Applying Systems Thinking to Public Policy Regulating in the Power Industry

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ReliabilityFirst
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INCOSE Cleveland NE-Ohio Chapter Meeting

Abstract

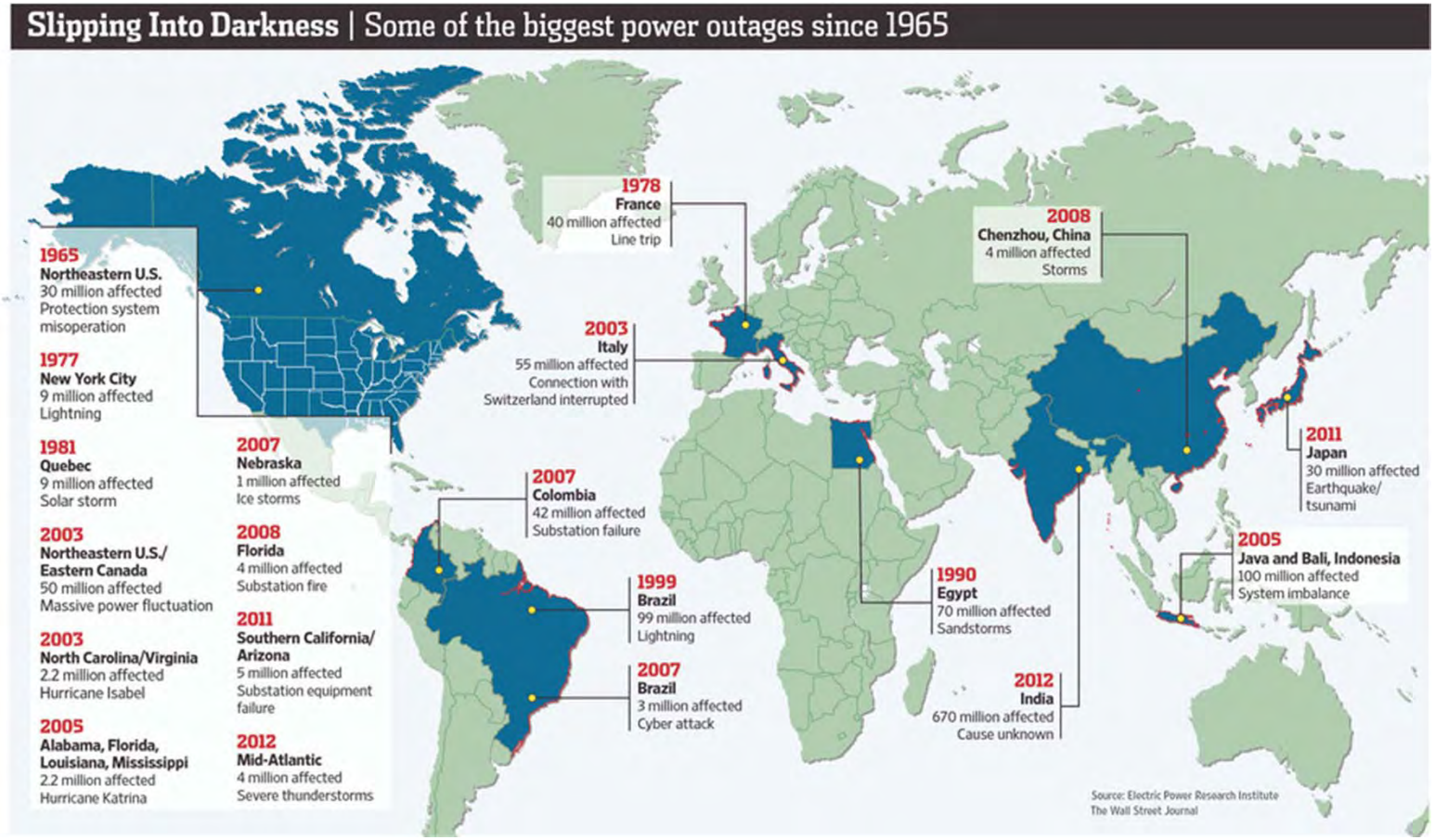
ReliabilityFirst is a non-for-profit organization that has been given authority in the Northeastern US to enforce the Federal Energy Regulatory Commission (FERC) CFR Title 10 Energy Regulations for Ensuring Power Grid reliability as defined by the North American Electric Reliability Corporation (NERC.) ReliabilityFirst has decided strategically to apply Systems Engineering principles to optimize their regulation of the Power Industry. This presentation will first discuss the complex sub-system of Power Grid Reliability and the surrounding complex system that regulates the Power Grid Reliability Sub-system (i.e. Systems of Systems Approach.) Then the modeling and optimizing of this regulatory scheme will be outlined, describing the interaction between Engineers, Attorneys, and Industry Leaders in the development and deployment of these processes. Comparisons will be drawn between the regulatory scheme and the INCOSE process areas.

Outline

- ✓ Overview of Reliability*First*
- ✓ Regulatory Complex System
  - Grid Reliability Complex Subsystem
    - ➢ Power Grid Subsystem (Power Flow Modeling)
    - ➢ Risk Harm Measurement
    - ➢ Design Structure Matrix (N-Squared Diagrams)
    - ➢ Cascade/Chaos Analysis
  - Entity Behavioral Complex Subsystem
  - Reliability*First* Complex Subsystem
- ✓ System Engineering Process Areas and the Regulatory Scheme
- ✓ Roadmap

Overview of ReliabilityFirst

Historical Blackouts



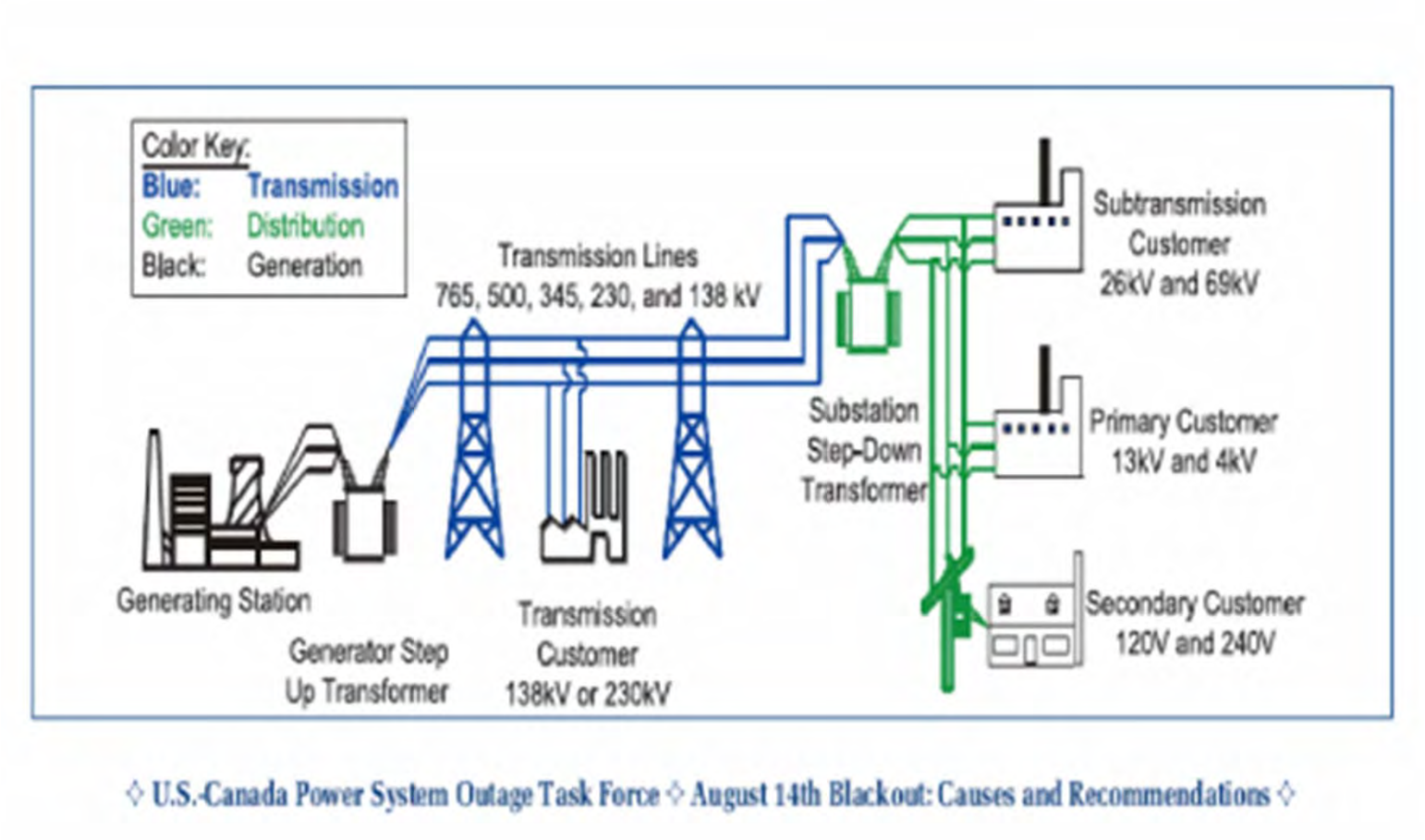
Size of the Power Grid

NATIONAL
US Power Market $250B
940 Million Pounds of Coal Per Day
830GW of Power Flow per Day
(14KWhr / person / day)

RELIABILITY FIRST REGION
188GW Peak Load
66,067 Miles of Transmission Line
1600+ Plants

RELIABILITY FIRST

Transmission (Ring Topology)
Distribution (Radial Topology in US)



Reliability*First* Members

Regional Transmission Organizations (RTOs) 2/0

Midwest Independent Transmission System Operator, Inc.
PJM Interconnection, LLC

Small LSE 10/2

Allegheny Electric Cooperative, Inc.
Atlantic City Electric
Buckeye Power Inc.
City of Vineland NJ
Cloverland Electric Cooperative (CEC)
Delmarva Power
Illinois Municipal Electric Agency
Lansing Board of Water and Light
Michigan Public Power Agency
Old Dominion Electric Cooperative
Southern Maryland Electric Cooperative, Inc.
Wabash Valley Power Association, Inc.

Medium LSE 3/1

Consumers Energy Company
The Detroit Edison Company
PEPCO Energy Services, Inc.
Wisconsin Electric Power Company

Large LSE 2/0

American Electric Power Service Corp.
Exelon Corporation

Supplier 9/12

AES North America Generation
Calpine Energy Services LP
CMS Enterprises Company
CMS Energy Resource Management Company
Dominion Energy, Inc.
Dynegy Inc.
Edison Mission Marketing & Trading, Inc.
FirstEnergy Solutions Corp.
Hazleton Generation LLC
Louis Dreyfus Energy Services L.P.
Morgan Stanley Capital Group Inc.
NextEra Energy Resources, LLC
Ohio Power Co.
PPL Brunner Island, LLC
PPL EnergyPlus, LLC
PPL Holtwood, LLC
PPL Lower Mount Bethel Energy, LLC
PPL Martins Creek, LLC
PPL Montour, LLC
PPL Susquehanna, LLC
Tenaska, Inc.

