

Empowering Sustainable Mobility Transition



54th Annual Report
 2023-2024

THE AUTOMOTIVE RESEARCH ASSOCIATION OF INDIA



ARAI Vision and Mission

Our Vision

- To become a world-class Mobility Engineering, Research and Innovation Institution.
- To be a leading Global Automotive Certification, Testing and Evaluation Organization.

Our Mission

- Create and facilitate SAFE, SUSTAINABLE and SMART Mobility Solutions.



2023 IESA Industry Excellence Award

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- **Financial Year 2023-24: A Year of Many Firsts**
 - Surpassed Rs. 500 crore Operational Income milestone
 - Type Approval of Hydrogen Fuel Cell EV (Bus)
 - Issue of Certificate for Gas Engine for CPCB IV+
 - Testing & Validation under Basic Customs Duty (BCD) Exemption Scheme
 - Testing for Bharat NCAP Rating
 - Domestic Value Addition (DVA) Certification for Auto PLI
 - Test as per UN R 135 - Pole side impact (using WorldSID dummy)
 - Grant of Twelve Patents to ARAI by 'The Patent Office', Government of India
- Recognized with '2023 IESA Industry Excellence Award on Battery Safety'
- HCNG Engine meeting CPCB IV+ Emission Limits developed along with OMC and Industry Partner
- Nominated by Ministry of Road Transport & Highways (MoRTH) as 'Scheme Implementing Agency' (SIA) for implementation of Pilot Projects for use of Hydrogen in Transport Sector under National Green Hydrogen Mission
- Launch of ARAI's MARG 2.0 (India-wide GIS based Road Roughness and Special Events Database) during SIAT 2024
- Successful organization of Symposium on International Automotive Technology – SIAT 2024 and Automotive Materials and Manufacturing Conference – AM&M 2023



SIAT 2024 Inaugural Ceremony

Empowering Growth of Mobility Eco-system Under the Support of Ministry of Heavy Industries

Major technological advances to both products and manufacturing processes are accelerating innovation throughout the global automotive industry. The industry is witnessing megatrends in the form of Electrification and Alternative Powertrains, ADAS and Autonomous Driving, Connected Vehicles, New Mobility Concepts, etc. The Indian automotive industry is also treading in this direction, ably supported by Government of India's policies & schemes, like Make in India initiative, Production Linked Incentives (PLI), Faster Adoption and Manufacturing of Electric vehicles (FAME), etc.

In line with this, Ministry of Heavy Industries (MHI), Government of India, has launched various initiatives, one of these being 'Scheme for Enhancement of Competitiveness in the Capital Goods Sector', which supports capital goods sector, including mobility eco-system. This scheme is to make the sector globally competitive, facilitate self-sustaining eco-system for research and innovation, enhance skills, support infrastructure creation for testing quality of processes/products developed, create common engineering infrastructure for designing and manufacturing, promote smart manufacturing and to nurture indigenization of technologies.

ARAI is being supported by MHI under this scheme for projects on augmentation of its Testing & Certification facilities in the areas of safety, viz. Battery Safety, Verification & Validation (V&V) of Advanced Driver Assistance Systems (ADAS) & Cylinder Testing, establishment of Centre of Excellence for Intelligent Vehicle Technology (IVT), setting up of Common Engineering Facility Centre (CEFC) for Digital Twinning and collaborative development of indigenous technologies through Technology Innovation Platform – TechNovuus.

● **Advanced Battery Safety Lab:**

Battery safety testing facilities at ARAI are being augmented to cater to futuristic national and international standards/ regulations. They are going to be technology agnostic and will support various sectors, apart from automotive applications, like consumer electronic, medical

devices, industrial equipment and stationary storage. These facilities will support Indian industry to develop, validate and certify their battery technologies locally.

Some of the major battery safety testing equipment being installed include:

- Walk-in Chamber for Battery Testing
- High Force Electrodynamic Vibration Shaker along with Climatic Chamber
- Mechanical Shock Test System
- Environmental Simulation facilities like Altitude, Salt Spray Chamber, Dust, Crush, Fire and Short Circuit Test facility

● **Modular Infrastructure for Verification & Validation (V&V) of ADAS:**

The infrastructure being established for V&V of ADAS will support Start-ups, MSMEs, Research Institutes working in the domain of advanced/intelligent vehicles and those engaged in

ADAS Test Track Equipment



Large Motion Platform



Car Target



Adult Bicyclist Dummy

developing control systems for different OEMs and Tier 1 manufacturers. These facilities can be directly utilized by different stakeholders for validating their ADAS control systems in vehicle and traffic environment. Along with these facilities, which are being established under the funding support of MHI, ARAI is also establishing 'Simulated City' level test track, which will be useful for field level validation of ADAS/ Autonomous Vehicles.

Some of the major ADAS Test Track equipment installed include:

- Motion Platforms
- Test Dummies
- Driving Robots
- Software
- Networking Equipment

● **Cylinder Testing:**

The facilities being established for cylinder testing will cater to meeting industry's requirement of approval of gaseous cylinders covering Type-I to Type-IV (type approval, batch approval, periodic testing and development testing). It will also foster technology upgradation in terms of light weight cylinders required for CNG and HCNG applications. Also, these facilities will be useful for approval of gaseous cylinders for various applications as per Gas Cylinder Rules, 2016.

Some of the major cylinder testing equipment being installed include:

- Hydrostatic Burst Rig
- Hydraulic Pressure Cyclic Rigs
- Volumetric Expansion Rig (Hydraulic)
- CNG Pressure Cyclic Rig
- CNG Permeation Rig
- Ultrasonic Machine
- Universal Testing Machine

Currently, orders for various equipment for battery safety testing and cylinder testing facilities have been placed. In case of ADAS V&V facility, ADAS test track equipment have been installed and

commissioned. Further, various complicated scenarios were demonstrated to the industry using the ADAS test equipment procured during ADAS V&V Conclave organized in November 2023. Also, couple of industry projects on development testing have been successfully executed utilizing the ADAS test equipment.

● **Centre of Excellence (CoE) for Intelligent Vehicle Technology (IVT):**

The technology solutions envisaged for development at this CoE include models for Indian traffic objects and infrastructure detection, cost effective vision/radar-based solution for Front Collision Warning System (FCWS) and alert to mitigation adaptation use case for AEBS (Automatic Emergency Brake System).

At present, data has been collected for about 15,000 km for annotation and with this data over 70,000 2D bounding boxes & 10,000 semantic segmentations have been created for building models for Indian traffic objects and infrastructure detection. In case of solution for FCWS, controller architecture has been finalized along with the Industry Partner and software model developed is being trained to increase the accuracy. Regarding solution on alert to mitigation adaptation use cases for AEBS, functional requirement of the system has been studied and hazard analysis risk assessment (HARA) has been completed.



Semantic Segmentation

● **Common Engineering Facility Centre (CEFC) for Digital Twinning**

Digital Twin Centre for Emerging Automotive Systems is being setup under Hub & Spoke model, with Hub located at ARAI, Pune and the two spokes

located at Bengaluru and Guwahati. This CEFC will help MSMEs and Start-ups for their product development, validation and training requirements. It comprises of:

- a. Centre for System Development using Artificial Intelligence and Machine Learning Techniques
- b. HIL Farm facility comprising of various "Hardware in Loop" Systems
- c. Centre for Integrated Computational Materials Engineering Simulation Platform

Currently, operations of HIL Testing have commenced at Pune and Bengaluru centres.



300 V EV HIL System with Start-up BMS at Pune

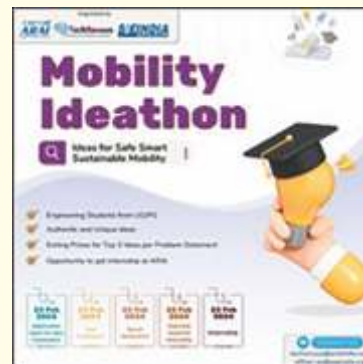
● **TechNovuus:**

TechNovuus, a Technology Innovation Platform of ARAI, is a collaborative eco-system for enabling indigenous technology, innovation and solution development through an open innovation and technology development platform. It facilitates development of solutions for challenges related to mobility to start with, and gradually will cater to other sectors, like Defence, Aerospace, Telecommunication, Railways, etc. providing an impetus to Government of India's Make in India and Atmanirbhar Bharat programs.

TechNovuus, built under the support of MHI, brings together solution providers and seekers to unlock the potential of new technologies that are driving and shaping the future technological revolution. It helps in addressing challenges in mobility area through India specific solutions using frugal and value engineering methodologies. It also helps in enabling India to emerge as a Technology and

Innovation hub across the world. This platform has different sub-portals, viz. Collaborative Technology Solutions, Technology Discussion Forum, Technology Transfer Portal, Technology Consortium Portal (Build Your Team) and Resource Sharing Platform. It currently has over 14,500 active users with 100 academic institutes and 150 experts from mobility domain.

Through its engagement programs, the platform has successfully delivered 2 Student Challenges, 1 Mobility Hackathon and 1 Mobility Ideathon for students, and 1 Grand Challenge for Start - Ups. Solutions to more than 200 industry problem statements have been addressed through these programs. Further, 8 innovations have been achieved through Student Hackathons and 7 innovations through UpTech program (up levelling program) for Start-ups. The Platform has also successfully conducted over 60 webinars by prominent industry experts in different automotive technology domains. In addition to this, 7 Workshops/ Design Clinics were also conducted with participation of 2,285 people across the country.



Mobility Ideathon for Safe Smart Sustainable Mobility

TechNovuus has facilitated training of more than 4,600 people in a myriad of topics, like E-Mobility, Innovation, etc. Further, internship programs have enabled more than 250 students to gain industry experience, which will be helpful in their career enhancement. Under these internship programs, students were provided opportunities to work on projects in domain areas of their interest. The current batch has around 45 students, who have opted internship for 3 to 6 months.

PRESIDENT	Dr. N. Saravanan , President & Chief Technology Officer, Ashok Leyland Ltd.
VICE PRESIDENT	Ms. Anjali Pandey , Chief Operating Officer, Cummins India Ltd.
DIRECTOR	Dr. Reji Mathai

ARAI is under the administrative control of Ministry of Heavy Industries, Govt. of India.

MEMBERS

- | | | |
|---|---|--------------------------------------|
| 1. Ashok Leyland Ltd. | 9. Hyundai Motor India Ltd. | 17. Tata Cummins Pvt. Ltd. |
| 2. Bosch Ltd. | 10. Kirloskar Oil Engines Ltd. | 18. Tata Motors Ltd. |
| 3. Cummins India Ltd. | 11. Mahindra & Mahindra Ltd. | 19. Toyota Kirloskar Motor Pvt. Ltd. |
| 4. Cummins Technologies India Pvt. Ltd. | 12. Maruti Suzuki India Ltd. | 20. Tractors and Farm Equipment Ltd. |
| 5. Eicher Motors Ltd. (Royal Enfield) | 13. Mercedes-Benz India Pvt. Ltd. | 21. TVS Motor Co. Ltd. |
| 6. Fiat India Automobiles Pvt. Ltd. | 14. Piaggio Vehicles Pvt. Ltd. | 22. VE Commercial Vehicles Ltd. |
| 7. Force Motors Ltd. | 15. Simpson & Co. Ltd. | 23. Volvo Group India Pvt. Ltd. |
| 8. Honda Cars India Ltd. | 16. Skoda Auto Volkswagen India Pvt. Ltd. | 24. Wheels India Ltd. |

GOVT. OF INDIA REPRESENTATIVES

Ms. Arti Bhatnagar

Additional Secretary & Financial Adviser,
Govt of India
Ministry of Heavy Industries
Udyog Bhavan, New Delhi 110 011

Dr. Hanif Qureshi

Additional Secretary,
Govt of India
Ministry of Heavy Industries
Udyog Bhavan, New Delhi 110 011

Mr. Rajnesh Singh

Director (Auto),
Govt of India
Ministry of Heavy Industries
Udyog Bhavan, New Delhi 110 011

INVITEES

- Society of Indian Automobile Manufacturers
- Automotive Component Manufacturers Association of India
- Tractor and Mechanization Association

SECRETARY TO THE GOVERNING COUNCIL

Mrs. Prajakta M. Dhere

OFFICE

Survey No. 102, Vetal Hill
Off Paud Road, Kothrud
Pune 411 038, INDIA
Phone : 91-20-6762 1122, 6762 1111
Email: director@araiindia.com

BANKERS

Bank of Baroda
HDFC Bank Ltd.

STATUS OF INSTITUTE

- Registered under The Societies Registration Act, XXI of 1860 Regn. No. 133/66 GBBS dated 10.12.1966
- New Regn.No. Maha/2066/2016/Pune dated 13.12.2016
- Registered under The Maharashtra Public Trust Act, 1950, on 12th April, 2016 in Mumbai and subsequently transferred to Pune Reg. No. F-48091/Pune dated 13.12.2016

STATUTORY AUDITORS

M/s. Kirtane & Pandit

Chartered Accountants,
5th Floor, Wing A, Gopal House,
S. No. 127/1B/1, Plot A-1,
Kothrud, Pune 411 038

Members

1. Action Construction Equipment Ltd **
2. Aargee Equipments Pvt. Ltd. ~
3. Adient India Pvt. Ltd. (Formerly Johnson Controls Automotive Ltd.)
4. A.J. Auto Pvt. Ltd.
5. Ammann India Pvt. Ltd. *
6. ARaymond India Pvt. Ltd.
7. Ashok Leyland Ltd.
8. Ather Energy Pvt. Ltd.
9. Atul Auto Ltd.
10. Autocomp Corporation Pansa Pvt. Ltd. *
11. Bajaj Auto Ltd.
12. Behr-Hella Thermocontrol (India) Pvt. Ltd.
13. BEML Ltd.
14. Bharat Forge Ltd.
15. Bosch Ltd.
16. Brakes India Pvt. Ltd.
17. BMW India Pvt. Ltd.
18. Chemito Infotech Pvt. Ltd.
19. Cooper Corporation Pvt. Ltd.
20. Cummins India Ltd.
21. Cummins Technologies India Pvt. Ltd.
22. Daimler India Commercial Vehicles Pvt. Ltd.
23. Eicher Motors Ltd.
24. Enginetech Systems Pvt. Ltd.
25. Escorts Kubota Ltd *
26. FCA India Automobiles Pvt. Ltd.
27. Fiat India Automobiles Pvt. Ltd.
28. Force Motors Ltd.
29. Greaves Cotton Ltd.
30. Greaves Electric Mobility Pvt. Ltd. (Formerly Ampere Vehicles Pvt. Ltd.)
31. Gromax Agri Equipment Ltd. (formerly Mahindra Gujarat Tractor Ltd).
32. Hero Electric Vehicles Pvt. Ltd.
33. Hero MotoCorp Ltd. **
34. Honda Cars India Ltd.
35. Hyundai Motor India Ltd.
36. India Japan Lighting Pvt. Ltd.
37. India Kawasaki Motors Pvt. Ltd.
38. Isuzu Motors India Pvt. Ltd.
39. JCBL Ltd.
40. JSW MG Motor India Pvt. Ltd. #
(Formerly MG Motor India Pvt. Ltd.)
41. Kabra Extrusion Technik Ltd. *
42. Kia India Pvt. Ltd. (formerly Kia Motors India Pvt. Ltd.)
43. Kinetic Green Energy & Power Solutions Ltd. *
44. Kirloskar Oil Engines Ltd.
45. Kohler Power India Pvt. Ltd. (Formerly Lombardini India Pvt. Ltd.)
46. Lear Automotive India Pvt. Ltd.
47. Madras Engineering Industries Pvt. Ltd.
48. Mahindra & Mahindra Ltd.
49. Mahindra Last Mile Mobility Ltd. **
50. Maruti Suzuki India Ltd.
51. Masstrans Technologies Pvt. Ltd.
52. Mercedes-Benz India Pvt. Ltd.
53. MLR Auto Ltd.
54. MSKH Seating Systems India (P) Ltd.
55. Omega Seiki Pvt. Ltd. *
56. PCA Automobiles India Pvt. Ltd.
57. Piaggio Vehicles Pvt. Ltd.
58. Pinnacle Mobility Solutions Pvt. Ltd. **
59. P M Diesels Pvt. Ltd.
60. Randhawa Automobile Engineering Pvt. Ltd.
61. Renault Nissan Automotive India Pvt. Ltd.
62. Rocket Engineering Corporation Pvt. Ltd.
63. Rotary Electronics Pvt. Ltd.
64. Simpson & Co. Ltd.
65. Skoda Auto Volkswagen India Pvt. Ltd.
66. S. M. Auto Engineering Pvt. Ltd.
67. SML Isuzu Ltd.
68. Switch Mobility Automotive Ltd.
69. Tata Cummins Pvt. Ltd.
70. Tata Motors Ltd.
71. Terex India Pvt. Ltd.
72. T. M. Automotive Seating Systems Pvt. Ltd.
73. Toyota Kirloskar Motor Pvt. Ltd.
74. Tractors and Farm Equipment Ltd.
75. Trimble Mobility Solutions India Pvt. Ltd.
76. TVS Motor Co. Ltd.
77. Vanaz Engineers Ltd.
78. VE Commercial Vehicles Ltd.
79. Visteon Technical and Services Centre Pvt. Ltd.
80. Volvo Group India Pvt. Ltd.
81. Wardwizard Innovations & Mobility Ltd. *
82. Wheels India Ltd.
83. ZF Commercial Vehicle Control Systems India Ltd.
(Formerly WABCO India Ltd.)

* New Membership

** Membership approved w.e.f. 1st April 2024

~ Withdrawal

Change in Name

FINANCE & INTERNAL AUDIT COMMITTEE (FIAC)

CHAIRMAN

Ms. Anjali Pandey

Vice President- ARAI

Chief Operating Officer, Cummins India Ltd.

MEMBERS

Mr. Balaram Pradhan

General Manager, Finance
Mercedes-Benz India Pvt. Ltd.

Mr. Abhinav Sogani

Head of Tax & Customs - India Centre of
Excellence, Tax & Customs, Finance,
Skoda Auto Volkswagen India Pvt. Ltd.

Mr. Dinesh Gandhi

Vice President - Finance
Maruti Suzuki India Ltd.

Mr. Gopal Bhutada

Sr. General Manager, Supply Chain
Tata Motors Ltd.

Mr. Chetan Kamdar

Finance Director
Cummins India Ltd.

Mr. Rasesh Joshi

CFO - Mahindra Last Mile
Mobility Ltd.

Mr. Ankur Gupta

CFO, B2B Business,
Kirloskar Oil Engines Ltd.

Mr. Banu Prasanna

General Manager - Finance,
Ashok Leyland Ltd.

Members from ARAI

Dr. Reji Mathai

Director-ARAI

Mr. Atul Bhide

Deputy Director

(HoD- Finance & Accounts), Member Secretary

PROJECT EVALUATION & MONITORING COMMITTEE (PEMC)

CHAIRMAN

Mr. Aniruddha Kulkarni

Vice President & Head CVBU Engineering, Tata Motors Ltd.

