Futuristic Technologies for Defence through DIA-CoEs

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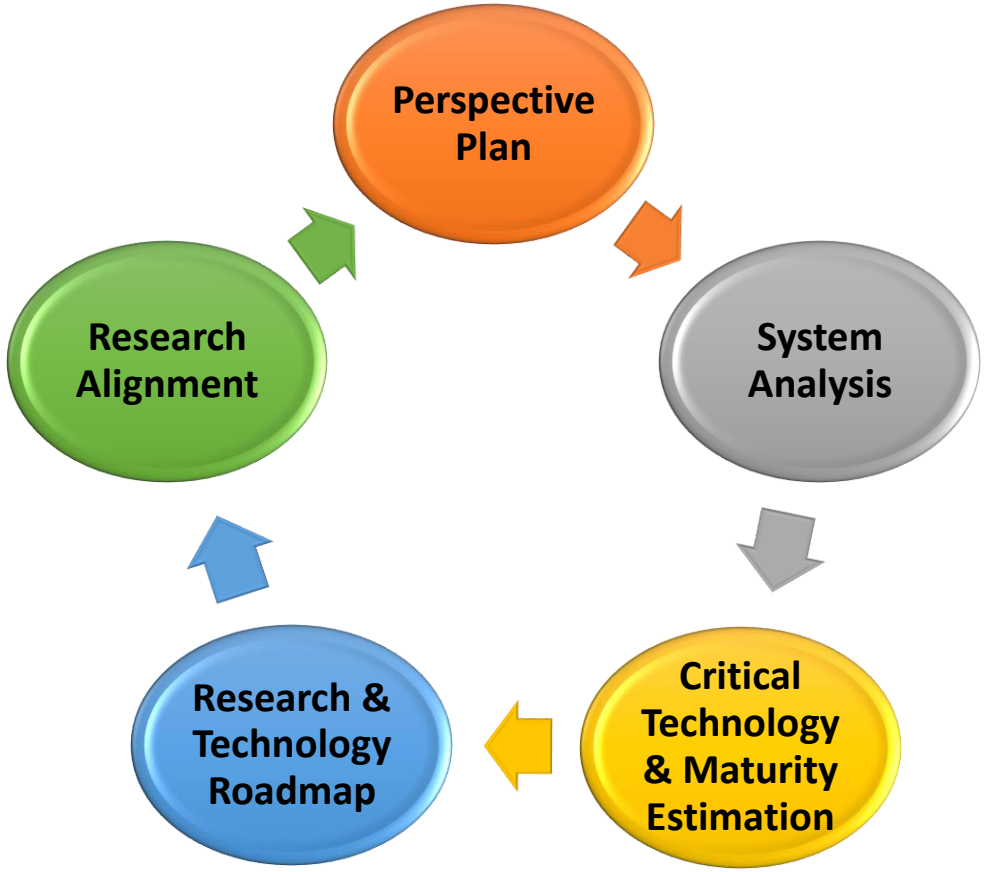
Presentation Outline

- Introduction
- About DFTM
- Long Term Directed Research
- DRDO Industry Academia – Centre of Excellence (DIA-COEs)
- Strategy, Planning and Execution of Directed Research through DIA-CoEs
- Engagement of Industries through DIA-CoEs
- Engagement of NRIs with DIA-COEs
- Technologies developed at DIA-COEs

About DFTM

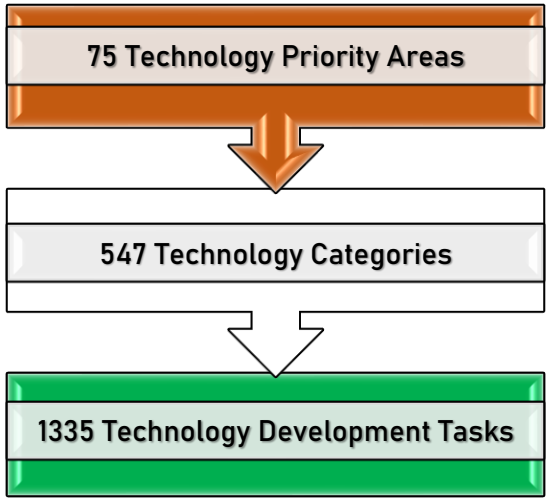
- Act as ‘Think Tank’ and render advice in **forecasting of futuristic weapon system and technologies**.
- Evolve a **System Analysis Policy** and ensure its implementation in DRDO.
- Analysis of **Services requirements** for systems to be imported / acquired / integrated and arrive at acceptable final QRs
- **Identify crucial technologies / technology gaps** with maturity level less than 4.
- Work on broad specifications for the work packages related to identified technologies / technology gaps for the purpose of focused and directed R&D
- Enter into **contract with identified agencies / consortium** and coordinate with them for achieving the desired objective
- Identify and **establish national level facilities**.
- **Coordinate with other scientific organizations** for resources at national level.



DRDO Technology Foresight

A Precursor to S&T Roadmap of DRDO

- Document released in 2023 and revised in 2024
- Document consists of Lab's current and futuristic Technology tasks
- Technology tasks classification with respect to 75 technology areas and 547 sub-areas

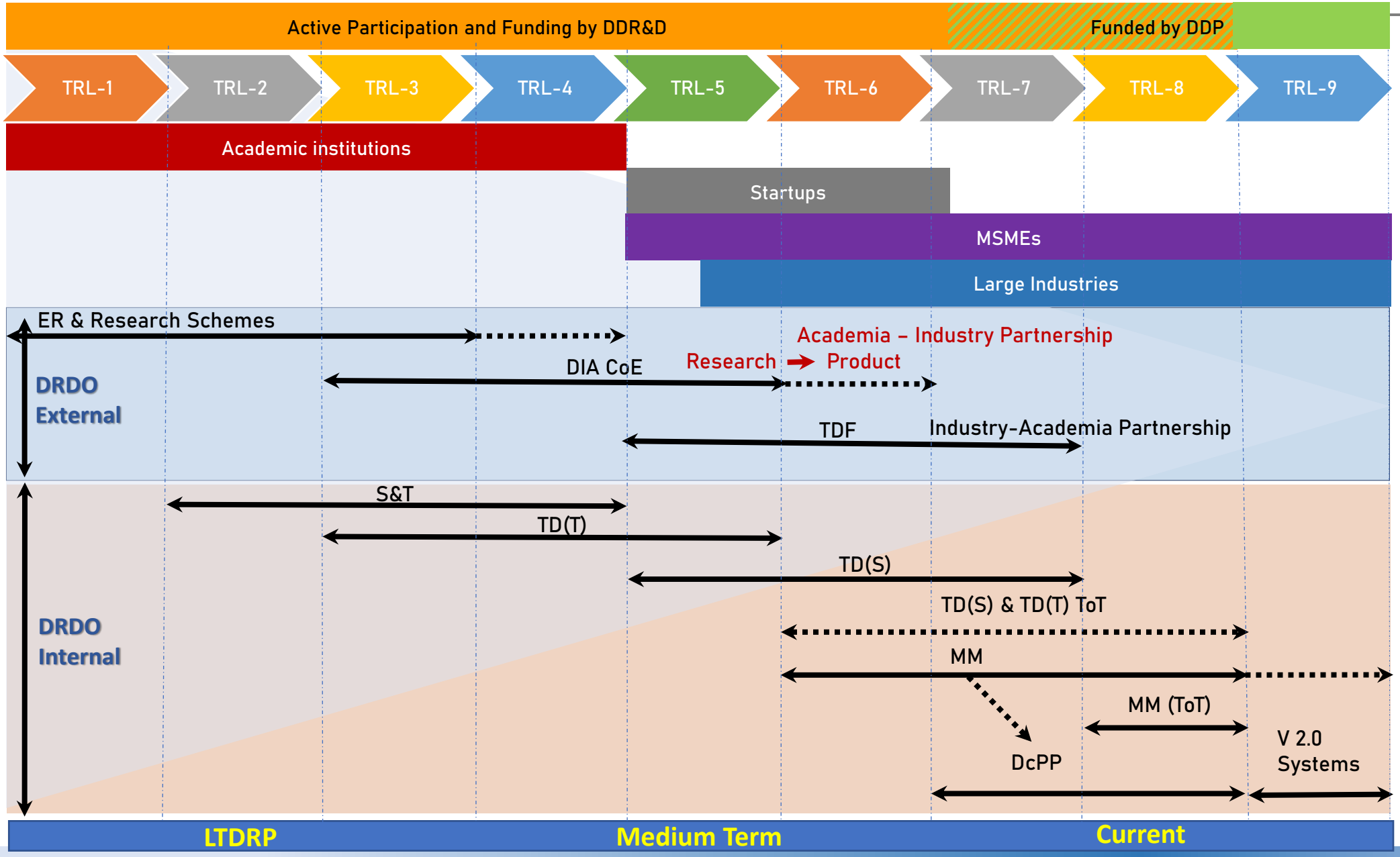


Additive Manufacturing	Camouflage Technology	Embedded Systems	Mines & Mines Detection	Seeker
Aero Structures	CBRN Defence	Energy	Missile Systems	Sensors/Detectors
Aerodynamics	Communication	Environment Protection	Multi-Barrel Rockets	Soldier Support
Aeromechanical Systems	Control Systems	Environmental Testing	Munition/Ammunition	Sonar
Agro Technology for Military Support in High Altitude Areas	Counter Swarm Technology	Fire Fighting	Natural Hazard Management	Space Situational Awareness
AI/ML Technology	Cyber, Information & Communication Security	Guidance & Navigation	Non Destructive Evaluation	Space Technologies
Alternative Power Plant	Decoys	Guided Artillery	Ocean Profiling	Surveillance and Tracking
Antennas	Detonics & Mechanisms	Gun Technology	Parachute Technology	Swarm Technology
Armoured & Combat Vehicles	Diesel Engine	Hardware In Loop Simulation	Passive Countermeasures	Terahertz
Autonomous Systems and Robotics	Directed Energy	High Performance Computing	Propulsion Technologies	UAV
Behavioural Analysis for Soldiers	Electric Power Technology	Hydro Structures	Protective Clothing & Gears	UGV
Bio Defence	Electro Optics	Hypersonic Technologies	Quantum Technologies	Underwater Defence Technologies
Bio Remediation	Electronic Devices	Life Support	Radar	Wargaming
Biomedical Engineering & Technologies	Electronic Warfare	Materials	Radome	Warhead/Explosive & Ballistic Protection
C4ISR	EM Rail Gun	Military Food Technology	Respiratory Management	Waste Management

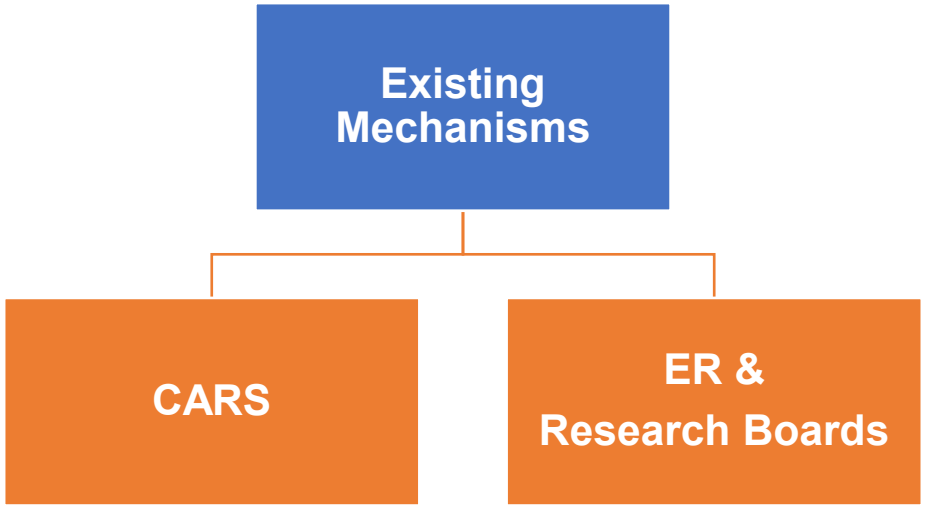
Breakdown of Systems into Technology

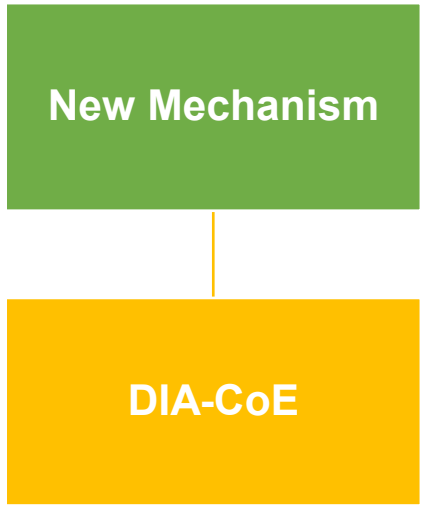
- 75 Technology Areas covering a wide range of defense-related domains, including aerospace, electronics, materials, naval systems, cyber security, and more
- Breakdown of Technology Areas into 547 Technology Categories
- Spread of 1335 Technology Development Tasks
- The prioritization Defence technologies enable focused R&D efforts to enhance India's defense capabilities
- Though technology may be applicable to multiple defence domains, an attempt is made to group them in various domains

Technology Growth Through DRDO Industry Academia



Existing Mechanism to boost Defence R&D in Academia





Current Project requirements

Research support to Projects

Bottom-up approach

Low TRLs

Top-Down approach

Long Term Directed Research

Ease of Doing Research:

(1) **Simplification of the process** for sanction & execution

(2) **Shortening the time** for sanction

(3) **Engaging Student** as Summer Interns

Long Term Directed Research through DIA-CoEs

Long Term Directed Research

Anchor: Directorate of Futuristic Technology Management

Long term directed research is planned with perspective of futuristic defence applications and outcomes useful to future programs

Enabling multi-disciplinary and multi-institutional directed research through collaborative framework by engaging academic / scientific institutions and startups/industries.

Features	
	Technological Thrust through Academic Pursuits
	Strong Stake-holding of Research Initiatives
	Explicit & Tacit Knowledge Management
	Accelerated Research & Technology Development

Triple Helix Structure – DRDO Industry Academia

Execution of the LTRDP through DIA-CoEs

A framework for long-term collaborative multi-institutional and multi-disciplinary directed research through DRDO Industry Academia-Centre of Excellences (DIA-CoE) within an academic institute.

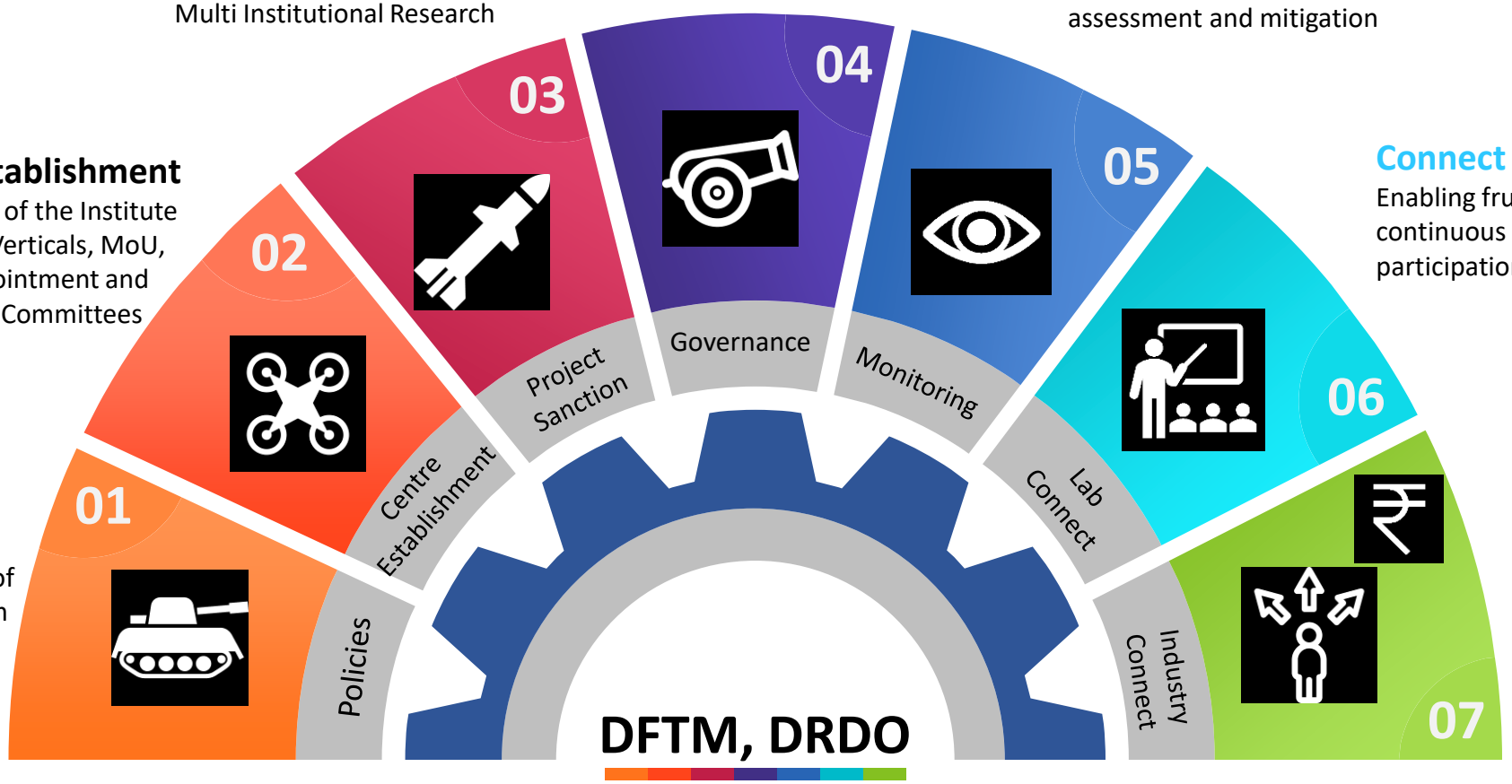
Governance Mechanism
Three stage governance mechanism for the Review of Project Execution and Centre Performance

Sanction Process
Call for Problem Statements, Review Mechanism and Sanctioning Procedure for Multi Institutional Research

Monitoring Execution
Project progress monitoring and continuous risk assessment and mitigation

Centre Establishment
Identification of the Institute and Related Verticals, MoU, Director Appointment and Formation of Committees

Connect with Labs
Enabling fruitful and continuous interaction and participation of related labs



Policies Revision
Reviewing the efficacy of policy and revising them for better outcomes

Industry Enablement
For converting the research into useful product enabling the industry association

Role of stake holders

Role of DRDO

- Participation in research work by Scientist
- Fund projects for directed basic and applied research
- Extend test and evaluation facilities in support

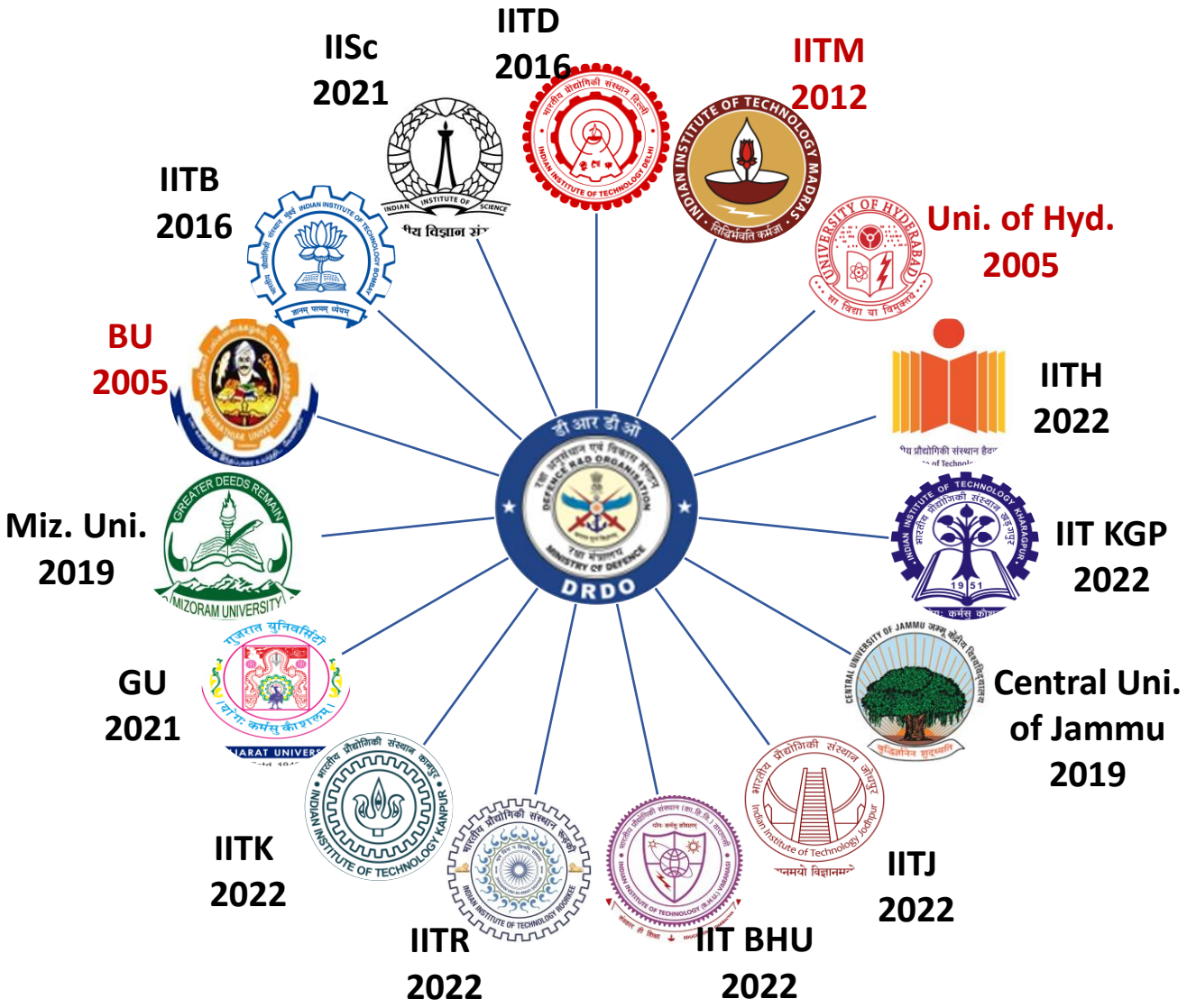
Role of Academia

- Develop core competence
- Skill development and generating scientific and technological trained manpower
- Enable faculty and researchers to participate in multi-institute research

Role of Industry

- Joint Research & Development
- Engagement for enhancing Technology Maturation & Prototype /Product Development
- Trained Human Resource Development

DFTM Engagements



- No. of Research Verticals : **82**
- Projects Awarded : **345**
- Funding (Rs in Cr.) : **1274**
- DRDO Labs Engaged : **48**
- Institutes Engaged : **65**
- Faculty Engaged : **535**
- Researchers Engaged : **1200**
- DRDO Scientists Engaged : **366**

82 Research Verticals in DIA-CoEs

IIT Delhi
1. Advanced Ballistics and Protection Technologies (ABSSP)
2. Advanced Electromagnetic for Terahertz and Millimeter Wave Technologies (ETMWT)
3. Brain Computer Interface and Brain Machine Intelligence (BCIAMI)
4. Bio Mechanical Devices (BMD)
5. Photonics Technologies and Specialty Optics for Laser Applications (PTSOLA)
6. Quantum Communication (QCOMM)
7. High Speed Imaging and Devices (HSID)
8. Smart and Intelligent Textile Technologies (SITT)

IISc Bangalore
1. Aerospace Systems Design and Characterization (ASDC)
2. Aerospace Structural Materials (ASM)
3. Advanced Unmanned Aerial Vehicle (AUAV)
4. High Temperature Materials for Aero Engines (HTM)
5. Lifing and Remaining Life Assessment of Materials (LRLAM)
6. Micro and Nano Systems Science and Technology (MNSST)
7. Artificial Intelligence and Autonomous Systems (AIAS)
8. Quantum Phenomena and Device Technology (QT)
9. Strategic Technology Studies (STS)

Mizoram University
1. Agro-Bio Resources for Soldier Survival (ABRSS)
2. Defence Waste Management (DWM)
3. Harnessing Environment for Soldier Survival (HESS)
4. Human Cognition Studies under Extreme Environmental and Combat Stress (HCS)

