

**OKLAHOMA STATE UNIVERSITY**  
**CEAT UNDERGRADUATE PROJECT**  
**STANDARD OPERATING PROCEDURE**  
**Revision: 0621**

This document is for use by the Project Team to develop a Standard Operating Procedure (SOP) and sent to the NCL Safety Review Board. **The completed SOP should be shared with all the members of the team.** The SOP should be revised whenever a significant change to the location or scope of work occurs. The NCL and ENDEAVOR Safety Review Board (SRB) are available to assist in completion or review of the SOP. For questions, please email [ceatsop@okstate.edu](mailto:ceatsop@okstate.edu). Submit the completed SOP by emailing an electronic copy to [ceatsop@okstate.edu](mailto:ceatsop@okstate.edu) with the subject heading: SOP\_<Team/Group name>. The SOP should be submitted as a single document, using the following file name format (<team/group name>\_<date-of-submission> Ex: *ImpactTester\_2018-01-31*). Please allow at least two business days for approval or requested revisions.

**The following SOP generally follows under:**

<input type="checkbox"/>	SOP is for a general lab operation/process that could apply to several chemicals
<input checked="" type="checkbox"/>	SOP is for a specific protocol/experiment/procedure
<input type="checkbox"/>	SOP is for a specific chemical or class of chemicals with similar hazards

**Section I.**

Project Title:	Horizontal HF		
Principal Investigator/Project Manager:	Dr. Chuck Bunting	Department:	Electrical and Computer Engineering
Email:	charles.bunting@okstate.edu	Phone:	405-744-2479
Project Duration:	Fall 2025		

**Location of Fabrication/Testing** Include room number(s) as appropriate

NCL		ENDEAVOR	
ATRC		UAFS	
Other	Richmond Hills Research Labs (REFTAS Lab)		

OSU Contact Person:		Phone:	
Local (Field) Contact Person:	Dr. Pavithrakrishnan Radhakrishnan	Phone:	405-269-2044

**Group/Project Members** (Attach an addendum as needed)

Name	Email	Team Leader	Team Member
Juliette Reeder	juliette.reeder@okstate.edu	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Jack Hicks	john.hicks@okstate.edu	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Forrest Tuschhoff	ftuschh@okstate.edu	<input type="checkbox"/>	<input checked="" type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>

## Section II.

**Procedure Overview:** Provide a brief description of the project and/or procedure.

(Addendum document as needed)

Naval vessels rely on shipboard electronics that must operate safely in strong HF communication fields. The Naval Surface Warfare Center Dahlgren Division (NSWCDD) evaluates these systems' electromagnetic compatibility before deployment. Current testing procedures (HERO, EMV) use a vertical whip antenna with missiles suspended vertically; however, this setup is impractical for large missiles due to crane limitations and handling difficulties.

This project aims to develop a horizontal, broadband HF antenna capable of producing a uniform electromagnetic field for HERO and EMV testing. The antenna will feature a wide 3 dB beamwidth, reasonable VSWR across the HF band, and scalable design for high-power operation. To demonstrate feasibility, the team has assembled a large LPDA antenna for proof-of-concept horizontal testing.

The setup and takedown procedure ensures portability and field readiness: all wire elements are wound around insulators for transport, support beams and stakes are disassembled, and RF components such as the balun and coaxial cable are handled with care. During setup, supports are erected, the boom is connected, elements are unfurled, and tensioned using taught-line hitches to maintain proper geometry for testing.

