

NYSEARCH Risk Modeling of Pipeline Interacting Threats

*Pipeline Risk Modeling Methodologies Public Workshop
Crystal City Marriott– September 9-10, 2015*

*David Merte, P.E.
Senior Project Manager
NYSEARCH/Northeast Gas Association*

Background

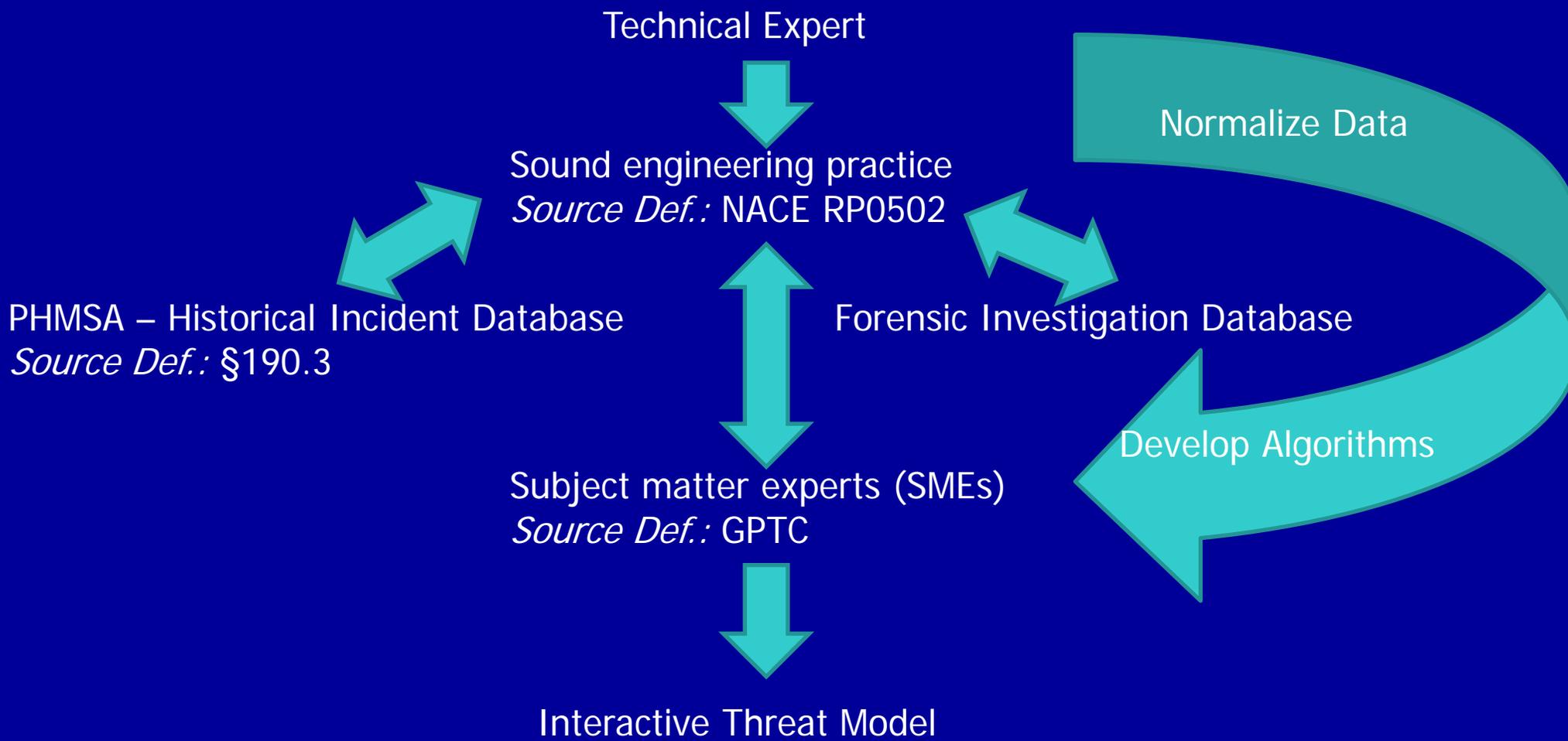
- Integrity Engineers familiar with NYSEARCH/NYGAS work in late 1990s with Kiefner on relative Risk Model
- Regulators indicated need to address interacting threats in a more thorough fashion; led to NYSEARCH project
- Identified need for study on interacting threats
- In 2011, PHMSA also expressed need for more technical work on assessment of interacting threats

Threats/Risks

- 9 / 20 primary threats from ASME B31.8S
 - External corrosion
 - Internal corrosion
 - Stress corrosion cracking
 - Manufactured related defects
 - Welding/fabrication related defect
 - Equipment
 - Third party/mechanical damage
 - Incorrect operational procedure
 - Weather-related and outside force

