



EPA/NHTSA Greenhouse Gas and Fuel
Efficiency Standards for Medium- and
Heavy-Duty Engines and Vehicles –
Phase 2 Rulemaking

July 18, 2016

Allison Transmission at a Glance

- World's largest manufacturer of fully-automatic transmissions for medium- and heavy-duty commercial vehicles
- Founded in 1915, global headquarters in Indianapolis
- Approximately 2,700 employees
- Allison products are specified by >350 of the world's leading vehicle manufacturers and serving over 15,000 fleets
- Product support through worldwide distribution network

North America On-Highway End Market

	Class 1-3	Class 4-5	Core Addressable Market				Class 8 Metro	Class 8 Tractor
			Motor Home	School Bus	Class 6-7	Class 8 Straight		
Vehicles								
Weight (000s of lbs)	< 14 lbs	14 – 19 lbs	16 – 33 lbs	16 – 33 lbs	19 – 33 lbs	33 lbs+	33 lbs+	33 lbs+
2015 Industry Units Produced	6,974,454	86,774	18,270	31,689	95,684	79,241	76,629	167,412
2015 Allison Share	0%	5%	40%	98%	77%	61%	7%	0%

Notes: "Metro" is a term for tractors that are used primarily in urban environments, which represent ~30% of the Class 8 tractor market
Analysis excludes Allison's Transit/Coach Bus and Hybrid Transit Bus volume.

Source: Class 1-3 from Wards 2015 Factory Sales North America; Core Addressable Market and Class 8 Tractor from Allison and ACT Research.



1000/2000 Series



3000 Series



4000 Series



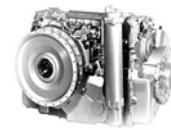
TC10 TS



5000, 6000, 8000 & 9000 Series



H 40/50 EP



X1100



X200

On-Highway

Off-Highway

Hybrid

Defense

Very Diverse End Markets

Global	On-Highway	Distribution	Emergency	Motorhome	Rugged Duty	School/Shuttle Bus	Transit
		  	  	   	   	 	  
							
					  	  	
Defense	Medium- and Heavy-Tactical						
Aftermarket	Parts, Support Equipment & Other		 Retran				

Allison Comments on Proposed Rule / Final Recommendations for Final Phase II Rule

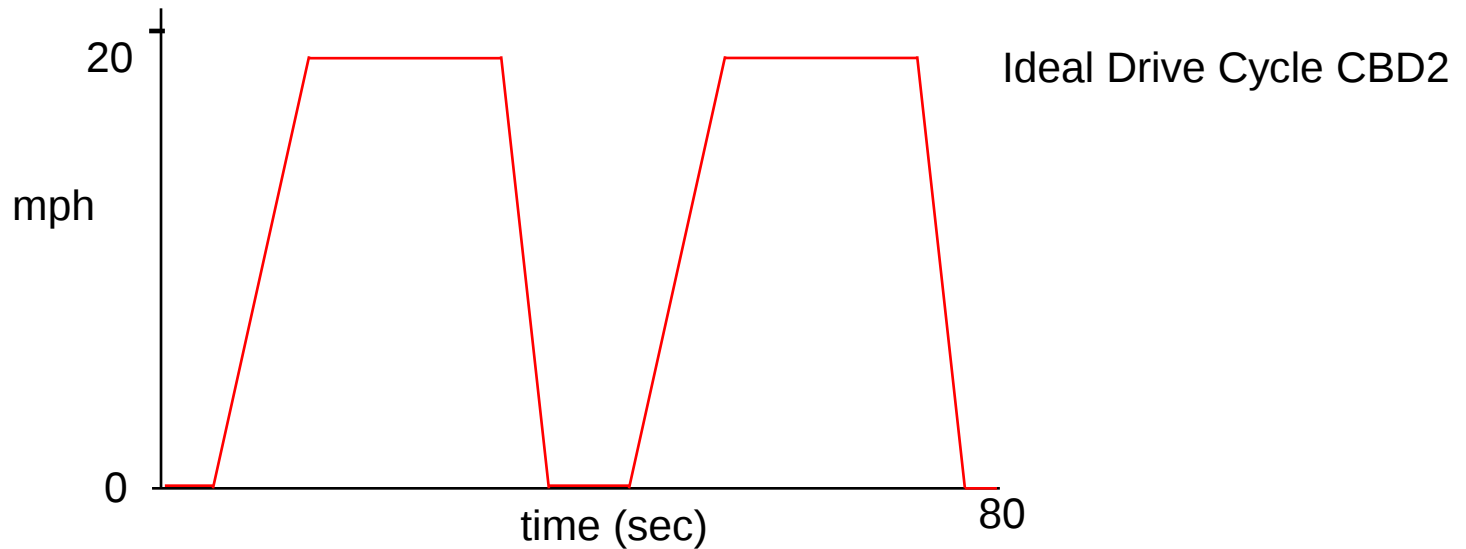
- EPA and NHTSA must ensure that competitive transmissions – automatic and automated manual -- are treated fairly based on their respective architectures and real world performance
- Greenhouse Gas Emission Model (GEM) needs to be improved
 - Should be primary certification tool; avoid excessive powertrain testing
 - Model needs further improvement to reflect Oak Ridge National Lab testing, correct modeled shifting errors, and address operational differences between transmission architectures
 - Improve weighting given to different drive cycles
 - Drive cycles should better represent road grades and real world driving conditions
- Adoption rates are overstated and cost estimates are understated for hybrids and advanced technologies; realistic adoption rates preclude selection of Alternative 4

