Transportation Technology, Sustainability and Time Scales

Steve Lockwood
Parsons Brinckerhoff

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What are my main points:

1. Key problems and opportunities both lie with the automobile-highway system (other modes interesting, but marginal)
2. The vehicle-highway system is a loose public-private partnership
3. Improvements in sustainability involve tightening this relationship
4. A tighter relationship affects the time scale of significant change regarding sustainability

Key Sustainability Issues in Surface Transportation

<table>
<tr><th>Social</th><th>Economic</th><th>Environmental</th></tr>
<tr><td colspan="2">Mobility
Fatalities
Financial Viability</td><td></td></tr>
<tr><td></td><td colspan="2">Global climate change</td></tr>
</table>

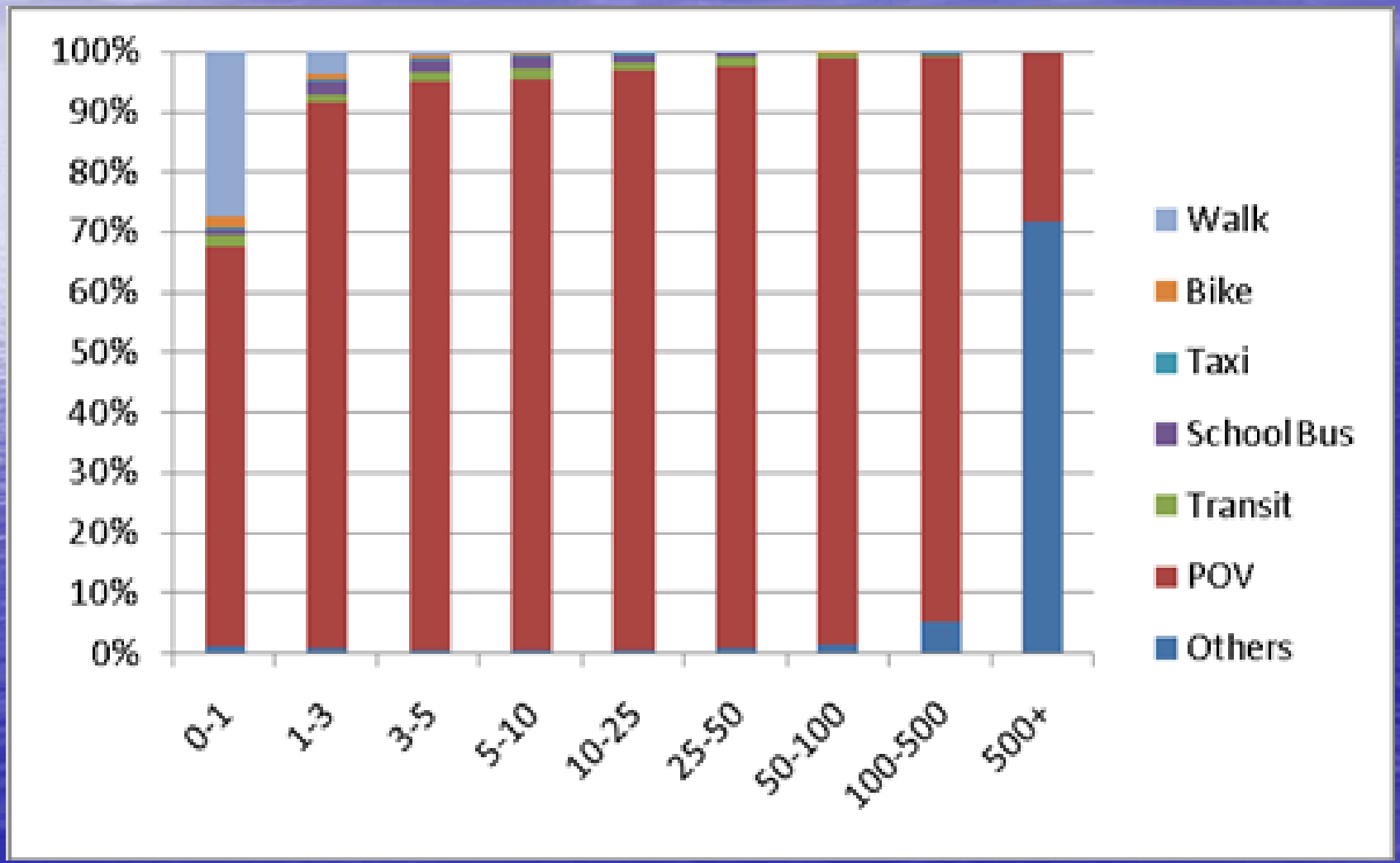
Why focus on the Vehicle-Highway System?

Vehicle/highway system dominates surface transportation – both positive and negative effects:

- 90 % person trips by mileage
- 80% percent of freight by value
- High fatality level (40K)
- Congestion -- Level of service declining
- GHG – light duty vehicles = 18%
- Finance – investment/VMT below maintenance level

