Integrating and Aligning Informational and Operational technology

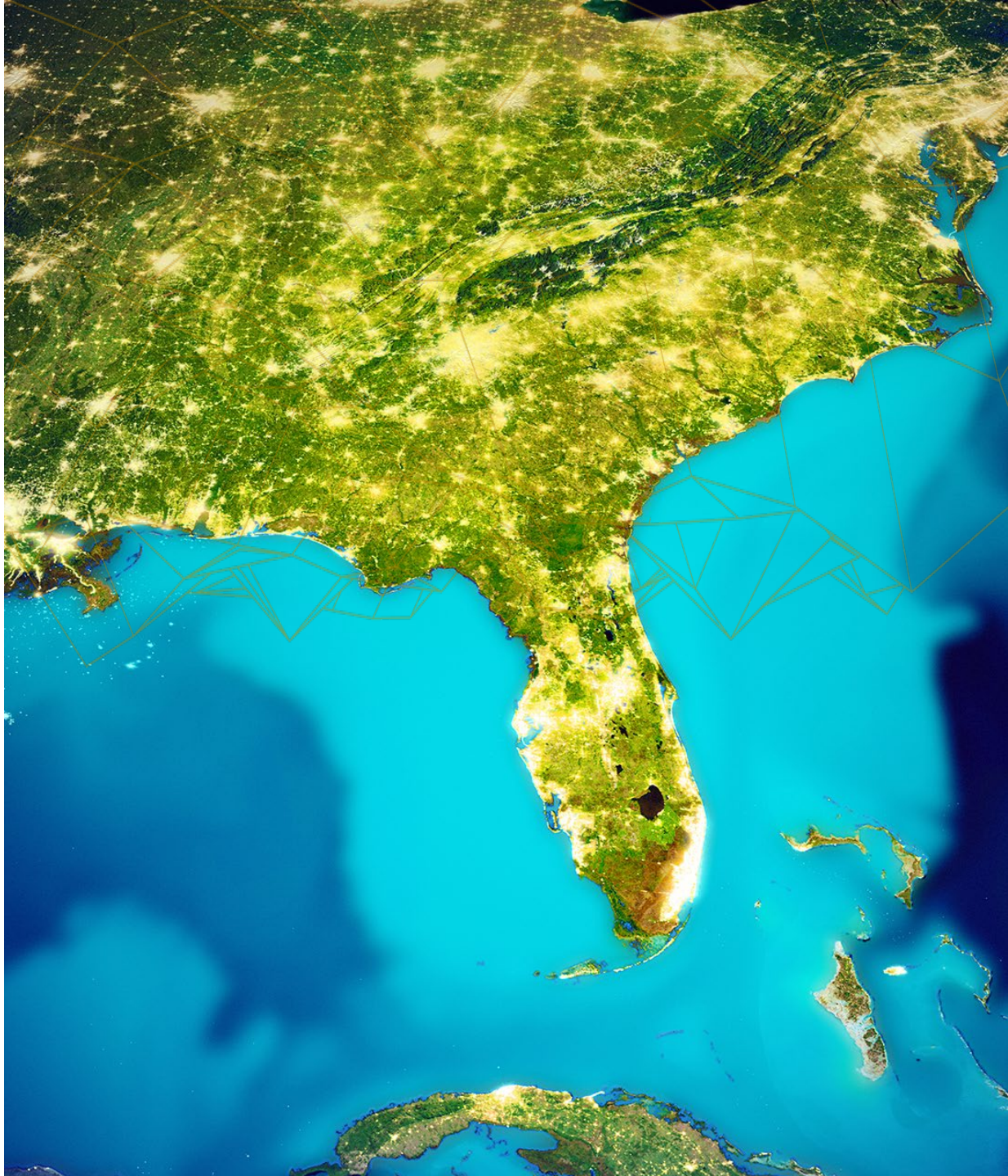
Tom Byron, PE
Infrastructure Advisor
Rawlins Infra Consult, LLC

WE CAN NO LONGER “DO” TRANSPORTATION WITHOUT TECHNOLOGY.

FDOT MADE A FUNDAMENTAL SHIFT TO THE INTEGRATION OF BROADER TECHNOLOGY SOLUTIONS INTO THE TRANSPORTATION LIFE CYCLE.

APPROACH TECHNOLOGY AS AN ENTERPRISE ASSET.

HOWEVER, THAT MEANS FUNDAMENTAL CHANGES IN ORGANIZATION AND BUSINESS PROCESSES



FDOT GOALS & EXPECTED BENEFITS

- Better leverage financial resources to fund technology investments.
- Develop a rationale and framework for identifying proposed technology investments.
- Reduce the risk of security / cyber breaches with standardized security policies and practices.
- Provide more efficient and cost-effective technology service delivery.
- Establish data governance standards to support agency decision making and sharing with our customers.
- Lower costs by reducing the incidence of duplicative or redundant systems, skills and competencies.
- Lower costs of software, hardware and vendor services with enterprise-wide sourcing.

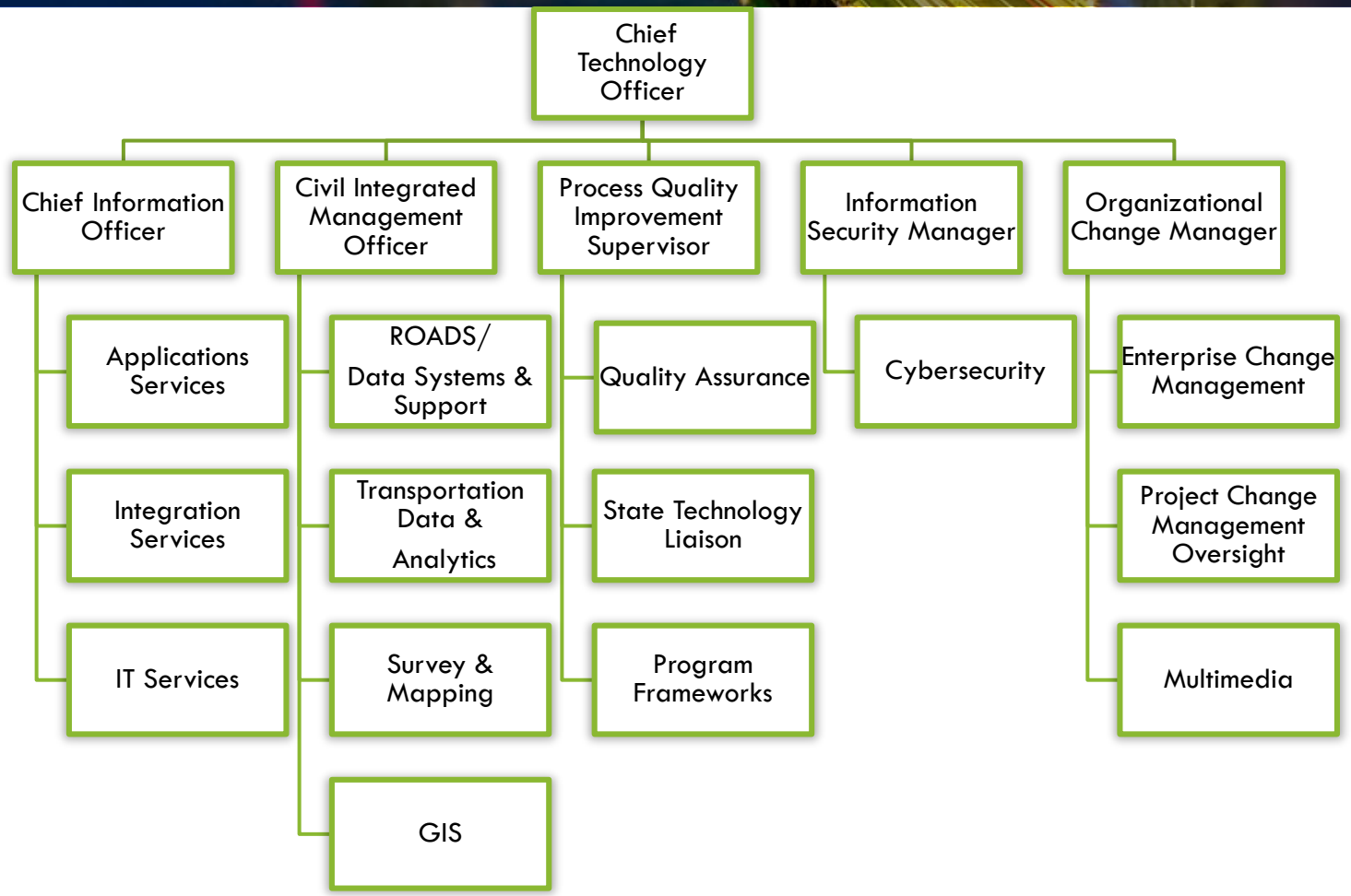
POTENTIAL RISKS OF IT/OT INTEGRATION

- State legislature may not agree with selected technology investments.
- It means significant change (disruption) to the agency.
- It takes a LONG time to fully implement – as in, multiple administration and budget cycles
- Operations/field staff are resistant to changes necessary to realize alignment benefits.

TRANSPORTATION TECHNOLOGY GOALS

- Manage technology infrastructure projects with the same proven **discipline** (standards, tools, policies, consistent vendor management) as we have managed our information technologies
- Reduce risks by ensuring continuity of operations and cyber **security compliance** by addressing systems at the enterprise level
- **Leverage the power of data** and information more effectively to make better decisions by increasing access to internal and external data
- Prioritize the financing of transportation technologies with **Work Program funds** (vs. operational budgets) if the outcome can directly tie to, and impact, our mission

TRANSPORTATION TECHNOLOGY ORGANIZATION



LESSONS LEARNED

- It's a significant change for a DOT – organizational and business processes
- It's hard
- It takes a long time
- It must have executive level champion(s) – preferably, the CEO
- It must have champions throughout the agency
- It requires aggressive and recurring communications / messaging throughout the agency
- Finally, it's worth it

Thank You

Tom Byron, PE
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TODAY, TOMORROW AND THE FUTURE OF 3D MODELS IN DESIGN, CONSTRUCTION, AND IN DIGITAL TWINS

GEORGE LUKES, UTAH DEPARTMENT OF TRANSPORTATION

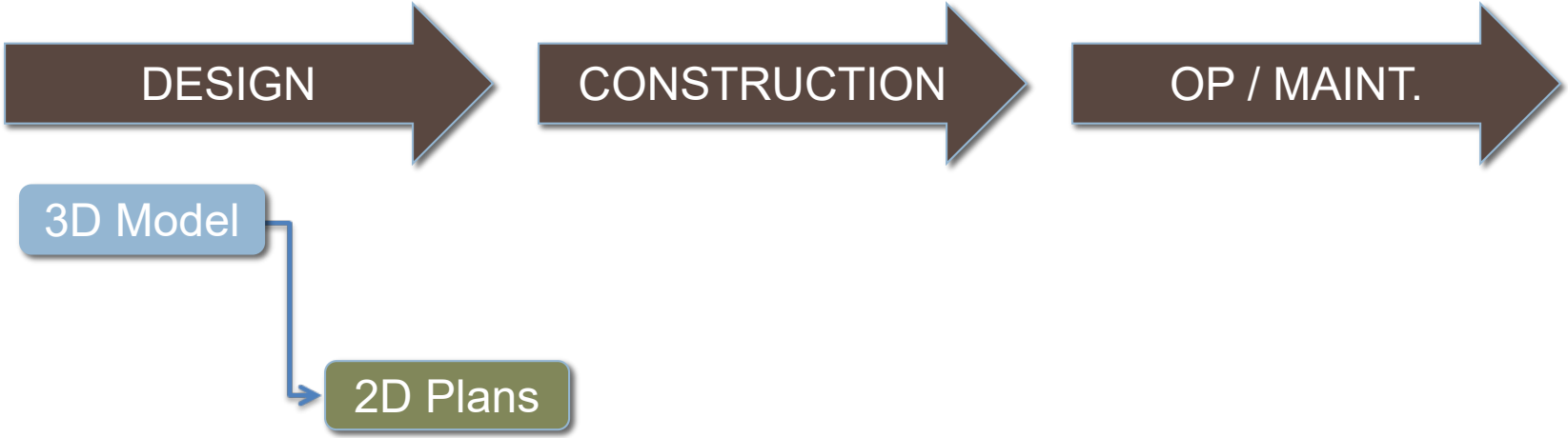
Friday, July 15, 2022

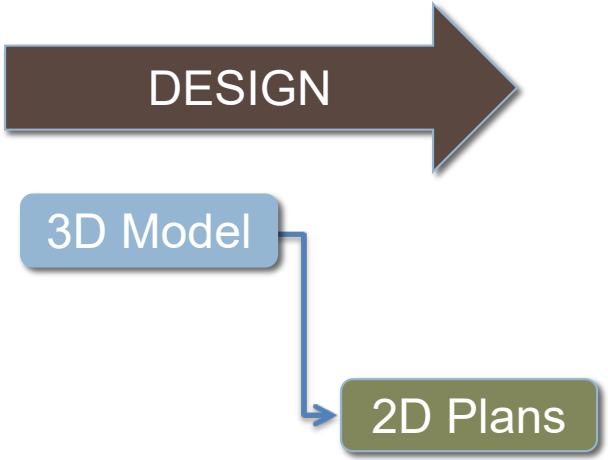
Objective

To help advance the state of the industry (and generate stimulating discussions) from a traditional paper-based paradigm in design, construction and asset management to a data centric organization using data exchange in lieu of paper or files.


