Risk Prioritization Methodology for PTC System Implementation

REVISION HISTORY

Date	Revision	Description	Author

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1 Risk Prioritization

Risk prioritization is a continuous process that is accomplished throughout the life-cycle of a system. Effective risk prioritization depends on planning; early identification and analyses of risks; continuous monitoring and reassessment; communication, documentation, and coordination. This planning, identification, prioritization and ranking process provides the railroad a sample methodology for the ranking of PTC system deployment efforts.

Prioritization can be based on quantitative methods, qualitative methods, or a combination of both. The qualitative methods described rely on a holistic response or common sense ranking. The quantitative approaches rely more on comparative analysis that can be translated into mathematical scores. When the number of attributes that are considered pertinent is relatively small, a subjective or qualitative process may be used. The greater the number of attributes, the more likely it is that a more quantitative approach will be useful in assigning priority. A qualitative method judges the priorities based on perceived pros and cons (i.e., benefits and costs). The method is best used when it is not possible, or appropriate, to identify a quantitative measure of benefits and costs. Each action can have a unique advantage or disadvantage that can subsequently be used for prioritization.

A simple score quantitative method is to assigns relative scores based on qualitative factors. Importance is rated as High, Medium, and Low, with respect to Social, Technical, Administrative, Political, Legal, Economic, and Environmental factors. These factors are uniformly treated, with no distinction between them. A common-sense adjustment is the weighted score method which attempts to compensate for the limitations of simple score by adding emphasis to those factors judged to be more important.

The proposed approach for prioritization is the weighted score method. Each of the factors is evaluated, and given a score between 1 (lowest risk) and 5 (highest risk) that defines the individual relative level of risk associated with that factor.

$$\text{Individual relative level risk} = \{1, 2, 3, 4, 5\}$$

Once the level of individual relative risk associated with that factor has been determined, it is multiplied by the relative importance of risk factor relative to all of the factors. The values assigned to the importance factors must sum to 1.

$$1 = \sum \text{(individual relative importance}$$

For example, consider the situation where there is one railroad line segment with three risk factors A, B, and C. Analysis of A, B, C results in A being assigned a score of 5, B assigned a score of 1, and C assigned a score of 3. In terms of importance, A has been assigned a relative importance of 0.4 with respect to B and C, B a relative importance 0.5 with respect to A and C, and C a relative importance of 0.1 with respect to A and B.

$$\text{Line Segment Risk} = (5)(0.4) + (3)(0.5) + (1)(0.1) = 3.6$$

This process is carried out for all line segments, allowing the risk associated with each line segment to be compared relative to the other line segments. For example if the analysis of line segment 2 resulted in a line segment risk of 2.4, and the analysis of line segment 3 resulted in a line segment risk of 4, the relative level of risk for these three line segments from highest risk to lowest risk would be

Line segment 3, risk = 4.0
Line segment 1, risk = 3.6
Line segment 2, risk = 2.4

There is a danger in providing this sample methodology. First of all, because it is written as a guide for a general audience, it may not satisfy all of the needs of any particular railroad. Second, there is the possibility that some prospective user will simply adopt the methodology as written, despite the fact that it does not fit his or her program. We discourage this. The reason for providing this sample methodology is to give railroads a starting point for their own planning process.

2 Prioritization Attributes and Weighting Factors

49 CFR 236.1011 defines a minimum set of risk factors that are to be considered to determine the level of risk associated with a particular line segment. The railroads analysis shall consider these factors. The minimum critical factors that must be addressed are:

1. Annual Million Gross Ton (MGT) levels;
2. Presence and volume of passenger traffic;
3. Presence and volume of TIH/PIH material (loads and residue) transported;
4. Number of tracks;
5. Method of Operation;
6. Speeds of train operations;
7. Track grades and curvatures;

However, additional factors may also be present. Each railroad must tailor their analysis to account for these additional factors. Other route attributes bearing on risk that may be considered include:

1. Rail traffic density;
2. Trip length for route;
3. Track type, class, and maintenance schedule;
4. Presence or absence of block signal, train control, or cab signal systems;
5. Presence or absence, and types, of wayside hazard detectors;
6. Number and types of at-grade crossings (both highway-rail and rail-to-rail); x
7. Frequency and location of track turnouts;
8. Public venues along the route (high population density, stations, events, places of congregation, etc.);
9. Presence of other equipped and non-PTC-equipped traffic along the route (shared track);
10. Past accident/incident statistics;
11. Hazards to human health and the environment.

