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Use of STPA in the Development of a Reactor Protection System at NuScale Power

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Acknowledgement & Disclaimer

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About Me and NuScale Power

- Instrumentation and Controls Engineer
  - 7 years at NuScale
  - 30+ Years Experience in I&C
  - 6 Years Experience in STPA
- Performed Hazard Analysis on the NuScale MPS
  - 3 Revisions
  - ~1000 Pages of Documentation
- Performed HA on the NuScale safety display and instrumentation system
- Trained analysts for additional systems
- NuScale Power – Power for all Humankind

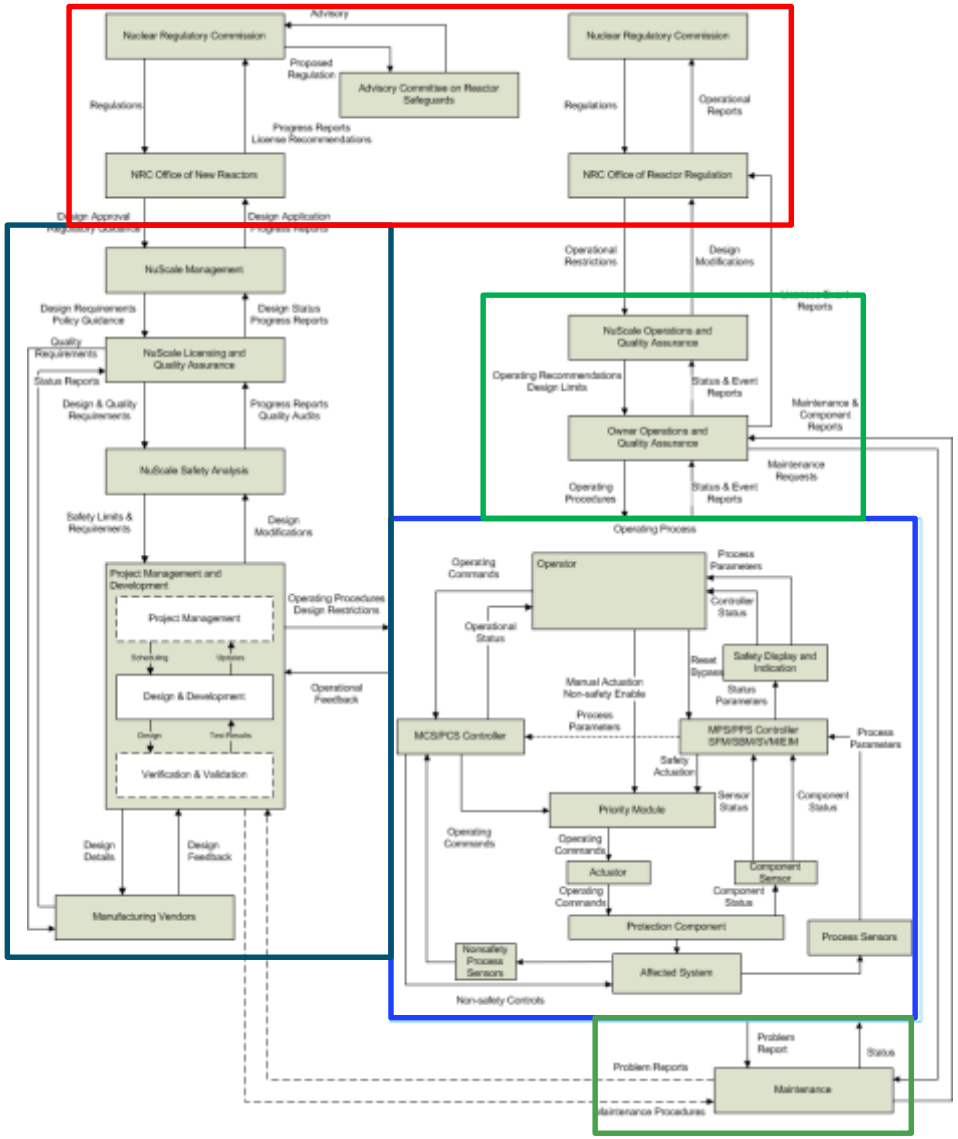
Normal Nuclear Processes

- High degree of safety is key in any nuclear project
- Typical analysis methodology
  - Preliminary Hazard Analysis (PHA)
  - Failure Modes and Effects Analysis (FMEA)
  - Fault Tree Analysis (FTA)
- Failure Modes and Effects and Fault Tree Analyses have commonly been used to evaluate system failure modes.
  - These methods have limitations when applied to modern digital control systems