### Section III.

Hazards Inherent to the Project (Check all that Apply)	
<input type="checkbox"/> Extreme Temperature (outside range of -20°F to 120°F) <input type="checkbox"/> Electrical Hazard > 50 volts or high current <input type="checkbox"/> Noise Generated > 85 dBA <input type="checkbox"/> Exposed Sharp Edges <input type="checkbox"/> Pinch points <input type="checkbox"/> Flying Debris or Impact <input type="checkbox"/> Pressure Vessel/Compressed Gas <input type="checkbox"/> Bungee Cables/Elastic Energy Storage <input type="checkbox"/> Fire Hazards (open flame, welding, cutting) <input type="checkbox"/> Handling Hazardous Materials <input type="checkbox"/> Dusts/Other Particulate Hazards <input type="checkbox"/> Work in Confined Space (natural or man-made) <input checked="" type="checkbox"/> Overhead Falling Objects <input type="checkbox"/> Heights (roofs, lifts, towers, catwalks, etc.)	<input type="checkbox"/> Trenching/Excavating <input type="checkbox"/> Explosion <input type="checkbox"/> Potential for Oxygen Deficiency or Other Atmospheric Hazard (i.e. gas, vapor) <input type="checkbox"/> Storage of Hazardous Materials on site <input type="checkbox"/> Lithium Batteries <input type="checkbox"/> Transportation of Hazardous Materials <input type="checkbox"/> Other: <b>Equipment Used</b> <input type="checkbox"/> Golf Cart/ATV/Go-Kart <input type="checkbox"/> Forklift <input type="checkbox"/> Tractor <input type="checkbox"/> Airborne Drone <input type="checkbox"/> Other

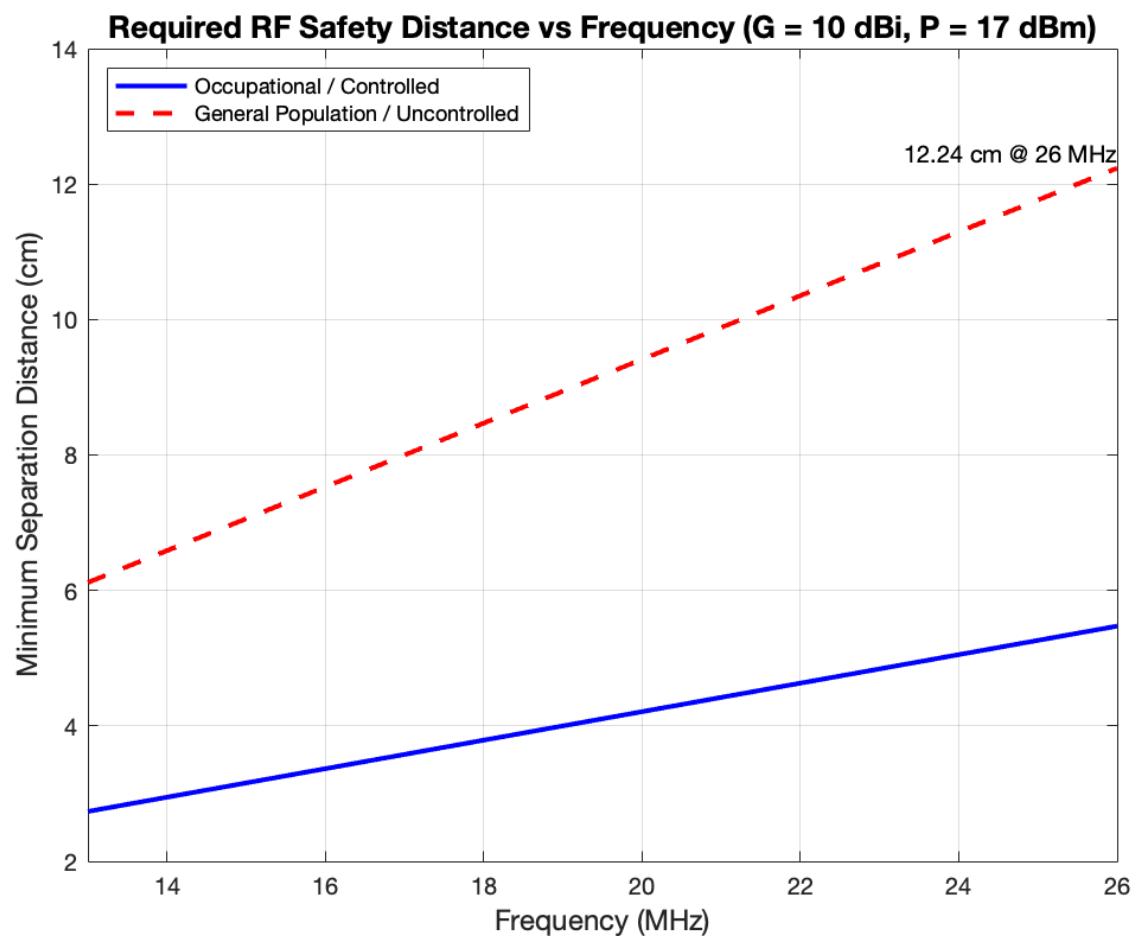
**Health and Safety Information:** Briefly describe the hazards associated with the materials or equipment used during the procedure. (Addendum document as needed)

Some ropes and wires will be above group members' heads. A **ladder will not be used** because ropes and wires will be affixed to top of pole before tilting it up and securing it with guy lines.

