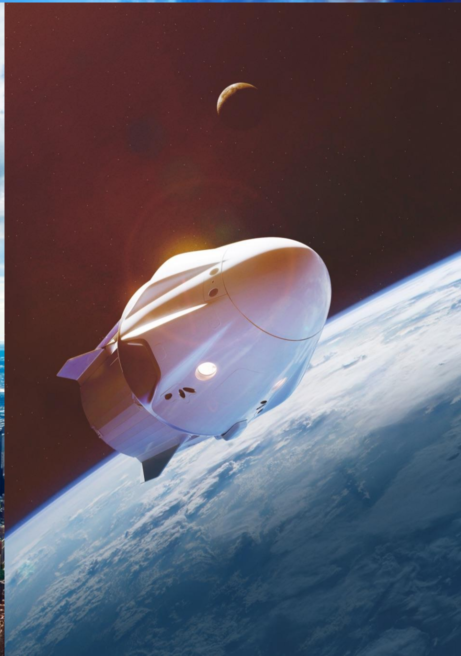
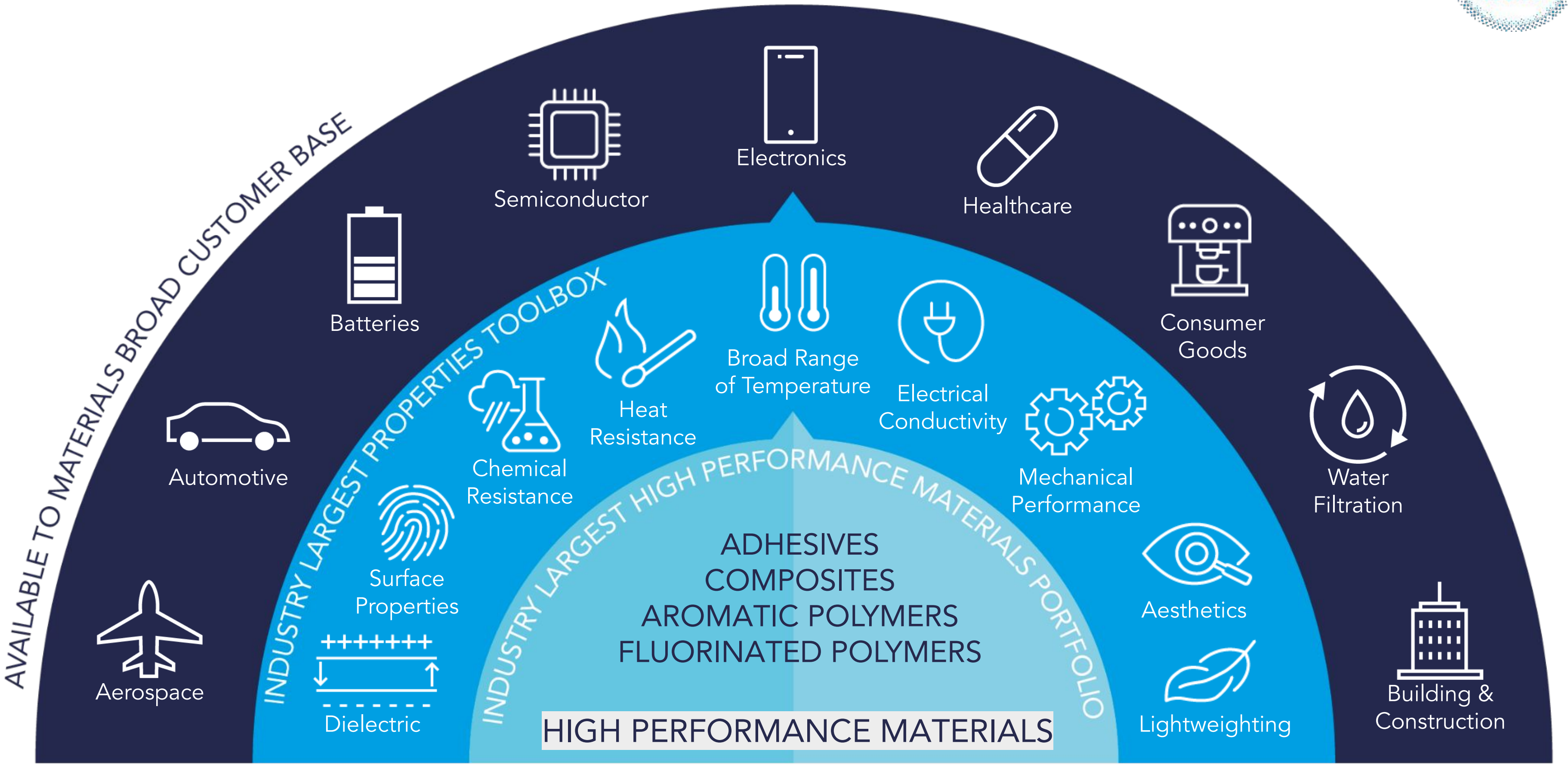
Progress beyond

