More on the Goals and Outcomes section

ENGR 3100

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> *Explain what you are trying to achieve? Explain your objectives using absolutely no jargon.*

The Objectives section is the most important section of the proposal. It is your first chance to explain to the reader what you want to achieve and what you want to do. You want to tell the reviewer *right away* what your goal is and, if the research is successful, how you would fill a critical need, close a gap in knowledge, or be able to do something new.

The Objectives section is also a discussion of your whole proposal in miniature. This is a chance to set expectations by the reader. As the reader continues to read, you want them to reach your conclusions and make choices for the research that are your choices. You can do this by telling them what to expect now. If you do this well, by the end of the proposal, they will agree with you that what you propose needs to be done and is the best path to achieving your objectives.

1 Goal Paragraph

The first paragraph should be very short—no more than 1–2 sentences. You are merely stating the overall goal of the proposal. It should start this way:

The goal of this research is to ...

or like this

The purpose of this research is to ...

2 Introductory Paragraph

In this paragraph, your goal should be to introduce your research subject and quickly capture their attention. This paragraph should describe a **gap in knowledge** and a **critical need** that fills this gap. It is critical to know your funding entity's mission statement and ensure the critical need you are trying to fill fits well within its mission. This paragraph should include the following information:

- *First sentence/Hook:* Use this sentence to grab your reader and convey a sense of importance or urgency to your research. This should describe WHY it is critical that you conduct the research (i.e., saving lives, preventing cancer, etc.)
- *Known information:* (3–5 sentences) State what is currently known. Ground the reader in the subject. Provide only the necessary details about why you are proposing the work.

- *Gap in knowledge or ability:* State clearly the gap in knowledge that needs to be addressed.
- *Critical need:* The knowledge (hypothesis-driven), technique, material, or process that you propose to develop. This is the reason your proposal should be funded.

The contents of this paragraph should match the overall message of the State of the Art and Limits of Current Practice section: The State of the Art is the Known Information; The Limits in Current Practice is the Gap in Knowledge. What is unique here is that you identify, as the point of this paragraph, a certain Critical Need that needs to be filled. How you will fill this need is explained in the next paragraph.

> The goal of this research is to be able to assess in real-time the risk of cyber-attacks on nuclear instrumentation and control systems.
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> A certain danger to our nuclear facilities is the possibility of a cyber-attack and the subsequent destruction of critical nuclear assets. Currently, defense plans for such facilities isolate from the internet the critical safety and security systems. Even so, it is understood that cyber-attacks can jump an air gap and that a cyber-attack is possible. To be able to evaluate our security and and prioritize defenses, we assess and evaluate these risks. Probabilistic risk assessment (PRA) tools are being adapted to the cyber-realm, and tools like Cyber Informed Risk Analysis (CIRA) can be used to evaluate risk. But, these traditional methods for cyber-safety are limited. They can only evaluate assumed threats. They are incapable of adjusting an analysis to a changing cyber-landscape. They are unable, due to their *a priori* approach, to incorporate new information into their analysis. To overcome these difficulties, what is needed is the capability to model and simulate control systems and their vulnerabilities, to provide up-to-date assessments of risk using *a posteriori* information, and to provide these estimates in real-time.
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> Color key: Hook, Known Information, Gap/Limit of Current Practice, Critical Need

3 Approach Paragraph

In this paragraph, you want to introduce the solution that fills the gap in knowledge. It is critical to convince your reviewers that you have the solution to address this gap and the expertise to accomplish this solution. Keep your wording simple, relevant, and to the point. You will want to address the following points:

- What do you want to do?
- Why are you doing it?
- How do you want to do it?

There is some flexibility in this paragraph, depending upon how your proposal is structured and what your goals are. For example, your research may be strictly hypothesis-driven, and you want to test that hypothesis. In other cases, you may want to develop a critical tool or technique. It should include the following information:

- *Solution:* This how you will fill the critical need. Keep your wording general in this sentence — you are stating your overall plans, and the reviewers understand that the specifics may be subject to change.

- *Rationale:* Explain how you arrived at your central hypothesis (for example, using past studies and published literature). Briefly, state what your project's completion would make possible (e.g., new engineering analysis or methods), and tie it to the funding entity's mission.

- *Hypothesis:* Your proposal should contain both of these components. Describe how your project addresses the critical need, and clearly state the proposed solution.

  The hypothesis is a conjecture about cause and effect that connects planned actions to desired outcomes. It tells an "if-then" story: if we take certain ac:on, then we will get a desired result. State your central hypothesis clearly, specifically, and with simple language. You want to demonstrate to the reviewers that you have a hypothesis-driven proposal that is specific, unambiguous, measurable. and falsifiable. Avoid vague hypotheses because it will be unclear to the reviewers what you expect to determine with the proposed research.

- *Pay-off:* Describe what the pay-off is for this effort. How does it help you meet the overall goal of the project? How does it help you move past the limits of current practice outlined in the Introductory Paragraph?

- *Qualifications:* You might briefly state why your experimental design and your team are the best to accomplish the research goals. You can mention factors such as your preliminary data, personnel qualifications, laboratory equipment, etc., but it is important to keep it concise.

