Leveraging Test and Measurement to Accelerate Digital Twin for Industrial Machinery

Qiao Guo

APAC Principal Field Marketing Manager

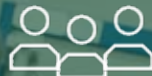Electronics/Energy/Industrial Machinery/Life Sciences

$1.36 BILLION IN 2019

OPERATIONS IN 50+ COUNTRIES

35,000+ CUSTOMERS WORLDWIDE

16% INVESTMENT IN R&D

以软件为中心的平台提高测试、测量和控制系统的开发速度和生产力

NI亚太区总部
上海

NI SOFTWARE-CONNECTED SOLUTIONS
ENABLING INNOVATION AND PRODUCTIVITY ACROSS THE PRODUCT DEVELOPMENT CYCLE

PRODUCT ANALYTICS AND TEST OPERATIONS
SystemLink™

Research	Design and Validation	Production	Deployment and Maintenance

APPLICATION AND DEVELOPMENT SOFTWARE
LabVIEW   TestStand   VeriStand   C#/.NET   Python   FlexLogger™   DIAdem   ...

MODULAR HARDWARE
PXI   CompactDAQ   VST   CompactRIO   USRP   ...

SERVICES
Software Services   Hardware Services   Consulting + Integration Services   Education Services   NI Partners

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TAILORED, APPLICATION-SPECIFIC SYSTEMS

Semiconductor Test System   Electric Vehicle Battery Test System   Condition Monitoring   ...

SERVICES

Software Services   Hardware Services   Consulting + Integration Services   Education Services   NI Partners

Industry-Leading Hardware to Fit Your Needs

The industry's broadest portfolio of products for automated test and automated measurement is:

- Best-in-class, precise, and accurate, from a trusted provider

- Scalable and flexible to adapt quickly to your evolving test and measurement needs

- Highly configurable and software-connected so you can get your job done in a timely manner

ni.com

NI深耕中国制造多年
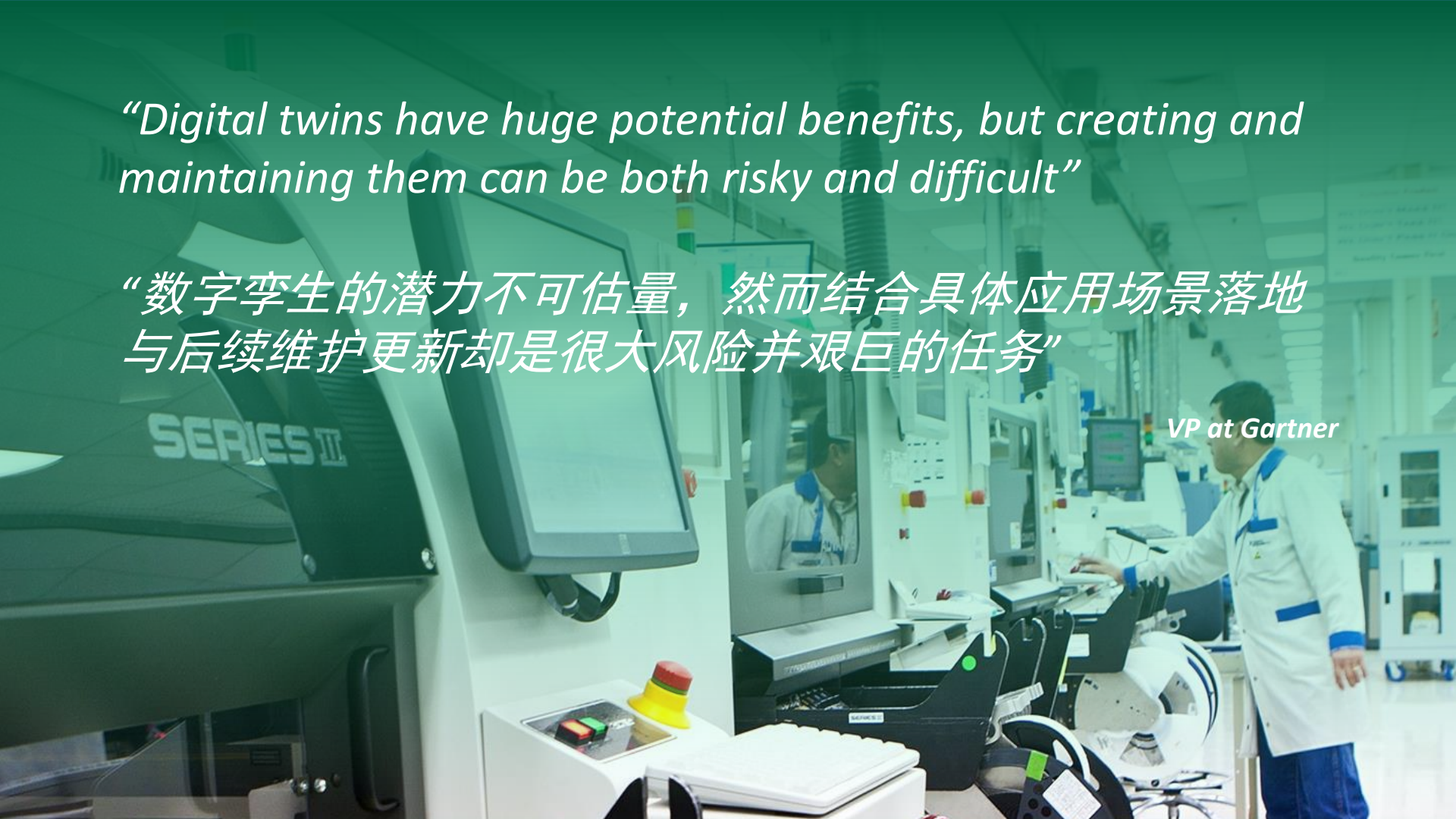
- 提高测试、测量和控制系统的开发速度和生产力 （物理世界）
- 无缝对接生态圈第三方软件 （数字世界）