IIT Roorkee
1. Smart Infrastructure and Hardened Structures for Defence Applications (SIHS)
2. Energy Storage Device (ESD)
3. Landslide, Snow and Avalanche Studies (LSAS)
4. Laser Technology for Ranging and Detection (LTRD)
5. Shock and Detonics (SD)
6. Thermal Management (TM)
7. Emerging RF Technologies for Application in Defence Communications (RFT)
8. Advanced Electro Optic Technologies (EOT)

IIT Kanpur
1. Flexible Electronics and Substrates (FES)
2. Sensing, Stealth and Surface Protection Using Nano Materials and Meta Materials (SSSP)
3. Accelerated Material Design and Development (AMDD)
4. High Energy Systems (HES)
5. Bio- Engineering and CBRNE Applications (CBRNE)
6. Software Defined Radio and Military Communication Technologies (SDRMC)

IIT Bombay
1. Aero Engines: Small Turbo Fan Engine & Large Aero Engine (AE)
2. Solid Propulsion Technologies (SPT)
3. Advanced Aircraft Structures (AAS)
4. Hypersonic Propulsion (HYP)
5. Advanced Conventional Manufacturing Technology for Aero Engine Applications (ACMT)
6. Advanced Propulsion Technologies for Defence Applications (APT)
7. Compound Semiconductor Technologies (CSCT)

IIT Jodhpur
1. Applications of Advanced Technologies for Desert Warfare(ATDW)
2. Futuristic Omni Mobility Drones (OMD)
3. AI For Information Warfare and War Gaming Technologies (AIWG)

IIT Kharagpur
1. Advanced Extractive Metallurgy and Metal Recycling Technologies (AEMMRT)
2. Advanced Surface Engineering Technologies (ASST)
3. Unmanned Underwater Robotic Sensors and Actuators (UURSA)
4. Cognitive Technologies and Cyber Physical Defence Systems (CTCPDS)
5. Quality, Reliability and Safety Studies (QRSS)
6. Cryptography & Information Security (CIS)

SVPCoE Gujrat University
1. Application Vulnerability Analysis (AVA)
2. IoT Security (IoTS)
3. Malware Analysis (MA)
4. Blockchain and Web Forensics (BWF)
5. Big Data Analytics (BDA)

IIT Madras
1. Power Electronics and its Thermal Management (PETM)
2. Hydro-Dynamics, Control and Acoustics (HDCA)
3. Advanced Combat Vehicle Technologies (ACVT)
4. High Power CW Laser Technology (> 10kW) (HPLT)
5. Advanced Rare Earth Materials (AREM)

University of Hyderabad
1. High Energy Materials (HEM)
2. Technologies for Handling Explosives (THEX)
3. High Power Pulsed Laser Technology: Nano Second, Pico Second and Femto Second (HPPLT)

IIT Hyderabad
1. Ultra- High Temperature Materials for Hypersonic Applications (UHTM)
2. Artificial Intelligence for Missile and Missile Defence (AIMMD)
3. Space Systems for Defence (SSD)
4. Adaptive Imaging and Image Processing (AIIP)
5. Nano-Ornithopter Technologies (NOTT)
6. Seeker and Homing Technologies (SHT)
7. Additive Manufacturing (AM)
8. Laser Beam Combining based Communication, Power Transmission and Manufacturing (LBC)
9. Extraction, Recycling and Sustainability of Materials (ERSM)

Bharathair University
1. Biosensors and Counter Measure Evaluations (BSCM)
2. Environmental Toxicity Management (ETM)
3. Respiratory Support for Extreme Environment (RSEE)
4. Natural Polymers and Fibres for Defence Application (NPF)

IIT BHU
1. Powder Metallurgy (PM)
2. Ceramics (CER)
3. Functional Materials (FMAT)
4. High Power Micro Wave Sources and Devices (HPMW)

Central University of Jammu
1. Computational System Security (CSS)

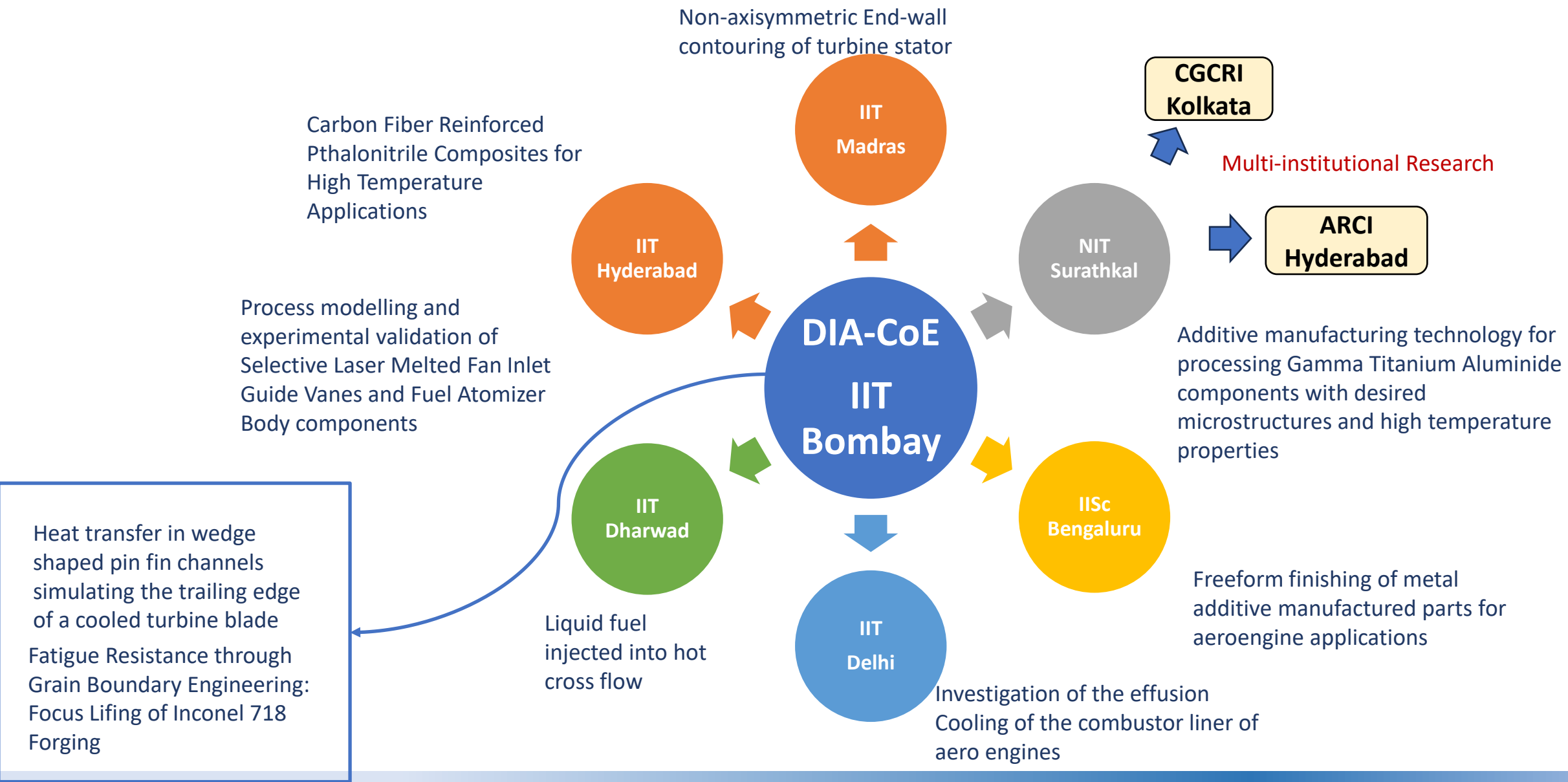
Hub and Spoke Model

- DRDO-Industry-Academia Centres of Excellence for research coordination at Fifteen Academic Institutes

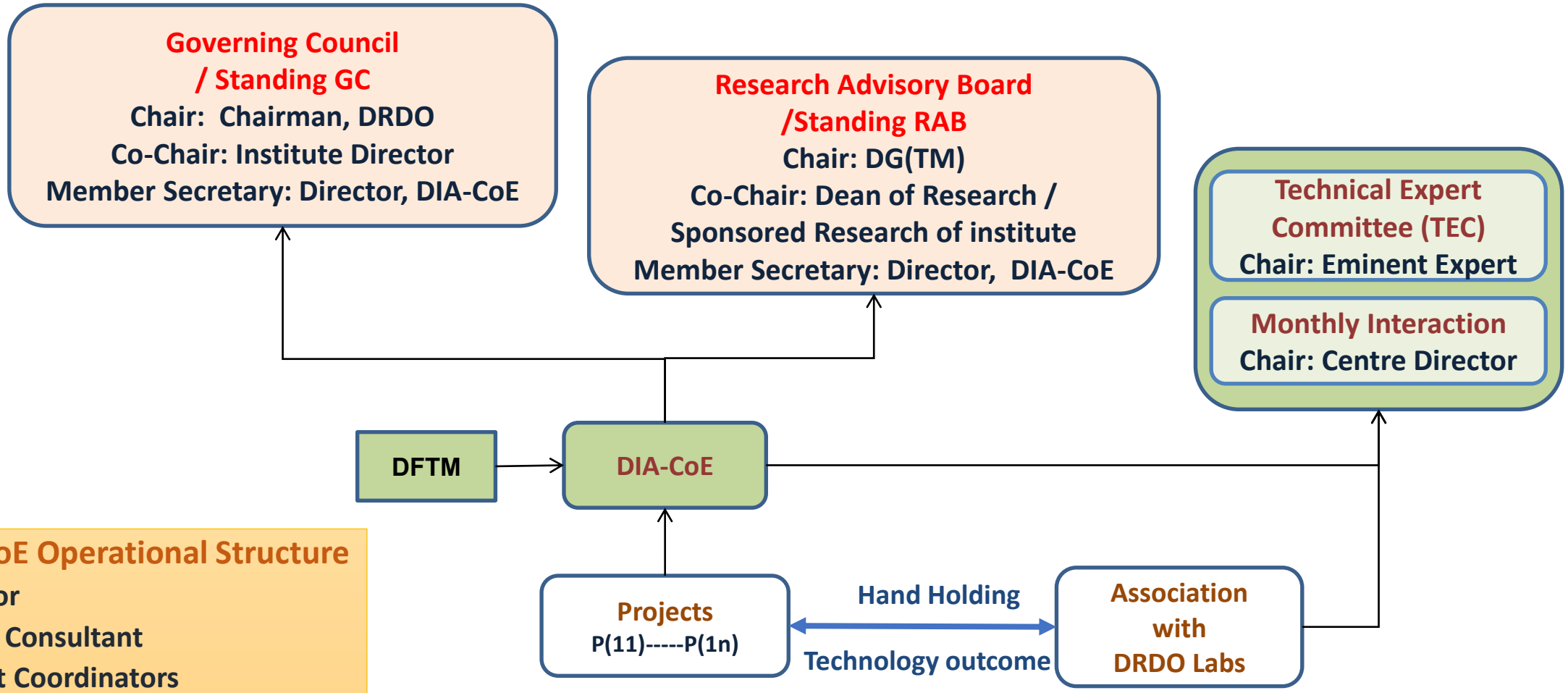
- Hub and Spoke Model - Centralized coordination of resources and roadmaps of a technical vertical at a hub, which extends projects and collaborations in the technical domain to various other institutions or entities as spokes.

- Multi-Institute Engagement - Co-PIs from Other Institutes: The model encourages collaboration among multiple institutions. This can enhance the diversity of expertise and resources, leading to more comprehensive research outcomes. Co-Principal Investigators (Co-PIs) from different institutes can collaborate to promote interdisciplinary research.
    - Separate Funding for Each Co-PI: Each participating institute or spoke receives its funding, which helps ensure that all partners have the necessary resources to contribute effectively to the project.

