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Information biology

Understanding the Aerospace Resin Infusion Market Satisfaction Gaps

**Mississippi State University
Advanced Composites Institute**

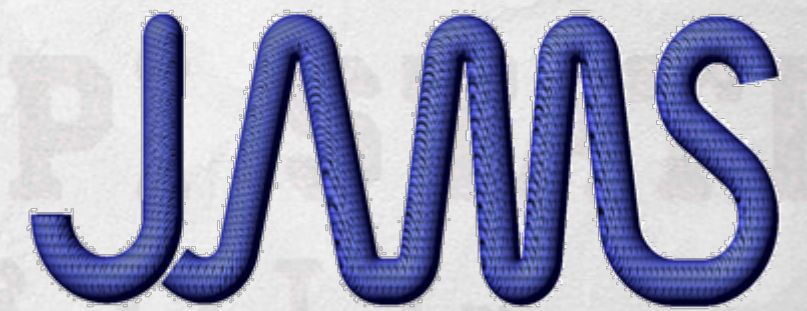
Home of the Marvin B. Dow Stitched Composites Development Center

Presenter: Wayne Huberty, PhD
Director of Research, ACI

JAMS Technical Review
9/29/21



**Federal Aviation
Administration**



Joint Centers of Excellence for Advanced Materials



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MISSISSIPPI STATE
UNIVERSITY™

Technology Readiness Assessment for Stitched and Unstitched Resin Infusion

Federal Aviation Administration



**Federal Aviation
Administration**

Ahmet Oztekin, PhD

Program Manager, JAMS, FAA

Dave Stanley

Technical Monitor, JAMS, FAA

Advanced Composites Institute

Home of the Marvin B. Dow Stitched Composites Development Center

Christopher Bounds, PhD, MBA

Director, ACI

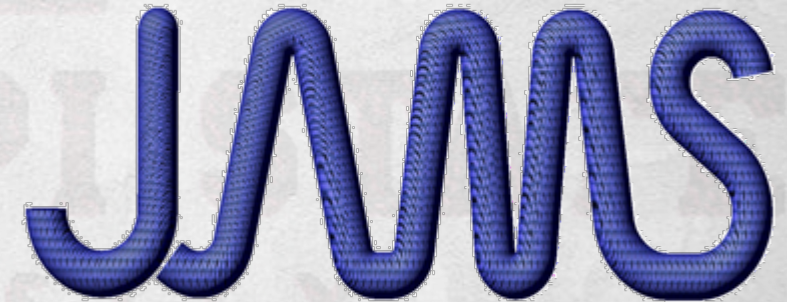
Tonia Lane

Deputy Director, ACI

Wayne Huberty, PhD

Director of Research, ACI

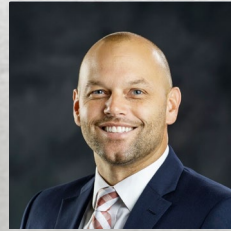
Source of matching funds: Various industrial partners



Joint Centers of Excellence for Advanced Materials



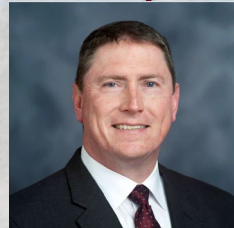
ACI Leadership Team and Faculty Collaborators



Dr. Chris Bounds
ACI Director



Courtney Jethroe
Accountant



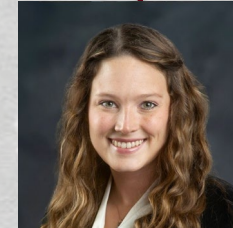
Edward McGinnis
Business Manger



Tonia Lane
Deputy Director



Dr. Wayne Huberty
Research Director



Paige McCraine
Ops Manager



Dr. Chuck Pitman
Prof. Emeritus



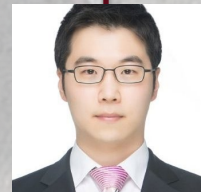
Dr. Mathew Priddy
Professor Mech Eng.



Dr. Santanu Kundu
Professor Chem Eng.



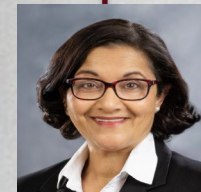
Dr. Zhenhua Tian
Professor Aero Eng.



Dr. Han-Gyu Kim
Professor Aero Eng.



Dr. Davy Belk
Prof Aero Eng.



Dr. Rani Sullivan
Head Aero Eng.