The metal stakes and ropes may present a **trip hazard**; nylon rope will be neon yellow and stakes will also be spray painted neon yellow.

#### No RF safety zone is necessary for this project as per MPE guidelines:

The transmitter in this project is limited to 17 dBm ( $\approx 0.0501$  W) and operates in the 13–26 MHz band. Using the OET Bulletin 65 / 47 C.F.R. §1.1310 method ( $S = PG/4\pi R^2$ ,  $S = E^2/377$ ) with the antenna maximum gain of 10 dBi (EZNEC prediction) yields conservative minimum separation distances to meet MPE limits. The maximum minimum-separation required for General-Population (uncontrolled) exposure is  $\approx 12.24$  cm (at 26 MHz); for Occupational (controlled) exposure the maximum is  $\approx 5.47$  cm. Required RF Safety Distance for the high and low frequencies are plotted below. Because these distances are only a few centimeters, **no special RF exclusion zone is required** for this project provided personnel are not located within  $\sim 0.13$  m of the antenna main-lobe (use the value appropriate to the actual frequency and orientation). The calculations assume continuous transmission and 30-minute averaging per OET guidance; if the duty cycle, time-averaged power, or actual antenna pattern differ, distances will change. (OET Bulletin 65; 47 C.F.R. §1.1310.)



### Adverse Weather Policy

- Wind advisory: decommission antenna
- Temperatures under 0°F: decommission antenna
- Ice or snow: decommission antenna 12+ hours in advance
- Monitoring: Regularly check weather apps for adverse weather warnings.
- Action: If precipitation, extreme temperatures, or wind advisory are within 25 miles, all testing must be halted and antenna must be decommissioned. Group members must seek shelter as soon as possible.
- Wait Time: Antenna shall not be reassembled until 24 hours after adverse weather.

### Lightning Safety Procedures

- Monitoring: Lightning is tracked within a 10-mile radius of location.
- Action: If lightning is detected within 10 miles, everyone must seek shelter immediately.
- Wait Time: Remain in shelter for 30 minutes after the last detected strike within 10 miles before resuming outdoor activities.

**JHA:**

Task Step	Potential Hazards	Controls / Mitigations
<b>1. Site Preparation</b>	Tripping over cables, uneven terrain, or stakes. Contact with overhead power lines.	Inspect site for obstructions before setup. Maintain a minimum 30 ft clearance from all overhead lines. Ensure all trip hazards are neon yellow in color.
<b>2. Equipment Inspection</b>	Cuts or abrasions from frayed wire or rope.	Wear gloves during inspection and handling. Replace any damaged wire or rope before use.
<b>3. Assembly of Support Poles (13 ft and 4 ft)</b>	Falling objects or poles during erection. Strain injuries from lifting.	Use at least two people to raise tall poles. Secure poles with tethers and stakes before release. Lift with knees, not back.
<b>4. Element Installation (Wire and Rope Tensioning)</b>	Rope burns or cuts from tensioning. Eye injury from snapping tensioned wire or rope.	Wear gloves and safety glasses. Maintain safe distance during tensioning. Do not over-tension elements.
<b>5. Electrical Setup (Balun and Coax)</b>	Electric shock from connected RF equipment. Trip hazards from loose coax cables.	Ensure all transmitters are powered off during connection. Route coax away from walkways and secure with cable ties.
<b>6. Operational Testing</b>	RF exposure, burns from high power transmission. Equipment damage due to mismatch or arcing.	Confirm proper grounding before transmitting. Maintain safe operator distance (per FCC RF exposure limits). Verify SWR < 2:1 before applying full power.
<b>7. Takedown and Transport</b>	Cuts, entanglement, or tripping during disassembly. Back strain from lifting poles or stakes.	Power down and disconnect RF equipment first. Coil wires loosely and store properly. Use proper lifting techniques or two-person carry for poles.
<b>8. Storage and Maintenance</b>	Equipment damage from moisture or rough handling.	Store all components in dry containers. Cap RF connectors and check for corrosion regularly.
<b>9. Adverse weather</b>		

## Section IV.

**Personal Protective Equipment or Clothing Required:** All activities require basic protection including appropriate clothing, hand protection, safety shoes/boots, and eye protection. Any additional PPE requirements based on the hazards identified as part of minimizing risk of exposure, injury or illness. (Check all that Apply)

Required checked if the SDS or safety procedures calls it out directly.

