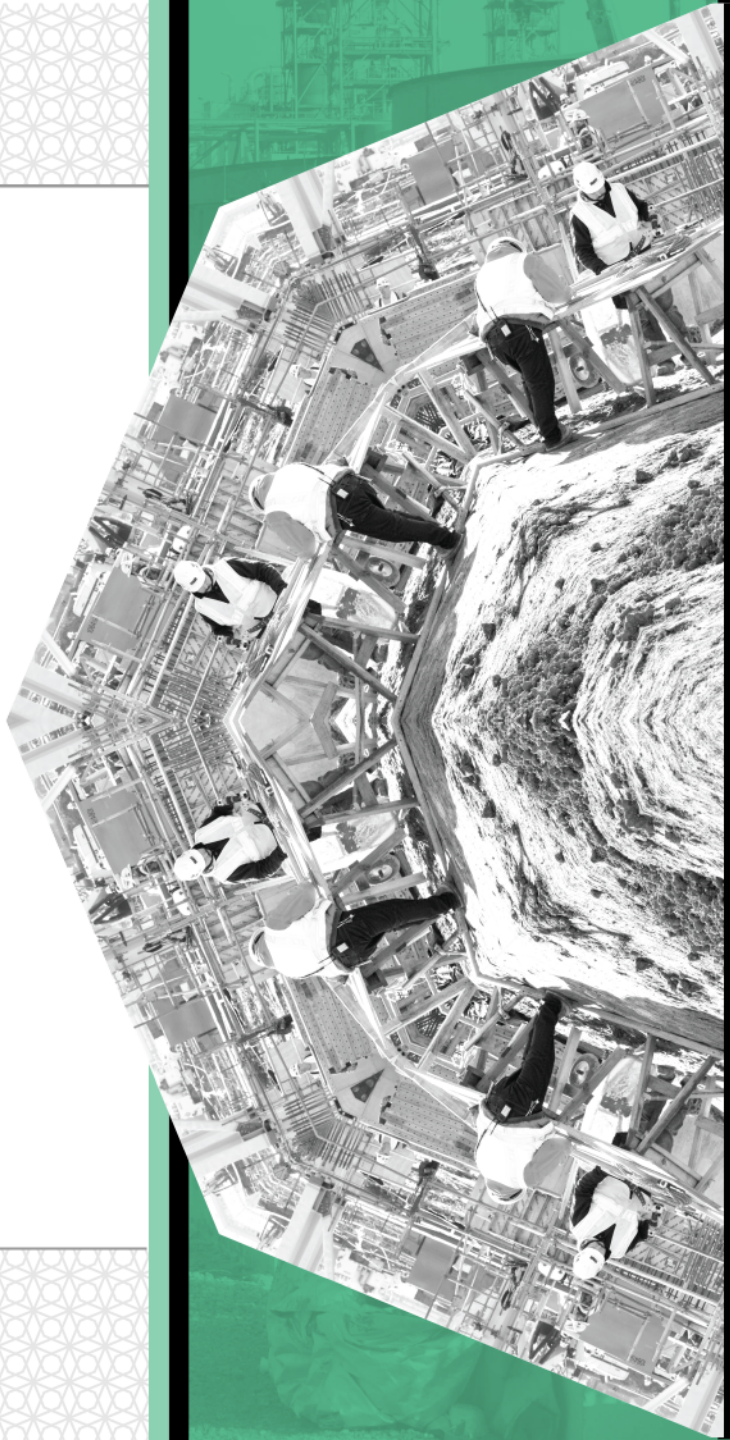
PerspECCtive

Theme:
Win Together to Share Success NOW!

Virtual Construction: VR-Enabled Project Delivery

CII Research Team TC-02

Stephen Mulva, CII
Dan Gibson, Black & Veatch
Max Eklund, Fluor



ECC

Year:	Date:	Location:
2019	Aug. 28-31	The Broadmoor Colorado Springs, CO

Overview of CII

- History
  - Founded in 1983 by 28 organizations; now 145
  - Organized Research Unit (ORU) of the Cockrell School of Engineering (CSE) at the University of Texas at Austin (UT)
  - First structured owner-contractor-academic research collaboration for the constructed project
  - Merged Fiatech (technology group) into CII in January 2018
- Strategy: Increase Impact and Reach
  - Amplify the scale of financial returns emanating from capital projects and lifecycle management
  - Catalyze our industry with inventive business processes, organizational structures, and technological developments
  - Expand CII's global reach
  - Expand industry sector representation

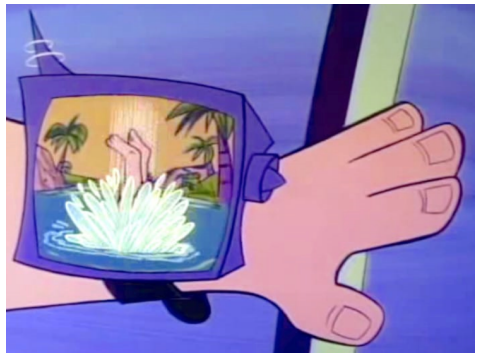
CII Strategic Initiatives

Funded Studies	AI for Advanced Work Packaging
Funded Studies	Integrated, Collaborative Delivery
Funded Studies	Workforce 2030
Membership & Comms	C-Suite Engagement
Membership & Comms	Membership Campaign
Technology	Digital Structured Project Delivery
Technology	Technology Path to the Future
Deployment	DP1 (Project Assurance)
Deployment	NextGen Benchmarking
Sectors	Key Business Objectives

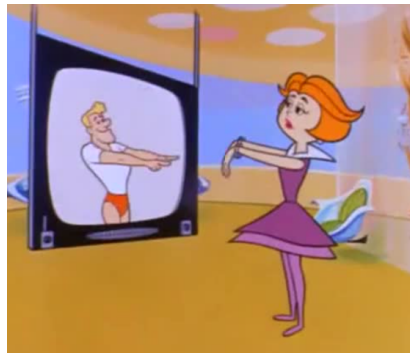
The Jetsons (1962-1963)

