NARCON 2015
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NAR 69321

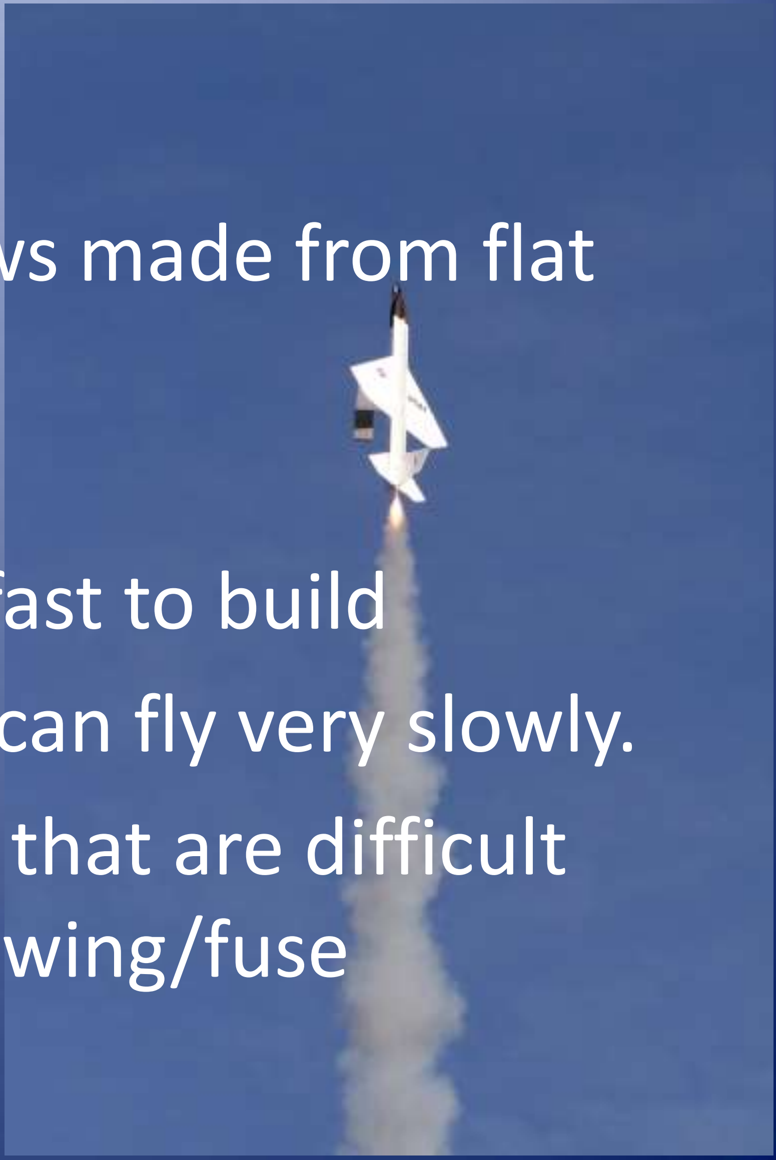
Design and Construction of Rockets and RC Rocket Gliders Using Lightweight Depron Foam

RC RG Design Philosophy

- Make it look like an actual airplane/rocketplane
- Keep them Simple and Light
- Maximize the lifting surfaces
- Keep the thrustline as close to the centerline as possible
- Vertical Boost
  - Use standard pad/rail
- NO fancy CG adjustment in flight, everything stays with the model

Intro to Profile Designs

- Not a full shaped fuselage
- Utilizes top and/or side views made from flat plates.
- Maximizes lifting surface
- Simple and Light, Easy and fast to build
- Flies well in high wind, and can fly very slowly.
- Enables modeling of planes that are difficult or to fly using conventional wing/fuse