Dr. Dennis Smith
Prof & Head Chem

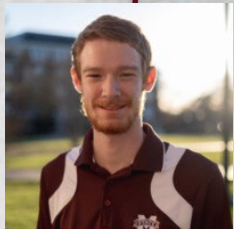


Dr. Thomas Lacy, Jr
Prof Mech Eng. Tx A&M

Ideation, Design, and Research & Development



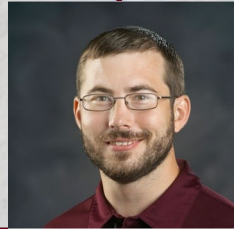
Dr. Wayne Huberty
Research Director



Nathan Pachel
Graduate Student



Joe Capriotti
Sr. Research Eng.



Brandon Warner
Sr. Design Eng.



Matthew Roberson
Engineer



Bowen Cai
PhD Candidate



Easton Williams
Grad. Student



Hunter Watts
Undergrad

Technology Readiness Assessment Stitched and Unstitched Resin Infusion (SURI)

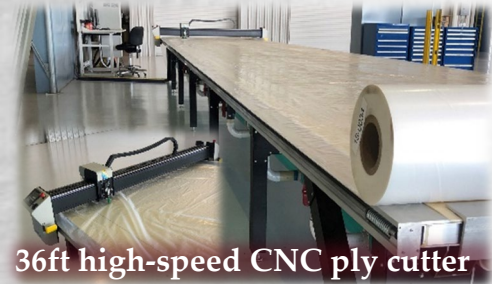
Objective: identify current state, potential future, and address market concerns for SURI

Resin infusion allows for lower cost, higher rate composite manufacturing.
What prevents its adoption, and can we address these concerns?



Advanced Composites Institute Capabilities

Focused on Industry-Scale Development



36ft high-speed CNC ply cutter

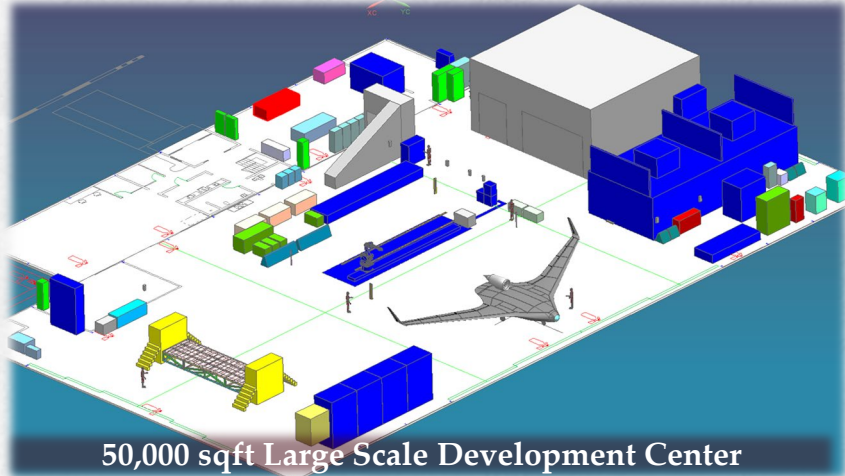


Temp & Humidity Controlled Layup



Room Temp VARTM Process

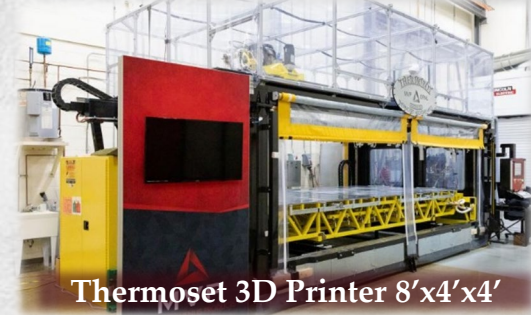
Pilot-scale layup tooling



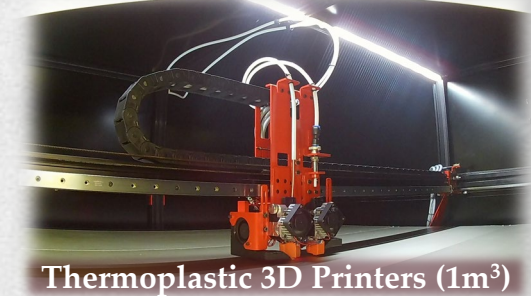
50,000 sqft Large Scale Development Center



28,000 sq ft high-bay



Thermoset 3D Printer 8'x4'x4'



Thermoplastic 3D Printers (1m³)



