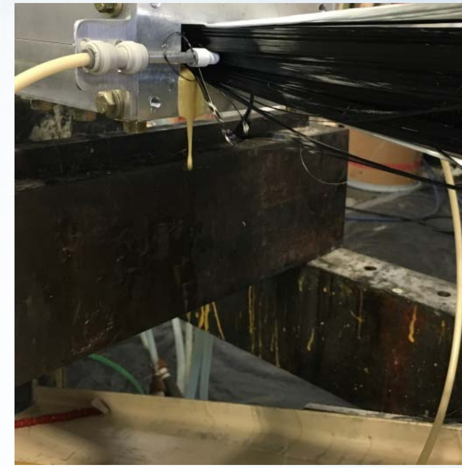
IACMI 9 Meter Technology Demonstration Blade

Derek Berry
Wind Turbine Technology
Area Director

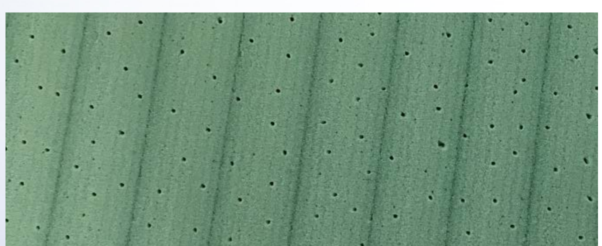
IACMI 9m Demonstration Blade Specifications

- Blade Dimensions:
  - Length: 8.325 m [27’-3.75”]
  - Root Diameter: 0.535 m [21.05”]
  - Max Chord: 0.789 m [31.06”]
  - Root Laminate Thickness: 32.25 mm [1.27”]
- Blade Weight and Center of Gravity
  - Weight: 116.82kg [257 lbs]
  - Spanwise CG 2.197 m [7’-2.5”]

IACMI 9m Demonstration Blade Technology



- Low cost carbon fiber
- Textile PAN carbon fiber
- Polyurethane pultrusion
- ELIUM® thermoplastic resin system
- Room temperature cure
- Thermoplastic sizing
- Recycled PET foam



IACMI 9m Demonstration Blade Industry Partners

ARKEMA
INNOVATIVE CHEMISTRY

ELIUM® Thermoplastic Resin System
On-site Manufacturing Support

Johns Manville

Specialty Sized Fiberglass
On-site Manufacturing Support

Axson
BUILDING TRUST
Sika

Epoxy Adhesive System
On-site Manufacturing Support

tpi COMPOSITES

Blade Tooling and Fixtures
Technical Analysis

HUNTSMAN

Polyurethane Resin System
Pultrusion Die
On-site Manufacturing Support

STRONGWELL

Pultrusion Trials
On-site Manufacturing Support

IACMI 9m Demonstration Blade Industry Partners

COMPOSITES ONE®

On-site Manufacturing Support

CHOMARAT

Carbon Fiber Conversion
And Re-Spooling
On-site Manufacturing Support

DOWAKSA

Carbon Fiber

CREATIVE FOAM CORPORATION

Recycled PET Foam

Chem Trend

Mold Sealants and
Release Agents

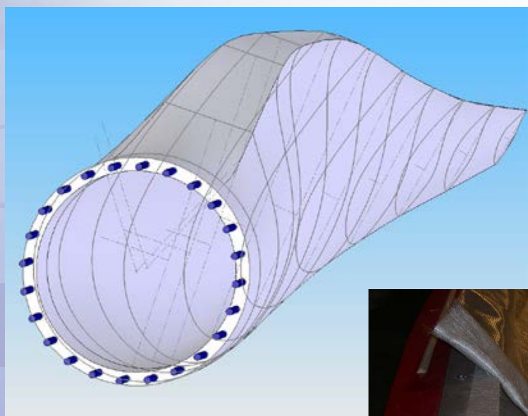
IACMI 9m Demonstration Blade Purpose

- Demonstrate scale-up of blade material and processing technologies
- Identify lower cost blade materials
- Identify path to reduction of embodied energy
- Demonstrate potential reduction of in-mold cycle time versus baseline epoxy
- Lead to larger scale projects with wind OEMs and blade suppliers
- Augment path to commercialization for innovative composite materials

Blade Design

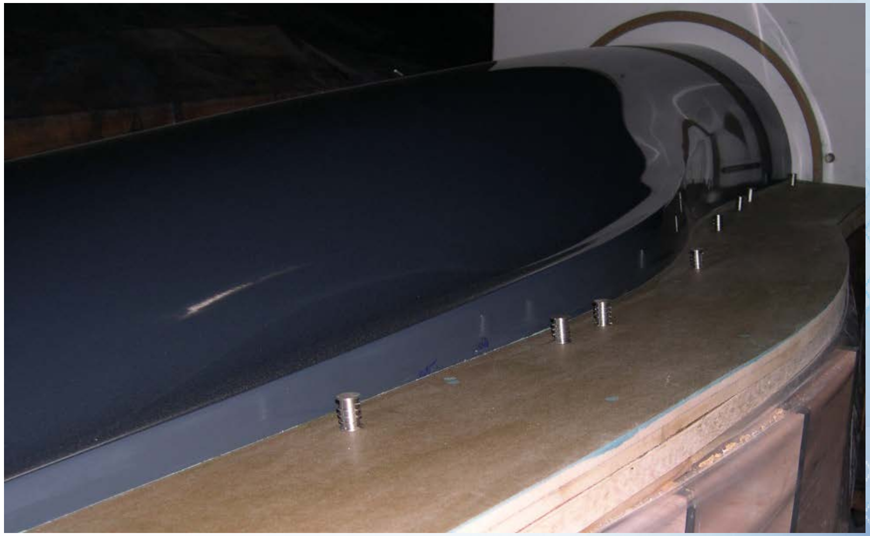
IACMI 9m Demonstration Blade Design: BSDS Baseline

- Blade design based on original Blade System Design Study (BSDS) program
  - Collaboration between TPI Composites, Mike Zuteck, Kevin Jackson, Case van Dam and Sandia National Laboratories
  - Focus on composite materials and manufacturing for future megawatt-scale blades
  - Designed and built a 9 meter blade platform for technology evaluation
  - Tools fabricated and original blades produced at TPI in 2004 and 2005



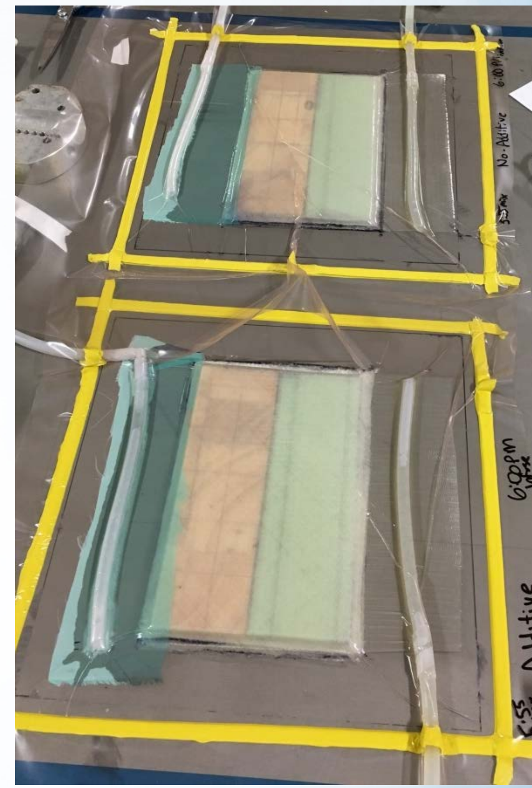
IACMI 9m Demonstration Blade Tooling: BSDS

- Tooling designed and fabricated by TPI Composites
- Key features of a megawatt-scale blade:
  - Large root diameter
  - Thinner root laminate
  - Inboard flatback airfoils
  - Outboard high performance airfoils
  - Carbon fiber spar cap
  - Offset leading edge assembly joint (HP skin)
  - Embedded root studs vs. T-bolts
- Tooling and fixtures donated by TPI



IACMI 9m Demonstration Blade Design

- Key differences of IACMI 9m blade from previous BSDS design:
  - Textile PAN carbon fiber
  - Polyurethane pultruded carbon spar caps
  - ELIUM® reactive thermoplastic resin system
  - Johns Manville fiberglass with specialized TP sizing
  - Recycled PET foam core – shear web and outboard skins
  - SikaAxson Adekit A140 structural epoxy adhesive



IACMI 9m Demonstration Blade Design

Material List for the IACMI 9m Demonstration Blade

IACMI 9m Demonstration Blade Infusion Assumptions

IACMI 9m Demonstration Blade Skin (LP and HP) Laminate Schedule

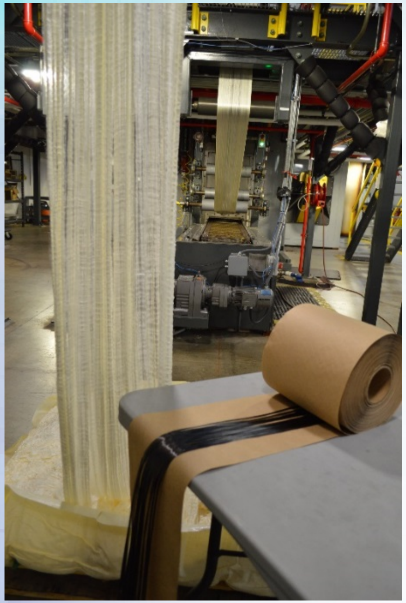
IACMI 9m Demonstration Blade Bonding Analysis

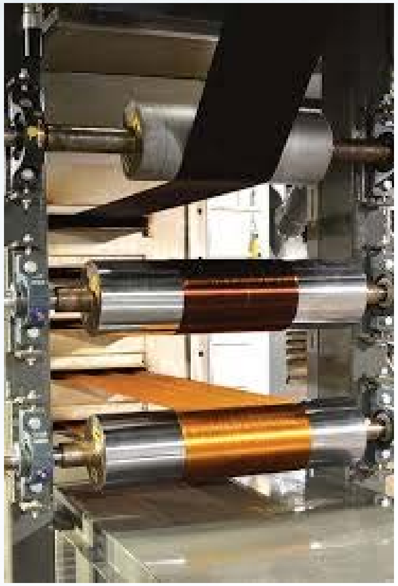
BOM for the IACMI 9m Demonstration Blade

