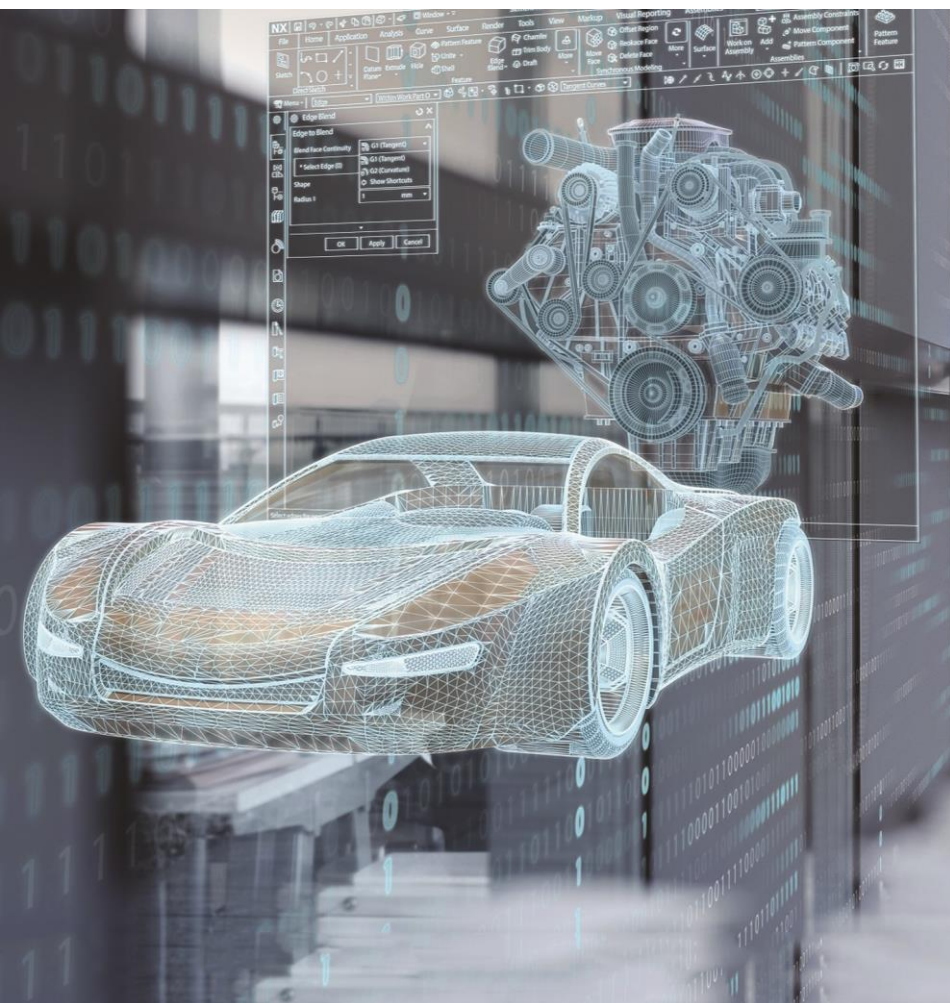


FloEFD&Flomaster集成技术在汽车电子行业应用

——1D&3D热分析集成方法介绍

主讲人：薛志杰

zhijie.xue@siemens.com



1. 车辆行业的发展趋势与挑战
2. Simcenter多学科多维度集成分析解决方案
3. 1D&3D 多维度CFD分析的必要性
4. Flomaster与FloEFD车辆电子热分析集成应用
5. 1D&3D 案例介绍
6. 总结

汽车市场发展趋势

SIEMENS
Ingenuity for life

新动力系统



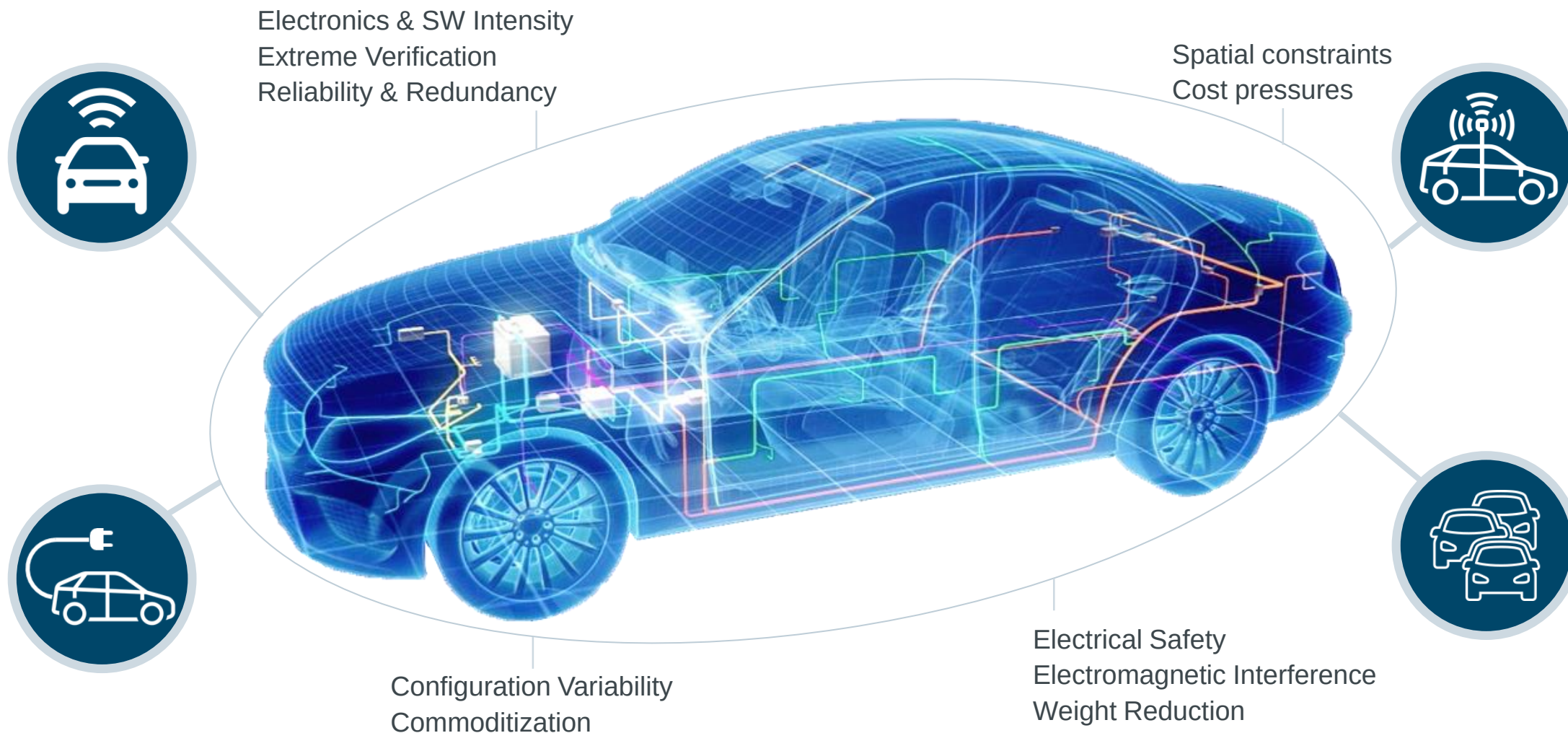
5G互联



汽车市场发展趋势

e-Powertrains, ADAS & Autonomous systems, Connectivity, Mass Customization

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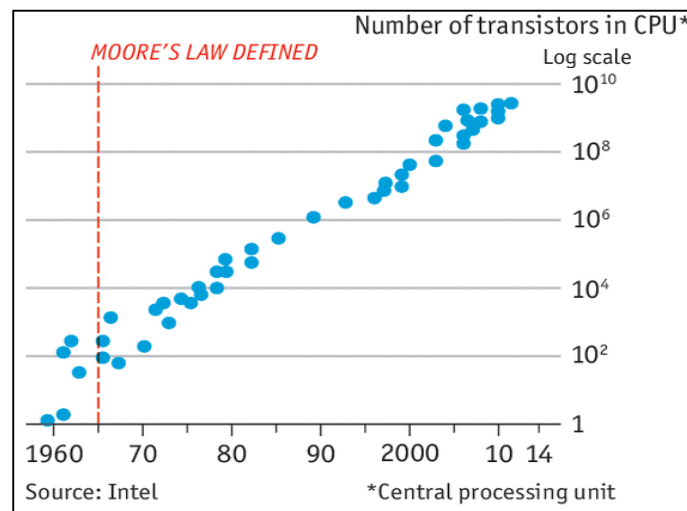


The Challenges Faced by Engineering Teams

工程团队面临的挑战

System Complexity

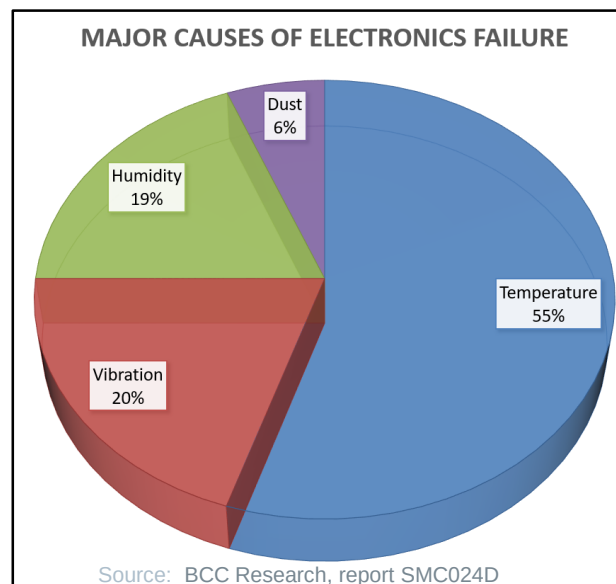
系统复杂性不仅表现在电路板级别的增加，而且表现在 IC、封装和模具级别也在增加



Source: www.economist.com

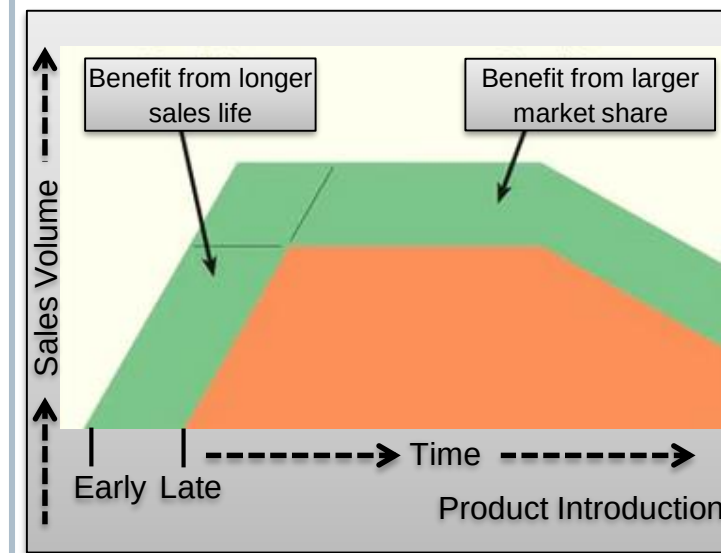
Reliability Requirements

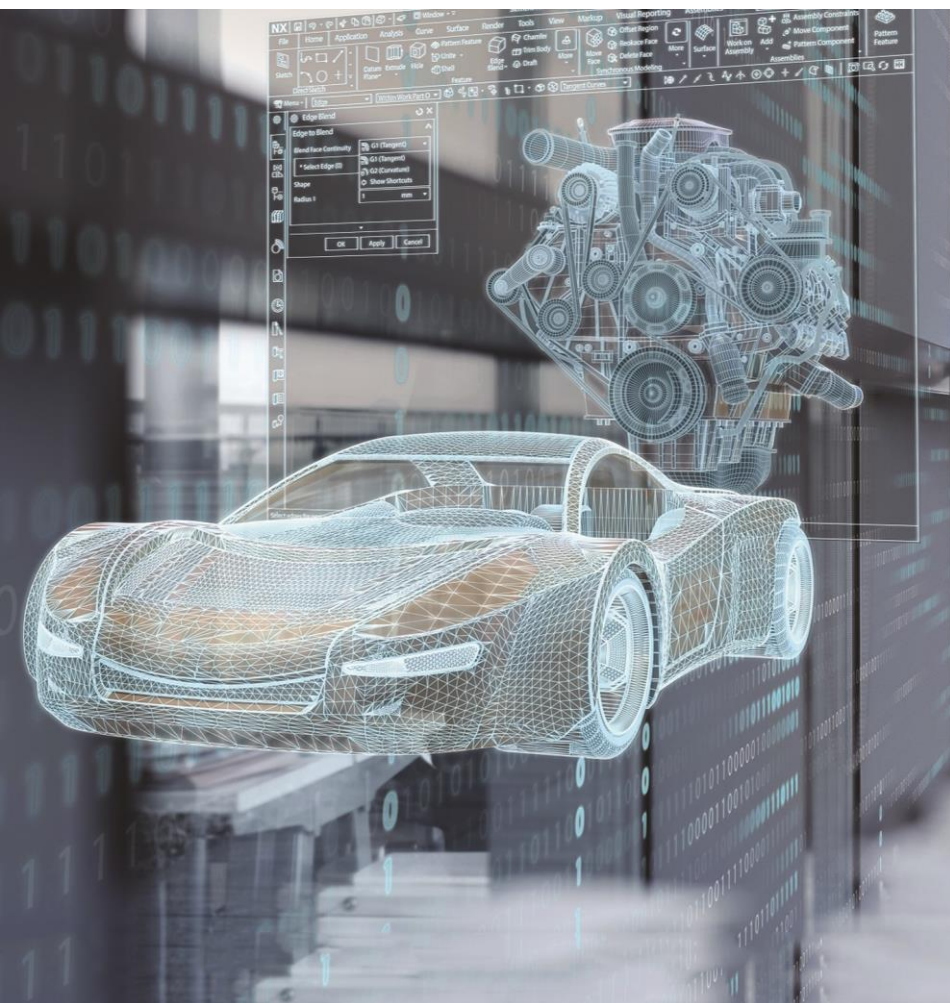
在导致代价高昂的停机、产品召回和声誉损害之前，必须找到并修复系统故障。



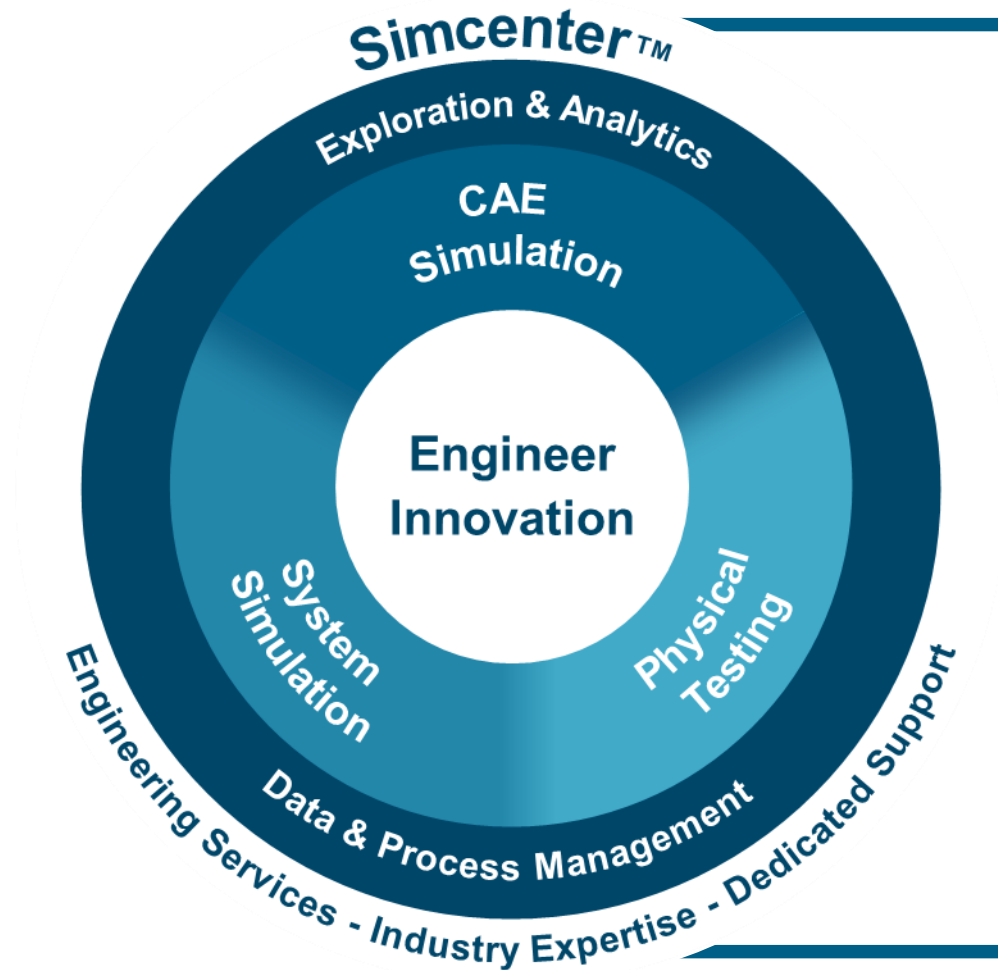
Time-to-Market Pressure

产品推新速度太慢会削弱或失去产品将要销售到的潜在市场。





1. 车辆行业的发展趋势与挑战
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Simcenter™

Engineer innovation

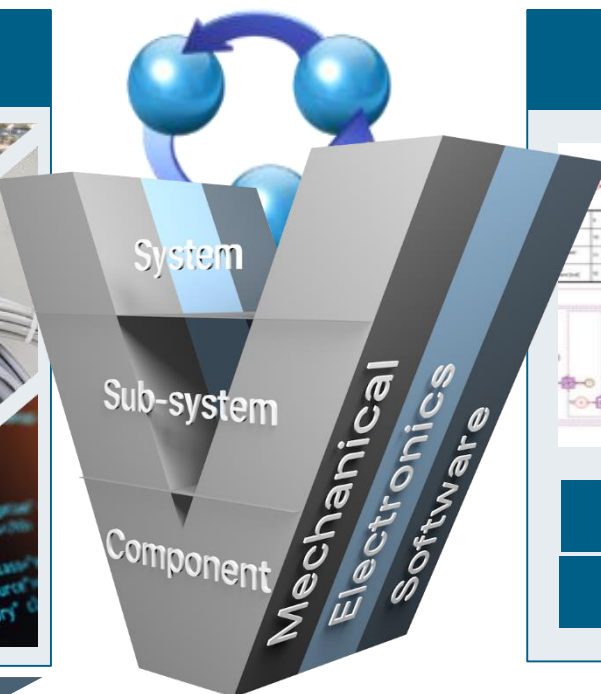
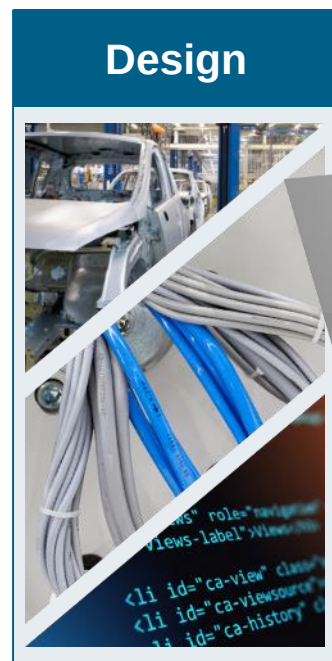
Simulate. Explore. Test.

Simcenter: Simulation and Test Solutions

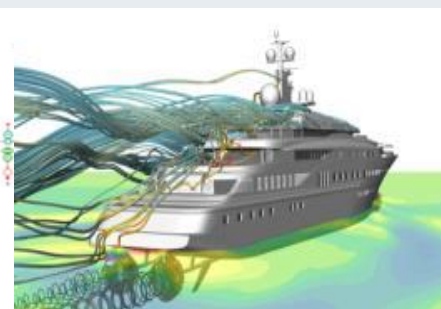
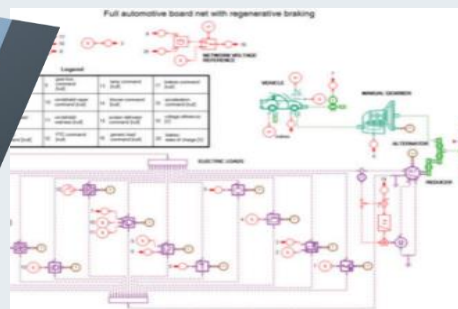
基于闭环性能的预测性工程分析平台



Enabling “Digital Twin” for Closed Loop Performance Engineering



Simcenter™ Portfolio

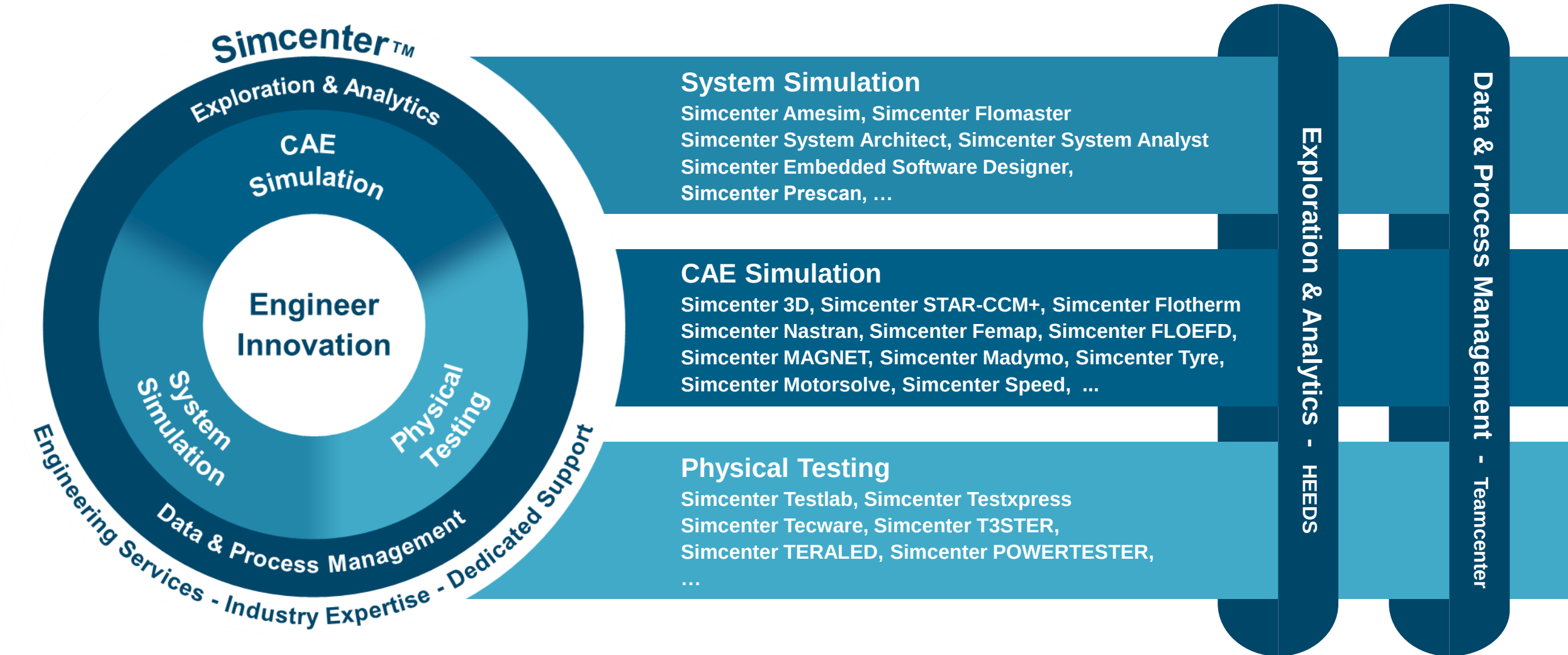


系统仿真 | CAE 仿真 | 物理测试
设计空间探索

Teamcenter - Digital Continuity for Multi-Domain Traceability, Change and Configuration

Simcenter overview

仿真、优化、测试整套工具集



Simcenter overview

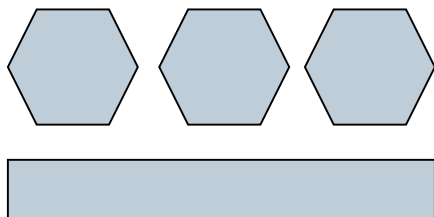
多学科仿真平台打通不同学科仿真

从多学科到多物理，取决于手头的工程问题

手头的工程问题在当时处理每个学科/物理。例子:

- 3D: Acoustics / Durability/ Crash/ Motion/ ...
- 1D: Fluids / Electrical / Mechanical/ ...
- Test: Structures/ Rotating / Vibration Control/ ..
- CFD: Flow, DEM, Spray,

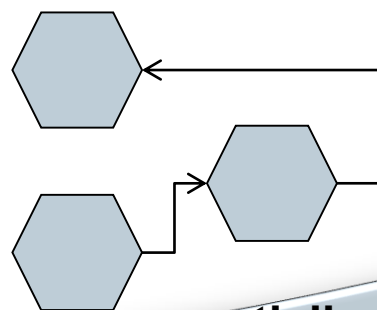
在学科/物理领域重复使用最大模型(灵) 有其好处.



