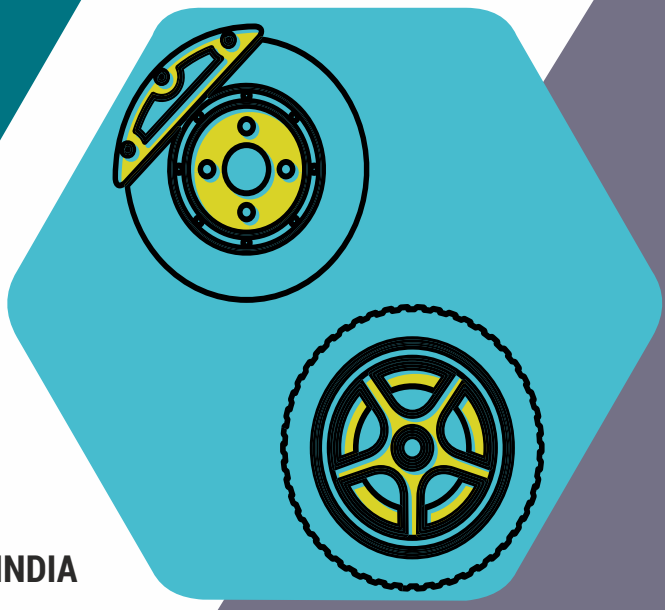
ARAI

Progress through Research



52nd Annual Report

2021-2022

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

Contents

AKAM Week Celebrations

Azadi ka Amrit Mahotsav (AKAM) is an initiative of Government of India to celebrate and commemorate 75 years of independence, the glorious history, culture and achievements of our country. This celebration commenced on 12th March 2021 with a 75-week countdown to our 75th anniversary of independence and will culminate post a year on 15th August 2023.

To celebrate and commemorate 75 years of Independence, ARAI celebrated 'AKAM Iconic Week' from 10th to 16th January 2022 through various programs organized under the guidance of Ministry of Heavy Industries (MHI), Government of India. This event commenced with inauguration by Director – ARAI and was followed by various programs organized during the week on aspects like Sustainability Development & Environment, Swachh Bharat, Swastha Bharat, Ayushman Bharat, Aarogya Bharat, Youth Involvement, Aatmanirbhar Bharat, Innovation & Sustainability and Unsung Heroes of Freedom Movement.

ARAI had the honour of Hon'ble Ministers and many senior officials from Ministries and Industry gracing the programs organized during this iconic week. The guest list included Dr. Mahendra Nath Pandey, Hon'ble Minister for Heavy Industries; Shri Krishan Pal Gurjar, Hon'ble Minister of State for Heavy Industries; Ms. Nidhi Chhibber, AS – MHI; Mr. Jeetendra Singh, JS – MHI; Mr. Pradeep Kurulkar, Outstanding Scientist & Director, Research & Development Establishment (Engrs.); and Mr. Rajendra Petkar, President – ARAI and President & CTO, Tata Motors Ltd.

Some of the programs organized included 2-day webinar on ethanol flex fuel, seminar on compressed bio-gas; launch of hackathon & on-boarding of start-ups for UpTech (up-levelling program) under TechNovuus (Technology Innovation Platform of ARAI); expert lectures; inauguration of bumper test facility; screening of AKAM film, wall painting, drawing and essay writing competitions for students, plantation, walkathon, etc. This iconic week was celebrated with enthusiasm by the participants, which included ARAI employees, industry professionals and student community.

Visit of MHI Dignitaries

- Dr. Mahendra Nath Pandey, Hon'ble Minister for Heavy Industries interacted with industry luminaries from SIAM and ACMA on Production Linked Incentive (PLI) Scheme and addressed the Press. Other major highlights of this visit were:
  - Virtual laying of foundation stone of ARAI's Advanced Battery Safety Test Lab
  - Demonstration of capabilities and in-house developed technology solutions by ARAI



- Shri Arun Goel, Secretary, Heavy Industries reviewed ARAI's performance and interacted with Senior Executives, ARAI Academy and TechNovuus students. Other major highlights of this visit were:
  - Exchange of MoUs with seven Start-ups selected for UpTech Program under TechNovuus platform
  - EV Charger Technology Know-how transfer
  - Laying of foundation stone of ARAI's Advanced NVH Development Centre



Governing Council

PRESIDENT
Mr. Rajendra M Petkar
President & Chief Technology Officer (ERC),
Tata Motors Ltd

VICE PRESIDENT
Mr. Ravi Gogia
President, Fiat India Automobiles Pvt Ltd

DIRECTOR
Dr. Reji Mathai

ARAI is under the Administrative Control of Ministry of Heavy Industries, Govt. of India.

MEMBERS

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

GOVT. OF INDIA REPRESENTATIVES

Mr. Shashank Priya
Special Secretary & Financial Adviser
Govt. of India
Ministry of Heavy Industries
Udyog Bhavan New Delhi -110 011

Mr. Amit Mehta
Joint Secretary
Govt. of India
Ministry of Heavy Industries
Udyog Bhavan New Delhi -110 011

Mr. R.K. Jaiswal
Development Officer (Engineering)
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
Fax : +91-20-6762 1104
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 GBBSD dated 10/12/1966
New Regn.No. Maha/2066/2016/Pune dated 13/12/2016
Registered under The Maharashtra Public Trust Act, 1950
Reg. No. F-48091/Pune dated 13/12/2016.

STATUTORY AUDITORS

M/s Gunwani & Kolapkar, Chartered Accountants
Mumbai Office:
602, Pooja 7th Road,
Santacruz, Mumbai - 400055
Pune Office :
Flat No. B-6, Ghodke Classic, Near Kamla Nehru Park,
Erandwane, Pune - 411 004

Members

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

* New Membership
** Membership approved by 1st April 2022
~ Withdrawal
~~ Cancellation of membership
~ # Membership approved and withdrawn during the year

FINANCE & INTERNAL AUDIT COMMITTEE (FIAC)

CHAIRMAN

Mr. Ravi Gogia
Vice President- ARAI
President, Fiat India Automobiles Private Ltd

MEMBERS

Mr. Balaram Pradhan
General Manager Finance
Mercedes-Benz India Pvt. Ltd.

Mr. Gopal Bhutada
General Manager - ERC
Tata Motors Ltd.

Mr. Pawan Agarwal
CFO
Kirloskar Oil Engines Ltd.

Mr. Abhinav Sogani
Head of Tax & Customs-Finance
India Centre of Excellence
Skoda Auto Volkswagen India Pvt. ltd.

Mr. Chetan Kamdar
Finance Director
Cummins India Ltd.

Mr. Mahendra K Harit
General Manager- Finance
Ashok Leyland Ltd.

Mr. Dinesh Gandhi
Vice President (Internal Audit)
Maruti Suzuki India Ltd

Mr. Rasesh Joshi
Head-Business Planning & Product Development (F&A Business Planning)
Mahindra and Mahindra Ltd.

ARAI Members

Dr. Reji Mathai
Director-ARAI

Mr. Atul Bhide
Deputy Director
(HoD- Finance & Accounts), Member Secretary

PROJECT EVALUATION & MONITORING COMMITTEE (PEMC)

CHAIRMAN

Shri 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. Rajinder S Sachdeva
Chief Operating Officer
V E Commercial Vehicles Limited

Mr. Alok Jaitley
Sr Vice President (Engg)
Maruti Suzuki India Ltd.

Ms. Anuradda Ganesh
Director – Research, Innovation and Compliance, India ABO
Cummins Technologies India Pvt. Ltd.

Mr. S. Janardhanan
Vice President (Co-ordination)
Simpson & Co. Ltd.

Mr. Pankaj Sonalkar
Chief of Electric Vehicle Technology Centre
Mahindra & Mahindra Ltd

Mr. S. Sriraman
Sr. Vice President ((R&D)
Tractors and Farm Equipment Limited

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

Mr. Rajendra Petkar
President, ARAI

Mr. Ravi Gogia
Vice President, ARAI

Dear Members,

I am pleased to share with you ARAI's performance during the Financial Year 2021-22. Over the last two years, the impact of COVID-19 pandemic has left us all vulnerable. Despite the toughest of times posed by the pandemic, our resolve to shape a better and healthier work environment has strengthened. I am proud of the determination of our employees for standing up to the challenges and also, for the passion to grow.

Despite the ongoing challenges due to the pandemic, our Operational Income grew by over 45%, albeit on a lower base registered in the previous financial year which was impacted to a great extent due to the pandemic. However, the silver lining lies in the fact that we were successful in going past the revenue generated in pre-pandemic period, i.e. financial year 2019-20. Further, we ended the year with a robust pipeline of work orders, despite the challenging market environment. These results are reflective of the success of our growth strategy, our singular focus on creating value for clients and most importantly, the unwavering dedication of our people.

> "These results are reflective of the success of our growth strategy, our singular focus on creating value for clients and most importantly, the unwavering dedication of our people."

We are focused on capitalizing technology transfer opportunities having achieved a significant breakthrough during the preceding financial year, wherein we had transferred the know-how of AC and DC Charging Stations to a PSU. This year we tested and certified the charger manufactured by the PSU from this transferred know-how. We continued to take further such breakthrough developments this year too, as we successfully transferred in-house developed Battery Management Systems technology to MSME and Tier-1 company. Other notable achievements of this year include delivery of Drive by Wire platform for a Start-up and Innovation hub, HIL validation of EV controllers for a global customer, development of E-axle Powertrain kit for 3-wheeler application, Light Electric Vehicle AC charge point, Acoustic Vehicle Alerting System (AVAS) for quiet vehicles, etc. I am sure these innovative solutions will generate value for all our stakeholders.

> "With this recognition, ARAI has achieved a status of being the only Indian test agency and one amongst very few in the world, to obtain accreditation for virtual test scope."

Our focus on providing simulation based testing services has scaled newer heights with ARAI being accredited by NABL to carry out virtual testing and approval for scopes like front underrun protective device, rear underrun protective device, strength of superstructure of large passenger vehicles, etc. With this recognition, ARAI has achieved a status of being the only Indian test agency and one amongst very few in the world, to obtain accreditation for virtual test scope.

Every year, we contribute significantly as a technical secretariat for standardization and harmonization activities. We continued with this tradition as we contributed in various national and international committees/ forums like Automotive Industry Standards Committee (AISC), CMVR Technical Standing Committee (CMVR – TSC), Standing Committee on Implementation of Emission Legislations (SCoE), CPCB Standing Committee, Bureau of Indian Standards and WP.29 & its Sub-groups.

We are continuing to build deeper relationships with our clients and growing the trust they have in us. In order to strengthen the bonding with our clients, we have formed a Customer Relation Cell which interacts with the visitors at ARAI to understand and address their issues. This initiative, along with our other customer focused measures will definitely have a profound impact and help in ensuring utmost customer satisfaction.

Our engagement with employees continues to strengthen. We continue to bring our employees expanded opportunities for upskilling and reskilling through periodic training programs in functional, as well as behavioural and leadership aspects. Our approach enables all employees to work for the benefit of our clients and support them. We see this as being a key differentiator in how we engage with our clients and also, across the institute.

Our skilling initiative is not limited to our employees, but also encompasses imparting training to industry professionals too. For this purpose, we organize Proficiency Improvement Programs (PIPs) and E-Learning courses in different automotive engineering domains. This year, we organized 45 PIPs, wherein eminent academicians, technologists and domain experts from ARAI trained over 2000 industry professionals. In addition to this, we are offering 15 E-Learning courses in various automotive domains for benefit of industry professionals and academia. Also, through our collaborations with national universities, we continue to offer undergraduate, postgraduate and doctorate programs with specialization in automotive engineering for the student community. Similarly, our TechNovuus platform – set up under a mandate of Ministry of Heavy Industries (MHI) – is engaging Start-ups, MSMEs, Innovators and Youth to connect with experts for collaborative working on industry's problem statements.

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The future is not something that any of us can predict. The lingering impact of the pandemic accompanied by increased volatility, is confronting businesses with complexities and challenges. At the same time, the mobility ecosystem's future needs in emerging automotive areas, together with upcoming norms, are creating tremendous opportunities for differentiation and to establish a strong foothold for us in newer areas. All these years, we have been a trusted navigator for our clients as they seek to create value from our domain expertise, especially on the development testing and certification fronts and we are focused on building on this trust.

"I believe, we are firmly and resolutely on a journey to unlock the potential emerging opportunities in the mobility sector through continuous capability enhancement, prudent investment and building a lasting customer connect."

The opportunity that lies before us to make an indelible mark with our domain expertise and our investment in employees is greater than it has ever been. This gives us great optimism about the future and equally puts great responsibility on us to make that future happen. As we forge ahead, our business continuity will remain rested on serving the emerging needs of the industry. I believe, we are firmly and resolutely on a journey to unlock the potential emerging opportunities in the mobility sector through continuous capability enhancement, prudent investment and building a lasting customer connect.

In closing, I would like to express my gratitude 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 Members of Project Evaluation and Monitoring Committee; ARAI Members; and Director – ARAI for their continued support. I would like to thank our customers and associates for their overwhelming trust, support and confidence reposed in us. I would also like to thank everyone at ARAI for their commitment. Without their continuous and tireless contributions, none of our many achievements of this year would have been possible. This dedication and perseverance assures that many more successes lie in store for us in the future.

Rajendra Petkar

Dr. Reji Mathai
Director - ARAI
director@araiindia.com

Director's Report

The Governing Council of ARAI has great pleasure in presenting the Annual Report along with Overview of Operations and Audited Statement of Accounts for the year ending 31st March 2022.

Year 2021-22 was a satisfying one for ARAI. We proved resilient amidst continued uncertainty due to the COVID-19 pandemic. We overcame the challenges to deliver fairly strong performance, while continuing to advance our aspirations and maintaining the well-being and safety of our team. I am tremendously proud of Team ARAI for its dedication to continuously deliver quality solutions to our customers and stakeholders.

We overcame the challenges to deliver fairly strong performance, while continuing to advance our aspirations and maintaining the well-being and safety of our team.

Our focus on consolidating our strengths in certification, developing technology solutions and continuous development of our people have enabled us to grow despite a challenging business environment. After witnessing a significant drop in Operational Income in the financial year 2020-21, we have managed to regain considerable ground in 2021-22, with our Operational Income surpassing the figure registered in the pre-pandemic year of 2019-20, reflecting strong underlying performance across all business verticals.

Our aspirations and purpose inspire us to deliver innovative and sustainable solutions that have the potential to transform the mobility ecosystem.

Our aspirations and purpose inspire us to deliver innovative and sustainable solutions that have the potential to transform the mobility ecosystem. They motivate us to continuously improve how we interact with our customers and associates as we strive to foster a culture which is the key differentiator of our growth. Significant achievements during 2021-22 like transfer of BMS technology for Li-ion battery pack, Light Electric Vehicle AC charge point know-how transfer, deployment of AEB control strategy for ADAS development and assignments in Hydrogen Fuel Cell are a testimony to this. Also, these demonstrate our purpose and the confidence reposed by our customers in our capabilities in emerging technology areas.

