Global vs. local optimization of system setup using a partial system simulator

Math 164: Thomas W. Barr

Make car go fast.

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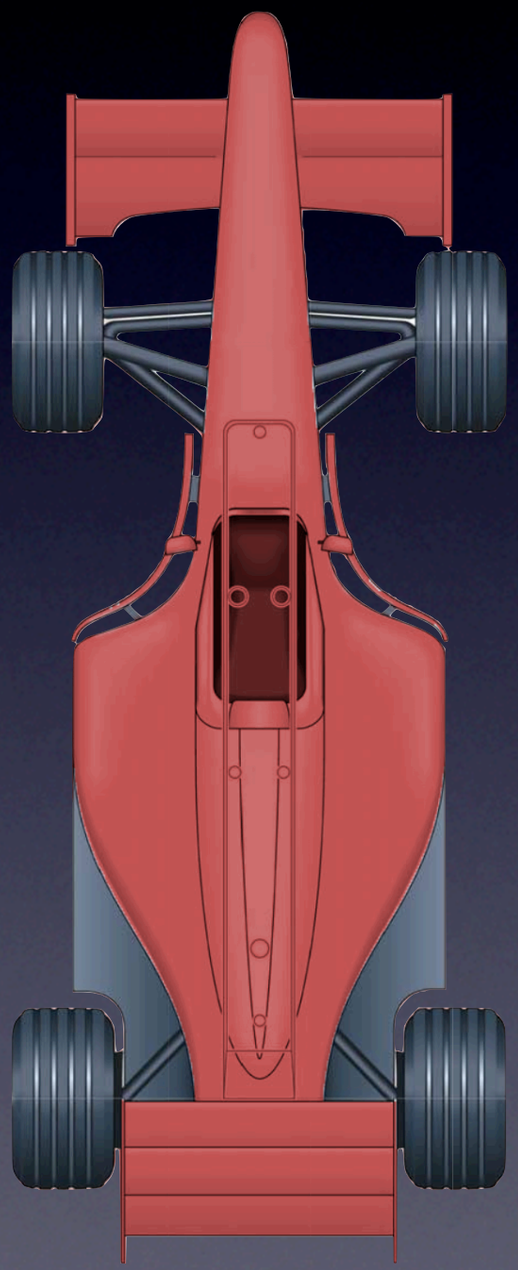
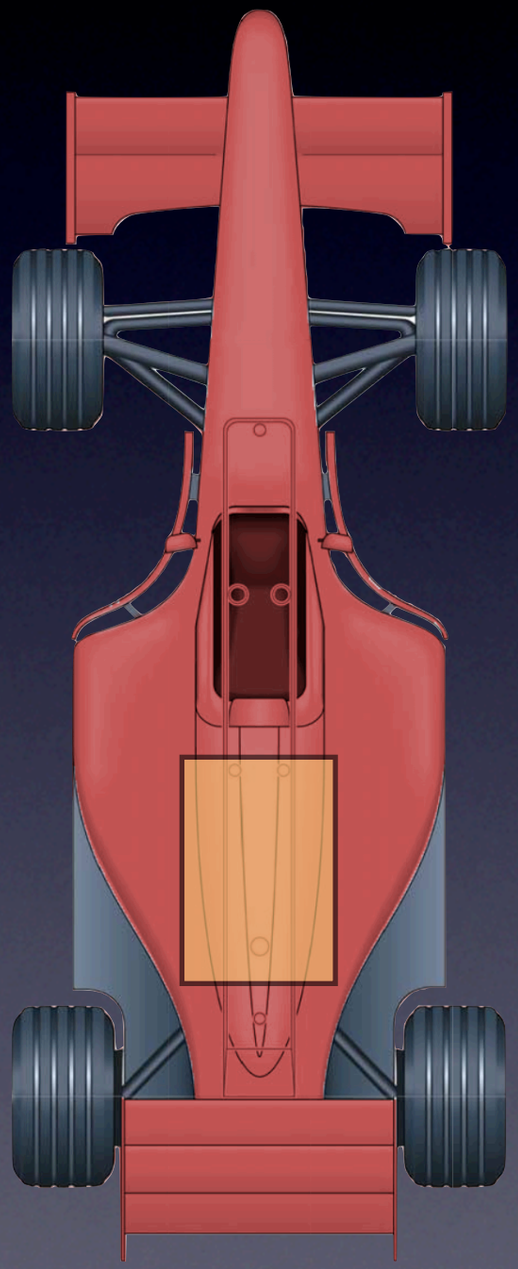
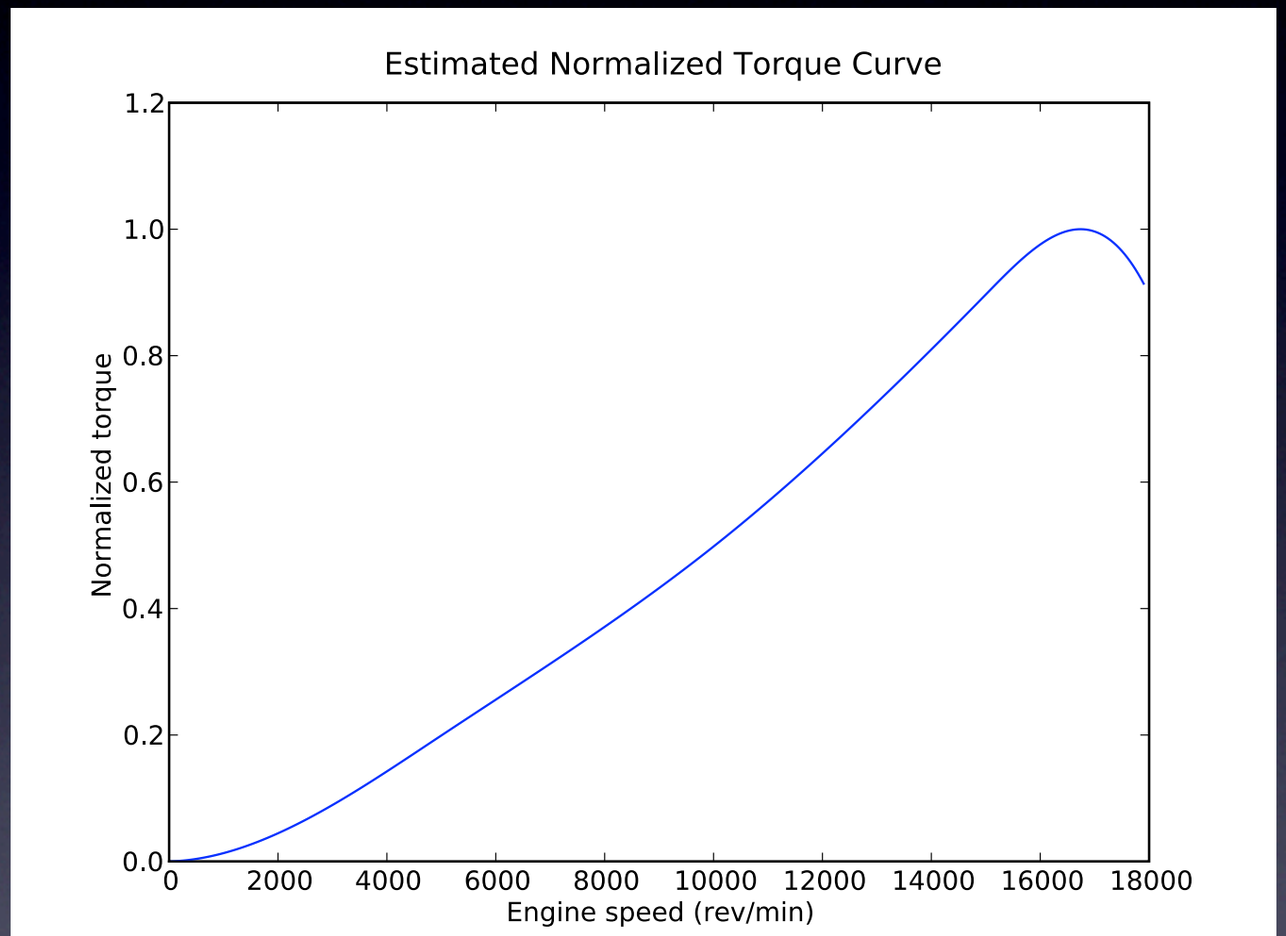
Formula One



