RISK MODEL WORK GROUP MEETING AGENDA and Notes

Meeting Day and Date: Tuesday, October 4 (8:30 AM) to Thursday, October 6 (3:00 PM)

Location of Meeting: Kinder Morgan, 1001 Louisiana St, Houston, TX 77002

Meeting Purpose: Consequence Aspect of Risk

**Date:** October 4-6, 2016

**Attendees:**

Participants listed at the conclusion of this document.

**Meeting Action Items (identified by “\*\*” in the notes)**

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| **Item** | **Description** | **Responsible** | **Complete** |
| 1 | Meeting logistics for the November 30-December 1, 2016 RMWG meeting (facility risk) | Saulters | X |
| 2 | Trade groups to provide consolidated comments on 1st cut rough draft of technical guidance document by end of October 2016. [Individuals are free to comment as well.] | Kurilla/Saulters/Osman |  |
| 3 | Investigate potential involvement in comment process for PHMSA R&D project DTPH56-14-00004 “Improving Models to Consider Complex Loadings, Operational Considerations and Interactive Threats” | McLaren |  |
| 4 | Add template RMWG presentation to the RMWG portion of the PHMSA PTR site (documents section) | Kuhtenia | X |
| 5 | Confirm with Matt Nicholson that Shahani will be his replacement on the RMWG | McLaren | X |
| 6 | Doodle survey RMWG for January/February RMWG meeting | Kuhtenia | X |
| 7 | Contact NTSB with respect to industry-assigned risk modeling recommendations to see if the RMWG technical document may be helpful in closing the recommendations. Include listing of applicable NTSB Recommendations in appendix of guidance document for time being for completeness. | Saulters/Kurilla/INGAA/Kuhtenia |  |
| 8 | Provide reference for DOE human performance improvement document available on the web | Hereth | X |
| 9 | Investigate if CSA paper on human factors is available for RMWG distribution. | Westrick |  |
| 10 | Get ISO 31000 and CSA Z662 Annex O for use as reference in Guidance document in definition section. Get ISO 31010 for use as reference in Guidance document and in the model/tool discussion appendix/section. | Holohan (ISO)/Spillers (CSA) | /X (CSA) |

**Agenda and Meeting Notes** [Action items indicated by \*\*]

1. Introductions / Safety Moment (Charlie Childs/Chris McLaren)
	1. Introduction of Attendees, Safety Moment, Meeting Logistics and Timing

Be careful of pedestrians vs. cars (cars tend to win).

Sign-up sheet going around for attendees.

Next meeting – November 30-December 1 (Wednesday/Thursday) at API offices in Washington, D.C. \*\* Meeting logistics to be provided by Stuart Saulters for next meeting.

1. Past Business (Admin) (Chris McLaren)
	1. Meeting minutes from last conference call previously distributed via e-mail. Any edits/changes? None identified.
	2. Review of past meeting action items
* B31.8S: No specific action items on-board related to risk modeling; Erin Kurilla has her own action item to alert the B31.8S of anything relevant from the RMWG Technical Guidance Document (for January 2017 B31.8S meeting).
* Industry/trade input on 1st cut rough draft of technical guidance document – how prefer to get comments to PHMSA. \*\* Trade groups working to get consolidated association comments together by end of October.
* PRCI report from Leewis – received one related to mechanical damage, but still need the referenced PRCI fault tree report. Action item revised to Mark Hereth.
* Team noted ongoing PHMSA R&D project DTPH56-14-00004 “Improving Models to Consider Complex Loadings, Operational Considerations and Interactive Threats” that is being conducting by Keifner/Applus RTD for PHMSA. Project roughly another 10 months to go. \*\* RMWG requested involvement in the project comment process.
* Use of RMWG Pipeline Technical Resources (PTR) site? Positive feedback. \*\* Add RMWG Team Activities (template) presentation to the RMWG PTR site (documents portion)
* \*\* Check with Matt Nicholson to see if his spot will be switched with Shahani for the RMWG, given the TransCanada acquisition of Columbia.

1. Timing and Location of Next Meeting(s) (Vincent Holohan)
	1. “Doodle survey” will be used to assist in determining the overall schedule for the rest of year so that travel arrangements can be made and assignments re-scheduled, as appropriate. Proposed dates: January 31-February 2, February 7-9, February 14-16.

\*\* Need to avoid TAC meeting (February 6) and API liquid IM meeting, NARUC meeting 2/14-15, Super Bowl is in Houston on 2/5/16. Location? Some place warm; TBD. Team may need to add a 4th week option.

1. Past Business (Chris McLaren)

Technical Guidance Document Draft Material – Team review comments and discussion on initial 1st cut rough draft material (introductory and likelihood-related sections).

TOC – Some sections in likelihood cover both likelihood and consequence aspects (e.g., selection of approach). May be better to put this as some sort of combined discussion vs. being discrete (e.g., II.C being pulled up into section I, or maybe a new Section). Also suggested to add a table of strength/weaknesses of the various approaches.

Muhlbauer says will lobby hard for one model (whatever is chosen) being what works best. Charlie Childs says maybe in theory, but in practice, there seem to be places where differing approaches may be necessary.

Kent Muhlbauer also commented that use of term “threat” is an industry issue (failure mechanisms, etc.). Suggestion for enhanced discussion on definitions, including “tools,” “models,” and “process” (see details in separate Kent Muhlbauer technical presentation).