电力 　　 石油化工 　　 重型装备 　　 钢铁

"Digital twins have huge potential benefits, but creating and maintaining them can be both risky and difficult"
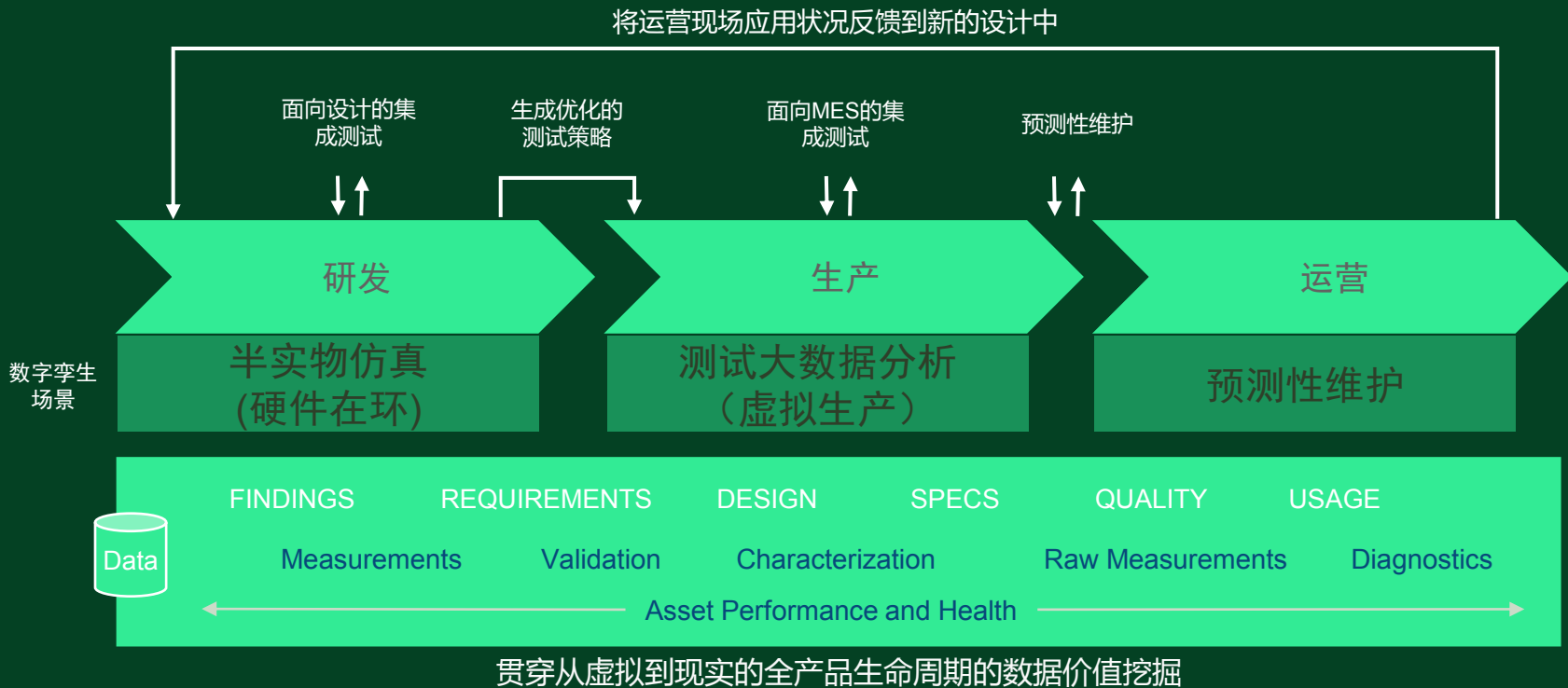
"数字孪生的潜力不可估量，然而结合具体应用场景落地与后续维护更新却是很大风险并艰巨的任务"
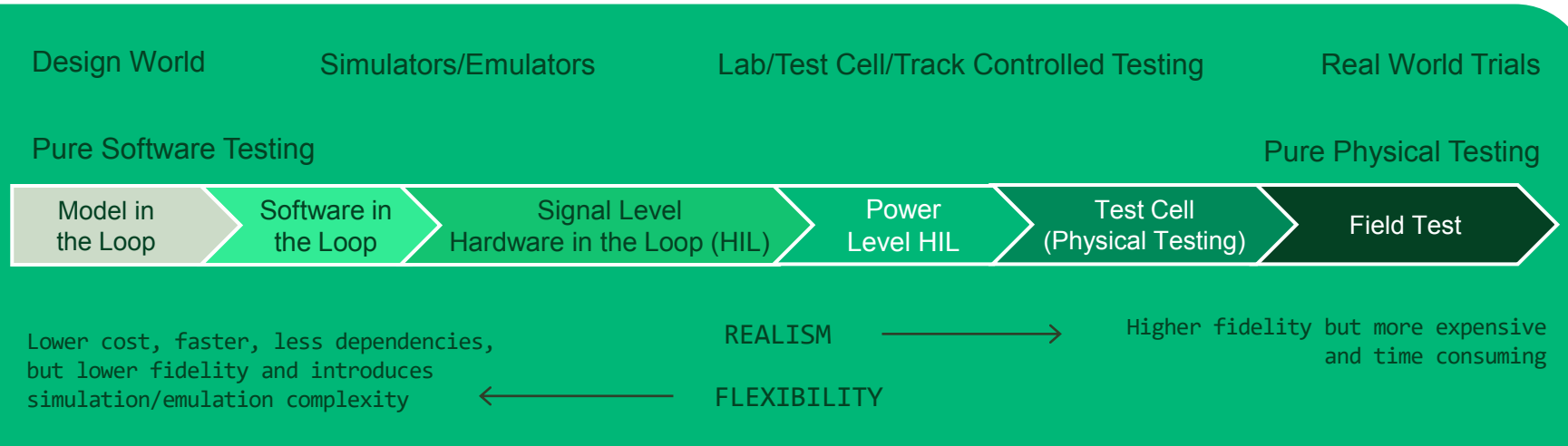
VP at Gartner

