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Autocomposites Commercialization Launchpad Kickoff Meeting

June 27, 2013

Post Meeting Report

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Meeting Description & Agenda

On June 27, 2013, Rocky Mountain Institute (RMI) and Munro & Associates hosted the **Autocomposites Commercialization Launchpad** Kickoff Meeting. Meeting goals were to

- Produce a commercialization timeline and plan for a specific high-volume automotive application of carbon fiber composite, focusing initially on the door inner
- Identify means of addressing remaining technological and investment gaps to commercialization
- Identify and assign initial team roles and responsibilities

Thursday, June 27th

All events at Munro & Associates, 1749 Northwood Dr., Troy, MI

8:15am	**Arrival and Introductions**
8:30	**Meeting Kickoff** *Autocomposites Workshop review: approach, findings, and promising parts* *Autocomposites Commercialization Launchpad vision* *Value proposition and roles by stakeholder* *Stage-gate product development process* *Investment required for commercialization*
10:00	**Breakout Session Problem Statement**
10:15	**Breakout 1: Identifying and Addressing Technical Challenges**
11:15	**Breakout 2: Identifying and Addressing Investment Challenges**
12:00	**Lunch**
1:00	**Report out from Breakouts**
2:00	**Commercialization Roadmap and Workplan**
4:00	**Immediate Roles, Responsibilities and Next Steps**
5:00	**Adjourn**

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Meeting Participant List

Name	Title	Affiliation	Email	Group
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*invitees who did not attend

I: Investment Group
T: Technical Group

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Context

Ultralight, ultrastrong vehicles offer dramatic improvements in fuel efficiency, safety, and performance and allow powertrains to be smaller, lighter, and more cost-effectively electrified. Such vehicles will consist of a diverse mix of materials, but advanced composites—particularly carbon fiber (CF) composites—play a central role by offering the greatest vehicle weight reduction potential.

Automakers and their supply chains generally recognize these benefits. What's missing is a feasible path to high-volume commercialization that can address key barriers—high cost, inadequate manufacturing scale and technology, insufficient analysis toolsets, and immature repair and recycling techniques—to ultimately unlock CF composites' transformative potential.

Workshop participants identified parts and subassemblies that offer a technically feasible and economically attractive means of achieving the unprecedented production volume of 50,000 units per year. Promising applications tended to be those that were stiffness-critical, placed a high value on weight reduction, and offered additional manufacturing and user value such as reduced part count, increased space, reduced maintenance, and secondary weight reduction to surrounding parts.

Building from the workshop's results and foundation of participants, RMI and Munro are kicked off the **Autocomposites Commercialization Launchpad**. Figure 1 (right) summarizes key participants and roles in the Launchpad.

