International Council on Systems Engineering
A better world through a systems approach

Integrating configurator and model-based verification and validation to streamline the design process of large-scale ETO systems

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Today's Agenda

- Toshiba's MBD/MBSE's concept
- Structured approach to the configurator development
- Requirements engineering for the product design
- Building configuration rules and logic
- Integrating the configurator with Model-based V&V
- Implementation of the MBD Configurator
- Engineering process improvement results

About me

HOANG LE ANH

Born in Hanoi, Vietnam
Living and working in Japan

Education

Nanyang Technological University of Singapore
B.E., Computer Engineering, First Class honors

Japan Advanced Institute of Science & Technology
Master of Science, Knowledge Science

Hobbies

Camping, hiking
Reading, piano

Experience

2007
Joined Toshiba. Start working as a researcher at Toshiba Production Innovation Technology Center, Japan
https://www.global.toshiba/ww/technology/corporate/cmc.html

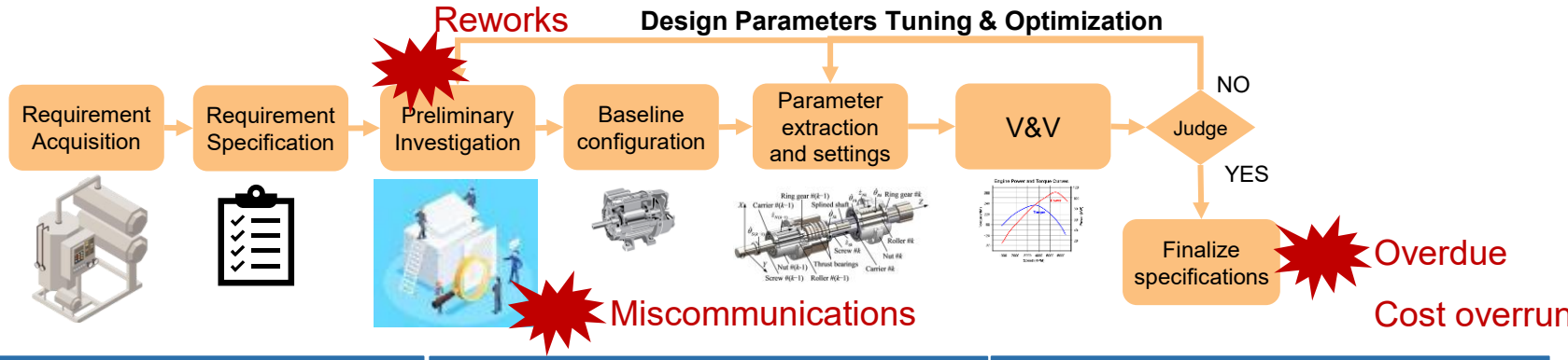
2009
Process Research Department
Performed simulation & optimization of semiconductor manufacturing process

2015
Global Manufacturing Innovation Department
Developed supply chain management and IoT technology for logistics (Vietnam, Thailand, U.S, China, Japan)

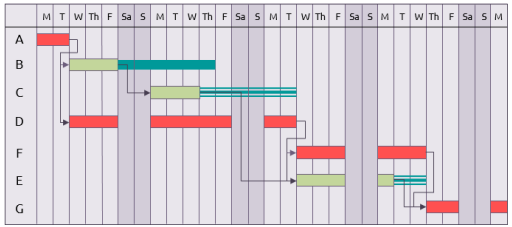
2017
Rotation to Kaga Toshiba Electronics
PM in charge of developing the Production Management System for the factory

2019~ present
Design & Manufacturing Innovation Department
Project Manager in charge of R&D in Engineering Process Innovation.
Develop Product Configurator, MBD/MBSE methodology for infrastructure & systems products

