Technology for Transportation Infrastructure

Steve Jones
Senior Director, Industry Insights Research, Dodge Data & Analytics

OCTOBER 16, 2019

Presenter

DODGE DATA & ANALYTICS
See Ahead Think Ahead Stay Ahead

Steve Jones (steve.jones@construction.com)

- BA: Johns Hopkins University; MBA: Wharton
- 19 years in Architecture/Engineering
  - *Principal and Board of Directors of major A/E firm Burt Hill (now Stantec)*
- 4 years in Construction Technology
  - *Vice President, Primavera Systems (now Oracle)*
- 16 years with Dodge Data & Analytics (formerly McGraw-Hill Construction)
  - *Senior Director, Industry Insights Research*
  - *Focus on how technology advances and process improvements are impacting the global construction industry*

Dodge Data & Analytics

Dodge Construction Central

1st construction market & collaboration platform

Project intelligence & leads

Bid management

Firm intelligence

Competitive intelligence

Market analytics

Product analytics

Market forecast

Market research

Industry trends & insights

CRM integration

Brand awareness

Sweets.com

Leading source of information about building products

Industry Insights Research

DODGE DATA & ANALYTICS
See Ahead Think Ahead Stay Ahead

Quantify the business value and challenges of key trends that are impacting the industry

- *Technology and Information Mobility*
- *Managing Safety*
- *Managing Risk*
- *Sustainable Design and Construction*
- *Lean Design and Construction*
- *Project Delivery*
- *Managing Uncertainty and Expectations*
- *Key Business Metrics for Commercial Contractors (Quarterly reports)*
- *The Smarter Worksite (Annual report)*
- *More…….*

FREE RESEARCH REPORTS:
construction.com/toolkit/reports

Source: Dodge Data & Analytics – Benefits of BIM for Infrastructure, 2017, Business Value of BIM for Infrastructure SmartMarket Report (US, UK, Germany, France)

Industry Insights Research

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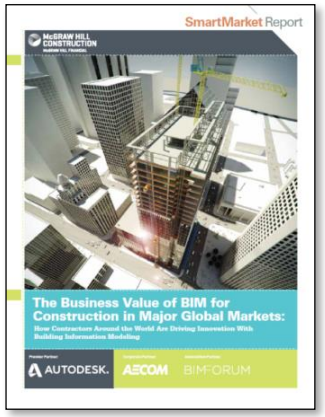
See Ahead Think Ahead Stay Ahead

Free Research Reports on Many Topics (construction.com/toolkit/reports)

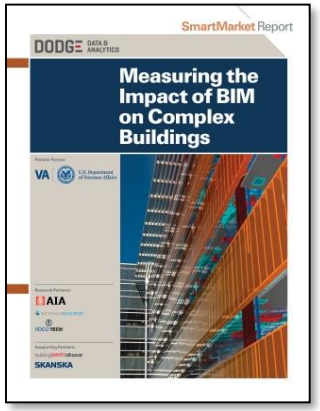
TECHNOLOGY/INNOVATION

Information Mobility

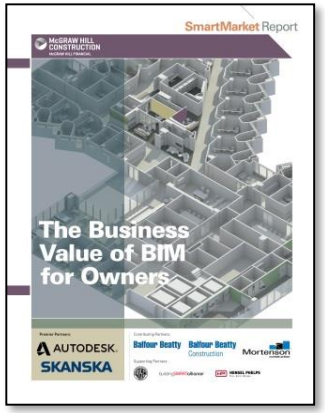
BIM for Contractors



Measuring BIM

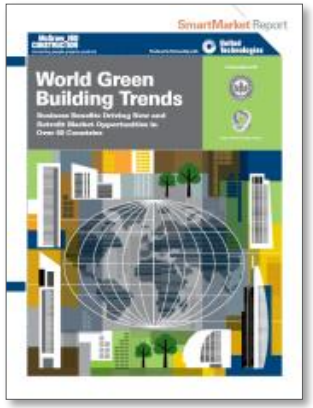


BIM for Owners



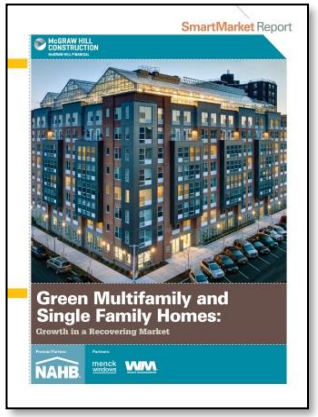
SUSTAINABILITY

World Green Trends



Design for Health

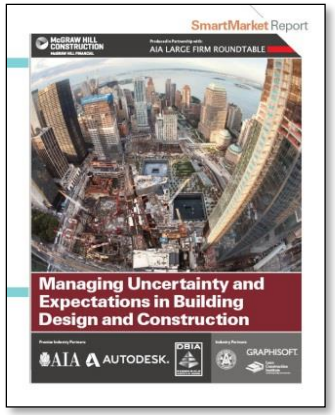
Green Homes



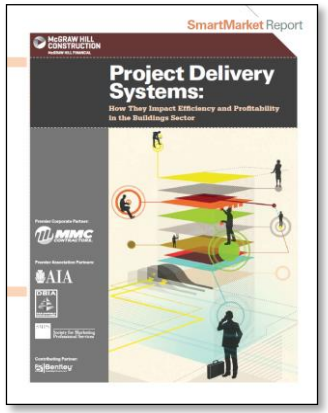
Green Schools

PRACTICES/PROCESSES

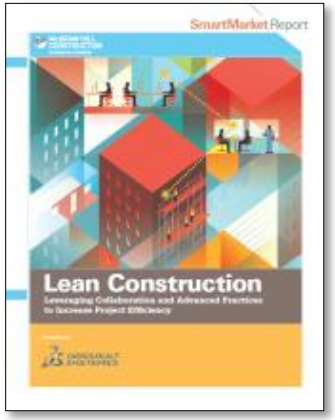
Managing Uncertainty



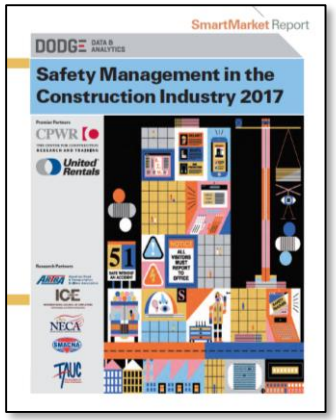
Project Delivery Systems



Lean



Safety (3x)



Industry Insights Research

DODGE DATA & ANALYTICS
See Ahead Think Ahead Stay Ahead

Modeling Technology for Transportation Infrastructure [*roads, bridges, tunnels, aviation, rail and mass

- Free 66 page report about a survey in four countries
  - US, UK, France and Germany
  - Engineers, contractors and owners that do transportation projects*
- Focuses on use of BIM for transportation projects*
  - Where, when and how BIM is being used (past, present, future)
  - Project and internal benefits
  - Investments, ROI
  - Why non-users aren't engaged, and what would trigger them
- Includes case studies, interviews and feature

(construction.com/toolkit/reports)

Source: Dodge Data & Analytics, Benefits of BIM for Infrastructure, 2016; Business Value of BIM for Infrastructure SmartMarket Report (US, UK, Germany, France)

Agenda

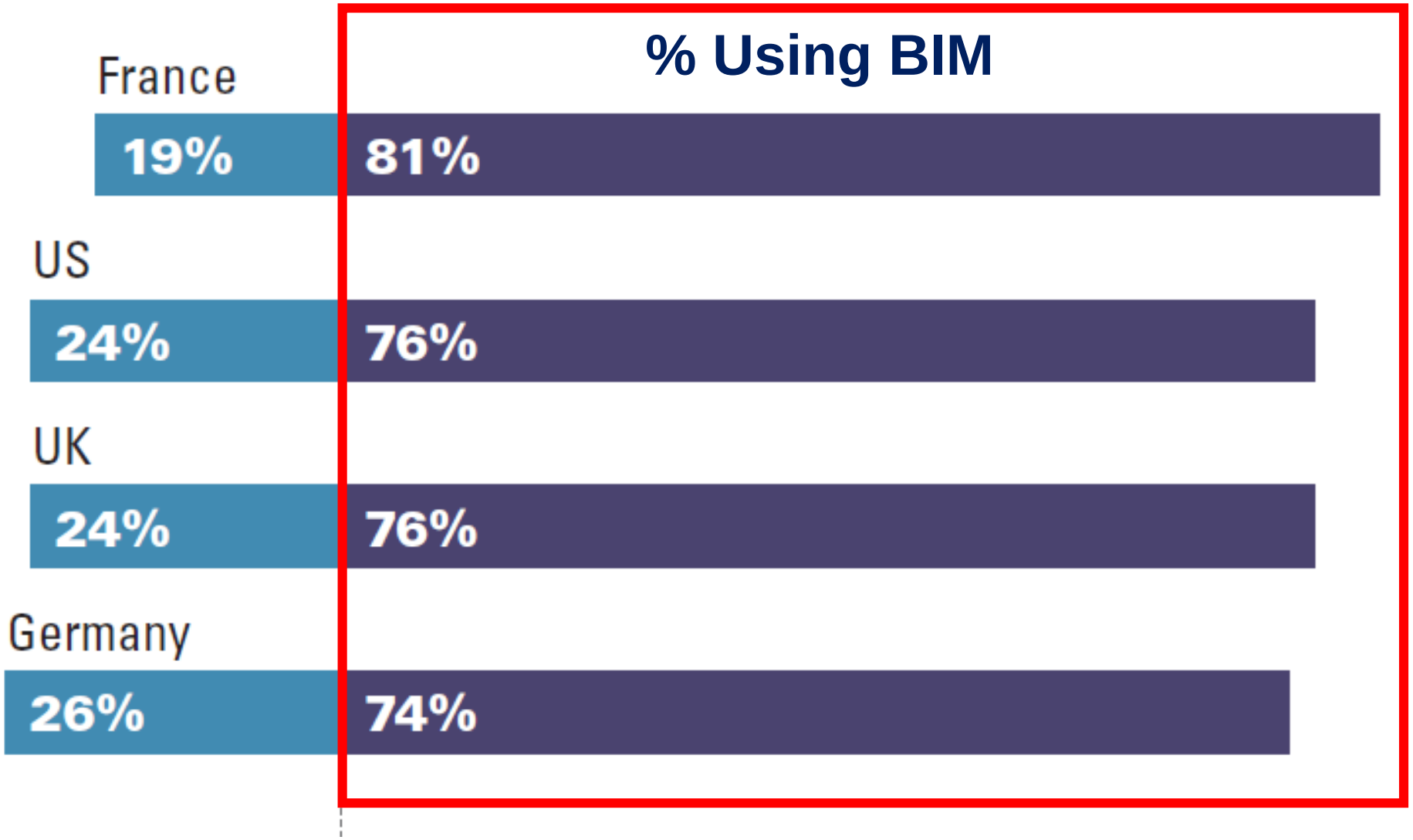
DODGE DATA & ANALYTICS
See Ahead Think Ahead Stay Ahead

- Impact of Modeling and Related Technologies on Design, Planning and Construction of Transportation Infrastructure
  - ***Adoption and Implementation***
  - ***Benefits (Project and Business)***
  - ***Uses of Technology that Generate Benefits***
  - ***ROI and Future Benefits***
  - ***Innovations and Emerging Uses of Technology***
  - ***Recommendations***

Adoption of BIM for Transportation Projects

DODGE DATA & ANALYTICS
See Ahead Think Ahead Stay Ahead

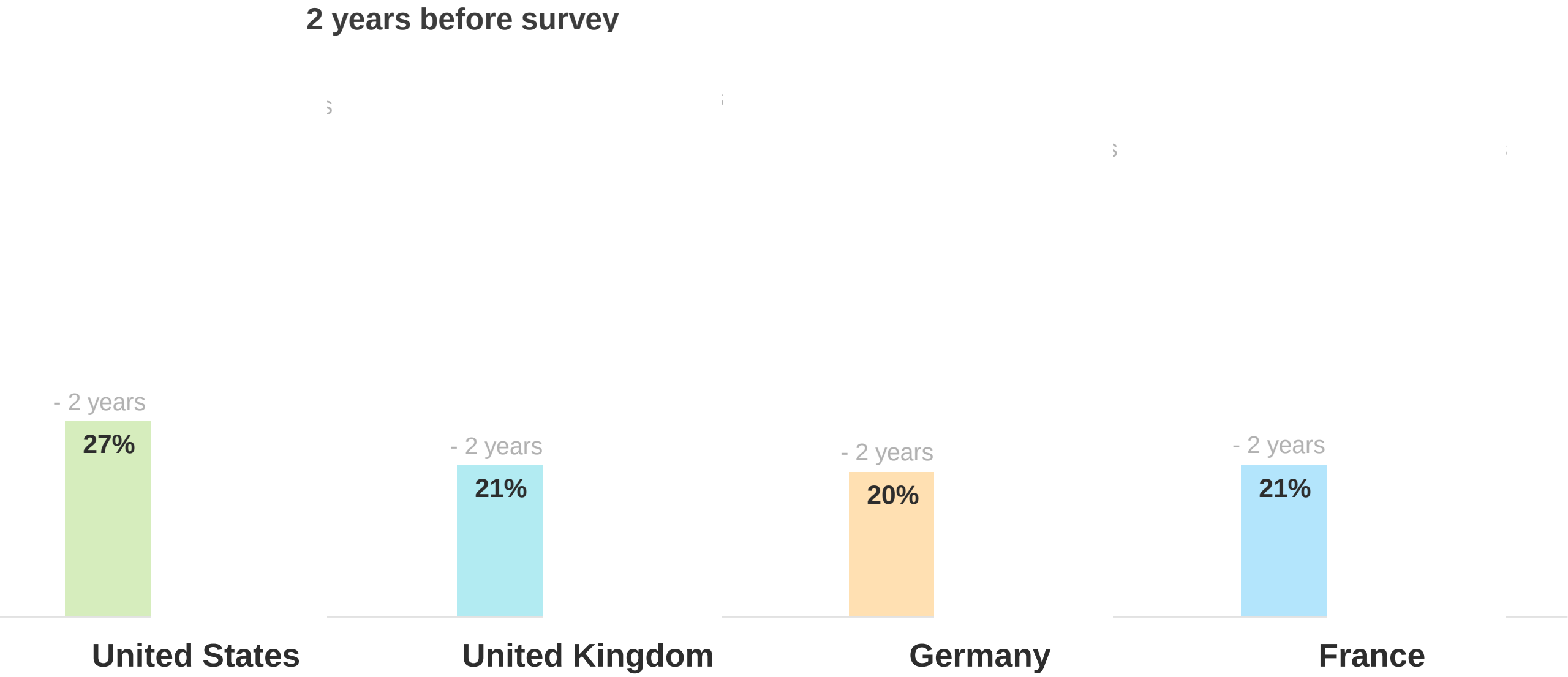
BIM processes and technologies are being used by **three quarters or more** of the survey respondents



Source: Dodge Data & Analytics – Benefits of BIM for Infrastructure, 2017, Business Value of BIM for Infrastructure SmartMarket Report (US, UK, Germany, France)

Implementing BIM on **at Least 30%** of Transportation Proje

DODGE DATA & ANALYTICS
See Ahead Think Ahead Stay Ahead



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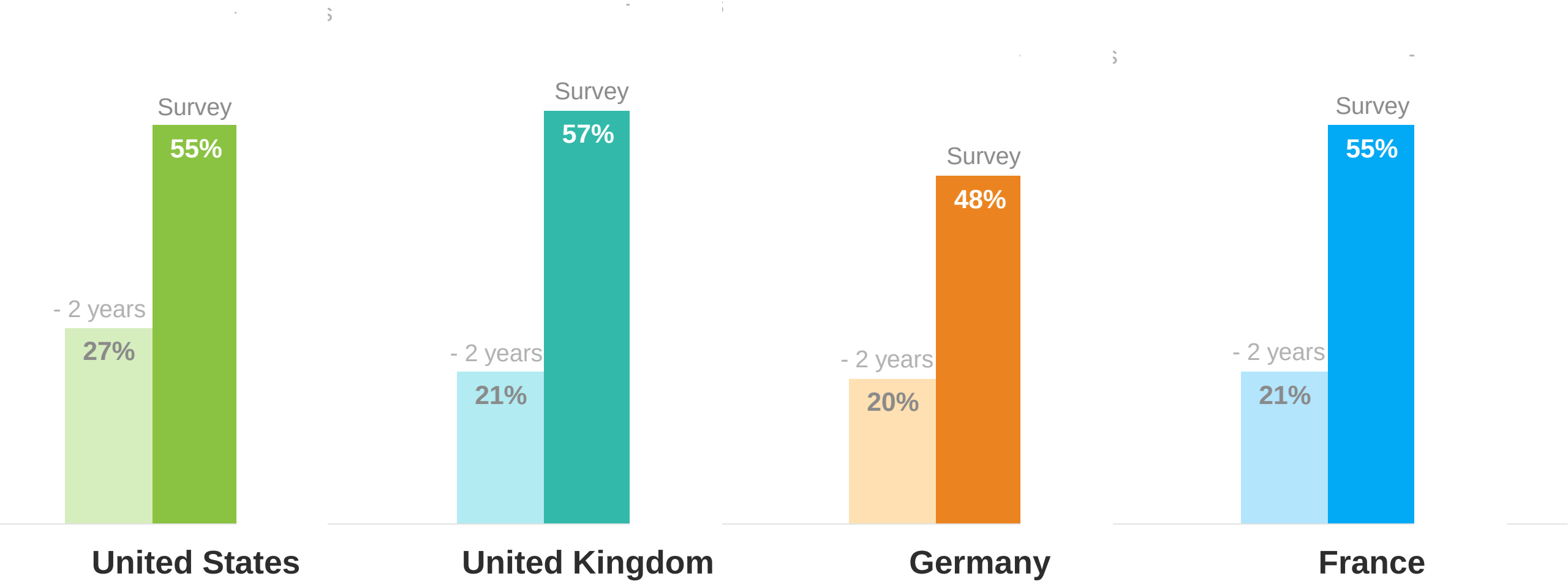
*anticipated in two years
**excludes owners

Implementing BIM on **at Least 30%** of Transportation Proje

DODGE DATA & ANALYTICS
See Ahead Think Ahead Stay Ahead

2 years before survey; **At time of survey**



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Implementing BIM on **at Least 30%** of Transportation Proje

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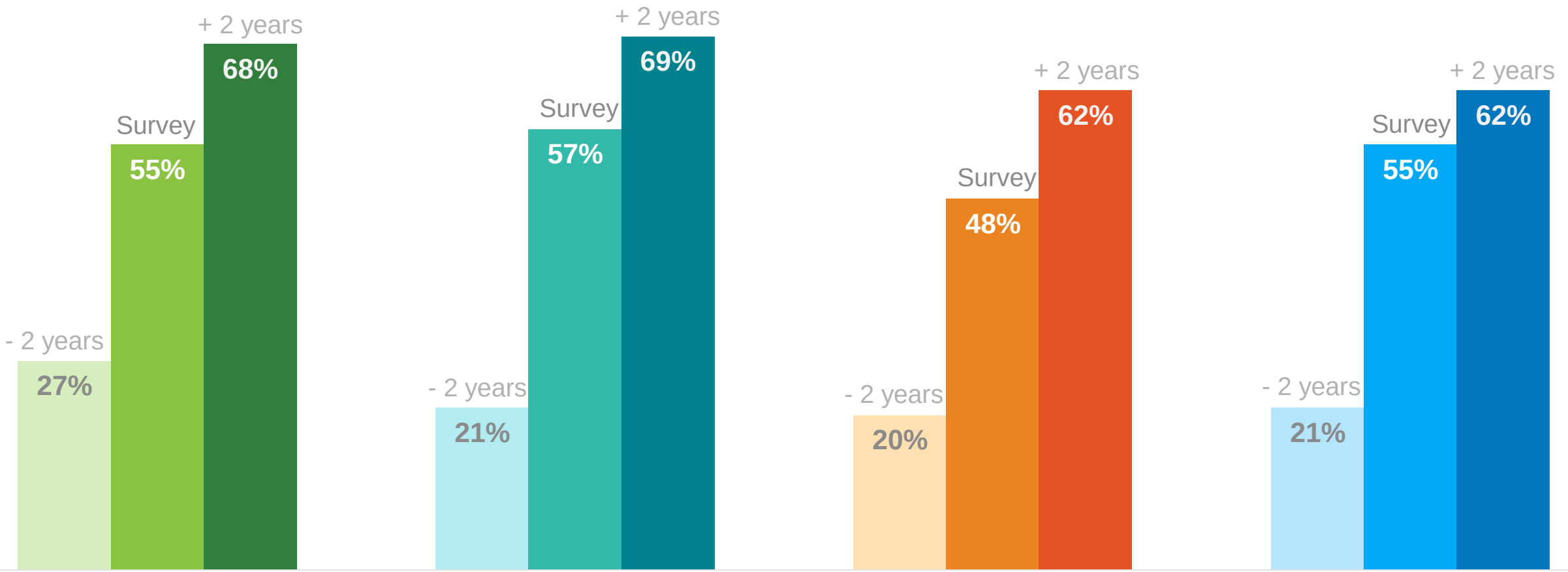
See Ahead Think Ahead Stay Ahead

