Electric Arc Welding EMI

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INTRODUCTION

- Electromagnetic interference (EMI) from orbital tube welding (OTW) near avionics causes degradation, or altogether failure of sensitive components
- Simulating near-field EMI from the Department's TIG welder (Miller Syncrowave 350 LX) to establish distancing, shielding recommendations for late-stage development welding
- Current solutions: distancing the avionics from welding requires full propulsion system assembly up-front (current standards are excessive); installing grounded avionics enclosures adds to vehicle weight and requires significant pre-launch testing
- H-field tolerance limit of avionics: 0.0502-0.100 A/m [from MIL-STD-461G, RS101 for Army applications]

NEED STATEMENT

A way to assess potential risks of electromagnetic interference from orbital tube welding in the presence of sensitive electronics in spacecraft assembly, so that more clear distancing and mitigation procedures can be made available for industrial use.

REQUIREMENTS

- Simulation:
  - Models behavior & strength of EMI across free-air distance to determine safe distancing recommendations for avionics
  - Implements proposed mitigation techniques
- Demonstrator:
  - Adjustability mirrors simulation modularity
  - Illustrates continuity in EMI readings between experiment and simulation

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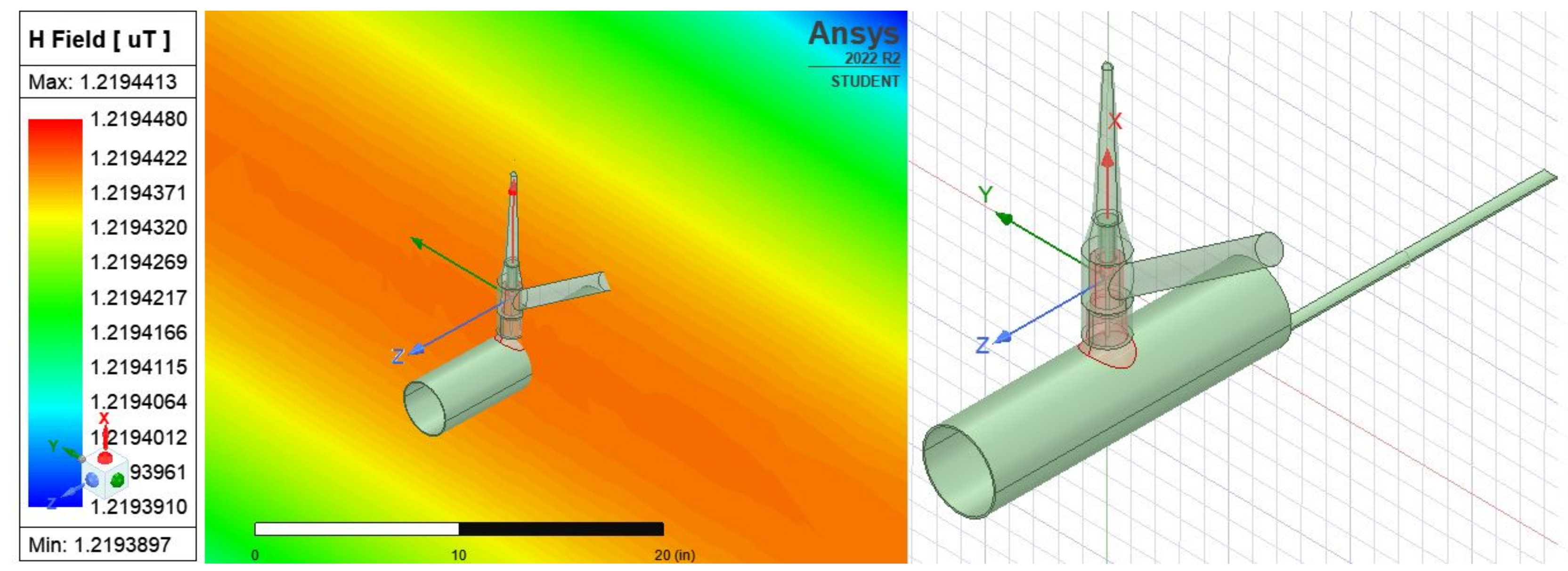
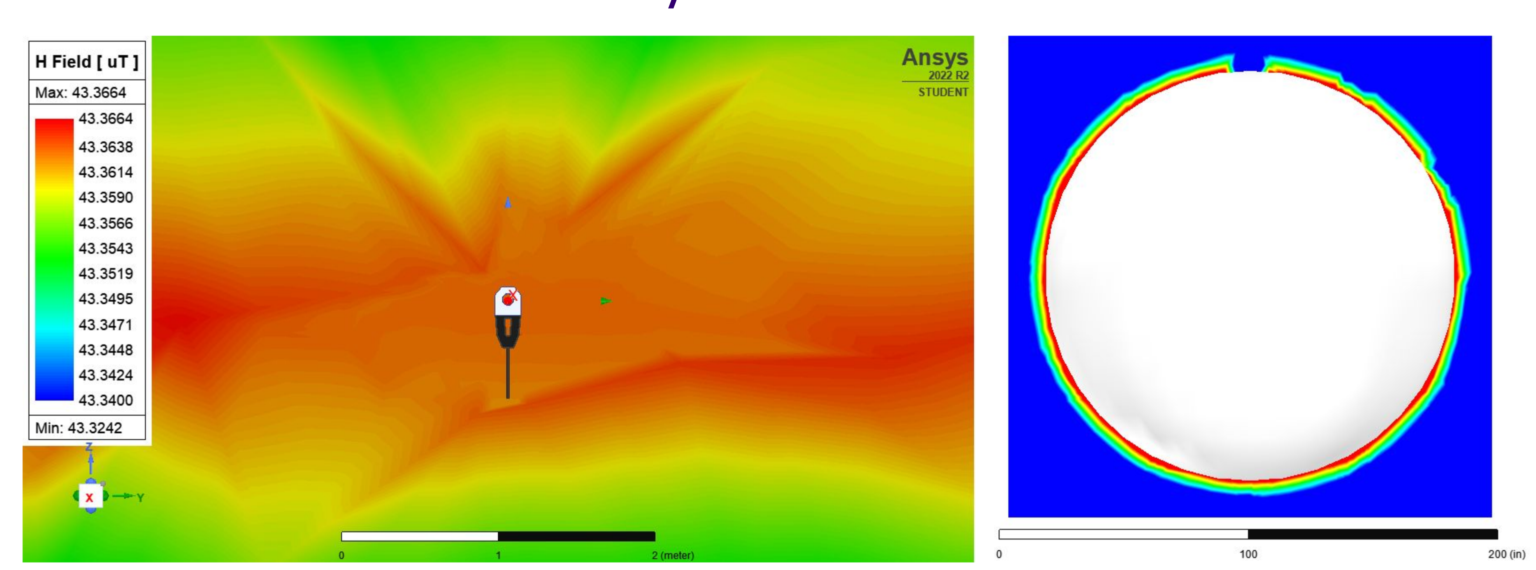
SIMULATION DEVELOPMENT



