



Preliminary Presentation



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Scope and Objectives

Northrop Grumman Corporation (NGC)

- Requested team design of functional handling arm
- Able to hold avionics
 - To prevent dropping expensive components
- Articulating/maneuverable
- Soldering/other necessary activities
- Used during system integration and testing

Black Box Model



Figure 2. Black Box Model

Detailed Decomposition Model

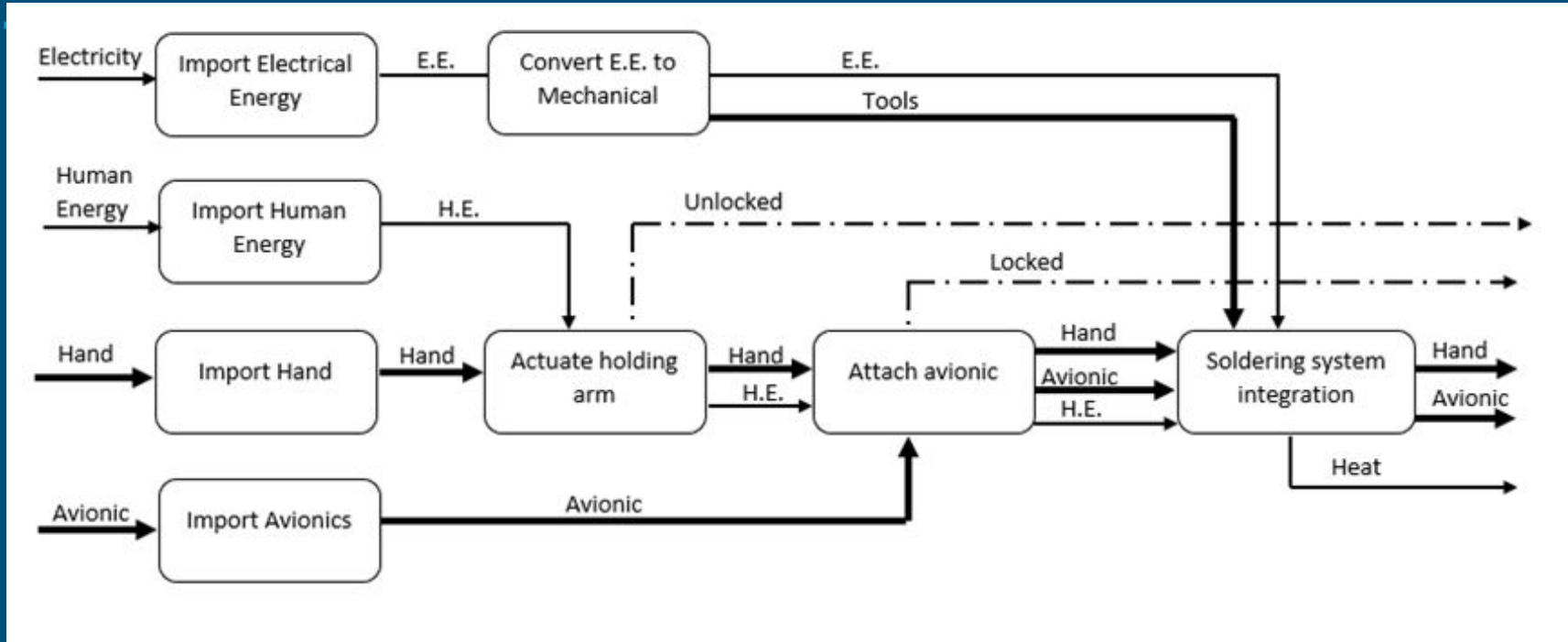


Figure 3. Functional Model

Bio-Inspired Leg Springs

- Springs allow for easy manipulation and movement
- Springs support weight even in an “unlocked” position
- Uses Zero-Length Springs
- Two joints
- Based off galagos/bushbabies

