The role of Simulation and AI in the implementation of a Digital Twin

Dr. Graham Bleakley. IBM Offering manager Modelling and MBSE solutions

Graham.bleakley@uk.ibm.com

Outline

- Todays challenges
- Main areas of interest from our customers
- Introduction to Digital Twins
- Different types of Digital Twin
- How IBM supports the Digital Twin
- Use cases for Digital Twins
 - Demo example

Today's leaders of systems solutions face significant challenges In 2019 how to find new sources of productivity and acceleration....

Hi-rate of Technology Innovation

> Solution platform pressure

innovation

In-Service

Integration & Supply pressure New market entrants

> Lead-time & cost pressure

Unprecedented opportunities & challenges for technology companies

Engineering remains at the heart of innovation

How to move engineering & innovation to a new level ?

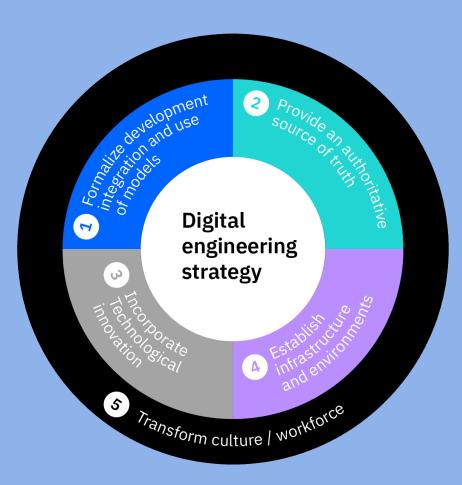
Predictability Productivity Quality Flexibility

Industry vision: Digital Engineering initiative by US Department of Defense

"conduct engineering in more integrated virtual environments to increase customer and vendor engagement, improve threat response timelines, [..], reduce cost of documentation and impact sustainment affordability.

Such engineering environments will allow DoD and industry partners to evolve designs at conceptual phase, reducing the need for expensive mockups, premature design lock, and physical testing."¹

1. DoD Digital Engineering Initiative: https://www.acq.osd.mil/se/initiatives/init_de.html



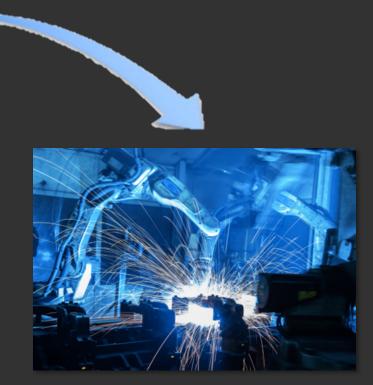
Some key concepts to support Digital Transformation in A&D



