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Integrated Test Range (ITR)

DRDO, Chandipur

Report

On

Orientation Programme

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INTRODUCTION TO ITR:

Defence Research & Development Organisation (DRDO) works under Department of Defence Research and Development of Ministry of Defence. DRDO dedicatedly working towards enhancing Defence Systems and undertakes design & development leading to production of world class weapon systems and equipment according to the qualitative requirements laid down by the military services.

Indian defence divided into 3 categories:

1. Military service (army, navy, air-force)
2. Manufacturing (HAL)
3. Quality control (**ITR**)

ITR stands for **INTIGRATED TEST RANGE.** Function of ITR is to provide instrumentation and location for the testing of missile which are manufactured indigenously by DRDO or imported from foreign countries. using the instrumentation devices data are collected during the testing. After the testing ITR provide the data to the manufacturer. And after 5 successful launches missile system is handed over to the military force.

Due to its **technical** & **geographical** availability, ITR is the only facility in the world which have the capacity to test all kind of missiles irrespective of speed, range and source-destination of missile.

ITR got a long corridor up to 5000km in the Bay of Bengal, to test the missile. as it is a long run ocean there is no threat to human lives.

Instrumentations like **RADAR, telemetry, EOTS** deployed over a long distance at the eastern coast of India. And in the island port Blair. There is also 2 down range ships to deploy target and collect data.

Along with collecting data from the launched missile, ITR also perform research to manufacture high precision indigenous instrumentation devices and improve data processing & power distribution system.

RADAR (RAdio Detection And Ranging):

Radar is a primary tracking device being used since world war II until today. Radar use electromagnetic system for tracking the missile. It sends and receive electromagnetic wave, and perform calculation to find the current range of the missile.

- Radar use 2 modes:
  - Skin mode: reflection of wave
  - Transponder mode: amplification and retransmission by missile

- EM wave is transmitted 2 types of way:
  - Pulse transmission
  - Continuous transmission

- Bands of radar:

  S-band: 2-4 GHz
  C-band: 4-8 GHz
  X-band: 8-12 GHz
  Ku-band: 12- 18 GHz
  K-band: 18-27 GHZ
  Ka-band: 27-40 GHZ

- Formula to calculate range:

  R=c.dt/2

  R= range
  C=speed of EM wave (3 x10^8 m/s)
  dt=time between transmission and receive

- RADAR is used to monitor Time Space Positional Information (TSPI).

Range instrumentation RADAR:

- Single target tracking.
- S-band radar
- Range up to 3000km (transponder mode)
- Ex: KAMA-N

Phased Array Instrumentation RADAR:

- Multi target tracking

C/X/Ka band RADAR:

- single target tracking
- less range
- more accurate

Air-borne & Ship RADAR:

- gyro stabilization is used to calibre the radar

Air defence RADAR:

- generate multiple beam and track multiple air defence targets

Super instrumentation RADAR:

- c-band
- monopulse tracking: additional encoding of radio signal

Advantages of RADAR:

1. High range detection capacity.
2. Provide position of missile to EOTS.
3. Gives accurate measurement of Range, Relative Motion, Azimuth, Elevation.
4. All weather operation.
5. Track both cooperative and non-cooperative target.
6. Simplistic reduction of data.

Disadvantages of RADAR:

1. Less precision compares to telemetry and EOTS.
2. Can't detect launch time.
3. Can't track beyond line of sight.
4. Can't track if missile is close to surface.

TELEMETRY:

Telemetry is an automated communication system which used to acquire data from the remote location which are inconvenient, inaccessible and unsafe.

In defence organisation, telemetry is used to measure the parameters of the flights and the airborne weapons(missiles) to the base station.

Telemetry is vital in the development of missiles, satellites and aircraft because the system might be destroyed during or after the test. Engineers need critical system parameters to analyse the performance of the system. In the absence of telemetry, this data would often be unavailable.

Parameters observed by telemetry are:
Propulsion: combustion chamber status, oxidiser, air bottle pressure
Structure: vibration, temperature, strain
Navigation: velocity, acceleration, range
Control: actuator command, feedback signal
Electrical: battery voltage, relay status, flight termination system

TRACKING (by ANTENNA)

To keep track of the missile, telemetry system emits signals to the base via blade antenna (which help in both flight and data transmission). And at the base we use parabolic antenna to receive the message sent by the missile.