Group: It would be good to have a definitions list is needed for consistency in the document (preferably at the front of the document). [R&D project DTPH56-14-00004 definitions may be one benchmark.] Also discussed throughout the meeting the use of ISO 31000, ISO 31010, and CSA Z660 Annex O definitions to ensure consistency. Mark Hereth mentioned that the development team on API RP 1173 worked through industry definitions in their development, and review of that document could provide insights on ensure consistency in definitions used in the guidance document.

Types of facilities/assets also need to be considered in the model selection process.

Youngblood: Traditional nuclear/NASA/etc. approaches set up risk in terms of scenarios; pipeline approach seems somewhat different (not saying bad, but just different).

Process safety type of approaches – apply to line pipe? Haase says are starting with DOT facilities; if works, may look to applying to line pipe; still conceptual.

McClymont: Does anyone use scenario-based models for line pipes? Mark Hereth: Yes; event tree driven approaches have been done in the past. Probably more like other industry practices. Hazop starts with “what can go wrong” and builds from there. McLaren: Knows of past uses, but seem to have been abandoned for line pipe due to resource constraints.

Kurilla: If industry can agree on a list of threats, that essentially defines the scenarios. Enterprise say can have way too many scenarios, so would need to be fairly high level to be useful. Kent Muhlbauer distinguishes between actual “model” and “tools”. I.e., event trees, scenarios, etc.) lead to models.

Phone participant: Entire approach is a process for ending up with a model that provides for good results.

Overall, team noted that “threats” are often the same as initiating events. Industry has already sorted through the scenarios, and these have been settled on as the list of “threats.” Need to better discuss this in the definition of risk as applied to pipeline risk modeling.

National Grid: Their approach starts with ASME threats, but then go through and look at many associated scenarios that could lead to a loss of integrity for each threat (and figure out better preventive measures). Use a semi-quantitative approach. How apply – do a one-mile section thought to be of higher risk (see Thursday R&D presentation for additional detail).

Westrick: Definitions available in ISO 31000 may be useful.

Phone: Suggest discussion of application of results into the overall risk management process. Team noted that the RMWG mission statement does not include a lot of detail on that topic, but can perhaps do in a small way. Team also noted it would be good to better define scope of the document and overall purpose/objective of guidance, especially for new readers.

Team: Should leave time at the end of the RMWG process to circle back after all meetings have been concluded to see if document organization needs to be tweaked to best bring all the information together. [Current document structure is based around the meeting structure.]

Comments on Overall Report – Level of detail, etc.? [Specificity appears to be appropriate in this guidance document, and expectations may lead to a larger document (with extensive appendices) than originally envisioned by some.]

AGA/APGA: Think models are often fine, but problems cited by PHMSA in the introduction section are not model deficiencies as much as they are model *implementation* deficiencies. AGA push back on the document position that most operators current approach (i.e., relative risk models) is inadequate for IM risk analysis purposes is too strong.

Noted that if have issues with populating data, etc., it won’t make a difference if model is better.

Data integration meeting may be a good place to address these issues.

McLaren: Maybe an “Implementation” appendix with examples of risk analysis tools and scenarios/solutions or a new section is needed? Team: Too early to say.

Hereth: Perhaps the criticizing “not good enough” bullets simply need more explanation. Also, draft document statements where incidents/accidents are cited also could use additional clarification as to what about those events is relevant (will help less experienced readers better understand the point).

Spillers: Overall, accident rates have not come down as expected, so something better needs to be done/implemented.

\*\* Trades noted the need to reach out to NTSB with respect to industry-assigned risk modeling recommendations to see if the RMWG technical document may be helpful in closing the recommendations. McLaren: Three NTSB recommendations assigned to this group by PHMSA are listed in the draft report; industry may want to add theirs as well.

Kurilla: Regulatory requirements section says necessary to quantify risk reduction for risk reduction (pp. 18) (and also later related conclusions on pp. 25). Say P&M measures needing to be quantifiable is not correct and do not like the tone of the current verbiage.

Phone: Need more verbiage related to the need for an unbiased way to combine results for different threat categories, if different approaches are used (also interactive threat aspect of using different approaches).

Saulters: How get to the implementation aspects of risk modeling? I.e., how train/help industry to actually do it right, whatever the modeling approach may be. Not sure is a PHMSA role, but important to think about.

Any need for an implementation type of presentations (workshop?) to better the actual practice of risk modeling? Potential topic for the RMWG data meeting – how measure effectiveness of modeling approach?

Human performance modeling. Not clear as to purpose/main point of this separate section? Does it need to be a separate section? Either strengthen explanation of this section via elaborating as to why is important by discussing actual events, or combine with other sections.

1. Technical Presentation #1: Integration of Likelihood and Consequence Estimations for Line Pipe Risk (Kent Muhlbauer)

Heightened time of sensitivity to pipeline accidents. Need to improve industry performance.

Marshall, MI event – $1B+ loss. If happened to be a 1E-3/yr type of event, Expected Loss (EL)=1E6 $/yr. Role of good risk analysis is to put sound numbers in front of decision makers.

Dynamic segmentation is important, vs. pre-defined lengths.

Risk-based decision making is complex, but dealing with complexity is worthwhile. Risk assessment is the centerpiece of IM. Representing risk in units allows for risk to be expressed as possible “expected loss” units for making risk based decisions. Turning relative assigned values into units is not as complex as it may seem to some. Index models can be converted into unitized models as most attributes that operators are using in relative index models are based on unitized values.

