VariGlide® Beltless CVT

September 2016

Honesty & Integrity

Good Corporate Citizen

Open Communication

Continuous Improvement

Agenda

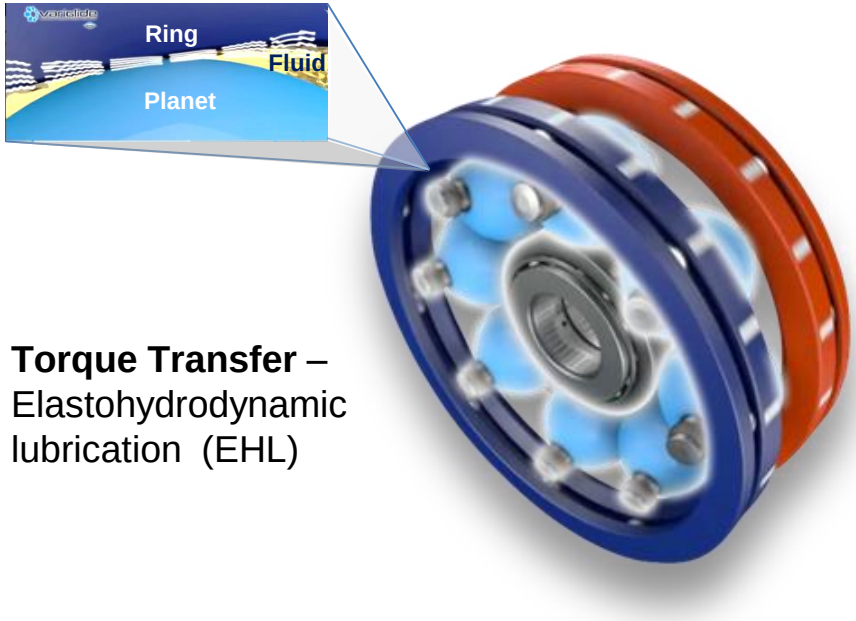
- Introduction (Video)
- Brief Technical Overview
- Background and Licensees
- Fuel Economy Benefits & Configurations
- Comparison to Belt CVTs
- Application in Hybrid Systems
- Questions

variglide® Planetary Variator

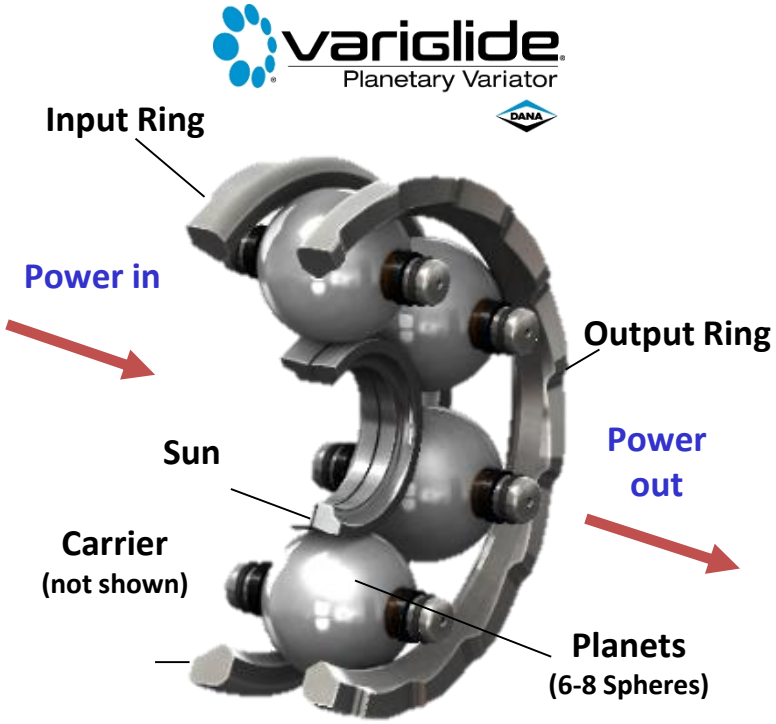
VariGlide® Introduction

VariGlide® Technology Overview

Changing Ratio - Angle of planets determines ratio over a ratio range of 4:1



Torque Transfer – Elastohydrodynamic lubrication (EHL)



