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25 - R&D Management

Passenger Rail Corridor Risk Assessment

Presentation to State Passenger Rail Officers and the Federal Railroad Administration

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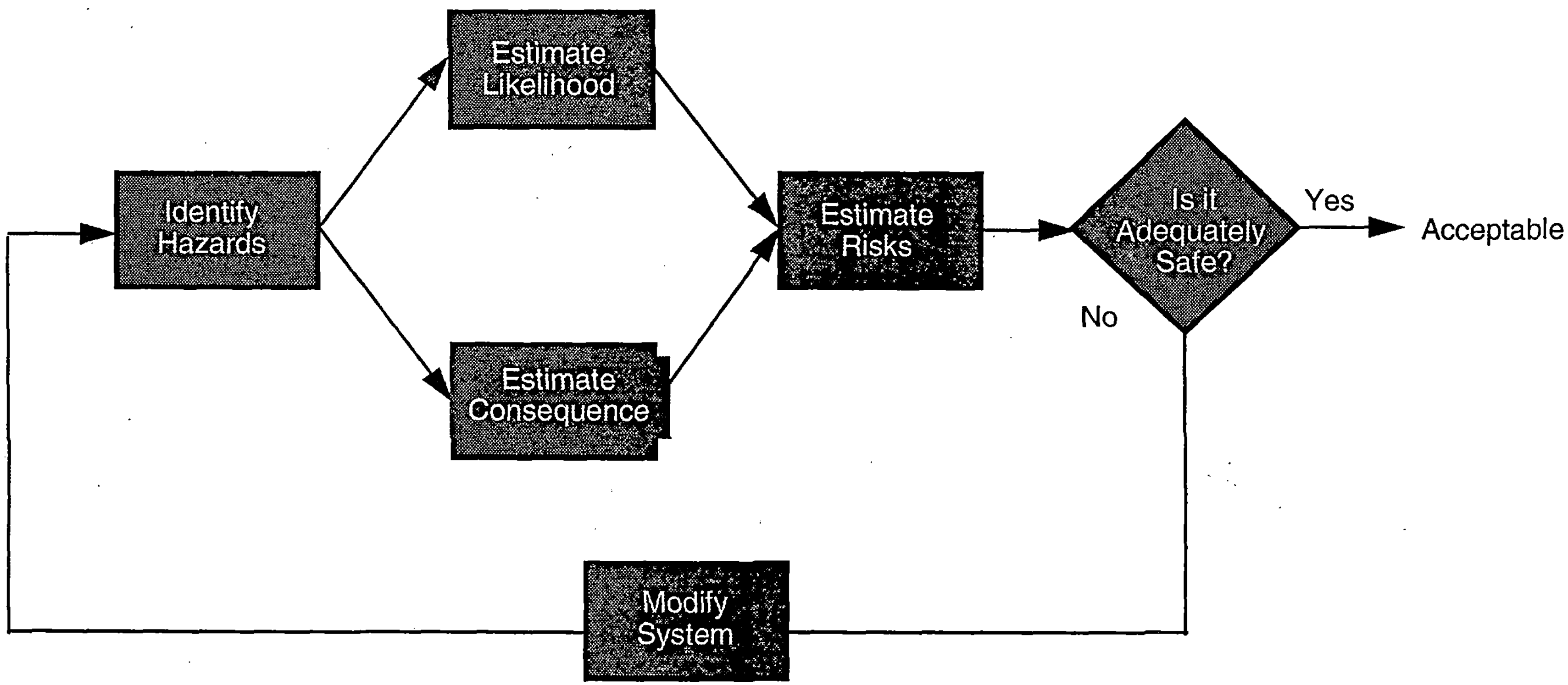
This presentation discusses the applications of and methodologies for performing risk assessments for passenger rail corridors.

- Introduction to risk assessment and risk assessment terminology.
- Uses of a rail corridor risk assessment.
- Role of the FRA and rail industry associations in passenger rail safety assurance.
- Risk assessment methodologies.
- Typical results from a rail corridor risk assessment.

Risk assessment is a logical process of identifying hazards, and evaluating the seriousness of each hazard, and assessing the effectiveness of risk reduction measures.