B31.8S threat categories – Kent Muhlbauer does not like “time stable” – says is actually “resistance” or “vulnerability” to either time dependent or time independent threats. Also says if treated correct will virtually eliminate interactive threats. Says Time Dependent threat list is missing fatigue (especially for liquid lines). Prefers corrosion and cracking categories (with appropriate subcategories) for time dependent threats.

Stated industry often confuses tools vs. models. Terminology is not consistently used (quantitative, semi-quantitative, PRA, etc.). Noted that in the practical sense, likelihood and probability are effectively the same.

IM objectives vs. RA techniques. Need numbers for failure rate, mitigation effectiveness, and time to failure estimates (time dependent threats) to achieve stated goals/requirements of IM.

Types of models – Absolute Results (consequence/probability combined in the results) or Relative Results. [Not SME, relative, scenario, probabilistic, etc.)

Ingredients in all models – Probabilistic methods and SME (input and validation) [Not qualitative, quantitative, semi-quantitative, probabilistic, etc.]

Weightings are basically a non-starter for Kent Muhlbauer. Stated are now not relevant for IM purposes; were designed for simple prioritization purposes. PHMSA criticism of index models is well founded; scoring issues are severe for applying to IM purposes.

Inspection of risk assessments to identify weaknesses should be straightforward.

“Map Point Test” – Should be able to pick a spot on any pipeline and be able to quickly get a risk profile of the various threats. If not able to do this readily, then model is probably not sufficient. Can always estimate data if not available (and work to get it better over time). Risk model validation can be provided by IM assessment methods (i.e., types of anomalies and number).

Stated using a weak model due to lack of data availability is a very bad practice. QRA does not really require vast amounts of incident histories; all assessments work better with better information, but that should not hold back from usage.

Essential elements of a risk analysis – eight listed. In particular, PoF: each failure mechanism must have the following elements independently measured – exposure (events/mi-year for time independent; mm/yr for time dependent), mitigation (%=1-(remaining threat)), resistance (use wall thickness as a surrogate “effective wall thickness” parameter). Time dependent threats must also calculate remaining life. Need all three for correct PoF estimate.

Consequences – Must consider range of most probable and worst-case. CoF=ProdHaz\*Spill\*Spread\*Receptors. Calculate consequence/incident. Kent Muhlbauer approach is to take incidents and prepare a table of potential outcomes (large, medium, small) and run through the CoF estimates to get a composite value.

GTI – How deal with conditional probabilities? Updated data; more rigorous applications use distributions for variables vs. point estimates and use Monte Carlo type of quantification.

Application to Facilities – utilize the same models/approach as developed for pipelines.

1. Technical Presentation #2: Emergency planning & response performance modeling (human action impact on consequences) (Pat Westrick (Marathon))

Presentation of MPLX approach to better estimating two important human actions – operator response time, and emergency response time.

Operator response time – Asking control center personnel is difficult to obtain a reasonable point estimate (tend to say “10 minutes”). Is an important factor in spill calculations, so needed a better approach. Use Monte Carlo methods to approach the problem.

Break down procedures into small sequential steps (operator actions and system response), and assign distribution for each (distributions such as Beta, that utilize min, max, most likely as the necessary parameters). Some internal logic structure involved as well (AND, OR gates).

Result is a composite distribution of response time; can apply the respective percentiles to determine characteristic operator response times.

Assumption is that the action will always eventually get done (the “fail to act” option is not currently modeled; evaluating incorporation in future analyses). Have only modeled ruptures to-date; small leaks/seepers/etc. not yet modeled.

Estimating emergency response time –

Similar approach; mix of random (uniform distribution) variables and those assigned a Beta distribution.

 Calculate response time distribution and downstream migration distance distribution.

Group: For decision making, which distribution percentiles are used? Typically use P50 for staging equipment, etc. Tend to use P95 for identifying potential receptors, etc. In general, results have shown longer than previously estimated response times. Are using this information to improve procedures to shorten times (can now quantify the amount of improvement).

Modeling of human factors for likelihood modeling? – Airline industry has ID’d a “dirty dozen” – fatigue, distractions, stress, lack of knowledge, lack of communication, complacency, lack of teamwork, lack of resources, pressure, lack of assertiveness, lack of awareness, norms. MPLX does not consider all of these, but think that several of these factors are related to likelihood. Would need to come up with associated measures to put into a model.

Complexity is one issue thought to be relevant. Communications are also important (shift turnover, etc.). Drills can be a potential source of data for human actions.

Team: Noted PG&E system (EMPAP?) to encourage ID of perceived deficiencies on the system. Involves human actions to some degree.

NTSB possible data source for human factors data.

MPLX does complexity analyses for field operations as part of their overall risk reduction activities.

Hereth: DOE human performance improvement document available on the web (<http://energy.gov/sites/prod/files/2013/06/f1/doe-hdbk-1028-2009_volume1.pdf>). Knows of one operator that is applying to all field operations.

MPLX noted that human factors is a relevant cause for accidents, so any guidance the document can provide will be helpful.

CSA group has paper out on human factors (\*\* available for RMWG use?) (Pat Westrick); PRCI is looking at potential project to look at human factors related to pipeline operations.

1. Technical Roundtable Discussion with the day’s technical presenters (Dane Spillers) Not conducted; team discussions in respective technical presentation discussions deemed adequate.