Engineering for Connected Products







Cyber Physical System for Connected Operations/Products

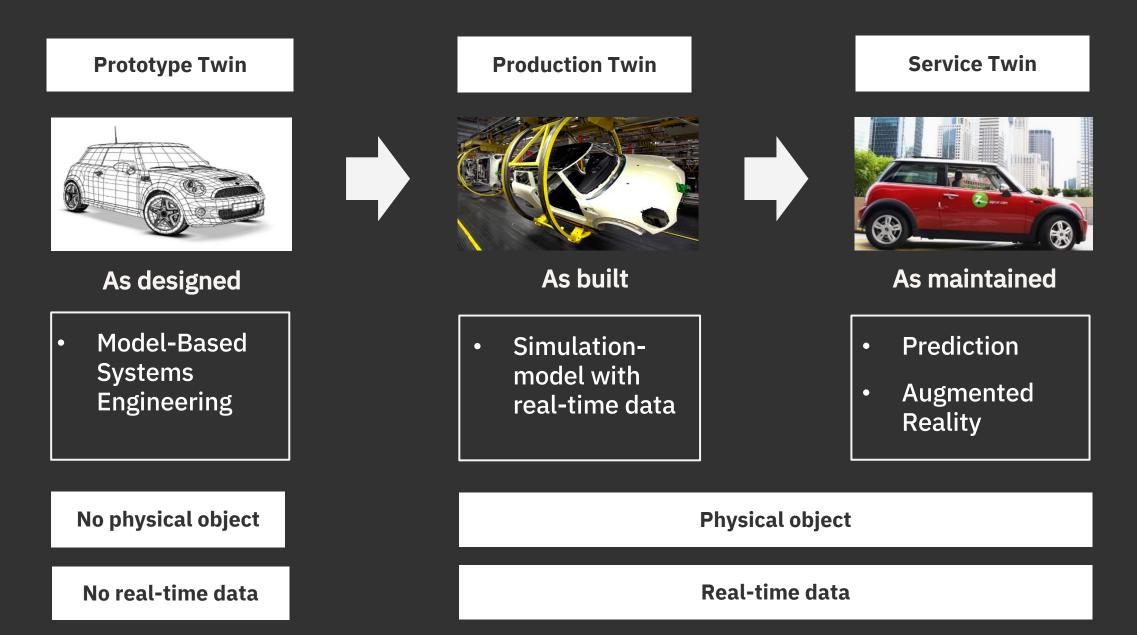


What is a Digital Twin?

"The Digital Twin is the virtual, state-full representation of a physical product and the system behind across its life-cycle using operational real-time data and other sources to enable understanding, learning, reasoning, and dynamically recalibrating for improved decision making"



Digital Twin is a journey



Digital Thread for engineering collaboration

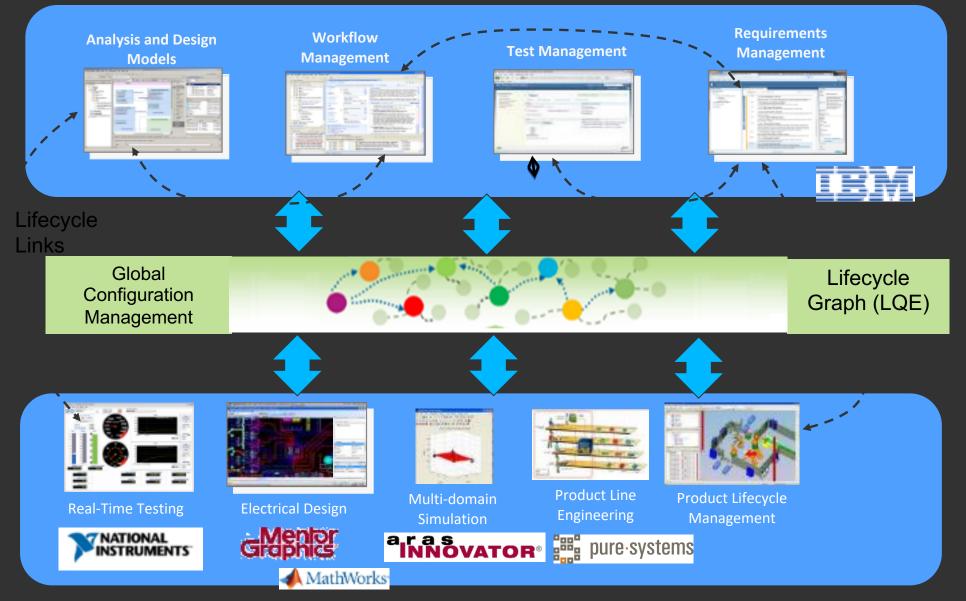
- A standards based engineering lifecycle management architecture and technology platform
- Linking data across disciplines and tools
- Central lifecycle knowledge graph for analytics

