Going for NAR Level 3

Who am I?

L3 Start To Finish

By: Steve Lubliner, 9968 East Domenic Ln, Tuscon, AZ 85730 (103056.621@compuserve.com)
NARCON 2003

- **I'm Steve Lubliner, NAR 22152**
  - Flight test and instrumentation engineer for Raytheon Missile Systems
  - Over 30 years in the sport rocketry hobby
  - Former L3CC chairman
- **Contact me at:**
  - Phone: 520-296-1689
  - Email: 103056.621@compuserve.com
  - Snail mail:

    Stephen Lubliner
    9968 E. Domenic lane
    Tucson, AZ 85730

Going for NAR Level 3

What are the requirements?

- **You must be Level 2 certified**
- **Flight requirements**
  - The flight requirement is a safe, stable flight powered by a “M”, “N”, or “O” motor
  - Any NAR or Tripoli certified motor is permitted
    - ✔ Hybrids are permitted
      - » Individual must show experience with hybrids prior to Level 3 usage
- **Model requirements**
  - No clusters or staging for certification attempts
  - “Substantially” built by the modeler, general guidelines are:
    - ✔ Fabrication of the engine mount with centering rings (as applicable)
    - ✔ Alignment and mounting of the individual fins
      - » Prefabricated fin canisters are specifically disallowed)
    - ✔ Installation of the attachment points for the recovery system
    - ✔ Mounting and installation of the airframe electronics
    - ✔ Final flight preparations including pyrotechnics installation, recovery system packing, motor preparation and installation

Going for NAR Level 3

What are the requirements (continued)?

- **Model requirements (continued)**
  - Each parachute event must be initiated by redundant control systems
    - ✔ Redundant power sources, safe and arm provisions, control logic and output devices (e.g. bridgewires, electric matches)
    - ✔ Redundancy is not required for:
      - » Energetic materials (e.g. black powder)
      - » Parachutes
      - » Attach points
      - » Risers and disconnects
  - Must be able to “disarm” all pyrotechnic devices in the rocket
    - ✔ Disarm mean breaking the connection between the pyrotechnic device and the power source
    - ✔ Turning off the device controlling the pyrotechnic is not sufficient

Going for NAR Level 3

Model design choices

- **Model design**
  - Conventional “three fins and a nosecone” is the suggested approach
    - ✔ Analysis tools are available and proven
    - ✔ Basic construction skills are demonstrated
  - “Oddrocs” are not specifically disallowed
    - ✔ Spools and pyramids a generally frowned upon by the L3CC
      - » Analysis tools are lacking, e.g.
        - ▲ Barrowman stability equations do not apply
      - » Demonstration of construction skills may not be easily discerned
    - ✔ Other oddroc designs may be considered on an individual basis

Going for NAR Level 3

Model Design and Approval

- **Step 1 - Preliminary design**
  - Choose a basic model configuration
    - ✔ If you insist on an oddroc contact a L3CC representative for approval of the model type
    - ✔ This is an area of considerable discussion among the L3CC members
  - ”Pre-design” the model
    - ✔ Basic diameter, length, fin configuration
      - » Parts lists showing the intended components are good
    - ✔ Intended motor
    - ✔ Expected weight
    - ✔ Parachute size(s)
    - ✔ Internal layout including recovery compartments, electronics bays
    - ✔ Electronics components selections
    - ✔ C.G. and C.P. positions

Going for NAR Level 3

Model Design and Approval (continued)

- **Step 1 - Preliminary design (continued)**
  - Electronics components selections (continued)
    - ✔ It is recommended that the redundant systems not be identical
      - » A design or common manufacturing flaw may cause both units to fail at the same time
      - » A personal preference is that the sensing method for each system be unique, sensing methods include:
        - ▲ Barometric
        - ▲ Magnetic sensing (Earth's magnetic field)
        - ▲ Acceleration
        - ▲ Time
    - ✔ Arming and disarming methods
      - » Pyrotechnics must be disconnected from their power source
        - ▲ A shunt across the pyrotechnic leads is not sufficient

Going for NAR Level 3

Model Design and Approval (continued)

