Developing an integrated safety system for the Indian automotive industry

Systematic Vehicle Safety

The growing number of powerful vehicles on Indian roads is imposing increasingly tough demands on the vehicles' safety. On behalf of the Indian automotive industry and the Ministry of Commerce and Industry, the Automotive Research Association of India (ARAI) is producing a concept for high-performance safety systems, together with a sample process for the model-based development of such systems.

Safety Systems for the Indian Car Market

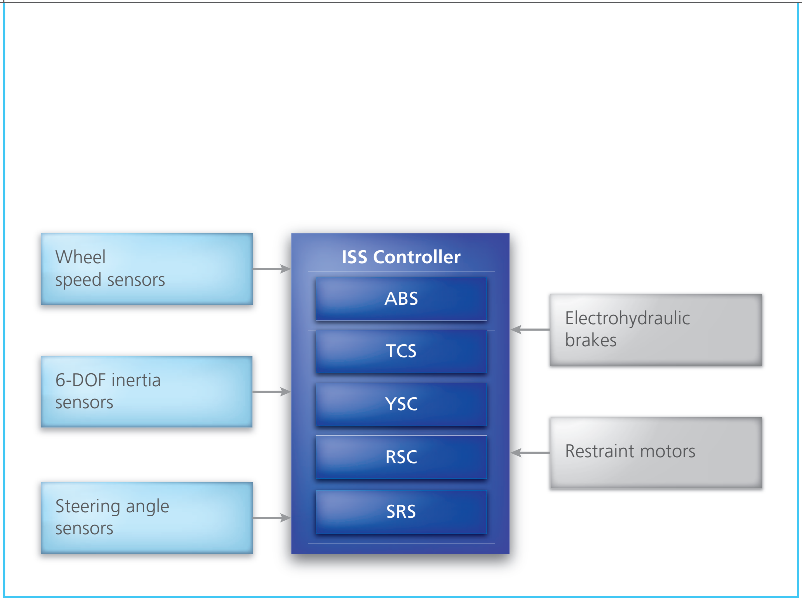
India has one of the largest populations in the world – over 1.2 billion people – and is experiencing a rapid expansion in mobility. The ideal means of transport for many local conditions are pick-ups and sport-utility vehicles (SUVs), large off-road vehicles with powerful engines. ARAI undertook to produce the technical concept and perform proof of concept for developing optimal safety systems for this class of vehicle. The objective of the project was to develop an integrated safety system (ISS) that uses the existing infrastructure of the brake modulator and the integrated sensor cluster in an SUV. The proof of concept involved designing and developing the following functions:

- Electronic stability control (ESC) including an antilock braking system (ABS), traction control system (TCS) and yaw stability control (YSC)
- Roll stability control (RSC)
- Active seat belt restraint system (ASBRS)

Far-Reaching Project Goals

The automotive electronics department (AED) at ARAI performed the kick-off project for an integrated safety system and is making the results available to the Indian automotive industry. Development of the active safety systems was completely model-based and focused on the following project goals:

- Design an integrated, self-developed safety system to be further developed for the Indian market



The integrated safety system (ISS) comprises several safety functions. It evaluates signals from various vehicle sensors and controls the brakes and the belt restraint motors.

- Build expertise in the model-based design of embedded automotive control systems
- Help the auto industry to develop its own solutions for future requirements

New Methods and Tools

Prior to this project, ARAI was using traditional handcoding for controller software. Because the new safety system was of importance to multiple companies, the decision was taken to systematically apply model-based development. This made it necessary to introduce a new, integrated tool chain for model-based development with MATLAB®/Simulink®.

Before starting the project, ARAI thoroughly evaluated various commercially available products for rapid control prototyping (RCP), hardware-in-the-loop (HIL), etc. The developers examined whether each system was suitable for its specific tasks in the new development project and evaluated how well it integrated into the process.

For the rapid control prototyping (RCP) system, ARAI decided to use a combination of MicroAutoBox and RapidPro from dSPACE. The hardware-in-the-loop test station uses a dSPACE Simulator. Together with dSPACE's software tools AutomationDesk® and ControlDesk® Next Generation, these systems form a tool chain that seamlessly supports controller development and electronic control unit (ECU) testing.

