

BNSF Railway

Electronic Train Management System and Safety Larry Milhon

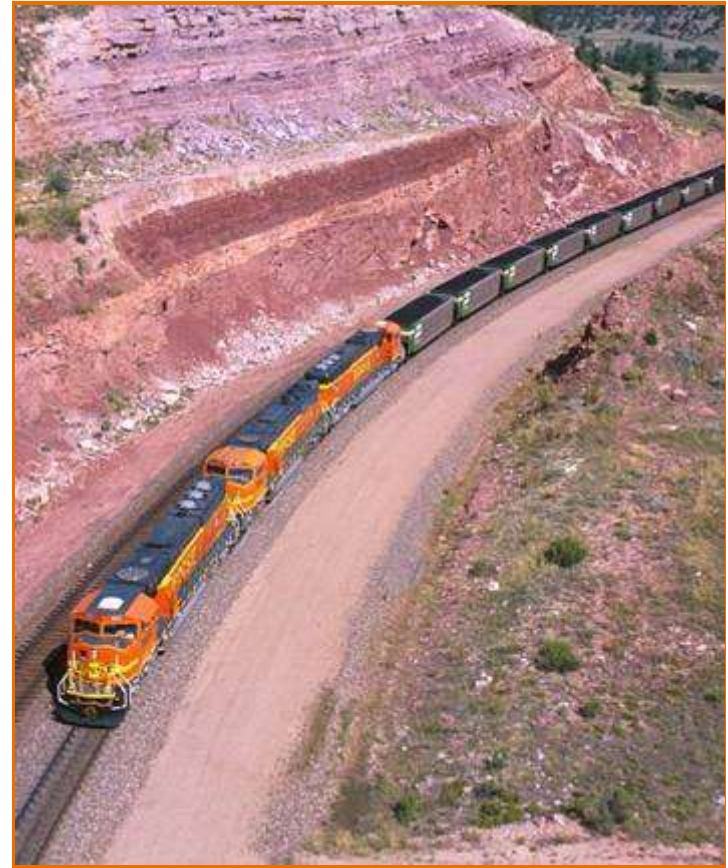
March 9, 2007



Derailment Prevention

Technical Research & Development

- **Small Team of Technical People (15)**
- **Derailment Investigation / Training**
- **Technical Consulting**
- **Simulation - Stopping Distance Analysis**
- **Safety Analysis**



Derailment Prevention

Web Based Training

Technical Research & Development

Derailment Info:



[INVESTIGATION PHOTOS](#)

[DERAILMENT STATISTICS:](#)

How is your area doing in reducing derailments? See latest stats, 5 year trends, Derailment Map, etc.

CLASSES:

[Derailment Workshop](#)

See the schedule, and register to attend.

CONTACT LISTS:

-[TR&D Contacts](#)
-[Transportation Contacts](#)
-[Engineering Contacts](#)
-Mechanical Contacts (N/A)

FORMS:

INVESTIGATION ASSIST:

-[Accident Investigation Standard Procedures Manual](#)

An on-line derailment investigation manual, including a listing of the [cause codes](#).

-[Playbook](#)

-[List of items to take to a derailment](#)

Assistance in investigation procedures.

-Measurements:

See procedures on how to take [mechanical](#) (equipment), [engineering](#) (track), and [operating](#) (transportation) measurements, and see what [tools](#) to use to take the measurements.

-Detectors:

