Advanced Non-Destructive Testing Methods for Automotive Components

Ensure faster and more accurate safety assessments already during the development cycle

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White paper

Abstract

The rapid integration of advanced technologies in automobiles and automotive components has dramatically increased pressure on vehicle and original equipment manufacturers (OEMs) to speed the development process for new vehicles. In this environment, the demand for efficient, accurate and cost-effective testing of prototype vehicles and components is resulting in a greater emphasis on virtual simulations based on finite element analysis (FEA) principles and non-destructive component testing. It is also leading to the development of state-of-the-art non-destructive component testing solutions that can more accurately simulate the effect of full-scale crash testing, thereby reducing development time as well as the expense associated with such testing.

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About the TÜV SÜD experts

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With TÜV SÜD since 2004, Michal has worked for the past three years managing physical simulation testing of side impact crashes in TÜV SÜD's dynamic component testing laboratory. During this time, he was involved in the development of the side crash test rig and various other testing procedures. Michal also received his engineering education at the Czech Technical University in Prague, where he is currently pursuing his Ph.D.

Vehicular safety: a continuing journey

Over the past 60 years, significant advancements in safety technologies have contributed to steady declines in fatality rates connected with motor vehicles. The introduction of structural innovations like deformable zones in the vehicle structure and the addition of critical safety components like seat belts and air bags have made important contributions to overall vehicle safety and have saved countless lives. As a result, even as our dependence on vehicular travel has grown and the total miles travelled has dramatically increased, automobiles are safer than ever before.

Nonetheless, the automotive industry continues to actively address vehicular safety in the 21st century. For example, in recent years, regulators around the world are seeing increases in the number of motor vehicle accidents and fatalities. In many instances, the causes for these increases can be attributed to poor driver behaviours, such as texting while driving, driving while under the influence of alcohol or other substances, and the failure to properly utilize essential automotive safety equipment like seatbelts. Although it is impossible to completely protect drivers and passengers from their own negligent behaviours, automotive manufacturers are continuously exploring new ways to integrate systems and features that help reduce the likelihood that such behaviours will lead to catastrophic consequences.

At the same time, the advent of the autonomous vehicle presents a new set of safety challenges to the automotive industry, as well as new opportunities to improve vehicular safety. Indeed, the potential for truly autonomous vehicular travel greatly expands traditional safety parameters. In addition to evaluating vehicle structural designs and safety components for use under previously unenvisioned operating conditions, manufacturers are now investigating the safety and effectiveness of new systems and components required to detect and react in real-time to road conditions and hazards, as well as establishing defences against malicious cyber attacks against onboard vehicular systems.

Finally, ongoing testing and research is providing automotive manufacturers with greater insight into how new and existing safety systems and components actually perform in vehicular crash conditions. This research, often supplemented by assessments of testing data collected from simulated crashes, gives manufacturers concrete evidence regarding the effectiveness of current safety technologies and clues about modifications that could lead to improved safety results. Testing also provides an effective tool to evaluate prototype safety systems and components under simulated conditions, thereby helping to ensure their effectiveness in the real world.

New safety challenges but also the opportunity to improve safety arise with the development of autonomous vehicles.

Required safety testing during the vehicle development cycle

Testing of critical safety-related parameters during the product development cycle of new vehicles has been a requirement for automotive manufacturers since the late 1970s. At that time, the U.S. National Highway Traffic Safety Administration (NHTSA) established the world's first new car assessment program (NCAP) in response to legislation intended to encourage automotive manufacturers to build safer vehicles. Under the NHTSA's NCAP, new car models receive a safety rating based on the results of pre-market testing of critical safety parameters. The vehicle's NCAP safety rating is then posted on the vehicle's sales sticker to provide consumers with information on the vehicle's overall safety profile.

Since then, NCAPs have been adopted by many other automotive industry programmes around the world. These include the European New Car Assessment Programme (Euro NCAP), Japan's New Car Assessment Programme (JNCAP) and the China New Car Assessment Programme (C-NCAP), as well as comparable programmes in Korea, India, Latin America and Australia/ New Zealand. The Euro NCAP is modelled after NHTSA's NCAP, while other programs are complementary in structure, but not necessarily identical in terms of specific testing requirements.

