Team 27(ME)/18(ECE): Mars Lander Robot Recharger

MEAC Presentation

1982 FLORIDA STATE UNIVERSITY FLORIDA A&M UNIVERSITY COLLEGE OF ENGINEERING

QinetiQ

NASA

Team Members/Advisors

- Team Members
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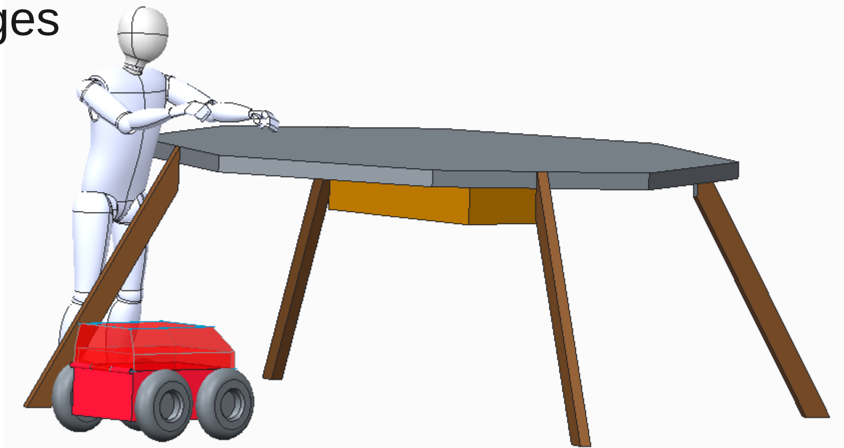
  - Dr. Arora – ECE Advisor
  - Van Townsend – QinetiQ Liaison
  - Michael Solomon – QinetiQ Intellectual Property Contact

Tyler Norkus

Mission

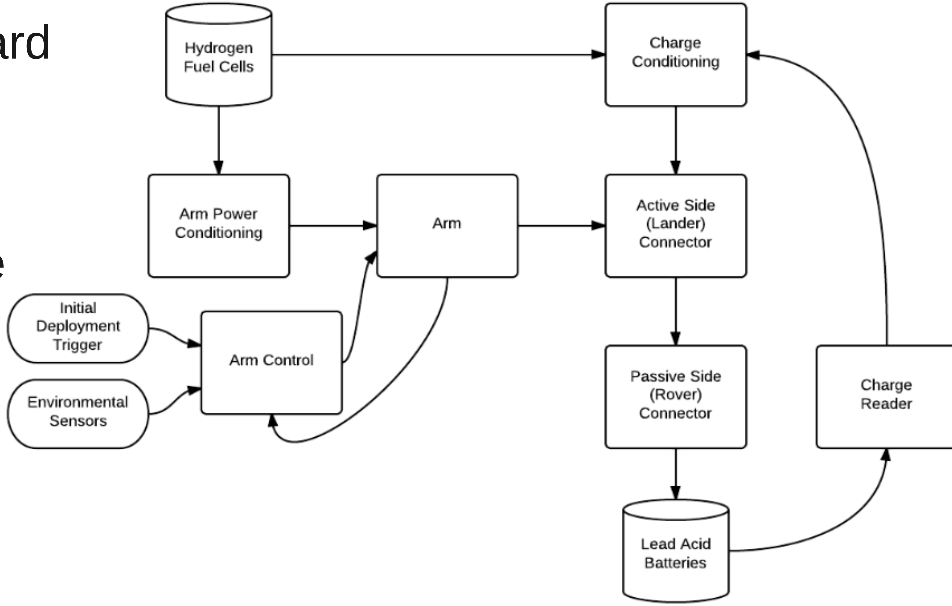
- NASA has a need for more efficient exploration missions
- Reducing mass increases efficiency
- Design a mission around a stationary lab/fuel station
- A fleet of rovers explores and collects samples
- Deposit samples at the base and recharges
- No need for large, heavy batteries and power generation systems onboard the rovers.