'Parallel'
Multi-Discipline

单学科/物理的输出是下一个学科/物理的必需输入。不同的学科/物理在每个状态上互不相影响。例子:

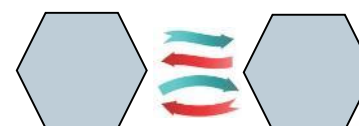
- Aero acoustics
- Vibro-acoustics (non-coupled)
- EMAG acoustics



'Sequential'
Multi-Discipline

不同的学科/物理在每个状态上相互影响，因此两个学科/物理需要一起处理。例子:

- Motion + 1D子系统
- 1D + Acoustics
- CFD + Structure耦合
- FSI



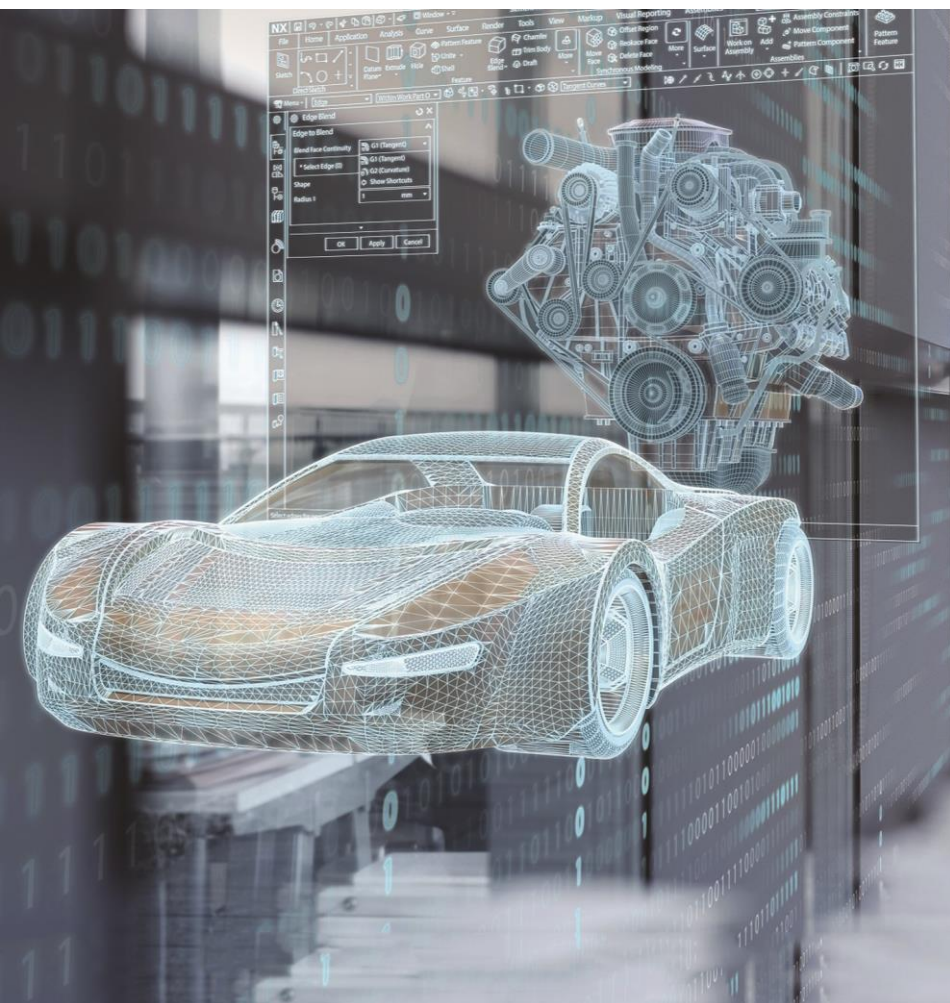
'Co-Simulated'
Multi-Physics

与之前相同，但为了精度、性能和稳定性，需要耦合仿真。例子:

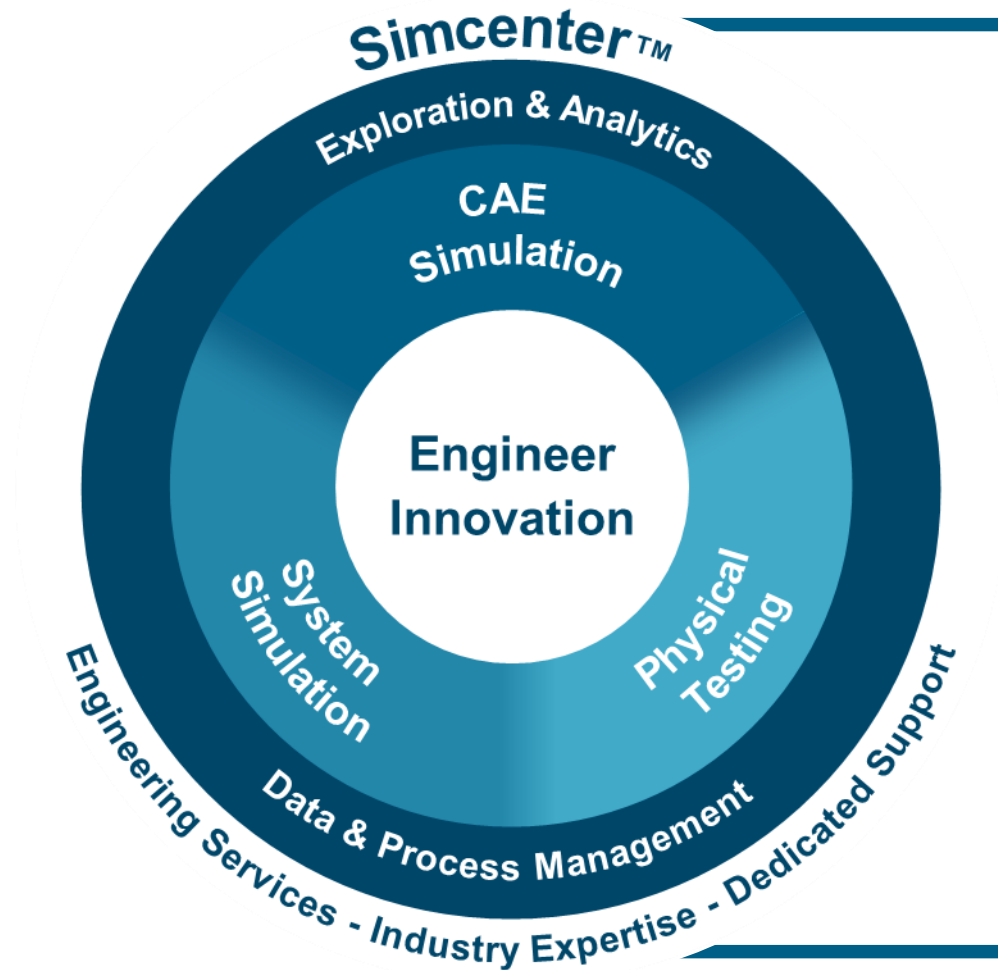
- 耦合Vibro-acoustics in NX Nastran
- 热/流, 1D+3D CFD
- 机械/热



'Coupled-Simulated'
Multi-Physics



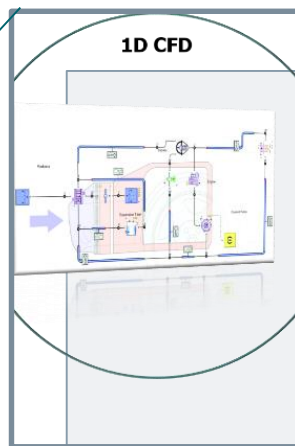
1. 车辆行业的发展趋势与挑战
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Simcenter™

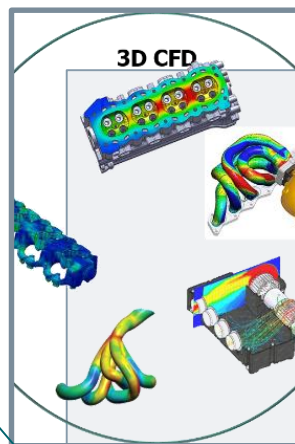
Engineer innovation

Simulate. Explore. Test.



一维系统CFD

- 简化或无需复杂的几何
- 能够快速给出流体动力学分析结果，如流量、压力变化和温度
- 关注部件选型匹配与系统宏观性能

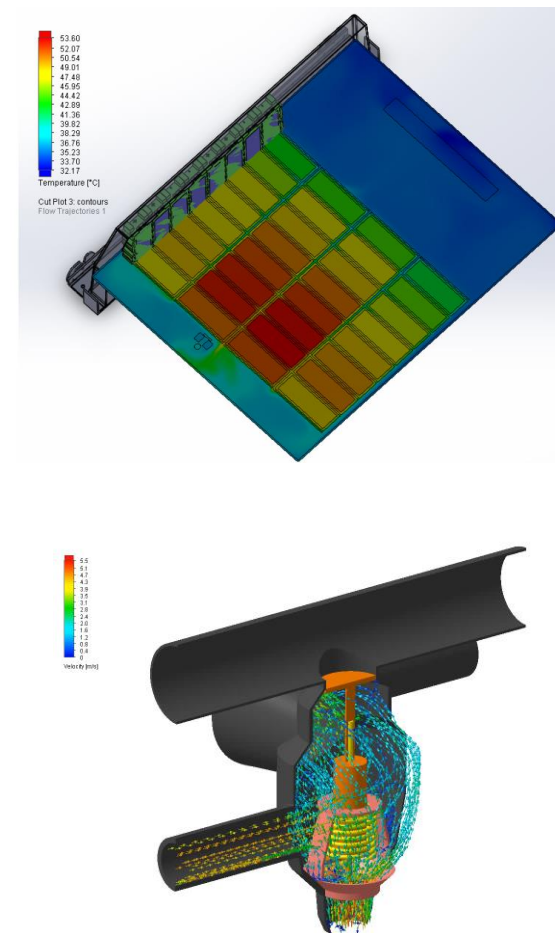
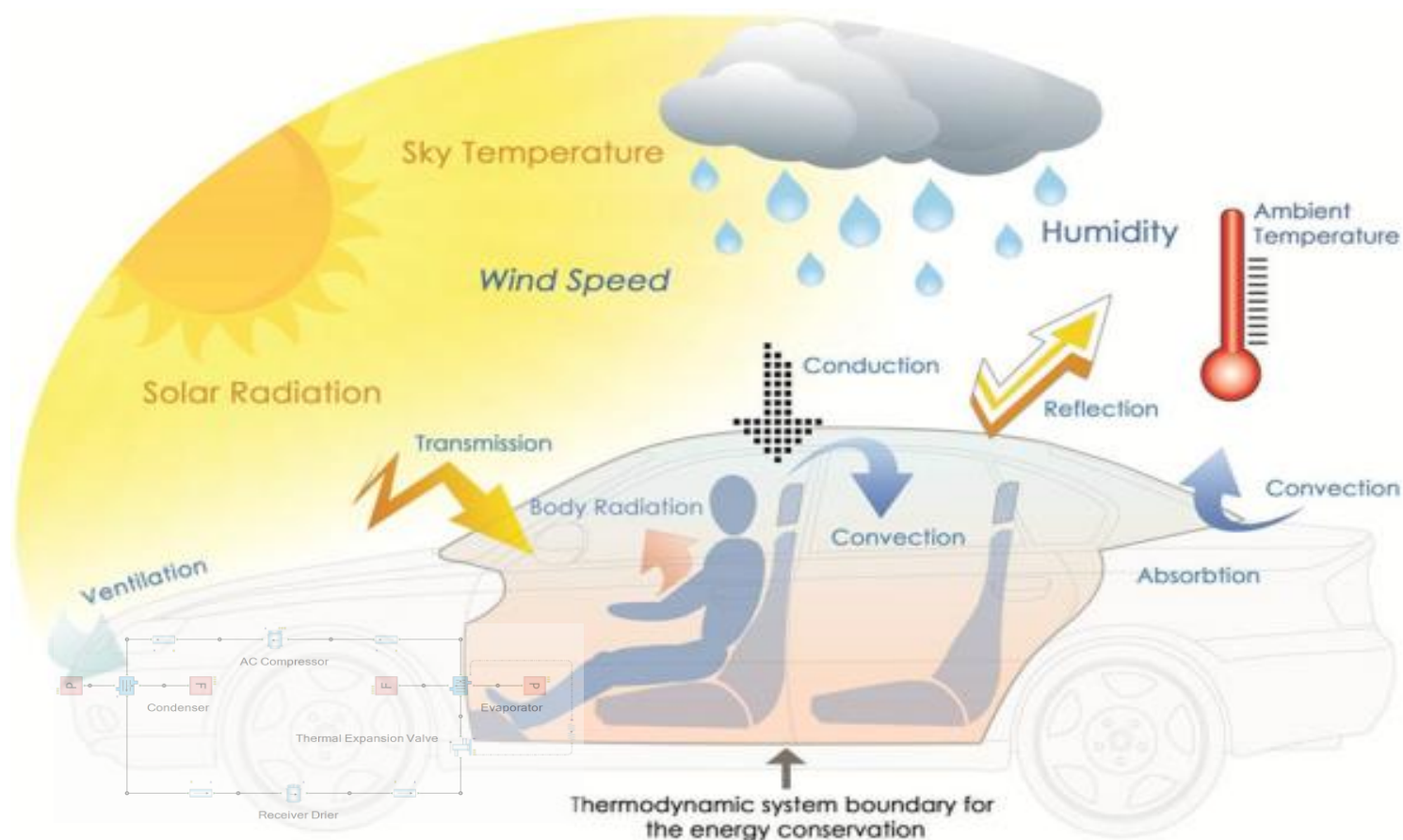


三维组件CFD

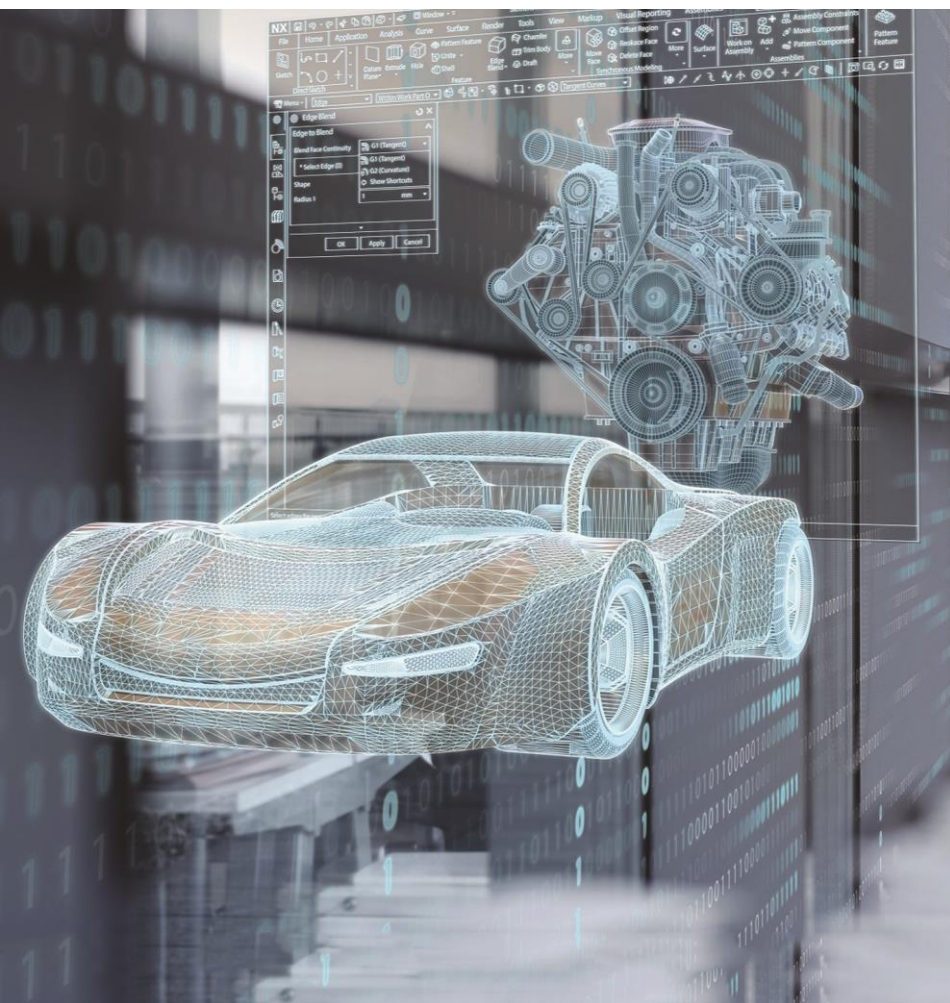
- 模拟复杂的几何，如电机、控制器的水套元件
- 能够详细给出流体动力学信息，如流动形态、相变和化学反应
- 关注部件空间场特征与结构局部改进

为什么需要1&3D CFD集成分析

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将详细的3D模型与完整驾驶工况下1D系统模型相结合可以更真实、更准确的预测性能表现



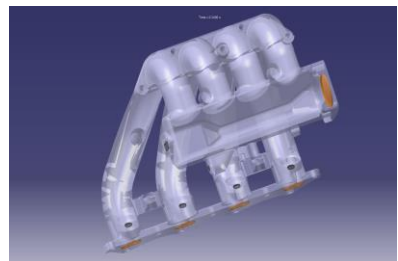
1. 车辆行业的发展趋势与挑战
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面向设计人员的CAD嵌 入式前端CFD—— FloEFD

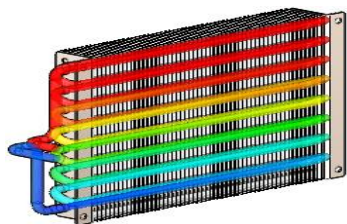
Simcenter FloEFD 工程流体分析

面向设计人员的CAD嵌入式前端CFD

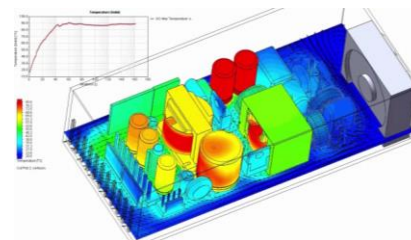
SIEMENS
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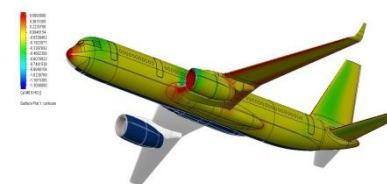
MIXING FLUIDS



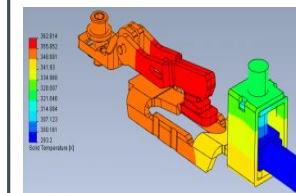
REFRIGIRANTS (Real Gas)



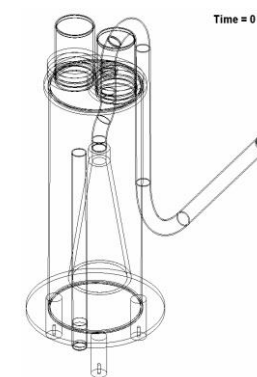
ELECTRONICS COOLING



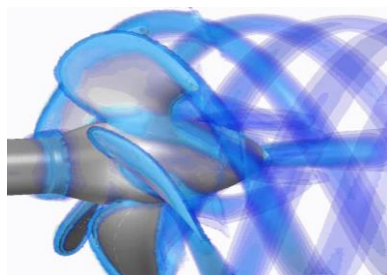
AERODYNAMICS



JOULE HEATING



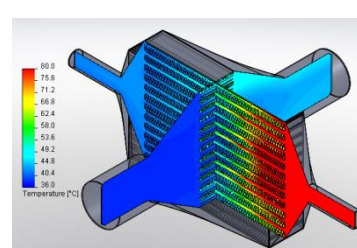
FREE SURFACE



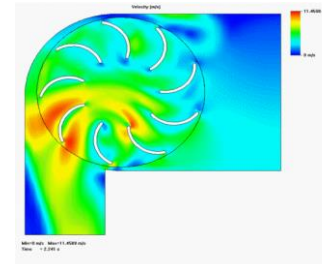
CAVITATION



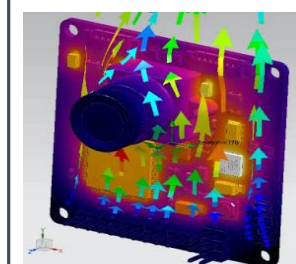
CONDENSATION



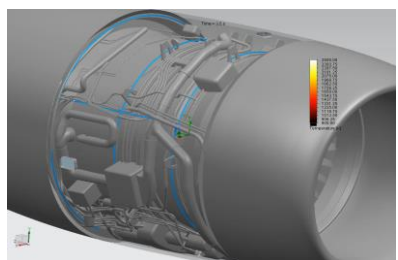
HEAT EXCHANGER



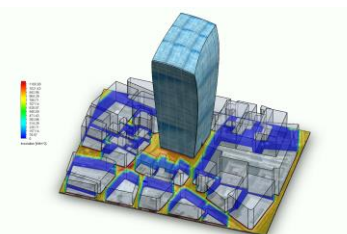
ROTATING EQUIPMENT



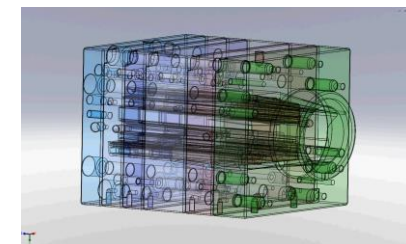
PCB MODELING



COMBUSTION



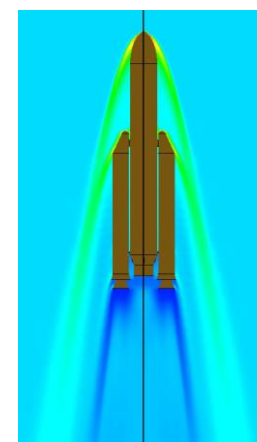
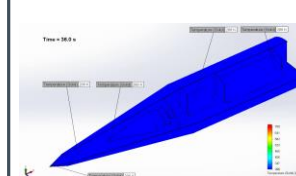
RADIATION



NON-NEWTONIAN

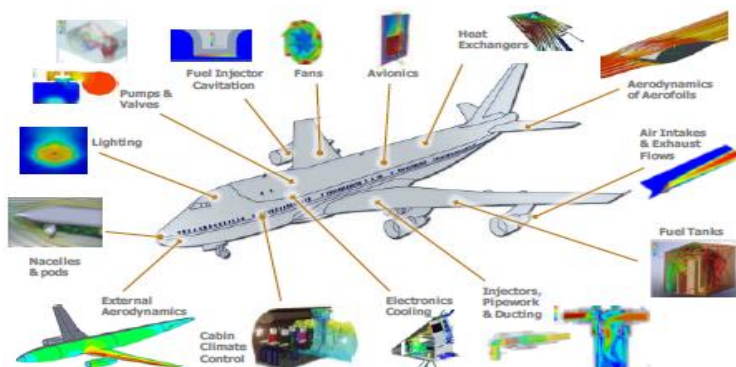


VENTILATION

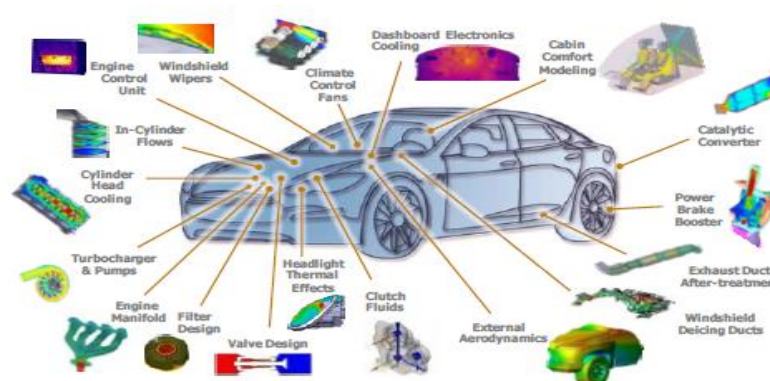


Simcenter FloEFD 行业广泛应用

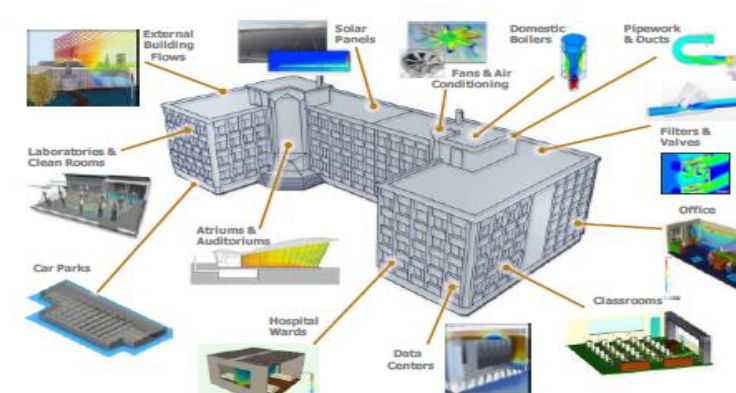
SIEMENS
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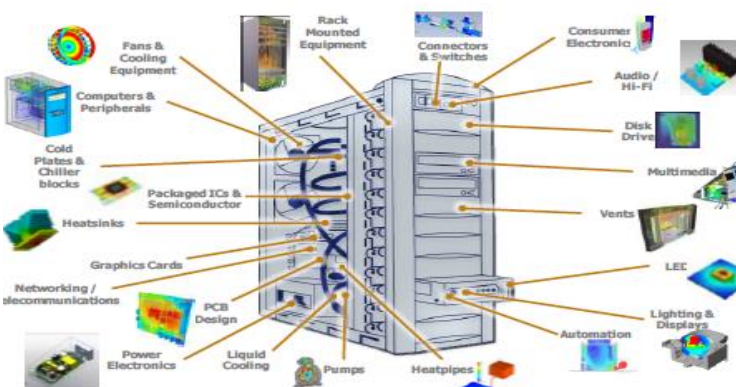
Military / Aerospace



