U.S. Based HEV and PHEV Transaxle Program
HF35

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Overview

Timeline	Risks and Barriers
Start: October 1, 2009 Finish: September 30, 2012	Functional Financial Marketing Purchasing
Budget	**Partners**
Total Project Funding DOE: $62.5M Ford: $62.5M Funding received in FY10 = $8.6M Funding received in FY11 = $28.7M Funding received in FY12 = $3.3M	No official partners identified in grant

Relevance – HEV and PHEV Applications

Hybrid Electric Vehicle (HEV)

- Combines an internal combustion engine with an electric motor and battery
- Electric power is used for vehicle launch and lower-speed operation
- Internal combustion engine takes over for higher demand operation and charges the battery

Plug-in Hybrid Electric Vehicle (PHEV)

- Combines HEV technology with a high-voltage storage battery like that used in a Battery Electric Vehicle (BEV)
- Ford's PHEV is a blended PHEV – optimally first using the battery charge and then operating in regular hybrid mode
- Offers consumers the best possible fuel economy, smallest battery and most affordable solution.

Relevance – Fuel Economy Leadership

NOW

ESCAPE HEV

Most Fuel Efficient SUV on the Planet

CITY MPG	Fuel Economy Information	HIGHWAY MPG
34	DOE EPA	31

FUSION / MKZ HEV

Most Fuel Efficient Mid Size Sedan in North America

CITY MPG	Fuel Economy Information	HIGHWAY MPG
41	DOE EPA	36

COMING SOON with HF35!

CMax (HEV/PHEV)

FUSION (HEV/PHEV) / MKZ (HEV)

FHEV will be 47 city mpg / 44 highway mpg

PHEV will be > 100 mpge

The HF35 is a key contributor to Ford's Fuel Economy Leadership going forward

Relevance – Electrification Strategy

2007 2011 2020 2030

Near Term

Begin migration to advanced technology

Mid Term

Full implementation of known technology

Long Term

Near Term

- Significant number of vehicles with EcoBoost engines
- Electric power steering 70 – 80%
- Dual clutch and 6 speed transmissions replacing 4 and 5 speeds
- Four Hybrid applications
- Increased unibody applications
- Introduction of additional small vehicles
- Battery management systems 75%
- Aero improvement up to 5%
- Stop/Start systems (micro hybrids) introduced