TIG welder geometry and magnetic field (in μT)

Final Simulation

- Incident planar wave 281-562 V/m depending on welding distance (365 V/m most common at 0.2in)
- Perfect H-field in plasma & radiation external boundary in air
- Plots of interest:
  - H-field: Magnetic field values
  - E-field: Electric field values
  - Jvol: current density on a conductive surface
  - Current calculation: integrate magnetic field over a distance to identify current in a conductor

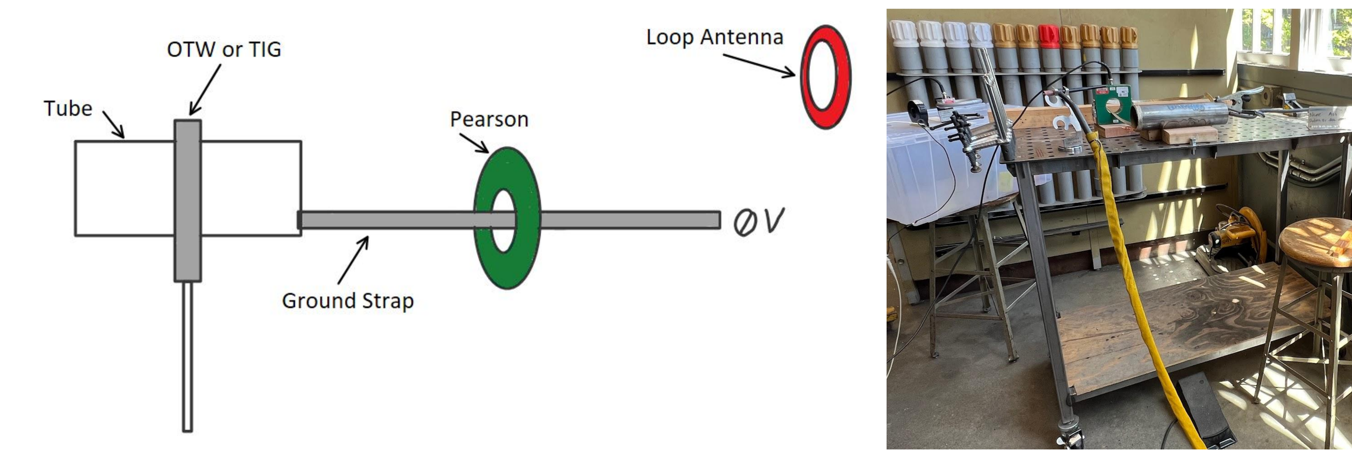


OTW geometry and magnetic field (in μT), and TIG safe distance (top view)

Results & Implications

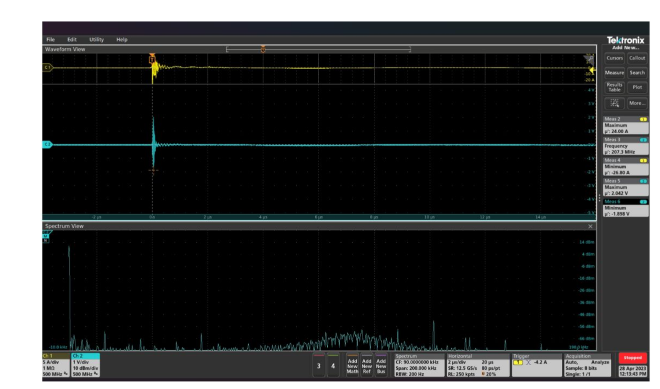
- For the TIG simulation, H-field (given an incident wave excitation of 365 V/m): 0.970 A/m
- At 1 m (through 0.04" radius conductor), I = 0.02 mA
- Safe distance: 2.50-4.25 m [8.20-14.0 ft]
  - H limit at 100 kHz (min) vs. interpolating to 500 kHz (max); applying SF = 2 to each case
- OTW (applying 130 V across 0.01 m): 34.5 A/m
  - Safe distance: 8.19-14.0 m [26.9-46.0 ft]

VALIDATION/DEMONSTRATION

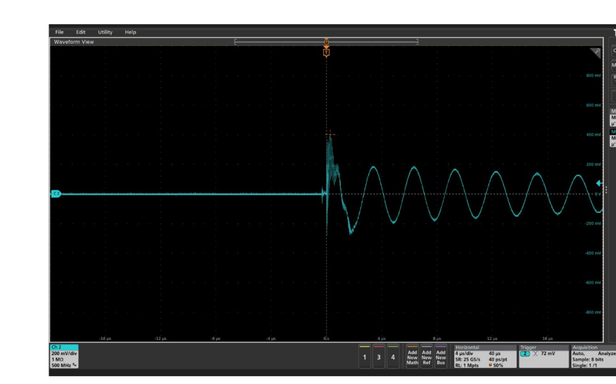


TIG welder physical demonstrator mock-up and actual setup

- Demonstrator H-field varied significantly depending on orientation at 1 m separation distance from weld, compared with expected spherical geometry
- Percent error varies from 2.66% to 22.7%, depending on measurement orientation; aiming for <25% error between simulation and demonstrator



Ground loop current, voltage, magnetic field



No ground loop voltage

CONCLUSION & FUTURE WORK

- Strengths: Simulation produces accurate numbers and can be used to get quick calculations on-site; concurs with the physical demonstrator; and can be shared with Blue
- Weaknesses: Element size is limiting; ANSYS has no time domain; OTW could not be tested
- Next Steps: Blue's EMI group will continue testing
- Modifications: using higher accuracy machines/ measuring tools/space, testing OTW and other programs

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