THE CURRENT STATE OF COMPOSITE MATERIALS IN THE BICYCLE INDUSTRY

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YOUR HOST

Richard Matthews, M.A.Sc, P.Eng.
Director, MacFarlane Matthews Innovations Inc.
Senior Engineer at Bridge Bike Works

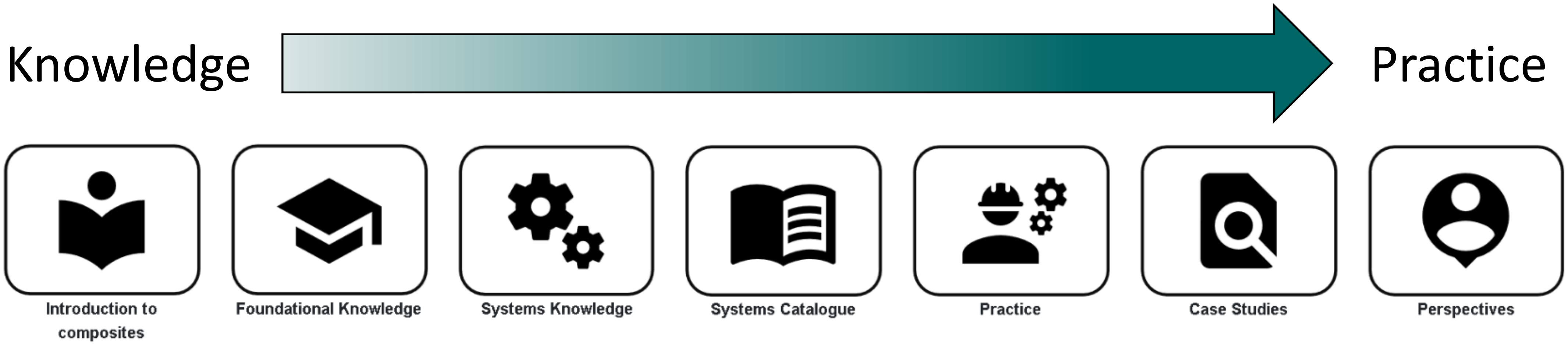
- B.A.Sc. in Civil Engineering
- M.A.Sc. in Aerospace Engineering
- Over 32 years experience in industry and academia working on composite materials, product design and FEA in aerospace, automotive, consumer products and sports industries
- 16+ years experience in the bicycle industry, leading design, development, R&D and manufacturing of high-end composite bicycles
- Experienced with composite manufacturing in Asia, North America and Europe

KNOWLEDGE IN PRACTICE CENTRE (KPC)

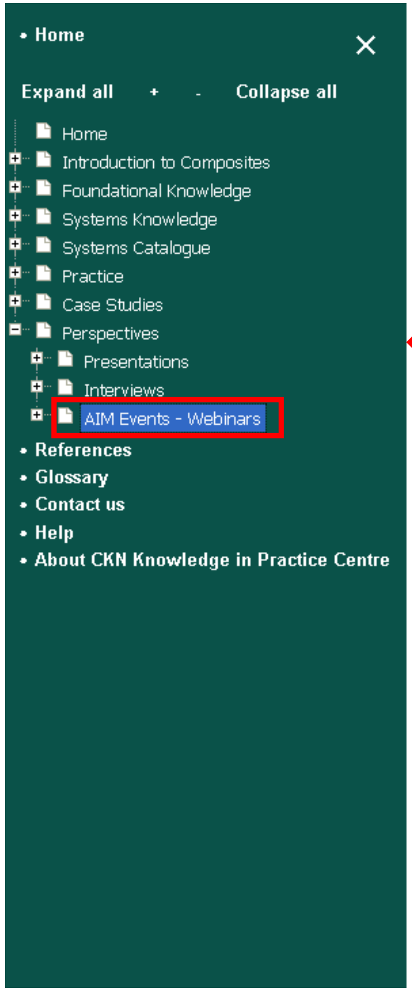
- A freely available online resource for composite materials engineering:

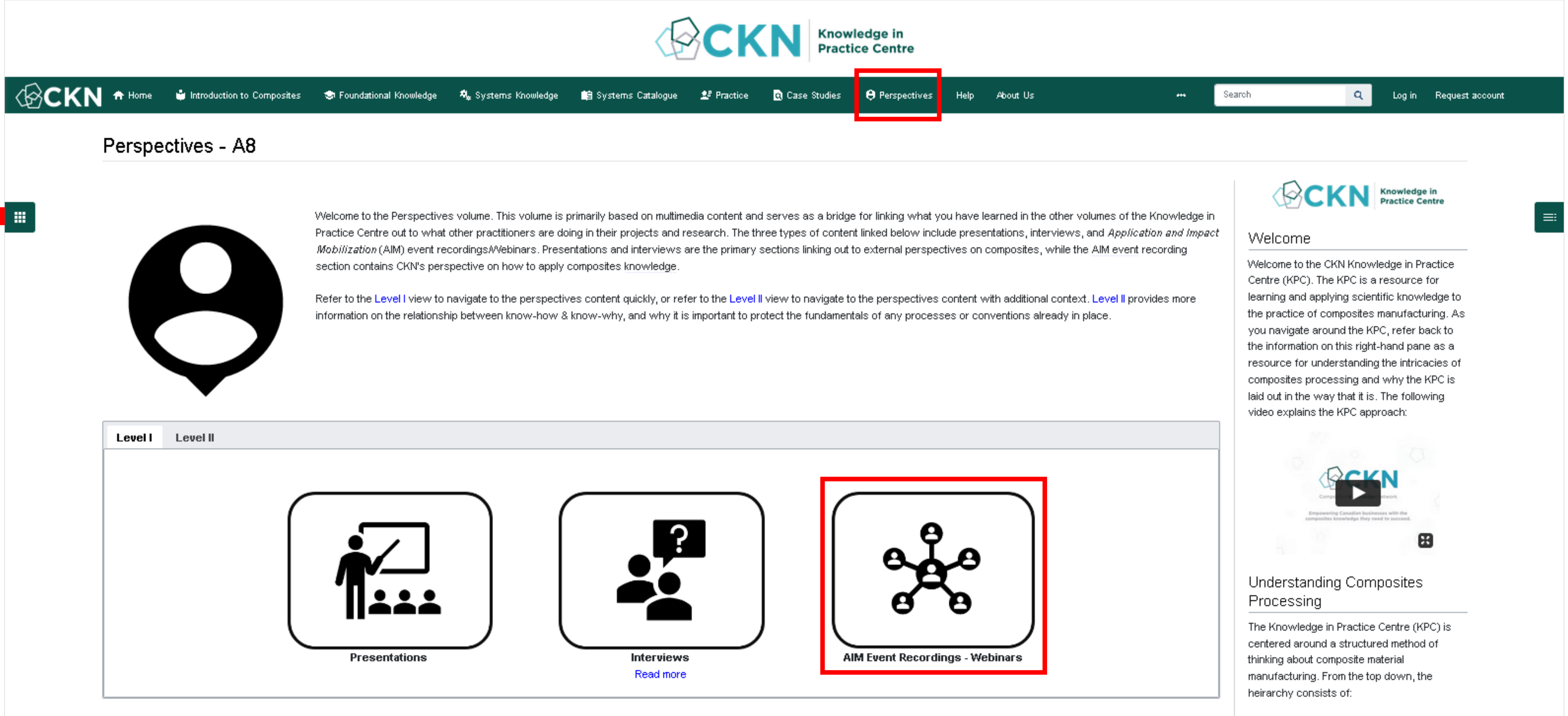
compositeskn.org/KPC

- Focus on practice, guided by foundational knowledge and a systems-based approach to thinking about composites manufacturing



PAST WEBINAR RECORDINGS AVAILABLE





Today's Webinar will be posted at:
https://compositeskn.org/KPC/A377

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TODAY'S TOPIC:

The Current State of Composite Materials In the Bicycle Industry

OUTLINE

- Review of typical carbon composite bicycle manufacturing
- New processes currently in use
- Future potential

Image © Bridge Bike Works

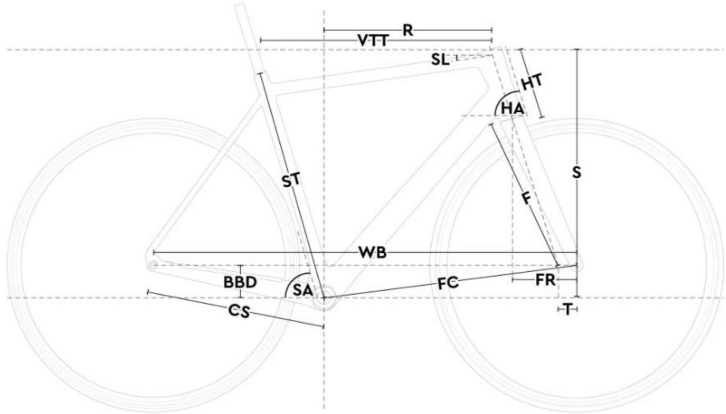
COMPOSITE BICYCLE DESIGN

- Why?
  - Take advantage of the high specific strength and stiffness properties of composites
  - Weight is a critical factor with human powered vehicles
- Typically used mostly at the high-performance / high-cost end of the spectrum
- General Categories
  - Road bikes
  - Mountain bikes

