



中国一汽

模型开发在DCT控制软件中的运用

庞学文

2015-06-18

十年历程

2003，引入MATLAB、Simulink工具，结合快速原型工具

2005，第一次使用自动代码工具进行产品代码生成

2009，第一次使用Embedded Coder生成产品代码

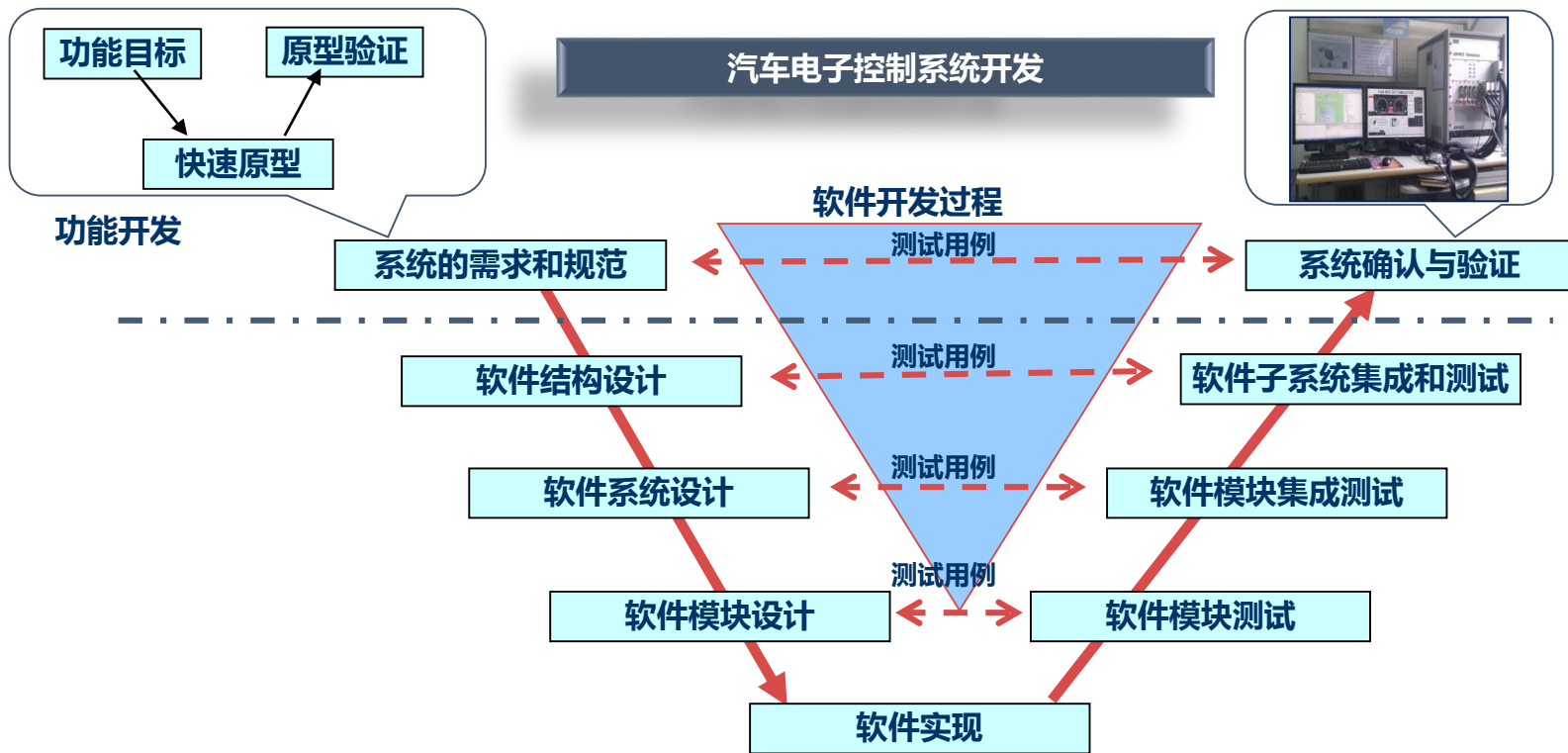
2010，开始关注建模规范化

2012，关注V&V

2013，开始工具定制

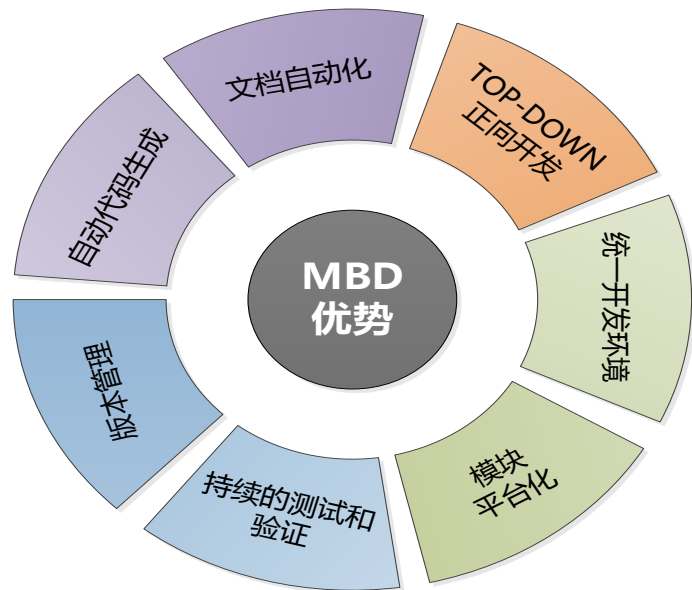
当前，理念统一，MBD是企业行为

生产力提高依靠生产方式的发展



流程优势通过什么样的开发方式发挥？

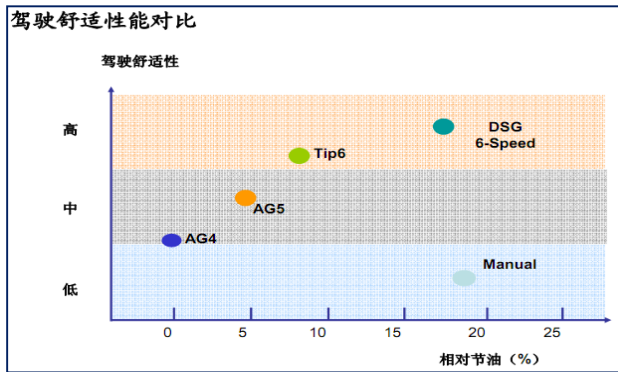
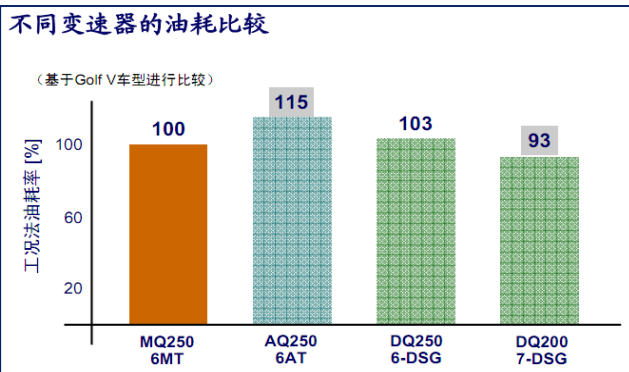