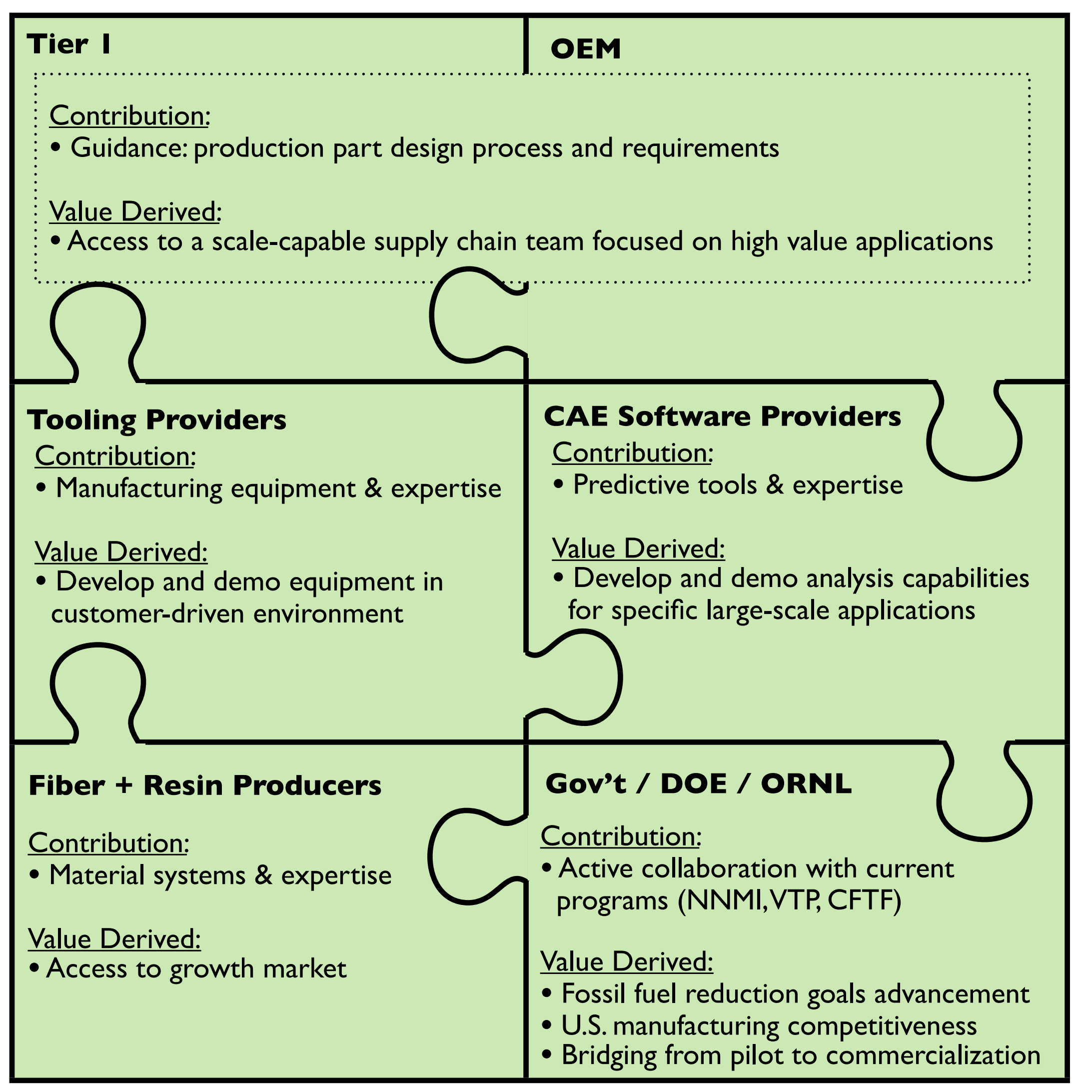

Figure 1: Key Roles in the Autocomposites Commercialization Launchpad

Context Cont...

The Launchpad's immediate aim is to assemble a competent and competitive CF composite automotive manufacturing team to **design and produce a part for a 2018 model year vehicle at a volume of 50,000 units or greater**.

CF composite parts are poised to become a tremendous growth market. Just one part on four mainstream models would double world automotive demand for carbon fiber and unlock $6B in market value. A number of organizations are interested in participating in the Launchpad: BASF, Zoltek, Momentive Specialty Chemicals, Plasan Carbon Composites, SABIC Innovative Plastics, Allied Composite Technologies, Dodworth Design, Ticona Engineering Polymers, Magna-Vehma, Oak Ridge National Laboratory, Continental Structural Plastics, Plasticomp, and Altair Engineering.

In the long term, the Autocomposites Commercialization Launchpad will operate as and sync with existing efforts to establish an "innovation hub" (Fig. 2) to address critical and as-yet unmet industry needs and pave the way to a transformed industry built around lighter, stronger, safer, and higher-performing composite-intensive vehicles:

- Manufacturing demonstration equipment and standard test rigs
- A launchpad for competitive, application-specific commercialization projects
- A clearing house for aligning academic, private, and government R&D with industry needs
- A center for developing and proving out solutions to collective R&D challenges such as joining
- A source for material data

