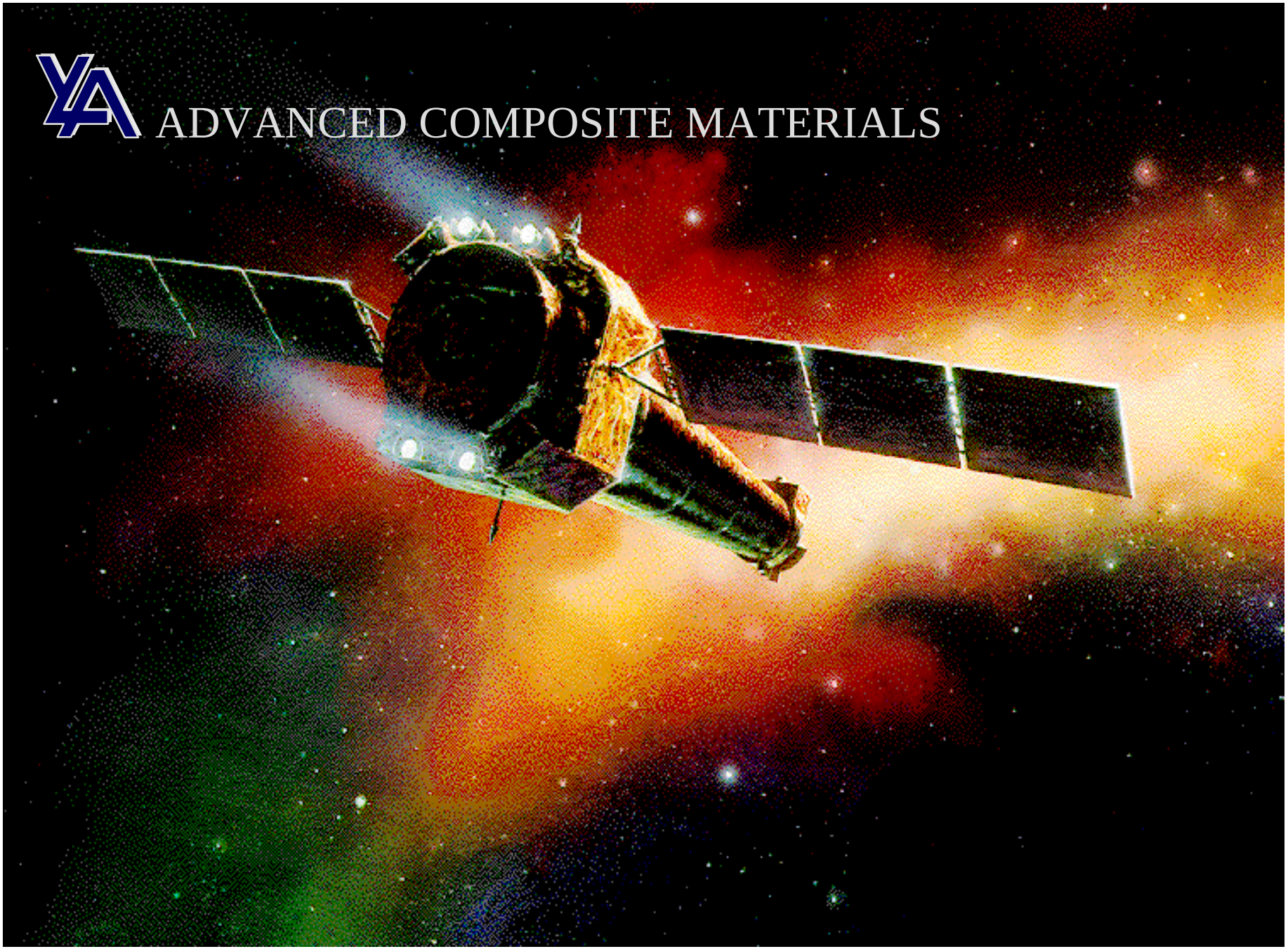
ADVANCED COMPOSITE MATERIALS



LOCATION OF YLA, INC.