Ex: Hub and Spoke for Aero Engine Technologies



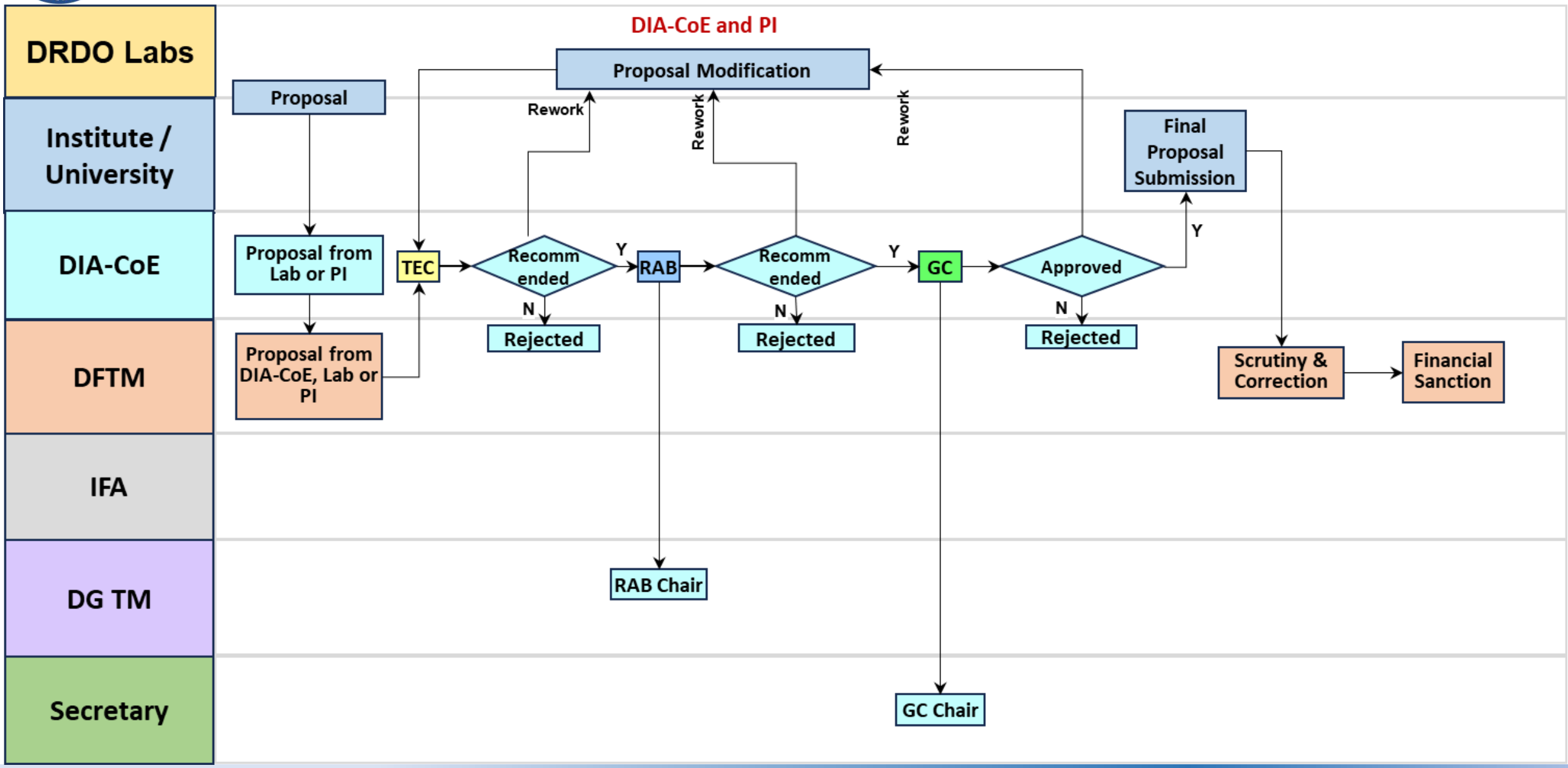
Governance & Review Mechanism



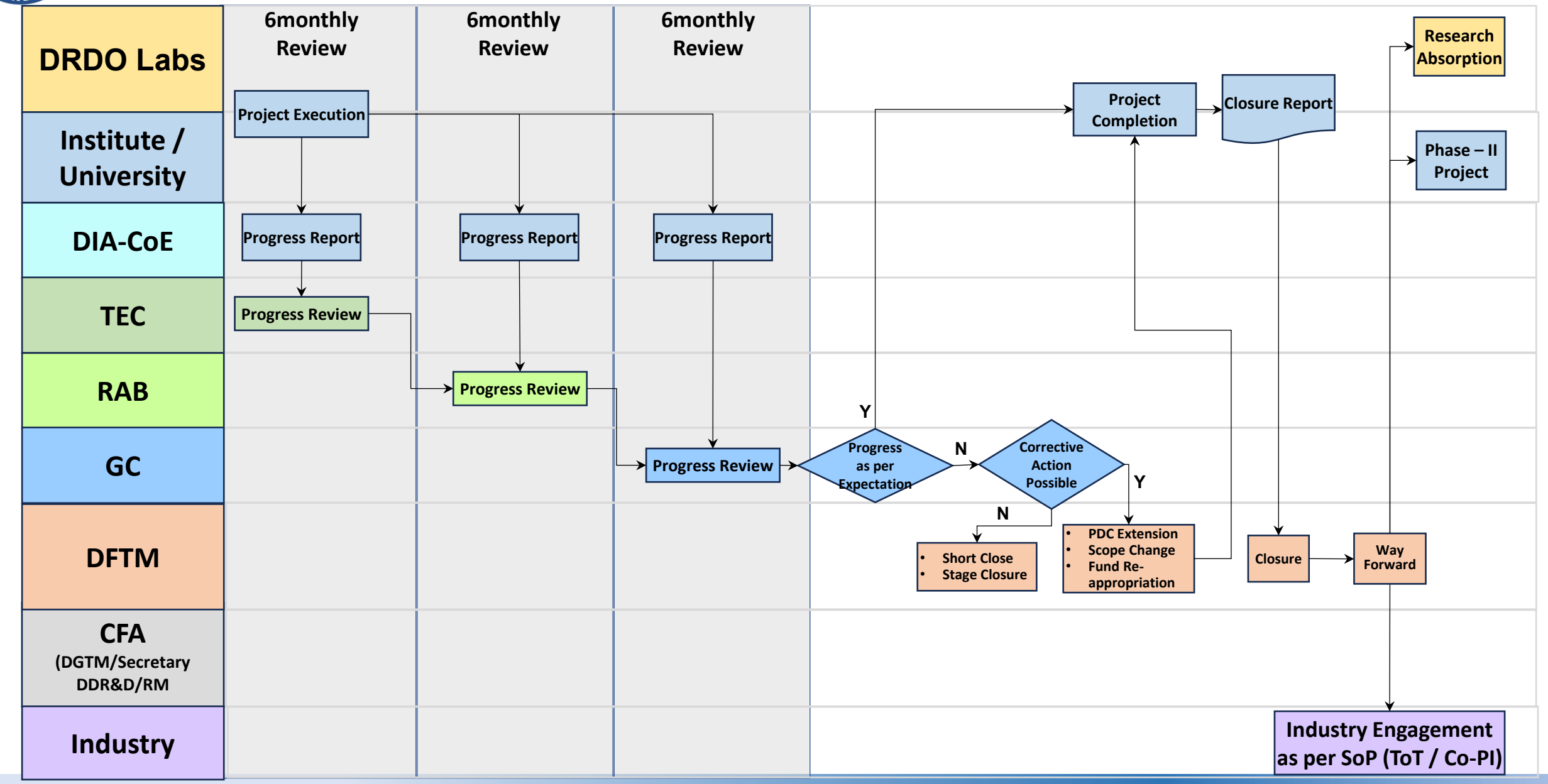
DIA-CoE Operational Structure

- Director
- Senior Consultant
- Project Coordinators
- Administrative / Technical Officer
- Accounts Officer
- Support Staff

Project Planning and Formulation Process



Project Progress Review & Way Forward



Monitoring Technology Progress – Figures of Merit

A. "Figure of Merit"- Project investigators must mention the Figures of Merit relevant to Aims/Objectives/Targeted Areas of project Proposal.

B. "Methodology"- Project investigators must state the protocols and methodologies for measurement to be carried out for the Figure of Merit.

C. Figure of Merit (FoM) values to be recorded at start, at reviews and at conclusion of the project.

Property	Parameter	Targeted Value	International Value	Measurement Methodology
Weight of Hybrid Cooling Vest (PCM + Battery)	Weight	3.5±0.3 kg	Leight weight models: 0.45 kg to 0.9 kg Mid-range models: 0.9 kg to 1.8 kg Heavier models: 1.8 kg to 2.7 kg	Weighting balance
Performance of the engine	Thrust-to-weight ratio	1.0 to 1.1	1.2	In flight measurement

Financial Framework of Proposal

1. Pay and Allowance
    i. Students Internship and Hackathon
2. Equipment and Spares
3. Operation and Maintenance
4. Expendables
5. Prototype or Hardware Engineering model construction
6. Lab Infrastructure Upgrade
7. Workshop
8. Travel
9. Contingency
10. Visiting Faculty or Research Consultants
11. Procured Services and Metered Utilities
12. Institutional Overhead

Way Forward

i. **Research Translation and Absorption by Stakeholding DRDO Lab:** The stakeholding DRDO lab is responsible for implementing or utilizing the outcomes of the project in their current and future programs. The PI, in collaboration with DIA-CoE/RC, will provide the necessary support and guidance to facilitate the implementation process.

ii. **Follow-up Research:** Following the closure of a project, further research may be conducted to increase the technology readiness and absorption level, in accordance with the procedures described in this document. Follow-on projects will adhere to the same approval procedures as new projects.

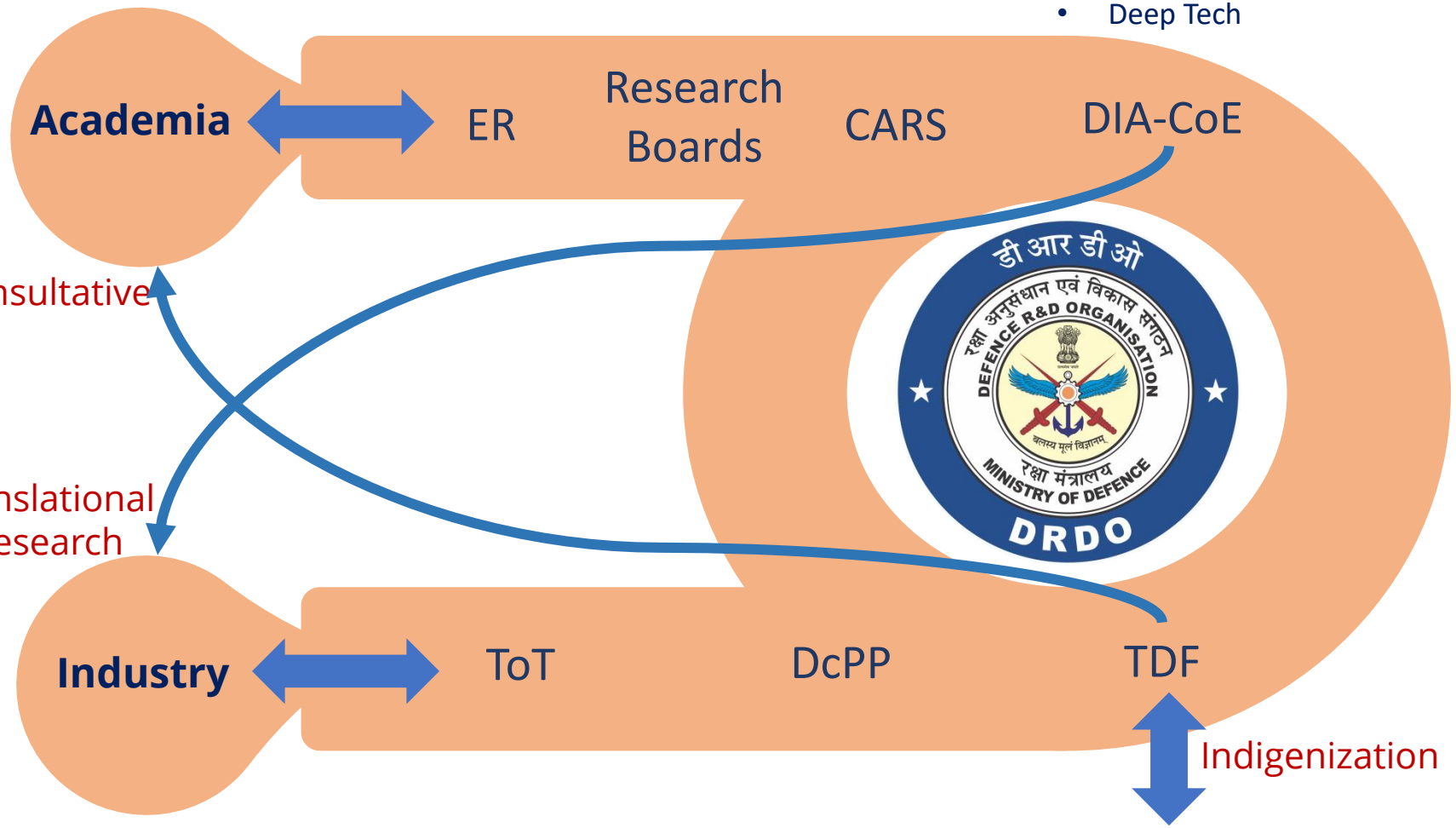
iii. **Industry engagement:** Industry/ Startup/MSME can be engaged as Co-PI for enhancement of existing technology readiness level or Transfer of Technology to industry for further utilization/ new product development.

