Analyzing Variability in Decision Making in Complex Systems: A Case Study

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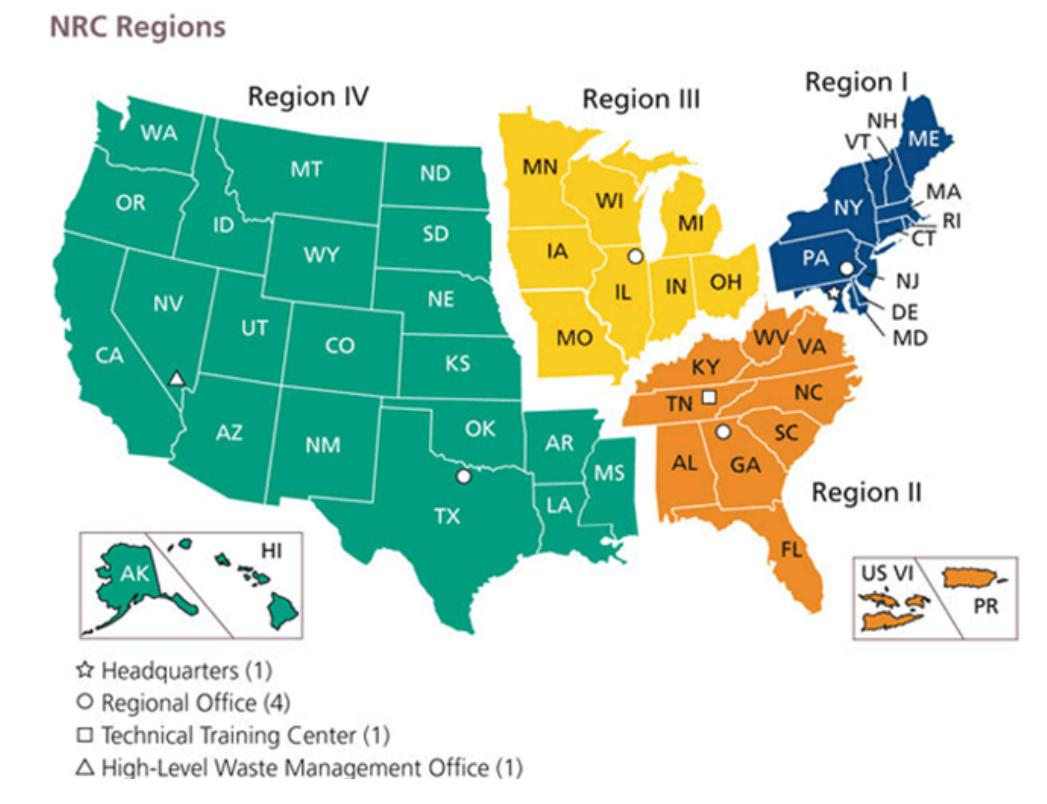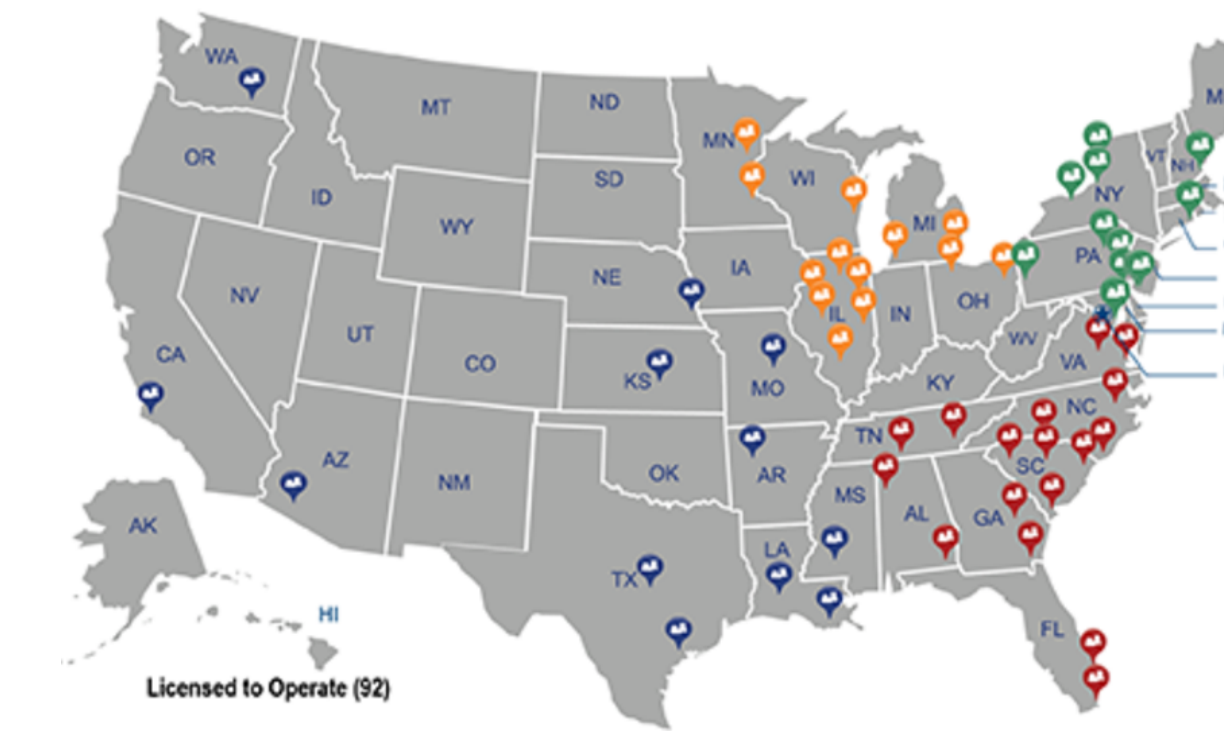