Benchmarking Level Crossing Safety

1. *Why do we do it?*
2. *How do we do it?*
3. *How to apply in Reality?*

Steve Laffey, Railroad Safety Specialist
Illinois Commerce Commission
Springfield, ILL USA
slaffey@icc.illinois.gov

Intro

Apply benchmarking to five examples and evaluate potential to use benchmarking to improve safety.

1. Three Classes of American Rail Operation: 2008-2012 Fatalities
2. U.S. Pedestrian and Trespasser Fatalities: 2006-2010
3. Fatality Rates for Selected Nations within the European Union
4. Highway-Rail Crossing Collisions by State: 1990-2012
5. Highway-Rail Crossing Collisions by Railroad: 1990-2012

Benchmarking Defined

Process of comparing one's business processes and performance metrics to industry bests or best practices from other industries.

"In the process of best practice benchmarking, we learn how well the targets perform and, more importantly, ***the business processes that explain why these firms are successful***."

Analysis Objective

1. Identify states and railways with superior rates of safety, as measured by the rate of collisions or fatalities per measure of risk
2. Discern what is what makes the performance of the best, better than the worst
3. ***Future / Ultimate Objective*** Is to apply the difference to reduce incidents

Process

1. Develop metrics to evaluate the relative safety of one state or railway against another, as well as classes of rail operation against one another (freight v. passenger).
2. Apply metric
3. Rank outcomes
4. Apply composite ranks

Method & Data

1. Stepwise regression – used to identify helpful dependent variables
2. Rankings – ordering by best to worst
3. Composite ranking – summing individual ranks into a composite
4. Composite scoring – summing individual rates into a composite rate

Need: Safety data – number of incidents
Exposure data – amount of activity

Major question *– use raw numbers, rates or some modification such as log transformations?*

Intro Example: USA Railways by Type (Freight, Amtrak, Commuter)

Type of Railroad	Fatalities: 2008 - 2012	Fatalities Per Million Miles	Train - Vehicle Collisions: 2008 - 2012	Train - Vehicle Collisions Per Million Miles
Class-1 RRs	2,389	0.84	7,361	2.60
Amtrak	617	3.04	499	2.46
Commuter RRs	336	1.43	273	1.16
Sub-Total	3,342	1.02	8,133	2.49
All Other RRs	104	0.90	172	1.49
Total	**3,446**	**1.02**	**8,305**	**2.46**

Range in Fatality and Collision Rates for American Railroads: 2008-2012

Best

0.84 Fatalities per million miles – Class 1 Railroads

1.16 Collisions per million miles – Commuter Railroads

Worst

3.04 Fatalities per million miles – Amtrak

2.60 Collisions per million miles – Class 1 Railroads

Example 2: Ped/Trespassers (Rank)

19 States: 2006 - 2010 with 50 or More Pedestrian & Trespass Fatalities	Pedestrians & Trespassers Killed	Rank - Per Million Population 2010 (Census)	Rank - Route Thousand Route Miles 2011 (AAR)	Rank - Per Thousand Carloads 2011 (AAR)	Rank - Composite
Missouri	52	8	1	1	**10**
Georgia	72	3	4	7	**14**
Michigan	50	2	2	11	**15**
Tennessee	54	5	8	4	**17**
Indiana	65	13	3	2	**18**
Texas	207	4	6	8	**18**
Ohio	108	11	7	5	**23**
New York	92	1	11	15	**27**
Arizona	66	15	14	3	**32**
Maryland	50	7	17	9	**33**
Louisiana	53	18	5	10	**33**
Pennsylvania	126	12	10	12	**34**
Illinois	192	19	12	6	**37**
Washington	70	16	9	13	**38**
Florida	161	6	15	18	**39**
New Jersey	82	10	19	14	**43**
North Carolina	96	14	13	17	**44**
Massachusetts	57	9	16	19	**44**
California	405	17	18	16	**51**
Total	**2,058**				

