The Composites Manufacturing HUB

Synoptic Description: The goal of this proposal is to develop and support the ***"Composites Manufacturing HUB,"*** an online platform based on HUBzero™ technology, the foundation of the NSF nanoHUB. This HUB will host existing simulation tools for composite manufacturing and develop new tools essential for the evolution and integration of innovative manufacturing methods critical to the manufacture of ultra-light weight carbon fiber composite vehicles. Simulation methods are essential to enable manufacturing on an economically sustainable scale in the 10,000-100,000 unit range. When this level of production is reached, we will revolutionize the energy efficiency of civil land-based vehicles and alternative energy products while further supporting the emerging manufacturing and simulation infrastructure industries. Extraordinary fuel efficiency and performance gains have already been demonstrated through use of advanced composite materials and structures (i.e., the Boeing 787 Dreamliner and the Airbus 350). However, today's manufacturing systems are not appropriate to the reach production levels in numbers two-orders of magnitude greater than that of aircraft.

Responsiveness of project objectives and expected outcomes to the FOA and subtopic goals/objectives: This proposal focuses on the ***Innovative Manufacturing Processes/Sustainable Manufacturing*** topic/subtopic**.** Simulation-based development of manufacturing technology for carbon fiber composite products will foster the next generation of manufacturing technology that will lead to significant gains in energy efficiency, reduce environmental impacts for land-based vehicles and support the growth of alternate energy systems. Global competition requires significant innovation to drive the next wave of manufacturing for energy efficient vehicles, commercial aircraft, wind energy systems, photovoltaic support structures and civil infrastructure. The ***Composites Manufacturing HUB*** will significantly contribute to the area of sustainable manufacturing by promoting the creation of increasingly efficient processes that in turn produce highly-efficient and highly-valued products and services.

Technical merit and level of innovation of the proposed R&D: This project brings together technical expertise from academia and industry in a manner unprecedented in the manufacturing industry. The technical merit and level of innovation range from supporting insightful basic research needed to develop the knowledge base for the new simulation tools for composites manufacturing, to the integration of existing commercial simulation tools on the ***Composites Manufacturing Hub,*** where users can test and explore comprehensive treatments of complex manufacturing processes involving composite materials. The HUBZero platform, upon which this new HUB is based, has received over $30 million in National Science Foundation funding over the past nine years and specializes in enabling complex simulation tools to be shared amongst a group of users who can access the platform from anywhere in the world. A key feature of this capability is the availability to the user of browser-accessed computer power required in tool use, while providing interaction with the invigorating communities that the HUB will foster across space and time. The project envisions a wide range of users ranging from personnel within large professional organizations, to small groups or even individuals. The user community can adopt a modular approach to selecting existing tools to solve their manufacturing needs, and then, in turn, engage the online community about gaps that need to be filled. For example, a user can "shop" for simulation tools and assemble a combination sufficient for a manufacturing process, such as infusion molding or out-of-autoclave processing. In both of these examples, polymer flow can be modeled by the same tool, but each application must be augmented by other tools on the HUB to complete the simulation. The user community will identify gaps in functionalities and these gaps will guide the basic research program. Through the standing scientific committees associated with this HUB, identified gaps can then be brought to the university participants and research programs will be undertaken to create new tools. As such, the

project will embrace technology readiness levels of TRL2-TRL6 and foster rapid deployment of manufacturing processes poised for commercialization.

Soundness of planned technical approach, budget and schedule to accomplish the project objectives: This technical approach, of hosting existing simulation tools, exposing them to a relevant user community and support the development of new/better tools, is based on solid experience in both the hosting and development elements of the project. Approximately half the funding will be utilized to develop and support the ***Composites Manufacturing HUB***. We will use the additional funding to support the research, as described above, for research and development of new simulation tools. Our budget request is for $4.5 million over 3 years. Given the maturity of HUBZero and its capabilities to meet our technical needs, and given the willingness of our team members to provide the user community with relevant high-quality simulation tools with which to begin the project, we are confident that both the time scale and budget we propose are adequate for our team to meet with the goals with success.

Project is consistent with stated TRLs and is no earlier than TRL 2 and not later than TRL 6: The program simultaneously embraces technology readiness levels of TR2-TR6. At the TRL6 level, existing simulation software will be provided to the user community with the goal of establishing gaps in functionality required for complex composites manufacturing process simulations. The TRL2 level work will be the research necessary to address the scientific foundation of the simulation tools identified to fill the missing gaps. In this way, the ***Composites Manufacturing HUB*** will become a "food chain" for development of the comprehensive portfolio of manufacturing simulation tools needed.

Potential for significant U.S. manufacturing energy productivity improvement and/or reduction of greenhouse gas emissions: Extraordinary fuel efficiency and performance gains have been demonstrated in the aerospace industry through advanced composite materials and structures. To move this technology to widespread utilization, the challenge is the need to provide for large scale manufacturing. Continued discovery and development of entirely new manufacturing approaches will be essential. There are polymer processing and manufacturing methods capable of high volume production of identical items, but without meeting structural requirements of the systems described above. This is in sharp contrast to aerospace composites manufacturing where continuous fiber tape systems dominate the industry and less than 1000 units are typically manufactured. Clearly the characteristics of manufacturing methods must reflect the production volume expected and simulation-based innovation is the critical pathway to achieve this objective.

Potential market for and economic viability of the proposed technology over existing technology: The world-wide market for carbon fiber composite products is measured today in the $ billions, but the applications have been largely restricted to aeronautics. Double digit annual growth in manufacturing revenues is anticipated from these innovations in manufacturing technology for carbon fiber composite materials and structures in the energy efficient vehicle technology of the future.

Technical and commercial capabilities of the proposed team: The technical and commercial team is made up of five major universities: Purdue University, University of Delaware, Ohio State University, McGill University and The University of British Columbia. In addition, Oak Ridge National Laboratory and its low cost carbon fiber program will participate. Simulation tool developers, both large and small, will also participate as tool providers. The user community will be the diversified composites manufacturing industries and organizations who have competency in this field such as Boeing, Moldex3D, Lockheed, Aniform, GM, GE Energy, VW, Ford, Mercedes, BMW, ESI Group, Convergent, MoldFlow, ANSYS, Honeywell, UTC, Simula, SGL Automotive, Beacon Power, Vestas Wind Systems, Northrop-Grumman, ESN and others.