Industry Engagement Through DIA-CoEs

Bridging Academia and Industry

Scientific and Experimental

- Advanced Technology Requirements of DRDO
- Upstream and Downstream Developments
- Deep Tech



Business Development and Investment in Production

- Armed Forces Requirements
- DPSUs
- DRDO Requirements

Technology R&D and Industry

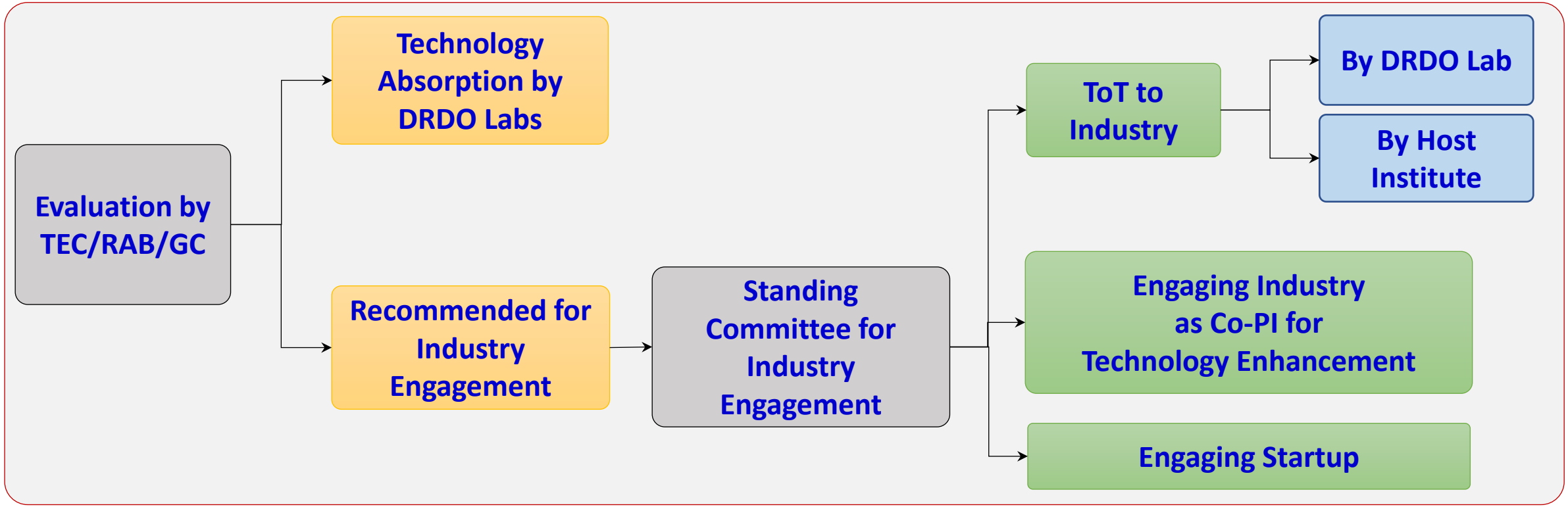
- Technology Readiness Levels
  - TRLs can start from: ~2-4
  - Each project intends for at the most 4 TRL jumps
  - Not expected to go beyond TRL 6

- Expected result is at least **prototype demonstration** for pure academia projects, in addition to reports, papers and IPR

- Industry can be onboarded based on the **maturity of the technology**

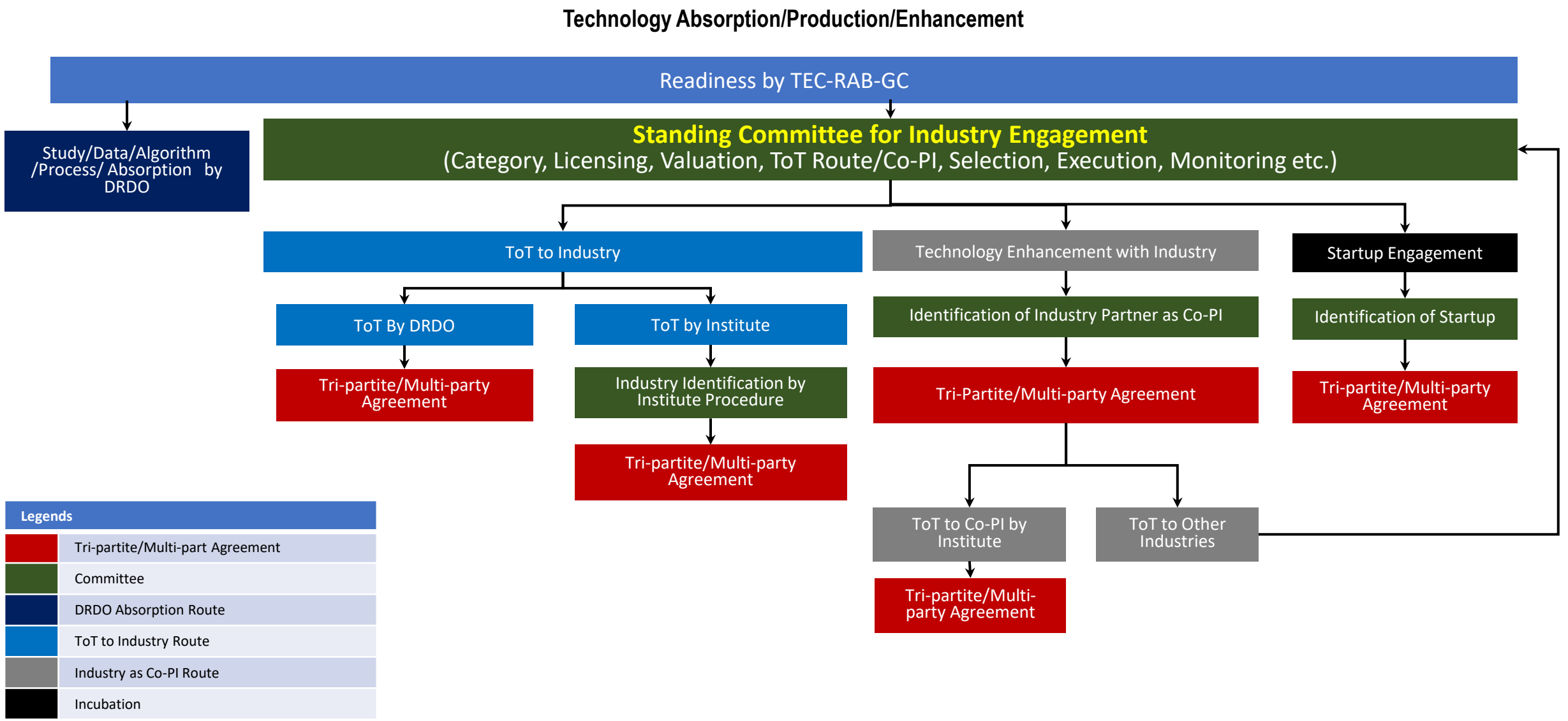
- Projects developed jointly with Industry –
  - Industry can be **Co-Principle Investigator** (R&D by Industry) or ToT Licensee
  - Flexibility of operating through institute mechanisms for Industry interface

Framework for Engagement of Industry Engagement



1. ToT for Ongoing / Completed Projects from Academia - Activated
2. ToT for Ongoing / Completed Projects from DRDO Lab - Not Activated
3. ToT : Investment by Industry - Activated
4. Industry as Co-PI: Investment by Industry - Activated
5. Industry as Co-PI: Investment in Equipment by DRDO - Ongoing
6. Industry as Co-PI: Reimbursement of Sanction for Qualification Testing - Ongoing

Framework for Industry Engagement



Technology Absorption by DRDO

Technology Absorption of DIA-CoE Projects

- Technology developed through DIA-CoE projects will be shared with stake holding DRDO labs for absorption.
- Joint IP of DRDO and Academia will be referred in the DRDO project inputs as unique project-id.
- The artefacts from the projects will become internal DRDO IP (as a shared IP between DRDO and Academia).
- The project will refer the usage of DIA-CoE Project outcomes in its project proposal or project closure as applicable

Transfer of Technology to Industry by DRDO

Transfer of Technology of DIA-CoE Projects through DRDO

- DRDO Labs takes up the outcome artefacts and adopts into a technology for transferring to industry for production.
- **ToT and documents will be responsibility of DRDO Lab**, based on the DRDO procedures of ToT Policy in vogue.
- ToT will be a **Tri-partite activity** with defined responsibilities, and acknowledgements in the ToT document.
- The institute will be involved in the process of Know-how transfer to industry along with DRDO labs.
- **Six months** is considered as a reasonable timeframe for executing this transfer of technology.
- Status of such ToTs will be reviewed as per LTDRP.
- DFTM & DIA-CoE will liaison with the institute to align the support from the institute and the PIs for ToT activity through DRDO policy and procedures.

Transfer of Technology to Industry by Institute

- For identifying industry, an **Expression of Interest (EoI)** will be prepared by PI and DIA-CoE & floated through institute norms.
- EoI will contain information outlining project requirements and evaluation criteria to attract qualified industry partners & will be approved by the Standing Committee.
- **Standing Committee will shortlist a pool of qualified industry candidates** based on defined selection criteria & negotiate the project terms.
- **NDA** will be signed as per project scope of work.
- A technical document including the design, process details will be prepared & shared by PI for **'know how' / 'know why'** transfer to industry.
- **Industry will bear the cost incurred during technology transfer** & liaison with the users for further certification or user trials.
- Licensing Agreement for Transfer of Technology (LAToT) is entered between stakeholders.
- Transfer of Technology (ToT) will be given on **Non-Exclusive basis** for all technologies developed through the DIA-CoE.
- The **IPR** will be held between DRDO and Institute.

Technology Enhancement through Industry

- The projects related to industry for technology enhancing & product development will be sanctioned by DFTM, DRDO HQRs through DIA-CoEs with **Industry partner as Co-PI.**
- The research collaborating industry partner will leverage their experience and infrastructure with R&D strength of academia, to develop and mature the technology.
- Technology enhancement will be done through listed pathways.
  - (i) Conversion of Technology to Product
  - (ii) Enhancement / Optimization for Performance
  - (iii) Adoption for Reliability, Quality & Economic Production
  - (iv) Product Variant Development
  - (v) Indigenization of Materials
- In Technology Enhancement Projects, PI will be from academia and industry partner will be Co-PI. The existing governing mechanism of LTRDP will supervise the entire process.
- **First project can include industry as Co-PI**, in case the technology maturity is feasible for production and associated risk factors are low.
- The **follow-on project with Industry as Co-PI**, for purpose of pre-production, facilitation will be initiated after the successful R&D validations in the first project as pure academia project.

Industry as Co-PI in Phase-2 projects

- Multiple Technology tasks required for technology development will be derived mutually by academia and industry and will be submitted to DIA-CoE as research proposals with PI from academia and Co-PI from industry.
- The proposal will be evaluated and approved as per LTDRP.
- Proposed duration of the collaborative projects with industry as Co-PI will be **12-18 months**.
- **PI and the researchers of the project will directly work with the industry partners for upscaling, process optimisation and know-how/know-why transfer to the industry.**
- **Technical gaps which may require R&D improvements will be complemented by academia researchers for technology demonstration.**
- With industry as Co-PI in the projects, Tripartite MoAs will be worked out between DRDO, Academia and Industry partners.
- Industry as Co-PI will **invest its manpower in R&D** and research facilities for technology development.
- Funding will be provided to the institute and industry partners (PI and Co-PI) as per existing norms against audited Statement of Expenditures.
- After the technology is developed for adapting into the production process, the **technology can be transferred to the industry as Co-PI** by the Institute based on the recommendations of Design Validation Committee.