2 years before survey; At time of survey; **Anticipated in 2 years**



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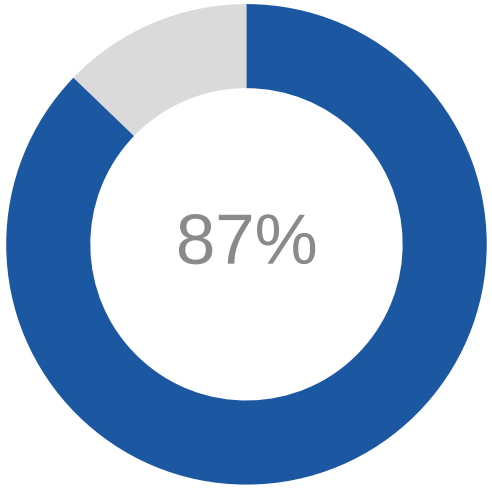
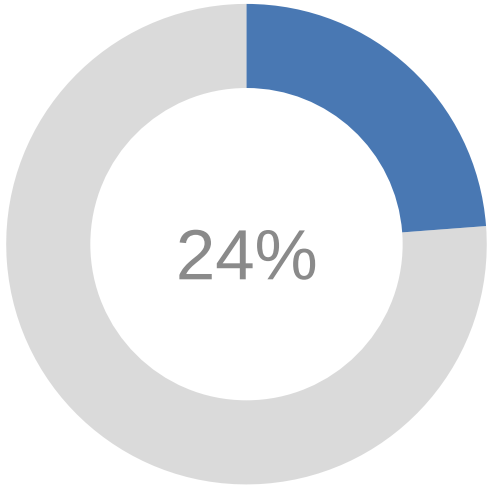
Value from BIM

[US, UK, Germany & France combined]

Experiencing some benefits from use of BIM



Experiencing 50% or greater of BIM's full potential



Source: Dodge Data & Analytics – Benefits of BIM for Infrastructure, 2017, Business Value of BIM for Infrastructure SmartMarket Report (US, UK, Germany, France)

Process and Outcome Benefits of BIM Transportation Proje

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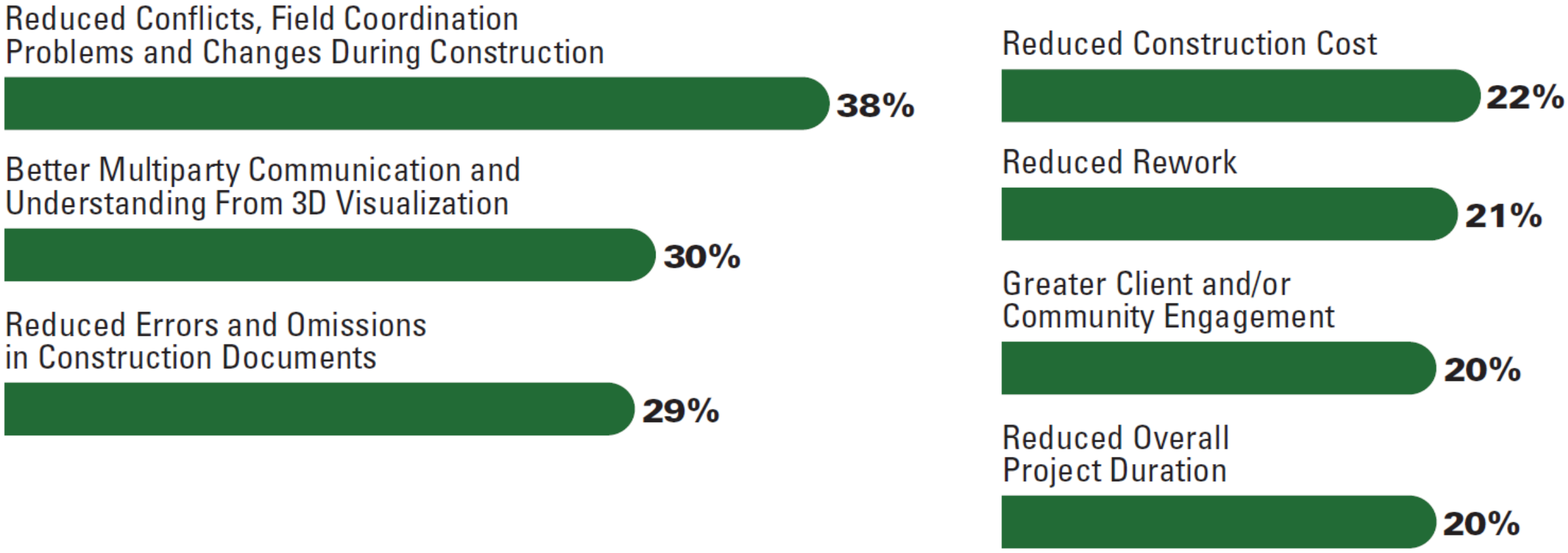
See Ahead Think Ahead Stay Ahead

Top 7 Project Process and Outcome Benefits from BIM

[US, UK, Germany & France combined]

(Selected Among Top 3 Benefits From List of 12 by at Least 20% of BIM Users



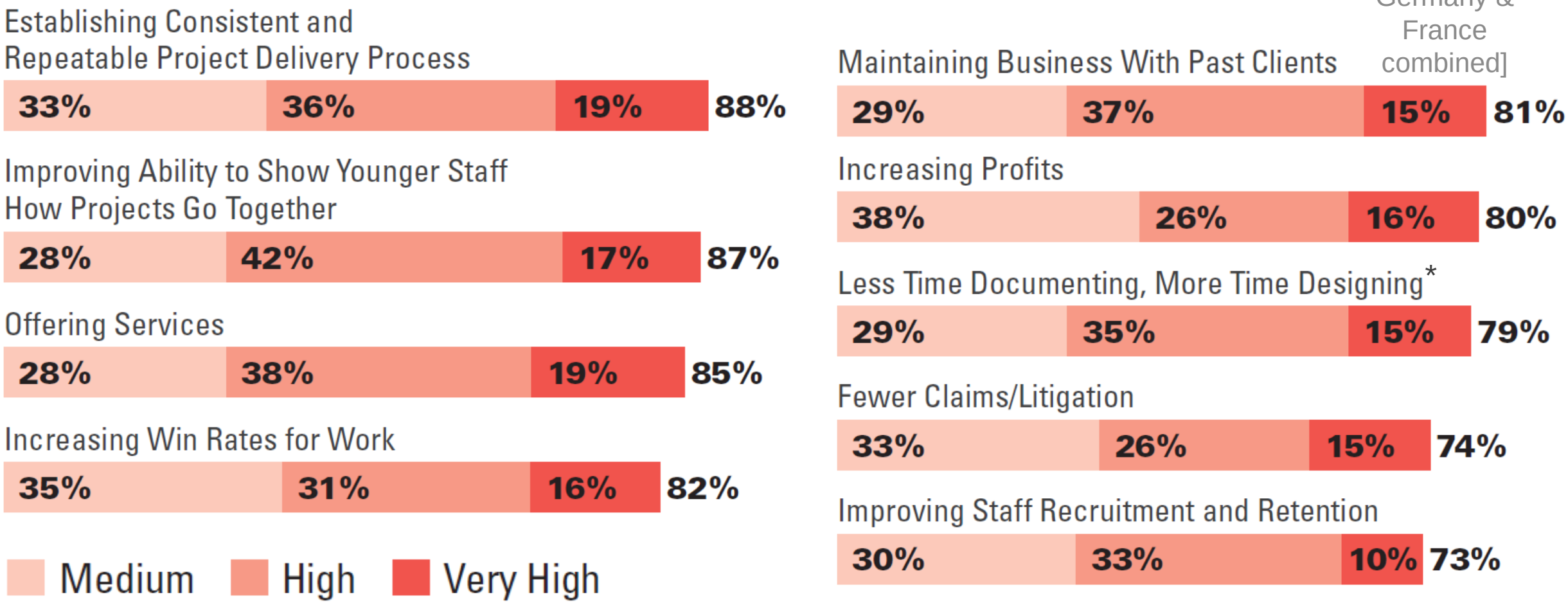
Source: Dodge Data & Analytics – Benefits of BIM for Infrastructure, 2017, Business Value of BIM for Infrastructure SmartMarket Report (US, UK, Germany, France)

Internal Business Benefits from BIM on Transportation Proje

DODGE DATA & ANALYTICS
See Ahead Think Ahead Stay Ahead

Top Internal Benefits from BIM (>70% rated Medium, High or Very High)

[US, UK, Germany & France combined]



* (among Engineers)

Source: Dodge Data & Analytics – Benefits of BIM for Infrastructure, 2017, Business Value of BIM for Infrastructure SmartMarket Report (US, UK, Germany, France)

Increasing Benefits on BIM Transportation Projects

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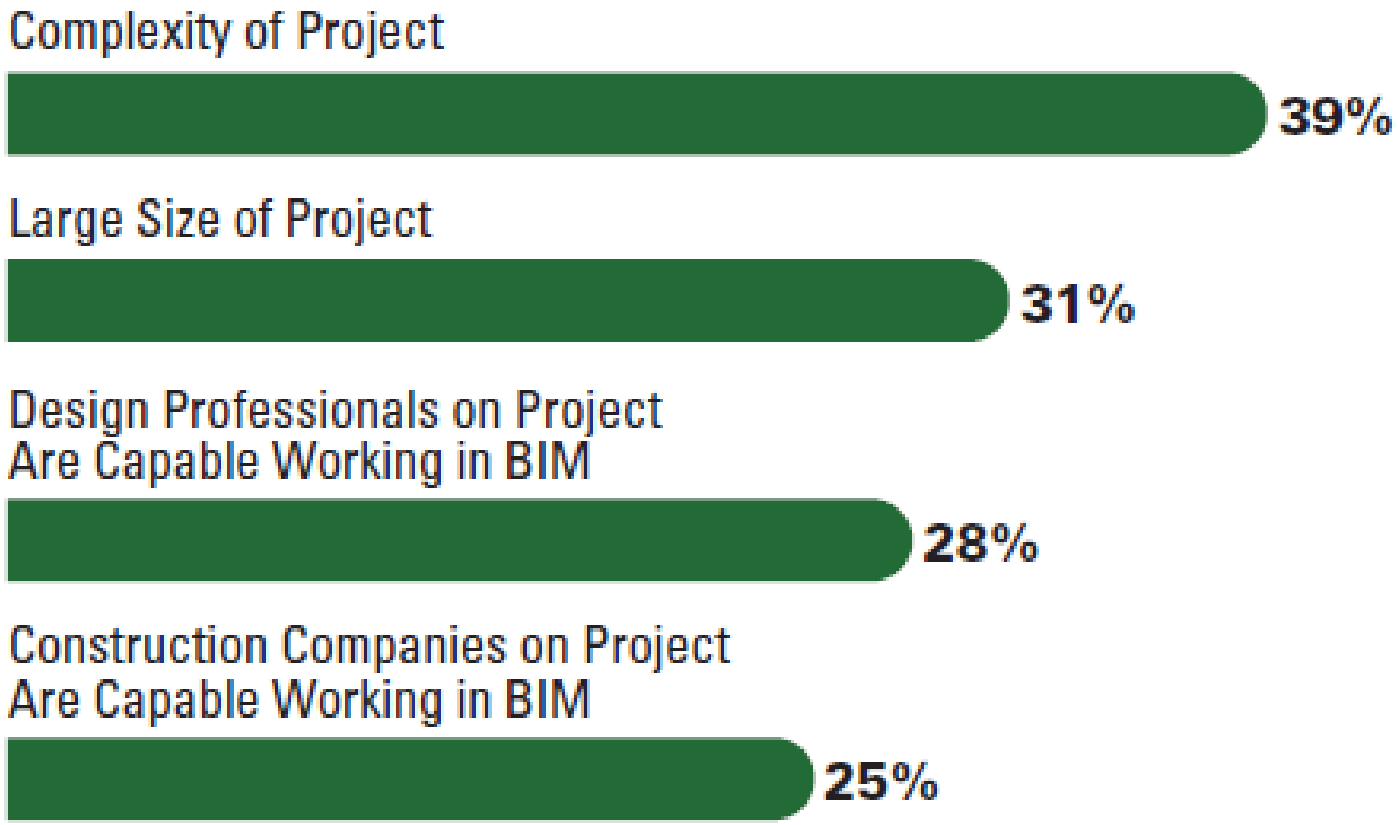
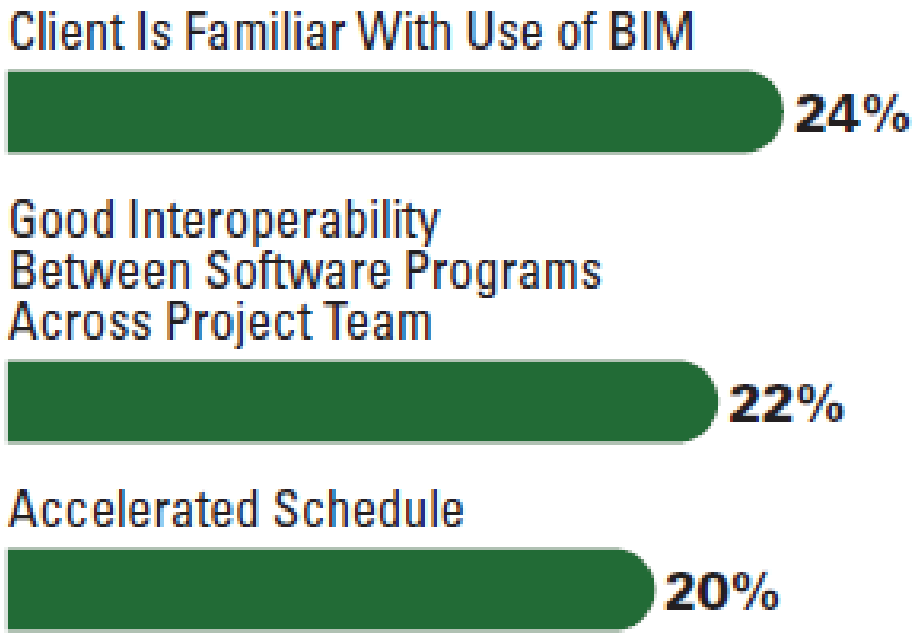
See Ahead Think Ahead Stay Ahead

Top 7 Project Factors That Increase Ability to Experience Value From BIM

(Selected Among Top 3 Benefits From List of 11)

[US, UK, Germany & France combined]





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Technology Uses That Generate Benefits

DODGE DATA & ANALYTICS
See Ahead Think Ahead Stay Ahead

- New business
- Analysis & Coordination
- Cost/Schedule/Labor/Materials Planning
- Approvals/Submittals/Other Tasks

280 mil usuarios por día

7.5 Km de longitud

9 Estaciones

Technology Uses That Generate Benefits

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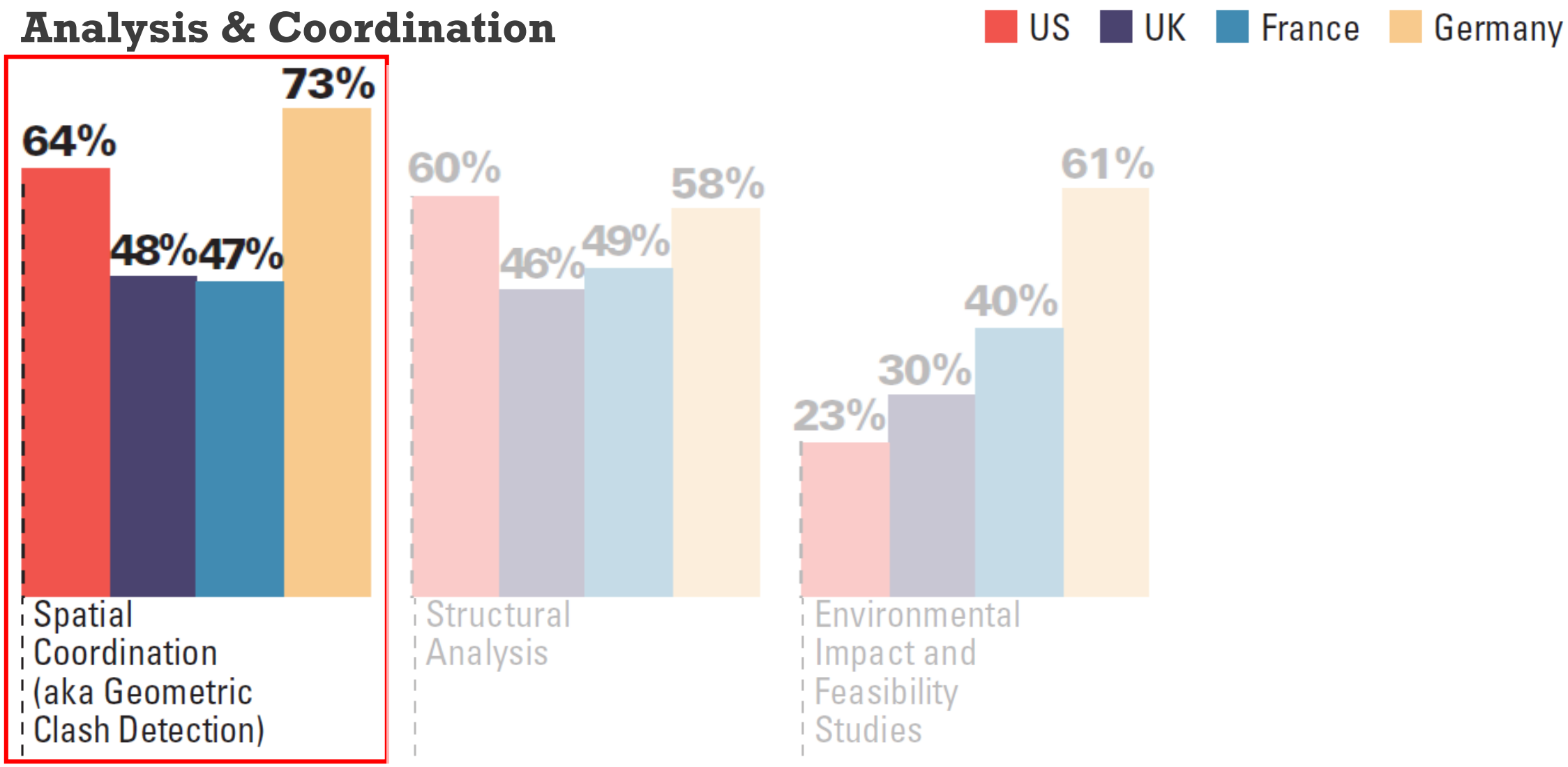
Use of Models that Generate Greatest Value (High/Very high)

DODGE DATA & ANALYTICS
See Ahead Think Ahead Stay Ahead



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Seattle, Washington

Tunnel proposed as solution

2-level highway vulnerable to seismic damage

Urban-scale BIM

Source: Parsons Brinkerhoff

Simulation:
Impact of a Richter 4 seismic event on viaduct and adjacent infrastructure

Source: Parsons Brinckerhoff

Integrate Tunnel Design into Urban-scale BIM

Source: Parsons Brinkerhoff

Technology Uses That Generate Benefits

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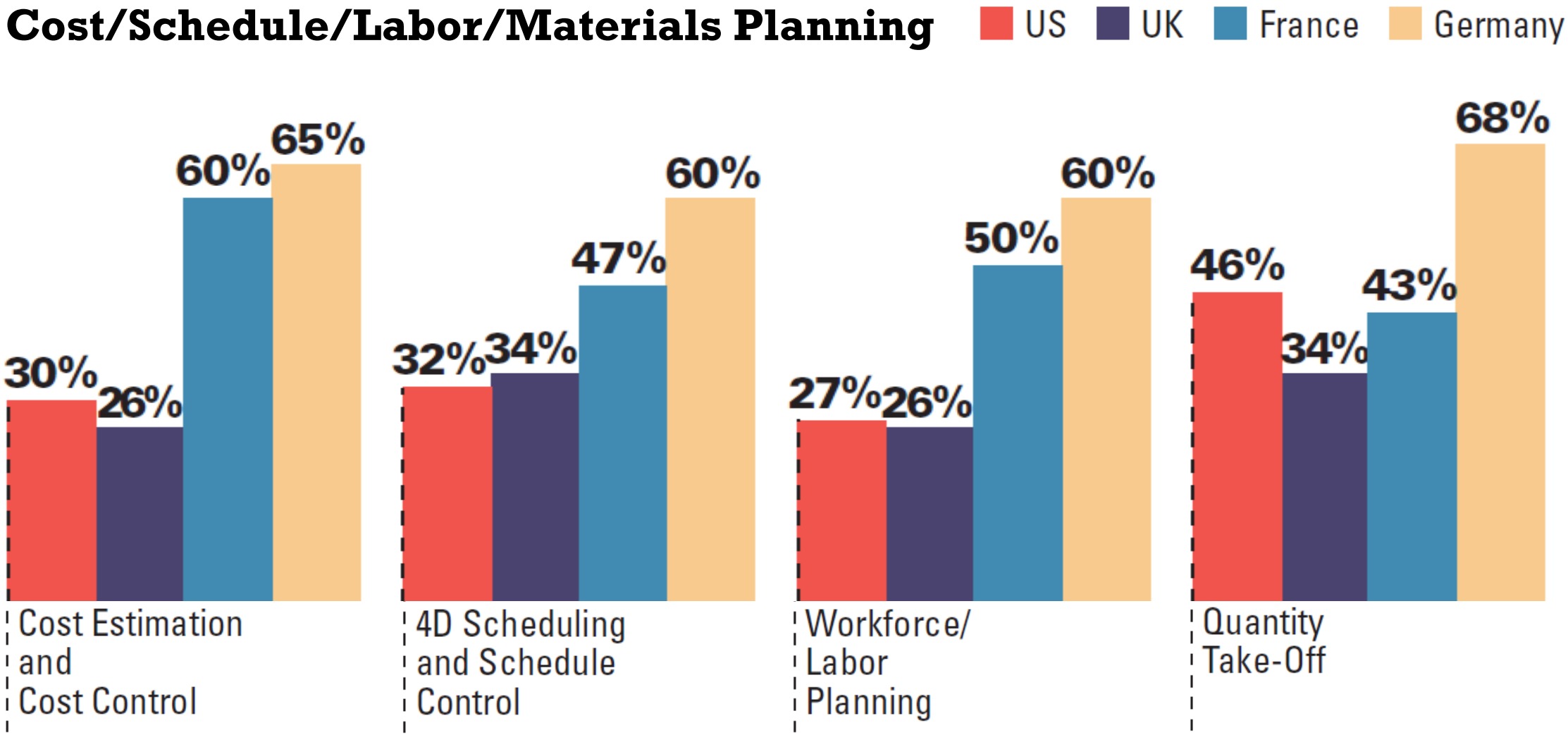
DODGE DATA & ANALYTICS
See Ahead Think Ahead Stay Ahead

