Design Update

SpudNik-1 CubeSat: Ground Station

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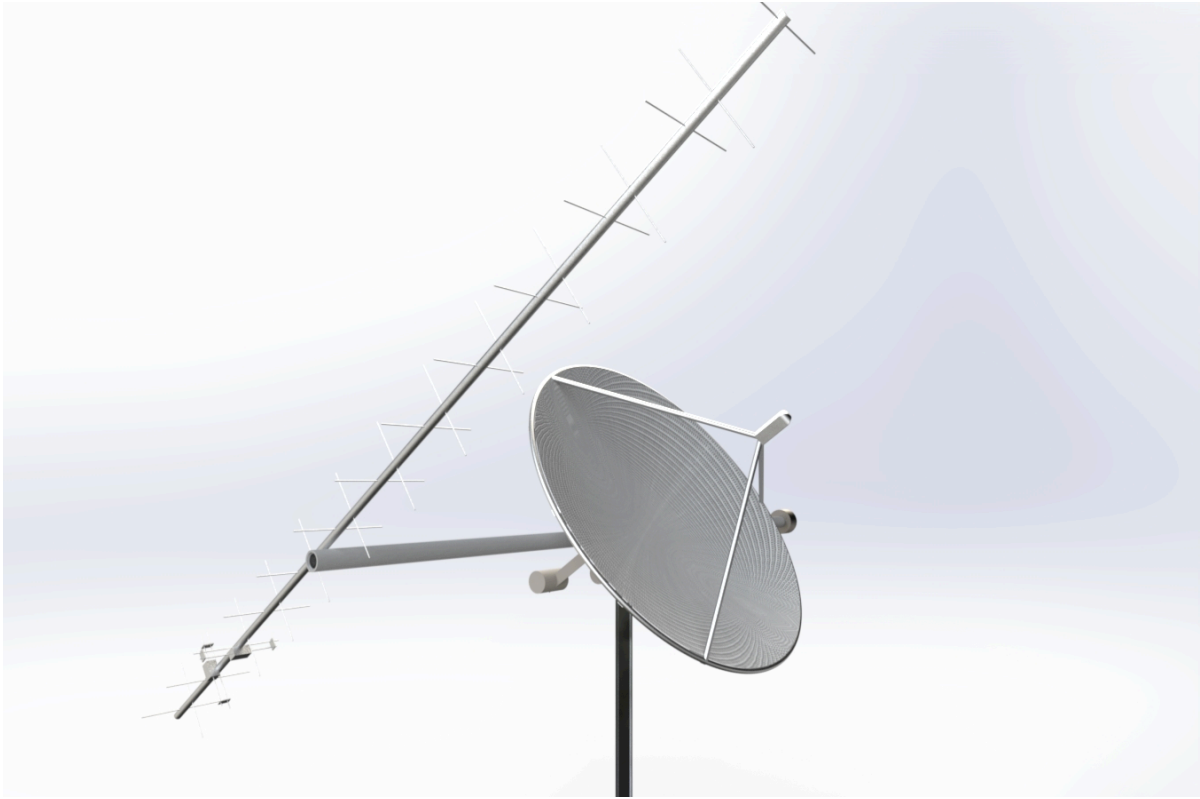
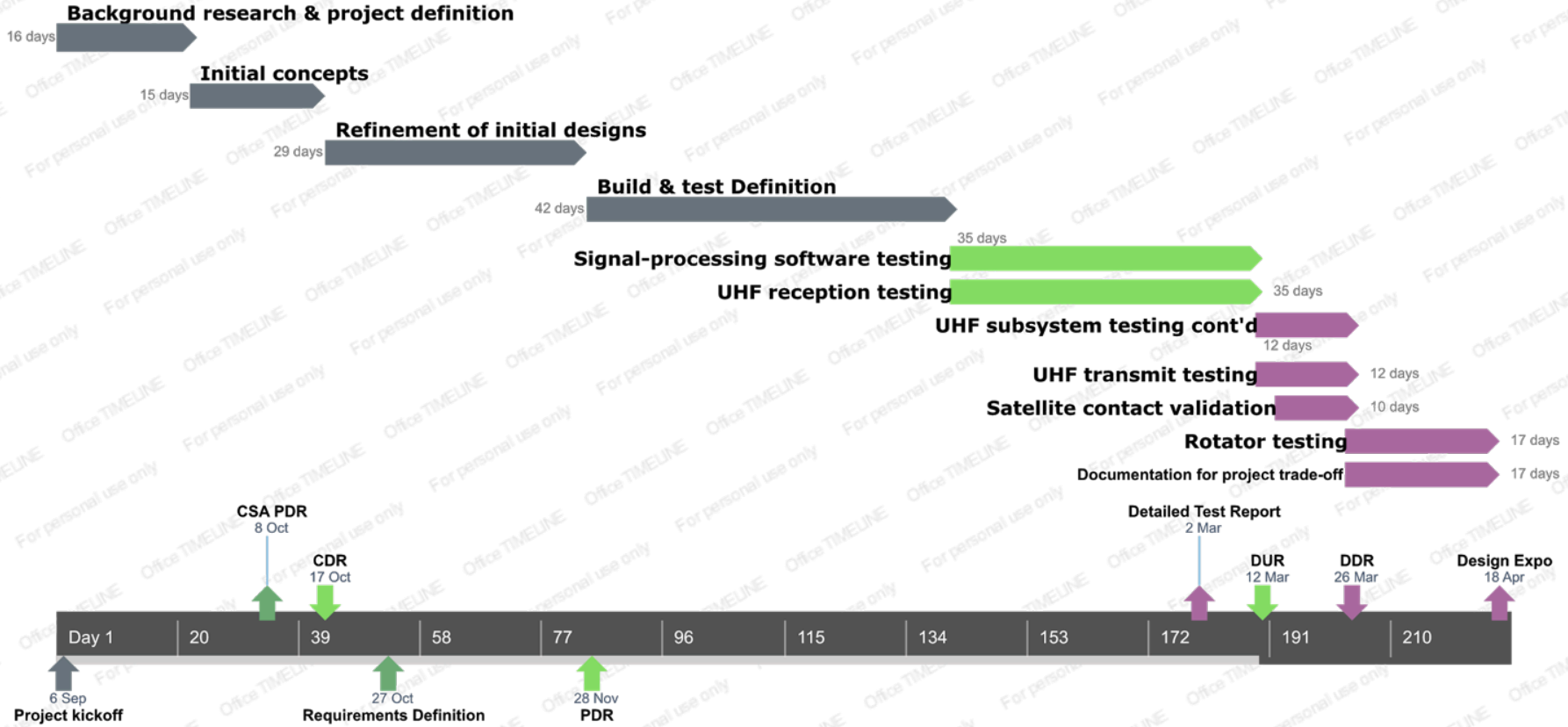
Presented to: ENGN 3720 Project Based Pro-Practice II
Instructors: Dr. Bishnu Acharya & Mr. David Taylor

