Overview

- Online Railroad Traffic Report
- Highway-Rail Grade Crossing Research
- Automated Track Geometry Monitoring
- Great Northern Corridor Model

I. Online Rail Traffic Report

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RESOURCES

- Research Reports
- Geographic Roadway Inventory Tool (GRIT)
- Event Proceedings
- Staff Presentations
- Other Resources *(Surface Selection Tool, Grain Industry Data, etc.)*

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North Dakota Rail Traffic Reports

The reported data is developed using the Annual Public Use Waybill, available from the Surface Transportation Board. Various reported statistics have been estimated using weighted means and other statistical measures. Examples of the weights used from the Annual Public Use Waybill include expanded cars, exact expansion factor, and expanded tons.

Search for Reports

Report Type: --All Reports--

Include years from: to *(format YYYY)*

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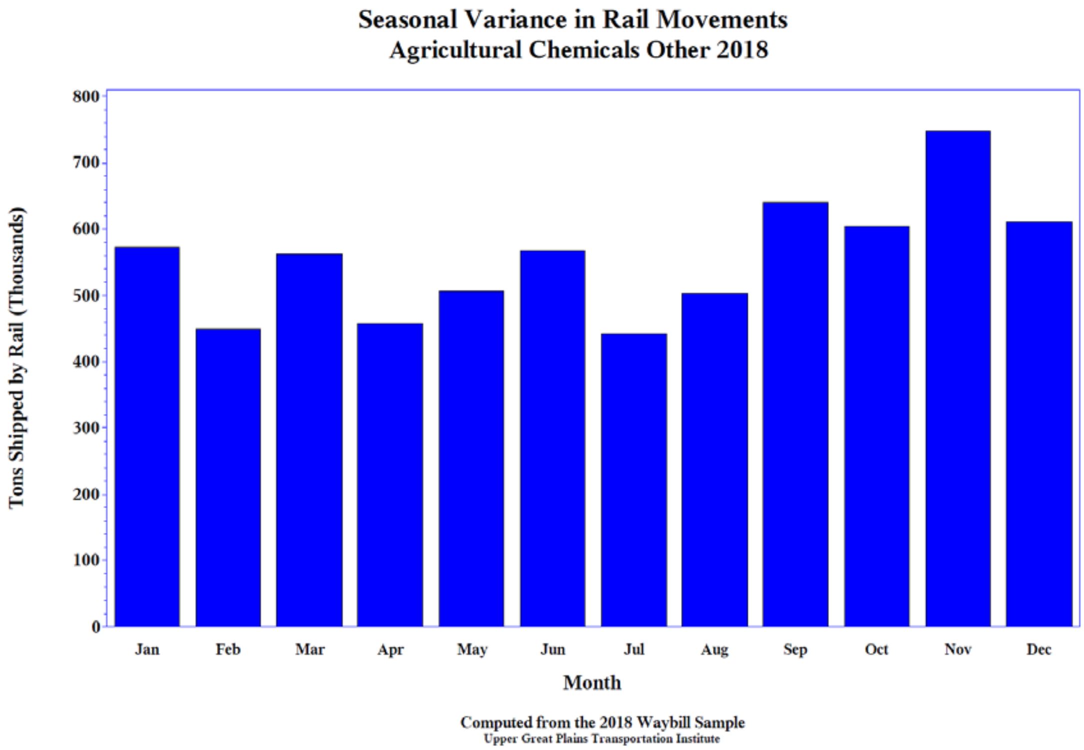
Newest Reports Available (2018)

- Non-Commodity Reports:
  - North Dakota Rail Traffic Report *(PDF, 147K)*
- Commodity Reports:
  - All Commodities *(PDF, 80K)*
  - Agricultural Chemicals Other *(PDF, 81K)*
  - Alcohols *(PDF, 80K)*
  - Ammonia or Ammonia Compounds *(PDF, 80K)*
  - Barium Calcium Mag Strontium *(PDF, 80K)*
  - Barley *(PDF, 80K)*
  - Broken or Crushed Stone or Riprap *(PDF, 82K)*
  - By Products of Liquor Distilling *(PDF, 82K)*
  - Coke Produced from Coal *(PDF, 81K)*
  - Corn *(PDF, 81K)*

Example Chart from Commodity Report



II. Highway-Rail Grade Crossing Research

Research Briefs/Digests

1. Data Preparation (attached)
2. Robust Model to Predict Crash Occurrence and Severity Likelihood (attached)
3. Understanding the Effects of Contributor Variables, including Highway Geometric Features
4. Website Development to Visualize Research Results
5. Ranking Crossings Based on Crash Frequency and Severity

