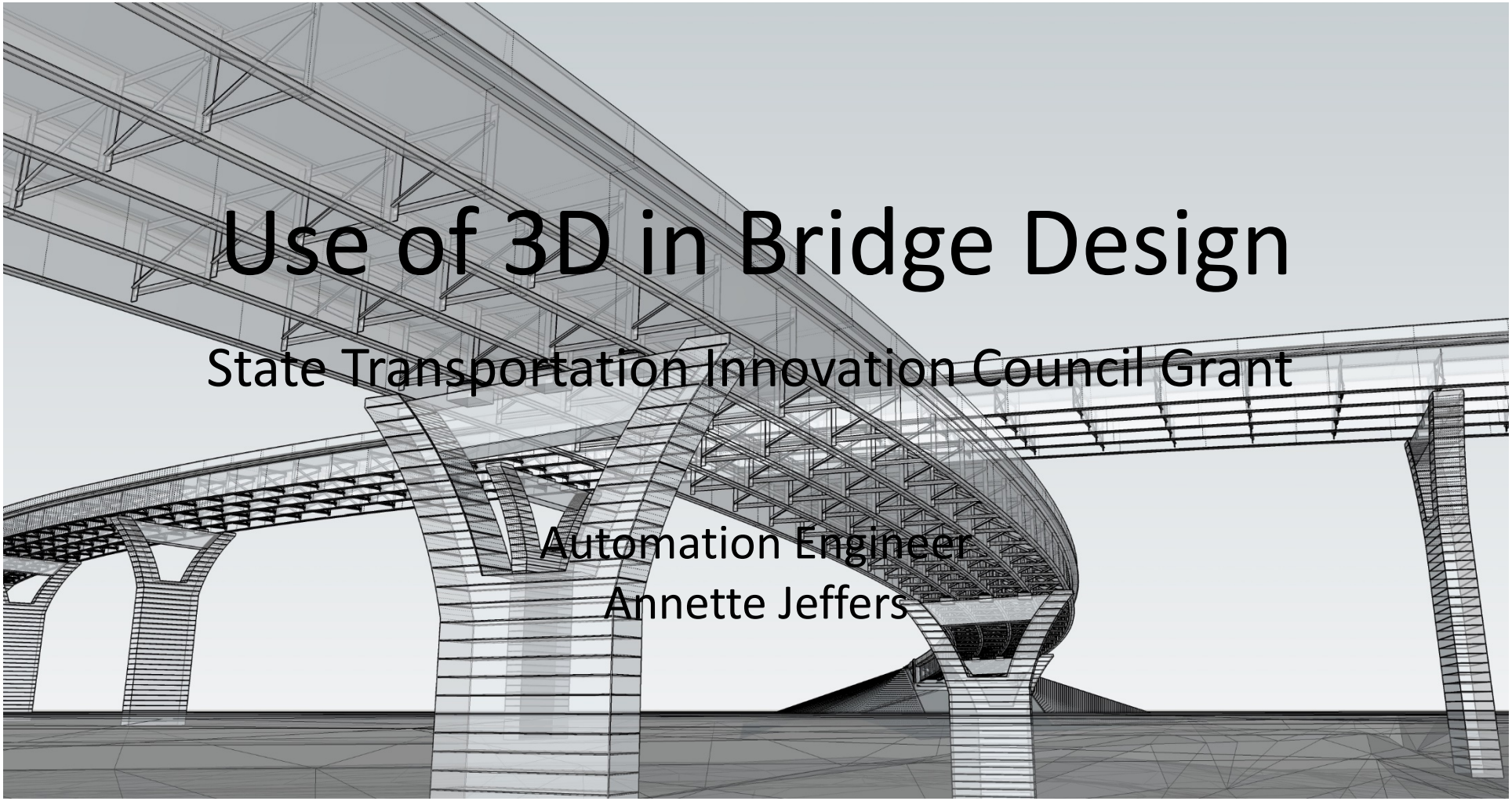


Use of 3D in Bridge Design

State Transportation Innovation Council Grant

Automation Engineer
Annette Jeffers

WORK PLAN - Background

- The use of 3D has been successfully demonstrated by Iowa DOT's Office of Design for roadway projects and its use has been expanded to bridge projects by other State DOTs (i.e. Oregon). Iowa DOT Office of Bridges and Structures has implemented 3D for visualization and constructability on selected projects, however, 3D has not been integrated into structural detailing.

WORK PLAN - Scope

- **Scope:** The scope of this project is to investigate the feasibility of using 3D tools by Iowa DOT's Office of Bridges and Structures and to develop an implementation plan. The Research Team will examine the current use of 3D tools by other DOT offices (internal) and other state DOTs (external). To accomplish this work, the following tasks will be completed. These tasks will allow the Research Team to identify potential applications for 3D modeling (i.e. detailing, analysis, data integration, and visualization) in bridge design and evaluate how effectively it can be integrated into normal work flow.

WORK PLAN - Tasks

- ***Task 1 – Assemble the Research Team***
  - ✓ During Task 1, a team of OBS engineers and CAD users that are knowledgeable with current design and detailing practices was assembled.

RESEARCH TEAM

- Annette Jeffers (Automation Engineer) – Team Leader
- John Colle (Design Technician)
- Steve Fisher (Design Technician)
- Paul Sodahl (Design Technician)
- Steve Seivert (Preliminary Design Engineer)
- Kimball Olson (Aesthetic Bridge Specialist)
- Stuart Nielsen (Methods Engineer)
- Michael Nop (Design Support Engineer)
- Dean Bierwagen (Final Design Section Leader)
- Jim Nelson (Final Design Section Leader)

- Andrew Wilson (FHWA – Iowa Division)
- Brent Phares (ISU – Bridge Engineering Center)
- Vanessa Goetz (Iowa Highway Research Board/State Transportation Innovation Council)
- Ahmad Abu-Hawash (Chief Structural Engineer) – Project Monitor

WORK PLAN - Tasks

- ***Task 2 – Identify Stakeholders and Customers (both internal and external)***
  - ✓ Develop a list of internal and external stakeholders and customers. Internal stakeholders/customers may include Iowa DOT staff outside the Office of Bridges and Structures such as various offices in the Central Complex and field staff in the six Districts. External stakeholders/customers include consultants, contractors, and fabricators.
- ***Task 3 – Conduct Stakeholders/Customers, and state DOTs Surveys***
  - ✓ Conduct electronic surveys and follow-up phone interviews of selected state DOTs

