

2020 MathWorks 中国汽车年会

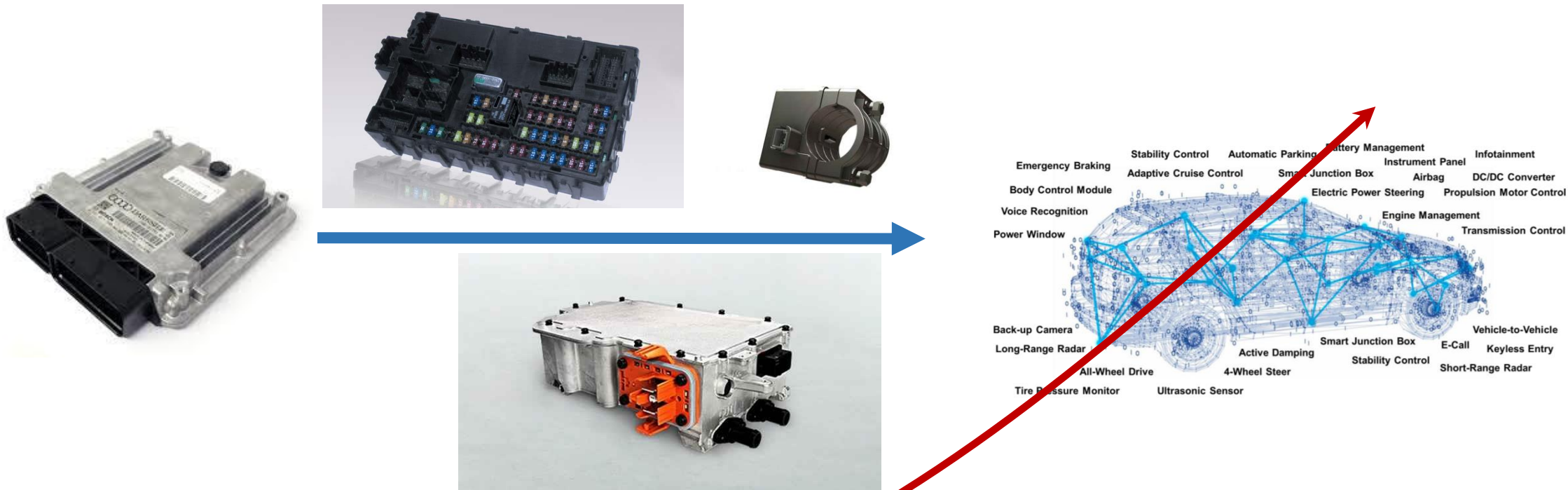
基于模型开发流程评估的收获
—— 行业成熟度的趋势及经验

John Lee

MathWorks总部 高级咨询服务顾问



数字化转型: 嵌入式软件无处不在



设计复杂度

1980

1990

2000

2010

2020

2030

汽车的数字化



电动汽车



自动驾驶



车辆互联

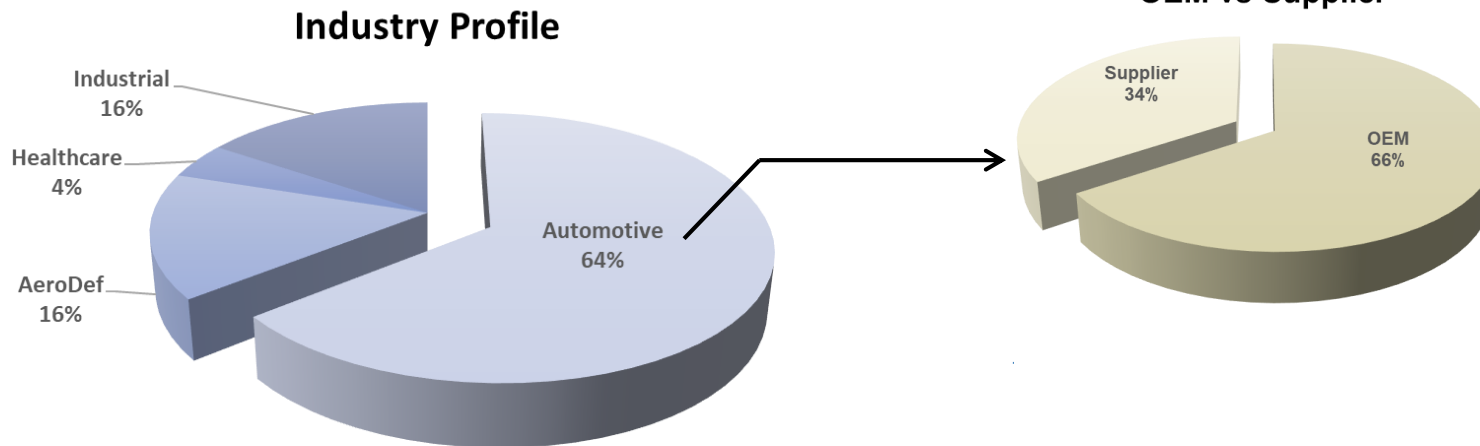
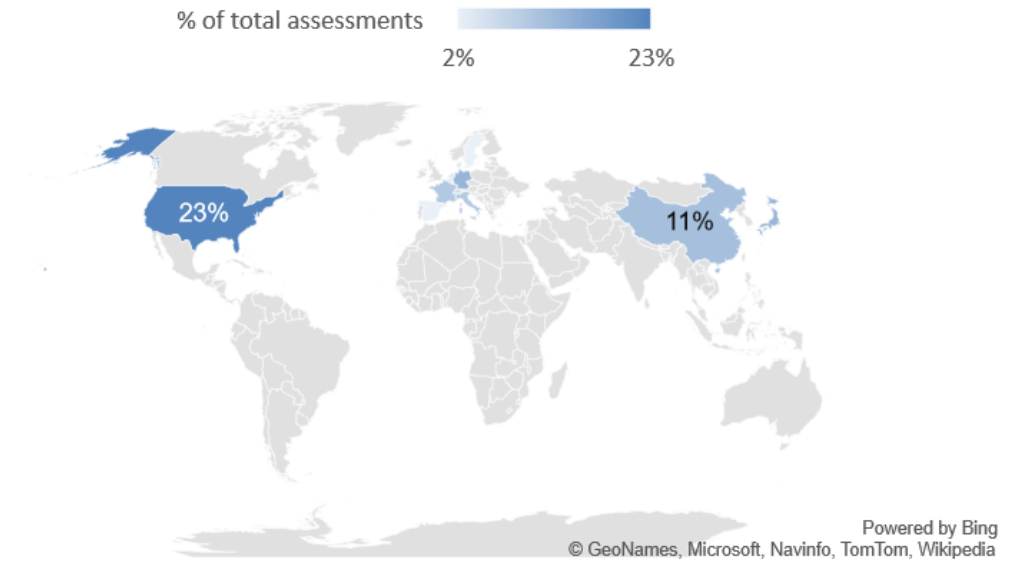
- 数字化转型对工具和流程提出新的挑战

