

Automated Tape Layer Processing for Composite Components

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Key Discussion Topics

- ◆ **Automated Tape Layer Background**
 - development history
- ◆ **Review of Automated Tape Layer Technology**
 - material delivery technology
- ◆ **How Tape Layers Are Currently Used**
 - some aerospace applications
- ◆ **Potential for Non-Aerospace Applications**
- ◆ **Presentation Summary**

Background

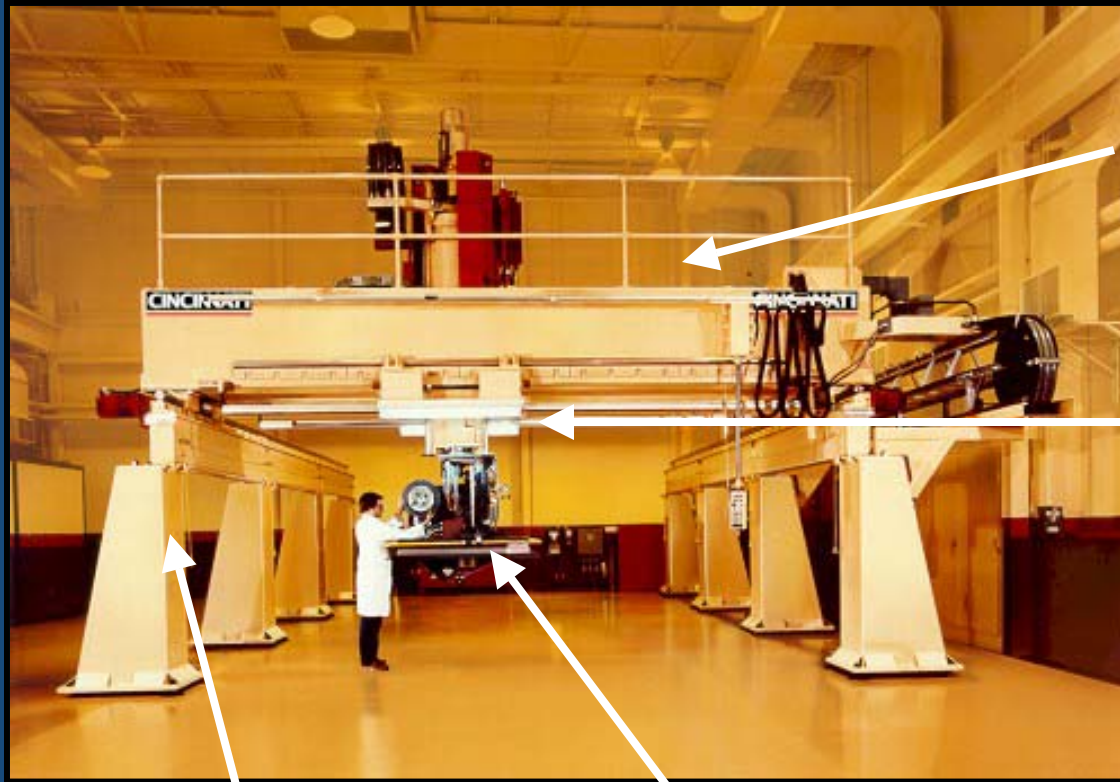
◆ What is an Automated Tape Layer (ATL)?

- ◆ Tape Layers are “composites machine tools”**
- ◆ Computer controlled machine movements**
- ◆ Multi-axis gantry with rack & pinion drives**
- ◆ Automated placement of prepreg tape materials on a tool surface**

Tape widths of 3” ... 6” ... 12”

Tape Layers are known as a high output process with limited applications

Automated Tape Layer System



**Cross Rail
Gantry (Y-axis)**

Machine Z-axis

**X-axis rail
& supports**

**Material
Delivery Head**

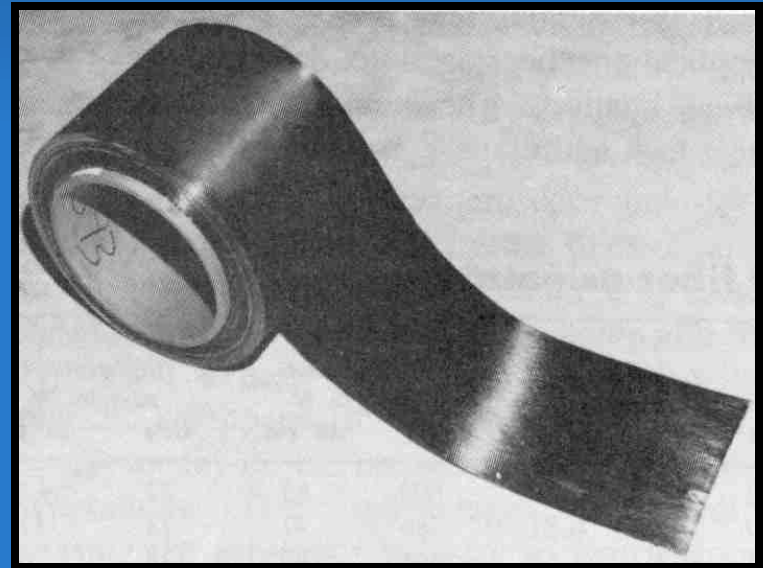
**Cincinnati
Machine ATL
System**

ATL History.....

