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Bad assumptions in a good month

What a month! It's been an eye-opener to many. The focus shifted from the variant of interest to the variant of concern instead. The Union Health Minister is known to have confirmed that the new "double mutant" variant of SARS-CoV-2 has been detected in 18 states in addition to the three "variants of concern", first noticed in the UK, South Africa and Brazil. At a time when the country continued to open its vaccination drive and seemed to reverse the tide, the rise of unknowns and the infection rate comes as a big jolt.

In a silver lining, the manufacturers can continue to function at full capacity for now as per the latest guidelines. However, the workforce must be reduced to ensure adequate social distancing on the production floor. To ensure social distancing, manufacturers are free to increase the working shifts at their respective units in line with the approvals of the local authorities. I urge you to not take this resurgence lightly and to ensure appropriate checks and balances to see this period through, successfully, speaking from personal experiences.

Covid-19 aside, the month passed by at a hectic pace. The fifth edition of the ACI Awards - 2021 entered its final leg of racing to the finish. As we humbly declare the winners in this 'Awards Special' April issue, I take this opportunity to thank you all for your continued support over the last half a decade. The nominations and well-documented supplementary data by most nominees helped us conduct a seamless jury process. In cases, this proved to be the deciding factor for the jurors.

Talk about ending the month on a high with the winners declared and the Ever Given "successfully refloated"! The latter, a sigh of relief for countless businesses including manufacturers spanning from motor spare parts to fork-lift trucks. That's part of an estimated USD 9.6 billion of trade, each day, freed up! In business parlance, wish you a happy new financial year.

> **"Talk about ending the month on a high with the winners declared and the Ever Given "successfully refloated"!**

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Marquardt Group R&D centre

Germany based Marquardt Group into electromechanical and electronic switches, and switching systems has established a global R&D centre in Pune, Maharashtra. Spread across 16,000 sq. ft. in Hinjewadi, the centre is believed to be state-of-the-art. Focussed on meeting the demands of both its domestic and global clientele, Battery Management Systems (BMS) is expected to be a key focus area at the centre. The centre employs around 300 highly-skilled engineers and is equipped to accommodate 900 workspaces. It also holds a product validation lab measuring about 600 sq.m. with highly sophisticated equipment. Marquardt India is additionally working on developing complex mechatronics products with Autosar and a model-based software claimed to have the highest degree of functional safety and cyber security.

Talbros Automotive JV bags multiyear order

Talbros Automotive Components bagged a multiyear order valued at Rs.304 crore along with JV partners Talbros Marugo Rubber and Magneti Marelli Talbros Chassis Systems. Split across its domestic and international customer base, the multiyear order will start in the current fiscal year and is spread over a five years period.

New Advik Hi-Tech acquisition

Advik Hi-Tech has completed the acquisition process of South Korea based Hanon Systems' Bengaluru operations. Known to manufacture automotive water and vacuum pumps for global automotive leaders, the acquisition is expected to help the company to capitalise on the global manufacturing and R&D capabilities in powertrain systems. As part of the acquisition, Advik Hi-Tech will add a new manufacturing facility for the orders booked. Manufacturing, engineering, and administrative resources across the existing facilities of 10 plants spread out across India, Indonesia and Vietnam will remain a focus area for the company.

Chairman and CEO MAHLE parts ways

Dr Jörg Stratmann, Chairman and Chief Executive Officer at MAHLE resigned from his position effective March 31, 2021. As per a company release, the ex-Chairman and CEO, in a mutual agreement, with Professor Dr Heinz Junker, Chairman, Supervisory Board, MAHLE Group decided to give up his posts. Averred Dr Junker, "On behalf of the Supervisory Board, I would like to thank Jörg Stratmann for his many years of consistently loyal and successful service to the group. We wish him all the best for the future." Having served the MAHLE Group for 13 years across executive positions, and from 2014 as Chairman Dr Stratmann rose the ranks since his appointment in 2008 as a Member, Management Committee.

Bosch Bengaluru campus

For representation purpose only.

Bosch India will invest Rs.800 crore for the upgradation of its Adugodi campus, in Bengaluru. Home to Bosch power tools, powertrains and automotive aftermarket divisions, the investment is aimed at turning the campus Artificial Intelligence of Things (AIoT) compliant. Expected to be the largest digital-savvy campus, outside of Europe, the new campus will employ the second-highest strength of Bosch employees, globally. It is slated to be full-functional by June 2022 overlapping the group's centenary celebrations. Bosch currently employs 31,500 associates and 18,000 engineers across seven locations in India. The Bengaluru campus alone will seat an estimated 10,000 software engineers by then.

Amara Raja research hub

Amara Raja Batteries Ltd. (Amara Raja) has set up a research hub for lithium-ion cells at its Tirupati facility, in Andhra Pradesh. Claimed to become India's first lithium-ion technology and research hub from the private sector, it will leverage the 2019 technology transfer agreement with the Indian Space Research Organisation (ISRO). The Rs.20 crore investment towards the hub will not involve any royalty fees for technology transfer and requires the company along with nine other such companies to pay only the bidding and technology transfer fees. Bharat Electronics of Pune, Carborundum Universal of Kochi, Exicom Tele-Systems of Gurugram, GOCL Corporation of Hyderabad, Jyoti CNC Automation of Rajkot, Nalcom of Bhubaneswar, Sukhbir Agro Energy of Delhi, Tata Chemicals, and Thermax are among those.

Vikram Kirloskar receives IIM-JRD Tata Award

Toyota Kirloskar Motor Ltd. Vice-Chairman, Vikram Kirloskar received the prestigous IIM-JRD Tata Award for 2020 from the Indian Institute of Metals (IIM). Instituted in 2007, the IIM-JRD Tata award is conferred annually at the National Metallurgists Day instituted by the Ministry of Steel & Mines. Awarded for 'Excellence in Corporate Leadership in Metallurgical Industries', he averred, "I have strongly been guided by a vision of making India a world-class manufacturing hub and my commitment has always been towards developing world-class manufacturing competencies and building great talent." "Driving a socio-economic growth agenda, it fosters growth not just for the company but for the people, the society and the country at large," he added. The fourth-generation successor of the Kirloskar Group, also the Chairman and Managing Director of Kirloskar Systems Ltd. has led in several prestigious positions across SIAM, CII and ARAI. In its 74 year journey, IIM has recognised eminent metallurgists, material scientists, industry professionals, researchers, teachers, and students for their significant contributions towards minerals, metals, materials, and their applications, since inception.

Dr R Mukhopadhyay honoured as Distinguished Alumnus

Dr R Mukhopadhyay, Director (R&D), at JK Tyre has been honoured with the 'Distinguished Alumnus Award 2020' by the Indian Institute of Technology (IIT) Kharagpur at the 66th convocation. Awarded in recognition of professional achievements, determination, and contribution as an alumnus of IIT, the event was addressed by Prime Minister Narendra Modi in the presence of eminent academicians, scientists, industry experts, technocrats and social activists. Expressed Dr R Mukhopadhyay, "It is a matter of pride for me to be standing alongside the well-regarded alumni awardees with outstanding achievements in separate spheres bringing back fond memories of my stint here." "I would also like to dedicate this award to the entire team who has worked with me for the upliftment of rubber science and tyre technology," he said. A graduate from the University of Calcutta, Dr R Mukhopadhyay pursued MSc and PhD from IIT Kharagpur where he started his journey as a faculty member in applied chemistry. His over five-decade contribution in rubber science and tyre technology is well regarded.

Critical raw material for components manufacturing

Vedanta Ltd. has launched an aluminium cylinder head alloy. Deemed as a critical raw material for manufacturing cylinder heads among other components, the new addition to the company's aluminium product line is claimed to leverage material design for enhanced efficiency of BSVI and CAFE compliant internal combustion engines. Unveiled for the domestic industry at the second 'Automotive Raw Material Localization Conclave' hosted by the Automotive Components Manufacturers Association of India (ACMA), the company is known to have invested in a capacity creation of 10,000-tonne. It is claimed to have deployed state-of-the-art technology from Befesa (in Spain) and Properzi (in Italy).

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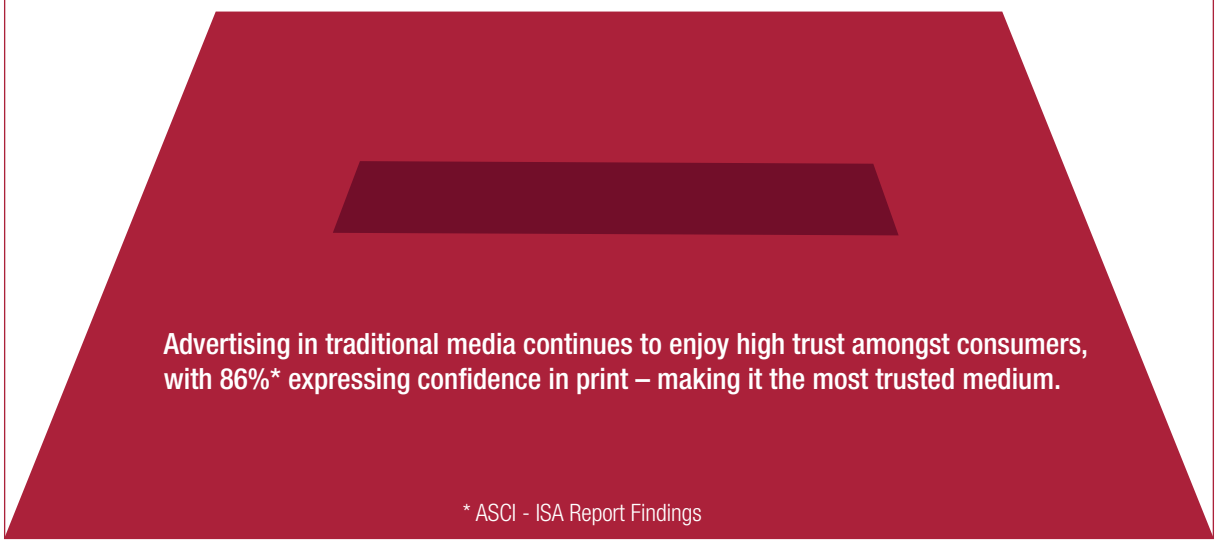

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* ASCI - ISA Report Findings

ACMA against reservation

Image Courtesy Satyam Auto Components Pvt. Ltd

The Automotive Component Manufacturers Association (ACMA) approached the Haryana state government to reconsider the 75 per cent reservation policy in favour of locals across private enterprises. On March 02, 2021, the Haryana State government with the Governor's approval notified the 'Haryana State Employment of Local Candidates Bill' to become a law. It entitles locals for reservations across factories and other blue-collar jobs.

Mentioned Deepak Jain, President, ACMA, "Hiring in our sector is done based on merit and talent rather than the domicile of the candidates. The reason for the industry to employ candidates from outside the state is due to the shortage of adequately skilled and locally available manpower." The move is feared to adversely impact the ease of doing business in Haryana and also be detrimental to the state's image as an industry-friendly destination, as per Jain.

Devaraya M Sheregar is President TAGMA

The Tool And Gauge Manufacturers Association (TAGMA) has elected Devaraya Manjunath Sheregar as the new President. Currently the Managing Director and Chairman of Devu Tools Pvt. Ltd. he is known to have been instrumental in the development of TAGMA activities as an executive committee member of the previous term (2017-2020). Expected to work closely with the policymakers and mediate on behalf of the toolmakers, the new team has sought the guidance of its predecessor as a mentor. D Shanmugasundaram was elected as the Vice President for the term 2020-2023.

Ola Siemens partnership

As per reports, Ola and Siemens have signed an Rs.2400 crore deal with the Government of Tamil Nadu. Ola will leverage Siemens integrated digital twin design and manufacturing solutions to digitise and validate product and production ahead of operations commencing at Ola's first electric scooter manufacturing plant. To be built with an initial annual production capacity of two million units, it will serve as a global hub for both the domestic and export markets like Europe, the United Kingdom, Latin America and ANZ. The state-of-the-art industry 4.0 compliant manufacturing facility will deploy 5000 robots.

Ola ABB partnership

Ola has partnered with ABB for robotics and automation solutions to be deployed at its upcoming, mega-factory. The automation solutions will be utilised for key manufacturing process lines, including painting and welding, especially across the battery and motor assembly lines. It involves the ABB IRB 5500 paint and IRB 2600 Integrated dressing robots for the paint and weld processes, and the IRB 6700 series for assembly and material handling in battery and motor assembly. According to a statement of Bhavish Aggarwal, Chairman and Group CEO, Ola, the ABB solutions will be fired by Ola's own proprietary AI engine and tech stack. "We are bringing in global expertise and stitching up partnerships that will help us build our factory at record speed and roll out the first of our electric scooters in the coming months," he mentioned.

New Appointments at TVS Motor Company

TVS Motor Company has appointed Prof. Sir Ralf Speth to its Board of Directors with effect from March 24, 2021. The company also appointed Kuok Meng Xiong, scion of the Kuok Group, as an Independent Director Chennai on March 24, 2021, for a period of five years. In line with the future roadmap, Prof Sir Ralf Speth regarded as the global automotive industry icon, widely acclaimed for his leadership at Jaguar Land Rover (JLR) and known for transforming JLR into the global marquee, continues to serve on its board as Vice Chairman as also on the board of Tata Sons. Averred Venu Srinivasan, Chairman, TVS Motor Company, "It is a momentous occasion for TVS Motor Company to welcome Ralf to its Board. His passion for technology, eye for products and commitment to building brands are truly remarkable. His thoughts will add immensely to TVS Motor as the company shapes itself for the future." "Ralf's deep insights and guidance will be invaluable to the management team as TVS Motor Company embraces the future of mobility," he said.

Sir Ralf's journey can be traced back to his beginnings in BMW where he rose to a very senior level at a young age. A PhD at Warwick Manufacturing Group, he later joined Premier Auto Group and took charge of product planning and quality. He moved to the chemical giant Linde later where he ran global operations. The Chief Executive Officer of JLR for over 11 years is regarded as the most glorious period in the history of the British marquee. Knighted by the Queen in 2018 for his contributions to British industry, the Royal Society recognised his passion for science in 2020 for making him a Fellow of the Royal Society, a rare honour for a business leader. Venu Srinivasan, Chairman of TVS Motor Company, credited for building the company in 1980 and taking it to the top five global manufacturers of two and three-wheelers, becomes Chairman Emeritus effective January 2023. Sir Ralf will succeed him as Chairman.

