NORTHROP GRUMMAN

SAR Imager

DESIGN REVIEW II

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Outline

- Project Scope
- 1st Generation
- SAR Theory
- Calibration & Testing
- Future Plans

SAR Introduction

What is an SAR?

Synthetic Aperture Radar: Typically, a single antenna is attached to an aircraft flying over a target zone capturing several high resolution images to create a single image map.

- Typically for Military

Project Scope

- **Objective:**
  - Develop a static, multi-antenna Synthetic Aperture Radar (SAR) Imager
    - In brief: Giant metal detector

- **Why?:**
  - Security – Prevention of guns, knives, or dangerous objects from entering public facilities
    - Schools
    - Airports
    - Office buildings

First Generation Goals

- Create a Synthetic Aperture Radar:
  - Project Features:
    - Weapons detection for homeland security
    - Multi-Antenna
    - Stationary
    - Low resolution
    - Concealable
    - Low Cost
    - Relatively mobile

1st Generation Project – Class of 2015

Second Generation Goals

Mechanical Engineering

- Mobility
- Lower Weight
- Horn Adjustment
- Increase Stability
- Minimize Cost

Electrical Engineering

- Identify reflector at 20 feet
- Standalone functionality

Current Status

Task	Design	Prototype	Optimization
Component Testing	✓	N/A	✓
Signal Processing	✓	N/A	o
Data Processing & Image Formation	✓	N/A	o
Structure	✓	✓	o
Component Housing	✓	o	✗
Horn Holders	✓	✓	o
Testing & Calibration Equipment	✓	✓	o

Legend
✗ - Not Started
o - In Progress
✓ - Completed

Conventional SAR

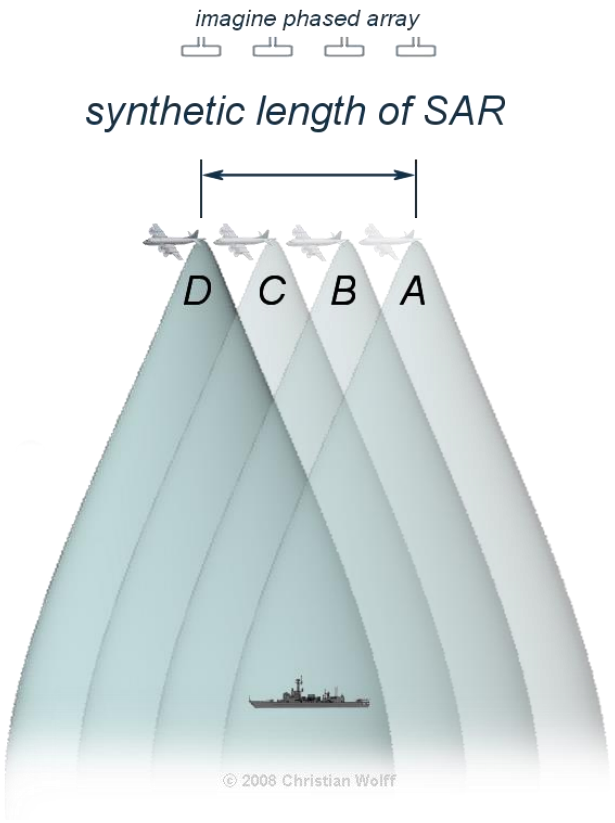
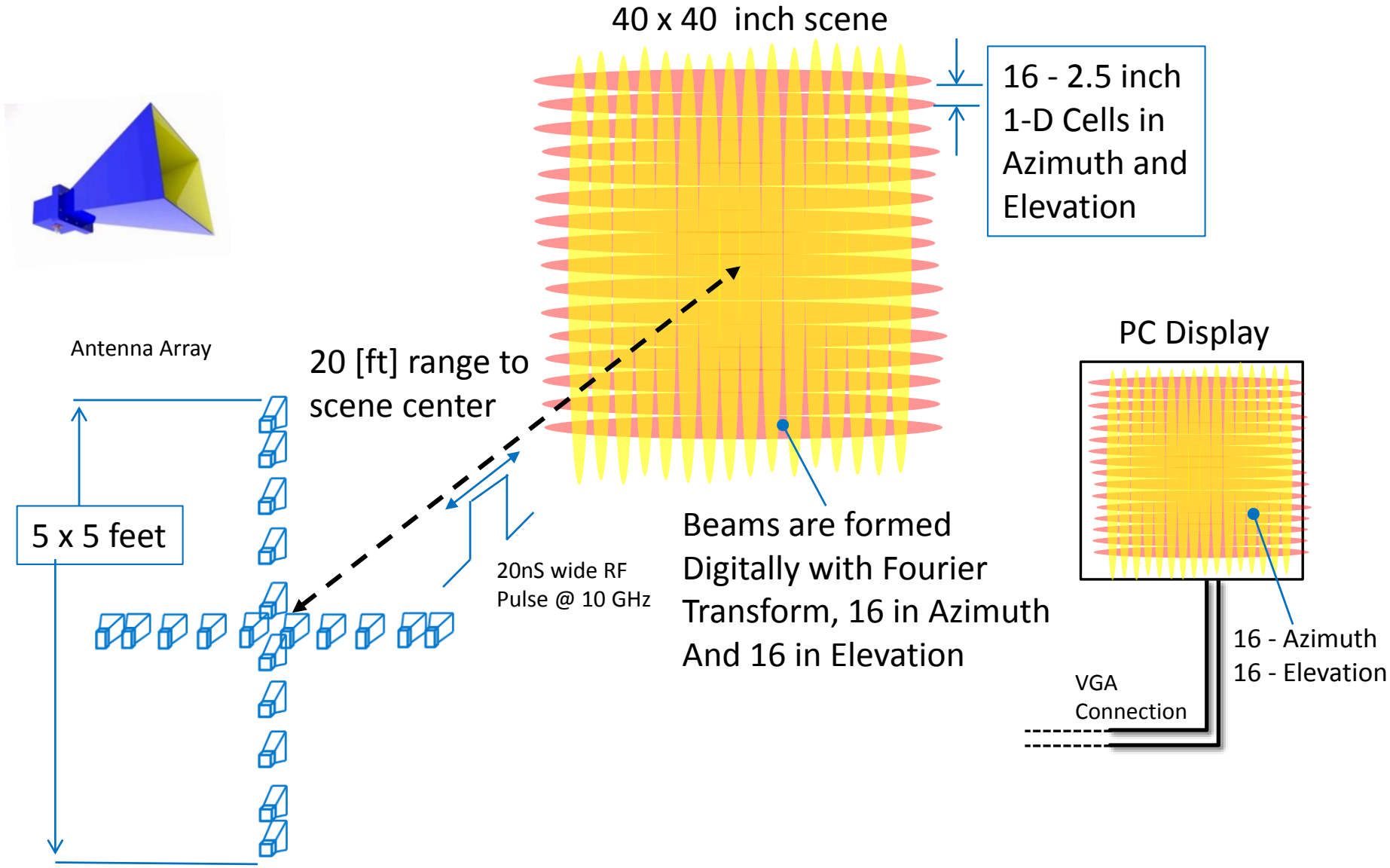


Image Formation

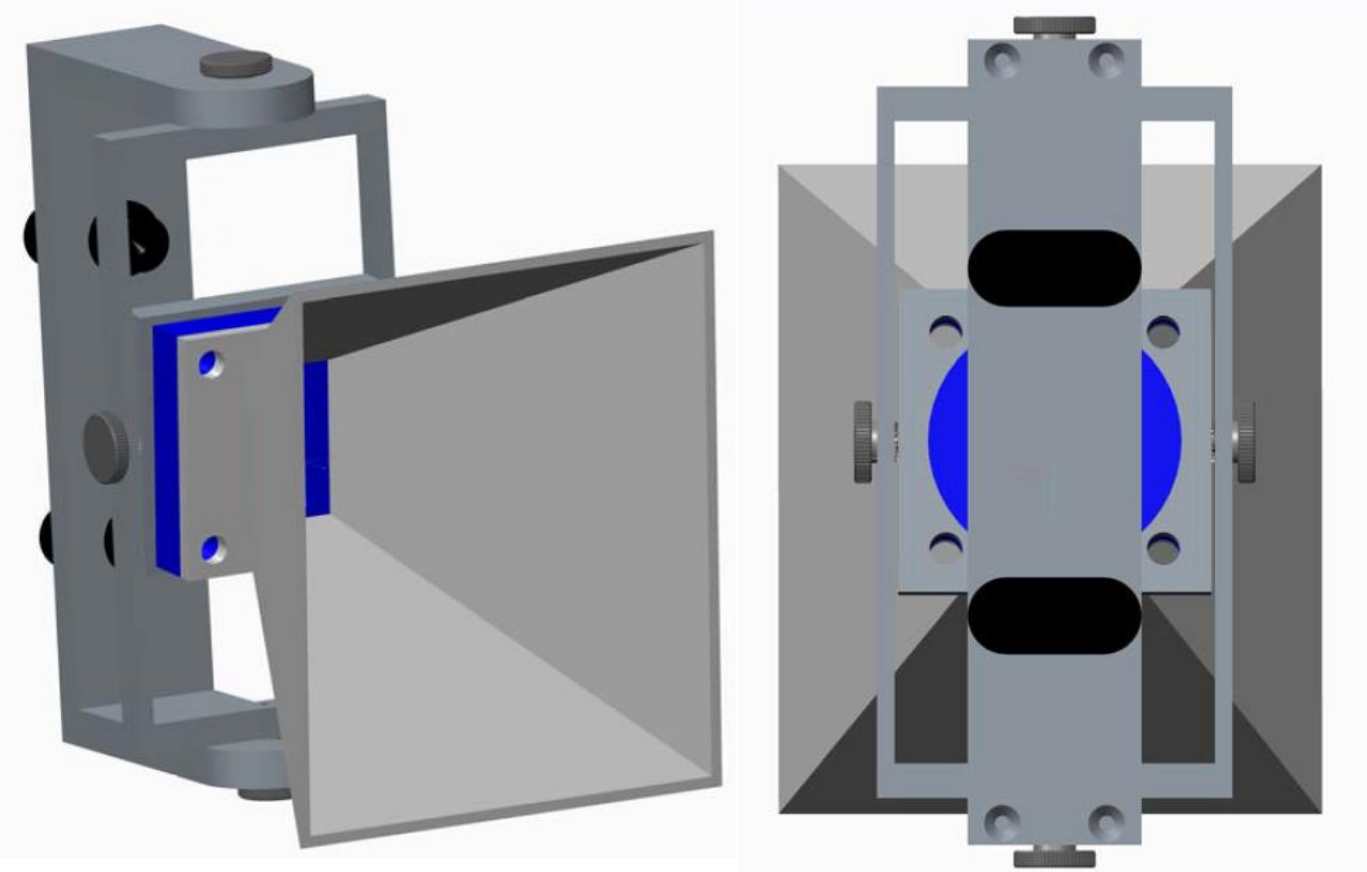


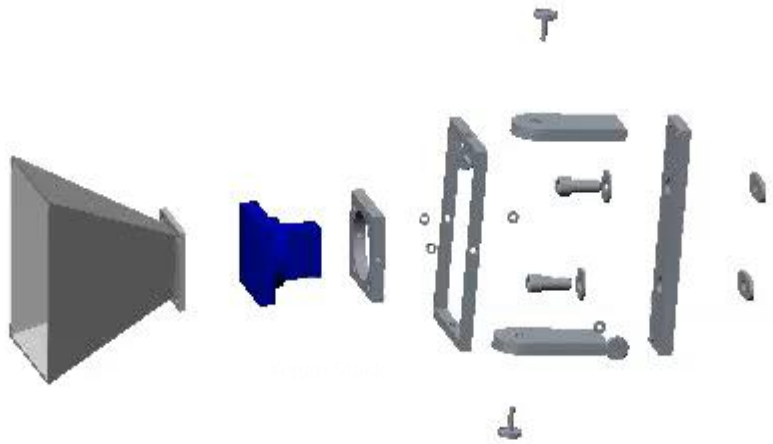
Horn Holder Design

- Design Goals
  - Independent axis adjustability
  - Independent axis locking
  - Lightweight
  - Ease of adjustability and alignment
  - No clearance issues

