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Dynamic Instructions for Nuclear Power Plant Field Workers

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Changing the World's Energy Future

Idaho National Laboratory

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ABSTRACT

Most tasks conducted at a nuclear power plant are guided by a procedure in one way or another. Some tasks must be conducted by strictly adhering to the prescribed steps, while other tasks use the procedures as a reference guide. Traditionally, the procedure process in the nuclear industry has been paper heavy. In recent years however, the nuclear industry has considered adopting more dynamic solutions to improve the efficiency of their work management process, advance human and system performance, as well as reduce the cost of handling paper copies of documentation. As a first step, many nuclear utilities in the U.S. deployed solutions that electronically route the documents through the review and approval processes and where the worker in the field uses an electronic copy of the instruction or procedure on a handheld device. These electronic copies are very similar to the format of the paper instruction but do have some additional capabilities to capture recorded input and notes.

In even more recent years, the industry has started to look for solutions beyond electronic copies due to the fact that the industry has not yet seen the human performance benefits they anticipated when transitioning from paper to electronic versions. In order to gain these benefits, one needs to rethink and redesign the way the field worker interacts with the instructions and not just mimic the same process on a digital device. This is achieved via dynamic instructions that guide the worker through the correct task path based on the decisions and input recorded along the way. Relevant additional information is available at the worker’s finger tips whenever it might be needed.

Idaho National Laboratory (INL) and NextAxiom Technology, Inc. entered a partnership in 2018 to develop a dynamic instructions solution. The goal of the partnership was to develop a product that provides field workers a streamlined and dynamic work experience to improve human performance and overall efficiency. INL and NextAxiom submitted a proposal to the Department of Energy Office of Technology Transitions and were awarded a 24-month-long commercialization grant, which was initiated in June 2018. This report provides a summary of the overall effort including individual activities conducted.

The effort focused on these two main tasks:

1. Develop a commercial-grade field worker interface, which the field worker uses to access work instructions and information. This tool will guide the field worker through the correct work execution path.

2. Engage with industry and stakeholders. A key activity to secure the successful commercialization of the dynamic instructions solution is to ensure that the market is aware of its existence and value.

Since the conclusion of the effort, the nuclear industry has continued to move towards adopting and deploying smart forms and dynamic instructions to enable individual initiative for digital work execution.

INL's involvement in this effort was funded by the U.S. Department of Energy Office of Technology Transfer Technology Commercialization Fund under DOE Idaho Operations Office Contract DE-AC07-05ID141517. The specific project number is TCF-17-13408.

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ACRONYMS

EPRI	Electric Power Research Institute
INL	Idaho National Laboratory
NextAxiom	NextAxiom Technology, Inc.
DIP	dynamic instruction platform
EWP	electronic work package
MWP	mobile work package
TCF	technology commercialization fund
LWRS	Light Water Reactor Sustainability
APS	Arizona Public Service
PPA	Procedure Professionals Association
DIRECTOR	Dynamic Instructions Editing Tool Requirements
NEWPER	Nuclear Electronic Work Packages–Enterprise Requirements
TAG	topic area group
OPG	Ontario Power Generation

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This effort was funded by the U.S. Department of Energy Office of Technology Transfer Technology Commercialization Fund under DOE Idaho Operations Office Contract DE-AC07-05ID141517

Dynamic Instructions for Nuclear Power Plant Field Workers

1. INTRODUCTION

1.1 Background

Idaho National Laboratory (INL) and NextAxiom Technology, Inc. entered a partnership in 2018 to develop a scalable dynamic instructions solution. The goal of the partnership was to develop a product that provides field workers with a streamlined and dynamic work experience to improve human performance and overall efficiency. INL and NextAxiom submitted a proposal to the Department of Energy (DOE) Office of Technology Transitions and were awarded a 24-month-long commercialization effort, which was initiated on June 2018 with software development completed on November 10, 2019. This report provides a summary of the overall effort, including individual activities conducted.

In support of DOE's efforts to increase industry engagement and commercial impact of the national laboratories and to fulfill the statutory direction provided in the Energy Policy Act of 2005, the Office of Technology Transitions awards proposals that are funded with the statutorily established Technology Commercialization Fund (TCF). TCF focuses on supporting the commercialization and deployment of promising energy-related technologies developed at the national laboratories that have commercial potential. The TCF is part of a broader set of initiatives designed to foster stronger partnerships between the DOE national laboratories, private sector companies, and other entities involved in bringing energy-related technologies to the marketplace.