MEMBERS

Mr. R. K. Jaiswal

Development Officer (Engineering),
Government of India,
Ministry of Heavy Industries

Mr. Alok Jaitley

Sr. Vice President (Engg)
Maruti Suzuki India Ltd.

Mr. S. Janardhanan

Vice President (Co-ordination),
Simpson & Co. Ltd.

Mr. Rajinder S. Sachdeva

Chief Operating Officer,
V E Commercial Vehicles Ltd.

Mr. Abhijit Phadke

Director,
CTCI Lab & Test Operations,
Chief of Staff - Technical Leadership
Team, Cummins India Ltd

Mr. S. Sriraman

Sr. Vice President (R&D)
Tractors and Farm Equipment Ltd.

ARAI Members on PEMC:

Dr. Reji Mathai

Director-ARAI

Mr. N. B. Dhande

Sr. Dy. Director, ARAI

Mr. Suyog Gadgil

Manager, Member Secretary

President's Statement



Dr. N. Saravanan
President, ARAI



Ms. Anjali Pandey
Vice President, ARAI

Dear Members,

Financial Year 2023-24 was a historic year for ARAI, as we registered a record Operational Income of Rs.508.72 crore (~21% YoY growth). Throughout the year, we demonstrated the power of our capabilities and provided solutions to our customers to serve their emerging needs. In terms of milestones achieved, this was a 'Year of Many Firsts'. Apart from the historic operational income milestone, we emerged as the first Indian Automotive Test Agency to release Domestic Value Addition (DVA) certificate under Auto PLI Scheme, certify Hydrogen Fuel Cell EV Bus in India, carry out testing & validation under Basic Customs Duty Exemption Scheme and certify CPCB IV+ Gas Engine. We also carried out testing as per UN R 135 for pole side impact using WorldSID dummy and Bharat NCAP Rating test for the first time. We continued to extract value from our portfolio of opportunities in certification business, as we registered record number of certification assignments covering electric buses, trucks, trailers, ambulances, caravans, genset engines, export homologation projects, etc. Another notable milestone achieved was relating to patents, with ARAI being granted twelve patents during the year. With regard to regulations and standardization activities, we contributed extensively in various national and international committees, like AISC, CMVR-TSC, SCoE, BIS and WP.29. These accomplishments, combined with resilience of our employees, make me very optimistic about our future.

In terms of milestones achieved, this was a 'Year of Many Firsts'

"Innovation is essential to our success and so, is one of our primary focuses"

Innovation is essential to our success and so, is one of our primary focuses. This strategy has enabled us in building more capabilities and competencies, resulting in new offerings to our customers, not limiting to automotive, but also to other sectors, like space, railways, defence, consumer durables and healthcare. Further, it has played a pivotal role in achieving breakthroughs in commercialization of in-house developed technologies in the last couple of years. During the year 2023-24, we successfully carried out engine development and engine upgradation projects to meet India Genset Emissions Stage IV+ (IGES IV+) norms, along with other projects, like CNG engine development for bus application and HCNG engine development for genset application. The software developed in-house for Acoustic Vehicle Alerting System (AVAS) was upgraded with refined functionalities and optimizations tailored to real-time audio synthesis, adjustment and modulation. Also, software package for systematic updation of road roughness database was developed in-house. Moving ahead, we are committed to develop solutions in intelligent vehicle technologies and alternate fuels that advance sustainable future. I firmly believe the innovations we create today will help lay the groundwork for our sustainable growth in the future.

Our disciplined and focused investments have generated significant value for ARAI. We scaled up our investments not only in new facilities, but also in upgrading and augmenting the existing ones. Some of the major facility additions during the year included 4x4 chassis dynamometer, advanced acceleration sled facilities, advanced NVH development centre, advanced photometry & optics laboratory and battery pack crush/ fire facility. We are also investing in facilities like hydrogen engine test cell, machine-in-loop test facility for E-powertrain, 2 dyno set up for E-axle & EV drivetrain testing, high energy impact testing, etc. Also, emphasis on skilling has resulted in about 27,000 man-hours of training for our employees, covering both technical and non-technical areas.

“Our disciplined and focused investments have generated significant value for ARAI”

As always, we worked in pursuit of our commitment to knowledge dissemination across industry professionals and student community – from upskilling of industry professionals through Proficiency Improvement Programs (PIPs), to nurturing student community through B. Tech., Post Graduate Diploma and M. Tech. programs in collaborations with various Universities. During the year, we conducted thirty-one PIPs for industry professionals and added JSPM University to our list of prestigious collaborations for conducting academic programs.

“While we take pride in our achievements, we also remain grounded and humble, mindful of the challenges ahead”

I am proud of what Team ARAI has achieved. While we take pride in our achievements, we also remain grounded and humble, mindful of the challenges ahead. The technology landscape is evolving fast, demanding a deep commitment to innovation and

adaptation. As we continue working on our growth story in this evolving technology landscape, the increased expectations of the entire eco-system strengthen our resolve to deliver all-round performance year after year and reaffirm brand ARAI with renewed energy.

So, as we move into the future, the choices we make at this defining moment for our organization are key to shaping our long-term vision – one that extends beyond strengthening our leadership position in certification, to becoming an enabler for development of India specific innovative technologies and solutions in mobility domain. Our long-established leadership in certification, the breadth of our portfolio, the trust we have built with our customers and our collective commitment to innovation give me great confidence in our future and our ability to capture many opportunities ahead.

“So, as we move into the future, the choices we make at this defining moment for our organization are key to shaping our long-term vision...”

I would like to express my sincere appreciation to the Vice President – ARAI and Members of the Governing Council; Ministry of Heavy Industries (MHI); the Chairman and Members of Finance and Internal Audit Committee; the Chairman and the Members of Project Review and Monitoring Committee, the Chairman and the Members of Project Evaluation and Monitoring Committee; ARAI Members; and Director – ARAI for their continued guidance and support. I would like to thank all the employees for their dedicated work and commitment to excellence. I would like to close by thanking all our customers, partners and associates for their unwavering faith in ARAI.

Dr. N. Saravanan



Dr. Reji Mathai

Director - ARAI
 director@araiindia.com

Director's Report

The Governing Council of ARAI has great pleasure in presenting the Annual Report and Audited Statement of Accounts for the year ending 31st March 2024.

Financial Year 2023-24 was a milestone year for ARAI as our Operational Income surpassed a significant milestone of Rs.500 crore. We delivered record operational income of Rs.508.72 crore, up 21% year-on-year. Even more impressive is that we achieved this while successfully navigating a dynamic operating environment. This remarkable performance is a clear indication of

This remarkable performance is a clear indication of the power of our capabilities and operational agility.

the power of our capabilities and operational agility. I am incredibly proud of our employees, whose committed efforts enabled us to deliver these results and to create value for not only our stakeholders, but also our society.

Certification has been a major driver of our growth over the past many years and our customers increasingly recognize this. We continued to build on these strengths during this year, as we successfully delivered services like Domestic Value Addition certification under Auto PLI scheme, testing for Bharat NCAP, testing & validation under Basic Customs Duty Exemption scheme, etc. for the first time for the Indian Automotive Industry.

At the same time, we have been investing in our future through our research programs for building innovative eco-system and competencies.

At the same time, we have been investing in our future through our research programs for building competencies and innovative eco-system for the automotive industry. I am happy to share that these efforts are yielding commendable results, as we continued with building on monetizing our in-house developed technologies and venturing into newer service domains. As a result of our focus on building innovative eco-system, we were awarded

twelve patents by the Patent Office, Government of India. I congratulate all the projects teams for this magnificent achievement.

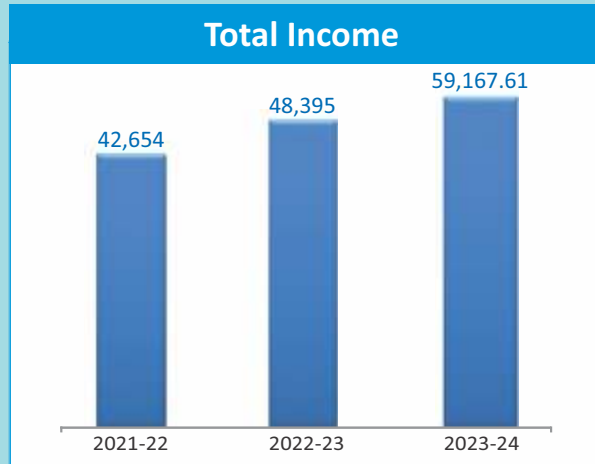
To summarize, we had a phenomenal year. Our financial year 2023-24 results demonstrate the strength of our operations today and are a solid foundation for future growth. Moving ahead, I am excited as the future holds great promise for us. I am confident, our leadership position in certification, together with our relentless pursuit for technology development, will enable us to scale new heights.

To summarize, we had a phenomenal year. Our financial year 2023-24 results demonstrate the strength of our operations today and are a solid foundation for future growth.

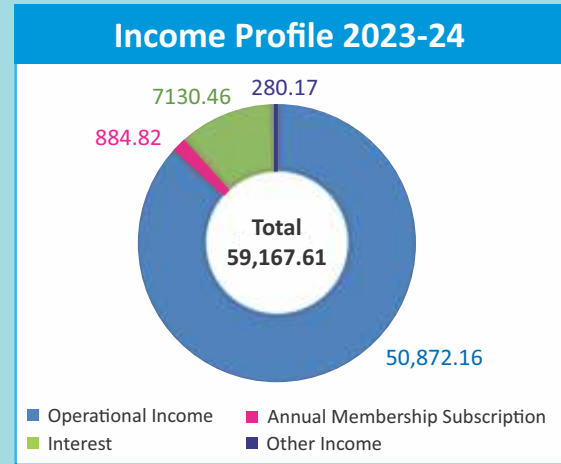
On behalf of Team ARAI, I would like to thank the President, the Vice President, Members of the Governing Council, Finance & Internal Audit Committee, Project Evaluation & Monitoring Committee, Project Review & Monitoring Committee, ARAI Members and Senior Officials of Ministry of Heavy Industries for their continued support and guidance.

Dr. Reji Mathai

(Rs. in lakh)



(Rs. in lakh)



OPERATIONAL HIGHLIGHTS

● Finance & Accounts

Income & Expenditure Account, Balance Sheet and Auditor's Report are presented herewith.

■ Financial Performance

During the Financial Year 2023-24, Operational Income is Rs.50,872.16 lakh as compared to Rs. 41,951.57 lakh in 2022-2023. Total Income is Rs. 59,167.61 lakh as compared to Rs. 48,395.10 lakh of last year.

■ Investment of funds

The cash & bank assets available with ARAI have been invested in Scheduled Banks / Financial Institutions in term Deposits and in Government Securities as per the Governing Council's guidelines.

■ Appointment of Statutory Auditors

M/s. Kirtane & Pandit, Chartered Accountants, Pune were appointed as Statutory Auditors for the Financial Year 2023-24, in the Annual General meeting held on 12th September 2023.

■ Membership Subscription

The total number of members of ARAI as on 31/3/2024 is 79 and the Annual Membership Subscription for the year under report is Rs. 884.82 lakh.

■ Recognition by DSIR

ARAI is recognized as a Scientific and Industrial Research Organization (SIRO) by the Department of Scientific & Industrial Research, Ministry of Science & Technology, Govt. of India for the period from April 2023 to March 2026.

■ Income Tax

Central Board of Direct Taxes has approved ARAI for exemption purposes under Sec. 35 (1) (ii) of Income Tax Act, 1961, vide Notification No. 9/2007 (F.No. 203/18/2005-ITA –II) dated 28-3-2007 effective 01-04-2004.

● Government Supported Projects

Various ongoing projects approved by Ministry of Heavy Industries (MHI) for enhancing capabilities & capacities are-

- Development of web-based Technology Innovation Platform, viz. TechNovuus
- Augmentation of existing facilities at ARAI, viz. Battery Safety Lab, Modular Infrastructure for V&V of ADAS and Cylinder Testing
- Establishment of Digital Twin Centres for Emerging Automotive Systems

- Establishment of Centre of Excellence (CoE) for Intelligent Vehicle Technology (IVT)

Projects supported by other ministries-

- Project on Development of R&D Roadmap Document for E-mobility in India - supported by Office of the Principal Scientific Adviser, Government of India
- Evaluation of Retrofitment of 2-wheeler & 3-wheeler vehicles with Electric Drive as an option for improvement in air quality in NCR – supported by Centre for Air Quality Management in National Capital Region and Adjoining Areas
- Development of SiC based Battery Emulator with CDAC – supported by Ministry of Electronics & Information Technology, Government of India
- Prototype Aluminium Seat Frame for passenger buses with Jawaharlal Nehru Aluminium Research Design & Development Centre (JNARDDC) – supported by Ministry of Mines, Government of India

● Research and Development

ARAI is also undertaking projects under internal funding to enhance competencies and meet industry's future requirements, like controller for switched reluctance motor, life cycle analysis study on lithium-ion battery recycling, GISSMO material card databank, study of camera monitoring system, dummy kinematics assessment, etc.

● Model Inspection & Certification (I&C) Test Centres

ARAI has been identified by Ministry of Road Transport & Highways (MoRTH) for facilitating establishment of model test centres for Inspection and Certification (I&C) of in-use vehicles. Under this program, ARAI has facilitated establishment of I&C Centres in five states and is working in another five states. Currently, ARAI is providing consultancy to Transport Department of

Maharashtra for setting up I&C centres at forty-four different locations across the state. Apart from this, audits of thirteen vehicle fitness test centres of private parties have been carried out as per the approved procedure of Rajasthan State Government.



Inspection & Certification Centre at Bengaluru

● Business Development Initiatives

- MoUs for collaborations in the areas of zero emission transport, vehicle & component homologation, tyre regulation services, alternate energy & fuel systems, inspection & certification, engine development, etc.
- Organized Symposia / Workshops / Training Programs like Symposium on International Automotive Technology (SIAT 2024), International Conference on Automotive Materials and Manufacturing (AM&M 2023), International Conference on Advanced Powertrains for Mobility & Power Generation Applications, ADAS V&V Conclave 2023, Workshop on Automotive Cyber Security, Customer Meet at Chennai, etc.
- Showcasing and demonstration of capabilities at exhibitions like, Automotive Testing Expo 2023; India Energy Storage Alliance (IESA); Connected, Autonomous & Electric Vehicle (CAEV 2023); Automotive Materials & Manufacturing (AM&M 2023); ET Auto EV Conclave; Bharat Mobility Expo 2024; Conclave on Autonomous Technology & System (CATS); SIAT 2024 etc.

- Capitalizing business opportunities through Regional Centres at Chennai, Hyderabad and Bengaluru
- Establishment of Creative Cell for corporate communication
- Leveraging Social Media Platforms for reaching out to potential clientele

● **Capacity Building and Augmentation**

ARAI is committed to continue investing in new capacities and upgrading existing facilities to strengthen its position and deliver superior services to the emerging needs of customers. During the year, ARAI invested in facilities, like 4x4 chassis dynamometer, advanced acceleration sled facilities, BSR test rig, reverberation chamber, hemi-anechoic chamber, goniometer, hydraulic burst testing equipment, ADAS test track equipment, climatic chambers, servo hydraulic facility, particulate measurement system, fuel conditioning system, low power e-motor test bed, battery pack crush/ fire facility, gravel bombardment equipment, etc. This augmentation strategy will continue in the coming year with addition of new facilities in the areas of electric vehicle and hydrogen like machine-in-loop test facility for E-powertrain, 2 dyno set up for E-axle & EV drivetrain testing, hydrogen engine test cell and other equipment, viz. PEMS and 350 kW transient dynamometer.

● **Domestic Value Addition (DVA) Certification for Auto PLI**

Government of India has introduced Production Linked Incentive (PLI) Scheme for Automobile and Auto Component industry for enhancing India's manufacturing capabilities for advanced automotive products. This PLI Scheme is for boosting domestic manufacturing of Advanced Automotive Technology (AAT) products and attract investments in the automotive manufacturing value chain.

ARAI has been appointed as a Test Agency to carry out Domestic Value Addition (DVA) Certification according to Auto PLI Standard Operating Procedure (SoP). Inline with this mandate, a separate PLI Cell formed at ARAI has issued thirty nine certificates during 2023-24 and ARAI was the first amongst all the authorized test agencies to release DVA certificate.

● **Systems Compliance and Quality Management**

- Successful completion of 2nd Surveillance Audits of ISO 9001:2015, ISO 14001:2015, ISO 45001:2018 and ISO 27001-2013 by TuV SUD, India
- Recognition by Bureau of Indian Standards (BIS) for thirteen safety components as per relevant IS Standard
- Successful completion of Reassessment by National Accreditation Board for Testing and Calibration Laboratories (NABL) as per ISO/IEC 17025:2017 (for Calibration Scope at Kothrud and Chakan Centres of ARAI)
- Successful completion of Reassessment by NABL as per ISO/IEC 17025:2017 for Testing Scope at ARAI Kothrud and ARAI-HTC, Chakan (seventy six new test services added in the scope)
- Recognition by RDW, Netherlands as 'Technical Service Provider' to carry out CoP verification audits
- Accreditation by Land Transport Authority (LTA) and National Environmental Agency (NEA), Singapore as 'Recognized Overseas Test Lab'
- Accreditation by NABL for Virtual Testing (only test agency in India and one of the very few in the world to obtain accreditation for virtual test scope)
- Accreditation of load cell calibration facility as per ISO/IEC 17025:2017

- Approval of NTSEL for Exhaust Emissions of Motor Cycles (WMTC) as per TRIAS 31-J044GTR002-01

● **Continual Improvement Initiatives**

ARAI strongly believes in continual improvement culture. Following are some of the continual improvements carried out to build and strengthen operational excellence during the year.

- Establishment of Advanced NVH Development Centre at FID-Chakan, Acceleration Sled facility at FID-Chakan and Advanced Photometry and Optic Laboratory at HTC-Chakan
- Establishment of test instrumentation for ADAS/ Autonomous Vehicle testing under field level conditions
- Installation of Solar Power Plants at Kothrud, HTC – Chakan and FID - Chakan
- Expansion of Servo-hydraulic facility
- Installation of high-performance computing server for handling large computational models
- Upgradation of RDE vehicle preparation area, dyno lab, fire lab, high intensity lighting system at bungee sled facility and various softwares
- Modification of existing Coolant Rig for suitability to JIS standard
- Automation of concentrations calculation in Microbalance
- Interactive web portal software for certification of components and sub-system

● **Environment, Occupational Health & Safety**

ARAI believes in working in harmony with the environment. In line with this, ARAI focuses on

environmental protection, occupational health and safety, and also, endeavours for continual improvement in environmental, health and safety performance of employees and stakeholders. During the year, following events were organized with active participation of all employees.

