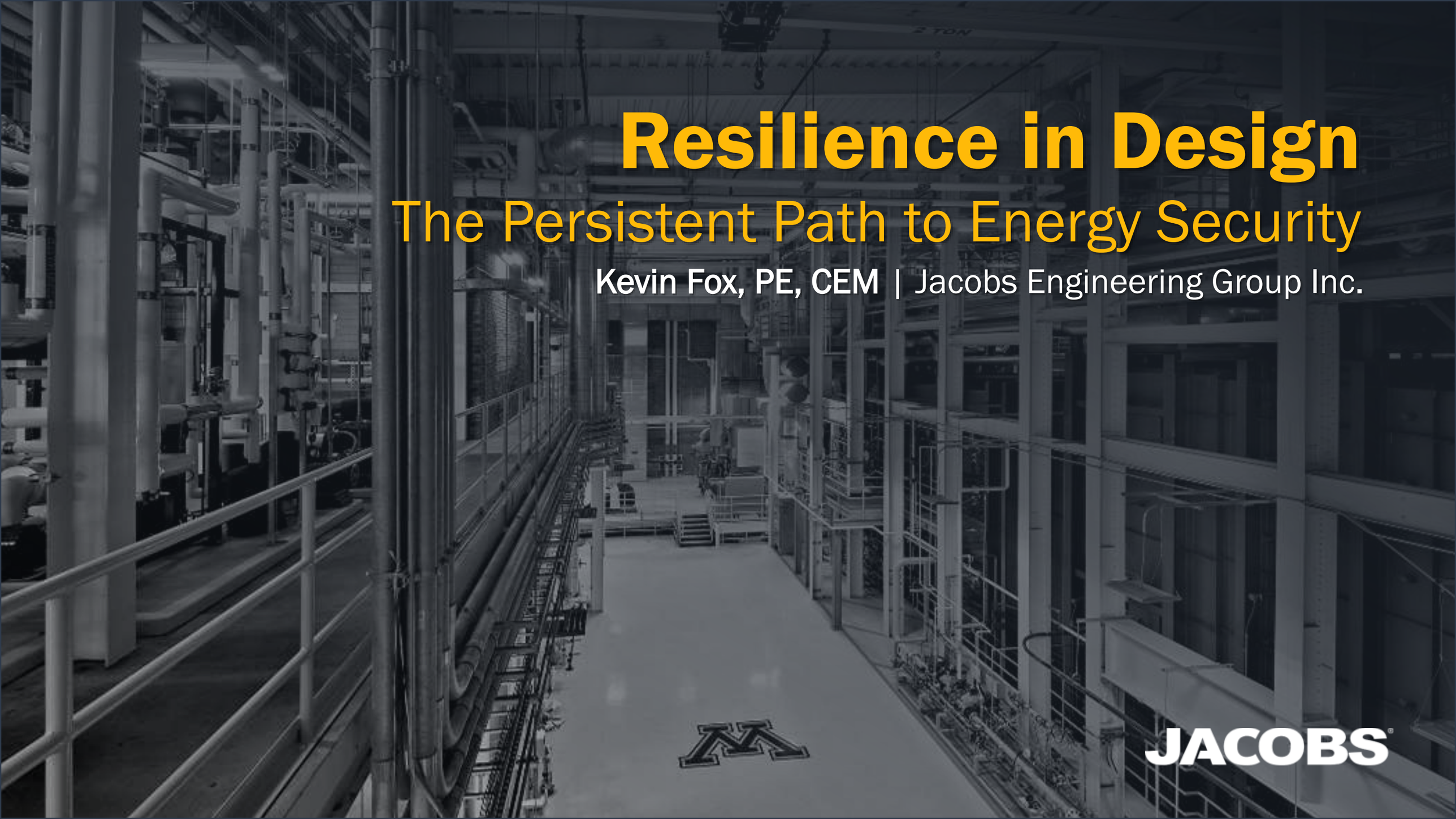

Resilience in Design

The Persistent Path to Energy Security

Kevin Fox, PE, CEM | Jacobs Engineering Group Inc.

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Resilience in Energy

How do you **value** resilience?

How do you **achieve** resilience?

How do you **measure** resilience?