Transmission Company 17/4

American Transmission Co., LLC
Appalachian Power Co.
The Dayton Power and Light Co.
Duke Energy Shared Services, Inc.
Duquesne Light Company
FirstEnergy Services Company
Hoosier Energy Rural Electric Cooperative Inc.
Indianapolis Power & Light Company
International Transmission Company
Linden VFT LLC
Michigan Electric Transmission Company, LLC
Neptune Regional Transmission System, LLC
Northern Indiana Public Service Company
Ohio Valley Electric Corporation
Potomac Electric Power Company
PPL Electric Utilities Corporation
Public Service Enterprise Group Inc.
Rockland Electric Company
Trans-Allegheny Interstate Line Company
Vectren Energy Delivery of Indiana, Inc.
Wolverine Power Supply Cooperative, Inc.

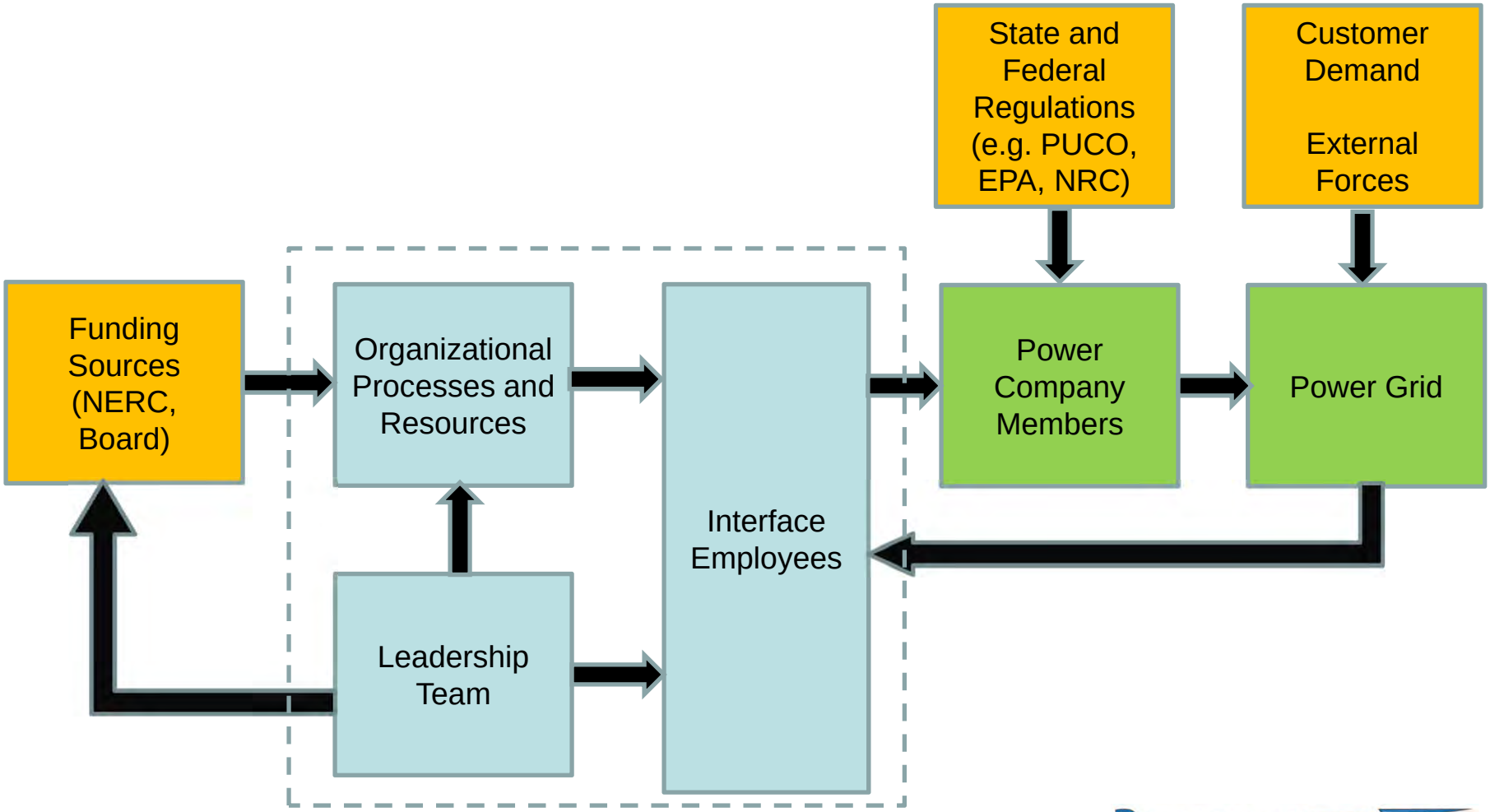
Adjunct Members

AEP Energy Partners, Inc.
Illinois Citizens Utility Board
Office of Peoples Counsel District of Columbia
Pennsylvania Office of Consumer Advocate
Tennessee Valley Authority
Utility Services, Inc.

