AE1350 Final Project and Rocket Competition

Fall 2008

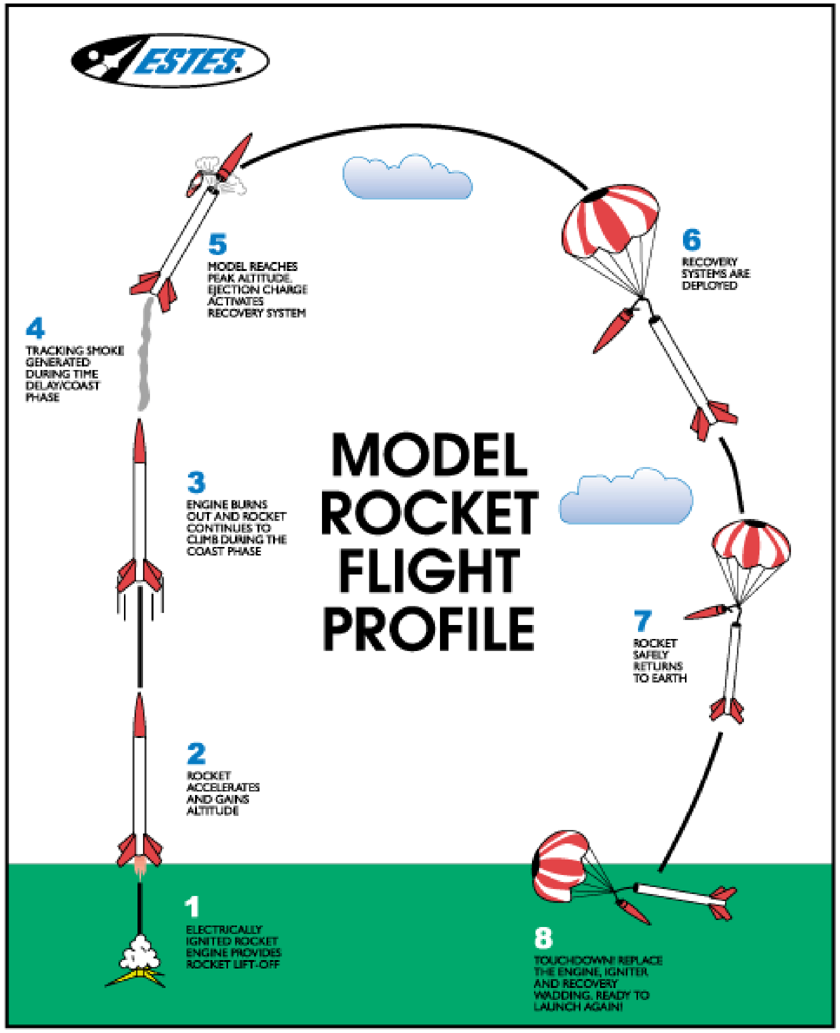
Goal

- In a single project, include most major aspects of typical Aerospace Engineering activities
  - Creativity and problem solving
  - Working to specifications
  - Sizing and trade studies
  - Prediction of aerodynamic forces and weights
  - Building
  - Simulation
  - Flight testing
  - Working in a team
  - Communicating with reports

Your Mission

- A team of 3-4 people; design, analyze, build, and fly a rocket that:
  - Uses a single type C motor or smaller
  - Carries a 15 gram, instrumentation payload, supplied by instructor on launch day
  - Is made of paper, wood, or breakable plastic, and contains no substantial metal parts
  - Is deemed airworthy by instructor

Model Rocket Flight Profile



Mission Specification

- An apogee altitude of 300 feet
- A total time of flight of 20 seconds (launch to touchdown)
- A vertical speed of 12 feet per second at touchdown