Basic Understanding

Context for Energy Infrastructure

Department of Defense (DoD)	Resilience is the ability to prepare for and recover from energy disruptions that impact mission assurance on military installations.
National Academy of Sciences	Resilience is the ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse event.
Pacific Northwest National Laboratory	Resilience is, “the ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions.”

End Game
for System Development

...PREPARE

...ABSORB

...RECOVER

Misconceptions…

Resilience is not delivered by **planning** alone.

Selecting a particular system does not **guarantee** resilience.

Delivering Resilience

After the planning dust settles, the system **must deliver results!**

Resilience in **Design**

Imperative – **Broad Perspective**

Reliable

Safe

Sustainable & Efficient

Maintainable

Addressing Resilience in **Design**

1

Assess Threats

HazID to Find Risks

- External
- Facility/Ops
- Health
- Project/implementation

2

Mitigate Risks

Failure Modes/Fault Analysis

- Loss of Service
- Loss of Availability
- Unmet Performance Standard
- Secondary Defect

Addressing Resilience in **Design**

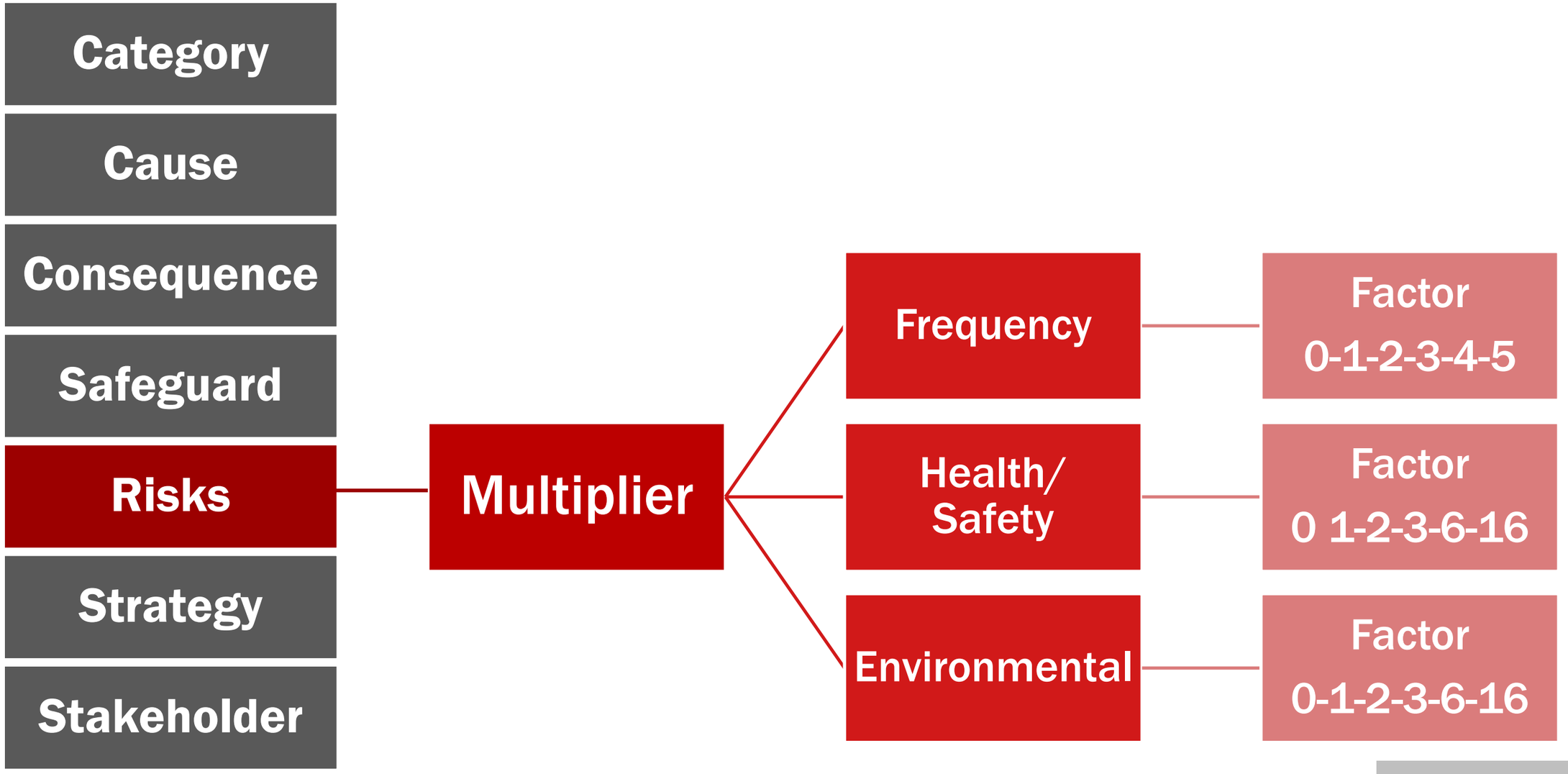
It is **imperative** to collaborate amongst a strong and diverse team in these two steps.