- **Step 1 - Preliminary design (continued)**
  - Perform the initial performance analyses
    - ✔ Expected altitude, maximum velocity
      - » Recommend staying away from transonic and supersonic flight
        - ▲ Aerodynamic environment changes
        - ▲ Changes may adversely affect barometric sensing electronics
    - ✔ Initial acceleration and velocity at the end of the launch rail/rod
      - » Target is 4 to 5 g's initial acceleration
    - ✔ Descent rate during recovery
      - » Not greater than 20 feet per second is the guideline

Going for NAR Level 3

Model Design and Approval (continued)

- **Step 2 - Preliminary design review**
  - Submit you preliminary design to the L3CC for review
    - ✔ This is optional but recommended
      - » Provide the design and performance information
        - ▲ Computer printouts and drawing are not required
        - ▲ The documentation just needs to tell the whole story
    - ✔ The L3CC will offer suggestions or cautions as necessary

Going for NAR Level 3

Model Design and Approval (continued)

- **Step 3 - Start building the model**
  - Prepare the Construction Package
    - ✔ L3CC needs to see the construction methods during model build
      - » Either have the L3CC member physically inspect the model during construction
      - » Or, take lots of photographs
        - ▲ Digital or film technologies are both acceptable
        - ▲ Try to have a size reference (e.g. a coin or ruler) in the picture
    - ✔ Prepare the Construction Package documentation
      - » Final drawings
        - ▲ Needs to show the layout of the parts and pieces
        - ▲ Does not have to be computer aided design or professionally drawn (but it's nice if it is)
      - » Parts list
      - » Photographs showing construction

Going for NAR Level 3

Model Design and Approval (continued)

- **Step 4 - Construction Package Affidavit**
  - Present the Construction Package to the L3CC
  - At least 5 days prior to the flight attempt
    - ✔ More time is better
  - The L3CC is looking for the essential information
    - ✔ Lots of “stuff” does not always make an adequate report
    - ✔ Clear and concise does!

Going for NAR Level 3

Model Design and Approval (continued)

- **Step 5 - Prepare the Recovery Package**
  - Document the recovery system components, including:
    - ✔ Drogue parachute (size, type, manufacturer)
    - ✔ Main parachute (size, type, manufacturer)
    - ✔ Parachute packing devices (e.g. bags, sleeves)
    - ✔ Anchor and connecting (e.g. quick links) hardware
    - ✔ Risers and riser routing
  - Description of the recovery initiation control components
    - ✔ Logic and control modules
    - ✔ Power sources
    - ✔ Safe and arm provisions
    - ✔ Output devices (e.g. flashbulbs, electric matches)
    - ✔ Schematic/wiring diagram
    - ✔ Mounting structure/access features
    - ✔ Pyrotechnic devices (type, quantity, volume/weight of pyrotechnic materials)

Going for NAR Level 3

Model Design and Approval (continued)

- **Step 5 - Prepare the Recovery Package (continued)**
  - Describe the operation and analysis of the recovery system
    - ✔ Sequence of events
    - ✔ Parachute size/descent rate determination
      - » e.g. manufacturer's recommendations
      - » Calculations
    - ✔ Determination method for pyrotechnic materials volume/weight
  - Describe how the pre-flight tests of the recovery electronics
    - ✔ Ground tests
    - ✔ Flight tests
    - ✔ Document the extent of the tested components, including:
      - » Electronic modules
      - » Power supplies
      - » Safe and arm provisions
      - » Bridgewire type

Going for NAR Level 3

Model Design and Approval (continued)

- **Step 6 - Recovery Package Affidavit**
  - Present the Recovery Package to the L3CC
    - ✔ Does not have to be the same L3CC member who reviewed the Construction Package
  - At least 5 days prior to the flight attempt
    - ✔ Again,more time is better
  - A recovery failure is the most likely cause of a failure to certify
    - ✔ Document your recovery system thoroughly
      - » It will help your L3CC representative help you

Going for NAR Level 3

Model Design and Approval (continued)

- **Step 7 - Certification Package**
  - Contains the Construction and Recovery Systems packages
  - Calculations containing center of pressure
    - ✔ May be hand or computer simulations
      - » Some L3CC members have expressed a preference for hand calculations
        - ▲ Thought is that a hand calculation shows a better understanding of the process
  - Scale drawing showing:
    - ✔ Major dimensions
      - » e.g. dimensions required for stability analysis
      - » Calculated center of pressure
      - » Aft center of gravity limit in the Level 3 flight configuration

