Managing Technological Change

- **Technological evolution is driven by multiple processes:**
  - **Technical**
  - **Economic**
  - **Social**
  - **Political (including Regulatory)**
  - **Organizational**

- **Technological changes are typically cyclical:**
  - **Variation (a discontinuity comes along)**
  - **Ferment (substitution, design competition, old v new)**
  - **Selection (dominant design(s) emerge)**
  - **Retention (incremental change, technological momentum)**

- ***Effectiveness in making technological change:***
  - ***Does it "just happen" or can it be nurtured?***

Tech. change for N. American railroads

- **Automatic air brake invented (+24 years) 1869**
- **Automatic coupler invented (+20 years) 1873**
- **Standard Time adopted nationwide 1883**
- **Standard gauge adopted nationwide 1886**
- **Safety Appliance Act enacted 1893**
- **Dieselization (~31 years) 1923-1954**
- **AC traction R&D (10 years)* 1983-1992**
- **AC traction adoption (~20 years) 1992-2012**
- **ECP braking (20 years & counting) 1993-**

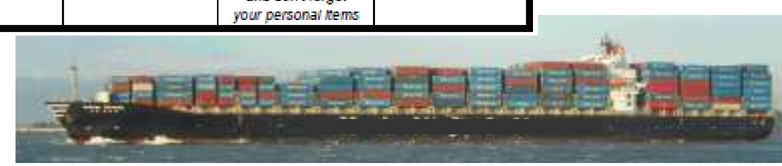
* Preceded by decades of AC development and operation in Europe

Wheel on rail

- **1: What makes rail unique?**
- **2: Importance of (N. American) network interoperability**
- **3: Aggregate realities of rail (internal & external forces)**
- **4: Where do we go from here/now?**
- **5: Managing technology (& technological change)**

Part 1: Comparing transport modes

Mode	*Infra. is common?*	*Infra. ownership*	*Fleet carrier ownership*	*Fleet non-carrier ownership*	*Eqpmt. life*	*Eqpmt. Interop.*	*"Cockpit to crew" ratio*
RAIL	**Yes**	**100% private**	**33% cars (locos. ~100%)**	**66% cars**	**20-40 years**	**Extensive**	**Low 1:1** **High 8:1** (DP trains)
TRUCK	**Yes**	**Public** (exc. terminals etc)	**~100% private** (rigs)	**Little**	**2-3 years** (initial fleet,cascade mult. owners)	**Little to none**	**1:1**
PIPE	**No**	**Private**	**N/A**	**N/A**	**N/A**	**Little to none**	**N/A**
WATER	**Yes**	**Public**	**Private** (tow boats & barges	**N/A**	**Est. 30 years**	**Little to none** (exc. ISO boxes	**1:1**
AIR	**Yes**	**Public**	**~100%**	**None**	**3-21 years**	**Psgrs-only** ("gate changes") … *and don't forget your personal items*	**1:1**