Completed Tasks/Outcomes

1. **Time-series database** for North Dakota from 1990 to 2018 matched with accident/incident data so that the crossing protection and traffic data are for the year of the crash.
2. **Added highway geometry** (1) the distances from the crossing to nearby roadway intersections, and (2) the smallest crossing angle, which affects the sight perspective of drivers as they approach the crossing at an acute angle.
3. **Robust crash prediction model** that jointly predicts crash occurrence and severity level, avoiding the statistical problems associated with separate crash occurrence and severity level modes and the use of the general linear models that are traditionally used.

4. Analysis of the **effects of contributory factor**s including highway geometric effects

Variables in UGPTI Grade Crossing Database	
Type of Train Service	
	Freight
	Intercity Passenger
Train Detection System	
	None
	Constant Warning Time (CWT)
	Motion Detection (MD)
	PTC
	DC
Commercial Power (Is Commercial Power Available?)	
	Available
	Not Available
Roadway Paved Condition	
	Paved
	Not Paved
Crossing Control Types	
	Crossbucks Only
	Crossbucks + Stop Sign
	Gates
	Gates + Audible Warning
	Gates + Standard FLS + Audible
	Gates + Standard FLS+ Audible + Stop Signs
	Cantilever FLS + Standard FLS + Audible
	Gates + Cantilever FLS + Audible
	Gates + Cantilever FLS + Standard FLS
	Gates + Cantilever FLS + Standard FLS + Audible
Total Day Time Through Trains	
Total Night Time Through Trains	
Total Switching Trains	
Maximum Train Speed	
Annual Average Daily (Highway) Traffic	
Percent of Trucks	
Distance to the Nearest Highway Intersections	
Crossing Angles	
Number of Traffic Lanes	
Number of Main Tracks	

Published Journal Articles

1. Amin Keramati, Pan Lu, Yihao Ren, Denver Tolliver, and Chengbo Ai. ***Investigating the Effectiveness of Safety Countermeasures at Highway-Rail At-Grade Crossings using a***

Competing Risk Model. Journal of Safety Research, (***in press, accepted on Feb 3, 2021***), 2021

2. Amin Keramati, Pan Lu, Xiaoyi Zhou, and Denver Tolliver. ***A Simultaneous Safety Analysis of Crash Frequency and Severity for Highway-Rail Grade Crossings: The Competing Risks Method***. Journal of advanced transportation, Volume 2020, article ID 8878911, 2020
3. Pan Lu, Zijian Zheng, Yihao Ren, Xiaoyi Zhou, Amin Keramati, Denver Tolliver, and Ying Huang. ***A Gradient Boosting Crash Prediction Approach for Highway-Rail Grade Crossing Crash Analysis.*** Journal of Advanced Transportation, Volume 2020 Article ID 6751728. 2020
4. Xiaoyi Zhou, Pan Lu, Zijian Zheng, Denver Tolliver, and Amin Keramati. ***Accident Prediction Accuracy Assessment for Highway-Rail Grade Crossing using Random Forest Algorithm Compared with Decision Tree***. Reliability Engineering & System Safety, Volume 200, 106931, August 2020
5. Amin Keramati, Pan Lu, Denver Tolliver, and Xingju Wang. ***Geometric Effect Analysis of Highway-Rail Grade Crossing Safety Performance.*** Accident Analysis and Prevention, Volume 138, 105470, April 2020
6. Zijian Zheng, Pan Lu, and Danguang Pan. ***Predicting Highway-Rail Grade Crossing Collision Risk by Neural Network Systems.*** ASCE Journal of Transportation Engineering, Part A: Systems, Volume 145 Issue 8, August 2019.
7. Zijian Zheng, Pan Lu, and Denver Tolliver. ***Decision Tree Approach to Accident Prediction for Highway-Rail Grade Crossings: Empirical Analysis,*** Transportation Research Record, 2545, 115-122, 2016
8. Pan Lu, and Denver Tolliver. ***Accident Prediction Model for Public Highway-Rail Grade Crossings***, Accident Analysis & Prevention, 90, 73-81, 2016

III. Automated Track Geometry Measurement

1. Smart phone sensor systems that detects anomalies and departures from uniformity
2. Use of lidar with mobile devices to assess track uniformity

