

OMG @ Hyatt Regency Cambridge

*Systems Assurance and  
Behavior Modeling :  
Requirements for OMG*

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**TOYOTA MOTOR CORPORATION**

# *Ohata's Introduction*



## *Higashifuji Technical Center*

Akira Ohata (Alex): Senior General Manager of Toyota

- mainly engine control system developments
- not software engineer (still a control engineer.)
- Highly promote Model-Based Development
- Recent focus area → modeling
- final target → verification & validation

# *Overview*

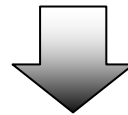
1. Expectations and the background
2. Focusing points
3. Introduction of Model Based Development (MBD)
4. Advantages and disadvantages of OMG
5. Possible actions in OMG
6. Summary

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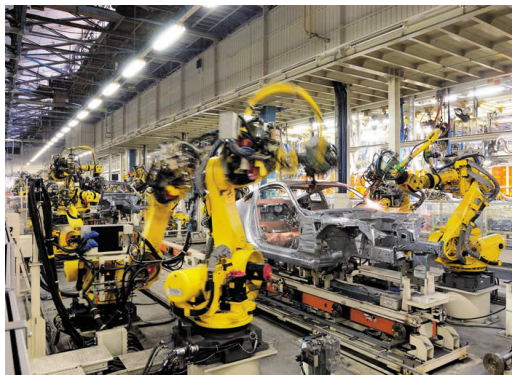
# *Background*

1. Automotive control system has been rapidly getting complex and countermeasures have been highly demanded.
2. The current framework of system assurance can be based on factory machinery safety such as ISO 12100 and ISO 14121.
3. It would be insufficient from the view point of consumer machine including automobiles and service robots.



Consumers and manufactures should be able to take benefits from the framework reasonably enhanced in the consumer machine point of view.

# *Factory and Consumer Machines*



*Factory machine*

*Consumer machine*

## *Major Differences*

	Factory machineries	Consumer machines
the number of the production	a few $\leftrightarrow$ many	a huge number
users	experts	amateurs
cost	high	low
maintenance	real field (strongly managed)	service stations (weekly managed)
environment	factory environment (almost stable)	factory environment
		User environment (quite dynamic)

In the case of consumer machines, the trace through the developments, the productions and the states of usage by users must be considered

# *Open and Closed Environments*

## **Factory environment:**

The environment is highly managed by experts and the operation condition can be almost stable.

## **Consumer environment:**

The products are used by many amateur users on various condition including unexpected usages and interactions with others.

It is difficult to define all use cases of product and continuous improvement is the basic process to manage the reliability in such the open environment.



## *Expectation for OMG*

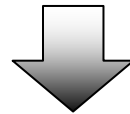
1. Activities for the standard framework to assure consumer machine reliability and dependability
2. To show implementations of processes, methods and tool chain to establish the reliable and dependable production and the maintenance processes
3. To extend the framework to the other international standards, such as ISO and IEC