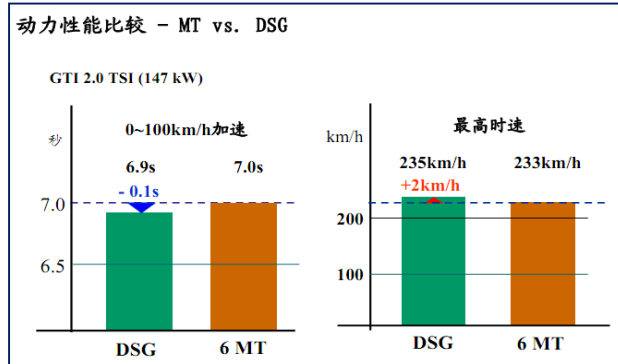
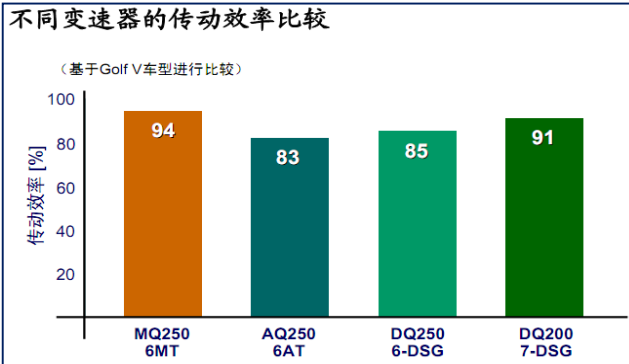
MBD优势



MBD，减少对硬件及实物的依赖，减少硬件成本，缩短开发周期，提高软件质量

基于模型设计在DCT控制软件中的运用

双离合自动变速器控制技术



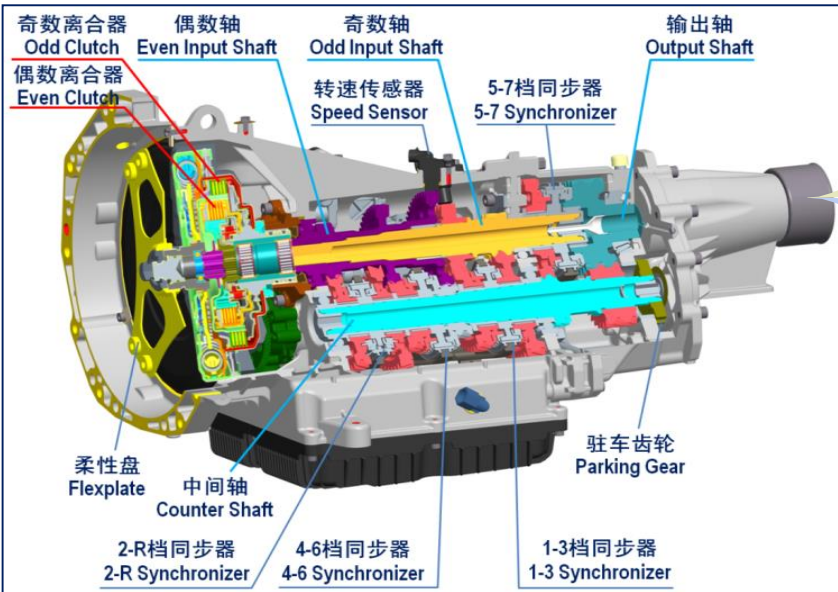
DCT双离合变速器：同时具有AT的舒适性和MT的动力性

基于模型设计在DCT控制软件中的运用

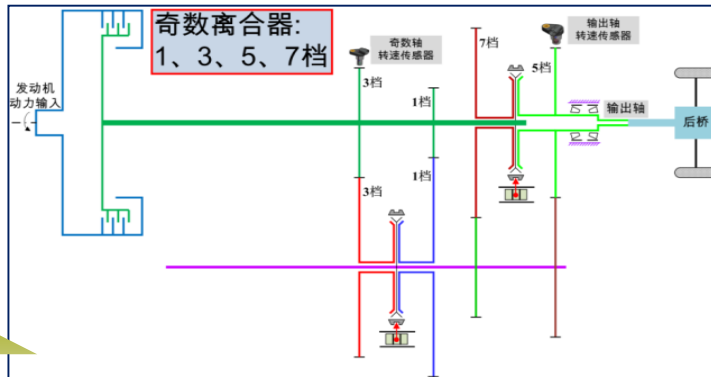
双离合自动变速器控制技术

DCT控制软件：

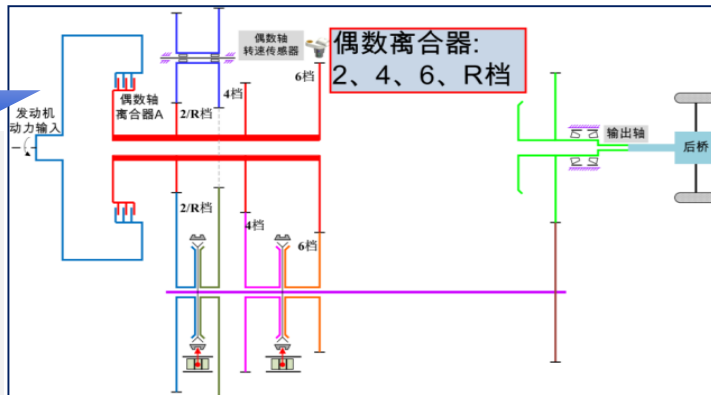
DCT特有的预选档控制
 多种行驶工况下的换档规律控制
 奇偶离合器快速切换控制，动力输出不降低
 实现两个“独立变速器”间的复杂逻辑控制