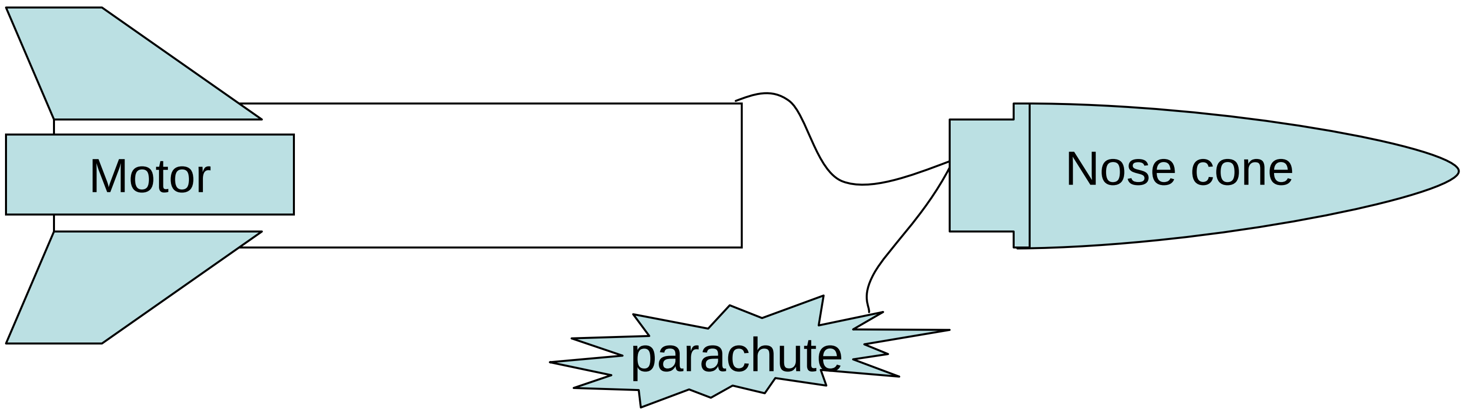
Instrumentation Payload

- PerfectFlite Alt15K/WD Rev 2
  - 78.7mm x 13.9mm x 16.3mm
  - 15gram
  - Records altitude as a function of time (measures static pressure)
  - USB data transfer

