LEARN. BUILD. FLY.™ EAA Homebuilders Week

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Woodworking 101

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Middle School Industrial Arts Educator 1982-2013

EAA member and Private Pilot

Instructor/Trainer Stewarts Systems

Oshkosh and Sun N Fun fabric covering workshop presenter

Builder Wag Aero 2+2 ….. 90% complete and 90% to go

My Current Wag Aero 2+2 project:

Fuselage complete, ready to cover

Wings complete, ready to cover

Control Surfaces covered, ready for topcoat

Firewall and engine mount complete

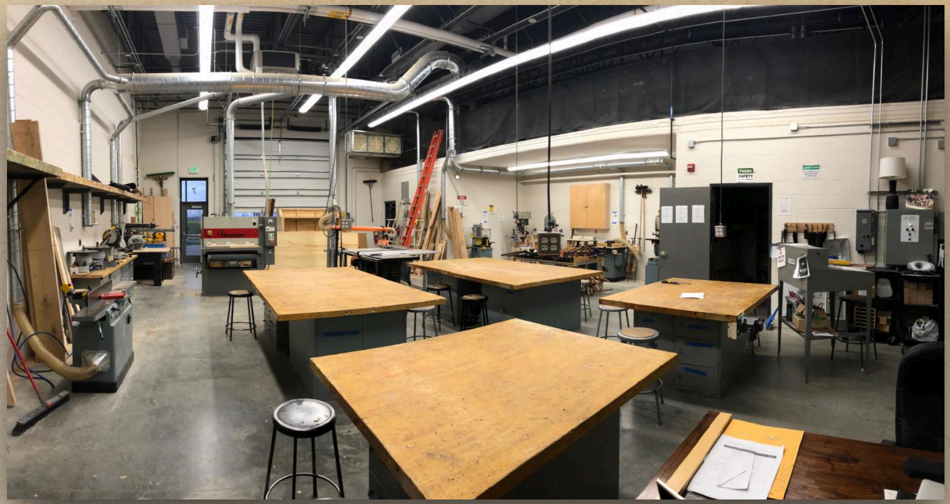
Boot Cowl in cardboard patterns

Lots of work ahead!

Woodworking 101 Outline:

Wood Aircraft Examples – Timeless
Why Wood?
Types of Wood and Properties of Wood
AC43.13-1B and Reference Materials
Sitka Spruce
Sitka Spruce Sources
Plywood
Tools for Wood Working
Adhesives
Construction Methods
Bending and Laminating Wood
Finishing and Covering

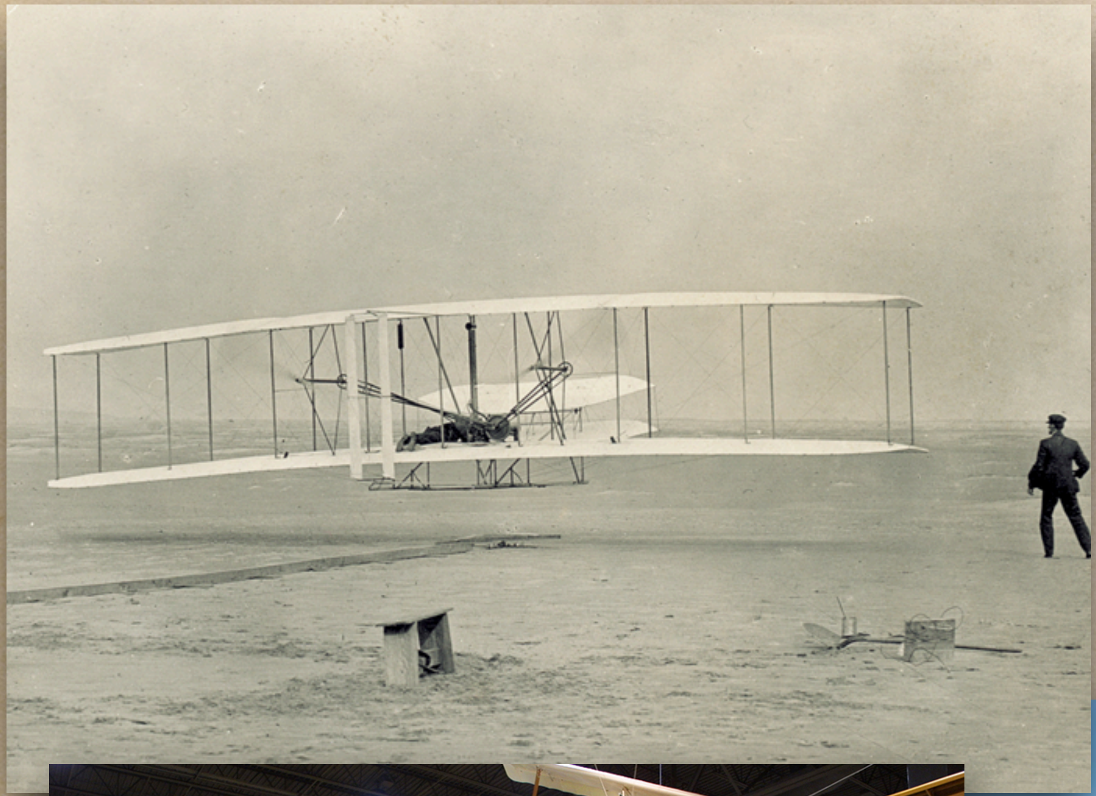
Why work with wood?

