

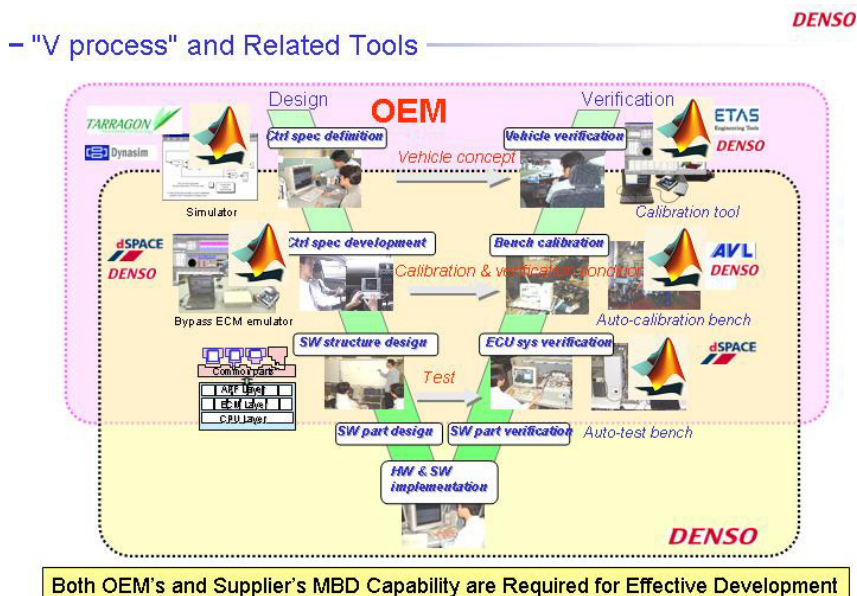
Manji Suzuki, DENSO CORPORATION – Japan

The ECU software size grew enormously as vehicles have added more and more functionality. Many OEMs have tried to introduce Model-Based Design process as to reduce development time and improve software quality as well. However, the problem is that ECU development process is across OEMs and suppliers. Suppliers' Model-Based Design capability is one of the key issues to win a success in introducing a Model-Based Design process. DENSO began preparing for Model-Based Design process in 1996 to meet future expectations from OEMs, and we have accumulated knowledge and technology for nearly 10 years.

Overview

1. "V Process" and Related Tools
2. Model-Based Design Process Development in DENSO
3. KSF (Key Success Factors) for Introducing Model-Based Design
 - 3-1. Advanced
 - 3-2. Initiative
 - 3-3. Reinforce
4. Practical Example
 - Increase Productivity by Using ACG (Auto-Code Generator)
5. How Suppliers should be in Model-Based Design

1. "V Process" and Related Tools



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Figure 1: "V Process" and Related Tools

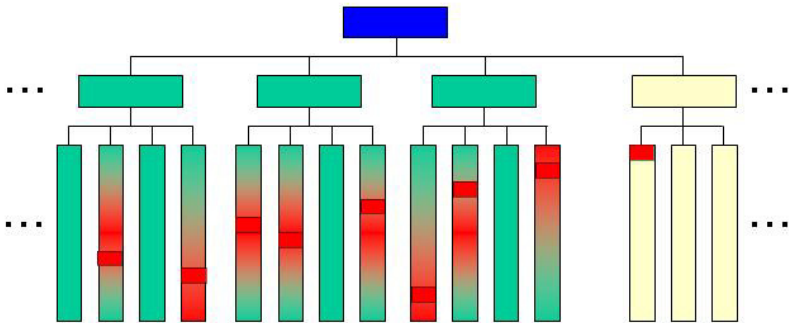
Improving the OEM-side Model-Based Design process does not make a lot of sense in automotive product development, because we have complex interfaces between OEM and suppliers. To achieve maximum efficiency, the Model-Based Design capability of suppliers is very important. (Figure 1)

2. Model-Based Design Process Development in DENSO

DENSO

- MBD Process Development in DENSO

- 1996: Start MBD Project in R&D.
- 1998: Start Project Meeting to Share MBD Knowledge in DENSO.
- 2000: Build a Task Force Team with Key Engineers from Production Department.
- 2003: Key Engineers Start MBD Projects in Each Production Departments



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Figure 2: Model-Based Design Process Development in DENSO

We started the first Model-Based Design projects in 1996 in a small team in our R&D department, and we spent two years to build up the required technology and knowledge through pilot projects in R&D.