٠

Global configuration management for federated lifecycle tools

OSLC

OASIS 🕅



Digital Thread = Collaboration of Toolchain

F	Features Selection	E Feature 488 DIAG-FUN-REQ-1640	E Feature 445 DAB Silde Show	E Feature 416 AMFM-FUN-REQ-023	E Feature 424 Rear-view Camera (R	E Feature 394 V8-FUN-REQ-025235	E Feature 399 AMFM/2-FUN-REQ-0	E Feature 401 VOLv2-REQ-014817/
	Feature 370 AMFM/2-FUN-REQ-0	Feature 371 VOL-SR-REQ-014824	Feature 372 AUDSET-FUN-REQ-0	Feature 381 AMFM-FUN-REQ-023	Feature 383 V8-FUN-REQ-025341	Feature 390 AMFM-FUN-REQ-023	Feature 368 V8-FUN-REQ-025218	Feature 389 AMFM-FUN-REQ-023
	E Feature 283 DAB-FUN-REQ-1329	Feature 295 AMFM-FUN-REQ-023	Feature 294 AMFM-FUN-REQ-023	Feature 298 AMFM-FUN-REQ-023	Feature 297 AMFM-FUN-REQ-023	Feature 298 AMFM-FUN-REQ-023	Feature 298 AUDSET-FUN-REQ-0	Feature 329 AMFM-FUN-REQ-023
	Feature 283 AMFM-FUN-REQ-023	Feature 288 VOL-FUR-REQ-0148	Feature 268 AUDSET-FUN-REQ-0	Feature 212 AMFM-FUN-REQ-023	Feature 231 V8-FUN-REQ-025213	Col-FUR-REQ-0882	Feature 233 AMFM-FUN-REQ-023	Feature 234 VOLv2-FUR-REQ-026
	E Feature 200 VS-FUN-REQ-025206	E Feature 184 VOL-FUN-REQ-0148	E Feature 143 AMFM-FUN-REQ-023	Feature 149 VOL-SR-REQ-014825	E Feature 131 DIAG-UC-REQ-01645	E Feature 132 DIAG-FUN-REQ-0164	E Feature 108 DIAG-SR-REQ-10365	E Feature 110 DIAG-FUN-REQ-0164
I	E Feature 72 DIAG-FUN-REQ-1157	E Feature 29 DIAG-FUN-REQ-0164						