- ◆ **Taper Layers were developed specifically for laying a new material form uni-tape**
- ◆ **ATL was first automated process for composite aircraft primary structure**

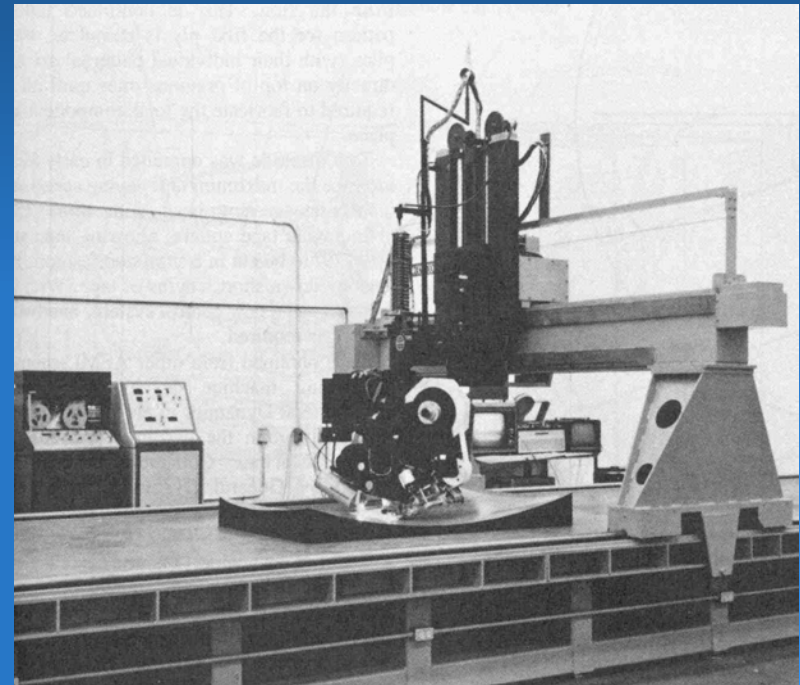
Unidirectional tape invented in the early 60's ATL process development in the late 1960's

First commercial machines available in late 1970's



ATL Development

ATL process was developed by a collaboration of aerospace companies and material suppliers



First ATL systems were small, fixed bed machines similar to metal cutting “skin mills”

ATL History

- ◆ **Tape Layers were used extensively in the 1980's on military aircraft programs**
 - ◆ B2 Stealth Bomber and other programs
- ◆ **Machine sales were very good in the 1980's reached a peak in 1988**
 - ◆ Eight (8) large systems installed in 1988
- ◆ **Interest in ATL declined in the 1990's due to lack of applications ... and aerospace industry focus on fiber placement and RTM processes**
 - ◆ ATL was the forgotten process

ATL Current Status

- ◆ **In the last few years interest in ATL has re-emerged in the aircraft industry**
 - ◆ New aircraft programs are providing good applications for the ATL process
 - ◆ Companies who operate ATL systems have discovered new ways to use the machines and take advantage of their high output rates

Automated Tape Layers will be used to build wing structure on the new Boeing 787

Automated Tape Layer Technology

Tape Layer Technology

Contour Tape Layer Machine (CTLM)

For laying tape on a contoured surface. CTLM's lay 3 in and 6 in wide tape

Flat Tape Layer Machine (FTLM)

For laying flat laminates FTLM's lay 6 in and 12 in wide tape. FTLM combined with a "hot forming" process makes the tape layer process very versatile

**Most tape layers operating in the industry
today are contour layers**

ATL Material Delivery Technology

Single-Phase Process tape materials are processed through a delivery head that cuts individual courses to shape and length (industry standard)

