Interim Design Review

HARRIS

Group 12: Bevel Gear Test Bed

David Jones
Brad Childers
Darrel Anderson
Andrew Dalesandro

Overview

- Introduction
  - Problem Statement
  - Updated Product Specifications
- Design Concepts
  - Test Bed Animation
  - Exploded View
  - Expected Parts
- Calculations
  - Gears
  - Bearings
- Cost Analysis
- Conclusion
  - Resolved & Unresolved issues
  - Gantt chart
- Future Plans
- Acknowledgement

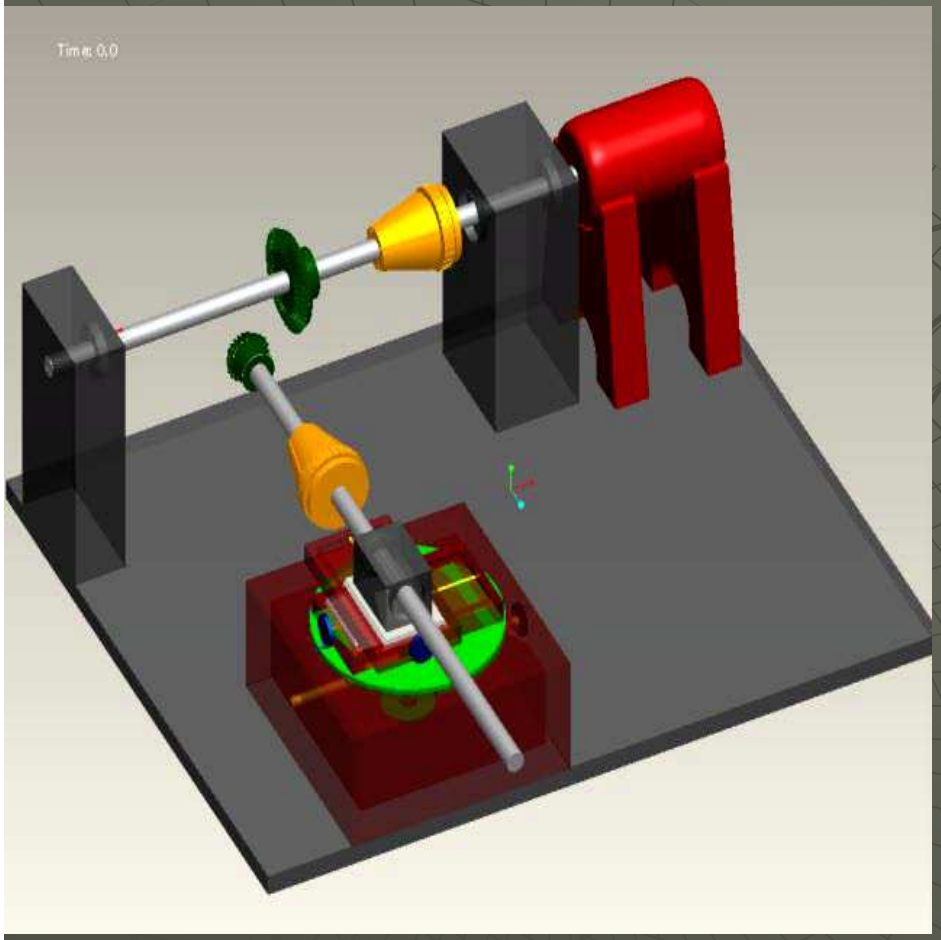
Problem Statement

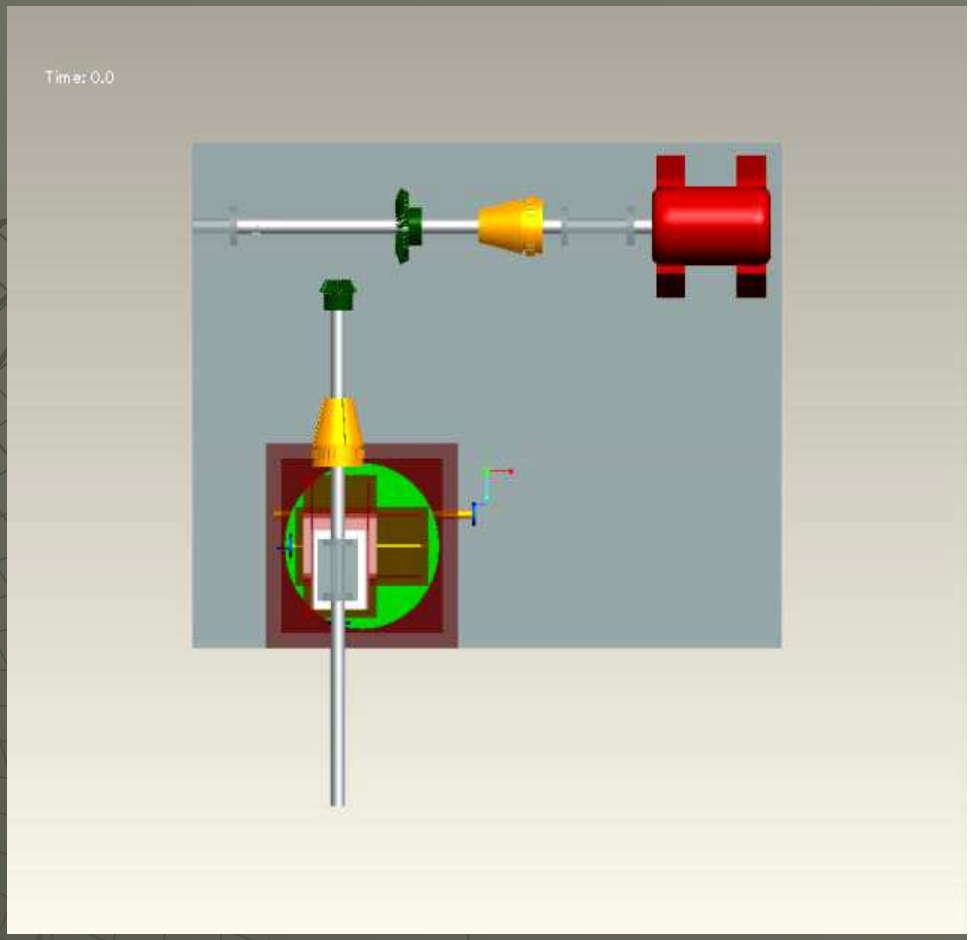
- Harris Corporation ran tests on bevel gears needed for a project
  - They did not achieve the expected standards
- Possible problems
  - Misalignment
  - Anodic coating failure
- Objective:
  - Design a very precise bevel gear test bed compatible with a variety of bevel gear sizes and materials

