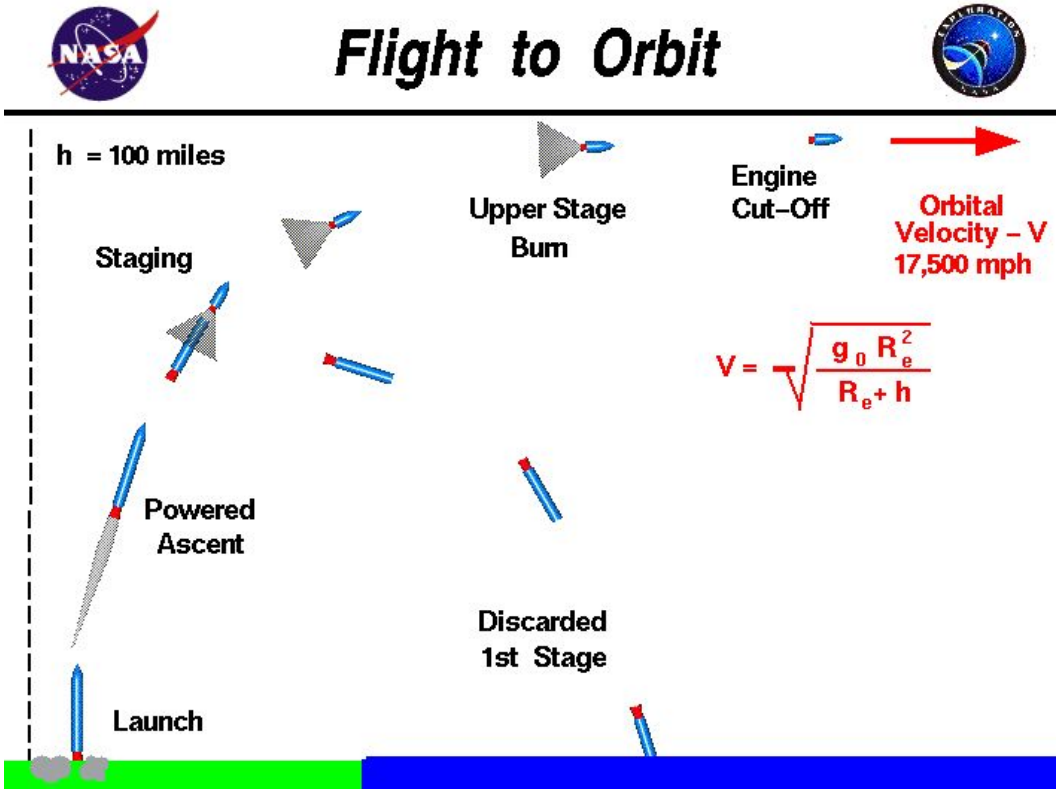

Rocket Trajectory Optimization

Overview


Flight to Orbit
h = 100 miles
Staging
Upper Stage
Burn
Engine
Cut–Off
Orbital
Velocity – V
17,500 mph
$V = \sqrt{\frac{g_0 R_e^2}{R_e + h}}$
Powered
Ascent
Discarded
1st Stage
Launch