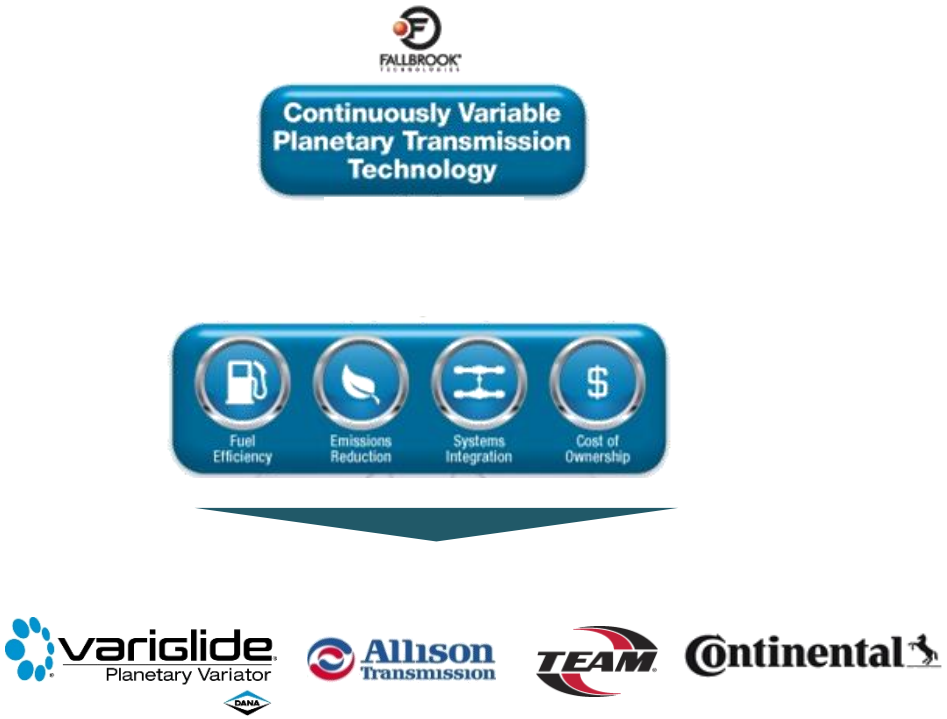
***VariGlide's* Planetary Kinematics Enable**

- 300+ Discrete options with CVP + geared planetary
- Co-axial power flow enables tight integration into conventional planetary gear arrangements

Technology Background and Licensees

- Dana acquired a license for Fallbrook's Technology in 2012
- Dana is marketing the technology under the VariGlide® brand
- The licensed fields of use include primary drive transmissions for:
  - Light vehicles (cars and trucks) up to 10,000 lb. GVW
  - Select off-highway applications; e.g., forklift trucks, utility tractors, teleboom handlers, & wheel loaders
- Four major licensees at present (Dana, Allison, TEAM and Continental)

Technology Licensees



Note: Over 70,000 hours of durability accumulated on core technology

VariGlide® Development

Design

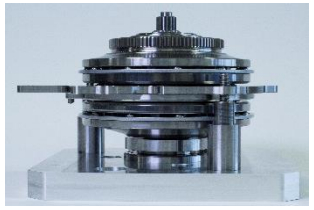
Gen 1

- Designed for VariGlide® demo vehicle

Gen 2

- 26% Cost Reduction
- Compatible with demo vehicle

Gen 3 (Customer Unit)



- +30% Cost Reduction
- 22% Weight reduction
- 50% Power Capacity Improvement

Test & Demos

- 94.6% transmission efficiency on customer test stand
- Core durability test unit