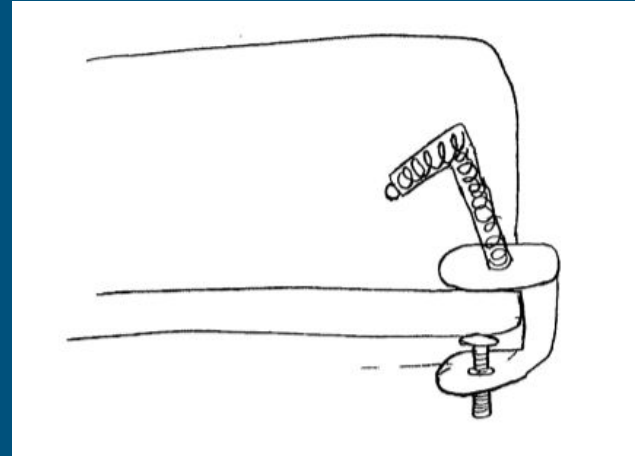


Figure 4. Concept 10

Clamped Shock Assisted Central Locking Arm

- Utilizes dual clamps to secure to the workbench
- Sleeve with set screw for vertical adjustment
- Center pivot with locking knob
- Shock assists with load capacity and manipulation
- Quick detach head connection

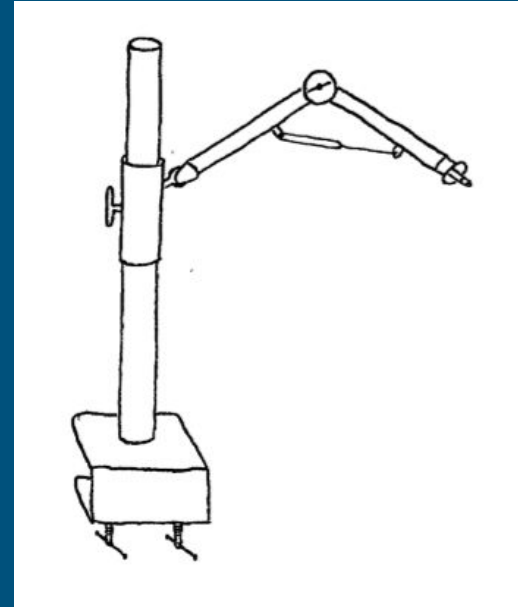


Figure 5. Concept 18

Bolt-Pattern Mount Head

- Industrial-grade clamp
- Ability to swivel
- Mounts with screws & bolts
- Made out of aluminum

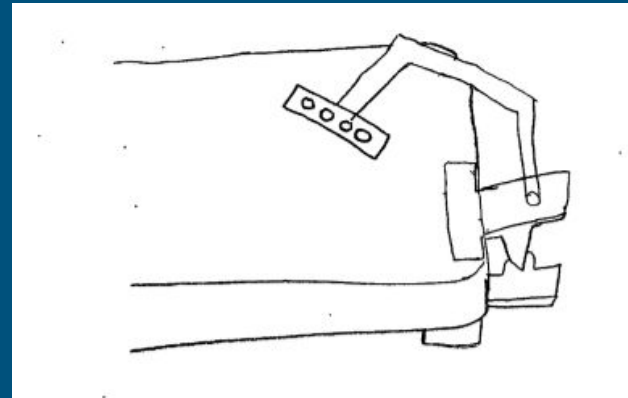


Figure 6. Concept 6

Hydraulically Assisted

- Weighted base
- Hydraulically assisted for easy manipulation
- Allows for yaw and pitch and vertical movement
- Missing roll and extension

