

**Advanced Research Sensor and
Controls Project Review Meeting**

DOE NETL

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**EMBEDDED ACTIVE FIBER OPTIC SENSING
NETWORK FOR STRUCTURAL HEALTH
MONITORING IN HARSH ENVIRONMENTS**

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Outline

- Motivation, Overview & Objectives
- Background and Fundamentals of Proposed Technology
- Project Scope and Work Plan



MOTIVATION AND OBJECTIVES



Motivation

- **Non-Destructive Evaluation (NDE) of structural health in advanced energy systems.**

Examples:

- Ultra Supercritical (USC) systems:
 - Steam temperature 760°C, pressure 5000 psi.
- Integrated Gasification Combined Cycle (IGCC):
 - Temperature well above 1000 °C ,2000 psi.

Challenges:

- High temperature, high pressure, severe corrosion.



Project Overview & Objectives

- Objectives:
 - Develop an embedded, remotely controlled/monitored quasi-distributed sensing network for NDE of advanced fossil power systems.
 - Potential for simultaneous multi-parameter measurement (temperature, strain, corrosion, cracks).
 - CPT will develop a fiber-optic NDE sensing system and evaluate it by a laboratory test apparatus.



Technical Merits

	Traditional FO	Traditional NDE	FO NDE
Measurands	Temperature (T) Strain (S)	Cracks, Corrosion	T, S, Cracks, Corrosion
Embeddable	Yes	Challenging	Yes
Multiplexing	Yes	Complex	Yes
Active/Passive	Passive	Active	Active
On-site Power	No	Yes	No
Sensor Dimension	<200µm (O.D.)	Millimeter ~ Centimeter	<200µm (O.D.)
Temperature/ Pressure	T>800°C, P>5000psi	T<500°C, Low Pressure	T>800°C, P>5000psi
EMI/Corrosion Immunity	Yes/Yes	No/No	Yes/Yes



The proposed sensing technology will demonstrate better performances in all the listed aspects.



Impacts

- Increased safety, reduced cost, better performance:
 - NDE for advanced fossil power systems:
 - USC boilers.
 - IGCC gasifiers.
 - NDE for other applications:
 - Civil.
 - Security/Military.
- A new concept: “active” sensing in a “passive” configuration.



BACKGROUND AND FUNDAMENTAL TECHNOLOGY



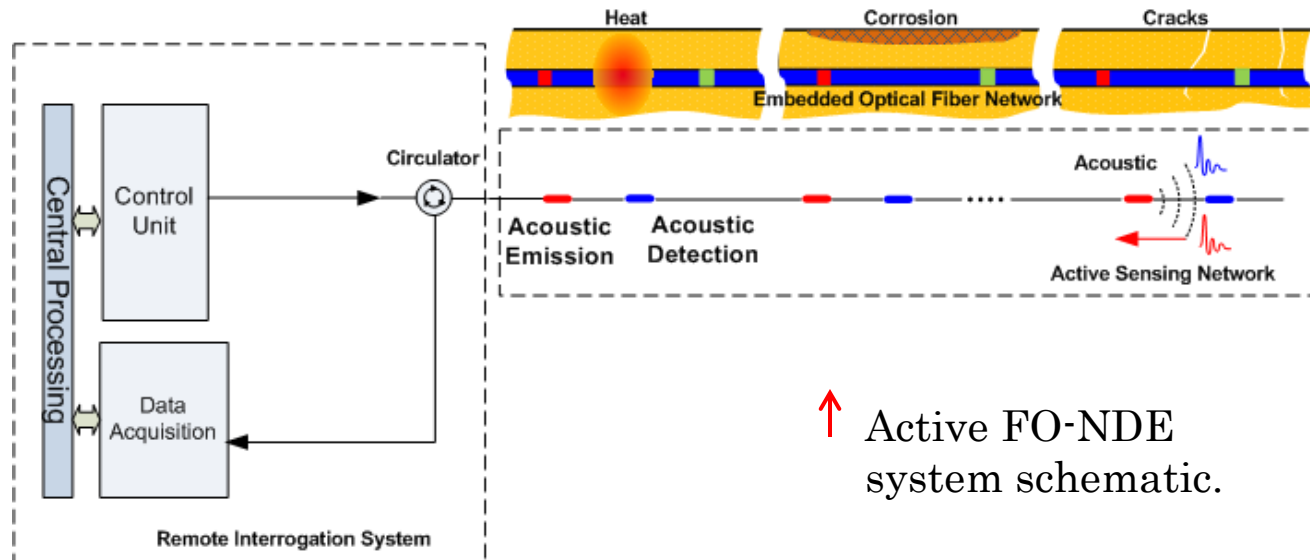
Existing Technologies (NDE)

- Thermal imaging:
 - Distributed temperature on outer shell
 - Heavily insulated – only appropriate as a final safety measure.
 - Requires on-site access.
- Remote piezoelectric transducer:
 - Generally low temperature.
 - Degradation associated with EMI and corrosion.
 - Requires on-site electric power.



