सीएसआईआर – राष्ट्रीय वांतरिक्ष प्रयोगशालाएं
CSIR-National Aerospace Laboratories

Presentation to Industry Meet

18 October 2019 , CSIR – NAL, Bangalore

CSIR-NAL

75 Years of CSIR Touching Lives

CSIR-NAL's Roadmap for Future Plans & Projects

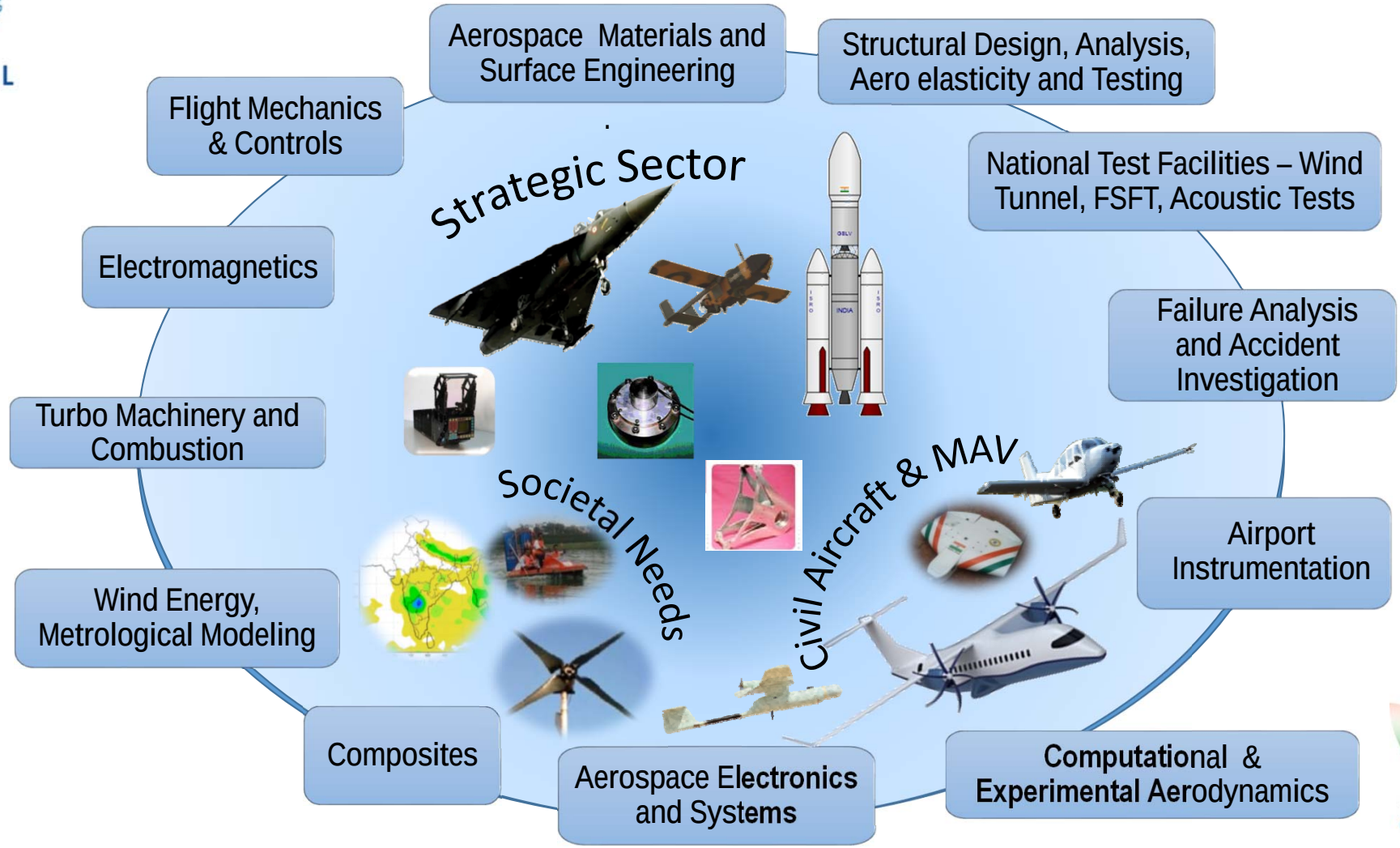
- Annual Expenditure – Rs. 290 crs (75 % CSIR, 25 % External Sources)
- 973- Employees, 360 Scientists,
- Lab Reserve Fund (LRF) 2018-19 : 50.37 cr (40 % of salary budget)

