1. To Begin With

MBD has been used as a magical word in the development field for many years. MBD is an abbreviation of Model Based Design or Model-Based Development. Currently, Model Based Development can be considered to be the established term. It is necessary to upgrade automobile control and respond promptly to environmental regulations. For automotive development that is becoming more advanced and complicated, such as that subsequent to the introduction of advanced driver-assistance systems and networked vehicles, efficiency at the design stage is indispensable. Specifically, the importance of carrying out the development and performance evaluation process by virtual simulation without using the actual vehicle is expanding.

2. MBD is not a Magical Tool

MBD has been used as a synonym for the misunderstanding that when development efficiency improves, anything can be seamlessly developed. In recent years, various industries have adopted and their understanding has deepened. However, when introducing the MBD process in an activity group like the Japan MATLAB Automotive Advisory Board (JMAAB), vehicle manufacturers often consider suppliers using MBD processes as a critical matter. This is because the roles are different between vehicle manufacturers and suppliers. It is natural that the development work becomes increasingly detailed as the V process progresses. It is important for vehicle manufacturers and suppliers to understand the whole MBD as they start development.

As an example, there is the misunderstanding that MBD can shorten the development period. This in itself is not wrong as an expression. The misunderstanding occurs when MBD can not be utilized in its original form. Just changing the application software hand-coded in the editor to MATLAB or Simulink does not change anything. Rather, it takes time to verify the auto code, so labor expended may increase. In comparison for one specification component, MBD takes more time than hand code development. As hand code development repeats trial and error, it matures the specifications. That is, the hand code development is repeated from the beginning of each V process to the beginning of the next V process every time. With MBD, a simulation is conducted at the start of the V process. Therefore it is possible to minimize the repetition of trial and error. It takes time to study this simulation and control, but to
endure is the way to success. If one loses the desire to test with an actual vehicle immediately using auto code, development using MBD will fail. In addition, since it is possible to generate C source with only one button, it leads to the absurd misunderstanding that it is quicker than hand code.

The hand code repeats the V process to mature specifications. Trial & error work will increase. Although one cycle is short, the total cost is large.

MBD is maturing specifications by simulation at the beginning of each V process. Trial & error work is little. Since one cycle is long, it is often misunderstood that the development time is long, but the total cost is small.

Fig. 1 Approach to development man-power

3. How to Effectively Use MBD

Two approaches are needed to attain merits in the use of MBD: The development of control software and the development of the controlled items.

Although MBD of control software has various designations, it is often called “control design.” It is this that creates software using classical control theory, modern control theory, robust control, etc. Modeling the controlled item is also called plant model development and is often called “modeling” in general.

The advantage of using MBD can be realized if one can simulate firmly at the start of the V process by combining both the control software and the controlled items. However, the actual vehicle as a controlled object is completed earlier than the plant model in many cases. It is faster to test with an actual vehicle than to model the mechanism later. It runs into a “trial and error spiral” which is not different from the hand code mentioned above. In other words, if I was doing the development, I would simply use the same model tool as the hand code editor. In order to make model development succeed in the future, it is very important to firmly realize both “control design” and “plant model development.” MBD engineers will be required to know both control and mechanisms. Recently electromagnetic field analysis software JMAG is also popular as a plant model of the motor, and the correlation with the actual vehicle has improved considerably. Even if one cannot make a plant model oneself, it is also important to master the areas shown in Fig. 2.

Fig. 2 Two elements necessary for MBD
4. The Future of MBD

MBD currently is part of the MATLAB and Simulink mainstream. In many cases TargetLink is adopted due to the advantages of auto code. It is easy to imagine that simulation development will evolve further and new tool chains will emerge. The propulsion of the automobile is changing over from gasoline to electricity and the volume of vehicles about ten times of that of ten years ago. Furthermore, in order to realize autonomous automobiles, an enormous amount of control factors and data must be implemented. MBD is one of the solutions reduce the load of such a development volume.

However, I think that MBD has superiority if mass-produced with floating point models. Let us assume that the vehicle manufacturer provides a floating point model that has passed simulation tests to the supplier. Suppliers need to verify that there is no runtime error and mass-produce the unit with a floating point. However, this cannot be accomplished that easily. Full floating point requires more memory than fixed point, and thus a higher grade microcomputer must be used. High-grade microcomputers are expensive and lower the cost competitiveness of products.

In order to lower the cost, the control model has to be fixed point. Furthermore, it is not much different from the hand code, such as the range of variables and the examination of resolution. An important point in the future of MBD is the timing at which the development cost of fixed point development can reverse the microcomputer cost. In order to realize this, suppliers need to work from the top of the V process as much as possible, and shift the role of control design from vehicle manufacturers to suppliers.

5. Finally

Once the automobile is motorized, the control volume as a power train will be easier, and thus MBD will be easier. In Europe, “Modelica” is beginning to be used, but large-scale control logic is
still often created by MATLAB and Simulink. This is because it is necessary to implement the control logic created as actual program code. The physical model created by Modelica can be passed as Simulink’s S-Function or the functional mockup unit (FMU) conforming to AUTOSAR’s connection standards.

Well, will the control volume for MBD increase in the development of autonomous vehicles as well? Various languages are used for current situation-specific AI, such as Python, Ruby and JAVA. The graphics processing unit (GPU) used in autonomous systems seems to be a Linux operation, but various languages are used. Thus, except for the core area, that is the area where software and hardware developed by simulation does not change much, I think that a new solution will appear on the plant model side.

MBD is evolving day by day and it will become ever more necessary to use it. To repeat, in order to use MBD fully, I think that it is most important to change the development roles so that suppliers can develop models.

References

(1) JMAAB Open Conference 2017, Keihin MBD initiative example