- Observance of World Environment Day
- Observance of Swachhta Pakhwada
- Observance of National Safety Week
- Observance of National Road Safety Month
- Training organized on Sustainability
- Training organized on Road Safety for Drivers
- LiFE pledge taken by employees



Observance of National Safety Week

● **Corporate Social Responsibility (CSR)**

At ARAI, being socially responsible is at the core of how we define ourselves and act. We believe in a shared responsibility to operate in ways that respect, protect and benefit our communities and our environment. To support this, we encourage employee volunteerism through our Social Responsibility Support Group (SMSG). As a part of CSR activities of ARAI, this group focuses on social initiatives in education, healthcare and community development. This year we supported Ratnagiri

based Swagruhi Seva Sanstha, engaged in supporting old age orphanage, with lunch tables and incinerator for disposal of used diapers. We also supported Pune based Aniket Sevabhavi Sanstha, engaged in supporting special children, with heavy-duty cloth washer and dryer. Apart from these, science laboratory on wheels to perform science experiments under the guidance of experts, was provided to Vidnyanvahini. This organization is engaged in teaching Physics, Chemistry and Biology to 8th, 9th & 10th grade students in rural areas, where such laboratories are not readily available in schools.



Science Laboratory on Wheels for Students from Rural Areas



Visit of ARAI's SRSR Team to Aniket Sevabhavi Sanstha

● ARAI – AMTIF

ARAI-Advance Mobility Transformation & Innovation Foundation (ARAI-AMTIF) is a section-8 company promoted by ARAI to nurture innovation and startup eco-system in mobility space. MHI funded Industry Accelerator program is being implemented through ARAI-AMTIF, wherein ten different technologies are being supported to develop market ready solutions in the areas of E-mobility system & sub-systems; sensors, electronics & controls; and safety components. ARAI-AMTIF is also currently supporting startups and innovators at different stages through Startup India Seed Fund Scheme (SISFS) of Department for Promotion of Industry and Internal Trade (DPIIT).



Dr. Hanif Qureshi, Additional Secretary, MHI at ARAI-AMTIF Stall



ARAI-AMTIF and TechNovuus Stall at SIAT EXPO 2024

Research & Development

Testing and Certification

Role in Standardization

New Facilities

Human Resource Development

Publications and Patents

Business Development

Events

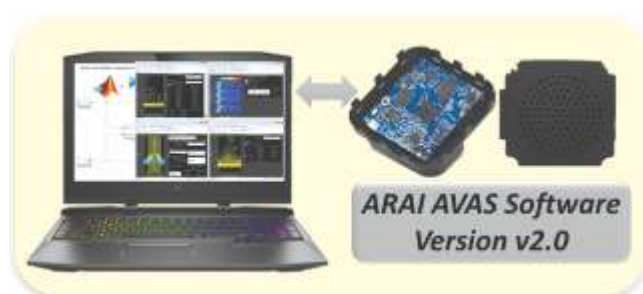
ARAI Academy

ARAI undertakes research and development programs to build competencies, capabilities and competitiveness, which in turn, has reflected in its consistent growth. Leveraging its inherent strengths in different automotive engineering domains, ARAI has successfully executed various Government supported/ industry funded/ internally funded research projects. Some of the research projects implemented during 2023-24 are listed below.

DESIGN & DEVELOPMENT

- Acoustic Vehicle Alerting System (AVAS) Software Upgradation

ARAI had developed Acoustic Vehicle Alerting System (AVAS) couple of years ago meeting minimum sound emission and frequency shift requirements as per UN R138 and AIS-173. It serves as an effective warning mechanism bolstering overall safety measures and mitigating accident risks. The software of this system has now been upgraded (V2.0) with refined functionalities and optimizations tailored to real-time audio synthesis, adjustment and modulation. With this upgrade, users have the capability to dynamically adjust the frequency spectrum of the synthesized sound, allowing precise manipulation of octave bands to refine sound quality and mitigate harshness across various speed ranges. The model-based framework facilitates seamless optimization and deployment across broad spectrum of 32-bit microcontrollers, equipped with requisite hardware, thereby enhancing portability.



Upgraded AVAS Software (V2.0)

- Controller for Switched Reluctance Motor

A project on developing closed-loop control strategy algorithm for Switched Reluctance Motor is currently being implemented. This project has been taken up for development of an indigenous solution, as currently PM drives and solutions are imported and also are not optimized for operation in Indian conditions. This development process includes design of system architecture at hardware & software level, control strategy & plant model development, hardware architecture design of controller, finalization of controller components, controller hardware and software integration and functional testing.

- Payload Surpass Detection in Commercial Vehicle

This ongoing project is on development of cost-effective payload measuring solution for commercial vehicles in 1 to 15 ton category. The proposed solution will be based on a non-contact displacement sensor. Under this project, appropriate technology for load sensing is being finalized based on for the existing technologies and international norms for load monitoring. The developed solution will be integrated with the vehicle and then tested against calibrated loads. This solution will indicate surpass of defined payload of vehicle.

- Life Cycle Analysis of Lithium Ion Battery Recycling

This study is undertaken to quantify environmental impact of various battery recycling processes being used commercially in India and understand most suitable technology, which can be scaled up in an environment-friendly way. For this purpose, ARAI is engaging with multiple industries to understand the recycling process of lithium ion battery and carry out data mining for life cycle analysis. Lithium ion cells will be procured and pilot recycling study will be carried out with the

industry to evaluate the potential of using the recovered material as raw material for manufacturing the batteries again. This exercise will help in understanding efficiency of the said process. Subsequent to this, life cycle analysis will be carried out and results will be discussed with the industry for refining.

- CPCB II Engine Development to meet IGES IV+ / CPCB IV+

A 12 Cylinder 600 kVA CPCB II Engine has been developed meeting India Genset Emissions Stage IV+ (IGES IV+) / CPCB IV+ norms. In this development process, after-treatment selection was carried out along with extensive engine calibration in order to meet tail pipe PM and NOx emissions. This has resulted in reduction of NOx, PM, HC and CO by more than 95% as compared to baseline engine. The end result has been development of the engine meeting final tailpipe emission targets with more than 30% margin.

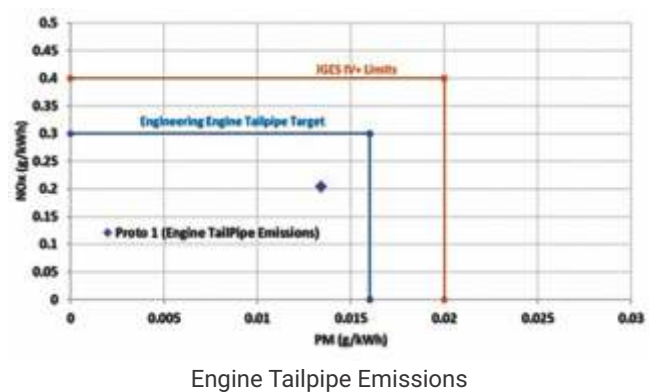
- BS-VI CNG Engine for Bus Application

This project was for development of a CNG Engine for bus application. Towards this development, 1 D thermodynamic simulation was carried out for performance prediction and selection of intake & exhaust system, EGR, throttle body and turbocharger. Further, with the help of 3 D simulation, bowl selection was arrived at, along with compression ratio, and location of CNG injector & P-theta was finalized. Also, exhaust temperature was predicted using 3 D simulation. Model built, based on the analysis, was validated and recommendations were made on performance and combustion package.

- Upgradation of Engines to meet IGES IV+

Three engines of different capacities have been upgraded successfully to meet India Genset Emissions Stage IV+ (IGES IV+)

emission norms, with electronically controlled mechanical fuel injection, including OBD (engine +NCD). It involved acquisition & analysis of base engine data for building base engine model and its validation, simulation of hardware DOE matrix, 1 D thermodynamic simulation, prediction of cycle emissions, hardware finalization & its procurement. The engine built with the hardware was then calibrated for engine out emissions and engine tail pipe emissions. Also, OBD calibration was carried out on virtual test bed, as well as test bed. Further to the calibration, all the three engines were observed to meet tail pipe emission for IGES IV+ norms, that too with limited hardware combinations.

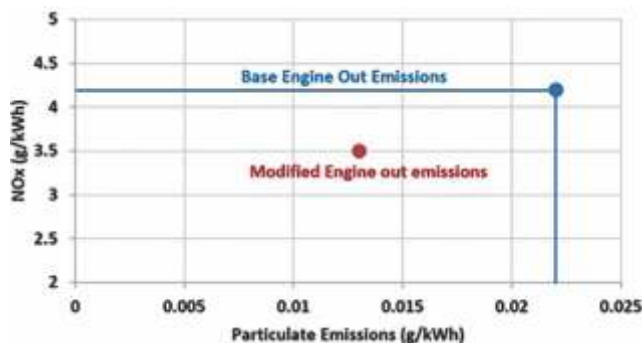


- Diesel Genset V-Twin Engine Upgradation to meet CPCB IV+ Norms

This ongoing project is for upgradation of twin cylinder engine for power rating 15.5 kW @ 3000 rpm to meet CPCB IV+ emissions with mechanical fuel injection unit pumps & EGR system. The project commenced with data acquisition & analysis of base engine test data for base engine 3 D combustion model build and its validation, simulation of hardware DOE matrix, 1 D thermodynamic simulation and thereby prediction of cycle emissions, hardware finalization & its procurement. Further, engine was built with the selected hardware. Currently calibration is in progress for targeted engine out and tail pipe emissions.

- Combustion Hardware Selection to meet Trem V Norms

This project was for exploring combustion hardware parameters through 1 D and 3 D combustion simulation and to select suitable combustion hardware combinations for BSFC & emissions, and BSFC improvement of NA diesel engine for 50HP power rating. In this project, 3 D combustion simulation approach was used evaluate the existing hardware limitations and derive suitable hardware to meet stringent engine out emissions. The proposed hardware worked out was then evaluated on NA engine and for tail pipe emissions to achieve best PM and BSFC.



Emissions Values with Selected Hardware Combination

- Drive Cycle based Energy Audit and Range Estimation

The objective of this ongoing project is vehicle energy audit, estimating range and parameter sensitivity analysis of a light commercial electric vehicle. The methodology being adopted for this purpose includes acquiring of 3000 km of duty cycle data and its condensing on chassis dyno. Also, testing will be carried out to evaluate drag area along with testing of components like motor, battery, differential and tires. Thereafter, simulation model will be built. This entire process will help in energy audit of

the base vehicle, estimation of range, parameters sensitivity analysis and arriving at possible recommendations on battery sizing for the selected vehicle.

- Packaging of Common Rail Injector for Cylinder Head

A Project for integrating common rail fuel injection system for meeting CPCB IV+ emission norms has been successfully completed. Under this project, cylinder head was redesigned with minimal changes in order to package two common rail injectors. It also included redesigning of intake port in new cylinder head from downward opening intake manifold to side opening intake manifold. Subsequent to these design changes, packaging and integrating of common rail injectors meeting CPCB IV+ emission norms were achieved.

- Design & Development of Power Distribution Unit (PDU)

ARAI is currently working on design and development of PDU (e-axle) for small and light commercial electric vehicles. In this project, architecture of e-axle powertrain along with sizing, and packaging of components is being designed. Also, it includes development of control logic functions and demonstration of vehicle performance in the field. The end deliverable of this project will be an e-axle based electric vehicle converted from base IC engine platform.

- E-axle for Light Commercial Vehicle

E-axle is being designed and developed for Light Commercial Vehicle application as a retrofit option. This project involves development of architecture of e-axle based electric powertrain, sizing and packaging of the components, development of control logic functions and demonstrating performance of the vehicles in field.

- 4 Cylinder Engine for CNG Application

ARAI is working on design of components and sub-systems of a 4 Cylinder CNG Engine for BS-VI OBD II emission requirements. Under this project, engine is being designed from concept level, including thermodynamic and mechanical design layout. This project involves carrying out FEA & CFD, simulations of engine thermal & structural systems, 3 D CAD models, 2 D drawings. Also, support to vendors for component manufacturing and proto development is being provided. The proto engine built will be tested for performance validation and calibrated for meeting the desired engine performance targets as per BS-VI OBD II emission requirements. Currently, design & simulation phases have been completed and design is being finalized for proto manufacturing.

- Design Modifications and Analysis of Engine Components

This ongoing project is on raising torque of the existing 3 and 4 Cylinder Engine up to 65 Nm and 85 Nm respectively. Methodology adopted to increase the existing torque to target value includes revising stroke length, assessment of existing intake manifold volume, valve timings & fuel curve base engine testing for generating inputs for 1 D thermodynamic simulation, validating base engine performance and assessment of existing water jackets of engines for increased engine torque performance through CFD analysis. Subsequent to finalization of stroke value and performance target, detailed design of power train components, including crankshafts & connecting rods, will be carried out.

- Electric Water Pump for Automotive Application

ARAI is working on design and development of Electric Water Pump (30W and 65W) for

automotive application. Under this project, 3 D CFD simulation of both electric water pump models and motor design activity have been completed. Further, prototypes are being developed for manufacturing, subsequent to which they will be tested for their target performance. These electric water pump models will then be used for circulation of coolant in IC Engine and also in EV/ HEV.

- Closed Die Forging Process Development for Magnesium Alloys

ARAI, along with an industry partner has developed a closed die forging process for magnesium alloys, under the internally funded project. This process has been developed on an aerospace component made of AZ80 alloy. In this project, thermo-mechanical simulation was carried out to generate material properties in simulation software. In addition to this, die design and optimization of forging process parameters was also done. This process is expected to be a substitute for the current process of extrusion + machining.

- GISSMO Material Card Databank for Sheet Metals

This internally funded project is on characterizing and validating Advanced High Strength Steels and Aluminium Alloys in sheet metal form (used for BIW applications). Under this project, Generalized Incremental Stress State Dependent Damage Model (GISSMO) cards will be developed. These cards will be available to designers from the industry in databank format – spanning OEMs, Engineering Service Providers, etc.

Similar to the above project, competency enhancement for material model card generation for plastics and composites has been taken up. Under this project, ARAI is working with renowned global entities to

develop competence in material model card generation for plastics and composite materials. This competence is much needed by the industry and designer fraternity, as usage of these materials at critical and crash sensitive locations is increasing.

- Road Scanning and Software Development

ARAI is continuously updating road roughness database with the help of its 2 D Road Profiling System and has geo referenced road roughness database of 15,000 km. This database is regularly sourced by OEMs and Tier-1 suppliers. In order to use this database effectively, ARAI has developed a software package for systematic updation and licensing to the customers for their applications. The developed software provides interface/ framework for GIS based display and statistical analysis of ARAI's road roughness data.

- Methodology for Sound Quality Analysis

Methodology for sound quality analysis has been developed for electric passenger cars. It defines sound quality in terms of single value descriptor (pleasantness index). Under this project, noise source identification was carried out to identify cause of poor sound quality and possible improvement solutions. The Driver Ear Level (DEL) in-cab sound samples for different EVs were recorded at various speeds on rough/



DEL Sound Quality Measurement Setup

smooth roads, as well as on Chassis Dyno for its objective of evaluation of sound quality parameters. Also, subjective evaluation of sound samples for perceived pleasantness was carried out through jury evaluation method. The results of objective and subjective evaluation were checked for their correlation. The derived pleasantness index was correlated with the parameters viz, loudness, sharpness, roughness and articulation index. Subsequently, pleasantness index equation was formulated through regression analysis. After mitigating the identified noise sources, 20% improvement was achieved in pleasantness index.

- Methodology for Sound Package Performance Evaluation

ARAI has developed a methodology for sound package evaluation and optimization using Alpha cabin and vehicle level evaluation in Anechoic Chamber. Under this project, comparative evaluation of lightweight materials used in EVs / ICE was carried out for sound absorption performance on different trim parts using Alpha cabin method. During this process, new technique has been developed for evaluation of sound package material performance at vehicle level using acoustic transfer function and trim-wise noise reduction analysis in hemi anechoic chamber/ free field environment. This methodology has helped in supporting the customer for effective lightweight sound package treatment through localization.

SIMULATION BASED DESIGN SOLUTIONS

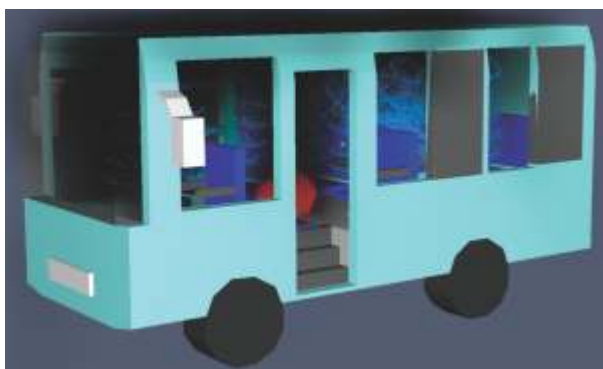
- CNG Engine Development using Simulation

Simulation model has been built and validated for developing 105 kW CNG Engine for bus application. In this project, exhaust system, EGR, throttle body and turbocharger were selected using 1 D Thermodynamic simulation. Further, 3 D Simulation was used for selection of bowl

and compression ratio, CNG injector location and exhaust temperature prediction. Subsequent to this, recommendations were finalized based on performance and combustion package estimation.

- Fire Detection and Suppression Methodology

ARAI has developed methodology for fire detection and suppression for passenger compartment of buses. This development process involved determining location and direction of suppression agent discharge point prior to installation of Fire Protection System (FPS), measurement of quantification of fire in terms of Heat Release Rate (HRR) along with its verification, and nozzle characterization as per the specifications in AIS 135. Further, analysis of nozzle characterization with the help of CFD technique and correlation of physical bus fire & simulated fire as per AIS-135 Part III and IV for fire in passenger compartment was carried out. This methodology has been found to be effective fire detection and suppression method for bus passenger compartment, thereby, enabling safe window in terms of time for evacuation of passengers.

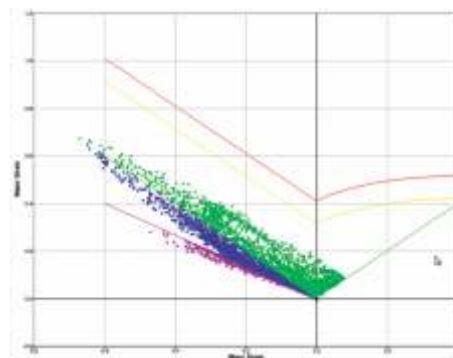


Bus Fire Simulation

- Sheet Metal Forming Process

ARAI has developed sheet metal forming process using simulation technique in the project on sheet metal oil pan weight optimization. This developed process adds

value to the sheet metal component manufacturers in terms of reduction in component sheet thickness, component weight & rejections, input material savings of around 22% per component and low energy consumption. A notable feature of this forming process is that it does not affect the component strength and manufacturing tolerances. During metal forming of oil pan, simulation technique was used to address rejections in sheet metal components and FEA technique was deployed for strength assessment.



FLD Curve

- Development of Magnesium Forging Process

ARAI has deployed its competency in flash less forging process to develop magnesium forging process for Plate Oil Pump having application in aerospace industry. The developed forging process has resulted in design of flash less (near-net) forging, light weighting of complete assembly, yield of about 99.9% and lower energy consumption in manufacturing and assembly operations.