Joint IPR Aspects

- **Academia can use the Joint IPR for further research but not for commercial exploitation (India IPR act 1970).**
- IPR created by DRDO, institute and industry prior to the award of the collaborative project, shall rest with the respective party.
- DRDO, institute and industry shall be deemed to have royalty free, nonexclusive and all paid-up license to use the background IP rights for the purposes of the approved project.
- **Any value additions by the industry(ies), the foreground IPR will owned by DRDO, Institute and Industry(ies) through a Non-Disclosure Agreement.**
- Industry as Co-PI will automatically gain the non-exclusive rights (licence) for manufacture of the products.
- DRDO, academic institute and industry shall consult each other before publishing (in public domain) any foreground information generated during the cooperative activities to ensure that no proprietary information is released and the foreground IPR are protected.
- **Filing of IPR applications including patent applications shall be processed through DRDO or Academic Institute.**

Engagement with Startup

- The Company/Limited Liability Partnership (LLP) should be **registered as a Startup as per Ministry of Commerce and Industry (DPIIT)** gazette notification no. G.S.R 127(E) dated 19 Feb 2019 and as amended from time to time.
- **No seed funding to Startups.**
- **The amount of grant will be decided based on the Standing Committee recommendation with a maximum up to Rs. 5 Crore in a project.**
- **Budget Head will be similar as applicable to Industries.**
- **The prevailing guidelines and policy of Government of India for engaging with Deep Tech and Defence Startups will be followed.**
- A Startup is considered as 'owned' by resident Indian citizen(s) if **minimum 51% of the capital** is beneficially owned by resident Indian citizen(s) and / or Indian companies.
- **Startup will be a Co-PI** and should be represented by a project leader.
- The Company/LLP as Startup must have its **own in-house R&D facility** in the given domain

Fund Head for Industries

a. **Equipment – Unique machinery or tools which are for one of its kind facility necessary for the outcome of the project.**

b. **Expendables – Necessary for prototyping, testing and experimentation for the project outcomes.**

c. **Contingency – Upto 3% of the total cost of the project.**

d. **Prototype or Hardware Engineering Model – for raw materials and expendables used for prototyping and to be delivered to stake holding DRDO Labs.**

Case Study: Personal Body Armour Technologies

ABHED

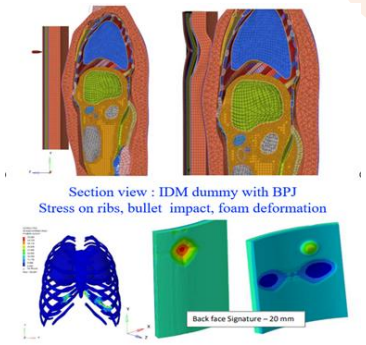
Academia

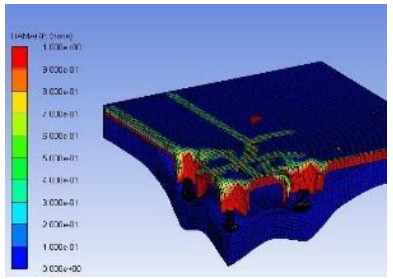
- Material Characterisation
  - Material Indigenisation
    - UHMWPE
    - Alternative DPE
    - Boron Carbide
    - Silicon Carbide
- Human Body Modelling
- Modelling of Ballistic Impact
- Tissue and Organ Characterisation

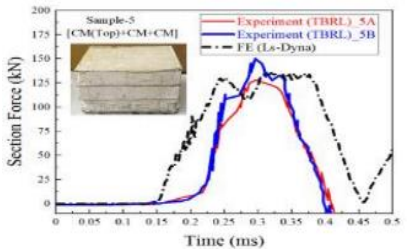
Upstream

- Body Armour
  BIS Level 5 & 6
  - Soft Armour
    Areal Density 3kg/m2
  - Hard Body Armour

Downstream





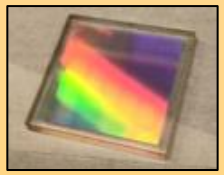


Industry Engagements through DIA-CoEs

Transfer of Technology

1. **Light Weight Bullet Resistant Jacket (ABHED- Advanced Ballistic Hight Energy Defect): IITD**
   - i. MIDHANI, Rohtak;
   - ii. SMPP Pvt. Ltd., Delhi
   - iii. AR Polymers (MKU), Kanpur

2. **Diffractive Optical Element as Spectral Beam Combiner: IITD**
   - i. BEL, Pune



3. **Multilayer Coated and Laminated Textile Material for Aerostat Applications (In Process) : IITD**

- Total Industries Engaged: 11
  - ToT: 4
  - Co-PI: 7
- In Process of Engagement: 6

R&D Support by Industry Partner as Co-PI

1. **Extreme Heat Protective Clothing: IITD**
   - i. Arrow Garments, Tirupur
   - ii. Aeronav Industrial Safety Appliance, Delhi;
   - iii. Katalyst TECHTEX Ltd, Delhi

2. **Extreme Cold Weather Jacket: IITD**
   - i. Aeronav Industrial Safety Appliance, Delhi;
   - ii. Arnaf Industries Ltd
   - iii. Arrow Garments, Tirupur

3. **Indigenous development of ballistic material for Bullet Resistant Jacket: IITD**
   - i. Reliance Industries Ltd.

4. **Armour Grade Ceramic Material (In Process) : IITD**
   - i. CUMI
   - ii. Bhukahanvala Industries Pvt. Ltd.
5. **Large Scale (100Kg) Inert Gas Atomiser (In Process) : IITBHU**
   - i. Innomate Advanced Material Ltd.
6. **Optimized Self Cleaning Air Filtration System of Production Grade (In Process) : IIT Madras**
7. **Hull and Turret Interface Bearing for AFV (In Process) : IIT Madras**

Engagement of NRI Researchers Through DIA-CoEs

International Collaboration in Defence R&D

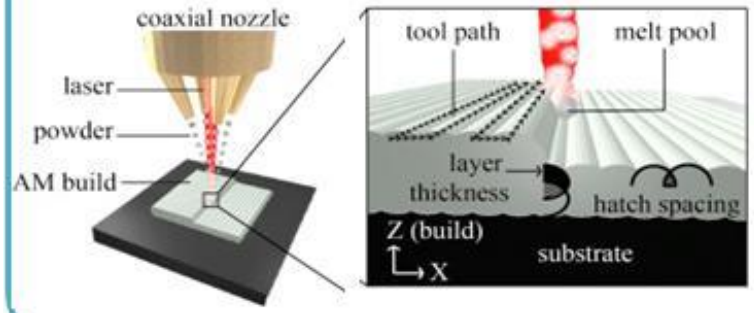
ICC Policy	Scheme-1 Research Collaboration	Scheme-2 Short-term consultancy for specific tasks	Scheme-3 Consultancy for Review of Highly Complex Technologies and Deep Tech Areas	Scheme-4 Training at Academia Institutes through DIA-CoEs	Scheme-5 DRDO Faculty/ Expert Chairs at DIA-CoEs
Objectives	Develop Solutions to key Problems in the areas of Defence Technology through Joint Projects	Selected problems for which expertise not available in country	Get Expert Advice in Review of Projects of Highly Complex Technologies and Deep Tech Areas	Organizing Specific Training Courses/ workshops for DRDO Scientists	Strengthening Research in Advanced Defence Technology Areas
Duration	03 years	03 months	10 days	10 days	5 Years
Eligibility/ Sanction Process/ Funding	PI-Indian Faculty Co-PI – NRI/Foreign Faculty/Researcher (identified by PI)/Certified by TEC on non-availability of research scope/ Funded & Monitored through DIA-CoEs	Subject Expert/ Approval through Screening Committee/ Honorarium US$15000 for 1st month and Subsequently US$10000p.m.	Subject Expert/ US$8000/5000 for 12-14hrs and upto US$12000/9000 for 20-28 hrs for Physical Contact / E-consultancy	Subject Expert/US$8000/5000 for 12-14hrs and upto US$12000/9000 for 20-28 hrs for Physical Contact / E-consultancy	NRI, OCIs, Scientists, Faculties worked in Foreign R&D Institutes / Remuneration As Recommended by Selection Committee

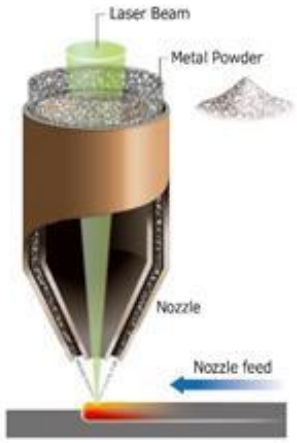
Technologies Developed Through DIA-CoEs

Advanced Manufacturing Technology

Large Area Additive Manufacturing Facility: DIA-CoE, IITH
(The Biggest 3D printer in India)

Laser and Blown-Powder based Direct Energy Deposition (DED) form of **Additive Manufacturing** where metal powder fuses into melt pool created by laser.





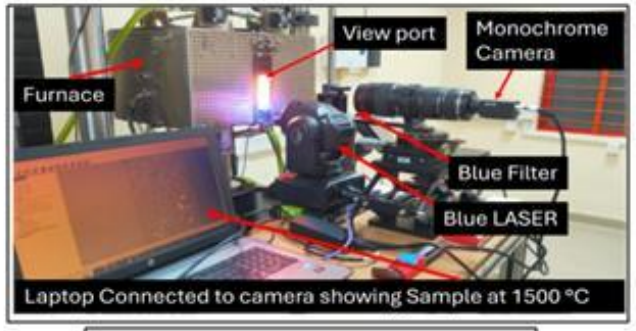
- 1m x 1m x 3m build volume
- 2 kW Ytterbium doped Fiber Laser System
- Coaxial Ring Nozzle Type Cladding Head
- Independent Control of Both Heads
- Turn Table for Greater Reach
- Two sets of Laser Cladding Heads for Thermal Balancing
- Robot Arm for Additional Activities like Machining, Coatings
- Total: 7 axis Cartesian CNC + 6 axis robot (Vertically Moving)

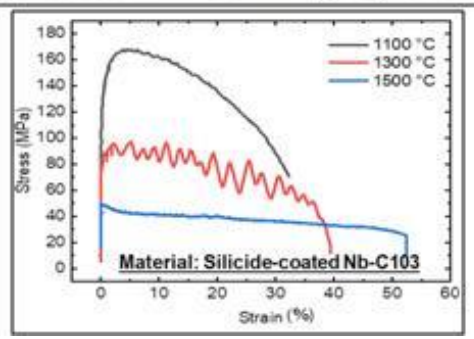
- Technology for Electron Beam Powder – bed Fusion and Wire Arc based AM: DIA-CoE, IITH
- AM of Ti-Al Intermetallic Components, Conical Shape Charge Liners: DIA-CoE, IITH
- Process for Additive Manufacturing of Blisk and other Aeroengine Components: DIA-CoE, IISc and DIA-CoE, IITH
- Powder for AM and Powder Making Equipment: DIA-CoE, IIBHU

Hypersonic Technologies

Testing of Material Properties upto 2000°C: DIA-RCoE, IISc Bengaluru

- A Very High-Temperature Universal Testing Machine (UTM).
- Present capability to Test Samples up to 1500 °C in Air (or an Inert Gas Environment).
- Integrated 2kW Laser System for Sample Heating
- Strain Field measurement using Digital Image Correlation (DIC).
- 2000°C System to be ready in a year.





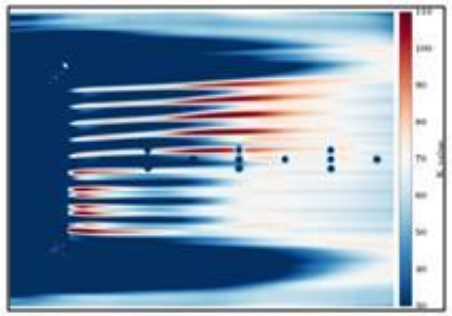
Facility for Heated Models Testing in Shock Tunnel under Hypersonic Flow: DIA-RCoE, IISc Bengaluru

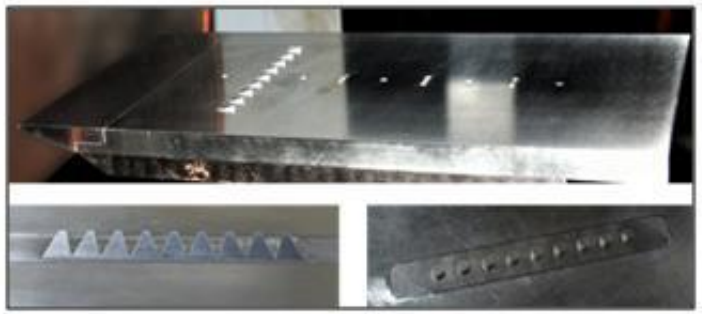
- Facility for In-situ Heating of Aerodynamic Models in shock tunnel & non-Contact IR Measurement
- Measurement of Heat Flux In Hypersonic Regime at Realistic Wall Temperature to Recovery Temperature Ratios in Shock Tunnel.
- Surface Heat flux Measurements are inputs for Design of Thermal Management Strategies for Hypersonic Vehicles.

