High-Power Rocketry

Presented at NARCON-2014 by

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High-Power Rocketry

1. What constitutes HPR?
   a. HPR terminology & definitions
   b. HPR motors - commercial, "research" (TRA homebrew), solid propellant, hybrid fuels
   c. Launch site & equipment requirements
   d. Costs

2. History of HPR
   a. Early efforts by pre WW2 & post-war amateur societies; Sputnik-era to mid-60's
   b. 1970's-80's, conflicts w/NAR, birth of TRA
   c. Commercial motor development - H thru K single-use motors in mid 80's to reloadable systems
   d. Certification program - started out as single level H+, now 3 levels

3. HPR certification thru NAR
   a. Level 1: H - I
   b. Level 2: J - K - L
   c. Level 3: M+
   d. Level 3 Certification Committee (L3CC) - administers L3 cert program

4. HPR Design & Construction - Methods & Materials
   a. Types of construction - commercial/prefab components, custom fabrication
   b. Composites - Fiberglass, Quasiglass, carbon fiber, resins, adhesives
   c. Fins - solid G10, plywood, built-up hollow-core, stressed skin
   d. Motor & Shock Cord Mounts - load transfer, hardware
   e. Avionics Bay
   f. Nose Cone
   g. Reference materials - print & online

5. Simulation Programs
   a. RockSim
   b. OpenRocket
   c. wRASP
   d. VCP

6. Motors
   a. Single use
   b. Reloadable
   c. Hybrid
   d. Clustering & staging

7. Recovery systems & methods
   a. Parachutes - sizing, descent rate; other more exotic methods (glide, helicopter)
   b. Single event vs dual deployment
   c. Activation - motor ejection vs electronic e.g. altimeter, timer, accelerometer
   d. Locators - audible, radio telemetry, GPS
   e. Shovels - spade vs flat, post-hole digger, folding camp-type

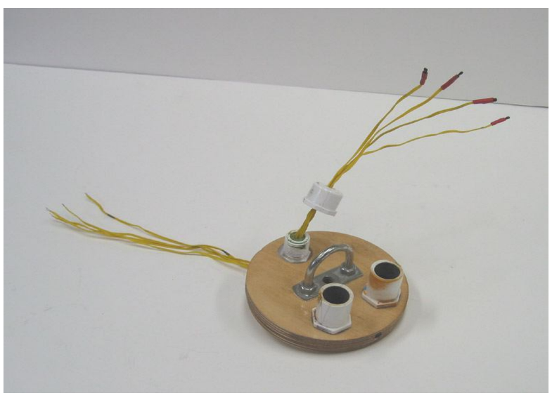
8. Hazards
   a. Motor failure
   b. Airframe failure
   c. My personal favorite; recovery failure (see Item 7e)

Avionics Bay Construction

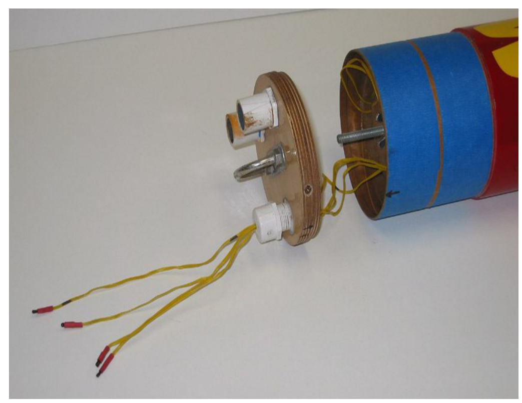
Avionics bays come in a variety of shapes and forms, depending upon the size, function and type of rocket. Some bays are integral to the rocket and cannot be removed, with access to the electronics by way of a removable hatch or bulkhead plate. Others can be completely removed from the rocket, and are typically held in place with mounting screws. Removable bays have the advantage of easy access for maintenance and repair, and can also be interchanged, which allows them to be used on different rockets or replaced with a different bay on the same rocket.

For barometric altimeters, static ports must be placed so that the altimeter can sense air pressure. The bay must securely hold the electronic devices in place, preferably isolated from vibration & typically by way of a removable sled that slides over the eyebolt or through-bolt. It must provide a means of safely arming and disarming the devices without triggering an event such as ejection charge activation or airstart/cluster ignition. It also must be sealed to isolate the devices from contamination from pyrotechnic gas & heat effects. And most importantly, it must provide anchor points for the recovery systems-- provided the flier remembers to hook it all up!