需要回答的问题

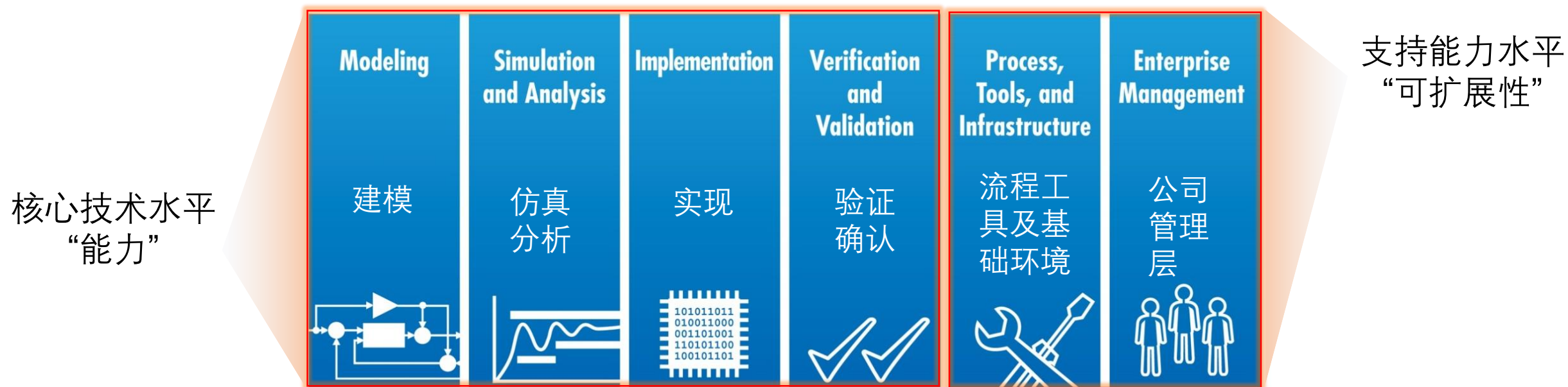
今天的讨论

- 多年来，MathWorks在全球各个行业完成了大量基于模型设计流程评估项目
- 分享项目成果，包括汽车行业工具和流程改进的总体趋势及其相关性

Process Assessment Locations

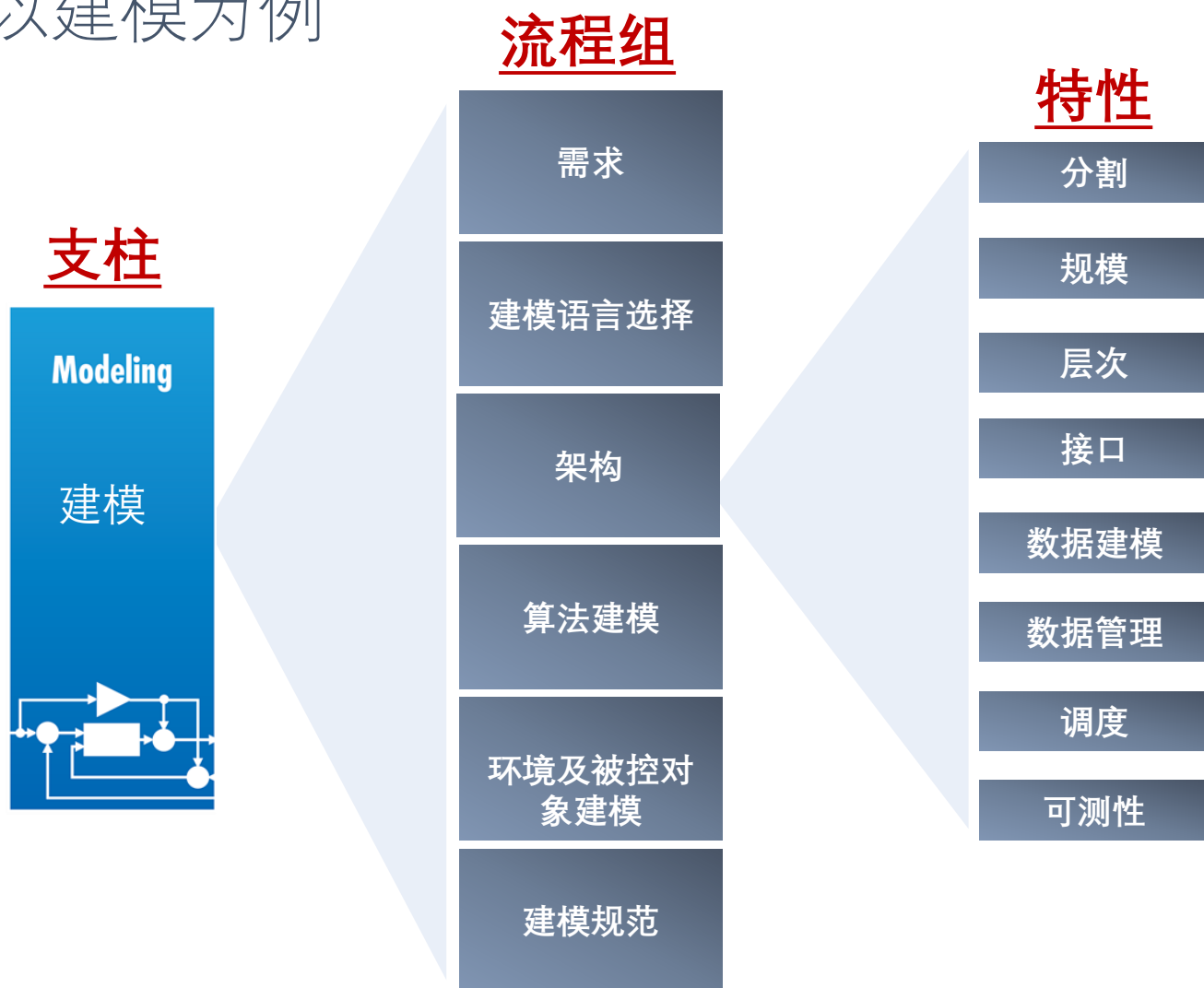


根据基于模型设计成熟度框架™进行流程评估



- 主要特性
 - 能力综合度量
 - 每个能力独立度量
 - 适用于任何专业水平

基于模型设计成熟度框架™ -- 以建模为例

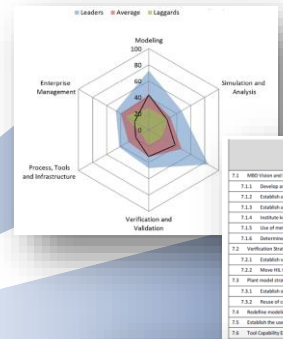


- 通过以下内容打分确定成熟度：
 - 6 支柱
 - 28 关键流程组
 - 200+ 特性

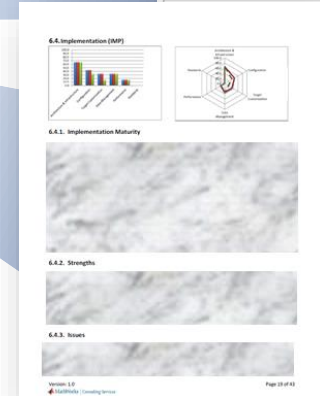
流程评估的具体实施



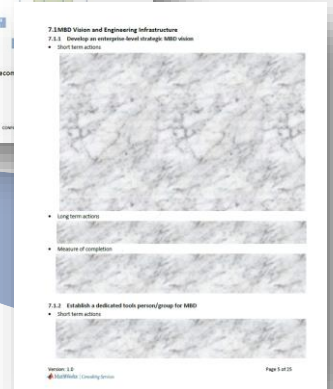
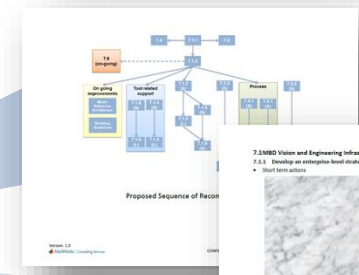
MBD 流程评估报告