Flying Cars

Video Calls

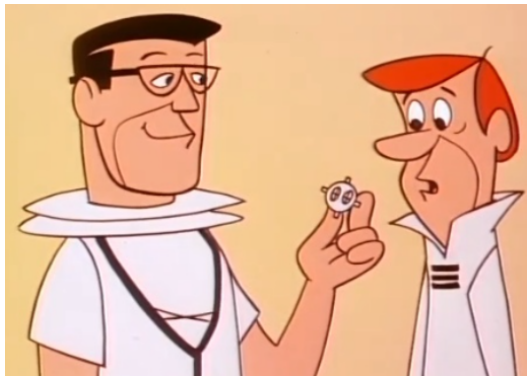


Wearables

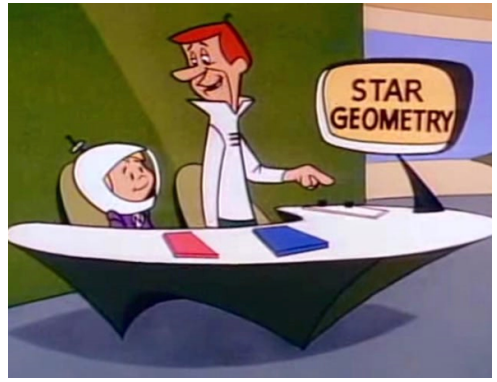


Flat Screens

Jet Packs

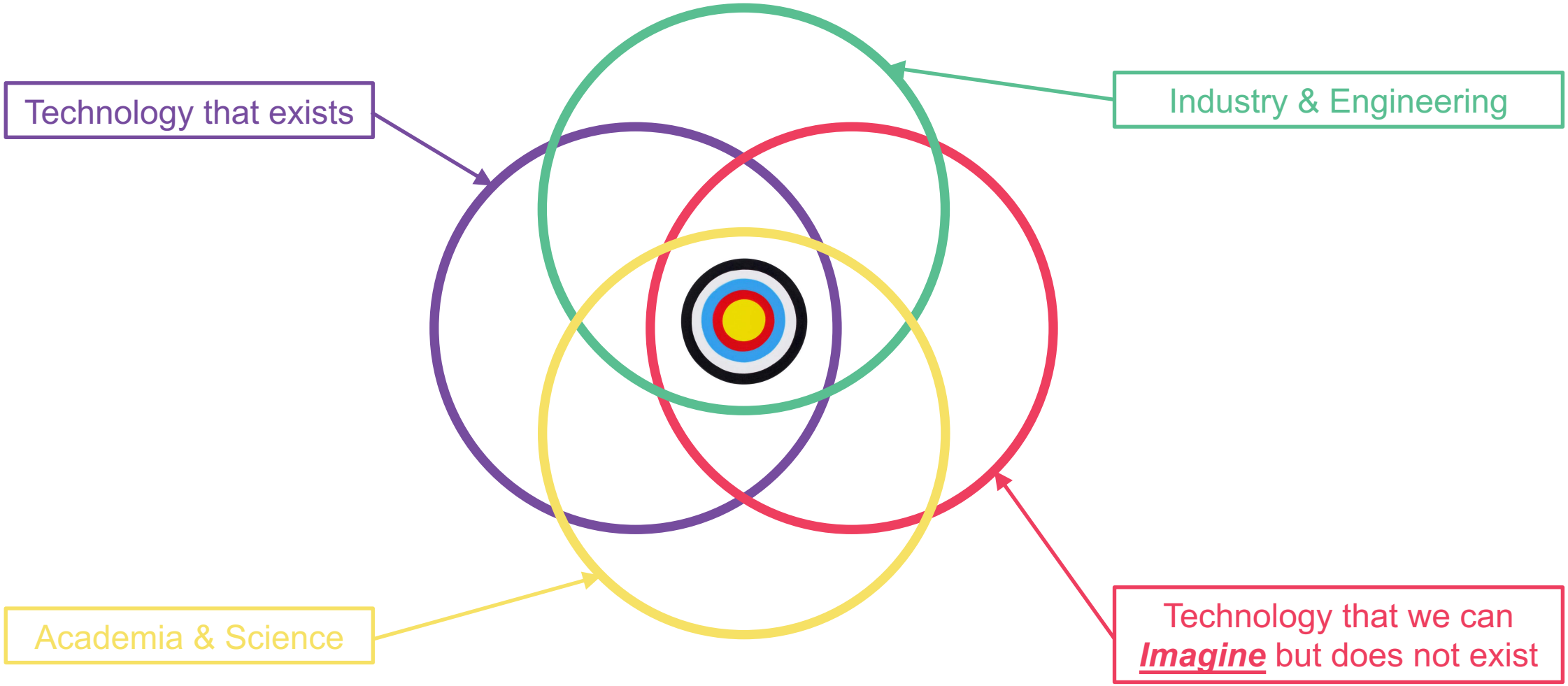


Wireless Endoscopic Robots



Internet Learning

CII Technology Path to the Future



Digital Delivery

- CII Technology Committee Strategic Initiatives
  - Technology Path to the Future
  - Digital Structured Project Delivery

PROCESS INDUSTRY PRACTICES

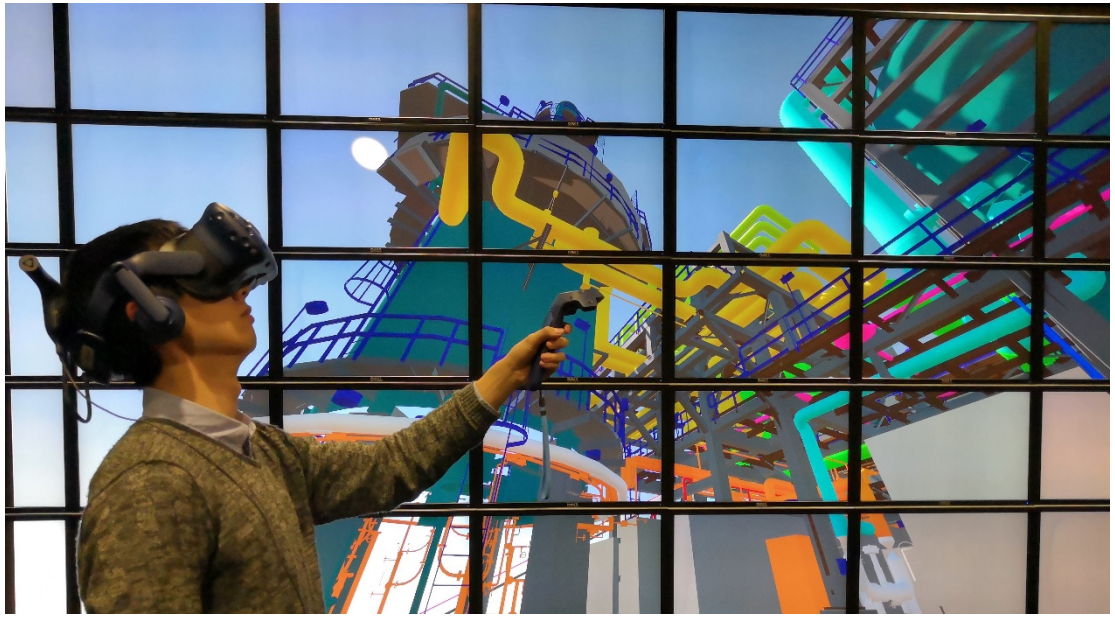
Source: McDermott
A digital rendering of Pemex's PB-Litoral
A production platform in the Bay of Campeche

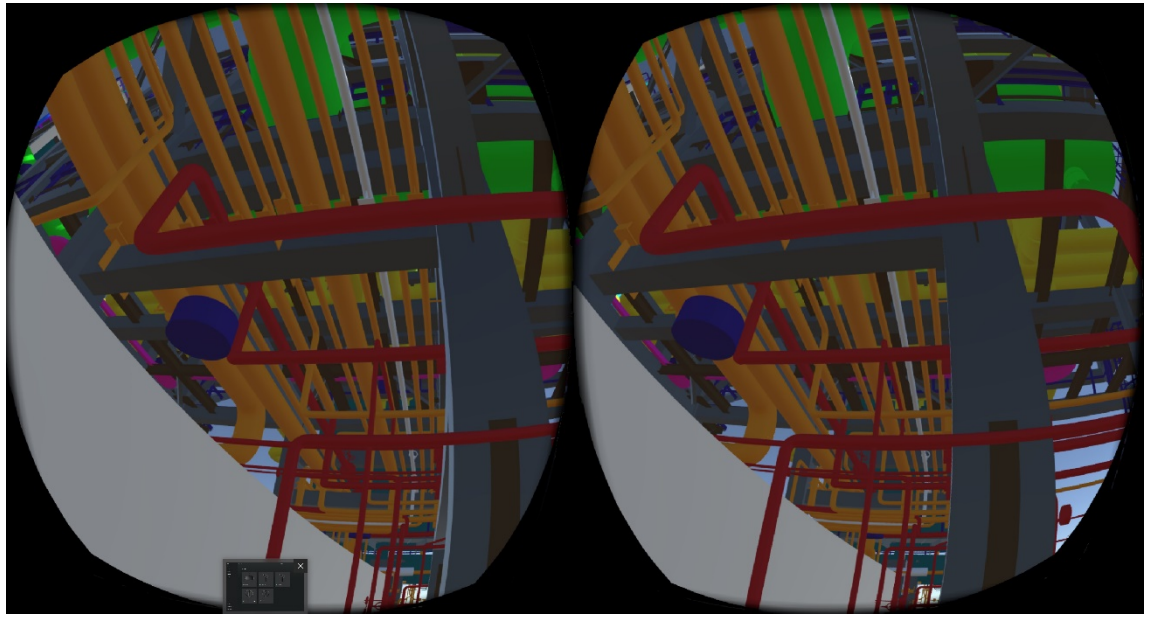
Welcome to the Future!