Below are images of an altimeter bay, and on the following pager are schematic diagrams showing the characteristics of a typical altimeter bay.

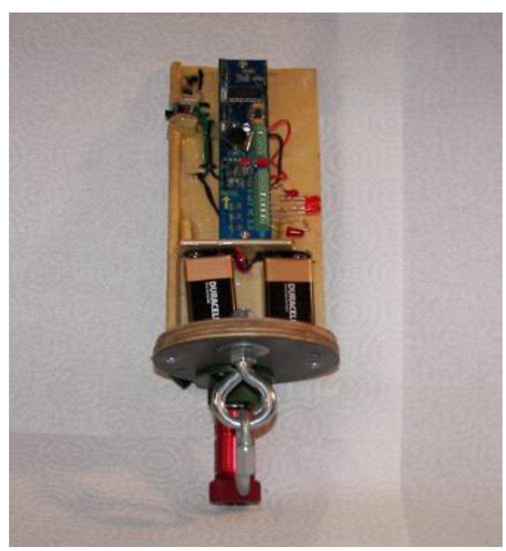


Removable bulkhead with ejection charge squibs & holders

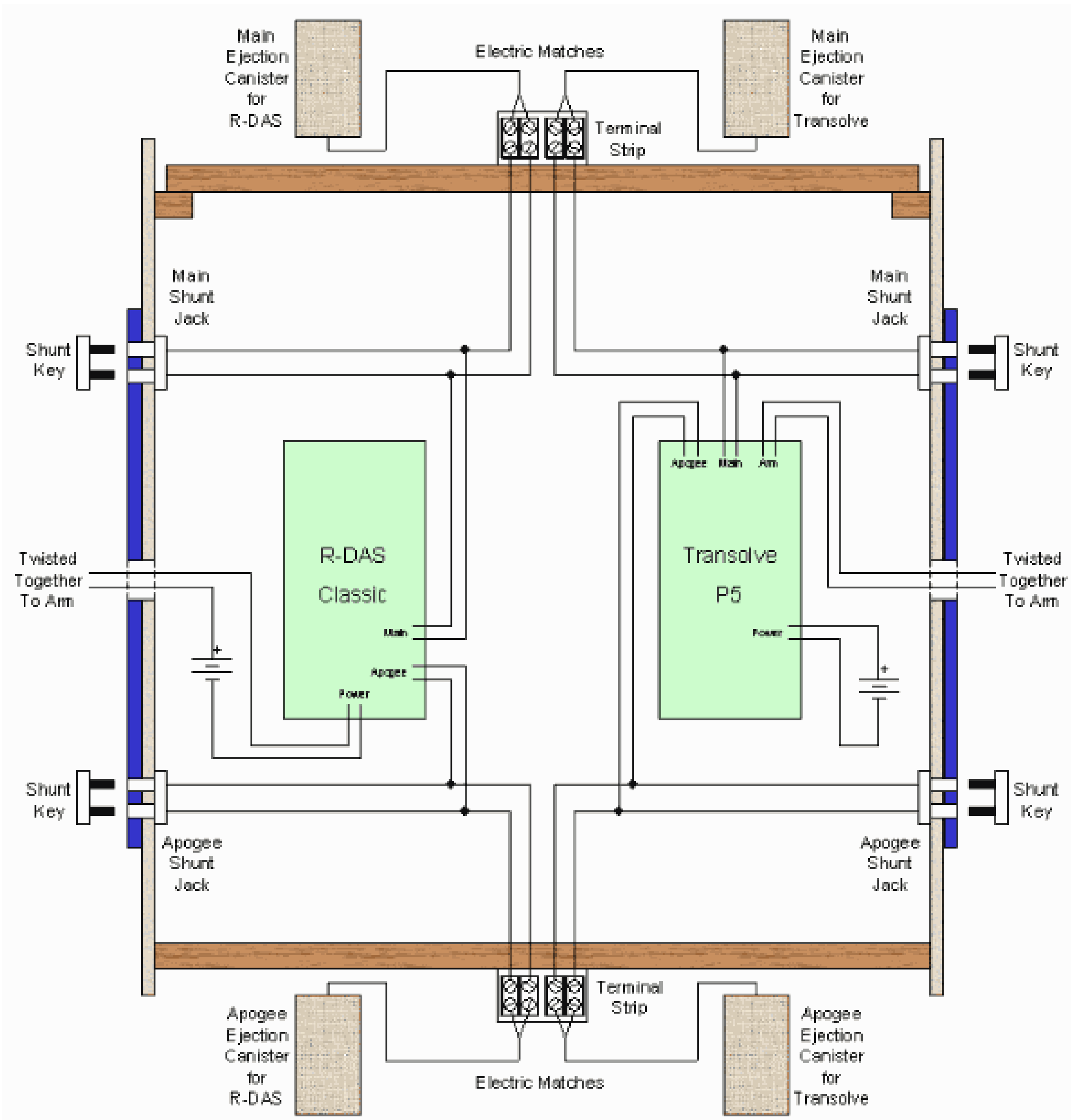


Installation of bulkhead onto through-bolt & coupler

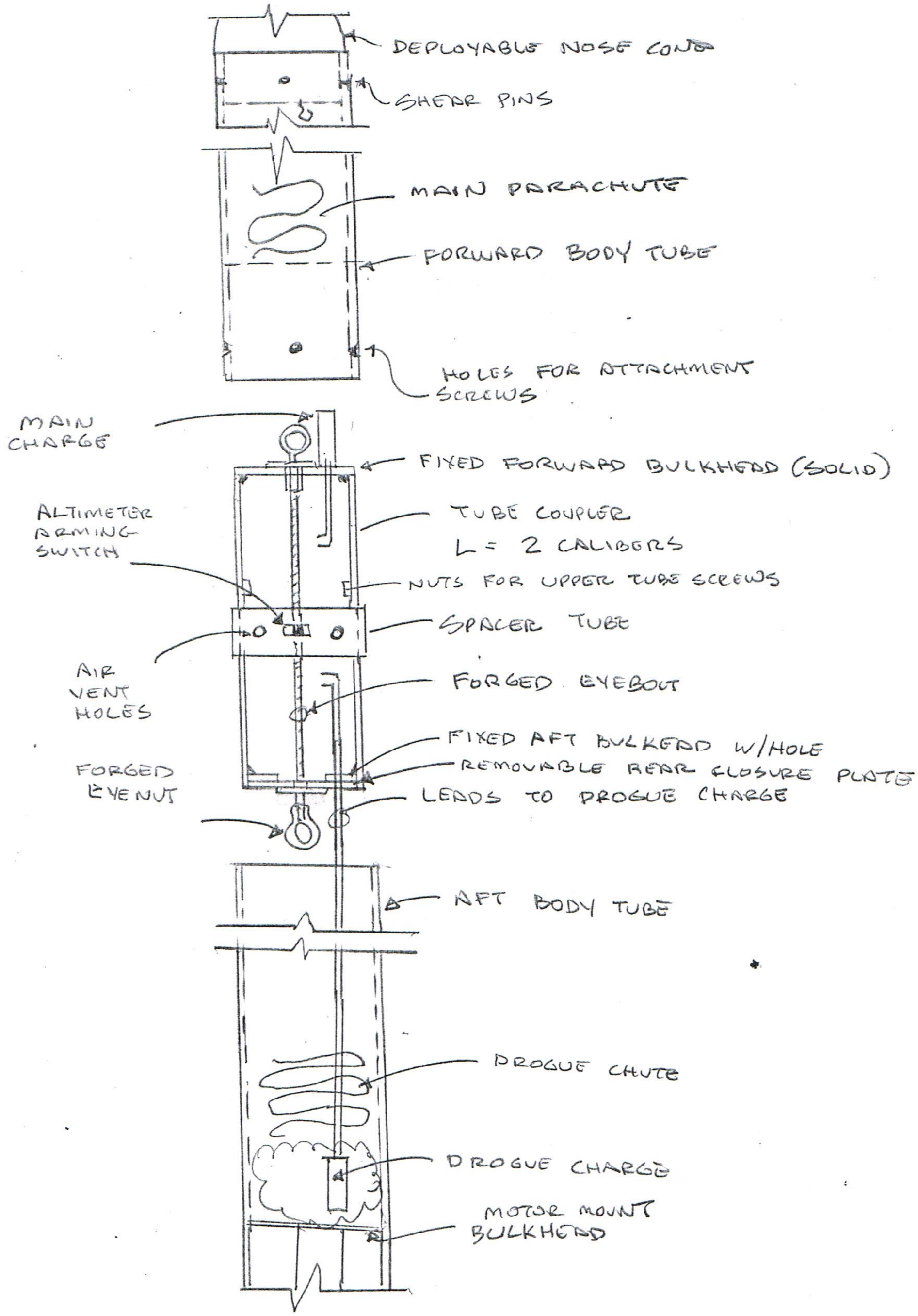
Basic altimeter bay components - aft bulkhead, through-bolt, coupler and forward bulkhead