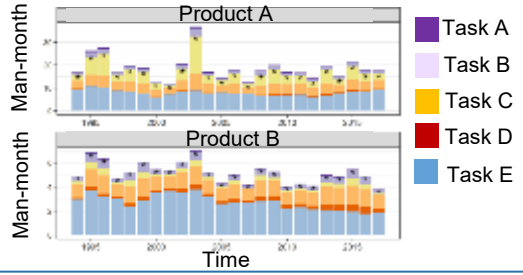
Challenges in manufacturing Engineer-to-Order(ETO) products



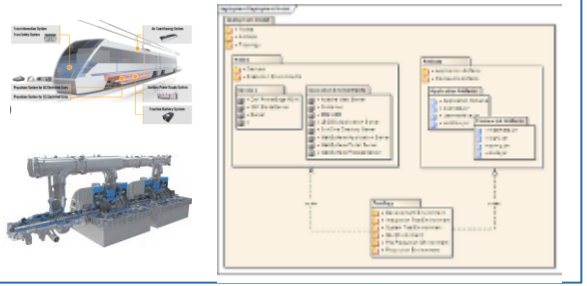
Predict lead time accurately



Optimize engineering resource allocation



Optimize the design of a complex product structured



Toshiba's concept of utilizing MBD/MBSE in ETO System Design and Development

System Layer

MBSE

Model Based Systems Engineering

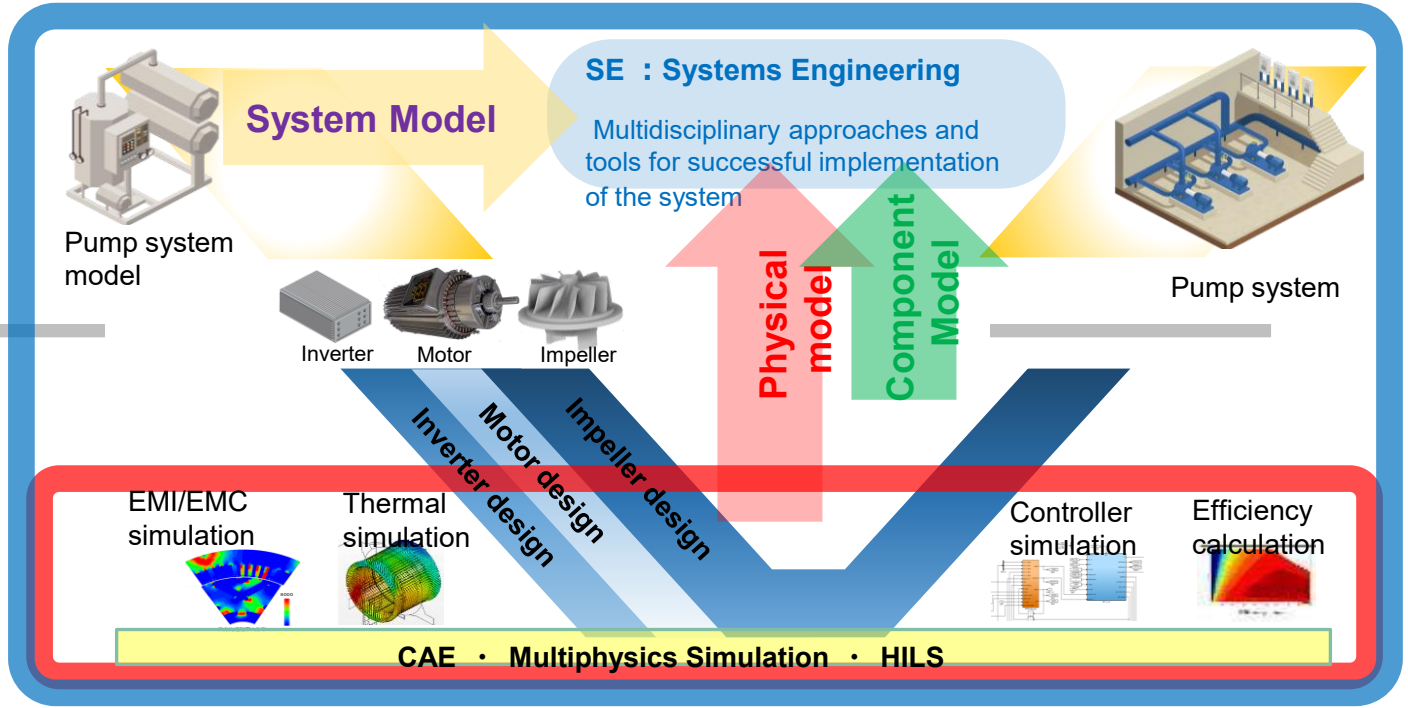
Requirements engineering (user requirements elicitation & analysis, concept of operations) while verifying compatibility and validity of the system architecture using the top-level system models