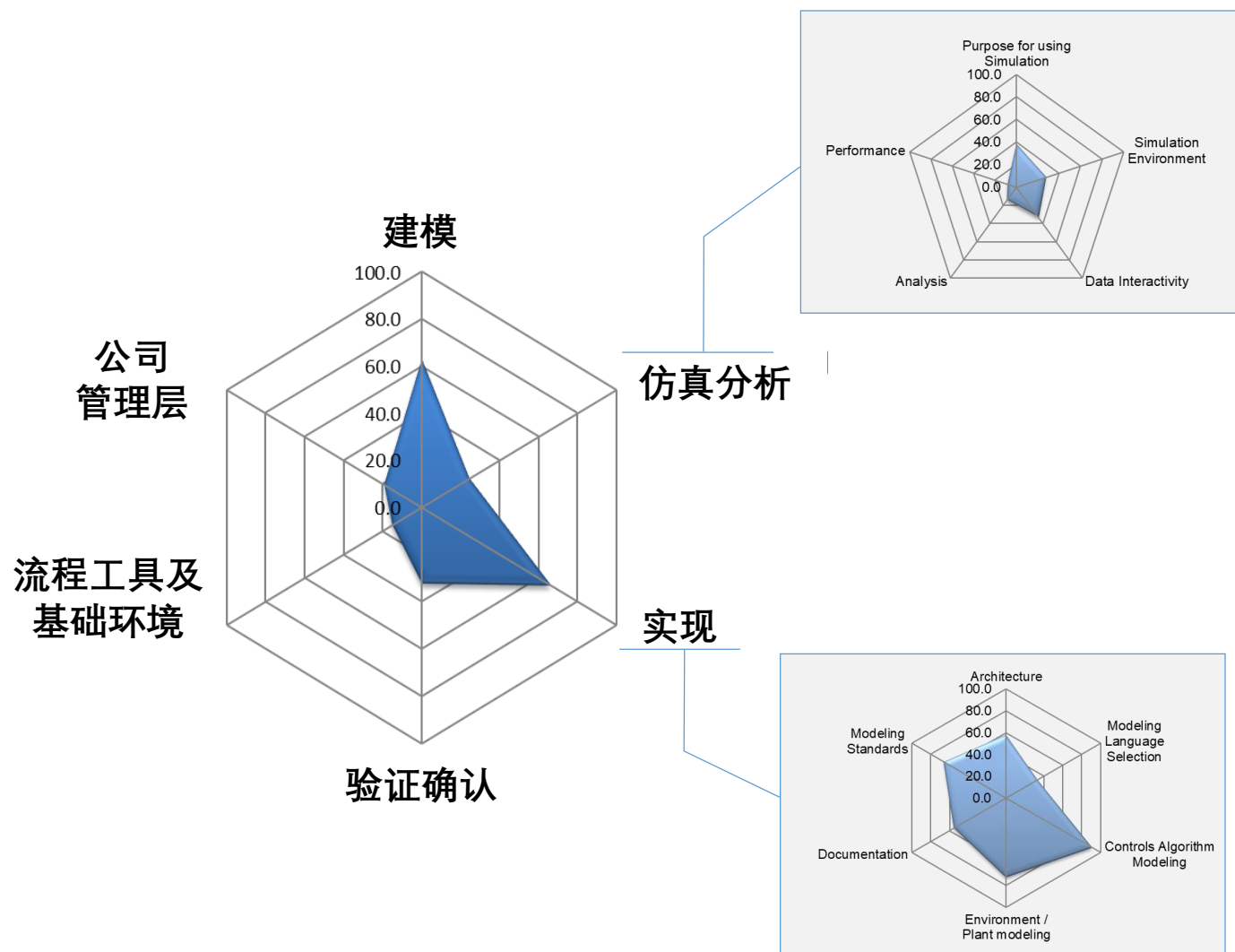
Recommendations	Impact	Level of Difficulty
7.1 MBD Vision and Engineering Infrastructure		
7.1.1 Develop an enterprise level strategic MBD vision	High	High
7.1.2 Establish a dedicated team/group for MBD	High	High
7.1.3 Establish a suitable software development process	High	Medium
7.1.4 Establish knowledge sharing and management	Medium	Medium
7.1.5 Use of metrics for forecasting project status, process improvement, and workload	High	Medium
7.1.6 Determine a tool agnostic strategy	Medium	Medium
7.2 Verification Strategy and Implementation		
7.2.1 Establish verification strategy	High	Medium
7.2.2 Move V&V testing to the ECU level based requirement testing	Medium	Medium
7.2.3 Establish strategy for plant modeling	High	High
7.2.4 Reuse of current V&V plant model for integration level testing	Medium	Medium
7.2.5 Enable modeling integration with separate functional generator and integrator engine (FGE)	Medium	Medium
7.3 Establish the use of simulation for system optimization and performance analysis for the requirement's group	High	Medium
7.4 Tool Capability Enhancement	Low	Low
	Medium	Low
	Medium	Medium
	Medium	Medium
	Low	Low
	Medium	Low
	Medium	Medium



MBD 流程评估实施计划



我们如何评审数据?...一个简单的例子



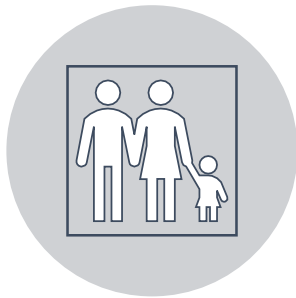
• 分析结果

- 实现（代码生成）方面较强
- 验证与确认、仿真与分析做得不够完善
- 基于模型设计主要聚焦在了软件实现方面

流程评估 - 数据分析

- 定量分析
 - 流程评估数据图
- 定性分析
 - 详细的分析报告



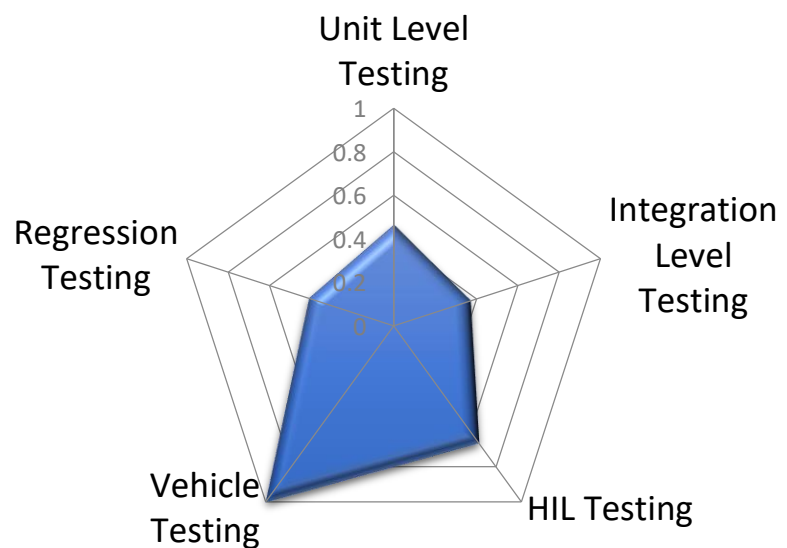


现在的验证与确认流程跟
ISO26262要求还有多大差距？



验证与确认支柱与 ISO26262-6的映射

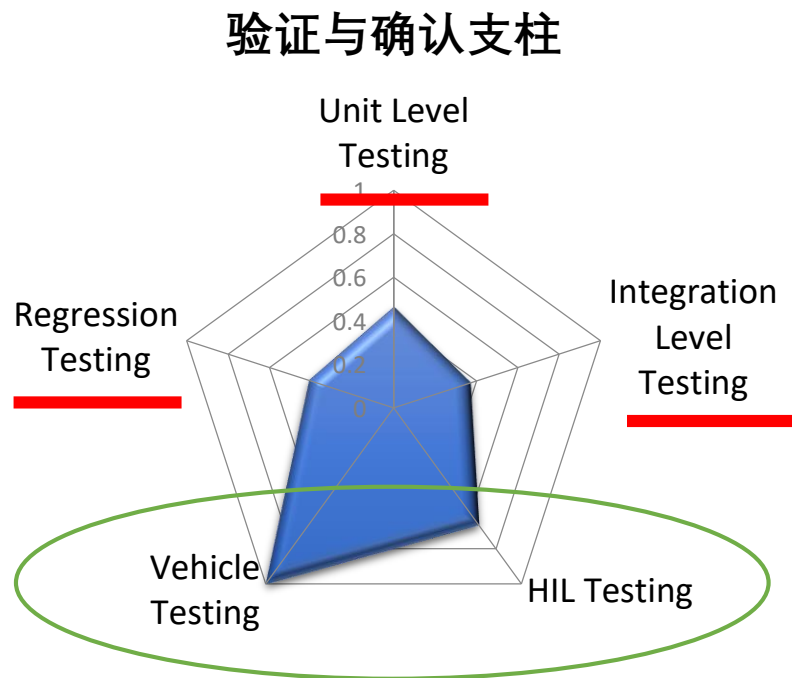
验证与确认支柱



验证与确认支柱	ISO 26262
单元测试	ISO 26262-6 第9章 软件单元验证
集成测试	ISO 26262-6 第 10章 软件集成与验证
实车及硬件在环测试	ISO 26262-6 第 11章 嵌入式软件的测试
回归测试	ISO 26262-8 第 9章 验证