Example Profile Oddroc

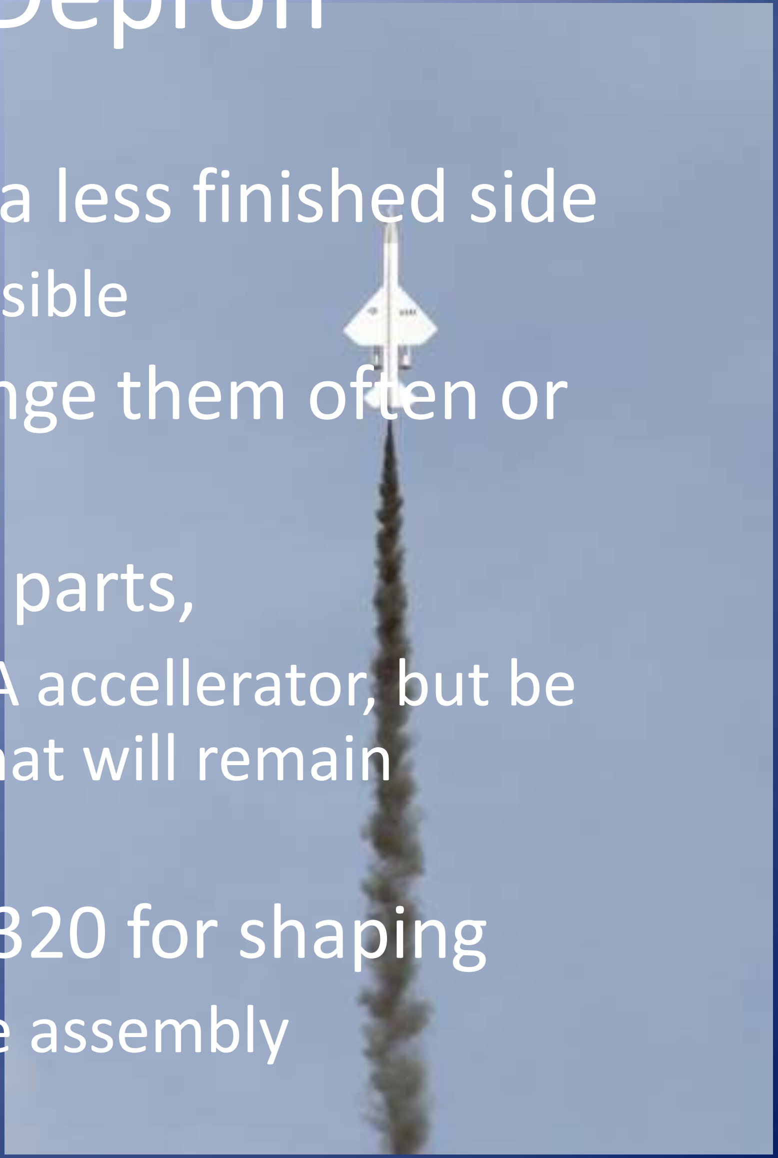
- [Star Blazers Rocket Glider Movie]()

Depron

- Closed cell styrofoam
- Strong and light
- Easy to cut and shape
- Comes in different thickness
- Can be laminated, or used to create built up structures

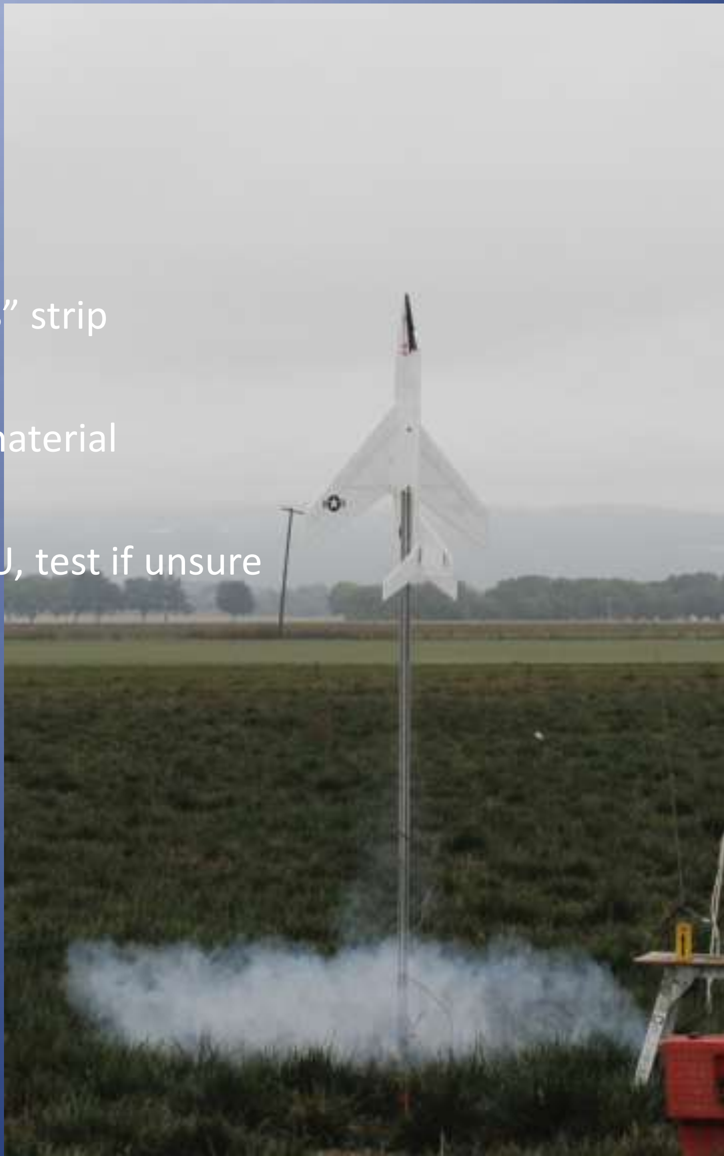
Working with Depron

- Has a more finished side and a less finished side
  - Plan for which side you want visible
- Use sharp exacto blades, change them often or you will tear the foam
- Use sharpie pens for marking parts,
  - can be mostly removed with CA accellerator, but be careful not to get it on parts that will remain unpainted.
- Sands very easily, use 220 or 320 for shaping
  - Pre-sand rounded edges before assembly