Tech. Center - 2014

ATS Demo

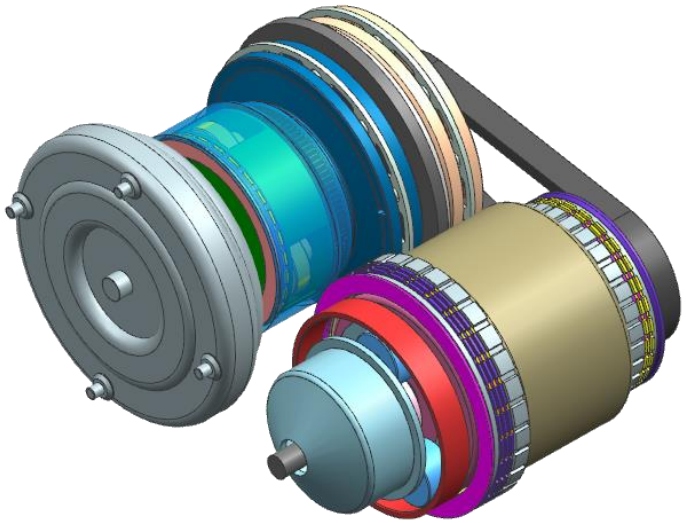
FLT Demo

Customer Programs

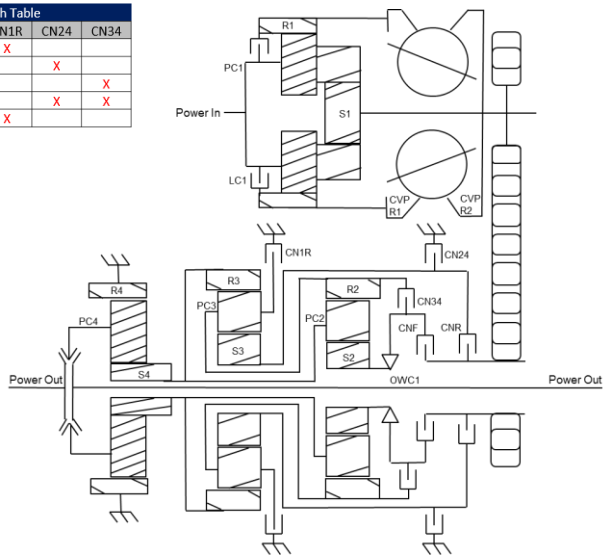
2012 — 2013 — 2014 — 2015 — 2016

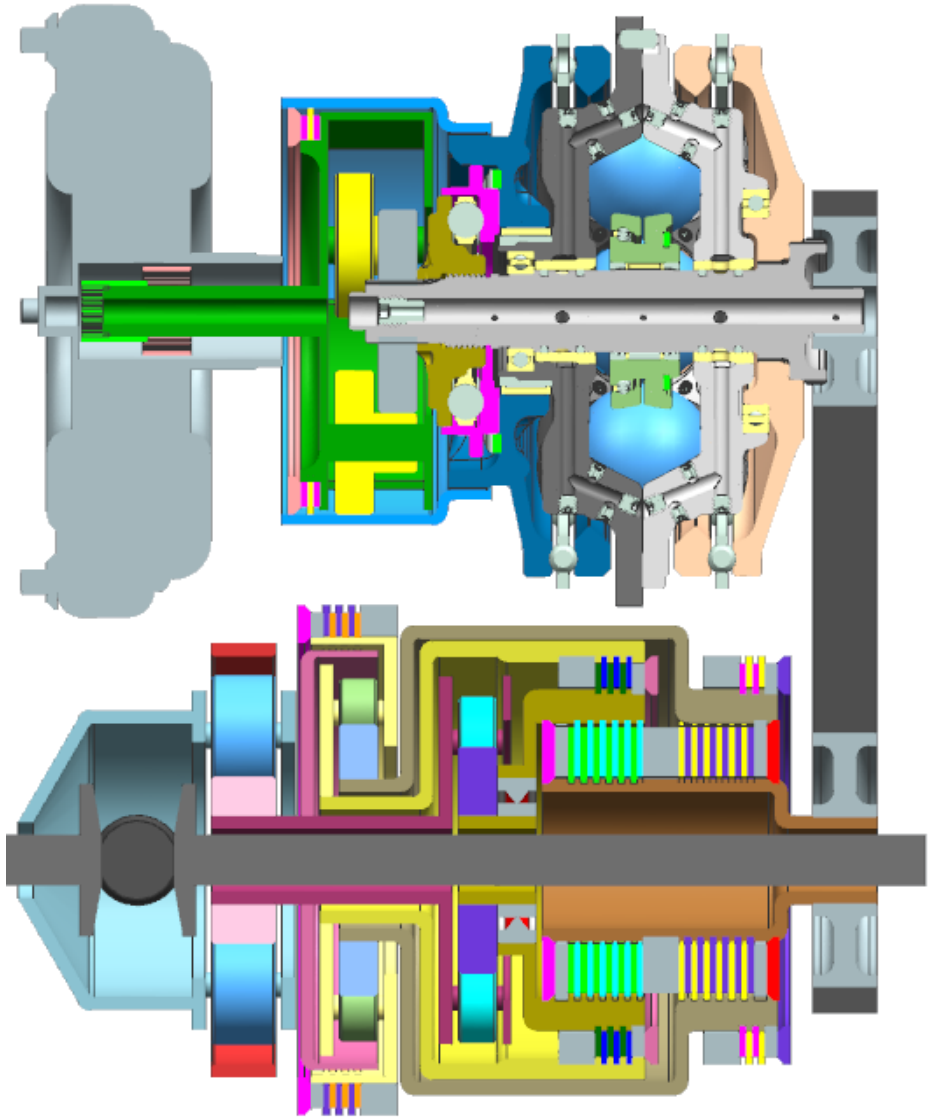
Allison Transmission — DANA — TEAM — Continental