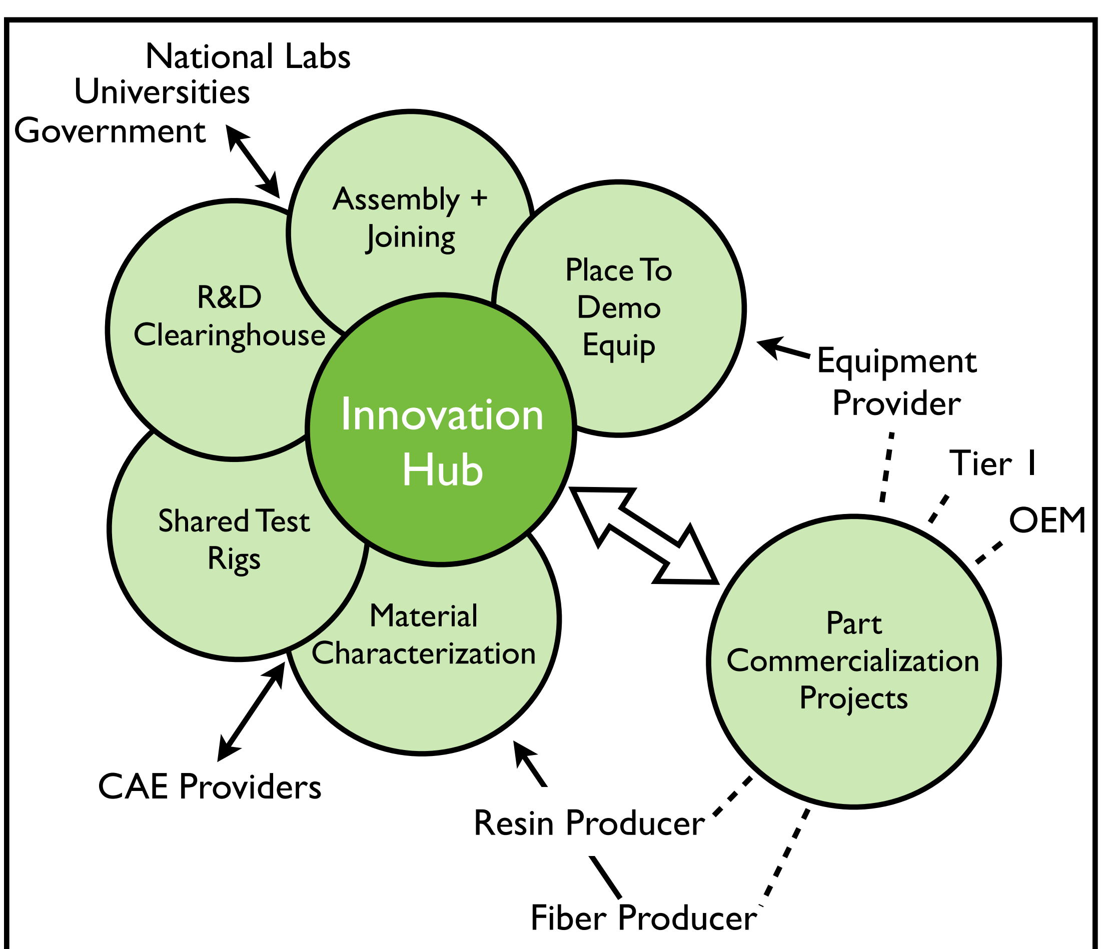

Figure 2: Big Picture: The Autocomposites Commercialization Launchpad

Initial launchpad goals are to

- Produce a commercialization timeline and plan for a specific high-volume automotive application
- Identify means of addressing remaining technological and investment gaps to commercialization
- Identify and assign initial team roles and responsibilities

Breakout Topic #1 Description: Investment Challenges

Breakout Session #1 was focused on identifying key investment challenges associated with esablishing and funding a high-volume, pilot manufacturing line for a carbon fiber composite door inner.