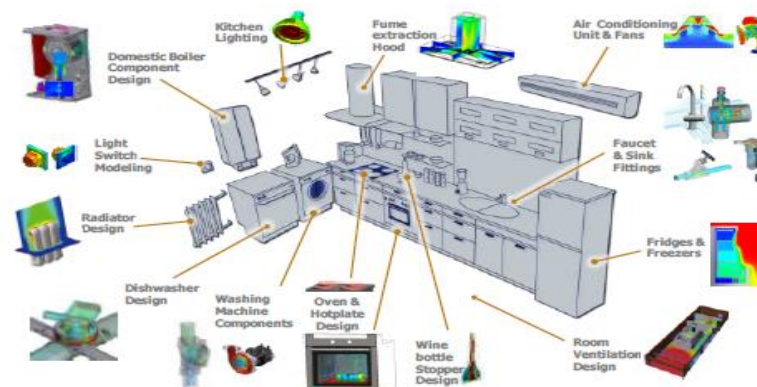
Automotive



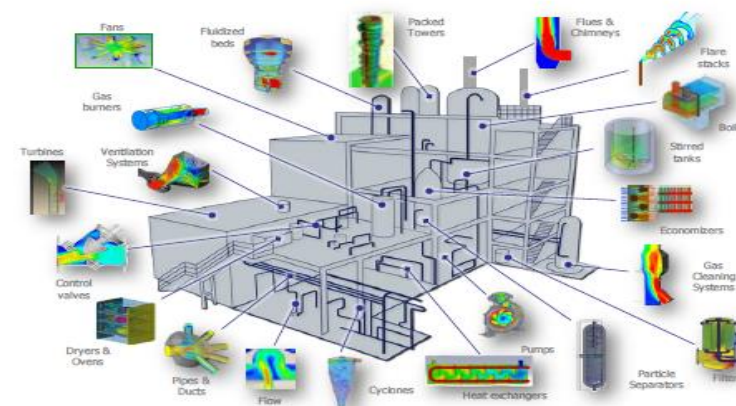
HVAC&R



Electronics



Household & Home Products



Process Industries & Manufacturing

Reference Customers Automotive

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LIEBHERR



PORSCHE



HONDA



RENAULT



MAHLE

TOYOTA



BOSCH



DAIMLER

Driven by performance



Bühler Motor



Audi



bertrandt



schefenacker



Filtrauto



TOGNUM

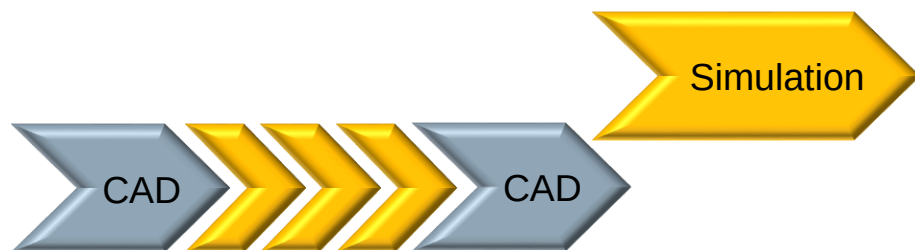
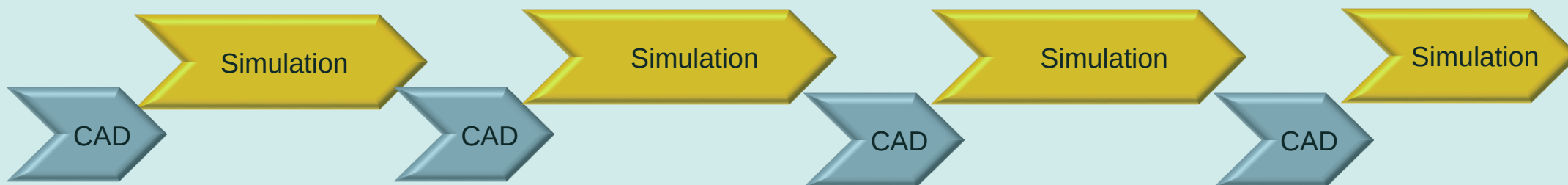
Power · Propulsion · Progress



前端 – 新的 workflow

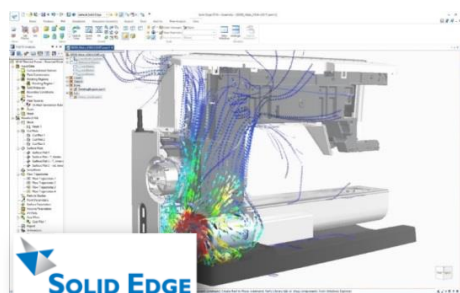
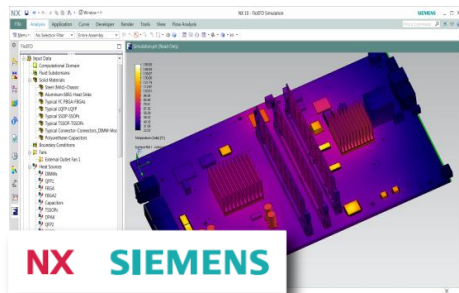
机械结构与CFD分析同步进行

新的 workflow 假定在将任务提交给分析人员之前在 CAD 前端执行多个模拟，因此总开发时间会大大减少。

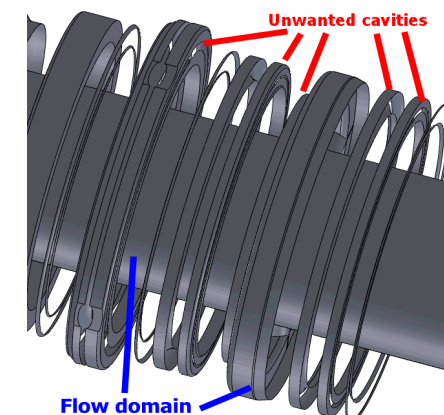
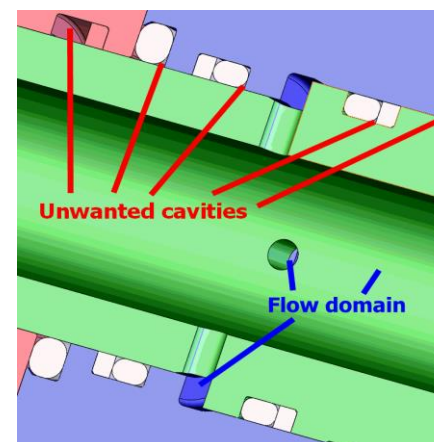


Simcenter FloEFD 关键技术 嵌入CAD中实现快速仿真

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- 自动检测流体域
- 检测几何改变: 模型与分析同步
- 分析条件输入 (前处理) 在 CAD中定义
- 后处理结果显示在CAD软件界面
- CAD界面友好 – CAD工程师易学易用
- 嵌入CAD中: 高效的网格划分及求解, 直接使用详细的几何信息。



Simcenter FloEFD关键技术

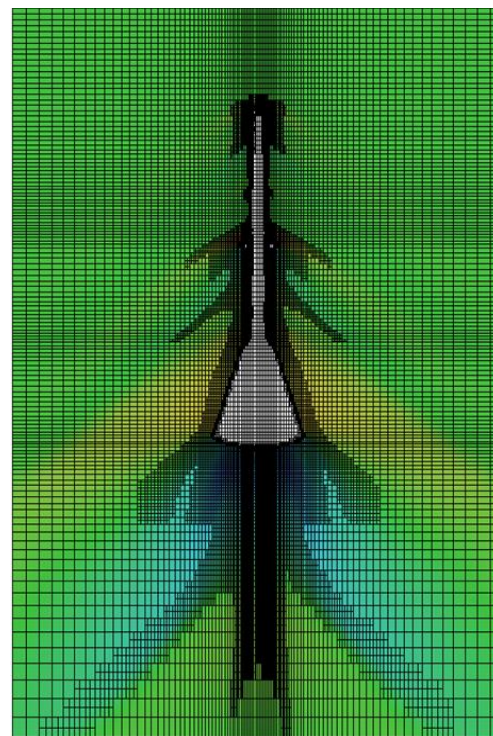
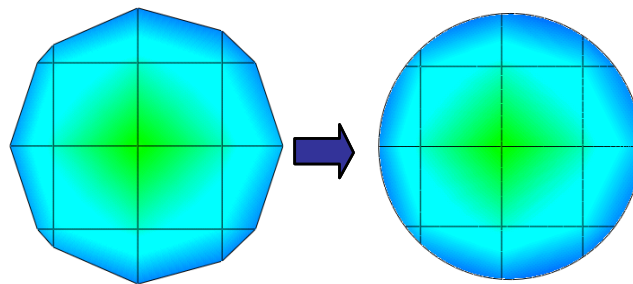
基于SmartCell™技术的自动网格划分

自动化网格划分技术

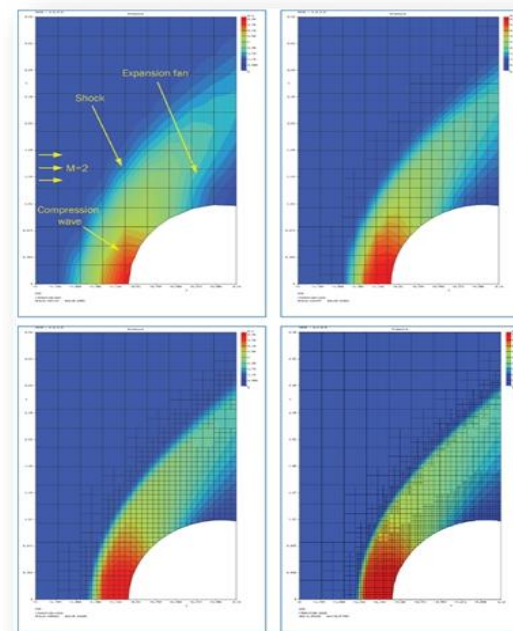
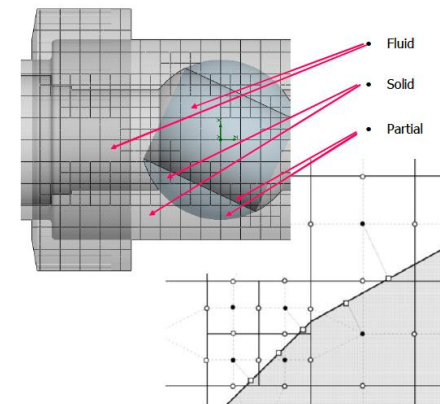
- 直接使用原始几何模型，CAD与CFD无需切换
- 快速处理“烂几何”
- 自动划分流体与固体网格
- 基于几何的优化 & 自适应网格技术
- 自动收敛

手动网格控制

- 支持手动控制网格生成
- 细小固体特征、狭长通道、公差、曲率优化控制



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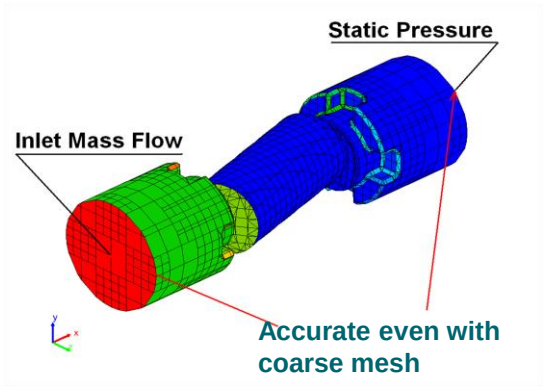
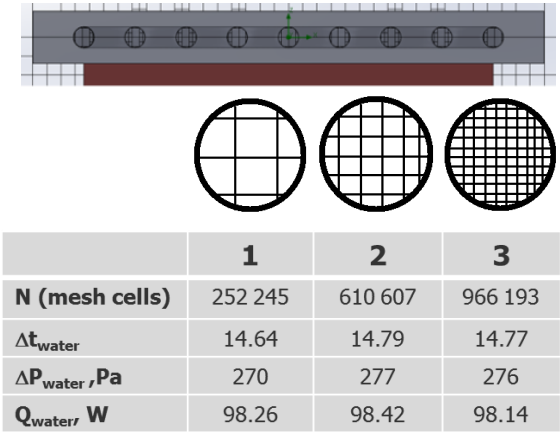
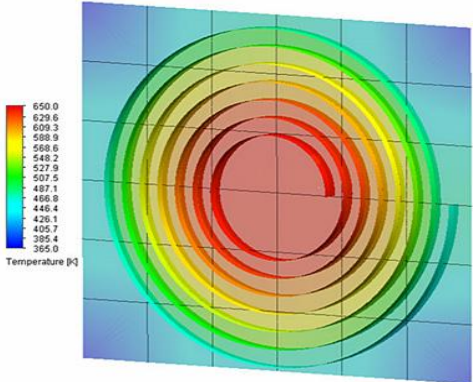
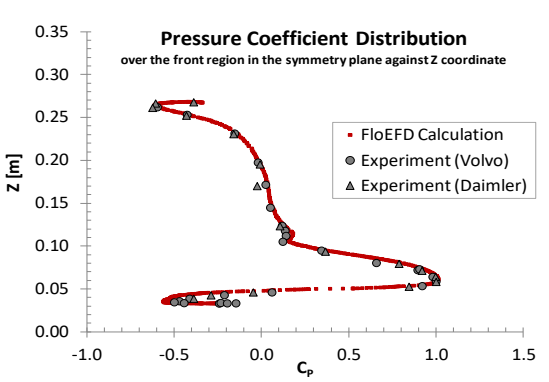
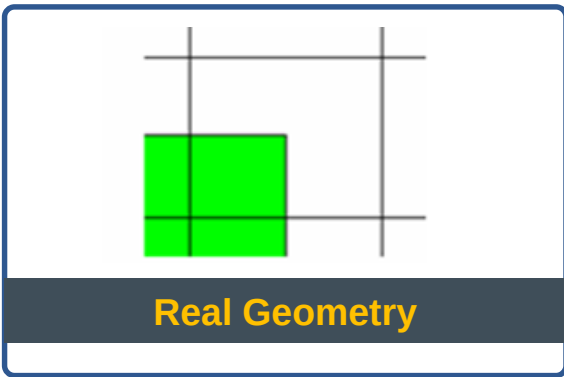
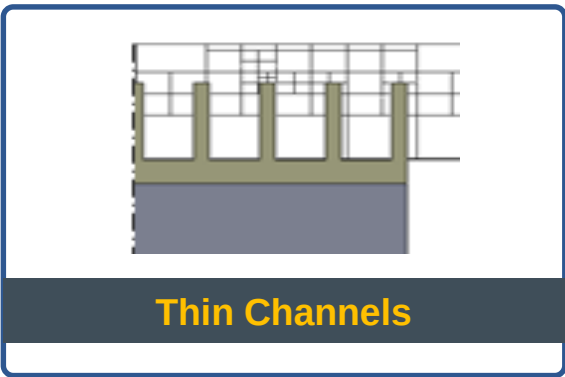
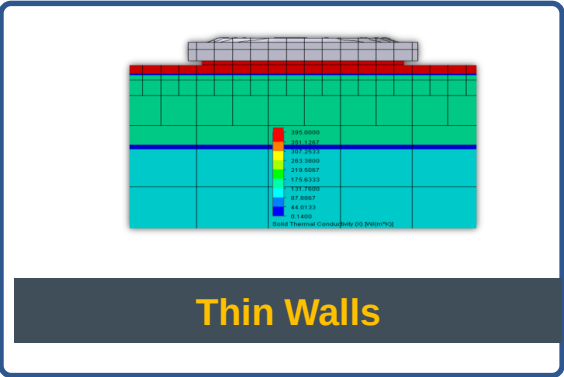
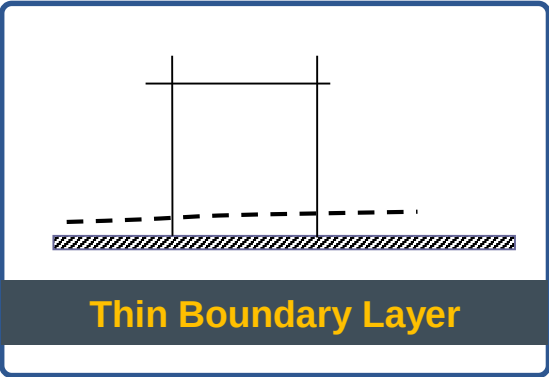


Simcenter FloEFD关键技术

基于SmartCell™技术的自动网格划分



FloEFD 自动解析流体域，在数值解决的分辨率不足的时候，自动判断应用解析或半经验的解决方案— **而且网格的生成既简单又快速**



Simcenter FloEFD关键技术

集成工程经验数据的混合算法



求解器结合了特殊的工程经验模型和解析模型

与传统CFD工具不同的是，FloEFD 使用了**独特的结合**了数值方法、半经验方法及解析模型的方法。

传统CFD工具

FLOEFD 扩展

RANS with
Wall Functions

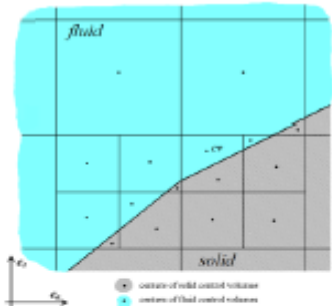
Prandtl BL Model

Analytical Equations

Empirical Models

Unique SmartCell™ Technology

Partial Differential Equations



$$\frac{\partial \rho}{\partial t} + \frac{\partial}{\partial x_i}(\rho u_i) = 0$$

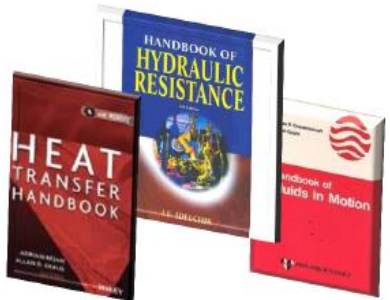
$$\frac{\partial \rho u_i}{\partial t} + \frac{\partial}{\partial x_j}(\rho u_i u_j) + \frac{\partial p}{\partial x_i} = \frac{\partial}{\partial x_j}(\tau_{ij}^v + \tau_{ij}^R) + S_i \quad i=1,2,3$$

$$\frac{\partial \rho H}{\partial t} + \frac{\partial \rho u_i H}{\partial x_i} = \frac{\partial}{\partial x_j} \left(u_j (\tau_{ij}^v + \tau_{ij}^R) + q_i \right) + \frac{\partial p}{\partial t} - \tau_{ij}^R \frac{\partial u_i}{\partial x_j} + \rho \varepsilon + S_i u_i + Q_H$$

$$H = h + \frac{u^2}{2}$$

Analytical (theory) Equations

$$\rho c_p \frac{\partial T}{\partial t} - \text{div}(\lambda \text{grad}(T)) = f + q_J$$



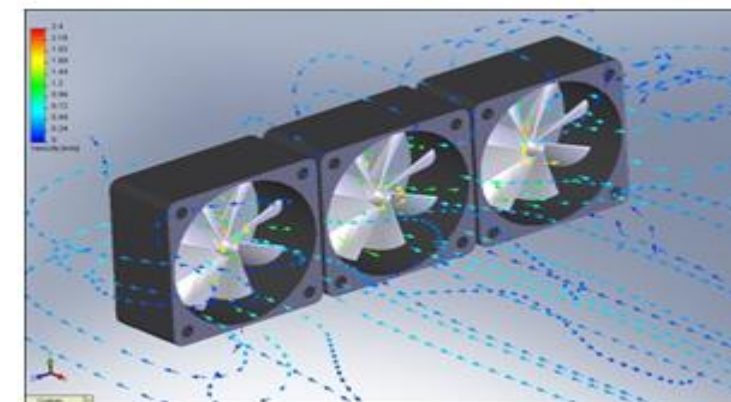
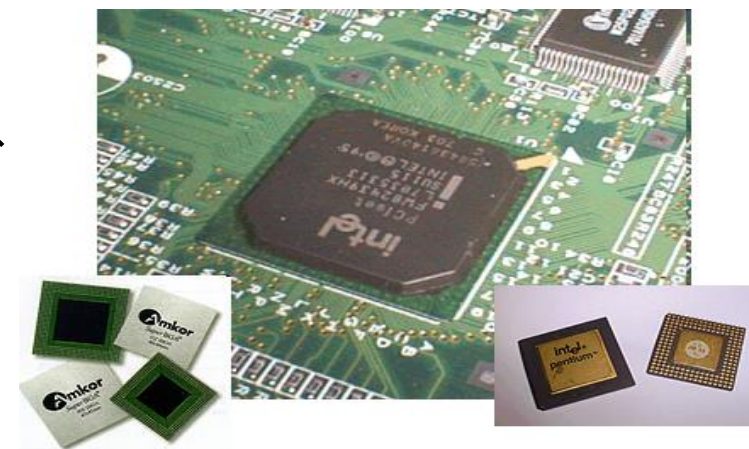
Empirical Data