- 605 kg
- 4g turn
- $500 mil/yr

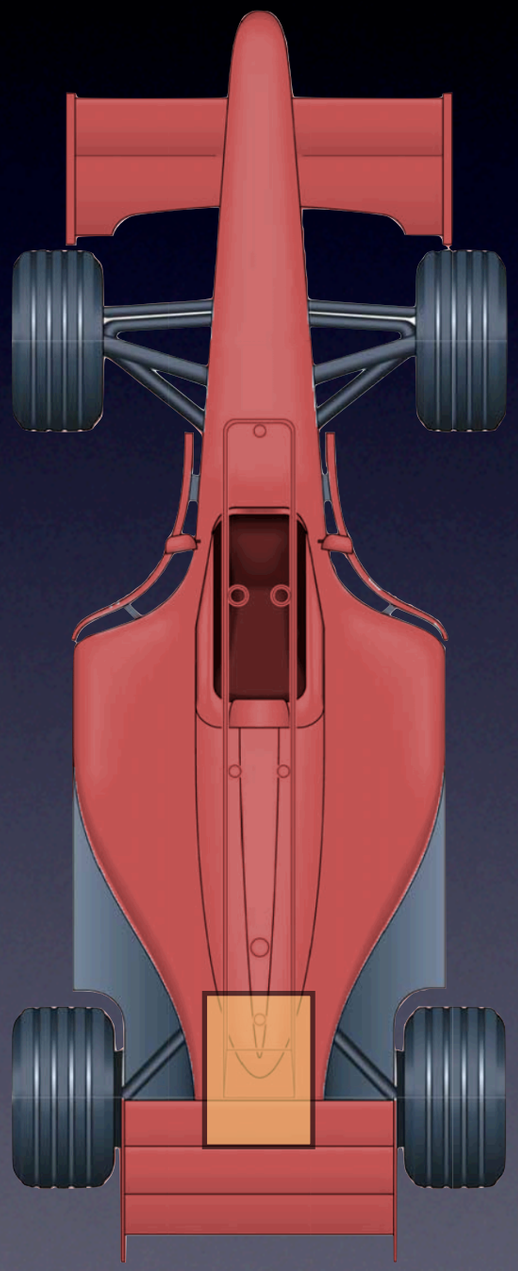
Engine





force(rpm) = k torque(rpm)

Transmission



Gear	Ratio
1	0.001
2	0.002
3	0.003
4	0.004
5	0.005
6	0.006
7	0.007

rpm(v) = v / ratio[n]