YLA HISTORY

- Young Lee and Associates was purchased in August 1987 by Gary Patz and Mike Fellman. In September 1987 YLA was moved to Concord, CA.
- Perstorp A. B. acquires 15% of YLA equity in September 1989.
- YLA moves to larger facility in Benicia, CA in January 1991.
- Perstorp A. B. acquires majority equity of YLA in December 1994.
- Gary Patz retains equity position and is appointed President and Chief Executive Officer.

YLA
Business Philosophy

Together with our customers in strong teaming relationships, YLA applies innovative chemistry and process technology to define, create, and produce the exact material for customers' applications. Every YLA employee is an integral part of the team.

YLA OVERVIEW
September 1997

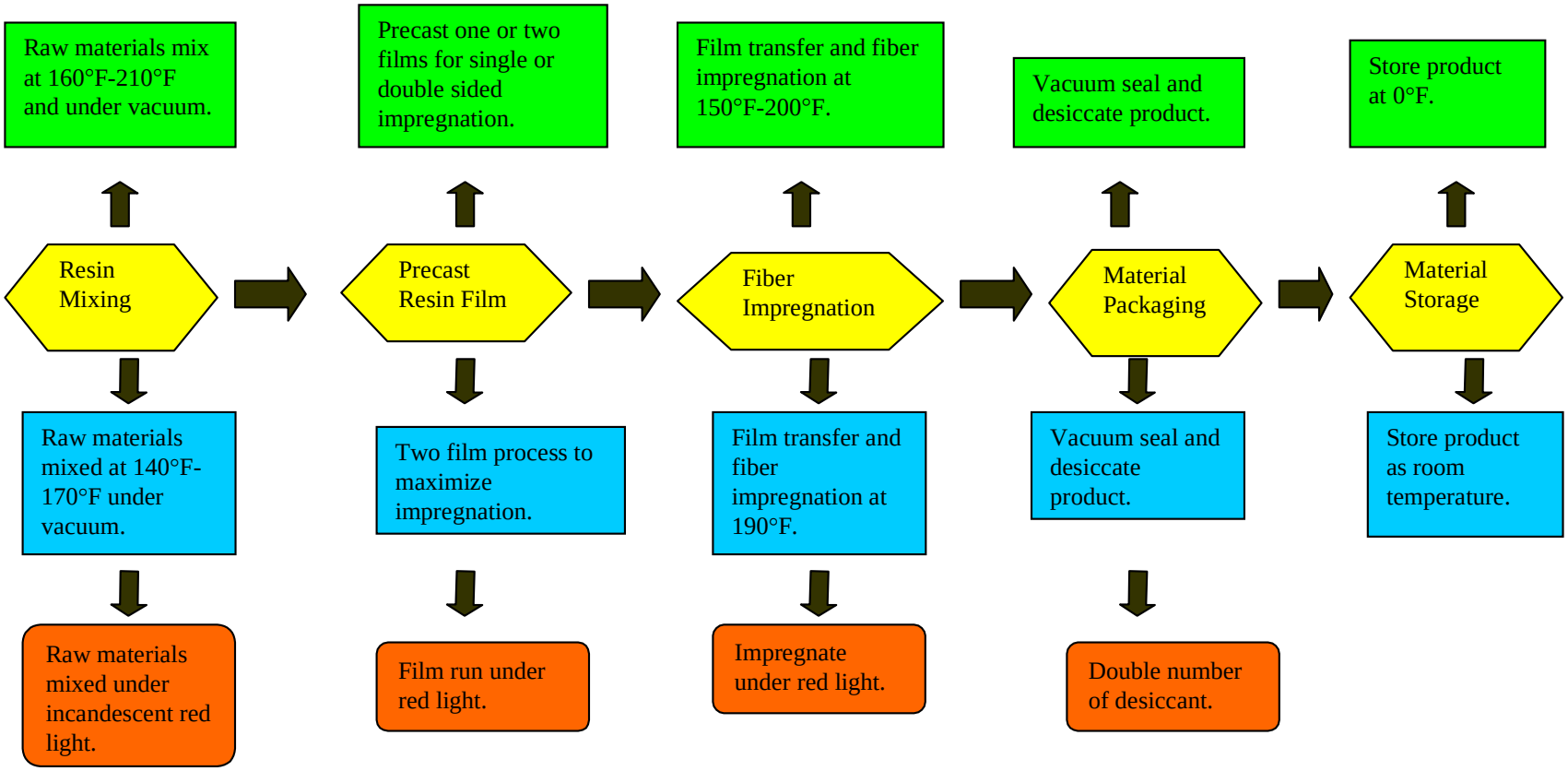
- Employees: 36
- Facility: 42,000 sq. ft.
- Production Capabilities:
  - 50” Hot Melt Prepreg and Film
  - 12” Unidirectional Tape
  - 24” Reverse Roll Coater
  - 24” Unidirectional Tape
  - 64” Hot Melt Prepreg and Film Machine now being built for carbon-free prepregging
  - 12” Unidirectional Tape Machine now being built for R&D
  - Additional 24” Unidirectional Tape Machine has been approved and is scheduled to be on line by April 1998

