系统模型在设计初期进行性能预测的動向簡介」

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Motivation

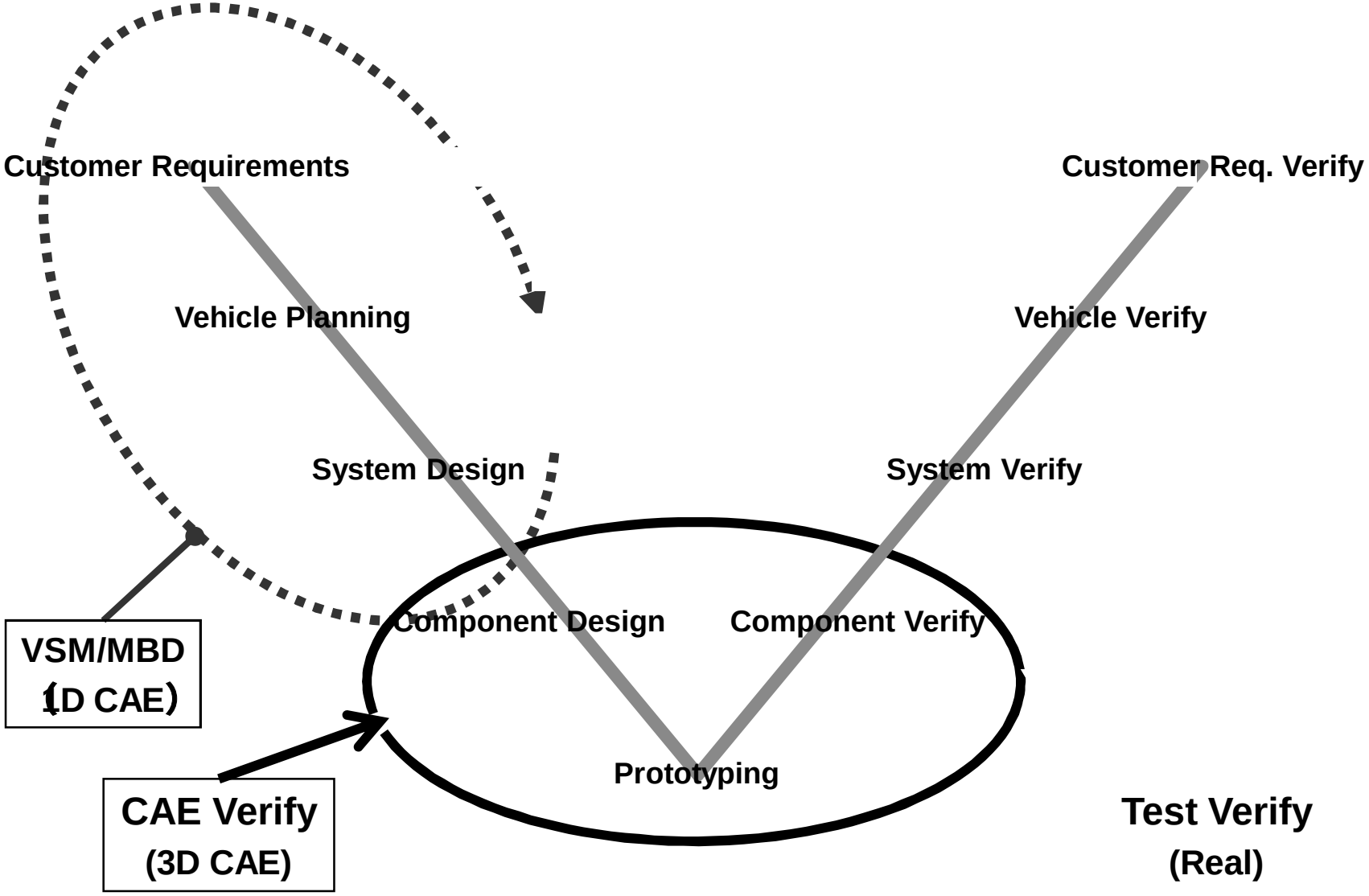
1. **Reduce the time from concept design to manufacturing**
   - The key point is to make RIGHT decision in concept design stage, by fully utilizing simulation technologies based Vehicle System Model (VSM) to avoid re-design work in the system verification stage.