数字孪生的基石：模型数据(数字)VS 测量数据 (物理)

NI：软件定义的自动化测量为数字孪生的物理世界贡献核心价值

将运营现场应用状况反馈到新的设计中

面向设计的集成测试	生成优化的测试策略	面向MES的集成测试	预测性维护
↓↑		↓↑	↓↑

研发   **生产**   **运营**

数字孪生场景

半实物仿真(硬件在环)	测试大数据分析（虚拟生产）	预测性维护

Data

FINDINGS   REQUIREMENTS   DESIGN   SPECS   QUALITY   USAGE

Measurements   Validation   Characterization   Raw Measurements   Diagnostics

← Asset Performance and Health →

贯穿从虚拟到现实的全产品生命周期的数据价值挖掘

数字孪生场景
研发：半实物仿真（硬件在环）

Test Approaches Along the Design Lifecycle

Design World   Simulators/Emulators   Lab/Test Cell/Track Controlled Testing   Real World Trials

Pure Software Testing   Pure Physical Testing

Model in the Loop	Software in the Loop	Signal Level Hardware in the Loop (HIL)	Power Level HIL	Test Cell (Physical Testing)	Field Test

Lower cost, faster, less dependencies, but lower fidelity and introduces simulation/emulation complexity

REALISM ⟶

FLEXIBILITY ⟵

Higher fidelity but more expensive and time consuming

Goal ⟵

Confidently Test Earlier in the Development Cycle

- Increasing ability to choose scenarios
- Flexibility to test different technology
- Less dependence on real system availability
- Accelerate test (faster than real time)

Increasing Cost, Risk, Time to Fix, and Effort

HIL Testing – Virtual Reality for Your DUT

ECU

Simulated System

Signal Paths

Embedded Software

Connectors
Bulkhead connectors that are compatible with the DUT

SLSC (Switches, Loads, Signal Conditioning)
- Fault insertion
- Loads to simulate real world conditions
- Front end signal conditioning