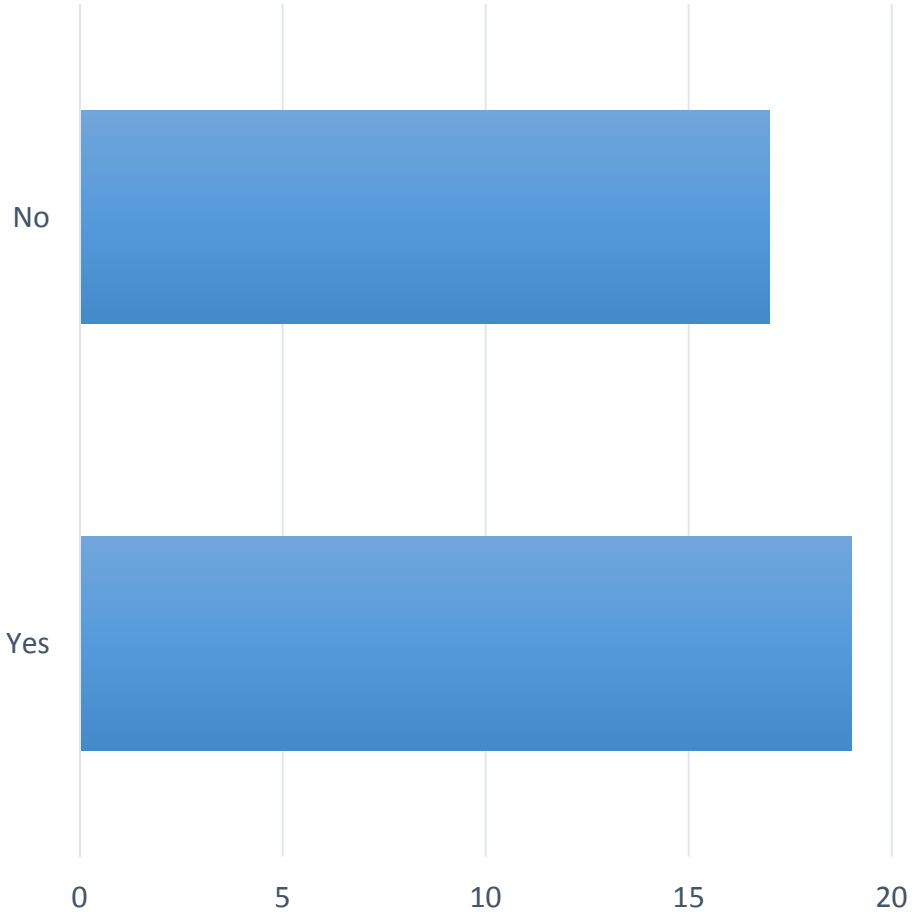
STATE DOT SURVEY

Distributed June 2014

States providing a survey response.

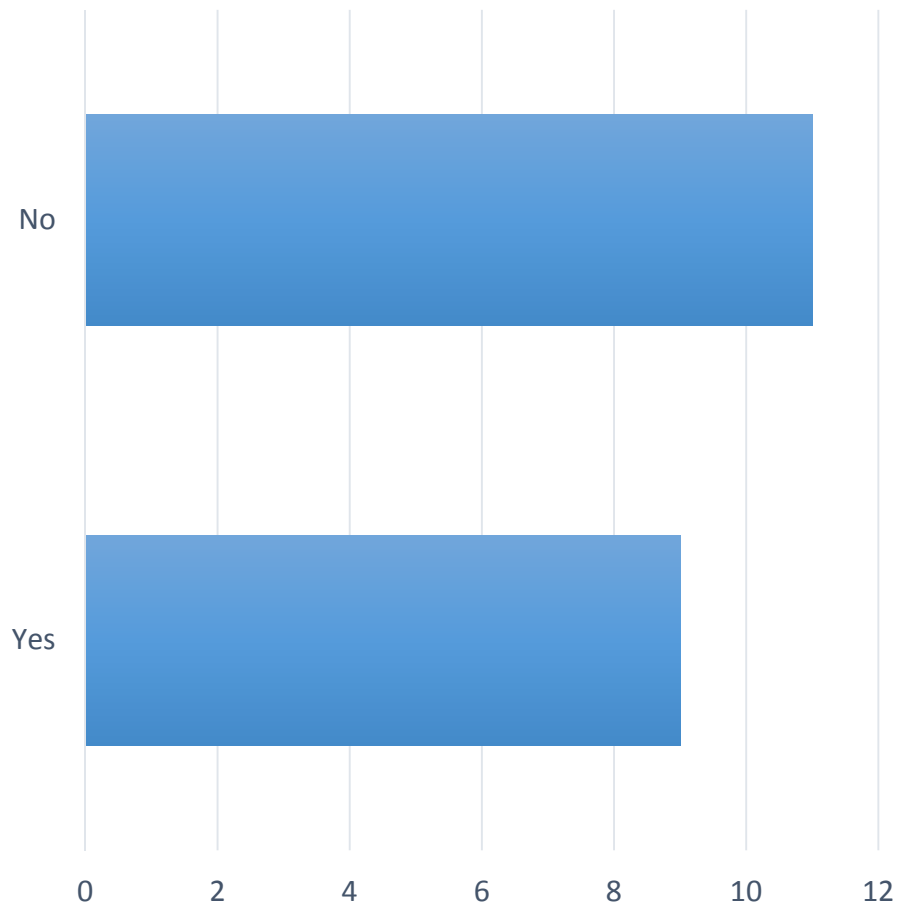
AK	MI	OK
AZ	MN	OR
FL	MO	SC
GA	MT	SD
HI	NC	TN
IA	ND	TX
IN	NE	UT
KS	NH	VA
KY	NJ	WI
LA	NM	WY
MD	NY	
ME	OH	

Do you use 3D modeling in your bridge design or detailing process?