Greenhouse Gas Emissions Model (GEM)

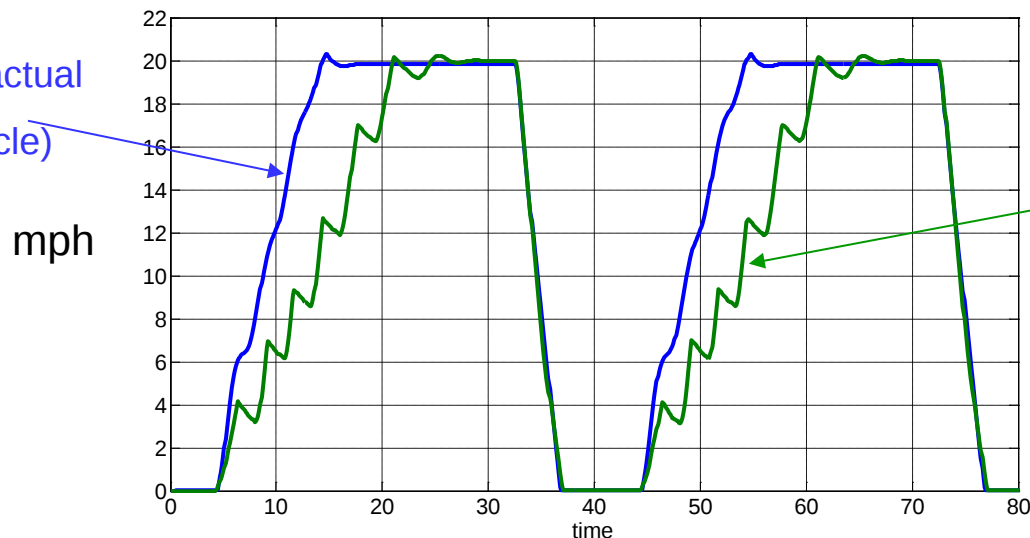
Allison Concerns with GEM

- EPA has been responsive to address concerns
- Flaws in modeling of automatic vs. automated manual transmissions remain even after March 2nd NODA; GEM modeling flaws must be corrected *before final rule is issued*
- Even small flaws in the modeling add up; the combined effects could substantially affect fuel consumption rates and GHGs
- Some issues have been addressed, but other issues remain
 - Shift points
 - AMT power interrupt is underrepresented
 - Transmission losses
- GEM is not merely a basis for the stringency of the rule – it also serves as the compliance mechanism for the Phase 2 rule
- Therefore, subsequent changes to GEM require notice-and-comment rulemaking
- Flawed GEM assessment of technology performance could unjustly reward/penalize different transmission architectures and skew market adoption of different technologies