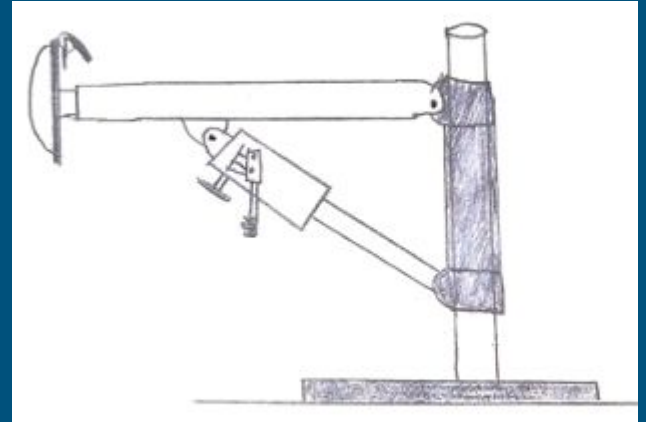


Figure 7. Concept 14

Clamped Shock-Assisted Arm

- Utilizes dual clamps to secure to the workbench
- Bearings at the base and between rectangle tubing and first pivot allow for smooth rotation
- Two 1 DOF pivot joints
- Shock assists with load capacity and manipulation
- Quick detach head connection

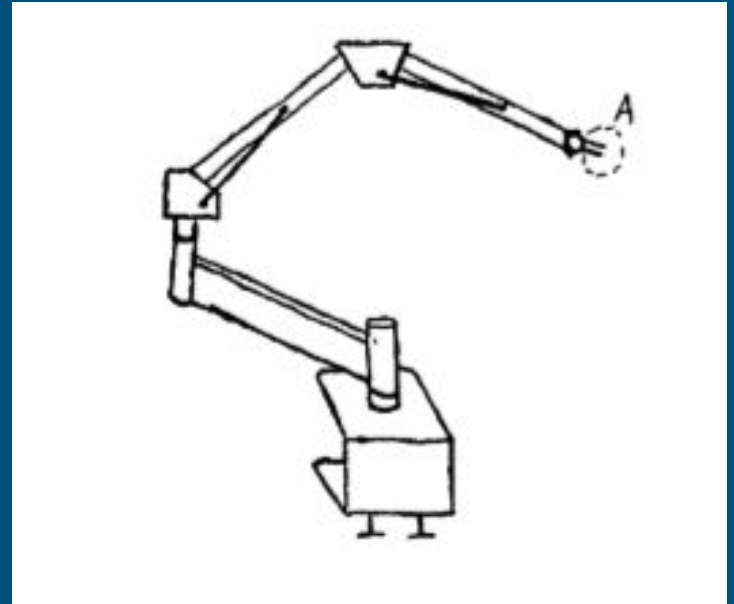


Figure 8: Concept 17

Pugh Chart

- Chose datum
- Ranked 20 concepts against datum
 - 1: Performs better than datum
 - 0: Performs the same
 - -1: Performs worse
- Summed totals
- Ranked totals to find top 5 concepts



Figure 9. Datum for Pugh Chart [2]

Pugh Chart (Continued)

