S&P Global
Energy

CERA Consulting

Defense and the Essential Role of Specialty Chemicals and Materials

May 2026

CERA Consulting is the consulting arm of S&P Global Energy

Agenda

- Introduction
- Scene Setting: Defense Sector & Current Drivers
- Role of Advanced Fibers & Composites
- Role of Advanced Engineering Polymers
- Enhancing Current Material Performance
- Key Messages
- Q&A

Former IHS Markit - S&P Global Energy division draws on the full depth and breadth of the company & its industry sector expertise

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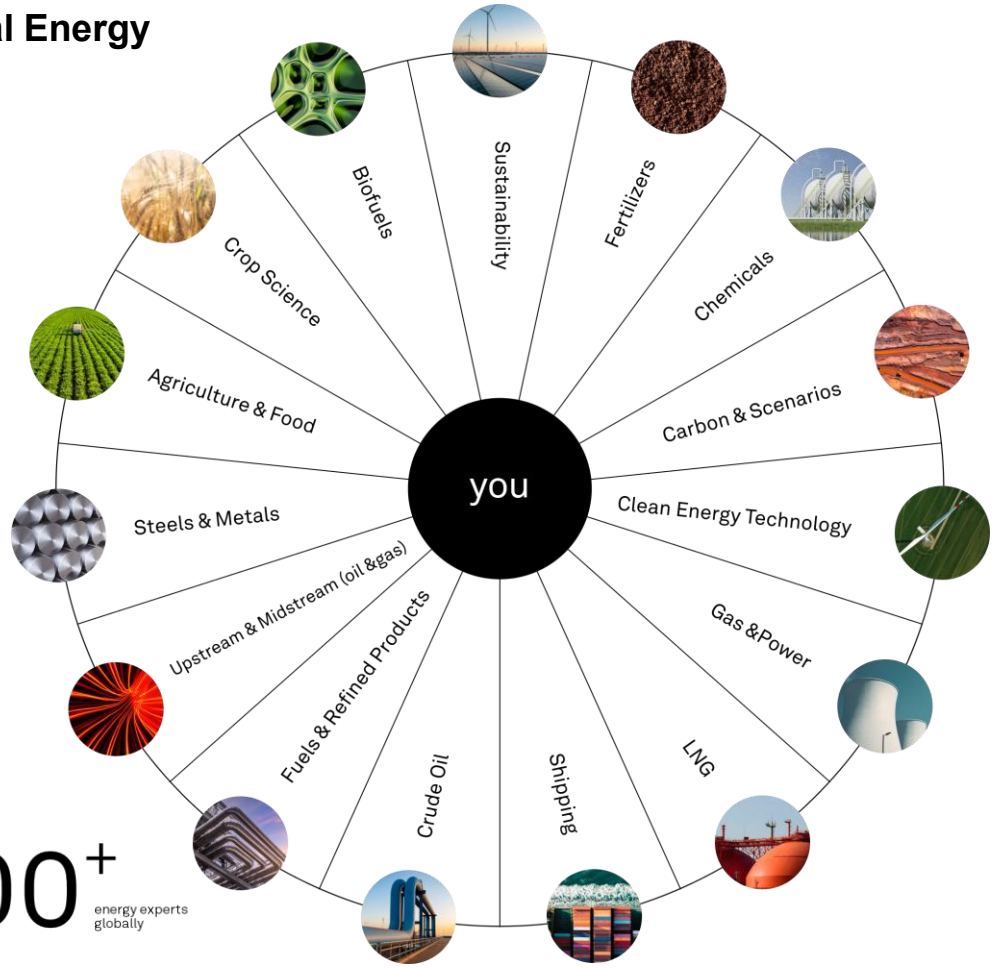

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CERA Consulting

Specialty Chemical Team

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S&P Global Energy CERA: Integrated Research & Analytics to Enable Confident Decisions

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RESEARCH
From well to “Walmart”

Most advanced tools

INTEGRATED ANALYTICS
Industry experts, complex models

Actionable insights

CONFIDENT DECISION
Successful clients

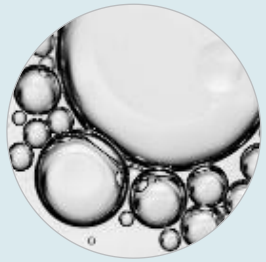
CERA S&P Global Energy

CERA Consulting: We Answer the Most Difficult Questions Across All Major Value Chains

Defense

Some of the High-performance specialty polymers needed in defense equipment are currently sourced from European and Asian producers.

Additionally, the US imports explosive and propellant materials.



Specialty Chemicals

In recent years, the US transitioned from being a net exporter of **specialty chemicals**, exporting $11 billion worth of specialty chemicals in 2011, **to being a net importing** country in 2022.

Construction and Data Centers

The U.S. is a leading consumer of construction chemicals and polymers. To sustain growth amid ongoing infrastructure modernization, and affordable housing. Additionally, **data centers construction is expected to increase tenfold in the next decade** requiring polymers and cooling systems.

Pharma & Medical Equipment

The US is a global leader in pharmaceuticals ($600B) and medical equipment ($200B), driven by strong R&D investment, and significant export capabilities.

Electronics and Consumer Goods

With continuous technological advancements and the increasing demand for electronic devices, **the US electronics imports accounted for $486 billion** in 2024, a 5% increase from the previous year.

Automotive

In 2024, the United States imported approximately **$474 billion worth of automotive products**, including $220 billion in passenger cars.

Speakers

Rev'd, Dr. Mark Morgan
Vice President Chemical Consulting
mark.morgan@spglobal.com

Mark serves as Vice President, Chemicals Consulting for S&P Global, based in the UK. Mark joined the company in 2011 and today has global responsibility for consulting in specialty chemicals, including advanced materials. In this sector, Mark's work covers high-performance fibers such as carbon fibers, aramids, UHMWPE fibers, etc., while his experience in advanced plastics and composites covers a broad range of high-performance thermoplastics and thermoset systems.

Prior to joining S&P Global, Mark worked for various privately-owned boutique consulting firms and prior to that for BP as a technologist working across R&D, engineering and various business groups to develop and commercialize new and innovative chemical processes ranging from commodities through to fine and performance chemicals as well as advanced materials. Mark has strong experience in advanced plastics having worked on new technology developments and novel polymers. Mark was also a former officer in the British Army where this experience is often key to linking new developments in advanced plastics and fibers into existing and emerging application areas in the defense sector.

Dr. Luca Raffellini
Executive Director Chemical Consulting
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Luca is a senior director of S&P Global Energy based in the London office and the Head of Chemical Consulting, Europe, Africa, CIS. He has 30 years' experience in the chemical industry, both as a management consultant and as a company executive, with a focus on business strategy and technology optimization, primarily in Specialties.

Luca has held international positions with ENI Versalis, Arthur D. Little, Booz & Co (now PWC Strategy&). He was the Global Marketing Manager of Infineum, an ExxonMobil - Shell JV, and a Vice President with Frost & Sullivan. Lead advisory roles on projects across many segments of the chemical industry, including composite materials, advanced elastomers, fluids and lubricants in Aviation and Marine.

Luca served as a 1st Lieutenant in the Italian Army, commissioned to NATO TRMF-South (Theater-Ready Monitoring Facilities) and in charge of military and civilian personnel involved in diagnostics & maintenance of artillery weapon systems.

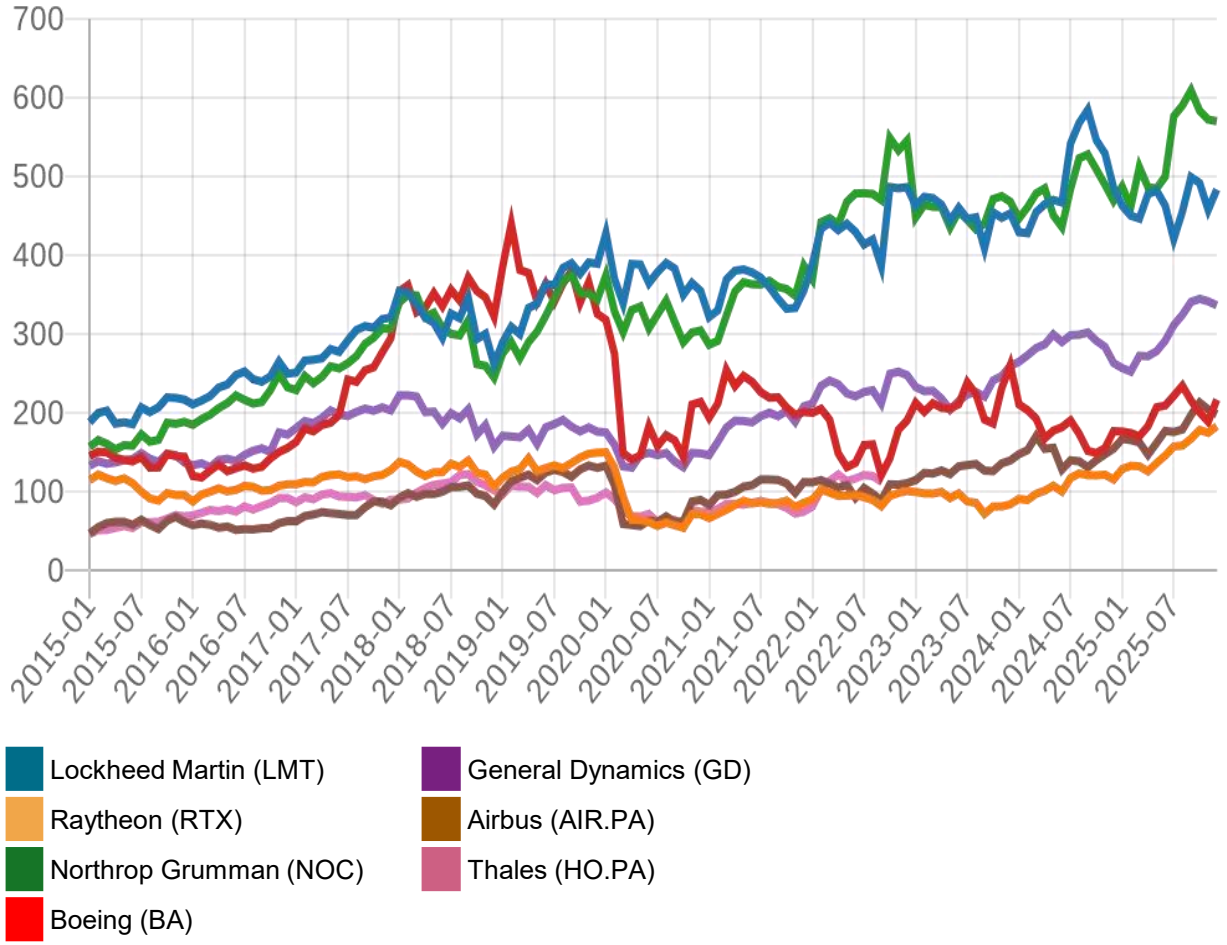
Key Messages

- Geopolitical dislocations and two major conflicts, Ukraine and Iran, have been resetting the calculus and outlook for Defense around the world
- Substantially expanded budgets for Defense represent an unequivocal opportunity for the main players in its supply chain, of which the Chemical Industry is one
- Supply security, advanced manufacturing, and making innovation count, are they issues that the Chemical Industry is eminently well positioned to address – this in the context of disproportionate sourcing and production shifts from West to East, primarily in China
- We understand the Defense supply chains from minerals, raw materials, intermediates, to advanced materials with a “line of sight” into weapon systems
- While any and each of those steps may be critical to military strategies and deployment, the Advanced Materials space presents some specific vulnerability
- We see Defense platforms evolving calls for ever higher performance, need for new materials and chemistries, wider theatres of operation
- With multiple chemical innovations within grasp, we cannot emphasize enough the need for significant R&D spend and targeted investment

Setting the scene

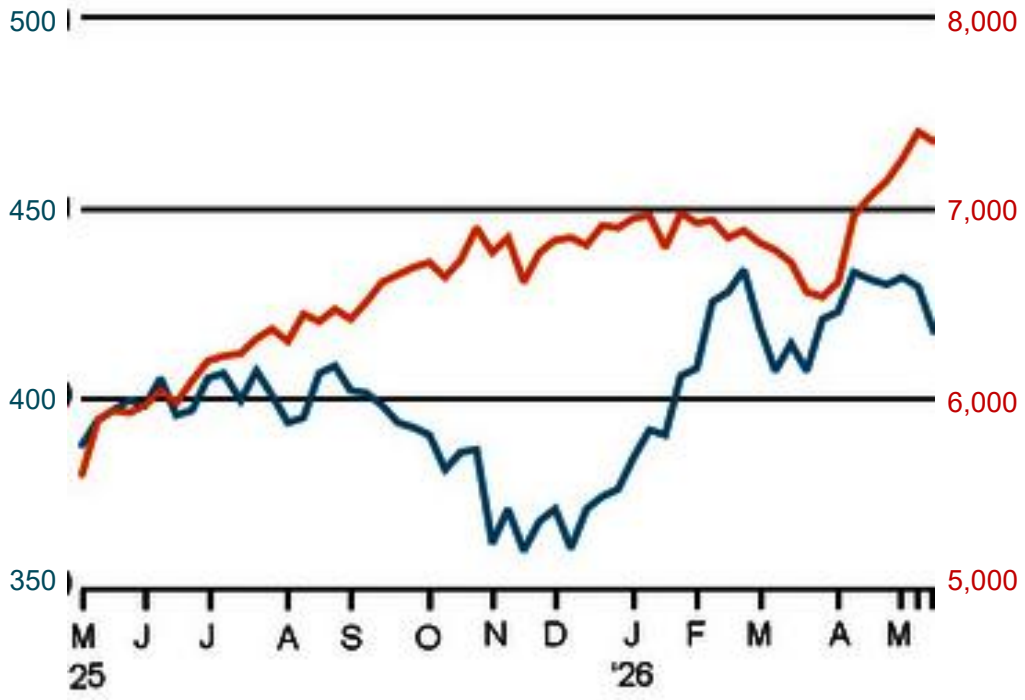
The Defense sector story is largely one of growth. In contrast, the Chemical industry whole performance – despite their close interdependence – tells a very different story

