

Reach Out and Teach Someone

Who is this guy?

- **I'm Steve Lubliner, NAR 22152**
 - Flight test and instrumentation engineer for Raytheon Missile Systems
 - Over 30 years in the sport rocketry hobby
 - ✓ Launches from 1/4"A" to "M"
 - ✓ Model rocket competition
 - ✓ Member of the National Association of Rocketry (NAR) Board
 - ✓ Chairman of the NAR's Sport Services Committee
 - » Responsible for NAR high power certification programs
 - » Responsible for the NAR Trained Safety Officer Program
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- **Target audience for this talk**
 - Educators
 - ✓ Primarily elementary through junior high school
 - Youth group leaders, e.g.
 - ✓ 4-H, scouting organizations, Civil Air Patrol, summer camp
- **Objective**
 - How to plan and prepare for a model rocket “build and fly” session for:
 - ✓ Youngsters (typically eight (8) to thirteen (13) years old) who are:
 - ✓ First or second time model rocket activity participants
 - Model rocket operation will be discussed to a lesser extent
 - ✓ Potential safety concerns will be addressed
 - ✓ Safety practices will be addressed
- **Questions?**
 - Don't wait to the end; ask it when you think of it

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Rocket Science

- **What is Model Rocketry?**
 - It's safe!
 - ✓ Uses commercial, pre-made, certified model rocket motors
 - » Individuals do not mix propellant or "pack" their own motors
 - » Motors are highly reliable
 - ✓ Models are made of lightweight materials
 - » Typically wood, paper, and plastic
 - » Metal is limited to use in small components
 - ✓ Launch procedures are based on range safety procedures used by U.S. government test ranges, e.g.
 - » Safe distance from the launch pad
 - » Launch countdown and electrical motor ignition

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Rocket Science (continued)

- **What is Model Rocketry (continued)?**

- It's educational!

- ✓ Various scientific and math principles are demonstrated, e.g.

- » Newton's laws of motion

- » Concepts of drag and stability

- ✓ Useful as a tool for teaching engineering techniques, e.g.

- » Computer simulations

- » Trade studies

- » Design optimization

- » Design of experiments

- It's fun!

- ✓ Craftsmanship skills

- ✓ Creative outlet

- ✓ Competition

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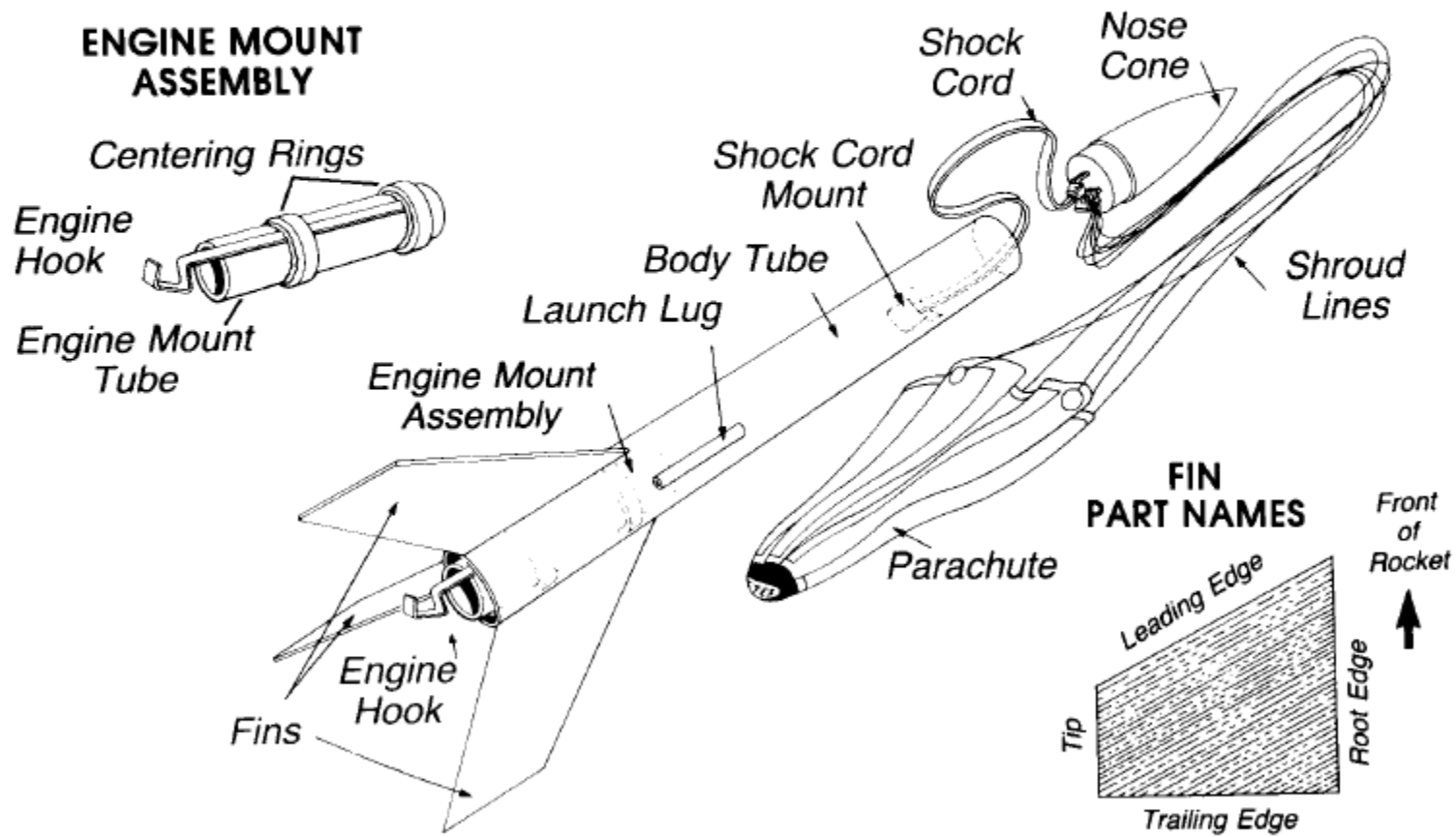
Rocket Science (continued)