Mid Term

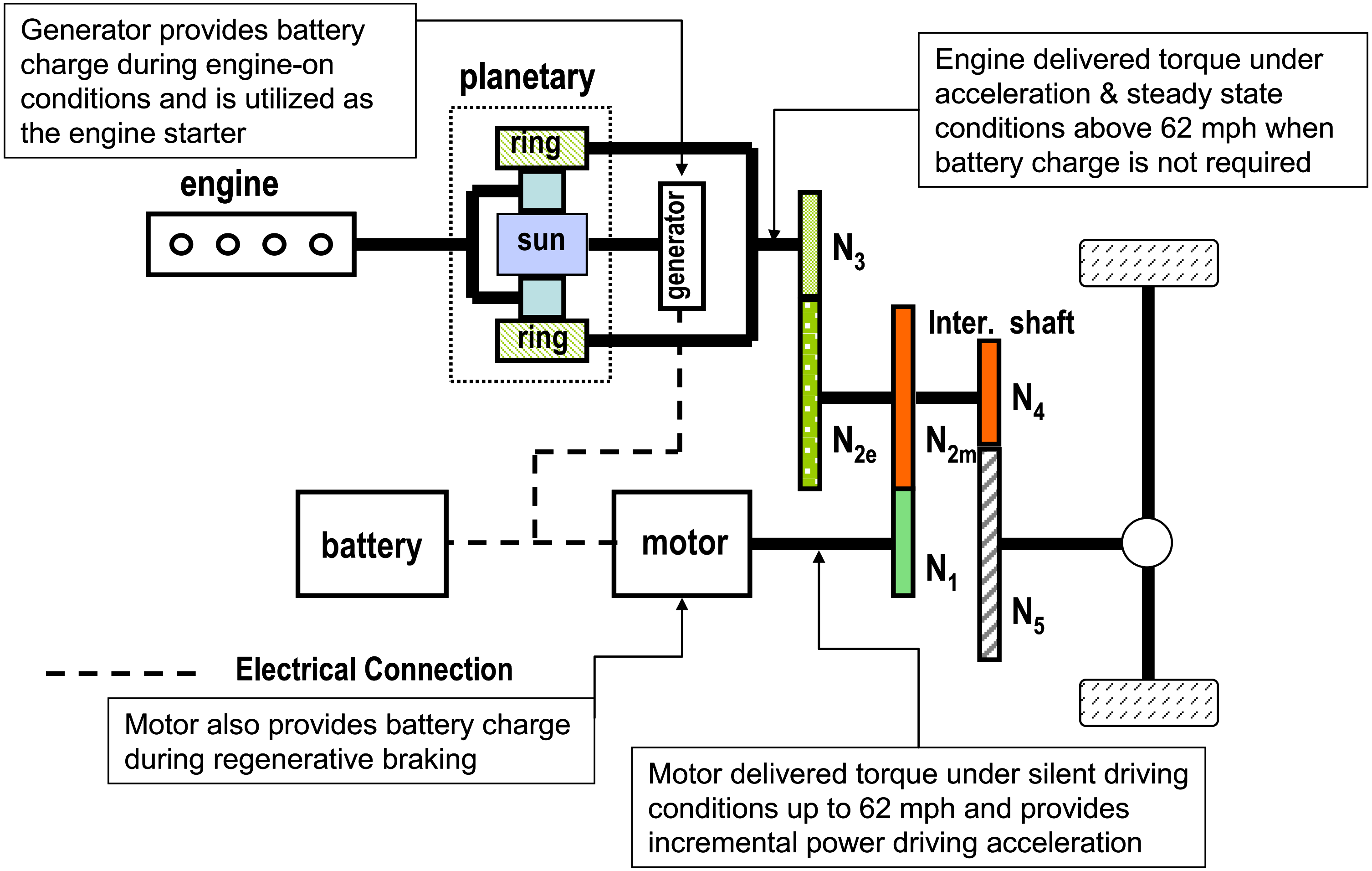
- EcoBoost engines available in nearly all vehicles
- Electric power steering 100%
- Six speed transmissions 100%
- Weight reduction of 250 – 750 lbs
- Engine displacement reduction aligned with weight save
- Additional Aero improvements to 5%
- Increased use of Hybrids
- Introduction of PHEV and BEV
- Diesel use as market demands
- Increased application of Stop/Start

Long Term

- Percentage of internal combustion dependent on renewable fuels
- Volume expansion of Hybrid technologies
- Continued leverage of PHEV, BEV
- Introduction of fuel cell vehicles
- Clean electric / hydrogen fuels

As part of our overall transformation, Ford Motor Company is committed to bringing hybrid and plug-in hybrid vehicles to market quickly and affordably. The HF35 transaxle program is a major catalyst in support of this strategy.