Basic Differences in Automatic vs. Automated Manual Transmissions



AT (Automatic Transmission) actual
(meets drive cycle)



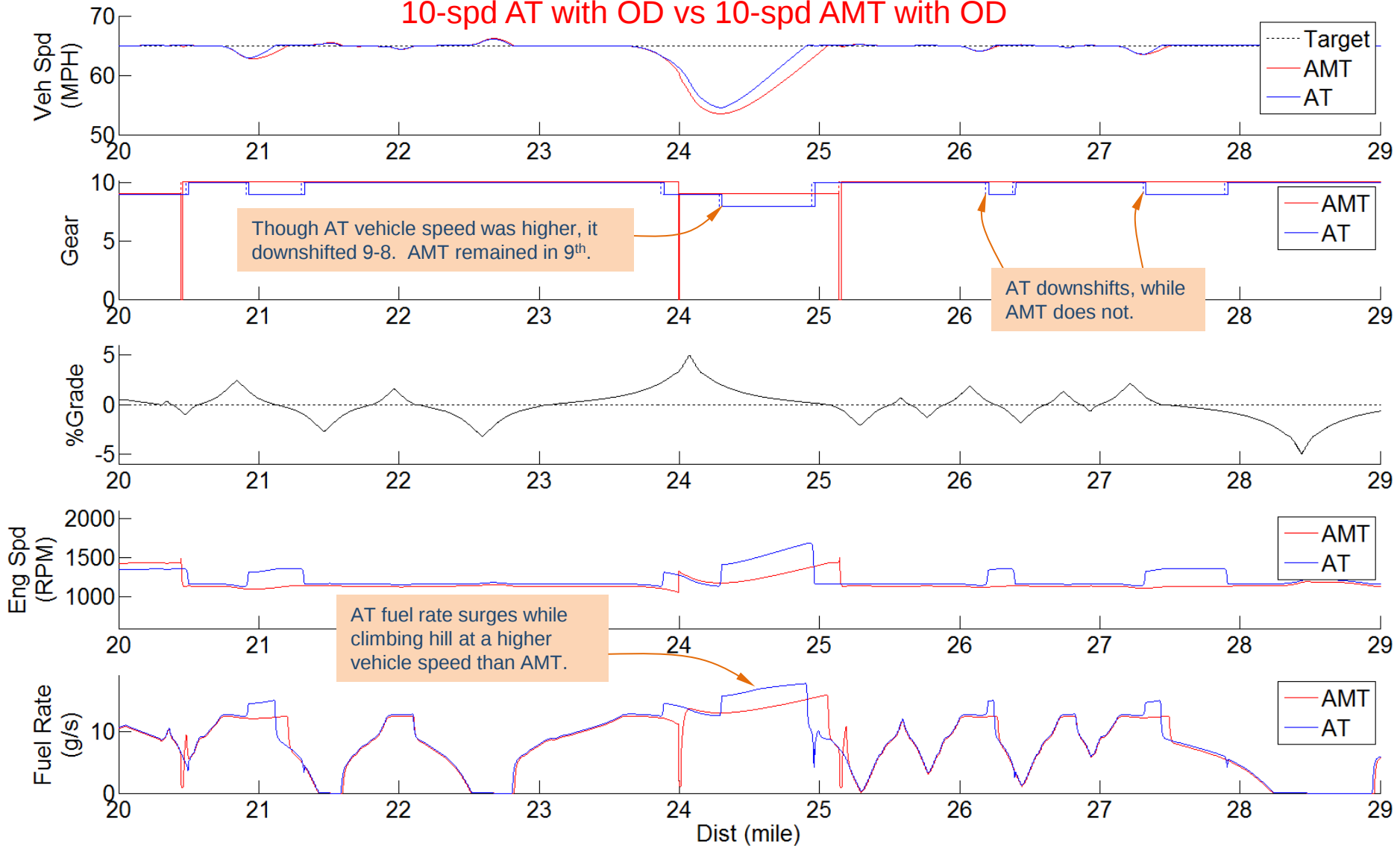
AMT (Automated Manual Transmission) actual