Certified ISO 9001-2015 QMS Standard

Activities

- Civil Aircraft D & D (SARAS,HANSA- NG)
- Design & Engineering Services
- Aerospace Tech developments
- Test Facilities, Skill development
- Societal Mission, Airport Instrumentation

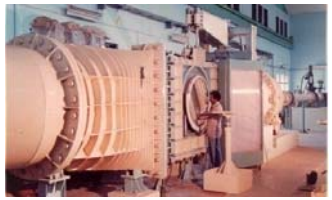
Core Competence of CSIR-NAL



Unique National Facilities @ CSIR-NAL

AERO THERMAL

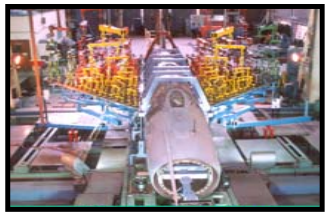
1.2m Wind Tunnel



0.6 m Wind Tunnel

1.5m Low Speed WT

High Speed Comp



Fatigue Test Facility

High Velocity Airgun

Sled Test

Accident Investigation & Failure Analysis

STRUCTURAL & MATERIAL

SYSTEMS ENG

Engineer-in-the loop simulator

AEE

Acoustic Test Facility

IGAPS & Real Time Integrated Test Station

Electromagnetic Lab

CSIR-NAL

CIVIL AVIATION PROGRAMS

Platinum Jubilee 1942-2016
75 Years of
CSIR Touching Lives

HANSA – NG aircraft Flying Trainer

HANSA-NG FEATURES

Key Features

- Advanced Turbo Charged Engine
- Glass Cockpit & Digital Engine Monitoring
- Electromechanical Flap Actuation
- Steerable Nose Wheel
- Improved Ingress/Egress
- IFR compliance
- Endurance 6 hrs
- Range – > 900 km
- Cost – 50 to 60 % lower

Status & Plan

- Project sanctioned by CSIR in Aug 2018
- Flight Tests by March 2020
- MESCO is a Production partner

Glass Cockpit

CSIR-NAL

Light Transport Aircraft –SARAS Mk 2 (Civil /Military)

Key Features :

- 19 Seat Pax
- Low Acquisition/operational cost
- Operable from ill equipped & high altitude Air fields
- Pressurized Cabin
- Glass Cockpit
- Autopilot & Hydraulic boosted Rudder
- Single lever engine control
- Low noise & Light weight
- FAR 23 compliance

	SARAS Mk II (India)	Do 228 NG (German)	Beechcraft 1900D (USA)	LET 410 NG (Czehs)	Lapan N219 (Indonesia)
Take-off Weight (kg)	7400	6400	7764	7000	7030
Max Cruise Speed (km/hr)	540	440	533	417	389
Range with Max Payload (km)	700	440	679	442	889
Cabin	Pressurized	Unpressurised	Pressurized	Unpressurised	Unpressurised
Specific Range (km/kg)	1.6	1.4	1.52	1.22	1.11

Status :

- Two PSA version & STS to be developed
- Aircraft shall be certified for military followed by civil under FAR23
- HAL –Kanpur production partner

Design and Development of New Gen Regional Transport Aircraft (RTA 90-NG)

India Specific Requirements for RTA

- **Geo-specific Requirements**
  - Hot (ISA+35) and High Airfields (SL to 3000m)
  - Runway lengths varying from 700m to 3000m (target ~1200m)
- **Operator Requirements**
  - More cabin and cargo space
  - 25% reduction in ownership costs
  - 15-20% reduction in fuel burn
  - 30-40% reduction in maintenance costs
  - Environment friendly

- Acquisition cost : 20-25 % lower
- Operating cost: 20-25% lower
- Fuel Consumption : 10-15 % lower
- Maintenance cost: 20-25% lower

- Take Off & land from unequipped airfields
- All weather operation
- Emissions lower by 70%
- Enhanced safety

Performance :

❑ Range with 90 Pax	1500 Km
❑ Balanced TO Field Length (ISA, SL, MTOW)	1200 m
❑ Landing Field Length (ISA, SL, MLW)	1100 m
❑ Ceiling	27000 ft
❑ Cruise Speed	550 kmph

