

Coupling Speed Regulation

Coupling Speeds -> Damage Study

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#1 Global

- Chlor alkali producer
- Seller of membrane grade caustic soda
- Supplier of epoxy materials
- Seller of chlorinated organics

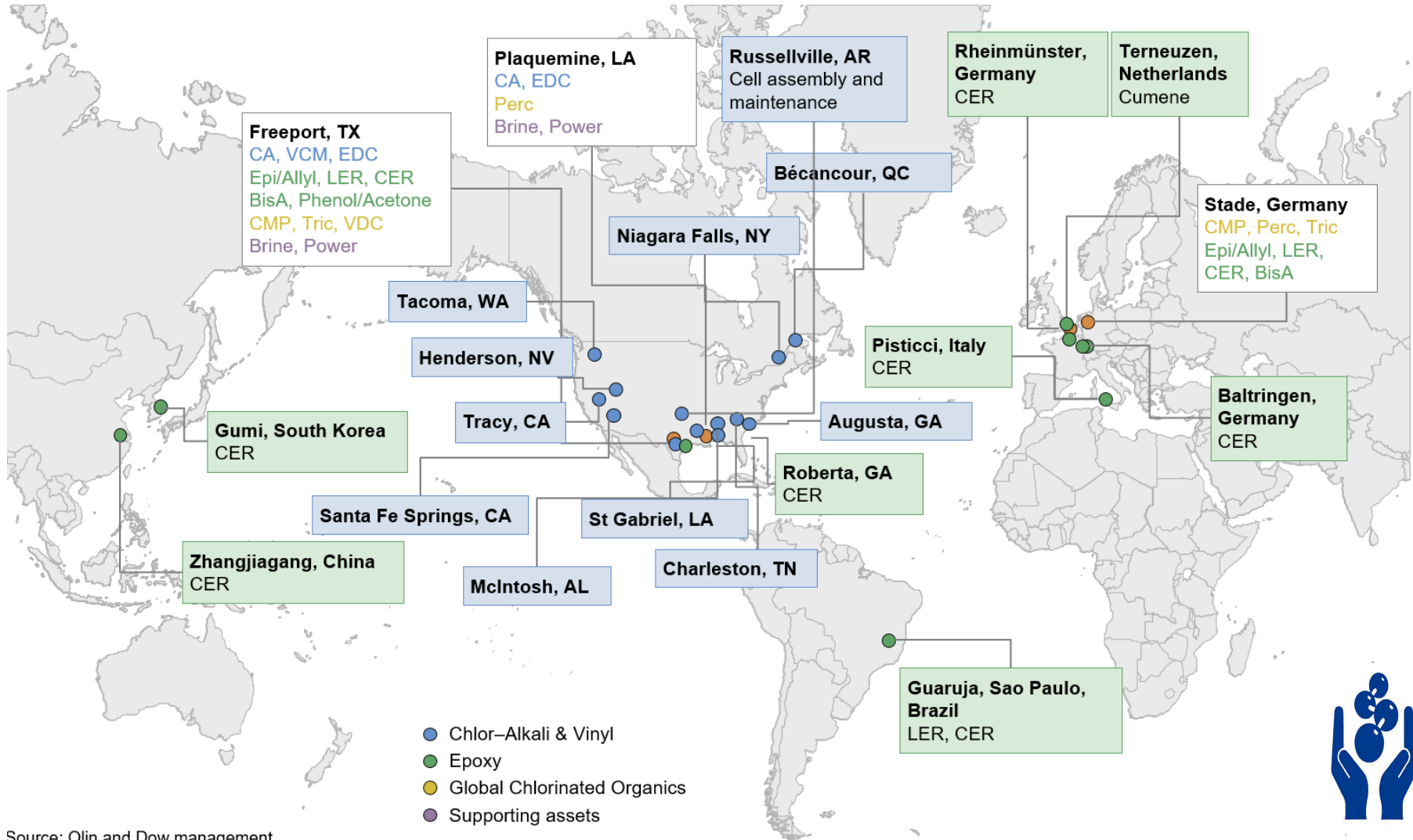


#1 North American

- Seller of chlorine
- Seller of industrial bleach
- Seller of on-purpose hydrochloric acid

