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"Technology, Trade and Military-Civil Fusion: China's Pursuit of Artificial Intelligence, New Materials and New Energy"
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AMERICAN COMPOSITES MANUFACTURERS ASSOCIATION

Members of the U.S.-China Economic and Security Review Commission,

I am Daniel Coughlin, Vice President of Composites Market Development at the American Composites Manufacturers Association (ACMA). Thank you for the opportunity to provide perspectives from the composites industry on "Technology, Trade, and Military-Civil Fusion: China's Pursuit of Artificial Intelligence, New Materials, and New Energy."

Composites are combinations of fiber reinforcements, most commonly glass or carbon among many other materials, and tough engineered polymers. The resulting material combination is lighter, stiffer, and stronger than the constituent materials individually. Composites are formulated to provide characteristics specifically tailored for maximum performance in a host of different applications. Their performance characteristics allow for delivery of greatly improved performance relative to other material options while reducing long term costs and extending service life.

The domestic composites industry contributes more than $50 billion in direct economic benefit to the US economy and is growing at more than twice the national Gross Domestic Product. When looking at the litany of other sectors that are enabled by key composite technologies, like aerospace, electric vehicles, rail, defense, renewable energy, and longer lasting infrastructure to name a few, the economic contribution of these materials and component products is much greater.

ACMA represents an industry of more than 3000 companies in the domestic composites industry. While the Association represents many large corporations, the majority of the industry is made up by small-to-medium sized companies that offer highly competitive wages in a growing and technologically evolving industry with manufacturing located in every state.

Glass fiber reinforced polymer composites (GFRP or fiberglass) have been used in military applications since World War II. GFRP was originally developed as a replacement for molded plywood for use in aircraft radomes because the material is transparent to radio frequencies. The additional benefits of the material – high strength, light weight, durable, and blast and corrosion resistance – have allowed GFRP to be used in numerous additional applications. Fiberglass recreational boats are a well-known and instructive example of composites. Saltwater destroys traditional metal and wood hulls for boats, but fiberglass remains unscathed after decades of high salinity contact and has come to dominate that sector due to its superior performance.

Carbon fiber reinforced polymer composites (CFRP) were developed in the 1950s and began to see significant use in military aircraft in the early 1960s, initially in engine fans and then more widely in other structural and equipment applications. CFRP offers an ideal solution for aerospace and other applications that require extremely high strength and light weight.

Every composite is a highly engineered material, designed to meet specific load requirements with consistent durability and performance throughout its service life. There are some material combinations and manufacturing processes that yield outputs better suited to high intensity structural stress than others. For example, composites used in space applications have higher load requirements and therefore higher performance and higher cost than those used in sporting goods.

The structural performance of composites relative to traditional materials is a key driver of industry growth. Because they are strong, corrosion-proof and long lasting, composites are increasingly used in infrastructure and construction applications like bridges, water systems, utility structures and more. Because they are lightweight without compromising safety, composites are increasingly used in automotive and aerospace applications to provide superior performance while reducing fuel consumption costs. Composites are an important enabling technology for autonomous vehicles, urban air mobility, drones and a host of new transportation innovations because of the ability to embed sensors and self-healing technologies directly into the material system.

The United States has led the world in the development of composite materials from the very beginning, but the gap is closing rapidly. As this testimony will elaborate on, the United States is failing to harness the full potential of federally-funded initial stage research and translate it into jobs and growth in a key industry that supports nearly every major industrial sector. If left unaddressed, this path could allow China to gain the upper hand in the composites marketplace, and by extension the breadth of markets the industry serves including key transportation and defense technologies.

The U.S.-China Relationship in Composites

The composites industry has a complex, global supply chain. Many companies manufacture composites in multiple countries and do so with raw materials that compete on a global basis. The major raw materials needed to produce composites such as resins, reinforcements, fillers, and additives, have a solid base of supply from U.S. manufacturers. U.S. raw material suppliers are facing increasing foreign competition, most notably from glass fiber manufacturers. An exception to the solid U.S. base of raw material supply chain is PolyAcryloNitrile (PAN) pre-cursor needed to manufacture carbon fiber. There is limited domestic production of PAN, and carbon fiber manufacturers rely heavily on imported PAN, largely from Japan.