Approach – Powersplit Architecture

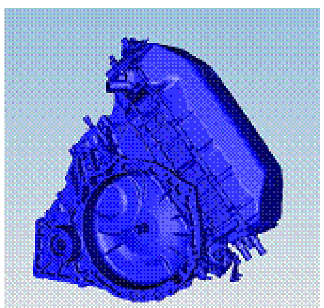


The HF35 Strategy takes advantage of a known, robust transaxle design

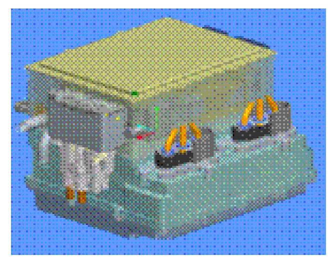
Approach – Architecture Evolution

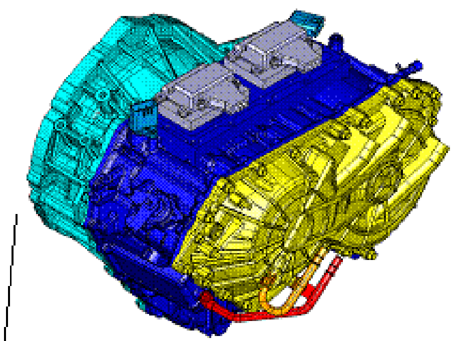
	2004 – 2011 Gen I	2008 – 2012 Gen II	2012+ HF35
Engine	2.3 L / 2.5 L Atkinson	2.5 L Atkinson	2.0 L Atkinson
Transmission	• AW PowerSplit Trans	• AW PowerSplit Trans	• HF35 Transmission
	• AW Controls	• AW Controls	• Ford Controls & Calibration
	• Integrated Power Electronics	• Integrated Power Electronics with Variable Voltage Control	• Remote Power Electronics with Variable Voltage Control
Battery	• 250 Cell NiMH	• 208 Cell NiMH	• Li Ion

Gen I & Gen II



HF35

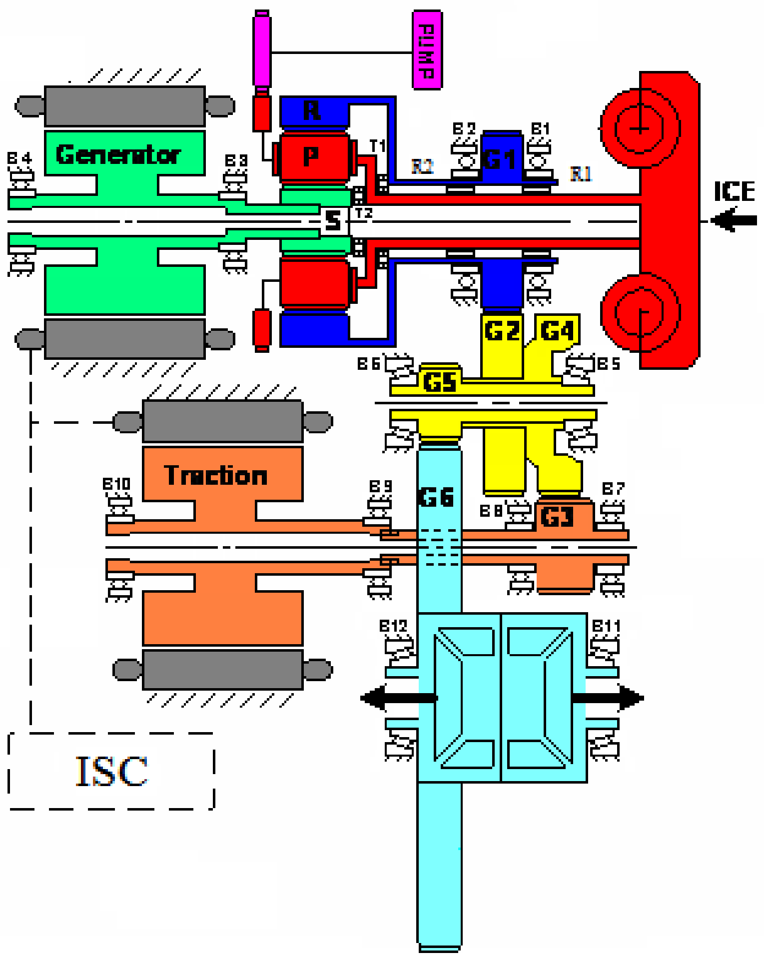




Separate power electronics from trans hardware & motors

The HF35 is Ford's third generation Powersplit transaxle, and the 1st internally manufactured – taking advantage of evolutionary design of a robust product