Altimeter installed on a sled



Typical wiring schematic for dual-deployment system with redundant backup device

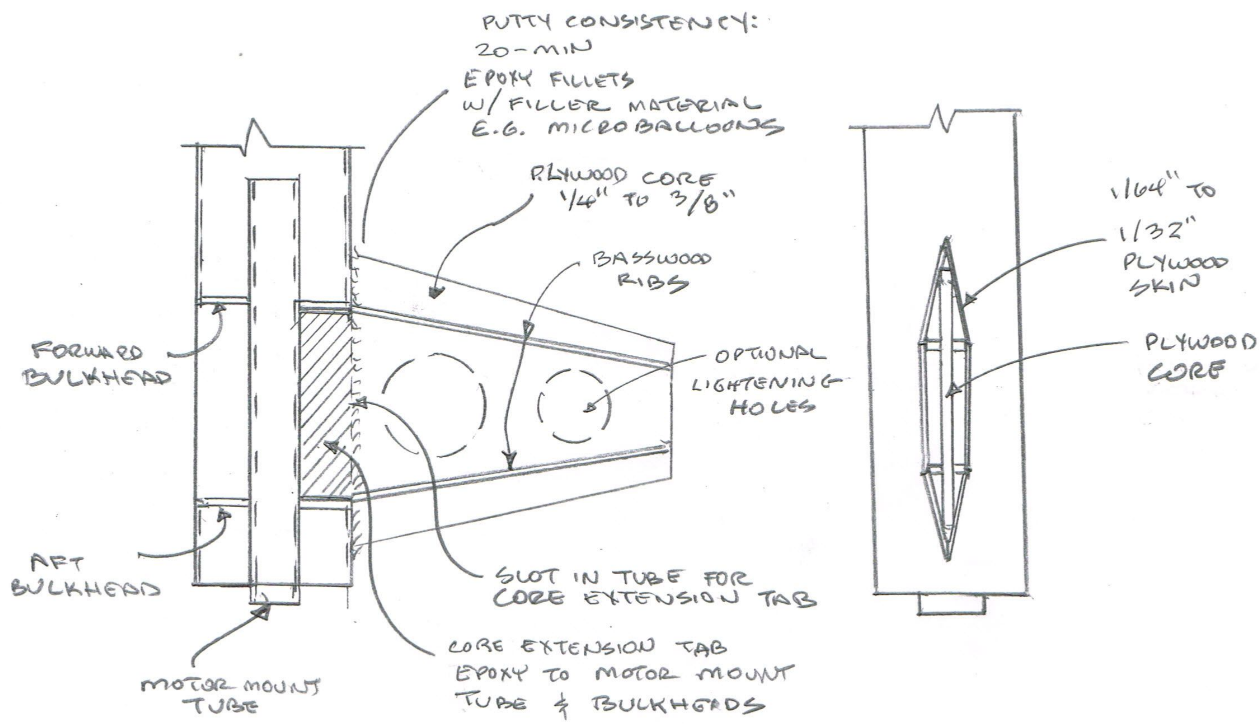


A TYPICAL / GENERIC ALTIMETER BAY

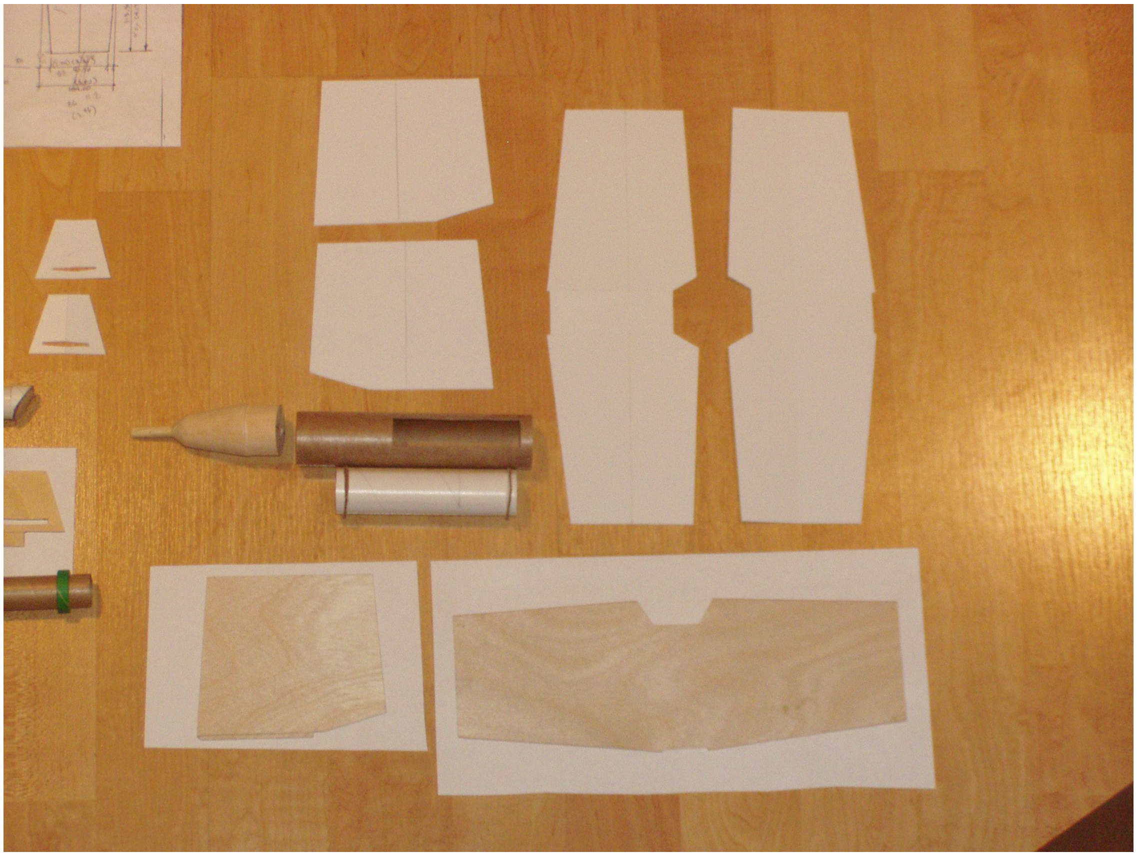
Built-up Fin Construction

For high-power rockets, built-up fins offer several advantages over the usual plywood/G10 slabs that are typically seen. Built-up fins are lighter, which in itself may not matter so much on high-power rockets but the weight savings translates to a CG that is farther forward, thus improving stability or allowing smaller fins to be used, thus reducing drag. Built-up fins facilitate airfoiling; one can easily taper the fin thickness or bevel the edges, making it relatively simple to create a scale profile