DESIGN
CONSTRUCTION
OP / MAINT.

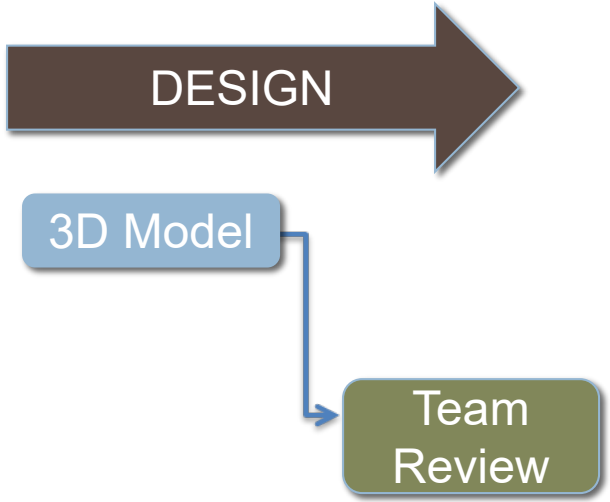
3D Model


DESIGN
CONSTRUCTION
OP / MAINT.
3D Model
2D Plans



TODAY/TRADITIONAL

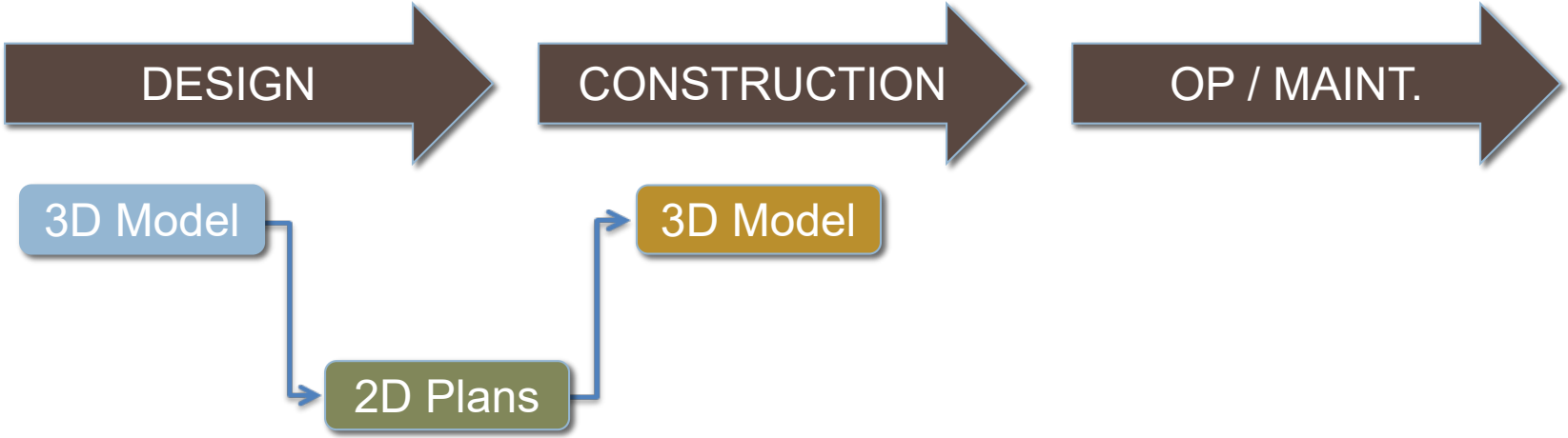
- Models are produced and used for plan sets
- Plan sets are distributed to team for Milestone for review and comment
- Many times, models are left incomplete because plan production ~ 40-70% effort
- The majority of work is developing plans for the final deliverable



TRANSITION/TOMORROW

- Up front work developing model
- Teams use digital tools to review model
- Design team adds attributes/meta data to elements

- Now/Near future: Advertise project with files either FIO or MALD.
- Coming soon: Design publishes to digital twin. Contractors/field use digital twin as project design source for bidding and constructing


DESIGN
CONSTRUCTION
OP / MAINT.
3D Model
2D Plans
3D Model

TODAY/TRADITIONAL

3D Model

- Contractors use the plan set (but prefer design files) and build a 3D model in a different software (TopCon, Trimble, Leica, AGTEK, etc.)

- Contractor 3D model files are loaded for AMG, when allowed, (survey grids/staking are also still used for grading/surface validation).

- Owner Surveyors validate surfaces on grids against plan set.

- Plans/Sheets are used to inspect along with measure and pay requirements.

CONSTRUCTION

TRANSITION/TOMORROW

3D Model

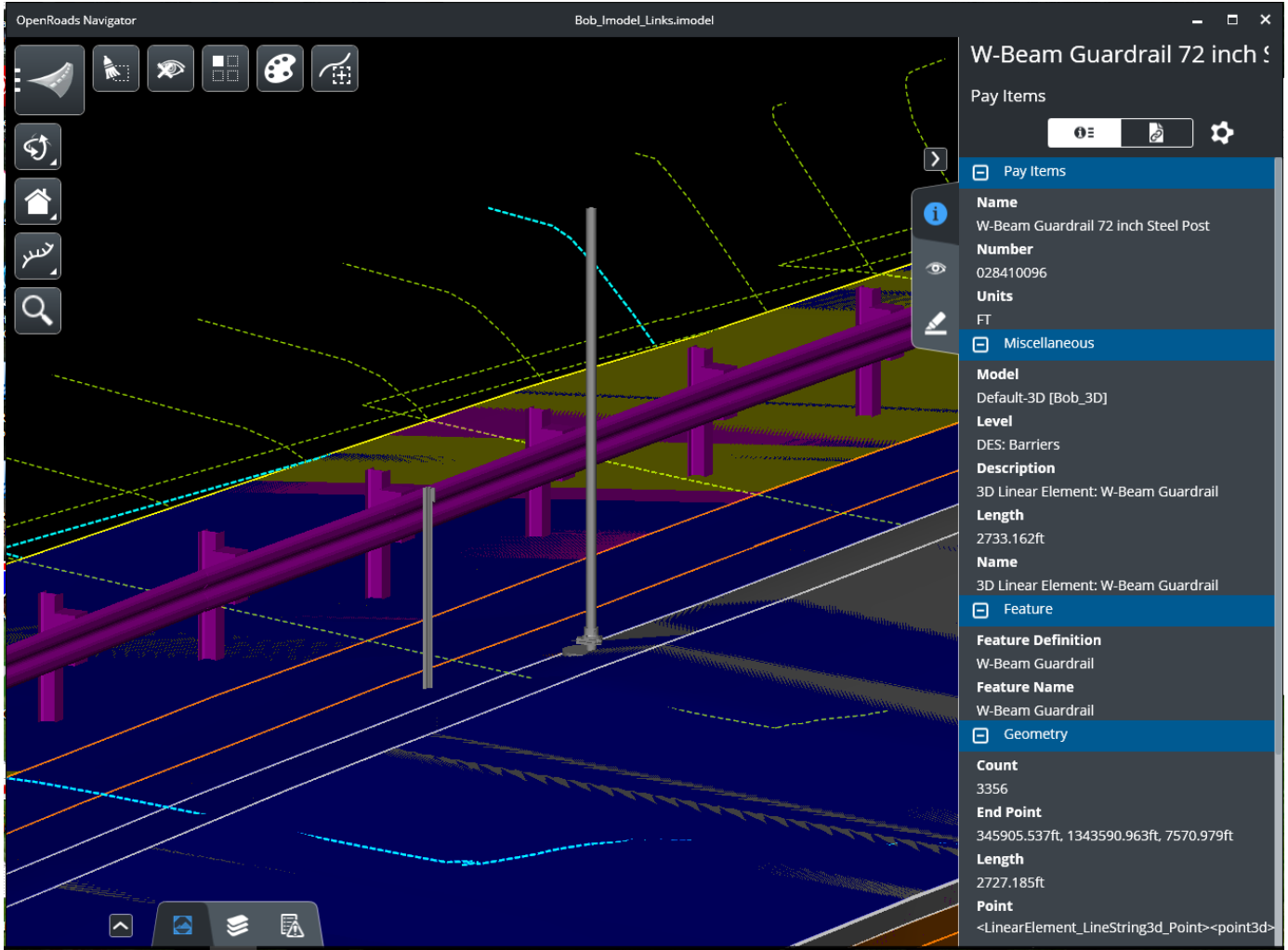
- Design model is awarded as the legal document.
  - ❖ Files for contractors are provided as For Information Only.
  - ❖ Contractor builds own 3D model at risk.
  - ❖ Contractor loads contractor's model on AMG or uses digital survey network
  - ❖ Sheet production For Information Only

******soon, BIM platform will allow design models to be published to a database, contractors open model (from the database) in their software.***

TRANSITION/TOMORROW

3D Model

- Contractor's 3D model is at risk. Contractor may choose to validate by:
  - ❖ Plan set (if available)
  - ❖ Develop staff fluent in agency software to compare w/contractor's model
- Models loaded on rovers/mobile devices for construction crews
  - ❖ Discontinue sheet production
- Database at the center of the project as one source of the "truth."
  - ❖Trimble, Esri, Autodesk, Bentley all rolling out solutions