Simcenter FloEFD关键技术

电子冷却模块—ECAD与MCAD无缝集成



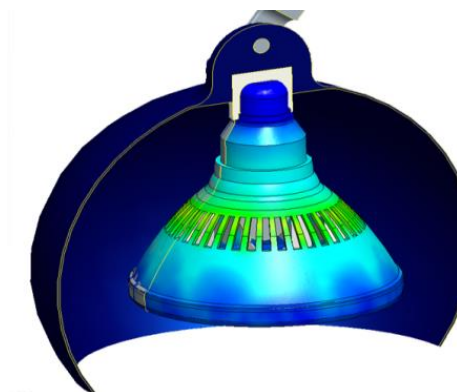
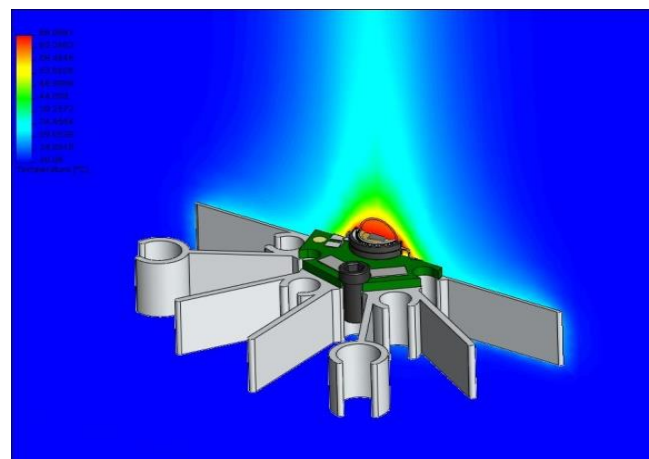
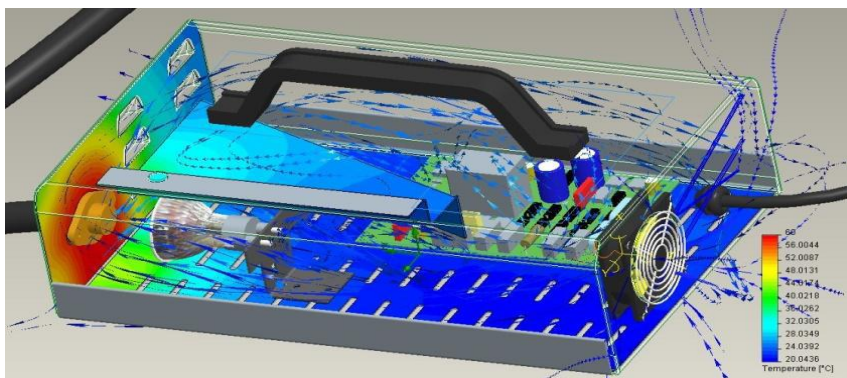
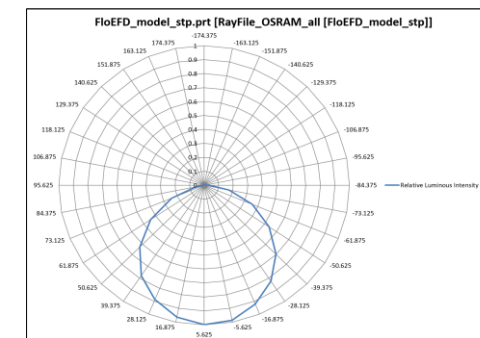
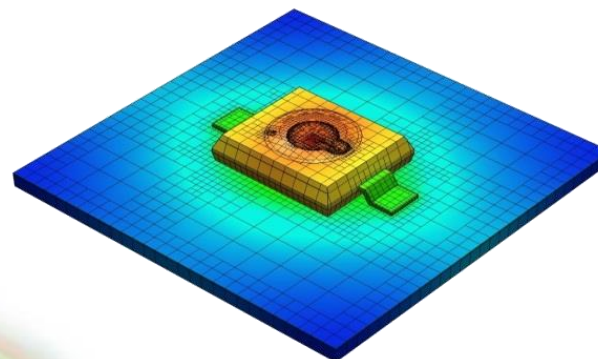
- 针对电子散热分析领域的“升级”模块；
- 支持丰富的电子热分析功能，包括：焦耳热、双热阻简化模型、善的风扇模型等；
- 包含了大量的工程数据库：
 - 风扇库
 - 标准的JEDEC组件库
 - 双热阻模型库
 - 多孔板库
 - 热电致冷（TEC）库
 - 电子固体材料库
 - 导热胶材料库
 - 辐射面库
 - 过滤器库



Simcenter FloEFD关键技术 LED模块

SIEMENS
Ingenuity for life

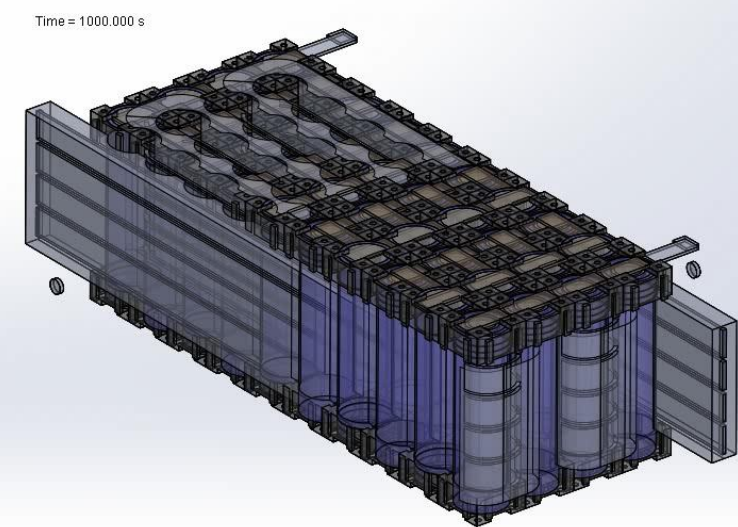
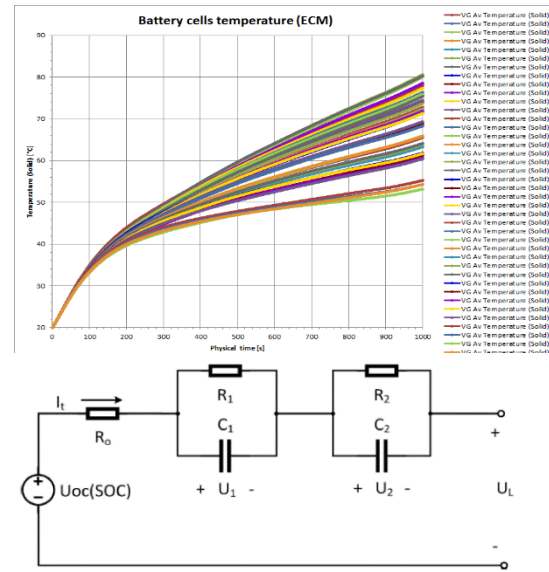
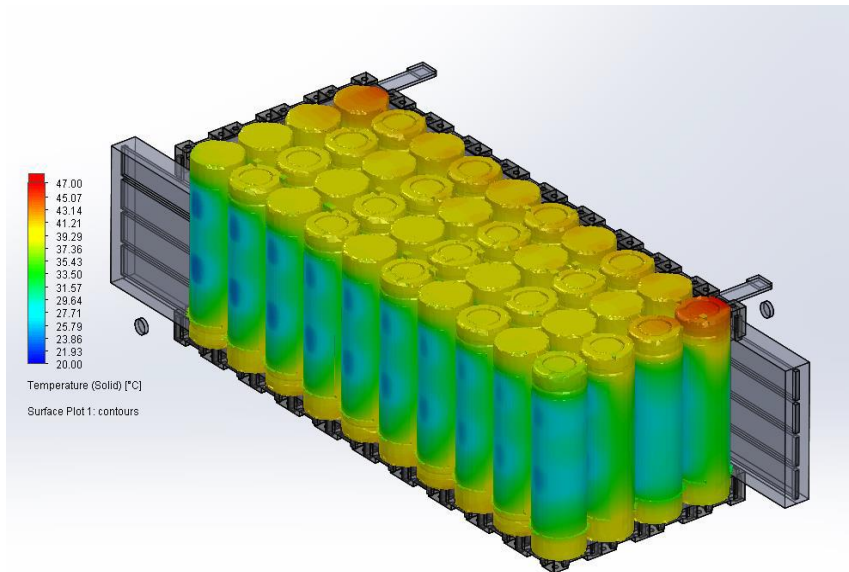
- 两种LED简化模型
 - 简单双热阻模型
 - 高级RC阶梯模型
- 预定义LED
- PCB简化模型
- 用以考虑LED Lens热特性的高级热辐射模型
- 流明度计算
- 支持瞬态仿真



Simcenter FloEFD关键技术 电池模块



- 新的电池紧凑型模型根据电池的电气或电气化学特性计算散热率。所得散热率应用于电芯。预测SOC、U、I及T分布。支持两种模型: ECM (equivalent circuit, 2nd order) and ETCM (electro-chemical).



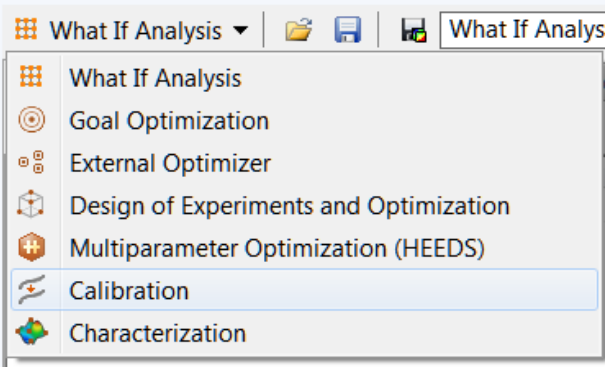
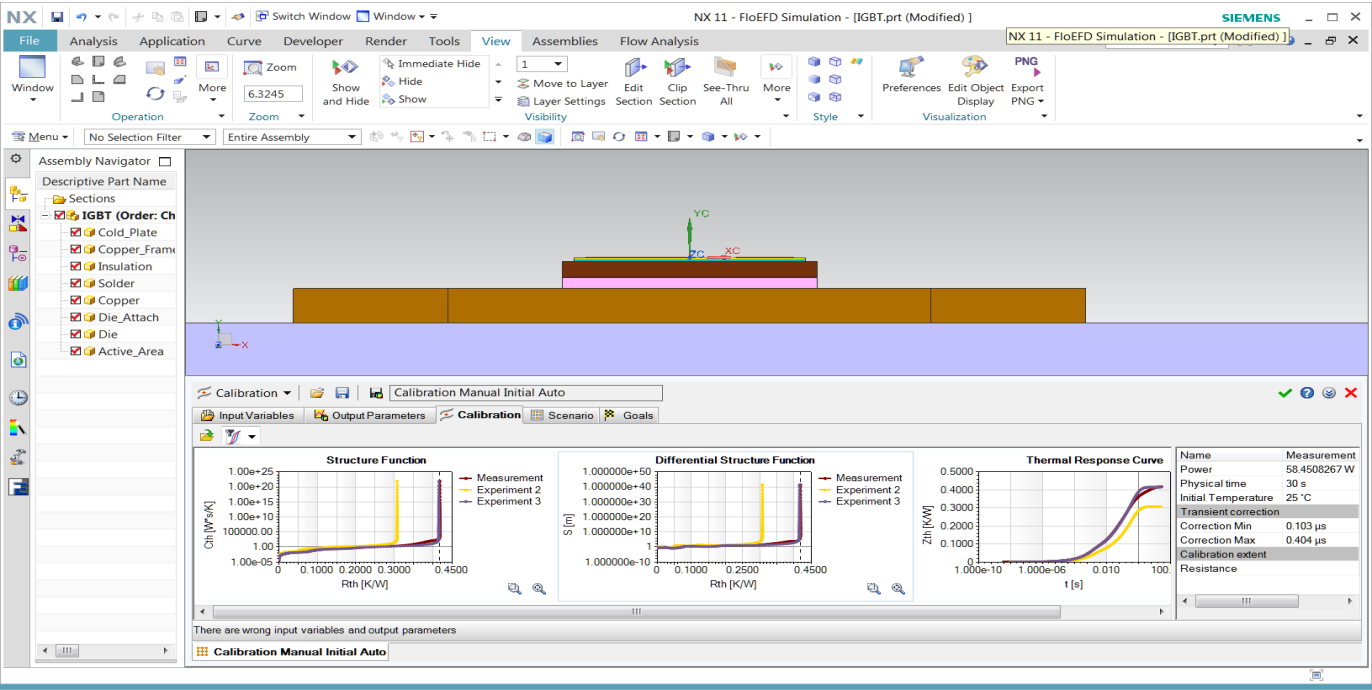
Simcenter FloEFD & T3Ster

Auto-Calibration 自动校准测试功能



Simcenter T3STER™获得封装的瞬态热响应。

新的自动校准使用内置的参数学习来获得与测量响应相符的封装属性。在仿真中更准确地表示 IC 封装。



Simcenter FloEFD关键技术

多变量设计分析

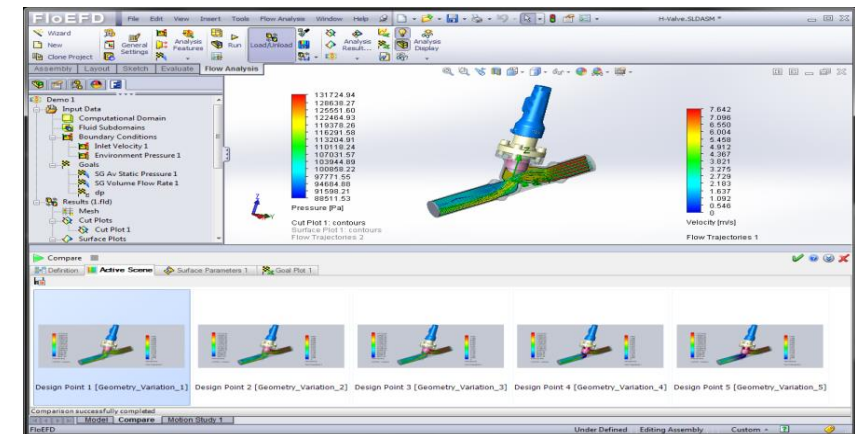
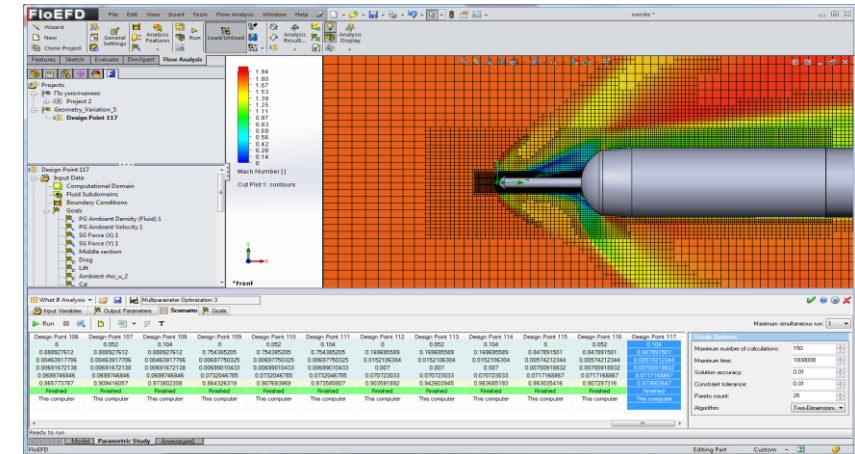


多变量设计分析

- 支持假定分析的项目克隆技术，无需对模型进行任何定义
- DoE + Response Surface允许对产品设计进行变量模拟
- 完全支持MCAD产品配置概念的方案对比优化
- 支持批处理运行

价值

- 多模型变工况想定分析，优化设计
- 将CFD专家的精力集中于技术难题的攻关

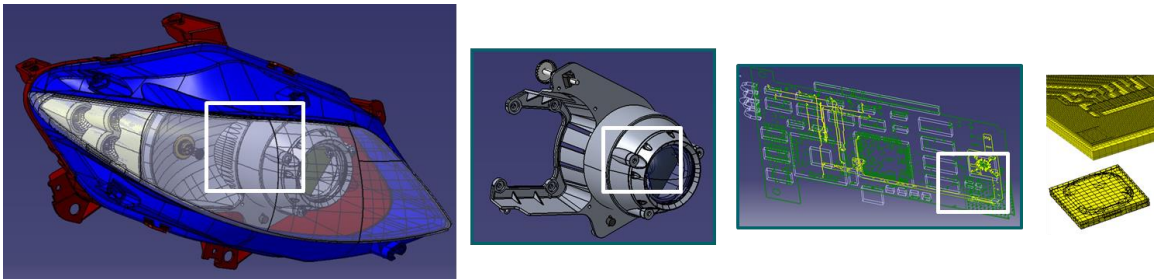


Simcenter FloEFD

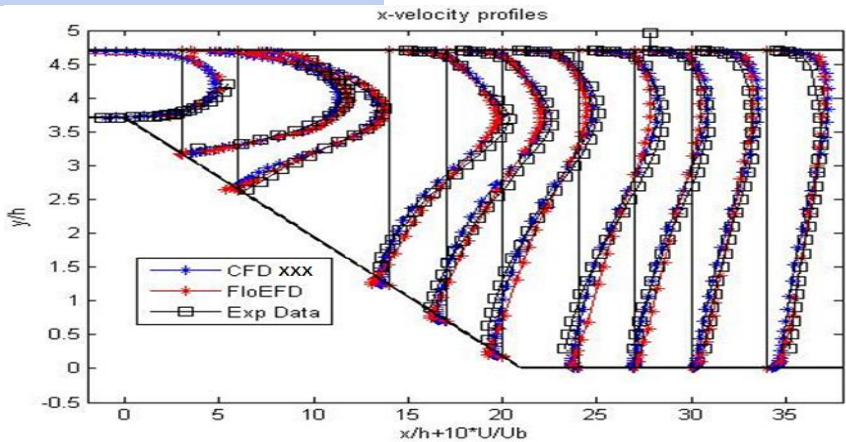
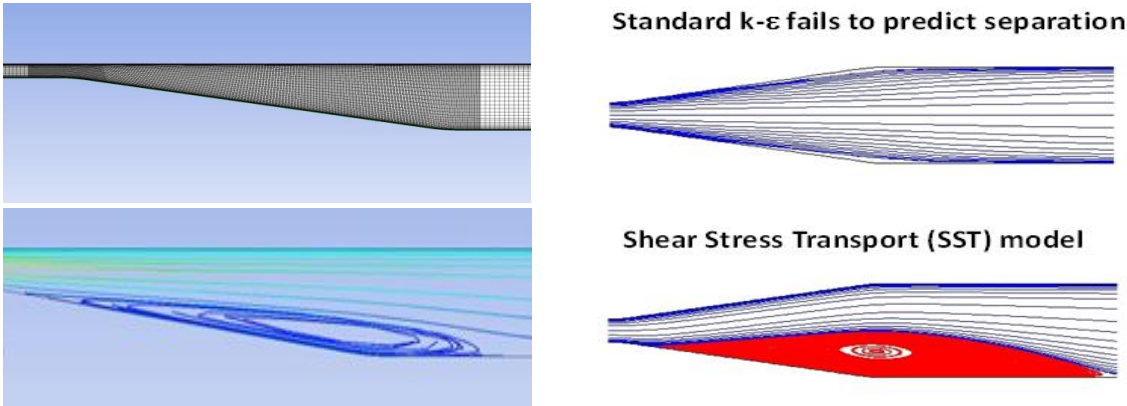
更简单、更快速但不失精度

CAD+SmartCell + 自适应求解

- 无需为CFD过多简化几何
- 无需将模型转入转出CAD，检测变化
- 无需选择湍流模型，求解器设置适用广泛
- 从网格到求解，无需过多介入
- 自动判断收敛
- 方案快速迭代



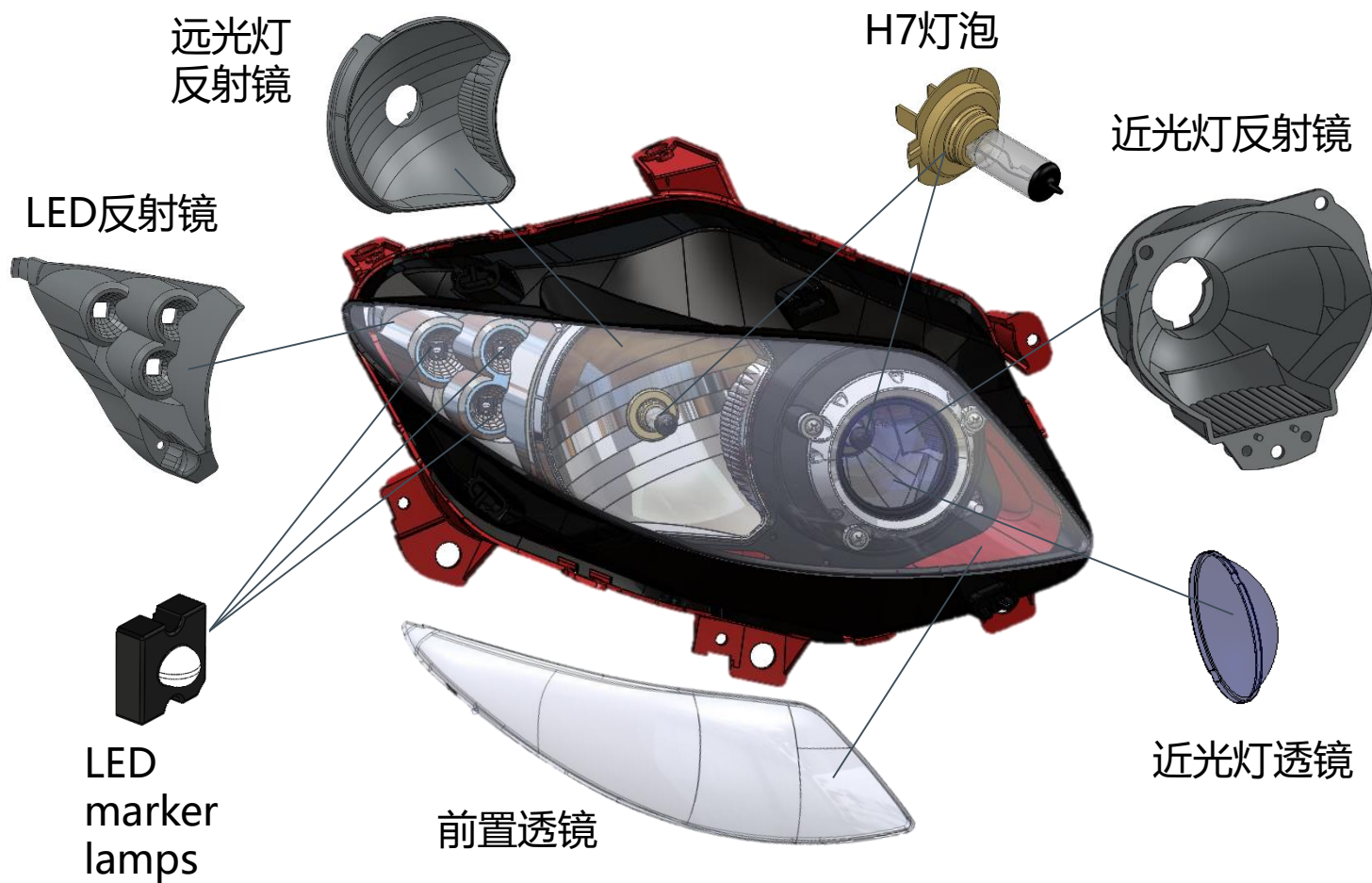
前灯模型准备=5.5h，解算器=16h（20核）



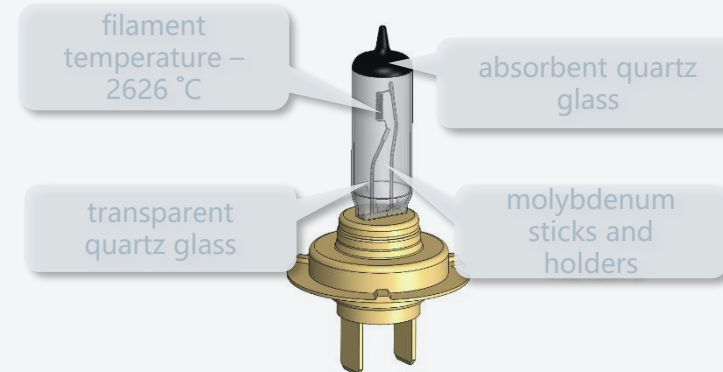
Touch + Processing Time			
	FloEFD	CFD	%diff
Geometry Generation	~4H	~4H	Similar
Mesh	<1H	10H ICEM	10x reduction
Solve	~6.8H	~5H	Similar
Post Process	48H	~48H	Similar

Simcenter FLOEFD车灯案例

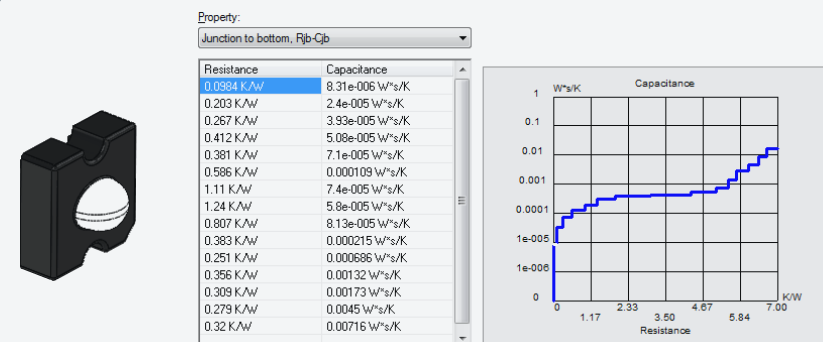
前灯典型结构



SIEMENS
Ingenuity for life



H7 Bulb - Power: 55 W



LED - Forward Current = 0.7 A

Simcenter FLOEFD车灯案例

车灯热流仿真技术挑战

非常复杂的CAD几何模型处理

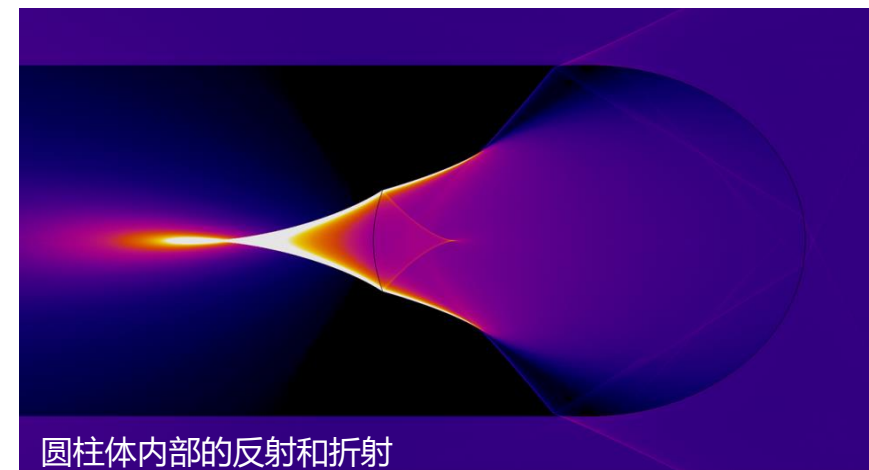
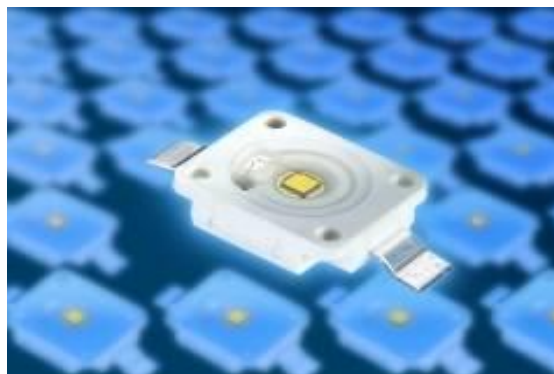
- 多个实体和流体区域，几何特征尺寸差异巨大，网格划分具有挑战

