

AE1350 Final Project and Rocket Competition

Fall 2008

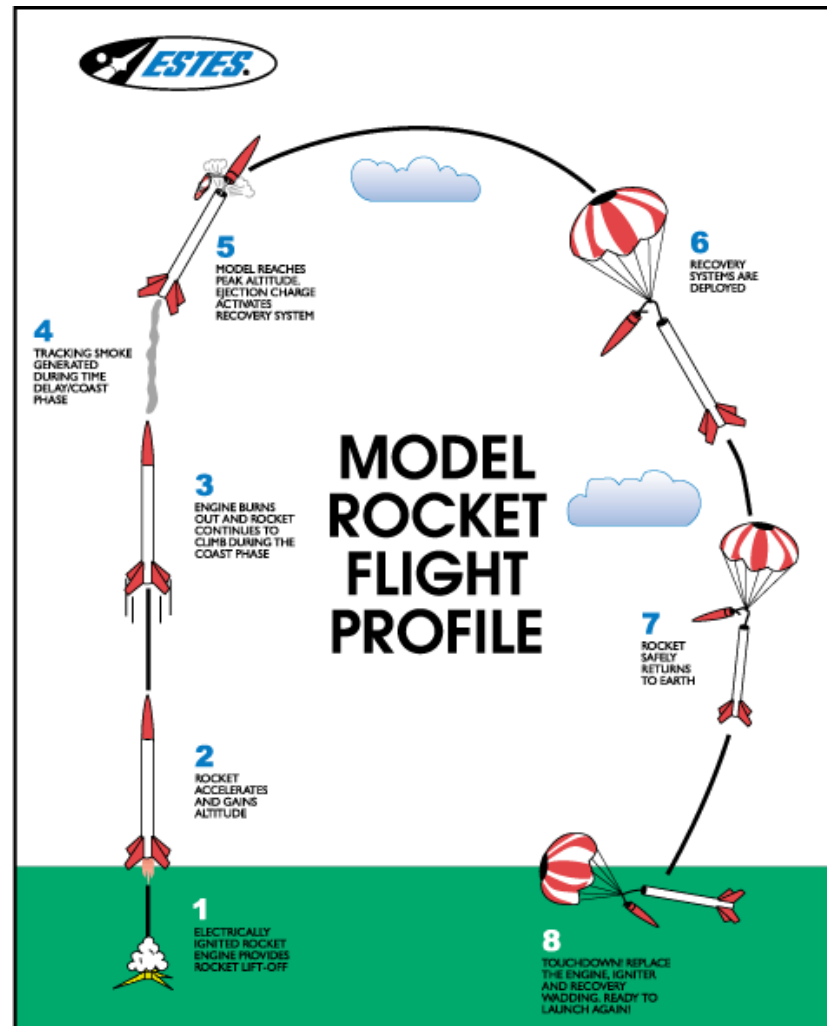
Goal

- 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

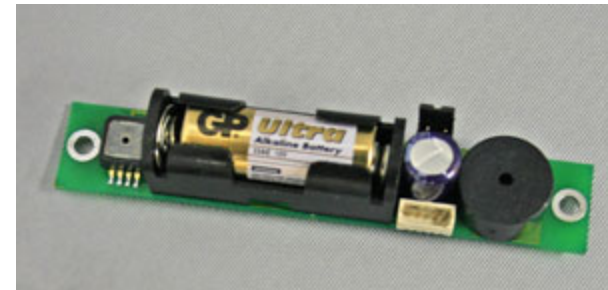


Mission Specification

- 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