Going for NAR Level 3

Model Design and Approval (continued)

- **Step 7 - Certification Package (continued)**
  - Description of the expected flight profile including:
    - ✔ Intended motor
    - ✔ Launch weight
    - ✔ Estimated drag coefficient
    - ✔ Velocity as the rocket leaves the launch system
    - ✔ Maximum expected velocity
    - ✔ Maximum expected altitude
    - ✔ Maximum expected acceleration
    - ✔ Flight profiles under worst case and best case as well as nominal conditions are recommended
  - Pre-launch checklist
  - Post-recovery checklist
  - “Contingency” checklist for a failure or launch abort
  - Declaration of design features for breakaway or easy replacement to minimize landing damage

Going for NAR Level 3

Model Design and Approval (continued)

- **Step 7 - Certification Package (continued)**
  - Checklist comments
    - ✔ Include an equipment and consumables list, e.g.
      - » Launch pad items
      - » Accessibility items (e.g. ladders)
      - » Tools
      - » Wadding, black powder
      - » Safety equipment (e.g. face shield, eye protection)
    - ✔ Highlight areas where extra caution is required or hazards are present
      - » Loading pyrotechnic charges
      - » Testing pyrotechnic systems
      - » Arming

Going for NAR Level 3

Certification Flight

- **Step 8 - Certification Pre-Flight**
  - Two (2) flight witnesses are required
    - ✔ One must be a L3CC member
      - » The L3CC member is not required to be one of the members who signed the Construction or Recovery affidavits
  - Model will be pre-flight inspected against the Certification Package
  - Safety for flight will be verified
    - ✔ Stability is acceptable
    - ✔ Flight profile is safe and within the FAA waiver limits

Going for NAR Level 3

Certification Flight (continued)

- **Step 9 - Certification Flight**
  - The model is flown, recovered, and inspected
    - ✔ Flight requirements
      - » Stable
      - » Within FAA waiver limits
        - ▲ Certification failure if the waiver is “busted”
      - » Safe recovery
        - ▲ Anomalous operation of the recovery system will still allow for certification if the recovery was safe
        - ▲ No separation of larger parts (>8 ounces) that do not have their own recovery device
    - ✔ Post-flight requirements
      - » Motor casing remains within the airframe
      - » Airframe is complete
      - » No damage requiring repair that prevents an immediate reflight of the model

Going for NAR Level 3

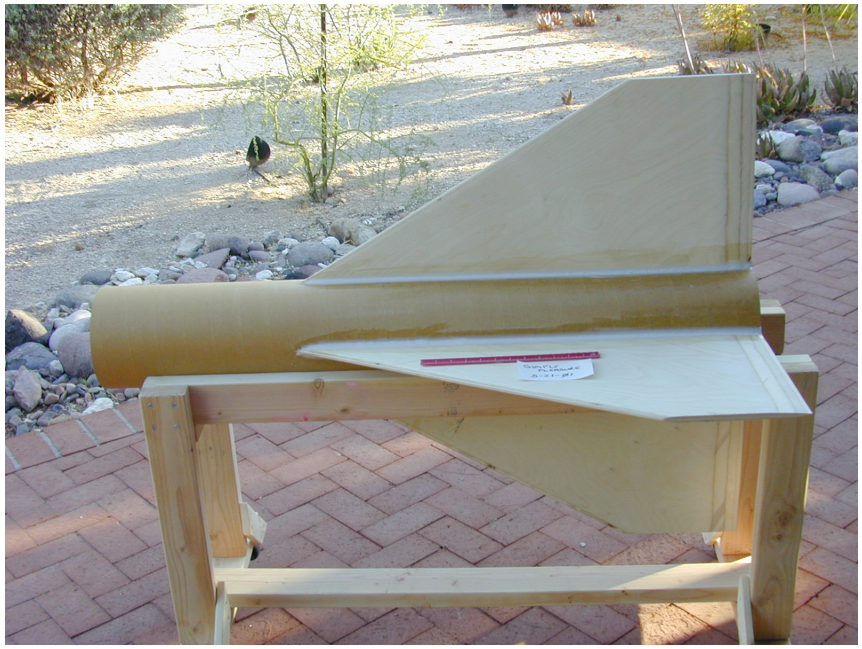
Certification Flight (continued)

