PennState College of Engineering

GE Transportation

GE Transportation

Freight, Fuel, & Emissions

Introduction to Engineering Design
EDGSN 100 Section 001

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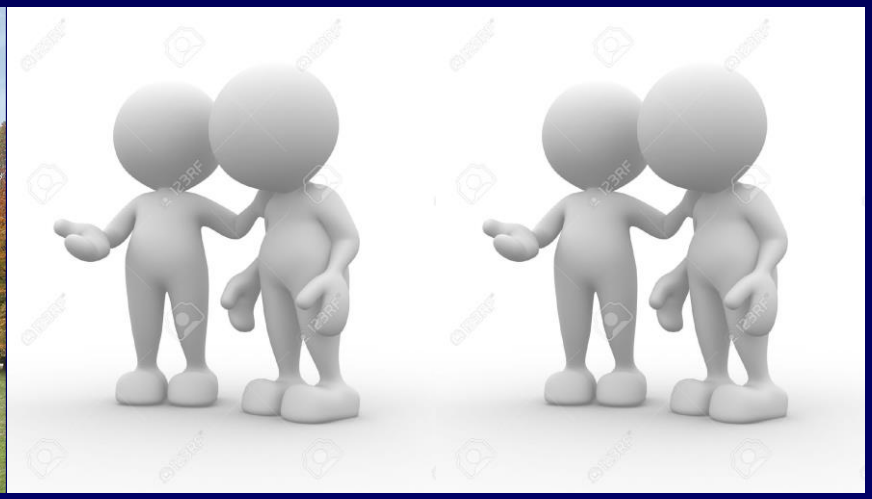


Presented to: Prof. Berezniak
Date: 12/11/2015

Introduction

-most efficient method to move 165,000 tons of freight (or more) in and out of Pittsburgh

-goal: to reduce smog and meet more stringent EPA standards

-sponsored by GE Transportation

- -headquartered in Chicago, IL
- -been in business for over 100 years
- -multinational team of 13,000 memb
- -over 65 sites worldwide

GE Transportation

-considerations:

- -emissions/regulatory requirem
- -costs: fuel/infrastructure
- -freight throughput/capacity
- -public opinion
- -on-time delivery

Transportation Infrastructure Condition and Capacity

Infrastructure in Pennsylvania	Grade Summaries
Bridges	D+
Freight Rail	D
Ports	C+
Inland Waterways	D+
Roads	D-

Transportation Infrastructure Condition and Capacity

Bridges:

- 22660 bridges in Pennsylvania.
- 33% is categorized as SD while 19% is FO
- 15% of trucks passing the bridges were “overweight”.
- Deicing chemical leads to corrosion of steel members.
- Average age of bridges ≈ 54 years, SD bridges ≈ 75 years
- Due to load capacity issues for SD bridges, there will be weight restrictions and “bridge posting”.
- The capacity for traffic (bridge width) in the state is inadequate.

Transportation Infrastructure Condition and Capacity

Roads:

State traffic safety has been stable over 5 years.

Pennsylvania 1.3 fatalities per 100 miles of travel is higher than national average.

Rural non-interstate routes are facing rate of fatalities 2.5 times higher than state average.

Interstate system has 4% over 100 miles rated in poor condition.

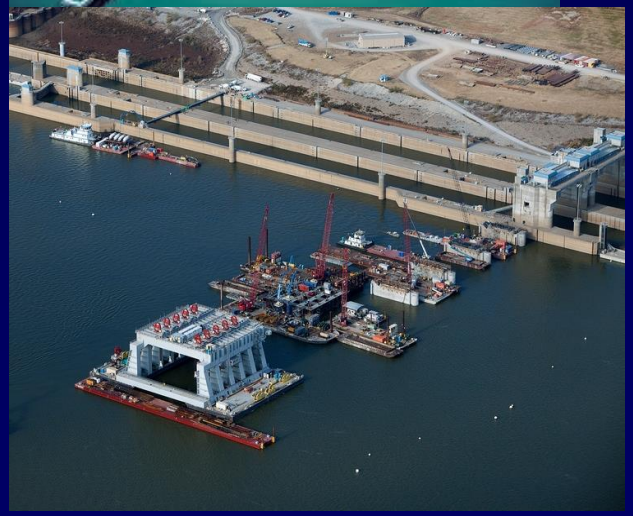
Statewide has 23% poor condition roadways.