30 ft Layup tooling



50ft industrial curing oven



100-gal auto infusion



40ft x 8ft travel Robotic Stitching

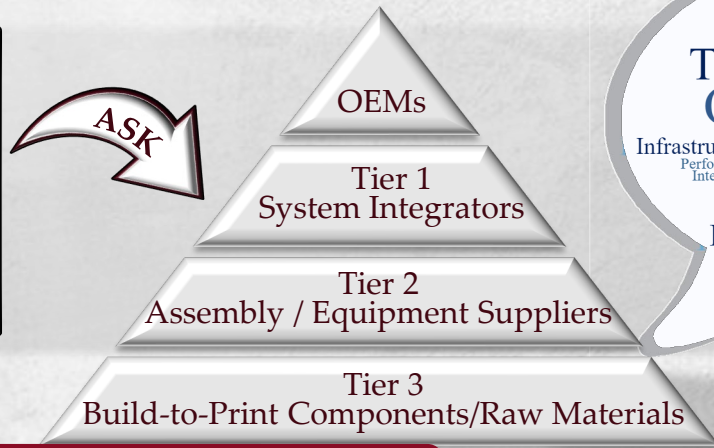
New Product Blueprinting: Voice of the Market

Discovery ID Problem Statements

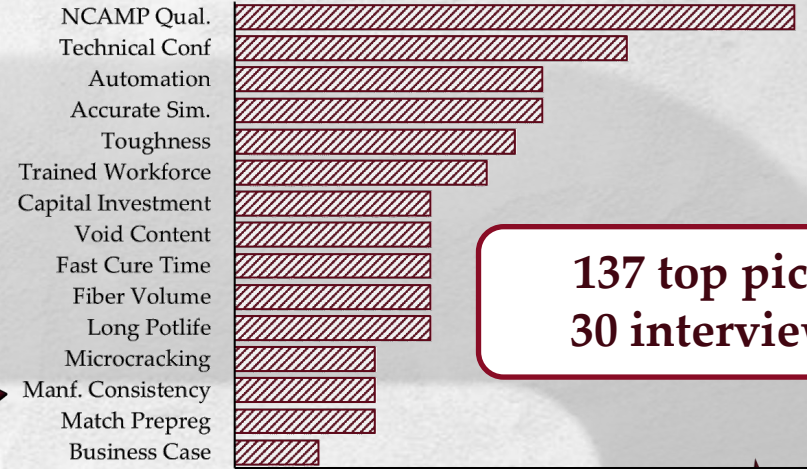
Preference Quantify Market Satisfaction Gaps

New Product Blueprinting: Voice of the Market

Discovery:
 1. Current?
 2. Problems?
 3. Ideal?
 4. Outcome?