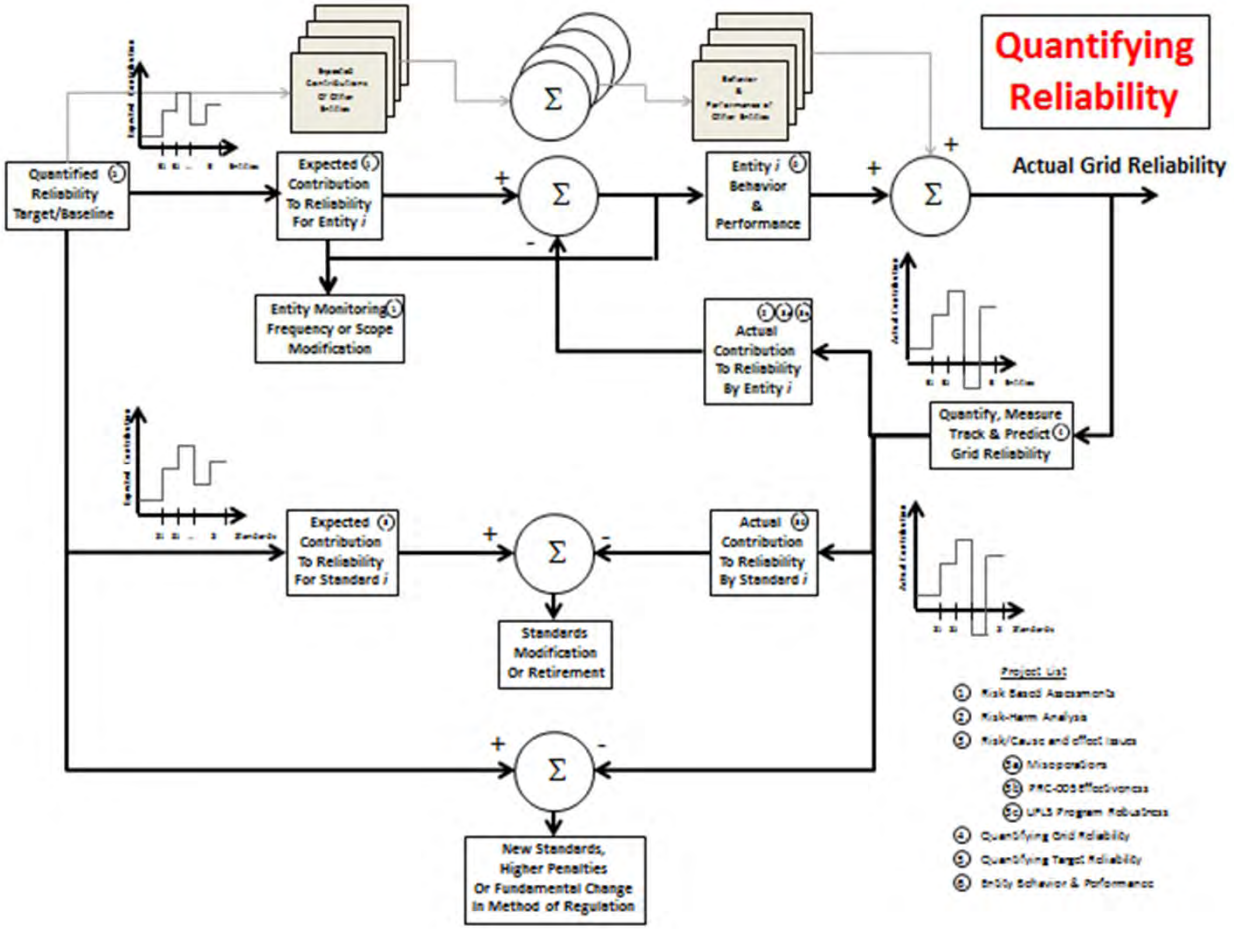
RELIABILITY*FIRST*

Regulatory Complex System

Power Industry Regulation Overview

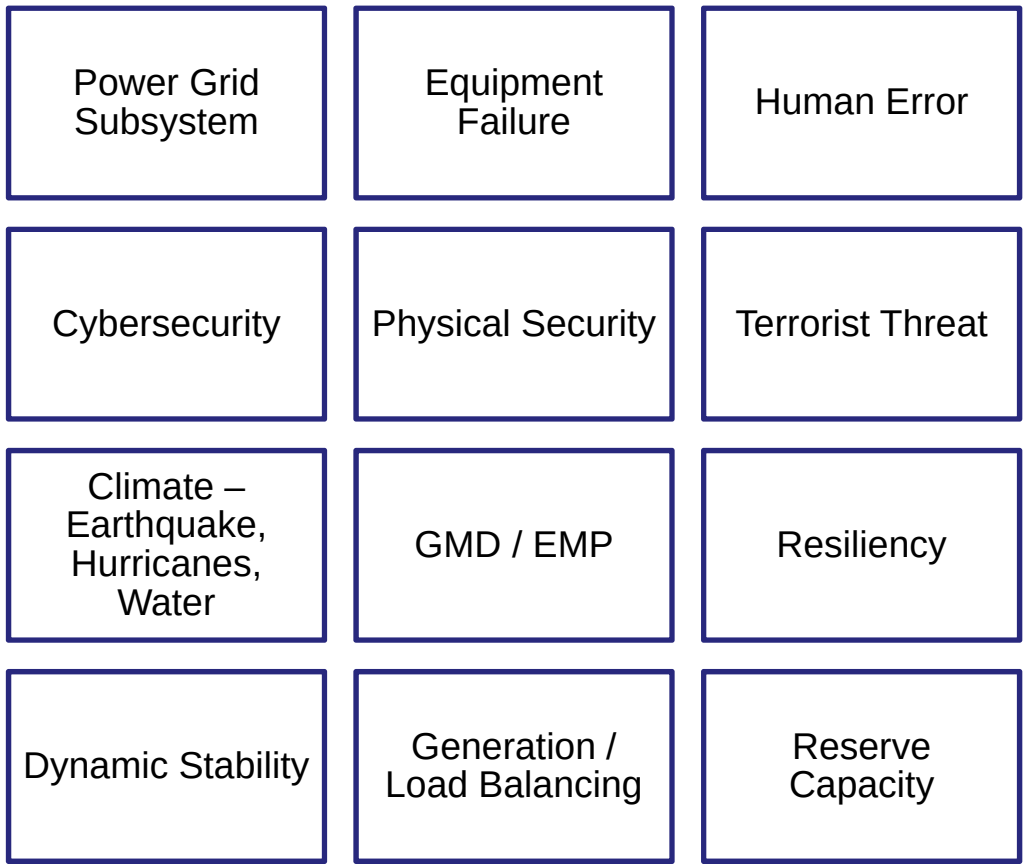


Regulatory Complex System

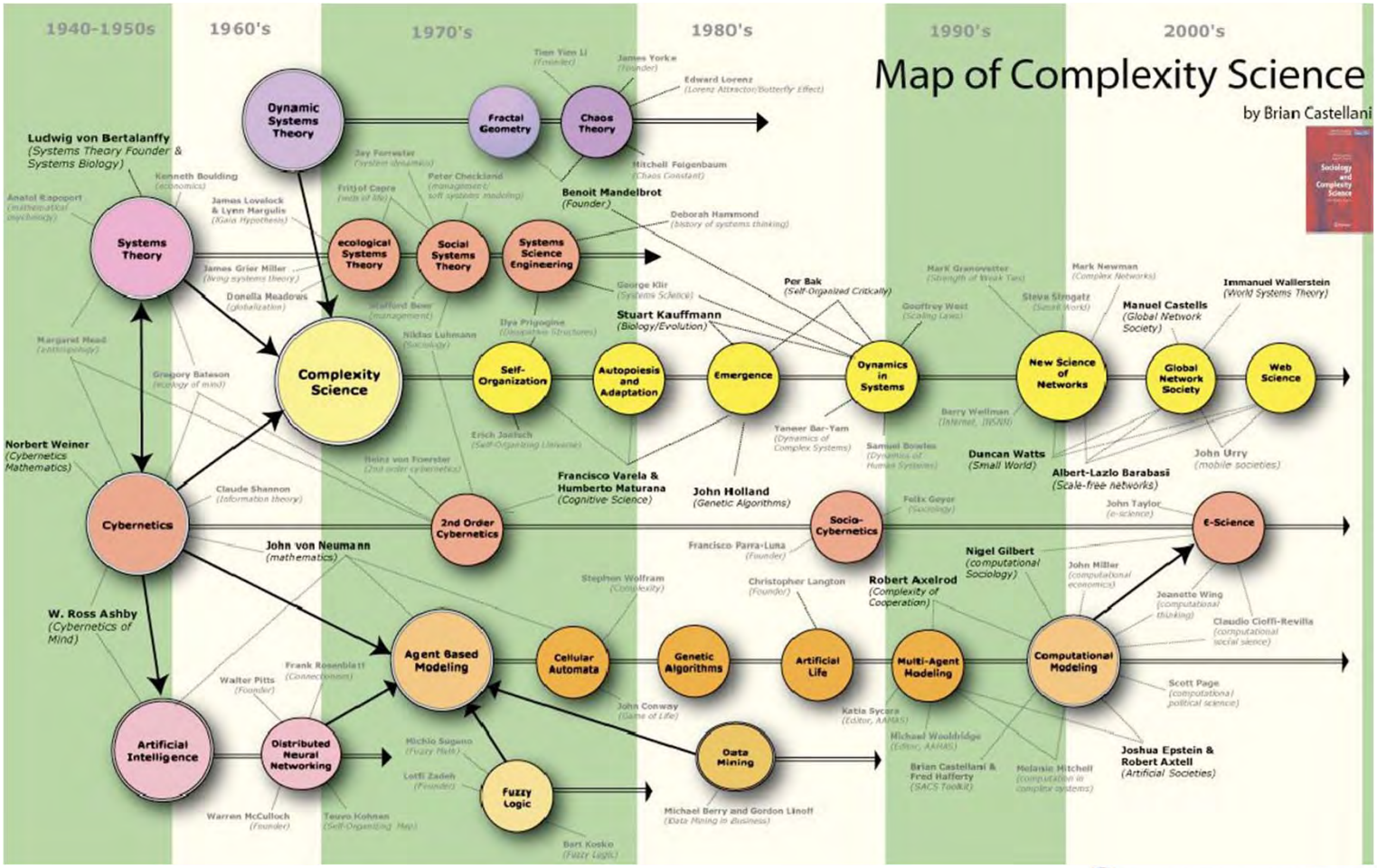


Grid Reliability Complex Subsystem

Grid Reliability Complex Subsystem



Methods of Engineering Complex Systems



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Resiliency – Human Error

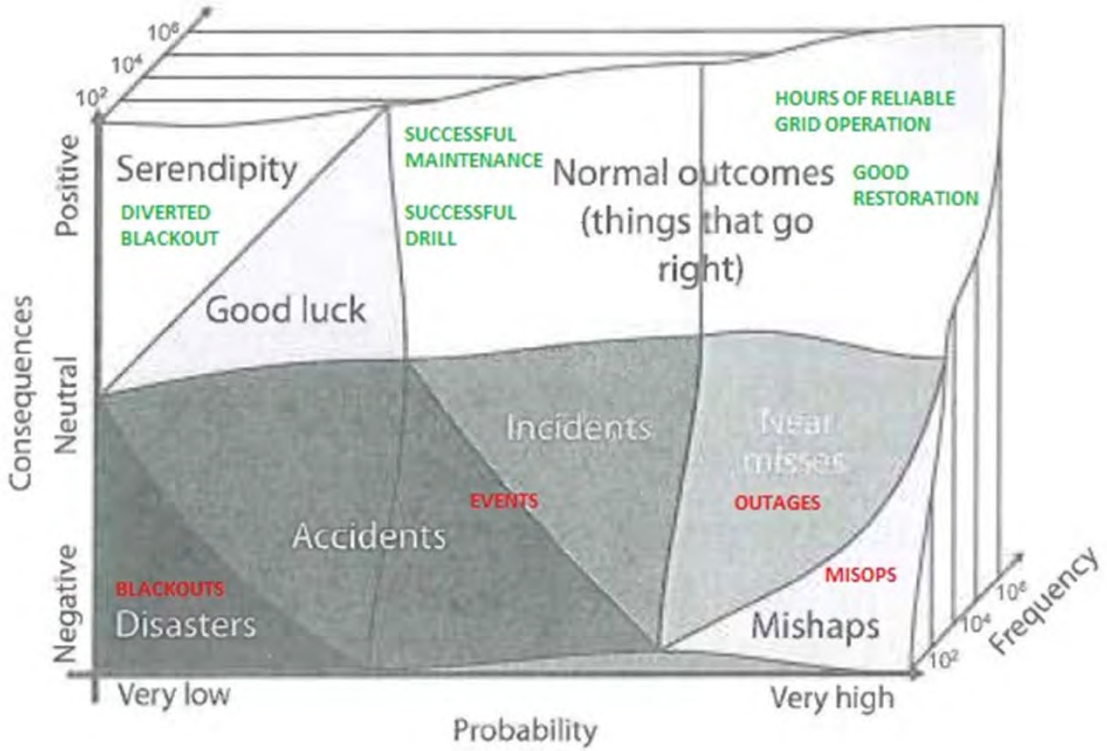

Figure P.3 **The frequency of various outcomes**

Source: Hollnagel 2008

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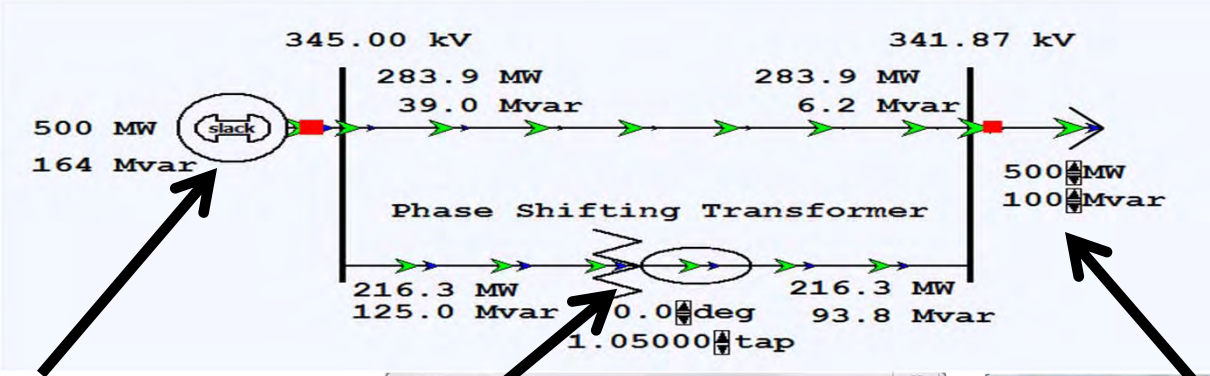
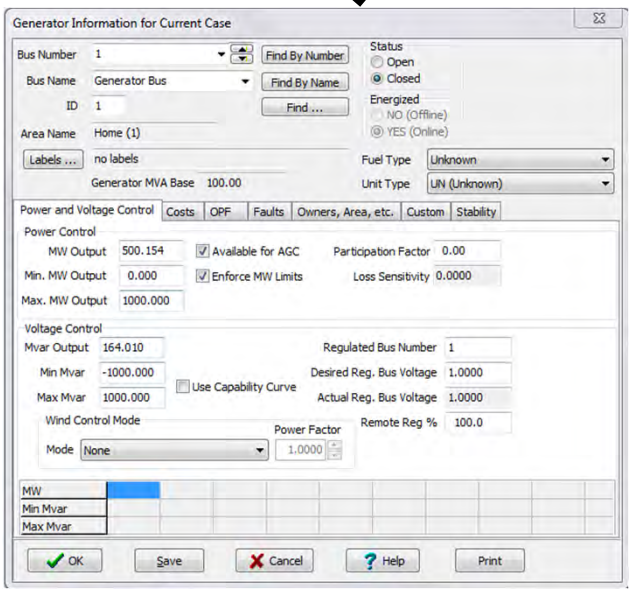
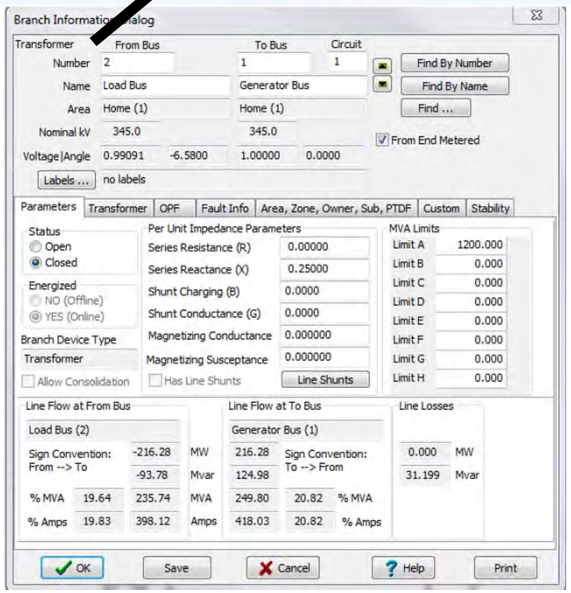
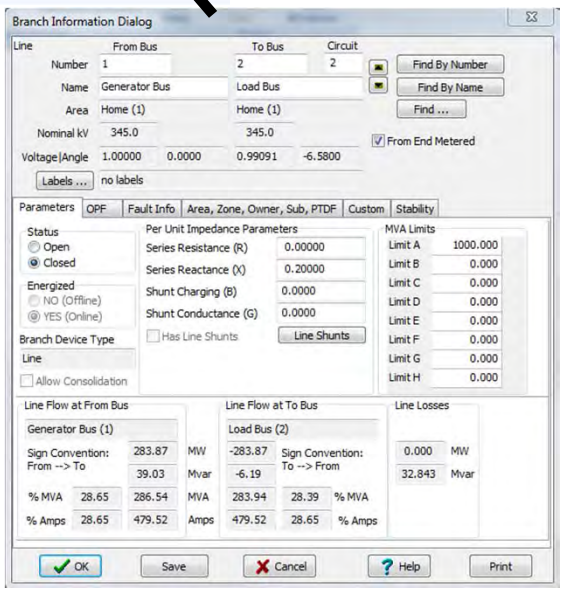
Power Grid Subsystem (Power Flow Modeling)