Final Design Iteration

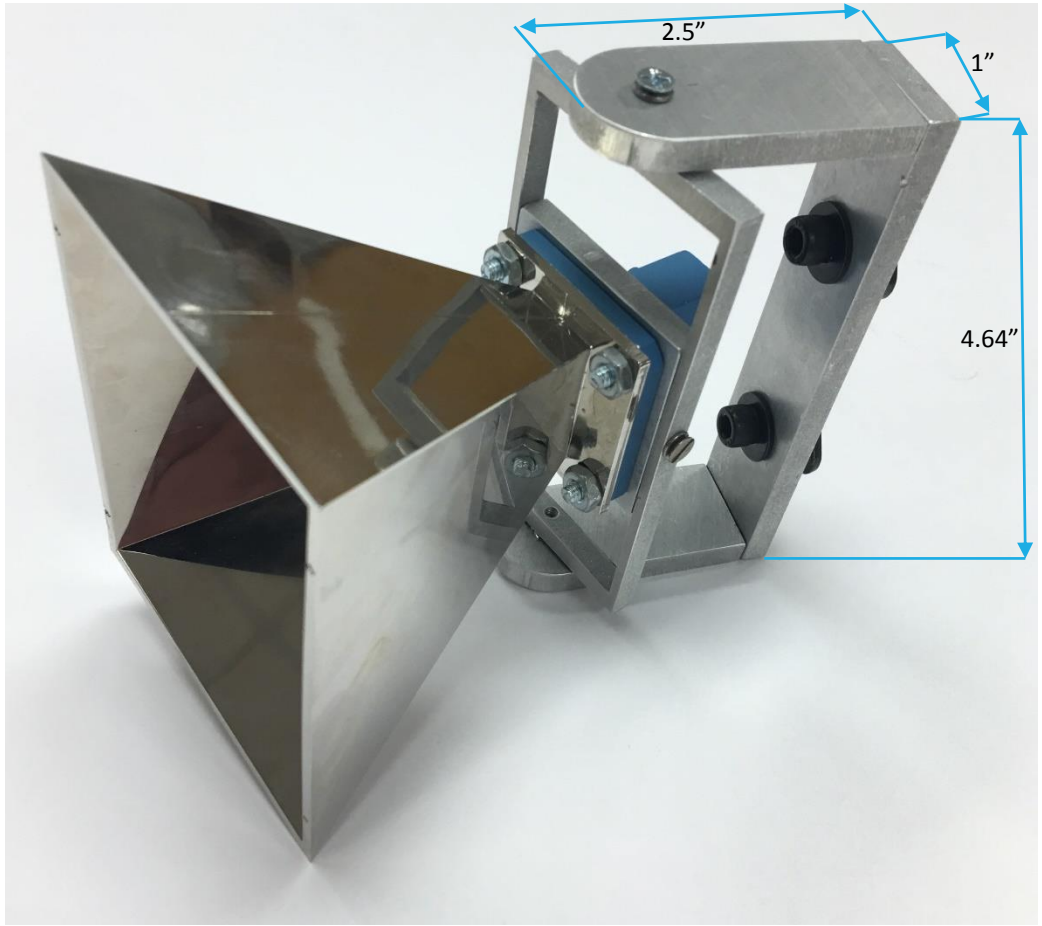
- Removed clearance issues
- Moved axis of rotation
- Minor dimensional changes
- Corrected T-nut series





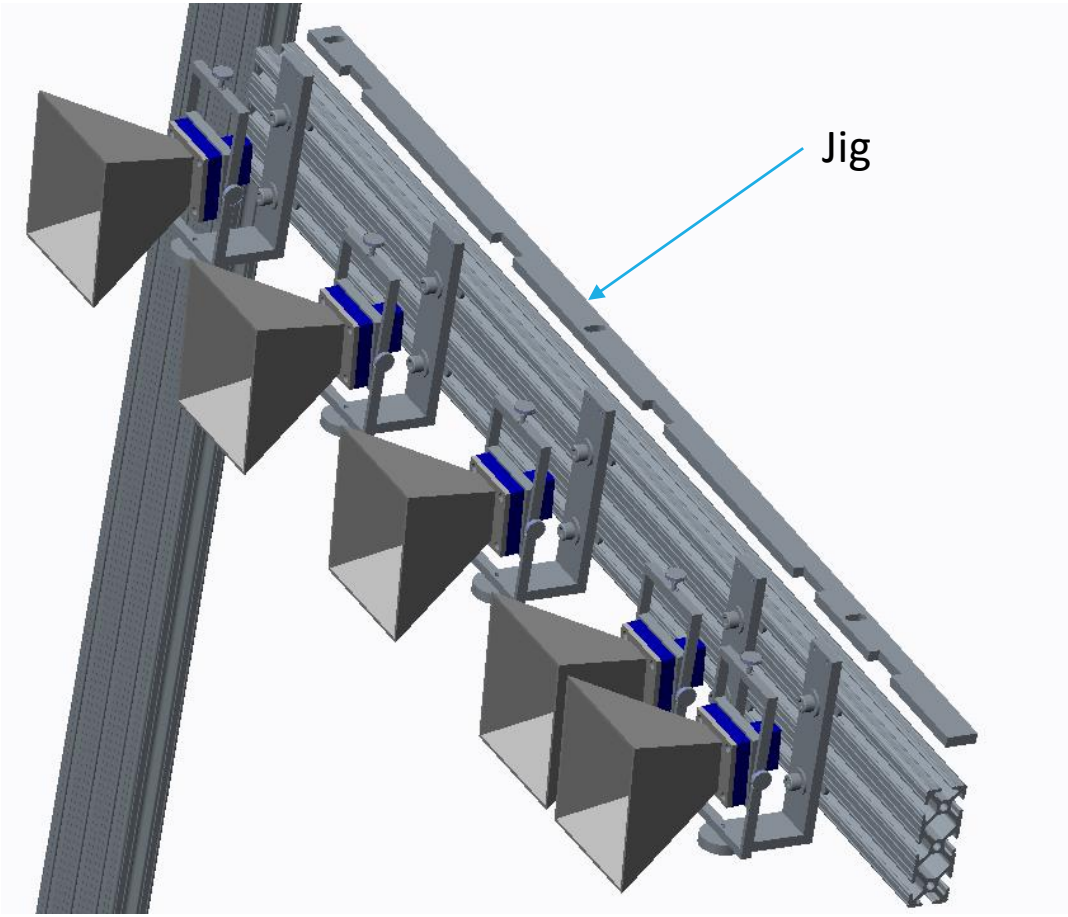
Explode State:EXOLODEEEEEE(+)

Horn Holder Prototype



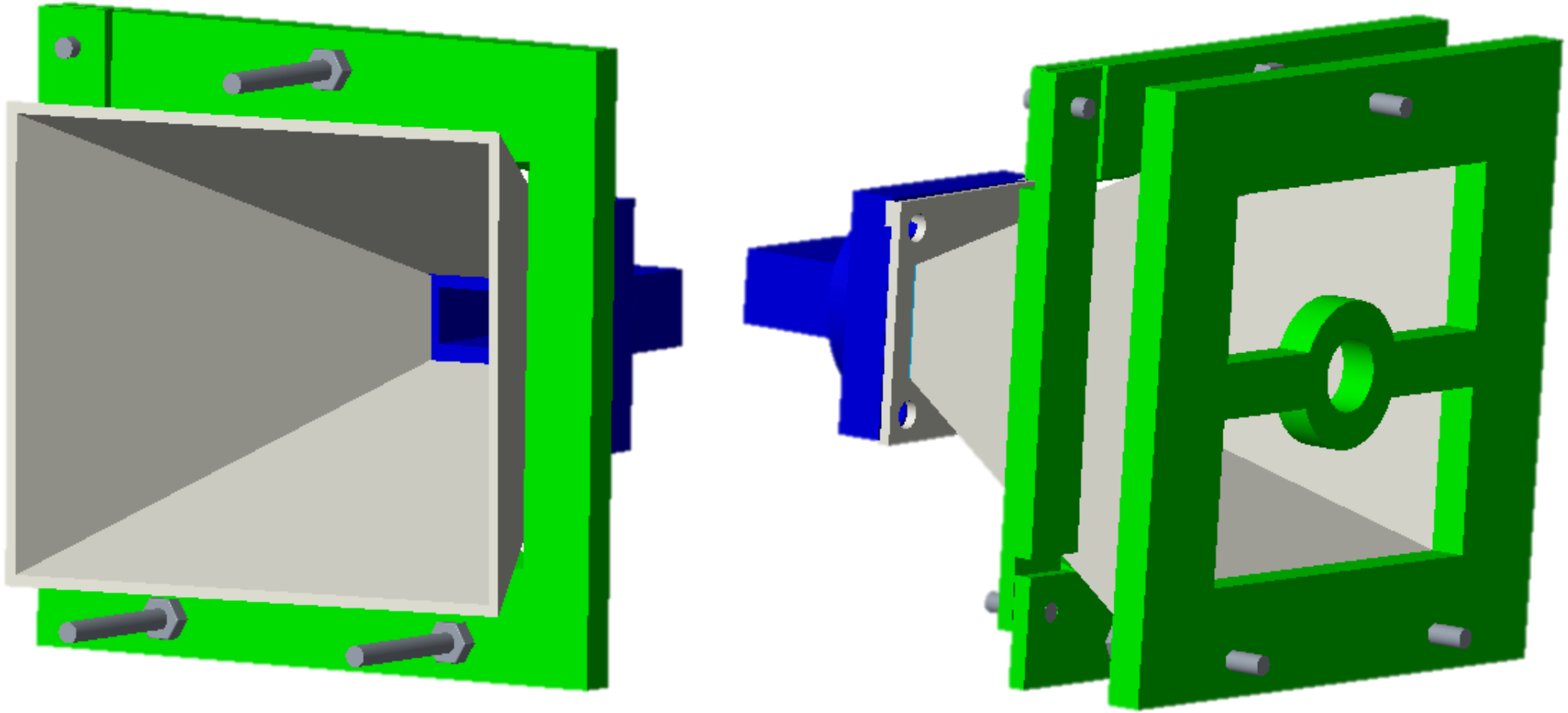
- Status: Prototype confirmed
  - Full scale work order submitted
  - Optimize fastening method
- Weight: 1.5lb
- Cost: $15 per horn holder
- What’s left?
  - Complete fabrication / install onto frame

