



2022 Prevention through Design Workshop: PtD Journey from What to How

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Acknowledgments:

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Available at: <https://ptd.engineering.asu.edu/ptd-workshop-2022/>

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1. Introduction

This document describes the 2022 Prevention through Design (PtD) workshop, which is the third instance within a PtD 5-year Initiative¹ of five workshops funded by the National Institute of Occupational Safety and Health (NIOSH)². The purpose of the series of workshops is to advance PtD knowledge and promote the implementation of PtD within the construction industry and the instruction of PtD in construction management and construction engineering programs at US colleges and universities. This third annual workshop event was hosted virtually by Arizona State University on May 24 and 25, 2022. The theme of the 2022 Workshop was “PtD Journey from What to How.” This third PtD workshop focused on HOW to implement PtD practices to increase safety, efficiency, and profitability while striving for zero accidents and injuries. Examples of PtD applications, including case studies and benchmarking results, were provided to demonstrate how PtD enhances a project’s safety and provides a safe environment for workers and end-users. Moreover, this workshop explored how various emerging technologies such as wearables, exoskeletons, and Building Information Modelling (BIM) improve workers’ safety and contribute to innovative PtD practices.

The Purpose of the 2022 PtD Workshop was to focus on HOW to implement PtD practices to increase safety, efficiency, and profitability while striving for zero accidents and injuries.

The event brought together representatives from 44 industry organizations as well as 33 universities to exchange and leverage their experience and expertise on how PtD practices are implemented for a safer environment by interacting with professionals worldwide. The workshop created an excellent opportunity for engineers, architects, contractors, construction companies,

¹ The PtD Initiative can be found in Appendix C.

² The first and second PtD workshop’s keynote presentations and report can be found at: <https://ptd.engineering.asu.edu/ptd-workshop-2020-neu/> and <https://ptd.engineering.asu.edu/ptd-workshop-2021-neu/>

manufacturers, project owners, insurers, and academia to exchange and leverage their experiences and expertise in terms of how PtD practices are implemented for a safer environment.

Due to the COVID-19 Omicron variant outbreak and in order to limit virus transmission— as well as to reach global audiences— the Steering Committee³ decided to use a virtual events platform to host the 2022 PtD Workshop. For this purpose, vFairs⁴ was selected because of its best-in-class features and giving visitors something as close to a physical show experience as possible, interactively participating in sessions, connecting and networking with professionals, and visiting exhibitors’ booths during the workshop. The vFairs virtual lobby is shown in Figure 1.

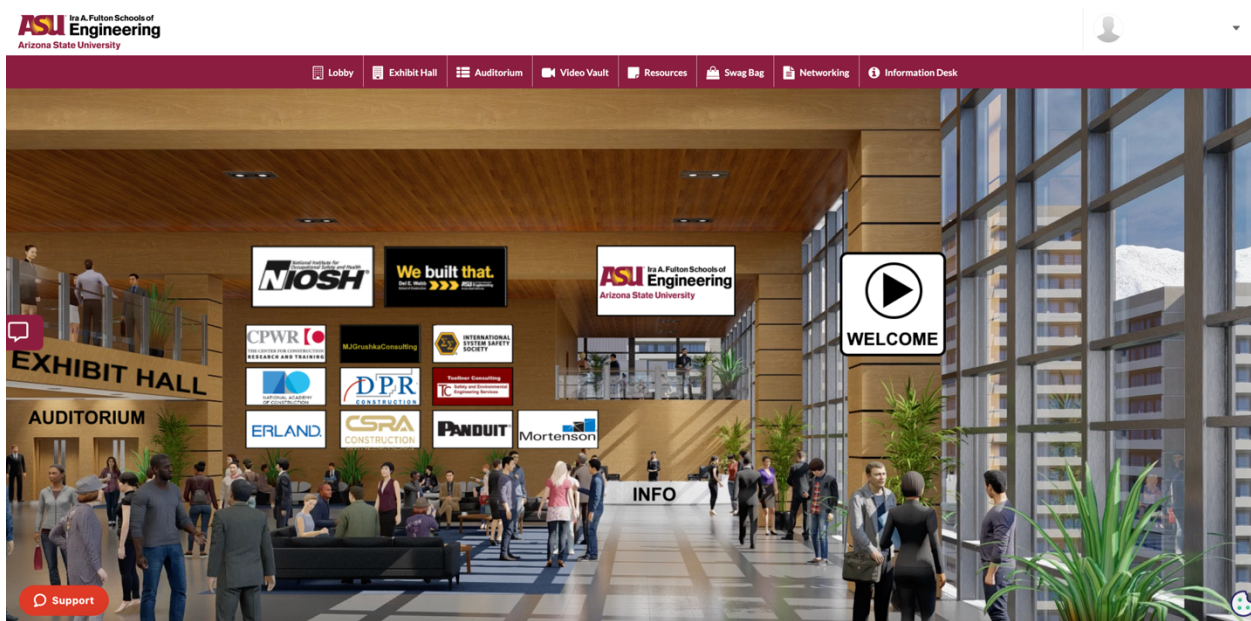


Figure 1. vFairs Virtual Lobby

The 2022 PtD Workshop occurred over two consecutive half-days with three sessions per day. Each session had pre-recorded videos with the video presentations from the keynote speaker(s) followed by a live Question and Answer (Q&A) or Panel discussion, during which the keynote speaker(s) and panelists addressed the attendees' questions in real-time. Moreover, with the vFairs platform, networking breaks between sessions provided attendees an excellent opportunity to

³ The Steering Committee is listed in Appendix D.

⁴ The vFairs platform’s features can be found in Appendix H.

network and build new connections with PtD experts. Finally, at the end of each half day, concurrent Virtual Meet and Greet Sessions were held, during which attendees met and interacted with keynote speakers,⁵ moderators,⁶ Co-Chairs,⁷ and other attendees through Zoom.

In total, 130 attendees⁸ engaged with the PtD Workshop. Eleven keynote speakers and panelists, with educational and industry backgrounds, provided a baseline for HOW to implement PtD practices and promote a positive safety culture. Key learnings from each of these presentations is presented in the succeeding section, and the workshop agenda is provided in Appendix B.

⁵ Presenter bios can be found in Appendix E.

⁶ Moderator bios can be found in Appendix F.

⁷ Co-Chair bios can be found in Appendix G.

⁸ The list of attendees can be found in Appendix A.

2. Day one

The 2022 Workshop's Co-Chair, Dr. David Grau (Arizona State University), opened the workshop and welcomed the attendees. He provided a summary of the 5-year PtD Initiative, introduced the Steering Committee and Sponsors, and discussed the Workshop theme and daily structure.



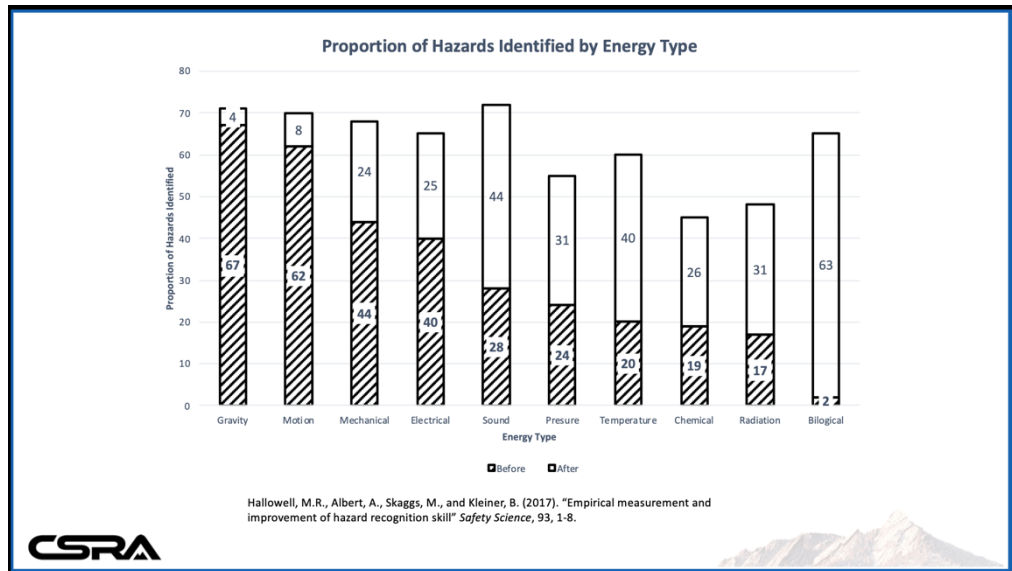
Dr. David Grau, Workshop's Co-Chair

The first day consisted of three sessions followed by live Q&A at the end of each. The first session of day one consisted of two sequential presentations on data analysis in support of PtD. The kick-off presentation focused on exploring the hazard recognition ability during the design process and how to implement it during PtD reviews. The second presentation illustrated the importance of Front-End-Planning and its impact on construction safety performance. The second session of the day consisted of three sequential presentations focusing on wearables and exoskeletons in Prevention through Design. In this session, how different types of wearables and exoskeletons can increase workers' health and safety and improve the quality of work were explored, including their application in the design of safer work environments. Finally, the third session concentrated on BIM and Prevention through Design and demonstrated the promise of digital twin models to leverage planning, monitoring, and controlling for safer, more productive, and emissions-free work environments.

2.1 Session 1. Data Supporting PtD

The first session consisted of two keynote speakers followed by a live Q&A discussion moderated by Dr. John Gambatese of Oregon State University. Dr. Matthew R. Hallowell of the University of Colorado at Boulder was the initial speaker. He is currently a Professor and the Executive Director of the Construction Safety Research Alliance.

His presentation gave an overview of the results of an empirical study on how energy-based hazard recognition helps improve the ability to recognize and



Dr. Matthew R. Hallowell's Presentation, Energy-Based Hazard Recognition in Design

address hazards in the design phase of capital projects. Dr. Hallowell emphasized barriers to the implementation of PtD, the need for safety education, and the development of tools and techniques to increase designers' ability to anticipate and mitigate hazards in the early phases of the project. He detailed designers' hazard recognition skills and the proportion and type of recognizable hazards in the design process. He elucidated that providing field experience helps designers think broadly, and their hazard recognition ability may improve through "simple cognitive reminders."

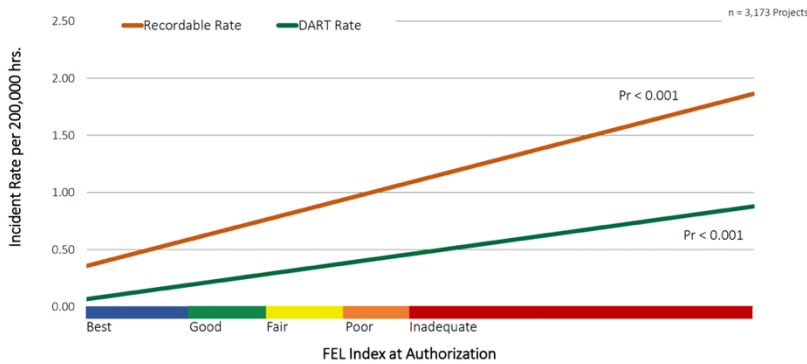
Dr. Andrew Griffith from Independent Project Analysis (IPA) delivered the second presentation. Dr. Griffith is the Director of the IPA Institute. His presentation focused on how "Driving Superior Construction Safety Performance Begins Early." He shared the result of the study with a sample of over 3,000 completed projects worth more than \$700 Billion in Total Project Cost (TPC). The results indicate that the level of scope definition of the project in the early phase of the project (Front-End Loading index) significantly correlates with improved levels of construction safety. Thus, the study corroborates that proper project development during the definition phase of front-

end planning improves construction safety performance. Dr. Griffith's presentation emphasized that completing the project scope definition before authorization minimizes late changes and



provides a stable and effective environment for detailing the design and implementing PtD principles, resulting in superior construction safety performance.

FEL at Authorization Drives Construction Safety Results



Projects with Estimated Total Costs >\$10MM (2022) Authorized Since 2000
Controlled for Year of Authorization and Project Size

Dr. Andrew Griffith's Presentation, The correlation between FEL Index and Incident Rate

Dr. Gambatese moderated the Q&A session, and Dr. Hallowell and Dr. Griffith addressed the attendees' questions and discussed the importance of identification of hazards right after the project authorization, owner involvement during the FEL and PtD process, the designer's experience in hazard identification, and the connection between contract type and safety records.



Q&A session. Moderator: Dr. John Gambatese, Speakers: Dr. Matt Hallowell and Dr. Andrew Griffith

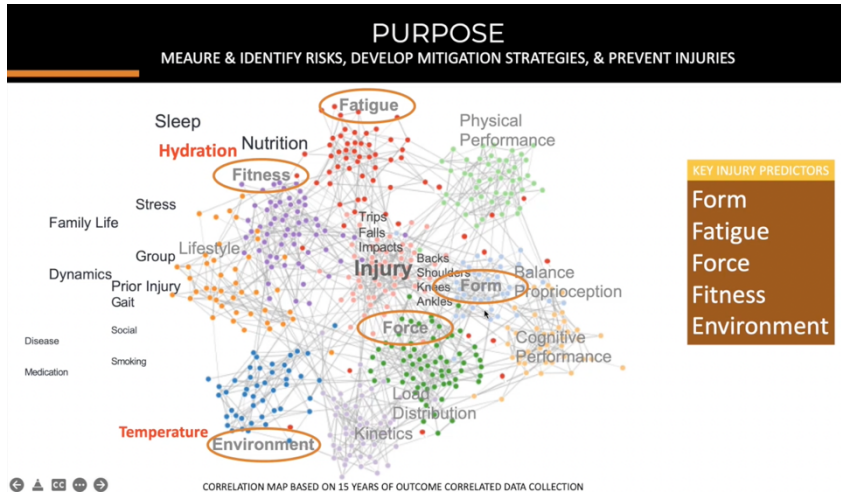
2.2 Session 2. Wearables and Exoskeletons in Prevention through Design

The second session consisted of three presentations and Q&A discussion. Mr. Mike Flowers moderated this session and introduced the keynote speakers. First, Dr. Sugar, a professor at Arizona State University, provided a presentation on “Exoskeletons, Assisting Human Movement.”

