accordingly. Similar action is to be taken in respect of black listed items packed with the parent store eg detonator packed with Grenades hand No 36. The parent store is to be subject to red card action until the black listed item have been replaced.

Responsibility of Air Headquarters

6. DA&W is responsible for the fol:

a. Compiling the results and reports of inspection of explosive found on proof test.

b. Circulating the results of inefficient and dangerous explosives to Base/Units

c. Maintaining a record of black list of explosives. Responsibility of Units/Stations

7. The units/bases are responsible for the following :

a. To maintain a black list register.

b. Maintain AP 3149 up -to-date to ensure that the required action is taken. All explosives holding units must have a copy of this Air publication.

c. Where disposal by destruction is ordered, it is to be done in accordance with AP110A-0102-1.

d. The correct identification of black listed stores is to be maintained by use of F 2884 marked from corner to corner with a black cross. The forms are to be placed on the stock immediately the black list instructions are received, and they are to remain in position until disposal action has been completed. The black listed explosives are to be segregated from all other stores.

e. Demands for replacement of stores are to be made in the normal manner.

f. Explosives stores black listed by AP 3149 through CBLs (BAF) will not be disposed off by units, till their disposal is confirmed by Air Headquarters.

g. Disposal instructions are to be complied with, unless superseding authority is received from Air Headquarters.

h. When disposal action has been completed a certificate to that effect is to be sent to Air Head quarters and records are to be completed accordingly are to remain in position until disposal action has been completed. The black listed explosives are to be segregated from all other stores.

j. Demands for replacement of stores are to be made in the normal manner.

k. Explosives stores black listed by AP 3149 through CBLs (BAF) will not be disposed off by units, till their disposal is confirmed by Air Headquarters.

l. Disposal instructions are to be complied with, unless superseding authority is received from Air Headquarters.

h. When disposal action has been completed a certificate to that effect is to be sent to Air Head quarters and records are to be completed accordingly.

n. Should black listed explosives arrive at a unit as part of a normal consignment they are to be disposed off as directed. A statement is to be sent to Air Headquarters (A&W Dte) indicating the stores received and the unit from which they were dispatched.

p. All vouchers transferring black list stores between units are to be endorsed Black listed.

q. A return No RCN 743 is to be submitted quarterly to Air Headquarters (DA&W) in respect of stocks effected on each base.

r. Lot Register maintained at unit/base for the explosives is to be amended accordingly.

TASK-12

INVESTIGATION REPORTING OF ARMAMENT ACCIDENT

1. Introduction. The need for investigation, accurate reporting and recording of all accidents involving armament equipment and explosives cannot be over-emphasized; it is only by these means that technical defects can be eradicated, training techniques can be perfected and safety in operation, transit, and storage, be assured.

Definitions

2. Armament Accident. An armament accident is an irregular incident involving armament equipment (including explosives), whether or not the incident results in damage to equipment or property, or death or injury to personnel.

3. Investigating Team. An investigating team consists of an armament officer assisted by any other specialist officer that may be necessary.

4. Responsibility for Investigating & Reporting Armament Accidents. The under mentioned officers are responsible for initiating investigations into, and for submitting reports on, armament accidents:

   a. At User Units. Commanding officer, who normally delegates his responsibility to the base armament officer.

   b. At Explosives Storage Units. The commanding officer of the units.

5. The senior person at an armament accident is responsible for reporting immediately to the officer in charge Armt Sqn all known details of the accident. The officer in charge Armt Sqn is responsible for passing the information to the commanding officer (see para 4 above) and for ensuring that the equipment is not disturbed (unless this is necessary for purposes of rescue or safety) until the arrival of the investigating team.

6. The officer responsible for conducting the investigation is to inform the CO about the seriousness of the accident and to ask for the assistance of any other officer, as necessary.

7. The procedure normally to be followed in investigating, reporting and recording armament accidents is detailed in the following paragraphs.

Investigation Procedure

8. Immediate Investigation. When an armament accident occurs the responsible officer is to initiate an immediate investigation into the cause of the accident. This investigation is to start at the earliest opportunity and if possible, at the scene of the accident and while the personnel involved are present. If it is not possible to carry out an immediate investigation, the responsible officer is to ensure that the eqgipment has been made safe against the possibility of further accident, irregular release, or firing. When an accident involving aircraft or projectile launching installations occurs, the aircraft crew is to ensure that all weapon system,switches are OFF or set SAFE as applicable, that the

caircrafts are taken to the prescribed safety area, and park it so that the guns or projectiles are pointing in the safe fest direction possible. After ensuring that adequate precautions have been taken to render the equipment safe, attempt should made to simulate the conditions in which the accidents occurred. In the event of an accidental bomb release the crew should repeat the action carried out immediately before the accident. No, live ammunition will be used during investigation.

9. Detailed Investigation. The immediate investigation will usually indicate the probable cause of the accident, but it may necessary to carry out a more detailed investigation to establish the cause beyond doubt. In this event, it may be necessary to ask for the assistance of technical, equipment, or quality control staff at Air HQ. Such assistance must be asked for when the cause in dispute or is obscure, and the request is to be made without delay, by signal where necessary, by the senior technical officer or the chief equipment officer as appropriate, ft is imperative that the specialist have access to be equipment involved and are able to interrogate the personnel concerned before the evidence destroyed and all concerned still have the circumstances clearly in mind.

10. Board of Inquiry. Officer Commanding may order a board of inquiry for the investigation in case of personnel injuries, accidental deaths, damage to property, fires and explosion etc.

11. Form 765C. When the investigation has been completed the base armament officer is to forward all the relevant information required for inclusion in Form 765C to the senior technical officer.

12. Reporting Action. Detail of all armament accidents may be transmitted by telephone to Air HQs, but the details are to be confirmed by signal which will be known as the immediate report within 24 hours of the occurrence in the following cases:

a. An armament accident resulting in damage to aircraft.

b. Other armament accident when:

(1) The cause is 'nitially attributed to a serious defect, and there is possibility of a recurrence of the accident.

(2) The accident results is serious damage or casualties.

(3) It is apparent that there is as immediate requirement for specialist assistance from Air HQs.

13. Contents of Immediate Report. The immediate report is to contain the following information where applicable:

a. Date, time and location of accident.

b. Type of armament accident (airborne/ground weapons explosives) etc.

c. Aircraft, special installations, buildings, vehicles type of armament equipment (including explosives), etc. involved and whether the accident occurred on requisitioned, leased or private property.

d. Cause or presumed cause of accident.

e. Casualties (if any service and civilian, known or believed to be involved.

f. Whether Air Headquarters assistance is required immediately.

g. Any other relevant detail.

14. Preliminary Report. A preliminary report on BAF Form 3845 for all armament accidents is to be submitted to Air HQs within 48 hours of the occurrence. The preliminary report is to contain all the available information clearly, including the details as summarized in para 12 above, details of any local remedial action being taken are to be added under subheading (d) of the form.

15. Detailed Report. A detailed investigation is to be the subject of a written report sent to Air HQs within seven days of the submission of the preliminary report. If the investigation cannot be completed and the report forwarded within the prescribed time the report is to be sent with an explanatory note. A detailed report is to be sent irrespective of whether the accident is the subject of a formal investigation or board of inquiry. It is also to include a reference to any other reporting action taken eg unsatisfactory report.

16. Additional Reports. In the circumstances specified in paragraphs 17 to 32 appropriate additional reporting action is to be taken.