Acceleration equation

force(rpm) = k * torque(rpm)

Acceleration equation

force(v) = k’ * torque(v / ratio[n])

Acceleration equation

force(v) = (k / ratio[n]) * torque(v / ratio[n])

Overall DE

$$x'' = ((k / ratio(x')) * torque(x' / ratio(x')) - d(x')) / m$$

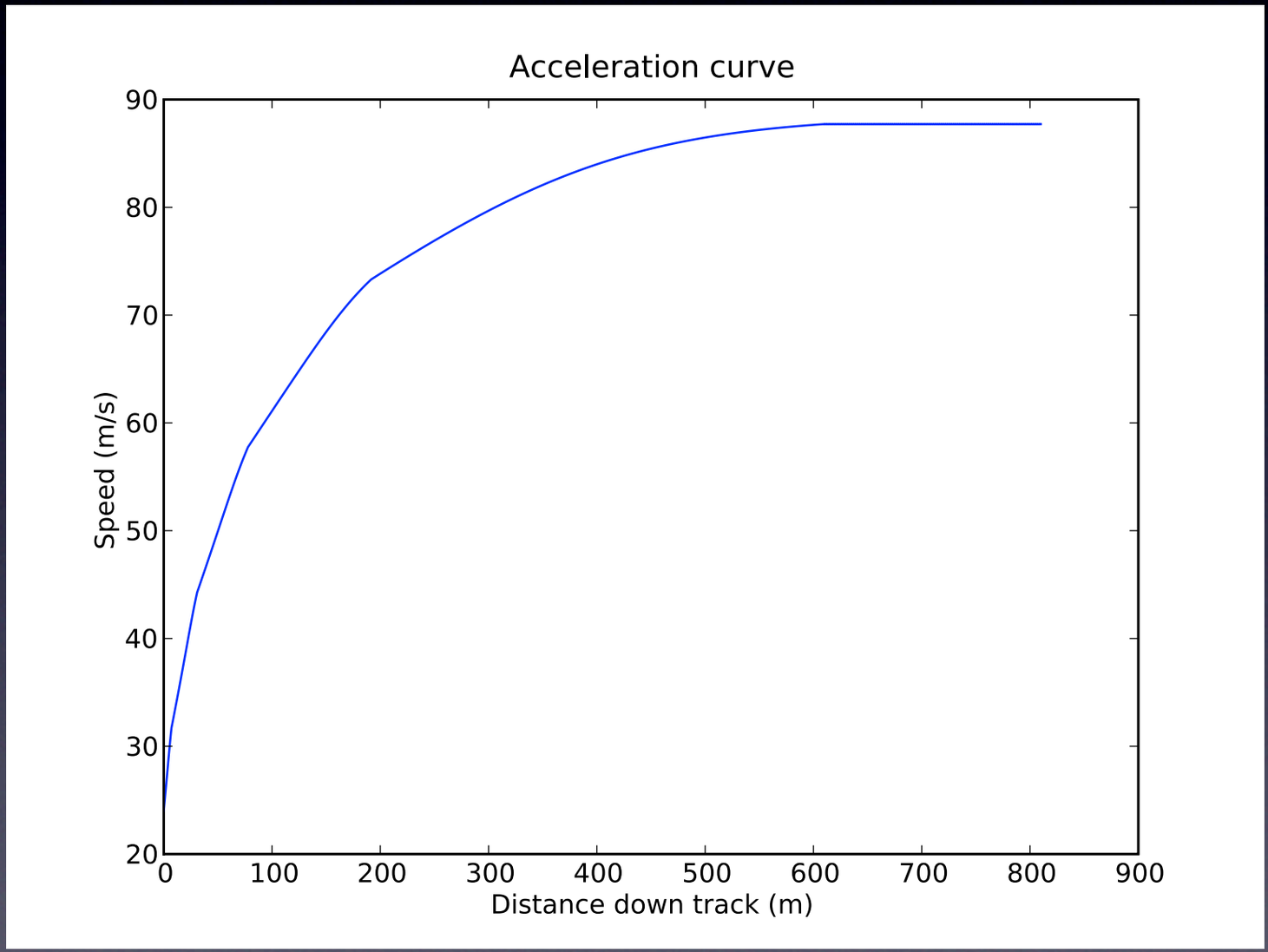
Simplifying assumptions

- Shifts take zero time
  - Calculate gear on every time step
- Drivers are perfect on straights
  - Ideal brake point taken