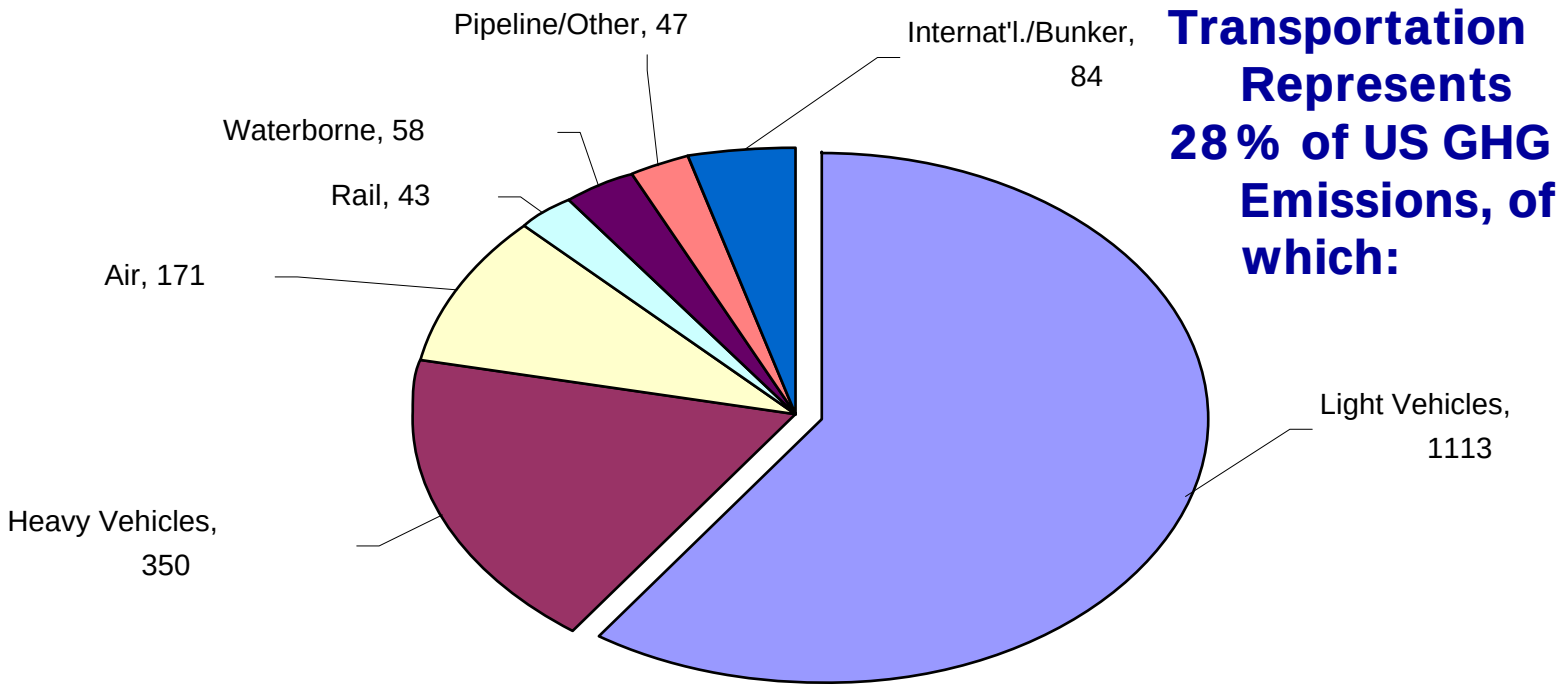
Bottom line: improvements in transportation sustainability must have major focus on vehicle-highway system

Vehicle-Highway Domination of Travel



Vehicle-Highway Domination of GHG from Transportation

U. S. Transportation Carbon Emissions by Mode, 2003
(Million metric tons CO2)



Transportation Represents 28% of US GHG Emissions, of which:

Note: Transit serves 1% of U.S. Person miles of Travel and 0% freight

Promising Vehicle-Highway Sustainability System Concepts in Play

- Hybrid vehicles/fuels (HEV, biofuels)
- Operational Efficiency (Vehicle-Infrastructure-Integration – towards automation)
- Pricing travel (Ex: Vehicle mile fees)
- Eco-driving – a la Prius

[Define]

Relationships to Sustainability Issues

TECHNOLOGY SYSTEMS	SUSTAINABILITY ISSUES AND IMPACTS			
	Mobility	**Fatalities**	**GCC**	***Financial***
Hybrids	Mileage limits?		**Reduced carbon emissions**	*Market Demand w/o taxes?*
Vehicle-Infrastructure Integration	Real time info to reduce delay	**Crash avoidance**	Reduced congestion	*Federal/state subsidy*
Road Pricing	**Congestion reduction**	??	Reduced VMT/CO2	*Self supporting*
Eco-Driving			**Reduced Carbon emissions**	*free*

Potential GHC Impacts/costs

Technology	GHC Reduction (mmt), Cumulative, 2010-2050	Cost ($B) Cumulative, 2010-2050	Assume
New vehicle/fuel technology	6,000	<50	(McKinsey)
Carbon tax or pricing	1,100	+/- 0	@ 82c/gal tax equiv
Eco driving	1,200	+/- 0	20% drivers adopt
Transit expansion	300	500	3.5 %/year increase
Improved operations/ITS	300	90	all strategies consistently applied
HSGT	100	110	10%/year increase over new HSR baseline*