Controller Prototyping

After being modeled, the control algorithms have to be tested and optimized on the actual controlled system. This classic RCP task is carried out first in the laboratory and then on a MicroAutoBox in a vehicle. The MicroAutoBox acts as a prototyping ECU which runs the controller models. The RapidPro system adjusts (conditions) the signals to the needs of the controlled system.

Because most parts of the controller model had already been tested by model-in-the-loop (MIL) simulation, it was easy to transfer them to the MicroAutoBox and run them immediately. ControlDesk Next Generation was the central user interface for loading and running models and monitoring signals.

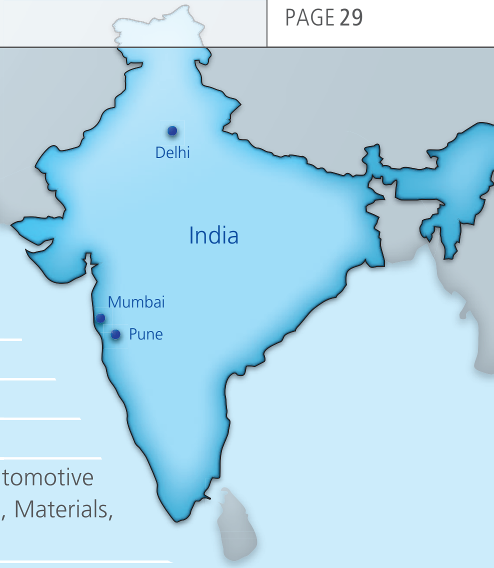
Further Development and Optimization on the HIL Test Rig

This was the first project in the field of chassis control, so a part of the development was performed in an experiment environment in the laboratory. A test rig consisting of real brake hardware and a simulator was set up for this. The ISS model ran on the MicroAutoBox, where it could easily be modified and optimized.

This procedure offers possibilities that MIL simulation does not readily provide. For example, it ensures the precise time behavior of critical components.

The test system was also used to test communications with elementary vehicle components and with actuators and sensors, to detect

The vehicle used to carry out the ISS project and test the developed controllers.



Profile: The Automotive Research Association of India (ARAI)

Established:	1966
Location:	Pune, INDIA (150 km south-east of Mumbai)
Manpower:	More than 530
Facilities:	11 laboratories with a focus on: Emissions, Safety & Homologation, Automotive Electronics, Passive Safety, Vehicle Evaluation, NVH, Structural Dynamics, Materials, Calibration, Post Graduate Academy
Accreditations:	ISO 9001, 14001, OHSAS 18001 & NABL

The Automotive Research Association of India (ARAI) is an industrial research association of the automotive industry in collaboration with the Indian Ministry of Commerce and Industry. The objectives of the association are research and development in the field of automobile construction for industry, product design and development, the evaluation of automotive accessories, standardization, technical information services, courses on using modern technology, and performing special tests. ARAI has been playing a crucial role in ensuring safe, less polluting and more efficient vehicles. The association provides technical expertise in R&D testing, certification, homologation and the framing of vehicular regulations.

> "Because the dSPACE systems were easy to use and very convenient, we were able to concentrate completely on developing the control algorithms."

Arun B. K-omawar, ARAI

errors, and to tackle fundamental calibration tasks. The test sequences can be automated and are completely reproducible, so the controller and the bus communication can be examined and evaluated efficiently and systematically.

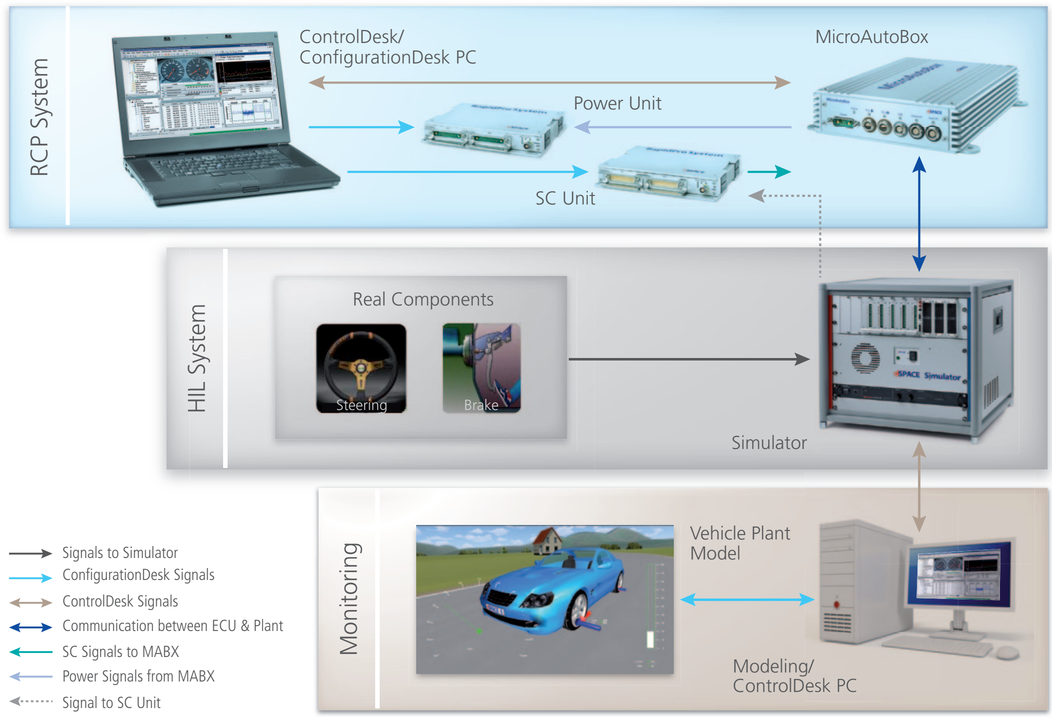
Structure of the Test Rig

The test rig is made up of a simulator and real components. The simulator, consisting of a dSPACE Simulator Mid-Size configuration with a quad-core DS1006 Processor Board combined with DS2202 and DS2211 HIL I/O Boards, runs a vehicle model to test its vehicle dynamics behavior. The real components are the vehicle's actual brake assembly including the tandem master cylinder (TMC), brake booster, hydraulic modulator, vacuum pump, control pedals, steering wheel and gear selector. The rig also houses power drivers to drive the pump motor and the modulator. The overall rig replicates the braking system of the vehicle and provides a human-machine interface (HMI) for realistic chassis control development. The HMI essentially comprises the real pedals, the ControlDesk experiment software, and a real-time visualization of the simulated vehicle. The target vehicle has a manual transmission, so the selected gears are simulated by a position switch. The steering is implemented as a dummy steering wheel and provides the steering angle via a potentiometer. The accelerator pedal is also captured electronically.

Signal Capture with ControlDesk Next Generation

ControlDesk Next Generation is the central software for signal capture, display and test activation. The UI displays parameters such as the brake pressure (of the model and the test rig), individual wheel speeds, vehicle speed, accelerator

The RCP system consisting of MicroAutoBox and RapidPro is installed in the car. It can also be used in the laboratory.



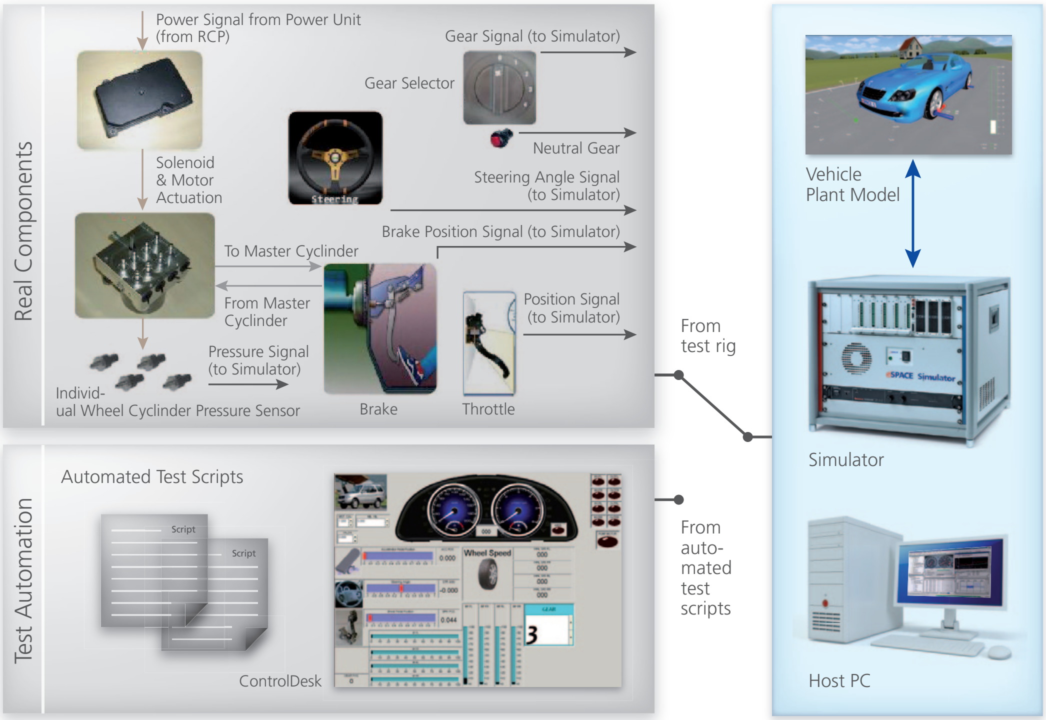
The test rig consists of a simulator, various real components, and the RCP system. It is first being used to develop and optimize the ISS algorithms.

pedal position, brake position, steering angle, etc. The tests can be executed via manual commands on the test rig and also by automated test scripts. It is also possible to quickly switch between automated and manual testing to simulate specific maneuvers. ControlDesk was used from the beginning to the end of the project. Thanks to the basic calibration functions in ControlDesk Next Generation, the developers were able to perform extensive calibration tasks in various project phases.

> "We were able to perform extensive calibration tasks even in early development phases by using dSPACE ControlDesk Next Generation."
>
> *Ujjwala Karle, ARAI*

Safety Objective Achieved

Tata Consultancy Services, Pune, and Tata Motors European Technical Centre, UK, were the development and consulting partners during execution of the program.
The project was completed on schedule with the development of control algorithms for various ISS functions: anti-brake locking system (ABS), traction control system (TCS), yaw stability control (YSC), roll stability control (RSC) and active seat belt restraint system (ASBRS). The algorithms were implemented on the target hardware and were calibrated and validated by both MIL and HIL simulation. The ABS algorithms were deployed on the MicroAutoBox-RapidPro combination in the vehicle. The project enabled ARAI to build up expertise and experience in using simulation techniques for embedded control system design and functional verification/validation of ECUs. Because proof of concept was provided for the stability control in SUV applications, and because it can be adapted to small passenger vehicles and commercial vehicles alike, the project results are also being used in production projects. The reliability of the dSPACE products proved to be extremely high. They were also easy to handle, which was decisive for the fast development of the controller software.



The test rig is designed for manual and automated test tasks. The pedals, steering wheel and gear selector are the real hardware components of the HMI.

ARAI Keeps up the Good Work

ARAI is actively involved in promoting the model-based development method and anticipates migrating to it completely in years to come. ARAI will now be offering its customers in the automotive industry the possibilities provided by HIL validation of ECUs.

ARAI is seriously considering further work in the areas of powertrain controls, such as strategies for gasoline direct injection, diesel common rail, etc., and is thinking of applying chassis control algorithms to hybrid-electric vehicles. The association will continue to use the methods that were developed and to actively promote their introduction into manufacturing companies. ■

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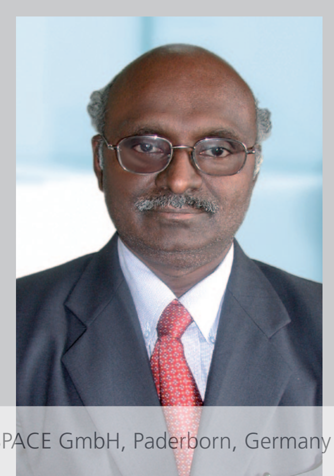

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