Rational Team Concert Featur

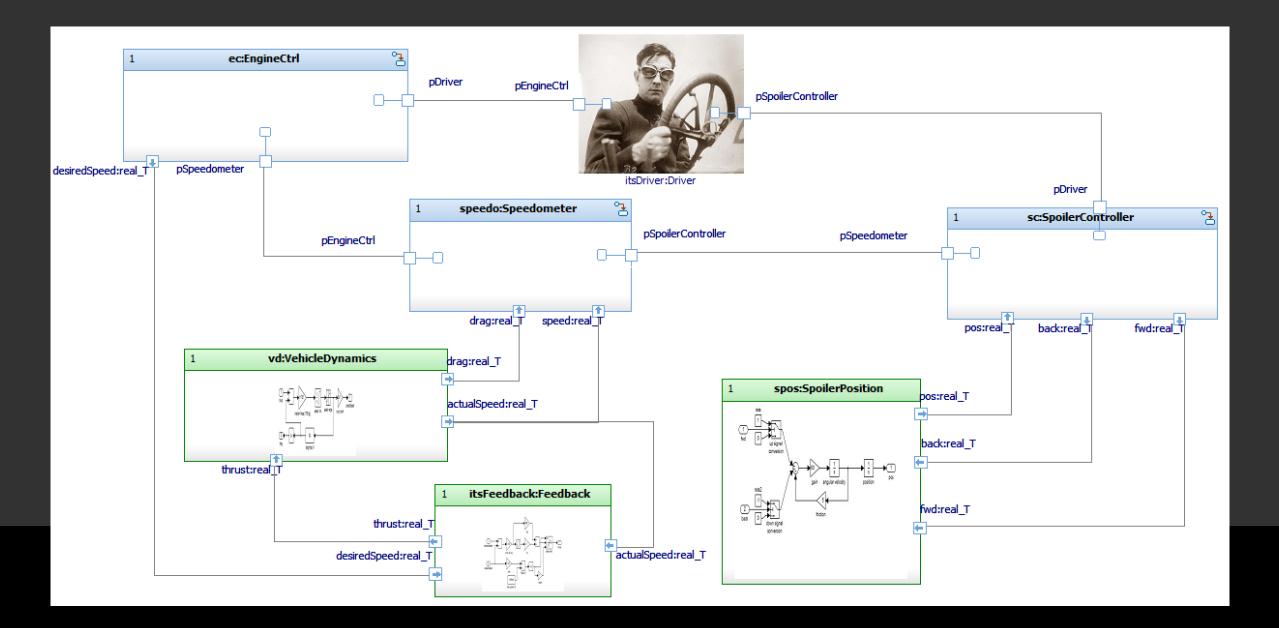
Doors Next Generation

Rational QualityManager

Feature	Sys	tem Requirements		Software Requirements	TestCase	Test Execution Record
E Feature 445	b	lin case one image is		Blideshow objects she	E T82_TC51_UC1.7 -	8
DAB Side Show		When DAB is started,		On receiving a sidest	H T82_T051_UC1.6 -	
1		TriggerTime greater th	1	🖉 🕞 The Reassembly Buff	T82_T051_UC1.4-	s T82_TC51_UC1.6 - 8
		For a JPEG format im		🕎 🕞 The Sildeshow feature	■ T82_TC51_UC1.2-	5 T82_TC51_UC1.4 - 8
		🛿 The Image should be 🛁		The Hold buffer conte	T82_TC51_UC1 - 8	
		The AHU shall receive		The Reassembly Buff	T82_T051_UC1.3-	8 T82_TC51_UC1.2 - 8
		The AHU shall support		Only objects with Ima;	T82_TC51_UC1.5-	в тв2_тс51_UC1.3-в
		The SildeShow applic	-44-1	FIG0/13 (User Applice	I T82_TC51_UC1.8-	
		The AHU shall ignore	/// /	FIG0/13 (User Applice		T82_TC51_UC1.5 - 8
		TriggerTime Now => 1	///	An object in the hold b		T82_TC51_UC1.8-8
		The presentation time	HF	An object in the hold t		
		🗟 No TriggerTime 🛶 Th		Freessembly Buffer fu	Rational Design Manage	ar in the second se
		🗟 in order to act upon T		Reassembly Buffer fu	Design	
		The simple profile def		🐙 🗟 The Hold buffer functi	heature alideation	
		The AHU shall synchr	H	The content of the Ho		
		in the event that the S	$ \longrightarrow A $	he Hold Buffer conte		
		The SildeShow user a		>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>		
	Valin V	For a PNG format Ima	/ IFT	Hold buffer shall content		
		The AHU shall synchr		The Hold buffer function	40X////	
	V/////	3 Images are buffered		Reassembly Buffer fu	V/X///	
	80000	if a received image ex	-////	🕎 🗟 The maximum image	<u> </u>	
	W	The Image should be	///////////////////////////////////////	The content of the Ho		
	WWX =	B If an animated PNG in		In case the update ob	1/	
		If TriggerTime is upda	FF-/	Bildeshow objects she	<u>/</u>	
		The AHU shall receive		Diplate Objects const		
	100	TriggerTime less than	1			
	1	The AHU shall reserve				
	1	The Image should be				
	Y 12	TriggerTime equal to t				



Digital thread as a Model

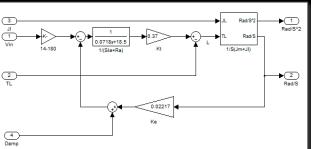


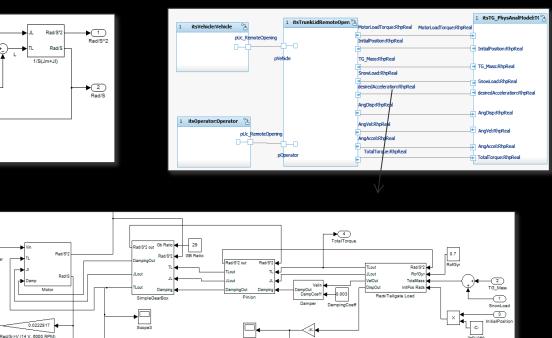
Digital Twin = Simulated representation of physical device