Olin is the Leading Chlor Alkali Supplier Globally

Geographic Coverage



Source: Olin and Dow management



More Info leads to better Decisions



In-Transit Data Sources

- GPS with Open/Close Dome Detection
- Motion Detection Image Capture

GPS

- **Impact and Deceleration Data**

- NOAA – Hurricanes Storms

- USGS – Earthquake Data

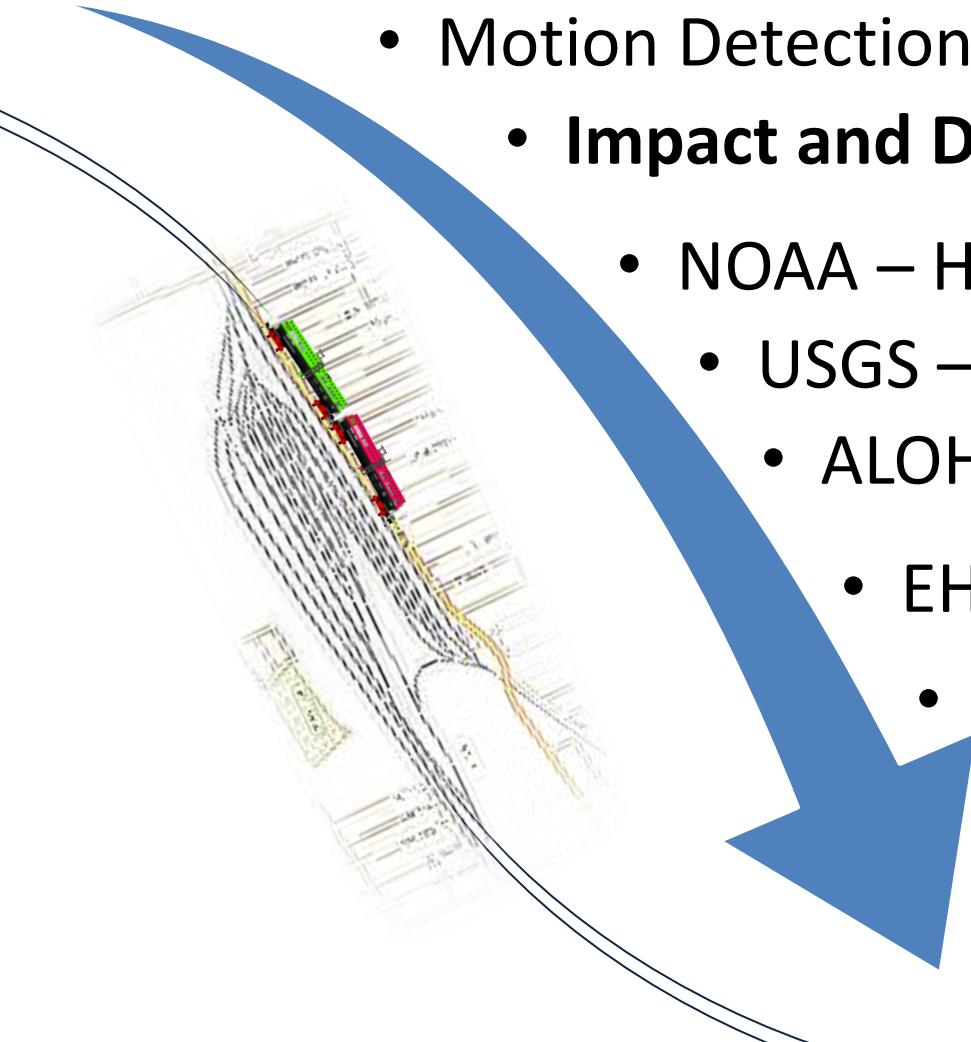
WEB

- ALOHA Plume Modeling

- EHM Alert Data

RailInc

- CLM Data



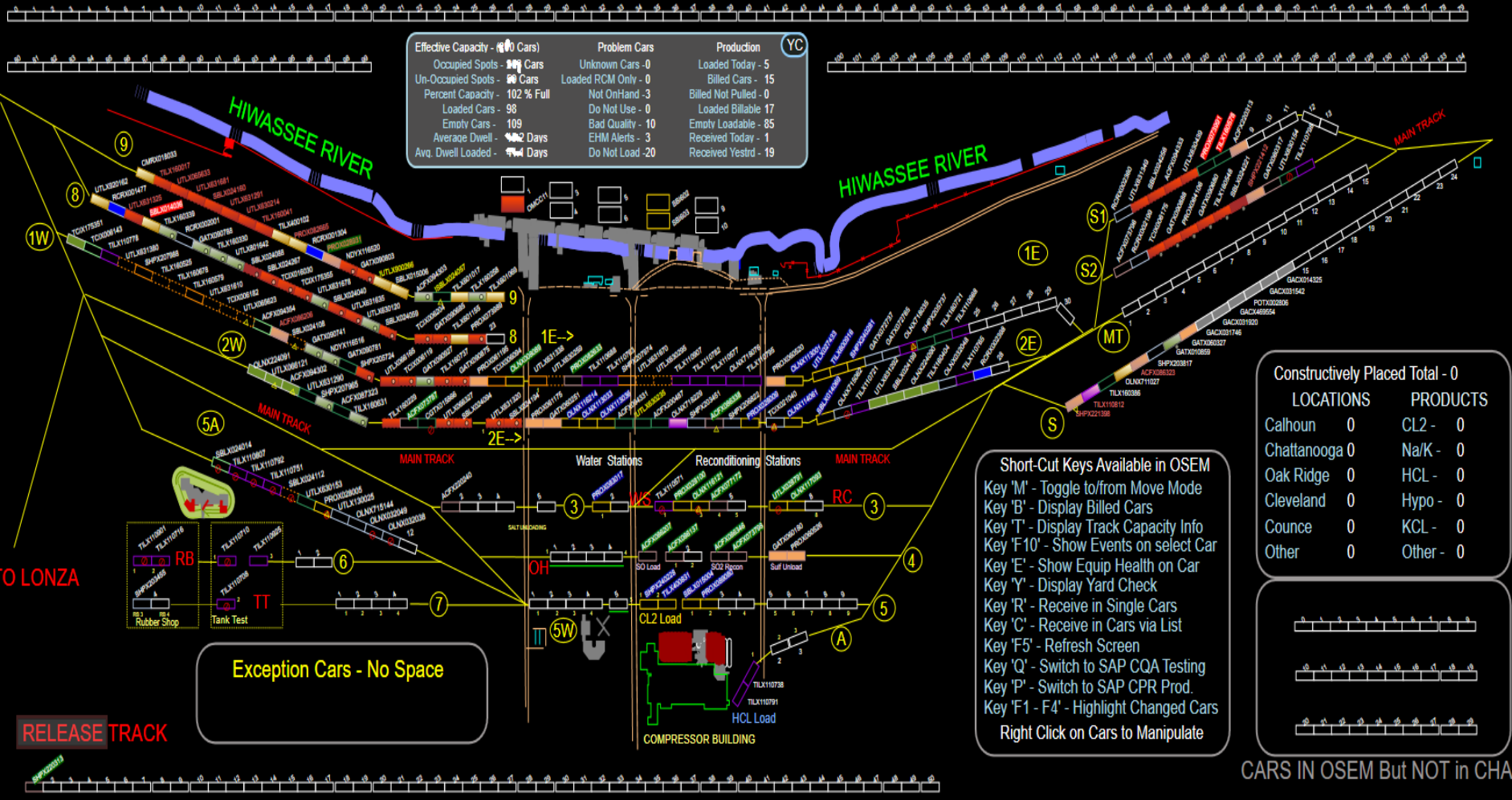
Info via Olin Yard View

Constructive Placed 109

Receivable Cars - 122
Click to Receive Cars



Effective Capacity - 100 Cars	Problem Cars	Production
Occupied Spots - 90 Cars	Unknown Cars - 0	Loaded Today - 5
Un-Occupied Spots - 10 Cars	Loaded RCM Only - 0	Billed Cars - 15
Percent Capacity - 102 % Full	Not On Hand - 3	Billed Not Pulled - 0
Loaded Cars - 98	Do Not Use - 0	Loaded Billable - 17
Empty Cars - 109	Bad Quality - 10	Empty Loadable - 85
Average Dwell - 142 Days	EHM Alerts - 3	Received Today - 1
Avg. Dwell Loaded - 94 Days	Do Not Load - 20	Received Yestr'd - 19