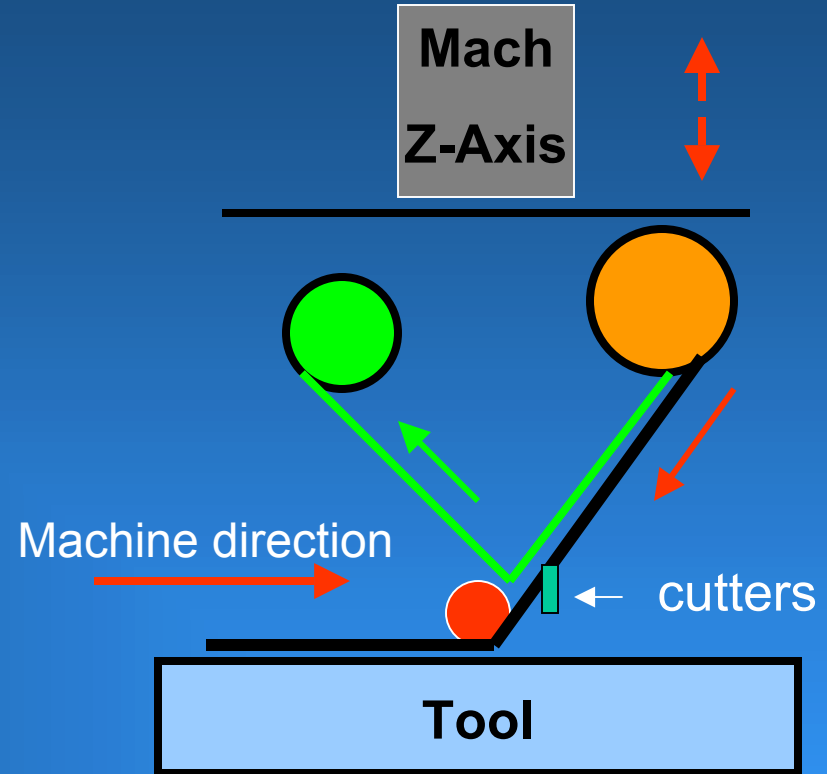
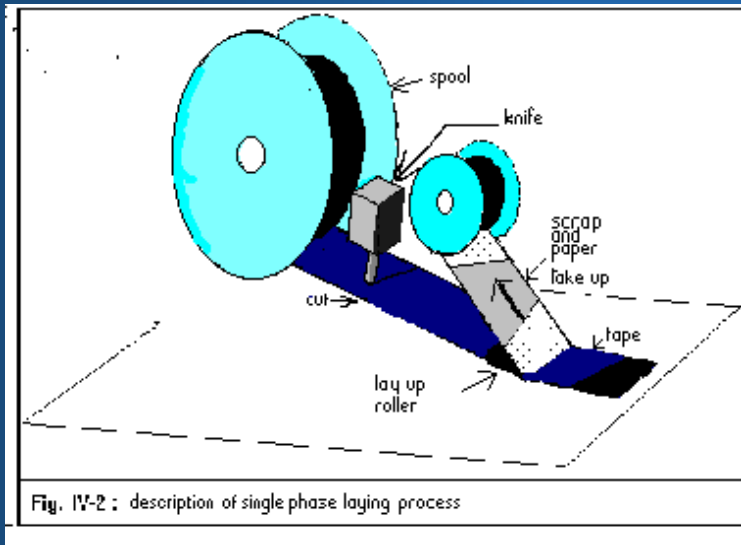
Two-Phase Process tape courses are cut off-line re-spooled on a cassette and transferred to a laying machine

Dual-Phase Process combines the single and two phase processes on one delivery head

Dual-Phase processing is the most versatile and efficient form of automated tape laying

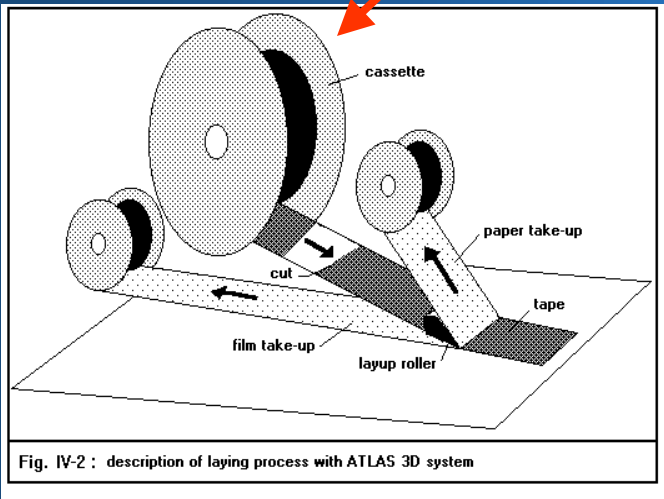
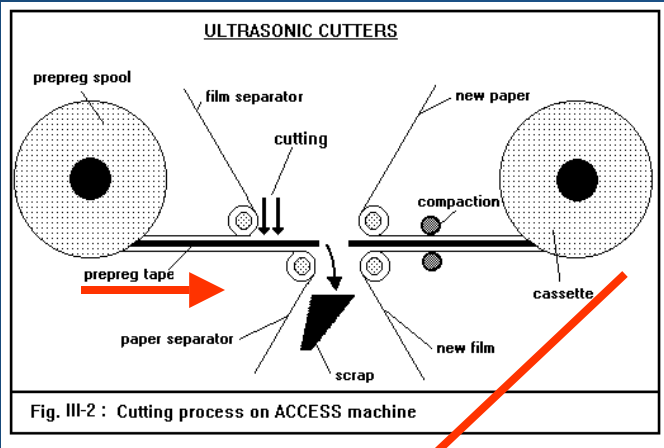
Single-Phase Tape Laying

Entire process is completed on the gantry machine the industry standard technology



Tape material is cut to size and shape as it passes through the delivery head and applied to the tool with compaction pressure