Sub-system Layer (Component Layer)

MBD

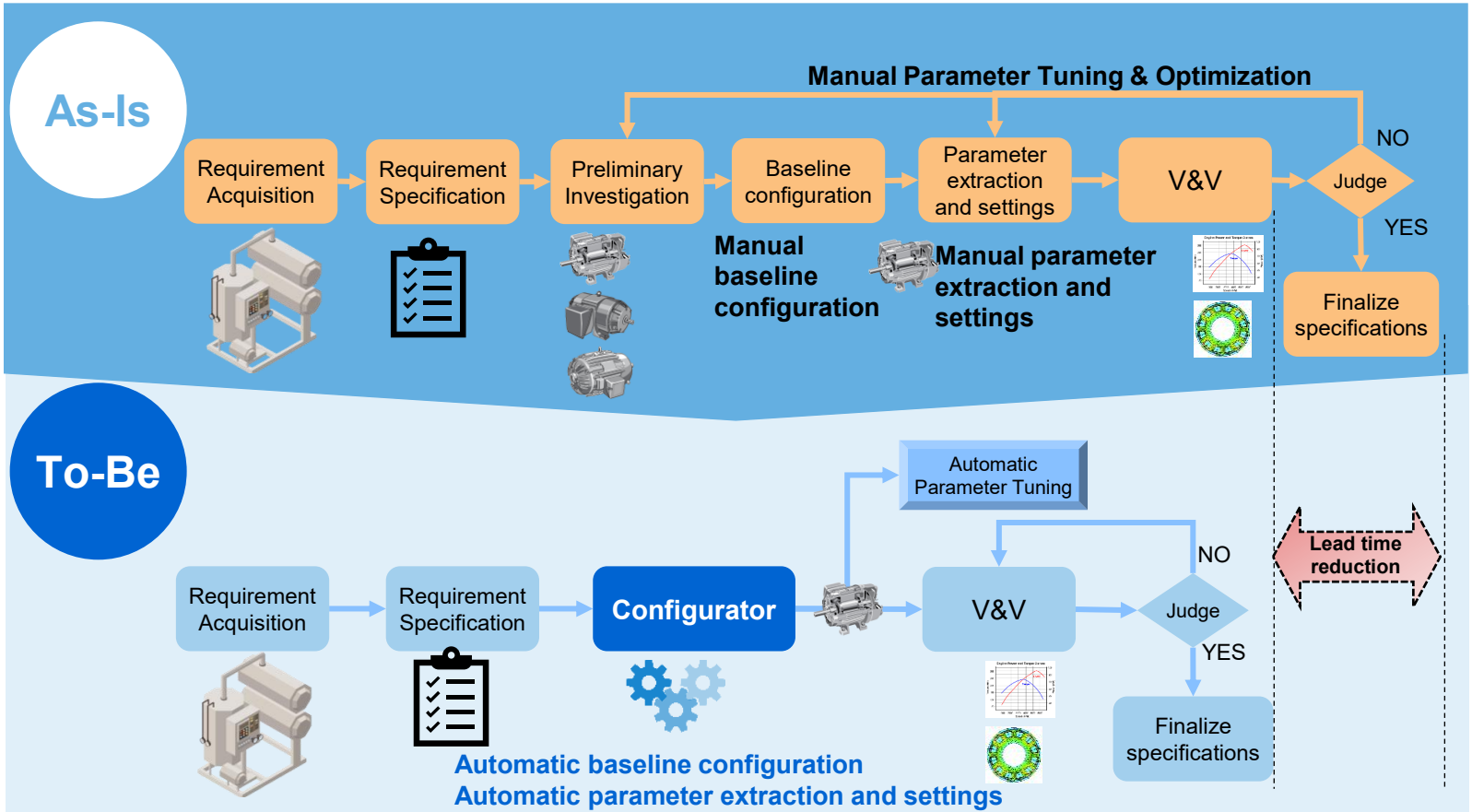
Model Based Development

Predicting the characteristics of actual components or sub-systems by analyzing models created in the design phase of the left side of the V-model to prevent rework at manufacturing and V&V of the actual components.

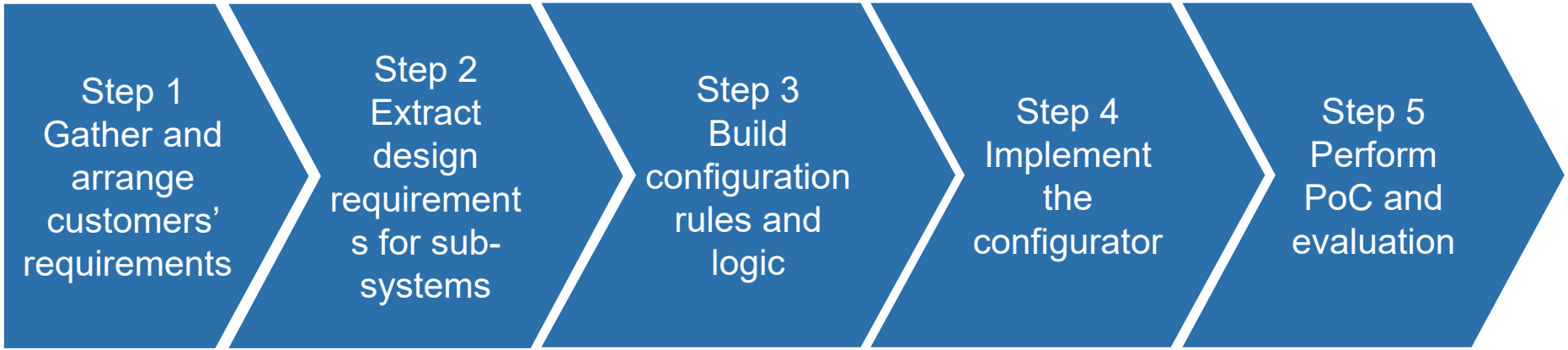


CAE : Computer Aided Engineering
HILS : Hardware In the Loop Simulation
EMI : Electromagnetic Interference
EMC : Electromagnetic Compatibility

Toshiba's concept MBD/MBSE in ETO System Design



Structured approach to the configurator development



Extracting and Structuring of Sub-System Design Requirements

Customer

Customers' RFP,RFQ

Requirements Engineering

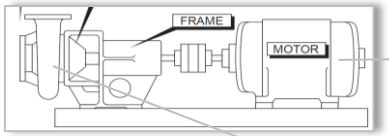
- Interview
- Requirements Elicitation
- Requirements Analysis
- Requirements Validation

Customer requirements Specification document

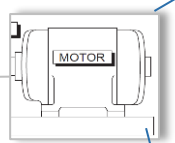
Sub-systems' design requirements extraction

Design requirements for motors

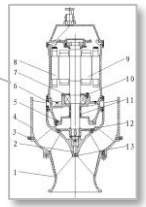
System Component	Specifications	Unit
Motor	Motor Type	Nil
Motor	Cooling Method	Nil
Motor	Rated Power	kW
Motor	Height	mm
Motor	Width	mm
Motor	Length	mm
Motor	Ambient Temp.	oC
…	…	….