Hypersonic Technologies

Trip technology Development for High Speed Boundary Layer Flow Transition – DIA-RCoE, IISc, Bengaluru

- A first-of-its-kind Project in India, looking at Hypersonic Boundary Layer Flow in detail.
- Shock Tunnel Experimentation supported by Robust Modeling Tools for Flow Transition
- Prediction and Design of Wall Mounted Tripping Devices.
- Project Outcomes will enable Advanced Management of Thermo-Structural Loads on a Long-Duration Hypersonic Cruise Vehicle/Platform.





High Temperature Materials Development

- Zirconia based Thermal barrier Coating Material for Nb Alloys for operation upto 20000C: DIA-RCoE, IISc
- Carbon Fibre Reinforced Hafnium Tantalum Carbide Siliconborocarbide Cf/[Hf-Ta-C-SiC(B)] Ultra-High Temperature Ceramic Matrix Composites (UHT-CMCs): DIA-CoE, IITH
- High Emissivity Coating for Thermal Protection System of Space Vehicles: DIA-CoE, IITH
- Doped Zirconia Fibers by Sol-Gel Processing for High Temp Ceramic Matrix: DIA-CoE, IITH

Aero Engine Technologies

Prototype Combustor Technology Development for GT Engine: DIA-CoE, IITB

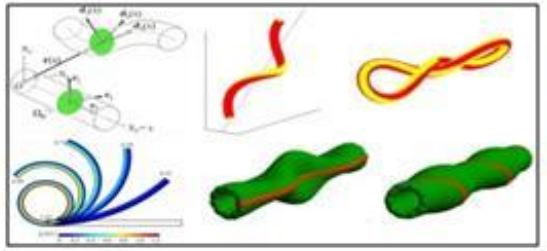
The Small Gas Turbine Combustor can be tested with Kerosene, Propane and other Gaseous Fuels like H_2, CH_4 under Atmospheric and Pressurized (up to 5 bar) conditions with inlet Cold and Hot Air to the Combustor

Advanced Technology Development for Aero Engine: DIA-CoE, IITB

- Effusion Cooling of Combustor Liner of Aero Engines
- Carbon Fiber Reinforced Pthalonitrile Composites for High Temp applications
- Fault Tolerant System for Gas Turbine Engines
- Dynamic Analysis of Tip Shrouded Turbine Blades
- Design, Development and Testing of High Shear Atomizer
- Airblast Injector Development for Next Gen Aero Engines
- Development of Electronic Engine Regulator
- Damage Tolerance & Risk Assessment of Gas Turbine Engine Critical Parts

Production of Defect-Free PCS Fibers with strict control over Fiber Properties using a Custom-Built Lab-Scale Melt Spinning Facility (DIA-CoE, IITH)

1. Development of a Lab-scale Setup for Melt-Spinning of Multiple Defect-Free upto 50 micron PCS Fibers with Capability to Measure Temperature Profiles and Fiber Diameter Real-Time.
2. Study the effect of the Oxygen environment on cross-linking of Fibers during Stabilization and for qualitative understanding of shrinkage during pyrolysis.



Simulations and continuum modelling of microfibers

High Pressure Turbine Parts

UAV Technologies

Variable Altitude Long Endurance UAV with Guided Munitions: DIA-RCoE, IISc, Bengaluru

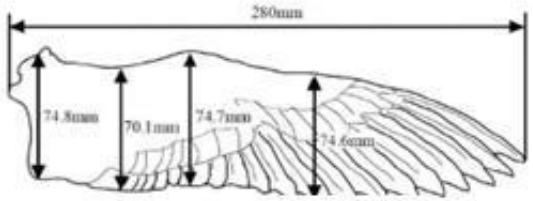
- VTOL UAV with ICE Power in a Hybrid Configuration with Battery
- VTOL UAV with Fuel Cell Power in a Hybrid Configuration with Battery
- Maximum Cruise Altitude – 5000MSL
- Payload – 5Kg
- 3 -4 Hrs Endurance

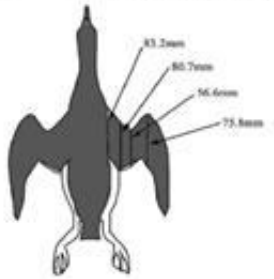
Flapping Wing Micro Air Vehicle (FWMAV): DIA-CoE, IITH

- Lightweight Metamaterial Structures Development for Flapping Wing Systems
- Stiffness Tailoring via Curvilinear Fiber-reinforcements of Flapping Wings for Enhanced Modal Performance in Ornithopters
- Establishment of a Platform that would aid a Nano Ornithopter to Learn to Fly

Bio-inspired Flapping Wing Model with Morphing Capability for Aerial and Aquatic Locomotion: DIA-CoE, IITJ

- Design and Fabrication of Flapping Mechanism and Wing Morphing.
- Devising New Wing Morphing Mechanisms and Exploring the Scope of Different Wing Materials Adept for Morphing.
- Demonstration of Water Entry and Propulsion Underwater.





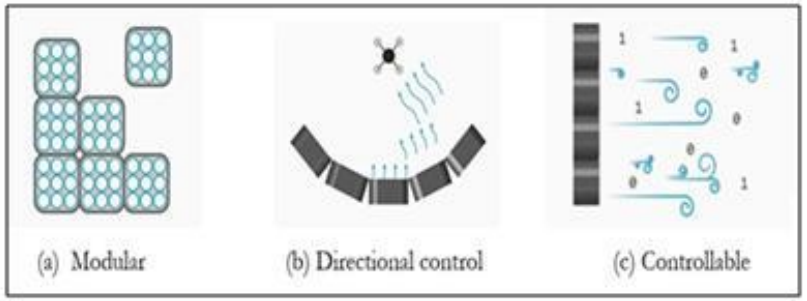
Multiagent Amphibious Quadcopter System: DIA-CoE, IITJ

- Multi-vehicle Formation Control Algorithms in both Air and Water.
- Top Layer responsible for Aerial Maneuver & Bottom Layer equipped with Aqua Propellers responsible for Underwater Locomotion.

UAV Test Facilities

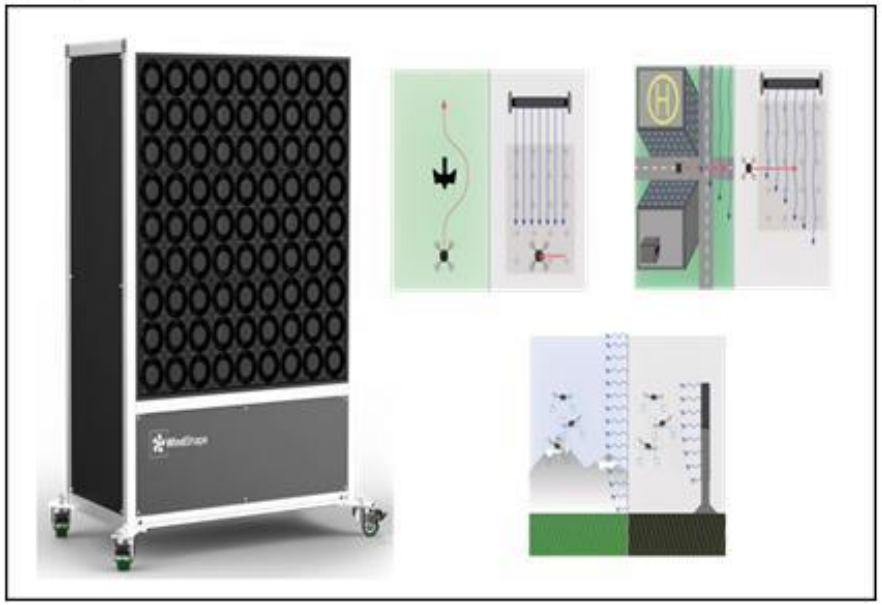
Experimental Climate Test Facility: DIA-RCoE, IISc Bengaluru

- Test Chamber: 5m X 10m X 5m
- Evaluate the Combined Effect of Altitude & Wind
- Measure the Effect of Turbulent Wind on UAV Performance
- Performance Evaluation of Various Motor/Propeller/ESCs



Unsteady Wind Tunnel for Simulating Flight Flow Conditions for a Micro or Nano UAV: DIA-CoE, IITH

- Test Section: 2.4m X 2.4m
- Air Speed: 15 – 20 m/s
- No. Of Fans: 900
- Produce an Arbitrary Wind Profile to Simulate Real-world Flows, Allowing Better Testing of the Capabilities of Drones of Varied Scales (Micro – Nano)

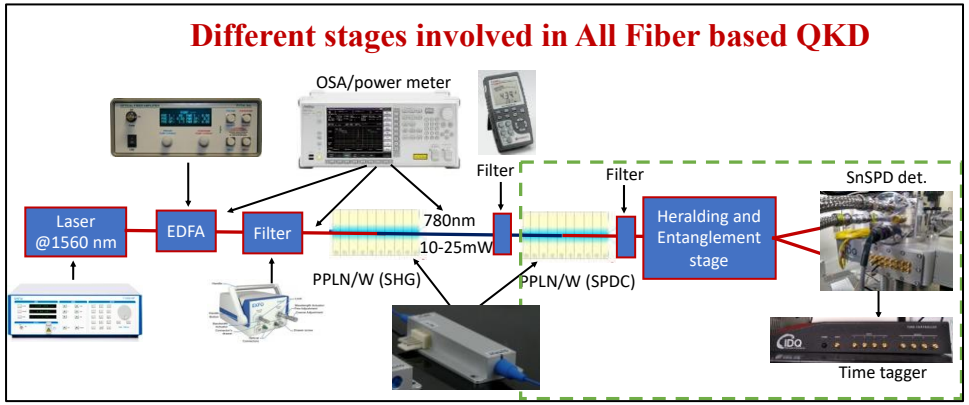


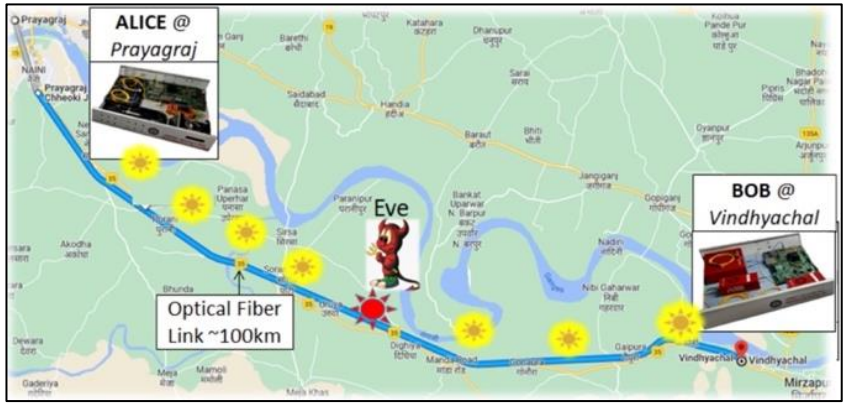
Quantum Technologies

Quantum Communication Technologies: DIA-CoE, IITD

1. Fiber Based Quantum Key Distribution

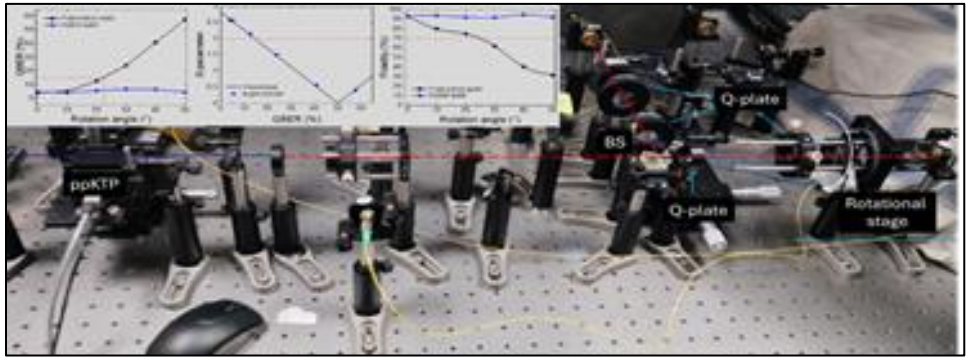
Successful Demonstrations of Entanglement Distribution and QKD have been achieved over a 150 km Fiber Link in continuation of 100km DPS QKD (Vindhyachal – Prayagraj).