Test Software
- User Interface
- Stimulus Profiles
- Control
- Data logging

DAQ and Processing
- I/O
- Real-time models
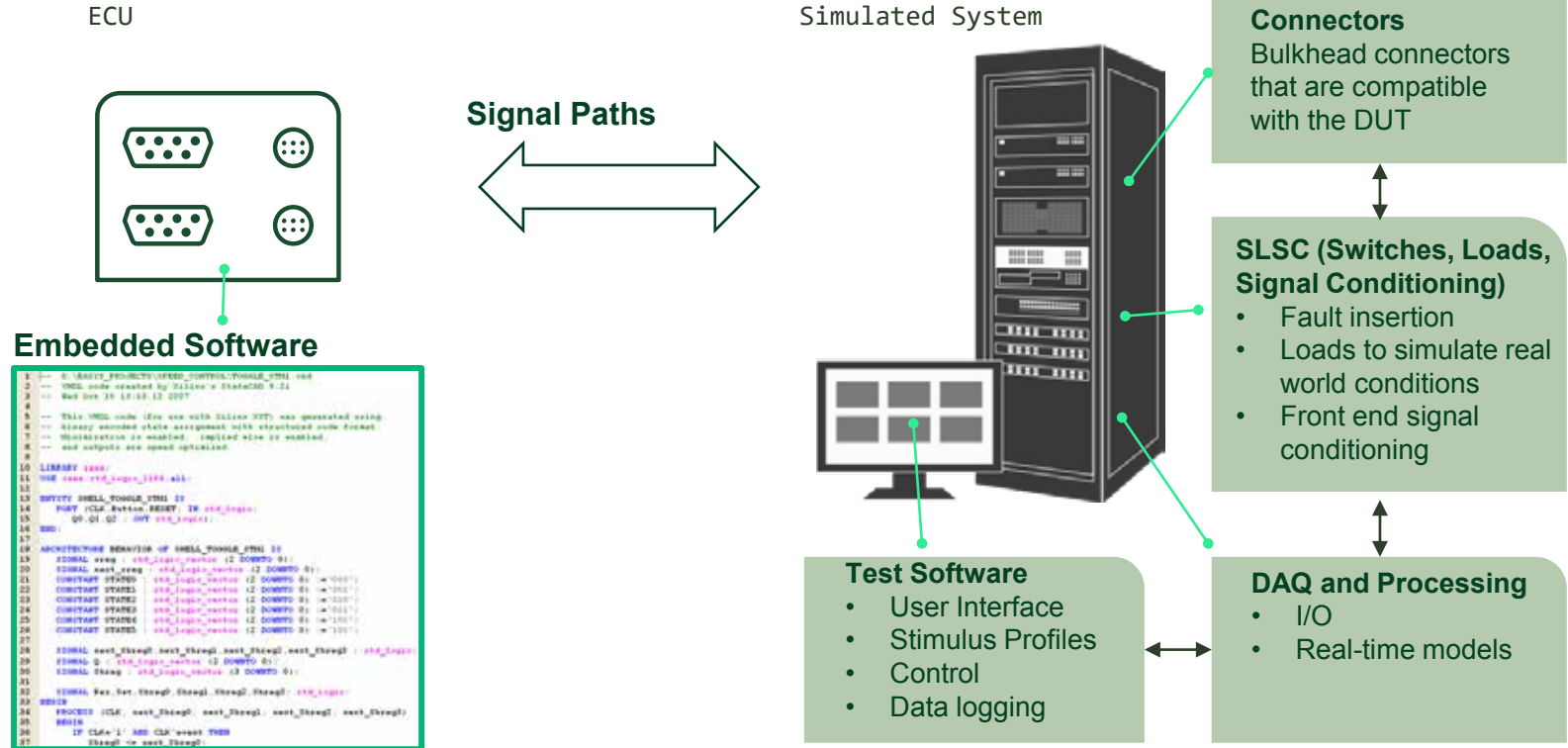
Model Sources

- Existing Model from 3rd party environment (dll)

- Create based on knowledge of the system using modeling environment

- Automatically Generated based on test data (SysID)
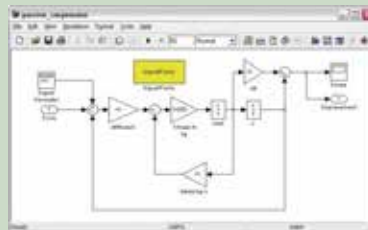
The MathWorks, Inc. Simulink® Software

ANSI C

NI LabVIEW

OPAL-RT eHS
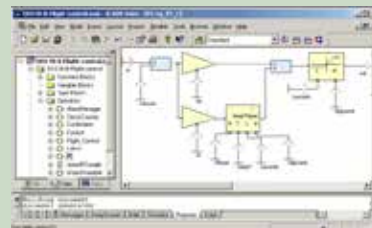
Esterel SCADE

MapleSoft MapleSim

Simulink® is a registered trademark of The MathWorks, Inc. All other trademarks are the property of their respective owners.

Model Integration in NI Platform

- Synchronized execution across host, real-time processor, and FPGA
- Connectivity to I/O

Host	Real-Time CPU	FPGA	I/O	DUT

I/O: Analog Digital PWM Comms Resolver Encoder Power Fault Insertion And more...