- **What is a Model Rocket?**
 - A model rocket weighs less than 1 pound at launch
 - A model rocket contains less than 4 ounces of propellant
 - A model rocket's structural parts, including the body, nosecone, and fins, are made of lightweight materials, e.g. plastic, paper, and wood
 - A model rocket has a means of returning itself to the ground such that it may be flown again, e.g. a parachute
 - A model rocket may not carry a payload that is designed to be flammable, explosive, or harmful to persons or property
 - A model rocket may not carry a live biological payload

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Rocket Science (continued)

Model Rocket Exploded View (pun intended)



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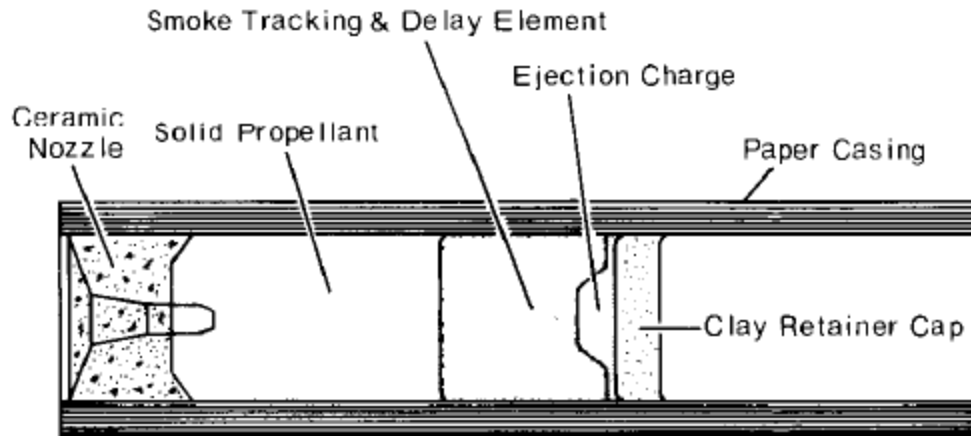
Rocket Science (continued)

- **How does a model rocket motor work?**
 - The model rocket motor consists of the following components:
 - ✓ Case (typically made of thick wall paper tubing)
 - » Contains all of the model rocket motor components
 - ✓ Nozzle (typically made of clay)
 - » Accelerates the exhaust gases from the combustion chamber to produce thrust
 - ✓ Propellant charge (black powder in most model rocket motors)
 - » This is the fuel that powers the model during the launch phase
 - ✓ Delay charge
 - » This is the time delay that allows the model to slow down and coast to apogee
 - » It also provides smoke to track the model during its ascent
 - ✓ Ejection charge
 - » This is the charge that pushes the parachute or streamer from the model

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Rocket Science (continued)

How does a model rocket motor work?



