

# North American Power Electronics Supply Chain Analysis

## *Interim Update*

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**SYNTHESIS PARTNERS, LLC**

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Project ID  
#APE032

# Overview

## Timeline

- Start: October 2013
- End: September 2014
- Percent complete: 50%

## Budget

- Total project funding
  - DOE share: 100%
- Funding for FY13: \$235K
- Funding for FY14: \$249K

## Barriers Addressed

- Ability of technology supply chain to support aggressive planning for increased power electronics manufacturing in North America.
- Pathways to cost reduction for more competitive manufacturing and workforce base in traction drive power electronics in North America.
- Need for accurate information about power electronics and electric motors manufacturing capability in North America.

## Partners

- Interactions/ collaborations:
  - USCAR Electrical and Electronics Tech Team (EETT); OEMs, Tier 1-4s; DOE National Labs.
- Project lead: Synthesis Partners, LLC (SP)

# Objectives/Relevance

- Analysis of primary and secondary source data generates improved situational awareness for VTO and electric drive supply chain partners regarding North American (N.A.) power electronics and electric drive vehicle manufacturing capabilities and markets.
- Project research is aimed at eliminating known and newly discovered information gaps that can negatively impact plans to expand power electronics and electric motors manufacturing capabilities in N.A.
- Actionable recommendations are being developed to help VTO achieve its primary objectives.

# Approach/Strategy

- Achieve objectives through integrated primary and secondary source information and analysis:
  - Mostly English, with targeted foreign language assessments
    - Selected topics reviewed in Chinese and Japanese language sources
  - Research and analyze the N.A. supply chain for advanced power electronics (PE) for automotive traction drive, including:
    - OEM and Tier 1-4 participant background information
    - OEM and Tier 1-4 in-depth viewpoints on technical and/or non-technical N.A. PE supply chain challenges and opportunities
    - Paths to cost reduction through manufacturing process improvements
    - Manufacturing cost benchmarks for WBG (SiC and GaN) based components
  - Update data-set on N.A. electric motor supply chain
    - Update data collection and provide descriptive analysis.

# Approach/Strategy

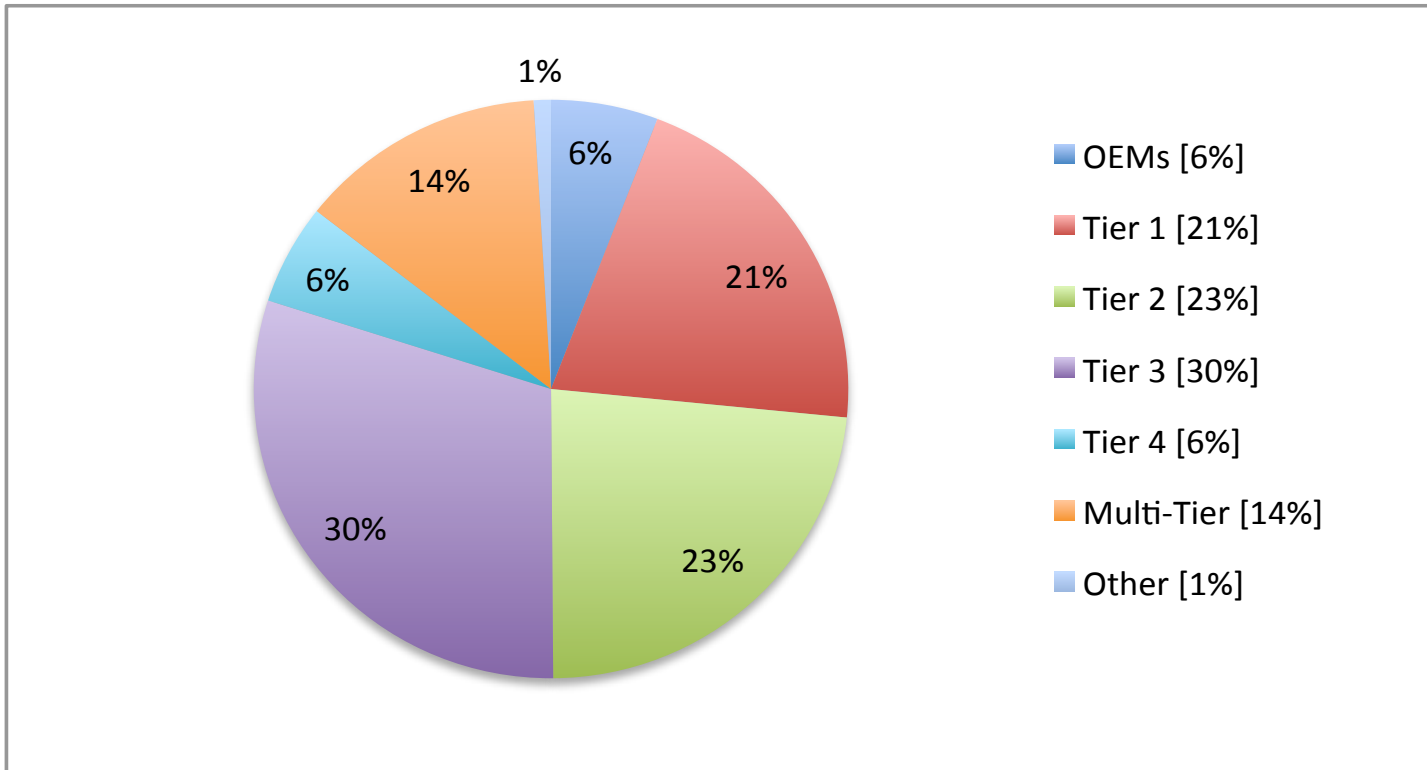
- Objectives cont'd.