Product Specifications

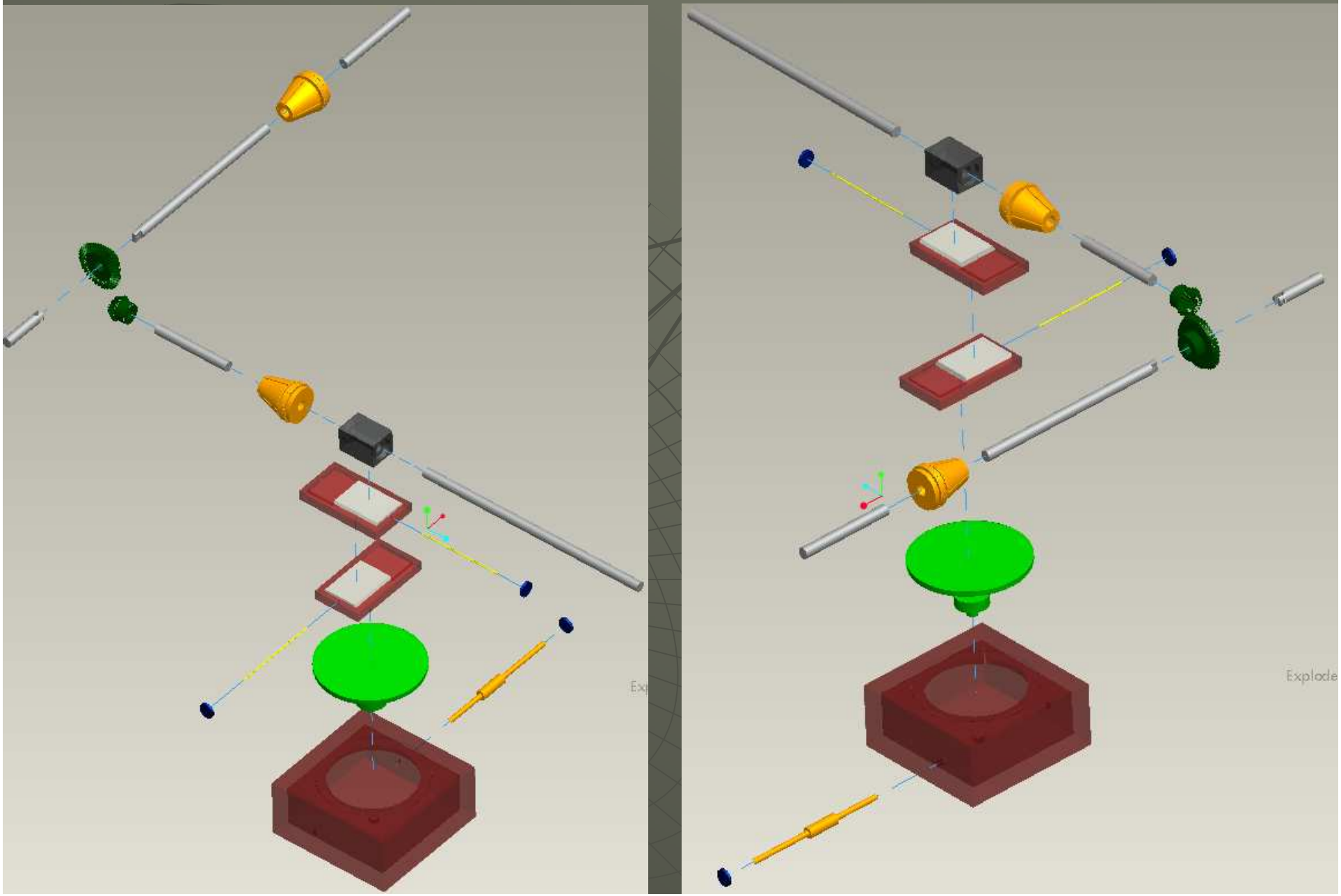
Specifications	U.S. Units	SI Units
Variable Torque	0 in.-lb - 50 in.-lb.	0 Nm – 5.6 Nm
Variable Speed	0 rpm – 100 rpm	0 rad/s – 10.4 rad/s
Gear Size Range	1/3 in. – 5 in.	8.467 mm – 127 mm
Mounting Distance Accuracy	+/- 0.001 in.	+/- 0.0254 mm
Variable Shaft Angle Range	+/- 0.5 degrees	+/- 0.00873 rad
Shaft Angle Increments	0.001 degrees	1.75*10^-5 rad