Regarding the import of glass fibers, the listing of various glass fiber formulations to the Section 301 tariffs list has had a negative impact on some manufacturing companies in the composites industry. ACMA surveyed members in 2018 for their perspectives on the trade escalation with China to better inform our efforts in this area. Their responses were wide-ranging and the majority of members did not respond. However of those who did respond, the majority indicated that they support efforts by the Administration to pursue a balanced trading relationship with China based on free and fair trade. A key concern for U.S. manufacturers are subsidies for Chinese producers which can create incentives for increased exports to the U.S. This concern is particularly focused on high volume component parts, like composite building materials.

Our members view the growing Chinese economy as a key export market as well, but the current trade environment is not balanced. For example, China has an import duty of 15% to 17.5% on carbon fiber products, however the United States has no duty on carbon fiber products coming from China. This imbalance provides China greater access to the American carbon fiber and carbon fiber composites market than is equally afforded to American firms in China.

An area of concern is leadership in tooling and manufacturing technology. Efforts by the administration to address dumping of steel and aluminum have not fully addressed end products produced from those materials. For example, CNC machinery can come in without any duty. Some European governments even provide a tax rebate for companies in their countries exporting that equipment. ACMA members also report Chinese machining technology products are sometimes first exported to Europe, rebranded, and sold in the United States under an 'Imported from Europe' moniker.

Further, it is important to note that there have been significant Chinese efforts to gain market share and technology leadership in key sectors that are supplied by the composites industry. This is especially true in aerospace and vehicles, particularly in newer innovations. For example, the Chinese have far greater state investment in technology development and a more focused policy framework for the broader deployment of electric vehicles. For instance, KDX Group, BAIC Group, and Changzhou Hi-Tech Group jointly invested $1.8B in 2017 to produce a "new-energy vehicle carbon fiber body and components project[1]."

Risks

One area where the United States is falling short is the failure to foster promising research into commercially viable products in key growth sectors. The federal government invests significant funds into early stage research at programs at DOE, DOD, NIST, and NSF, among several other agencies. The DOD does create market pull for military goods that rely on composites and as noted above this was the spark that started the industry. However, we cannot rely on military applications alone if the U.S. wants to remain competitive in the years to come. We are increasingly seeing that composites innovation is driven from non-military applications in sectors such as commercial aviation, electric vehicles, and advanced infrastructure and construction applications. Therefore, our old model of relying on military applications to drive commercial innovation alone leaves the U.S. at a competitive disadvantage in the global marketplace. Many large companies who once had the ability to commercialize early stage research now rely on research collaboratives and acquisitions to pull new technologies into their portfolio. Therefore, a lot of promising early stage research is first commercialized overseas where there are more active and vibrant public-private partnership programs.

Whereas United States industrial policy does not widely commit public resources to the commercialization of nascent technologies for non-military applications, the same is not true of competitive economies. Many countries have government-backed apparatuses to commercialize promising innovations. The Fraunhofer system based in Germany aligns public funding with private investment to drive research and development in technologies with high commercial viability across many markets. This ecosystem brings together diverse stakeholders, including companies that may ultimately compete in the end market, to address the challenges in bringing new technologies to market.

The Fraunhofer system in Germany is among the best developed, but not unique. The VTT Technical Research Centre of Finland is another example which was started in 1942 and continues to operate with 36% of its funding from the public sector in Finland. The Netherlands and the UK have effective networks of Public-Private Partnership institutes. Today, Japan spends about 7% of

[1] http://www.jeccomposites.com/knowledge/international-composites-news/china-driving-whole-car-supply-chain-electric-vehicles-are

its government R&D budget on this translational research. Germany spends about 12%. South Korea spends about 30%. The U.S., in contrast, spends just 0.5%[2]. Since most of the U.S. basic science research is done in the public domain, other countries such as China have access to the results of $60.8B (2015) spent in the U.S. to feed the pipeline of innovations in their translational research programs[3].

Among the key technology areas that are vital to US competitiveness in composites in the future:

1. Tooling, machining, automation, and process equipment technologies
2. Carbon fiber production including PAN precursor production
3. Non-destruction testing, inspection and evaluation technologies including big data analytics
4. Embedded sensors and multi-functional composite materials
5. High performance thermoplastic composite technologies
6. High volume composite additive manufacturing technologies
7. Composites recycling technologies
8. Technological breakthroughs in resin feedstocks

In this testimony, I will focus on item (1) - Tooling, machining, automation, and process equipment technologies as one example which is currently at risk to illustrate the need for a revised U.S. manufacturing policy needed to sustain US manufacturing over the long term to compete effectively on a global basis.