*验证与确认支柱成熟度平均分根据实车测试进行标化

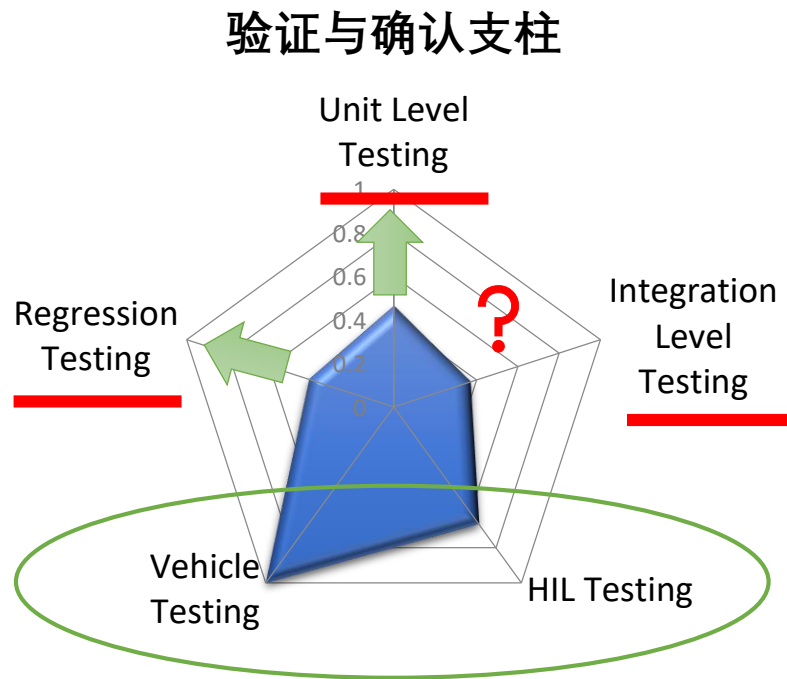
验证与确认支柱的状态及趋势



- 由于遗留原因，实车和硬件在环测试做得比较完善
- 其余三个流程组成熟度偏低表明很难满足ISO 26262这样的安全标准

*验证与确认支柱成熟度平均分根据实车测试进行标化

验证与确认支柱的状态及趋势

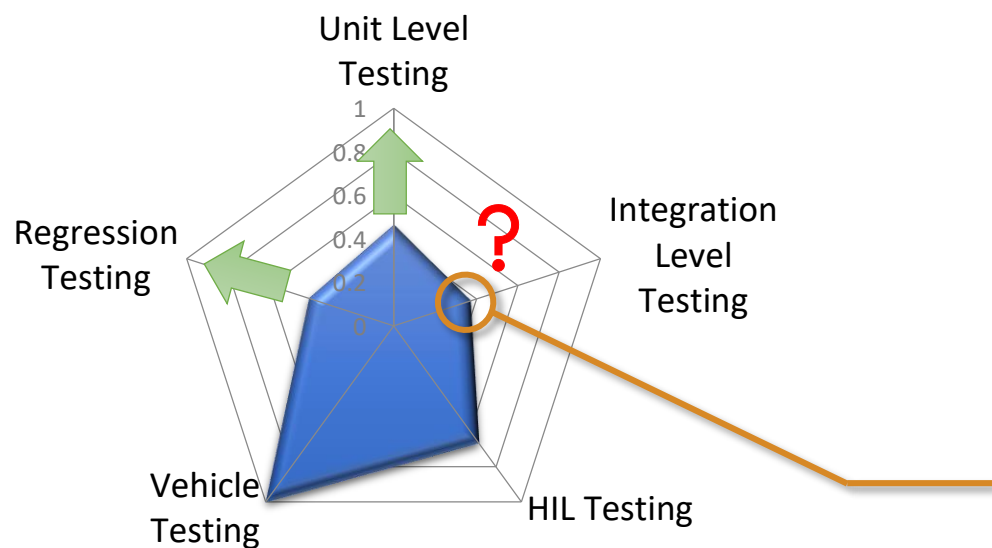


- 积极的趋势:
 - 单元测试和回归测试越来越严格
 - 原因:
 - 系统复杂度的增加
 - 像ISO 26262 和 ASPICE这些标准的要求
 - 应用复杂度的提高导致这一项成熟度的提升 — AV/ADAS/AD
- 令人疑惑的地方:
 - 集成测试做得怎么样呢？

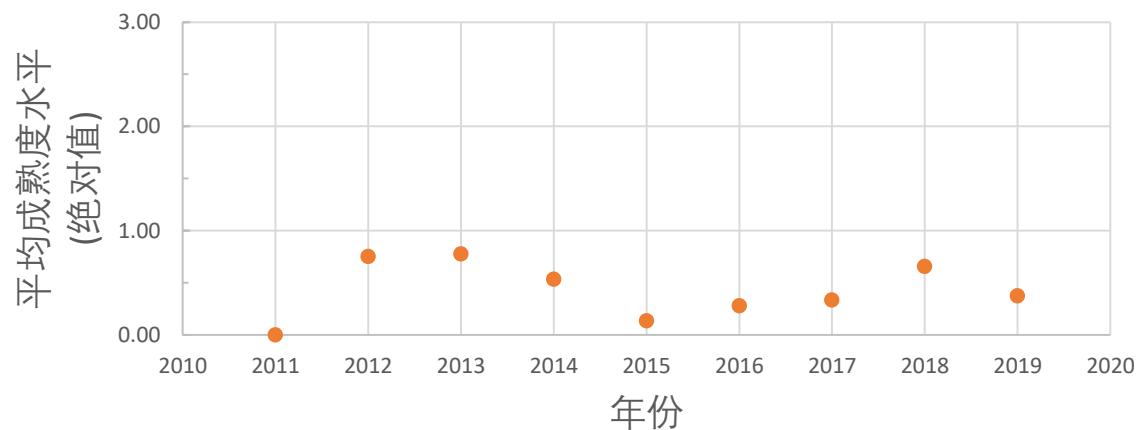
*验证与确认支柱成熟度平均分根据实车测试进行标化

验证与确认支柱的状态及趋势

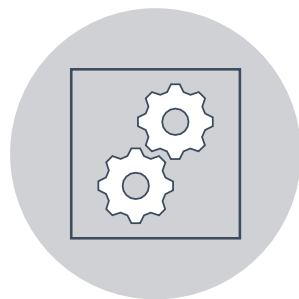
验证与确认支柱



集成测试的趋势



*验证与确认支柱成熟度平均分根据实车测试进行标化



为什么没有充分利用集成测试呢？



为什么说集成测试非常重要?

- 安全标准

- 详细的得单元测试验证
- 通过集成测试确保多个单元能协同工作

- 需求确认

- 自上而下得设计方法
- 确保需求得正确性

The "digital" car

Fighter planes	:	20 M lines of code
High end cars	:	100 M lines of code
Electronics SW	:	< 20% of car cost in 2005
Electronics SW	:	Almost 40% today
Innovation Spend	:	90% in Electronic Systems
Spend on innovation	:	US\$ 105 B in 2014, 4% of revenue
SOC market	:	USD 31B, 7.5% growth



OEMs increasing Model choices but decreasing number of Vehicle Architectures

一辆“数字化”的轿车包含上亿行代码

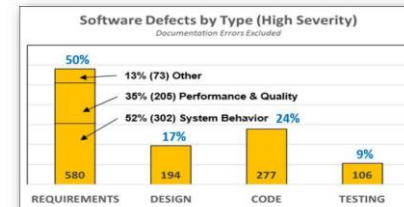
TATA ELXSI

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THE SOURCE OF SOFTWARE ISSUES



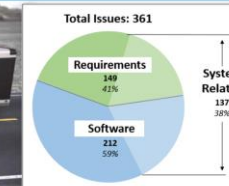
"The IV&V Program documented 10,677 software artifact defects on 22 NASA projects in 2007...The IV&V Program analyzed the defects sorting them by severity and type of defect."