After that we started sharing knowledge and experience with production departments through Project Meetings.

In 2000, DENSO top management decided to build a special task force team in combination with R&D engineers and key personnel from the production department. We completed many projects with the production departments, because they had pressure from several customers at that time. The task force team was a limited-time organization; the activity was completed in 2002.

Since 2003, key persons with Model-Based Design knowledge and experience started their own activities.

DENSO has had nearly 10 years of experience in Model-Based Design, and we have this knowledge and experience not only in R&D but also in our production departments. (Figure 2)

3. KSF (Key Success Factors) for Introducing Model-Based Design

We think that there must be several KSF (Key Success Factors) for introducing Model-Based Design.

3-1. “Advanced”

- Global Standard Conformance
- Research/Evaluate/Introduce state-of-the-art Technology and Tools

Global standard conformance is a critical issue to meet global customers’ request. We always tried to carefully monitor the latest global trends. For instance, we joined ASAM in 2000 as the 63rd global member (the 1st member from Japan). (Figure 3)

Our in-house calibration/measurement tool called “Meister”, supports ASAM-MCD-2MC,3MC.

Besides watching global trends, we’ve been actively involved in beta-test programs of state-of-the-art new technology and tools in very early phases of the development.

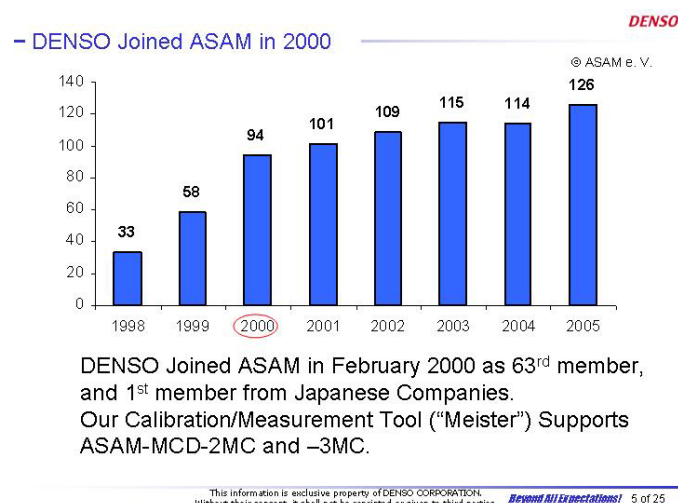


Figure 3 : DENSO joined ASAM in 2000

3-2. “Initiative”

- In-house Tools Development/Deployment
- Support for OEMs and Internal Users

finding good commercially available tools is important. However, to understand Model-Based Design technology in more detail, we also tried to develop some tools by ourselves. The knowledge and experience we got during the development of those tools helped us a lot afterward.

We also share the outcomes with our customers and DENSO internal users. Although, DENSO's in-house tools (Rapid Prototyper and Measurement/Calibration Tool) are not as powerful as commercial ones, they could support production engineers' daily efforts with appropriate functions. Many Japanese users prefer these kinds of "simple" tools against "all-in-one" complex, commercial tools.

Since we are not a tool vendor, and we do not have any intention to start tool business, we are providing those tools for our customers only.

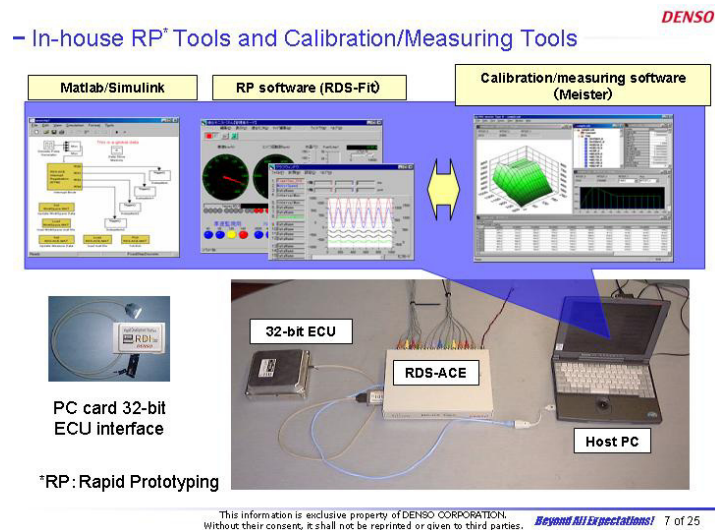


Figure 4 : DENSO in-house tools

3-3. "Reinforce"

- Develop Managers'/Engineers' Model-Based Design Skills
- Build Model-Based Design Environment Infrastructure

Developing technology and tools is not enough to build a Model-Based Design process. Developing skills and infrastructure is also very important, and those should be implemented simultaneously with technical issues.