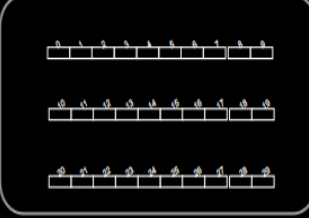


Constructively Placed Total - 0

LOCATIONS	PRODUCTS
Calhoun 0	CL2 - 0
Chattanooga 0	Na/K - 0
Oak Ridge 0	HCL - 0
Cleveland 0	Hypo - 0
Counce 0	KCL - 0
Other 0	Other - 0

- Short-Cut Keys Available in OSEM
- Key 'M' - Toggle to/from Move Mode
 - Key 'B' - Display Billed Cars
 - Key 'T' - Display Track Capacity Info
 - Key 'F10' - Show Events on select Car
 - Key 'E' - Show Equip Health on Car
 - Key 'Y' - Display Yard Check
 - Key 'R' - Receive in Single Cars
 - Key 'C' - Receive in Cars via List
 - Key 'F5' - Refresh Screen
 - Key 'Q' - Switch to SAP CQA Testing
 - Key 'P' - Switch to SAP CPR Prod.
 - Key F1 - F4' - Highlight Changed Cars
- Right Click on Cars to Manipulate

Exception Cars - No Space



CARS IN OSEM But NOT in CHAS

RELEASE TRACK

TO LONZA

COMPRESSOR BUILDING



Hurricane / EarthQuake

Execution Time: 6.578 Seconds for 7496 items

File Help Refresh Data Maximize Data View Recent QUAKES Weather Radar Current Weather Alerts Hide Hurricanes

Tools Show Car Color Legend Show Customer Layer

Reset Map Clear Pins

Weather Options Special Maps

Selections and Route Info Pipeline Car Status Maintenance EHM Show Sightings Show Route BOL COA Reset

UNITED STATES MEXICO CUBA

Gulf of Mexico Caribbean

1000 miles

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Selections and Route Info... TRK L... Data Summ...

Days Out(65) 7 Days + (245) Unknown (56) Plant Summaries

Draw Map 1735 Cars OLIN-SAP;... Any Material Any Car Any Plant Any Status Load or Em... Any Road 5 No Mv Days Any Condition Print/Email

shipped_from shipper shipped_on road going

1735 Cars

Hurricane MATTHEW
10/3/2016 11:00:00 AM
120 KT 140 MPH

...POWERFUL HURRICANE MATTHEW EXPECTED TO BRING LIFE-THREATENING RAIN...WIND...AND STORM SURGE TO PORTIONS OF HAITI...
As of 11:00 AM EDT Mon Oct 3
the center of MATTHEW was located near 15.6, -75.0
with movement N at 6 mph.
The minimum central pressure was 941 mb
with maximum sustained winds of about 140 mph.

Hurricane MATTHEW will have traveled 0 miles from current point

Coupling Speed Regulation History

- Canada TDG Act (10.7) - August 2002
 - DG Cars must not couple > **6 mph**
 - Above **-13°F** Single Car cuts not couple > **7.5 mph**
 - Underframe & Draft Gear Inspected before moved
 - Report to Owner in **10 days** Inspection and Result
 - Owner **CANNOT** Reuse car until Shop Stub Sill inspection



Latest TC Update 7/8/2016

- **Uses chart to define Over-speed Coupling Events**

Coupling Mass	Ambient Temp	Max Cpl Speed
> 330,693 lbs	$\leq -13^{\circ} \text{ F}$	6 mph
> 330,693 lbs	$> -13^{\circ} \text{ F}$	7.5 mph
$\leq 330,693 \text{ lbs}$	$\leq -13^{\circ} \text{ F}$	8 mph
$\leq 330,693 \text{ lbs}$	$> -13^{\circ} \text{ F}$	9.5 mph

- **Within last year – Olin has been receiving Overspeed notifications from CA RR DDCT Rule 1**

RSAC Initiatives

Railroad Safety Advisory Committee

- Coupling Speed Task Force
 - Should FRA regulate similar to TDG 10.7 ?
 - Should it be a regulation or an AAR Standard Operating Practice ?
- Effort to find Coupling Speed to Damage correlation data – Olin has this data

Multi-K Sensor Equipped GPS Devices





Olin Summarized Rail-Yard Deceleration Data for US and CANADA

Olin Corporation-Don Loftis (7/19/2016)