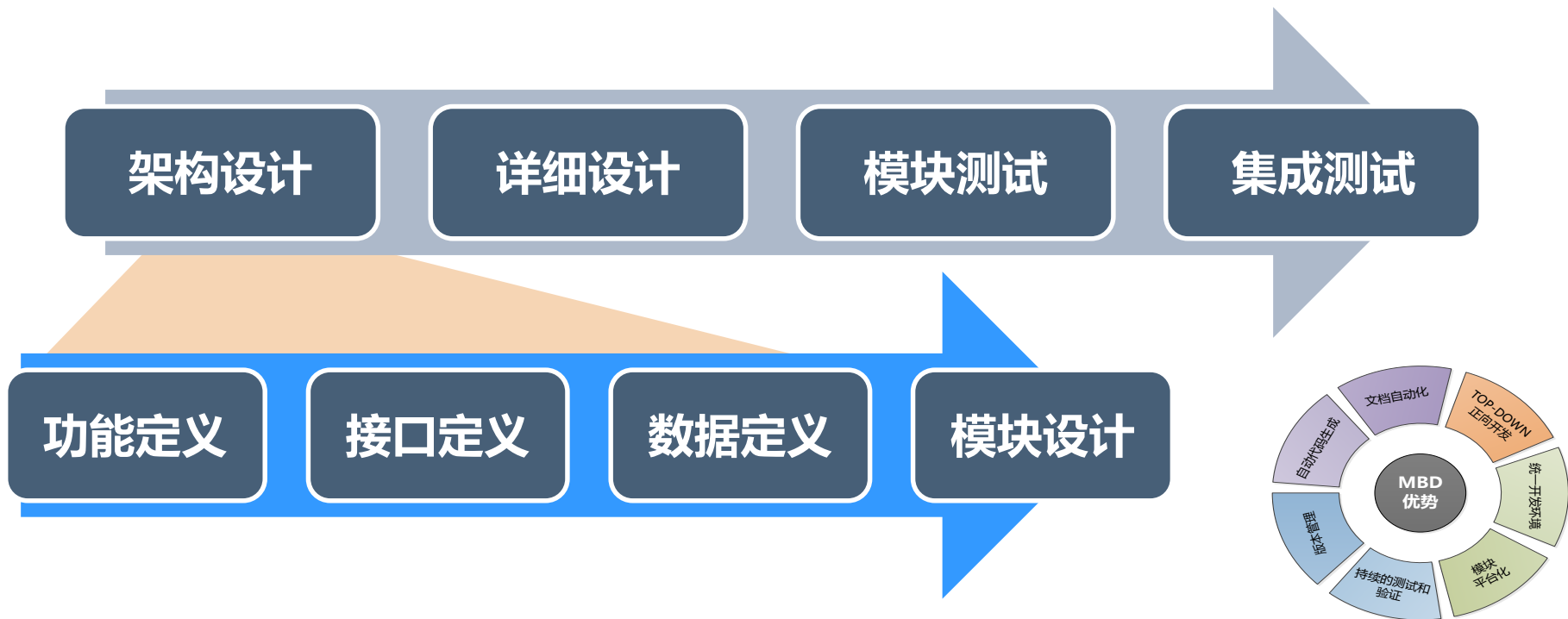
奇数
|
变
速
器



偶数
|
变
速
器



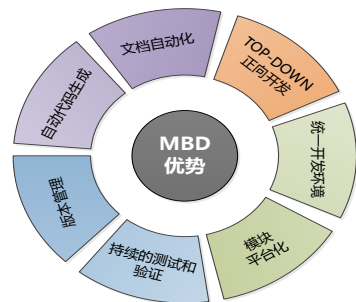
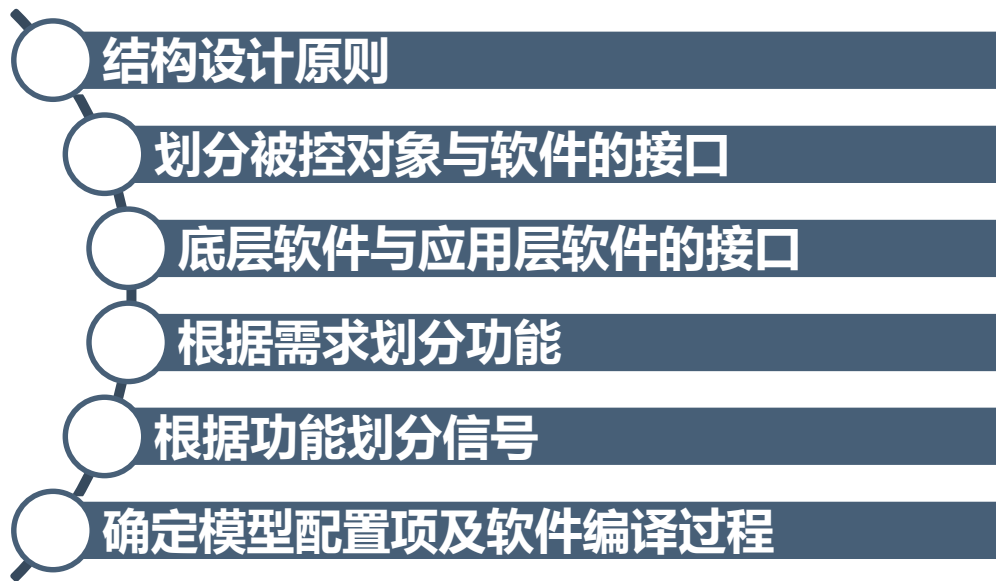
TOP-DOWN正向开发