Horn Spacing - Jig

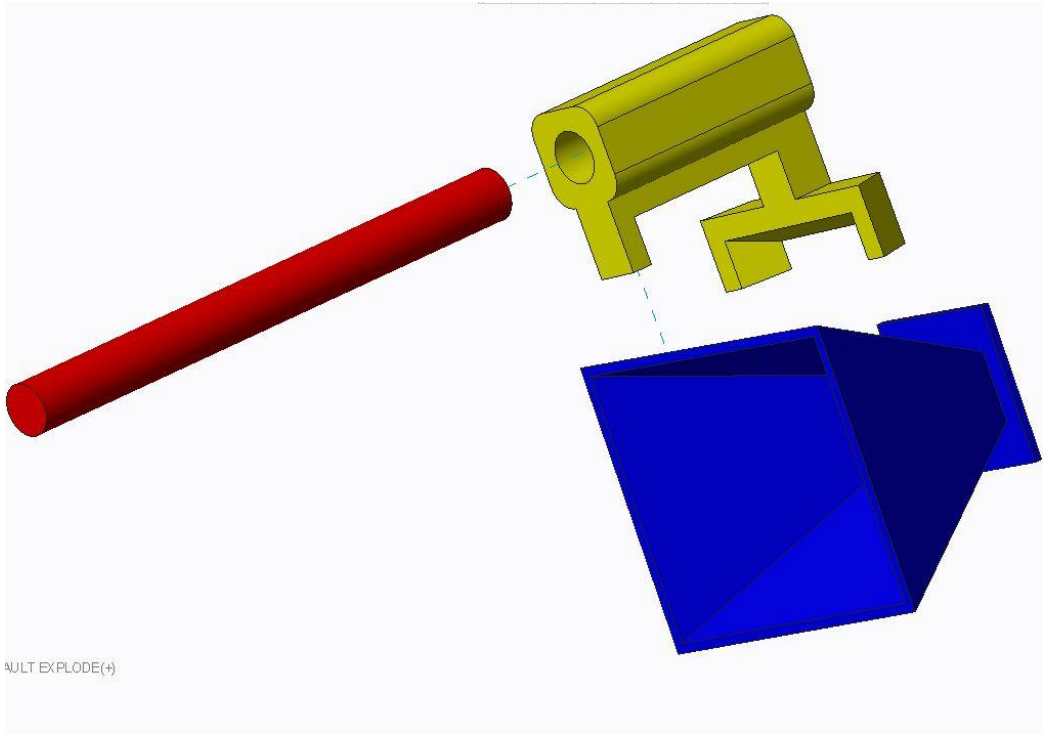


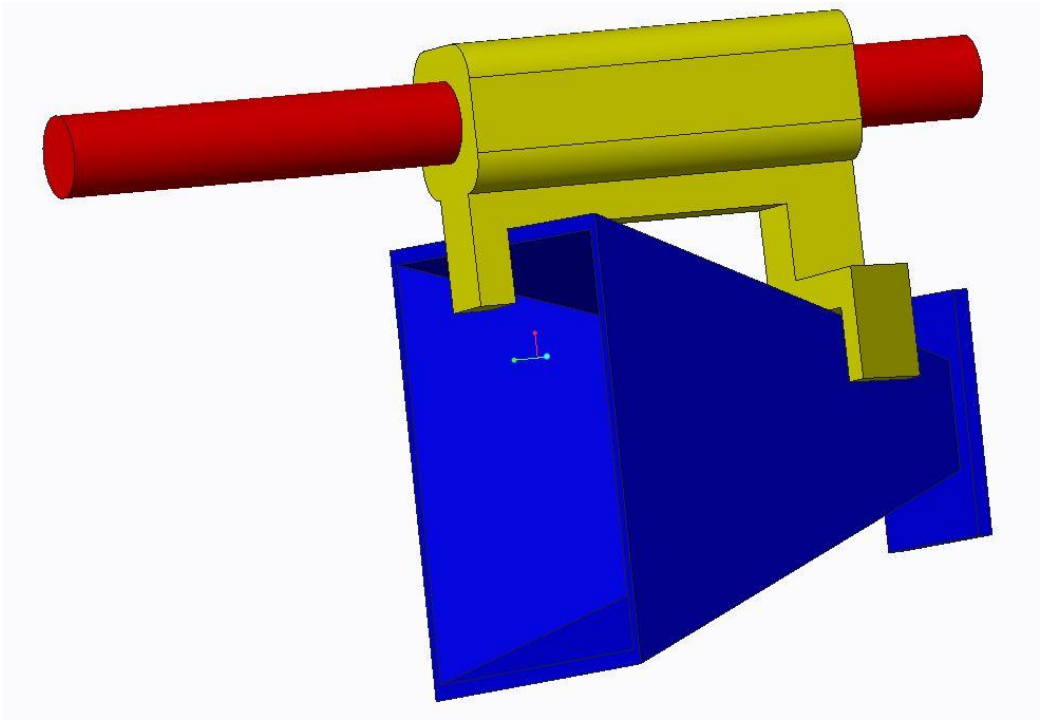
- Simplest way to ensure exact horn spacing
  - Compared to individual measurements
- Jig made from 1/8” aluminum 6061
- Cut in house with the water jet
  - Accurate to within 0.003”
- Measures from the intersection of the frame – out
- Status: Purchase order submitted
- Completion approximately 1 week

Horn Calibration – Option 1



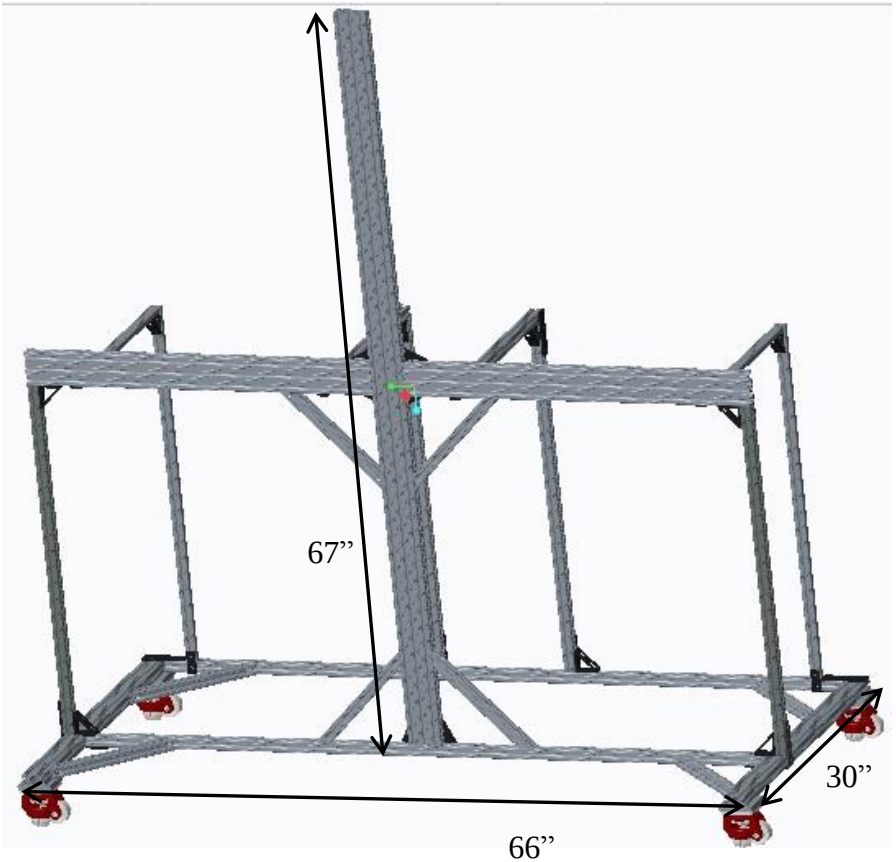
Horn Calibration – Option 2





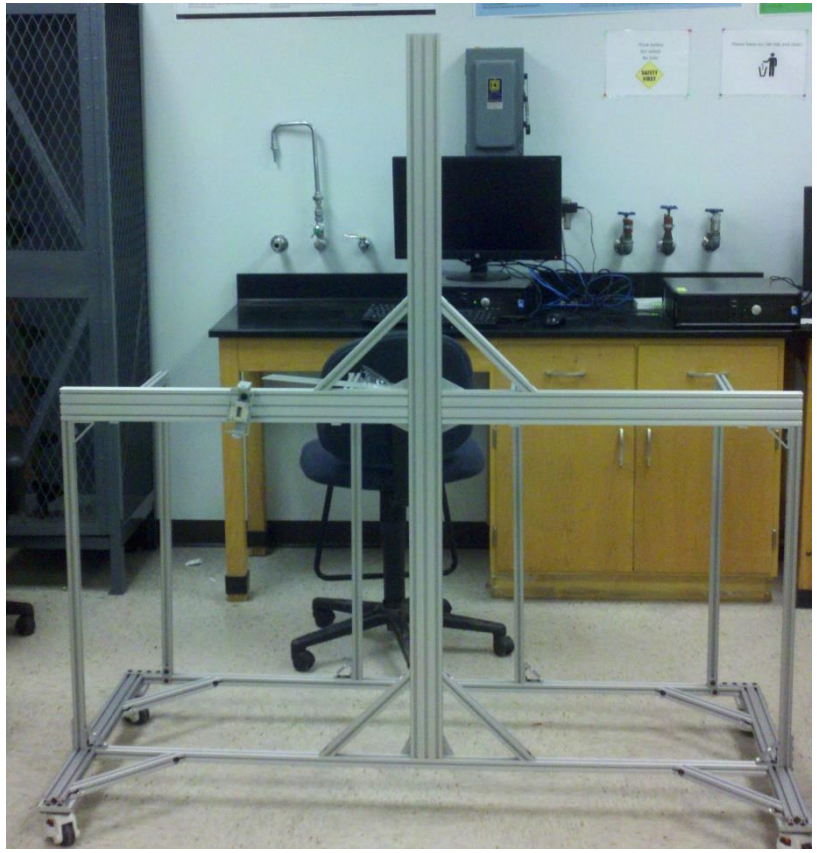
Structure Revision: Version 4

- Weight analysis of V3.1 was 174 lbs without electrical components
- Return to 10 series to reduce weight to 80lb goal
- Beam along front removed for potential reflections
- Introduction of leveling casters for alignment
- Addition of triangle pieces for extra support
- Weight reduced to ~55 lbs



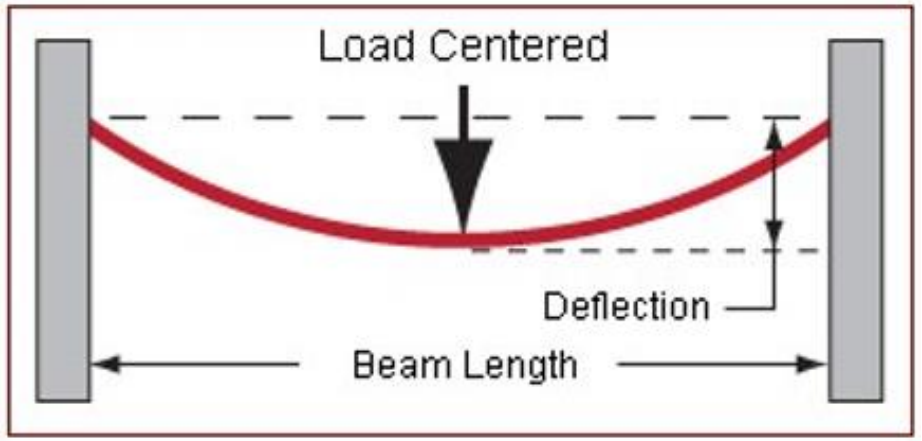
Structure Assembly

- Physically assembled this version (4hrs)
- Some noted challenges
  - Leveling casters small 2” plastic wheel
  - Slight bend in horizontal beam
  - Front and back base beams oscillate independently if shook