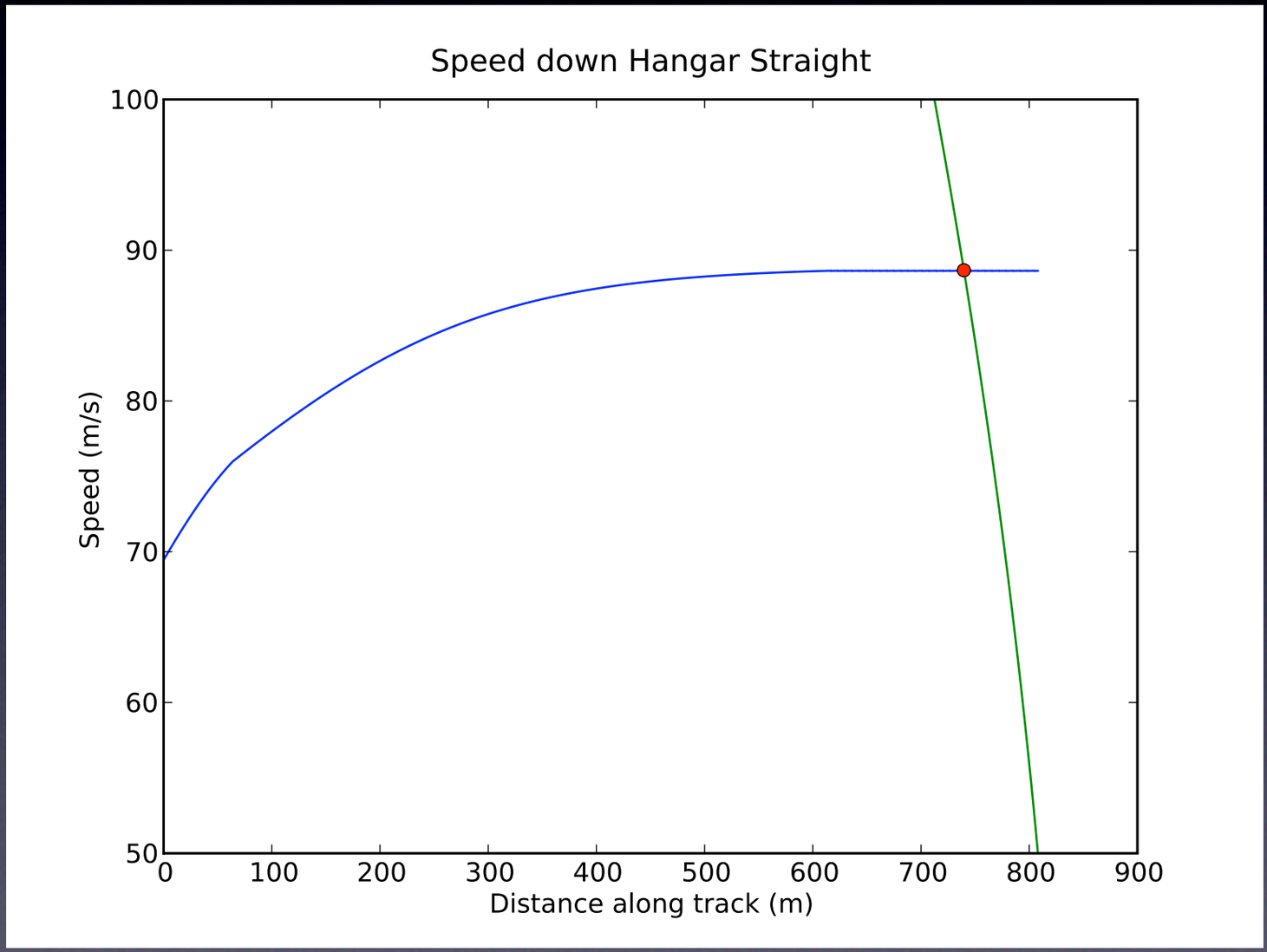
Datasets

- Synthesize
  - Torque curve
  - Drag curve
  - Braking curve
- Interpolate
  - Spline, linear between points