The inside story!

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Rocket Science (continued)

- **What do the numbers on the model rocket motor mean?**

For example: A8-3

- The “A” is the total impulse or total “power” of the rocket motor
 - ✓ An “A” motor has a total impulse of 1.26 to 2.50 Newton-seconds
 - ✓ A “B” motor has a total impulse of 2.51 to 5.00 Newton-seconds
 - ✓ A “C” motor has a total impulse of 5.01 to 10.00 Newton-seconds
- Note that the total impulse doubles with each successive letter
 - ✓ A “G” motor has a total impulse of 80.01 to 160.00 Newton-seconds
- The “8” represents the average motor thrust in Newtons
 - ✓ Divide by 4.45 to get pounds force
- The “3” is the delay from motor burnout to ejection charge operation in seconds
 - ✓ A short delay is typically required for heavier models
 - ✓ A long delay is typically required for lightweight models

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Planning Essentials

- **Running a model rocket “build and fly” session takes advance planning**
- **There are four major questions to be addressed to plan the session:**
 - The age group of the participants
 - Time available for building and flying
 - Space available for building and flying
 - The budget for the activity

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Choosing the Model

- **Choose simple rockets for beginners and younger participants**
 - Less building time (for shorter attention spans)
 - Easier instructions
 - Less skill dependent
 - Easier flight preparation
- **Features of simple rockets**
 - Single piece plastic fin units (e.g. Estes Alpha III, Estes Generic E2X)
 - Single piece nose cones (Estes models)
 - Streamer recovery
 - Motor retention clips (all models on the following page)
- **Features that add complexity**
 - Wooden fins (e.g. Estes Alpha, Quest Astra)
 - Parachutes (all models on the following page)
 - “Friction” fitted motors

Choose a skills appropriate model!

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Sample Beginner's Models



Estes Alpha, Estes Alpha III, Quest Astra



Custom Razor



Estes Generic E2X

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Do you have time?

- **Simple kits take about 60 to 90 minutes to build**
 - Need to allow time for adhesives to set-up
 - ✓ Some steps require subassemblies to be dry before they are installed
 - Some items are just time consuming, e.g.
 - ✓ Parachute assembly
 - More complex kits can be built in the time span with prefabrication
- **Preparing the models for flight will take 15 to 20 minutes**
 - Safety briefing needs to be made
 - ✓ Takes about 5 minutes
 - ✓ Covers where to stand, no horseplay, countdown
 - Install the rocket motor, prepare the recovery system

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Do you have time (continued)?

- **Flying each rocket will average about 5 minutes per flight**
 - Set up the launch equipment (do it in advance if you can)
 - Place the model on the launch pad and hook up the igniter clips
 - Launch countdown, flight, and recovery
 - The time per flight can be considerably reduced by multiple launch pads
 - ✓ Allows parallel launch operations
 - ✓ Minor increase in hazard level because more activities are happening at once

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Do you have time (continued)?

- **Time management strategies**

- Split building and flying sessions into separate sessions
- Prefabricate time consuming items
- Sequence the building steps to finish gluing operations early in the session
- Have a “snack “or lunch break after the models are assembled
 - ✓ Gives time for the models to “dry”
 - ✓ Do the safety briefing during the break
- Multiple launch systems to speed up the launches

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Is space available?

- **Building space**

- Need tables and chairs
 - ✓ Tables should be covered for protection from glue drips
 - » Newspaper or butcher paper
 - » Cheap paper or plastic tablecloths
 - ✓ Cutting surfaces should be provided if knives are required for construction
 - » Corrugated cardboard works well
 - ✓ Students need space to spread out
- Good ventilation is needed
 - ✓ Especially if plastic cements are required
 - » Plastic cements have unpleasant and hazardous fumes
- A wash basin is desirable to remove white or wood glue from hands

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Is space available (continued)?