Material	UOM	Area (sq ft)	Area (sq yd)	Volume (gal)	Units (each)	Units (rolls)	Length (ft)	Blade Weight (lbs)	Unit Cost	Cost (USD)	Scrap (%)	Scrap Weight (lbs)	Scrap Area (sf)	Scrap Volume (gal)	Scrap Units (ea)	Scrap Units (rl)	Scrap Length (ft)	Scrap Cost (USD)	Volume (1 blade)	UOM	Volume (3 blade) w/ scrap	Cost (3 blade) w/ scrap
3/4oz Mat	lb		14.1					6.0	$1.58	$9.42	20	1.19						$1.88	7.15	lb	21.5	$33.90
JM-076-Biax	lb		56.1					67.3	$1.20	$80.74	25	16.82						$20.18	84.10	lb	252.3	$302.76
JM-076-UD	lb		67.3					80.7	$1.76	$142.02	25	20.17						$35.50	100.86	lb	302.6	$532.56
Pultruded Carbon Uni	ft						40.99	24.8	$10.00	$409.94	15						6.15	$61.49	47.14	ft	141.4	$1,414.30
Balsa, 3/8"	sf	14.80						4.6	$1.22	$18.05	30		4.44					$5.42	19.23	sf	57.7	$70.40
Balsa, 1/4"	sf	69.96						14.58	$1.07	$74.86	30		20.99					$22.46	90.95	sf	272.9	$291.95
Elium (Part A)	lb							63.72	$3.50	$223.01	30	19.12						$66.90	82.83	lb	248.5	$869.75
Elium (Part B)	lb							1.91	$3.50	$6.69	30	0.57						$2.01	2.48	lb	7.5	$26.09
Gelcoat	lb							14.30	$3.28	$46.92	30	4.29						$14.08	18.60	lb	55.8	$182.98
Bostik Part A	ga			4.31				33.40	$49.90	$215.04	30			1.29				$64.51	5.60	ga	16.8	$838.66
Bostik Part B	ga			0.43				6.18	$49.90	$21.50	30			0.13				$6.45	0.56	ga	1.7	$83.87
5/8" Threaded Rod	ea				24			22.90	$13.95	$334.80	0				0.00			$0.00	24.00	ea	72.0	$1,004.40
Root Plate	ea				24			8.6	$40.00	$960.00	0				0.00			$0.00	24.00	ea	72.0	$2,880.00
Release Agent	ga			0.09					$59.40	$5.62	10			0.01				$0.56	0.10	ga	0.3	$18.56
Tackifier Adhesive, Cans	ea				0.30				$6.65	$2.00	15				0.05			$0.30	0.35	ea	1.0	$6.90
Non-Sanding Peel Ply	sf	62.33							$0.15	$9.35	15		9.35					$1.40	71.67	sf	215.0	$32.25
Peel Ply	sf	136.23							$0.18	$24.52	20		27.25					$4.90	163.48	sf	490.4	$88.28
Flow Medium	sf	95.36							$0.06	$5.72	20		19.07					$1.14	114.43	sf	343.3	$20.60
Silicone flange tape	rl					2.86			$21.11	$60.31	15					0.43		$9.05	3.29	rl	9.9	$208.08
Vacuum Bag	sf	204.35							$0.20	$40.87	30		61.30					$12.26	265.65	sf	797.0	$159.39
Tubing, 3/8"	ft						136.56		$0.07	$9.56	15						20.48	$1.43	157.05	ft	471.1	$32.98
Tubing, 1/2"	ft						136.56		$0.07	$9.56	15						20.48	$1.43	157.05	ft	471.1	$32.98
Tubing, 5/8"	ft						136.56		$0.15	$20.48	15						20.48	$3.07	157.05	ft	471.1	$70.67
Tubing, 3/4"	ft						136.56		$0.19	$25.95	15						20.48	$3.89	157.05	ft	471.1	$89.52
Tubing, 7/8"	ft						136.56		$0.15	$20.48	15						20.48	$3.07	157.05	ft	471.1	$70.67
2" masking tape tan	rl					2.73			$2.50	$6.83	15					0.41		$1.02	3.14	rl	9.4	$23.56
2" masking tape green	rl					2.73			$5.50	$15.02	15					0.41		$2.25	3.14	rl	9.4	$51.83
							Weight (lbs)	349.0	Material Cost:	$2,799.27							Scrap Cost:	$346.69			Material Cost (3 blades):	$9,437.87
							Weight (kgs)	158.3	Cost (with scrap):	$3,145.96												

Spar Cap Pultrusion

Textile PAN-based Carbon Fiber



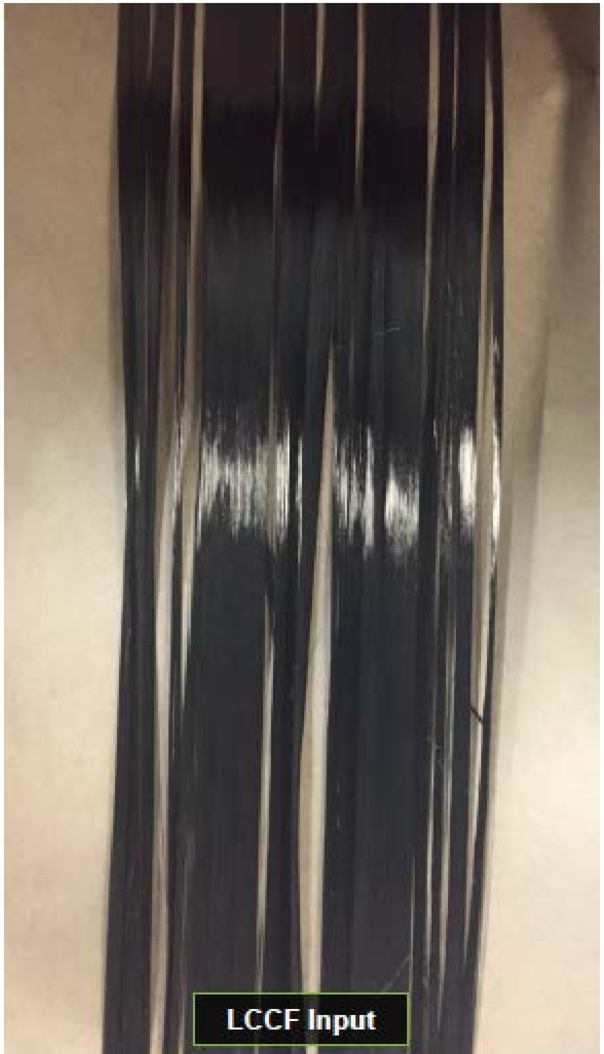


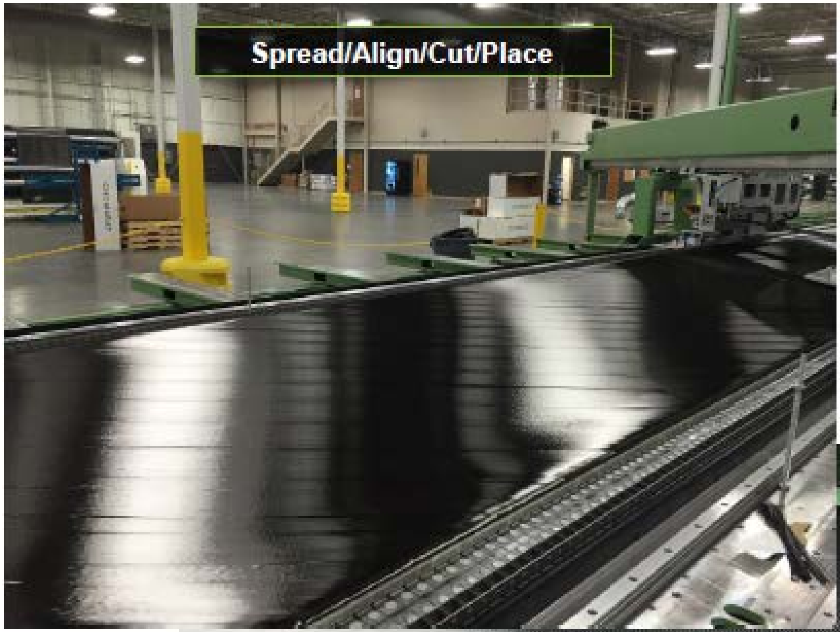
- Uses low cost industrial precursor
- Carbonized at ORNL Carbon Fiber Technology Facility
- Potential for significant cost reduction of carbon fiber
- Wide band requires some adaptation

Chomarat Experience with Textile PAN Carbon Fiber

LCCF Conversion to Fabric (BX240 shown below)

CHOMARAT





Carbon Fiber Preparation

- Initial desire to use only textile PAN carbon fiber if the product form permitted easy pultrusion
- Back up plan to use a combination of commercially available A42 carbon fiber from DowAksa with portion of textile PAN at an acceptable level.
- Limited quantity of textile PAN fiber available for use in trials
- Chomarat provided assistance with rewinding of textile carbon fiber, combining three tows onto a spool, plus breaking down larger spools of DowAksa A42 into smaller packages to support needed number of 24K tows.

Carbon Fiber Properties (nominal)

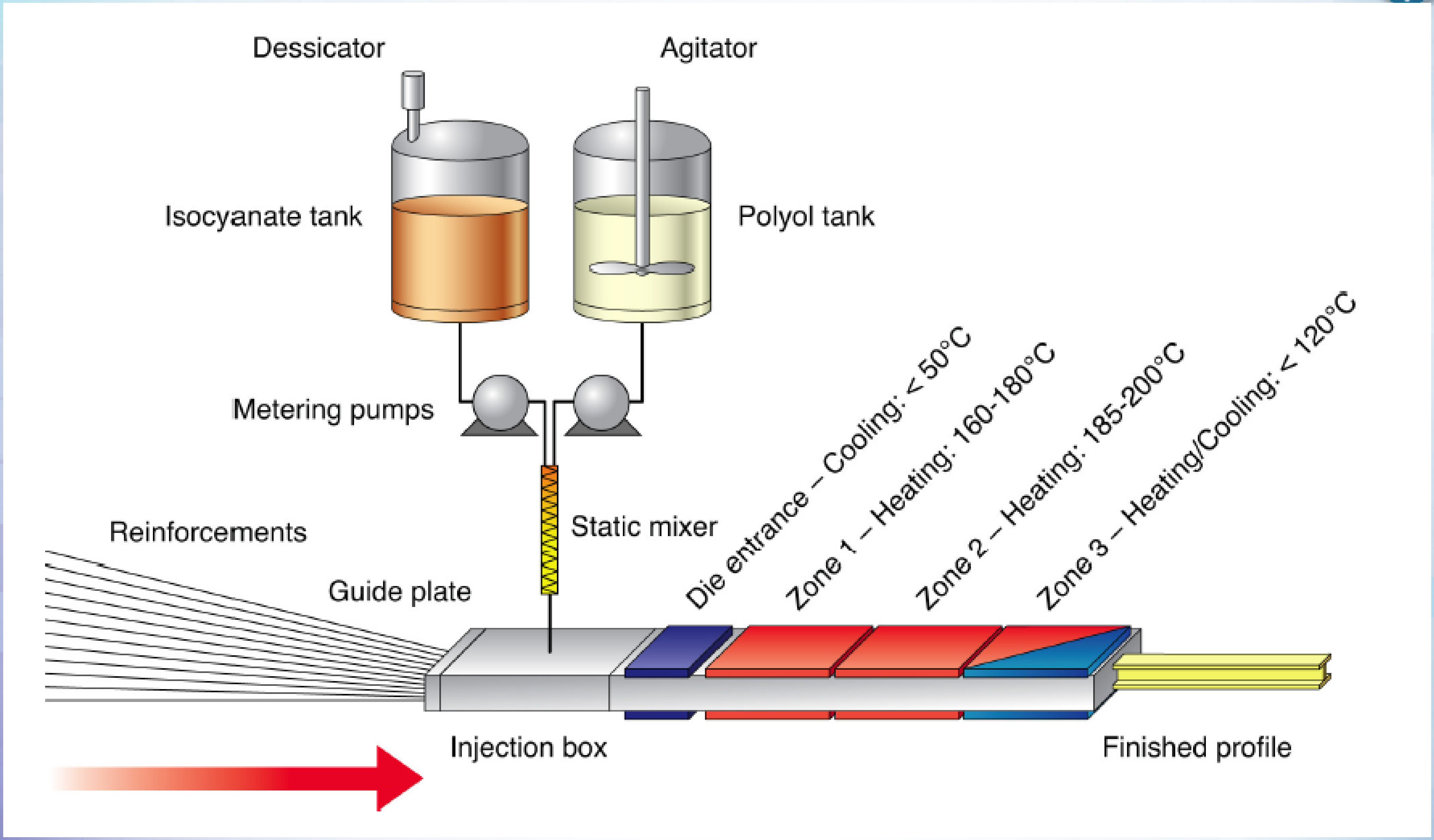
	DowAksa A42	CFTF Textile PAN
Tow size	24K	457K
Tensile Strength	610 ksi (4200 Mpa)	399 ksi (2750 Mpa)
Tensile Modulus	34.8 Msi (240 Gpa)	37.1 (256 Gpa)
Strain	1.8%	1.08%
Density	1.78	1.77
Yield	1.6 g/m	14.35 g/m
Sizing	1.0 – 1.5%%	1.35%

Sources: DowAksa A42 Data Sheet, Oak Ridge National Labs

Polyurethane Resin for Pultrusion

- Huntsman Polyurethanes provided the resin system used for the spar cap pultrusion trials:
  - RIMLINE® SK97018 (polyol blend with internal mold release)
  - SUPRASEC® 9701 (MDI-based isocyanate)
- Key resin features:
  - Low initial mixed viscosity (450-500 Cps), designed for efficient wet out of carbon fiber and high fiber volume glass fiber profiles
  - Long open time for ease in processing and elimination of viscosity build up in pultrusion injection box
  - Snap cures at high pultrusion die temperatures permitting fast line speeds
- Huntsman also furnished 3mm x 100mm die and injection box, mixing/pumping system and on-site technical assistance at Strongwell.