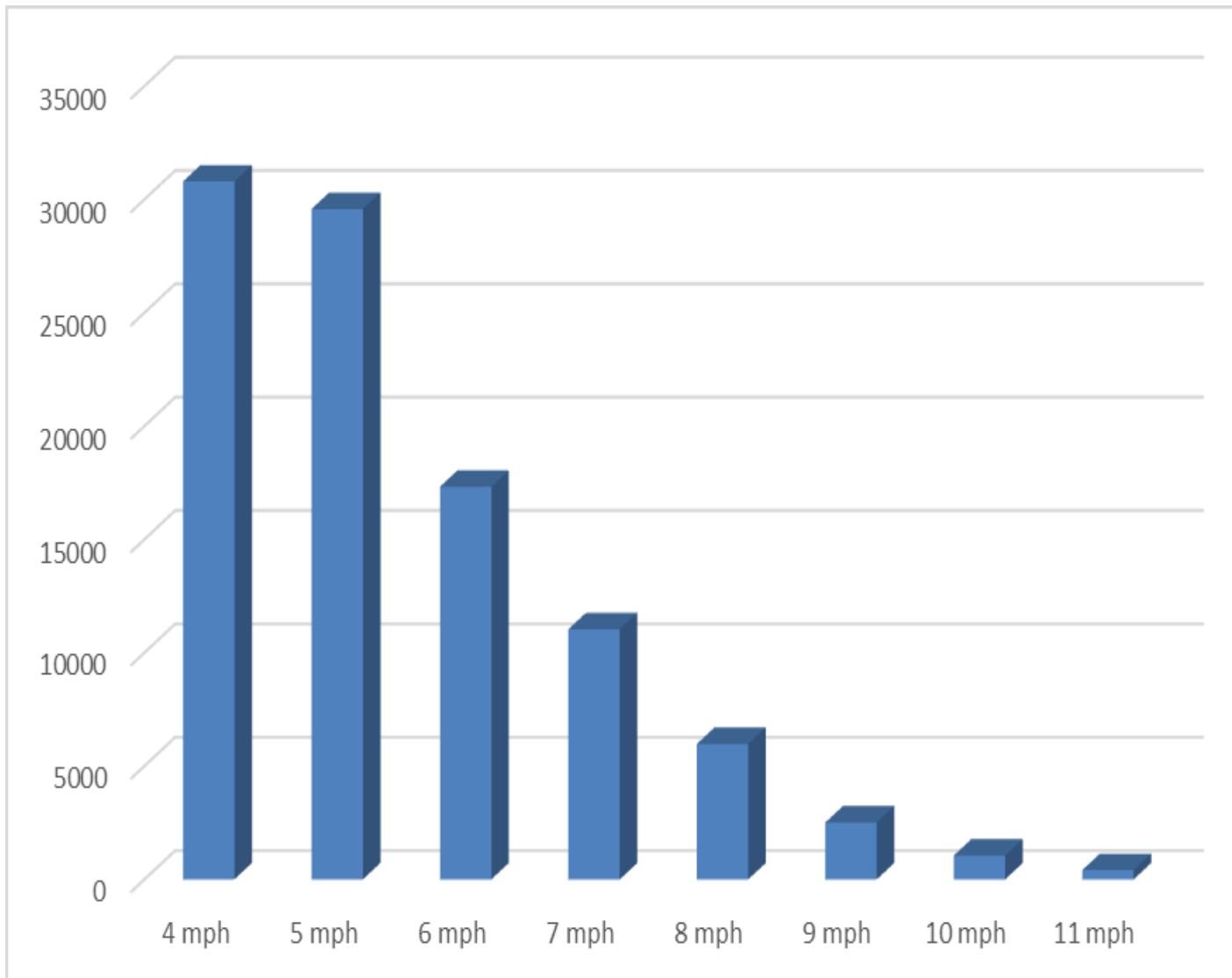
- Filtered out Coupling Events Based upon:
 - Under Bridges Geofence
 - Within Retarder Equipment Geofence
 - Couplings that did not register Impact Force
 - Only devices Post 2011 firmware (no errors)
- Larger than 2g and 3 mph
- Data set 2011 – 2015 -> 394K to 191K

System Wide Coupling Speed Profile

- 36 Months of Data Jan 1, 2013 – Jan 1, 2016
- All Yards (FLAT, HUMP, End Point)
- Coupling Speeds Rounded to nearest whole #
- Speeds between 3 and 3.49 discarded
- OBJECTIVE:
 - Chart Coupling speed profile starting with **4 mph – 11 mph**
 - Data set 98,672 couplings occurred on 25,200 bills

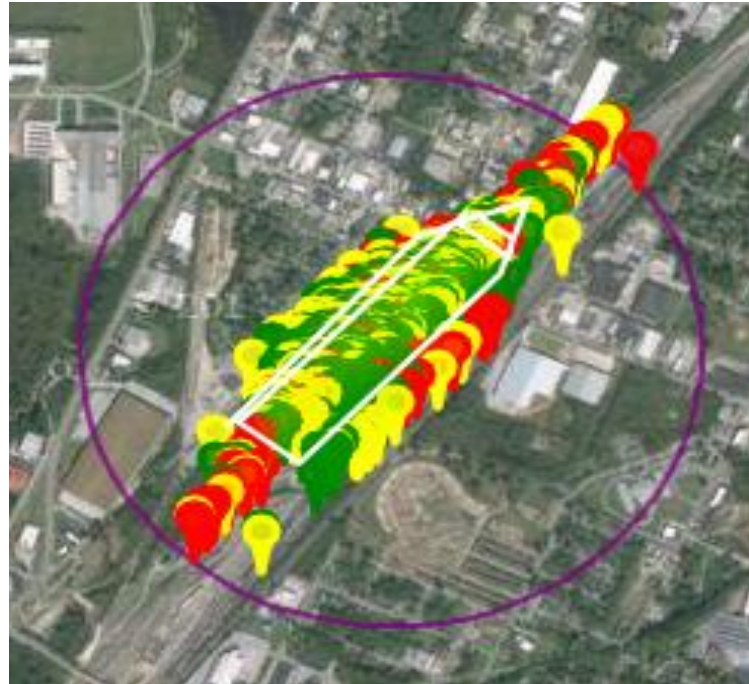


System Wide Coupling Speeds 2013 - 2015



Speeds	Event Count	Total %
4 mph	30788	31.20%
5 mph	29573	29.97%
6 mph	17320	17.55%
7 mph	11037	11.19%
8 mph	5978	6.06%
9 mph	2511	2.54%
10 mph	1055	1.07%
11 mph	410	0.42%
Total	98672	