Cost/Schedule/Labor/Materials Planning



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Use of Models that Generate Greatest Value (High/Very high)

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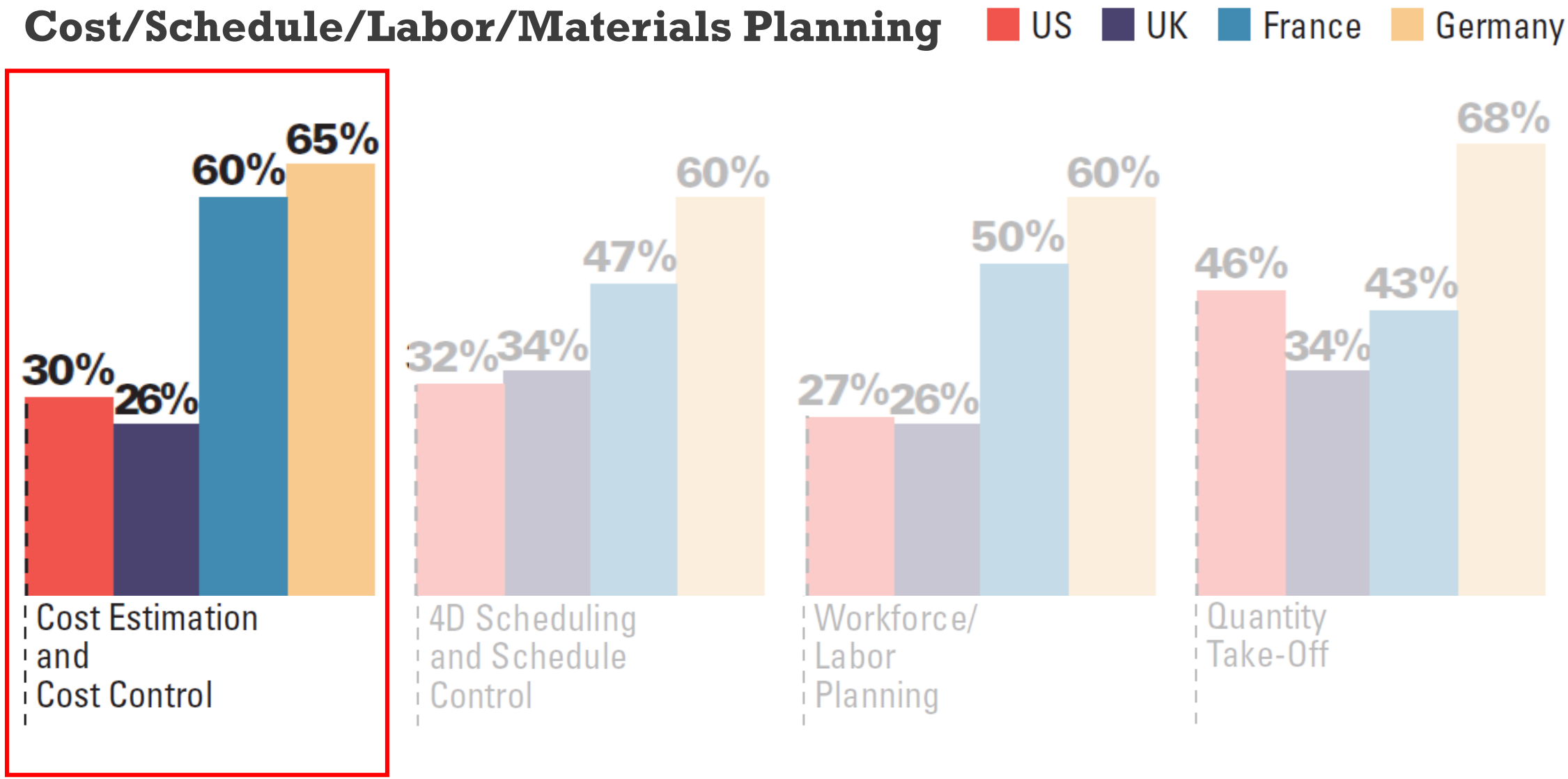
See Ahead Think Ahead Stay Ahead

Cost/Schedule/Labor/Materials Planning



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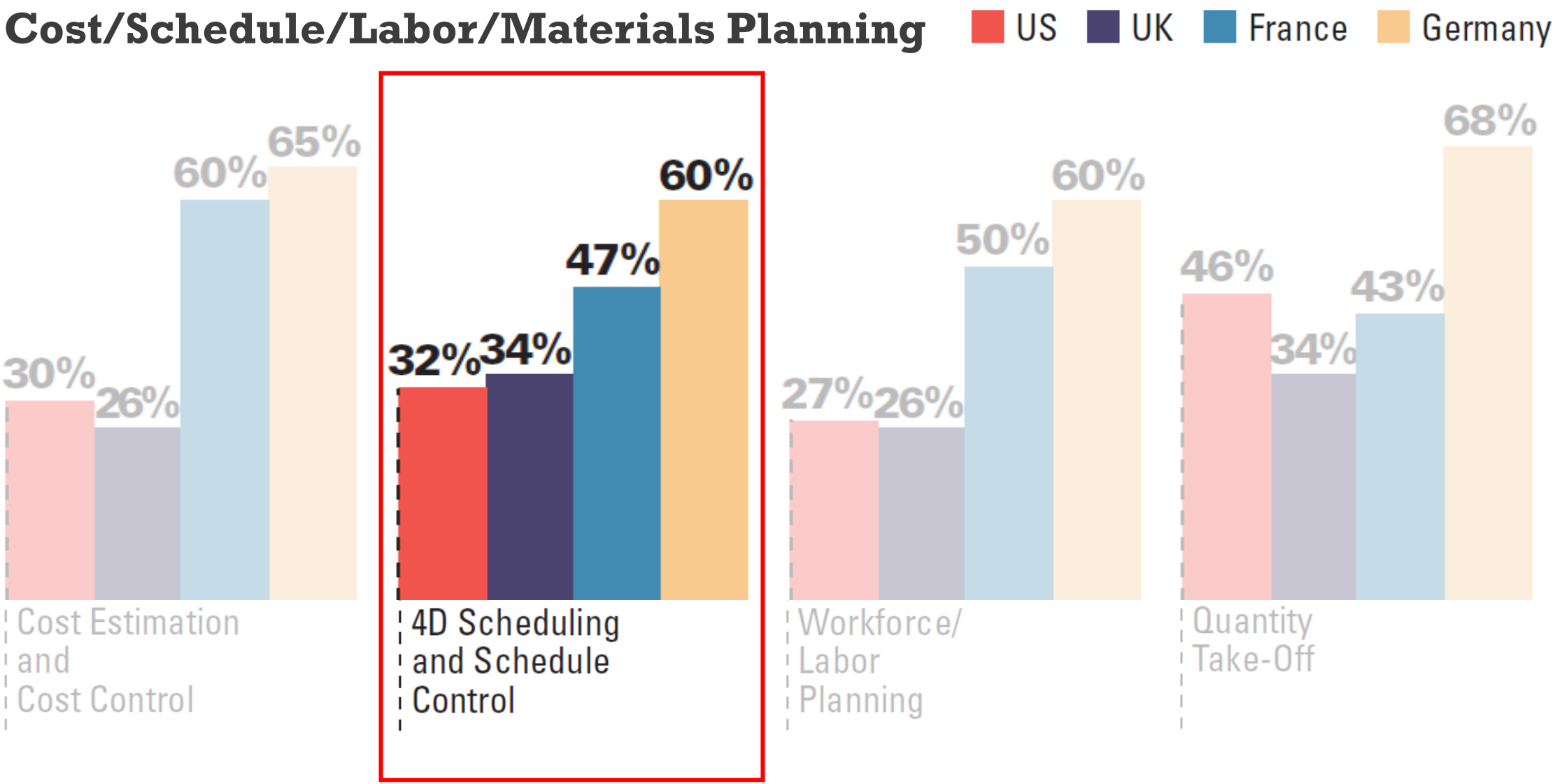
mara ma
master
Road
West First Street
Roads › West First Street
Attributes
Function
Local
Speed
30.0 mph
Design Standards
AASHTO_Imperial_...
Lane Marking
Lifespan
Creation Date
Termination Date
Geometry
Length
3012.06 '
Elevation Range
11.84' - 24.91'
Grade Range
0.07 % - 2.53 %
Advanced
Description
CUT
261.21
541.21
FILL
QUANTITIES
STREAMS
Select a component road

Use of Models that Generate Greatest Value (High/Very high)

DODGE DATA & ANALYTICS
See Ahead Think Ahead Stay Ahead



Source: Dodge Data & Analytics – Benefits of BIM for Infrastructure, 2017, Business Value of BIM for Infrastructure SmartMarket Report (US, UK, Germany, France)

San Francisco-Oakland Bay Bridge East Span
Risk Analysis

Cumulative Impact (Months)		
0-1	[LOW]	
1-2	[MODERATE]	
>2	[HIGH]	

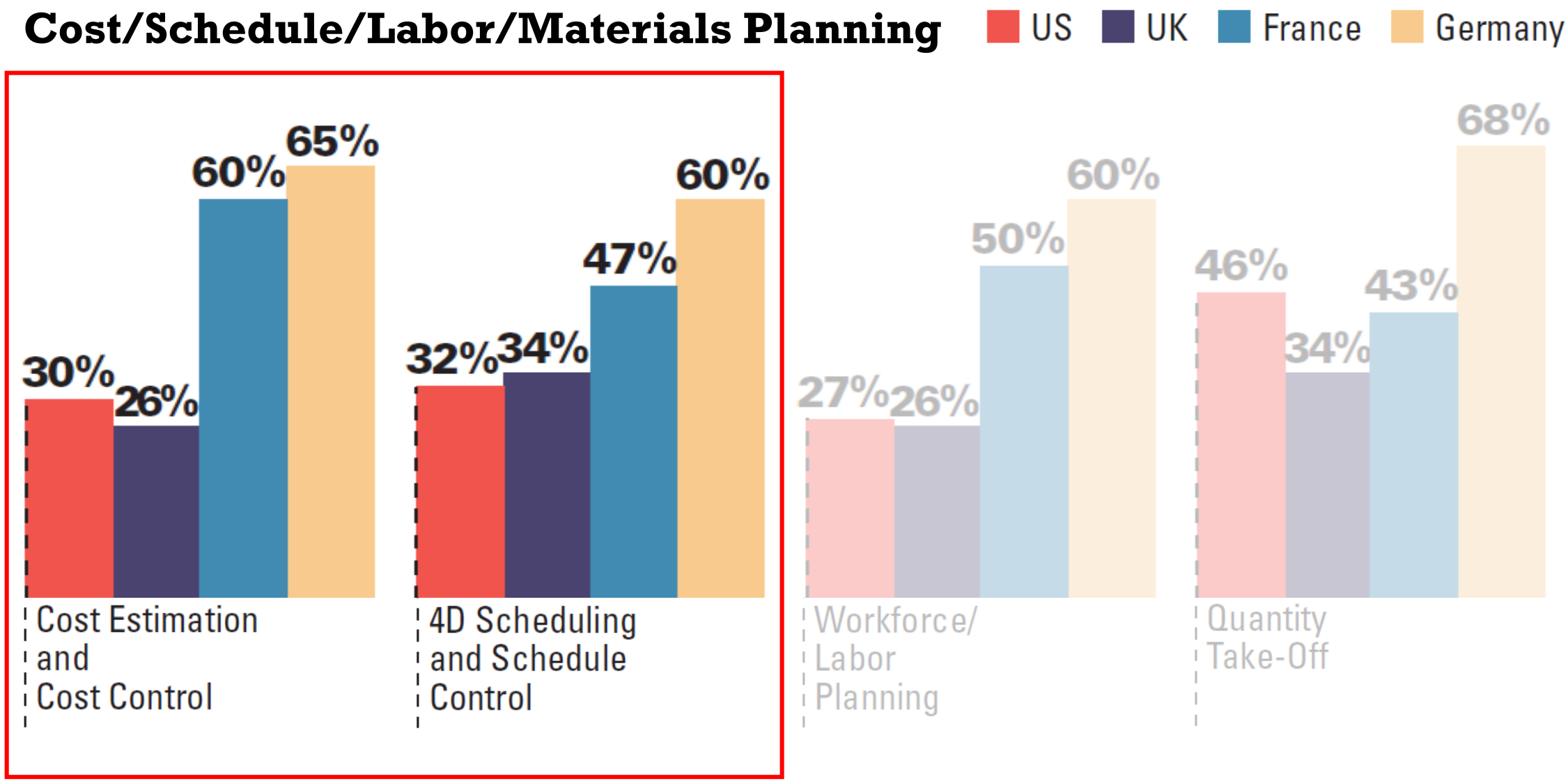
Top 5 Risks [in order of occurrence]

> Unforeseen subsurface obstructions delay pile and pile cap installation
> Late changes to bridge deck construction sequence impacts adjacent contracts
> Adverse weather conditions delay cast-in-place bridge deck concrete placement
> Constructability issues and spatial restrictions delay deck construction
> Late delivery of prefabricated seismic joints delays bridge deck completion

Use of Models that Generate Greatest Value (High/Very high)

DODGE DATA & ANALYTICS
See Ahead Think Ahead Stay Ahead

Cost/Schedule/Labor/Materials Planning



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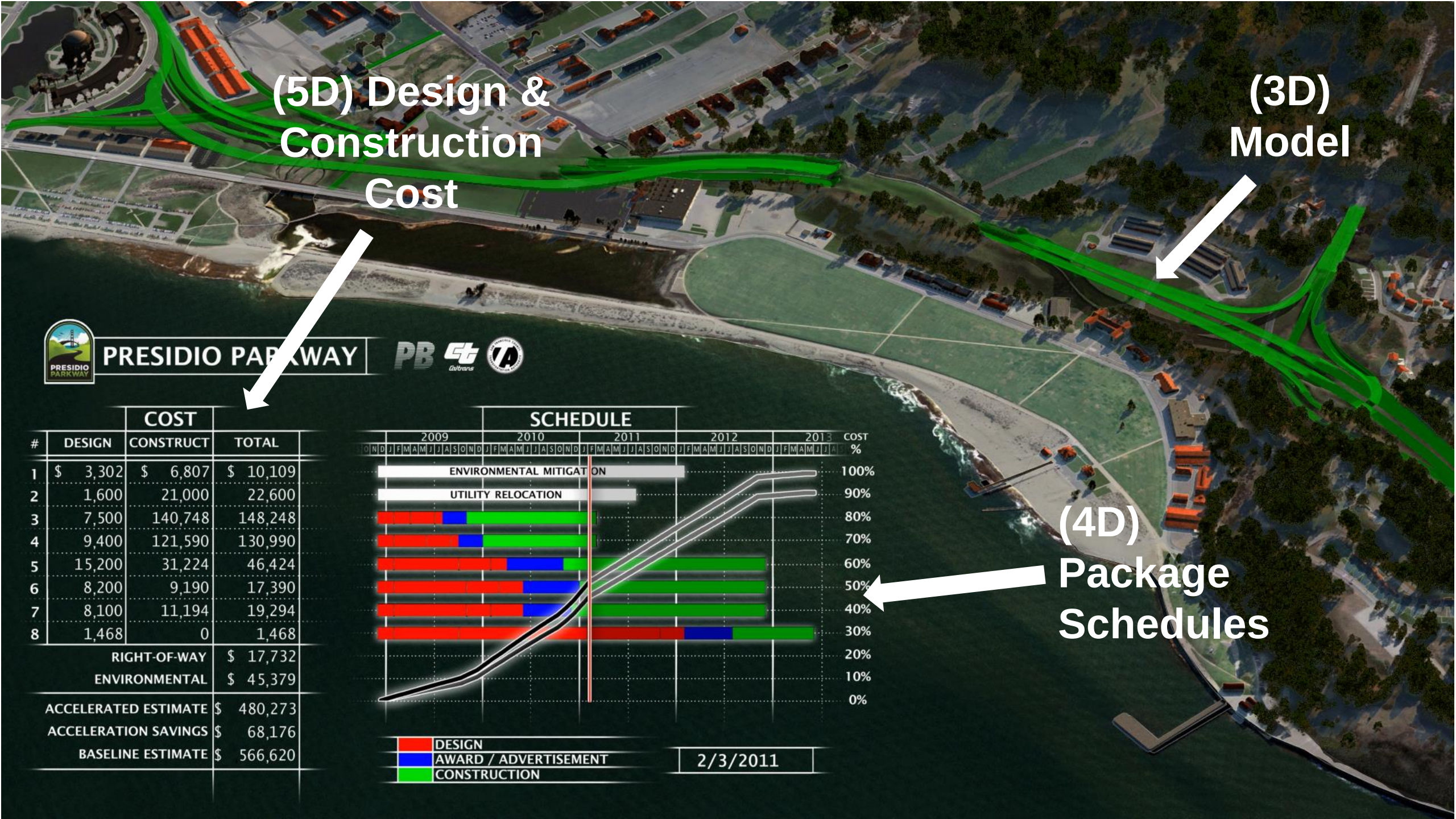
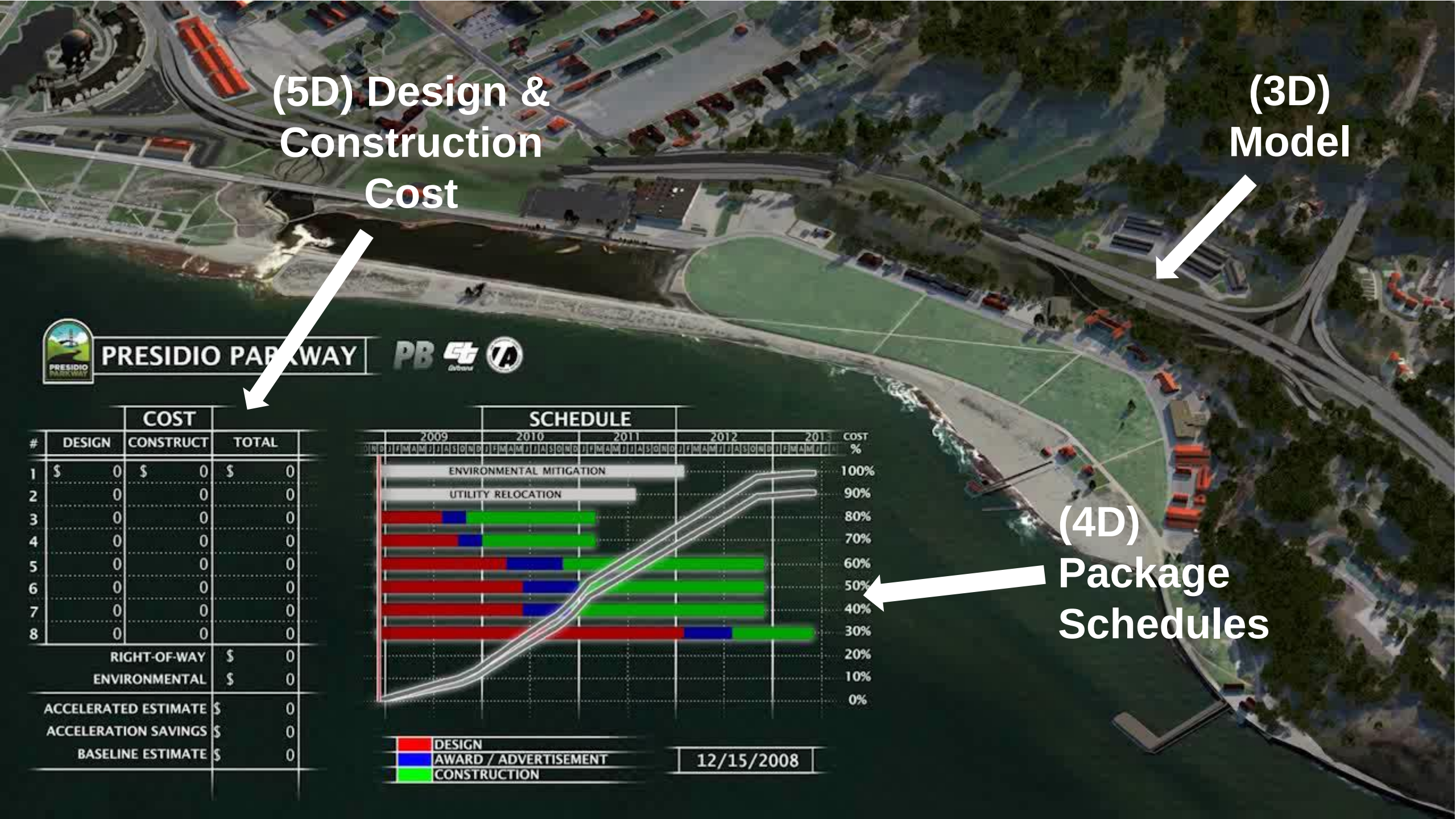