As Needed checked if the user elects to use but it not required.

	Dust Mask	Face Shield	Foot Protection	Hair Net	Protective Clothing	Respirator	Sun Protection	Breathing Apparatus	Eye Wash Station
Required	<input type="checkbox"/>								
As needed	<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>				
	Hand Protection	Hearing Protection	Safety Glasses	Safety Harness	Safety Helmet	Safety Vest	Laser Safety Glasses	Welding Mask	Safety Shower
Required	<input type="checkbox"/>								
As needed	<input type="checkbox"/>			<input type="checkbox"/>					

Other(s):

Respirator Type: Cartridge/Filter Type:	Laser Safety Class: Frequency	Fire Extinguisher Class:	Welding Type: Lens Shade:
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### Safety Training Required

<input type="checkbox"/> Advanced First Aid	<input type="checkbox"/> Confined Space
<input type="checkbox"/> CPR	<input type="checkbox"/> Laser Safety
<input type="checkbox"/> Emergency Action and Preparedness	<input type="checkbox"/> Forklift/Other Heavy Equipment
<input type="checkbox"/> Project Specific Hazard Communication	<input type="checkbox"/> N95 Particulate Mask Disclaimer
<input type="checkbox"/> Compressed Gasses	<input type="checkbox"/> Respiratory Protections
<input type="checkbox"/> HotWorks (Welding, Torch/Plasma Cutting)	<input type="checkbox"/> Fire Extinguisher
<input type="checkbox"/> Ladder	<input type="checkbox"/> Other:

## Section V.

**Method Procedures:** Give a step-by-step instruction for the procedure. (Addendum document as needed)

### Initial Assembly:

Antenna shall be a large LPDA antenna, with the longest element 37.8 feet in length and the antenna boom 32 feet in length. The antenna boom shall be composed of rope and wire, and all elements shall be wires held in tension via stakes, with rope secured to the stakes using a taught line hitch. Dog-bone insulators shall be used to connect rope to wire, using a bowline knot. The antenna shall be angled, with the largest elements meeting at a height of close to 13 feet, while the shorter elements shall meet at a height of around 3 feet. A 13 foot pole with tether supports and stakes shall be used for the taller support beam, and a 4 foot PVC pipe shall be used for the shorter support beam.

### Setup/Takedown Procedure:

Antenna shall be made portable by wrapping wire elements around dog-bone insulators for transport. Central boom shall be removed from support beams. Stakes shall be removed and transported separately. Discrete parts for transportation shall be: central boom with all elements rolled around insulators, loosely rolled; 13 foot support beam; 4 foot support beam; all stakes; 4:1 balun and coaxial cable, taking special care transporting fragile RF connectors. Setup shall occur in reverse: supports shall be erected, central boom shall be connected, elements shall be unfurled, elements shall be retied to stakes using taught line hitch to hold elements under tension.

1. Preparation
  - a. Inspect all antenna components for wear or damage (wires, rope, insulators, stakes, poles, balun, and coax).
  - b. Verify site safety: level ground, no overhead lines, and adequate distance for HF operation.
  - c. Lay out the 32 ft boom on the ground and confirm element spacing per the design chart.
2. Initial Assembly
  - a. Attach each wire element to a dog-bone insulator using a bowline knot.
  - b. Connect rope between insulator and stake point using a taut-line hitch for adjustable tension.
  - c. Erect the 13 ft main support pole (with tethers and stakes) and 4 ft secondary support (PVC pipe).
  - d. Raise the boom between supports so that large elements reach ~13 ft height and shortest elements ~3 ft.
3. Deployment
  - a. Unroll each element and secure to its respective stake, keeping uniform spacing and alignment.
  - b. Attach the 4:1 balun at the feedpoint and connect the coaxial feedline with proper strain relief.
  - c. Confirm all elements are under even tension and not contacting the ground or other wires.
4. Operation
  - a. Ensure the transceiver and power supply are properly grounded.
  - b. Connect the feedline from the balun to the transceiver output.
  - c. Verify that the antenna tuner (if used) is in bypass or set for the intended frequency band.
  - d. Begin with low RF power (<=10 W) and verify acceptable SWR.
  - e. Gradually increase power, until reaching 100 W PEP (DO NOT EXCEED 1500 W PEP -- General class limit per FCC Part 97).
  - f. During operation, regularly monitor:
    - i. SWR readings for sudden increases (indicating detuning or loose connections)
    - ii. Support stability (tensioned ropes and stakes)
    - iii. Feedline strain relief and connector integrity
  - g. If high SWR or instability occurs, immediately cease transmission and inspect connections and element tension.