可测试性、可维护性、可扩展性

TOP-DOWN正向开发

架构定义

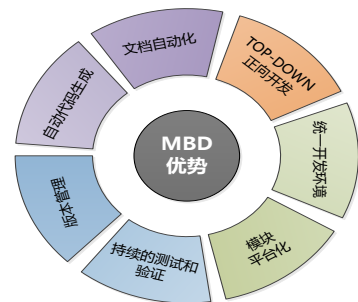


可测试性、可维护性、可扩展性

基于模型设计在DCT控制软件中的运用

统一开发环境

- MATLAB
- Simulink
- Stateflow
- Polypace



整个开发过程围绕统一的工具进行标准化作业

基于模型设计在DCT控制软件中的运用


双离合变速器控制技术

经济性换挡模式

动力性换挡模式

手动换挡模式

预选档估计



坡道换挡模式

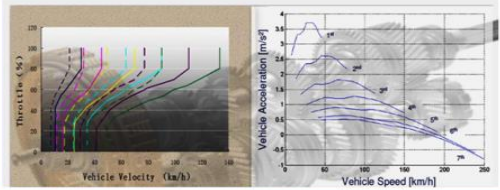
暖机模式

弯道档位限制

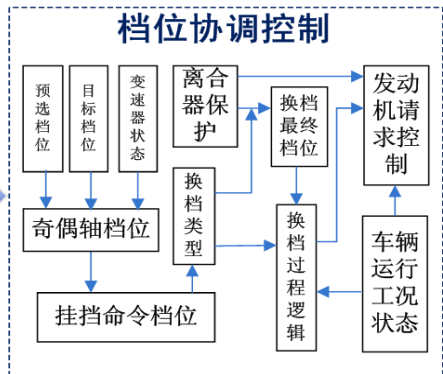
动力降档需求

热模式

滑行降档控制

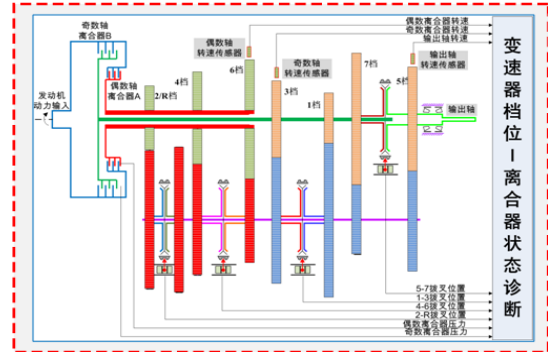
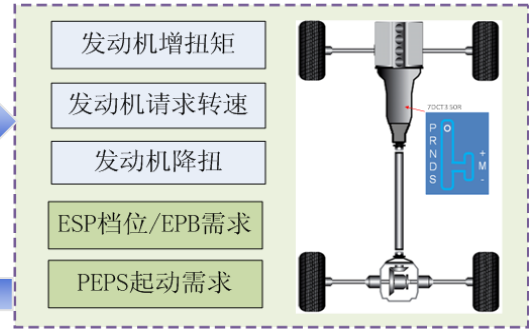


多工况换挡规律控制



扭矩请求

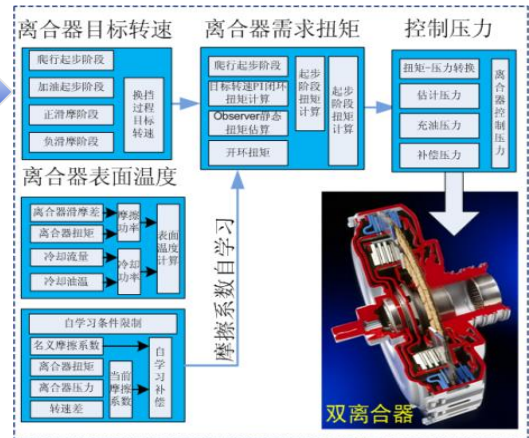
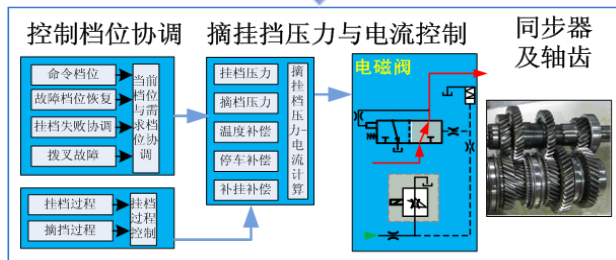
档位请求



故障状态

档位控制

离合器控制



基于模型设计在DCT控制软件中的运用

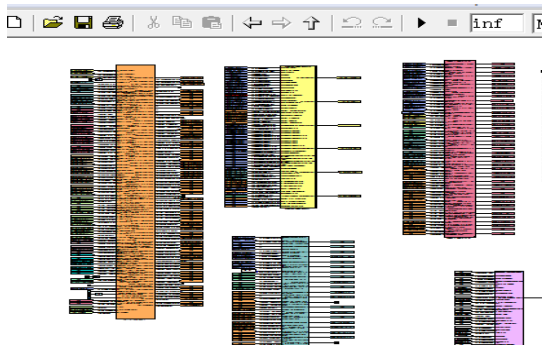
TOP-DOWN正向开发

变量名称	描述	单位	类型	取值范围	默认值	精度	编译	源模块	目的模块
TST_DemandGear	TST需求档位								
TST_Awake	TST module initialized and ready.								
TST_PowerDownOK	运行时无报警								
CLT_ClutchCstState	State of CLT module. 0: CLT_Reset 1: CLT_EngageToGear 2: CLT_DisengageToNeutral 3: CLT_DisengageToLastpoint 4: CLT_GoosidtoStart								
CLT_ClutchCstStatus	Status of CLT module. 1: CLT_IdleProgress 2: CLT_Complete 3: CLT_Failed								
CLT_POSTStage	换挡安全状态 0:未完成 1:完成 2:失败								
GAC_GearCstState_Out	State of GAC module. 0: GAC_Idle 1: GAC_SelectGear								
CAN_VehicleSpeed_kmh	车速								
CAN_Accel pedal_pos	油门踏板位置								

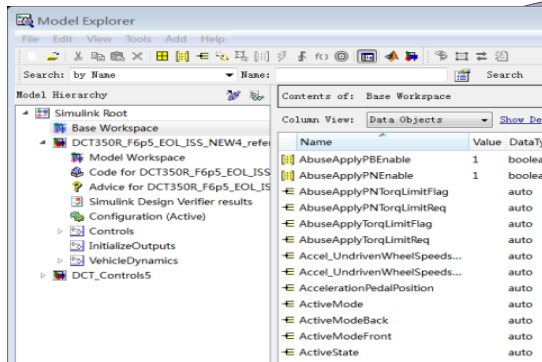
变量名称	描述	单位	类型	取值范围	默认值	精度	编译	源模块	目的模块
SC0_ClutchCstReq	SC0 command request to the CLT module. CLT_EngageToGear CLT_DisengageToNeutral CLT_DisengageToLastpoint Current type of shift. 0: Neutral selection. 1: SC0_PowerOnUpshift. 2: SC0_PowerOnDownshift. 3: SC0_PowerOffUpshift. 4: SC0_PowerOffDownshift. 5: SC0_EngageGear		UInt8	[0,4]	0	270	0		CLT
SC0_CurrentShiftType			UInt8	[0,5]	0	270	0		CLT
SC0_CurrentTyGear	Current gear engaged accessed by SC0.		UInt8	[0,6]	0	270	0		ENG, SC0, TST

变量名称	描述	单位	类型	取值范围	默认值	精度	编译
SC0_POWERSAFEVEHSPEED	Vehicle speed below which it is safe to perform POST	kmh	Int16		5		
SC0_POWERDOWNTIME	Amount of time after TST confirms that power-down is OK before SC0 forces TCU power down.	s	UInt16	500	1/200	0	
SC0_FORCEASGSHIFTIME	Max time allowed for a shift to complete.	s	UInt16	800	1/200	0	
SC0_MAXSHIFTIME	Max time allowed for a shift to complete.	s	UInt16	1000	1/200	0	
SC0_POWERDOWNTORQUEHYST	Hysteresis below threshold which power on becomes power	%	UInt8	2	270	0	
SC0_POWERDOWNTORQUEHRESHOLD	Torque threshold above which power on type shifts are used	%	UInt8	2	270	0	
SC0_POWERONUPTORQUEHYST	Hysteresis below threshold which power on becomes power	%	UInt8	2	270	0	
SC0_POWERONUPTORQUEHRESHOLD	Torque threshold above which power on type shifts are used	%	UInt8	2	270	0	
SC0_SHIFTWITHFALEDEING	Condition for perform shift with ENG1 failed		Bool		1	270	0
SC0_POWEROFFDOWNNGEAR	For a power off down shift, engage clutch without waiting for speed phase		Bool		0	270	0
SC0_POWEROFFZONACCPEED	Accel pedal threshold to determine on throttle during off throttle up		Bool		1	270	0
SC0_POWEROFFZONUPENABLE	Enables power off up to on function		Bool		5	270	0