Kuok Meng Xiong, the scion of the Kuok Group, regarded as one of Asia's most respected business houses and the founder of venture firm K3 Ventures started his career at the Group's Shangri La Hotels, expanding it to Europe, West Asia and Sri Lanka. At the venture firm K3, he led early investments in 38 of the world's leading startups and many Asian unicorns. These include

Venu Srinivasan, Chairman, TVS Motor Company

investments in Grab, Bytedance, Palantir, Airbnb, GoPay, Wiz. ai, SpaceX and others. He is on the Board of many Kuok Group Companies and the advisory Board of TPG, among others. "MX brings a unique mix of strong corporate values and a clear vision of the future digital world, and it will be a privilege to have him on our Board", expressed Srinivasan. The Board is said to have accepted the resignation of Rajesh Narasimhan who has joined the Board of Sundaram Clayton, in addition to his executive role at TVS Digital, where he leads investments in startups related to the Group's business.

Prof. Sir Ralf Speth

Kuok Meng Xiong, Founder and Managing Partner at K3 Ventures

TVS Srichakra 11

TVS Srichakra launched a range of 11 replacement tyre sizes to align with the post-pandemic demands of personal mobility and commercial fleets. Team ACI shares a first look of the new addition to the OEM portfolio.

TVS Srichakra Ltd. is building on the positive feedback for launches of the recent past. In a bid to further streamline its portfolio, the company has expanded its existing range for the aftermarket with the addition of new tyre sizes. The tyre manufacturer broadened its aftermarket range with the launch of 11 new sizes under the existing series of 'SPORTORQ', 'JUMBO GT', 'CONTA', 'DURAPRO' and 'e-DURAPRO' tyres to meet the projected, post-pandemic demand. On one end of the spectrum, the company will cater to the demand for commuter and high-performance bikes while on the other end of the spectrum, it will also cater to e-rickshaws. Out of the new 11, eight are high-performance tyres for the motorbikes, two are for scooters and one size is for the e-rickshaws.

Sharing the company strategy behind the aftermarket range, averred P Madhavan, EVP – Sales & Marketing, TVS Srichakra Ltd. "We have introduced over 20 new products in the recent past and all of them have been received well in the market. To address the increasing demand in the post-pandemic era, we are now launching these 11 new products that will add to our already extensive range." With a focus on innovation, superior quality standards and high performance, the company, according to Madhavan is looking to redefine personal mobility and commercial fleet segments. It is claimed to have done so by blending the best of mileage, performance and durability capabilities. Add to it, the company is also claimed to have addressed the need for superior braking performance and higher safety in different terrains the tyres are expected to ply on. The experience in two-wheeler tyre design and manufacturing backed by global R&D capabilities is especially expected to hold the company in good stead, meeting the preferences of millennial riders, he opined.

DURAPRO (Commuter Bikes)	JUMBO GT (Commuter Bikes)	SPORTORQ (Commuter Bikes)	CONTA 725 (Scooters)	e-DURAPRO (Passenger/Cargo e-rickshaw)
80/100-18 TL	100/90-17 TL	80/100-17 TL	90/90-12 TL	90/90-12 TT
2.75-18 TL	100/90-18 TL	2.75-17 TL		
3.00-17 TL				
3.00-18 TL				
90/100-10 TL				

The Power of 11

To be made widely available pan India, across urban metros and rural towns, of the new range, the 'SPORTORQ' has two new additions in the 80/100-17 TL and the 2.75-17 TL. Designed with a reinforced tri-polymer compound, the two are claimed to offer a superior grip on both wet and dry surfaces. For instance, the unique tread pattern is to offer superior control at higher speeds. The grooves are designed to enhance water dispersion evenly at all lean angles. The rounded and extended shoulder profile is said to enable better stability and traction while cornering.

The 'JUMBO GT' has two new additional sizes in the 100/90-17 TL and the 100/90-18TL. The 'DURAPRO' gets five new sizes in the 80/100-18TL, 2.75-18TL, 3.00-17 TL, 3.00-18 TL and 90/100-10 TL. Both 'JUMBO GT' and 'DURAPRO' are banking on a claimed, rugged design to tackle diverse road conditions. The treads are aligned and

P Madhavan, EVP – Sales & Marketing, TVS Srichakra Ltd.

optimised for better mileage and superior stability aimed at the commuter bikes segment. For scooters, the 'CONTA' 725 range gets a new size in 90/90-12 TL. Claimed to offer superior mileage and grip, the new addition has also been designed, keeping safety at high-speeds as the topmost priority.

The 'e-DURAPRO' range joins the existing three-wheeler range of 'STREETKING', 'BADSHAH' and 'JAYA'. The 90-90 12 TT is claimed to have been optimised for long-lasting durability. It is designed especially for the cargo-segment with a heavy load-carrying capability along with a high degree of stability. The all-new improved tread design is claimed to support high mileage. Besides, the company also offers the 'e-CONTA' range in sizes 90/90-12 and 3.75-12 for e-rickshaws. **ACI**

Headquartered in Madurai, TVS Srichakra has manufacturing facilities in Madurai (Tamil Nadu) and Pantnagar (Uttarakhand) with a production capacity of over three million tyres a month. The company has a design centre in Milan, Italy supporting the R&D centre in Madurai. The tyres are known to be tested in Indian, European, and Japanese road conditions to cater to over 85 countries across the world.

SPORTORQ	JUMBO GT	DURAPRO	Conta 725	e-DURAPRO
Reinforced tri-polymer compound	Rugged design and grip	Rugged design and grip	Rounded and extended profile for excellent straight line and lean control	Optimised for long-lasting durability
Superior grip on both wet and dry	Aligned and optimised tread	Aligned and optimised tread	Safety at high-speeds	Designed especially for heavy loads
Stronger casing designructure provides superior durability	Shoulder to help expel water quickly	Strong carcass shoulder grooves withstand demanding loads and providing excellent durability	Strong casing structure to dry bonding	Improved tread design
				A high degree of stability

System Integrators In The Automotive Value Chain

The role of system integrators in the automotive value chain is crucial to bring component subsystems together and to function as a whole. Ashish Bhatia looks at this scope of linking OEMs to a wider supplier base.

The role of system integrators is deemed crucial, more than ever before! Be it hybrid or electric. With their strengths in integrating component subsystems, system integrators ensure that these subsystems function together as a whole. Such system integrator companies are known to offer an invaluable proposition to the process of automotive manufacture. The proposition includes and is not limited to developing and maintaining the system integrations and components, application to application integrations, services, internal and external API broadly. Such a platform on offer must offer scalability and flexibility, certified cloud and

on-premise integrations, real-time data availability and monitoring, and the mobilisation of business processes. A typical system integration life cycle includes multiple stages including planning, system analysis, system design, development, implementation, integration and testing, operations and maintenance.

Linkage to a wider supplier base

When a European car manufacturer was looking for a partner to enable and deliver global connectivity of managing carrier networks and subscriptions, Tata Communications is known to have helped the OEM integrate the connectivity elements for it. Allowing the manufacturer to focus on vehicle development and manufacture, using the dual eSIM approach, Tata Communications through its MOVE eSIM Hub ensured seamless operations across different networks and between different vendors. It was made possible by a single API abstraction layer, independent of any single provider. The car manufacturer, in effect, was able to bundle services given the benefit obtained out of optimum connectivity costs. Others with stronger capabilities of design, development, manufacture for the OEMs offer integrated drivetrains (motor, inverter and transmission) for passenger vehicles including two and three-wheelers and commercial vehicles. The company, in this case, provides services to both India and global OEMs as well as tier1 suppliers.

In another instance, Visteon and ECARX are working together to commercialise an integrated cockpit project for a variety of vehicle platforms this year. The two will use Qualcomm® Snapdragon™ Automotive Cockpit Platforms to further develop such intelligent technologies. Sachin Lawande, President and Chief Executive Officer deems the digital content as "the battleground" for OEMs as human interfaces become more complex, connected technologies are increasingly turning important to improve the cockpit. "Visteon is pleased with the work we've done with ECARX and Qualcomm Technologies. Our teams have undergone rapid development, design and integration together, and are committed to delivering technology and creativity for a high-quality cockpit experience across multiple segments," he stated. Ziyu Shen, Chief Executive Officer, ECARX mentioned, "ECARX has a leading position in China with a strong and an unique ecosystem structure, leading HMI, connectivity and infotainment." "This is the latest example of a growth strategy that will continue to create new and global business opportunities by engaging the best digital electronics and software talents in our technology industry," he added.

Visteon smartcore technology collaboration

Altair, into simulation, high-performance computing and artificial intelligence through full system analysis tools offers integration of mechanical, thermal, electromagnetic and embedded code design flow with the PCB design. The upgraded simulation solutions boast new workflows claimed to simplify and automate structural stress analysis, vibration, thermal, and drop-test performance for non-experts thereby potentially widening the supplier base.


Altair's new electronic system design toolset includes thermal simulation of PCB components

The Altair SimLab™ applications, a process-oriented multidisciplinary simulation environment, for instance helps to accurately analyse the performance of complex assemblies. It is claimed to help reduce the time involved in the creation of finite element models and the interpretation of results.

Multiple physics including structural, thermal, and fluid dynamics can be easily set up using highly automated workflows as per James Scapa, Founder and Chief Executive Officer, Altair. Improved simulation and optimisation of wireless connectivity, including 5G and electromagnetic compatibility, visual firmware development supporting more widely used microcontroller families are among the notable upgrades. It also offers capabilities for PCB fabrication, assembly, and end-of-line testing besides the expanded workflows to simplify and automate analysis of structural stress, vibration, thermal, and drop-test performance for the non-experts. Through the expanded simulation-driven design for manufacturing, Altair has introduced manufacturing simulation in the early stages of concept design with its fast, accurate solvers and intuitive interfaces. It spans casting, stamping, moulding, extrusion, additive, and foaming.

Simulation-driven design of a steering wheel with polyurethane foam manufacturing analysis

Mixed roles

Theoretically, it is the tier1 supplier that dons the hat of a system integrator. After all, it is the tier1 supplier that is deemed to have the capability to fully engineer, assemble and integrate automotive systems. These capabilities are known to span across multiple modules and sub-suppliers in turn. On ground zero, however, suppliers are also known to take up mixed roles. According to Roland Berger inputs in a University of Michigan study, as suppliers act as system integrators, tier1's and even tier2s, their future strategies are largely defined by their primary business.

The rules of the game

Who will define the rules of the game? Will it be the system integrators or will they follow the Original Equipment Manufacturer? Questions on the pace of change and the factors influencing the acceleration or slowdown of such a change are among those that need to be answered. The study identifies tensions and the resultant dilemmas and drivers of the ecosystem. For instance, sharing or shielding proprietary information has been identified as a leading dilemma for system integrators. In the system integrator and OEM relationship, the level of confidence and commodity threat have been identified as the drivers. Lack of standardisation has led to the dilemma of building or dismantling of the proprietary network. Fuelled by technology constraints, third parties continue to gain competitive advantage, case-in-point being the Computer Aided Design (CAD) implementation of the 1980s. To give a backdrop here, it is alleged, back then, the practice of OEMs building their proprietary systems added to supplier complexities. Even as all stakeholders yearn for standardisation, it is said to be conflicted by the need to maintain such proprietary networks and in a bid to protect data.

Increasing value or decreasing costs is another business case dilemma the system integrators have faced. As per the study, while the system integrators are likely to implement the OE requirements, in case of developments above and beyond the customer requirements, the business case development is dependent on the decision of hard cost savings or the inherent potential to increase value. The lead in e-Business will determine the road ahead. Given the control of power over product development, OEMs are expected to continue to influence what power they surrender or retain. It continues to translate to more alliances or the latter shedding their engineering capabilities to increasingly rely on the system integrators. **ACI**

	Tension	Dilemma	Drivers
1	Transparency	Sharing or shielding information	• SI/OEM relationship • Level of confidence • The "commodity threat"
2	Standards	Building or dismantling the proprietary network	• Technology constraints • Third parties (e.g. covisint) • Competitive advantage
3	Business case	Increasing value or decreasing costs	• Customer demand • Impact on innovation • Hard cost reductions • "Soft" benefits
4	Power	Weaving the web or being trapped in it	• Balance of responsibility and control

Source: OSAT; Roland Berger - Strategy Consultants

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ACI April 2021

Nerves Of Steel

The 5th Auto Components India Awards acknowledges the resilience and strength of equal, OEM partner suppliers, in the pandemic marred 2020. Efficient rollouts and delivery of clean tech solutions with an inclusive approach are testimony to the stakeholders of this industry having nerves of steel.

2020 is proof that the stakeholders of the components and allied industries have nerves of steel. Despite unprecedented challenges, the calendar year 2020 can be remembered for going beyond the call of duty; efficient rollouts; delivery of clean tech solutions with an inclusive approach and commercialisation for both the domestic and export markets. This feat was duly acknowledged as a standout effort of all the five edition of the awards. Keeping the safety of this brave community, the foremost concern, the fifth edition of Auto Components India Awards - 2021, opted for an 'In-magazine' announcement over the erstwhile format of hosting a ground event with the rest of the processes unchanged.

The awards this year attracted nominations from over 25 companies with only 21 making the cut to qualify for the jury round. Each of the qualifying company, in turn, put forth multiple nominations, for the category deemed relevant to its product/people and processes. This year, of the 11 categories for which nominations were invited over the month of February and March 2021 in an exhaustive exchange with the companies, none from the pool of nominations received fit the popular category - 'Auto Component Emerging Company Of The Year'. Encouraging SMEs (including startups), this category was left uncontested by the jury members in the interest of keeping the integrity behind its inception, intact. We hope to see deserving companies qualifying and contesting over the course of future editions.