Test Bed Animation





Exploded View



X-Y Tables

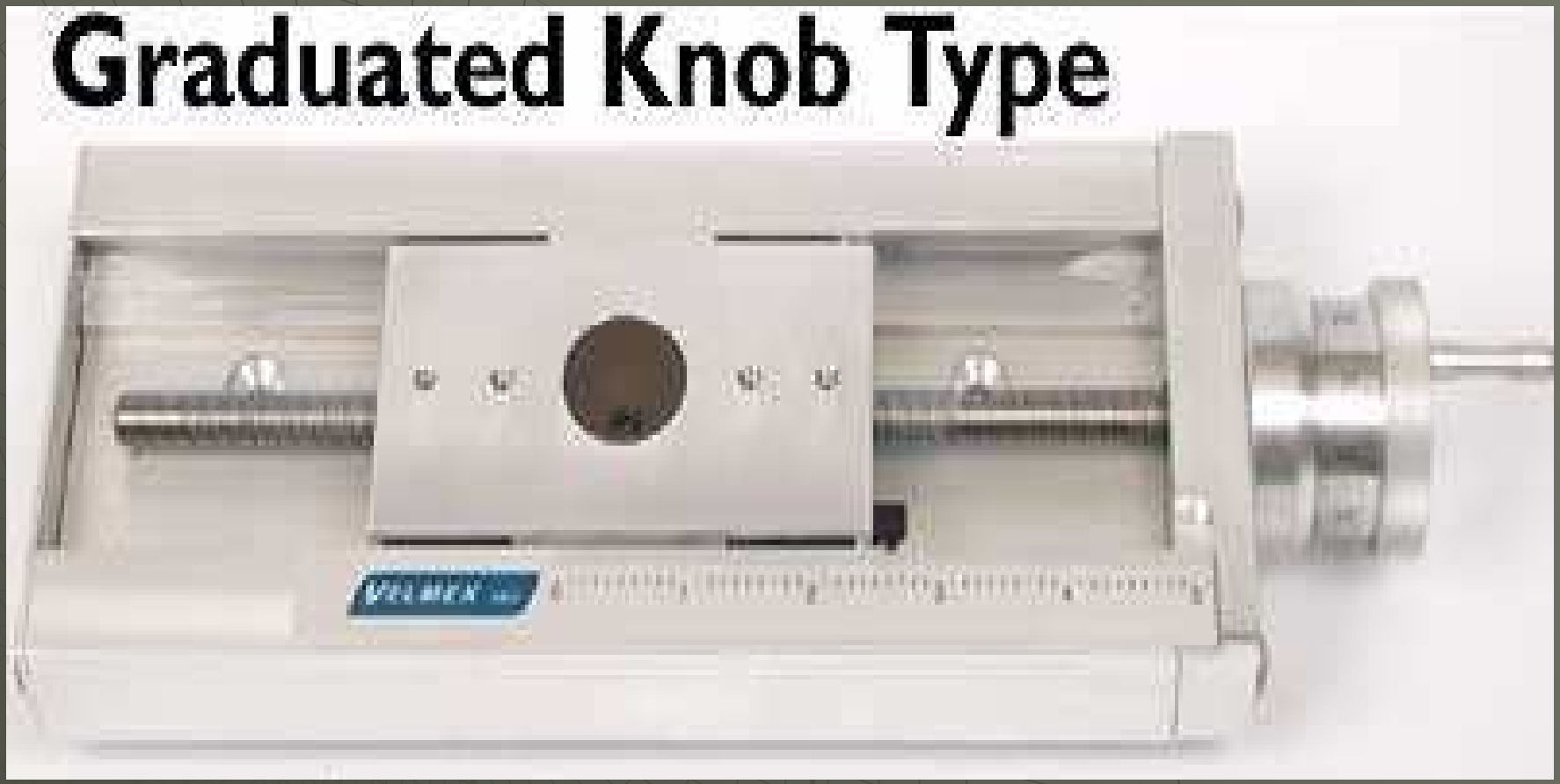


Image taken from: http://velmex.com/manual_cross_sections.asp?series=4000

X-Y Tables (cont.)