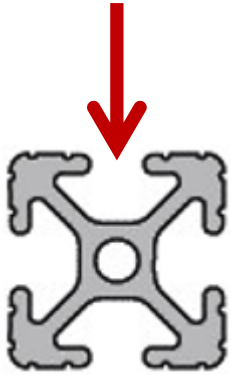
Structure Force Analysis

- Performed a force analysis to check deflection and find improvements
- Application of test force in center of beam with rigid endpoints
- Force set to 20 lbs to account for the vertical beam and half of component box
- Length set to 62”



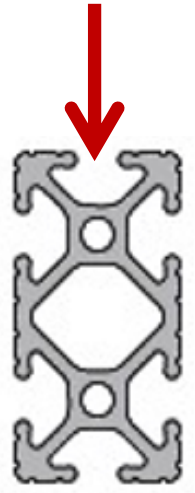
Structure Force Analysis Results

ORIGINAL 1010



- Total Deflection: 0.0623 In

NEW 1020

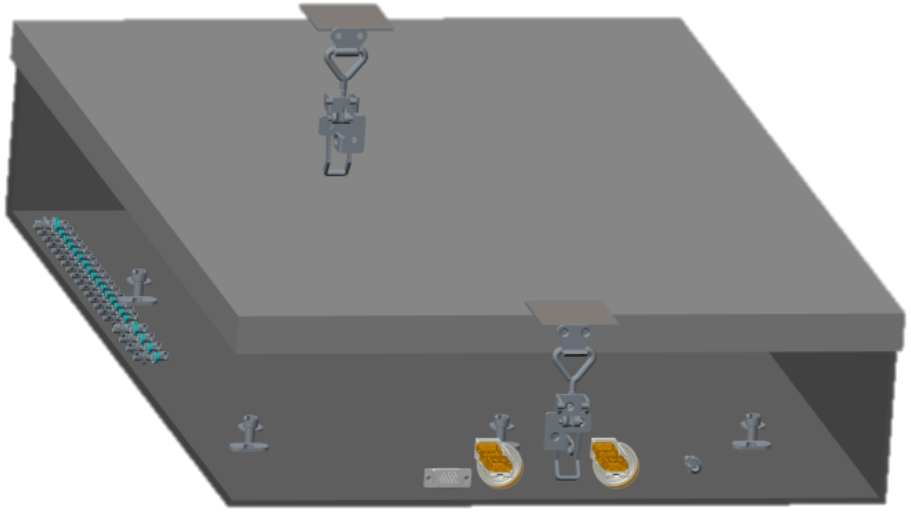


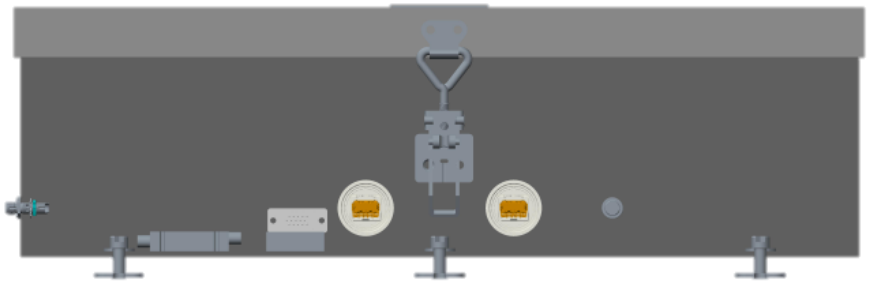
- Total Deflection: 0.0098 In
- 6x less deformation

New Structure Revision: Version 5

- Modification of current structure
  - Weight no longer issue
  - Goal is for a stable structure
- Switch to rubber 4” casters
  - No leveling caster presents alignment dilemma
  - Solved with foot floor lock (red) and adjustable vibration feet (yellow)
- More 45 degree pieces added to resist forward vibration resistance and rotation
- Base pieces changed to 1020
- 1030 piece added to middle of base to join halves

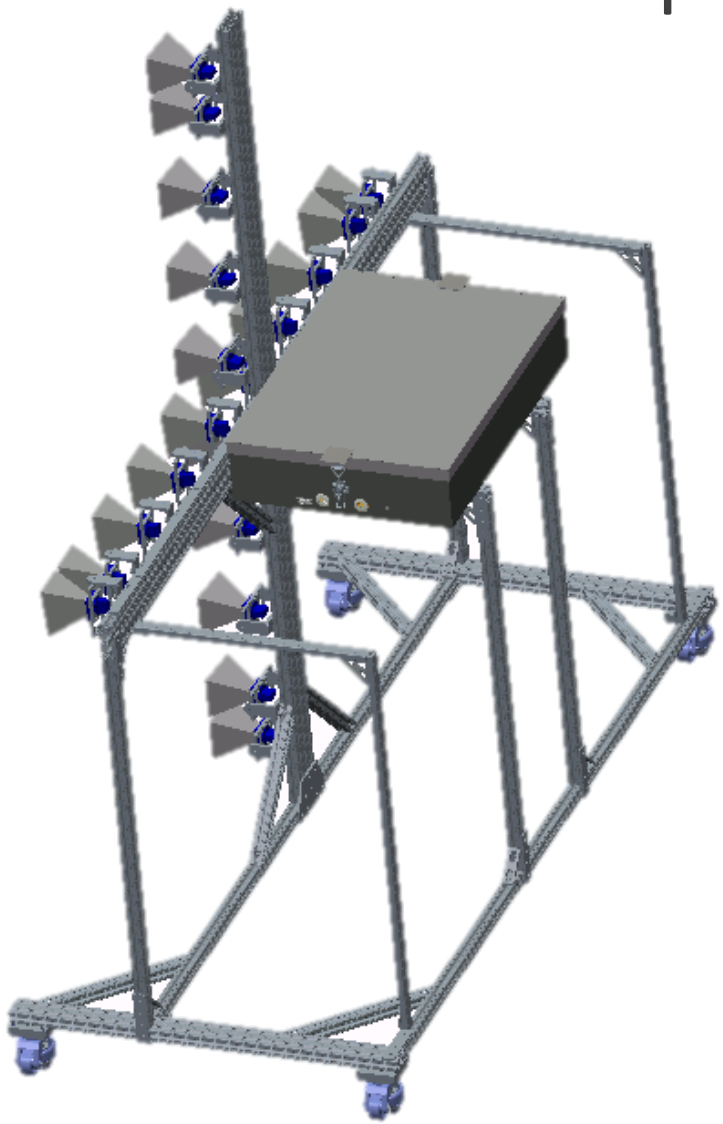
Component Housing

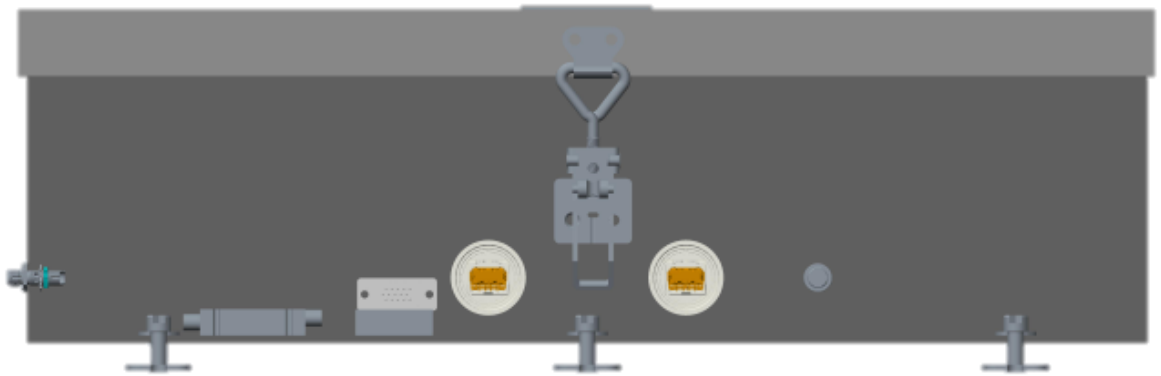




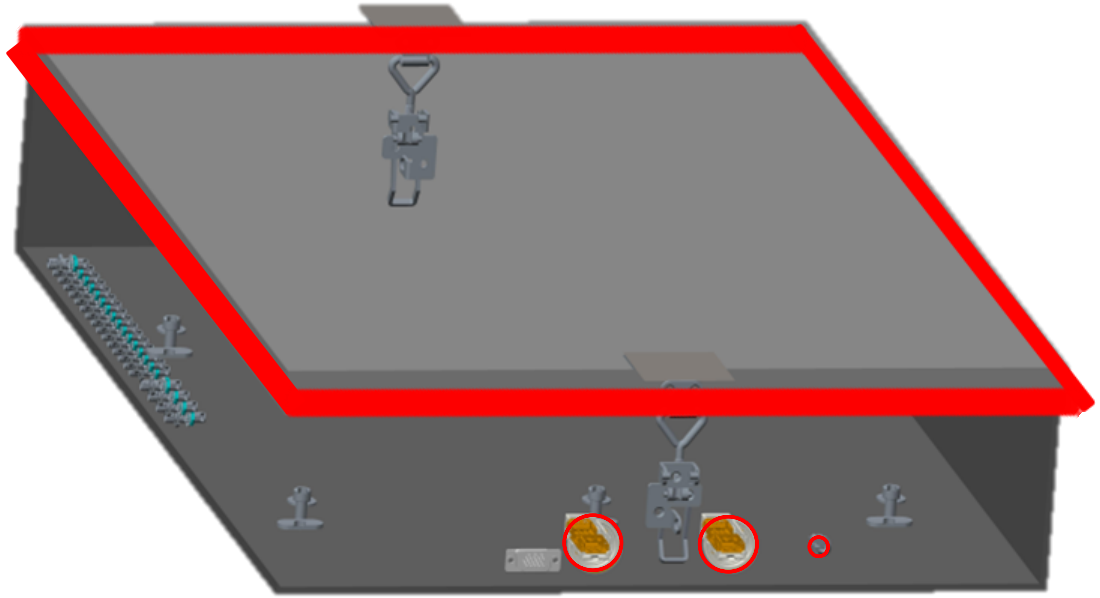
- Aluminum 6061
- Exterior panel mounted connectors
  - VGA
  - USB x2
  - Power
  - SMA
- 24”x17”x5” at 0.09” thickness
- Weight: 12.9 lbs
- Lockable