Simple Power Grid in Powerworld®









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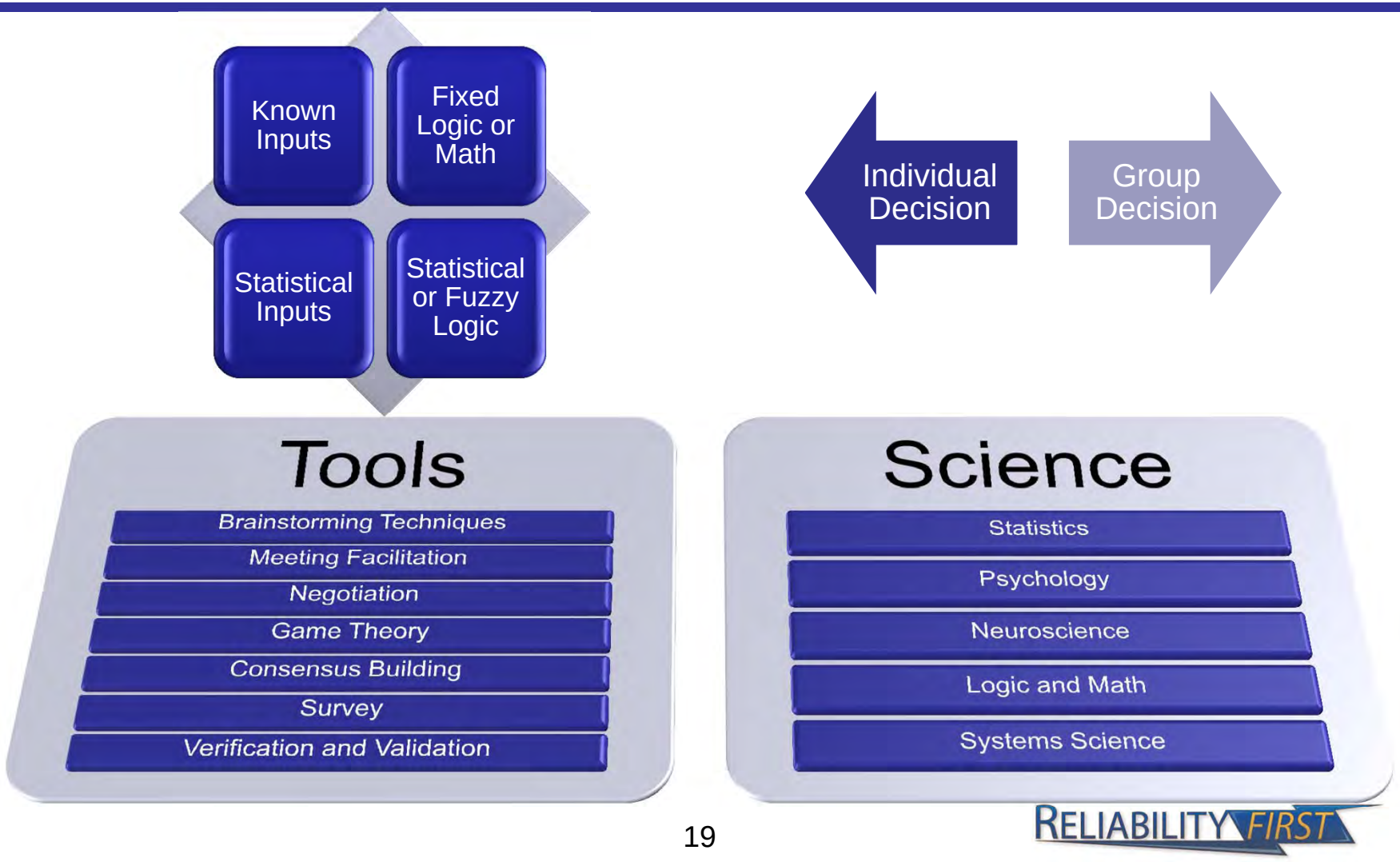
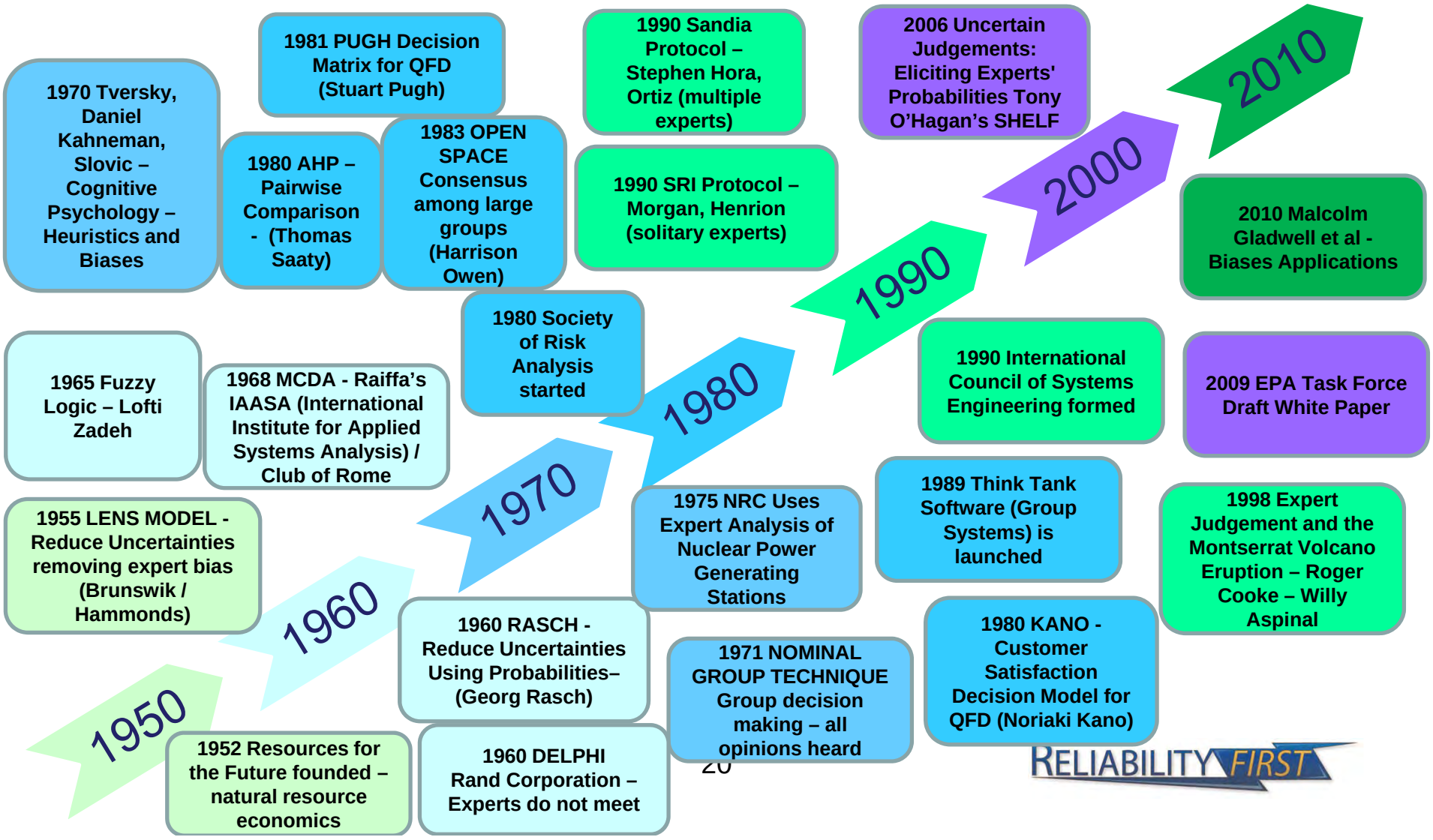
Risk Harm Measurement

Decision Making Components



Decision Making Timeline



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Basic Steps of Decision Making with Experts

- **Develop the Cognitive Skill of Estimation**
- **Consider their Expertise in Field during Questioning**
- **Update Skill Yearly (requires practice to maintain)**

- **Remove Ambiguity**
- **Believe the Data**

- **Decide based upon information**
- **Document decision**

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EPA Draft White Paper - 2009

- ✓ "Expert elicitation (EE) is a systematic process of formalizing and quantifying, typically in probabilistic terms, expert judgments about uncertain quantities."