- **Launch site size**

- Rocket motor selection affects the recommended launch site size

- ✓ “1/2A” motors 50 ft by 50 ft launch site
- ✓ “A” motors 100 ft by 100 ft launch site
- ✓ “B” motors 200 ft by 200 ft launch site
- ✓ “C” motors 400 ft by 400 ft launch site
- ✓ “D” motors 500 ft by 500 ft launch site
- ✓ “E” motors 1000 ft by 1000 ft launch site
- ✓ “F” motors 1000 ft by 1000 ft launch site
- ✓ “G” motors 1000 ft by 1000 ft launch site
- ✓ 2 x “G” motors 1500 ft by 1500 ft launch site
 - » The above table is for single motor models.
 - » If multiple motors are used determine the equivalent motor on the above chart
 - » Note that individuals must be 18 years old or older to use “G: motors

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Is space available (continued)?

- **Launch site size (continued)**

- Model performance characteristics may modify the recommended launch site size
 - ✓ An alternative launch site size may be calculated as 1/2 of the maximum expected altitude
 - ✓ Models such as “B” powered egglofters typically do not exceed 200 to 300 feet in altitude
 - » This would suggest a 100 to 150 foot square launch site (smaller than the recommendation)
 - ✓ Recovery system types also should be considered
 - » Models with parachutes will drift further than tumble or streamer recovered models

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Is space available (continued)?

- **Launch site size (continued)**

- Launch sites should be situated to avoid:
 - ✓ Buildings
 - ✓ Vehicles and roadways
 - ✓ Trees and vegetation
 - ✓ Non-participants and spectators
 - ✓ Natural hazards (e.g. ditches)
- Consideration should be given to the flight paths and landing areas for models that have recovery failures
 - ✓ The launch site should be relatively free of flammable materials, e.g. tall dry grass,
 - » To prevent fire in the event of a ground parachute deployment
 - ✓ Ballistic models (no recovery) can damage vehicles and buildings

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How much will it cost?

- **Budgetary items**
 - Rocket models
 - ✓ Models recommended for beginners will typically cost between \$5.00 and \$10.00 each
 - » Bulk packs (12 to 25 models per pack) are available at discount
 - Rocket motors
 - ✓ “A” through “C” motors typically used for the recommended beginner models typically cost about \$1.25 to \$2.00 each
 - » Remember that the motors are single use only; one for every flight
 - » Motors are typically sold in 3 or 4 packs
 - ▲ Bulk packs of up to 24 motors per pack offer price breaks
 - ▲ Motor bulk packs may also include spare igniters and wadding

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How much will it cost(continued)?

- **Budgetary items (continued)**

- Launch equipment (launch pad and launch controller)
 - ✓ Purchased equipment from the major manufacturers is available for between \$20.00 to \$30.00 per system
 - ✓ Launch pads can be built cheaply from 2" x 2" or 2" by 4" lumber for less than \$5.00 per launch pad
 - ✓ Launch controllers can be build for controlling a single launch pad or multiple launch pads
 - » Costs can be cheaper than purchased equipment to more expensive depending on the components used
 - » Schematics are available from the instructor or the book "Handbook of Model Rocketry" by G. Harry Stine

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How much will it cost(continued)?

- **Budgetary items (continued)**

- Expendables

- ✓ Wadding

- » Rocket manufacturer's wadding typically costs \$3.00 to \$4.00 a package

- ▲ One package is good for 15 to 20 rocket flights

- ▲ Wadding is sometimes included with the motor bulk packs

- » Cellulose home insulation may also be used

- ▲ Costs about \$7.00 a bale

- ▲ One bale will last a "lifetime"

- ▲ More difficult to use and harder to measure than manufacturer's wadding

- » **NEVER** use paper towel, toilet paper, or any flammable material as wadding

- ▲ The potential for fire is too great

- ✓ Igniters

- » Included with the rocket motors

- » Spares are recommended because igniters sometimes fail

- » Approximately \$0.50 each, figure on a 10% to 20% failure rate

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How much will it cost(continued)?

- **Budgetary items (continued)**
 - Supplies
 - ✓ Adhesives and application bottles
 - ✓ Table protection
 - ✓ Paper towels
 - ✓ Sandpaper
 - ✓ Model decorations
 - » Self adhesive stickers are recommended
 - ✓ Toothpicks, cotton swabs
 - ✓ Masking tape