OpenRoads Navigator
Bob_Imodel_Links.imodel
W-Beam Guardrail 72 inch S
Pay Items
Pay Items
Name
W-Beam Guardrail 72 inch Steel Post
Number
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Units
FT
Miscellaneous
Model
Default-3D [Bob_3D]
Level
DES: Barriers
Description
3D Linear Element: W-Beam Guardrail
Length
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Name
3D Linear Element: W-Beam Guardrail
Feature
Feature Definition
W-Beam Guardrail
Feature Name
W-Beam Guardrail
Geometry
Count
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End Point
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Length
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Point
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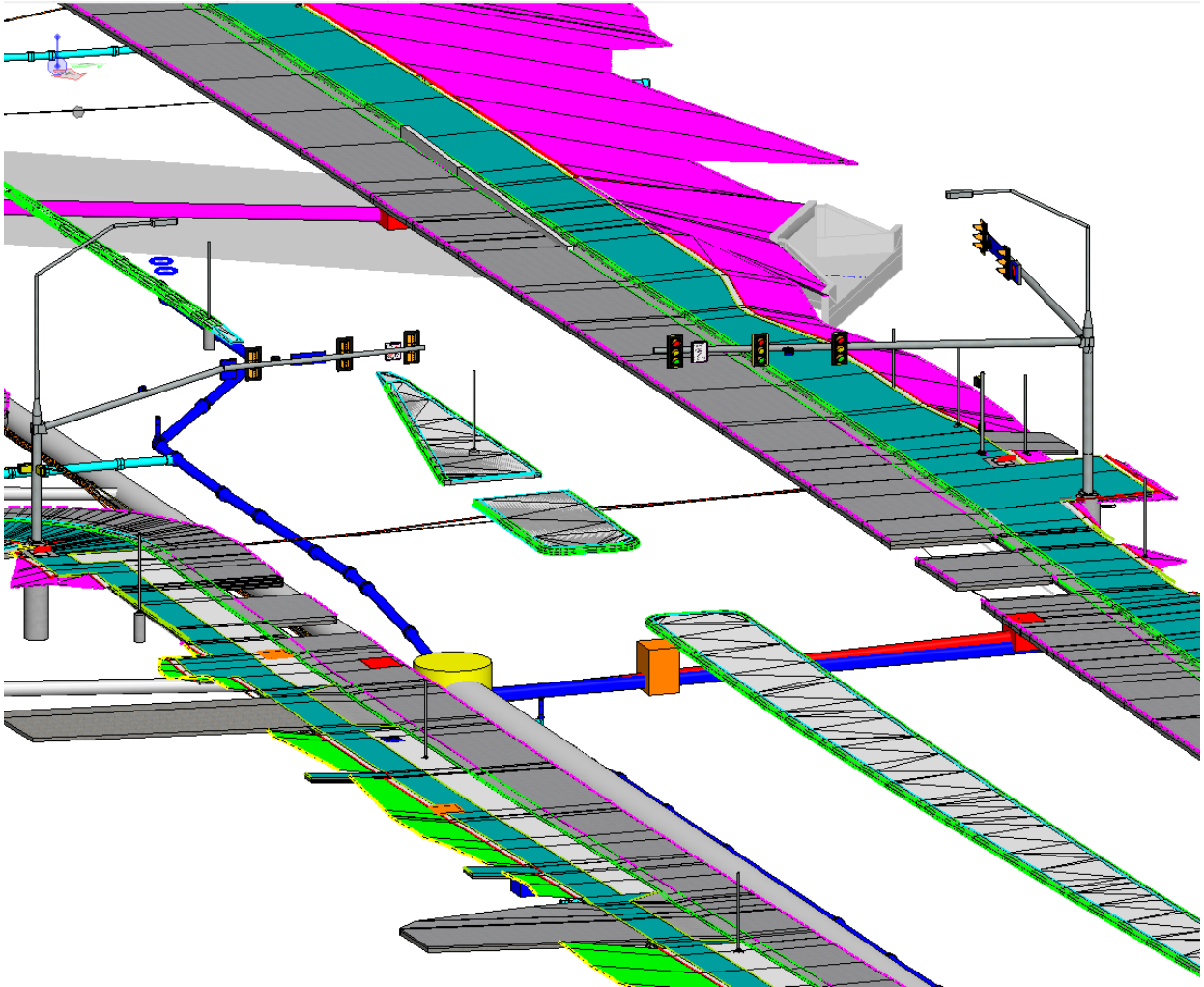
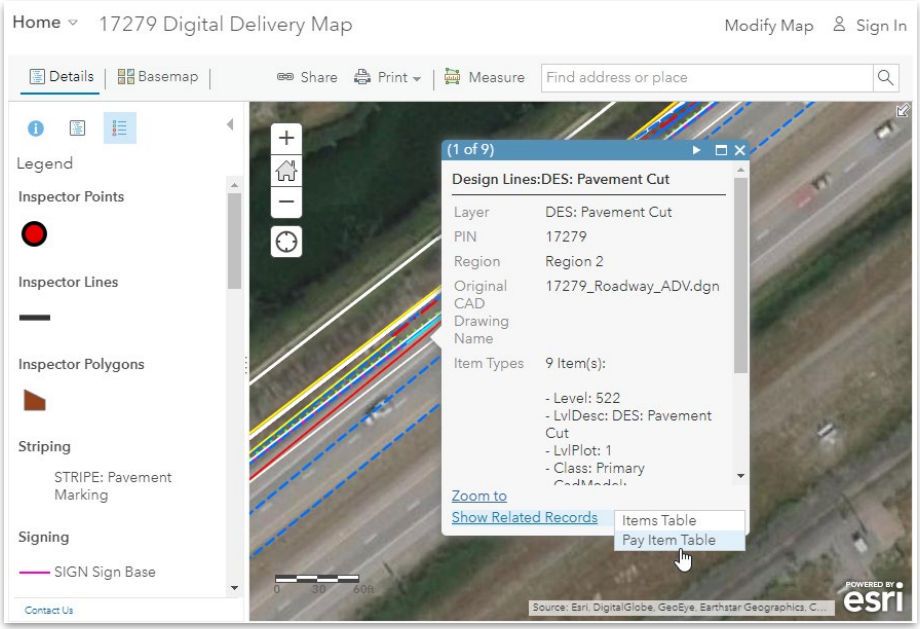


