

Ambitious

# Climate Goals

Precise control of the cab temperature is the be-all and end-all of developing vehicle climate control systems. Bergstrom aims at reducing the time-consuming calibration of these systems by 80%. For this, the climate experts use a model-based approach with various dSPACE tools.

Commercial and specialty vehicles always have to perform their demanding tasks reliably, even in extreme climate conditions. In order for drivers to 'keep cool' and be able to focus on their job, their driver cabins have to provide an optimal working environment. Bergstrom Inc. significantly contributes to such reliable climate conditions.

#### **Ambitious Goal**

Bergstrom offers two commercial products in the cab climate systems branch: one classic engine-powered system and one battery-powered system (known as NITE, No-Idle Thermal Environment) for air conditioning in a parked vehicle. A core component of all Bergstrom systems is the automated temperature electronic control unit (ECU) whose tests

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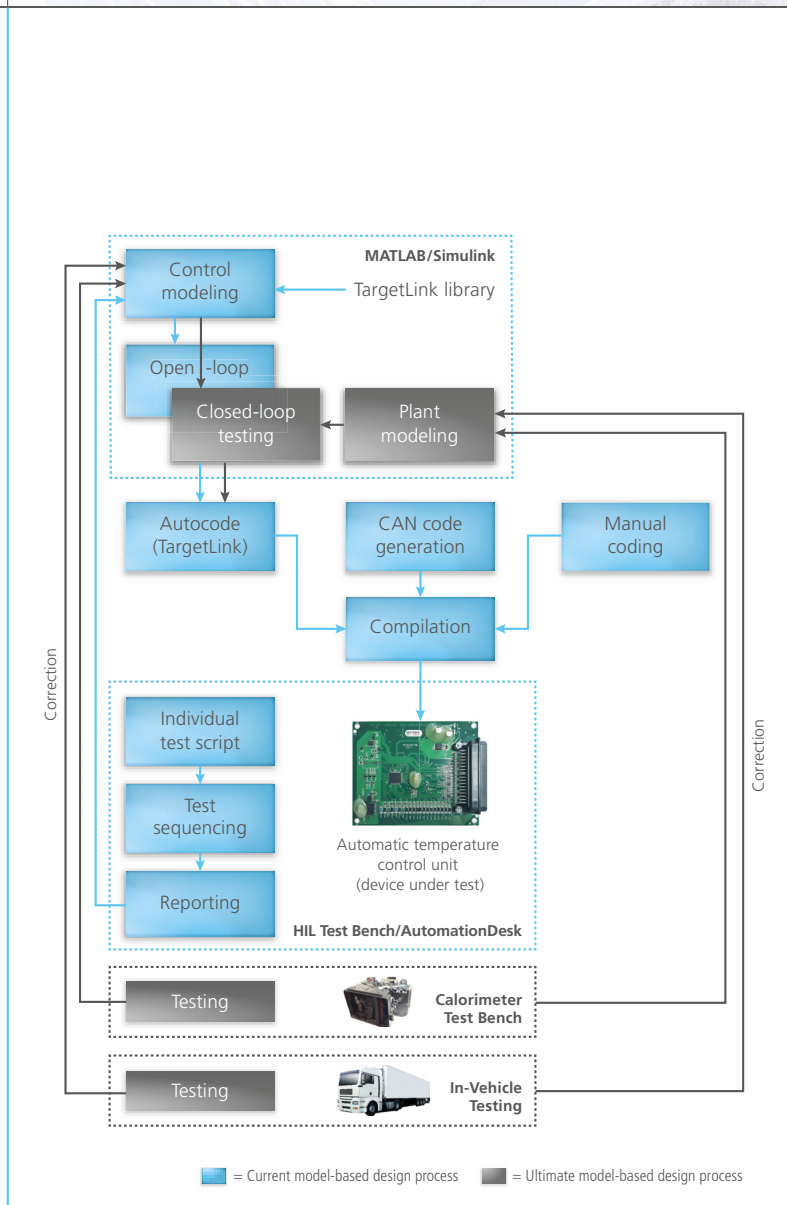


Figure 1: Current (blue) and ultimate (gray) model-based development process at Bergstrom.

and calibration have always required long iteration times. This is why Bergstrom aims at accelerating the ECU's development in the long term and performing more calibration steps offline in a new, model-based development process. The company is very ambitious right from the start: In the near future, Bergstrom wants

to develop 85% of its control software virtually and reduce the calibration time by 80%.