17. Casualty Reporting. When as accident results in the death of or injury to personnel, action is to be taken in accordance with the provisions for casualty procedure,

18. Armament Accidents Involving Aircraft. When armament accident results in damage to aircraft, reports (normal signal message 'A') are to be distributed as follows:

a. Air HQs (accident Investigating Board).

b. Parent unit of the aircraft and the crew if accident occurred away from parent unit.

c. High commissioner or ambassador of Bangladesh in an aircraft is presumed or is known to have crashed in foreign country.

19. Accidents Attributed to Defective Armament Equipment. When a serious defect or failure is discovered, all other equipment (except sealed items) of the same category at the unit is to examined, where practicable, to see if similar defects exist, and such defects are to be reported by signal. The base armament officer is to decide whether a defect or failure is sufficiently serious to warrant reporting by signal. The types of defects which are to be reported by signal include:

a. Any defects or failures affecting the safety of the aircraft and personnel or require urgent remedial action.

b. Any other defect which the base armament officer decide requires urgent consideration at higher level.

20. The signal is to be sent to be Director A&W at Air Headquarters and is to be reported to DADTS (Wps) and ADSP 2 (a) in case of explosives. The signals are to include:

a. Complete information with nomenclature and stock number of the defective item.

b. Brief particulars of the defects, the nature and actual position of the defect.

c. Details of the extent to which similar equipment has been examined at the unit.

Accidents Due to Irregular Release or Firing From Aircraft. When an accident is due to the irregular release of stores from aircraft armament installations, or to the irregular firing of guns or launcher of projectiles, responsibility for investigation rest primarily with the base commander of the base to which the aircraft belongs. The base commander is to make an immediate factual investigation of any incident referred to him and is to report the matter to Air HQs. All cases of irregular release are to be reported to DA&W who will in the light to the attendant circumstances give direction on the type of report or investigation required. A board of inquiry is to be convened whenever injury to persons or damage to property has occurred. The purpose of the inquiry is to apportion blame and determine the cause of the irregular release and technical or administrative filings and to assess the extent of injury or damage where this has occurred. The base commander is to initiate disciplinary action where necessary and is to make recommendations to higher authority about technical failure or administrative weaknesses which are beyond his own jurisdiction. Unsatisfactory report is to be completed by the unit where such action is appropriate. For attached aircraft ie aircraft operating from an airfield other than their own parent base, immediate reporting action is to be taken by the base commander of the base to which the aircraft is attached. He is to report the circumstances to the officer commanding of the aircraft's parent base with a copy to Air HQ's. All further investigations and action will be undertaken by the parent unit. When an irregular release is known to have occurred at *a* considerable distance from the base from which the aircraft is operating, the incident is to be reported to the CO of the BAF unit nearest to the place at which the missile has fallen and he is to be asked for a factual report of the circumstances and of any damage which has occurred. Further investigations then will be undertaken by the CO of the parent unit. If during peace time, a missile has fallen or is reported to have fallen from an unidentified aircraft the matter is likely to be reported to a nearby BAF base by the police or civil authorities. In such circumstances the base commander is to investigate the facts and report the incident to Air HQ's by signal. Subject to a thorough investigation of the attendant circumstances, a missile may be removed or demolished under normal arrangements by the base to which it reported. This action is to be taken irrespective of whether the aircraft concerned is airborne or on the ground.

21. Armament Accidents. Involving Outbreak of Fire. When an accident is attributed to, or results in, an outbreak of fire, the following procedure is to be adopted and base commander or unit commander is to take action as detailed below :

a. Complete the Appropriate Fire Report Form. One report form is to be sent direct by fastest means to air Headquarters (Director of Weapons and Provost Marshal).

b. Units are also to report fire outbreaks immediately by telephone to Provost Marshal at Air Headquarters. Much information should be given as possible.

c. When there is any suspicion that a fire has been caused deliberately, such suspicion and the reason for it is at once to be referred confidentially to the provost Marshal.

d. In any fire, where service personnel or civilian employee are killed or injured to any degree, the fire and casualties must be reported by signal to Air HQ's. It is to be repeated to record office in case of airmen.

22. Record of Armament Accidents. A record of all armament accident is to be maintained at Air HQ's. The record is to show :

a. The unit concerned.

b. The equipment involved.

c. A brief summary of the circumstances, including the date place, and personnel involved.

d. Whether the accident was due to :

(1) Defective equipment.

(2) Faulty servicing.

(3) Incorrect procedure.

(4) Improper use.

(5) Other causes.

(6) Cause which has not been established.

e. Remedial action, if any, taken by Air HQ's.

f. Casualties, if any.

g. Allocation of responsibility and disciplinary action taken if any.

h. Reference to other reports.

j. Unit serial number.

TASK-13

CLASSIFICATION OF AMMUNITION

1. Definitions

a. Munitions. Munitions consist of everything necessary for the conduct of war and training therefore, except personnel. They include weapons, ammunition, equipment, supplies, food, clothing, forage, and related items.

b. Military Ammunition. Military ammunition is that type of munitions that consists of explosive or chemical agents, with their characteristic mechanical devices, designed for use against military objectives.

c. Weapons. A weapon is any instrument of combat. For descriptions of weapons, see pertinent technical manuals pertaining to each weapon.

d. A round of ammunition consists of all the necessary expendable components to fire the system once.

2. Classification. Ammunition is classified according to the characteristic in 'A' through 'J' below :

a. Type

(1) Small Arms Ammunition. Small arms ammunition consists of cartridges used in rifles carbines, revolvers, pistols, submachine guns, and machine guns and shell used in shotguns.

(2) Grenades. Grenades are explosive or chemical filled projectiles of a size and shape convenient for throwing by hand or projecting from a rifle.

(3) Artillery Ammunition. Artillery ammunition consists of cartridges, shot, shell that are filled with high explosive, chemical, or other active agent; and projectiles that are used in guns, howitzers, mortars, and recoilless rifles.

(4) Bomb. Bombs are containers filled with an explosive, chemical or other active agent, designed for release from aircraft.

(5) Pyrotechnics. Pyrotechnics consist of containers filled with low explosive composition, designed for release from aircraft or for projection from the ground for illumination or signals.

(6) Rockets. Rockets are propellant-type motors fitted with rocket heads containing high explosive or chemical agents.

(7) JATOS. JATOS consist of propellant type motors used to furnish auxiliary thrust in the launching of aircraft, rockets guided missiles, target drones, and mine clearing detonating cables.

(8) Land Mines. Land mines are containers, metal or plastic, that contain high explosive or chemical agents designed for laying in or on the ground for initiation by, and effect against, enemy vehicles or personnel.

(9) Guided Missiles Guided missiles consist of propellant type motors fitted with warheads containing high explosives or other active agent and equipped with electronic guidance devices.

(10) Demolition Materials. Demolition materials consist of explosives and explosive devices designed for use in demolition and in connection with blasting for military construction.

(11) Cartridge actuated Devices Cartridge actuated devices are devices designed to facilitate an emergency escape from high speed aircraft.

b. Standardization Ammunition is classified as :

(1) Standard.

(2) Substitute standard.

(3) Limited standard

c. Use. Ammunition is classified according to use as :

(1) Service.

(2) Practice.

(3) Drill (dummy).

d. Form. Ammunition is classified as fixed, semi-fiexed, separated or separate loading.

TASK-14

AIR WEAPON RANGES

Description

1. Air Weapons Ranges. Air weapons ranges are classified as follows:

a Air-to-Ground Ranges

(1) Gunnery.