Example 2: Ped/Trespassers (Rank by Composite Rank and Rank by Composite Rate)

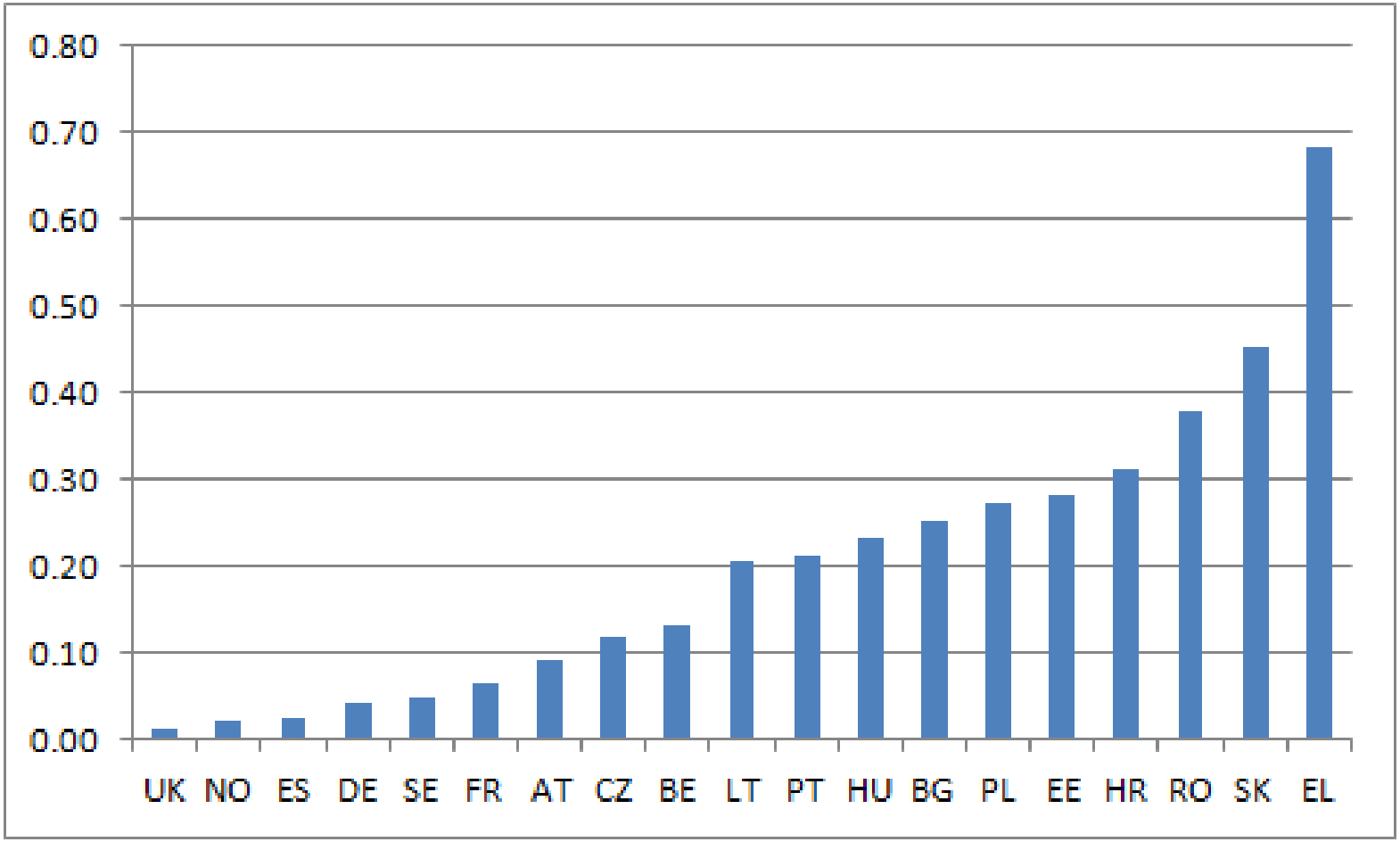
Result when combining the RANK when sorted by best composite ranking and by the RANK when sorted by best composite RATE