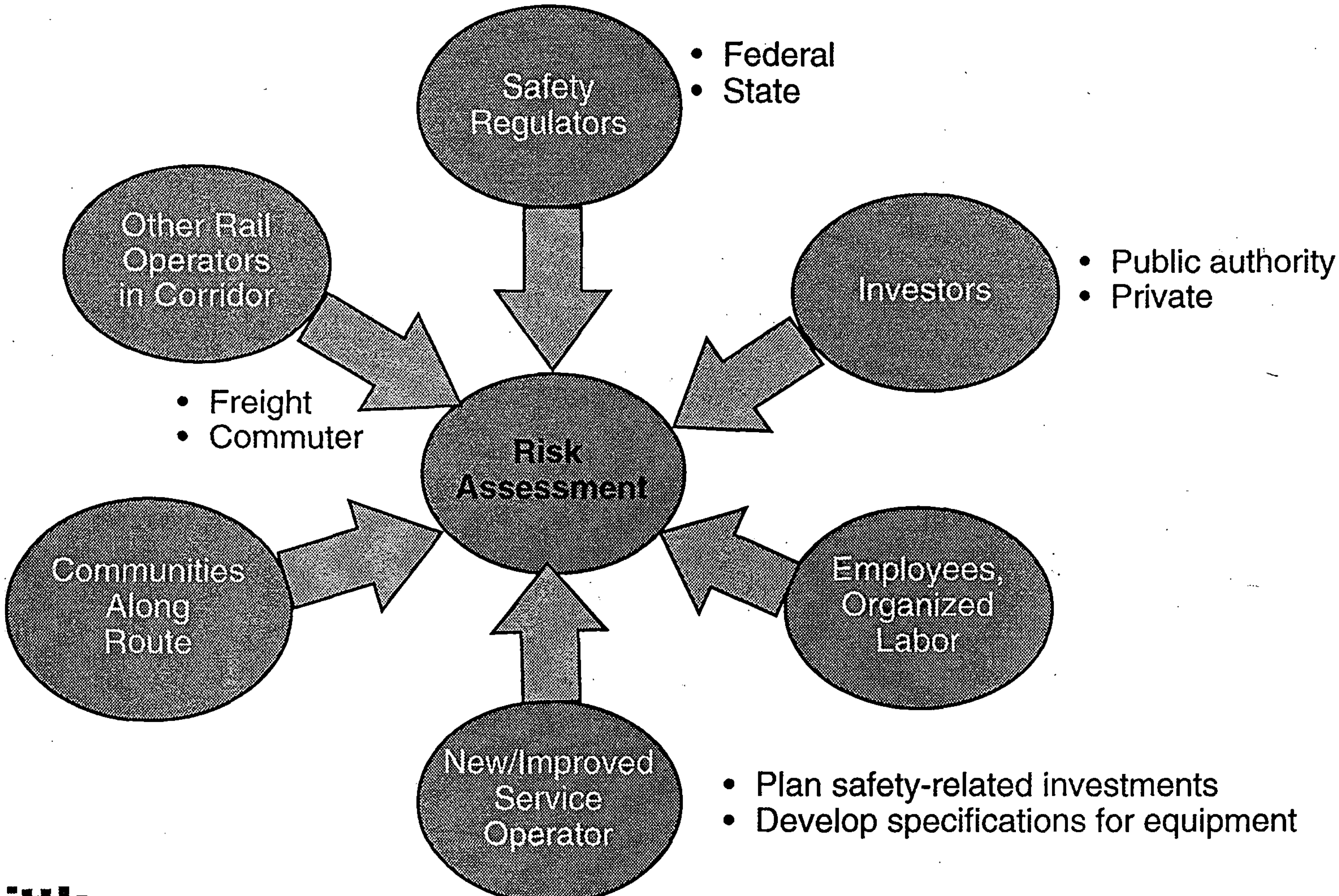
There are some critical concepts and definitions which are useful in understanding and discussing risk assessment

- A *hazard* is a condition, event, or activity that may present some degree of risk. (e.g., travel by high-speed rail or transportation of toxic/flammable materials);
- A *risk* is the potential for realization of some unwanted consequence arising from a hazard. (e.g., collision of two trains which yields property damage and injuries or a release which results in fire/explosion/exposure/environmental impact)

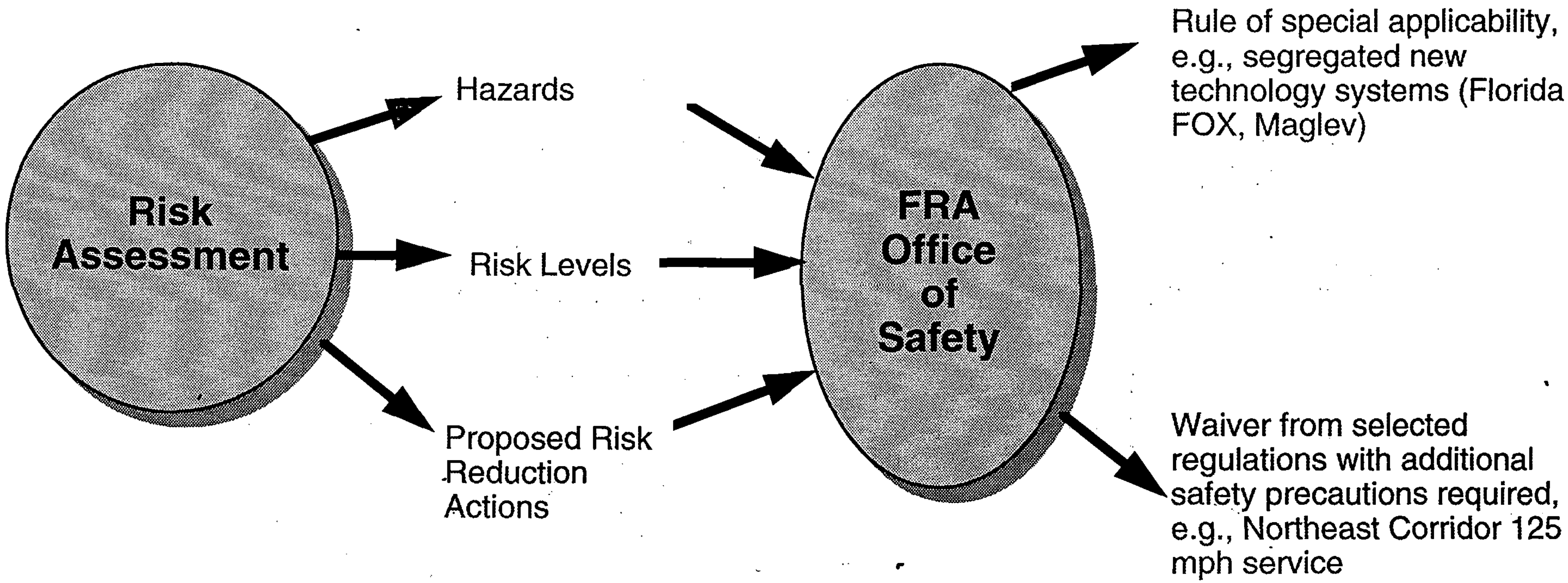
Risk always has two components:

- The *likelihood* or probability of the unwanted consequence occurring, and
- The *magnitude* or severity of the consequence if it occurs

Risk assessment is a powerful tool for assuring safety authorities and other constituencies affected by in a new or improved rail passenger service that the operation will be safe.



The FRA Office of Safety will likely require a safety evaluation of any new or improved intercity passenger service involving new or unusual technical or operations features.



Note that a risk assessment is not a formal FRA requirement, but is helpful in presenting a safety plan to the FRA

Rail industry associations have a significant role in rail system safety assurance by developing and maintaining numerous rules, standards and recommended practices.

