Applying a Systems Approach to Automation in Rail and Road Transport

Managing the risks emerging from complex, software-based autonomous systems in the transition to a world with self-driving vehicles

This article explores the history of automation in the transport sector and the lessons learned along the way for application going forward; it looks at the similarities and differences between rail and road and discusses how a systems approach to safety can be used to manage the risks emerging from complex, software-based autonomous systems in the transition to a world with self-driving vehicles. The text considers examples and cases of automation, predominantly from the United Kingdom (UK), and draws parallels between road and rail transport.

This think piece comes at a time when the Government (Department of Transport[1]) is exploring the safety implications of higher levels of automation in road transport, while professional institutions, such as the Institution of Engineering and Technology[2], see value in learning lessons from other modes of transport (e.g. rail) where changes in operational practices have been deployed and even increased safety in the UK.

Looking at the level of automation uptake in the two industries, rail has progressed further than road; the reasons are beyond the scope of this article. However, we can look at how some of the cutting-edge systems-based frameworks and tools used in rail can support future progress in the road sector, helping to ensure safe integration of future technology in a complex operational environment such as road transport, which is very different from rail.

1 "Activities drivers can safely perform in conditionally automated vehicles, including Automated Lane Keeping Systems (ALKS)," Department for Transport, UK Government, accessed. October 19, 2021

2 "Advancing Safety in Transportation through automation," the Institution of Engineering and Technology, accessed. October 19, 2021

Contents

History of Automation

The automation of transport systems dates back to 1912 when extended travel times forced the development of autopilot systems for long-range aircraft. Much later, in 1967, the first semi-automatic train was implemented on the London Underground's Victoria Line. The metro line was operated with Automatic Train Operation (ATO), although a driver was present in the cab. This was ground-breaking technology at the time, especially as the system used was invented in-house. The successful integration of all technical sub-systems and disciplines has been fundamental to realising the benefits of ATO and other new technologies that aim to improve performance and safety; almost 55 years later, safe integration remains fundamental to the development and implementation of today's autonomous systems.

During the 20th century much ground was covered to implement automation; now in the 21st century, we have finally come to the point where ATO is a standard feature on urban metro railways and autonomous cars are actively tested on our roads. While a world filled with robot-cars is not yet a reality, cars today do contain many autonomous features, such as assisted parking and braking systems. Meanwhile, work on full-fledged autonomous cars continues, with the goal of making driving a car safer and simpler in the coming decades.

Lessons Learned Along the Way

In the recent years, several incidents and accidents have demonstrated that automation, despite being technologically advanced, raises particular safety concerns due to the complexity of these high-integrity, software-based systems and their interfaces. There are also security implications associated with the use of automation in all sorts of engineered systems, not only transport systems (e.g. Stuxnet). Below are some characteristic examples from which we can learn and build upon to design safer autonomous systems and increase their uptake:

- **Tesla's 'autopilot' and Volvo's pilot assist** – In 2016 in Florida, the first known death caused by a self-driving car was disclosed by Tesla Motors[3]. According to Tesla, Model S's sensors system failed to distinguish a large white 18-wheel truck and trailer crossing the highway, under clear weather conditions. The company said, "Autopilot is getting better all the time, but it is not perfect and still requires the driver to remain alert". The first recorded case of a pedestrian fatality involving a self-driving car after a collision occurred in 2018. The victim was struck by a prototype Uber self-driving car. The Volvo car had been operating in autonomous mode and the car's human safety backup driver did not intervene in time to prevent the collision. As claimed by Uber, drivers were trained to keep their hands very close to the wheel all the time while driving the car, so they were ready to quickly take control if necessary[4].
- **Cambrian line** – In 2017, four trains travelled over the Cambrian Coastline, while temporary speed restriction data was not being sent to the trains by the signalling system, as mentioned in the investigation report[5]. No accident resulted, but a train approached a level crossing at 80 km/h (50 mph), significantly exceeding the temporary speed restriction of 30 km/h (19 mph) needed to give adequate warning time for level crossing users. This incident demonstrated the major impact of software failures on railway asset safety. Failures were identified both in the software system and the processes during development, testing and implementation.
- **Hong Kong MTR** – In 2019, according to the investigation report[6], a two-train collision incident happened during an exercise on the new signalling system of the Tsuen Wan Line. As stated in the formal investigation findings, the cause of the incident was a programming error introduced during software rectification of the new signalling system at the design and development stage. The Automatic Train Protection system could not function as required to prevent two trains from entering the crossover track at Central Station at the same time; this failure led to the train collision.
- **Stuxnet** – A malicious computer worm first uncovered in 2010 and thought to have been in development since at least 2005. Stuxnet targets SCADA (Supervisory Control And Data Acquisition) systems and is believed to be responsible for causing substantial damage to the nuclear program of Iran[7].