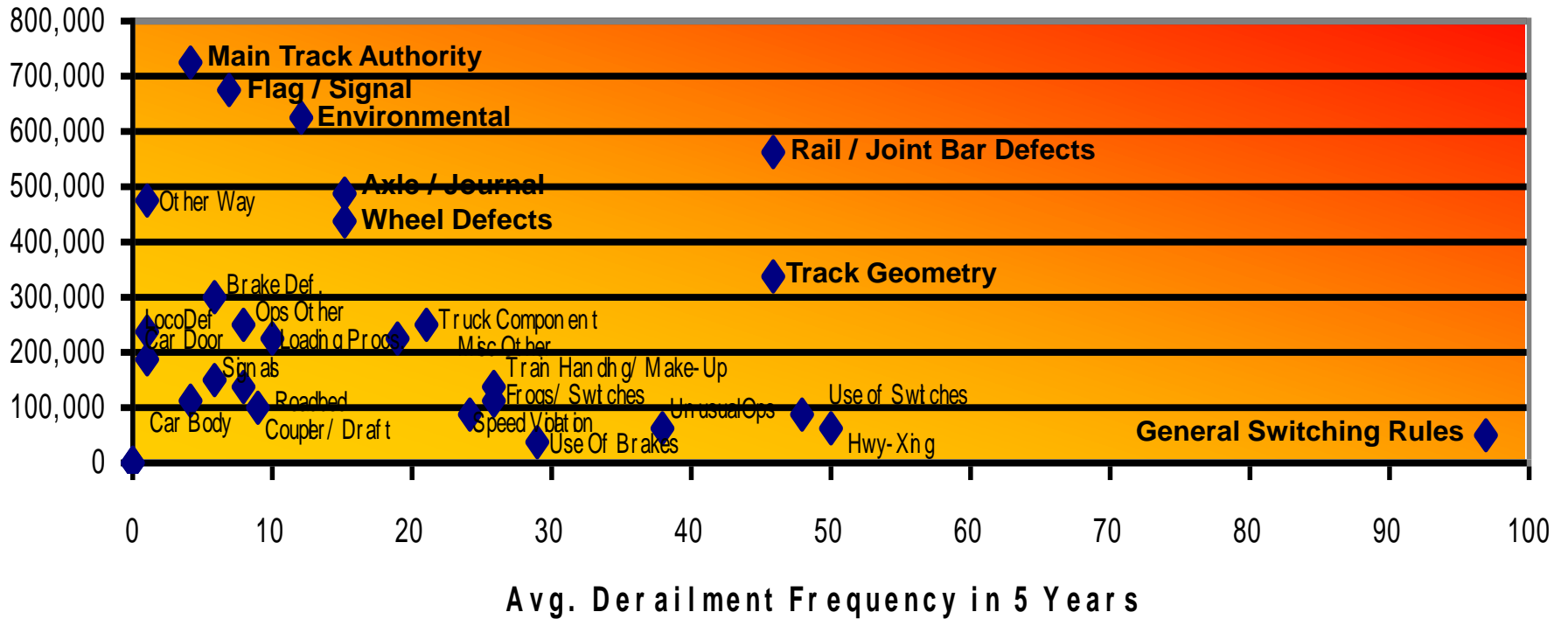
[Mech. Detector Map & Data](#)
[Eng. Detector Map & Data](#)
[Ops. Detector Map & Data](#)
[Misc. Detector Map & Data](#)

- **Schedule Derailment Training Classes**
- **Review Procedures**
 - **Safety**
 - **Scene Management**
 - **Photographs Needed**
- **Investigation Process**
- **Measurements Required by Various Disciplines**
- **Glossary**

Derailment Prevention

Risk Analysis

Average \$ in Derailments By Cause Group



ETMS and Safety

ETMS Basics

- **Electronic Train Management System**
 - **Primary purpose is to keep trains from colliding**
 - **Another important feature is to prevent trains from entering work zones without permission**
 - **Also prevents trains from over-speeding**
- **Video**

ETMS and Safety

ETMS Background

- **Previous Efforts – BNSF Involvement**
 - **ARES – Advanced Railroad Electronic System**
 - **PTS – Positive Train Separation**
 - **NAJPTC – North American Joint Positive Train Control**

ETMS and Safety

FRA Approval Process

- **Federal Regulation Developed using RSAC**
49 CFR Parts 209, 234, and 236 subpart H
 - **First step is to develop an Railroad Safety Program Plan - RSPP**
 - **Product Safety Plan - PSP**
 - **System Description and Operation Plans**
 - **Training / Maintenance Plans**
 - **Safety Analysis**

ETMS and Safety




RSPP

- **Railroad Safety Program Plan**
 - **Design Specification Document for All Processor Based Signal and Train Control Systems**
 - **Describes Railroad Safety Concepts and Philosophy**
 - **What Standards Were Used**
 - **Describes Railroad's Safety Critical Development Plans**
 - **RSPP Lays Out the Architecture of the PSP**

