MIT TSET
System Overview
Climber Specs

- The scoring equation for last year’s competition was
  \[ m_{\text{payload}} \times \frac{V_{\text{avg}}}{m_{\text{structural}}} \]
- The climber had to be able to ascend a 50m ribbon at an average speed of 1m/s.
- Maximum beamed power of 100KVA.
- No previously stored energy.
- Maximum energy storage of 25% at any time.
- 10kg < \( m_{\text{structural}} \) < 25 kg
- Fully autonomous
- Safety regulations must be met
- Power Transmission belt ribbon
Early Goals

Based on the competition rules, the team delineated some goals concerning the climber, that were believed to maximize performance on competition day based on the scoring equation:

- It should travel at an average speed of 1 m/s.
- It should weigh about 25 kg without payload.
- It should be able to carry 25 kg of payload while maintaining its average speed.
First Recursion
Lessons from First Recursion

- 1st recursion was a crash course in climber design in which the team mostly experimented brainstormed ideas.
- Construction and machining mandated that several aspects of the initial design be modified.
- After testing the first recursion, the team discovered that the roller configuration was flawed for it could not generate enough torque.
- The team also discovered that the climber was too heavy and flimsy.
CURRENT DESIGN
Modifications

- The team applied the lessons from the first recursion to create a better climber.
- The team decided to switch to a two motor configuration with 50:1 gear ratio which provides substantially greater torque and weighs as much as the earlier recursion.
- Polycarbonate is the primary material instead of aluminium.
- Changed overall design layout to increase stiffness.
- Included additional design for a more complete climber setup that included mount points for failsafe brakes, guide rollers, belay hooks, payload and electronics.
Current Design

Components

- Motor-roller module
- Payload module
- Electronics module
- Power module
- All modules except electronics module have been modified
Motor-Roller Module

- Powered by 2 DeWalt power drill motors.
- Structure made of polycarbonate (including the roller) which provides greater strength compared to aluminum.
- Motors are geared to generate necessary torque.
Payload and Power Modules

► Solar panels have been replaced by rectanna array so the payload bucket’s status is currently unknown.

► Rectanna array will be attached to bottom of climber via kevlar or wood attachment.
Current Design
Current Design
Power System

- Climber powered by beam source
- Beam source must direct most of its energy at climber
- Turn on/off at a command
- Only a quarter of the total energy can be stored
Microwave System

- Microwave
  - Efficient
  - Need magnetron, rectennas
  - Developing field
- 800 W Magnetron
  - 5.81 GHz
  - Diode Vacuum Tube-Oscillates to create microwave
Microwave System

MIT Space Elevator Team
Microwave power beaming system.
Microwave System

- Waveguide
- Directs the extracted RF energy to the antenna
- Antenna
  - Circularly polarized
  - Helical Antenna
  - Out-of-phase microwaves
Microwave System

► Dish/Reflector
  - 14 foot satellite dish
  - Collimates beam

► Rectennas
  - Rectifiers and Antennas
  - Receives microwaves energy and converts oscillating current to DC
Control & Logic

► Controlled by Bitsy
  ▪ Single Board Computer
  ▪ Runs Linux
  ▪ 802.11
  ▪ Runs logic
► Stop/Start
► Reverse
► Speed Regulation
Power Transmission

- Design a better, more efficient transmission system.
  - Fixed Input - 750W, 5.801GHz signal via waveguide or coax
  - Fixed Output - circularly polarized microwaves at same frequency
  - Current design uses waveguides to transmit signal up to a hemispherical reflector and back to a parabolic dish, before traveling in a beam up to the rectenna array.
  - Goal - to transmit 400W of power to the rectenna array
Rectenna Design

Current Design - based on a Texas A&M design which transmitted power on small scales (10W)

Patch Antennas and rectifying circuitry

Primary Goals - cheaper and more efficient (60-65%)

Secondary Goals - Lighter and stronger (self supporting)
Control System Design

► Current control system is an analog control system supported by an onboard computer

► Requires finding many optimal parameters within the circuit.

► Many of the issues involved are pretty complicated and require us to find a delicate balance
  ▪ Varying-voltage power supply
  ▪ 15kF of capacitors that are restricted to 2.5V
  ▪ Motors that can act with or against our power circuitry depending on operating levels
Gear Ratios

► Current design - Two DeWalt drill motors
  - .667 N/m of torque @ 21000 rpm

► Gear Ratio - 46.7:1
  - 1.4 N/m torque @ at rollers

► Second “Hi Speed” configuration - 10.5:1 gear ratio

► Goals - optimize combination of torque and speed supplied the rollers.
Weight Minimization

Allowed weight - 10 to 25kg

Current Design
- Polycarbonate is used instead of aluminum or steel to cut mass
- Hollowed out gears
- Weight saving roller design

Goal – Maximize payload to weight ratio without sacrificing performance.