on, say, a Nike booster or a Saturn 1B. Built-up fins can be made much thicker at the root to prevent flutter. And, since most “real” sounding rockets & finned space boosters use some sort of stressed-skin, hollow-core fin design, the built-up fin represents a realistic application of “rocket science!”

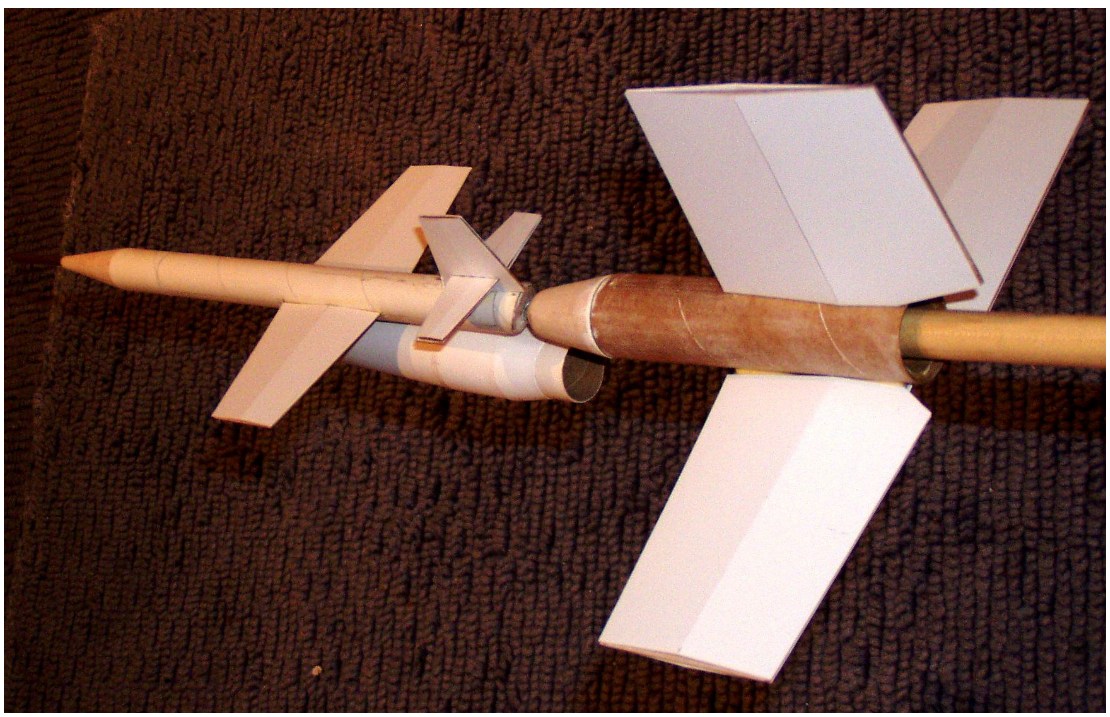
Below is a sketch of a typical Nike-style hollow-core built-up fin. This is one of the simplest fins, but the same techniques can be applied to virtually any design, and easily scaled up or down to whatever size is needed. Small scale models can use balsa or thin plywood cores and thin styrene sheets to obtain excellent results relatively quickly and easily, as shown in the photos of the Lockheed X-7A scale model.