Tyler Norkus

Project Scope

- Get power from the stationary lander to the rovers
- Hydrogen fuel cell bank on board the lander
- Two 12V Lead Acid Batteries onboard the rovers
- Rovers drive up to be refueled
- Station records current charge state
- Fills batteries to 100%



Tyler Norkus

Design Constraints

- Efficiency
  - >75% Required
  - >90% Preferred
- Mass
  - Rover Connection
    - <2 kg Required
    - <1 kg Preferred
  - Arm
    - <4 kg Required
- Charge Time
  - 8 hrs maximum

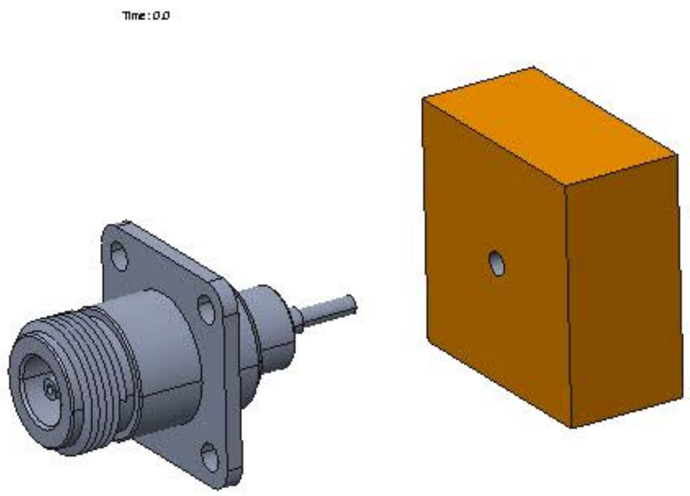
Tyler Norkus

Power Transfer Method

- Contact or Wireless Power Transfer?
  - Contact Power Transfer
  - Types of Wireless Power Transfer:
    - Inductive
    - Laser
    - Microwave
  - Researching Capacitive Power Transfer (CPT) Lead Us to a Unique Solution
    - External Contact with CPT Backup System (Hybrid)
- Ruled out wireless using a Decision Matrix

Concept 1: Pin-Socket

- Physical
- Pros
  - Simple
  - Light
  - Symmetric
  - Efficient
- Cons
  - Dust
  - Sophisticated arm control
  - NASA/QinetiQ says to avoid



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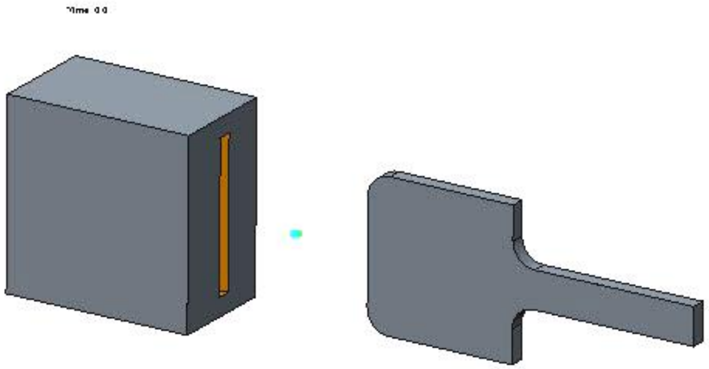
Concept 2: Paddle/Slot

- Physical
- Pros
  - More robust than pin
  - Brushes reduce dust
- Cons
  - Sophisticated arm control
  - Difficult to align paddle with slot



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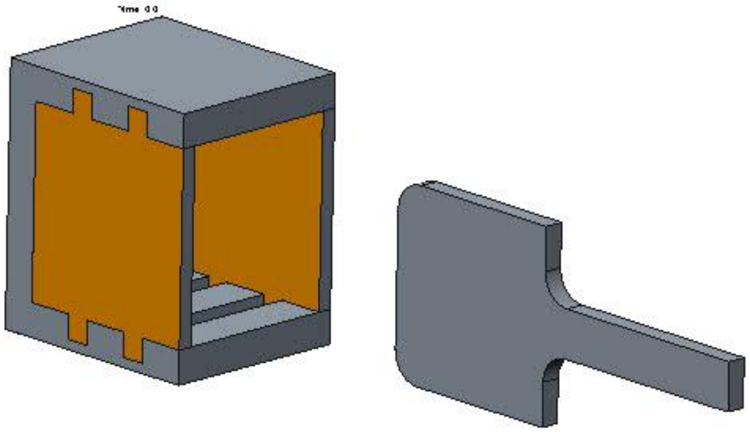
Concept 3: Paddle/Clamp

- Physical
- Pros
  - More robust than pin
  - Remedies alignment difficulties of paddle/slot design
- Cons
  - Sophisticated arm control
  - More moving parts
  - Cavity collects dust