Table 1. Pugh Chart for 20 Designs

| | Visio Computer Mount | Steel tube, ball and socket | Zero Length Spring | Vertical post with vertical pivots | Flexible Lamp Mount | Rolling Joint Claw | Bolt Pattern Mount Head | C-Clamp Mount Plate | Dual Joint Removable Head | Bio-Inspired Hawk Beak | Bio-Inspired Leg Springs | Lots of 360 Joints | Adjustable Wrench | Shock Turned | Hydraulic | Inclineable Arm | Weighted Base with Central Locking Arm | Clamped Shock Assisted Arm | Clamped Shock Assisted Central Locking Arm | Monkey | Clamp w/ Joints and Corner Clamps |
|-----------------------|----------------------|-----------------------------|--------------------|------------------------------------|---------------------|--------------------|-------------------------|---------------------|---------------------------|------------------------|--------------------------|--------------------|-------------------|--------------|------------|-----------------|--|----------------------------|--|------------|-----------------------------------|
| | DATUM | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| | | Concept 1 | Concept 2 | Concept 3 | Concept 4 | Concept 5 | Concept 6 | Concept 7 | Concept 8 | Concept 9 | Concept 10 | Concept 11 | Concept 12 | Concept 13 | Concept 14 | Concept 15 | Concept 16 | Concept 17 | Concept 18 | Concept 19 | Concept 20 |
| Safety | 0 | -1 | -1 | 0 | -1 | 1 | 0 | 0 | 0 | 0 | 1 | -1 | 0 | -1 | 1 | 0 | 1 | 1 | 1 | -1 | 0 |
| ESD Compliant | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -1 | 0 |
| Load Capacity | 0 | -1 | -1 | 0 | -1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | -1 | 1 | 0 | 1 | 1 | 1 | -1 | 0 |
| Component Size | 0 | 1 | -1 | -1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 |
| Torque | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | -1 | -1 | 1 | 1 | -1 | 0 |
| Degrees of Freedom | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | -1 | 1 |
| Longevity | 0 | 0 | -1 | -1 | -1 | 1 | 1 | 0 | 0 | -1 | 0 | -1 | 0 | -1 | 1 | 1 | 1 | 1 | 1 | -1 | 1 |
| Structural Integrity | 0 | -1 | -1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | -1 | 0 | 0 | 1 | 1 | -1 | -1 | -1 | 1 | 1 |
| Compatible with Table | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | -1 | 0 | 1 | 1 | -1 | 0 |
| Device Weight | 0 | 0 | 0 | 0 | 1 | -1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | -1 | 0 | 1 | -1 | -1 |
| Cost | 0 | -1 | -1 | -1 | 1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 |
| $\Sigma+$ | +0 | +2 | +2 | +2 | +4 | +5 | +6 | +4 | +3 | +4 | +7 | +3 | +3 | +1 | +6 | +2 | +5 | +7 | +8 | +2 | +4 |
| $\Sigma-$ | -0 | -4 | -6 | -3 | -3 | -2 | -1 | -1 | -1 | -2 | -1 | -4 | -1 | -4 | -1 | -3 | -4 | -2 | -2 | -9 | -2 |
| Σ | 0 | -2 | -4 | -1 | 1 | 3 | 5 | 3 | 2 | 2 | 6 | -1 | 2 | -3 | 5 | -1 | 1 | 5 | 6 | -7 | 2 |
| Rank | N/A | 7 | 9 | 6 | 5 | 3 | 2 | 3 | 4 | 4 | 1 | 6 | 4 | 8 | 2 | 6 | 5 | 2 | 1 | 10 | 4 |

*Top five highlighted in purple

Decision Matrix

Table 2. Decision Matrix

| Decision Matrix | | ALTERNATIVES | | | | | | | | | | How to rate an option? | |
|--------------------------------|--------|-----------------------|-------|----------------|-------|--------------|-------|-----------|-------|---------------|-------|------------------------|---------------|
| Decision Model | | Bio-Insp. Leg Springs | | Shock Assisted | | Bolt-Pattern | | Hydraulic | | Clamped Shock | | Rating | Description |
| Criterion | Weight | Rating | Score | Rating | Score | Rating | Score | Rating | Score | Rating | Score | | |
| Safety | 0.15 | 3 | 0.45 | 4 | 0.6 | 3 | 0.45 | 4 | 0.6 | 3 | 0.45 | 0 | No fit |
| ESD Compliant | 0.15 | 3 | 0.45 | 3 | 0.45 | 3 | 0.45 | 3 | 0.45 | 3 | 0.45 | 1 | Low fit |
| Load Capacity | 0.11 | 4 | 0.44 | 4 | 0.44 | 3 | 0.33 | 3 | 0.33 | 3 | 0.33 | 2 | Fit |
| Component Size | 0.11 | 3 | 0.33 | 4 | 0.44 | 3 | 0.33 | 4 | 0.44 | 4 | 0.44 | 3 | Good fit |
| Torque | 0.08 | 3 | 0.24 | 4 | 0.32 | 3 | 0.24 | 4 | 0.32 | 2 | 0.16 | 4 | Excellent fit |
| Degrees of Freedom | 0.08 | 4 | 0.32 | 4 | 0.32 | 4 | 0.32 | 3 | 0.24 | 4 | 0.32 | 5 | Above |
| Longevity | 0.07 | 4 | 0.28 | 2 | 0.14 | 3 | 0.21 | 4 | 0.28 | 3 | 0.21 | | |
| Structural Integrity | 0.07 | 3 | 0.21 | 4 | 0.28 | 3 | 0.21 | 4 | 0.28 | 2 | 0.14 | | |
| Compatible with Table | 0.07 | 5 | 0.35 | 5 | 0.35 | 5 | 0.35 | 5 | 0.35 | 5 | 0.35 | | |
| Device Weight | 0.06 | 4 | 0.24 | 4 | 0.24 | 3 | 0.18 | 4 | 0.24 | 4 | 0.24 | | |
| Cost | 0.05 | 3 | 0.15 | 3 | 0.15 | 3 | 0.15 | 3 | 0.15 | 3 | 0.15 | | |
| Total | 1 | 39 | 3.46 | 41 | 3.73 | 36 | 3.22 | 41 | 3.68 | 36 | 3.24 | | |
| Score = Rating * Weight | | | | | | | | | | | | | |