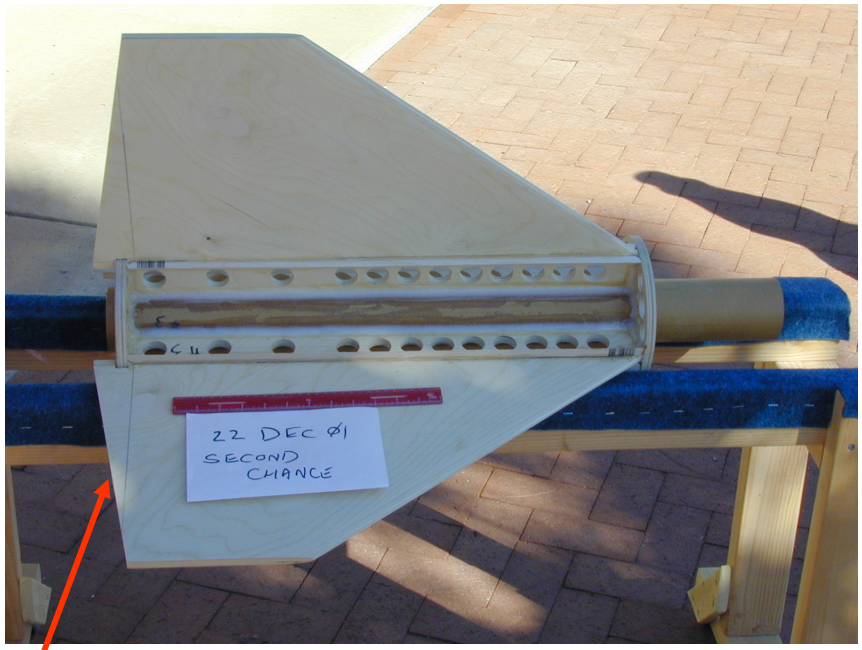
- **Step 9 - Certification Flight (continued)**
  - Sign off the certification documentation for successful flights
  - Submit the certification documentation to NAR Headquarters
    - ✔ The certification package does not have to be provided to NAR Headquarters
- **And then you are certified!**

Going for NAR Level 3

Lessons Learned (continued)

- **Lesson 2- Avoid swept back or straight fin trailing edges**
  - Susceptible to landing damage