FWD Configuration Example

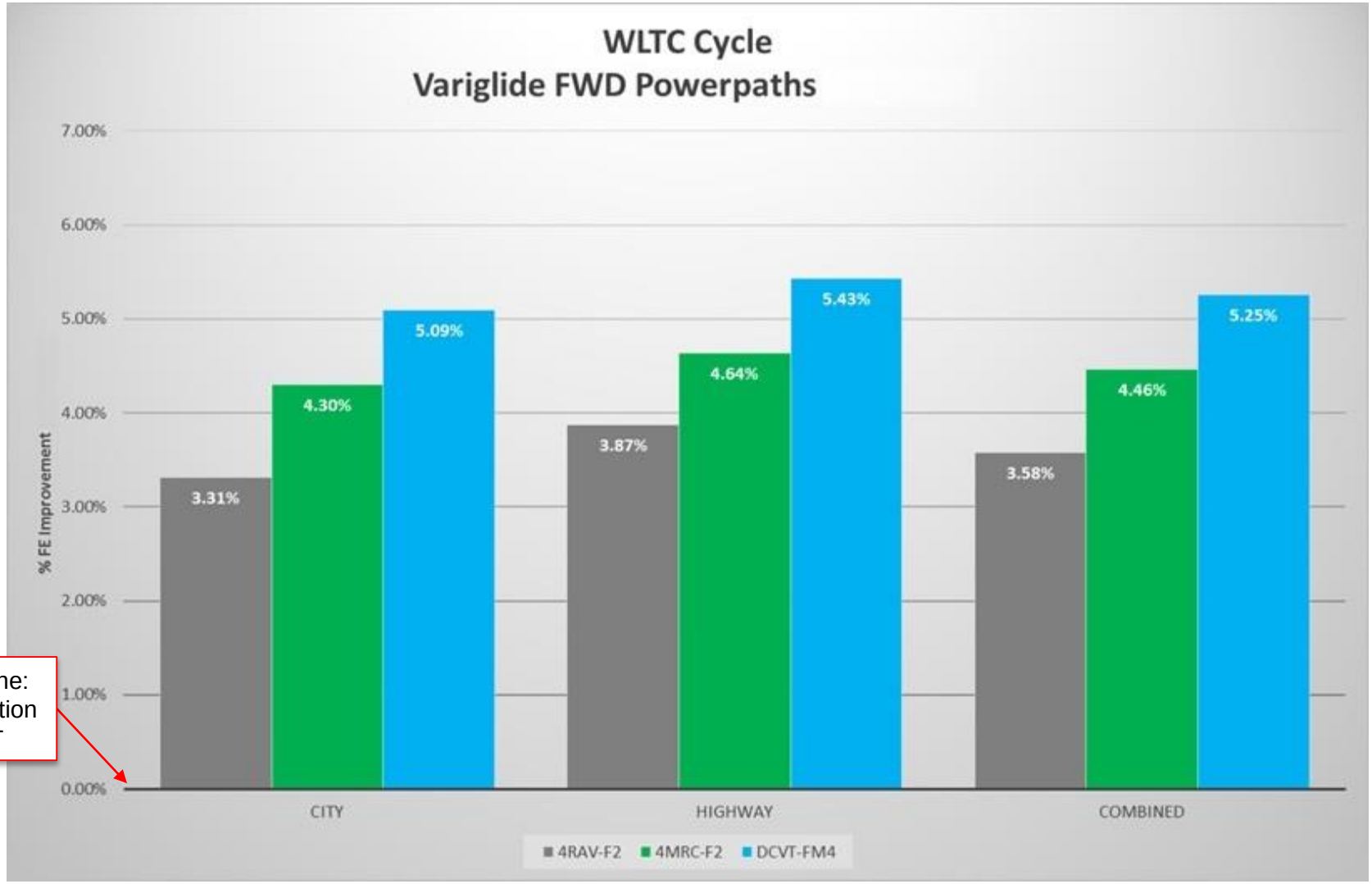


4MRC-F Clutch Table					
	CNF	CNR	CN1R	CN24	CN34
Mode 1	X		X		
Mode 2	X			X	
Mode 3	X				X
Mode 4	X			X	X
Reverse		X	X		





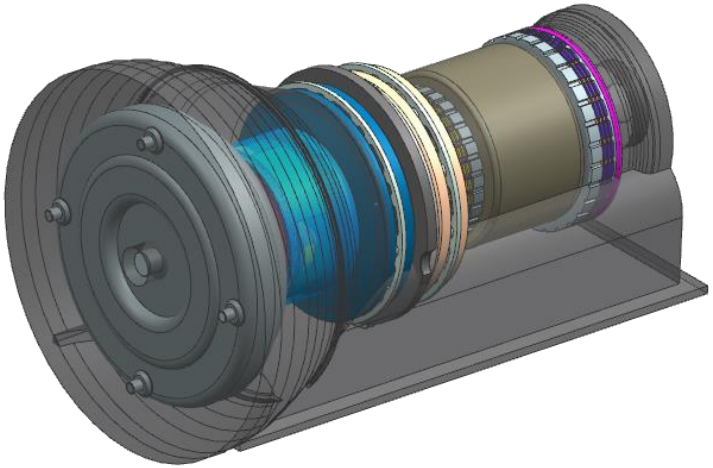
WLTC – FWD VariGlide® Powerpath vs. Production CVT