[1]Monterey Technologies, Inc. [2]Nuclear Regulatory Commission
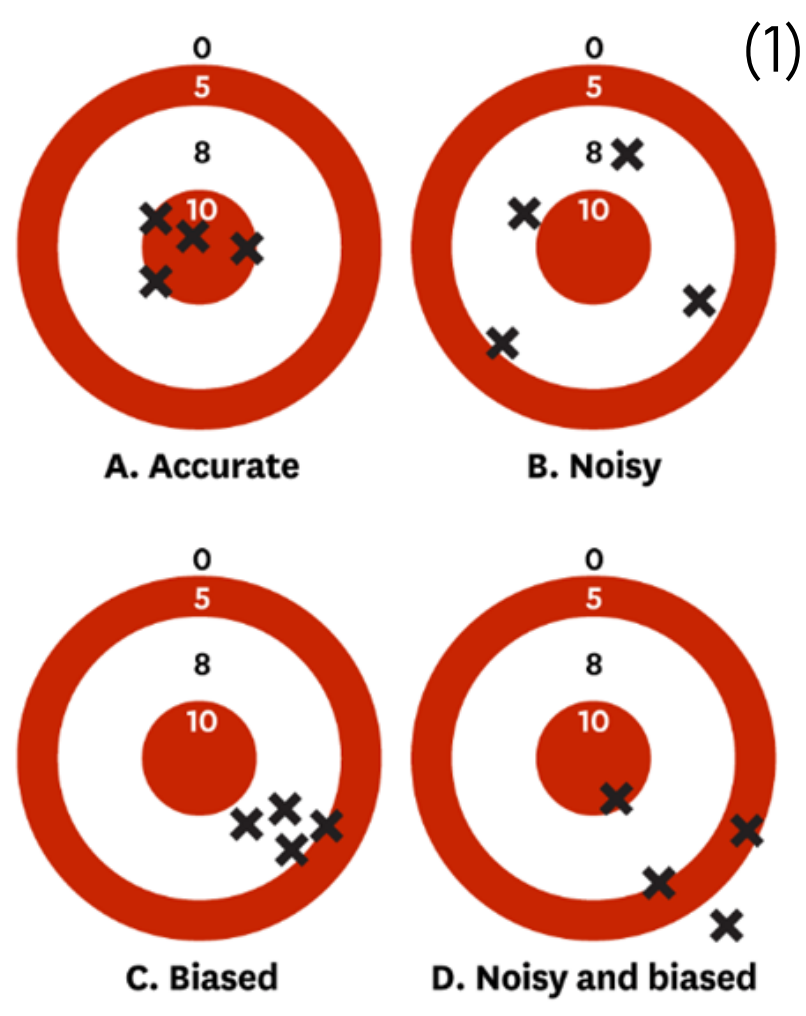
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Key Takeaways