Two-Phase Tape Laying

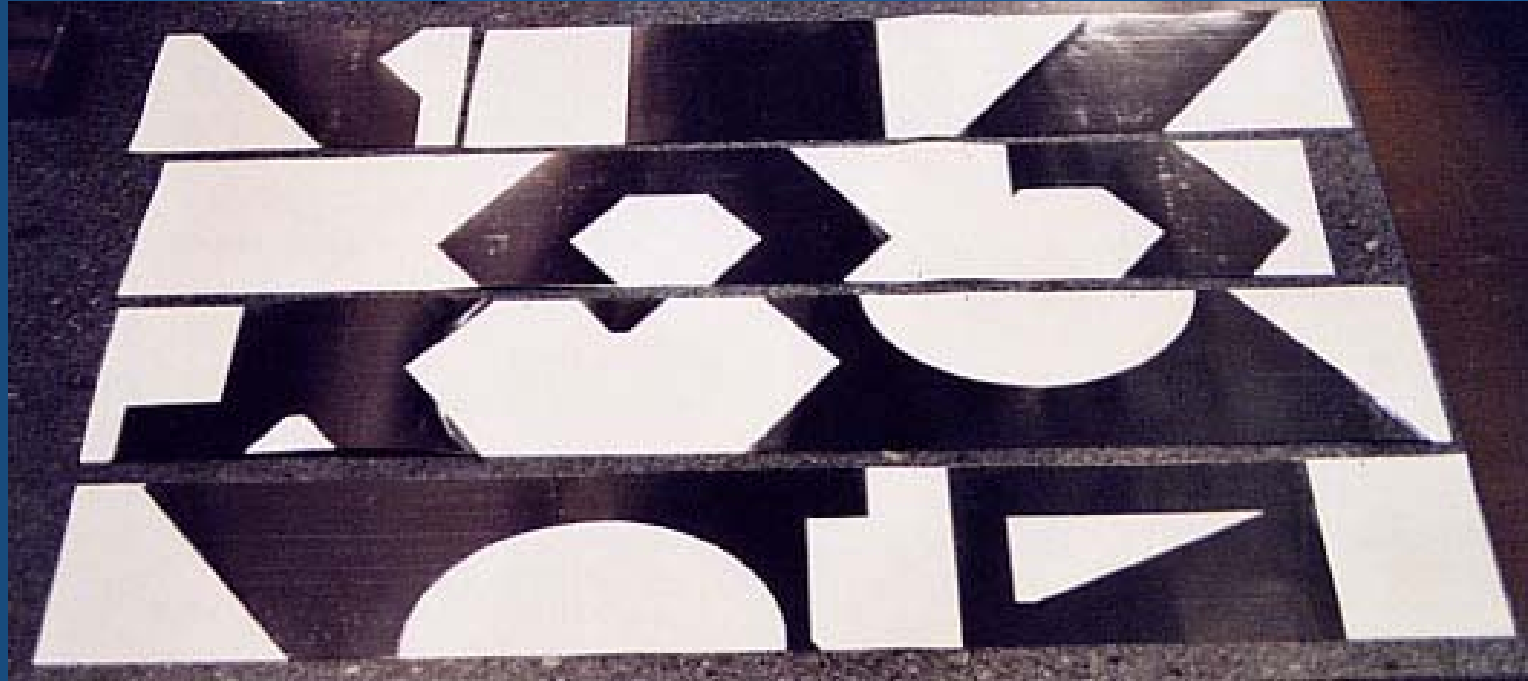


Tape courses are cut to shape and size “off-line” ... re-spooled on a cassette ... transferred to a laying machine