Building Materials

- Depron Foam
  - 2mm-skin/sheeting
  - 3mm-skin/sheeting/side panels
  - 6mm-Wing/fuse/core structures and control surfaces
- Carbon Fiber
  - As needed, typically 1/8” rod or tube, 3/16” tube, 1/8” strip
- Sheet Styrene
  - For reinforcing, rail button attachment, landing skid material
- Paint
  - Model Master, Testors, Krylon short cuts, 50/50 WBPU, test if unsure
- Markings
  - Trim Monokote, Sharpie pens, Vinyl
- 3M Blenderm tape
  - For hinges, hatches, holding wires in place
- Foam Safe CA, CA+
  - Primary construction adhesive
- 3m77 spray
  - For laminating/sheeting



Motor Choices and the Sweet Spot

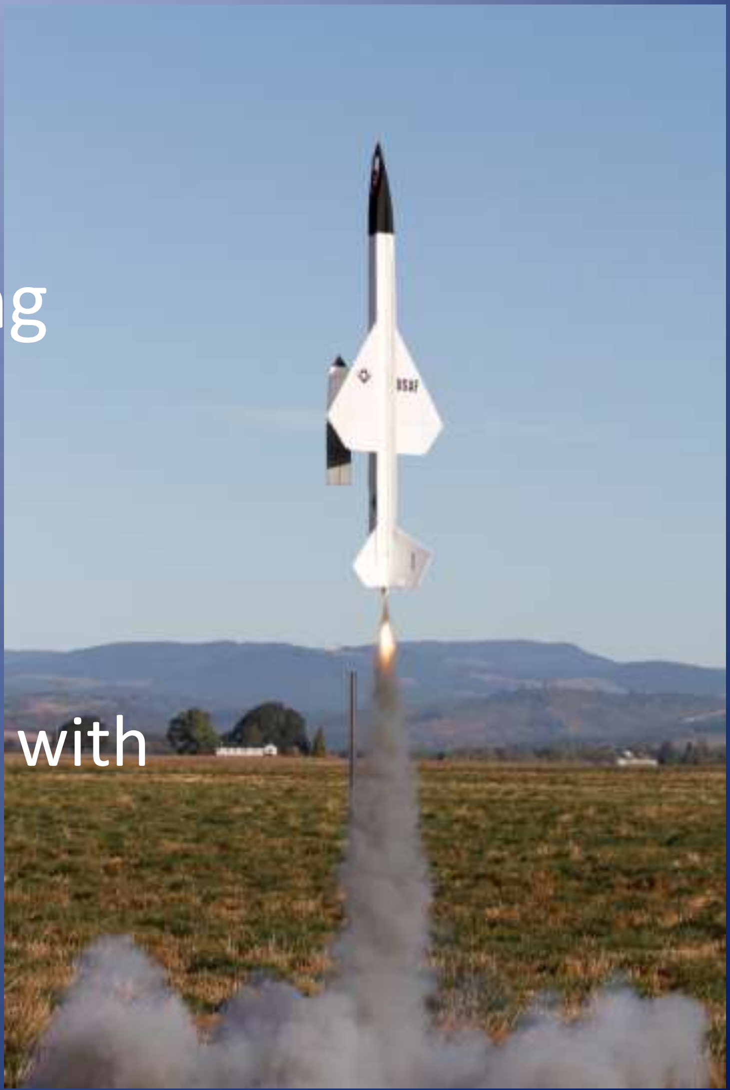
- E-6(1.5 oz motor)
  - 39” long, 8-14 oz rtf
  - Wing loading 5-7oz/ft^2
  - CG shift ¾” to 1.25”
- G-25 (5.5 oz motor)
  - 60-72” long, 5-10 oz/ft^2, 32-40 oz rtf
  - CG shift 1-2”

Design

- Start with a 3 View
- Decide on approx wing area and size desired for wing loading and motor and draw the outlines.
- Size and determine your control surfaces and pivot points
- Determine fuselage/wing structure and any reinforecement
- Plan interlocking structures if possible
- Calculate starting CG
- Draw Templates and assemble basic structure
- Glide tests
- Tweak as needed and adjust component placement as needed for CG.

Cruciform Fuse Design

- Top and Side view that intersect in the middle
- Simple, strong and light
- Maximize fuse and wing lifting area
- Good for mid mounted wing models
  - Best if tail surfaces are aligned with wing
- CG further forward.