(5D) Design & Construction Cost
(3D) Model
(4D) Package Schedules
PRESIDIO PARKWAY
PB
Caltrans
COST
| DESIGN | CONSTRUCT | TOTAL
1 | $ 3,302 | $ 6,807 | $ 10,109
2 | 1,600 | 21,000 | 22,600
3 | 7,500 | 140,748 | 148,248
4 | 9,400 | 121,590 | 130,990
5 | 15,200 | 31,224 | 46,424
6 | 8,200 | 9,190 | 17,390
7 | 8,100 | 11,194 | 19,294
8 | 1,468 | 0 | 1,468
RIGHT-OF-WAY $ 17,732
ENVIRONMENTAL $ 45,379
ACCELERATED ESTIMATE $ 480,273
ACCELERATION SAVINGS $ 68,176
BASELINE ESTIMATE $ 566,620
SCHEDULE
2009
2010
2011
2012
2013
COST %
ENVIRONMENTAL MITIGATION
UTILITY RELOCATION
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
DESIGN
AWARD / ADVERTISEMENT
CONSTRUCTION
2/3/2011


(5D) Design & Construction Cost
(3D) Model
(4D) Package Schedules
PRESIDIO PARKWAY
PB
COST
SCHEDULE
DESIGN CONSTRUCT TOTAL
1 $ 0 $ 0 $ 0
2 0 0 0
3 0 0 0
4 0 0 0
5 0 0 0
6 0 0 0
7 0 0 0
8 0 0 0
RIGHT-OF-WAY $ 0
ENVIRONMENTAL $ 0
ACCELERATED ESTIMATE $ 0
ACCELERATION SAVINGS $ 0
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2009
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100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
DESIGN
AWARD / ADVERTISEMENT
CONSTRUCTION
12/15/2008

Technology Uses That Generate Benefits

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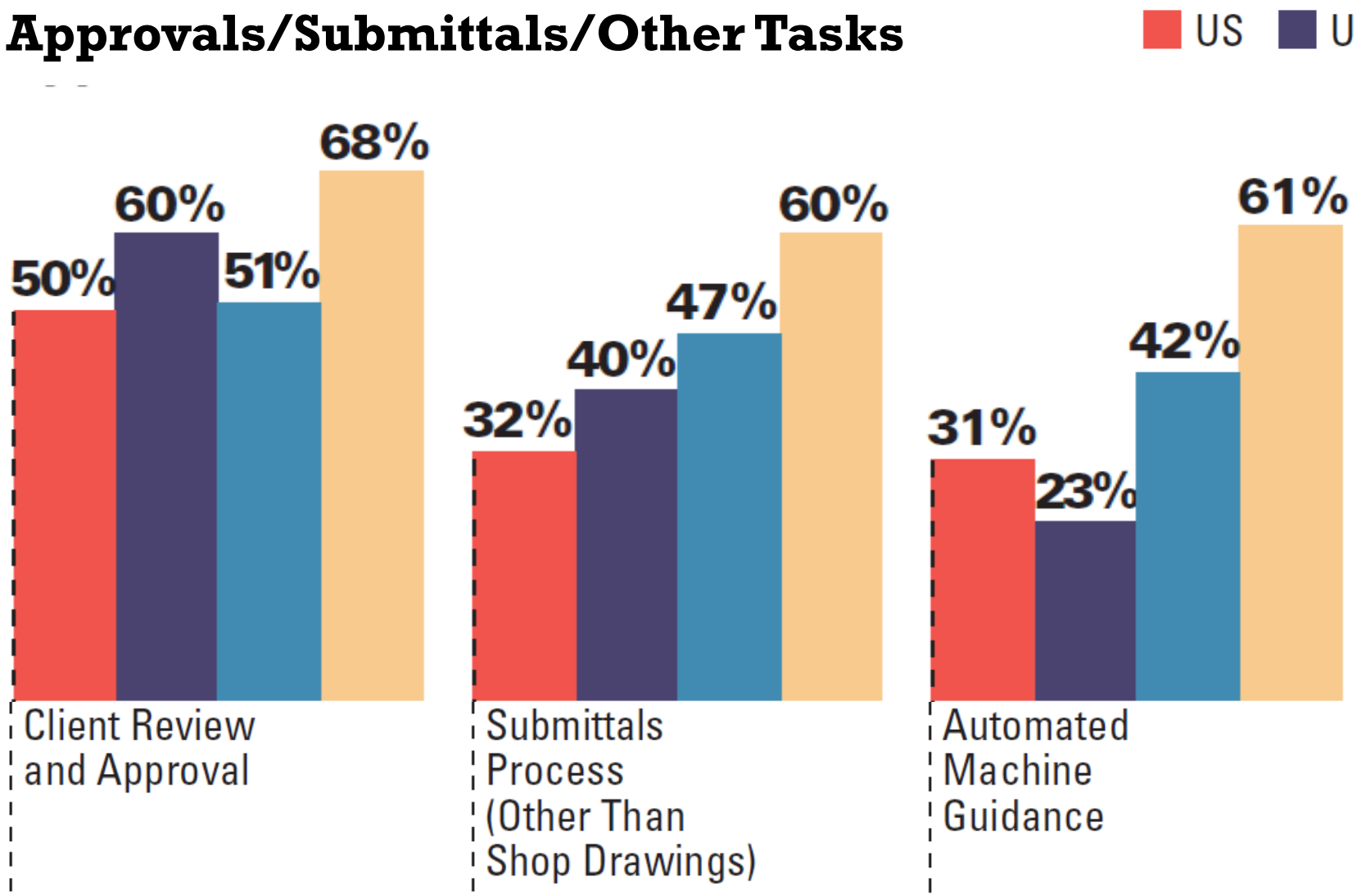

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Use of Models that Generate Greatest Value (High/Very high)

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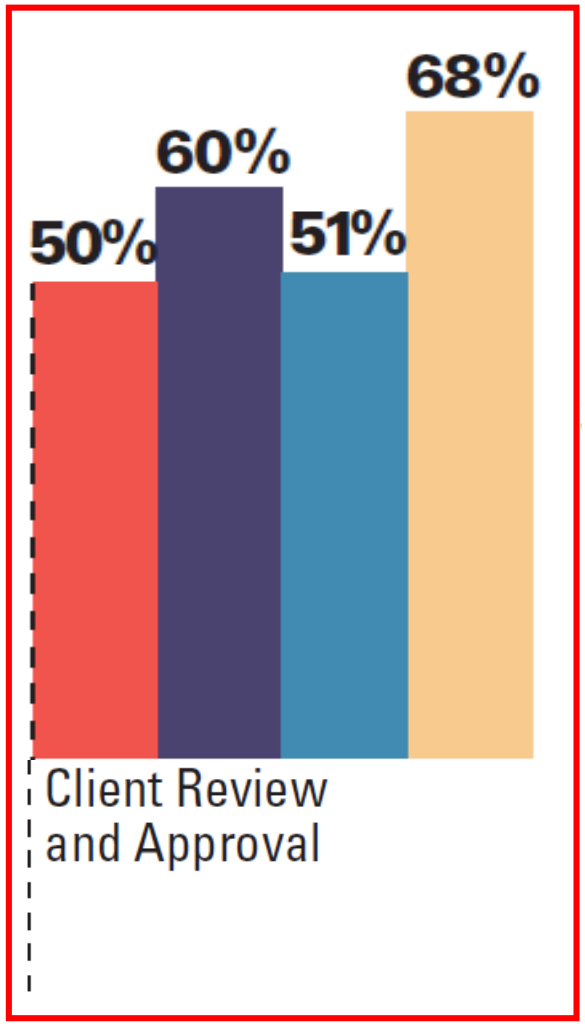
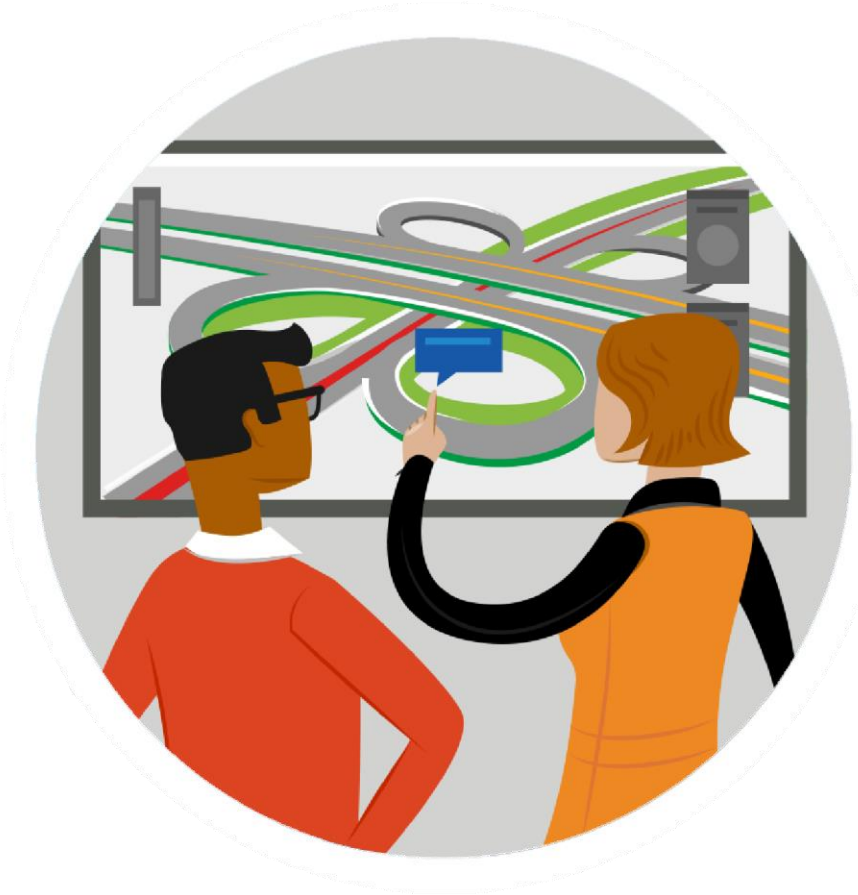
Approvals/Submittals/Other Tasks

US UK France Germany





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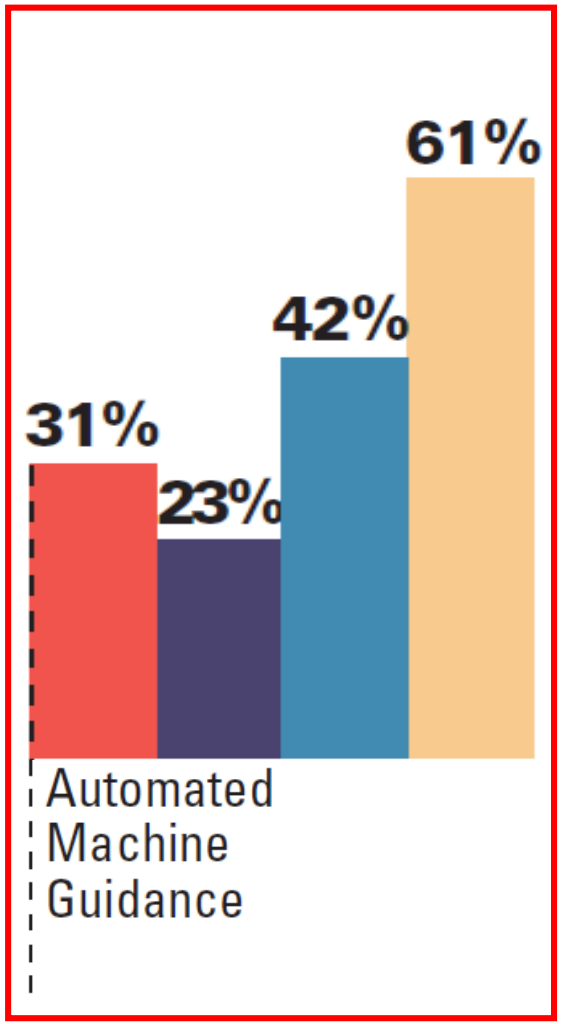
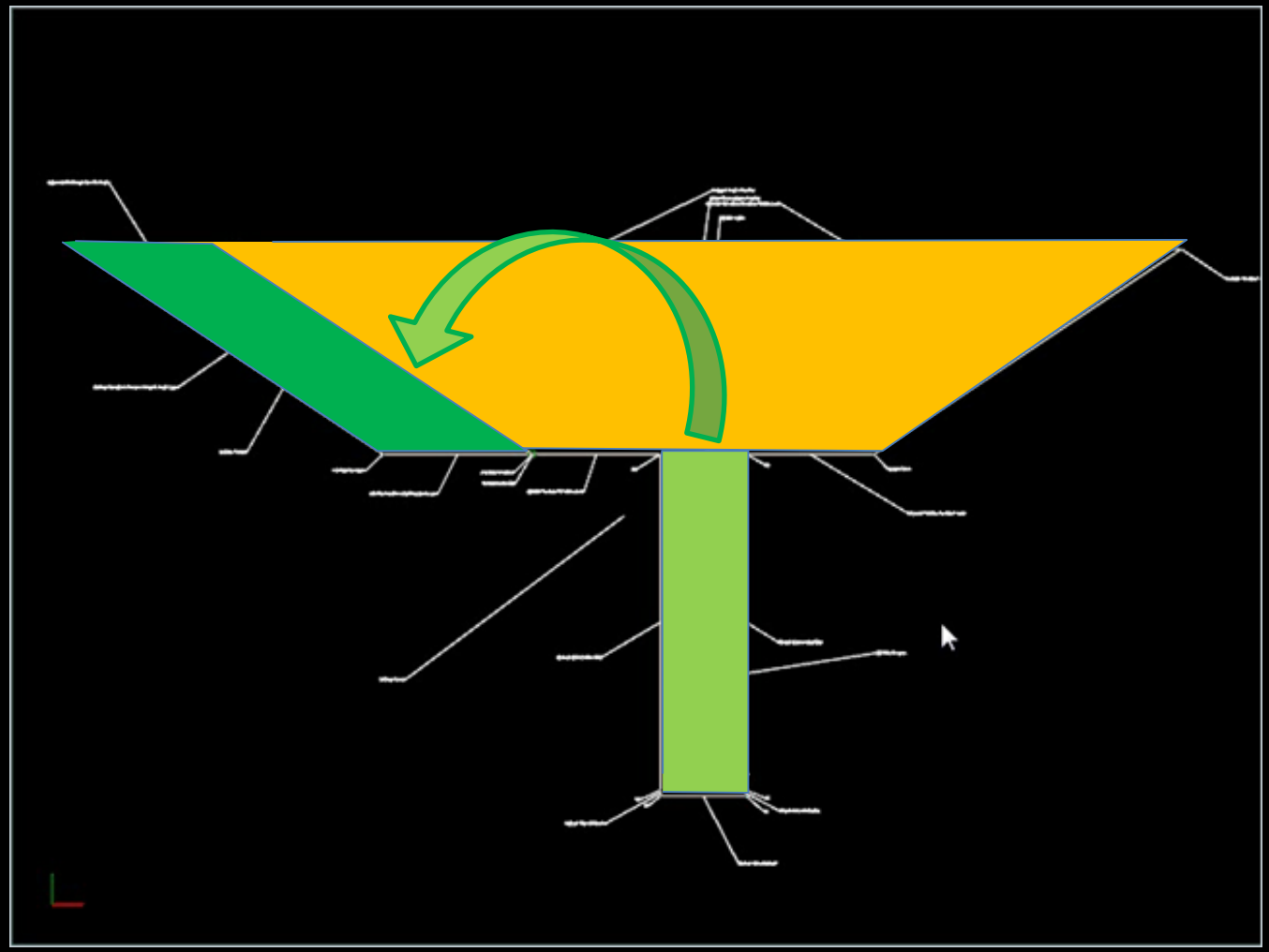


Source: Dodge Data & Analytics – Benefits of BIM for Infrastructure, 2017, Business Value of BIM for Infrastructure SmartMarket Report (US, UK, Germany, France)

Challenging double-profile trench excavation to 40 feet for utility pipe

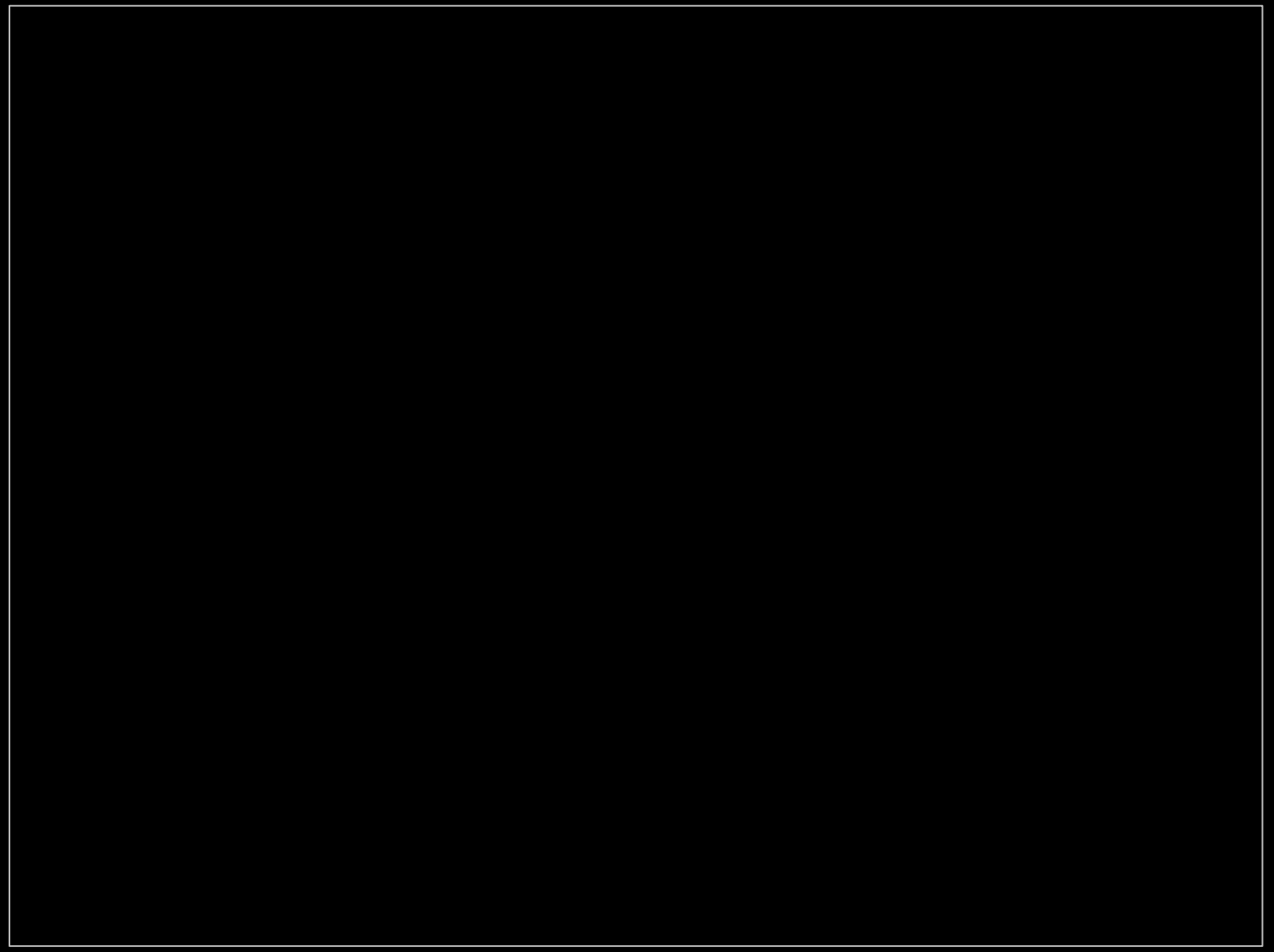


Source: Sundt Construction

Scan and Model:

Every 500’:

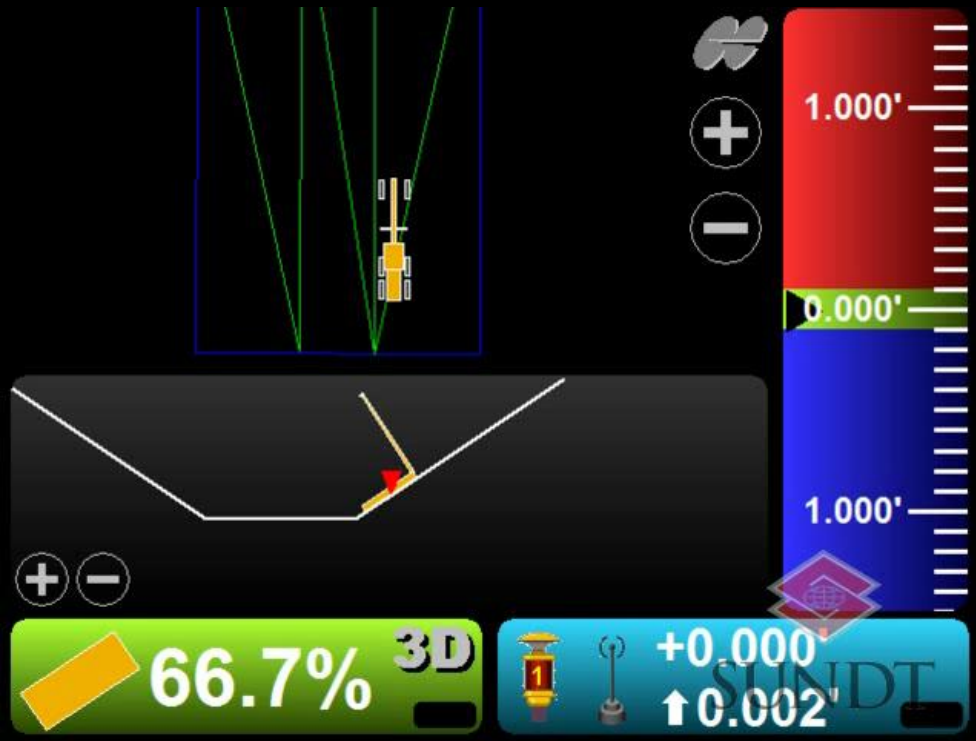
- Scraper Pass Surface
  - *Line work*
- Excavator Pass Surface
  - *Line work*
- Temporary Access Ramps Surface