Let's invest now – building VR into SOPs

Empower workforce

Attract, train, and retain next gen workforce





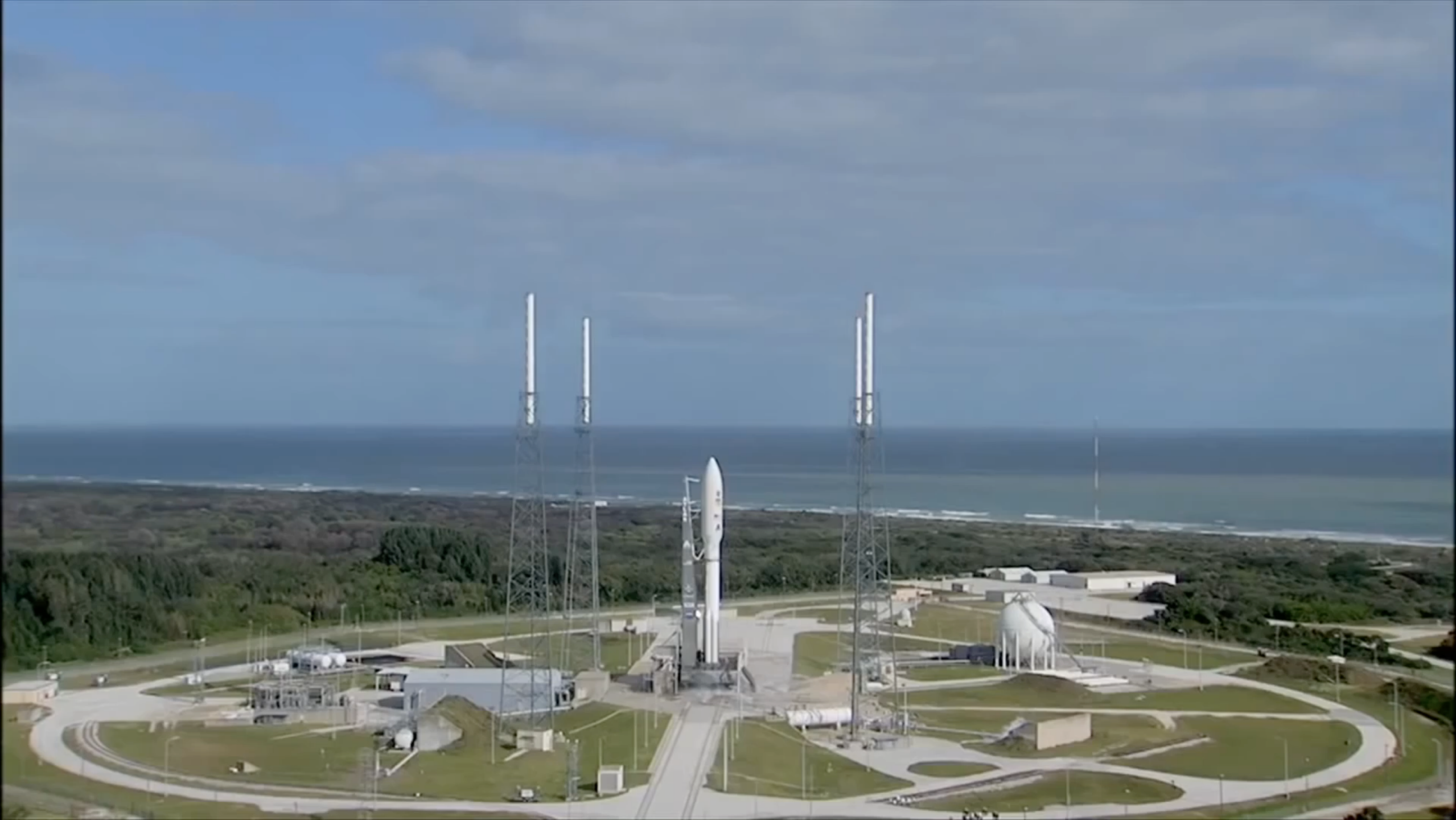
What Will You Learn Today?

- Performance Measurements
- Implementation Guidance
- Cost-Benefit Analysis
- Virtual and Mixed-Reality Demos

Vision for the Future

Stephen Mulva, CII

Virtual Construction: VR-Enabled Project Delivery



What is the future of VR in construction?

Collaborative Communication / Design & Issue Resolution

Modify and Manipulate Model Data in VR

Safety Planning & Site Logistics

Schedule Optimization & Progress Monitoring

Research Development

Stephen Mulva, CII

Virtual Construction: VR-Enabled Project Delivery

Research Team TC-02

THE UNIVERSITY OF TEXAS AT AUSTIN

- Principal Investigator: Dr. Fernanda Leite
- Graduate Student: Bing Han

INDUSTRY TEAM MEMBERS

- Chair: Predrag Jokovic, Hatch
- Dan Gibson, Black & Veatch
- TG Jayanth, McKinsey & Company, Inc.
- Peter Robar, Fluor Corporation
- Todd Sutton, Zachry Corp
- Dave Tyner, Autodesk, Inc.

Summary of Results

IMPROVEMENTS IN DESIGN AND WORK PACKAGING REVIEW TASKS

IMPLEMENTATION GUIDEBOOK

"WHAT'S THE ROI OF ONE LIFE?"

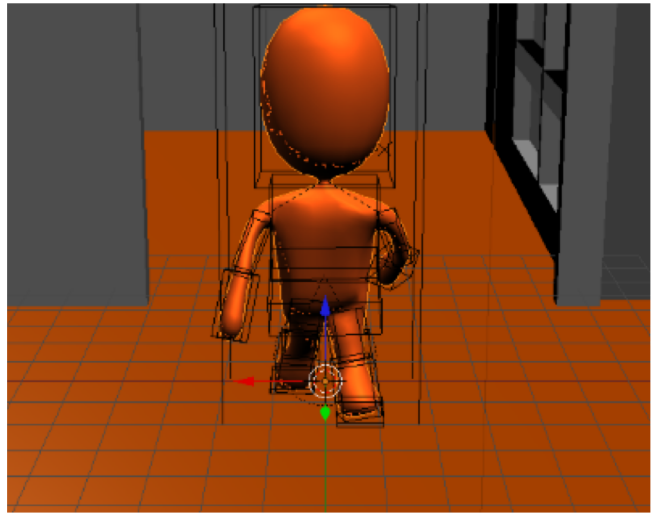
Existing VR Applications

ENTERTAINMENT

SERIOUS APPLICATIONS

VR in the Construction Industry

DESKTOP-BASED
VR



GAME ENGINE-BASED
VR

IMMERSIVE
VR

Immersive Virtual Reality (IVR)

DEFINITION

A computer-generated virtual simulation that is experienced through Head Mounted Displays (HMD) and other input/output devices.

Immersive Virtual Reality

KEY FEATURES

Block the real world, provides immersive experience in virtual world

Augmented Reality (AR)

KEY FEATURE

Overlay virtual world on the real world based on software settings, e.g., location information

Mixed Reality (MR)

KEY FEATURE

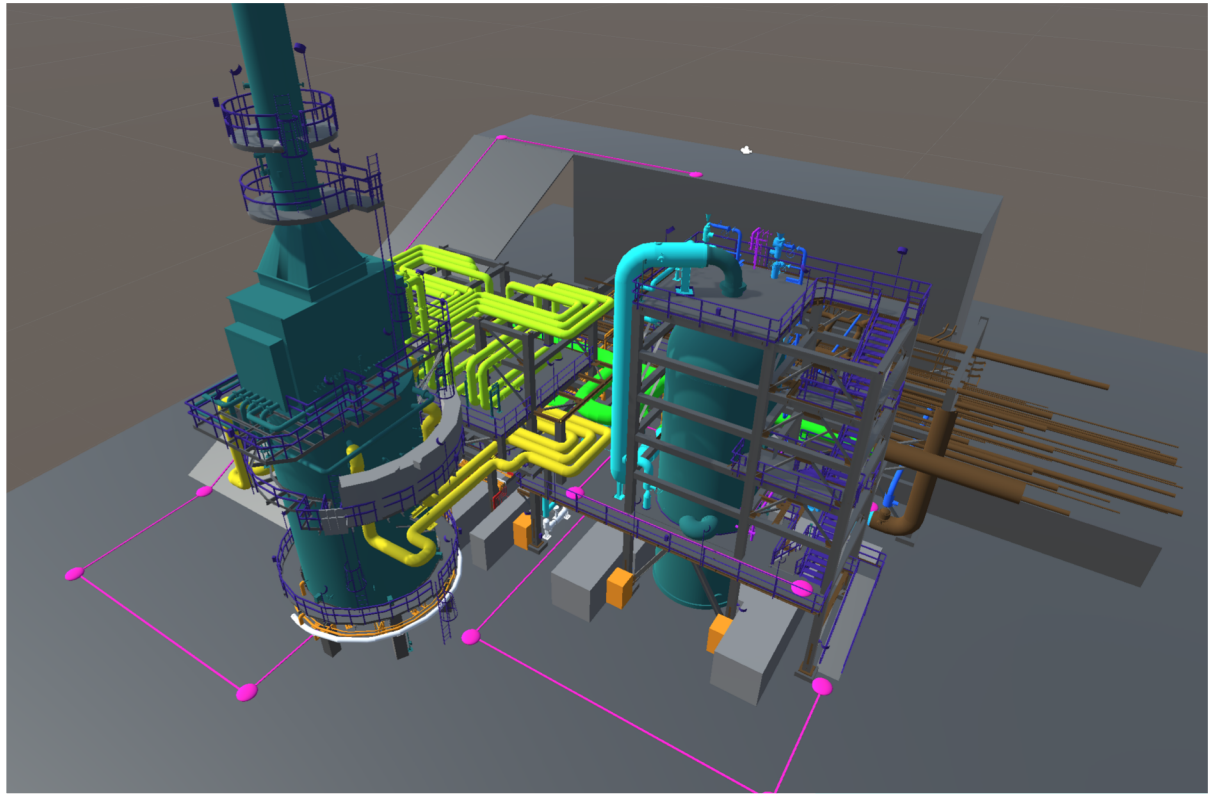
Overlay virtual world on the real world based on technology understanding of the real world