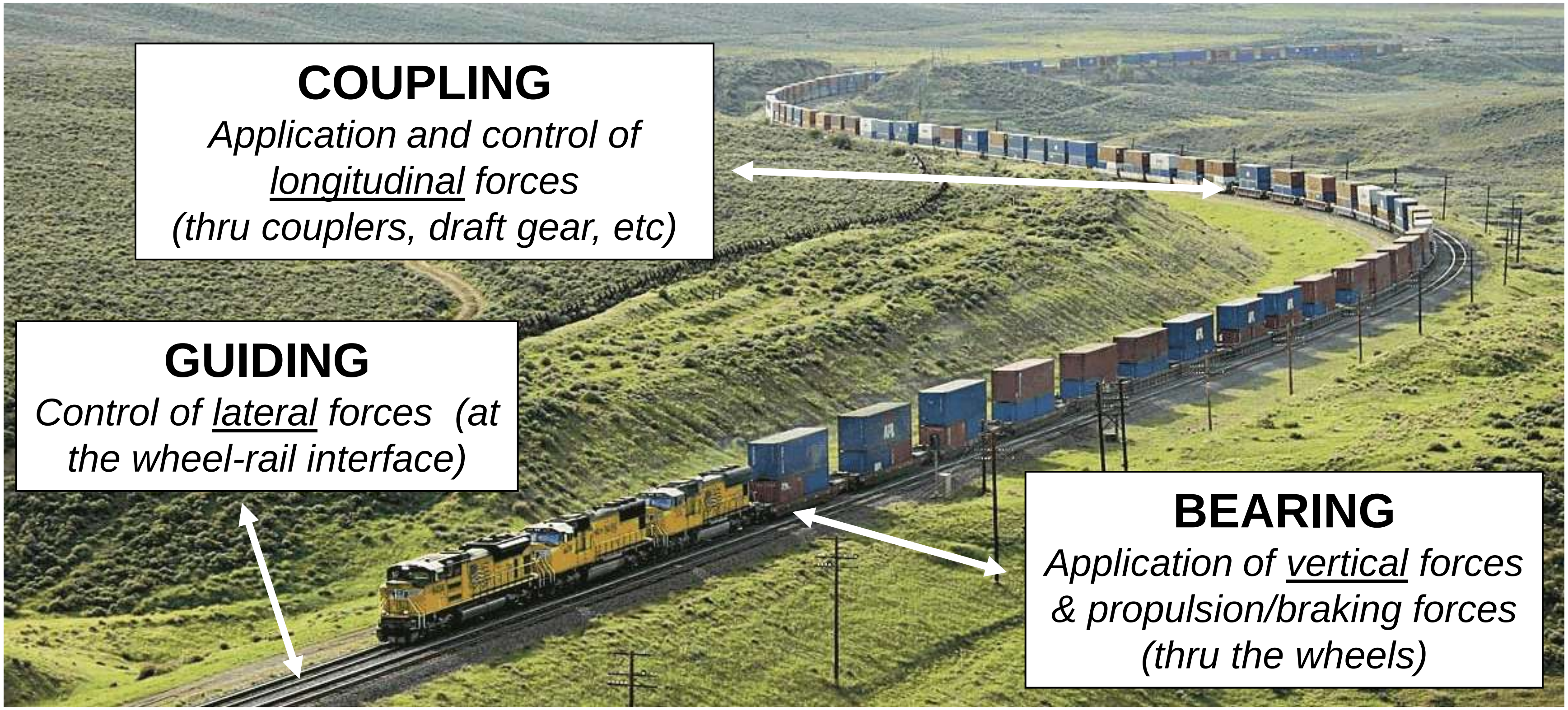


What makes rail unique?

- **"Genetic technologies" (=3; other modes may have some, never all)**
- **Network**
- **Capex intensive**
- **Asset lives are long (car ownership also split 33:67 RRs:non-RRs)**
- **Interoperable**
- **Intermodal**
- **Bidirectional equipment**
- **Deregulated but regulated**
- **Many external (and internal) factors & changes acting simultaneously**

- ***Safety continues to improve***
- ***Most environmentally-friendly mode of ground transport***
- ***Market share has been growing***
- ***Sustaining & successful segment of the transport market***

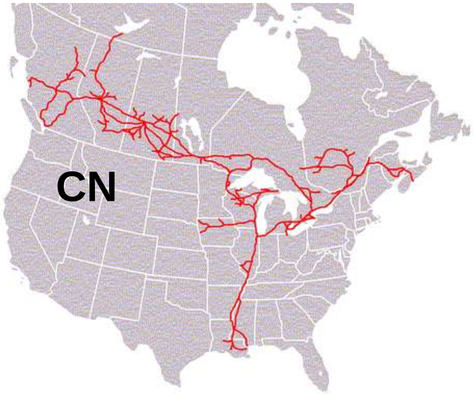
Rail's "DNA"