(does not meet drive cycle due to power interrupts)

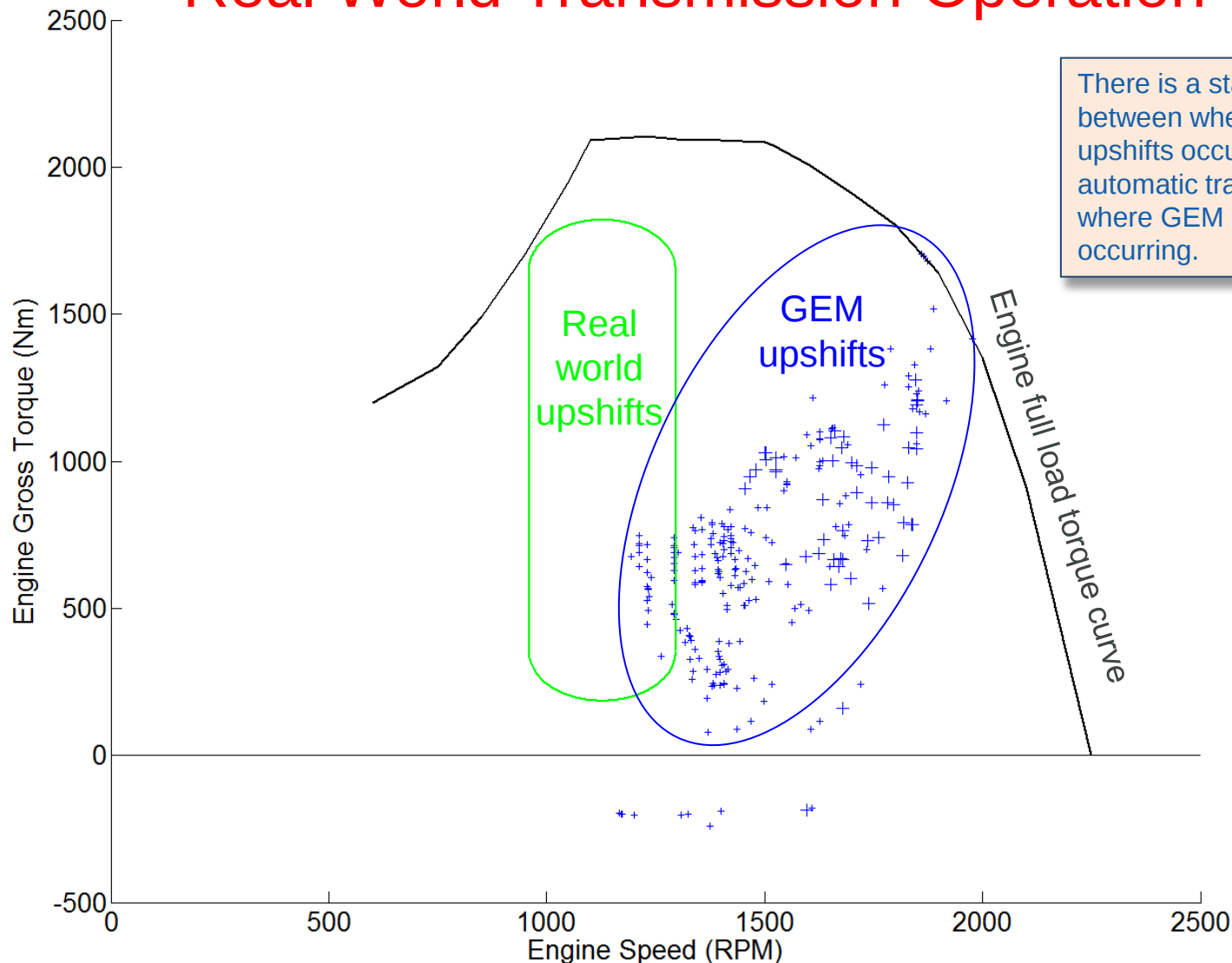
MT (Manual Transmission) is similar but with more power interrupt time due to driver influence)