Share Price Index*: Selected Defense Companies, 2021 – 2025



Lockheed Martin (LMT)
Raytheon (RTX)
Northrop Grumman (NOC)
Boeing (BA)
General Dynamics (GD)
Airbus (AIR.PA)
Thales (HO.PA)

Share Price Index: CW75 vs. S&P500, May 2025 – May 2026

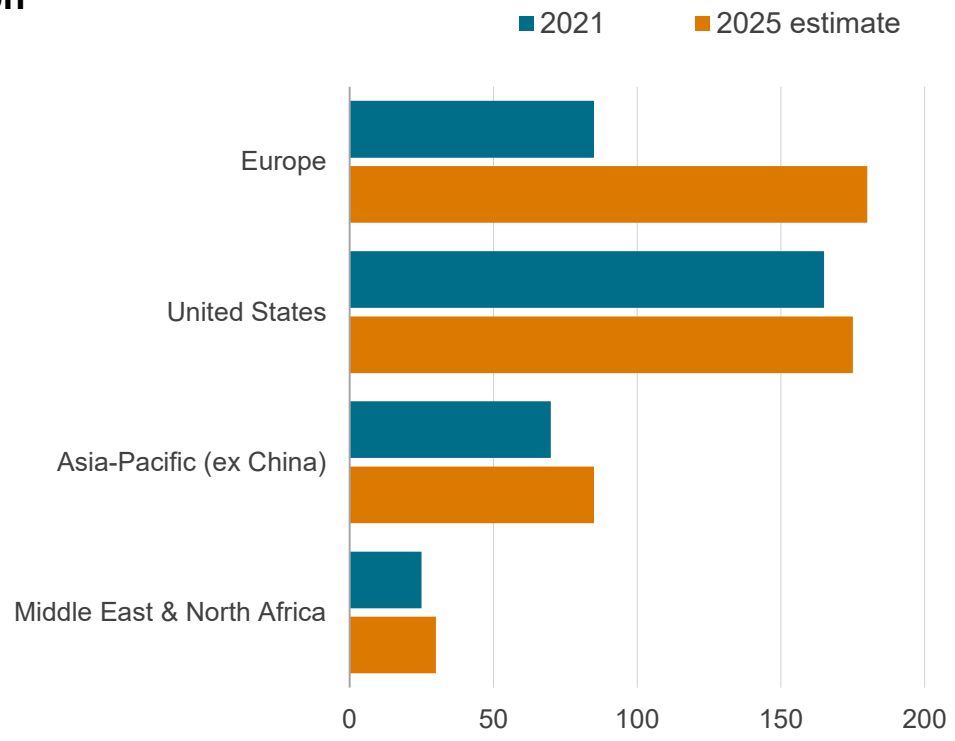


CW75 Index (Top 75 Chemical Companies in S&P Chemical Week Tracker)
S&P500 Index

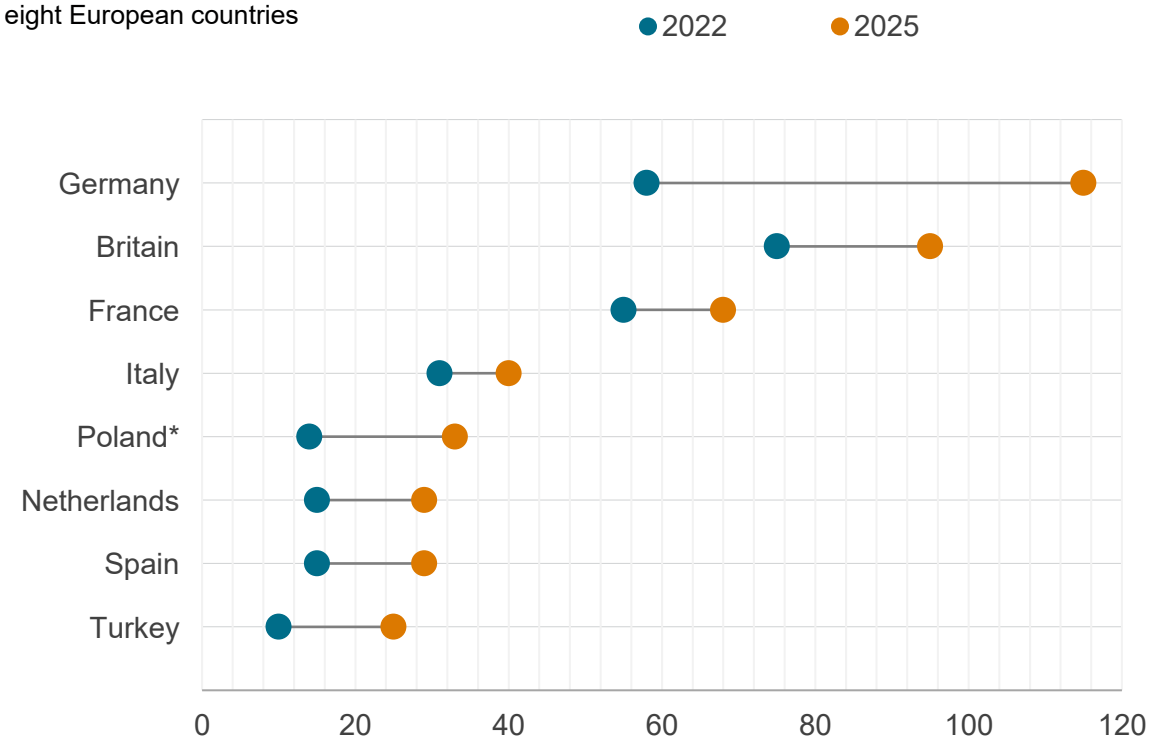
(*) Defense company index is normalized to median RTX = 100 in January 2015
Source: S&P Global Energy, The Economist, Chemical Week

The Defense fundamentals are national budget and related procurement, with the Ukraine conflict a turning point – even Europeans, historically reluctant, have started spending

Global Defense procurement spend (selected countries), $bn



Europe Defense budget (selected countries), $bn



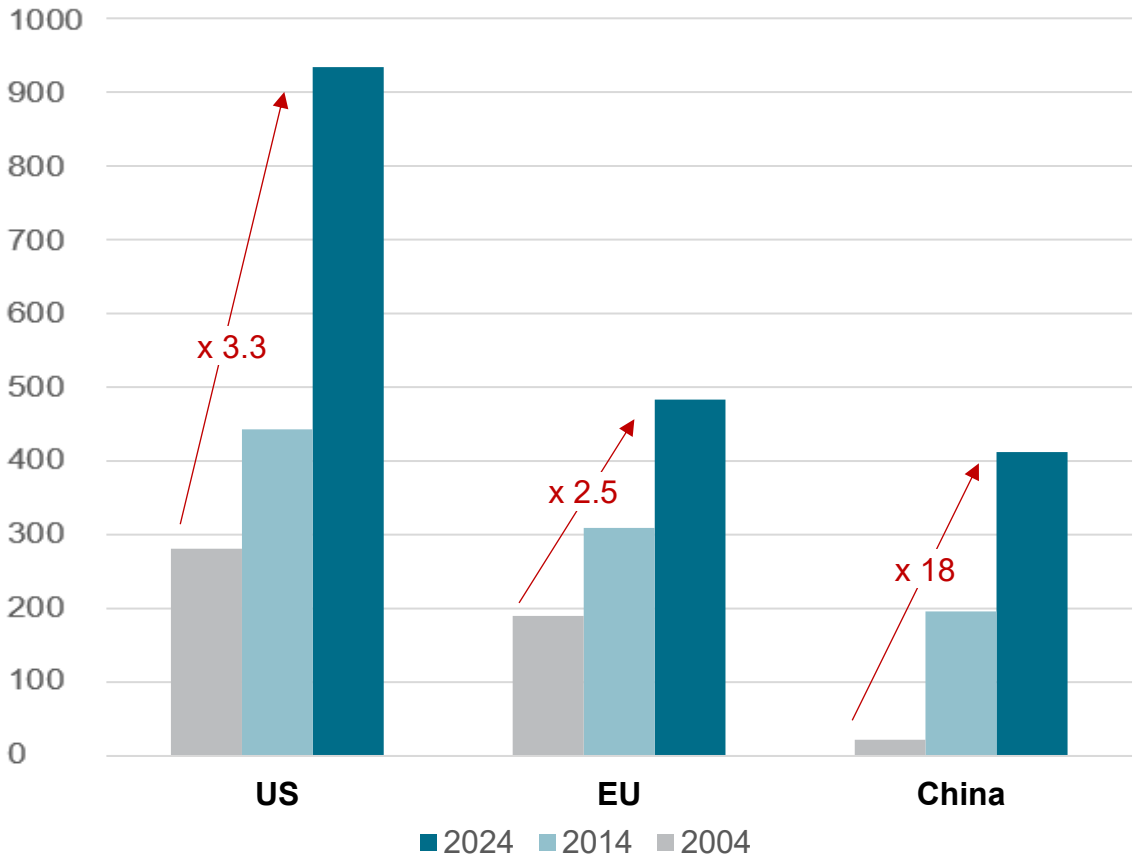
World military expenditure rose to $2,800 billion in 2024, meaning that spending increased every year for a full decade, going up by 37% between 2015 and 2024. This is the highest level ever recorded and the steepest year-on-year increase since the end of the Cold War.

Source: Bloomberg; Aviation Week Intelligence Network, S&P Global analysis

*Not including Armed Forces Support Fund
Source: IISS Military Balance, S&P Global analysis

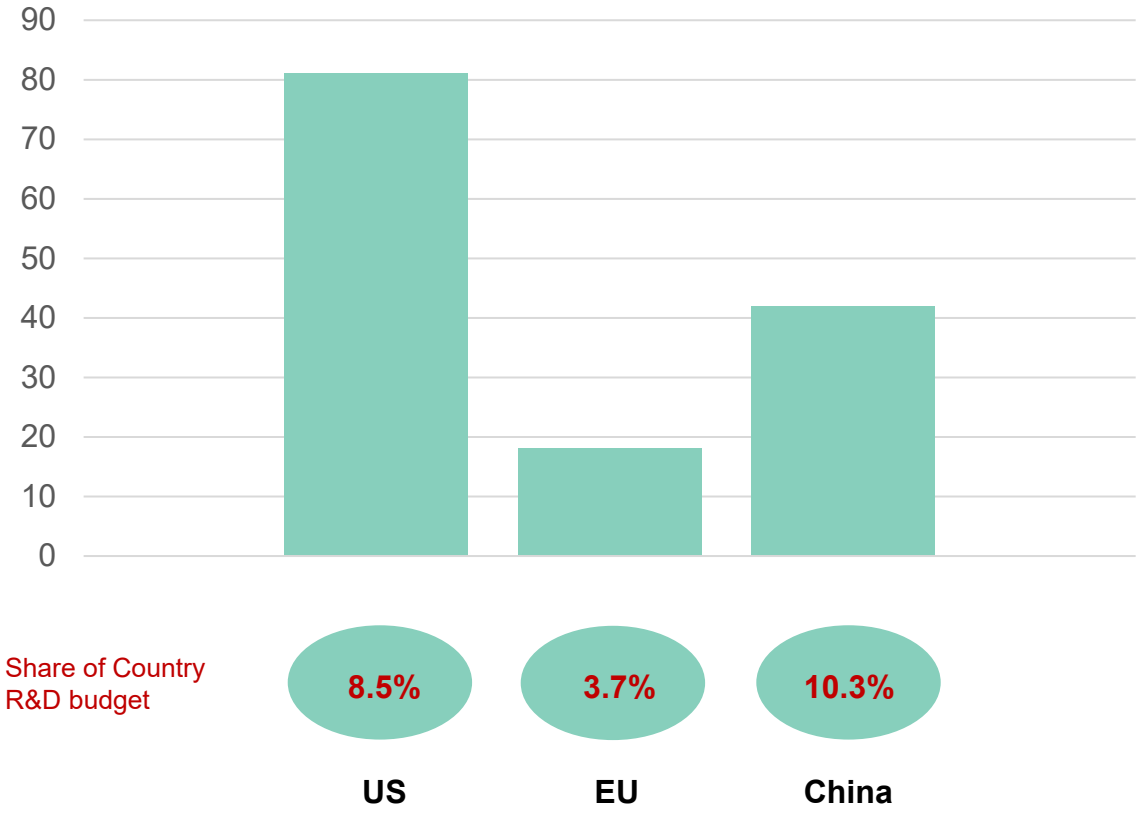
Comparing R&D for different countries – a good predictor of future Defense capability – is a sobering picture: China, though starting from a low base, is leaping forward

Country R&D budget*, 20-year period ($bn)



(*) Gross domestic expenditure on R&D including business enterprise, government, higher education, and private non-profit spending