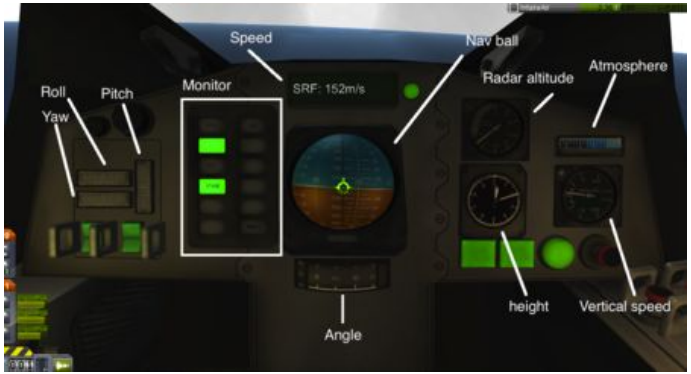
Control System

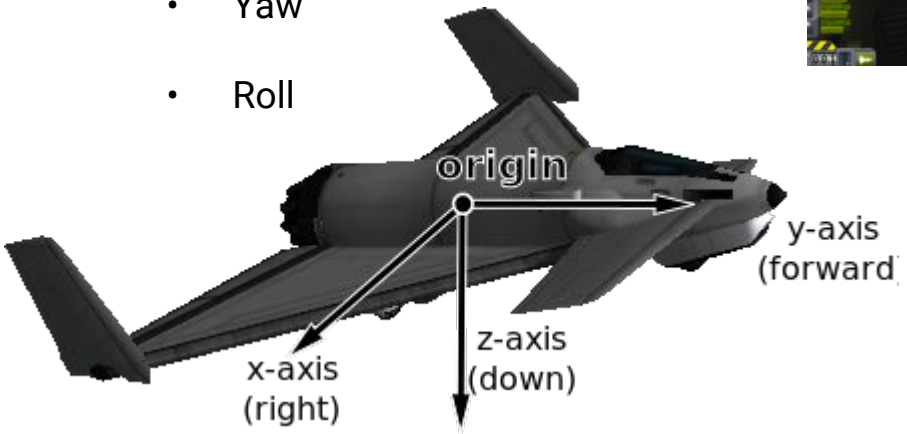
Inputs

- Speed
- Pitch
- Heading
- Roll
- Altitude

Outputs

- Throttle
- Pitch
- Yaw
- Roll



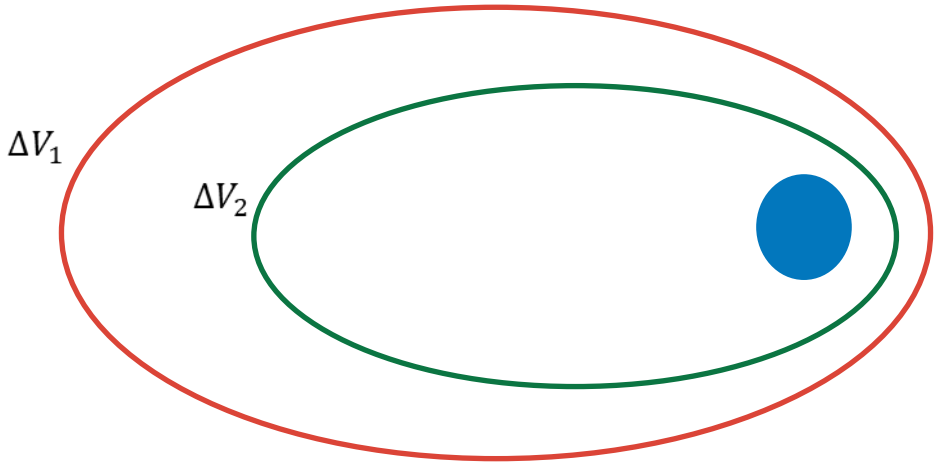


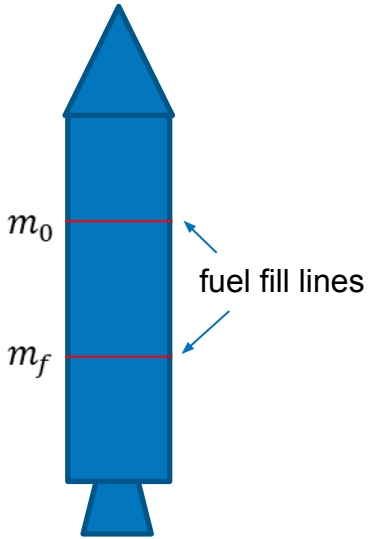
Neural Net

- Neural network to control the flight of a rocket
- Evolved using genetic algorithms
- Implements NEAT
  - Fast identification of global minimas (especially useful here)
  - Rewards innovation
  - Keeps balance between innovation, complexity and elitism.

Proposed Fitness Function - Orbital Flight

$$\Delta V = v_e \ln(\frac{m_0}{m_f})$$





Fitness function rewards individuals that efficiently reach an orbit:
if $\Delta V_{orbit} - \Delta Vre$ is small, than an individual has higher fitness

Proposed Fitness Function - Problems

Calculating the ΔV for a given orbital trajectory is difficult.

It requires knowing the optimal path to reach that orbit (the problem we are trying to solve).