In his presentation, he discussed how exoskeletons could reduce workers’ fatigue, prevent long-term chronic injuries, reduce Musculoskeletal injuries, and improve the long-term safety of the workforce. Dr. Sugar described the different types of exoskeletons and outlined the exoskeletons' challenges to be applied widely in industry. Then he introduced the APEx or Aerial Porter exoskeleton, designed and tailored to pushing and lifting objects onto large cargo airplanes and tested by the US Air Force. The Aerial Porter exoskeleton has successfully conquered exoskeletons' challenges and is portable, lightweight, does not impair the user’s motion, and seamlessly interacts with the user. Moreover, it can assist workers in preventing accidents and injuries by changing the work process, reduce the causes of accidents, and increase workers’ ability to respond to hazards.



Dr. Thomas Sugar's Presentation, The Aerial Porter exoskeleton

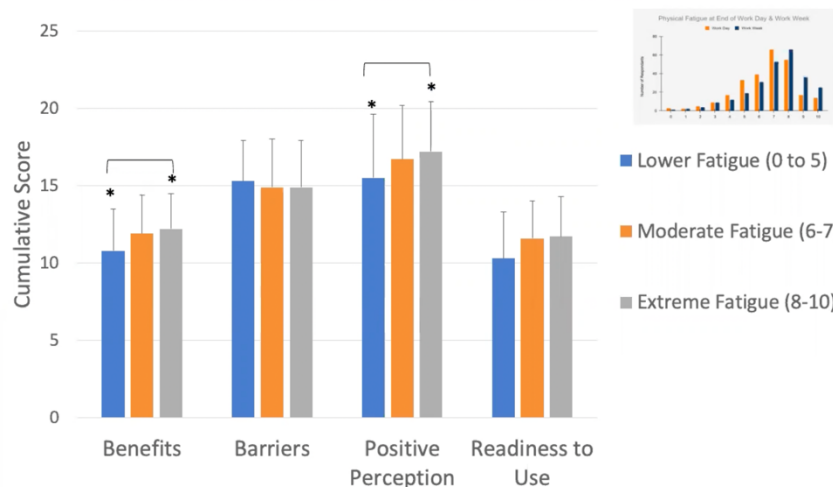


Dr. Joe Hitt's Presentation, Key Injury Predictor

measure and identify the risks per individual and their work environment by collecting accurate data regarding fatigue, fitness, forces, form, and environment, which are key predictors of injury. Then mitigation strategies and changes in design, behavior, and work conditions can be implemented to reduce these risks to prevent injuries. Dr. Hitt shared three use cases where measuring the key predictor of injuries helped identify the hazards and led to substitutes or redesign, which resulted in 50% reduction of injuries by making small design and behavioral changes.

Finally, Dr. Carisa Harris-Adamson, Associate Professor at the University of California San Francisco UC Berkeley, presented preliminary results of surveys and interviews of construction

Exoskeleton Receptivity by Fatigue



Dr. Carisa Harris-Adamson's Presentation, Exoskeleton Receptivity by Fatigue

Second, Dr. Joseph Hitt from GoX Lab explained how wearable technologies could help with PtD. He discussed how wearables can assist in accurately collecting the data, which can be used to identify and eliminate risks through design. He explained that wearables can be used to

industry stakeholders to obtain input to assess safety concerns for using the exoskeletons (EXOs) in construction. She presented potential barriers to exoskeleton use and demonstrated how an understanding of the worker's perception of EXOs is required for an effective

adoption of EXOs. Finally, Dr. Harris outlined multiple research studies on safety that are driven as a result of their study.

Mr. Mike Flowers moderated the discussion that followed the presentations. Dr. Thomas Sugar, Dr. Joseph Hitt, and Dr. Carisa Harris-Adamson addressed the following topics during the Q&A:

- The ways that wearable technologies such as exoskeletons can be made attractive to investors
- The advantage of wearable technologies in enhancing the productivity of the workforce, reducing injury, improving worker wellness, reduction in claims, and increasing return on investment
- How wearables can influence and change the design of a project
- Example of wearable applications in designing the best work environment and designing out the hazards
- Barriers and drivers for exoskeleton implementation in the construction industry
- Application of wearables on risk management process and continuously improving workers' safety and productivity performances



Q&A session. Moderator: Mr. Mike Flowers, Speakers: Dr. Thomas sugar, Dr. Joe Hitt, and Dr. Carisa Harris-Adamson

2.3 Session 3. BIM and Prevention through Design

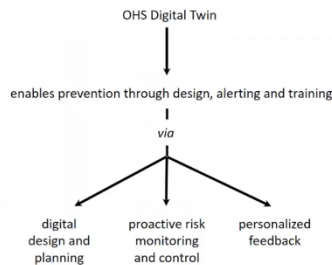
DIGITAL TWIN FOR CONSTRUCTION SAFETY

Our objective:

- Assurance of the occupational health and safety (OHS) of construction workers

Achieved in three steps:

- System of prevention through design and planning (PtD/P) in construction operation design and planning
- Proactive risk detection and warning on construction sites
- Rapid personalized feedback in learning and decision making



Teizer, J., Johansen, K.W., Schultz, C. (2022). "The Concept of Digital Twin for Construction Safety." Construction Research Congress, Arlington, Virginia, USA, 1156-1165. <https://doi.org/10.1061/9780784483961.121>.

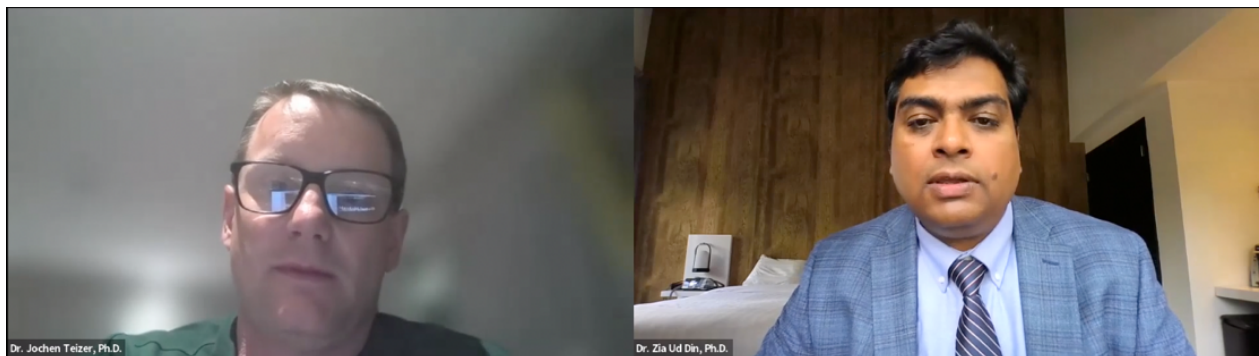


Dr. Jochen Teizer's Presentation, Digital Twin for Construction Safety

Dr. Zia Ud Din moderated the third and last session of the first day. Dr. Jochen Teizer, professor at the Technical University of Denmark, presented the application of BIM and digital twins in PtD. Dr. Teizer detailed the digital twin's opportunities to

leverage planning, monitoring, and controlling for more productive, safer, and emissions-free work environments. He provided the attendees with multiple cases of applying Building Information Modeling and Augmented Reality in safety rule checking, conformance checking, safety monitoring and alerting, reporting and feedback process, proactive alerts, detecting hazardous areas, and active learning.

During the Q&A, examples of construction safety rules, commercial software providers, autonomous vehicles, and the application of Virtual Reality and Augmented Reality in hazard detection, gamification, and worker training were discussed.



Q&A Session. Moderator: Dr. Zia Ud Din, Speaker: Dr. Jochen Teizer

2.4 Summary Day One

Dr. David Grau provided a summary of key thoughts and themes and wrapped up the first day of the third PtD Workshop. The summary included the following topics:

- Construction experience and design expertise positive influence on hazard recognition ability
- The challenges of anticipating all hazards in the design process
- The relation between the Frond-End Loading index and safety performance provides a stable basis for PtD through early project definition
- Improvement of safety through monitoring key predictors of work injuries
- Exoskeleton's impact on preserving health and safety, quality of work, aging workforce, and reducing fatigue
- Key differences between passive exoskeletons and active exoskeletons
- Opportunities and threats of exoskeletons in the construction industry
- Importance of exoskeletons as a new source of energy for hazard recognition
- The ability to prevent fatigue, heat stress, slips, trip falls, and back injuries using wearable devices
- The promise of real-time warnings and communications to workers on their health and ergonomic performance through wearables and exoskeletons
- The opportunity to leverage BIM during the PtD process and automate safety compliance
- The ability to extend safety compliance checks on the job site through augmented reality
- The promise of accident reduction through virtual design and production planning to remove safety hazards
- Hazard recognition through the application of digital twins

2.5 Meet and Greet Day One

At the end of the first day, attendees met the keynote speakers, moderators, panelists, and attendees in virtual Zoom rooms.

Meet and Greet

Room 1	 Dr. John Gambatese, Host	 Dr. Matthew R. Hallowell	 Dr. Andrew F. Griffith	
Room 2	 Mike Flowers, Host	 Dr. Thomas Sugar	 Dr. Joseph Hitt	 Dr. Carisa Harris-Adamson
Room 3	 Dr. Zia Ud Din, Host	 Dr. Jochen Teizer		

Meet and Greet Session Day One

2.6 Efficacy of the Workshop's First Day

At the end of the day, attendees provided an evaluation by means of a survey. A number of questions were asked using a Likert Scale of 1 to 5, with 1 being poor and 5 being excellent. The weighted average of each question is given in Table 1.

Table 1. Workshop Attendee Subject Evaluation of Contents (n=32)

Questions	Average Rating
Applicability to your present or future assignments	4.22
Format and organization	4.41
Workshop content quality	4.38
Overall Workshop rating	4.38

In addition, several “yes/no” questions were asked to gauge the overall value of the Workshop. The percentage of yes/no answers for each of the questions is given in Table 2.

Table 2. Workshop Attendee Subject Evaluation of Overall Value (n=32)

Questions	Yes %	No %
Did the Workshop improve your overall understanding of PtD?	96.9%	3.1%
Did the Workshop improve your understanding of how to implement PtD?	93.8%	6.3%
Was this Workshop worth the time that you spent attending?	100.0%	0.0%
Would you recommend a future similar Workshop to others?	96.9%	3.1%

3. Day Two

The 2022 Workshop's Co-Chair, Dr. G Edward Gibson (Arizona State University), opened the second day and welcomed the attendees. Dr. Gibson introduced the Steering Committee and thanked them for their support. After acknowledging the 2022 Workshop sponsors, he discussed the Workshop theme and Workshop daily structure. As previously discussed in this report, Dr. Gibson summarized the first day of the Workshop:



Dr. G. Edward Gibson, Workshop's Co-Chair

- The link between hazard recognition ability and construction experience/design expertise
- The challenges of recognizing all hazards in the design process
- Providing a stable basis for PtD by way of effective early Front-End Planning
- Wearables and Exoskeletons' impact on worker's health and safety and productivity
- An overview of the different types of exoskeletons
- The challenges of using exoskeleton in construction and manufacturing
- An overview of wearables and their ability to help us understand key predictors of work injuries
- BIM and its use and efficacy in impacting prevention through design
- The promise of identification of potential hazards and preventing injuries through simulating the environment

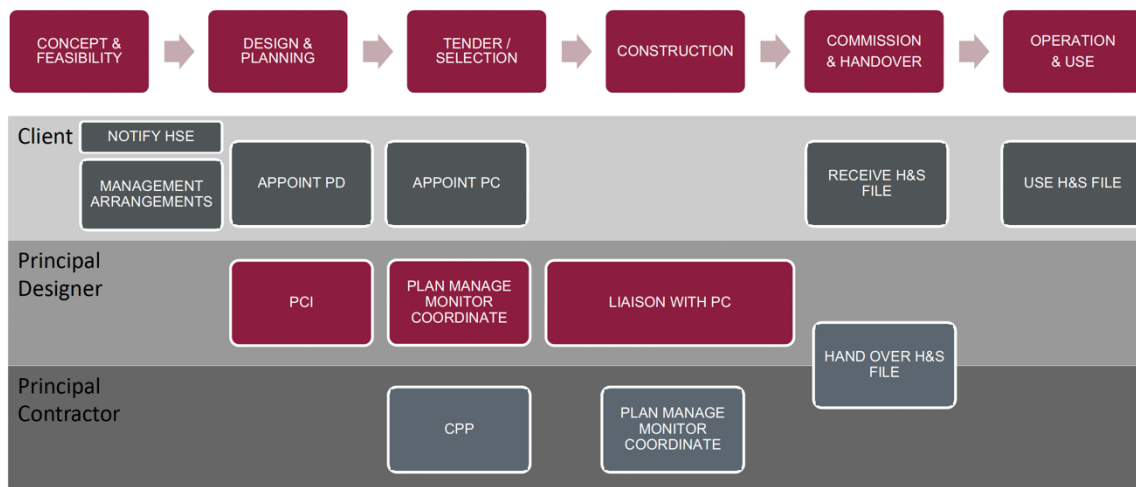
Dr. Gibson explained that the second day of the Workshop consisted of three sessions followed by live Question and Answer or Panel discussions. The first session of day two consisted of two sequential presentations focused on reviewing PtD regulation and legislation from the UK perspective. In this session, the lesson learned from Construction (Design and Management) Regulations (CDM) in the United Kingdom and the opportunities of the digital revolutions to

improve occupational safety and health were discussed. The second presentation was a case study concentrated on PtD processes and safety management strategies of the Vera C. Rubin Observatory. The third and final session was a case study on how Mortenson is using modularization and PtD techniques to eliminate hazards and create a safe working environment as they continue their journey to Zero accidents.

3.1 Session 1. PtD a UK perspective

The first session of day two consisted of two keynote speakers from the United Kingdom followed by live Question and Answer discussion. Dr. Scott Earnest from NIOSH moderated this session and introduced the keynote speakers. Dr. Billy Hare, professor at Glasgow Caledonian University, was the opening keynote speaker on the second day. He provided an engaging keynote presentation on PtD from a UK perspective. He reviewed how the introduction of the Construction (Design and Management) Regulations (CDM) in the UK has shaped the designer’s role in helping to manage Occupational Safety and Health (OSH) risks during the construction phase and beyond. Dr. Hare Outlined the lessons learned about the difficulties of enforcing PtD with legislation and good practice. He presented the findings from innovative research on what influences designers when carrying out their legal duty to eliminate hazards, reduce risks and provide OSH information. Limitations of depending exclusively on BIM to solve OSH problems and potential solutions to bridge the learning gap were also shared.