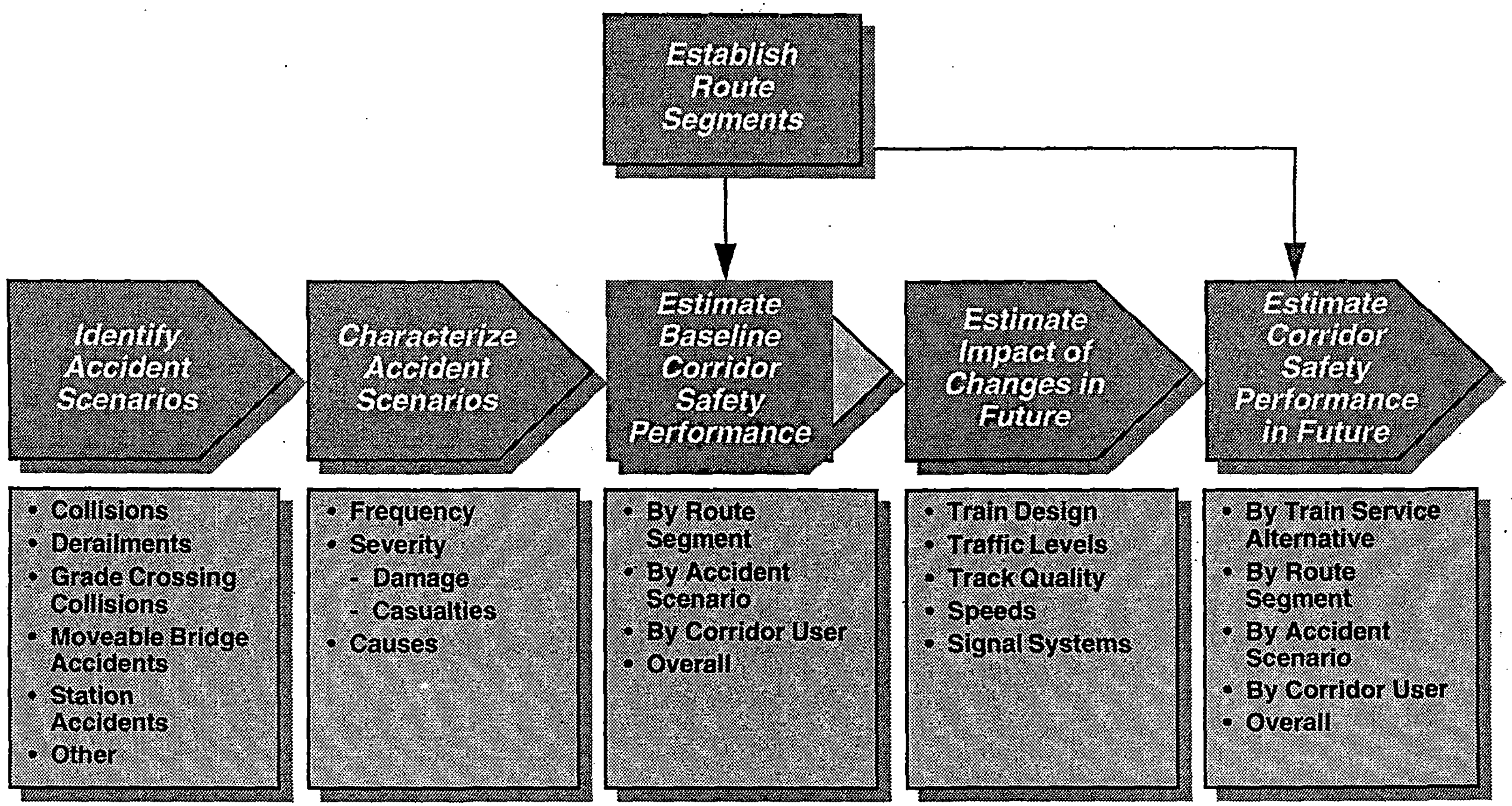
Association	Requirements	Purpose

Association of American Railroads	• Interchange rules
	• Manual of Standards and Recommended Practices:
	  • Mechanical Division
	  • Communications and Signals
	• Standard Code of Operating Rules
		• Inter-railroad compatibility
		• Coupler, brakes, wheels
		• Signal systems
		• Operations