2. **Meet the high demanding requirements from regulations and market (fuel, emission, drivability, comfortability, steering, etc.)**
   - The key is to optimize major design parameters at system level to meet overall performance targets, and provide design criteria to components.
   - Change the design process from Enterprise top level down to department level. VSM can be extended from reduced to detailed and real-time.

3. **Start developing the controller in parallel with hardware design**
   - Applying MBD approach based on VSM enable developing control scheme at earlier stage of V-cycle to SILs/HILs in later validation stage.

4. **Innovation and creative**
   - Gaining knowledge, sharing knowledge and re-use knowledge via VSM. This is the power tool for innovating and creating new technologies.
   - VSM is the communication tool across component design departments.

VSM in design process



What is the VSM? How does it work?

1. **Thermal management VSM**
   - Including all necessary and related components from engine, transmission/oil circuit, vehicle/driveline, coolant circuit, engine oil circuit and driver controller.
   - Each component has different degree of modeling details (from detailed predictive model, semi-detailed model to map based model and etc.) depends on its function and purpose.

What are the benefits of VSM?

2. The computational results

- It is physically and numerically coupled model in one software GT-SUITE, with all design parameters that designer wants to play with.
- The model has been validated with measured data of temperature on several components.

3. The value to designer

- It allows one to study a great number of design combinations for vehicle (sedan, SUV), engine (4 cylinder, 6 cylinder, different displacement, turbo-charged), transmission (manual, automatic, dual clutch, CVT), EV/HEV (motor, battery) and environment (hot, cold and extreme climate).
- It helps designer better understanding the detailed flow of thermal energy, which leads to innovation and creation of new ideas and technologies.

What can VSM bring for you further?

4. Further value to designer

- It helps designer better understanding the detailed contribution of frictions of each components, which leads to innovation and creation of new ideas and technologies.

5. Innovation and creation of new ideas and technologies

- It allows designer to try out many different design strategies and components easily to compare their contribution and sensitivities to the targets (fuel economy etc.).

Verify the performance targets by optimizing with VSM

6. Optimization and study the trade-off at planning stage

- It allows designer to optimize fuel economy, study the trade-off between several important performance targets such as fuel, emission, drivability, comfortability and steering at planning stage. this is very important for making decision at the planning stage.

Develop the controller with VSM before hardware

7. It enable to start develop the controller in parallel with hardware design

- Finalize control scheme design with VSM SILs/HILs and shorten the delivery the controller to prototyping group.

Real Engine

Input(Valve open signal)