- ✓ "If performed using appropriate methods and quality standards, including peer review and transparency, EE can be a reliable component of sound science."

- ✓ "Expert elicitation has been used by federal agencies, the private sector, academia, and other groups."
  - EPA's Office of Air Quality, Planning and Standards (OAQPS) exposure-response lead and ozone.
  - AQPS relationship between exposures to fine particles and the annual incidence of mortality.
  - DOE nuclear waste and other related issues.
  - Other uses by government and academia include cost-benefit analysis, risks associated with climate change, technology development, and food safety.

Risk-Harm Overview

OCCURRENCE
90% CONFIDENCE RANGE

High	1	> 1 in 1
High	2	1 in 3
Serious	3	1 in 8
Serious	4	1 in 20
Unlikely	5	1 in 80
Unlikely	6	1 in 400
Unlikely	7	1 in 1,000
Minimal	8	1 in 15,000
Minimal	9	1 in 150,000
Not Likely	10	< 1 in 1,500,000

DETECTION
90% CONFIDENCE RANGE

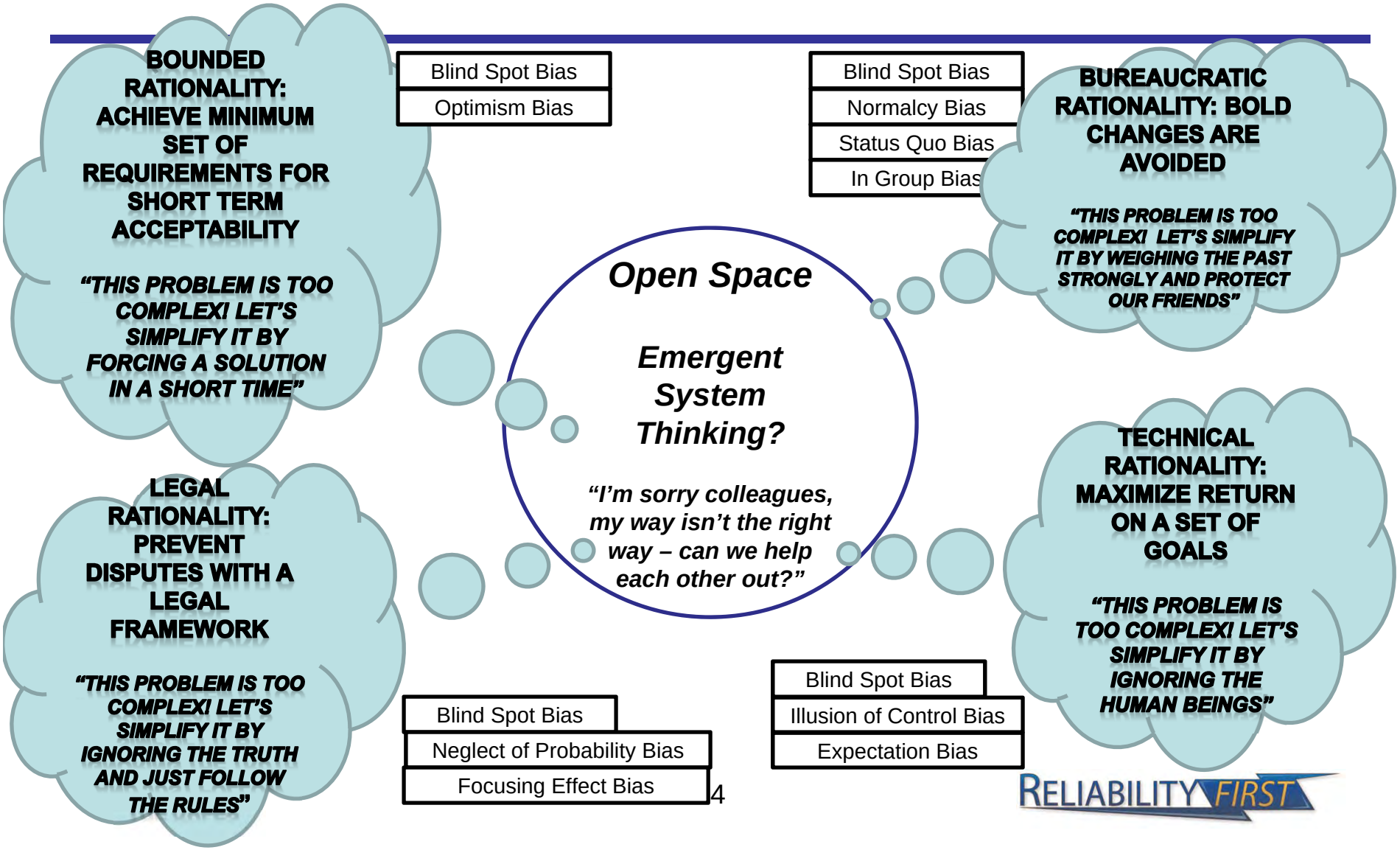
Almost Impossible	1	> 1 in 2	50.0%
Very Remote	2	1 in 5	80.0%
Remote	3	1 in 6	82.0%
Very Low	4	1 in 7	85.0%
Low	5	1 in 8	87.5%
Moderate	6	1 in 10	90.0%
Moderately High	7	1 in 13	92.5%
High	8	1 in 20	95.0%
Very High	9	1 in 40	97.5%
Almost Certain	10	< 1 in 200	99.5%

POTENTIAL HARM
90% CONFIDENCE RANGE

Name	Rank	Loss of Equipment	Loss of Generation/Load	Loss of Visibility	System Restoration
Extreme	1	Loss of more than three (3) pieces of BES equipment of > 200 kV, Loss of more than three substations ≤ 200 kV	Unintended loss of load and/or generation > 10,000 MWs	EMS, ICCP, SCADA - 100% Data Affected -or- Loss of visibility of multiple Utilities' (or TOs) transmission and generating substations	System Restoration Time greater than 24 hrs following an event
Substantial	2	Loss of up to three (3) pieces of BES equipment > 200 kV, Loss of up to three (3) substations ≤ 200 kV	Unintended loss of load and/or generation from 5,000-to-10,000 MWs	EMS, ICCP, SCADA - 75% Data Affected -or- Loss of visibility of a single utility's (or TO) transmission and generating substations	System Restoration Time from 18- 24 hrs following an event
Intermediate	3	Loss of a single piece of BES equipment > 200 kV, loss of up to three (3) pieces of BES equipment ≤ 200 kV	Unintended loss of load and/or generation from 999-to- 4,999 MWs	EMS, ICCP, SCADA - 50% Data Affected -or- loss of visibility of multiple transmission or generating substations (or RTUs)	System Restoration Time from 12 – 16 hrs following an event
Minor	4	Loss of a single piece of BES equipment ≤ 200 kV	Unintended loss of load and/or generation from 300-to-999 MWs	EMS, ICCP, SCADA - 50% Data Affected -or- loss of visibility of one transmission or generating substation (or RTU)	System Restoration Time from 6 – 12 hrs following an event
None	5	No loss of any BES equipment	Unintended loss of load and/or generation < 300 MWs	EMS, ICCP, SCADA - less than 25% Data Affected	No impact on system recovery following an event

FINAL RISK HARM
SCALE OF 1 to 12

Rationalities / Biases



The Field

“Out beyond ideas of wrong-doing and right-doing,
there is a field.
I'll meet you there.

When the soul lies down in that grass,
the world is too full to talk about.

Ideas, language, even the phrase each other
doesn't make any sense.”

Rumi - 1207-1273

Design Structure Matrix (N-Squared Diagrams)

ASSET DSM

Can a failure of the asset in this column cause a forced or unforced outage of an asset in this row? ◦=*Rarely* ○= *Sometimes* ●=*Almost Always*	Generation(including GSU,Xrfm, I/C)	Substation Transformers	Relays	Transmission	Substations	Circuit Breakers	Capacitors	Reactors	Protection System (including SPS)	Automatic UFLS	Automatic UVLS	Blackstart resources	Phase Shifter	CCA, ESP, PSP
Generation resources (including GSU,Xrfm, Int		◦	●	●	●	○	◦		○	○	○			●
Substation Transformers	◦		●	●	●	○	●			○	○	○		●
Relays	●	●		○	○	○	◦		●			●		●
Transmission	●	●	●		●	●	○	◦	●	○	○		○	●
Substations	◦	○	●	◦		●			◦	○	○			●
Circuit Breakers	○	●	●	●	●		◦		○			○		●
Capacitors	◦	○		●	●	●				○	○			●
Reactors	◦	◦		●	●	●				○	○			●
Protection System (including SPS)	◦	◦	●	●	●	◦		○				○		●
Automatic UFLS			●											●
Automatic UVLS			●											●
Blackstart resources		◦	●	●	●	○	◦		○	○	○			●
Phase Shifter	◦			●	●	●	◦							●
CCA, ESP, PSP														

PROMPT QUESTION:

To fill in this DSM, as yourself "Can a failure of the asset listed at the top of the column cause a forced or unforced outage of the assets listed in the rows below it?"

Fill in a 1 for rarely, 3 for sometimes, and 5 for almost always

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STANDARDS DSM

INPUT -> OUTPUT ^	BAL-001	BAL-002	BAL-003	BAL-004	BAL-005	BAL-006	BAL-502	CIP-001	CIP-002	CIP-003	CIP-004	CIP-005	CIP-006	CIP-007	CIP-008	CIP-009	COM-001	COM-002
BAL-001	■																	
BAL-002		■																
BAL-003			■															
BAL-004				■														
BAL-005					■													
BAL-006						■												
BAL-502							■											
CIP-001								■										
CIP-002									■									
CIP-003									•	■	•	•	•	•	•	•		
CIP-004											■							
CIP-005									•	•	•	■	•	•	•	•		
CIP-006										•	•	•	■	•	•	•		
CIP-007										•	•	•		■				
CIP-008														•	■			
CIP-009																■		
COM-001																	■	
COM-002																		■

PROMPT QUESTION:

To fill in this DSM, as yourself "Does the standard listed at the top of the column receive inputs from any of the standards in the rows listed below it?"