Solving problems at scale requires collaboration with diverse partners. In line with this thinking, we have launched UpTech Program for technology up leveling under our TechNovuus Platform, which has been set up under the aegis of MHI. Seven mobility start-ups have been selected and on boarded to work on solutions on a pool of industry problem statements. These start-ups are being provided mentorship support and financial assistance.

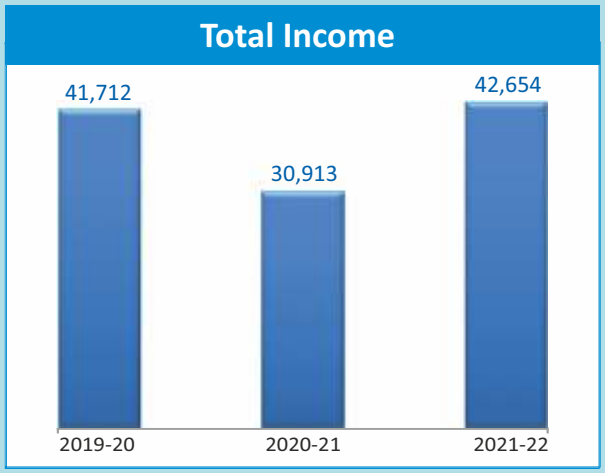
Finally, the basis of our success is our people. They are the ones who serve our customers with quality services; and also build solutions and drive innovation to shape our future growth. Having a great team of people with integrity and capabilities to navigate challenging circumstances while maintaining high standards of professional excellence is what ensures our prosperity, now and in the future. I would like to thank Team ARAI who continue to show the same passion and commitment which is reflected in our success. I also would like to thank our customers, associates and stakeholders for their continued trust in us.

Finally, the basis of our success is our people. They are the ones who serve our customers with quality services; and also build solutions and drive innovation to shape our future growth.

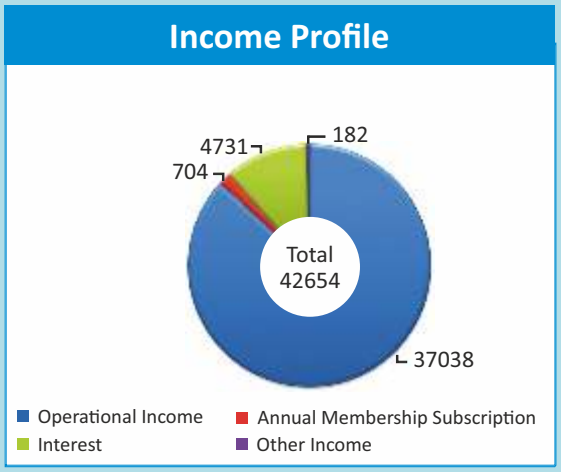
On behalf of Team ARAI, I would like to thank the President, Vice President, Members of the Governing Council, Members of Finance & Internal Audit Committee, Members of Project Evaluation & Monitoring Committee, ARAI Members and Senior Officials from MHI for their continued support. As we move on, I am very excited about the progress we have made, the path we are on, and we are confident of building on this incredible momentum.

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 2021-22, Operational Income is Rs.37,037.59 lakh as compared to Rs. 25,540.41 lakh in 2020-2021. Total Income is Rs. 42,654.14 lakh as compared to Rs. 30,913.36 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.

- **MHI Supported and Internal R&D Projects**

  Projects approved by MHI's (a) Main Committee out of Development Council for Automobile & Allied Industries (DCAAI) funds (b) Project Implementation and Sanctioning Committee (PISC) under FAME-India Scheme and (c) Apex Committee under Scheme on Enhancement of competitiveness in the Indian Capital Goods Sector (CG Scheme) are Non-Recurring Grant-in-Aid. ARAI also takes up R&D projects funded from its internal funds.

- **Appointment of Statutory Auditors**

  M/s. Gunwani and Kolapkar, Chartered Accountants, Pune were appointed as Statutory Auditors for the Financial Year 2021-22, in the Annual General meeting held on 08th October 2021.

- **Membership Subscription**

  The total number of members of ARAI as on 31/3/2022 is 72 and the Annual Membership Subscription for the year under report is Rs. 703.56 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 2020 to March 2023.

- **Income Tax**

  The 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.

- **Research and Development**

During the year, a project supported by Ministry of Heavy Industries (MHI), Government of India on Development of E-axle Powertrain Kit for 3-wheeler application in India was completed. A scalable solution of E-axle Powertrain kit for entire 3-wheeler range of L5 category (both cargo & passenger vehicles) has been developed in this project. This solution can either be a retro-fitment on in-use vehicles or can be installed in OE vehicles. It consists of right powertrain sizing along with unique auto-shift two-speed gear system to meet India specific requirements. It also offers optimized efficiency through integral packaging leading to optimized weight and matching gear ratios to ensure motor operations in better efficiency regions and intelligent vehicle control unit.

Other projects currently being implemented under the support of MHI include the following.

- Development of guidelines for accelerated validation of safety critical axle components due to increase in axle load specifications / norms, change in driving pattern and infrastructure
- Development of Efficient Battery Thermal Management System for Two and Three Wheeler EV application through design of innovative Packaging Material
- Development of web-based web-based Technology Innovation Platform, viz. TechNovuus (facilitates collaborative research for indigenous technology development)

Further, in order to enhance competencies and to meet industry's future requirements, new projects have been taken up for implementation under internal funding in emerging mobility areas.

- **Technology Innovation Platform – TechNovuus**

ARAI has developed a web-based Technology Innovation Platform, viz. TechNovuus under the aegis of the MHI. This is a collaborative ecosystem for enabling indigenous technology, innovation and solution development focused towards Indian mobility CASE (Connected & Shared, Affordable, Safe, Environment friendly & towards Energy Independence). It facilitates development of solutions for challenges related to mobility to start with, and will gradually 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.

Various programs for Start-ups and Students were undertaken during the year under TechNovuus. These included Altair Start-up Challenge 2021; On-boarding of Start-ups under UpTech program (technology up levelling program); launch of Hackathon with problem statements on Smart, Safe and Sustainable Mobility solutions for Aatmanirbhar Bharat; Student Engagement programs like internships, poster presentation competitions; etc. Also, TechNovuus successfully engaged with the student and research community through various webinars on automotive technologies, quiz competitions, expert interaction programs, institution interactions and weekly newsletters. Currently, TechNovuus has over 12200 registered users, which includes 169 organizations, 100 industrial experts, 15 Academia and over 11900 professionals and students.

- **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 at Nashik in Maharashtra; Nelamangala (Bengaluru) in Karnataka; Railmagra in Rajasthan; Surat in Gujarat and Cuttack in Odisha. In addition to these centres, ARAI is currently facilitating establishment of centres in another five states in

India under MoRTH scheme. Further, ARAI has been awarded one I&C Centre at Kurla, Mumbai by Maharashtra Road Transport Corporation (MSRTC) and another 23 centres by Transport Department, Government of Maharashtra. ARAI has also provided consultancy to Karnataka State Road Transport Corporation (KSRTC) for establishment of I&C Centres at two places in Karnataka, viz. Mysore and Dharwad. In addition to this, as per the instructions and approved procedure of Rajasthan State Government, ARAI has carried out audits of vehicle fitness test centres belonging to private parties for their authorization.

- **Business Development Initiatives**
  - Brand Building :
    - Industry interactions: hosted senior level delegations of various organizations and also visited many customers for business promotion
    - Showcasing and demonstration of capabilities at virtual expos, viz. Future Mobility Show 2021 and Aero India 2021
    - Leveraging Social Media Platforms: Reached out to the industry through periodic updates on capabilities, events, new developments, etc. on social media platforms, viz. LinkedIn, Instagram, Facebook, YouTube and Twitter
  - Technical Collaborations/ Strategic Tie-ups:
    - MoU with IIT Hyderabad – For collaborative work on India specific technology development for ADAS/ Autonomous Driving
    - MoU with INS Shivaji Center of Excellence (Marine Engineering) – To collaborate and pursue industrial/ application-oriented projects for developing efficient and environment friendly solutions for marine engineering applications
    - MoU with CSIR-National Chemical Laboratory – For exchange of scientific knowledge; undertaking joint research work for development of products, process and technologies and joint workshop for imparting skills for the benefit of society and industry
    - Various MoUs with Industry in following areas:
      - ADAS/ AV and V&V
      - Functional Safety, Electronics Reliability & Cyber Security
      - EV related EV sound package development
      - Testing, Validation & Certification of e-motor, electronic control systems, electronic/ electrical systems
      - Technology licensing, development & testing, material science, education & training, software development
  - Workshops/ Training Programs/ Expert Talks Organized:
    - Dr. Pawan Goenka's inspiring and insightful talk virtually to team ARAI on the occasion of Technology Day
    - Training on Electro-Magnetic Compatibility (EMC) for construction equipment manufacturer
    - Training on Electric Vehicle Certification to start-ups and vehicle manufacturer
    - Capacity Building Program on Air quality monitoring, Emission inventory and Source apportionment of Particulate Matter
    - Workshop on Low Carbon & Sustainable Mobility Roadmap for Pune city
- **Systems Compliance and Quality Management**
  - Renewal of NTSEL accreditation of Japan Motorcycle exhaust gas emission test as per TRIAS31-J044(2)-01

- Completion of certification audits by TUV for the scope of ISO9001/ ISO14001/ ISO45001/ ISO27001
- Completion of Re-assessment audits by NABL as per ISO/IEC 17025:2017 for Testing and Calibration scope
- Completion of surprise audit by BIS as per LRS2020 for Safety Glass/ Tyre/ Bicycle Reflector/ Wheelrim
- Renewal of BIS Recognition as per LRS2020 for Mechanical Testing scope. Addition of new IS standards, viz. IS2835 and IS14900 successfully demonstrated through desktop assessment

- **Continual Improvement Initiatives**

  ARAI strongly believes in continual improvement culture. To build and strengthen the operation excellence in our services, we have taken up following initiatives.

  - Online portal for Internal Customer Satisfaction Survey
  - Development of video based presentation training module with voice-over facilitating administration of self-paced training
  - Waste water treatment plant at ARAI, Kothrud
  - Rooftop Solar Power plant at ARAI – FID
  - Various activities during 'Swachhta Pakhwada' organized during 16th to 31st August 2021 including webinars on 'Sustainable Eco-friendly Ideas' and 'Waste to Energy Perspective'
  - Launch of CMVR-Type Approval Software (CMVR-TAS)
  - In-house developed set-ups for Bumper Impact Test, Drop Impact Test, Free Fall/ Drop Test, Vehicle Preparation & Soak Rooms, etc.

- **Corporate Social Responsibility (CSR)**

  ARAI is mindful of the needs of the communities and strives to make a positive difference and create maximum value for the society. Our efforts are focused for enabling healthier and happier lives, helping develop thriving and resilient communities, and on stewarding the planet's natural resources for future generations. We started CSR activities voluntarily almost decade and half ago. The implementation of the CSR activities at ARAI is executed through Social Responsibility Support Group (SRSG) – a group formed specifically for this purpose. Every year, our SRSG identifies deserving projects in the field of education, health, environment, community development, etc. The identified projects are extended financial support in order to bring out a lasting impact towards creating a sustainable society. This year, projects of three organizations were supported under CSR initiative.

- **Roadmap for Ethanol Blending in India 2020-25**

  Hon'ble Prime Minister Shri Narendra Modi released the report of the 'Expert Committee on Roadmap for Ethanol Blending in India 2020-2025' on the occasion of World Environment Day, i.e. 5 June 2021, during an event organized jointly by Ministry of Petroleum & Natural Gas and Ministry of Environment, Forest and Climate Change to celebrate World Environment Day. Director – ARAI was part of the inter-ministerial committee formed under the Chairmanship of Additional Secretary, NITI Aayog for preparing this report. Also, ARAI has been identified as the agency for evaluation of E20 on in-use 2 and 4 wheeler vehicles along with SIAM and Indian Oil Corporation Ltd. (IOCL)

Highlights of the Year

- **Technology transfer of Battery Management System (BMS) for Li-Ion Battery Pack for Low Voltage and High Voltage applications**
- **Technologies developed:**
  - Cost effective AC Charge Point for Light Electric Vehicles
  - E-axle Powertrain Kit for 3-Wheeler application
  - Acoustic Vehicle Alerting System (AVAS) meeting minimum sound emission and frequency shift requirement as per UN R138 and AIS-173
- **Patent granted for 'Bimetal Mixture Forging Process'**
- **Patent filed on 'A composition for blending fuel and a method thereof'**
- **NABL accreditation for carrying out virtual testing (ARAI is the only Indian Test Agency and one amongst very few in the world to obtain accreditation for virtual test scope)**
- **Launch of CMVR – Type Approval Software (features include real-time dashboard, query module, tracking facility, document repository, etc.)**
- **TechNovuus Platform:**
  - Launch of Hackathon with problem statements on Smart, Safe and Sustainable Mobility solutions for Aatmanirbhar Bharat
  - On-boarding of Start-ups under UpTech (technology up-levelling program)
- **Successful organizing of SIAT 2021 and SIAT EXPO 2021 on virtual platform**

Research & Development

Testing and Certification

Role in Standardization

New Facilities

Human Resource Development

Technology / Research Publications

Business Development

Events

Knowledge Centre

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 2021-22 are listed below.

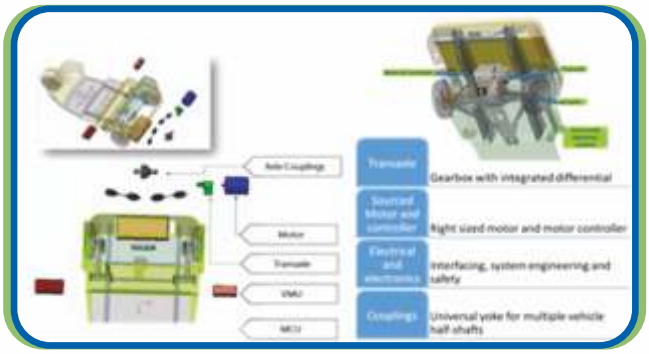
DESIGN & DEVELOPMENT

- **Light Electric Vehicles (LEV) AC Charge Point**

ARAI has designed and developed an intelligent and cost effective AC charge point for Light Electric Vehicles (LEV) under a project supported by Department of Science and Technology (DST). After finalization of requirements and technical specifications, the prototype of LEV AC charge point was developed, tested and validated. Subsequent to this, 100 numbers of the charge points were manufactured through charger manufacturers and deployed at various locations across the country. It is noteworthy to see that NCT of Delhi is deploying the developed LEV charge points across Delhi NCR region on large scale. This charge point works through a mobile app without requirement of any kind of display and internet connectivity. A Bluetooth communication protocol for communication between LEV AC charge point and mobile app has been developed for this purpose. Also, Indian Standard (IS) for LEV AC charge point has been prepared and finalized.