Approach – HF35 Architecture



HF35 Major Components

- Motor/Generator Set
- Planetary Gearset
- Transfer Gears
- Final Drive Differential
- Shafts
- Bearings
- Pump/Filter
- Flywheel/Damper Assy

Components not shown

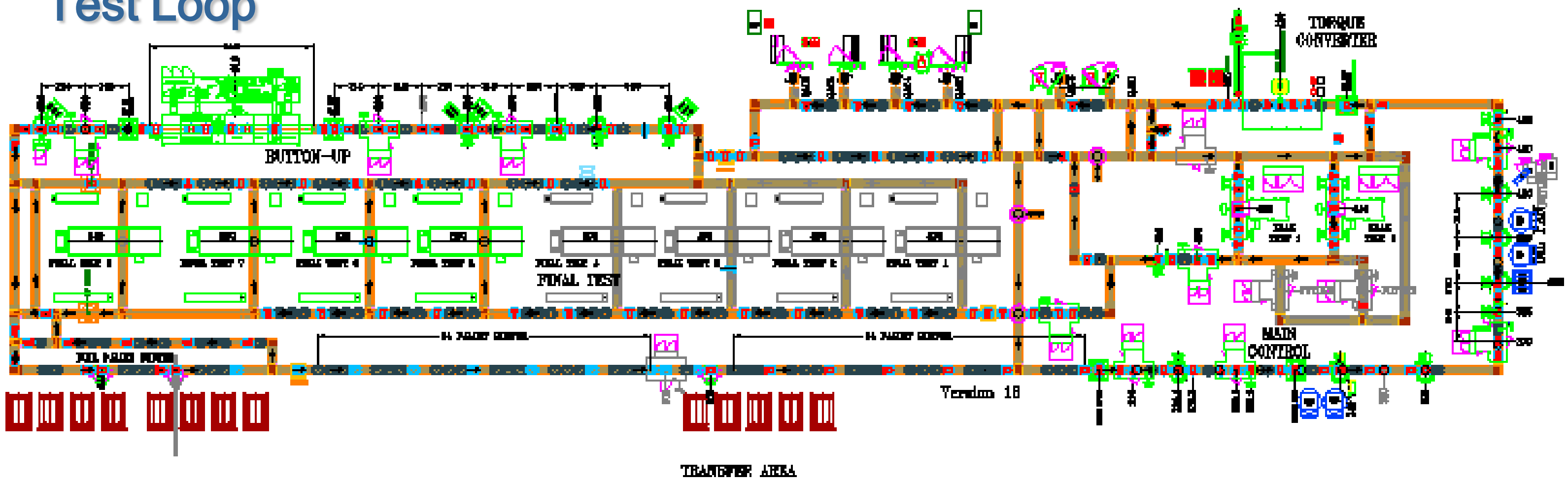
- Park System
- Electrical wiring/sensors
- Case and Bell Housing

134 New Parts
43 Carryover parts

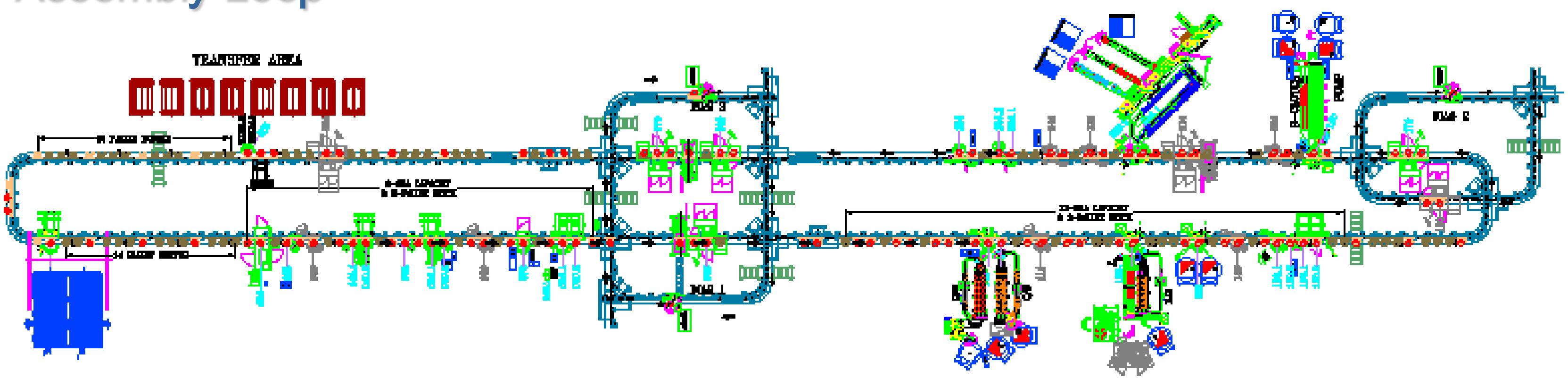
The cost of the HF35 is mitigated with the utilization of components common with other Ford transaxle products.