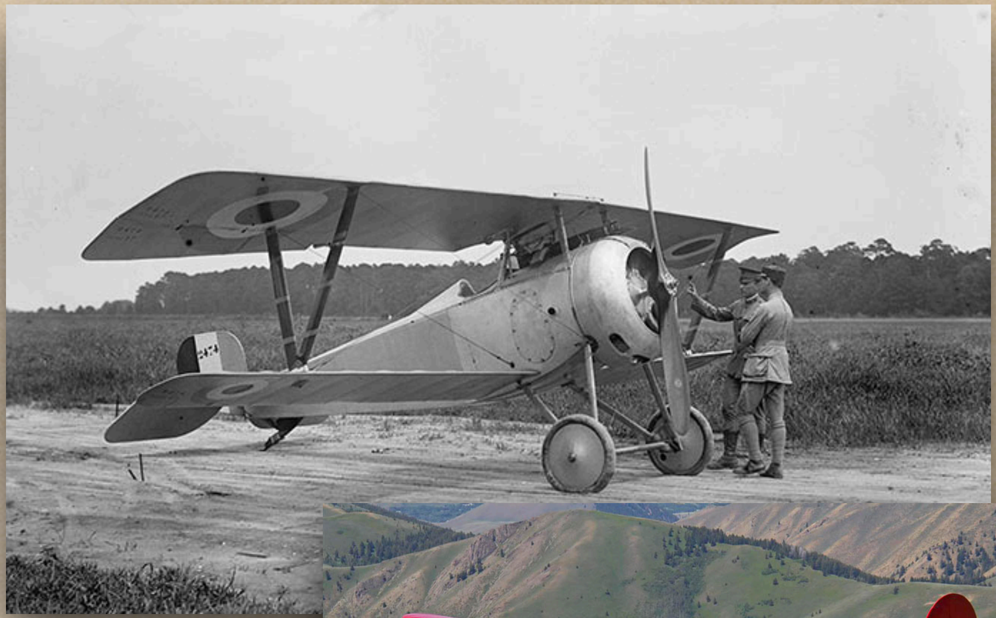


- Timeless material
- Wide level of basic understanding
- Many tools already in the shop
- Natural resource
- Ease of construction
- Lower cost to get started
- Strong and light weight