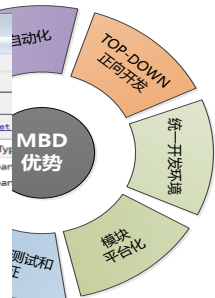
结构设计、接口划分



模型

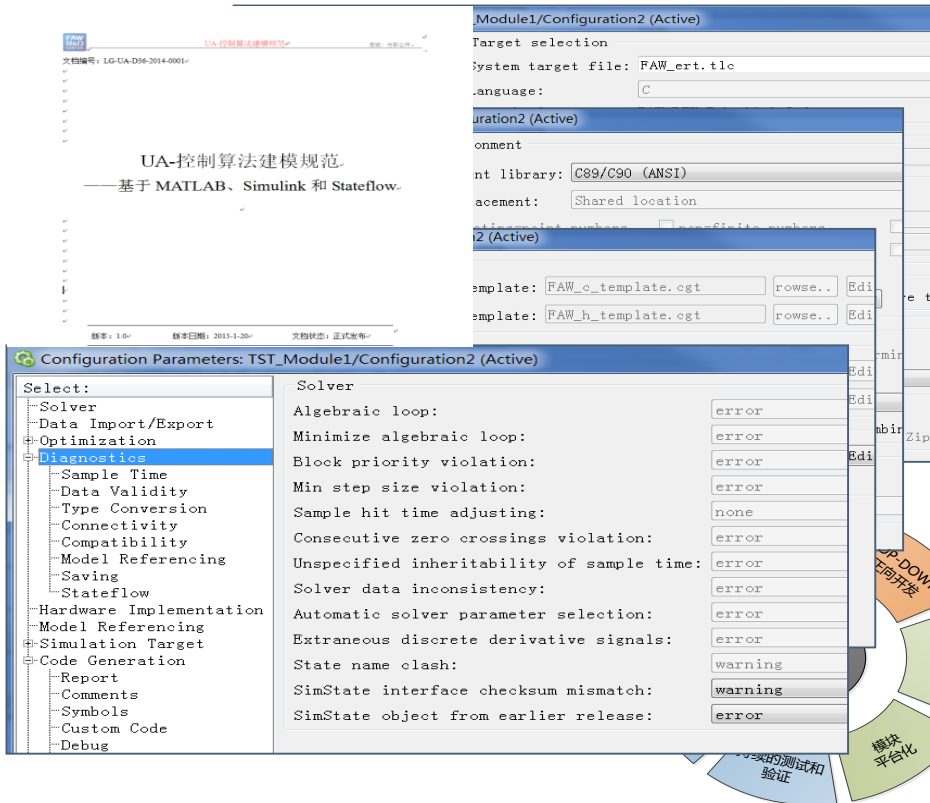
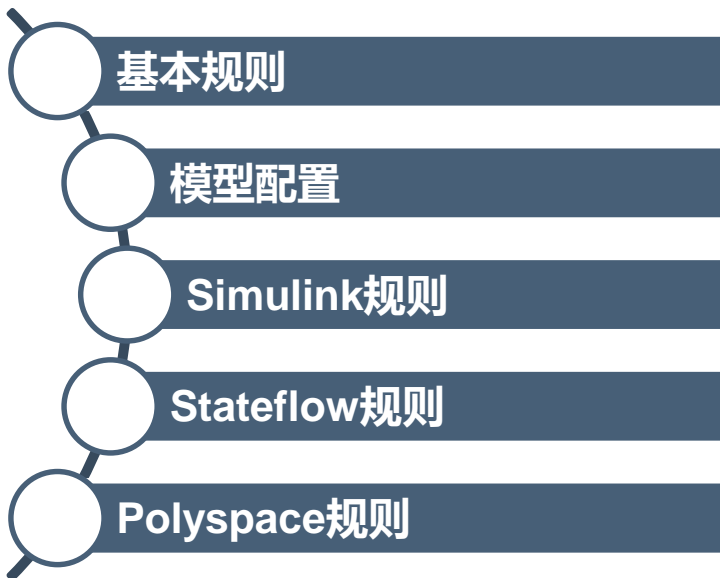


数据



统一开发环境

➤ 模型规范



UA-控制算法建模规范
——基于 MATLAB、Simulink 和 Stateflow.

Module1/Configuration2 (Active)

Target selection
system target file: FAW_ert.tlc
language: C

Configuration2 (Active)
Comment
Component library: C89/C90 (ANSI)
Placement: Shared location

Configuration2 (Active)
Template: FAW_c_template.cgt rowse.. Edit
Template: FAW_h_template.cgt rowse.. Edit

Configuration Parameters: TST_Module1/Configuration2 (Active)

Select:	Solver
Solver	Algebraic loop: error
Data Import/Export	Minimize algebraic loop: error
Optimization	Block priority violation: error
Diagnostics	Min step size violation: error
Sample Time	Sample hit time adjusting: none
Data Validity	Consecutive zero crossings violation: error
Type Conversion	Unspecified inheritability of sample time: error
Connectivity	Solver data inconsistency: error
Compatibility	Automatic solver parameter selection: error
Model Referencing	Extraneous discrete derivative signals: error
Saving	State name clash: warning
Stateflow	SimState interface checksum mismatch: warning
Hardware Implementation	SimState object from earlier release: error
Model Referencing	
Simulation Target	
Code Generation	
Report	
Comments	
Symbols	
Custom Code	
Debug	