1/ Moving Cooler: Aggressive Strategies table 4.1

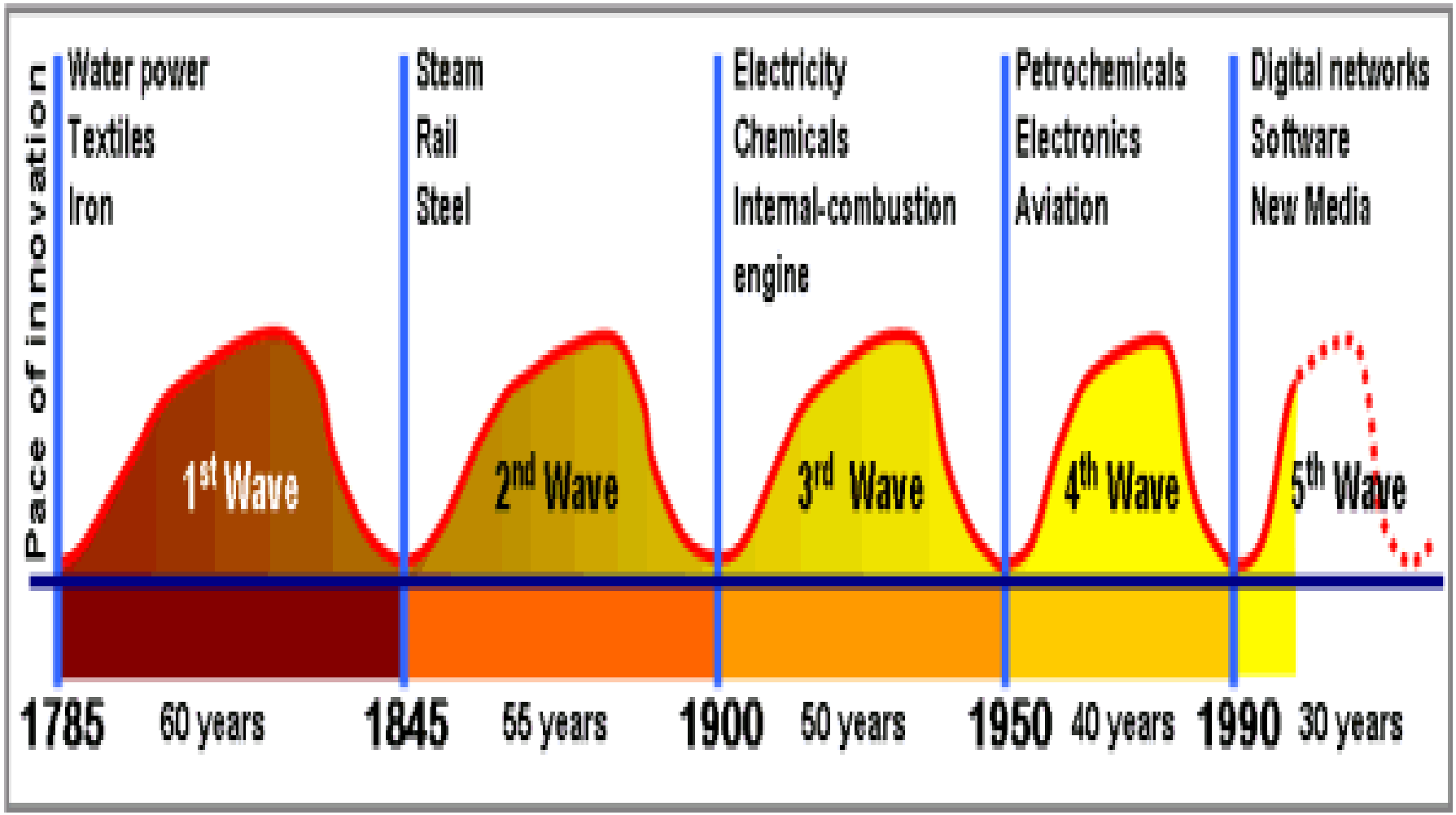
But: Transportation "Technologies" Impact Rates of Change

- Number of "systems" to be integrated: infrastructure, vehicles, drivers, information interfaces
- Factors for each system component
  - *Infrastructure*: public sector: policies & politics, finance, fragmentation, technical capacity, NIMBY, need for PPP
  - *Vehicles*: industry: perceived markets, R& D investment, risk, market penetration/life cycles, regulation, antitrust
  - *Drivers*: consumer values/habits, attractiveness/acceptability, affordability, privacy/security)
  - *Information/communications providers:* non-transportation orientation (integration, service provision)

Sectoral Roles Impact Rate of Change

Technology systems	Sectoral Roles			
	Public	Automotive Industry	Information Industry	Users/ customers
Hybrids	• Policy • Regulation • Sponsored research	• R & D • Product development • Marketing • production		• Accept technology
Vehicle Infrastructure Integration	• Policy • R & D (partnerships) • Infrastructure funding	• R & D • Product development • Marketing • Production • competition	• Technology adaptation to transportation • Marketing/production	• Accept technology
Road Pricing	• Policy • R & D • incentives		• Technology adaptation to transportation • Marketing/production	• Conform with requirements
Eco-driving	• Incentives	• R & D • Product development • Marketing • production		• Voluntary acquisition • Voluntary use

Conventional New Technology Time Lines



Source: Adapted from the Economist, February 20th 1999.