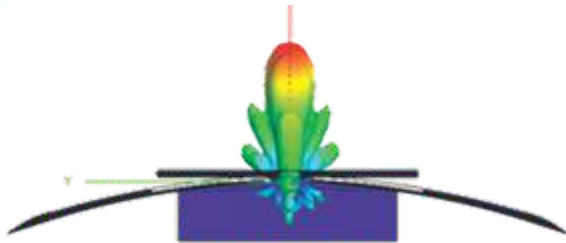


Virtual Simulation of Plate Oil Pump

- Optimizing of RADAR Placement using Simulation

ARAI has developed antenna characterization of RADAR for ADAS applications. Under this project, antenna pattern & gain were matched with physical model specifications provided by RADAR manufacturers to optimize RADAR placement. The optimized antenna pattern can be used in simulated environment for ADAS testing. With the help of this competency, ARAI can add value through following inputs to the OEMs and RADAR manufacturers.

- Antenna placement on vehicle for studying effect of vehicle body on antenna pattern
- Identification of optimum position of antenna to minimize RADAR FOV loss
- Effect of material and thickness of near-by parts on RADAR FOV

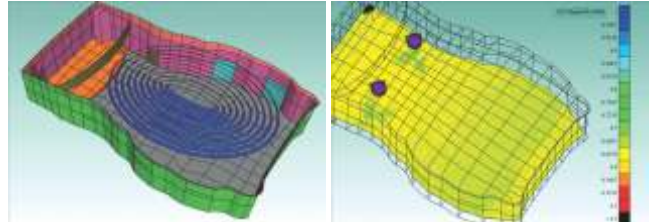


Radar FOV Prediction

- Acoustic Simulation Solution

Optimized acoustic treatment counter measures for a large auditorium of 5000 m³ were provided using simulation approach. Acoustic simulation of the baseline concept was carried out to predict critical acoustic parameters like Reverberation Time (RT) and Speech Transmissibility Index (STI). Further, parametric simulation iterations were carried out to evaluate sensitivity of parameters like acoustic insulation on floor, side walls and roof acoustic treatment. Subsequent to the analysis,

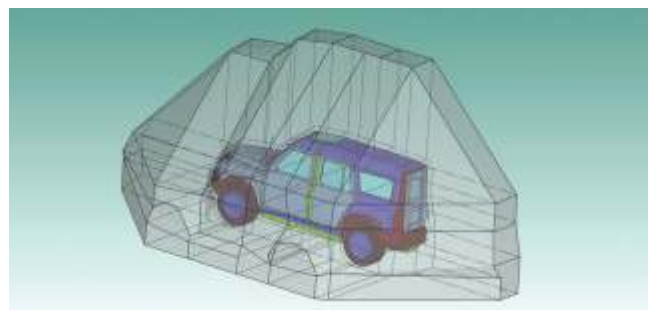
optimized acoustic treatment counter measures were arrived at to achieve the required re-evaluation time and acoustic performance.



Auditorium Acoustic Model along with STI Simulation Results

- In-Cab Noise Simulation for EV

This project was to study sensitivity of baseline vehicle concept for in-cab noise levels during the product development stage and that too without physical proto. Under this project, acoustic transfer functions were predicted for tire and motor noise excitations. Further, contribution analysis was carried out to understand dominant air borne paths and panel contributions. With this project, ARAI has developed competency in building acoustic model of complete EV using Statistical Energy Analysis (SEA) technique for air borne sources.



Acoustic Model of EV

- Vehicle NVH DVP

ARAI has carried out NVH DVP considering major sources in dynamic conditions like E-powertrain NVH, exterior noise, powertrain &

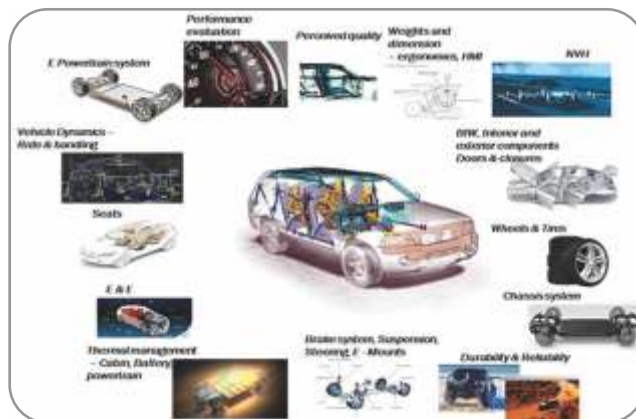
suspension mounts isolation, road NVH, judder vibration, half shaft launch shudder, vehicle level cooling module, E-compressor, CRFM, Power steering, etc. Static level assessment was conducted on the trim for NTF, VTF & driving point transfer functions evaluation. Based on the analysis, detailed report with probable inputs was prepared for further improvement.



NTF Measurements on Trim inside Hemi-anechoic Chamber

IN-HOUSE DEVELOPMENTS

- Light Electric Vehicle (LEV) DC Simulator as per IS17017-25
- Competency in EV durability and ADAS evaluation
- Design Validation Plan (DVP) development and execution with test and load cases at vehicle, system and component levels
- Automation of Concentrations calculation in Microbalance
- Modification of existing Coolant Rig suitable to JIS standard



DVP Development and Execution

● Other Significant Projects

- Development of Overhead Automated Charging Device for battery electric trucks
- Development of Fuel Cell powered Electric 3 Wheeler
- Finite Element Analysis of Power Take Off Shaft
- Design and virtual validation of Aluminium Seat for passenger bus application
- Digital twin of Indian traffic scenarios for functionality of ADAS verification & validation
- Study of Camera Monitoring System (CMS) as replacement of Rear-view Mirror for Indian Roads
- Dummy Kinematics Assessment based on ergonomic inputs from Size India Anthropometry database



Modified Coolant Rig

Certification and testing are ARAI's strengths and these have been acknowledged by various authorities through their below mentioned accreditations and recognitions.

- *Accreditation by National Accreditation Board for Testing and Calibration Laboratories (NABL) for Virtual Testing (only Test Agency in India and one of the very few in the World to obtain accreditation for virtual test scope)*
- *Recognition by Bureau of Indian Standards (BIS) for 13 safety components as per relevant IS Standard*
- *Recognition by RDW, Netherlands as 'Technical Service Provider' to carry out CoP verification audits*
- *Accreditation by Land Transport Authority (LTA) and National Environmental Agency (NEA), Singapore as 'Recognized Overseas Test Lab'*
- *Accreditation of load cell calibration facility as per ISO/IEC 17025:2017*
- *Approval of NTSEL for Exhaust Emissions of Motor Cycles (WMTC) as per TRIAS 31-J044GTR002-01*
- *Successful completion of Reassessment by NABL as per ISO/IEC 17025:2017 for Calibration scopes, at ARAI Kothrud and ARAI-FID, Chakan Facilities.*
- *Successful completion of Reassessment by NABL as per ISO/IEC 17025:2017 for Testing scopes, at ARAI Kothrud and ARAI-HTC, Chakan Facilities (76 new test services added in the scope)*

During the year, ARAI has executed assignments relating to certification, testing, validation, evaluation, data analysis, etc. Details of some of the projects are given below.

CERTIFICATION & TESTING PROJECTS

- Type Approval & Certification
 - Over 60 Certificates issued for Electric 2Ws and 3Ws under Electric Mobility Promotion Scheme (EMPS) – 2024
 - Electromagnetic Compatibility (EMC) as per AIS-160 Phase II (Safety Requirements for Construction Equipment Vehicles)
 - EMC testing of Electric Vehicles as per ECE R10.06 for REESS related functions
 - Certification of Cells used for making REESS as per IS 16893 series
 - EMC & Environmental Validation as per IEC 60571 Indian Railways application
 - Export homologation of Tractor Engine fueled with 20% Bio-diesel (B20) for Euro Stage-V norms and EPA Tier-IV
 - Evaluation for Reefer Vans as per AIS-164
 - Evaluation of Road Train as per AIS-113
 - Evaluation of Footrest of two-wheelers as per AIS-148
 - Evaluation of Compressed Gaseous Hydrogen Fuel Cell Vehicles as per AIS-157
- Noise Compliance for Generator Sets
 - Diesel Genset models as per CPCB guidelines
 - Extension of Type Approval Certificates to Generator Original Equipment Manufacturers (GOEMs) as per Central Pollution Control Board (CPCB) guidelines
 - Conformity of Production (COP) tests for OEM & GOEM plants
 - Conformity of Production (COP) tests for Petrol Generator Sets
 - Conformity of Production (COP) tests for Gas Generator Sets

EVALUATION AND VALIDATION PROJECTS

- Evaluation of Retrofitment of 2-wheeler & 3-wheeler with Electric Drive

The objective of this ongoing pilot project is technical assessment of retrofitment of IC engine based 2-wheelers & 3-wheelers using electric powertrain. This project is being undertaken with the support of Commission for Air Quality Management. Herein, few identified IC engine based 2-wheelers and 3-wheelers are being retrofitted with electric drives. It involves architecture & wiring harness design, mechanical & electrical integration of drive-train with battery system level trials & testing, running of retrofitted vehicles for data collection and submission of recommendations on potential reduction in pollution.



3-Wheeler EV Retro-fitment

- Validation of BS-VI 4-Cylinder TCIC Diesel Engine in VTB

The main objective of this project was to establish validation of BS-VI 4-Cylinder TCIC Diesel Engine for performance and emissions in Virtual Test Bed. The methodology adopted for this validation included setting up of engine & EAS model in CRUISE-M to generate real time model (.fmu file), which can be integrated with MATLAB model in D-space configuration desk to generate .sdf file. The same “.sdf” file acts as

real time run model to communicate across ECU hardware, SCALEXIO hardware and PUMA-Automation desk. The VTB set up was used for closed loop commissioning of BS-VI 4-Cylinder TCIC Diesel Engine, along with functionality checks, OBD calibration – diagnostics verification, limited urea level and temperature. This experience helped in establishing required VTB set up, which was using ETAS real time hardware and LABCAR execution environment.



Virtual Test Bed Setup

- Thermal mapping of HVAC system in Passenger Car

Cooling system in a vehicle facilitates cabin comfort and improves performance through powertrain cooling. However, there is trade off between powertrain performance and Heating Ventilation & Air-conditioning (HVAC) in the vehicles. Optimization of these cooling systems so that they use minimal driving energy, is an avenue to address this trade-off and, in turn, reduce electrical loads & energy wastage and also improve engine performance.

ARAI has carried out thermal mapping of vehicle and its sub-systems for optimization of cooling system in the project. This thermal mapping was carried out with thermocouples and sensors in the areas, like engine, transmission, condenser,

radiator, evaporator, in-cabin, boot, exhaust, etc., to simulate harsh environmental conditions and to maintain consistency while testing. This thermal mapping has helped the customer to understand thermal behaviour of vehicles and also for validation of calibration of various systems.



Temperature and Airflow Measurement Grid on AC Condenser

- Methodology for Subjective Evaluation of ADAS Features

ARAI has developed the methodology for subjective evaluation of ADAS features, including four critical systems, viz. Automatic Emergency Braking (AEB), Adaptive Cruise Control (ACC), Lane Keeping Assist/ Lane Departure Warning (LKA/ LDW) and Smart Pilot Assist. The rigorous testing protocol covers 250 to 300 test cases per vehicle, each designed to evaluate system response across diverse range of scenarios. This assessment includes target object variations for 2-wheelers, 3-wheelers, trucks, trailers, pedestrians, bicycles and also complex infrastructure challenges, like different lane types, visibility conditions and traffic scenarios. The evaluation framework covers broad spectrum of driving scenarios, ensuring



Real-world Evaluation of ADAS Features on Indian Roads

robust performance across all scenarios. From assessing target vehicle interactions to analyzing system behaviour at speeds ranging from 10 to 100 km/h, our evaluation framework leaves no aspect of system performance unexplored. It provides not only insights into system usage and rating in controlled environments, but also, offers comprehensive analysis of system functionality in real-world scenarios, delivering invaluable insights for fine-tuning and optimization.

- Bridge Parapet System Evaluation on Vehicular Impact

A project on performance evaluation of bridge parapet system on vehicular impact as per criteria defined in EN1317-2 has been undertaken. For this purpose, vehicular impact on bridge parapet system was simulated as per procedure mentioned in ECE standard so as to assess performance of parapet system in design stage itself. Based on simulation outcome, necessary design changes were carried out in the parapet system and suggestions on behaviour of bridge parapet system during vehicle impact, severity for vehicle occupant in case of an impact and scope for optimization in design were provided.

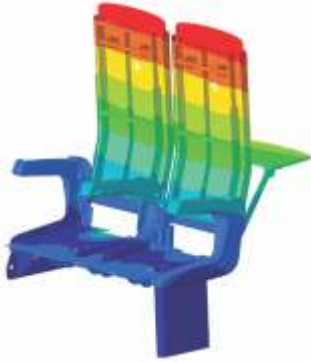


Bridge Parapet System Evaluation

- Evaluation of Railway Seat Structure

In this project, Vande Bharat train's seat strength was assessed as per international standard UIC-566 using FEA technique. The two different seat structures of semi high-speed train were evaluated for abusive loading, viz. vertical, lateral & longitudinal 'g' loading conditions, including load cases for design of fasteners. For evaluating the seat recliner strength under

abusive loading condition, endurance durability test was also simulated. The outcome of the project was providing suggestions on structural modifications to meet requirements specified in the standard.



Railway Seat Structure Evaluation

- Buzz, Squeak and Rattle (BSR) Evaluation

This project was on evaluating subjective noise from floor console assembly. In this project, tests were performed for pre-vibration endurance, post 90 hours of vibration endurance and post 180 hours of vibration endurance. During these tests, floor console was subjected to sine sweep and random vibration profiles for identifying the noises for BSR issues from console structures, viz. armrest lead assembly, cushion, armrest, track, etc. in order to meet customer's needs current capacity is being augmented with dedicated facilities for BSR evaluation together with Quiet Room at ARAI's Kothrud facility.



BSR Evaluation of Floor Console Assembly

- AVAS Performance Evaluation of Electric Vehicle

As a part of this project, electric vehicle was mounted on 2 wheeler drive Chassis Dyno inside Hemi-anechoic Chamber to evaluate minimum sound emission at 10 & 20 kmph. The electric vehicle was tested for exterior minimum sound emission evaluation as per UNR 138 & AIS-173. On evaluation, noise emission was observed to be below expected limits. So the AVAS device developed at ARAI, was installed to generate additional sound to meet minimum sound emission requirements as per regulation. The measurements with the AVAS installed vehicle were found to meet the regulation requirements.

- Export Homologation of Off-Highway Vehicles

Numerous projects have been undertaken for homologation requirements with respect to noise & vibrations of off-highway vehicles, like compactors, excavators, loaders, etc., as per European norms. Under these projects, evaluation of sound power levels as per ISO 6393 & ISO 6395, sound pressure levels measurements at operators' position as per ISO 6394 & ISO 6396 standards and human exposure to whole body and hand-arm vibrations as per ISO 2631 & ISO 5349-1 standards have been carried out. ARAI is further building capacities with new facilities for noise evaluation of CEVs at its upcoming facility at Mobility Research Centre (MRC) Takwe. This will benefit the customers in meeting noise norms for their export markets.

- Clean Air Project in India (CAP India)

This ongoing project is supported by The Swiss Agency for Development and Cooperation (SDC). It is being implemented by the consortium of institutions led by TERI to assist the stakeholders, such as Maharashtra Pollution Control Board (MPCB) and Pune Municipal Corporation (PMC) for effective air quality management. ARAI is working for the Pune region of this project.

Under this project, chemical transport modelling-based source apportionment of fine particulate matter (PM_{2.5}) has been completed. WRF-Chem model with locally developed emissions inventory was used for assessment of source contributions from different polluting sectors in Pune region. In addition to this, pilot project on “Retrofitment of older IC engine based two-wheelers with electric drive”, in association with an industry partner has been completed.

MEASUREMENT AND ANALYSIS PROJECTS

- Assessment of ED10 Fuel in Commercial Vehicle Engine

Diesel fuel with 10% Ethanol (ED10) blending was assessed on 6-cylinder TCIC Diesel Engine compliant to BS-VI OBD-II norms. To start with, baseline engine performance on diesel fuel was observed and then, the engine was run for fuel adaptation with ED10 fuel, for 50 hours. Subsequently, trials for performance and emissions with ED10 fuel were carried out. Results with ED10 fuel indicated slight deterioration of power with respect to diesel fuel, which is mainly because of lower calorific value of ethanol. The engine was observed to comply with BS-VI emission norms with ED10 fuel blend and with reduced CO, THC, NOx, PM and smoke emissions, as compared to diesel fuel.



Engine Test Bed Setup

- Stress Measurement on Construction Equipment

Stresses endured during operation serve as key indicators, guiding structural design process of construction equipment. In one of the projects for measuring stress for different loading profiles in construction equipment, more than 100 strain channels were placed at identified locations of the test vehicle chassis structure. This extensive network facilitated precise measurement of strain under varying conditions, mirroring real-world scenarios encountered during concrete mixture and pouring operations. Further, to ensure accuracy and reliability, different loading profiles were meticulously identified and tested. Each profile represented a unique set of conditions, enabling capturing of comprehensive spectrum of stress data. The resulting test data was then analyzed through techniques, like statistical, damage calculation and rosette analysis. The understanding gained with respect to impact of various loading profiles on stress distribution, has helped in optimizing the designs for desired operational conditions with enhanced durability and performance.

- Performance and Durability Testing of E-axle

ARAI has carried out project on performance and durability testing of E-axle. It involved efficiency mapping at various operating voltages, overspeed running, temperature rise



E-axle Performance and Durability Testing with 2 Dyno Setup

test, etc. For this purpose, durability testing was conducted for 500 hours on E-axle, in line with the Modified Indian Driving Cycle (MIDC), and E-axle operation in both drive and regeneration mode was evaluated by running the drive cycle. This test was carried out in accordance with Road Load Simulation to replicate cornering, gradient, acceleration, braking on the rig.

- Torsional Vibration Identification

This project was on identification of Torsional Vibration (TV) on 2-wheeler CVT vehicle. Dedicated software & hardware was used to measure TV at drive and driven pulley on three vehicles, including benchmark vehicle. Subsequently, the test data was analyzed for TV at individual pulley & transfer of vibrations to rider floor and the results of the benchmark vehicle & other vehicles were compared. Based on the evaluation, solutions were suggested to reduce transfer of TV to rider floor.

- Vibration Assessment of PCB

Vibrations in a Printed Circuit Board (PCB) of a medical equipment were assessed in High Accelerated Life Testing (HALT) chamber. The approach used for this assessment included measuring of vibrations at critical locations of components, mounting of interface attachments for identifying failure points of PCB during device application & transportation. Further to the



Vibration Assessment of Printed Circuit Board

analysis of the results, probable failure points were identified for improvement.