Requirements are the leading source of software defects. System requirements are the leading source of requirement defects.

50% 的缺陷来自于需求

THE SOURCE OF SOFTWARE ISSUES



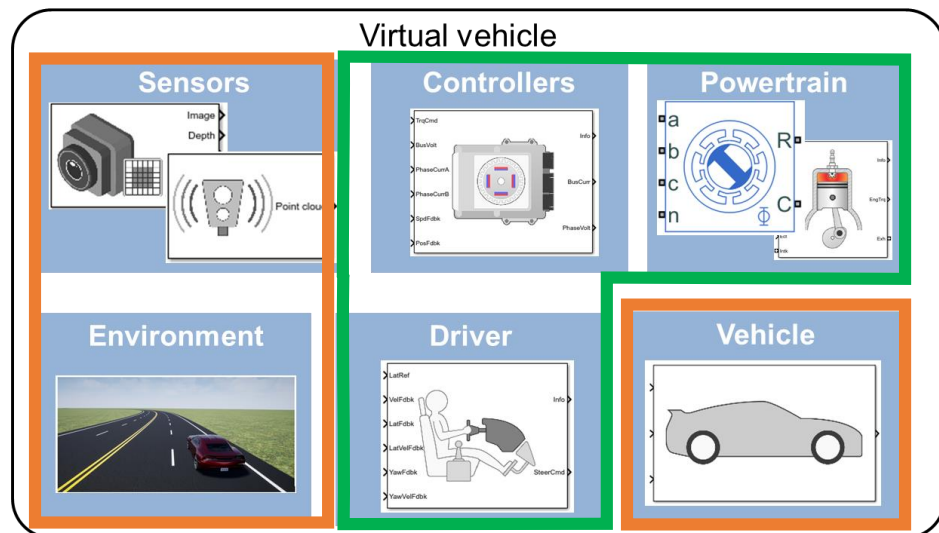
41% of Software issues found during development of the 2016MY F-150 Pro Trailer Backup Assist Feature were related to the requirements, and 38% of all software issues were system-related.

38% 软件问题跟系统相关

构建集成级别模型的关键

- 单元模型集成的自动化
- 与软件/模型仓库更强的集成
- 开箱即用的被控对象模型
- 仿真的可扩展性
- 设计合适的软件架构，比如调度器
-等等.

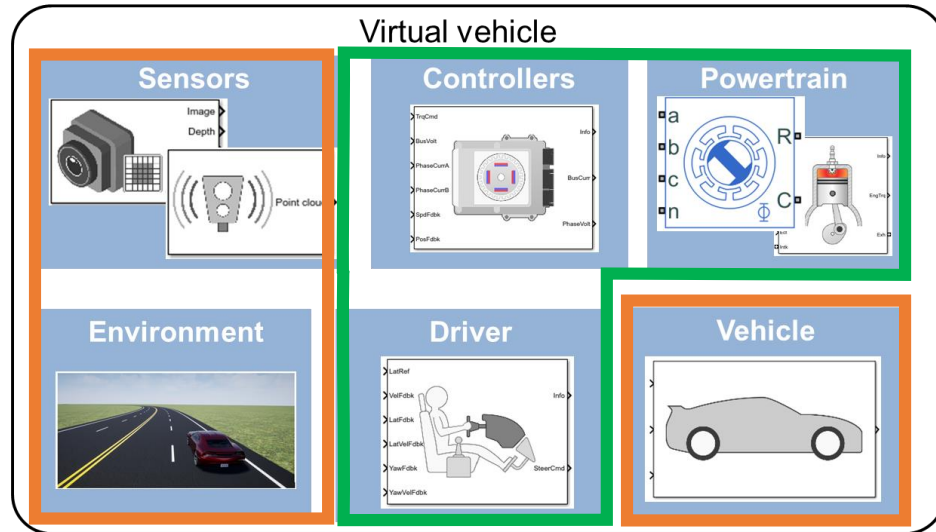
集成测试开发






R2016b release – Powertrain Blockset

R2018a release – Vehicle Dynamic Blockset

实现集成测试



MathWorks 咨询服务

-  **Model Architecture**
Model assessment
Simulation performance
Interface standardization
...
-  **Construction**
Build process automation
Database/Repo interface
Model-Building know-how
...
-  **User Experience**
GUI driven workflow
Tool compatibility support
Artifact creation
...

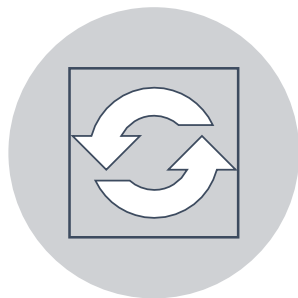


开箱即用的功能

定制虚拟车辆解决方案

R2016b release – Powertrain Blockset

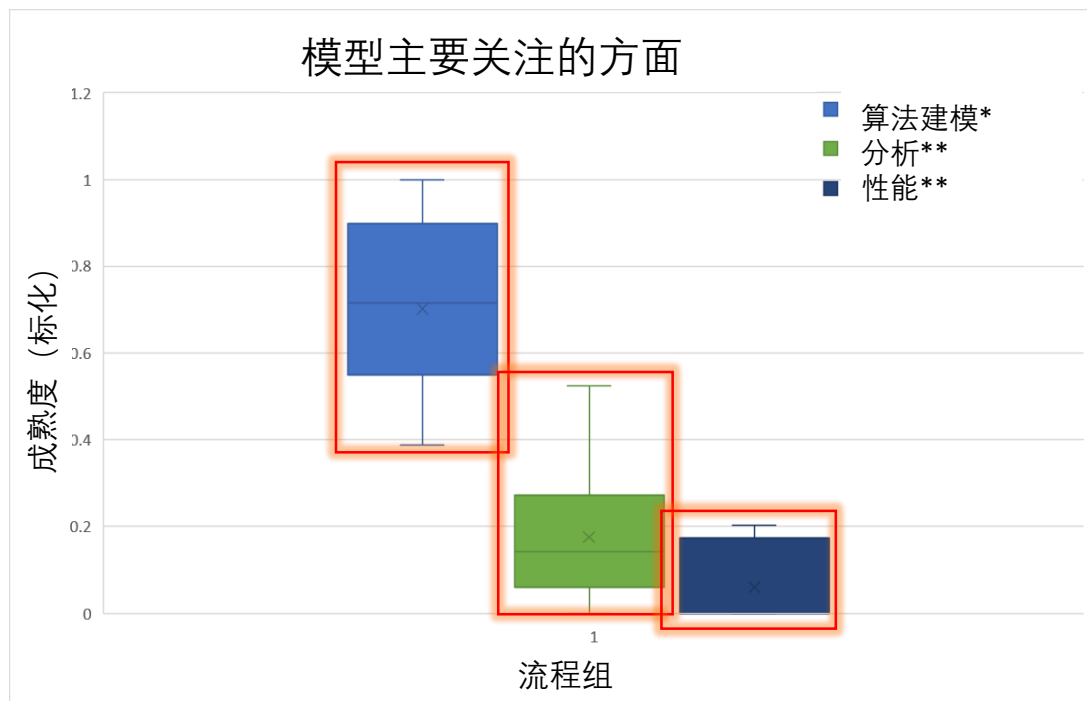
R2018a release – Vehicle Dynamic Blockset