Component Housing





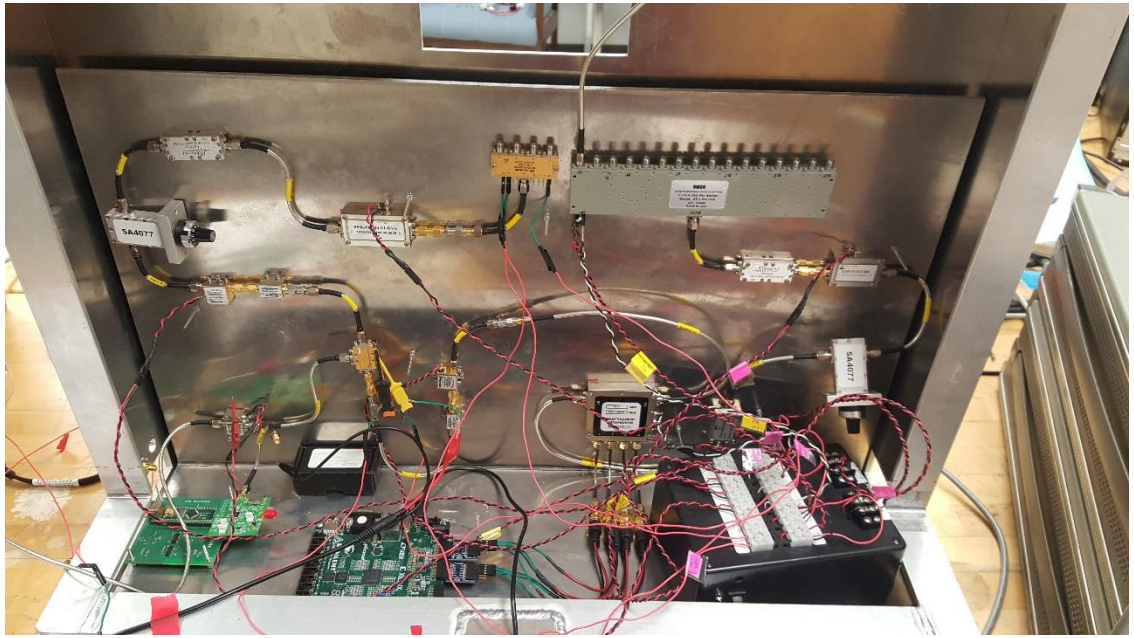
Electromagnetic Interference & Shielding



- Electromagnetic interference must be minimized when designing an electrical component housing
- Methods used to minimize EMI include simplifying circuitry, and shielding via gaskets
  - Conductive elastomer
- Make every surface sealed with a conductive material

Component Housing Migration

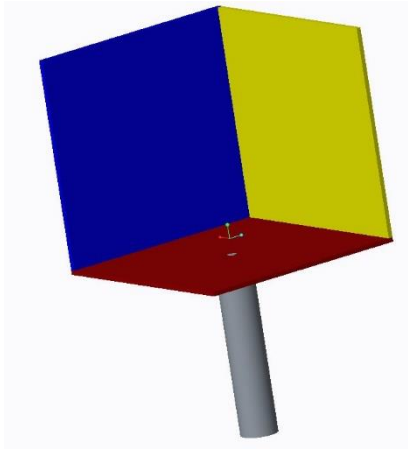
CURRENT

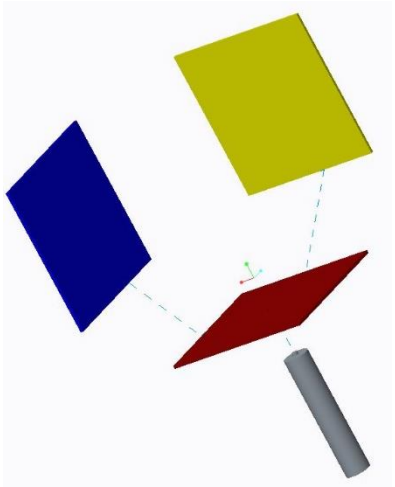


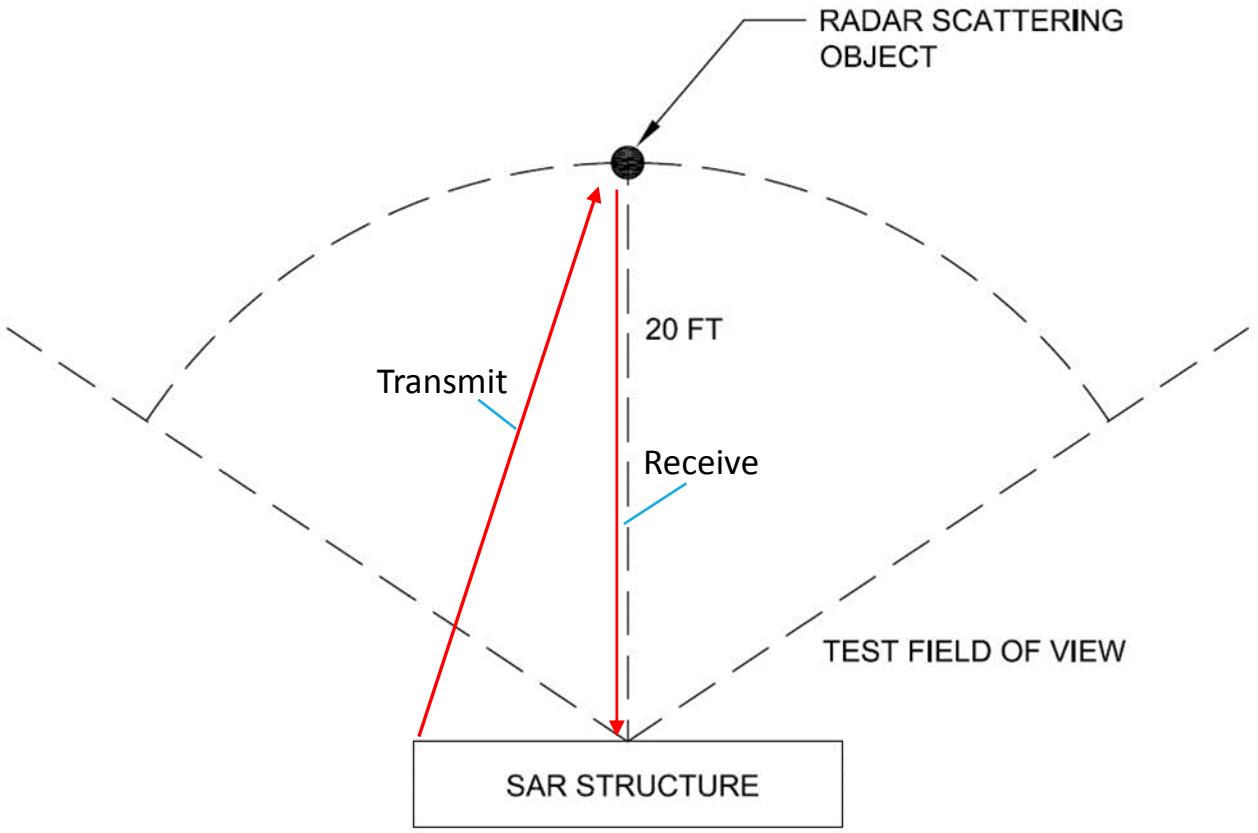
PLANNED

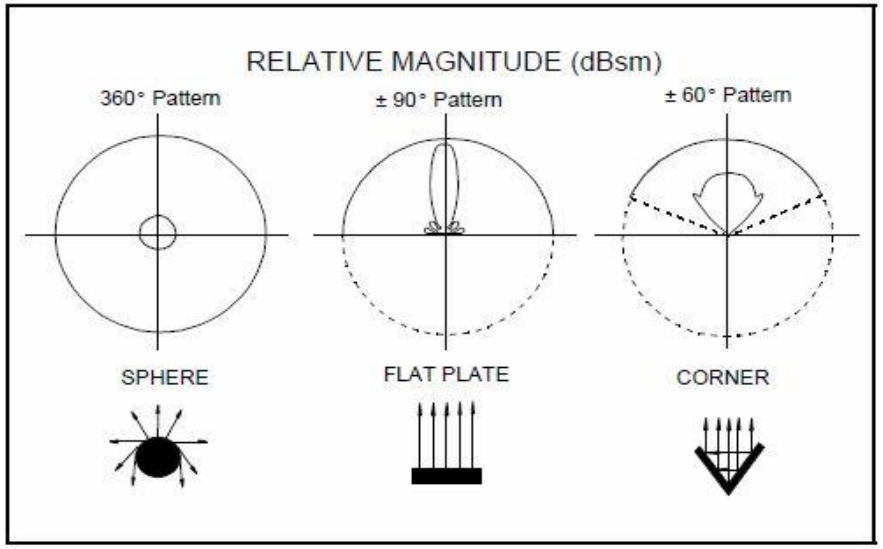
Radar Reflectors

- Purpose is to create backscatter
  - Reflects transmitted RF back to receiving horns