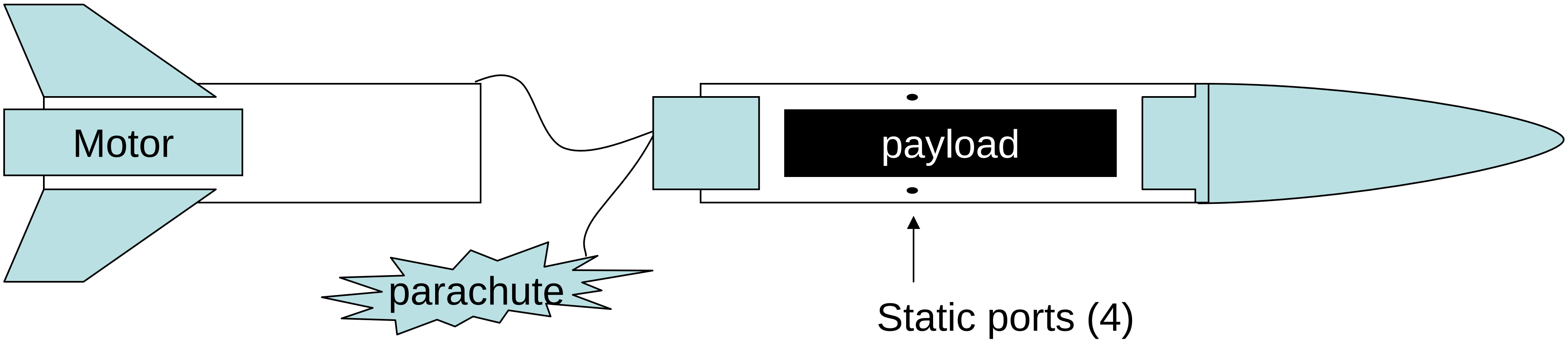
Integrating Payload

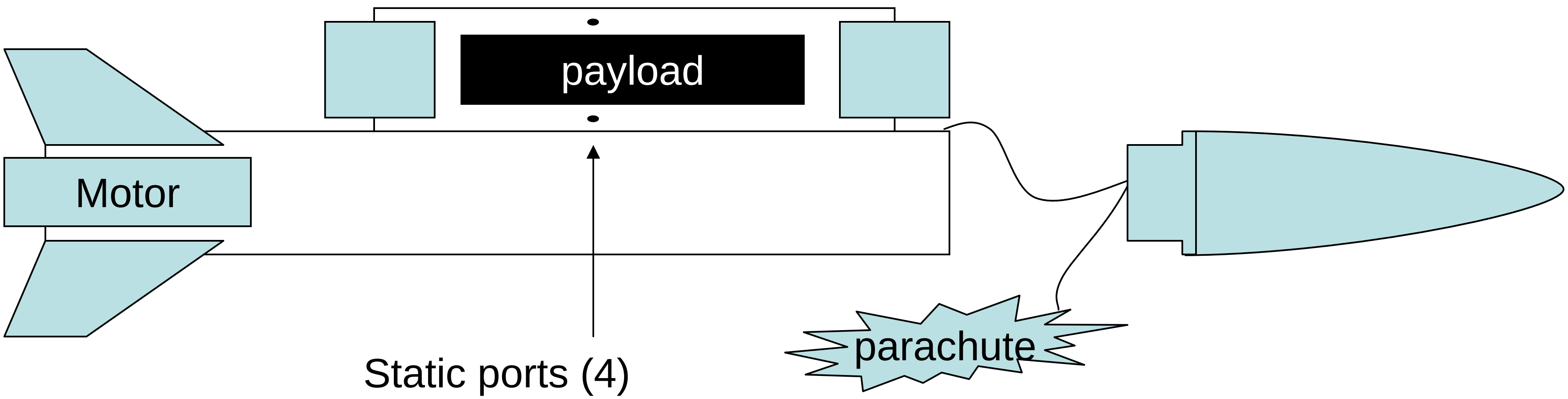
- Payload needs to be in a separate compartment to protect from parachute deployment charge
- Payload needs static ports on all four sides, at least 2 body diameters from any fins or other curves (such as nose cone)
- Static ports pin-prick size (very small), smooth to surface
- Need to able to load in less than 30 seconds

“Normal” Rocket



Integrating Payload: Examples





The Competition

- Competition winners (across all 3 sections of AE1350) will be chosen based on a single launch on launch day:
  - Winner for coming closest to required apogee altitude
  - Winner for coming closest to required total flight time
  - Winner for coming closest to required touchdown vertical speed

  Note:
    - A single rocket/team could win all three prizes
    - Rocket is disqualified if it does not land intact or lands outside designated landing area
    - Teams will be allowed to repeat a failed attempt only at the discretion of the instructor
    - Instructor can disqualify any rocket/team for safety issues or bad sportsmanship

Project Report

- Project grade will be based largely on the team's report
- This report should clearly describe the team's pre-flight predictions of aerodynamic drag, stability, propulsion, and trajectory performance
  - Exact requirements for report on web page
  - There will be a small penalty if the rocket fails to fly on launch day

Analysis

- Drag
  - Find suitable data for the drag coefficient of rocket bodies, fins, and parachutes then dimensionalize

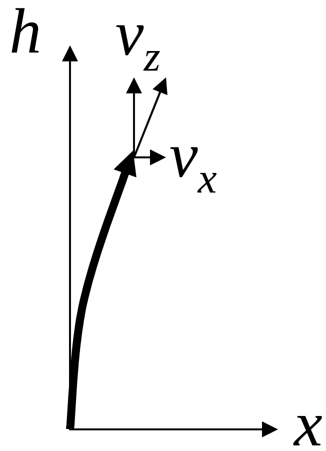
$$D = SC_D(t)\frac{1}{2}\rho V^2$$

- Propulsion
  - Data available on the total impulse and even thrust profile of these rocket motors

$$T = T(t)$$

Simulation

- Define four states:
  - horizontal position (x), altitude (h), horizontal velocity (v_x), vertical velocity (v_z)



- Assume all states start at zero

Simulation

- Determine time derivative of all states
  - While on a vertical launch rod (1st 2 ft altitude)

$$V = \sqrt{v_z^2 + (v_x - wind)^2}$$

$$D = SC_D(t)\frac{1}{2}\rho V^2, T = T(t)$$

$$\dot{v}_z = \tfrac{1}{m}(T - D) - g$$

$$\dot{v}_x = 0$$

$$\dot{h} = v_z$$

$$\dot{x} = v_x$$

  - After that

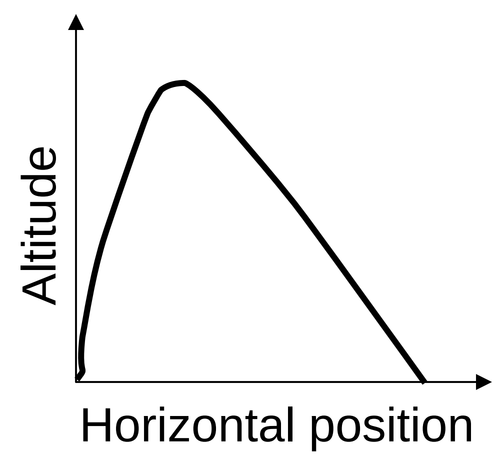
(assume stable rocket aligns thrust with velocity):