Signal/Variable Configuration

Model Execution

Faster Model Execution
Microseconds

Vehicle Dynamic Models
Other ECU Models

Fastest Model Execution
Nanoseconds

Motor Models
PE Models
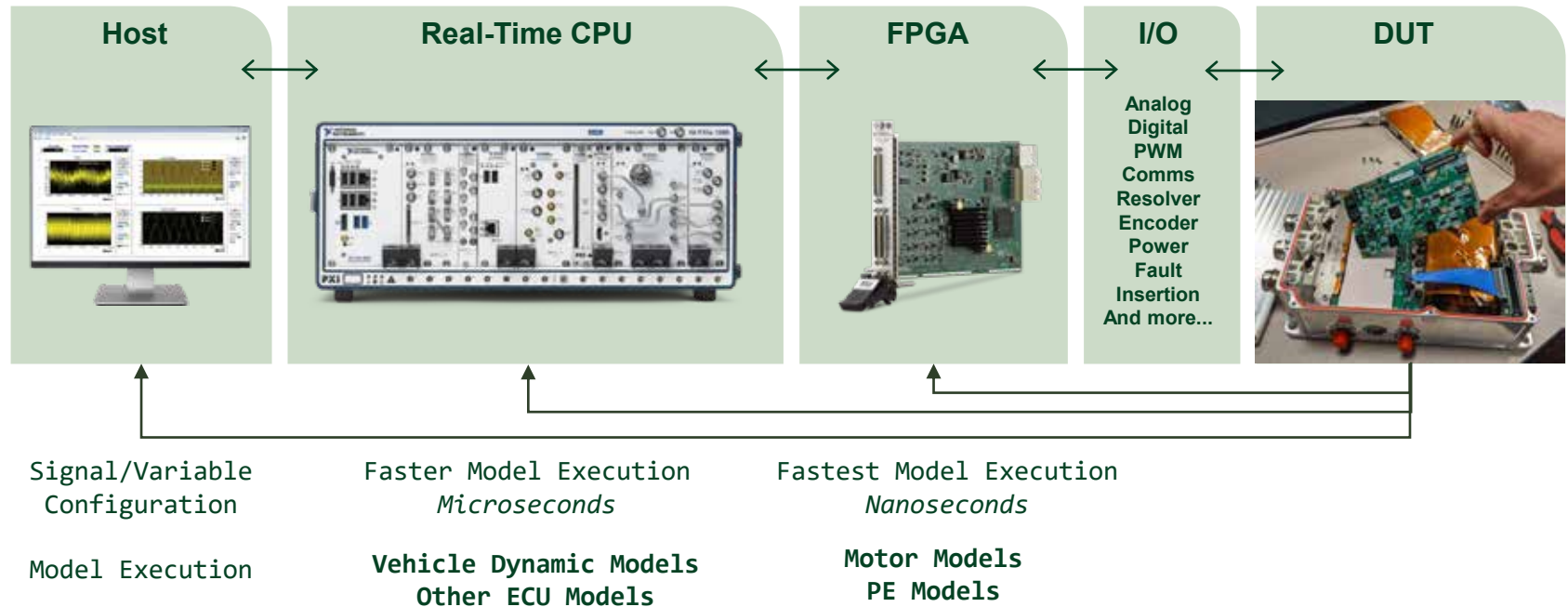
基于工况模型的超级电容动态测试

超级电容功率密度高，循环性能强，广泛应用于电动汽车能量回收系统，新能源微网，航空航天，舰船等

NI与北京博电联手打造超级电容自动化测试平台

- 功率覆盖 800V/100A（更高可定制）
- 最高精度达到100ppm，稳定性达到20ppm/min
- 支持多种国内外测试标准：GBT34870.1-2017，IEC 62391-2-1，QCT 741-2014
- 集成NI VeriStand支持NEDC/WLTC/CLTC等各种实际工况模型
- 充放电无缝切换，全自动测试（从单人7小时提升至单人15分钟）

电网一次/二次设备仿真测试

功率级带仿真模型的完整测试系统

- 电流电压互感器
- 数字化变电站设备
- 继电保护设备
- 电力滤波器
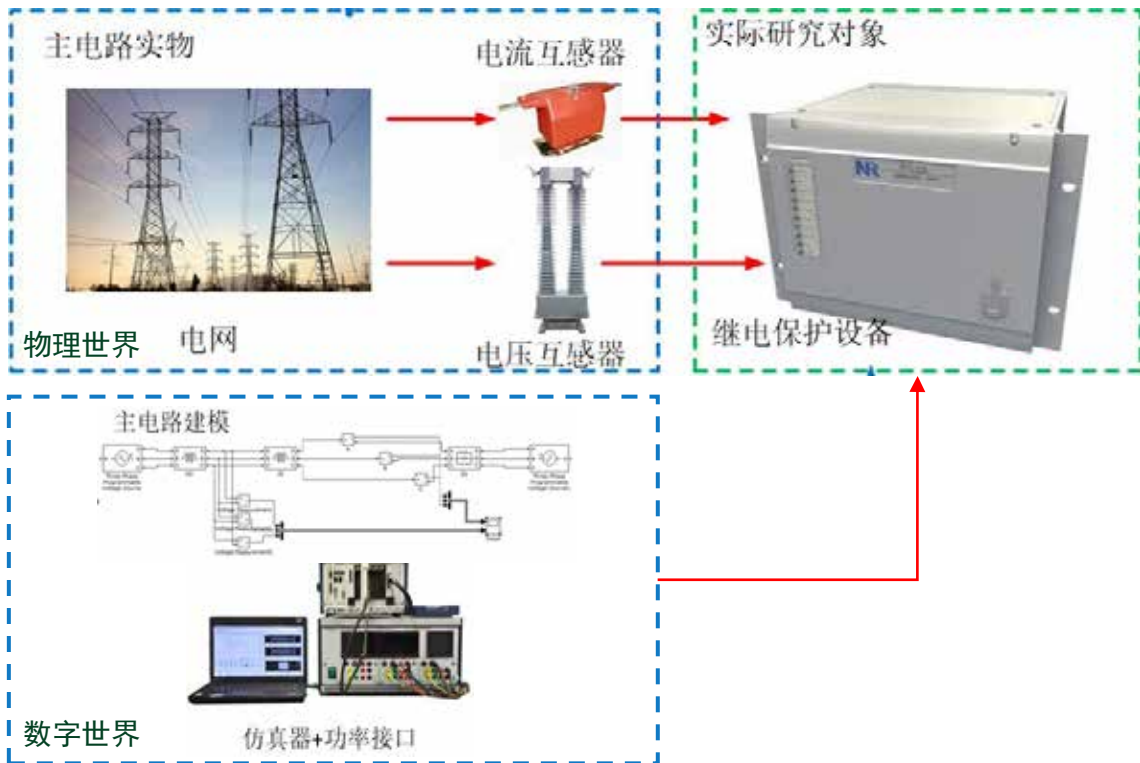
数字孪生场景
生产：制造/测试大数据