Build on previous Woodworking experience

Historical Significance





Current Homebuilts using wood

Falco

Barracuda

Starduster ll

Pietenpol Air Camper

Super Baby Great Lakes

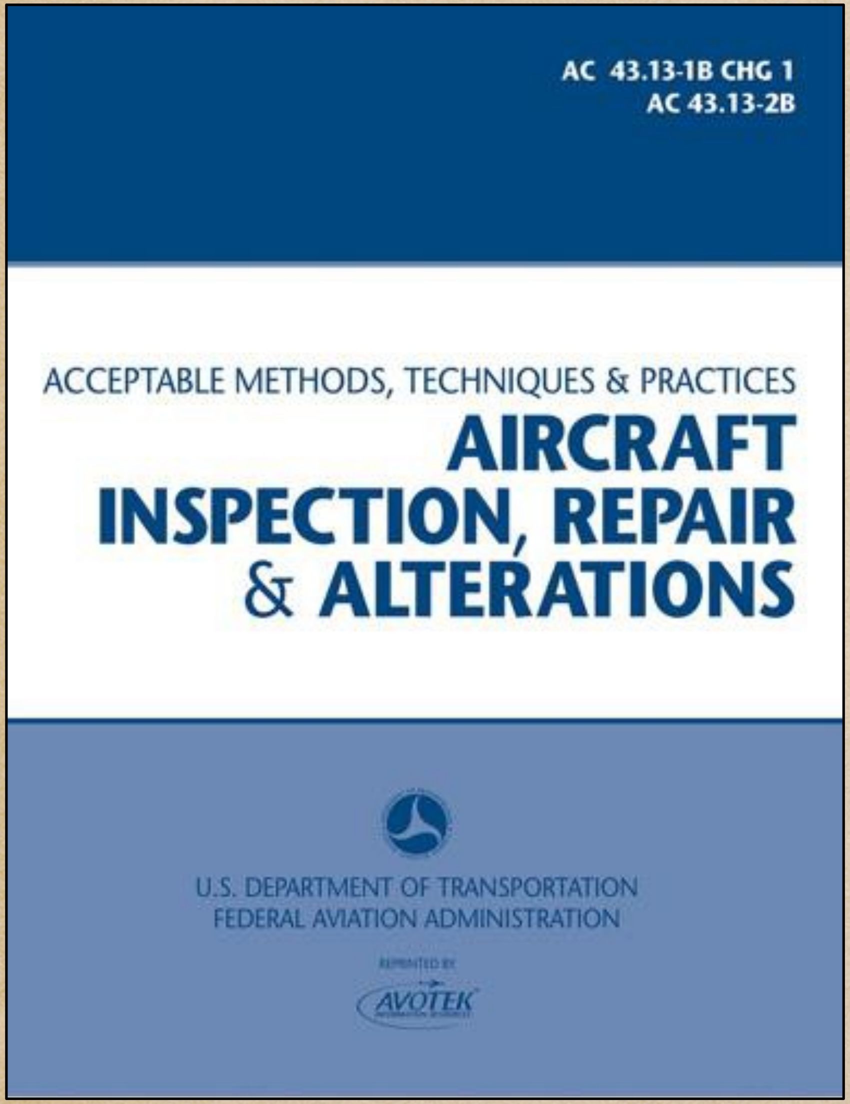
Reference Materials

- EAA
- Internet
- Bookstores
- AC 43.13-1B
- Woodworking groups on social media

Suitable Aircraft Woods

Species of Wood	Strength Properties (as compared to spruce)	Maximum Permissible Grain Deviation (slope of grain)	Remarks
1	2	3	4
Spruce (Picea) Sitka (P. sitchensis) Red (P. rubra) White (P. glauca)	100%	1.15	Excellent for all uses. Considered standard for this table.
Douglas fir (Pseudotsuga taxifolia)	Exceeds spruce	1.15	May be used as substitute for spruce in same sizes or in slightly reduced sizes if reductions are substantiated. Difficult to work with hand tools. Some tendency to split and splinter during fabrication and much greater care in manufacture is necessary. Large solid pieces should be avoided due to inspection difficulties. Satisfactory for gluing .
Noble fir (Abies procera, also known as Abies nobilis)	Slightly exceeds spruce except 8% deficient in shear	1.15	Satisfactory characteristics of workability, warping, and splitting. May be used as direct substitute for spruce in same sizes if shear does not become critical. Hardness somewhat less than spruce. Satisfactory for gluing.
Western hemlock (Tsuga heterophylla)	Slightly exceeds spruce	1.15	Less uniform in texture than spruce. May be used as direct substitute for spruce. Upland growth superior to lowland growth. Satisfactory for gluing.
Northern white pine, also known as Eastern white pine (Pinus strobus)	Properties between 85% and 96% those of spruce	1.15	Excellent working qualities and uniform in properties, but somewhat low in hardness and shock-resistance. Cannot be used as substitute for spruce without increase in sizes to compensate for lesser strength. Satisfactory for gluing.
Port Orford white cedar (Chamaecyparis lawsoniana)	Exceeds spruce	1.15	May be used as substitute for spruce in same sizes or in slightly reduced sizes if reductions are substantiated. Easy to work with hand tools. Gluing is difficult, but satisfactory joints can be obtained if suitable precautions are taken.
Yellow poplar (Liriodendron tulipifera)	Slightly less than spruce except in compression (crushing) and shear	1.15	Excellent working qualities. Should not be used as a direct substitute for spruce without carefully accounting for slightly reduced strength properties. Somewhat low in shock-resistance. Satisfactory for gluing.

FAA Reference



Contains information considered vital for maintaining general aviation aircraft and is useful as a basis for approval for major repairs and alterations in certain situations.

-Acceptable practices and techniques reference

-Inspection and repair of non-pressurized aircraft

-Corrosion inspection and protection

-Aircraft weight and balance

9/8/98 AC 43.13-1B

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Sample from 43.13

CHAPTER 1. WOOD STRUCTURE

SECTION 1. MATERIALS AND PRACTICES

1-1. GENERAL. Wood aircraft construction dates back to the early days of certificated aircraft. Today only a limited number of wood aircraft structures are produced. However, many of the older airframes remain in service. With proper care, airframes from the 1930's through the 1950's have held up remarkably well considering the state of technology and long term experience available at that time. It is the responsibility of the mechanic to carefully inspect such structures for deterioration and continuing airworthiness.

1-2. WOODS.

a. Quality of Wood. All wood and plywood used in the repair of aircraft structures should be of aircraft quality (reference Army Navy Commerce Department Bulletin ANC-19, Wood Aircraft Inspection and Fabrication). Table 1-1 lists some permissible variations in characteristics and properties of aircraft wood. However, selection and approval of woodstock for aircraft structural use are specialized skills and should be done by personnel who are thoroughly familiar with inspection criteria and methods.

b. Substitution of Original Wood. The wood species used to repair a part should be the same as that of the original whenever possible; however, some permissible substitutes are given in table 1-1. Obtain approval from the airframe manufacturer or the Federal Aviation Administration (FAA) for the replacement of modified woods or other non-wood products with a substitute material.

c. Effects of Shrinkage. When the moisture content of a wooden part is lowered, the part shrinks. Since the shrinkage is not equal in all directions, the mechanic should consider the effect that the repair may have on the completed structure. The shrinkage is greatest in a tangential direction (across the fibers and parallel to the growth rings), somewhat less in a radial direction (across the fibers and perpendicular to the growth rings), and is negligible in a longitudinal direction (parallel to the fibers). Figure 1-1 illustrates the different grain directions and the effects of shrinkage on the shape of a part. These dimensional changes can have several detrimental effects upon a wood structure, such as loosening of

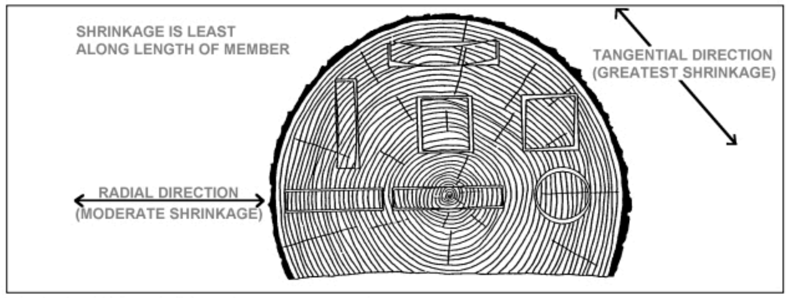


FIGURE 1-1. Relative shrinkage of wood members due to drying.

TABLE 1-1. Selection and Properties of Aircraft Wood. (See notes following table.)

Species of Wood	Strength properties as compared to spruce	Maximum permissible grain deviation (slope of grain)	Remarks
1.	2.	3.	4.
Spruce(Picea) Sitka (P. Sitchensis) Red (P. Rubra) White (P. Glauca).	100%	1:15	Excellent for all uses. Considered as standard for this table.
Douglas Fir (Pseudotsuga Taxifolia).	Exceeds spruce.	1:15	May be used as substitute for spruce in same sizes or in slightly reduced sizes providing reductions are substantiated. Difficult to work with handtools. Some tendency to split and splinter during fabrication and considerable more care in manufacture is necessary. Large solid pieces should be avoided due to inspection difficulties. Gluing satisfactory.
Noble Fir (Abies Nobiles).	Slightly exceeds spruce except 8% deficient in shear.	1:15	Satisfactory characteristics with respect to workability, warping, and splitting. May be used as direct substitute for spruce in same sizes providing shear does not become critical. Hardness somewhat less than spruce. Gluing satisfactory.
Western Hemlock (Tsuga Heterpphylla).	Slightly exceeds spruce.	1:15	Less uniform in texture than spruce. May be used as direct substitute for spruce. Upland growth superior to lowland growth. Gluing satisfactory.
Pine, Northern White (Pinus Strobus).	Properties between 85 % and 96 % those of spruce.	1:15	Excellent working qualities and uniform in properties, but somewhat low in hardness and shock-resisting capacity. Cannot be used as substitute for spruce without increase in sizes to compensate for lesser strength. Gluing satisfactory.
White Cedar, Port Orford (Charaecyparis Lawsoniana).	Exceeds spruce.	1:15	May be used as substitute for spruce in same sizes or in slightly reduced sizes providing reductions are substantiated. Easy to work with handtools. Gluing difficult, but satisfactory joints can be obtained if suitable precautions are taken.
Poplar, Yellow (Liriodendrow Tulipifera).	Slightly less than spruce except in compression (crushing) and shear.	1:15	Excellent working qualities. Should not be used as a direct substitute for spruce without carefully accounting for slightly reduced strength properties. Somewhat low in shock-resisting capacity. Gluing satisfactory.