1. Many complex systems require risk-informed judgment and decision-making by multiple individuals
2. Decisions are influenced by human cognitive biases & variability ("noise") (1)
3. Decision support systems should be informed by the actual human decision processes at play
4. Current project identifies presence and sources of decision "noise" in the nuclear energy regulatory domain, with aim of reducing it

"Noise" in Decision-Making

(1)

A. Accurate
B. Noisy
C. Biased
D. Noisy and biased

- Error = Bias + Noise
- Many types of biases; noise not often considered

	Definition	Example
Level Noise	Variability in the average level of judgments by different judges	• "Hanging" judges give harsher sentences than "Bleeding Heart" judges (2) • Interpretations of questions; what does "highly likely" mean to you?
Pattern Noise	Variability in judges' responses to particular cases	• Judges with greater leniency only for white-collar criminals • Statistical interaction term
a) Stable Pattern Noise	Variability among judges	• Individual differences • Personality, risk tolerance, preferences
b) Transient "Occasion" Noise	Occasion-specific, irrelevant factors; "Random" error	• Physicians more likely to prescribe opioids late in day (3) • Transient factors including time of day, mood, hunger

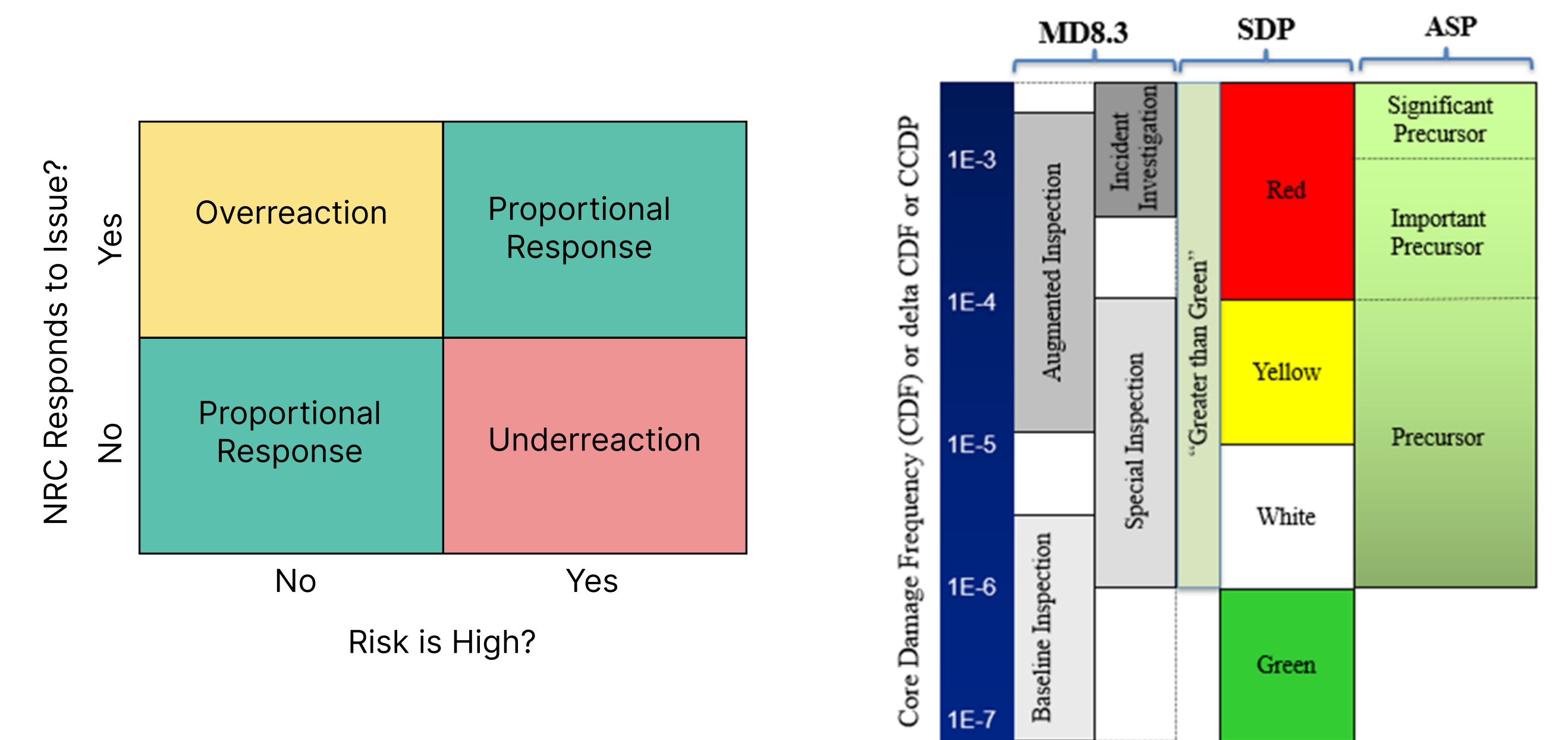## U.S. Nuclear Power Plants & Nuclear Regulatory Commission