3 Danny Yadron and Dan Tynan, "Tesla driver dies in first fatal crash while using autopilot mode," The Guardian, July 1, 2016

4 Rory Cellan-Jones, "Uber's self-driving operator charged over fatal crash," BBC, September 16, 2020

5 Loss of safety critical signalling data on the Cambrian Coastline, GOV.UK, Report 17/201920 October 2017

6 "Investigation Report on Incident of the New Signalling System Testing on MTR Tsuen Wan Line," Electrical and Mechanical Services Department, Government of the Hong Kong, accessed October 19, 2021

7 Kim Zetter, "An Unprecedented Look at Stuxnet, the World's First Digital Weapon," WIRED, March 11, 2014

Stuxnet specifically targets Programmable Logic Controllers, which allow the automation of electromechanical processes such as those used to control machinery and industrial processes, including gas centrifuges for separating nuclear material. There have been similar cyber-attacks on rail systems. One characteristic example was when hackers took control of passenger trains in the Northwest of the United States, disrupting signals and creating delays[8].

The table below shows the system property compromised in the above-mentioned incidents and accidents and the specific aspects of automation that introduce risks, which require particular attention in the future. This mapping is based on information publicly available (e.g. accident/incident reports and expert opinion.).

From the table we observe a set of recurring elements that were present in all accidents/incidents. The lessons we can draw from this table is that human-machine interface (HMI), training and competence, software and requirements are the most critical aspects that require better understanding and improvement to prevent future automation accidents and incidents.

	System property		Aspects of automation			
	Safety	(cyber) Security	HMI	Training/ Competence	Software	Requirements
Tesla Model S	√		√		√	√
Volvo Uber	√		√	√	√	√
Hong Kong MTR	√		√	√	√	√
Cambrian line	√		√	√	√	√
Stuxnet		√	√	√	√	√

GoA and SAE

Rail and road have developed different automation classification systems. In road, a classification system with six levels was published in 2014 by SAE International, an automotive standardisation body[9]. According to the International Association of Public Transport, there are five Grades of Automation (GoA) of trains.

There is an obvious difference between the two classification systems; that is, the number of levels. The table below presents a comparison between the definitions of automation level used in rail and road. Based on our interpretation, GoA 3 incorporates both SAE Level 3 and 4. This could be explained simply by the fact that a car driver can perform more functions than a train driver, e.g. a car can overtake another vehicle.

The following table draws the parallels between the two automation classification systems.

8 "Hackers attack U.S. railways," Homeland Security News Wire, accessed October 19, 2021

9 "SAE International Releases Updated Visual Chart for Its 'Levels of Driving Automation' Standard for Self-Driving Vehicles," Society of Automotive Engineers, accessed October 19, 2021