(2) Practice rocket projectile (inert head).

(3) Live rocket projectile (Live head).

b. Air-to-Air Ranges

(1) Gunnery.

(2) Rocket projectile.

(3) Guided missile.

c. Air-into-Air Firing Ranges.

d. Bombing Ranges. Bombing ranges may be used for more than one purpose, depending on the size of danger areas and the facilities provided.

e. Moving Waterborne Target Ranges.

Siting

2. All weapon ranges are to be sited such that they:

a. Cause the minimum of inconvenience and danger to the public, compatible with satisfying service requirements.

b. Are clear of airways, ir advisory routes, main shipping lances, fishing grounds, and built-up and tickly populated areas.

c. Do not occupy good agricultural land, land reserved for forestry, and cantonment areas for water supply.

TASK-15

TOW TARGET SYSTEM

Introduction

1. The tow target system is introduced in BAF to train pilots for gaining accuracy and efficiency in air-to-air firing. The tow target system may also be used for firing training of the AAA staff against air targets. In BAF, sleeve targets (Banner) are towed by F-6 and F-7 aircraft by means of frame & cable in conjunction with air control systems.

Types of Targets

2. There are different aspect of air targets in use in the world eg sleeve targets, Dart targets, Drone etc. But in BAF only the sleeve targets (Banner type) are used at present. Sleeve targets used by BAF are of the following types :

a. Type 3A Air target (Used in F-6 ACJ\ /

b. Type Y Air target (Used in F-7 AC).

Y-TYPE AIR TARGET

Characteristics

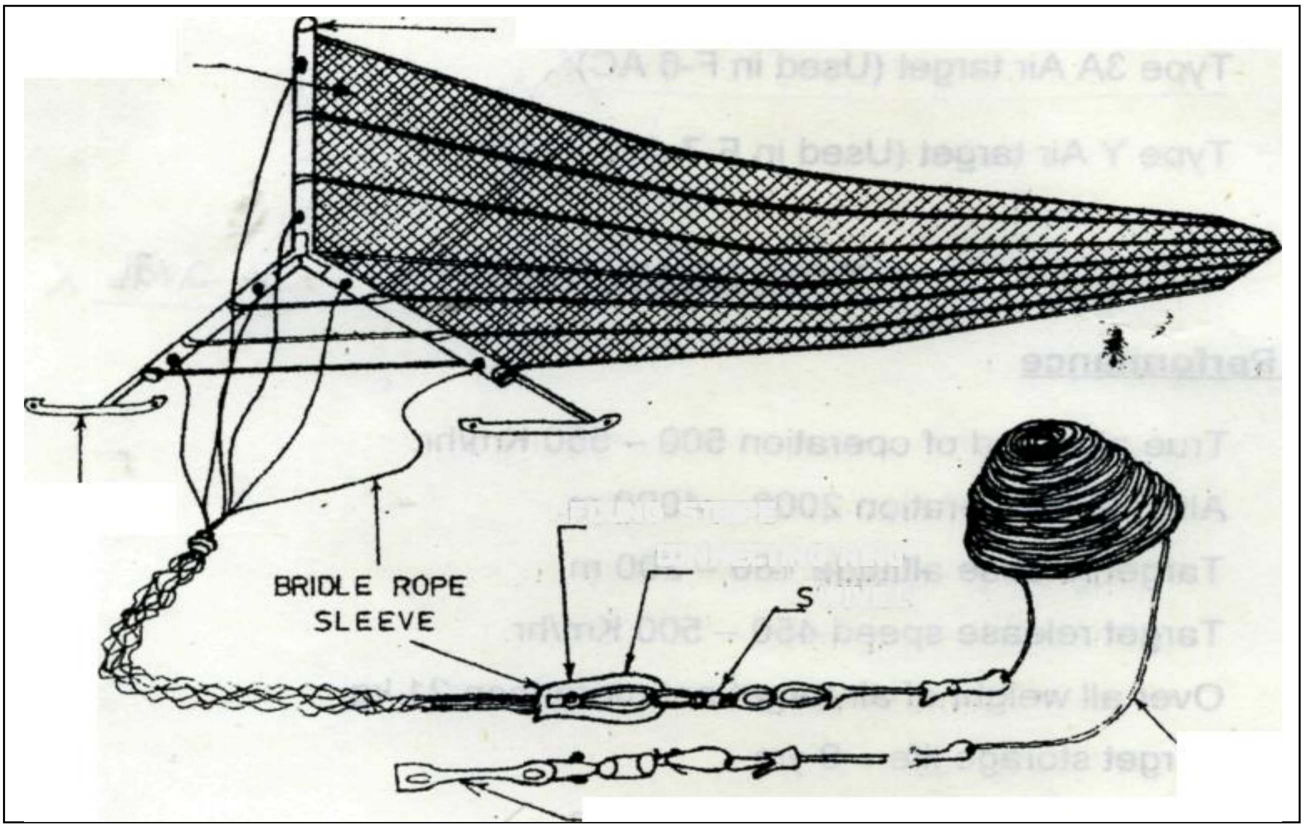
3. Y Type air target has got the following characteristics:

a. High towing speed, high altitude good stability, only slight impulse.

b. It's geometrical dimensions are similar to the fighter aircraft fuselage, there is no apparent difference on the attacked area from all directions, hence it can be attacked at any angle, which is close to the actual fighting case.

c. Small Sink Age. The height of the target is .10 m lower than the towing plane approximately. The target tail swings with high frequency but small amplitude, its loss during cash flight is about 0.3 m off write band, 10, 8m off the target, frame is a mark to judge the angle-off.

d. Simple structure, high strength of operation and maintenance.



Technical Performance

a.	Working Height	:	2000-4000m.
b.	Allowable Operating	:	700 km.
c.	Weight	:	About 20 kg.
d.	Life time of Target	:	05 times generally (Each time 40 minutes

Construction and Function

4. The Y Type air target is composed of the target face, target frame 6 strand, rope, spring hook, polyamide fibre band, rotating joint, temperature resistant steel wire rope, connecting rod etc.

a. Target Face. The aim to be taken. It is the main part of the air target, the total length of which is 12.5 m, and the effective face width is 1 .35-1 .56m

b. Target Frame. It is used for supporting the target face and connecting the 6 strand rope to ensure the ground running and air stability.

c. Six Strand Rope. It is used for connecting the target frame and the spring hook, and ensuring the towing rope to draw the target main smoothly. It is made of polyamide fibre band, and the total length is 6m, one end of each strand is rounded as a ring to allow the 6 fastening points be put into them respectively (the serial number of the fastening points is marked on each strand), while the end of the 6 strands merge into the connecting ring of the spring hook. Each set of rope consists of 6 strands, so it is named 6 strand rope.

d. Spring Hook. It is used for connecting the polyamide fibre band and the 6 strand rope. The cover the spring are provided for preventing the rope from sliding off from the strand end ring.

e. Towing Rope. It is used for towing the target main, and for keeping a certain distance between the target main and the towing aero plane thus to ensure safe operation of the towing plane during attack.

f. Temperature-Resistance Steel Wire Rope. It is used for protecting the wire rope from burning due to the high temperature jet spurted out from the plane.

g. Rotating Joint. It is used for eliminating the twist of the towing rope, and is connected to the two ends of the towing rope.

h. Connecting Ring. It is used for hanging the towing rope on the throw out mechanism of the towing plane, one end of the ring is connected to the temperature - resistant wire rope. It is made by modifying the hanging rod of the drop oil tank.