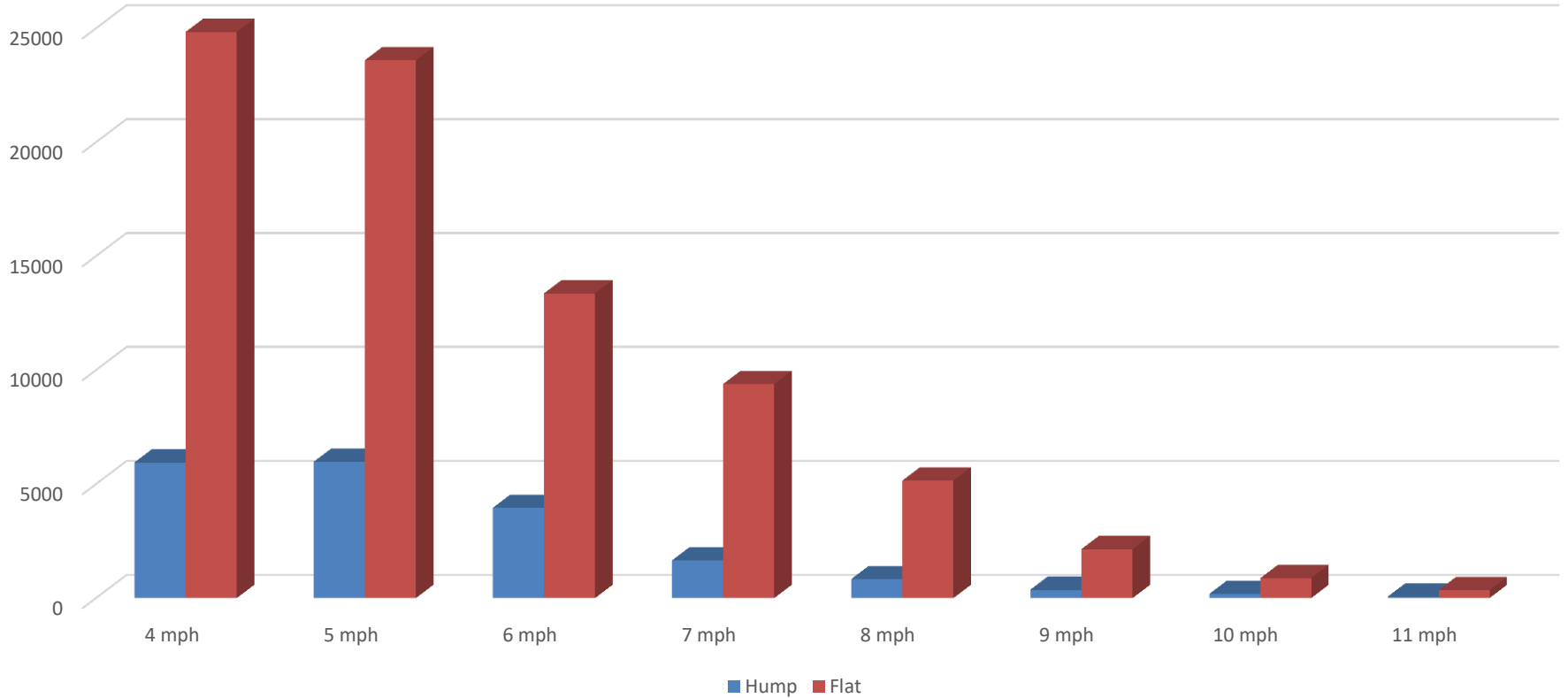
System Coupling Speed Broken into Hump and Flat Yard Profile:



- 59 Hump Yards in US and Canada
- GeoFence around retarder areas and Hump portion of yard
- Could be some data from Adjacent Flat or Thru Tracks included



Coupling Speeds 2013 - 2015 Hump & Flat



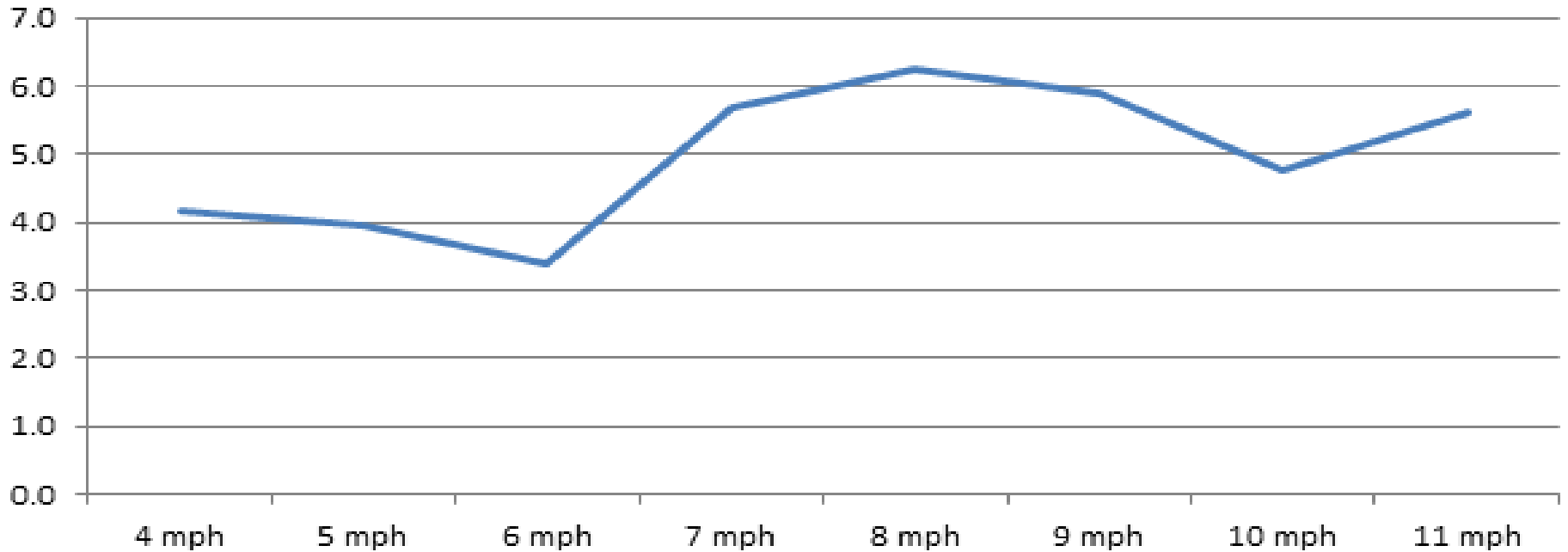
Average:
4 to 1 Flat to Hump

Do not know ratio of visits Flat to Hump

Speeds	Hump	Flat	Total
4 mph	5948	24840	30788
5 mph	5975	23598	29573
6 mph	3957	13363	17320
7 mph	1651	9386	11037
8 mph	827	5151	5978
9 mph	364	2147	2511
10 mph	183	872	1055
11 mph	62	348	410
Total	18967	79705	98672