10 Dave Keevill, "Implications of Increasing Grade of Automation," APTA Rail Conference, June 11-14, 2017

Rail[10]	Operation	Description	Road	Operation	Description
GoA 0	On-sight	No automation. Movement authority, including route locking and maximum speeds, granted by a variety of means, e.g. wayside signals and verbal instructions via radio.	Level 0	No Driving Automation	Manual control. Human performs all driving tasks. Automated system issues warnings and may momentarily intervene but has no sustained car control.
GoA 1	Manual	Train driver controls starting and stopping, operation of doors and handling of emergencies or sudden diversions. Automatic train protection protects train from hazards, e.g. apply brakes to a stop.	Level 1	Driver Assistance	The lowest level of automation. The car features a single automated system for driver assistance, such as steering or accelerating (cruise control).
GoA 2	Semi-automatic	Starting and stopping are automated, but a driver operates the doors, drives the train if needed and handles emergencies.	Level 2	Partial Driving Automation	Car can control steering and accelerating/ decelerating. Automation falls short of self-driving because a human sits in the driver's seat and can take control of the car at any time.
GoA 3	Driverless	Starting and stopping are automated, but a train attendant operates the doors and drives the train in case of emergencies.	Level 3	Conditional Driving Automation	Cars have 'environmental detection' capabilities and can make informed decisions for themselves, e.g. accelerating past a slow-moving car. But still require human override.
			Level 4	High Driving Automation	Car does not require human interaction in most circumstances. However, a human still has the option to manually override.
GoA 4	Unattended train operation	Starting and stopping and operation of doors and handling of emergencies are all fully automated without any on-train staff, hence all stations should have platform screen doors[11].	Level 5	Full Driving Automation	No human intervention is required at all. Cars will not even have steering wheels or acceleration/ braking pedals.

11 Piers Connor, "Platform Protection Systems," Rail Technical Pages, August 13, 2011

Automation in rail

Around the world, many metro lines now operate using an ATO system, with the aim of improving the frequency of service. ATO technology has been developed to enable trains to operate even without a driver in a cab, either with an attendant roaming within the train or with no staff on board. Many ATO systems are GoA 2. The first fully automated driverless mass-transit rail network is the Port Island Line in Japan (GoA 4)[12]. The second in the world (and the first such driverless system in Europe) is the Lille Metro in France[13].

In the UK, after the Victoria line, London's second rapid-transit system to be automated, DLR (Docklands Light Railway) (GoA 3), part of the Transport for London (TfL) network has operated with driverless trains since its opening in 1987. TfL now uses modern computer-based train control systems on most of its lines, which incorporate ATO functionality. Currently in the UK, partially automated trains are used on Victoria, Jubilee, Central and Northern lines[14]. These trains still require operators to open and close the doors, and to assist in the event of an emergency (i.e. GoA 2 and GoA 3).

Introducing ATO onto a mainline railway seems to be more difficult. Applying ATO in a mainline environment where different train types running on different routes share the same infrastructure is inevitably a more complex proposition, and perhaps more analogous to the challenges faced for automation in road transport, but it is now becoming technically feasible. In Germany, mainline ATO trials commenced earlier this year (2021)[15]. The trains will operate with ATO over ETCS (European Train Control System). Two grades of automation are tested: fully autonomous operation but with an attendant in position to intervene in case of emergency in regular passenger operation (GoA 3); operation in which no attendant is used, and with remote control being possible is tested for shunting (GoA 4).

A UK success is the completed development of layering an ATO GoA 2 package onto an ETCS-equipped railway, as it happened in the London Thameslink central core section. ATO has effected major change in the railways and supports revolutionary potential for the future[16]. The Shift2Rail joint technology initiative is driving research into ATO for mainline applications through its Innovation Programme 2[17], which seeks to develop and validate a standard ATO system up to GoA 3/4 over ETCS.

Automation in road

Earlier this year (2021) the Department for Transport (DfT) said automated lane-keeping systems (ALKS) would be the first type of hands-free driving legalised in Great Britain. According to the road automation classification system, ALKS is SAE Level 3 conditional automation.

The ALKS report was produced by TRL Limited on behalf of DfT and is based on extended research and analysis of the activities drivers can safely perform in conditionally automated cars, including ALKS[18]. According to this report, the introduction of conditionally automated driving systems could fundamentally change the role of the driver if he/she is permitted to disengage from the driving task. For the first time, drivers may be allowed to divert their attention to non-driving related tasks.

