Michigan State University
College of Engineering; Dept. of Electrical and Computer Eng.
ECE 480 Capstone Design Course Project Charter

Sponsoring Company/ Organization: ECE, MSU

Contact Information:
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Background Information:

Business Case:

- Explain why is this an attractive opportunity for your company to pursue now.

With increasing use of composites for light weighting without sacrificing strength, there is a need for new sensor arrays and systems that can provide rapid detection and characterization of manufacturing and in-service damage. Nondestructive Laboratory (NDEL) presently has several cutting-edge single-probe sensors operating in both far- and near-field regimes using low- and high-frequency electromagnetic waves. With the design of a geometrically flexible sensing array and data acquisition (DAQ) system, efficiency and accuracy of composites NDE will be significantly improved with optimized sensing and data analytics methodology.

- Describe the discontinuity creating the competitive opening in the marketplace that makes this project timely. (Competitive action, Legislation, Regulation, etc.)

Most commercially available electromagnetic sensing arrays for NDE applications are above $50,000 and working at low frequencies, e.g. eddy current. There is no commercially available imaging array system in high frequency regime. Furthermore, no dedicated electromagnetic sensor arrays for composite materials characterization and damage detection are available. The proposed project should fill this gap and make the system commercially competitive by operating in multi-band and in both far- and near-fields to offer multi-resolution capabilities.

- Explain how this product / service will be positioned as a commodity (low cost to serve) or a differentiated (value priced) offering. Why?

I think this would be a differentiated offering to serve the specific needs of researchers and operators in this field.

- Outline the competitive barriers to marketplace entry the Design Team needs to take into consideration.

Competitive eddy current array systems exist, but are not optimized for composites. New geometrically-flexible arrays are needed that can be applied to complex surfaces of inspection. High costs would be another competitive barrier for

high frequency systems and the Design Team should develop an efficient platform to be practical for industrial applications.

- What is the hypothesized basis of for a sustainable competitive advantage?
    - Patents, Trade Secret, Low cost, privileged relationships?
      Commercially available products and scientific journal articles.

Project Intellectual Property Considerations:

- Will the student Design Team be required to sign a Non-Disclosure Agreement?
  Yes
- Will the Design Team be able to post their work on the course web site?
  Yes, with sponsor's approval
- Will the student Design Team be working with technology contained in pending patents not yet granted?
  No
- Can the electronic design be shown, but the embedded software protected?
  Yes

Opportunity Statement:

- What **clearly defined Customer Problem** you hope to solve with this project?
    - Is this problem solvable in a 13 week working semester with students?
      Yes, this problem is solvable in a 13 week working semester. A multi-channel high-sampling rate NI DAQ module will be purchased to help and facilitate the design and development.
    - Does the design challenge need to be run across two back-to-back semesters?
      No
- Does this problem exist now, or in the future?
    - How long will the window of opportunity be open to alternative solutions?
    - What will drive the window of opportunity closed in the future?
- Who is the customer?
    - Who makes the buying decision?
      The Design Team.
    - Who will the ECE 480 Design Team deliver their project to at the end of the semester?
      Yiming Deng
    - Describe the benefit to the end Customer for this project.
      Benefit will be to train graduate students in ECE, ME and CEE who are working in NDE and SHM fields, and to researchers and operators who are interested in damage diagnosis for composites.

Deliverables:

- Describe what is to be delivered at the end of the semester.

- Proof-of-Concept design? (Bread-boards, wires connecting sub-systems, etc., ugly looking – but functional, development software non-user-friendly interface)
- Working prototype? (PC boards, cabling between sub-systems, refined software and user friendly interface)
  Working prototype
- Sub-system ready to fit into the overall system?
- Final solution ready for end use deployment?

Goals:

- Describe what success will look like at the end of the semester.

A multi-channel, multi-band and multi-resolution electromagnetic sensing array system prototype integrating optimized sensors available in NDEL, and dedicated data analytics methodology will be delivered at the end of the semester. The Design Team will be trained as the potential workforce and leaders in the area of NDE and composite manufacturing.

- Goals should be SMART
  - **Specific** – Exactly what is to be delivered?

    A multi-channel, multi-band, and multi-resolution EM sensing array system that includes:

    1) prototype of a multi-channel array probe (up to 16 channels) that is geometrically flexible for complex structures and materials.
    2) Computer control of the x-y-z-scanning stage and data acquisition and pre-processing using NI DAQ and FPGA modules.
    3) Integration of NDEL sensors operating at different frequencies (MHz to GHz): inductive T/R coils, capacitive sensors, near-field microwave sensors, etc.
    4) A demonstration of the system by imaging a set of customized composite samples with artificial and real damage that show the capabilities and limitations of the array system.
    5) A data post-processing and analysis tool to improve the SNR and damage detectability.
  - **Measurable** – Describe the measurement system that will determine the degree of success.

    The imaging resolution, contrast, speed of the array system will be compared and assessed using other NDE and destructive methods with the system capabilities and limitations described.
  - **Attainable** – Can a student team, with little to no industrial experience complete this project in 13 weeks to your satisfaction?

    I believe so. If not, then we can continue the work in a subsequent semester.
  - **Relevant** – Limited to this design challenge.
  - **Time Bound** – 13 week working semester (Students loose a week getting organized and a week preparing for Design Week presentations.)

Scope:

- Clearly define what is IN and OUT of Scope for the Design Team. What are the clearly defined boundaries to prevent the project form getting too large and complicated?

  IN: - Mechanical structure to hold up to 16 channels of sensors
  - Mechanical structure to deploy the array to structure surface flexibly
  - Software to control the x-y-z-scanning stage, data acquisition and processing
  - Demonstration of the completed system capabilities
  - Fully assembled system should be compact and clean (look good)

  OUT: - single sensor design and optimization for damage diagnosis
  - Software does not need to be from scratch (i.e.: can use and modify existing codes in NDEL)

- Clearly list chipsets, software, equipment, test set-ups, working systems, etc. that will be supplied to the Design Team to facilitate their efforts and keep project cost reasonable.

  The following will be supplied:

  1) Inductive, capacitive and high-frequency EM sensors for composites NDE
  2) 16 channel NI DAQ and FPGA modules
  4) An x-y-z-scanning stage and control system
  5) The x-y-z-scanning stage control system manual
  6) a set of customized composite samples with artificial and real damage

Constraints:

- List all constraints on the project team.
  - Examples include: Equipment the team must interface with, past Capstone Designs the team must build upon previous results, chip sets / software team must use in the design, etc.

Cost for Sponsorship: $4000

Project Team: (Completed once semester begins)

Name	Responsibility

Faculty Advisor: (Assigned by ECE Dept . based on project requirements)

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