Notes for Table 1-1

1. Defects Permitted.

a. Cross grain. Spiral grain, diagonal grain, or a combination of the two is acceptable providing the grain does not diverge from the longitudinal axis of the material more than specified in column 3. A check of all four faces of the board is necessary to determine the amount of divergence. The direction of free-flowing ink will frequently assist in determining grain direction.

b. Wavy, curly, and interlocked grain. Acceptable, if local irregularities do not exceed limitations specified for spiral and diagonal grain.

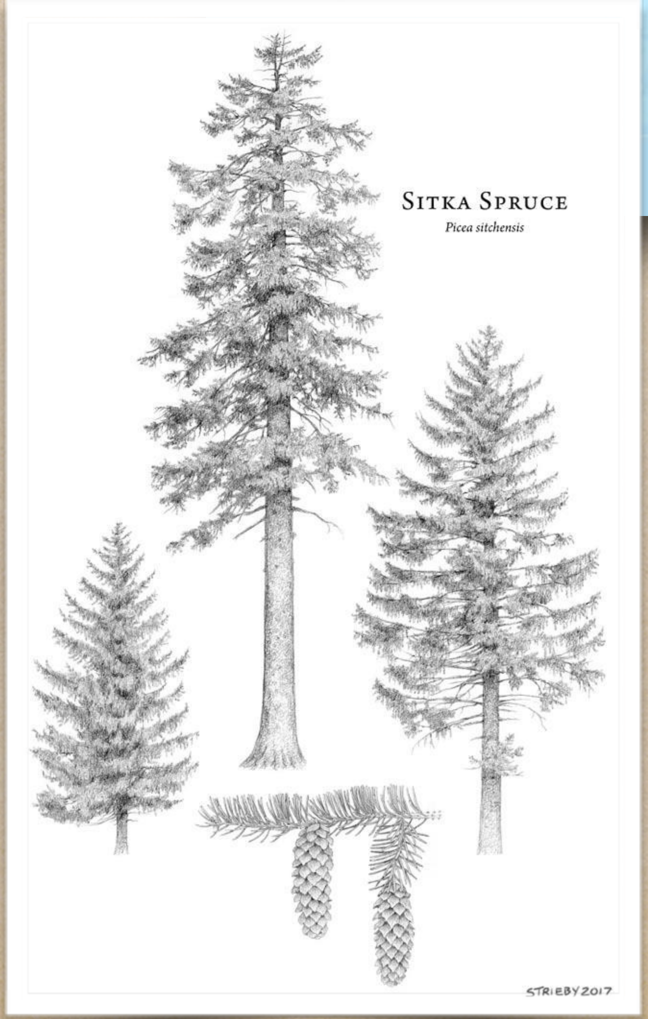
c. Hard knots. Sound, hard knots up to 3/8 inch in maximum diameter are acceptable providing: (1) they are not projecting portions of I-beams, along the edges of rectangular or beveled unrouted beams, or along the edges of flanges of box beams (except in lowly stressed portions); (2) they do not cause grain divergence **at the edges of** the board or in the flanges of a beam more than specified in column 3; and (3) they are in the center third of the beam and are not closer than 20 inches to another knot or other defect (pertains to 3/8 inch knots—smaller knots may be proportionately closer). Knots greater than 1/4 inch must be used with caution.

d. Pin knot clusters. Small clusters are acceptable providing they produce only a small effect on grain direction.

e. Pitch pockets. Acceptable in center portion of a beam providing they are at least 14 inches apart when they lie in the same growth ring and do not exceed 1-1/2 inches length by 1/8 inch width by 1/8 inch depth, and providing they are not along the projecting portions of I-beams, along the edges of rectangular or beveled unrouted beams, or along the edges of the flanges of box beams.

f. Mineral streaks. Acceptable, providing careful inspection fails to reveal any decay.

Sitka Spruce: The Standard



Sitka Spruce

- Largest of all spruce trees
- Clear lumber of almost any length required for aircraft building
- Often 40-80 feet spans without branches 200 + feet in height
- Straight Grained
- Uniform Texture
- Moderately Light
- High Strength to Weight Ratio
- High Strength and Toughness compared to wood of similar weight
- Moderately Resistant to Decay
- Contains very few resin ducts