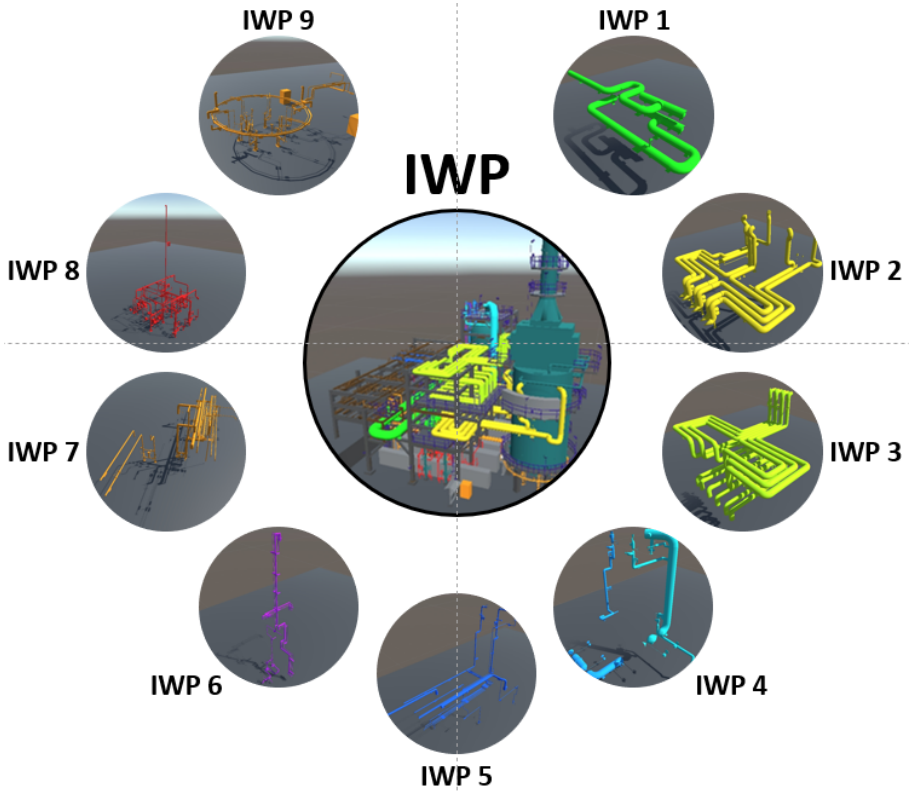
Immersive vs. Desktop-based Virtual Reality User Tests

Stephen Mulva, CII

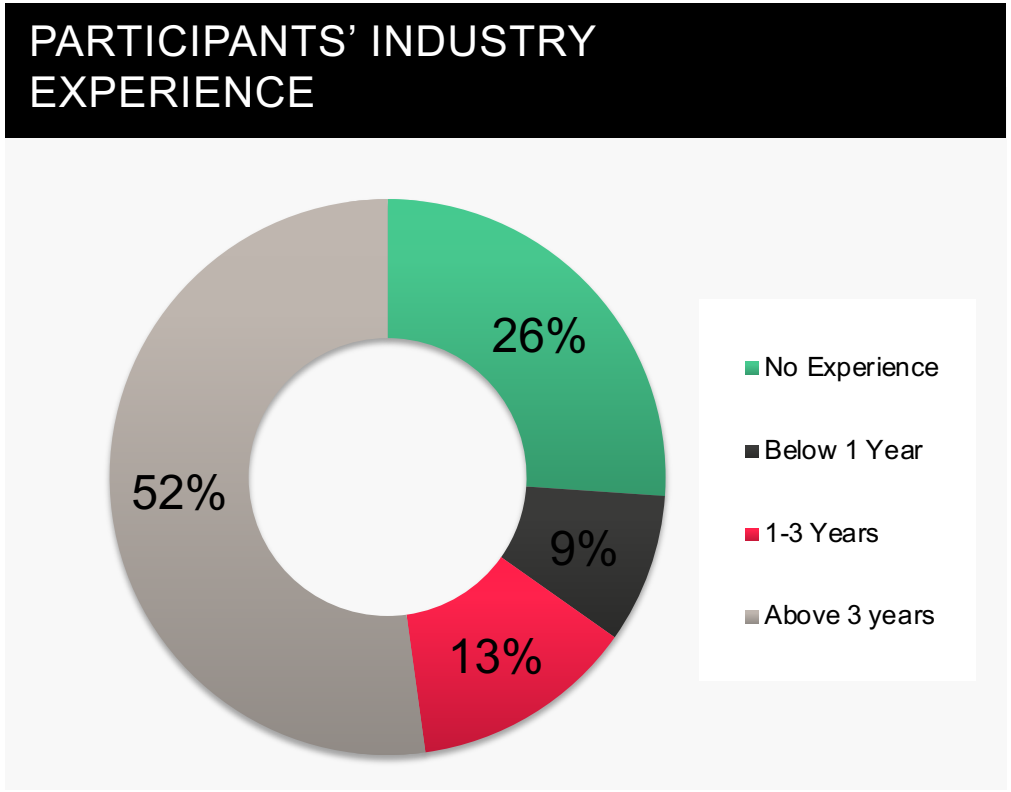
Virtual Construction: VR-Enabled Project Delivery

