

VEHICLE VALIDATION TESTING

KEY WORDS AND TOPICS

- New engine test and development
- Chassis Dynamics test and development
- Powertrain test and development
- Electrical systems test and development
- On-vehicle Data-Logging, Display and Telemetry system
- Performance road car development

REQUIREMENT

During 2002 we were approached by a client developing a new 2 seater Supercar with a need to record a significant amount of data from the car during vehicle and engine development and validation. Their existing data acquisition system was based on a 19" rack mounted chassis and was, therefore, too large to place anywhere on or inside the vehicle other than the passenger seat. However, their testing programme for the new car required that at some stages a passenger had to be seated inside the vehicle, rendering the use of their existing system impossible. Therefore their first requirement was to source a more compact data acquisition system.

Listed below are the main requirements outlined in the client's brief:

- A more compact data acquisition system than their existing 19" rack mount system.
- To record a combination of both vehicle CANBus data from multiple ECU's based around the car and from other external sensor inputs (particularly temperatures).
- To record up to a total of 128 channels. 40 of these channels are for external channels from dedicated sensor inputs with the remaining 88 coming from the vehicle's CANBus and ECU network.
- A hardware and software solution to enable both collection and the analysis of the data.
- System must have a driver display to facilitate real-time visual feedback to the test driver of selected channels and parameters. Their existing system did not have this facility.
- Up to 70 Configurable alarms with warning lamps and display warnings to facilitate real-time visual feedback to the test driver of when selected channels and parameters exceeded pre-determined safe operational limits. Their existing system did not have this facility.
- One-way telemetry system to facilitate the transmission of real-time data from the car to a remote station during test track sessions. Their existing system did not have this facility.

PROPOSED SOLUTION

128 Channels. Up to 200Hz/channel. Up to 8000 total samples/sec. 32Mbyte (or 64Mbyte) memory.....

The proposed solution, which fulfilled all of the clients original requirements, was created using the components from our Modular 900 System range. Each on-board system consisted of a number of modules, all connected together on a Stack CAN Network (separate to the vehicle CANbus). The Stack CAN Network enables the sensor interface modules to be located around the vehicle (e.g. one at each corner of the vehicle, where temperature restrictions allow), adjacent to the components to be monitored, minimising the sensor harnessing. The system components included are listed below:

- ◉ A Stack recorder module ("R" Module)
- ◉ A Stack CAN Gateway module ("G" Module)
- ◉ Five input expansion modules ("E" Module each with 8 universal inputs)
- ◉ A Display/Telemetry module ("DS" module)
- ◉ An LCD Display unit with four warning lamps and four driver interface buttons
- ◉ A GSM Telemetry modem
- ◉ Stub sensor harnessing
- ◉ An expandable Stack CAN Network harness
- ◉ Stack DataPro data collection and analysis software
- ◉ Stack Designer System Configuration software
- ◉ Stack Telemonitor real-time telemetry software

THE APPLICATION

The system was used in the prototype testing and development of both a new road going 2-seater supercar and the engine with which it would be powered by. Four test and development teams, representing Chassis Dynamics, Powertrain development, Electrical Systems and Engine Development, were employed at this stage of the project.

The key challenges for the data acquisition system in this project were:

- The extreme environment, particularly high temperatures, in which the system needed to operate.
- A very limited amount of space in which the system could be located.
- Weight. For optimal performance a car needs to be lightweight, especially a supercar. Therefore, any systems placed on the vehicle during testing would have to be as lightweight and compact as possible in order to minimise any adverse affect on the vehicle's dynamics.
- Flexibility. Any delay in getting a vehicle under development to market as quicky as possible can have a significant effect on the profitability of the final product. The system had to be easy to change to accomodate new development tasks, as well as offering inherent cost and time savings to the development cycle.
- Test driver and remote station monitoring of vehicle parameters. Visual displays, both on-vehicle and via a telemetry link were required to provide both the driver and the engineers at the track side with constant real-time monitoring.
- Up to 70 configurable alarms and warnings were required for automated monitoring of engine parameters. This was perhaps one of the most important tasks for the system. Engine and Powertrain development requires that vehicles are tested to their physical limits - a task that is fraught with potential problems, particularly if an engine breaks beyond repair and brings a critical halt to the programme. It was imperative that the new engine survived the duration of the programme and in order to achieve this it would require constant real-time monitoring of a large number of paramters - 70 in total. This number was too large for the test driver to monitor manually and, therefore, the process had to be automated. Parameter limits could be configured by the engineers and in the event of a limit being exceeded, a visual alarm light would flash accompanied by a warning message displayed on the LCD driver display, enabling the driver to bring the test to an end if necessary, before engine failure .
- Usability. With 4 test and development teams, located across 3 countries, travelling to a variety of locations, it was imperative that the system be implemented with minimal training and time constraints. The usability of the Stack system meant that each development team required just one day of training before they were able to begin using the system under test conditions.