ETMS and Safety

RSPP

SEVERITY					
PROBABILITY		I	II	III	IV
A	UN	UN	UN	UN	AC
B	UN	UN	UN	UN	AC
C	UN	UN	AC/WR	AC	AC
D	UN	AC/WR	AC	AC	AC
E	AC/WR	AC	AC	AC	AC

	- UNACCEPTABLE
	- ACCEPTABLE WITH REVIEW BY BNSF MANAGEMENT
	- ACCEPTABLE WITHOUT REVIEW

Severity

- I. Catastrophic
- II. Critical
- III. Marginal
- IV. Negligible

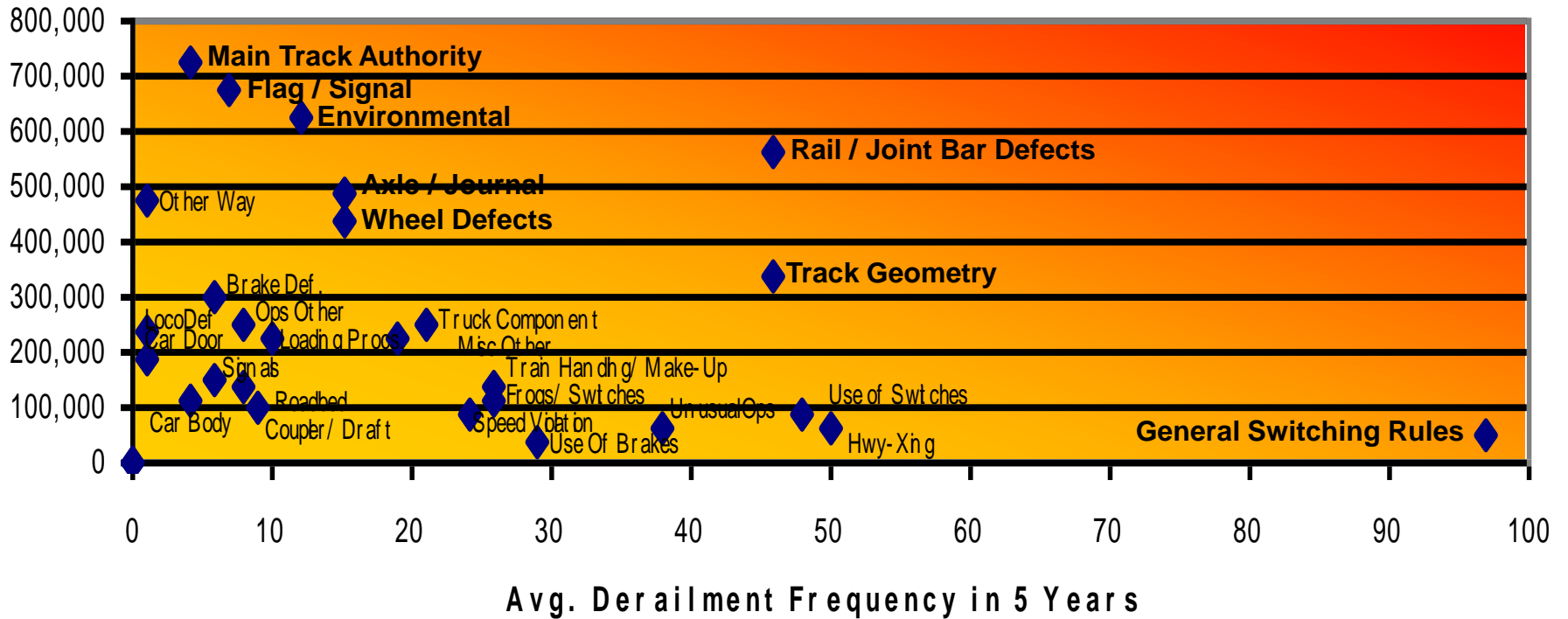
Probability

- A. Frequent
- B. Probable
- C. Occasional
- D. Remote
- E. Improbable

Derailment Prevention

Risk Analysis

Average \$ in Derailments By Cause Group



ETMS and Safety

PSP

- **Product Safety Plan**
 - **Detailed Description of the Proposed System**
 - **Description of Railroad Operations using this System**
 - **Description of Sub-systems**
 - **Description of the Safety Aspects of System**
 - **System Architecture**
 - **Hazard Log**

