How to Manage Test Capabilities in the Rapidly Evolving Automotive Sector

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Introduction

The automotive industry is undergoing a major upheaval as we move from driver-controlled vehicles through the tiers of Advanced Driver Assistance Systems (ADAS) to the approaching prospect of fully autonomous vehicles. The underlying technology is becoming ever more complex, as additional functionality is integrated, architectures are reinvented and vehicles start to support higher degrees of connectivity. Driving will almost prove to be a secondary aspect in these new intelligent travel spaces that are destined to dominate our roads in the not too distant future.

Advances in automotive engineering must develop a pace in order to deliver vehicles that will meet the needs of tomorrow's consumers - especially in the areas of sensor fusion, power management and artificial intelligence. While the implementation of emerging technologies present design engineers with considerable challenges, it is at the same time also placing great strain on the resources within test departments. Consequently new more sophisticated test strategies may be required to address the automotive revolution that is now upon us.

In this white paper, test sourcing specialist Electro Rent will look at the changes in the automotive sector and the impact that the accelerating rate of innovation that is now being experienced will have on the test function. The document will then explore some of the ways in which vehicle OEMs and their tier 1 suppliers are now partnering with test solutions providers to address the numerous test issues emerging in this sector. In particular it will give a detailed description of the consultative approach taken by Electro Rent and how the company is proving itself to be invaluable when it comes to advising on the best way for automotive engineers to access and manage the test technology with radical cost benefits.


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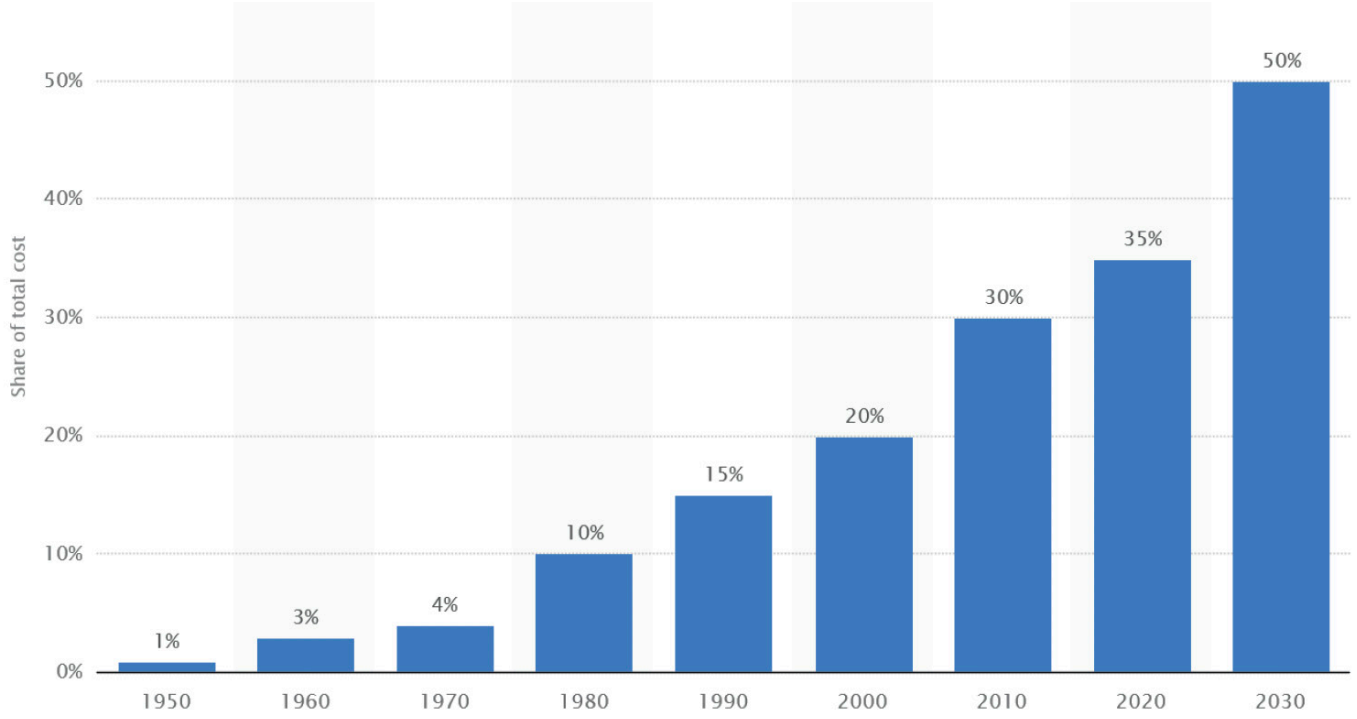
Automotive innovation - the road ahead

Clearly, fully autonomous vehicles is one the primary long term objectives of the automobile industry. This journey began some years ago as more electronics started to be added to vehicles, mostly as separate modules that provided additional features and functionality. In more recent times OEMs have looked to replace outdated mechanical functionality in vehicles with new solid-state electronic systems - thus reducing vehicle weight (and thereby raising fuel economy levels) as well as improving overall reliability. These significant advances mean that today's vehicle models have computing and processing capabilities way beyond what would have been found in the past in large mainframe computers.