In general, NCAPs require manufacturers to conduct a pre-market evaluation of the safety-critical aspects of new vehicles, including the testing of some or all of the following systems or components:

- Frontal crash protection
- Side barrier crash protection
- Side pole crash protection
- Rear view video system
- Blind spot detection
- Lane departure warning system
- Lane keep assistance system
- Forward collision warning system
- Automatic emergency braking system
- Crash avoidance systems

In addition to safety testing generally required under NCAPs, most jurisdictions around the world are participants in the United Nation's World Forum for Harmonisation of Vehicle Regulations, which operates under the auspices of the Sustainable Transport Division of the UN's Economic Commission for Europe (UNECE). Working Party (WP) 29 of the Forum, formally known as the Working Party of experts on technical requirements of vehicles, is charged with creating unified automotive standards and regulations to facilitate international trade.

OEMs and suppliers face the challenge to simplify the process of ensuring safety compliance.

At present, there are more than 100 separate regulations under the scope of the UNECE applicable to passenger cars, covering vehicle safety, energy efficiency, theft resistance and environmental issues. Some of the UNECE regulations directly applicable to vehicle passive safety include:

- R11 – door latches and door retention components
- R14 – safety belt anchorages
- R16 – safety belts and restraint systems
- R17 – seats, seat anchorages, head restraints
- R21 – interior fitments
- R44 – child restraint systems
- R80 – strength of seats and anchorages
- R94 – frontal collision protection
- R95 – lateral collision protection
- R129 – enhanced child restraint systems
- R135 – pole side impact
- R137 – frontal impact with focus on restraint systems

In addition to NCAP and UNECE requirements and regulations, vehicle and vehicle component manufacturers may be subject to additional, pre-market safety testing in some jurisdictions. This further complicates the challenge for global manufacturers seeking to simplify the process of ensuring compliance with applicable safety requirements, especially when many manufacturers are also simultaneously attempting to introduce new and innovative automotive safety systems and components.

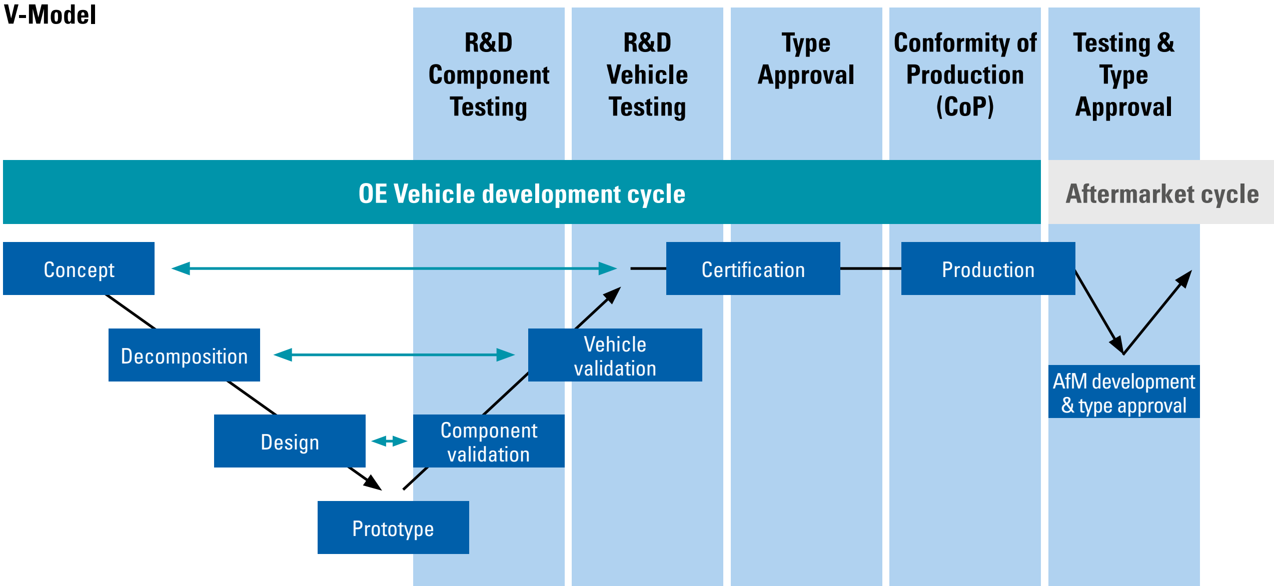
The use of non-destructive testing (NDT) techniques in safety validation testing of automotive components

