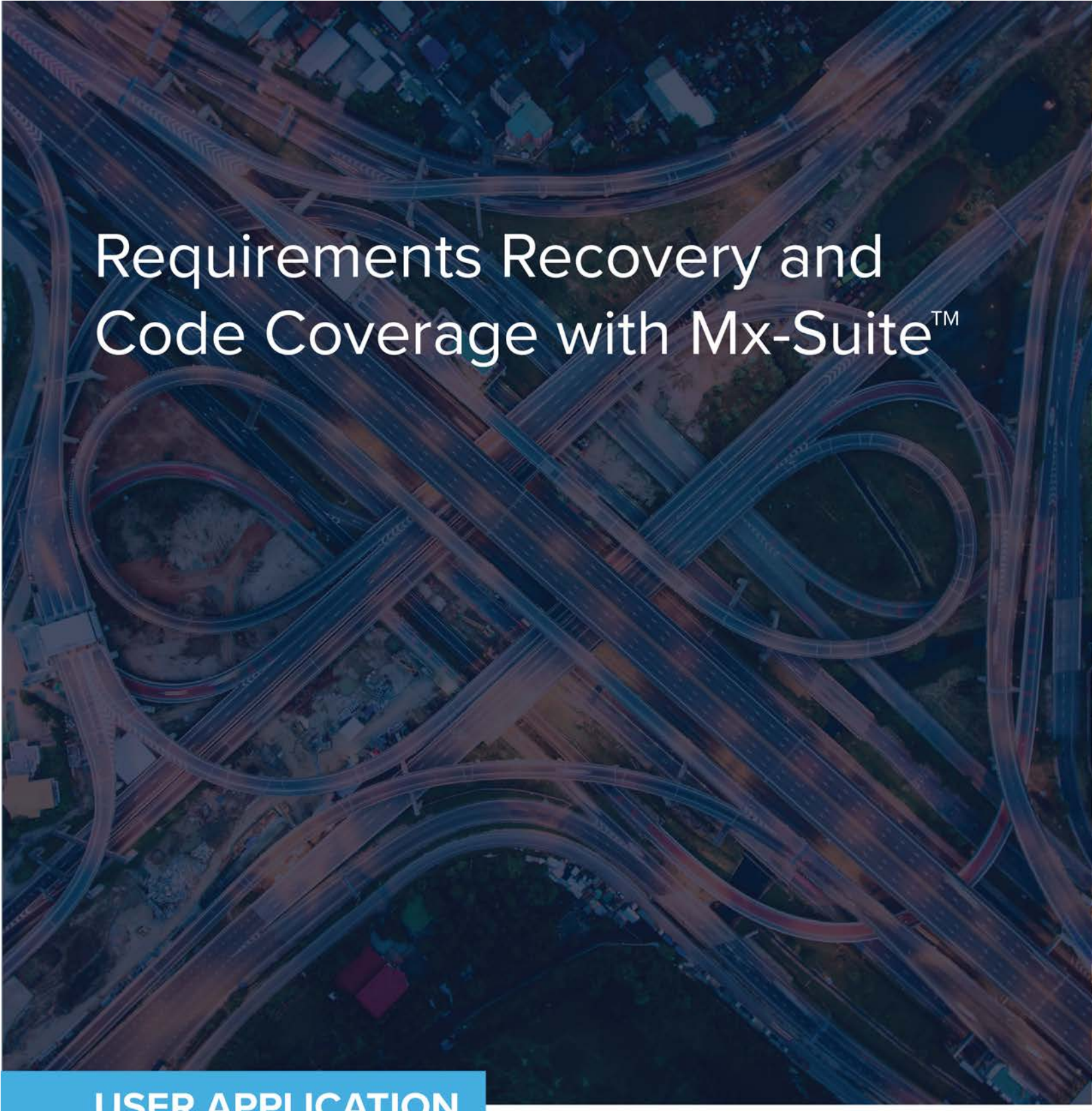


Requirements Recovery and Code Coverage with Mx-Suite™

USER APPLICATION

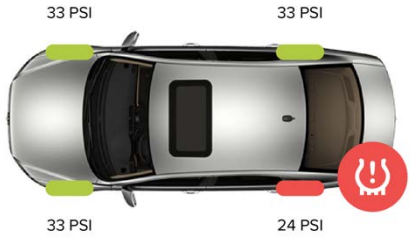
DANLAW®
AUTOMOTIVE MADE SMART

Business Summary

Increasing cost pressure, compressed development timelines, and zero-defect quality requirements imposed by automotive OEMs continue to push the limits of Tier-1 supplier software development processes. In addition to these problems, the complexity and sophistication of automotive electronic control units and their embedded software continues to expand, thus pushing the limits of a supplier's ability to test their software to the quality standards required by today's automotive OEMs. The result of these issues not being managed effectively can lead to warranty claims and eroded customer satisfaction.

Technical Summary

An automotive OEM began having warranty issues with a vehicle's tire pressure monitoring system (TPMS) due to intermittent embedded software failures. The OEM was preparing to issue a product recall and prior to doing so, asked the ECU supplier to provide its engineering and test artifacts in order to perform a quality assessment. Unfortunately for the supplier, a third-party subcontractor was used to develop the software, and did not create documented test cases to provide traceability and code coverage for their deliverable.