- DOE to meet In-cab & Regulatory NVH Requirements

This project was for devising DoE of LCV proto vehicle to meet in-cab and regulatory NVH requirements. Under this project, NVH benchmarking was carried out to provide the NVH target for designing the proto vehicle. Thereafter, newly developed proto vehicle was tested for overall NVH & regulatory requirements. The various tests carried out on the proto vehicle included pass-by noise, in-cab noise & tactile vibrations, powertrain NVH, engine & suspension mount vibration isolation, exterior noise, NTF and VTF to analyze the improved NVH performance and identify gaps for achieving the benchmark level milestone. This DoE helped proto vehicle in meeting all the regulatory requirements and overall NVH performance.

- Development of Emission Inventories and Source Apportionment Studies

Multiple projects on development of emission inventories and source apportionment studies are being executed at ARAI. Project on development of emission inventories, which commenced in 2020-21, is supported by Centre for Development of Advanced Computing (C-DAC), Pune under National Supercomputing Mission (NSM) for Urban Modelling project. It is aimed at developing high resolution emission inventories and conducting dispersion modelling analysis for four Indian cities, i.g. Bengaluru, Pune, Ahmedabad and Nagpur. During the year, modelling and simulations of pollutants over Bengaluru city using AERMOD model and development of SOPs for dispersion modelling using AERMOD model were carried out.

In addition to this, ARAI is working on emission inventory generation of pollutants and carrying out particulate matter (PM₁₀ & PM_{2.5}) source

apportionment for Angul-Talcher, Rourkela, Kalinga Nagar – Jajpur Road, Bhubaneswar-Cuttack and Balasore regions in Odisha. These projects are being undertaken for State Pollution Control Board, Odisha (OSPCB). Similar study is also being undertaken for Gurugram, Sonipat and Panipat regions for Haryana State Pollution Control Board (HSPCB).

- Measurement of Undiluted Exhaust Emissions in Underground Mines

This ongoing project is on measurement of exhaust emissions and determination of diesel particulate matter (DPM), noise, vibration and operators' field of view assessment before commissioning of vehicle in underground mines. As a part of this project, currently, measurement activities, as per the guidelines defined by Directorate General of Mines Safety (DGMS) for diesel vehicles operated in the underground mines, have been carried out at the site.

- Evaluation of Cleaning Effect of Emission Control Devices for PM

This project was on evolution of cleaning effect of Emission Control Devices used in BS-VI compliant vehicles in polluted urban environment. In this project, unique set up was made wherein different PM_{2.5} air quality indices were created and fed to the inlet of the vehicle. To generate dirty air, a BS-IV vehicle was



Evaluation of Cleaning Effect of Emission Control Devices for PM

mounted in another test cell and dilute exhaust of this vehicle was fed to the test vehicle. This test vehicle was operated at different speeds and loads to generate different levels of PM. Further, a CPCB compliant PM_{2.5} sampler was used to measure AQI sub-index of PM_{2.5} just before the inlet of test vehicle. Air with PM_{2.5} AQI ranging from 50 to 650 was fed to the test vehicle and exhaust emissions were measured and compared with the baseline data.

Other Validation & Evaluation Assignments

- Testing as per Bharat New Car Assessment Program (BNCAP)
- Validation testing of Non-road Mobile Machinery (NRMM) at different climatic conditions
- Static and dynamic testing of 3W EV at different climatic conditions
- Drive shaft torque measurement on passenger car
- Wheel force and vibration parameter measurement of Electric 3W
- Measurement of strain & vibration on VISCO clutch
- Drive file creation and multi-axial structural durability testing of lower front assembly
- Vibration measurement, drive file creation and multi-axial durability test of cooling module assembly
- Structural validation of bus suspension system
- 8DOF Motor Cradle Assembly Testing
- Noise evaluation of White Goods
- Genset testing at different climatic conditions, along with raw engine out emissions measurement and data acquisition
- Evaluation of proposed draft methodology to determine effect of Air Conditioning on fuel economy and CO₂ emissions in Passenger Car

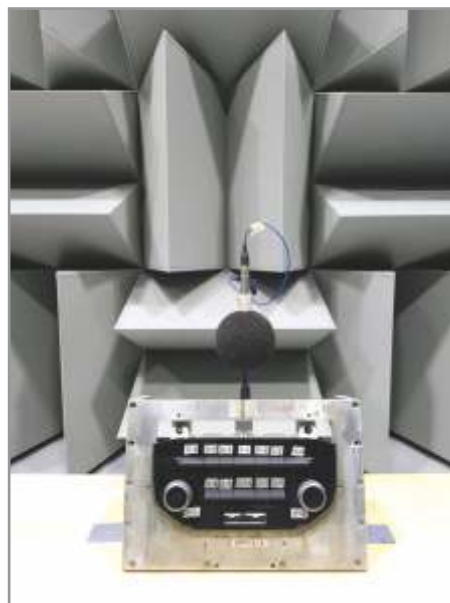
- Fuel economy evaluation based on WMTC for candidate vs reference oil on BS-VI compliant Indian motorcycle
- Bushing material corrosion test as per CE 60053
- Component validation projects covering engine, suspension, chassis, interior & exterior
- Battery housing validation for passenger car
- Fatigue properties (S-N curve, E-N curve) and high strain rate properties of various steels, cast iron and plastic materials
- Metallurgical failure analysis
- Chemical Transport Modelling (CTM) for surface ozone production over Delhi-NCR
- Noise evaluation of white goods in Hemi-anechoic Chamber
- Sound quality of EV components in Hemi-anechoic Chamber
- Test Track accreditation
- ADAS data acquisition



BNCAP Testing



Noise Evaluation of White Goods



Sound Quality Evaluation of EV Components

ROLE AND CONTRIBUTION IN VARIOUS NATIONAL AND INTERNATIONAL COMMITTEES/ FORUMS

Automotive Industry Standards Committee (AISC)

- Director ARAI, officiates as Chairman of AISC
- Secretariat Services to AISC
- Organized and participated in 2 meetings of AISC and several meetings of Technical Panels working under AISC

- Technical Secretariat Services to CMVR-TSC
- Participated in 1 meeting of CMVR-TSC

CMVR – Technical Standing Committee

Standing Committee on Implementation of Emission Legislation (SCOE)

- Technical support to Central Pollution Control Board (CPCB) & Standing Committee on Emissions (SCOE).
- Contribution in formulation of standards on Emission for Power Generating Set Application
- Contribution in formulation of standards on Emission for Retrofit Emission Control Devices (RECDs) for in-use DG sets
- Contribution in formulation of standards on noise as a Member of National Committee

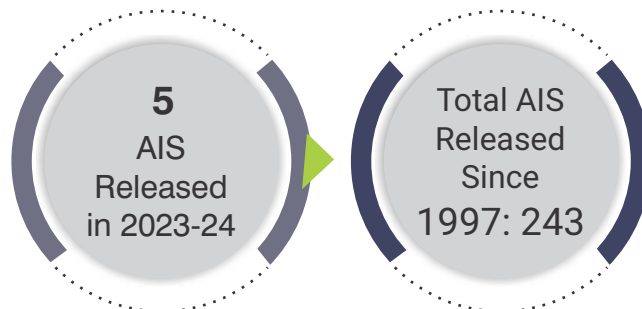
- Participation in various sectional committees and Division Councils of BIS
- Chairmanship of six TED (Transport Engineering Department) Sectional Committees of BIS

Bureau of Indian Standards (BIS)

WP. 29

- Technical Secretariat Services to National Committee on WP.29 matters and Core Group on WP.29 related activities
- ARAI participated in Technical Sessions of WP.29 and GR meetings during the year as part of various Indian delegations.
- Coordinated WP.29 India sub-group activities on GRPE, GRE, GRBP, GRSP, GRSG, GRVA

FORMULATION OF SAFETY STANDARDS



NEW AIS, REVISED AIS AND AMENDMENTS TO EXISTING AIS

New AIS

1. AIS-184: Driver Drowsiness and Attention Warning System
2. AIS-195: Safety and Procedural Requirements for Type Approval of Hydrogen Powered Vehicles (Liquid / Compressed Gaseous Hydrogen)
3. AIS-197: Bharat New Car Assessment Program

Revised AIS

1. AIS-001 (Part 1) (Rev. 2): Devices for Indirect Vision – Specifications
2. AIS-002 (Part 1) (Rev. 2): Devices for Indirect Vision – Installation

Amendments to Existing AIS

1. Amd. 12 to AIS-007 (Rev.5): Technical information to be submitted by vehicle manufacturer
2. Amd. 3 to AIS-017 (Part 6): Whole Vehicle Safety COP
3. Amd. 4 to AIS-024 and AIS-028 (Revision 1) (Part A): Gaseous Fuel Vehicles (CNG, LNG) - Automotive Application
4. Amd. 3 to AIS-046: with Automotive Vehicles - Hand-Holds for Three, Four and more than Four Wheeled Motor Vehicles - Specification
5. Amd. 2 to AIS-129: End-of-Life Vehicles
6. Amd. 2 to AIS-074: Approval of vehicles with regard to their protection against unauthorized use – two and three wheeled vehicles
7. Amd. 4 to AIS-075: Protection against Unauthorized use - Four Wheeled Vehicles
8. Amd. 3 to AIS-076: Vehicle Alarm Systems (VAS) for M1 and N1 Category of Vehicles

9. Amd. 3 to AIS-084: (Part 1 and Part 2) Performance requirements of Demisting and Defrosting Systems
10. Amd. 3 to AIS 102 (Part 1): TA of Hybrid Electric Vehicles
11. Amd. 1 to AIS 102 (Part 2): TA of Hybrid Electric Vehicles
12. Amd. 8 to AIS-113: TA of Trailers / Semi-Trailers of categories T2, T3 and T4 being towed by Motor Vehicles of categories N2 and N3
13. Amd. 4 to AIS 119 (Rev. 1): Specific Constructional Requirements for Sleeper Coaches
14. Amd. 2 to AIS-128: Testing Procedure and Requirements for Headlamp Beam testing and Brake Testing at authorized testing stations using headlight tester and roller brake tester
15. Amd. 1 to AIS 133: Electronic Stability Control System
16. Amd. 2 to AIS-135: Fire Detection and Alarm System (FDAS) & Fire Detection and Suppression Systems (FDSS) for Buses
17. Amd. 4 to AIS-137 (Part 2): TA and COP of L5 category Vehicles for Bharat Stage VI emission norms
18. Amd. 8 to AIS-137 (Part 3): TA and COP of M & N Category Vehicles having GVW \leq 3500 kg for Bharat Stage VI emission norms
19. Amd. 1 to AIS-137 (Part 4): TA and COP of M & N Category Vehicles having GVW exceeding 3500 kg for Bharat Stage VI emission norms
20. Amd. 1 to AIS-137 (Part 5): TA and COP of L, M and N with regard to measurement of Net Power and Maximum 30 Minute Power of Electric Drive Trains.

21. Amd. 2 to AIS-150: Requirements for Approval of Vehicles of Categories M2, M3, N and T with Regard to Braking
22. Amd. 4 to AIS-156: Type Approval procedure for swappable battery for Electric Vehicles
23. Amd. 1 to AIS-157: Safety and Procedural Requirements for Type Approval of Compressed Gaseous Hydrogen Fuel Cell Vehicles
24. Amd. 4 and 5 to AIS-160: Safety Requirements for Construction Equipment Vehicles.
25. Amd. 1 to AIS-171 Ethanol % Ethanol Blend Motor Gasoline (EBMG) Vehicles (for Blends above 20%)
7. AIS-099 (Rev. 1): Approval of Vehicles with regards to the Protection of the Occupants in the event of a Lateral Collision
8. AIS-100 (Rev. 1): Pedestrian Protection Systems
9. AIS-101 (Rev. 1): Protection of Fuel Systems in Rear Impact
10. AIS-115 (Rev. 1) (Part 1): Driver-Perceived Noise Level of Agricultural and Forestry Tractors – Method of Measurement
11. AIS-115 (Rev. 1) (Part 2): Permissible Sound Level at Bystander of Agricultural and Forestry Tractors – Method of Measurement

AIS Standards Finalized (To be released in the Year 2024-25)

1. AIS-008 (Rev. 3): Lighting Installation for Light and Light Signaling devices for four wheeled vehicles
2. AIS-009 (Rev. 3): Lighting Installation for Light and Light Signaling devices for two and three wheeled vehicles
3. AIS-034 (Rev. 3) (Part 1): Provisions concerning the Approval of Filament Lamps for use in Approved Lamp Units on Power-driven Vehicles and their Trailers
4. AIS-034 (Rev. 3) (Part 2): Provisions concerning the Approval of Gas-discharge Light Sources for use in Approved Gas-discharge Lamp units of Power-driven Vehicles
5. AIS-083 (Rev. 1): Headlamp Cleaners and of Power-Driven Vehicles with Regard to Headlamp Cleaners
6. AIS-098 (Rev. 1): Requirements for the Protection of the Occupants in the event of an Offset Frontal Collision
12. AIS-162: Advanced Emergency Braking Systems (AEBS) for M2, M3, N2 and N3 category vehicle
13. AIS-175: Worldwide harmonized Light Vehicle Test Procedure (WLTP) of M and N Category Vehicles having GVW not exceeding 3500 kg
14. AIS-178: Adapted Vehicles two wheelers, three wheelers and tricycles
15. AIS-180: Vehicles for transportation of Dangerous Goods.
16. AIS-181: Approval of Tank Vehicles with regard to Rollover Stability
17. AIS-182: ISOFIX Anchorage systems
18. AIS-183: Type Approval Requirement for Three wheeled moped of L1-1 category
19. AIS-185: Approval of vehicles with regard to the Advanced Emergency Braking System (AEBS) for M1 and N1 Category vehicles
20. AIS-186: Blind Spot Information System (BSIS)
21. AIS-187: Moving off Information System (MOIS)
22. AIS-188: Approval of vehicles with regards to Lane Departure Warning System (LDWS)

23. AIS-189: Cyber Security and Management System (CSMS)
24. AIS-190: Software Updates and Management System (SUMS)
25. AIS-191: (Part 1): Approval of vehicles with regards to Emergency Lane Keeping System (ELKS)
26. AIS-192: Uniform provisions concerning the approval of vehicles with regards to Event Data Recorder (EDR)
27. AIS-193: Automated Vehicles Steering Systems and Methods of Evaluation
28. AIS-195 (A): New AIS on Safety and Procedural Requirements for Type Approval of Hydrogen Powered construction equipment vehicles (liquid / compressed gaseous hydrogen)
29. AIS-198: Uniform Provisions Concerning the Approval of Light Signaling Devices and Systems for Power-Driven Vehicles
30. AIS-199: Uniform Provisions Concerning the Approval of Light Signaling Devices and Systems for Power-Driven Vehicles
31. AIS-200: Uniform Provisions Concerning the Approval of retro –Reflective devices and markings for power driven vehicles and their trailers
32. AIS-201: Requirements for the Protection of the Occupants in the event of a Frontal Collision with focus on Restraint Systems
33. AIS-204: Requirements for School Vans
34. AIS-205: Provisions ensuring uniform conditions for the implementation of interoperability and compatibility of on-board weighing equipment
35. AIS-206: New AIS on Safety and Procedural Requirements for Type Approval of Hydrogen Powered L category vehicles (liquid / compressed gaseous hydrogen)

CO-OPERATION WITH BUREAU OF INDIAN STANDARDS (BIS)

Indian Standards on automotive safety components and systems are formulated in various TED (Transport Engineering Department) Sectional Committees of BIS. Transformation/ adaptation of AIS into IS is one of the major activities in TED. Additionally, ARAI provides technical guidance/ expertise to BIS and also has the responsibility of Chairmanship of following TED Sectional Committees.

- TED 4: Automotive Braking Systems, Vehicle Testing, Steering and performance Evaluation Sectional Committee
- TED 6: Automotive Body Chassis Accessories and Garage Equipment
- TED 22: Transport Tractors, Trailers and Industrial Trucks
- TED 26: Automotive Vehicles Running on Non-Conventional Energy Sources
- TED 29: Passive Safety Crash Protection Systems
- TED 34: Springs and Suspension Systems Sectional Committee Sectional Committee

CMVR AND ITS IMPLEMENTATION

CMVR Technical Standing Committee (CMVR-TSC) and Standing Committee on Implementation of Emission Legislation (SCOE)

CMVR-TSC and SCoE have identified following subjects of national importance for formulation of Policies/Norms/Standards and implementation thereof:

- Advanced Driver Assistance Systems
- On-board Weighment in Commercial Vehicles
- Battery Durability
- Common Receptacle for Electric Vehicle Charging

- Safety and Procedural requirement for Type Approval of Hydrogen Powered Fuel Cell for Construction Equipment Vehicles
- Caravan Trailer pulled by Passenger Vehicles
- Passenger Car Fuel Efficiency measurement with AC ON condition
- Bharat Stage VII Emission Norms

INTERNATIONAL COOPERATION AND HARMONIZATION OF NATIONAL STANDARDS

ARAI provides Technical Secretariat for National Committee on WP.29 matters and Core Group on WP.29 related activities. India became signatory to 1998 Agreement under UN ECE as a part of our commitment to harmonization of automotive regulations. Under this agreement, Global Technical Regulations (UN GTRs) are being formulated. During this year, India has voted in favour of following documents.

- Proposal for Amendment 1, Addendum 2 to Mutual Resolution No. 1
- Consideration of technical UN Regulations in the Compendium of Candidates of UN GTR: Listing Number 15: Japan's Real Driving Emission (RDE) Methodology.
- Proposal for new UN GTR on Laboratory Measurement of Brake Emissions for Light-Duty Vehicles.
- Proposal for amendment 1 to UN GTR 13 (Hydrogen and Fuel Cell Vehicles)

Participation in Technical Sessions of WP.29 – Highlights

During the year, India participated in several technical sessions of WP.29, its subsidiary working parties and Informal Group meetings. Secretariat at ARAI provided technical and other support to the national delegations for attending sessions at United Nations, Geneva, Switzerland.