- **E-axle Powertrain Kit for 3-wheeler Application**

Working prototype of an E-axle powertrain kit for 3-wheeler application has been developed along with an industry partner under a project supported by Ministry of Heavy Industries (MHI). This solution can either be a retro-fitment on in-use vehicles or can be installed in OE vehicles of L5 category. The development process involved designing & packaging of E-axle and its related accessories with minimal modifications to existing vehicles and to build demonstrator E-axles integrated on prototype vehicles based on L5 category of different applications (people carrier/ load carrier).



- **Efficient Battery Thermal Management System for 2 & 3-wheeler EV application**

ARAI is working on developing an efficient battery thermal management system for 2 & 3-wheeler EVs using innovative packaging material under a project supported by MHI. This project was taken up considering the need for devising a cooling strategy which works efficiently in Indian conditions. This project aims at developing a solution for Lithium ion batteries used in EVs operating in Indian conditions. In this project, benchmarking of battery pack for the identified vehicle has been carried out for finalization of target properties for efficient battery thermal management. Solutions using different materials & approaches have been developed, followed by thermal & structural simulation and validation. Prototype manufacturing, testing in laboratory and validation for its actual on-road performance

for the optimal solution has also been carried out. The final target is to develop thermally conductive packaging material solution based on two approaches - Silicone and Phase Change Material (PCM) along with conventional heat transfer modifications and demonstrate the thermal management with the optimal solution.

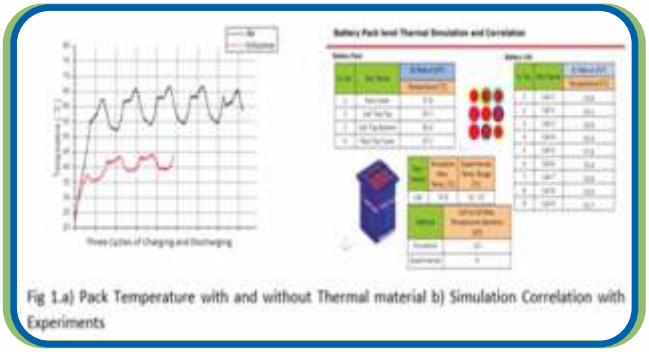


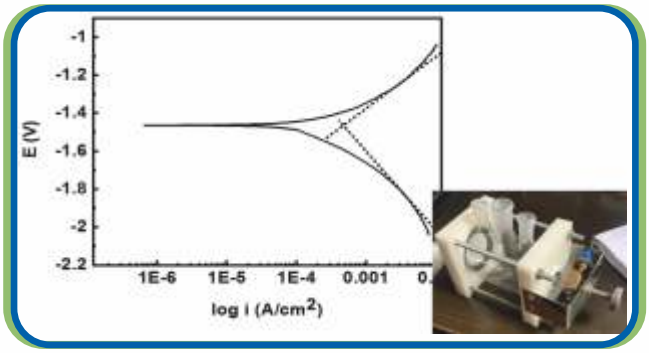
Fig 1.a) Pack Temperature with and without Thermal material b) Simulation Correlation with Experiments

- **AVAS and its Methodology**

An internal project for development of Acoustic Vehicle Alerting System (AVAS) and its methodology for quiet vehicles (electric & hybrid electric vehicles) has been successfully completed. It has been designed using V development cycle and model based design toolchain. The prototype developed has been tested - both in lab and on-road. The developed system meets minimum sound emission and frequency shift requirement as per UN R138 and AIS-173.

- **Magnesium Material Characterization**

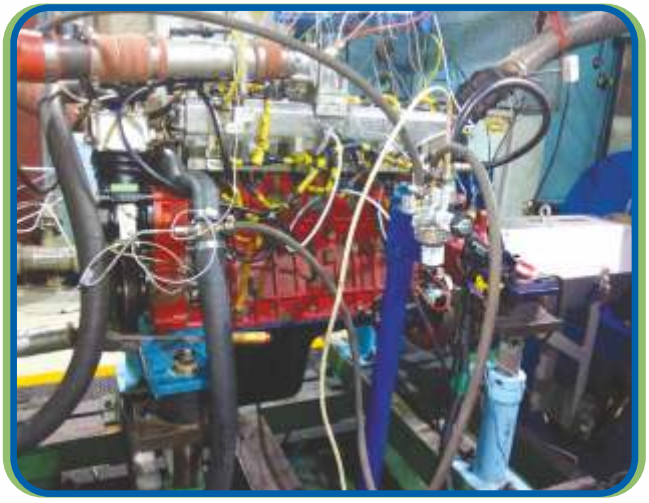
Considering upcoming demand for Magnesium alloys in automotive industry, ARAI is undertaking a project to build competency in Magnesium material characterization and processing techniques. Multiple characterization techniques have been adopted to understand behaviour of various Magnesium grades & components, and their interdependency with respect to processing & heat treatment. Material & flow stress model has been developed using thermomechanical simulation to ascertain behaviour of Magnesium and its correlation with process route, grades and applications in automobile. Further, a framework has been developed for optimization of existing forging facility to carry out closed die forging for Magnesium based component. The development of Magnesium based component will be carried out with an industry partner. The competency developed will enhance ARAI's capabilities in Magnesium material characterization and processing to cater to the industry's needs.



- **Development of 6 Cylinder TCIC CNG Engine**

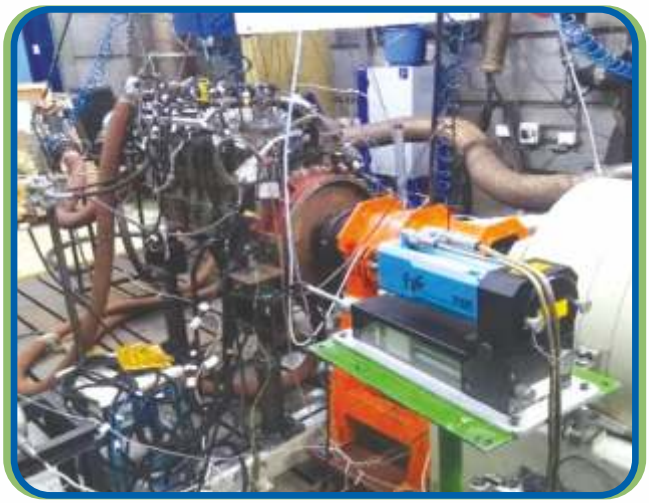
BS-VI Engine compliant to emission legislation has been developed from an existing BS-IV compatible CNG Engine and further, it has been demonstrated for BS-VI OBD-1 along with data generation for IUPR and RDE. Minimal change in existing engine architecture has been done during this developmental process to make it cost effective for the customer and end user. It involved studying the baseline performance of existing BS-IV CNG engine and the gap in existing emission levels and BS-VI emission levels to be achieved. The methodology included review of the design parameters and simulation study to achieve targeted emission results, after-treatment review & it's selection, steady state

calibration to achieve desired power performance, transient calibration to achieve BS-VI emission norms, BS-VI OBD-I calibration for emission & non-emission related faults, support for RDE & ISC and demonstration of BS-VI emission compliant CNG Engine. The final outcome of this project was development of BS-VI compliant 6 Cylinder TCIC CNG Engine with consistency measured on 3 different engines.



- **Up-gradation of BS-IV CNG HCV Engine to meet BS-VI Emissions**

Government of India has notified BS-VI emission norms for Diesel/ CNG vehicles and which are the most robust regulations and include measurement of Particulate Matter, Particulate Number & NH_3. However, so far no benchmarking work in respect of CNG for BS-VI emission norms has been carried out in the Indian context. So, this project was undertaken to study all these aspects and to understand the effect of methane content on emission. Under this project, the gap in existing emission levels and the BS-VI emission levels to be achieved were studied. The methodology included review of the design parameters and simulation study to achieve targeted emission results, steady state calibration to achieve desired power performance, after-treatment review & selection, transient calibration to achieve BS-VI emission norms, BS-VI OBD-I calibration of 3 important faults majorly affecting emissions. Subsequent to this BS-VI emission compliant CNG Engine was demonstrated and a report on effect of varying methane content on engine performance and emission was prepared.



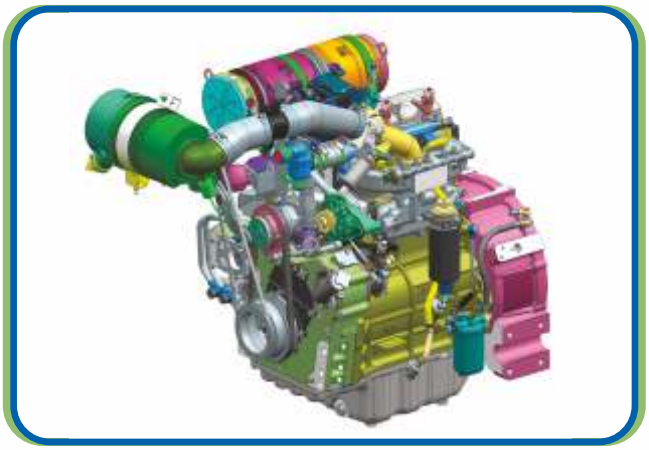
- **Dual Fuel Engine Development for Tractor Application**

Under this project, an existing Diesel Engine has been converted to Dual Fuel (Diesel-CNG). This developed engine meets the emission compliance (TREM-IIIA) on Diesel and Dual Fuel mode. In this development process, 8 mode emission test was carried out on the baseline Diesel Engine and PTP & FTP data was collected. The calibration target for emission & BSFC was set for each engine RPM. CNG was introduced in the steps of 10% stepper motor opening and emission & BSFC data was monitored. Further to this, CNG substitution activity for various RPMs

was carried out and the optimum point of CNG substitution for each RPM was arrived at. PTP, FTP and 8 mode emission test on Dual Fuel mode was also carried out. The data generated for Diesel and Dual Fuel mode were then compared and the results were observed to be within the acceptable limit. The outcome of this project was achievement of emission target on Dual Fuel mode, Diesel replacement of 5% - 60% in the engine torque map between 30% and 90% of full loads and at the same time power was maintained within 2% of base diesel.

- **Design Modifications for Height Reduction**

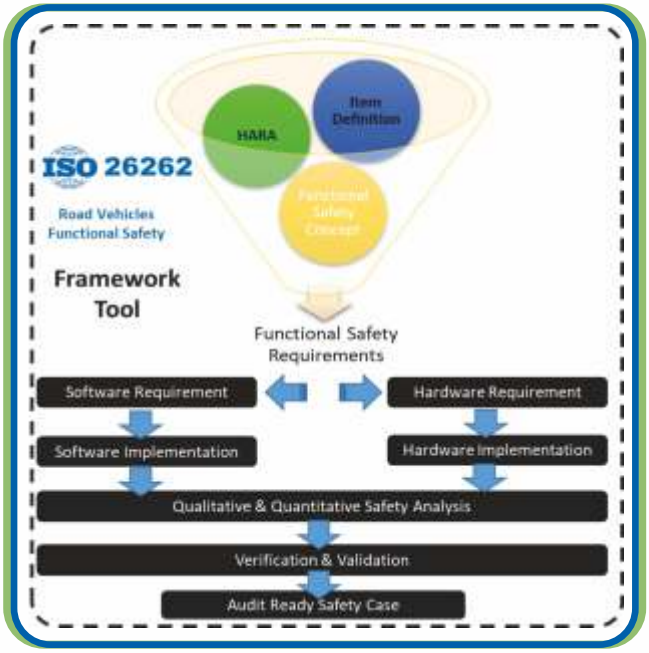
This ongoing project is on carrying out design modifications for height reduction of 3 Cylinder CRDi Diesel Engine. The possibility of height reduction is being explored so that the after treatment devices can be fitted within the bonnet (considering upcoming emission norms), since the current height of cylinder head along with rocker cover is higher. The feasibility study is being carried out initially on baseline design with minimum clearance target among various sub-assemblies to fit under the bonnet.



EMERGING OPPORTUNITIES

- **Framework creation and demo case for implementation of functionally safe product, for ARAI developed BMS- eMI4**

This project is on developing a framework through a systematic process in accordance with guidelines set by ISO 26262. The process being established is being demonstrated on the internally developed BMS - eMI4. It enables in calculating the estimate of the rate of hazard occurrence due to random hardware failures in the BMS System. It will help in developing a framework which ensures compliance throughout the development life cycle and also, in optimizing the functional safety management aspects of the system. The artefacts generated though this project will act as a benchmark/ or industry standard for companies venturing into BMS development and validation.



- **AEB Control Strategy Deployment and Verification**

This project was for testing a basic Autonomous Emergency Braking System (AEBS) algorithm in a Hardware-in-Loop (HIL) simulation set-up. The algorithm built was run on a rapid control prototyping (RCP) unit and sensor input from an ideal & simulated RADAR sensor were taken. The control strategy sent the control signals to the vehicle dynamics model running in real-time on the HIL simulation hardware. Further, car-to-car rear moving scenarios were simulated to test the

basic AEBS algorithm. In future, the simulated RADAR sensor can be replaced with a real camera in a monitor-HIL set-up.

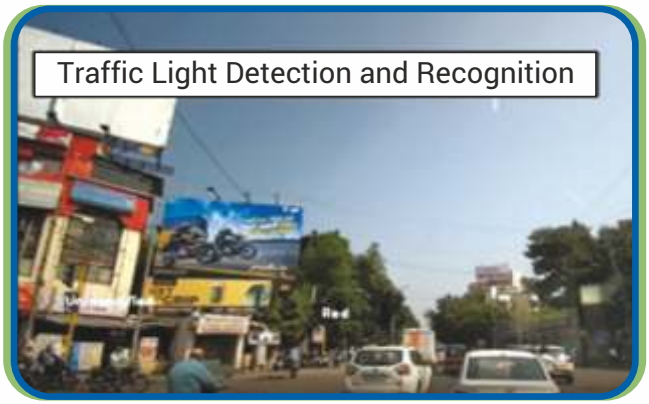
- **Traffic Light and Traffic Sign Detection and Recognition**

Computer Vision and Artificial Intelligence have brought about significant breakthroughs in autonomous driving. Autonomous Driving system includes three main functional modules, viz. Perception, Cognition and Execution. The Perception module makes use of sensors such as LiDAR, RADAR, Camera, IMU etc. Traffic Light and Traffic Sign Recognition is an essential part of the perception system. It plays a major role in traffic control and collision avoidance. A typical recognition system consists of two parts - detection and recognition.

In-line with the emerging requirements of the industry, ARAI is working on detection and recognition of traffic lights and traffic signs. Deep learning algorithms are being used for detection of traffic lights & traffic signs and various techniques like image processing, machine learning and deep learning are being used for their recognition. Further, accurate labels are being predicted for traffic light and traffic sign recognition under good lighting conditions so that the color and information on those structures are clearly visible and differentiable.

- **System for Synchronous Data Acquisition**

Advanced Driver Assistance Systems (ADAS) is enabling drivers to handle different situations effectively semi-autonomously. It automates dynamic driving tasks like steering, braking and acceleration of vehicle for controlled and safe driving with the use of radar, vision and various sensors, including LIDAR. In order to integrate data from all the vehicle mounted sensors, it is essential to build a system which acquires data from all the sensors synchronously.