IV. Great Northern Corridor Transportation Planning

- Task force with BNSF and state DOTs
- Develop model of the corridor from Chicago to Seattle (western part first)
    - Railroad network
    - Highway network
    - Grade crossings
    - Major facilities
- Simulate effects of potential improvements (bottlenecks, substandard segments, etc.)
- Funding opportunities
- Initial proposal; planning grant
- Lead to corridor plan for grade crossing improvement

1. Data Preparation

UGPTI's research efforts utilize three main data resources: (1) the North Dakota (ND) roadway network, railway network, roadway intersections, and highway-railroad grade crossing (HRGC) data and shape files from the North Dakota Department of Transportation's GIS Hub Data Portal; (2) highway-rail grade crossing accident/incident data from the Federal Railroad Administration (FRA); and (3) the highway-rail grade crossing inventory from the FRA. The final dataset includes all reported crashes/incidents records and their related information, recent and historical (from 1990 to 2018) inventory information for each crossing, and measured geometric factors relative to the connecting highways and railroads.

FRA's grade crossing inventory includes only current information. Therefore, one cannot use the inventory for 2018, for example, to analyze crashes that occurred in earlier years, because the protection, traffic, and other factors at a crossing listed in the current (2018) inventory may be quite different than the levels in effect during the year the crash occurred. Consequently, our first step was to recreate a times-series grade crossing inventory for each year from archived FRA inventory files. Each data record for each year reflects the crossing protection and other factors in effect during that year—e.g., a record for crossing # 100 in 1994 reflects the level of protection, trains per day, and highway traffic for crossing # 100 in 1994.

It took a while to recreate this database for North Dakota.[1] But now, meaningful statistical analyses can be performed. After cleaning the data, the final database includes features and information for 3,194 unique public grade crossings in the state (3,310 crossing records), including 475 crossings where crashes occurred (we treat the crash records separately if same crossing encounter multiple crashes) and 2,835 records (crossings) where no crash records occurred from 1990 to 2018. These data have been used to identify three crash severity levels: property damage only (PDO), injury, and fatality. Table 1 shows all the contributors and variables used in UGPTI's studies. In 2018, the majority of grade crossings in the database experienced no crashes (86%) and the proportions of PDO, injury, and fatal crashes are 8% (261 accidents), 4% (147 accidents), and 2% (67 accidents), respectively (see Figure 1.1 for details from 1990 to 2018).

[1] We encountered missing information for certain crossings in certain years. In these cases, we interpolated and filled the missing values to the best of our best knowledge. For example, for missing highway traffic data (i.e., AADT), we used linear interpolation methods. For missing traffic control devices, if the before- and after- missing values were the same type of device, then all the missing values for years in between were filled with the same type of device. However, if the values were different, we assumed the change in traffic control devices happed during first record year.