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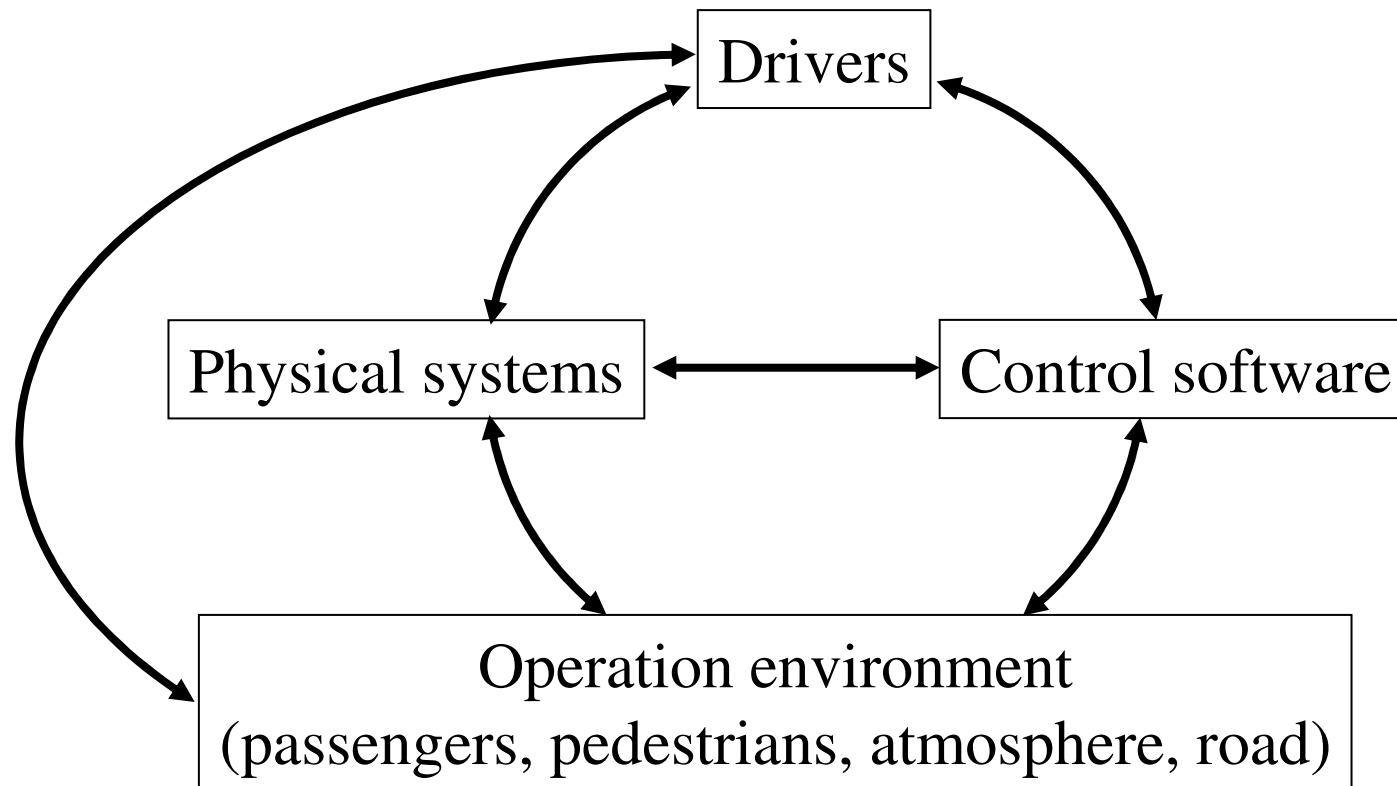
# *Current Issue*

1. Almost closed factory environments are supposed but consumer machines are produced and used in the open environment that means close linkage with the outside.
2. The framework doesn't show concrete processes to ensure the reliability of product in the market place.



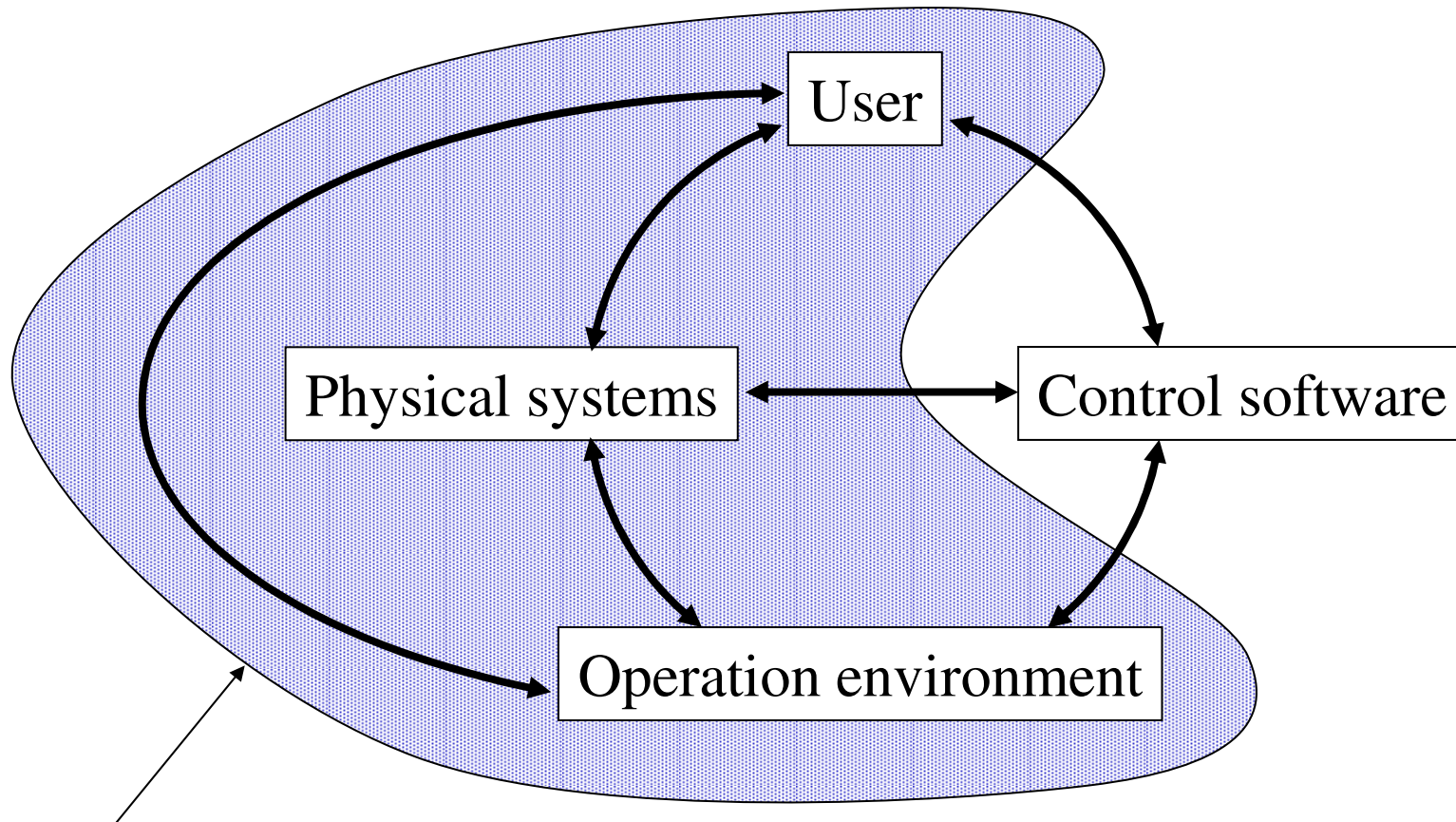
Consumer based machine assurance guidelines and standards are desired and methods how to ensure the reliability must be shown.