- Make recommendations regarding types of actionable collaboration and communication that may help VTO enable a N.A. industrial base expansion
  - Where possible, identify practical options for information exchange to support North American supply chain expansion in advanced PE and electric motor supply chain objectives
  - Where possible, identify, analyze and recommend select organizations with active, notable plans or technologies that may work in concert in VTO to achieve advanced PE and electric motor supply chain objectives
  - Document and follow-up on actions taken as a result of recommendations, as needed.

# Progress Toward Objectives

- OEM and Tier 1-4 participation in N.A. PE supply chain
  - More than 350 organizations identified as having current or potential role in the N.A. power electronics and electrical machine supply chain.
    - Please see next slide
  - For key organizations, collecting and updating information on:
    - Points of Contact (POCs)
    - Key Capabilities
    - Tier classification
    - Significant investments in North American supply chain
    - Wide band gap (WBG) interests and capabilities
    - Other
  - The OEM and Tier 1-4 PE data-set is used to produce analysis and results regarding all project objectives:
    - Subject to source confidentiality agreements.

# Progress: Organizations in N.A. PE Data-Set, by Type



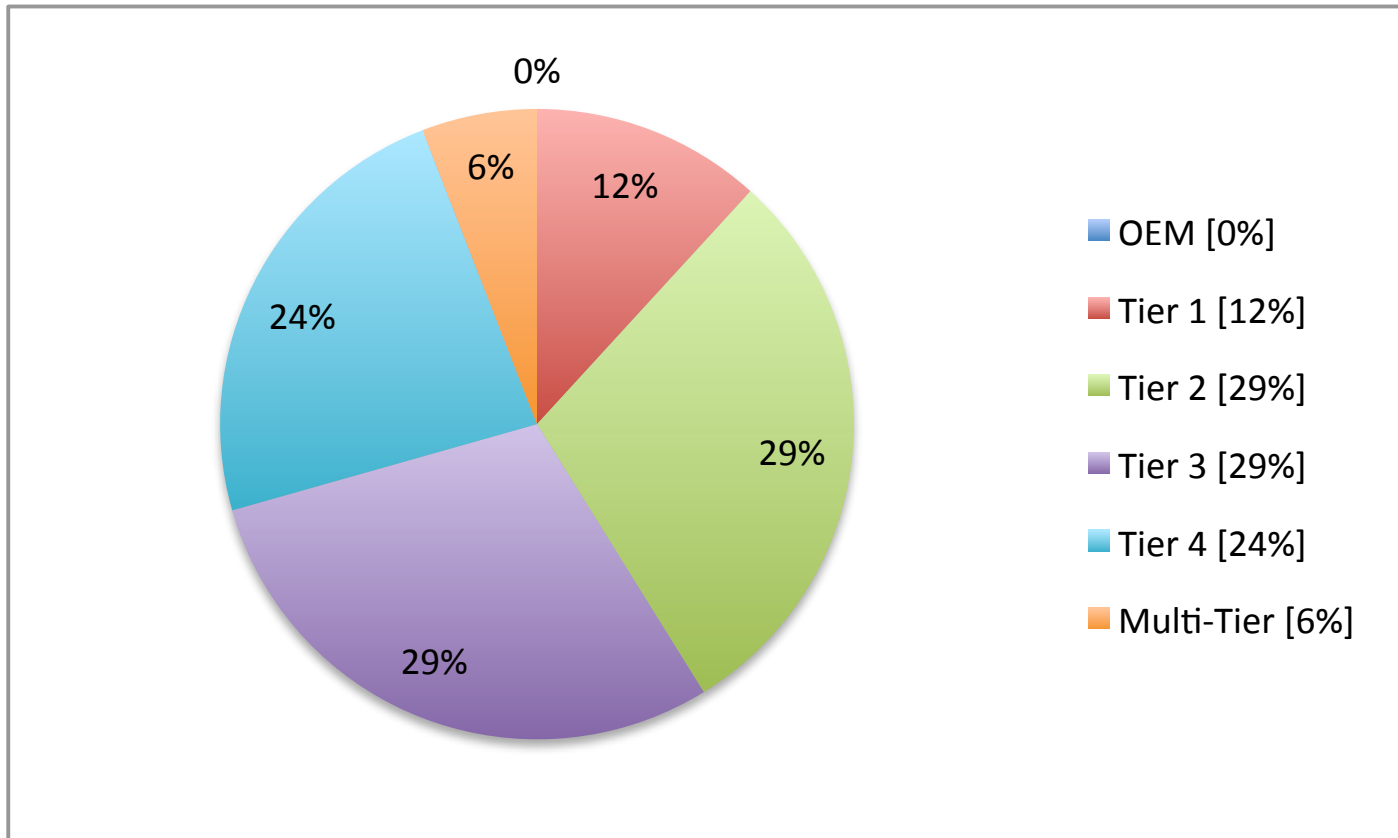
Source: SP North American PE data-set (April 2014).

# Progress Toward Objectives (cont'd.)

- Collecting OEM and Tier 1-4 in-depth views on challenges and opportunities they face in the N.A. PE supply chain
  - Especially regarding manufacturing process improvements, paths to cost reduction and WBG cost benchmarks
  - 107 unique contacts made to-date
    - In some cases, multiple contacts are made within individual companies
    - Different perspectives from different people within same large companies
    - Follow-up as needed to support continuous refinement of the SP knowledge-base
  - 15+ in-depth interviews completed to date, many with extensive secondary research to frame the interviews and trigger follow-up conversations
    - Interviews contain proprietary information
    - Content is transcribed and reviewed by sources before use by Synthesis
    - SP relies on confidentiality agreements and anonymized information to produce actionable intelligence for VTO.



# Progress: In-Depth Interviews Completed, by Type of Organization



Source: SP in-depth interviews (as of April 2014).