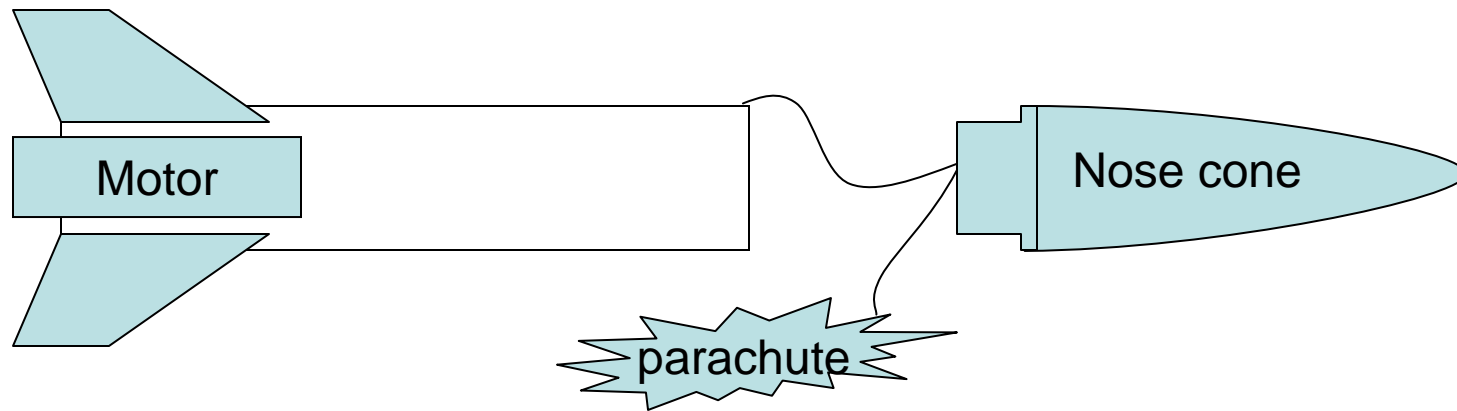
- PerfectFlite
Alt15K/WD Rev 2
 - 78.7mm x 13.9mm x 16.3mm
 - 15gram
 - Records altitude as a function of time (measures static pressure)
 - USB data transfer



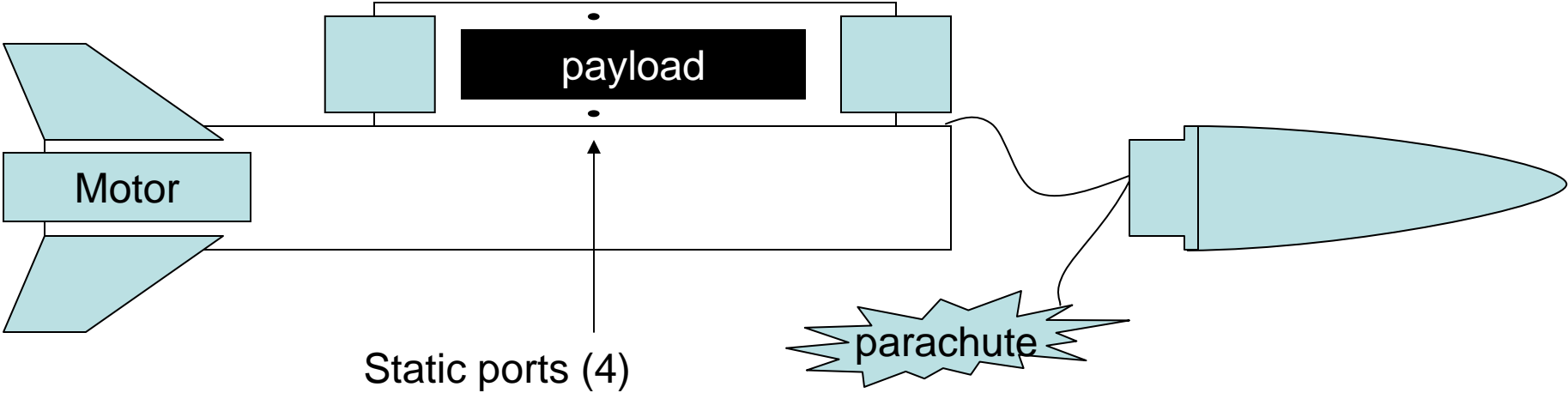
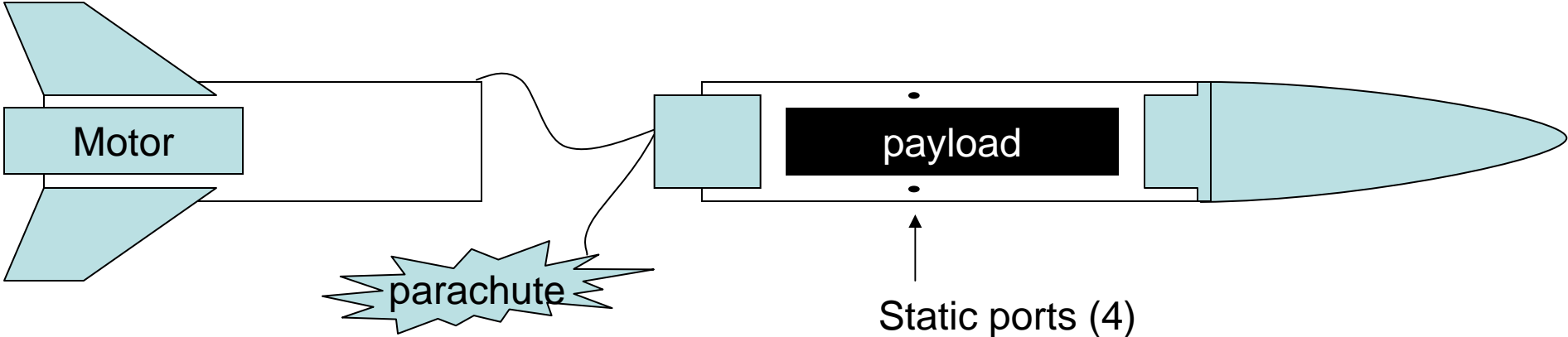
Integrating Payload