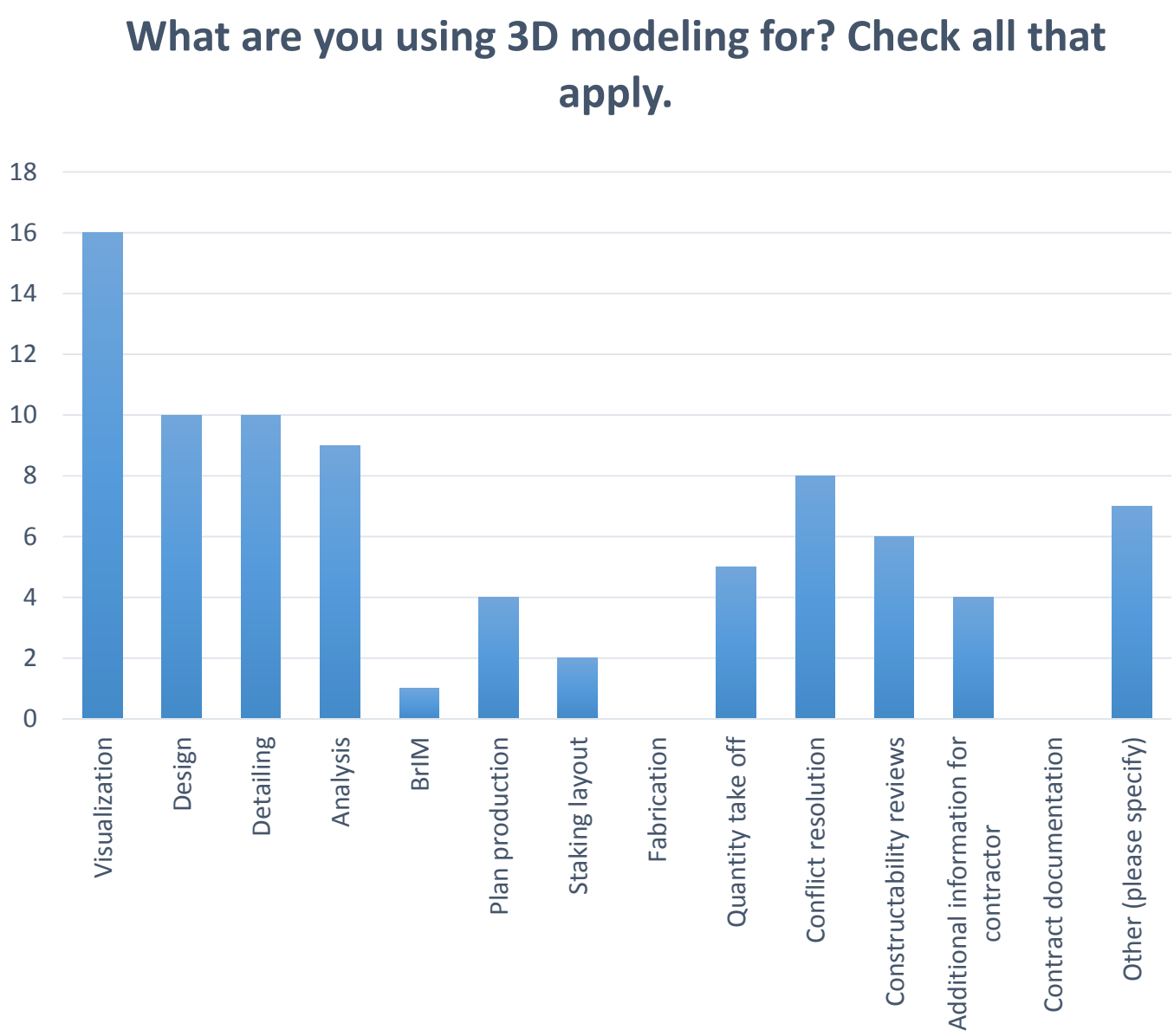
Yes	No
AZ	AK
FL	GA
IA	HI
ID	IL
IN	KY
KS	LA
ME	MD
MI	MT
MN	NC
MO	ND
NE	NH
NY	NJ
OH	NM
OK	OR
SC	SD
TX	TN
UT	VA
WI	
WY	

Are you considering adding 3D modeling of bridges to your process?