- Independent federal agency with broad authority to regulate civilian use of nuclear materials
- Protects public health, safety, security, and the environment
- Assesses events and conditions that occur at nuclear power plants to evaluate level of risk and decides the regulatory response

Method

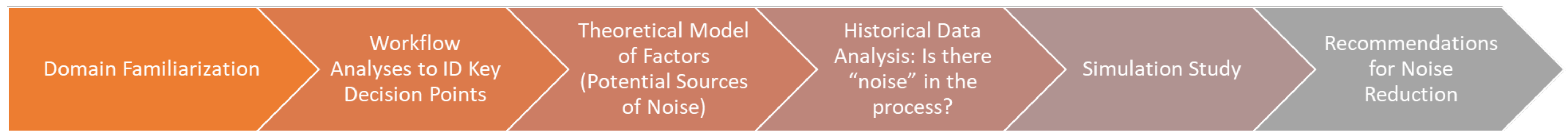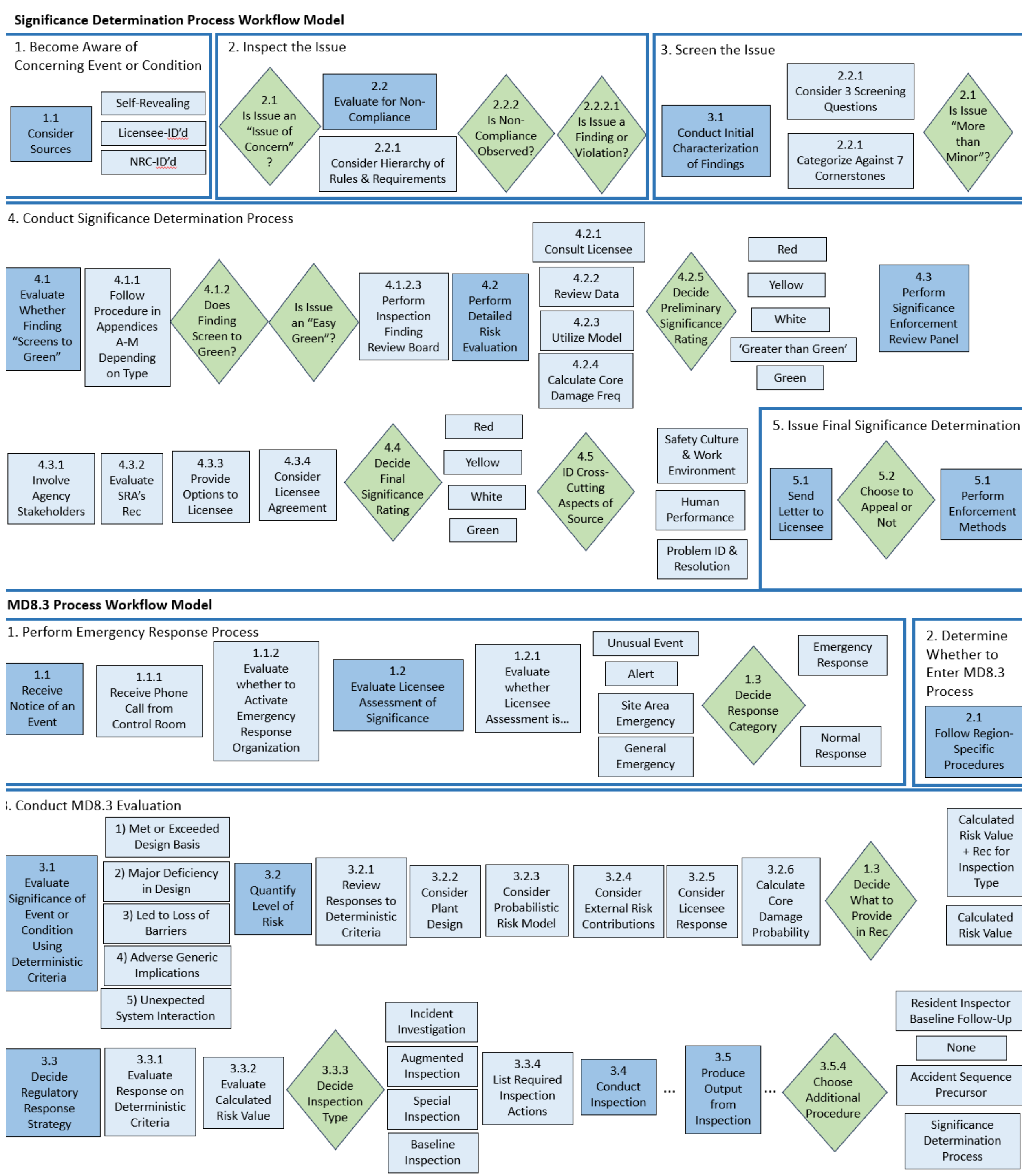Domain Familiarization → Workflow Analyses to ID Key Decision Points → Theoretical Model of Factors (Potential Sources of Noise) → Historical Data Analysis: Is there "noise" in the process? → Simulation Study → Recommendations for Noise Reduction