CD	Construction Damage
CW	Cold Weather
DFW	Defective Fabrication Weld
DGW	Defective Girth Weld
DP	Defective Pipe
DPS	Defective Pipe Seam
	External
EC	Corrosion
EM	Earth Movement
GF	Gasket Failure
HRF	Heavy Rains/Floods
	Internal
IC	Corrosion
IO	Incorrect Operation
LIGHT	Lightning
	Malfunction of
MCRE	Control/Relief Equipment
MISC	Miscellaneous
PDP	Previously Damaged Pipe
	Stress
SCC	Corrosion
SPPF	Seal/Pump Packing Failure
	Third
TP	Party
	Threads Stripped, Broken
TSBPC	Pipe Coupling
V	Vandalism

Technical Overview



NYSEARCH/Kiefner Original Risk Model

- Evaluates 9 primary threat interactions
 - Time dependent, independent and stable
- Quantifies consequence
 - Threat exposure, mitigation and resistance
- Utilizes operator specific data
 - Provides feedback mechanisms
 - Enhance with quantifiable industry data
- Incorporates SME and regulatory input
- **Interactive Threats**
 - Earth movement/girth welds
 - SCC

External Corrosion (EC)
Internal Corrosion (IC)
Stress Corrosion Cracking (SCC)
Manufacturing Defects (MFR)
Construction Defects (CD)
Equipment Failure (EQ)
Incorrect Operations (IO)
Third-party Damage (TPD)
Weather Related and Outside Forces (WROF)

NYSEARCH/Kiefner IT Goals

- Identify interacting threats
 - Kiefner Failure Database
 - SMEs from NYSEARCH Advisory Group (EC+PDP)
 - Industry papers, past experience
 - PHMSA 'Reportable Incidents Database'
- Develop rationale/technical support for selected interactions
- Develop method for quantifying interacting risks
- Develop software for calculating interacting risks



Defining Interacting Threats

$$P_{(\text{Threat 1 \& Threat 2})} > P_{\text{Threat 1}} + P_{\text{Threat 2}}$$

- Two or more threats acting on a segment or pipeline that increase the probability of failure to a level greater than (the sum of) the effects
- Significant % of DOT incident data analyzed - 2 or more interacting threats
- Interacting threat incidents included in original Kiefner risk model (SCC & EM/girth welds)
- 30 additional threat interactions identified- relative risk algorithms (9 and 20 threat versions)

Example of Interacting Threat

- External corrosion (EC) on previously damaged pipe (PDP) will occur more frequently if the external coating is damaged in an area where the cathodic protection was ineffective at preventing external corrosion
 - Thus (EC) and previously damaged pipe (PDP) are interacting where the external coating of the pipe has been damaged BUT they are not interacting when the external coating is intact



(EC+PDP)

Algorithm Development

- Normalize the number of failures due to the interaction of threats to the number of failures due to one threat only
- Compare each interacting threat to one of the individual threats. Identify one threat as the baseline (constant) and let the other threat be a variable
- Determine whether the baseline threat was associated with the driving factor or the primary cause of the failure and the other interacting threat represented a contributing condition or situation which in some way contributed to:

Algorithm Development (Cont'd)

- 1) a more rapid degradation of the pipe,
- 2) an increased stress or load on the pipe or,
- 3) a reduced tolerance of the pipe to the original flaw or loading condition

Increased likelihood of failure (%) incorporated into algorithms

- $R_{\text{INTERACTING}} = R_{\text{PRIMARY}} + \sum P_i * (R_{\text{PRIMARY}} + R_{\text{VARIABLE}})$

P_i = increased likelihood of failure for a pair of threats

20 Threat Matrix Example

ORIGINAL SCORE	
EC	115
IC	40
SCC	25
DP	40
DPS	135
DFW	10
DGW	60
CD	10
MCRE	5
TSBPC	5
GF	5
SPPF	5
IO	60
TP	295
PDP	50
V	5
EM	40
HRF	25
LIGHT	5
CW	5



INTERACTION COMPONENT
42.12
11
0
0
0
0
0
0
3.41
8.76
0
0
0
17.75
8.48
6.68
0
30.40
40.68
1.75
1.58



INTERACTING SCORE
157.12
51
25
40
135
10
60
10
13.76
5
5
5
77.75
303.48
56.68
5
70.40
65.68
6.75
6.58

TOTAL 940

1109.19

20 Threat Matrix Example (cont'd)

CD	Construction Damage
CW	Cold Weather
DFW	Defective Fabrication Weld
DGW	Defective Girth Weld
DP	Defective Pipe
DPS	Defective Pipe Seam
	External
EC	Corrosion
EM	Earth Movement
GF	Gasket Failure
HRF	Heavy Rains/Floods
	Internal
IC	Corrosion
IO	Incorrect Operation
LIGHT	Lightning
	Malfunction of
MCRE	Control/Relief Equipment
MISC	Miscellaneous
PDP	Previously Damaged Pipe
	Stress
SCC	Corrosion
SPPF	Seal/Pump Packing Failure
	Third
TP	Party
	Threads Stripped, Broken
TSBPC	Pipe Coupling
V	Vandalism