The TCF is a funding opportunity that leverages the research and development funding in the applied energy programs to mature promising energy technologies with the potential for high impact. These funds are matched with funds from private partners to promote promising energy technologies for commercial purposes. The goals of the TCF is to (1) increase the number of energy technologies developed at the national laboratories that graduate to commercial development and achieve commercial impact and (2) enhance the Department's technology transitions system with a forward-looking and competitive approach to lab-industry partnerships.

The TCF effort described in this report has the project number identifier: TCF-17-13408.

1.2 Paper-Based Procedures in the Nuclear Industry

All tasks conducted in nuclear power plants are guided by procedures, which help ensure the safe and reliable operation of the plants. One prominent goal of the nuclear industry is to minimize the risk of human errors. To achieve this goal, workers must ensure that tasks are correctly and consistently executed. This is partly achieved by training and by a structured approach to task execution, which is provided by procedures and work instructions.

Procedures are used in the nuclear industry to direct the field worker's actions in a proper sequence. The governing idea is to minimize the reliance on memory and choices made in the field. However, the procedure document may not contain sufficient information to successfully complete the task. Therefore, the field worker might have to carry additional documents, such as turnover sheets, operation experience, drawings, and other procedures to the work site.

The field worker may carry a large stack of documents needed to complete a task in the field. Even though the paper process has aided industry safety for decades, there are limitations to using paper. Paper procedures are static (i.e., the content does not change after the document is printed), difficult to search, and rely heavily on the field worker's situational awareness and ability to consistently meet the high expectation of human performance excellence.

For a paper procedure to be applicable to the constantly changing environment in the plant, the procedure must be written to encompass multiple different scenarios. This makes the paper procedure bulky and hard to navigate, which forces the field worker to search through a large amount of irrelevant information to locate information applicable to the task at hand. This can take up valuable time the field worker could have spent on task execution, and it can potentially lead to unintentional deviations and errors. Other challenges related to the use of paper procedures are managing multiple procedures, place-keeping, finding the correct procedure for a task, and relying on other sources of additional information to ensure a functional and accurate understanding of the current plant status.

1.3 Electronic Work Packages and Electronic Procedures

As the nuclear industry aims to improve human performance and overall efficiency, the utilities began deploying electronic work package (EWP) solutions. In other words, the nuclear industry started to transition by abandoning timely and costly paper-based work processes. The EWP solutions present the procedure to the field worker by using various types of electronic documents (e.g., a PDF document with hyperlinks and overlays) to streamline work processes, routing the documentation to the relevant reviewers, gathering approval signatures to authorize work, and efficiently archiving the documentation when work in the field is complete.

Electric Power Research Institute (EPRI) defines an EWP as an electronic file or series of files that makes up a work package used to complete a work task using a portable device (such as a tablet).

All EWP solutions currently used at nuclear utilities only support electronic procedures. In its simplest form, an electronic procedure is an electronic copy of the paper procedure (i.e., a PDF or similar document that displays the procedure content in a manner that is very similar to the paper-version). The more advanced electronic procedures use hyperlinks to provide additional information such as photos and appendices, some user inputs such as recorded values, links between procedures, and mark-up capability such as writing notes and conduct traditional place-keeping in the PDF.

The initial philosophy was that, by using electronic procedures on handheld devices, the utility would see great savings in paper costs and improved human performance. While there are documented cost savings from the reduced use of paper, the industry has started to realize that human performance will not automatically improve when switching to executing electronic procedures on a handheld device. In fact, human performance might decrease. It has been recognized that executing procedures in the exact same manner on a handheld device as on paper will most likely not be as time efficient as when using a paper copy. A PDF on an electronic device is not as easy to flip back and forth or compare two pages. For the nuclear industry to obtain the human performance improvements and overall system efficiencies, the paper process needs to be replaced with a procedure system that provides more benefits than an electronic procedure that mimics the paper process. It is not enough to simply display the procedure on a digital device, the additional capabilities of introducing said devices into the plant should also be leveraged during the procedure execution.