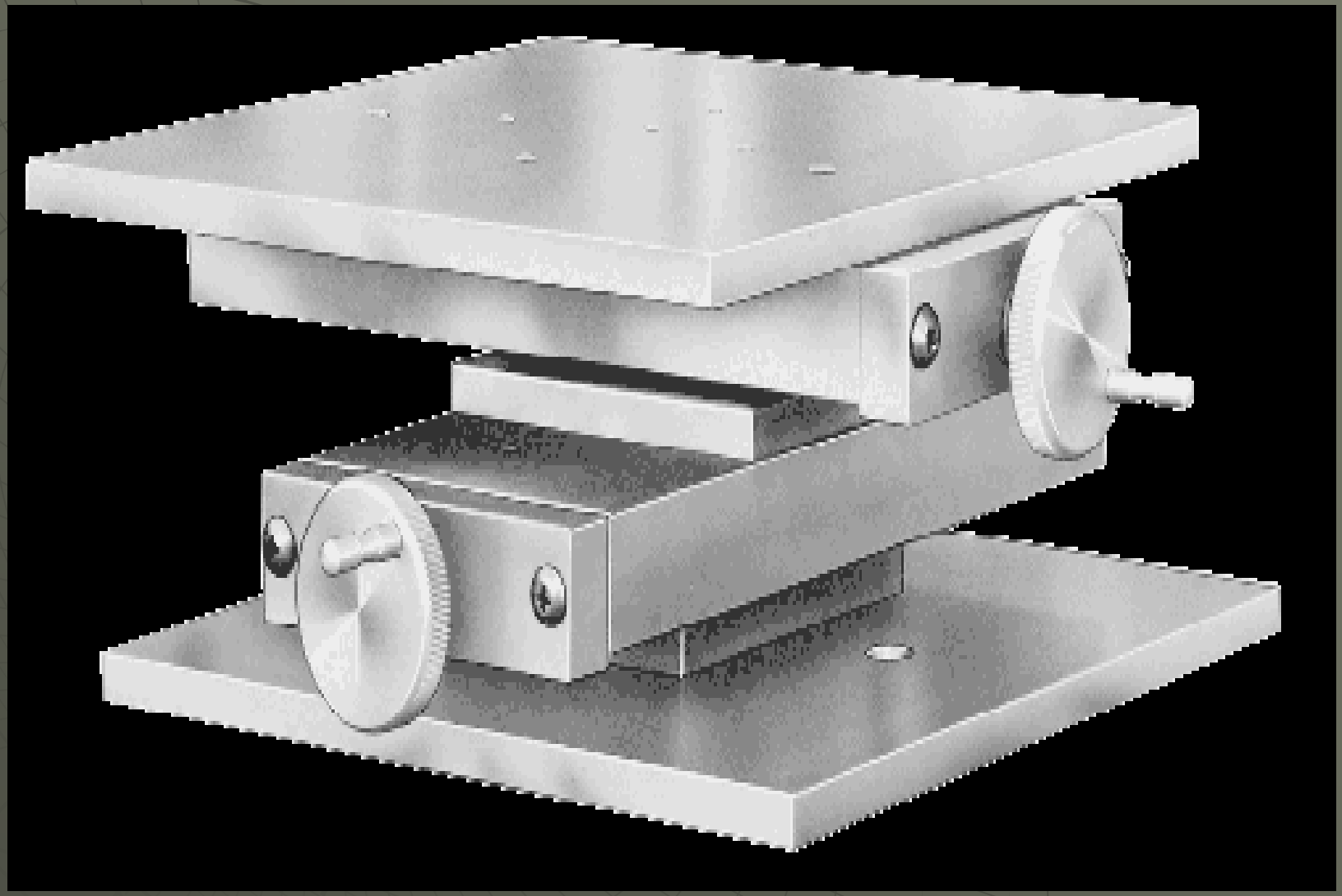


Image taken from: http://velmex.com/manual_maxy_tables.html

Rotary Table

Image taken from: http://velmex.com/manual_rotary_tables.html

Example Gear Set

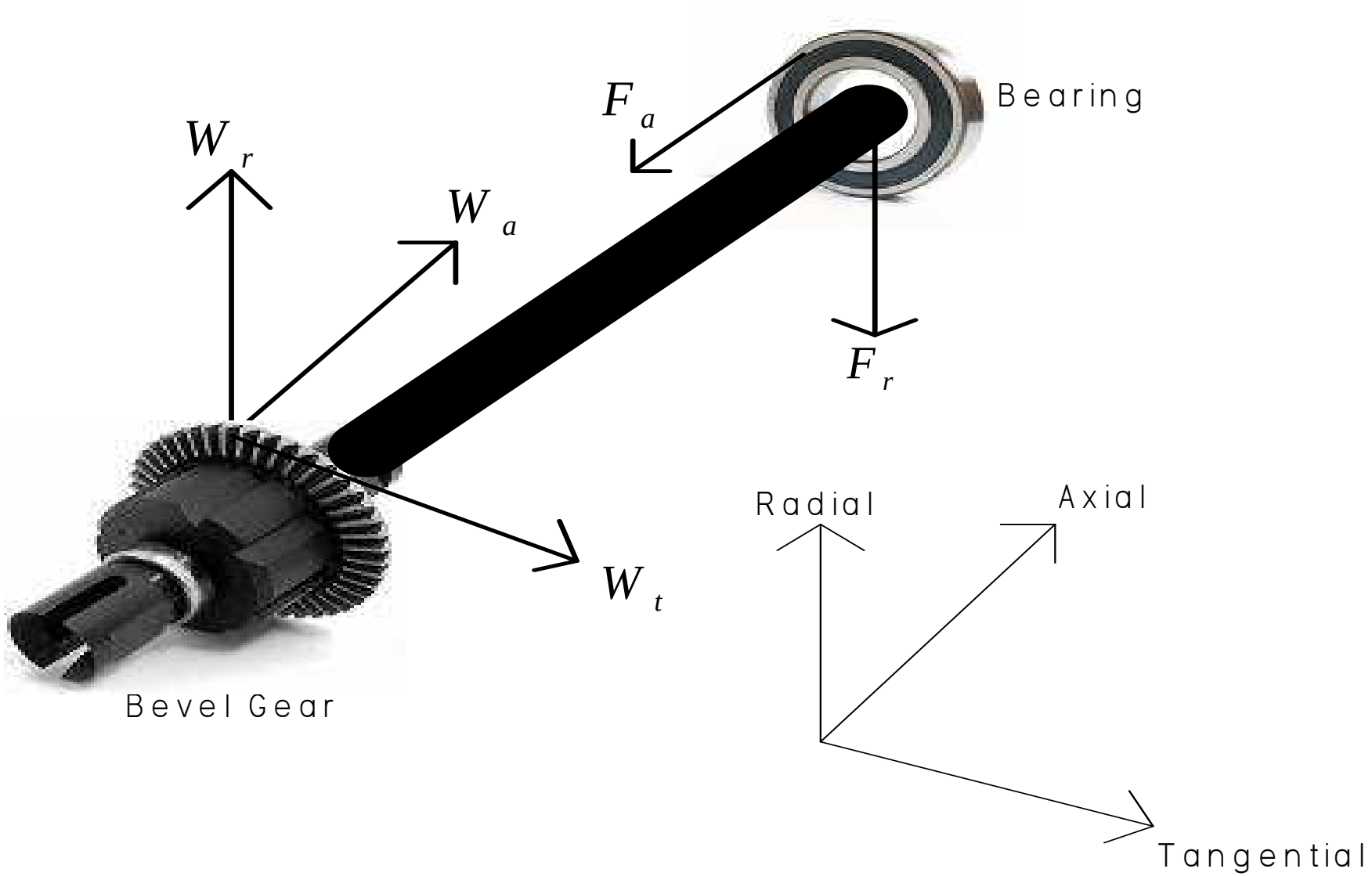
Image taken from: http://www.wmberg.com/catalog/product.aspx

Chucks (2)

Jacobs 1/2-in Keyed Replacement Drill Chuck with 3/8-24 Mount

Image taken from :
http://www.sears.com/shc/s/p_10153_12605_00988891000P?vName=Tools

Free Body Diagram



Possible Gear Set

- Bore : 1/2 in.
- *Material : Aluminum Anodized (Pinion)/Aluminum Anodized (Gear)*
- *Pitch Diameter : 1.250 in. (PINION) / 1.250 in. (GEAR)*
- *Ratio : 1 to 1*
- *Diametral Pitch : 16 teeth/in.*
- *Pressure Angle : 20 deg*
- *AGMA Quality : 10*
- *Teeth : 20/20*
- *Mounting Distance (Gear) : 1.25 in.*
- *Mounting Distance (Pinion) : 1.25 in.*
- *Face Width : 5/16 in.*

Gear Factor of Safety Calculations

Governing Equations | ***Calculated Values***

$$S_{fb} = \frac{K_L \cdot S_{fb\,prime}}{K_T \cdot K_R}$$

$S_{fb} = 1.315 \times 10^8$ Pa

$$S_{fc} = \frac{C_L \cdot C_H \cdot S_{fc\,prime}}{C_T \cdot C_R}$$

$S_{fc} = 3.933 \times 10^8$ Pa

$$\sigma_c = C_p \cdot C_b \cdot \sqrt{\frac{2 \cdot T_{pmax} \cdot C_a \cdot C_m \cdot C_s \cdot C_f C_{xc}}{F_1 \cdot I_1 \cdot d_p^{\,2} \cdot C_v}}$$