NASA
67043
USAF
NASA
66671


5302

2D fuse Design

- Good for Low or High mounted wings
- Good where side view is more important


145580
580


AD
SAGEBURNER
VF 101 DET A
NAVY
180

Full Fuse Design

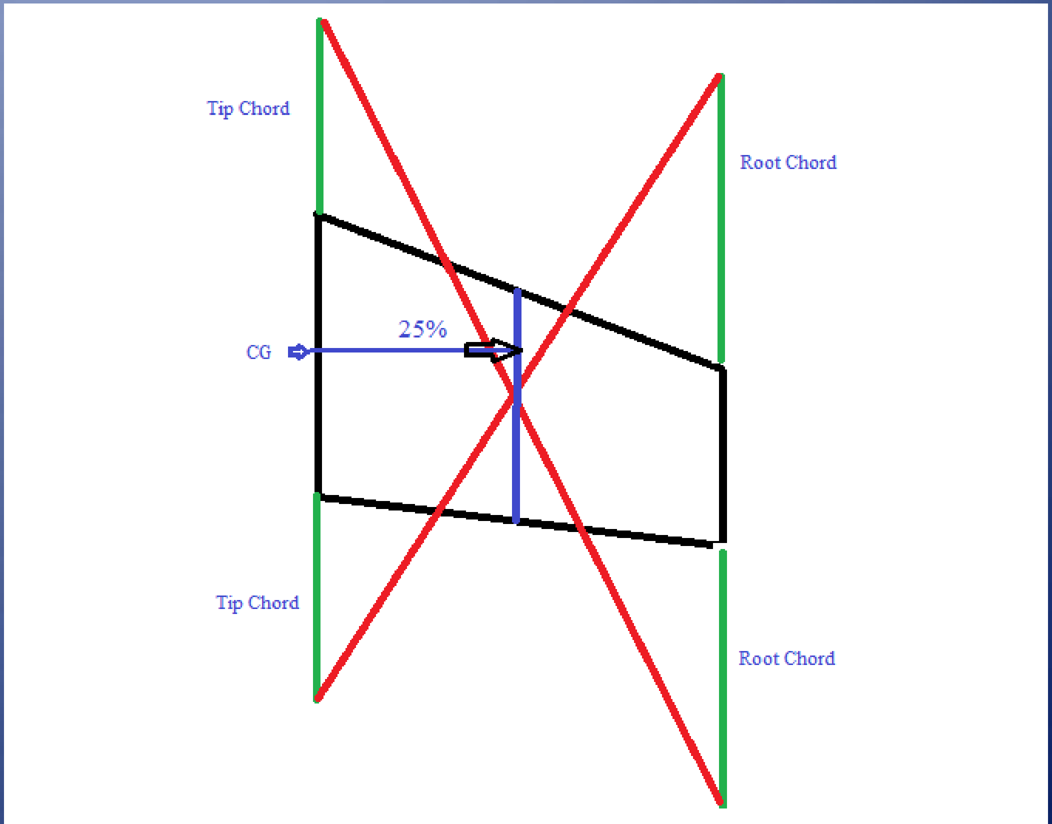
- Strong
- Hides components
- More frontal area
- Scales well


BOEING
ALCM
AF
4


INTREPID

CG calculation

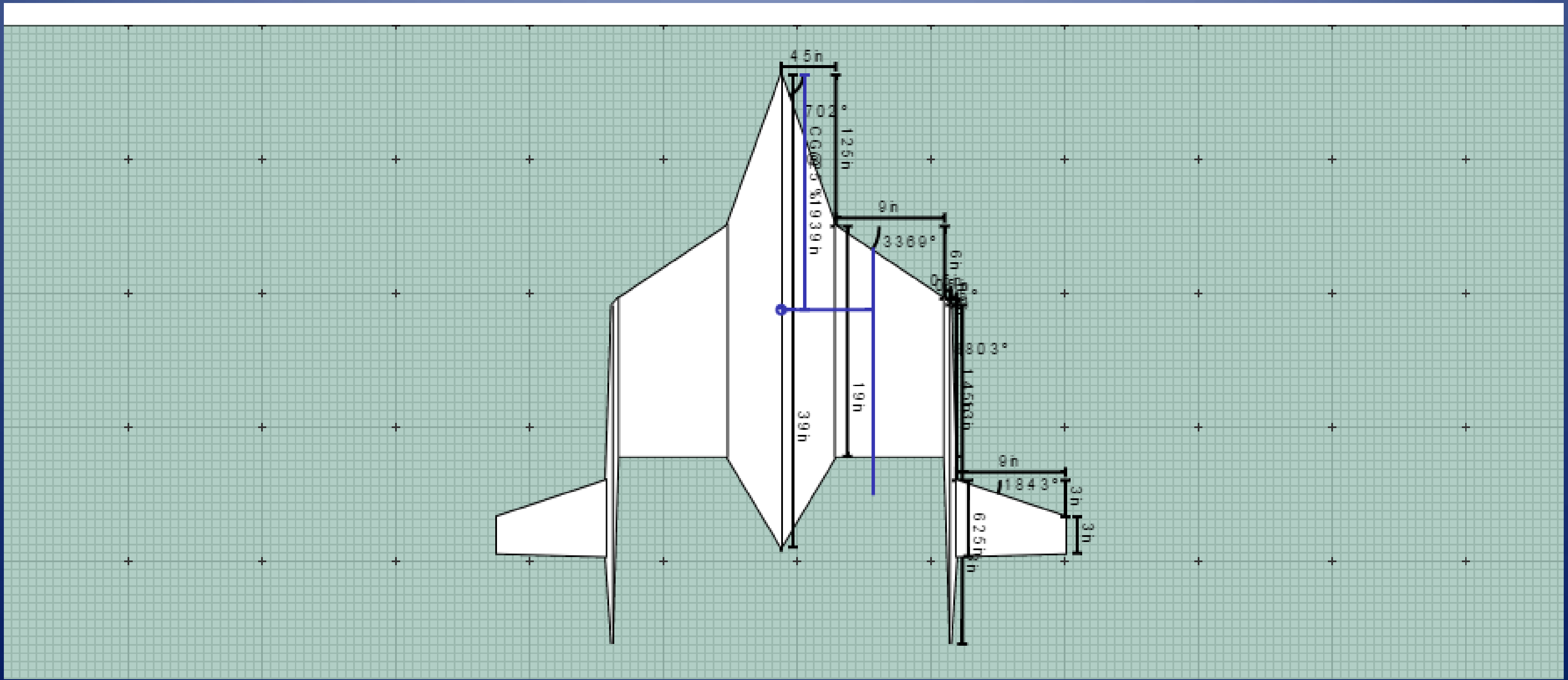
- Typically 20-30% of mean chord
- For simple wings can be calculated using geometric method.
- For delta wing will typically be 40-45% of root chord