An independent review and study of market analysis for dynamic instructions system for field workers was conducted internally at INL by the Technology Deployment office in May 2016. The analysis is a brief study of the intellectual property, publications, and competitors within the dynamic work instruction market. The study concluded that focused and product-specific claims may be available to patent and that there is potential to copyright related software. The study identified two EWP system vendors (ATR, Inc. and DataGlance, Inc.) as companies of interest. DataGlance offers an EWP solution with electronic procedures (i.e., smart PDFs). The identification of DataGlance indicates the value the nuclear industry sees in the transition from a paper process to an electronic process. The ATR Inc. contribution is the ability to convert the content in the paper procedures to data, which then can be used to generate the procedure content into any predefined template for checklists or procedures. The identification of ATR Inc. indicates the value of converting static procedure content into data to enable a flexible and dynamic representation of the content. ATR Inc. also indicates the need for supporting applications, such as a procedure designer and conversion tool.

Examples of other companies that offer EWP solutions to the nuclear industry are NextAxiom, BWXT, Westinghouse, DevonWay, and CurtissWright.

During 2012–2016, research conducted at INL provided evidence that transitioning from paper or electronic documents to a dynamic instructions solution that dynamically guided the field worker through the correct task execution would increase human performance and worker efficiency. INL filed a patent application in December 2017 for the “methodology used to enable dynamic computer-based procedures” (Oxstrand, Le Blanc, Al Rashdan, & Bly 2017), where computer-based procedures is a legacy term for what now is called dynamic instructions. The next section will discuss INL’s dynamic instructions concept in more detail.

1.4 Dynamic Instructions

To address the limitations of both paper and electronic procedures, improve efficiency, and enhance performance, INL researchers developed a dynamic instructions concept. The dynamic instructions system provides a streamlined work process and dynamic support to guide the field worker through the task execution, which will help them focus on the task at hand rather than on the process. The dynamic instructions guide the field worker seamlessly through the logical sequence of the procedure. In addition, the dynamic instructions system makes use of the inherent capabilities of the technology, such as incorporating computational aids, easy access to additional information, just-in-time training, and digital correct component verification. A dynamic instructions system offers a more dynamic means of presenting procedures to the field worker, displaying only the relevant steps based on operating mode, plant status, and task at hand. A dynamic presentation of the procedure guides the field worker down the path of relevant steps based on current conditions. This feature reduces the field worker’s workload and inherently reduces the risk of incorrectly marking a step as not applicable and the risk of incorrectly performing a step that should be marked as not applicable. Some of the key functionality of the dynamic instructions system are:

Automatic place-keeping. The dynamic instructions system highlights the active step (i.e., the step being conducted). Other steps are shown, but the field worker can only take actions related to the active step. This function makes it easy for the field worker to stay on the specified path. This built-in procedural adherence has proven to reduce the amount and severity of human errors.

Simplified step logic. A conditional step in a procedure is a step that is based on plant conditions or a combination of conditions to be satisfied prior to the performance of an action. The dynamic instructions remove complexity from step descriptions by presenting conditional statements as simple questions. For example, statements such as “IF starting Pump A, THEN perform the following…” are presented as “What pump do you want to start; Pump A or Pump B?” Depending on the answer, the procedure will take the field worker to either the step with the actions needed to start Pump A or the step with the actions needed to start Pump B.

Component verification. There are multiple ways correct component verification can be implemented and improved by using technology. Researchers at INL have explored correct component verification via barcodes, optical character recognition, and manual input. When using barcodes or optical character recognition, the system will match the input with a component database. If the correct component is verified, the field worker will be able to continue on with the step. If the correct component is not verified, the field worker will have to find the correct component before being able to proceed through the procedure.

An effective field worker interface will address the limitations and challenges of paper procedures, incorporate strengths of the existing process, and add additional functionality that is available when using digital devices. In addition, the dynamic instructions should be easy to use, allow for flexibility of use, and prevent human error.

Between 2012 and 2016, the INL researchers conducted dynamic instructions research as a part of the DOE Light Water Reactor Sustainability (LWRS) Program. Together with the nuclear industry, the researchers investigated the possibility and feasibility of replacing current paper procedures with dynamic instructions.