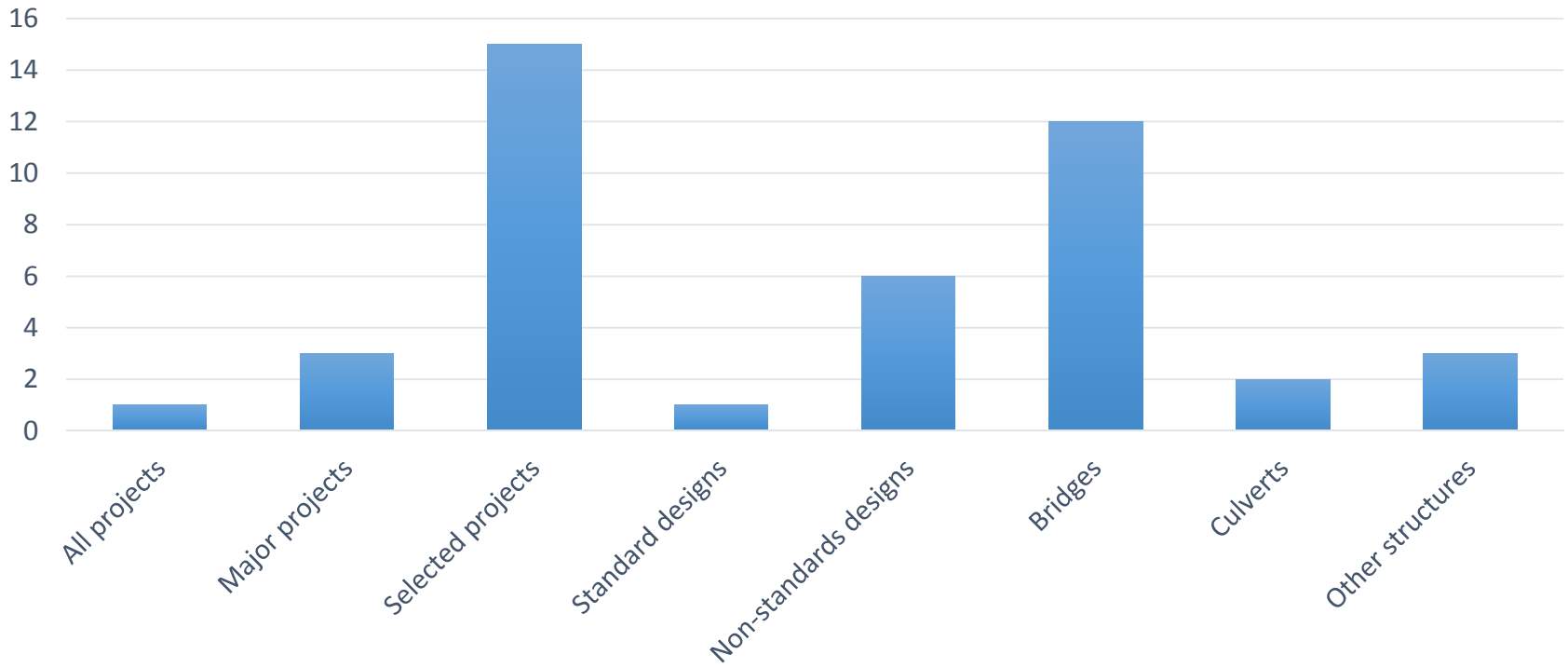
Yes	No
GA	AK
KY	HI
MT	IL
NE	LA
NM	MD
OR	NC
TN	ND
VA	NH
WI	NJ
	SC
	SD

Comments
GDOT has created a 3-D visualization group in the office that provides graphic support. While the current efforts are not specifically geared for bridge design, we will implement at some point in the future.
We wouldn't do this for in-house design but would consider requiring for a consultant-designed project.
Some components have been modeled using 3D FEA software for more complex structures
We use 3D for Seismic in west KY. Evaluating Midas Civil 3d for design.
Maybe
We HAVE used visualization with MicroStation a couple times (once for a concrete spandrel arch) to accurately depict project complexities. I have one technician who is pretty good at the visualization. I don't recall whether she learned via a class provided by Bentley or whether she learned from someone else's class books. FHWA recently hosted an EDC seminar on 3D here at DOT, which was predominantly geared to roadway construction. I then asked a couple of our bridge contractors if they (or the fabricator) would gain anything by us providing them a 3D file of the bridge. They said, "No." So we will continue to use where visualization is needed, but we don't intend to do this much.
Not at this time.
Recently purchased AutoCAD Civil 3D package. Waiting on training to implement 3D modelling.
Oregon is doing one pilot project.
For major bridges/ bridges that have complex geometry
For Major Bridges / complex bridges - full model - For simple bridges - definition

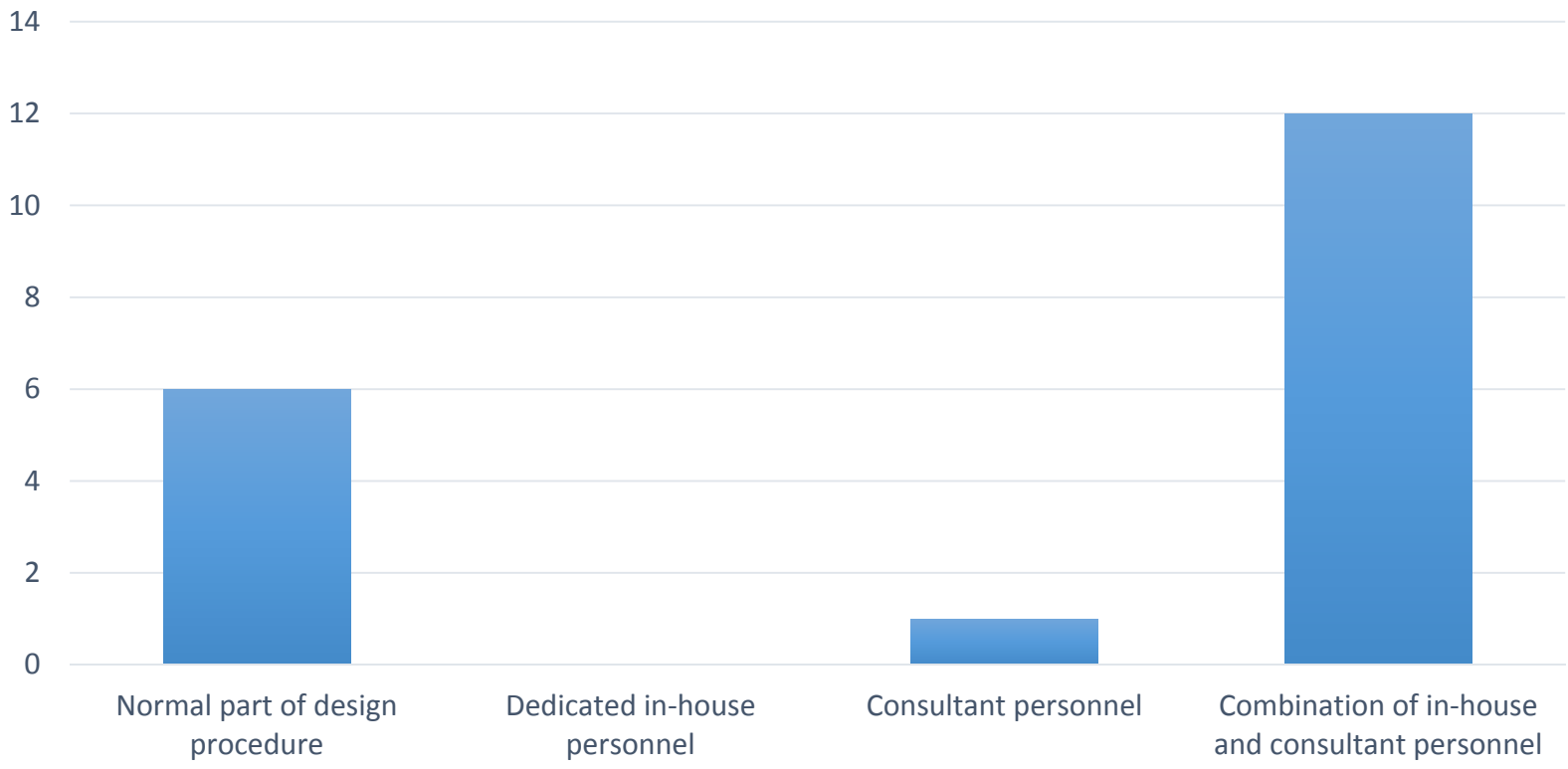


Other
Visualization is used for public presentations on select projects (major structures, aesthetic bridges, ABC). On ABC projects it has been used for pre-bid meetings with contractors. Occasionally we have included isometric views of more complex details in our plans.
Public presentation
For the great majority of plans and analysis we us a traditional 2D approach. For some projects we have created 3D visualization and quantities.
3D design is not typically used. When it is used it is primarily for more complicated analysis or visualization of conflicts and rarely for quantities.
3D modeling is only used for the most complex bridges. Typical bridges do not use 3D modeling. Fairly complex bridges (curved, bifurcated steel girder bridges) use 3D modeling for analysis, but that's all.
Visualization is used for public presentations on select projects (major structures, aesthetic bridges, ABC). Constructability Reviews, Analysis, Sequence, construction timing and sequencing, 3d FEM models. Plan Verification