Severe winter and chemical used during snowy conditions reduce life of pavement.

Transportation Infrastructure Condition and Capacity

Inland Waterways:

- In 2012, approximately 35 million tons of commercial tonnage was transported.
- 37,000 annual lockages over the past four years recreational lockages averaging about 12,000 lockages per year.
- 17 navigation dams in the western Pennsylvania inland water system reveals that none of the dams has a satisfactory rating.
- 18 percent of the locks have a satisfactory rating.



Transportation Infrastructure Condition and Capacity

Freight Rail

Commodities coming into and going out of Pennsylvania by rail are dominated by coal and intermodal freight

There are a number of rail lines in Pennsylvania considered at risk because of low traffic density

With annual traffic less than five MGT, 124 Pennsylvania rail lines are considered at risk of abandonment.

Standard Capacity for Alternate Transportation Modes

Transportation Modes	Standard Capacity
Barges	Before: 195 ft long x 35ft wide Capacity: 1500 tons Newer barge: 290ft long x 50ft wide
Trucks	GTWR Light duty : 0-14000lb Medium duty: 14001-26000lb Heavy duty:>26001lb
Trains	A modern railcar has a gross capacity of 286,000 lbs or 125.5 tons moving in trains consisting of 100 cars or more, yielding a total carrying capacity of 12,500 tons,

Transportation Costs

	Trains	Barges	Trucks
Cost Per Ton-Mile ($)	$2.24	72 cents	$26.61
Purchase Cost ($)	$32,000,000	$24,750,000	578,000,00

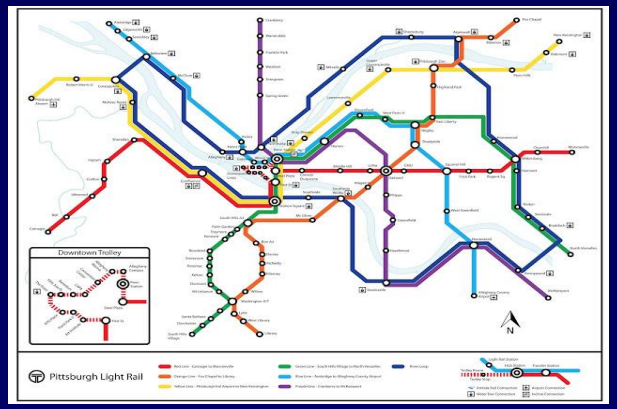
While the barges are more cost effective, trains are our solution because of their other advantages

Transportation Costs (cont.)

Concept of Operations (ConOps)

J & L Tunnel

Since Pittsburgh is currently adding to its rail line and the the fact that we are renovating the fleet, there will not be an issue with railway capacity.



Concept of Operations (Cont.)

Pittsburgh will not be heavily affected environmentally, as we are upgrading our fleet to tier 4

EPA Diesel Emission Standards

Table 1
Tier 0-2 Locomotive Emission Standards, g/bhp·hr

Duty Cycle	HC*	CO	NOx	PM
Tier 0 (1973 - 2001)				
Line-haul	1.0	5.0	9.5	0.60
Switch	2.1	8.0	14.0	0.72
Tier 1 (2002 - 2004)				
Line-haul	0.55	2.2	7.4	0.45
Switch	1.2	2.5	11.0	0.54
Tier 2 (2005 and later)				
Line-haul	0.3	1.5	5.5	0.20
Switch	0.6	2.4	8.1	0.24
Non-Regulated Locomotives (1997 estimates)				
Line-haul	0.5	1.5	13.5	0.34
Switch	1.1	2.4	19.8	0.41
* HC standard is in the form of THC for diesel engines				

Table 2
Locomotive Smoke Standards, % opacity (normalized)

	Steady-state	30-sec peak	3-sec peak
Tier 0	30	40	50
Tier 1	25	40	50
Tier 2 and later	20	40	50

EPA Diesel Emission Standards-(cont.)