	ORIGINAL SCORE	INTERACTING SCORE	% CHANGE
EC	115	157.12	37%
IC	40	51	28%
SCC	25	25	0%
DP	40	40	0%
DPS	135	135	0%
DFW	10	10	0%
DGW	60	60	0%
CD	10	10	0%
MCRE	5	13.76	275%
TSBPC	5	5	0%
GF	5	5	0%
SPPF	5	5	0%
IO	60	77.75	30%
TP	295	303.48	2.9%
PDP	50	56.68	13%
V	5	5	0%
EM	40	70.4	76%
HRF	25	65.68	263%
LIGHT	5	6.75	35%
CW	5	6.58	35%



TOTAL 940

1109.19

18%

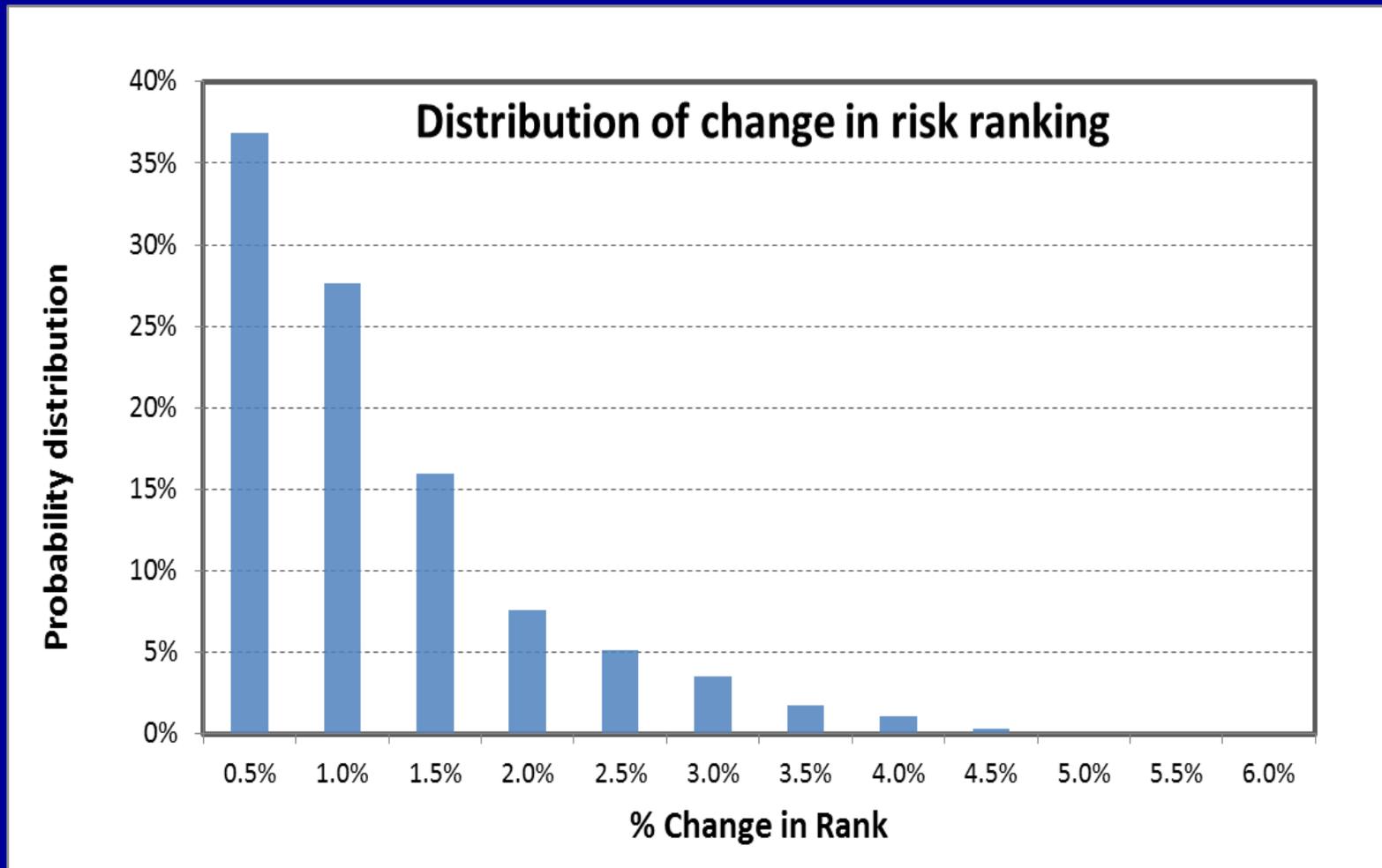
Operator Implementation

- Operators have options for updating their risk models to include NYSEARCH/Kiefner interacting threats:
- Updated NYSEARCH/Kiefner risk assessment model with an interactive threat module
- Interacting threats risk model incorporated into quantitative model (excel spreadsheet)
 - NYSEARCH Threat ID™ on-line version incorporated into quantitative model (csv files)

Operator Implementation (Cont'd)

- NYSEARCH Threat ID™ on-line version provides (9) or (20) threat versions
- The NYSEARCH designed application gathers an operator's threat data (csv files) and operational selections (e.g. ERW vintage, seamless, DSAW, couplings), a web service interface calculates the Interactive Threat results, and displays them

Operator Implementation Example



- One large operator's initial change in risk model segment risk ranking
- ($\approx 28,000$ segments)

NTSB Safety Study IT Findings

17. The **inadequate evaluation of interactive threats** is a frequently cited shortcoming of integrity management programs, which may lead to underestimating the true magnitude of risks to a pipeline.
18. The prevalence of interactive threats in gas transmission pipeline incidents cannot be determined because the Pipeline and Hazardous Materials Safety Administration does not allow operators to **select multiple, interacting root causes when reporting pipeline incidents.**
20. **Many pipeline operators do not have sufficient data** to successfully implement probabilistic risk models.

NTSB Safety Study IT Recommendations

10. Update guidance for gas transmission pipeline operators and inspectors on the **evaluation of interactive threats**. This guidance should list **all threat interactions that must be evaluated** and acceptable methods to be used.
15. Revise Form F7100.1, Annual Report Form, to **collect information** about which methods of high consequence area identification **and risk assessment approaches** were used.