"This [ALKS] is a major step for the safe use of self-driving vehicles in the UK, making future journeys greener, easier and more reliable while also helping the nation to build back better. But we must ensure that this exciting new tech is deployed safely, which is why we are consulting on what the rules to enable this should look like."

Rachel Maclean, Transport Minister

Source: GOV.UK

12 Nobuhiko Sato, "The World's First Automated Driverless Railway Opened in Kobe in 1981," WORKINJAPAN.TODAY, May 12, 2020

13 Mykola Zasiadko, "Fully automated metros run in six EU countries," RailTech.com, November 19, 2019

14 Clive Kessel, "LU Northern line goes CBTC," RailEngineer, May 8, 2015

15 Kevin Smith, "German mainline ATO trials to commence in 2021," International Railway Journal, May 27, 2020

16 "Automatic Train Operation/Autonomous Train Control (ATO/ATC)," Global Railway Review, accessed October 19, 2021

17 "Innovation Programme 2," Shift2Rail, accessed October 19, 2021

18 "Activities drivers can safely perform in conditionally automated vehicles, including Automated Lane Keeping Systems (ALKS)," Department for Transport, UK Government, accessed October 19, 2021

Allowing cars to operate under conditional automation does not necessarily imply that human intervention is no longer required. Drivers will be required to take control in either planned (e.g. exiting at a junction) or unplanned (e.g. sudden heavy fog) circumstances. Disengagement from the driving task could impair drivers' availability to safely resume control where the automated system reaches a functional limit and issues a transition demand. At the point of the automated system issuing a transition demand, the driver must already be prepared to re-engage while disengaging from any other task being undertaken that is not allowed for drivers of conventional cars (e.g. texting, eating, reading a book etc.). Takeover is impacted by specific situational variables (i.e. traffic complexity, takeover demand warning, human-machine interface design, secondary task type) and individual variables (i.e. age, experience and skill). These all impact the driver's situational awareness[19]. Situational awareness is one of the most important aspects of driving safely and refers to the drivers' perception and comprehension of their environment and is related to accurate anticipation and hazard perception[20].

The ALKS system, specifically, will be used on roads where pedestrians and cyclists are prohibited and where there is a physical separation that divides the traffic moving in opposite directions. These criteria essentially mean that in Great Britain the system can only be used on the motorway network. The technology controls the position and speed of a car in a single lane, and the speed will be limited to 37 mph (60km/h). According to TRL, this constraint is pertinent to how the vehicle operates and interacts with other vehicles.

Different Levels of Assimilation in Road and Rail

Practice has shown that to date the rail industry has embraced automation to a greater extent than road transport. Perhaps an obvious explanation is that trains operate in a more controlled and closed environment—tracks—, whereas autonomous cars operate in an open system; on an unguided path, crossing (freely) over several lanes. Moreover, in rail the relevant technology has been tried and tested, whereas autonomous vehicles are still being tested and the regulatory environment is not complete yet.

The Institution of Engineering and Technology (IET) recently published an article[21] on Smart Motorways as a response to questions posed by the Department for Transport. Among other sectors, the IET Policy Panel compares road to rail transport. Namely, the panel argues that railway safety is in large part achieved by the reliability of the system as well as the competence of the users (in normal, degraded, and emergency modes) and the trust they have in the system; if a driver is given a green signal, he/she is confident the track ahead is clear.

According to the IET article, UK railways are highly regulated, and constraints (from the regulator as well as the infrastructure owner) mean that no vehicle (i.e. train) can move on them unless approved for use and all risks have been managed to an 'as low as reasonably possible/ practicable' (ALARP) standard[22]. This includes using competent and tested staff. Similarly, changes to infrastructure undergo a comprehensive evaluation to ensure overall safety of the system is not affected detrimentally in either normal, degraded or emergency operation. In rail, there is a safety culture that encourages recording of incidents (not just accidents but also near misses), so lessons can be learned without an accident happening. At the same time, all fatal accidents (and many less serious) are investigated by an independent body to identify the root cause—as opposed to allocating blame.