- 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 be 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

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

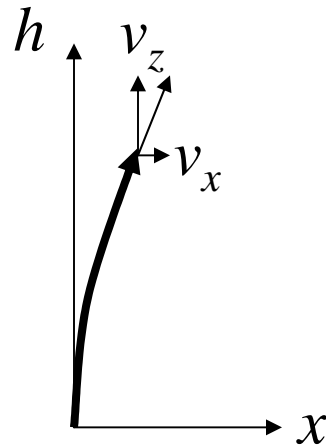
- Propulsion

- 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)

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

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


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

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

$$\dot{h} = v_z$$

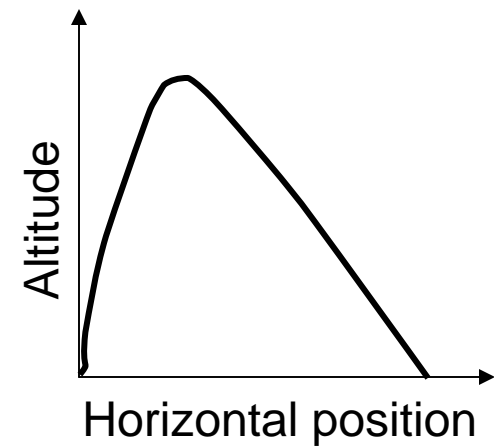
$$\dot{x} = v_x$$

– After that
(assume stable rocket
aligns thrust with velocity):