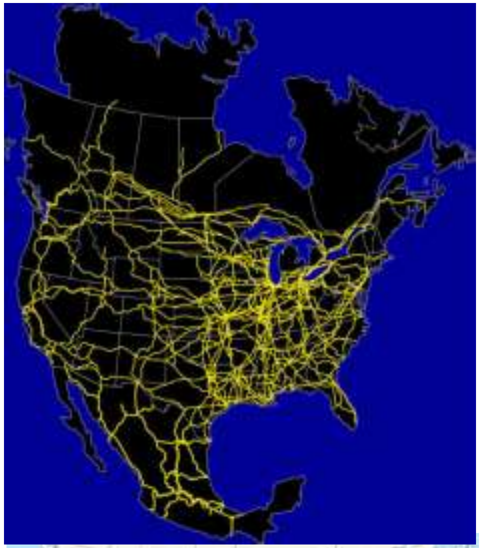


"Bearing, Guiding and Coupling are the three genetic technologies that distinguish railways from all other transport modes."

Dave van der Meulen, "Railway Globalization and Heavy Haul", IHHA, Kiruna, Sweden, 2007

Part 2: Impact of network interoperability

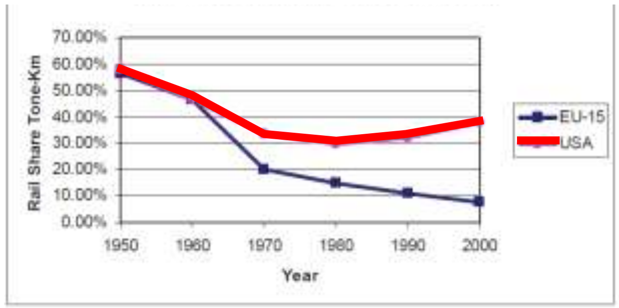




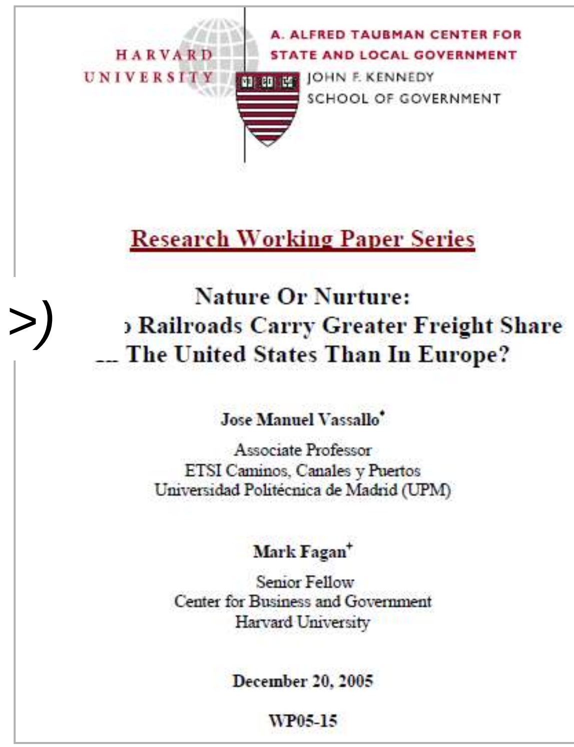
Ferromex
(not shown)

How important is interoperability?

EU v US: *rail share of freight transport*



(*) Pipeline and coastal transportation are not included in 1950 and 1960
Source: US data from Eno Transportation Foundation, Inc.
From 1970 to 2000 EU data from EUROSTAT
From 1959 to 1960 Europe Data from the Economic Division for Europe of United Nations


HARVARD UNIVERSITY

A. ALFRED TAUBMAN CENTER FOR STATE AND LOCAL GOVERNMENT
JOHN F. KENNEDY SCHOOL OF GOVERNMENT

Research Working Paper Series

Nature Or Nurture:
Railroads Carry Greater Freight Share
The United States Than In Europe?