ETMS and Safety

PSP

- **Product Safety Plan (cont.)**
 - **Comparison of Risk – Existing to Proposed MTTHE**
 - **Description of Methodologies Used for Safety Analysis**
 - **Preliminary Hazard Analysis – PHA**
 - **Functional Fault Tree - FFT**
 - **Sub-System Hazard Analysis – SSHA**
 - **Verification / Validation Processes**
 - **Human Factors Analysis**

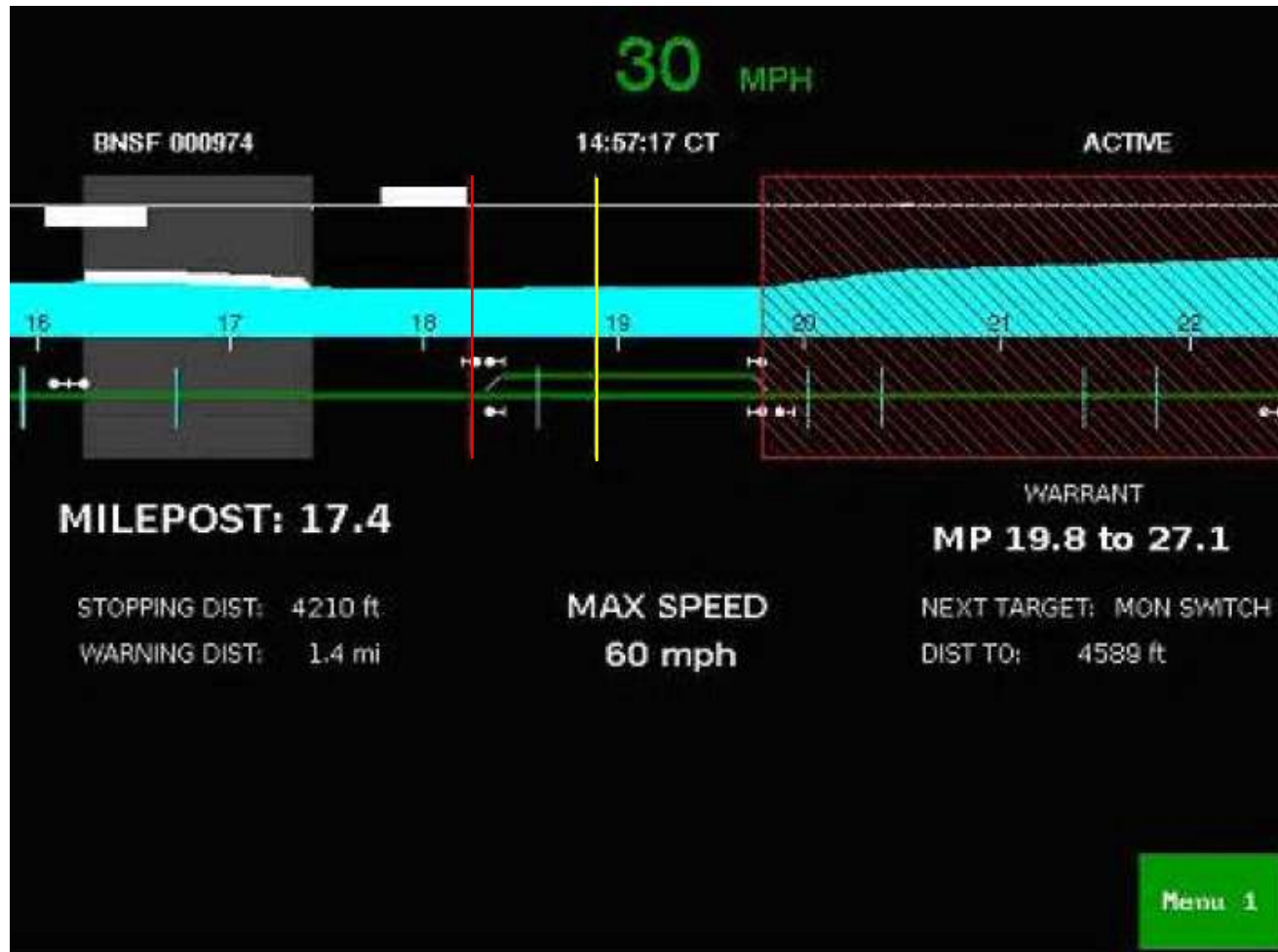
ETMS and Safety

PSP

- **Product Safety Plan (cont.)**
 - **Training of Operators and Maintainers**
 - **System Operations and Maintenance Manual**
 - **Test Procedures**
 - **Post Implementation Monitoring**

