Appreciation to Those Responsible

- Planners and Coordinators
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  - Cliff Eberle
  - Chris Janke
  - Lynn Klett
  - George Wrenn
- Other Session Leaders
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  - Tom Knobel
  - Vince Lopata
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- Presenters
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- Sponsors
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  - Oak Ridge National Laboratory
  - Oak Ridge Centers for Manufacturing Technology
  - Engineering Technology Division

Electron Beam Curing Overview and Review of Previous Workshops

R. E. Norris

Oak Ridge National Laboratory

Electron Beam Curing of Composites Workshop

Oak Ridge, Tennessee

April 20, 1999

Objectives of This Workshop

Foster Implementation of Electron Beam (EB) Curing Technology Through Discussion and Interaction, Including:

- Technology Updates - Progress and Issues
- Program Directions and Opportunities
- Identification of Needs

How Can We As a Technology Community Best Marshal Resources to Go Forward?

What is Electron Beam (EB) Curing

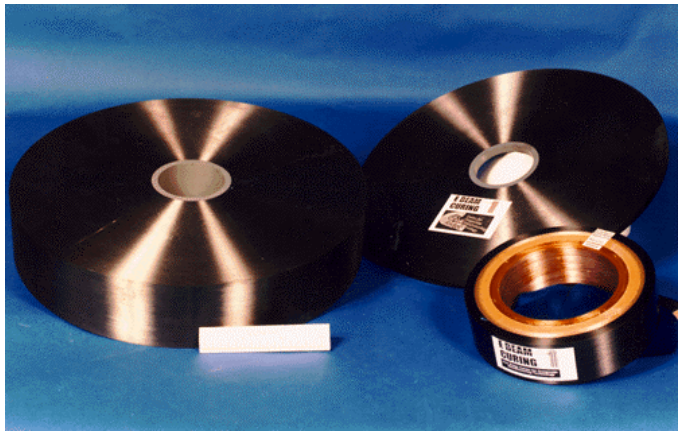
- High Energy Electrons And/or X-rays Used to Cure Polymers at Controlled Rates
- Curing Is Volumetric Versus Diffusion Controlled
- Degree of Cure Related to Absorbed Radiation, Not Temperature Achieved

	Traditional Thermal Curing	E-Beam Curing
Resin System	Resin and Hardner	Radiation-Sensitive Resin No Hardener Required
Cure Temperature	High	User Selectable
Cure Speed	Slow	Fast

Advantages of EB Curing

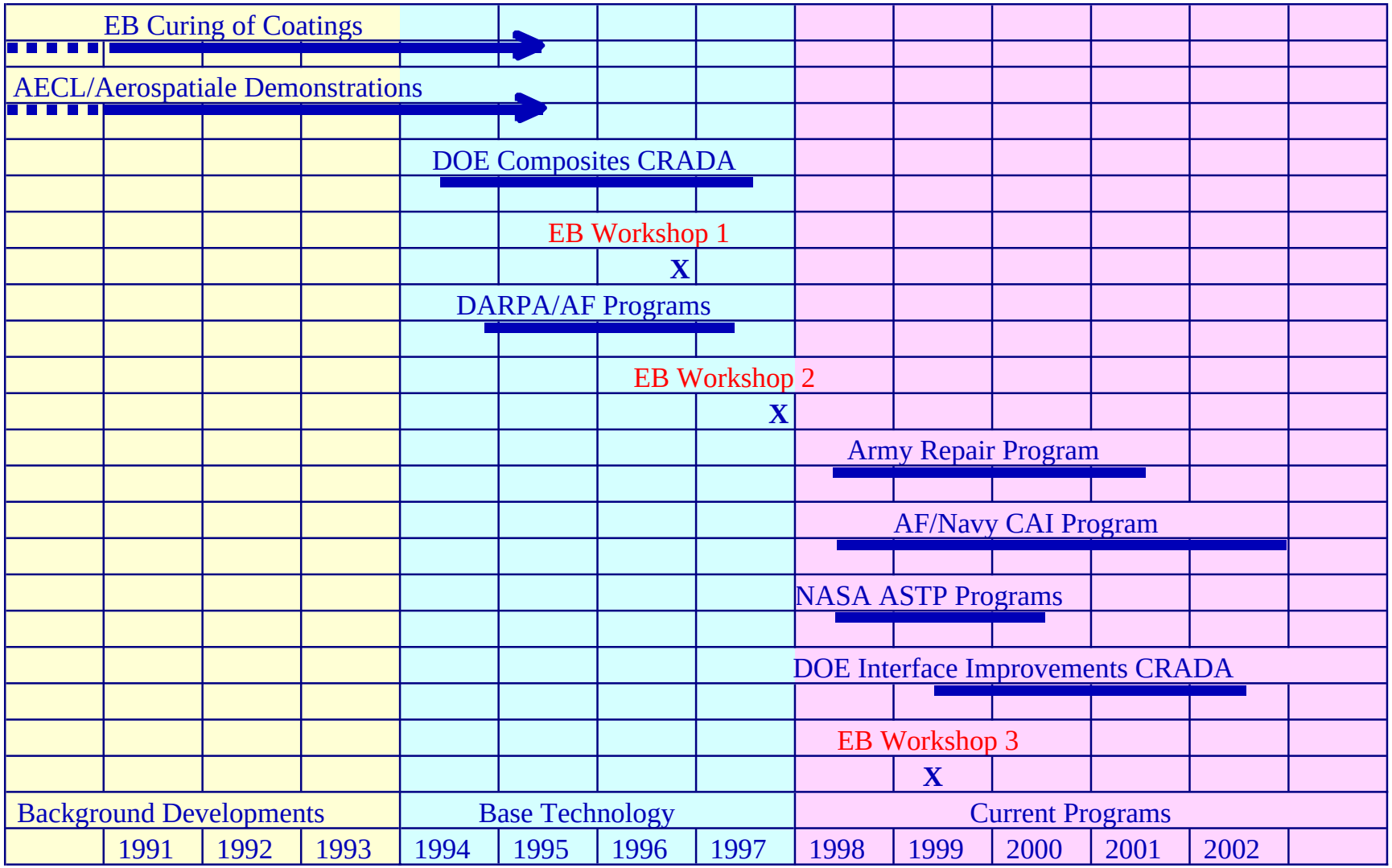
- Fast
- “Green” and Clean
- Long Pot Life
- Selectable Cure Temperature