5. Testing
  - a. Perform continuity and impedance checks before applying RF power.
  - b. Measure VSWR across the HF band; adjust element tension or height as needed.
  - c. During test operation, monitor for arcing, imbalance, or high SWR and correct immediately.
6. Takedown
  - a. Power down and disconnect all RF connections.
  - b. Detach elements, coiling each wire around its insulator for storage.
  - c. Remove boom and support poles; collect all stakes, tethers, and cables separately.
  - d. Protect RF connectors with caps and store all components in a dry container.
  - e. Store equipment with ropes and wires loosely coiled to prevent kinking.

FCC License is required for this project. Group leader, Juliette Reeder, holds a General License for Amateur Radio through the FCC, which allows for transmit in the HF range.

Call sign: KJ5HDX

License Class: General

Expiration: 08/09/2034

## FCC License Data Search Results

Search by:	<b>REEDER, JULIETTE, KJ5HDX</b>
Call Sign:	6310 Windmill Cir
	DALLAS, TX 752522425
	Licensee ID: L02830619
Name:	License Class: General
	FRN: 0035772383
City:	Radio Service: HA
	Issue Date: 08/09/2024
State:	Expire Date: 08/09/2034
	Date of Last Change: 09/22/2025 (License Modified)

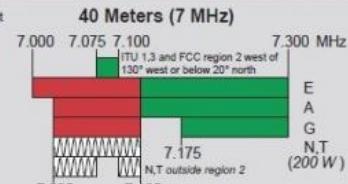
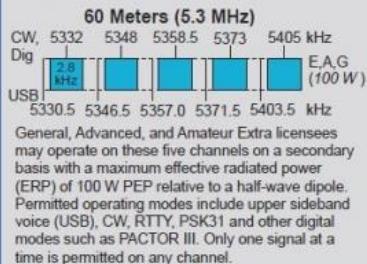
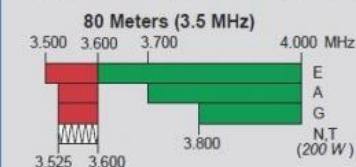
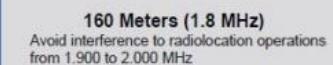
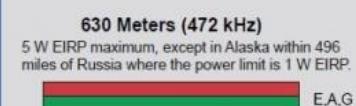
# US Amateur Radio Bands

US AMATEUR POWER LIMITS — FCC 97.313 An amateur station must use the minimum transmitter power necessary to carry out the desired communications. (b) No station may transmit with a transmitter power exceeding 1.5 kW PEP.



ARRL The national association for AMATEUR RADIO®

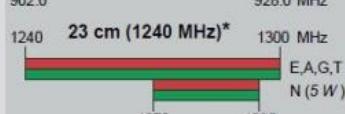
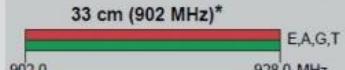
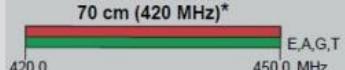
Amateurs wishing to operate on either 2,200 or 630 meters must first register with the Utilities Technology Council online at <https://utc.org/plc-database-amateur-notification-process/>. You need only register once for each band.



See Sections 97.305(c), 97.307(f)(11) and 97.301(e). These exemptions do not apply to stations in the continental US.



\*Geographical and power restrictions may apply to all bands above 420 MHz. See *The ARRL Operating Manual* for information about your area.