The migration already being witnessed towards greater electrification and semi-autonomous driving runs the full gamut of vehicles. Not just the high-specification luxury models, but their lower end economy versions too. Even commercial, construction and agricultural vehicles are becoming more automated, efficient and safer through the introduction of new electronic systems. No matter whether the drivetrain is based upon the internal combustion engine or one of the newer Electric Vehicle (EV) or Hybrid Electric Vehicle (HEV) types, electronic content is proliferating and will continue to do so. In fact, according to Statista, the electronics content in an average car is now around one third of its total cost, and this is predicted to grow to nearly half over the course of the next decade.



Automotive innovation - the road ahead

Through increasing the electronic content in vehicles it will be possible to shift more of the responsibility for decision-making from the human driver to the vehicle itself. While some see this as a revolution, it is in fact a process of evolution. In the United States the Society of Automotive Engineers (SAE) have mapped out the path towards full vehicle autonomy and defined each of the key stages in the journey.

Each of the stages outlined in SAE J3016 shows how the key functions of piloting a vehicle will be deferred to the vehicle and its systems. We are already some way along this path, with many vehicles being produced today already at either SAE Level 1 or Level 2.

SAE level	Name	Narrative Definition	Execution of Steering and Acceleration/ Deceleration	*Monitoring* of Driving Environment	Fallback Performance of *Dynamic Driving Task*	System Capability *(Driving Modes)*
***Human driver* monitors the driving environment**						
0	No Automation	the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a
1	Driver Assistance	the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	Human driver and system	Human driver	Human driver	Some driving modes
2	Partial Automation	the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/ deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	**System**	Human driver	Human driver	Some driving modes
***Automated driving system* ("system") monitors the driving environment**						
3	Conditional Automation	the *driving mode*-specific performance by an *automated driving system* of all aspects of the dynamic driving task with the expectation that the *human driver* will respond appropriately to a *request to intervene*	System	**System**	Human driver	Some driving modes
4	High Automation	the *driving mode*-specific performance by an automated driving system of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a *request to intervene*	System	System	**System**	Some driving modes
5	Full Automation	the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*	System	System	System	**All driving modes**

The implications for automotive test

While the changes that the automotive industry faces will be of radical nature and the timeframes relatively short, the steps involved are all very well defined. Nevertheless, there remains a significant amount of uncertainty within the industry. Firstly, there is little definition or understanding of the technical issues that lie ahead. Despite the huge amount of manpower and financial resources being dedicated to developing the vehicles of the future, the industry will, almost certainly, be on the receiving end of some unexpected challenges.

If we turn to the industry analysts and commentators for certainty, we will be disappointed. Depending on which column you read, you could be convinced that fully autonomous motoring is just around the corner - or conversely that it is many years away. Even governments are defining policies, such as the recent pronouncement by the UK government that, by 2040, all new cars sold in the UK will be electric, with seemingly little consideration for what the consequences might be (such as whether the supporting infrastructure needed to support such a move will actually be in place by that time). One of the areas where we can be certain of at least a few things is automotive test. As new technologies emerge, so test strategies must be developed accordingly. In some cases, this may mean a reconfiguration of existing facilities or perhaps an upgrading of equipment to items that can measure faster or more accurately. In other cases, it may be a completely new function that requires a different type of instrumentation to be introduced to the mix.

The pace of change and lack of visibility regarding which technologies might be adopted are going to drive an unprecedented need for automotive test departments to react quicker and become far more flexible. Equipment is likely to become defunct earlier in its lifecycle, meaning that budget-constrained test engineers will need new strategies to address the often-competing goals of getting the job done and still appreciating the associated financial factors.

The wide range of technologies (including power management and control, high data rate communication busses, wireless connectivity and sensing technologies) employed in modern vehicles will only serve to add to the pressures involved. In the next section we will take a look at some of the main areas for testing as well as giving some examples of market-leading test equipment available that relates to each of these areas.

Electrical powertrain: Especially relevant to HEV and EV, managing the efficient use of power from the battery string will become a key competitive advantage for vehicle manufacturers. The complex vehicle power system will include DC-DC converters that supply different parts of the vehicle, as well as systems to recover energy from braking, ensuring that all available energy is directed towards increasing the range that the vehicle can travel before it needs to be recharged.