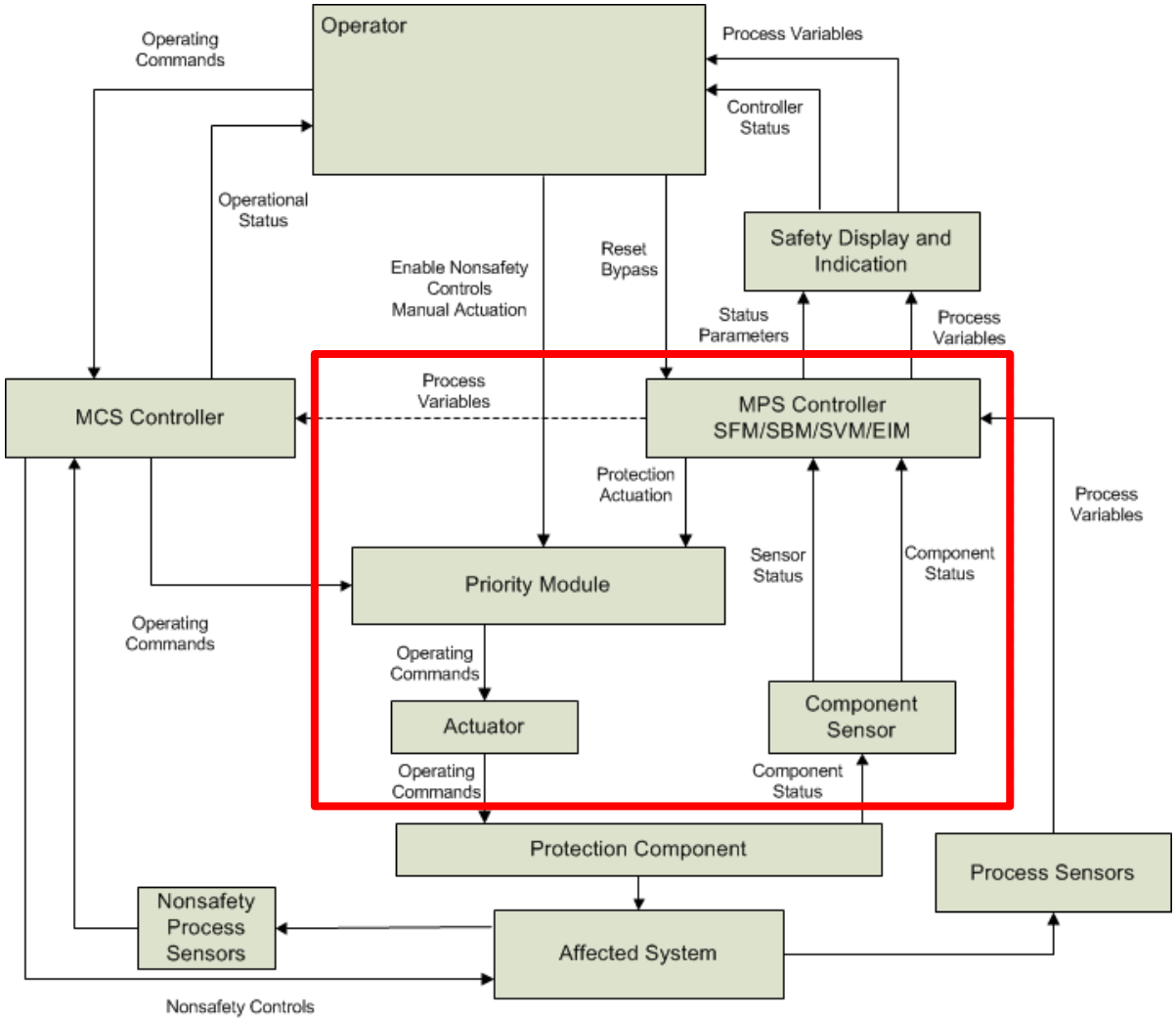
Defining the Scope

- Limited resources
  - New method in an industry where change is slow
  - Instrumentation and control priorities
  - Regulatory requirements
- Scope defined as
  - Module protection system
  - Plant protection system
  - Neutron monitoring
  - Safety display and indication
- However, we decided to show the potential scope

Processes Affecting Design



Limited Scope



Analysis Workflow

- Broke down the system into primary functions
  - Signal acquisition and processing
  - Trip analysis functions
  - Voting
  - Trip actuation
- Built the control diagrams
- Performed the analysis
- Incorporated safety constraints in system design - Note
- Performed a cross-reference to Preliminary Hazard List
- Performed a cross-reference of safety constraints to system requirements
  - Analyzed relationships through various design phases

Cross-Reference Example

Safety Constraint ID	Constraint		Comments
	Requirement ID	Contributing	Evaluation
SC-1.1.	Inputs to the signal conditioner should be reliable and continuous.		
	E011-MPS-FR-7123	Yes	The requirement imposes the need to sense accident conditions.
	E011-MPS-FR-7135	Yes	
	E011-MPS-FR-7143	Yes	