Source: Sundt Construction

GPS-guided equipment directed by the model

Model-driven Automated Machine Guidance



Source: Sundt Construction

Agenda

DODGE DATA & ANALYTICS
See Ahead Think Ahead Stay Ahead

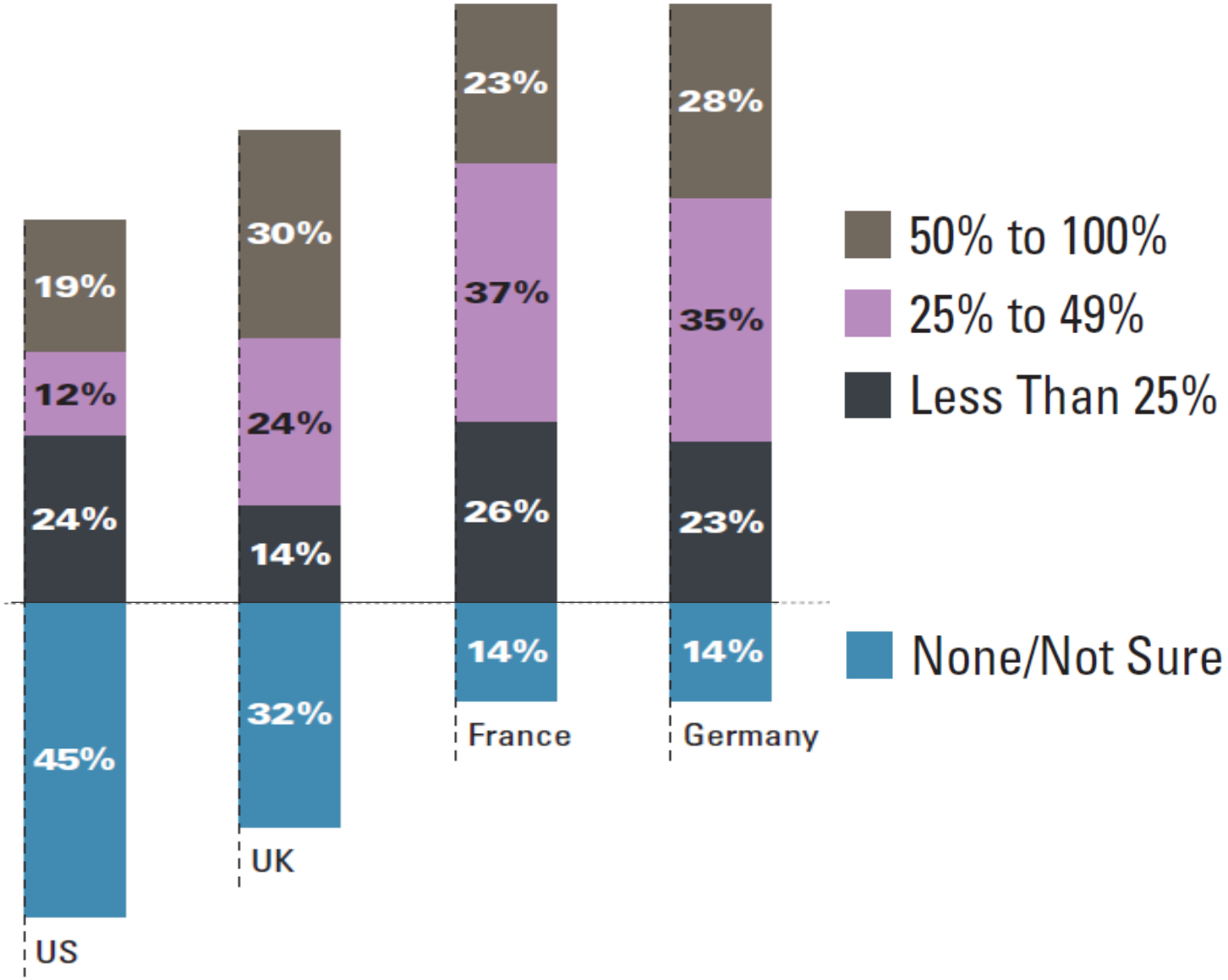
- Impact of Modeling and Related Technologies on Design, Planning and Construction of Transportation Infrastructure
  - ***Adoption and Implementation***
  - ***Benefits (Project and Business)***
  - ***Uses of Technology that Generate Benefits***
  - ***ROI and Future Benefits***
  - ***Innovations and Emerging Uses of Technology***
  - ***Recommendations***

Percent of Projects on Which ROI is Formally Measured

DODGE DATA & ANALYTICS
See Ahead Think Ahead Stay Ahead

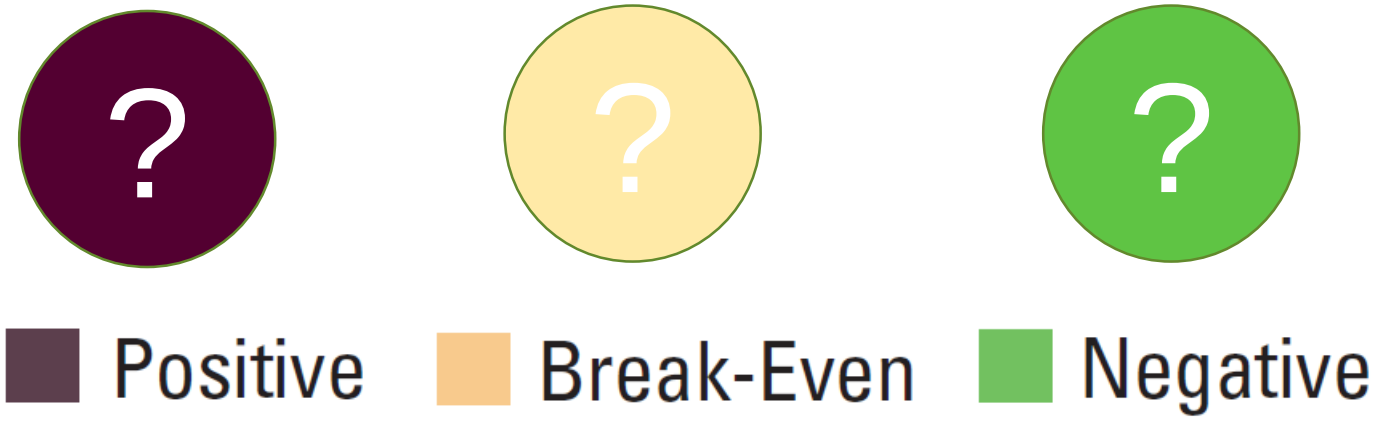
[engineers and contractors]

France and Germany lead in formal measurement of BIM



Source: Dodge Data & Analytics – Benefits of BIM for Infrastructure, 2017, Business Value of BIM for Infrastructure SmartMarket Report (US, UK, Germany, France)

Perceived ROI from Using BIM

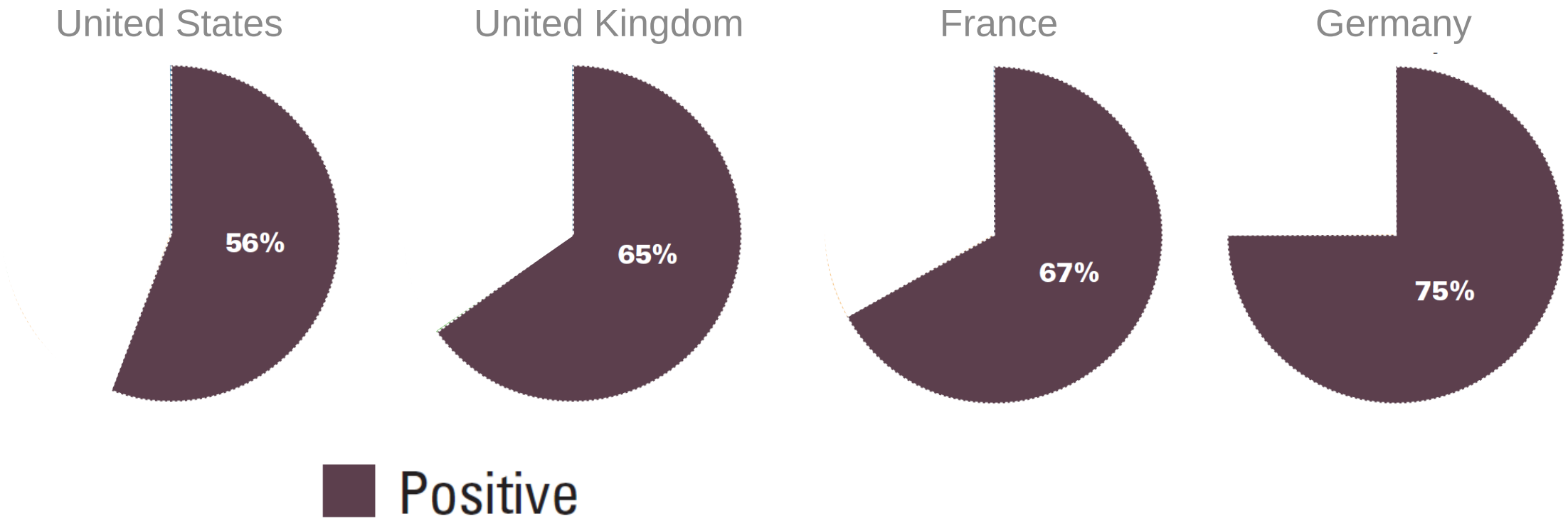


*excludes owners

Source: Dodge Data & Analytics – Benefits of BIM for Infrastructure, 2017, Business Value of BIM for Infrastructure SmartMarket Report (US, UK, Germany, France)

Perceived ROI from Using BIM

[engineers and contractors]



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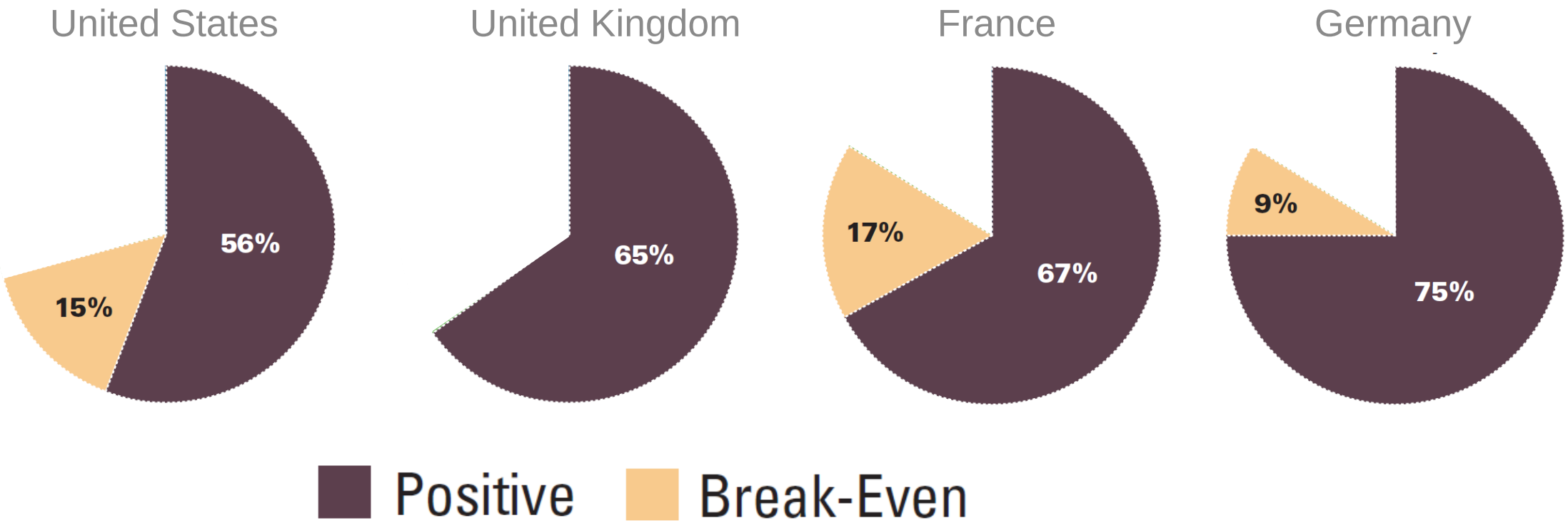
Perceived ROI from Using BIM

[engineers and contractors]



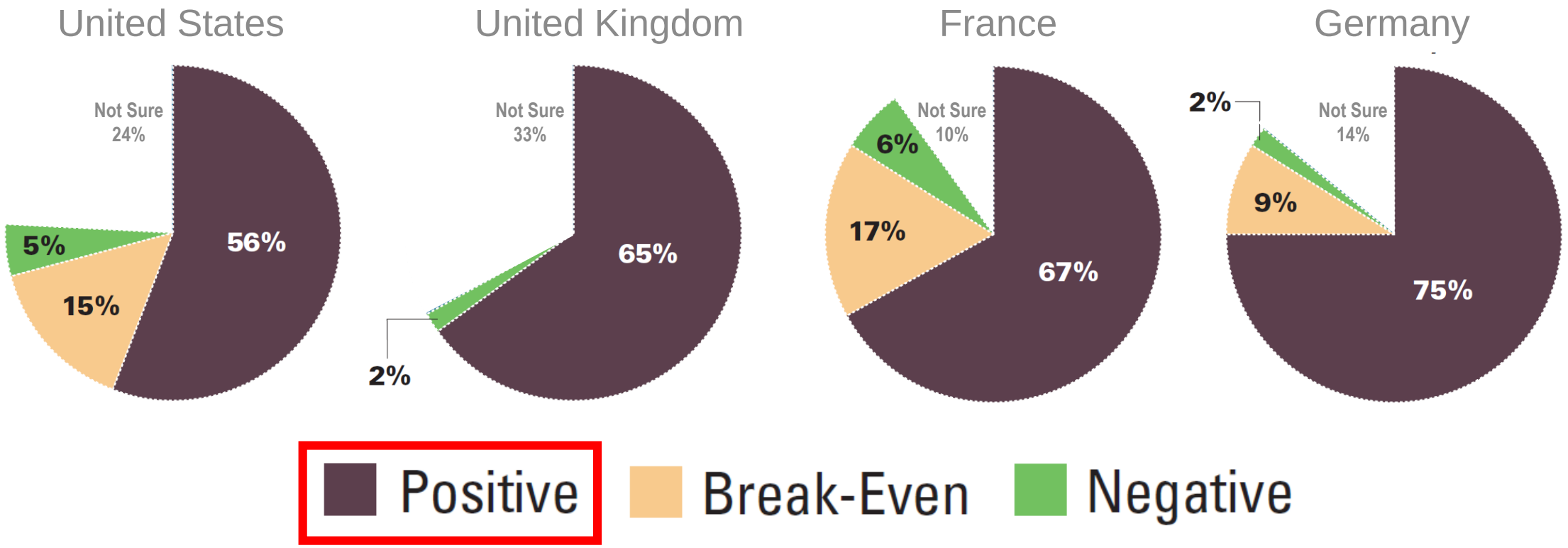
*excludes owners

Source: Dodge Data & Analytics – Benefits of BIM for Infrastructure, 2017, Business Value of BIM for Infrastructure SmartMarket Report (US, UK, Germany, France)

Perceived ROI from Using BIM

DODGE DATA & ANALYTICS
See Ahead Think Ahead Stay Ahead

[engineers and contractors]



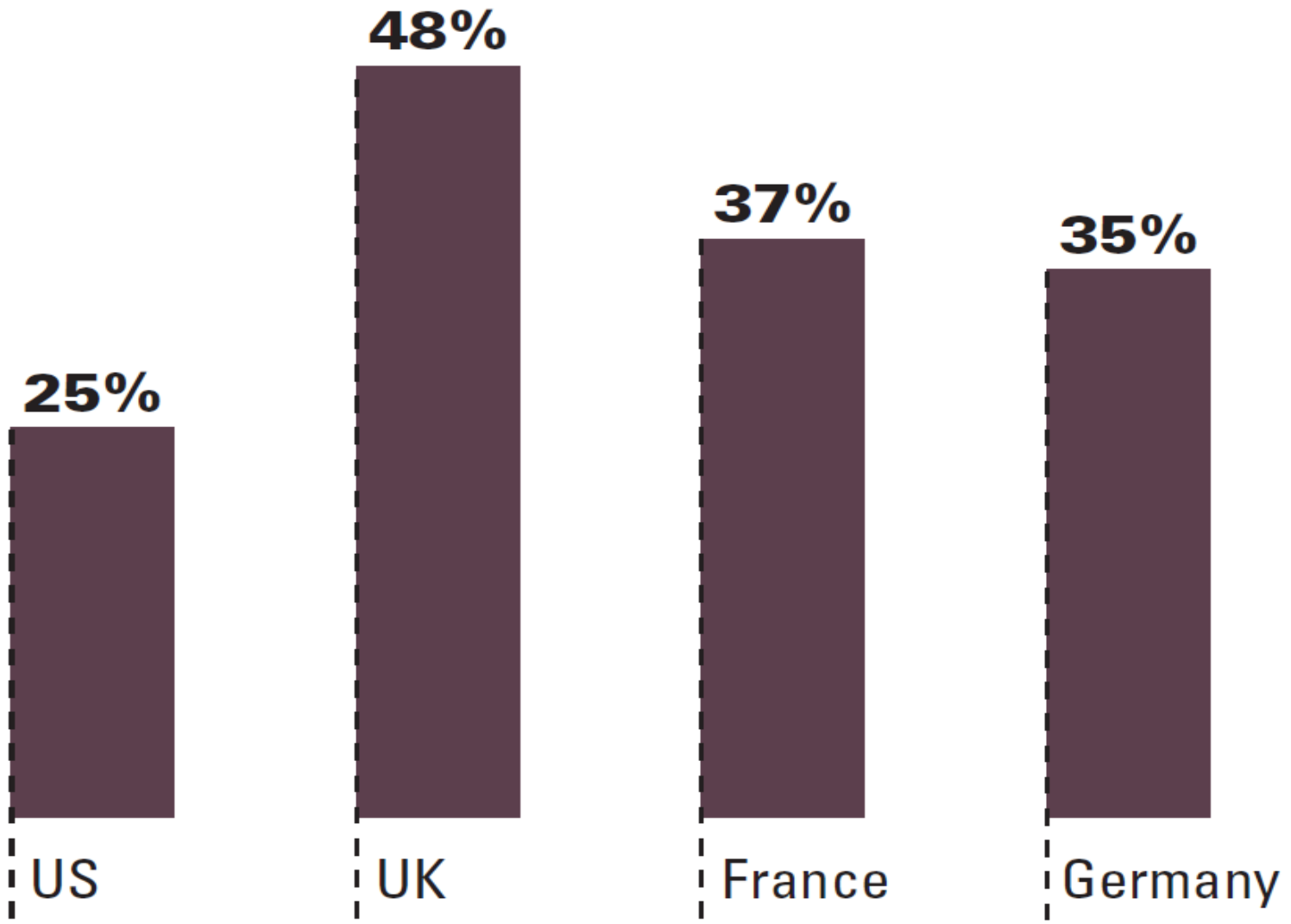
*excludes owners

Source: Dodge Data & Analytics – Benefits of BIM for Infrastructure, 2017, Business Value of BIM for Infrastructure SmartMarket Report (US, UK, Germany, France)

Perceived ROI of 25% or Higher

[engineers and contractors]

UK leads in percentage of users who believe their ROI is **25% or higher**



*excludes owners

Source: Dodge Data & Analytics – Benefits of BIM for Infrastructure, 2017, Business Value of BIM for Infrastructure SmartMarket Report (US, UK, Germany, France)

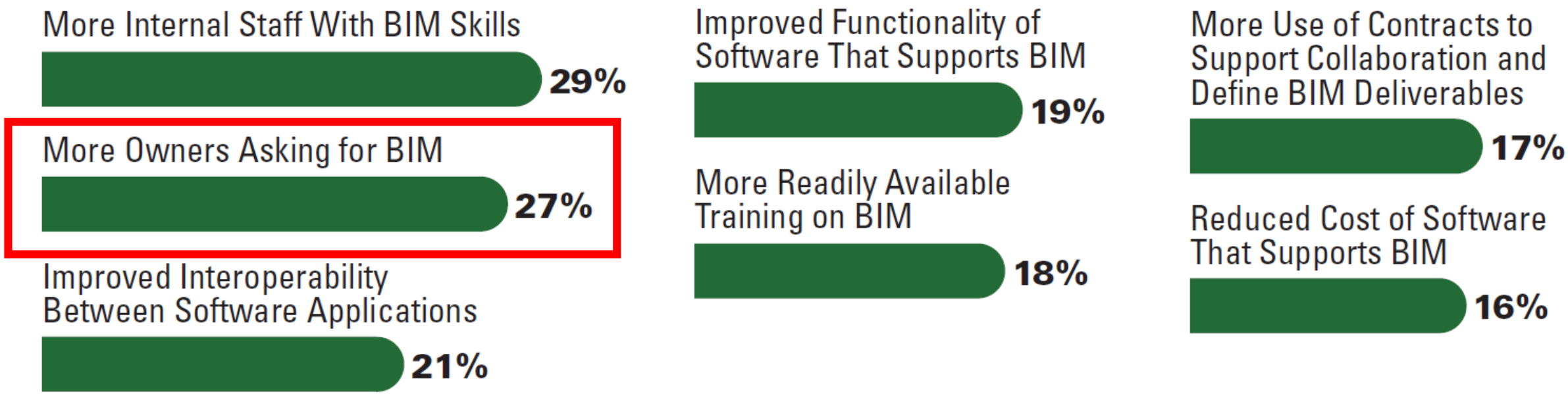
Increasing Benefits on BIM Transportation Projects

DODGE DATA & ANALYTICS
See Ahead Think Ahead Stay Ahead

Top Seven Factors With the Greatest Positive Impact on Increasing the Ability to Experience BIM Benefits on Future Transportation Projects