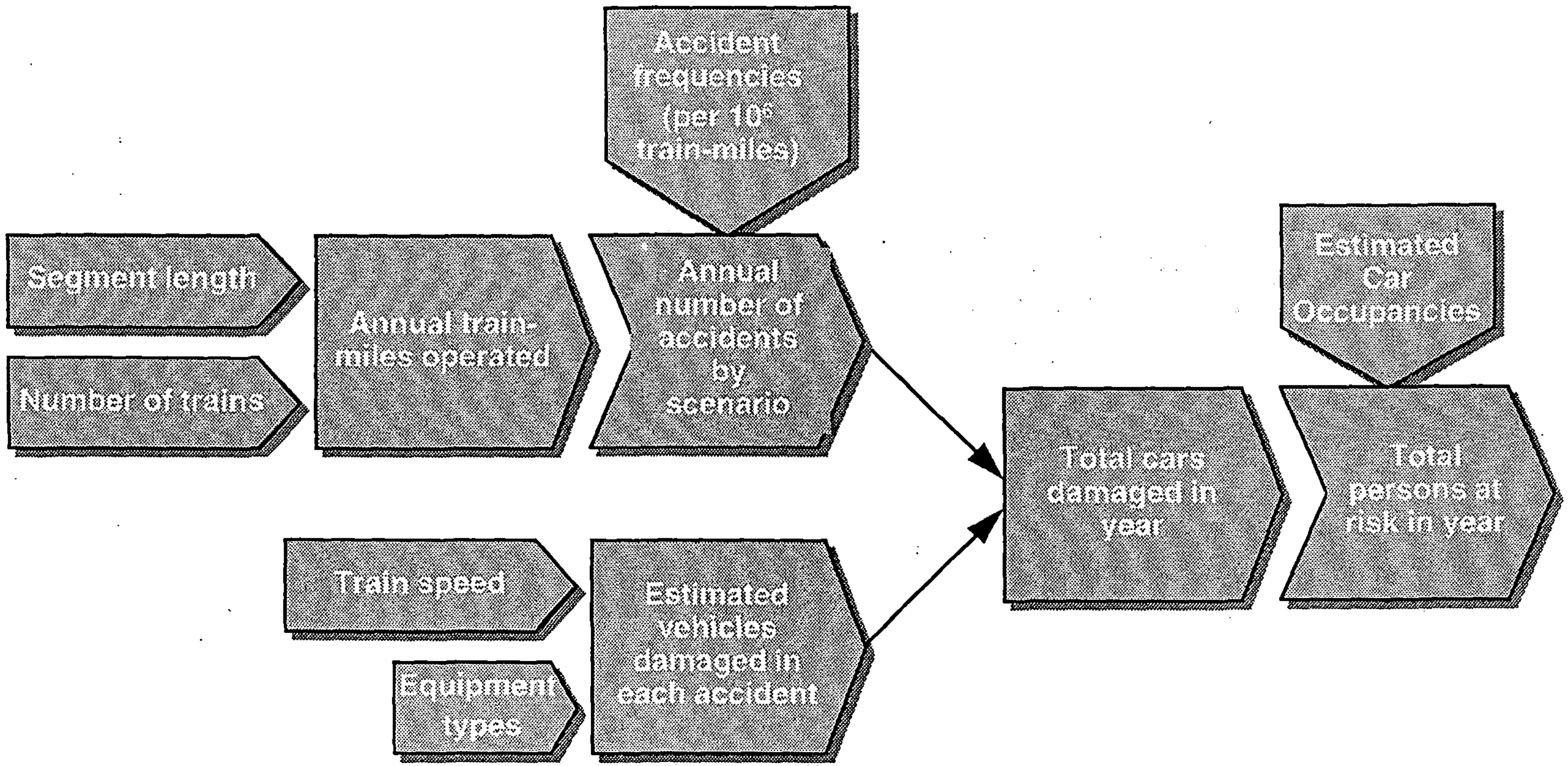
American Railway Engineering Association	Manual for Railway Engineering	• Track • Civil works • Electrification
American Public Transit Association	• Passenger Rail Equipment Safety Standards (PRESS) (in preparation) • Manual for the Development of System Safety Program Plans	• Equipment construction and maintenance • Safety management approach

Deviation from these requirements is permitted but may result in a greater effort to demonstrate adequate safety.

Present and future safety performance on a corridor is estimated using historic data and analysis of the impact of planned changes on current performance.



The analysis procedure used to calculate accident risk by segment and accident scenario can be implemented on a computer spreadsheet.



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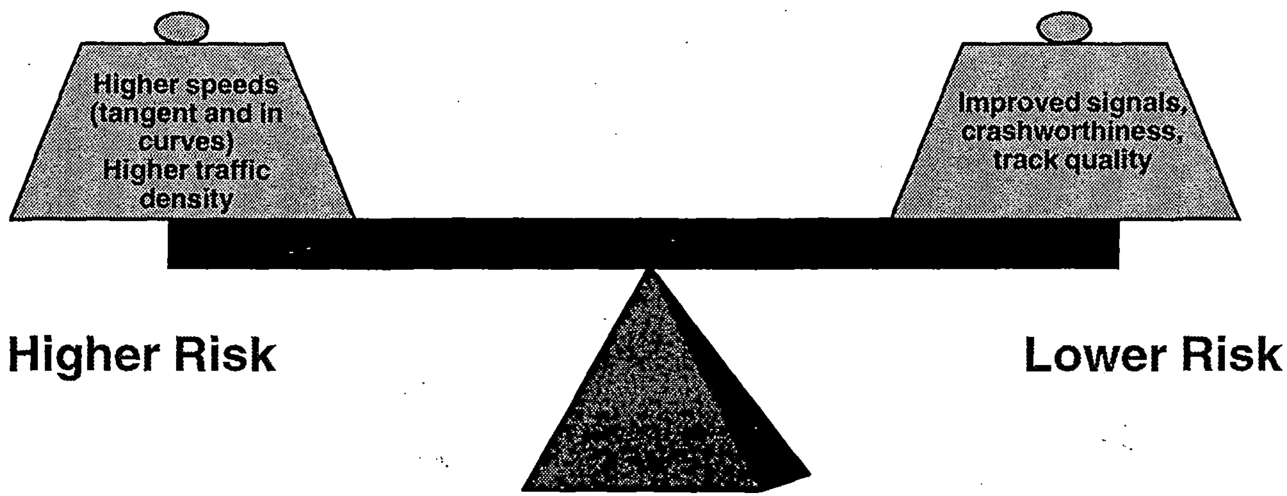
Accident scenarios and accident exposure estimates are derived from analysis of past accidents on a reference route, using FRA accident data and NTSB reports.