Configuration : 90 seat (civil), Cargo , Military

CSIR-NAL

TECHNOLOGIES & PRODUCTS

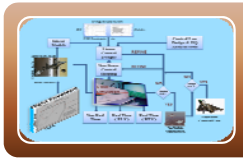
Platinum Jubilee 1942-2016
75 Years of
CSIR Touching Lives

Industry Meet

Building Partnerships between Industry and CSIR-NAL

System Engineering

Avionics & Instrumentation



Flight Mechanics & Controls

Electromagnetics

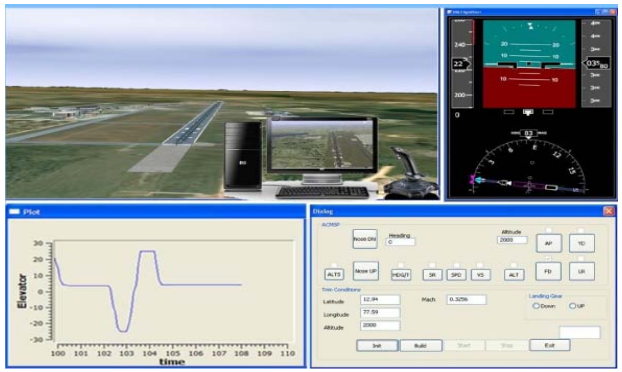
MAVs/UAV

Acoustic Test Facility

75 Years of CSIR Touching Lives

System Engineering Technologies & Products

NALSim Desktop Flight Simulator



Key Features: TRL : 8

- Matlab Simulink and RT Windows Target
- Model based design, Low Cost
- RPT for control law evaluation and research
- Real time out of the window visuals developed using OpenSceneGraph

Applications : Testing of aircraft subsystems models, Evaluation of performance of autopilot, Terrain data integrity monitoring studies, Handling Qualities studies

Integrated Global Bus Avionics Processing System (IGAPS)

Applications :

- Indigenized IGAPS can be used in Fighter and Civil aircraft and UAV

Market Potential

- RTA 90
- AMCA
- GHATAK

Key Features : TRL : 7

- State-of-the-art Integrated Global bus Avionics Processing System (IGAPS) with ARINC 653 Time and Memory partitioned platform.
- ARINC 818, ARINC 664 based global bus interconnect. Dual Redundant design with Dual-Dual features.
- VITA 46 – PCIx based backplane communication.

System Engineering

Technologies & Products

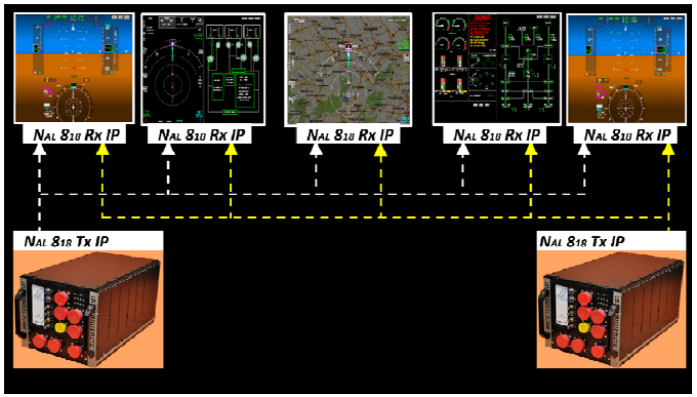
Packaged Autopilot System

Key Features: TRL : 8

- state-of-the-art indigenous autopilot hardware - weight budget of 2.6 grams using Programmmable System on Chip (PSoC) based controller,
- 10 degree of Freedom (10DoF) sensor suite, pressure altimeter sensor, microSD real-time recording device, interface to servo actuators and GPS receiver, and other sensor/devices.

Potential Applications : MAV/UAV

FPGA based ARINC 818 IP-core



Key Features: TRL :7

- Supports links speeds of 1X, 2X, 3X,4X
- Compatible with range of resolution VGA,XGA,SXGA,SXGA+ pixel resolution
- 24 bit RGB color support
- CEMILAC Certification

Applications: Avionics Display Computer, Cockpit display unit, camera & video storage

Market Potential: 300 numbers in the next 10 years. Each display may cost around Rs.20 lakhs (1/5th of imported cost)

System Engineering

Technologies & Products

DRISHTI –runway visibility measuring system

Key Features: TRL : 10

- Base line : 30m
- Measurement range: 10-10000m (MOR), 50-2000m (RVR)
- Reporting range: 10-3000m
- Meets ICAO & WMO requirement (ICAO 9328)
- 47 nos. installed in 21 international airports (India) and 54 systems in 18 IAF Airbases