Fill in a 1 for yes 0 for no

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Our DSMs and DMMs Today

- ✓ We decided at this point, to fill out the following elements of our Periodic Table:

	STANDARD	CONTROL AREA	ENTITY	VIOLATION	INTERNAL CONTROL	ASSET	MTBF	MTTR	COSTS
STANDARD	STANDARDS DSM			VIOLATION X STANDARDS DMM					
CONTROL AREA			UNDER CONSTRUCTION				MTBF X CONTROL AREA DMM		
ENTITY									
VIOLATION									
INTERNAL CONTROL									
ASSET	STANDARDS X ASSET DMM	CONTROL AREA X ASSET DMM				ASSET DSM	MTBF X ASSET DMM		
MTBF									
MTTR									
COSTS									

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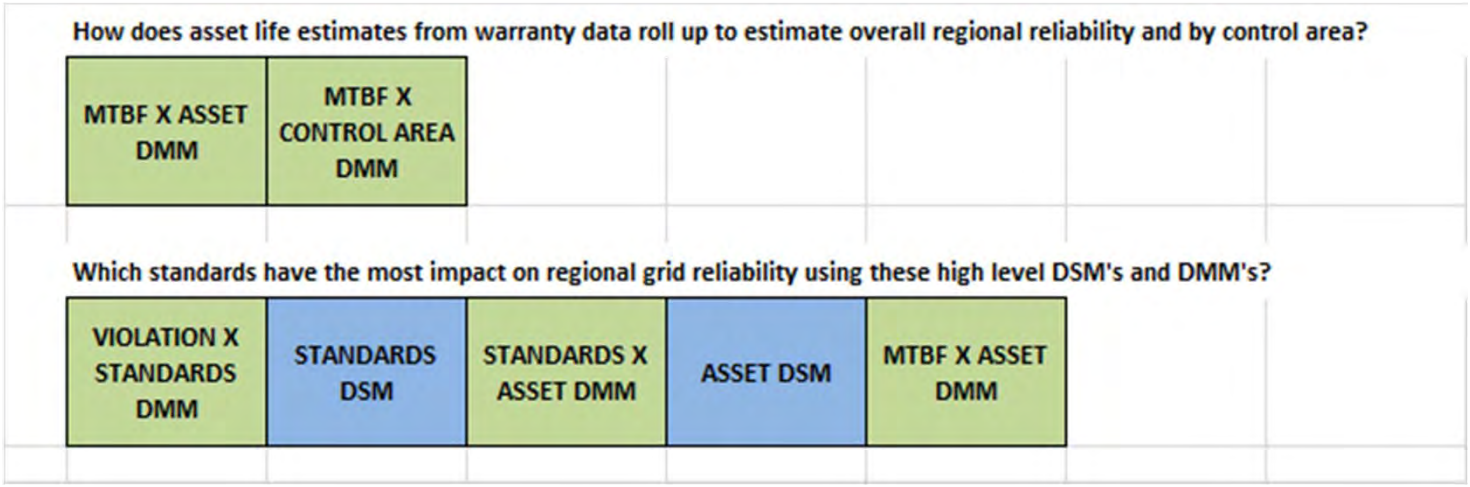
Combining Elements on the Periodic Table

- ✓ Like chemists combining elements to form new molecules, we combine DSMs and DMMs to answer specific questions:



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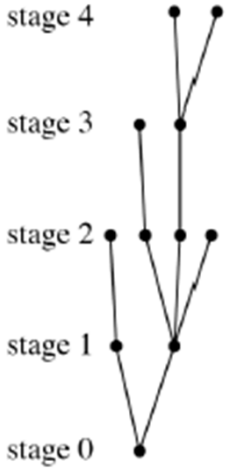
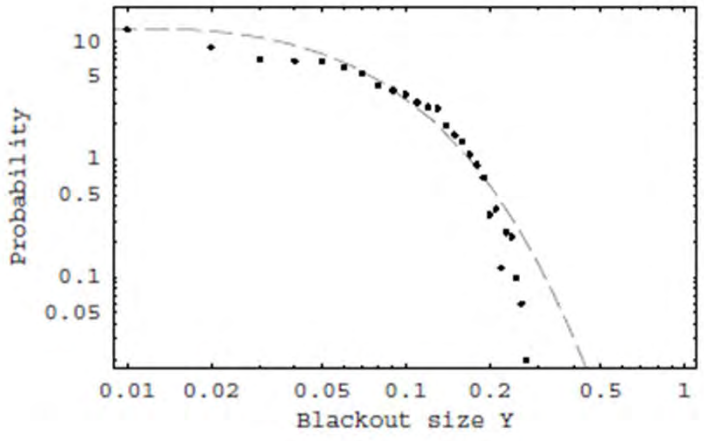
Cascade/Chaos Analysis (Ian Dobson)





Entity Behavioral Complex Subsystem

Approach to Entity Behavior

"…If those responsible for controlling risks lack the analytic fabric to disaggregate the overall problem into actionable projects, then they cannot work on them intelligently; nobody will know what to do tomorrow – except to do the same things they did yesterday."

Sparrow – The Regulatory Craft

RELIABILITY FIRST

Modeling

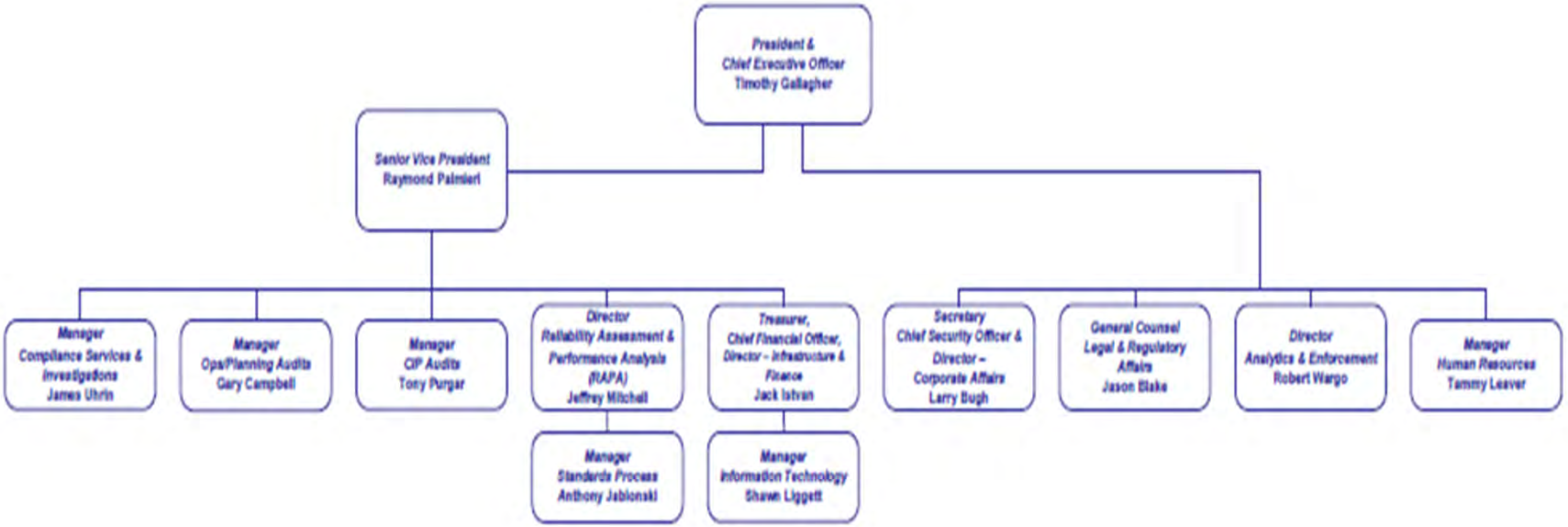
How does the INPUT in each row effect the OUTPUT in each column impact to Grid Reliability

+5 Strong Positive Effect
+3 Positive Effect
+1 Weak Positive Effect
0 No Effect
-1 Weak Negative Effect
-3 Negative Effect
-5 Strong Negative Effect

	Fostering a Self-Reporting Culture	Having Just enough Compliance to Standards	Being open and sharing their Compliance to Standards with their	Being open and sharing their Compliance to Standards with other	Taking proactive stances on compliance, not reactive stances	Not having a false or "shell" compliance program on paper only	Having an internal compliance committee like "the rock" at PJM	Having "Compliance Blitz" meetings	Organizing evidence of compliance very well	Spending time on Audit Prep	Spending time between audits, not waiting until audit	Having an appropriate size Compliance Staff	Having appropriate staff experience in their Compliance Staff	Having an appropriate number of Compliance SMEs	Having a Self-Assessing Culture (e.g. Root cause analysis)	Showing Good Participation on standards drafting teams and con	Sharing between other entities or industry	Having sincere "reliability at heart" interactions w/RFC	Having good voting history on standards	Not having "Musical chairs" for those who were good at driving R	Having a good Whistleblower program for reliability issues	Having Leadership with strong message about reliability	Willingness to say what they recommend to others	Having fewer Violations	Not showing Undisciplined Behavior and high human error	Having and appropriate Reliability Risk Tolerance	Having good Situational Awareness about Reliability	Taking the shortest possible time to Detect a Violation	Having a Passion for Reliability on their Performance Evaluations	Having Strong Internal Controls
Reliability First's Response Time when an Entity has a Request	-1	0	0	0	0	0	0	0	-1	0	-1	-3	-3	-3	-1	0	-3	-1	0	0	0	0	0	-1	-1	0	-1	-3	0	0
Reliability First's Credibility and Confidentiality with our Entities	-3	0	-1	-1	0	0	0	0	0	0	0	0	0	0	0	0	-1	-1	-3	0	-3	-1	0	-1	-3	-1	-1	0	0	-3
Reliability First's Formal Information Requests of Entities	1	1	0	0	0	0	-1	-1	-1	0	0	-3	-3	-3	-3	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0
Reliability First's Informal Information Requests of Entities	0	-3	-1	-1	0	0	-1	-1	-1	0	0	-3	-3	-3	-3	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0
Reliability First's Interactions with Members in our Region	-3	0	-1	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	-1
Reliability First's Board of Directors interaction with ReliabilityFirst Staff	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0
Reliability First's Seminars and Workshops we Host	-1	1	-1	-1	-1	0	-1	-1	-1	-1	-1	-1	-1	-1	-3	0	-1	-1	0	0	-1	0	-1	-1	-1	-3	-1	0	0	-1
Reliability First's Committee Participation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Reliability First's Trade Groups and Forums Participation	-1	0	1	1	0	0	0	-1	-1	0	-1	0	0	0	0	-1	-1	-1	0	0	0	0	0	-1	-1	-1	0	0	0	0
Reliability First's Professional Organizations we Belong to	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	-1	-1	0	0	0	0	0	0	0	-1	0	0	0	-1
Reliability First's Communication Devices (like surveys)	0	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Reliability First's Entity Data Collection	0	0	0	0	0	0	0	0	-5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Reliability First's Monthly Newsletter Document	0	0	0	0	-1	0	0	-1	0	0	-1	-1	-1	-1	-1	0	-1	-1	0	0	0	-1	0	-1	0	0	0	0	0	-1
Reliability First's Employees Skills and Background	-1	0	0	0	0	-1	0	0	0	0	0	-1	-1	-1	-5	0	0	-1	0	0	0	0	0	0	0	-5	-1	0	0	-5
Reliability First's Employees Personal Professional Relationships with Indust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	-1	-1	0	0	0	0	0	0	-1	-1	0	0	-1
Reliability First's Consistency of Message Amongst Ourselves (without confl	-1	0	1	1	-1	-1	-3	0	-3	-1	-1	-1	-1	-1	-1	0	-1	-1	-1	0	-1	-1	0	-1	-1	-1	-1	0	0	-1
Compliance's Self Certification	-1	0	0	0	-1	-1	0	-1	-3	-3	-3	-1	-1	-1	-1	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0
Compliance's Audits	-1	-1	0	0	-1	-1	-1	-1	-3	-5	0	-5	-5	-5	-3	-3	-1	0	-3	0	1	1	-1	1	-1	1	0	0	-1	-1
Compliance's Spot Checks	-1	0	0	0	-1	-1	-1	-1	-3	-3	-1	-1	-1	-1	-1	-1	-1	0	1	0	0	0	0	0	0	0	0	0	0	0
Compliance's Assist Visits	0	0	-1	-1	-1	0	0	0	0	0	0	-1	-1	-1	-1	0	-1	-1	0	0	-1	0	0	-1	-1	0	0	0	0	0
Compliance's Monthly Compliance Monitoring Schedule Document	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Compliance's Lessons Learned Documents	-1	0	-1	-1	-1	0	1	-1	-1	-1	-1	-1	-1	-1	1	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0