5. Preliminary Work before The Flight Day:

a. Before mounting the towing frame, Inspect the booster mechanism by means of testing meter see if the mechanism works correctly. After that true the "work-inspect" switch on the "inspect" position.

b. Mount the towing frame, ensure the fastening is reliable and the cable connector is in good connecting condition.

c. Inspection the GG3-6A bomb rack see if it works well.

6. Inspection before Flight

a. Re-check the reliability of the fastening of the towing frame and the connection of the cable connector.

b. Check the GG3-6A bomb rack performance.

c. The hanging 'hook of GG3-6A should be licked, the connecting plug of the booster mechanism should be inserted into the socket firmly.

d. The "work- inspection" switch on the hanging beam of the drop oil tank should be put on the "work" position.

7. Inspection before Re-takeoff

a. Re-check the reliability of the fastening of the towing frame and the connection of the cable connector.

b. Check the GG_3 -6A bomb rack performance.

c. The bomb rack GGs -6A should be licked.

d. Check the rear bottom section of the aeroplane of the hanging frame for towing should be reliable.

9. Inspection After Flight

a. Carry out the items under "1. The preparatory work before the Flight Day.

b. Inspect the hanging frame for towing see if there is any damage, deformation or cracking.

c. Fill out the technical documents.

9. Special Inspection. After the target has been towed 100 times, dismount the two bolts for fastening the bomb-rack and the hanging rod inside the banging frame, then inspect them by magnetic testing. At the same time, inspect the electric performance of the GG3-6A bomb-rack, see it complies with the technical requirements. Clean the "normal throw-out" button.

TASK-16

GUIDED MISSILE TECHNOLOGY

The Fundamental Concepts of Missile

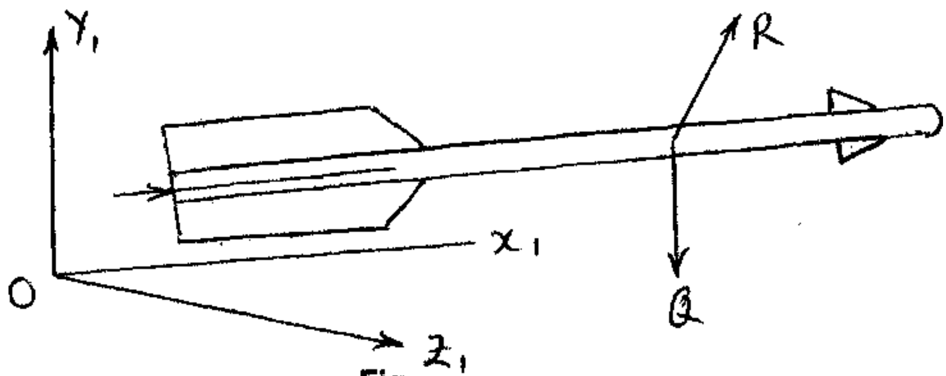
1. Features of Missile. The crafts for military purpose are aircraft, rocket and missile (guided missile). What is called missile? What features does it have? To answer these questions, we may compare them. From the comparison we can find: aircraft is operated by pilot; rocket and missile are no-man controlled; missile is controllable and rocket is uncontrollable; the engine of missile is rocket engine or air jet engine but the engine of rocket can only be rocket engine.

2. Missile & Engine. On the base of the comparison results, we can conclude that missile is a craft which is controllable but with no pilot and the rocket is a no pilot craft impulsed by rocket engine. The rocket engine is the engine which completely does not rely upon any exterior matter (eg the oxygen in the air) and produces propulsion by the combustion gas ejection that is then produced completely by detonating the propellant (solid, liquid or mixture of solid and liquid) carried by rocket engine itself.

3. Air-to-Air Missile. There are many ways of missile classification. According to the difference of launching point and landing point, we may say that air-to-air missile is the missile which is launched by the flying aircraft and hit the target (aircraft or missile) flying in the air.

Forces and Torques Acting on Missile

4. Forces Acting on Missile. During the flight of missile there are 3 kinds of forces acting on the missile, they are aerodynamic force, impulse and gravity of missile itself.

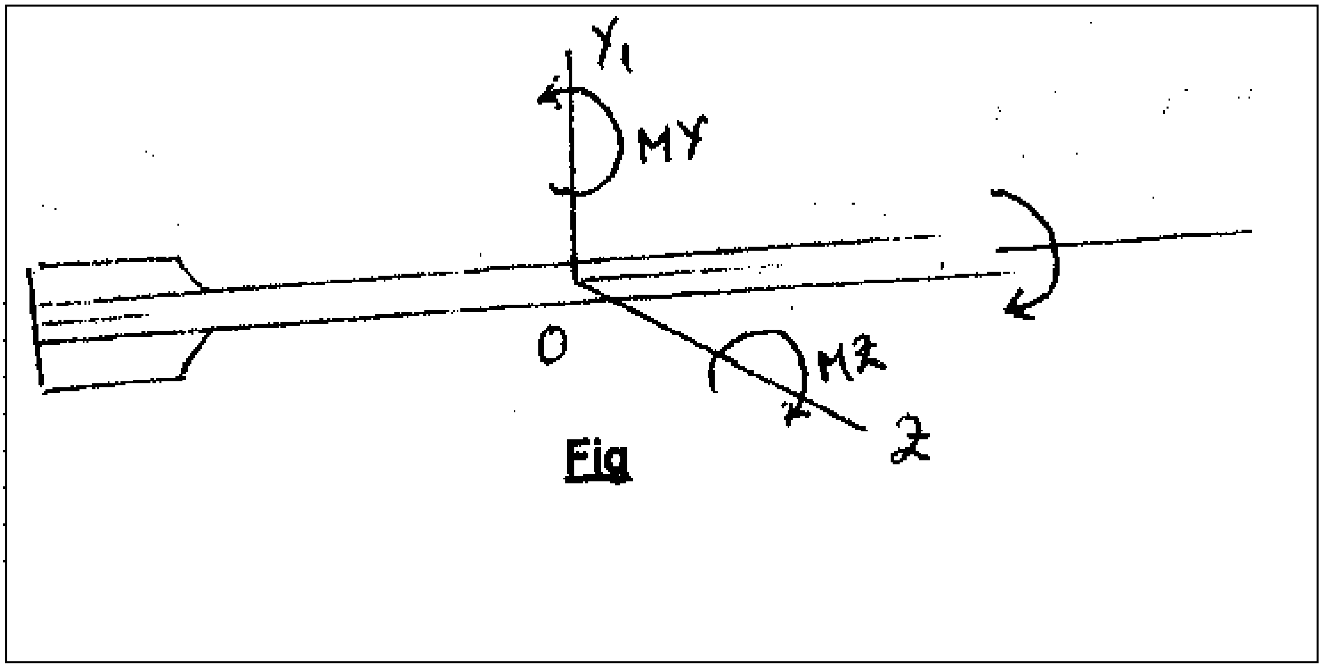


Fig

5. Torques Acting on Missile. What is called torque is the measurement of a force relating to appoint. It equals to the production of force and arm of force in quality.

Torque Force X Arm of Force

We usually use three torques around the three axes 0X1 OT1 and OZ1 in missile body coordinate to describe the aerodynamic torque acting on missile. The three torques correspondingly are the elevation torque MZ1 around OZ1 axis, the roll torque MX1 around 0X1 axis and the yaw torque MY1 around OY1 axis.