The factor relative risk, as well as the factor importance, may vary depending on the environment in which the railroad is conducting operations. Each railroad will have to adjust these parameters to account for their own unique situation.

2.1 Estimation of Hazards to Human Health and Environment

As part of the Non-Accident Release Program, the AAR, in cooperation with the American Chemical Council and the Canadian Chemical Producers Association, has developed the Non-Accident Release Risk Index (NARRI) that provides “a mean to review and study incidents in a multi-dimensional format by evaluating the critical risk elements” The NARRI index can be used as a means of evaluating the impact of not only TIH, but other critical hazards materials and their impact on human health and the environment. The NARRI Index evaluates preventative factors, shipping & packages, product hazards, extenuating risk factors, environmental impact, and human impacts that can be used to determine an incident severity index. This incident severity index in turn can be used as the un-weighted estimator of the hazards to human health and the environment.

Table 1, extracted from Association of American Railroads Hazardous Materials (BOE) Working Committee Report of February 2001, provides the scoring factors used to determine the un-weighted estimator.

A. Preventative Factor (use Highest Score)	
Obvious or Blatant Human or Process Failure	5
Other Non Accidental Release	2
B. Shipping Packaging Factor (Use Highest Score)	
Loaded Bulk Container	5
Residual Bulk Carrier	4
Loaded Non Bulk Carrier	3
Residual Non Bulk Carrier	1
C. Product Hazard Value (Use Highest Score)	
Division 1.1, 1.2, 1.3, 2.3, 5.2 (Organic Peroxides) 6.1 (Explosive Zones A and B) and 7	10
Division 4.3 (Anhydrous Ammonia)	9
Class 8, Class 8.1 (Packing Group 2)	7
Division 2.1	5
Division 3, 4, 5.1 (Packing Group 2)	5
Class 8, 6.1, (Packing Group 2)	5
Class 3, 4, Packing Group 2)	3
Division 1.4, 1.5, 5.1, 5.2 (Packing Group 2)	3
Class 8, 6.1 (Packing Group 3)	3
Division 2.2 (except Anhydrous Ammonia)	1
Class 9	1
Class 3, 4, 5.1 (Packing Group 3)	1
Combustible Liquids	1
D. Extenuating Factors (Add All Scores that Apply)	
Product is environmentally sensitive chemical	5
Product is PIH (Excluding Class 2.3, Division 6.1, and Anhydrous Ammonia)	2
Product has a subsidiary hazard class of 6.1 or 8	1
Product is a hazardous waste	1
E. Environmental Impact Factor (Use Highest Assigned Score Only)	
Greater than 1000 gallons or greater (or) 10,0000 pounds or more released	5
Greater than 100 gallons to 1000 gallons (or) greater than 1000 pounds to 10,000 pounds released	4
Greater than 10 gallons to 100 gallons or greater than 100 to 1000 pounds released	3
0 to 10 gallons (or) 100 pounds released	2
F. Human Impact Factors (Use Highest Assigned Scores Only)	
Evacuation of yard, facility or public area and/or closure of public roadways (does not include isolation measures)	4
Death resulting from exposure (employee or public)	10
Hospitalization due to exposure (employee or public)	7
Exposure to product resulting in injury (FRA reportable employee or public)	5
Exposure to product requiring decontamination or treatment and release from medical facility and/or on-site first aid (Not FRA reportable)	2

Table 1: NARRI Factors (Source AAR)

Incident Severity Index (IS) = Un-weighted Hazards to Human Health and Environment(HHE)

$$HHE = A(B + C + D)(E + F)$$

As an example calculation, consider the situation where the railroad projects the following accident scenario that may occur based on historical data.