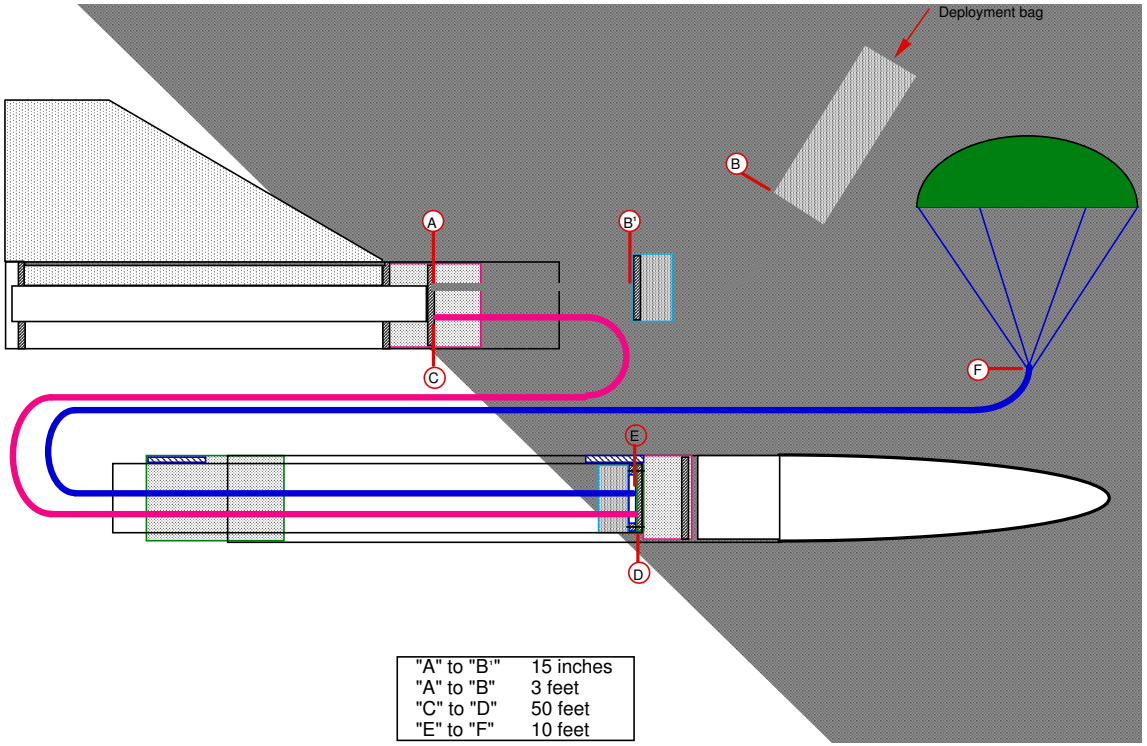


Forward swept trailing edge

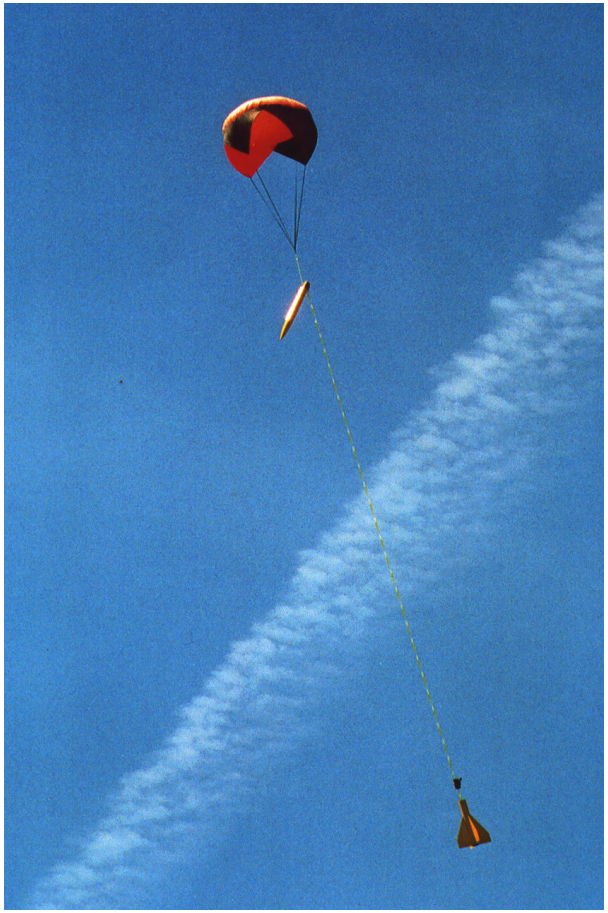
Going for NAR Level 3

Lessons Learned (continued)