Flight Characteristics of Air To Air Missile

6. Maneuverability. AAM's maneuverability is the ability of missile to change its flight speed and direction. Maneuverability can be expressed with the amount of normal overload and tangent overload along the flight track. What we usually concern is the normal Maneuverability of missile. Under the condition of same flight and flight speed, the higher the normal maneuverability of missile is, the smaller the turning radius, and the higher the percentage of hits. Missile's Maneuverability will directly influence the flight effect of the missile.

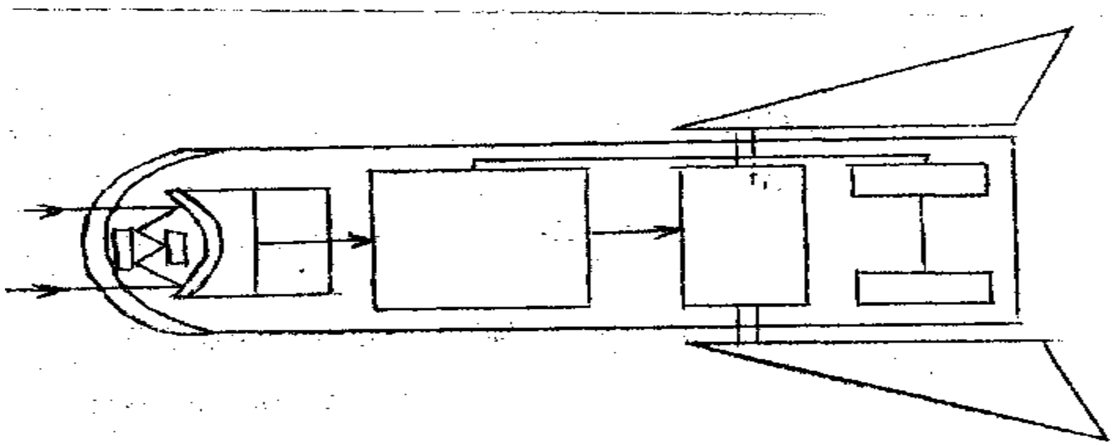
7. Stability. During the missile's flight, the missile will deviate from the original flight state because of some interference, after the interference disappeared the missile should return to its original flight status. The ability of missile returning to the original state is called stability.

8. Controllability. It is needed to change missile's flight state continuously during the process of missile attacking target. (The degree of difficulty for missile to change from one flight state to another flight state is called controllability.)

AAM's Basic Units and Their Function.

9. AAM's Basic Units. There are many kinds and models of missile and all these missiles have different features. As the attacking weapons, they all have four principle parts ie. Guidance system, detonation system, propulsion system and missile body.

10. Constitution and Function of IR Guidance System. The function of guidance system is guiding the missile to hit target. In the concrete, there are tasks in two aspects. One task is, according to the features of the target, to determine the track along which the missile should fly and to control the missile flying along this track. The another task is to assure that missile stability fly in this track. There are many kinds of guidance system. We only introduce IR guidance system. By the device in the missile, IR guidance system directly senses the IR radiation of the target and produces control order and guides the missile flying to the target. This IR guidance system is a kind of passive target-seeking guidance system. This system can be divided into IR homing unit and control unit according to its function. The function of homing unit is to range the relative position between missile and target and the actual flight track of missile, to form a correction order (ie controlling signal) required for missile to fly along the demanded 'track, and send the order to the control unit. The general function of control unit is to execute correctly and rapidly the controlling signal which is output by homing unit and control unit according to its function. The function of homing unit is to range the relative position between missile and target and the actual flight track of missile, to form a correction order (ie controlling signal) required for missile to fly along the demanded track, and send the order to the control unit. The general function of control unit is to execute correctly and rapidly the controlling signal which is output by horning unit and related to the changing of missile flight track, and to assure that the missile stably fly during any section of the track. To explain this matter, we take a certain AAM as an example. This AAM'S IR guidance system consists of IR homing head and actuator. Its diagram is shown below.



The homing head consists IR receiver and electronic circuits, IR receiver is made up of optical system and IR detector. The operation principle is; the IR receiver receivers IR signal from the target converts the optical signal to electric signal by optical electric conversion with IR detector, and outputs the electric signal to electronic circuits for signal processing to form the controlling signal. The controlling system is principally the actuator system. Its operation principle is; it sends the controlling signal obtained from homing system to the actuator system to control the fins deflection for the aim of changing the flight track.

11. <u>Construction And Function of Detonation System.</u>

a. <u>Constitution of Detonation System.</u> The Detonation system is mainly composed of fuse and warhead. Its function is to detonate the warhead device at the most favorable movement to destroy the target.

b. <u>Function of the Fuse.</u> There are three cases in which the missile and target come across; the missile files by the target, the missile directly his the target, missile doesn't meet the target. Three fuses are designed on the missile for the three cases, they are 8 Mtrs proximity fuse, impact fuse and self-destruction fuse. Their functions are described as following:

(1) The proximity fuse's function is detonating the warhead to destroy the target at a suitable moment as the missile comes close to the target.

(2) The impact fuse's function is detonating the warhead to destroy the target when the missile hit the target.

(3) The self-destruction fuse {also called self-destruction mechanism) has the function of detonating the warhead to destroy itself for avoiding hurt its own personnel and lost secret when the missile doesn't meet the target.

c. <u>Function of the Warhead.</u> Warhead is the missile's effective lead and its function is to destroy the target.

12. <u>The Constitution and Function of Propulsion System</u> The propulsion system of air-to-air missile is generally splid rocket engine. It mainly has combustor, propellant, igniter device and blast tube, its function is to produce the power making the missile move. It is used to ensure that the missile pursues the with a sufficient flight speed.

a. <u>Function of Combustor.</u> The combustor is a place for charging and combusting the solid fuse. It is a container, which can withstand high temperature and high pressure.

b. <u>Function of propellant (Grain).</u> Propellant is the source of engine.

c. <u>Function of Igniting Device.</u> The function of ignition device is igniting the grain, starting engine to its working state, and providing a initial state with a certain pressure and a certain temperature.

d. <u>Function of Blast Tube.</u> The function of blast tube is covering the thermal energy of combustion has to kinetic energy, obtaining a blasting speed of combustion gas then getting a great thrust.

e <u>Engine's Total Impulse And Specific Impulse</u>. Engine's main performance parameters are thrust, working time, total impulse and specific impulse.

Thrust is the acting force which is get from reacting force of high speed combustion gas blasted from blast tube and propulse the missile forward.

What is called working time is the engine's working time. For different engines and different usages. The required working time is different. For the engines with equal thrust, the working time may be different and missile's flight distance may also be different.

Only the thrust or working time is unable to express the working ability of engine. Total impulse is the performance parameter which express the working ability of engine. The greater the total impulse is, the longer the missile flight distance is. If the thrust of engine is constant, the total impulse is the production of thrust and working time. In other cases, the total impulse will be a result of integration.

Specific impulse is the amount of impulse produced by 1 kilogram grain. Specific impulse is one of the quality parameters used to measure the quality of grain.

13. Construction and Function of Missile Body. The missile body consists of casing, wings and fins. The missile body is used to contain effective load, instrument and propellant, to connect missile's every parts organically to form a whole structure with required aerodynamic shape and to assure the missile can complete the predetermined combat mission.

a. Function of Wings. The main function of wings is producing air lift to bring about missile's maneuvering flight.

b. Function of Missile Casing. The casing has two uses: carrying load (effective load, fuel and other instrument and accessory) and connecting missile's all parts firmly to a whole.

c. Function of Fins. They are necessary executive assembly for missile to realize maneuvering flight.