19 States: 2006 - 2010 with 50 or More Pedestrian & Trespass Fatalities	Rank by Rank	Rank by Rate	Rank + Rate
Georgia	2	1	**3**
Missouri	1	3	**4**
Michigan	3	2	**5**
Tennessee	4	5	**9**
Texas	6	4	**10**
Indiana	5	6	**11**
Ohio	7	7	**14**
Arizona	9	10	**19**
Louisiana	11	9	**20**
Pennsylvania	12	8	**20**
New York	8	14	**22**
Maryland	10	12	**22**
Illinois	13	13	**26**
North Carolina	17	11	**28**
Florida	15	15	**30**
Washington	14	17	**31**
New Jersey	16	18	**34**
California	19	16	**35**
Massachusetts	18	19	**37**

Example 2: Ped/Trespassers (Best & Worst by Composite Rate)

19 States: 2006 - 2010 with 50 or More Pedestrian & Trespass Fatalities	Pedestrians & Trespassers Killed	Rate - Per Million Population 2010 (Census)	Rate - Route Thousand Route Miles 2011 (AAR)	Rate - Per Thousand Carloads 2011 (AAR)	Rate - Composite
Low (Best)	50	4.75	13.14	0.007	**18.9**
High (Worst)	405	14.96	83.42	0.148	**92.8**
Difference	**8.1**	**3.15**	**6.35**	**21.143**	**4.9**
Low (Best)	MI & MD	NY	MO	MO	GA
High (Worst)	CA	ILL	NJ	MA	**MA**

Example 3: EU Countries



Example 3: EU Countries

Country		Rate		
United Kingdom	UK	0.01		
Norway	NO	0.02		
Spain	ES	0.03		
Germany	DE	0.04		
Sweden	SE	0.05		
France	FR	0.06	**Min**	**0.013070**
Austria	AT	0.09	**Max**	**0.684053**
Czech Republic	CZ	0.12	**Range**	**52.339250**
Belgium	BE	0.13		
Lithuania	LT	0.20		
Portugal	PT	0.21		
Hungary	HU	0.23		
Bulgaria	BG	0.25		
Poland	PL	0.27		
Estonia	EE	0.28		
Croatia	HR	0.31		
Romania	RO	0.38		
Slovakia	SK	0.45		
Greece	EL	0.68		

Example 4: Collisions Between Trains and Vehicles Between 1990 and 2012 by State

Forward stepwise regression identified three exposure variables that best explained the number of collisions - adjusted R-Square of 89.1

Once the independent variables that yield explanatory power were identified, a composite ranking was developed by:

1. Calculating the collision rate for only the **three "kept" variables** and only for the 32 states that experienced 500 or more collisions between 1990 and 2012. The 32 states accounted for 94.7 percent of the 70,728 collisions. The states were then ranked in order by the rate of collisions for each of the kept variables.
2. The three individual ranks were then summed to develop a "composite" rank.
3. Oregon was the "best" state and Texas the "worst" comparatively speaking.

Variables of Significance

Rate per crossing
Rate per licensed driver
Rate per million VMT

Independent Variables	R	R Square	Adjusted R Square	Std. Error of the Estimate
PubXings, VMT10, License09	0.947	0.897	0.891	13.856