What’s Next?

Stephen Heinz



SOLVAY MATERIALS AT A GLANCE



Materials Matter for Step-Changes in Vehicle Design

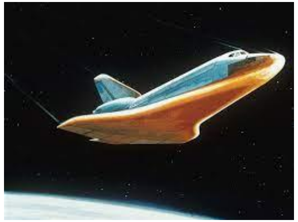
SOLVAY

History shows advances in *Material System* is at the forefront of any new class of aerospace vehicles

Speed / Envelope


New Alloy formation for Inconel and Ti to achieve mission requirements

Polymer composite edges to sustain high-mach stiffness need



Need of exotic composites and materials such as ceramic tiles and C/C edges

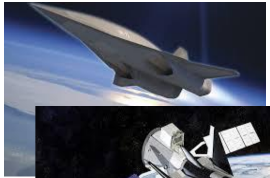
New Al alloy and advanced composite to enable weight savings and large integrated assemblies

New materials were critical to achieve cross-atlantic and/or mission range




Highest composite usage in commercial aviation for weight savings

Enabler of range, cabin comfort, lowest maintenance cost and lowest fuel burn in the history of wide-bodies


Next-gen high-temp/ high-rate, high stiffness and damage tolerant composites will enable efficient and sustainable urban, hypersonic and space travel

Past

Materials are a pillar of design innovation

Future

Materials Matter for Production System Evolution

SOLVAY

Production System Need

2000's

Defense and space - affordable prototyping, low rate production

Out of Autoclave processes, affordable tooling for large structures

Complex, larger integrated structures and shapes

Automated Tape Laying, AFP, Hot Drape Forming, Cocuring of large structures

2010's

High Rate Composite Structures

High performance resin injection systems - resin & fiber forms

High volume, high rate thermosets, (aero performance with auto rate)

Rapid press cure for small to medium parts

Production Needs driven by new and upcoming aerospace markets

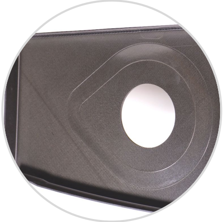
Materials and Manufacturing Solutions for new aerospace market segments (Space, HSCT, UAM etc.)

2020's

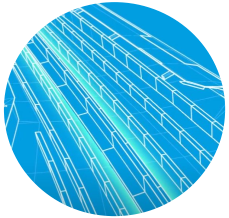
Image courtesy of Virgin Galactic

Image courtes

Image courtesy of LEAP



Part courtesy of Boeing RAPM program



M&P Industry Innovation

Materials and Processes are strictly connected and interdependent

Materials Matter to Enable Market Evolutions

SOLVAY

Emerging Propulsion Technologies

Environmental Sustainability Trend is driving Propulsion Technologies

Materials matter to enable new and emerging requirements (battery boxes, pressure vessels, efficient blades, temp and chem resistance)

New Design and Mission Envelopes

New Mission Requirements drive new complex shapes and multifunctional requirements

Materials matter to enable design envelope not achievable with current design philosophy

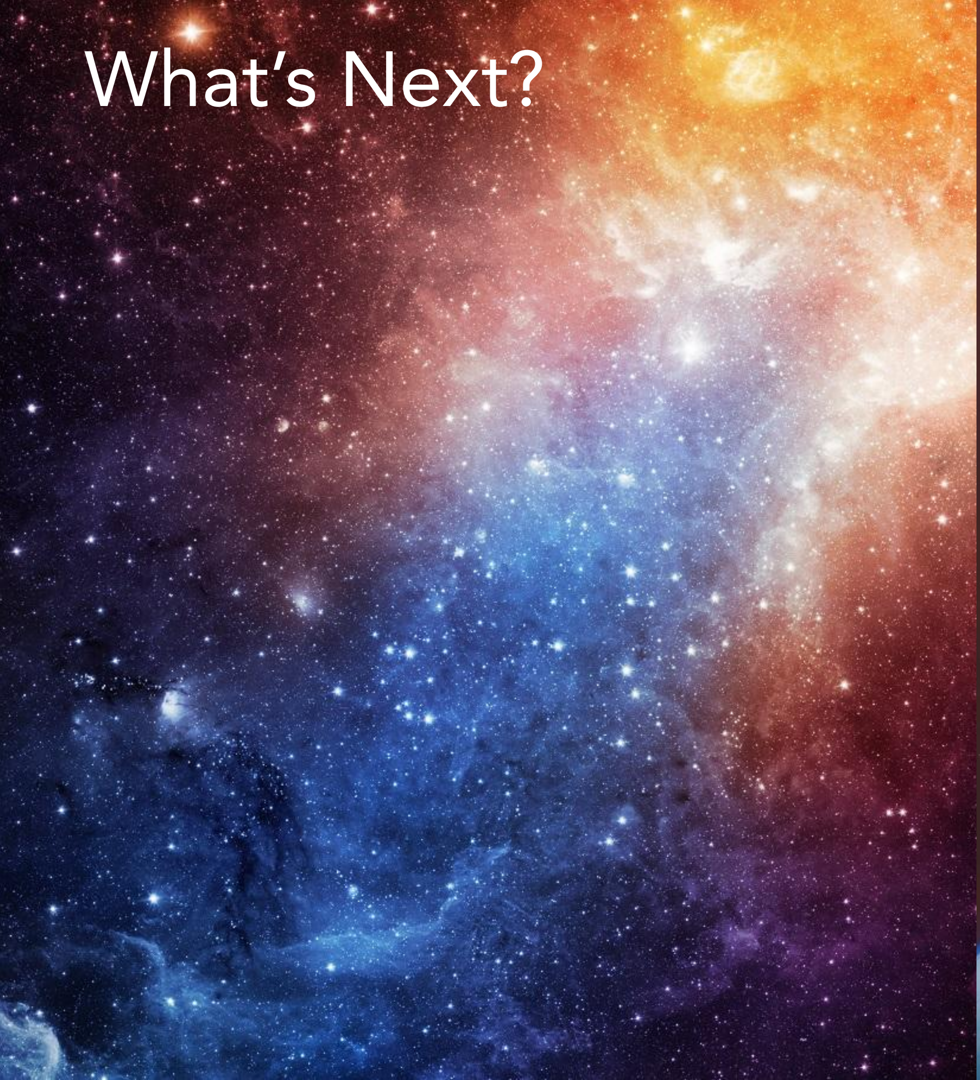
Higher Manufacturing Demands

Higher manufacturing rates are driving need for materials-for-manufacturing

Materials Matter to enable higher mfg rates, more quality robustness, greater process capability.

Evolving market needs drive material development technology

What’s Next?



Progress beyond

Are materials the what or the hov

"Next Generation" of Composite M&P Needs

SOLVAY

High Rate Composite Fabrication

- Future Single Aisle
- UAM
- LCAAT

Robust Finishing & Assembly

- Advanced automation
- Bonded / Joined structures
- Quality and Inspection / Cert.

Materials with Balanced Cost and Performance

- Lightweighting driven by ultimate performance
- Broad application requires affordable implementation

Extreme Environments

- Space
- Hypersonics / Fast Platforms

Sustainability

- No longer a nice to have
- Regulation and consumer driven

High Rate Composite Fabrication

High Rate Fabrication - Framing the Problem

What is considered high rate?

All parts are not equal

Small vs. Medium vs. Large structures

Part Complexity

Part count / commonality

Integration vs assembly

Monolithic vs core stiffened

Where do you focus your efforts?