Launching Method of Air-to-Air Missile

14. Launching is the starting sign of the whole tactical application process of missile. What is called missile launching method is the way in which the missile departs form the carrier. The launching method which is often used is rail launching method. The feature of this launching method is describe as follows. In the missile launching process, missile's initial movement is limited and guided by rail of the launching device. When the missile is leaving the carrier, it is in the direction pointed by rail. These features will reduce the deflection missile with respect to the ideal track.

The Test for Air-to-Air Missile

15. As a one shot flying weapon, missile must pass a series tests in manufacturer to assure missile's combat reliability. The tests are meteorological environmental tests, aerodynamic environmental tests, etc.

a. Meteorological Environmental Tests. Meteorological tests include high-temperature test, low-temperature test, temperature cycling test, temperature shock test, humidity test, low-temperature and low-pressure test, aerodynamic heating test, sand-dust test etc.

b. Aerodynamic Environmental Tests. The aerodynamic environmental tests are mechanical vibrating test shock collision test, transportation test, etc.

The Service and Maintenance For Air-to-Air Missile

16. There are respective instruction manuals for the service and maintenance to various missiles. To guarantee the application reliability of missile, the correct service and maintenance must be completed according to the missile's service and maintenance instruction manual seriously. The correctness of operation and the level of maintenance will has a direct or indirect influence upon the missile's lifetime and the completion of combat mission.

TASK-17

GENERAL SIGHTING THEORY AND HARMONISATION OF AIRCRAFT GUNS

Introduction

1. The purposes of any form of gun sight is to assist a fire to bring the fore of his weapon to bear accurately on to a target Irrespective of whether the target or the fire is stationary or moving. His ability to achieve this successfully will largely depend upon his knowledge of the weapon, and of the theory of sighting and the various factors involved.

2. The complete coverage of theory of sighting dealing with internal and external ballistics of weapons, bullets and projectiles, etc, is beyond the scope of these notes. This task is therefore intended to cover in a general way, the basic considerations involved in sighting so far as they apply to individual weapons fired at ground level and to multi-weapon installations fired in the air (which will be of assistance to the armament tradesman).

3. When considering the theory of sighting it is essential to appreciate the various factors that affect a bullet or projectile during its flight when fired at ground level and in the air, since each produces its own set of problems. These problems are dealt with separately to illustrate that although similar in principle, the method of overcoming them differs, particularly when applied to aircraft weapons, ie guns and rockets.

4 Factors in General Affecting Sighting

a. Muzzle Velocity. The muzzle velocity of a bullet or projectile is the speed at which it leaves the muzzle of the weapon; this will vary with different types of ammunition, ie ball, incendiary, tracer, etc. and also with the caliber of the bullet or projectile. For example, the muzzle velocity of a 0.303 in, bultet-is2, 440 ft. per sec, that of a, 20mm projectile 2,850 ft per sec, and that of a 30 mm projectile 2,000-2, 600 ft. per sec. Because of other factors its initial velocity with distance.

b. Trajectory. This the curved path taken by the bullet or prdjectflel during its flight to a target resulting from the effects upon it of gravity and air resistance At short ranges the path is relatively flat but with increased range the curvature of the trajectory increases appreciably causing the bullet or projectile to fall below its Line of Departure.

c. Gravity. The force of gravity acts on the bullet or projectile immediately it leaves the muzzle and tends to draw the bullet or projectile downwards until it eventually strikes the ground. Because this is an accelerative force a bullet or projectile will be pulled towards the ground more rapidly the longer it is in flight. The table below service to illustrate the effect of gravity on 303 in and 20 mm bullets and projectiles at different distances.

d. Air resistance. Immediately the bullet or projectile leaves the muzzle its forward velocity is impended by the resistance of the air, which causes the velocity to fall appreciably. To illustrate the effect of air resistance, a .303 in. bullet with a muzzle velocity of 2,440 ft, per sec, will travel 600 yds in its first second of flight, 400 yds in the second and 300 yds in the third, when fired at ground level.

e. Elevation. When firing individual weapons at ground level, the effects of gravity and air resistance on a bullet or projectile can be overcome by adjusting the sight of the weapon. This adjustment has the effect, when aiming, of elevating the muzzle, that is, lifting the Line of Departure as much above the target as the bullet or projectile would fall below it if the axis of the barrel were pointed at the target. This is known as the Angle of elevation.

f. Cross-Wind. A constant cross-wind on the path of a bullet or projectile has considerable effect at all ranges except the very shortest; head or tail winds may be ignored except at exceptionally long ranges. To counteract the effect of a cross-wind, the fire must first align his sights on to the target, and then aim off at some point into the wind which will enable the wind to bring the bullet or projectile back on to the target. The amount aimed off will depend on the wind strength and the target distance.

g. Movement. When firing at a moving target, the fire must first align his sights on to the target, and then aim at some imaginary point in front at which he estimates the target and projectile will arrive simultaneously. The amount aimed off will depend upon the rate and direction of movement of the target and upon the distance. The angle between the line of aim and the line of sight is termed the Deflection Angle.

Characteristics of Automatic Weapon Fire

5. Cone of Fire. When an automatic weapon is firing the bullet or projectiles do not all travel along the same flight path because each bullet or projectile has its own ballistic features which will vary very slightly from those of the other bullets or projectiles. In addition, the vibration of the gun barrel and of the gun as a whole' in its mounting causes the bullets or projectiles to spread. The pattern formed is oval in shape its density decreasing from the centre outwards, with its axis along the trajectory. This cone is of small angle and is known as the cone of Fire.

6. Bullet Group. The cross-section of the cone of fire at any given range is the area through which all the bullets or projectiles must pass and is referred to as the Total Bullet group'. The centre area of this section through which 75% of the bullets or projectiles will pass is known as the 75% bullet group' corresponding to the given range. The size of this group will increase in proportion to the range.

Sighting In Respect Of Aircraft Guns

7. Introduction. When considering the theory of sighting in connection with aircraft guns it must be appreciated that in addition to those factors which have already been dealt with the sighting of a modern fighter aircraft armament which is in a fixed position and may be made up of different types of weapons, ie guns and rockets, introduces other factors which must be considered separately and allowed for when sighting through a central gun sight.

8. In the previous paragraphs the factors affecting a bullet or projectile have been considered when firing from a stationary weapon at ground level. It is now necessary to review those factors to ascertain their effect on a bullet or projectile fired from an aircraft at altitude.

Factors Affecting Sighting

9. Muzzle Velocity. When a bullet or projectile is fired from an aircraft in flight, it leaves the muzzle of the weapon with a velocity (initial velocity) which is the resultant of the muzzle velocity and true airspeed of the aircraft. At altitude this velocity will be maintained longer than that of a bullet or projectile fired at ground level.

10. Air Resistance. The greater the altitude at which the weapon is fired, the less will be the air resistance offered to the bullet or projectile, because air density decreases with height. Thus a bullet or projectile fired at 20,000 ft. will travel further forward (per unit of time) than a similar projectile fired at ground level, always providing at the lines of departure are parallel.

11. Gravity Drop. The effect of gravity on a bullet or projectile fired at altitude is somewhat less (per unit of time) than that on a similar projectile fired at ground level; this is because of the increased forward velocity ie. combined airspeed and muzzle velocity, and decreased air resistance.