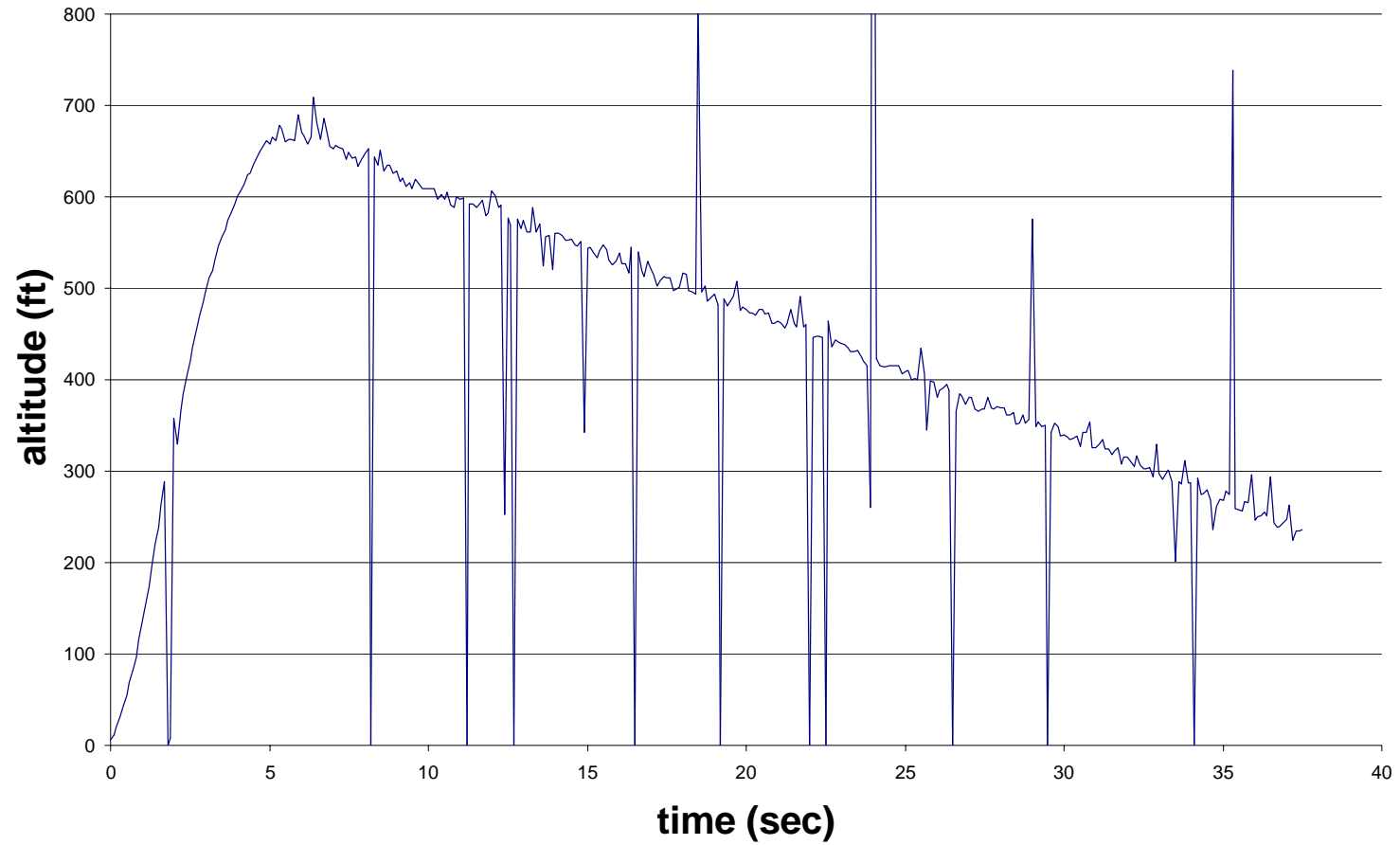

$$\dot{v}_z = \frac{1}{m} (T - D) \left(\frac{v_z}{V} \right) - g$$
$$\dot{v}_x = \frac{1}{m} (T - D) \left(\frac{v_x - \text{wind}}{V} \right)$$

