PREVENTION THROUGH DESIGN: A COLLABORATIVE PROCESS TO ENHANCE CONSTRUCTION SAFETY

Philadelphia Chapter ASSP
Professional Development Conference
May 19, 2026

Mike Toole, PhD, PE

OVERVIEW

- Design feedback is critical
- PtD Concept
- Examples
- Processes

Prevention through Design
= Design for Safety
= Engineering for Safety

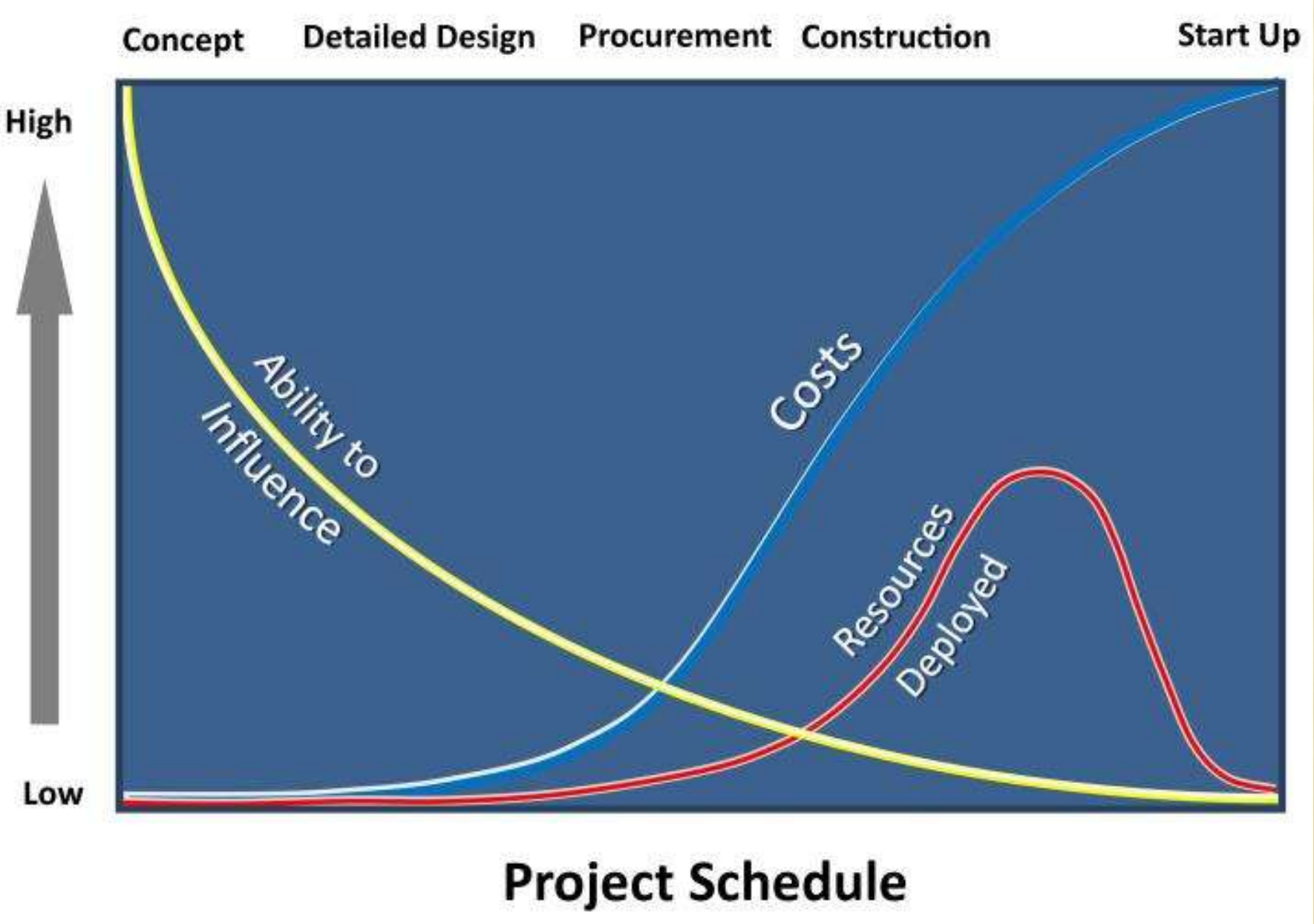
CONSTRUCTION IS UNIQUELY CHALLENGING

- Majority of work occurs on unique sites
- Highly specialized labor
- Disjointed design and construction process
- Disjointed assembly process
- Contracts often “hard bid” fixed price
- Immigrants are large part of labor force