Tractor Example of Inappropriate Shifting

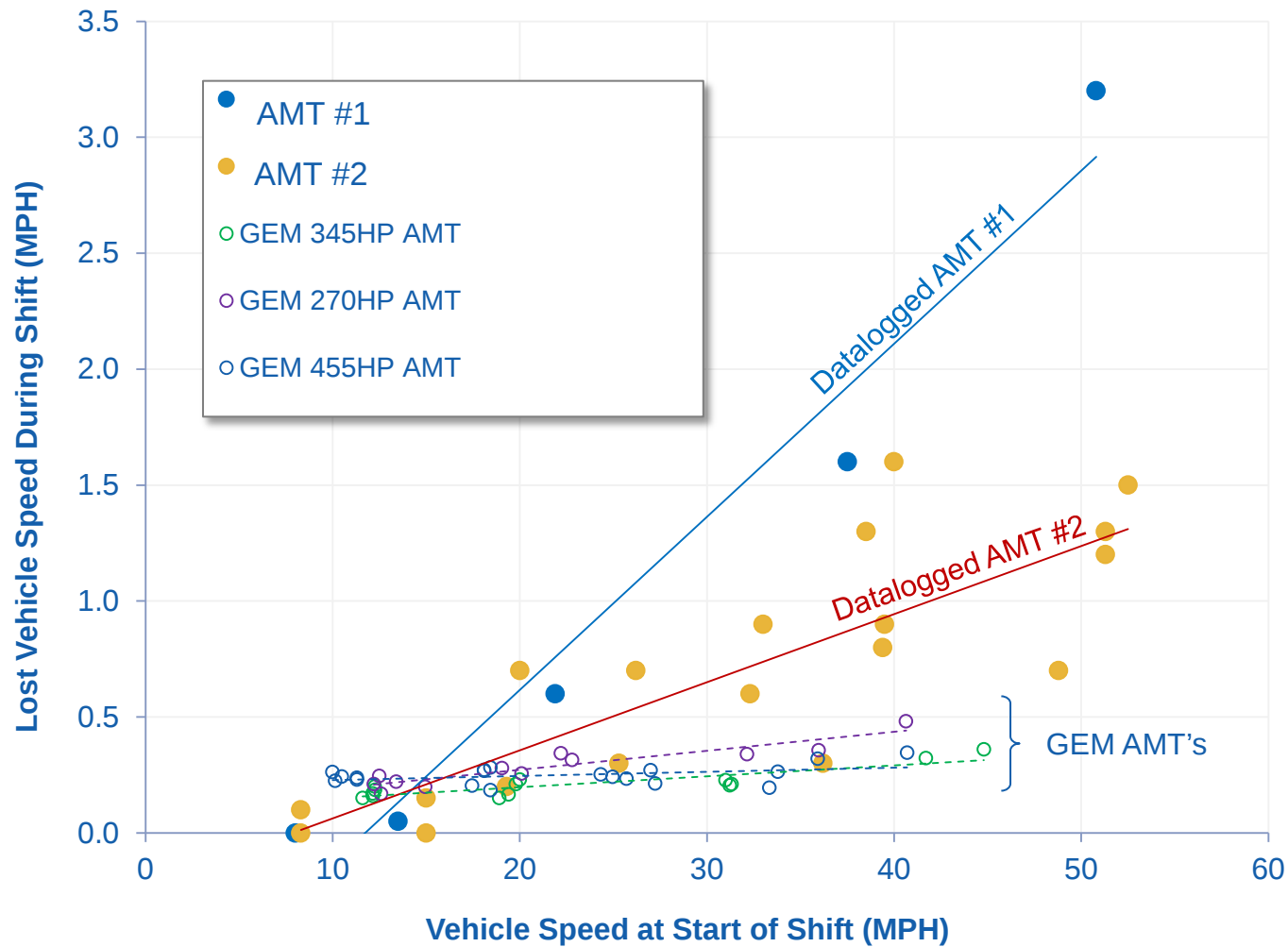
10-spd AT with OD vs 10-spd AMT with OD



GEM Shift Schedules Are Not Representative of Real World Transmission Operation



GEM Does Not Account for Vehicle Speed Lost During AMT Power Interrupt Shifts



AT Losses are More Conservative than MT/AMT Losses

Configuration	% Change of CO ₂ Reduction to Baseline
Day Cab MT	-1.5%
Day Cab AT	-3.2%
Sleeper Cab MT	-1.4%
Sleeper Cab AT	-2.6%

- The percentage change compares the GEM default baseline to measured transmission losses
- Larger loss impact on automatic transmission vs. manual transmission indicates the following:
 - Automatic transmission defaults are more conservative than the manual transmission and therefore penalize the automatic transmission as compared to the manual transmission
 - Forces the burden of powertrain testing inequitably on manufacturers of automatic transmission-equipped vehicles/transmissions

Small differences in GEM add up, creating disparate and unjustified results for GHG emissions and fuel economy

- In real world, ATs *have GHG advantage* over AMTs and MTs in stop-and-go traffic (transient cycle) but GEM *favors* AMTs