Mine Data

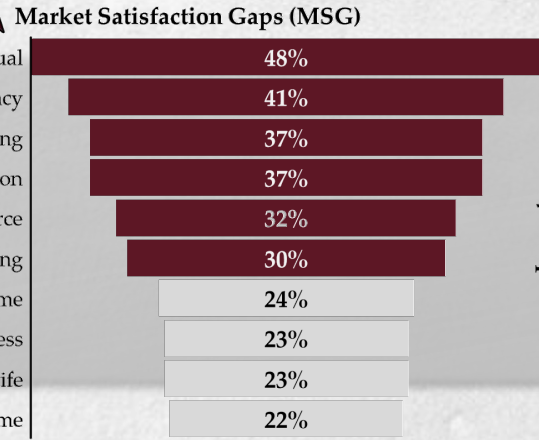


**137 top picks
30 interviews**

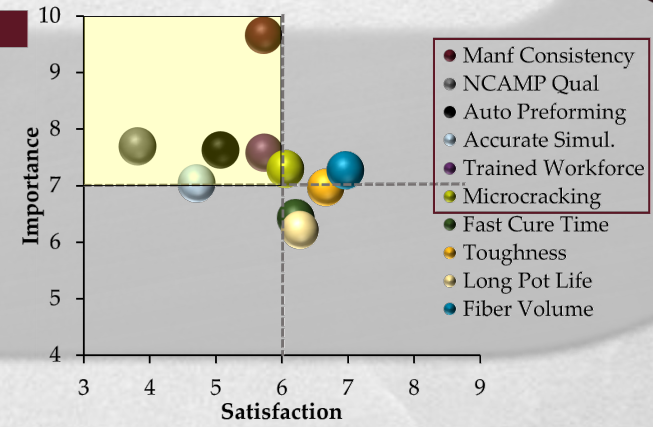
215+ targets 27 interviews

Outcome	Target	Test Method
NCAMP Qual	variation, cost, physicals	
Manf. Consistency	99% non-scrap	6 sigma
Auto Preforming	accuracy, output, cost	
Accurate Simulation	dry fabric, resin, process, manuf. inconsistency	
Trained Workforce	learn "why", local, ready	
Microcracking	match Boeing 787 prepreg	T800s/8552
Fast Cure Time	tact & tool time	50% lower EP2400
Toughness	match Boeing 787 prepreg	T800s/8552
Long Pot life	improve 50%	EP2400
Fiber Volume	60% ± 1-3%	ASTM D3171

Quantify



Prioritized Outcomes



Prioritize

Preference:
 1. Importance?
 2. Satisfaction?
 3. Targets?
 4. Measure?

NPB results – Entire Market



Rating	Importance	Satisfaction
1	Not important at all	Totally unsatisfied
3	Not too important	Unsatisfied
5	Moderately important	Barely acceptable
7	Very important	Good
10	Critical	Totally satisfied

Conclusions

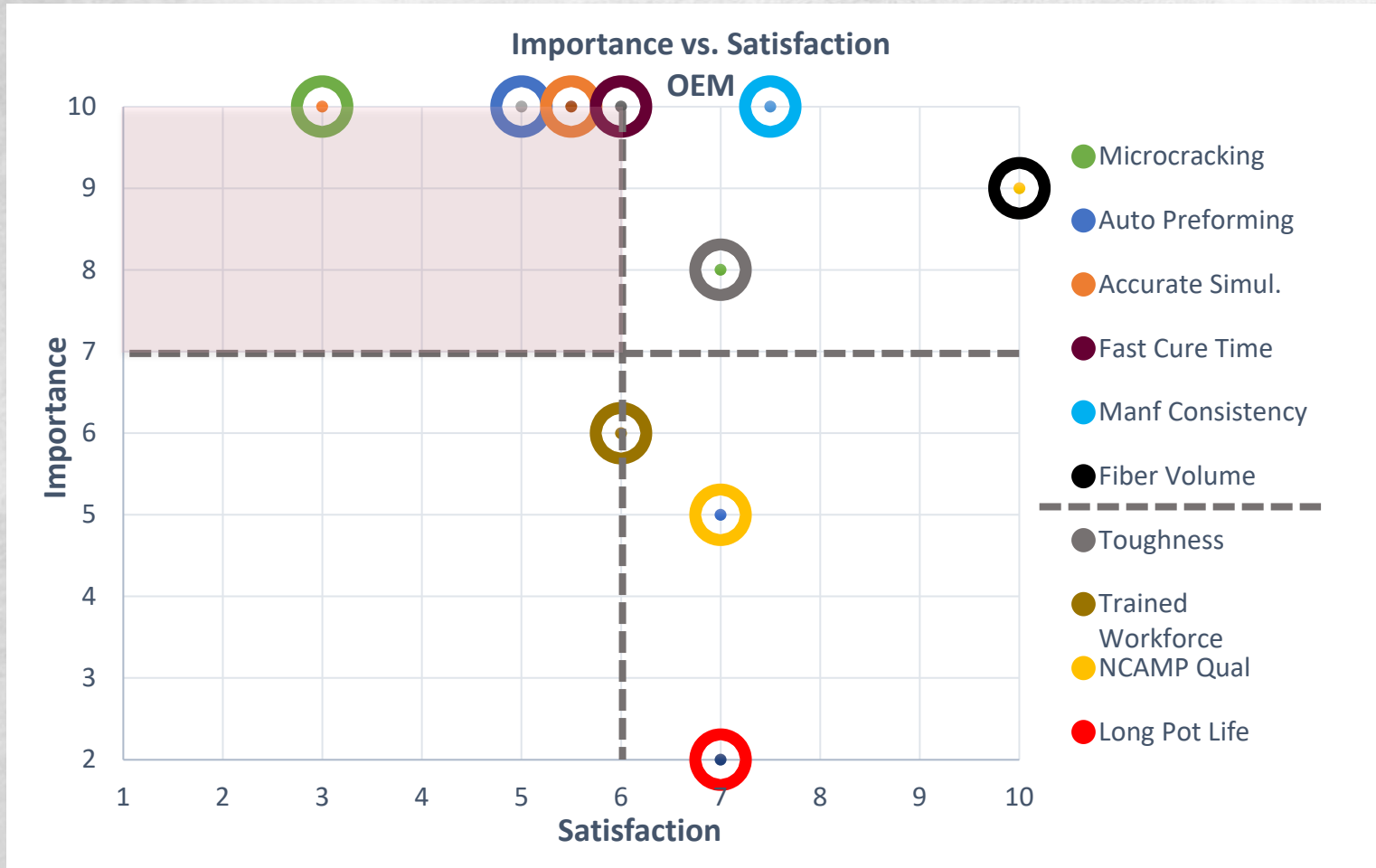
NCAMP and accurate sim. are most important and least satisfied