Presentation Schedule

- Project Management
- Detailed Design
- Prototyping and Testing
- Road to Design Expo
- Conclusion

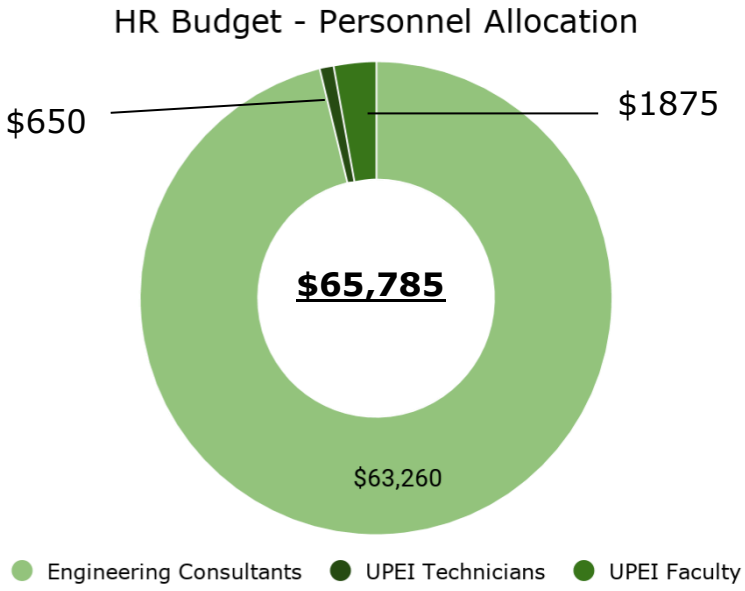


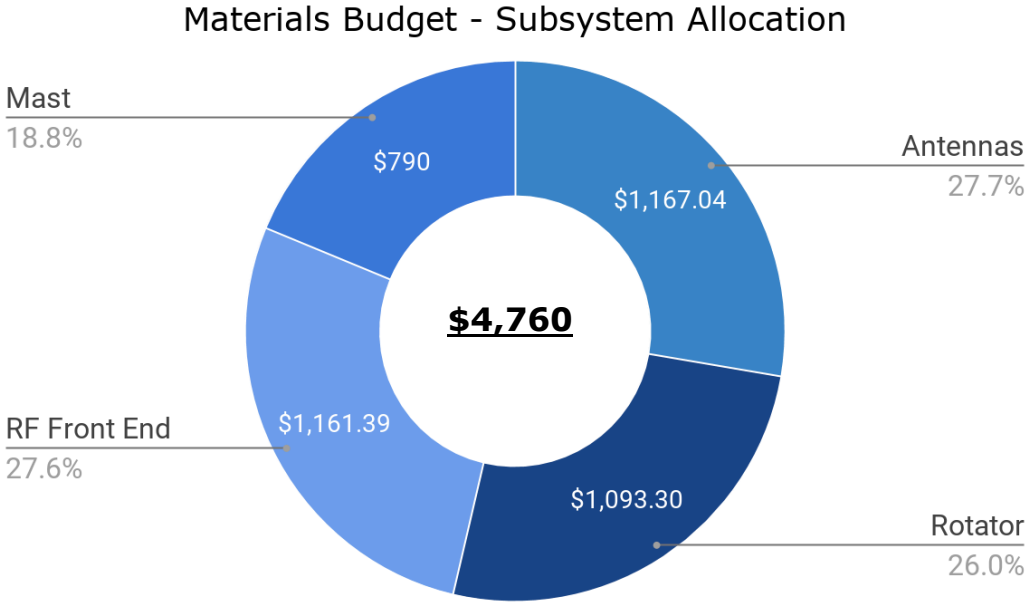
Project Management Update



Project Management Update

Budget Breakdown





Total current project budget = $70,545 CAD

Project Management Update

Risk Management

Initial high-level project risks

1. Licensing
2. Unfamiliarity with satcoms
3. Long-lead time items
4. Unreliable tracking system
5. No link between CubeSat and GS
6. Inappropriate radiation emissions
7. Insufficient time for full systems test
8. Component compatibility

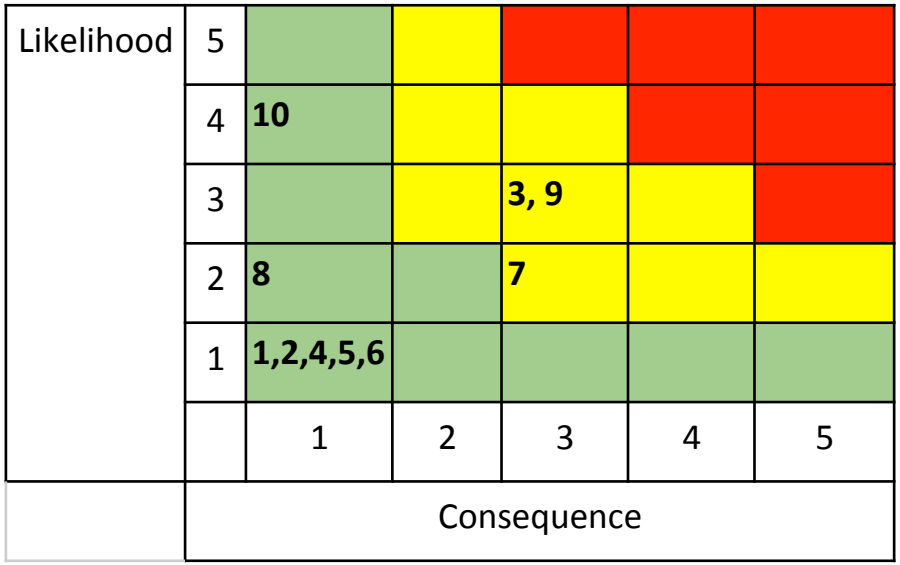
Likelihood	5			**8**		**3**
	4				**2,7**	**4**
	3			**1,6**		**5**
	2					
	1					
		1	2	3	4	5
	Consequence					

Project Management Update

Risk Management

Revised high-level project risks

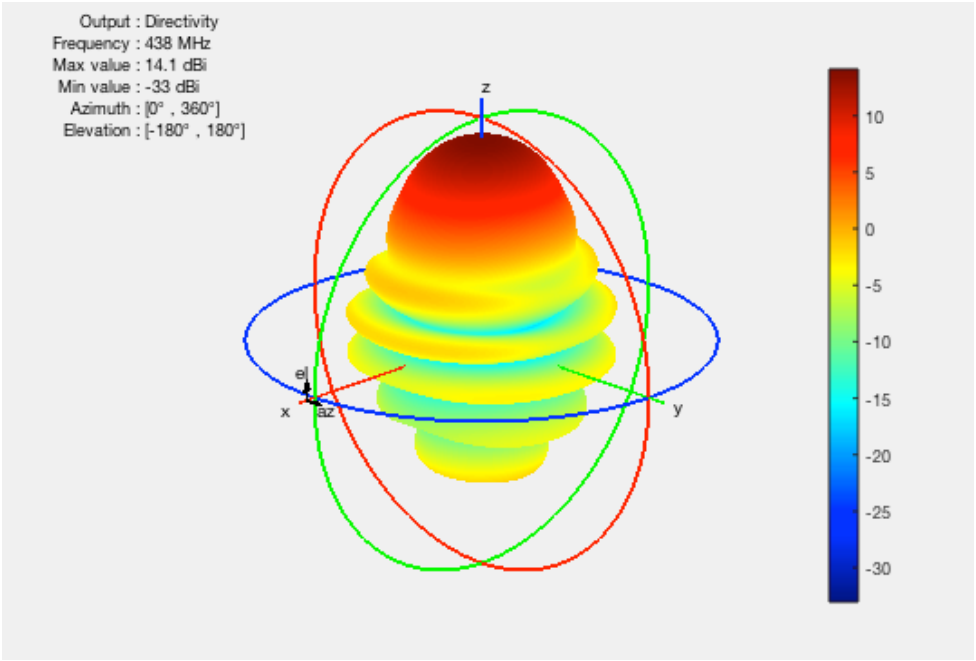
1. Licensing
2. Unfamiliarity with satcoms
3. Long-lead time items
4. Unreliable tracking system
5. No link between CubeSat and GS
6. Inappropriate radiation emissions
7. Insufficient time for full systems test
8. Component compatibility



Newly identified risks

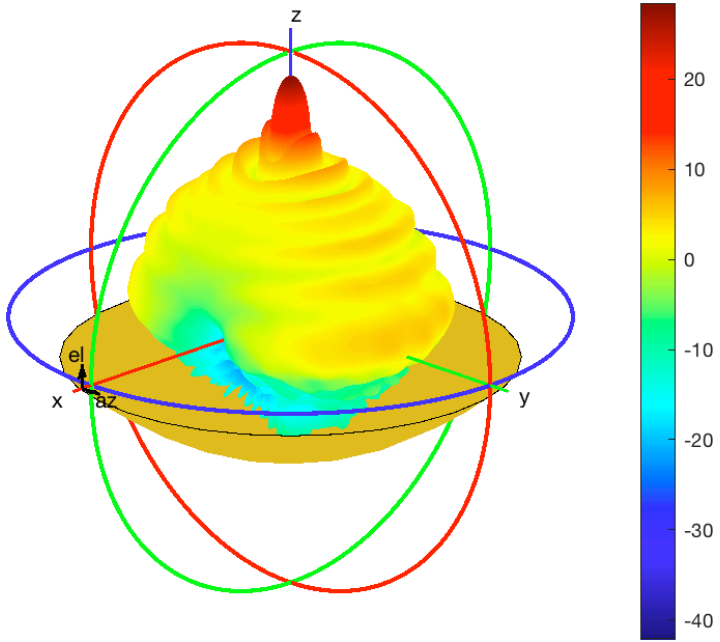
1. Shipping delay of international components
2. Changes to CubeSat comms system