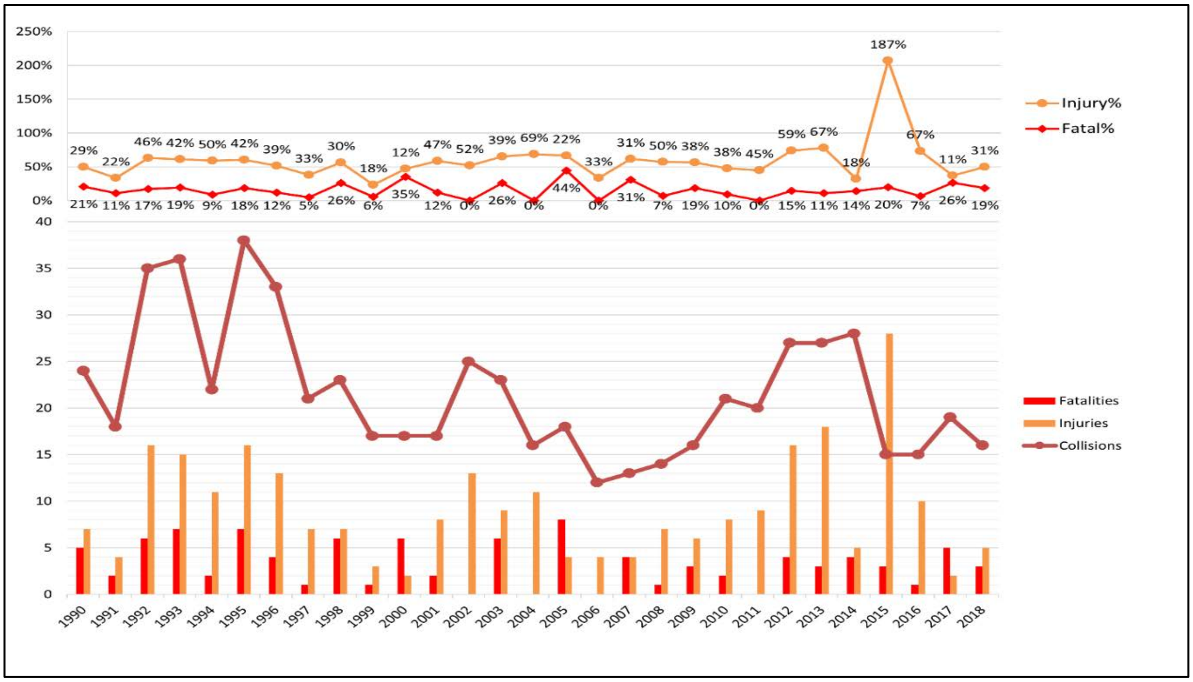


Figure 1.1 HRGC Crash Frequency and Severity Count North Dakota, 1990-2018
Source: Federal Railway Administration

In addition to the inventory variables, two numerical geometric features have been measured that are not in the FRA's grade crossing inventory using geoprocessing methods and geographical information system (GIS) techniques: (1) the distances from the crossing to nearby roadway intersections, and (2) the smallest crossing angle, which affects the sight perspective of drivers as they approach the crossing from an acute angle. The angle (θ) is measured continuously in degrees. Each crossing is located precisely on both the railroad and highway, which requires cross-referencing of data sources and photographic verification.

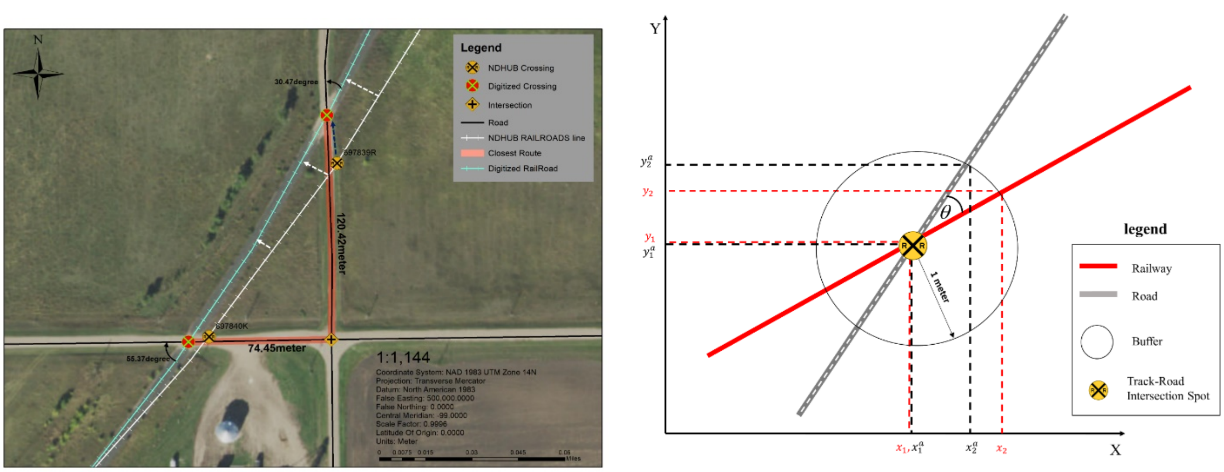


Figure 1.2 Geometric feature verification and measurements

Table 1.1 Variables in UGPTI Grade Crossing Database			
Variable	**Categorical Variable Values**	**Min Freq/Value**	**Max Freq/Value**
Crash Severity			
	No Crash	3,163	3,192
	PDO	2	18
	Injury	0	11
	Fatal Crash	0	6
Type of Train Service			
	Freight	2,718	2,807
	Intercity Passenger	387	476
Train Detection System			
	None	2,398	2,402
	Constant Warning Time (CWT)	375	378
	Motion Detection (MD)	42	43
	PTC	1	1
	DC	374	376
Commercial Power (Is Commercial Power Available?)			
	Available	2,107	2,107
	Not Available	1,087	1,087
Roadway Paved Condition			
	Paved	563	563
	Not Paved	2,631	2,631
Crossing Control Types			
	Crossbucks Only	2,451	2,676
	Crossbucks + Stop Sign	44	78
	Gates	4	22
	Gates + Audible Warning	6	92
	Gates + Standard FLS + Audible	27	184
	Gates + Standard FLS+ Audible + Stop Signs	2	14
	Cantilever FLS + Standard FLS + Audible	2	6
	Gates + Cantilever FLS + Audible	2	28
	Gates + Cantilever FLS + Standard FLS	1	9
	Gates + Cantilever FLS + Standard FLS + Audible	2	21
Total Day Time Through Trains		0	35
Total Night Time Through Trains		0	33
Total Switching Trains		0	12
Maximum Train Speed		5	79
Annual Average Daily (Highway) Traffic		5	25,600
Percent of Trucks		1	22.67
Distance to the Nearest Highway Intersections		0.78	2502
Crossing Angles		7.9	90
Number of Traffic Lanes		1	4
Number of Main Tracks		1	3