The U.S. has relied on a higher degree of technical and engineering knowledge and capability, but this disparity is diminishing. With the Chinese economy largely state directed, their industrial policy is far more aggressive. The Made in China 2025 Initiative has already committed $300 billion dollars to producing higher-value products in key sectors including aerospace and robotics. Rather than continuing to manufacture component parts, the plan seeks to expand domestic supply chains and broadly enhance technological research and development. These efforts have also included significant Chinese investment in overseas manufacturers of machining technologies, including a billion-dollar acquisition of major German tooling manufacturer KraussMaffei.

In addition to KraussMaffei, critical aerospace composite technology companies have also been acquired. These include composite tooling company FFT Group by Fosun, the robotics company Kuka by Midea Group, Brötje Automation (process automation) by Shanghai Electric. Since China is already producing basic raw materials, these acquisitions provide China with vital process technology to turn the raw materials into value-added parts and finished goods. The tooling and equipment suppliers share technology and manufacturing with global partners to ensure access the best available technology for a given application. Acquisitions by China in this area suggest a need to look critically at whether a shifting supply base could limit access needed for American manufacturers to continue to be leaders in the end-use markets they serve, like aerospace.

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[2] https://science.house.gov/imo/media/doc/03.25.19%20CStevens%20OS%20Advanced%20Manufacturing%20Hearing.pdf

[3] https://fas.org/sgp/crs/misc/R44307.pdf

Tooling and machining companies provide key enabling technologies for high performance defense and aerospace applications. Many key advancements in composites come from the aerospace sector and trickle down into other markets. In addition to our existing commercial aerospace market, emerging markets will be important to the growth of the aerospace industry. Urban Air Mobility (UAM) which includes such applications as last mile delivery, air metro, and air taxi[4]. As these products are developed, this will spur the development and commercialization of high-volume process technologies. Improved process technologies will also benefit the production of single and multi-aisle commercial aircraft. Although estimates vary widely in this developing market, volumes of UAM production are on the order of 1000 vehicles per month, as compared to single aisle commercial aircraft volumes on the order of 100 per month. Therefore, the tooling, automation, and process equipment suppliers are key to maintaining competitiveness globally.

Leadership in aerospace composites will enable China to grow composites technology in other markets such as automotive, infrastructure, construction, medical devices, rail, renewable energy, and sporting goods. Composites are a key enabling technology for all these markets. U.S. leadership in composites technology is vital not only to the composites industry, but to all of the industries we serve. Support for translational research is a vital component of an integrated manufacturing policy. As other countries like China are increasing their targeted research efforts and making strategic acquisitions of technology companies, America runs the risk of maintaining technological superiority in key sectors.

China is looking hard toward the future as well. The Chinese government financially backs significant numbers of students to attend American and European universities in key STEM fields. This is particularly visible to our industry in material and mechanical engineering and may be the case in others. Many of these students become part of research teams working on promising early stage technologies in composites, robotics, and other key strategic areas. Much of this research does not see commercial light as noted previously, however students can return to China and are provided resources to take these technologies to the next level.

Advanced composites manufacturing is used in aerospace, automotive, energy, marine, sporting equipment, health care, infrastructure, and other industries to produce strong, light weight products. Jobs are high tech, involve working in clean environments, and require specific training.

STEM programs focused on advanced composites will provide the skills needed to innovate systems, processes, and material development critical to assure our technological superiority for decades to come, as well as, familiarize students with dual use technologies for both military and commercial application.

Lucintel, a global market research firm, found in a study commissioned by IACMI, The Composites Institute, that the composites industry is expected to experience substantial growth in the coming years. Carbon fiber composite applications are expected to grow more rapidly than glass fiber – an indication that advanced training is required to fill the need for advanced composites manufacturing technicians.

[4] https://www.nasa.gov/sites/default/files/atoms/files/uam-market-study-executive-summary-v2.pdf

In manufacturing, for every job that requires a master's degree or more, two jobs require a four-year degree, and seven jobs require a one-year certificate or two-year degree according to the Manufacturing Workforce Development Playbook[5]. In order to attract the next generation needed to fill the technician level positions requiring less than a four year degree, it is important to gain the interest of students before they exit high school.

As we know, not every child is pre-disposed to go on to college. Of the 16.4 million credentials needed by 2025 to meet workforce demands, more than one-third will be drawn from individuals with some college credit and no degree according to a report published by the Education Commission of the States in 2017[6].