$\sigma_c = 1.745 \times 10^8$ Pa

$$N_{bp} = \frac{S_{fb}}{\sigma_{bp}}$$

$N_{bp} = 2.835$

$$N_{bg} = \frac{S_{fb}}{\sigma_{bg}}$$

$N_{bg} = 2.835$

$$N_c = \left(\frac{S_{fc}}{\sigma_c}\right)^2$$

$N_c = 5.078$

BEARING CALCULATIONS

Governing Equations	Calculated Values
$W_{ap} = W_t \cdot \tan(\phi) \cdot \sin(\alpha_p)$	$W_{ap} = 0.018\,kN$
$W_{rp} = W_t \cdot \tan(\phi) \cdot \cos(\alpha_p)$	$W_{rp} = 0.018\,kN$
$W_{ag} = W_t \cdot \tan(\phi) \cdot \sin(\alpha_g)$	$W_{ag} = 0.018\,kN$
$W_{rg} = W_t \cdot \tan(\phi) \cdot \cos(\alpha_g)$	$W_{rg} = 0.018\,kN$
$F_r := W_{rp}$	$F_r = 0.018\,kN$
$F_a := W_{ap}$	$F_a = 0.018\,kN$
$F_{bb} := \sqrt{F_a^{\,2} + F_r^{\,2}}$	$F_{bb} = 0.026\,kN$
$C_{bb} := F_{bb} \cdot L_{bb}^{\;\frac{1}{a}}$	$C_{bb} = 5.581 \times 10^{-3}\,kN$

-The calculated loading on the single bearing is far below any of the maximum allowable loadings for any of the bearings from the FAG series we are most likely going to order
-We picked the 6200 FAG series bearings since they will match our static loading.