Defense R&D spending, 2024 ($bn)**

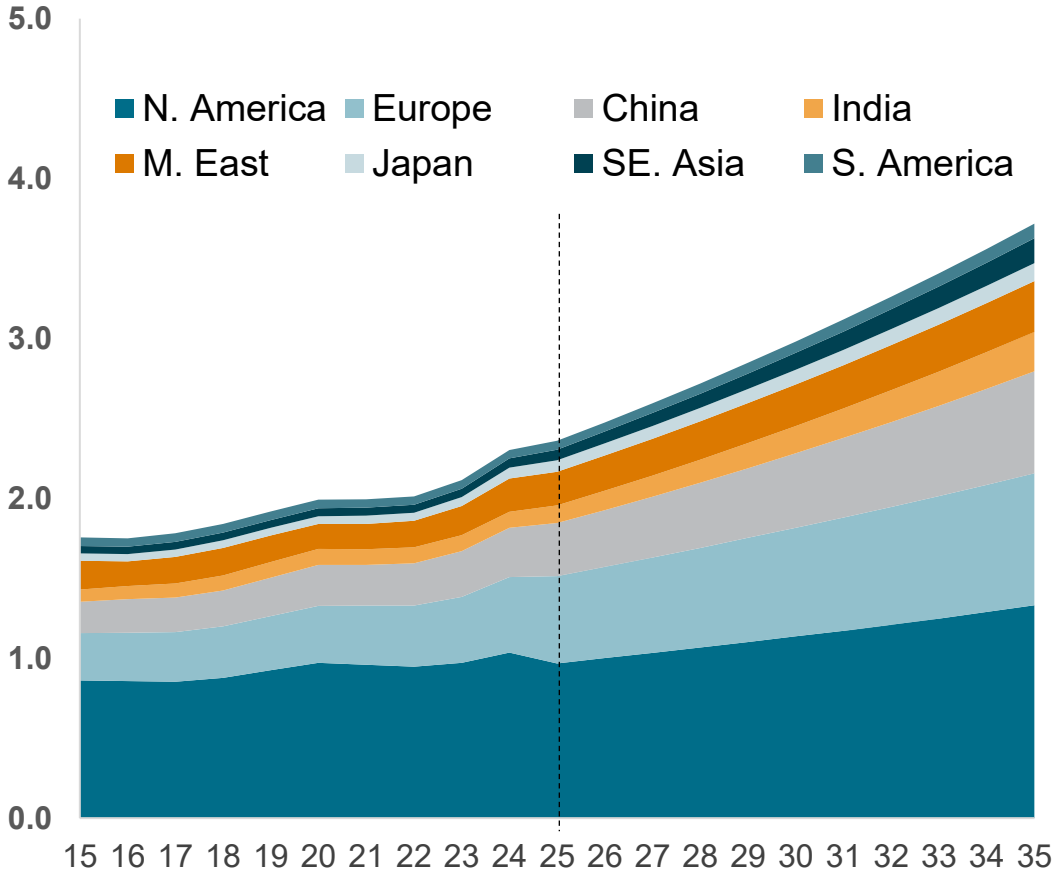


(**) Public and private R&D spending in Aerospace and Defense sector, including basic research, applied research and experimental development

Source: The World Bank, European Parliament Research Services, America Enterprise Institute for China, S&P analysis

Defense sector growth likely to continue, driven by geopolitical uncertainties encouraging increased military spend in many countries. How can the Chemical Industry respond?

Total Defense spend (selected countries / regions) 2015 – 2035, $tn



Geopolitical climate

- Ongoing conflicts/ possible resolution
- Shifting sands of alliances
- Drive for “Self-Sufficiency”

Increasing defense budgets

- UK targeting 5% of GDP by 2032
- US targeting $1.5 TN in 2027?
- India/China accelerating spend

Opportunities and issues for chemicals

- Supply security
- Advanced manufacturing
- Making innovation count

Source: S&P Global Energy

Mapping the very end points of the material supply chain in Defense can be meaningful but has limitations: granularity, criticality, and “line of sight”

Europe: supply imbalance for critical minerals vs. weapon systems

 Fighter Aircraft	Aluminium Graphite	Beryllium Chromium Cobalt	Copper Dysprosium Germanium	Iron/Steel Lanthanum Nickel	Neodymium Platinum Praseodymium	Samarium Tantalum Titanium	Tellurium Terbium Tungsten	Vanadium Yttrium Zirconium	Barium Borates Cadmium	Gallium Indium Lead	Lithium Manganese Molybdenum	Niobium Silver Tin	Thorium Zinc Zirconium	Gold Hafnium Selenium
 Main Battle Tank	Aluminium Graphite Copper	Beryllium Chromium Copper	Germanium Iron/Steel Neodymium	Nickel Tantalum Tellurium	Titanium Tungsten Vanadium	Yttrium	Borates Cadmium Gallium	Indium Manganese Molybdenum	Selenium Thorium Zinc	Hafnium				
 Missile	Aluminium Cobalt Copper	Chromium Phosphorus Samarium	Dysprosium Iron/Steel Neodymium	Nickel Tantalum Tellurium	Silicon Metal Tantalum Titanium	Tungsten	Barium Lithium Lead	Niobium Molybdenum Zirconium						
 Submarine	Aluminium Graphite	Chromium Cobalt Copper	Platinum Samarium Titanium	Tungsten Vanadium	Barium Lithium Lead	Manganese Niobium Silver	Hafnium							
 Corvette	Aluminium Graphite	Cobalt Chromium Copper	Iron/Steel Nickel Samarium	Titanium Tungsten	Barium Lithium Lead	Molybdenum Manganese	Gold							
 Artillery	Aluminium Graphite	Beryllium Chromium Copper	Germanium Iron/Steel Neodymium	Nickel Tantalum Tellurium	Vanadium Yttrium	Cadmium Molybdenum Manganese	Indium							
 Ammunition	Aluminium Graphite	Beryllium Copper Germanium	Neodymium Tantalum Tellurium	Titanium Yttrium	Cadmium Indium									
 Torpedo	Aluminium	Chromium	Lead Lithium Manganese	Zirconium Silver										

Very high risk

High risk

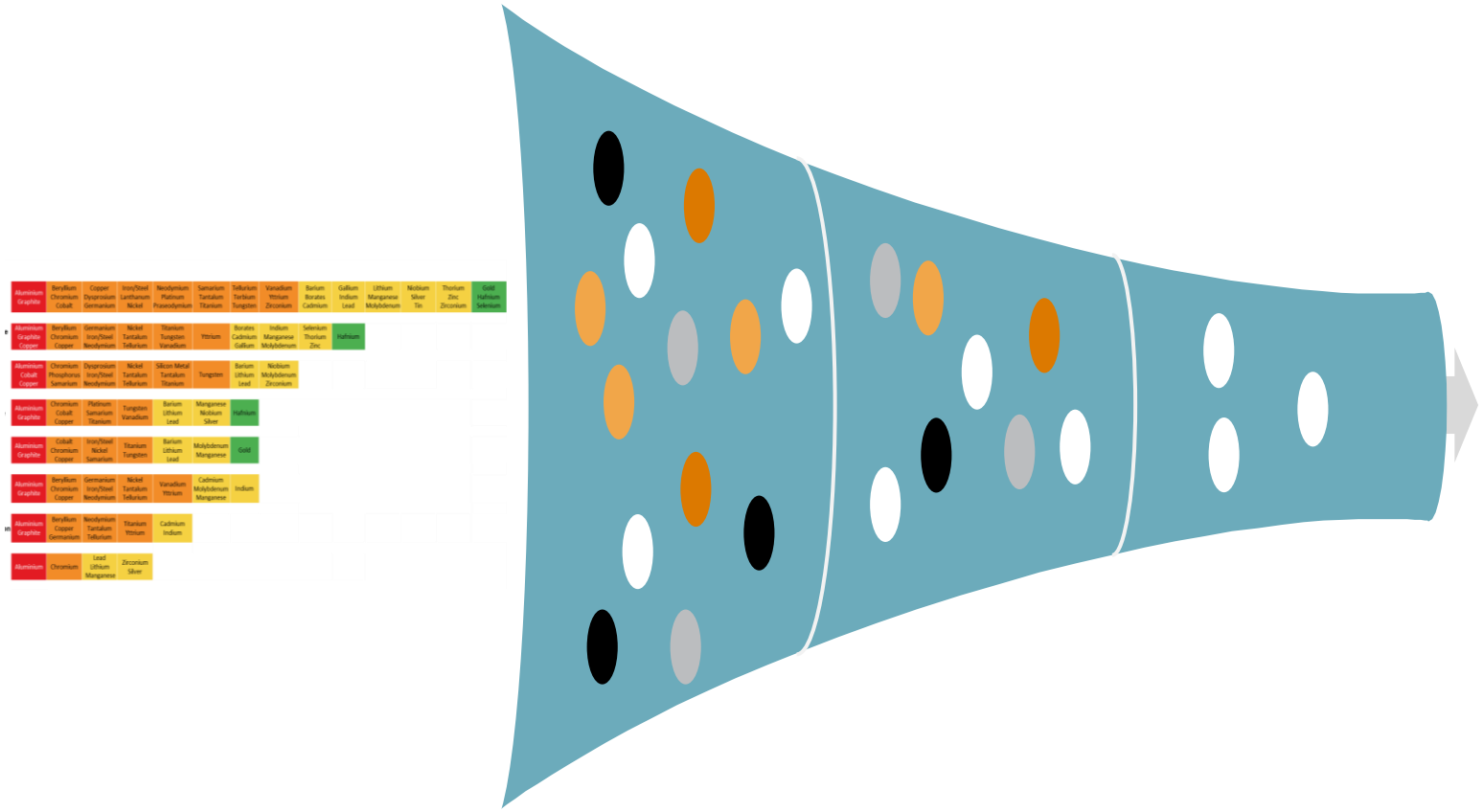
Medium risk

Low risk

Source: The Hague Center for Strategic Studies, NATO classifications, S&P Global analysis

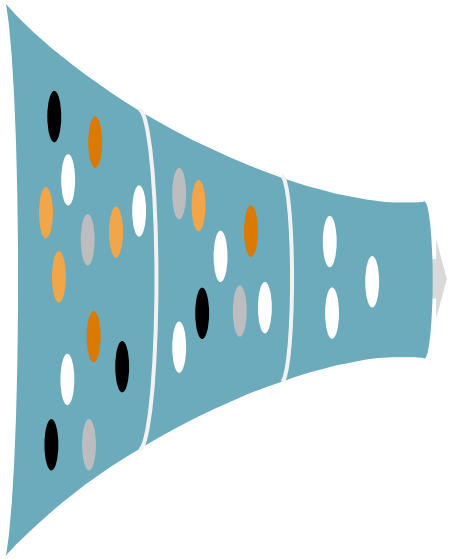
One approach is to identify *truly* critical materials (not just in short supply) for Defense systems…

Defense Critical Materials: Filtering Criteria



1. Integral to Defense Capabilities: fundamental components in producing high-performance military hardware and electronic systems. Their absence or disruption could impair functionality and effectiveness of these systems.
2. Supply Chain Vulnerability: sourced from regions with concentrated production, making their supply susceptible to geopolitical tensions, trade restrictions, or disruptions. Secure and resilient supply chain vital for maintaining operational readiness.
3. Limited Substitutability: possess unique physical or chemical properties—such as high strength, lightweight, corrosion resistance, or magnetic characteristics—that are difficult or impossible to replace without compromising system performance.
4. Strategic and Geopolitical Risks: Control over their supply concentrated in certain countries. could be leverage to exert influence on military capabilities during crises.

…by linking them to specific performance capabilities / components in weapon systems (example: Minerals / Raw Materials)



Class	Mineral	Current defence applications
M	Aluminium	Aircraft frames, ammunition, corvette, artillery, submarine, missiles, armoured vehicles, torpedoes
M	Beryllium	Missile guidance systems, ammunition, artillery, fighter jets, main battle tanks
M	Cobalt	Jet engines, missiles, submarines, corvettes
M	Lithium	Batteries for electric motors & propulsion (e.g., nuclear submarines, naval vessels, missiles)
M	Manganese	Armament (e.g., MBT, principal surface combatant), batteries for electric-motor propulsion
M	Titanium	Ammunition, fighter jets, MBT, principal surface combatants, missiles, assault rifles
M	Tungsten	Ammunition, MBT, missiles, naval vessels, fighter aircraft
PGM	Platinum-group metals	Fighter jets, armoured vehicles, submarines, main battle tank
SC	Gallium	Semiconductor devices, radar systems, satellite communications
SC	Germanium	Infrared optics, fibre optics, night-vision equipment, ammunition, artillery
RE	Rare Earths (HREEs)	Motors, missile guidance, lasers, radar & sonar transducers
RE	Rare Earths (LREEs)	Lasers, displays, high-strength materials
C	Graphite	Armament (e.g., MBT), principal surface combatant (propulsion, sensors)

Legend: M = Metal; PGM = Platinum group metals; SC = Semiconductors; RE = high / low rare earths; Carbon

Note: list is not exhaustive
Source: S&P Global Energy

We look at critical materials for Defence holistically (not limited to critical minerals) by considering three main value chains – today's focus is on Advanced Materials

Minerals / Raw materials	▪ Metals ▪ Semiconductors ▪ Rare earths ▪ Graphite
Intermediates / Energetics (explosives, Propellants)	▪ TNT (trinitrotoluene), RDX, HMX* ▪ Nitrocellulose, nitroglycerine ▪ Ammonium perchlorate ▪ Hydrazine, UDMH** ▪ Nitrates (Cu, Ba, Li, Mg) ▪ Hydroxyl-terminated liquid polybutadiene
Advanced Materials and Fluids	▪ *Carbon fibers / CFRP* ▪ *Kevlar / Aramid* ▪ *High-performance thermoplastics* ▪ *Ceramics (boron carbide, silicon carbide)* ▪ Fluoro-compounds ▪ Ultra-performance lubricants, hydraulics, coolants

Deeper Dive

* RDX (cyclotrimethylenetrinitramine) and HMX (cyclotetra methylenetetranitramine) — high-performance military explosives. ** UDMH (Unsymmetrical Dimethylhydrazine) – rocket propellant

Advanced Materials for Wide Application Across the Defense Sector

Defense industry seeks to surpass challenging technology barriers, today and tomorrow; how will chemicals industry respond?

Industry demands more:
- Combat range and resilience
- Higher ceiling and payload

Manned versus unmanned

Hypersonic battlefield challenges

Material challenges not exclusive to:
- Lightweighting with improved performance
- Stretching thermal barriers

Implied need for new materials

New chemistries and processing approaches in both fibers and polymers

Advanced fibers can be derived using different chemistries to achieve exceptional performance for defense and related applications

High-performance fibers

- Aramid
- UHMW-PE
- Carbon

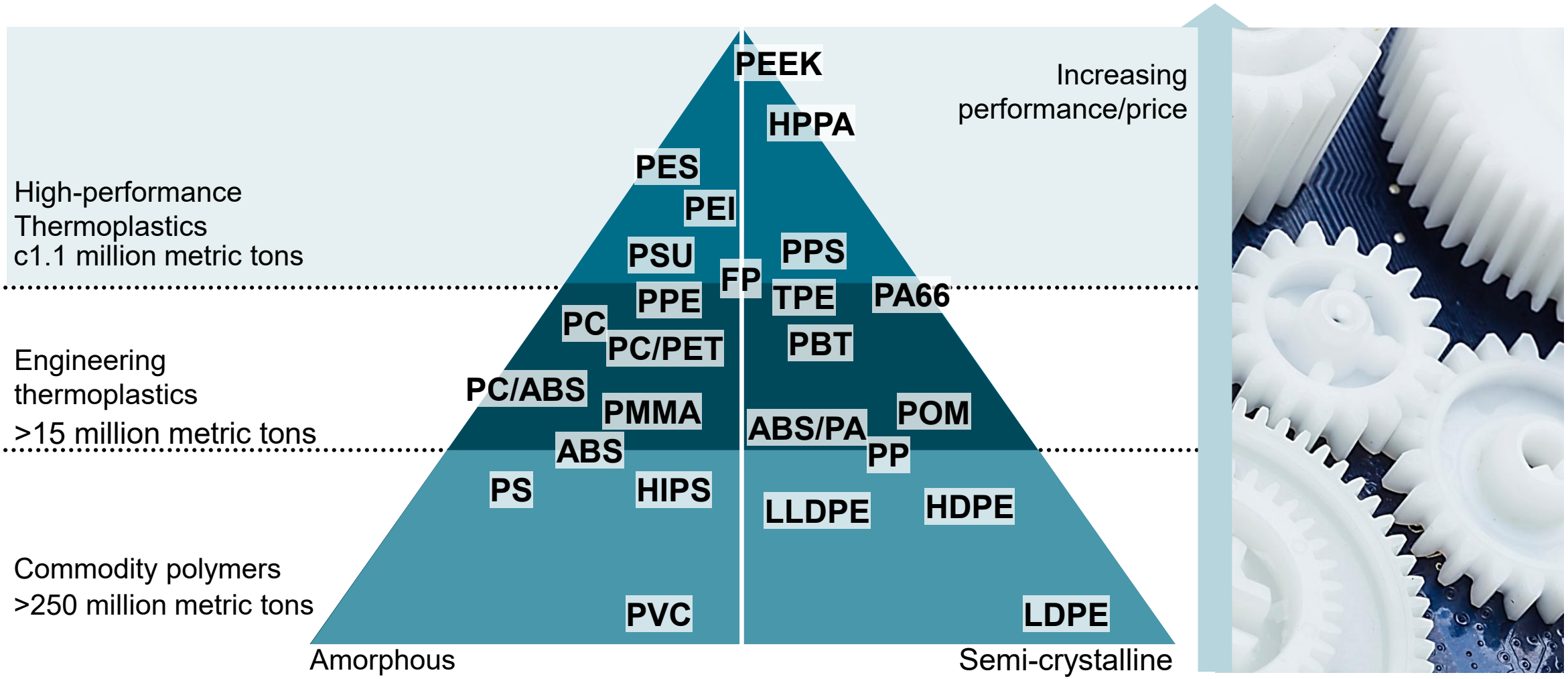
Key properties

- Exceptional strength/mass ratio
- Variable modulus
- High heat resistance

Demand is growing globally

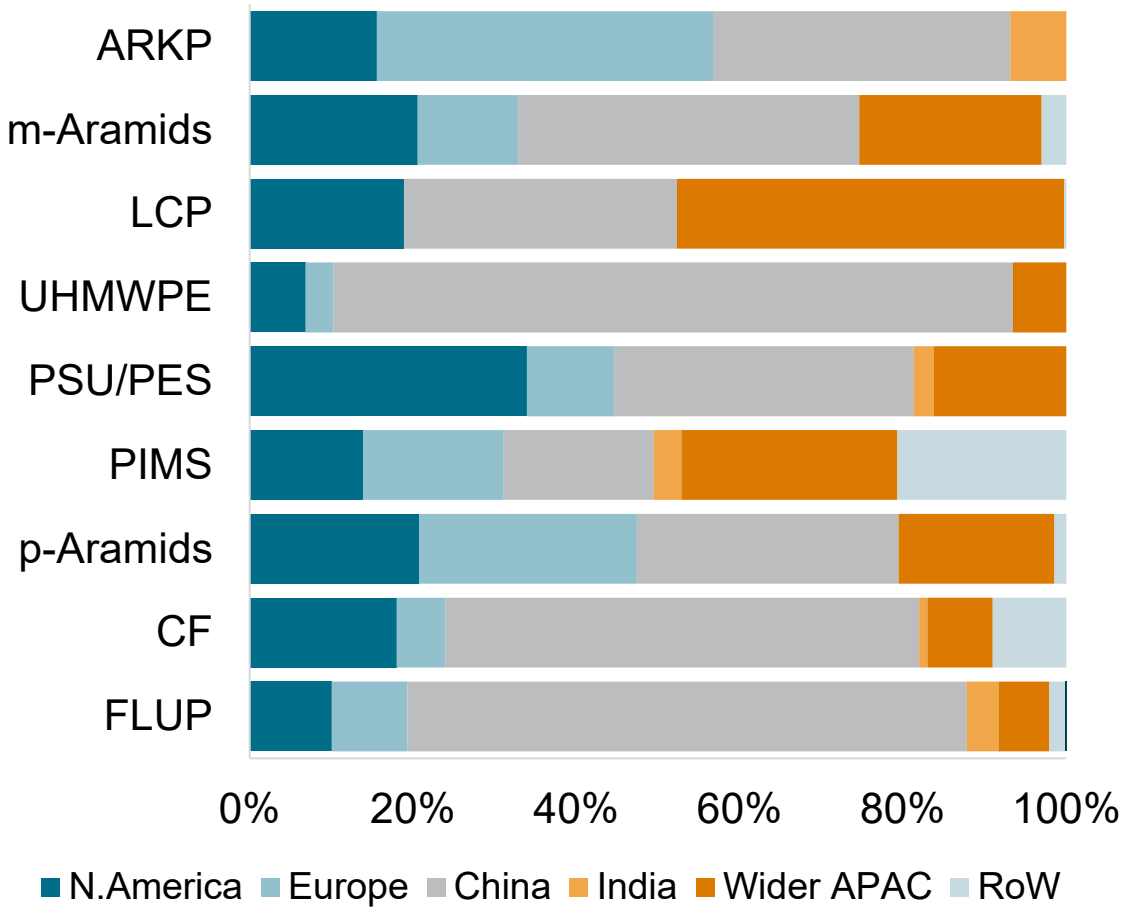
- Ballistic and fire protection
- Filtration, aircraft, optical fibers, medical
- Energy and materials transition
- Special consumer apparel

The defense industry utilizes a vast array of high-performance engineering polymers spanning specialty polyamides, PEEKs, and high-performance fibers such as Aramid and carbon fibers



The production capacity and supply chain for high-performance engineering polymers and fibers over the past decades has migrated toward Asia. China is leading.

Global Regional Capacity Share in Advanced Polymers and Fibers, End 2025



- Accelerated in China for Advanced Materials
- China accounts for circa 55% of supply
- In contrast the US is now only 15%
- US defense industry increasingly reliant on external supply, however …
  - European supply base under pressure
  - More building block supply through imports
- Supply risk in polymers and building blocks
- How will the US DoW guarantee future supply needs?

FLUP: Fluoropolymers, **LCP:** Liquid Crystal Polymers, **PSU/PES:** Polysulphones, **ARKP:** Aromatic Ketone Polymers, **PIMS:** Polyimides
CF: Carbon Fiber, **m-Aramids:** Meta-Aramids, **p-Aramids:** Para-Aramids, **UHMWPE:** Ultrahigh Molecular Weight Polyethylene.

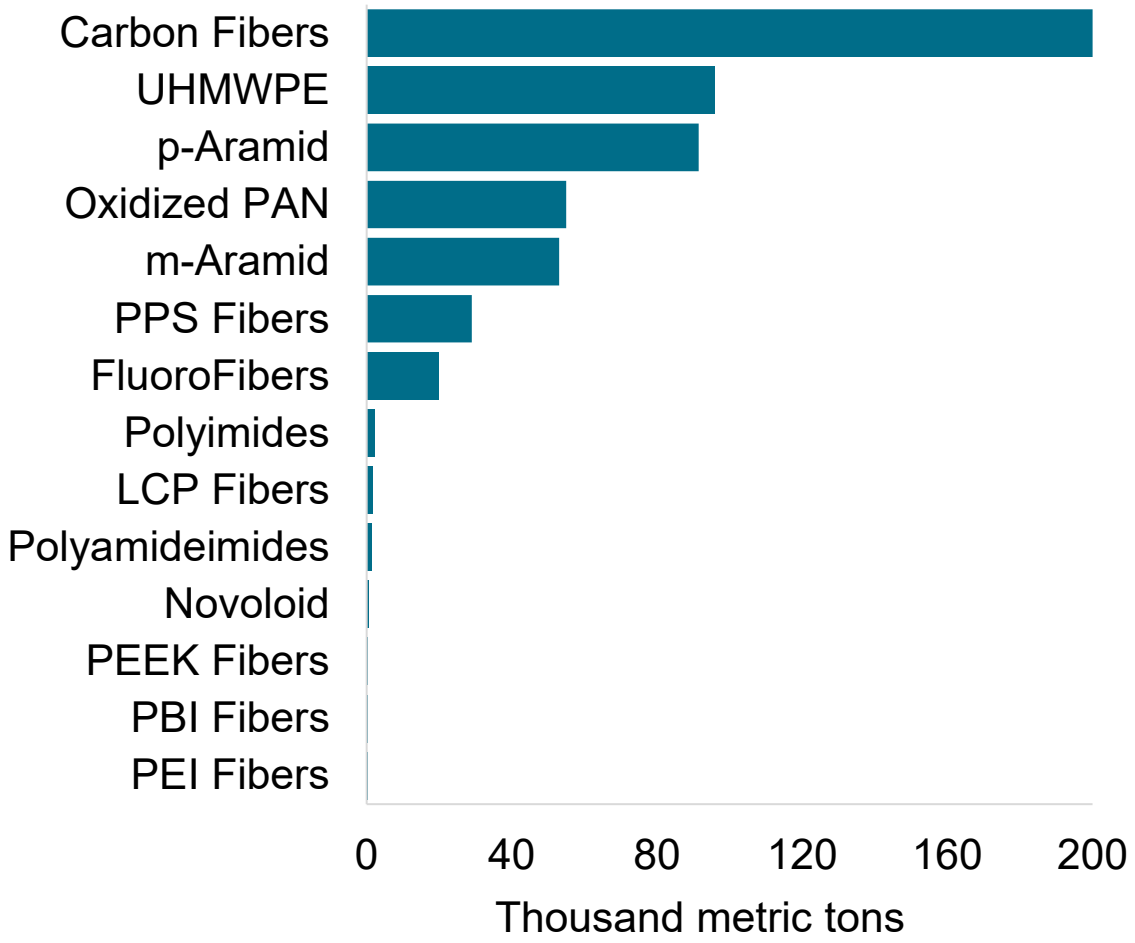
Advanced fibers can be derived to achieve exceptional performance for defense and related applications; *however...*

Chemistry
- Complex
- Often many steps from cracker/reformer
- Cross value-chain interactions

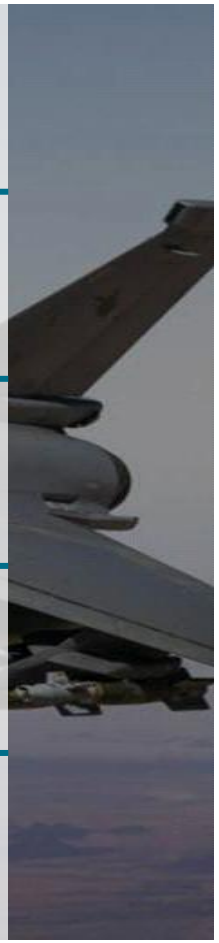
Regulation and supply chain controls
- Quality and monitoring
- Environmental - movement
- Environmental – waste management

Business issues
- M&A, e.g., DuPont sells Aramids, Q3/2025
- China becoming self-sufficient
- Feedstock supply vulnerabilities
- Challenges in intermediate supplies