Demo & User Test





User Test Participants



Novices: 11 participants

- No industrial experience: 6
- Below 1 year: 2
- 1-3 years: 3

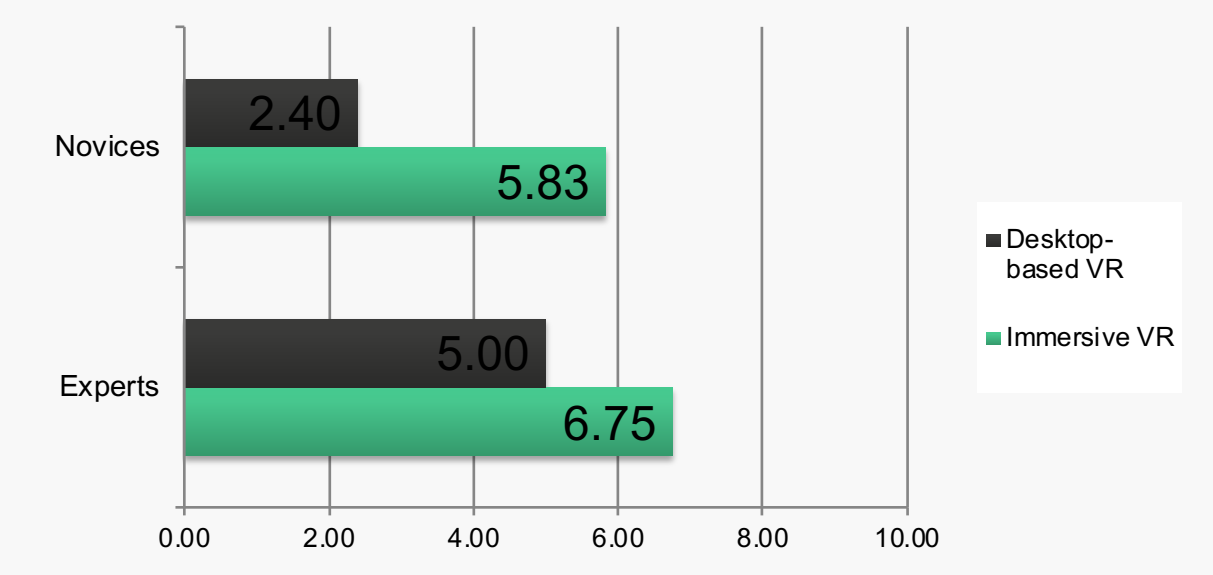
Experts: 12 participants

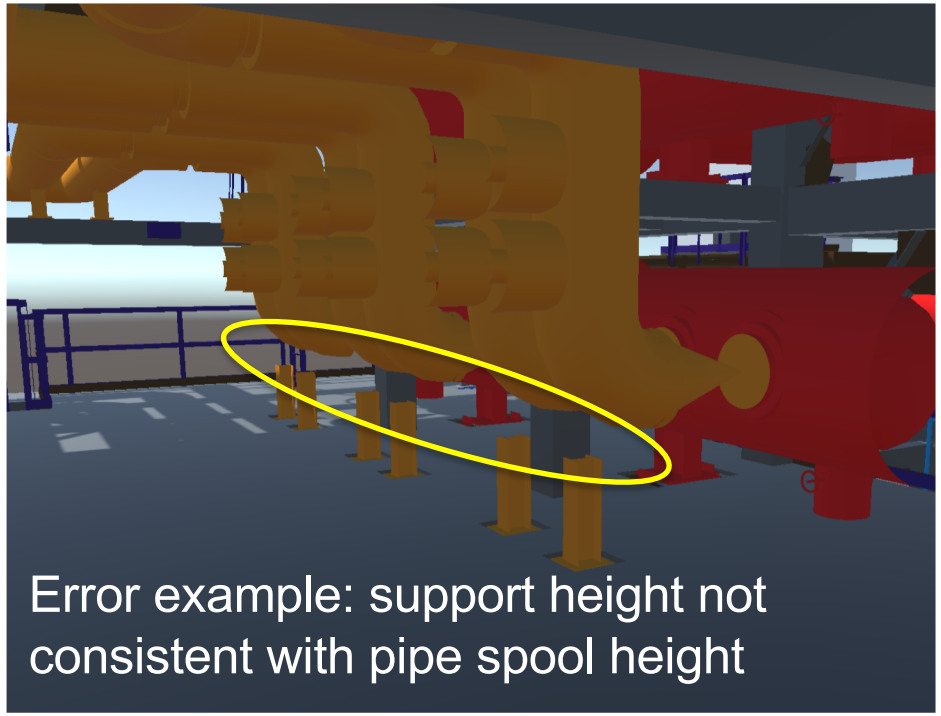
- 3 years+ industrial experience

User Test Results

Design Error Detected (Mean)

Significant Influence from Experience and Device
(P = 0.038, 0.002 in Linear Regression Analysis)

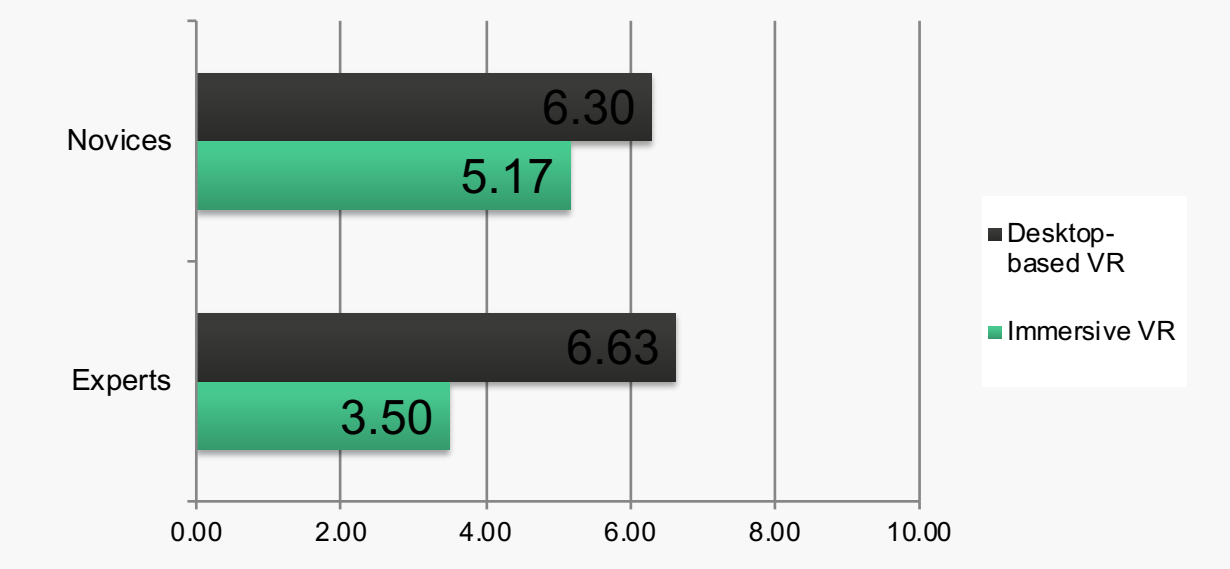


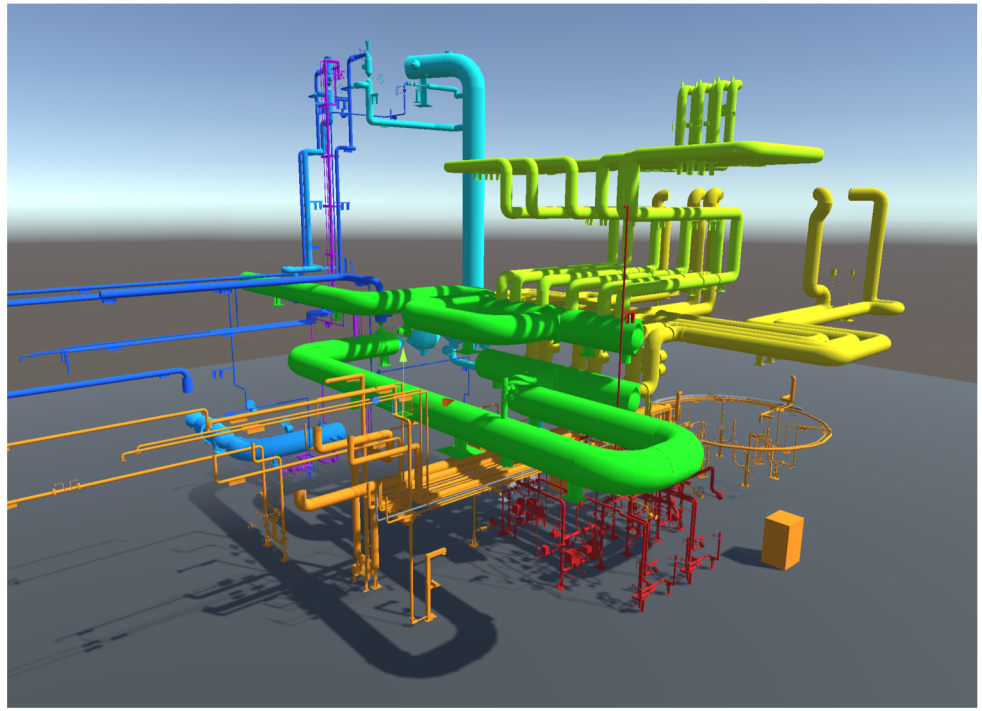


User Test Results

Mistakes in Sequence (Mean)

Significant Influence from Device
(P = 0.012 in Linear Regression Analysis)