No satisfaction above 7

NPB results – Market segments can differ



NPB results – OEM



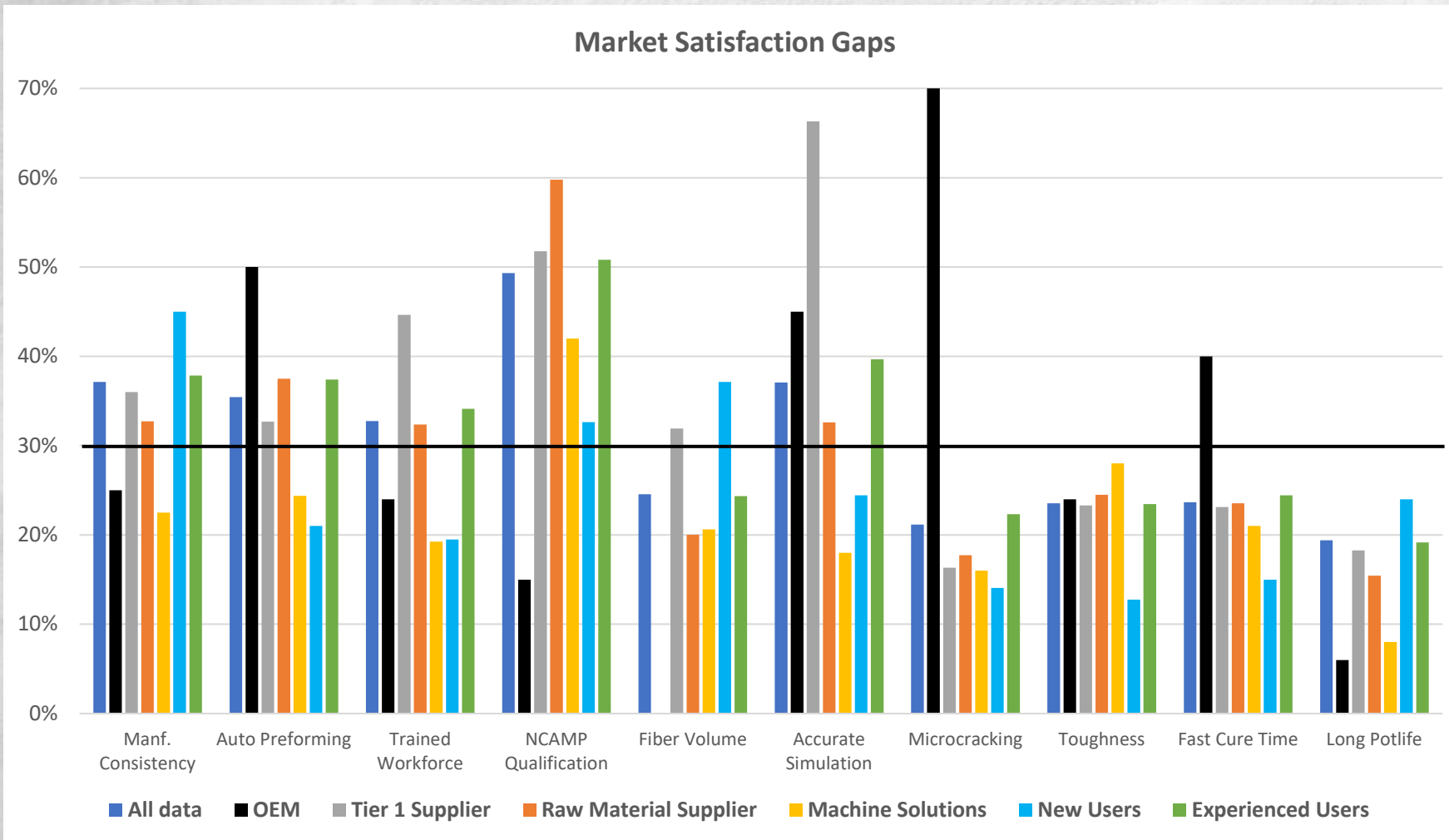
Rating	Importance	Satisfaction
1	Not important at all	Totally unsatisfied
3	Not too important	Unsatisfied
5	Moderately important	Barely acceptable
7	Very important	Good
10	Critical	Totally satisfied

Conclusions

6 items are critical in importance

First time microcracking in top left

NPB results – Market Satisfaction Gaps



How to read graph

MSG > 30% is significant

Mathematical transform of importance. vs satisfaction.