Table 3
Line-Haul Locomotive Emission Standards, g/bhp·hr

Tier	MY	Date	HC	CO	NOx	PM
Tier 0[a]	1973-1992[c]	2010[d]	1.00	5.0	8.0	0.22
Tier 1[a]	1993[c]-2004	2010[d]	0.55	2.2	7.4	0.22
Tier 2[a]	2005-2011	2010[d]	0.30	1.5	5.5	0.10[e]
Tier 3[b]	2012-2014	2012	0.30	1.5	5.5	0.10
Tier 4	2015 or later	2015	0.14[f]	1.5	1.3[f]	0.03

a - Tier 0-2 line-haul locomotives must also meet switch standards of the same tier.
b - Tier 3 line-haul locomotives must also meet Tier 2 switch standards.
c - 1993-2001 locomotive that were not equipped with an intake air coolant system are subject to Tier 0 rather than Tier 1 standards.
d - As early as 2008 if approved engine upgrade kits become available.
e - 0.20 g/bhp-hr until January 1, 2013 (with some exceptions).
f - Manufacturers may elect to meet a combined NOx+HC standard of 1.4 g/bhp-hr.

Table 4
Switch Locomotive Emission Standards, g/bhp·hr

Tier	MY	Date	HC	CO	NOx	PM
Tier 0	1973-2001	2010[b]	2.10	8.0	11.8	0.26
Tier 1[a]	2002-2004	2010[b]	1.20	2.5	11.0	0.26
Tier 2[a]	2005-2010	2010[b]	0.60	2.4	8.1	0.13[c]
Tier 3	2011-2014	2011	0.60	2.4	5.0	0.10
Tier 4	2015 or later	2015	0.14[d]	2.4	1.3[d]	0.03

a - Tier 1-2 switch locomotives must also meet line-haul standards of the same tier.
b - As early as 2008 if approved engine upgrade kits become available.
c - 0.24 g/bhp-hr until January 1, 2013 (with some exceptions).
d - Manufacturers may elect to meet a combined NOx+HC standard of 1.3 g/bhp-hr.

Diesel Engine Exhaust Emissions (DEEE)

Forms of NOx:

-rxns: $CH+N_2$ during combustion, NH_2+NO from fossil fuels, HCCO+NO. or combustion of hydrocarbons in O_2 or N_2

1) **-NO: most common, but least harmful due to low solubility in water**
   -rapidly converted to NO_2 and N_2O.
1) **-N_2O: not very reactive, but depletes ozone with a half-life of 100-150yrs**
2) **-NxOx: dissolves in water to form nitric or nitrous acid**
3) **-50% of NOx is from transportation equipment**

Forms of PM (Particulate Matter):

-small particles
-liquid droplets
-metals
-organic chemicals
-soil or dust particles
-acids formed from nitrates and sulfates
-inhalable coarse particles (between 2.5 and 10 micrometers in diameter)
-fine particles (smaller than 2.5 micrometers in diameter)

Diesel Engine Exhaust Emissions (DEEE)-(cont.)

CO_2

-makes up 82% of greenhouse gases produced by people

-in the U.S., 31% of CO_2 emissions are from transportation equipment

-can be absorbed by plants, trees, and other organic materials, but is hard to destroy

Hydrocarbons

-are formed during the combustion of C-containing compounds in air, which consists mainly of N_2 and O_2 with some H_2

-CH_4 is the most common, but more harmful hydrocarbons also form

-can react with O_2 to form CO_2 and H_2O

Diesel Engine Exhaust Emissions (DEEE)-(cont.)