Jose Manuel Vassallo*
Associate Professor
ETSI Caminos, Canales y Puertos
Universidad Politécnica de Madrid (UPM)

Mark Fagan+
Senior Fellow
Center for Business and Government
Harvard University

December 20, 2005

WP05-15

Interoperability limitations in the EU *(#1 issue per >)*

TRACK GAUGES

ELECTRIFICATION VOLTAGES

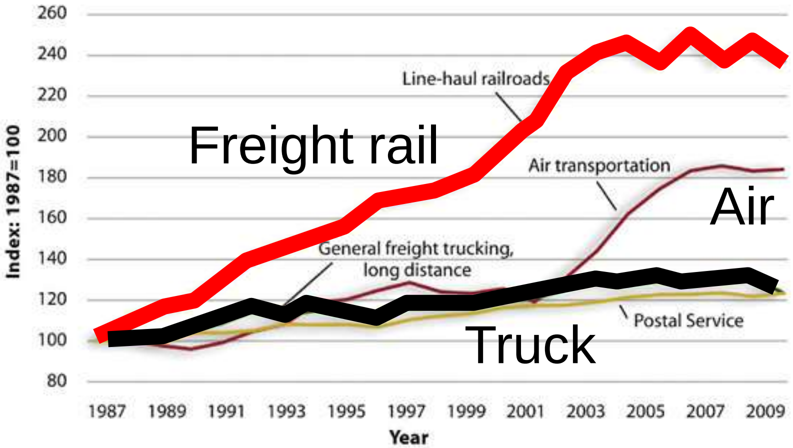
CLEARANCES

Maps from http://www.bueker.net/trainspotting/voltage_map_europe.php

Why modes have mixed “tools”

For US freight rail, it "all adds up"

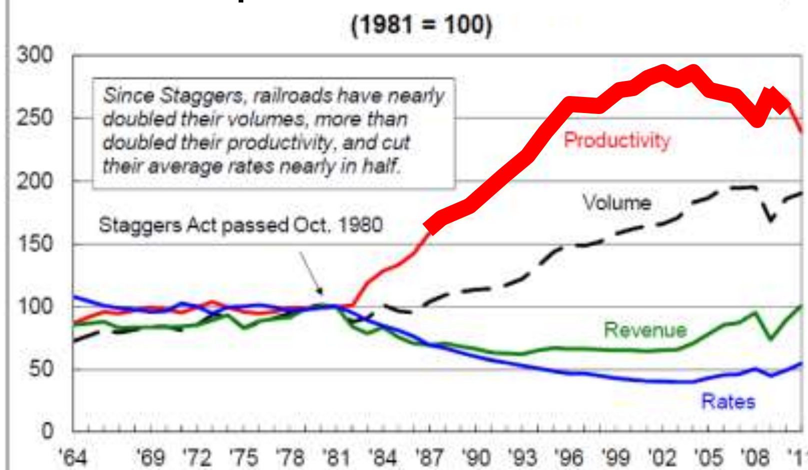
Freight transport productivity per US DoT FHA '87-'09



'Based on the number of paid hours. Real gross domestic product (GDP) in the business and nonfarm business sectors is the basis of the output components of the productivity measures. These output components are based on and are consistent with the National Income and Product Accounts, including the GDP measure, prepared by the Bureau of Economic Analysis of the U.S. Department of Commerce.

Notes: In 2009, the Bureau of Labor Statistics (BLS) revised its data for air transportation output per hour worked to include both full-time and part-time workers. Prior to 2009, BLS assumed all air transportation workers were full-time employees.

US freight RR productivity per AAR '64-'11



"Rates" is inflation-adjusted revenue per ton-mile. "Volume" is ton-miles. "Productivity" is revenue ton-miles per constant dollar operating expense. The decline in productivity in recent years is mainly due to the effect of higher fuel prices in the productivity calculation. Source: AAR

Part 3: External forces

- "External" changes cannot always be foreseen
- Trailers (TOFC) were eclipsed by containers (COFC)
- Globalization > double-stack trains beginning in 1984
- Export containers morphed into longer domestic containers

- *External change (boxes) has driven internal (car design)*

• 1^{st} "wave":	import/export	20'-40' boxes	ocean-rail-truck
• 2^{nd} "wave":	domestic	~~45'-48'~~-53'	rail-truck
• "Wave" 2.5:	special "	28' boxes	rail (56' well)-truck

• 1^{st} gen. stack cars	40' well	20'-40' boxes
• 2^{nd} generation		~~45' boxes~~ (some wells)
• 3^{rd} generation	48' well	~~48' boxes~~
• 4^{th} generation	53' well	53' boxes

Part 4: Where do we go from here?