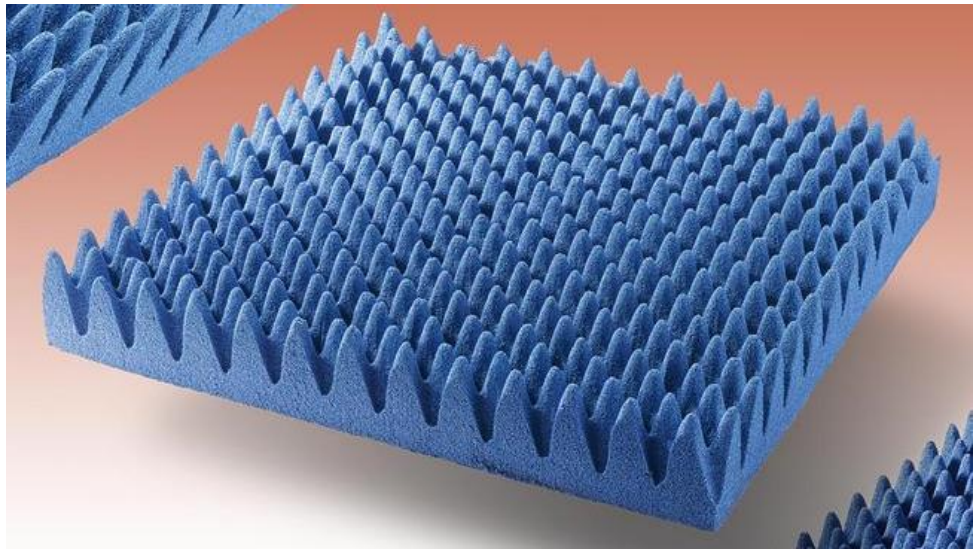




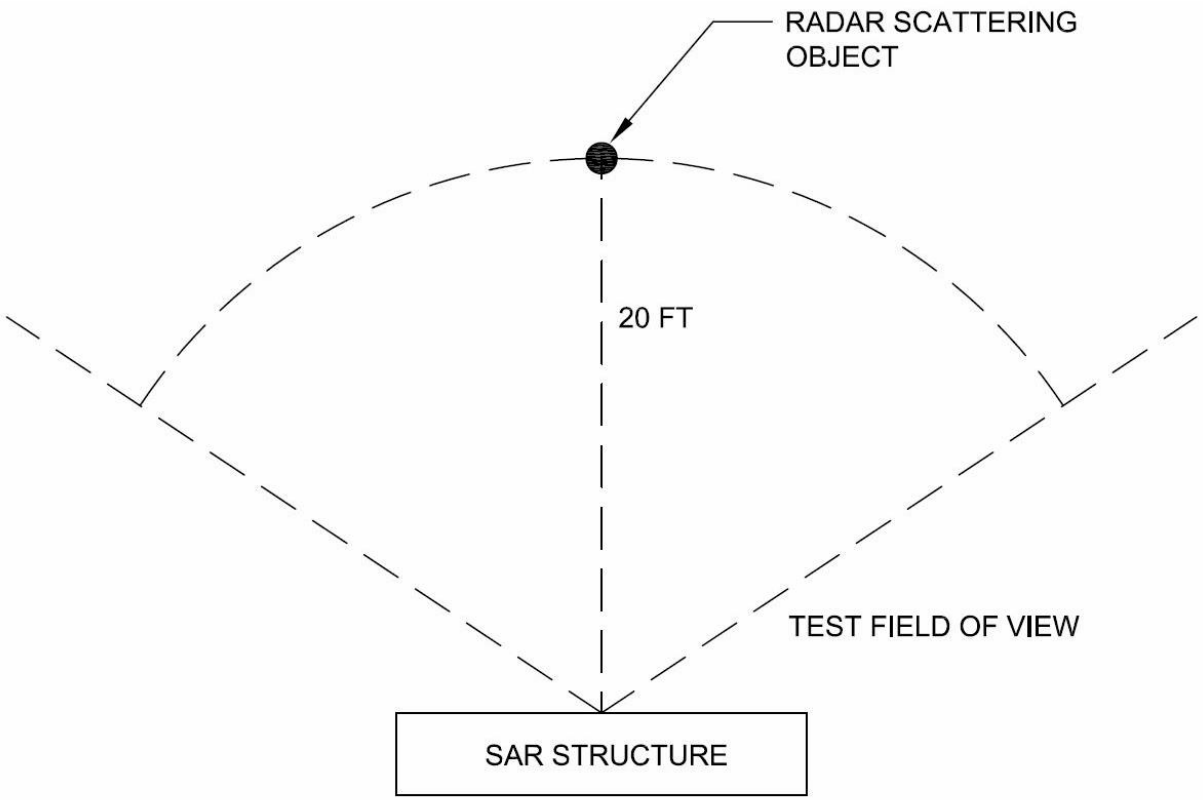


Room Setup

- Considerations:
  - Room requirement (30 ‘ x 30’)
  - Minimal RF interference
  - Easy student access



Anechoic Material

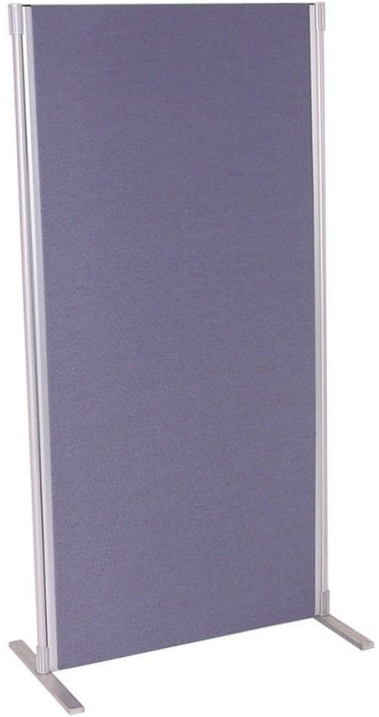


SAR Testing Layout

Room Setup

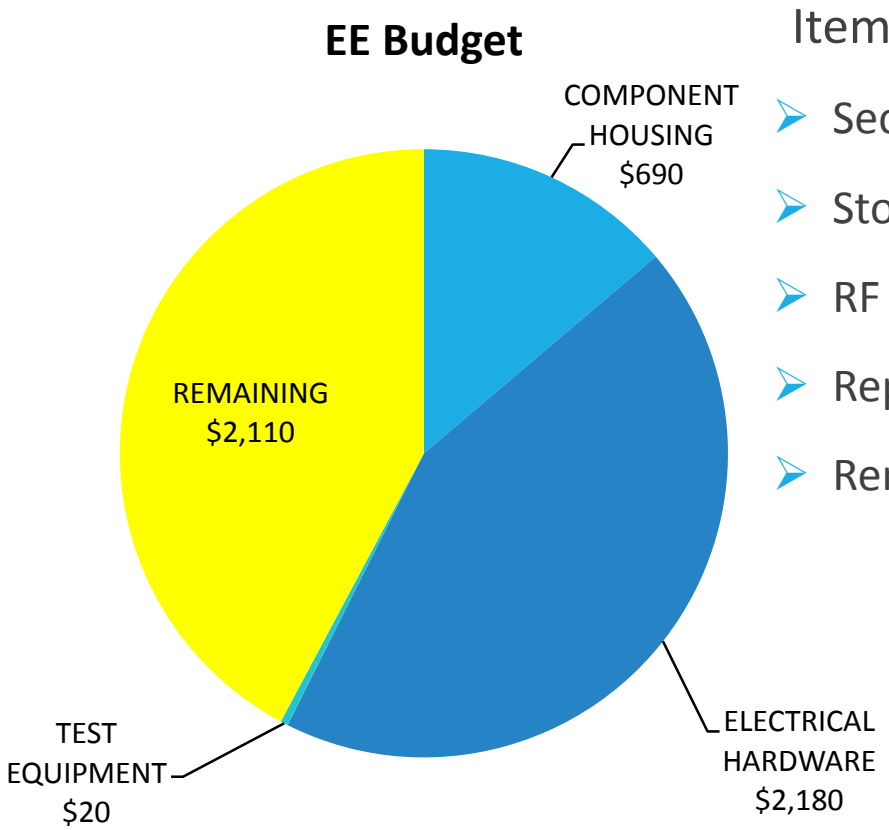
- Problem:
  - Developing anechoic room would cost $7000+
  - No permanent access to a particular room

- Solution:
  - Create collapsible anechoic arrays
  - Cover hotspots of interference
  - Cost: $1500



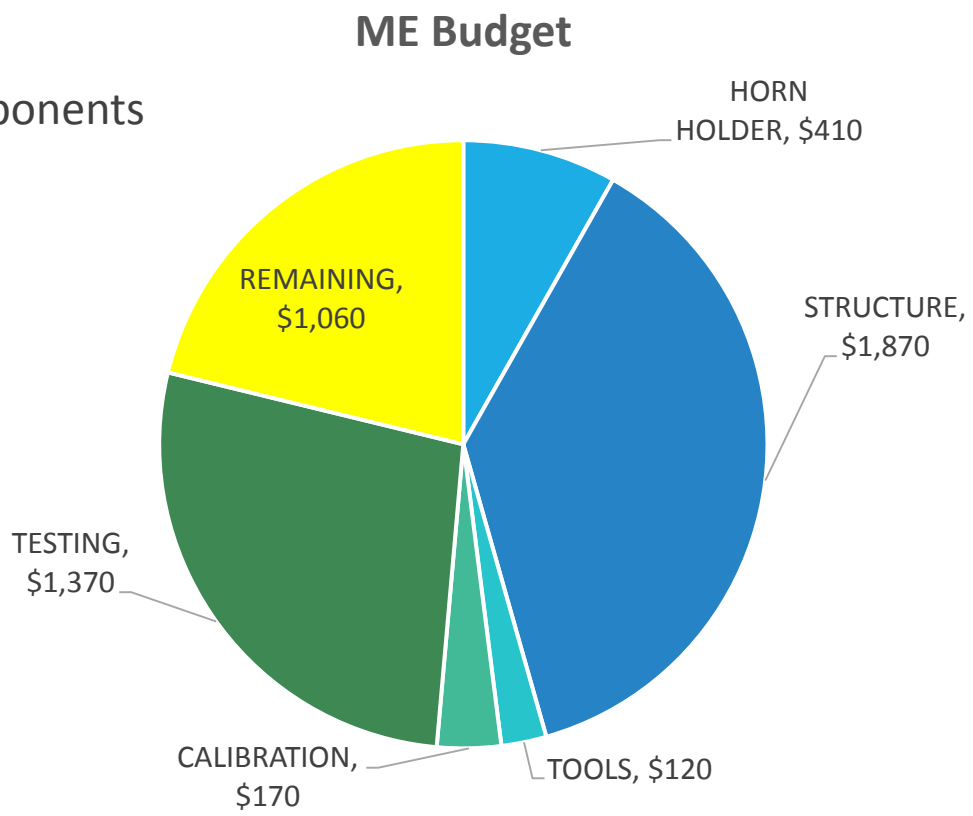
Adhere anechoic material to modular display boards

2015-2016 Budget



Items yet to be purchased:

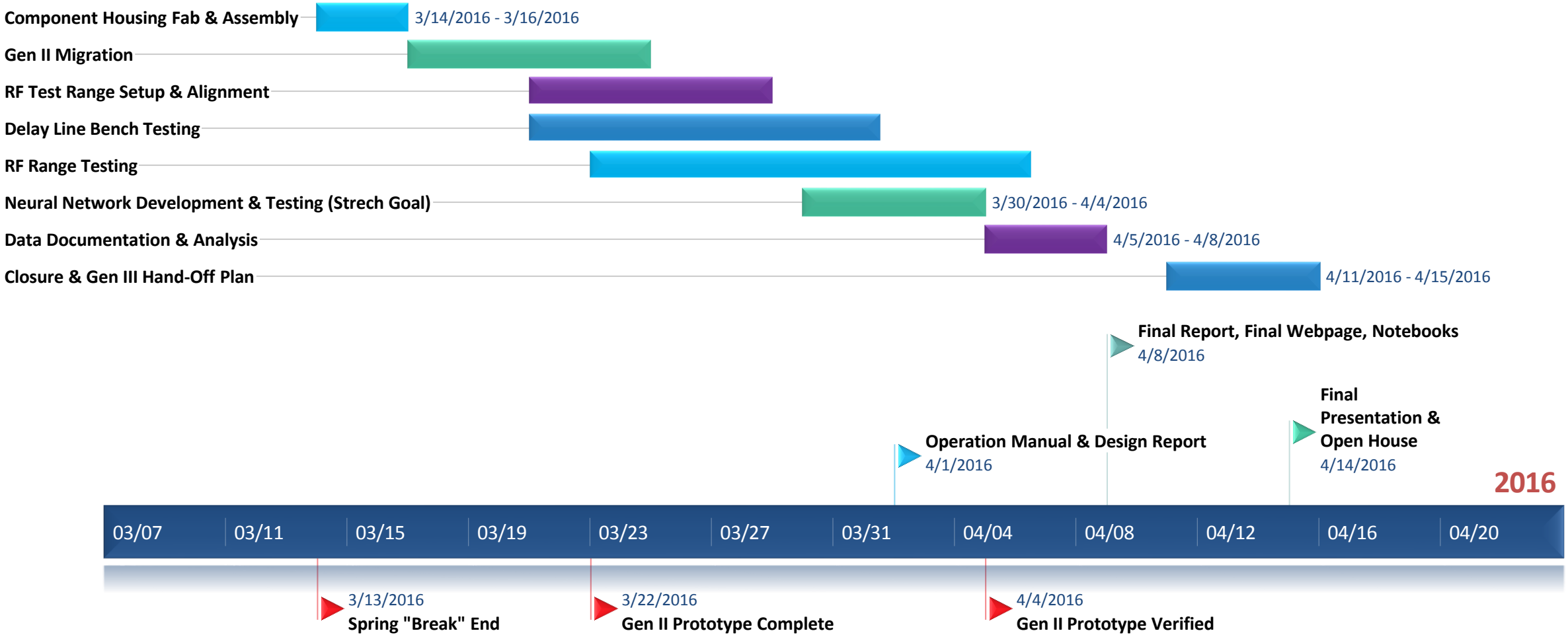
- Secure case for electrical components
- Storage for testing equipment
- RF Panel setup
- Replacing faulty equipment
- Renting testing equipment