We developed two different training materials, for Managers and Engineers. The important issue is they do need different skills. Training material for Managers are "flash-based" web contents, and the main purpose is "Feeling and Understanding Simulink®" with the lowest barrier. (Figure 5)

However, engineers need to build models by themselves, so training materials for engineers are prepared using Mathcad, so they can launch Simulink in the training. (Figure 6)

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- Training Material for Managers (eLearning)

Training Program Top Page

Hands-on Simulation for Basic Operations (Flash)

Electronic Text (PDF)

Easy Way to Learn about Operation

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Figure 5: Training materials for Managers

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- Training Material for Engineers (Mathcad)

Text (Paper/PDF)

mathsoft mathcad

Executable Worksheet

Launch Simulink

- Hands-on Learning by Real Simulink Models
- Easy graphing and documenting
- Good for Parameter Study in Early Design Phase
- Design Standard can be also Defined in Mathcad Worksheet

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Figure 6: Training materials for Engineers

We're also trying to build an appropriate environment for Model-Based Design. Here is an example for a model version managing utility called ecVERSIM, which is effective for managing model versions with subsystem level without splitting mdl files. (Figure 7)

Building human skills and Model-Based Design infrastructure simultaneously with technical issues is one of our critical factors for success.

DENSO

- MBD Environment Infrastructure : ecVERSIM

User 1: Modify the model, then I should check it out

User 2: Let's see the history of modification...

User 3: Oops! User1 locked this Block...

User 4: I'll check out this version...

ecVERSIM Database

Building Basic MBD Environment by This Kind of Utilities are also very Important

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Figure 6: Model-Based Design Environment Infrastructure : ecVERSIM

4. Practical Example – Increase Productivity Using ACG

Here is a practical example of increasing productivity using ACG (Automatic Code Generator) with Toyota Motor Corporation (TMC). The Model-Based Design project with TMC started in 2000 as Interface only, and started using as specification in 2001. However we still used hand-coding at that time.

In 2003, we started applying ACG for production ECU implementation, and ACG is applied for several production projects currently. (Figure 7)

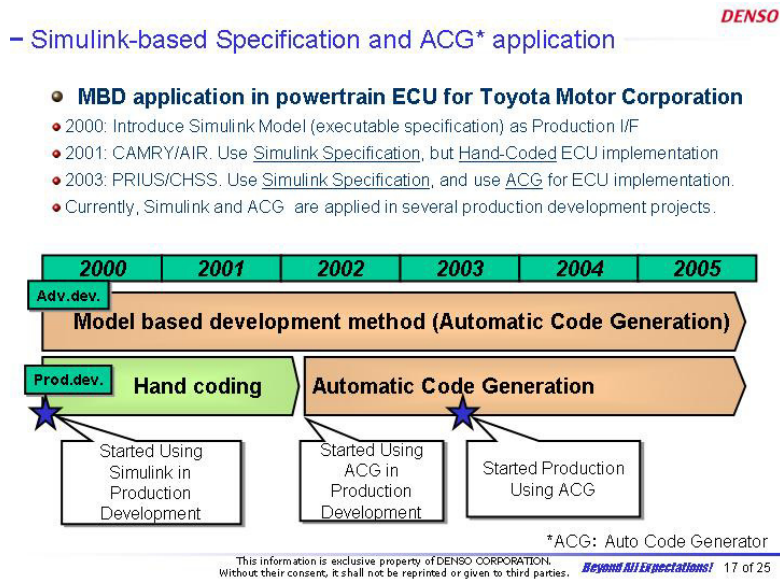


Figure 7: Simulink based specification and ACG application

There were several critical requirements for ACG for production use; therefore, we needed customization and special technical support to meet those requirements. (Figure 8)