强烈的物理现象耦合

- 自然和强迫对流(风扇)，包括传导、对流、辐射等
- 薄壁、狭长通道的简化计算
- 太阳辐射
- 光学影响
- 相变: 冷凝，除雾，除霜、固体吸收

LED，PCB和元件等

(LED结温热瞬态仿真)



圆柱体内部的反射和折射

Simcenter FLOEFD车灯案例

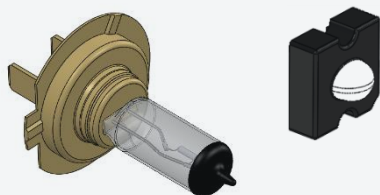
前灯计算工况

Scenario:

一辆汽车在寒冷潮湿的环境中停了下来750 秒后, LED 指示灯打开20 分钟 (1200 秒) 后, 发动机和灯将打开

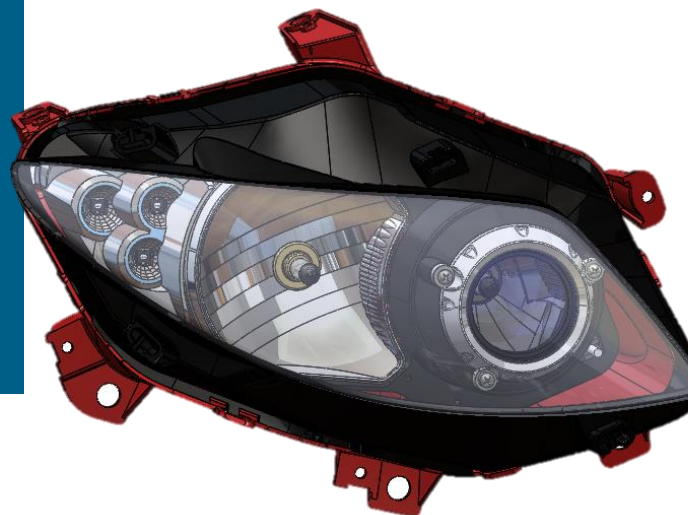
Objective:

预测瞬态流/热分布和透镜上冷凝/冰的形成



LEDs are on at $t = 750s$,
H7 bulbs on at $t=1200s$

前透镜的内表面是湿润的



前镜头的外表面: HTC 和温度
变化模拟寒冷外部环境

Pressure: 101325 Pa
Inner Temperature: 25 C
Outer Temperature: -20 C
Relative Humidity: 95%

前照灯的外面: HTC and
temperature change are
specified to simulate the
underhood space during
the stop and after the
engine is switched on

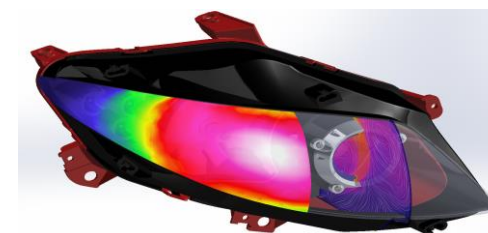
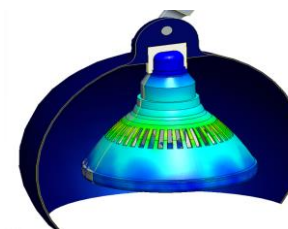
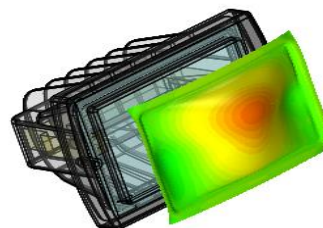
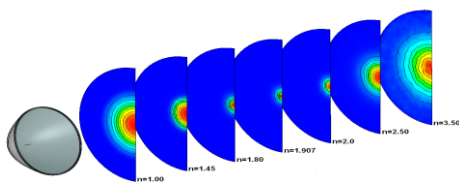
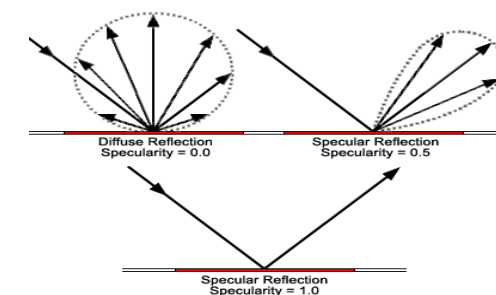
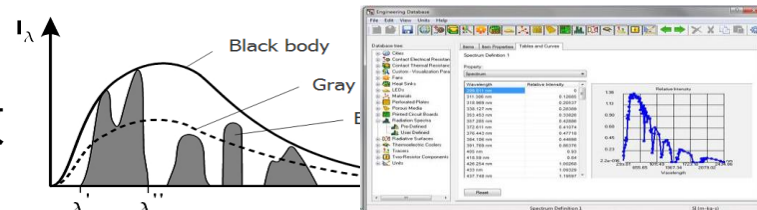
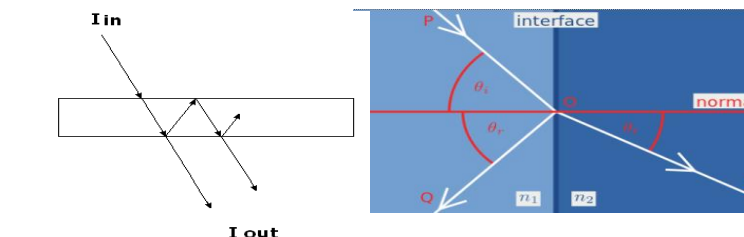
Simcenter FLOEFD车灯案例

辐射建模技术



支持现象

- 热辐射,环境辐射
- 太阳辐射(光线发散),
- 衍射反射、镜面反射和高斯反射几何光学(通过透镜聚焦, 折射)
- 半透明体内的吸收波长依赖性:日光光谱,依赖发射率的波长and吸收系数
- 定向和扩散辐射源灰体和非灰体模型(带和基于射线的光谱模型)
- Monte-Carlo, DO, DTRM radiation models
- 光线文件支持



Simcenter FLOEFD车灯案例

LED热仿真技术方法

简化双热阻模型

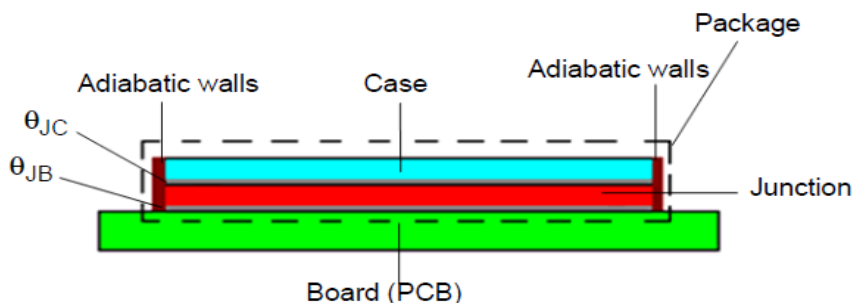
- 基于双热阻模型

输入:

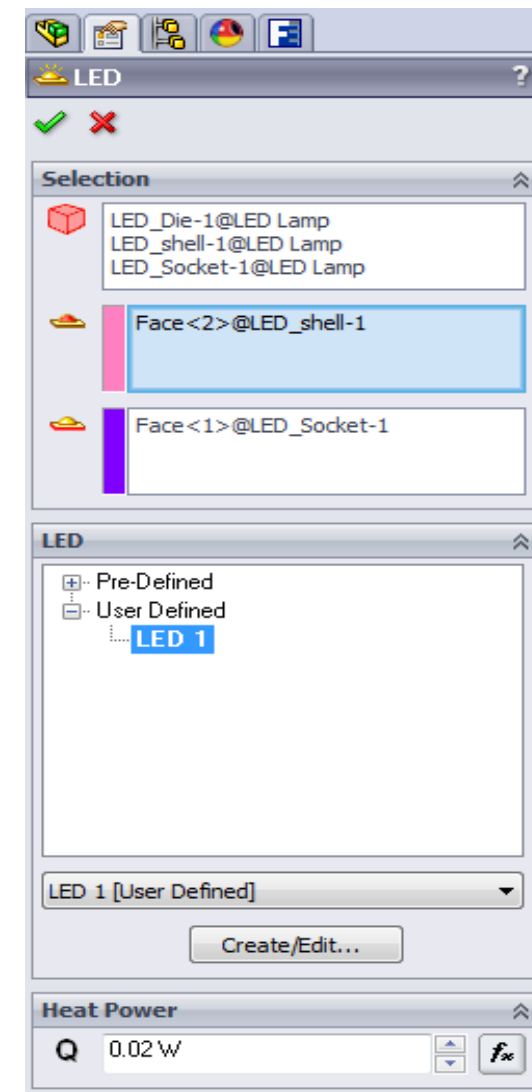
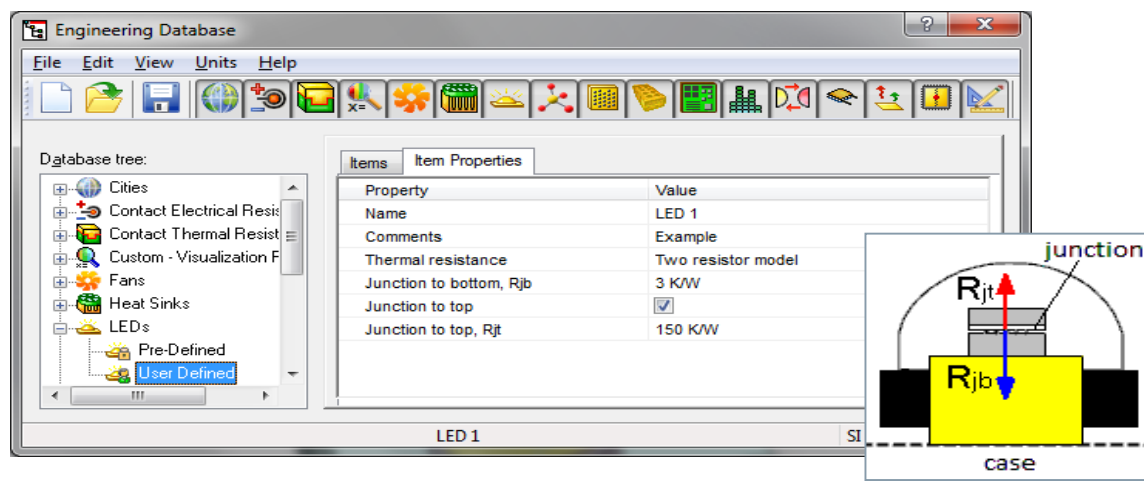
- R_{jb} (结点至底部)
- R_{jt} (结点至顶部) (可选, 默认 = $50 \cdot R_{jb}$)
- PH (实际的发热量)

输出:

- 只支持 TJ (结温)



LED	
Type	LED 1
Power	0.02 W
T junction	?



Simcenter FLOEFD车灯案例

LED热仿真技术方法



高级RC阶梯模型

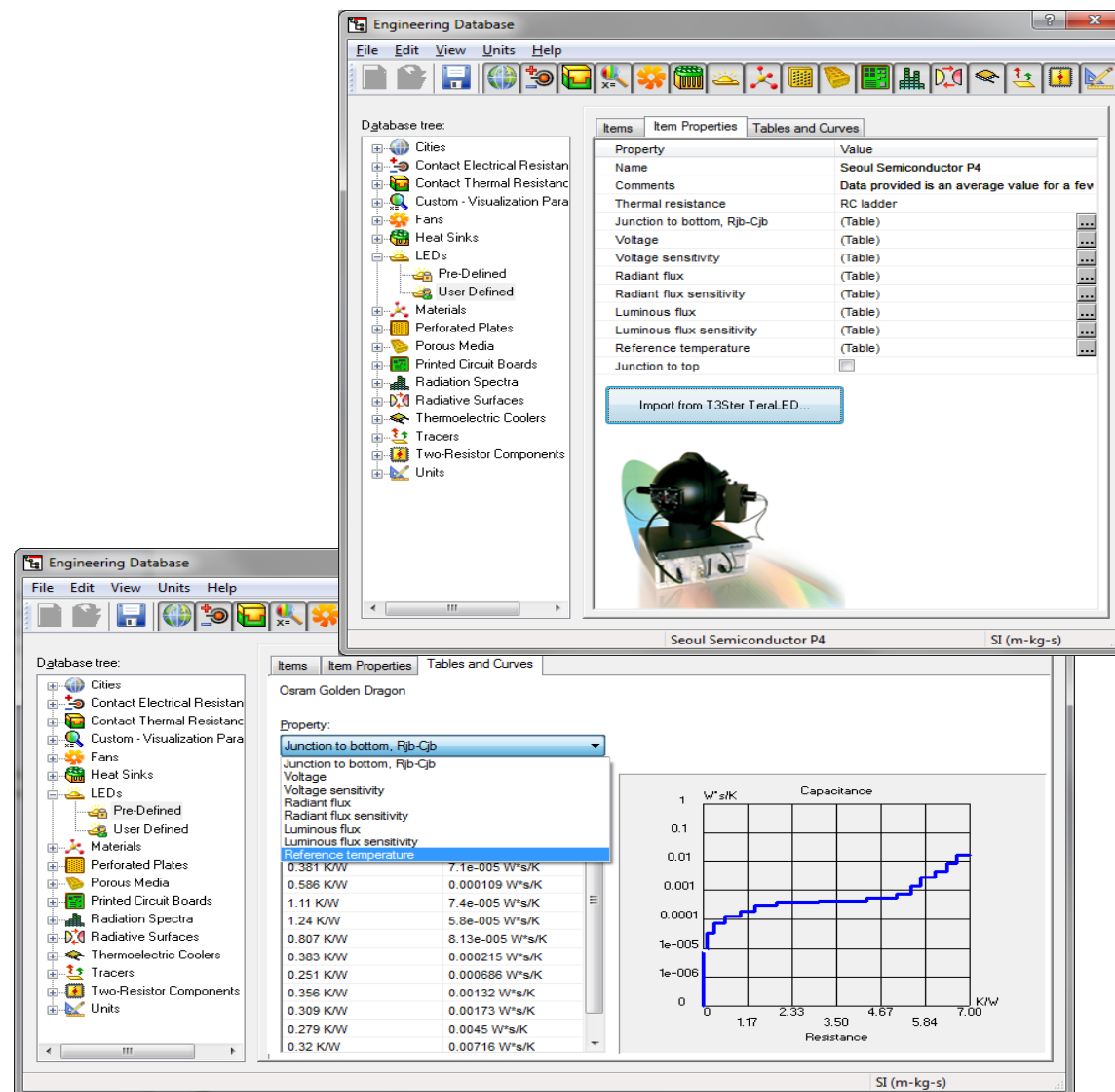
- 对于固态照明设计挑战独一无二的解决方案
- 在计算LED热功耗时，正确地考虑LED发出的光能

输入:

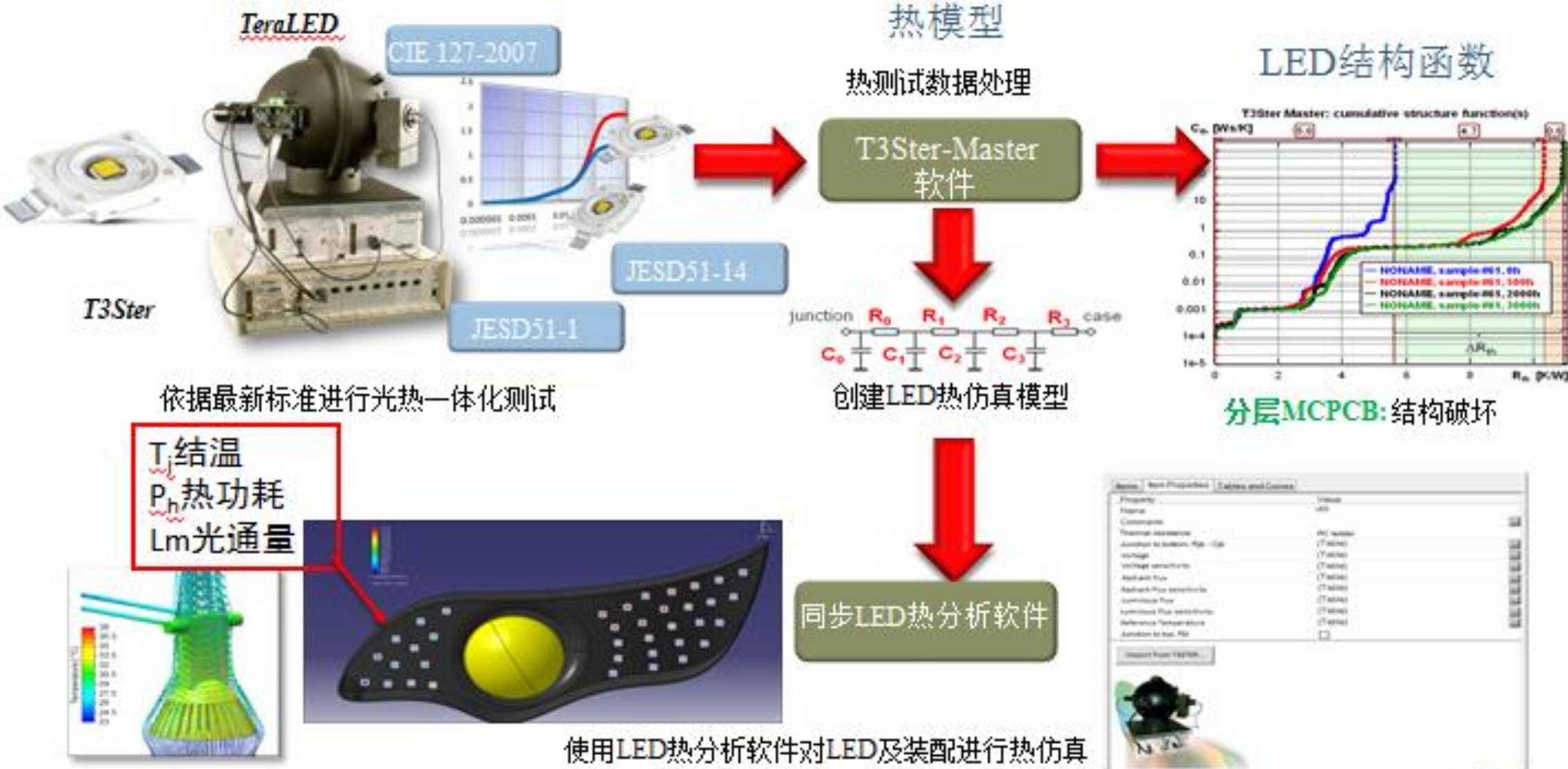
- IF (恒定的前向电流)
- LED 热特性
 - (通过T3Ster & TERALED测量得到)
- 光输出
 - (通过T3Ster & TERALED测量得到)

输出:

- 结温
- LED 发热量
- 光通量

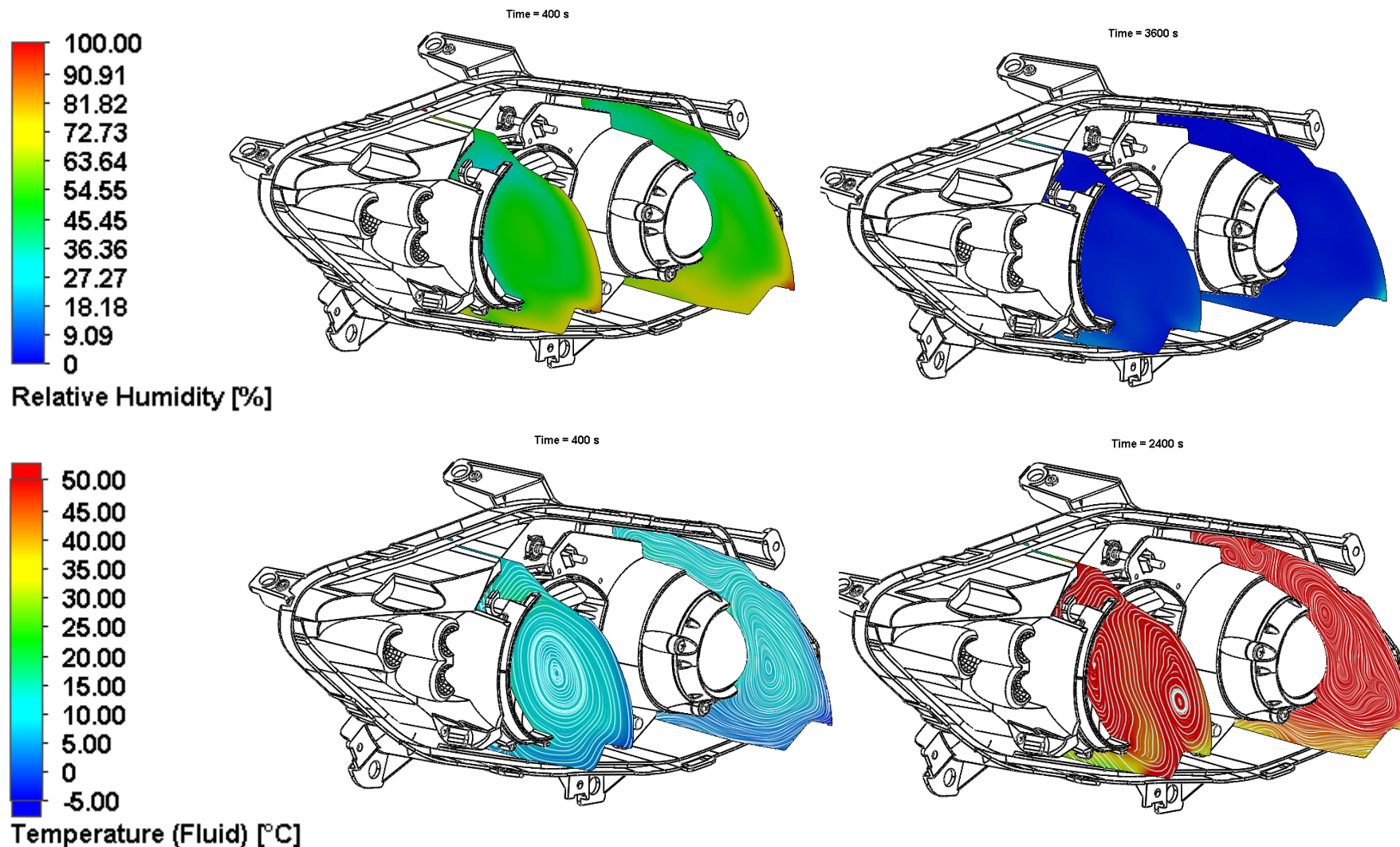


Simcenter FloEFD&T3Ster TeraLED联合光热一体化方案



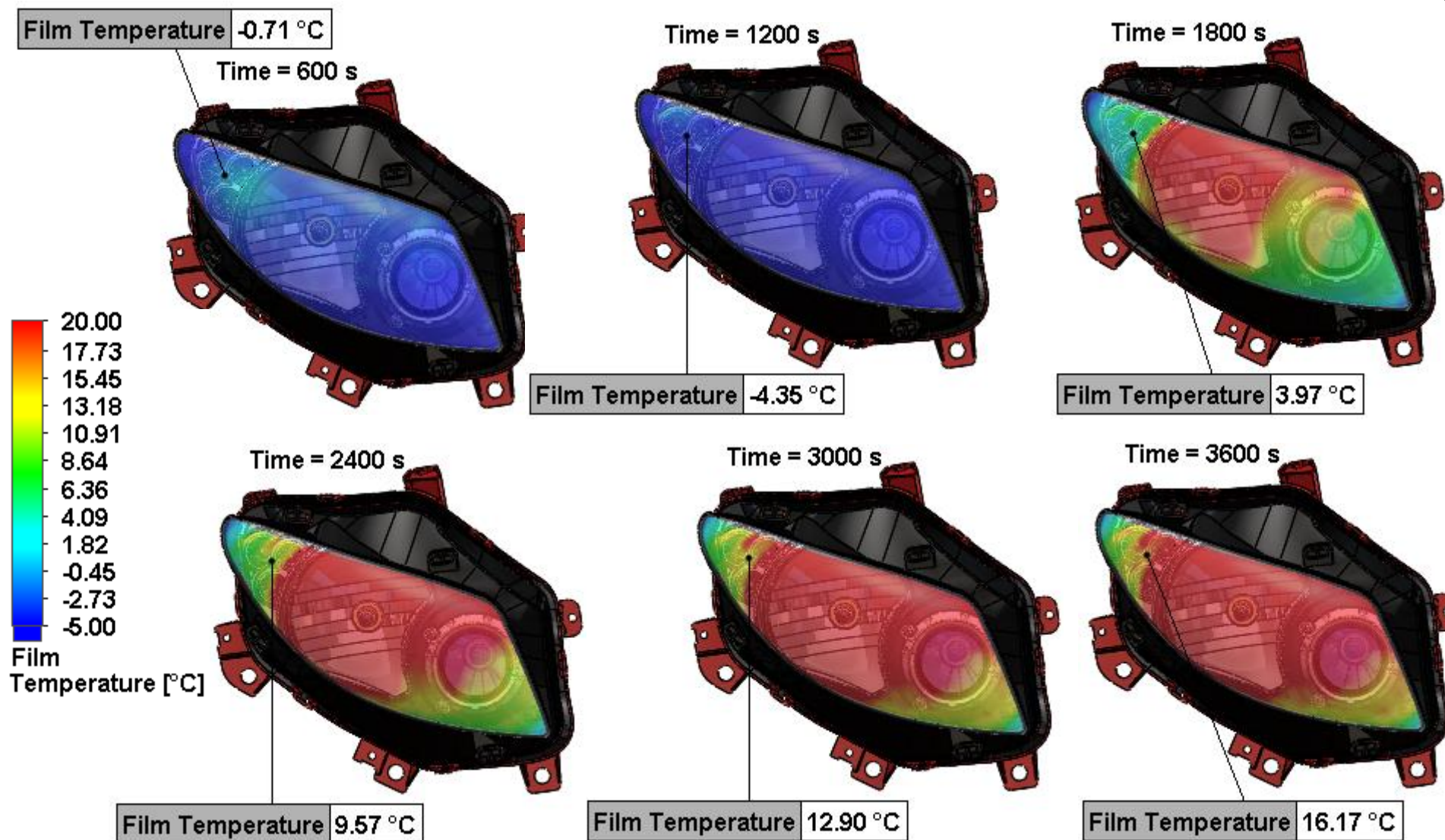
Simcenter FLOEFD车灯案例

温度和湿度分布



Simcenter FLOEFD车灯案例

薄膜温度变化



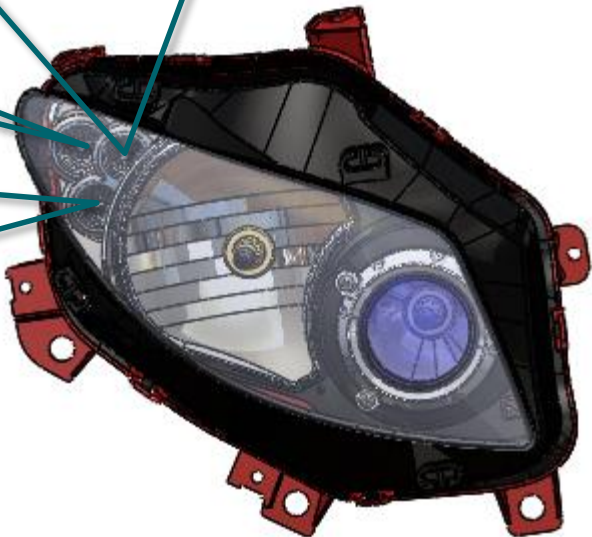
Simcenter FLOEFD车灯案例

LEDs performance

LED (Input)	
Type	Osram Golden Dragon QA
Current	Dependency
LED (Output)	
T junction	91.76 °C
LED Heat Generation Rate	0.912 W
Luminous Flux	99.56 lm

LED (Input)	
Type	Osram Golden Dragon QA
Current	Dependency
LED (Output)	
T junction	93.62 °C
LED Heat Generation Rate	0.913 W
Luminous Flux	99.08 lm

LED (Input)	
Type	Osram Golden Dragon QA
Current	Dependency
LED (Output)	
T junction	93.00 °C
LED Heat Generation Rate	0.913 W
Luminous Flux	99.24 lm

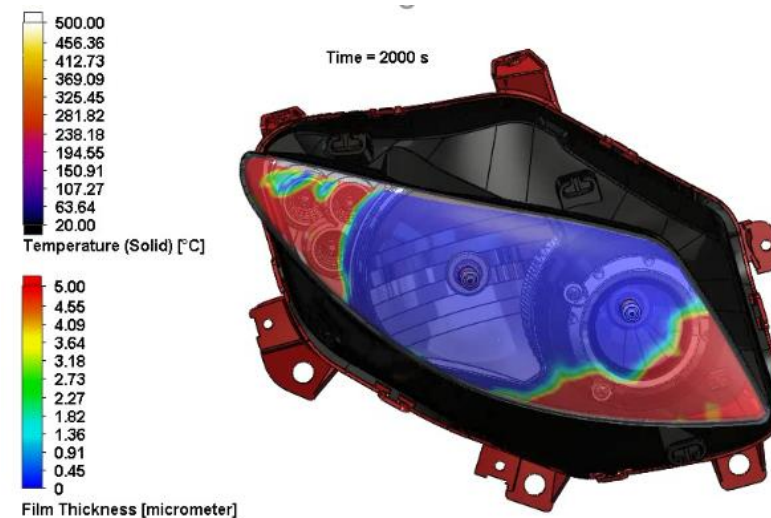
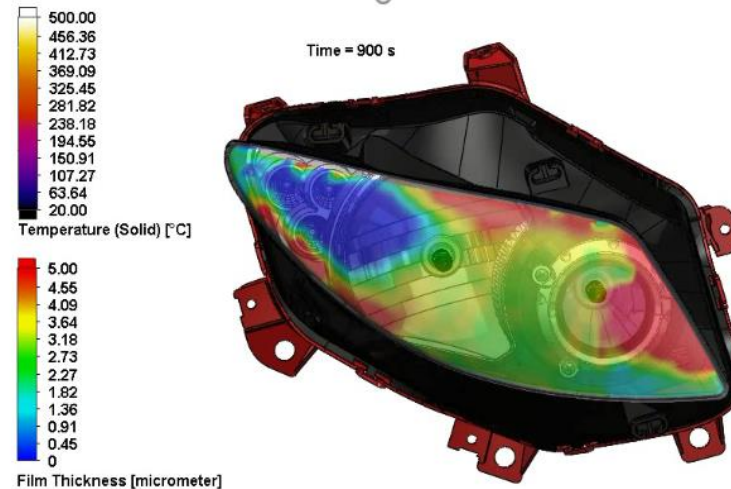
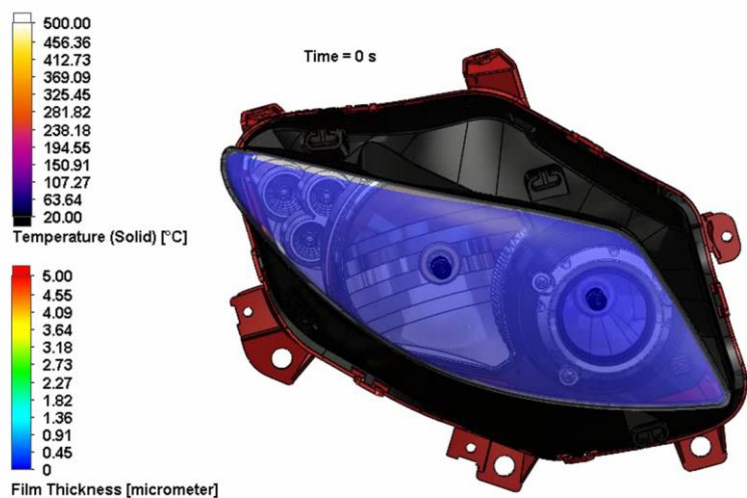


Time = 2400 s

Simcenter FLOEFD车灯案例

薄膜厚度变化 (Animation)

SIEMENS
Ingenuity for life



Simcenter FLOEFD车灯案例

薄膜相态变化

SIEMENS
Ingenuity for life

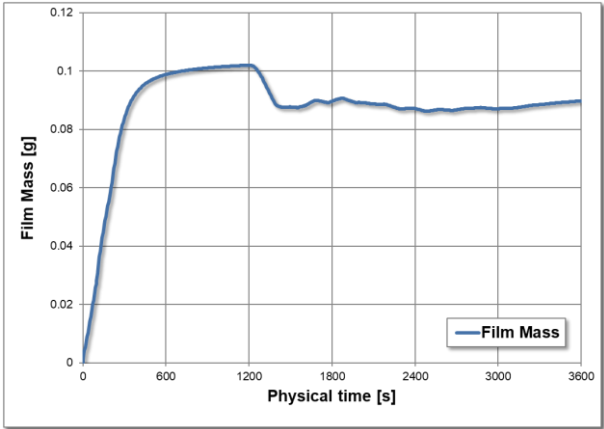
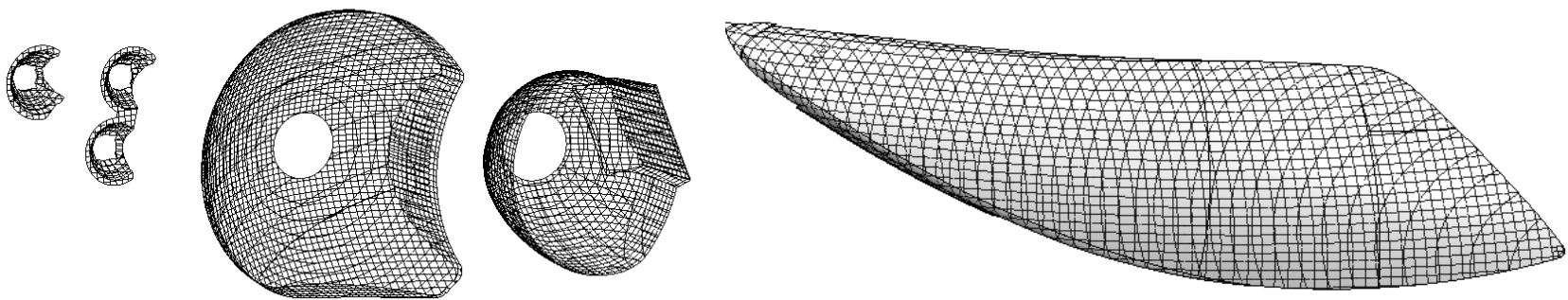


Simcenter FLOEFD车灯案例

仿真计算摘要



Task definition including mesh set up	40 min
Radiation model	Monte Carlo, 20 millions rays
Meshing	1 min
Mesh count	200 000 cells
Solution time	1 day
Physical time calculated	60 min
Computer	Intel Xeon 3.3 GHz 8 cores

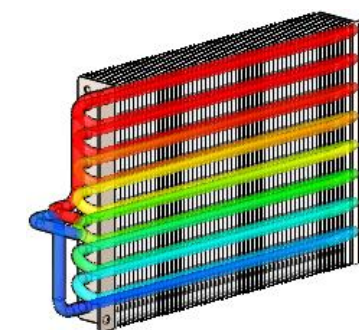
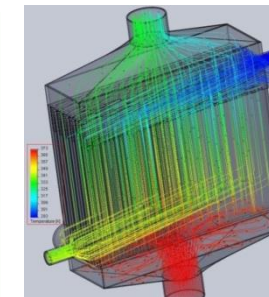
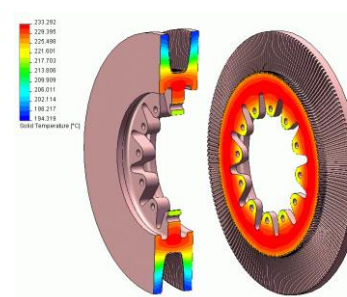
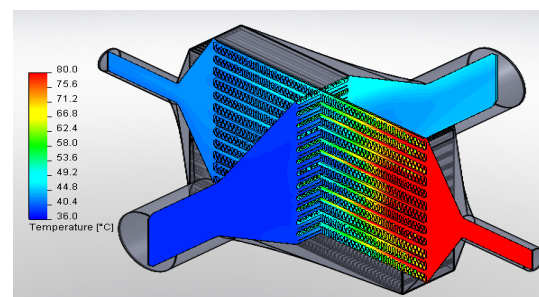
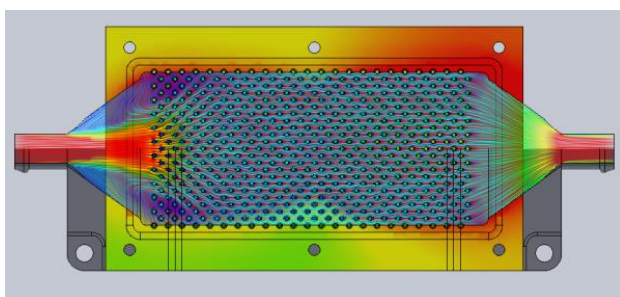
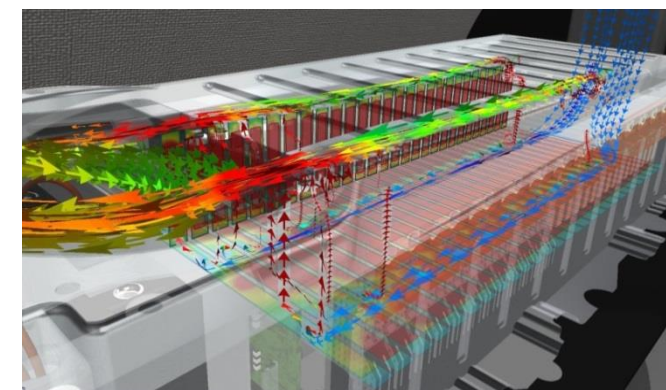
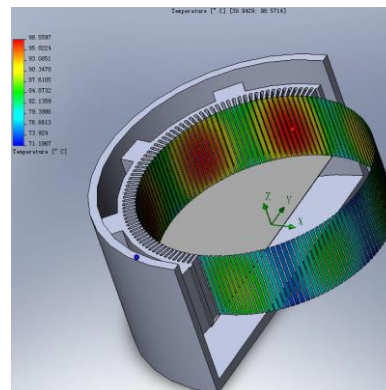


Film Mass vs Time

Simcenter FLOEFD关键零部件 换热器

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- IGBT and ECU冷却.
- 换热器和中冷器.
- 电池冷却.
- 相变制冷剂.
- 水套
- 盘式制动器冷却



FLOEFD Technology Customers in Lighting

Automotive Lighting (Magneti Marelli) (GER, USA, PL, I, CN)

Valeo (F,CN)

Koito (JP)

Hasco Vision (CN)

Hella Leuchtensysteme (SLO)

Stanley (JP)

Ichikoh (JP)

ZKW (GER)

Daimler (GER)

VW Lighting (GER)

Delvis (GER)

Toyota Lighting (JP)

Audi (GER)

Hyundai IHL (KR)

Innorex (KR)

Odelo/Farba (GER /TR)

Renault (F)

Ford (USA)

North American Lighting (USA)

Qing Chuan(CN)

Liao Wang(CN)

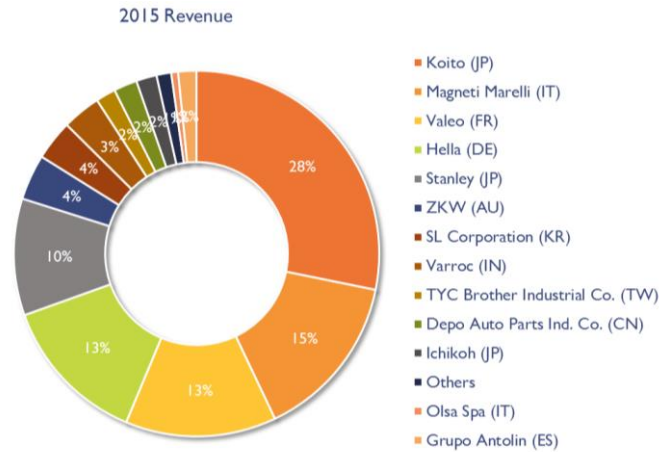
Boeing (USA)

SEC (CZ)

Bee Design (UK)

Bertrandt (GER)

Depo (TW)



SIEMENS

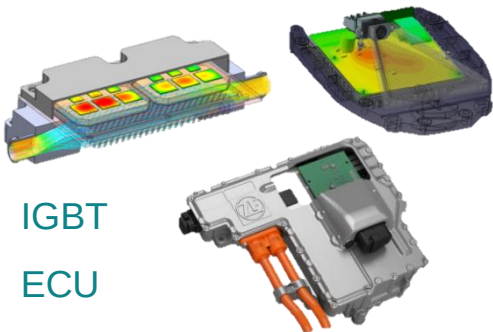
Ingenuity for life



FloEFD e-Powertain Key Customers

SIEMENS
Ingenuity for life





IGBT

ECU

ADAS camera





ECU

IGBT

Generators

MOFSET

Car Multimedia





ECU





Connectors

Wires





ECU

MOFSET

IGBT





ECU

IGBT

MOFSET

Generators

Car Multimedia

Lighting, HUD



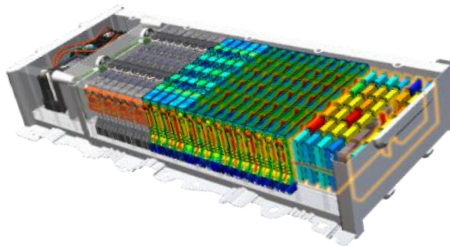


ECU

Battery

Junction Box

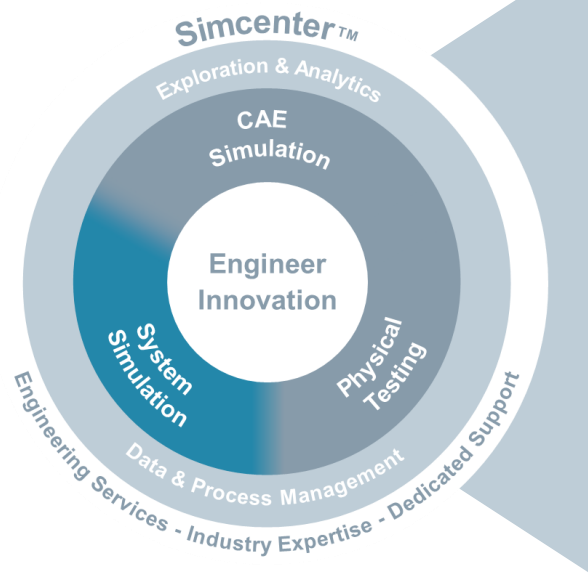




Battery

热流体系统仿真软件 Flomaster

Simcenter 1D system Flomaster & Amesim



Flomaster



面向工程的一维热流体系统仿真软件，通过系统仿真帮助工程师设计、验证、优化复杂的流体系统：

- 任意工况下各点压力、温度、流量等分布/分配计算与预测
- 管网阻力平衡计算及布置指导
- 设备/部件选型设计分析，如冷却泵、换热器、调节阀、喷嘴等
- 复杂流路稳态/瞬态流动及传热计算，如水锤、泵启停、蒸发冷凝等
- 控制系统策略验证...

Amesim



基于模型系统工程的多学科、多领域复杂系统建模仿真平台，用户可在此平台上进行机、电、液、热、控等仿真计算和深入分析：

- 从早期开发阶段开始分析机电系统的功能及性能
- 零件、部件、设备到系统不同复杂度的稳态和动态性能
- 优化机械、液压、气动、热电/电子系统之间的复杂交互用
- 提高产品的整体性能和质量
- 避免设计缺陷、探索创新设计和加速产品开发...

Simcenter Flomaster 特色简介

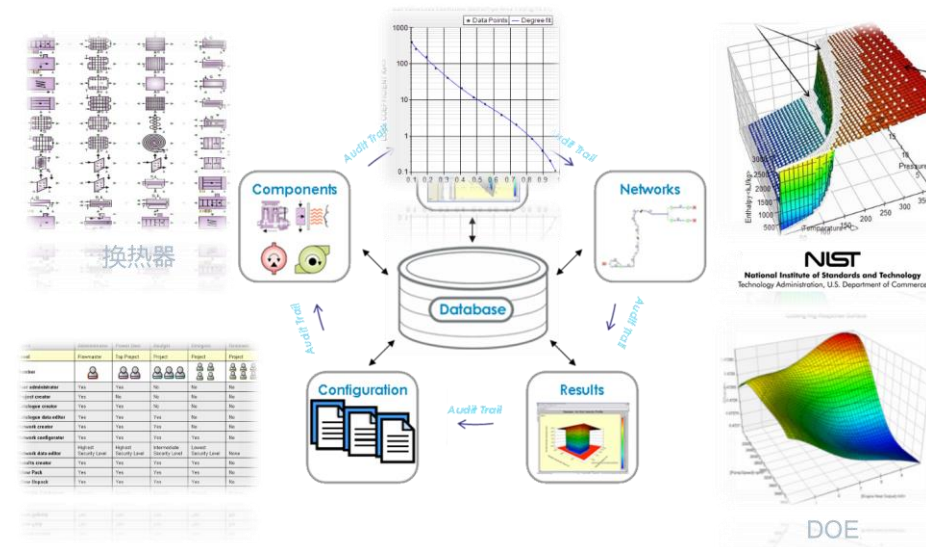
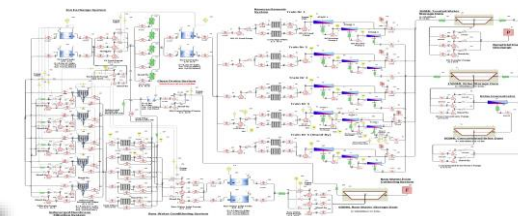
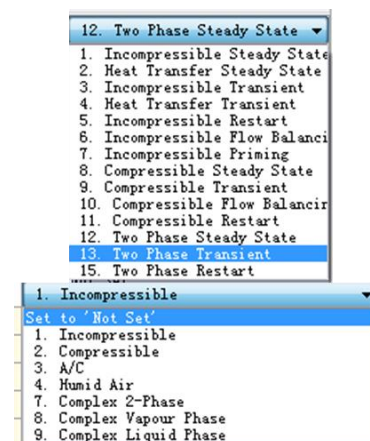
SIEMENS
Ingenuity for life

多种求解器

- 系数矩阵迭代求解
- 流动、换热、相变、配平、填充等
- DOE、水锤力、体积力求解等

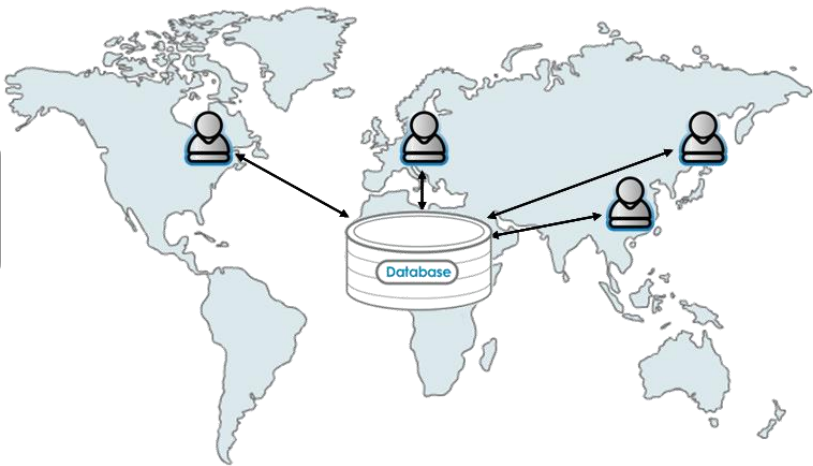
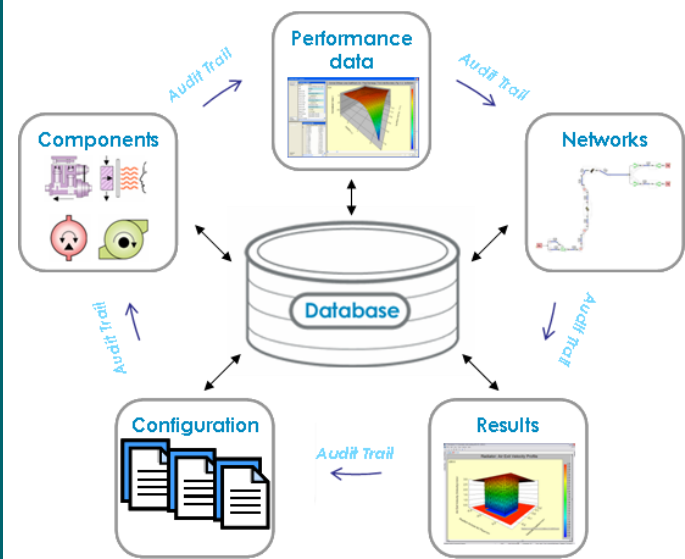
数据库

- 涵盖流体机械、控制、电气等**400+**元件库
- 集成NIST等多种物性库
- 控制、前后处理自动化等脚本库
- 10000小时+试验数据库
- 面向企业级应用的数据存储与协同管理能力



Simcenter Flomaster 面向企业级应用数据管理平台

- 数据集中存贮与管理
 - 中心数据库可存贮所有相关数据，管理功能专业而强大
 - 用户角色与权限定义
- 查证与跟踪
 - 追踪设计历程的所有变更对系统性能的影响，便于开展想定分析
- 数据定制
 - 构建适用于特定专业应用的元件以及特性数据，并存贮在中心数据库之中



Name	Administrator	Power User	Analyst	Designer	Reviewer
Level	Flowmaster	Top Project	Project	Project	Project
Number					
User administrator	Yes	Yes	No	No	No
Project creator	Yes	No	No	No	No
Catalogue creator	Yes	Yes	No	No	No
Catalogue data editor	Yes	Yes	Yes	No	No
Network creator	Yes	Yes	Yes	No	No
Network configerator	Yes	Yes	Yes	Yes	No
Network data editor	Highest Security Level	Highest Security Level	Intermediate Security Level	Lowest Security Level	None
Results creator	Yes	Yes	Yes	Yes	No
Allow Pack	Yes	Yes	Yes	Yes	No
Allow Unpack	Yes	Yes	Yes	Yes	No
Available Catalogues	Inspect ...	Inspect ...	Inspect ...	Inspect ...	Inspect ...