Cure dwell

Deposition rate

Integration

Temp ramp

Quality / Inspection

Finishing

Assembly

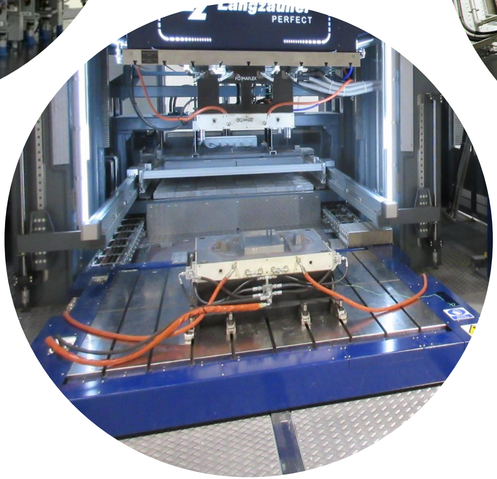
Automation

Thermoplastics

Does improving one area lead to a different choke point?

To better understand and achieve high rate, we must avoid functional silos and focus on understanding trade-offs

Automation Technologies for High Rate



Where are the gaps in automation technology?

Multiple Material & Process Options for Rate

Balancing rate, performance and quality

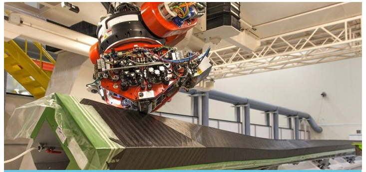
Resin Infusion

IRKUT MC-21

Airbus / Bombardier A220

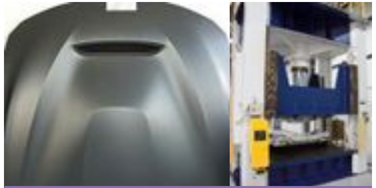
CFM LEAP

Traditional Thermoset Prepreg

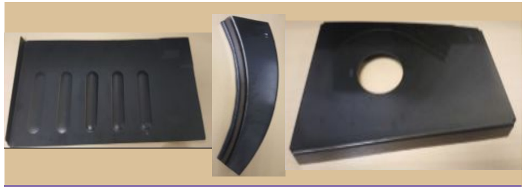


AFP and ATL

Cryogenic Tank (NASA & Boeing)



Automotive



Aerospace

High Rate Press Manufacturing

Cleansky EcoDesign Demonstrator

Fokker Tapas Torsion Box

Airbus A400M Cockpit Floor

Thermoplastic Composites

Future Developments Must Focus on Extracting More From Existing Materials *and* Custom Developments for Future Manufacturing Approaches

Robust Finishing & Assembly

Composite Finishing and Assembly

Composite Materials and Fabrication get 90% of the attention,
but the other steps can cause 90% of the problems

Surfacing and Lightning Strike protection

Traditional Drill and Fill (tolerancing, shimming)

Surface prep and Bonding

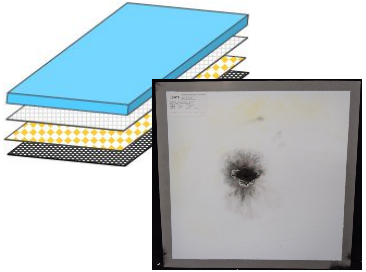
Paint, paint, paint

Increased attention on innovation after the part fabrication is needed to ensure continuous improvement in composite utilization

Materials Advancements for Finishing and Assembly

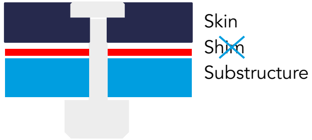
Surface: Weight matters, especially for thin structures

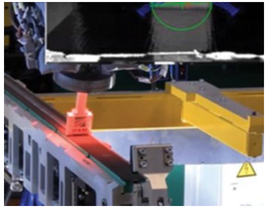
Less Paint, Controlled Paint Thickness



Lighter Weight LSP

Faster Shimming



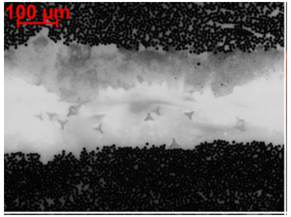


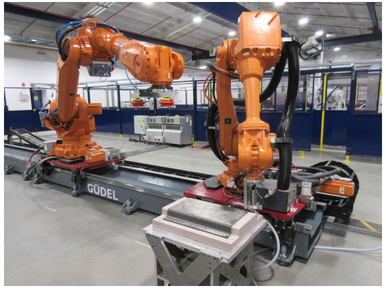
Shimless Assembly

Materials to enable "one-up" assembly

Advanced Surface Prep and Bonding

Indiscernible Interfaces (Welding / FusePly™)