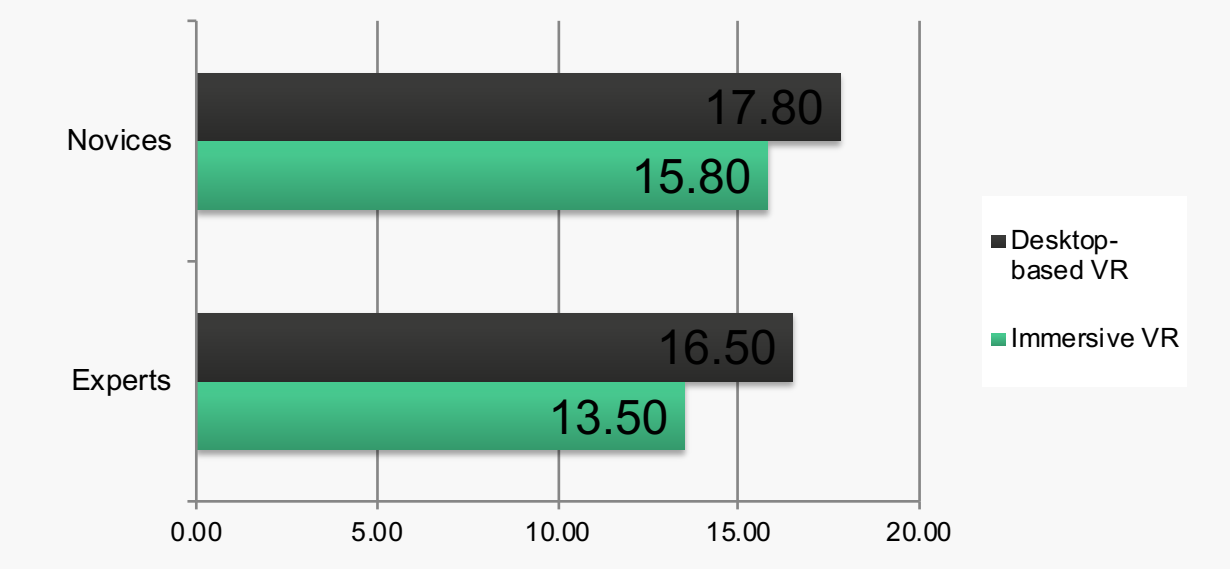


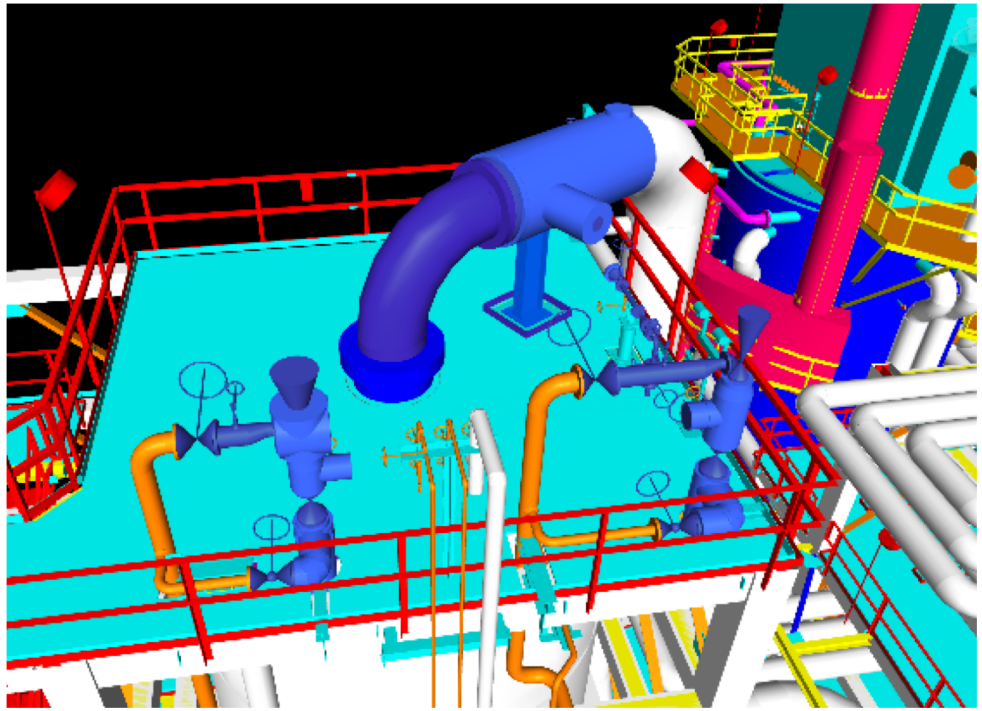


User Test Results

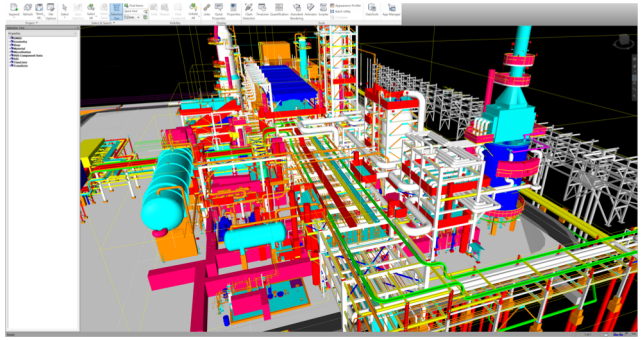
Recalled Items (Mean)

