# 

# Digital Twin Advancements

Simon Horsley, Vice President

Regional Executive UKIA, Bentley Systems Bentley Advancing Infrastructure









# **Digital Twins**

- What is an Infrastructure Digital Twin?
  - A digital twin is "a realistic digital representation of assets, processes or systems in the built or natural environment".
- Why invest in Digital Twins?
  - Improving quality of life...... "Convergence of smart infrastructure, modern methods of construction and the digital economy presents growing opportunities to improve citizens quality of life"
  - Improving value......"Large industrial companies using digital twins are expected to gain a 10% improvement in effectiveness"

*Reference "Gemini Principles" cdbb (Centre for Digital Built Britain)* 



### The Gemini Principles

Digital twins of physical assets are helping organisations to make better-informed decisions, leading to improved outcomes.

Creating an ecosystem of connected digital twins – a national digital twin – opens the opportunity to release even greater value, using data for the public good.

This paper sets out proposed principles to guide the national digital twin and the information management framework that will enable it.



Latin for Twins, Northern Constellation, Bright Stars Castor & Pollux

Jan 28, 2019

# The Gemini Principles

<b>Purpose:</b> Must have clear purpose	<b>Public good</b> Must be used to deliver genuine public benefit in perpetuity	Value creation Must enable value creation and performance improvement	<b>Insight</b> Must provide determinable insight into the built environment
<b>Trust:</b> Must be trustworthy	<b>Security</b> Must enable security and be secure itself	<b>Openness</b> Must be as open as possible	<b>Quality</b> Must be built on data of an appropriate quality
<b>Function:</b> Must function effectively	<b>Federation</b> Must be based on a standard connected environment	<b>Curation</b> Must have clear ownership, governance and regulation	<b>Evolution</b> Must be able to adapt as technology and society evolve

**Function:** Must function effectively



## Veracity

# Fidelity

**Purpose:** Must have clear purpose

Demonstrator Projects Useful cases: Digital Workflows

**Trust:** Must be trustworthy Connected Data Environment

Open "Dark Data"

**Function:** Must function effectively

Reality

Veracity

Fidelity

# ✓ Reality?



✓ Reality ⇒ Context
 • Continuously surveyed



# ✓ Reality ⇒ Context

- Continuously surveyed
- Connected to IoT

### 

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Overview

Asset Status Overview

### PAWorld MindApp 🗄 🛅 Separator Pipes Motors Calves B C Pumps 🗄 🗀 Pump 1 🕑 🗀 Pump 2 🗄 🗋 Pump 3 + C Electrical 🖲 🛅 Switches E C Structure

### AWorld MindApp (Management)

Management Production



### Messages/ Alerts

Asset		Status			
TIMESTAMP	NAME	SEVERITY	REASON	STATUS	
2017-04-07 14:22	Pump 1	CRITICAL	Flow rate low	UNACKNOWLEDGED	
2017-04-03 14:22	Pump 2	INFO	Mainenance scheduled	ACKNOWLEDGED	
2017-04-07 14:22	Pump 3	WARNING	Energy use - high	UNACKNOWLEDGED	



Maintenance

### Total energy consumption



2017-04-19 10:19:00





Production



Pump 2 Flow Rate

1.7

2217-02-27 13:00:00

Separator efficiency

50.0

2017-04-19 11:30:00

Asset				Health Performance		Risk	
MANUFACTURER	ASSET	START-UP YEAR	ASSSET AGE	HEALTH INDEX %	HEALTH CONDITION	RISK INDEX	RISK
RTE	Separator	2005	12	47.52	•	12.3	•
Delta Star	Pump 3	2010	7	63.50	•	0.1	•
Line Material	Pump 2	2015	2	65.00	•	0.45	•
Pensylvania	Pump 1	2014	3	14.45	•	0.01	•

# ✓ Reality ⇒ Context ✓ Veracity?



✓ Reality ⇒ Context
 ✓ Veracity ⇒ Components
 • From BIM models



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Reality Context
 Veracity Components
 From BIM models
 From Machine Learning



✓ Reality ⇒ Context
 ✓ Veracity ⇒ Components
 ✓ Fidelity?