Image © Bridge Bike Works

BICYCLE FRAME KEY DESIGN PARAMETERS

- Road Bikes
  - Rigid frames and forks
  - Pedaling stiffness (BB stiffness) and Steering stiffness (HT stiffness) are critical performance parameters
  - Must meet minimum strength requirements (ISO 4210)
  - Weight is important and critical for race bikes
  - Aerodynamics important esp. for time trial races
  - Frame dimensions (geometry) are primary design parameters
  - Must fit industry standard components
  - Fork strength is a critical design parameter
  - Frame design still driven by UCI rules, even for non-race bikes



	Size 51	Size 53	Size 55	Size 57	Size 59
S-Stack	510	539	568	596	625
R-Reach	376	383	391	398	405

Image © Bridge Bike Works

BICYCLE FRAME KEY DESIGN PARAMETERS

- Mountain Bikes
  - Main styles:
  - Hardtail - HT (similar to road bikes)
  - Full Suspension - FS
  - Strength and durability are critical performance parameters
  - Pedaling stiffness is also important
  - Must meet minimum strength requirements (ISO 4210)
  - Weight is important for race bikes, but shape is not governed by UCI rules
  - Suspension geometry is primary design parameter for FS
  - Stiffness and flexibility (comfort) are important for HT
  - Must fit industry standard components
  - Forks and suspension components typically purchased

Image © We Are One Composites

ISO 4210 KEY REQUIREMENTS

- Primary bicycle safety requirements
- Key tests:
  - Head Tube Impact (falling mass)
  - Pedaling fatigue
  - Horizontal (fore-aft) fatigue
  - Vertical (saddle) fatigue
  - Falling frame
  - Disc brake static and fatigue strength
  - Fork rearward impact (falling mass)
  - Fork steerer impact and fatigue (new)

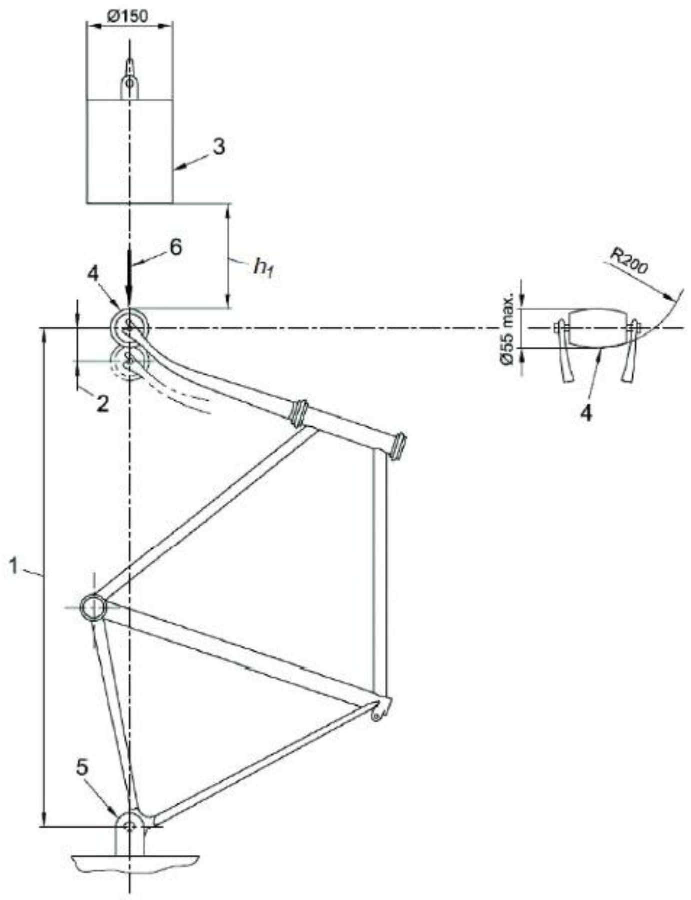
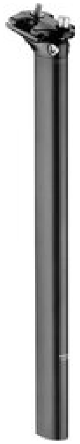


Image © ISO

COMPONENT COMPATIBILITY

- Typically bicycle frames and forks are designed to work with a selection of industry standard components including:
  - Wheels and tires (sizes critical)
  - Seatposts and saddles
  - Handlebars and stems
  - Derailleurs, shifters, brakes
  - Pedals, cranksets (pedal arms)
  - Bottom brackets (crankset bearings)
    - Press fit
    - Threaded