除了代码生成，是否还利用模型进行确认和分析呢？
这些模型是如何维护的呢？



模型的使用

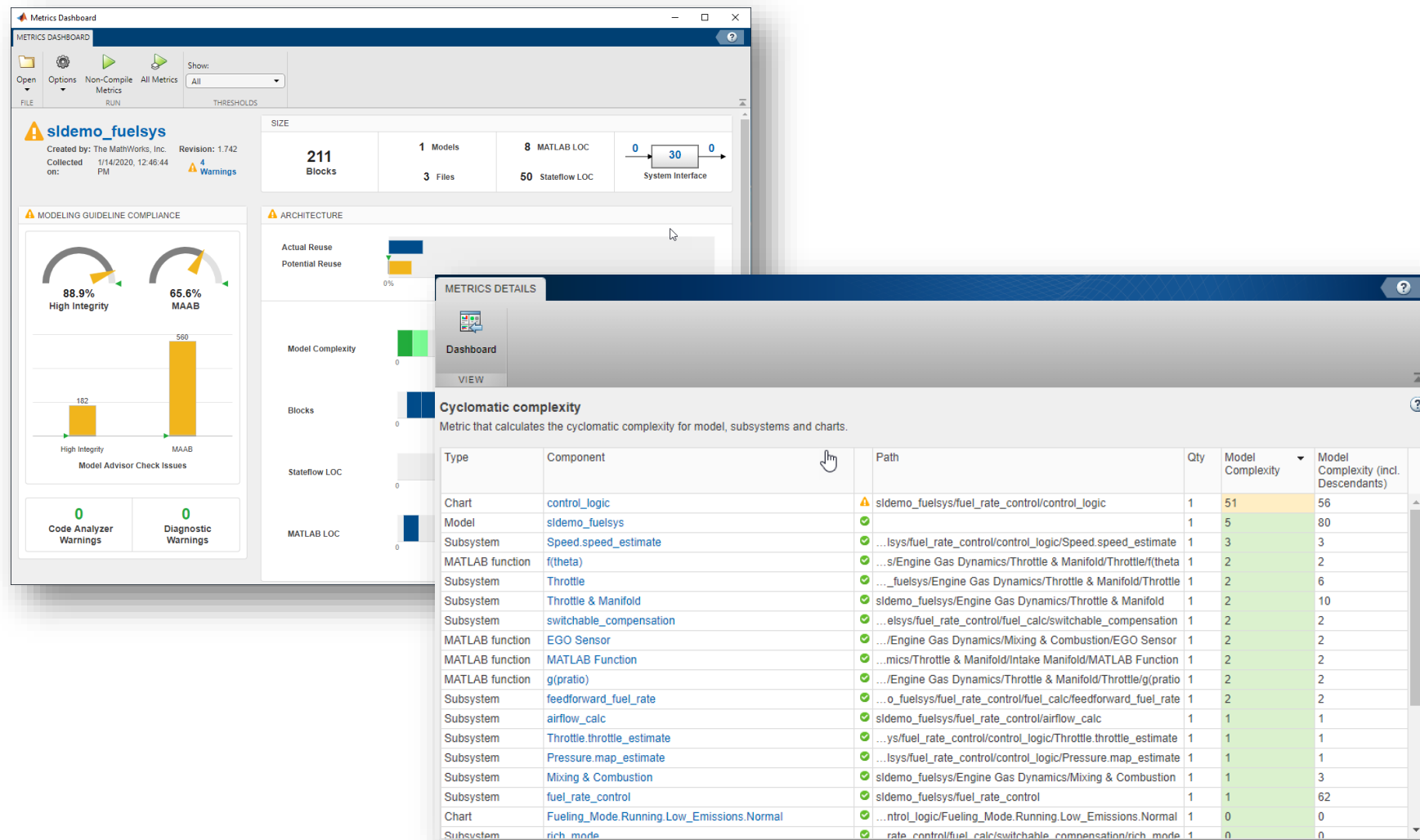


* 建模支柱部分
** 仿真分析支柱部分

- 大多数公司建模是为了算法开发
- 领先的公司建模还为了：
 - 需求确认
 - 性能优化
- 领先的公司维护模型并且
 - 测量模型指标并生成报告
 - 优化仿真速度
- 模型的使用是领先公司和落后公司之间存在巨大差异的地方

通过建模指标进行模型的生命周期管理

- 开箱即用
 - 建模指标面板



通过建模指标进行模型的生命周期管理

- 开箱即用
 - 建模指标面板
- 与应用行业的合作
 - 模型质量目标 (MQO)



1.10 Authors

This document was prepared by the MQO working group from the following OEMs and suppliers.

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Patrick Munier	MathWorks
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Table 2 below provides the list of Model Quality Requirement (MQR) applicable to achieve the quality objective of each type of design models. The details of each MQR are specified in section 3.2.

MQR ID	MQR Title	MQO-1	MQO-2	MQO-3	MQO-4
MQR-01	Model layout	M	M	M	M
MQR-02	Model comments	M	M	M	M
MQR-03	Model links to requirements	M	M	M	M
MQR-04	Model testing against requirements	M	R	M	M
MQR-05	Model compliance with modeling standard		M	M	M
MQR-06	Model data		M	M	M
MQR-07	Model size			M	M
MQR-08	Model complexity			M	M
MQR-09	Model coverage			M	M
MQR-10	Model robustness			M	M
MQR-11	Generated code testing against requirements			R	M
MQR-12	Generated code compliance with coding standard			R	M
MQR-13	Generated code coverage			R	M
MQR-14	Generated code robustness			R	M
MQR-15	Generated code execution time				M

3.2.7 Model size

MQR-07 Model size

Description The model shall have less than 500 elements including:

- The number of Simulink blocks
- The number of MATLAB executable lines of codes
- The number of Stateflow transition, states, and connections
- The number of truth tables decision

Recommendation level

MQO-1	MQO-2	MQO-3	MQO-4
		Mandatory	Mandatory

Notes The model reference block only counts as one element. The company standard utility function (e.g. Simulink library block, MATLAB function file) only counts as one element. Please refer to MathWorks guidance on large-scale modeling in Simulink documentation.

References /Examples of techniques

Rationale Very large models are more difficult to merge and are more likely to be modified by several users at the same time. Smaller models are more likely to be reusable and easily configurable. Generated code of very large models cannot be incrementally tested.

Last update 1.0

3.2.8 Model complexity

MQR-08 Model complexity

Description The model and its subsystems, Stateflow charts, and MATLAB functions shall have a local cyclomatic complexity lower or equal to "30".

Recommendation level

MQO-1	MQO-2	MQO-3	MQO-4
		Mandatory	Mandatory

Notes Local complexity is the cyclomatic complexity for objects at their hierarchical level. Aggregated cyclomatic complexity is the cyclomatic complexity of an object and its descendants. The threshold of 30 for local cyclomatic complexity is a recommendation and can be adapted on a project basis. The number 30 for cyclomatic complexity has been derived from the MISI code metric and adapted to Model-Based Design.

Examples of techniques Cyclomatic complexity is a measure of the structural complexity of a model. It approximates the McCabe complexity measure for code generated from the model. The McCabe complexity measure is slightly higher on the generated code due to error checks that the model coverage analysis does not consider. To compute the cyclomatic complexity of an object, such as a block, chart, or state, model coverage uses the following formula:

$$c = \sum (|b_i| - 1)$$

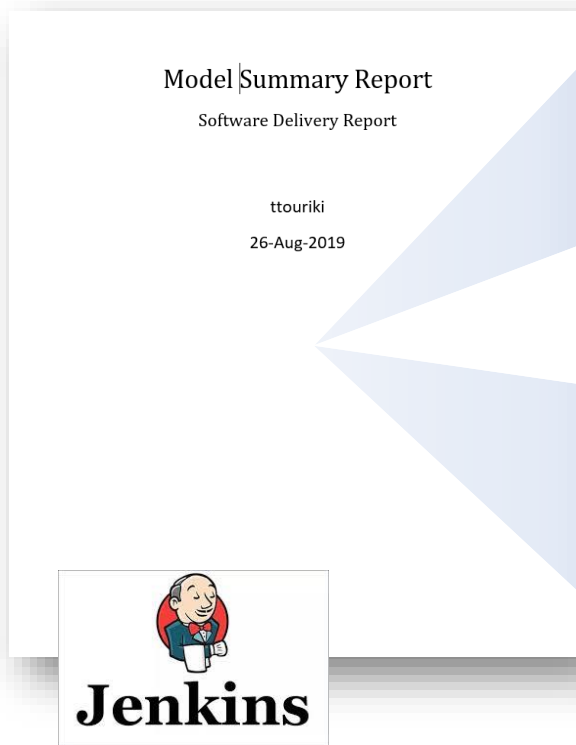
N is the number of decision points that the object represents and on is the number of outcomes for the nth decision point. The tool adds one to the complexity number for atomic subsystems and Stateflow charts.