Conclusions

Enormous MSG for sim. for Tier 1 and M.C. for OEM

Large discrepancy between new and experienced users

NPB results – the real Blueprint!

Problem Statements	Target	Test Method
NCAMP Qualification	Variation of fabric & resin, lower cost (equivalency), full physicals, shapes, full data (not peak)	
Manufacturing Consistency	99% defect free	5-6 sigma
Auto Preforming	Accuracy, quality, laydown rate , lower cost, flexibility	Prepreg
Accurate Simulation	Drapability, resin flow, springback, 2D to 3D part, manuf. inconsistency and structure, process (digital twin/thread)	Compare to test panels
Trained Workforce	Learn “why”, local, ready immediately	Placements
Microcracking	Match Boeing 787 prepreg. Correlation between temperature, moisture, and microcracking.	Toray T800S/3900, Hexcel 8552; 1,000-3,000 thermocycles
Fast Cure Time	Tact time, lower cure temp.	4 h (50% lower than EP2400 @ 8 h)
Toughness	Match Boeing 787 prepreg. Expect RI can exceed.	Toray T800S/3900, SolvayEP2400, HexPly M21E & 8552
Long Pot life	Improve 50%	20 h (10 h @ 100° C Solvay EP2400)
Consistent Fiber Volume Fraction	60% ± 1-3%	ASTM D3171

NPB results – the real Blueprint! – Auto Preforming

Topic	Target
Pick and place accuracy	± 2 mm
Fiber direction	UD $\pm 3^\circ$, fabric $\pm 5^\circ$
Lay down rate	40-50 m ² /h small course, 100+ m ² /h large course
Fabric slitting tolerance	± 0.005 "
End effector tolerance (lap/gap)	± 0.002 " / ± 0.008 "
Course-to-course tolerance (lap/gap)	± 0.015 " / ± 0.015 "
End placement	± 0.100 " for up to 1/2 " tapes; ± 0.015 " for 1.5" tapes

Summary

Showed the process of NPB

Collected Importance vs. Satisfaction plots

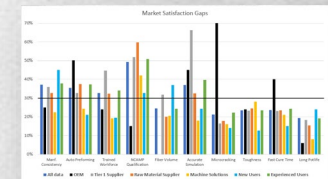
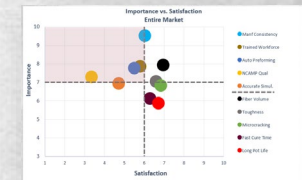
Determined Market Satisfaction Gaps for different market segments

Quantitative outputs to address

New Product Blueprinting: Voice of the Market

Discovery
ID Problem Statements

Preference
Quantity Market Satisfaction Gaps



NPB results – the real Blueprint!

Problem Statements	Criteria	Test Method
NCAMP-Questionnaire	Accuracy of info. & items, Good user engagement, full 100% info. gaps, full data over 2000	5 or higher
Manufacturing Consistency	95% defect free	Prep
Auto Performance	Accuracy, quality by defect rate, lower cost, flexibility	Prep
Accurate Simulation	Virtual only, real time process, single click, 2D compare, 3D part, internal consistency and structural integrity	Compare to real parts
Standard Workforce	Learn 'value' local, ready immediately	Placement
Microvibrating	Match Boeing '00' prepreg, Consistent between transportation, operation, and conversion	Teary 1000/300, Havel 450, 1.000, 1.000, 1.000
Fast Case Time	1st time, lower cost prep.	4.5, 0.5, lower time (1.000 R 0.5)
Lightness	Match Boeing '00' prepreg, Keynet 00 can exceed	long 1000/300, Havel 450, 1.000, 1.000, 1.000
Long Part Life	Significant life	200, 1000/300, Havel 450, 1.000, 1.000, 1.000
Customer Value Substitution	60% & 3%	ASTM D1071

Questions

Presenter: Wayne Huberty, PhD

Director of Research, ACI

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