Image courtesy of www.cartalk.com

"The future ain't what it used to be."

Lawrence Peter Berra

“Specialized Generalists” needed

	BEARING (incl. wheels)	COUPLING	GUIDANCE
BRIDGE			
CAR			
LOCO.			
SIGNAL			
TRACK			

“The best heavy haul railways are vague about the distinction between civil and mechanical engineers … joint management of the contact between steel wheel and steel rail is tantamount to the success of the enterprise.”

Mike Roney, CPR, IHHA paper, 2005

Part 5: Managing technology

Name badge plate on a Great Western High-Speed Train (HST) power car in Paddington Station, London, November 2005

"We made too many wrong mistakes."

Lawrence Peter Berra

“The most important single task in managing technology is to maintain the proper tension between effort devoted to conventional technology and the work that seeks to replace it.

“Implicit in this tension is the existence of effective programs in each category of work.

“There can be no tension if all the effort is devoted to conventional technology and one only bemoans the absence of candidate replacements.

“The nature of technological progress and the conditions that must be present to foster innovation are, unfortunately, subject to many misconceptions.”

Lowell Steele, author of “Managing Technology” (1989, McGraw-Hill, pp 52-67), article originally published in Harvard Business Review, November-December 1983 as “Managers Misconceptions About Technology”

"The most important single task in **managing technology** is to maintain the proper tension between effort devoted to conventional technology and the work that seeks to replace it.

"Implicit in this **tension** is the existence of effective programs in each category of work.

"There can be no tension if all the effort is devoted to conventional technology and one only bemoans the absence of **candidate replacements**.

"The nature of technological progress and the conditions that must be present to foster innovation are, unfortunately, subject to **many misconceptions**."

Lowell Steele, author of "Managing Technology" (1989, McGraw-Hill, pp 52-67), article originally published in Harvard Business Review, November-December 1983 as "Managers Misconceptions About Technology"

Misconceptions (& realities) re technological change*

9 common misconceptions	9 experience-based realities
Go for "best possible"	Use what is "good enough"
Technology is selected rationally	Past practice limits future change
Change occurs as planned	Plan for things to go wrong
Initial application leads to success	Future unknowns carry risk
Intrinsic value of technology	User determines value
Radical change always succeeds	New is not necessarily better
Investment guarantees success	Infrastructure is critical
Enhancements guarantee progress	Standards, constraints are critical
Overlay new tech. on existing ops.	New support system for new tech.

* From the book "Managing Technology" (1989, McGraw-Hill, pp 52-67), by Lowell W. Steele; originally published in Harvard Business Review, November-December 1983 as "Managers Misconceptions About Technology"

Example from western coal

- At least four (4) diverse technologies
- Developed separately by different “users” and “interest groups”

1. AC traction technology
2. Locomotive engine horsepower
3. Distributing locomotives within trains
4. Shift from steel to aluminum carbodies

Europe: AC; US: focus on HP & DC

1st AC experiment: Canada '84

AC R&D in US '85-'92

AAR AC sub-comm.