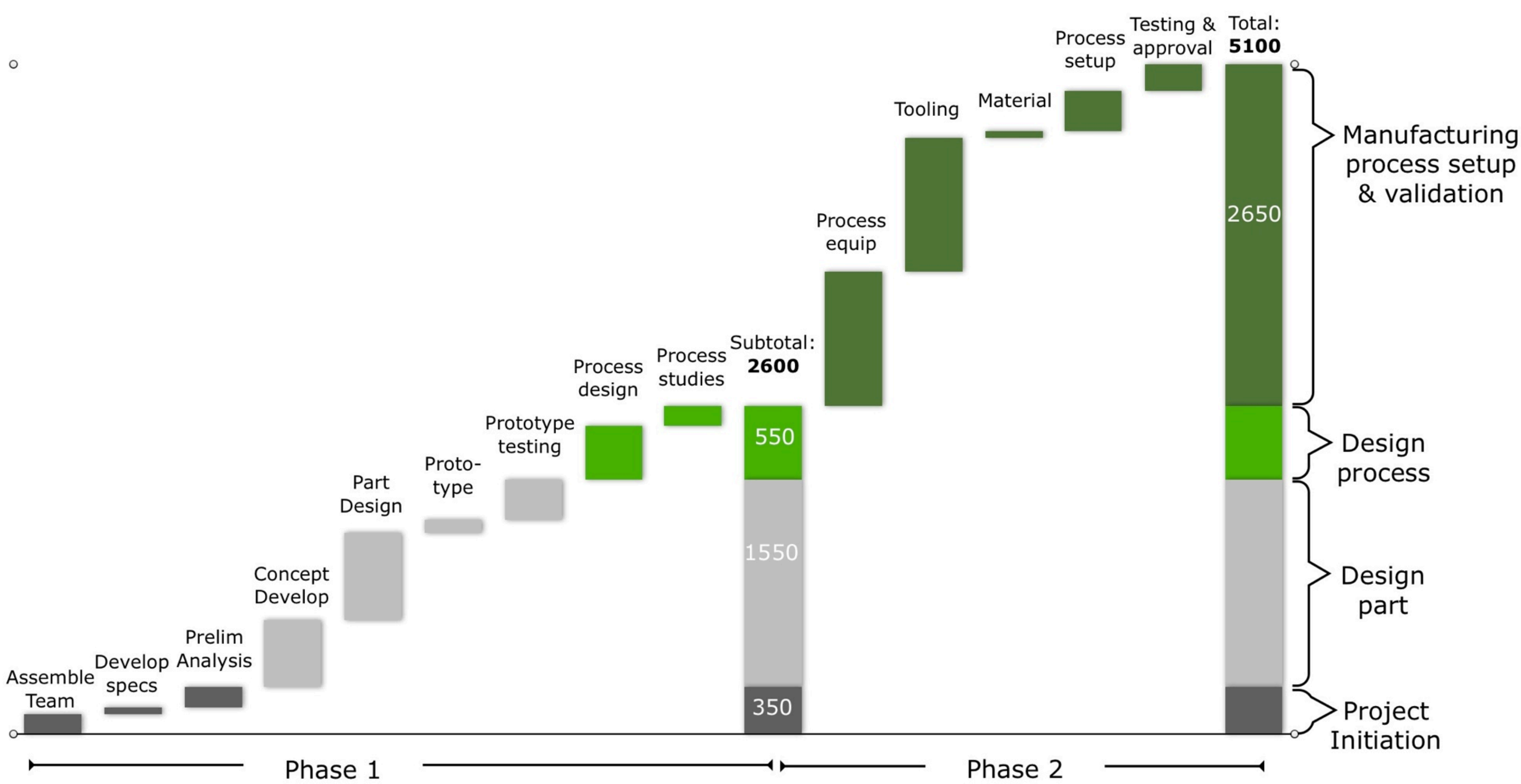

Figure 3: Illustrative Investment Costs for CF Composite High Volume Manufacturing Line

Figure 3 shows illustrative costs; participants developed more accurate specific estimates for the door inner for many of the process steps shown above. See Key Findings, starting on the next page, for these more granular estimates.