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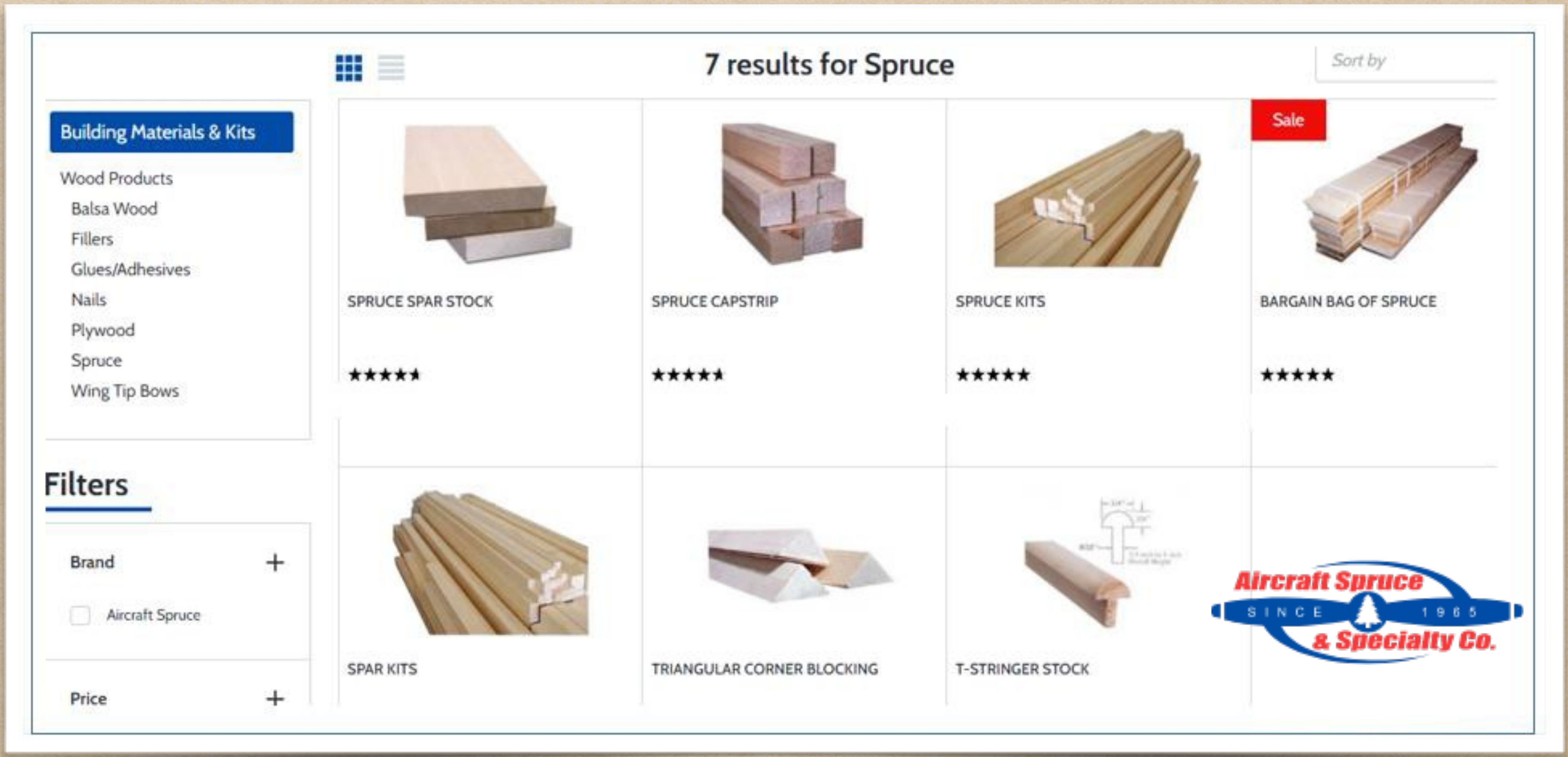
Sitka Spruce Sources

- Aircraft Spruce and Specialty – Corona, CA. & Peachtree City, GA.
- Wick's Aircraft – Highland, IL.
- Other Aircraft Supply Houses



Sitka Spruce Sources
Lumber Yards

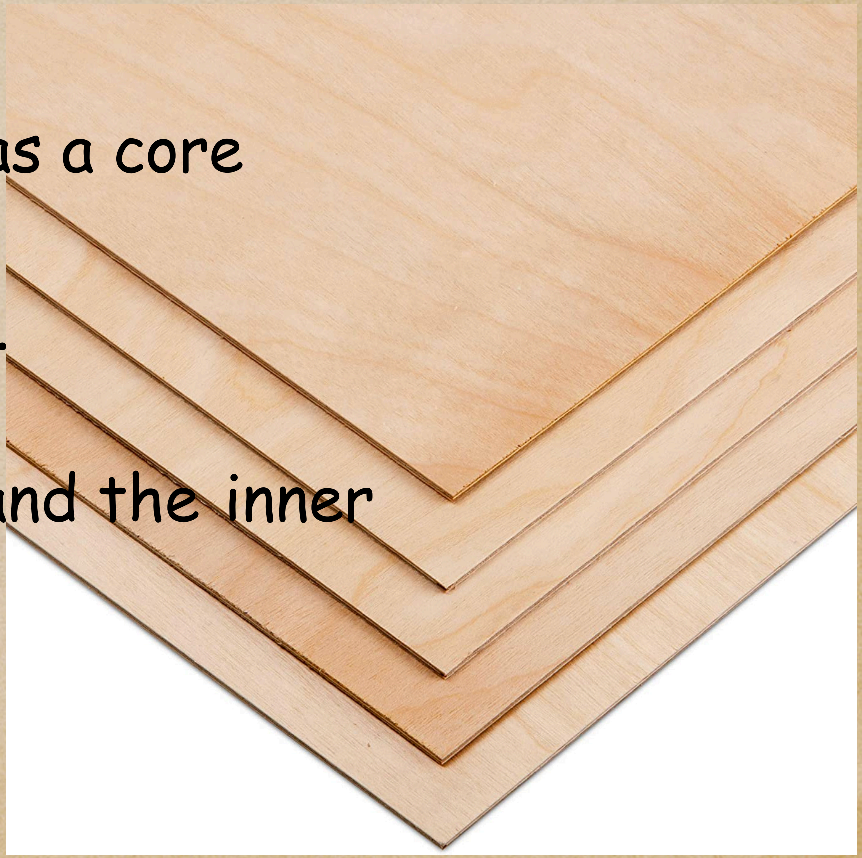
- McCormick Lumber – Madison, WI
- Condon Lumber – White Plains, New York
- Public Lumber – Detroit, MI.
- McClanahan Lumber
  Forks, WA
- Crosscut Hardwoods – Seattle, Portland, WA.
- Boat Building Suppliers
  Chesapeake Light Craft – Annapolis, Maryland

Search Online for a Supplier Near You

What is aircraft plywood?