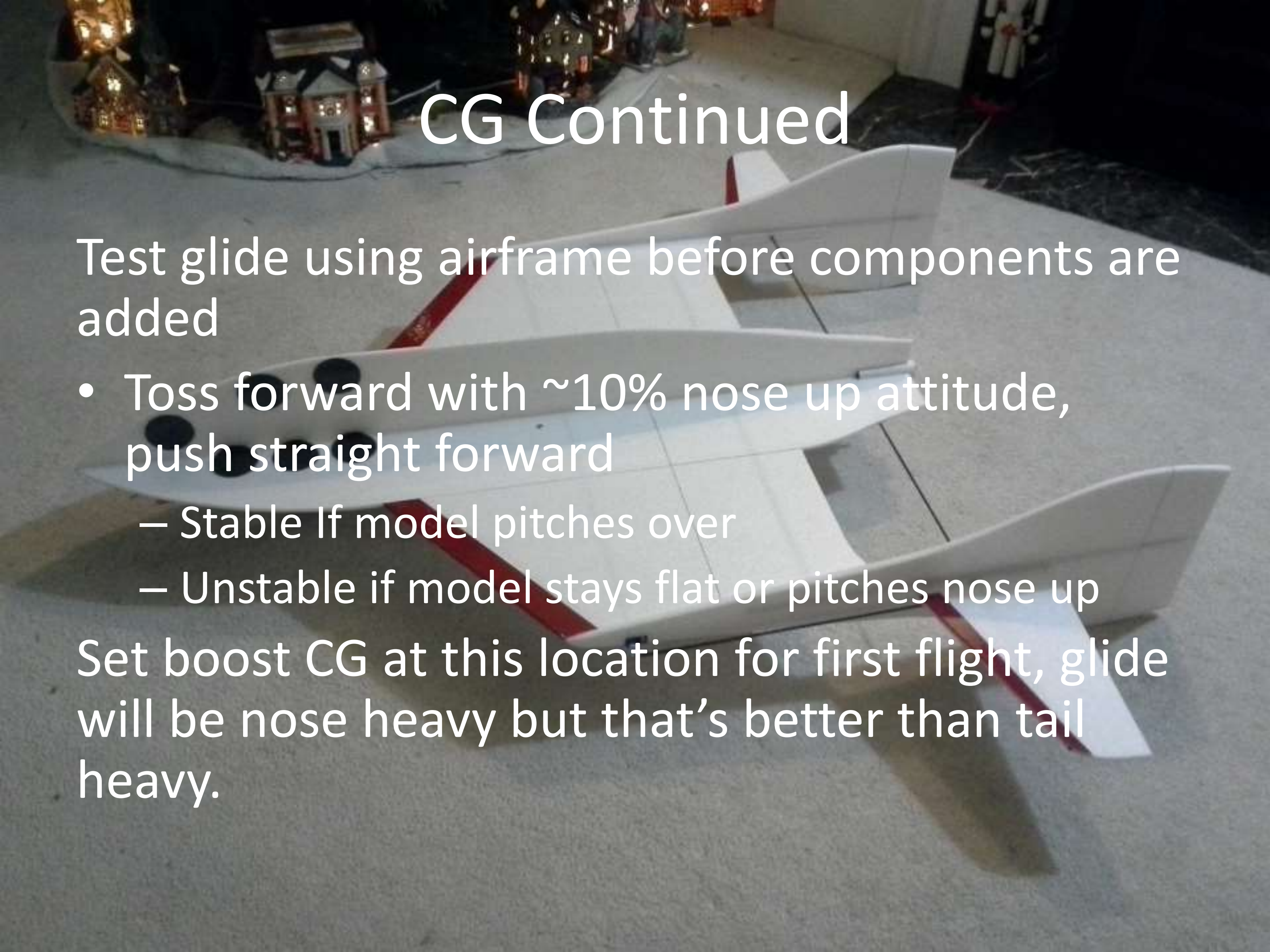


SS1 Complex wing calc example

For more complex wings or cruciform fuse(need to include fuselage lifting surface in calculation)

Use bruder wing calc [Bruder Wing Calc Example]





CG Continued

Test glide using airframe before components are added

- Toss forward with ~10% nose up attitude, push straight forward
  - Stable If model pitches over
  - Unstable if model stays flat or pitches nose up

Set boost CG at this location for first flight, glide will be nose heavy but that's better than tail heavy.