Aside from demonstrating compliance with safety requirements and regulations, safety testing during the product development cycle can be an effective way to actually shorten the time required to bring new and innovative vehicle safety technologies to market. Today, pre-market testing utilising advanced, non-destructive testing techniques can facilitate the use of virtual simulations based on finite element modelling principles. This approach to non-destructive testing allows manufacturers to evaluate multiple real-world scenarios to improve the accuracy and predictability of automotive safety systems and component performance.

While not completely eliminating the need for real vehicle crash simulations, the use of non-destructive testing techniques can reduce the dependence on whole-vehicle crash testing to generate critical safety data, thereby helping to curb the overall cost of testing. Non-destructive testing can also significantly reduce the total time required for testing, making safety testing more efficient and less time-consuming.

NON-DESTRUCTIVE TESTING (NDT) TECHNIQUES SUPPORT CUSTOMERS ON EVERY STAGE OF THE PRODUCT LIFE-CYCLE

V-Model



Non-destructive testing provides multiple benefits for automotive manufacturers and suppliers.

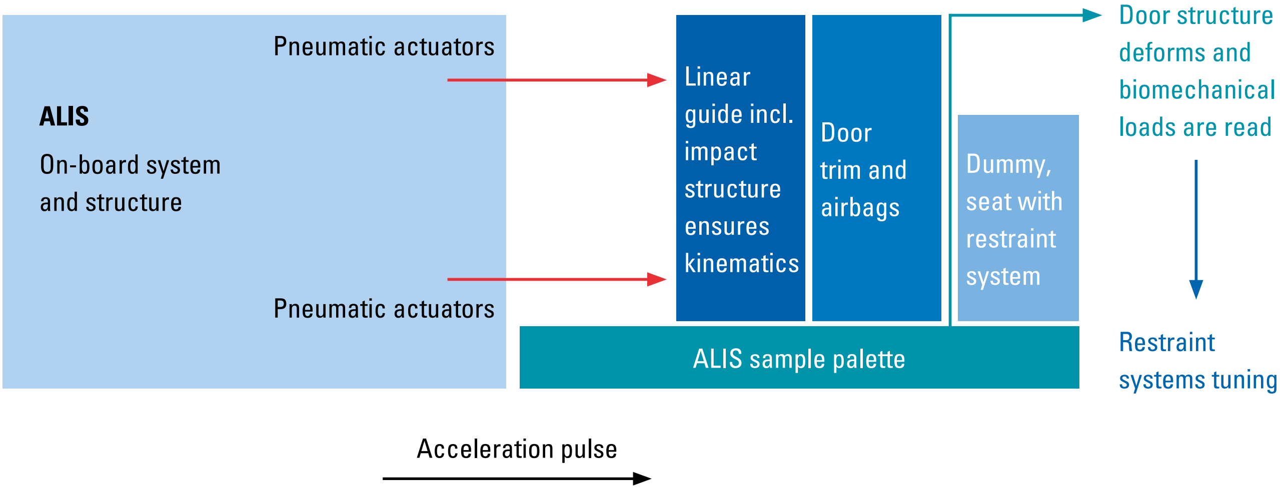
Dynamic component testing (DYCOT) is a specialized non-destructive testing technique specifically applicable to automotive systems and components. Instead of requiring whole-vehicle testing, DYCOT allows for the testing of individual systems and components. This approach enables manufacturers to evaluate safety and performance aspects of key interior parts, including seats, safety belts and head restraints during the earliest stages of new product development.
Testing data collected through DYCOT can be used to assess the performance of individual components in combination with a wide range of alternative systems and components. This enables OEMs and component manufacturers to proactively refine and modify component designs well in advance of whole vehicle testing. DYCOT also provides substantive data in support of component validation efforts and, ultimately, type approval, certification and other forms of recognition as required by vehicle manufacturers and regulatory authorities.