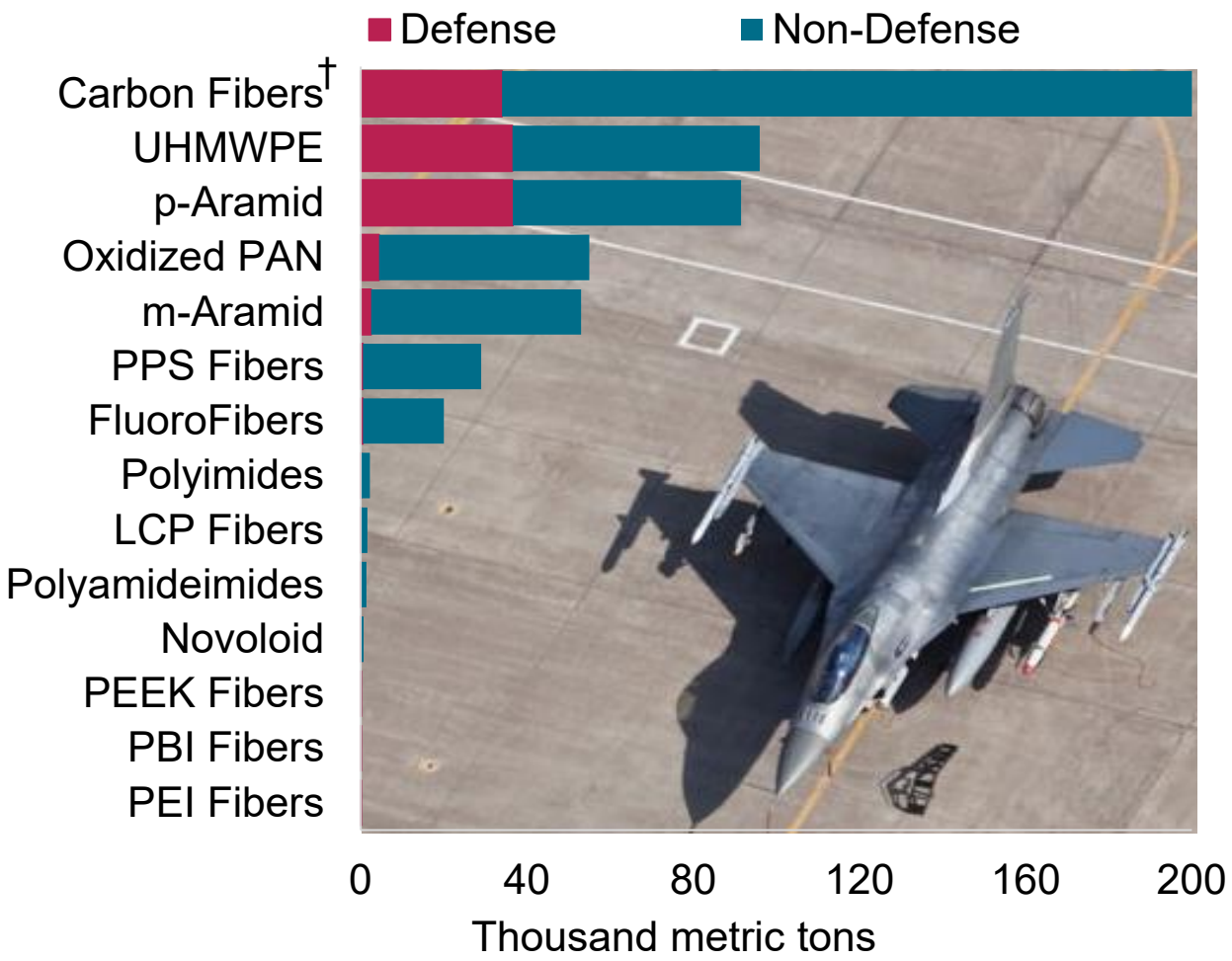
High-performance fibers are growth market supporting many applications where lightweighting, safety, thermal and mechanical properties are needed



- Market value $15-$20 billion
- Complex value chains
- Carbon fiber AAGR > 7.0%
- Aramid/UHMWPE AAGR > 5.0%
- China now major market



The defense relies on high-performance fibers for structural applications, ballistic protection, rubber reinforcement, filtration, and much more



Estimated defense sector use, 2025

21% globally

25% of CF use in US

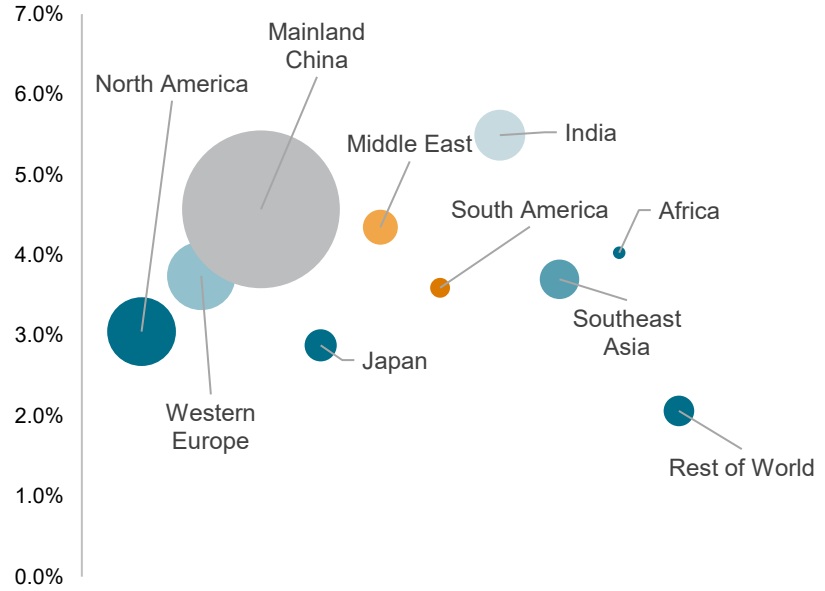
> 50% of p-Aramid use in W. Europe/US

> 33% UHMWPE fiber use in China

† Include defense and aerospace

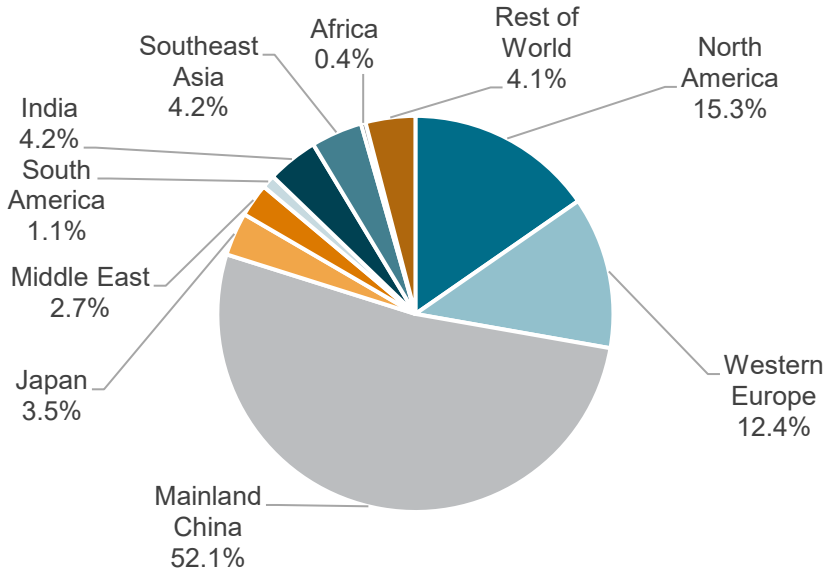
Carbon fiber demand led by China with rapid growth in wind, automotive, aerospace, and defense applications

Global Demand (2055), Long-Term Growth



Source: SPGE

Carbon Fiber Demand by Region (2025)



Demand 2025 > 200,000 metric tons

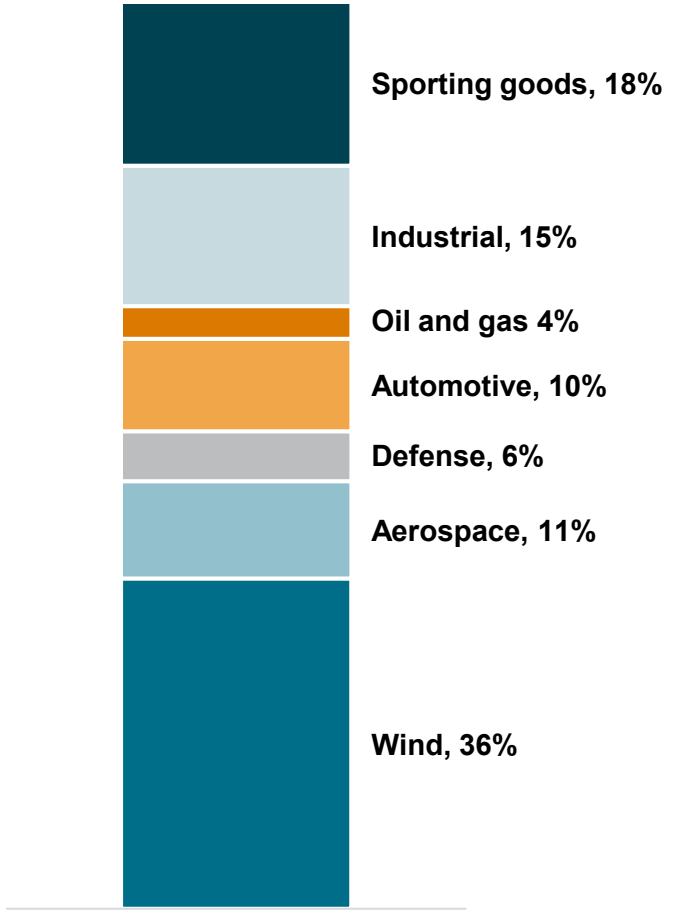
Source: SPGE

- Overall, China leads though industrial development and technological progress
- Strong growth in emerging markets – India and SE. Asia
- Developed markets mature but innovation accelerating

Short-term demand growth in defense and aerospace sectors at near double-digit levels including drones, UAVs, air defense, primary/secondary structures and engine developments