Lateral Stability

- Need to verify stability in both side and top view(pitch and yaw)
- Problem in profile models with long forward fuselages or large forward fuse area.
- Solve by increasing vertical tail area.
- Can also use cruciform fuse or move wing forward, moves CP/CG forward

Electric Motor Pod fits into 24mm Motor Mount

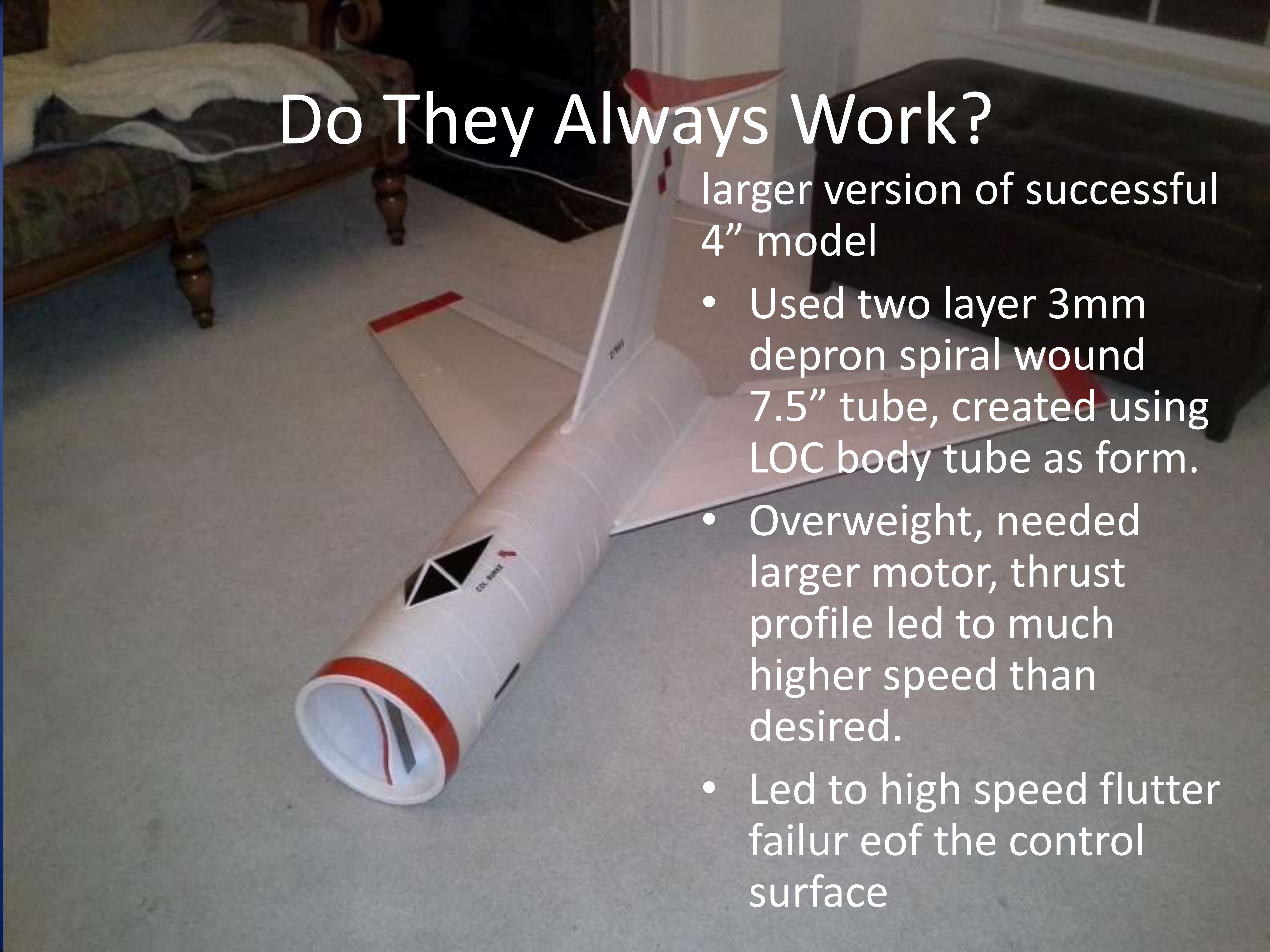
- Replace pure BEC with ESC w/BEC (similar weight)
- During rocket flight, the ESC provides regulated power to the receiver/servos and uses 2s battery
- Swich to 3S battery for electric flight to maintain CG