Aircraft grade plywood is **made to aircraft specification MIL-P-6070, NSN 5530**. The plywood veneer face plies and inner plies are free from open defects and bonded with heat set phenolic water and fire proof adhesive. ...
Plywood inner plies typically used are basswood and poplar

- Typical veneer used: Mahogany or Birch with a core material, usually poplar.
  - Birch, basswood, or maple is also acceptable as a core material.
- Each ply must be 90 degrees to the adjacent ply.
- The outside plies of material are called "faces" and the inner plies are termed "core and cross bands."
- Use aircraft grade, not big box store plywood



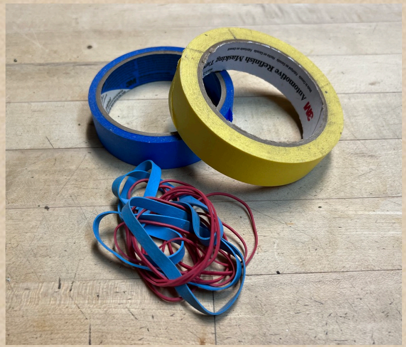
Tools for Wood Working

- Bandsaw
- Table Saw
- Radial Arm Saw
- Drill Press

More tools ....

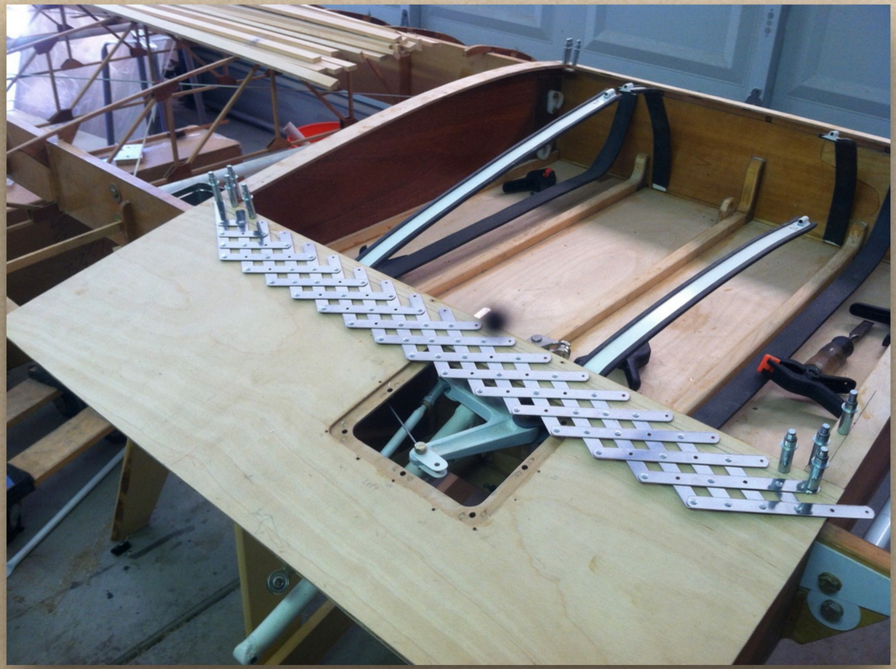
- Router
- Router Table
- Drills
- Belt Sander
- Surface planer

and Clamps…….



Various Other Common Hand Tools

Tack Hammer Hand Drill
Hand Plane
Squares
Rasps and Files Hand Saws
Rules and Tape Measures Straight Edges
Pliers
Trammel Points
Rivet Fan



Adhesives ......

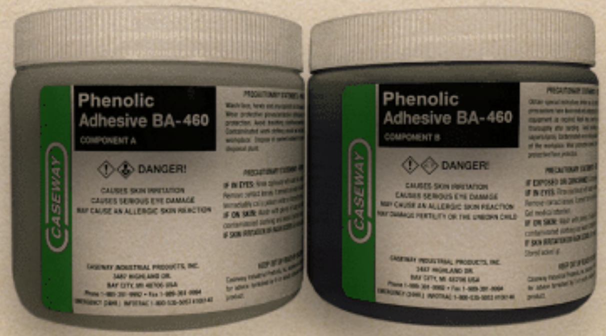
- Imagine the critical role adhesives play in wood aircraft construction

- Use adhesives that meet all performance requirements necessary for use in certificated civil aircraft. Use each product strictly in accordance with the aircraft and adhesive manufacturer's instructions.

- Refer to AC 43.13 – 1B *

Past Aircraft Adhesives

- Casein Adhesive
- Plastic resin glue (urea-formaldehyde resin glue)
- Resorcinol Adhesive
- Phenol-formaldehyde adhesive
- All Discussed in AC 43.13-1b



Adhesive of Choice today

- Epoxy adhesives

✓ T-88, System Three

- Will cure without shrinkage.
- T-88 is clear amber and becomes virtually invisible when varnished
- Mix at a convenient 1:1 by ratio.
- Exhibits outstanding adhesion on a wide variety of materials.
- Gap filling properties
- Hardens in ~8hrs.

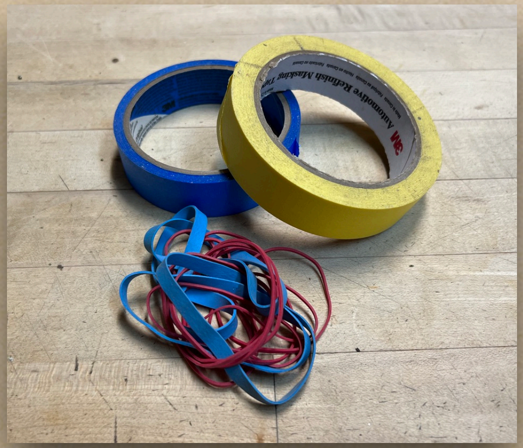
✓ West Systems

- Resins and hardeners form a two-part epoxy specifically for wood and composite boat construction.
- Mix Hardener to resin in a ratio of 5 parts Resin to 1 part Hardener.
- Yields a high-strength, rigid solid with excellent cohesive properties and provides an excellent moisture vapor barrier.