Proposed Approach:

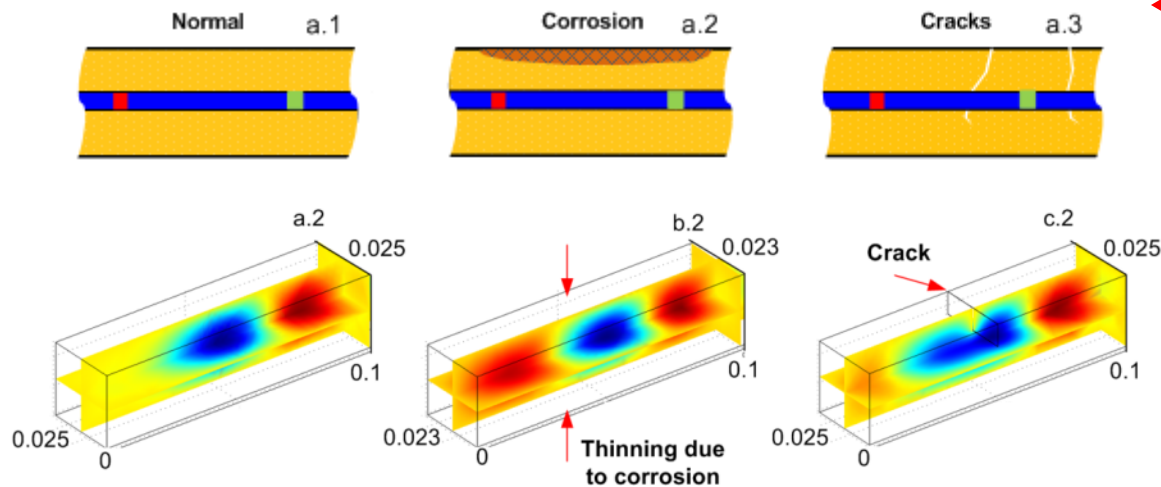
- Active FO-NDE:
 - Long-span, multi-parametric, quasi-distributed.
 - Each sensing cell comprises a pair of acoustic emission and detection sensors.
 - Optoacoustic acoustic emission.
 - High temperature acoustic detection.



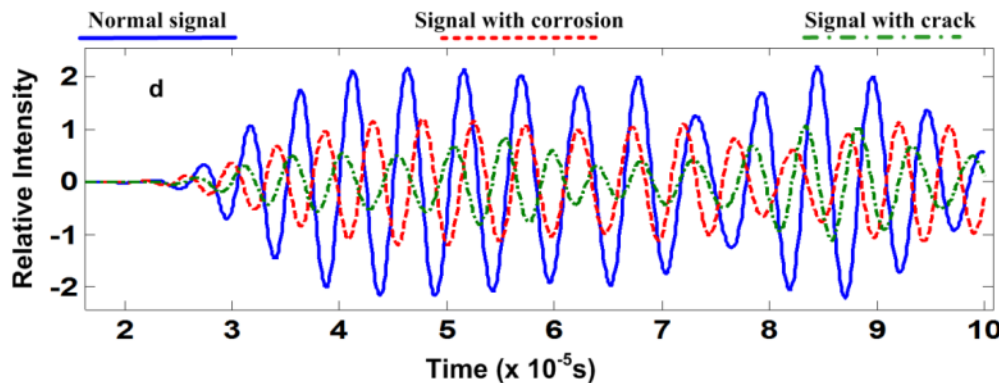
↑ Active FO-NDE system schematic.

Proposed Approach: Principle

- Key: acoustic signature encoded with plentiful information.



← Numerical results showing the acoustic field under the influence of various parameters and the detected signature.



PROJECT SCOPE AND WORK PLAN



Project Team

Organization:

Organization	Responsibilities
Virginia Tech CPT largest university fiber sensor R&D group in the U.S.	Overall project management and coordination All sensor development efforts

Personnel:

Personnel	Responsibilities
Anbo Wang (CPT)	Project PI: project oversight
Cheng Ma (CPT)	Oversight sensor development and testing
GRA x3(CPT)	Execution of research tasks



Scope of Work

- Design & construct FO-NDE system.
 - Development of FO acoustic emission and detection elements.
 - Development of sensing system.
- Conduct computer simulation.
 - Develop computational model to describe acoustic generation and propagation.
- Construct test apparatus.
 - Develop laboratory test apparatus for sensor testing.
 - Develop sensor embedment techniques.
- Lab test of sensing system.
 - Operation at 1000°C.
 - Multi-parameter measurement.