Hoshang S. Billimoria,
Founder & Mentor,
Next Gen Publishing Pvt. Ltd.

Ashish Bhatia,
Executive Editor, Auto Components India

Hoshang S. Billimoria, Founder & Mentor, Next Gen Publishing Pvt. Ltd., expressed hope on the industry regaining pre-Covid levels of business in the near future. "I'd like to give my congratulations to all the winners of the fifth edition of the Auto Components India Awards 2021. 2020 was a very testing time for the automotive industry as also for the components industry. The latter as did the industry as a whole reacted to the pandemic with a great degree of resilience and strength," he mentioned. Billimoria opined that Government intervention came to the aid of the industry as it addressed supply-side concerns from time to time through the year. "The announcement of the scrappage policy which is expected to help the industry in due course of time continues to be a work in progress and only time will tell how it impacts the tier suppliers and ancillaries both of which are vital cogs of the automotive ecosystem," he added.

Referring to the Covid-19 resurgence, he also acknowledged that the industry was better prepared to deal with the associated

Kaushik Madhavan, Vice President - Mobility, Frost & Sullivan

VG Ramakrishnan, Managing Partner & MD, Avanteum Advisors

Bhushan Mhapralkar, Editor, Commercial Vehicle magazine

volatility compared to the same period last year when the pandemic wreaked havoc. Billimoria thanked Shapoorji Pallonji for their rock-solid and unconditional support over the years. Last but not the least, he also thanked the technical partners in Frost & Sullivan and Avanteum Advisors besides the validation and knowledge partner in Mazars for the 2021 edition of the awards.

Ashish Bhatia, Executive Editor, Auto Components India humbly thanked the stakeholders of the components and allied industry for yet again wholeheartedly supporting the intellectual property of Next Gen Publishing Pvt. Ltd. At first, he drew attention to the industry support multiplying with each passing year over this half a decade old journey since the first edition was hosted in 2017. He thanked the industry for a welcome opportunity to honour excellence and best practices particularly in the calendar year 2020. "It comes at a time when the world economy came to a grinding halt and here we are hosting the awards with a pool of nominations," he expressed. In an endeavour to keep the integrity of the awards intact, the jury rose to the challenge yet again. "Well aware of the resilience and strength on the show by all nominees, the jury proved yet again that it was up to the task of gauging excellence, in instances by a narrow margin," he stated. "By scoring metrics across the domains of excellence in technology, business and sustainable best practices, the jury picked the most deserving winner amongst winners but not without the trademark banter," he quipped.

Jury process

Continuing from the previous editions were old hands and technical pillars in VG Ramakrishnan, Managing Partner & MD, Avanteum Advisors, Kaushik Madhavan, Vice President - Mobility, Frost & Sullivan. Bhushan Mhapralkar, Editor, Commercial Vehicle magazine and Ashish Bhatia, Executive Editor, Auto Components India brought their own to the mix. A first for the jury, the process this year was conducted virtually with the respective jurors joining from their native states. From the Covid-19 hotspot, Maharashtra to then poll-bound and emerging hotspot Tamil Nadu. The constructive arguments on behalf of each of the nominees formed the ethos of the jury process this year as well. "There was a conscious effort to streamline the nominations such that every category held its own with at least two nominations at par," he explained.

This year, the awards inducted two new categories: 'Ancillary Of The Year' and 'Supply Chain Management Of The Year'. Through the first category addition, the idea was to reach out to a wider supplier base and give tier suppliers and ancillaries into the aftermarket space a fair opportunity to hold their own when compared to the tier1 suppliers up the automotive value chain. As a testimony to the continual evolution of the niche awards, the second category was introduced to honour the supply chain efficiencies added as part of an overhauling exercise undertaken by most in 2020 including paying close attention to the vendor level management. Through the nominations, this year, the inclusive approach of the Original Equipment Manufacturers, tier supplier partners and ancillaries also drew attention from the jury. The industry can take great pride, in hindsight, as it attempts to fast-track growth in the quarters to follow.

Scores gathered across these heads made for a grand total in each juror's dossier. Post the jury scores were collated, the company with the highest cumulative score was adjudged as the winner in each of the respective categories. The jury also unanimously agreed to dive deeper into the vendor level efficiencies and overall management processes in a bid to make the awards a matter of pride for participating companies. The objective being to acknowledge the product, process, machinery and the people involved throughout the development cycles. While the complexities of refining the information to suit the relevance and underline the winning potential in the respective category continued to pose a challenge this year as well, nominees were scrutinised thoroughly even if it meant going back to the company for further elaboration on any areas deemed grey or weakly represented in the information suite. It takes that much more to be counted as credible in the niche spacehe explained. **ACI**

Winner: BorgWarner

Innovative E-Mobility Solution - Component Supplier Of The Year

Nominees are:

● **BorgWarner**	Dual-Sided-Cooled Silicon Carbide Inverter
● **Nipsea Group Automotive Refinish Unit (Nippon Paint Group, Japan)**	Paint Partner (Digital Colour Software Solutions)
● **Tapco Pneumatics Ltd. -**	Elektra (Electric Auto Door Controller)


SiC Inverter

Driven by the climate change commitments of the Indian Government during the COP21 Summit, in Paris, to reduce emission intensity by 33-35 per cent by 2030 from the 2005 levels, electric mobility continues to be high on the agenda for the Government of India and the stakeholders of the components industry. Improving upon the erstwhile generation of inverters, the winning company eventually raced ahead, scoring the winning points with its product - 'Dual-Sided-Cooled Silicon Carbide Inverter'. Claimed to be the first-to-market inverter to use Silicon Carbide (SiC)-based power switch for an 800-volt application, the BorgWarner component can deliver increased efficiency for enhanced voltage flexibility besides offering improved recharging times, better range and smaller battery size for cost reductions. In effect, the Original Equipment Manufacturers (OEMs) stand to gain room for creating more compelling consumer propositions for hybrid and electric vehicles. The additional room is believed to have the potential to lead to a broader acceptance of e-mobility in compliance with the government-mandated emissions targets.

Winner: NGK Spark Plugs (India) Pvt. Ltd.

Green Practice of The Year

Nominees are:

● **Advantek Fuel Systems Pvt Ltd**	A single integrated CNG filling valve
● **BorgWarner**	Diesel Control Module (ECU)
● **Eaton**	Refuelling Vapor Recovery
● **Jamna Auto Industries Ltd.**	BSVI compliant leaf spring series
● **NGK Spark Plugs (India) Pvt. Ltd.**	BSVI spark plugs, two-wheeler fuel injection systems and oxygen sensors

Ignition Coil

In a pandemic marred 2020, the one thing that the world working from home valued was the nature healing itself. A phenomenon across the globe, people sat back and took notice of their immediate surroundings in full glory. With the cries like "How Dare You?" finding resonance, climate change, the defining issue of our times gained much-needed attention. For it, economies had to come to a standstill. With a clear action plan to adhere to green practices and give back to society, this year, the winning company was picked by the jury for its integrated offerings benefitting the environment. As the first company to launch BSVI compliant 'Spark plugs' and two-wheeler 'Fuel injection' and 'Oxygen Sensors'., the sheer impact of its application multiplied to the volume segment known to be an otherwise significant polluter held it above the competition. Its aftermarket offerings for the four-wheeler segment added to the scores.

Winner: Minda Corporation Ltd. (Spark Minda)

Components Shopfloor Management Of The Year

Nominees are:

● **Laxmi Group (Nahars Engineering India Pvt. Ltd.)**	Kanban method
● **Minda Corporation Ltd. (Spark Minda)**	Kaizen method

Shop floor management includes pre-planning, planning, staffing, directing, monitoring and control of activities to enhance efficiency and analysis. It is here that the best practices play a key role in the process of transformation of materials (inputs) into the desired output (product or services). With a vision to follow World Class Manufacturing (WCM), the winner, with an elaborate presentation on its Pune-based Die-Casting Division, compelled the jury to acknowledge several action points. The company successfully prioritised safety, discipline, diversity, CSR, skill mapping, training, employee engagement, JH Time, Kaizen Hour, HR Helpdesk, Cross-Functional Teams with appropriate Covid-19 management. As part of the ER strategy, the company continues to stay focused on supervisor skill development, policies and process adherence, associate life-cycle management, relationship building, knowledge and skill development of associates besides the cost and compliance management.

The SPARK focus as part of the ER strategy

Winner: Nippon Paint India Pvt. Ltd. (Automotive Business)

Supply Chain Management Of The Year

Nominees are:

● **Eaton**	Global Supply Chain CoE - Pune
● **Nippon Paint India Pvt. Ltd. (Automotive Business)**	Drop Shipment Model
● **Tyrolit India Super Abrasive Tools (Swarovski Group, Austria)**	Supply of Grinding Wheels with value addition

Supply Chain Management gives a considerable competitive advantage. Correlated to the Original Equipment Manufacturers (OEMs) strategic goal, the goal spans improvement of the visibility of information, reduction in-transit damage and or speeding up the flow of parts. The winner, went back to the drawing board to look at the reduction of turnaround time with greater efficiency, commercial compliance and secured realisation. Compared to products being stored in distribution centres and then moved to different regional warehouses before being sold to the channel partners and then billed to the OEM customers, the company used the drop shipment model for managing and executing operations with its OEM partner workshops. In the bill to ship to process, the OEM gets direct orders from its dealerships across India and then the OEM issues purchase orders to Nippon paint for the fulfilment of those orders to the partner workshop. The company then further uses its nearest channel partner to the OEM and issues purchase orders to service the OEM dealership.

Drop Shipment Model

Winner: Valeo Friction Materials India Pvt. Ltd.

Auto Component Exporter Of The Year

Nominees are:

● **Advantek Fuel Systems Pvt. Ltd.**	A single integrated CNG filling valve
● **Valeo Friction Materials India Pvt. Ltd.**	Facings for clutches, tractor brakes and friction washer
● **ZF India Pvt. Ltd.**	Commercial vehicle axle shock absorbers

Clutch Facings

The outbreak of the pandemic aggravated the situation and impacted global trade equations. Indian auto component manufacturers, in the first half of fiscal 2020-21, for the first time ever, witnessed a trade surplus. Auto component exports declined by 23.6 per cent to Rs.39,003 crore (USD 5.2 billion) in H1 2020-21 from Rs.51,028 crore (USD 7.4 billion) in H1 2019-20 to give a backdrop. The winner's total export sales accounted for seven per cent of total annual business in 2019. In 2020, the company entered new territories such as South America, Balkans, SAARC nations and ASEAN countries. Establishing its exports business, the winner was able to achieve a significant milestone of 145 per cent growth in exports accounting for 19 per cent of the overall annual business. The company attributes the success to key initiatives like strategic pricing of the products, effective negotiation, submitting the samples to prospective customers, rapid testing and validation, proactive and effective planning of deliveries to circumvent the logistic and supply chain challenges, reaching out and re-establishing connect with the existing network to leverage new business opportunities, identification of new customers in new geographies besides participation in overseas automobile/components expo to create awareness around its products and technologies.

Winner: NGK Spark Plugs (India) Pvt. Ltd.

Auto Ancillary Of The Year

Nominees are:

● **Carrier Wheels Pvt. Ltd.**	High-performance styled wheel for tractor application
● **NGK Spark Plugs (India) Pvt. Ltd.**	Ignition coil and glow plugs
● **Adeptus Servo-Mechatronics Pvt. Ltd.**	Data acquisition, reporting system for the testing starter motor, alternator and starter solenoids. 4-axis robot automation solution.

On the other side of the automotive industry, ancillaries deal with the manufacturing and selling of intermediate parts, equipment and chemicals among others. Including OEMs, tier1, tier2, tier3 manufacturers and intermediaries, it's the OEMs that are known to deal in high-value instruments and dominate the market. The unorganised sector is known to serve the aftermarket and deal in low-value products in comparison. The winner made an impact in the aftermarket with its range of ignition coil and glow plugs for the four-wheeler segment.

Glow Plug

Ignition Coil

Winner: Minda Kosei Aluminium Wheel Pvt. Ltd.

Auto Ancillary JV Of The Year

Nominees are:

- **Minda Kosei Aluminium Wheel Pvt. Ltd.** — An alliance between Minda Industries Ltd. and Kosei Aluminium Co. Ltd.
- **Valeo Friction Materials India Pvt. Ltd.** — An alliance between Valeo France and ANAND Automotive India

Aluminium alloy wheels for major passenger vehicle OEMs

Ancillaries with a JV are expected to accomplish their tasks with greater efficacy. Be it access to new territories and distribution networks, joint capacity, equal distribution of risks and liability, or the leverage of a joint knowledge and resource pool. Established in Bawal, Haryana and in Gujarat, the JV under the umbrella of the Uno Minda Group engages in development, manufacture and sales of aluminium alloy wheels for major passenger vehicle OEMs. On one hand, the majority stakeholder company, Uno Minda Group (70 per cent) brings to the table a rich legacy of multiple strategic alliances including alliances with Tokai Rika, Emer, Toyoda Gosei, Kyoraku, and Torica, Kosei makes available JapaneseGDC technology in aluminium casting. As a business segment, Light Metal Technology (LMT) contributed six per cent, 12 per cent and 15 per cent to the revenue mix over Q1FY2021, Q2FY2021 and Q3FY2021 respectively.

Winner: Arvind Goel, MD & CEO, Tata AutoComp Systems Ltd.