Ratio Flat to Hump Coupling Events



Ratio Flat increases over 6 mph. Humps better controlled 4-9 mph but both susceptible 10-11 mph events

SPEED	HUMP	FLAT	% HUMP	% FLAT	Ratio Flat to Hump
4 mph	5948	24840	31.4	31.2	4.2
5 mph	5975	23598	31.5	29.6	3.9
6 mph	3957	13363	20.9	16.8	3.4
7 mph	1651	9386	8.7	11.8	5.7
8 mph	827	5151	4.4	6.5	6.2
9 mph	364	2147	1.9	2.7	5.9
10 mph	183	872	1.0	1.1	4.8
11 mph	62	348	0.3	0.4	5.6
Total	18905	79357			4.2

Railcar Damage Pilot Data

Goal: Pick alert set-point for Inspection

- Study 200 **Loaded Tank cars over 1 year**
 - 50 pressure cars 105J600W – 286 K lbs
 - 50 pressure cars 105J500W – 263 K lbs
 - 100 non-pressure 111A100W – 263 K lbs
 - All Type E Double Shelf Couplers
 - Knuckles (650K ft lbf) Bodies (900K ft lbf)
 - Un-cushioned Draft Gear
 - 75% < 2 yr Old; 25% Recently Shopped
- Results - DOT car type didn't matter so combined data to have larger data set

Study Parameters

- 200 LOADED Tank cars
- Record **Max** Coupling speed **loaded** leg
- Inspect car on return for damage
- Retrieve car repair billing data on car
- Count damage components vs mph
- Results: Only Draft Gear Damage
 - Coupler Pin, Knuckles, C Body, S Plate
 - Repairs by Olin maint, Mobile Crew, CRB (i.e. No External Shopping Required)



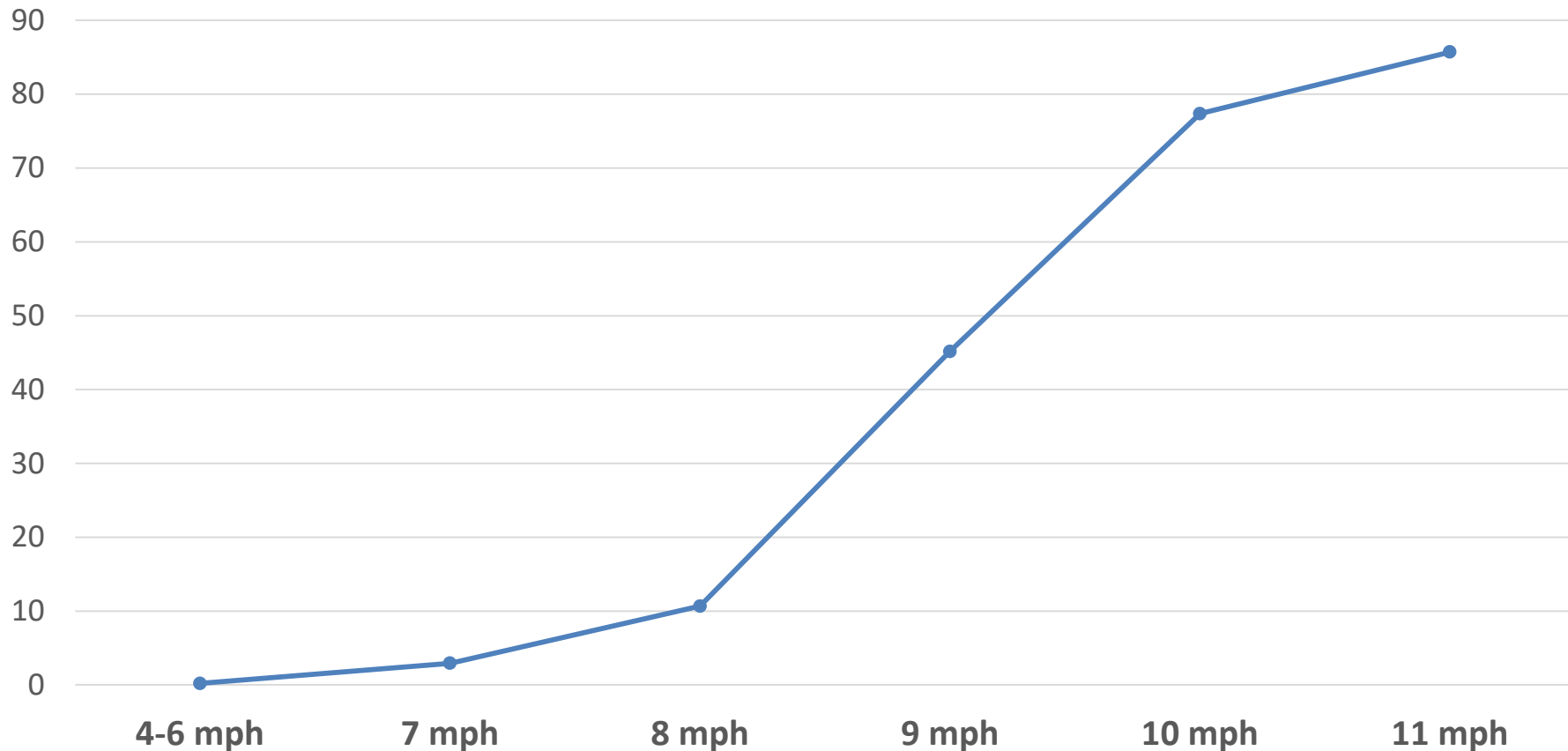
Damage Done

SPEED	Cplr_Pins	Knuckles	Cplr_Body	Striker_Plate	#Max_events	#Bad_Components
4-6 mph	3	1	0	0	2002	4
7 mph	7	2	0	0	308	9
8 mph	12	6	3	0	197	21
9 mph	23	9	7	3	93	42
10 mph	17	8	9	7	53	41
11 mph			3	3	7	6
Total	62	26	22	13	2660	123