TO ACHIEVE PROJECT GOALS, DESIGN FEEDBACK IS NEEDED FROM STAKEHOLDERS WITH EXPERTISE

- Construction cost
- Construction duration (prefabrication)
- Quality (service life, performance)
- Operational efficiency
- Sustainability (energy, water, waste)
- Safety (construction, operations, maintenance)

ACHIEVEMENT OF PROJECT GOALS IS DEPENDENT ON DESIGN



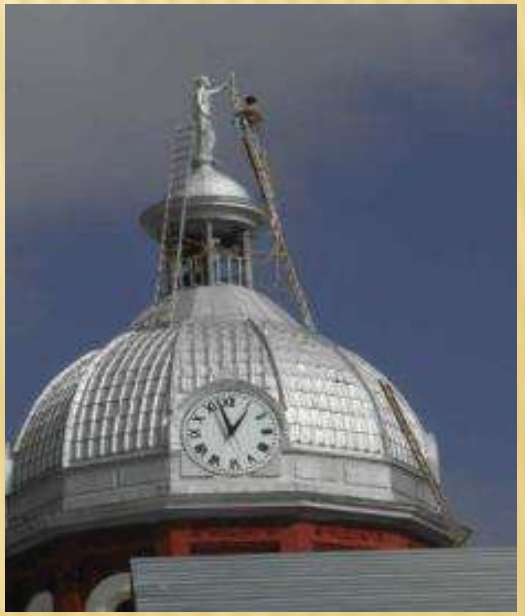
WHY PtD? ANNUAL CONSTRUCTION ACCIDENTS IN U.S.

- Nearly 200,000 serious injuries
- 1,000+ deaths

PREVENTION THROUGH DESIGN (PtD)

"Addressing occupational safety and health needs in the design process to prevent or minimize the work-related hazards and risks associated with the construction, manufacture, use, maintenance, and disposal of facilities, materials, and equipment."

(http://www.cdc.gov/niosh/topics/ptd/)