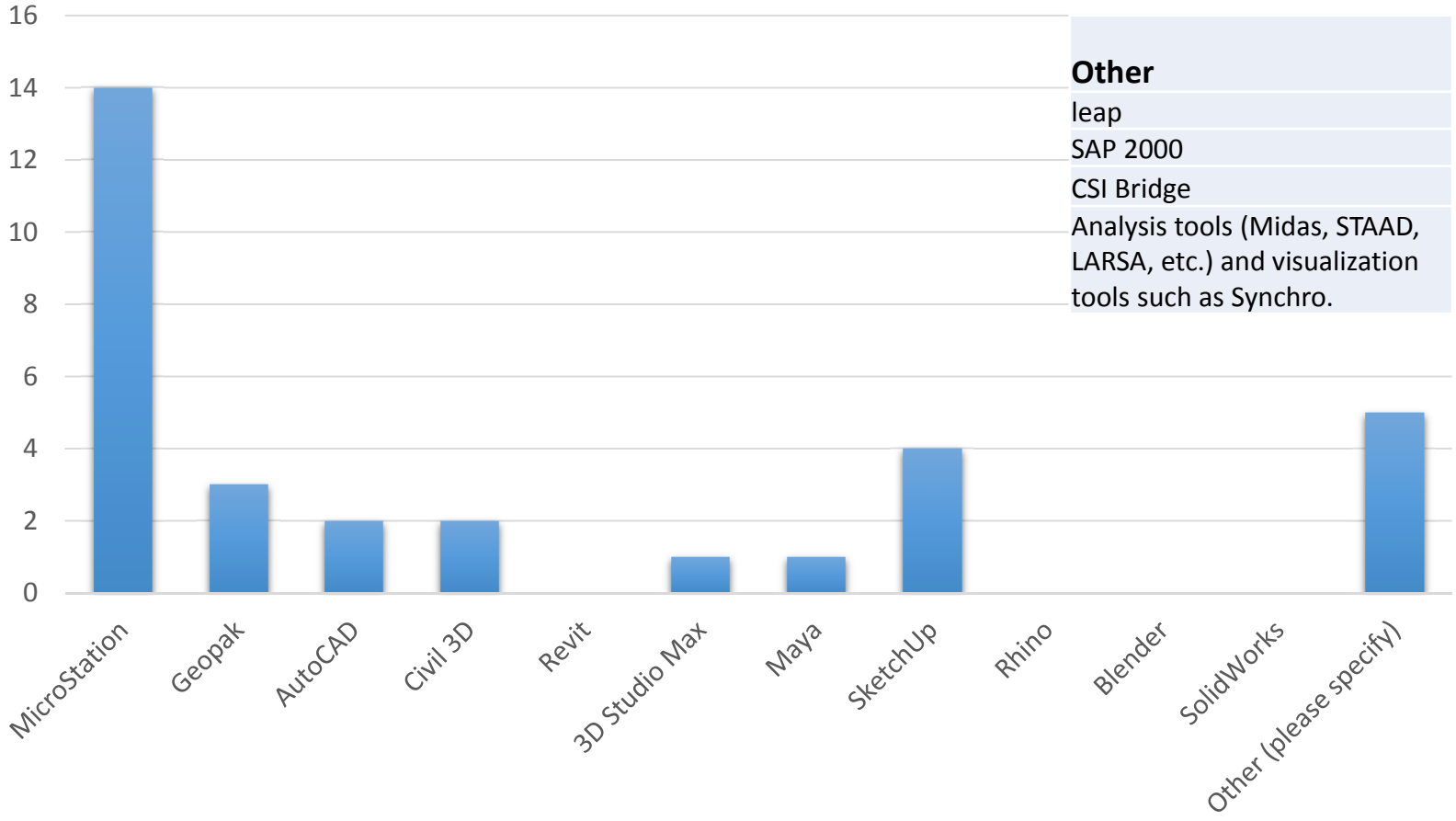
3D modeling is included for the following projects. Check all that apply.



How is the effort of providing the 3D modeling accomplished? Check all that apply.



What software applications are used to develop the 3D model? Check all that apply.