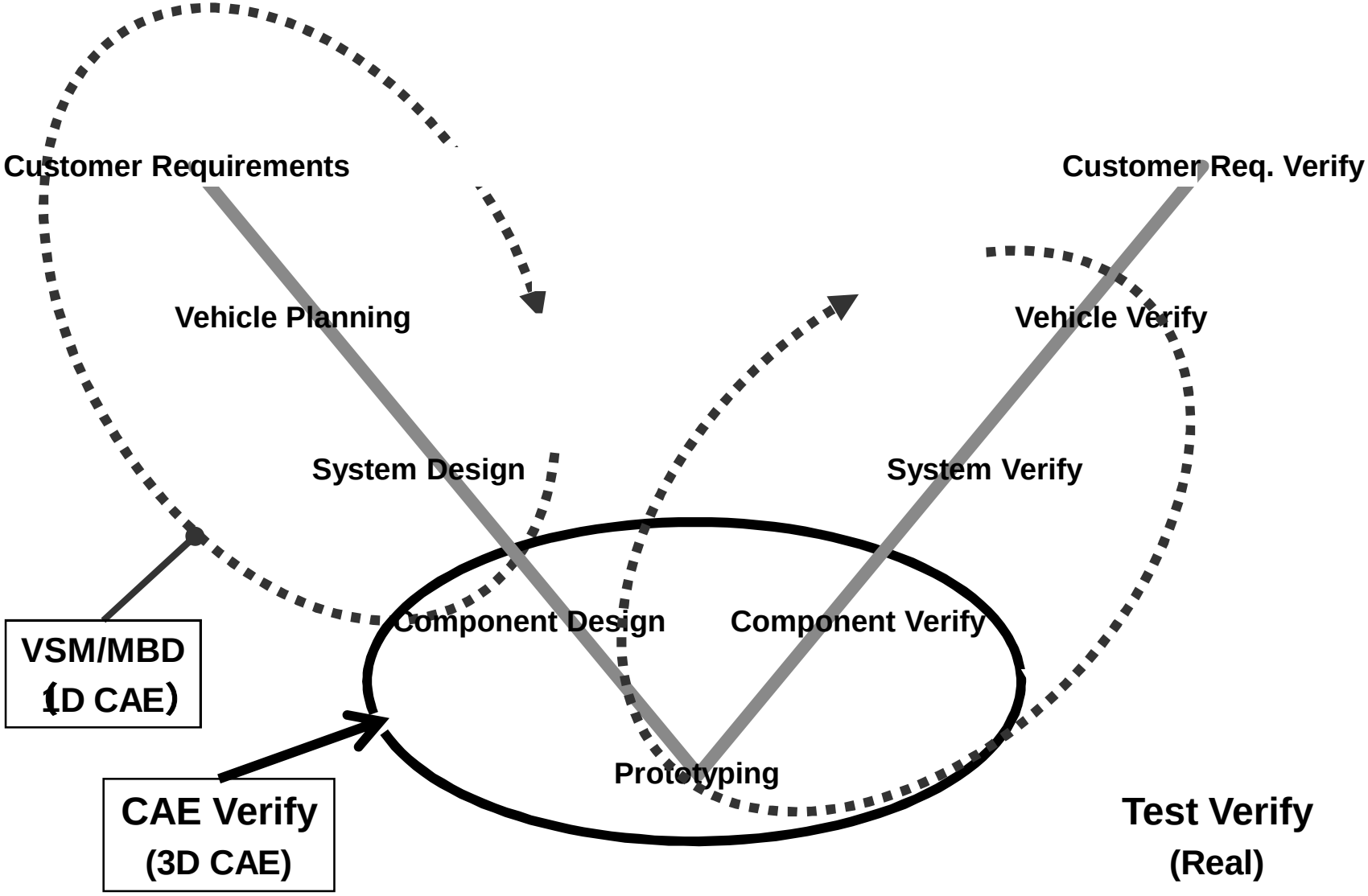
Output(Valve lift value)

R/T VSM

Control model (SILs validated)

Fast computer for real time VSM model

VSM in design process



What are the challenges for VSM

1. Data collection

- VSM needs large number of data that in many cases they are existing in different departments. The enterprise leadership is necessary and important for pushing for VSM.

2. Reasonable accuracy

- VSM needs to have reasonable accuracy and reliability for a range of design parameter change.

3. Validated/calibrated by measurements or 3D CAE

- While build up VSM, there are many sub-models (such as engine combustion, gas-flow, frictions and others) need to be validated/calibrated by measurement or 3DCAE data that may require works and time. Automatic validation/calibration system is required.