Off-Line Cutting System

Off-line cutting system will create a wide variety of shapes



Triangles, Arcs, Cutouts, Square cuts, Angle cuts

Dual-Phase Tape Laying

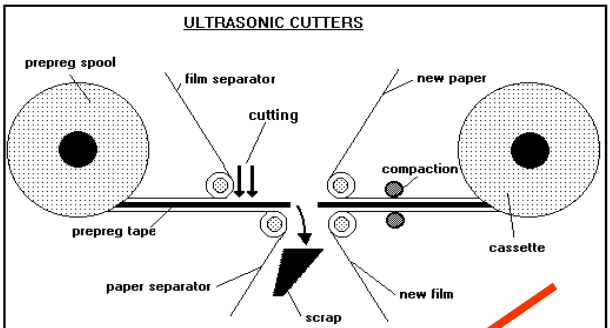


Fig. III-2 : Cutting process on ACCESS machine

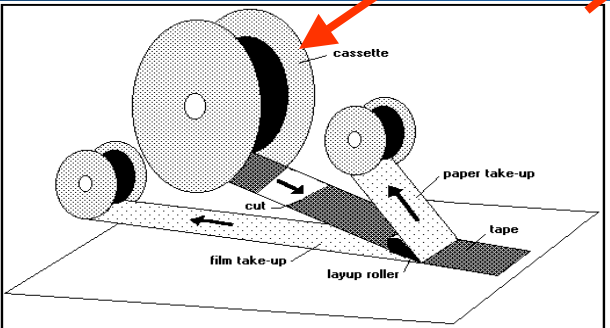


Fig. IV-2 : description of laying process with ATLAS 3D system

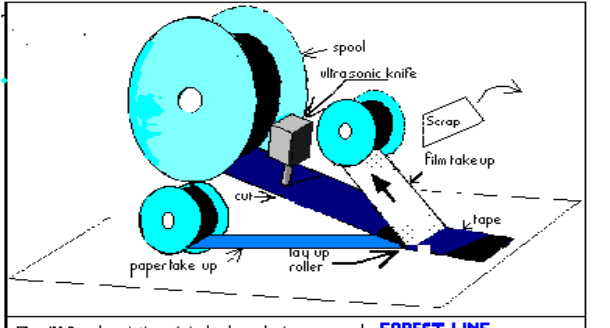
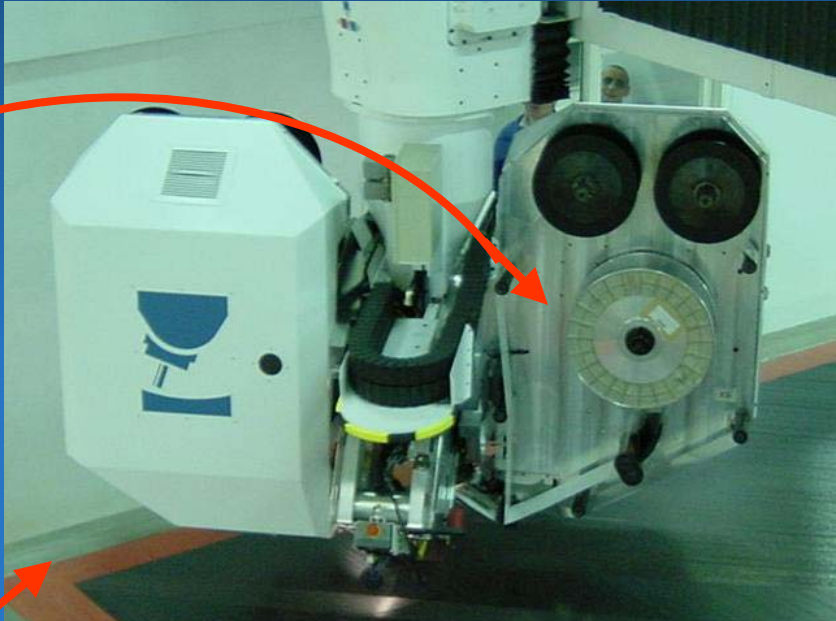
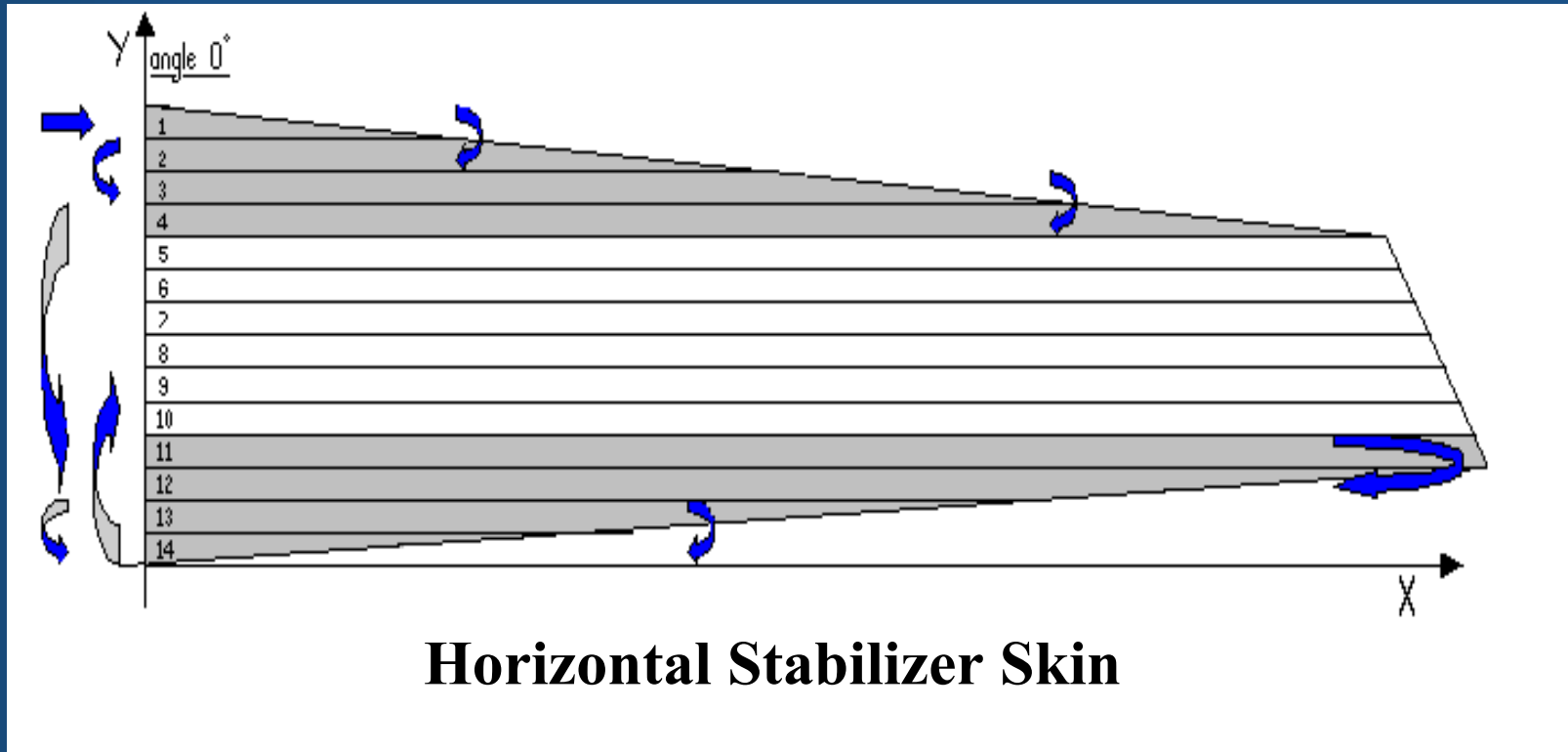