Approach – Flexible Assembly

Test Loop

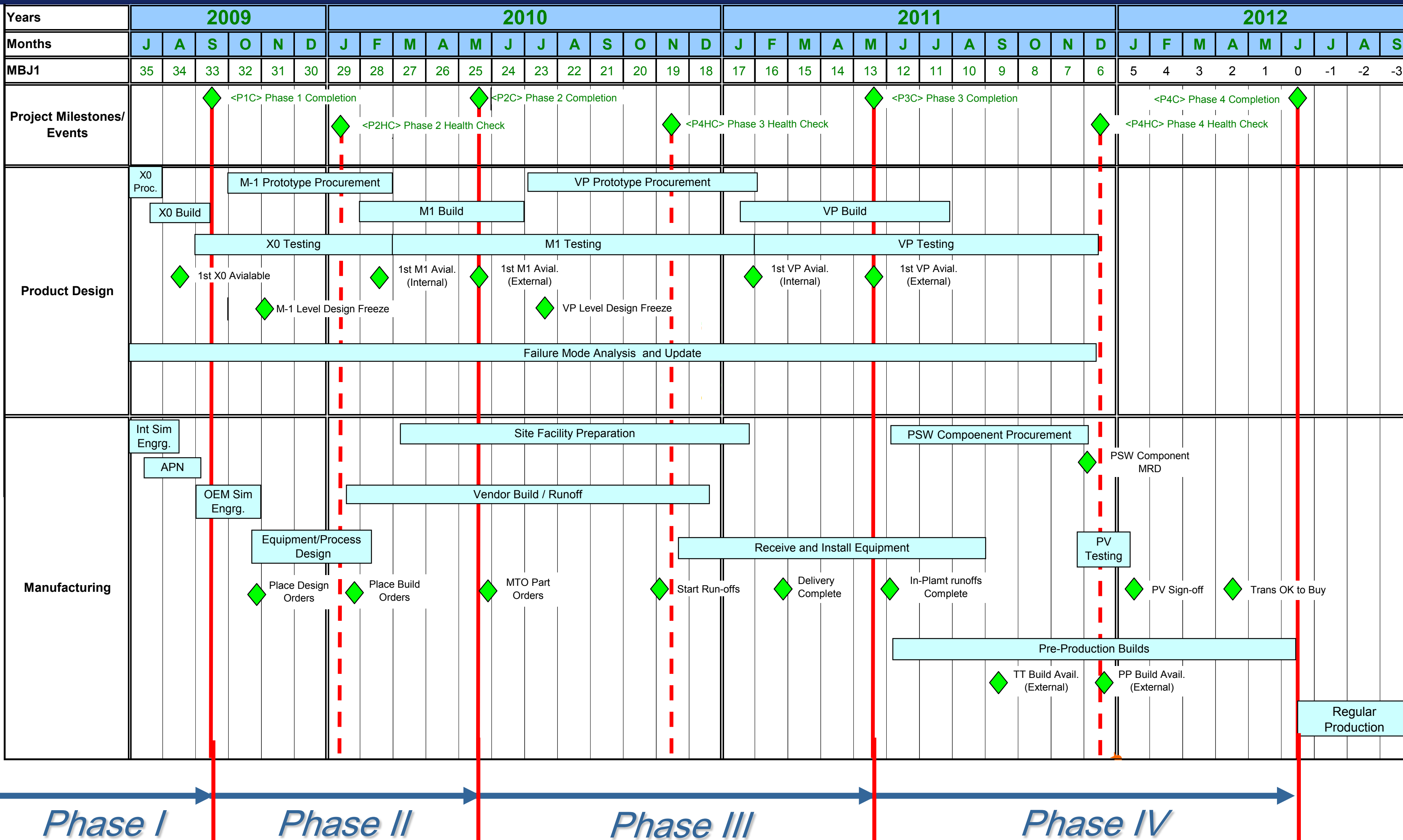


Assembly Loop



Ford's 1st flexible transaxle assembly process for gas and hybrid models enables nimble response to customer demand fluctuations

Approach – Phased Project Plan



Approach – Phased Project Plan

Milestones Completed in Phase I (Period ending September 2009):

- ✓ **<Unit PTC> Program Target Compatibility GPDS Milestone – September 2009 (Go / No Go Decision Point)**
- ✓ Long Lead Funding Approved – September 2009
- ✓ Component Sourcing Agreements Signed – September 2009
- ✓ First Phase I (X0) Transaxle Available – September 2009

✓ = Completed

The objective of Phase I is to finalize the initial design and deliver the first functional prototype transaxle for testing.

Milestones Occurring in Phase II (Period ending May 2010):

- ✓ Phase II (M1) Level Design Freeze – October 2009
- ✓ Production Equipment Design Orders Initiated – October 2009
- ✓ **<Unit PA> Program Approval GPDS Milestone – February 2010 (Go / No Go Decision Point)**
- ✓ Component Commercial Pricing Agreements Signed – February 2010
- ✓ First Phase II (M1) Transaxle Available (Internal) – February 2010
- ✓ Production Equipment Build Orders Initiated – February 2010
- ✓ First Phase II (M1) Transaxle Available (External shipped to build site) – May 2010

✓ = Completed

The objective of Phase II is to refine the Phase I design and address any failure modes found during Phase I testing.

Milestones Occurring in Phase III (Period ending May 2011):

- ✓ Machine Tryout Parts Ordered – June 2010
- ✓ Phase III (VP) Level Design Freeze – July 2010
- ✓ Production Equipment Run-off's Initiated – November 2010
- ✓ **<FDJ> Final Data Judgment GPDS Milestone – December 2010 (Go / No Go Decision Point)**
- ✓ First Phase III (VP) Transaxle Available (Internal) – January 2011
- ✓ First Phase III (VP) Transaxle Available (External) – May 2011

✓ = Completed

The objective of Phase III is finalize design refinements and build confirmation prototypes

Milestones Occurring in Phase IV (Period ending June 2012):