Auto Components Business Leader Of The Year

While a leader is as good as his team, there is no debating how only a good leader can get the best out of an equally good team. The winner, leading a rank nine company (based on consolidated financials) with an elaborate 83-slide presentation, made the task of the jury easier this year. The Business Leader to stand out this year fought with Covid-19; balanced inorganic along with organic growth; covered the spectrum of EV charging to driving, with rupees six lakh worth of components (EV components + existing components) in Tata Nexon EV as a case-in-point; digitised learning and development; prioritised CSR; attained operational excellence through TBEM, TQM and QSM. He also saw through the formation of six Joint Ventures (JV), two technological agreements and one acquisition (acquired Sweden-based TitanX, a global leader in engine and powertrain cooling systems). Growing at a 16 per cent CAGR over the past four years, under his leadership, the company was awarded 'Emerging Industry Leader' at the JRD QV Program on July 29 2020. Among several customer accolades received by the company, the 1st Prize for Tata Autocomp GY Batteries - Supplier Quality Improvement Contest 2020 from Kirloskar Oil Engines Ltd. (KOEL) caught the jury's attention. The year 2020 also brought in accolades from industry bodies like Confederation of Indian Industry (CII) and Automotive Component Manufacturers Association (ACMA) for group companies: Tata Green Batteries, Tata Ficosa, Tata AutoComp-Composites Division, Tata AutoComp Hendrickson Suspensions and Tata AutoComp Systems Ltd. (Interiors and Plastic Division), in Bengaluru. Attached to various industry bodies, the Auto Components Business Leader Of The Year - 2020 rose to the challenges and simply put, used to good effect his decades of experience across engineering, manufacturing and as head of several business units.

Special Recognition For Technological Excellence

Pursuing 'Technological Excellence' is the ability to foresee and eliminate an issue before it has the potential to jeopardise safety, schedule, budget, quality, and most importantly, client satisfaction. Challenged on all fronts in the pandemic marred year, two companies compelled the jury to take notice and acknowledge their product offerings.

Winner: ZF India Pvt. Ltd.

The winner ZF India Pvt. Ltd. impressed with its focus on 'Make In India' that is expected to help increase revenues, multifold, over the next half a decade. The company invested in its Pune facility and has committed to further incremental investments over the expansion of production capacity and widening of the manufacturing footprint. A significant quantum of this has been invested to uplift suppliers to help attain global standards, best practices and build quality products for the world. The local built of capital equipment to ZF specifications, and development of testing and engineering capabilities impressed as well. Its internal fulfilment by the move to import child parts and assemble a finished CV shock absorber to global ZF locations has paved the way for the development of more global parts numbers from India as a testimony of its technological excellence.

Commercial vehicle shock absorber

Winner: Advantek Fuel Systems Pvt. Ltd.

The winner Advantek Fuel Systems Pvt. Ltd. focuses on clean energy solutions for the Medium and Heavy Commercial Vehicle (M&HCV) segment. The company addressed a long-standing issue at CNG fuelling stations. Reinventing the erstwhile CNG filling valve panel with 12 different components, 14 joints prone to leakages and risking safety were eliminated. The former arrangement also requires manual intervention. Overcoming the flaws, the company has designed an integrated filling system. The single integrated valve system offers benefits like a mono block with no joints, automatic functions, a 50 per cent higher filling speed to double the filling capacity at filling stations thereby making the queues redundant. Made through the feedback of stakeholders including that of the actual drivers by studying their usage on the field, the problem-solving capability of the new design and development process is a testimony of its technological excellence.

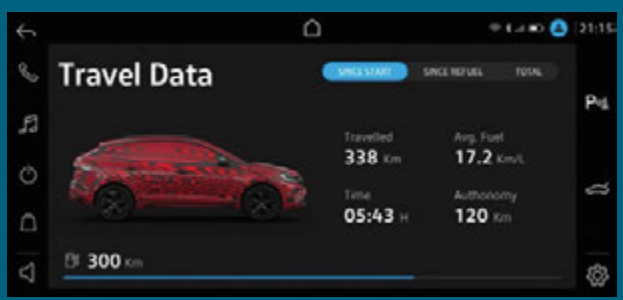
Single integrated CNG filling valve

Winner: Visteon Technical and Services Center Pvt. Ltd.

Auto Components Manufacturer Of The Year

Nominees are:

- Advantek Fuel Systems Pvt. Ltd.
- Continental Automotive India Pvt. Ltd.
- Goldseal-Saargummi India Pvt. Ltd.
- Jamna Auto Industries Ltd.
- Laxmi Group (Nahars Engineering India Pvt. Ltd.)
- Minda Corporation Ltd. (Spark Minda)
- National Engineering Industries Ltd. (NBC Bearings)
- NGK Spark Plugs (India) Pvt. Ltd.
- Tapco Pneumatics Ltd.
- Tata AutoComp Systems Ltd.
- Minda Industries Ltd. (Uno Minda Group)
- Visteon Technical and Services Center Pvt. Ltd.
- ZF India Pvt. Ltd.



Industry-first Android-based infotainment system for Volkswagen Nivus engineered in India (for Brazil)

Hybrid cluster and Tripper Navigation for Royal Enfield Meteor 350 (for India and 78 other countries)

The quest for going beyond the call of duty, excellence and 100 per cent localisation against the odds has been the hallmark of the manufacturer nominees this year. Resorting to an inclusive approach in their value chain, the nominees proved themselves yet again as responsible partners to the OEMs when it was required the most to rise to the occasion. The Winner this year impressed the jury with an all-around effort and a mega portfolio. Playing a major role in shaping automotive cockpit electronics, the winner in 2020, launched a remarkable 50 plus products globally with the Indian engineering arm contributing to a majority of these. To name a few, the key launches include the Android-based infotainment system for Volkswagen Nivus. The company also launched the hybrid cluster and tripper navigation for Royal Enfield Meteor 350 for India and 78 other countries. The instrument cluster and Tripper were designed and engineered by Visteon's technology centres in Chennai and Pune, and are known to have been manufactured at Visteon's Chennai plant. In an effort to enhance its regional supplier position in the digital cluster segment, in India, the company also launched an instrument cluster for Hyundai Creta, built on the 2019 launched, Kia Seltos hybrid instrument cluster. The cluster was designed and engineered by the company's technical centre in Chennai and manufactured at the Chennai plant.

Auto Component Of The Year

Winner: NGK Spark Plugs (India) Pvt. Ltd.

Nominees are:

● **Advantek Fuel Systems Pvt. Ltd.**	A single integrated CNG filling valve
● **Continental Automotive India Pvt. Ltd.**	Fully Digital Instrument Cluster
● **Eaton**	Mechanical Locking Differential (M-Locker®)
● **Eaton**	Fuel vapor valves
● **Freudenberg Filtration Technologies India Pvt. Ltd.**	Micronair cabin air filters
● **Jamna Auto Industries Ltd.**	BSVI compliant leaf spring series
● **Minda Corporation Ltd. (Spark Minda)**	Joint 4-Way braking system part (four-wheeler)
● **Minda Corporation Ltd. (Spark Minda)**	Smart key electronic steering column lock
● **NGK Spark Plugs (India) Pvt. Ltd.**	BSVI spark plugs, two-wheeler fuel injection systems and oxygen sensors
● **Visteon Technical and Services Center Pvt. Ltd.**	Android-based infotainment system for Volkswagen Nivus (for Brazil)
● **Visteon Technical and Services Center Pvt. Ltd.**	Hybrid cluster and Tripper Navigation for Royal Enfield **Meteo**r 350 for India and 78 other countries
● **Visteon Technical and Services Center Pvt. Ltd. (Instrument Cluster for Hyundai Creta)**	Instrument Cluster for Hyundai Creta

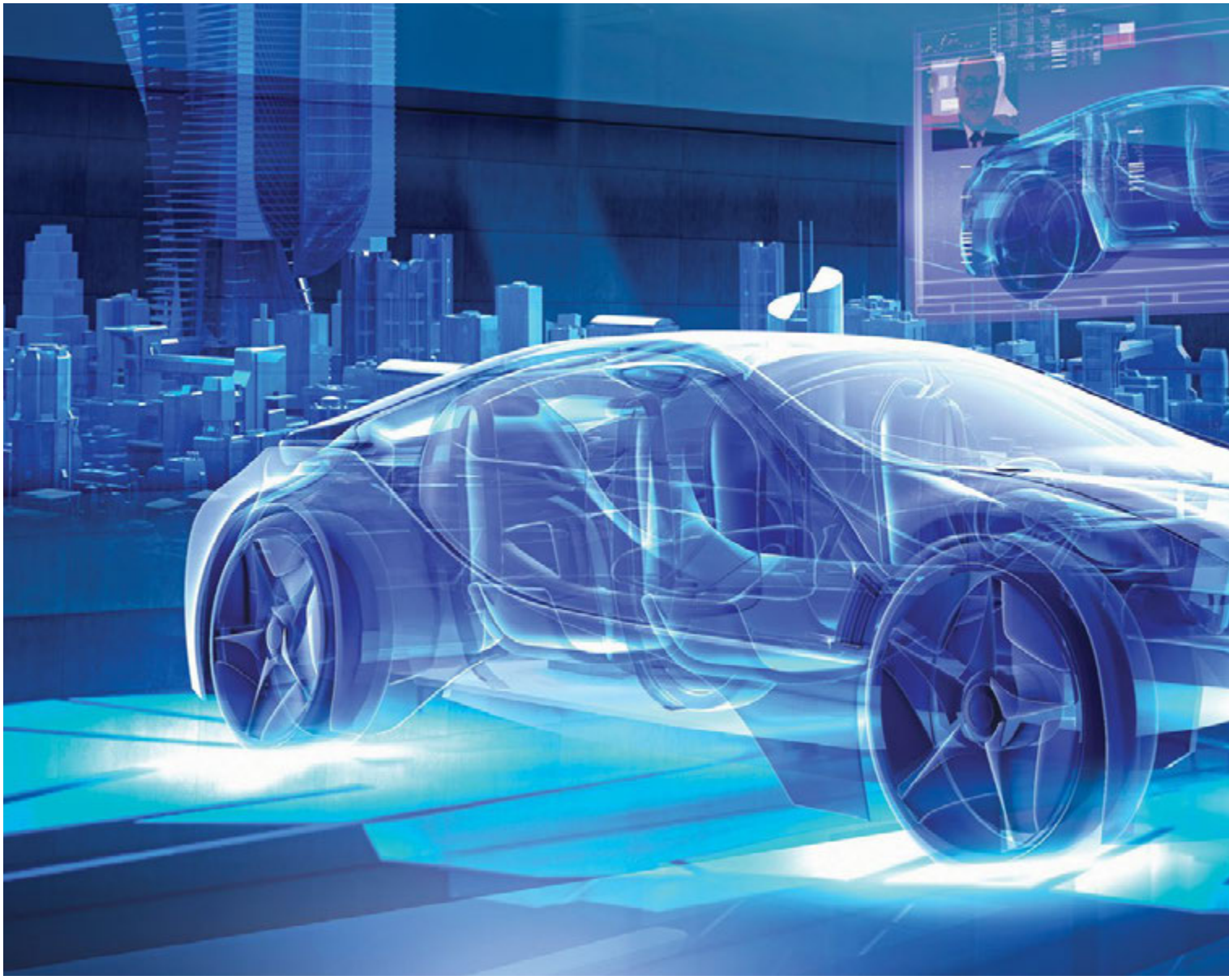
An auto component is at the heart of any vehicle and it is what an auto component manufacturer strives to excel at all through the year. The coveted award for the year goes to the company that nominated a product suitable for BSVI fuel, the fuel injection system and oxygen sensor. Standing out as a relevant whole in 2020, the jury deemed the winning component as a crucial component for OEMs to meet the stipulated emission compliance norms that came into force on April 01, 2020. The jury, in a unanimous consensus, took cognizance of the component of the year playing an important role in reducing the exhaust gas emissions, especially in the high volume two-wheeler segment in 2020. In a year when OEM exposure reduced for most partner suppliers, the winning company also adjudged the winner in the categories: 'Green Practice Of The Year' and 'Auto Ancillary Of The Year' stood out as the first company to launch BSVI compliant 'Spark plugs' and two-wheeler 'Fuel injection' and 'Oxygen Sensors'. The company also extended its winning impact on the aftermarket with a new range of 'Glow Plugs' and 'Ignition coil' for the four-wheeler segment. Platinum spark plugs as emissions control device are also known to last much longer.

BSVI compliant spark plug

Congratulations to all the winners and the nominated entries this year. We will be back for the next edition of the ACI Awards in 2022. We thank you for your continued support and look forward to yet another edition with an exciting mix of entries. For those who couldn't send in their entries and or qualify this year, we look forward to your participation in the next edition.

Mobility Technology Trends

Dr Arun Kumar Sampath, Chief Engineer and Head Innovation, Global Technology Centre, Mahindra Electric Mobility Ltd. & Chairman, Branding and Communications Board, SAEINDIA highlights functional safety in 'Drive by Wire' vehicles in an in depth article.



Dr Arun Kumar Sampath, Chief Engineer and Head Innovation, Global Technology Centre, Mahindra Electric Mobility Ltd. & Chairman, Branding and Communications Board, SAEINDIA

Modern vehicles are continuously becoming more complex with vehicle development becoming increasingly challenging since additional and more complex functionalities from different domains are being demanded not only by customers but also by regulators. In the past, the design approach in embedded systems in the automotive industry has been to use mechanical sub-systems with electronic control due to multiple advantages including increased reliability of using electronically supervised systems, faster introduction and implementation of features in vehicles and greater authority of vehicle level functions through more effective digital interfaces between the vehicle sub-systems. Electronic control has been mainly used to control and supervise the functionality and to adapt the behaviour of mechanical systems. In case of an error in electronic control systems, the performance of the mechanical system is reduced while still providing minimum functionality (fail-safe operation). 'Drive by Wire' systems (XBW) do not have mechanical systems as backup and in the presence of an error, electronic systems will have to provide minimum functionality and ensure that the errors are confined.