12. Gross-Wind. The effect of a constant cross-wind on the path of a bullet or projectile fired from an airborne weapon is very different indeed from the effect on a similar projectile fired from a stationary weapon at ground level, since it may be, assumed that the aircraft flying in a constant cross-wind process the velocity of the wind in addition to its own forward velocity. The projectile is moving the-refore with the velocity of the wind superimposed on its own forward velocity at the moment of leaving the muzzle. This means that relative to the air there is little or no deviation at short ranges.

13. Aircraft Attitude. A bullet or projectile fired from a fixed gun in an aircraft, in the first instance, follows the path of the aircraft. If the gun mounting is not parallel with the fore and aft axis of the aircraft, the bullet or projectile, on leaving the muzzle, initially follows a path paralleled to the plane of the gun mounting. The aircraft attitude depends upon its type, its load and its airspeed, allowance is made for it when the guns are harmonized.

14. Sighting Allowances. From the preceding paragraphs it is clear that if accuracy of fire from aircraft guns is to be assured, sighting allowances must be made to counteract the following:

a. Gravity drop.

b. Air Resistance.

c. Target rang

d. Aircraft attitude.

e. Speed and course of aircraft.

The above allowances can be effectively made by harmonizing the gun and gun sight to a particular pattern according to the type of aircraft.

15. Modern fighter aircraft have two or more remotely controlled guns mounted in the main plane or fuselage which, on the operation of a central, firing switch, will fore simultaneously. As a result, instead of one bullet group as referred to in para, 12 there will one group for each weapon. The guns are usually aligned so that the groups will overlap sufficiently to ensure the greatest concentration of fire effect at a given range, ie at the harmonization range, and is range is one which will very for different fighter aircraft.

16. fl Harmonization may be described as the whole process of adjusting the direction of the gun barrels so that the bulled groups of all the guns of the installation form the required pattern at a given range, and of adjusting the gun sight in elevation to allow for the gravity deep at that range.

17. The modern gyro predictor or computing gun sight incorporates both fixed and moving sighting graticules; the moving graticule automatically positions itself so that when it is on the target, the correct allowance is being made for the varying gracity drop at different ranges. The range is fed into that sight by the operation of a twist grip throttle control unit and a potentiometer incorporated in the gun sight circuit. The rate of turn of the sighting line is also measured, and in conjunction wit the range, gives the correct allowance to be applied.

18. Rocket Dispersion. When group of rockets of the same design is fired from an aircraft, the rockets don't all have the trajectory and after a given time of flight they will have traveled different distances along their respective trajectories. This known as 'rocket dispersion[1], and may be attributed to the minor differences in:

a. Charge weight.

b. Burning time.

c. Velocity at all burnt. >

d. Shape and weight of shell. Although every care is taken during the manufacture and processing of the propellant charge to ensure that it is of the correct weight and shape, there is always as light variation in both in each charge, and this vacation, although very slight, will effect the centre of gravity position. The slight variation in the burning time is due to the effect of the initial temperature of the charge which varies with that of the air through which the rocket is traveling. The greater the temperature of the charge, the higher will be the burning rate and the greater will be the forward thrust of the rocket ie its forward velocity. Similarly the shape and weight of the shell will also effect both the trajectory and velocity the larger the shell the greater are the air resistance and drag on the rocket.

19. Sighting Allowances. The only difference between the sighting allowance for fir-to-surface rocket firing and those of air-to-surface gunnery is that the allowances in rocket firing are greater because of the lower velocity of the rocket and its consequent longer time of flight. The min allowances are:

a. Gravity drop.

b. Wind speed.

c. Target movement.

HARMONIZATION

Introduction. On account of being subjected to the influences in taking off, landing, firing, dismounting and mounting in maintenance work and other factors eventuality the relative positions of the gun sight, bun camera, gun and rocket systems are changed, which directly effects the accuracy of shooting. Therefore, armament personnel should perform harmonization to make armament system operate well.

Definition. Harmonization is the process of adjusting the axis of gun bore, gun camera, gun sight and rocket/missile launchers to a pre-determined position so as to provide accurate aiming of target.

Occasion of Harmonization. The aircraft is harmonized on the following occasion:

a. After the aircraft is received from factory by Air Force unit.

b. On replacement of gun sight, gun barrel, mounting and windscreen.

c. When relative-position of gun and gun sight is undermined.

d. When the pilot is suspicious to the accuracy,

e. During 100 hours inspection of aircraft or once in a year.

24. Procedures.

a. Prepare the aircraft for harmonization. '

b. Collect required tools and equipment's.

c. Position aircraft at butt point 50_m away from target.

d. Align the aircraft with target.

e. Jack up and level the aircraft properly.

f. Firing the guns.

(1) Take necessary safety measures, raise red flag at visible point.

(2) Fire four rounds (in single shot) from the master gun.

(3) Find out MP. 1, place the target chart and mark the point of left and

right gun sight and camera and remove target chart.

(4) Fire the wing guns in turn, if there is error adjust accordingly.

g. Check the gun sight and camera and adjust if required.

h. Suspend the rocket launchers, put the adaptor with bore sighting tool. If the cress mark of bore sight and mark at target do not coincide, adjust the mounts.

TASK-18

MARTIN BAKER EJECTION SEAT (MKBD 10D)

Introduction

1. The ejection seat is *a* fully automatic, cartridge operated, rocket assisted ejection seat, providing safe escape for most combinations of aircraft altitude, speed, attitude and flight path, within the envelope of zero altitude at zero speed in a substantially level attitude and at speeds up to 600 knots IAS between zero altitude and 50,000ft (15 240m).

Ejection is initiated by pulling the seat firing handle situated between the things on the front face of the seat pan and the seat is ejected through the canopy. After ejection, man/seat separation and parachute deployment are automatic. A manual separation (override) system provides for possible failure of the automatic system.

The seat is ejected by the action of gas pressure developed within a telescopic ejection gun when the cartridges are ignited. A rocket pack situated under the seat pan is fired as the ejection gun reaches the end of its stroke and sustains the thrust of the ejection gun to carry the seat to sufficient height to enable the parachute to deploy even though ejection is initiated at zero speed, zero altitude in a substantially level attitude. After ejection the seat is stabilized and forward speed retarded by a duplex drogue system followed by the automatic deployment of a man carrying parachute and separation of the occupant from the seat.

2. Warning.

a. Ejection seats are a potential Source of Lethal Injury if Inadvertently Operated.

b. Safety pins Having Red Labels or Discs and Attached to a red streamer are provided to render safe the explosive devices of the escape system whilst the aircraft is on the ground. These pins must all be removed before flight.

c. On entering the cockpit/cabin of an aircraft check to ensure that the safety precautions have been applied.

3. Data Sheet

a.	Ejection Seat	: MKBD10D
b.	Unit Delay	: 1.50s + 0.10s
c.	Barastat Nominal Setting Tolerance	: 1300 ft (11,500 to 14,500)
d.	Drogue Gun Delay	: 0.5s ±0.1s
e.	Ejection Gun Ejection Velocity	: 65 ft/s (19.8m/s) approx
f.	Rear seat of twin seat installation Thrust	: MBEU 3448RU (Coloured red) 45001bf for 0.25s

g. Seat pan actuator Duty working cycle : 1 minute in *8* minutes
2.75 in ± 0.05 in
j. Stroke Operating Voltage : (69.85mm ± 1.27mm)
28V DC

k. Harness power retraction unit Acceleration load : Locks if forward velocity of pilot exceeds 0.6m/s (2ft/s)

l. Emergency Oxygen set Max pressure : 20001 bf in^2

m. Emergency Oxygen set Max pressure : 10 minutes (approx)

n. Supply duration Ejection acceleration forces Maximum g Rate of rise :
14 to 16g approx 180-21 Og/s approx

General Description

4. General. The installation consists of three main assemblies, the ejection gun and guide rail assembly, the seat structure and the seat pan.