$$\dot{v}_z = \tfrac{1}{m}(T - D)\left(\tfrac{v_z}{V}\right) - g$$

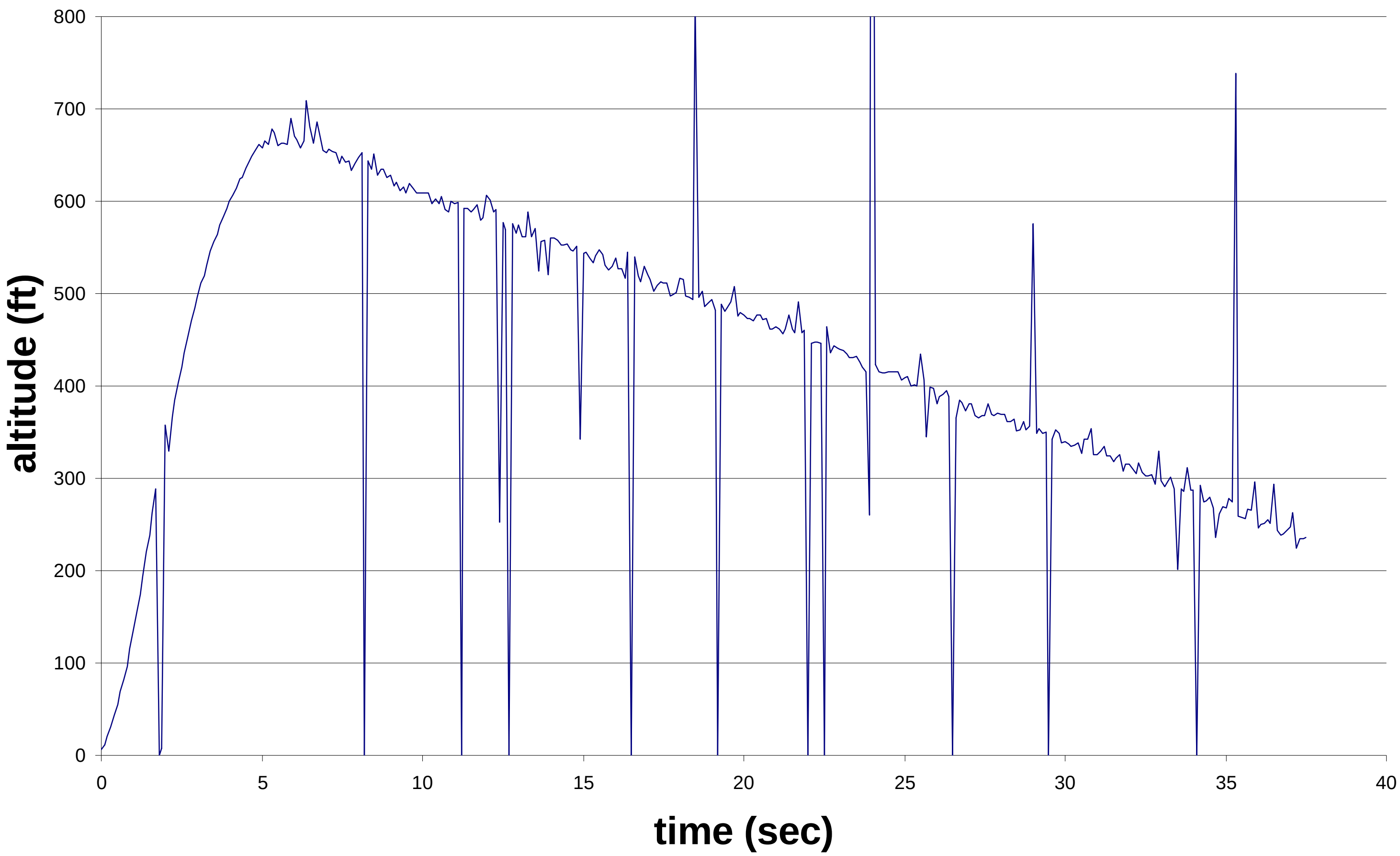
$$\dot{v}_x = \tfrac{1}{m}(T - D)\left(\tfrac{v_x - wind}{V}\right)$$