# *Characteristic of Consumer Machine*



There would be frequent interactions among control software, the physical system, the environment and the user.

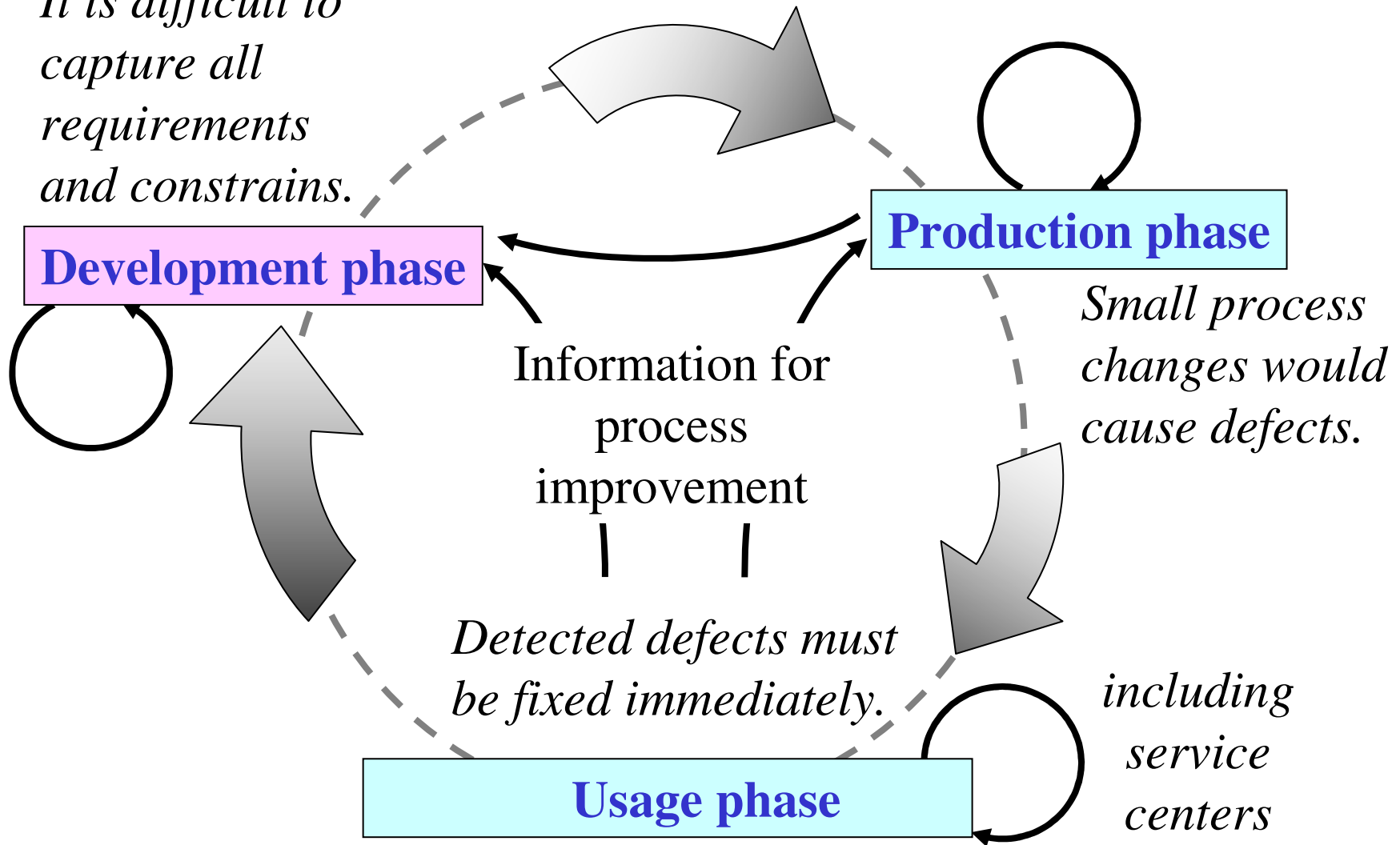
# *System Behavior*



System behavior can be estimated if the portion should be modeled. → modeling

# *Focusing Point*

*It is difficult to capture all requirements and constraints.*