Breakout Topic #1 Key Findings

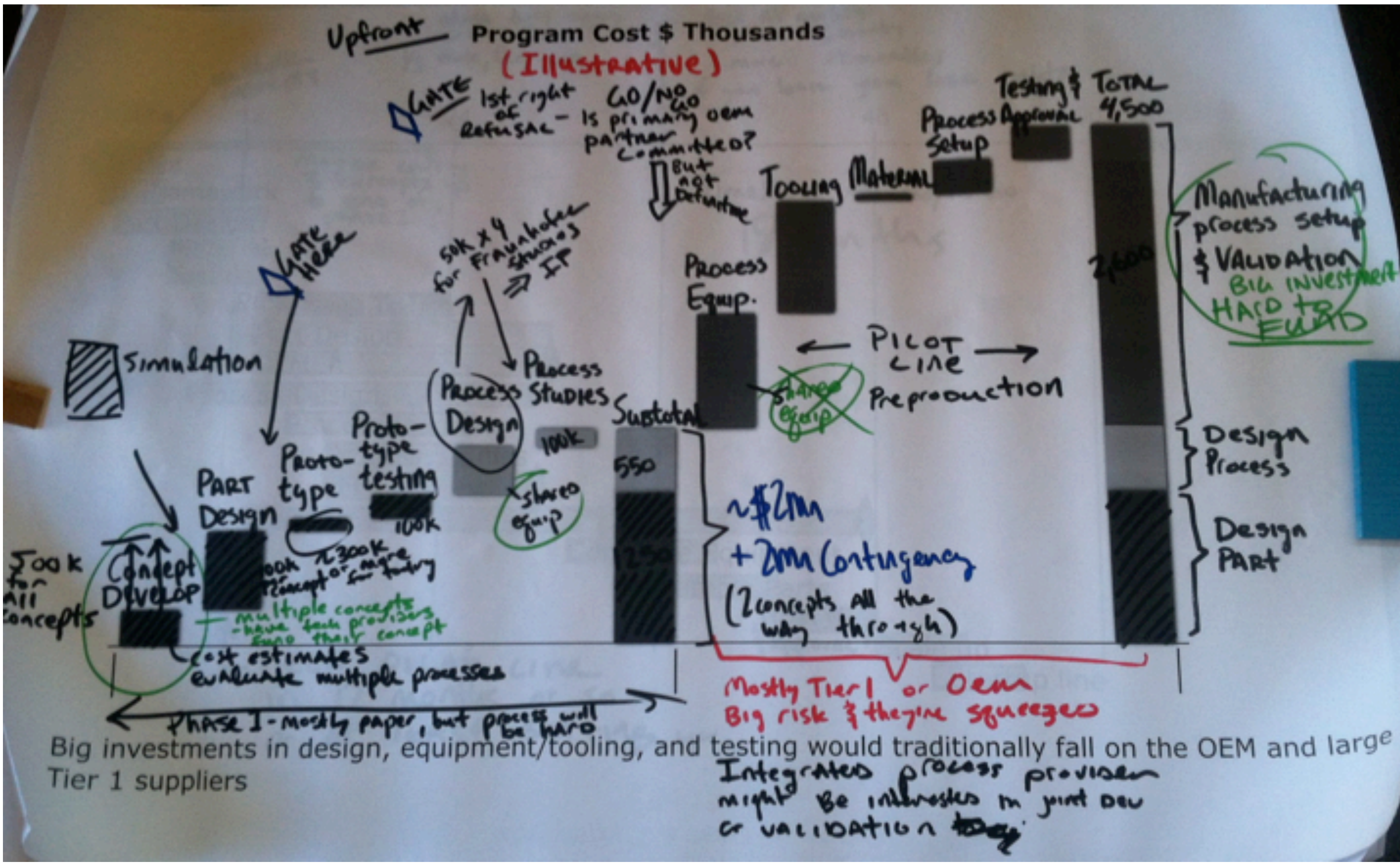

Figure 4: Breakout Session #1 Worksheet

Phase 1 (Part & Process Design) Discussion Notes

- Total cost of Phase 1 was estimated at $2-4M

Concept Development

- Cost of concept development alone: $500k
- Concept development is relatively expensive because it may be important to evaluate multiple materials/processes—e.g.. thermoplastic, thermoset, injection mold, etc.
- Different stakeholders will be interested in funding different concepts (i.e. applicable to their own techs/products). Should work to have each fund their own concepts. E.g. Resin and fiber providers can fund concepts that utilize their own resin/fiber type—thermoset vs. thermoplastic, prepreg, etc.
- More time, effort, and expense at the simulation phase will help save cost for expensive prototypes later on.
- Time and money to run simulations should be incorporated into the plan
- It is probably not possible to choose a concept from simulation only. Simulations have limitations. Maybe simulations can help pick 2 or 3 concepts and then will need to prototype and test.
- Multiple concepts really start to get expensive when you get to tooling. You can probably share equipment to save money but still need unique tooling
- Costs after the concept phase will depend on how many concepts we carry forward.
- The group estimated part design cost at $80k per concept.

Breakout Topic #1 Key Findings

Phase 1 (Part & Process Design) Discussion Notes Continued

Prototyping and Prototype Testing

- The group estimated prototype development cost at $300k—mostly for tooling. Thermoset will likely be more expensive to prototype than injection molded thermoplastic (which could be much less than $300k). There are ways to cut corners by using soft tooling, but probably not a good idea.

Process Design

- The key focus here will be to take known processes and make them applicable to higher volume production in an integrated line. Process design will probably be focused on taking a known composite process and scaling up to 50k volume. Shared equipment will be key to saving money during this scale up process. Fraunhofer would be a great place to work on process design. Each Fraunhofer project would last a few months each and cost $50k per project.
- This stage is likely to generate some IP which could be valuable
- Injection molding may be easier to prove out at scale than other processes. Simulation isn't difficult and, once established, is very repeatable and easy to scale up.