IMPLEMENTATION AND PROJECT DEVELOPMENT

As the client began to use the system under test conditions it was quickly concluded that the heat developed by the vehicle was greater than originally anticipated and that temperature levels would require more focused observation. Therefore, data had to be collected from a greater number of individual temperature probes placed around the vehicle. The proposed and supplied system provided for up to 40 external channels of data collection from the 5 'E' modules, but the revised client requirements called for a system with at least 60-70 external channels running K-type thermocouple devices. As the project progressed we met this demand by upgrading the original system to include an additional 5 'E' modules with thermocouple interfaces, thus doubling the total number of available external channels of data to 80.

A big advantage of the Stack system is its compact and modular design, allowing engineers to spread the acquisition system around the vehicle. This minimises the harnessing required as it means individual sensor interface modules can be located near to a group of sensors, feeding back to the central recorder through just one cable; the Stack CAN Network. Weight is therefore minimised as well as being more evenly distributed resulting in a diminished and negligible effect on the vehicle's dynamics - something not possible with the 19" rack mount system.

However, with temperatures exceeding 100°C/212°F at virtually every point on the prototype vehicle, the only available space where the equipment could be located was within the driver/passenger compartment. Keeping in mind the original requirements a solution had to be reached that would not encroach on occupant accommodation. The compact size and modular design of the Stack system facilitated a swift alternative by relocating the equipment behind the passenger seat and in front of the engine bay bulkhead - a space measuring just 600mm x 400mm x 30mm.

Three further changes to the original system were implemented over the period of the development programme and these are listed below:

- The client wished to make use of lap markers and lap timing whenever the car was being tested on a track, so an Infra-red Lap Timing System with track side beacon and vehicle based receiver was added.
- Changes and updates to the vehicle's CANbus configuration were frequent occurrences throughout the development cycle. In the early stages of the programme the Stack DataPro software had to be amended manually whenever these changes occurred in order that the collection and analysis of this data remained compatible. In order to automate this process our software developers built support for the DBC files into Stack Designer enabling a seamless synchronisation.
- A year after the project started, a second vehicle CANbus was added to each of the prototype vehicles, which called for an additional requirement for a second CAN Gateway module with each Stack system.

THE OUTCOME

The development programme has continued as a successful venture and 2 years on from the original implementation, the client has doubled the number of data acquisition systems used in the field as the number of prototype vehicles has increased. Below are the benefits the client has reaped through the use of the Stack system:

- More compact and flexible than existing system, making on-vehicle data acquisition possible.
- Lightweight, modular equipment can be spread around the vehicle allowing engineers to distribute the load and minimise the overall effect on the vehicle's dynamics.
- Ability to record a combination of both vehicle CANbus data and from other external sensor inputs (particularly temperatures).
- Alarm capacity. Being able to configure and implement up to 70 alarms, combining CAN and sensor channels, meant that they were able to achieve what the test driver could not do alone and provide a means to constantly monitor and avoid the failure of the development engine.
- Real-time telemetry also provided a means for engineers to monitor the vehicle/engine performance during high-speed testing.
- Upgradeability of system - able to accommodate clients changing requirements.
- Compatibility. With the data acquisition system integrated with the prototype vehicle as an on-board system, it meant that it would travel with the car to all of the testing facilities for the duration of the programme, ensuring compatibility of system hardware, software and data collected, as well as ensuring consistent data comparisons.
- Cost and efficiency of software. Vehicle development programmes will typically have a limited number of prototypes under evaluation, but with a large number of engineers in a variety of different project groups, as well as global locations. Many alternative software applications are provided with a "Seat" licence and a hardware dongle key. With so many engineers on one programme this can be expensive if they each need their own licence and dongle. Stack DataPro software is provided on a "Site" licence, which you purchase once and enables an unlimited number of engineers (affiliated with the programme) to load and use the software on their own PCs. Furthermore, the software is protected using a PIN number, providing a more convenient way to access and share the data as well as negating the possibility of arriving at a test location only to discover you've left the dongle back in the office.
- Cost and efficiency of hardware. In order to collect data using DSP type sensors alternative data acquisition systems will only operate using an expansion box with 8 channels and 8 DSP sensors, even if only one channel is required. With Stack, the 'E' expansion module's will receive direct input from a wide variety of sensors, including individual DSP sensors, which represents a significant cost saving.

FURTHER DEVELOPMENTS

- Event Recorder. Later developed to facilitate the triggering of pre and post recording (duration determined by the user) either side of an event.
- Audio Memo Recorder. Enabled voice recording by test driver of comments during evaluation.

ASSOCIATED APPLICATION NOTES

- Event Recording.