Simulation

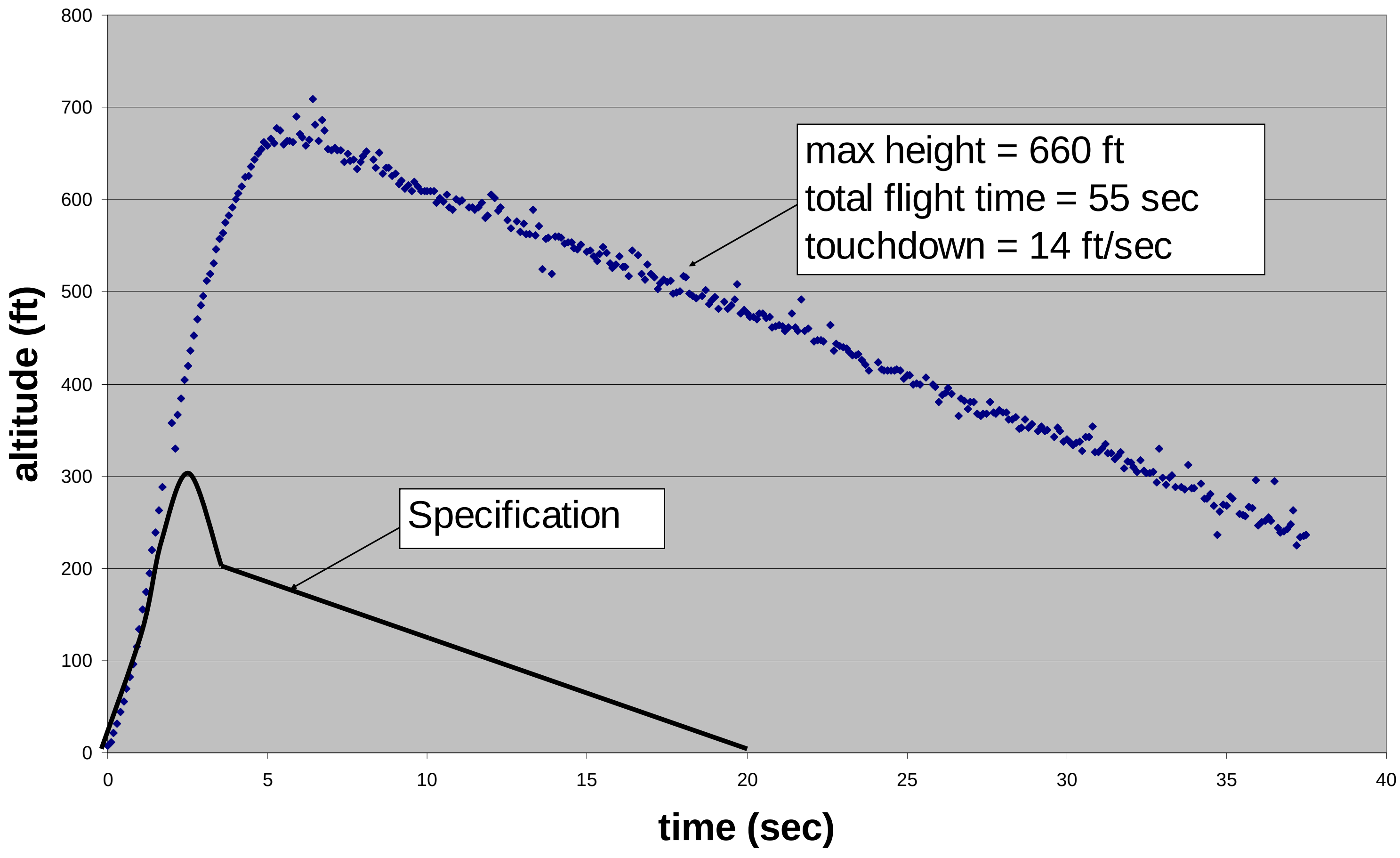
- You now have a set of equations to integrate through time to generate a time history of rocket flight
  - Compute derivatives of states
  - Predict how state changes over small time interval
    - Numerical integration scheme
    - Implement your own, or use something like Matlab ode45 command
  - Repeat until rocket lands (h<0)



Flight Test Data (Raw)



Flight Test Data



Dates

- Launch day November 24th (Monday)
- Report due from team beginning of class December 3 (section A), December 4 (B/C)

Suggestions

- Try to have someone on your team who has done model rockets before
- Organize the team
  - Get started now
  - Chose a team leader
  - Design spiral, multiple variants, testing