- In steady state operations (55 and 65 mph cycles), GEM modeling contains unrealistic shift patterns for ATs, creating further disadvantages vs AMTs.
- Calculations show net effect for HHD construction vehicle classified as multi-purpose – CO₂ emissions for AT should be *lower* than AMT or MT

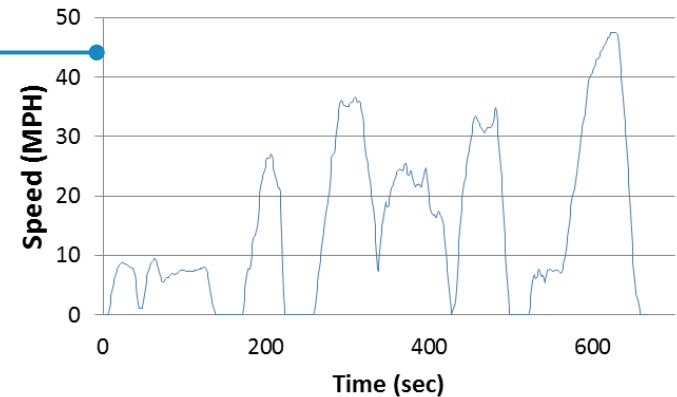
HHD Construction Vehicle (Multipurpose) Transmission Configuration	55 mph Cycle		65 mph Cycle		Transient Cycle		Total CO ₂
	CO ₂	Shifts	CO ₂	Shifts	CO ₂	Shifts	
AMT 12 Speed	163	2	198	0	245	83	224
MT 18 Speed	166	13	200	3	249	107	227
AT 6 speed; 2L; Neutral Idle (4000)	171	6	202	15	271	18	247
AT 6 speed; 2L; Neutral Idle (4500)	171	8	203	9	269	20	246

Duty Cycles

Regulatory Duty Cycles

Duty cycles are defined to determine a vehicle's CO₂ performance

1. ARB Transient Cycle (distance based)
2. 55 MPH with Grade (distance based)
3. 65 MPH with Grade (distance based)



Vocational vehicles further divided into LHD, MHD and HHD subcategory

1. LHD, MHD, and HHD drive cycles should have common weightings between LHD, MHD, and HHD vehicles in urban, multipurpose, and regional subcategories
2. The Multipurpose and Regional subcategories should have higher ARB Transient Cycle weight, with reduced 65 MPH weight to reflect real world operation