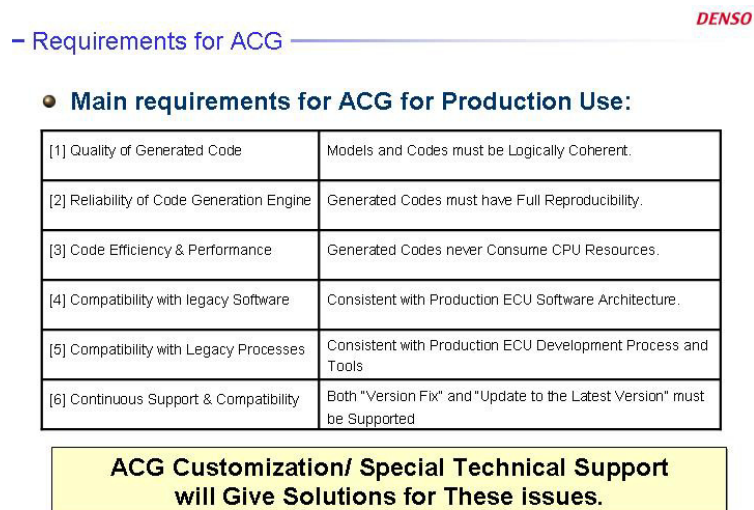


Figure 8: Requirements for ACG

Through benchmarking among several ACGs, we decided to adopt Real-Time Workshop Embedded Coder as a base for customization. We also discuss on special support contract with The MathWorks and Cybernet System to get long-term support for production projects where we will keep using the fixed version through the life time of the project. Finally, we reached a mutual agreement, as you can see in The MathWorks press release in August 2005. (Figure 9)

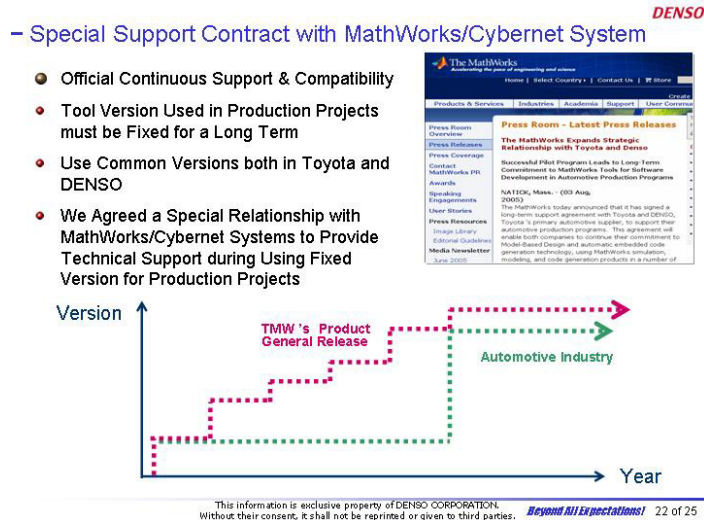


Figure 9: Special support contract with The MathWorks and Cybernet Systems

5. How Suppliers should be in Model-Based Design

In Model-Based Design process, overall development efficiency depends on the interface between the OEM and the supplier significantly more than in the legacy process.

Key Supplier Capabilities

1. Flexible task sharing with the OEMs (Component – System Level).
2. Flexibility to meet the OEMs' unique development environment.
3. Ability to manage larger, more complex development projects.
4. Technology development capability in areas where the supplier should take the lead, such as software implementation and ECU testing.
5. System development capability with vehicle system view similar to that held by the OEM.

6. Conclusion

Since 1996, DENSO has been promoting Model-Based Design implementation, deployment and penetration. Currently, each production departments operates Model-Based Design activities independently.

KFS (Key Success Factors) for Model-Based Design promotion and Implementation are AIR (“Advanced” “Initiative” and “Reinforce”).

Productions Departments are trying to investigate effective use of ACG, managing large-scale Model-Based Design, and so on.

DENSO moves forward from “MATLAB® Based Development” to real “Model-Based Development”, and continue to accelerate Model-Based Design through tight collaboration of the R&D team and the production departments.

(Of course, using MATLAB as a core tool, and trying to use other peripheral tools to leverage total environments.)