Fig. IV-2 : description of single phase laying process by FOREST LINE



Dual-Phase tape layers will be used to build the Boeing 787 wing box

Example of Dual-Phase ATL Processing



Two-Phase processing is faster than Single-Phase as the machine does not slow or stop for material cuts

Suppliers of ATL Systems

Cincinnati Machine.. the leading supplier

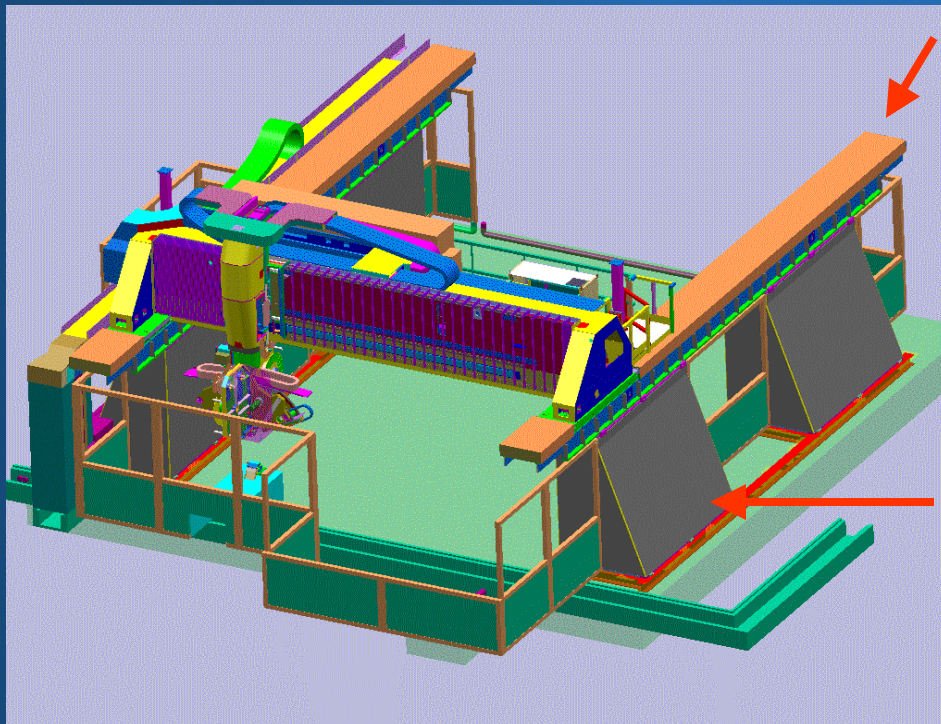
Forest-Line European company has all (3) material delivery systems ... unique gantry