Data Item	Description	N	Mean	Std. Deviation	Result
Crash9012	Number of Crashes 1990 thru 2012	51	1,387	1,442	Dependent
License09	Number of Licensed Drivers in 2009	51	4,110	4,370	Kept
PubXings	Number of Public Highway-Rail At-Grade Crossings	51	2,551	2,094	Kept
VMT10	Total Vehicle Miles Traveled	51	58,182	60,279	Kept
AADT13	Annual Average Daily Traffic	51	5,929,611	6,891,329	Excluded
Bach09	% of Population w/ Bachelors Degree in 2009	51	28	6	Excluded
Employee10	Number of Employed persons in 2010	51	2,723	2,983	Excluded
Expose13	AADT * Daily Trains	51	74,965,254	124,900,000	Excluded
Female10	Female Population in 2010	51	3,078	3,458	Excluded
Gates	Number of Public Highway-Rail Crossings with Gates	51	864	950	Excluded
HwyMiles09	Number of Route Miles of All Types of Highways in 2009	51	79,426	54,533	Excluded
LandKm	Square Kilometers of Land	51	179,361	221,519	Excluded
Loads11	Number of Carloads Carried in 2011 (AAR)	51	3,035,206	2,643,803	Excluded
Male10	Male Population in 2010	51	2,976	3,367	Excluded
Pop10	Total Population in 2010	51	6,053,834	6,823,984	Excluded
Quads	Number of Public Highway-Rail Crossings with 4-Quad Gates	51	7	17	Excluded
Register09	Number of Registered Vehicles in 2009	51	4,829	5,710	Excluded
RtMiles	Railroad Route Miles	51	2,717	1,946	Excluded
SqKm	Total Square Kilometers of Land & Water	51	192,775	250,936	Excluded
Tons11	Number of Rail Tons Carried in 2011 (AAR)	51	161	144	Excluded
Xings	Total Number of At-Grade Crossings	51	4,161	3,130	Excluded

Example 4: Collisions by State

States With 500 or more Collisions: 1990 - 2012	Collisions (1990 - 2012)	Rate Per Crossing	Rate Per Licensed Driver	Rate Per Million VMT	Composite Rank
Oregon	546	0.305	0.192	0.016	**20**
Colorado	736	0.431	0.199	0.016	**28**
New York	734	0.274	0.065	0.006	**31**
Idaho	570	0.444	0.540	0.036	**31**
Kansas	1,553	0.304	0.759	0.052	**32**
Washington	975	0.407	0.194	0.017	**34**
New Jersey	715	0.476	0.121	0.010	**35**
Nebraska	1,149	0.385	0.852	0.059	**35**
Virginia	904	0.475	0.169	0.011	**36**
Minnesota	1,918	0.436	0.591	0.034	**39**
Pennsylvania	1,466	0.418	0.169	0.015	**41**
Missouri	1,666	0.483	0.395	0.024	**41**
Oklahoma	1,800	0.483	0.776	0.038	**44**
Kentucky	1,406	0.595	0.478	0.029	**48**
Iowa	2,076	0.478	0.968	0.066	**49**
Florida	2,008	0.529	0.143	0.010	**50**
North Carolina	2,035	0.508	0.313	0.020	**50**
Arizona	621	0.841	0.141	0.010	**51**
South Carolina	1,560	0.587	0.477	0.032	**53**
Michigan	2,464	0.528	0.348	0.025	**54**
Wisconsin	2,198	0.545	0.535	0.037	**55**
California	3,337	0.565	0.141	0.010	**57**
Georgia	2,866	0.550	0.454	0.026	**57**
Tennessee	1,813	0.659	0.405	0.026	**58**
Mississippi	2,248	1.014	1.164	0.056	**62**
Arkansas	2,089	0.770	1.012	0.062	**62**
Ohio	3,527	0.613	0.444	0.032	**68**
Alabama	2,683	0.963	0.709	0.042	**69**
Illinois	4,275	0.546	0.515	0.040	**70**
Indiana	4,242	0.733	0.764	0.056	**74**
Louisiana	3,530	1.203	1.144	0.078	**74**
Texas	7,255	0.799	0.472	0.031	**76**
32 States	**66,965**	**0.577**	**0.364**	**0.026**	
USA Total	**70,728**	**0.544**	**0.337**	**0.024**	