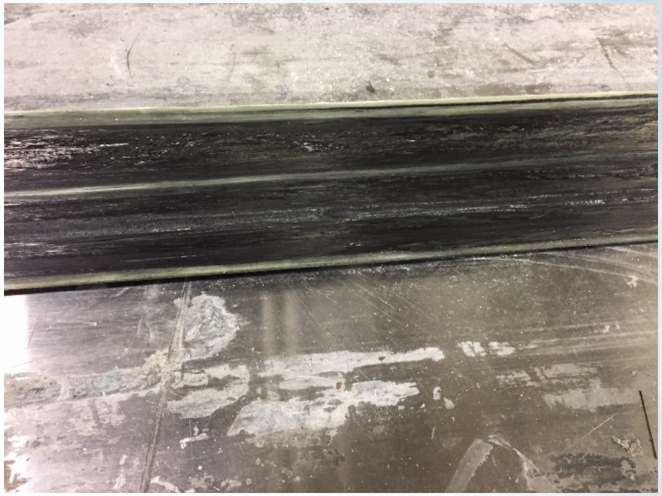
Polyurethane Pultrusion Process

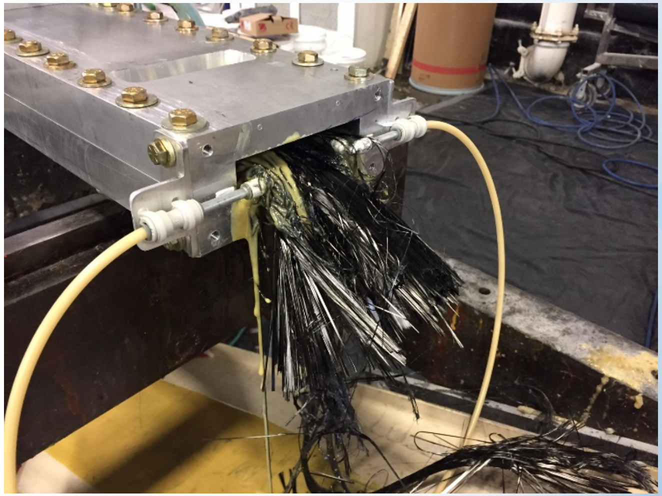


Source: Huntsman Polyurethanes

Initial Pultrusion Trial – December 6, 2016

- Pultrusion trials early December at Strongwell (Bristol, VA).
- First trial used glass tows to draw in textile PAN fiber incrementally until 15 tows (five 3-ply layers) were being pulled
- Due to uneven tension in feed tows, die locked up after 10 meters of pultruded product
- Points to need to improve packaging of textile PAN fiber





Second Pultrusion Trial – December 7, 2016

- Combination of textile PAN and DowAksa A42 fiber
  - Glass veil top/bottom
  - Three textile PAN tows beneath and over veil
  - 146 tows A42 in center of laminate
- Overall fiber volume fraction 58%
  - 27% Textile PAN CF
  - 73% DowAksa A42 CF
- Line speed 18 inches/min
- Die temperatures 300-325°F

Second Pultrusion Trial – December 7, 2016

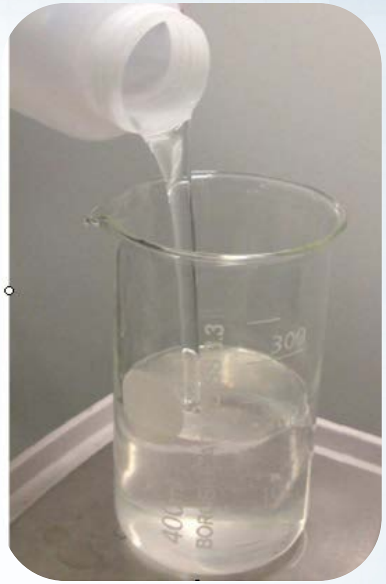
- Once in continuous operation, run was smooth
- Produced 93 meters (305 feet) of pultruded stock before textile PAN fiber ran out
- Spar caps shipped to Colorado for use in prototype blade
- Future work:
  - Improve textile PAN CF tension control and packaging
  - Increase percentage of textile PAN CF in future pultrusions
  - Demonstrate higher pultrusion speed (over 40 inches per minute)

Pultrusion Trial Team

ELIUM® Process Trials

ELIUM® Resin

- ELIUM® - *Liquid* Thermoplastic Resin
  - Two-part reactive resin
  - Low viscosity: 100-500cps
  - Capable of RT cure
  - Styrene Free
- ELIUM® Composite Parts
  - High modulus and toughness
  - Thermoformable
  - Recyclable
- Designed for a wide range of applications
  - Aesthetic parts
  - Structural mechanical parts



ELIUM® Resin
(100- 500 cPs)

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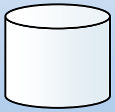

Initiator
(ex. LUPEROX® AFR40*)*

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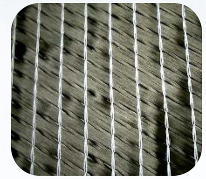
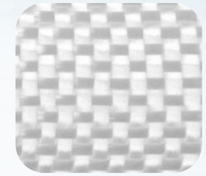
Fiber
Glass / Carbon
or other

- Low pressure injection (RTM, Infusion)
- High MW fiber-reinforced parts.
- No tooling changes

Source: Arkema

Properties of ELIUM® Composites





	Pure ELIUM® Resin		ELIUM® Resin with Carbon (structural parts)		ELIUM® Resin with Glass (structural parts)		ISO Method
Tensile strength	76	MPa	1280	MPa	557	MPa	527
Tensile modulus	3300	MPa	59	GPa	27	GPa	
Flexural strength	130	MPa	870	MPa	700	MPa	14125
Flexural modulus	3250	MPa	65	GPa	27	GPa	
Compressive strength	130	MPa	480	MPa	347	MPa	14126
Compressive modulus	-		54	GPa	28	GPa	

Details: ELIUM® RT-300 resin, room temperature RTM process | Carbon – T700SC 12K NCF 53%vol. | Glass - Chomarat 600T PW fabric 600GSM, 53%vol.

Basic mechanical properties similar to epoxy
with same reinforcement loadings

Source: Arkema

High Modulus and Toughness

EXCELLENT STIFFNESS **SUPERIOR** TOUGHNESS

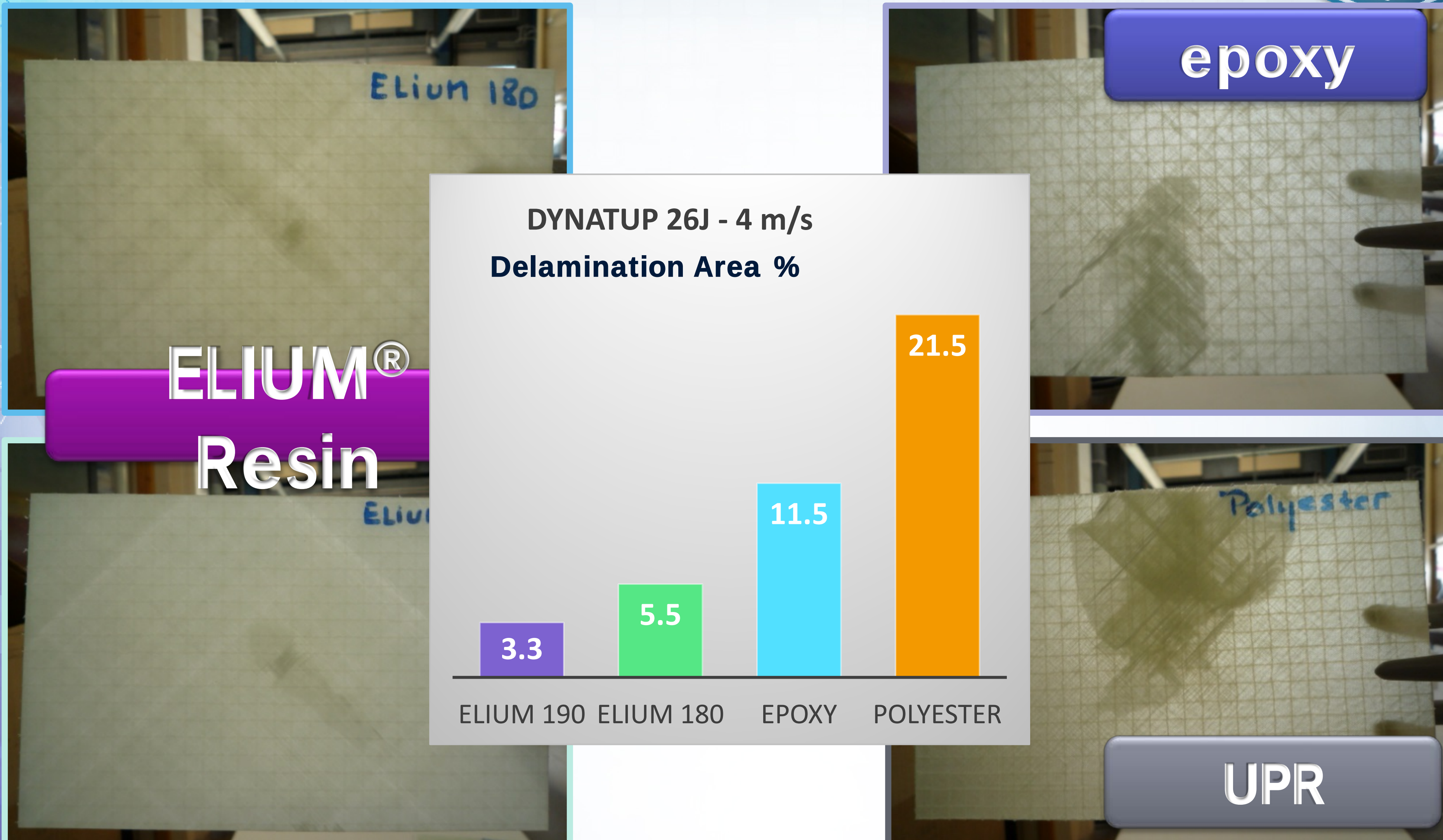
	Max Stress (MPa)	Modulus (GPa)	Elongation at Break (%)
UPR	210	13	2.7
Epoxy	250	9	4.8
ELIUM® resin	343	11	> 20

Details

- ISO 14125 Flexural Test
- Vacuum infusion process
- 2 plies of GF BX45 1200GSM
- Sizing SE2020 for epoxy and SE4740 for UPR and ELIUM® 180