World: 2025 Carbon Fiber Demand By End-Use

Demand = 201 Thousand Metric Tons

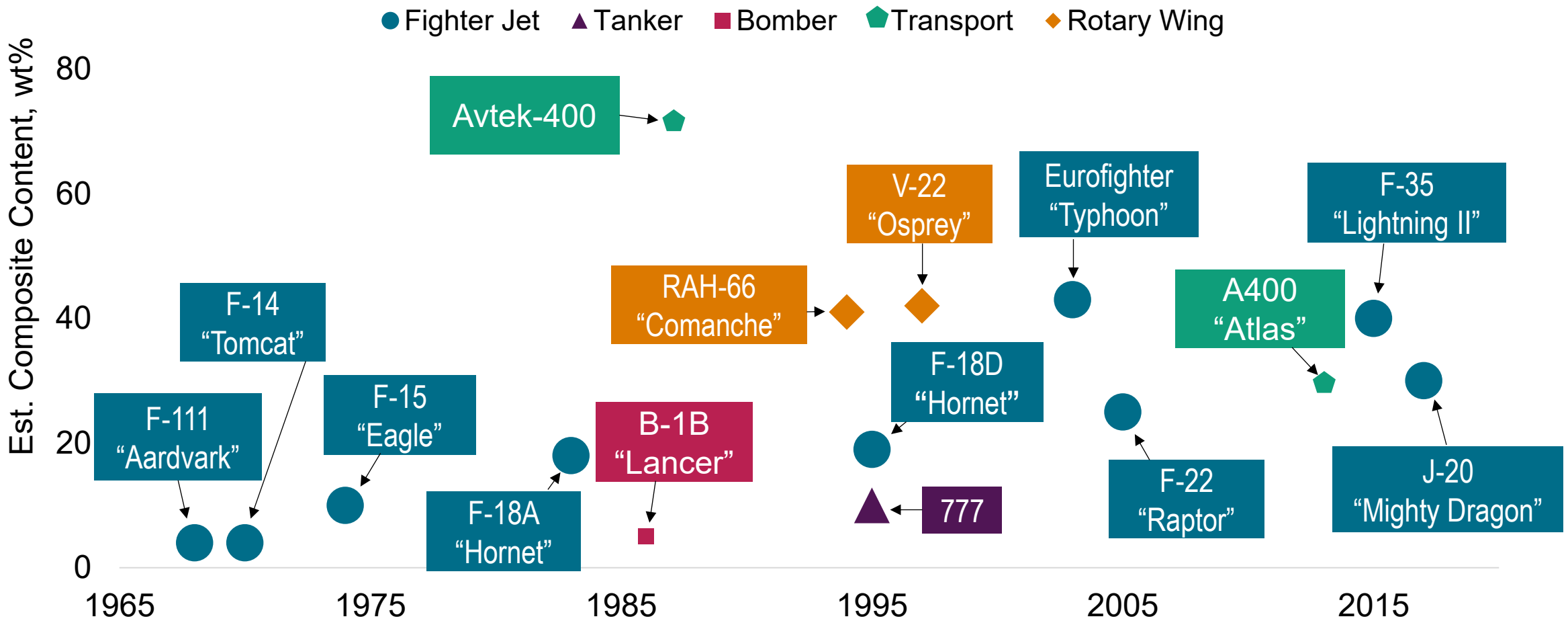


Drivers

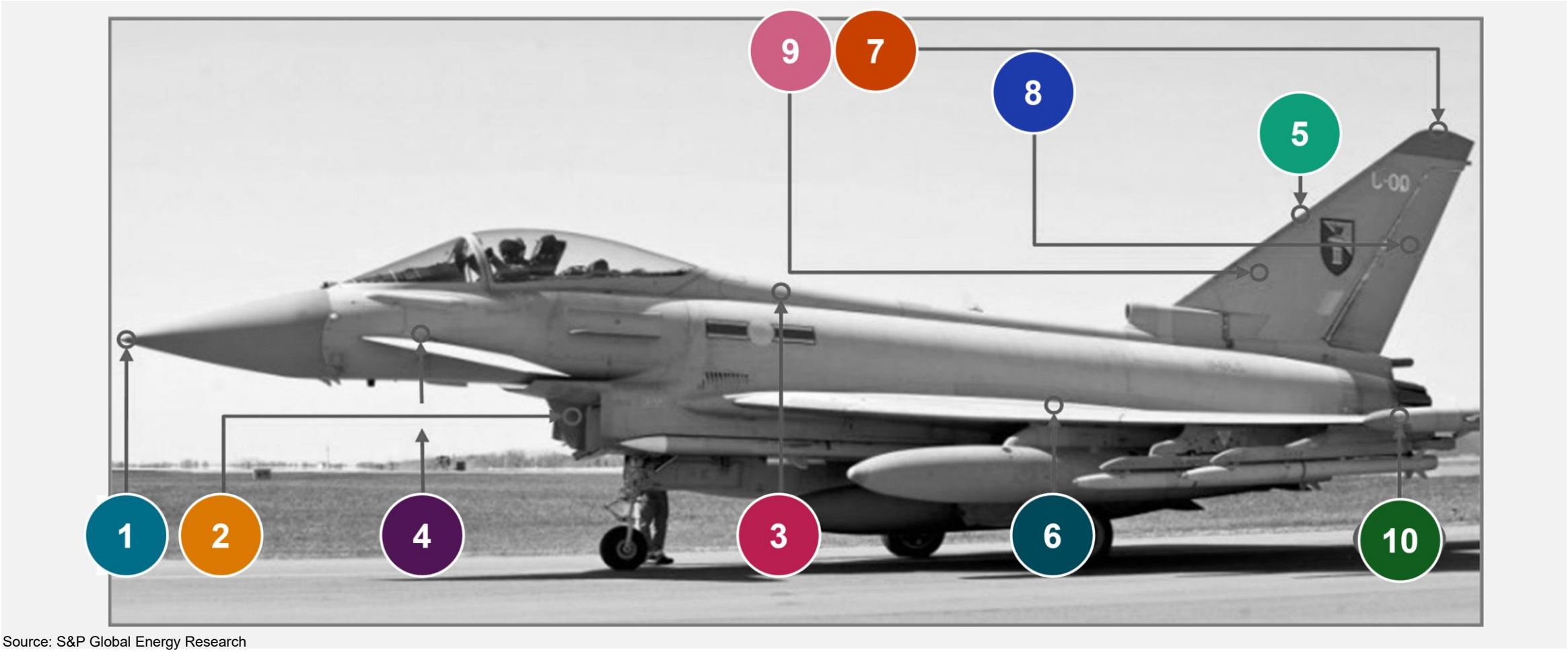
	Sporting Goods: Consumer demand for high-performance, lightweight equipment and innovation in sports technology driving market growth.
	Industrial: Rising demand in non-automotive pressure vessels, Marine, Civil, Electrical, and electronics applications
	Oil and Gas: Offshore exploration, pipeline upgrades, and demand for corrosion-resistant materials and increasing CNG refueling stations.
	Automotive: Shift to electric/hydrogen vehicles, emissions regulations, and pressure vessel growth for hydrogen/CNG fueling demand for lightweight, durable components. .
	Defense: Rising global defense spending, military aviation modernization, and advanced materials adoption for next-generation platforms
	Aerospace: Aircraft fleet modernization, fuel efficiency mandates, and rising defense budgets driving adoption of advanced lightweight composites.
	Wind: Capacity additions (greenfield projects and repowered additions), increasing blade length, increasing CF content in blades, development of CF cable-stayed rotor wind turbine, introduction of CF-based cables for power transmission.

Source: S&P Global Energy.

After a “slow start,” composite use markedly increased in military aviation; likely to accelerate further as performance requirements increase

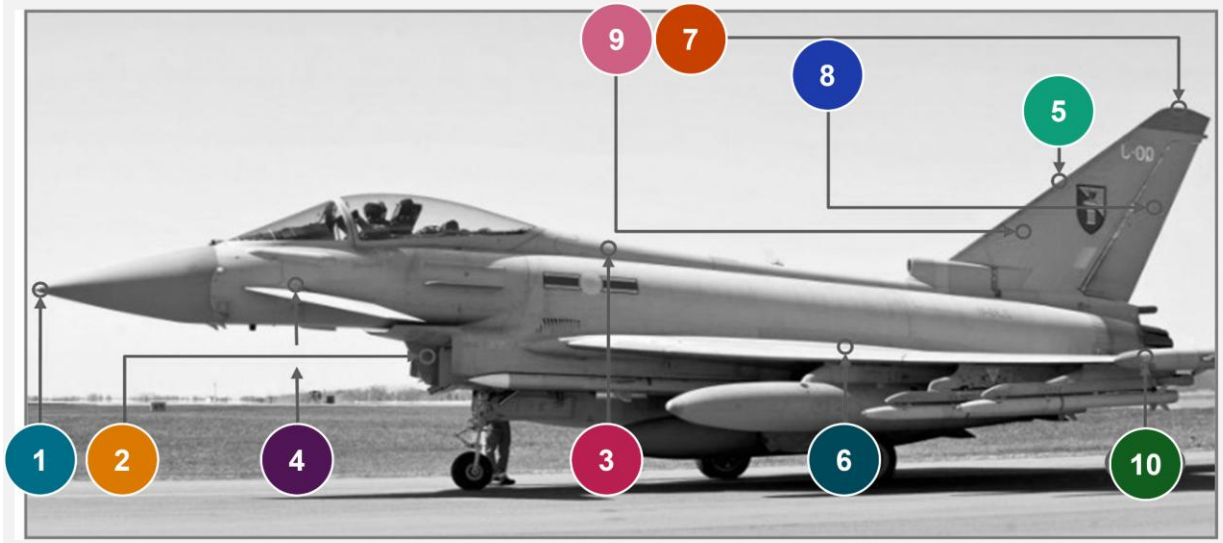


Modern aviation “platforms” need composites to achieve current performance needs covering speed, operational ceiling, payload and range



Source: S&P Global Energy Research

Innovations cover composite use in primary and secondary structure; thermoset systems predominate but thermoplastic systems emerging



Source: S&P Global Energy Research

1	**Radar transparent radome**
2	**Engine intake/wing extension**: Epoxy-CF prepregs
3	**Fuselage panel sections**: Epoxy-CF prepregs; non-metallic honeycomb core and Redux® adhesives
4	**Leading edge devices/canards**: Epoxy-CF/GF prepregs
5	**Fin fairings**: Epoxy-CF/GF prepregs
6	**Wing skins and ribs**: Epoxy-CF/GF prepregs
7	**Fin Tip**: Epoxy/quartz-CF prepregs
8	**Rudder**: Epoxy-CF prepreg
9	**Fin**: Epoxy-CF/GF prepregs
10	**Flying Control Surfaces**: Epoxy-CF/GF prepregs; honeycomb core material and Redux® adhesives

New developments are needed in manufacturing existing/new materials to meet the challenges of future defense performance needs

Major focus on ceramic matrix composites (CMC)
- Lightweight
- In-service high temperature operation

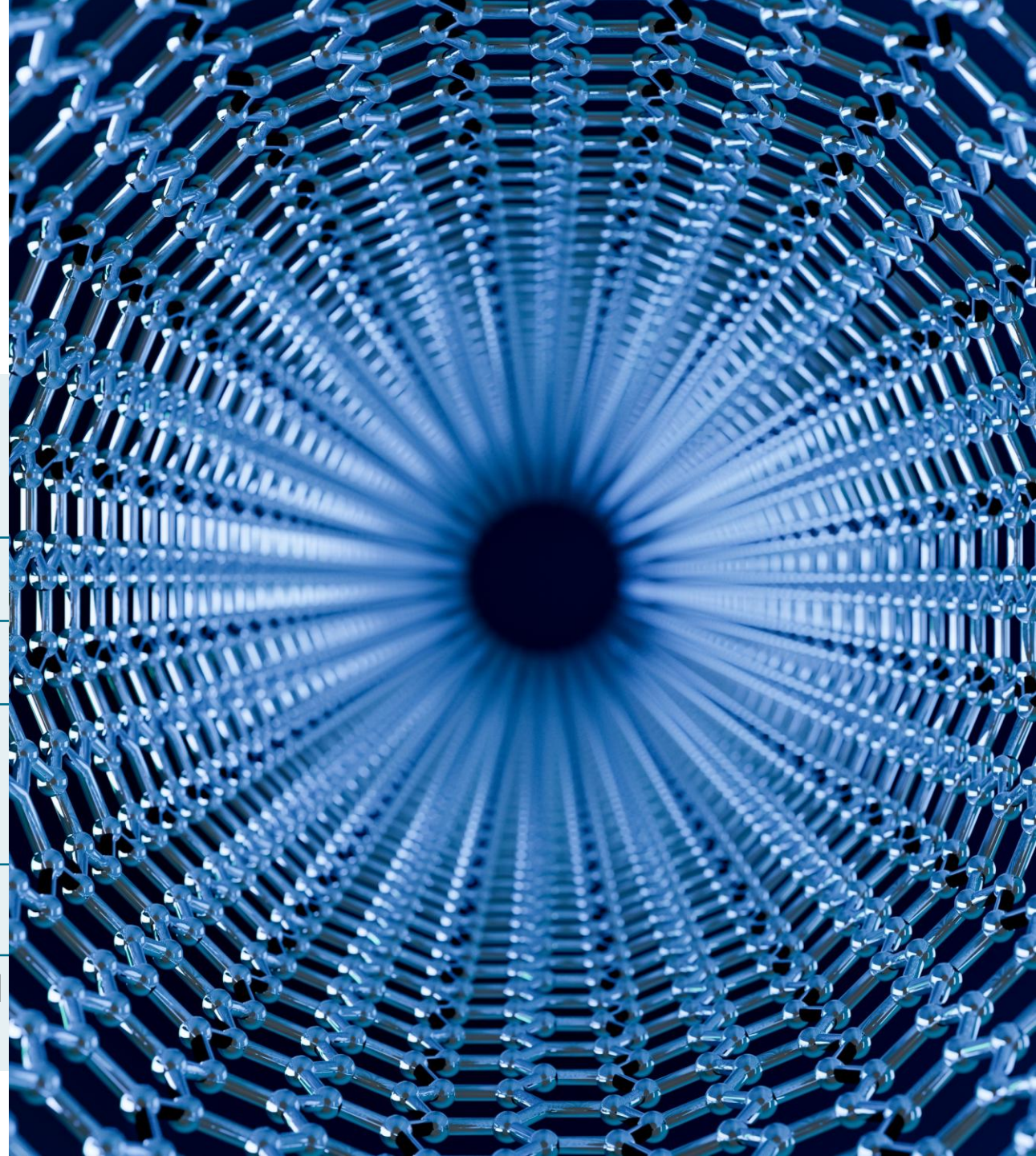
Chemistries involve silicon carbide, etc.

Substrates include carbon and SiC fibers

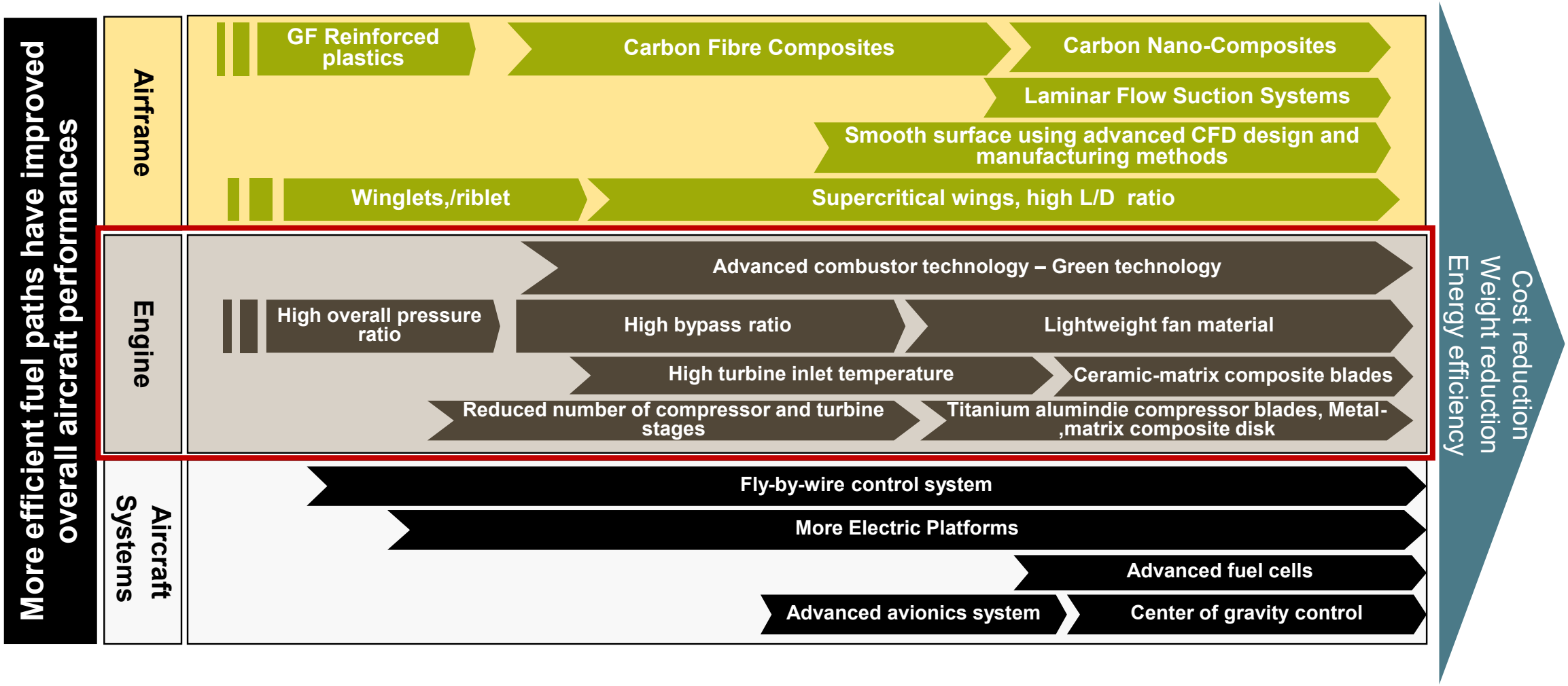
Manufacturing routes include:
- Polymer Impregnation and Pyrolysis (PIP)
- Chemical Vapor Infiltration (CVI), etc.