Construction Methods

Gluing and Clamping

- Staples
- Clamping



Containers filled with led shot

Clamping with brads to be removed when dry

Mechanical Fasteners

Coat all bolts with wax before inserting

- Brads
- Nuts & Bolts
- Pre-finish drilled holes

Clamping using Nails

Brad Nails – 20 gauge

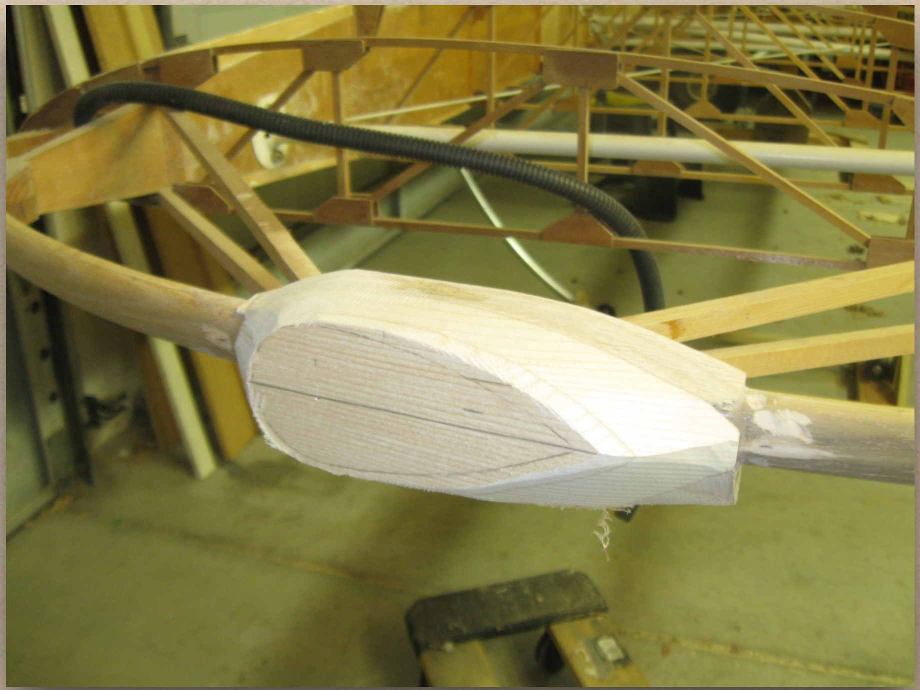
AN301 aircraft nails

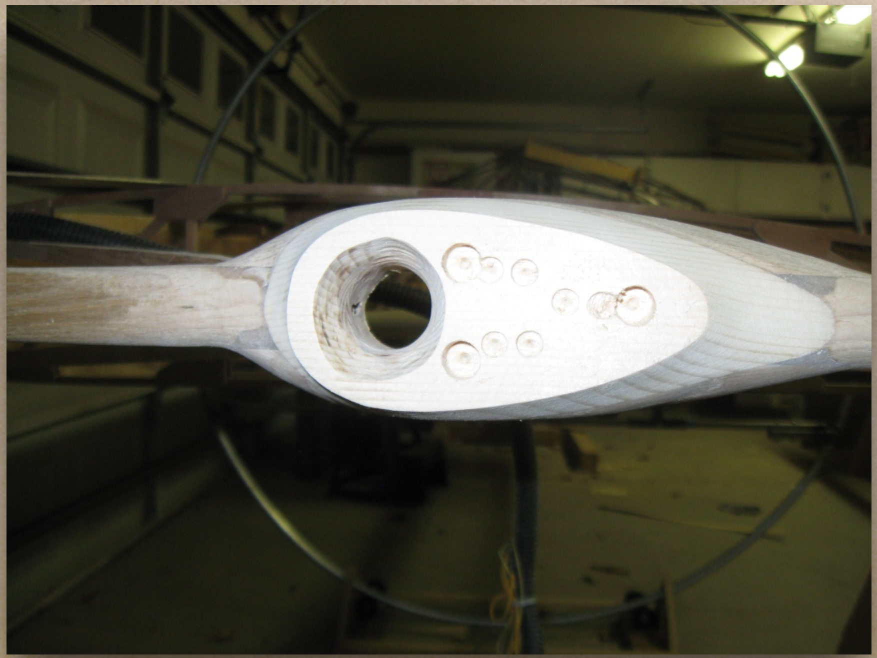
Bolting - Large Washers

Use AN970 Washers opposed to AN960

Corner Blocking

Block Laminating





Laminating and Bending

Simple cap strip

Complex wing tip bow

The process ….. Wing tip Bow

Build a form

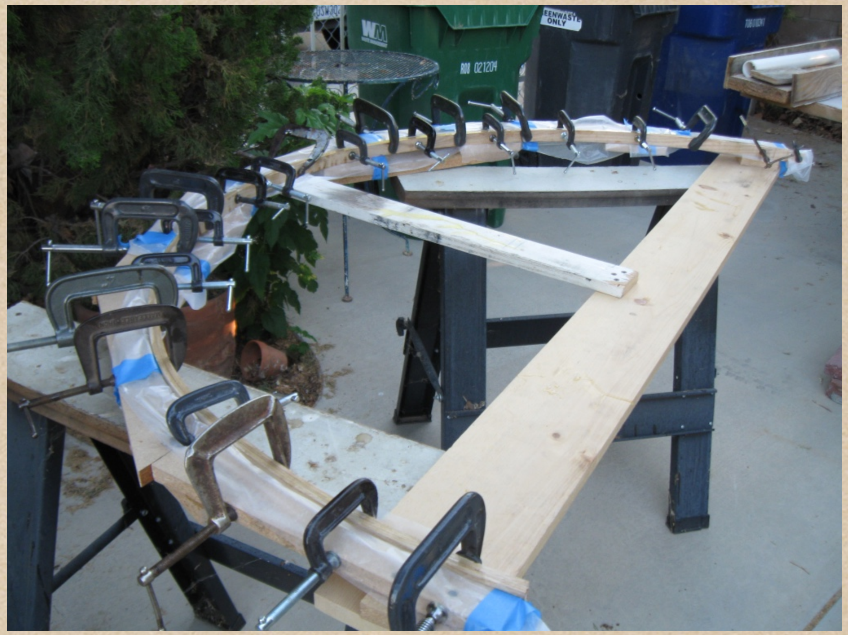
Cut strips to bend and laminate

Soak in PVC pipe 30 minus

Bend over
pipe
w/ heating
element
inside

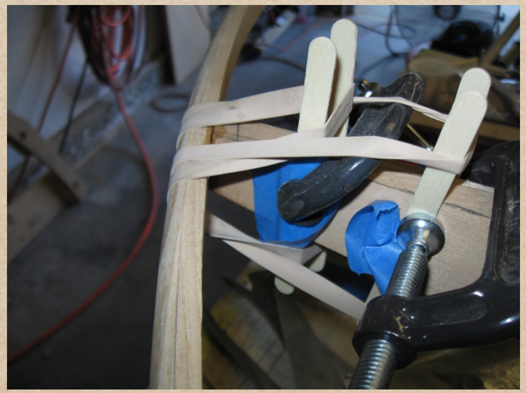
The process ….. Wing tip Bow

Clamp in place
for wood to dry



Clamp and glue with T88.