16. Revise Form F7100.2, Incident Report Form, (1) to collect information about both the results **of previous assessments and previously identified threats** for each pipeline segment involved in an incident and (2) **to allow for the inclusion of multiple root causes when multiple threats interacted**.
17. Develop a program to **use the data collected** in response to Safety Recommendations [15] and [16] to **evaluate the relationship between incident occurrences** and (1) **inappropriate elimination of threats**, (2) **interactive threats**, and (3) **risk assessment approaches** used by the gas transmission pipeline operators.

- Prior to implementation of IMP risk models, Operators:
 - Collected limited interactive threat data
 - Conducted independent system analysis on threat interactions
 - Experienced difficulty quantifying and integrating interactive threat risk scores into model
- NYSEARCH IT spreadsheet or NYSEARCH Threat ID™ implementation - IT component risk scores are **data quantified and integrated** into an Operator's risk assessment model
- Utilizes industry incident & Kiefner forensic failure database

Related Operator Activities

- Identify interactive threats in all root cause incident analysis
- Conduct periodic reviews of algorithm coefficients
 - Based on operator experience (failure/incident data)
 - Based on PHMSA incident database updates
 - 2014 and subsequent annual updates planned
- Provide feedback for future enhancements

Nine Threat **Twenty Threat** **Import Lines**

Original Index		Interacting Threats										Total
Scores		Threats	EC	IC	SCC	MFR	CON	EQ	IO	TPD	WROF	Interaction
EC	115.00											
IC	40.00											
SCC	25.00											
MFR	175.00											
CON	80.00											
EQ	20.00											
IO	60.00											
TPD	350.00											
WROF	75.00											
Total:												940.00

Primary	EC	IC	SCC	MFR	CON	EQ	IO	TPD	WROF	Interaction
EC					3.31			6.04		9.36
IC					2.28					2.28
SCC										
MFR										
CON										
EQ	7.96									7.96
IO	9.62				3.22	8.08				20.93
TPD			33.38		9.46		2.46			45.30
WROF					38.28	8.74		41.65		88.67
Total										174.50

Welds: Seamless, DSAW, or post-1989 ERW pipe

Coupled: Unknown

Model: Nine

Submit



Final Report

Development of a Methodology for
Incorporating Interacting Threats into
Relative Risk Ranking Models - Online
Version

W.G. Morris, J.D. Mackenzie, H.H. Haines, and J.F. Kiefner
June 25, 2015



Inquiries on NYSEARCH Threat ID™

www.nysearch.org

Contact: dmerte@northeastgas.org