All licensees except Novices are authorized all modes on the following frequencies:

2300-2310 MHz 10.0-10.5 GHz ‡ 122.25-123.0 GHz

2390-2450 MHz 24.0-24.25 GHz 134-141 GHz

3300-3500 MHz 47.0-47.2 GHz 241-250 GHz

5650-5925 MHz 76.0-81.0 GHz All above 275 GHz

‡ No pulse emissions

## KEY

= RTTY and data
= phone and image
= CW only
= SSB phone
= USB phone, CW, RTTY, and data
= Fixed digital message forwarding systems only
E = Amateur Extra
A = Advanced
G = General
T = Technician
N = Novice

See *ARRLWeb* at [www.arrl.org](http://www.arrl.org) for detailed band plans.

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Exams: 860-594-0300 email: [vec@arrl.org](mailto:vec@arrl.org)

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## Section VI.

**Waste Disposal:** Give a step-by-step instruction for the procedure (if applicable). (Addendum document as needed)

N/A

## Section VII.

### **End of Project/ Decommissioning Procedure:** Directions for end of project disposition.

- Is it to be moved to a specific location for immediate student or research use? If so, specify the location and any precautions to be taken before transport.
- Is it to be stored in a specific place for use later? If so, what needs to be done prior to long term storage? Fluids drained? Lines purged? Partially disassembled?
- Will it be dismantled? If so, are there any precautions that should be observed? Hazardous materials to be disposed of? Is there a certain order in which it should be taken apart?

If this project carries over then indicate end target date. (Addendum document as needed)

Antenna shall be decommissioned in the same manner as takedown for transport. Wire elements shall be wrapped around dog-bone insulators. Central boom shall be removed from support beams. Stakes shall be removed and stored separately. Discrete parts shall be: central boom with all elements rolled around insulators, loosely rolled; 13 foot support beam; 4 foot support beam; all stakes; 4:1 balun and coaxial cable, taking special care storing fragile RF connectors.

1. Detach elements, coiling each wire around its insulator for storage.
2. Remove boom and support poles; collect all stakes, tethers, and cables separately.
3. Protect RF connectors with caps and store all components in a dry container.
4. Store equipment with ropes and wires loosely coiled to prevent kinking.

All materials shall be stored, clearly marked, in REFTAS lab, to be available should project carry over to Spring 2026.

## Section VIII.

**First Aid Procedures:** Give a step-by-step instruction for the procedure. (Addendum document as needed)  
This section should also contain the address and location(s) that the SOP will be used.

**All incidents require that as soon as possible the Instructor of Record and Profession Staff over lab be notified.**

Location: 5202 N Richmond Hill Rd, REFTAS Lab (west end of building)

Location of Nearest Hard Phone Line or Emergency Callbox: 5202 N Richmond Hill Rd

Nearest Location of a solid Cell phone signal: 5202 N Richmond Hill Rd

Emergencies:

- One person is assigned to stay with the injured personal
- One person should be assigned to call 911, this person will stay on the phone and state the following
  - Location of the accident (This should include building and room)
  - Type of injury
- One person should be assigned to escort the emergency response crew to the location

## Section IX.

**Spill/Release Containment, Decontamination, and Clean-up Procedures:** Give a step-by-step instruction for the procedure (if applicable). (Addendum document as needed)

N/A

## Section XI.

**Approvals Required:** Describe any special approvals required before conducting this work such as approval by Principal Investigator or lab supervisor before beginning work (if applicable). (Addendum document as needed)