Considering this, ARAI is developing a system for synchronous data acquisition. This will be useful for developing multiple algorithms as well as applications, viz. sensor fusion algorithm, perception algorithms, traffic object detection application, synthetic scenario generation from real data, etc. Algorithms and applications developed with the use of this synchronous data from various sensors, will provide higher level of confidence and make ADAS functions safer to implement.

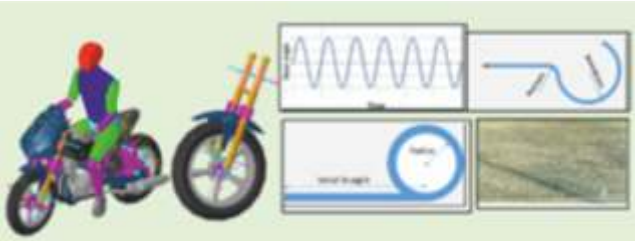
- **Improving Fuel Economy using Tyre Rolling Resistance**

ARAI has installed rolling resistance test machine catering to testing of all types of tyres. This facility is accredited as per ISO/IEC 17025. An internal project has been implemented, wherein ARAI has generated rolling resistances reference data of various popular tyres from Indian market. Subsequent to this, the data generated from tyre rolling facility was correlated and successfully aligned with international reference labs. With this successful alignment, the tyre rolling resistance facility at ARAI can be used for international homologation, viz. European Homologation, Gulf Standards, FMVSS etc.

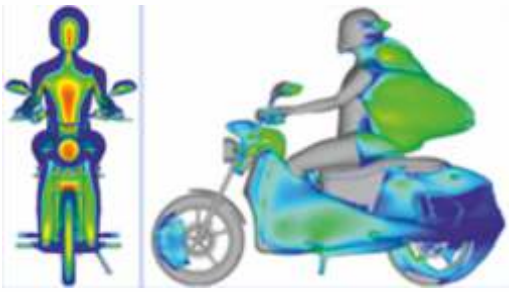
SIMULATION BASED DESIGN SOLUTIONS

- **EV 2W Vehicle Performance Assessment**

Simulation based design support has been provided to EV Start-ups for EV 2-wheeler application. This included structural strength assessment, crashworthiness, battery thermal management, ride & handling assessment and improving overall vehicle performance. These solutions have helped the Start-ups in assessment of vehicle performance at the design stage itself.



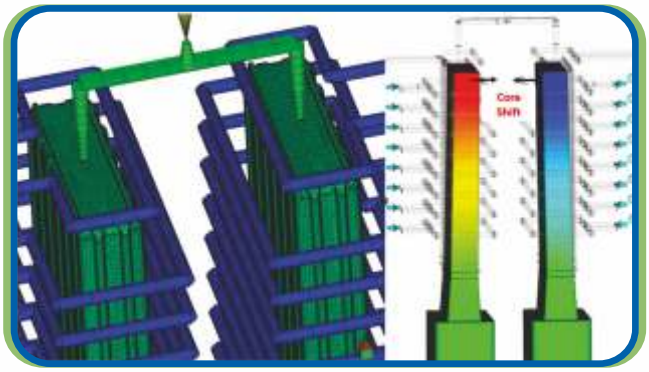
Evaluation of vehicle Ride and Handling performance



Vehicle level Aerodynamic analysis

- **Plastic Injection Molding of Battery Container/ Cover**

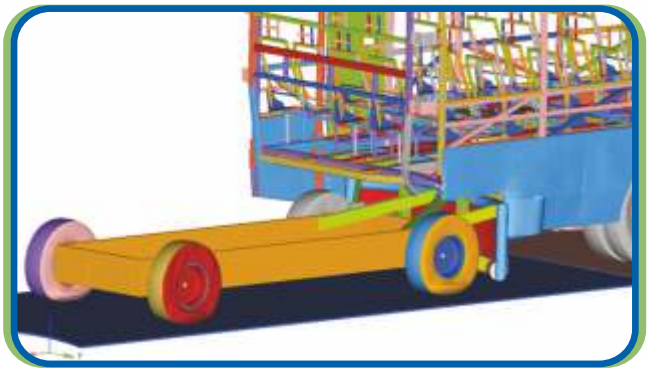
Battery Container designs require intensive study since geometry of the part is deep seated while there is hardly any scope to make structure rigid from inside surface due to packaging constraints. This creates further constraints at mold/ manufacturing level making the mold very



complex. Under this project, ARAI has explored the possibility to understand whether better insights can be obtained on this issue through manufacturing simulation. This exercise revealed geometry of design being a serious contributor of the challenge to which mold design had to compliment and which was giving rise to side effects such as core shift and warpages. With complete geometry as a constraint, gate combination was worked out with customer to restrict the deviations within reasonable tolerances.

- **Fuel System Integrity Evaluation**

Under this project, fuel system integrity of bus under rear impact has been evaluated using



simulation. A moving rigid barrier as per SASO/FDS 31843 (with reference to FMVSS No. 301 for Fuel system integrity) was used for this purpose. In order to carry out the evaluation, the barrier was impacted with velocity of 48 km/h on the rear structure of bus with 70% overlap. Further to this, deformation on the structural parts of fuel system and integrity of fuel lines during this high-speed impact was checked.

- **Duty Cycle based Fuel Efficiency Assessment**

Under this project duty cycle based fuel efficiency for a Tractor application is being assessed using simulation methodology. This project involves acquisition of Real World Usage Pattern (RWUP) under different field operations and on field fuel consumption measurement. This will be used for development of Tractor duty cycle. The component level data will be generated either through component testing or data sourced with the support of the industry. Subsequent to this, simulation model will be built and the results will be correlated with the field data.

- **Vehicle Energy Audit and Parameters Sensitivity Analysis**

Simulation approach has been deployed to carry out vehicle energy audit, parameter sensitivity analysis and vehicle fuel consumption prediction. Vehicle and component testing with required instrumentation was carried out to generate input data and further this data was post processed for simulation purpose. Further, drivetrain loss was estimated on chassis dynamometer. Subsequently, measured field fuel consumption was validated with the simulated one. Through this exercise, base vehicle energy audit and parameters sensitivity analysis was carried out through simulation and recommendations were arrived at for possible avenues for improving fuel consumption.

IN-HOUSE DEVELOPMENTS

- **Test Automation Software for automated functional validation as a part of in-loop validation**

In-loop validation is popular as it helps in early detection & rectification of faults and thereby, reduces product delivery time. However, Hardware-in-Loop (HIL) and Vehicle-in-Loop (VIL) require large number of test cases for validation of different critical and safety related functions of any system and so, it is cumbersome and time consuming for manually running and executing such large number of tests cases.

Considering this, ARAI has developed test automation software for automated execution of test cases in HIL and VIL validation. This test automation software has been deployed in the emulation hardware and runs in real-time giving real-time performance. It works on a simple MS Excel test script, based on a pre-defined format, logs data for further analysis and also, determines pass/ fail for each step in the test case based on pre-defined test criteria.

- **Free Fall and Drop Test Facility**

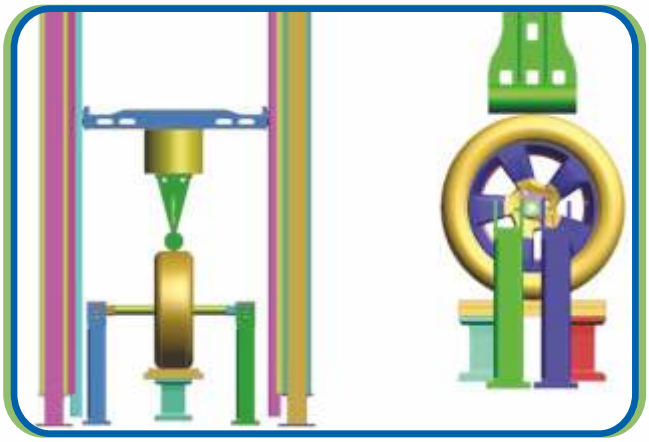
Free fall and drop test facility for automotive electronics components and sub-assemblies has been successfully developed. This facility simulates a condition wherein, a component or sub-assembly is removed from or is installed in its

intended assembly and accidentally drops causing physical/ performance related damage. This is a very critical test for safety critical components / sub-assemblies. Even though this facility is designed for automotive components and sub-assemblies, it can also be used for testing of non-automotive components.

- **Drop Impact Test Facility**

Testing facility for drop impact test on automotive alloy wheel rim with tyre as per test specification and boundary condition has been developed in-house. This development has been carried out using flat & cylindrical impactor. The key features of this facility include:

- Adjustable height up to 5.5 m
- Helps in avoiding second or recurrent impacts by using suitable arrangement of impactor arrestor
- Energy up to 11000 Joule
- Measures data of tri-axial loads, Acceleration, Strain, High speed videography etc. during the impact



Certification and testing is ARAI's strength and this has been acknowledged by various authorities through their accreditations and recognitions as given below.

- **Recognition by National Traffic Safety and Environment Laboratory (NTSEL),** Japan to carry out the Tests as per TRIAS 31
- **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'
- **Recognition by Department of Infrastructure, Australia** to provide Test Reports in compliance to ADRs (Australian Design Rules)
- **Accreditation by Telecommunication Engineering Centre, DoT** as "Conformity Assessment Body" for Testing of Telecom Equipment
- **Accreditation by National Accreditation Board for Testing and Calibration Laboratories (NABL)** for various testing and calibration as per ISO/IEC 17025
- **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 concerned IS Standard

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 PROJECTS

Type Approval & Certification

- BS-VI Certification
- Certification testing for "Replacement of in-use diesel engine by a new CNG engine" (BS-IV Automotive)
- First LNG retro-fitment certification testing (BS-IV Automotive)
- Emission compliance testing of Retro-fit Emission Control Devices (RECD) for Diesel Power Generating Set Engines (up to Gross Mechanical Power 800 kW)
- Remote/online certification test for Genset engine
- Full throttle Engine performance test as per ISO 9249:2007
- Truck Code, Trailer Code, Ambulance Code
- Certification as per FAME Scheme
- Electric Buses
- In-service conformity testing as per BS-VI
- BS-VI Stage 2 Certification
- Mass Emission Testing as per Japan WLTP (TRIAS 31-J042(4)-02)
- CEV - BS IV and V and as per Safety standards
- Export Homologation as per British Standards
- Retro Fitment
- Combined Harvester
- Motor Caravan
- Mining Truck Dumper for DGMS Regulation Compliance
- Walk Behind Roller for EN500-1 Regulation
- Certification of Earth-moving machinery (Articulated frame lock Performance requirements as per IS/ISO: 10570:2004)

- Certification of Earth-moving machinery (Lift-arm support devices as per IS/ISO: 10570:2004)

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 Genset models
- Type Approval of Gas Generator models

EVALUATION AND VALIDATION PROJECTS

- **Validation of EV Controllers**

  The objective of the project is to validate the Electric Vehicle Controllers, viz. Battery Management Systems, Inverter Control Unit and Vehicle Control Unit for an Indian Vehicle. The controllers were integrated with the HIL system and the battery cell emulators. The models were parameterized to replicate behaviour of the physical systems involved, viz. Battery for BMS, PMSM motor for the Inverter and entire vehicle for the vehicle control unit. The unique feature of the system is that it simulates entire vehicle and systems for the controllers. Various validation exercises carried out were for BMS algorithms & diagnostics, inverter control algorithms, vehicle control unit algorithms and UDS & other protocols.

- **Integrated E-Powertrain Validation**

  Machine-in-loop (MIL) environment is being used for functional and performance validation of integrated e-powertrain. All e-powertrain components, including e-motor and inverter, were connected to facilitate their working similar to the working in an actual vehicle. The necessary emulation system has been designed and developed to emulate different I/Os and communication, viz. CAN and LIN, similar to an actual vehicle environment. Currently, different test cases in MIL environment are being run for functional validation of different functions relating to e-powertrain components.

- **After-exhaust Retrofit Technologies to Control Emissions**

  ARAI along with CSIR-National Environmental Engineering Research Institute (CSIR-NEERI) has carried out a pilot study under the support MoEFCC. Under this project, a limited scale pilot study was carried out with focus on preliminary assessment of the potential of retrofitting After-exhaust Emission Control Devices (ECDs) on identified classes of in-use heavy commercial and passenger car vehicles and deriving of inferences on potential of these devices for possible PM emission reduction. As part of this project, lab and on-road testing of the test vehicles fitted with different ECDs as per the planned test matrix were carried out.

- **Clean Air Project in India (CAP India)**

  This is an ongoing project started in 2019-20 for implementing “Clean Air Project in India” in

Pune and Nashik (partial role) cities for 'The Swiss Agency for Development and Cooperation' (SDC). This project is for supporting India's efforts to improve air quality and contribute to public health, environment & climate change mitigation. It emphasizes on improved data measurement and analysis on clean air; development & implementation of clean air policies and action plans; and raising awareness for clean air. During the year, estimation of gridded population for Pune district at 2 x 2 km2 for the year 2021 was carried out. Other activities completed during the year include road network extraction and digitization on GIS platform for Pune district; mapping of gridded activity relating to hotels, restaurants, bakeries, crematoria, brick kilns & slum areas in Pune district; primary surveys for emission inventory sectors like parking lot, residential and slum areas, hotels, restaurants, bakeries & brick kilns for municipal councils (Baramati and Junnar) and rural areas (Sangavi and Barav); data collection in respect of construction activities in Pune district from MahaRERA database; baseline (Year 2021) emission inventory for Pune district; winter season chemical data analysis for two sites in Nashik city; and receptor modelling using Chemical Mass Balance Model for winter season.

In addition to the above, a two-days program on "Air Quality Monitoring, Emission Inventory and Source Apportionment of Particulate Matter" for building capacity was conducted for Maharashtra Pollution Control Board (MPCB) and Pune Municipal Council (PMC) officials.

- **Noise and Vibration Measurements**

  Noise and vibrations have been measured on a poker model. For this purpose, sound pressure level (LpA) measurements were carried out at 10 measuring points around the poker at 1 m

distance as per EN 12649 and ISO 3744, the poker was immersed in water throughout the testing. Also, sound pressure level (LpA) measurement was carried out at operator's position as per EN 12649 and ISO 11201. For measurement of vibrations, the hose was placed at 2 m distance from the poker as per EN 12649 and EN ISO 20643.