ETMS and Safety

ETMS Onboard Screenshot - ConOps



ETMS and Safety

ETMS Safety Analysis - PHA

ID	Function	Hazard/Failure Modes	Consequence	Severity
ETMS01.01	Warn Train Approaching Unacknowledged Work Zone	Failure to Warn of Impending Unacknowledged Work Zone	None (Crew Controls Train) Enforcement w/o Warning * Collision w/ Work Gang **	None Negligible Catastrophic
ETMS01.02	Warn Train Approaching Unacknowledged Work Zone	Early Warning of Unacknowledged Work Zone (>75 sec)	Increased Work Load	Negligible
ETMS01.03	Warn Train Approaching Unacknowledged Work Zone	Late Warning of Unacknowledged Work Zone (<75 sec)	None (Crew Controls Train) Crew unable to properly set-up train Collision w/ Work Gang **	None Negligible Catastrophic
ETMS01.04	Warn Train Approaching Unacknowledged Work Zone	Visual Warning of Unacknowledged Work Zone without Audible Warning	None (Crew Controls Train) Crew misses warning - Enforcement w/o Warning Collision w/ Work Gang **	None Negligible Catastrophic
ETMS01.05	Warn Train Approaching Unacknowledged Work Zone	Audible Warning of Unacknowledged Work Zone without Visual Warning	Increases Work Load – Reason for Warning unknown to Crew	Negligible