	Scenario	Exposure Measure for Estimating Accident Frequency
Main Line Accidents	Train-to-Train Collision (incl. head, rear, side)	Train-miles
	Derailments and other accidents - main line	Train-miles
	Collision after initial accident	Traffic density - trains per day
	Grade Crossing Collision	Crossing Passes
	Moveable Bridge Accident	Bridge Crossings
	Accident in major station (all types)	Station Movements*

*Origination, termination, through

Generally, higher speeds and traffic densities tend to increase risk, and signal and train control, track quality and crashworthiness improvements reduce risk.



A major up-front activity in a risk assessment is to assemble and organize the input data needed by the risk assessment model.

- Historic, present and planned future rail traffic levels, train designs and consists
  - High-speed passenger
  - Conventional passenger
  - Freight
- Details of planned infrastructure improvements
- Present and planned future train speeds
- Accident frequencies and consequences as a function of train type, infrastructure conditions, speeds, etc.
  - Historic safety performance
  - Impact of higher speed, traffic density
  - Impact of train and infrastructure improvements

In the United States, the primary sources of accident data are in Federal Government reports and databases.

- Federal Railroad Administration annual Accident/Incident Bulletin
- Federal Railroad Administration annual Rail-highway Crossing Accident/Incident and Inventory Bulletin.
- Federal Railroad Administration annual Railroad Accident/Incident Report database
- National Transportation Safety Board reports on serious accidents

A significant problem in safety analysis is a lack of good exposure data -- breakdown of train-miles operated by speed, track quality class, and traffic density.

In one risk assessment study, accident frequencies were calculated from accident history on the Northeast Corridor over 7-1/2 years.

Accident Type (FRA Designation)		In Major Terminals (Washington, New York, New Haven, Boston)		Main Line	
		Minor	More Serious	Minor	More Serious
1	Derailment	6P	6P	10P 11F	4P 4F
2	Head-On Collision	-	1P	-	2*
3	Rear-End Collision	-	-	2	4*
4	Side Collision	-	1P	-	2*
5	Raking Collision	1P	-	3F	
9	Obstruction	3P	-	15P	3P 1F
12	Other	3P	2P	-	1F 1P

P = Passenger train
F = Freight and other train types

More serious accident
Damage > $50,000 and/or train occupant injury.

Fires and Pantograph/Catenary accidents have been omitted.

Accident frequency data derived from historical experience are adjusted to reflect changes, for example in signal system design and track quality.

- Accident causes in each scenario are reviewed (e.g., signal failure, brake failure, human error for a collision)
- The fraction of accidents due to each cause that would have been prevented by the planned changes are estimated, and used to calculate new accident frequencies
- Both statistical analysis and engineering research results from the literature are used to estimate future accident frequency.

The end result is a set of accident frequencies for different operating and infrastructure conditions.

Dividing by exposure yields a set of accident frequencies for "more serious" accidents for each accident scenario and infrastructure alternative.

Accident Scenario	Measure	Value by Signal System: Base	Improvement 1	Improvement 2
Train-to-train Collision	Per million train-miles	0.038	0.025	0.014
Derailments and Other: Fair Track - FRA Class 4-5 Good Track - FRA Class 5-7 Excellent Track - Exceeding FRA Class 6	Per million train-miles	 0.121 0.113 0.105	 0.100 0.092 0.084	 0.082 0.074 0.066
Moveable Bridges	Per million bridge passes	0.60	0.40	0.20
Major Stations	Per million train movements	4.15		
Grade Crossings	Per million crossing passes	0.30 (present) 0.71 future (higher road/rail traffic)		
Freight Train Accidents	Per million train-miles	3.5 (way freight operations)		
Conditional probability of collision after initial accident		0.001 x trains/day		

In one study, accident severity was quantified by a 'damage index' indicative of the relative numbers of seriously damaged conventional passenger cars in each type of accident.