# *Linkage between Requirements and Behavior Models*

- Behavior model is useful to evaluate if the developed system satisfies requirements.
- However, modeling isn't easy and iterative process is required to get the sufficient accuracy.
- That means the necessity of the connection between modeling and testing.



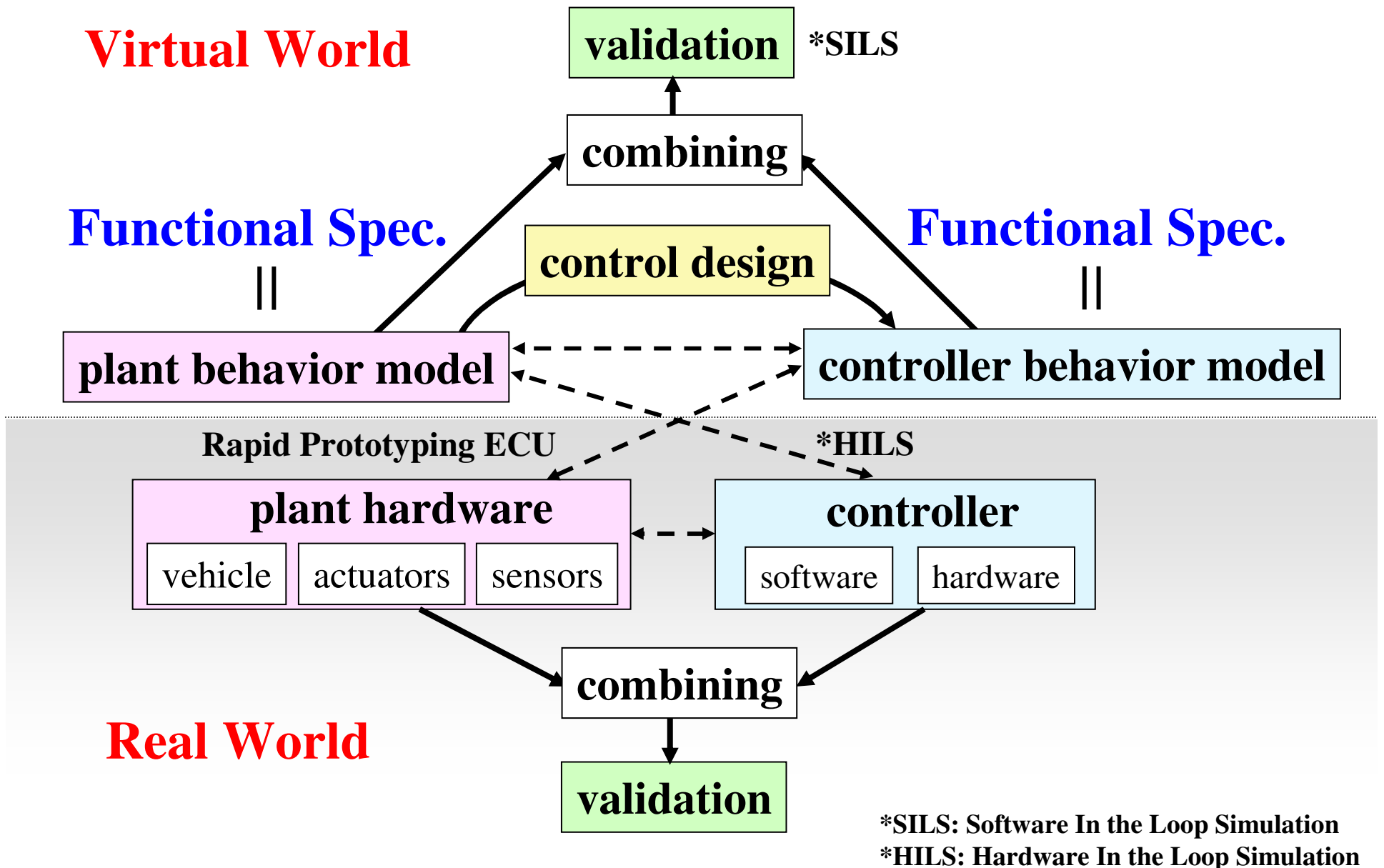
This means that OMG can expand the activities to the modeling and testing areas.