X-15 upscale example

- Original Small version was 43” long, 20” ws, 10 oz rtf
- Upscale 72” long, 33” ws, 38oz rtf
- Profile structure required doubling fuselage/wing material for stiffness
- ~3x lifting area, 6x airframe weight, 4x RTF weight

Large X-15

- Large X-15 Flight Video



Do They Always Work?

larger version of successful 4” model

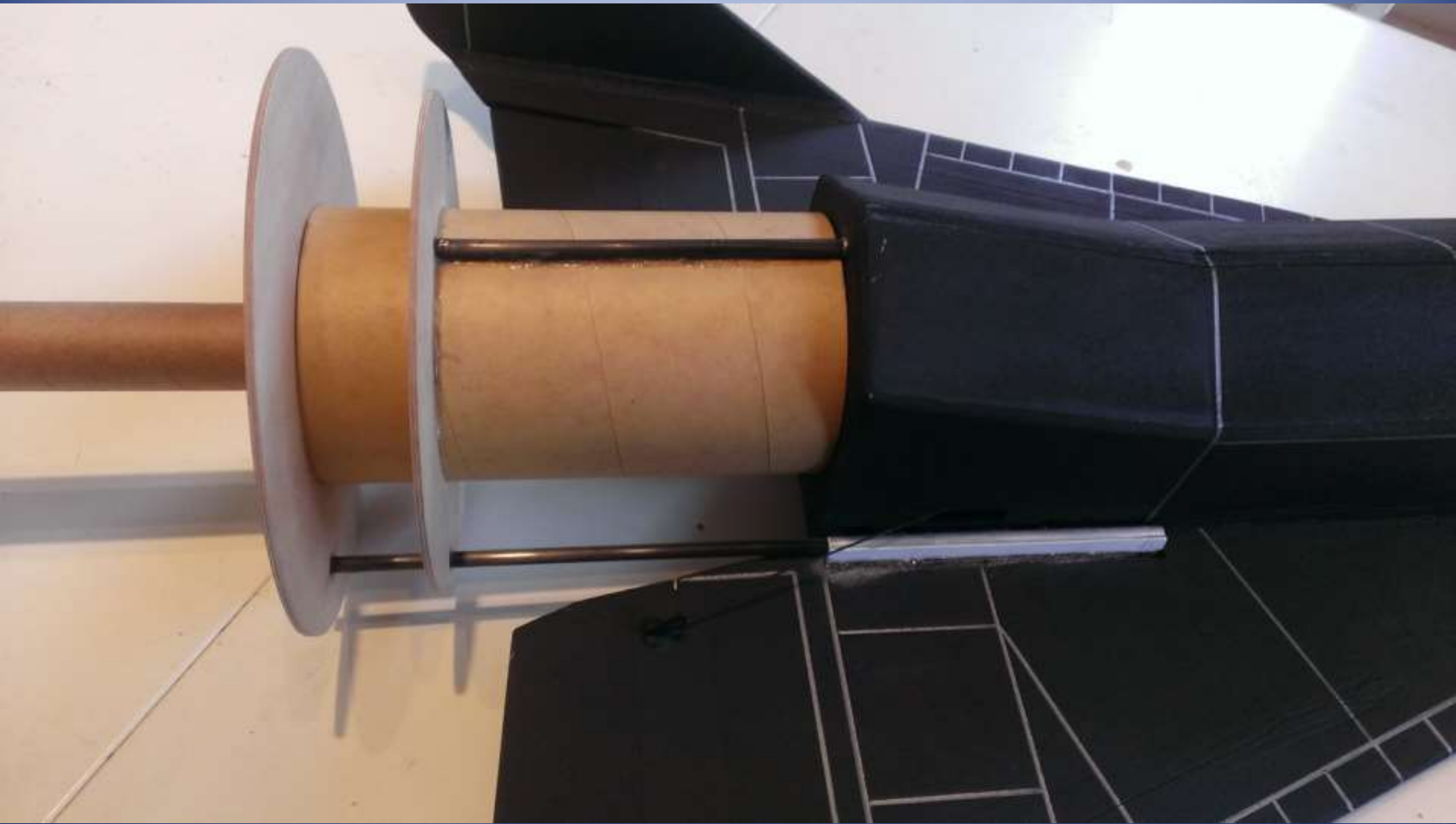
- Used two layer 3mm depron spiral wound 7.5” tube, created using LOC body tube as form.
- Overweight, needed larger motor, thrust profile led to much higher speed than desired.
- Led to high speed flutter failur eof the control surface