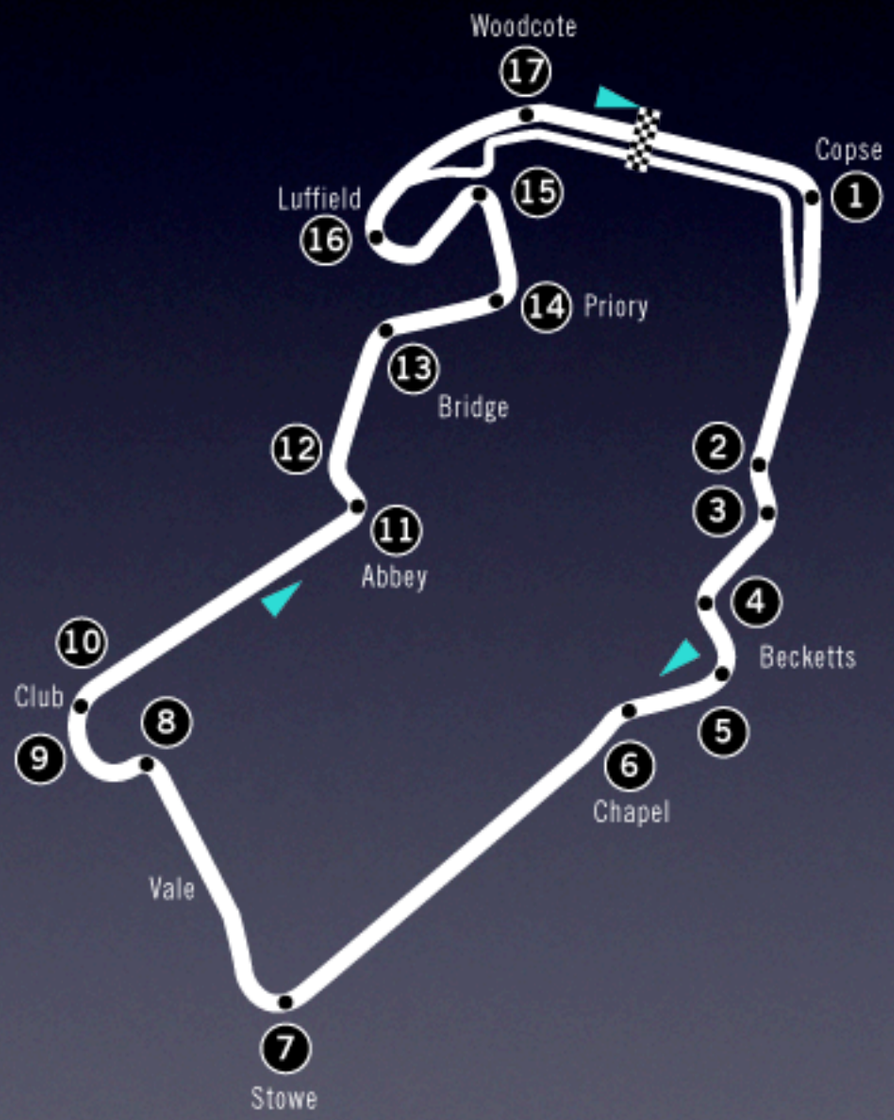
Acceleration run



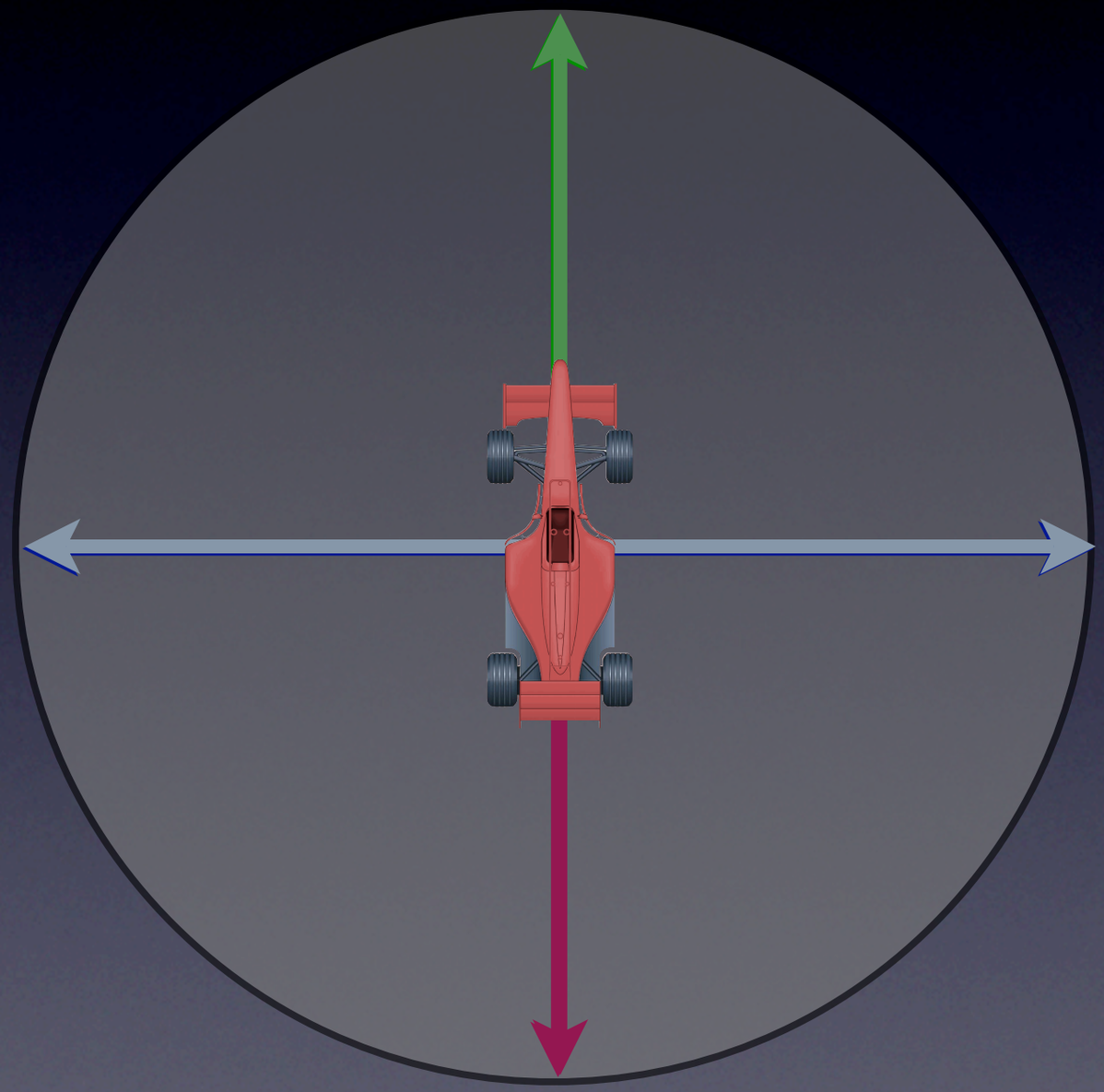
Acceleration run



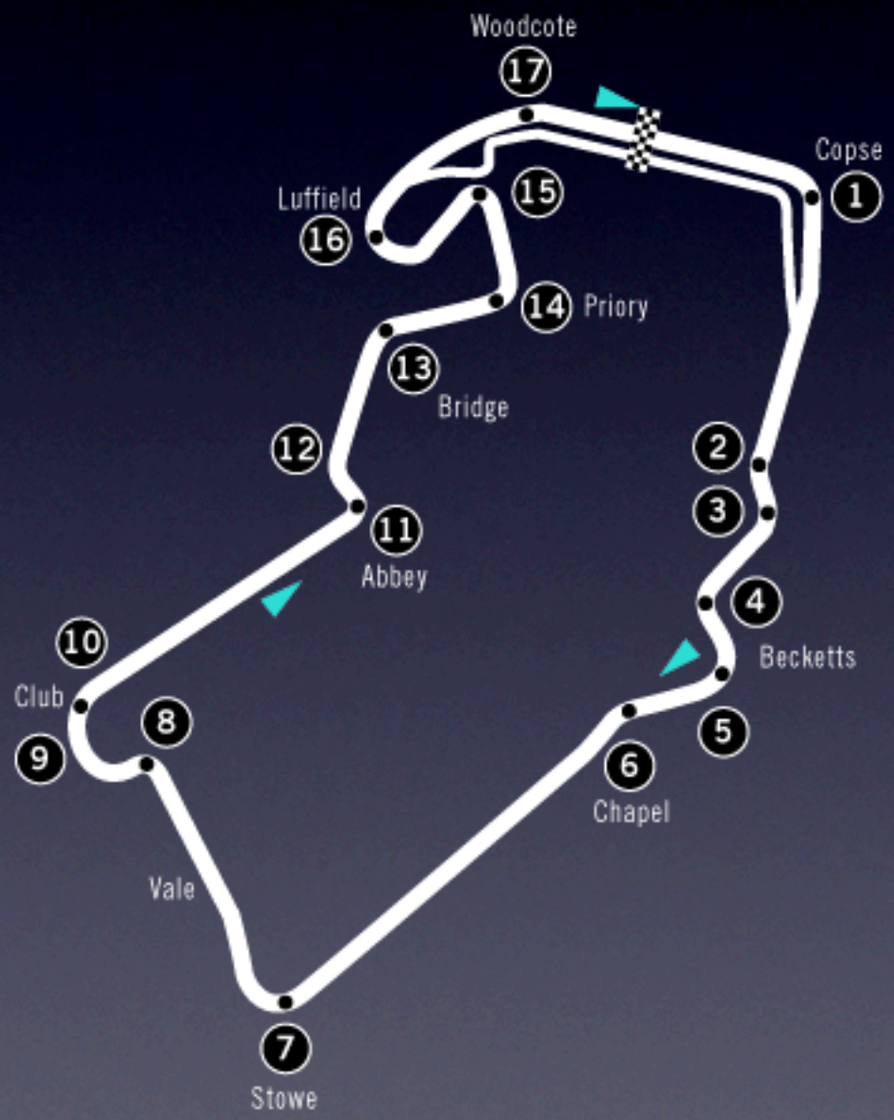
Global optimization



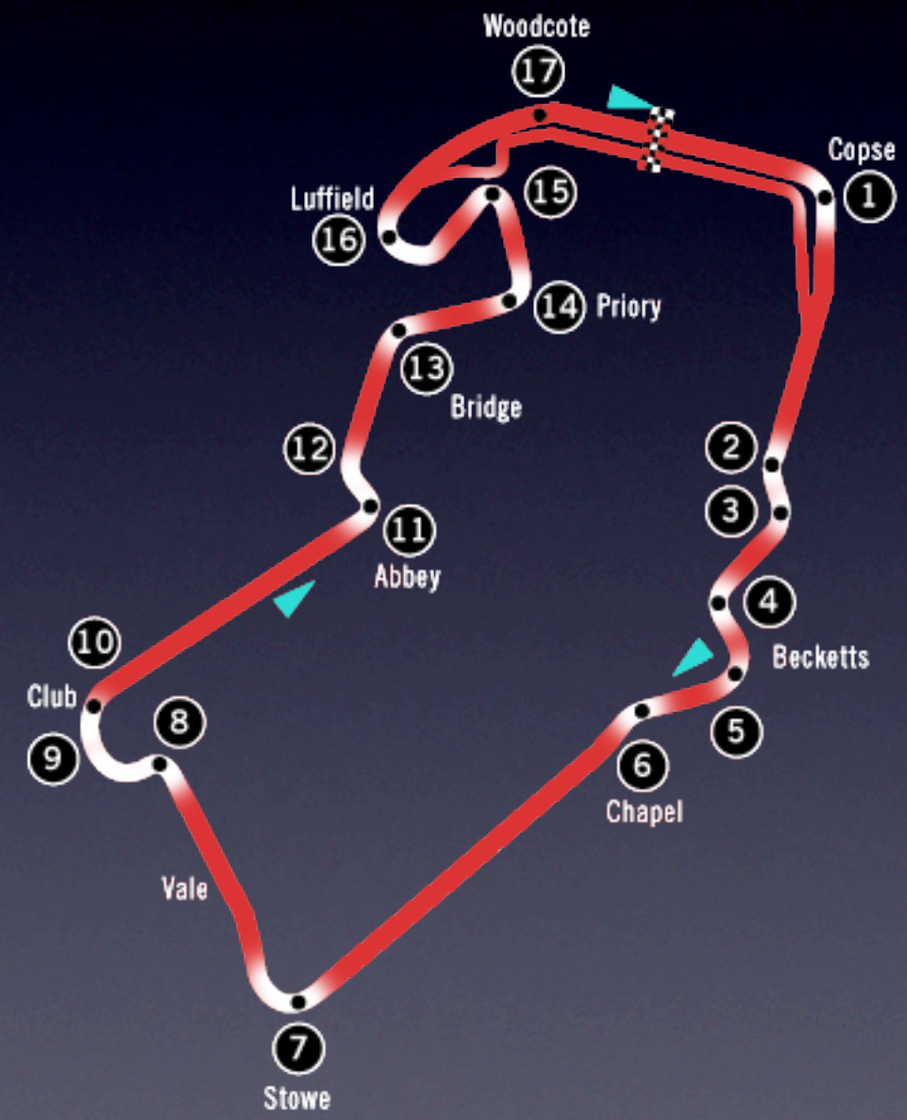