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# Concept of MBD



# *Requirements and Constraints*

**System requirements = Desired system behaviors**

(Examples)

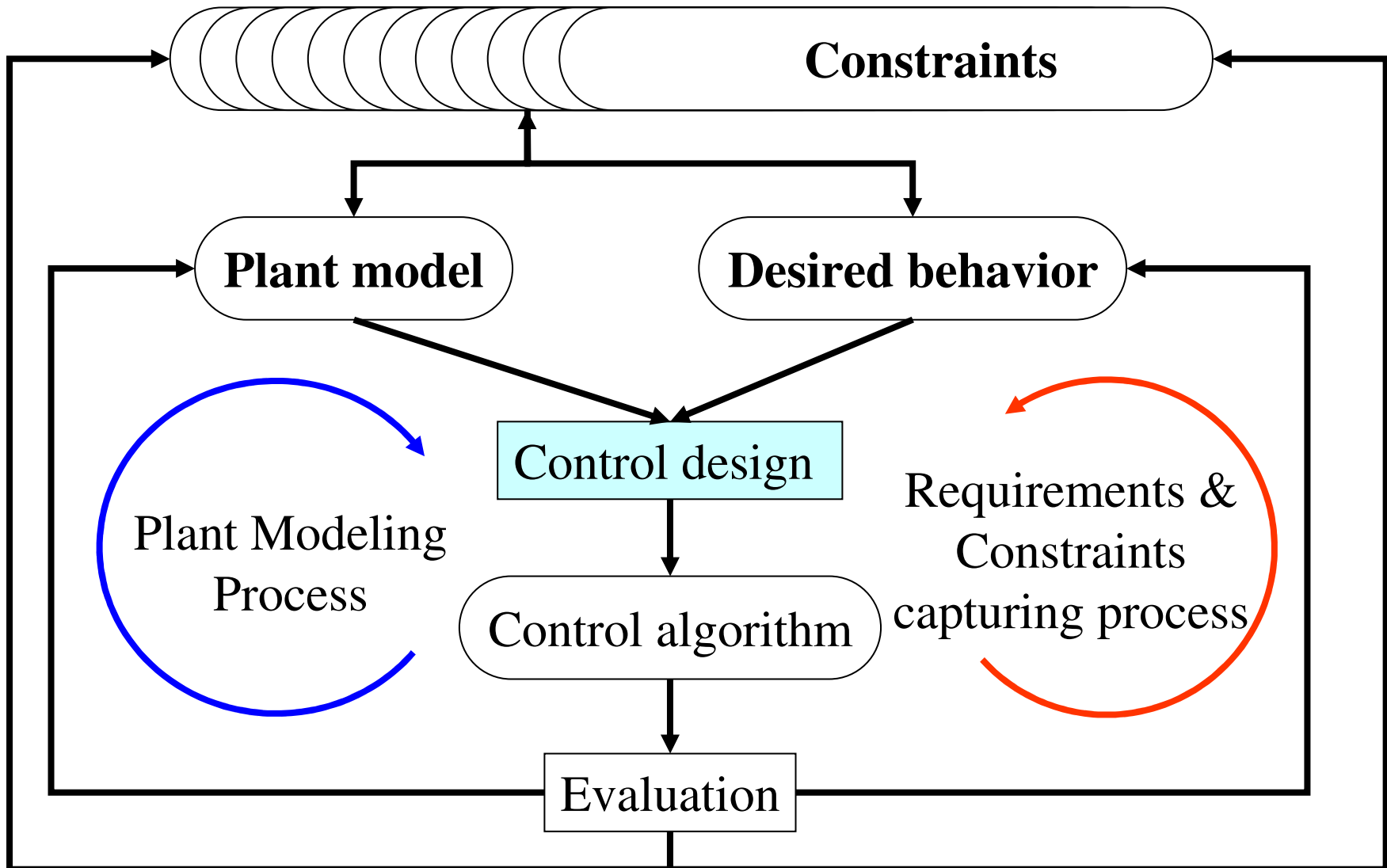
- *The car must satisfy PZEV exhaust gas emission regulations.*
- *The fuel consumption must be improved by 10%.*
- *The catalyst temperature must be under 1200K.*
- *The idle engine speed is regulated at 650rpm accurately.*
- *etc.*