Market Potential – 200 systems in next 5 years
UDAN RCS. 1/4th cost of imported system

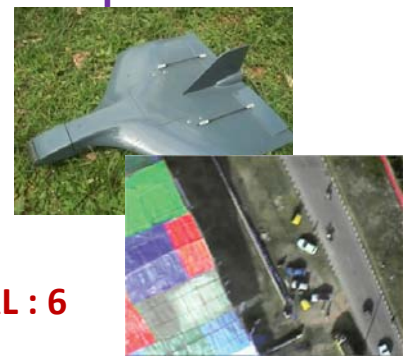
MAV & Mini UAV

SUCHAN

TRL : 6

Range	: 8-10 km
Endurance	: 60-90 min
Speed	: 10-20 m/sec
Wing Span	: 1.85 m
Length	: 1.5 m
Weight	: 5 kg

Pushpak 450



Range	: 2 km
Endurance	: 40 min
Speed	: 15-30 m/sec
Wing Span	: 0.45 m
Length	: 0.55 m

Black Kite 300

Range	: 2 km
Endurance	: 30 min
Speed	: 13-25 m/sec
Wing Span	: 0.30 m
Length	: 0.35 m

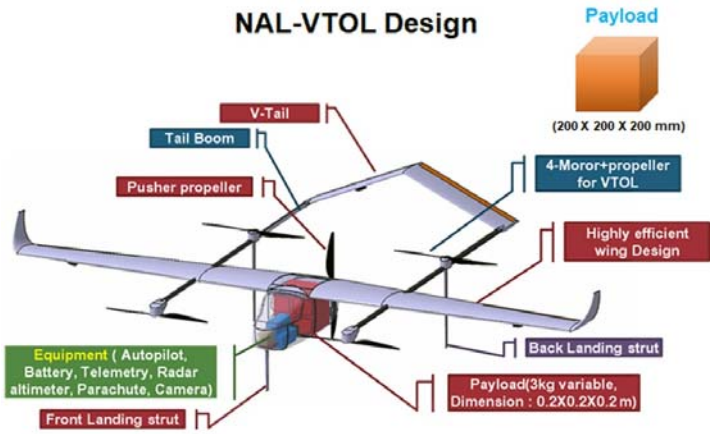
Applications : Surveillance, Traffic monitoring , ISTAR Missions, Search and rescue mission, Forest Fire Detection, Weather data collection, etc.

Market Potential – about 1500 numbers for UAVs in next 5 years.
1/3rd cost of imported system

System Engineering

Technologies & Products

VTOL Winged Unmanned Aerial Vehicle



Key Features: TRL : 8

- AUW : 13 kg
- Wing Span : 3 m, Length : 1.7 m
- Range : 40 km
- Endurance : 45 minutes
- Cruise Speed : 20-22 m/s
- Operational Altitude : upto 1500 m above MSL
- Multi-payload : 0.2 to 3.0 kg

Potential Applications : Delivery of medicines, patrolling, crop assessment, Surveillance & Reconnaissance

Market: 30 to 40% share of UAV market

Stealth Coatings/Structures

Key Features: TRL :6

- Thin & light weight
- Broad-band and environmentally stable with low maintenance cost

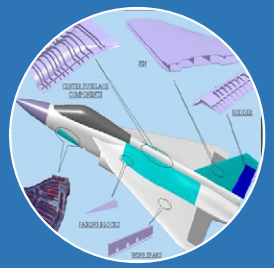
Applications: HAL, DRDO labs and Pvt. industries can use for stealth platforms – aircraft, ships, submarines and missiles

Industry Meet

Building Partnerships between Industry and CSIR-NAL

Structures & Materials

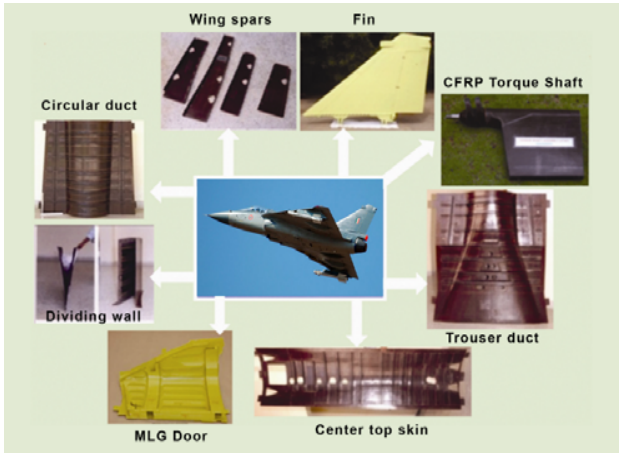
Structures



Advanced Composites

Special Technologies

Composites in LCA



Parts	Reduction of part count due to co-curing
LCA Fin	200 parts to 15 parts
LCA Rudder	50 parts to 6 parts
LCA Centre Fuselage	500 parts to 44 parts
LCA undercarriage Doors (Aft and Fwd)	40 parts to 5 parts