No Significant Influence from Experience or Device





Traditional Workflow



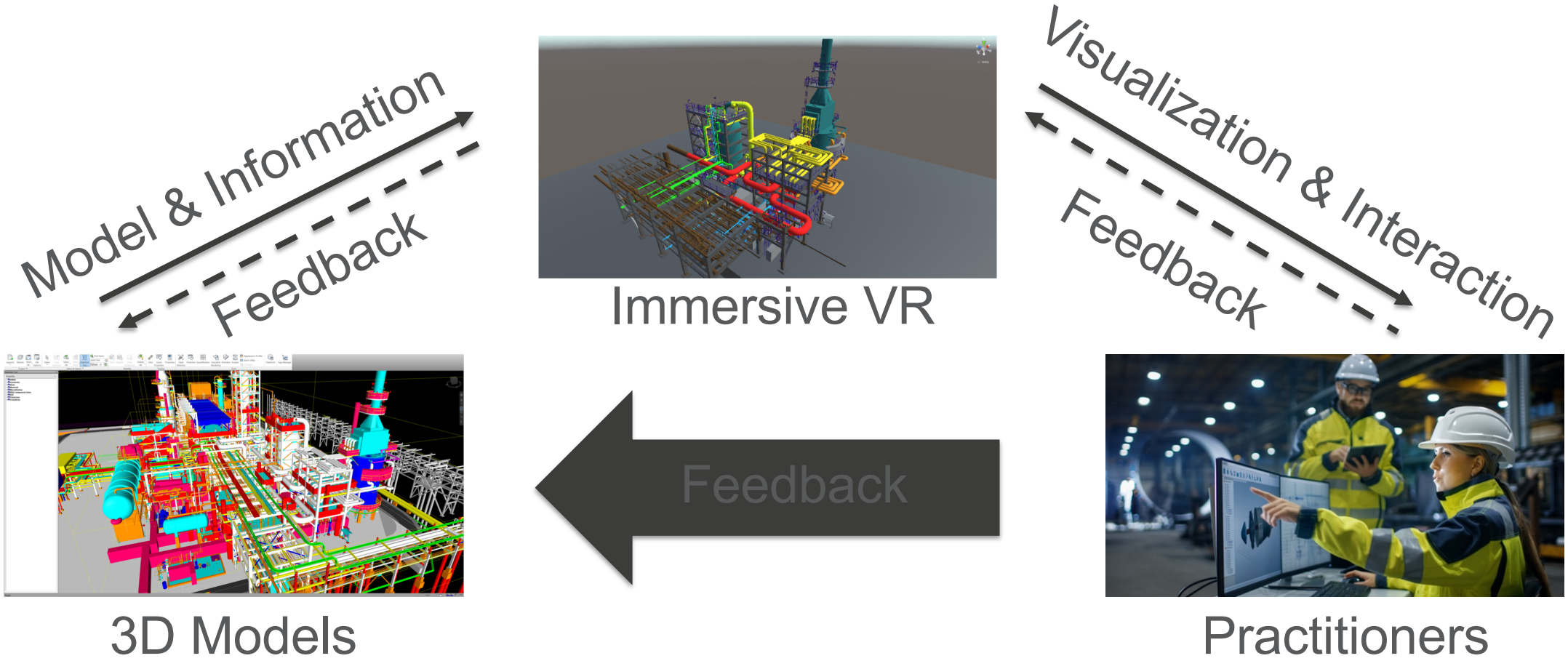
3D Models

Information →

← Feedback

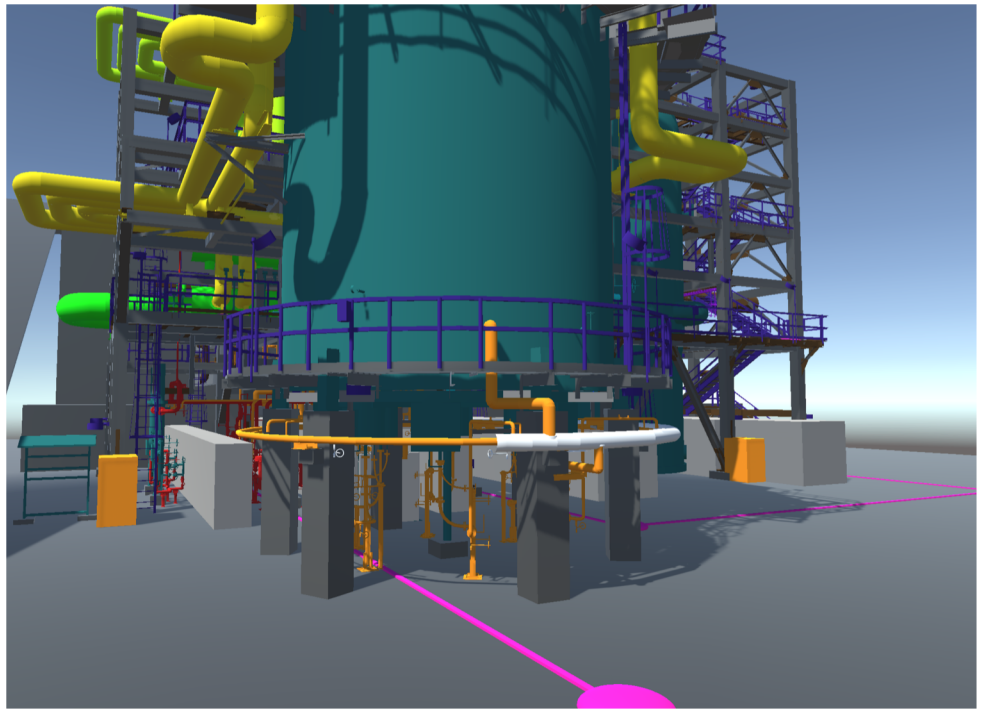
Practitioners

Immersive VR-included Workflow



Key Factors for Implementation

- Selection of Implementation Scenario
- 3D Model Quality
- VR Model Functions
- User Experiences with VR



Immersive VR Implementation Guide for the Construction Industry

Stephen Mulva, CII

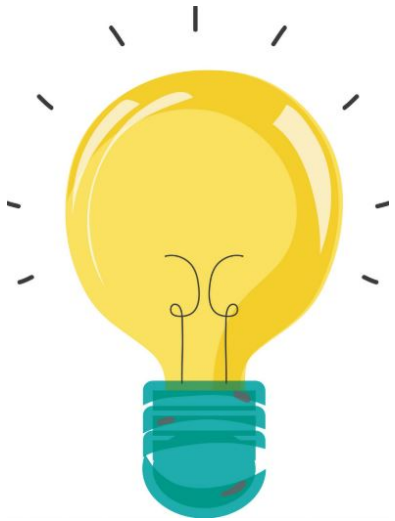
Virtual Construction: VR-Enabled Project Delivery

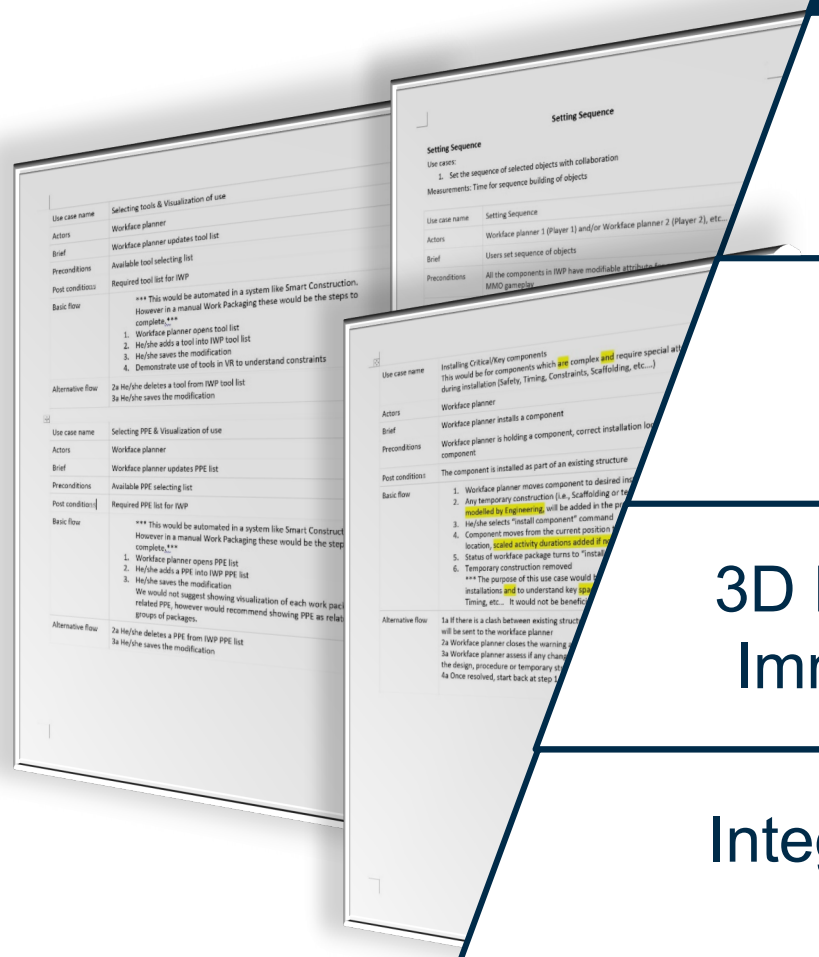
What do I do?

IMPLEMENTATION GUIDEBOOK

- Planning
- Tools Selection
- Training
- Model Preparation
- Opportunities

Strategy and Use Cases





Implementation Strategy and Use Cases

- Hardware and Software Selection
- Training of Users and Developers
- 3D Model Preparation for the Immersive VR Environment
- Integration and Further Developments