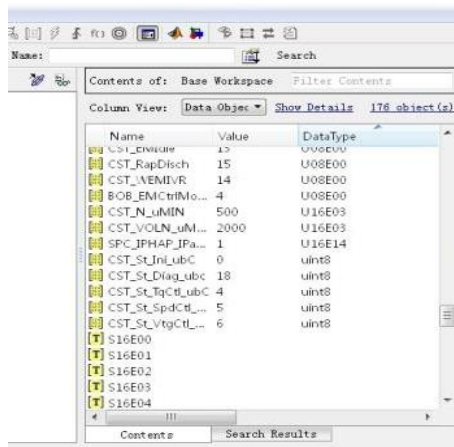
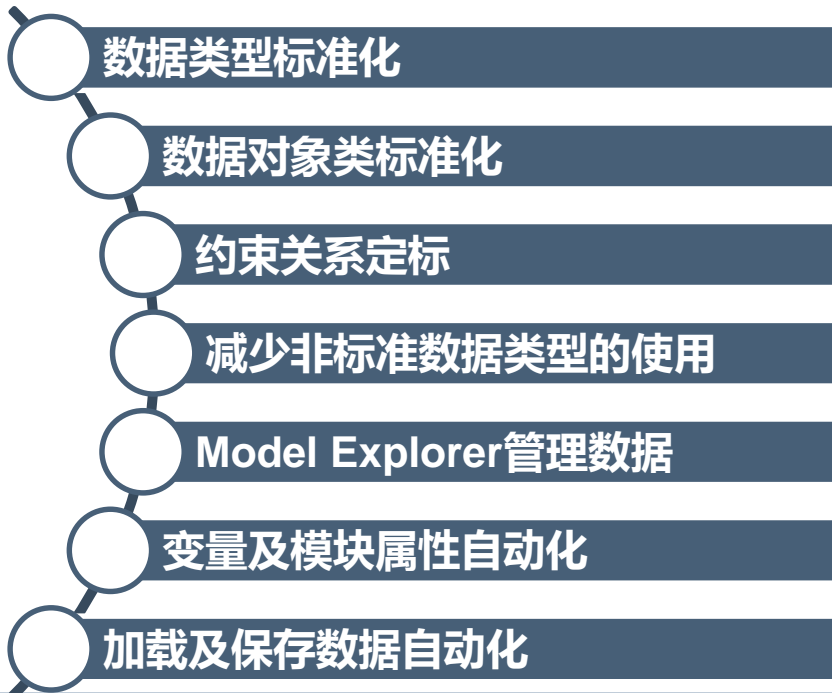
UP-DOWN 双向开发
统一开发环境
模块平台化
模型的测试和验证

整个开发过程围绕统一的工具进行标准化作业

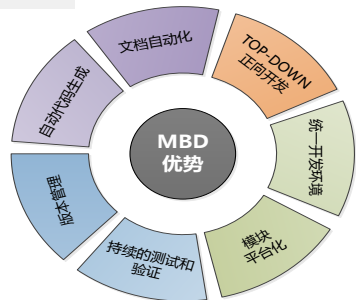
基于模型设计在DCT控制软件中的运用

统一开发环境

➤ 数据字典管理



Name	Value	DataType
CST_LstEvrcture	15	U08E00
CST_RapDisch	15	U08E00
CST_VEMIVR	14	U08E00
BOB_EMCtrlMo...	4	U08E00
CST_N_uMIN	500	U16E03
CST_VOLN_uM...	2000	U16E03
SPC_JPHAP_JFa...	1	U16E14
CST_St_InLubC	0	uint8
CST_St_Diag_ubc	18	uint8
CST_St_TqCt_ubc	4	uint8
CST_St_SpdCt_...	5	uint8
CST_St_VtgCt_...	6	uint8
S16E00		
S16E01		
S16E02		
S16E03		
S16E04		



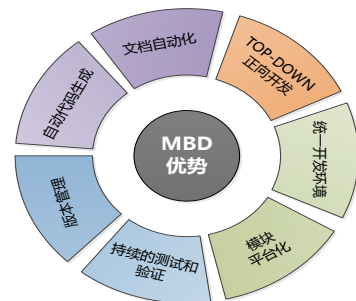
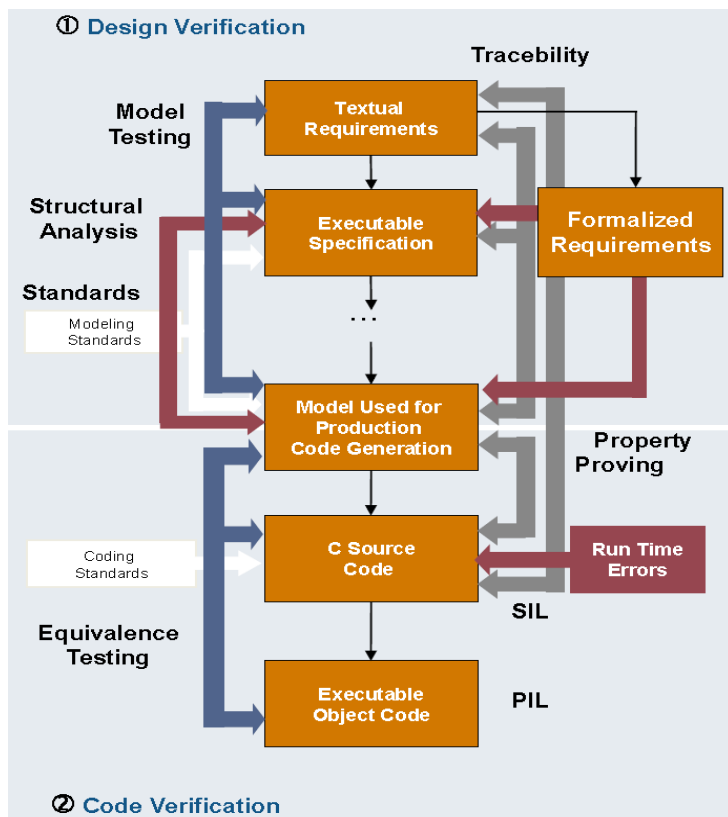
整个开发过程围绕统一的工具进行标准化作业

基于模型设计在DCT控制软件中的运用

持续的测试与验证

- 需求
- 模型
- 代码

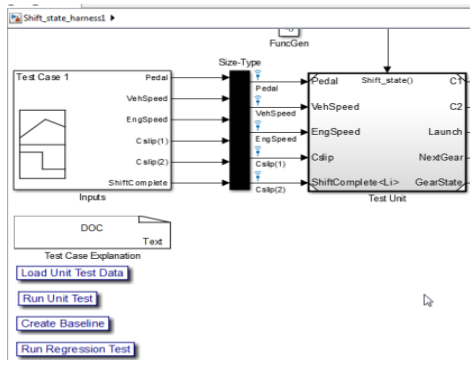
- 功能测试
- 覆盖度测试
- 回归测试



一切为了测试高效

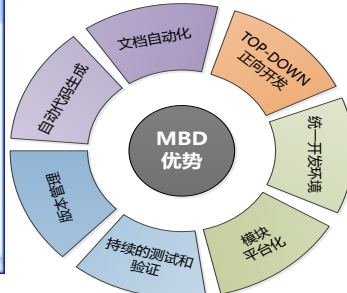
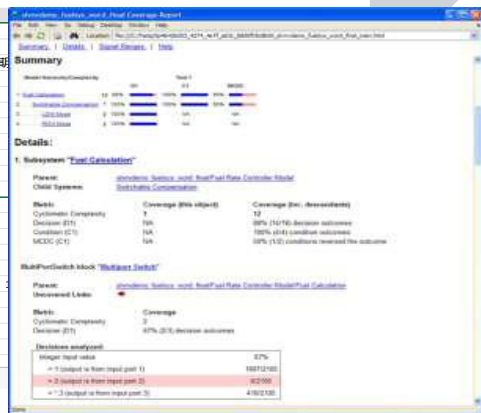
基于模型设计在DCT控制软件中的运用