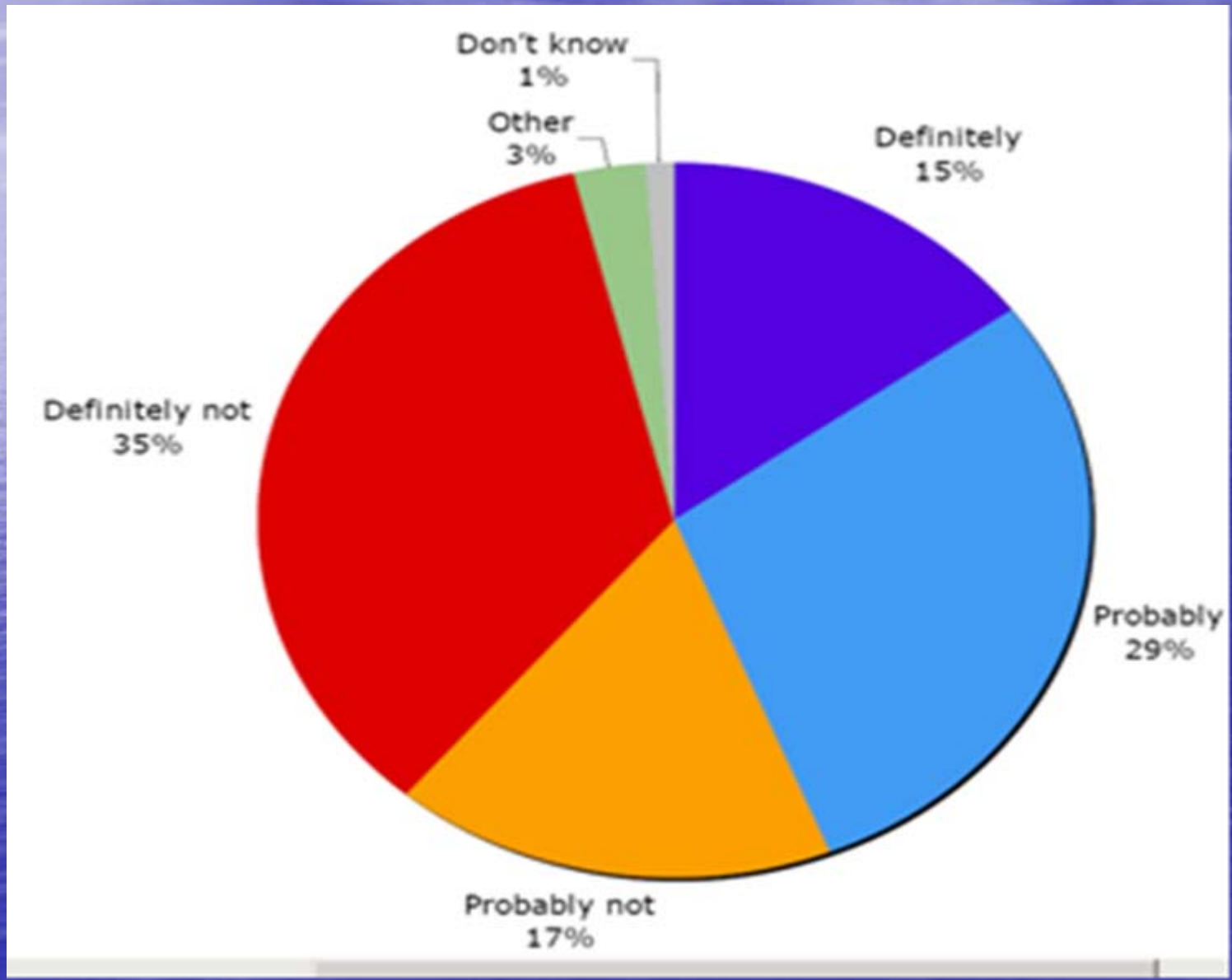
Lagging Factors (F) as Pacing Issues

Many relevant technology systems involve:

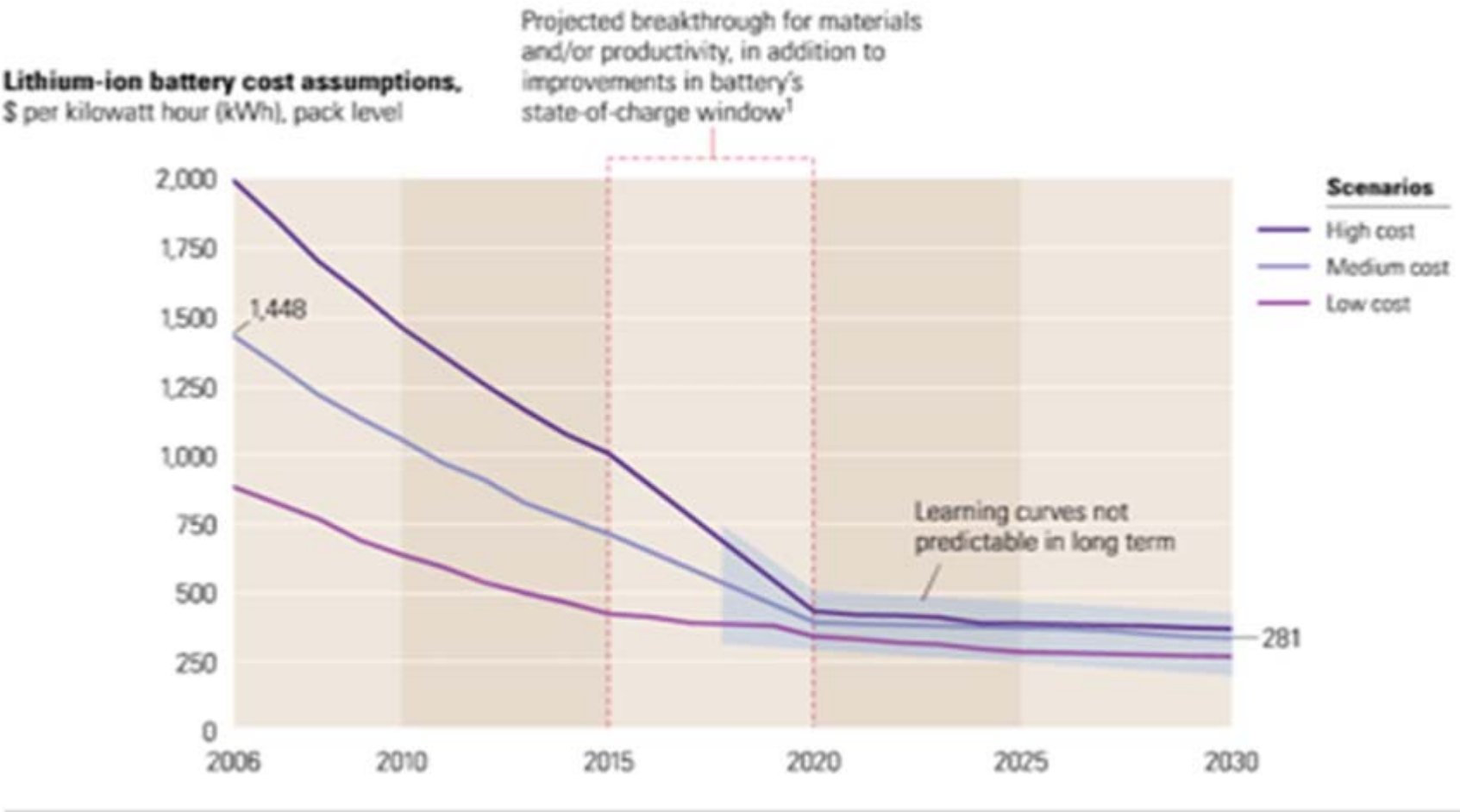
- Changes in public policy/Regulation
- Public sector R & D (as well as private)
- Vehicle *(multiple private industry/owner)* – Infrastructure (*multiple gov'ts*) integration barriers
- Slow Penetration rates – market and deployment
- Driver behavior

These factors significantly impact the likelihood and timing of promising technologies

F1. Public Acceptability of Pricing ?