Identification of Key Decision Points

Significance Determination Process Workflow Model

MD8.3 Process Workflow Model
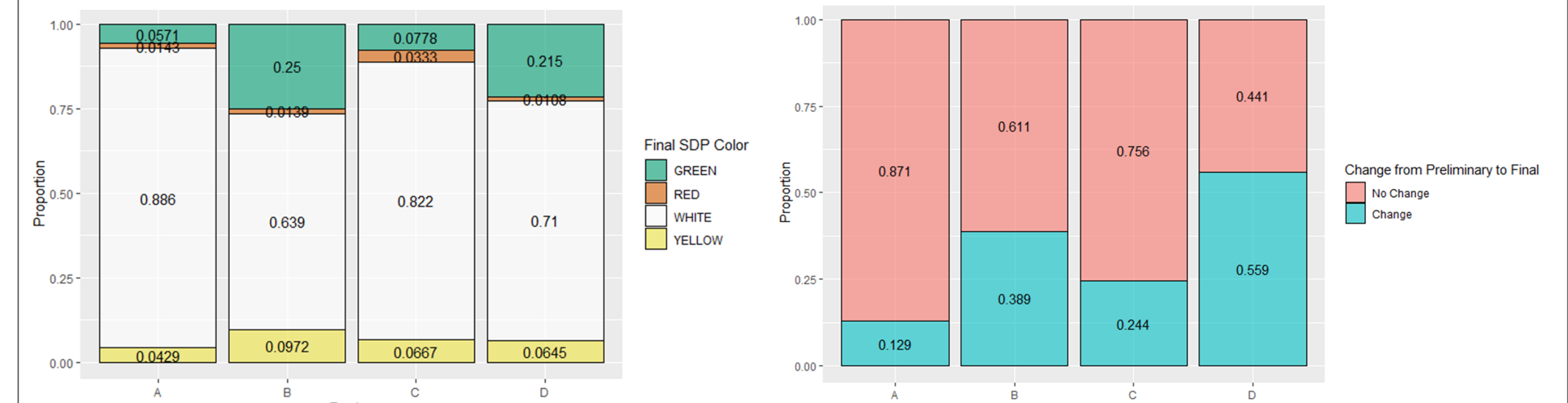
Results from Historical Data Analysis