The researchers explored ways to use advanced technology to design a dynamic instructions prototype to include the dynamic presentation of the procedure content, context-driven job aids, and integrated human performance tools. All these innovations help the field worker focus on the task at hand rather than the tools. A design concept was developed that ensured a high level of human performance and system efficiency while requiring minimal training. Three evaluation studies were conducted in training facilities at collaborating nuclear utilities using actual field workers as participants: Arizona Public Service's (APS) electrical laboratory, Duke Energy's flow loop facility, and APS's instrumentation and control laboratory (Oxstrand, Le Blanc, and Bly 2013). In addition, four field evaluation studies have been conducted at nuclear power plants operated by APS, Duke Energy, Pacific Gas and Electric, and Southern Nuclear (Oxstrand, Le Blanc, and Bly 2014; Oxstrand, Al Rashdan, Le Blanc, Bly, and Agarwal 2015; Oxstrand, Le Blanc, Bly, Medema, and Hill 2015). In each field study, a small set of procedures was converted to the dynamic instructions system and then used by the field workers during normal operation for a couple of months. The field workers then provided feedback to the researchers about the system's usability and potential areas of improvement.

The researchers sought input from across the nuclear industry and researchers actively collaborated with and/or received valuable feedback from Ameren, APS, Dominion, Duke Energy, Energy Northwest, Exelon Nuclear, First Energy, NextEra, Pacific Gas and Electric, SCANA, South Texas Project, Southern Nuclear, Talen Energy, Tennessee Valley Authority, and Xcel Energy. All of which were members of the Nuclear Electronic Work Package—Enterprise Requirements initiative, which was facilitated by the INL researchers. The INL researchers are also leading the Dynamic Instructions Editing Tool Requirements (DIRECTOR) industry-wide initiative, which was launched in 2019. DIRECTOR is described in more detail in Section 7.2. This widespread collaboration helped to ensure that the dynamic instructions concept was not only effective at enhancing efficiency and reducing error but was also applicable to the industry at large.

In summary, the research activities demonstrated several benefits, including increased efficiency and improved human performance by using automatic place-keeping and the ease of moving between and within procedures. The dynamic presentation of the procedure and simplified step logic were identified as highly desirable features. Context-sensitive cues in the procedure proved to increase the worker's focus on the task at hand. Digital component verification was proved to reduce the risk of manipulating an incorrect component. Photos of components included in the procedure steps increased efficiency and reduced the risk of human error. Computational aids, such as performing calculations based on worker inputs, were proven to reduce the risk of human errors.

A demonstration of the proof-of-concept dynamic instructions system as well as a presentation of the design guidance can be viewed at http://dynamic instructionsdemo.inl.gov/. A copyright was asserted on the underlying software in 2017 (Oxstrand, Le Blanc, Bly, & Hansen 2017).

The INL dynamic instructions research is recognized both nationally and internationally. In September 2016, the "Design Guidance for Computer-Based Procedures for Field Workers" (Oxstrand, Le Blanc, and

Bly 2016) was published, which has been used as a basis for multiple nuclear utilities' requests for proposals for dynamic instructions solutions. The INL researchers leveraged their dynamic instructions usability expertise to develop a commercial-grade graphical user interface for the field worker, as described in this report.

For a dynamic instructions system to be a viable option to the nuclear industry, it must streamline the work process not only for procedure execution, but in work planning, scheduling, and procedure development. The dynamic instructions solution must seamlessly encompass the process from start to finish. The dynamic capabilities and the computational capabilities in the dynamic instructions system will enhance performance and efficiency during the execution of the procedure. A successful dynamic instructions system will include a procedure conversion framework to provide the capability to convert the tens of thousands of existing procedures into a structured data format, a procedure designer to be used when writing new procedures, and a commercial-grade, well-designed, graphical interface for the field worker. In addition, for the dynamic instructions system to reach its full potential, it needs to be integrated with other applications (e.g., EWP system) and plant systems (e.g., work management system). The dynamic instructions system needs to be able to effectively communicate with other applications to check available equipment, current plant status, access additional information, and easily update plant systems with information gained throughout the procedure execution (e.g., plant configurations or the submittal of a condition report). The next section describes what was in the scope of the INL-NextAxiom partnership and what parts of a comprehensive dynamic instructions system NextAxiom developed outside of the described partnership.

2. SCALABLE DYNAMIC INSTRUCTIONS SYSTEM FOR FIELD WORKERS

The goal of the INL-NextAxiom dynamic instructions solution was to increase the safety and human performance related to work execution in the field by including a dynamic presentation of procedures, context-driven job aids, and integrated human performance tools. The dynamic instructions solution would incorporate human performance improvement features into the electronic work process, such as computational aids, easy access to additional information (e.g., drawings and operational experience), just-in-time training at the job location, and digital correct component verification. The scope of the INL-NextAxiom effort was to develop the dynamic presentation of the procedure (i.e., the performer tool) and for that tool to be incorporated into NextAxiom's comprehensive dynamic instruction platform (DIP).