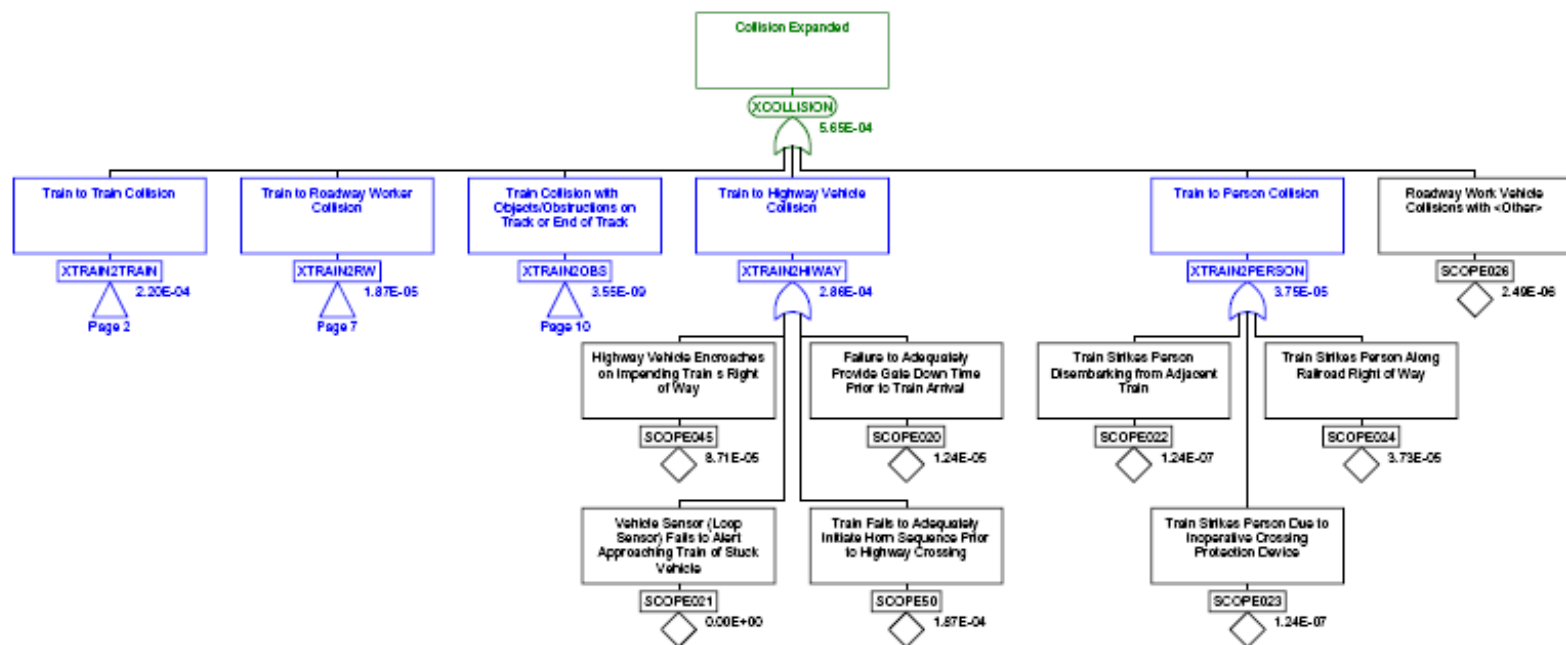
ETMS and Safety

ETMS Safety Analysis - PHA

Event	Description	Failure Rate (failures/hr)	Yearly Occurrence
BROKEN_RAIL	Broken Rail Occurs	7.4E-4	6000
DISPATCH01	Dispatch misreads Authority Data to Crew	3.73E-4	30
DISPATCH02	Dispatch Supplies Erroneous Form B Data to Crew	6.22E-7	5
DISPATCH03	Dispatch misreads Speed Restriction Data to Crew -ETMS Data Correct-	1.24E-5	100
HF001	Crew Fails to Adhere to Existing Operating Rules	1.24E-3	10000
HF002	Crew Incapacitated or Inattentive	1.24E-4	1000