- **Lesson 3- Riser attachment points**
  - Bad design causes zippers



Simple Pleasure Rigging Plan

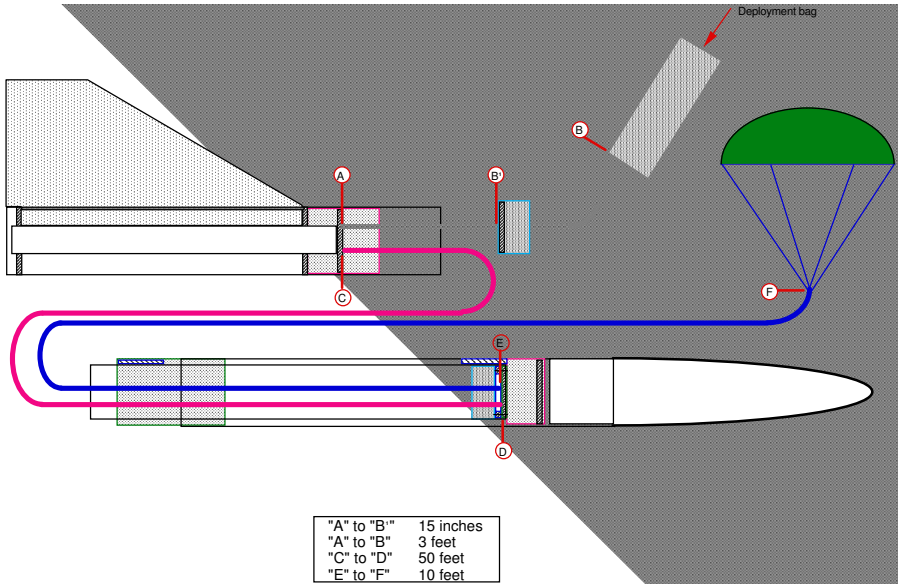


Simple Pleasure Recovery

Going for NAR Level 3

Lessons Learned (continued)