Solution - Mx-Suite™ restores OEM's confidence in supplier's development process

Through the use of Danlaw's Mx-Suite, the supplier was able to quickly import the ECU software into a virtual microcontroller on a workstation, generate comprehensive test cases, and measure critical software code coverage, while providing traceability to the OEM's functional requirements. The end result of the supplier's use of Mx-Suite ensured the highest level of software quality, while providing the necessary documentation and test coverage evidence required by the OEM, thus avoiding costly warranty claims and product recalls.

User Application

An automotive OEM deployed a Tire Pressure Monitoring System (TPMS) in a line of luxury vehicles. Development timelines for the launch were compressed and supplier resources were stretched. The supplier in this case was working to expand its business in the TPMS area, and in an attempt to mitigate these issues, the automotive supplier subcontracted the software development. The tight schedule did not allow for full design reviews and the level of comprehensive testing that would normally be performed. Despite lacking these documents, the ECU software passed both bench level testing and field testing. While the TPMS software "passed" testing, unfortunately the subcontractor was unable to provide the requisite design and testing artifacts to substantiate the effectiveness of their efforts. As Murphy's Law would have it, intermittent problems with the TPMS system were being reported by vehicle owners, indicating low tire pressure warnings even though the tires were properly inflated.

Due to the extent of the customer complaints and the perceived impact of a safety critical system such as a TPMS, the OEM was ready to issue a recall, and thus the issue needed to be resolved quickly. The supplier investigated the subcontractor's process and found that several quality steps had been omitted during development. The supplier needed to re-qualify the software and decided to do it independently of the subcontractor.

The OEM mandated that the supplier identify the root-cause of the issue, repair the software defect, and produce traceable evidence that requirements were completely covered by testing. In addition, software-code coverage was required. Since the supplier only had the requirements specification and the source code provided by the subcontractor, the need for recovery of design requirements, test cases and test reports became critical. Ultimately, the supplier needed to solve the dilemma quickly and economically.

Issue Resolution

Mx-Suite was chosen by the supplier because it simplifies the design requirements recovery process. Mx-Suite allows for the import and measurement of production code coverage during testing and has built-in support for traceability.

While other methods and tools were considered, they would have involved expensive electronic equipment, test setups, and skilled test engineers.

The steps to set up and execute the tests were simple: (1) import the production code into Mx-Suite, (2) derive test cases from the requirements, (3) measure the code coverage, (4) update the test cases for additional code coverage, and (5) generate detailed reports, test data, and high level executive test summaries.

One of Mx-Suite's components, "Signal Transforms" managed the complexities of the hardware and software testing process. This component allowed test engineers to create signals and messages to be injected and received for both white and black box testing. Mx-Suite was integrated with BullseyeCoverage, an inexpensive high-quality coverage tool, and was used to provide immediate feedback of how well the tests covered the implementation's code paths.

The Mx-Suite intuitive graphical interface helped engineers to quickly set up the test environment. A software programmer was able to connect the production software to the virtual microcontroller (the simulated ECU environment). This was enabled by a graphical test case framework whereby test cases are written using universally understood engineering conventions. Using Mx-Suite's graphical interface, these test cases were then grouped into functional scenarios, tagged for special reports, and sequenced for execution.

Customer Approach

The supplier used a simple but effective strategy by first proving the code met functional requirements ("positive testing"), followed by more comprehensive negative condition and boundary condition tests ("negative testing"). While positive testing for requirements is a fairly straightforward process, comprehensive negative testing can be a time-consuming effort. To minimize the amount of time and effort required, executed code path measurements and negative test measurements are performed in a coordinated manner.

The supplier performed code path measurements during the positive testing effort, where it was determined that 63% of the code was covered without errors. Negative testing of high-risk areas followed, yielding 89% coverage, however no errors were found. Mx-Suite's ability to inject failures into arbitrary code paths became necessary to uncover the hidden errors in the code base. By systematically reviewing unexecuted code, additional white-box tests were devised to test core code libraries that were thought to be safe by the supplier. Two fault conditions were identified, repaired, and retested. The supplier estimates it would have taken a year or more to perform the analysis testing from scratch. With Mx-Suite, they delivered the results in three to four months with a minimum investment.

Benefits

The investment in time and money needed to provide full-coverage testing is considerably reduced with Mx-Suite. Mx-Suite provides executive summaries, requirements-traceability, code-coverage, and detailed test cases to prove that software is fully tested. The software-in-loop testing framework (consisting of a Windows® PC) can be reused at any time to regression-test future code changes. Mx-Suite allowed the supplier to detect fault conditions that traditional testing had overlooked.

About Danlaw

Danlaw is a leading global supplier of technology and services to the automotive and aerospace industries for safer, smarter, and more secure systems. Thirty years ago, we designed software for the first 8-bit Electronic Engine Control module, and today, we continue to develop forward-looking technologies. Danlaw's engineering professionals provide embedded electronics solutions to OEMs and Tier-1 suppliers. Our team specializes in embedded systems development and testing for Embedded Control Units, vehicle network communications, infotainment, and telematics. With engineering centers in the USA, Europe, India, and China, Danlaw is one of the largest suppliers of connected products, tools, and services in the world.