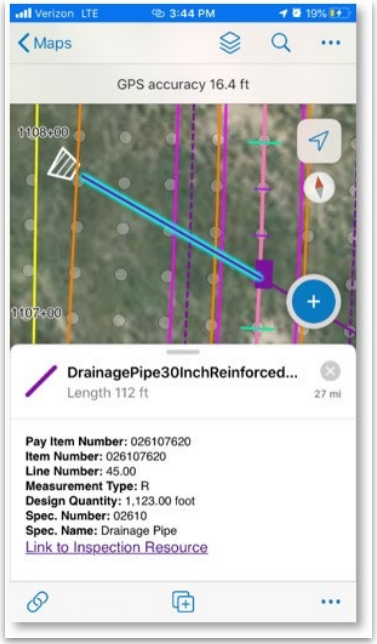
CONSTRUCTION

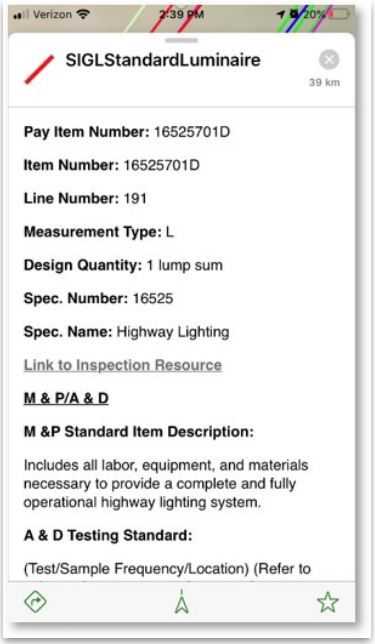
TRANSITION/TOMORROW

Esri: Uplan Map



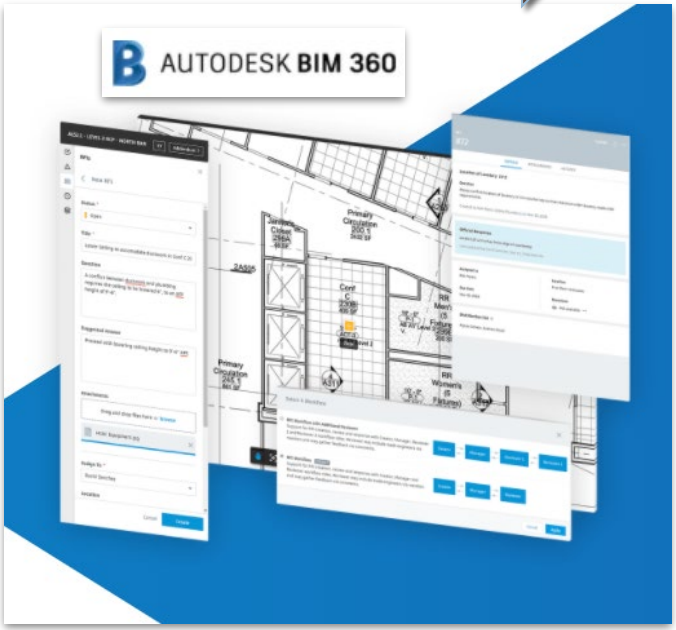
Esri: Collector





CONSTRUCTION

TRANSITION/TOMORROW

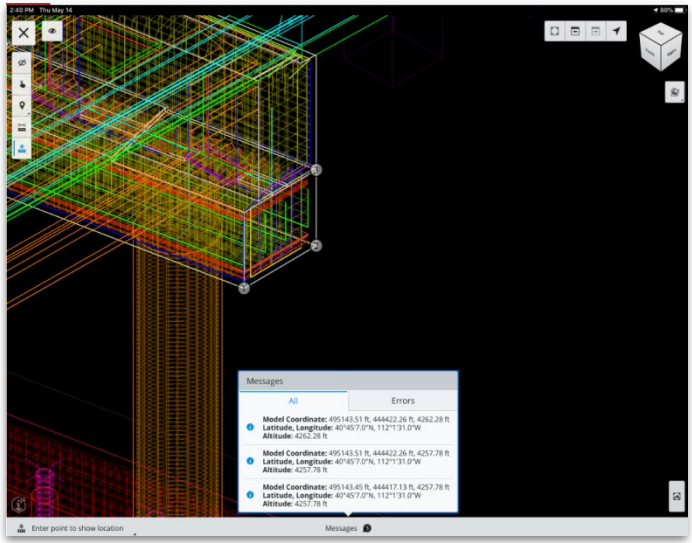


https://www.autodesk.com/bim-360/

https://sitevision.trimble.com/urban-transportation-planning/

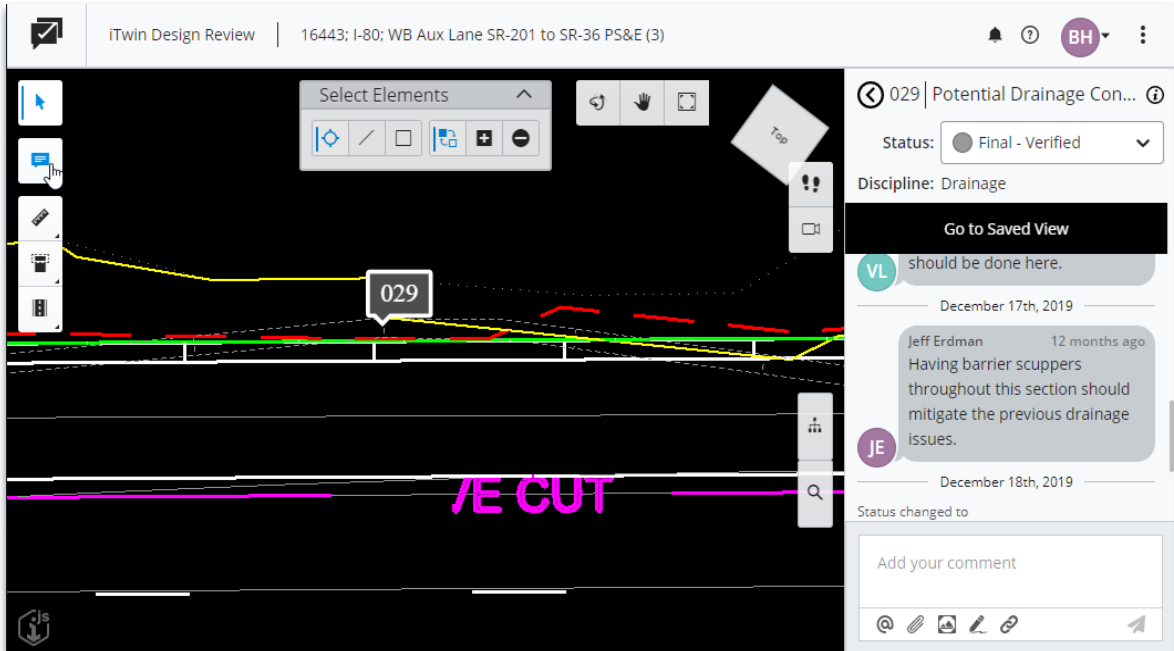
CONSTRUCTION

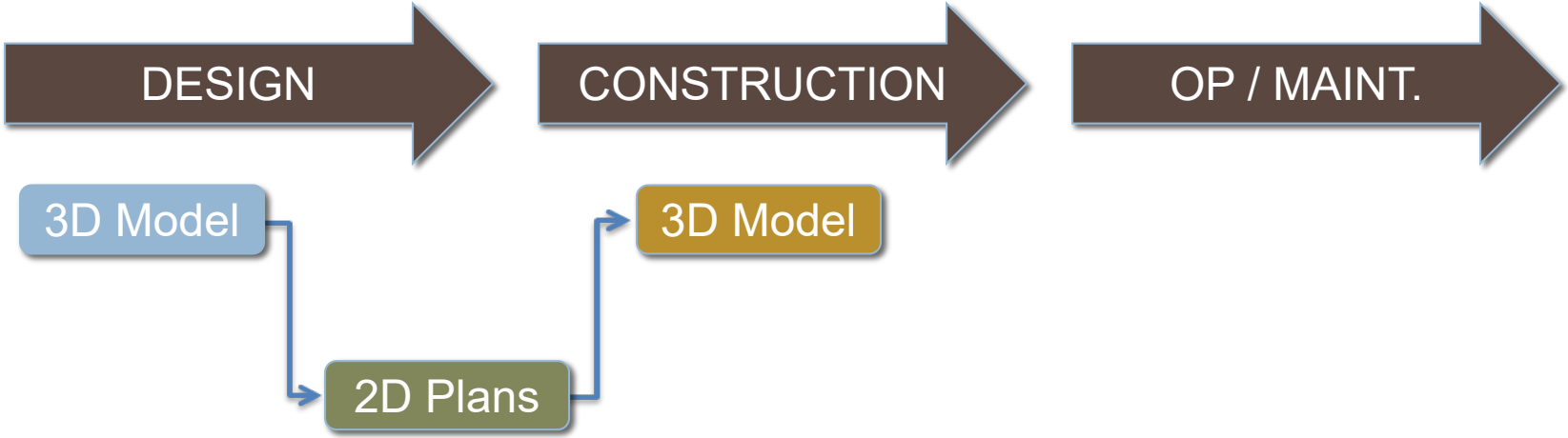
Bentley Synchro



TRANSITION/TOMORROW

Bentley iTwin Review

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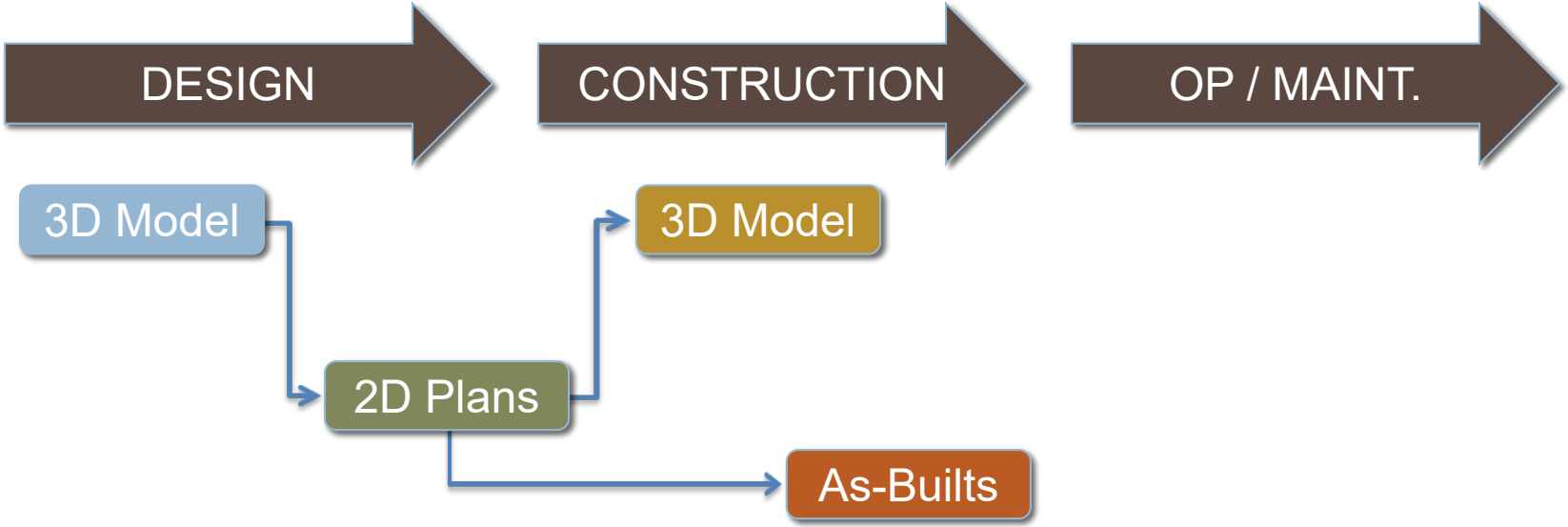
DESIGN
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2D Plans
3D Model
As-Builts

CONSTRUCTION

TODAY/TRADITIONAL

As-Builts

- Plan set is field modified (pen/sharpie, etc.)
- Paper is filed or
- Paper is scanned and put in document management system

CONSTRUCTION

TRANSITION/TOMORROW

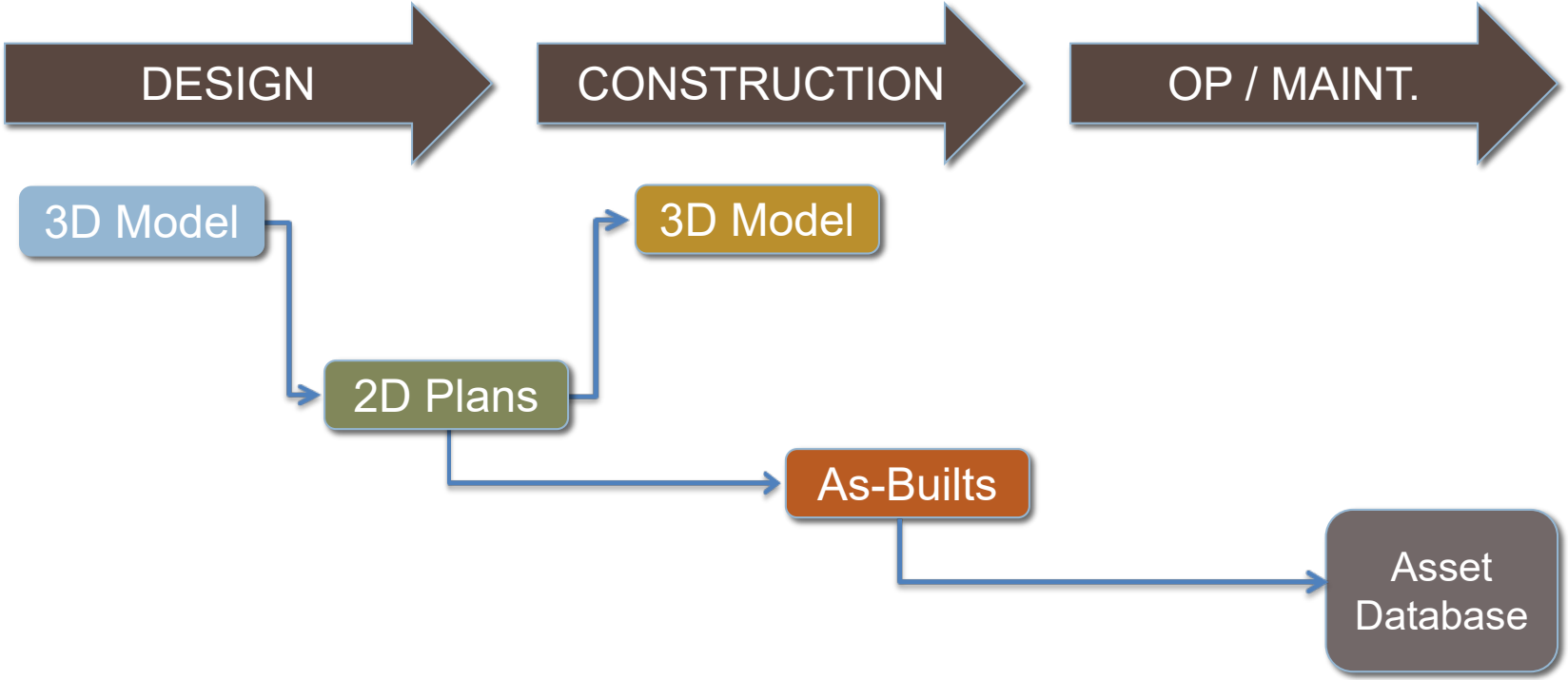
As-Builts

- Drones
  - ❖ Surfaces (validate by draping over design surface – heat map)
  - ❖ Images (future visual)
- Terrestrial and Mobile LiDAR
  - ❖ Point cloud Imagery (3D representation of finished product)
- Mobile devices – loaded with design 3D model (MALD)
  - ❖ Validate design information – populate database
  - ❖ Document field changes – populate database


UAS
Unmanned Aerial Systems
UDOT
Keeping Utah Moving

TRANSITION/TOMORROW

As-Builts


DESIGN
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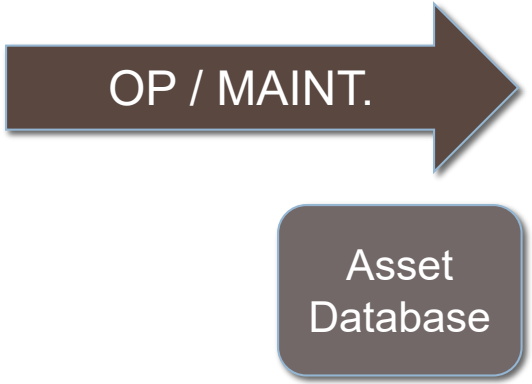
As-Builts
Asset Database



TODAY/TRADITIONAL

- As-builts made available to maintenance
- Asset Management has various systems for tracking and maintenance

TRANSITION/TOMORROW

Asset Database

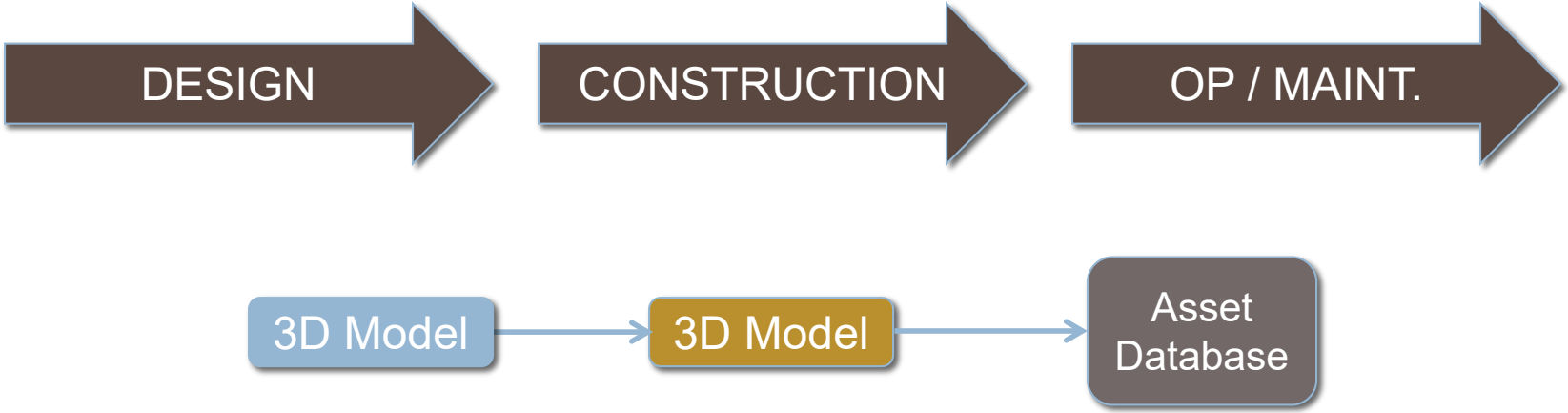
- 3D as-constructed models consumed by MMS
- Enterprise geo-databases hold project information – populates asset management system
- Layer existing GIS platforms to see history of site


DESIGN
CONSTRUCTION
OP / MAINT.