Production Partner: TAML

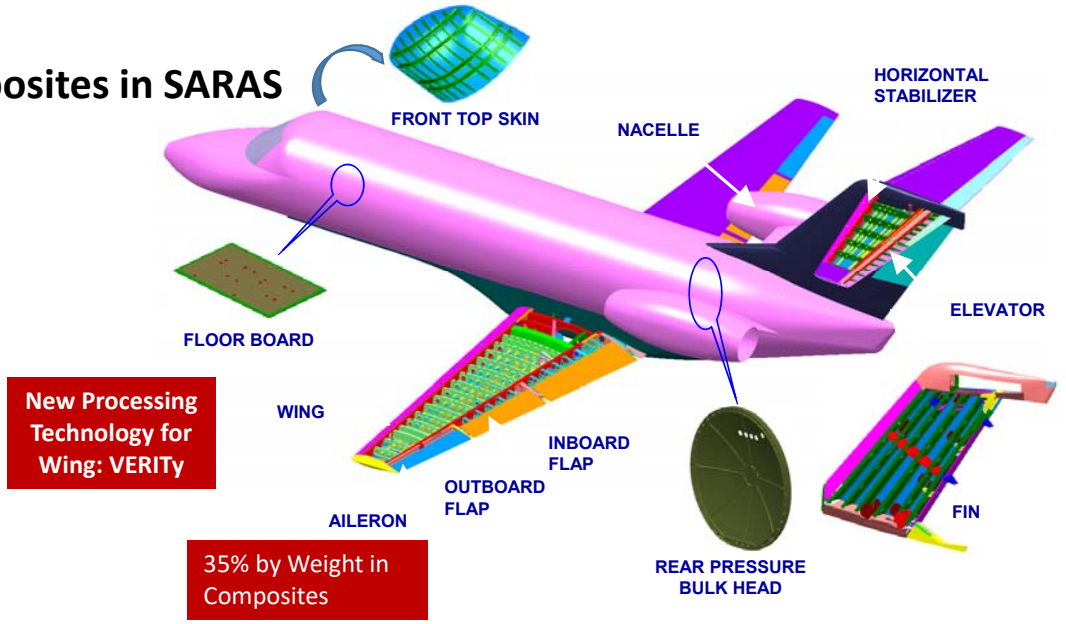
Market Potential 123 LCA-Tejas

Co-cured Composite Structures for Aircraft

Key Features: TRL : 10

- Tejas airframe is 45% composite by weight & 90% by area
- Innovative and cost effective fabrication : Cocuring technology has resulted in more than 20% savings in cost and about 15% reduction in weight.
- Development of high temperature composites structures using Bismalemide resin system

Composites in SARAS



Structures & Materials

Technologies & Products

Large Aerospace grade Autoclaves - for composite airframe production

Compact lab scale Autoclaves : *for Advanced composites R&D*

Key Features: TRL : 9

- Dual PC & PLC control
- Up to 1.5MW Power
- Up to 6m Dia
- Up to 15 m length
- Up to 425 °C, & 20 barg,
- 0.9m Dia
- 1.0m Length
- 200 °C, 7 bar
- PC & PLC control
- 23kW Power

ToT to : KRR Eng. Chennai UCE, Mumbai

Market : Rs.100 cr Indian Mkt.

Cost Economics : 70% of the cost of imported Autoclave.
Orders Executed : ASL, HAL, ADE,VSSC, IIT-Kanpur, MIT-Manipal
Recent Orders: VSSC, SHAR, IIT- Mumbai,Delhi, Hyd, ISAC

Multi Zone Hot Bonder

Key Features: TRL : 9

- 7” Colour touch screen (PLC-HMI) controller
- 2 simultaneous repairs with independent 12-zone temperature control
- Maximum temperature: 230°C (for silicon heater blankets)
- Menu driven program to create, run, view Cure Cycles (CC

Applications : In situ repair / hot bonding of composite structures in aircraft, helicopter, UAV, Wind turbine blades, etc. Market: MROs in India & abroad

ToT to : SAN Process Automation & Ajay Sensors

Structures & Materials

Technologies & Products

Desktop Aerospace Autoclave

Key Features: TRL : 9

- 450mm dia x 500 mm length
- Max. Temp : 200 Deg C
- Heating rate: 0-3 Deg C/min on air
- Cooling rate : 3 Deg C /min
- Power : 7kW single phase

Potential Application :

Ideal for academic & research institutions – 100-120 systems in 10 years

ToT : Milvus, Datasol & Lakshmi Eng.

Airborne Radomes

Jaguar nose cone composite Radome

Jaguar Aircraft

Key Features: TRL : 9

Composite structural aerodynamic shaped enclosure to nose radar of a commercial-aircraft (Navigation/Weather/Radar) & military aircraft (Fire control Radar)

Potential Application :

Requirements of Jaguar aircraft upgradation projects by HAL

ToT : HAL

Ground Base Radomes

DWR Radome installed at Cherrapunji, Meghalaya, N-E India

DWR Radome installed at Bhuj, Gujarat

Key Features: TRL : 9

- Composite spherical shaped enclosure to large size Weather Radar.
- Designed to withstand 250km/h wind speed & gusts 300km/h

Potential Application :

Large requirements of weather/early warming radar system by IMD all along Indian coastal line

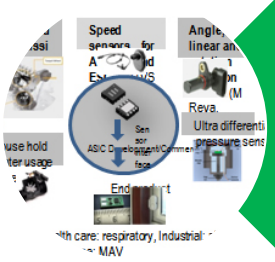
ToT : BEL

Industry Meet

Building Partnerships between Industry and CSIR-NAL

Structures & Materials

Materials & Carbon Fibre Technologies



Surface Modification Technologies

Structures & Materials

Technologies & Products

A process for preparation of PZT-5H grade powders

Key Features: TRL : 7

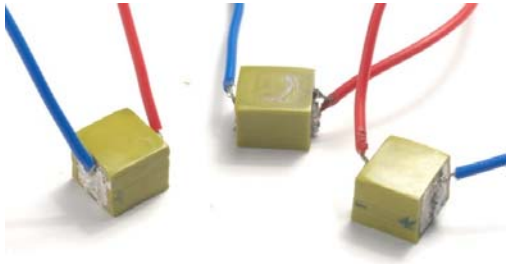
- By wet-chemical route-consistent Properties, sub-micron sized
- (d_{33} >500 pC/N), K at RT:3120
- Loss factor (tan δ): 0.028

Applications

- PZT Devices, actuators and sensors, sonar transducers etc.

ToT : IPA Pvt. Ltd. Bangalore

Technology for making PZT and other ceramic multilayered stacks.



Key Features: TRL : 7

- By Tape-casting technique
- Varied thickness ~50-200 µm.
- No of layers in the stack: 10-100 nos.
- Displacement 10-12 µm and block force of 5200N.

Applications

- Vibration control of aero structures Energy harvesting
- Precision flow control

Flexible piezoceramic coating for various engineering applications

Key Features: TRL : 6

Thickness : 100-500 µm
Size: ϕ = 10 - 250 mm
Oper. Temp.: upto 200°C
Easy to coat on complex surface

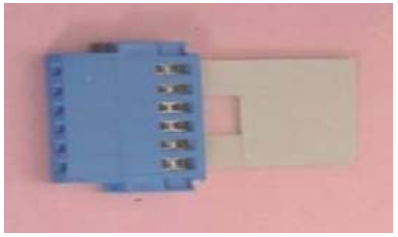
Applications

- Integrated sensors (MEMS devices, FeRAM, IPDs) and Microsystems (e.g. microfluidic, micro-pumps, micro-valves)

Structures & Materials

Technologies & Facility

Poly Vinylidene Fluoride (PVDF) sensors



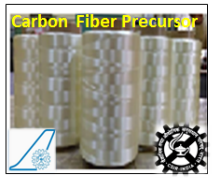
Key Features: TRL : 7

- **Frequency range: Wide, from 1Hz to 10 MHz**
- **Impedance: Low acoustic matches with water and human tissue**
- **Elastic compliance: High**
- **Dielectric strength: High, withstanding strong fields (75KV/mm)**