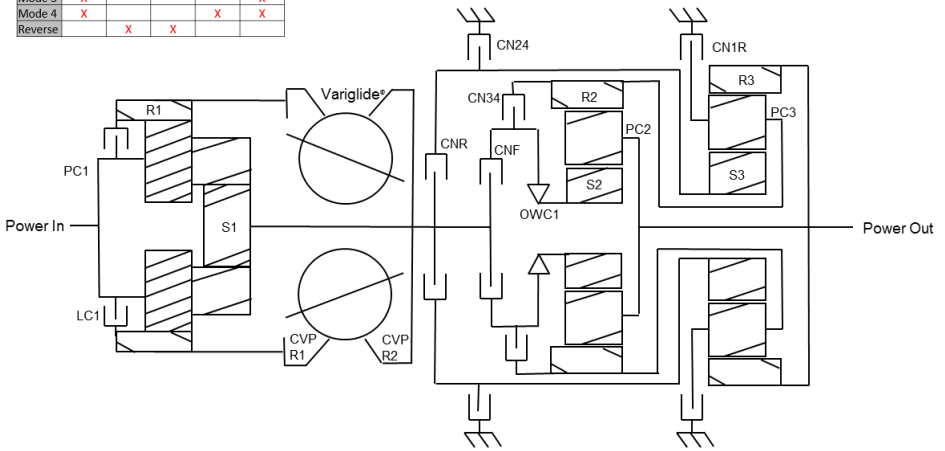
Baseline: Production CVT

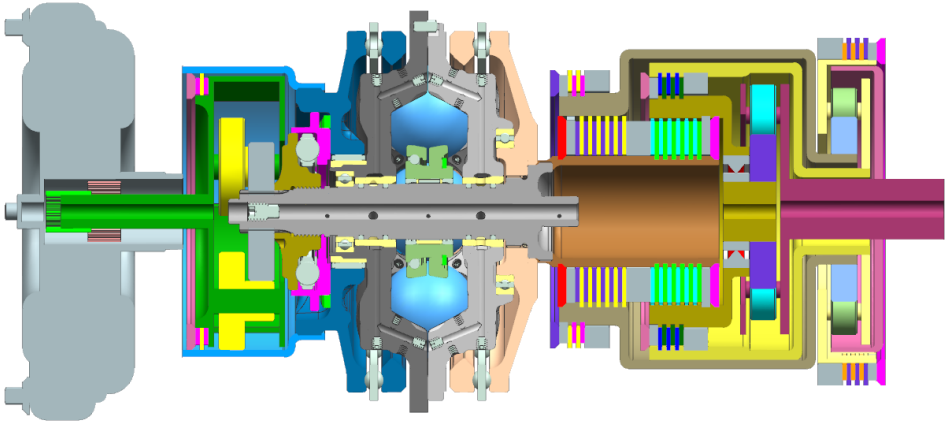
RWD Configuration Example

Production 8 speed Housing Outline (RWD)