- **Lesson 3- Riser attachment points (continued)**

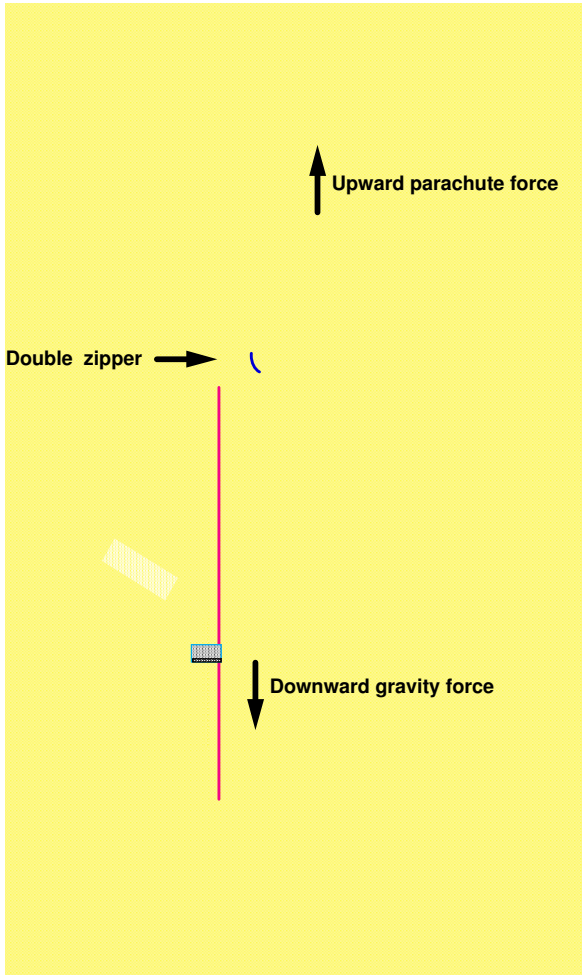


Note that the risers are pulled in separate directions

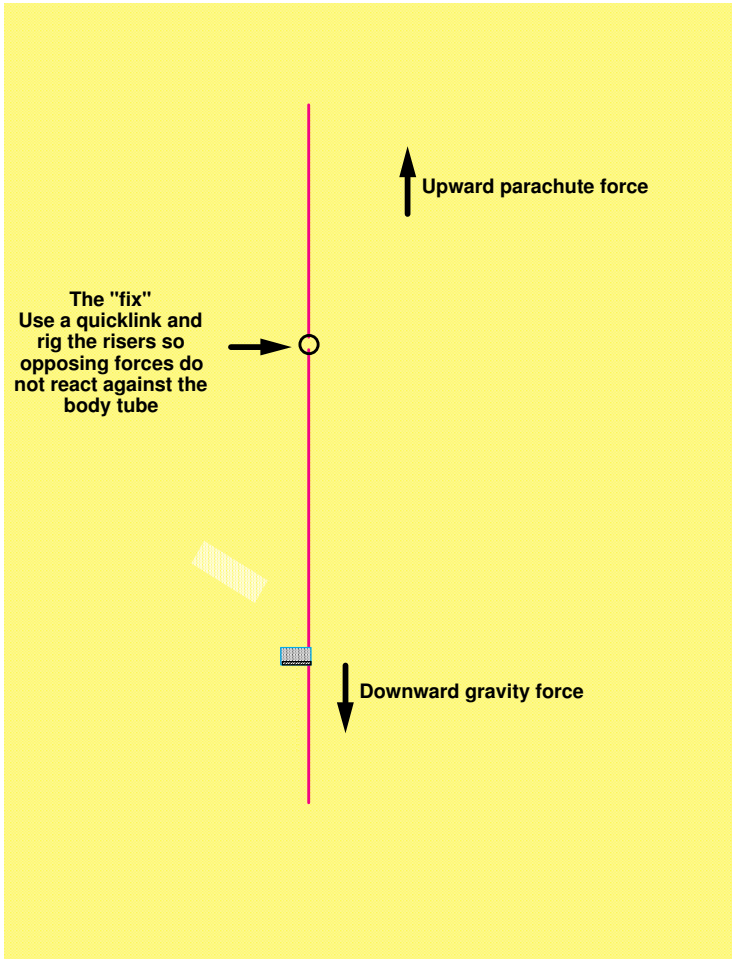
Going for NAR Level 3

Lessons Learned (continued)