# Progress:

## Interim Actionable Information (“IAI”)

- What is interim actionable information?
  - Information collected and analyzed to support *concrete* private-public steps that can be taken *today* to address the barriers addressed by this project, specifically:
    - Capability of N.A. supply chain to support aggressive e-drive roll-out targets
    - Pathways to cost reduction for more competitive manufacturing and workforce in N.A.
    - Information to enable expansion of N.A. power electronics and electric motors capabilities
  - ... and which will be further vetted over next 6mos!
- Other points to consider in interpreting the following slides:
  - Valid as of April 2014
  - Recommendations will be submitted to VTO to support planning and development of concrete options based on this information
  - Names of organizations and/or technologies not publically available at this time – but may become so, with source approval, in future.

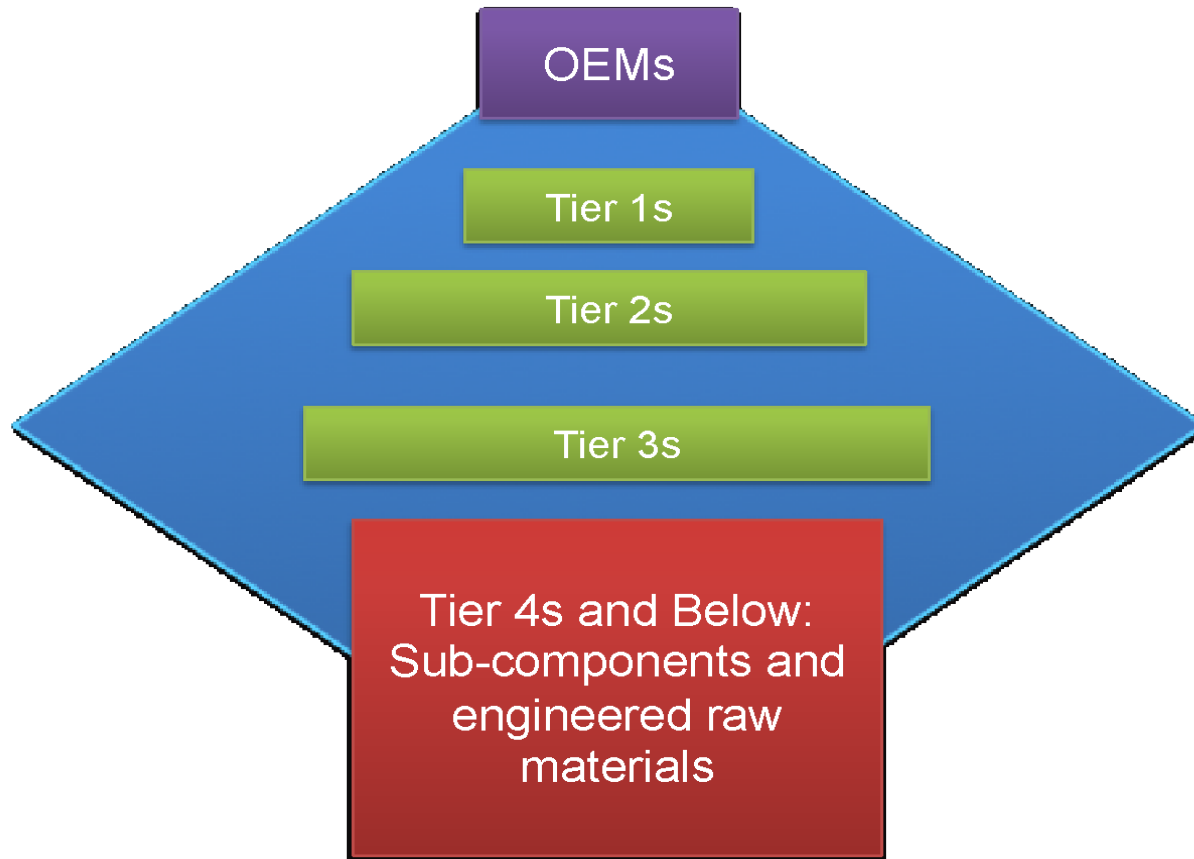
# Progress: IAI (cont'd.)