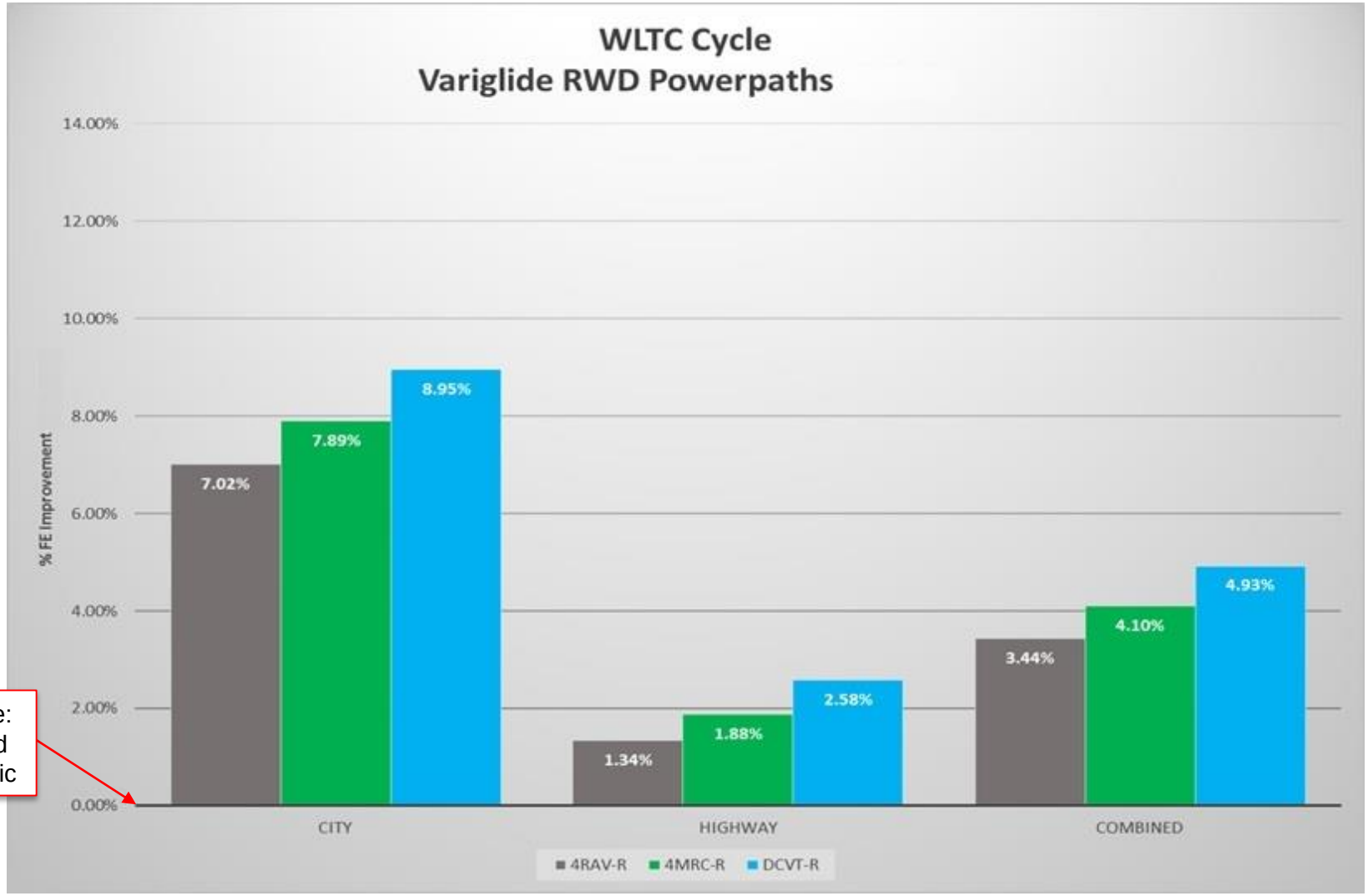


4MRC-R Clutch Table					
	CNF	CNR	CN1R	CN24	CN34
Mode 1	X		X		
Mode 2	X			X	
Mode 3	X				X
Mode 4	X			X	X
Reverse		X	X		





WLTC – RWD VariGlide® Powerpath vs. Production 8 speed

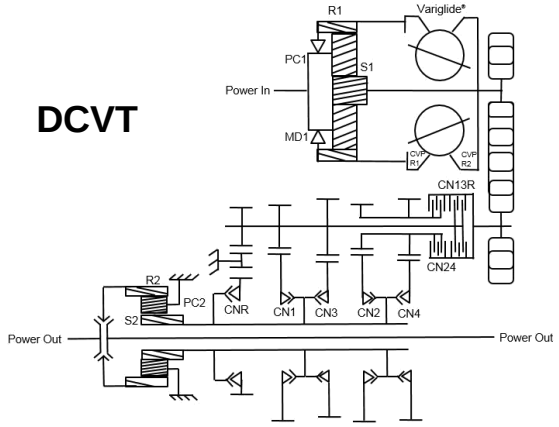


Baseline:
8 Speed
Automatic

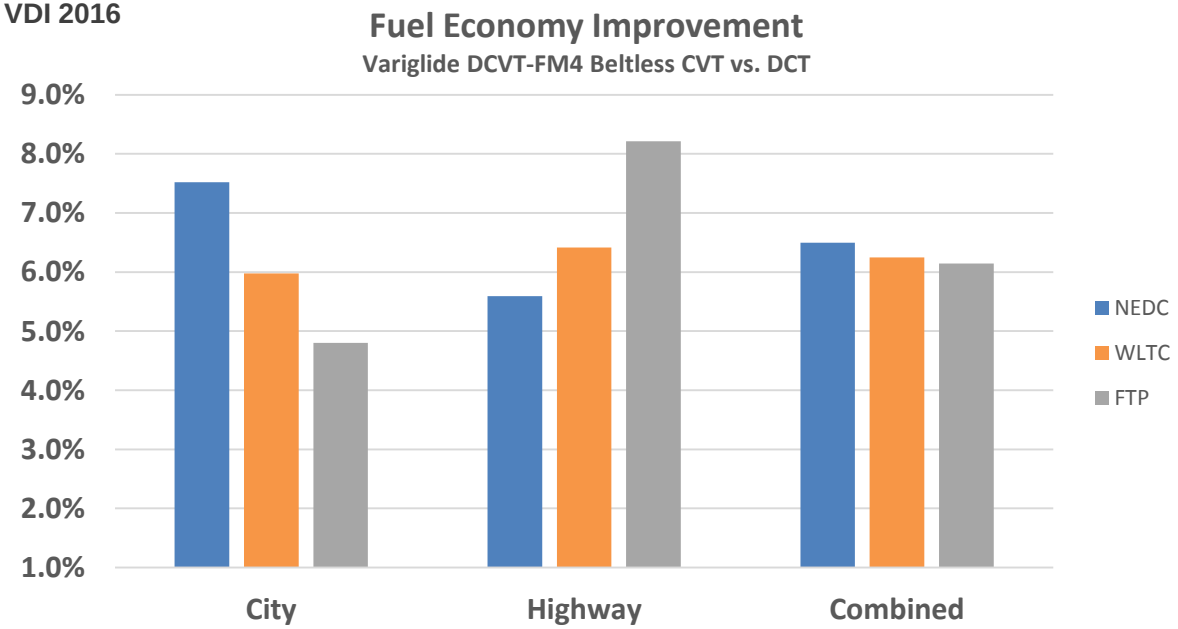
DCT Example (7 Speed & 1.4L Turbo Gas Engine)