Source: Arkema

Impact/Damage Tolerance



 Source: Arkema

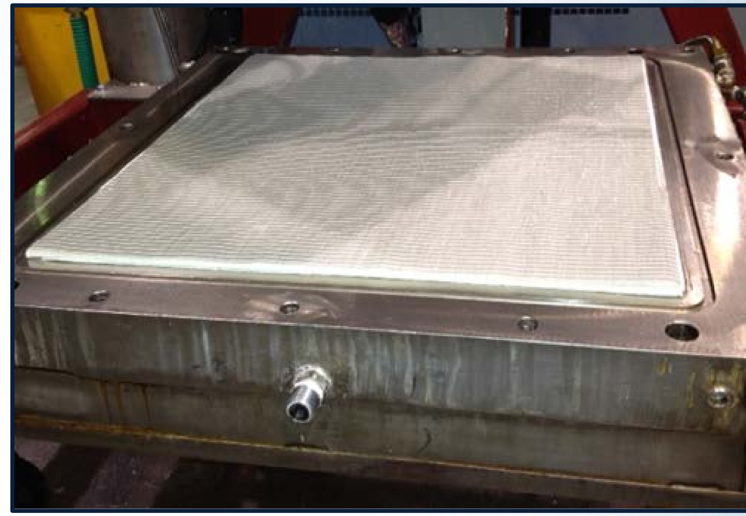
9m Blade Project Building on IACMI 4.2 Thermoplastic Project

- Develop new thermoplastic process technology and materials for wind turbine blade manufacturing. Project outcome is a structurally verified thermoplastic blade component, which will demonstrate commercial feasibility of integrating thermoplastics in wind turbine blade production.
- Partners: NREL, ORNL, Johns Manville, Colorado School of Mines, TPI Composites, Arkema, Purdue University, Vanderbilt University

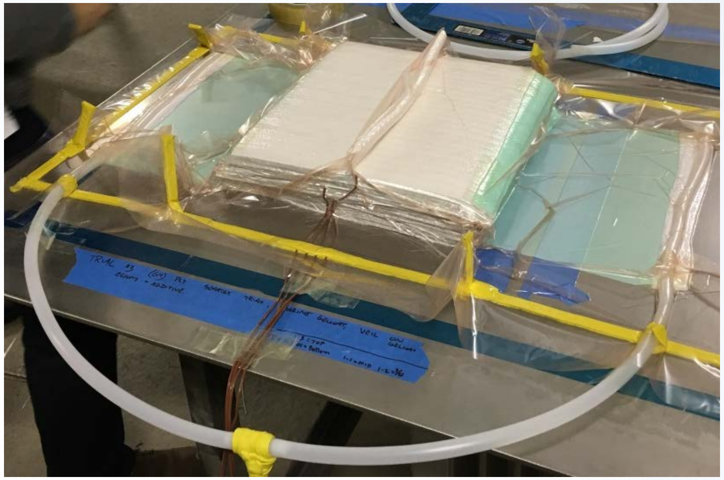
TRL 3-4 (BP1)
- Glass sizing
- Resin process modeling

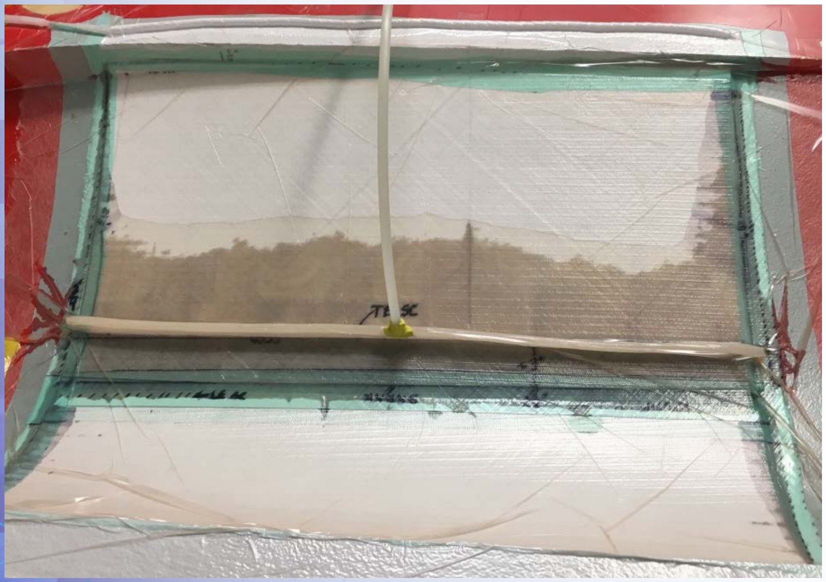
TRL 5-6 (BP2)
- Panel production
- Coupon testing
- Techno-economic modeling

TRL 7 (BP3)
- Full-scale blade root component
- Component testing



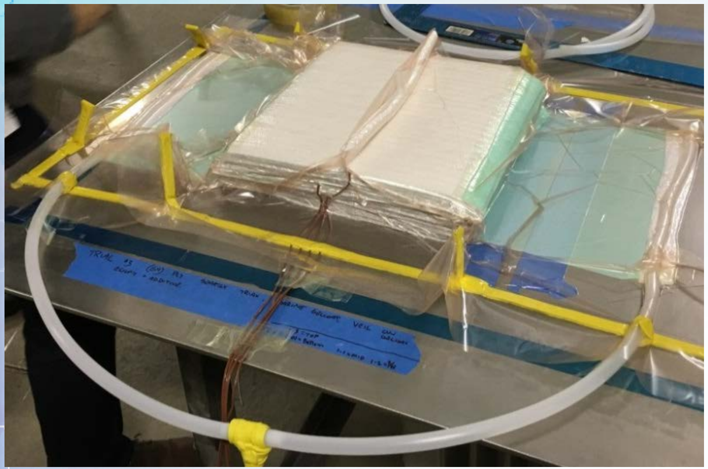
ELIUM® Molding Trials at CoMET: 19-21 December

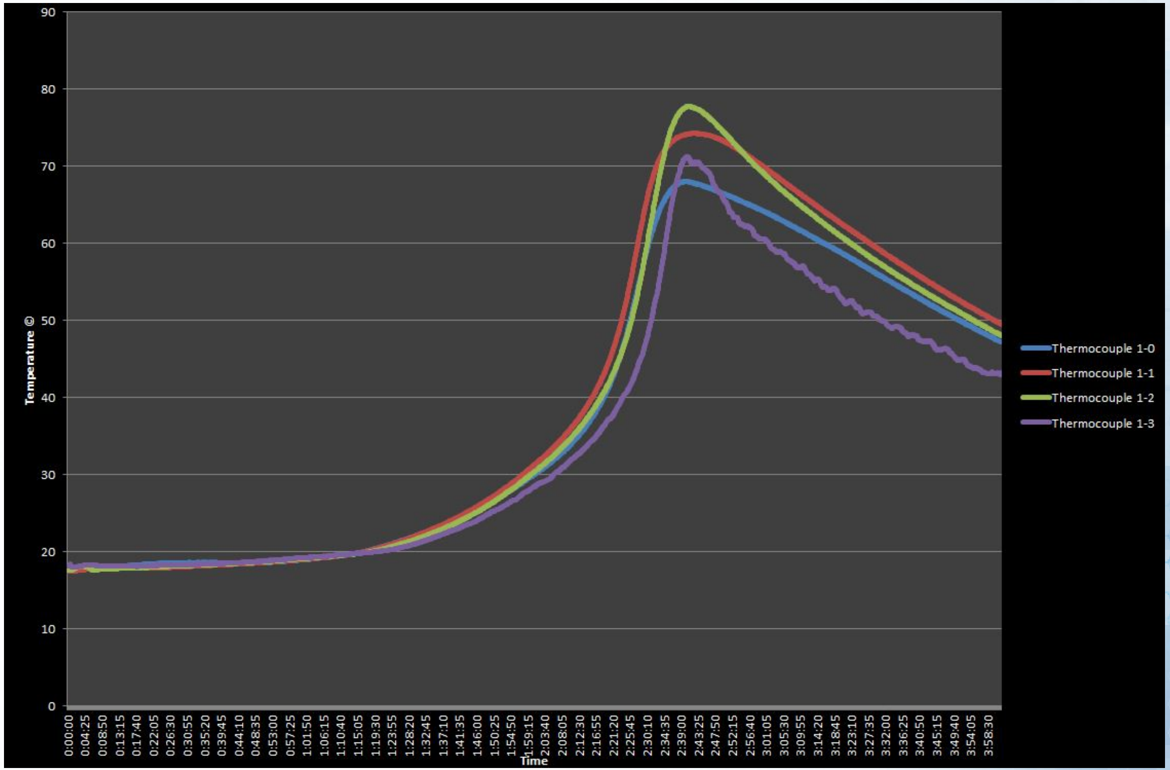




- Arkema staff (Dana Swan and Nate Bachman) traveled to Colorado to perform ELIUM® trials
- Thin and thick panels
- Tapered panels
- In-mold Max chord

ELIUM® Molding Trials at CoMET: 19-21 December





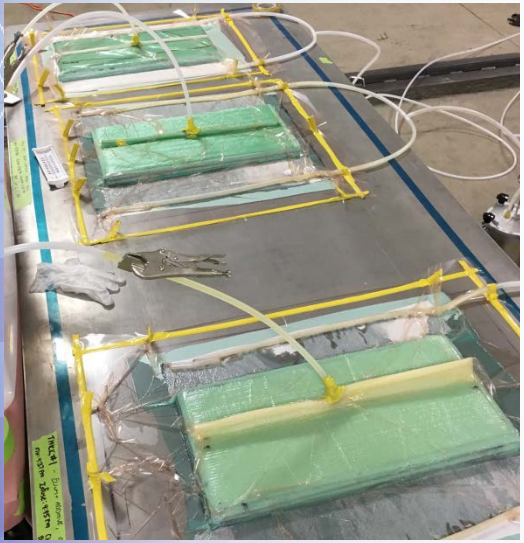
- Thick panel trial
- 56 mm thick
- Thermocouple exotherm measurement shows all areas below 80° C

ELIUM® Molding Trials at CoMET: 27-30 December

- CoMET staff continue ELIUM® trials
- Thin and thick panels
- Tapered panels
- In-mold max chord
- Cutting and drilling

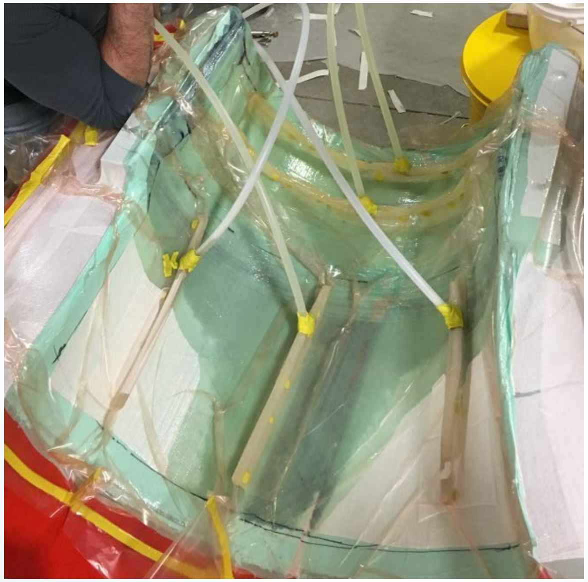
ELIUM® Molding Trials at CoMET: 3-6 January

- CoMET staff continue ELIUM® trials
- Tapered panels
- In-mold max chord
- Temperature challenges