3D Model


DESIGN
CONSTRUCTION
OP / MAINT.


3D Model
3D Model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Asset Database

Digitaldelivery.udot.utah.gov

Digital Twins and Smart City Impact on Design, Build, and Management of Transportation Projects

Ron Perkins

What is a Digital Twin and how can we prepare ourselves for the future of Smart Cities?

Digital Twin

What?

A digital twin is a virtual model of a process, product or service. This pairing of the virtual and physical worlds allows analysis of data and monitoring of systems to head off problems before they even occur, prevent downtime, develop new opportunities and even plan for the future by using simulations.

Forbes

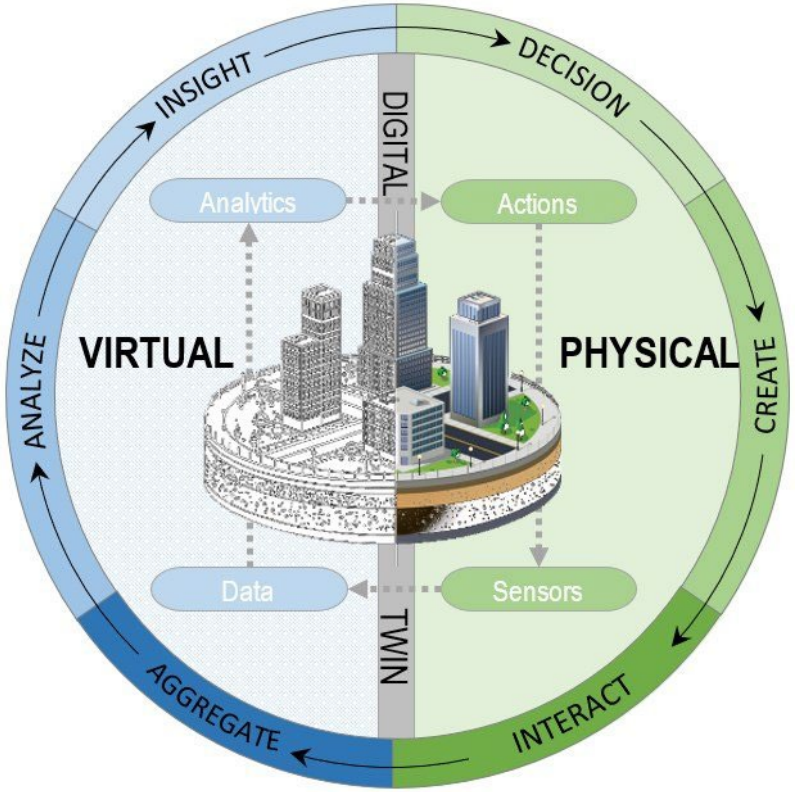
Digital Twin

Why?

If policy makers and businesses get it right, linking the physical and digital worlds could generate up to $11.1 trillion a year in economic value by 2025.

McKinsey&Company

Digital Twin ecosystem



Digital Twin for Construction

Digitization: The most basic level, essentially converting analog data to digital format. This acts as the base for all the other upper levels. It comes with limited benefits like better document management, enhanced security features etc. which have become an operation necessity now a days. All the technologies like digital document managements etc. lie in this category.

Visualization: This level essentially helps us to visualize what is happening in the world in a better way. This may include wireless monitoring, Augmented reality/Virtual Reality, BIM, Drone technology etc.

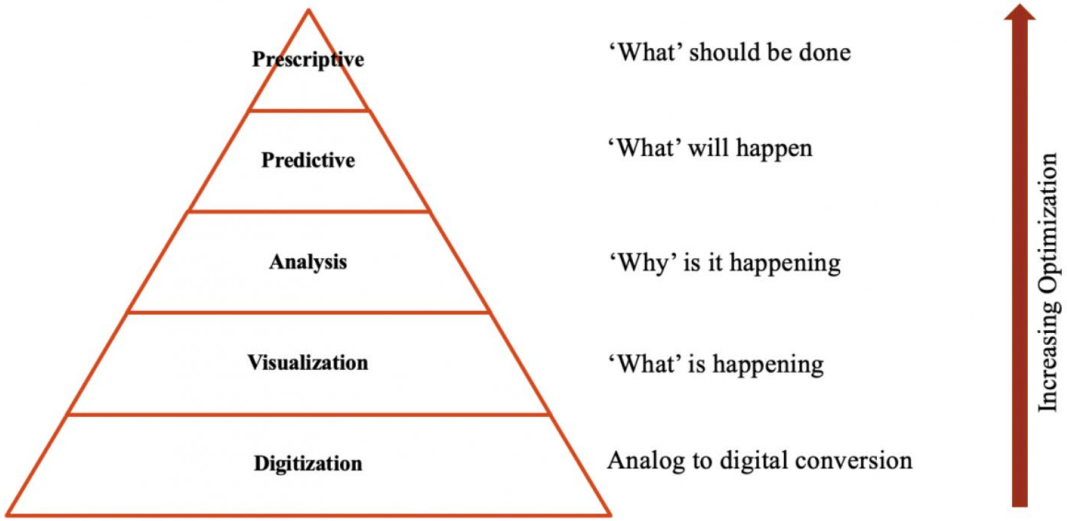
Analysis: Here we start to get insights from the data and are answering the questions around why certain things or situations are occurring. Data analysis become a common part at this stage. The progression towards a digitally mature organization starts happening at this stage. All the basic data analytics, parametric methods etc. lie in this zone.

Prediction: Here we start answering what will happen in the future and make decisions according to that. All the generative methods, design simulations, artificial intelligence algorithms come at this level.

Prescriptive: Finally, here the machine starts recommending us what is the ideal thing to for a given situation therefore reaching the maximum degree of sophistication possible.

Stanford | ENGINEERING

Levels of Digitalization



CIFE
CENTER FOR INTEGRATED FACILITY ENGINEERING

EDC-6 Innovations (2021-2022)

U.S. Department of Transportation
Federal Highway Administration

DIGITAL AS-BUILTS

Using digital data such as 3D models to build road projects is becoming an industry standard. Sharing the design model and associated digital project data allows agencies and contractors to streamline project delivery and contract administration and to collaborate on challenges "virtually" before they get to the field. The digital information is further leveraged when the model is updated, and other data incorporated, to reflect the project's as-built condition for future maintenance, asset management, and rehabilitation activities.

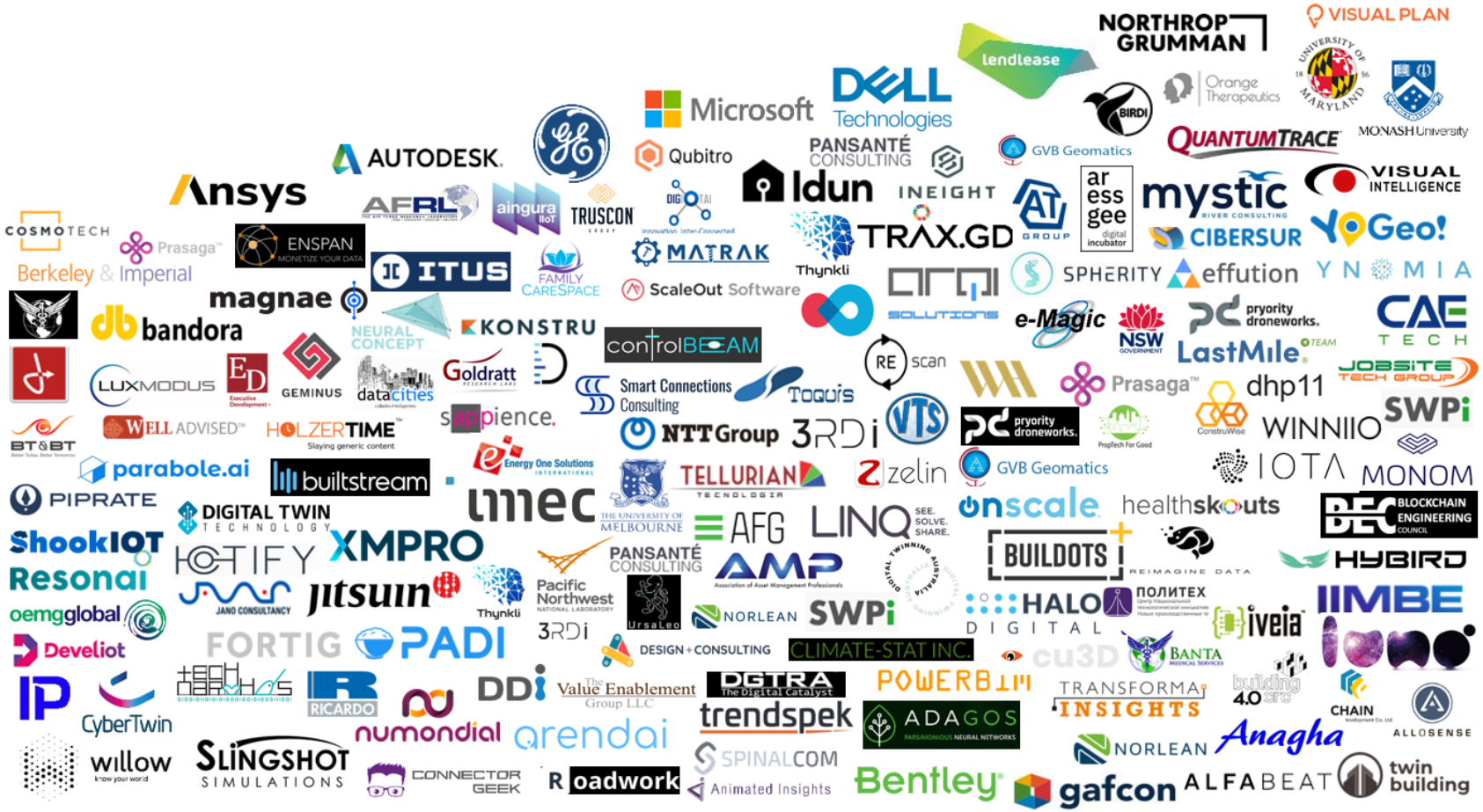
Benefits

- **Safety.** Construction using digital information can lead to safer projects and shorter work zone traffic impacts.
- **Time Savings.** Digital information provided to construction enhances planning and can streamline project delivery. Digital as-builts including utility locations and other asset information will improve post-construction decisions and shorten future project delivery.
- **Quality.** Digital as-builts can provide enhanced historical data, enabling State DOTs to better maintain the transportation infrastructure and develop future projects.