PUMP SYSTEM



MOTOR



IMPELLER

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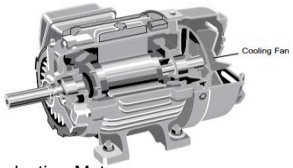
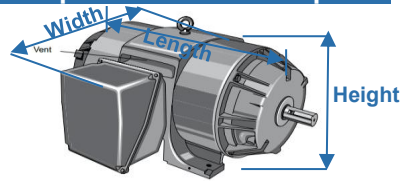
Motor Baseline Configurations & Specifications Example

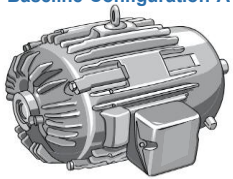
Motor Type
Cooling Method
Rated Power



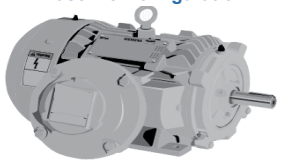
Induction Motor
Totally enclosed fan cooled enclosure
120kW
Baseline Configuration A



Induction Motor
Open Drip Proof Enclosure
120kW
Baseline Configuration B



Induction Motor
Totally enclosed non-ventilated enclosure
150kW
Baseline Configuration C

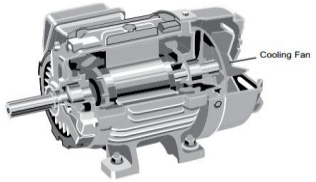


Induction Motor
Explosion proof enclosure
150kW
Baseline Configuration D

Configuration rule structure

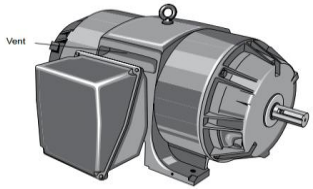
System Component	Specifications	Unit
Motor	Motor Type	Nil
Motor	Cooling Method	Nil
Motor	Rated Power	kW
Motor	Height	mm
Motor	Width	mm
Motor	Length	mm
Motor	Ambient Temp.	oC
…	…	….

Baseline Configuration Candidates



Induction Motor
Totally enclosed fan cooled enclosure
120kW

Baseline Configuration A



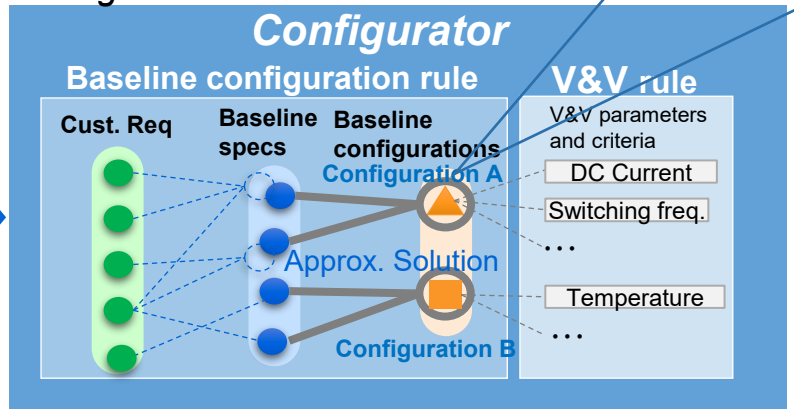
Induction Motor
Open Drip Proof Enclosure
120kW

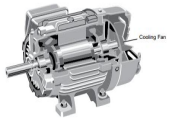
Baseline Configuration B

Design Requirements

- Motor Type
- Cooling Method
- Rated Power
- Height
- Width
- Length
- Ambient Temperature
- …