Note: Changing a knuckle or coupler body also included a new coupler knuckle pin which was not included in the coupler pin count. The idea was **not** to double count coupler damage from the same Max Event but still be able to see severity. The severity from least severe to most severe is coupler knuckle pins, knuckles, and Coupler body.



% Damage Probability



% Damage =
BadComponents /
MaxEvents
at each speed level

SPEED	#Max_events	#Bad_Components	% Damage
4-6 mph	2002	4	0.20
7 mph	308	9	2.92
8 mph	197	21	10.66
9 mph	93	42	45.16
10 mph	53	41	77.36
11 mph	7	6	85.71
Total	2660	123	

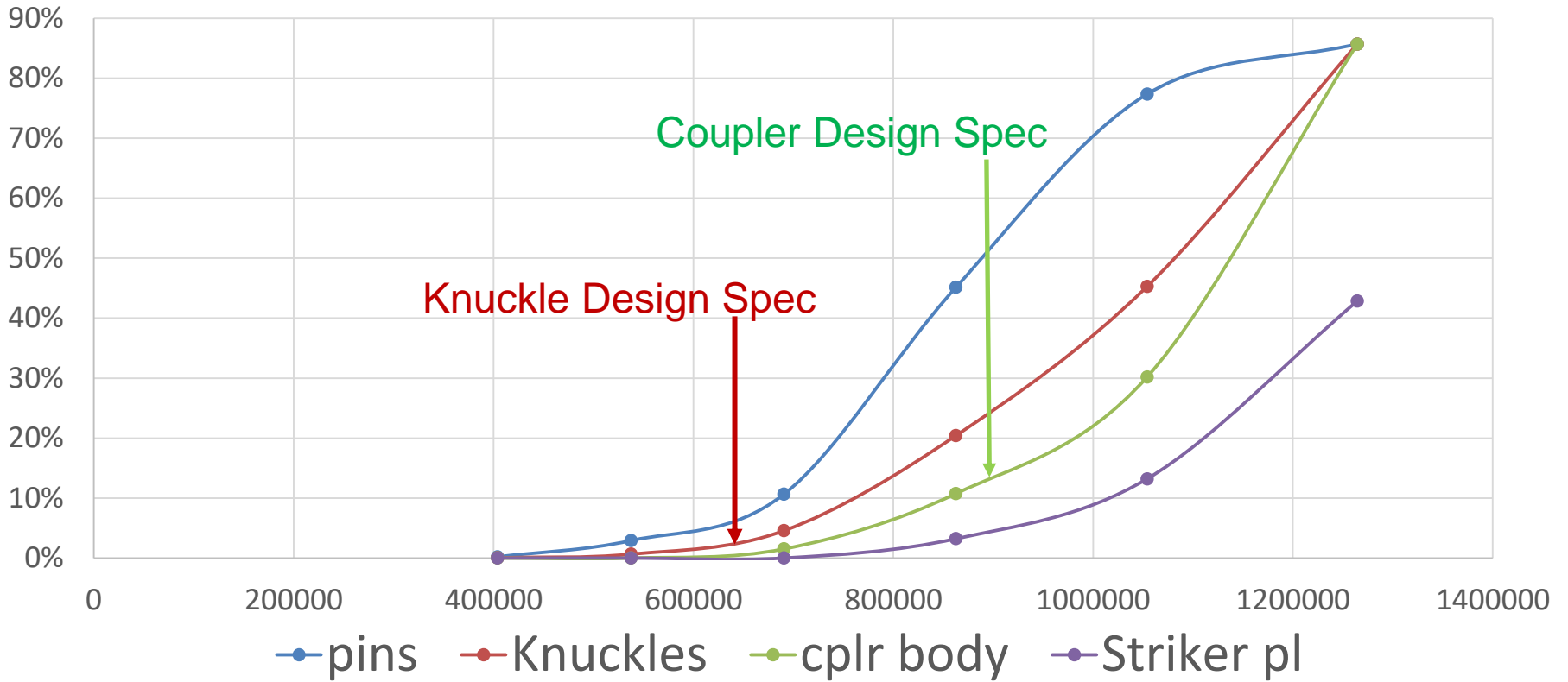
Damage per Energy

- $F = \text{Mass} \times \text{Acceleration}$
- $\text{Energy} = \frac{1}{2} \text{Mass} \times \text{Velocity}^2$

Assuming the max speed for each speed category (i.e. 7 = 7.5 because 7 represents 6.5 to 7.49) and converting speed mph to Feet per second and assuming a Mass of 129727kg (286000 lb. representing max loaded 286 car) then energy at each speed level can be calculated in Foot Pounds of Force.