- **Efficiency Mapping of E-Motor**

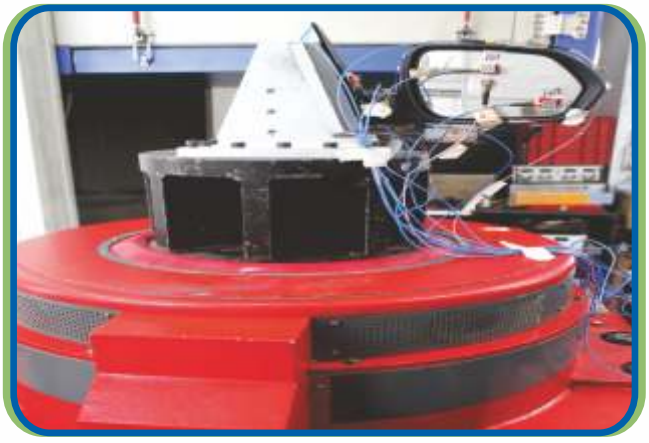
  ARAI has gained significant strength in development testing and calibration of heavy duty E-Motors. This strength has been deployed for one of the projects wherein, performance optimization by tuning inverter and efficiency mapping of E-Motor has been carried out. This project involved establishing of CAN communication with DUT (Device Under Test), which was controlled by the test bench. E-Motor was subjected to different

ambient & coolant temperatures, DC voltages and coolant flow rates during the efficiency mapping. Motor inverter tuning / calibration was performed to get the required performance from motor and it was subjected to various duty cycles to observe the behaviour in different driving conditions. Further to this, the Efficiency Map as per various motor operating speed and torque conditions was developed.

- **Side View Mirror Modal Co-relation between Vehicle and Component**

  Scope of work is to correlate the 1st modal frequency of the side view mirror when tested in vehicle and component. Vehicle Power Spectral Density (PSD) was acquired on mirror centre when vehicle was operated at 100 kmph on smooth road. Later, mirror component vibrations were acquired with road profiles input (PSD) on shaker. 95% correlation for the 1st modal frequency was achieved between vehicle and component.

  The outcome was achievement of 3.7% correlation for the 1st modal frequency vis-à-vis the target.



MEASUREMENT AND ANALYSIS PROJECTS

- **Emission Inventories Development**

  ARAI is part of consortium of National Supercomputing Mission (NSM) for Urban Modelling project. This ongoing project, which commenced in 2020-21, is for development of high-resolution emission inventories and conducting dispersion modelling analysis for four Indian cities, viz. Bengaluru, Pune, Bhubaneswar and Ahmedabad. This project involves primary data collection for generating activity data in the selected cities, development of high-resolution city-level emission inventories, projection of baseline emission loads, development of control scenarios for future, conducting city-level dispersion modelling analysis and chemical speciation, and receptor modelling based source apportionment of PM2.5 (only for Bengaluru city). The various activities completed during the financial year 2021-22 include summer season sampling of PM2.5 at five locations in Bengaluru city, development of city level emission inventory at high resolution i.e. 1 km^2 and 400 m^2 for baseline year 2021 and development of SOP for dispersion modelling using CALPUFF model.

- **Emission Inventory and Source Apportionment Study**

  For Bhopal City :

  ARAI is working on emission inventory generation of pollutants and carrying out particulate matter (PM_{10} & $PM_{2.5}$) source apportionment for Bhopal city. The various activities carried out in 2021-22 included summer season sampling of Particulate Matter (PM_{10} & $PM_{2.5}$) using speciation samplers at five locations in Bhopal city; laboratory analysis of $PM_{2.5}$ and PM_{10} samples for elements, ions, carbon fractions and molecular markers for winter season samples; receptor modelling analysis of winter season $PM_{2.5}$ and PM_{10} samples using Chemical Mass Balance Model; primary surveys for vehicle counts, parking lot, residential, and hotel &

restaurants; and GIS mapping of new construction areas using google earth application.

For Angul-Talcher, Rourkela, Kalinga Nagar - Jajpur Road in Odisha :

Similar to the above project, ARAI is also working on emission inventory generation of pollutants and carrying out particulate matter (PM_{10} & $PM_{2.5}$) source apportionment for non-attainment cities of Angul-Talcher, Rourkela, Kalinga Nagar - Jajpur Road in Odisha. Under this project, 16 sites have been identified for sampling of air pollutants in three cities and winter sampling of Particulate Matter (PM_{10} & $PM_{2.5}$) using speciation samplers has been completed in these cities. Other activities carried out during the year include laboratory analysis of $PM_{2.5}$ and PM_{10} samples for elements, ions, carbon fractions and molecular markers for winter season samples; and primary surveys for vehicle counts, parking lot, residential, hotel & restaurants in Rourkela and Kalinga Nagar - Jajpur Road.

- **Emission scenarios analysis using air quality modelling**

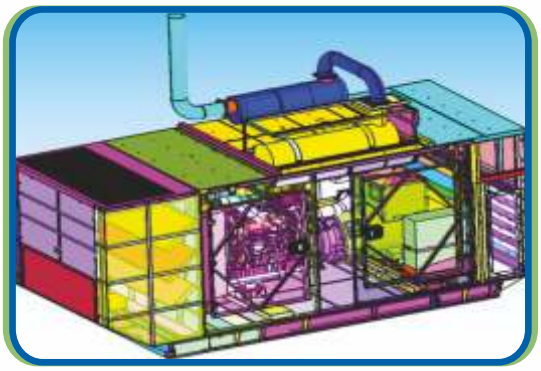
  This project was on analyzing historic trends of air quality, developing baseline & future anthropogenic emission scenarios and prediction of air quality conditions for respective emission scenarios in Pune city. As part of this project, current status and historic trends of air quality in Pune city were evaluated based on ambient air measurements and contribution of different sources to ambient $PM_{2.5}$ and PM_{10} using previous studies were assessed. Further to this, baseline and future emission scenarios for Pune city were developed considering the proposed policies and regulations with special focus on transport sector. Based on this, the impact of different emission scenarios on air pollutant levels in Pune city was assessed.

- **Low Carbon and Sustainable Mobility Roadmap for Pune**

  ARAI along with WWF-India has carried out a study to evaluate potential changes in emissions and air quality benefits of implementing various control measures focused at low carbon and sustainable mobility in Pune city. The scope included studying the impact of the eight major strategies appropriate to Pune city, viz. implementation of BS-VI, roll-out of Ethanol blended Gasoline (E20), increasing Electric Vehicle penetration, Non-Motorized Transport, Mass Rapid Transit System, improvement in public transport, shared mobility and high capacity Mass Transit Corridor on air pollutants ($PM_{2.5}$, PM_{10}, NOx, CO, SO_2 and CO_2) across major transportation modes and segments (2-wheelers, Autos, Passenger Cars, LCV, HDV and Buses.) This study was carried out using AERMOD system for dispersion modelling.

Other Validation & Testing Assignments

- Development Performance and Emission Tests
- Developmental Crash tests
- Ped-Pro & Head Impact tests
- Investigation on collapse behaviour of Bumper Beam in low speed crashes
- Pedpro Latin NCAP evaluation with Flex PLI and Upper legform
- Structural durability testing of Electric Scooter
- Front and rear corner module rotating bending test
- Drive file creation and structural durability test of rear suspension
- Interior & exterior validation of components
- Road Load Data Acquisition & Wheel Force measurement on load carrier vehicle
- On-road durability test and validation of Electric Vehicle
- Loco and Metro Bogie Frame validation as per international standards
- Machine level validation and fatigue testing of Back-hoe loader
- Series of drop impact test on Alloy Wheel Rims
- Validation of E-axles for Auto Rickshaw application
- Validation of hydraulic cylinder of tractor
- ADAS data acquisition
- Real Drive Emission test on gasoline Passenger Car
- Fuel Economy evaluation
- CEV Engine calibration in VTB
- CEV – NVH Benchmarking, NSI and solution to meet dynamic conditions
- Pass-by Noise (PBN) evaluation, source identification and its reduction
- Noise and Vibration measurement for Transmission Whine assessment



Diesel Generator Enclosure Design to meet CPCB IV+ Norms

Efficiency Mapping of Tractor Driveline

Single Input - Multiple Output Gearbox Testing

Noise Barrier in-situ Acoustic Performance as per EN 1793 – Part 4, 5, 6

ROLE AND CONTRIBUTION IN VARIOUS NATIONAL AND INTERNATIONAL COMMITTEES/ FORUMS

Automotive Industry Standards Committee (AISC)

- Secretariat Services to AISC
- Participated in 2 meetings of AISC and several meetings of Technical Panels working under AISC

- Technical Secretariat Services to CMVR-TSC

CMVR - Technical Standing Committee

Standing Committee on Implementation of Emission Legislations (SCoE)

- Technical Secretariat Services to SCoE

- Technical support to CPCB Standing Committee
- Contribution in formulation of standards on noise as a Member of National Committee

CPCB Standing Committee

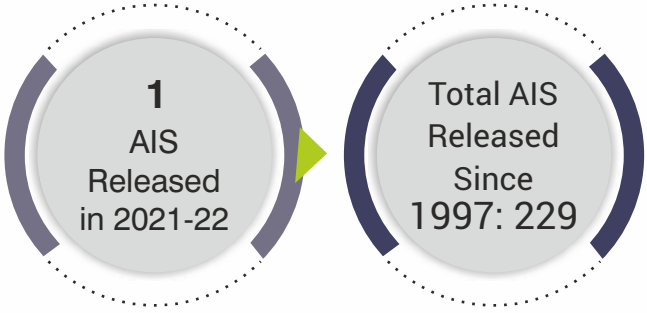
Bureau of Indian Standards (BIS)

- Technical guidance / expertise to BIS
- Chairmanship of 5 TED (Transport Engineering Department) Sectional Committees of BIS

- Technical Secretariat Services for National Committee on WP.29 matters and Core Group on WP.29 related activities
- ARAI was part of 15 delegations that participated in Technical Sessions of WP.29 and GR meetings during the year
- Coordinated WP.29 India sub-group activities on GRPE, GRE, GRBP, GRSP, GRSG, GRVA

WP. 29

FORMULATION OF SAFETY STANDARDS



New AIS

(I) AIS-164: Constructional and Functional Requirements for Insulated Vehicles

Amendments to Existing AIS

(i) Amd 10 to AIS-007 (Rev.5): Information on Technical Specifications to be submitted by Vehicle Manufacturer (Rev.5)

(ii) Amd 2 to AIS-017: Procedure for Type Approval and Certification of Vehicles for Compliance to Central Motor Vehicles Rules

(iii) Amd 3 to AIS-017: Procedure for Type Approval and Certification of Vehicles for Compliance to Central Motor Vehicles Rules

(iv) Amd 1 to AIS-017 (Part 6): Procedure for Establishing Whole Vehicle Safety Conformity of Production (WVSCoP) for L, M, N category of vehicles, E-rickshaws & E-carts

(v) Amd 5 to AIS-023: Automotive Vehicles - Seats, their Anchorages and Head Restraints for Passenger Vehicles of Categories L7, M2, M3 and Goods Vehicles of Category N - Specifications

(vi) Amd 1 to AIS-028 (Rev.1) (Part A), (Part B) and (Part C): Code of Practice for use of Gaseous Fuels in Internal Combustion Engine

(vii) Amd 10 to AIS-037: CoP of Safety Component

(viii) Amd 1 to AIS-038 (Rev.2): Specific Requirements for Electric Power Train of Vehicles Part I: Requirements of a Vehicle with regard to Specific Requirements for the Electric Power Train Part II: Requirements of a Rechargeable Electrical Energy Storage System (REESS) with regard to its Safety

(ix) Amd. 1 to AIS-039 (Rev.1): Electric Power Train Vehicles - Measurement of Electrical Energy Consumption

(x) Amd 1 to AIS-040 (Rev.1): Electric Power Train Vehicles - Method of measuring the range

(xi) Amd 12 to AIS-052 (Rev.1): Code of Practice for Bus Body Design and Approval

(xii) Amd 1 to AIS-062 (Rev. 1): Agricultural Tractor Lighting

(xiii) Amd 5 to AIS-065: Statutory Plates and Inscriptions for Motor Vehicles, their Location and Method of attachment - Vehicle Identification Numbering System

(xiv) Amd 3 to AIS-071 (Part 1): Automotive Vehicles - Identification of Controls, Tell-Tales and Indicators

(xv) Amd 3 to AIS-075: Approval of Vehicles with regards to their protection against unauthorized use-four wheeled vehicles

(xvi) Amd. 1 to AIS-089 (Rev.1): Approval of Rear Marking Plates for Heavy and Long Vehicles

(xvii) Amd. 1 to AIS-090 (Rev.1): Approval of Retro-Reflective Markings for Motor Vehicles, their Trailers and Semi-Trailers

(xviii) Amd 4 to AIS-110: Automotive Vehicles - Temporary Use Spare Wheel/ Tyres and Run Flat Tyres

(xix) Amd 6 to AIS-113: Code of Practice for Type Approval of Trailers/ Semi-trailers of categories T2, T3 and T4 being towed by Motor Vehicles of categories N2 and N3

(xx) Amd 3 to AIS-123 (Part 1): CMVR Type Approval of Hybrid Electric System Intended for Retro-fitment on Vehicles of M and N Category having GVW <= 3500 kg

(xxi) Amd 1 to AIS-123 (Part 2): CMVR Type Approval of Hybrid Electric System intended for Retro-fitment on Vehicles of M and N Category having GVW exceeding 3500 kg

(xxii) Amd 3 to AIS-123 (Part 3): CMVR Type Approval of Electric Propulsion Kit intended for Conversion of Vehicles for Pure Electric Operation

(xxiii) Amd 4 to AIS-123 (Part 1): CMVR Type Approval of Hybrid Electric System intended for Retro-fitment on Vehicles of M and N Category having GVW <= 3500 kg

(xxiv) Amd 1 to AIS-124: Procedure for Type Approval and Certification of Motor Caravans for compliance to Central Motor Vehicles Rules

(xxv) Amd 4 to AIS-125 (Part 1): Constructional and Functional Requirements for Road Ambulances

(xxvi) Amd 1 to AIS-129: End of Life of Vehicle

(xxvii) Amd 1 to AIS-135: Fire Detection and Alarm System (FDAS) & Fire Detection and Suppression Systems (FDSS) for Buses - Requirement

(xxviii) Amd 5 to AIS-145: Additional Safety features for Category M & N Vehicles

(xxix) Amd 6 to AIS 153: Additional Requirements for Bus Construction

(xxx) Amd 1 to AIS-156: Specific Requirements for L Category Electric Power Train Vehicles Part I: Requirements of a Vehicle with regard to its Electrical Safety Part II: Requirements of a Rechargeable Electrical Energy Storage System (REESS) with regard to its Safety

(xxxi) Amd 1 to AIS-160: Construction Equipment Vehicles

(xxxii) Amd 1 to AIS-163: Special Purpose Vehicles

AIS Standards Finalized (To be released in the Year 2022-23)

(I) AIS-035 (Rev.1): Arrangement of Foot Controls of Vehicles

(ii) AIS-149: Conformity of Production (CoP) Procedure for verifying compliance to Constant Speed Fuel Consumption Norms for Vehicles with GVW/ GCW exceeding 3.5T

(iii) AIS-166: Protective Devices for Two Wheeled Motor Vehicles - Requirements

(iv) AIS-169: Guidelines on Provisions for Adapted Vehicles of categories M1, N1 and M2

(v) AIS-173: Requirements for Approval of Quiet Road Transport Vehicles (QRTV) with regard to their reduced audibility

(vi) AIS-174: Specific Requirements for Electric Power Train Construction Equipment Vehicle(s)

(vii) AIS-177: TA Requirements for Vehicle of Category L2-5 of Electric Powertrain (Combi Vehicle)

(viii) AIS-179: AIS on Carriage of Dangerous Goods Packed in Limited Quantity and Excepted Quantity

Cooperation 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 activity in TED. Additionally, ARAI provides technical guidance/ expertise to BIS and also, has the responsibility of Chairmanship of following TED Sectional Committees.