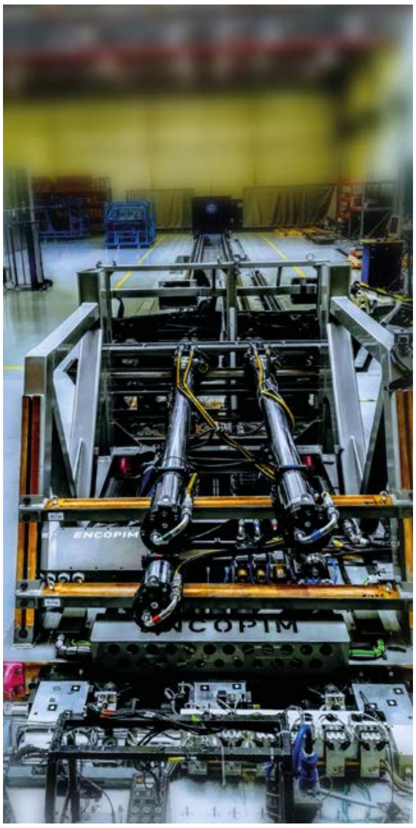
Recent advances in non-destructive component testing

As previously noted, data from ongoing research into vehicle crashes often identifies safety aspects of vehicle design that may benefit from more rigorous oversight and regulation. Examples of this include potential safety issues associated with side impact collisions, in which some studies using finite element modelling have determined that brain stress due to lateral impact is significantly greater than the same pressure applied through frontal impact. Responding to these and similar findings, the UNECE and a number of NCAPs and regulators now include lateral impact safety requirements applicable to vehicle safety systems and components.

To keep pace with these and other changes, innovative non-destructive DYCOT technologies are now being introduced to facilitate required

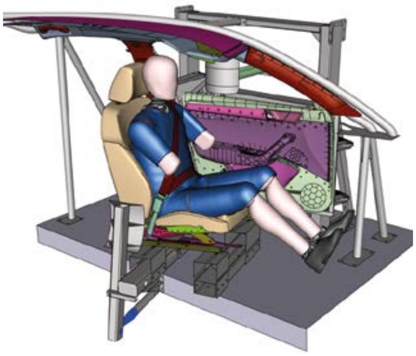
SET-UP OF THE ACTIVE LATERAL INTRUSION SIMULATION (ALIS) TEST BENCH





assessments of automotive safety systems and components. In the area of safety related to side impact collisions, active lateral intrusion simulation (ALIS) testing systems are available to assess the performance of critical vehicle safety components in physical simulations of side impact crashes. These advanced, non-destructive DYCOT systems can be particularly useful in evaluating the performance of passenger restraint systems including frontal and side airbags.

ALIS testing systems utilize a sled catapult device as well as separate pneumatic/hydraulic actuators that simulate the crucial aspects of the side collision impacts, such as an intrusion of the side vehicle structure into the occupant space. Entire systems are designed and carefully controlled by computer-generated simulation software based on finite element mathematical models.
The Finite Element Analysis (FEA) support is an integral part of vehicle development projects with the ALIS system. A virtual image of sled tests provides a comprehensive insight into the problems of the system set-up and helps to achieve maximum efficiency of the tests.



Multiple displacement actuators can be applied in a wide range of configurations along the side of the facsimile vehicle under test, allowing technicians to simultaneously evaluate the results of simulated side and pole impact for both front and rear passengers. Initial testing results can be used to refine ALIS simulation testing parameters in real-time to optimise the accuracy of the overall testing process.