- Quality at the right price trumps a vertically integrated supply chain
  - FY13 findings-at-work
  - SP seeing significantly increased interest by key players in independent guidance to help make trusted contact with Tier 2-4 N.A. suppliers, to help build needed N.A.-based advanced PE and electric motor supply chain in order to reduce time-to-market (and maybe reduce costs).
  - *Actionable: Specific requests received for gap-filling information and private-public interactions to help to catalyze growth of a segment of the N.A. power electronics and electrical motor supply chain.*

# Progress: IAI (cont'd.)

- Business tolerance for certain gaps in the N.A. PE technology supply chain is decreasing as the market for electric drive grows
  - FY13 findings-at-work
  - Key companies are pro-actively seeking targeted information and technology development exchanges to fill selected N.A. PE technology gaps – even if traditional supplier relationships will be challenged as a result of these interactions.
  - *Actionable: Multi-supplier-to-VTO RDT&E interactions identified that can help define and fill a N.A. technology gap and thereby expand the N.A. power electronics and electrical machines supply chain.*

# Progress: IAI (cont'd.)



The N.A. PE supply chain is an unstable environment because it sits on an extremely narrow base, causing critical, single-string dependencies.

# Progress: IAI (cont'd.)

- Initial view of the North American electric motors industry:
  - More than 50 organizations identified as having current or potential role in the N.A. electric motors supply chain
  - Collection on-going.
- Paths to cost reduction through manufacturing process improvements in N.A., esp. in WBG:
  - Coordination (early stages)
    - Next Generation Power Electronics Innovation Institute; EETT; others
  - Inverter/Converter
    - 600-1200V/20-70A
    - WBG systems, including capacitors, microprocessors, JFETs, MOSFETs, IGBTs and Diodes
  - Wafer-to-Component
    - Wafer sizes: 2" (50 mm); 4" (100 mm); 6" (150 mm); 8" (200 mm).

# Progress: IAI (cont'd.)

## Initial Estimates of WBG Substrate Manufacturing Costs

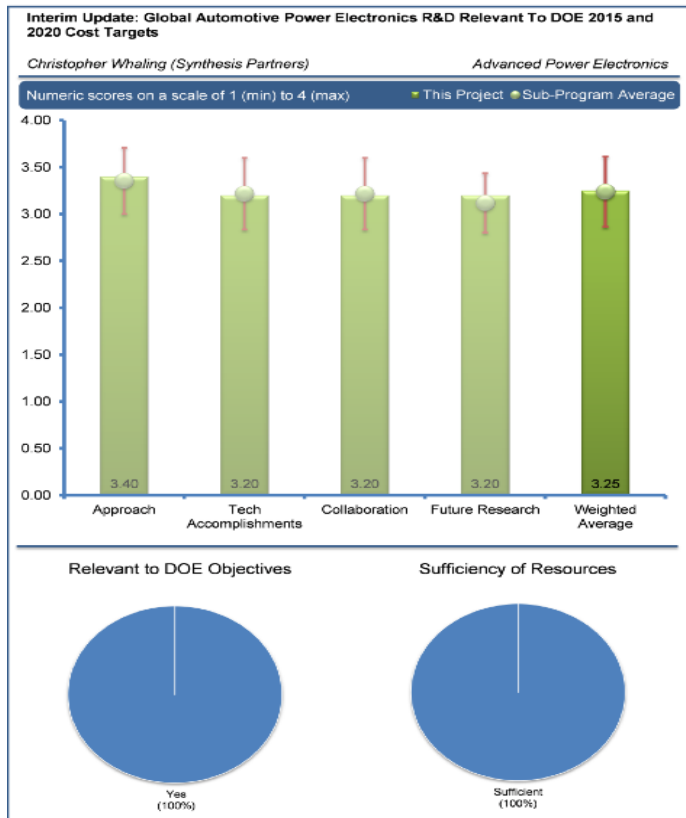
Product	Details	Si Substrate *	SiC-on-SiC Substrate*	GaN-on-GaN Substrate *	GaN-on-SiC Substrate *	GaN-on-Si Substrate*
6" Wafer or Epiwafer  (Unless otherwise specified.)	Manufacturing cost estimate	\$12 for average 6" wafer. (2013)  \$25-\$50 for a 6" Si substrate. (2012)	\$24-\$100  At the component level, SiC costs remain about double that of Si. (2014)	\$2,000 for a 2" GaN substrate. (2013)  \$1,900 for a 2" bulk GaN substrate. (2012)	\$29-\$120  GaN on SiC wafers cost about 20% more than their SiC-on-SiC counterparts. (2013)	A little less than \$1,000.  (2011, 2012, 2013, 2014)