The number of interconnections and interdependencies in the Electrical and Electronic (E/E) systems is rapidly increasing on the functional and hardware level, which in turn leads to an increased vehicle complexity. Engineers continue to face the dual challenges of the need to address increased complexity while simultaneously addressing Functional Safety (FuSa) of the systems in the vehicles. With the advent of drive by wire (XBW) systems in modern vehicles, especially in Electric Vehicles (EVs) with electrified powertrains and accessories, steering, and braking systems, failure of EE components or a faulty decision by an on-board controller can lead to disastrous results and even lead to vehicle crashes and fatalities. The increased complexity

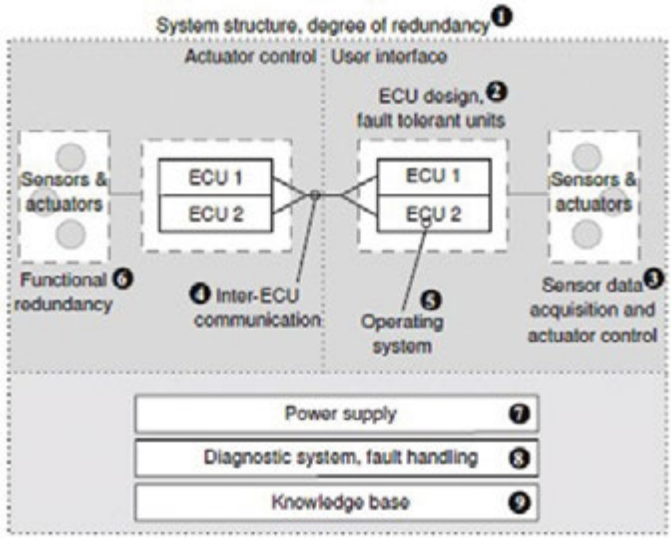


Fig 1. Drive by Wire (XBW) Systems – Generic Architecture (Ref. [1])

and demand for FuSa in EVs demand fundamental reconsideration of established E/E architecture, especially for XBW systems.

Most drive by wire (XBW) systems can be split into two physically separated sections as shown in Fig 1 (Ref. [1]). One section consists of the User Interface (UI) while the other section controls the actuators on the vehicle that are used for steering, braking, suspension and ride control etc. For UI, customers are given the choice through gesture control or voice or haptic feedback, or plain touch screen. The actuators and sensors are controlled and monitored by closely mounted decentralised Electronic Control Units (ECUs). Depending on the level of safety being offered by a specific system in the vehicle, the redundancy of ECUs is determined, especially for safety-critical systems as no single unit can achieve the required failure rates. However, it is important to keep the degree of hardware redundancy minimal to optimise the costs.

In general, two components for one task, in combination with a sufficiently powerful diagnostic and decision unit and a fail-safe behaviour of each component are assumed to be able to achieve the required failure rates. A combination of two or more units is regarded as a Fault Tolerance Unit (FTU). In certain instances, an FTU can also be constructed based on only one ECU if the ECU features a multi-core architecture and an appropriate board design in combination with special mechanisms to allow the execution of multiple safety-critical functions independently on this platform.

An alternate approach to reducing the number of redundant ECUs is to have a network-centric architecture, wherein the distributed network nodes monitor each other. If a single ECU fails, other ECUs react by adapting their mode of operation. Though the number of ECUs is reduced, the complexity of individual ECUs will increase. For example, Brake-by-Wire (BBW) systems typically benefit from a network-centric approach if each brake is set up as an independent unit, which is capable of coordinating with other brakes.

Similar redundancy strategies have to be applied for sensors, on the lines of ECUs, to ensure safe operation. Measurements are required with three sensors simultaneously to allow majority voting among the measurements and thus to detect faults. To reduce Hardware (HW) costs, one or two sensors could be replaced by Software (SW) algorithms.

A vehicle must have proper networking to connect all the electronic components with at least one redundancy including physical separation in the wiring. The overall network has to support a precise timing of messages to ensure that the lost or delayed messages are detected and a maximal roundtrip time is guaranteed. Examples of such networks include TTCAN, TTP/C, FlexRay, and Ethernet in combination with time-triggered extension. The safety-related applications within the network are synchronised using precise data timings to ensure defined latencies which are enabled by operating systems such as modified OSEK, OSEK Time, FTCom, and AUTOSAR.

As a basis for the safe operation of XBW systems, availability of fault-tolerant power supply system is mandatory. Typically, systems with redundancy and mutual isolation are implemented. Certain vehicle architectures are known to implement double redundancy and an additional control unit to configure the power supply in case of failure.

To monitor the overall system, a suitable diagnostic unit or function has to be implemented. These units have to

ensure that faults that are occurring are detected such that the remaining system can be reconfigured to maintain sufficiently safe operation. As per regulatory requirements, the system has to tolerate at least one independent fault and still maintain (degraded) performance. Most components of the XBW system already provide local diagnostic functions and provide the output of these functions. Additionally, information can be extracted by network overarching monitoring mechanisms for timings and interfaces. To derive suitable actions from this information, different approaches, mostly relying on heuristics and probabilistic mechanisms, are applied. The challenges for these algorithms are to guarantee short execution times and to provide traceable decisions, which render most Machine Learning (ML) based approaches unsuitable. Typically, the vehicle is regarded as not "self-healing", wherein restart of components is considered to heal the system and improve functional safety.

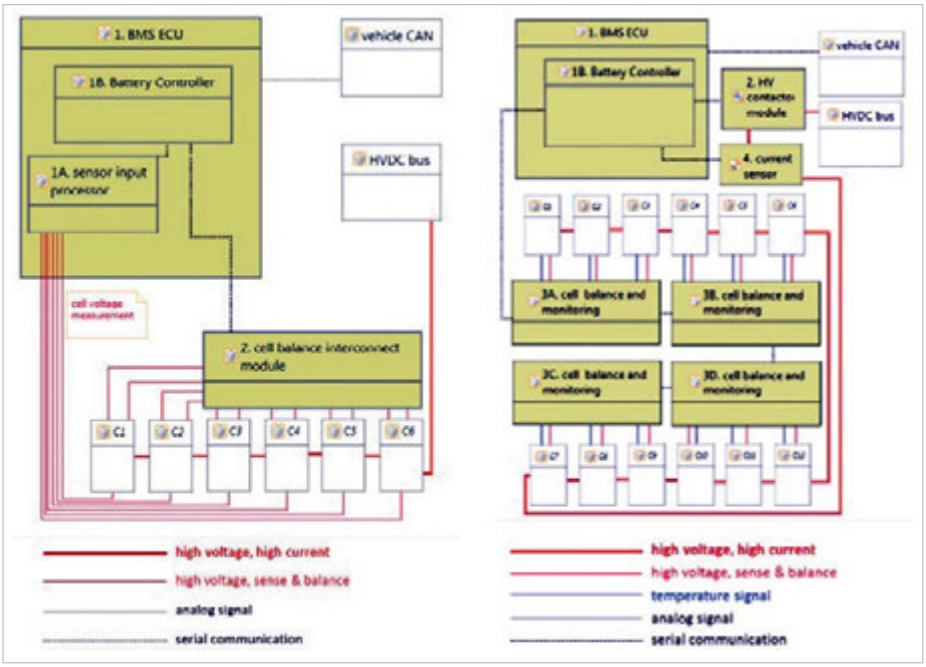


Fig 2. a) BMS Architecture w/o Safety (Ref. [3]) Fig 2. b) Updated Architecture w/ Safety (Ref. [3])

Recent trends in FuSa indicate the need to consider the overall system including the power supply, Battery Management System (BMS), steering system, and a propulsion system capable of accommodating torque vectoring.

I. Functional Safety in Battery Management Systems

The ISO 26262 standard establishes a standardised process for Hazard and Analysis and Risk Assessment (HARA), which can be applied to a gamut of automotive systems (Ref. [2]). Recent studies have attempted to illustrate several key steps of an ISO 26262 compliant development process for automotive battery systems and develop a system architecture and functional safety requirements for BMS, elucidate the use of decomposition method to achieve higher ASILs, and to compare alternate BMS architectures against the ISO 26262 standard in order for the system designers to be able to provide multiple options based on FuSa compliance, cost, quality and timeline.

In Figure 2(a), a typical BMS architecture comprising of multiple cells arranged in a series/parallel configuration to achieve the required voltage and traction power to propel an EV is shown. Though such BMS architectures incorporate active or passive cell balancing and the advanced State of Charge (SoC) estimation algorithms to improve charge/discharge efficiency, durability, and extended battery life, they do not incorporate the required FuSa requirements. The updated BMS architecture to reflect the safety goals outlined in Figure 3 is shown in Figure 2(b) wherein the architecture incorporates cell temperature sensors, cell voltage sensors, battery-pack current sensor, serial communication, HV contactor and associated logic to isolate the battery pack from HV DC bus in case of exigencies, to monitor cell internal shorts, and to achieve upgraded SoC estimation.

number	safety goal	ASIL
SG-BMS-001	battery overcharge condition shall be prevented	ASIL D
SG-BMS-002	battery overcurrent condition shall be prevented	ASIL D
SG-BMS-003	unintended power delivery to HVDC bus shall be prevented	ASIL B
SG-BMS-004	power to HVDC bus shall be provided when requested	ASIL A
SG-BMS-005	thermal event from cell internal short shall be prevented	ASIL D
SG-BMS-006	thermal event from thermal management failure shall be prevented	ASIL D

Fig 3. Proposed Safety Goals and ASILs for BMS (Ref. [3])

I. a) Proposed Safety Goals for BMS

For an automotive BMS, safety goals are proposed as per Figure 3 with the assumptions that HV contactor, temperature and voltage data of individual cells are available along with battery pack voltage and current data. The HV

contactor helps connect or disconnect the battery pack while the current sensor helps determine battery pack SoC; individual cell voltage sensors help determine overcharging or internal shorts and cell balance or imbalance, and temperature sensors help monitor overheating of cells that may lead to thermal runaway of the battery pack.

I. b) FuSa Architecture with Decomposition and ASILs

To meet the safety goal "battery overcharging shall be prevented", two different concepts can be developed independently. As per the guidelines provided in ISO26262 (Ref. [2]), this goal can be "decomposed" into separate requirements, with major reductions in process rigour of each requirement. The specific safety goal of "battery overcharge prevention" can be achieved through controls enabled in powertrain controller (overcharge prevention through control) and also through self-monitoring mechanism built into the BMS (overcharge prevention through self-isolation). These two mechanisms work independently to meet the same safety goal allowing decomposition into separate requirements as per the ISO26262 framework, part 9, clause 5. The ASIL D requirement in this case can be decomposed into two ASIL B(D) Functional Safety Requirements (FSR), as shown in Fig. 4 (Ref. [3]). The critical benefit of decomposition of ASIL D requirement into ASIL B(D) FSR is the reduced process rigour, which allows nearly all the ISO26262 requirements to be achieved at ASIL (B) level itself. The corresponding BMS architecture is shown in Fig. 5 (Ref. [3]).

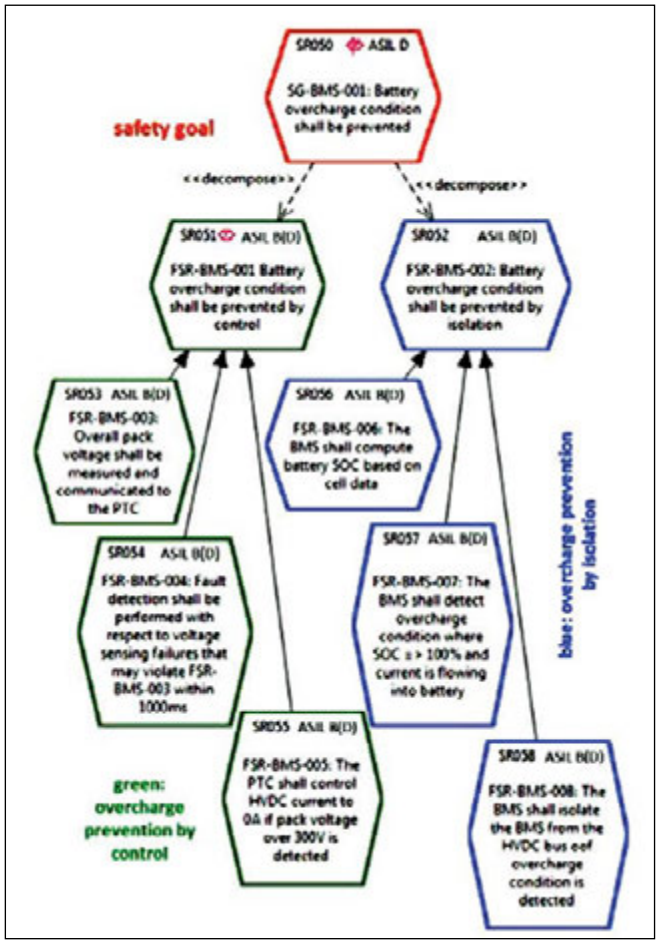


Fig 4. Safety Goal SG-BMS-001 and extension to FSR with decomposition (Ref [3])

In the "Overcharge prevention through Control" mechanism, the BMS would provide battery pack voltage information to the Powertrain Controller (PTC). If the battery pack is fully charged, the PTC would take the battery pack voltage and take decisions not to carry out additional charging of the battery pack which otherwise may lead to the risk of fire or explosion. If the sensed pack voltage itself is not accurate, BMS sends a "signal-not-available" message via

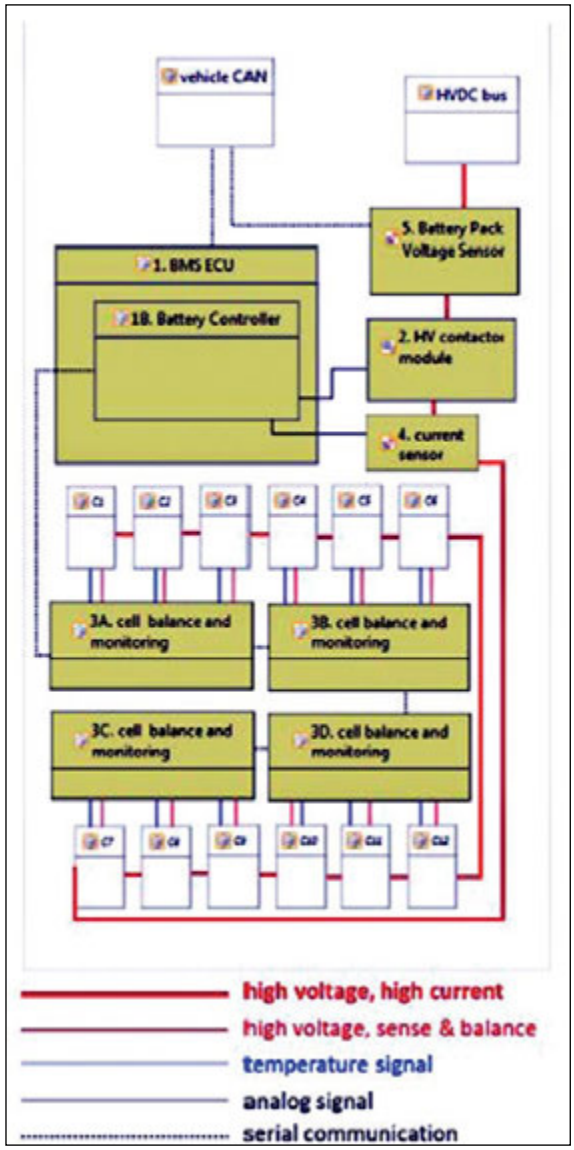


Fig 5. Revised BMS Architecture to meet Safety Goal SG-BMS-001 with Decomposition (Ref [3])

CAN to PTC which would, in turn, respond by stopping any battery charging functions in the charger.