Simulation

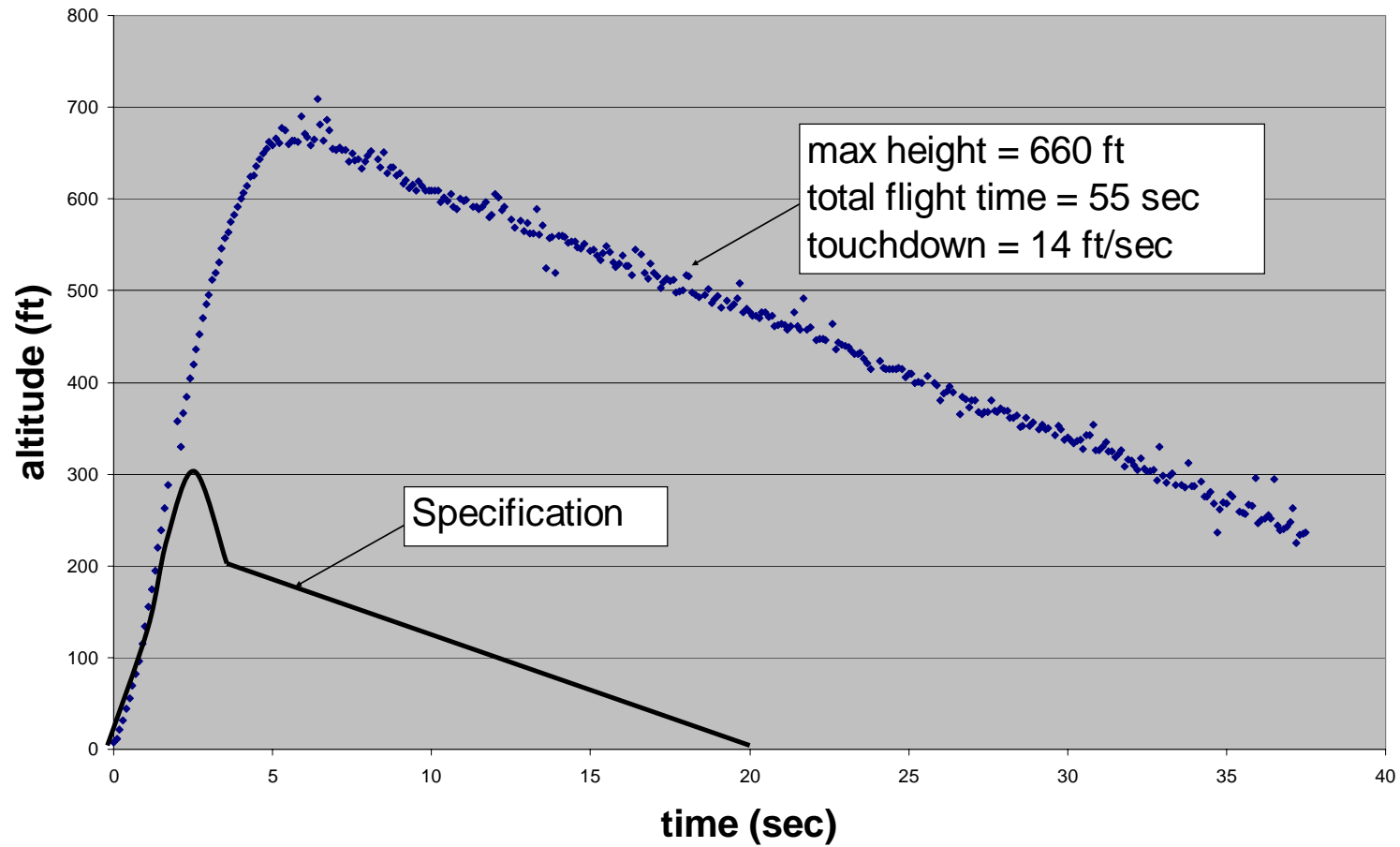
- You now have a set of equations to integrate through time to generate a time history of rocket flight
 - Compute derivatives of states
 - Predict how state changes over small time interval
 - Numerical integration scheme
 - Implement your own, or use something like Matlab ode45 command
 - Repeat until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



Flight Test Data (Raw)



Flight Test Data



Schedule

- Launch day November 24th (Monday)
- Report due from team at the beginning of class on December 3

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