Phase 2 (Manufacturing Process Setup and Validation) Discussion Notes

- The group agreed this phase would be more expensive than the first phase, but did not estimate costs for each phase as in the Phase 1 discussion.
- A key challenge at this stage will be to to develop a full speed line for 50k units per year in order to prove process reliability and repeatability and part quality. A full speed line could be very expensive to set up.
- A full speed line may be preceded by a preproduction line: Cedric Ball described something like this in the early days of Saturn that was used to dial the new manufacturing processes. It was not clear to the group whether Fraunhofer would handle something like this or what their involvement might be—they would typically focus on applied R&D for a part of the process, not necessarily the whole integrated plant design.
- If Fraunhofer doesn't participate in the fully integrated approach, the team should probably start setup within the first year of the project.
- In a subsequent afternoon group call with Fraunhofer, they suggested this would not be a problem. It is important to note, however, that Fraunhofer is not typically in the business of producing parts/production runs, but rather demoing a line for a few days or weeks to prove a process is doable.
- NACMI, depending on how quickly it is established and how extensively its capabilities are built out at early stages, may also play a role in filling this gap.
- Another option could be a government-backed pilot line. The government would essentially own the line and if proven out and successful, the line would be sold to the tier 1 or OEM so that government can recover part of its investment.
- An integrated process provider such as Dieffenbacher may be interested in donating equipment and partnering in preproduction line setup/validation. However, it's harder to make the case for them to donate/invest because their contribution would be all up-front and therefore risky. Contrast that type of invesment to resin/fiber producers whose in-kind donations are incremental and lead to recurring revenue as the part goes into production.

Breakout Topic #2: Production Timeline and Technical Challenges

Breakout Topic #2 was focused on identifying key technical challenges in the context of the production part approval process (Figure 5).