强大的中心数据库及数据管理功能

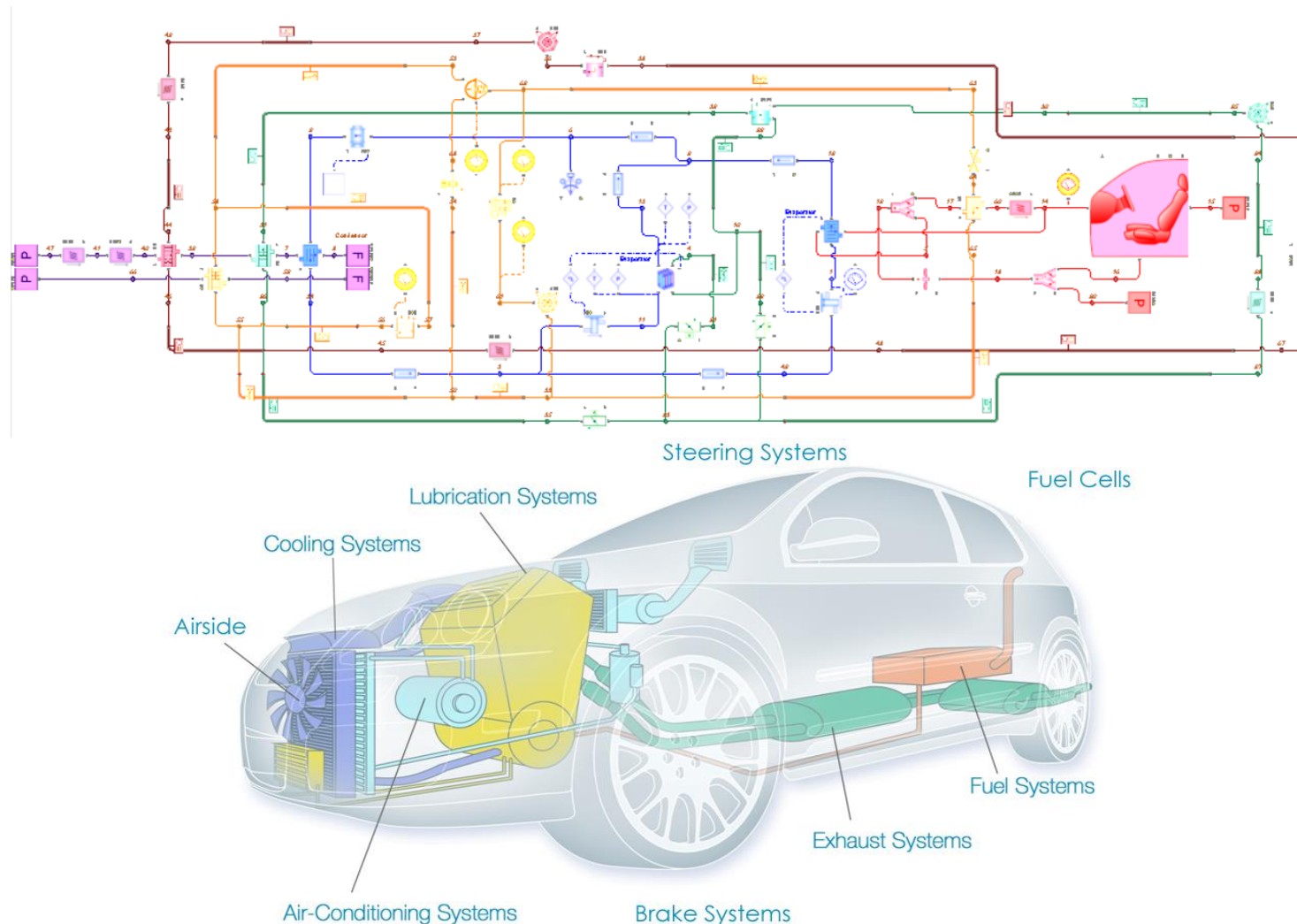
Simcenter Flomaster

汽车行业应用

SIEMENS
Ingenuity for life

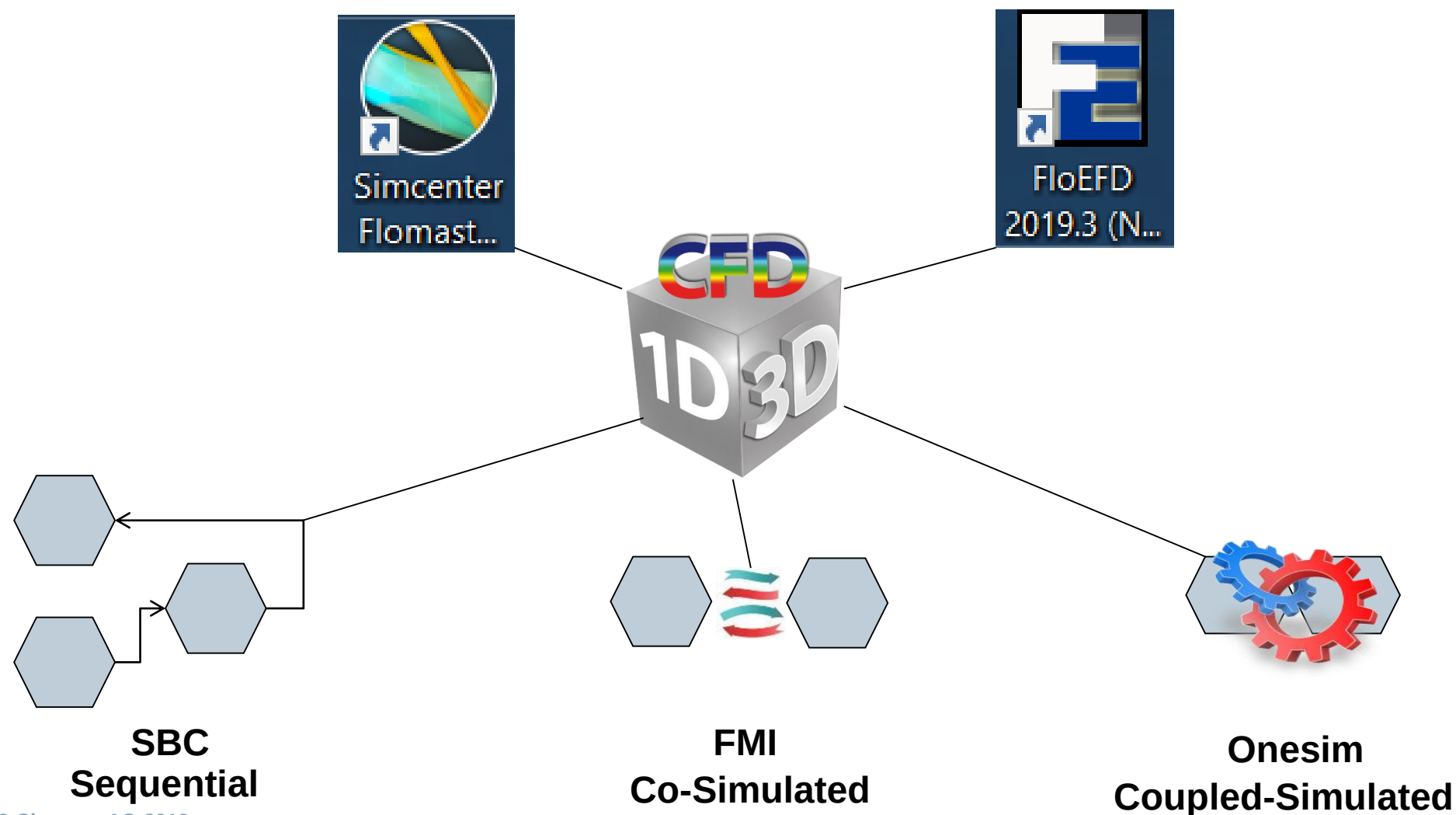
工程应用

- 冷却系统系统性能分析
- 润滑系统系统性能分析
- 空调系统性能分析
- 乘员舱舒适性分析
- 空气侧系统性能分析
- 废热回收ORC系统性能分析
- 排气系统性能分析
- 整车热管理性能分析
- 电池热管理分析
- ...



Flomaster&FloEFD 1&3D集成方法介绍

Simcenter Flomaster&FloEFD 1&3D多维度CFD集成仿真方法



系统仿真难点

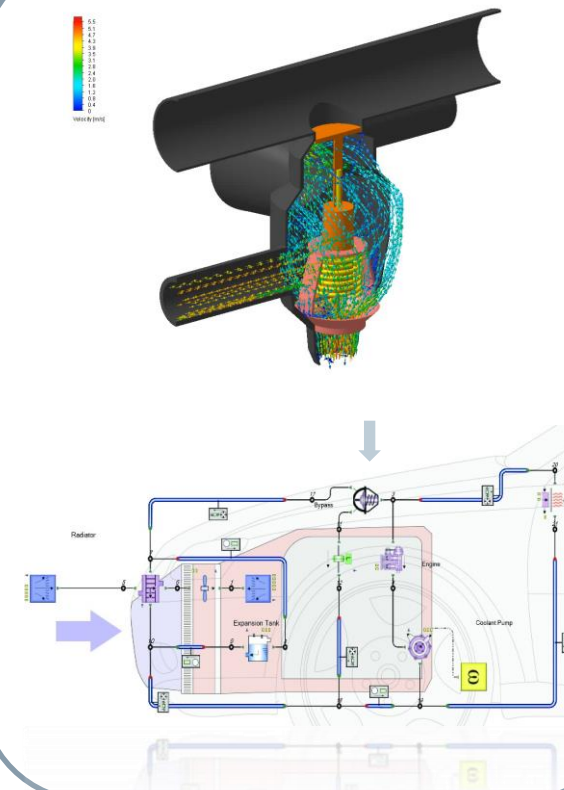
- 准确的元件特性参数
- 特定需求的分析模型

解决办法

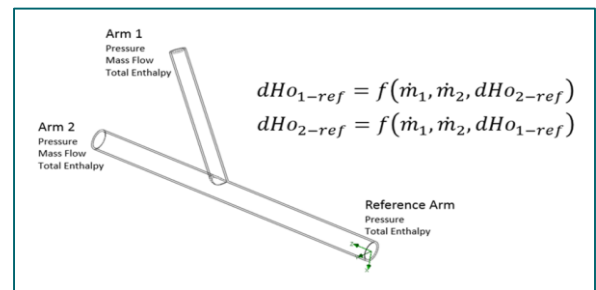
- 内置经验数据及公式
- 等效简化
- 虚拟仿真试验

SBC特征参数模型

3维自动转换1维模型



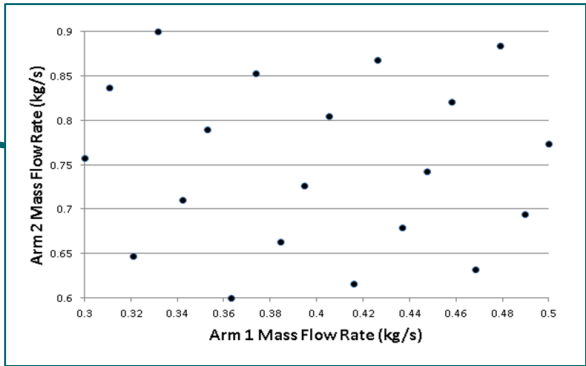
Simcenter FloEFD & Flomaster SBC (Simulation Based Characterization) 方法介绍



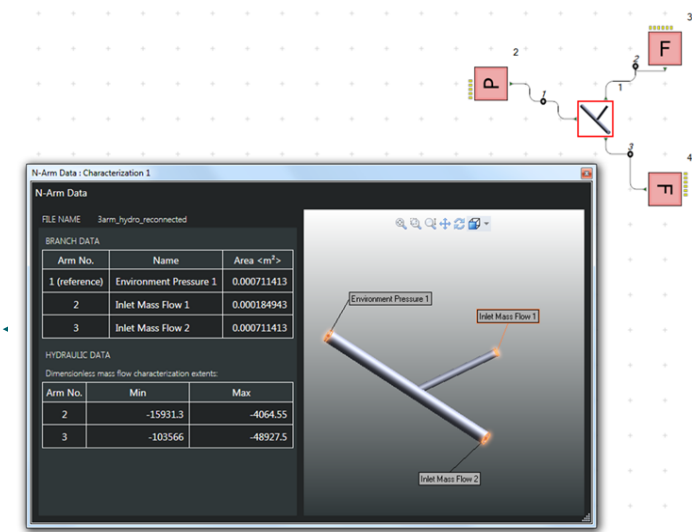
定义三通各接口压降、焓差与流量关系

Parameter	Current Value	Variation Type	Values
Mass flow rate (Inlet Mass Flow 1)	0.35 kg/s	Range	0.3 < Value < 0.5
Mass flow rate (Inlet Mass Flow 2)	0.9 kg/s	Range	0.6 < Value < 0.9

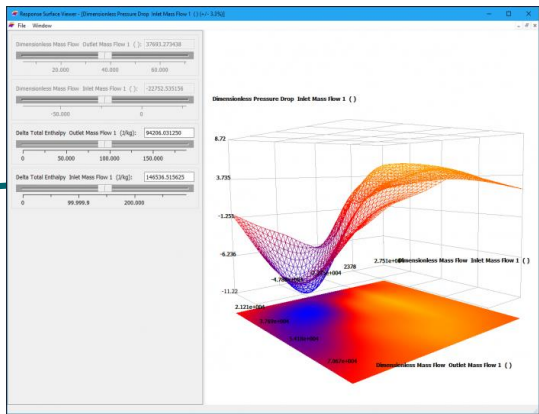
三通特性提取范围上限和下限



定义三通特征样本空间分布



三通3D特征提取后的等效1D元件模型



非标三通接口无量纲特征响应面模型

Summary	Experiment 1	Experiment 2	Experiment 3	Experiment 4	Experiment 5	Experiment 6	Exp.
Mass flow rate (Inlet Mass Flow 1) [kg/s]	0.5	0.447368421	0.363157895	0.489473684	0.384210526	0.342105263	0.33
Mass flow rate (Inlet Mass Flow 2) [kg/s]	0.773604211	0.743105263	0.6	0.694736842	0.662105263	0.710526316	
Dimensionless Mass Flow (Inlet Mass Flow 1) []	-27608.1202	-24701.979	-20052.2194	-27026.914	-21214.6869	-18889.7519	-183
Dimensionless Mass Flow (Inlet Mass Flow 2) []	-28992.2628	-27808.9028	-22483.8017	-26033.8816	-24850.5217	-26625.5429	-337
Dimensionless Pressure Drop (Inlet Mass Flow 1) []	-4.05303218	-3.70023504	-3.82599382	-4.53965214	-3.55015071	-2.61835497	-1.3
Dimensionless Pressure Drop (Inlet Mass Flow 2) []	-2.15989287	-2.276872	-2.35976414	-2.05394874	-2.37231901	-2.56380269	-2.6
Status	Finished	Finished	Finished	Finished	Finished	Finished	FI

无量纲三通计算结果

Simcenter FloEFD & Flomaster OneSim强耦合方法介绍



A. OneSim' is a tightly coupled co-simulation workflow:

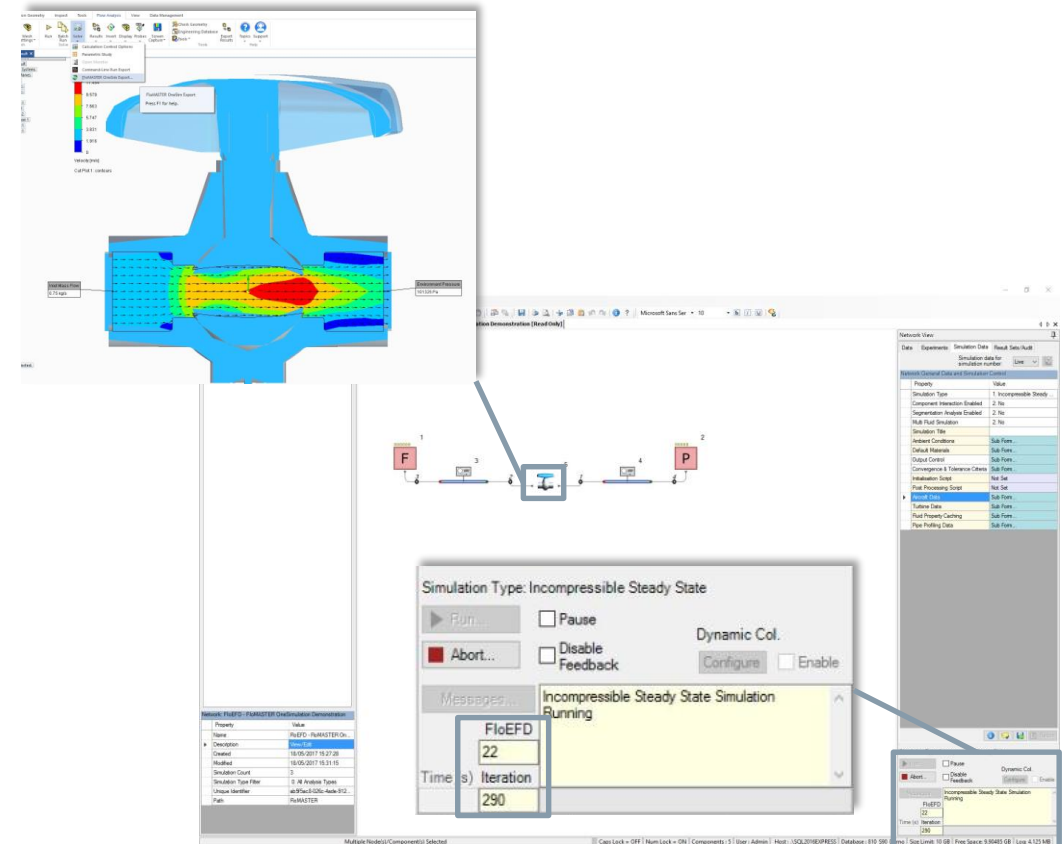
- 使FloEFD 3D模型被视为Flomaster系统仿真模型的连接部分
- 单个模拟过程可同时考虑所有零件计算