Detailed Design



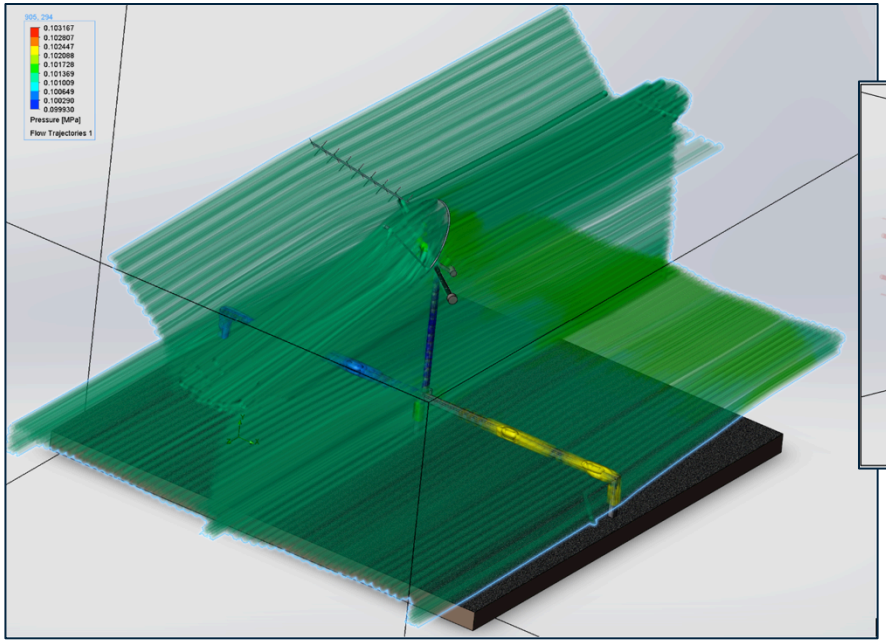
MATLAB model of Yagi radiation pattern

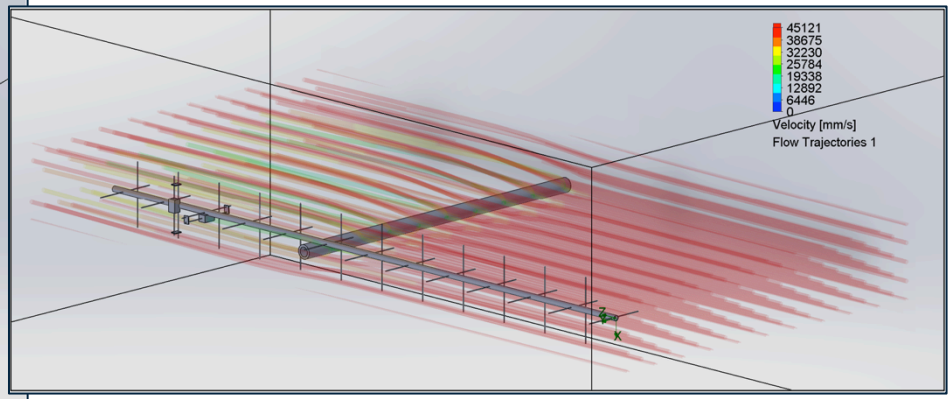
Detailed Design



MATLAB model of parabolic reflector radiation pattern

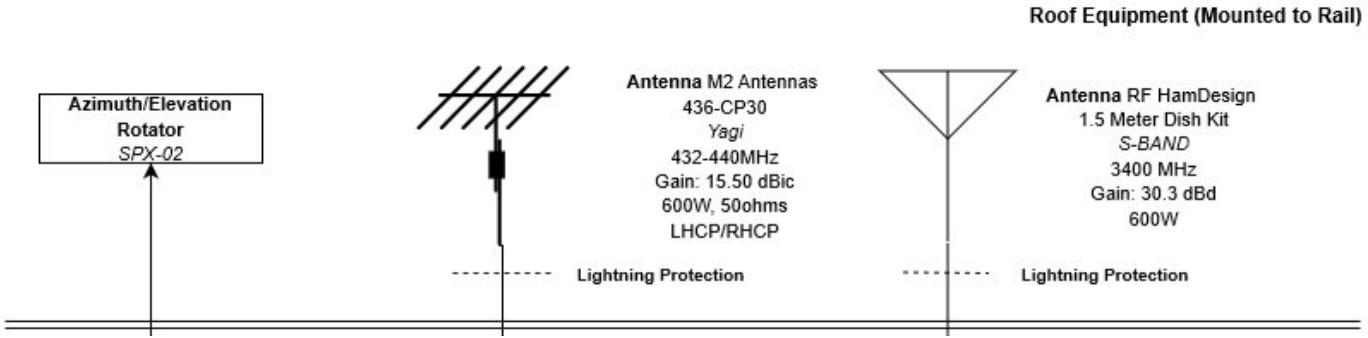
Detailed Design



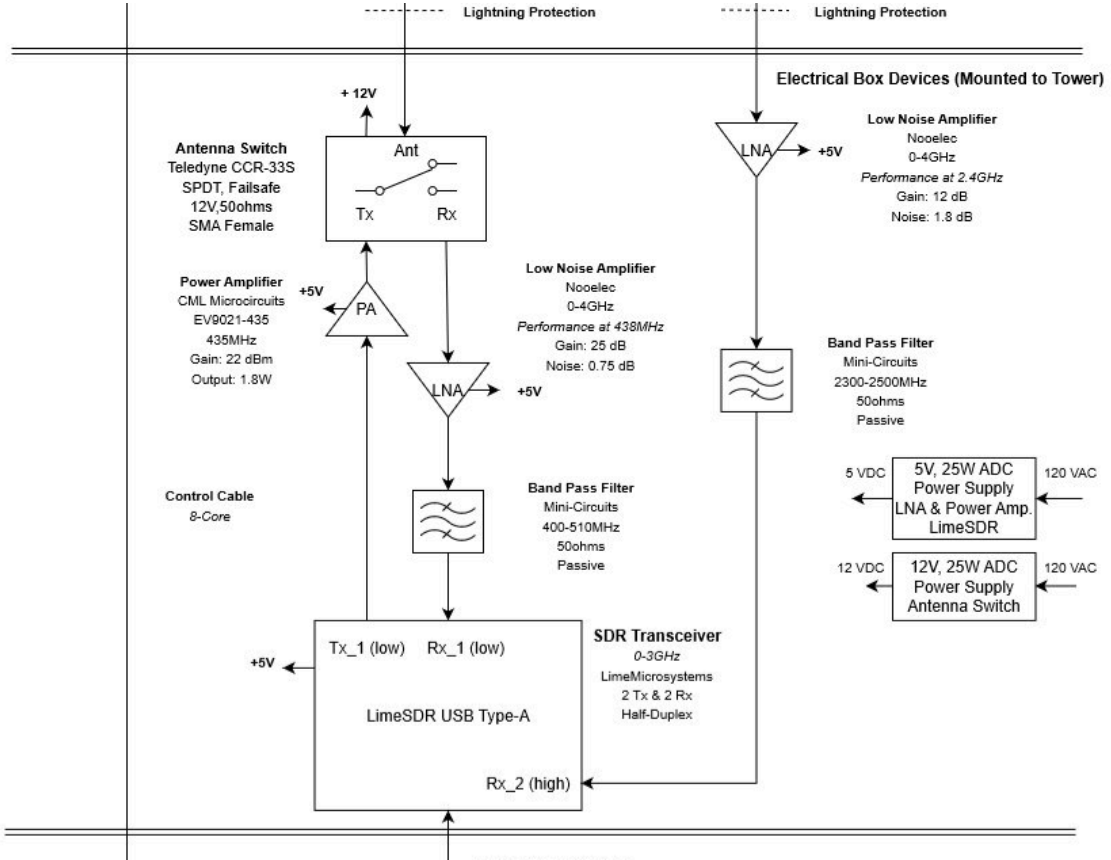


Solidworks wind loading simulations on full ground station (left) and on Yagi antenna (right).

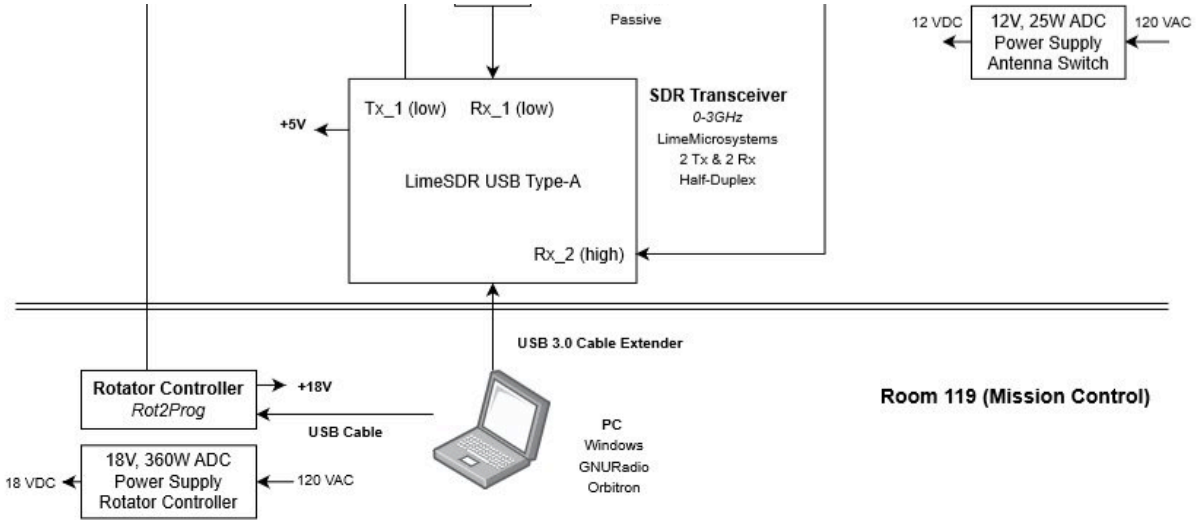
System Layout



System Layout



System Layout



Bill of Materials

Item	Manufacturer	Supplier	Quantity	Cost (CAD)	Part No.	Description
Antenna Assembly						
Yagi Antenna	M2 Antennas	R&L Electronics	1	$386.38	436CP30	UHF antenna.
1.5m Mesh Dish	RFHamdesign	RFHamdesign	1	390.15	FPB1M5KIT	Parabolic mesh dish for s-band antenna/
Dish Feed Antenna	RFHamdesign	RFHamdesign	1	$213.11	CIR2320	S-band antenna
Dish Feed Clamp	RFHamdesign	RFHamdesign	1	$177.40	CLX-06	Secures antenna to parabolic dish.