TYPE APPROVAL CERTIFICATION

ARAI has carried out Type Approval Certification of several safety components as per the notified safety standards. Additionally, type approval of different categories of vehicles for latest emission norms was carried out. Major highlights are given below:

Key Safety Standards and Emission Norms Implemented in 2023-24:

- Safety Standards:
 - Implementation of IS 2553 (Part 2): 2019 Safety Glass
 - Improved Braking Performance) including Electronic Vehicle Stability Control System (EVSC) for Buses covered in AIS-153
 - Implementation of QCO for Wheel rim used in L, M, N, T3 and T4 category vehicles and implementation of revised standards for wheel rim under CMVR
 - Constant Speed Fuel consumption (CSFC) for vehicles above 3.5 ton as per IS 11921.
 - CoP of Traction Batteries
 - Non-renewal of Certificate of registration of Government Vehicles older than 15 years.
 - Fire Alarm and Protection system in occupant compartment of Type III buses of category M3 and school buses
 - Rolling Resistance and Wet Grip of C1, C2 and C3 category tyres
 - Type approval of liquid or compressed gaseous hydrogen internal combustion engine vehicles
 - Definitions of Electric and Hybrid Electric Vehicles
 - Bharat New Car Assessment Program

- Emission Standards:
 - Constant Speed Fuel consumption (CSFC) for vehicles above 3.5 ton
 - Indian Real Driving and Conformity factor
 - OBD II / OBD II-A (as applicable) emission norms
 - Modifications in Applicability of Tests requirements for BS VI Type Approval of various categories and Ethanol Blending

Notifications on Safety Standards and Emission Norms for Implementation in 2024-25:

- Safety Standards:
 - Stage 2 safety norms for CEV
 - Rolling Sound of C1, C2 and C3 category tyres
 - Revised Standards for Devices for indirect vision or rear-view mirrors

- Emission Standards:
 - CEV V emission norms and Stage 2 noise limits

Notifications for Implementation of Safety Standards and Emission Norms infuture after 31st March 2025:

- Safety Standards:
 - Mandating Air Conditioning (AC) in Truck Cabin
 - Cancellation of self certification provision for buses built by bus body builders and mandating Type approval from Test Agencies
- Emission Standards:
 - OBD Stage II-B Thresholds for BS-VI vehicles for 2/3 W motor vehicles
 - Implementation of TREM V for Agricultural Tractors

Note: Please refer relevant AIS and relevant notification for applicability of the standard to the vehicle category.





Advanced Acceleration Sled Facility



Climatic Chamber integrated with Vibration Shaker



Anechoic Chamber
Advanced NVH Development Centre

Reverberation Chamber



Goniometer Type A
Goniometer Type C
Advanced Photometry and Optics Laboratory



4x4 Chassis Dynamometer



Test Facility of Camera Monitoring System



Ion Chromatography



Creep Testing Machine



Hydraulic Burst Testing Equipment



Helium Leakage Testing Equipment

- Upgraded 2-wheeler Emission Test Cell
- Expansion of servo-hydraulic facility
- Facility for Vibration Isolator Testing in 45° Compression
- Facility for Drop Impact Testing of Seat Riser Assembly
- Facility for Durability Test on Restrictor Can Assembly
- GPS based Data Acquisition System
- Conditioned Air Supply System
- Particulate Measurement System
- Fuel Conditioning System
- Opacimeter
- Hemi-anechoic Chamber
- High Intensity Lighting System
- Universal Test Rig for EV Transaxle and E-axle DVP
- Facility for Rod End Fatigue Testing and Backlash Measurement
- Upgradation of various Software
- High Performance Computing Server for handling large computational models
- Fire Test Rig
- Gravel Bombardment
- Enhancement of capacities Radiated Immunity Test, EFT/Surge/Ring Wave Immunity, High Voltage Test and Electrical Tests for Electrical/Electronic Components
- EV Charging Station and Power Analyzer

ARAI has had a long-standing commitment for fostering collaborative work culture at workplace. At the core of our success are our employees, which we consider as our most valuable asset. At ARAI, we have been working towards keeping our employees engaged and inspired, as we believe that engaged and inspired employees are more satisfied, productive and committed.

Employee Well-being

Health, safety and well-being of our employees is of paramount importance and so, we focus on enabling a safe workplace and creating a culture that encourages employee engagement. Accordingly, we strive towards working on initiatives which yield physical and mental well-being of our employees and their families. Our employee wellness initiatives encompass various benefits to our employees, like health insurance policy (for employees as well as their dependent parents and children), group term life insurance policy, safety shoes, uniforms training on fire safety & first aid, etc.

Learning and Development

As organizations pursue their future growth, skills of their employees, especially in the emerging technologies, are becoming vital for long-term success, and so we are investing in building efficiencies into the learning path for upskilling and reskilling our employees. We are also focusing on supporting our employees in staying relevant in dynamically changing market environment by continuously evolving training programs for development of their functional, technical and

behavioural skills. Apart from in-person training programs, we have also been focusing on training through our Learning Management System (LMS) platform on Human Resource Management System (HRMS), considering the significance of digitalization. We finalize and publish our training calendar at the beginning of the financial year to enable our employees prioritize and select training programs spread across various technical, functional and behavioural areas. During the year, our training programs evinced enthusiastic response from the employees, with about 27,000 man-hours of training imparted. Additionally, we also organized expert talks, which were delivered by the distinguished speakers on various domains.

Employee Engagement

As we continue the journey towards our future, we recognize the importance of employee engagement, as this facilitates a customer focused, performance driven and future ready team that will not just meet, but also surpass our growth ambitions. In line with this, several initiatives were drawn up to engage our employees to stay motivated for delivering their best and also develop a strong sense of belonging. During the year, we organized a host of employee engagement programs, like Annual Day, Independence Day, Republic Day, National Technology Day, World Environment Day, National Safety Week, Vigilance Awareness Week, National Unity Week, Janjatiya Gaurav Divas, Hindi Day, Swachhata Pakhwada, Blood Donation Camp and various Sport Competitions. All these events witnessed enthusiastic participation from the employees.



Vigilance Week



Independence Day



Blood Donation Camp

- 'Optimization of casting process to increase component yield' by A. R. Kumbhar in May 2023 at Automotive Materials and Manufacturing 2023 Conference (AM&M 2023), Pune
- 'Computational material modelling for damage prediction of Advanced High Strength Steel' by S. M. Mulla, Sanket Nemade, M. G. Vhanaje, S. R. Nigade, R. S. Mahajan and Ms. M. S. Jambhale in May 2023 at Automotive Materials and Manufacturing 2023 Conference (AM&M 2023), Pune
- 'Role of silicone based thermal encapsulants for 2 & 3W Battery Module Thermal Management applications' by Dr. P. K. Ajeet Babu, Y. G. Ambhore, Dr. Ravindra Kumar, K. D. Udawant and Ms. U. S. Karle in May 2023 at Automotive Materials and Manufacturing 2023 Conference (AM&M 2023), Pune
- 'Quick analysis of elemental composition of automotive materials using non-destructive technique' by Dr. Y. J. Patil, M. A. Bawase and Dr. S. S. Thipse in May 2023 at Automotive Materials and Manufacturing 2023 Conference (AM&M 2023), Pune
- 'Current industry trends and opportunities' by K. S. Patel in September 2023 at EDS Technologies, Pune
- 'Physical security product performance assessment towards hostile vehicle mitigation – Site specific solutions' by S. R. Deshpande in October 2023 at Milipol India
- 'Evaluation of highway safety barrier performance as per EN 1317 using LS-DYNA®' by D. R. Sonawane in November 2023 at Arup LS DYNA India User Conference, Pune; and by S. R. Deshpande in November 2023 at Arup LS DYNA India User Conference, Bengaluru
- 'Study of electric vehicle powertrain performance for Indian conditions' by N. A. Kulkarni in November 2023 at VISHWACON 2023, Pune
- 'Evaluation of cleaning effect of diesel particulate filter used in BS-VI compliant vehicle in polluted urban environment' by M. V. More of ARAI and Mr. S. Basu of ECMA in November 2023 at 14th International Conference on Leaping to Cleaner Air for Tomorrow (ECT 2023), New Delhi
- 'Optimization in forging process using computer simulation' by A. R. Kumbhar in November 2023 at Forgetech Conference, Pune
- 'Flash less forging of single pin crankshaft for yield improvement' by A. R. Kumbhar in December 2023 at Arkeycell Forging Conference, Chennai
- 'Microstructural and compositional analysis of cyclic aged Lithium-ion 18650 cylindrical cells Nickel Manganese Cobalt (NMC) & Lithium Iron Phosphate (LFP)' by Ms. A. S. Waghmare, S. P. Pandit, N. S. Mahagaonkar and Ms. M. S. Jambhale in December 2023 at eAMRIT – Accelerating e-Mobility Revolution for India's Transportation 2023 Conference' Chennai
- 'Die wear prediction using simulation technology' by A. R. Kumbhar in January 2024 at AIFI, Pune, India
- 'Development & testing of a camera-based Driver Monitoring System' by Ajinkya Bhagat, Ms. J. G. Kale, N. A. Pachhapurkar, M. L. Karle and Ms. U. S. Karle in January 2024 at SIAT 2024 Conference, Pune
- 'Synthetic scenario generation from real road data for Indian specific ADAS function verification and validation' by R. Manish, Ms. J. G. Kale, N. A. Pachhapurkar, M. L. Karle and Ms. U. S. Karle in January 2024 at SIAT 2024 Conference, Pune
- 'Frame-work for the verification & validation (V&V) of Advanced Driver Assistance Systems' by Ajinkya Bhagat, R. Manish, Ms. J. G. Kale, N. A. Pachhapurkar, M. L. Karle and Ms. U. S. Karle in January 2024 at SIAT 2024 Conference, Pune

- 'Effects of low temperature on forged steel materials in hydrogen internal combustion engines applications: Assessing ductile-brittle transition' by Dr. P. K. Ajeet Babu, Y. G. Ambhore and Ms. U. S. Karle in January 2024 at SIAT 2024 Conference, Pune
- 'Generation of tire digital twin for virtual MBD simulation of vehicles for durability, NVH and handling evaluation' by N. R. Bakal, O. P. Joshi, Dr. P. R. Pawar and V. V. Shinde in January 2024 at SIAT 2024 Conference, Pune
- 'Development of India specific biaxial test cycle for fatigue testing of wheel rims and wheel hub bearings for heavy commercial vehicles' by N. R. Bakal, V. S. Kuwar, O. A. Thorat, Dr. P. R. Pawar and V. V. Shinde in January 2024 at SIAT 2024 Conference, Pune
- 'Development of methodology for accelerated validation of axle components in relation to static load capacity' by V. S. Kuwar, O. A. Thorat, N. R. Bakal, O. P. Joshi, Dr. P. R. Pawar & V. V. Shinde from ARAI and Mohan Sutar, Anil Potdar, Sachin Tak, Abhijit Nilangekar & Milind Kulkarni from AAM India in January 2024 at SIAT 2024 Conference, Pune
- 'Development of system level testing method for passenger car engine mounts' by U. B. Tormal, S. N. Satale, Y. V. Dhage and V. V. Shinde in January 2024 at SIAT 2024 Conference, Pune
- 'Powertrain and cabin cooling performance improvement by optimization of its components' by R. S. Khairnar from ARAI and N. S. Mirajkar from Stellantis in January 2024 at SIAT 2024 Conference, Pune
- 'The impact of uncertainty quantification and sensitivity analysis in CAE simulation based regulatory compliance' by S. R. Deshpande and R. S. Mahajan in January 2024 at SIAT 2024 Conference, Pune
- 'Comparative analysis of electromagnetic radiated emission for electric powertrain and conventional spark ignition (SI) powertrain' by Ms. S. R. Pawar and M. M. Desai in January 2024 at SIAT 2024 Conference, Pune, India
- 'Methanol—as a future alternative fuel for Indian Automotive' by D. Bandyopadhyay, P. S. Sutar, S. B. Sonawane, M.I. Jamadar, S. D. Rairikar and Dr. S. S. Thipse in January 2024 at SIAT 2024 Conference, Pune
- 'Duty cycle based fuel consumption calculation using simulation methodology for Agricultural Tractor' by S. U. Gijare, K. Karthick, Dr. S. D. Juttu and Dr. S. S. Thipse in January 2024 at SIAT 2024 Conference, Pune
- 'Hydrogen as a carbon neutral ICE fuel for future India' by D. Bandyopadhyay, P. S. Sutar, S. B. Sonawane, S.D. Rairikar and Dr. S. S. Thipse in January 2024 at SIAT 2024 Conference, Pune
- 'Cost effective pathways toward highly efficient and ultra-clean CI Engines, Part I: Combustion system optimization' by S. A. Gothekar, P. G. Bhat & Dr. S. S. Thipse from ARAI and Ashish Shah, Praveen Kumar, Rafael Sari & David Cleary from Aramco in January 2024 at SIAT 2024 Conference, Pune
- 'Cost effective pathways toward highly efficient and ultra-clean Compression-Ignition Engines, Part II: Air handling and exhaust aftertreatment' by S. A. Gothekar, Dr. P. G. Bhat & Dr. S. S. Thipse from ARAI and Praveen Kumar, Ashish Shah, Rafael Lago, Manuel Echeverri Marquez & David Cleary Aramco in January 2024 at SIAT 2024 Conference, Pune
- 'Regulatory trends for enhancement of road safety' by P. R. Nayak, V. P. Rawal, K. B. Patil, V. A. Tandon and A. A. Badusha at SIAT 2024 Conference, Pune
- 'Importance of pole side impact test for assessment of curtain airbags' by D. Jaju and

D. D. Kulkarni in January 2024 at SIAT 2024 Conference, Pune

- 'Design and development of E-axle as a Retro and OE fitment solution for light commercial vehicles ranging from 1.5 to 5 Ton GVW' by Kumar Vaibhav, R. V. Mulik and Dr. S. S. Ramdasi in January 2024 at SIAT 2024 Conference, Pune
- 'Study of changes in exhaust after-treatment system components in M & N category vehicles from the RDE monitoring stage to the RDE compliance stage' by A. P. Singh, R. K. Bathina, and K. P. Thakare in January 2024 at SIAT 2024 Conference, Pune
- 'Quantification of alertness and evaluation method for vision based driver drowsiness alertness warning system' by Ch. Bala Subrahmanyam, Satish Viswanatham and A. A. Badusha in January 2024 at SIAT 2024 Conference, Pune
- 'Regulatory framework of Construction Equipment Vehicles in India' by S. N. Babar and A. A. Badusha in January 2024 at SIAT 2024 Conference, Pune
- 'Electric Vehicle conductive charging station backend communication current scenario and challenges in India' by U. Sreekumar in March 2024 at India Smart Utility Week (ISUW 2024), New Delhi, India
- 'Electromagnetic compatibility (EMC) analysis for e-Motors and Controllers of Electric Two-Wheelers' published by Ms. S. R. Pawar and M. M. Desai at SIAT 2024 Conference
- 'Simulation methodology development for vibration test of Bus Body Structure code AIS 153:2018' published by K. S. Patel at SIAT 2024 Conference
- 'Physical testing methodology and evaluating Windscreen wiping with respect to vision zones for vehicle category other than M1' published by Amol Joshi, S. H. Nikam, A. K. Patil, A. B. Doshi and Dr. B. V. Shamsundara at SIAT 2024 Conference
- 'Noise reduction on Electric Two-Wheeler by structural modification and gear design optimization' published by S. D. Chivate, A. A. Gaikwad, G. N. Taware and Dr. N. H. Walke at SIAT 2024 Conference
- 'Assessment of VECTO tool on 42T rigid truck' published by Dr. S. D. Juttu, K. Karthick, S. U. Gijare, Dr. S. S. Thipse and Dr. N. H. Walke in Technical Reference Bulletin at SIAT 2024 Conference
- 'Design and development of indigenous EV Motor Test Rig for small capacity motor testing' published by U. Sreekumar in ARAI Journal of Mobility Technology
- 'ARAI indigenously developed OCPP Server and OCPP Stack for EV Charging Station' published by U. Sreekumar, A. A. Deshpande, A. B. Mulay and P. G. Mengaji in ARAI Journal of Mobility Technology
- 'Assessment of M15 Fuel on BS-IV 2 and 3-Wheeler' published by M. I. Jamadar, S. D. Rairikar, S. B. Sonawane, P. S. Sutar, D. Bandyopadhyay and Dr. S. S. Thipse in ARAI Journal of Mobility Technology
- 'Accelerated Life Prediction of Automotive Elastomers using Thermo-Gravimetric Analysis' published by M. A. Bawase, Sushil Chaudhari and Dr. S. S. Thipse in ARAI Journal of Mobility Technology
- 'Rear Axle whine reduction by gear contact patch optimization' published by A. A. Gaikwad, S. D. Chivate and Dr. N. H. Walke at in ARAI Journal of Mobility Technology
- 'A feasibility study of utilizing directly recycled LiFePO4 Cathodes for second life usage in stationary applications' published by Dr. P. K.

Ajeet Babu, Ojas Bangal, M. A. Bawase & Ms. U. S. Karle from ARAI and Amrutha Melepurakkal, Vikash Chaturvedi & Dr. Manjusha V. Shelke from National Chemical Laboratory (NCL) in March 2024 at IEEE International Transportation Electrification Conference (ITEC-India)

- ‘Microstructural and compositional analysis of cyclic aged Lithium-ion 18650 cylindrical cells Nickel Manganese Cobalt (NMC) & Lithium Iron Phosphate (LFP)’ published by Ms. A. S. Waghmare, S. P. Pandit, N. S. Mahagaonkar and Ms. M. S. Jambhale in Material Science Engineering
- ‘In-situ sound reflection and sound insulation evaluation of noise barriers in controlled

environment and comparison with laboratory test data’ published by S. K. Jain, Ms. M. P. Joshi, P. P. Kamble and Dr. N. H. Walke at 29th International congress on sound and vibration (ICSV)

- ‘Sound character of Electric (EV) and Internal Combustion Engine (ICE) buses’ published by P. D. Jawale, S. D. Supare and Dr. N. H. Walke at FISITA 2023 World Congress, Barcelona
- ‘Complete design development of control strategy and rapid prototyping platform for Acoustic Vehicle Alerting System (AVAS)’ published R. G. Shah, M. L. Karle, P. D. Jawale, Ms. U. S. Karle and Dr. N. H. Walke at FISITA 2023 World Congress, Barcelona

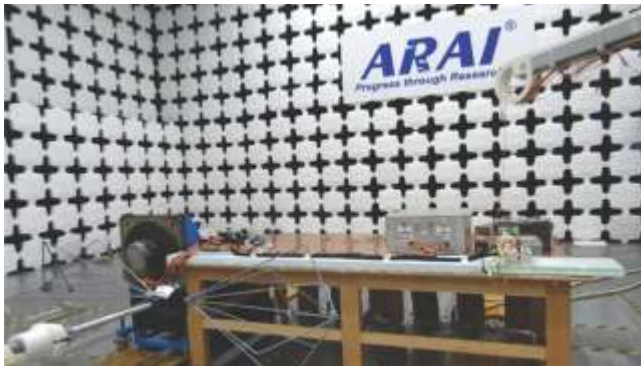
List of Patents granted to ARAI in 2023-24 by The Patent Office, Government of India