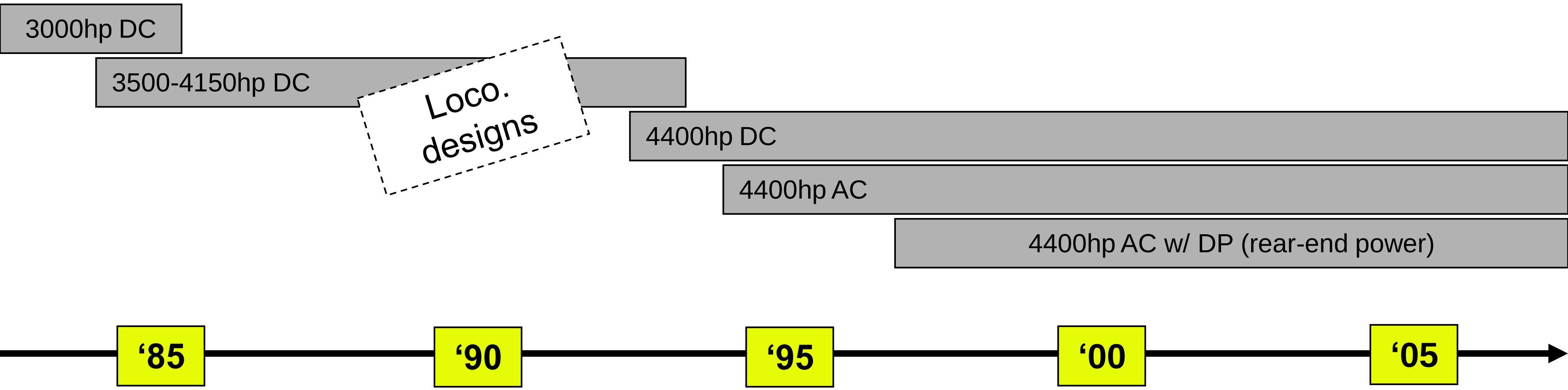
AC traction technology

Europe had long used AC motors account AC-powered electric locos. US/Canada had always used DC motors. By 1980s AC technology was being explored.

1st AC fleet in US ordered in 1992. AC has overtaken DC commercially.

'85 '90 '95 '00 '05

AC enabled unit reductions (3-for-4 or 2-for-3) but head-end coupler issues still existed.



Locomotive and diesel engine power increased over time.

(Adhesion demands for 4000+hp made AC "natural".)

Increase in net-to-tare ratio of freight cars.

Shift from steel-to-aluminum (and larger bearings) and increase in GCW increased net car load by 22%.

Follows historical path:

100K > 200K > 220K > 250K > 263K > 268K > 286K (+some 315K)