In "Overcharge prevention through self-isolation" mechanism, the BMS carries out regular self-monitoring through measurement of cell voltages, cell temperatures, SoC, and pack-level current. If SoC has already reached 100 per cent and if the PTC still tries to overcharge the HV battery pack, the BMS isolates the contactor and protects the battery pack. In advanced contactor management strategy implementations, the contactor may remain closed but the current allowed might be (close to) zero, effectively not charging the battery pack any further.

It is important to understand that the decomposition of ISO26262 requirements necessarily requires independence between the decomposed requirements, which in turn demands that there are no common failure modes between the decomposed requirements, which get extended to hardware and software that they do not have common failure modes. The specific design features that may be used to achieve independence of decomposed requirements include the following:

- Use of separate and distinct sensor designs for the two methods of preventing overcharge, which can be achieved using a battery pack voltage sensor that can communicate to the PTC through CAN protocol. The cell temperatures and voltages could be processed by BMS alone with independence from PTC.
- Independence of data processing with no commonality in Hardware or Software.
- Rating for PTC of at least ASIL B in order to perform the function that meets ASIL B(D) FSR.
- Physical separation of the independent circuits in general such that common cause failures such as EMI EMC, short circuit paths etc. are avoided.
- Independent design and manufacturing test procedures for soldered connections, harness connections etc. to protect against systematic errors in the design of components.

I. c) Functional Safety Hardware Architectural Metrics

In order to meet the ASIL D requirement, ISO26262 defines several Hardware Architectural Metrics (HAM), given as follows:

- The Single Point Fault Metric (SPFM), which quantifies the HW architecture's exposure to single point failures as a share of total failure rate. The SPFM requirements are 90 per cent, 97 per cent, and

ASIL	Failure Rate	SPFM	LFM
A	<1000 FIT (<10^{-6}) h^{-1}	Not Applicable	Not Applicable
B	<100 FIT (<10^{-7}) h^{-1}	≥ 90%	≥ 60%
C	<100 FIT (<10^{-7}) h^{-1}	≥ 97%	≥ 80%
D	< 10 FIT (<10^{-8}) h^{-1}	≥ 99%	≥ 80%

Table 1. ASILs and Failure Rates as per ISO 26262 Standard (Ref [2])

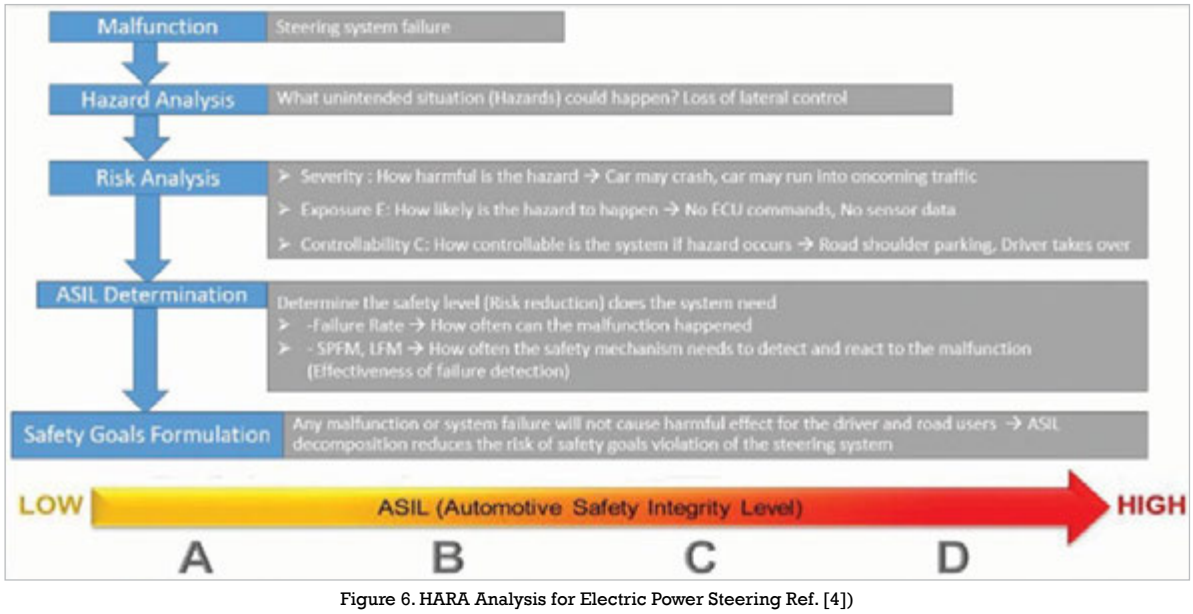


Figure 6. HARA Analysis for Electric Power Steering Ref. [4])

99 per cent for ASIL B, ASIL C, and ASIL D systems, respectively.

- The Latent Fault Metric (LFM), which quantifies the HW architecture's robustness against latent failures as a share of total failure rate. The LFM requirements are 60 per cent, 80 per cent, and 90 per cent for ASIL B, ASIL C, and ASIL D systems, respectively.
- The Probabilistic Metric for Hardware Failure (PMHF), which quantifies the risk of safety related random HW failure. The PMHF requirements are < 10^(-8)/hour, < 10^(-7) hour, and < 10^(-7) hour for ASIL B, ASIL C, and ASIL D systems, respectively.

The BMS architecture in Figure 6 with decomposition meets lower requirements of ASIL B(D). However, the HAM should be performed at the Safety Goal level before decomposition to comply with ASIL D, ensuring that nearly all HW failures are not Single Point Failures (SPFs) as redundancy is paramount. In the architecture shown in Figure 5, HW or SW errors arising out of BMS board do not lead to SPF as redundancy is established through the safety requirement in PTC by "prevent overcharge by control" requirement, leading to high levels of SPFM. On similar lines, errors through HV contactor weld do not lead to SPF and may not need a redundant contactor in HV battery pack. High levels of LFM need to be achieved through detection and prevention of Latent Failures in the entire system by a) self-diagnosis status of BMS to be communicated to PTC through CAN and b) self-diagnosis status of PTC to be conveyed to BMS through CAN.

II. Functional Safety in Steering Systems

As modern vehicles are moving away from Electro-Hydraulic Power Steering (EHPS) towards Electric Power Steering (EPS) systems, there is an increasing need to design for FuSa requirements of the EPS units consisting of three key elements viz a) power supply unit, b) microcontroller, and c) Gate Driver Unit (GDU). The functional safety of these units is driven by the safety goals and the ASIL determination of the EPS systems. Though the ASIL levels and failure rate metrics as per ISO 26262 Part 5 Section 8.4.5 as shown in Table 1 (Ref [4]) are applicable for Functional Safety in Steering systems also, the use of more Advanced Driver Assistance System (ADAS) application in the EPS and the continuous need for increased torque and better manoeuvrability of vehicles has been posing new challenges for EPS systems in the form of higher forces at the steering rack and increased ADAS functionalities.

Proposed severity class	Exposure	Controllability		
		C1	C2	C3
S3	E1	QM	QM	A
	E2	QM	A	B
	E3	A	B	C
	E4	B	C	D

Table 2. New ASIL assignment for ADAS and higher steering rack forces (Ref [4])

This resulted in changes in ASIL computation for the EPS system because any sudden loss of assistance (LOA) may lead to catastrophic accidents. In Figure 6, the steps taken to determine the ASIL of the steering system in the vehicle based on Hazards and Risks (HARA analysis) are shown. The objectives of HARA include a) identification of the hazard events of sudden LOA caused by a malfunction in the steering system and b) formulation of the safety goals with their corresponding ASILs in order to mitigate any hazard event and avoid any unreasonable risk.

As the definition of controllability in ISO 26262 is not fully mature, a recent study proposed a new metric to relate a range of torque magnitudes to the controllability class C0 – C3 in Table B.6 part 3 of ISO 26262 standard, as shown

	QM	ASIL A	ASIL B	ASIL C	ASIL D
Safety Handling	Rigorous design and test to avoid potential failures			Control potential failure	
SPFM	No	No	≥ 90%	≥ 97%	≥ 99%
LFM	No	No	≥ 60%	≥ 80%	≥ 90%
PMHF	No	No	<100 FIT	< 100 FIT	< 10 FIT
FTA	No	No	No	Yes	Yes
DFA	No	No	No	Yes	Yes
FMEA	No	No	Yes	Yes	Yes

Table 3. Handling of Safety Matrices of ASILs (Ref [2])

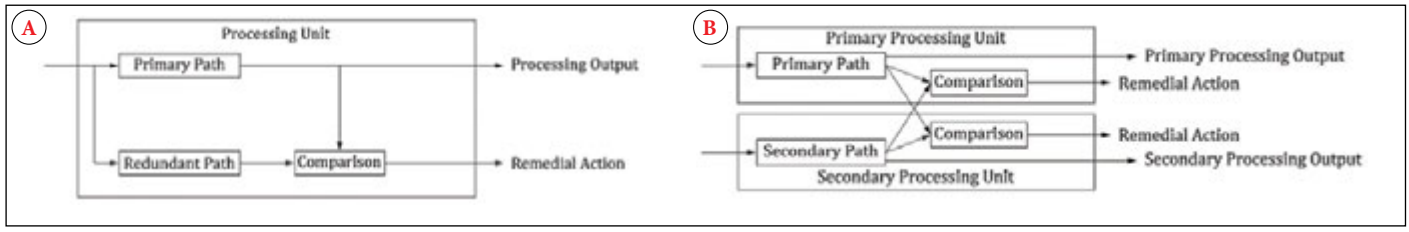


Fig 7. Redundant SW Comparison using a) same processing unit; b) different processing units (Ref. [4])

in Table 2 (Ref [4]), wherein the controllability class has changed from C2 to C3 with ASIL changing from B to C.

As ASIL C accepts up to three per cent of single point failure and 20 per cent of latent failure as shown in Table 3 (Ref [2]), for steering systems with ASIL C levels, a single logic or control system is not adequate to mitigate or reduce any potential risk of sudden LOA. This inherently calls for redundancy for the control and logic gates of the EPS system to ensure high reliability and avoid sudden LOA. Two kinds of redundant systems are applicable for EPS viz, Homogeneous and Heterogeneous. In the case of Homogeneous redundancy, multiple elements of a single type of component are used to achieve redundancy, such as the use of dual ECUs, microcontrollers, sensors, and power supplies for steering motor. It is easier to implement but susceptible to systematic faults. In the case of Heterogeneous redundancy, multiple components of different types are used to achieve redundancy such as steering control using differential brakes. This design is inherently more resistant to systematic faults.

The Functional Safety requirements as per ISO 26262 Part 5 Annex E are applicable to both non-programmable and programmable elements such as Application Specific Integrated Circuits (ASICs), Field Programmable Gate Arrays (FPGAs), and Programmable Logic Devices (PLD). The main Failure in Time (FIT) contributor is the microcontroller with a range of Probabilistic Metric for Hardware Failure (PMHF) 41 per cent to 45 per cent considering The Single Point Fault Metric (SPFM), which is more than the safe allowance of three per cent SPFM for ASIL C as per Table 3. In order to mitigate the potential risk of sudden LOA due to FIT from microcontroller, it is imperative to incorporate redundant logic in EPS system architecture. The Software (SW) redundancy can be achieved using the same processing unit or different processing units, as shown using different architectures in Figure 7 (a) and 7 (b). The aim of the SW redundancy is to detect failure in the processing unit as early as possible by dynamic SW comparison whether using same or different processing units. In the case of failure of primary path, the redundant path is responsible for verifying the primary path's calculation and taking appropriate actions if a failure is detected. This can be done using separate algorithm designs and code to provide SW diversity. As per the SW redundancy using reciprocal comparison of SW in different processing units shown in Fig. 7 (b), failures are detected as early as possible through exchange and comparison of data in each unit on a real-time basis to detect differences which might cause failure. The SW architecture in Fig 7 (b) allows for HW and SW diversity in addition to processor types (dual or tri-core), separate algorithm designs, code and compilers.