The two main tasks in the project were to:

1. Develop a commercial-grade field worker interface, which the field worker will use to access work instructions and information. This tool will guide the field worker through the correct work execution path.
2. Engage with industry and stakeholders. A key activity to secure the successful commercialization of the dynamic instructions solution is to ensure that the market is aware of its existence and value.

Commercial nuclear power plants were the main market targeted for this effort. All commercial nuclear power plants use procedures to conduct the majority of activities. Each nuclear power plant has multiple organizations that use procedures, including control room operations, field operations, maintenance, and chemistry. In addition to the commercial nuclear power industry, national laboratories, research laboratories, chemical process plants, and virtually any organization that uses structured work instructions is a potential market for the dynamic instructions solution.

At the time of the INL-NextAxiom TCF project there were no commercial "off-the-shelf" technology for highly dynamic instructions systems or platforms that target the field worker at nuclear facilities. The nuclear industry needs to reduce operation and maintenance costs in order to continue operating in competitive energy markets. This goal to reduce operation and maintenance costs by 30% is clearly communicated through the nuclear promise (Nuclear Energy Institute 2016) and hence is a focus for the industry.

A well-designed dynamic instructions platform will increase the proportion of time devoted to conducting work while reducing waiting time and administrative burdens. Maturing the dynamic instructions technology to the point at which it can enable the commercialization of the comprehensive dynamic instructions platform will enable the more effective and efficient completion of work in the nuclear power industry, which will result in reduced operation and maintenance costs.

Thomas, Lawrie, and Niedermuller developed a business case for highly dynamic electronic work orders for the nuclear industry. They concluded that approximately $3.5 million ($3.3 million of harvestable labor savings and $0.2 million of nonlabor savings) can be saved annually by transitioning from a paper process to a highly dynamic system, which would allow for an investment of over $20 million in present terms (Thomas, Lawrie, and Niedermuller 2015). The main cost-saving opportunities identified in the business case are from reduced human errors and a more streamlined work process. By adding capabilities to support other organizations and activities, such as chemistry activities in the field, engineering's plant design modifications, and plant surveillance, the annual savings will be even greater.

The main concerns raised by the nuclear industry when discussing the transition to a dynamic instructions system are the costs involved with converting or rewriting all existing procedures into a format that supports dynamic instructions, the concern that procedure writers and planners will need to be software developers to compose new procedures, the worry about the administrative burden of updating and maintaining an additional system, the risk of needing to reconcile information coming from multiple sources, and the risk that the field worker will become more inefficient and error prone when using new technology and work processes.

Therefore, INL recommends that any dynamic instructions platform is designed to address these concerns and challenges by containing a procedure conversion framework, which supports the automatic conversion of large batches of paper procedures into a digital format that supports dynamic instructions. A large batch conversion framework will greatly reduce the cost of transitioning to a dynamic instructions system. In other words, the procedures need to be converted into the basic building blocks needed for dynamic instructions. These building blocks will be used by the field worker interface to dynamically guide the field worker through the work execution. The metadata structure should also be used in the procedure designer (also known as an authoring or editing tool) to ensure that both old converted procedures and newly written ones all have the same functionality. Both the conversion framework and the procedure designer should be designed so that the users of the comprehensive dynamic instructions platform do not need to be software developers and it will be as easy to use (or easier) as the Word templates currently used.

To facilitate the effective integration of procedure-related information with other plant applications, the metadata should include the tags for describing interface calls between the field worker interface and a dynamic instructions enterprise server. In this way, any dynamic instructions enterprise server will be able to access functionality and data from all different applications needed for the performance of a comprehensive dynamic instructions platform to communicate. This middleware will pull relevant information from multiple applications and seamlessly integrate it into the field worker user interface. During work execution (or when work is complete) the middleware technology should ensure that all applications impacted are updated with correct values or information. This removes the administrative burden of manually pulling and pushing information to all different applications used to plan and execute work in the field. It also removes the risk of redundant information and the potential of this information to be out of sync.