263K w/ steel body (coal) → 286K w/ aluminum body

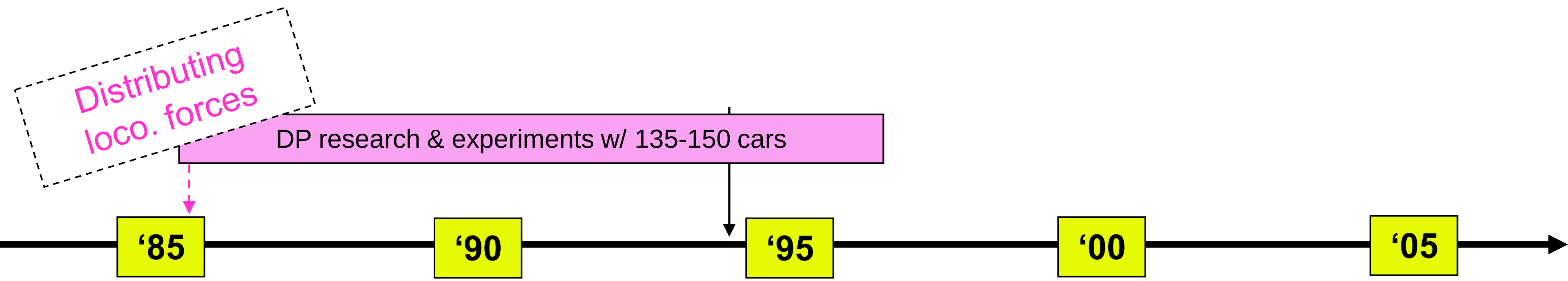
‘85 ‘90 ‘95 ‘00 ‘05

Frt. Car designs

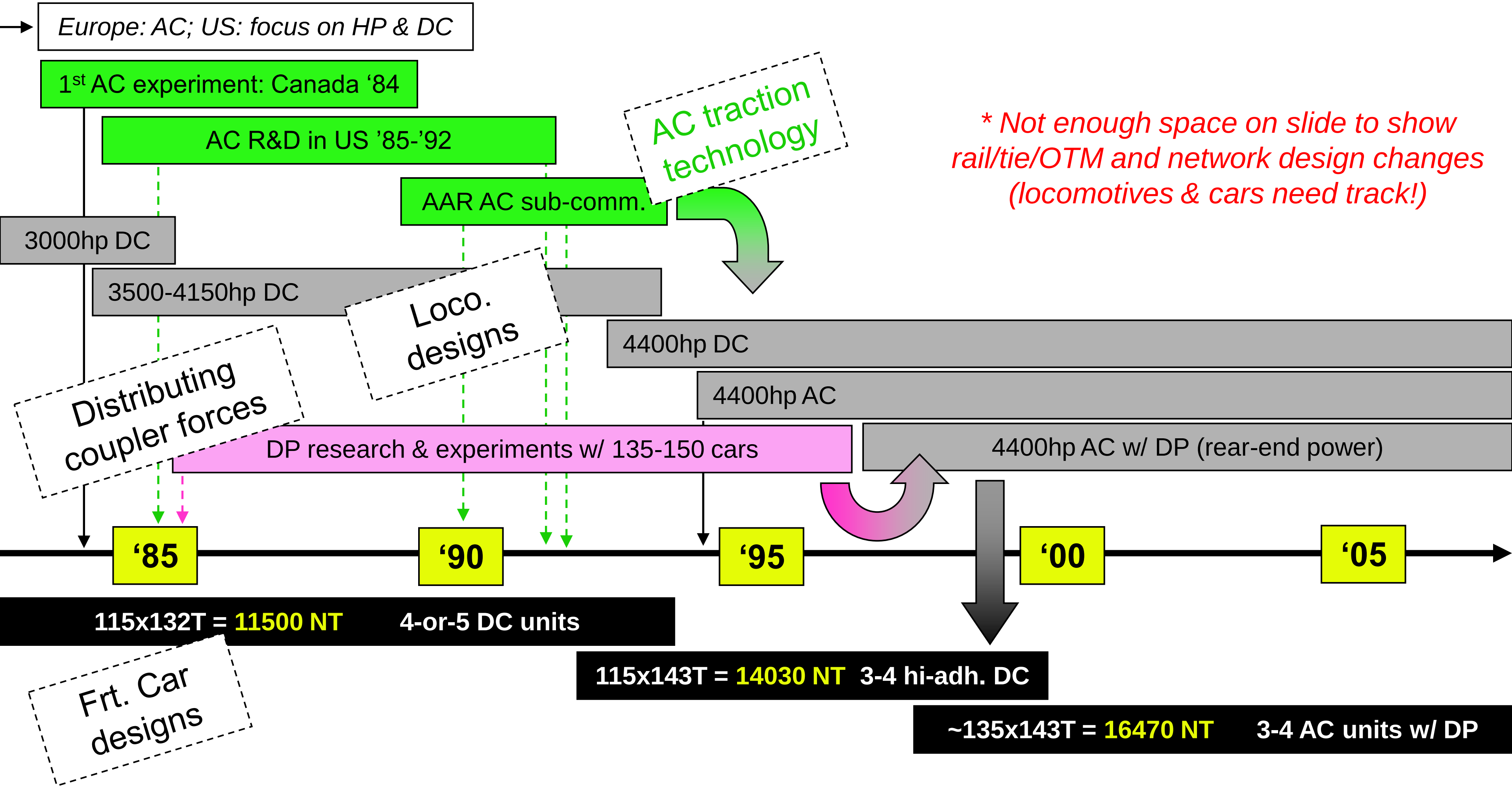
Distributing power was “mature” technology going back to ‘62 but with limited use.

Became a surrogate for even-stronger couplers and an enabler of longer trains (esp. on heavy grades).