Top Two Designs → Final

Clamped Shock-Assisted Arm

- All Degrees of freedom
- Secure C clamp
- Only one lock
- Will drop when unlocked

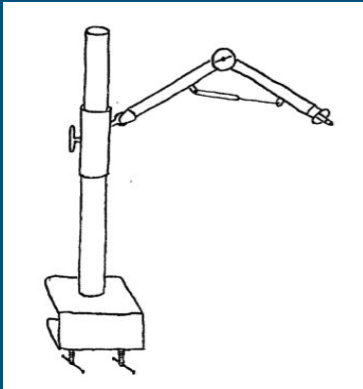


Figure 10. Concept 18

Hydraulically Assisted

- Slow controlled movements
- Weighted base infeasible
- Only some of the degrees of freedom

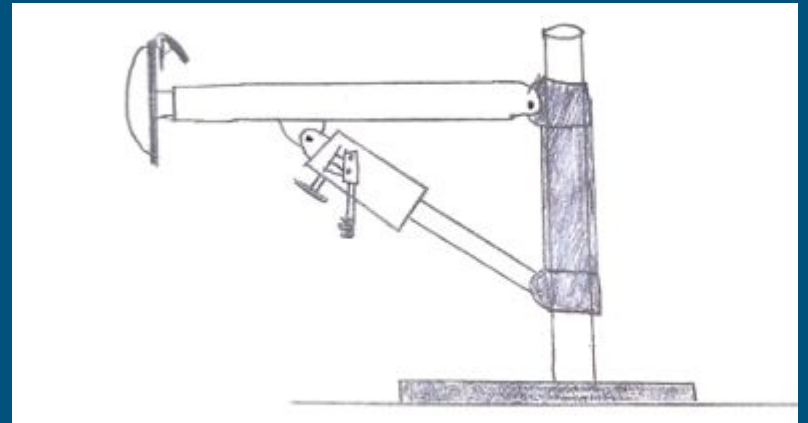


Figure 11. Concept 14

Final Design

- Utilizes dual clamps to secure to the workbench
- Sleeve with set screw for vertical adjustment
- Center pivot with locking knob
- Shock assists with load capacity and manipulation
- Quick detach head connection