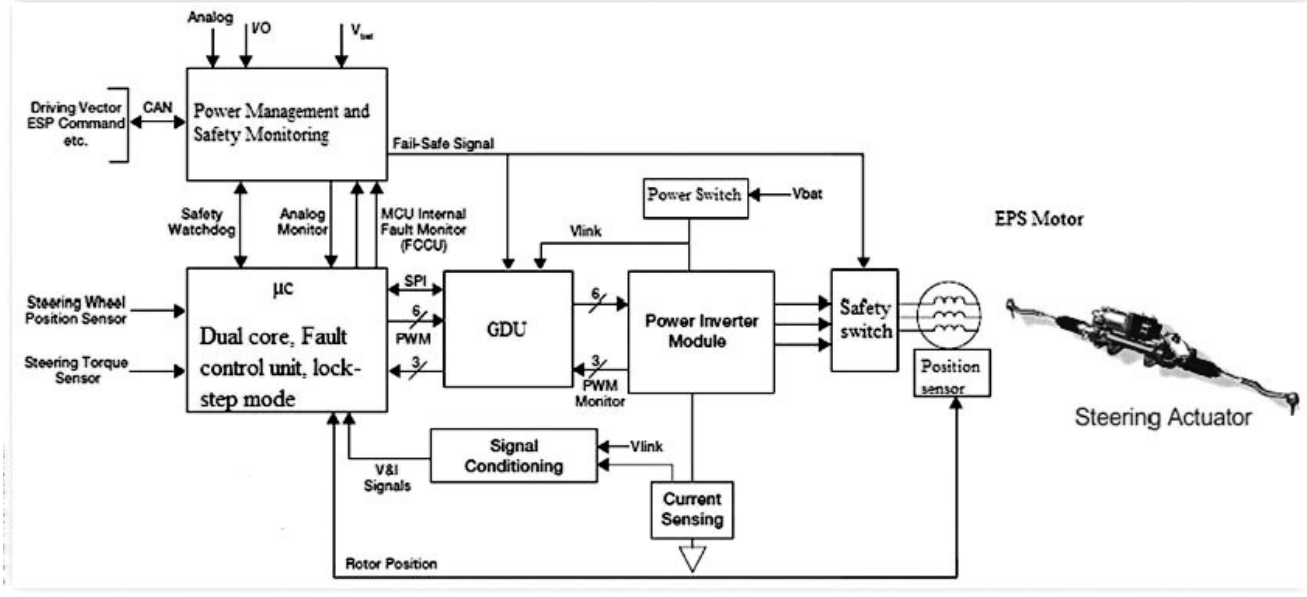


Fig 8. EPS Control path using a dual core microcontroller integrated with power management and safety monitoring (Ref. [4])

Safety Handling	QM	ASIL A	ASIL B	ASIL C	ASIL D
	Rigorous design and test to avoid potential failures			Control potential failure	
SPFM	No	No	≥ 90%	≥ 97%	≥ 99%
LFM	No	No	≥ 60%	≥ 80%	≥ 90%
PMHF	No	No	<100 FIT	< 100 FIT	< 10 FIT
FTA	No	No	No	Yes	Yes
DFA	No	No	No	Yes	Yes
FMEA	No	No	Yes	Yes	Yes
Path Architecture	Single logic path is sufficient			Dual-core logic path satisfies or fulfils all above metrics	

Table 4. Safety and ASIL Target Metrics and Logic Requirements (Ref [4])

The EPS control path using multicore microcontroller (dual or tri-core) with integrated power supply management, as shown in Fig 8 (Ref [4]), enables an internal self-test and lockstep mode, monitors the microcontroller and controls the safety switch of the EPS motor thus providing a higher level of safety. The Failure in Time (FIT) for this architecture significantly reduces to be in line with ASIL C requirements (PMHF < 100 FIT). This architecture provides high availability and controllability for the EPS systems to decompose ASIL-C determination of EPS in case of LOA. The ASIL target metrics and the logic path architecture of the EPS system are shown in Table 4.

Function	Provide drive torque		
Malfunction	Provide torque when not requested	Provide more drive torque than requested	Provide braking torque
Driving Situation	Driving in city or on country roads behind another car	Pedestrian area (e.g., cross-roads, parking lots).. Low speed	Highway (Wet road)
Impact	Front/rear collision with the vehicle in front.	Frontal collision with pedestrian	Unintended rotational motion
Exposure of operational situation	E4	E3	E3
Severity of potential harm	S3	S3	S3
Controllability of hazardous event	C2	C3	C3
ASIL	C	C	C
Safety Goal	MCU shall not provide drive torque when drive torque is not requested	MCU shall not provide more drive torque than requested	MCU shall not provide braking torque when drive torque is requested

Fig 9. Electric Drivetrain HARA Analysis (Ref [5])

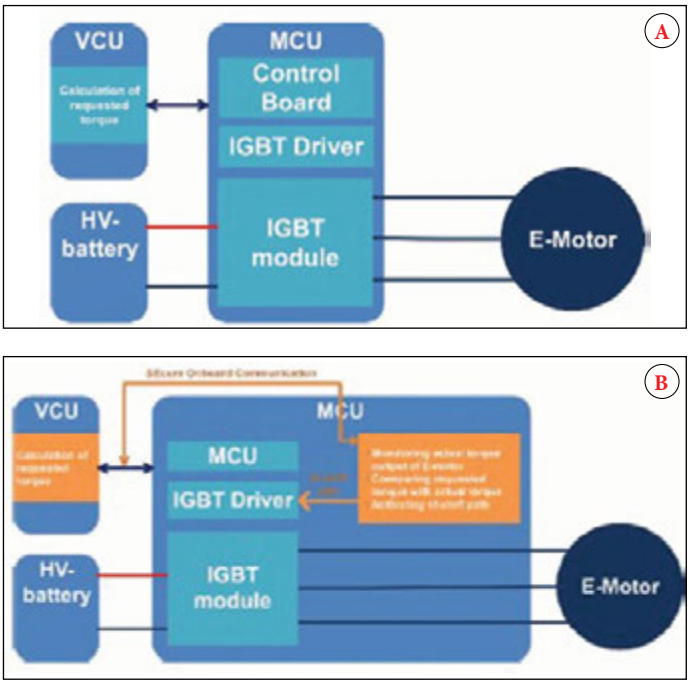


Fig 11. Electric Drivetrain System Architecture a) without and b) with Functional Safety (Ref [5])

III. Functional Safety in Motor Control Systems

The traction control systems in Electric Vehicles (EVs) have been increasingly using Permanent Magnet Synchronous Motors (PMSM) with high power density and high energy efficiency. Owing to the criticality of motor control systems, high ASILs (Level C and above) are typically assigned to these systems during design and development.

NO	Safety Goal	Safe State	ASIL
1	MCU shall not provide drive torque when drive torque is not requested	Motor generates no active torque	C
2	MCU shall not provide more drive torque than requested	Motor generates no active torque	C
3	MCU shall not provide braking torque when drive torque is requested	Motor generates no active torque	C
4	MCU shall not provide more brake torque than requested	Motor generates no active torque	C

Fig 10. Electric Drivetrain Safety Goals (Ref [5])

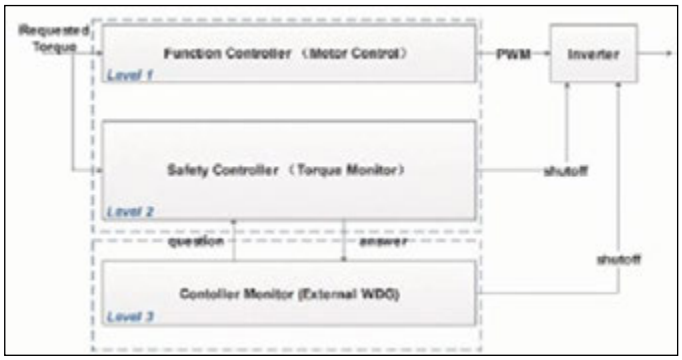
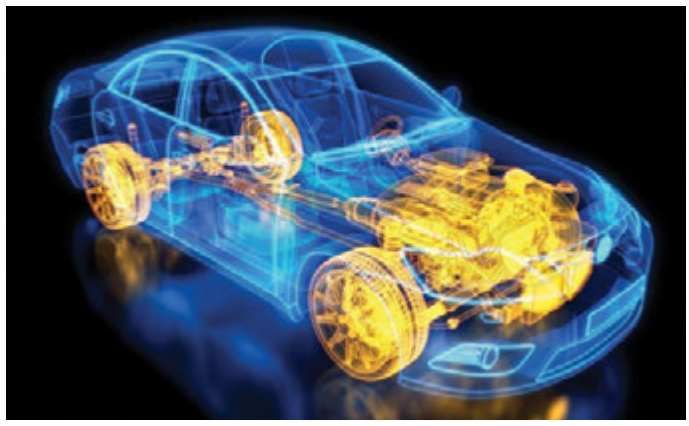


Fig 12. Electric Drivetrain Functional Safety 3-Layer Architecture (Ref [5])



For the basic EV drivetrain architecture shown in Figure 11 (a), a portion of the HARA analysis is captured in Figure 9 wherein the malfunctions, driving situations, and impact on the vehicle and users are elucidated with severity of potential harm as S3 and controllability of hazardous event ranging from C2 to C3, resulting in ASIL C level in each case (Ref [5]).

In Figure 10, the corresponding safety goals are depicted ranging from the Motor Control Unit (MCU) not to provide drive torque when it is not requested (SG 1) to MCU not providing more brake torque than what was requested (SG 4) with all of them having ASIL C requirements.

A three-layer system architecture to capture the Functional Safety requirements for the EV drivetrain is captured in Figure 12 (Ref [5]) wherein Layer 1 (functional level) accounts for Vehicle level management functions, Layer 2 (function monitoring level) recognises the faults in functional SW of Layer 1, and Layer 3 (controller monitoring level) interacts with the function controller and enables HW and SW diagnostics.

The EV drivetrain system architecture with Functional Safety implementation is shown in Figure 11 (b) wherein the system is implemented with a multicore microcontroller which is developed as a safety element out of context (SEOOC), supports up to ASIL D application, and provides two-lock stepped CPUs (core 0 and core 1) and one non-lock-stepped core (core 2). While Layer 1 is assigned to core 0, Layer 2 is assigned to core 1, and Layer 3 periodically checks the microcontroller and monitors the supply voltages to the system for other layers to function properly. Both

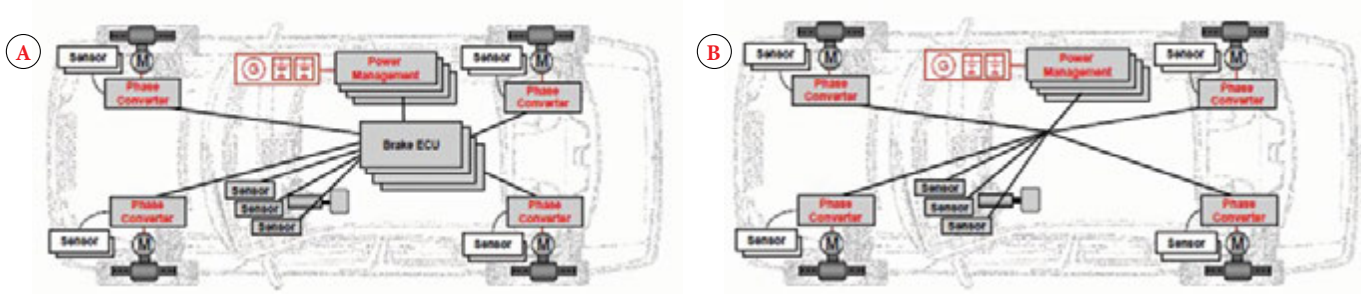


Fig 13. BBW Systems with a) Centralised Redundancy and b) Distributed Redundancy (Ref. [6])

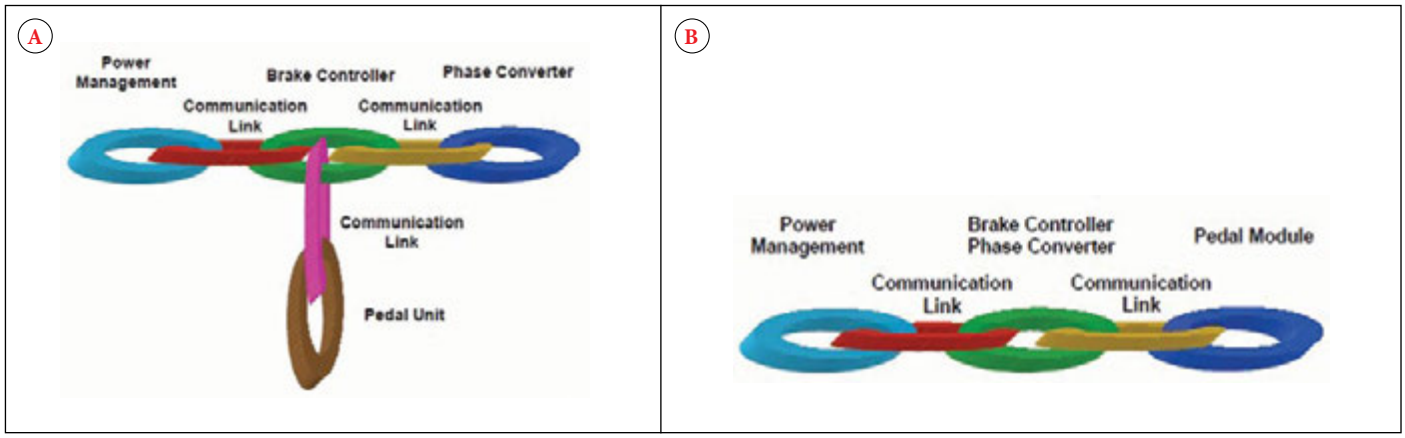


Fig 14. Dependencies of BBW Systems with a) Centralized Redundancy & b) Distributed Redundancy (Ref. [6])

S.	Module	No. of Errors Tolerated	Sub-systems	Resource Requirements
1	Fault Tolerant Pedal Module	1-2 errors	3 (microcontroller, sensor, power supply, communication	4 high end microcontrollers, 4 for brake modules, 3 low end microcontrollers for pedal module, 8-16 mid-range microcontrollers for power management module and phase converters. Total: 15-23 microcontrollers, 11 ECUs, 9 communication links
2	Fault Tolerant Electronic Brake Module	1-2 errors	2 fail safe systems (4 microcontrollers, 4 control paths)	
3	Fault Tolerant Power Management Module	1-2 errors	2 fail safe systems (4 microcontrollers, 4 control paths)	
4	Phase Converter	1 error	4 for each actuator for 4-wheel braking	

S.	Module	No. of Errors Tolerated	Sub-systems	Resource Requirements
1	Fault Tolerant Pedal Module	2 errors	3 (microcontroller, sensor, power supply, communication link)	3 low end microcontrollers for pedal module, 4 mid-range microcontrollers each for power management module and phase converters. Total: 11 microcontrollers, 9 ECUs, 8 communication links
2	Fault Tolerant Power Management Module	1-2 errors	2 fail safe systems (4 microcontrollers, 4 control paths)	
3	Wheel Brake ECU a) Fault Tolerant Electronic Brake Module b) Phase Converter	2 errors	1 high end microcontroller, Power Electronics, Sensor I/O	

Layer 2 and Layer 3 offer shutoff with Layer 2 acting as Torque Monitor and Layer 3 providing a redundant shut-off path in case Layer 2 fails (Figure 12).