**System constraints = limited system performances  
and possible resources**

(Examples)

- *The development budget must be less than \$100M.*
- *The development period must be less than 30 months.*
- *The amount of fuel injection must be within [1, 100] mg.*
- *The actuated speed of throttle valve must be less than 20 r/s.*
- *etc.*

# *Control Design*

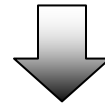


# *Characteristics of MBD*

Behavior models  
(executable models)

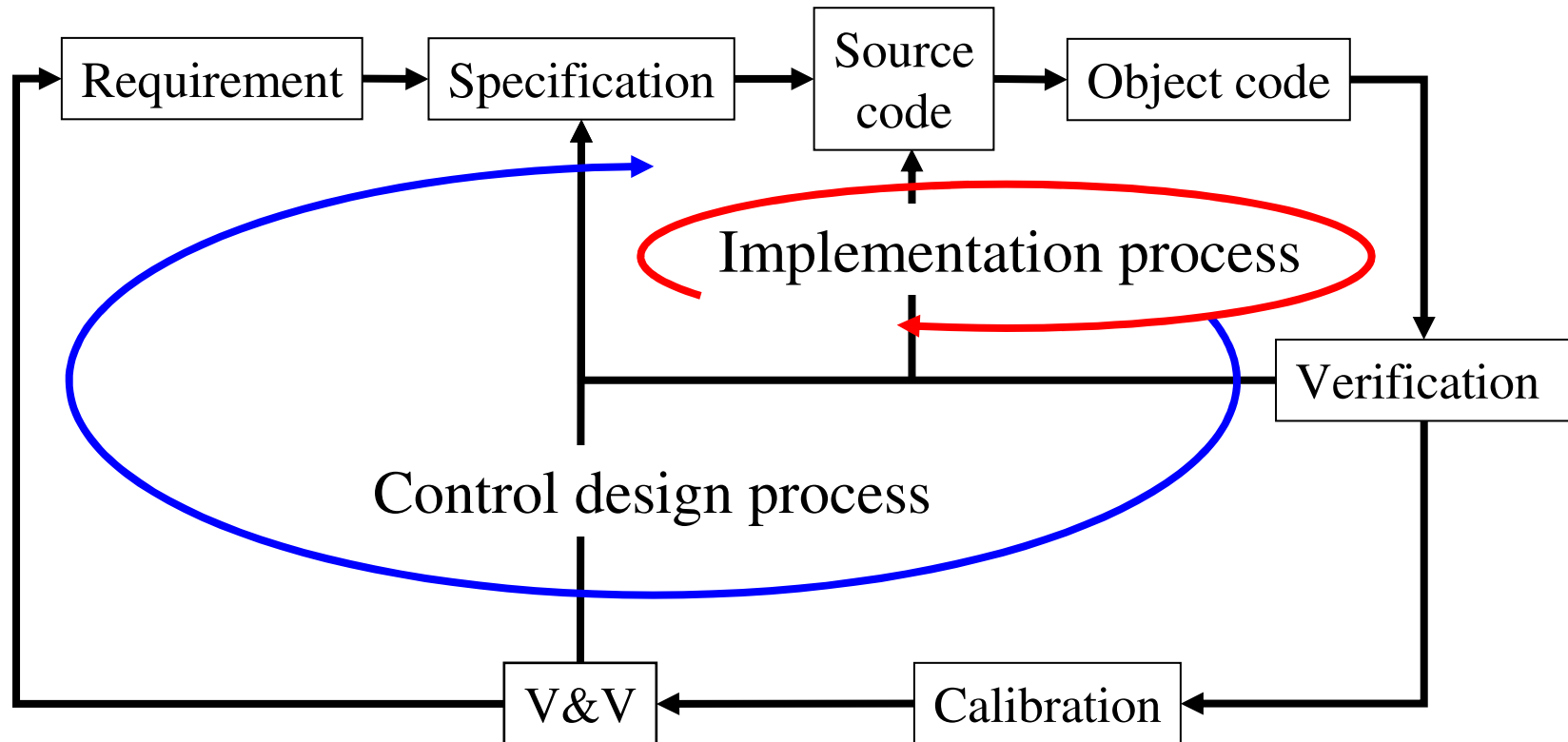
**Mathematical  
descriptions**

1. Controlled object models
2. Control models
3. Desired behavior models
4. Deriver models
5. Environment models



- A) Deriving control and control parameters
- B) Estimating system behaviors

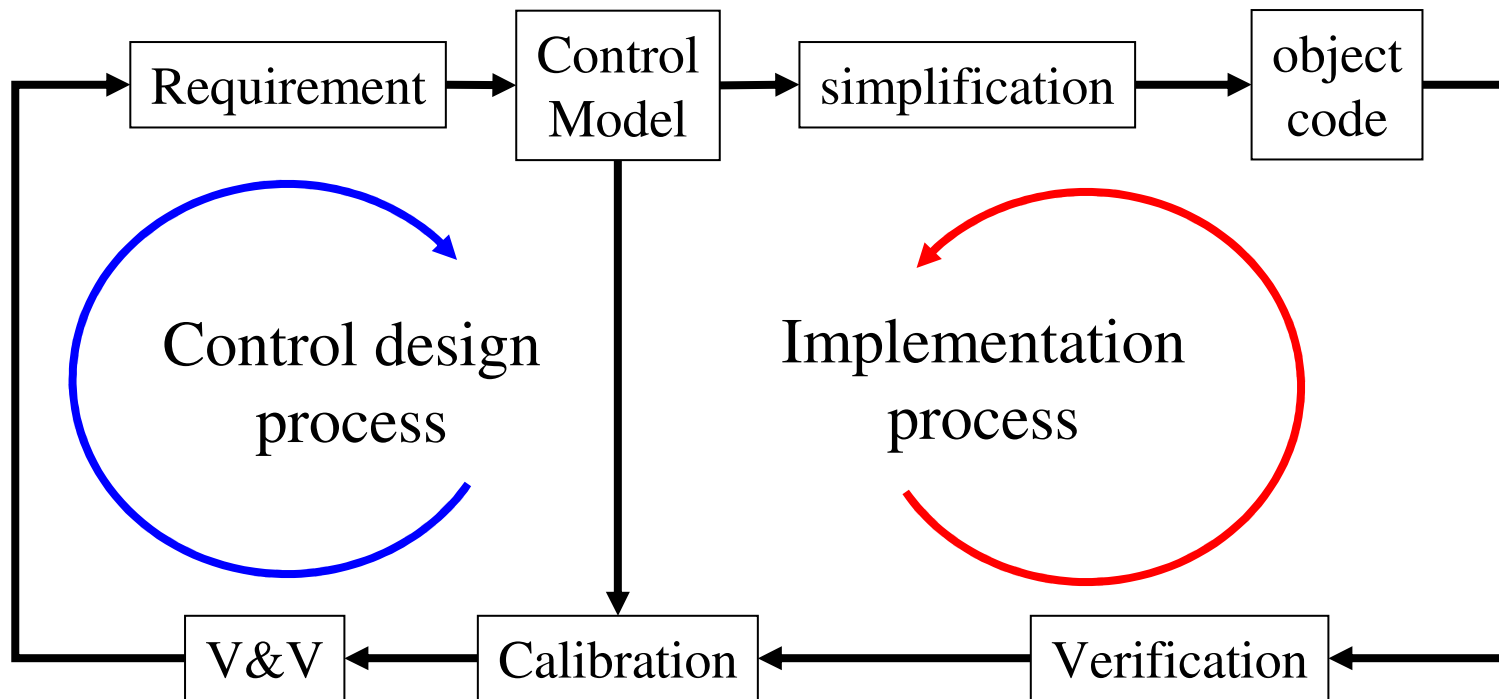
# *Current Control Design Workflow*



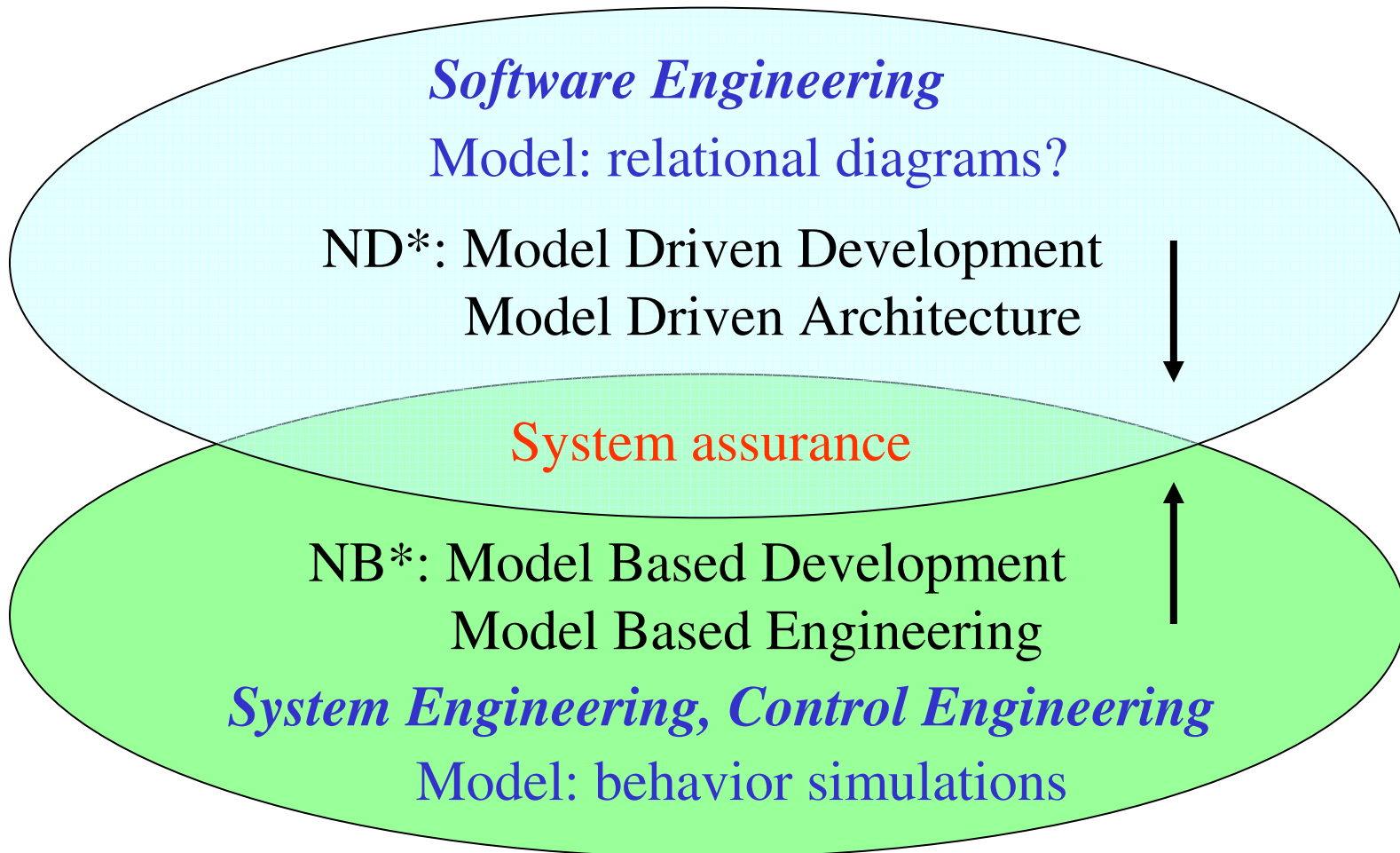
Control design process includes time consuming implementation process

# *Direction of MBD Workflow*

- Control design and implementation are separated.