(Selected Among Top 3 Benefits From List of 14)

[US, UK, Germany & France combined]

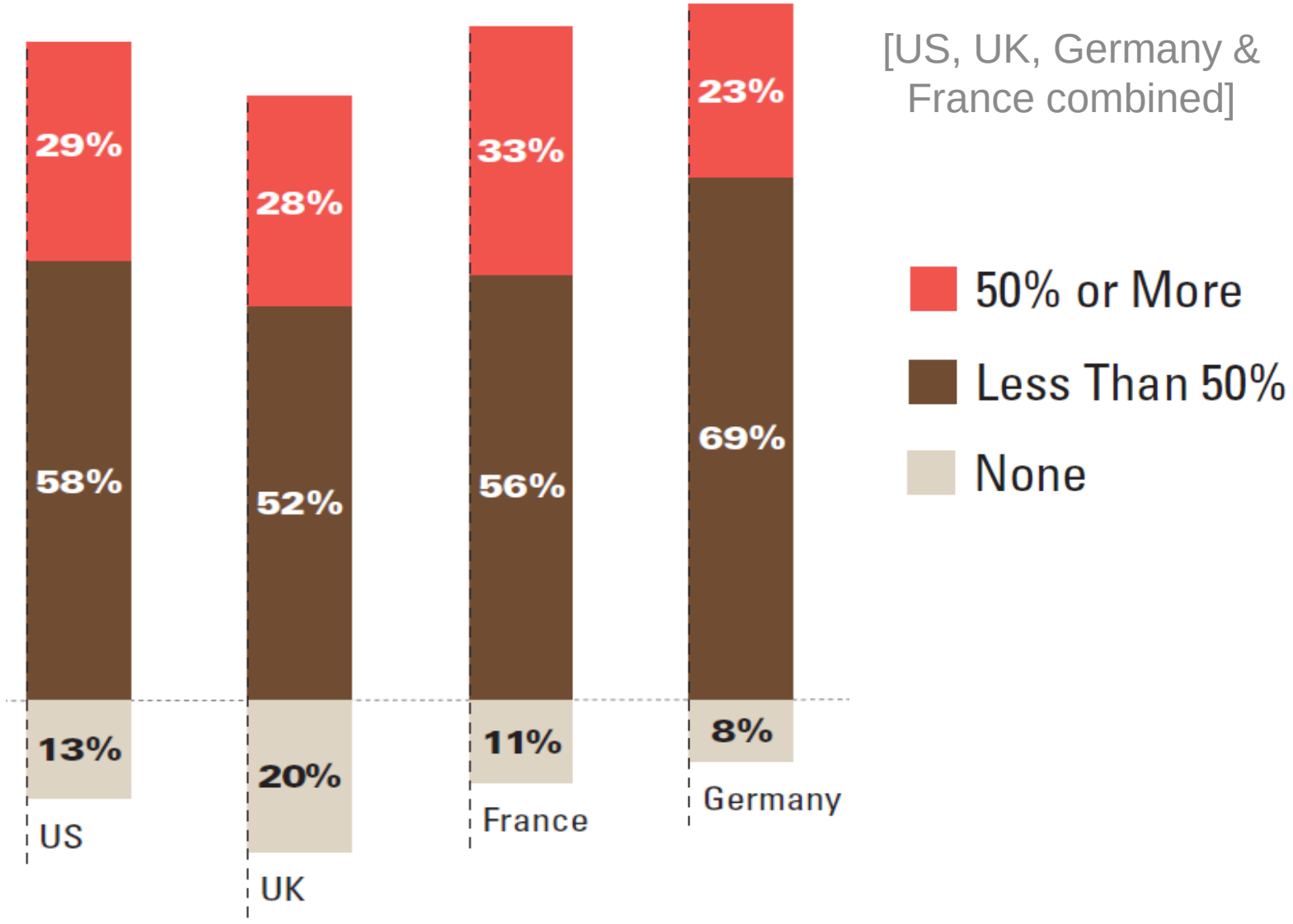


Source: Dodge Data & Analytics – Benefits of BIM for Infrastructure, 2017, Business Value of BIM for Infrastructure SmartMarket Report (US, UK, Germany, France)

Owner demand for transportation BIM

Percentage of transportation projects on which owners request BIM

(Asked of BIM users)



Source: Dodge Data & Analytics – Benefits of BIM for Infrastructure, 2017, Business Value of BIM for Infrastructure SmartMarket Report (US, UK, Germany, France)

Agenda

DODGE DATA & ANALYTICS
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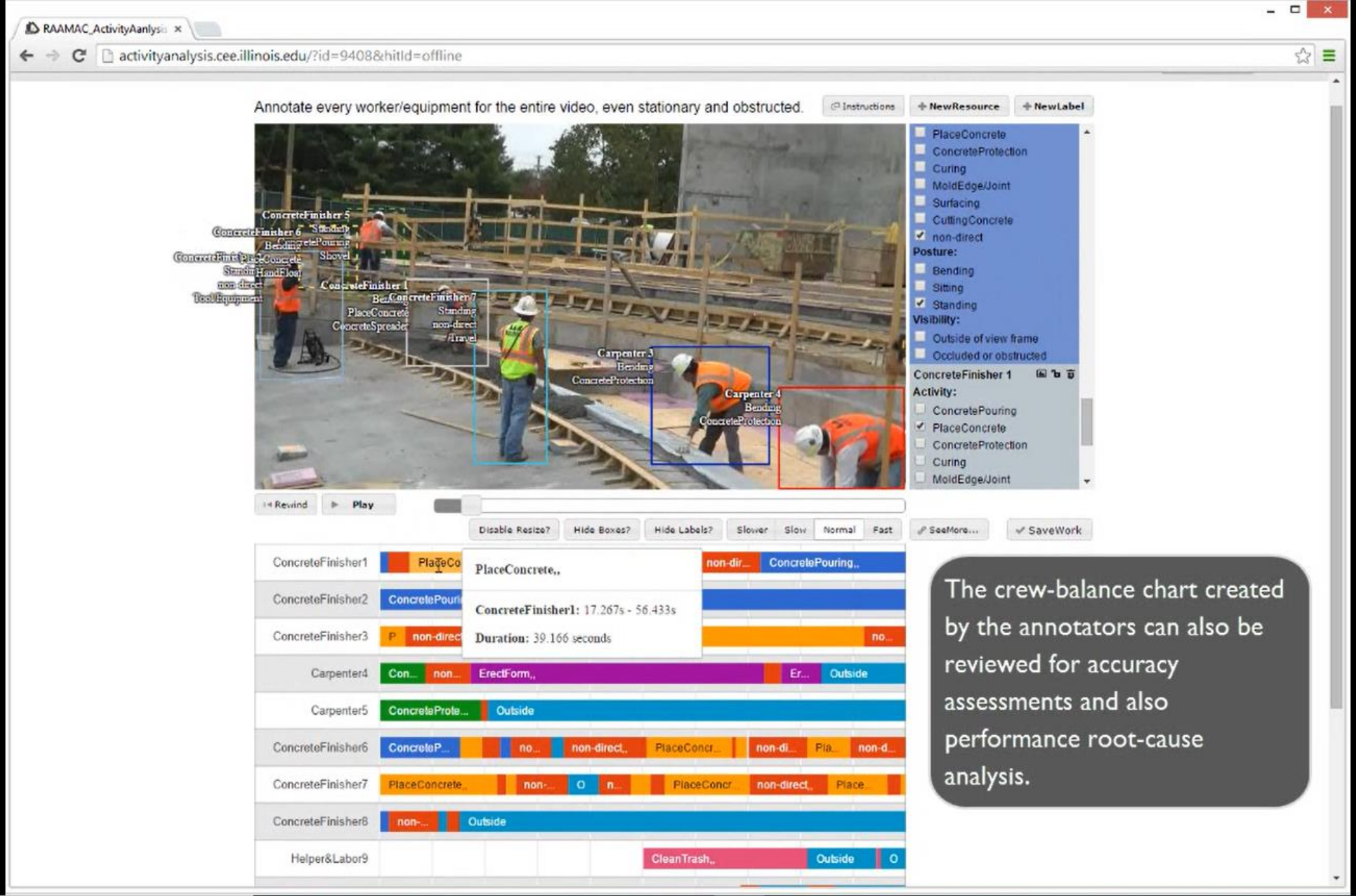
Innovations and Emerging Uses of Technology

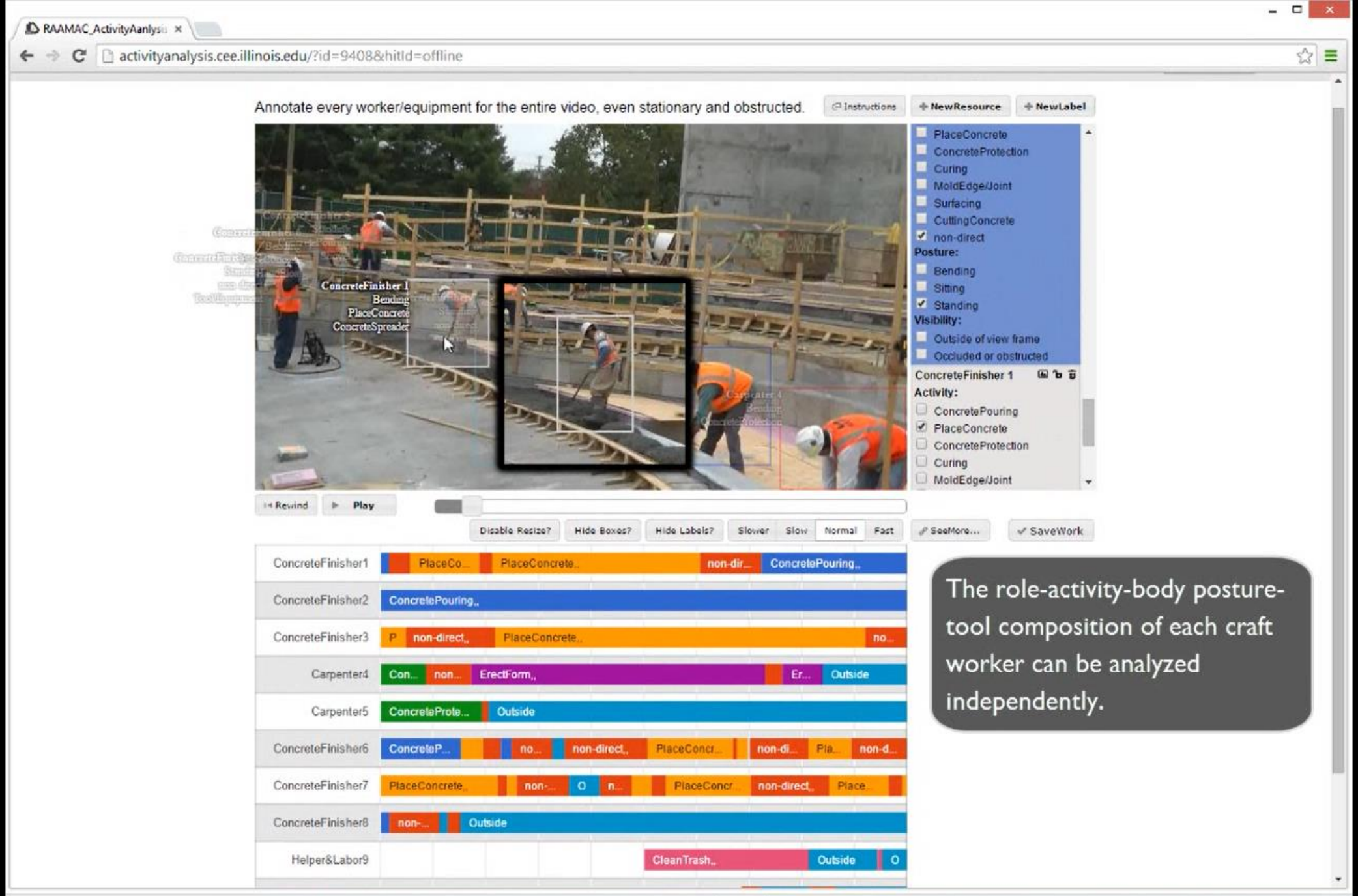
DODGE DATA & ANALYTICS
See Ahead Think Ahead Stay Ahead

- Site Cameras to Analyze Safety and Labor Productivity
- Reality Capture
- Internet of Things
- 3D Printing
- Digital Twin

Source: reconstructinc.com

Ergonomic Analysis for Occupational Health (OSHA) and Productivity Analysis


RAAMAC_ActivityAanlysis
activityanalysis.cee.illinois.edu/?id=9408&hitId=offline
Annotate every worker/equipment for the entire video, even stationary and obstructed.
Instructions
+ NewResource
+ NewLabel
PlaceConcrete
ConcreteProtection
Curing
MoldEdge/Joint
Surfacing
CuttingConcrete
non-direct
Posture:
Bending
Sitting
Standing
Visibility:
Outside of view frame
Occluded or obstructed
ConcreteFinisher 1
Activity:
ConcretePouring
PlaceConcrete
ConcreteProtection
Curing
MoldEdge/Joint
ConcreteFinisher 5
ConcreteFinisher 6
ConcreteFinisher 1
ConcreteFinisher 7
Carpenter 3
Bending
ConcreteProtection
Carpenter 4
Bending
ConcreteProtection
Rewind
Play
Disable Resize?
Hide Boxes?
Hide Labels?
Slower
Slow
Normal
Fast
SeeMore...
SaveWork
ConcreteFinisher1
ConcreteFinisher2
ConcreteFinisher3
Carpenter4
Carpenter5
ConcreteFinisher6
ConcreteFinisher7
ConcreteFinisher8
Helper&Labor9
PlaceConcrete,,
ConcreteFinisher1: 17.267s - 56.433s
Duration: 39.166 seconds
ErectForm,,
Outside
CleanTrash,,
The crew-balance chart created by the annotators can also be reviewed for accuracy assessments and also performance root-cause analysis.


RAAMAC_ActivityAanlysis
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Annotate every worker/equipment for the entire video, even stationary and obstructed.
Instructions
+ NewResource
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ConcreteFinisher 1
Bending
PlaceConcrete
ConcreteSpreader
PlaceConcrete
ConcreteProtection
Curing
MoldEdge/Joint
Surfacing
CuttingConcrete
non-direct
Posture:
Bending
Sitting
Standing
Visibility:
Outside of view frame
Occluded or obstructed
ConcreteFinisher 1
Activity:
ConcretePouring
PlaceConcrete
ConcreteProtection
Curing
MoldEdge/Joint
Rewind
Play
Disable Resize?
Hide Boxes?
Hide Labels?
Slower
Slow
Normal
Fast
SeeMore...
SaveWork
ConcreteFinisher1
ConcreteFinisher2
ConcreteFinisher3
Carpenter4
Carpenter5
ConcreteFinisher6
ConcreteFinisher7
ConcreteFinisher8
Helper&Labor9
PlaceConcrete..
non-dir...
ConcretePouring..
ConcretePouring..
non-direct..
PlaceConcrete..
ErectForm..
Outside
Outside
non-direct..
PlaceConcrete..
CleanTrash..
Outside
The role-activity-body posture-tool composition of each craft worker can be analyzed independently.

Innovations and Emerging Uses of Technology

DODGE DATA & ANALYTICS
See Ahead Think Ahead Stay Ahead

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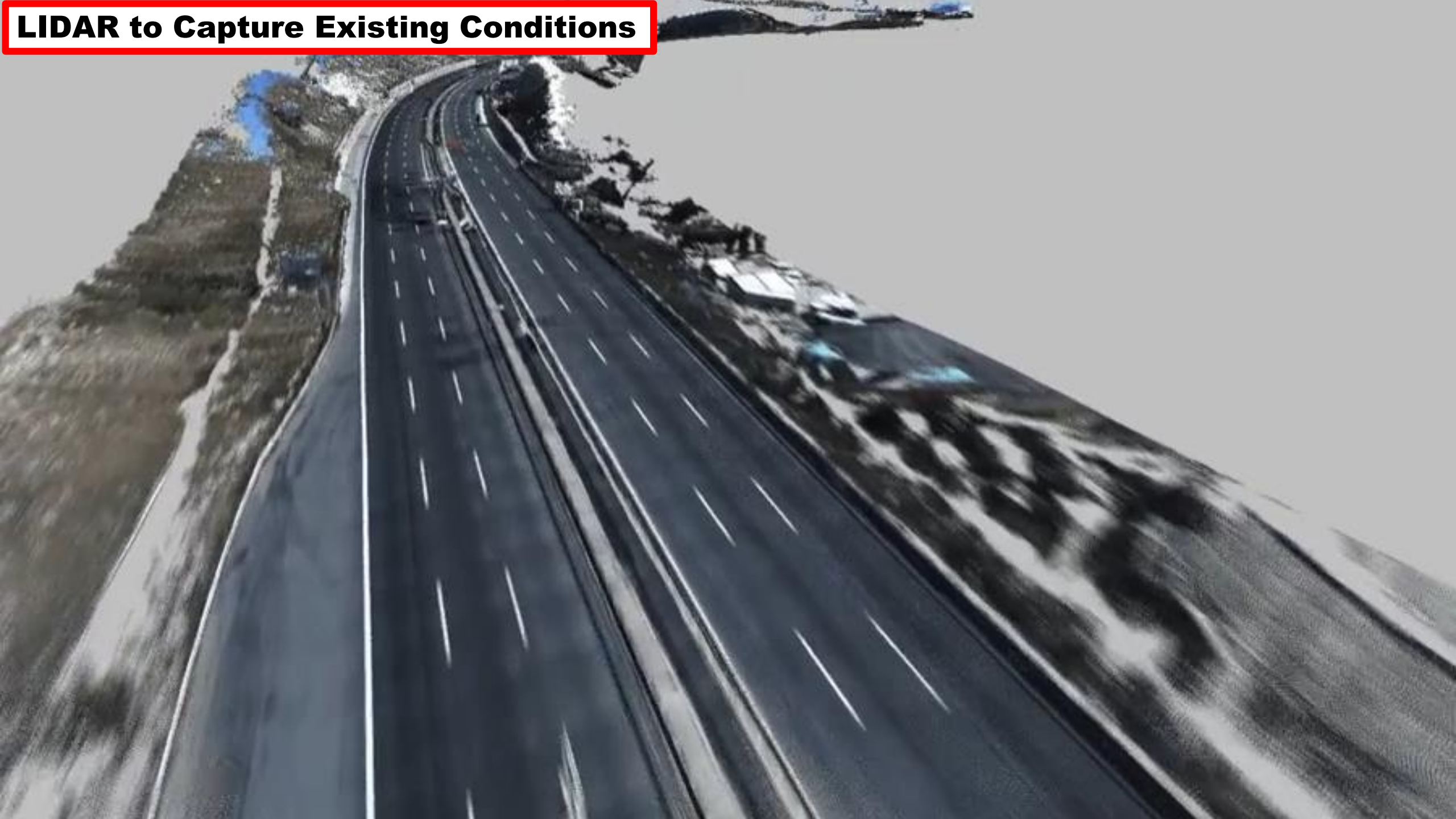
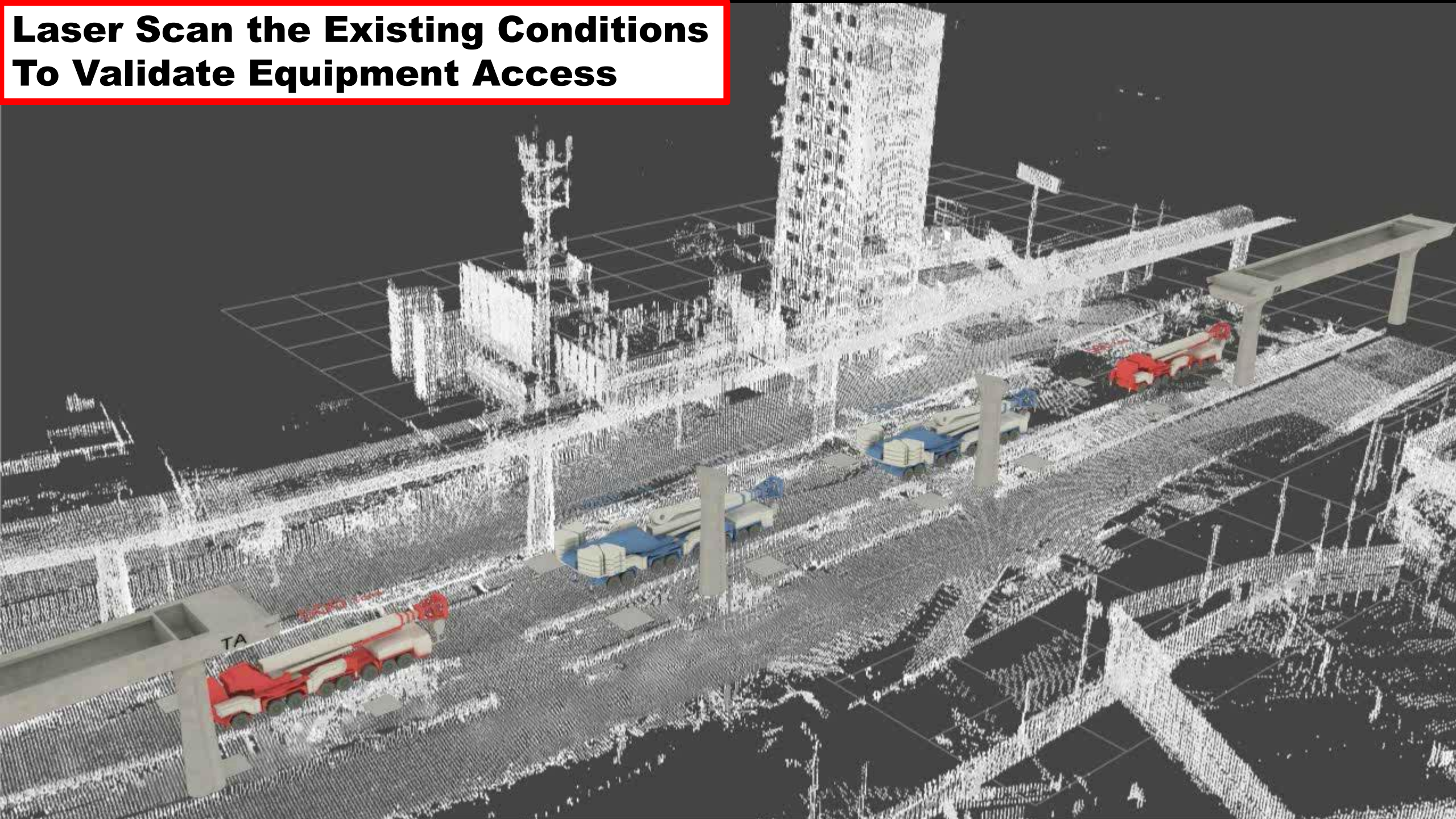
LIDAR to Capture Existing Conditions