Torres Machine European company most sales in Europe

American GFM small ATL system

Unique ATL Technology

Forest-Line Tape Layers are the most unique machines in the composites industry



**Gantry machine tool has
Linear motor drives on X,
Y, and Z axis**

Faster axis speeds

Quiet operation

**X-axis rails are supported
by concrete piers**

Integral with machine
foundation

Who Uses ATL Processing

NORTH AMERICA

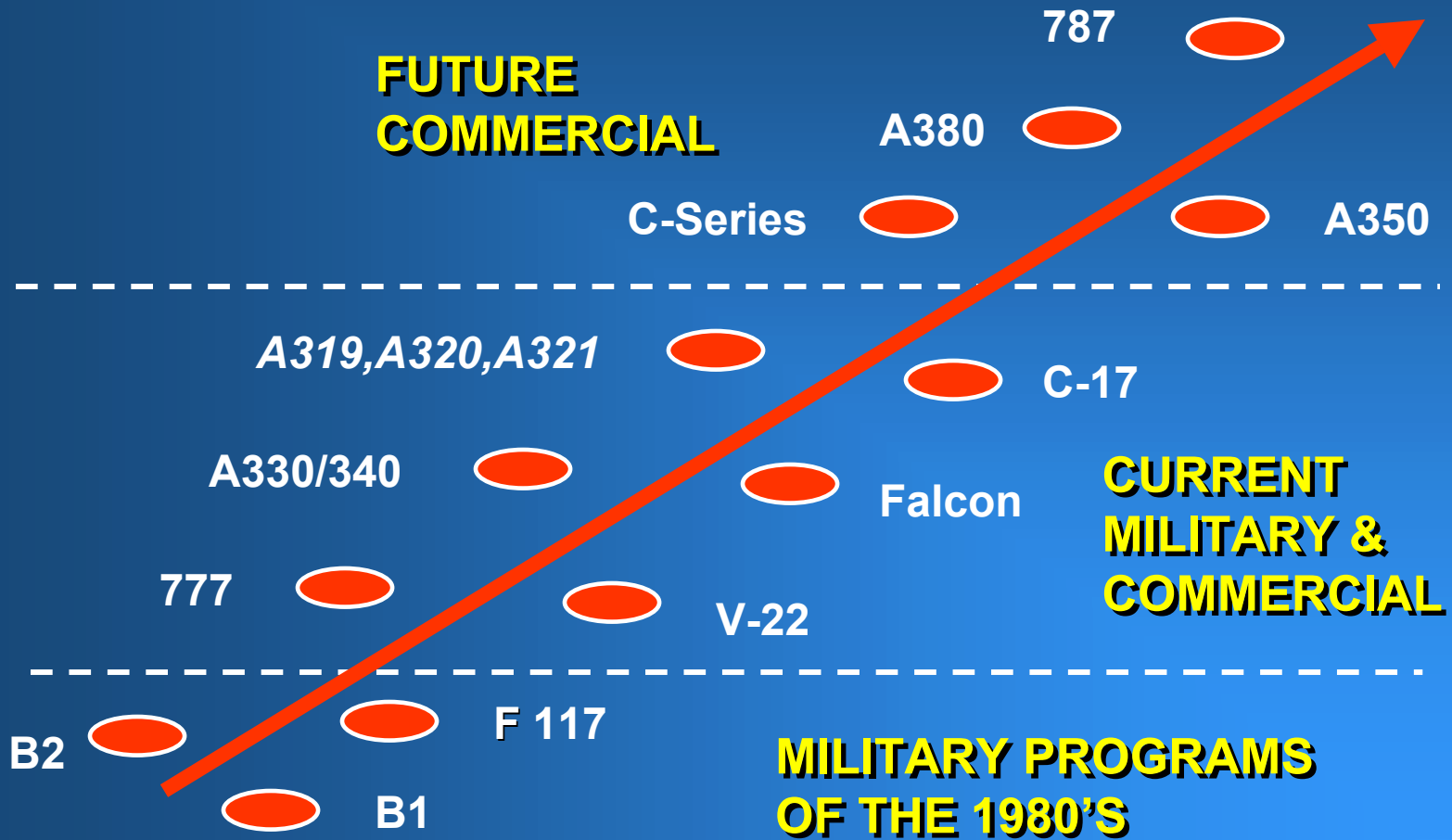
Boeing	Various locations	21
Aerostructures	Nashville, TN	2
Vought Aircraft	Dallas, TX	1
Bell Helicopter	Ft Worth, TX	3

EUROPE AND ASIA

Airbus	all partners	17
Dassault Aviation	France	2
Alenia	Italy	2
Fuji Heavy Industries	Japan	2
BAE Systems	United Kingdom	1

Automated Tape Layer Applications

Tape Layer Applications



Airbus Tape Layer Applications

Airbus uses tape layers for fabrication of the vertical and horizontal stabilizer on most aircraft

- ◆ **A330 / A340**
- ◆ **A340-500 / 600**
- ◆ **A318 / A319 / A320
A321**
- ◆ **A380**
- ◆ **A350 (most likely)**



A340 Horizontal Skin Assy

Boeing Tape Layer Applications

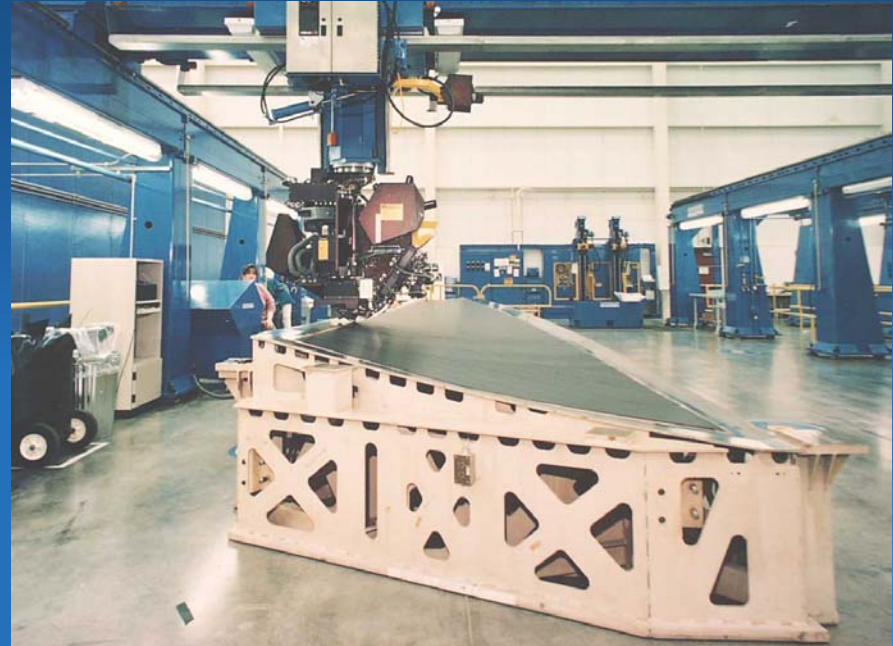
**Boeing is the USA
leader in tape layer
processing**