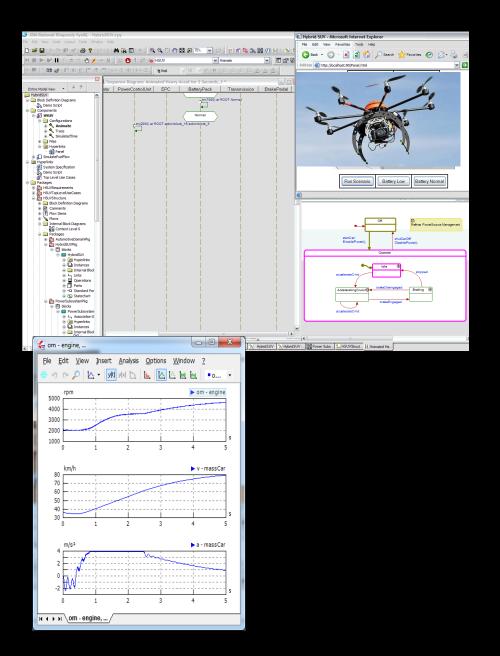
- Allows virtual testing and prototyping of the systems
 - State based models
 - Activity based models
- Hi Fidelity heterogenous models used to validate systems behavior requirements

▶ (5)

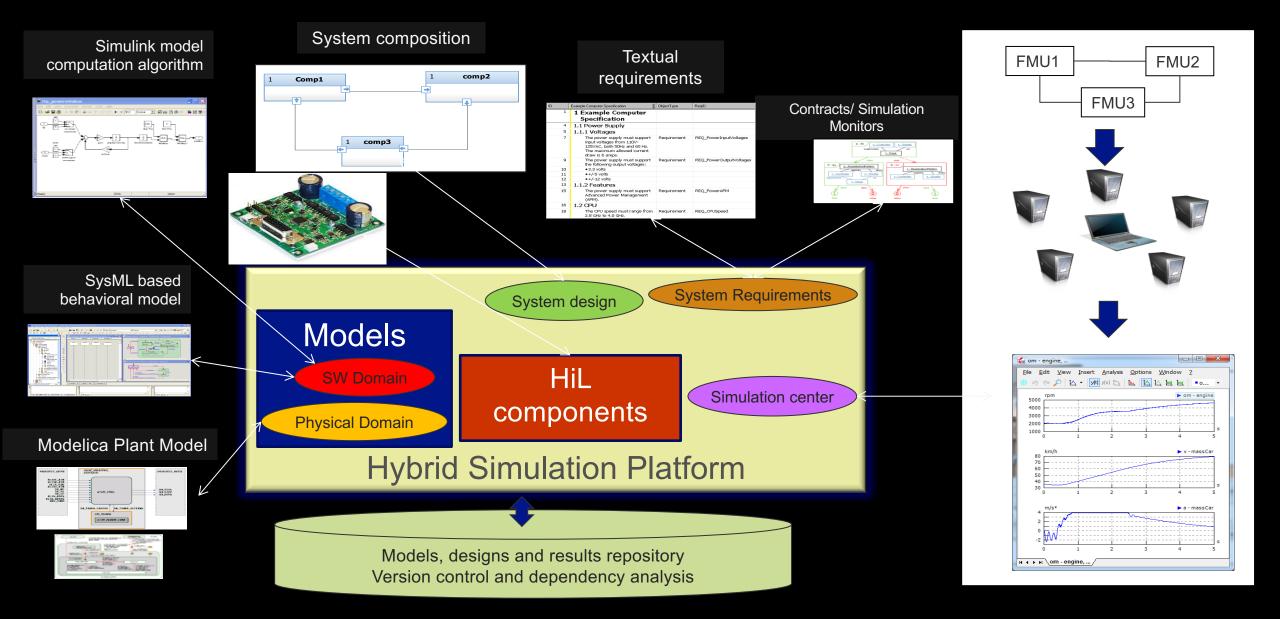
24