CDM 2015

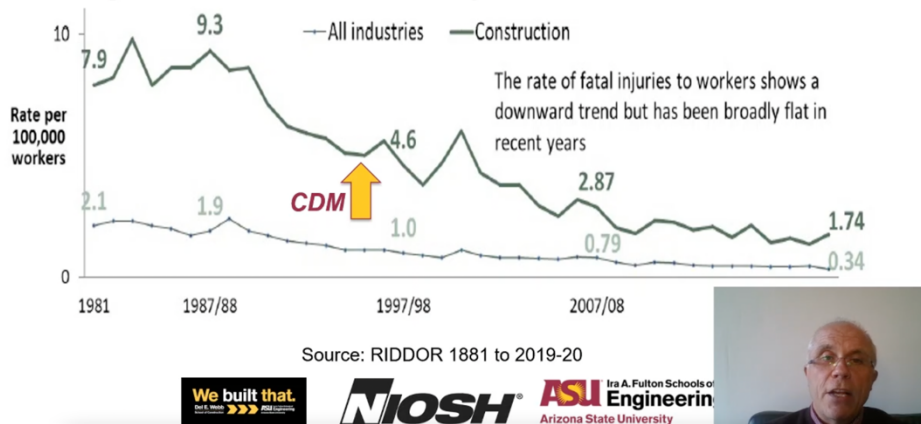


Dr. Billy Hare's Presentation, Construction (Design and Management) Regulations (CDM)

Also, Dr. Alistair Gibb, Emeritus, professor at Loughborough University, UK, presented “Highlighting Current Learning from the UK’s PtD Construction.” He explained the opportunities of the BIM and digital twin to improve occupational safety and health. Dr. Gibb highlighted the

UK PtD Impact

• Long term trends in rates of fatal injuries to workers 1981-2019/20



Dr. Alistair Gibb's presentation, UK PtD Impact

London's Grenfell Tower disaster and the latest UK legislation, which explicitly requires both designers and contractors to consider the safety of the users of the building or facility.

Dr. Scott Earnest moderated the Q&A and Keynote speakers answered the questions posed by attendees, and the following topics were discussed:

- Proactive leading indicators for safety in the design and construction process
- Managing new hazards as a result of PtD solutions
- Architects and civil engineers' ability to identify hazards in design processes
- CDM regulations influence on improving health and safety in the UK
- Driving factors in decreasing fatal accidents over time in the UK construction industry
- CDM impact on creating synergies efforts in PtD training and education

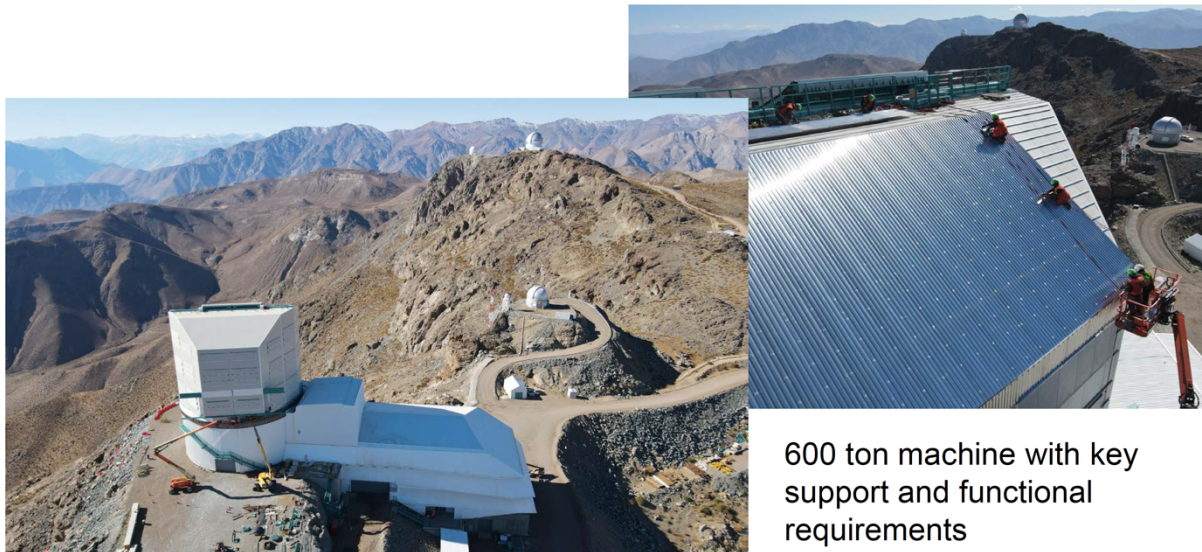


Q&A Session. Moderator: Dr. Scott Earnest, Speakers: Dr. Billy Hare and Dr. Alistair Gibb

3.2 Session 2. How Big Astronomy is Using Prevention thru Design to Succeed

Mr. Mark Grushka moderated the second session and introduced Mr. Victor Krabbendam and Mr. Chuck Gessner from Vera C. Rubin Observatory project as the keynote speakers of this session. Mr. Krabbendam and Mr. Gessner shared their unique experience integrating a foundational PtD

Summit Facility Dome



600 ton machine with key support and functional requirements

Mr. Victor Krabbendam, and Mr. Chuck Gessner's Presentation, Vera C. Rubin Observatory project

support system over a multi-year basis of a world-class telescope known as the Vera C. Rubin Construction Project in Chile. In response early designing for safety initiatives, integrated systems safety, and safety management strategies were used to support the goal of loss prevention in a large and multi-national/multi-cultural telescope project. They discussed their safety, health, and environmental management system that recognizes and accepts different safety cultures, rules, and expectations within the project and complies with regulations and safety standards. Mr. Krabbendam and Mr. Gessner detailed their unique risk management approach and hazard analysis process during the design process of the Vera C. Rubin Observatory project.

Mr. Mark Grushka moderated the panel discussion that followed the presentation. Mr. Victor Krabbendam, Mr. Chuck Gessner, and Mr. Austin Roberts from Vera C. Rubin Observatory

Project served as the panelists. Panelists answered the questions posed by attendees, and the following topics were discussed:

- Lessons learned from sustaining PtD leadership during the LSST project
- The importance of effective and constant communication during the management of safety risks
- Implementing a unified PtD methodology and hazard analysis process across all contractors
- Examples of hazards facing maintenance personnel that were mitigated or eliminated during the design
- Means and methods of tracking risk mitigation activities consistent with PtD goals
- Effect of multiple U.S. stakeholders and different national requirements on the LSST project's safety system
- The relation between PtD and safety culture



Panel Session: Moderator: Mr. Mark Grushka, Panelists: Mr. Victor Krabbendam, Mr. Chuck Gessner, and Mr. Austin Roberts

3.3 Session 3. Mortenson: a Journey to Zero, a Case Study

Finally, the last session of the second day was a case study followed by a panel discussion. Mr. T.J. Lyons from DPR construction moderated the session and introduced the keynote speakers. Mr. Jason Hopper and Mr. Justin Riley from Mortenson explained how Mortenson uses manufactured products and PtD to eliminate hazards, improve ergonomics and create a safe

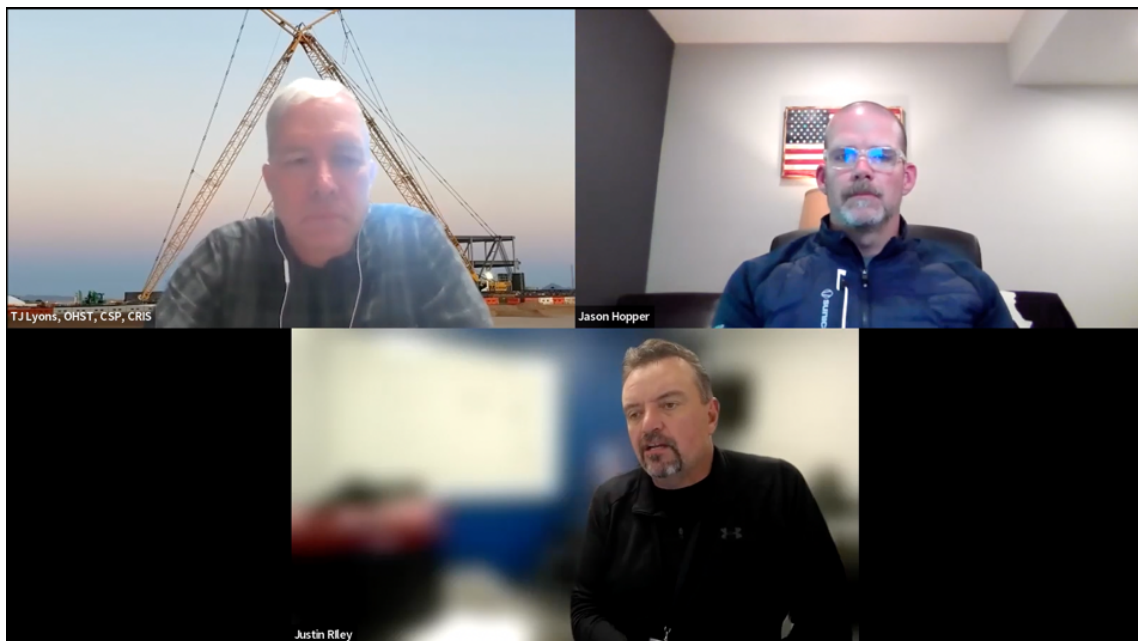


Mr. Jason Hoper and Mr. Justin Riley's Presentation, Precast Ductbank

working environment for their craft team members as they continue on their journey to Zero accidents and injuries. Their presentation emphasized the shift towards industrialization and manufactured products in the construction of hyper-scale data centers. They explained how utilizing components, assemblies, and sub-assemblies manufactured in offsite facilities reduces onsite labor and safety exposure for site-installed features and increases safety, quality control, efficiency, and schedule reliability. Hopper's and Riley's presentation highlighted specific case studies that illustrated the benefits of Design for Manufacturing and Assembly (DFMA) and design for safety practices utilized on several data center projects. these examples included precast duct bank, manufactured walls and precast grade beams.

Mr. T.J. Lyons moderated the Q&A session that followed the presentations. Mr. Jason Hopper and Mr. Justin Riley discussed the following topics:

- The advantages of requiring prefabrication or modular assembly in contracts
- The need to build a culture of collaboration and sharing best practices and lessons learned among all stakeholders involved in the project
- The strengths and benefits of the 5S program (Sort, Straighten, Shine, Standardize, Sustain) on safety
- The collaborative approach they used for risk identification
- Decreasing incidents rates after applying modularization and prefabrication approach
- The importance of the owner's perspective on prefabrication
- Specialized labor skills required for modularization
- Improving project performance and productivity through modularization and manufactured products in the construction



Q&A Session: Moderator: Mr. Tj Lyons, Speakers: Mr. Jason Hopper, and Mr. Justin Riley

3.4 Summary Day Two

Dr. George Gibson wrapped up the second day and the 2022 Workshop with a summary of key thoughts and learning, which included:

- Improvements in safety performance result from early planning and hazard identification
- The importance of field experience on hazard recognition ability during the design
- The difficulty of recognizing all hazards during the design process
- Wearables and exoskeletons' potential for new developments for improving safety performance, including reducing fatigue and assisting in redesigning work practices
- Wearables can assist in redesigning the work process and training the workforce through monitoring workers
- The ability to extend worker's productive careers through using exoskeletons
- BIM and its impact on PtD, including assistance to designers and workers through visualization and simulation of complex systems
- The impact of CDM regulations on the UK's construction industry
- Comparing the UK and US construction safety records; the UK's fatality record is five times better than the US
- Fines and penalties in the UK do not result in lower construction accident rates
- Grenfell Tower in London and the latest UK legislation that requires considering end-users safety during planning
- Vera C. Rubin Observatory's client emphasis on safety and engagement in the PtD process, including contractual safety requirements with vendors and the early hazard recognition process while recognizing, addressing, tracking, communicating, and mitigating both construction and operations hazards
- The challenges of creating a safety culture in a multinational project
- PtD applications in hyper-scale data centers projects, including the key benefits of off-site modularization, pre-fabrication, and pre-assembly on safety and productivity
- Mortenson's very successful 5S program (Sort, Straighten, Shine, Standardize, Sustain)










Dr. Gibson summarized the two days with the simple statement, "PtD matters! It saves lives." Reduction of accidents and injuries is achievable through effective implementation of PtD, which

should start during front-end planning, involve experts with field experience in the design process, engage with clients with the right attitude toward safety, and apply digitalization and usage of innovative technologies to better identify and mitigate construction, manufacturing, and operations hazards during the design phase.

3.5 Meet and Greet Day Two

At the end of the first day, attendees met the keynote speakers, moderators, panelists, and attendees in virtual Zoom rooms.

Meet and Greet Day 2

Room 1	 Dr. Scott Earnest, Host	 Dr. Billy Hare	 Dr. Alistair Gibb	
Room 2	 Mark J. Grushka, Host	 Victor Krabbendam	 Chuck Gessner	 Austin Roberts
Room 3	 TJ Lyons, Host	 Justin Riley		

Meet and Greet Session Day 2

3.6 Efficacy of the Workshop’s Second Day

Workshop attendees were asked to fill out an evaluation survey at the end of the day. A number of questions were asked using a Likert Scale of 1 to 5, with 1 being poor and 5 being excellent. The weighted average of each question is given in Table 3.

Table 3. Workshop Attendee Subject Evaluation of Contents (n=33)

Questions	Average
Applicability to your present or future assignments	4.61
Format and organization	4.79
Workshop content quality	4.79
Overall Workshop rating	4.64
Technology provider	4.18

A number of yes/no questions were asked to gauge the overall value of the Workshop. The percentage of yes/no answers for each of the questions is given in Table 4.

Table 4. Workshop Attendee Subject Evaluation of Overall Value (n=33)

Questions	Yes %	No %
Did Day 2 of Workshop improve your overall understanding of PtD?	97.0%	3.0%
Did Day 2 Workshop, improve your understanding of how to implement	100.0%	0.0%
Was this Workshop worth the time that you spent attending?	100.0%	0.0%
Would you recommend a future similar Workshop to others?	100.0%	0.0%

Additional suggestions for future content were also received, and these will be used as a basis for crafting the next Workshop. The Steering Committee will take these, and additional comments, and use them to improve the next Workshop.