Active Lateral Intrusion Simulation (ALIS) system is a unique, state-of-the-art technology for non-destructive physical simulation of side crashes.

By subjecting interior safety components to side impact testing using ALIS systems during the earliest stages of the product development process, component manufacturers can more effectively capture and measure the unique variables that characterize the safety performance of their components under real-world conditions. Further, they can assess how their products perform when integrated with other safety components and features, providing a more comprehensive and realistic assessment of passenger safety. Data collected through ALIS testing can then be used to modify safety component designs to optimize their performance in the context of side impact collisions.

Your benefits of conducting non-destructive automotive component testing with TÜV SÜD

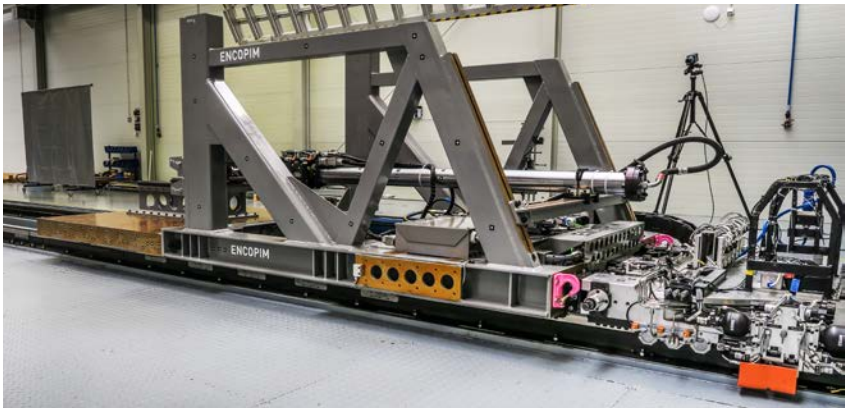
TÜV SÜD's DYCOT testing laboratory in the Czech Republic is equipped with the most advanced equipment for the non-destructive testing of automotive structures and components. Most recently, the laboratory has made significant investments in advanced DYCOT technologies from industry-leading developers of testing systems and equipment, including Imaging Systems Technology (IST) for the catapult and ENCOPIM for ALIS. Our newest programmable ALIS testing system was expressly developed for TÜV SÜD to effectively simulate the impact on vehicle safety components from lateral impact, in accordance with NCAP and UNECE requirements and purchasing specifications of vehicle manufacturers.
These enhanced testing capabilities enable TÜV SÜD to provide automotive manufacturers with a single source for virtual and physical testing of vehicle systems and components. In addition, TÜV SÜD's DYCOT testing laboratory is ISO/IEC 17025 accredited, while also meeting the requirements of the Trusted Information Security Assessment Exchange (TISAX) for the secure handling of automotive prototypes.

TÜV SÜD's DYCOT laboratory offers full support throughout the whole vehicle development process.

TÜV SÜD has more than a century of vehicle safety testing and certification experience.
Our extensive knowledge and international reputation enables us to work as a partner with our global customers, including the leading OEMs and automotive suppliers. Our state-of-the-art testing facilities, combined with our extended network of technical experts, can provide your company with a single-source solution for achieving compliance with all applicable regulatory requirements and standards and voluntary industry schemes for automotive structures and components. Furthermore, we are directly involved in the development of safety regulations, standards and efficient automotive testing solutions to drive the future of mobility.

Conclusion

For the automotive industry, working to ensure the safety of drivers and passengers is a never-ending pursuit that requires continuous focus and innovation. Non-destructive testing of critical vehicle safety systems and components is an important tool in the effort to introduce advanced safety functions and features to the market in a timely and cost-effective manner.
The deployment of new and advanced non-destructive testing systems, such as ALIS testing systems, is essential to keep pace with the today's automotive safety innovations, and to help vehicle systems and component manufacturers meet the demands of industry, regulators and the general public in their quest for increased vehicle safety and quicker market access.