Applications

- **Sensors: Accelerometer, Pressure sensor, SHM, and acoustic emission, detonator for mines.**
- **Actuators, Communication: & Energy Harvesting**

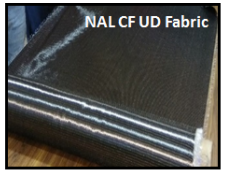
Process Technology for Continuous preparation of Carbon Fiber (NAL-CF1)

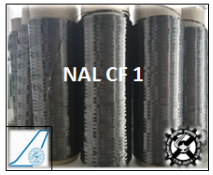


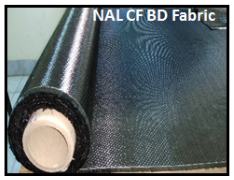
NAL CF 1

CEMILAC CERTIFIED

STANDARD MODULUS GRADE CARBON FIBER TECHNOLOGY







Key Features: TRL : 6

FULLY INTEGRATED TECHNOLOGY

(Acrylonitrile ⟶ PAN copolymer⟶ Special acrylic fiber⟶ carbon fiber)

- Polymer production at 35 kg/h rate
- Precursor fiber spinning at 5 TPA
- Conversion of Precursor fiber to Carbon fibers at 5 TPA

Application & Market Potential

- **Aerospace & Strategic Applications -100 TPA**
- **Civil applications like automobile, sports, power plant, civil infra etc.,- 3000 TPA**

Structures & Materials

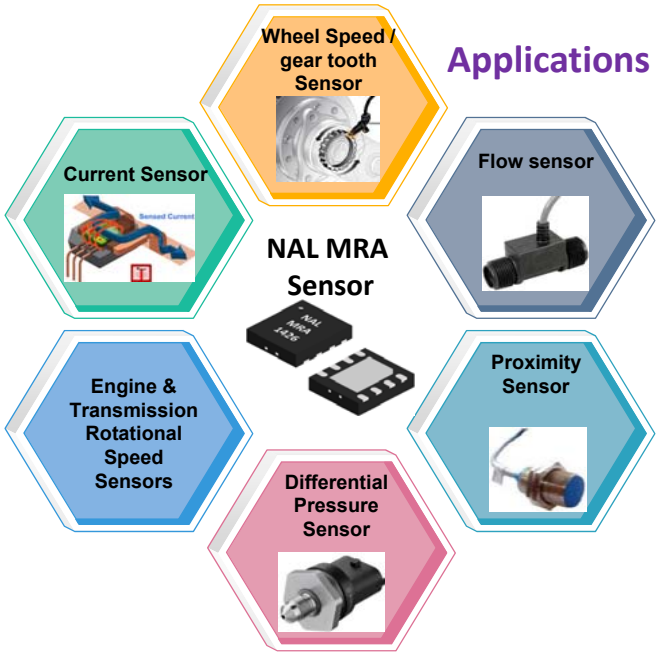
Technologies & Products

GMR based Magnetic Sensor

Key Features : TRL : 8

- Operation temperature: -40 to +125°C
- Supply voltage: 5 – 40 V
- Output: 0 – 5 V, 4- 20 mA / 7 - 14 mA
- Frequency range: 2.2 kHz, Air gap : up to 4 mm
- EMC/ESD up to 15 kV. High voltage (33 V), RP and SC protection

Magnetic Field Sensors Market worth 4.16 Billion USD by 2021



Exp. Volume: 5 – 10 million units/year

Tapecasting Technology for Dense Alumina,YSZ & AlN Tapes

TRL : 7 for alumina, YSZ **TRL : 6 for AIN substrates**

Applications

Tape casting process for Al_2O_3 and ZrO_2 substrates for space electronics, oxygen sensor and solid oxide fuel cell applications

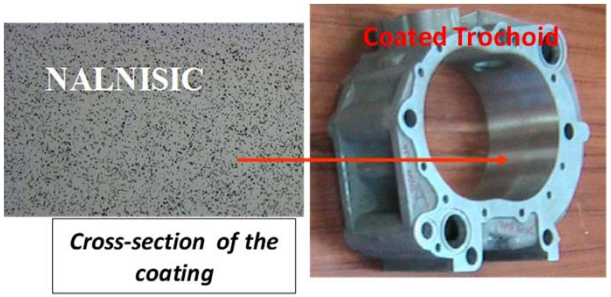
- Global sales USD 8.68 billion by 2022
- CSP-LED ceramic substrates market USD 700 million