4. vFairs Platform

Due to the new COVID-19 variant outbreak and to limit virus transmission as well as to reach global audiences, the Steering Committee decided to use a virtual events platform to host the 2022 PtD Workshop. For this purpose, vFairs was selected because of its best-in-class features and giving visitors something as close to a physical show experience as possible to interactively participate in sessions, connect and network with professionals and visit exhibitors' booths during the workshop. This chapter reviews the attendees' activity on the vFairs platform during the live event days and subsequent one month of On-Demand viewing.

4.1 User Activity

This third PtD Workshop brought together architects, engineers, contractors, construction companies, project owners, academics, and other PtD professionals representing 44 construction industry organizations and 33 universities to collaborate, network, learn and share success stories and challenges. During the two days of the workshop, 98 attendees logged in to the vFairs platform, and on average, 60 attendees were actively involved with vFairs platform features, watching the presentations and inquiring during the live Q&A (Figure 2).

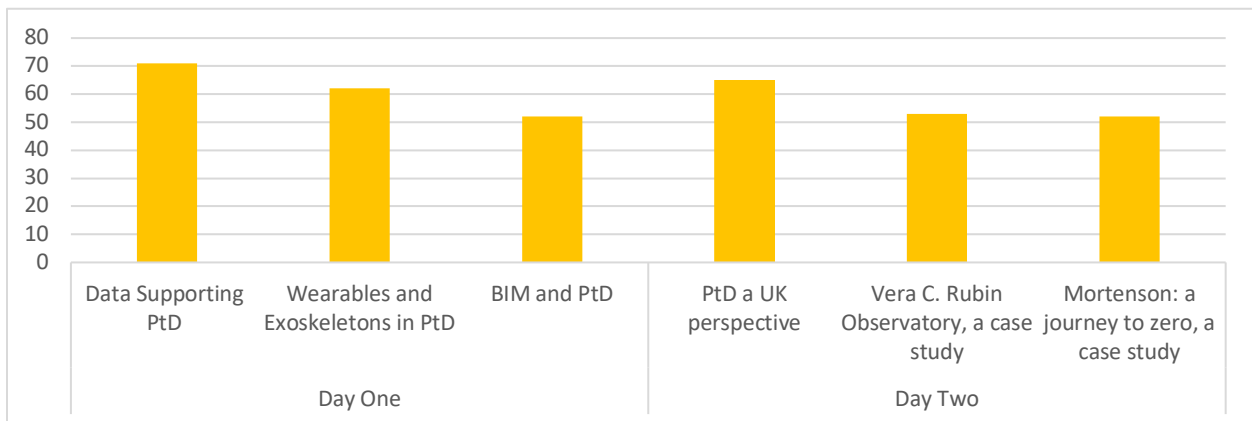


Figure 2. Attendees per Session During the two workshop Days

As shown in Figure 3, attendees visited different tabs during the two days of the workshop, specifically the networking tab, where attendees had the opportunity to develop connections and interact with PtD experts and professionals through vFairs' user-friendly virtual networking and chat features.

During one month of On-Demand viewing, all the recorded sessions and other content were accessible through vFAIRS until July 2, 2022, in asynchronous mode. As shown in Figure 3. more than 48 attendees logged into vFAIRS to take advantage of the platform’s features during On-Demand viewing. Asynchronous attendees watched the sessions, visited the exhibition booths, and downloaded the documents and videos of the booths.

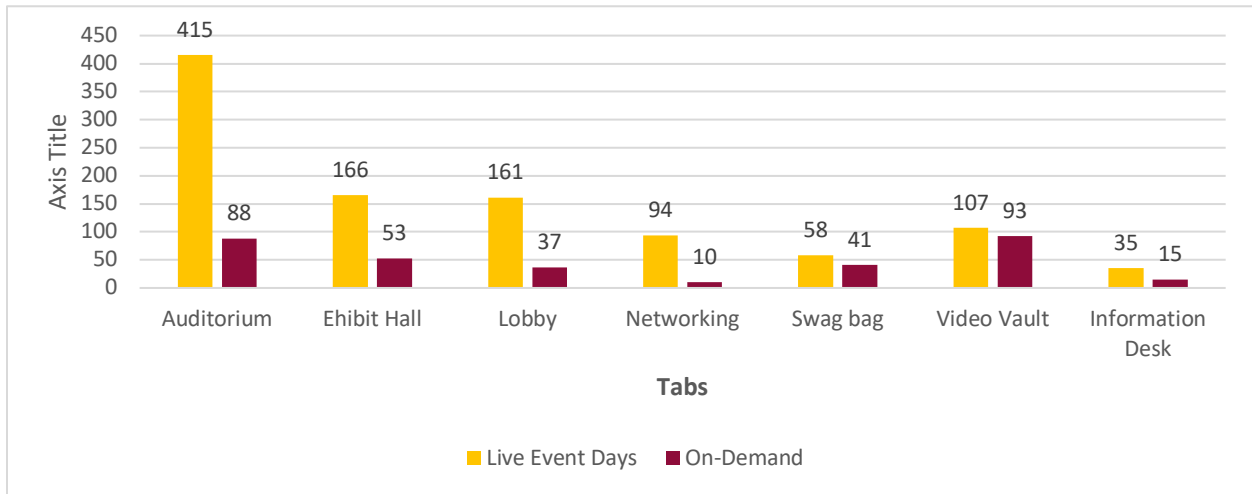


Figure 3. Hall Navigation Report

Dr. Matthew R. Hallowell’s presentation on “Energy-Based Hazard Recognition in Design” had been watched 23 times during On-Demand viewing. Also, Dr. Andrew Griffith, Mr. Jason Hopper and Mr. Justin Riley, Dr. Billy Hare, and Dr. Joe Hitt’s personations had been watched most, respectively (Figure 4).

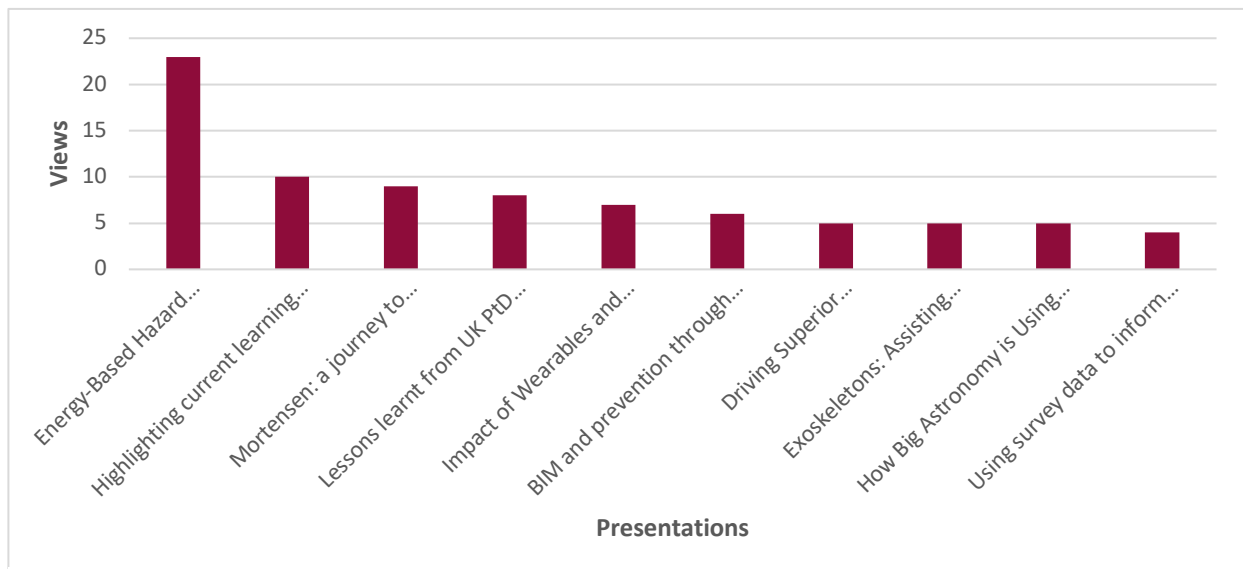


Figure 4. On-Demand Viewing Report

4.2 Exhibition Hall

The Prevention through Design Initiative, CPWR—the Center for Construction Research and Training, the Del E. Webb School of Construction, the International System Safety Society (ISSS), and the National Academy of Construction (NAC), Toellner Consulting, MJGrushkaConsulting, Construction Safety Research Alliance (CSRA), Panduit, and Erland Construction each hosted a booth in the Exhibition Hall. During the Workshop days and On-Demand, 131 audience members in total visited the exhibitors’ booths through the exhibition hall area (Figure 3).

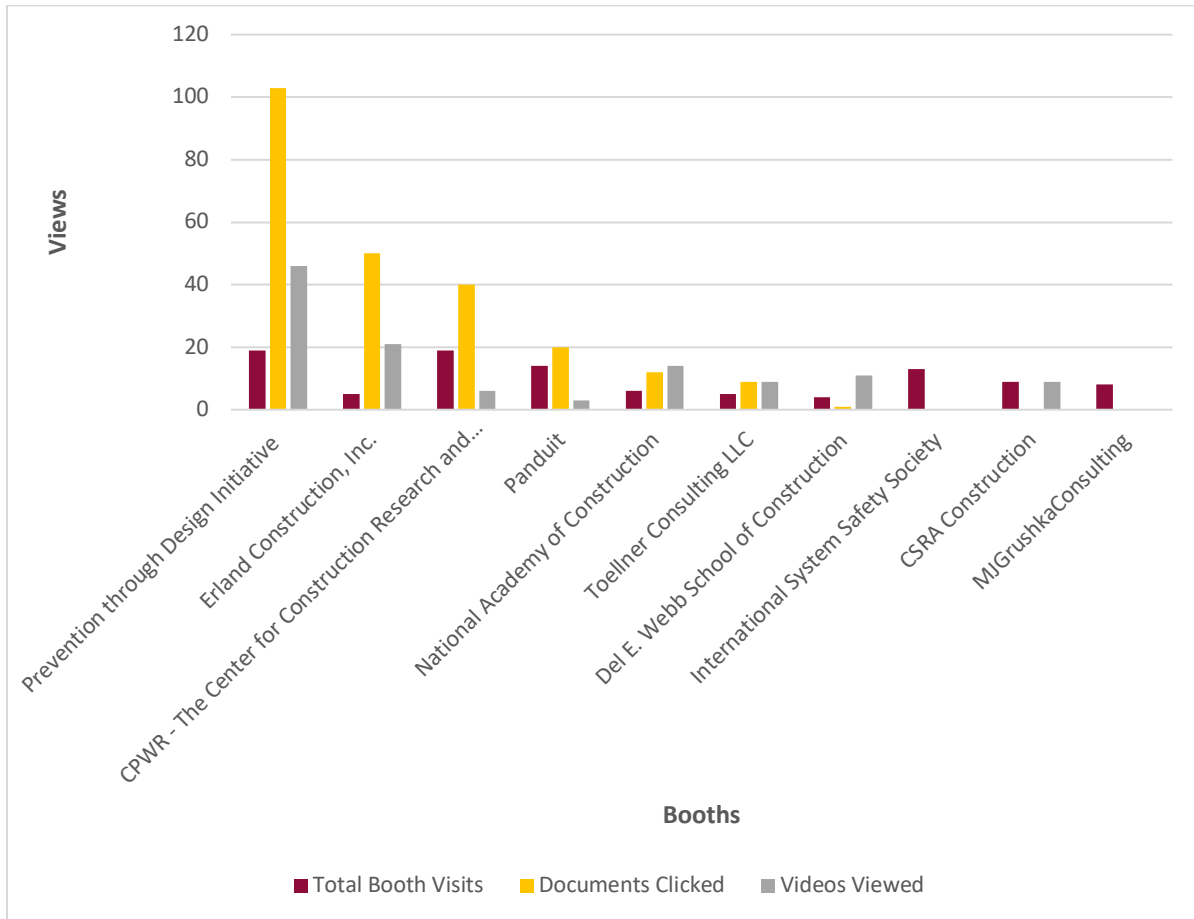


Figure 5. Booths Report

Each booth provided attendees with documents, videos, and other PtD resources. Attendees could add such resources in a virtual “Swag Bag.” Attendees could download or email the content of the Swag Bag (Figure 3 and Figure 6). Furthermore, attendees had access to documents, videos, and resources in the booths, and also all Workshop content, through a “Video Vault” tab. The tab listed

and consolidated all videos and documents (Figure 3). In addition, attendees had access to the past PtD Workshops' resources and content through the Prevention through Design Initiative booth.