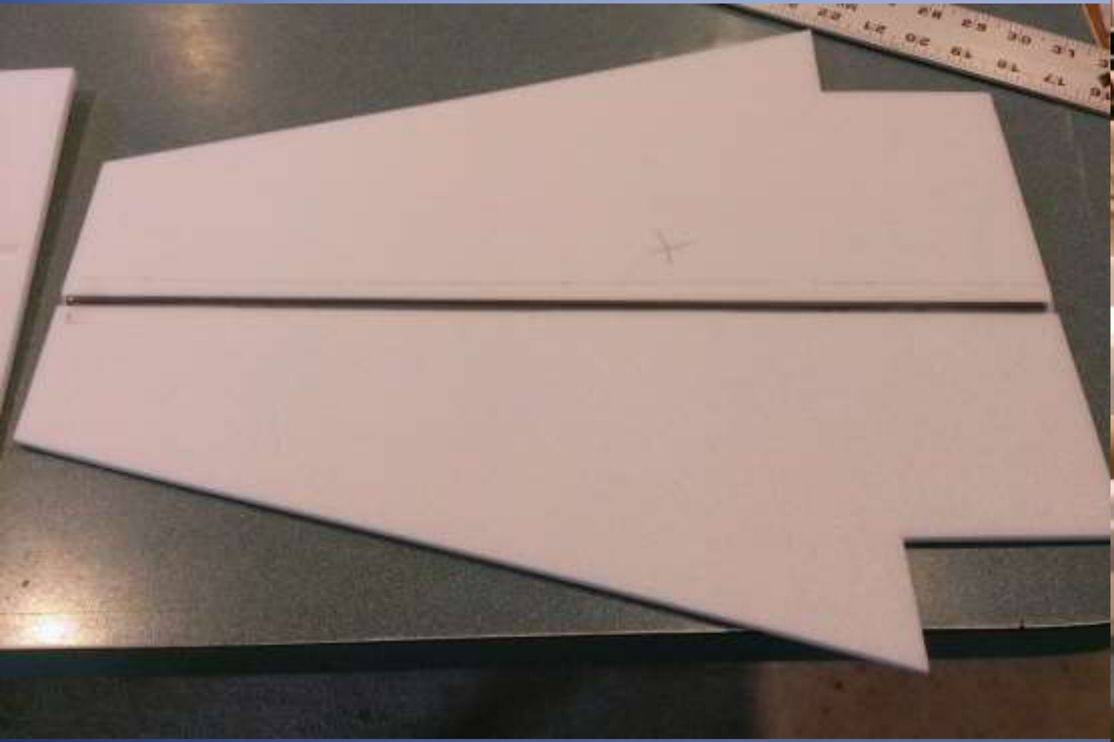
Wing flutter failure

- Wing flutter failure video

Dyna-Soar/Titan Stack

- Already had 30” long by 20” ws Dyna-soar BG built and flown using lighweight construction, wanted a titan booster.
- Titan is 8” diameter, 75” long
- Need to keep speed ~150 fps to avoid destruction of lightweight glider.
  - Normal construction would require 23# titan booster
  - Motor choices for stable launch parameters yields too high max speed for glider.
- Completed stack weighs 75 oz rtf with H97.
- Large fins reinforced at tips and using carbon spars, carbon struts take landing loads.
- Need to set Elevator surface control reversal when mounted on stack(acts like a canard), back to normal direction for glide.





Successful Maiden Flight

- Maiden Flight Video with Onboard and Flight footage
- Second flight on H-97 Motor

Applying Lightweight Foam Construction to Large Rockets

Plan ahead for all components

- Use openrocket or Rocksim to plan CG location ahead of time, use real numbers
  - know how much nose weight you will need, plan for where it will go and how/where it will attach.
- Use components scaled for the application/weight
  - Don’t just use whatever the hardware store has, things add up, especially in the tail.

Construction

- Use interlocking pieces(tab/slot) to align pieces and provide mechanical joints
- Plan and pre-build fin boxes if needed.
- Think about recovery and landing loads, decent rate, parachute size
- Space your centering rings and longerons close enough to give sufficient support to your skin.
- Make sure the skin bonds to the stringers and centering rings, this provides much of the stiffness.
- Plan for sufficient fin stiffness to prevent flutter and landing damage.

Design Study

Fullscale Hellfire Missile using normal HPR components

- ~64” long, 7” diameter, small fins, forward fins.
- Two 60” chutes
- 7# nose weight
- Using loc 7.5” tubing, fiberglass nose cone, 38mm motor mount, ¼” birch ply and centering rings and proper nose weight meant ~18-20 pounds RTF using I435 or bigger.
- ~600’ altitude

Lightweight Version

- 29mm stuffer tube, PML 4” by 10” parachute bay
- One 54” chute
- 13 oz nose weight
- 45 oz airframe/fin weight
- Just the very tip of the nose ejects
  - Balast is attached to the front parachute bay on the outside so nose is not heavy
  - Avoids two part recovery
- 80-83 oz RTF with H135-I205
- ~650-1250’ altitude

Compression test

6mm depron rated at 21psi+ with 10% deformation

Test of 75# on partial structure @~19.5psi with no deformation

Should rate 150# on complete structure

Flight Videos

- Flight on H-135 motor to 720'
- 2nd Flight on I205 motor to 1250'

For more information

- Plans available at: Plans Link

- Blog with more pictures and info at: Burke's blog
- Flight Videos at: Youtube Videos