- **Lesson 3- Riser attachment points (continued)**



Failure Cause

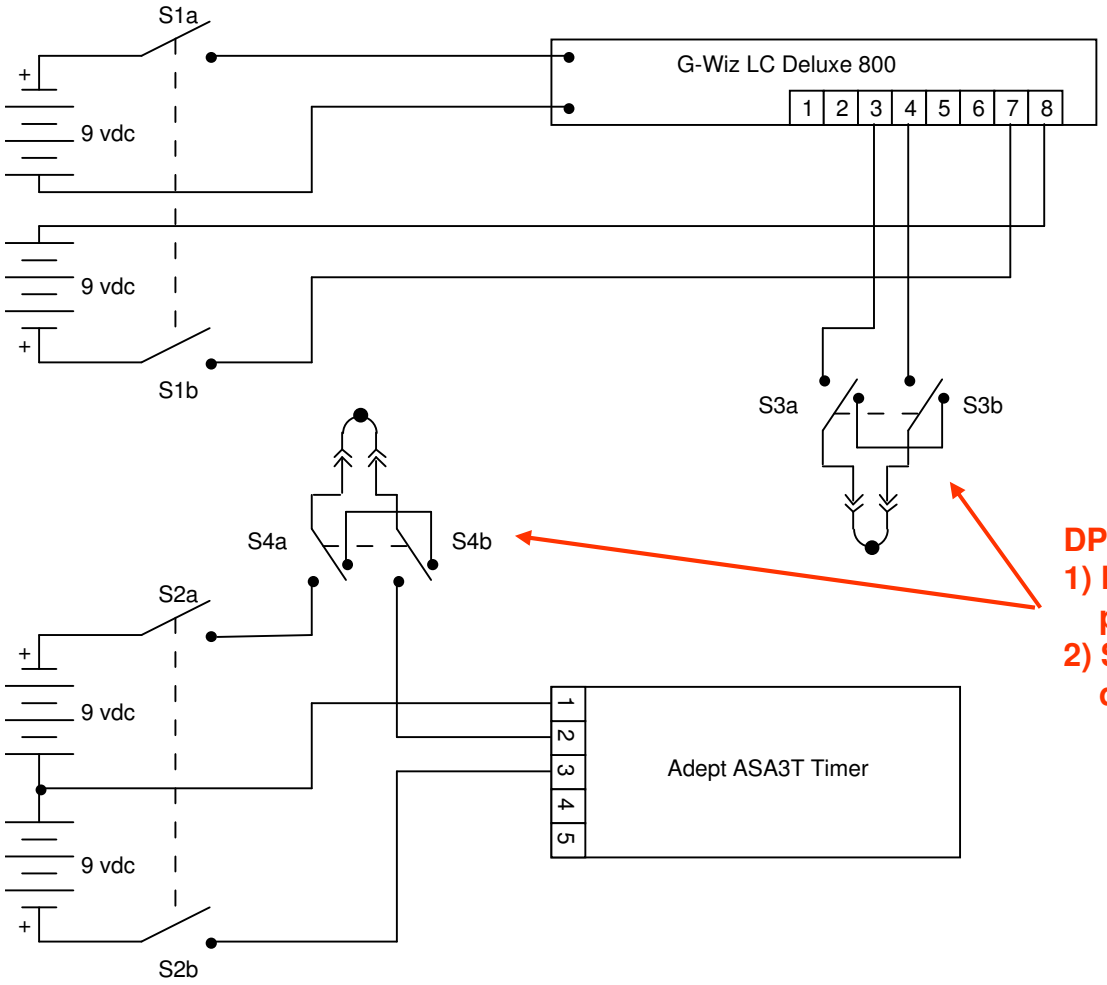


Failure Fix

Going for NAR Level 3

Personal Practices

- **Use double pole double throw (DPDT) switches for pyrotechnic safing**



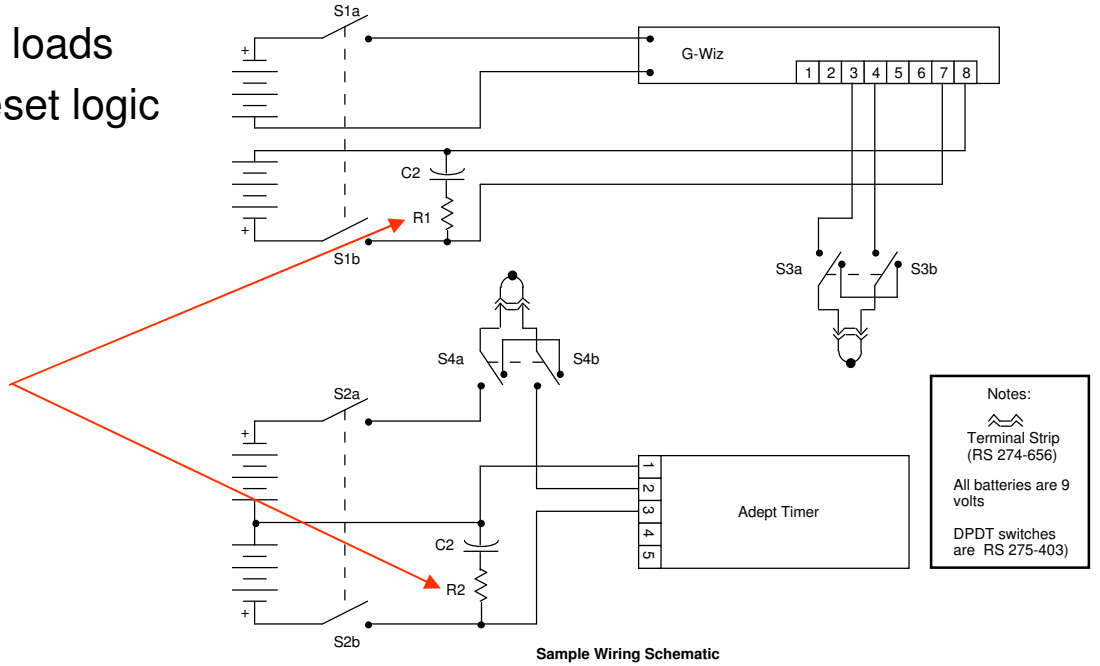
DPDT Switch (2 places)
1) Disconnects power from pyrotechnics
2) Shorts pyrotechnic device

Going for NAR Level 3

Personal Practices (continued)

- **Use "double" bus design**
  - Use a minimum of two batteries to split loads
    - ✔ Continuous load bus
      - » Logic circuitry
      - » Use capacitors downstream of on-off switches to "filter" power in case of switch contact bounce from vibration/acceleration
    - ✔ Pulse load bus
      - » Bridgewire firing loads
      - » Pulses do not reset logic

R1 and R2 resistors are to limit current draw from the batteries during turn-on



Sample Wiring Schematic

Going for NAR Level 3

Personal Practices (continued)

- **Pyrotechnic sizing**
  - Used “margin” firing method
    - ✔ Gradually increased the charge size until the minimum charge that achieved the desired separation was found (1.5 grams of black powder for Simple Pleasure)
    - ✔ Doubled that charge for flight (3.0 grams of black powder for flight)

Simple Pleasure Margin Firing