消费电子产品产线测试的流程

| Main PCB | → | SMT | → | ICT | → | Electrical | → | Wireless | → | Assembly | → | Wireless | → | Active Noise Canceling | → | Final Acoustic | → | User Interface | → | Ship |

| Daughter PCB | → | SMT | → | ICT | → | Electrical |

| Component Assembly | → | Speaker Acoustic |

| Battery | → | Battery Charging |

Example of Distributed Production Line for Wireless Headphones

| | Process Step | | Basic Test Station | | Functional Test Station |
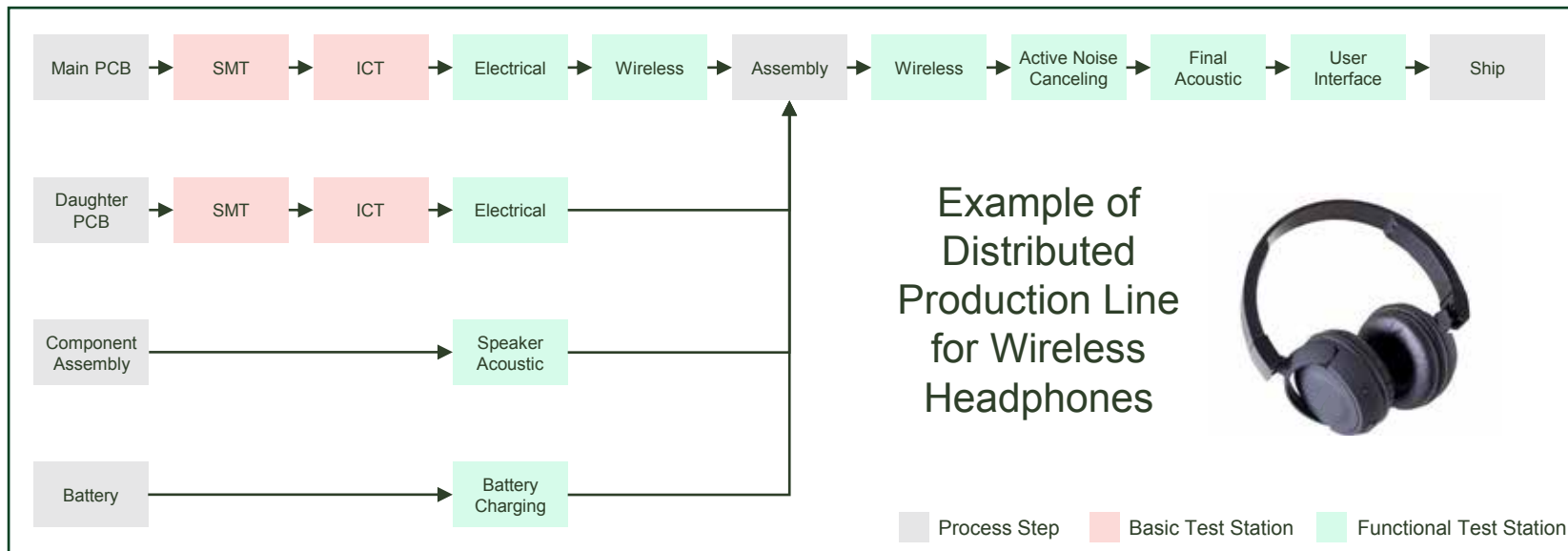
Common challenges

1 Line down too often affecting throughput

2 Line imbalance affecting efficiency

3 Too many false calls in inspection (SPI, AOI, AXI, etc.)

4 Costly material attrition and scrap

5 Process escapes due to operator overrides

6 Time consuming to root-cause defects/ anomalies

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Combined NI Enterprise Software Portfolio

NI provides actionable product analytics to **improve product outcomes** and test operations software to **maximize test efficiency.**