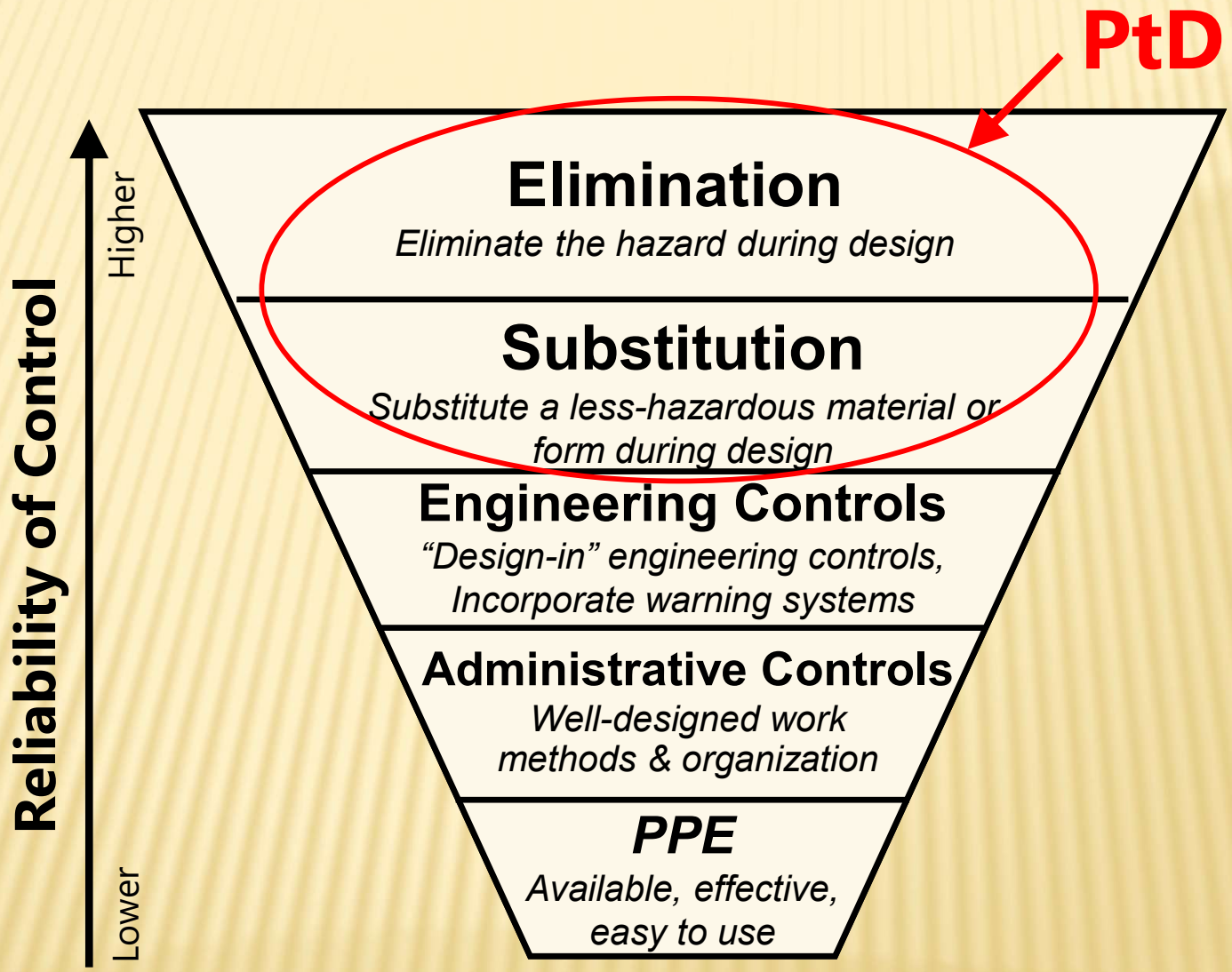


PtD IN CONSTRUCTION IS…

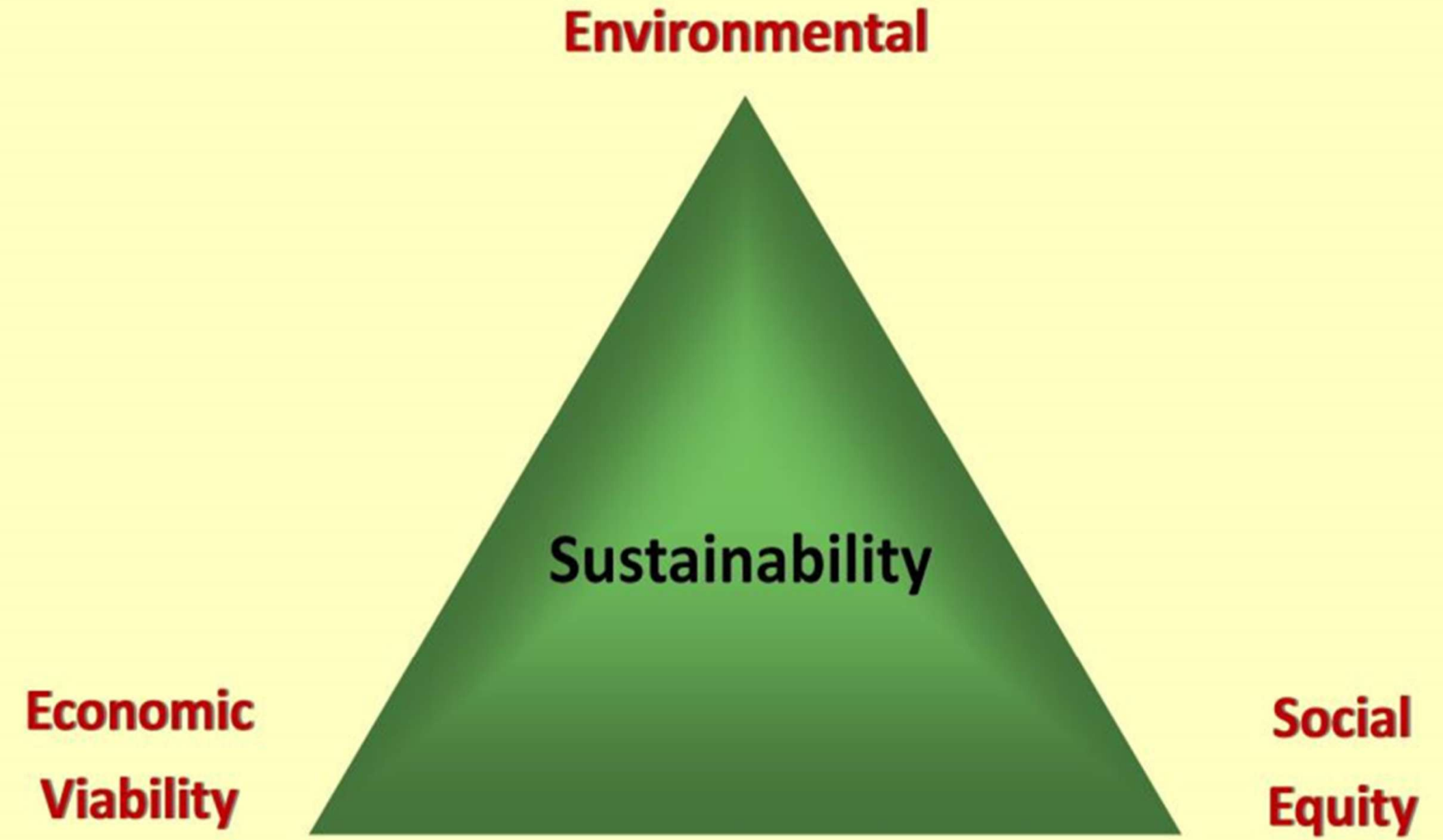
- Explicitly considering construction and maintenance safety in the design of a project.
- Being conscious of, and valuing, the safety of construction and maintenance workers when performing design tasks.
- Making design decisions based in part on a design element's inherent safety risk to construction and maintenance workers.

"Safety Constructability and Maintainability"

HIERARCHY OF CONTROLS



WHY PtD? SUSTAINABILITY



Sustainable Development

Capital projects that do not unfairly affect people who are not at the table

Further reading:
Toole, T. M. and G. Carpenter (2013). "Prevention through Design as a Path Towards Social Sustainability." *ASCE Journal of Architectural Engineering* 19(3):169-173.

THE ETHICS OF PTD

- American Society of Civil Engineers Code of Ethics
  - *1.a. first and foremost, protect the health, safety, and welfare of the public;*
  - *2.c. mitigate adverse societal, environmental, and economic effects*
  - *6.c. foster health and safety in the workplace;*
- Don't our duties include minimizing all risks over which we have control?
- Don't we have the same duties for construction workers as we do for the "public"? Is it ethical to create designs that are not as safe as they could (practically) be?