All things considered, the specific characteristics of the UK railway system and the framework within which the UK rail system operates inspire confidence in terms of safety and encourage drivers and passengers to perceive high levels of automation as acceptable, and even 'normal'.

How to Improve Use and Adoption

Based on our rail expertise and holistic thinking, we recommend a threefold approach to improving the use and adoption of automation in road transport:

1. **The human factor** – Training and trust gained through consistent high-quality signalling/telematics and driver assistance with impactive messaging, regulation and a focus on the core causes of previous accidents (e.g. incorrect implementation of software requirements generate misleading messages and warnings). Learning lessons from rail and other modes of transport that already use some kind and level of advanced driver assistance, drawing conclusions about train drivers' behaviours and responses to situations and assessing them within a road transport system.

19 "Leadership and worker involvement toolkit," Health and Safety Executive, accessed October 19, 2021

20 Mikela Chatzimichailidou and Ioannis Dokas, "The Risk Situation Awareness Provision Capability and its Degradation in the Uberlingen Accident over Time," Procedia Engineering, October 5-6, 2015

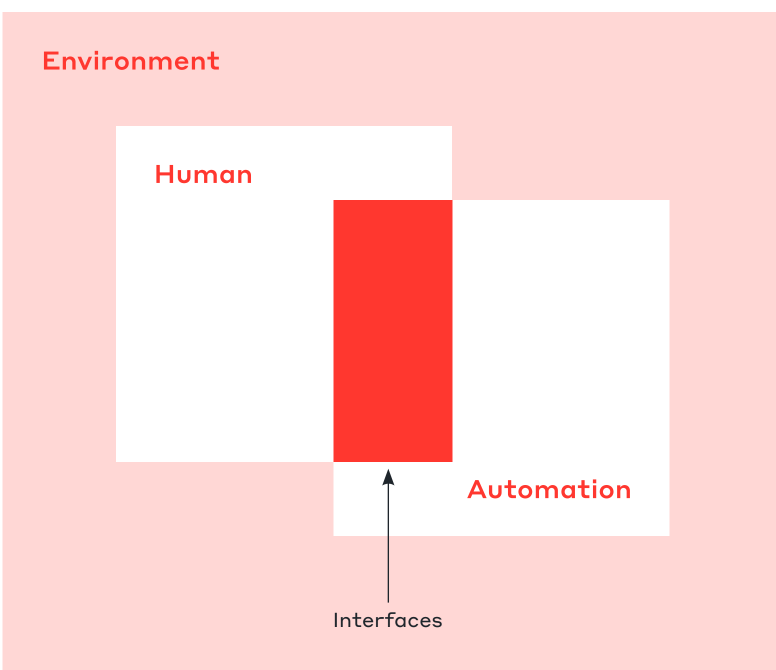
21 Anna Bonne, "How to make Smart Motorways safer?," the Institution of Engineering and Technology, May 21, 2021

22 "Reducing Risks, Protecting People," Health and Safety Executive, accessed October 19, 2021

2. **The autonomous system** – Making the most of what we have already available (e.g. conditional automated driving as a lower level of automation) and ensuring we are ready for future autonomy (e.g. fully automated cars). This means, engineers need to understand the environment within which autonomous cars will operate and design a safe driving ecosystem where road users will feel safe and act safely as well. Therefore, it is not only about manufacturing reliable cars but ensuring that autonomous cars can communicate effectively and safely with the driver, other cars, road users and road signalling.
3. **Keeping the human in the loop** – It is also of paramount importance that human-machine interfaces are not treated as black boxes, but the driver is aware and understands the functionalities, limitations and operational constraints of automation. A study from Cornell University[23] concentrated on the problem of liability in a collision involving a self-driving car. They found that the human 'drivers' of self-driving cars put a good deal of trust in the 'intelligent' car, going so far as to take more risks. According to the same study, human drivers may take advantage of this technology by driving carelessly or taking more risks by not being mentally engaged because they know that self-driving cars are designed to drive more conservatively.