B. 将FloEFD中的2D CAD边界面连接到Flomaster回路中的节点上

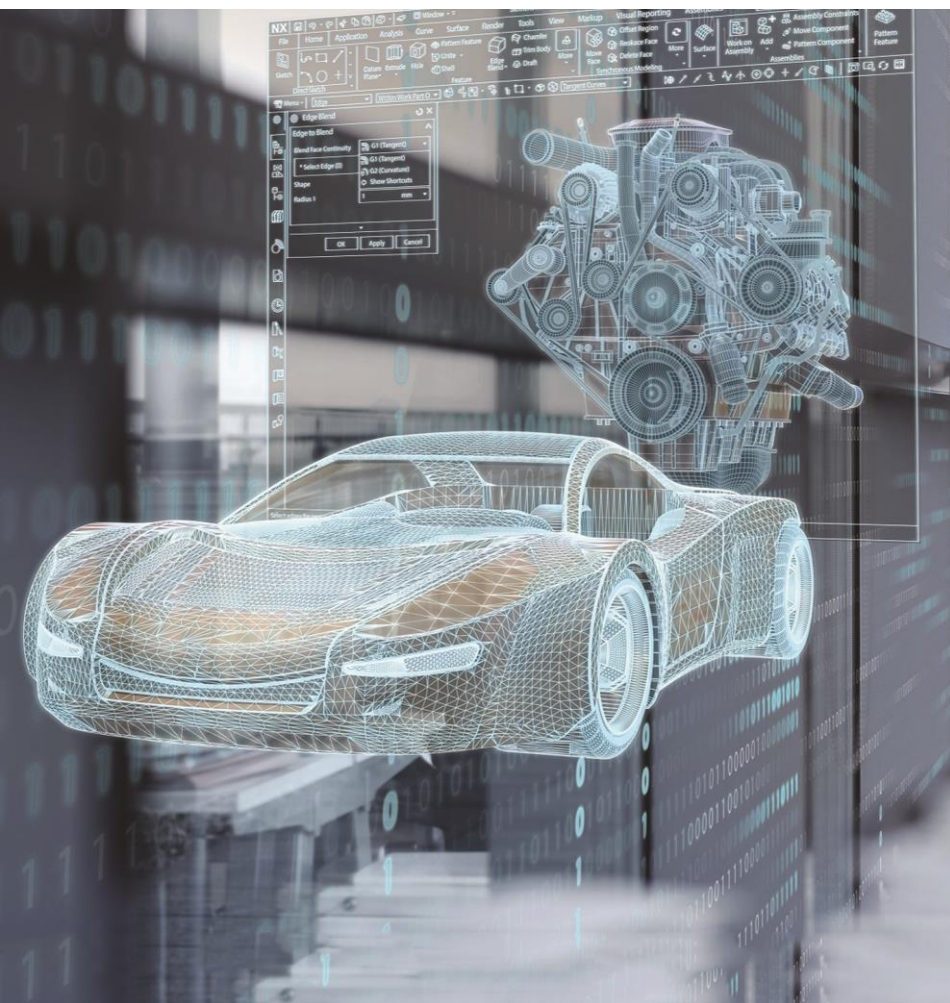
C. Flomaster模拟与3D FloEFD模拟合并

D. 单次模拟由Flomaster发起的

- FloEFD求解三维矩阵及组合的网络拓扑
- Flomaster求解元件

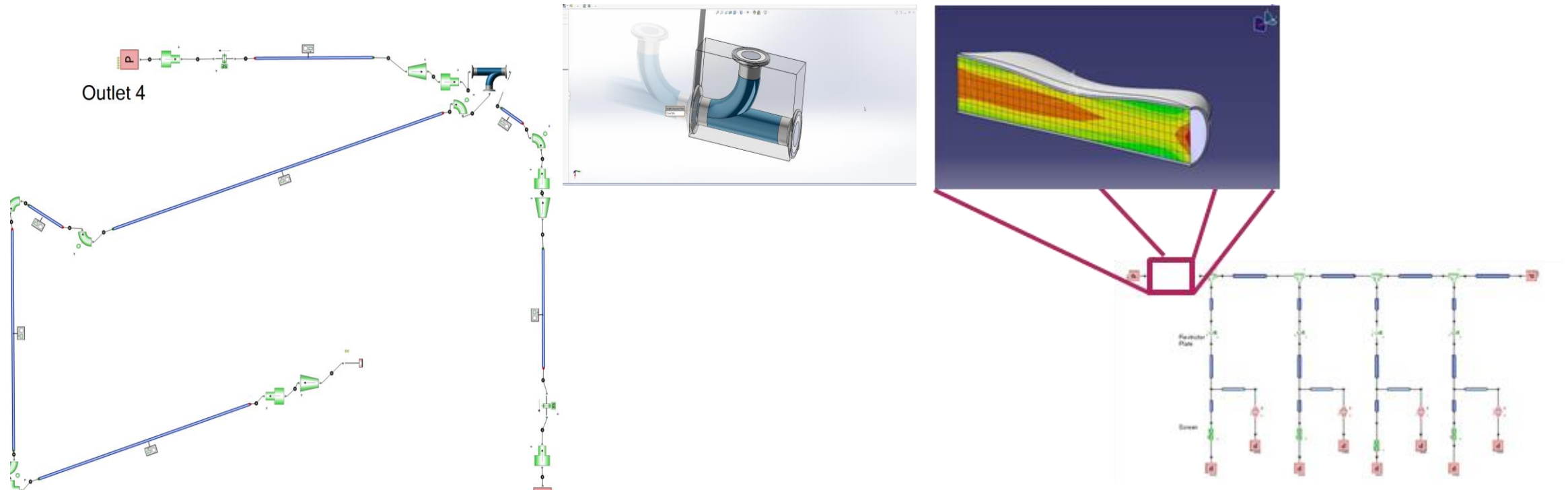


Highly implicit coupling results in increased solution stability



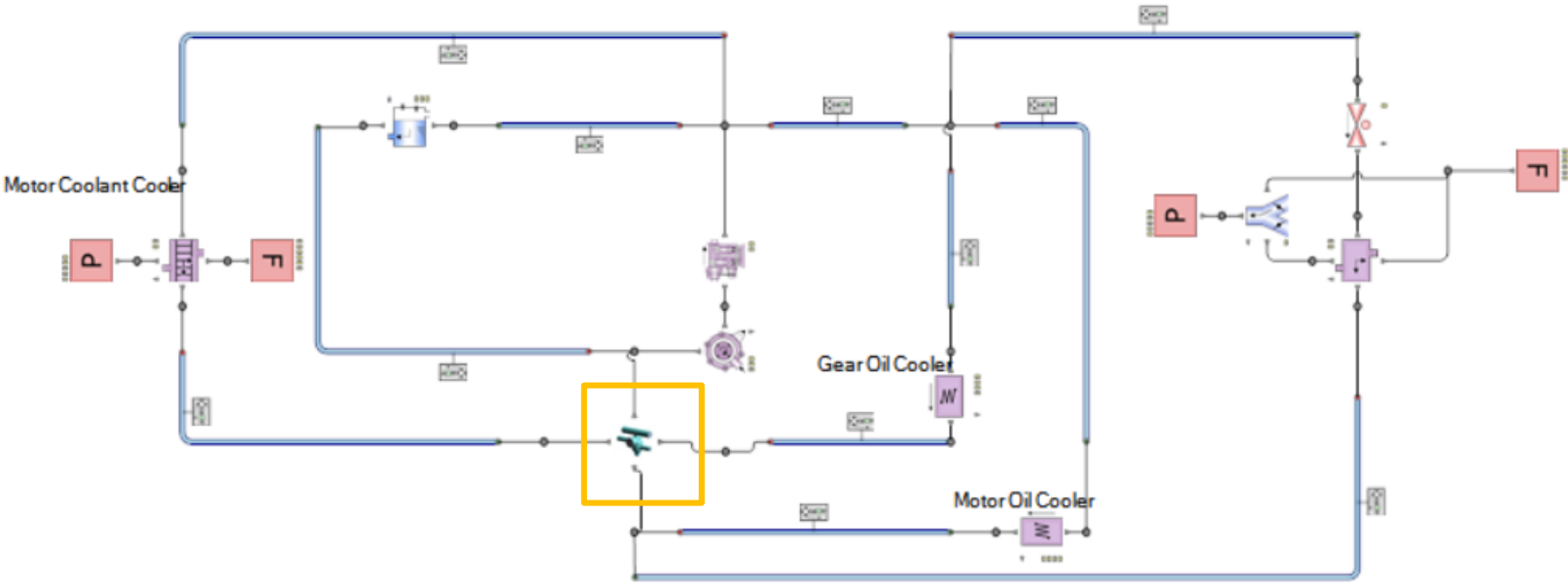
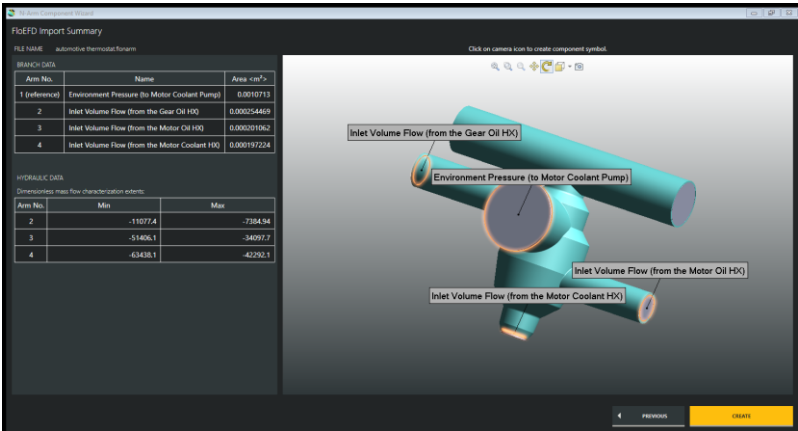
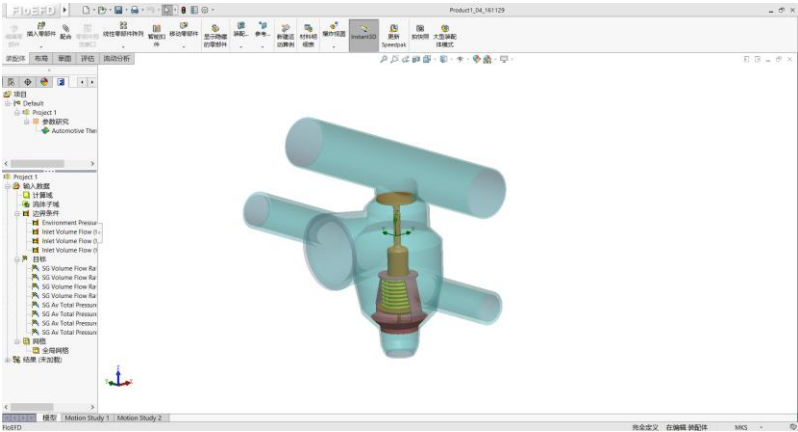
1. 车辆行业的发展趋势与挑战
2. Simcenter多学科多维度的集成分析解决方案
3. 1D&3D 多维度CFD分析的必要性
4. Flomaster与FloEFD车辆电子热分析集成应用
5. 1D&3D 案例介绍
6. 总结

Simcenter FloEFD & Flomaster SBC-异形结构三通与管路系统集成

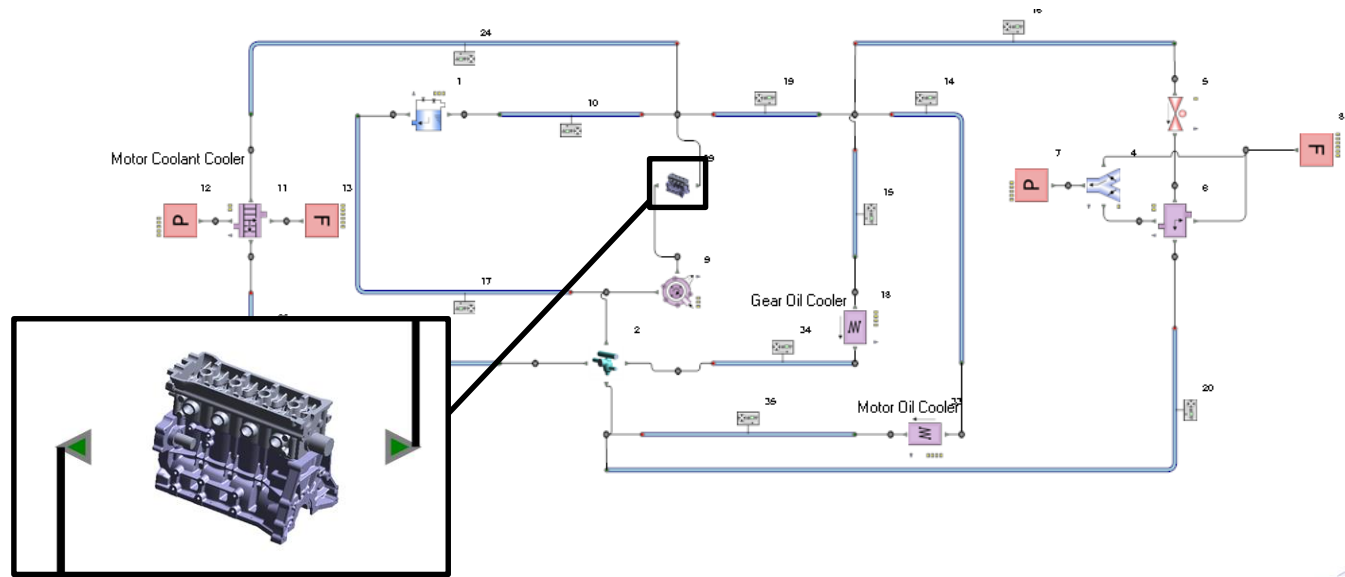


Simcenter FloEFD & Flomaster

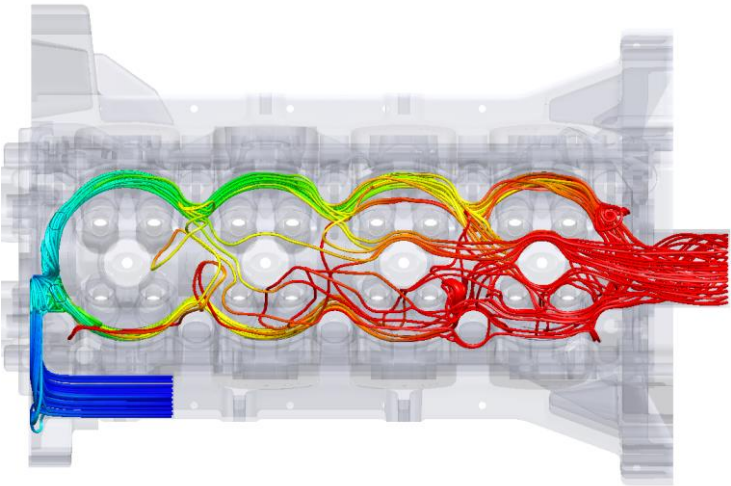
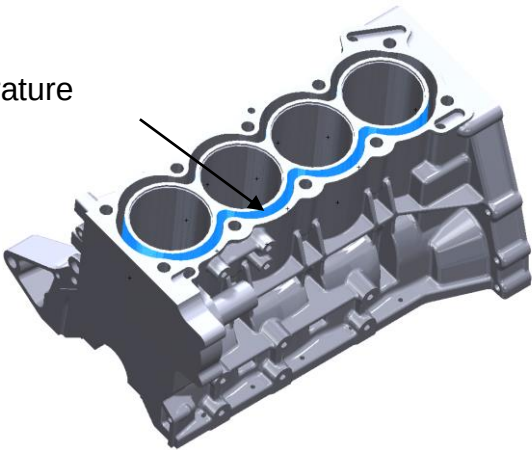
SBC-多接口节温器及冷却系统集成



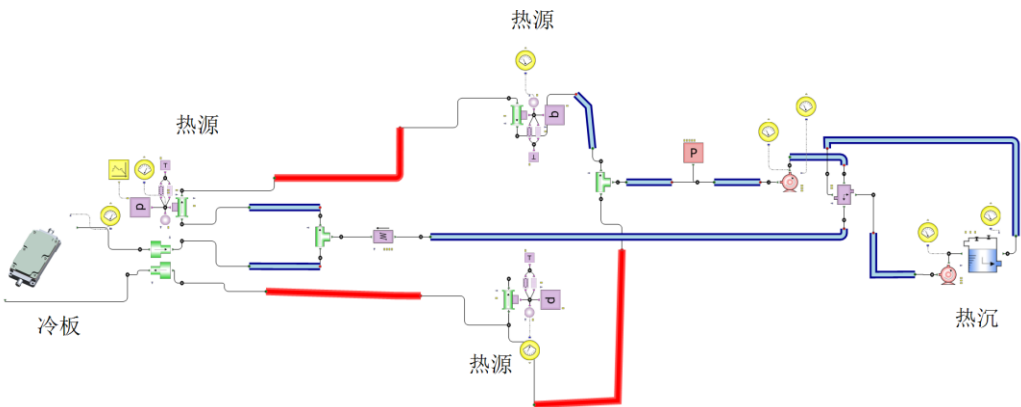
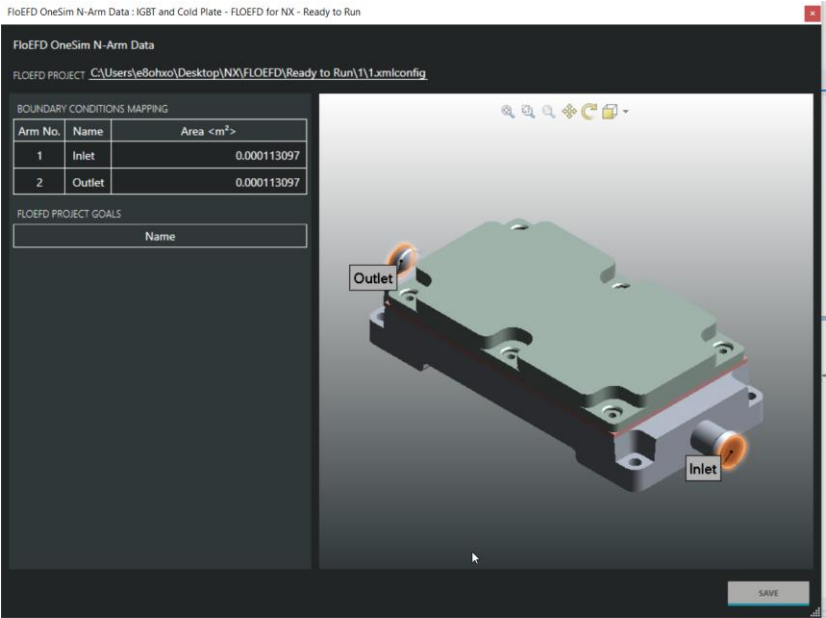
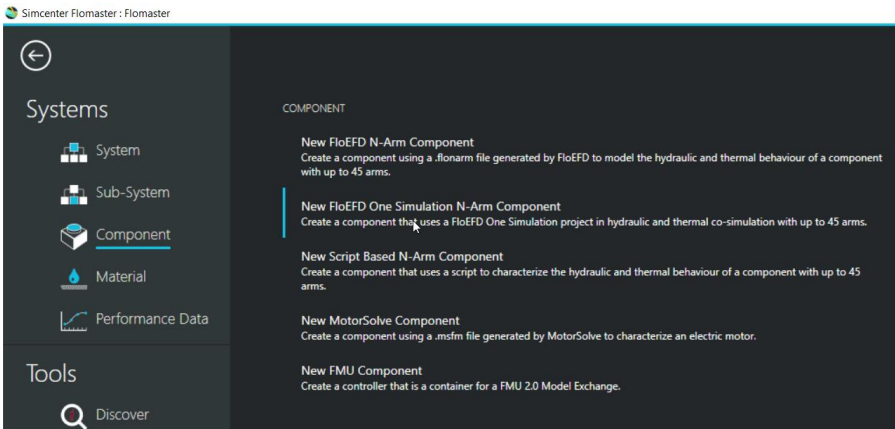
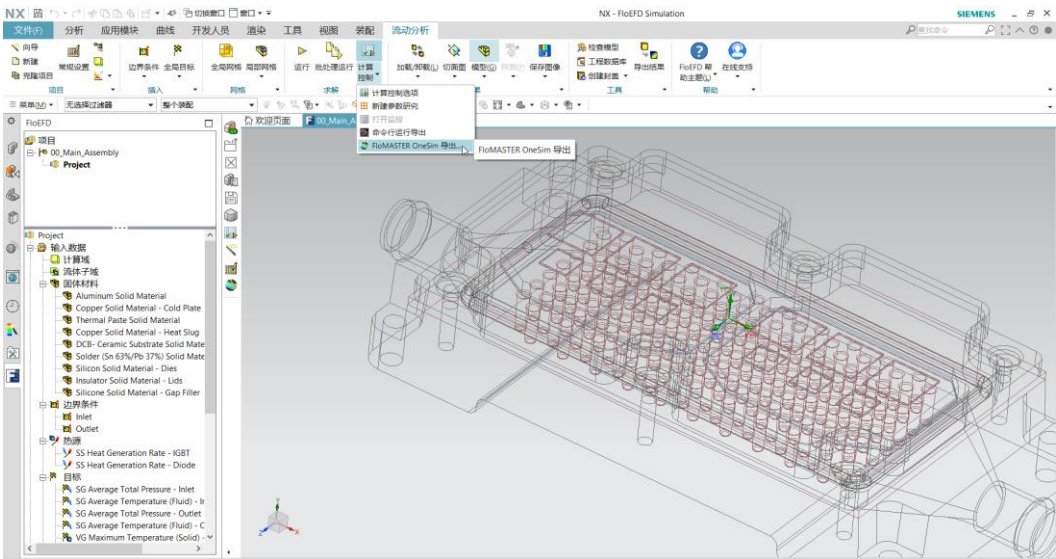
Simcenter FloEFD & Flomaster SBC-发动机水套及冷却系统集成

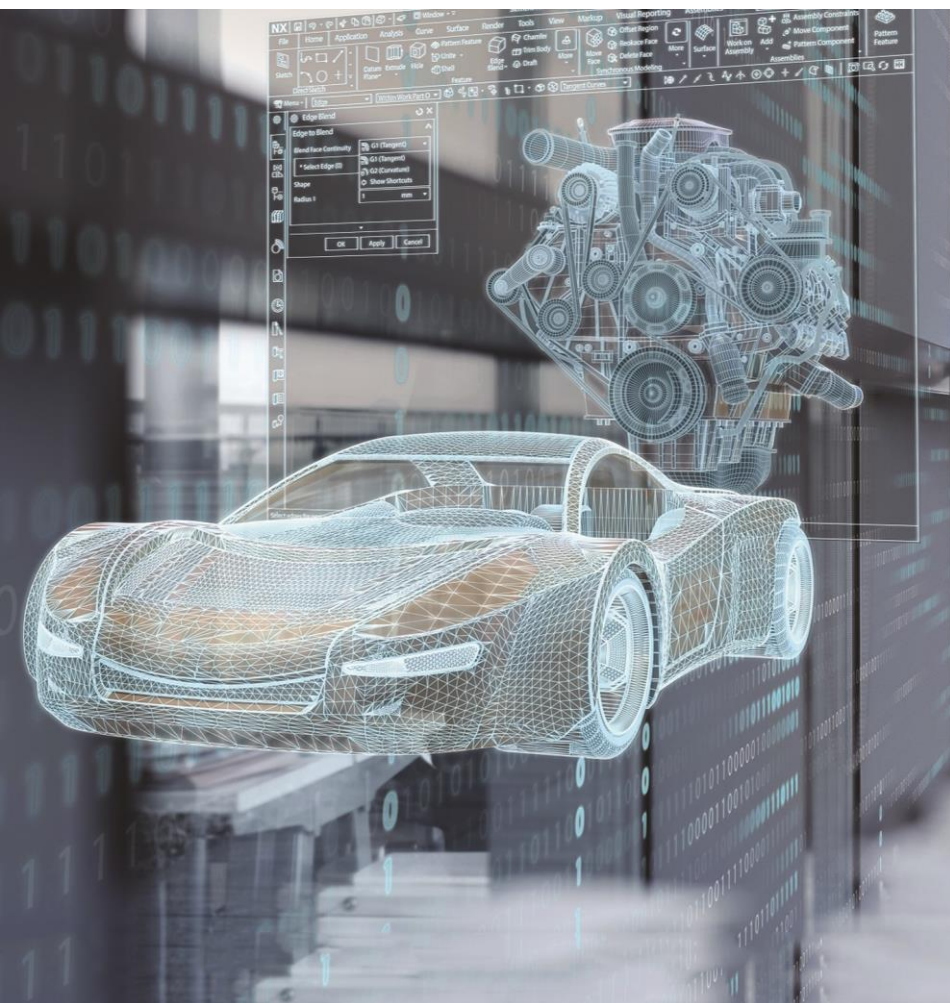


300 degC
Surface temperature
(blue)



Simcenter FloEFD & Flomaster OneSim-液冷系统与冷板强耦合仿真

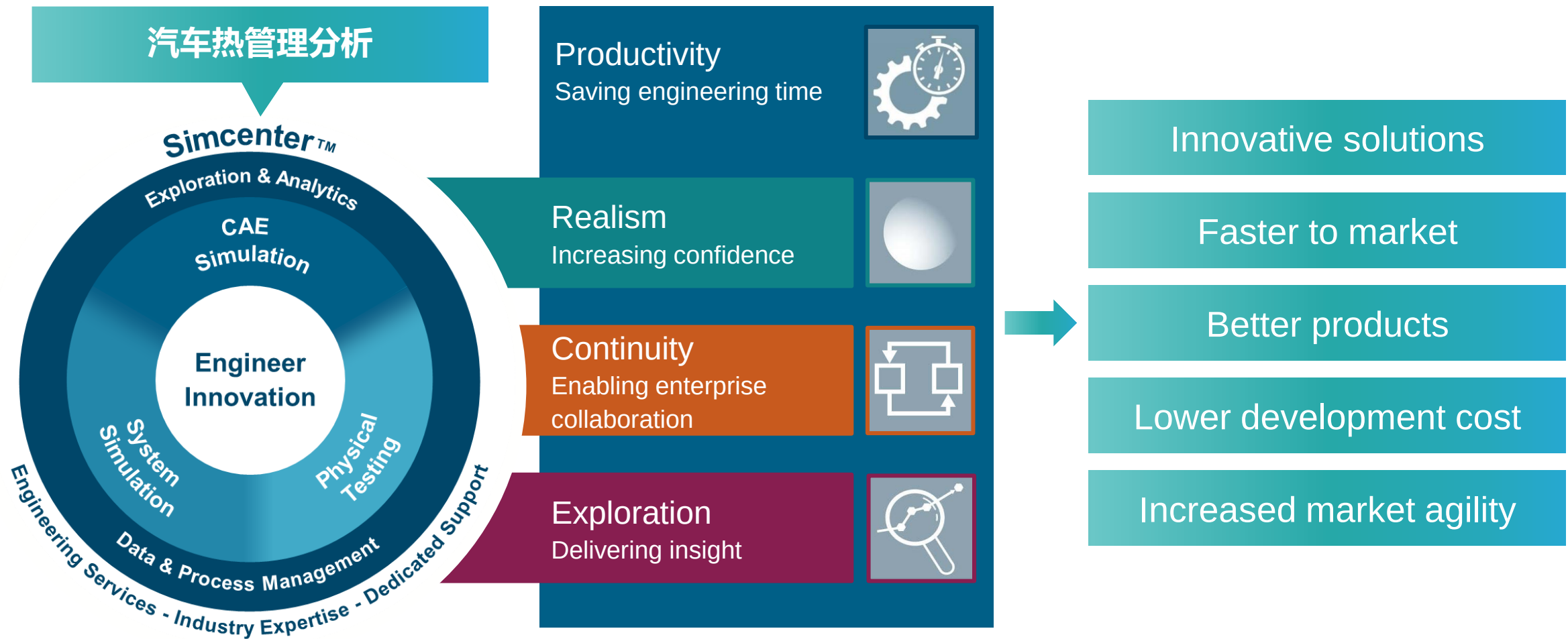




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6. 总结

Simcenter Portfolio

Engineer innovation





数字化工业软件技术期刊

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Make CFD Faster and Easier

谢谢