Configurator rule structure





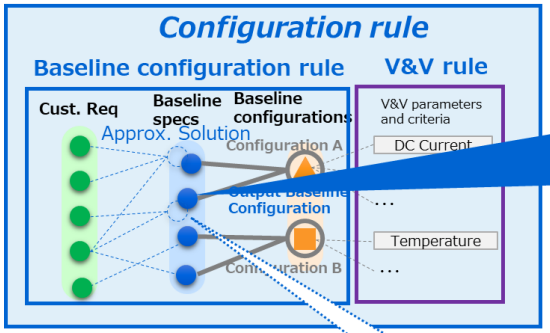
Configuration A

Feasibility verification

V&V parameters and criteria
DC Current
…

Adoption judgement
Optimum specs
Customization policy

Defining baseline configuration rule



Spec. Items	Constraint rules
Motor Type	EQUAL
Cooling Method	EQUAL
Rated Power	EQUAL
Height	LESS THAN OR EQUAL
Width	LESS THAN OR EQUAL
Length	LESS THAN OR EQUAL

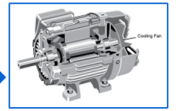
Standard configuration

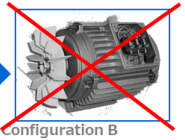
Required Specs	Motor Type	Cooling method	Rated Power	Height	Width	Length
	=IM	=Encl. w/fan	=120kW	≦800	≦800	≦1600

Config.	Motor Type	Cooling method	Rated Power	Height	Width	Length
A	IM	Encl.w/fan	120kW	500	600	700
CHECK RESULT	Pass	Pass	Pass	Pass	Pass	Pass

Config.	Motor Type	Cooling method	Rated Power	Height	Width	Length
B	IM	Encl.w/fan	120kW	850	650	750
CHECK RESULT	Pass	Pass	Pass	Fail	Pass	Pass

Baseline configurations (candidate standard units)


Configuration A


Configuration B

Spec. Items	Constraint rules
Motor Type	EQUAL
Cooling Method	EQUAL
Rated Power	EQUAL
Height	LESS THAN OR EQUAL with excess margin 10%
Width	LESS THAN OR EQUAL with excess margin 10%
Length	LESS THAN OR EQUAL with excess margin 10%

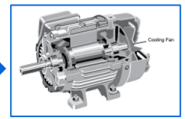
Approximate configuration (Flexible rule)

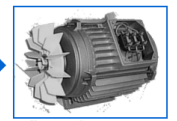
Required Specs	Motor Type	Cooling method	Rated Power	Height	Width	Length
	=IM	=Encl. w/fan	=120kW	≦(800 +80)	≦(800 +80)	≦(1600 +160)

Config.	Motor Type	Cooling method	Rated Power	Height	Width	Length
A	IM	Encl.w/fan	120kW	500	600	700
CHECK RESULT	Pass	Pass	Pass	Pass	Pass	Pass

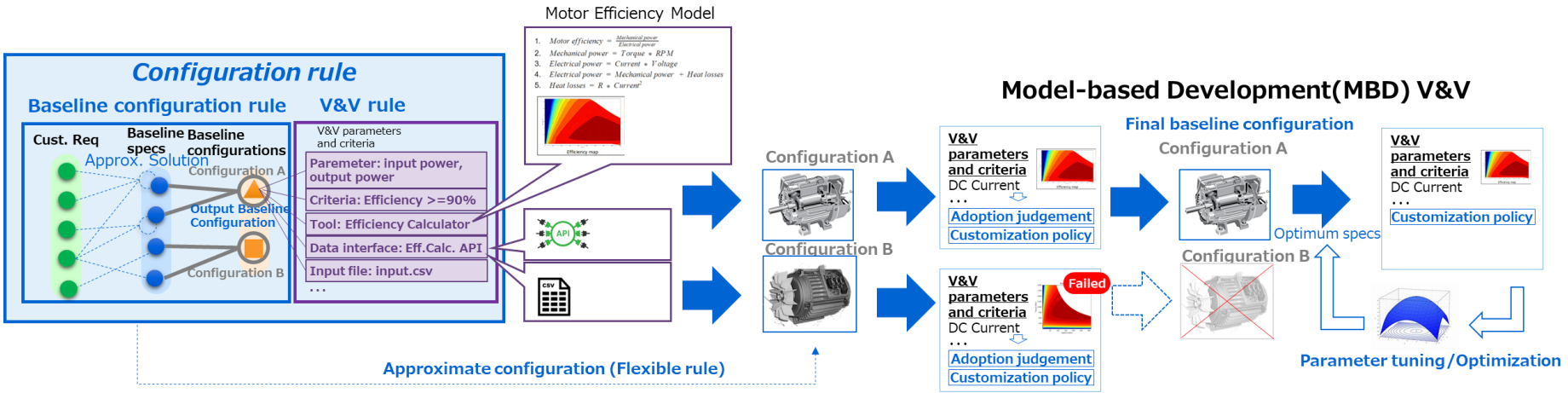
Config.	Motor Type	Cooling method	Rated Power	Height	Width	Length
B	IM	Encl.w/fan	120kW	850	650	750
CHECK RESULT	Pass	Pass	Pass	Pass	Pass	Pass