Hardware and Software

Implementation Strategy and Use Cases

Hardware and Software Selection

Training of Users and Developers

3D Model Preparation for the Immersive VR Environment

Integration and Further Developments

Training Programs

Implementation Strategy and Use Cases

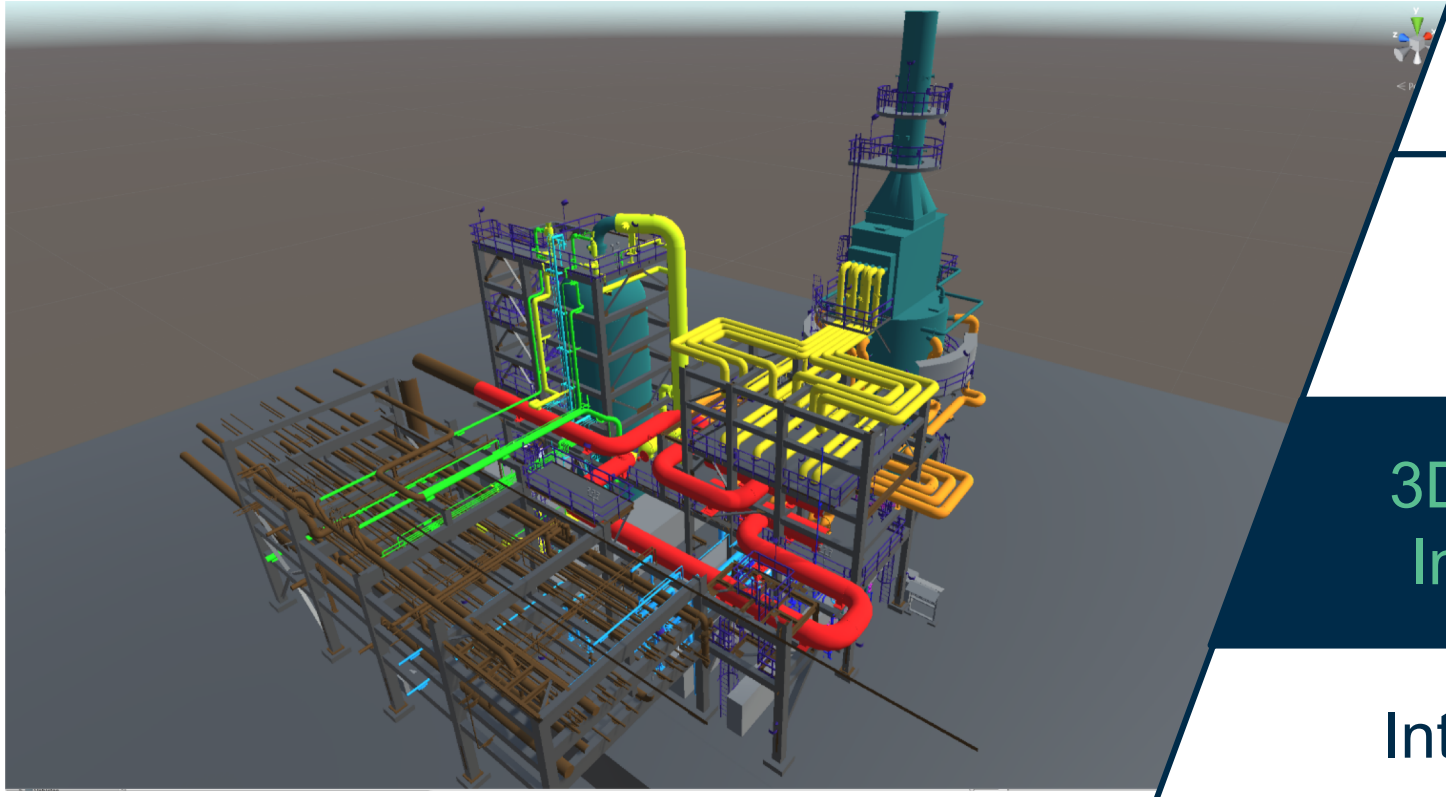
Hardware and Software Selection

Training of Users and Developers

3D Model Preparation for the Immersive VR Environment

Integration and Further Developments

Model Preparation



Implementation Strategy and Use Cases

Hardware and Software Selection

Training of Users and Developers

3D Model Preparation for the Immersive VR Environment

Integration and Further Developments

Future Developments

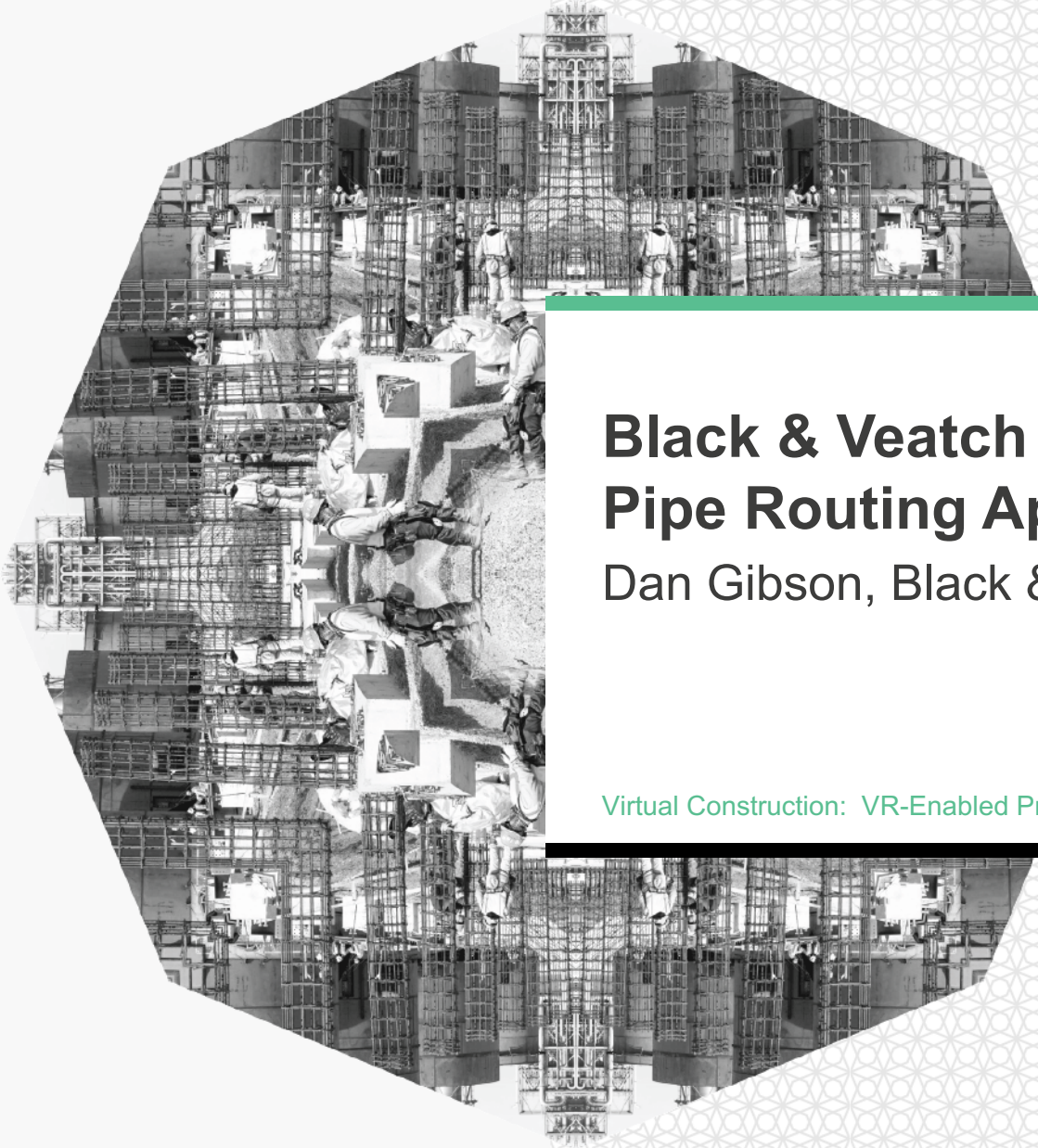
Implementation Strategy and Use Cases

Hardware and Software Selection

Training of Users and Developers

3D Model Preparation for the Immersive VR Environment

Integration and Future Developments



Black & Veatch Pipe Routing App

Dan Gibson, Black & Veatch

Virtual Construction: VR-Enabled Project Delivery

Mixed Reality – B&V Example

CONCEPT:
Develop a solution to reduce time
to collect non-model design data for SB-Pipe
and Conduit routing

Design on the fly

Made with unity

Mixed Reality – Benefits

- Provide simultaneous comparison
- Empower the workface to create
- Provide a quick turnaround solution

Fluor Safety Training Program

Max Eklund, Fluor

Virtual Construction: VR-Enabled Project Delivery

Fluor VR Safety Training - Fluor Life Critical Campaign

Life Critical focus on the operations we execute that have the greatest potential for serious injury or fatality

- Working at height
- Motorized heavy equipment
- Motor vehicle operation
- Material handling
- Confined space entry
- Cranes and rigging
- Trenching and excavations
- Electrical work
- Hazardous energy control / line breaking

Life Critical promotes our single most important goal
- Protecting the lives of workers

Fluor VR Safety Training - Working at Height

1 Put on your HSE Equipment

You start off with your gloves on and put on your hardhat, safety glasses and select a scenario

2 Work At Height

Working at height starts off up on a platform with an open area in the handrail for material delivery

3 Tie off Lanyard

Before you can start, you must tie off your lanyard.

4 Move tripping hazards

Ensure that you move any tripping hazards before proceeding

5 Falling objects

Learn about falling objects and they impacts they can have

6 Spot the hazard

Take some time and spot hazards in the scene

Cost-Benefit Analysis

Costs

- Hardware
- Software Description
- Software Implementation
- Software Maintenance
- Training Services
- Content Curation
- Workspace

Benefits

- "What's the ROI? One life"
- Effective Workforce Training
- Reduced RFIs
- Reduced Change Orders
- Reduced Rework
- Increased Product Quality
- Match Commodity Trending
- Reduced Travel Expenses
- Fewer Personnel on Site
- Efficient Craft Coordination
- Increased Scope of Contract
- Precise Progress Tracking
- Faster Project Delivery
- Optimized Schedule
- Faster Understanding on Design
- Better Visualization for Reviewer
- Improved Recall Rate
- Longer Memory Retention

Key Lessons

- Hardware cost minimal; invest in people
- Be intentional when selecting use cases for VR/AR/MR
- Empower the workforce

Questions?

Virtual Construction: VR-Enabled Project Delivery