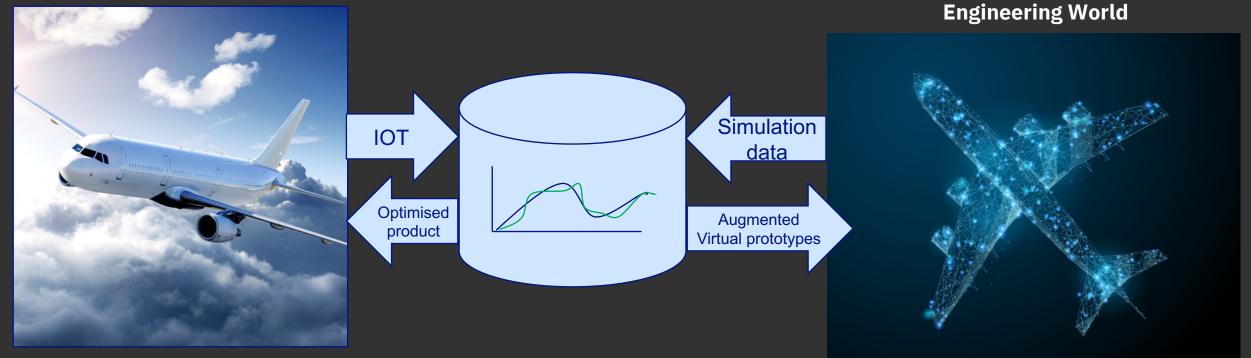


Hybrid Simulation Platform supporting the Digital Twin



Digital Twin as a Digital Shadow enabled by IOT

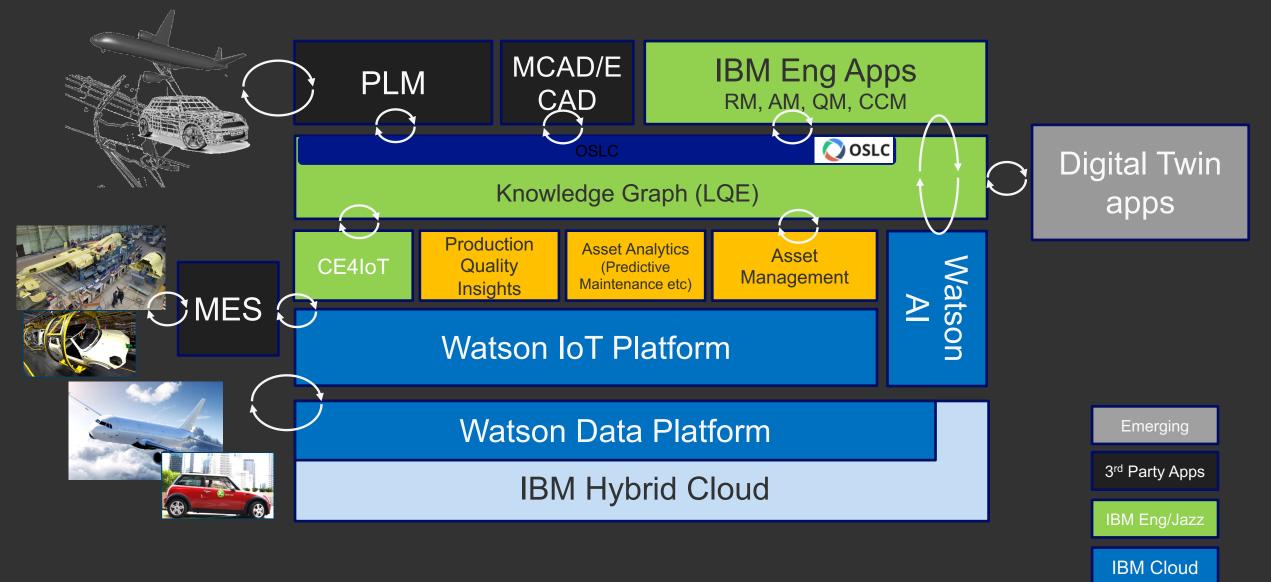
Data from the real artifact captured and compared to information in the virtual prototype Real World