- VariGlide® (DCVT-FM4) vs. DCT
  - Fuel Economy Improvement for all drive cycles
    - 6.1 – 6.5% better for combined driving
  - Engine stays at optimal BSFC
    - <2000 RPM for drive cycles

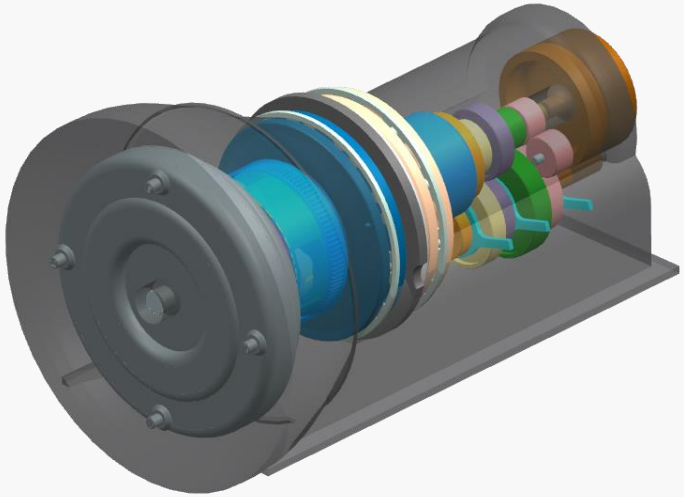
DCVT



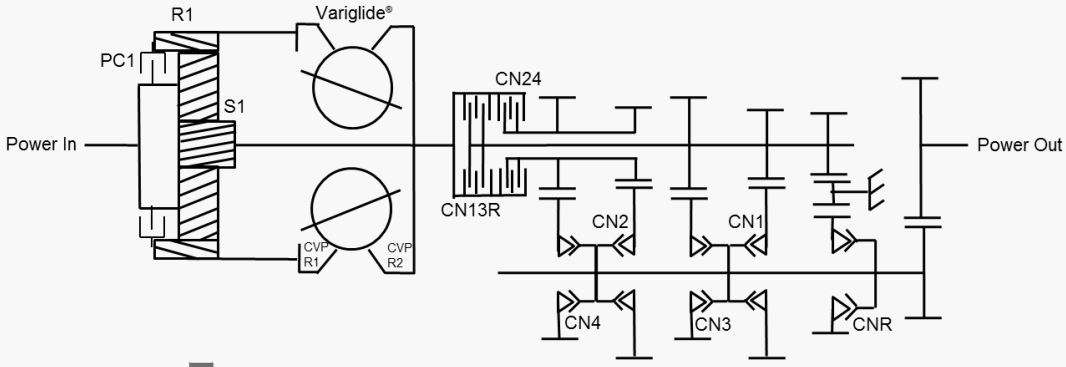
VDI **Presented at VDI 2016**

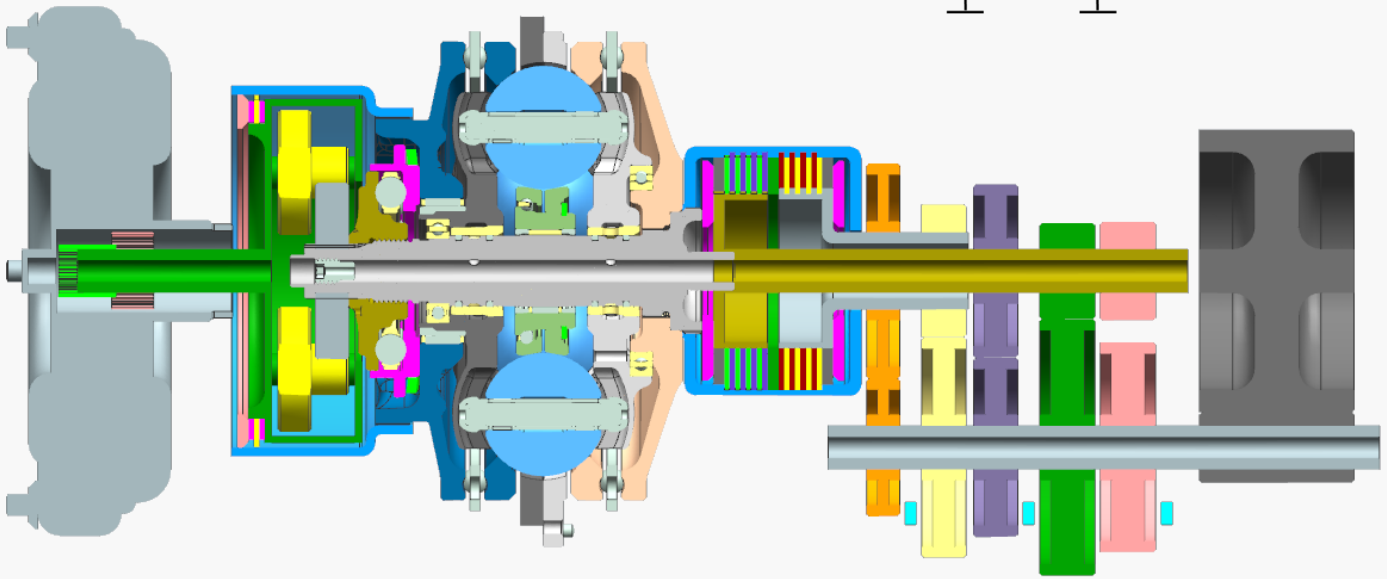


DCVT-R – RWD Variable DCT Example



DCVT-R	CN13R	CN24	CN1	CN2	CN3	CN4	CNR
Mode 1	X		X				
Mode 2		X		X			
Mode 3	X				X		
Mode 4		X				X	
Reverse	X						X



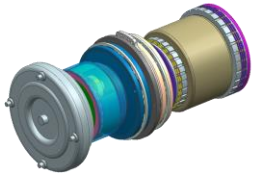


Value Proposition - VariGlide® vs. Belt CVT

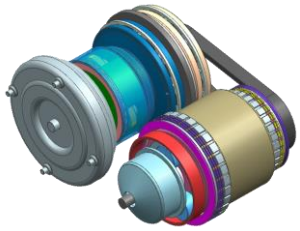
Beltless CVT Technology

Attribute	variglide Planetary Variator	Traditional Belt CVT
Robust Against Slip Induced Damage	✓	✗
Higher System Efficiency (Jatco & Aisin)	✓	✗
Co-Axial Design Uniquely Supports **RWD** Applications	✓	✗
Supports High Torque Mid Size FWD Applications	✓	✗
No High Pressure Pump or Associated Components / Complex Control System	✓	✗
Lower Potential System Cost	✓	✗

RWD Configuration



FWD Configuration