持续的测试与验证



Enter Test Description	Ref: CTR	DTCControl-3.2.2	Current Gear Selection
1			1 怠速
2			2 加速踏板pedal 超过0.01%, 发动机转速超过850. 踩下加速踏板, pedal达到0.1, 车速达到5
3			3 车速达到1档升2档门限值
4			4 车速超过2档门限值
5			5 超过0.5秒延迟, 进入2档
6			6 车速达到2档升3档门限值
7			7 车速超过3档门限值
8			8 超过0.5秒延迟, 进入3档
9			9 车速达到3档升4档门限值
10			10 车速超过4档门限值
11			11 怠速
27			27 怠速

Default	Time	Pedal	VehSpeed	EngSpeed	Cslip(1)
32	1	0	0	850	
33	2	0.1	0.02	0	860
34	3	0.5	0.1	5	900
35	4	1	0.1	10	1000
36	5	1.1	0.1	11	1000
37	6	1.5	0.1	11	1000



一切为了测试高效

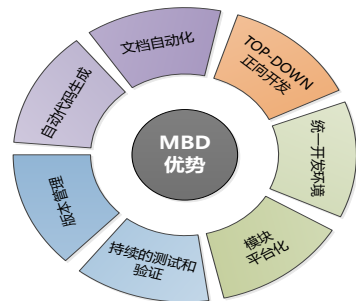
基于模型设计在DCT控制软件中的运用

持续的测试与验证

集成级

MIL (Model-In-the-Loop) 验证是利用虚拟的总成和整车半物理模型来替代实物而进行的一种控制逻辑验证手段。

被控对象模型的建立是关键因素。

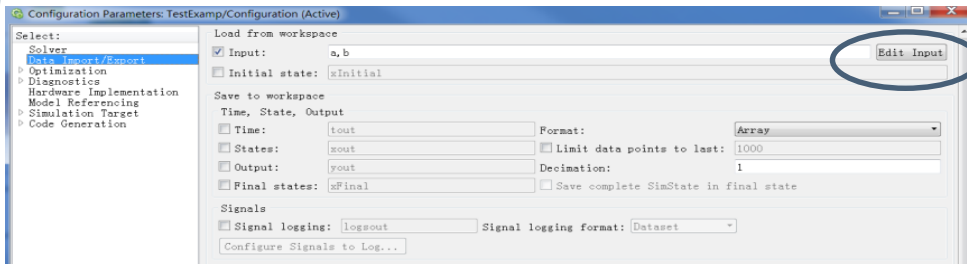
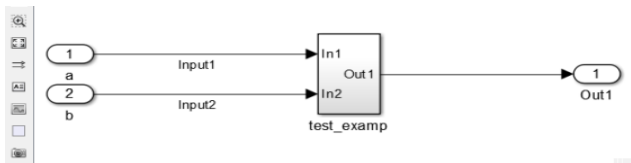


一切为了测试高效

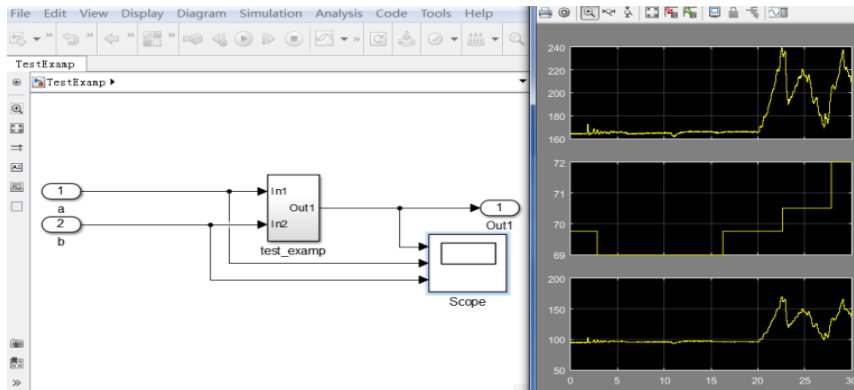
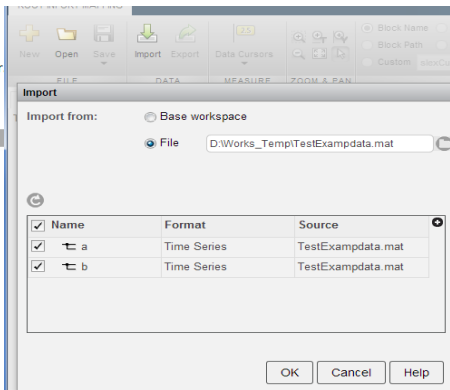
基于模型设计在DCT控制软件中的运用

基于已有测试数据的模型测试

试验数据、模型快速重现软件行为



- 0519-1619.mat
- 20150527-1458.mat
- 20150521-1134.mat
- slexAutoTransRootInportPassingManeuver
- Untitled.mat
- fda.mat
- fasdfasfdat.mat
- TestExampdata.mat