- TED 2: Automotive Prime Movers, Transmission Systems and Internal Combustion Engines
- 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

CMVR and its Implementation

CMVR Technical Standing Committee

CMVR-TSC has identified various key subjects for formulating Policy / Norms / Standards. Some key subjects are given below :

- Advanced Emergency Braking Systems
- Transportation of hazardous goods
- Bharat New Car Assessment Program (BNCAP)

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 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 4 to UN GTR No. 4 (WHDC)
- Proposal for amendments to Mutual Resolution M.R.1 and M.R.2
- New UN GTR on In-vehicle battery durability for electrified vehicles

Additionally, India's Durability Driving Enforcement Procedure for two-wheeled vehicles was included in the Compendium of Candidates for UN GTRs.

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. Indian delegations participated in the GR and WP.29 sessions through virtual platform. Secretariat at ARAI provided technical and other support to these national delegations for attending the sessions.

WP.29/GRPE activities

ARAI coordinated the activities of WP.29 GRPE India group and its sub-groups EPPR, and WLTP. Indian delegation (consisting of members from Industry and Test Agency) participated in 83rd session of GRPE held via webex during 1-4 June 2021. During this session, a special workshop on "low- and zero-emissions heavy duty vehicles: Regulatory gaps and expected legislators' needs" was held on 2nd June 2021. In this workshop, ARAI made a presentation on "Status from India - Heavy Duty Electric and Fuel Cell Vehicles", which was appreciated by the GRPE Chair. Indian delegation also participated in the 84th special session of GRPE held on 12th November 2021, which was dedicated to discussion on open issues relating to electric vehicle regulations. Indian delegation participated in the 85th Session of GRPE held via webex during 11th to 14th January 2022. Apart from the main sessions of GRPE, Indian delegation also participated in the concurrent informal group meetings of EPPR, VIAQ, PMP, etc.

India had provided important inputs for the finalization of 2 GTRs under Phase-2 of EPPR IWG sessions held during the year.

- GTR 2 amendment 5
- New GTR on durability of pollution control devices for L-Category of vehicles

GTR 2 Amendment 5: GRPE in its 85th session, adopted latest draft for Amendment 5 to UN GTR No. 2 (without the accompanying technical report) prepared by EPPR-IWG and requested the secretariat to submit it to WP.29 and AC.3 for consideration and vote at their June 2022 sessions as draft Amendment 5 to UN GTR No. 2. GRPE agreed to have the final technical report to be submitted directly to WP.29 by EPPR-IWG.

New GTR on durability of pollution control devices for L-Category of vehicles: GRPE adopted the latest draft for a new UN GTR on durability of

pollution-control devices for two and three-wheelers (without the accompanying technical report) prepared by EPPR-IWG and requested the secretariat to submit it to WP.29 and AC.3 for consideration and vote at their June 2022 sessions as a draft new UN GTR on durability of pollution-control devices for two- and three-wheelers. GRPE agreed to have the final report and the technical rationale to be submitted directly to WP.29 by the EPPR-IWG.

Type Approval Certification

ARAI has carried out Type Approval and Certification for several safety components and emission norms as per safety standards and emission norms for different categories of vehicles. Also, it has initiated work for safety norms to be implemented in 2022-23. Major highlights are given below.

Safety Standards and Emission Norms Implemented in 2021-22 :

Safety Standards :

- Implementation of Revised Brake Standard IS 11852 (2013)
- Implementation of Revised Brake Standard AIS 151 or IS 15986 (2015)
- Implementation of Electronic Stability Control System (ESC) (if fitted)
- Implementation of Brake Assist System (BAS) (if fitted)
- Approval of Safety Glass as per IS 2553(Part 2): 2019 under CMV Rule 100
- Implementation of Vehicle Recall provision
- National Road Safety Board Rules 2021
- Recognition, Regulation and Control of Automated Testing Station
- Implementation of Phase 1 Safety Norms for CEV
- Helmet Quality Control Order
- Helmet Certification as per IS 4151: 2015
- Implementation of Modular Hydraulic Trailer requirements as per AIS-158 under CMV Rule 125
- Front passenger airbag as per AIS-145
- Approval of Electric Agricultural tractor as per AIS 168
- BIS Quality Control Order for Wheel Rims
- Implementation of revised wheel rim standards
- Special Purpose Vehicles, Mobile Canteens, 2W-fire responder, insulated vehicle motor caravan
- Vehicle Scrapping facility
- Ethanol (E12 and E15) fueled vehicles not exceeding 3.5T
- Implementation of AIS 038 (Rev.2) and AIS - 156 (Specific Requirements for Electric Vehicles)
- Use of Crash Helmets for child pillion riders
- Allowing three decks for two-wheeler carriers and two decks for four-wheeler carriers
- Implementation of Road Train as per AIS-113

Emission Standards :

- Conversion of in-use Diesel vehicles
- Implementation of AIS-171 Safety Procedure for Anhydrous Ethanol or blends of Ethanol with Gasoline
- Implementing AIS-137 (Part 8) Document on Test Method, Testing Equipment and Related Procedures for 4 Gas Analyzer & Diesel Smoke Meter: Testing Type Approval and Conformity of Production (COP) of PUC Equipment as per CMV Rules 115, 116

- Implementation of fuel specification for Ethanol (E12 and E 15) fueled vehicles not exceeding 3.5 T
- Fuel efficiency correction factor modification for BS-VI vehicles

Notifications on Safety Standards and Emission Norms for Implementation in 2022-23:

Safety Standards:

- Implementation of Revised Brake Standard IS 11852 (2013) including endurance braking system for all models
- Implementation of Revised Brake Standard AIS-151 or IS 15986 (2015) for all models
- Implementation of Electronic Stability Control System (ESC) (if fitted) for all models
- Implementation of Brake Assist System (BAS) (if fitted) for all models
- Postponement of implementation of IS 2553 (Part 2): 2019 Safety Glass
- Implementation of Whole Vehicle Safety CoP
- Implementation of AIS-163 (Special Purpose Vehicles Cash Van and Mobile Canteen)
- Implementation of AIS-164 (Insulated Vehicles)
- Implementation of AIS-167 (Two-Wheeled First Responder - Fire)
- Implementation of Fire alarm and protection system in occupant compartment for M3 Category Type III buses and school buses
- Electronic Stability Control System (ESC) (if fitted) for M1 and N1 category
- Use of harness for children below age of four years
- Implementation of AIS-163 Cash Vans

Emission Standards :

- Postponing implementation of TREM IV norms to 1st April 2022 and correction in full form of Non-Road Steady Cycle (NRSC)

Notifications for Implementation of Safety Standards and Emission Norms in future after 31st March 2023

Safety Standards :

- Construction Equipment Vehicle (CEV) Phase II Various test for conditions for emission sound pressure level at operator's ear position in phase II for CEV (1st April 2024)
- QCO on safety glass (1st April 2023)

Emission Standards :

- OBD Stage II-A Thresholds for BS-VI vehicles for all motor vehicles as applicable (1st April 2023)
- OBD Stage II-B Thresholds for BS-VI vehicles for all motor vehicles as applicable (1st April 2023)
- Implementation of TREM / CEV V norms for Agricultural Tractors and CEV (1st April 2024)

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

New Facilities

Chassis Dynamometer for EV Testing

High Voltage EV Discharge Unit

Multi Degrees (4/6) of Freedom Spindle Coupled Rig

Gas Chromatograph with Mass Spectrometer

Haze Measurement Setup

Plastic Fatigue Testing Machine

- Special sensors for developmental crash testing
- Barrier Handling System for crash test facility
- Portable Gas Analyzer for ambient air monitoring
- Pass by noise measurement system as per ECE R41 & R51
- Data Center concept for ADAS/ AV
- Upgradation of metallographic analysis facility
- Servo Motor Drive System in Hemi-anechoic Chamber for alternator and fan testing
- Ammonia and multi-component Measurement System
- Thermal Optical Carbon Analyzer
- High Voltage Tester for Cable Testing
- Tyre Rolling Resistance Test Facility
- Dual Channel Dust Samplers for air quality monitoring

We, at ARAI, believe that employees are the most important resource and source for all added value. This belief drives us to nurture our human assets by endowing them with professional capabilities. We focus on creating an enabling learning environment and investing in building new capabilities within the institute through variety of modes. Throughout an employee's career, we support development through a blend of learning approaches, including in-person and virtual trainings, and leadership development programs. This enables our employees in not only building skills, but also to gear up for the changing technology landscape. It is precisely due to this approach that our employees have made a mark in their respective domains.

Employee Well-Being

Commitment to safety and employee health is ingrained in our culture. Our dedication to health and safety of our employees is reflected in our comprehensive policies, best practices and procedures associated with health and safety. We offer benefits to care for the diverse needs of our employees and keep them feeling resilient, innovative and engaged. Highlights of some of our initiatives for our employees undertaken during the year included annual medical check-ups, insurance coverage (term life and group medical), COVID-19 vaccination drive for employees and their families; online yoga sessions and implementation of National Pension System (NPS) from 1st April 2022.

Learning and Development

We invest in a culture of learning to support the upskilling of our employees, which encourages them to grow their skills and maximize their potential. We facilitate upward growth through role and skill-based training and a robust learning

Covid-19 Vaccination Drive

Republic Day Celebration

Rashtriya Ekata Divas

International Women's Day

ecosystem for employees at all levels. We focus on offering a range of different learning programs that provide more targeted learning opportunities. Our training programs help our employees in gaining an insight in technical, functional, behavioural and leadership aspects. With the easing of COVID 19 pandemic situation and the regulations thereof, we started organizing classroom training programs, in addition to the online sessions. During the year, over 19300 man-hours of training was imparted to the employees. Also, an inspiring and insightful talk by Dr. Pawan Goenka was organized for team ARAI on the occasion of Technology Day.

Digitization of HR Processes:

We continue to digitalize and transform our internal systems to drive outcomes and enhance employee experience. In-line with this, we have initiated digitizing of our HR processes through Human Resource Management System (HRMS), with base modules like HR Foundation, Work Force Management and Payroll being implemented in the initial phase and advanced modules like Performance Management, Learning Management (LMS), Tour/ Travel Management and Recruitment being planned in the second phase.

Employee Engagement

Our people are our strength and at the centre of everything we do, and the core of this is to ensure creating of a workplace where they feel included and respected. For this purpose, we engage with our employees through various events like Annual Day, Independence Day, Republic Day, International Women's Day, Rashtriya Ekata Divas, National Safety Week, Hindi Pakhwada, Swachhata Pakhwada, Blood Donation Camp, etc.

Knowledge Dissemination

- Training on Electro-Magnetic Compatibility (EMC) for construction equipment manufacturer
- Training on Electric Vehicle Certification to start-ups and vehicle manufacturer
- Capacity building program on Air Quality Monitoring, Emission Inventory and Source Apportionment of Particulate Matter
- Workshop on Low Carbon & Sustainable Mobility Roadmap for Pune city
- Webinar on Improving Road Safety by using Active Safety Technologies in Automobiles
- Webinar by industry expert on Sustainable Eco-friendly Ideas
- Webinar by industry expert on Waste to Energy for school/ college students

Independence Day Celebration

Blood Donation Camp

- Functional Safety and Hazard Analysis as per ISO26262 for a retrofit P3 Hybrid LCV Controller' by Swapnil Ghugal, Rathin Shah, Ravindra Shah, Nisha Lemos, M. L. Karle and Ujjwala Karle in May 2021 at 5th International Electric Vehicle Technology Conference 2021 (EVTeC 2021)
- 'Intelligent Vehicle Controller (iVCON) Platform for xEV' by Swapnil Ghugal, Rathin Shah, Ravindra Shah, Ninad Pachhapurkar and Ujjwala Karle in May 2021 at 5th International Electric Vehicle Technology Conference 2021 (EVTeC 2021)
- An Innovative 2W Hybrid Concept- DVI' by Ashwin Kaundinya, Sriyan Garapati, Swapnil Ghugal, Ravindra Shah, Rathin Shah and Ujjwala Karle in May 2021 at 5th International Electric Vehicle Technology Conference 2021 (EVTeC 2021)
- 'Characterization of LI-ion battery for mechanical abuse' by S. S. Dandge in July 2021 at LS DYNA Conference
- 'Development of mission profile based simulation methodology for fuel consumption prediction and validation for light, medium and heavy commercial vehicles' by S. U. Gijare, K. Karthick, Dr. S. Juttu, Dr. S. S. Thipse & A. A. Badusha of ARAI and Melin Jan of Volvo Group in September 2021 at FISITA 2021 World Automotive Congress
- 'Development and validation of powertrain controls for a compact non-plug-in hybrid platform for single cylinder engines' by Ashwin Subramanian Kaundinya, Sriyan Garapati, Rathin Shah, Swapnil Ghugal, Ravindra Shah and Ujjwala Karle in September 2021 at FISITA 2021 World Automotive Congress
- 'Hardware in loop simulation based approach for development and validation of Battery Management System' by Ravindra Shah, Swapnil Ghugal, Rathin Shah, Siva Murugesan and Ujjwala Karle in September 2021 at FISITA 2021 World Automotive Congress
- 'Bimetal mixture forging process and its influence on intermetallic phase seam properties for an automotive component' by P K Ajeet Babu, Asmita S Waghmare and M R Saraf in September 2021 at FISITA 2021 World Automotive Congress
- 'Electric Vehicle conductive charging station backend communication current scenario and challenges in India' by Sreekumar Uthaman in September 2021 at SIAT 2021 Conference
- 'Study to compare CO2 emissions from M1 Bharat Stage VI Passenger Vehicles at chassis dynamometer and Indian real traffic conditions' by Kiran Thakare, Abhay Singh, Obaid A. Shah and Revanth Kumar Bathina in September 2021 at SIAT 2021 Conference
- 'Simulation methodology for duty cycle based fuel consumption calculation for Heavy Commercial Vehicles' by K. Karthick, S. U. Gijare, Dr. S Juttu, Dr. N. H. Walke, N. V. Marathe, Sagar Babar & A. A. Badusha of ARAI and Melin Jan of Volvo Group in September 2021 at SIAT 2021 Conference
- 'Evaluation of cable harness of an EV Powertrain through simulation' by H. Rajesh in September 2021 at SIAT 2021 Conference
- 'Failure of Li-ion 18650 cylindrical cells subjected to mechanical loading and computational model development' by H. Rajesh in September 2021 at SIAT 2021 Conference
- 'Development of systematic technique for design of electric motor mounting system in EV/ HEV application' by H. Rajesh in September 2021 at SIAT 2021 Conference
- 'Investigation of SNRD in vehicle components using simulation and DoE techniques' by A. Walke and K. S. Patel in September 2021 at SIAT 2021 Conference