OVERVIEW

- Design feedback is critical
- PtD Concept
- Examples
- Processes

Prevention through Design
= Design for Safety
= Engineering for Safety

TRUE STORY FROM NIOSH F.A.C.E REPORT

- Groundwater monitoring well plan called for a well to be installed under overhead power lines.
- Drill rig operator was electrocuted by arc flash from power line to rig
- Had design engineer known about proximity of power line and possibility of arc flash, the well location could have been shifted out of hazard zone

EXAMPLES: FALL PROTECTION

Skylights

Parapet walls

Anchorage Points

EXAMPLE: STRUCTURAL STEEL

Detailing Guide for the Enhancement of Erection Safety

Published by the National Institute for Steel Detailing and the Steel Erectors Association of America

The Erector Friendly Column

- Include holes in columns at 21” and 42” for guardrail cables and at higher locations for fall protection tie-offs
- Locate column splices and connections at reasonable heights above floor

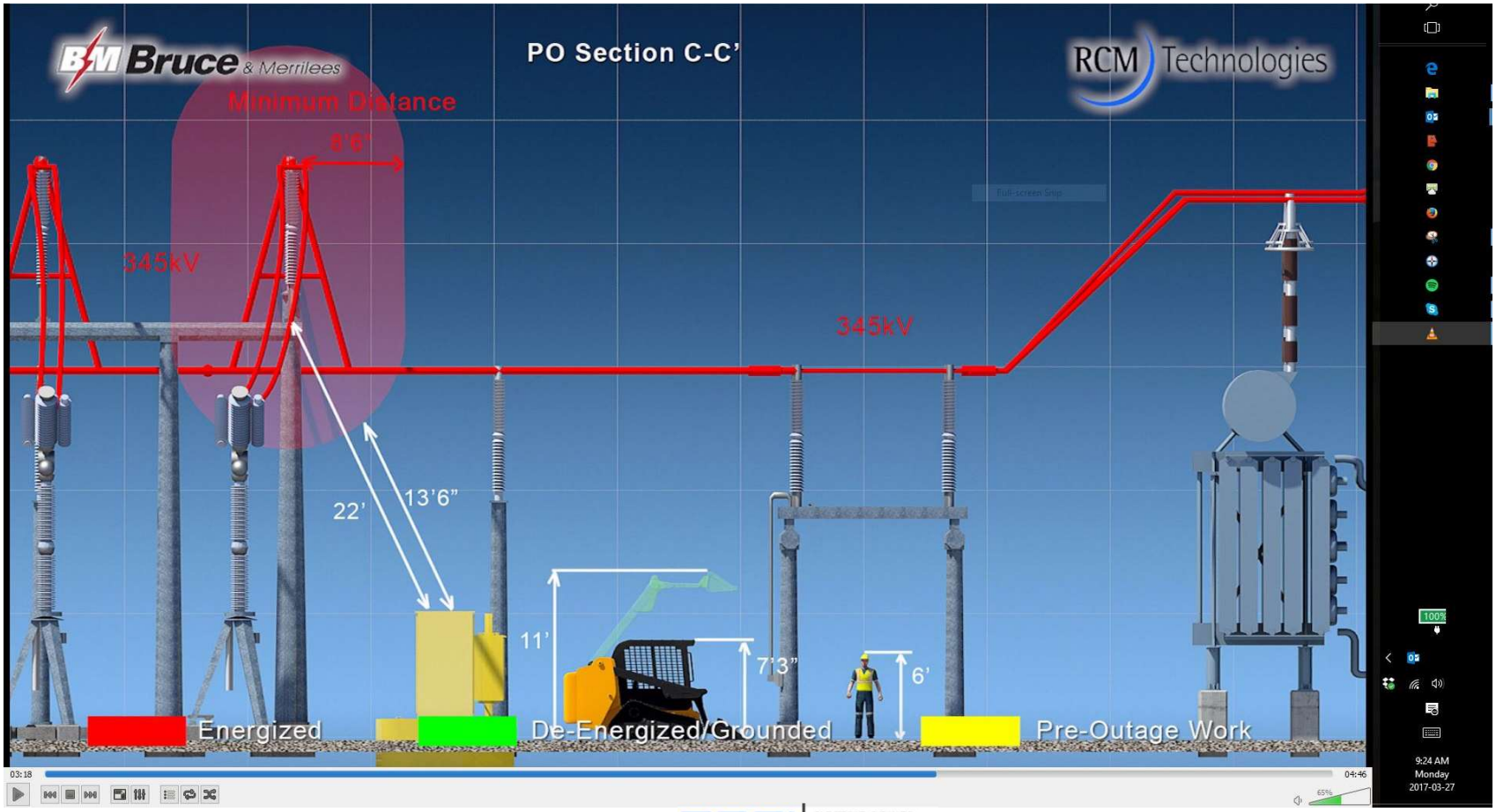
Photo: AISC educator ppt

- Know approximate dimensions of necessary tools to make connections

Photo: AISC educator ppt

Safety by Design / Integrated Design & Construction

- Error Trap/Risk Identification
- Induction of HuP Tools into the Design and Construction
- Creating a culture of Behavioral Change through Design