Wednesday, October 5 (8:30 AM - 4:30 PM)

1. Safety Moment (Charlie Childs/Steve Nanney)

Ladder safety – be careful over the holidays!

1. R&D Project Briefing #1: Paper Study on Risk Tolerance (<https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=639>) (Susan Rose, Principal Engineer, Kiefner/ApplusRTD)

Comparative study related to risk “limits.” Discussion on establishing tolerable and intolerable risk bands for application as criteria for when risk reduction activities must be made based on quantitative risk analysis results.

Task 1 – Literature Survey:

Quantitative and semi-quantitative risk values described, along with respective risk criteria units for individual risk and societal risk.

Pipeline specific risk criteria – Few regulatory bodies have explicit risk criteria for pipelines. Brazil, Netherlands, UK have defined individual risk criteria and societal risk criteria. UK and Netherland approaches are widely applied as the underlying basis for defined risk criteria.

UK has risk-based zone around pipelines for new developments – three levels for individual risk (IR); F-N curve for societal risk (SR).

Netherlands apply ALARA; individual risk criteria, includes vulnerable and less vulnerable receptors. Societal risk uses F-N curve.

Brazil have IR and SR criteria; full QRA required if can reach off-site receptors. State-specific criteria. Only one state requires evaluation of SR for pipelines.

Others:

France: Semi-quantitative for new facilities.

USA: Agency-specific approaches; PHMSA has class locations (gas), and HCA’s for gas and hazardous liquid. DOE has “aiming points” (not requirements) for nuclear facilities. DOD explosives handling op’s have numerical criteria; DOD defense systems use a semi-qualitative risk assessment matrix.

C-FER applies IR criteria based on class location; SR (fixed expectation, aversion function). [Noted that IR and SR are not necessarily self-consistent; are applied separately to identify which is more limiting. Use best-estimate values vs. worst-case when calculating values.] Part of Annex O in Canada as a voluntary standard.

Some approaches use Impact (Consequence Endpoint) criteria – impact only; no consideration of likelihood.

Aviation approaches are somewhat different, based on inspection/service life considerations.

Report includes has advantages/dis-advantages summary tables for qualitative/semi-quantitative/quantitative risk criteria. Also for individual risk, societal, and impact risk criteria.

Team: Does benefit of facility/operation come in to play in these evaluations? Yes, but seems to be case-specific. AGA noted that some lines have substantial societal benefit (cold weather natural gas supply) that can be season-specific that need to be considered. Spillers noted this is part of the risk a company obligates itself to when providing a service. Discussion also noted the need to recognize the overall aggregated risk/benefit in addition to the individual location-specific risk.

Task 2 – Industry Survey (pipeline companies; 24 respondents):

Most using semi-quantitative techniques (i.e. risk matrices with numerical ranges for likelihood and/or consequences) to evaluate risk.

Relative risk/index models and risk matrices are the most common methods of presenting risk tolerance levels, followed by comparison criteria and individual risk (IR).

Several operators surveyed have not established risk criteria levels, but instead use relative risk ranking to prioritize ILI assessments, identify facilities for risk assessments, and as a basis to continually work toward reducing risk.

Overall, the study found a mismatch between the risk tolerability criteria published across government agencies and international organizations (very quantitative in nature requiring the use of QRA) and the risk models used by the pipeline industry (relative risk-based, semi-quantitative). Would be difficult to apply the criteria developed by these other agencies to most risk models used by the pipeline industry.

Team: How do class locations correlate to European type individual risk criteria (for example, using the 1E-6/yr IR)? [National Grid may have insight (see separate technical presentation)]. Muhlbauer – Turns out the class 3 and class 4 risk levels seem to correlate well with the international standards.

1. R&D Project Briefing #2: Critical Review of Candidate Pipeline Risk Models (<https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=656>) (Jason Skow, Manager, Integrity & Operations, C-FER Technologies)

Create guidelines for developing and assessing probabilistic quantitative pipeline risk models based on a survey of the industry participant, regulators and subject matter experts on the attributes of a quantitative pipeline risk assessment. Also a critical review of existing quantitative risk models (including models used in other industries). Has pros/cons tables for various approaches of QRA.

Guidelines:

Developed a list of ideal model attributes – highest ranked (but not by much) by respondents were inputs, threats, resolution, and decision-making.

Obstacles to implementation – highest ranked (but, again, not by much) by respondents were level of effort for data collection/risk analysis, lack of accepted risk evaluation criteria, and lack of standardized quantitative risk models.

Most important to standardization – list of threats, including interactive. In addition, there is a reluctance to standardize the data inputs and the data storage platform – the use of existing data in all available formats to reduce the data collection effort, was preferred instead.

Literature Review:

QRA uses included meeting regulatory requirements, IM, asset risk management, and comparison of design options.

 QRA outputs most common were Individual Risk and Societal Risk.

Two approaches for combining probabilities from different threats: summation of frequencies of failures, and “weakest-link” methodology. [Both give same result for small values of probability (E-5, E-6); not that way for larger values.] [One approach scales for length, one does not.]

Other industries – probability estimation methods similar to pipeline industry, consequence models specific to each industry. Human error quantified as probabilities (detailed methods for expert elicitation).

Nuclear: standardized approaches for selected threats (have industry standard to define generally acceptable methods by the regulator). NRC has regulatory guides that define an acceptable method for PRA (endorses the industry standard).