Diameter of the antenna varies from 1m to 11m. we can't use same antenna for all purpose. Because Beam width INVERSELY proportional to the antenna diameter. So, if diameter of the antenna is high then beam width is small; and so, to track a missile flying close to antenna, antenna has to move fast to track the missile, which will be difficult because of its large size. Large antenna is not suitable for high speed missile like BRAHMOS.

Range is DIRECTLY proportional to the antenna diameter. greater the diameter greater is the range up to which it can track. Large antenna is suitable for tracking long range missile like AGNI.

TELEMETRY SYSTEM:

SENSORS → AIRBORNE SEGMENT → GROUND SEGMENT → CENTRAL COMPUTER

AIRBORNE SEGMENT:

SENSORS → ANALOG MUTIPLEXER →
PCM FORMATER → PISO → TRANSMITTER
TIME, DIGITAL DATA → DIGITAL MULTIPLEXER →

GROUND SEGMENT:

ANTENNA → LOW-NOISE AMPLIFIER → TELEMETRY RECEIVER → BIT & FRAME SYNCRONIZER→ DECOMMUTATOR

MULTIPLEXING:

As there are multiple sensors, so to send data of all the sensors multiplexing is used. Single channel is used to transmit values from all sensors; to do this, time-division multiplexing and frequency multiplexing is used.

MODULATION:

For time-division multiplexing (TDM) pulse-code modulation (PCM)is used. And its preferred to use bi-phase digital modulation. e.g. BIΦ-M, BIΦ-S etc.

For more accurate data frequency modulation is used.

COMMUTATION:

1.super commutation: take multiple data from one sensor. E.g. vibration info.
2.sub commutation: one position over time has multiple meaning. A multiplex generated at a slower rate than of a frame.

TRANSMISSION:

Omni-directional antennas are used in missile to radiate equal power in all direction, to get data irrespective of orientation.
Linear polarised antenna is used in missile system.

Advantages:

1. Gives total health status of missile
2. Can provide data even the speed of missile is very high.
3. Can provide data beyond line of sight.
4. More precise compare to radar.

Disadvantages:

1. less range comparatively to radar.
2. Can't track non-cooperative target.

Electro Optical Targeting System (EOTS):

Out of all the instrumentation device EOTS is the most accurate one. As it provides the visual image, unlike RADAR which provides only calculated positional display. EOTS is more reliable.

With the precision 0f **10 arc sec** (0.001^{o}) in azimuth and elevation its data are also more precise. Drawback of EOTS is it can only see in the line of sight up to 400km. so its get complicated to track a missile with higher range.

Tracking strategies:

1. From GPS or RADAR collect the current position of the missile.
   (for more precision we use **differential GPS**)
2. By manually adjusting bring the image of missile in to the frame.
3. Next steps happen automatically according to the algorithm.
   - remove noise
   - binarize the pixels of the frame
   - calculate change between frames
   - adjust azimuth and elevation accordingly.

Even though ITR use EOTS for instrumentation of missile path and location, its also used **in UAVs** to get the visual feedback about the enemies and do attack accordingly.

- ITR also implement EOTS in UAVs to get the data for high range missiles to overcome the limitations of it.

To track high range missiles via EOTS,

- ITR has placed multiple EOTSs across the eastern coast of India.
- Each EOTS gets the current location of missile from radar and differential GPS.
- If the missile is in the range, it tracks the missile.
- If it gets out of range, control transfers to the next closest EOTS.
- With appropriate software data blackout is avoided during control switching from one EOTS to another.

Advantages of EOTS:

1. Most accurate compare to telemetry and radar.
2. Better visual output.
3. Auto target focusing.
4. EOTS can be mobile.

Disadvantages of EOTS:

1. Need manual adjustment for airborne targets.
2. Less range compare to telemetry and radar.
3. Can’t see beyond line of sight

MISSILES:

during the early ages of war **rockets** has been used to hit the enemies at the distance. but its drawback was, it was not sure where the rocket will hit. Sometime the rockets also hits the allies force. To overcome this Nazis created **missiles**. Its specialty was it can be guided to the target.