Accident Types	Damage Index: Normal Speed (Typically 60-90 mph)	Damage Index: High-Speed* (over 110 mph)
Car in collision with another passenger car	1	3
Car in collision with a locomotive	2	5
Locomotive to locomotive collision	1	3
Derailment or other accident	0.5	1.5
Collision after initial accident	1	2
Station accident	0.5 (low speed only below 20 mph)	N/A
Moveable bridge accident	1	N/A
Grade crossing collision	0.5	N/A

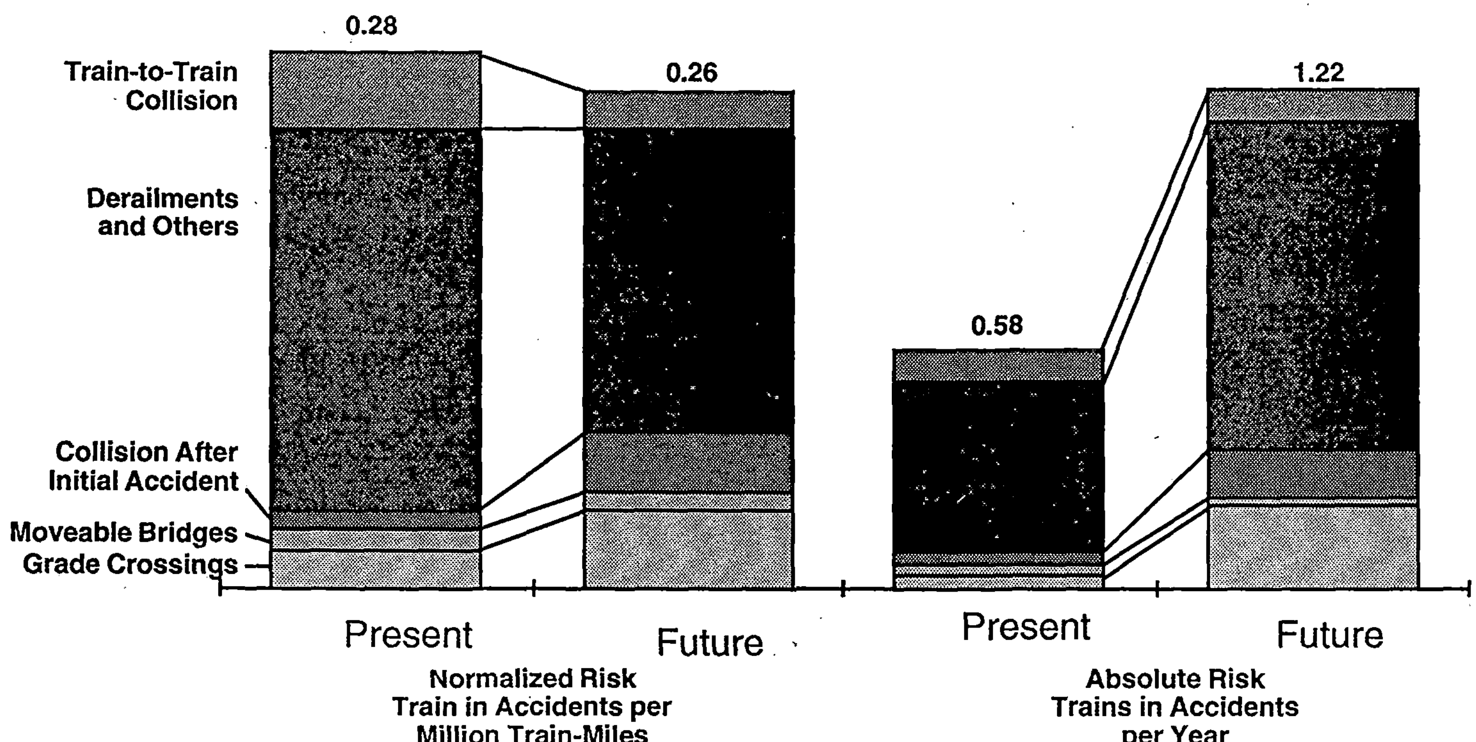
*Conventional car without added crashworthiness features.

Rail accident risk (trains in accidents and passenger at risk per year) can be presented in three ways.