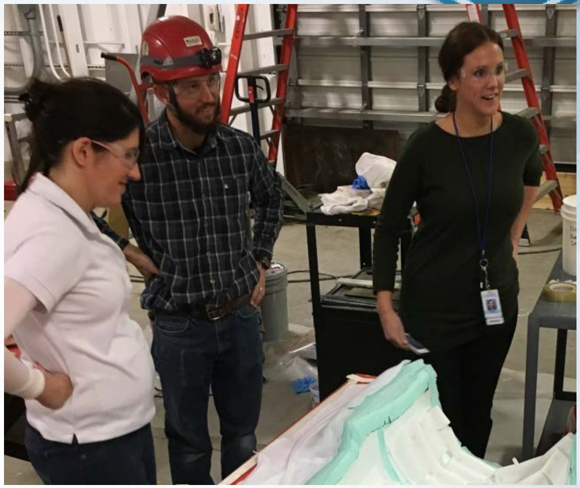


ELIUM® Root Trial at CoMET: 9-10 January

- CoMET staff, Arkema (Dana Swan), SikaAxson (Jason Cilio) and IACMI (Dale Brosius) perform ELIUM® root trial
- In-mold LP skin
- Great progress – thin laminate issues



ELIUM® Process Trial Team



9 Meter Blade Fabrication

Shear Web Fabrication: Laminate Schedule

IACMI 9m Demonstration Blade Shear Web Laminate Schedule

Layer	Material	Comments	Begin STA	End STA	Planform Area (sq m)	Area (sq yd)	Layer Weight (lbs)	Layer Thickness (mm)	Layer Thickness (in)	Web Thickness (in)	Flange Thickness (in)
1	JM-076-Biax	Entire Surface	0440	7,487	2.14	2.57	4.74	0.75	0.030	0.030	0.030
2	JM-076-Biax	Entire Surface	0440	7,487	2.14	2.57	4.74	0.75	0.030	0.030	0.030
3	Foam, 1/4"	Web Only (Not on Flanges)	0440	7,487	1.37	1.64	4.62	9.53	0.375	0.375	
4	JM-076-Biax	Entire Surface	0440	7,487	2.14	2.57	4.74	0.75	0.030	0.030	0.030
5	JM-076-Biax	Entire Surface	0440	7,487	2.14	2.57	4.74	0.75	0.030	0.030	0.030
									Total Thickness (per section) [inches]:	0.49	0.12
									Total Thickness (per section) [mm]:	12.54	3.02

JM-076-Biax	
10.28	sq yd
18.96	lbs

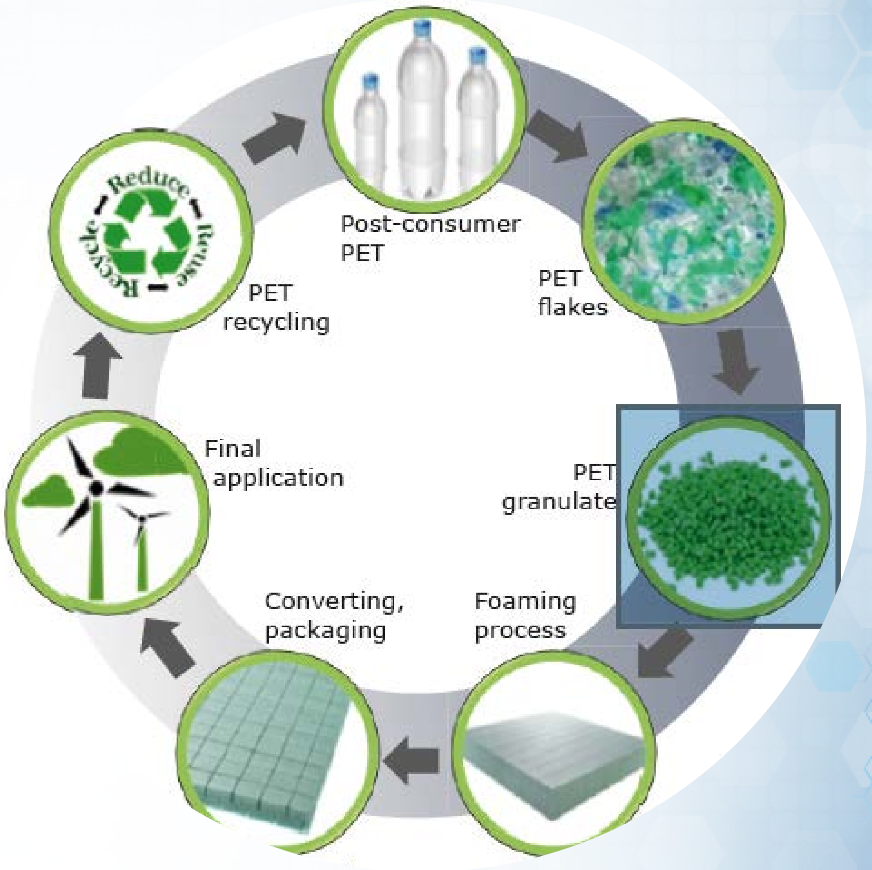
Foam, 1/4"	
14.80	sq ft
4.62	lbs

Elium	
10.58	lbs

Web Weight	
34.16	lbs

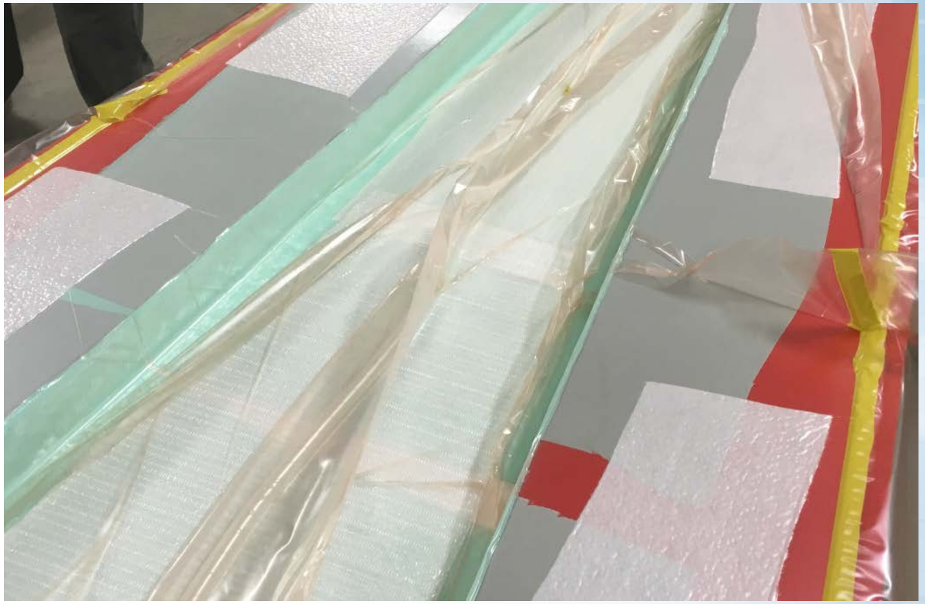
ArmaFORM® PET/W GR: ‘green’ structural foam core

- Produced by Armacell (Belgium) from 100% post-consumer PET
- Supplied to project by Creative Foam (Fenton, MI) in 0.25” (blade skins) and 0.375” (shear web) thickness
- 33% lower CO_2 equivalent than virgin PET foam and over 50% lower than other structural foams
- Key properties:
  - Density: 6.2 lb/ft^3 (100 kg/m^3)
  - Compression strength 220 psi (1.52 Mpa)
  - Shear strength: 110 psi (0.76 Mpa)
  - Shear modulus 2,900 psi (20 Mpa)



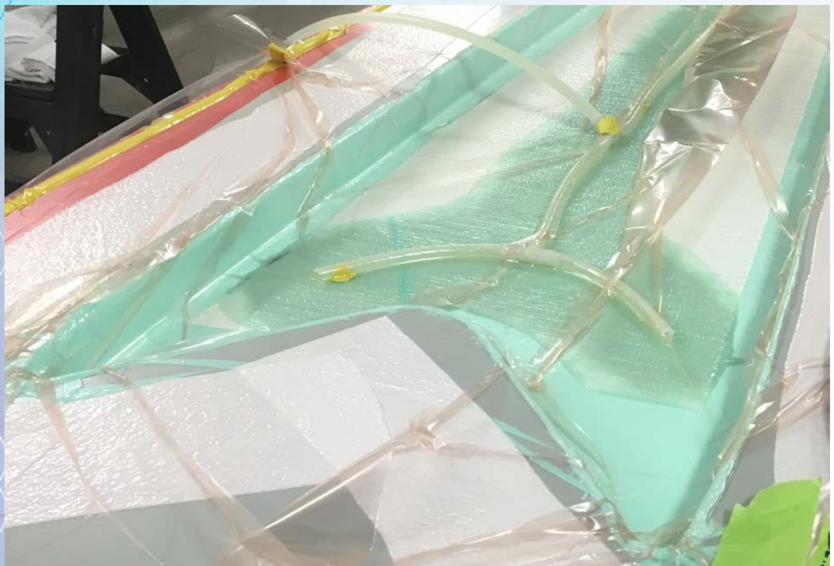
Source: Armacell

Shear Web Fabrication: ELIUM® Formulation and Bagging



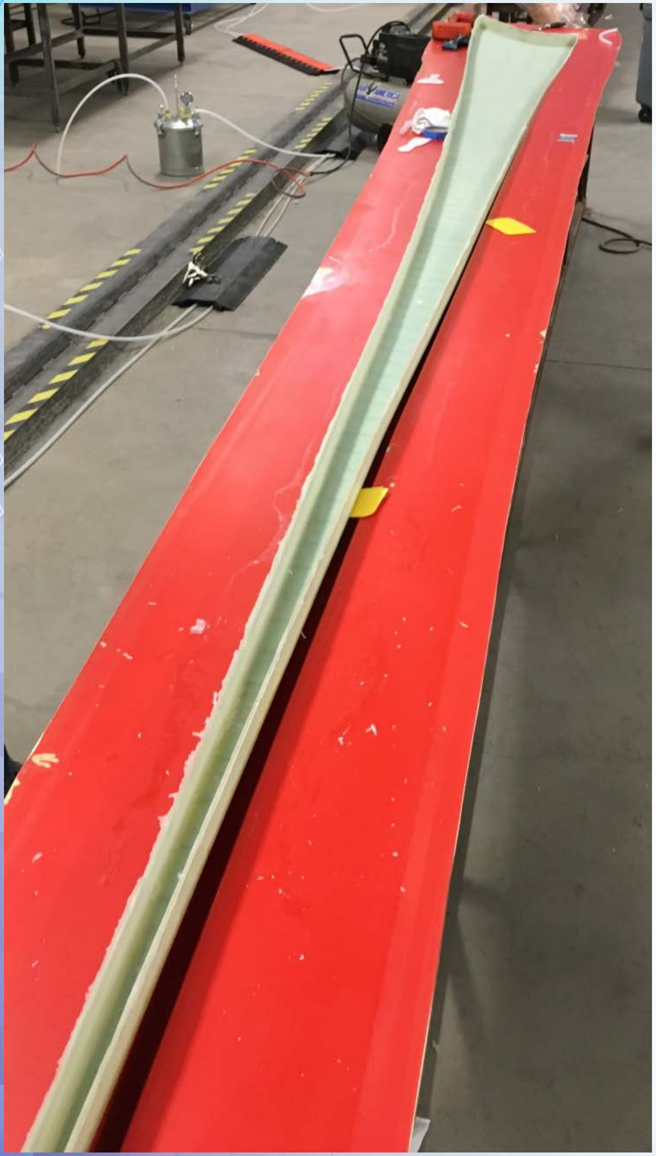
Elium Mix Calculations		
Total Elium for part:	10.58	lbs
Total Elium for part:	4,799	grams
Add 50% for excess:	7,199	grams
Overide: Use 3% Luperox for SW:	0.03	
Luperox (3% of Elium):	216.0	grams