Creating STEM programs that grant dual credit towards a certificate or a national certification, such as ACMA's Certified Composites Technician program, with local community and technical colleges is a model that would close that gap while providing the student with a portable, validated credential enabling that individual to accelerate his or her entry into the workforce. IACMI is teaming with Davis Technical Institute and other community colleges aligned to the DOD manufacturing enterprise to deploy such a model on a national scale to establish a talent pipeline for the advanced composites industry.

Pathways Forward and Policy Recommendations

The closest the United States has to an organized commercialization apparatus is in defense and space, where a form of innovations developed in NASA or DOD research programs can trickle into civilian markets. For example, the use of carbon fiber composites as a structural material in the Boeing 787 Dreamliner was preceded by numerous military jet programs. But in an era of rapid innovation, this paradigm leaves far too much on the table.

Around the world, governments are organizing and leading supply-chain stakeholders in the form of public-private partnerships to commercialize basic research. The United States needs a similar approach.

A step in the right direction has been the advent of the Manufacturing USA network of innovation institutes. The Institute for Advanced Composites Manufacturing Innovation (IACMI) has made tremendous strides in taking very early stage research originating at national or university laboratories and translating it up the commercialization chain. It is successful because it brings together stakeholders from industry, academia, and government to collaborate on promising technology. Other institutes in the Manufacturing USA network are doing the same thing in other industries.

Stable long term support is needed to ensure that these institutes remain viable. The authorizing legislation directed government funding for an initial five-year period only. The industry financial and in-kind commitment to IACMI far exceeds the federal share, and the easy answer is to say that large corporations have large research budgets that can fund early stage research. Unfortunately,

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[5] https://www.nist.gov/sites/default/files/documents/2017/04/28/Manufacturing_Workforce_Dev_Playbook.pdf

[6] https://www.luminafoundation.org/files/resources/state-innovations-for-near-completers.pdf

this is not borne out. Other countries with successful translational research programs recognize that a core of public funding is needed to attract industry and state funding. Since many companies are global, their research funding can be shifted to those countries which embrace this model. Matching public resources mitigate financial risk and illustrate a commitment by government to see development of technology in the relevant area. This has a magnifying effect on industries. If it is clear that the government is committed to the viability of a key sector, greater investment will flow into that sector and America has a better chance to achieve or maintain a comparative advantage.

A good start in the development of a needed comprehensive industrial policy would be continued funding to those Manufacturing USA institutes with demonstrated ability to commercialize viable research. A next step is aligning the resources of the National Laboratories network to develop basic research further toward commercial viability, rather than leaving it at a low level of technology readiness and moving to the next project. Not every project will yield overwhelming success, but assuredly more new products will enter the flow of commerce and benefit the American economy as a whole.

To assure America maintains superiority in key industries including, but not limited to, composites, Congress needs to look holistically at the manufacturing ecosystem. The government should do a better job of promoting manufacturing trades as a career pathway. Products are needed and even in an era of increasing automation, they cannot be produced without people. Ushering more people into the high-tech manufacturing workforce will assure the United States has the capacity to lead the world in key sectors.

There are also regulatory drags that stymie innovation. As new vehicle technologies become more mainstream like autonomous vehicles, electric vehicles, and drones, America is behind because we lack the regulatory framework for their broad and safe introduction and the infrastructure to support them. Similarly, lacking a unified vehicle emissions standard for the whole domestic market makes it difficult for automakers to manage innovation in a consistent fashion. The same situation is equally pronounced in the infrastructure sector, where the development of codes and standards as well as the length of time needed to permit new starts has slowed growth of deployment of innovative construction materials and techniques. China and other countries are faster to clear these hurdles and are already reaping the benefit.

Conclusion

It is no longer enough to rely exclusively on American entrepreneurial spirit to maintain dominance in the world economy. The world has changed. We are no longer facing competition just between companies, entire countries are acting in a coordinated way to ensure their manufacturing sector thrives for through strategic investments and partnerships.

The federal government needs to provide consistent, long term investments based on smart policy choices that foster innovation and the retention of vital technologies which the manufacturing section relies upon. In turn, industry needs to provide its share of support for collaborative, pre-competitive research. By involving industry, the research will be more focused on programs which have commercial value. By building a stronger ecosystem for public-private collaboration, we can achieve a safer future, greater prosperity, and a renewed entrepreneurial spirit all Americans can be proud of.