✓ Reality ⇒ Context
 ✓ Veracity ⇒ Components
 ✓ Fidelity ⇒ Chronology
 • 4D Construction Modeling



✓ Reality ⇒ Context
 ✓ Veracity ⇒ Components
 ✓ Fidelity ⇒ Chronology
 • 4D Construction Modeling

Change synchronization



- ✓ Reality ⇒ Context
   ✓ Veracity ⇒ Components
   ✓ Fidelity ⇒ Chronology
  - 4D Construction Modeling
  - Change synchronization
  - Predictive performance

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PAWorld MindApp	PAWork	d MindApp > Pumps > Pւ	ump 1 (Management)					3 Bentle Advancing Infras	ey.
	Management	Production Maintenance	5	Messages/ Alerts					
Pump 1     Pump 2     Pump 3     Electrical				Asset			Sta	atus	3
■ Structure				TINESTAMP 2017-04-07 14:22	Pump 1	SEVERITY	REASON Flow rate low	STATUS	





**Purpose:** Must have clear purpose

Demonstrator Projects Useful cases: Digital Workflows

**Trust:** Must be trustworthy Connected Data Environment

Open "Dark Data"

**Function:** Must function effectively

Reality

Veracity

**Fidelity** 

<b>Purpose:</b> Must have clear purpose	Demonstrator Projects	Useful cases: Digital Workflows
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# Infrastructure Digital Twin Requirements: Must be trustworthy



Openness refers to the degree of accessibility



Connectedness refers to the depth, breadth and robustness of links between elements.

Source Gartner, Top 10 Strategic Trends for 2019



### Infrastructure Digital Twin Requirements: Must be trustworthy "Dark" Data "Open" (Query-able) Data **Continuous** and Comprehensive Status Review via 5 Web Browser Image courtesy of SWECO .0 . **DpenBuilding** iTwin **ProjectWise** Services Design Quality Analytics **Connected Data** Environment Image courtesy of Mott MacDonald **OpenRoads** .0 . Change Accountability **Digital Components** 4 100 4 100 4 100 Revit **Digital Context** Image courtesy of Mott MacDonald **4D** Construction Modeling

Image courtesy of LAX



Bentley Public Relations Jennifer Maguire Corporate Communications Director 1-610-458-2695 Jennifer.Maguire@Bentley.com Tweets by <u>@BentleySystems</u>

### Bentley Systems Releases Open-Source Library: *iModel.js*

Open-source JavaScript library for creating immersive connections to infrastructure digital twins

LONDON, U.K. – The Year in Infrastructure 2018 Conference ← 17 October 2018 – Bentley Systems, Incorporated, the leading global provider of comprehensive software coutions for advancing the design, construction, and operations of infrastructure, today announced the initial release of its *iModel.js* library, an open-source initiative to improve the accessibility, for both visualization and analytical visibility, of infrastructure digital twins. *iModel.js* can be used by developers and IT professionals to quickly and easily create immersive applications that connect their infrastructure digital twins with the rest of their digital world. *iModel.js* is the cornerstone of Bentley's just-announced *iTwin*<sup>™</sup> Services that combine iModelHub, reality modeling, and web-enabling software technologies within a Connected Data Environment (CDE) for infrastructure engineering.

Bentley's iModels have become a de facto standard for visibility into digital engineering models. iModelHub manages an iModel as a distributed database with an intrinsic ledger of changes—enabling alignment, accountability, and accessibility of its digital components—to form the backbone of an infrastructure digital twin.

The *iModel.js* library is a comprehensive collection of JavaScript packages that build on the



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Infrastructure Digital Twin Requirements: Must have clear purpose

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# **Conceptioneering Digital Twins**



# Infrastructure Digital Twin Requirements: Must have clear purpose



# **Construction Digital Twins**

# **Bentley Systems**

Infrastructure Digital Twin Requirements: Must have clear purpose

# Constructioneering Digital Twins





# Infrastructure Digital Twin Requirements: Must have clear purpose



# **Resilience Digital Twins**

# OpenFlows FLOOD – Flood Risk Assessment



# OpenFlows FLOOD – Flood Risk Assessment

• Analysis of Losses



# OpenFlows FLOOD – Flood Risk Mitigation

### No Mitigation

With Mitigation

- Implement Mitigation Measures
- Comparison of Scenarios





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"It's an O.K. phone, but it takes great pictures."

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# The Year in **INFRASTRUCTURE** 2019 Conference

Bentley Institute

and the same allowed

Advancing BIM through Digital Twins

October 21 – 24,2019 | Marina Bay Sands | Singapore | #YII2019



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