Maybe we need new substrates?

Organizations like GE Aerospace, Safran, NASA, and AECC in China leading developments



New substrates could include new forms of carbon fiber made from carbon nanotubes (CNT) provided CNT scale economies can be achieved



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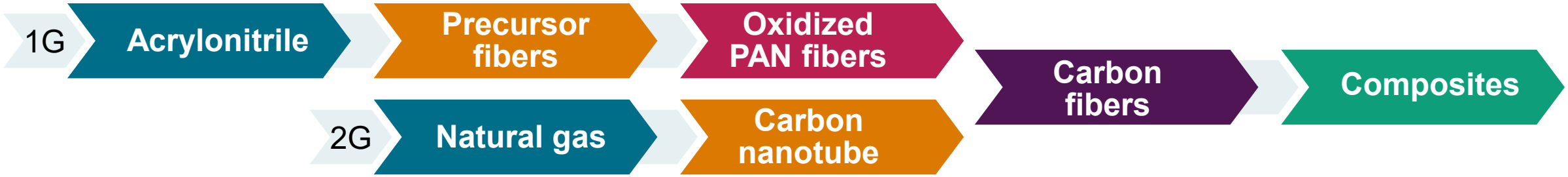
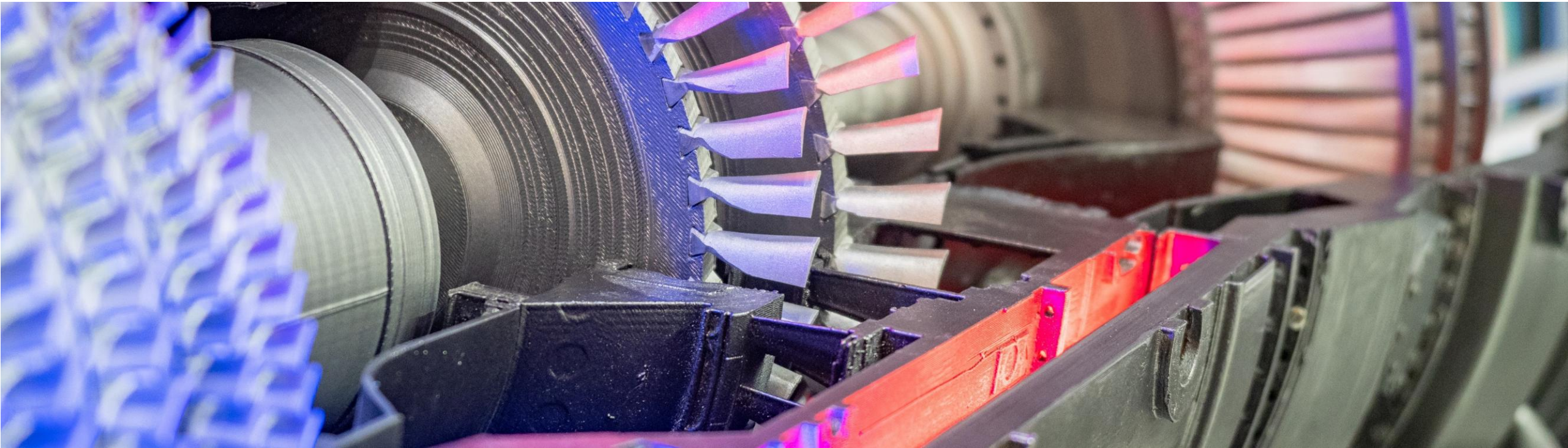
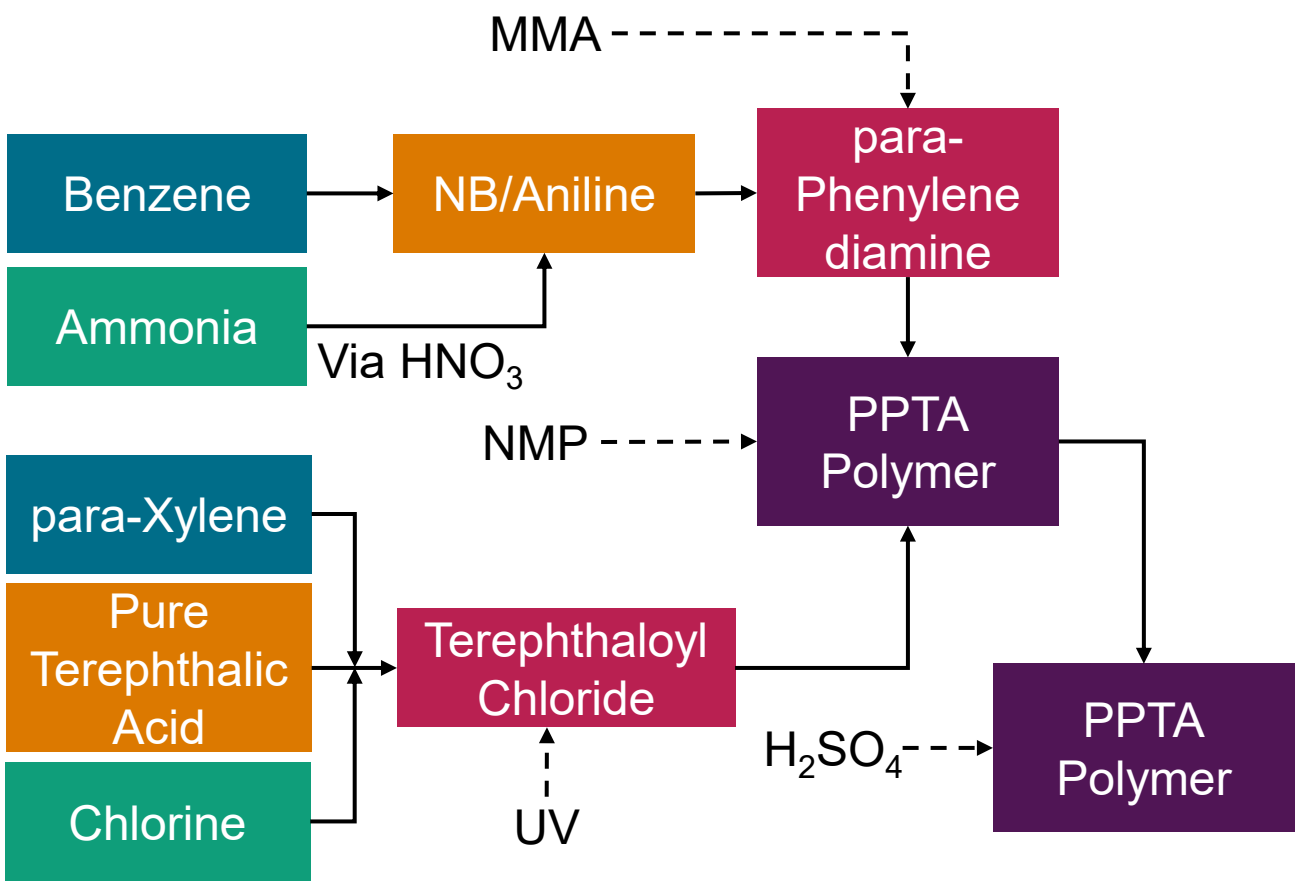




Supply chain challenges

- Specialty fibers
- High-performance thermoplastics

Para-Aramid (aromatic polyamide) production involves several steps which should ideally be integrated with ready access to building blocks