ReliabilityFirst Complex Subsystem

Organization



RELIABILITY FIRST

System Engineering Process Areas and the Regulatory Scheme

NERC Standards

CYBERSECURITY/SECURITY

- **CIP - Critical Infrastructure Protection (Security and Cybersecurity)**

OPERATIONS/PLANNING

- **BAL - Resource and Demand Balancing**
- **COM – Communications (Operators…)**
- **EOP - Emergency Preparedness and Operations**
- **FAC - Facilities Design, Connections, and Maintenance**
- **INT - Power Interchange Scheduling and Coordination**
- **IRO - Interconnection Reliability Operations and Coordination**
- **MOD - Modeling, Data, and Analysis**
- **NUC - Nuclear**
- **PER - Personnel Performance, Training, and Qualifications**
- **PRC - Protection and Control**
- **TOP - Transmission Operations**
- **TPL - Transmission Planning**
- **VAR - Voltage and Reactive**

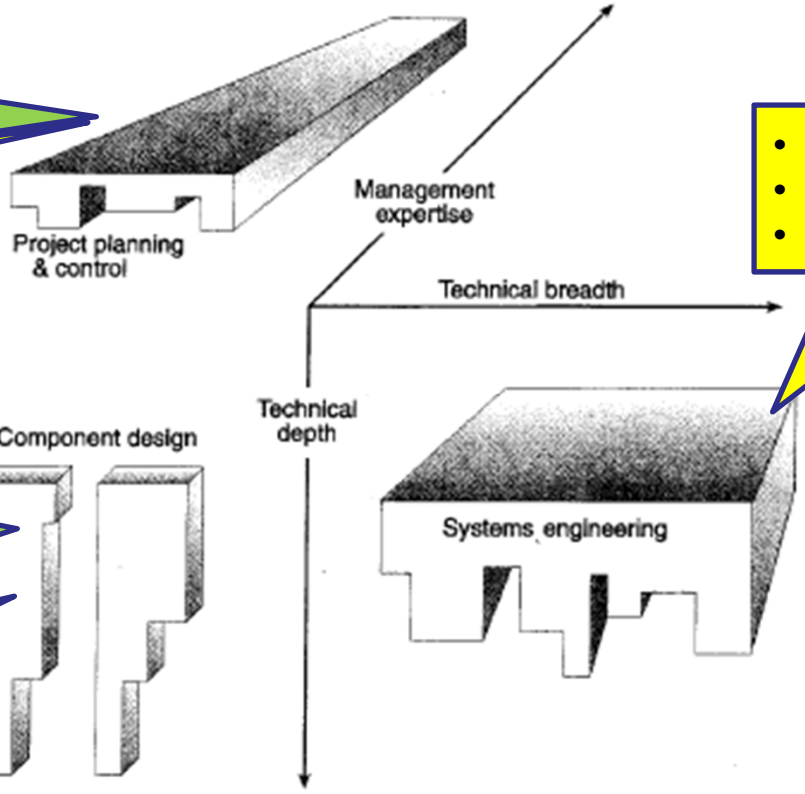
INCOSE Process Areas and NERC Standards

INCOSE process areas:	NERC Reliability Standards:							
CONFIGURATION MANAGEMENT	5	CIP-002	EOP-009	IRO-010	MOD-016	PRC-008		
ASSESSMENT								
CONTROL								
PLANNING	14	BAL-002-WECC	BAL-502-RFC	BAL-STD	CIP-008	CIP-009	EOP-001	EOP-003
		EOP-007	IRO-004	TOP-002	TOP-003	TPL-001	TPL-005	TPL-006
QUALITY MANAGEMENT								
STAKEHOLDER REQUIREMENTS DEFINITION	4	FAC-001	FAC-002	FAC-008	FAC-009			
SUPPLY								
DECISION MAKING								
SYSTEM LIFE CYCLE PROCESS MANAGEMENT								
INTEGRATION								
RISK MANAGEMENT								
IMPLEMENTATION								
VALIDATION	4	PRC-007	PRC-009	PRC-010	PRC-014			
VERIFICATION	16	MOD-001	MOD-004	MOD-008	MOD-010	MOD-012	MOD-014	MOD-015
		MOD-017	MOD-018	MOD-019	MOD-021	MOD-024	MOD-025	MOD-028
		MOD-029	MOD-030					
REQUIREMENTS ANALYSIS								
INFORMATION MANAGEMENT	11	IRO-002	IRO-015	IRO-016	MOD-011	MOD-013	MOD-020	PRC-012
		PRC-013	PRC-015	PRC-020	PRC-021	TOP-005		
ARCHITECTURAL DESIGN								
TRANSITION								
OPERATION	54	BAL-001	BAL-002	BAL-003	BAL-004	BAL-004-WECC	BAL-005	BAL-006
		COM-001	COM-002	CIP-001	CIP-003	CIP-005	CIP-006	EOP-004
		EOP-005	EOP-006	EOP-008	FAC-010	FAC-011	FAC-012	FAC-014
		INT-001	INT-003	INT-004	INT-005	INT-006	INT-007	INT-008
		INT-009	INT-010	IRO-003	IRO-005	IRO-006	IRO-008	IRO-009
		IRO-014	NUC-001-2	PRC-001	PRC-002	PRC-002-NPCC	PRC-003	PRC-006
		PRC-016	PRC-018	PRC-022	PRC-023	TOP-004	TOP-006	TOP-007
		TOP-008	TPL-002	TPL-003	TPL-004	VAR-001	VAR-002	VAR-002-WECC
MAINTENANCE	8	CIP-007	FAC-003	FAC-501-WECC	PRC-004	PRC-005	PRC-011	PRC-017
DISPOSAL								
ENTERPRISE ENVIRONMENT MANAGEMENT								
INVESTMENT MANAGEMENT								
RESOURCE MANAGEMENT	9	CIP-004	EOP-002	IRO-001	PER-001	PER-002	PER-003	PER-004
		PER-005	TOP-001					
ACQUISITION								

Systems Engineering at Reliability*First*

- Management Team
- Standards Committee Chairmen

- Public Policy and Law (Regulation)



- Systems Engineers
- Risk Management
- Systems Thinkers

- Power Systems Engineers
- Cybersecurity IT/Eng
- Administrative Lawyers (Energy)

- Risk Analysts
- Statistical Analysis

Source: A. Kossiakov
Sytems Engineering Principles and Practice

Reliability Assessment and Performance Analysis Group

Area of Work	Activity(ies)	Proficiencies Gained
Resource Adequacy	Collection and analysis of demand (i.e. electrical load) and capacity (i.e. generation) forecasts and determination of resource adequacy.	Knowledge of demand and capacity data composition, probability techniques and methods (such as Loss of Load Probability and Loss of Load Expectation) used to determine adequacy *Reliability Engineering – Statistical Analysis*
Transmission System Modeling	Collection and assembly of power flow (e.g. nodes and branches) and dynamic (e.g. generator governor) data to build transmission system models of the Eastern Interconnection.	Knowledge of the detailed data and solution of complex transmission system models Developing system models solution techniques Familiarity with modeling software (e.g. PSS/e) *Systems Engineering – Verification and Validation*
Transmission System Studies	Performing power flow analysis, including transfer capability, voltage analysis, generation redispatch, contingency analysis, etc.	Knowledge of how to conduct complex transmission system analyses Developing contingency lists and writing technical reports Familiarity with power flow software (e.g. PSS/e, MUST, TARA) *Systems Engineering – Verification and Validation*
Protection of transmission and generation equipment	Reviewing generator outage data and transmission branch outage data and correlation with reported misoperation data.	Basic knowledge of transmission and generation protection schemes Corrective action for misoperations Basic knowledge of generation and transmission outage data and statistics *Systems Engineering – Architectural Design* *Reliability Engineering – Probability and Statistical Analysis*
Disturbance Reporting and Event Analysis	Reviewing reported disturbances, sequence of events, determining root causes, development of lessons learned.	Levels of events and reporting thresholds Reporting procedures for disturbances and events *Reliability Engineering – Root Cause Determination* *Systems Engineering – Decision Making*

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Compliance Services and Investigations Group

Area of Work	Activity(ies)	Proficiencies Gained
Compliance Services	Monitor and track entity performance, develop trends and metrics, etc.	Knowledge of the Compliance Monitoring Methods and the recognition of meaningful correlations *Reliability Engineering – Statistical Analysis*
Investigations	Participate in investigations.	Knowledge of the investigation process including identifying and interpreting the discrete features of deteriorated system causing the loss of an intended function *Reliability Engineering – Failure Reporting, Analysis and Corrective Action System (FRACAS) and Root Cause Analysis*
Certifications	Perform functional entity Certifications for Reliability Coordinators, Balancing Authorities and Transmission Operators.	Knowledge of the Functional Model describing the roles each entity plays in assuring reliability and stability of the electrical grid *Systems Engineering – Verification and Validation*
Registration of Entities	Analyze entity circuit configurations and apply Registration Criteria to determine their proper designation within the Functional Model.	Application of abstract models to actual system configurations. *Systems Engineering – Stakeholder Requirements Definition*
System Events	Review and perform a compliance analysis of system events.	Perform a post-mortem of system events, including a compliance evaluation *Reliability Engineering – FRACAS and Root Cause Analysis*
Complaints	Assess the validity of the facts associated with Complaints and determine any compliance impact.	Techniques for assessing items reported by entities to make compliance determinations *Systems Engineering – Validation*
Compliance Determinations	Gather and analyze entity data submittals as per the Annual Implementation Plan.	Analysis of all data submitted by the entities to make compliance determinations *Reliability Engineering – Statistical Analysis*
Annual Reporting	Develop and report regional data.	Knowledge of all reporting requirements to NERC and FERC *Systems Engineering – Stakeholder Requirements Definition*
Portal - Software Maintenance and Upgrading	Review, update, and assist in the development of the regional software application. Assist in the development of software initiatives.	Development of the business rules associated with compliance software *Systems Engineering – Architectural Design*