Appendix 1

Technical Parameters of the DYCOT test catapult at the TÜV SÜD laboratory in Czech Republic

INSTRON CSA ADVANCED CATAPULT
▪ Max force 2.5 MN
▪ Max acceleration 90 G at 1000 kg / 35G at 5000 kg
▪ Max decceleration -35 G at 800 kg
▪ Max Speed 100 kph
▪ Max gradient 14 G/ms
▪ Low G simulation 5-12 G
▪ Repeatability 0.5 kph or 1 G
▪ Working stroke 1.7 m
▪ Sled pallet 3.5 x 1.8 m
▪ Pulse iteration within 3 shots
▪ System expandable to Dynamic Pitching Motion

PERIPHERALS
▪ Hybrid III 5%, 50% and 95% with Kistler in-dummy DTI
▪ World SID 50% with Kistler in-dummy DTI
▪ Q1.5 / Q3 / Q6 and Q10 dummies
▪ AICON dummy positioning system
▪ Kistler KiDAU & Kistler sensor equipment
▪ High speed cameras HS Vision (PCO) 1600 x 1200 pix. @ > 2000 fps
▪ LED technology HS Vision, synchronised with cameras
▪ 3D static and 3D dynamic photogrammetry

Appendix 2

Technical Parameters of the ALIS test catapult at the TÜV SÜD laboratory in Czech Republic

TECHNICAL FEATURES OF ALIS
▪ ALIS – **A**ctive **L**ateral **I**ntrusion **S**imulation
▪ ALIS designed by ENCOPIM, Barcelona
▪ Structure deformation before and during sled movement
▪ Independent control of cylinders
▪ Full synchronisation between cylinders and also with sled system
▪ Cylinder mounts allows for front and rear seat simultaneous barrier test
▪ Driver and passenger loaded simultaneously – unique feature
▪ Up to 6 hydraulic cylinders, up to 120 kN
▪ Virtual simulation support
▪ Real close-loop velocity and position control system
▪ Improvement and accerleration deviations at each iteration
▪ Non-predictable contact forces real-time reaction
▪ Linear guide structure avoids inappropriate forces to the cylinder for better control

GLOSSARY OF ACRONYMS

ALIS – Active Lateral Intrusion Simulation
C-NCAP – China New Car Assessment Program
DYCOT – Dynamic Component Testing
Euro NCAP – European New Car Assessment Program
FEA – Finite Element Analysis
IST – Imaging Systems Technology
JNCAP – Japan's New Car Assessment Program
NCAP – New Car Assessment Program
NDT – Non-Destructive Testing
NHTSA – National Highway Traffic Safety Administration
OEM – Original Equipment Manufacturers
TISAX – Trusted Information Security Assessment Exchange
UNECE – United Nations Economic Commission for Europe
WP – Working Party

FOOTNOTES

[1] "USDOT Releases 2016 Fatal Traffic Crash Data," National Highway Traffic Safety Administration, U.S. Department of Transportation, October 6, 2017. Available at https://www.nhtsa.gov/press-releases/usdot-releases-2016-fatal-traffic-crash-data

[2] "Comparison of Brain Responses Between Frontal and Lateral Impacts by Finite Element Modeling," Journal of Neurotrauma, February 2001. Abstract available at https://www.researchgate.net/publication/12131424_Comparison_of_Brain_Responses_Between_Frontal_and_Lateral_Impacts_by_Finite_Element_Modeling

Find out more about TÜV SÜD's non-destructive dynamic component testing

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Add value. Inspire trust.
TÜV SÜD is a trusted partner of choice for safety, security and sustainability solutions. It specialises in testing, certification, auditing and advisory services. Since 1866, the company has remained committed to its purpose of enabling progress by protecting people, the environment and assets from technology-related risks. Through more than 24,000 employees across over 1,000 locations, it adds value to customers and partners by enabling market access and managing risks. By anticipating technological developments and facilitating change, TÜV SÜD inspires trust in a physical and digital world to create a safer and more sustainable future.

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