Shear Web Fabrication: Infusion



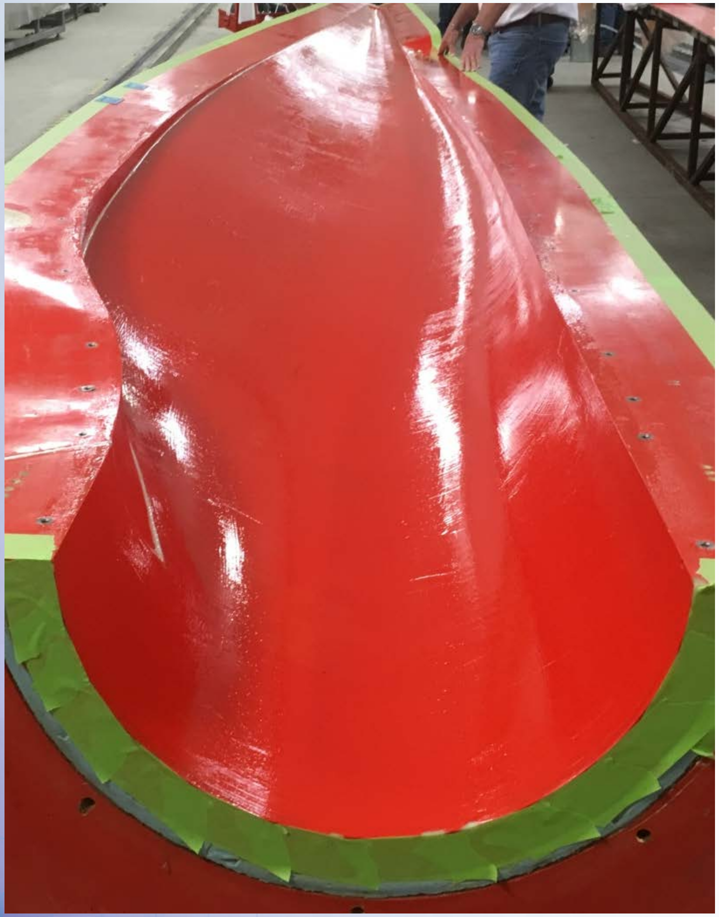
- Wet-out time: 30 minutes
- Gel time: 75 minutes
- Demold time: 180 minutes (from start of infusion)

Shear Web Fabrication: Two Successful Parts



LP and HP Skin Fabrication: Laminate Schedule

Layer	Material	Comments	Begin STA	End STA
1	Gelcoat w/catalyst	Entire Surface	0000	8,325
2	Glass veil	Entire Surface (with flanges)	0000	8,325
3	JM-076-Biax	Entire Surface (with flanges)	0000	8,325



LP and HP Skin Fabrication: Laminate Schedule

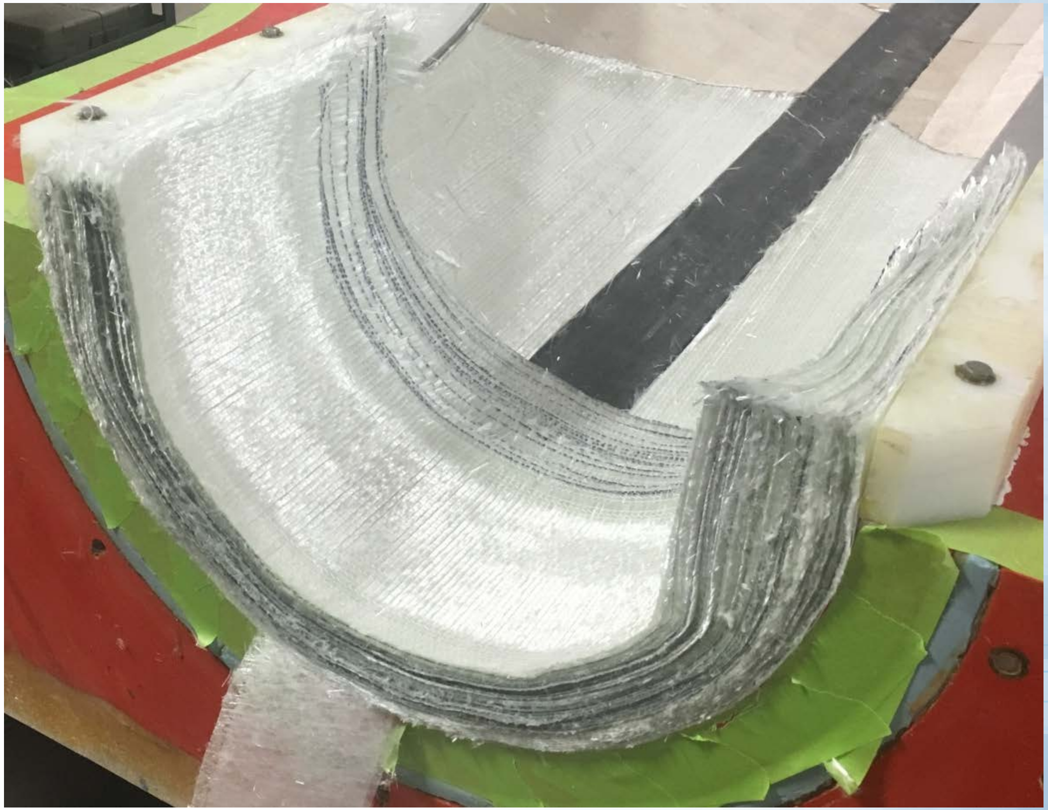
4	Pultruded Carbon Uni	Spar Cap	0150	7,875
5	Pultruded Carbon Uni	Spar Cap	0230	5,000

LP and HP Skin Fabrication: Laminate Schedule

6	Saertex Triax	Root Filler #1	0000	1,150
7	Saertex Triax	Root Filler #1	0000	1,150
8	Saertex Triax	Root Filler #1	0000	1,150
9	Saertex Triax	Root Filler #1	0000	1,150
10	Saertex Triax	Root Filler #2	0000	1,150
11	Saertex Triax	Root Filler #2	0000	1,150
12	Saertex Triax	Root Filler #2	0000	1,150

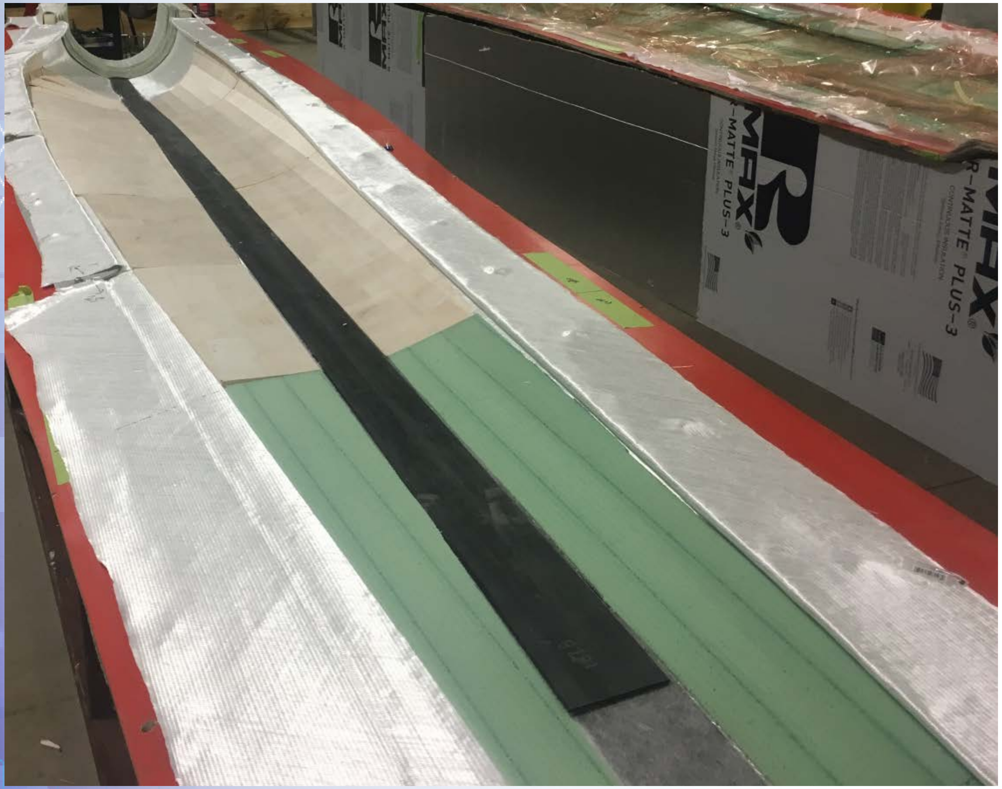
LP and HP Skin Fabrication: Laminate Schedule

13	Saertex Triax	Root Build-Up	0000	381
14	Saertex Triax	Root Build-Up	0000	375
15	Saertex Triax	Root Build-Up	0000	369
16	Saertex Triax	Root Build-Up	0000	363
17	Saertex Triax	Root Build-Up	0000	357
18	Saertex Triax	Root Build-Up	0000	351
19	Saertex Triax	Root Build-Up	0000	345
20	Saertex Triax	Root Build-Up	0000	339
21	Saertex Triax	Root Build-Up	0000	333
22	Saertex Triax	Root Build-Up	0000	327
23	Saertex Triax	Root Build-Up	0000	321
24	Saertex Triax	Root Build-Up	0000	315
25	Saertex Triax	Root Build-Up	0000	309
26	Saertex Triax	Root Build-Up	0000	303
27	Saertex Triax	Root Build-Up	0000	297
28	Saertex Triax	Root Build-Up	0000	291
29	Saertex Triax	Root Build-Up	0000	285
30	Saertex Triax	Root Build-Up	0000	279
31	Saertex Triax	Root Build-Up	0000	273
32	Saertex Triax	Root Build-Up	0000	267
33	Saertex Triax	Root Build-Up	0000	261
34	Saertex Triax	Root Build-Up	0000	255
35	Saertex Triax	Root Build-Up	0000	249
36	Saertex Triax	Root Build-Up	0000	243
37	Saertex Triax	Root Build-Up	0000	237
38	Saertex Triax	Root Build-Up	0000	231
39	Saertex Triax	Root Build-Up	0000	225