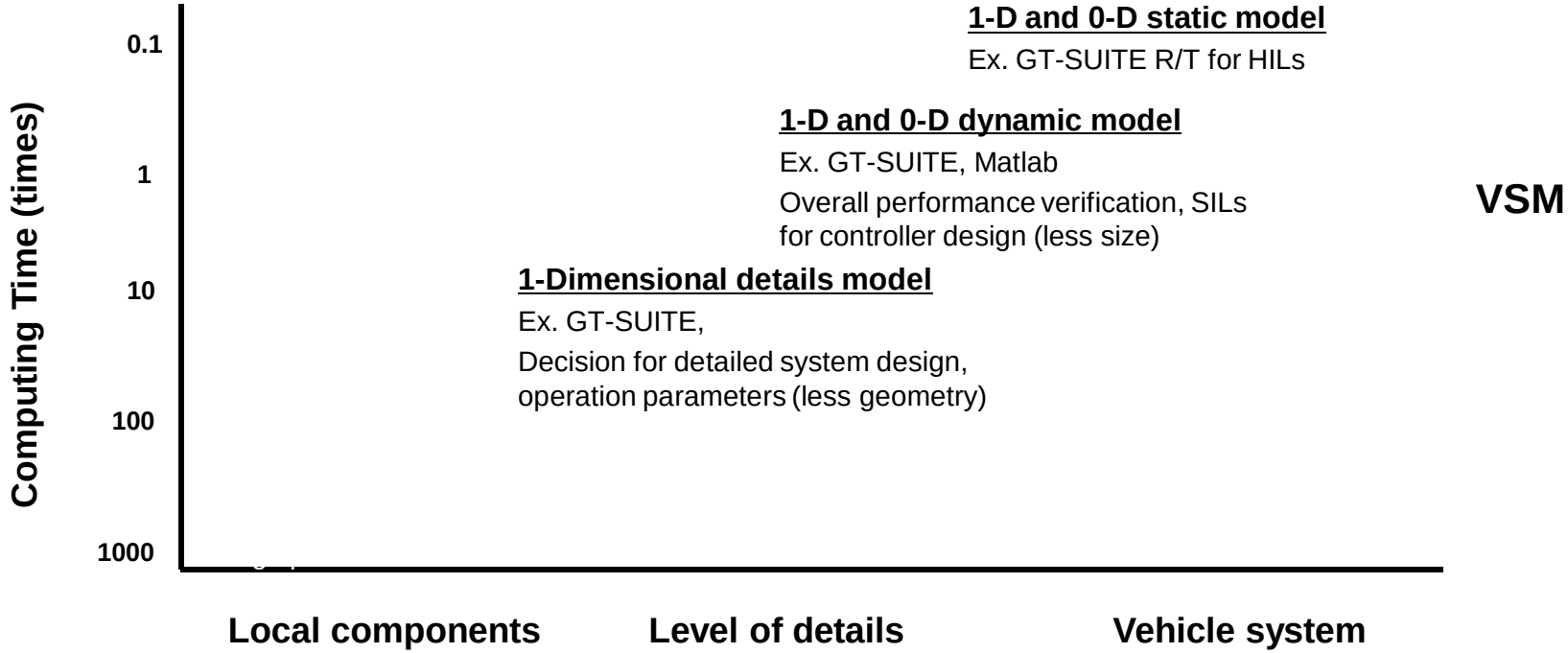
4. Choose right software

- Choose a right software which can modeling most major components, cover from planning stage to SILs/HILs. However non a single software can cover all components all the time. It will require multiple software co-simulation for VSM. But the efficiency and robustness are the issue .