Planning and Operations Audit Group

Area of Work	Activity(ies)	Proficiencies Gained
Planning and Operations Audits/Spot Checks	Participate in the completion of audits and spot checks following NERC and auditing standards and practices including the review of electrical power data and information. Creation of reports on the findings of audits and spot checks.	Knowledge of the BES and the functional interrelationships associated with the operation, planning and maintenance of the BES. Knowledge of the Reliability*First* Audit process and execution of key activities to complete the audit/spot-check within the established milestone timelines. Knowledge of Auditing Standards and Practices *Systems Engineering – Validation*
Entity Impact Evaluation	Utilize Entity Impact Evaluation (EIE) as part of developing of an Audit Plan for Reliability*First* audited entities. Support the development of the EIE process.	An understanding and awareness of the impact registered entities may have on the BES. An understanding of the factors which are important to creation of EIEs. *Reliability Engineering – Probability and Statistics Tools* *Systems Engineering – Risk Management*
Entity Outreach	Support registered entities though workshops, initiatives, and communications on compliance, audit processes, and other topics to assist the entities.	A thorough understanding of Compliance and Operations & Planning to be able to conduct effective training. *Systems Engineering – Integration*

Critical Information Protection Audit Group

Area of Work	Activity(ies)	Proficiencies Gained
CIP Audits / Spot Checks	Participate in the completion of audits and spot checks following NERC and auditing standards and practices including the review of electrical power data and information. Creation of reports on the findings of audits and spot checks.	Knowledge of the BES and the functional interrelationships associated with the operation, planning and maintenance of the BES. Knowledge of the Reliability*First* Audit process and execution of key activities to complete the audit/spot-check within the established milestone timelines. Knowledge of Auditing Standards and Practices *Systems Engineering – Validation*
Technical Feasibility Exception (TFE) Management	Participate in TFE Processing to include reviews and auditing of Approved and Terminated TFEs as part of CIP Audits.	Knowledge of what a TFE encompasses; and how TFEs are tracked, processed, and managed within the applicable CIP standards *Systems Engineering – Information Management*
Mitigation Plan Acceptance and Validation Reviews (MPARs and MPVRs)	For CIP related violations, perform acceptance of mitigation plans and verification of evidence for plans to mitigate risk to the Bulk Electric Systems.	Knowledge of industry approaches to mitigate violations in an effort to ensure reliability of the BES. Evaluate Root Cause Analysis efforts for validity *Reliability Engineering – FRACAS and Root Cause Analysis* *Systems Engineering – Validation*
Risk Based Assessment	Engage in the Risk Based Assessment Committee process and evaluation of Reliability*First* audited entities.	Knowledge about the potential risk to the reliability of the BES that each unique Reliability*First* registered entity may pose, based on their entity risk profile assessment *Reliability Engineering – Probability and Statistics Tools* *Systems Engineering – Risk Management*
CIP Outreach	Obtain and provide CIP Subject Matter Expertise and support, as required and able for the following activities: • Assist Visits • ERO Workshops • Reliability*First* Compliance Workshops • Registered entity inquiries • Compliance Training Needs	An understanding of the outreach efforts for RFC registered entities as well as Regional Entities, NERC and the Industry *Systems Engineering – Information Management*

Analytics and Enforcement Group

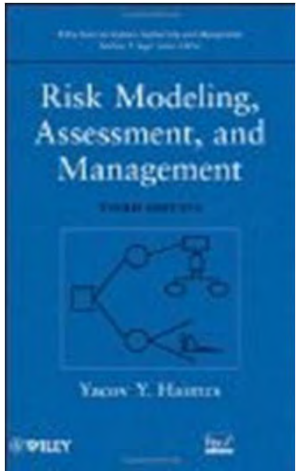
Area of Work	Activity(ies)	Proficiencies Gained
Facilitate Events using Brainstorming, C&E, Pareto Analysis	Facilitate events in the Analytics and Enforcement group requiring the collaboration of a group of people with the goal of solving a critical problem.	Gaining consensus for complex system problem sets. *Systems Engineering – Stakeholder Requirements Definition*
Perform Gauge R&R Studies	Analyze repetitive sets of data to make sure that the underlying process is statistically significant.	Providing testing, analysis and persuasive writings to support technical positions. *Reliability Engineering – Probability and Statistics Tools*
Facilitate a Process Mapping Event	Facilitate events in the Analytics and Enforcement group to help a group of individuals to map out and improve a current process.	Efficiency analysis and continuous improvement as core competencies. *Reliability Engineering – FRACAS and Root Cause Analysis*
Participate and Lead Risk Harm Assessments (FMECA Analysis)	Assess the Risk and Harm to the Bulk Electric System with a group of individuals using classic Failure Modes and Effects Analysis.	Predictive analysis and modeling as a form of a proactive reliability tool. *Reliability Engineering – Human Calibration and Estimation*
Perform Design of Experiment Projects	Use Design of Experiment methodology to reduce the number of tests required to draw a statistically significant conclusion	Ability to derive controlling elements in design or failure analysis. *Reliability Engineering – Design of Experiments*
Perform Validation of Mitigation Plans	Perform validation of evidence for plans to mitigate risk to the Bulk Electric Systems.	How to evaluate Root Cause Analysis efforts for validity *Reliability Engineering – FRACAS and Root Cause Analysis* *Systems Engineering – Validation*
Create Settlement Agreements	Analyze a set of facts and circumstances resulting in a violation of Reliability Standards and determine appropriate settlement terms.	Ability to reduce technical analysis to a description suitable for inclusion in a legal document. *Systems Engineering – Requirements Analysis*

Roadmap

Systems Engineering and Risk Analysis

"…The field of risk analysis will lose some of its current mystique, gain wider recognition, and more closely merge with the fields of systems engineering, systems analysis, and operations research…government officials, other professionals, and the public at large will have more appreciation of, and confidence in, the process of risk assessment and management…"

Yacov Haimes – *Systems Engineering and Management Series: Risk Modeling, Assessment, and Management* - 2009



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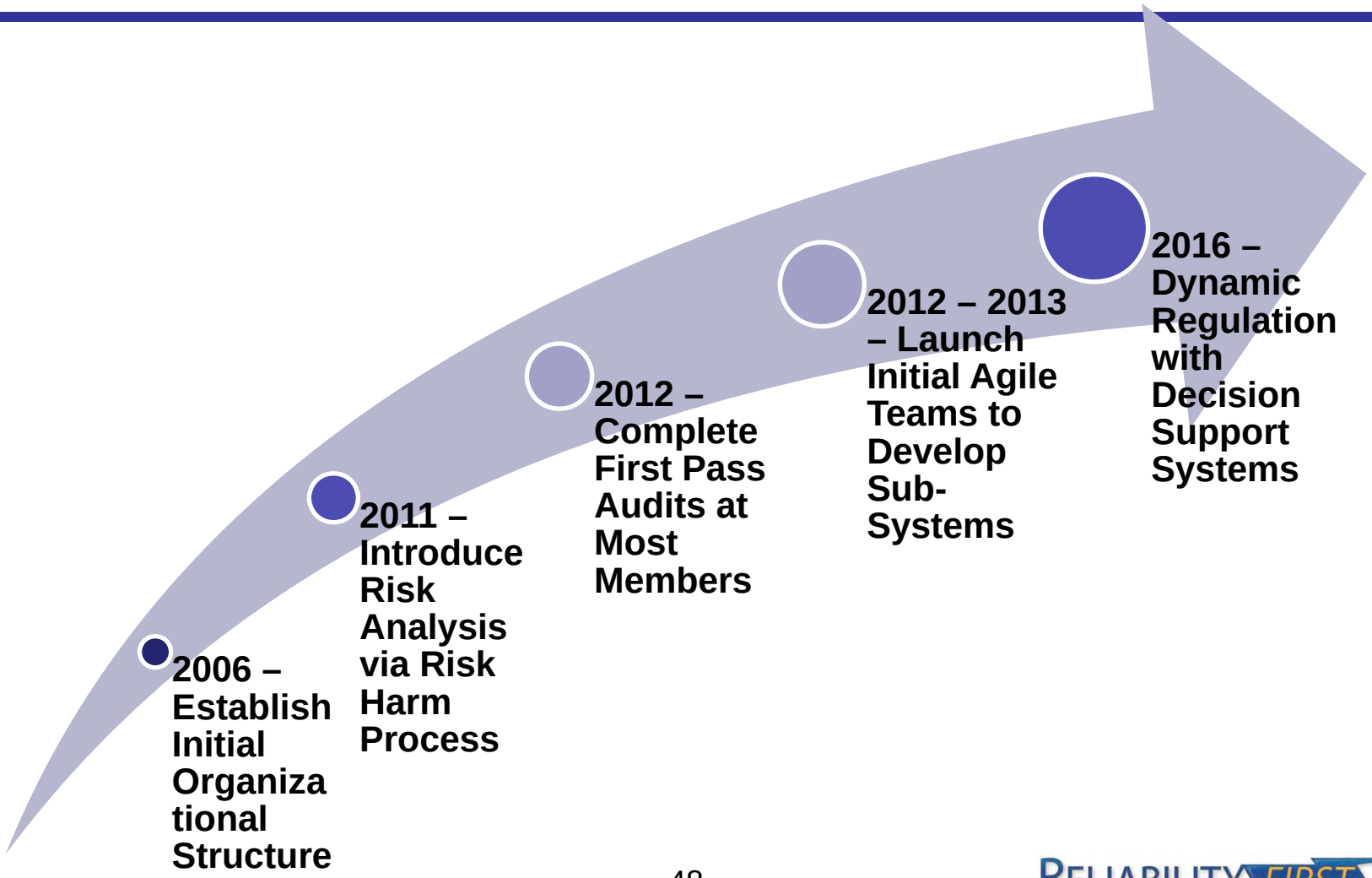
Roadmap



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Discussion

- ✓ **Is there a growing need for applying Systems Engineering and the INCOSE Model in the field of Public Policy, Law, and Regulation? If yes, how would legal professionals participate?**
- ✓ **How do the fields of Systems Engineering and Risk Management intersect?**
- ✓ **What topics covered here would be of interest in upcoming INCOSE conferences/journals or other conferences/journals?**