- Inexpensive Tooling
- Out of Autoclave Process
- Thick Sections (Via X-ray)
- Unique Parts/Processes



Ultimately a More Affordable Process

Growth of Major EB Programs



Technology Progress

- Technology
  - Materials comparable to thermal baseline
  - Deficiencies being addressed
- New Facilities and Equipment Coming On-line
- Applications Development
  - Aircraft
  - Space Vehicles
  - Ground Vehicles

1996 EB Curing Workshop

- Composites Applications and Requirements
  - Aircraft, spacecraft, missiles, marine vehicles, ground vehicles
- Current Technology Assessments
  - Materials, processing, tooling, repair, facilities
- Identification of Cross-cutting Applications and Needs

LONGFOG Missile Prototype

Key Points from 96 Breakouts

- Aircraft Session
  - Consider General Aviation as a starting point, other industries to support supplier base
  - Material expectations not totally fulfilled
- Space Session
  - Select a few materials to characterize
  - Demonstrate residual stress and dimensional stability benefits
- Marine/Ground Vehicle Session
  - Establish QC for exposure process
  - Develop processes for thick/3-D parts
- Cross-Cutting Points
  - Facility sizes/locations
  - Material qualification
  - Cooperation and information sharing as pathways to success

1997 EB Curing Workshop

EB Cured T-38 Canopy Frame

- Space
- Aircraft
- Alternate Uses
- Facility Issues
- Breakout Topics
  - Materials qualification
  - Program leveraging
  - Interface Improvements*

* Added in response to requests at the workshop

Key Points from 97 Breakouts

- Material Qualification and Leveraging Sessions
  - Ongoing programs addressing general qualification requirements issues
  - Lack of large new programs puts a premium on cooperation to leverage resources
- Interface Issues Session
  - Interface generally viewed as culprit for marginal shear properties
  - Inconclusive debate on why the interface is deficient and how to investigate
  - General agreement that shear properties are a barrier to widespread aerospace usage

1999 EB Curing Workshop

- Interface Issues
- Material Qualification
- Facilitization
- Partnership Opportunities
  - Aircraft
  - Space
  - Army
  - Automotive
- Technology Progress and Identification of Needs

Prototype Comanche
High Temperature Shaft

Summary

- Technology Has Progressed From Formative Stage to Current Emphasis on Applications Development and Targeted Research
- Interest and Opportunities Continue to Grow
- Highest Priority Issues Are Being Addressed
  - Facilities
  - Interface Properties
  - Qualification
- *How Can We As a Technology Community Best Marshal Resources to Go Forward?*