Note wax paper so it won't stick to form

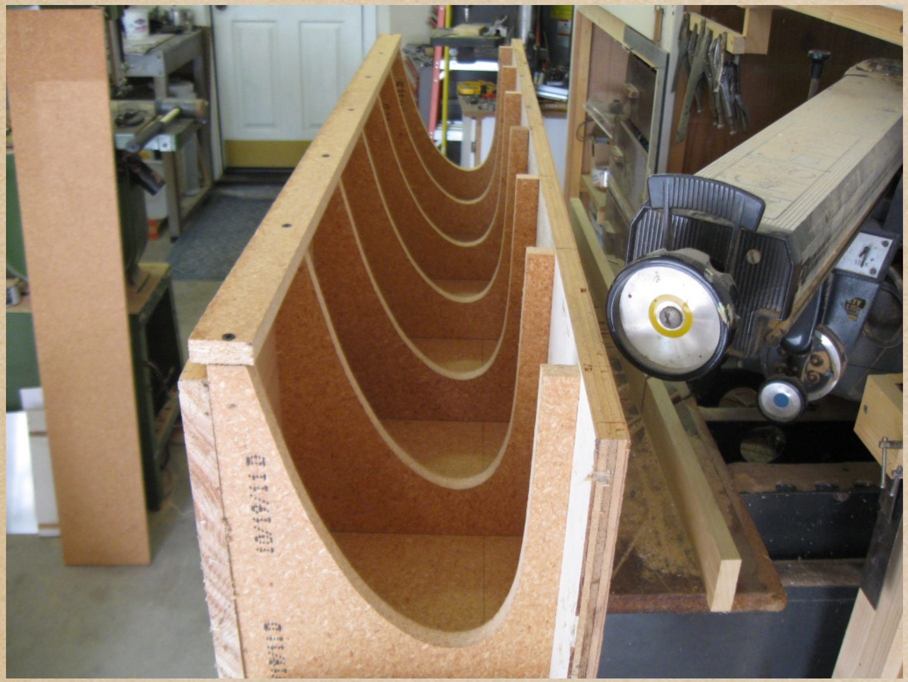
Remove and
compare shape



Rout edges and
dry fit

Glue in-place
and add
blocking
and
supports

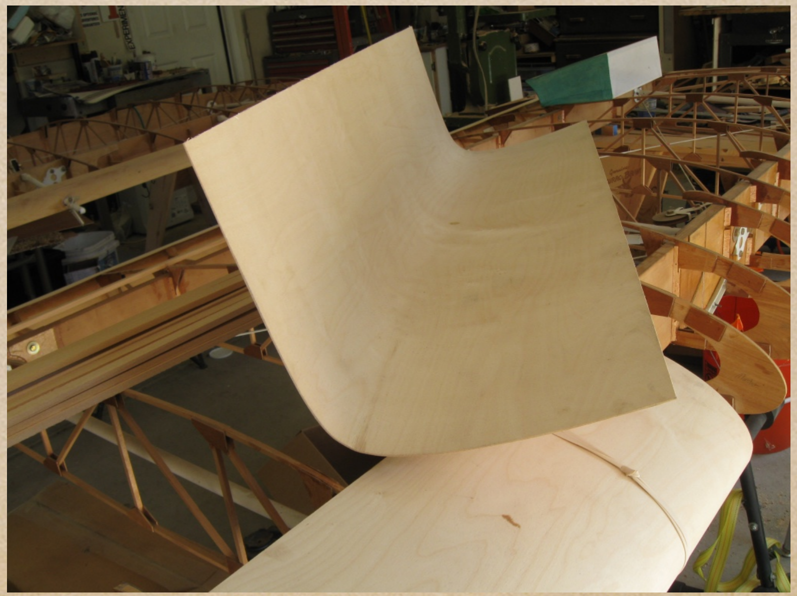
Bending leading edge ply



Build a form
Cut-outs become plug

Soak in Spa 30 min.

Clamp in form overnight



Ready to glue in-place

Attaching Leading edge

I've been building wood airplanes most of my life...

Sand leading edges

Test fit

Epoxy coat inside

Glue and Clamp in place

Attach edges with brad strip

Finishing and Covering

Wood surfaces are covered in the same fashion as Steel or Aluminum. Prior to covering, all surfaces must be coated with a waterproof finish.

- Solvent based
- Waterborne
- Epoxy

Fabric Covering

Fabric is attached following the selected system's procedural manual

So much more to tell ……….
contact at marty2plus2.com