- Implementation is defined as the recreation of the relationship between the inputs and the outputs with allowable error on ECU.



# *Models of MD\* and MB\**



Both have met with each other at system assurance.

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# *Advantages of OMG*

1. OMG has strongly contributed in software and tool development environments.
2. OMG has required the concrete implementations of the developed standards.
3. OMG has expertise of meta-modeling to generalize specified processes.
4. OMG has treated development processes including capturing requirement.
5. OMG can propose standardizations to ISO and IEC.

# *Disadvantages of OMG*

1. OMG hasn't covered physical systems.
2. OMG hasn't covered test facilities and system behavior data analysis.
3. Actual systems have frequent interactions between physical systems and control software.
  - *To ensure the system reliability, the consideration of physical system behavior is essential.*
  - *This may mean that OMG hardly covers system assurance although required software tools can be covered.*

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# *Possible Actions*

The following actions for consumer machine assurance can be expected in OMG:

1. Requirements and constraints capture and description
2. Physical modeling
3. Plant and system modeling (including empirical modeling)
4. Identification of system assurance
5. Continuous improvement of assurance management covering development, production and user usage phases.

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# *Summary*

1. Consumer machine is defined as the products used by general public users.
2. The current framework of system assurance would be insufficient because it would be based on factory machinery safety.
3. OMG is expected to lead the enactment of the standard framework for consumer machine assurance.
4. OMG can have the advantages in the areas of control software and the tool chain.
5. But, OMG would have to expands the activities toward physical system.