What are the challenges for VSM

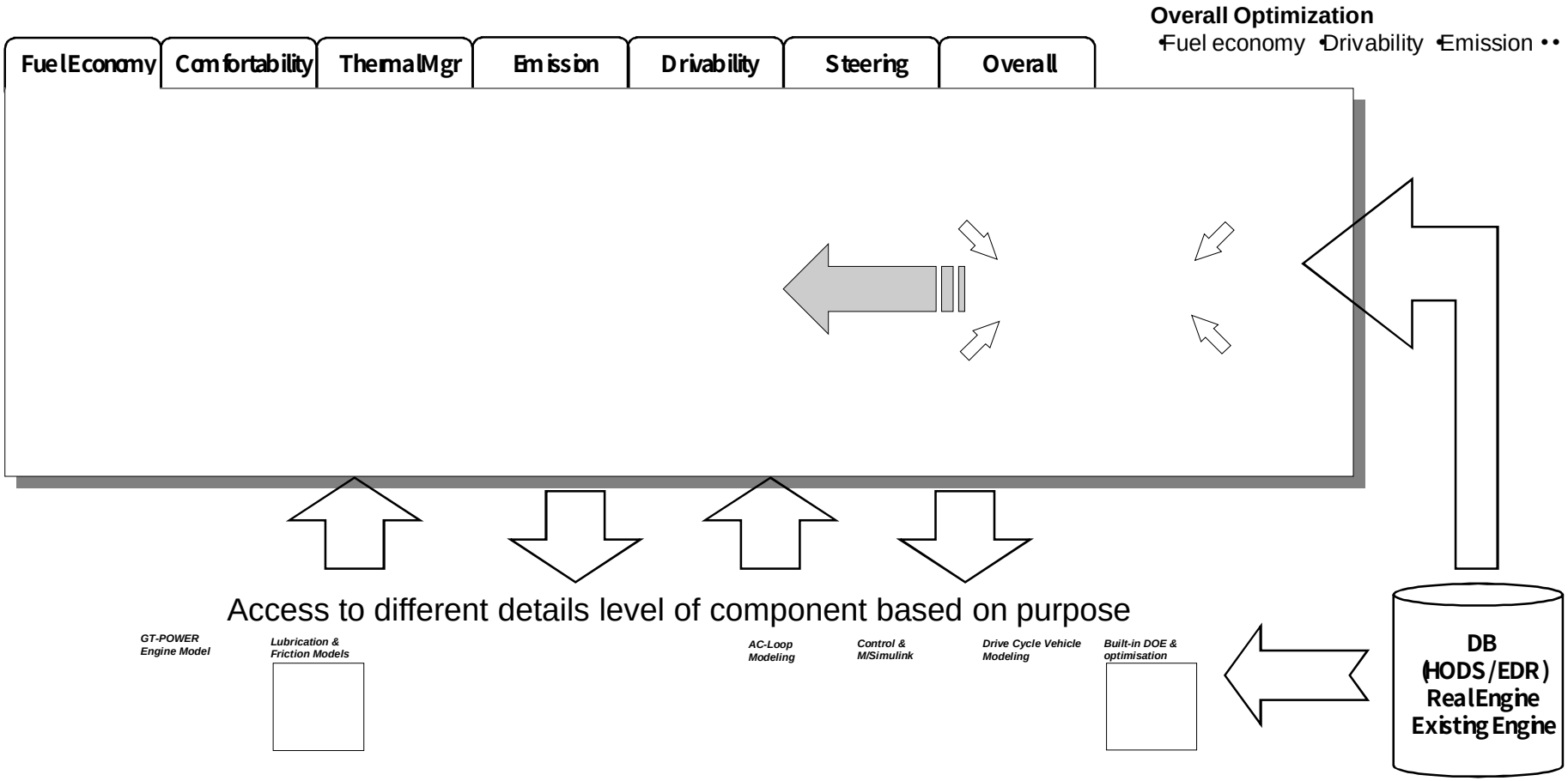
5. Level of details for each components

- VSM needs to be reasonable fast (few tens-minutes for SILs, real time for HILs) in order to accomplish its purpose. It requires all components modeled at reduced level (such as Map). However it also needs to have certain detailed level (predictive model) to minimize the dependence on empirical data. The decision on the modeling level needs more experience. Any change at component design shall be automatically synchronized to reduced model.
- Depending on design purpose, different VSMs need to be prepared. The common library of components including reduced models to very detailed models) is important.



VSM platform for Enterprise Decision Making

- Various VSM models for vehicle major performance targets verification.