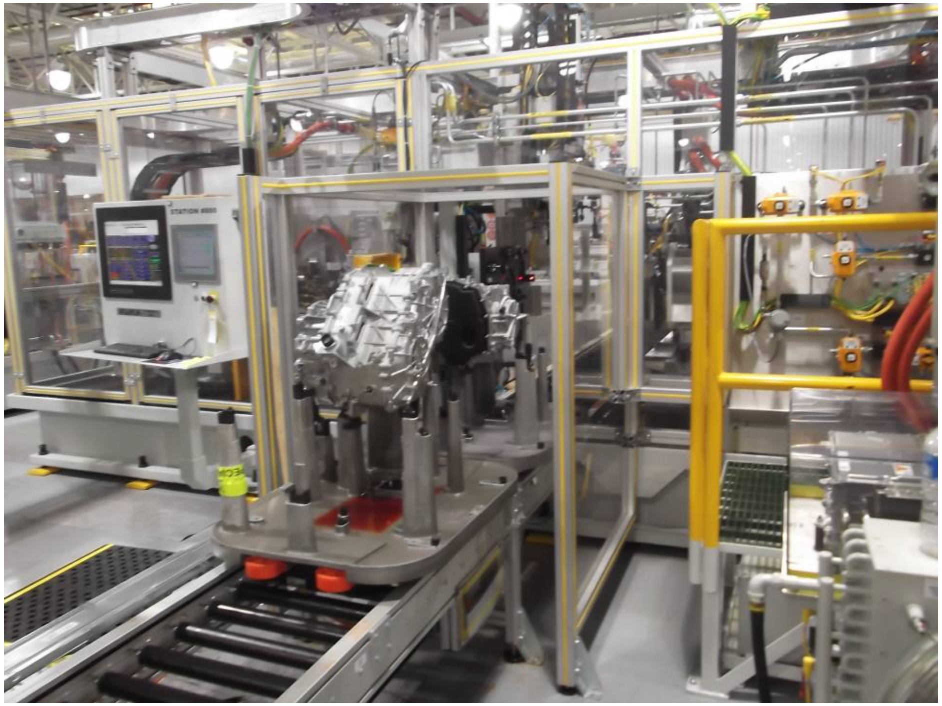
- ✓ Production Equipment Delivery Completed – July 2011
- ✓ Production Equipment In-Plant Runoffs Completed – September 2011
- ✓ 1st Production HF35 Build at Transaxle Assembly Plant – October 2011
- ✓ **<FEC> Final Engineering Confirmation GPDS Milestone – December 2011 (Go / No Go Decision Point)**
- ✓ HF35 Production Validation (PV) Testing Sign-off – January 2012
- ✓ 1st Production HF35 Build at Vehicle Assembly Plant – January 2012
- Transaxle OK-to-Buy – April 2012
- **<MP1> Mass Production 1 GPDS Milestone – June 2012**

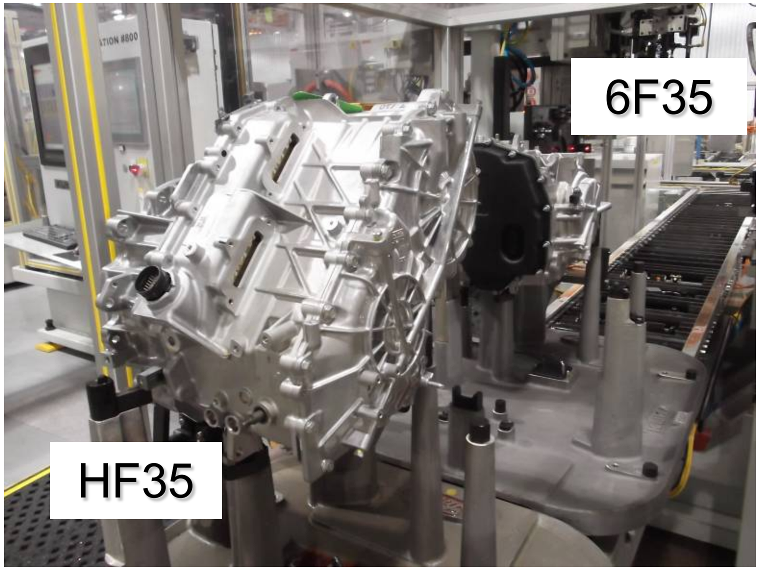
✓ = Completed

The objective of Phase IV is to deliver production level transaxles to the vehicle assembly plant and complete product launch