The implications for automotive test

To meet these test criteria, Electro Rent offers the WT series of power analysers from Yokogawa as one option. The new WT3000E offers the highest precision within the series at 0.01% of reading; the high currents present in today's vehicles are easily accommodated via the ability to use external current sensors. The Newtons4th PPA5530 three-phase precision power analyser offers class leading wideband accuracy (10mHz to 2MHz and DC) and a fast sample rate of 2.2MSample/s. To synthesise power feeds during the testing process, Keysight's N8900 series of high power single output autoranging DC power supplies is also available from Electro Rent. These highly flexible units offer a choice of 5kW, 10kW and 15kW of power with the autoranging delivering a wide range of voltage and current combinations at full power.

Not only do these items of test equipment support the development of on-board power architectures, they are invaluable in the testing of external charging points such as those found in residential use as well as the infrastructure that will grow in parallel with the rising consumer uptake of EVs.

In-vehicle networking: As vehicles move towards full autonomy, no longer can the electronic systems be a collection of disparate functional modules. In order to provide the intelligence and perception required to approach human awareness, each of these functions has to combine into a single ultra-intelligent system. As many of the functions involved are safety-critical (such as ADAS obstacle detection) then ultra-low latency within the system will be mandated.

In-vehicle networking is coming to the forefront and traditional automotive busses such as CAN-FD, LIN, FlexRAY and MOST are being augmented with other technologies such as Ethernet. High-speed busses in turn need high-speed test capability. The InfiniiVision 6000 X-Series of oscilloscopes from Keysight includes both digital and mixed signal models with bandwidths up to 6GHz and a 450,000wfms/s update rate that makes even the smallest signal details visible. The zero touch triggering function allows signals to be isolated in seconds and multi-language hands-free control provides heightened operator convenience.

The N8900 Series of Autoranging DC Power Supplies from Keysight Technologies

The implications for automotive test

The ZNB vector network analyser from Rohde & Schwarz sets new benchmarks for measurement speed, precision and ease of operation. The long-term temperature stability provides for long calibration intervals, thereby reducing operating costs for test departments. These versatile units measure frequencies up to 40GHz with 140dB of dynamic range and temperature stability of 0.01dB/°C.

Another useful instrument is the DL850EV scopecorder from Yokogawa, which combines a mixed signal oscilloscope with a portable data acquisition recorder to allow the capture of both high-speed transients and low-speed trends. Swappable CAN and LIN bus input modules make this unit highly optimised for multi-standard in-vehicle network testing.

Communications: Until recently, the communication functionality within vehicles were limited to the infotainment and satellite navigation systems. However, transformations are under way - with the prospect of vehicles becoming connected to the infrastructure of smart cities, so they can receive information about vacant parking spaces or delays on their proposed route due to an accident or traffic jams. This connectivity will also allow municipal authorities to monitor traffic flow and make adjustments to minimise congestion or pollution at peak times.

In addition to the vehicle-to-infrastructure (V2I) communication just described, in the future vehicles will also be able to communicate with each other via vehicle-to-vehicle (V2V) communication. This will enable one vehicle to broadcast its intention to leave a road lane or arrive at an intersection, thereby significantly reducing the risk of collisions occurring. Likewise, details of traffic issues (such as an unexpected obstacle ahead) will be passed between vehicles so as to make them aware of them in advance.

Modern vehicles are already allowing passengers to connect via their smart devices, giving them access to applications that can make journeys easier and smoother (especially in relation to younger passengers). Ongoing proliferation of communications within vehicles will lead to multiple protocols (such as WLAN, Bluetooth and NFC) being implemented in the vehicle itself with mobile protocols (such as LTE and LTE-Advanced) being used for communications with other vehicles and the local environment.

Assessing equipment for compliance to the various communications standards will require a range of test equipment and Electro Rent offers a number of instruments from leading suppliers. Keysight's N5181B MXG X-Series of RF analogue signal generators can provide signals from 9kHz to 6GHz as well as offering industry-leading output power. In-vehicle receiver performance can be thoroughly tested using these multi-function generator units to simulate complex analogue modulation scenarios.

The implications for automotive test

EMC considerations: As already stated, the amount of electronics in modern vehicles continues to rise. This brings two particular challenges with it relating to electro-magnetic compatibility (EMC); the amount of radiated energy created by the vehicle and the susceptibility of the sensitive electronics inside the vehicle to externally generated radiation. Fortunately, Electro Rent also has this covered with multiple solutions. The

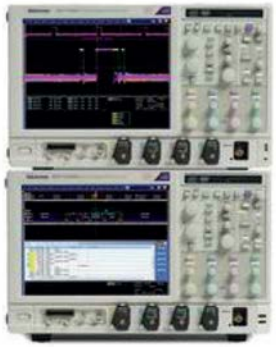
Keysight N9038B MXE EMI receiver has the ability to measure and monitor complex RF and microwave signals, such as EMC emissions from a vehicle, while the N9038A MXE EMI receiver can identify the frequencies of peak emissions prior to final measurement. The Ametek all-in-one multifunctional test generator meets international and vehicle-specific transient and power fail requirements, including EFT/bursts to 5.5kV and surge to 5.0kV. Susceptibility testing can be performed using the Teseq NSG 438 ESD simulator. This handheld device can meet any current automotive OEM's standards yet sits comfortably in the operator's hand and constantly displays operating parameters on a touchscreen.