Types of missiles on the basis of,

1. **TRAJECTORY**
   - Ballistic
   - Cruise
2. **RANGE**
   - Short (up to 400km) e.g. PRITHVI
   - Medium (up to 1000km) e.g. NIRBHAY
   - Intermediate (up to 5000km) e.g. AGNI V
   - Intercontinental (up to 10000km) e.g. MINUTEMAN
3. **LAUNCH PLATFORM AND TARGET**
   - Surface to Surface e.g. PRITHVI
   - Surface to Air e.g. AKASH
   - Air to Air e.g. ASTRA
   - Anti-tank guided missile e.g. NAG, JAVLIN
4. **SPEED**
   - Subsonic e.g. PRITHVI, TOMAHAWK
   - Supersonic e.g. BRAHMOS, MOSKIT

COMPONENTS OF MISSILE:

- Air frame
- Propulsion
  - Air breath
    - ✓ Turbo jet (air supplied to jet engine)
    - ✓ Ramjet (automatic air compression) {**minimum speed 2.5 Mach}**
    - ✓ Pulse jet
- Fuel
  - solid
  - liquid
- Navigation & guidance system
- Flight control system
  - Wings, fins, canards
- Warhead
  - Blast (shockwaves)
  - Fragments (high speed metal fragments)

even though there are many test ranges all around the world, out of them only **ITR** is the only test range which have the facilities to test all types of missile.

TARGET SYSTEM:

As the missiles are going to be used by Indian military force, missiles need to be reliable. Along with the Range we also need the missiles to be PRECISE. To collect the information about the precision we have to test the missile with a Target.

We can face attack from all three direction.

1. AERIAL
2. LAND
3. SEA

As we are talking about missiles in ITR, we only deal with sea surface targets.

- **AERIAL TARGET:**

  Aerial targets are of 2 type:

  1. Ballistic
  2. Sea skimming (test cruise missile)

  Chasing of aerial target is of 2 type:

  1. Head on (missile defence)
  2. Tail chasing (chasing enemy fighter plane)

  After the target **takes off**, the UAV **climb** to a certain height and **loiters**. Control of the target may be **automatic** or **remote control.**

- **SEA SURFACE & LAND TARGET:**

  Sea surface and land targets are of 2 type:

  1. Stationary
  2. Moving

  To tackle the moving targets ,missiles use **IR** and **RF.**

TARGET SYSTEM TYPES:

Basis of	Types
USAGE	Expendable, Reusable
SPEED	Subsonic, supersonic, hypersonic
ALTITUDE	Sea skimming, high
FLIGHT CONTROL	Automatic, remote control
LAUNCH	Stationary, thrust
LAUNCHER	RATO, Catapult
RECOVERY	Parachute

- To simulate a real big warhead/aircraft, payloads are added to the head of the drone, which give same result as the real missile/fighter in RADAR.

CAN & DATA CENTER:

As ITR is one of the most classified places in India; so to avoid falling of the research and test data in the wrong hands DATA CENTER division created an private Local Area Network which is not connected to the internet. And this network is used to relay information among the divisions, groups, departments, launch complexes and observation bases. And this explicit LAN is termed as Campus Area Network (CAN).

OBJECTIVE of CAN:

Its to incorporate office automation for administration & logistics aiming towards a paperless environment.

DRDO Rapid Online Network Access (DRONA) is also an intranet connecting all the facilities of DRDO, which can be accessed by the DRDO officers 24 x 7.

Campus Area Network (CAN)

hardware	software
1.blade server 2.storage 3.switches & routers 4.tape library 5.optical fibre (10 gb) 6.SAN/NAS switch	1.exchange mail 2.lync server 3.symente backup(automatic) 4.everest NMS 5.Oracle 11g 6.in-house developed application software

Facilities provided by CAN in ITR:
1. Employee info. Management
2. finance management
3. archive management
4. e- mail service
5. chatting
6. IMMG system
7. online video lecture

DATA CENTER is a facility composed of networked computers and storage devices, where large amount of data is stored, processed, organized and disseminated.

3 parts of data center:

Network equipment: provide & maintain network
Storage: store data
Server: responding according to the request

POWER SYSTEM:

the work of power system division is to provide **clean, reliable, uninterrupted, regular, quality power** to the different systems at ITR.

Peoples of power systems perform research on,

- Maximum power output
- Uninterrupted steady power supply
- Tackle sudden surge of current
- Establish backup power system
- Development of power system

At ITR, there is a centralized power system, which helps in easy management and monitoring of power supply.

During missile testing, instead of using main power line DGs are used; its to assure uninterrupted continuous power supply during the data collection.