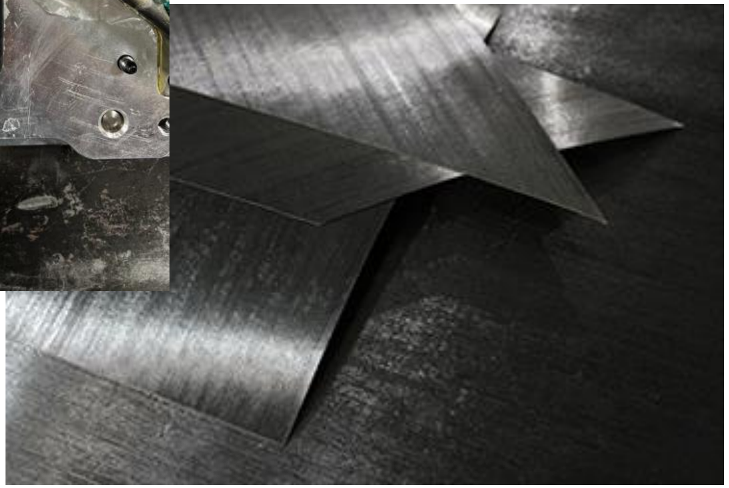
BICYCLE INDUSTRY SUPPLY CHAIN

- 99% of carbon composite bicycle frames are made in Asia
  - Taiwan, China
  - Moving to lower labor cost countries like Vietnam, Indonesia, Bangladesh
- Most components made in Taiwan, China, Malaysia
  - Co-location of frame and component manufacturing has benefits
- Largest markets are US and EU
  - For high end carbon frames
- Asian market growing quickly

TYPICAL MATERIALS AND PROCESSES USED

- Pre-preg (A171)
- Various fibers (A121)
  - Mostly standard carbon and glass
  - Mostly epoxy resin
- Bladder molding
- Various methods for internal pressure application (A182)
  - Air bags
  - Latex bladders
  - Latex over EPS
  - Plastic / wood mandrels
- Female tools in heated presses, air pressure

Image © Bridge Bike Works



TYPICAL FRAME DESIGN

- Hollow tubular structures made in various ways:
  - Semi-monocoque
  - Bonded multi-part
  - Full Monocoque
- Epoxy adhesive used for bonding
- Overwrapping of more pre-preg at joints for cosmetic reasons
- Metal Inserts for critical interfaces

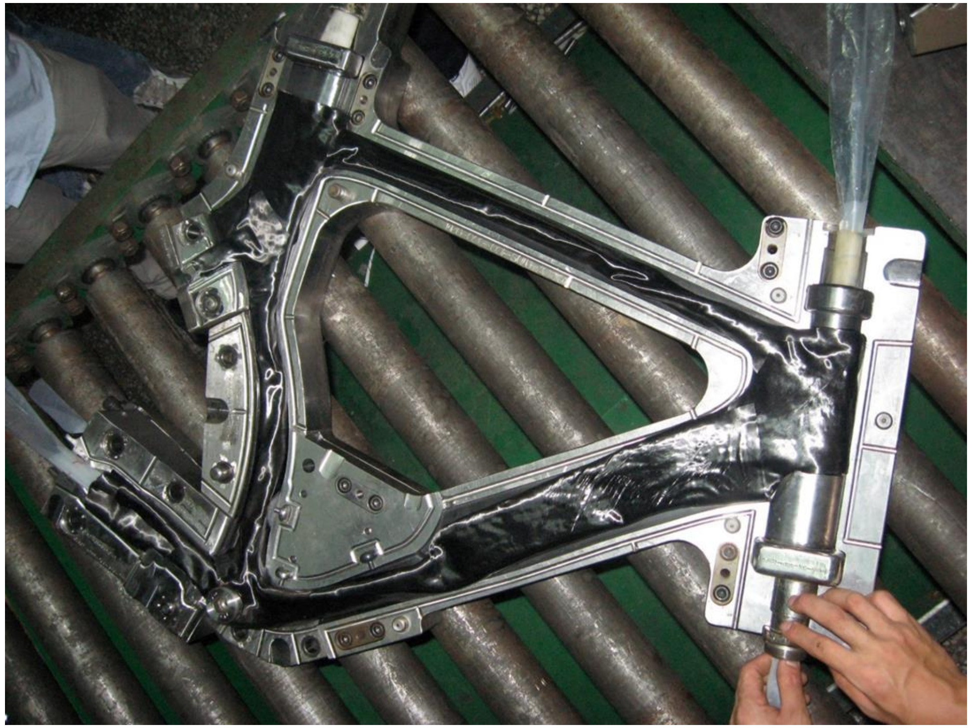
Image © Bridge Bike Works

TYPICAL FRAME MANUFACTURING

- Automated pre-preg cutting and manual kitting
- Hand layup
  - Complex shapes and complicated laminate schedules with very small radius of curvature
  - Plies wrap fully around tubes and in complex ways at transitions
- Manual molding
- Manual clean up and bonding
- Manual finishing and painting