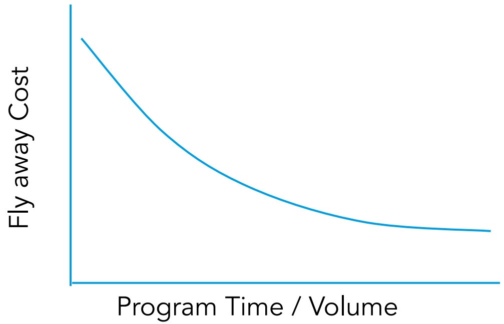


Rapid assembly paste adhesives

Idealized Future: Materials that enable streamlined fly away structure (i.e. Combination of manufacturing steps)

Materials with Balanced Cost and Performance

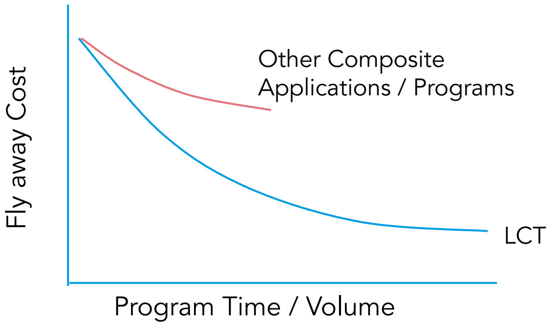
Affordable Performance



787 and A350 have revolutionized composite manufacturing (from material supplier to the OEM)

- Provided opportunities to focus on manufacturing excellence to drive cost out

However, these programs have increased disparity between high volume and low volume applications



Opportunities exist to reduce overall cost, but the industry must be careful to avoid a cost first mentality in order to avoid incrementalism

Innovation for Affordable Performance

Materials:

- Balanced performance and cost matrices and carbon fiber
    - Readily available and scaled raw materials
- Product forms that streamline costs

"Cheap" materials will require willingness to compromise

Standards / Access:

- Qualification / Allowable cost avoidance
- Ease of access / adoption
- Volume through multiple parties / programs

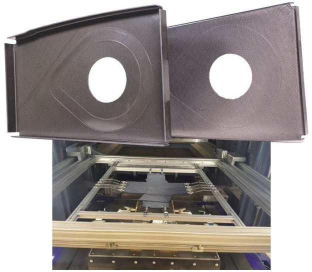
Standardization means no customization

Wichita State University

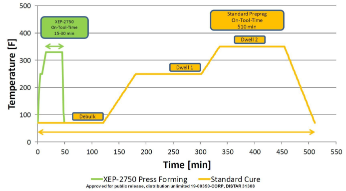
Manufacturing:

- Design for manufacturing
- Affordable tooling methodologies
- Automation (where appropriate)
- Manufacturing step reduction

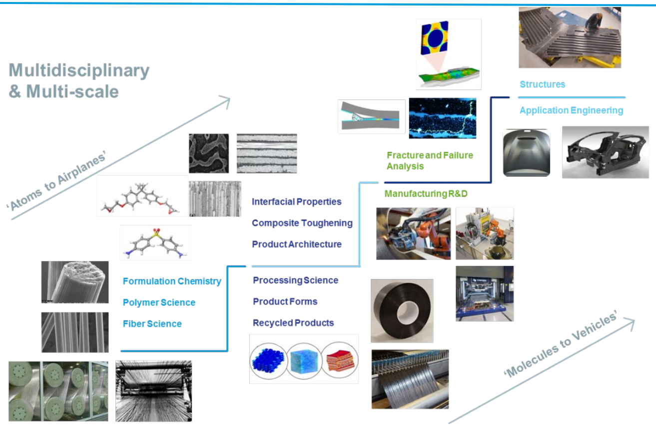
Significant opportunities still exist for designing materials & processes for affordable manufacturing