OBJECTIVE OF POWER SYSTEM DIVISION:

- Generation of electric power
- Optimal distribution of electric power
- Monitoring of electric power supply

POWER SUPPLIES:

- Main line
- DG (diesel Generator)
- UPS (Uninterruptible Power Supply)
- Battery

PROTECTION DEVICES:

- MCB (Miniature circuit breaker)
- MCCB (Module case circuit breaker)
- ELCB (earth leakage circuit breaker)
- SPD (surge protection devices)

LIGHTNING PROTECTION:

- Franklin rod
- Mesh type
- Catenary type

TYPE OF EARTHING:

- Pipe
- Plate
- Chemical

To increase the earth conductivity, ionic compounds are used along side the earthing plate or rod.

MISSION CORDINATION & MANAGEMENT:

A single missile test project includes more than 10 divisions team which are specialized in their own field. To complete a project, we need all the teams to work together with a proper coordination. For that purpose, there is a Mission coordination team which coordinate the jobs of different team to complete the project.

There is many **pre-mission, on-mission, post-mission** activities carried out by MCD (mission coordination division).

PRE-MISSION ACTIVITY:

- Interact with project people.
- Check feasibility
- Mission sequence
- Allotment of range (issue of NOTAM & date of JCC)
- Receipt of project
    - ✓ Flight test plan
    - ✓ Trajectory
    - ✓ Instrumentation distribution
    - ✓ Flight simulation report
    - ✓ Helicopter sortie

ON-MISSION ACTIVITIES:

- Phase III check (units check)
- phase IV check (electrical check)
- phase V check (compatibility check with launch pad)
- prepare RIC (range integration check) and countdown document
- conduct RIC

POST-MISSION ACTIVITIES:

- collect data from all the divisions
- handover the data to the customer

most important job of MCD is **information control.** as things don't happens as we wish, MCD have to transfer the data to other division carefully to avoid misunderstanding or miscoordination.

MISSION CONTROL CENTER:

The mission control center is a facility that manages missile test operations from launch to landing, or to the end of mission. A staff of flight controllers and support technical personnel located at the control center monitor all mission activities using telemetry, and send commands to the missile as necessary. Ensuring safety of public and of those onboard is the top task of a mission control center, but launch safety is usually dealt with by dedicated control centers because public safety is a concern also for the missile without warhead missions. Because the propellant of the missile is enough to do the damage to human life.

Each flight controller is a subject matter expert in his or her system and makes recommendations about the system to the flight director. A flight controller may recommend to terminate or abort a flight, or to take corrective actions in case of anomaly.

COMMUNICATION SYSTEM:

In ITR, communication system division look over the communication between missile & instrumentation device, network communication and data instrumentation data transfer.

Communication division divided in to 3 groups,

- satellite communication group
- network group
- RF (radio frequency) group

Network group works along side data center division to achieve flawless data transfer among the divisions and bases.

ITR communication system division works alongside RADAR, telemetry, EOTS, telecommand, data processing and flight safety divisions.

- They help in establish and maintain strong wireless connection between missile and the antenna.
- Communicate with multiple target at same time
- Clock synchronization among bases and instrumentation.
- Tackle real time traffic
- Dynamic network configuration (depend on mission requirements)

Environmental Safety

Environmental safety is the practice of policies and procedures that ensure that a surrounding environment, including work areas, laboratories or facilities, is free of dangers that could cause harm to a person working in those areas. A safe place to work is the key element of environmental safety.

Enhanced Safety, Health and Environment Outcomes through Improved safety, health and environment outcomes through better design are about eliminating or minimizing risks in the preliminary planning stages of a product. Better design provides a foundation for improved outcomes in the development, use and maintenance of a product like plant and equipment or a building. Improved outcomes in design require the many stakeholders who contribute to the design process to critically review its safety, health and environment implications. Therefore, the client, or end user, must be actively involved in the review to ensure that operational requirements and maintenance issues, intrinsically known to the client, are considered by other design stakeholders. For example, safety, health and environment implications inherent in the design of a building project may exist in its construction, use, maintenance and demolition, i.e. its complete lifecycle. Similar implications exist for the design of other products such as plant or equipment, e.g. its manufacture through to decommissioning.

In ITR,

- Most of the part of the campus is decorated with natural flora and fauna.
- To avoid pollution, electric autorickshaw is used for transportation.
- Annually tree plantation program take place by the employees