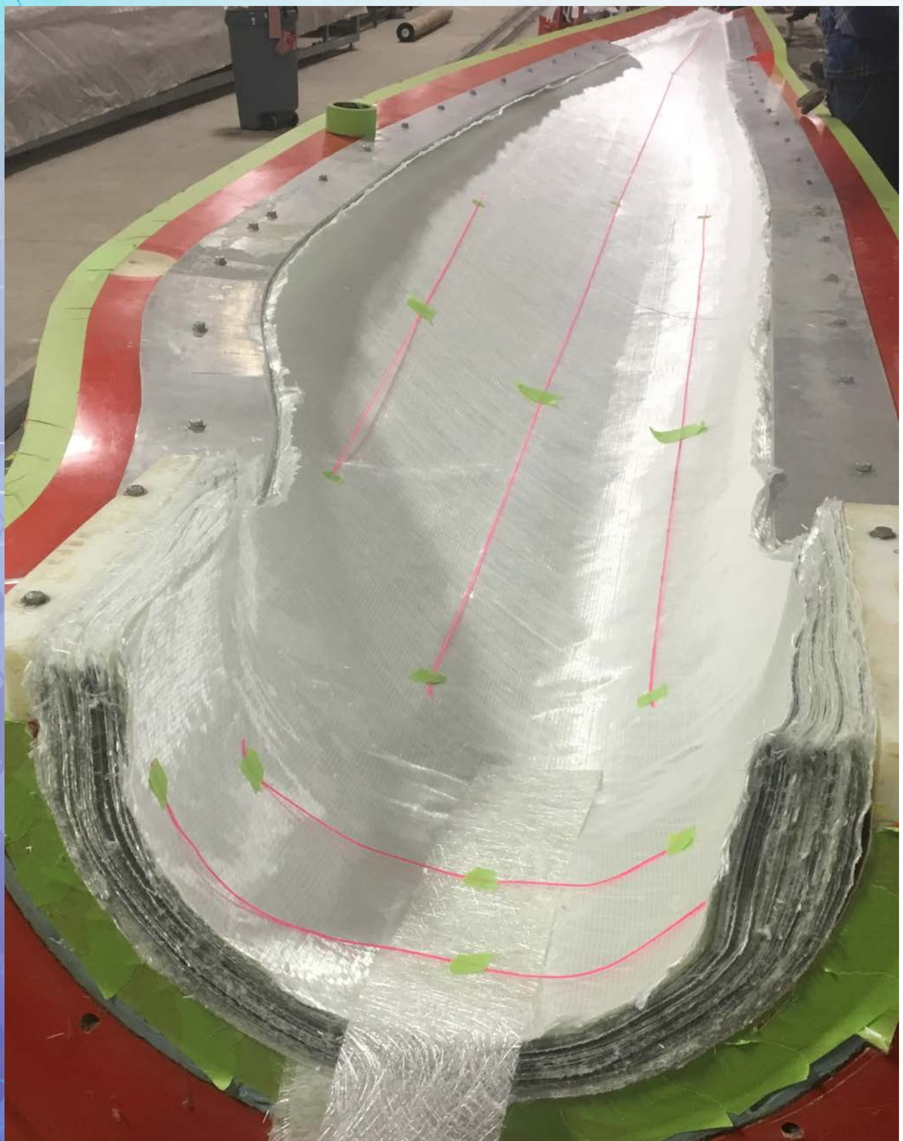


LP and HP Skin Fabrication: Laminate Schedule

40	Balsa, 1/4"	Inboard Aft Panel Balsa		4182
41	Balsa, 1/4"	Inboard Fwd Panel Balsa		4182
42	Balsa, 1/4"	Flatback Panel Balsa		
43	Foam, 1/4"	Outboard Aft Panel Foam	4182	
44	Foam, 1/4"	Outboard Fwd Panel Foam	4182	

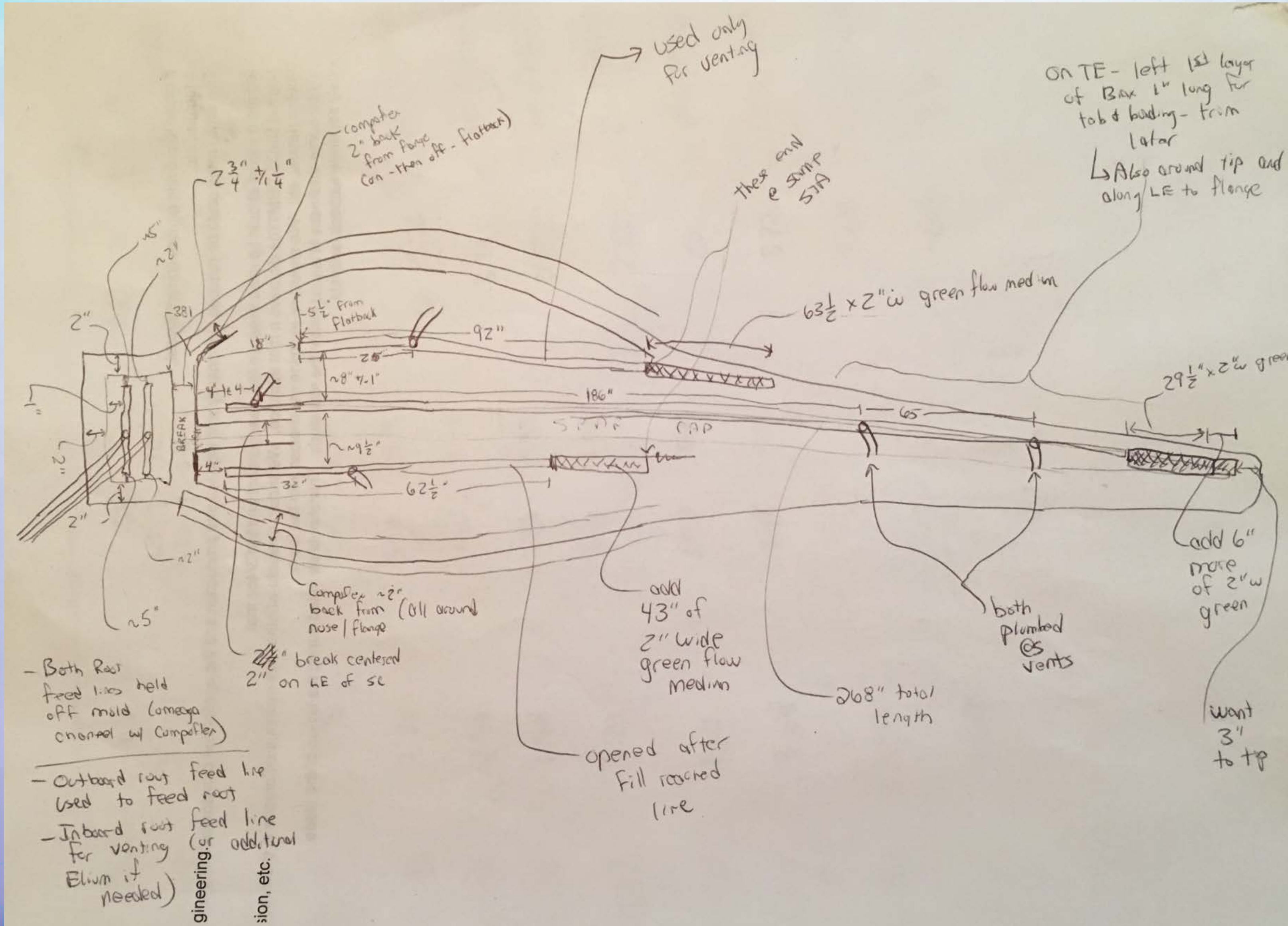


LP and HP Skin Fabrication: Laminate Schedule



45	JM-076-Biax	Tip Ply	7875	8,325
46	JM-076-Biax	Flange Reinforcements (x2)	0225	5000
47	JM-076-Biax	Entire Surface	0000	8,325

LP and HP Skin Fabrication: Vacuum Bagging



LP and HP Skin Fabrication: Vacuum Bagging

THE COMPOSITES iacmi INSTITUTE

LP and HP Skin Fabrication: Vacuum Bagging

LP and HP Skin Fabrication: Vacuum Bagging

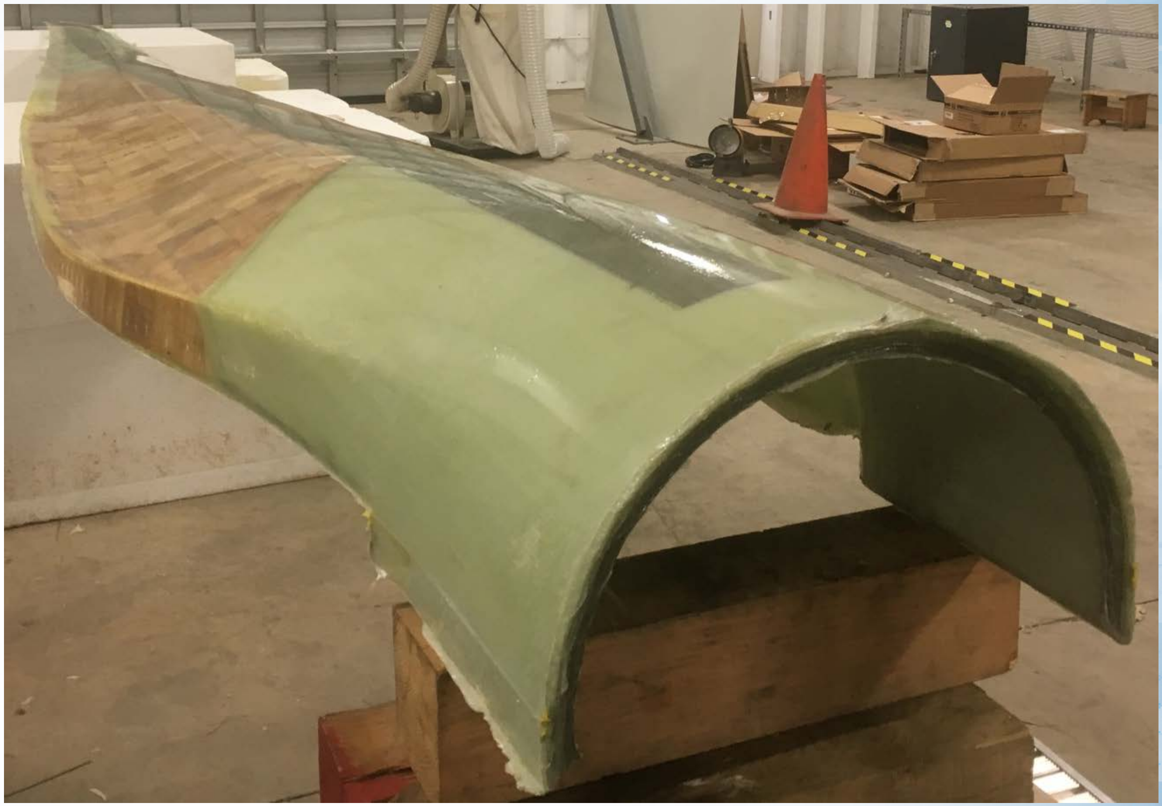
LP and HP Skin Fabrication: Infusion

Elium: Root Section - Mix Calculations		
Total Elium for part:	12.01	lbs
Total Elium for part:	5,445	grams
Add 75% for excess:	9,530	grams
Overide: Use 3% Luperox for SW:	0.03	
Luperox (2% of Elium):	190.6	grams

Elium: Outboard Section - Mix Calculations		
Total Elium for part:	23.74	lbs
Total Elium for part:	10,768	grams
Add 75% for excess:	18,844	grams
Overide: Use 3% Luperox for SW:	0.03	
Luperox (3% of Elium):	565.3	grams

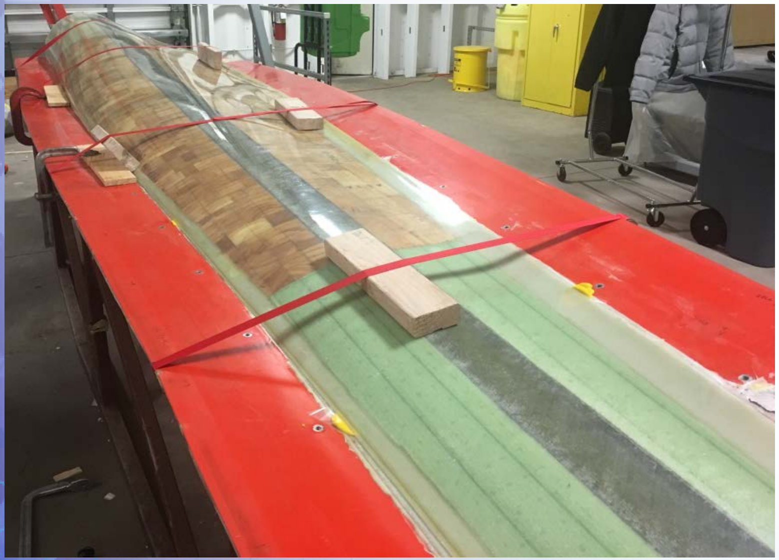
- Wet-out: 60 min
- Gel: 120 min
- Demold: 4 hr (from start of infusion)