To Do

- Mechanical
  - Component housing migration
  - Machine shop fabrication
  - Modifications to structure
  - Anechoic panel setup

FAMU/FSU COE Synthetic Aperture Radar
Spring 2016 Timeline

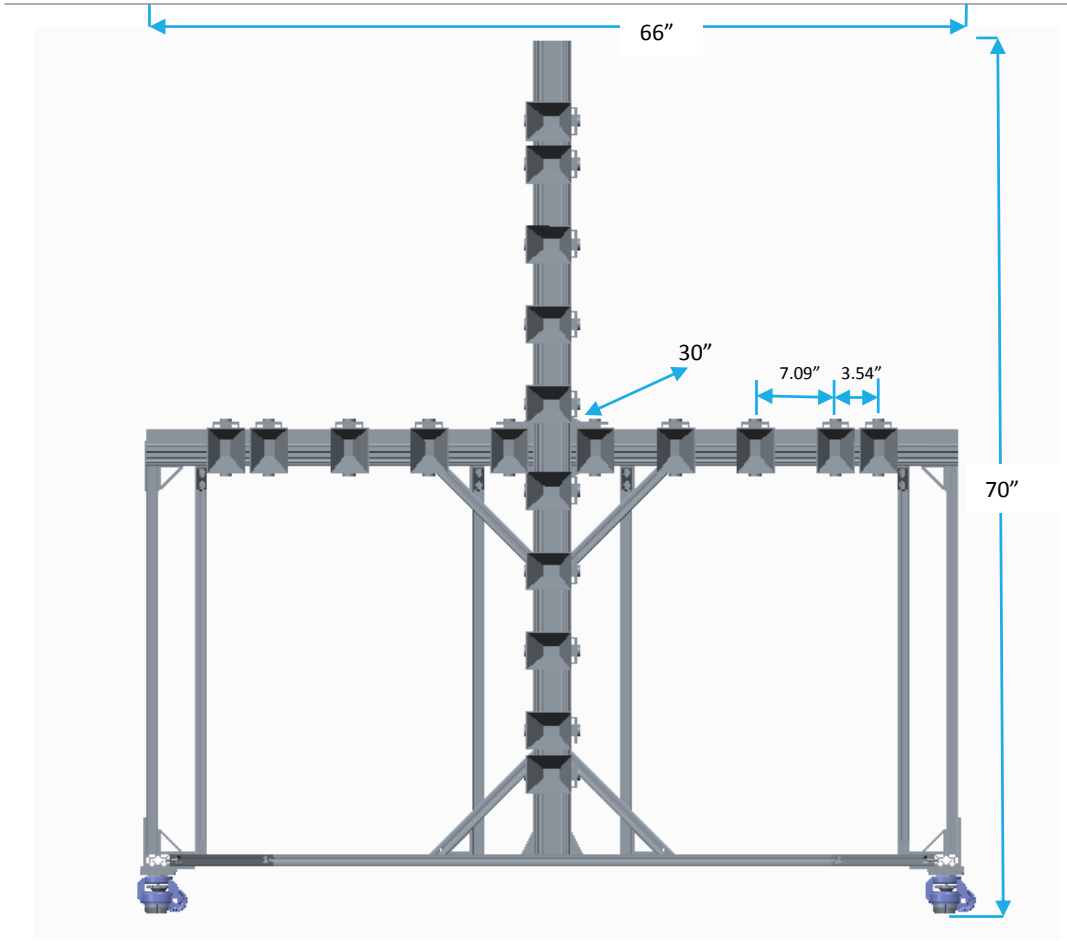


Questions?

References

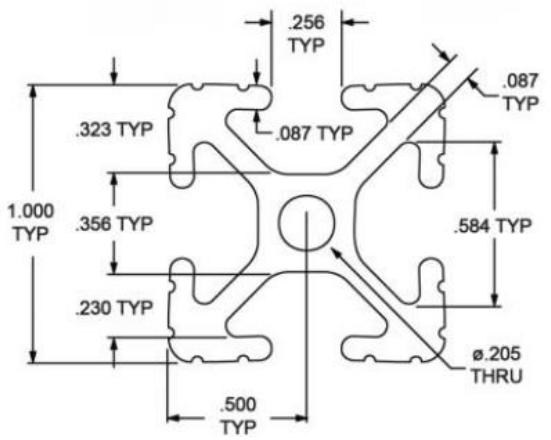
- http://stores.cumingmicrowave-online-store.com/c-ram-fac-3-x-24-x-24/
- http://www.eventfurniturehire.co.nz/catalog/product/gallery/id/99/image/109/
- http://www.northerntool.com/shop/tools/product_200377214_200377214

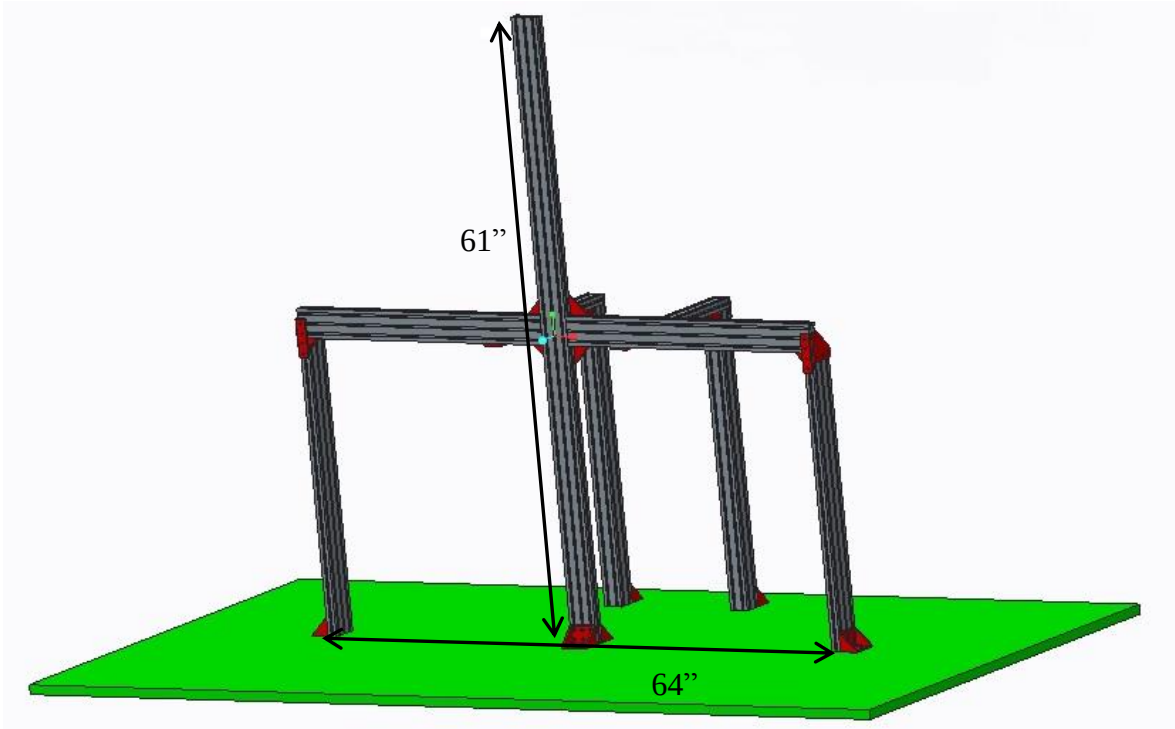
FRAME



Structure Examination: V1

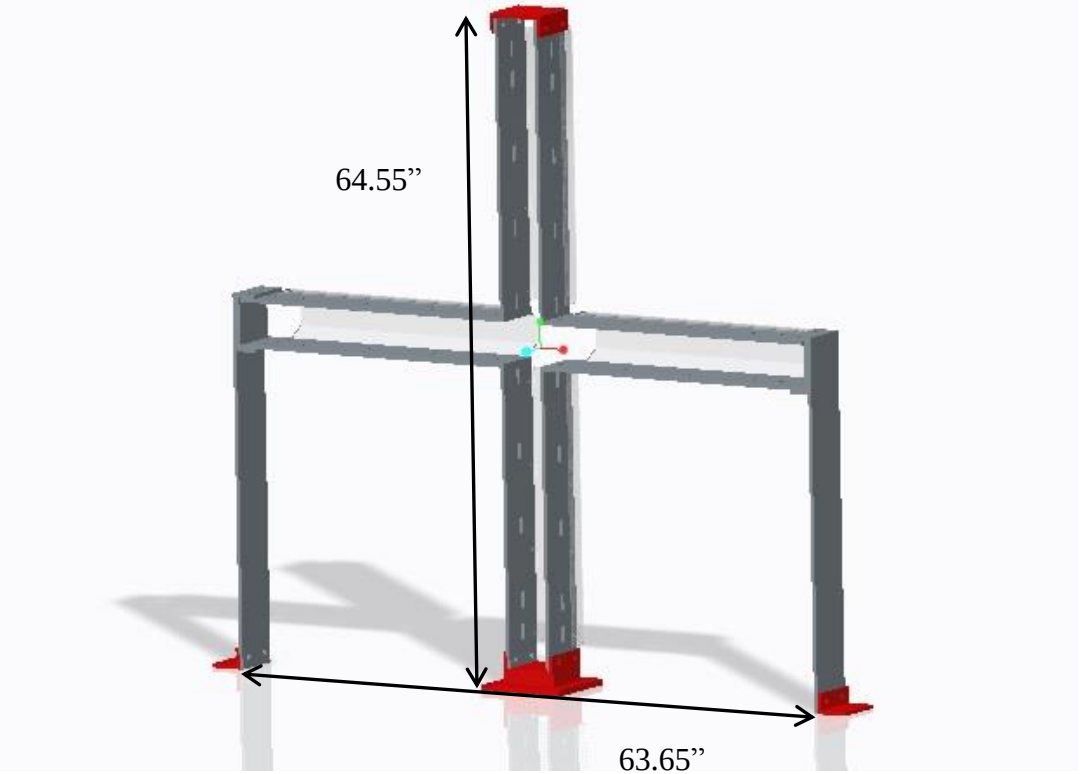
- 8020 Aluminum Beams
  - Provide excellent weight to strength ratio
  - Easy to assemble
  - Light Machining Required
  - Joined together by ¼-20 screws and plates
  - Recommended to us from Mike Blue
- Horns mounted to the front pointing normal to the beam