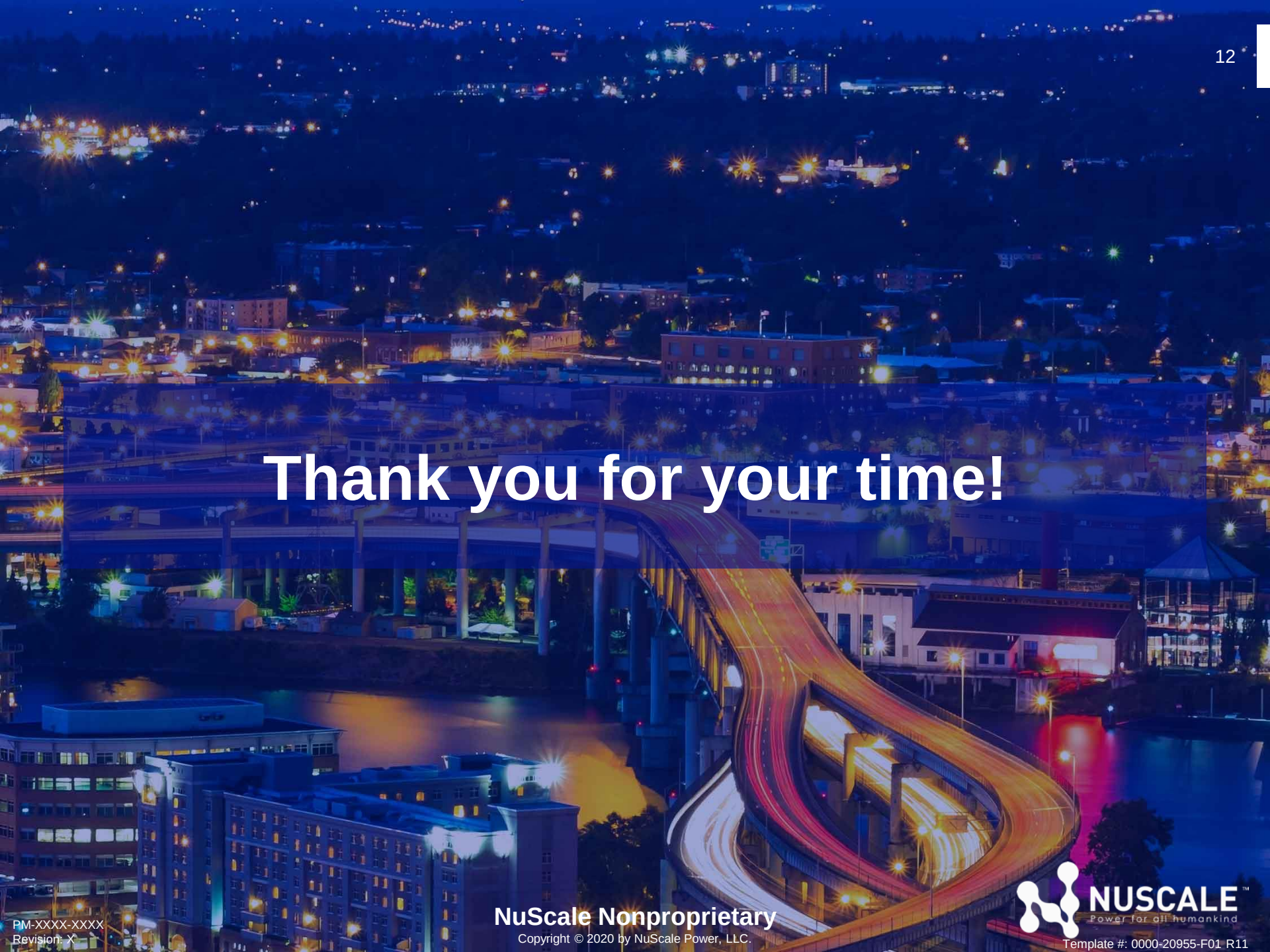
Relationship Statistics

	Functional Requirement Relationships	System Design Requirement Relationships	Design Solution Relationships
Total Relationships	942	2237	5525
Safety Constraints (SC) with 10 or more relationships	8	75	236
SC with no relationships	82	20	15
SC with less than 5 relationships	208	75	34

Acceptance

- NuScale and the NRC engaged for several years in development of Hazards Analysis framework
- The NuScale Design Certification Application was the first implementation of an HA for a digital I&C system design.
  - Overall positive results from NRC safety reviews
- Electric Power Research Institute (EPRI) – very interested

- Overall the response and acceptance was very positive



Thank you for your time!

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