The accident is obviously a human factors accident (A = 5), with a residual bulk carrier (B = 4) of anhydrous ammonia (C = 9) as a hazardous material (D = 1) that dumps 100 pounds (E = 2) that results in an employee death (F = 10)

$$HHE = 5(4 + 9 + 1)(2 + 10)$$
$$HHE = 840$$

2.2 Risk Factor Scoring

For other risk factors a specific relative risk value is assigned to each applicable factor threshold. A factor threshold may or may not be defined for each possible relative risk value. The assignment of relative risk values must be ordered consistently across all risk factors, e.g. lowest-to-highest.

An example of assignment of relative risk values to the required risk factors appears below. The risk factor thresholds and assignment of relative risk values to them in the example are strictly for illustrative purposes.

Risk Factor 1: Annual Million Gross Tonnage (MGT) Level;

- 0= less than 5 MGT
- 1= between 5 and 20 MGT
- 2= between 20 and 35 MGT
- 3= between 35 and 50 MGT
- 4= between 50 and 65 MGT
- 5= more than 65 MGT

Risk Factor 2: Presence and volume of passenger traffic on segment

- 0= No passenger
- 1= between 1 and 2 passenger trains per day
- 2= between 3 and 5 passenger trains per day
- 3= between 6 and 10 passenger trains per day
- 4= between 11 and 20 passenger trains per day
- 5= more than 20 passenger trains per day

Risk Factor 3: Presence and volume of TIH/PIH on segment:

- 0= 0 cars
- 1= between 1 and 100 cars annually
- 2= between 100 and 300 cars annually
- 3= between 300 and 700 cars annually
- 4= between 700 and 1000 cars annually
- 5= more than 1000 cars annually

Risk Factor 4: Number of Tracks

- 5= 1 Main Track
- 3= 2 Main Tracks

1= more than 2 Main Tracks

Risk Factor 5: Method of Operation
1= Any Method with ATC or ACS
2= Traffic Control
3= Bi-Directional ABS
4= Current of Traffic ABS
5= Non-Signaled

Risk Factor 6: Speeds of Train Operation
1= Less than 20 MPH
2= between 20 and 40 MPH
3= between 41 and 79 MPH
4= between 80 and 110 MPH
5= more than 110 MPH

Risk Factor 7: Track grades and curvatures;
1= grade less than 0.5 %
2= grade .5 %- .9 %
3 =grade1 % - 1.4 %
4=grade 1.5 %-1.9 %
5=grade 2 % or more

Risk Factor 8: Track type, class and maintenance of segment
5 =Class I or Excepted track
4 =Class II or Class III track
3 =Class IV or Class V track
2 =Class VI track
1 =Class VII or better

Risk Factor 9: Number and types of at-grade crossings (both highway-rail and rail-to-rail) per mile of segment;
1 = no crossing
2=.less than 1 per mile
3=1 to less than 2 per mile
4=2 to less than 3 per mile
5=3 or more per mile

Risk Factor 10: Frequency and location of track turnouts (sidings);
1 = no turnouts
2=less than 1 per mile of segment
3= 1 to less than 2 per mile of segment
4=2 to less than 3 per mile of segment
5=more than 3 per mile of segment

Risk Factor 11: Public venues along the route (high population density, stations, events, places of congregation, etc.);

1=wilderness rural
2=rural
3=suburban
4=town
5=city

Risk Factor 12: Presence of other equipped and non-PTC-equipped traffic along the route (shared track) on segment

1= no non equipped traffic
2=25% or less non-equipped
3= 25 to less than 50% non-equipped
4= 50 to less than 75% non-equipped
5= greater than 75% non equipped

2.3 Factor Relative Importance

For each risk factor to be included in the analysis, a specific importance value or weight is assigned. An example of assignment of importance values to risk factors appears below. The risk factors chosen and the assignment of factor importance values to them in the example are strictly for illustrative purposes.