#### Powerful Tool Chain Required

After setting the course for the model-based design journey, Bergstrom had to choose the right instruments for it. These instruments had

to provide efficient processes and a well-proven, powerful tool chain. The company opted for state-of-the-art development tools, including:

- A data management system to keep all data (models, documents, specifications, software, figures, tests, etc.) organized, up-to-date, and in one central location accessible to all development teams worldwide
- A software version control system for traceability across the product's life cycle
- A requirements management system for documenting, analyzing, tracing, and prioritizing the requirements
- A modeling environment (MATLAB®/Simulink®) for model-based software development
- The production code generator dSPACE TargetLink® for automatically generating efficient, production-ready code from the models
- The test automation software dSPACE AutomationDesk in combination with a dSPACE hardware-in-the-loop (HIL) simulation system for automating software tests.

#### New Structure for the Development Process

When these tools were first included in a basic model-based development process (figure 1, blue elements), one of the first tasks was to capture and document the requirements of existing products via reverse engineering. The obtained design information allowed Bergstrom to start modeling the control algorithms in MATLAB/Simulink. The same platform was used for immediate open-

“We embarked on our journey to model-based development with tools from dSPACE, because as the market leader, the company offers state-of-the-art products.”

Bjorn Hansson, Bergstrom Inc.

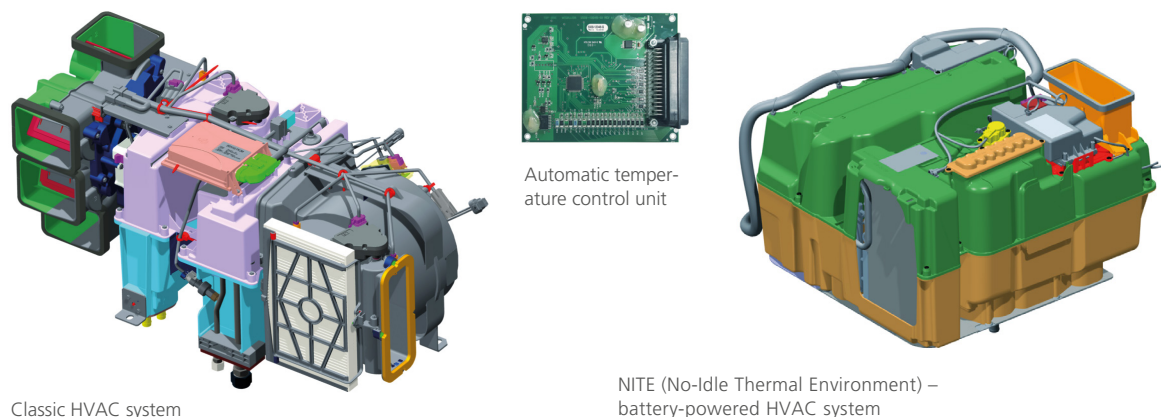


Figure 2: The automatic temperature control unit (center) is one of the key components in both Bergstrom's classic heating ventilation and air conditioning (HVAC) system (left) and the NITE (No-Idle Thermal Environment, right) battery-powered HVAC system.

loop function tests of the modeled control unit, giving the developers a first glimpse at the actual behavior of the ECU's algorithms in the design phase. If the tests were successful, the control models were translated into production code with TargetLink. This production code was then compiled and implemented on the ECU together with additional communication interfaces (CAN code), a calibration protocol (XCP), and additional, hand-written code. The next step was to thoroughly test the ECU on a HIL simulator. To make these tests easier, Bergstrom created a series of automated test cases with AutomationDesk. The developers were able to use the test reports to correct and adjust the control model.

#### First In-Vehicle Tests

After a prototype was tested on the HIL simulator, it was integrated into the driver cabin of a real truck. For this, TargetLink converted the controller and interface models into production code, which was then implemented on the ECU. The developers used a calibration system to fine-tune the ECU in the vehicle via the XCP protocol. The entire prototype functioned correctly in the vehicle, so the integration tests were successful.

#### Promising Interim Result

The successful in-vehicle tests showed that the software controller already fulfills all the requirements that were formulated in advance. But a functioning model is only the first step. Additional development effort is required to calibrate it and make sure it functions correctly. Currently, the Bergstrom engineers are tasked to transfer real-world insights to the models.

#### Path to the Ultimate Development Process

In the future, Bergstrom will fine-tune established model-based workflows and add further test procedures (figure 1, gray elements). For example, the correction loops that further improve the models will also consider test results from the calorimeter test bench and in-vehicle tests. Therefore, the actual calorimeters and vehicles will also be modeled in MATLAB/Simulink to perform closed-loop tests on controllers in the future. The model's functions can then be validated much earlier and more extensively. In the long term, these methods aim at achieving Bergstrom's goal of 85% virtual development and validation of control software before in-vehicle testing, thus reducing calibration time

at the mechanical level by 80%. From this, Bergstrom expects distinct time and cost savings. Hence, the drivers of commercial vehicles will not be the only ones to keep cool. At the end of the journey to model-based development, Bergstrom's financial controlling department can do so as well. ■

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