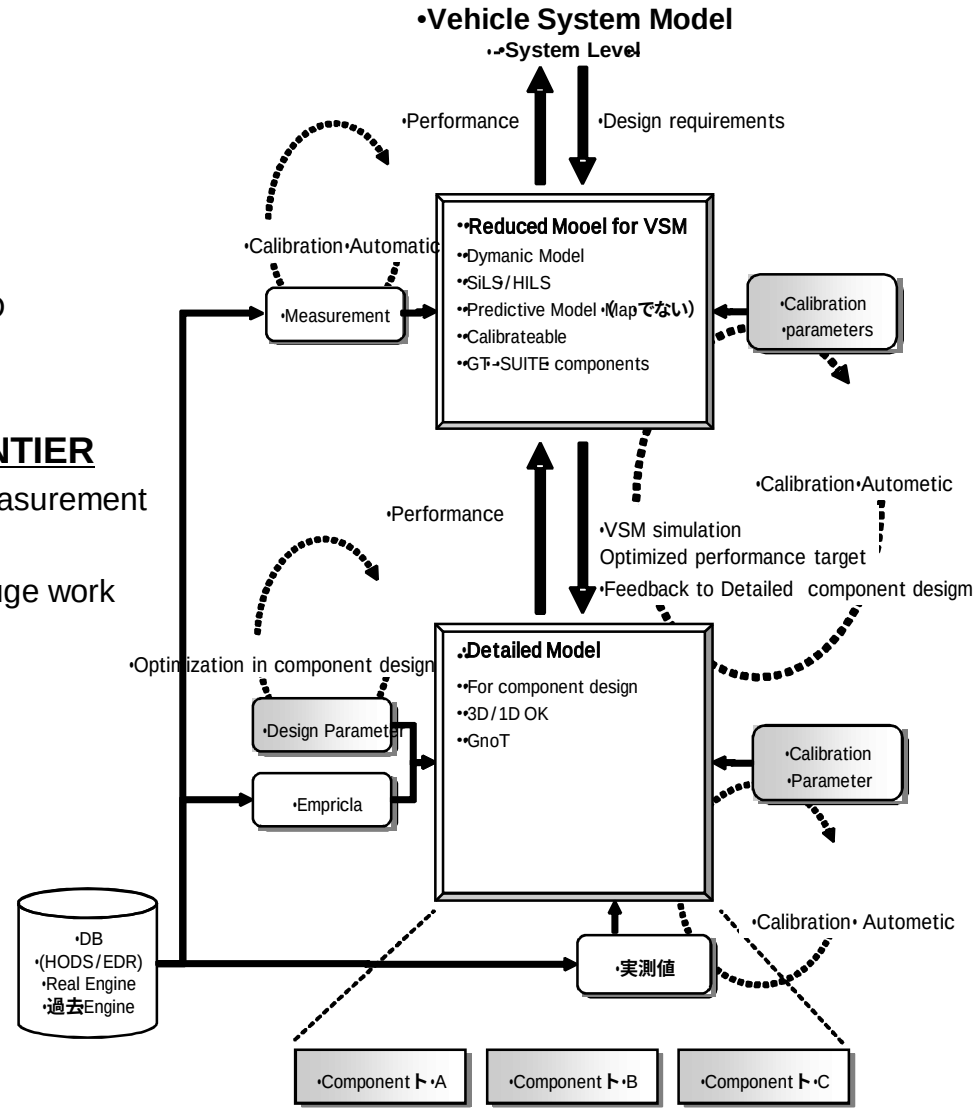


Auto calibrating and synchronizing for component

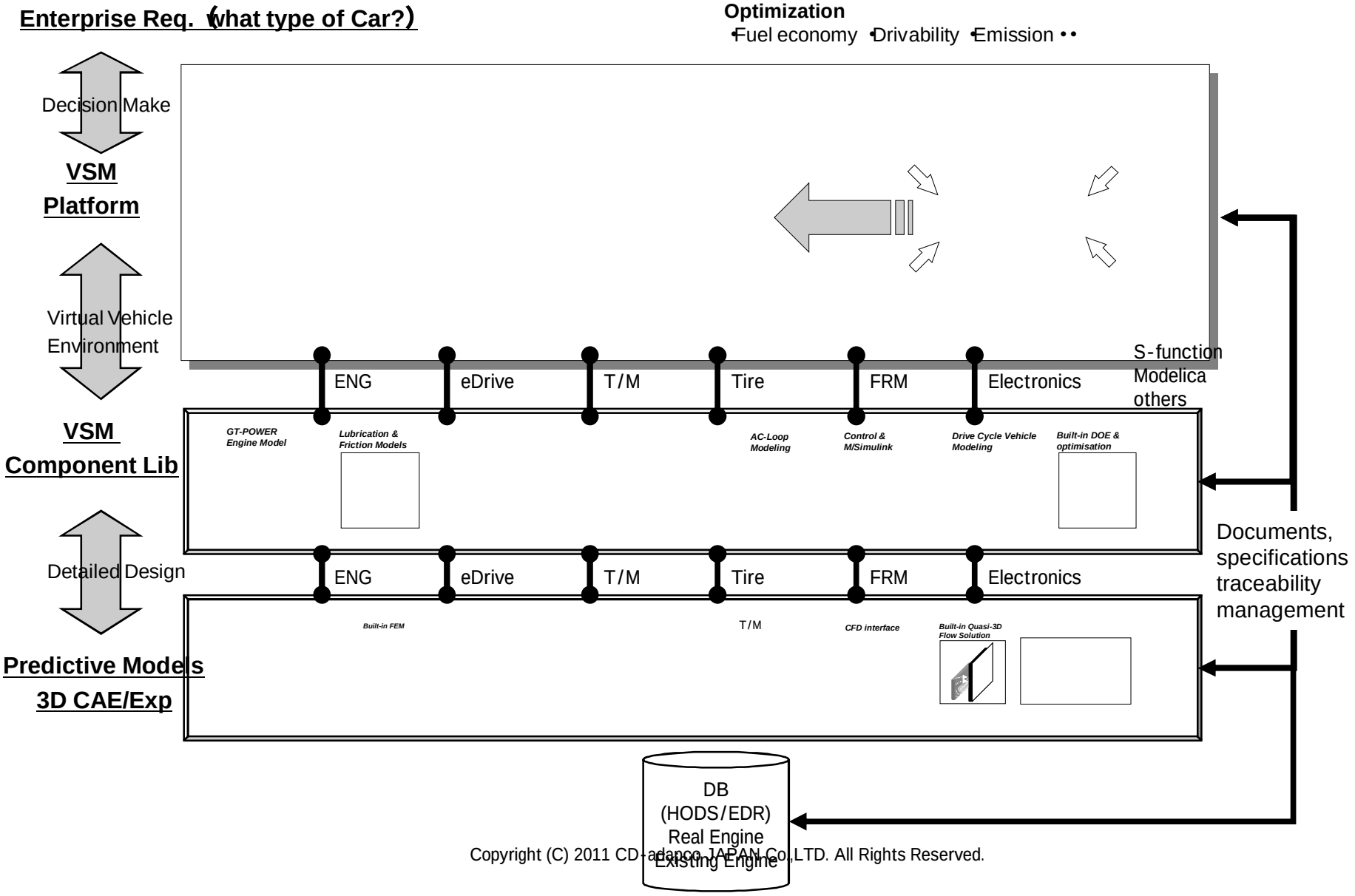
1. **Reduced Model for VSM**
   - Pre-built for various VSM with fixed in/out
   - Different reduced level depends on purpose

2. **Detailed Model for component design**
   - Not only GT-SUITE, can be any 3D CAE/CFD
   - More parameters for designer use

3. **Calibrated and Validated with modeFRONTIER**
   - Calibration and validation by 3D CAE and measurement
   - Maintain the accuracy of each model
   - Automatic system is required as it requires huge work



Auto Synchronize and Calibrate for VSM component lib.



Conclusion

1. **Better understanding full vehicle system and enable to make decision on major design direction at planning stage**
2. **Optimize and design study at sub-system design stage**
3. **Start developing the controller in parallel with hardware design**
4. **It is challenging to build up the proper VSM system**
5. **Innovation and creative**

Thanks for your attention