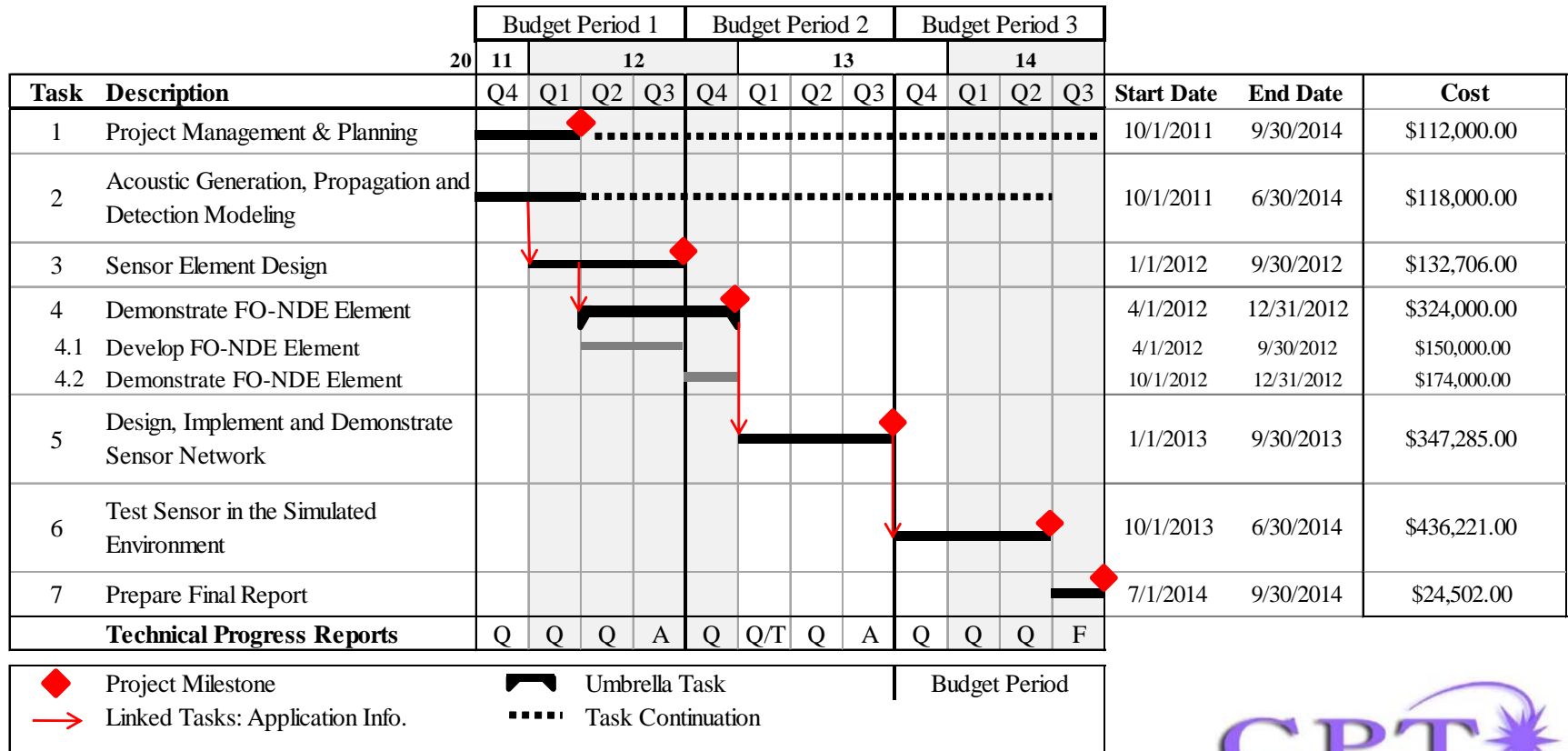


Tasks to be Performed

1. Project management & planning
2. Acoustic generation, propagation and detection modeling
3. Sensor element design
4. Demonstrate single FO-NDE element
5. Design, implement and demonstrate sensor network
6. Test sensors in the simulated environment
7. Prepare final report



Proposed Schedule



Reports: Q - Quarterly A - Annual T - Topical F - Final