State of the Practice

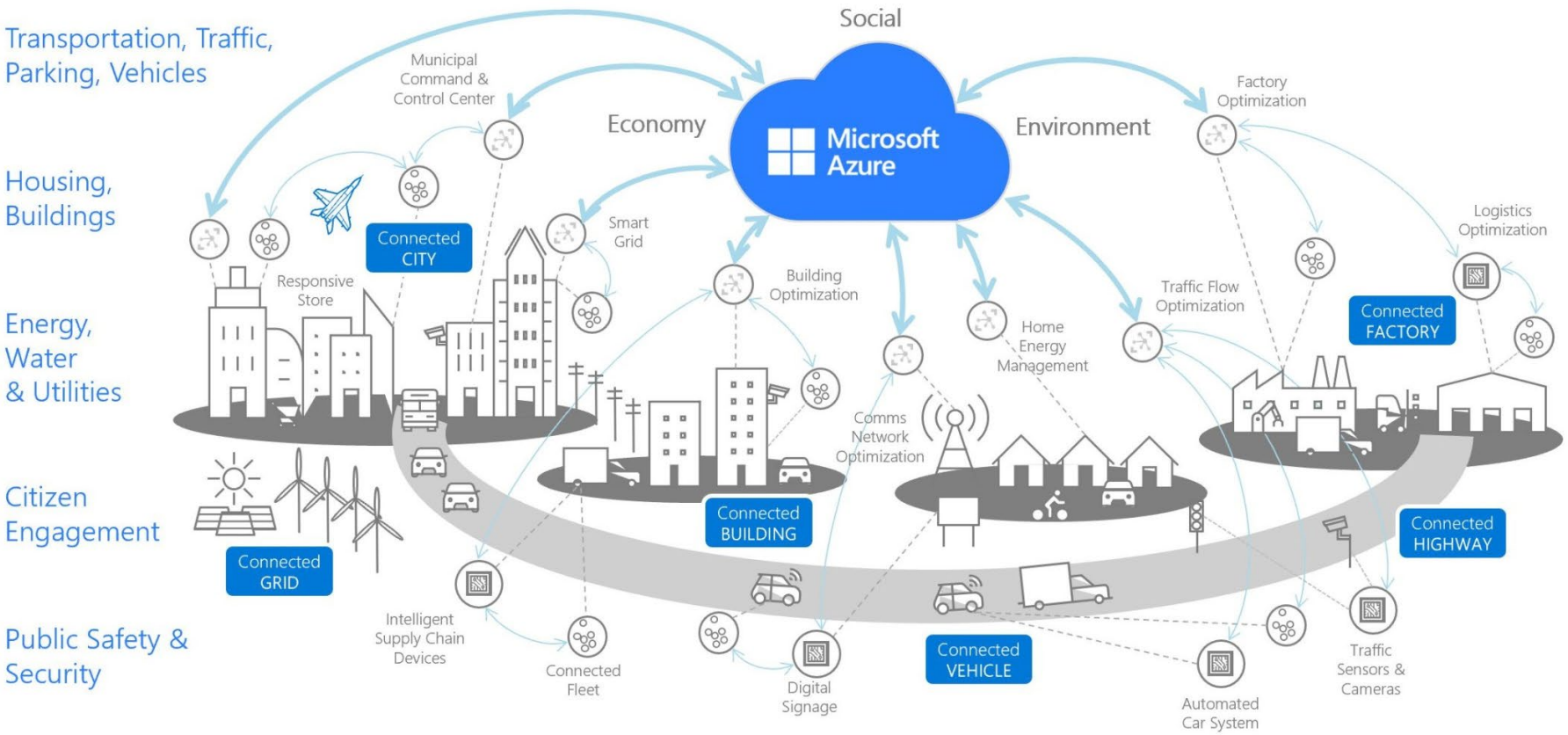
The Iowa, Minnesota, and Utah DOTs are recording as-built information on assets during construction. Michigan DOT is developing a digital as-built approach for utilities during permitting. Several States, including Oregon, Indiana, Montana, and California, are working to incorporate digital data into more effective construction delivery and management workflows. DOTs in New York, Iowa, and Utah are providing contractors enhanced contract documents using the 3D model as they consider more integrated and streamlined approaches to project delivery.

digital twin™
CONSORTIUM



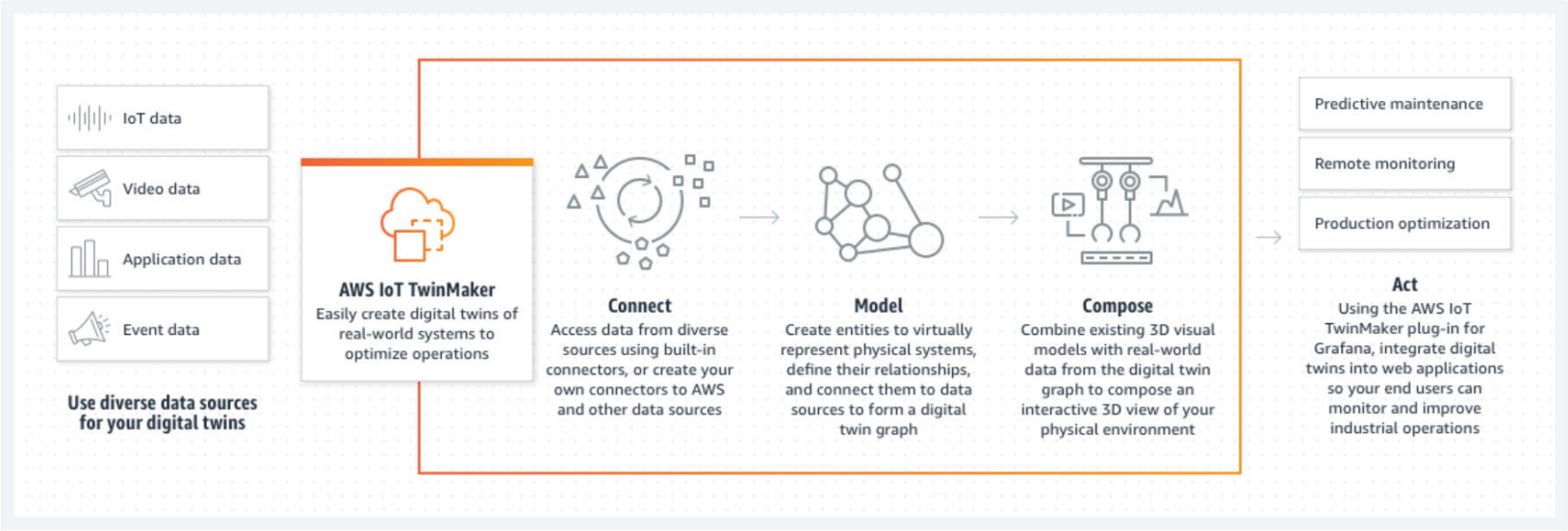
- The Digital Twin Authority
- Define Standards
- Identify Gaps
- Publish Research
- Drive Adoption
- Propel Innovation
- Accelerate the Market
- Partner – Industry/Academia/Government

Microsoft Azure
Digital Twins



aws

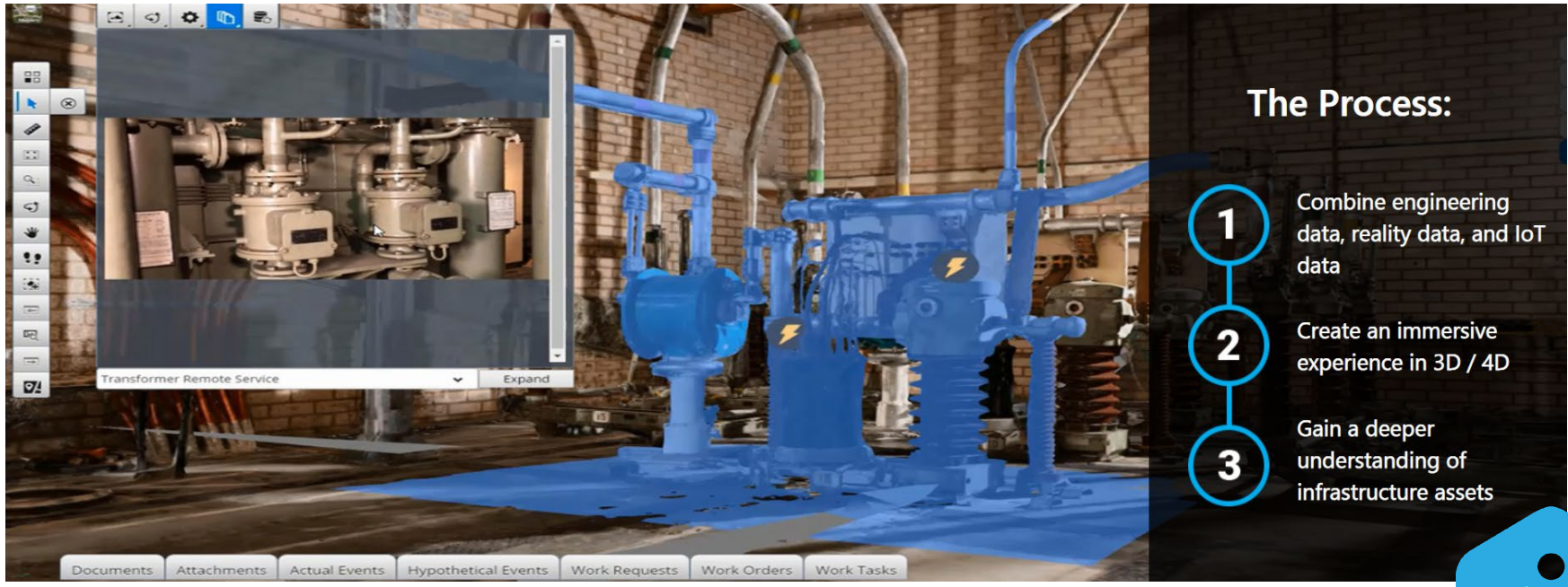
IoT TwinMaker



AWS IoT TwinMaker makes it easier for developers to create digital twins of real-world systems such as buildings, factories, industrial equipment, and production lines. AWS IoT TwinMaker provides the tools you need to build digital twins to help you optimize building operations, increase production output, and improve equipment performance. With the ability to use existing data from multiple sources, create virtual representations of any physical environment, and combine existing 3D models with real-world data, you can now harness digital twins to create a holistic view of your operations faster and with less effort.

Bentley
Advancing Infrastructure

iTwins



Digital Twins: Better planning, delivery, operation, and maintenance of infrastructure assets

Bentley®
iTwin Ventures

The Fund

- $100M fund
- Typical investment size: $1M to $5M initial investment
- We reserve capital for future financing rounds
- We aim to co-invest with top-tier venture capital investors, as a lead or follow-on investor

Solution Capabilities

- Asset Management & Performance (condition assessment; performance optimization; predictive maintenance; information security)
- Engineering, Design & Construction (design optimization; scenario-based simulation; construction simulation; real-time collaboration; automated / continuous surveying; immersive visualization / geo-spatial modeling)

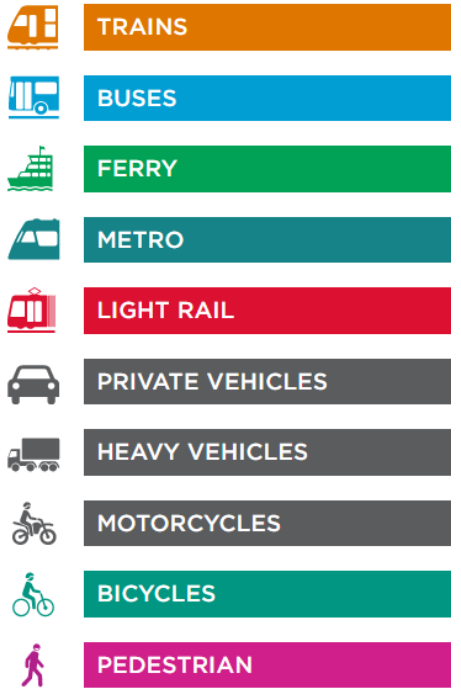
MEMBER digital twin CONSORTIUM Member since 2020

New South Wales Transport | Australia

NSW GOVERNMENT Transport for NSW

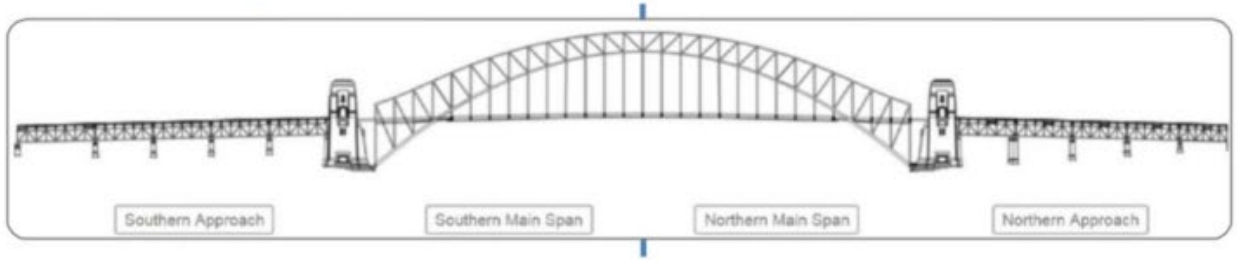
We lead the development of safe, integrated and efficient transport systems for the people of NSW. Our customers are at the centre of everything that we do, including transport planning, strategy, policy, procurement and other non-service delivery functions across all modes of transport - roads, rail, ferries, light rail and point to point.