结合2015a能够自动实现对testcase的双向管理和跟踪

基于模型设计在DCT控制软件中的运用

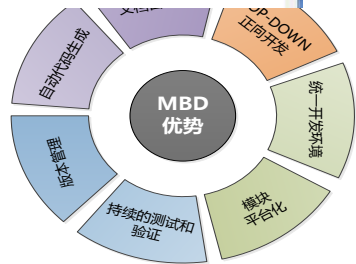
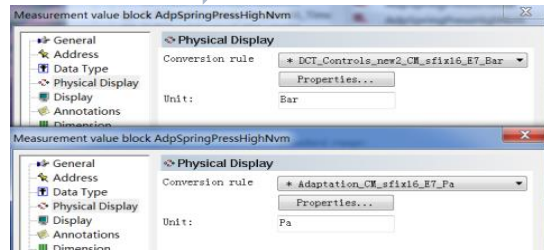
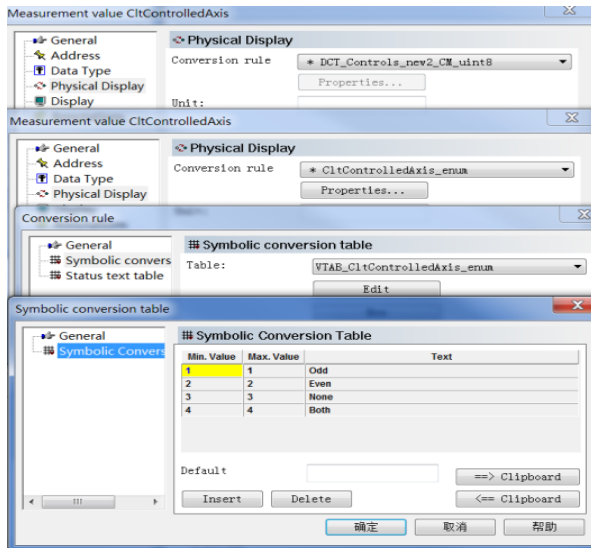
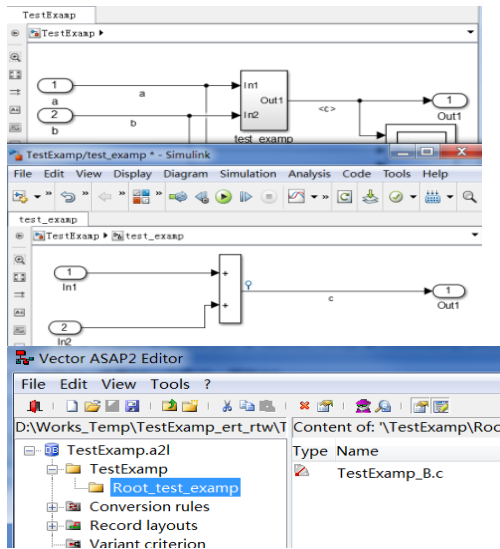
自动代码/A2L生成

参数配置优化

配置环境统一

代码生成模板

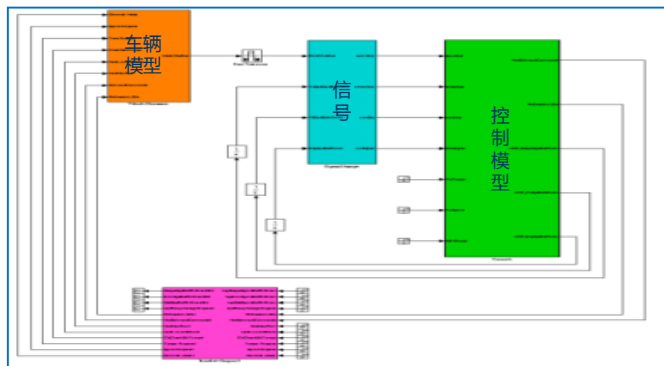
A2L文件生成



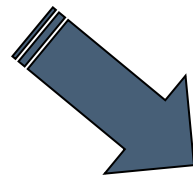
标准化、自动化作业

基于模型设计

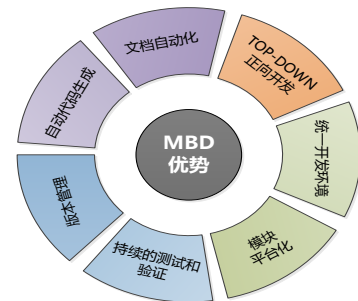
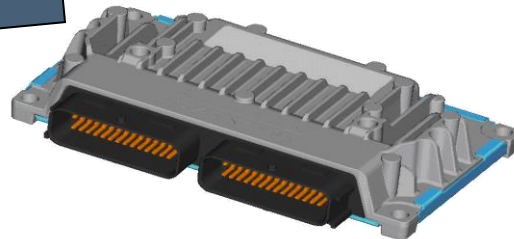
软件集成编译自动化



Build

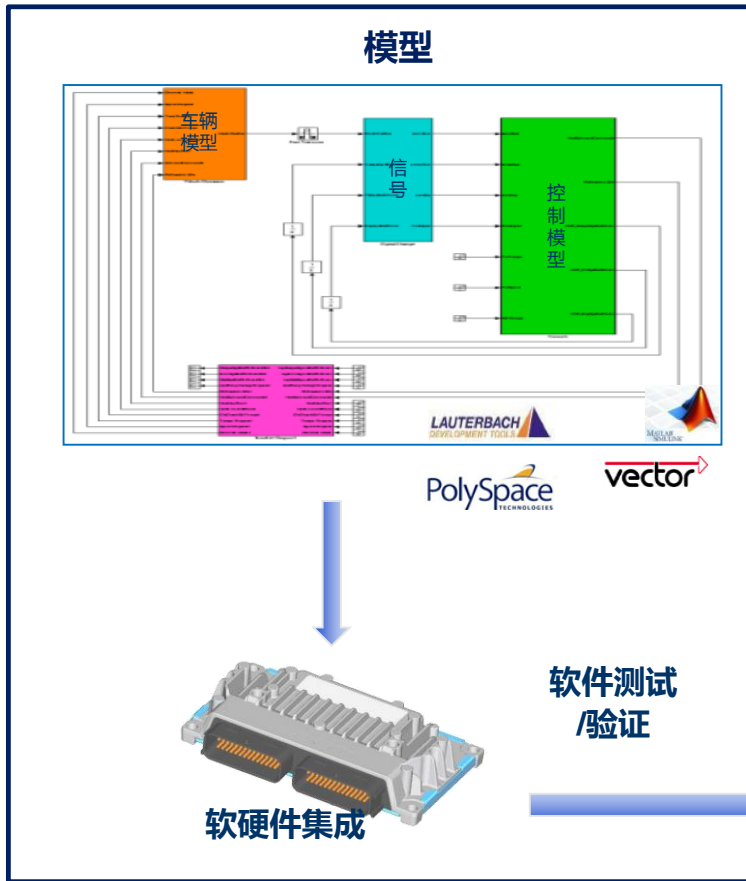


Flash



减少重复劳动、一切为了高效

目前状态



试验验证

HIL试验



台架试验



整车试验



环境仓

黑河

格尔木

海南

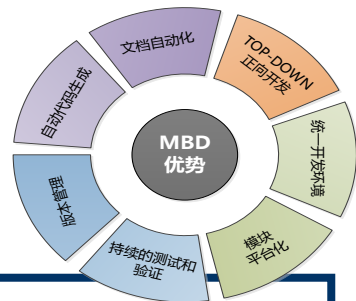
基于模型设计在DCT控制软件中的运用

自动化



总结

- 经过十余年的发展，一汽技术中心汽车电子MBD的理念已经是共识，自主软件开发也围绕着这一方式展开；
- 逐步完善可执行的、标准化的模型设计方式



建立标准、对标准实施自动化才能从根本上避免低级错误和提高效率
MBD是一个不断优化的过程，需要持续的投入和改进



中国一汽

关爱自然 服务社会

CARE THE NATURE AND SERVE THE SOCIETY

——让汽车更清洁 更节能

Contribute cleaner and more energy saving vehicle