As shown in Table 1.1, several levels of protection may be used at a given crossing. The levels build on each other in a sense. A higher level of protection may encompass lower levels of protection, as well as the additional protection offered by an added feature or device. For example, signs may be added to crossbucks (which are essentially the lowest level of protection). Flashing lights/signals (FLS) may be mounted on posts or suspended over the crossing by cantilevered arms. Gates may be used with or with or without signals and audible warnings devices.

Future digests in this series will describe the research that has been completed to date, as well as on-going and future research. In order for new crash risk and severity models to be validated and used, the methods and data must be widely vetted and subjected to peer review.

2. Robust Model to Predict Crash Occurrence and Severity Likelihood

The integrated time-series database for North Dakota and the main variables analyzed in the Upper Great Plains Transportation Institute's HRGC research program were described in Digest 1 (Data Preparation). In this research brief, the models developed in the research program are described and potential uses are illustrated.

Grade crossing crashes are rare events and pose statistical issues that cannot be adequately addressed through multiple regression or general linear models. Grade crossing crash data are not normally distributed. Moreover, the conditions at crossings may vary over time. No crashes occurred at many of the crossings in the database during the 30-year analysis period. A time-series database of grade crossing crashes is neither symmetrical nor consistent, hence precluding the use of general linear models.

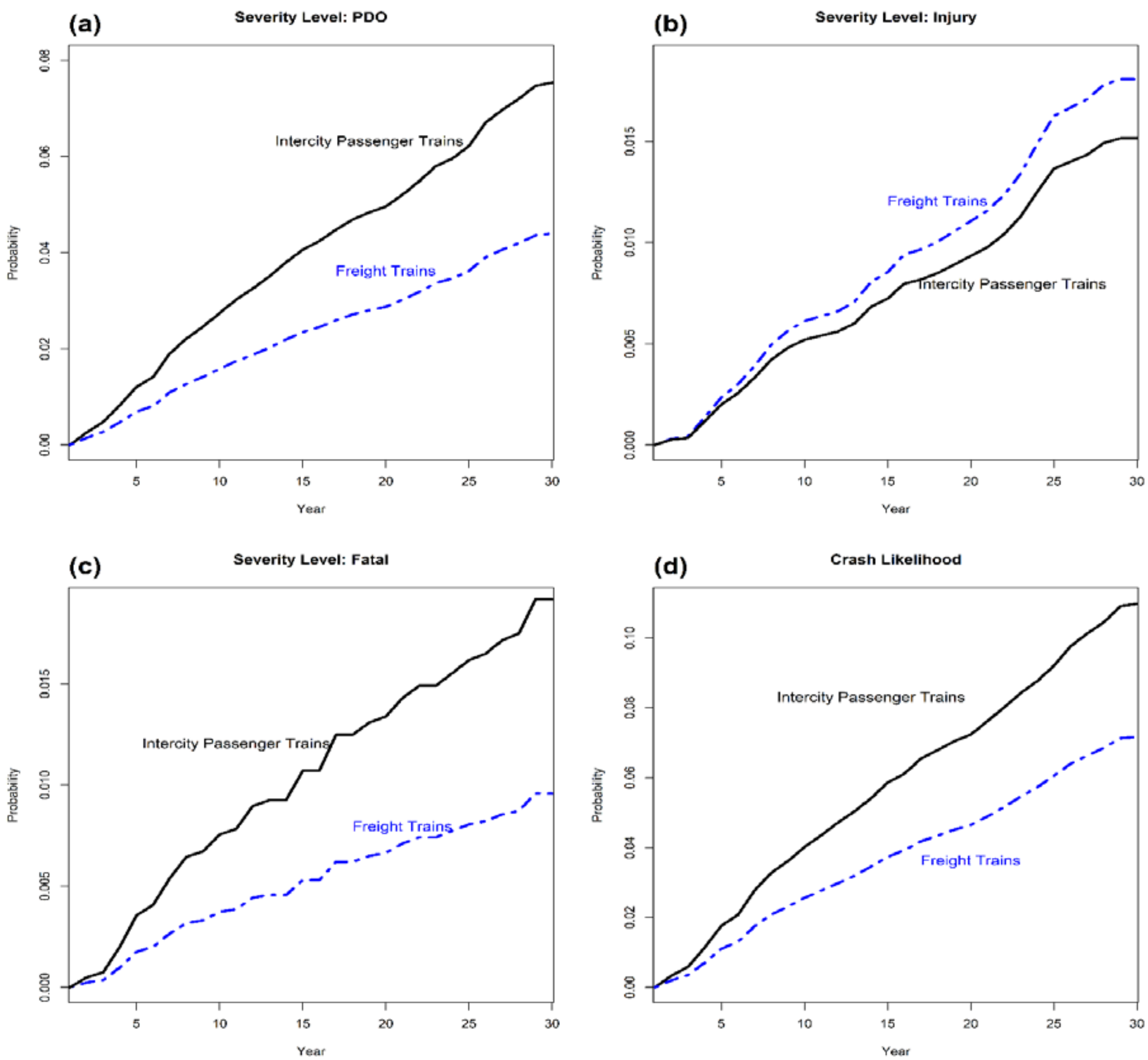
While the history of crashes at a crossing is an important factor, traffic control devices and levels of protection may be improved at a crossing following a crash, thereby affecting the validity of extrapolations. Moreover, a crash may produce different outcomes. The lowest level of crash severity is property damage only (PDO), with no injuries or fatalities. The next level of severity is a crash involving serious injuries, while the highest level is a crash that results in fatalities.