Offshore: Application of QRA generally applied to more significant decisions.

Aircraft: Have Operations and safety Data reporting methods for Hazard identification and Human factors

Power Transmission: Looking at overall network failures, so apply network failure risk methods via graphical network methods (fault tree models/Bayesian networks).

Risk Guidelines: Provide a framework for performing QRAs. Failure frequency units/mile-year; consequence units –dollar value, number of fatalities, spill volume, or area affected.

Validation of models noted as being a complex topic (historical event data limitations). Alternative validation techniques include: component verification, hindcasting, error bounds, benchmarking, sensitivity analysis.

Noted advantages/disadvantage of SME input to a QRA. Is generally a better practice to get in small “chunks” that feed into a frequency estimation technique. Various methods exist (Delphi, NRC, etc.) to get the best quality opinion from an SME process.

Historical data: generic data sets, and generic failure frequencies with modification factors both utilized. Historical data is useful, but need to be careful in application.

Probabilistic model approaches include structural reliability methods, graphical methods, and other more novel methods (fuzzy logic, etc.).

Team: Quantitative models are preferred, but need to be careful to not over-believe the numerical results, as they are subject to certain inherent limitations.

Any estimates as to degree of uncertainty of results in practice? Can always use SME input where data is lacking, and work to improve going forward.

How compare between different systems (for example) if data quality varies? Just need to understand the differences and potential differences in uncertainty of results. Note: Non-QRA efforts also have similar limitations, so need to evaluate this in the context of other available modeling options.

Consequence Model Selection – Life safety, environmental, business

Life safety – Found models for natural gas jet fires, HVP liquids, flammable lvp liquids (proprietary). No standard models for hazardous liquids (team noted availability of EPA oil spill model), natural gas has PIPESAFE and the PIR formula.

Environmental impact – no standard quantification

Financial impact – proprietary models

Failure modes – magnitude of release (small, large, rupture) impacts level of consequences (seepers being the potential exception).

Decision making – uses include comparing pipeline risk to risks to the risks associated with other facilities, ranking segments within a pipeline system, identifying dominant failure threats, and cost-benefit analyses.

1. R&D Project Briefing #3 Paper Study on Review of Approaches for Preventing Catastrophic Events (<https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=638>) (Ernest Lever, R&D Director, Infrastructure, GTI)

Events have complex causal factors. [Noted that safety culture is very important.] No silver bullet – diversity is key to prevention (diversity in this context defined as “multidisciplinary approaches involving all stakeholders at multiple levels, allowing local autonomy of decision making while enforcing communication between the lowest and highest strata in an organization and its surroundings.” Causal factors are often interrelated.

Ability of existing risk models to identify/prevent catastrophic events? Reviewed barrier models, QRA, Layers of Protection approaches. Importance of precursors noted, and operating/company safety culture. Multi-disciplinary approach allows for emerging threats and causal factors to be identified prior to low frequency failures. Understanding the interactions between supply chain, near miss analysis, performance metrics, human behaviors and errors, and other results of analyses help identify emerging threats on which risk reduction measures can be taken

Stakeholder interviews – eight specific areas of improvement identified: Defining Catastrophic Events; Safety Culture; Probability vs. Consequence; Hiding Behind the Code; Threat Interactions; Lack of Lessons Learned, Transparency, and Internal Audits; Lack of Imagination; Lack of System Understanding.

State of the art in risk assessment – moving away from linear methods; systems of systems thinking; the good judgment process (foxes and hedgehogs); addressing deep uncertainty through adaptation; likelihood modeling using accident precursors and approximate reasoning; understanding complex system interactions; understanding coupled systems,

Risk governance frameworks and enhancements – diversity of approach and frequent revisiting of assumptions is important. Using multiple models with diverse approaches increases the robustness of our decisions under extreme uncertainty. Difference between optimized organizations and vulnerable organizations is not really different close to the mean, difference is in the tails (e.g., very localized conditions can have a large impact on potentially catastrophic events occurring).

Cognitive reasoning frameworks stated as being needed that involve integration of data into a cognitive reasoning framework.

1. Technical Presentation #3: Hazardous Liquid consequence modeling (Brandon Cavendish (Colonial Pipeline))

Risk analysis provides an objective measurement of which option is “best”: Anchors subjective judgements to an objective number, and minimizes emotion. At end of the day, helps to inform decisions related to additional preventive measures and mitigative measures (but not entirely on its own).

Probabilities generally in terms of incidents/year; consequences in $/incident.

Consequences involve spill modeling, and identification of potential path to receptors (primarily HCA data (population, drinking water, etc.). Noted that assumed spill volumes tend to be very conservative; are generally not best-estimate.

At the current time, receptor data sets stated to be either too general, or inappropriately granular for risk analysis. As such, consequence estimates are generally not conducive to a defendable financial impact analysis. Presenter questioned the quality of commercially navigable waterway and ecological data.

Noted reluctance of industry to adopt human life monetary values.

Plan is to look at multiple spill scenarios (volumes) from different failure modes based on historical data. This prevents assuming a worst case scenario for every spill probability across all threats. Current key conservative assumptions being evaluated include origin of spill above-grade, no infiltration/evaporation, conservative stream velocities, no consideration for emergency response/spill mitigation.

Use multiple receptors to evaluate consequence, not just HCA data. This combination provides a better indication of potential expected loss of an event.