YLA
Process Control Capabilities

- All prepreg and filming equipment equipped with beta or gamma gauge process control
- 24” Reverse Roll Coater film tolerance of 1.5 g/m^2
  - Example: Prepreg FAW of 70 g/m^2 - YLA can maintain resin content of ± 2.0%
- Implementing new process control technology to reduce operator controlled variation in the prepreg process
  - Camera imaging equipment with a rule based computer system will control fiber areal weight and resin content inconsistencies never before identified using standard inspection methods

YLA
General Prepreg Operation Flowchart

Standard Hot Melt Prepreg Operation



E-Beam Prepreg Operation

YLA
Prepregging Precautions for Electron Beam Materials

- Use incandescent **red** lights in all production areas.
  - → *This limits advancement effects produced by natural, fluorescent, or mercury lights.*
- Reduce humidity in all production areas to minimum practical level and desiccate product well.
  - → *This limits moisture exposure to prevent unwanted reaction effects or possible side reactions.*

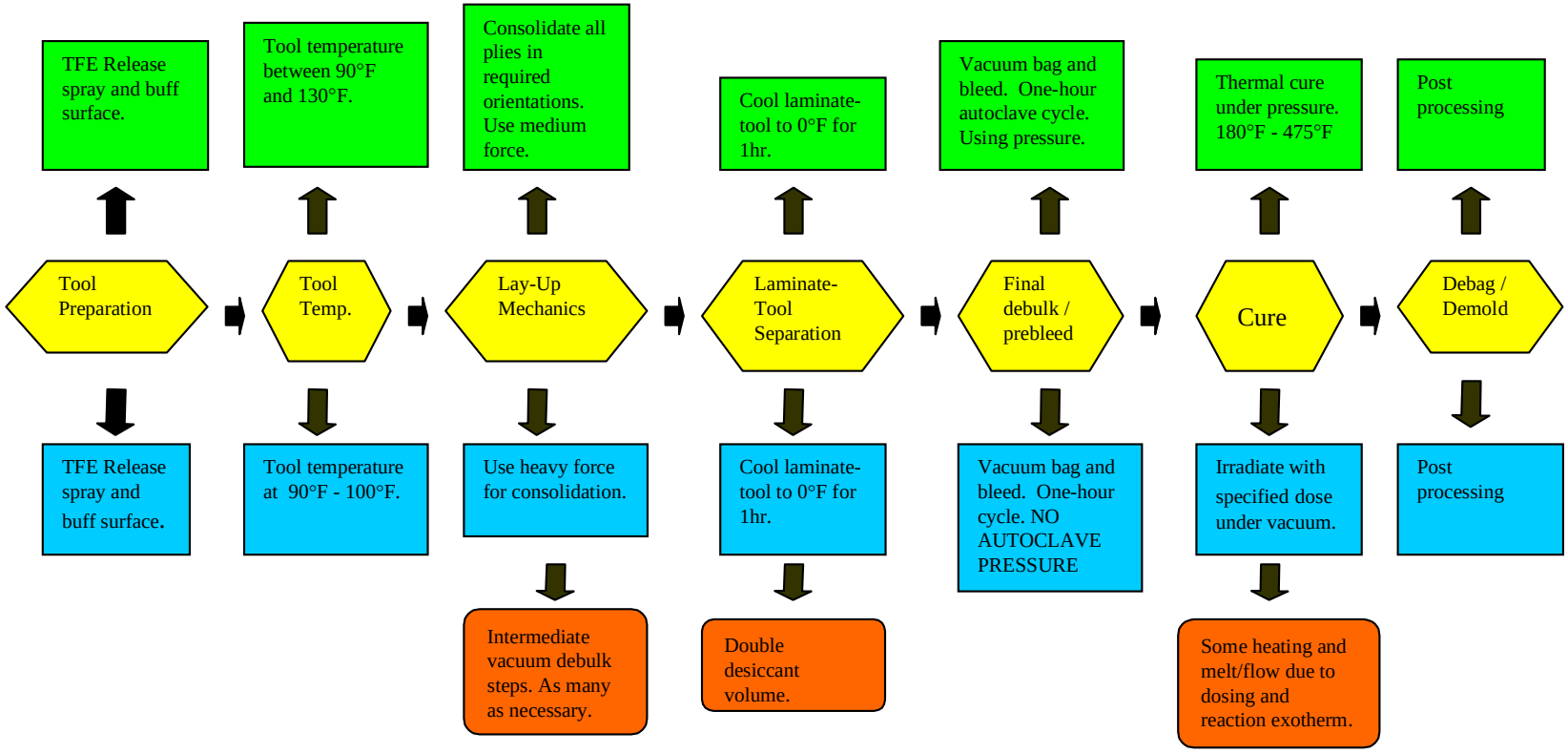
- ***Conclusion***:

  Only minor to moderate adjustments are required in manufacturing processes to produce E-Beam materials.

YLA

General Laminate Consolidation Flow Chart

Standard Lamination Procedure



E-Beam Lamination Procedure

YLA

Electron Beam Laminate Processing Summary

- Intermediate debulk steps are nearly mandatory.
  - → *This reduces the volume of entrapped air and volatiles.*
- Use heavy pressure to consolidate during lay-up to compensate for lack of autoclave pressure during consolidation and cure.
  - → *This increases compaction of plies and encourages knitting of individual laminae.*
- Reduce humidity in all work areas to minimum practical level and keep workpiece desiccated to greatest possible extent.
  - → *Limits moisture exposure and possible unwanted reactions.*
- ***Conclusions***:
  - → *Operator skill (or machine methodology/technique in future) is crucial to finished laminate quality. No unusual equipment is required for hand lay-up.*
  - → *Laminate quality(and properties) can vary over a wide range from very poor to excellent depending on material melt-flow parameters and operator technique and skill.*
  - → *Preparation prior to cure is likely to be significantly more involved when autoclave consolidation is not available.*

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Packaging/Transportation of "Green" Laminates

- Uncured ("Green") E-Beam laminates are susceptible to the same kinds of damage and abuse as uncured conventional laminates. They are: malleable, fragile, bendable, peelable, and subject to viscous flow.
- Since availability of accelerators is very limited; it is likely that early users of E-Beam materials will either have to contract cure, contract consolidate (at the accelerator site), or both.
- ***Proper packaging and transport can be the determining factors in success or failure of otherwise great laminates.***

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"Green" Laminate Packaging/Transport Suggestions

- Protect all surfaces of laminates with rigid/semi-rigid supports to prevent bending or other surface damage.
- Supports should be either the same size as laminates or have stops placed to prevent "roll-off" at edges and other vulnerable areas.
- Overbag, desiccate, and seal the laminate under vacuum to protect from moisture ingress during shipping/handling.
  - → *Be sure that laminate/support release is adequate to prevent damage!!*
- Although low temperatures are not necessary to retard advancement, low temperature shipping may be desirable to protect against viscous flow ("creep") during shipment.
  - → *Some resins have very steep viscosity vs. temperature curves which could make them susceptible to damage. Unrefrigerated packages shipped via common carrier can easily experience temperatures as high as 100° F for prolonged periods.*

YLA
Testing Capabilities

- World class capabilities in fabrication and mechanical testing of high strength/modulus laminates
  - 850 °F/500 psig Autoclave with State-of-the-art Control System
  - Chevalier 1632 Precision Cutting/Specimen Preparation System
  - 60 kip UTS microprocessor controlled tension/compression load frame and full range of Wyoming Test Fixtures. All major test methods supported.
  - Environmental Test Chamber: -250 °C to 500 °C mechanical test capability
  - MDS 2000 Rapid Laminate Digestion System for repeatable, precise fiber and void volume data.
- Analytical capabilities: FTIR, Rheometrics, DMA/DSC/TGA, and microphotographic. Partnerships with outside laboratories for other advanced techniques: SEM/ESCA/XRF, HPLC, GPC, etc.