F.2 Technology Learning Curve



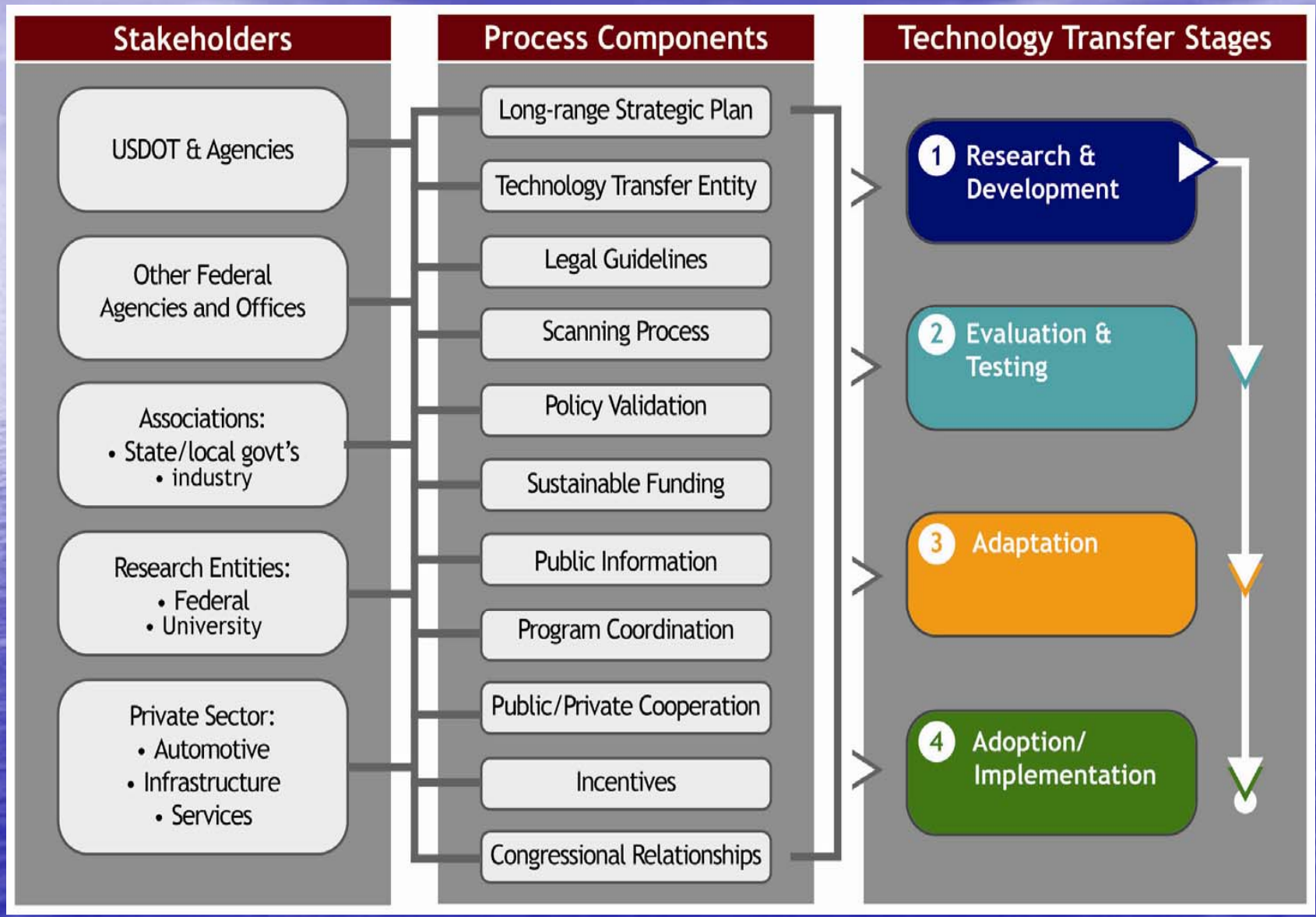
[1] State-of-charge window is the available capacity in a battery relative to its capacity when full. Conservative applications work within a 65% window, whereas more aggressive applications use 80%; over the next 5 to 10 years, most applications will likely migrate to the higher value.

Source: OEM and supplier interviews conducted in Asia, Europe, and North America; McKinsey analysis

F3. Sectoral R & D Investment

Industry	NAICS codes	All R&D	Federal	Company and other
All industries	21–23, 31–33, 42, 44–81	247,669	24,304	223,365
Manufacturing industries	31–33	171,814	16,584	155,230
Food	311	2,720	4	2,716
Textiles, apparel, and leather	313–16	547 i	0	547 i
Paper, printing, and support activities	322, 323	D	D	2,793
Petroleum and coal products	324	1,432	1	1,431
Chemicals	325	46,329	211	46,119
Basic chemicals	3251	2,152	98	2,054
Resin, synthetic rubber, fibers, and filament	3252	1,975	13	1,963
Pharmaceuticals and medicines	3254	38,901	88	38,813
Other chemicals	other 325	3,300	12	3,288
Plastics and rubber products	326	2,245	27	2,217
Fabricated metal products	332	1,499	67 i	1,432
Machinery	333	9,848	106	9,743
Computer and electronic products	334	56,773	8,522	48,251
Computers and peripheral equipment	3341	D	D	7,289
Communications equipment	3342	D	D	10,911
Semiconductor and other electronic components	3344	18,888	354	18,534
Navigational, measuring, electromedical, and control instruments	3345	18,300	7,860	10,440
Other computer and electronic products	other 334	D	D	1,076
Electrical equipment, appliances, and components	335	2,281	66	2,215
Transportation equipment	336	D	D	30,010
Motor vehicles, trailers, and parts	3361–63	D	D	16,562
Aerospace products and parts	3364	16,367	4,372	11,995
Other transportation equipment	other 336	D	D	1,453
Miscellaneous manufacturing	339	5,150	114	5,036