O+ Optimal+ — PRODUCT LIFECYCLE ANALYTICS

Quality & Reliability
Improve quality and reliability

Supplier Transparency
Trace failure patterns to source

Advanced Analytics
Deploy machine learning (ML) algos

Efficiency Analysis
Streamline manufacturing processes

Data Lifecycle
End-to-end Data Lifecycle Management

NPI Ramp
Accelerate product introduction

ML deployment
Holistic platform for AI/ML lifecycle

| Process Data | Machine Data | Test Data | In-Use Data | Repair Data |

S SystemLink — TEST OPERATIONS MANAGEMENT

Test Station Management
Qualification | Health | Configuration | Utilization

Test Execution Performance
Monitoring | Live KPIs | Process Control

Test Data Management
Ingestion | Search | Transform | Process

TEST DEVELOPMENT & AUTOMATION

Test Application Design

Measurement Science
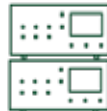
Hardware Interface

Data Logging

System architecture – SMT example
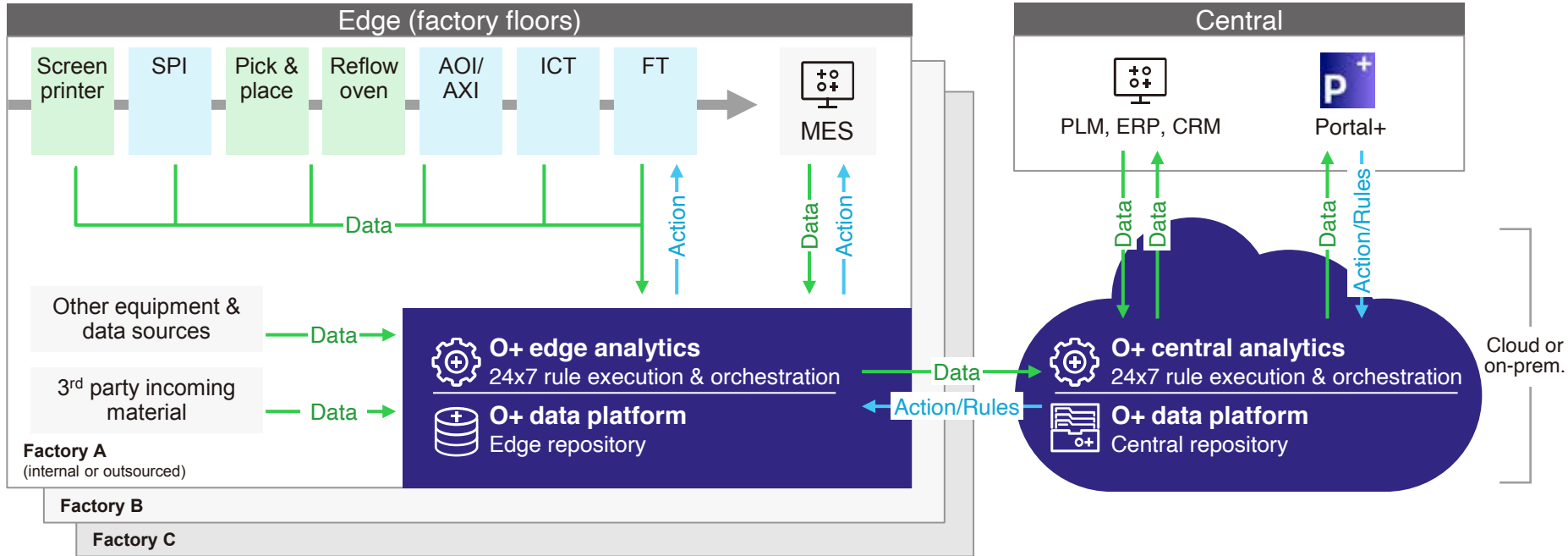
Actionable insights across all mfg. lines and facilities

Optimal+ SMT solution

1 Simplify factory management

2 Shift Left – early scrap detection

3 Connect data silos from incoming material to end product

4 Early Detection on tool wear

5 Create a holistic product and process view

6 Close the loop with alerts & MES integration

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数字孪生场景
运营：预测性维护

Smart, Connected Products (制造企业)

产品为中心

从制造向服务转型:
- 远程监控，故障诊断
- 设备利用率分析
- 新业务模式

产品差异化/竞争力/增值服务（开源）

Smart, Connected Operations (运营企业)