-alternate fuels such as algae-based biofuels, dimethyl ether, and natural gas
-SCR (Selective Catalytic Reduction)
-DOC (Diesel Oxidation Catalyst)
-DPF (Diesel Particulate Filter)
-EGR (Exhaust Gas Recirculation)
-CCV (Closed Crankcase Ventilation Systems)
-carcinogens in diesel exhaust include arsenic, benzene, formaldehyde, and nickel

According to the ARB (Air Resources Board):
-70% of the cancer risk to Californians from toxic air is from diesel emissions
-In 2000, the level of airborne diesel particles in California was high enough to cause an excess of 540 cases of lung cancer per million people

Locomotive Fleet Upgrade

No. of Existing Locomotives	Locomotive Group Designation	Assumed Existing Locomotive Mileage Range	Assumed Existing Diesel Type	Upgrade/Replacement	New/Upgrade Train (Millions of dollars)	After-market System (Millions of dollars)	Selling Price (Millions of Dollars)	Tier of Train
10	A	<150,000	Tier 2	UPGRADE Tier 3 + After market	-7.5	-2.5	0	Tier 4
10	B	>150,000 and <300,000	Tier 2	UPGRADE Tier 3 + After market	-7.5	-2.5	0	Tier 4
10	C	>300,000 and <450,000	Tier 2	UPGRADE Tier 3 + After market	-7.5	-2.5	0	Tier 4
10	D	>450,000 and < 600,000	Tier 2	NEW Tier 3 + After market	-30	-2.5	15	Tier 4
10	E	>600,000 and <750,000	Tier 2	NEW Tier 3 + After market	0	0	15	Tier 4
					-52.5	-10	30	
							-32.5	

Summary

-Upgrade all locomotives to meet tier 4 emission standards

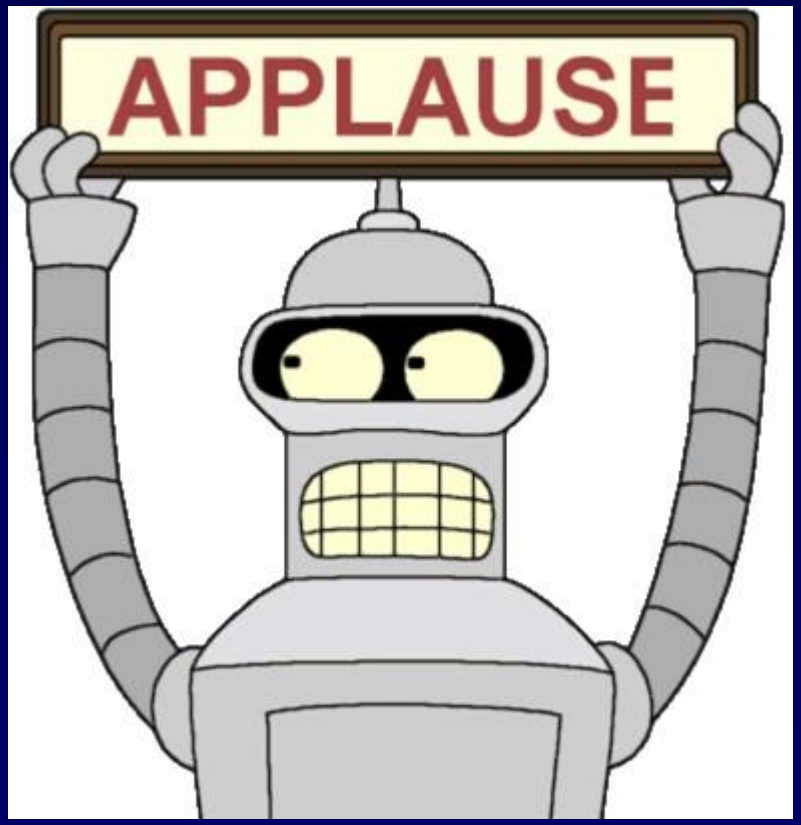
-Reduce the fleet size to 40 locomotives

-All new locomotives have a r.o.i. for of two years

-The cost of the upgrade will be 32.5 million dollars over three years

-Reduce NOx, PM, CO_2, and hydrocarbon emissions with SCR and EPG

-Better protect human and environmental health

-The cost of the barge is 8 million less than that of locomotives but the other advantages of trains outweigh this

Thank you for listening!
Questions?