Systems, processes and consequences must be thoroughly understood!

Assess Threats and Hazards

- Category
- Cause
- Consequence
- Safeguard
- Risks
- Strategy
- Stakeholder

Assess Threats and Hazards



Mitigate Risks

- Review Processes Based on HazID
- Brainstorm Failure Modes
- Rate the Risk
- Develop Strategy to Mitigate Risk
- Implement Corrective Actions
- Monitor and Reassess

Context

- Loss of Service
- Loss of Availability
- Unmet Performance Standard
- Secondary Defect

Mitigate Risks

- Review Processes Based on HazID
- Brainstorm Failure Modes
- **Rate the Risk**
  - Risk Priority Number
    - Rate Severity of Event
    - Rate Likelihood of Occurrence
    - Rate Likelihood of Detection
- Develop Strategy to Mitigate Risk
- Implement Corrective Actions
- Monitor and Reassess

Example

Fuel Sources + Systems

Hazard Identification

Risk Rating = F * max (HS, E)

F = Frequency Factor

HS = Health & Safety Impact

E = Environmental Impact

Hazard Identification Frequency Factor

Likelihood of Event?	Frequency	Factor
Not Possible	Never	0
Negligible	< Once in 100 years, not expected in lifetime of plant	1
Unlikely	Once in 20-100 years, could possibly occur in lifetime of plant	2
Possible	Once in 3-20 years, could occur once in lifetime of plant	3
Likely	Once in 1.5-3 years, could occur several times in lifetime of plant	4
Near Certain	More than once in 1.5 years, frequent occurrence	5

Hazard Identification Health & Safety Impact

H&S Impact?	Frequency	Factor
No	No impact inside or outside property	0
Minor	Medical treatment, first aid	1
Moderate	Incident resulting in multiple days off work; no permanent effect	2
Serious	Serious injury, high medical treatment; possible permanent negative effects	3
Severe	1-3 fatalities on site or 1 -3 serious injuries outside facility	6
Huge	More than three fatalities in or outside plant	16

Hazard Identification Environmental Impact

Environmental Impact?	Frequency	Factor
No	No consequences	0
Minor	Very limited impact (restitution time < 1 day)	1
Moderate	Short-term impact (restitution time < 5 days)	2
Serious	Medium-term impact (restitution time 1-3 weeks)	3
Severe	Long-term impact (restitution time 3-6 months)	6
Huge	Permanent impact (restitution time > 1 year)	16

Hazard Identification

Risk Rating = F * max (HS, E)

- 0-2
- 3-8
- >8

Hazard Identification

Hazard	Cause	Consequence	Mitigation	F	HS	E	RR	Action
Weather	Curtailment	Outage-planned	Fuel backup	4	0	2	8	Dual fuel
Security	Hostile	Outage-unplanned	Fuel backup; harden asset	3	0	3	9	Dual fuel
Pipe Failure	Construction	Outage-unplanned	Fuel backup	1	0	3	3	Dual fuel
Explosion	Compressor	Major damage	Upgrade utility gas source	2	16	6	32	Utility, Facility

Risk Mitigation

Hazard	Cause	Consequence	Mitigation	F	HS	E	RR	Action
Weather	Curtailment	Outage-planned	Fuel backup	4	0	2	8	Dual fuel
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Risk	Severity	Occurrence Probability	Non-Detect Probability	RPN	Mitigation
Improperly Classified Instruments	10	2	4	80	Submittal Reviews, Cx Due Diligence
Incorrect Relief Valve Locations	10	3	2	60	Quality Control, Vendor Coordination
Internal Pipe Blockages	10	3	7	210	Strainers, Pressure Monitor, Safety Shut-off

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