运维为中心

优化关键运营资产:
- 减少非计划停机
- 提升生产产品质量
- 保证产量

降本增效（节流）

NI 模块化、开放式OT平台快速构建工业预测性维护方案
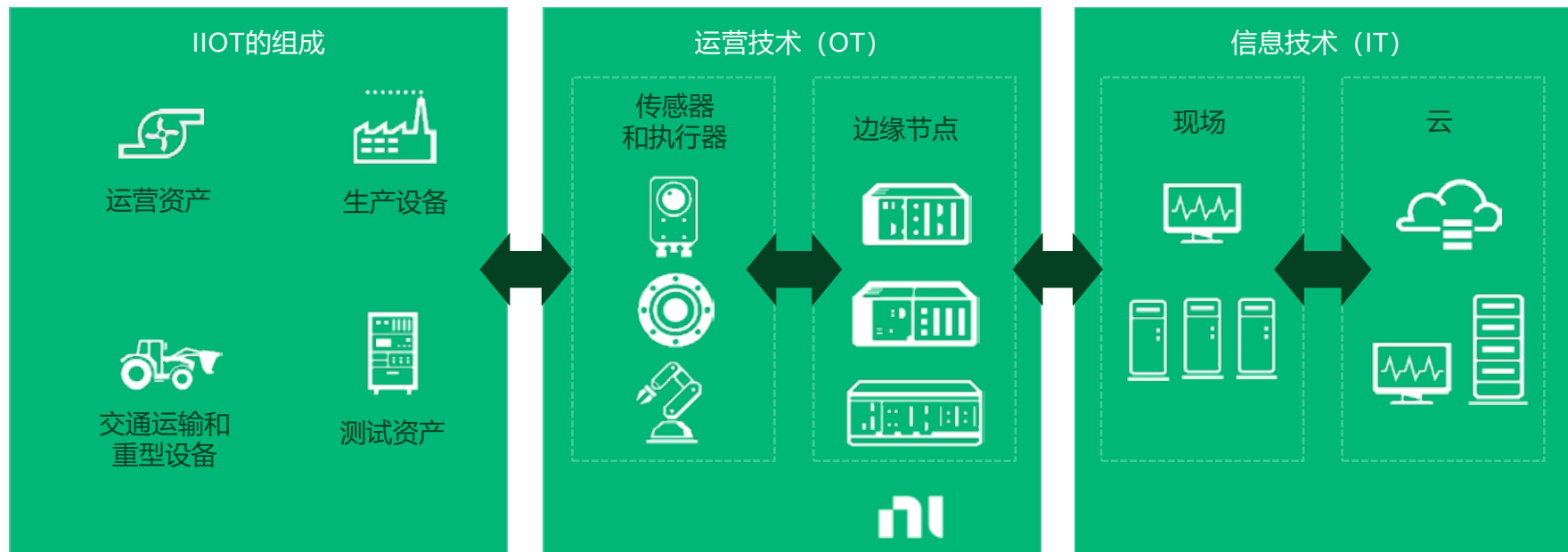
电机 – 泵在线监测与预测性维护系统

借力在线监测系统、增强现实技术，Flowserve轻松实现设备资产管理

恩艾NI知道 3月9日

工业状态监测对于设备维护和故障诊断不可或缺，但是由此产生的大量数据的分析问题给制造企业带来挑战。不过不用担心，NI联合合作伙伴为业界提供了全套的解决方案。尤其是对于NI LabVIEW、CompactRIO和InsightCM在监测领域的应用，有些企业已经运用的炉火纯青。

小编首先为大家奉上全球泵业的领导者Flowserve，专注于提供技术平台和解决方案的全球软件公司PTC、测试测量行业领导者NI联合打造的一个关于泵的在线状态监测的Demo，不要错过哦。

NI 钢铁在线监测与预测性维护方案汇总

汽轮机
辅机

| 原料 | → | 炼铁 | → | 炼钢 | → | 连铸 | → | 轧钢 |

焦炉

烧结机
• 混料滚筒
• 静电除尘器
• 漏风率

高炉
• 上料输送
• 布料器
• 炉内管道流

转炉
• 熔铣天车
• 引风机送风机

精炼炉

连铸机

板材轧机/棒材轧机
线材轧机与盘卷机
热轧厂
• 热轧机
• 粗轧机
• 精轧机
• 板坯定宽压力机
冷轧厂
• 罩式/连续退火炉
• 往复式/连续式冷
轧机

钢铁在线监测与预测性维护方案

实时趋势和故障监测

事件通知

群组广播

巡检抄表

噪声比对

公有云

热轧厂在线监测与预测性维护方案

支持主要故障类型：

- 粗轧机/精轧机打滑，扭振，轴间隙冲击，疲劳，断辊，边轧机齿轮箱异常，轧辊振动痕

- 板坯定宽压力机轴间隙冲击，齿轮轴承异常，不同步，耐磨板异常，避震器异常

台湾中钢使用成果：系统安装后意外停机时间统计

	2010	2011	2012	2013	2014	2015	2016	2017
清洗线	7.84	12.33	15.25	23.91	0.83	6	4	0
整平线	149.25	54.23	45.57	23.59	10.29	6.76	6.97	0
酸洗线	50.94	10.18	10.58	5.26	0	2.02	5.77	4.71
轧二线	32.3	81.59	3.59	9.44	8	10	7.74	0
调质线	4.29	2.13	4	3.2	0	0	0	2.74
公用线	5	0.21	2.08	0	0	0	0	0
总停机时间(小时)	249.62	160.67	81.07	65.4	19.12	24.78	24.48	7.45

其他预测性维护设备成功案例

电厂蒸汽/燃气轮机

电厂辅机设备：引风机，交流异步电机，泵，阀

柴油发电机组

化工厂冷冻机，造粒机

往复式/离心式压缩机

冲压机

磨床

切削机

数字孪生的基石：模型数据(数字)VS 测量数据 (物理)

NI：软件定义的自动化测量为数字孪生的物理世界贡献核心价值

将运营现场应用状况反馈到新的设计中

| 面向设计的集成测试 | 生成优化的测试策略 | 面向MES的集成测试 | 预测性维护 |

研发 **生产** **运营**

数字孪生场景

| 半实物仿真(硬件在环) | 测试大数据分析（虚拟生产） | 预测性维护 |

Data

FINDINGS   REQUIREMENTS   DESIGN   SPECS   QUALITY   USAGE

Measurements   Validation   Characterization   Raw Measurements   Diagnostics

Asset Performance and Health

贯穿从虚拟到现实的全产品生命周期的数据价值挖掘