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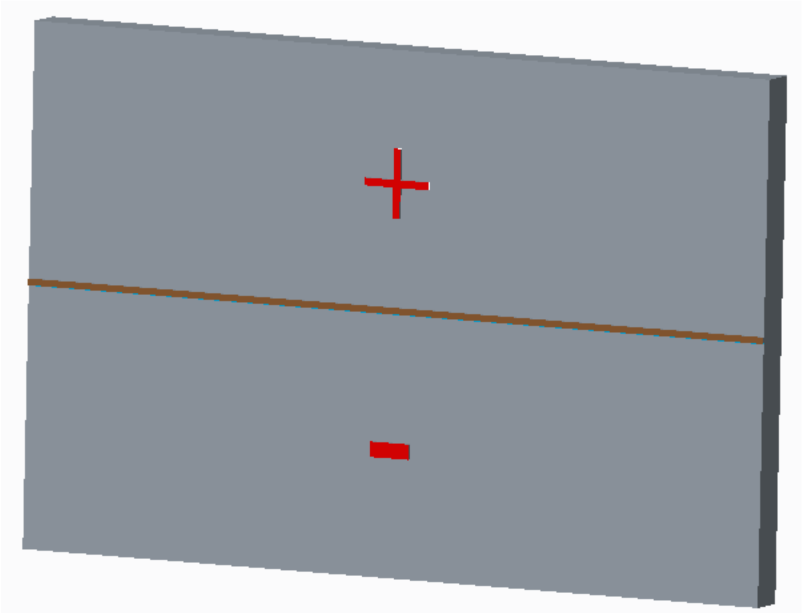
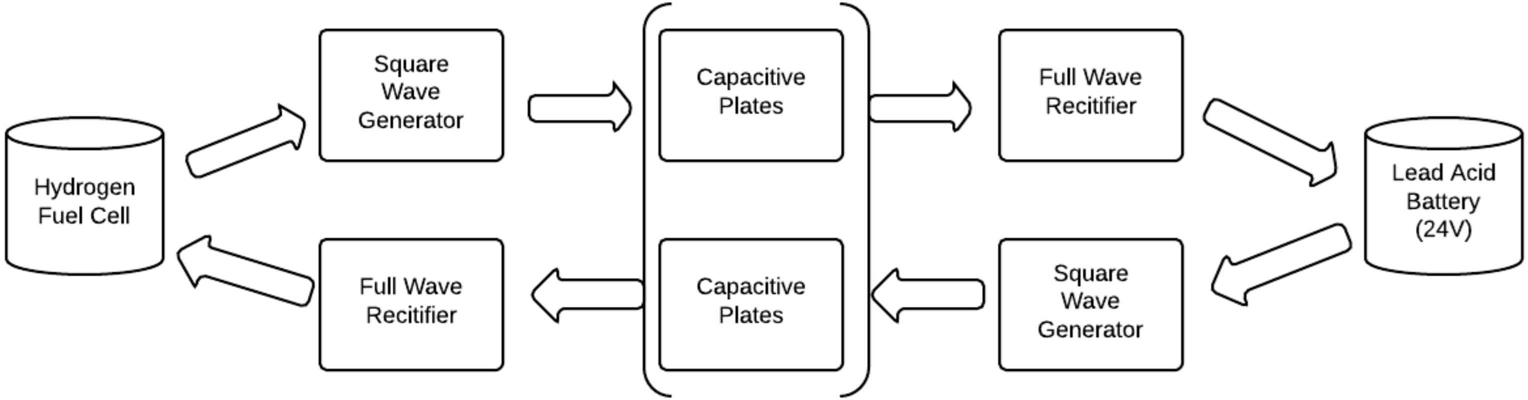
Contact/CPT Hybrid

- Primarily physical contact connection
- Two pairs of plates meet to transfer power
- Physical Obstruction initiates CPT backup
- High frequency power treats the plates as a capacitor
- Power is transferred through the electric field between plates
- 65-90% efficiency depending on conditions



Itiel Agramonte

CPT Diagram



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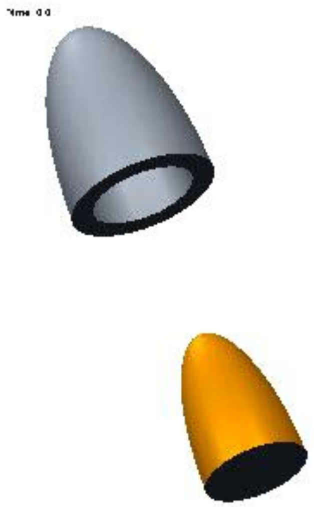
Concept 4: Blunted-Cone