Although a crash may result in all three outcomes (property damage, injuries, and fatalities), some levels of severity are mutually exclusive. By definition, PDO excludes the occurrence of injuries and fatalities. Because of the interrelations among potential outcomes, they must be analyzed jointly in the same model. A comprehensive model should calculate crash occurrence likelihoods base on all potential outcomes rather than the traditional approach in which separate crash severity and occurrence models are developed. Separate models to predict crash occurrence and severity level account for unmeasurable errors differently. Thus, the estimated likelihoods for occurrence and severity are inconsistent. Several new modeling techniques have been developed in UGPTI's research program, including a mathematical model referred to as the *competing risk* method, which has been used to simultaneously analyze highway-rail grade crossing crash frequency and severity over a 30-year period in North Dakota. The competing risk model is a special type of survival analysis technique that accommodates the competing nature of multiple outcomes from the same event. In grade crossing analysis, the competing multiple outcomes are the crash severities, while event of interest is the occurrence of a crash.

Through a series of studies, UGPTI's research program has yielded a straightforward and integrated estimation process that considers both crash frequency and severity likelihood in the same model. As a result, direct hazard rankings are possible that reflect crash frequency and severity likelihoods. Moreover, a better understanding of the long-term cumulative effect of contributor variables has been gained through the cumulative incidence function of the model.

Figure 2.1 shows only one example of the estimated cumulative crash/severity probabilities that can be generated from the model, based on the type of train service: e.g.., freight train or intercity passenger trains. Each chart in the figure shows the cumulative probabilities of the outcome over a 30-year period. While the probability of a crash (or any other outcome) is very small in a given year, the cumulative probabilities rise over time.

Figure 2.1 Cumulative Crash Likelihoods Generated from HRGC Model of Train Service Type



As shown in chart a, the cumulative probability of property damage increases for both types of trains. However, the cumulative probability increases at a higher rate for crossings with intercity passenger service (where economic losses from crashes can be higher than crashes involving freight trains). Charts b, c and d show the cumulative probabilities for injuries, fatalities, and overall frequency, respectively. For injury, the cumulative probability at crossings with freight trains increases faster than the cumulative probability at crossings with passenger trains. However, the difference is small. In interpreting the results of the model, it is important to understand that all other contributory factors list in Table 1.1 (of Digest 1) are held constant at their mean or baseline level in Figure 2.1.

In addition to type of train service, it is possible to depict similar charts for the type of train detection system or crossing control type (although the charts become more complex in the latter scenario). In addition to the charts, many types of tabular analysis are possible, some of which are highlighted in future digests.