Factor	**Variable**	**Relative Importance (Weight)**
Annual Million Gross Tons (MGT) Level	X_1	.20
Presence and Volume of Passenger Traffic	X_2	.25
Presence and Volume of TIH/PIH material (loads and residue)	X_3	.25
Number of Tracks	X_4	.05
Method of Operation	X_5	.10
Speeds of Train Operations	X_6	.10
Track Grades and Curvature	X_7	.04
NARRI Score	X_8	.01
TOTAL		1.0

2.4 Risk Calculation

The risk for any segment is given by the following formula:

$$Line\ Segement\ Risk = \sum_{i=1}^{n} FR_n\, FW_n$$

Where

FR_i = Factor i Relative Risk value; and

FW_i = Factor i Relative Importance value (weight)

In the case of the risk factors from 2.3 , and assuming
X_1=1; X_2= 3,X_3= 4, X_4= 1; X_5= 1,X_6= 2, X_7=2; X_8=HHE=

$$Line\ Segement\ Risk = (0.2X_1) + (0.25X_2) + (0.25X_3) + (0.05X_4) + (0.1X_5) + (0.1X_6) +) + (0.04X_7) + (0.01X_5)$$

$$Line\ Segement\ Risk = (0.2(1)\ \ ) + (0.25(3)X\ \ ) + (0.25(4)\ \ ) + (0.05(1)\ \ ) + (0.1(1)\ \ ) + (0.1(2)\ \ ) +) + (0.04(2)\ \ ) + (0.01(840)\ \ )$$

$$Line\ Segement\ Risk = 0.2 + 0.75 + 1 + .05 + .1 + .2 + .08 + .84$$

$$Line\ Segement\ Risk = 3.22$$

3 Deployment Sequence and Schedule

In order to define a practical implementation plan and minimize the need to file requests for amendment to the PTC implementation Plan line segments may be allocated into pools of similar risk scores. The number of pools may be determined by natural breakpoints in line segment score groupings or by other criteria relevant to the railroad. By allocating line segments into pools of similar risk, the railroads can allocate resources in order to progress work simultaneously on many line segments in a pool in accordance with work force availability, materials availability, route continuity, and labor agreements, while at the same time meeting the statutory requirement to commission PTC on line segments of greater risk before those of lesser.

For example, if the line segments have been divided into five separate pools based on risk ranking (with pool 5 having the highest risk line segments, and pool 1 having the lowest risk line segments), all line segments in pool 5 must be completed before moving on line segments in pool 4. Similarly all line segments in pool 4 must be completed before moving onto line segments in pool 3, all line segments in pool 3 must be completed before line segments in pool 2, and line segments in pool 2 must be completed prior to line segments in pool 1.

For example, suppose there are ten line segments on which the installation of PTC is being considered, that there will be three pools- Pool 1 (Highest Priority for Installation), Pool 2 (Medium Priority for Installation), and Pool 3 (Lowest Priority for Installation) and the risk scores for these 10 lines are as follows:

Line 1- 25.0 points	Line 6- 14 points
Line 2- 35:5 points	Line 7- 30.5 points
Line 3- 10.0 points	Line 8- 47.9 points
Line 4- 96.0 points	Line 9- 31.0 points
Line 5- 89.9 points	Line 10- 86.0 points

One possible division of the lines across the three pools of risk may be:

Pool 1: Line 4, Line5, Line 10
Pool 2: Line 1, Line 2, Line 7, Line 8, Line 9
Pool 3: Line 3, Line

Those line segments on which the railroad will not install PTC due to statutory exclusion should be omitted from the risk pooling or earlier processes even though they will have non-zero risk scores calculated in accordance with this model.