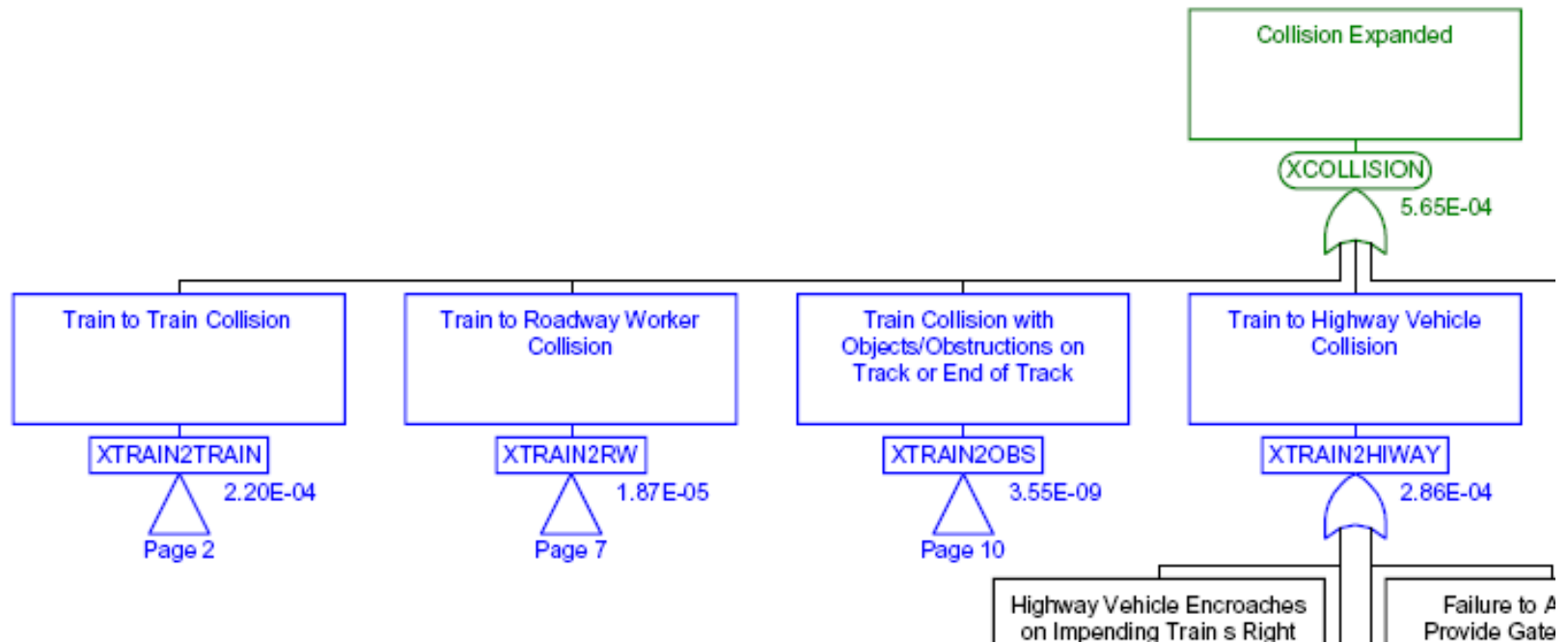
ETMS and Safety

ETMS Safety Analysis – Functional Fault Tree



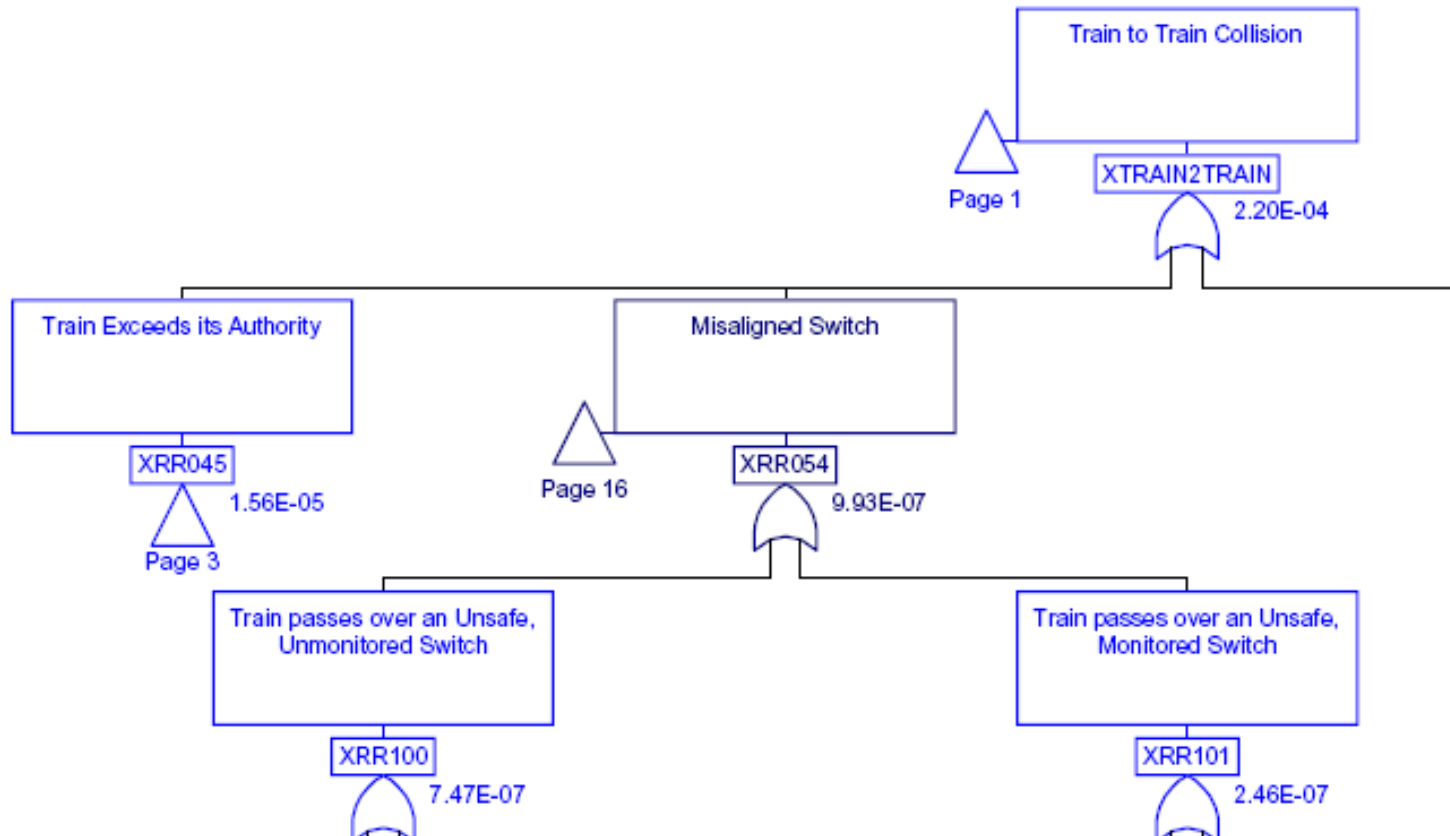
ETMS and Safety

ETMS Safety Analysis – Functional Fault Tree



ETMS and Safety

ETMS Safety Analysis – Functional Fault Tree



ETMS and Safety

ETMS Safety Analysis - Comparison

Hazard	Analysis	Failure Rate (failures/hr)	Events Per Year
Collision Train Exceeds Authority	Existing	1.56E-5	125
	ETMS	4.39E-8	.353
Collision Passes over Unsafe, Monitored Switch	Existing	2.46E-7	2
	ETMS	2.69E-11	0.0002
Collision Passes over Unsafe, Unmonitored Switch	Existing	7.47E-7	6