Rationale Cyclomatic complexity is a leading testability metric. Test harness can be created for simulation at model, subsystem, chart, and MATLAB function level.

Last update 1.0

通过建模指标进行模型的生命周期管理

- 开箱即用
 - 建模指标面板
- 与应用行业的合作
 - 模型质量目标 (MQO)
- 定制化解决方案 – 咨询服务
 - 定制与Jenkins集成的报告
 - 内嵌通过/失败门槛值设置



Model:	XXXX
Version:	1.223
Date:	26-Aug-2019
Page:	2

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- 5.1 Model Metrics Info 8
- 6. Model Specific Metrics 10
- 6.1 Model Specific Metrics Info 10

2 Figures

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3 Tables

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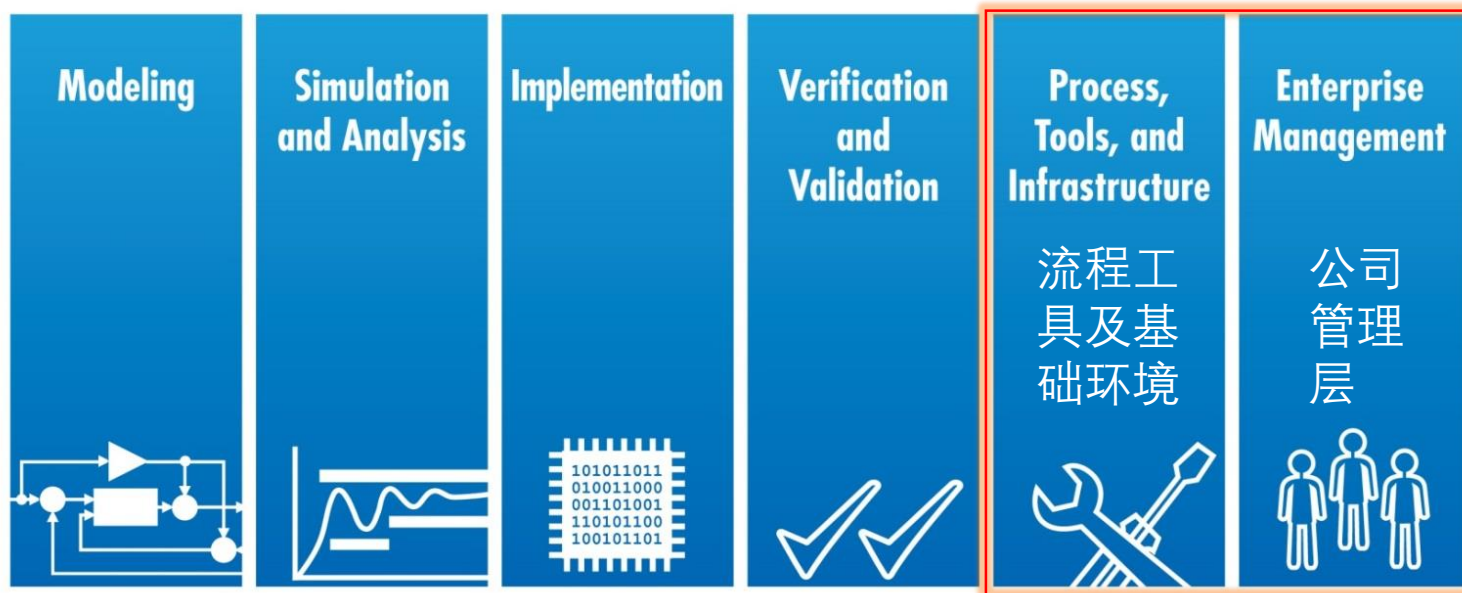
5. Model Metrics

5.1 Model Metrics Info

Metric	Details	Value
CloneDetection	AAAL_XXDFun_CasFun1	1
CloneDetection	AAAL_XXDFun_CasFun3	1
CloneDetection	XXXX/DummyOSTask/Triggered Subsystem1 XXXX/DummyOSTask/Triggered Subsystem2 XXXX/DummyOSTask/Triggered Subsystem9 XXXX/DummyOSTask/Triggered Subsystem3 XXXX/DummyOSTask/Triggered Subsystem7 XXXX/DummyOSTask/Triggered Subsystem6 XXXX/DummyOSTask/Triggered Subsystem8 XXXX/DummyOSTask/Triggered Subsystem14 XXXX/DummyOSTask/Triggered Subsystem13 XXXX/DummyOSTask/Triggered Subsystem5 XXXX/DummyOSTask/Triggered Subsystem12 XXXX/DummyOSTask/Triggered Subsystem2 XXXX/DummyOSTask/Triggered Subsystem11 XXXX/DummyOSTask/Triggered Subsystem10 XXXX/DummyOSTask/Triggered Subsystem4	15
CyclomaticComplexity	XXXX	47
DescriptiveBlockNames	XXXX	38
DiagnosticWarningsCount	XXXX	2
Inputs	-	5
Outputs	-	5
FileCount	XXXX	8
IOCount	XXXX	10