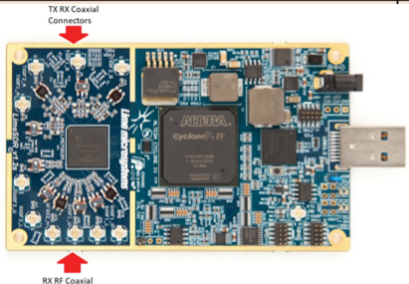
Bill of Materials

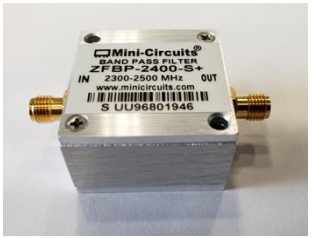
Rotator Assembly

Rotator w/ Controller	RFHamdesign	RFHamdesign	1
18V/20A Power Supply	Meishile	Amazon.ca	1
Controller Cable	RFHamdesign	RFHamdesign	25m

Bill of Materials

Item	Manufacturer	Supplier	Quantity	Cost (CAD)	Part No.	Description
RF Front End						
SDR Transceiver	Lime Microsystems	Crowd Supply	1	$391.69	N/A	Software-defined radio transceiver.
Low Noise Amplifier (Rx)	NooElec	Amazon.ca	2	$80.00	100812	Amplifies weak received signals
Power Amplifier (Tx)	CML Microcircuits	Digi-Key	1	$171.84	EV9021-435	Amplifies transmitted signals.
UHF Bandpass Filter	Mini Circuits	Mini Circuits	1	$79.95	ZABP-2400-S+	Filters out-of-band signals.
S-Band Bandpass Filter	Mini Circuits	Mini Circuits	1	$49.95	ZABP-450-S+	Filters out-of-band signals.