- Determined whether there is variability in decisions in the NRC
- No individual decision-maker identifiers; used region as a proxy
- Cases categorized into common "Cornerstones" and common Types
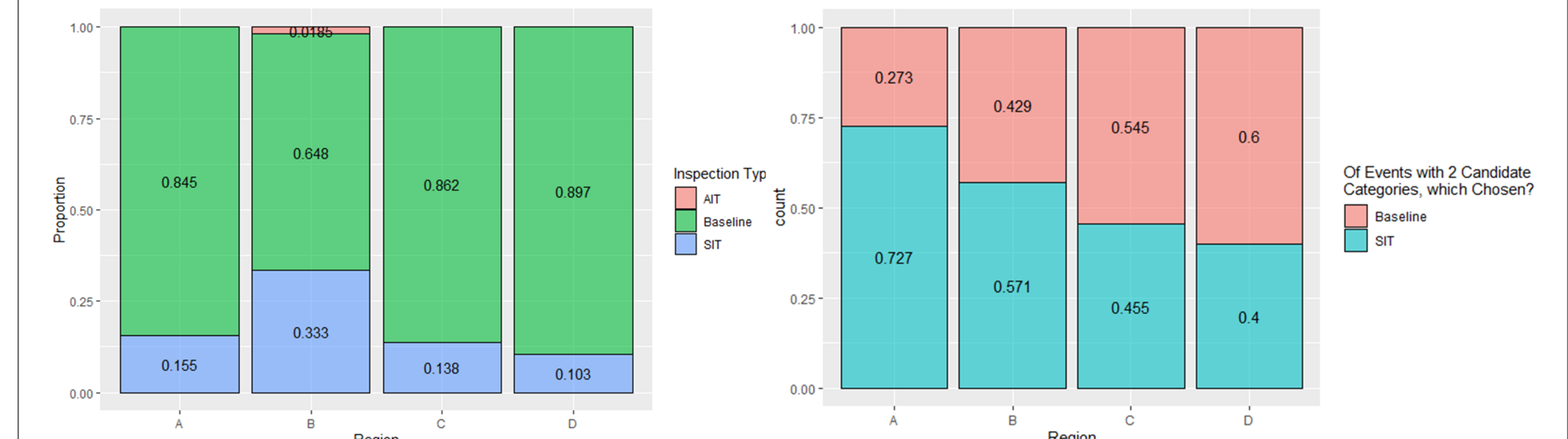- Regions de-identified to protect privacy

Significance Determination Process (SDP)

There is notable regional variation in % of cases that are categorized as green and white at final stage.

There is notable regional variation in % of cases that change risk levels from the preliminary to final stages, which may reflect differences in processes.

MD8.3 Process

There is notable regional variation in % of cases that were recommended to receive each inspection type.

For cases that qualified for multiple inspection types based on risk value, there is notable regional variation in % of cases that were recommended to receive the less severe inspection type.

Next Steps: Simulation Study

- Materials in preparation
- Exploratory research into sources of "noise"
- Online survey-based scenario study; many individual decision-makers respond to the same cases
- Goal is to pinpoint the sources of variability in the variation already found.

Applications to Defense Domain

- Anything that involves consideration of risk when formulating a decision
- Anything that involves multiple decision-makers, or a single decision-maker making multiple decisions
- e.g., Mission planning; command and control processes

References

(1) Kahneman, D., Sibony, O., & Sunstein, C. R. (2021). Noise: A flaw in human judgment. Hatchette UK.
(2) Clancy, K., Bartolomeo, J., Richardson, D., & Wellford, C. (1981). Sentence decisionmaking: The logic of sentence decisions and the extent and source of sentence disparity. J. Crim. L. & Criminology, 72, 524.
(3) Neprash, H. T., & Barnett, M. L. (2019). Association of primary care clinic appointment time with opioid prescribing. JAMA network open, 2(8).