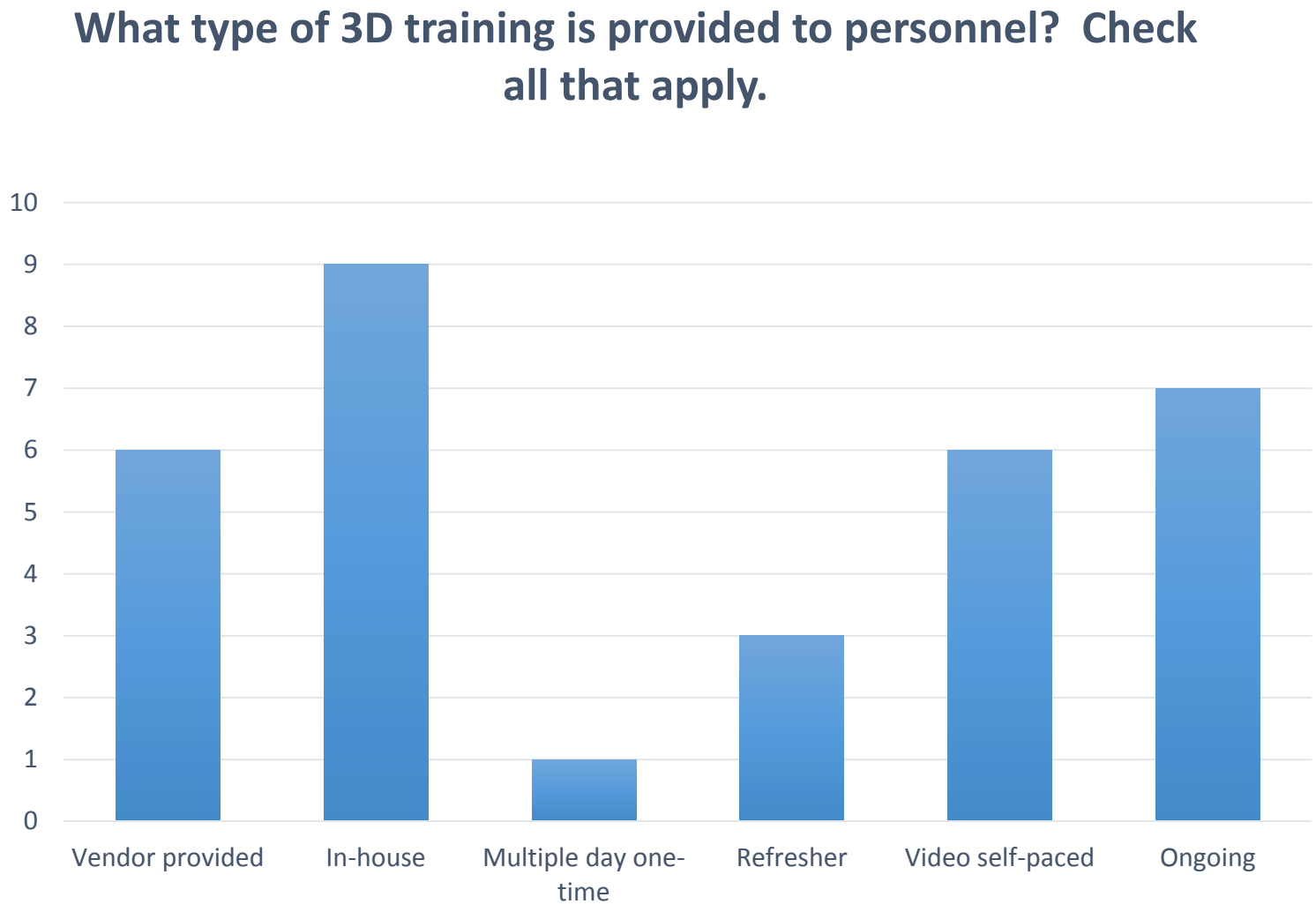
Other

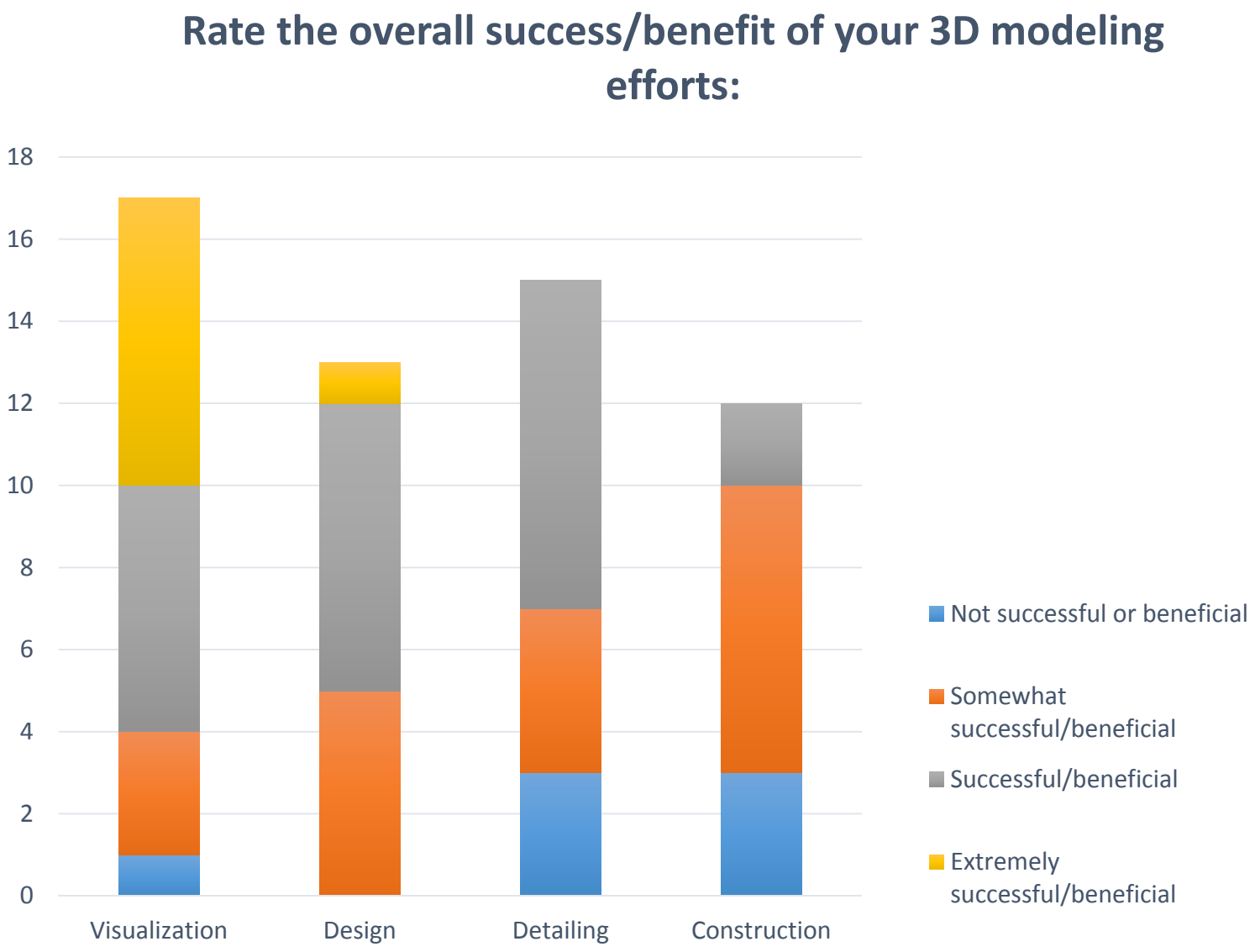
leap

SAP 2000

CSI Bridge

Analysis tools (Midas, STAAD, LARSA, etc.) and visualization tools such as Synchro.