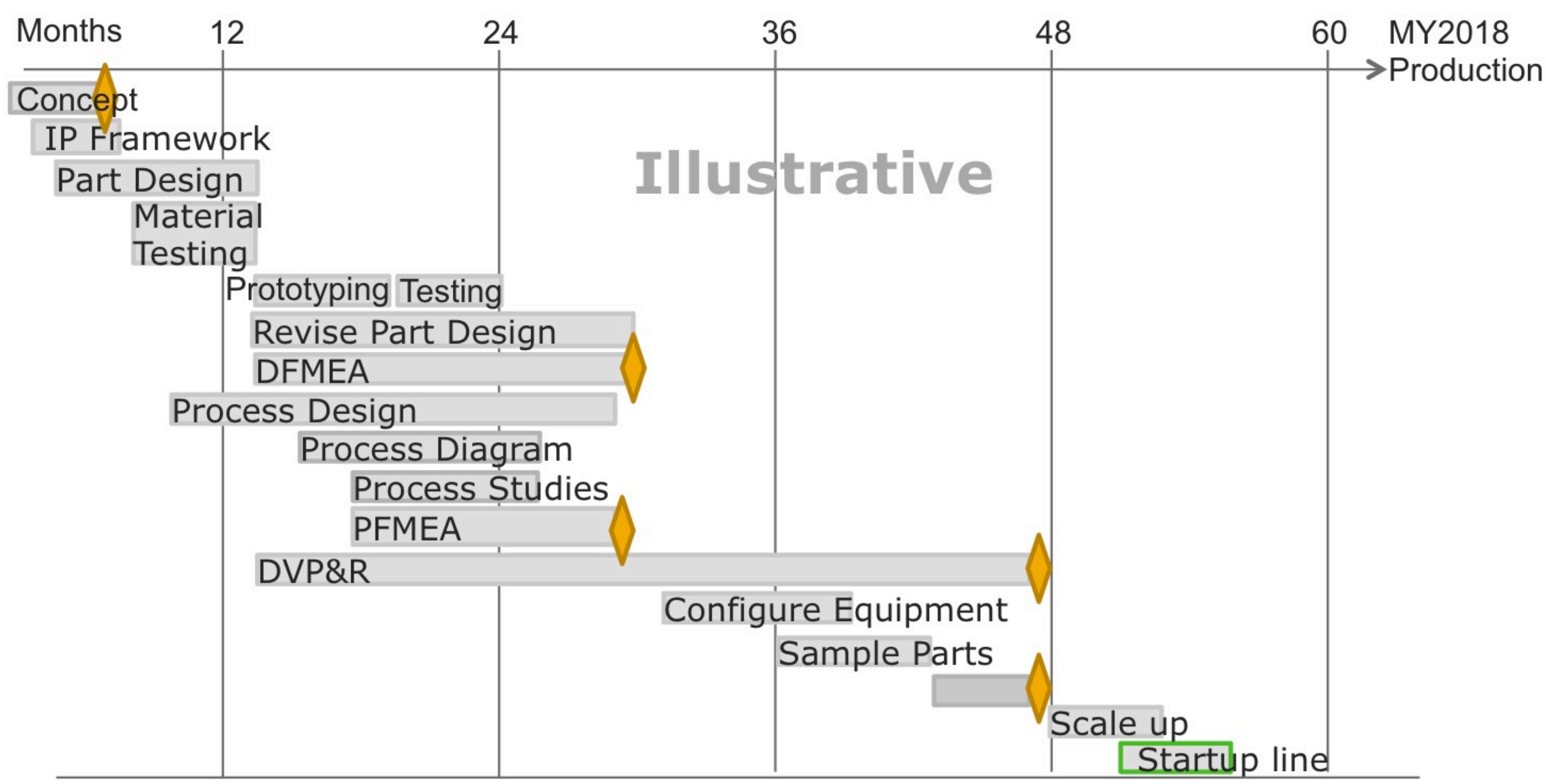

Figure 5: Illustrative Investment Costs for CF Composite High Volume Manufacturing Line

Figure 3 shows an illustrative timeline; participants developed more accurate specific estimates for the door inner for many of the production gates shows above. See Key Findings, starting on the next page, for additional discussion of these more specific estimates.