IV. Functional Safety in Brake by Wire Systems – Centralised vs Distributed Redundancy

The traditional centralised redundancy and advanced distributed redundancy Brake by Wire (BBW) architectures are given in Figures 13 (a) and 13 (b), respectively while the corresponding dependencies are given in Figures 14 (a) and 14 (b).

The dependencies in Figure 14 clearly indicate the benefits of 4 vs 3 modules and 3 vs 2 links as we go from Centralised towards Distributed Redundancy.

The traditional centralised redundancy architecture and dependencies in Fig 13 (a) and 14 (a) consist of the following (Ref [6]):

The advanced distributed redundancy architecture and dependencies in Fig 13 (b) and 14 (b) consist of the following (Ref [6]):

An important requirement for effective BBW distributed architecture is the communication protocol that is deterministic, connects and correlates the distributed control units, is fault-tolerant, encapsulates at the protocol and physical level, has compatibility with existing systems, is cost effective, and acts as a true open standard. Existing CAN communication protocols are not suitable for developing fault tolerant safety critical BBW applications because they are not deterministic, with unpredictability of the timing of messages. Multiple organisations and consortiums have been working on Time Triggered Protocol (TTP) CAN architectures with TTP/C and TTP/A being two real-time protocols of the Time-Triggered Architecture (TTA). The TTA offers high-bandwidth, scalable and fault-tolerant communication with the safety-related features of pure time-triggered communication and the flexibility to support event-triggered communication for other applications. TTP/C focuses on the interconnection of components in

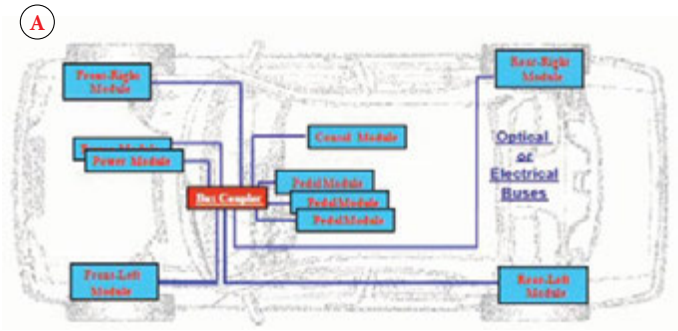


Fig 15. a) Distributed Star Topology (Ref. [6])

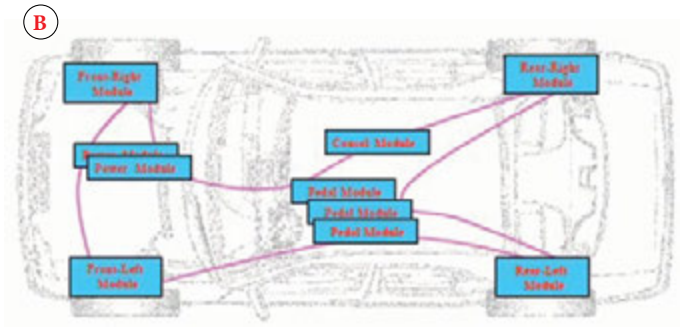


Fig 15. b) Unidirectional Redundant Ring Structure (Ref. [6])

order to form a highly dependable real-time system suitable for safety-critical XBW systems. TTP/A supports modular design, provides easy and economical integration and management of sensors and actuators into a network, and can be implemented on low-cost microcontrollers.

It is important for a BBW architecture to have fault-tolerant safety strategies built on inherent system redundancy and with deterministic communication systems connecting and encapsulating the distributed sub-systems from each other. Figures 15 a) and 15 b) depicting distributed star topology and unidirectional redundant ring structure, respectively, ensure that encapsulation is performed in the time domain and additionally to some extent in the value domain. The distributed star topology shown in Fig 15 a) suffers from inherent weakness of single point failure though it offers redundant bus-guardians and encapsulated sub-systems. The distributed ring architecture shown in Fig 15 b) offers very high robustness against local, mechanical or electrical failures. Unidirectional wires can be routed separately, such that a loss of any single connection and many combinations of multiple cuts do not cause any loss of information.

The distributed BBW architecture as implemented in a vehicle is shown in Figure 16 wherein multiple displacement sensors and force sensors are connected to the wheel nodes to capture driver intent. Each wheel node calculates the actuation commands for all four wheels. These commands are communicated via the network so each of the four-wheel nodes can compare their own actuation commands with those calculated by the other wheel nodes. The voting mechanism in the network layer of each wheel node can then disable the power to individual actuators in case of a fault. If a node needs to be shut down the brake force is redistributed to prevent the vehicle from yawing.

The advanced brake functions are executed in the two front-wheel nodes. If the front wheel nodes do not calculate the same output commands for these advanced brake functions, the function will be deactivated. This provides fail-safe operation. The dependable power supply is provided by two 42V batteries. Each battery is connected to a distribution box that protects the 42V net from short circuits. Each wheel node is connected to each distribution box providing redundant power supply. The communication system is itself failure tolerant. The computation and control are distributed to the available resources that verify against each other over the network with appropriate network support. Value domain encapsulation using a mutual distributed exclusion protocol feature is one further measure to allow detection of failures in the value domain across the network and without further software interaction. The communication protocol allows the incoming datasets to be compared against a reference dataset provided by the attached host and to determine the majority agreement within the network. In case of failure of one ECU that cannot detect its own faultiness, this network feature allows to prevent the commanding of actuation with data from such faulty nodes.

Summary

FuSa in automotive systems as per ISO 26262 standard is an increasingly necessary requirement due to higher levels of features and associated HW and SW architecture complexity in vehicles. Though ISO 26262 standard is a generalised document to ensure FuSa, it needs to be interpreted appropriately for specific systems such as BMS, steering systems, drivetrain, brakes etc. As FuSa standards evolved from IEC 61508 towards ISO 26262, avoiding SPFs through structured analysis and safety mechanisms is still the underlying design philosophy. To achieve ASIL D level compliance, decomposition into independent and redundant ASIL B(D) systems is a crucial tool to avoid all types of errors. The SPFM is almost 100 per cent because no random failures lead directly to violation of a safety goal. For FuSa applications on BMS, high levels of LFM are achieved through fault detection and communication through CAN between systems such as BMS and PTC. The HAM should be performed at the Safety Goal level before decomposition to comply with ASIL D.

The use of more ADAS application in the EPS and the continuous need for increased torque and better manoeuvrability of vehicles has been posing new challenges for Electric Power Steering (EPS) systems

in the form of higher forces at the steering rack and increased ADAS functionalities. Recent trends indicate design of highly available EPS system architecture with FIT significantly reduced to be in line with ASIL C requirements (PMHF < 100 FIT) using control logic paths utilising redundancy concepts. ASIL C mitigation was achieved by incorporating a dual-core microcontroller integrated with a power management and safety monitoring unit thus providing high availability and controllability for the EPS systems to decompose ASIL-C determination in case of LOA of steering systems.

As more and more OEMs demand their suppliers to provide drivetrain control systems adhering to ISO 26262 standard, innovative technical solutions employing multi-layer FuSa system architecture employing multicore microcontroller (developed as a safety element out of context (SEOOC)) are being pursued meeting ASIL C and higher requirements. The different layers of FuSa simultaneously address multiple ASIL C safety goals while also providing redundant shut-off paths in case a layer fails.

The distributed BBW architecture is the recent trend with multiple displacement sensors and force sensors connected to the wheel nodes, with each wheel node calculating the actuation commands for all four wheels. The fail-safe operation is provided by constantly checking if the specific wheel nodes do not calculate the same output commands for these advanced brake functions. Each wheel node is connected to each distribution box providing redundant power supply through the use of two 42V batteries that are protected from short circuits. The communication system itself is failure tolerant with the computation and control distributed to the available resources that verify against each other over the network.

In automotive systems with growing complexity, all safety goals must be satisfied simultaneously with associated ASIL levels in a single implementation by detecting and addressing systematic errors in advance through a higher of independence of systems. It is to realise decomposition to lower levels, which will continue to be a challenge to design ISO 26262 compliant systems.

[1] Reference: Peter Johannes Bergmiller, "Towards Functional Safety in Drive by Wire Vehicles" https://link.sppringer.com/book/10.1007/978-3-319-17485-3

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[4] Reference: Saif Salih and Richard Olawoyin, "Computation of Safety Architecture for Electric Power Steering System and Compliance with ISO26262" SAE Paper 2020-01-0649 https://www.sae.org/publications/technical-papers/content/2020-01-0649

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[6] Reference: Nico A. Kelling and Worthy Heck, "The BRAKE Project – Centralized vs Distributed Redundancy for Brake-by-Wire Systems" SAE Paper 2002-01-0266 https://www.sae.org/publications/technical-papers/content/2002-01-0266 **ACI**

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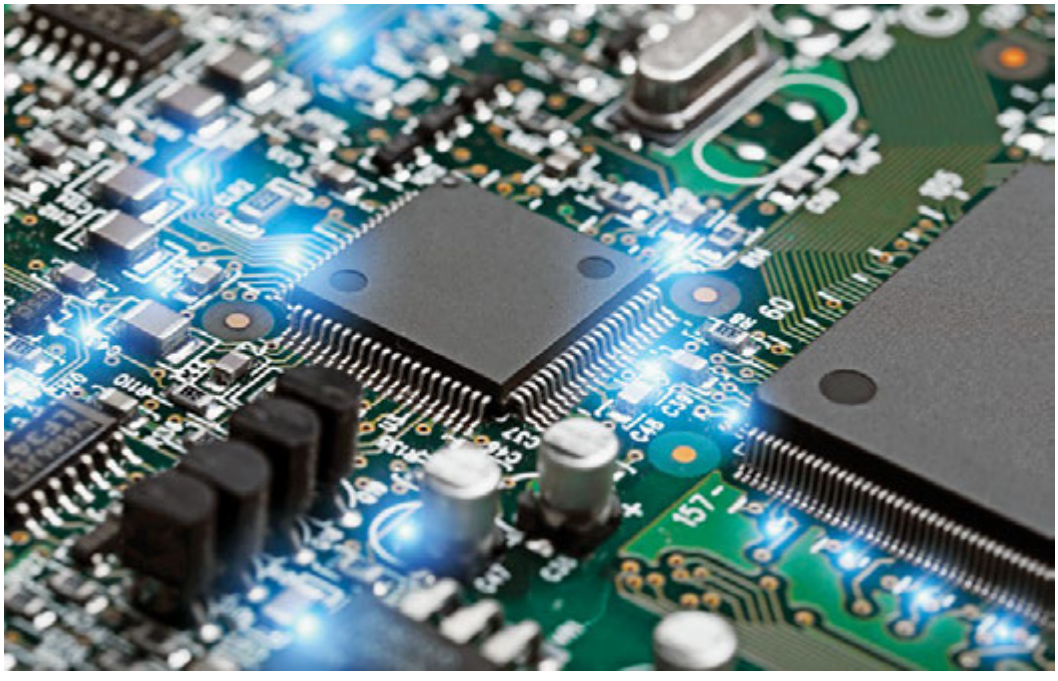

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The new Technology centres at Visakhapatnam and Bhopal were developed with an investment of Rs 123 Cr & Rs 121 Cr, respectively. These state of art training facilities will train more than 16,000 students annually & develop access to technology for MSMEs at the grass root level.

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"SIAM welcomes the concept and outline of Scrappage Policy. The most important step is to build an infrastructure of testing and scrapping centers fast all over the country and SIAM will work on this front with the government", said @siamindia @rajeshmenonSIAM @CNBCTV18Live

Warren Harris @warrenkharris

I continue to be inspired by the values that informed the formation of our Group in 1868. Founder's Day is a reminder that, whilst many things change, our commitment to "doing well by doing good" will always endure!

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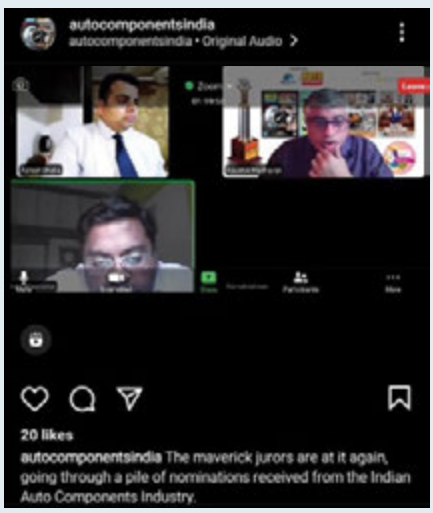

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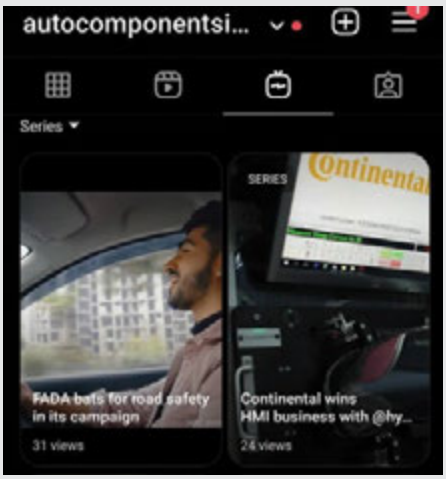

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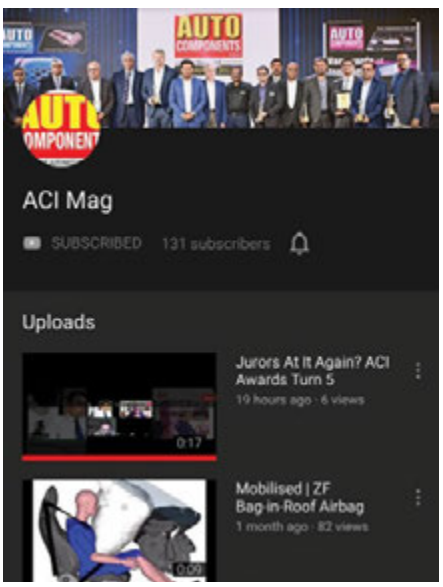

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