Rapid Cure Compared to Traditional OoA



Boeing / Solvay DARPA RAPM Program. Approved for Public Release



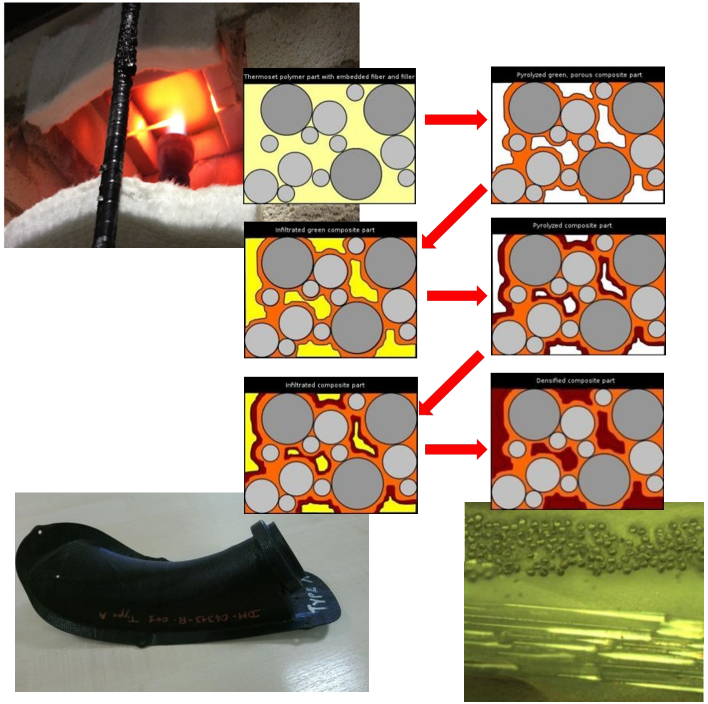
Composite materials are complex specialties, the design degrees of freedom are endless.

Extreme Environments

Extreme Environments

Significant industry investment (Private and Public) in materials development for extreme environments

[Materials Innovation is seen as the enabler!]()

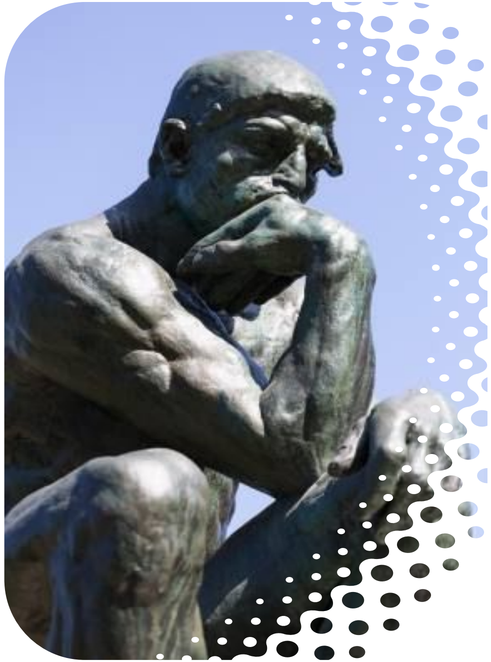


Sustainability

Composites meet Sustainability

What, how and when?

SOLVAY



What is Sustainability?

- *A philosophy?*
- *An opportunity?*
- *A supply chain strategy?*
- *A manufacturing challenge?*
- *A chemical journey?*
- *Is it here to stay, or will it go away?*
- *The responsibility of the individual or the group?*
- *An unanswered question with an impending deadline?*

- *Can it be quantified?*

Path to Sustainability

Composites are biased towards solutions not problems

Efficient use of materials and energy

- Reduced waste
- Energy efficient processing

Better use of materials

- Recyclable by design
- Inspired formulation design
- Simpler materials to begin with.

Responsible sourcing

- Sustainable sourcing
- Reduced use of hazardous materials

In service

- Increased use term
- Ability for easy repair

End of life management

- Simple recycling processes

Circularity?

Composites continue to be part of the sustainability solution, but we can and must do more to make composites themselves more sustainable

Progress beyond

Composites enabled the current generation of flight.

The reinvention of composites will enable the next

Opportunities for innovation are endless

The End