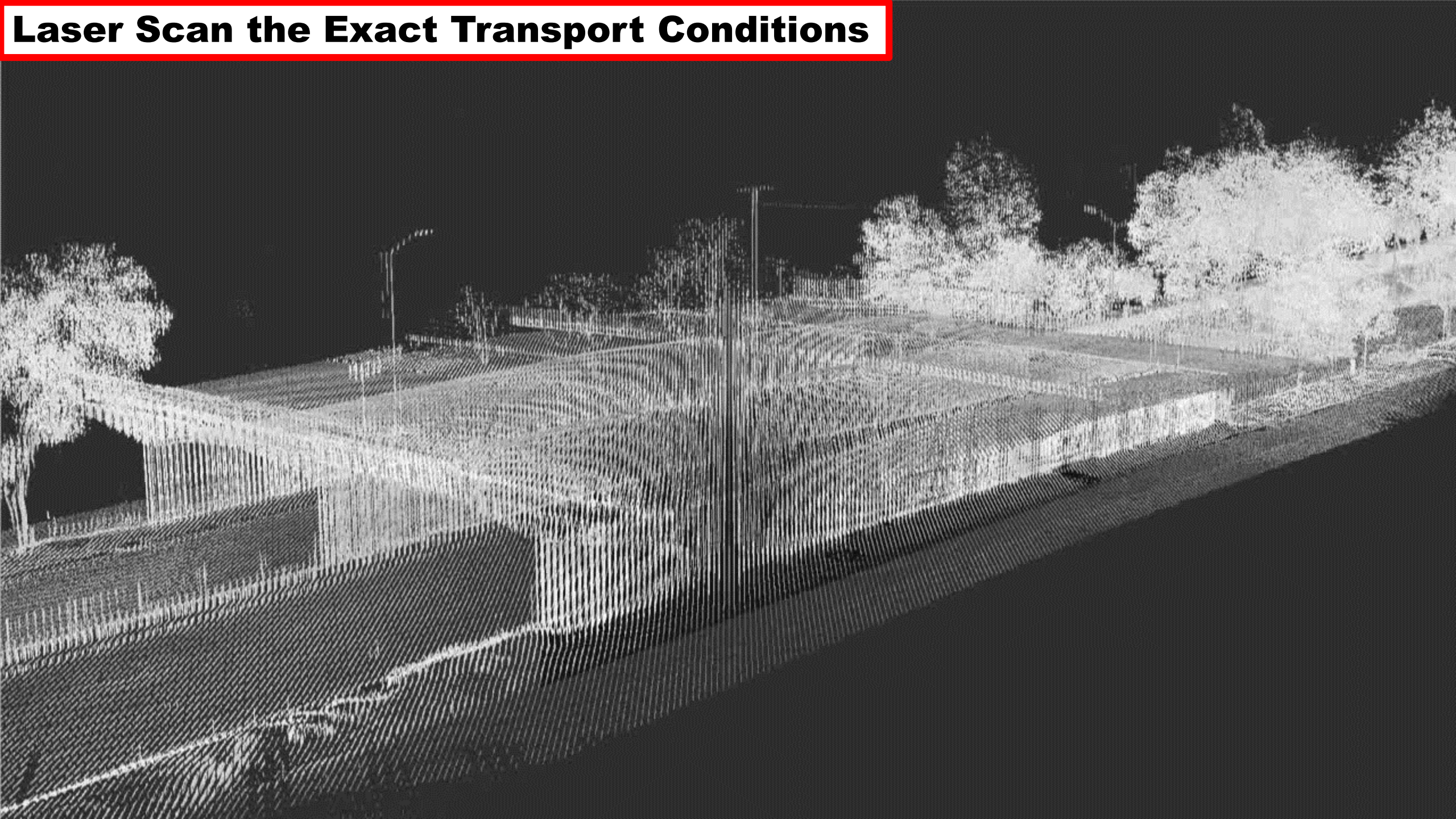
Laser Scan to Capture Existing Conditions

Integrate Model into Aerial Video

Laser Scan the Existing Conditions To Validate Equipment Access



Laser Scan the Exact Transport Conditions

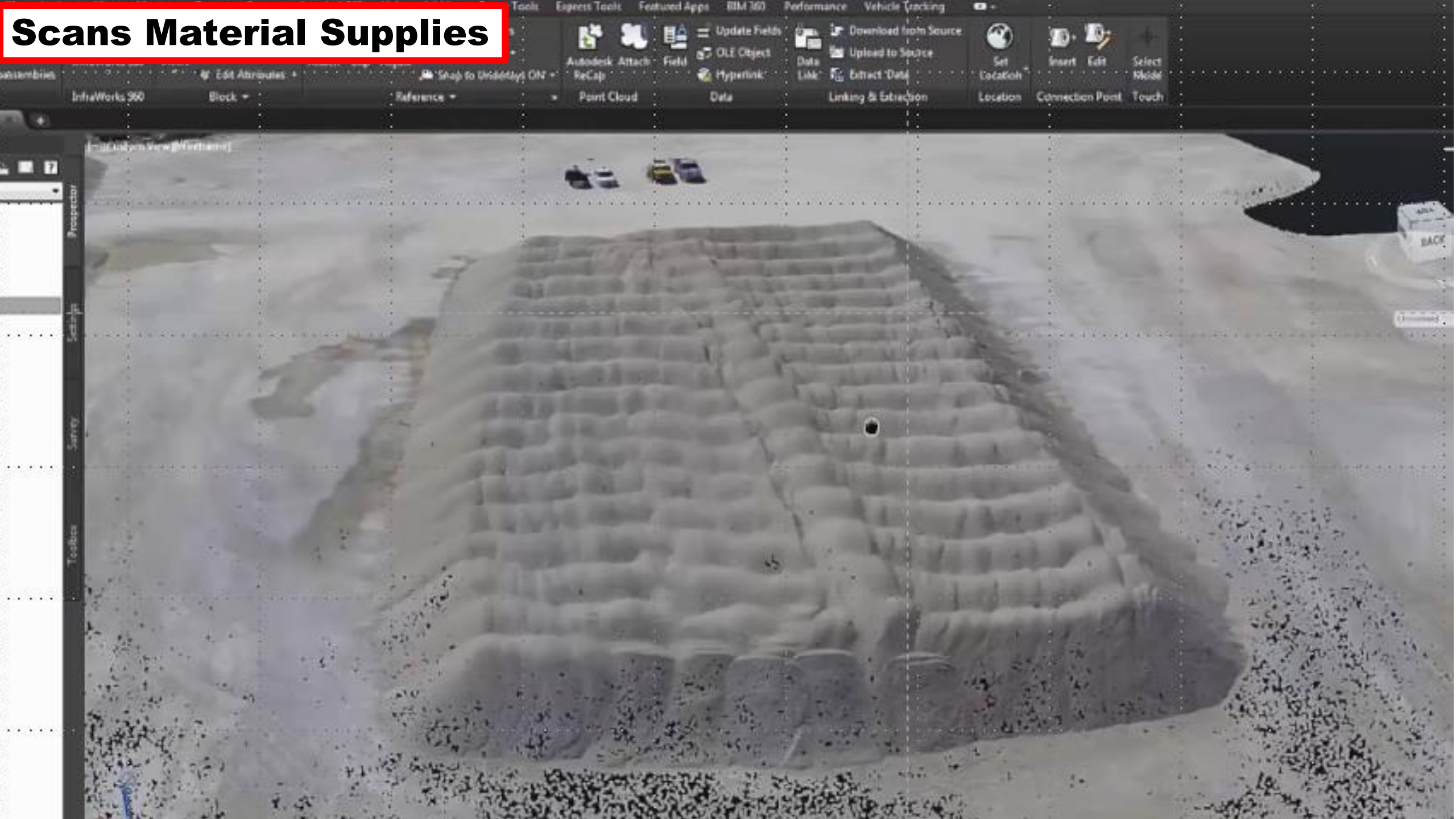


CERTAINTY

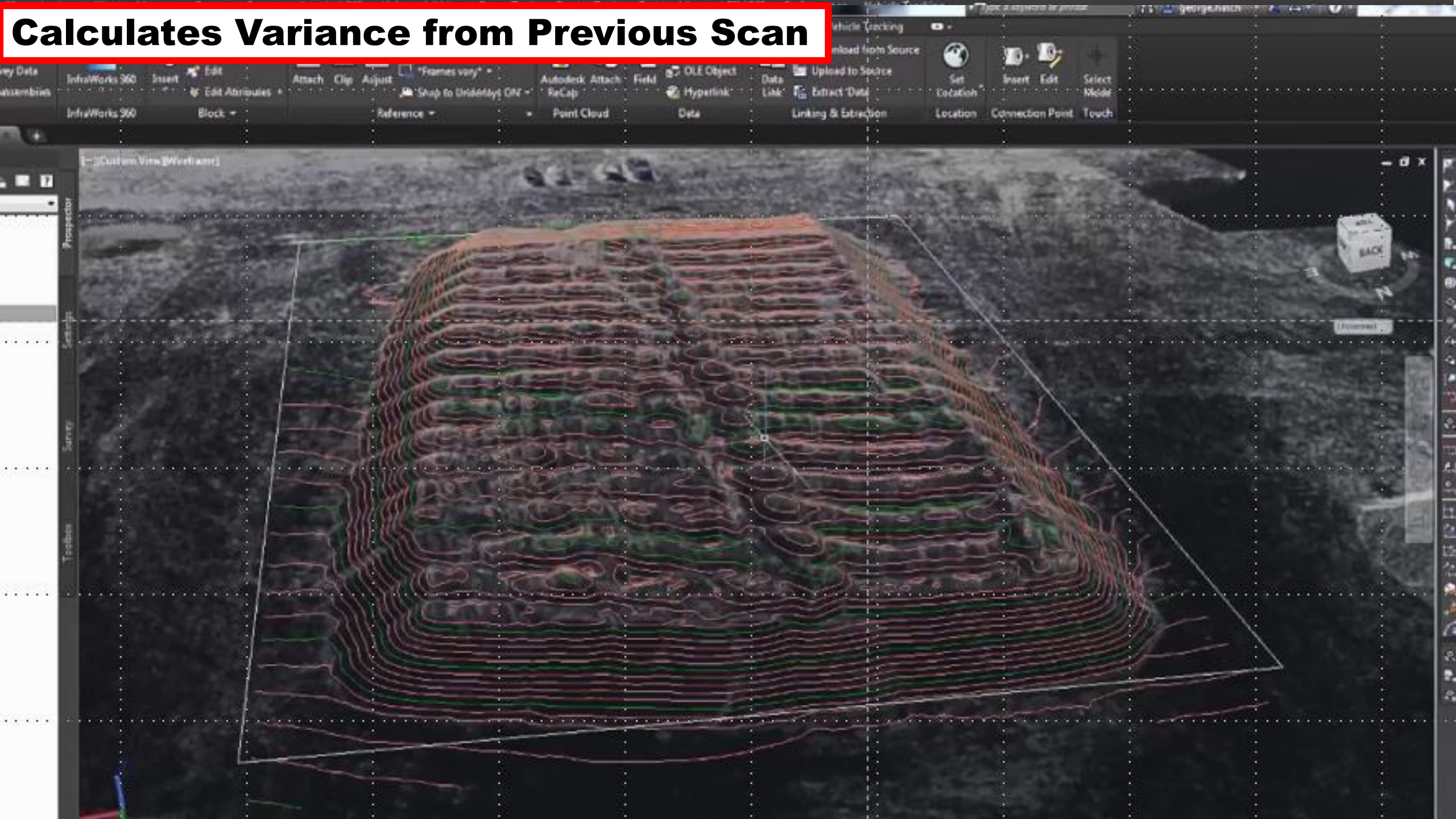
Drone to Measure Material Movement and Usage on Site

Automatically Establishes Flight Path

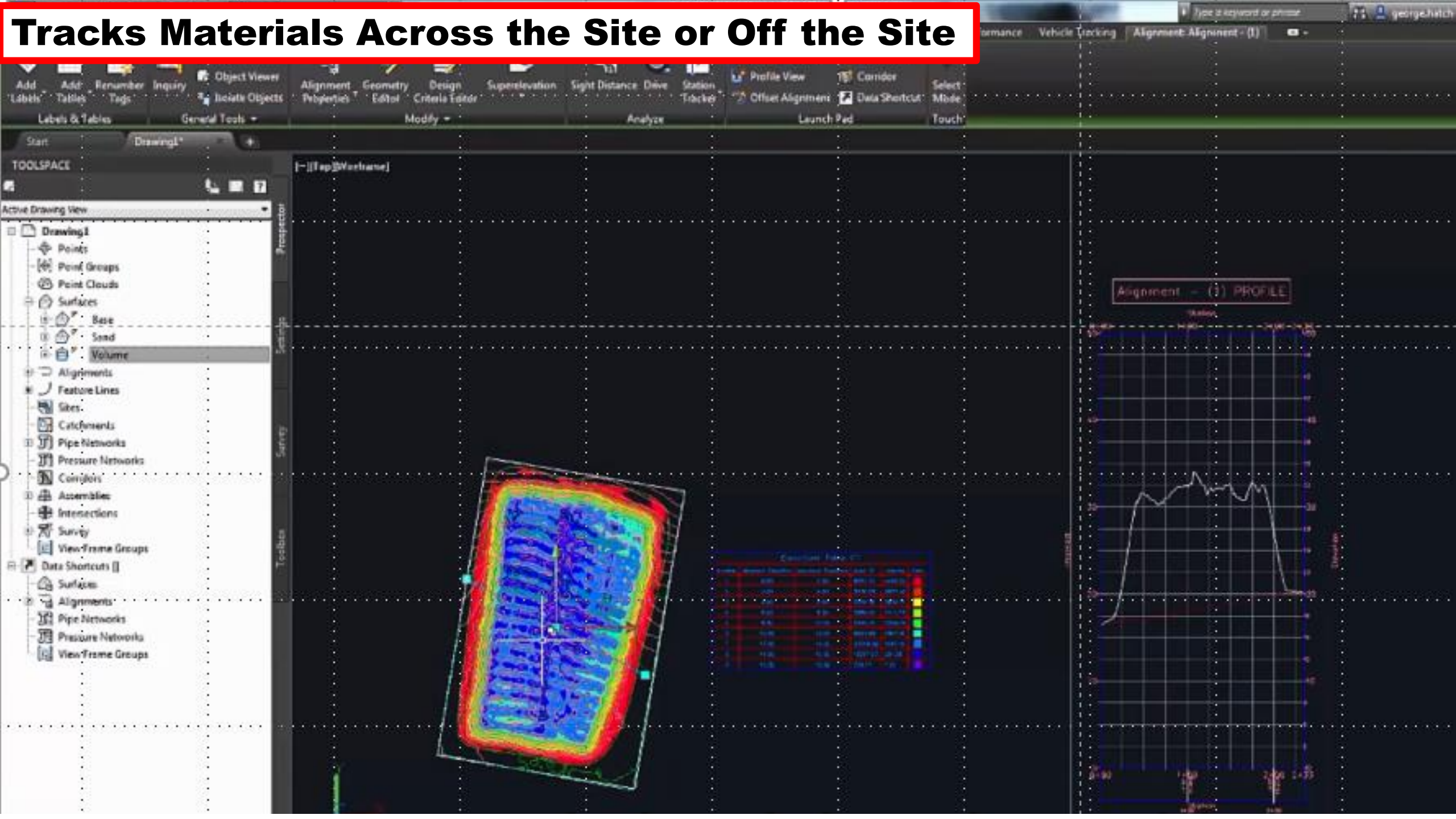
Scans Material Supplies



Calculates Variance from Previous Scan



Tracks Materials Across the Site or Off the Site



Innovations and Emerging Uses of Technology

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See Ahead Think Ahead Stay Ahead

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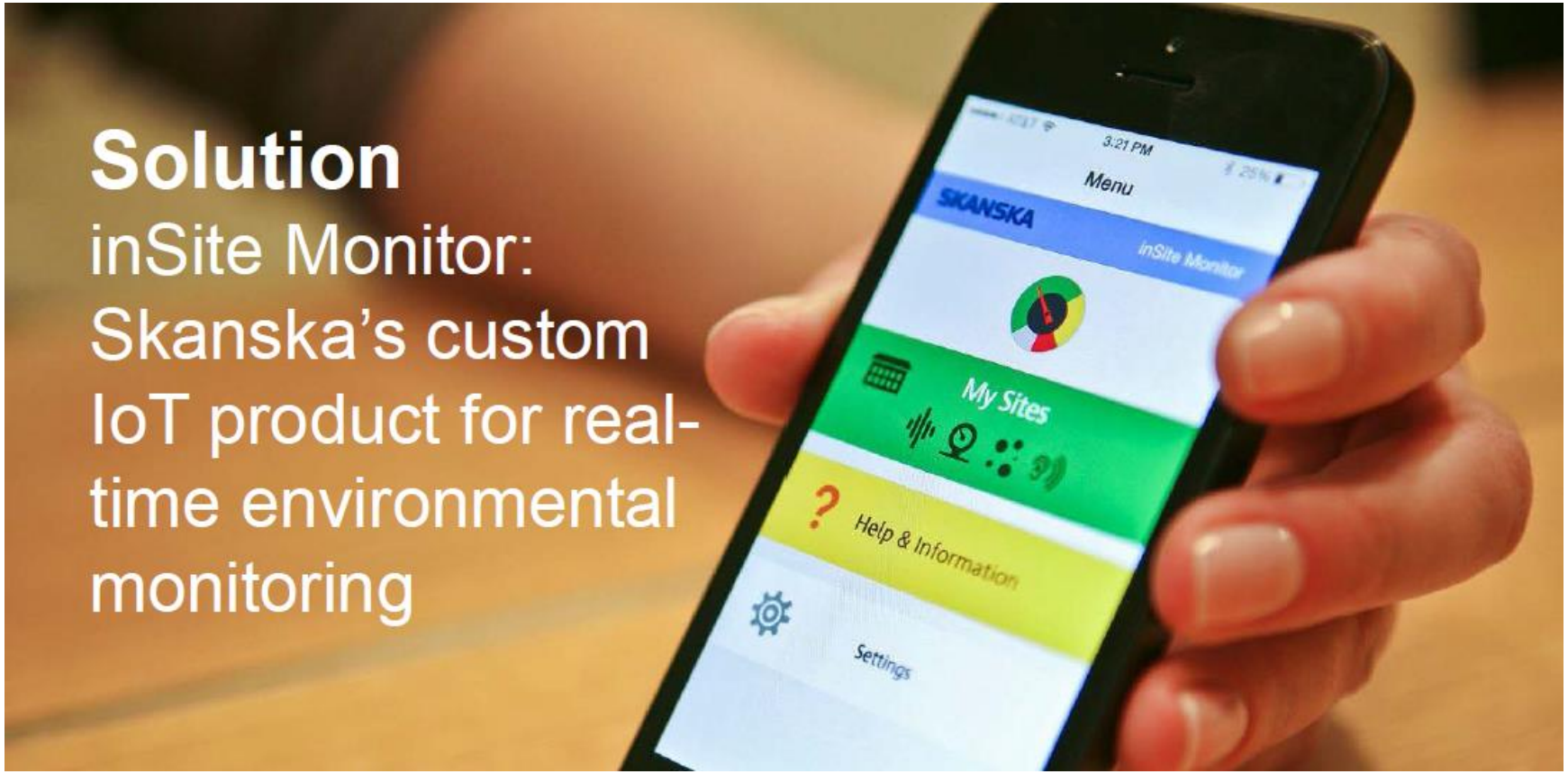
Internet of Things (IoT)