Point is to do a mitigation analysis to identify those options that have the best expected risk reduction value. Note: Only considering worst-case makes it hard to optimize resources (i.e., not waste $ on things that will essentially never happen).

Team: What level/percentile of consequence is acceptable? P95, P50, etc.? Not sure, but is worthwhile to estimate something different than worst-case. Analogy to nuclear power 95/95 criteria (no more than 5% uncertainty that 95% of values are accounted for) noted by the team.

Have not yet done detailed scoping studies to evaluate impact of revising the leak/impact estimates. Do not anticipate changing any HCA mileage designations.

1. Technical Roundtable Discussion with the day’s R&D presenters (Vincent Holohan) Not conducted; team discussions in respective technical presentation discussions deemed adequate.

Thursday, October 6 (8:30 AM - 3:00 PM)

1. Safety Moment (Charlie Childs, Chris McLaren)

Distracted driving – cognitive, visual, and manual. Texting while driving includes all three! Be careful on the way home.

1. Supplemental Technical Presentation #3: Hazardous Liquid consequence modeling (Brandon Cavendish (Colonial Pipeline))

Example shown (still worst-case) of spill migration; noted that may municipalities/counties have available land usage data, including property values, that can be useful in determining $/incident (e.g., may have to purchase property to remediate in some cases).

National Land Cover data set can provide additional ecological information.

Other impacts include downtime, cost of lost product, mobilization and direct costs, legal costs, investigations/corrective actions/fines, etc.

Have not yet decided how to address $/incident values; under evaluation. Have used an index model to-date. Reluctant to assign a $/life.

Benchmarked the recent real-life spill vs. the modeling of spills in that area? Comparison said to be “what they expected”; area of actual spill bounded by the spill migration analysis of record.

Team noted that subsurface features (including man-made things like field tiles) are generally not modeled; remaining area of evaluation for industry. Especially for non-worst case releases. Can be more important depending on local practices and geology.

Others noted that this level of detail is one reason that operators find relative models to be beneficial – e.g., may not know precisely where tiles go, but probably know if there is a higher concentration of drainage/tiles in one area vs. another.

1. Technical Presentation #4: Highly Volatile Liquids (HVL) consequence modeling (Jake Haase (Enterprise))

General background/perspective on risk modeling – There is a difference between what the operators’ perspective is vs. vendors, with PHMSA likely being somewhere in the middle. Guidance document should establish proper *usage* of risk models. Operators use risk models in different ways, so the effort should be useful in helping industry understand expectations. Enterprise supports the use of relative/index models. [Noted that have a lot of supporting engineering data for their index scores, so would likely have a good start if quantitative/probabilistic models are required by regulation.]

[Use PODS as the repository for hard asset data. Have separate database for ILI data, but is not really integrated with PODS. Bring various data sets together via an “exchange” process that feeds the risk model. Note: Moving to component-based data (pipe joint, elbow, etc.), so will likely not support a dynamically segmented model in the future.]

Currently use a Dynamic Risk relative model. Have range of commodities from crude to HVLs. 2” to 42” lines. Wide geographic area. Very diverse. Also have seasonal variations in transported commodities.

HVL modeling – Part 195 definition. Enterprise also includes Y-grade (natural gas liquids) in their internal definition (noted this commodity has a lot of variability in transported characteristics in practice). Risk model has to accommodate this range of commodity.

Consequence equation (from Dynamic Risk model) is a relative index. Do not assign specific $/life values or $/environmental impact. Neglect business considerations in the relative risk index; assign 0.5 weighting to both human and environmental scores.

Three impact types – Flammability Hazard Area, Toxicity Hazard Area (H2S content), Overpressure Area (vapor cloud scenario) – apply the one that is the most conservative for any given receptor area.

* Flammability hazard release rate assumptions are assigned by type of threat involved via assigning an average hole size. Derive a release rate based on basic physics. Apply API 581 information.
* Toxicity hazard based on API 581.
* Overpressure hazard area calculations based on TNT equivalent Equation for Hard radius.
* Then look at population density based on HCA areas (provides population density). Are not directly looking at dispersion circle, just look for highest impact HCA and apply the corresponding relative risk factor.
* Then calculate a safety hazard impact and assign a qualitative score (1-10) based on this calculated value.

Environmental consequence – use cleanup cost (based on HCA) as a proxy. Assign a qualitative score (1-10) based on cleanup cost.

Stated are very deterministic when it comes to P&M measures; risk results are considered, but not as a primary driver. Rely more on things like ILI runs and integrity engineer analysis.

Have a separate risk model for facilities (but can sometimes apply information from line-pipe risk/integrity efforts when appropriate). How manage risk between facilities with respect to balancing level of effort? Look at risk and what conditions may be present; if think needs attention, will address, but not in a risk model-driven way. How know where change is occurring? Performance measures, etc.? Not clear. Stated is more SME based; considers a variety of information, risk is just one part of that process.

Jacob Steere: Question usefulness of more quantitative models if have to make a lot of assumptions where data is not actually available (vs. using known information for relative models). Wondered if anyone has done an evaluation to see which is better?

Bottom Line: Enterprise stated that a quantitative risk model is really not necessary if integrity engineers have all of the information that would be adequate for a quantitative model – i.e., a risk model is not the preferred method of data integration for Enterprise; integrity engineers are better. Use relative risk to help prioritize the identified actions/needs.