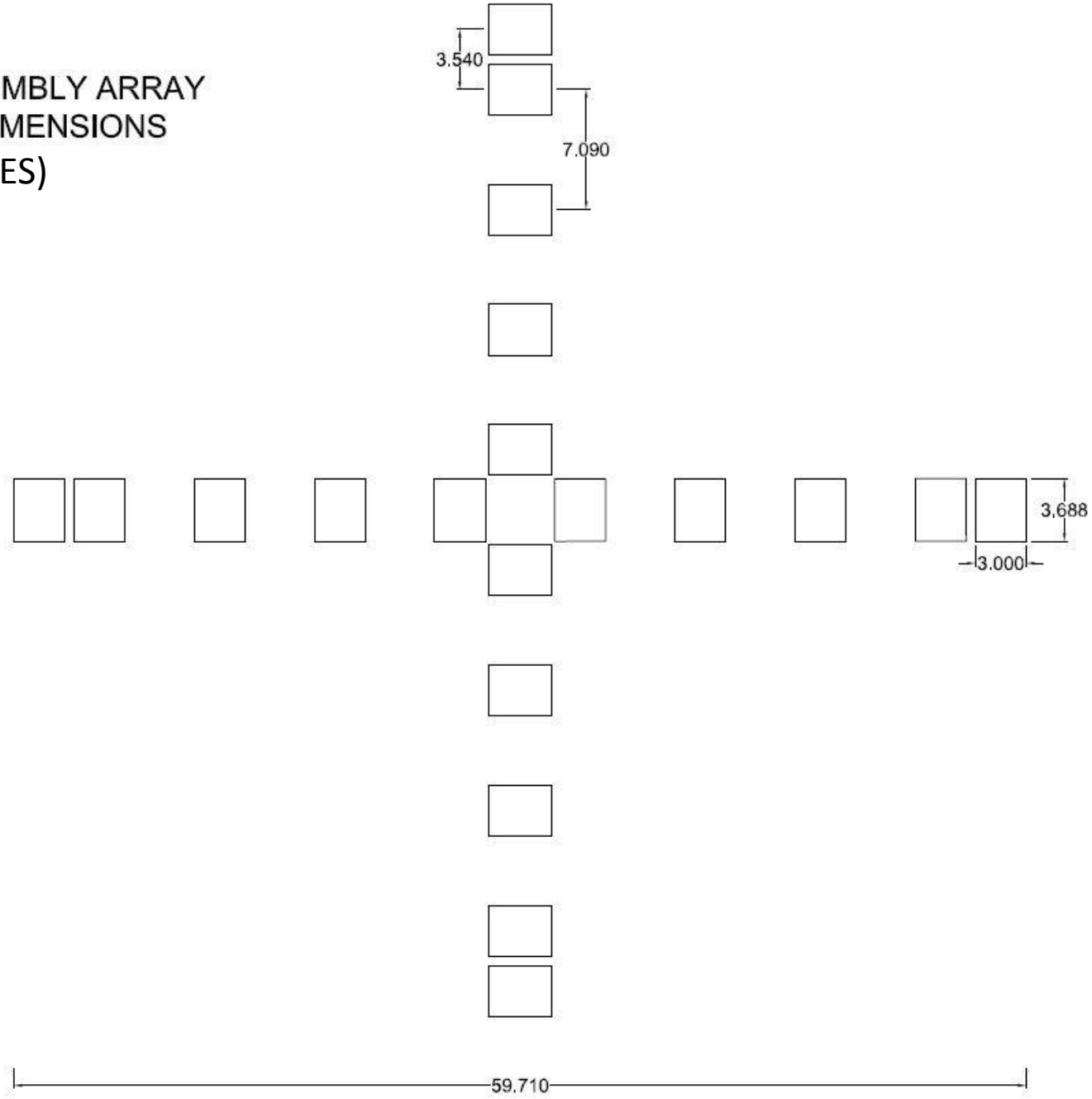


Structure Examination: V2

- Solid Aluminum Beams
  - Similar Design as last year's rendition
  - Number of beams reduced
  - Welded together for better strength
  - Heavy Machining Required
- Horns sandwich mounted between two 5" beams
- Design ultimately rejected due to machining difficulty



HORN ASSEMBLY ARRAY
SPACING DIMENSIONS
(INCHES)



Safety

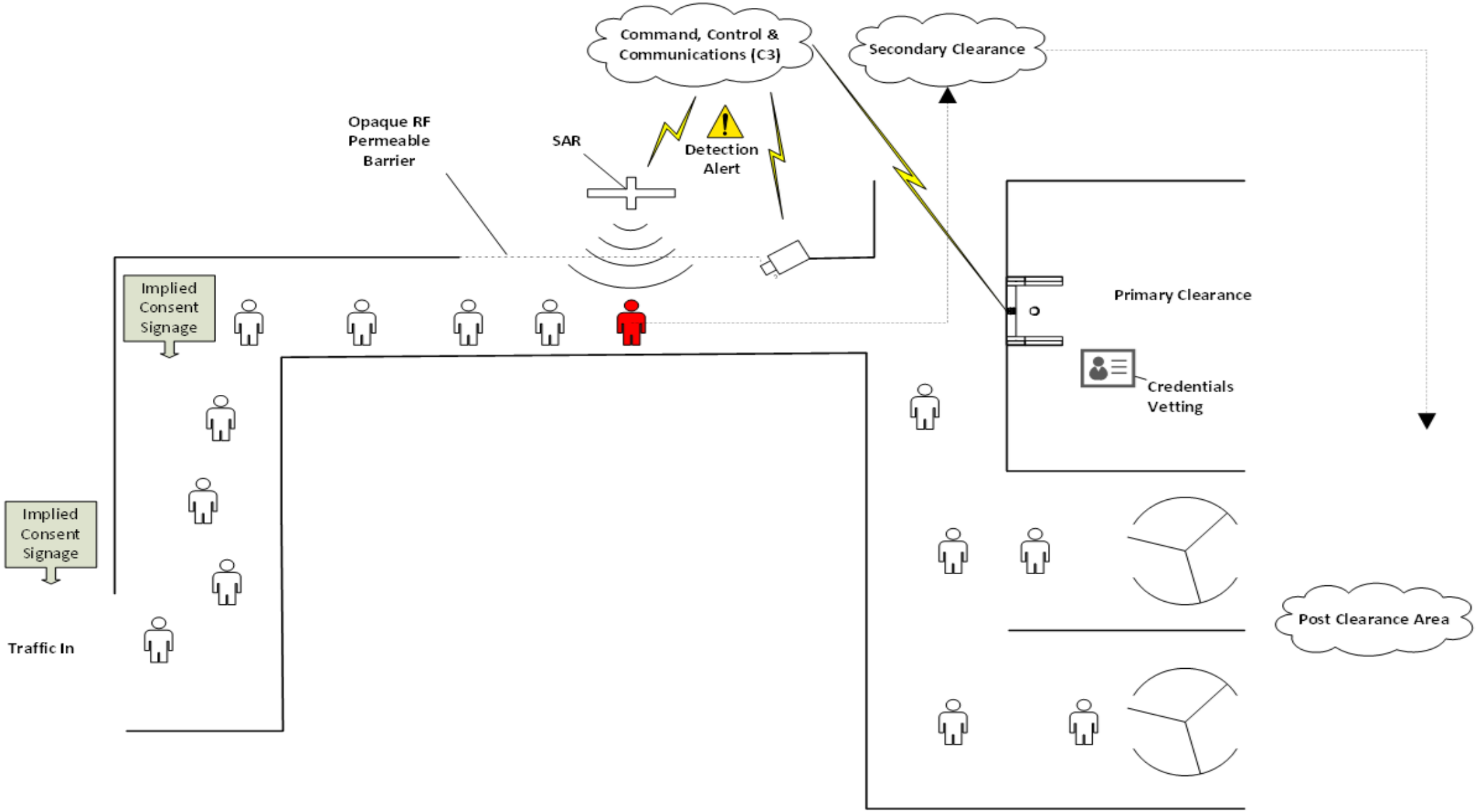
Uses low-powered X-band Radio Frequency (RF) to image objects from a distance (20 feet)

RF Exposure Safety Guidelines

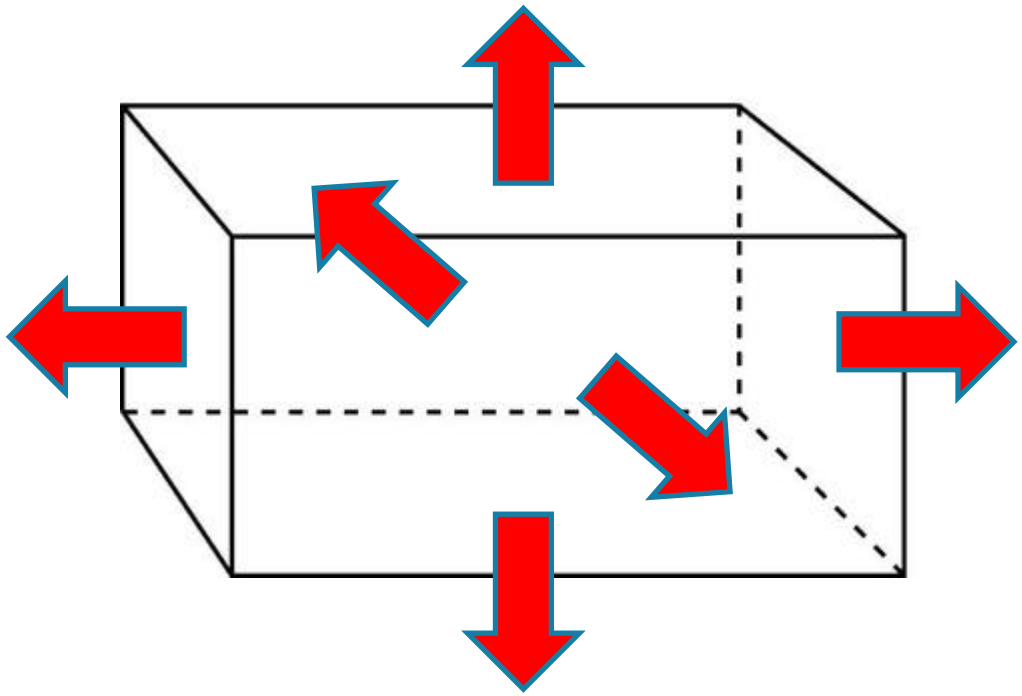
- ANSI/IEEE C95.1-1992
- FCC 47 C.F.R. 1.1307(b), 1.1310, 2.1091, 2.1093

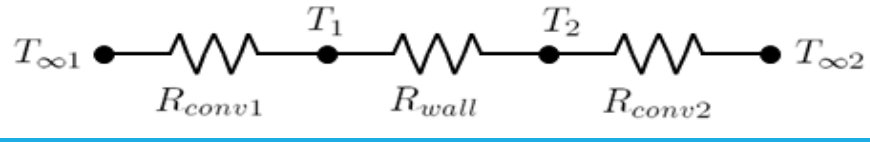
Limit for human exposure: 1 mW/cm^2

SAR Peak Transmit: 0.0076 mW/cm^2


Command, Control & Communications (C3)
Secondary Clearance
Opaque RF Permeable Barrier
SAR
Detection Alert
Implied Consent Signage
Primary Clearance
Credentials Vetting
Implied Consent Signage
Traffic In
Post Clearance Area

New Thermal Analysis: Component Box





$$\dot{Q}_{total} = \frac{T_{\infty 1} - T_{\infty 2}}{R_{total}} = 178.08\ W$$

$$N = \frac{\dot{Q}_{total}}{\dot{Q}_{supplied}} = \frac{178.08\ W}{34.8\ W} = 5.12$$