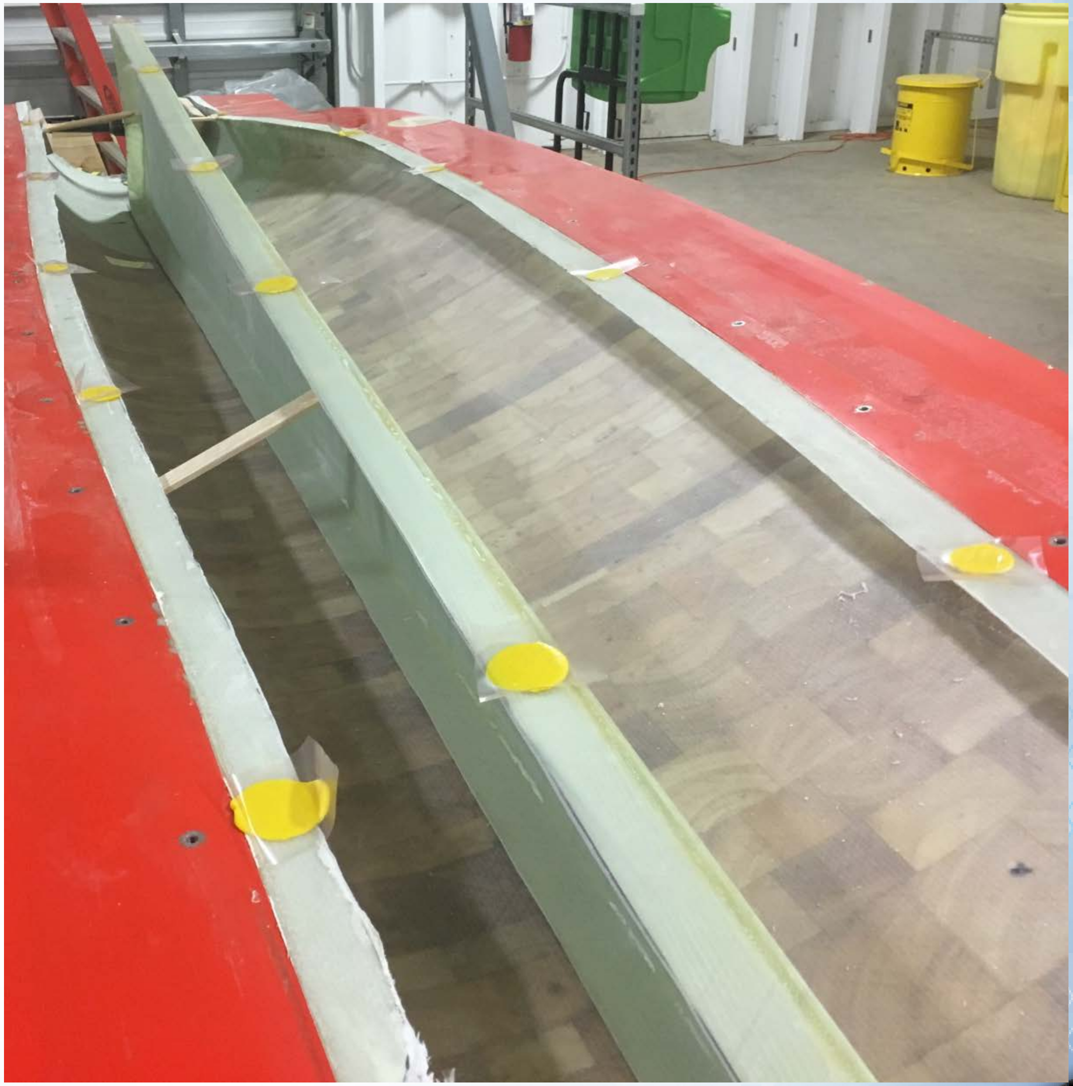
LP and HP Skin Fabrication



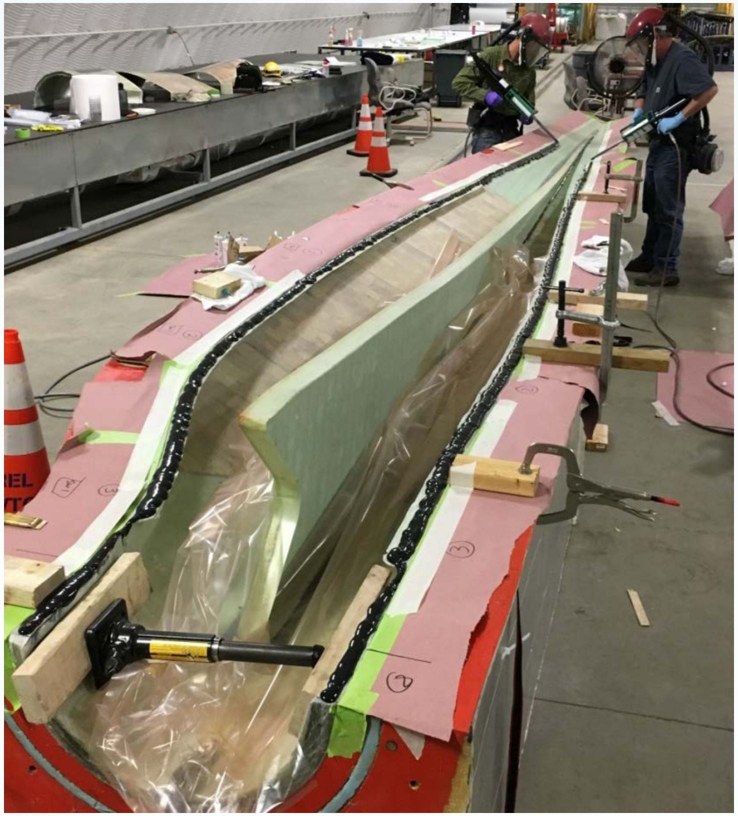
Blade Molding

Blade Bonding and Finishing: Dry Fit

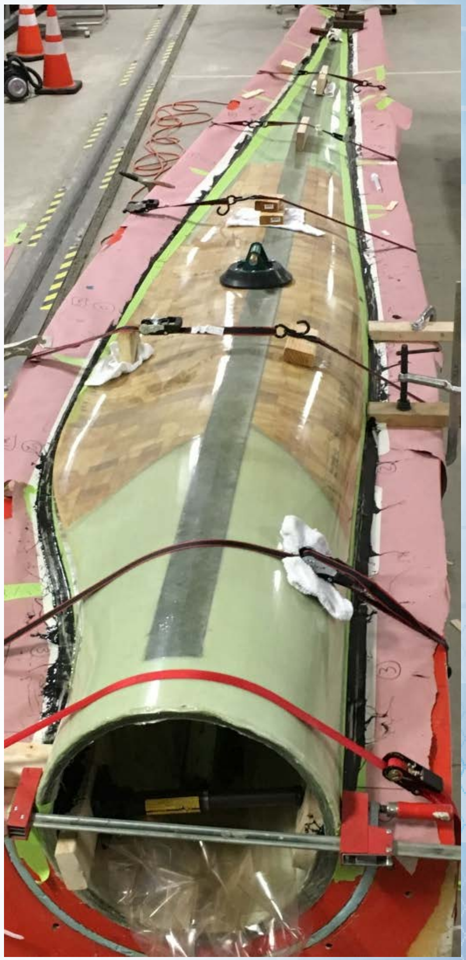




Blade Bonding and Finishing: Assembly



- SikaAxson Adekit A140 Epoxy Adhesive



Blade Bonding and Finishing: Demold

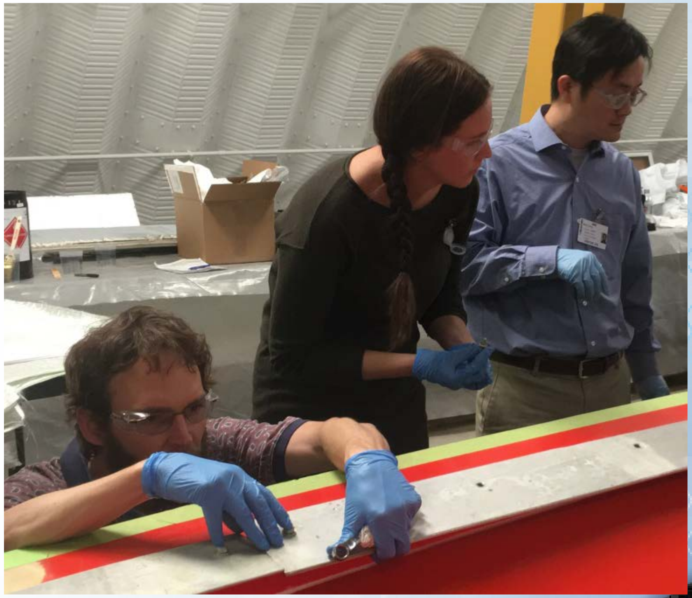
Blade Bonding and Finishing: Trimming

IACMI 9 meter Demonstration Blade

9m Blade Fabrication Team





Conclusions

IACMI 9m Demonstration Blade Achievements

- Assembled broad supply chain for blade fabrication trials
- Fostered collaboration between IACMI industry partners, government laboratories and IACMI technology areas
- Demonstrated innovative composite material and processing technologies at blade scale
- Demonstrated potential reduction of cure time and in-mold cycle time for ELIUM® versus baseline epoxy
- Successfully produced a full-scale 9 meter technology demonstration wind turbine blade with advanced composite materials to be displayed at the CoMET Ribbon Cutting, the IACMI Colorado Members Meeting and other venues
- Augmented the path to commercialization for several of the innovative materials and processes

IACMI 9m Demonstration Blade Team Members

ARKEMA INNOVATIVE CHEMISTRY	Dana Swan Sri Seshadri	Nate Bachman Nicolas Valloir
Axson / Sika BUILDING TRUST	Jason Cilio	Pat Cunningham
JM Johns Manville	Mingfu Zhang	Klaus Gleich
HUNTSMAN	Michael Connolly	Alex Elsey
STRONGWELL	David Gibbs Todd Berthold Jeff Chandler	Josh McCroskey David Oakley Joe Spanovich

IACMI 9m Demonstration Blade Team Members

TPI Composites	Steve Nolet	Bob D'Ascoli
Composites One®	Corbett Leach	Barry Wilson Smith
CHOMARAT	Chris Mikesell	Jesse Hartzell
Creative Foam Corporation	Carol (CJ) Graham	
DowAksa	D.J. Delong	Ravi Ramanathan

IACMI 9m Demonstration Blade Team Members

Chem Trend

Sam Dethloff

Oak Ridge National Laboratory

Craig Blue
Cliff Eberle
Bob Norris

U.S. Department of Energy

John Winkel

The Composites Institute (IACMI)

Dale Brosius
Renae Speck
Chelsea Ensey
Erin Brophy

NREL – National Renewable Energy Laboratory

David Snowberg
Ryan Beach
Bill Gage
Mike Jenks
Samantha Rooney
Robynne Murray
Troy Boro
Don Young

Future Work

- Current 9m blade to possibly be on display at JEC, AWEA WindPower, CAMX, etc.
- Potential additional 9m blade / component fabrication:
  - Validation / test blade
  - Blade to be sectioned (cut-up blade)
  - In-process and inspection NDE with Materials and Processing TA
  - Collaboration with Modeling and Simulation TA
  - Crossover with IACMI thermoplastic project
  - Process trials in conjunction with IACMI partners to drive towards commercialization

Special Thanks To:

COLORADO
Office of Economic Development
& International Trade

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NREL
NATIONAL RENEWABLE ENERGY LABORATORY

U.S. DEPARTMENT OF ENERGY

Thank You