Turning circle



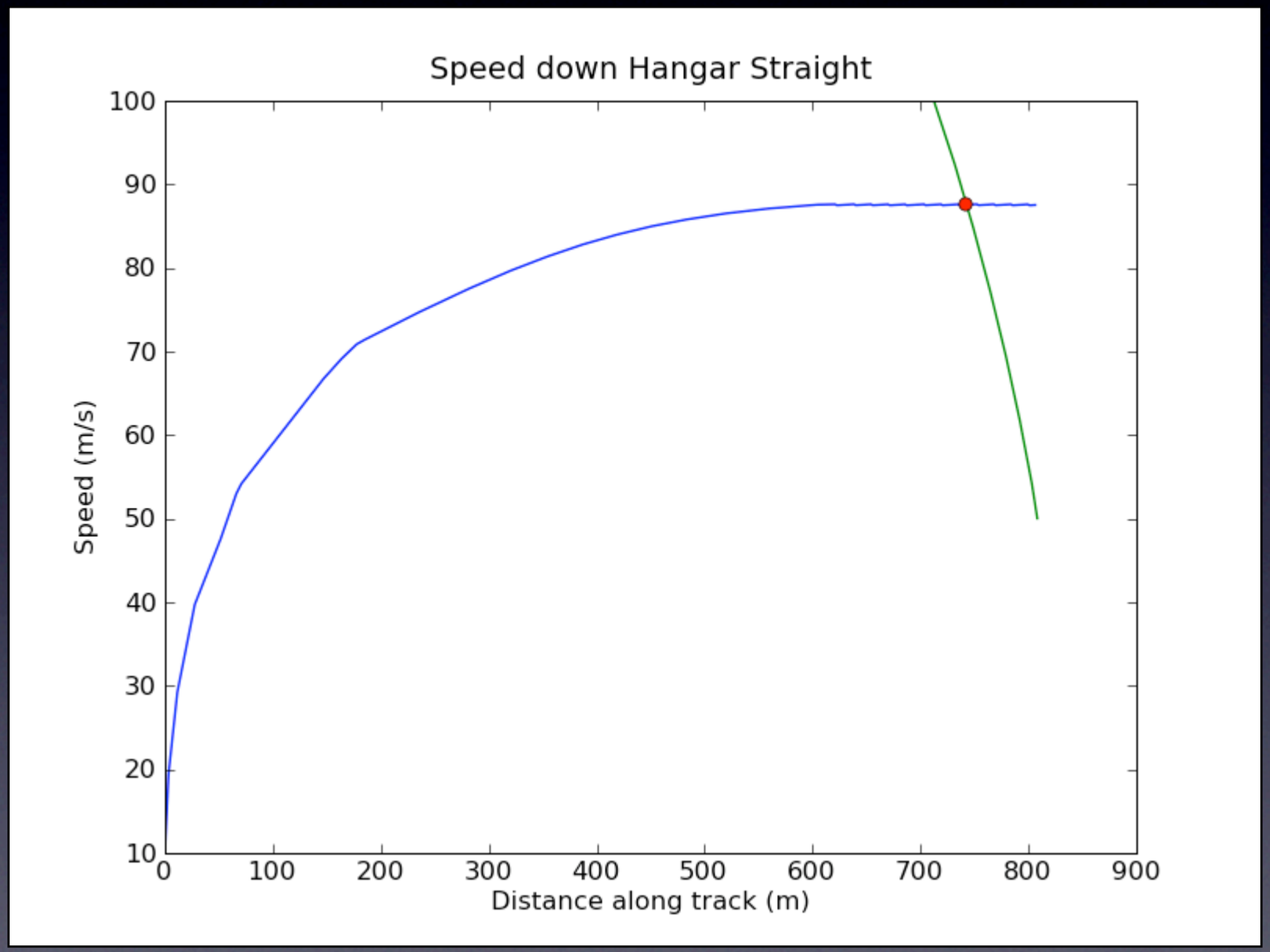
Global optimization



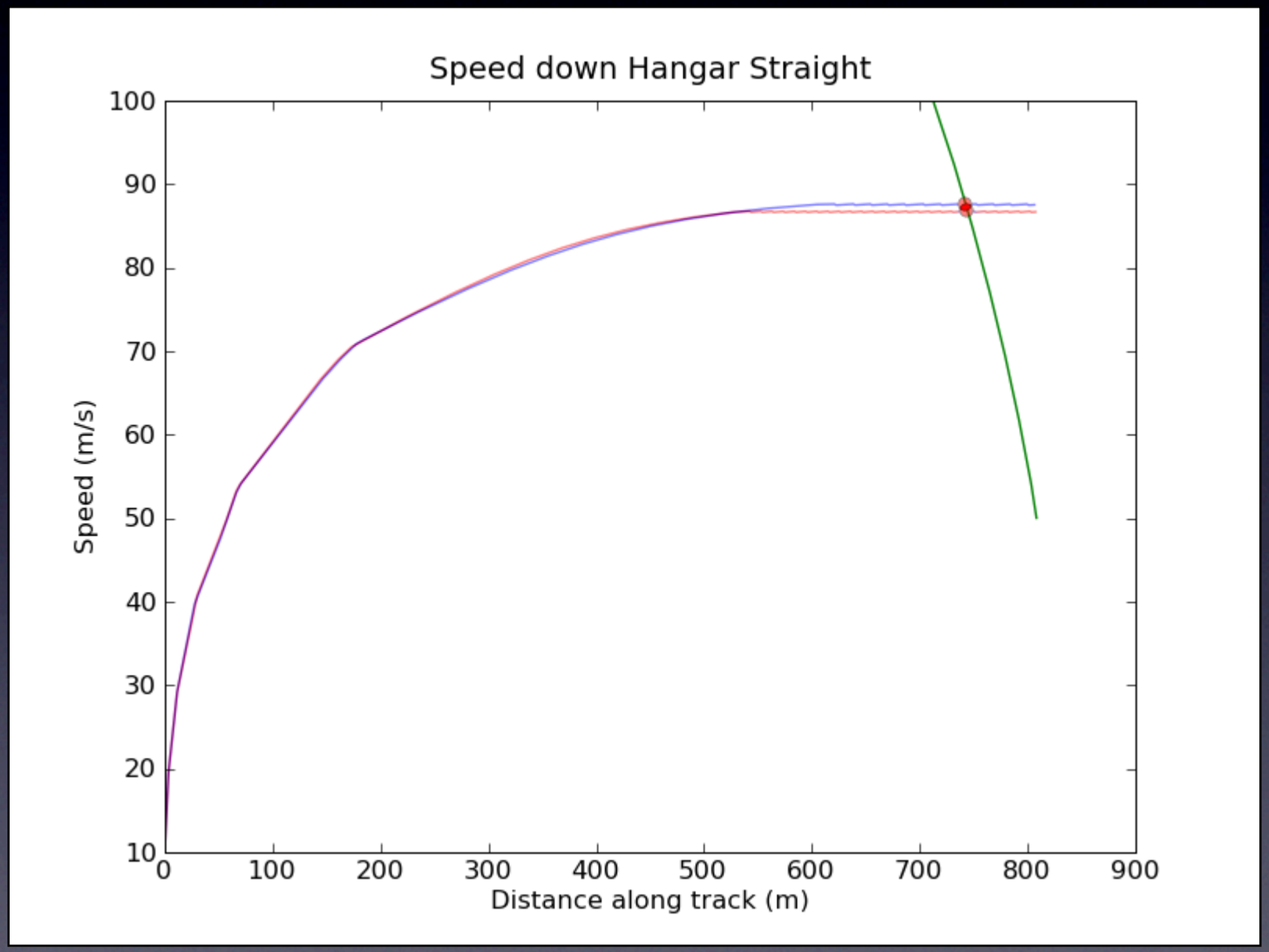
Partially global optimization



Results

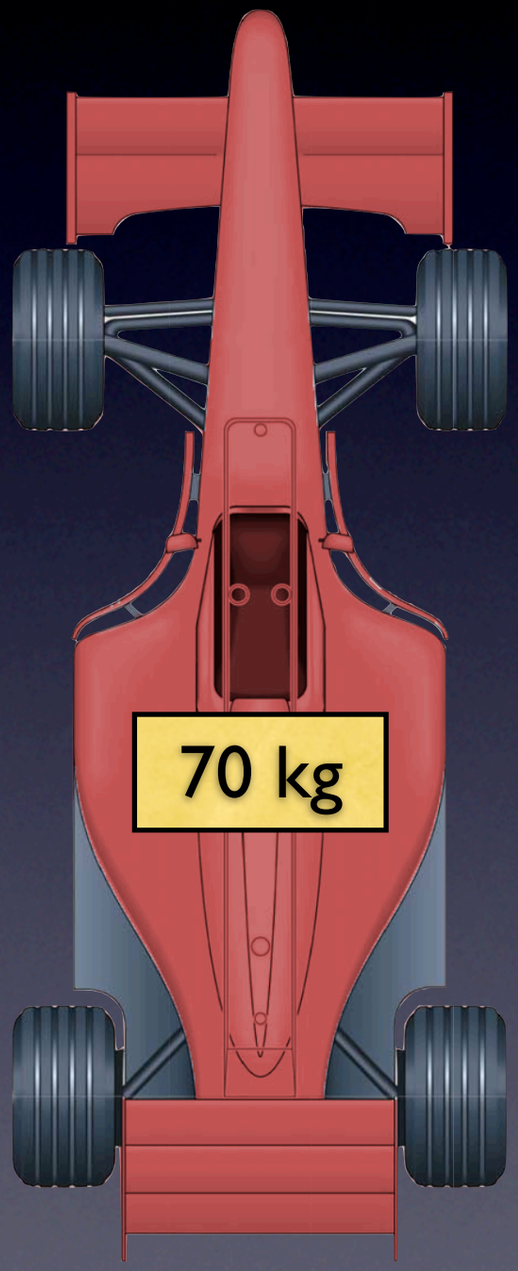

Speed down Hangar Straight
Speed (m/s)
Distance along track (m)
100
90
80
70
60
50
40
30
20
10
0
100
200
300
400
500
600
700
800
900

Results



Improvement: 0.240

Fuel Optimization



Optimization Target	Time
Light	56.949
Heavy	56.918
Combined	56.916

Conclusions

- Whole track optimization worth 0.240
- Fuel load optimization worth 0.031
- Optimal setup independent of shift point
- Coupled systems demand coupled optimization