Team: Do not know of any terrain-considering models used for vapor dispersion. Noted that most vapor clouds never fully develop (ignition often occurs first), so extent of impact estimates are usually conservative.

Team: Consider confined space for overpressure? Enterprise only uses unconfined, given their operating environment, line pressures, etc.

How handle products such as butane that have a boiling point close to ambient (i.e., HVL, liquid, or both)? Treat butane as HVL.

1. Technical Presentation #5: Gas Transmission Consequence Modeling (Mike Kern, Steve Altbacker (National Grid))

Modeling history – Phase 1: Started with Kiefner model with NYSEARCH. Also used Muhlbauer model and an SME model. All three perspectives provided a check and balance, used to prioritize IMP inspection programs. Gave some understanding of threats that drove highest risk-ranked pipeline systems.

Phase 2: Kiefner Interactive threat model with NYSEARCH; updated with newer IMP information. Then developed a common risk model with NG UK Gas Transmission – Muhlbauer. Use was mandated after acquisition by National Grid, who needed one model for all company assets.

Phase 3: Process safety – Company formed process safety group (trying to ID potential for major accidents). All major accident hazard groups in company required to perform PHA’s (process hazards analysis) and LOPA’s (layers of protection analysis). Identified highest ranked segment for – urban, suburban, rural areas. [Noted very hard to do a PHA for line pipe, but did help to understand relevant threats and potential mitigative action.]

Phase 4: Quantitative Risk Modeling. Wanted clear understanding of absolute risk for each operation company (did for highest risk-ranked segment for urban, suburban, rural for each company). Used Pipesafe modeling program (NG-specified based on UK experience) to calculate Individual Risk (IR) and Societal Risk (SR). Provides ability to measure impact of candidate P&M measures.

[Note: Use of QRA is not exclusive. NG now has a collection of tools developed over time that can be exercised as needed.]

 Have four cause categories – TPD, corrosion, construction et al.,

 Primary was TPD, so focused on that aspect for the application of QRA to-date.

Risk Tolerance – IR and SR calculated; if found to be in the ALARP region (in between way too high, and acceptably low risk), identify P&M measures to reduce risk.

 Inputs – Used 1 mile segments of pipe to characterize

 Failure cause – Primarily TPD (based on previous LOPA work)

 Failure Frequency – UK data modified for USA

 Failure Mode – Assumed rupture; 50/50 immediate/delayed ignition

 Consequence – Effects of thermal radiation on surrounding population

 Output - NG US specifies a broadly acceptable IR of 1E-6/yr and associated SR F-N curve

What If Scenarios – If over acceptable risk, look at P&M measures and estimate impact (depth of pipe, protective slab, increase pipe wall thickness, reduce MAOP, etc.)

Have modeled 11 pipelines to-date (representative 1-mile section)

Brooklyn Backbone (Class 4) – IR okay, SR in ALARP region. Note: Already in compliance with federal and state reg’s, but still wanted to bring SR down below limit. Changed ROW patrols to be daily; most cost effective way to reduce SR. Applied to all eight miles of section, based on the one-mile analysis.

Team: Consider transient/temporary population (subway going by, etc.)? No, just use the static population density. People indoor/outdoor? Not sure, but may not be much difference in this densely urban context as escape paths are limited. Estimate of resources? Roughly $10-20K for each pipeline section plus roughly 80 hours for data prep (actual PipeSafe analysis done by contractor).

PL-16 (Class 2 and 3) – One-mile section through a shopping plaza in upstate NY. IR and SR above acceptance limit. Increased patrolling to not to exceed three days for Class 3 locations. [Some options such as material grade measures and (especially) wall thickness increase were found to be effective risk-reducing actions, but are mostly being considered for future design considerations. Are evolving from a prescriptive code-based design process to more of a risk-based design process.]

Note: Some lines were replaced for both risk-based reasons and other circumstances that made replacement the best option.

 Other lines passed IR and SR criteria without further TPD preventive measures.

Lessons learned – First time to have risk in absolute terms helps to quantify options (also helps for rate case decisions); data requirements understood (internal and external); results need to translate in to real actions. Insights for future pipe design are also valuable for future risk reduction.

Team noted the value of a tiered approach to determining the best risk tool to apply to a given analytical need.

1. Review of Technical Presentations (Part I): Main take-aways (CJ Osman, Dane Spillers)

Main take-aways:

* 1. Technical presentation #1 Risk Analysis (Muhlbauer) Risk modeling is part of overall risk management, and both are complex processes that are helped by using risk models. Risk modeling is a central aspect of IM – if a prospective model can support the IM objectives, it should be an adequate tool to use. [Group discussion related to component failure treatment in the suggested Muhlbauer categorization of threats.]

Team noted need for discussion of various risk tools, and when appropriate to use in the guidance document. [Team noted ISO 31010 referenced a good source for this discussion.]

* 1. Technical presentation #2 Human Action Impact (Westrick) Figuring out a best-estimate value for operator actions via SME opinion is problematic; assigning distributions is helpful to minimize bias associated with point values, and provided better estimates.
	2. R&D Presentation #1 (Kiefner) Risk tolerability framework/philosophy of ALARP is relevant to all approaches (qualitative, quantitative, etc.). Team: Noted that qualitative resource can be perceived as less resource intensive, but may not actually be the case given the amount of review/interpretation associated with qualitative approaches.

Thresholds/target risk values have been established internationally and in other domestic industries. Most pipeline operators stated as currently using semi-quantitative approaches.