As stated earlier, the scope of the INL-NextAxiom effort was to develop the dynamic presentation of the procedure. That tool was then to be incorporated into NextAxiom's dynamic instructions platform, which also includes parts such as the comprehensive and structured Procedure Definition and Execution Language (PDEL), a conversion framework, a procedure designer, dashboards, and an enterprise server.

As part of the INL-NextAxiom scope, the project:

1. Developed a commercialization strategy to raise awareness of the technology, which included hosting a Dynamic Instructions Symposium and launching an industry-wide dynamic instructions initiative
2. Developed and evaluated the field worker procedure tool, which included the development of functional requirements and a design specification
3. Planned and conducted a pilot demonstration at a nuclear power plant.

Table 1 describes the parts of the dynamic instructions platform NextAxiom was developing outside the scope of the INL-NextAxiom project.

Table 1. Dynamic instructions platform parts developed by NextAxiom outside the INL-NextAxiom project.

PEDL	The metadata structure
Procedure Conversion	Used to convert existing procedures into PDEL
Procedure Designer	Used by planners to define procedures with automatic PDEL generation as artifact
Monitoring Dashboard	Used for real-time monitoring of dynamic instructions and a portal for hand-offs between roles.
Analytics Dashboard	Used to gain business intelligence by analyzing the field worker and overall dynamic instructions performance
Dynamic Instructions Enterprise Server (hyperService® based)	Comprehensive infrastructure and tools for real-time and near real-time integration to backend systems and for gathering information from field worker interfaces

3. FUNCTIONAL REQUIREMENTS FOR FIELD WORKER INTERFACE

Functional requirements serve as the baseline for what type of functionality the interactive instruction platform includes. The team used a four-step approach to identify and describe the functional requirements. First, the team compiled a list of all requirements needed for a comprehensive field worker interface. They leveraged all their knowledge and experience from writing and using work instructions in the nuclear industry. Hundreds of requirements were identified.

The second step was for four team members with various areas of work instruction expertise to individually prioritize each requirement. The goal was to identify which requirements must be addressed in order to get a functional, albeit simplified, version of a field worker interface and which requirements could be addressed in a later release. A five-point scale was used where one was the most important type of requirement and five was used for requirements that were for functionality that would be nice to have.

The third step was to discuss the individual ratings and to come to a consensus for each of the requirements. Requirements that were rated highest priority were the ones absolutely necessary to transition from paper-based use and adherence practices to a dynamic and interactive practice. Requirements that were basic functions that the application automates to alleviate unnecessary cognitive demands or administrative burden were also rated as highest priority. All the highest priority requirements were included in the first phase of development (i.e., within the scope of the INL-NextAxiom effort).

Seventy-five requirements were rated one. The remaining functional requirements will be addressed in future releases of the product.

The final and fourth step in the approach was to further define each of the seventy-five high priority requirements. Each requirement was described to address one or more basic functionalities:

- Basic human-computer interaction functionality for a user to easily navigate within a dynamic and interactive instruction
- Enable users to change the status of steps in a guided, controlled way that is easier than recording them on paper or an electronic PDF
- Enable users to contribute additional content to the interactive instruction, such as comments and media at the step level
- Application automatically handles certain processing functions that would otherwise (on paper or electronic PDF) require the user to handle such actions cognitively or administratively. Examples are validating that data entered is within defined specifications, branching, and repeating steps
- Introduce a question-and-answer-based approach to conditional action steps.

The top priority functional requirements were grouped into subcategories, such as navigation, step interaction, statusing a step, not applicable steps when branching, bulleted steps, data entry, conditional steps, dynamic variables, step comments, accessing relevant information, displaying contextual information, nested steps, repeat steps, application performance, job management, users management, undo functionality, and notes, cautions, and warnings. Each subcategory includes multiple requirements that support desired functionality. For example, navigation encompasses six specific requirements, including that the worker should be able to freely navigate the entire instructions set, see

Table 2.

Table 2. Functional requirements for navigation, a subset of the highest priority requirements.

Topic	Requirement	Definition
Navigation	Freely navigate the instruction	The user needs the ability to navigate back and forth in the instruction to maintain an overview of the whole task.
	Automatically navigate to active step	The user needs to be able to navigate back easily and quickly to the active step in case they have looked ahead or back through the completed steps.
	Access instruction overview	The user should always be able to navigate to the instruction overview, which provides a high-level overview of all the sections and steps in the instruction. From the instruction overview, the user can navigate directly to any selected section.
	Select step	There might be situations where the user needs to interact with a step other than the one selected by the application as the active step.
	Interaction with content blocks	The user needs to be able to easily identify the different content blocks as well as being able to physically interact with them with minimal risk of mis-selection.
	Automatically navigate to next sequential step	The application needs to automatically navigate to the next applicable sequential step upon completion or statusing of the current active step.