Example 5: Collisions Between Trains and Vehicles Between 1990 and 2012 by Railroad

Rate per crossing
Rate per route mile

Independent Variables	R	R Square	Adjusted R Square	Std. Error of the Estimate
Xings, MilesPass, RtMile	0.997	0.994	0.993	10.150

Data Item	Description	N	Mean	Std. Deviation	Result
Crash13	Number of Crashes in 2013	24	77	123	Dependent
MilesPass	Miles of Passenger Ops in 2013	24	3,106,898	8,221,297	Kept
RtMile	Railroad Route Miles	24	4,255	7,801	Kept
Xings	Total Number of At-Grade Crossings	24	5,573	9,906	Kept
AADT	Annual Average Daily Traffic	24	8,960,796	15,300,000	Excluded
Expose	AADT * Daily Trains	24	130,000,000	199,600,000	Excluded
Hours	Employee Hours Worked in 2013	24	17,093,931	28,730,000	Excluded
MilesFrt	Miles of Freight Ops in 2013	24	21,780,409	47,610,000	Excluded
MilesTotal	Total Miles of Operation in 2013	24	28,246,930	53,440,000	Excluded
MilesYard	Miles of Yard Ops in 2013	24	3,183,186	6,047,349	Excluded
PassMiles	Passenger Train Miles	24	601,000,000	1,549,000,000	Excluded
PubXings	Number of Public Crossings	24	3,557	6,335	Excluded
RevenuePass	Number of Revenue Passengers Carried	24	14,210,726	23,760,000	Excluded

Example 5: Collisions by Railroads

15 Reporting Railways with 10 or More Collisions in 2013	Crashes 2013 All	Rate per Crossing	Rate per Route Mile	Composite Rank
CP	48	0.009	0.012	**2**
BNSF	315	0.012	0.014	**5**
UP	373	0.012	0.014	**7**
CN	96	0.010	0.016	**6**
CSX	328	0.013	0.019	**10**
KCS	54	0.016	0.020	**13**
CRSH	24	0.021	0.020	**15**
NS	340	0.014	0.022	**14**
NJTR	14	0.034	0.026	**20**
MBTA	10	0.030	0.026	**20**
LI	13	0.038	0.041	**23**
FEC	19	0.027	0.054	**21**
SCAX	22	0.074	0.057	**27**
NIRC	19	0.048	0.096	**27**
ATK	113	0.638	0.172	**30**
15 Railways	**1,788**	**0.014**	**0.018**	
USA Total	**2,089**	**0.010**	**0.015**	

Findings

Example 1: United States summary by type of rail operation (freight v. Amtrak v. commuter rail) – Fatalities as low as 0.84 per million train-miles for Class 1 railways and as high as 3.04 per million train-miles for Amtrak; and for level crossing collisions as low as 1.16 per million train-miles for commuter railways and as high as 2.60 collisions per million train-miles for Class 1 railways

Example 2: Pedestrian and trespasser fatalities in the Chicago Metropolitan area – Fatalities as low as 4.75 per million population for Missouri and as high as 14.96 fatalities per million population for Illinois

Example 3: European Railway Level Crossing Fatalities – as low as 0.01 per million train-kilometers for the United Kingdom and as high as 0.68 fatalities per million train-kilometers for Greece

Example 4: United States level crossing collisions by State – as low as 0.274 collisions per crossing for New York state and as high as 1.203 collisions per crossing for Louisiana

Example 5: United States level crossing collisions by Railway – as low as 0.009 collisions per crossing for Canadian Pacific's American operations and as high as 0.638 collisions per crossing for Amtrak; or 0.048 for NIRC

Conclusion

Can we benchmark? Of course, it is actually pretty easy to do.

The truly hard part is finding what actually yields the difference between best and worst, and then,

Implementing change – challenging enough all by itself, but should be easier with good data and analysis to validate the reason behind the changes.