1. A Bench Level System for Testing Electromagnetic Interference of Ignition Components of a Vehicle (Inventors: Mr. Abhijit Mulay and Mr. A. A. Deshpande)
2. P1 configuration Hybrid -2-wheeler (Inventors: Mr. Ashwin Subramanian, Mrs. U. S. Karle, Mr. GarpatiSriyan, Mr. S. R. Ghugal and Mr. R. S. Shah)
3. A Method for Throttling Hybrid Vehicles (Inventors: Mr. Ashwin Subramanian, Mrs. U. S. Karle, Mr. GarpatiSriyan, Mr. S. R. Ghugal and Mr. R. S. Shah)
4. A Hybrid Vehicle (Inventor: Mr. Ashwin Subramanian)
5. Bimetal Mixture Forging Process (Inventors: Mr. M. R. Saraf and Dr. P. K. Ajith Babu)
6. Diesel Control Strategy in Dual Fuel Engine (Inventors: Mr. S. B. Sonawane, Late Mr. K. P. Kavthekar, Mr. Vinayak Sagare, Mr. S. D. Rairikar, Dr. S. S. Thipse and Mr. N. V. Marathe)
7. Deceleration Fuel Cut-Off for Gaseous Fuelled 2 And 3-Wheeler Vehicles for Improving Fuel Economy and Emissions Reduction (Inventors: Mr. S. D. Rairikar, Late Mr. K. P. Kavthekar, Dr. S. S. Thipse, Mr. S. M. Tembe, Mr. N. B. Dhande, Mr. Y. R. Jagdale and Mr. N. V. Marathe)
8. A Method for controlling Diesel in Dual Fuel Engine (Inventors: Mr. Shailesh Sonawane, Late Mr. K. P. Kavthekar, Mr. Vinayak Sagare, Mr. Sandeep Rairikar, Dr. S. S. Thipse, Mr. Neelkanth Marathe and Mr. S. J. Vispute)
9. A Joint for Assembling a Vehicle Body (Inventors: Mr. P. A. Nirmal, Mr. K. S. Patel, Mr. M. A. Patwardhan, Mr. R. S. Mahajan, Mr. Sudhir Jain and Mr. S. C. Dhamorikar)
10. Hybrid Electric Two Wheeled Vehicle Transmission System (Inventors: Dr. Sanjay Patil, Mr. K. P. Wani and N. S. Gopokrishnan)
11. Magnetic Suspension System for Two Wheeled Vehicles (Inventor: Mr. K. P. Wani)
12. A System for Navigating an Agricultural Vehicle (Inventors: Mr. Rafiq Babu Agrewale, Mr. Amitabh Das, Dr. Yogesh Bhatshvar and Dr. K. C. Vora)

New Services & Capabilities

- Certification under Electric Mobility Promotion Scheme (EMPS) 2024
- Advanced Automotive Technology (AAT) components validation as part of PLI Scheme
- LEV DC Fast Charger certification as per IS 17017-25
- Validation of V2V (Vehicle to Vehicle) and Vehicle to Grid (V2G) Power Transfer
- Certification of cells used for making REESS as per IS 16893 series
- ECE17 Seat EDP development and type approval
- Testing and certification of vehicles operated on E20 as per GSR 27(E)
- PEMS test on Non-Road Mobile Machinery (NRMM) vehicle for export homologation
- EMC testing of EVs as per UN R 10.06 for REESS related functions
- EMC testing of motorcycle with Antilock Braking System (ABS) function
- EMC and environmental validation as per IEC 60571 for RDSO
- Machine Electromagnetic Compatibility (EMC) as per AIS-160 Phase II for CEVs
- Inverter/ motor controller EMC testing with motor in loading condition
- Immunity to low voltage pulses on vehicle level
- Magnetic field exposure evaluation as per ICNIRP guidelines
- AC performance test as per IS 14618 2022
- Constructional and functional requirements for insulated vehicles as per AIS-164
- Hydrogen Fuel Cell testing as per AIS-157
- Hydrogen Powered Vehicle ICE testing as per AIS-195
- Driver Drowsiness Alertness Warning System (DDAWS) as per AIS-184
- Advanced Emergency Braking Systems (AEBS) in-line with UN R 131 and UN R 152
- Automatically Commanded Steering Function (ACSF) in-line with UN R 79
- Lane Departure Warning System (LDWS) in-line with UN R 130
- Emergency Lane Keeping System (ELKS) in-line with EU 2021/646
- Insulated van test as per AIS-164
- Road Trains evaluation as per AIS-113
- EMC test on motor controller in loaded condition
- Fire Alarm System (FAS) and Fire Protection System (FPS) certification for buses
- Tests as per EuroNCAP protocol and UN R135 regulation
- Under strike test to evaluate the EV battery performance
- FMVSS 301 Rear Impact Test
- Sled test on payment device as per ADR 68 for Australian market
- Side Impact Sled test on door handle assembly
- Sled test for 2-wheeler
- Seat validation
- Airbag performance check for high energy impact
- Seat side strength static loading performance check
- Side door pelvis pusher performance check
- Windshield glass dynamic and static performance check
- Certification process for Earth Moving Machinery/ CEVs and Camera Monitoring System
- Vehicle Air Conditioning System performance evaluation on HCV chassis dynamometer
- Light weight seat design
- Forging process simulation for magnesium oil sump
- FE modelling and evaluation of bridge parapet as per EN1317 (2010)

- Airbag module drop test
- Crash/ NVH/ Durability assessment
- Vande Bharat Railway Seat durability analysis
- Thermo-mechanical analysis of cask
- Johnson-Cook material card development and correlation
- Engine cooling circuit simulation for pressure drop estimation
- MBD simulation for gun carriage vehicle
- Moulding simulation services
- Aircraft Seat sled simulation
- VOCs test as per ISO-12219-2
- E-Axle/ Transfer Case torsional test
- Material modelling for structural adhesives
- Elevator panel testing as per IS 17900 (Part 1)
- Load relaxation testing on springs at high temperature
- Bolt preload measurement
- Wheel rim crush test
- Evaluation of structural integrity of flex plate
- Vibration & strain measurement for aviation application
- Modal hammer test on aviation vehicle
- In-cab noise simulation of EV using SEA approach
- Vibration assessment of printed circuit board
- Sound power evaluation of AC scroll chiller
- Buzz, Squeak and Rattle (BSR) evaluation for floor console and roofing system
- AVAS performance evaluation of EV inside hemi-anechoic chamber
- Phone booth/ POD/ Cuboid evaluation for speech intelligibility parameter index
- Design and development of e-axle powertrain based electric vehicles
- Hydrogen fuel cell-based powertrains for electric 3-wheeler & tractor applications
- Development of electric water pumps for EV applications
- Prediction of transmission error/ gear whine for transmissions and axles



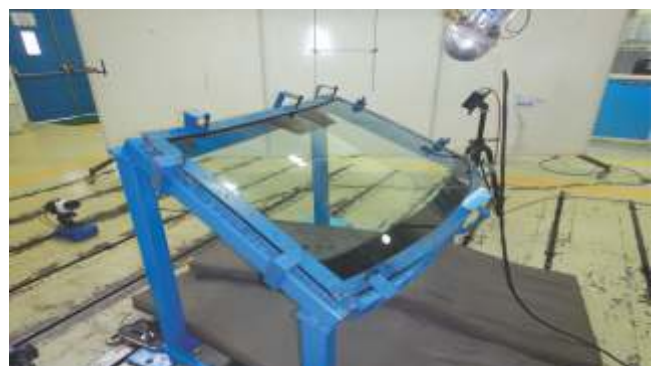
EMC Test on Motor Controller



EMC Test for CEV as per AIS-160 Phase II



Airbag Performance Check for High Energy Impact



Windshield Glass Dynamic and Static Performance Check



EuroNCAP Protocol and UNECE R135 Regulation Tests



ECE17 Seat EDP Development and Type Approval



E-Axle/ Transfer Case Torsional Test



Load Relaxation Testing on Springs



Bolt Preload Measurement



Wheel Rim Crush Test

Engagements for Brand Building

- Showcasing and demonstration of capabilities at expos, viz. Automotive Testing Expo 2023, India Energy Storage Alliance (IESA), Connected, Autonomous & Electric Vehicle (CAEV 2023), Truck Trailer Expo, Automotive Materials & Manufacturing (AM&M 2023), ET Auto EV Conclave, India International EV Show (IIEV Show), International Railway Equipment Exhibition, Bharat Mobility Expo 2024, Conclave

on Autonomous Technology & System (CATS), Symposium on International Automotive Technology (SIAT 2024), etc.

- Customer Meet organized at Chennai
- Capitalizing business opportunities through Regional Centres at Chennai, Hyderabad and Bengaluru
- Establishment of Creative Cell for corporate communication

- Expanding reach through Social Media – Periodic updates on the capabilities, events, new developments, etc. on social media platforms
- Reached out to the industry through periodic updates on capabilities, events, new developments, etc. on social media platforms
- Periodic posts and updates on ARAI website on the events and engagements



ARAI Stall at Bharat Mobility Expo 2024

Interactions with the Industry:

During the year, ARAI hosted various senior level delegations from Indian as well as overseas organizations and also visited many customers for business promotion. The idea of these interactions was to explore potential business avenues and collaborative opportunities. During these interactions, ARAI's capabilities and facilities were presented and demonstrated to the customers. They included ARAI's service offerings in the areas of certification, validation support, engine testing, component testing, transmission, EV, NVH, ethanol, fuel/ lubricant analysis, skill development initiatives, etc. The industry interactions have helped in understanding certification and development programs of the customers and created new leads for future business opportunities.

Technical Collaborations/ Strategic Tie-ups

- MoU with Centre of Excellence for Low Carbon and Fuel Cell Technologies (Cenex), UK – To pursue zero emission transport oriented projects
- MoU with Applus IDIADA – For collaboration in the areas of integrated safety, vehicle & component homologation, tyre regulations services, technical training courses and development projects
- MoU with AISICO Srl – To collaborate and pursue industrial/ application-oriented projects
- MoU with Department of Fisheries, Government of Maharashtra and ICAR – Central Institute of Fisheries Technology, Maharashtra – For development trials and performance verification (Proof of Concept) of alternate energy and fuel systems for fishing vessels
- MoU with MSIs and ARAI-AMTIFF – For implementation of Maharashtra State Innovative Startup Policy, 2018
- MoU with JSPM University – To offer B. Tech, M. Tech and Post Graduate Diploma in E-Mobility
- MoUs with Transport Commissioner, Maharashtra State – For establishment of Inspection & Certification regime in Maharashtra at twenty locations and providing Project Management Services for I&C Centre, Nashik
- Collaboration with IOCL and Industry Partner – For development of HCNG Generator Set Engine complying with CPCB IV+

Conferences/ Workshops/ Training Programs Organized

- ADAS V&V India Conclave 2023
- Symposium on International Automotive Technology, 2024 (SIAT 2024)
- International Conference on Automotive Materials and Manufacturing (AM&M 2023)
- International Conference on Advanced Powertrains for Mobility & Power Generation Applications
- Automotive Cybersecurity
- Hydrogen as a Carbon Neutral Fuel for Internal Combustion Engines

- Flex-Fuel Vehicles – An indigenous eco-friendly solution to Indian auto industry
- LNG as a new alternative fuel and its after-treatment devices
- Bio-mobility for automobile fleet and its new fuel technologies
- Advanced engine technologies and requirement for BS 6.2 norms
- Automotive fuel cylinder and fire safety for vehicles
- Nineteen training programs conducted at the behest of MoRTH for RTOs on EV Fire & Safety, Advanced Engine Technologies Requirement for BS6.2 Norms, Automotive Fuel Cylinder and Fire Safety for Vehicles, BS-VI Emission Certification, EV – Retro-fitment, Safety & Certification Homologation requirements, (CMVR procedure for approval), Automated Fitness Testing Stations, etc.



HCNG Generator Set Engine Development



Training Program for RTOs at Shillong



Visit of Shri Vijay Mittal, Joint Secretary, MHI



Visit of Dr. Renuka Mishra, Economic Adviser, MHI

SIAT 2024

Symposium on International Automotive Technology (SIAT) is a biennial event organized by ARAI, in association with SAEINDIA, and SAE International (USA). SIAT serves as a forum for exchange of ideas & brainstorming for the automotive industry, with participation of eminent worldwide experts in various mobility domains.

The eighteenth edition of this symposium, SIAT 2024, was organized by ARAI from 23rd to 25th January 2024 at Pune International Exhibition and Convention Center, Moshi, Pune. SIAT 2024 and SIAT EXPO 2024 was inaugurated by Dr. Mahendra Nath Pandey, Hon'ble Minister for Heavy Industries, Government of India. The other dignitaries present on this occasion included Dr. Hanif Qureshi, Additional Secretary, Ministry of Heavy Industries; Dr. David Schutt, CEO – SAE International; Dr. N. Saravanan, President and CTO, Ashok Leyland, Chairman – SIAT 2024 Steering Committee and President – ARAI; Dr. Reji Mathai, Director – ARAI and Chairman – SIAT 2024 Organizing Committee and Shri V. V. Shinde, Sr. Deputy Director, ARAI and Convener – SIAT 2024. The theme of SIAT 2024 was “Transformation Towards Progressive Mobility” aptly focused on innovative solutions for evolving mobility challenges. Some of the prominent highlights of the inaugural ceremony are as given below.

- Release of Symposium Proceedings containing Technical Papers, Technical Reference Bulletin (TRB) and Safety Handbook at the hands of Hon'ble Minister
- Virtual inauguration of new facilities, viz. Advanced NVH Development Centre, Accelerated Sled Laboratory and Advanced Photometry & Optics Laboratory at the hands of Hon'ble Minister
- Laying of Foundation Stone of ARAI's Mobility Research Centre (MRC), Takwe virtually by Hon'ble Minister



SIAT 2024 Inaugural Ceremony

SIAT 2024 was successful with participation of over 2500 delegates, which included overseas delegates from over 10 countries. During this symposium, 37 keynotes and 174 technical papers were presented by domain experts on various subjects, viz. E-mobility, ADAS, Alternate Fuels, Hydrogen, Advanced Powertrain, Vehicle Dynamics, Testing & Evaluation, etc. The symposium focused on recent advances in various mobility areas, such as Active and Passive Safety, Advanced Powertrain Technology, Autonomous Vehicles, Harmonization of Regulations, Simulation & Modeling, Advanced Driver



SIAT 2024 Technical Sessions

Assistance Systems, Alternate Fuels, E-mobility, Materials & Manufacturing, Hydrogen Fuel Cell, Hydrogen IC Engine, Tyre Technology, etc.

The symposium also featured 3 Plenary Sessions on the topics, viz. Sustainable Technologies for Next Decade, Safe Mobility, and Solutions for Future Mobility. Also, Panel Discussion on 'Transformation Towards Progressive Mobility' was organized. This Panel Discussion, moderated by Mr. Kavan Mukhtyar, PwC India, had eminent personalities, viz. Dr. N. Saravanan, President & Chief Technology Officer, Ashok Leyland Ltd.; Dr. Marc Stehlin, Head – Technology Centre, Skoda Auto Volkswagen India Pvt. Ltd.; Mr Sanjay Parashar, Executive Director (Supplies), Indian Oil Corporation Ltd.; Dr. Tapan Sahoo, Executive Director (R&D), Maruti Suzuki India Ltd. and Dr. Reji Mathai, Director, ARAI as the panelists.



SIAT Expo 2024

through various stalls. The exposition had participation of 216 exhibitors (spread over 330 stalls) from India, USA, UK, Japan, Germany, Austria, France, Finland, etc. and had a footfall of over 7000 visitors. A significant highlight of this exposition was a pavilion specifically dedicated for Medium & Small enterprises and Start-ups. This pavilion had a participation of over 70 such companies. Further, a Technology Pavilion, displaying futuristic technologies and products like Hydrogen Fuel Cell, Hydrogen IC Engine powered Truck, Hydrogen Engine and Type-IV cylinder for storage of Hydrogen, was also a part of this exposition. Student Poster Presentation competition was organized at this event, which showcased 15 posters in the areas of Safe Mobility, Sustainable Mobility and Intelligent Mobility.



Plenary Session



Panel Discussion

The concurrent SIAT EXPO 2024, was the biggest ever exposition organized in the history of SIAT. It was an appropriate platform for spectrum of worldwide companies to showcase their products/ technologies/ innovations/ services

SIAT 2024 concluded with Valedictory Function, with Dr. N. Saravanan, President & CTO of Ashok Leyland, Chairman – SIAT 2024 Steering Committee and President – ARAI, as a Chief Guest. During this Valedictory Function, awards for Best



Awards Ceremony

Technical Papers, Expo Stalls, Micro-Small-Start-up Stalls and Student Poster Presentation competition were presented. Also, in-house developed MARG 2.0 – a GIS database and analysis software tool, was launched on this occasion.



Launch of MARG 2.0

International Conference on Automotive Materials and Manufacturing (AM&M 2023)

The fourth edition of International Conference on Automotive Materials and Manufacturing 2023 (AM&M 2023) was organized by ARAI in association with SAEINDIA and ASM International (Pune Chapter) at Chakan, Pune from 31st May 2023 to 2nd June 2023. The theme of this conference was 'Shaping Progressive Mobility through Emerging Materials and Manufacturing Technology'. Dr. Hanif Qureshi, Additional Secretary, Ministry of Heavy Industries, Government of India inaugurated the conference as Chief Guest in the presence of Guest of Honour Shri Deepak Garg, Managing Director, Sany Heavy Industries Pvt. Ltd., Over 300 delegates attended this conference and relished 44 technical papers



Inaugural Function

and 20 keynote presentations by eminent experts from industry, academia and research institutes. Also, two Panel Discussions on futuristic topics, viz. 'Big data analytics for Materials and Manufacturing' and 'Materials for Sustainable Mobility', were organized. The concurrent exposition had 28 exhibitors, including start-ups, showcasing their innovative technologies, capabilities and services. The 'Students Materials Pavilion' at the exposition provided a great opportunity to budding engineers to put forth their innovative ideas to industry professionals. The conference concluded with a Valedictory Function, wherein, Mr. Lalitkumar Pahwa, MD – Pahwa, Metal Tech, was the Chief Guest and Shri Vijay Mittal, Joint Secretary, Ministry of Heavy Industries, Government of India, joining the function online.



Panel Discussion



Valedictory Function

ADAS V&V (Verification & Validation) Conclave 2023

ADAS V&V Conclave 2023 was organized at Pune International Exhibition & Convention Centre (PIECC), Moshi on 23rd November 2023. Shri Rajnesh Singh, Director, Ministry of Heavy Industries, Government of India, Inaugurated the

conclave in the presence a Chief Guest. Mr. Rajendra Petkar, CTO-Tata Motors Limited. It featured technical talks delivered by Thomas Semlitsch, 4 active Systems GmbH, Austria and Mrs. Ujjwala Karle & Shri. Konaki Ramu from ARAI. Also, Panel Discussion on 'Paving Road for Success of ADAS in India' was organized. This Panel Discussion, moderated by Mr. Sumantra Barooah of ET Auto, had inauguration & eminent personalities, viz. Mr. Aniruddha Kulkarni from TATA Motors, Dr. Tapan Sahoo from Maruti Suzuki India Ltd., Mr. Vinoth Ponnusamy from Mahindra & Mahindra Ltd., Mr. Jaidev Venkataraman from Valeo and Mr. Ganesh Rao from Continental Autonomous Mobility, Bangalore.

The conclave also hosted live demonstration of ADAS V&V, wherein, ADAS test equipment (procured by ARAI under the project supported by MHI) were used to demonstrate India case scenarios faced by ADAS vehicles. These comprehensive set of ADAS test track equipment allow simulating complex test scenarios on test track for thorough evaluation of ADAS in close-to-real-world scenario. The conclave received overwhelming response from the auto industry.