	ETMS	2.69E-11	0.0002
Collision Train Enters Work Zone w/o Permission	Existing	1.24E-5	100
	ETMS	5.70E-8	.458

ETMS and Safety

ETMS Safety Analysis - Reliance

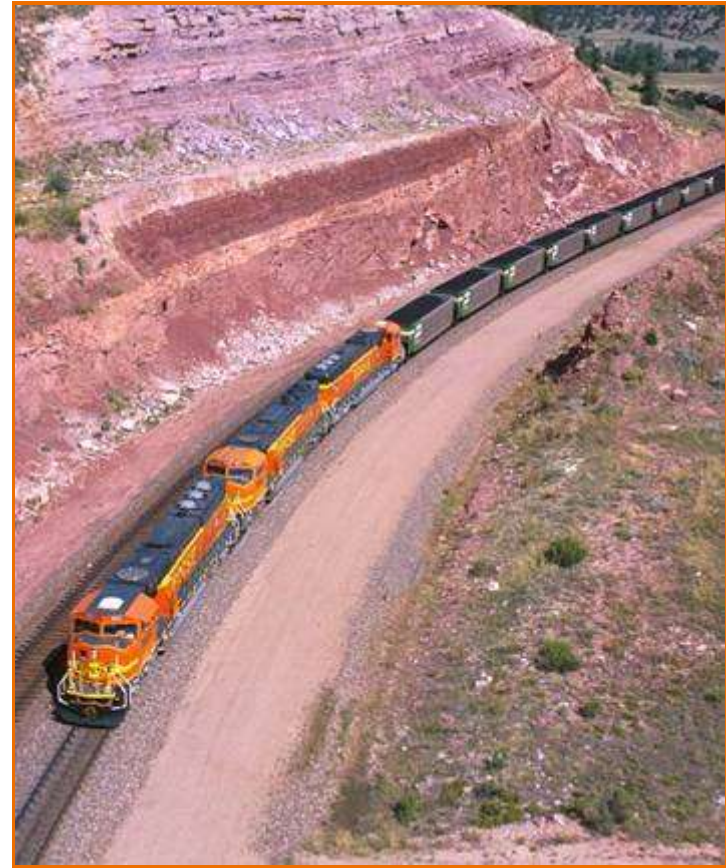
1. **Improper Use of ETMS Information**
2. **Improper Use of ETMS Functions**
 - **Training of Operators**
 - **Operations Testing**
 - **Post Implementation Monitoring**

ETMS and Safety

Derailment Prevention Through Technology

ETMS Improves Safety

- Prevents Train-to-Train Collisions
- Prevents Work Zone Incursions
- Prevents Overspeed Derailments
- Provides Platform for Future Development



BNSF
RAILWAY