  To solve this problem, we will combine models of the plant with models of the cyber-domain to make a complete cyber-physical simulation. This simulation will be used to characterize attack points and attack strategies. Subsequently, the simulation will be used with sequential Monte Carlo (SMC) approaches, real-time data, and operator knowledge to generate cyber-attack likelihoods. By combining a numerical simulation of the physical plant with the hardware-in-the-loop simulation of real cyber-hardware, we should be better able to more accurately model the attack surface and characterize the effect of attack on the physical aspects of the plant. If we can correctly capture the cyber-attack surface and consequences, then we will be able to completely describe the cyber-risk to a nuclear power plant. Understanding the risk associated with design decisions and being able to determine when an attack is occurring is fundamental to cyber-protection. The DHS, in its *National Strategy for Physical Protection*, calls for integrated modeling, simulation, and analysis into asset planning and decision support activities, and for integrated risk modeling of cyber and physical threats, vulnerabilities, and consequences. Real-time cyber-informed risk assessment will afford a direct way to achieve these goals, and will provide the nuclear industry a necessary tool to determine if attacks occur and how to respond.

  Color key: Solution, Rationale, Hypothesis, Pay-off/Impact

4 Outcomes Paragraph

In this section, you will describe briefly each of the outcomes for your research. These are the outcomes you listed when you first wrote this section.

Within 2–4 sentences each, you should describe what you should be able to do if the research is successful. Remember this is outcome focused. A typical grant will have between 2 and 4 Outcomes. Plan to describe each outcome in a separate paragraph. These tips may help you to formulate the outcomes:

- Give your outcome an active title that clearly states the what you are able to do if the work is successful
- Include a brief summary or description of the each anticipated outcomes.
- To make it easier for the reviewers to clearly read and understand each outcome, it is often helpful to use headings and/or bullets to delineate each one.

  If this research is successful, we should be able to do the following things:

  1. *Simulate digital I&C (instrumentation and control) systems under attack:* We will be able to simulate I&C systems using a combination a simulation of a generic PWR (GPWR) simulator with simulations of cyber-domain agents into a cyber-physical simulation. This simulation provides a platform for evaluating the characteristics and behaviors of components in digital I&C systems. Researchers and cyber-security experts can use it to simulate an I&C system under cyber-attack and to assess cyber-risks in real-time.
  2. *Assess attacks based on risk:* We should be able to characterize the threats to nuclear I&C systems on a cyber-physical basis, and determine what attack strategies can result in physical damage to safety and security systems. This will be formed by a risk-based understanding of the nuclear cyber-physical systems. We should be able to characterize system data flow, evaluate data access points, and the connectivity and interactions of cyber-components, and assess the vulnerabilities that can affect them. Combined with an analysis of the impact of attacks on the physical system, we should be able to define strategies that meet an adversary's goals, and estimate the probability of achieving them.
  3. *Detect cyber-attacks in real-time:* We should be able to use sequential Monte Carlo techniques in combination with Bayesian inference to provide estimates of an attack's likelihood. In this approach, an anomaly detector reveals when an attack occurs. The detector generates a likelihood of a particular attack strategy, and revises the likelihood using measured real-time data. The likelihood provides a degree of belief in the attack strategy and the real-time, up-to-date risk to the plant. Those attack strategies with highest risk can then be addressed.

  Color key: Outcome Title, Strategy, Outcome.

5 Impact Paragraph

This final paragraph of the Objectives is often overlooked, but it is vital for the impact of your proposal. The final paragraph should include the following important details:

- *Innovation:* Plainly state what is innovative about your project. What would completion of this proposal bring to the field that is not present currently?
- *Outcome Impact:* If your research is successful, what should you or the engineering community be able to do? Specifically state your expected outcomes for this project. Use plain language.
- *Impact/Pay-off:* Who cares? If you are successful what difference will it make? State how your project would help those who need it.

The project proposed here will address those features of nuclear systems that create vulnerabilities, and develop strategies to prevent and identify attacks. We will provide a needed complement and addition to the DOE's cybersecurity R&D efforts and meets the strategy of the DHS. This research will provide a real-time probabilistic assessment of cyberattacks. The consequences of the attacks form a risk-based assessment of the security of a digital I&C system. The true impacts of this research are the modeling and simulation of digital I&C systems for cyber assessment and the real-time probabilistic risk assessment of the security of cyber-physical systems.

Color key: Innovation, Outcome Impact, Impact/Pay-off

6 Overall Structure

This section follows the overall OCAR (opening, challenge, action, resolution) structure. The Goal and Introduction paragraphs are the opening. At their end is the challenge, which is the Critical Need. The Action is described in the Approach and Aims paragraphs. Finally, the Impact paragraph brings some resolution and shows what great things can happen if this work is successful.

Opening	¶ Goal
	¶ Introduction Hook Known information Gap in knowledge
Challenge	Critical need
Action	¶ Approach Solution Rationale Hypothesis Pay-off Qualifications
	¶¶ Outcomes 1. . . . 2. . . . 3. . . .
Resolution	¶ Impact Innovation Outcome Impact Impact/Pay-off