- Contact-CPT hybrid
- Pros
  - Fully symmetric
  - Resistant to dust
  - Simpler Arm Control
- Cons
  - Difficult to manufacture
  - Requires strict dimensional tolerances



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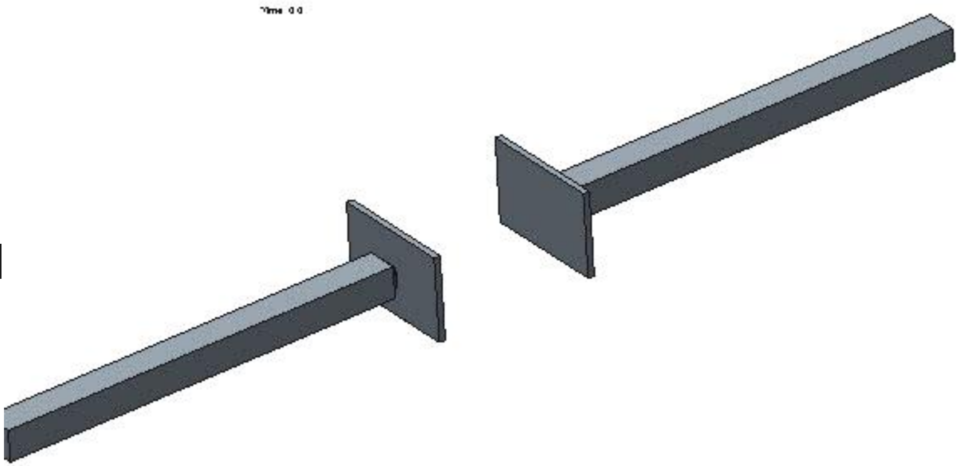
Concept 5: Moving Plate

- Contact-CPT Hybrid
- Pros
  - Resistant to dust
  - Easy to manufacture
- Cons
  - Sophisticated arm control
  - Non-Symmetric



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Concept 6: Docking Station

- Contact-CPT Hybrid Pros
  - Minimal arm control
  - Easy to prototype/test
  - Resistant to dust
- Cons
  - Not symmetric
  - Requires static Martian Surface

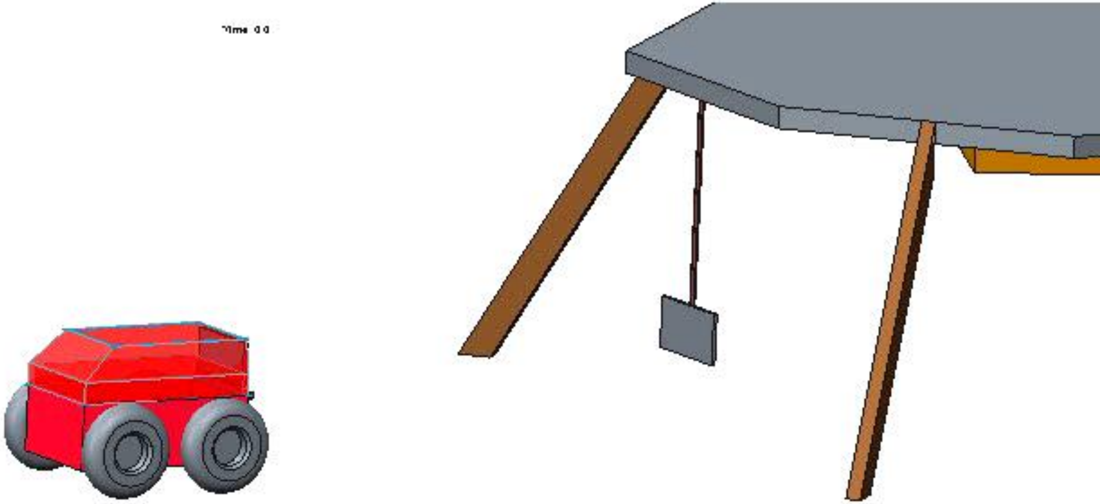

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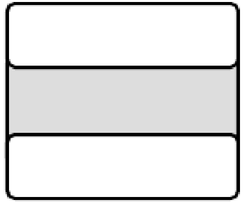
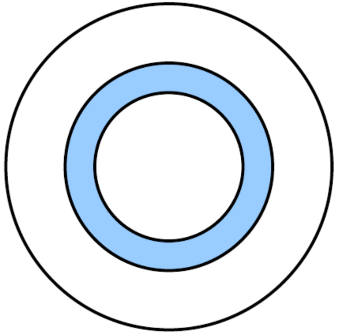
Plate Design