N/A

## Section X.

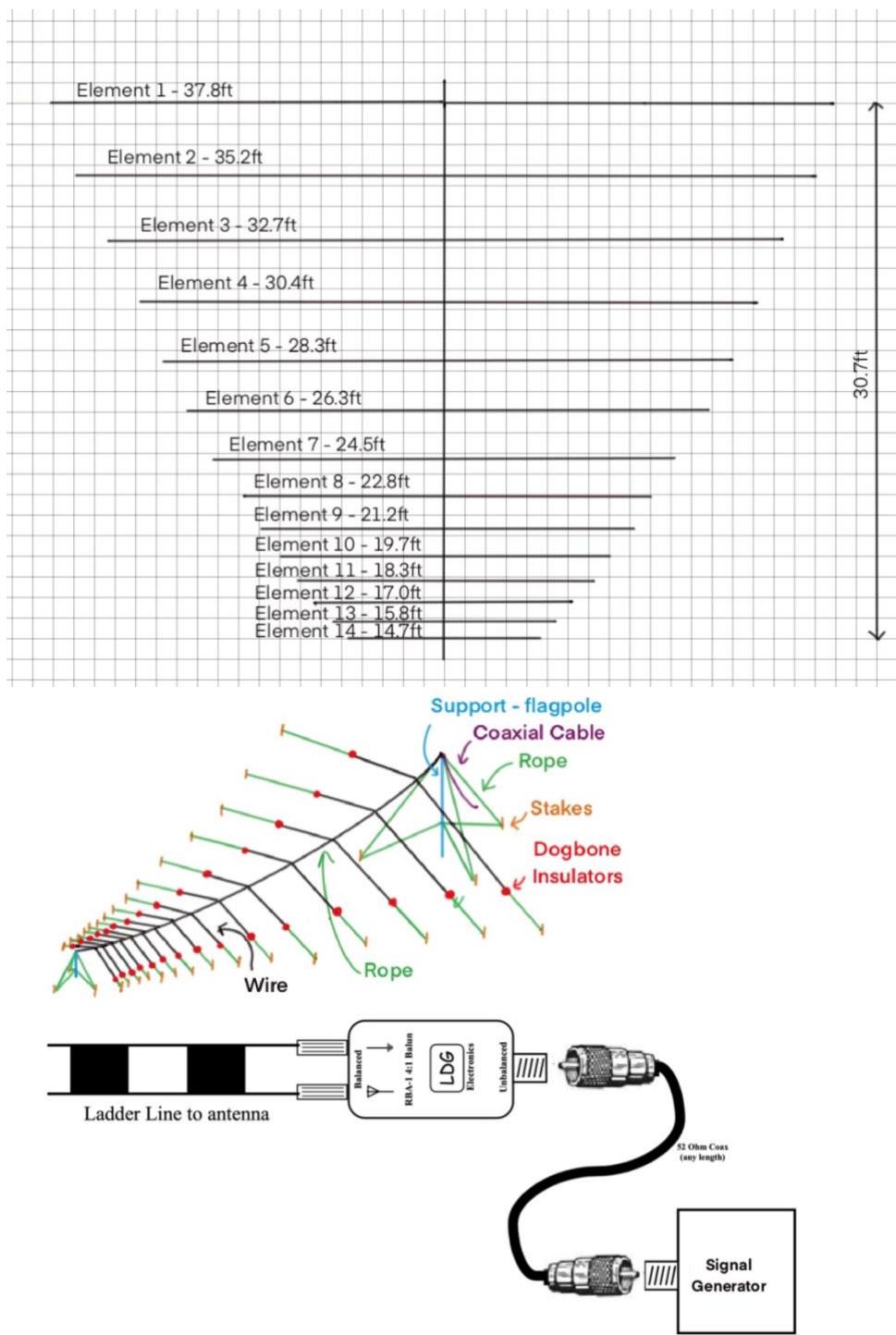
**Designated Area/Communications:** (For work involving particularly hazardous dangers, identify the area where the work will be conducted and to where it will be confined; identify any communication that will be done to assure others know the hazards and location of this work.) (if applicable). (Addendum document as needed)

N/A

## Section XII.

**Piping, Wiring, and Instrumentation diagram:** (This should include a detailed schematic illustration of the functional relationship of piping, instrumentation, and system equipment components. Should include expected loads (Voltage, Current, Flow Rate, Pressure, etc.)

(Attach separate page(s) with document if necessary)



Transmit signal will not exceed 1500 watts PEP due to FCC guidelines and is unlikely to exceed 100 watts.

The section below will be filled out using Adobe E-Sign Do Not Fill out.

Once the SRB has approved the document, all team members will be required to electronically sign the document below.

By signing below, I certify that I have read the Standard Operating Plan (SOP) and agree that all listed participants and I will abide by the SOP and adhere to all OSU policies and procedures as well as any local policies, procedures or guidelines.

PI Signature: \_\_\_\_\_

Participants: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Course  
Instructor(s): \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

SRB: \_\_\_\_\_  
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### **Section XIII.**

**Attachment Section:**