EPRI ELECTRIC POWER RESEARCH INSTITUTE

EXAMPLE: PREFABRICATION

Pipe Spools

www.wermac.org/documents/fabrication_shop.html

Concrete Wall Panels

MEP Corridor Racks

Concrete Segmented Bridge

PREFABRICATION: THE LINK BETWEEN ENVIRONMENTAL SUSTAINABILITY AND SAFETY

- Prefabricated construction is inherently safer than "stick-built."
- Work is shifted to engineered work environments and processes away from dangerous work environments:
  - at height
  - in trenches
  - in confined spaces
  - exposed to weather (wind, water, ice, mud, lightning)
- Prefabricated construction has
  - lower construction waste
  - lower embodied energy
  - lower embodied greenhouse gases

DESIGN FOR MAINTENANCE SAFETY

- Provide safe access for recurring maintenance/preventive maintenance
  - Light Bulbs, Air Filters, Belts, Valves
  - Avoid at height, confined space, awkward ergonomics
- Provide safe clearance for replacing units
  - Blower Units, Boilers, Compressors, Pumps
  - Consider issues with Isolation, Material handling, Path out and in

WHY PtD? TANGIBLE BENEFITS

- Reduced site hazards
  - Fewer worker injuries and fatalities
- Reduced workers' compensation premiums
- Increased productivity and quality
- Fewer delays due to accidents
- Improved operations and maintenance safety
- Encourages designer-constructor collaboration