ADAS V&V Conclave 2023

Workshop on 'Automotive Cyber Security'

A Workshop on Automotive Cyber Security was organized at ARAI on 13th March 2024. The major highlight of this workshop was insightful technical sessions delivered by eminent speakers from Automotive Industry and System providers on Cyber Security Management System (CSMS) and Software Update Management System (SUMS). In

addition to this, ARAI's preparedness for certifying/ approving vehicles as per cyber security compliance requirements was showcased. This workshop had participation of over 150 delegates from OEM, Tier 1 and System Providers.



Workshop on Automotive Cybersecurity

Seminar on 'Flex-Fuel Vehicles'

Seminar on 'Flex-Fuel Vehicles – An Indigenous Eco-Friendly Solution to Indian Auto Industry' was organized at ARAI on 24th June 2023. The objective of this seminar was to disseminate knowledge on new trends, laws and anticipated developments in the field of flex fuel vehicles to the Indian automotive industry. Dr. Reji Mathai, Director – ARAI Inaugurated the seminar in the presence of Mr. Shekhar Gaikwad, IAS, Former Sugar Commissioner, Maharashtra (Guest of Honour) and Dr. S. S. Thipse, Sr. Deputy Director, ARAI. This seminar was attended by over 270 delegates from Automotive Manufacturers, OMCs, Sugar Manufacturing Association, Fuel System Suppliers, Test Facility Providers and Test Agencies. Eminent speakers at this seminar included Mr. Shekhar Gaikwad, IAS, Ex Sugar Commissioner, Maharashtra; Mr. P. S. Ravi, Executive Director-Corporate Entities, BPCL; Mr. Tarun Agarwal, Executive Officer, Maruti Suzuki India Limited; Mr. K U Ravindra, Vice President – Engineering & Mr. Rajesh C, Lead System Engineer from Bosch India Limited; Dr. Alok Kumar, Sr. General Manager, Hero MotoCorp Ltd.; Mr. Kazuya Tsurumi, Jr. Corporate Officer – Head Mobility Solution Business, Horiba, Japan; Dr. Ravindra Utgikar, Vice President – Praj Industries Ltd.; Mr. Roger Guilherme, Manager of Biofuel and Product Development at R&D

Volkswagen South America and Dr. S. S. Thipse, Sr. Deputy Director, ARAI. The seminar succeeded in accomplishing its purpose of knowledge sharing and providing platform for exchange of thoughts among the experts and participants.



Seminar on Flex Fuel Vehicles

Seminar on 'Hydrogen as a Carbon-Neutral Fuel for Internal Combustion Engines'

A Seminar on 'Hydrogen as a Carbon-Neutral Fuel for Internal Combustion Engines' was organized at ARAI on 29th April 2023, with an aim to facilitate sharing of knowledge on regulations and upcoming trends in Hydrogen fuel for Internal Combustion Engines. Dr. Reji Mathai, Director – ARAI, Inaugurated this seminar in the presence of Dr. Anuradda Ganesh, Senior Advisor (Technical), Cummins India Limited. Over 300 delegates spanning Vehicle Manufacturers; CGD companies; Simulation Software companies; Gas Fuel System suppliers; Government Officials from Centre for High Technology(CHT), MoPNG; and Test Agencies attended this seminar. Eminent speakers at this seminar included Mr. Alok Sharma, Executive Director, CHT; Mr. Krishnan Sadagopan, Senior Vice President, Ashok Leyland Limited; Mr. K U Ravindra, Vice President, Engineering, Bosch Limited; Mr. David Worth, Director, Engine Management Systems, Westport Fuel System USA; Mr. Nayan Pandya, Managing Director, Cryogas Equipment Pvt. Ltd.; Mr. Vivek Kumar, Principal Engineer – Hydrogen Solutions & Mr. Pravin Nakod, Fluid Applications Head, India and ASEAN, Ansys Software Pvt Ltd.; Mr. Vivek Seshan from Reliance Industries Limited; Mr. Abhijit Phadke, Director, Lab and Test Operations, Cummins Tech Centre India; and Dr. S. S Thipse, Sr. Deputy Director, ARAI.

The seminar explored various topics like Hydrogen ICE development, its storage and compatibility; Safety and legislative regulation; types of hydrogen fuel and its production; engine performance and emission overviews; etc.



Seminar on Hydrogen as a Carbon-Neutral Fuel for ICE

Supporting SAEINDIA Activities

ARAI is associated with SAEINDIA's wide spectrum of activities, which are carried out for the benefit of practicing engineers, engineering students and school children. During the year, ARAI supported following programs organized by SAEINDIA Western Section.

- International Conference on Advanced Powertrains for Mobility & Power Generation Applications
- International Automotive Weathering Technology Symposium, 2023
- PDP on Hydrogen & Hydrogen Blended CNG IC Engine
- Seminar on Automotive Future Trends
- BAJA SAEINDIA, 2024
- Mobility Ideathon, March 2024
- AWIM Pune Olympics



Conference on Advanced Powertrains

ARAI undertakes skilling, reskilling and upskilling activities for disseminating knowledge through ARAI Academy's Learning Centre (LC) and Training Centre (TC). This includes training and educational programs to enhance human resource skills for meeting growing needs of mobility sector. For this purpose, ARAI Academy collaborates with various universities and industry.

Notable highlights of activities carried out in 2023-24 include:

- Memorandum of Understanding (MoU) with JSPM University to offer B. Tech, Post Graduate Diploma and M. Tech programs
- Development of Battery Management System (BMS) trainer kit under an internally funded project – Useful to industry working professionals and students for learning basics of BMS
- Augmentation of electric vehicle laboratory with facilities like power electronics workbench and motor trainer kit – are being utilized in training programs organized to facilitate upskilling on the latest technologies
- Ten new domain areas added to Proficiency Improvement Programs (PIP)
- Introduction of training program for a Non-automotive OEM – 25 participants trained in Power Electronics
- Webinars/ guest lectures organized online and at few colleges



MoU with JSPM University

LEARNING CENTRE

Learning Centre conducts undergraduate, graduate, postgraduate diploma and doctorate programs with specialization in Automotive Engineering and E-mobility through collaborations with various universities. Summary of the joint programs conducted with various universities is given below.

Collaborations for UG Programs:

- Christ University, Bengaluru – B. Tech. in Automobile Engineering
- Chitkara University, Punjab – BE in Automobile Engineering with specialization in EVs and HEVs
- SRM Institute of Science and Technology, Chennai – B. Tech. in Automotive Engineering with specialization in EHV
- JSPM University, Pune – B. Tech in Mechanical Engineering with AI/ML and B Tech in Robotics & Artificial Intelligence

Collaborations for PG Programs:

- COEP Technological University, Pune – M. Tech. in Automotive Technology
- Chitkara University, Chandigarh – M. Tech. in Automotive Engineering
- SRM Institute of Science and Technology, Chennai – M. Tech. in Automotive Technology with specialization in Electric & Autonomous Vehicles



Developed BMS Trainer Kit (displayed at SIAT 2024)

- Kalasalingam Academy of Research and Education (KARE), Tamil Nadu – M.Tech. in Automotive Engineering (Electric & Hybrid Vehicle and Powertrain Engineering)
- JSPM University, Pune – M. Tech in Robotics & Artificial Intelligence and Automotive Technology with AI/ML

Collaborations for Post Graduate Diploma Programs:

- COEP Technological University, Pune (Electric Mobility)
- Rajarambapu Institute of Technology, Sangli (Electric and Autonomous Vehicles)
- JSPM University, Pune (e-Mobility)

Collaborations for Doctoral Programs:

- Dr. Vishwanath Karad MIT World Peace University, Pune – PhD (Automotive Engineering)

TRAINING CENTRE

Training Centre organizes Proficiency Improvement Programs (PIP), specific industry focused programs, i.e, Domain Training Programs (DTPs) and e-Learning online courses for students as well as working professionals. During the year, 22 PIPs and 9 DTPs were organized, wherein lectures were given by ARAI personnel, academicians and eminent industry experts, including overseas speakers. These PIPs and DTPs had participation of over 830 delegates. Some of the various domain areas, in which these programs were conducted, are given below:

- Automotive NVH
- Automotive Regulations
- Automotive Testing & Certification
- Battery & BMS of Electric Vehicle
- Bharat New Car Assessment Program (Bharat NCAP)
- BS-VI Stage II Regulation & Implementation for Automotive Applications
- Certification of Construction Equipment Vehicles (AIS-160)
- Concepts in Advanced Driver Assistance System
- Electric Vehicle NVH
- Electric Vehicle Technology and Fire & Safety
- Engine Emission & Control
- Engine Testing & Certification
- Engine Performance & Emissions (Level III)
- EV Development
- EV-Retro-fitment, Safety & Certification
- Fundamentals of Automotive Electricals & Electronics
- High Voltage Safety for Electric Vehicles
- Hydrogen Powering Tomorrow: IC Engine Innovations
- Material Characterization & Modeling
- Power Electronics
- Thermal Runaway for EV Batteries



PIP on Bharat NCAP



PIP on EV Technology

**Independent Auditor's Report
&
Annual Statement of Accounts**

To,

**The Members of
The Automotive Research Association of India**

Report on the Audit of the Financial Statements

OPINION

We have audited the financial statements of THE AUTOMOTIVE RESEARCH ASSOCIATION OF INDIA, PUNE ("ARAI"), which comprise the Balance Sheet as at March 31, 2024, the Income and Expenditure Account and Receipt and Payment Account for the year then ended, and notes to the financial statements, including a summary of significant accounting policies.

In our opinion, the accompanying financial statements give a true and fair view of the financial position of the entity as at March 31, 2024 for the year then ended in accordance with the Accounting Standards issued by the Institute of Chartered Accountants of India (ICAI).

BASIS OF OPINION

We conducted our audit in accordance with the Standards on Auditing (SAs) issued by ICAI. Our responsibilities under those Standards are further described in the Auditor's Responsibilities for the Audit of the Financial Statements section of our report. We are independent of the entity in accordance with the Code of Ethics issued by ICAI and we have fulfilled our other ethical responsibilities in accordance with the Code of Ethics. We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our opinion.

RESPONSIBILITIES OF MANAGEMENT AND THOSE CHARGED WITH THE GOVERNANCE FOR THE FINANCIAL STATEMENTS

Management of ARAI is responsible for the preparation of the financial statements in accordance with relevant laws as applicable and for such internal control as management determines is necessary to enable the preparation of financial statements that are free from material misstatement, whether due to fraud or error.

In preparing the financial statements, management is responsible for assessing the entity's ability to continue as a going concern, disclosing, as applicable, matters related to going concern and using the going concern basis of accounting unless management either intends to liquidate the entity or to cease operations, or has no realistic alternative but to do so.

Those charged with governance are responsible for overseeing the entity's financial reporting process.

AUDITOR'S RESPONSIBILITIES FOR THE AUDIT OF FINANCIAL STATEMENTS

Our objectives are to obtain reasonable assurance about whether the financial statements as a whole are free from material misstatement, whether due to fraud or error, and to issue an auditor's report that includes our opinion. Reasonable assurance is a high level of assurance, but is not a guarantee that an audit conducted in accordance with SAs will always detect a material misstatement when it exists. Misstatements can arise from fraud or error and are considered material if, individually or in the aggregate, they could reasonably be expected to influence the economic decisions of users taken on the basis of these financial statements.

As part of an audit in accordance with SAs, we exercise professional judgment and maintain professional skepticism throughout the audit. We also:

- Identify and assess the risks of material misstatement of the financial statements, whether due to fraud or error, design and perform audit procedures responsive to those risks, and obtain audit evidence that is sufficient and appropriate to provide a basis for our opinion. The risk of not detecting a material misstatement resulting from fraud is higher than for one resulting from error, as fraud may involve collusion, forgery, intentional omissions, misrepresentations, or the override of internal control.
- Obtain an understanding of internal control relevant to the audit in order to design audit procedures that are appropriate in the circumstances, but not for the purpose of expressing an opinion on the effectiveness of the entity's internal control.
- Evaluate the appropriateness of accounting policies used and the reasonableness of accounting estimates and related disclosures made by management.
- Conclude on the appropriateness of management's use of the going concern basis of accounting and, based on the audit evidence obtained, whether a material uncertainty exists related to events or conditions that may cast significant doubt on the entity's ability to continue as a going concern. If we conclude that a material uncertainty exists, we are required to draw attention in our auditor's report to the related disclosures in the financial statements or, if such disclosures are inadequate, to modify our opinion. Our conclusions are based on the audit evidence obtained up to the date of our auditor's report. However, future events or conditions may cause the entity to cease to continue as a going concern.

We communicate with those charged with governance regarding, among other matters, the planned scope and timing of the audit and significant audit findings, including any significant deficiencies in internal control that we identify during our audit.

Report on Other Regulatory Requirements

Further, we report that: -

- a. We have obtained all the information and explanations which to the best of our knowledge and belief were necessary for the purposes of our audit.
- b. In our opinion, proper books of accounts as required by law have been kept by ARAI so far as it appears from our examination of those books.
- c. ARAI's Balance Sheet, the Statement of Income and Expenditure and Receipts and Payments Account dealt with by this Report are in agreement with the books of account.

For Kirtane & Pandit LLP
Chartered Accountants
Firm Registration No.105215W/W100057

Parag Pansare
Partner
Membership No: 117309

Balance Sheet as on 31st March 2024

(RS IN LAKHS)

PARTICULARS	SCHEDULE NO	31 MARCH 2024	31 MARCH 2023
I EQUITY AND LIABILITIES			
1. OWNERS' FUNDS			
A RESERVES AND SURPLUS	3	1,89,413.18	1,67,098.73
		<u>1,89,413.18</u>	<u>1,67,098.73</u>
2. NON-CURRENT LIABILITIES			
A OTHER LONG-TERM LIABILITIES	4	4,049.35	4,050.05
B LONG-TERM PROVISIONS	5	2,613.73	2,097.25
		<u>6,663.08</u>	<u>6,147.30</u>
3. CURRENT LIABILITIES			
A TRADE PAYABLES			
I TOTAL OUTSTANDING DUES OF MICRO, SMALL AND MEDIUM ENTERPRISES	6	1,072.58	-
II TOTAL OUTSTANDING DUES OF CREDITORS OTHER THAN MICRO, SMALL AND MEDIUM ENTERPRISES	6	2,880.25	2,481.46
B OTHER CURRENT LIABILITIES	7	15,524.31	14,318.39
C SHORT-TERM PROVISIONS	5	306.43	326.55
		<u>19,783.57</u>	<u>17,126.39</u>
TOTAL		2,15,859.82	1,90,372.41
II ASSETS			
1. NON-CURRENT ASSETS			
A PROPERTY, PLANT AND EQUIPMENT AND INTANGIBLE ASSETS	8		
I PROPERTY, PLANT AND EQUIPMENT		73,174.14	70,669.48
II INTANGIBLE ASSETS		441.89	402.74
III CAPITAL WORK IN PROGRESS		6,815.34	3,925.32
IV INTANGIBLE ASSET UNDER DEVELOPMENT		-	-
B NON-CURRENT INVESTMENTS	9	75,107.42	43,778.10
		<u>1,55,538.80</u>	<u>1,18,775.65</u>
2. CURRENT ASSETS			
A INVENTORIES	10	15.35	21.03
B TRADE RECEIVABLES	11	6,802.76	6,416.49
C CASH AND BANK BALANCES	12	46,525.47	59,440.23
D SHORT TERM LOANS AND ADVANCES	13	6,385.84	5,225.00
E OTHER CURRENT ASSETS	14	591.62	494.04
		<u>60,321.03</u>	<u>71,596.78</u>
TOTAL		2,15,859.82	1,90,372.41

BRIEF ABOUT THE ENTITY

1

SUMMARY OF SIGNIFICANT ACCOUNTING POLICIES

2

THE ACCOMPANYING NOTES ARE AN INTEGRAL PART OF THE FINANCIAL STATEMENTS

Dr.Reji Mathai

Director

Dr. N. Saravanan

President

Ms. Anjali Pandey

Vice President

AS PER OUR REPORT OF
EVEN DATE ATTACHED
FOR M/S KIRTANE AND PANDIT LLP
CHARTERED ACCOUNTANTS
Firm's Reg. No. W10057

Parag Pansare

PARTNER

Membership No. 117309

Date : 28 June 2024

Place : Pune

Statement of Income and Expenditure for the Year Ended 31st March 2024

(RS IN LAKHS)

PARTICULARS	SCHEDULE NO	31 MARCH 2024	31 MARCH 2023
I REVENUE FROM OPERATIONS	15	50,872.16	41,951.57
II OTHER INCOME	16	6,317.16	3,733.05
III TOTAL INCOME (I+II)		57,189.32	45,684.62
IV EXPENSES:			
A OPERATIONAL EXPENSES		5,537.55	4,597.00
B EMPLOYEE BENEFITS EXPENSES	17	22,365.94	19,818.99
C DEPRECIATION AND AMORTIZATION EXPENSES	18	4,480.05	4,424.02
D OTHER EXPENSES	19	7,176.55	5,566.19
TOTAL EXPENSES		39,560.09	34,406.19
V SURPLUS/(DEFICIT) BEFORE TAX (III- IV)		17,629.23	11,278.43
VI SIAT SURPLUS / (DEFICIT) TRANSFERRED TO GENERAL FUND		260.57	(0.33)
VII SURPLUS/(DEFICIT) TRANSFERRED TO GENERAL FUND (V-VI)		17,368.66	11,278.76

Dr.Reji Mathai
Director

Dr. N. Saravanan
President

Ms. Anjali Pandey
Vice President

AS PER OUR REPORT OF
EVEN DATE ATTACHED
FOR M/S KIRTANE AND PANDIT LLP
CHARTERED ACCOUNTANTS
Firm's Reg. No. W10057

Parag Pansare
PARTNER
Membership No. 117309

Date : 28 June 2024
Place : Pune

ARAI Management Committee



Dr. Reji Mathai

Director - ARAI
director@araiindia.com



Akbar Badusha
Senior Deputy Director



Nitin Dhande
Senior Deputy Director



Ms. Medha Mainkar
Senior Deputy Director



Anand Deshpande
Senior Deputy Director



Dr. Sukrut Thipse
Senior Deputy Director



Vikram Shinde
Senior Deputy Director



Ms. Medha Jambhale
Senior Deputy Director



Sandeep Medane
Senior Deputy Director



Dr. Nagesh Walke
Senior Deputy Director



Atul Bhide
Deputy Director



Rahul Mahajan
Deputy Director



Ms. Ujjwala Karle
Deputy Director



Charudatta Mukhedkar
Deputy Director



Ms Prajakta Dhare
General Manager



Sandeep Gogle
General Manager



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ARAI
Progress through Research

The Automotive Research Association of India

(Under the Administrative Control of Ministry of Heavy Industries, Govt. of India)

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