Team: Tiered approach can be an important aspect of practical approaches to pipeline risk modeling.

* 1. R&D Presentation #2 (C-FER) List of Ideal Model Attributes – inputs, threats, resolution, decision-making noted as being the most important. Variety of quantitative models being used. Better standardization for gas consequences than for hazardous liquid consequences. SME input is valuable but needs structure to be valid and repeatable.

Team: Noted important for technical guidance document to have guidelines for things like SME input, data preparation, model development, etc. in addition to just stating “simple index models are not good enough.”

* 1. R&D Presentation #3 (GTI) Historical accidents in various hazardous industries reviewed to gain lessons learned. Safety culture is very important (as focused on the actual hazardous process, not just work safety perspective), and organizations should not ignore the small precursor indications (abnormal events, etc.) that existed prior to the events.
	2. Technical presentation #3 HL Consequences (Cavendish) Resources must always be prioritized. Important to define terms when discussing risk (important for the guidance document). Analysis to-date based on worst-case spill cases; may be better to include more best-estimate analysis.
	3. Technical presentation #4 HVL Consequences (Haase) Apply a semi-quantitative index model; contains many elements of quantitative modeling.

Team: Noted organizational reluctance to always explicitly define quantitative results, so is easier to express in relative risk terminology.

Team also noted importance of risk results having a sufficient range of results in order to adequately discriminate changes in risk levels for system/P&M changes (may be important to include in technical guidance document). One example would be to evaluate impact of ILI assessment (as a preventive measure) on risk results – if no change, leads to questions of ability of model to reflect actual risk.

* 1. Technical presentation #5 GT Consequence Modeling (Altbacker/Kern) Not included in summary presentation (just completed).
1. Document Feedback Summary (McLaren)

Team discussed summary of feedback related to the next draft of the RMWG Technical Guidance Document.

1. Facility Risk modeling (lead-in for next meeting): Overview of facility risk modeling challenges (Chris McLaren) Industry representative speaker suggestions requested by October 12.
2. Types of models & approaches
3. Respective advantages & disadvantages
4. How to treat threats in conjunction with line pipe risk modeling?
5. Exit De-briefing (Chris McLaren)
6. Overview of technical guidance document meeting summary comments:
* Introduction section – Include the objectives of the team and document, how to use the guidance, the how and why,
* Definitions – Needs a specific definitions section in the front of document: look to ISO 31000, ISO 31010, AMSE B31.8S, z662 Appendix O. Include difference between models and tools; diagram showing relationship between risk analysis, risk assessment (including criteria), and risk management could be helpful.
* Make section 2C (Selection of Approach) including selection process and implementation discussion, its own section.
* Look at all NTSB Recommendations again related to RMWG (PHMSA, AGA, INGAA) and include in Appendix of consideration throughout process.
* Include Appendix with examples and scenarios related to selection and implementation.
* Tone of certain sections of guidance documents – address concerns on certain sections identified during meeting and to be identified in comments (e.g., 2C, 2I, and not limiting P&MM from index models). Discussed that implementation deficiencies identified during certain inspection can be issues regardless of whether or not models are an issue.
* Continue to discuss uncertainty leading towards data meeting.
* Continue to discuss human performance modeling and its impact on risk modeling
* Recommendations and implementation.
* Objectives of risk modeling:
	+ P&MMs
	+ High Consequence, low probability events – use of tools to identify where “tails” are significant enough to identify areas where barriers can be implemented.
1. Any needs from scribe for exit notes? None identified.
2. Any group member comments on the conduct of the meeting and any improvements that could be implemented? None identified.

**Attachment 1 – Meeting Participants**

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| **Pipeline Risk Modeling Work Group Meeting; October 4-6, 2016** |
| Name (First) | Name (Last) | Organization |
| Stephen | Altbacker | National Grid |
| Brandon | Cavendish | Colonial Pipeline |
| Peter | Chace | PUC of Ohio (NAPSR) |
| Charlie | Childs | Kinder Morgan |
| Mark | Clayton | CenterPoint Energy |
| Mohamed | Elaoudiy | Phillips66 |
| Robert | Fristoe | Phillips66 |
| Jake | Haase | Enterprise Products |
| Mark | Hereth | INGAA |
| Vincent | Holohan | PHMSA |
| LaCharles | Keesee | Excel Energy |
| Michael | Kern | National Grid |
| David | Kuhtenia | PHMSA (Cycla) |
| Erin | Kurilla | AGA |
| Ernest | Lever | GTI |
| Mason | Matthews | Athens Gas Utilities (APGA) |
| Andy | McClymont | PHMSA (Cycla) |
| Chris | McLaren | PHMSA |
| Kent | Muhlbauer | WKM Consulting |
| Christopher | Osman | INGAA |
| Sheila | Ramamurthy | CNP |
| Susan | Rose | Kiefner |
| Stuart | Saulters | API |
| Jason | Skow | C-FER |
| Dane | Spillers | PHMSA |
| Jarod | Tooley | Kinder Morgan |
| Pat | Westrick | Marathon Pipeline |
| Bob | Youngblood | Idaho National Lab |
| **On-line:** |
| Steve | Allen | URC of Indiana (NAPSR) |
| Peter | Chace | PUC of Ohio (NAPSR) |
| Steve | Nanney | PHMSA |
| Mark | Piazza | Colonial Pipeline |
| Jacob | Steere | Consumers Energy |