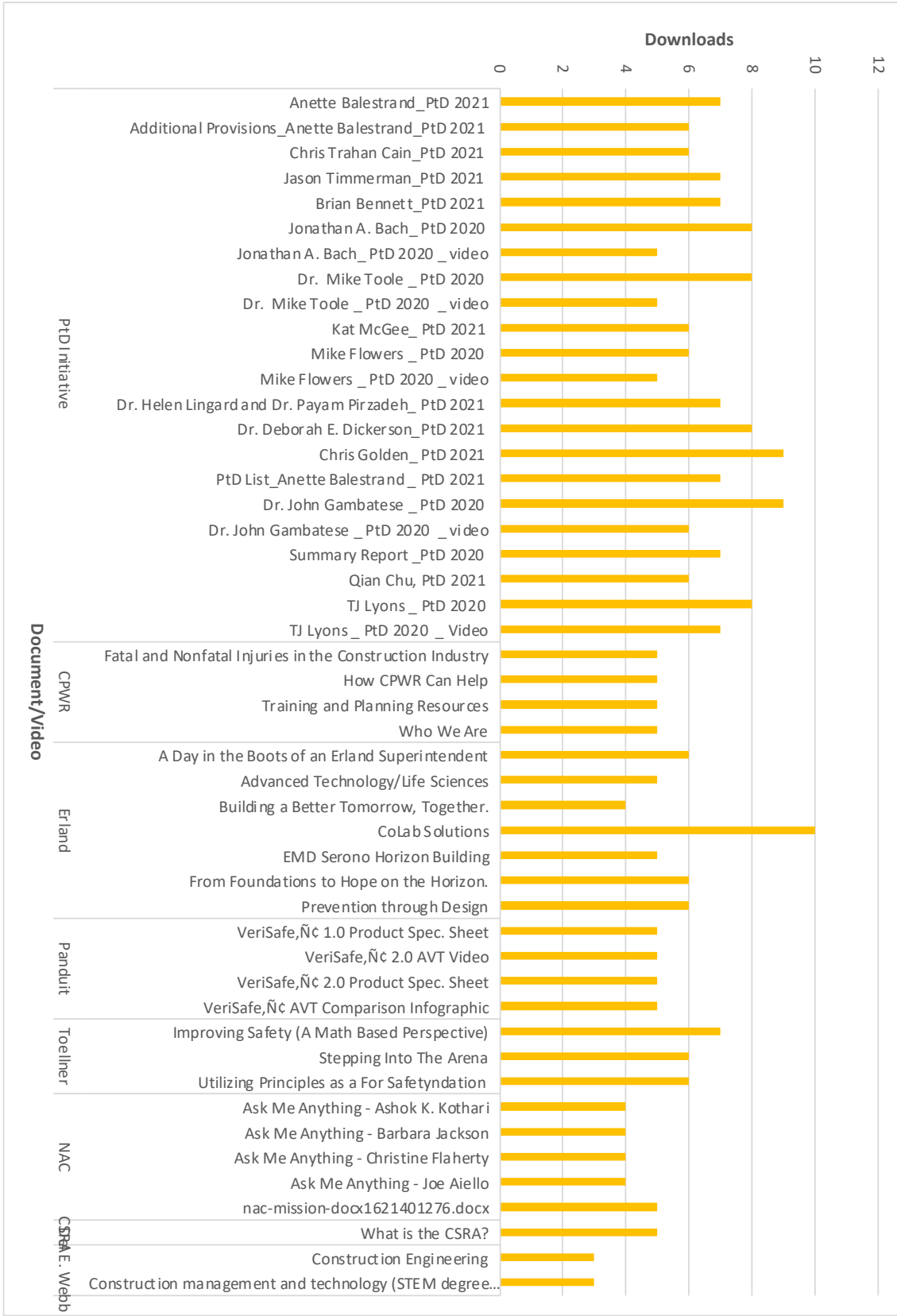


Figure 6. Swag Bag Report

Appendix A. Attendees

Full Name	Company/Organization
Abbey Dale Abellanosa	University of Alberta
Paul Alfonsi	Avangrid
Abdullah Alsharaf	North Carolina State University
Luis Amigo	Webber, LLC
Jonathan Bach	CDC NIOSH
Jane Beaudry	Jacobs
Robbie Berryman	American Contractors Insurance Group
Bryan Bishop	Columbia Southern University
Missy Blair	Pima Community College
Jason Bowie	Avangrid
Ben Boyd	Arizona State University
Shawn Bradfield	National Renewable Energy Laboratory (NREL)
Christine Branche	CDC NIOSH
Ricky Brown	Rosendin Electric
Rachel Bugaris	Panduit Corp.
Angela Bynum	NASA
Colin Cagney	KPMG
Hardik Chauhan	Rayat Bahra University
Chang-Ray Chen	University of Wisconsin-Stout
Ray Coleman	Jacobs
Ken Daigle	ERM
Brian Desrosiers	Environmental Resources Management
Mike Dickerson	American Contractors Insurance Group
Zia Din	University of Houston
Holger Drass	NOIRLab/AURA/Rubin Observatory
Scott Earnest	NIOSH
Mounir El Asmar	Arizona State University
Pedram Esmailzadeh	Arizona State University
Chris Evans	TAE Technologies
Michael Flowers	American Bridge Company
Javier Freire	UC Berkeley
John Gambatese	Oregon State University
Zach Ganster	Panduit
Cory Gaye	Liberty Mutual
Nicholas Genovese	Cornell University
Chuck Gessner	Vera C. Rubin Observatory
Alistair Gibb	Loughborough University, UK
Hamidreza Golabchi	University of Alberta
Sulyn Gomez	UC Berkeley
Elizabeth Gordon	DPR Construction
Andrew Griffith	Independent Project Analysis, Inc.

Mark Grushka	MJGrushka Consulting
Kim Gwan-Jun	Chung-Ang University
Jay Haller	DPR Construction
Matthew Hollowell	University of Colorado at Boulder
Billy Hare	Glasgow Caledonian University
Jacob Harris	Jacobs Engineering
Carisa Harris Adamson	University of California, San Francisco & Berkeley
Richard Hislop	Richard Hislop and Associates
Joe Hitt	GoX Labs
Charles Hoes	Hoes Engineering, Inc
Ken Hoff	Brown and Caldwell
Marni Hogen	Mortenson
Jason Hopper	Mortenson
Gayla Hurson	RUKCO
Deena Ibrahim	Cummins Inc
Isha Jain	Arizona State University
Bitu Jalali Mosalam	Arizona State University
Aslan Jalilnejad Hallajian	University of Houston
Sahar Javaid	CASD
Junhyeon Jo	Chung-Ang University
Karsten Johansen	Aarhus University
Lee Joo-Won	Chung-Ang University
Elyas Kamyab	Arizona State University
Alan Kassas	RMIT University
Chien-Ho Ko	University of Kansas
Victor Krabbendam	Vera C. Rubin Observatory
Thomas Kramer	LJB Inc.
Randall Kresge	JohnstonEHS
Chau Le	North Dakota State University
Wes Leavitt	ERM Worldwide Group Limited
Fernanda Leite	The University of Texas at Austin
Gregory Light	Avangrid
Pengkun Liu	Carnegie Mellon University
Tj Lyons	DPR Construction
Likith Mani	Arizona State University
Mark Martin	University of California Davis Health
Mike Martin	Exelon
Gail McEwen	Glasgow Caledonian University
Daniel Mehrabi	Arizona State University
Babak Memarian	CPWR
Russell Mitchell	Belcan
Maryam Moradnejad	SPS+ Architects
Emmanuel Moses	Ghana National Gas Company
David Nash	Board International
Uchenna Okoro	Glasgow Caledonian University

Martina Omar	Universiti Teknologi Malaysia (UiTM)
Valerie Onderka	Liberty Mutual /Ironshore Insurance Company
Joan Ongodia	Technische Universit
Sanjay Pandya	Everguard, Inc.
Chansik Park	Chung-Ang University
Mayank Patel	University Of Houston
Mallanagoud Patil	Arizona State University
Akeem Pedro	Chung Ang University
Jerry Peter	Sun Construction
Robert Pinney	Liberty Mutual
Nikolay Popov	ex SGS
Michael Quashne	Baltimore Gas & Electric
Jameka Richardson	EKU Student
Justin Riley	Mortenson
Anna Roark	Brayton Construction
Austin Roberts	Rubin Observatory
Hala Sanboskani	Arizona State University
Sherryl Schultz	Schultz
Andrew Scowcroft	Brown and Caldwell
Thomas Shanahan	NRCA
Rushikesh Shevkare	Arizona State University
Weifang Shi	University of Auckland
Suzanne Snowden	Avangrid
Ron Sokol	Safety Council Texas City
Thomas Sugar	Arizona State University
Omkar Suryawanshi	Arizona State University
Brian Swilley	PCL Construction
Ulises Techera	University of Colorado Boulder
Jochen Teizer	Technical University of Denmark
Grant Thompson	Federation University
Mike Toole	University of Toledo
Si Tran	Chung-Ang University
Douglas Trout	CDC/NIOSH
Todd Troutman	Mars Wrigley
Nicholas Tymvios	Bucknell University
S M Jamil Uddin	North Carolina State University
Kamran Ullah	Sarhad University of Science and Information Technology,
Tom Ventker	DPR Construction
Ruoxin Xiong	Carnegie Mellon University
Taehan Yoo	Chung-Ang University
Yang Zhan	University of Arizona

Appendix B. 2022 PtD Workshop Agenda
May 25-26, 2022 Prevention through Design Workshop

Theme: PtD journey from what to how

Pacific Daylight Time (GMT-7)

May 25

- 8:00-8:15 Welcome and Introduction
Dr. David Grau (Arizona State University)
Data Supporting PtD
- 8:15-8:35 *Energy-Based Hazard Recognition in Design*
Dr. Matt Hallowell (University of Colorado at Boulder)
- 8:35-8:55 *Driving Superior Construction Safety Performance begins Early*
Dr. Andrew Griffith (Independent Project Analysis)
- 8:55-9:15 Q&A (Moderator: Dr. John Gambatese)
- 9:15-9:30 *Networking Break*
- Wearables and Exoskeletons in Prevention Through Design*
- 9:30-9:45 *Exoskeletons: Assisting Human Movement*
Dr. Thomas Sugar (Arizona State University)
- 9:45-10:00 *Impact of Wearables and Data on PtD*
Dr. Joe Hitt (GoX Labs)
- 10:00-10:15 *Using survey data to inform prevention through design translational research*
Dr. Carisa Harris-Adamson (University of California, San Francisco & Berkeley)
- 10:15-10:45 Q&A (Moderator: Mr. Mike Flowers)
- 10:45-11:00 *Networking Break*
- 11:00-11:20 *BIM and prevention through Design*
Dr. Jochen Teizer (Technical University of Denmark)
- 11:20-11:40 Q&A (Moderator: Dr. Zia Ud Din)
- 11:40-11:50 Summary and wrapup
Dr. David Grau (Arizona State University)
- 11:50-12:00 *Networking Break*
- 12:00 – 13:00 Virtual Speaker Rooms with moderators

May 26

- 8:00-8:10 Welcome and Introduction
Dr. Edd Gibson (Arizona State University)
PtD a UK perspective
- 8:10-8:50 *Lessons learnt from UK PtD Legislation*
Dr. Billy Hare (Glasgow Caledonian University)
Highlighting current learning from the UK's PtD Construction
Dr. Alistair Gibb (Loughborough University)
- 8:50-9:15 Q&A (Moderator: Dr. Scott Earnest)
- 9:15-9:30 *Networking Break*
- 9:30-9:55 *How Big Astronomy is Using Prevention thru Design to Succeed*
Chuck Gessner and Victor Krabbendam (Vera C. Rubin Observatory)
- 9:55-10:25 Panel (Moderator: Mr. Mark Grushka; Panelists: Mr. Chuck Gessner, Mr. Victor Krabbendam, Mr. Austin Roberts)
- 10:25-10:40 *Networking Break*
- 10:40-11:05 *Mortensen: a journey to zero, a case study*
Jason Hopper and Justin Riley (Mortensen)
- 11:05-11:35 Panel (Moderator: Mr. TJ Lyons; Panelists: Mr. Jason Hopper and Mr. Justin Riley)
- 11:35 – 11:50 Day 2 Summary and wrapup
Dr. Edd Gibson (Arizona State University)
- 11:50-12:00 *Networking Break*
- 12:00 – 13:00 Virtual Speaker Rooms with moderators

Appendix C. Prevention through Design Workshop Initiative

Construction hazard PtD holds the promise to eventually reduce construction workers' exposure to safety and health hazards, and hence minimize accidents, morbidity, and fatalities. PtD aims to proactively identify and mitigate hazard exposure(s) through the design function, i.e., conceptual and detailed design, in contrast to the prevalent industry practice of waiting for construction in order to assess hazards. Hence, there is a critical need to advance PtD knowledge and disseminate and engage influencing stakeholders who are in the position to lead and advocate for implementing a holistic PtD approach. In order to address these gaps, highly influential stakeholders in client//owner, designer, and contractor organizations will be engaged with this PtD Workshop Initiative. With a kickoff Workshop in March 2020⁹, the second Workshop in May 2021¹⁰, and the third Workshop in May 2022 (this report) the aims of the 5-year PtD initiative follows:

Aim 1: To drive PtD implementation within large industry organizations. We will inform and engage highly influential stakeholders in large client/owner, designer, and contractor organizations. We will measure the cumulative engagement of these organizations with PtD during the 5-year effort.

Aim 2: To advance knowledge in PtD. We will collect implementation guidelines and tools, as well as identify case studies and business case models to effectively demonstrate concepts and strategies. We will query stakeholder participants, for example, on PtD drivers, benefits, and barriers. We will also identify and analyze information gaps, and propose a high-payoff research agenda. We will evaluate the number, quality, and broader impacts of knowledge contributions.

Aim 3: To promote PtD instruction in construction management and construction engineering programs at US colleges and universities. We will design and proactively disseminate six graduate instruction modules around PtD Workshop themes. We will cumulatively track academics and programs that are including the PtD approach in their curriculum.

⁹ PtD 2020 workshop's keynote presentations and report can be found at: <https://ptd.engineering.asu.edu/ptd-workshop-2020-neu/>

¹⁰ PtD 2021 workshop's keynote presentations and report can be found at: <https://ptd.engineering.asu.edu/ptd-workshop-2021-neu/>

Path Forward

A workshop on PtD will be offered annually until 2024. Each future workshop theme will be decided with the input from the Steering Committee and based on the accumulated outcomes from past workshops. Potential themes include the advancement of PtD through innovative technologies, PtD in training and higher education, incentives, barriers, and liability, or life-cycle benefits.

Appendix D. Steering Committee

Name	Organization
Anette Balestrand	Erland Construction
Rob Berryman	American Contractors Insurance Group (ACIG)
Dr. Deborah Dickerson	Virginia Tech
Dr. Scott Earnest	NIOSH
Mike Flowers	American Bridge Co.(ret)
Dr. John Gambatese	Oregon State Univ.
Mark Grushka	MJGrushka Consulting
Charlie Hoes	Hoes Engineering, Inc
TJ Lyons	Total Facility Solutions
Dr. Babak Memarian	CPWR
Jack Toellner	Toellner Consulting LLC
Dr. Mike Toole	University of Toledo
Dr. Zia Ud Din	University of Houston
Russ Mitchell	Base2 Solutions
Dr. David Grau	Arizona State University
Dr. Edd Gibson	Arizona State University

Appendix E. Keynote Bios

Carisa Harris Adamson, Ph.D., CPE, is an Associate Professor in the Department of Medicine at the University of California at San Francisco (UCSF). She is the Director of the Northern California Center of Occupational & Environmental Health at the University of California at Berkeley, Associate Director of research for the California Labor Lab (a NIOSH Total Worker Health Center), and the Director of the UCSF/UCB Ergonomics Research & Graduate Training Program. Dr. Harris and her team perform research in various areas focused on understanding and preventing work-related injuries and improving human performance, productivity, and health. Her team applies machine learning to wearable device data for primary and secondary prevention purposes and performs various intervention studies on occupational tasks with a high risk of musculoskeletal injuries. Her epidemiological research assesses and adjusts for healthy worker survivor bias in assessing physical, personal, and work psychosocial factors associated with musculoskeletal disorders and subsequent work disability. She and her team also engage in applied research in high injury sectors such as construction and janitorial work.