What type of 3D training is provided to personnel? Check all that apply.
10
9
8
7
6
5
4
3
2
1
0
Vendor provided
In-house
Multiple day one-time
Refresher
Video self-paced
Ongoing


Rate the overall success/benefit of your 3D modeling efforts:
18
16
14
12
10
8
6
4
2
0
Visualization
Design
Detailing
Construction
Not successful or beneficial
Somewhat successful/beneficial
Successful/beneficial
Extremely successful/beneficial

Please provide any additional comments you believe would be helpful to understand your 3D modeling efforts.

We are just getting started reviewing how we will use 3D and 4D (fourth dimension is time or project schedule) modeling in our bridge design and operation. we are interested in the results of this survey.
Resources for training are limited so skill level is often limited by designer's ability to learn advanced 3D functionality on the job. We have made a good start at developing standards for 3D Design and Detailing, but more work is need. A crude in-house BrIM system has been developed that links structural analysis, 3D parametric modeling, plan production and estimating using XML bridge data models. This BrIM work may have significant future benefits, but is currently limited to one design group.
It is not a common practice to use 3D model on bridges.
The times we have tried using 3D tools for design/detail in the past we have found them to be cumbersome and ineffecient.
All of our 3D design is done as an option by the designer/detailer based on their need to identify/resolve conflicts or develop detail. The final plans are still 100% 2D.
Use of 3D modeling for design is very limited at this time. Most 3D work is for visualizations and clash identification on complex structures
3D modeling is primarily limited to visualization for public input meetings. Other uses have been very limited up to this point. The need for 3D in other areas is not readily apparent, particularly for typical structures.
3-D modeling has only been used on a few projects on trial basis and has not led to it being a standard procedure.
3D modeling is primarily Used on Mega Projects Construction Model / Clash Detection.

SURVEY FOLLOW UP

- Selected five states based on usage response
  - Florida
  - Minnesota
  - New York
  - Utah
  - Wisconsin
- Conducted conference calls
  - Approximately 1 hour long
  - Conducted in August/September
  - Collected more details on use of modeling

SURVEY FOLLOW UP

- Summary of states 3D modeling efforts
  - Florida
    - Use on selected bridge projects
    - Primarily for visualizations and finite element analysis
    - 90% of projects are consultant designed
  - Minnesota
    - Use on selected complex bridge projects
    - Have done renderings for a long time
    - Some use for inspection with information modeling
  - Utah
    - Use on selected complex bridge projects
    - Visualization is used for public meetings
    - Effort is incremental, 10-15 selected projects over three years

SURVEY FOLLOW UP

- Summary of states 3D modeling efforts
  - New York
    - Use to some extent on all bridge projects
    - Consultants are required to provide 3D model of substructure
    - Supplemental information for contractor
    - Best practices were standardized and documented
  - Wisconsin
    - Schedule, potential risk, high visibility or political influence determines the use of 3D
    - Visualization is done for the stake holders
    - Finite element analysis models for complex structures
    - Clash detection for utilities and construction sequencing

CUSTOMER SURVEY

- Survey sent to internal and external customers in August
- Nearly 46% of 72 contacted responded
  - 5 internal
  - 16 consultants
  - 2 contractors
  - 8 suppliers

CUSTOMER SURVEY

- Consultant's comments on use of 3-D models
  - visualization of complex geometries to check for interference conflicts, to communicate with contractors and fabricators, and for detailing accuracy
  - checking constructability and analyzing temporary conditions for staged construction
  - analysis model for finite element modeling of complex bridges
  - renderings for proposals, client meetings or public meetings
  - visualizing complex elements such as finger joints and for calculating volume quantities for complex shapes

CUSTOMER SURVEY

- Contractor's comments on use of 3-D models
  - modeling critical crane lifts
  - crane erection and laydown area use
  - would be useful to be able to turn on and off phases of staged construction
  - good visualization tool

CUSTOMER SURVEY

- Supplier's comments on use of 3-D models
  - create bar lists directly from the model to send to the fabrication shop
  - helps with special bending
  - prepare shop drawings
  - identify interferences during full shop assembly
  - clarify what a complex structure looks like
  - see areas of congestion and develop strategies
  - coordinate hole alignment with the Diaphragms

WORK PLAN - Tasks

- ***Task 4 – Conduct Peer Exchanges***
  - ✓ State DOTs visits: members of the Research Team will select and visit 2 – 3 State DOTs that are identified as leaders in 3D bridge design to get first-hand knowledge of their practices.
  - ✓ Conduct a workshop: stakeholders/customers and other State DOTs will be invited to participate in a workshop. The purpose of the workshop is share information about the use of 3D bridge design.
  - ✓ Collaborate with AASHTO SCOB T-19 (technical committee on computers): Iowa DOT has begun the discussion with T-19 regarding to the use of 3D in bridge design by AASHTO members.

STATE VISITS

- Conference call review
- Selected two states based on information received during call
  - Wisconsin
  - New York

STATE VISITS

- Wisconsin DOT visit
  - Visited November 18
  - Attended by five members of the research team
  - Presentations provided included:
    - Use of 3D models for clash detection of utilities
    - 3D model creation through the LEAP ABC Wizard
    - Model development for ratings with MDX, CSiBridge or LARSA
    - 3D mesh development for analysis with SAP
    - future potential use of LiDar scans
    - visualization of a project

STATE VISITS

- New York State DOT visit
  - Visited December 3-4
  - Attended by three members of the research team
  - Presentations provided included:
    - LiDAR data use for solid models
    - Use of AutoCAD with Civil 3D and SS3 Open Roads in highway design
    - 3D models with construction survey
    - File organization for bridge design and estimation
  - Team members had time with Bridge Bureau Design Staff to observe their processes

WORKSHOP

SAVE THE DATE

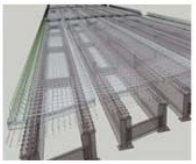
April 14-15, 2015

3D DESIGN AND MODELING FOR HIGHWAY STRUCTURES WORKSHOP

IOWA STATE CENTER SCHEMAN BUILDING | AMES, IA

BRIDGE THE GAP BETWEEN CONCEPTION AND COMPLETION WITH THIS INFORMATIVE WORKSHOP FOCUSING ON THE USE OF 3D DESIGN AND MODELING FOR HIGHWAY STRUCTURES.