Baseline configurations (candidate standard units)


Configuration A


Configuration B

Integrating the configurator with Model-based V&V



Implementation of the MBD Configurator

Design Requirements

- Motor Type
- Cooling Method
- Rated Power
- Ambient Temp.
- Height
- Width
- Length
- ...

MBD Configurator

GUI configuration settings | GUI input constraints | Standard units master | Baseline configuration rule | V&V rule

GUI construction → Baseline configuration → V&V rule configuration → V&V execution

Output

BOM, Optimal parameters combination

Baseline configuration

Cust. Req | Baseline specs | Baseline configurations

Approx. Solution

Configuration A

Output Baseline Configuration

Configuration B

V&V rule configuration

V&V parameters and criteria

- DC Current
- Switching freq.
- ...
- Temperature
- ...

Feasibility verification MBD V&V

Configuration A

V&V parameters and criteria

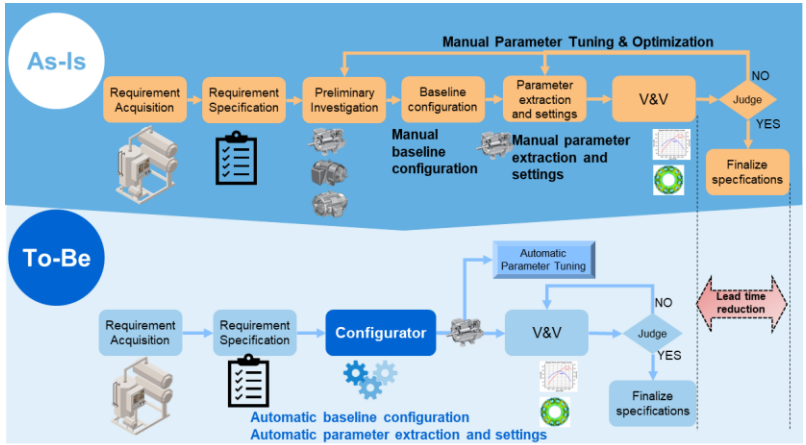
DC Current

...

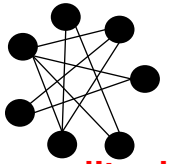
- Adoption judgement
- Optimum specs
- Customization policy

Parameter tuning/Optimization

Engineering process improvement results



Miscommunication

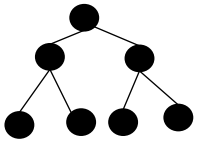


Low quality design

Rework

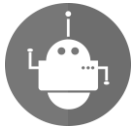
Manual Design

Effective communication



High quality design

No rework



Design automation

Summary

- We proposed a standard process which integrate top-level design process with low level design process targeting ETO systems with high design loads
  - Built a configurator enhanced with mode-based development interface to meet large scale customization
  - Added configurator functions to optimize key design parameters in collaboration with external simulators as well as optimization tools
  - Flexible constraints to assign an approximate configuration as a baseline configuration to accommodate higher levels of customization
  - Integration of the configurator with model-based V&V tools for optimization, to ensure the optimal customization
  - As a result, the approach delivers significant improvements in engineering lead time, design costs, and overall design quality

Questions and comments

Thank you for your attention !

We welcome questions and comments.

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