Charles (Chuck) Gessner has been the Head of Safety for the Vera C. Rubin Observatory Project since 2007. He has 35 years of experience providing safety expertise, hazard analysis, procedure development, training, and safety program management to the industry. He is proficient in program implementation, standards development, auditing, inspection, reporting procedures, and interpretation of and compliance with U.S. and Chilean Federal, State, and institutional laws, regulations, and procedures. Mr. Gessner has managed and mentored more than 40+ respected safety and health professionals throughout his career.

Alistair Gibb has led a research team in construction innovation, safety, and health for more than 28 years, pioneering work on the interaction between these two domains. He has led projects on nanotechnology, 3D concrete printing, offsite construction, platform technologies, transformational H&S, accident causality, and COVID. His research has engaged with mega-projects in the UK and across the globe. This has included pioneering work on Prevention through Design (PtD) in the USA over the last 20 years. He has been an influencer, working closely with the HSE, UK Government, professional institutions, and industry. He currently serves on panels

implementing learning from the Grenfell Tower disaster. Prior to joining Loughborough, he had a successful career as an engineer and construction manager on major projects.

Andrew F. Griffith is the Director of the Independent Project Analysis (IPA) Institute. He has been with IPA since 1997 as a Master Analyst and internal reviewer, and has led benchmarking studies, research studies, and individual project evaluations. Andrew is also an Adjunct Professor at George Washington University, Washington, D.C. His areas of expertise are project execution planning, project planning and scheduling, project system evaluations and reengineering, civil and building projects, construction safety, constructability reviews, and training. Prior to joining IPA, Andrew worked on capital projects as a design engineer, controls engineer, site project engineer, and project engineer for the U.S. Army Corps of Engineers. He received an award from the Sverdrup Corporation and a certificate of appreciation from the U.S. Department of State for his exemplary role in the U.S. Embassy Compound Project. Andrew holds a B.S. degree in Civil Engineering from Clemson University and an M.S. and a Ph.D. degree in Civil Engineering from the University of Texas at Austin. Andrew is a member of the American Society of Civil Engineers (ASCE), the Project Management Institute (PMI), and the American Association of Cost Engineers. He is a Registered Professional Engineer State of South Carolina and a certified Project Management Professional (PMP). He has authored research studies, published numerous articles, and given presentations at conferences held by PMI, AACE, and the ASCE.

Matthew R. Hallowell is a President's Teaching Scholar and the K. Stanton Lewis Professor of Engineering at the University of Colorado at Boulder. He is also the Executive Director of the Construction Safety Research Alliance. He earned a BS and MS in Civil Engineering and a Ph.D. focusing on Construction Engineering and Occupational Safety and Health. Before his academic career, he worked in construction as a laborer, project engineer, and quality inspector.

Billy Hare is a Professor of Construction Management within the School of Computing Engineering & Built Environment at Glasgow Caledonian University (GCU). He is Research Theme Lead for Built Environments, Deputy Director of the School's Research Centre for 'Built Environment & Asset Management (BEAM). Billy has a Ph.D. in Construction Management (H&S Thesis), BSc (Hons) in Construction Management & Engineering, and a BA in Occupational Health and Safety. He has delivered research on several HSE, IOSH, EPSRC, CITB, and industry-

funded projects totaling over £900k, 50+ peer-reviewed publications, and Impact Case Studies for the UK Research Excellence Framework. His research portfolio mainly focuses on improving safety, health, and wellbeing within the construction industry, including studies that have improved worker engagement, migrant worker H&S, and safety in design. He has developed several CPD courses on construction health and safety. He is currently the International Coordinator of the International Council for Research and Innovation in Building and Construction Safety Health and Wellbeing Working Group.

Joseph Hitt is the Co-founder and CEO of GoX Labs and DARPA Program Manager for exoskeletons, humanoid robotics, guided bullets, and wearable technology. Dr. Hitt is an Associate Professor at the United States Military Academy, ranked #2 in the national Mechanical Engineering Program. He started the biomechanics program at the United States Military Academy. Moreover, he is a highly successful business owner who took his first company from 2 to over 400 employees under contract in 36 months. It was #27 on the INC 500 in 2019. Additionally, he created the world's first bionic running leg showcased on the DISCOVERY CHANNEL with a Special Forces amputee running at eight mph four months after losing his limb.

Jason Hopper, Director of Design for Manufacture and Assembly (DFMA), evaluates opportunities for DFMA products to assist in customer-stated objective and works closely with Mortenson's manufacturing team to implement DFMA products on projects. He is responsible for detailed development and design support of off-site manufactured components to be included in on-site construction. Jason also monitors key performance indicators (KPIs) for manufactured products and works to continually improve effectiveness, reduce safety risks, and provide a controlled environment for our craft workers.

Victor Krabbendam is the Project Manager for the Rubin Observatory Project. He has been with the Project for 18 years, from the formative conceptual stages to the current fully authorized construction project. During the early design phase of the project, he led the team responsible for the telescope and site infrastructure. Since 2014, he has been the Overall Project Manager, bringing the project through the Final Design Review, the start of formal construction as an NSF MREFC Project, and its current 85% completion. Victor has a 35-year career focused on developing, constructing, and managing large optical systems for both ground and space applications. Prior to

joining Rubin/LSST, he was the lead engineer and Project Manager for the SOAR four-meter telescope construction in Chile. Before that, he was the Primary Mirror and site Integration Manager for the 11-meter Hobby Eberly Telescope in Texas.

Justin Riley is a proven performer with 30 years of industry experience and has been an essential leader in Mortenson's success in executing work with our customers and providing leadership to our teams. In Justin's role, he is responsible for executing all work on Mortenson's data center projects to ensure that each data center is completed in accordance with design, budget, schedule, and quality standards. His experience in leading complex data center projects supports our team in delivering our customers an exceptional customer experience.

Austin Roberts is the Systems Engineering Manager for the Vera C. Rubin Observatory. He has been with the Vera C. Rubin Observatory since 2018. Prior to joining the Vera C. Rubin Observatory, he spent 12 years in the Aerospace and Defense industry, including Boeing, Raytheon, and B/E Aerospace as a Mechanical Engineer and then Systems Engineer. He has experience designing, analyzing, and integrating complex systems which require a very high level of System Safety and Reliability. He has specialized in Model-Based Systems Engineering and has 2 MBSE certifications from the Object Management Group (OMG). He has worked with OMG as an industry collaborator for the last four years advancing the Systems Modeling Language (SysML), including the concepts for modeling Safety and Reliability Analyses.

Thomas Sugar works in the areas of wearable robotics for rehabilitation and gait assistance. He teaches design and project courses in the areas of mechanical design and robotics at the Arizona State University, Polytechnic campus. He is the program chair for Systems Engineering and the Associate Dean for Barrett, The Honors College at the Polytechnic campus. In industry, he worked as a project engineer for W. L. Gore and Associates earning a Professional Engineering License. He majored in business and mechanical engineering for his bachelor's degrees and mechanical engineering for his Master's and Doctoral degrees, all from the University of Pennsylvania. He is developing passive and powered exoskeletons for improved worker wellness.

Jochen Teizer is a Professor in the Department of Civil and Mechanical Engineering at the Technical University of Denmark (DTU), where his research seeks injury-free, lean, and green construction work environments. He earned a Ph.D. from The University of Texas at Austin in

2006 and a Dipl.-Ing. from the Karlsruhe Institute of Technology in Germany in 2002. Dr. Teizer is the Director of the Construction Automation and Information Technologies Laboratory and Vice-President for Industry Membership and Outreach of the International Association for Automation and Robotics in Construction (IAARC). He held several visiting researcher positions in the USA (e.g., NIST), Japan (e.g., Osaka University), and Germany (e.g., Technische Universität München). Since 2006, he has pioneered and successfully led research and development projects with funding of more than €40 million for right-time proactive construction safety, health, and wellbeing. He has over 280 peer-reviewed publications in books, journals, and conference proceedings. His team received numerous teaching and research awards from academia and the construction industry. Jochen Teizer serves as a visionary evangelist and consultant for the AEC/FM industry.

Appendix F. Moderator Bios

Zia Ud Din is an assistant professor in the Department of Construction Management at the University of Houston. Dr. Din's research interests include constructability analysis, construction safety, innovative pedagogies, and construction information technology. He is particularly interested in using immersive visual technologies to improve construction safety and productivity. His current research focuses on using augmented and virtual reality technology to improve the effectiveness of risk identification in construction. Dr. Din takes great pride in his teaching. Since 2017, he has taught various undergraduate and graduate courses at Arizona State University and the University of Houston. In recent years, Dr. Din has taught courses such as "Project Controls," "Building Information Modeling Applications for Construction Management," and "LEED and Green Construction Principles in Construction Management."

Scott Earnest is the Associate Director for Construction Safety and Health at NIOSH. Prior to joining the Office of Construction Safety and Health, Scott was Engineering Branch Chief in the NIOSH, Division of Applied Research and Technology from 2005-2015. Scott has over 70 peer-reviewed publications and technical reports. He began his career as an active duty commissioned officer in the U.S. Army, Corps of Engineers. He is a registered Professional Engineer (PE) and Certified Safety Professional (CSP) with M.S. and Ph.D. degrees in industrial and mechanical engineering.

Michael D. Flowers is the retired President and CEO of American Bridge Company. He received his Bachelor of Science in Civil Engineering from West Virginia University and his Master of Science Degree from the University of Pittsburgh. Flowers has worked for over 44 years in the engineering and construction high-rise buildings and complex bridges. He oversaw several notable bridge projects in his career, including the rehabilitation of the Williamsburg Bridge in New York City, the Lions Gate Bridge in Vancouver, the historic Wheeling Suspension Bridge in West Virginia, the retrofit of the Tagus River Bridge in Lisbon, Portugal, and the Woodrow Wilson Bridge in Alexandria, VA. Mike is the recipient of multiple awards, including the prestigious Golden Beaver Award for his work on the new Bay Bridge and ASCE's Roebling Award for outstanding leadership in the construction of the most challenging bridge projects ever attempted in the modern era. Mike is an active member of the National Academy of Construction, ASCE,

and the West Virginia Academy of Civil Engineers serves in an advisory capacity at both West Virginia University and the University of Pittsburgh and is a trustee at Berea College in Kentucky.

John Gambatese is a Professor at Oregon State University. His educational background includes Bachelor's and Master of Science degrees in Civil Engineering from the University of California at Berkeley and a Ph.D. in Civil Engineering from the University of Washington. He has worked in the industry for six years as a structural engineer in San Francisco and one year as a project engineer for a construction management firm in Seattle. Dr. Gambatese's expertise is in the broad areas of construction engineering, management, and structural engineering. He has researched and published numerous articles on construction worker safety, work zone design and safety, prevention through design, risk management, sustainability, constructability, innovation, and construction contracting. He is a member of the American Society of Civil Engineers (ASCE) and the American Society of Safety Professionals (ASSP). He is a licensed Professional Civil Engineer in California.

Mark J. Grushka is the Principal Consultant and Owner of MJGrushka Consulting in Tucson, Arizona. He has assisted organizations in achieving high levels of measurable safety, health, and environmental performance for over 40 years. He has held several technical and managerial positions in private and public sectors, including the University of Arizona, BHP Copper, Columbia University's Biosphere 2 Project, and Tucson Medical Center. He holds a Master of Science Degree in Safety Management from Northern Illinois University and is a Board-Certified Safety Professional. He holds a postgraduate certification in environmental management from Arizona State University. He is particularly interested in Prevention through Design and has supported ASU's Fulton Schools of Engineering Prevention through Design Initiative since 2012.

Tj Lyons is a safety professional working for DPR Construction. He supports field teams and operations in the United States from Malta, New York. Board-certified as an Occupational Health and Safety Technologist and Certified Safety Professional, he is proud to have taken some of these skills to his local community. A past assistant chief, New York adjutant fire instructor (hazardous materials), emergency medical technician, and still a volunteer firefighter, he sees the need to bring safety from the field to the home as often as possible. His safety passion is focused on working with people and the idea of preventing incidents through the smarter design of the structure being

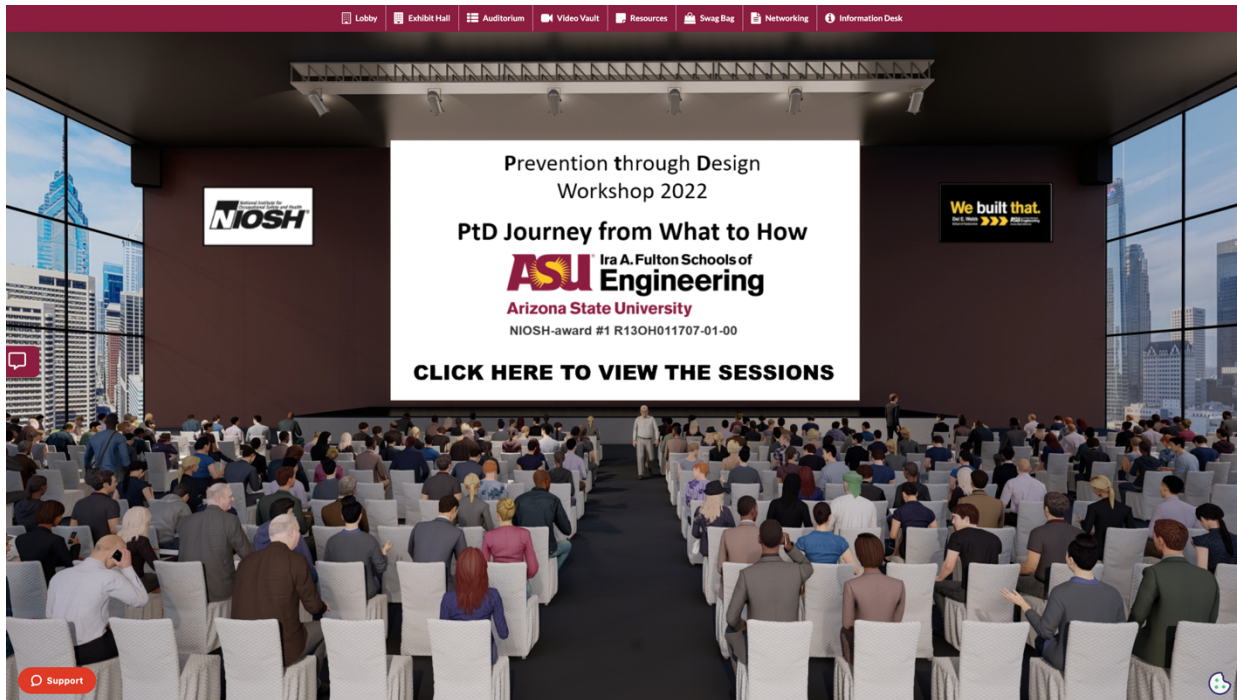
built and the way the building is built. Rather than install roof anchors on a flat roof and hope everyone will remember to attach their fall protection, build common parapets around the roof to eliminate the fall itself, implementing simple steps that he calls "design intervention.