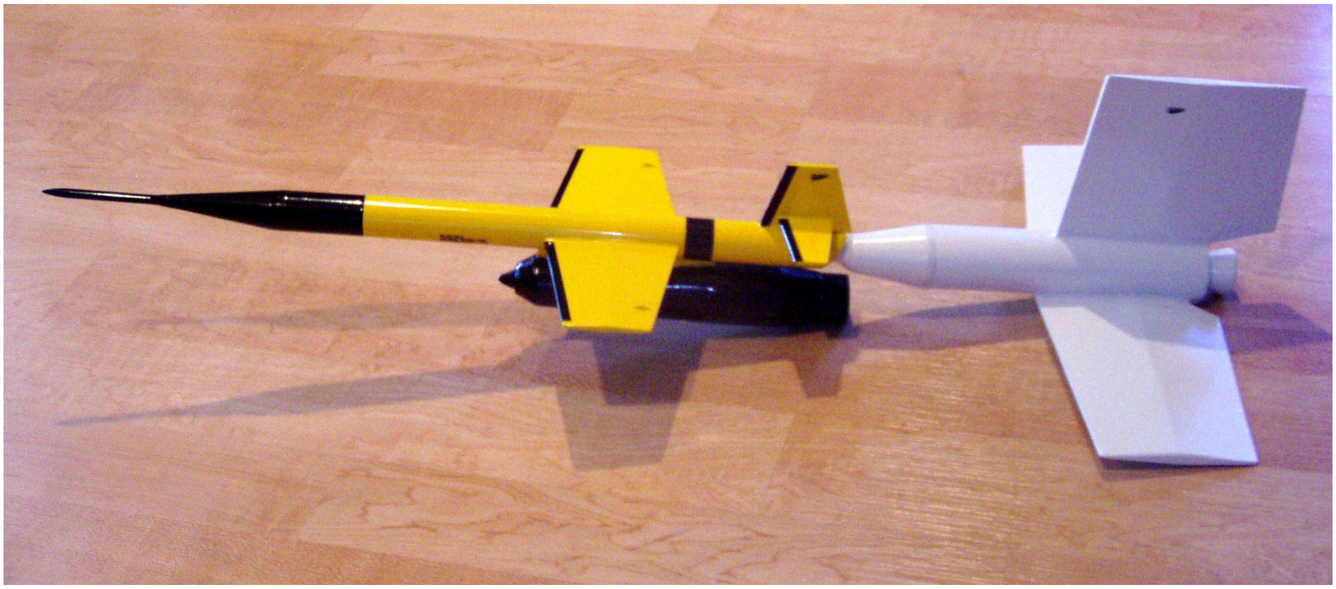
TYPICAL/GENERIC BUILT-UP FIN



Built-up wing and fin components for a scratchbuilt scale Lockheed X-7A. Cores are 1/32 plywood; skins are thin sheet styrene



Built-up wings and fins installed on scale model of Lockheed X-7A, showing wedge-shaped airfoil surfaces to good effect



Completed model of Lockheed X-7A

Lockheed X-7A in flight at NARAM-50
(photo by Chris Taylor)