We believe a 'systems-based' approach to safety must be used to manage the risks emerging from these three areas. In WSP, this systems approach involves two tools which lend themselves well to complexity: SI:D³ and System-Theoretic Process Analysis (STPA).

THE AUTONOMOUS SYSTEM



SI:D³ and STPA

WSP has developed a field-driven approach that creates clarity amid the complexity particular to each system. SI:D³ (Systems Integration: Develop, Define, Deliver) is a process framework that was originally developed in response to a growing demand for systems engineering services in the UK rail industry. SI:D³ has a suite of cross-cutting processes, techniques, and proprietary software tools that can support the development of a common purpose and clear governance to help all stakeholders see the transport system holistically, assess its complexity and its corresponding risk and to foster a collaborative environment throughout the development and deployment of automation in any mode of transport. Through its different thematic areas and sections, SI:D³ can address all three aspects as described above.

WSP has applied SI:D³ in several major rail programmes, including the Deep Tube Upgrade Programme (DTUP). The DTUP will introduce 101 new trains on the Piccadilly Line and forecasts a further 150 new trains on the Bakerloo, Central and Waterloo & City lines. It will also introduce 145 kilometres (km) of new digital signalling and communications on the Piccadilly Line and over 200 km on the Bakerloo, Central and Waterloo & City lines, as well as enhance the existing civil infrastructure.

In addition to these challenges alone, the new assets will be integrated into the existing operational railway whilst maintaining passenger services throughout to deliver an integrated system that can be accepted into operational service by the London Underground (LU) operational organisation.

23 Xuan Di, Xu Chen and Eric Talley, "Liability Design for Autonomous Vehicles and Human-Driven Vehicles: A Hierarchical Game-Theoretic Approach," Cornell University, September 7, 2020

To support this endeavour, LU sought a Prime Systems Integration (PSI) Support Partner for which WSP were awarded. Embedded within TfL's engineering organisation, our role was to define how the system is to be migrated from today's railway to the end state and ensure that the assets being procured will function as a single system that deliver the benefits and outcomes defined in the business case.

To supplement the SI:D[3] framework, WSP can also use its expertise in STPA[24] (System-Theoretic Process Analysis). STPA is a new hazard analysis that includes new causal factors that are not handled by traditional techniques such as HAZOP, FMEA, and FTA[25]. These causal factors emerge from the interactions in and between today's more complex, software-intensive sociotechnical systems. With STPA, we provide a structured, systemic and systematic method to identify design and software requirements, component interaction and cognitive human requirements, as well as social, organisational and management requirements.

STPA is being promoted in both the rail and road industry. Examples of the application of STPA in high speed rail can be drawn from Japan[26],[27], China[28] and the United States[29]. In the UK, STPA has been introduced by the Institution of Railway Signal Engineers[30] as a powerful hazard analysis for the extraction of residual risks in sophisticated and complex signalling systems. In a peer-reviewed paper published in the Safety and Reliability Journal, Dunsford and Chatzimichailidou (2020)[31] discuss how STPA can be used in the application of the Common Safety Method on Risk Evaluation and Assessment (CSM-RA), which is a regulatory risk management framework used in the UK and EU member states when undertaking engineering, operational and organisational changes to the railway.

In the automotive sector, General Motors has been leading the way in incorporating STPA into standards[32] and aligning it with regulatory recommendations[33] Likewise, Continental have been using STPA in compliance with ISO 26262 'Road vehicles – Functional safety'[34] in order to develop safe functional architectures for fully automated vehicles[35]. ISO 26262 is an international standard for functional safety of electrical and/or electronic systems that are installed in serial production road vehicles.

Most recently, we at WSP have used STPA to develop a standardised and customisable tool for performing interface hazard analysis on technologically advanced systems operated by National Highways. STPA provides us with confidence that hazards have been identified in a systematic and comprehensive manner looking at the end-to-end chain of functions involved. It also enables identification and allocation of safety requirements to mitigate identified hazards and gives confidence that safety risk from the introduction of new technology operations is understood and managed and that safety objectives can be achieved.