Need to capture

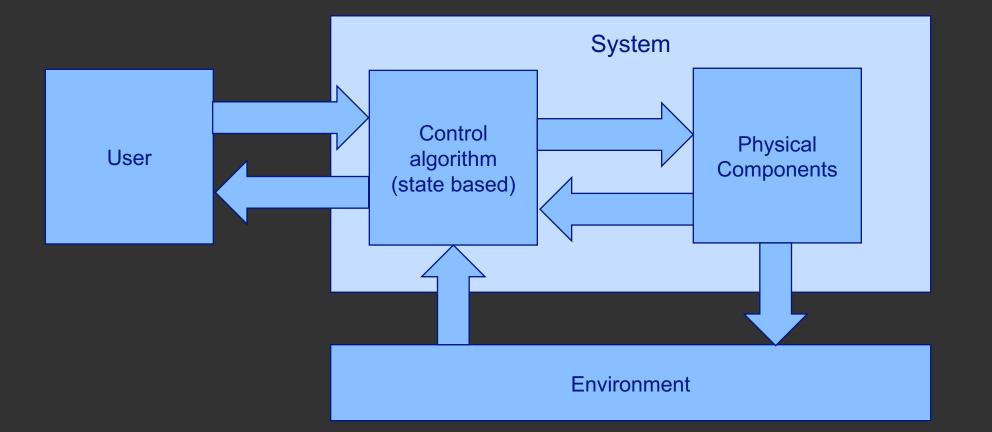
- Environment conditions
- Operator inputs
- Used to drive the Virtual model
- Machine Learning can be used to understand the expected behavior

IBM Watson IoT Engineering Solution Architecture



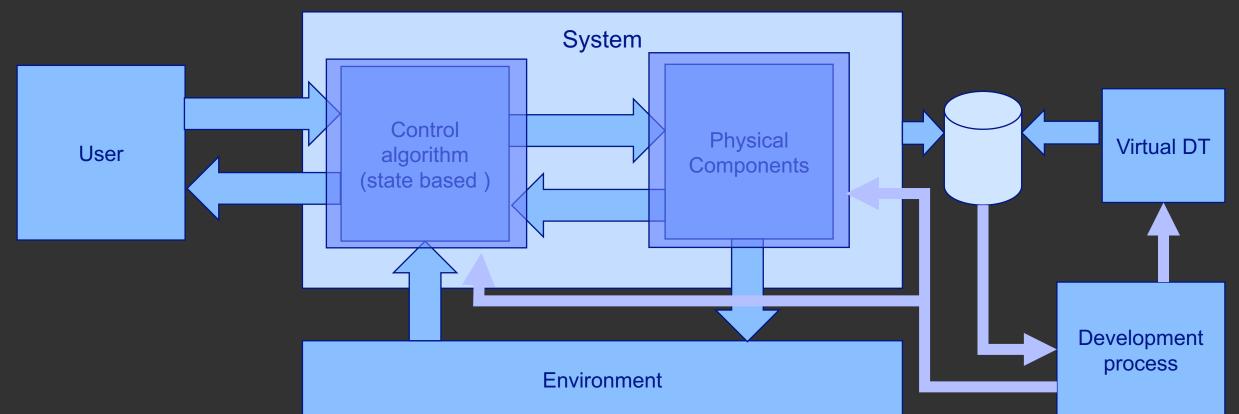
IBM Confidential

Role of Digital Twins and Shadows



Use cases for the digital twin:- SW and HW

Comparing information from a virtual model digital twin with a shadow digital twin from real systems



Improve the fidelity of the Virtual model (simplify the model to rules)

Identify issues and faults with the system and trigger the change request process

Improve the algorithm being used in the real world (Over the Air Updates)

AI and Machine Learning algorithms can used to replace the control algorithm <u>Virtual digital twin can also be replaced by the ML algorithm</u>



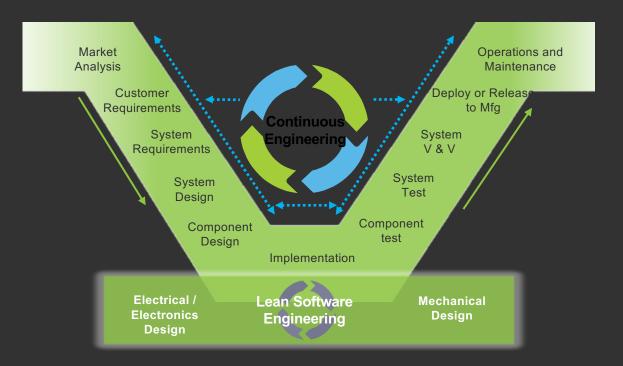


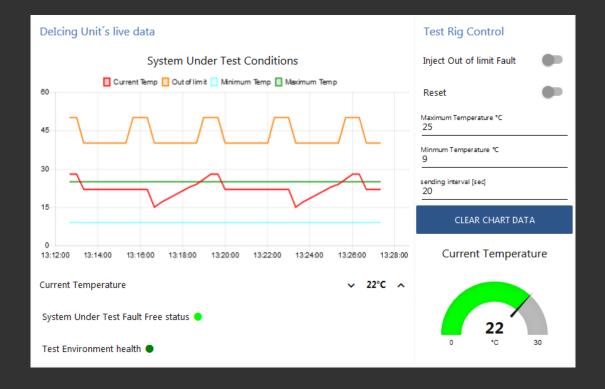


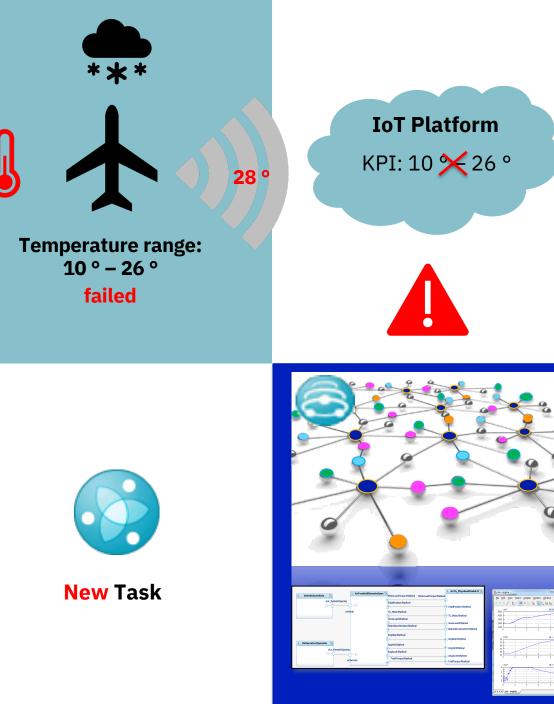
Connecting IoT World & Engineering World

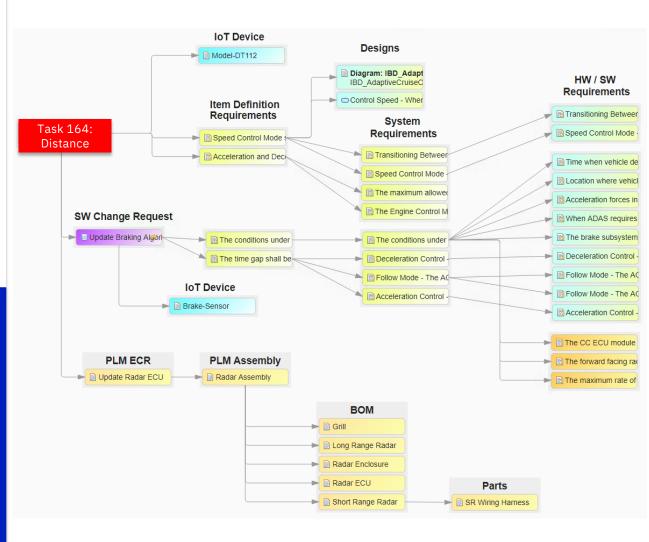
Engineering World = Jazz Platform

IoT World = IoT Platform









Summary

- To enable a digital twin it requires the implementation of a digital thread
- Digital thread allows you identify
 - Impact of change
 - Root cause analysis
- Digital twin is used to reveal failures in the system by comparing digital shadow
 - IOT sensor data to requirements and/or model constraints
 - Digital twin simulation consuming the IOT sensor data
- Digital twin can be used to do predictive fault analysis on the system based upon comparison of Virtual digital twin simulations and Shadow twin.
- ML can be used to represent physical and behavioural systems models
 - Very dependent upon the learning data being captured
- Engineering becomes an integrated part of your product lifecycle

Thank You

Any Questions ?