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E-Beam "Best of Breed" vs. Typical Satellite Materials

PROPERTY	E-BEAM RESIN VALUE	"SPACE" RESIN VALUE	COMPARISON BASIS	COMMENTS
Tension Str., ksi Tension Mod., msi	110 – 120 ~12	110 – 130 10 - 12	EB/IM-7 2 x 2 TW CE/T300 or IM-7	1. V. Good Comp. 2. Space Low End is w/T300 & High End is w/IM-7
Compr. Str., ksi Compr. Mod., msi	200 – 220 20 – 22	200 – 240 21 – 23	EB/IM-7 Uni CE/IM-7 Uni	1. All good quality panels. 2. Various C/PC for CE sys.
Flexural Str., ksi Flexural Mod., msi	240 – 285 22 – 25	< 200 22 – 24	EB/IM-7 Uni CE/M55 Scaled Uni	1. All high quality panels. 2. No dir. flex. data avail w/CE, so scaled M55 data used
Fiber Volume, % Void Volume, %	52 – 55 (Fabrics) 55 – 65 (Unitapes) 1 - 3	55 –65 (Fabrics) 55 – 65 (Unitapes) < 2 (Typ. < 1)	EB/IM-7 Various CE/Reinf.	1. Highest quality panels for both comparisons.
Outgassing: TML, % CVCM, %	 Meets* Meets*	 0.1 –0.3 0.03 – 0.07	 AECL Data for EB Various for CE	1. NASA reqs.: TML < 1., CVCM < 0.1
ILSS, ksi	9.5 – 11.5	9 – 12.5	EB/IM-7 Various CE/Reinf.	1. Highest quality E-Beam panels.
Tg, °C	>> 200	170 – 260+	Var. EB Various CE	1. EB and CE both easily meet ranges reqd. for space apps.

General Notes: 1) All CE's are autoclave cured, 2) All EB Panels are hot debulked under vacuum pressure only.

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E-Beam vs. Typical Satellite Materials: General Comments

- E-Beam data presented is for **good**, but not optimized resins, **good** but not optimized laminating, and **no** autoclave pressure for consolidation.
- Given other E-Beam resin benefits, space applications could still consider autoclave pressure for consolidation in order to maximize laminate quality.
- The most important current obstacle to widespread E-Beam implementation: INFRASTRUCTURE
  - → *Everyone owns an autoclave; very few own an accelerator.*
- ***Allowing for the assumptions which were made and some of the indirect comparisons:***
  - → E-Beam resins demonstrate that they could probably be successfully employed for satellite structures immediately!!

YLA R&D
Potential E-Beam Application Growth Areas

- Thermally conductive adhesives, prepregs, and molding compounds.
- Structural molding compounds.
- Low density, low dielectric syntactic materials.
- E-Beam adhesive films and pastes.
- Non-epoxy resin systems.
- RTM/wet-winding resins.
- New proprietary toughening technologies for E-Beam epoxy systems (hyperbranched polymers).

YLA
Summary

- Manufacture of E-Beam product forms (resins, prepregs, adhesives, towpreg, syntactics, molding compounds) can be readily accomplished with only minor to moderate adjustments in standard process methods.
- Consolidation of E-Beam resin based laminates can be successfully concluded without autoclave pressure.
- Certain applications; e.g., satellite structures are already rich for application of E-Beam resin system--even if autoclave consolidation is a practical necessity.
- ***YLA is strongly committed to supporting near and long term efforts in research, development, and commercialization of E-Beam materials.***

YLA
Acknowledgements

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- Mr. Ray Ramirez, YLA
- Mr. Steve Smith, YLA