Alternative Fitness Function - Orbital Flight

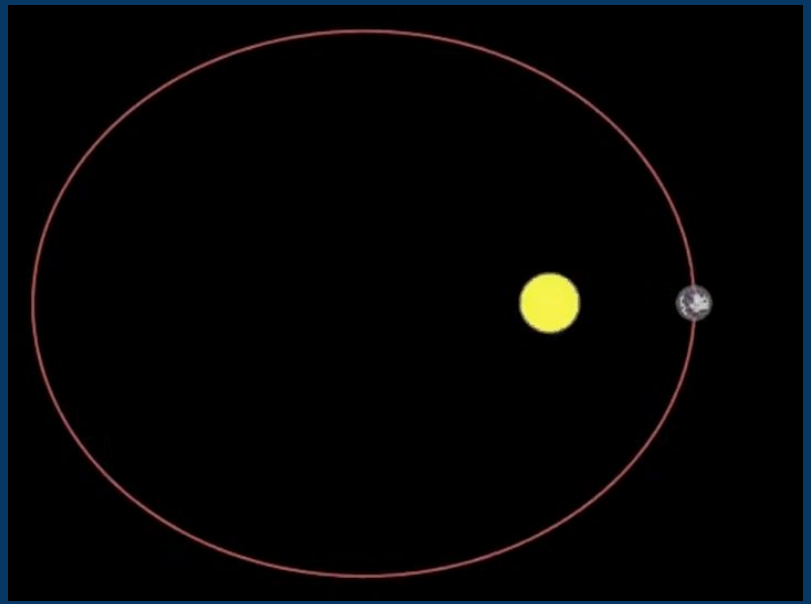
Orbital Energy

Calculate the energy of the final orbit reached:

GPE + **KE** = Orbital Energy

Conservation of Energy

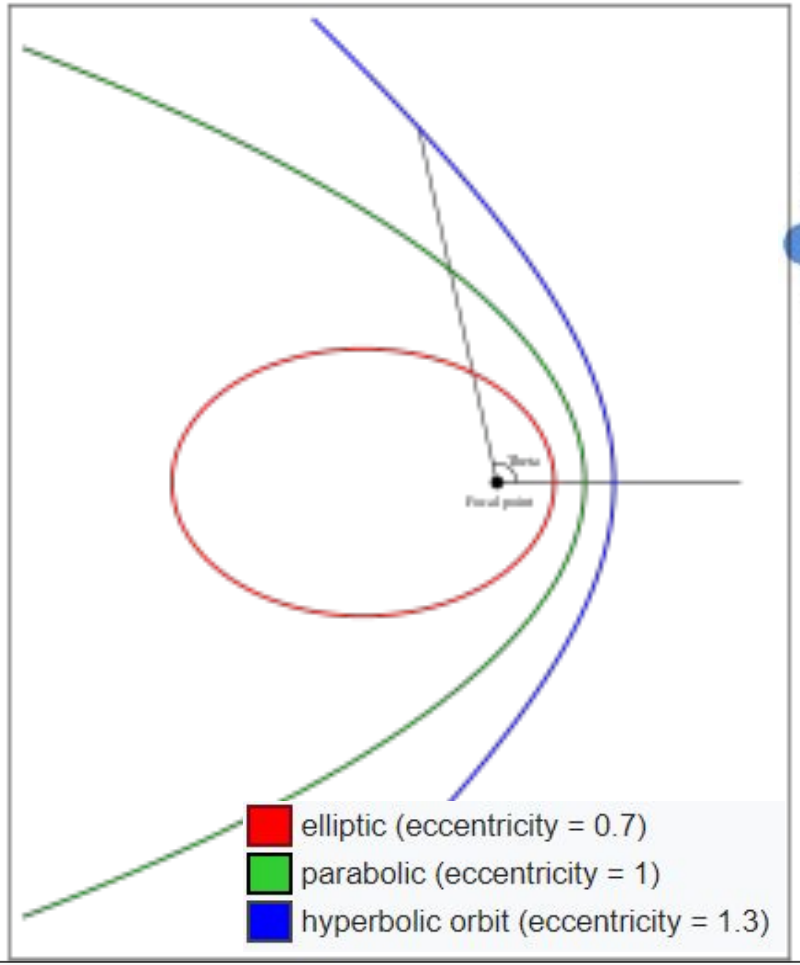
Kepler’s second law of planetary motion

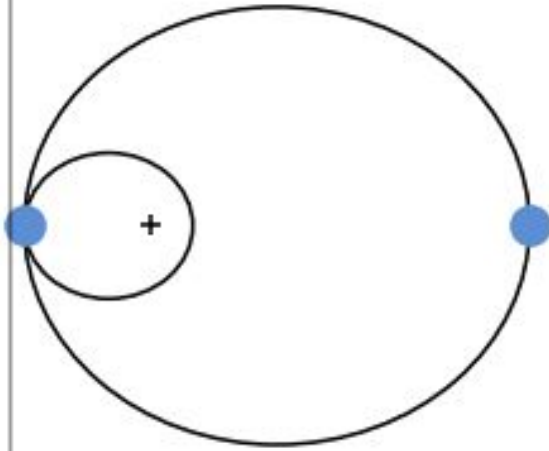


Fitness Function - Suborbital Flight

First considered:
maximum altitude reached

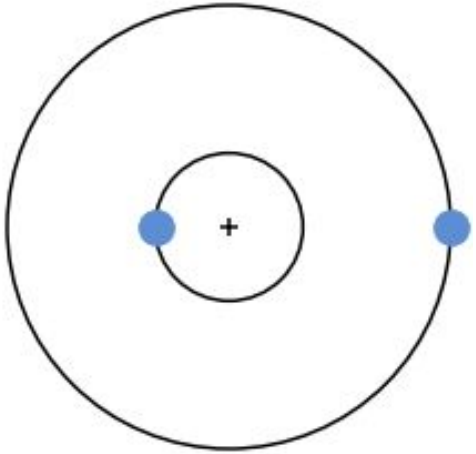
Problem:
escape velocity and vertical flight