- Plate Material – Aluminum
- Plate Coating – Still being researched
  - Materials and Techniques (If Necessary)





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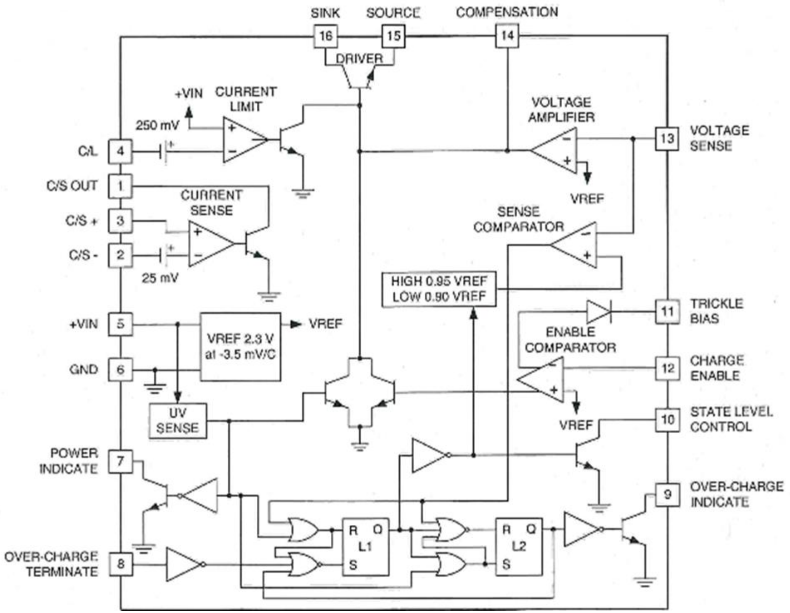
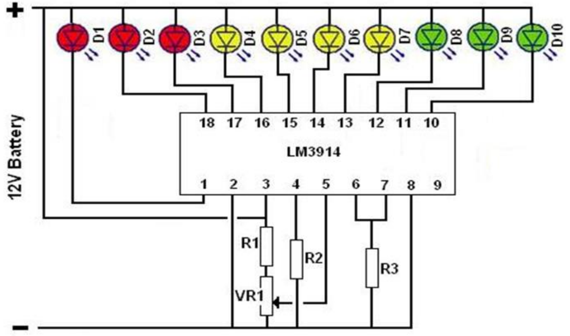
Charge Control Options

- Texas Instrument’s UC3906
  - Trickle Charge – If battery is below threshold
  - Bulk Charge – Full current delivered, majority of charge restored
  - Over Charge – Restores Full Capacity
  - Float Charge – Prevents damage from over charging
- LM3914
  - Voltage battery monitor circuit
  - To be used as a relay

Charge Control Options



UC3906



LM3914

Itiel Agramonte

Arm Design

- All design decisions are dependent on the connector
- The arm design is the next crucial design decision
- Design specifications include:
  - Material
  - Geometry
  - Movement
- Several considerations taken into account
  - Forces
  - Martian dirt and dust storms
  - Minimize movement
  - Ease of manufacture

James Whaley

Arm Design

- The arm will be attached to the top of the lander deck
- Deployed from storage upon initial trigger upon landing
- Possibly stored between uses