Tractor Duty Cycle Weightings Should Be Improved

- Allison has evaluated data from 16 different tractor fleets using TC 10 transmissions
- Real world operations average 1.5 stops/mile (range of 0.2 to 8.9 stops/mile)
- Allison recommends that transient cycle should be weighted more heavily and idle time added (for day cabs)

	ARB Transient	55 MPH	65 MPH	Idle
Phase 2 Proposal	19%	17%	64%	0%
Recommendation	35%	20%	45%	5%

Additional Concerns

Rule Should Avoid Overreliance on Powertrain Family Testing

- Allison supports Powertrain Testing, but it must be limited to infrequent cases of highly integrated powertrains
- Powertrain testing cannot be an alternative to a GEM that poorly models common transmission behavior
- Considerations for powertrain testing:
 - Production test article availability for engine, transmission and calibrations
 - Configuration and change management – especially with multiple companies involved
 - Powertrain test facility availability, time, and cost
- If more powertrain testing is required – consumer choice with regard to vehicle configurations will be reduced
 - In 2014, Allison sold (at least) 258 regulatory combinations based on the powertrain family definition

EPA Should Alter Approach and Assumptions Concerning Hybrids

- Weight of hybrids must be incorporated into the compliance model to better reflect the real world conditions
- Hybrid duty cycles should be the same as other vocational vehicles because the vehicle must perform the same work
- Hybrids and other advanced technologies should not get “extra” credit. They should be measured on the basis of GHG improvement relative to the baseline
 - Delegated assembly provides new opportunity to recognize hybrid benefits
- Hybrid cost estimates
 - Investment costs are understated based on Allison’s ARRA DOE grant program of \$130 Million
 - Transit bus battery cost is higher than EPA projections for entire system
 - Doubtful that battery costs will fall to projected levels for MD/HD applications
- There still exist major barriers to hybrid adoption; final rule cannot “assume” their utilization

OMB Process Should Reexamine Cost Estimates

- LDV to HDV costs are not scalable
 - HD vehicles have much different volumes than LDVs and different approach to meeting required duty cycles
 - HD vehicles have more complex architectures, higher material costs
 - Manufacturing capital is higher –manufacturers must continue to build older transmissions while developing and manufacturing new transmissions
 - Transition periods longer than for LDVs, can take many years
- Costs for new technologies are understated
 - Neutral idle - \$100 in direct material costs not included
 - Stop-start - \$2000 for a basic LHDV system – but need heat/exportable power (\$9,000)
 - Adding 2 more gears - requires a new transmission program with investment costs much higher than EPA assumed, transmission costs expected to be higher than projected

OMB Process Should Reexamine Cost Estimates

- Upfront costs of \$11,680 for tractors and \$3,380 for vocational vehicles projected (Alternative 3)
 - Even if figures accurate, payback for vocational vehicles is six years, compared with 3.2 to 3.4 years for LDV
 - If figures underestimated, payback period extends out further
- Cost for powertrain testing could have major impact under various alternatives
 - If assume powertrain testing were needed for about 50% of Allison's configurations (e.g., 140 configurations) total cost would be \$9.8 million per year

Summation

- GEM can never be 100% accurate -- but it still can be “biased” regarding its measurement of FE/GHG for different transmission technologies
- EPA/NHTSA must ensure GEM model flaws regarding automatic transmissions are addressed prior to final rule
- Transient cycle is generally underweighted in vocational vehicle and day cab categories, creating additional inaccuracies

Summation

- Powertrain testing is useful in limited circumstances, but not a panacea for GEM flaws
- OMB should review cost estimates and correct unrealistic estimates of new technologies
- Hybrids have benefits, but market adoption rate assumed in proposed rule is highly inaccurate

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Thank You