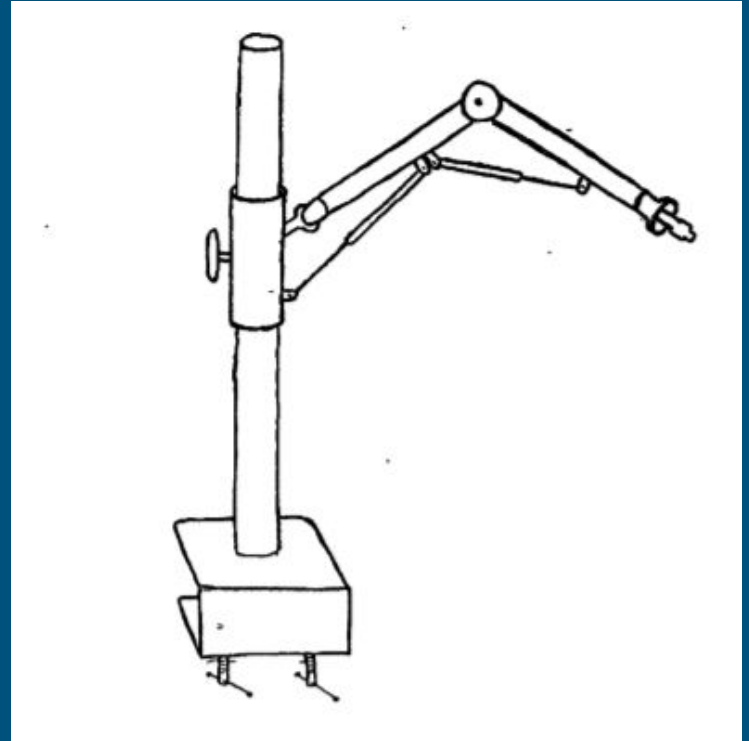


Figure 12. Final Design

Final Design Modifications

- After further team collaboration and consult with fabricator
- Change set screw to a clamping system
- Tube with slit that is clamped together
- Similar to a bike seat post clamp