Complex chemistry

"Improved" chemistry

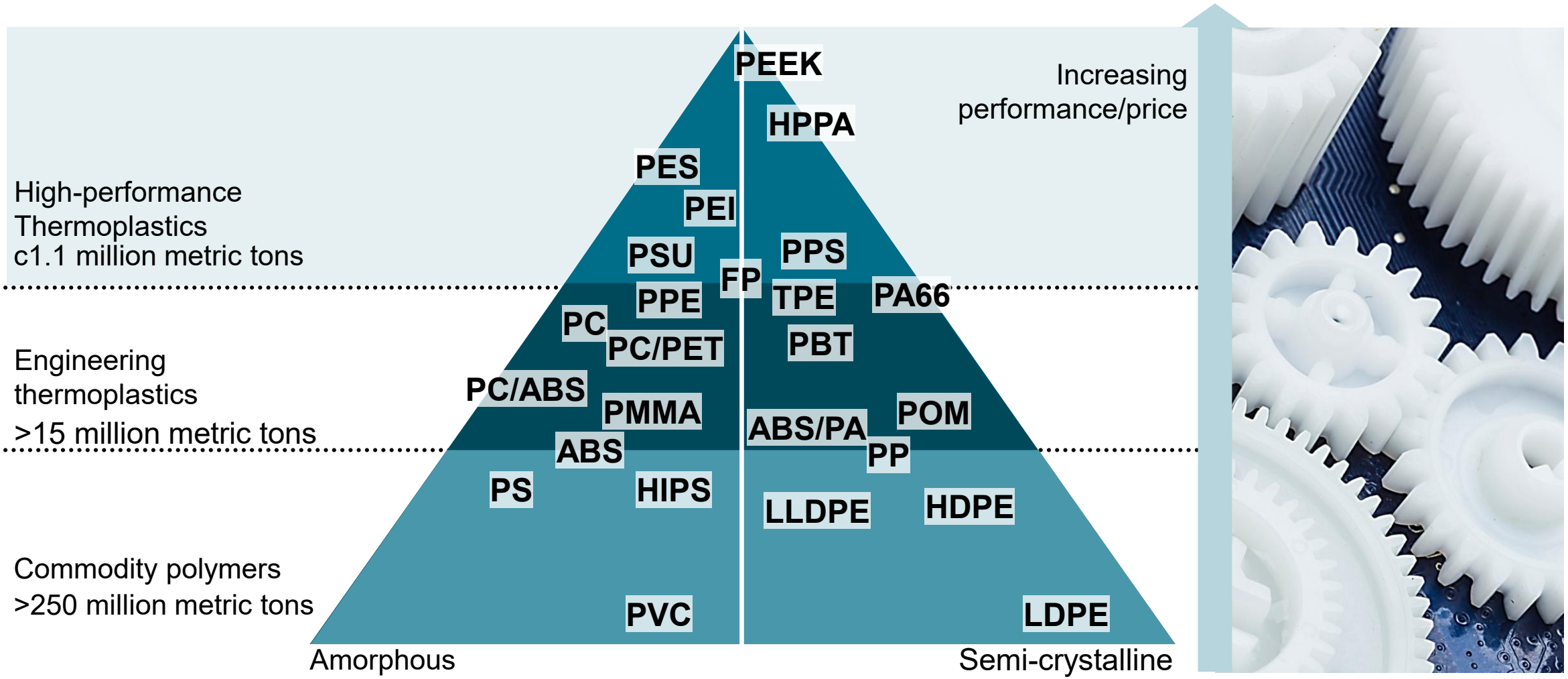
Integration ideal

Environmental challenges
- Potential carcinogens
- Maximize recycling

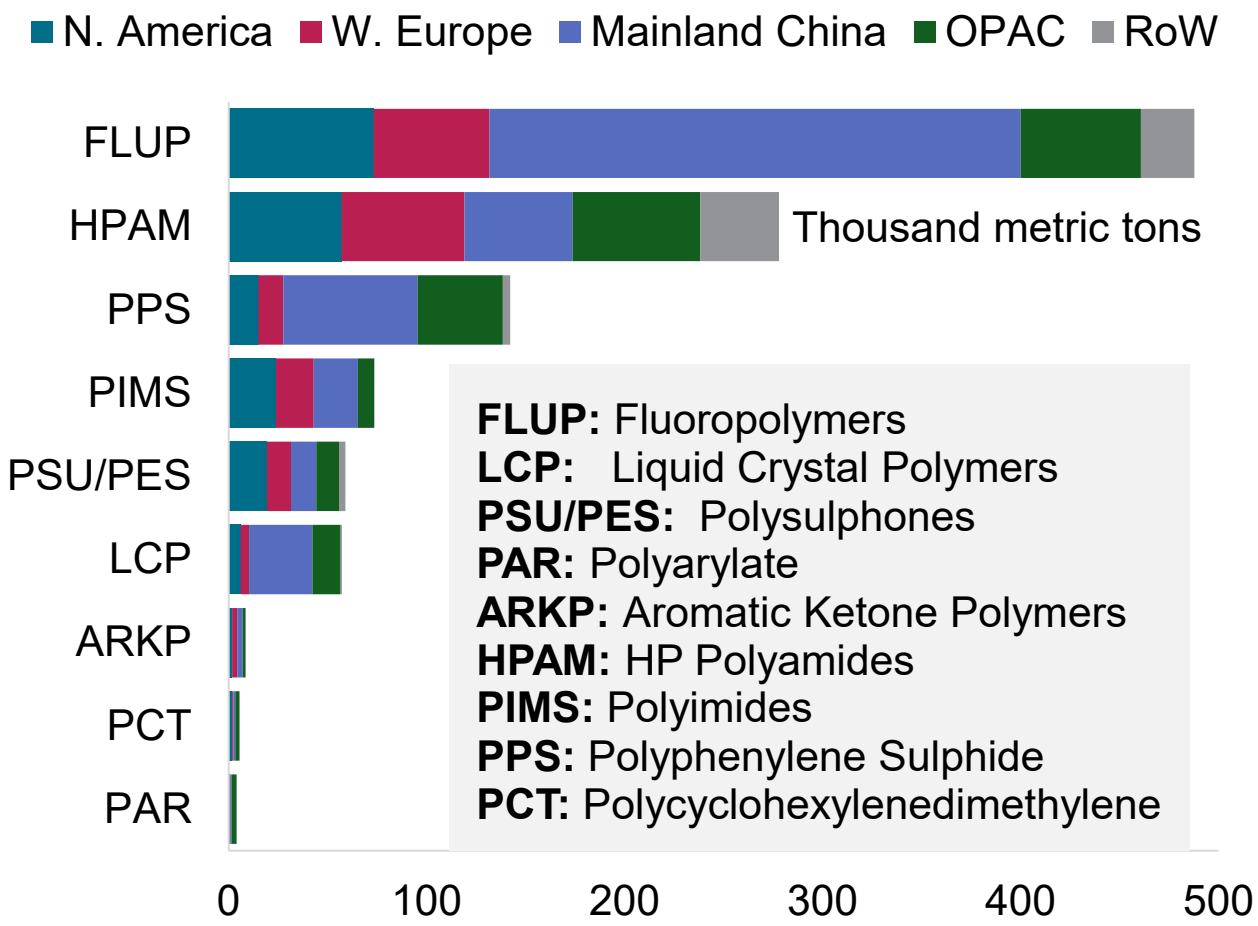
Ex-country intermediate supply

Potential supply disruption

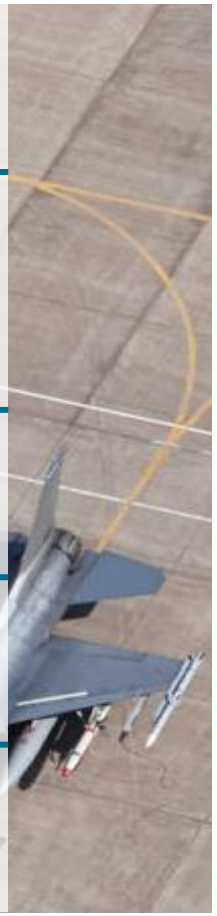
High-performance thermoplastics exhibit high heat, high strength, durability, etc., but market is relatively small, and synthesis is complex



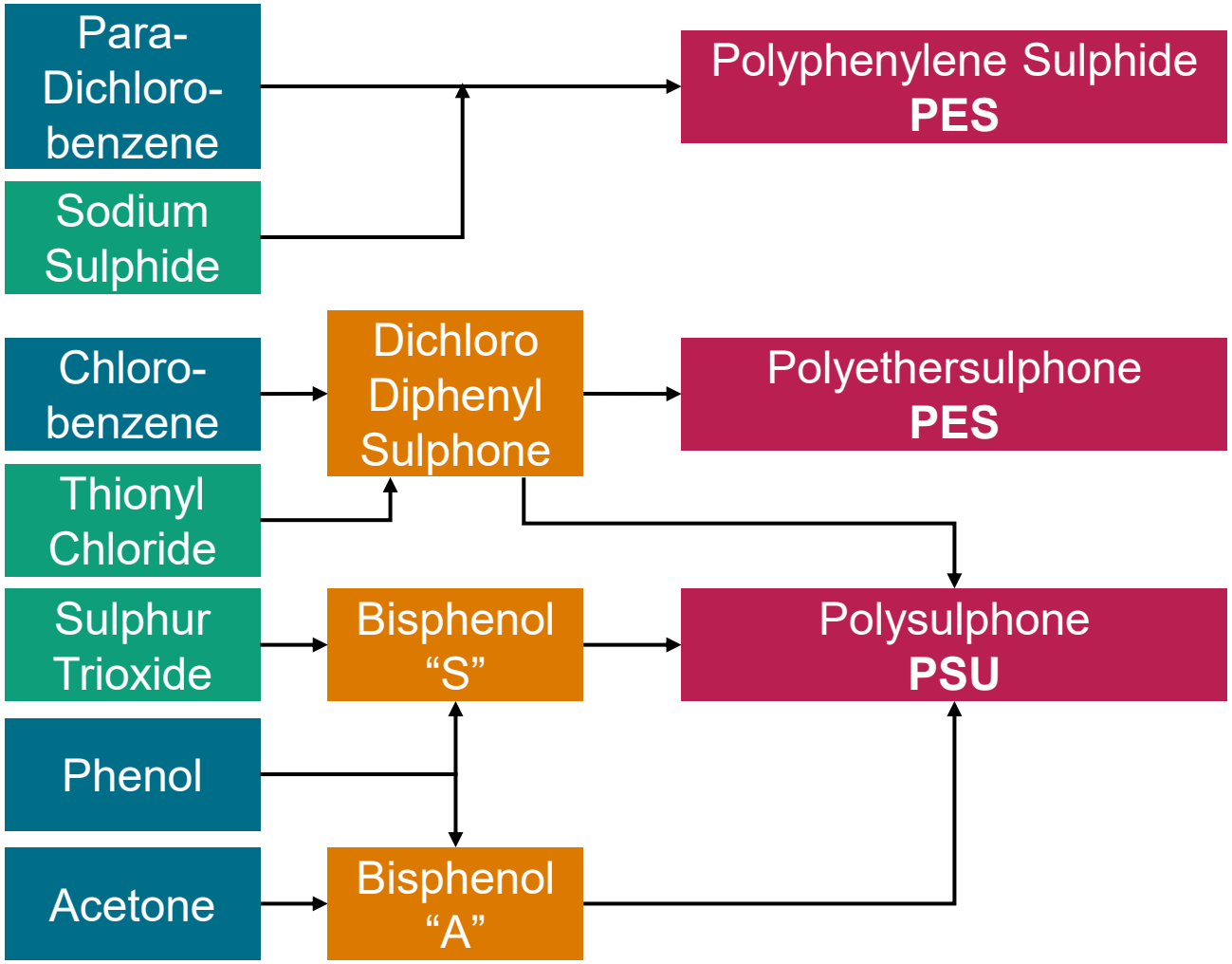
High-performance thermoplastics serve applications in aviation, automotive, E/E, medical and industrial sectors – now seen in composites



- Growth ahead of average GDP
- Strong growth in E/E, aviation applications
- China looking for self-sufficiency
- Branding is key
- Reliable quality imperative



Many high-performance plastics are linked back to aromatics and include inorganic components, often with challenging steps



Complex chemistry

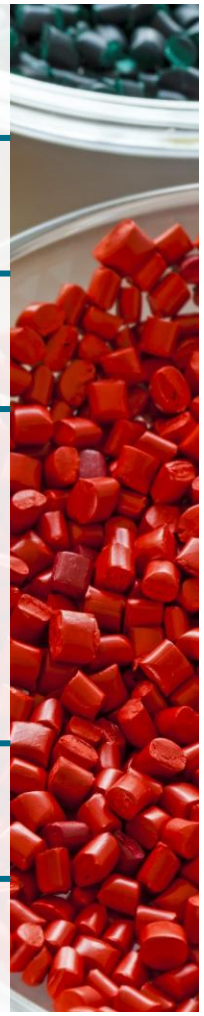
"Messy" chemistry

Integration ideal

Environmental challenges
- Permits to operate
- Movement restrictions

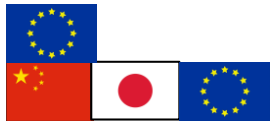
Ex-country intermediate supply

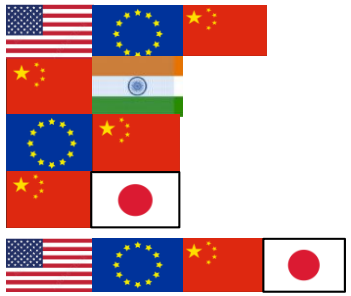
Potential supply disruption

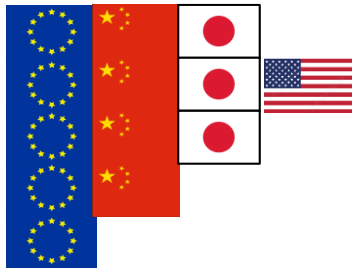


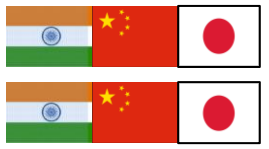
Many key building blocks for high performance engineering polymers are now imported and not made locally in the US

- Polyether Ether Ketone (PEEK)
  - Difluorobenzophenone – from MDA
  - Hydroquinone
- Polyetherketoneketone (PEKK)
  - 1,4-bis(4-phenoxybenzoylbenzene)
  - Terephthaloyl / isophthaloyl chloride (TCL/ICL)
- Polyimides
  - Trimellitic anhydride (TMA)
  - Pyromellitic dianhydride (PMDA)
  - benzophenone tetracarboxylic dianhydride (BTDA)
  - 4,4-Oxydianiline (ODA)
  - 4,4′-methylenedianiline (MDA)
  - p-/m-Phenylene diamine (PPDA/MPDA)
- Specialty Polyamides
  - Lauryllactam
  - Dodecanedioic acid (DDDA)
  - Dodecanediamine
  - Putrescene/Cadaverene
  - Aminoundecanoic acid
- Liquid Crystal Polymers
  - p-hydroxybenzoic acid
  - 4,4′-dihydroxydiphenyl
  - 6-hydroxy-2-naphthoic acid





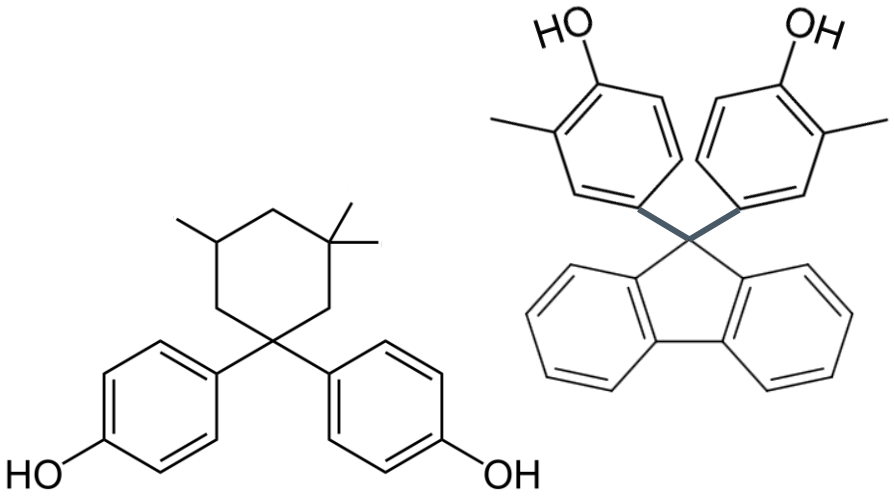


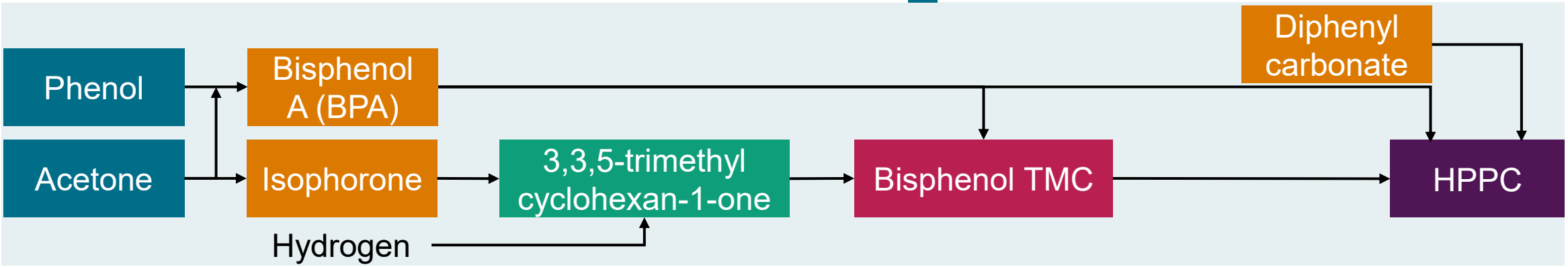


Enhancing current materials through innovation and new chemistries

Judicious comonomer use can significantly enhance properties of medium performance engineering polymers for improved strength, heat resistance, etc.

- Global polycarbonate market 6.5 million metric tons
- HPPC demand around 5-8% of total market
- Focus on high heat/higher temperature operation
- Different comonomer solutions exist such as :
  - Bisphenol TMC – derived from acetone and BPA
  - Biscresol Fluorene (BCF) from coal tar, etc.
- More civil-defense-focused product, e.g., firefighting
- Also used in automotive, medical, lighting, etc.





Key messages

Key Messages

- Geopolitical dislocations and two major conflicts, Ukraine and Iran, have been resetting the calculus and outlook for Defense around the world
- Substantially expanded budgets for Defense represent an unequivocal opportunity for the main players in its supply chain, of which the Chemical Industry is one
- Supply security, advanced manufacturing, and making innovation count, are they issues that the Chemical Industry is eminently well positioned to address – this in the context of disproportionate sourcing and production shifts from West to East, primarily in China
- We understand the Defense supply chains from minerals, raw materials, intermediates, to advanced materials with a “line of sight” into weapon systems
- While any and each of those steps may be critical to military strategies and deployment, the Advanced Materials space presents some specific vulnerability
- We see Defense platforms evolving calls for ever higher performance, need for new materials and chemistries, wider theatres of operation
- With multiple chemical innovations within grasp, we cannot emphasize enough the need for significant R&D spend and targeted investment

Q&A Session

Let's connect!

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