TOOLING

- Main part tools are usually steel
  - P20 for high volume production
  - Aluminum can be used for lower volume and prototypes
- Inserts are used for molding undercuts and complex shapes
- Fittings for air bag or bladder connection are important



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NEWER MATERIALS AND PROCESSES IN USE

- RTM (A126)
- Thermoplastic materials (A161)
- Automated kit cutting and kitting
- Robotic placement
- Robotic sanding / painting
- Natural fibers


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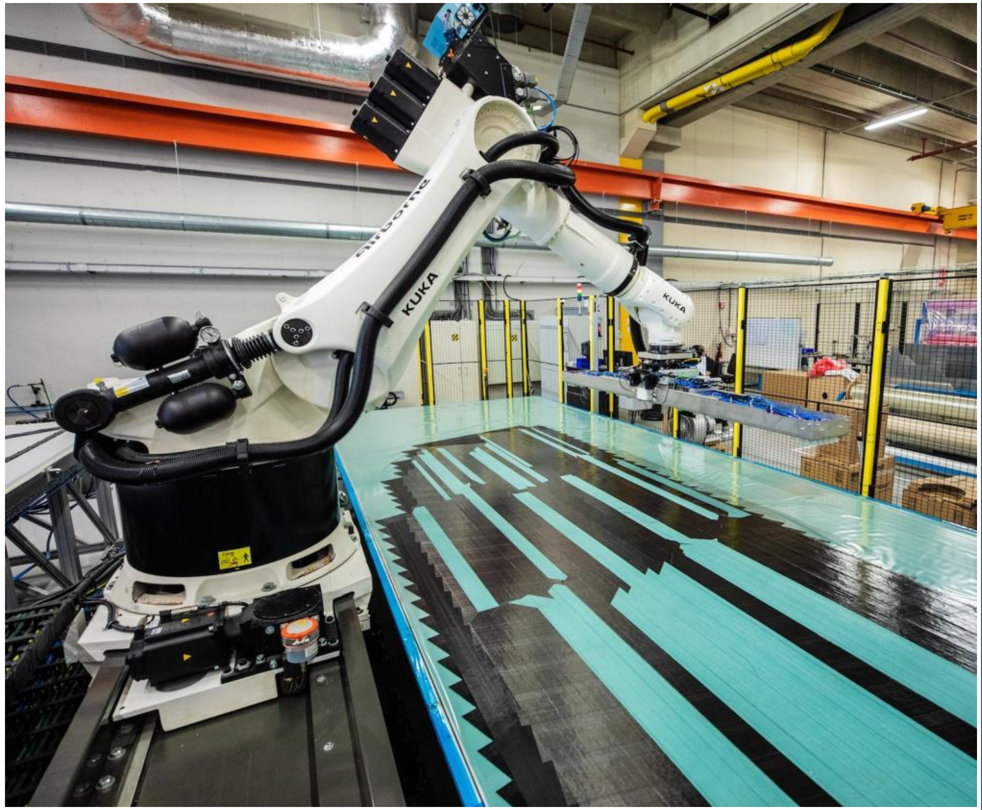
AREAS OF CONCERN

- Sustainability
  - High CO_2 emissions to create fibers and resins
  - Toxic chemicals and VOC's used in resins
- End of Life
  - Thermoset resins typically not recyclable, must be burned or landfill
  - Difficult to separate fibers from resin
  - Fibers often shortened in separation, leading to downgrade of performance for recovered materials

POTENTIAL FUTURE TECHNIQUES

- Automotive style processes and cycle times
- Automation to reduce labor costs
- AI for design / layup optimization
- Design changes to better suit automated manufacturing
- Recycling / re-use of end-of-life products



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Thank you for joining us!

Keep an eye out for upcoming AIM events:

"An Introduction to Quality Assurance and Quality Control in Composites Manufacturing"
Hosted by Dr. Casey Keulen
February 26, 2024
https://compositeskn.org/KPC/A378

And don't forget to visit the KPC for more information:

https://compositeskn.org/KPC

Today's Webinar will be posted at:
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