24 Ross Dunsford and Mikela Chatzimichailidou, "Introducing a system theoretic framework for safety in the rail sector: supplementing CSM-RA with STPA," Safety and Reliability, January 14, 2020

25 Andrew Dawson et al., "Assessment of the Utility and Efficacy of Hazard Analysis Methods for the Prioritization of Critical Digital Assets for Nuclear Power Cyber Security," U.S. Department of Energy, May 1, 2015

26 Yusuke Takano et al., "Application and extension of STAMP/STPA to Railway Signalling System," Japan STAMP Workshop November 27, 2017

27 Upvinder Singh, "New Safety Analysis Method as a Combination of STAMP & FTA," University of Tokyo, July 22, 2020

28 Li Chenling, "Using STAMP to analysis Chinese High Speed Railway Accident --7.23 Yong-wen Railway Accident," MIT STAMP Workshop, July 23, 2011

29 Soshi Kawakami, "Application of STAMP to Risk Analysis of High-speed Rail Project Management in the US," MIT STAMP Workshop, December 5, 2014

30 Yuji Hirao, "Techniques at the forefront of system safety and their application to railway signalling," Institution of Railway Signal Engineers News, June 16, 2020

31 Ross Dunsford and Mikela Chatzimichailidou, "Introducing a system theoretic framework for safety in the rail sector: supplementing CSM-RA with STPA," Safety and Reliability, January 14, 2020

32 Mark A. Vernacchia, "Introducing STAMP/STPA Tools into Standards," MIT STAMP Workshop, March 27, 2018

33 Shawn A. Cook et al., "Building Behavioral Competency into STPA Process Models for Automated Driving Systems," MIT STAMP Workshop, March 27, 2018

34 Asim Abdulkhaleq and Daniel Lammering, "Using STPA in Compliance with ISO26262," Automotive-Safety and Security 2017, May 31, 2017

35 Asim Abdulkhaleq et al., "A Systematic Approach Based on STPA for Developing a Dependable Architecture for Fully Automated Driving Vehicles," Procedia Engineering, September 13-15, 2016

Related WSP Capabilities

Automation has a notable impact on transport. Designing connected systems requires a holistic perspective that enables understanding of system interdependencies and coordination of changes to create and maintain safe interfaces between users, vehicles (i.e. cars or trains) and infrastructure. Moving toward zero deaths and serious injuries necessitates this shared all-inclusive, cooperative approach among multiple stakeholders that share the responsibility for traffic safety. This perspective is in alignment with both our WSP systems-thinking approach to managing complexity and our future mobility initiative.

While systems-thinking and future mobility are enabled by technology, they are about people and places and how they can adapt to future realities, challenges and stresses. These practices foster vigilance and prepare organizations and communities for the future we are anticipating as understood though the WSP Future Ready[36] programme.

"The WSP Systems Engineering, Integration and Assurance Group (SEIA) creates integrated solutions that support and advance safety; a holistic approach and proven methodologies deliver benefits, value and confidence to clients and all stakeholders throughout the project lifecycle.

We aim to bring clarity and provide assurance amidst an evermore complex environment brought by digitisation and the transition to smart, connected systems. Turning challenges into opportunities for clients demands the systems-thinking and structured working methods that we continue to apply, building on our experience from an array of projects and programmes around the world."

Paul Quintavalle, Group Director, SEIA, WSP in the UK

"Future mobility is at the heart of the Future Ready advice we provide to our clients. We look at the significant technology and behaviour changes in the transport sector and put these developments along with net zero carbon thinking at the heart of tailored transport and mobility strategies, policies, plans and schemes.

We set ourselves apart by taking a human-centric approach to all aspects of mobility—planning for the needs of everyone in society."

Rachel Skinner, Head of Transport, WSP in the UK

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