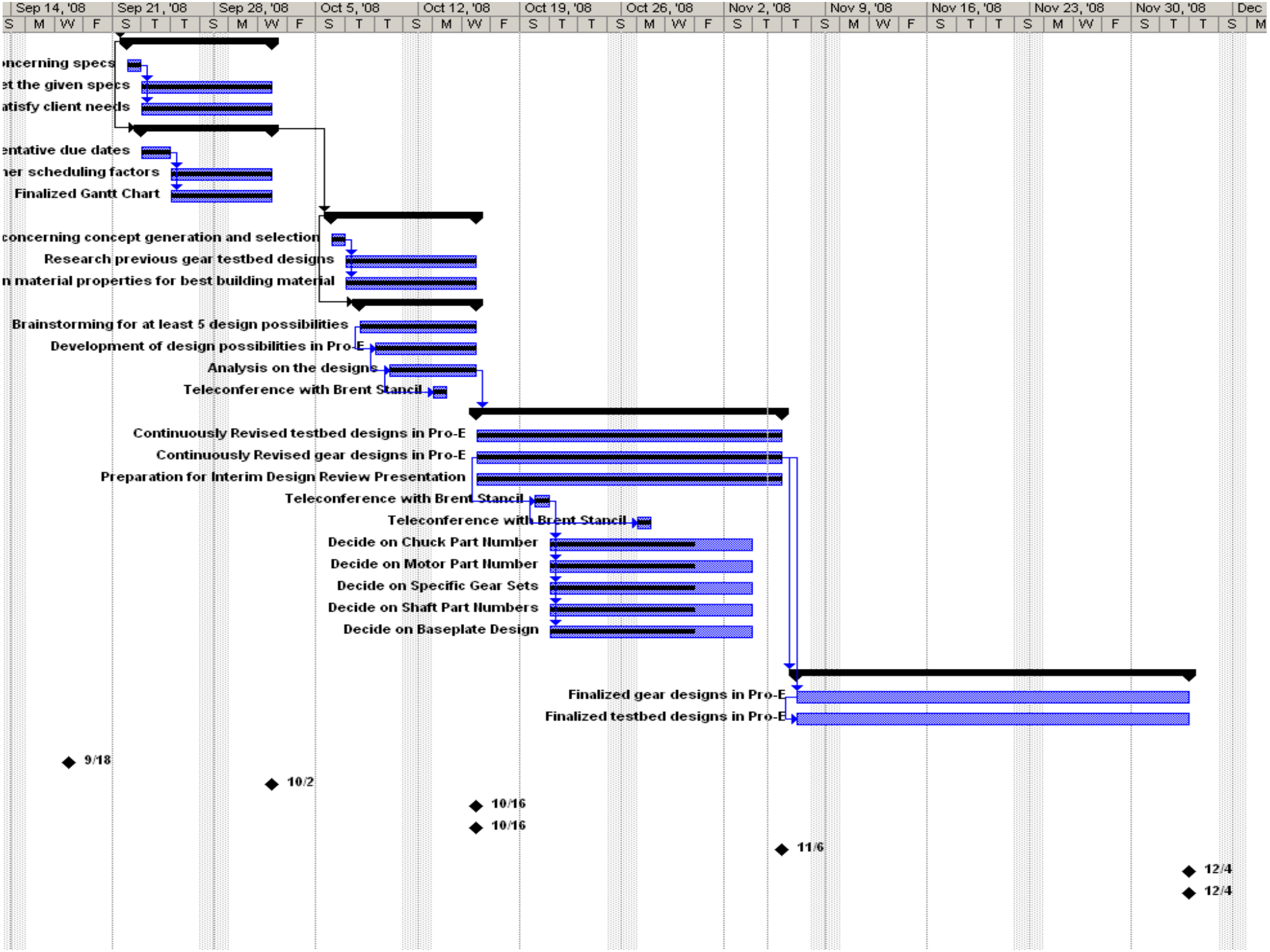
Cost Analysis

Name	Price Per Unit	Quantity	Total Price
X-Y Tables	$500.00	2	$1,000.00
Bearings	$7.00	5	$35.00
Shafts	$30.00	4	$120.00
Chucks	$20.00	2	$40.00
Controller	$80.00	1	$80.00
Motor	$70.00	1	$70.00
Bevel Gear Sets	$80.00	4	$320.00
Totals		24	$1,665

Additional Costs: Rotary Table, Steel Base Plate, and Aluminum Bearing Blocks

Conclusion

- Resolved Issues
  - Gear Calculations
  - Bearing Calculations
  - Detailed Pro-E modeling
  - Bill of Materials
- Unsettled Issues
  - Motor
  - Controller
  - Costs
  - Finance


Sep 14, '08
Sep 21, '08
Sep 28, '08
Oct 5, '08
Oct 12, '08
Oct 19, '08
Oct 26, '08
Nov 2, '08
Nov 9, '08
Nov 16, '08
Nov 23, '08
Nov 30, '08
Dec
ncerning specs
t the given specs
atisfy client needs
ntative due dates
er scheduling factors
Finalized Gantt Chart
concerning concept generation and selection
Research previous gear testbed designs
n material properties for best building material
Brainstorming for at least 5 design possibilities
Development of design possibilities in Pro-E
Analysis on the designs
Teleconference with Brent Stancil
Continuously Revised testbed designs in Pro-E
Continuously Revised gear designs in Pro-E
Preparation for Interim Design Review Presentation
Teleconference with Brent Stancil
Teleconference with Brent Stancil
Decide on Chuck Part Number
Decide on Motor Part Number
Decide on Specific Gear Sets
Decide on Shaft Part Numbers
Decide on Baseplate Design
Finalized gear designs in Pro-E
Finalized testbed designs in Pro-E
9/18
10/2
10/16
10/16
11/6
12/4
12/4

Future Plans

- Review Cost Analysis
  - Scale Down
  - Reduce Tolerances
- Extended Budget Inquiries
  - Mechanical Engineering Dept. (Dr. Shih)
  - Harris Corporation
- Find Proper Parts
  - Determine Delivery Span
- Preparation for Machining
  - Finalize Pro-E Drawings
  - Schedule Machining Time
- Update Project Plan

Acknowledgement

- Dr. Hollis
  - Calculations Review
  - Design Guidance
- Brent Stancil
  - Product Assistance
  - Clarifying critical specifications
  - Being Available

Questions