Appendix G. Co-Chairs Bios

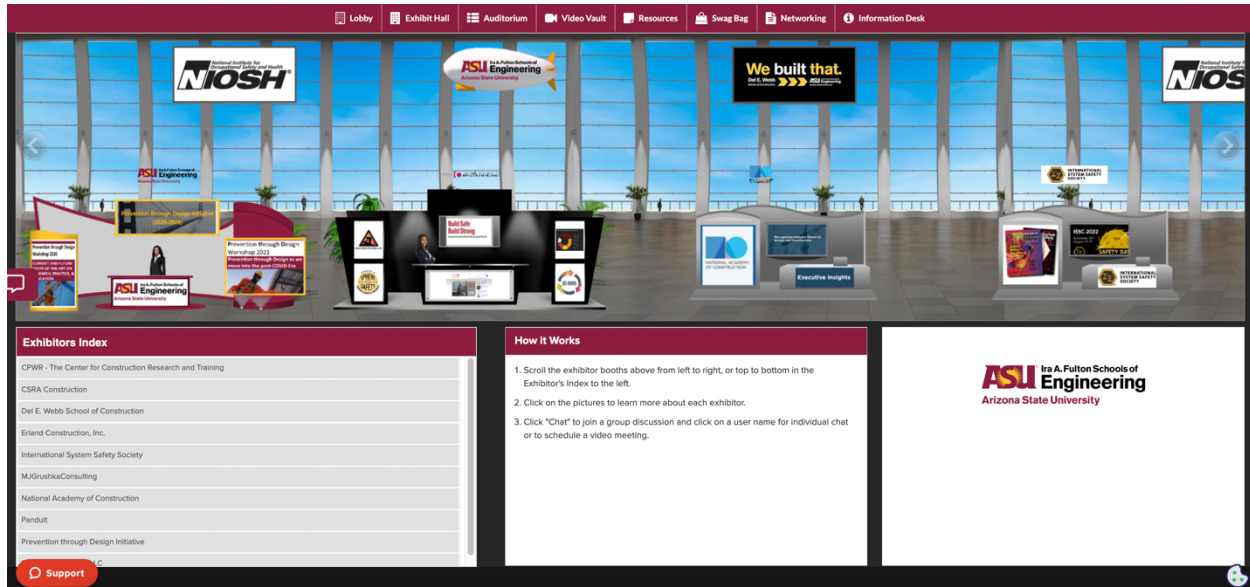
George Edward Gibson, Jr. is currently a Professor and holds the Sunstate Chair in Construction Management and Engineering in the School of Sustainable Engineering and the Built Environment (SSEBE) at Arizona State University. From 2010 to 2018, he served as SSEBE School Director, overseeing significant growth in its programs and rankings. In addition to ASU, he served on the faculty of North Carolina State, the University of Texas at Austin, the University of Alabama, Tuscaloosa, and Auburn University. His educational background includes a B.S. and Ph.D. in Civil Engineering from Auburn University and an M.B.A. from the University of Dallas. Dr. Gibson has been PI or co-PI on over \$11 million worth of funded research in his career with research and teaching interests that include front-end planning, safety leadership and systems, prevention through design, organizational change, asset management, alternative dispute resolution, knowledge management, earned value management systems, and risk management among others. Dr. Gibson has several years of industry experience, served as an Army officer, and is a licensed professional engineer in Texas. He is an elected member of the National Academy of Construction (NAC) in 2005 and a Distinguished Member of ASCE in 2020. He was awarded the 2016 ASCE R. L. Peurifoy Award for outstanding research, the 2020 Richard L. Tucker Service Award from NAC, and the Richard L. Tucker Leadership and Service Award from CII in 2022; he served as a Visiting Academic Fellow at Cambridge University in spring 2019.

David Grau is an assistant professor in the School of Sustainable Engineering and the Built Environment at Arizona State University. Grau graduated with a Master's degree and a doctorate in civil, architectural, and environmental engineering from the University of Texas at Austin and an industrial engineering degree from the Universitat Politècnica de Catalunya in Spain. Previous to his affiliation with ASU, he taught at the University of Alabama as an assistant professor for four years. During his academic career, Grau has received numerous teaching and research awards, including the Distinguished Professor Award by the Construction Industry Institute and the Celebration of Engineering & Technology Innovation (CETI) award by FIATECH. Complementing his academic career, he has worked in the private industry for more than ten years inclusive of positions such as program manager for heavy industrial projects and director of a large engineering design department. He has led large interdisciplinary and multicultural teams to deliver numerous capital projects in South America, Africa and Europe. Grau is a member of ASCE and ASEE professional societies and holds a professional license as an Industrial Engineer in Spain.

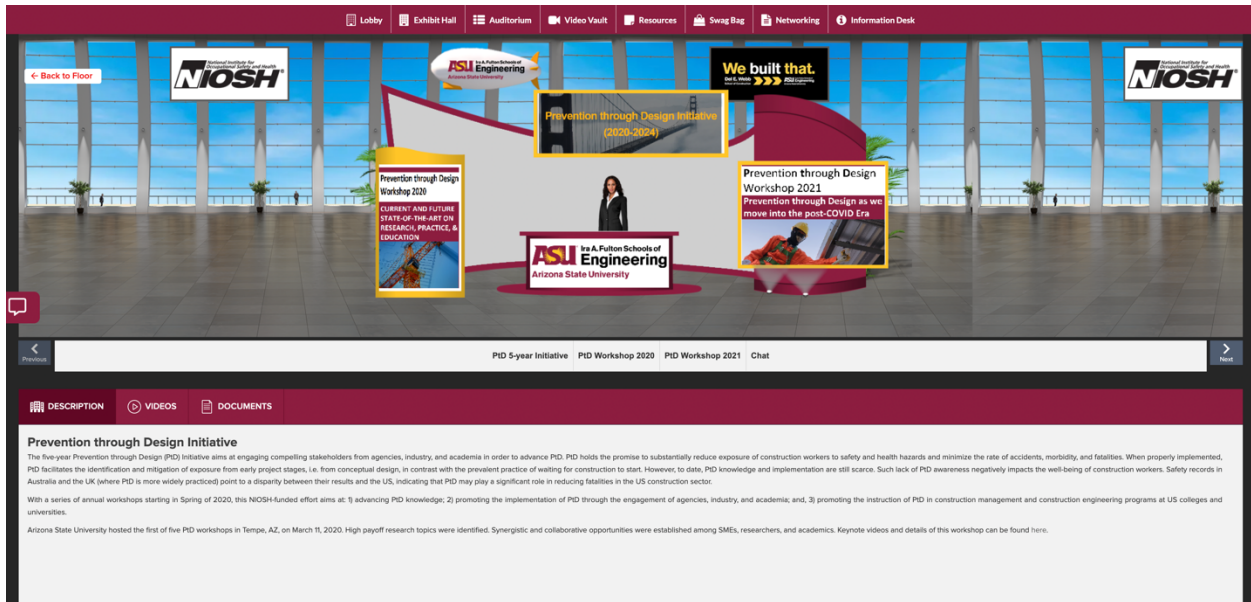
Appendix H. vFairs' Features



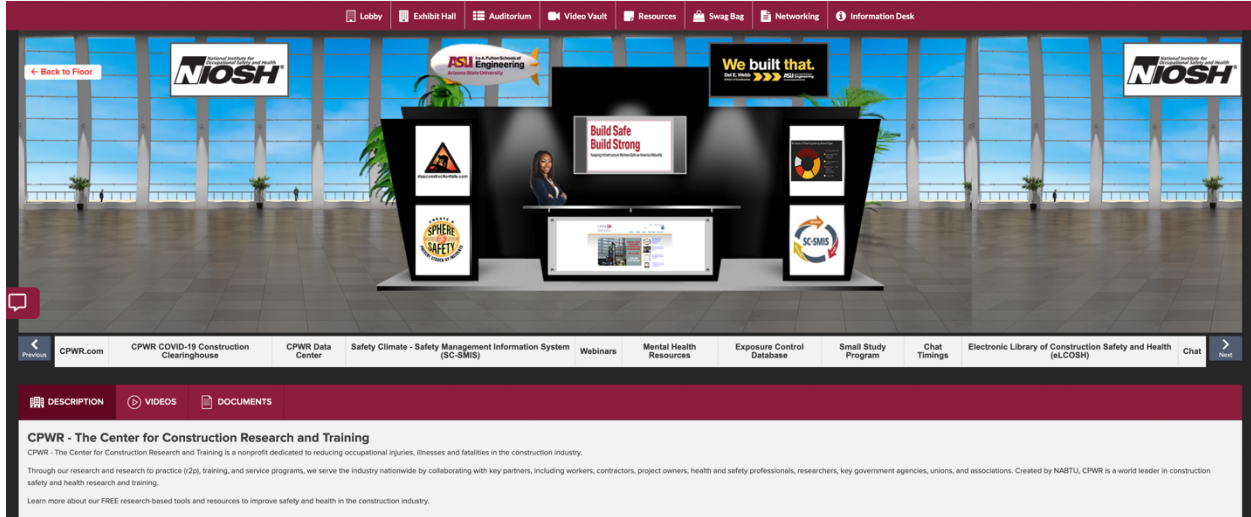
PtD 2022 Workshop Auditorium on vFairs Platform



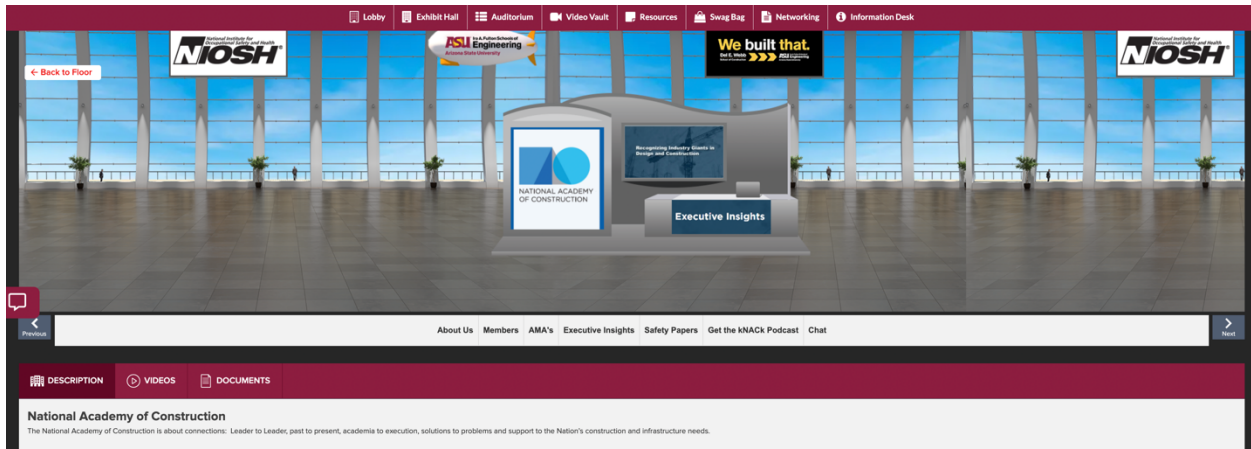
2022 PtD Workshop Exhibition Hall



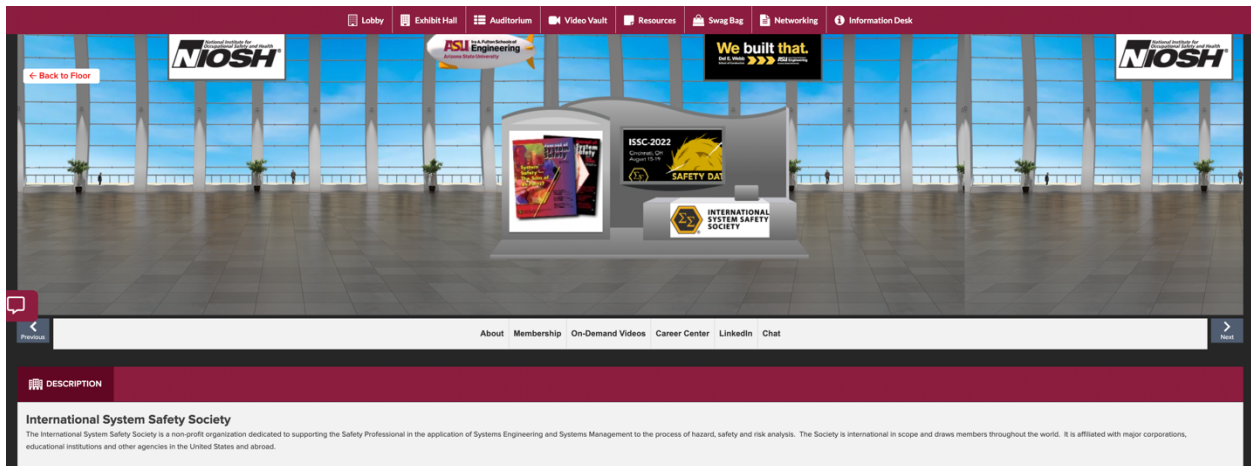
Prevention through Design Initiative's Booth



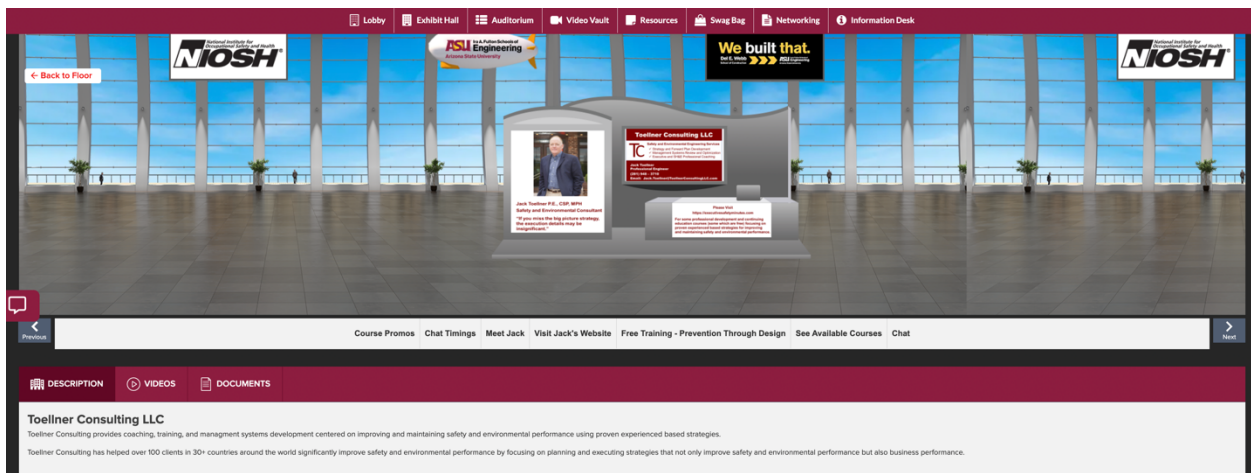
CPWR—the Center for Construction Research and Training's Booth