777 Empennage

B2 Bomber

F-22 Raptor

787 Dreamliner



**Boeing 777 Empennage
skin lay up on CTLM**

Boeing 787 Dreamliner



Mitsubishi Heavy Industries will build 787 wing box with ATL

Fuji Heavy Industries will build 787 center wing box with ATL

Summary of ATL Processing

- ◆ **Tape Layers have built more large primary structural components than any other aerospace industry composites process**

Mostly aircraft empennage structure

- ◆ **Pre-plying / hot forming process has opened up a wide variety of parts that can be made with automated tape layers**

Automated Tape Layer processing may be applicable to non-aerospace applications

***Potential for Non-
Aerospace Applications***

ATL for Non-Aerospace Applications

A large ATL system combined with a “hot forming” process could produce enough parts for a low rate production automobile (sports car)

- ◆ **Fast lay up of 120 ft x 20 ft tape laminate**

Machine also lays localized doublers/stiffeners

- ◆ **Process is compatible with low cost prepregs**

“Golf shaft” prepreg materials (\$10 - \$12 per lb)

- ◆ **ATL system could also be used as a “cutting table” to kit laminate into individual parts**

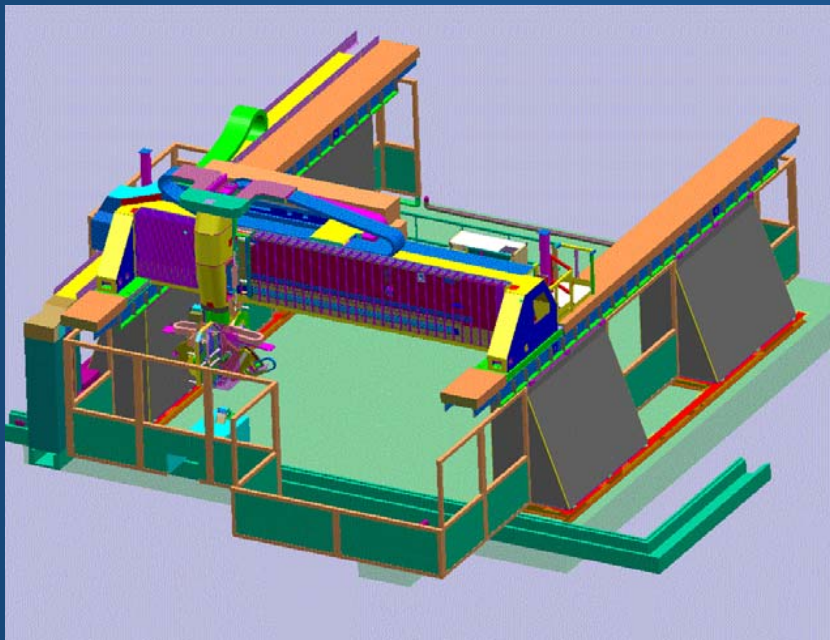
Approximately 200 - 300 formable panels could be produced daily on 3-shift operation

ATL for Non-Aerospace Applications

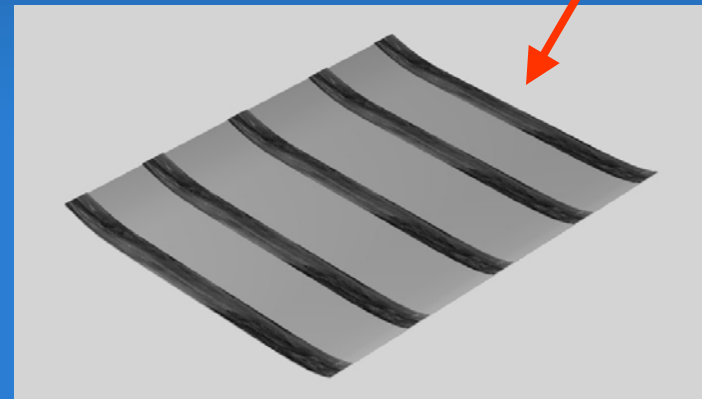
- ◆ **Parts should be low complexity shapes specifically designed for the process**
 - Minimize compound curvature
 - Hood Top Body Panels
- ◆ **Laminate could be a combination of fabric and tape (Fabric on inside and outside surface)**
- ◆ **Autoclave cure oven cure may be feasible**

***The bad news* this process would require a lot of individual tools but composite cure tools could be made off a master model**

ATL system can also function as a “kitting” machine ... cut laminate into individual parts



130 ft x 23 ft version of this gantry machine has already been built



Top panel with stiffening strips

Tooling and cure issues would need development

Presentation Summary

- ◆ **Automated Tape Layers have excellent material lay up rate capabilities**
 - ◆ ATL can process a variety of materials
- ◆ **Tape layers can be built in large sizes to produce a volume of parts required for some auto parts**
 - ◆ Efficient lay up of large flat laminates
- ◆ **The combination of huge machine sizes, excellent lay up rates, and hot forming processes may be attractive for some automotive parts**