\* Estimates based on SP research and interviews completed in 2013 and 2014.

# Reviewer

## FY13 Comments and Response

### FY13 AMR Review (Five reviewers)



- Good comments received on specific value and applicability of FY13 research
- Focus below is on helpful suggestions received and response
  - More information needed on process employed to ensure accuracy and validity of presented results.
  - Response: Across the multitude of sources we screen content by focusing on credible (i.e., individuals or publications with deep experience in a particular field) sources, use interview content only after written feedback, and ensure key findings have multiple sources. But there is always some bias, and so we endeavor to be clear about what we know is true, what we think is true (analyst opinion), and what we do not know.



# Reviewer

## FY13 Comments and Response(cont'd.)

- More clarity in roadmaps needed, to show investment decisions that can enable technologies to support future roll-out of electric drive vehicles.
  - Response: Agreed, this is a fruitful area for drill-down efforts by VTO and its stakeholders. Our review in FY13 showed that individual companies have valuable information in this area, but also protect it diligently. We are focusing on new ways to engage sources on behalf of VTO to exchange more roadmap knowledge in the context of specific engagements (see IAI information).
- Continued, identification of lower-cost reliable products can help to enable the market for electric drive vehicles.
  - Response: Agreed, to-date, we have analyzed cost reduction in traction drive inverters. In FY14 we are looking at cost reduction via manufacturing process improvements in advanced PE and electric drive, including through new types of Tier 1-4 engagements, and also at WBG cost benchmarks. When sources permit, we make specific recommendations to VTO.

# Project Milestones

**Project Duration: FY13 – FY14**

**Overall Objective: Technology and Market Intelligence**

**FY13 Focus: Assess the N.A. Supply Chain for Automotive Traction Drive Power Electronics**

Deliverables: On-going VTO decision-support intelligence, including briefings, reports and presentations. Coordination with EETT.