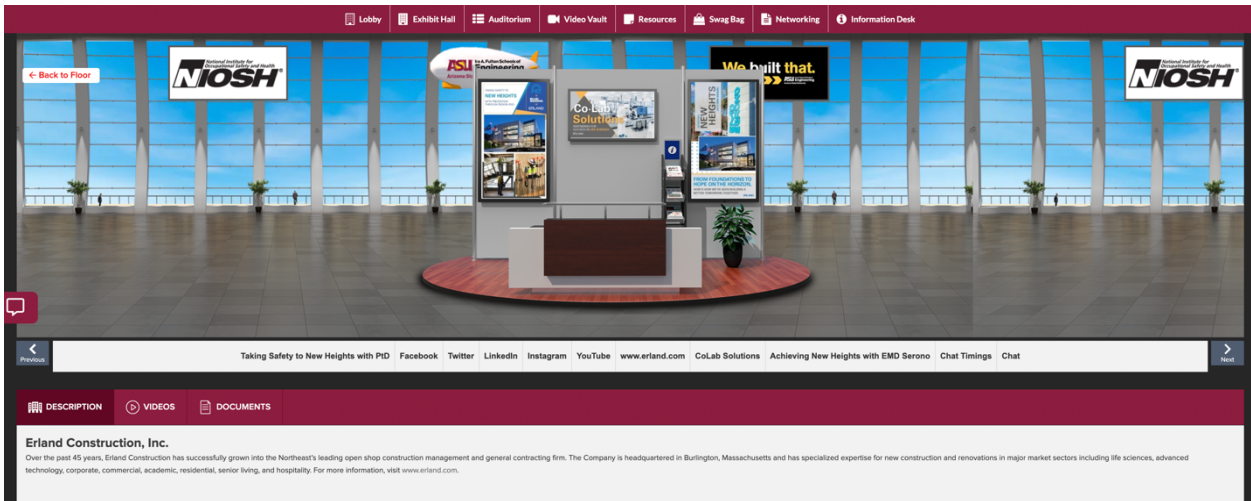
National Academy of Construction's Booth



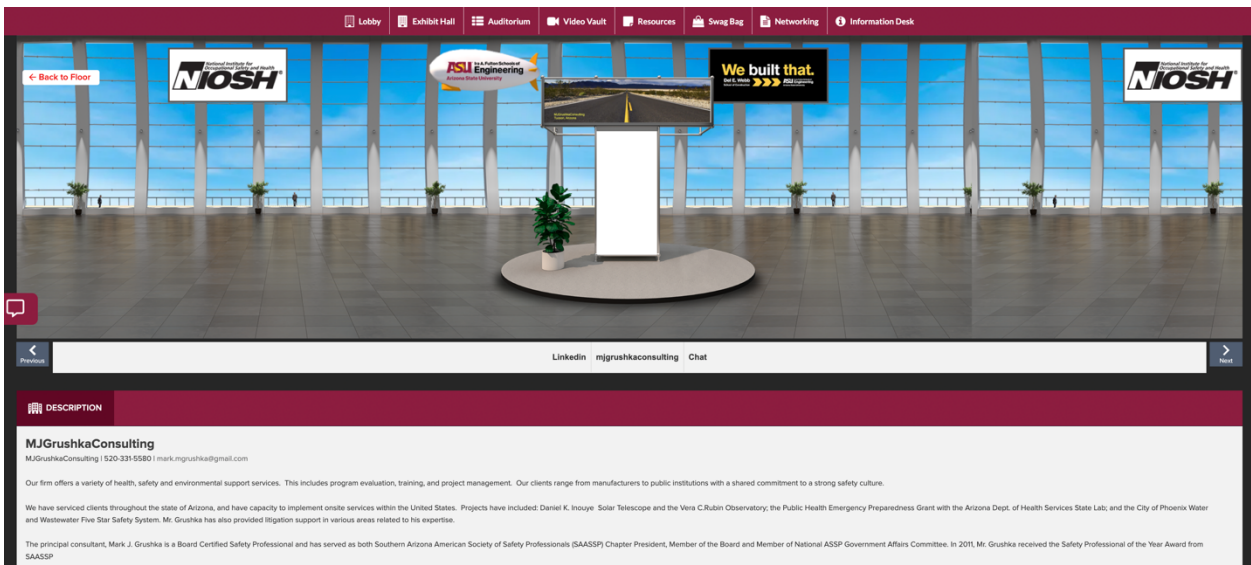
International System Safety Society's Booth



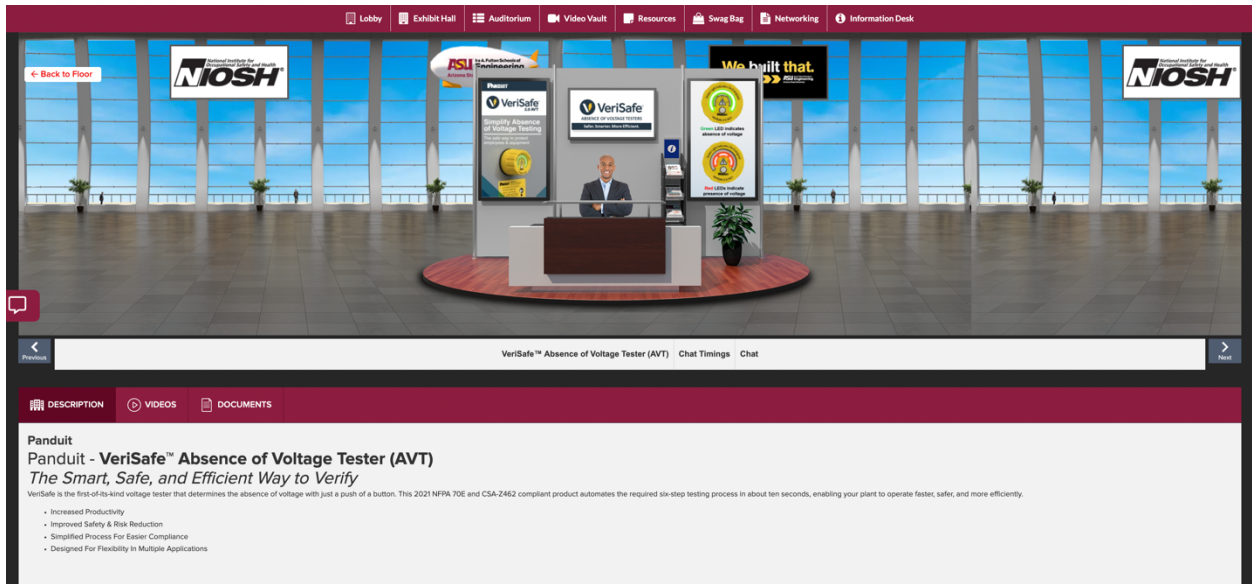
Toellner Consulting's Booth



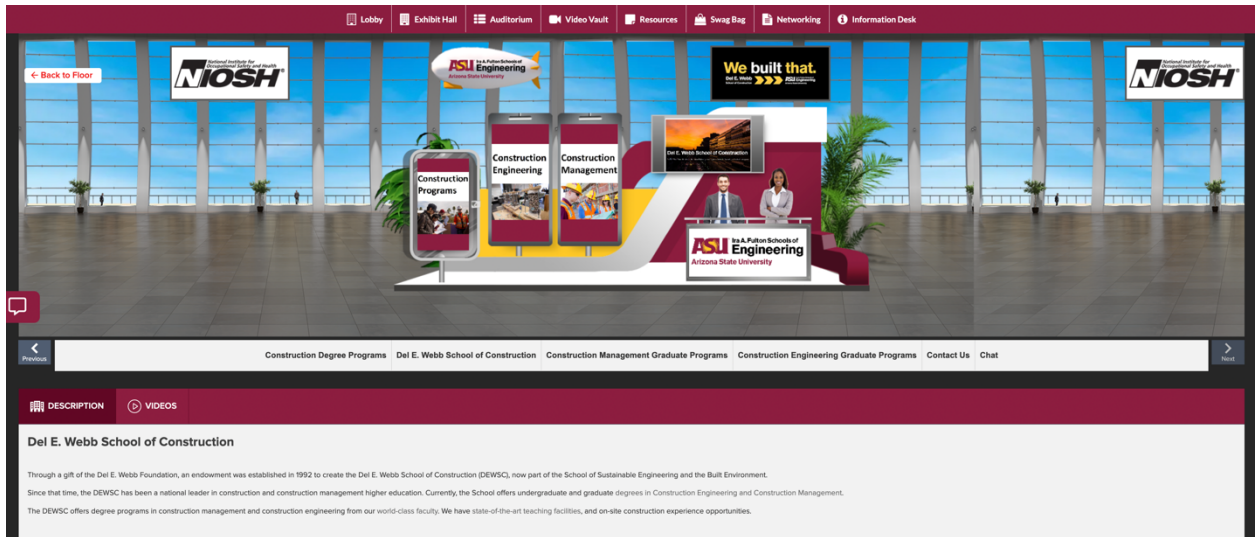
Erland Construction's Booth



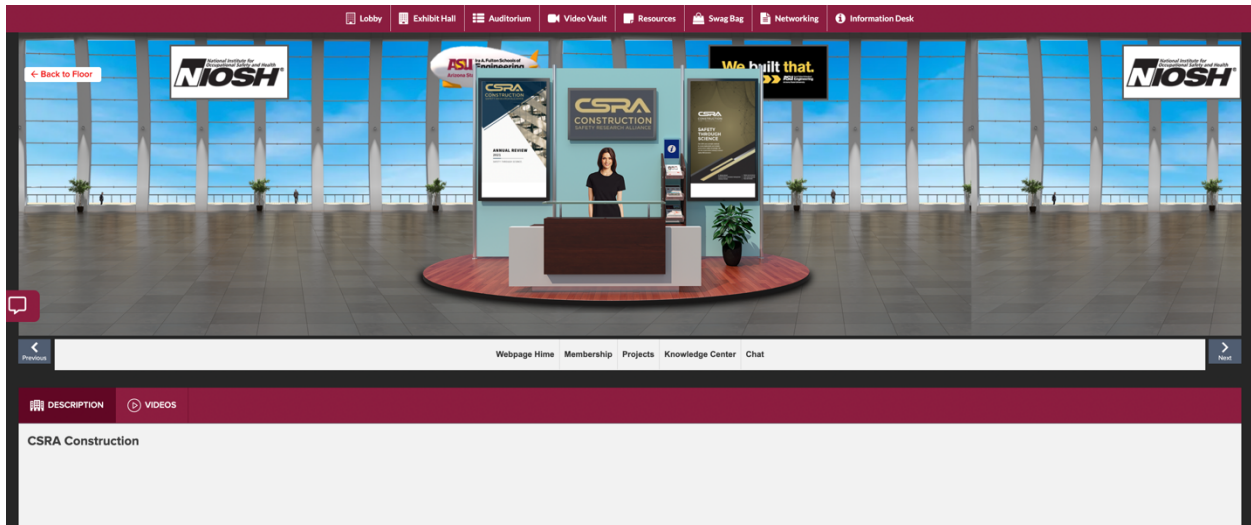
MJ Grushka Consulting's Booth



Panduit's Booth



Del E. Webb School of Construction's Booth




Construction Safety Research Alliance's Booth


Day 2 Day 1

MAY 26TH

Welcome and Introduction [Play](#)

 Dr. George Edward Gibson, Jr. Ph.D., PE, NAC, Dist.M.ASCE
Professor, School of Sustainable Engineering and the Built Environment (SSEBE), Arizona State University


Lessons learnt from UK PtD Legislation [Play](#)

 Dr. Billy Hare, Ph.D., BSc (Hon), BA, MCIQB
Professor, Glasgow Caledonian University

Billy's keynote will view PtD through a UK lens, reviewing how the introduction of the Construction (Design and Management) Regulations (CDM) have shaped the designer's role in helping to manage Occupational Safety and Health (OSH) risks during the construction phase and beyond. Lessons learnt from the difficulties of trying to enforce PtD with legislation will be explored, including the unintended consequences and good practice that has resulted. He will also present findings from innovative research on what influences designers when carrying out their legal duty to eliminate hazards, reduce risks and provide OSH information. Limitations of depending exclusively on BIM to solve OSH problems and potential solutions to bridge the learning gap will also be shared, with actionable takeaways that can help with strategies for PtD.

■ Dr. Billy Hare_Lessons Learnt from UK PtD Legislation_PtD 2022 Workshop

Highlighting current learning from the UK's PtD Construction [Play](#)

 Dr. Alistair Gibb, Ph.D.
Emeritus Professor, Loughborough University, UK

Alistair's keynote will build on Professor Hare's, highlighting current learning from the UK's PtD Construction (Design and Management) (CDM) Regulations. He will draw on his 30 year experience of the US context of implementing PtD without the legislative driver that is present in the UK.

He will also introduce new research into the exploitation of digital innovation and Building Information Modelling (BIM) to improve Occupational Safety and Health (BIM4OSH). Working with industrialists from major infrastructure construction projects, the team proposes setting up a BIM4OSH Observatory as a repository for lessons learned and good practice.

Alistair will also bring learning from the latest UK legislation instigated following London's Grenfell Tower disaster. This major legislation will have a major impact on UK design and construction, explicitly requiring both designers and contractors to consider the safety of the users of the building or facility. It is seen as a significant move onwards from the CDM regulations and will require decisions taken regarding safety-critical elements to form a 'golden thread' from inception through to end-user occupation and beyond.

PtD 2022 Workshop's Agenda