ToT : CUMI, Hosur

Structures & Materials

Technologies & Products

Wear Resistant Nickel Composite Coating for Aerospace and Automobile Applications



Key Features: TRL : 7

- Ni-SiC coating exhibits microhardness >400 VHN
- Improved wear resistance ($4x10^{-5}$ mm^3/m)
- Flexibility in the thickness and properties

Applications: Rotary and reciprocating engines of UAVs , Light weight aircraft, micro UAVs, hang glider and automobiles

Demand of Aluminium in the auto sector of India is likely to be 11 mn Ton by 2030

Replacement for Chromic Acid Anodization (CAA) Process

TRL : 7

Process Clearance from CEMILAC

- Compliance with RoHS and REACH regulations
- Lower sealing temp. (60 – 80°C)
- Withstands >1000 h of SST
- Self- healing property eq. to CAA

Chromate-free coating systems to be in place by 2026 as per NASF forecast.

Applications:
Pretreatment layer for the corrosion protection paint system (Aerospace Al-alloy AA 2024)

Hard and Superhard Coatings for High Speed Machining and Solid Lubricant Coatings for Bearing Applications

TRL : 7

Superhard Nanostructured Coatings
High hardness (>30 GPa), high toughness (3 MPa $m^{½}$), high oxidation resistance (700-800°C in air)

Nanostructured Solid Lubricant Coatings

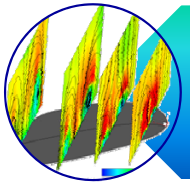
Applications: Cutting tools, watch industry, artificial jewellery, prosthetic device & medical tools

Global abrasive market -15000 Kilo Tons (US$ 37000 million by the year 2019)

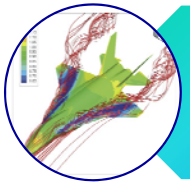
Industry Meet

Building Partnerships between Industry and CSIR-NAL

Aero thermal Sciences



Experimental Aerodynamics



Computational Fluid Dynamics

NTAF

Propulsion Technologies

Aero Thermal Sciences Technologies & Products

DHVANI

Detection and Hit Visualization using Acoustic 'N'-wave Identification

Key Features : TRL : 8

- Capable of detecting machine gun fire
- Caters to ranges up to 500m
- Extended to multi-lane ranges
- COTS low-cost components
- Cross-fire and Ricochet Detection
- Accuracy within 5mm on 5.56mm bullet
- Tested at Army Infantry School, Mhow

For Marksmanship Training in Indian Armed Forces

Cost effective : 60% of imported equipment

Demand : about 2000 systems

TOT : BEL, Bangalore

ABHIAS

Acoustic Based Hit Identification and Analysis System

Cost effective : 60% of imported equipment

Demand : about 2000 systems

ABHIAS undergoing field trials at BSF

- **Shots fired from Carbine (5 rounds) and Pistol (5 rounds). Diameter of bullets 9mm**
- **Accuracy of <7mm for 9mm bullet.**

Electronic target system for subsonic weaponry.

Aero Thermal Sciences Technologies & Products

Wankel Rotary Combustion Engine

NISHANT UAV
powered by WE

55 HP Wankel engine

30 hp

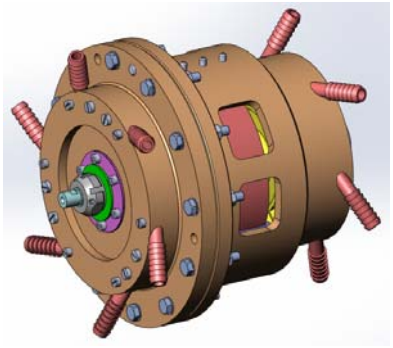
Key Features: TRL : 7

- High power to weight ratio
- Simplicity in design due to less number of components
- Fewer moving parts, Low noise and vibration
- Smooth power output, Ease of balancing

65 hp

Other Applications: Powered hang gliders / Personal air vehicles, Hybrid vehicles, Racing cars, Outboard motors and Compact power generators

Permanent Magnet Alternator



Alternator test rig
Model

Alternator- Turbine
Air Drive Assembly

Alternator Indigenously designed, developed and demonstrated for 4.5kW@30000 rpm. TRL : 5

Application

Alternator for small gas turbine engine

Demand (ADA,HAL &GTRE): 300 nos 0.1 to 5kW, speed 12,000-50,000 rpm

Thank You