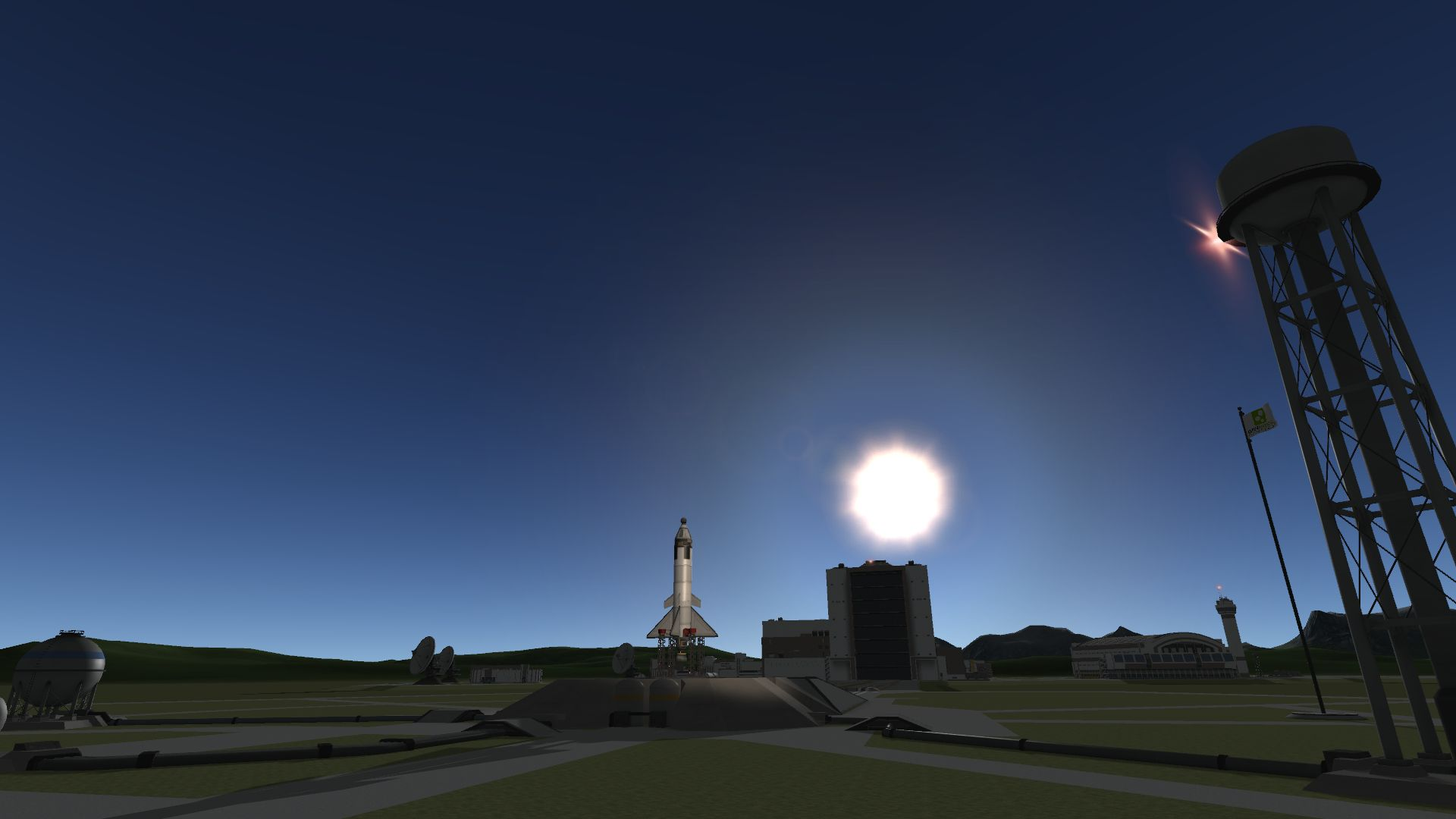
High $e \rightarrow$ low fitness

Low $e \rightarrow$ high fitness



Orbital Eccentricity

Platform: Kerbal Space Program



Results

https://www.youtube.com/watch?v=R7UNbXu4Irs


T+ 0y, 0d, 00:02:11
MET
Pe
Ap
Orbit
2706.6m/s
127°