Technical Accomplishments and Progress

HF35 Testing on Production Test Equipment





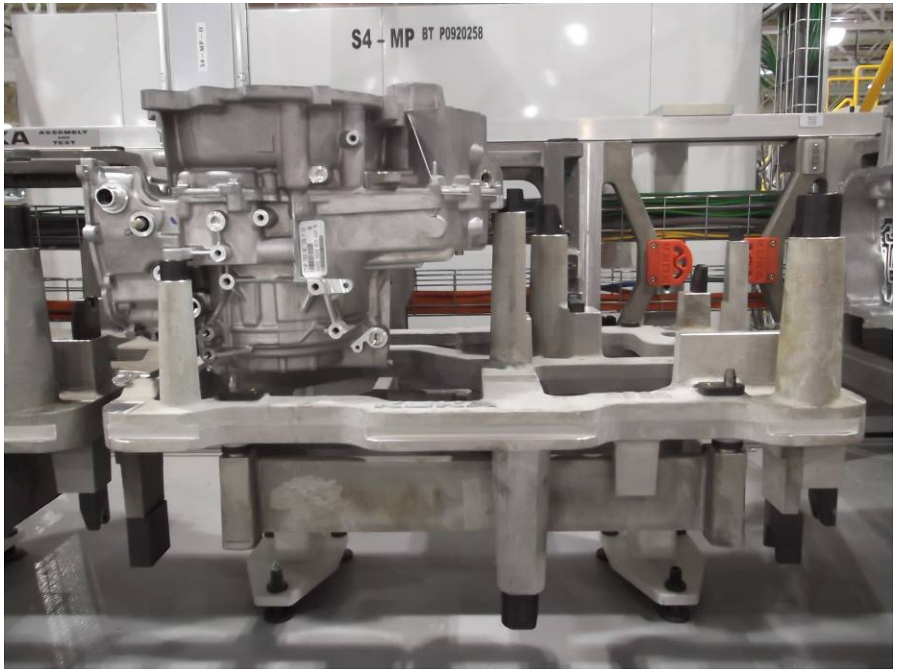
Same view => Zoom in

This picture shows our new HF35 hybrid transmission (near) trailing our existing 6F35 gas transmission into our flexible final test stand in production. True “batch of one” process capability!

Technical Accomplishments and Progress

Flexible Assembly System – Conveyor Selection and Pallet Design

Main Line Vertical Conveyor



6F35 Product on Flex Pallet

The conveyor system selected provides access to (3) sides of the product during assembly as well as future flexibility for changeover and / or expansion

The pallet design is flexible for both gas and hybrid versions of Ford’s FWD transaxles

Rotor Magnetization

Rotors queued up for processing

Rotors entering bearing press after magnetization

The Traction and Generator Rotors are carryover design, magnetized internally at Ford for the 1st time during the assembly process.

Major Milestones

June 2012

- <MP1> Mass Production 1 GPDS Milestone
    - Complete HF35 pre-production builds
    - Complete production validation
    - Achieve “OK to Build” for HF35 transaxle

Collaborations / Partnerships

No partners were officially identified for the DOE grant awarded to Ford

The ultimate success of the project will be a reflection of new and existing relationships that are furthered as a result of this project. These include but are not limited to:

Production Component Suppliers

- Toshiba, Weber Automotive, Auma-Bocar, Systrand, Yazaki NA, …

Machine Tool Suppliers

- Kuka AT, Magnetic Instrumentation, Cinetic, WMA Inc., …

Community

- United Auto Workers
- State of Michigan
- City of Sterling Heights, Michigan

Summary

- **The HF35 project facilitates the launch and commercialization of hybrid electric vehicles via U.S. design and production of a world-class HEV/PHEV transaxle system**
- **Our approach leverages robust design evolution, common components, and a flexible assembly system at a world class Ford manufacturing facility.**
- **We have accomplished or exceeded all objectives for Phase I, II, and III of the project**
    - Lessons learned through prototype testing and simultaneous engineering have been applied to the design leading into Phase IV
- **We are in mid-Phase IV of the project, and are on target to accomplish all objectives for this Phase**
    - All pre-production builds have been completed, road tested, and shipped to the vehicle plant customer to support their pre-production build activities
- **We are well positioned for the scope of work to be completed in time**
- **We remain confident in the execution and ultimate success of the HF35 project**