Contractors: *Sensors deployed for safety at the project site*



Source: Skanska

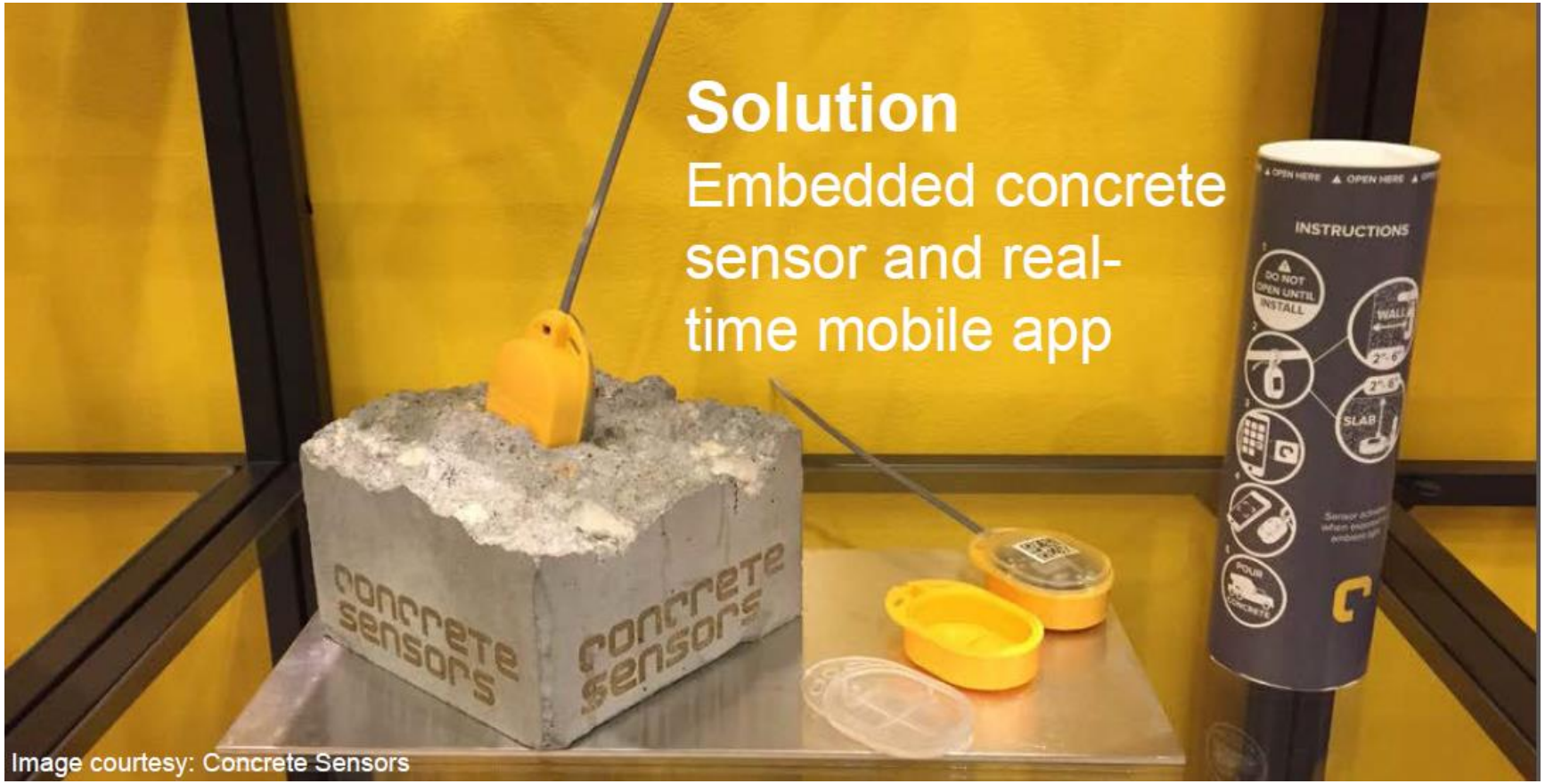
Internet of Things (IoT)

Contractors: *Sensors deployed for tactical purposes at the project site*

Source: Skanska

Internet of Things (IoT)

Contractors: *Sensors deployed for tactical purposes at the project site*



Source: Skanska

Innovations and Emerging Uses of Technology

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See Ahead Think Ahead Stay Ahead

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- Digital Twin

- 3D printing structural components for bridge in Europe

3D Printing

Mass-customization

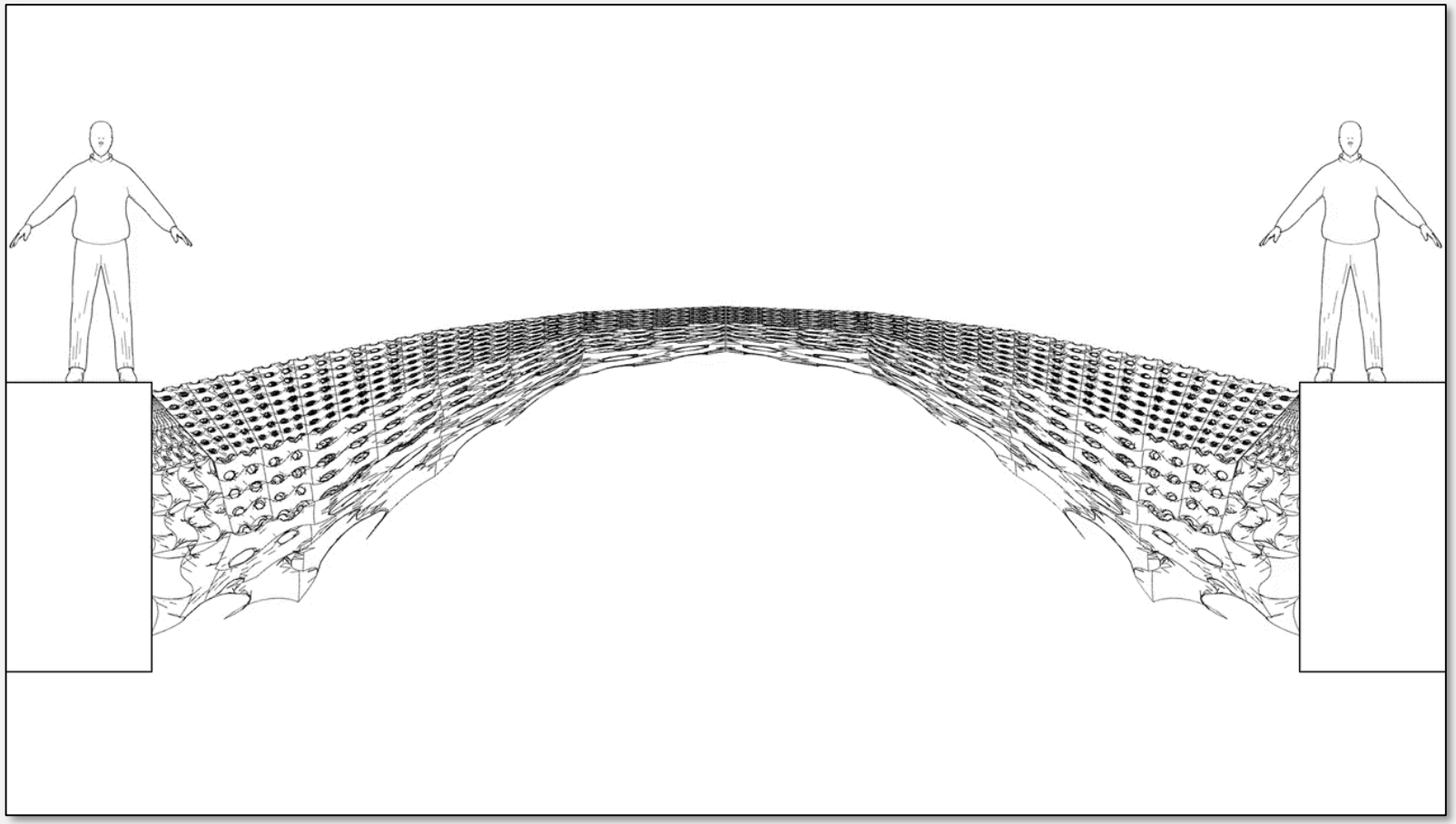
- MX3D in Amsterdam
- 3D printing of metal structures

Source: MX3D

3D Printing

Mass-customization

- MX3D in Amsterdam
- Generative design and 3D printing of bridge over a canal



Source: MX3D

3D Printing

Mass-customization

- MX3D in Amsterdam
- Generative design and 3D printing of bridge over a canal

Source: MX3D

3D Printing

Mass-customization

- MX3D in Amsterdam
- Generative design and 3D printing of bridge over a canal

3D Printing

Mass-customization

- 3D printing of structures

Source: MX3D

Innovations and Emerging Uses of Technology

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Existing conditions visibility

Reality-informed design

Agenda

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Recommendations

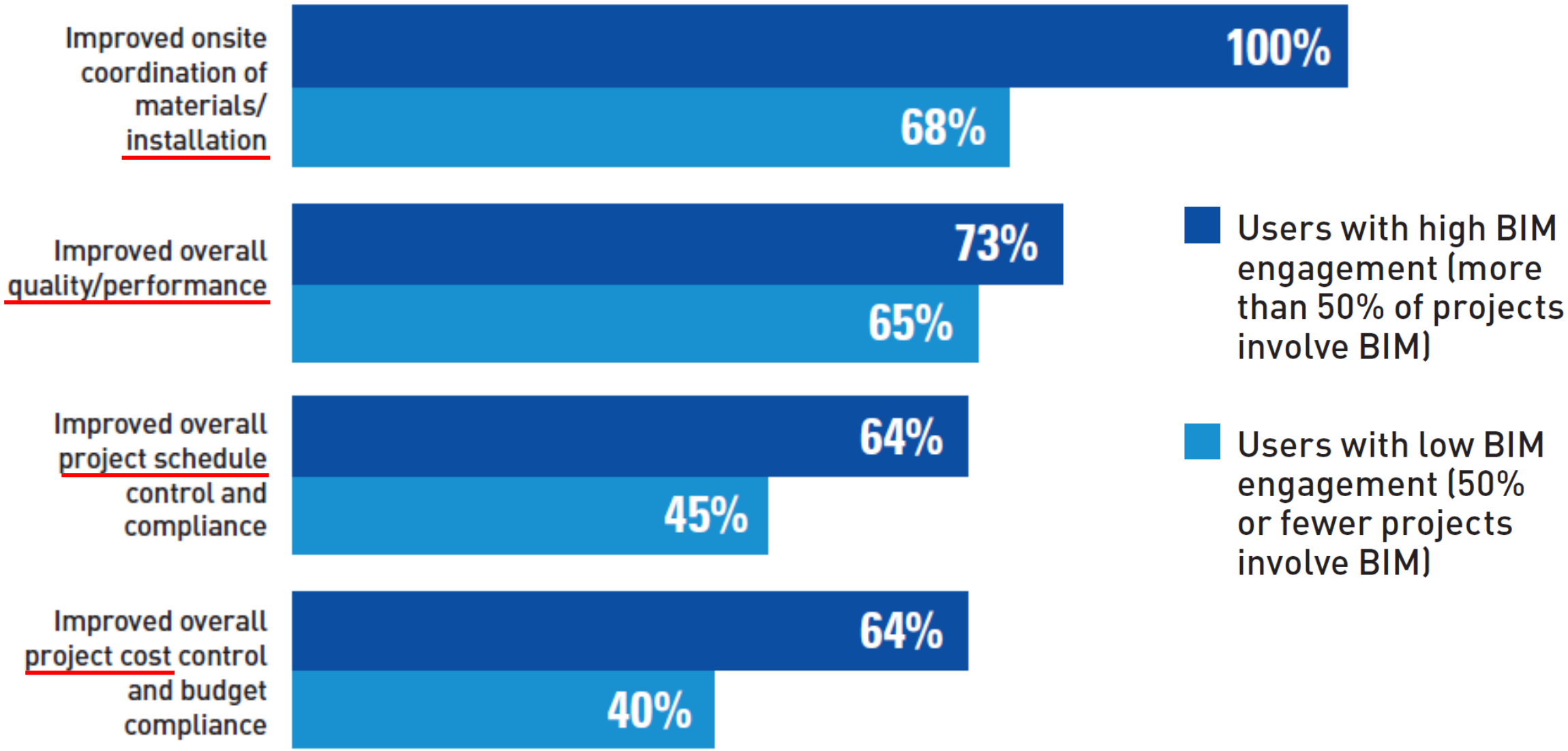
DODGE DATA & ANALYTICS
See Ahead Think Ahead Stay Ahead

1. Embrace Technology

- *Stop* thinking of technology as *INCREMENTAL* to the core business
- *Start* thinking of technology as *INTEGRAL* to the core business and their project teams
- Why? **Better Outcomes**

Improved Project Outcomes When BIM is Used by Engineers and Trades

Percentage of BIM users who cite each of four benefits generated by having key team members engaged with BIM



Recommendations

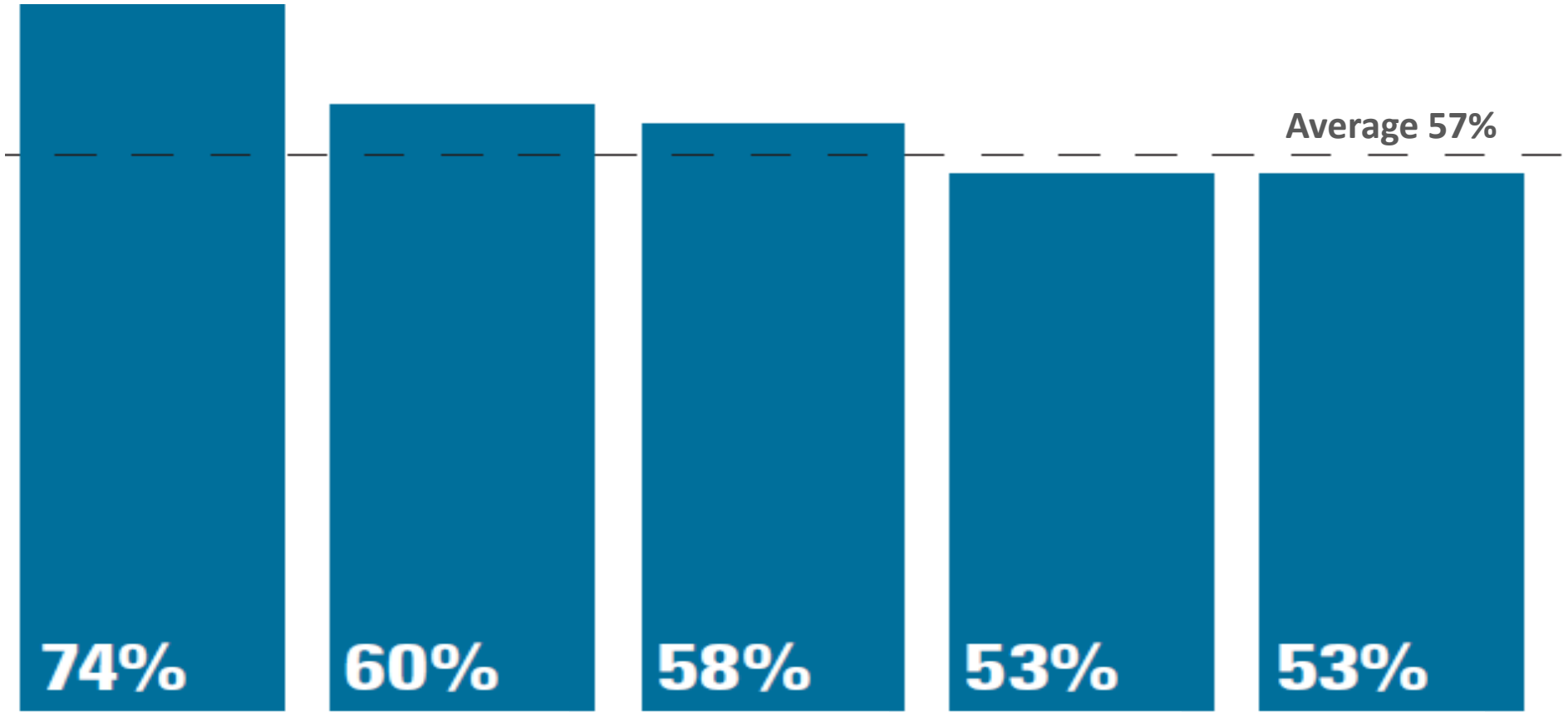
DODGE DATA & ANALYTICS
See Ahead Think Ahead Stay Ahead

2. Focus on driving integrated digital workflows among team members

- **Why?** Better Outcomes

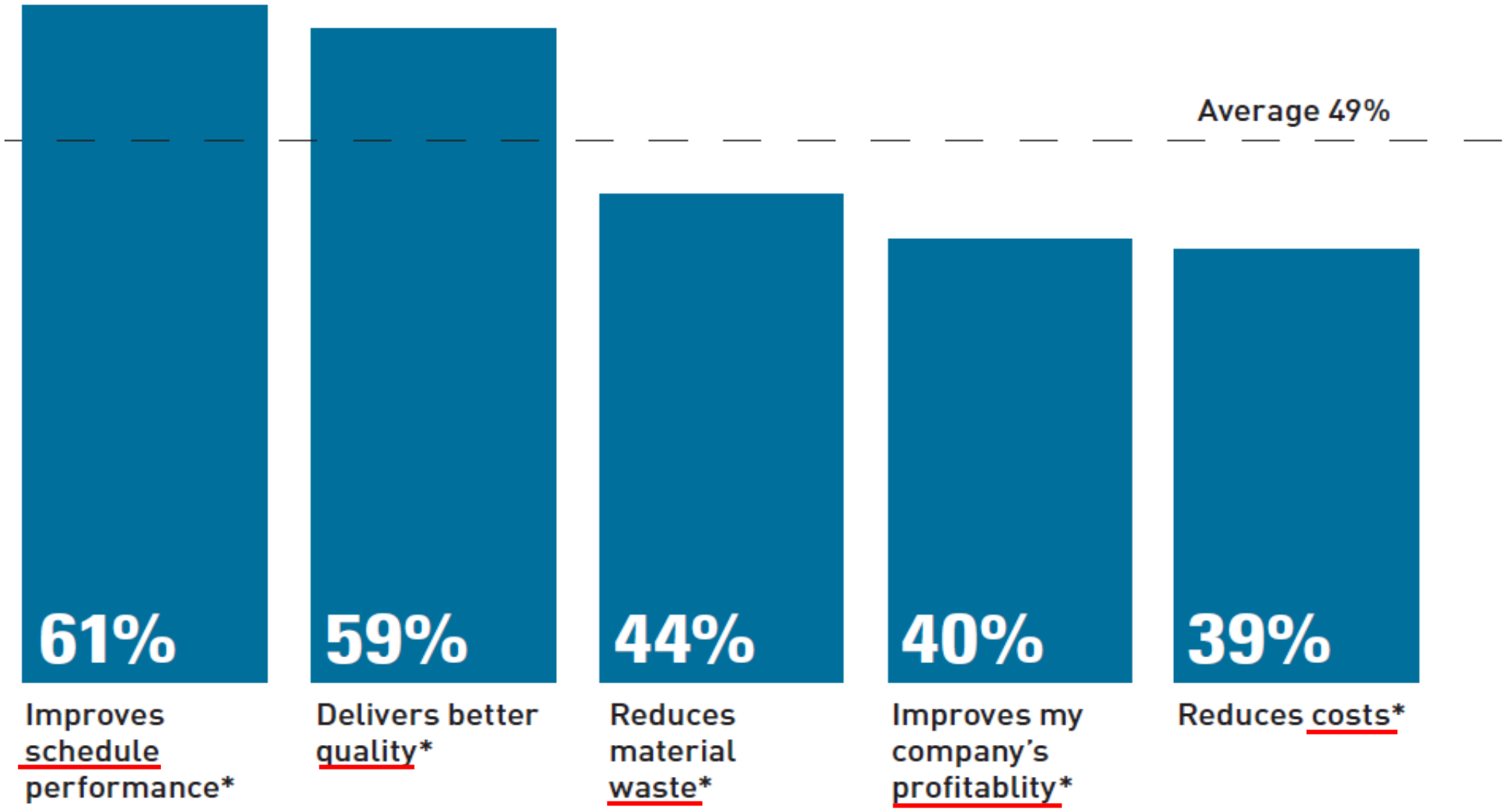
Impact on Design, Detailing and Fabrication

Percentage of high or very high impact ratings for 7 positive impacts of the integrated workflow



Impact on Project Outcomes

Percentage of high or very high impact ratings for 5 positive impacts of the integrated workflow on project outcomes

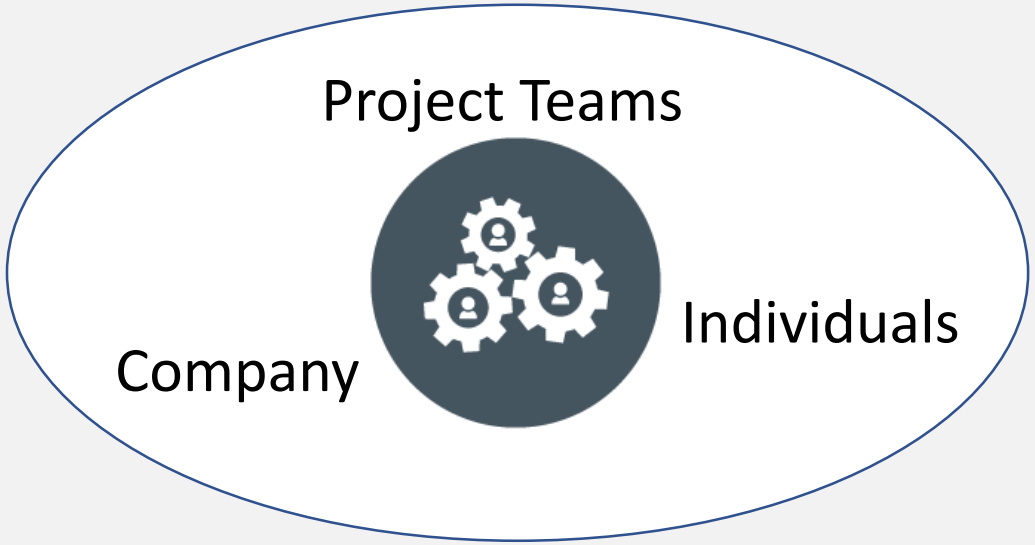


*Specifically related to the systems/aspects of the buildings addressed by the integrated workflow

Recommendations

DODGE DATA & ANALYTICS
See Ahead Think Ahead Stay Ahead

3. Formalize how you plan, invest, set goals and measure impact of technology.



Technology for Transportation Infrastructure

Steve Jones
Senior Director, Industry Insights Research, Dodge Data & Analytics

OCTOBER 16, 2019