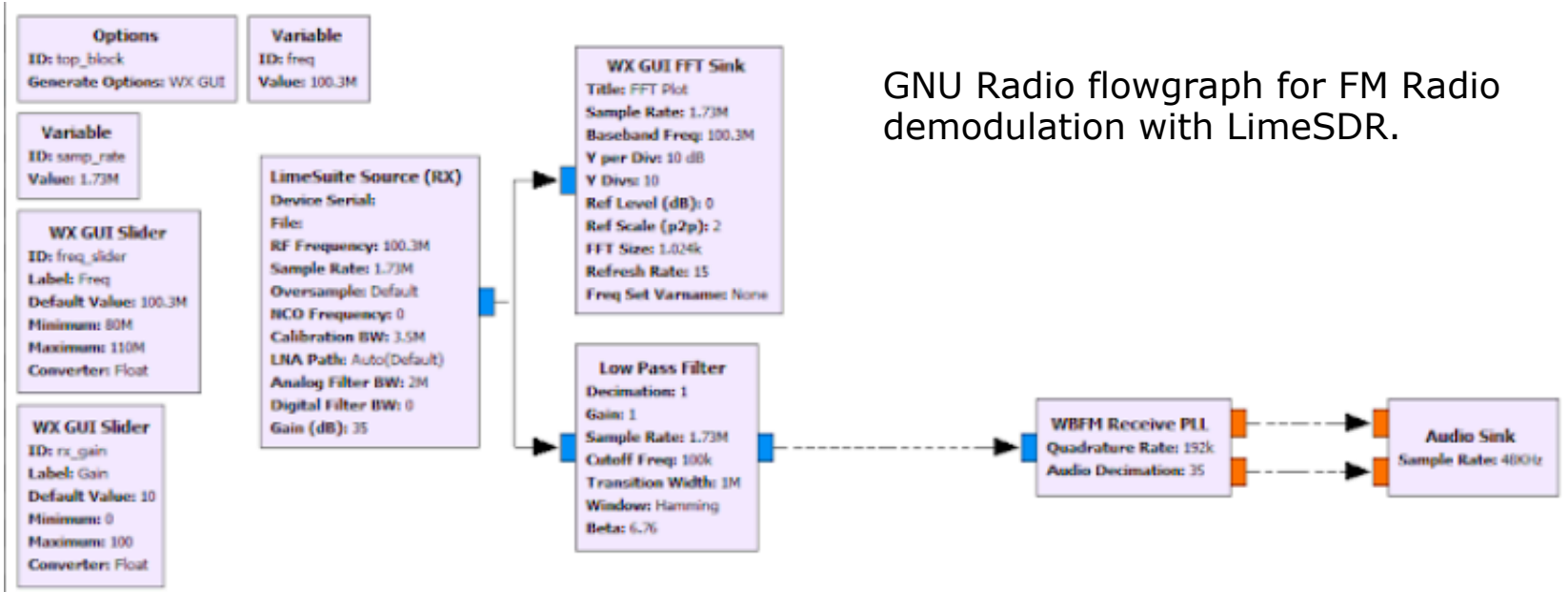
Bill of Materials

Item	Manufacturer	Supplier	Quantity	Cost (CAD)	Part No.	Description
RF Front End						
Rx/Tx Switch	Teledyne	Mouser	1	$200		Relay between Tx and Rx lines to protect devices.
5V, 25W Power Supply	MeanWell	Digi-Key	1	$18.98	RS-25-5	Power supply for amplifiers.
12V, 25W Power Supply	MeanWell	Digi-Key	1	$18.98	RS-25-12	Power supply for LimeSDR & Rx/Tx Switch
Misc. Short Coax Runs/Adapters	TBD	TBD	TBD	$100	TBD	Connects RF front end devices within electrical box
USB 3.0 active extension repeater cables	Tripplite	NewEgg	2	$220	TBD	Connects LimeSDR to mission control PC.

Bill of Materials

Item	Manufacturer	Supplier	Quantity	Cost (CAD)	Part No.	Description
Mast Materials						
Coaxial Cable	TBD	TBD	TBD	$150	TBD	Connects antennas with RF front end devices
Fiberglass Tube Cross-Boom	McMaster-Carr	McMaster-Carr	1	$75	8535K76	Locally sources, supports antennas and rotator
Expandable Foam	TBD	TBD	TBD	$15	TBD	Increases cross boom stiffness.
Metal and fasteners for tower	TBD	TBD	TBD	$350	TBD	Locally sourced, material for antenna tower
Electrical Box	TBD	TBD	1	$150	TBD	Locally sourced, enclosure to house RF front end devices.
Lightning Protection	TBD	TBD	TBD	$50	TBD	Protect components from surge damage.

Prototyping/Testing



GNU Radio flowgraph for FM Radio demodulation with LimeSDR.

Validates systems integration of antena, SDR and software. Can be modified to receive (and in transmit) digital data when modulation method is determined!

Prototyping/Testing

Standing Wave Radio Test

Measuring Yagi SWR using NanoVNA

- SWR = measure of impedance mismatch between antenna and feed line.
- Represents amount of RF energy “reflected” when transmitting
- Measured with Vector Network Analyzer (VNA)

Measured Yagi SWR = 1.49 : 1

Represents 4% of total transmitted RF energy reflected, or antenna efficiency of 96%.

Plan for Final Prototype

- Full systems integration and validation of UHF subsystem.
  - Antenna
  - Transceiver and front-end components
  - GNU Radio signal-processing codes for transmitting and receiving digital signals on UHF.

- Testing, validation, and integration of rotator subsystem.
  - Components should arrive in time for Expo, if not for DDR.
  - Short test period.

- Final prototype - Demonstrate that system can track and receive signals from passing satellites during Design Expo.

- "Phase 1" complete
  - Subsystem design decisions finalized
  - Hand-off plan for future students

Thank you!

The SpudNik-1 CubeSat Ground Station team would like to thank project PI Dr. Grant McSorley, technician Mr. Justin Perry, course instructors Mr. David Taylor and Dr. Bishnu Acharya, procurement liaisons Mrs. Janice Murphy and Mr. Wayne Simmons, IT technician Mr. Jeff MacDonald, and members of the PEI Amateur Radio community: Mr. Chris Vessey, Mr. Brent Taylor, Mr. Bill McMaster, and Mr. Bernie Cormier, as well as CSA CCP sat communications specialist Mr. Peter Kazakoff.

Backup Slides

Detailed Design

Link Budget

	UHF Uplink	UHF Downlink	S-band Downlink
Figure of Merrit (G/T)	-21.3 dB/k	-9.1 dB/K	
Modulation Method	GFSK	GFSK	DQPSK
System Margin (Eb/No)	17.9 dB at 19200 kbps	14.8 dB at 19200 kbps	
System Margin (SNR)	16.1 dB at 19200 bps	12.8 dB at 19200 kbps	

Filter Types