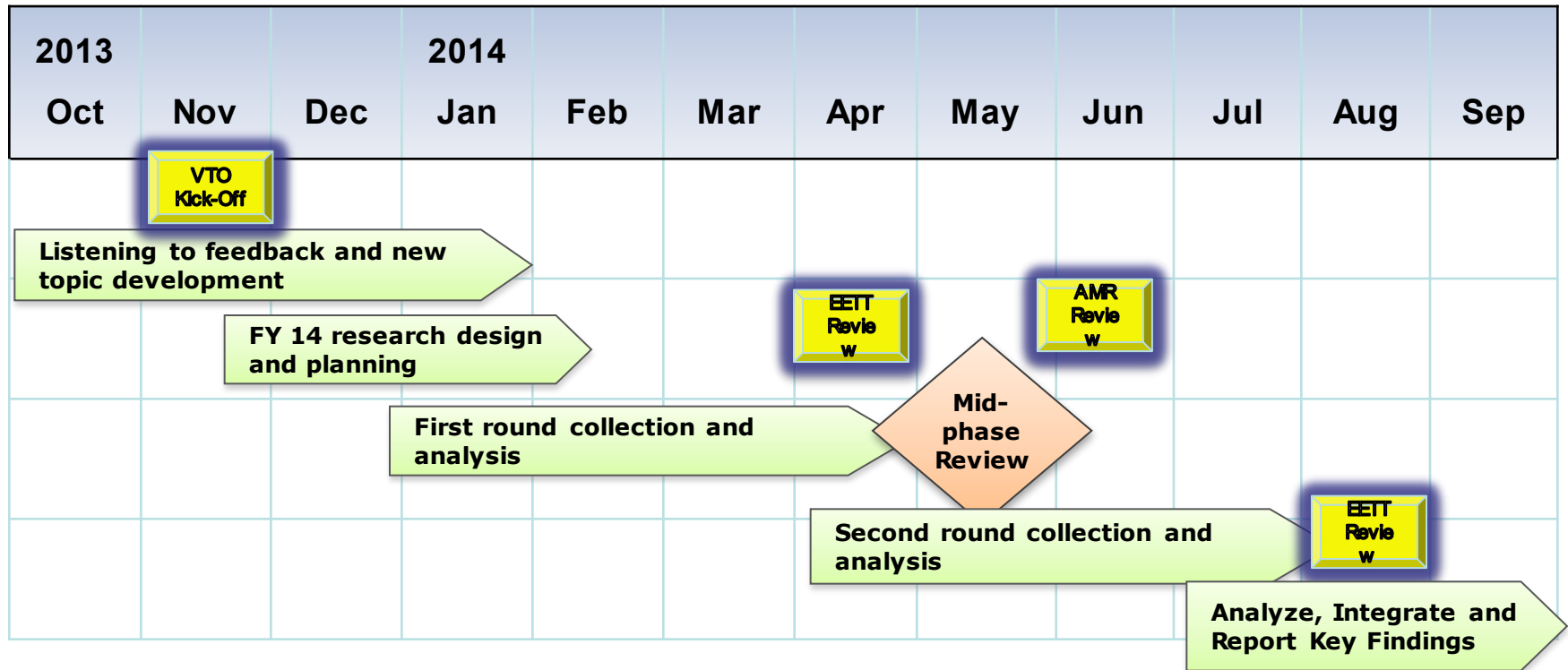
Go/No Go Decision Point: Periodic assessments by Steven Boyd and Susan Rogers, VTO

**FY14 Focus: Drill-Down Assessment of the N.A. Supply Chain for Automotive Traction Drive PE: Paths to Expansion, Manufacturing Process Cost Reduction and WBG Cost Benchmarks. Initial View of the N.A. Motor Supply Chain**

Deliverables: On-going VTO decision-support intelligence, including briefings, reports and presentations. Coordination with EETT.

Go/No Go Decision Point: Periodic assessments by Steven Boyd and Susan Rogers, VTO

# Project Timeline: Challenges/Barriers



**Go No/Go Decision Points:** Ongoing assessment, mid- and end-of-phase review.

## Challenges/Barriers:

Time to process and analyze large amounts of heterogeneous data; access to primary sources; navigation to highest-value data via source confidentiality agreements; management of large data-sets; focusing of foreign language data assessments.

## Key Deliverables:

Presentations and concise reports on key findings.

# Coordination and Collaboration

- Close coordination and involvement with USCAR Electrical/Electronics Tech Team.
- Close coordination and collaboration with industry, OEMs, Tier 1-4, universities, federal laboratories, and subject matter experts on both public and (as needed) proprietary basis.
- Engagement with domestic and international sources to identify low-cost technology development opportunities in support of VTO goals.
- Federal Research Labs: Targeted information exchange and coordination as needed with ORNL, Argonne, NREL, PNNL and Ames Research Lab

# Project Summary

- FY 14 research and analysis work is at mid-point
  - Interim findings will be vetted via additional sources and SP analysis over next six months period.
- FY research builds on prior years' work, relationships and findings
  - SP results come from leveraging a growing network of trusted sources, representing an increasingly deep pool of OEM and Tier 1-4s with valuable information that can be used to help address VTO objectives.
  - SP endeavors to build new, strong relationships with new sources by maintaining open lines of communication and encouraging new approaches to generate a maximally diverse range of actionable information and guidance.
- Collaboration and coordination with EETT is an essential element of our tasking focus.