Damage Frequency per Event vs Energy (ft-lbs)



SPEED	Energy (ft-lbf)	pins	Knuckles	cplr body	Striker pl
6.5	403942	0.001998002	0.0004995	0	0
7.5	537792	0.029220779	0.006493506	0	0
8.5	690764	0.106598985	0.045685279	0.01522843	0
9.5	862857	0.451612903	0.204301075	0.10752688	0.032258065
10.5	1054070	0.773584906	0.452830189	0.30188679	0.132075472
11.5	1264410	0.857142857	0.857142857	0.85714286	0.428571429

Summary

- Collision velocity of greater than **8.5 mph**, coupling damage is a frequent consequence whereas at velocities less than 7.5 mph, damage is rare
- Most Common damage **Draft Gear Comp.**
- All Damage repairable on site or intransit
- Set our **alert point at 7+ mph** to be conservative
- Data Validated on larger CRB data set

Additional Damage Info

- No Stubb Sills, truck, center pins damaged
- 4 Draft Keys replaced in CRB
- Cross couplings occurred on 9 study cars
no coupling events occurred (i.e. $< 3\text{mph}$)
- 1 PRV lift on non-press car 9mph coupling
- Side Skin damage on 4 non-press cars

Things to Consider:

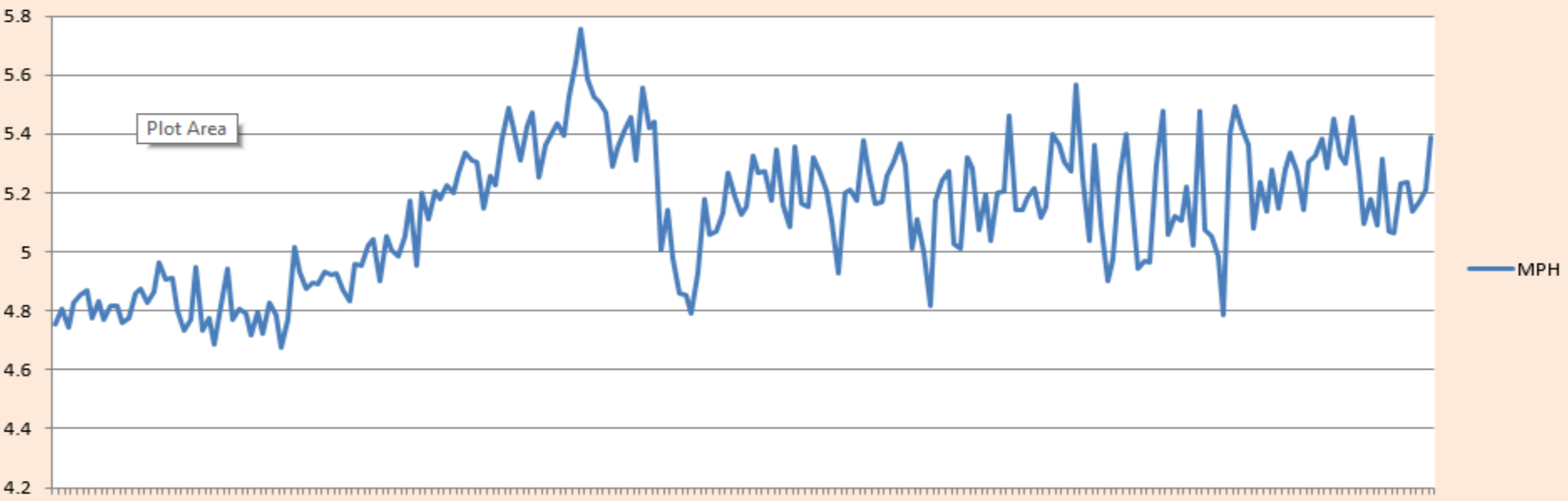
- A Shop Sill Inspection removes car from service for weeks
- None of our damage was Shop Worthy
- Notifications to owner are desired even if no draft gear damage was detected
- Overspeed couplings can cause NARs so ground level inspection for evidence of a relief should be part of field inspection



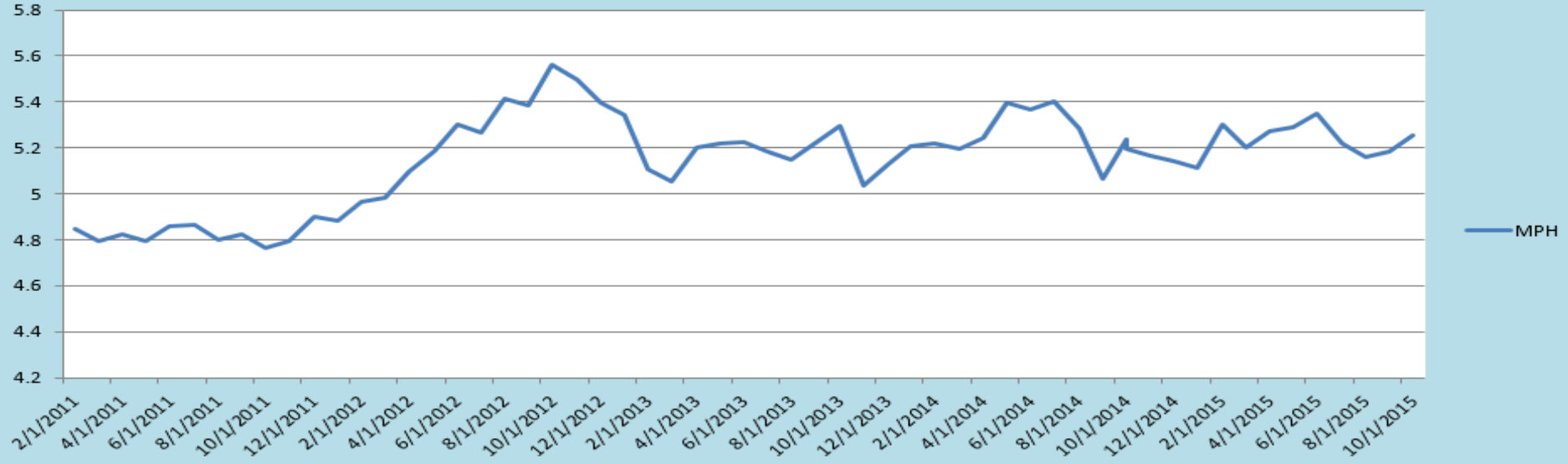
Discussion / Questions

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Weekly Deceleration Events 2011-2015



Deceleration Events by Month 2011 - 2015



Draft Gear Components

Typical E-Type Coupler Draft Arrangement