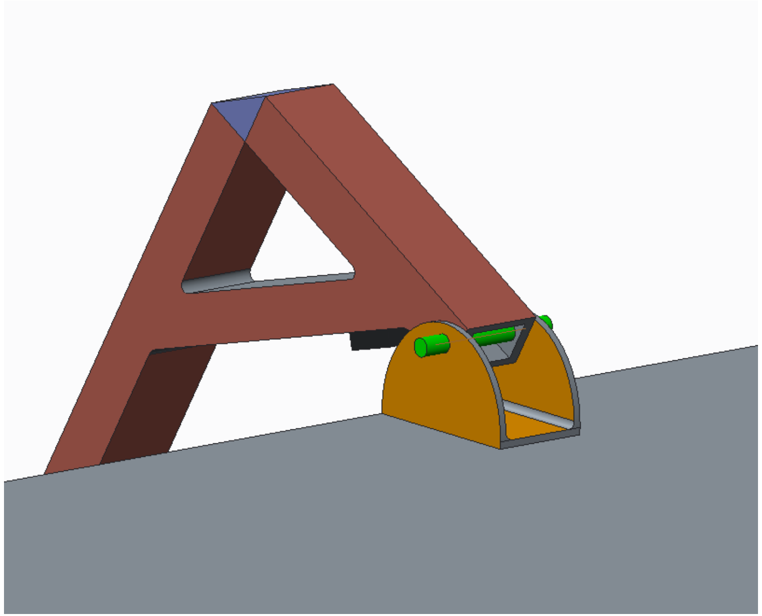
James Whaley

Arm Design

- Primary design considerations for the arm include the mass and control
- Control is to be passive, if possible
  - Fewer motors lead to less mass and less power consumption
  - Must be able to meet plate on rover accurately

James Whaley

Arm Design



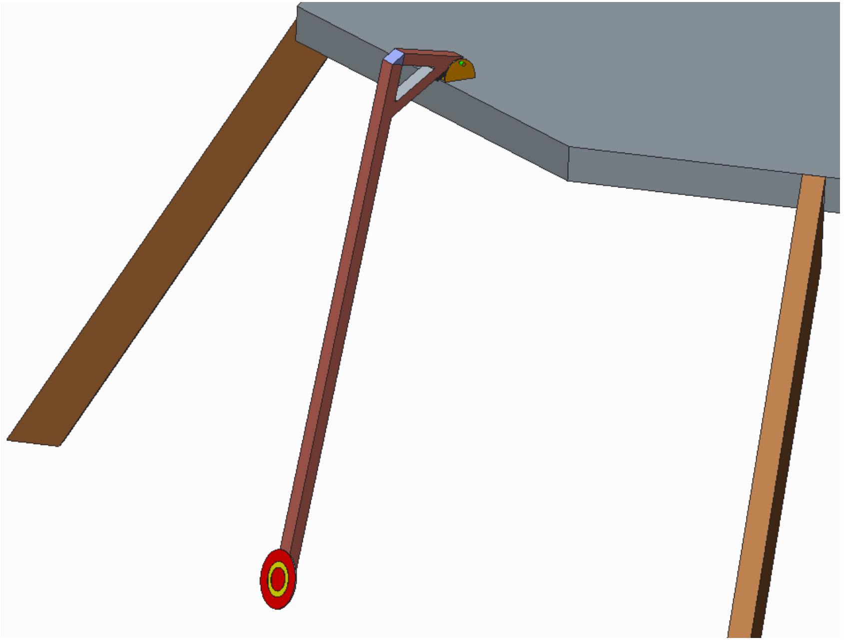


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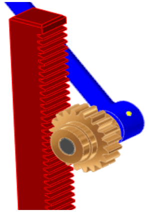
Plate Motion

- Plate will be moved and controlled by a mechanism located within the shaft of the arm

Types of Mechanisms:

- Rack and Pinion



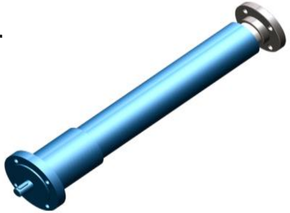
Pros

- Very simple
- Easy to implement

Cons

- Possibility of harming umbilicals
- Not a very accurate tolerance

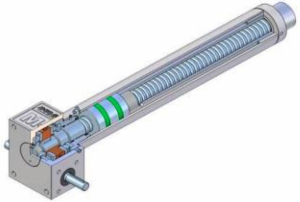
- Linear Actuator



- Perfect vertical linear motion
- Will not harm umbilicals

- Heavy in weight
- Consumes power

- Screwjack



- More accurate form of actuator
- Tighter tolerances

- Consumes most power
- Bigger in size (would have to make arm diameter larger)

James Whaley

Future Work

- Continued Analysis
  - Arm Structure
  - Arm Motion
- Continued Testing
  - Efficiency
  - Power Conversion

References

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Questions, Comments?