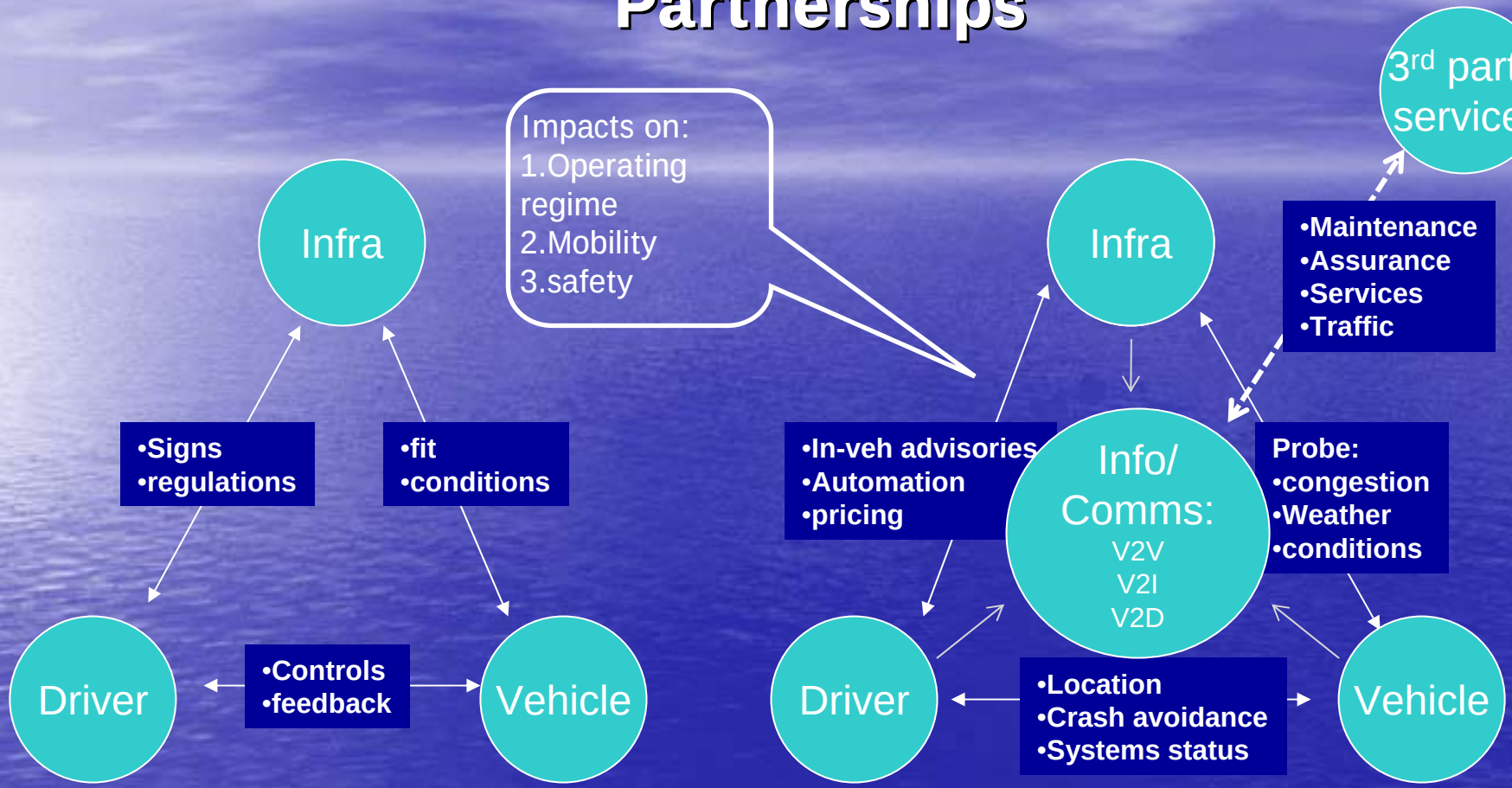
F4. Preconditions for T2 in the Public Sector



F5. The Pace of Policy Change

- 1970 - National Environmental Policy Act (NEPA)
- 1970 - Reorganization Plan No. 3 created the EPA
- 1970 - Clean Air Act (Extension) setting National Ambient Air Quality Standards
- 1990 - Clean Air Act Amendments set new automobile emissions standards.
- 1991 - Intermodal Surface Transportation Efficiency Act (ISTEA)
- 1994 - Executive Order 12898 on Environmental Justice
- 1998 - Transportation Equity Act for the 21st Century (TEA-21)
- 2002 - California AB 1493 sets standards for emissions of CO2 .
- 2003 - Clear Skies Act (proposed)
- 2005 - (SAFETEA) Reauthorization of Federal Transportation program
- 2008 – EPA proposals to include CO2 as a pollutant