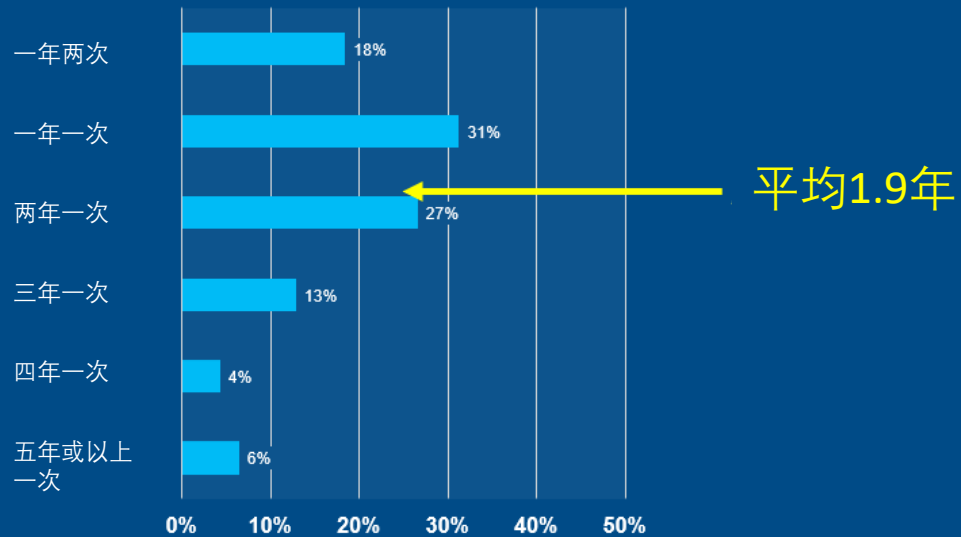


是否对流程和工具进行了革新以满足应用的需求呢？

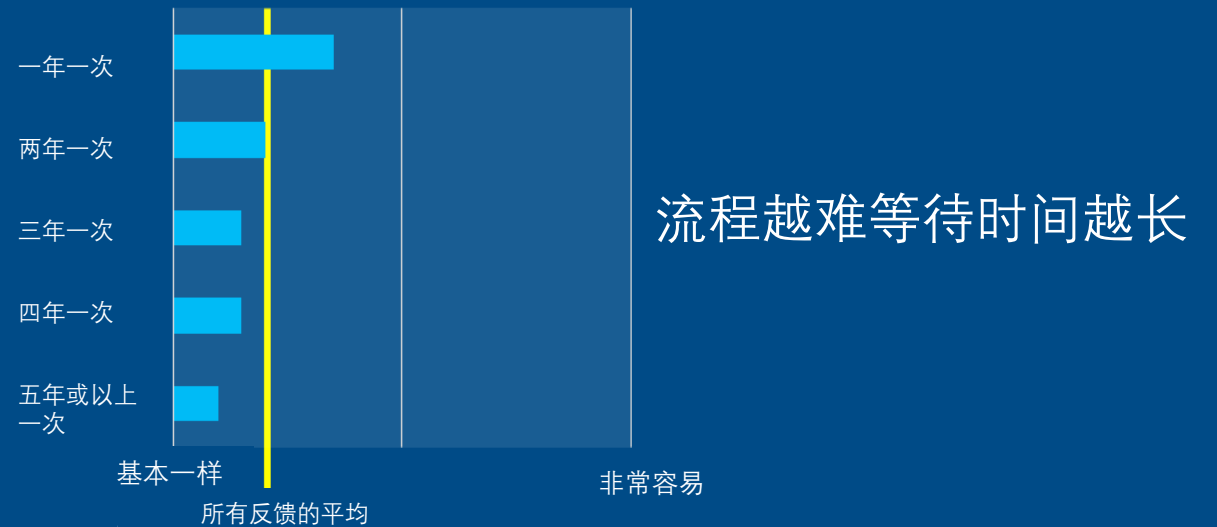


MATLAB版本升级 – MathWorks 顾问委员会 (MAB) 调查

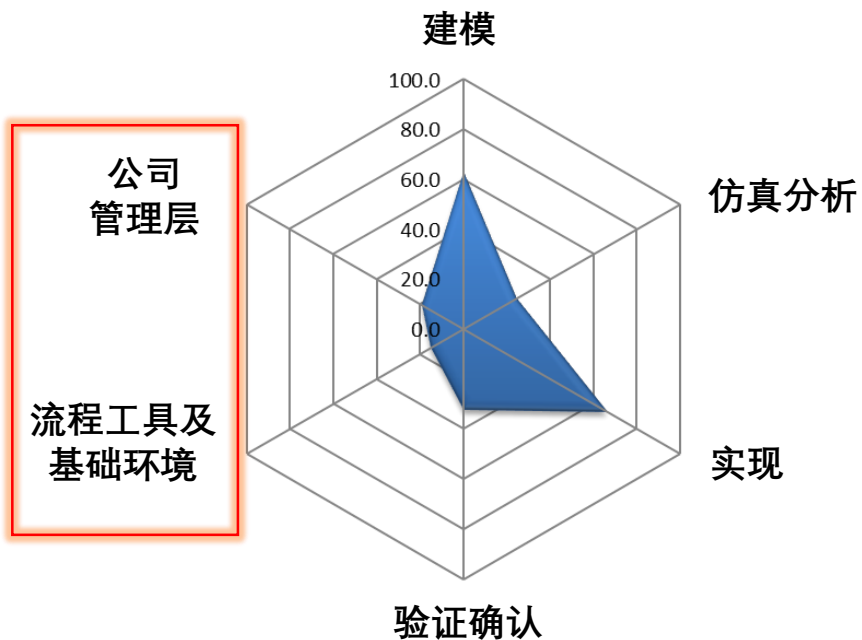
MATLAB版本升级频率



跟5年前相比升级流程难易度



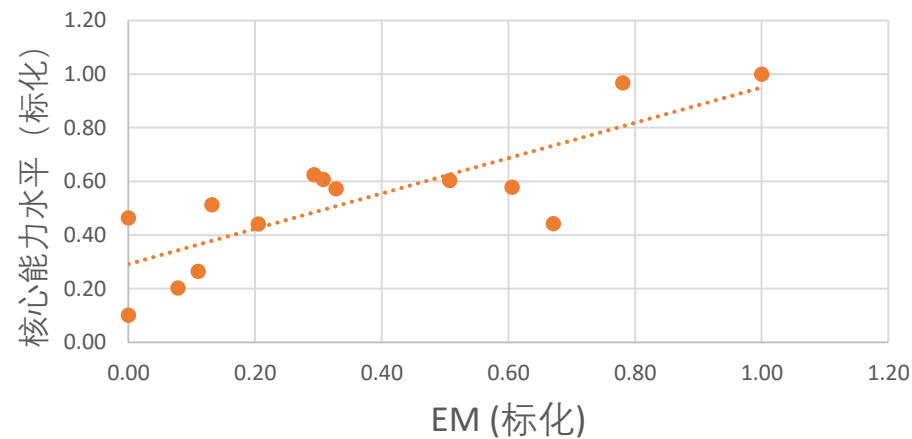
支持能力水平的影响



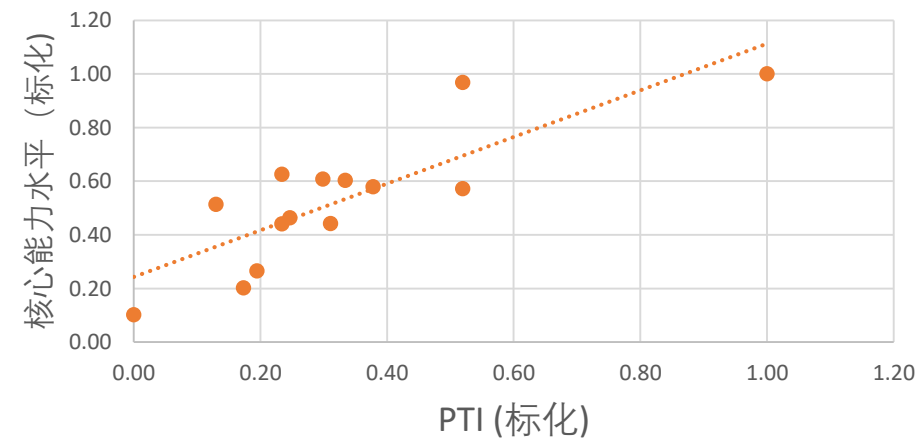
EM → 来自管理层的有力支持

PTI → 流程及工具方面的投资

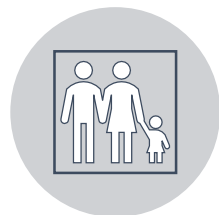
公司管理层的支持



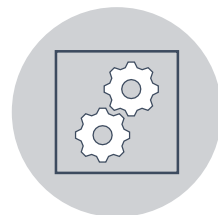
专用工具/流程方面的投资



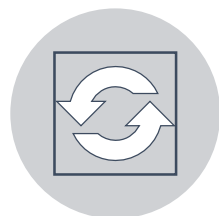
总结



改进验证确认流程以
满足安全标准



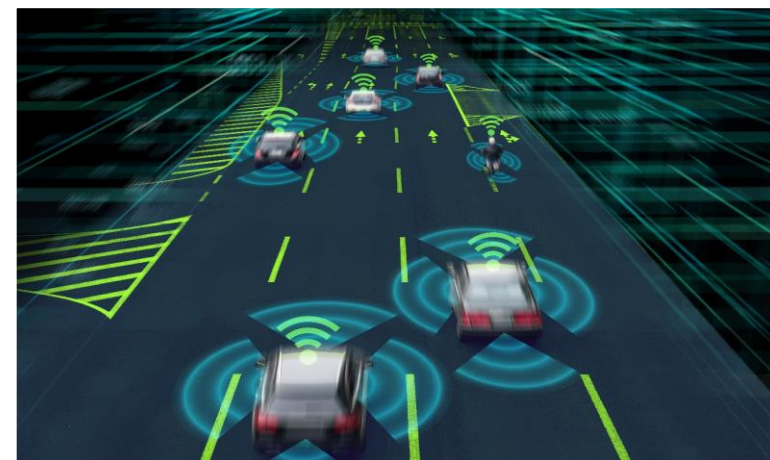
利用集成模型进行需
求确认



确保模型用于分析并
且利用主要指标进行
维护



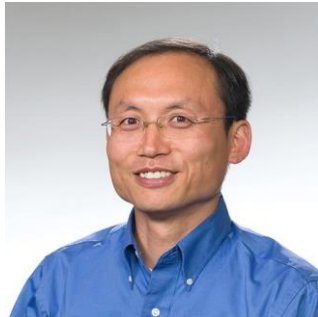
增加流程及工具的投资



谢谢关注!



如有问题请联系 Zhihui Li / John Lee:



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johnl@mathworks.com