Breakout Topic #2 Key Findings

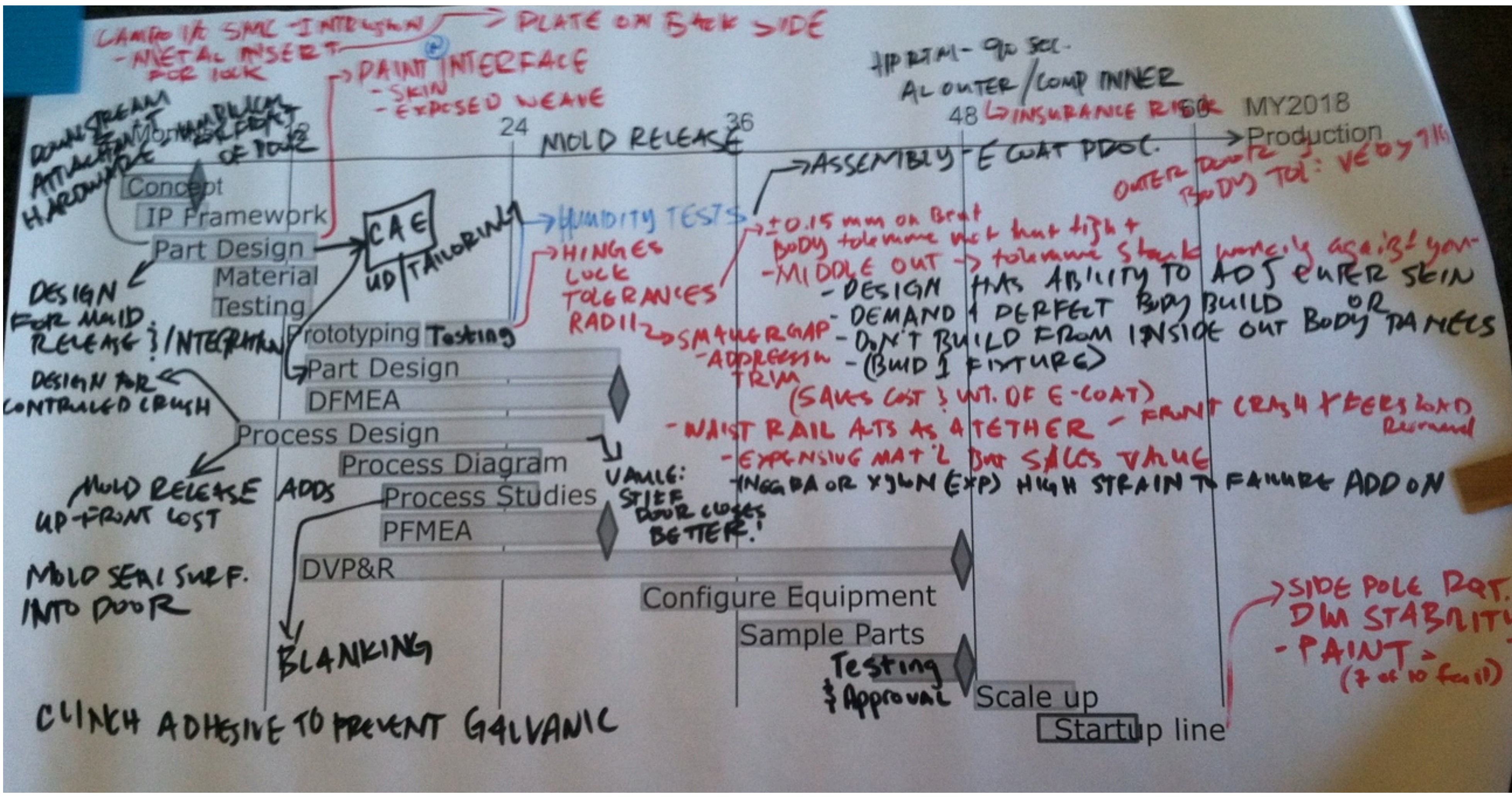

Figure 6: Breakout Session #2 Worksheet

Breakout #2 (Production Timeline and Technical Challenges) Discussion Notes

- Manufacturing process choice for the door inner will drive concept development at early stages. A critical first step is to select a applicable manufacturing processes and design concepts in line with their specific capabilities.
- Designing for mold release, for example, will require tight integration between manufacturing and design or a designer with failrly extensive molding expertise. Realistically, achieving this integration could add time and cost to the part design portion of the timeline.
- More generally, regardless of the manufacturing process involved, the gro up indicated more time and investment at the design phase than is indicated on the timeline will help avoid challenges later on during process design and blanking. Specific team expertise areas required on the integrated team would be trim, body, and assembly.
- The group had experience with aluminum outers mated (clinched) to a composite door inner and indicated this would be a good option (as opposed to a steel outer) .
- Designing for assembly to the body may also add time (and cost) to both the initial (pre-prototyping) design phase as well as the iterative stage following prototyping. Specific challenges include: mating the outer to the composite inner and selecting clinching adhesive or interface material so as to avoid galvanic interaction between the composite and aluminum.
- The tolerance associated with the door outer and body is very tight: often the door must meet +- 0.2 mm tolerance as a result. A composite door may require a body design that fits the body to the door structure rather than the other way around. When the body is built from the middle out, the tolerance stack works against the closures. It may be possible to develop a door design that has more flexibility and is more adjustable. An alternative would be to demand a perfect body build, which would be made easier by not building the body from the inside out.

Breakout Topic #2 Key Findings

- Paint presents a challenge despite the door inner not requiring full paint. The interface is visible. Potential solutions include a skin or simply going with exposed weave. The assembly process can and should avoid e-coat.
- The waist rail of the door inner, particularly if made from a high strain-to-failure material such as Zylon, can help transfer load rearward in the event of a frontal crash and may decrease intrusion in the event of a side impact. Zylon and other high strain-to-failure thermoplastics are very expensive but this safety value is probably sufficient to offset the up front cost premium. As always with safety benefits, however, additional CAE and predictive modeling capabilities would be required to enable automakers to actually make the up front investment in more expensive material.
- Radii of the door inner would have to be made larger than a stamped steel part, particularly to accomodate high-speed and repeatable molding processes.
- There may be an opportunity to integrate functionality into a composite door inner design, such as the window carrier, that would normally be fulfilled by separately assembled parts. This could save assembly cost and additional weight.
- Humidity tests require parts to withstand 240 hours in steam and could present a challenge or dictate material system choice.

Plenary Session: Next Steps

The final session of the workshop aimed to develop a clear and actionable set of next steps associated with moving forward with commercialization. The group developed the following 10-step plan to do so.

1. Develop a project overview document/report for team members to share at their organizations that clarifies the project goals, participants, and plan
2. Identify "pain points" at the OEMs (particular problems our commercialization effort may be well-positioned to address)
3. Develop OEM pitch to convey team capacity and capabilities to the OEMs
4. Identify and enlist customers, particularly fleets, with interest in the product
5. Present OEM pitch via "road show" with team members
6. Gather door specifications from OEM
7. Complete benchmarking and initial design concept
8. Create a plan for tooling and equipment procurement/scaleup, including cooperation with NACMI
9. Develop an IP framework that clarifies who will have shares in the commercialization profit once it moves forward
10. Go back to the OEM with the plan and ask for a cost share commitment (probably 50%)

- Other items to be aware of: fiber supply, recyclability

The team has completed steps 1 and 2 with progress toward the fourth. Step 3, developing a pitch and identifying a “road show team” among project participants to more fully engage the OEMs, is in process.