- 'Prediction of tyre dynamic behaviour for NVH and its experimental validation in anechoic chamber' by K. S. Patel in September 2021 at SIAT 2021 Conference
- 'Characterization of casting defects in grey cast iron by scanning electron microscopy and energy dispersive spectroscopy technique' by Asmita S. Waghmare, P. B. Deshmukh, Medha S. Jambhale in September 2021 at SIAT 2021 Conference
- 'Model order reduction technique to aid control system design' by Shivam Setia, V. S. Kuwar, P. R Pawar, Medha S. Jambhale in September 2021 at SIAT 2021 Conference
- 'Coupled electro-chemical and thermal modeling for cylindrical Lithium-ion Batteries' by Ravindra Kumar of ARAI and Prof. Dr. Sandip Chavan of MIT World Peace University in September 2021 at SIAT 2021 Conference
- 'Development of systematic technique for design of Electric Motor mounting system in EV/ HEV application' published by Ravindra Kumar and Tushar Dhanawade at SIAT 2021 Conference
- 'Process modelling of Aluminium Propeller Shaft by Integrated Computational Materials Engineering approach' by P. K. Ajeet Babu, Ujjwala Karle, Y. Ambhore and C. Choudhary in September 2021 at SIAT 2021 Conference
- 'A unique approach for motion planning for Autonomous Vehicle using Modified Lattice Planner' by Rajesh Saini, Jyoti Kale, M. L. Karle and Ujjwala Karle in September 2021 at SIAT 2021 Conference
- 'Machine learning based model development with annotated database for Indian specific object detection' by Ninad Pacchapurkar, Rathin Shah, Jyoti Kale, M. L. Karle and Ujjwala Karle in September 2021 at SIAT 2021 Conference and SAE International Journal of Advances and Current Practices in Mobility June 2022
- 'Simulation based verification & validation of AEBS' by Ajinkya Bhagat, Ujjwala Karle, M. L. Karle and Jyoti Kale in September 2021 at SIAT 2021 Conference
- 'Comparison study between Steel Forging and Aluminum Forging using simulation technology' by A. R. Kumbhar and S. A. Kulkarni in October 2021 at Advances in Forging Technology Conference
- 'Investigation of vehicle cable harness in EV for EMC performance using FEKO' by H. Rajesh in November 2021 at ATC – 2021
- 'Die wear prediction using simulation technology' by A. R. Kumbhar and S. A. Kulkarni in December 2021 at AIFI Webinar
- 'Performance evaluation of highway infrastructure using computer simulation as per global standard' by S. R. Deshpande in March 2022 at 4th National Conference on Traffic Technologies
- 'Challenges overwhelmed to meet BS-VI Emissions with SPFI Fuel System for Heavy-Duty CNG Engine application' by D. Bandyopadhyay, P. S. Sutar, S. B. Sonawane and S. D. Rairikar published at SIAT 2021 Conference
- 'EGR strategies pertaining to High Pressure and Low Pressure EGR in Heavy Duty CNG Engine to optimize exhaust temperature and NOx emissions' by P. S. Sutar, D. Bandyopadhyay, S. B. Sonawane and S. D. Rairikar published at SIAT 2021 Conference
- 'Effect of CCV and OCV System in Heavy Duty CNG Engine on the Particulate Emissions' by P. S. Sutar, D. Bandyopadhyay, S. B. Sonawane and S. D. Rairikar published at SIAT 2021 Conference

- 'Experimental analysis of Heavy Duty CNG Engine based on its aspiration and fuel system' by D. Bandyopadhyay, P. S. Sutar, S. B. Sonawane and S. D. Rairikar published at SIAT 2021 Conference
- 'Chemical profiling of exhaust particulate matter from Indian in-service vehicles' by M. A. Bawase, Y. V. Sathe, Suhail Mulla and Dr. S. S. Thipse published at SIAT 2021 Conference
- 'Measurement of permeability of fuels through Polymer Composite Materials' by Yamini Patil, M. A. Bawase, Y. V. Sathe and Dr. S. S. Thipse published at SIAT 2021 Conference
- 'Multi-axial road simulation for component level validation of engine mount structure and elastomer' by V. S. Kuwar, P. R. Pawar & V. V, Shinde from ARAI and Gorishkumar Mohare & Sandip Hazra from TML published at SIAT 2021 Conference
- 'Development of generic frame testing methodology by synthetic drive file generation technique' by Prakahar Swarnkar, P. R. Pawar, S. R. Munot & V. V. Shinde from ARAI and Atul Kajalkar & Nitin More from TML published at SIAT 2021 Conference
- 'Development of full car model for ride analysis of light duty bus using MATLAB Simulink' by A. Lad, S. Debnath, K. Achanta and M. Agrewale published at SIAT 2021 Conference
- 'Multibody dynamics analysis of tandem axle rubber suspension using MSC ADAMS' by M. Mutha, A. Rai, S. Annigeri and M. Agrewale published at SIAT 2021 Conference
- 'Light weighting of buses using Aluminum with safety and durability considerations' by M. A. Patwardhan, P. A. Nirmal and R.S. Mahajan published in ARAI Journal of Mobility Technology (Volume 1)
- 'Impact of 20% Ethanol-blended Gasoline (E20) on Metals and Non-metals used in fuel system components of vehicles' by M. A. Bawase and Dr. S. S. Thipse published in ARAI Journal of Mobility Technology (Volume 1)
- 'Development of Aluminum Sidewall load body Semi-Trailer – A Green Movement' by M. A. Patwardhan and K. S. Patel published in Aluminium in India (Jan 2022 issue)
- 'A comparison on PSO optimized PID Controller for inter-area oscillation control in an interconnected power system' by Y. K. Bhateshvar, Dr. K. C. Vora, Hitesh Datt Mathur and Ramesh C. Bansal published in Springer Journal, Vol.7
- 'Modelling of Automatic Transmission System with 12 speed gearbox configuration for Passenger Car' by A. S. R. K. Manikanta, Dr. S. A. Patil and K. P. Wani published in Design Engineering (Toronto), Vol 2021, Issue 5
- 'Muffler transmission loss optimization for a vehicle using generic algorithm' by Riziyamala Gavit and K. P. Wani published at CISCON 2021, MIT Manipal

Launch of ARAI Journal of Mobility Technology during SIAT 2021

New Services & Capabilities

EV / HEV:

- Product validation of e-motor/ e-powertrain
- Testing and validation of e-powertrain components
- Battery thermal propagation and suppression characteristics study
- Validation of Battery Management System using HeRTS HIL System
- Verification and validation of xEV control systems (BMS, MCU, VCU)
- EV testing on heavy duty vehicles
- Control strategies for Hydrogen PEM fuel cell based electric vehicles
- Design, analysis and development of e-axle based electric vehicles
- DVP creation & testing
- Drive file creation and durability testing of Electric Vehicle Motor mounting assembly using Road Load Data
- Vibration measurement and target setting on Electric 2W
- 3-D Profile Scanning of HV Battery pre-and-post crash
- AIS-038 / UN R100 - Dynamic Test on REESS / HV Batteries of Evs

Structures:

- Bumper Impact Testing as per UNECE R42 with Pendulum method
- Latin-NCAP CRS Installation Assessment
- Energy Dissipation Test as per UN R17
- Conversion of conventional vehicle to Drive by Wire and instrumentation support
- Full vehicle multi-axial 6DOF Test
- Full vehicle DVP for major subsystems of ICE
- Live axle gear slip test
- Accelerated durability testing of exhaust system component
- Objective customer usage definition & duty cycle development using IRI
- Exhaust & Air Intake System instrumentation (part & vehicle level)
- Complete interior & exterior component testing
- Hydraulic cylinder drift test
- Metro and Loco bogie frame testing
- Mechanical testing of noise barrier
- Fatigue analysis of plastic materials
- Excavator components evaluation by fatigue testing
- BSR testing of seats
- In-service conformity testing as per BS-VI
- BS-VI Stage 2 Certification
- Mass Emission testing as per Japan WLTP
- LNG retro-fitment certification testing
- Emission testing for new alternate fuel vehicles
- Tyre Rolling Resistance test as per AIS:142 and UN R117
- Noise barrier acoustic performance evaluation in-situ application as per EN 1793 – Part 4, 5, 6
- Power based noise reduction (PBNR) evaluation
- Accelerometer & Torque Wrench calibration
- RF Generator calibration

Simulation:

- Simulation and test scenario generation for V&V of ADAS function
- Flywheel/ rotating disk burst test simulation in FEA
- Sink mark optimization for front facia of covid vaccine manufacturing equipment
- Type A container simulation
- Structural Strength assessment and Breech mechanism simulation for defence application
- Core-insert (metal) shift study
- Rheology and structural coupled simulation
- Thickness optimization of 'Bucket' with respect to Rheology
- Lateral/ working stability as per AIS 093

- 2 wheeler drop test simulation
- Strength simulation for slow speed impact bumper test rig
- 2 Wheeler EV ride and handling simulation using MBD
- Strength evaluation of seat anchorages as per AIS 23

Materials:

- New material development using MatCalc software
- Analysis of exhaust gas of battery after catching fire
- Cyclic bending test and flexibility test for automotive cables
- Analysis of VOC emissions from polymeric materials

Brand Building

- Showcasing of capabilities at Virtual Expos, viz. Future Mobility Show 2021 and Aero India 2021

Virtual Stall at Future Mobility Show 2021

Director – ARAI delivering Inaugural Address at EV Expo

- Reached out to the industry through periodic updates on capabilities, events, new developments, etc. on social media platforms, viz. Linkedin, Instagram, Facebook, Youtube and Twitter

Interactions with Industry :

During the year, ARAI hosted senior level delegations of various organizations and also visited many customers for business promotion. The core idea of these interactions was to explore potential business avenues and collaborative opportunities. In addition to the interaction with customers, ARAI also hosted delegations from All India Rubber Industries Association, SIAM and ACMA. 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 IIT Hyderabad – For collaborative work on India specific technology development for ADAS/ Autonomous Driving
- MoU with INS Shivaji Center of Excellence (Marine Engineering) – To collaborate and pursue industrial/ application-oriented projects for developing efficient and environment friendly solutions for marine engineering applications
- MoU with CSIR-National Chemical Laboratory – For exchange of scientific knowledge; undertaking joint research work for development of products, process and technologies and joint workshop for imparting skills for the benefit of society and industry

MoU with Industry

MoU with IIT Hyderabad

MoU with CSIR-National Chemical Laboratory

MoU with INS Shivaji CoE (Marine Engineering)

- **Various MoUs with Industry in following areas**
  - ADAS/ AV and V&V
  - Functional Safety, Electronics Reliability & Cyber Security
  - EV related EV sound package development
  - Testing, Validation & Certification of e-motor, electronic control systems, electronic/ electrical systems
  - Technology licensing, development & testing, material science, education & training, software development

Foundation Stone Laying of Advanced Battery Safety Test Laboratory

ARAI is augmenting its existing battery testing capabilities, considering industry's growing requirement of testing, validation and development needs related to variety of xEV batteries, their sizes, capacities and volumes. The foundation stone of Advanced Battery Safety Test Laboratory was virtually laid at the hands of Dr. Mahendra Nath Pandey, Hon'ble Minister of Heavy Industries (MHI), Government of India on 20th November 2021. The other dignitaries present on this occasion included Mr. Amit Mehta, Joint Secretary, MHI; Mr. Rajendra Petkar, President – ARAI and President & CTO, Tata Motors Ltd.; Mr. Ravi Gogia, Vice President – ARAI and President, Fiat India Automobiles; Dr. Reji Mathai, Director – ARAI and other Senior Executives from ARAI. The proposed facilities being established at ARAI's CoE in Green Mobility at Chakan, Pune will help in meeting industry's testing needs pertaining to Electrical Abuse test and Mechanical Abuse test of Electric and Hybrid vehicles. The lab will have facilities for thermal runaway, full-fledged BMS simulator, water immersion and battery pack crush test.

SIAT 2021

Symposium on International Automotive Technology (SIAT) is a biennial event organized by ARAI in association with SAEINDIA, NATRiP 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 automobile arenas.

The seventeenth edition of this symposium, SIAT 2021 was organized virtually through a digital platform during 29th September 2021 to 1st October 2021. SIAT 2021 along with SIAT EXPO 2021 was inaugurated virtually by Dr. Mahendra Nath Pandey, Hon'ble Minister for Heavy Industries, Government of India. The other dignitaries present on this occasion included Mr. C. V. Raman, the then President – ARAI & CTO, Maruti Suzuki India Ltd.; Mrs. Rashmi Urdhwareshe, President – SAE India; Dr. Reji Mathai, Director – ARAI & Chairperson – SIAT 2021; and Dr. S. S. Thipse, Sr. Deputy Director, ARAI & Convenor – SIAT 2021. The theme of this edition of the symposium was 'Redefining Mobility for the Future'. During this inaugural ceremony, Symposium Proceedings, Technical Reference Bulletin, ARAI Journal of Mobility and Wissen Baum Safety Booklet were released.

SIAT 2021 was successful with participation of over 4000 delegates, which included overseas delegates from over 15 countries. During this symposium over 45 keynotes and 130 technical papers were presented by experts from India and abroad across 36 Technical Sessions. The symposium focused on recent advances in various automotive areas, such as Alternate Fuels, Safety, Emissions, Engines, Noise, Electric Mobility, Electronics, Intelligent Transportation, Vehicle Dynamics, Materials and Simulation & Modelling. It also brought to the fore innovative ideas and solutions in automotive technologies to meet future challenges. Also, Plenary Sessions on topics, viz. Sustainable Mobility, Future Trends for Mobility and Smart Mobility were organized.

SIAT EXPO 2021, held concurrently with SIAT 2021 symposium, offered an appropriate platform for spectrum of worldwide companies to showcase their products/ technologies/ innovations/ services through various stalls. The exposition had a participation of 103 exhibitors which included 26 stalls of overseas exhibitors. The technology displayed at SIAT EXPO 2021 was in line with SIAT theme, viz. 'Redefining Mobility for the Future'. The exposition covered the theme through display of technologies on Active & Passive Safety supported by Advanced Instrumentation & Data Acquisition Technologies, Intelligent Mobility through technologies in the area of Simulation, E-mobility, Battery Technology, Internet of Things (IOT) and Connected Vehicles. In addition to this, other stalls displayed trends in Vehicular Emissions, Advanced Powertrain & Materials, Alternate Fuels, Safety, etc.

