PRACTICAL SOLUTIONS TO TRL BARRIERS IN THE DEVELOPMENT OF COMPOSITE APPLICATIONS

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1 General Introduction
The use of advanced composite materials is accelerating worldwide due to cost and/or performance benefits vs. metals. The global composites industry is currently at $14B, and projected to reach $48B by 2020 [1]. At present, composite structures designers may choose from hundreds of different material systems and dozens of different manufacturing processes. However, despite the growth [1] and seemingly limitless potential of composites, many applications fail to penetrate TRL4 or TRL5 and get shelved before reaching market. As a result, structures remain sub-optimized despite sufficient technology maturity.

1 Root Cause of the Issue
1.1 Lack of broad awareness
Due to the complex, dynamic, and multi-disciplinary nature of the field, there is a relative lack of knowledge within any single company spanning the materials and processes used within all industries. As a result, material and process down-select decisions are often made based on very limited consideration for alternative materials and processes. This inevitably results in the use of suboptimal materials and processes for many applications.

1.2 Incapacity to estimate development cost
During the critical early stages of product development, cost is poorly or not at all estimated. Non-recurring and recurring cost are key drivers in the commercial success of composite products, however PD teams are rarely capable of estimating estimate past TRL 4 or 5 during the trade study phase of early development.

1.3 Lack of accessible source for composites data
At present there does not exist a practical, accessible source for all publically available data on composite materials. The large OEMs have the internal resources and expertise to operate completely independently of external knowledge. Meanwhile, small companies struggle to develop certifiable structures due to the absences of publically available design data. CMH-17 is gradually making progress, however it contains only a very small subset of data of the spectrum of existing materials.

2 Proposed Solutions to the Challenges
Practical solutions to overcome these issues include:

1. Create a single online source for all publically available composite material data, process specifications, and preliminary design values.

2. Develop a comprehensive method to facilitate the optimization of cost and performance of new composite structures. Method will enable cross-pollination between industries through a unified approach to compare different composite material/process configurations.

3. Automate the routine yet time-consuming aspects of product development of composite structures which are often completely overlooked in the trade study and early TRL assessment phases, including estimation of all non-recurring through certification.

3 Mechanisms for Achieving the Mission
3.1 Create a “WikiComposite”
The online repository would be a publically available database of materials properties, processes, analysis methods. It would be self-sustaining and updated by users (like Wikipedia).

3.2 Composite Product Development Method (CPD)
The proposed approach constitutes a method (CPD) for rapidly determine the ROM development cost (non-recurring) and unit production cost (recurring)
of a composite part or assembly during the initial trade study evaluate phase. The overall approach is depicted below:

Inputs include the definition of geometry (ex. solid laminate, hat stiffened, close-section), type of structure (Part 25, wind, marine, etc.) and environmental/performance requirements. The requirements are evaluated against a materials database (fibers, resins, laminates) and a process database (RTM, pre-prepreg, filament winding, etc.) to identify the most promising material/process candidate configurations. The process/material configurations are then costed against a certification/production database. The output non-recurring costs include itemized testing costs (material allowables development, elements, components, PPV, FPQ), tooling costs, non-recurring engineering, production planning and scale-up (including the process model), and capital expenditures. The recurring cost includes a breakdown of material, labor, and quality inspection. Finally, the business case summarizes the “dollars-per-pound” and gross/net revenue as a function of anticipated production volumes.

4 Benefits to Industry

- Enables product development teams to rapidly evaluate the business case of new composite structural concepts through certification!
- Establishes a consistent method for developing and iterating process models, test requirements, resource requirements, and technology development roadmaps. Can be used to identify cost sensitivities to changes in materials, processes, scope of testing, etc.

4 Example of Product Development with C-ply

C-ply’s unique characteristics of enabling unbalanced, shallow-angle laminates through the use of very thin bi-axial fabrics has the potential to radically decrease fabrication costs and increase structure efficiency in a multitude of applications [2].

The CPD method would be used to rapidly evaluate the potential business case of C-ply for a multitude of potential applications. For example, C-ply is identified as a candidate for a UAV rotor blade D-spar. CPD model evaluates the application of C-ply to the geometry of the rotor blade for the different applicable materials and processes, including CF/epoxy-VARTM, CF/epoxy-pre-preg pressure-bladder molding, and CF/PEKK-SmartTooling (SMP). For each material/process configuration, CPD estimates the total program non-recurring costs, per unit production cost, dollars-per-pound, and the business case as a function of production volume. With the ROM business cases in hand, the company is now able to make an informed decision to move forward to the next TRL phase. As the new application moves up the TRL scale, the model and business case is continuously updated, enabling and increasing the pull that is needed from the business community and supply chain partners to transition to production.

References: