SAE Baja - Drivetrain

Engineering Analysis

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Overview

- Introduction
- Design Analyses
  - Manual Transmission
  - Sequential Transmission
- Decision Matrix
- Gantt Chart
- Conclusion

Introduction

- Analysis between manual versus sequential transmissions
- The customer requires a reverse, lightweight, and safe transmission
- Continued research and analysis to further the understanding of the designs
- Updated Gantt Chart

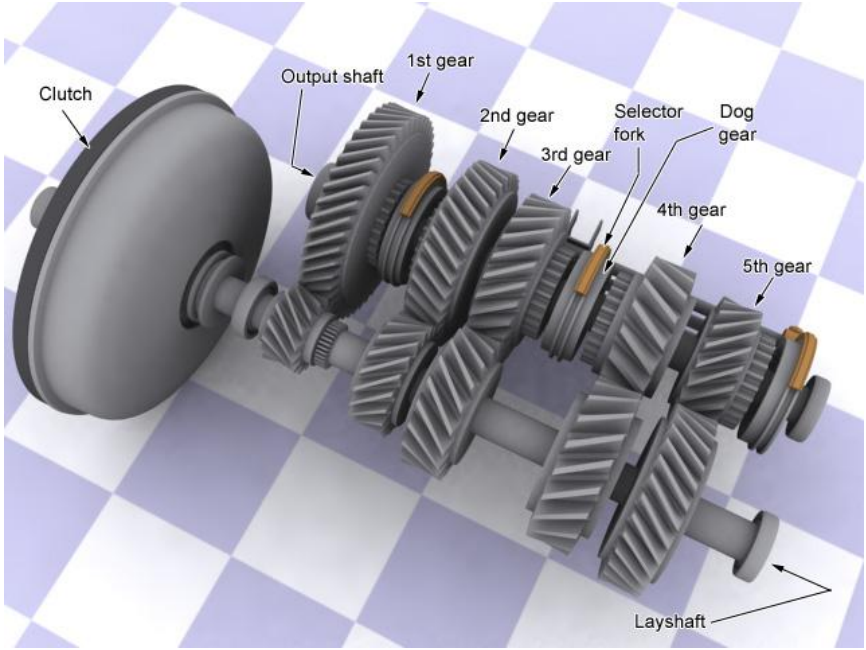
Manual Transmission

Pros:

- Reverse capable
- Reliable
- Cost effective

Cons:

- Long Shift Times



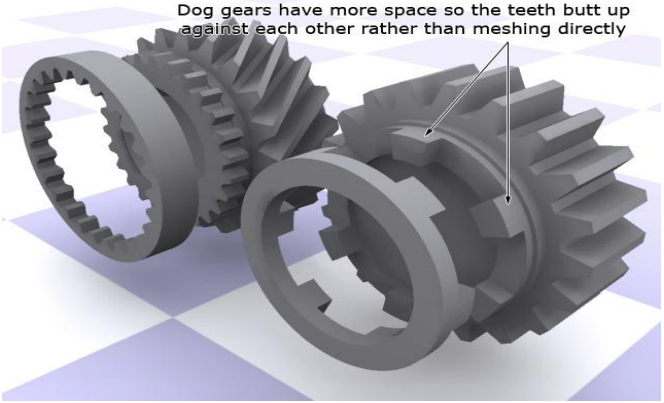
Sequential Transmission

Pros:

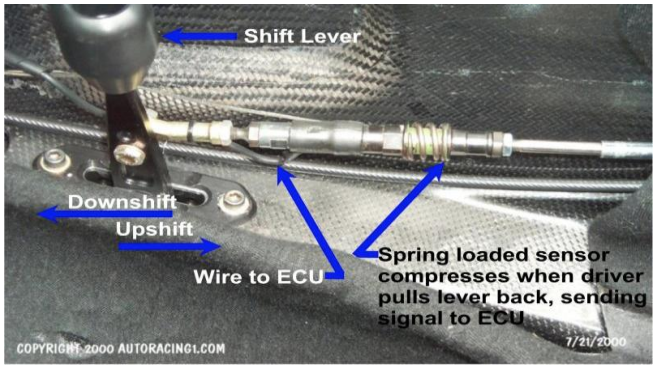
- Little loss of power
- **Short Shift Times**
- Lightweight/Compact
- Simple to operate
- Stronger and more reliable

Cons:

- Difficult to integrate reverse
- Possible increased cost



(Sequential Dog ring compared to Manual Dog ring)



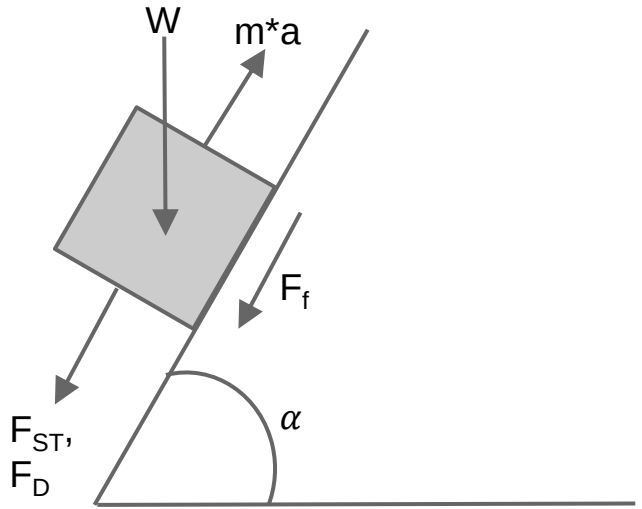
(Shift Lever for Sequential Gearbox)

Decision Matrix

Scale 1-5 5 = Best, 1 = Worst	Cost	Gear Ratio Range	Efficiency (Loss of Power)	Weight	Simplicity of Design	Reliability	Size/Volume	Reverse Gear Capable	Total
Sequential	3	5	5	4	3	4	4	3	3.95
Manual	3	5	4	3	4	4	3	4	3.85
Customer Weighting	15%	15%	20%	10%	5%	10%	5%	20%	

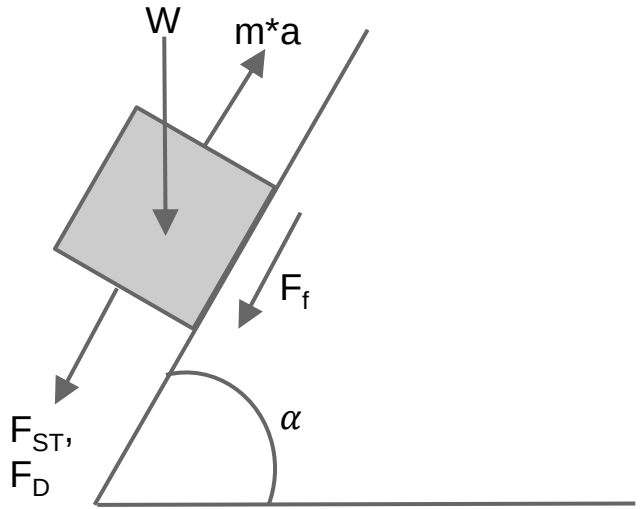
Final Design - Hill Climb

- Givens/Assumptions
  - W = 600 lb
  - $f_f = 0.16$
  - $c_D = 0.62$
  - P = 8.5 hp = 4675 lb*ft / s
  - $\alpha = 60°$
  - A = 9.98 ft^2
  - $\rho_{air} = 0.00228$ $slug/ft^3$
  - v_{wind} = 5 mph = 22/3 ft/s



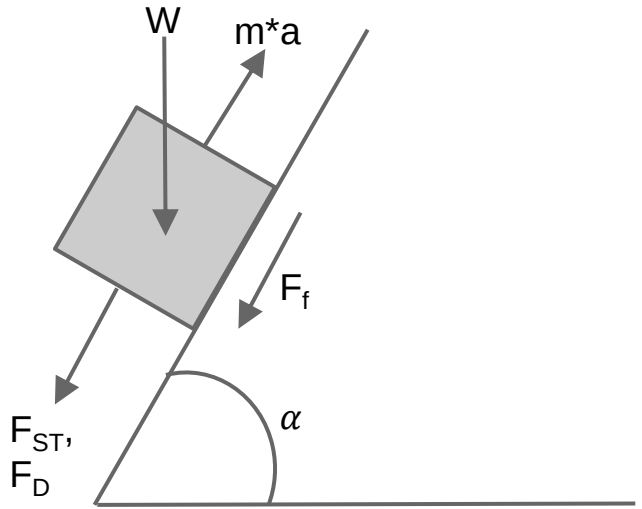
Final Design - Hill Climb

- Equations Used
  - $F_{ST} = W * \sin(\alpha)$
  - $F_D = f_f * W * \cos(\alpha)$
  - $F_f = 0.5 * \rho_{air} * c_D * A * (v_{wind})^2$
  - $F_{total} = F_{ST} + F_D + F_f$
  - $v_{vehicle} = P/F_{total}$



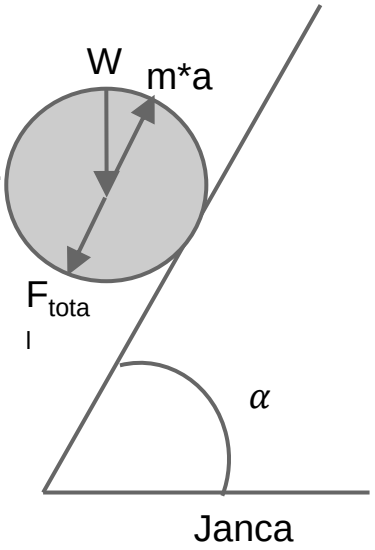
Final Design - Hill Climb

- Results
  - F_{ST} = 519.615 lb
  - F_D = 48 lb
  - F_f = 0.379 lb
  - F_{total} = 567.994
  - $v_{vehicle}$ = 5.616 mph = 8.236 ft/s



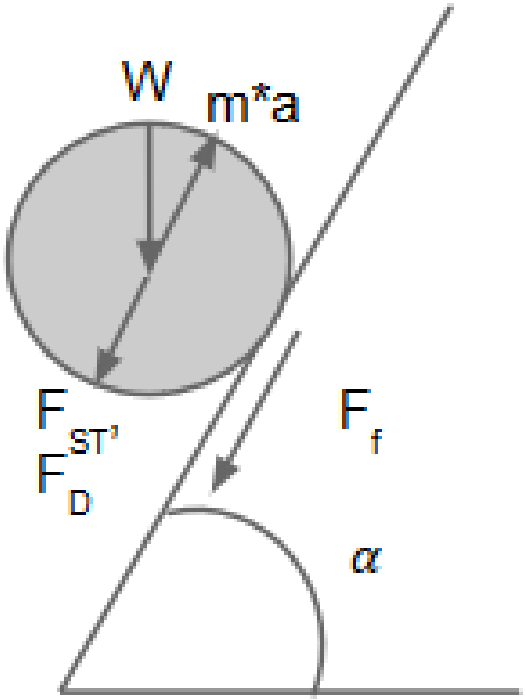
Final Design - Hill Climb

- First Gear Ratio Assumptions
  - Assume F_{total} = 600 lb (rounded F_{total} from previous slide)
  - Assume $v_{vehicle}$ = 6 mph (rounded from $v_{vehicle}$ from previous slide)
  - P = 8.5 hp, α = 60°
  - 22 in diameter tire, R = 11 in = 0.916 ft
  - N_{min} = 1800 rpm
  - N_{max} = 2800 rpm
  - Typical rock crawlers have ratios between 50:1 to 70:1



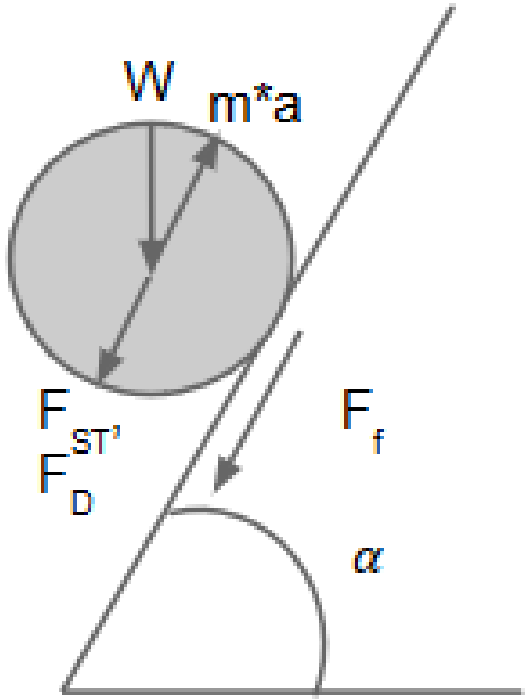
Final Design - Hill Climb

- First Gear Ratio Equations Used
  - $\omega = v_{vehicle}/R$
  - $\text{Gear Ratio}_{min} = N_{min}/\omega$
  - $\text{Gear Ratio}_{max} = N_{max}/\omega$
  - $T_{wheel} = R * F_{total}$



Final Design - Hill Climb

- First Gear Ratio Equations Used
  - ω = 91.67 rpm
  - Gear Ratio$_{min}$ @1800rpm = 19.63:1
  - Gear Ratio$_{max}$ @2800rpm = 30.54:1
  - **Gear Ratio$_{avg}$ = 24.1:1**
  - T_{wheel} = 550 lb*ft



Formulas - Acceleration

Distance = 100 ft

Time = 4 s

$x=v_0*x*t + 0.5*a*t^2$

$a=2*x/t^2$

$a=12.5\ ft/s^2$

$v=23\ mph$

$m=18.65\ lbm\ c\_a=9.92\ ft^2\ c\_w=0.62$

$F_{accel}=m*a = 233.1\ lbf$

$F_{Roll}=f\_r*m*g=8.4\ lbf\ \ f\_r=0.014$

$F_{air}=0.5*p\_l*c\_w*c\_a*v^2=8.3\ lbf$

$F_{Total\ H}=250\ lbf\ \ F_{Total\ L}=241\ lbf$

Final Design - Acceleration

High Ratio =(250lbf/2)*(11in/12in/ft)/13lbf*ft=8.8

Low Ratio =(241lbf/2)*(11in/12in/ft)/10lbf*ft=11.05

Weight = 130 lbs Total Time = 4.25 s

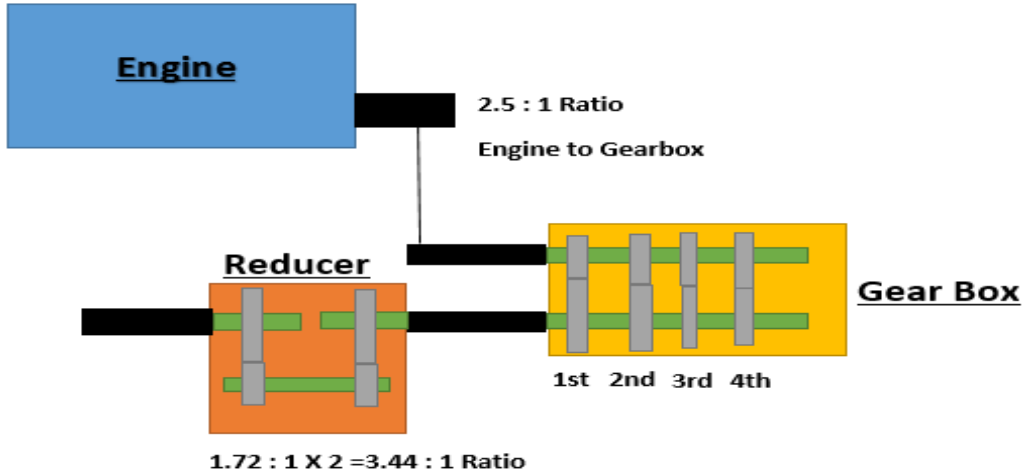
Overall Gear Ratios

Engine to Gearbox Ratio: 2.5:1

Gear Box Ratios

- 1st Gear: 2.4:1
- 2nd Gear: 1.25:1
- 3rd Gear: 1.033:1
- 4th Gear: 0.967:1

Reducer Ratio: 3.5:1



1st Gear: 2.5 x 2.4 x 3.44 = 24.16:1

2nd Gear: 2.5 x 1.25 x 3.44 = 10.75:1

3rd Gear: 2.5 x 1.033 x 3.44 = 8.88:1

4th Gear: 2.5 x 0.967 x 3.44 = 8.31

Number of Teeth Chosen

Engine to Gearbox **Pinion**:11 **Gear**: 28

Gearbox

1st Gear- **Pinion**: 16 **Gear**: 45

2nd Gear- **Pinion**: 27 **Gear**: 34

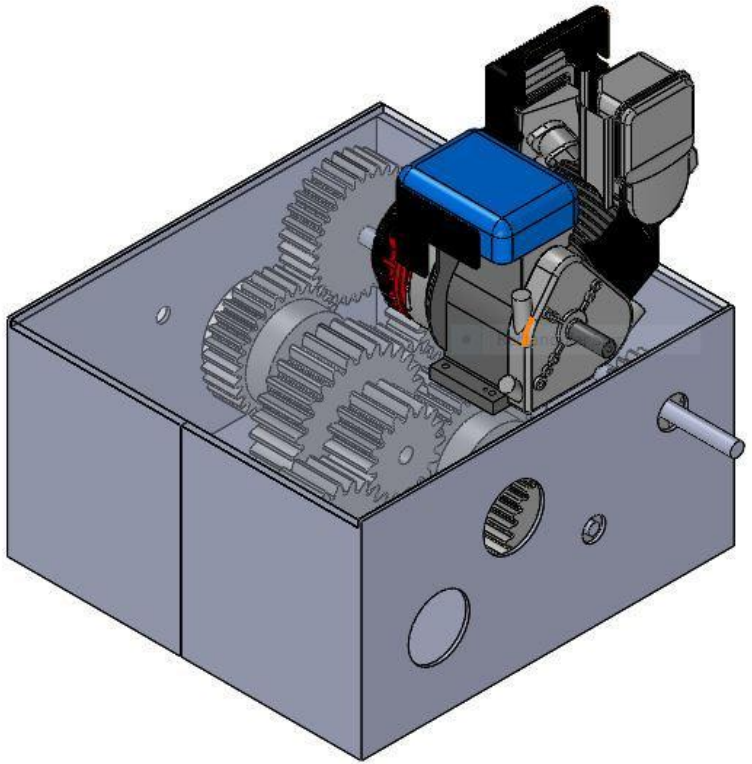
3rd Gear- **Pinion**: 30 **Gear**: 31

4th Gear- **Pinion**: 31 **Gear**: 30

Reducer

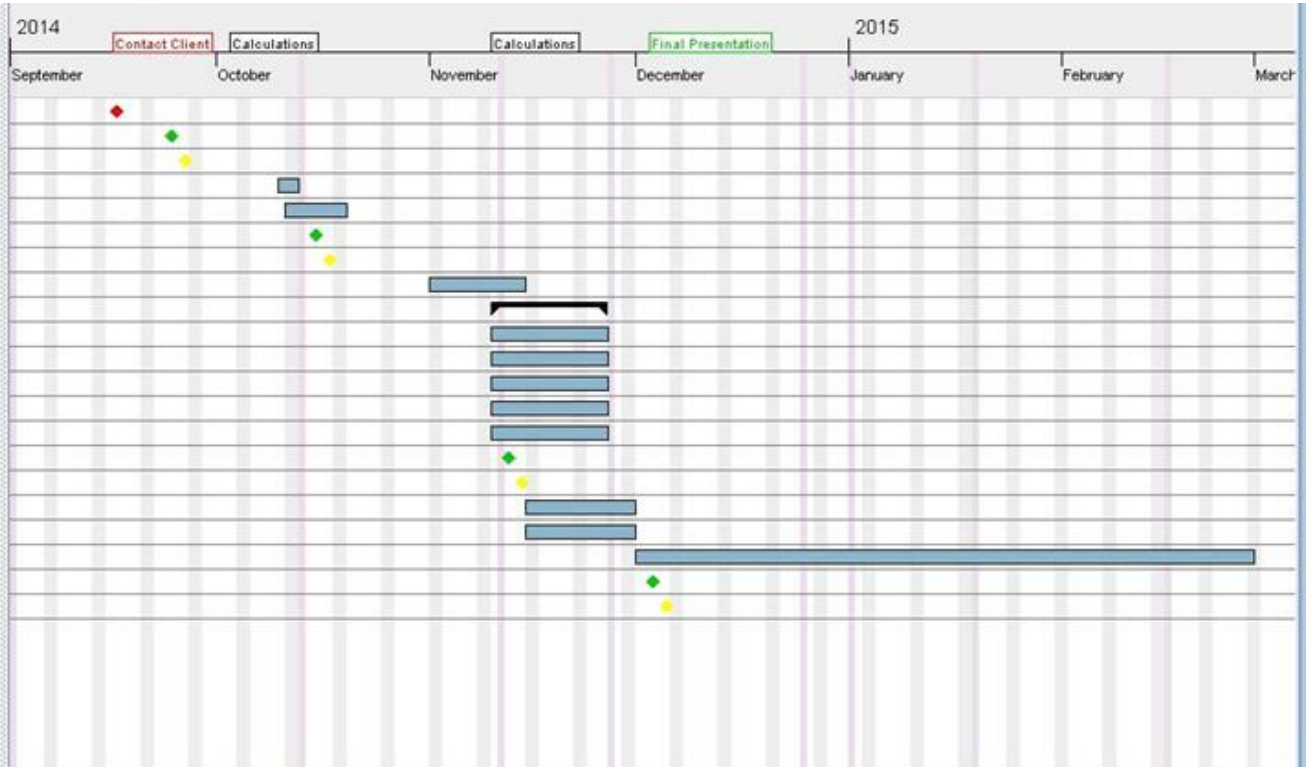
1st Mesh- **Pinion**:16 **Gear**:28

2nd Mesh- **Pinion**:16 **Gear**:28



Gantt Chart

Name	Begin date	End date
Contact Client	9/16/14	9/16/14
Presentation 1	9/24/14	9/24/14
Report 1	9/26/14	9/26/14
Test Motor	10/10/14	10/12/14
Gear Train Selection	10/11/14	10/19/14
Presentation 2	10/15/14	10/15/14
Report 2	10/17/14	10/17/14
3D Models for Parts	11/1/14	11/14/14
Calculations	11/10/14	11/26/14
Gear Ratio Calculations	11/10/14	11/26/14
Torque Calculations	11/10/14	11/26/14
Velocity Calculations	11/10/14	11/26/14
Shear Stress Calculations	11/10/14	11/26/14
Safety Factor Calculations	11/10/14	11/26/14
Presentation 3	11/12/14	11/12/14
Report 3	11/14/14	11/14/14
Parts Choosing	11/15/14	11/30/14
Parts Ordering	11/15/14	11/30/14
Manufacturing of Transmission	12/1/14	2/28/15
Final Presentation	12/3/14	12/3/14
Final Report	12/5/14	12/5/14



Worden

Conclusion

- Project Introduction
  - State which designs were chosen to be analyzed
- New Decision Matrix
  - Assessment of selected gearboxes
- Gantt Chart Update
  - Re-evaluating deadlines and milestones

References

- The Transmission Bible: Transmission, or Gearbox? http://www.carbibles.com/transmission_bible.html
- Transmissions Textbook: Lechner, G., Harald Naunheimer. Automotive Transmissions: Fundamentals, Selection, Design and Application. Berlin: Springer, 1999.
- Manual Picture http://alooroea.blogspot.com/2011/05/manuel-transmission.html

Questions?