Recent 38mm Prototype Hardware

Prototype Variator Status

Recent 38mm Customer Prototype Unit

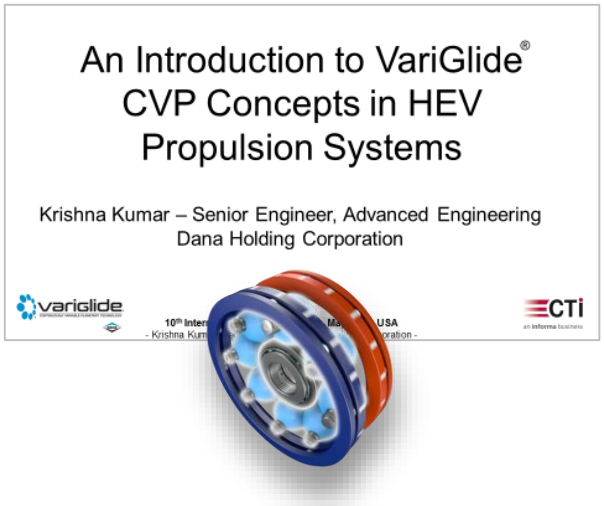
- Exceeded customer efficiency requirements ✓
- Exceeded power capacity requirements ✓
- Passed initial customer based durability tests (at Dana) ✓

Currently Performing DVP&R Testing

VariGlide® in Hybrid Applications

- VariGlide Offers the Potential to:
  - Optimize overall system efficiency
  - Expand overall ratio of transmission
  - Fit in all hybrid configurations
    - Powersplit & Parallel hybrid configurations possible
- 3 Main Configuration Options for VariGlide:
  - Variable torque split planetary differential in a powersplit hybrid configuration
  - Mechanical CVT in powersplit or parallel hybrid configuration
  - Alternating mechanical CVT or planetary differential

2016 CTI Paper



Optimum Performance & Driveability ✓

Fuel Economy Optimization ✓

VariGlide supports Stop/Start Hybrid systems while providing cost reduction opportunities

Cadillac ATS Demonstrator

Questions?

variglide® Planetary Variator