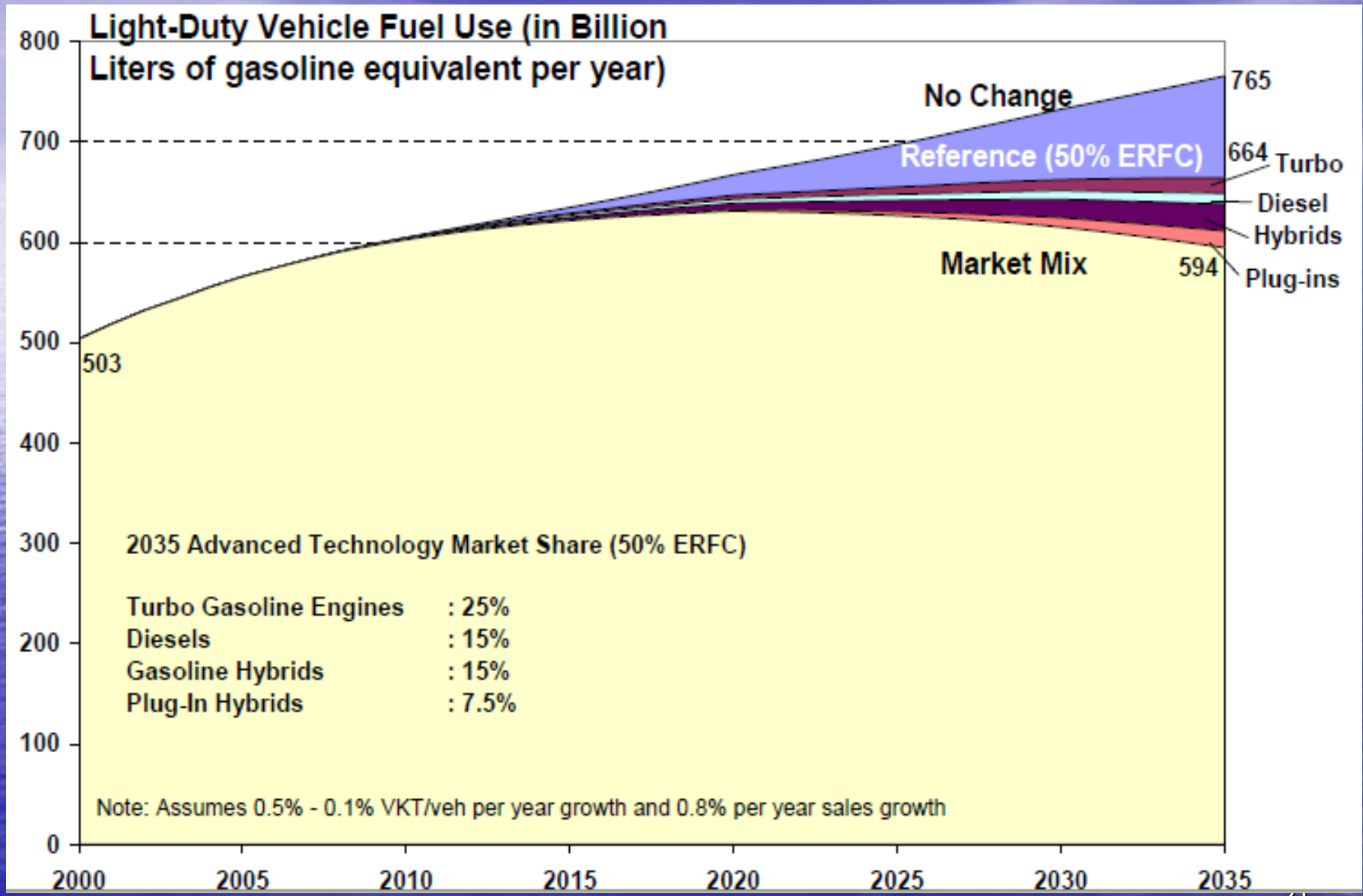
F6. Systems Integration: Public-Private Partnerships