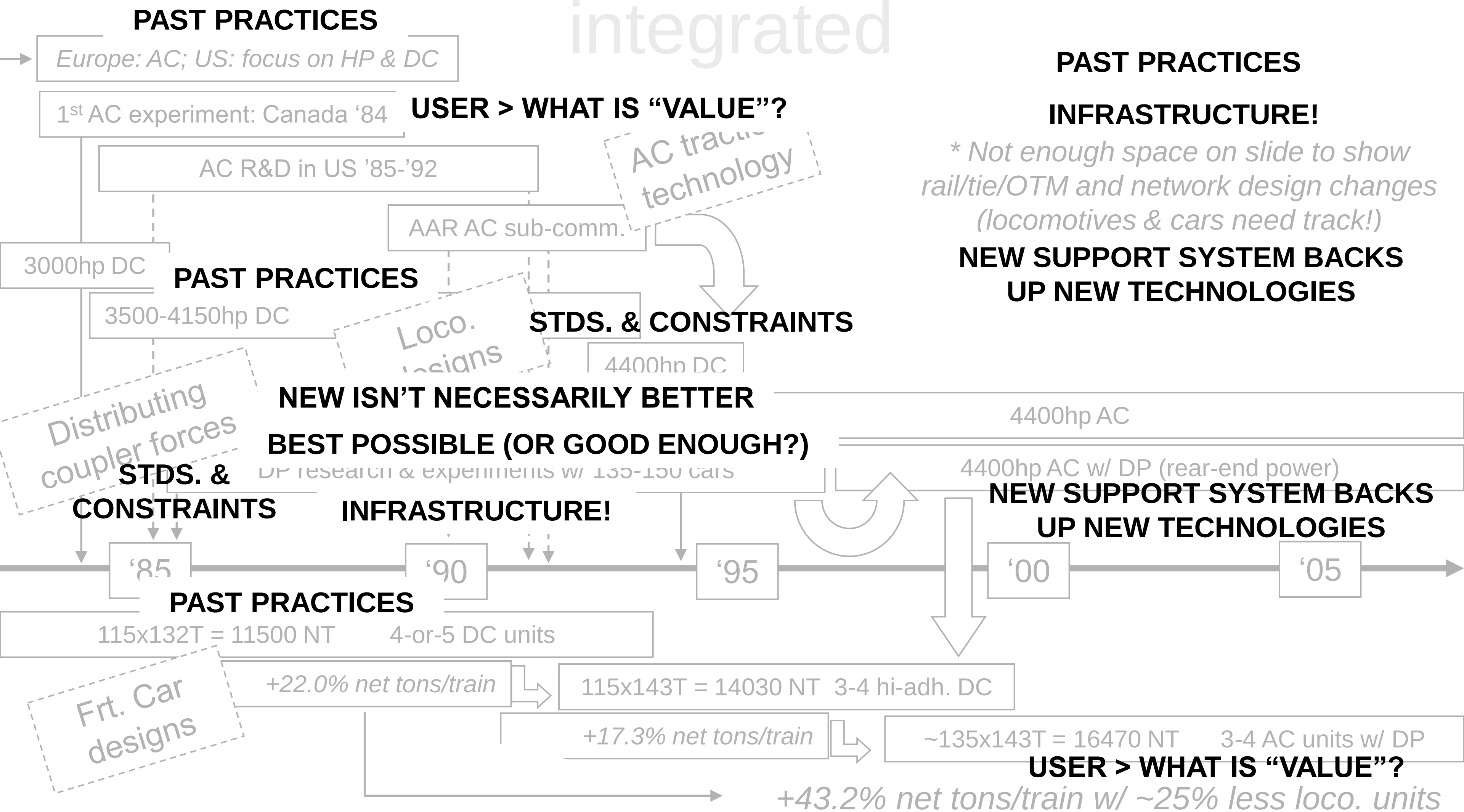
Had little perceived intrinsic value for first-25 years of existence.



Sum of the parts



W. Coal: how 4* technologies were integrated



Decisions made

Use what is "good enough"	1
Past practice limits future change	4
Plan for things to go wrong	?
Future unknowns carry risk	?
User determines value	2
New is not necessarily better	1
Infrastructure is critical	2
Standards, constraints are critical	2
New support system for new tech.	2

14

Questions & comments

At TTCI's Pueblo "frog farm"

*"The guy who invented the first wheel was an idiot.
The guy who invented the other three, HE was a genius."*

Sid Caesar