CASE STUDY Sydney Harbour Bridge



NSW GOVERNMENT | Transport for NSW

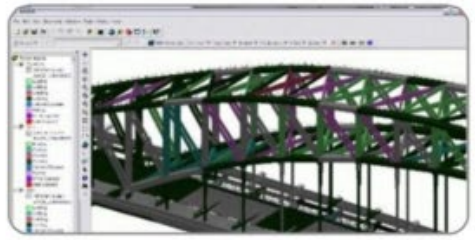
CASE STUDY Sydney Harbour Bridge



- Opened 1932
- 100 yr design life
- 1.15km main span
- 3500 elements



- The SHB bus lane (Lane 7) takes the highest traffic load
- Previously substructure jack arches were inspected at 2 year intervals
- In 2014 Data61 & Cisco developed an IoT monitoring system for the bridge
- 3 low cost tri-axial MEMS accelerometers have been installed on each of the 800 jack arches supporting Lane 7 i.e. 2400 sensors in total
- Monitoring now conducted 24/7, enabling early defects to be detected
- Further benefits achieved with Machine Learning and predictive analytics
- Links: YouTube (3 min) & Data61 website

- Previously the SHB maintenance crew completed maintenance and inspections with paper records and outdated software
- In 2009 RMS developed Baasis (Bridge and Asset Spatial Information System), which is a complete 3D model of the SHB on ERSI ArcGIS.
- This model enables off-site inspections and is used to track the condition of individual elements e,g, structural and fatigue capacity, paint condition etc
- Routine maintenance is now prioritised based on specific element condition, average condition, accessibility or visibility to the public.
- It also helps to identify 'hot-spots and predict future condition of bridge

NSW GOVERNMENT | Transport for NSW

CASE STUDY Sydney Harbour Bridge

Lesson	Details
1. Not just an IT project	• New technology alone won't achieve results. This is more about organisational change. • IT is an important element, however DE must be led from within the business
2. Appoint a sponsor	• Someone with appropriate seniority, who gets it and owns it • Possibly from numerous business groups e.g. PMO, Technical, Asset Mgmt etc
3. Appoint a champion	• Someone in-house (to retain knowledge) with dedicated capacity & understands agency • Someone who can wear numerous hats e.g. strategic, technical, political, comms, sales etc
4. Effective working group	• Attract diverse membership from across key business units/projects • Not just interest group. Must have senior level membership and buy-in
5. Need a vision	• Be creative and build a vision that will attract talent and inspire the team to achieve • The vision should dream big, but should also align the team and support business objectives
6. Staged funding and delivery	• Funding is essential to build a team of in-house capability coupled with industry expertise • Develop a long-term strategy, considering staged funding and key milestones/ assurance gates • Also address immediate issues e.g. consistent procurement of basic deliverables

NSW GOVERNMENT | Transport for NSW

CASE STUDY Sydney Harbour Bridge

Lesson	Details
7. Consult, consult, consult!	• Map the current landscape and develop roadmap towards future state inc. initiatives & interfaces • Constant engagement with key stakeholders, to educate and bring them along the journey
8. This is a journey	• Working group(s) won't have all the answers straight away • Business change is complex, with many feedback loops and "unknown unknowns"
9. Seek advice	• Seek out case-studies to identify best practice and pockets of excellence • Consult with your supply chain to understand current capability, strengths, future plans etc • Learn from individuals and organisations that have already made progress on this journey
10. Industry specialists	• "BIM Managers" don't have all the answers. Check their background e.g CAD, architects etc • BIM solutions for vertical buildings currently don't necessarily apply to linear infrastructure • Need consultants who have a blend of technical understanding and 'business acumen'
11. Global innovation	• Developments are evolving at a rapid pace e.g. technologies, IoT, best practice etc • Maintain awareness of emerging innovations e.g. Digital Twin, Smart Infrastructure, Smart Cities
12. Create sense of urgency	• Industry is seeking leadership from government clients. Now is the time to act! • See HBR paper: *"Leading Change - Why Transformation Efforts Fail" by JP Kotter (1995)*

State Infrastructure Strategy (SIS) – commenced 2/18

Infrastructure NSW
State Infrastructure Strategy
2018–2038
(Released Feb 2018)

Infrastructure Data Management Framework

(Release TBC 2020)

NSW Spatial Collaboration Portal

(Released Apr 2020)

NSW Digital Twin

(Released Feb 2020)

Smart Places Strategy

(Released Aug 2020)

Digital Built NSW (Business Case)

(Release TBC 2020)

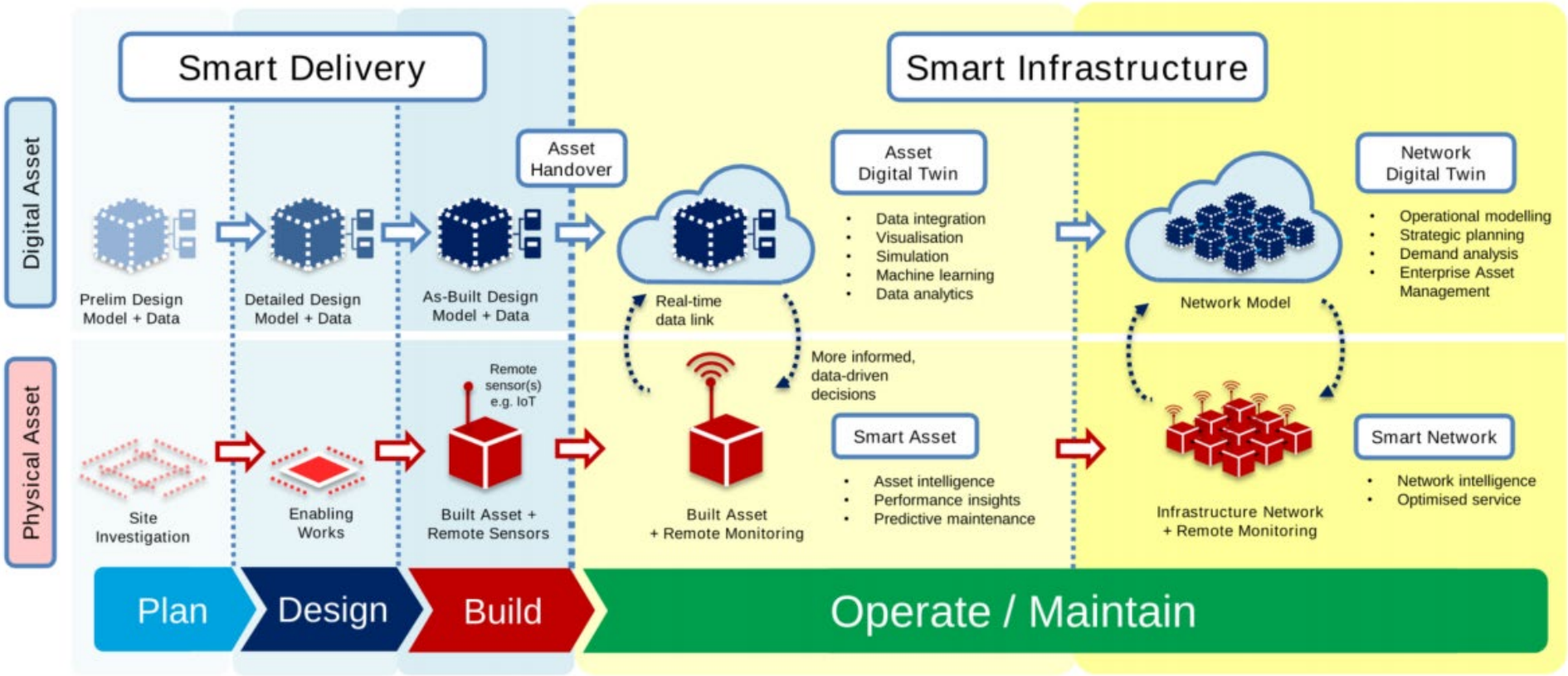
IoT Policy and Guidance

(Released Oct 2019)

Smart Infrastructure Policy

(Released July 2020)

Physical and **Digital Assets**



Smart Infrastructure: Enabled with IoT

CONSTRUCTION

1. Drone-based digital site capture, recording and reporting
2. Real-time progress and performance e.g. labour hours, plant usage, completion etc
3. Tracking of plant, personnel and activities
4. Pollution e.g. air, dust, noise, vibration etc
5. Environmental and hazardous conditions
6. Geo-fencing and workplace isolation
7. Prefab positioning/installations
8. Tracking of asset installations
9. Geo-location of new assets
10. Autonomous plant and machine control
11. Waste management
12. Temporary works monitoring e.g. excavations, tunnel sites etc
13. Worksite security and deterrence
14. Worker PPE, wearables and biometrics

ASSET MANAGEMENT

1. Remote/Structural Health Monitoring (Civil, Mechanical, Electrical) e.g. Service, Damage, Fatigue, Cathodic protection
2. Real-time status, conditions, observations and reporting e.g. weather conditions, rainfall
3. Fault detection of elements and machinery
4. Parts and Inventory management
5. Geolocation of mobile assets
6. Big-data, trends and root cause analysis
7. Machine Learning, AI enabled insights and response
8. Real-time updates to enterprise asset management platforms
9. Remote control of actuators/devices (possible links with OT? Remote Control/Automated)

OPERATIONS

1. Timetable performance
2. Patronage performance
3. Congestion tracking
4. Signalling systems
5. Intelligent transport systems
6. Smart motorway systems
7. Smart traffic lights
8. Wayfinding and signboards
9. Revenue collection
10. Safety and security
11. Worker fatigue tracking