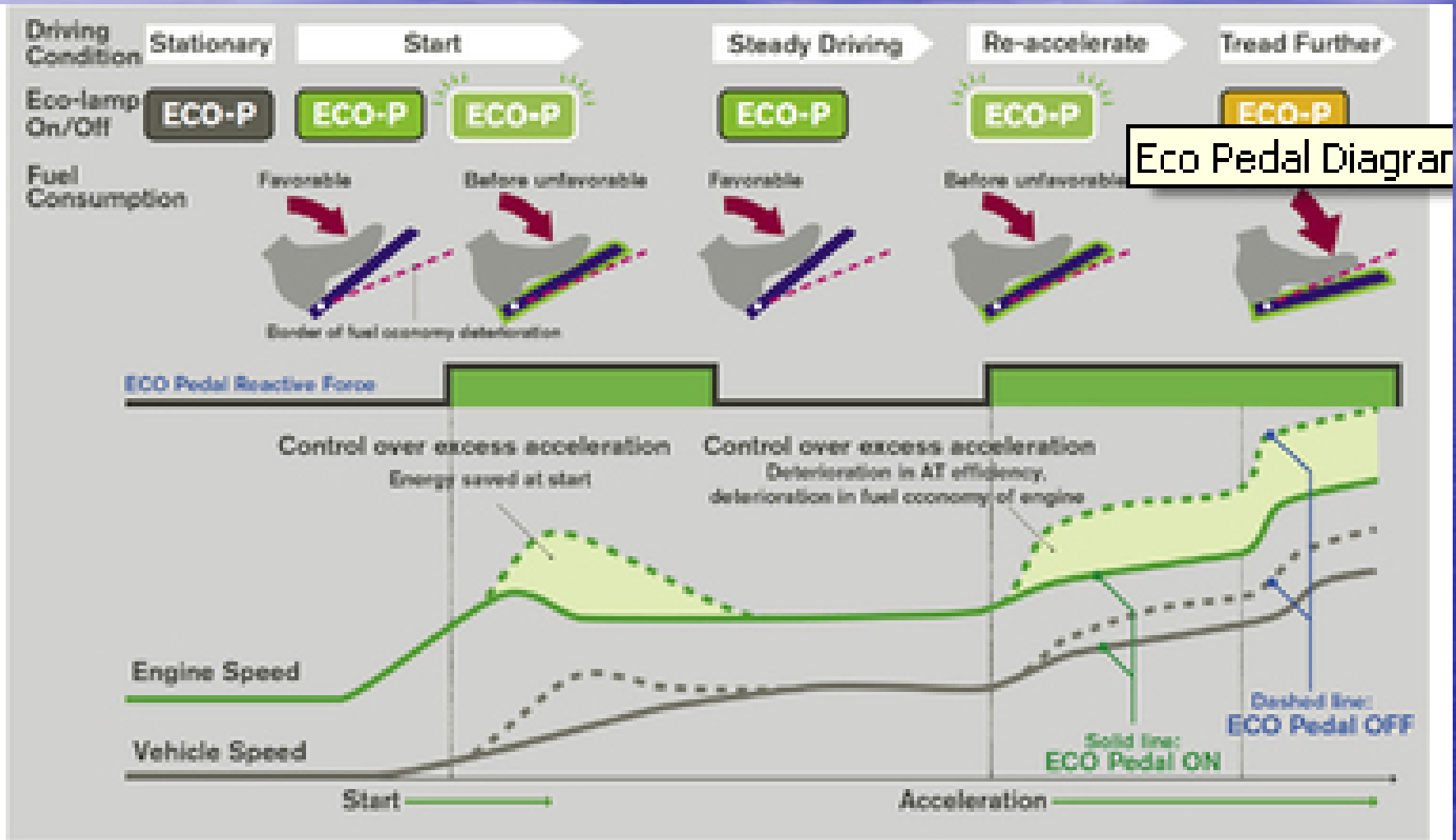
F.7 Past PPPs

- Urban bus
- Automated vehicle-highway systems
- Maglev
- VII
- PNGV

F8. Technology Life Cycle: Market penetration

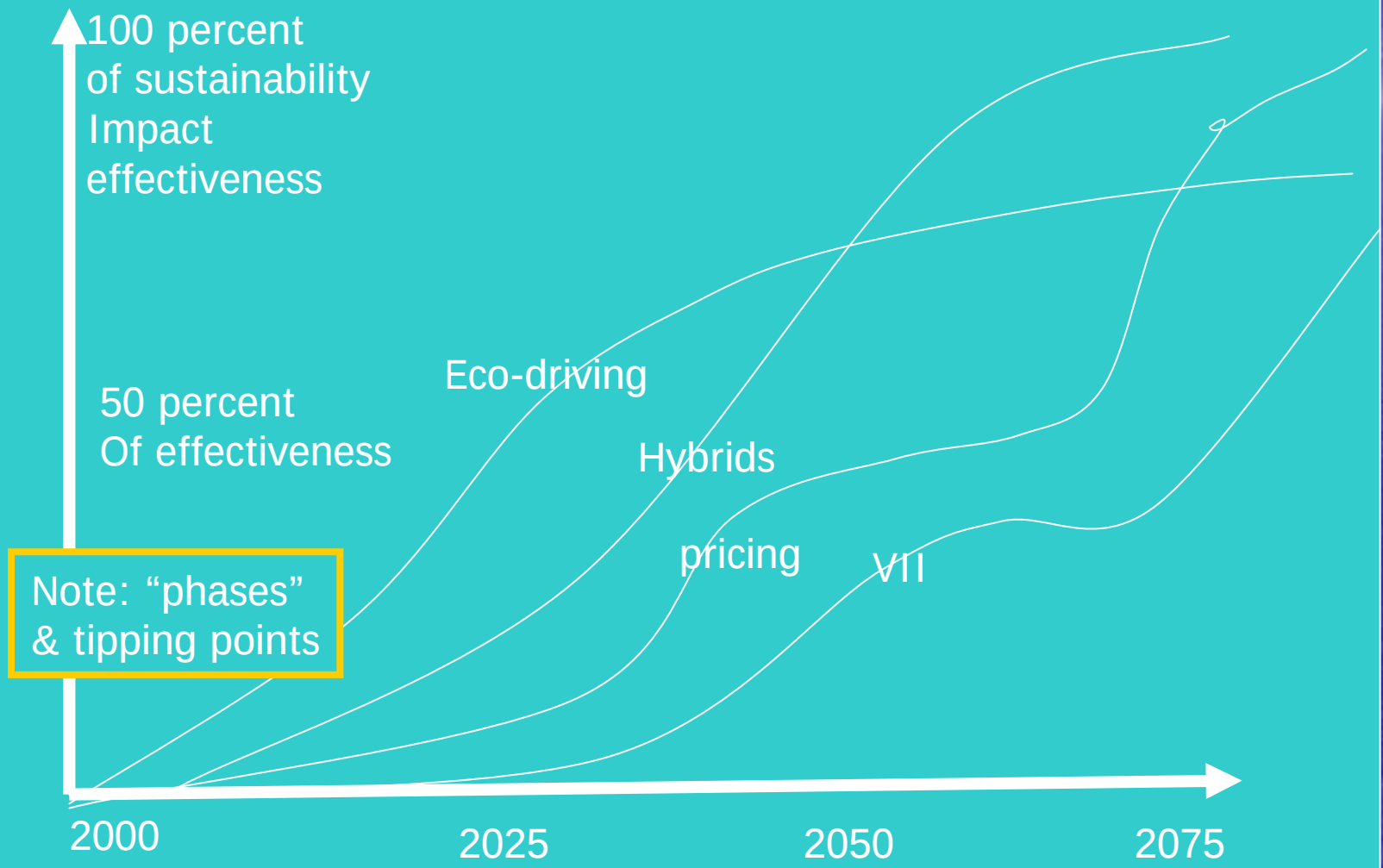


F9. Behavioral Change



Factoid: ecodriving by 20% drivers = 3X impact of transit x 3 @ 1/20K of cost

Resulting Time lines for Implementation



“Conclusions”

- Trade-off between effectiveness of technology and rate of transfer?
- Transportation public sector low tech/low responsiveness
- Challenges of public-private partnerships and “tight fit”
- Penetration rate inversely proportional to public sector role