REGISTER AFTER MARCH 6TH AT WWW.BEC.IASTATE.EDU/3DCONFERENCE



Bentley Sustaining Infrastructure

BRIDGE ENGINEERING CENTER

U.S. Department of Transportation Federal Highway Administration

IOWA DOT

3D Design and Modeling for Highway Structures Workshop Agenda

Iowa State Center Scheman Bldg, Ames, Iowa

April 14 – 15, 2015

Day 1 – Workshop

7:30 am - 8:00 am	**Registration**
8:00 am - 8:20 am	**Introduction and Welcome** Iowa DOT Office of Bridges & Structures Director, Norm McDonald FHWA Iowa Division Acting Division Administrator, Jeff McEwen
8:20 am - 9:00 am	**National Perspective** Iowa DOT Initiative – Iowa DOT OBS Automation Engineer, Annette Jeffers AASHTO Vision – AASHTO SCOB T-19 Chair, Scot Becker
9:00 am - 9:15 am	**Break**
9:15 am - 10:45 am	**Session 1 - State DOT Experience and Perspective** Use of 3D Modeling in ABC Projects - Iowa DOT, Jim Nelson 3D Highway Design - Iowa DOT, Tom Hamski and Brian Smith Southeast Freeways (SEF) Implementation Concerning CIM Uses of 3D Models - Wisconsin DOT, Lance Parve
10:45 am - 11:45 am	**Session 2 – Project Showcases** 4D Structural Analysis of Hastings Mississippi River Bridge for MnDOT and I71/670 Bridge for Ohio DOT - CH2M Hill, Randy Thomas and Tony Peterson 3D Modeling of Zoo Interchange for Wisconsin DOT - CH2M Hill, Chris Johnson
11:45 am - 12:45 pm	**Lunch**
12:45pm – 2:30 pm	**Session 3 – Project Showcases** 3D Modeling of kcICON Design-Build Project for Missouri DOT and Hastings Bridge for Minnesota DOT – Parsons, Henri Varaneckas An Evolution of Analyses for Complex Structures from 2D Through 4D Modeling – HNTB, Hans Hutton 3D Modeling Applications for St. Croix River Crossing - HDR, Craig Lenning
2:30 pm - 2:45 pm	**Break**
2:45 pm – 5:00 pm	**Session 4 – Software Applications** LEAP Bridge Steel – Bentley Systems, Shri Bhide ProConcrete Overview - Bentley Systems, Alex Mabrich PowerBridge Modeler - Bentley Systems, Sri Kanneganti
7:30 am – 5:30 pm	**Vendors Exhibits open**

Day 2 – Workshop

8:00 am – 9:30 am	**Session 5 – Industry Presentations** 3D Modeling Capabilities Available in AASHTOWare Bridge Design and Rating – Montana DOT, Jeff Olsen 3D Modelling – Contractor's Constructability Review in Structures - Walsh Construction, Karthik Ramkrishnan 3D Utility Surveying and Modeling - Utility Mapping Services, Philip J. Meis, P.E.
9:30 am - 9:45 am	**Break**
9:45 am - 11:15 am	**Session 6 – Industry Presentations** LiDar Survey for 3D Design Modeling - Iowa DOT, Jonathan Miranda BrIM in Structural Steel Fabrication- High Steel, Brad Dillman Bridge Structural Condition Assessment Using 3D Modeling and 3D Imaging Technologies - Iowa State University, Simon Laflamme and Yelda Turkan
11:15 am - 12:00 pm	**General Discussion/Closing**

Hands-on Training

8:00 am – 12:00 pm	Introduction to MicroStation 3D Tools- Bentley Systems, Tom Stogdill
1:00 pm – 5:00 pm	Bridge Modeling for Open Roads Users- Bentley Systems, Alex Mabrich *Creation of 3D models using the LEAP Bridge Enterprise and LEAP Bridge Steel applications.*

Bentley

BRIDGE ENGINEERING CENTER

U.S. Department of Transportation
Federal Highway Administration

IOWA DOT

WORKSHOP

- Presentations
  - 19 different presentations
  - 3D related topics include
    - highway design
    - structures projects
    - constructability
    - fabrication
    - survey
    - software applications
    - research
- Training
  - expanded to 50 trainees
  - waiting list

WORKSHOP

- Attendees
  - Over 140 total
  - 13 State DOTs
  - Over 40 from Iowa DOT
  - 15 Consultants
  - FHWA
  - Iowa State University
  - Contractors
  - Suppliers

WORKSHOP

British Columbia
Alberta
Saskatchewan
Manitoba
Canada
Ontario
Quebec
New Brunswick
Washington
Montana
North Dakota
Minnesota
Maine
Oregon
Idaho
South Dakota
Wisconsin
Vermont
New Hampshire
Massachusetts
Wyoming
Michigan
New York
Connecticut
Rhode Island
Nevada
Nebraska
Iowa
Pennsylvania
New Jersey
Illinois
Indiana
Ohio
Delaware
Maryland
California
Utah
Colorado
Kansas
Missouri
West Virginia
Virginia
U. S. A.
Kentucky
North Carolina
Tennessee
Oklahoma
Arkansas
Arizona
New Mexico
South Carolina
Mississippi
Alabama
Georgia
Texas
Louisiana
Florida
Russia
Alaska
Canada
Hawaii
Mexico
The Bahamas

WORK PLAN - Tasks

- ***Task 5 – Develop Implementation Plan***
  - ✓ The results of the preceding tasks will help evaluate the feasibility of using 3D in bridge design, identify road blocks, and potential applications for 3D. An implementation plan will be developed based on the results and may include the development of a section on the use of 3D design for insertion into Iowa DOT Bridge Design Manual (BDM).
- ***Task 6 – Documentation***
  - ✓ A final report documenting the process and the results will be prepared and disseminated.
- ***Task 7 – Technology Transfer***
  - ✓Members of the Research Team will be available to participate in various technology transfer events (presentations, webinars, articles, etc.).