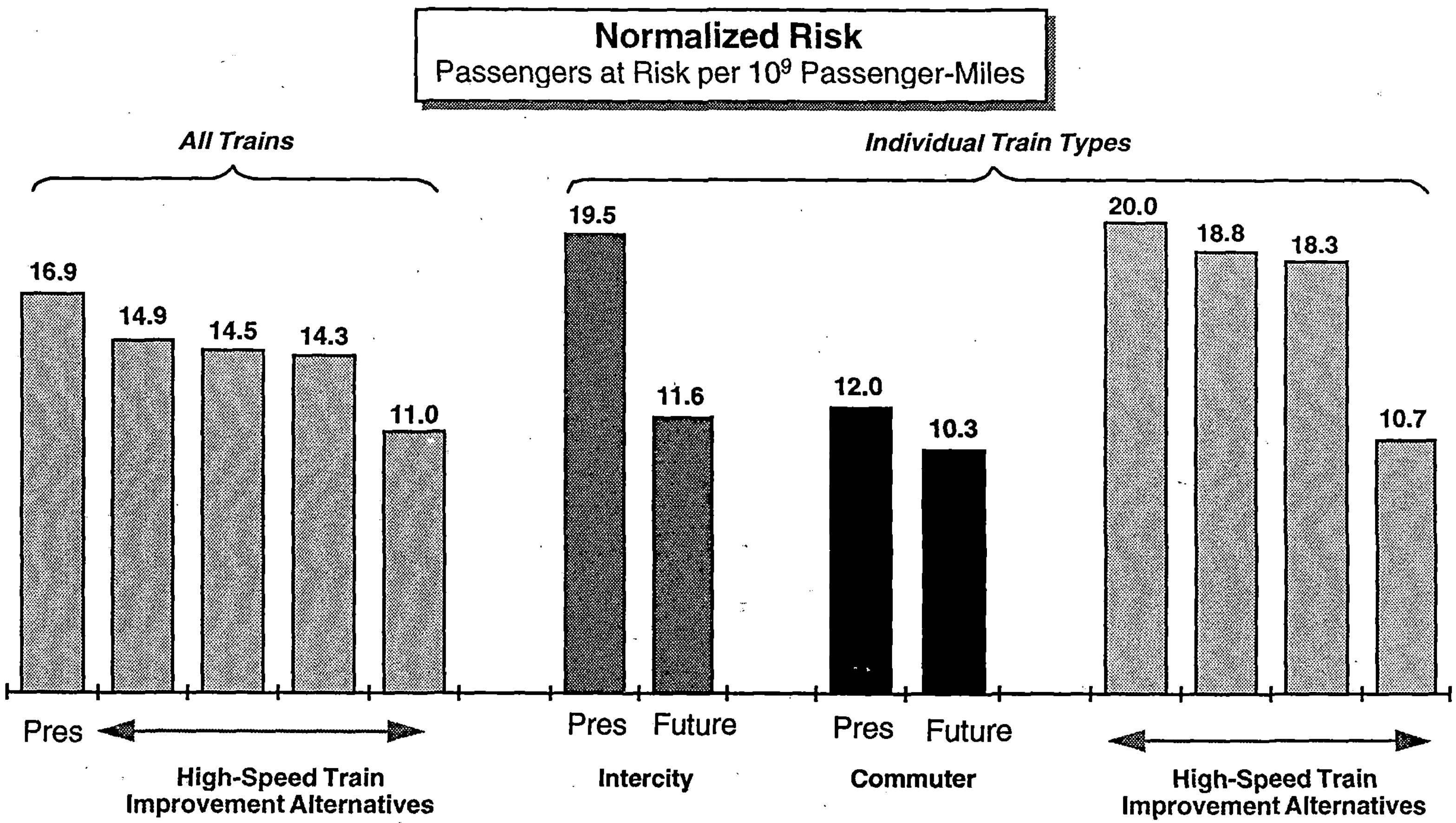
- As absolute estimates of a safety performance
  - The estimates provide the total number of accidents of each type and total 'passengers at risk' or casualties in a year
  - Absolute risk estimates must be treated as approximate: many assumptions and estimates are required to obtain a result
- As normalized absolute estimates of safety performance, obtained by dividing absolute estimates by rail traffic or patronage levels (train or passenger miles). Normalized estimates are an indicator of risk faced by a traveler or an individual train
- As a comparison of risk estimates between a reference service and the proposed new service. Comparisons are inherently more reliable than absolute estimates as fewer assumptions and estimates influence the results.

In typical analysis results, present and future accident risk from different causes can be compared.

Planned changes in example:
- High-speed service added
- Additional commuter trains
- Signals, track improved



Risk assessment can be used to evaluate benefits from technical improvements such as improved crashworthiness design for high-speed trains.



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