TEMPERATURE

TEMPERATURE 3 FOOT PROBE

RTD HIGH TEMPERATURE

RTD LOW TEMPERATURE

DUCT TEMPERATURE

WATER TEMP

4X QUAD TEMPERATURE

THERMOCOUPLE

HUMIDITY

WATER DETECT

WATER ROPE

MOTION DETECTION

OPEN / CLOSED

DRY CONTACT

0-200 VDC 0-200 VOLT METER

0-500 VOLT VOLTAGE METER

0-20 AMP AC CURRENT METER

150 AMP AC CURRENT METER

1-50 VDC 1-50 VOLT DETECT

24-500 VAC VOLTAGE DETECT

0-20 mA 0-20mA CURRENT METER

SINGLE-INPUT PULSE COUNTER

BUTTON PRESS

ACTIVITY

TILT

IMPACT DETECT

G-FORCE SNAPSHOT

VIBRATION METER

LIGHT METER

ULTRASONIC

THREE PHASE CURRENT METER

PRESSURE

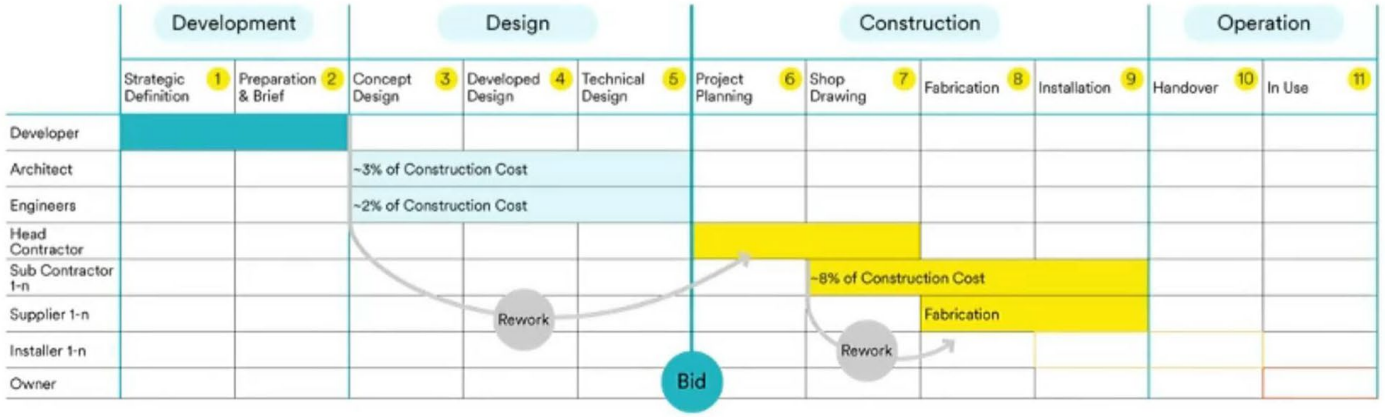
AIR VELOCITY

DIFFERENTIAL AIR PRESSURE

PM2.5 AIR QUALITY

Design and Construction Phase Process Shift

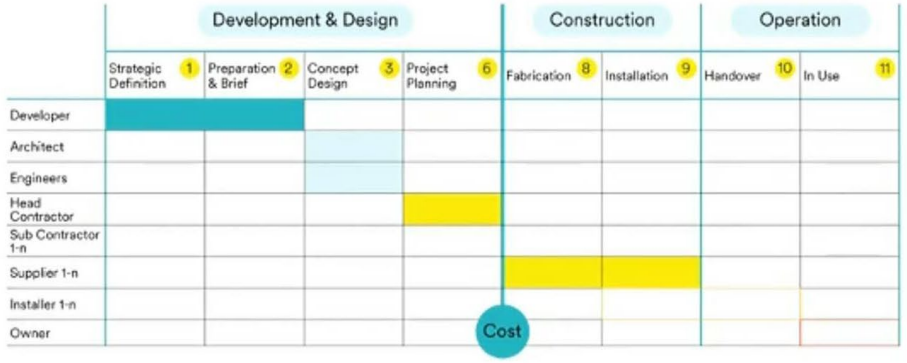
traditional approach



The Challenges to the traditional approach

- Design at planning stage carries cost risk
- At bid, the design is schematic and not fully resolved
- Tender spread is large and over-budget
- Not all consulting teams are novated resulting in loss of project knowledge and time in remobilizing
- Design work is repeated during construction at multiples of cost
- Errors are carried forward increasing management, costs and time

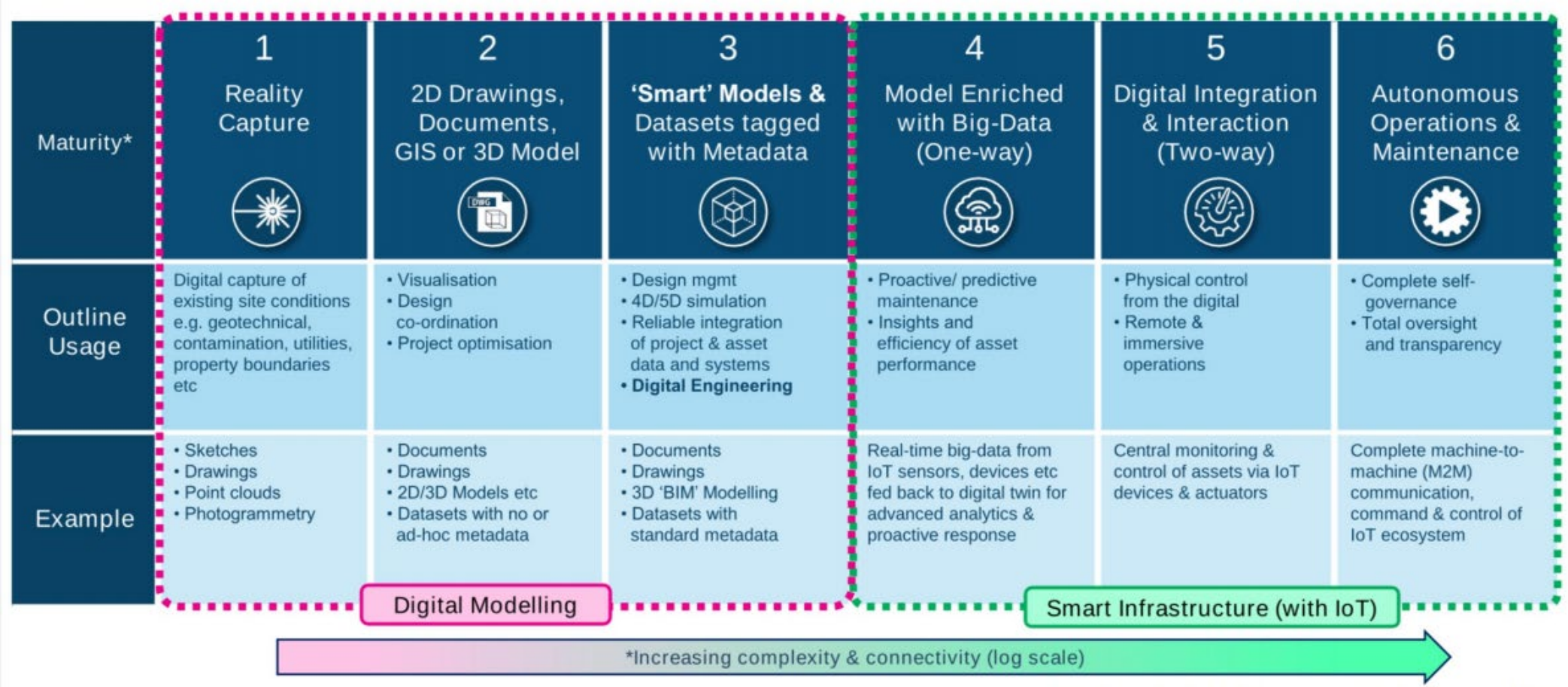
'Twin' approach



Improvements possible with a 'Twin' approach

- Design at planning is costed and scheduled
- Design at planning is comprehensive, prescriptive and resolved
- Supply Chain is engaged removing project and package tendering
- Knowledge is captured in digital processes for future projects
- Management, costs and time are reduced due to removal of design and coordination errors

Digital Twin Maturity



The Institution of Engineering and Technology

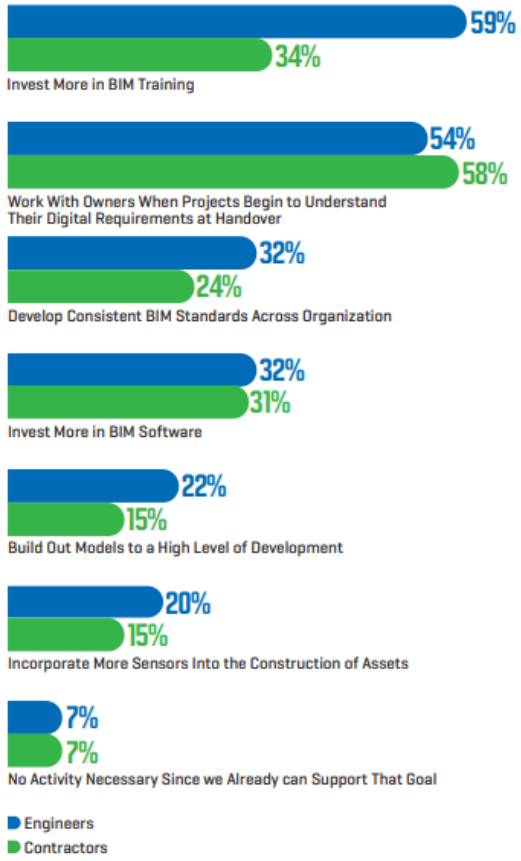
Actions Needed to Prepare for Owner Shift to Digital Twins

Civil engineers and contractors were asked how they would need to prepare to work with owners who are pursuing digital twins of their assets.

- Most of these respondents (93%) believe that they will need to take some actions to prepare for this, should it occur.
- Civil engineers placed the highest emphasis on investing in more BIM training and working with owners at project start to understand their digital requirements.
- Understanding the digital requirements of owners is also the top action reported by contractors by far, with 58% who regard this as important.
- In contrast, investing more in BIM training, which ranks second among contractors, was only selected by 34%.

Other than BIM software investments, which are selected by about one third of engineers and contractors, most of the other options, which include developing BIM standards, building out models to a high level of development and incorporating sensors, are selected by more engineers than by contractors. This may suggest that engineers have a better sense of what is needed to help owners build digital twins due to their wider use of BIM.

Actions Needed by Engineers and Contractors If Owners Want to Pursue Digital Twins of Assets



the road to
DIGITAL AS-BUILT

The starting point for Digital Twins is **e-construction**

e-Construction is the collection, review, approval, and distribution of highway construction contract documents in a paperless environment

- Transfer of electronic plans (supported under EDC-2, 3D Engineered Models for Construction) and electronic contract specifications and special provisions
- Mobile devices, software, and applications for field inspection and data collection Data hosting services (data clouds, share sites, virtual review rooms)
- Electronic review and approval processes (digital signatures/reviews)
- Communications tools (e-mail, text, social media, smart phones)
- Radio frequency identification (RFID) tags for resource tracking
- Asset management, electronic as-built drawings, and quality assurance records.

the road to
DIGITAL AS-BUILT

Field Data Collection

Digital Jobsite Workflow

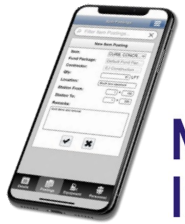
Visualize & Analyze Data

Leica Geosystems

Trimble

Command Alkon

EarthCam



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…and digital workflow solutions.

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+ Funding
+ Progress

Increase transparency and visibility by tracking all project activity in one hub, including contract management, funding info, field data collection, project progress, payments, and more.

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- Owners will increasingly demand for comprehensive Digital As-Builts to be provided at project handover
- Increasing number of designers and engineers are using BIM/CIM software and practices to start project on digital pathway
- Field data collection for progress monitoring, inspection and validation to the model and asset location is the foundation of Digital As-Builts.
- Assets included in Digital Twin require accurate location information and LIVE data access
- Digital As-Builts and 3D Models that incorporate LIVE data from IoT datapoints become the Digital Twin

Digital Twins and Smart City Impact on Design, Build, and Management of Transportation Projects

eConstruction + BIM + IoT = Digital Twin

+ Owner Demand
+ Process Shift
+ Model Design
+ Digital Project Site Workflow
+ Comprehensive Data Access
+ IoT Enabled Smart Infrastructure
+ Best Practices
+ Data Standards
+ Data Analytics
+ Self Governance

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