2. Free Space Based Quantum Key Distribution

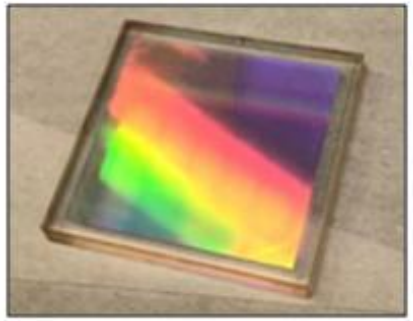
Successfully Demonstrated Hybrid Entanglement in a Free-Space Environment using BBM92 Protocol, Achieving a QBER of around 6% in the Laboratory over a Distance of 1km.



Directed Energy Technologies

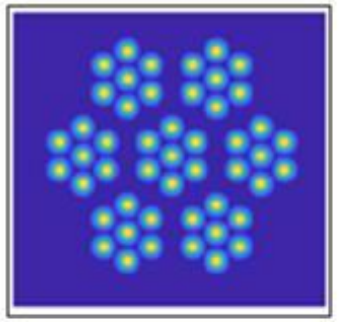
Diffractive Optical Element as Spectral Beam Combiner for High Power Laser Application: DIA-CoE, IITD

- Designed and Developed Multi-Layer Dielectric Grating for Spectral Beam Combining of Fiber Lasers
- Demonstrated Multi kW High-Power Beam Combining using the Developed Grating 1st time in INDIA



Nested Loop Coherent Beam Combination System for Power Scaling of Fiber Lasers: DIA-RCoE, IITM

- Design and Implementation of Nested Loop Phase Synchronous Algorithm for CBC.
- 1X7 Fiber Laser CBC Demonstrated.
- Development of Engineered 7X7 CBC System in Progress.

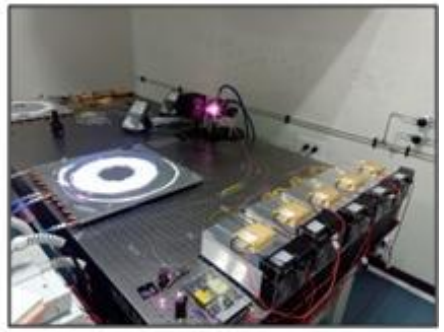


Narrow Line Width Fiber Laser: IISc (DIA-CoE, IITM)

- 1kW Narrow, 10GHz Fiber Laser Developed.
- 4kW, 10GHz Linew-idth 1064nm Fiber Laser under Development.

High power Fiber Laser Components : CGCRI (DIA-CoE, IITD)

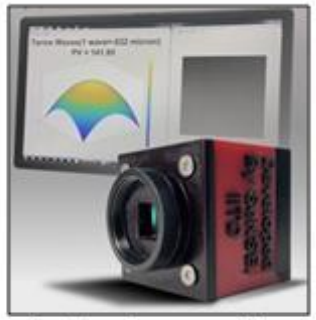
- Fabricated Active fiber , Pump beam Combiners and Fibre Bragg Grating for 1kW Fibre Laser.
- Components for 3kW Fiber Laser in Progress.



Directed Energy Technologies

Development of Freeform and Large Size Aspheric Optics for Thermal and Optical Imaging: DIA-CoE, IITD

- Designed and developed compact Shack-Hartmann Wavefront Sensor for in-situ measurements.
- Establishment of development process for freeform optics.
- Established Metrology technique for the Aspheric optics up to 300 mm.



Shack-Hartmann Sensor

Integration of SHS assembly on CNC Machine

Freeform Optics

Aspheric Optics

Laser Beam Control Technologies: DIA-RCoE, IISc Bengaluru

- Algorithms for High Precision Control of Laser Beam.
- Atm. Wavefront Distortion Compensation through Fast Steering Mirrors and Adaptive optics.
- Long Range Target Detection and Coarse Target Tracking.
- Long Range Image Processing for Target Tracking under High Atmospheric Turbulence.
- Fine Target Tracking and Beam Pointing within few Micro-radian Accuracy.
- Laser Matter Interaction Studies on Ground and Aerial Targets.

DIA-CoE Technologies

High Performance Hull Material for Aerostat: DIA-CoE, IITD

- Indigenous Development of Light Weight, Enhanced Helium Barrier and UV Protected Hull Material.
- Fabric 1
  - Weight – 345GSM, Helium permeability – 0.55L/m^2/day
  - Breaking Strength – 296kgf/5cm, Tear Strength – 48kgf
- Fabric 2
  - Weight – 293GSM, Helium permeability – 0.25L/m2/day
  - Breaking Strength – 400kgf/5cm, Tear Strength – 33kgf

Blast Protection Technology: DIA-CoE, IITD

- Anti-Mine Boot for protection against blast from 35gm explosive.
- Weight ~2.8kg as against existing 3 kg.

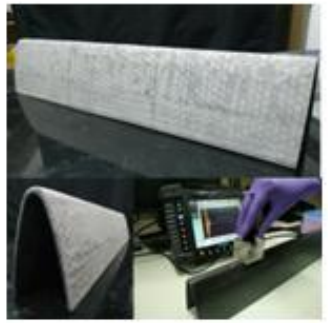
Terahertz technologies: DIA-CoE, IITD

- Time Resolved THz Imaging and Spectroscopy Systems for Studying High Energy Density Materials and Condensed Explosives Under Functionalized Conditions.
- Developed Terahertz Handheld Remote Explosive Detection Platform [THRED]
- Pre-developed Spectral Database for Identification of most of the Common Bulk Explosives, such as, RDX, HMX, DNTs etc.
- Developed Spintronics based Tunable and Powerful Broadband THz (Up to 5 THz) Emitters.
- Developed THz Components and Systems using Synthesized Sources and Phase Coherent Techniques
- Developed High Efficiency Broadband 0.1 to 2THz, 4x4 detectors based on Field Effect Transistors

Multi Spectral Stealth Solution

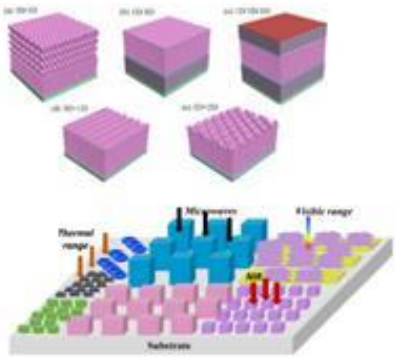
Advanced Multifunctional Polymer Composites for Airborne Application: DIA-RCoE, IISc Bengaluru

- Operating Frequency : 30 – 300 MHz
- Evolving a Highly Loaded Metallic Semiconductor / Metal / Dielectric Ink Formulation
- Precise Dispersion of Ink on Inexpensive and Rough Surfaces to Fabricate Multi-Layer Printed, Multi-Functional Devices (Printing Resolution: 1-10 µm)
- High Precision Composite (GFRP-CFRP) Fabrication Technology Development and Characterization



Multispectral Stealth Solutions covering Visible, NIR, Thermal and MW Ranges using Coatings and Patterned Surfaces: : DIA-CoE, IITK

- Wavelength Ranges: 380nm - 780nm, 680nm - 1280nm, 3µm - 5µm, 8µm - 12µm and the Microwave Frequency Range of 2 GHz - 18 GHz
- Design of Various Patterns for Multispectral Stealth
- Fabrication of Passive Meta surface for Stealth

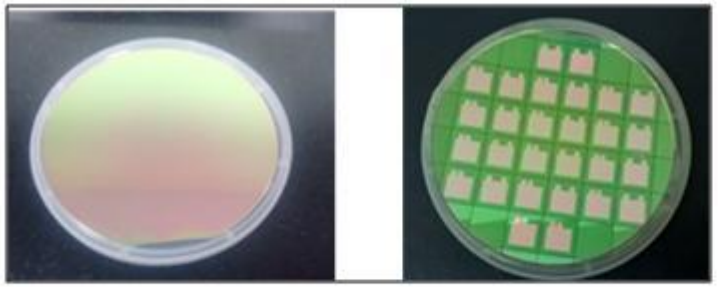


Active Tunable Electromagnetic Structures for Stealth Application: DIA-CoE, IITK

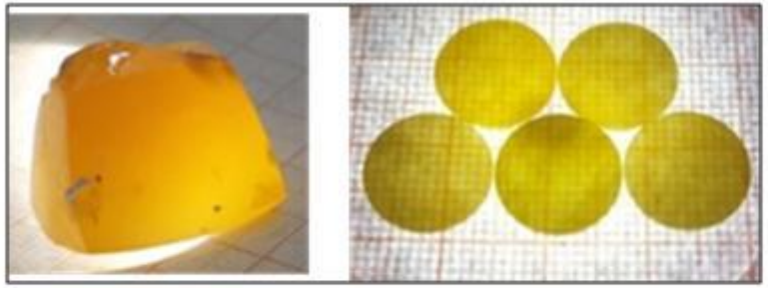
- Design and Development of Conformal Time-Modulated Metasurface
  - Frequency range : 4 – 6 GHz
  - Doppler Shift: 8 kHz to 17 kHz (0.7 - 1.5 mach at 5 GHz)
- Planar Reconfigurable Metasurface based Rasorber (Absorber with Transmission band)
  - Frequency Range : 2 – 6 GHz
  - 10dB Absorption Band: 2 to 2.5 GHz and 4 to 6 GHz
  - Transmission Bands: 3.0 to 3.5 GHz
- Planar/Conformal Tunable Metasurface based Absorber.
  - Frequency range : 1 – 6 GHz
  - Reflection Coefficient : -10dB

Technology Development for Sensors & Devices

Sensor Technology at DIA-RCoE, IIT Madras



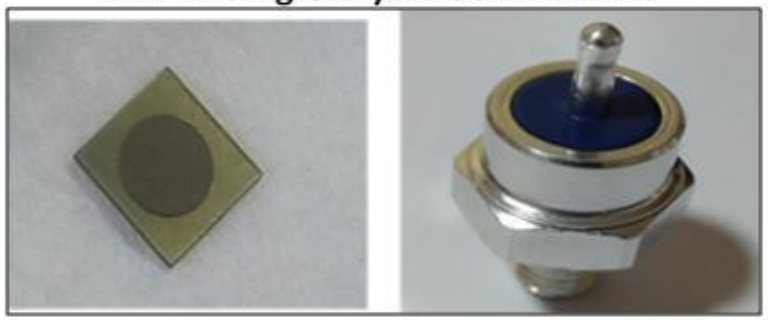
PZT/PLSZT Thin Films for MEMS Sensors



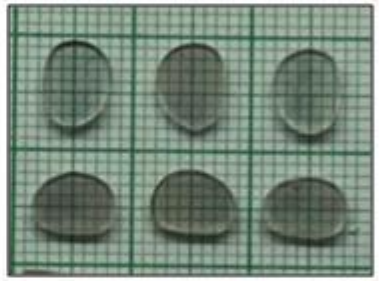
PZN-PT Single Crystals and Wafers

Piezoelectric Energy Harvester

SiC based SBD (Schottky Barrier Diode) Power Diodes



MEMS Acoustic Sensors & Flexural Hydrophone



Ga_2O_3 Single Crystal Wafers

Sensor technology at DIA-RCoE, IISc Bengaluru

- Capacitive Micro-machined Ultrasonic Transducer for Underwater Sensing
- Piezoelectric Micro-machined Ultrasonic Transducer for Underwater Sensing
- Silicone Photonic Integrated Circuits for Radar Application: Facility for packaging of Photonic IC
- Advanced Packing technology for 3D Integration of MEMS Sensors Dies


डी आर डी ओ
रक्षा अनुसंधान एवं विकास संगठन
DEFENCE R&D ORGANISATION
रक्षा मंत्रालय
MINISTRY OF DEFENCE
DRDO

Thank You