The valedictory function of the symposium was graced by Shri Nitin Gadkari, Hon'ble Minister for Road Transport & Highways, Government of India as the Chief Guest. The other dignitaries present on this occasion included Mr. Rajendra Petkar, current President – ARAI and President & CTO, Tata Motors Ltd.; Dr. Reji Mathai, Director – ARAI & Chairperson – SIAT 2021 Advisory Committee; Dr. S. S. Thipse, Sr. Deputy Director, ARAI & Convenor – SIAT 2021 and Mr. Nabeel Khan, Editor-Economic Times (ET Auto) as the Master of Ceremony. During this function, various awards like Best Technical Papers, Best International Paper, Best Paper on Safety, Best Paper on Simulation & Modelling, Best Paper on Electric Mobility, Best Paper on Environmental Pollution and Student Poster Presentation were presented.

Launch of ARAI Journal of Mobility Technology

ARAI Journal of Mobility Technology was launched virtually at the hands of Dr. Mahendra Nath Pandey, Hon'ble Minister of Heavy Industries, Government of India during SIAT 2021 on 29th September 2021. This quarterly journal is an online publication for dissemination of original research in automotive technology. It is a publication covering wide range of articles in automotive and allied topics for the benefit of professionals, academia and automobile industry.

Launch of CMVR-Type Approval Software (CMVR-TAS)

ARAI continues to digitalize and transform its processes and systems to enhance customer experience. In-line with this, ARAI has launched CMVR – Type Approval Software (CMVR-TAS) on 15th July 2022, which is an improvised version of previously used DELTA Software. This user-friendly portal for the benefit of vehicle and engine manufacturers was launched by Dr. Reji Mathai, Director – ARAI in the presence of Senior Executives of ARAI, viz. Mr. A. A. Badusha, Mr. K. Srinivas, Mr. N. B. Dhande and Mr. A. A. Deshpande.

Salient features of this platform include:

- Real-time dashboard for test requests and case list
- Query module for communication between customer and ARAI
- Alert option informs customers on ARAI's queries or tags
- Tracking progress of the cases
- Audit trail of the cases
- Repository for document retrieval

International Conference on Hydrogen and Fuel Cell Technology

ARAI had jointly organized International Conference on Hydrogen and Fuel Cell Technology along with SAEINDIA from 17th to 19th January 2022. This 3-day conference was inaugurated by Shri Arun Goel, Secretary, MHI. The other dignitaries present on this occasion included Dr. Reji Mathai, Director – ARAI, Mrs. M. S. Jambhale, Deputy Director, ARAI and Dr. S. S. Ramdasi, Deputy Director, ARAI & Convenor. The focus of this virtual conference was to bring out the advancements in areas like green Hydrogen generation and storage, Hydrogen as a fuel in IC Engines, advancements in fuel cell, futuristic Hydrogen mobility, etc.

The presentations at this conference highlighted various opportunities as well as challenges associated with the commercialization of Fuel Cell and Hydrogen Fuel. There were 11 keynote sessions and 4 technical presentations on topics like indigenous development of fuel Cell, Hydrogen mobility, supply chain development for mobility and power generation applications, advanced catalyst, stack development, Hydrogen storage, safety standards, Hydrogen and fuel cell development roadmap, etc. Also, three panel discussions on Accelerating implementation of Hydrogen and Fuel Cell Ecosystem and associated Challenges, A cost effective, sustainable & acceptable Hydrogen and Fuel Cell Product/ Supply Chain development for Mobility & Power Generation Applications, and Government Support/ Policy/ Framework/ Rules and Regulations for boosting Hydrogen Economy were organized. Over 147 delegates (including delegates from countries like USA, Brazil, Norway, Australia, Germany, Sweden and Israel) participated in this conference.

Online Global Technical Conference on Automotive Research & Development

A 2-day Online Global Technical Conference on 'Automotive Research & Development' was organized by ARAI in association with Christ University and Endurance Technologies Limited from 24th to 25th May 2021. This conference was inaugurated by Dr. V. Sumantran, Chairman, Celeris Technologies, in the presence of Dr. Reji Mathai, Director – ARAI; Mr. Ravindra Kharul, President & CTO, Endurance Technologies Ltd. and Dr. K. C. Vora, Retired Sr. Deputy Director, ARAI. Speakers from industry and academia shared their thoughts at this conference. A panel discussion on the topic 'Enhancing Employability in Automotive R&D' was also held at this conference. A total of 80 participants attended this virtual conference.

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 Advance Powertrains
- International Conference on Hydrogen & Fuel Cells Technology for Mobility & Power Generation Applications
- Conference on "Sustainability & Circular Economy of Materials – Through Understanding of ELV, RoHS (SoC), IMDS, REACH and CDX"
- Webinar on Bio Fuels
- Eminent Speaker Series Lecture on "Vision for a Successful Academia"

ARAI undertakes knowledge dissemination and skill development activities through ARAI Academy's Learning Centre (LC), Training Centre (TC) & Library. This includes training and educational programs to enhance human resource skills for meeting the growing needs of mobility sector. ARAI carries out these activities at ARAI – Forging Industry Division (ARAI – FID), Chakan. ARAI Academy's contribution is well known in the academia as well as industry. The year 2021-22 is significant for ARAI Academy as Indian Quality Assurance Council recognized its contribution by conferring it with 'IQAC Quality Excellence Award'.

LEARNING CENTRE

Learning Centre conducts undergraduate, postgraduate and doctorate programmes with specialization in Automotive Engineering through collaborations with various universities, viz. College of Engineering (Pune), Christ University (Bengaluru); Rajarambapu Institute of Technology (Sangli), Chitkara University (Chandigarh) and MIT World Peace University (Pune). The year 2021-22 witnessed further strengthening of collaboration with addition of SRM Institute of Science and Technology, Chennai, Kalasalingam Academy of Research and Education (KARE), Tamil Nadu. Also, a new PG Diploma program with College of Engineering, Pune was added during the year. The infrastructure at this centre has been augmented with addition of EV & HEV Lab and AI-ML Lab for the benefit of the students. A summary of the joint programs conducted with various universities is given below.

Collaborations for UG Programs:

- Christ University, Bengaluru – B. Tech. in Automobile Engineering
- SRM Institute of Science and Technology, Chennai – B. Tech. in Automotive Engineering (Electric & Hybrid Vehicle)

MoU with College of Engineering, Pune for Post Graduate Diploma Program

MoU with Rajarambapu Institute of Technology for M. Tech. Program

MoU with SRM Institute of Science and Technology for B. Tech. and M. Tech Programs

Collaborations for PG Programs:

- College of Engineering, Pune – M. Tech. in Automotive Technology
- Rajarambapu Institute of Technology, Sangli – 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 (Electric & Autonomous Vehicle)
- Kalasalingam Academy of Research and Education (KARE), Tamil Nadu – M. Tech. in Automotive Engineering (Electric & Hybrid Vehicle and Powertrain Engineering)

Collaborations for Post Graduate Diploma Programs:

- College of Engineering, Pune (Electric Mobility)
- College of Engineering, Pune (Materials Technology for Smart Manufacturing: Industry 4.0 Perspective)
- Savitribai Phule Pune University, Department of Technology (Electric Mobility)
- Cummins College of Engineering for Women, Pune (Electric Mobility)
- Rajarambapu Institute of Technology, Sangli (Electric and Autonomous Vehicles)

Collaborations for Doctoral Programs:

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

Further, other outreach activities for knowledge dissemination included Electric Vehicle Awareness program with ASDC, AICTE and MHI; free webinars for engineering students and internship programs under TechNovuus for mentoring of students.

TRAINING CENTRE

Training Centre organizes Proficiency Improvement Programs (PIPs); Domain Training Programs (DTPs); and E-learning Online Courses for students as well as working professionals. During the year, 45 programs (PIPs and DTPs) were organized, wherein lectures were given by ARAI personnel, academicians and eminent industry experts, including speakers from abroad. These PIPs & DTPs had a participation of over 2000 delegates.

PIPs and DTPs:

- Digital Library on Green Mobility (DLGM) and TechNovuus
- Motors and Controls for Electric Vehicles and Industrial Applications
- Electric Vehicle Technology
- Combustion Fundamentals (Blended)
- EV Motor performance characteristics using virtual approach
- Testing of Seating System
- Conference on Automotive Research & Development
- Systems Engineering Fundamentals
- Electric Vehicle and Autonomous Mobility
- Real Driving Emissions (Blended)
- EMC in Electric Vehicles
- EV Battery Performance and Ageing Characteristics (virtual approach)
- Simulation & Optimization of Thermal Management of xEV
- Light Weight Material for Automotive Application
- SCR for BS-VI Applications (Blended)
- Vision Zero
- Brake System Design & Safe T

- Battery Management System of Electric Vehicle
- FMEA & DVP
- Alternative & Advanced Battery Technologies for EV
- Automotive NVH
- Advanced Material Characterization and Component Testing
- Thermal Management of Electric Vehicle
- Electric Vehicles: Development, Validation & Certification
- Aluminium Welding
- Automotive Testing & Certification
- Hydrogen and Fuel Cell Technology
- Vehicle Dynamics
- Engine Emission & Control (blended)
- Global eMobility Overview, future challenges & Opportunities
- Improving Road Safety by using Active Safety Technologies in Automobiles (Online Webinar)
- Improving Road Safety by using Passive Safety Advances (Online Webinar)
- AMT Technology
- EV / HEV Technology
- Automotive Regulations
- EV Products and Technologies
- IC Engine Technology
- Vehicle & Engine Testing
- EMI / EMC
- Engine Technology
- Engine Performance & Troubleshooting (Level II)

e-Learning Courses (ePIPs):

- Reliability Engineering
- Engine Electronics & Management Systems
- Fuel Cell Technology
- Real Driving Emissions (RDE)
- Selective Catalytic Reduction (SCR)
- Emission Type Approval (including BS-VI): 2, 3, 4 Wheeled Vehicles
- Combustion in IC Engines
- HC/CO Emission Formation
- Emission Measurement Techniques
- NOx Emission Formation
- PM Emission Formation
- Diesel Particulate Filter
- Hybrid & Electric Vehicles Architecture

New Labs at ARAI Academy :

The mobility sector is witnessing an increasing penetration of electric mobility and application of Artificial Intelligence (AI) & Machine Learning (ML). Considering this, the demand of the mobility sector for skilled human resource with skill sets in emerging areas is growing. To support these needs of the industry, ARAI has established EV/ HEV lab and AI & ML lab at its Academy. These labs were inaugurated by Director – ARAI on 28th February 2022. These labs are for the benefit of the students, as they provide them with hands-on-experience while working on their various projects.

Inauguration of EV/ HEV and AI & ML Labs

Independent Auditor's Report

Annual Statement of Accounts

To -

The members of
THE AUTOMOTIVE RESEARCH ASSOCIATION OF INDIA

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, 2022, and the Income and Expenditure 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 of the entity are prepared, in all material respects, in accordance with accounting principle generally accepted in India.

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.

For M/s Gunwani & Kolapkar,
Chartered Accountants

Ghanasham Ranade
(Partner)
(Firm Registration No.128698W)
(Membership No. 100151)
Pune, Dated 24th June 2022

Balance Sheet as on 31st March 2022

(RS IN LAKHS)

Particulars	Schedule No	31 March 2022	31 March 2021
I EQUITY AND LIABILITIES			
1. Owners' Funds			
a Reserves and surplus	3	1,55,068.13	1,48,852.21
		1,55,068.13	**1,48,852.21**
2. Non-current liabilities			
a Other long-term liabilities	4	4,049.77	4.53
b Long-term provisions	5	3,336.51	2,967.31
		7,386.28	**2,971.84**
3. Current liabilities			
a Trade payables			
i Total outstanding dues of micro, small and medium enterprises	6	218.58	113.58
ii Total outstanding dues of creditors other than micro, small and medium enterprises	6	1,910.16	2,542.63
b Other current liabilities	7	11,596.13	8,696.38
c Short-term provisions	5	-	-
		13,724.87	**11,352.59**
Total		**1,76,179.28**	**1,63,176.64**
II ASSETS			
1. Non-current assets			
a Property, Plant and Equipment and Intangible assets	8		
i Property, Plant and Equipment		72,711.81	63,033.64
ii Intangible assets		480.08	635.45
iii Capital work in progress		2,995.36	13,504.08
iv Intangible asset under development		-	-
b Non-current investments	9	4,545.90	-
		80,733.15	**77,173.17**
2. Current assets			
a Inventories	10	27.43	30.14
b Trade receivables	11	5,500.03	2,992.40
c Cash and Bank balances	12	86,271.81	78,060.56
d Short Term Loans and Advances	13	3,267.67	4,603.91
e Other non-current assets	14	379.19	316.46
		95,446.13	**86,003.47**
Total		**1,76,179.28**	**1,63,176.64**
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

Rajendra Petkar
President

Ravi Gogia
Vice President

AS PER OUR
REPORT OF EVEN DATE
FOR GUNWANI AND KOLAPKAR
CHARTERED ACCOUNTANTS
Firm's Reg. No. 128698W

GHANASHAM RANADE
PARTNER
Membership No. 100151

Date : 24th June 2022
Place : Pune

Statement of Income and Expenditure for the Year Ended 31st March 2022

(RS IN LAKHS)

Particulars	Schedule No	31 March 2022	31 March 2021
I Revenue from operations	15	37,037.59	25,540.41
II Other Income	16	3,346.33	2,735.23
III Total Income (I+II)		**40,383.92**	**28,275.64**
IV Expenses:			
a Operational Expenses		2,897.29	2,503.99
b Employee benefits expenses	17	18,690.41	13,823.01
c Depreciation and amortization expenses	18	4,362.70	3,239.26
d Other expenses	19	4,737.25	3,872.64
Total expenses		**30,687.65**	**23,438.90**
V Surplus/(Deficit) before tax (III- IV)		**9,696.27**	**4,836.74**
VI SIAT Surplus / (Deficit) transferred to General Fund		173.56	(4.41)
VII Surplus/(Deficit) transferred to General Fund (V-VI)		**9,522.71**	**4,841.15**

Dr.Reji Mathai
Director

Rajendra Petkar
President

Ravi Gogia
Vice President

AS PER OUR
REPORT OF EVEN DATE
FOR GUNWANI AND KOLAPKAR
CHARTERED ACCOUNTANTS
Firm's Reg. No. 128698W

GHANASHAM RANADE
PARTNER
Membership No. 100151

Date : 24th June 2022
Place : Pune

ARAI Management Committee

Dr. Reji Mathai
Director - ARAI
director@araiindia.com

Akbar Badusha
Senior Deputy Director

Nitin Dhande
Senior Deputy Director

Anand Deshpande
Senior Deputy Director

Ms. Medha S. Mainkar
Senior Deputy Director

Sanjay Nibandhe
Senior Deputy Director

Dr. Sukrut Thipse
Senior Deputy Director

Vikram Shinde
Senior Deputy Director

Ms. Medha Jambhale
Deputy Director

Sandeep Medane
Deputy Director

Atul Bhide
Deputy Director

Charudatta Mukhedkar
Deputy Director

Shirish Dabir
General Manager

Vishal Bagare
General Manager

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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