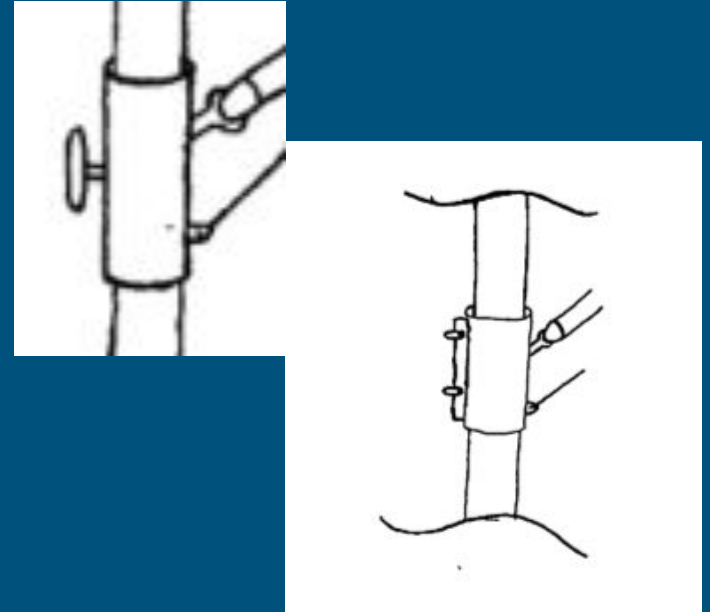


Figure 13. Clamping system

Scheduling

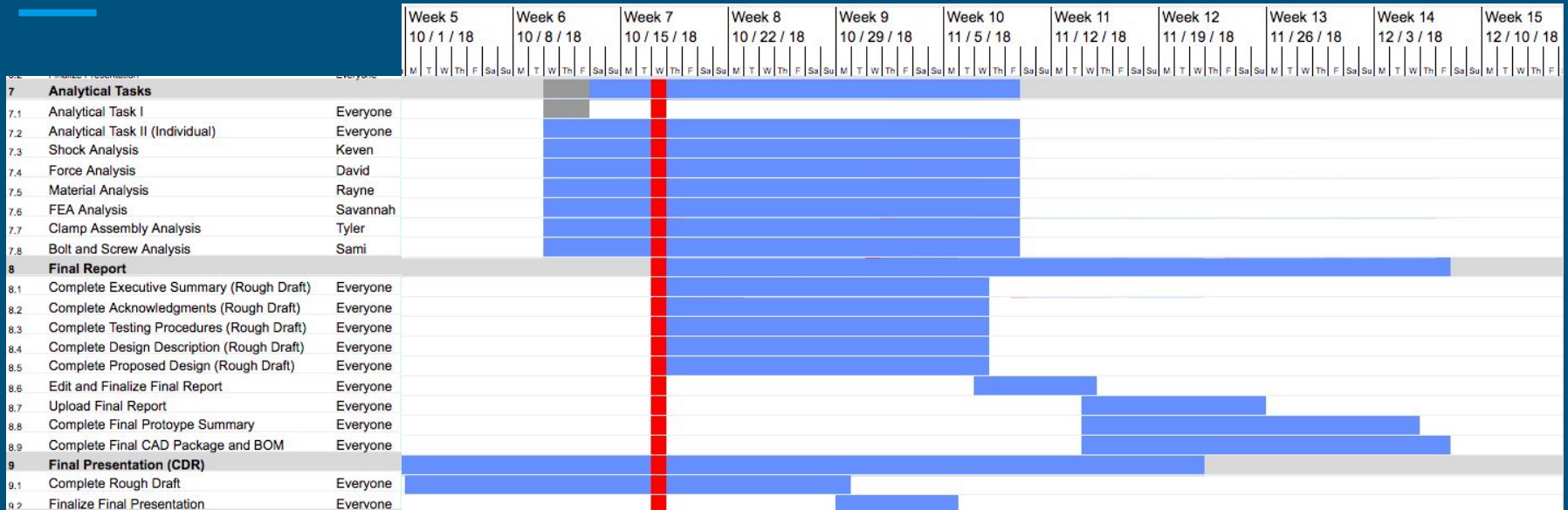


Figure 14. Gantt Chart for Rest of Semester

Budget

Table 3. Budget

| Item | Details | Miles | Quantity | \$/day | Total |
|---------------|-------------------------------|------------------|--------------------|---------|-------------------|
| Gas [5] | 2008 Chevy Silverado | 332 (round trip) | 5 trips | \$56.95 | \$284.75 |
| Prototyping | 3D printing, nuts, bolts, etc | | | | \$300 |
| Final Product | Finished and Final Product | | | | \$919.65 |
| | Client Budget | \$9,500 | Grand Total | | \$1,504.40 |

Bill Of Materials

Table 4. Bill of Materials

| Item | Material | Price | Quantity | Total | |
|----------------------------|-------------------|----------|----------|----------|-----------------|
| Shocks [6] | | \$19.95 | 2 | \$39.90 | |
| Clamp Spindle Assembly [7] | steel | \$30.09 | 1 | \$30.09 | |
| Link Tube [8] | carbon | \$48.81 | 1 | \$48.81 | |
| Link Tube | 6061 aluminum | \$21.40 | 1 | \$21.40 | |
| Ball Joint Material [9] | 12L14 steel | \$27.92 | 1 | \$27.92 | |
| End Joint Material | 6061 aluminum | \$29.64 | 1 | \$29.64 | |
| Center Joint Material | 6061 aluminum | \$20.53 | 1 | \$20.53 | |
| Vertical Tube [8] | HR steel | \$26.66 | 1 | \$26.66 | |
| C Channel | HR steel | \$41.56 | 1 | \$41.56 | |
| Sleeve | HR steel | \$22.05 | 1 | \$22.05 | |
| T Handle Knob [10] | Zinc | \$2.48 | 1 | \$2.48 | |
| Titan Support Arm [3] [4] | Anodized Aluminum | \$249.00 | 1 | \$249.00 | |
| CNC Machining Cost [11] | | \$80.00 | 3 Hours | \$240.00 | |
| Welding Cost [12] | | \$105.00 | 1 Hour | \$105.00 | Total |
| Plate for Clamp [8] | HR steel | \$14.61 | 1 | \$14.61 | \$919.65 |

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Questions