OVERVIEW

- Design feedback is critical
- PtD Concept
- Examples
- Processes

Prevention through Design
= Design for Safety
= Engineering for Safety

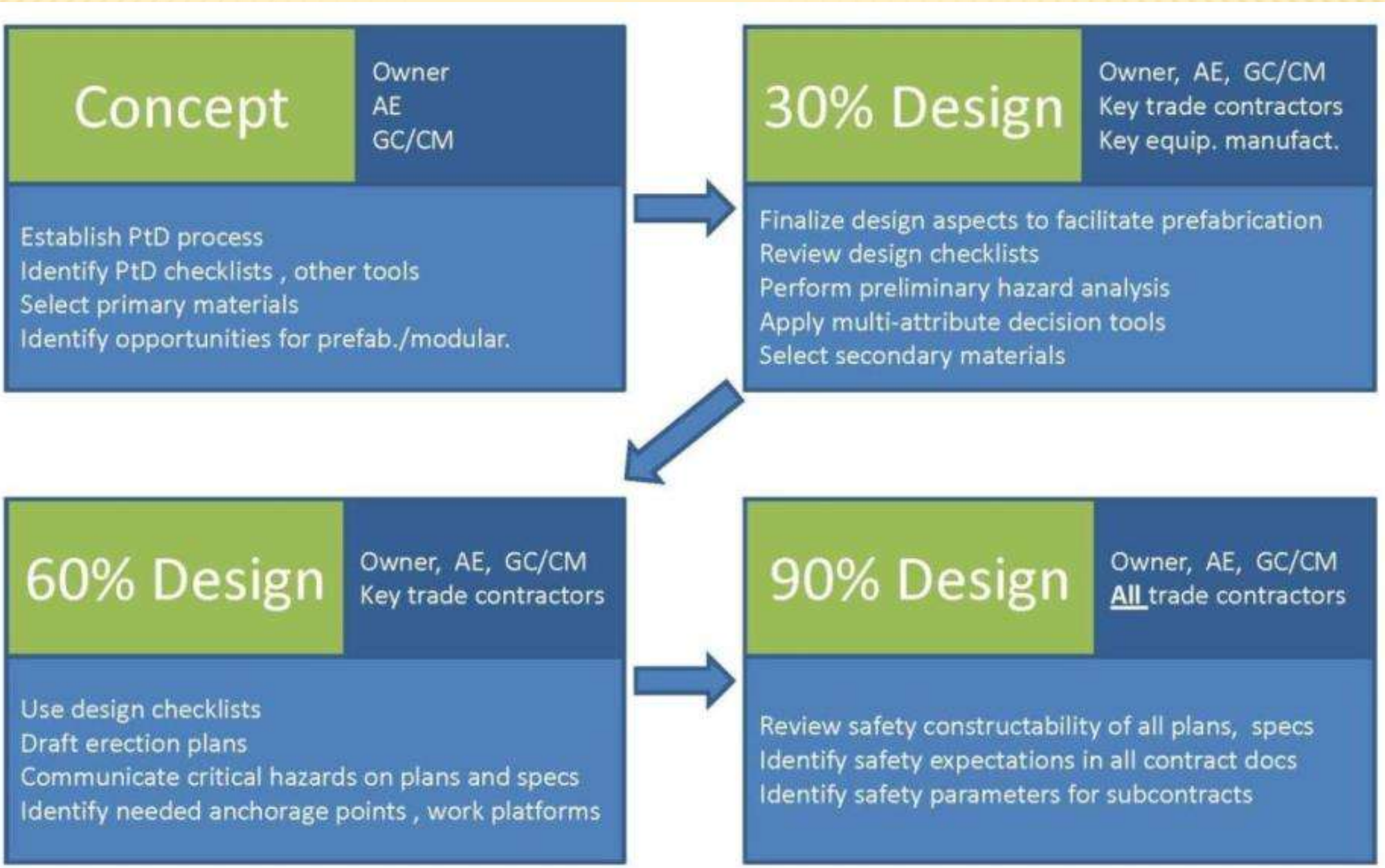
PtD DESIGN REVIEW

- Hazard identification
  - What construction and maintenance safety hazards does the design create?
- Risk assessment
  - What is the level of safety and health risk associated with each hazard?
- Design option identification and selection
  - What can be done to eliminate or reduce the risk?
  - Remember the hierarchy of controls…

PTD REQUIRES EFFECTIVE DESIGN REVIEWS

- Get the right people in the room
  - Specialty designers
  - Contractors: field ops, safety
  - Specialized equipment engineers
  - Operators
  - Maintenance: plant ops, safety
- Talking about the right things at the right time
  - Starting very early in the design process
  - Periodic, 2-4 days
  - Use visualization tools (BIM, 4D Simulation)
  - Use checklists and documentation tools
  - Establish norms to ensure all voices heard

PtD PROCESS



PTD ENABLED BY CHANGES IN PROCUREMENT PROCESSES AND CONTRACTS

- Traditional Design-Bid-Build does not allow PtD unless Design-Assist used
- Design-Build *may* integrate construction knowledge into design
- Integrated Project Delivery's use of Target-Value Design and Co-location facilitates integration
- INCLUDE operators and maintenance professionals!
- Designer training and tools needed
- Don't prioritize initial costs over lifecycle costs!

SUMMARY

- Achieving project goals on construction projects increasingly requires Integrated Design and Construction.
- Prevention through Design is a promising way to achieve economic, social and environmental sustainability.
- Successful implementation of PtD will require changed attitudes, processes and contracts.

THANK YOU FOR LISTENING!

- Questions, comments?

- Contact me: tmichaeltoole@gmail.com
- Free articles and slide decks: https://tmichaeltoole.com/
- Learn about PtD: https://designforconstructionsafety.org/