5. Ejection Gun and Guide Rail Assembly. The ejection gun provides the power to eject the seat. It comprises two telescopic tubes and a cylinder tube and is fitted with three cartridges, a primary cartridge percussion fired and two secondary cartridges fired by the pressure and heat from the primary. Attached to the side of the ejection gun are two guide rails, the complete assembly is secured to the aircraft structure by two mounting brackets attached to the cylinder tube.

6 Seat Structure. The seat structure consists of two main beams bridged by two cross beams. Three pairs of slippers fitted to the main beams engage in guide rails fitted to the ejection gun. The slippers guide the seat up the rails during ejection. The seat structure is locked in position on the ejection gun by a top latch assembly incorporated in the top cross beam. A powered harness retraction unit is fitted to the front of the seat structure to ensure that the occupant is pulled back to the correct posture during ejection. A rigid pack containing the man carrying parachute and drogue assembly is secured to the upper front face of the seat structure and includes a combined parachute and seat harness. A drogue gun secured to the port main beam automatically deploys the drogue assembly at the correct time after ejection. The automatic sequence for deployment of the parachute and release of the occupant from the seat is governed by a barastatic time release unit attached to the starboard main beam.

7. Seat Pan. A seat pan accommodating a personal survival pack, is attached to sliding members on the seat structure and can be adjusted for height using an electrically powered adjusting actuator controlled by a switch starboard rear of the seat pan. The telescopic tube is attached to a connection plate on the starboard side of the main beams. From the connection plate a pipe leads to a T-piece from which pipes lead to the breech unit of the power retraction unit and to the piston unit in the plunger housing at the top of the starboard main beam. Secured to the top rear of the main beams is a cross shaft. One lever on the cross shaft bears against the piston in the plunger housing and another lever is connected to the sear of the ejection gun firing unit by a link.

8. Operation. When the firing handle is pulled the sear is withdrawn from the seat firing unit and the cartridge is fired. The gas from the fired cartridge is piped to the harness power retraction unit breech to fire the cartridge and wind in the webbing straps. The gas is also piped to the piston unit to rotate the cross shaft on top of the main beams. Rotation of the cross shaft withdraws the sear from the ejection gun firing unit. The primary cartridge is fired and the seat ejected.

9. Emergency Oxygen System. The emergency oxygen system is fitted to the ejection seat to supply the occupant with oxygen for a limited period during ejection or in the event of a failure of the main oxygen supply. When ejection is initiated the supply is automatically tripped, if required at other times the supply can be operated by pulling up a manual operating handle and is sufficient to enable the aircraft to descend to a more tolerable altitude. The system comprises an emergency oxygen set, mounting brackets, supply tubing, a trip lever and operating linkages and a manual operating handle and linkage.

10. Seat Pan Actuator. The seat pan actuator is fitted to provide vertical adjustment to the seat pan in relation to the seat main beams, thereby enabling occupants of varying heights to assume the correct sitting position. The assembly consists of an electric motor and housing, a gear box, a bearing housing and a screw jack assembly all bolted together. The actuator is attached by a lug on the motor housing to the centre cross beam of the main beam structure and by a lug on the end of the extending piston to the bottom slide supporting the seat pan. Power supplies to the motor are fed from the aircraft supply via a connecting plug and placket assembly on the starboard main beam and a RAISE/OFF/LOWER switch on the starboard thigh guard. The switch is biased to the centre, OFF, position.

11. Electric Motor. The electric motor is a Mortley Sprague 28 Volt dc motor having a plit

series field and delivers a torque equivalent to approximately 0.7 hp. The motor forms the drive unit which is located at one end of the actuator. The supply voltage is controlled by the

raise/off/lower switch on the starboard side of the seat pan and by travel limiting switches within the actuator. The maximum duty cycle is 1 minute in any period of 8 minutes. A lug on the end if the motor housing accommodates a self aligning bearing through which is passed the mounting bolt attaching the actuator to the centre cross beam.

12. Personal Survival Pack (PSP). The survival pack fits in the seat pan. It is a fibre glass case topped by a cushion and serves the dual purpose of seat cushion and container for a life raft and survival equipment. The seat cushion is specially designed and shaped to give maximum support and comfort to the seated occupant. The padding although resilient, is slow to return to its original form after compression, thereby helping to absorb acceleration loads imposed during ejection. The pack is extended forward in the shape of two horns which give rigid support to the thighs on ejection. The survival pack has two side attachment straps each ending in a buckle. Through the buckles is passed a single handed release strap with an arrowhead connector at each end which mate with the quick release connectors on the parachute harness. Release of either connector allows the survival pack to fall away, the freed end of the release strap slipping through the buckles.

13. Ejection Sequence. On pulling the seat firing handle the sear is withdrawn from the firing unit in the seat pan, this action fires a cartridge, the gas from which :

a. Is piped to the harness retraction unit breech and fires the cartridge in the breech to operate the harness retraction unit which draws the occupant back to the correct posture during.

b. Ejection Passes on to the sear withdrawal piston unit at the top of the starboard main beam. A piston in the unit extends and rotates the cross shaft withdrawing the sear from the firing unit and the primary cartridge in the ejection gun is fired.

The gas pressure developed by the primary cartridge causes the inner and intermediate pistons of the ejection gun to rise releasing the top latch. The secondary cartridges are fired progressively as the rising pistons expose them to the heat and pressure of the primary cartridge gas.

14. As the seat ascends the guide rails :

a. The trip rods withdraw the sears from the drogue gun and barastatic time release unit.

b. The electrical connections are broken to disconnect the seat adjusting actuator circuit.

c. The emergency oxygen is tripped.

d. The leg restraint lines are tighten to draw back and restrain the occupant's legs. When these lines become taut the shear rivets incorporated in the lower attachments shear and the lines are freed from the floor brackets, the legs being restrained by the snubbing units.

e. The static line of the remote rocket initiator becomes taut and withdraws the sear to fire the cartridge as the ejection gun hears the end of its stroke. This fires the cartridge in the rocket pack which ignites the propellant and the rocket pack sustains the upward thrust of the ejection gun.

15. Withdrawal of the drogue gun sear allows the mechanism to function and after the delay mechanism has operated the firing pin is released and the cartridge is fired ejecting the piston. The ejected piston withdraws the closure pin securing the closure flaps of the drogue parachute pack and deploys the drogues. The drogues when fully developed stabilize and retard the seat and occupant.

16. On removal of the time release unit sear and when conditions of height are such that the barastat is no longer restraining the mechanism the unit commences to function. After the delay has elapsed the firing pin is released and the cartridge is fired. Gas from the cartridge is used to remove restraint from the scissors shackle allowing it to open and free the drogue shackle, operate the parachute mechanical lock releasing the parachute withdrawal line tie and operate the harness release system freeing the occupant from the seat. The occupant is momentarily held in the seat by the sticker straps.

17. The drogues, now freed from the scissor shackle withdraw the parachute from the pack. The parachute, when developed, lifts the occupant and survival pack from the seat pulling the sticker straps from their clips. This arrangement ensures that there is no possibility of collision between seat and occupant after separation. The emergency oxygen lanyard breaks the emergency oxygen disconnect at the lanyard connector on the seat pan.