Sensors: As vehicles need to be more aware of their environment, sensors are become ever more important and, as with any new technology, they require comprehensive testing and verification. GHz-band radar is a key development for vehicles and is also used in infrastructure applications for position sensing and object detection.

A test suite put together to address this function could include the Keysight E8257D PSG analogue signal generator. This offers 1W of power up to frequencies of 67GHz in order to test high power devices, including Doppler radar. Also from Keysight, the N5245B PNA-X microwave network analyser operates up to 50GHz and replaces racks full of equipment with a compact bench-friendly instrument.

The Tektronix MSO73304DX is highly suited to initial research and development use all the way through to production testing. It has the capacity to test high-speed sensing hardware, with a 33GHz bandwidth supported and rise times of just 9ps.

Safety functions: A major goal of the move towards automated vehicles is to increase safety on roads through ADAS. Through such systems it is possible to detect objects such as vehicles or pedestrians, thereby allowing them to be avoided without the need for driver intervention. In order to ensure these operational integrity of ADAS systems as they become increasingly complex, significant testing will be required - often to meet ASIL specification and other safety standards.



The E5071C ENA vector network analyser from Keysight offers high speed serial interconnect measurement up to 20GHz allowing vital sensor connections to be tested thoroughly. Thermal performance is often an issue with electronics often being installed in hard-to-access areas in vehicles, or areas that are exposed to heat from the sun or generated by the vehicle itself. The Fluke Ti200 infrared camera measures temperatures from -20°C to +650°C and incorporates proprietary LaserSharp™ auto focus technology to ensure correct focussing on the desired component.

Time for a test revolution

Accelerating development cycles and continually advancing technologies are putting a significant burden on test departments and their allocated budgets. The out-dated model of simply buying all necessary equipment will only serve to exacerbate the financial strain in these swiftly changing times.

With over 40 years of experience in the test business, Electro Rent is well positioned to provide advice and systems that give users information to make decisions as to what equipment to deploy, how and when as well as help manage it, substantially lowering the cost of test and providing flexibility to change as needed.

It is now recognised that complex, multi-site projects can rarely be served with a ‚one size fits all' approach and Electro Rent therefore offers an array of sourcing options to manage test equipment through the entire lifecycle of a project, from the concept phase on to prototyping, then development and finally to full scale production.
Instrumentation can be sourced through a multitude of different methods - short term renting, longer term leasing, rent-to-buy, brand new equipment, or benefiting from the company's extensive stock of certified pre-owned equipment. Equipment is only sourced for as long as it is of actual use. If a project comes to an end or a new technological advance means that different instrumentation is required, the rented items can be sent back or swapped with high spec units. This means that there are no risks of sourced equipment becoming outdated or that the investment made in them will be wasted. Similarly purchased equipment (whether originally bought new or acquired through the certified pre-owned program) can be sold back to Electro Rent, thereby enabling funds to be made available for sourcing other equipment. Mixing the solutions depending on assessment of needs, whether short-term or long-term, CapEx or OpEx, achieves the greatest savings and efficiencies.

LEO
Asset Management

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Beyond this, Electro Rent can provide a complete asset tracking, auditing and management service to test departments via their Asset Management services including LEO software. This modular platform gives the user complete visibility of their test assets, allowing them to be located in seconds and full details on their status to be accessed. An in-built workflow controls and manages the maintenance, repair and calibration schedules of each specific item of instrumentation, while the ability to monitor the utilisation and performance of assets allows test managers to eliminate unnecessary purchases and make decisions as to whether to sell unused instruments (thereby freeing up storage space and eliminating ongoing operational costs).

Conclusion

The automotive world is moving into a whole new era that will be defined by increasing connectivity, greater levels of electronic content and a progression towards autonomous operation. As a result, technologies are emerging which will broaden the scope of what needs to be tested and verified. To keep up with this within resources available, both financially and logistically, test departments must seek out intelligent and multifaceted solutions to can be tailored to satisfy their particular needs, rather than being forced to make compromises.

By gaining the right information from those with know-how in test management and understanding the many different sourcing options available that test engineers and managers have opportunities for choosing the combinations that prove to be the best fit for their different projects on a case by case basis whilst generating major savings for re-investment. If new technologies need to be supported, then they will have the flexibility to upgrade their instrumentation as required without major monetary outlay being needed. Likewise, if a project moves from prototyping to large scale production, the number of test units can be ramped up to meet the projected demand.

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