The full set of functional requirements developed is protected under the Collaborative Research and Development Agreement between INL and NextAxiom and, hence, unfortunately will not be shared in this report.

By only including the highest priority functional requirements in the first iteration of the dynamic instruction field worker interface, the types of instructions the interface could handle were limited. The basic instructions targeted in the first product iteration are simple, low-risk, routine maintenance procedures that:

- Flow linearly (meaning that the performance sections are sequenced in the order they are performed)
- Use a single role for the subject performer of the task
- May include step-level data collection
- May include branching limited to content within the same instruction
- May include basic binary type conditional steps
- Do not require the use of independent or concurrent verification for steps (though there may be simple workarounds for this within the basic application).

4. DEVELOPING DESIGN SPECIFICATION FOR FIELD WORKER INTERFACE

The purpose of the design specification was to develop and visualize design concepts for each of the high priority functional requirements. This included specifications for the application layout, application menu, controls menu, content menu, jump to active step, instruction overview, step display, step menu, add field notes, access related information, complete step, associated documents, marking step not applicable, nested steps, bulleted steps, conditional steps, branching, data entry, data entry with tolerances, dynamic variables, repeated steps, undo step or action, read-only mode, and notes, cautions, and warnings.

The INL and NextAxiom teams worked closely together for multiple months to develop a design specification that incorporated human factors expertise for the user interface. Each design decision made was informed by software development time and budget constraints as well as the bounds of the currently established procedure use and adherence policy.

The design philosophy for the field worker interface tool was a result of over seven years of computer-based procedure (nowadays referred to as dynamic instructions) research led by Johanna Oxstrand and Dr. Katya Le Blanc (Oxstrand, Le Blanc, & Bly 2016). This research included field evaluations of a performance tool prototype at several nuclear power plants. Although the design philosophy is continually updated and refined, consistent high-level design requirements for a field worker interface for dynamic instructions were created.

The high-level design requirements are listed as follows:

1. Provide context-sensitive information wherever possible
2. Support all expected task flow characteristics
3. Support the expected level of flexibility in performing task
4. Guide the worker through a logical sequence of the procedure
5. Provide information needed to control the path through the procedure
6. Provide computerized support where appropriate and possible
7. Include functionality that improves communication
8. Provide a method to review and save records.

Every concept in the design specification developed for the INL-NextAxiom effort were created to meet these eight fundamental design requirements. The design specification is protected under the Collaborative Research and Development Agreement between INL and NextAxiom and, hence, unfortunately will not be shared in this report.

5. DEVELOPING THE PERFORMANCE TOOL

The performance tool is the application that the field worker uses to execute the dynamic instruction in the field and the frontend of the performance tool is the field worker interface.

NextAxiom and INL both contributed software developing talent to the project and supported each other throughout the two-year scope. The INL team primarily consisted of two software developers while the NextAxiom team consisted of multiple developers. The performance tool was written in multiple languages; TypeScript (i.e., a superset of JavaScript), HTML, XML, and CSS. Additionally, the project was accomplished through an object-oriented design approach. The software developers stored locally saved copies of the developed code using GitLab. A repository was created on GitLab that allowed development changes to be updated and merged with existing code on NextAxiom's remote server. The development overhaul was divided into segments that supported related functional and design requirements. The INL developers were primarily responsible for authoring the frontend user interface of the web application while the NextAxiom developers authored the backend code for the performance engine and Smart Widget technology as well as storing and retrieving the XML and metadata. The INL developers led development for the following segments:

1. Date/time utility
2. Capture media utility
3. Displaying field notes
4. Capturing field notes
5. Add comments
6. Add media
7. Notes, cautions, and warnings
8. Steps display
9. Active step display
10. Content/control menu display.

The software development and the development of design specifications were conducted in conjunction with multiple iterations. Throughout the process end user feedback was gathered. The feedback was assessed and, when needed, appropriate revisions were made to both design specification and implementation.

6. PILOT OF DEVELOPED TECHNOLOGIES

Following the software development completion, INL, NextAxiom, and Palo Verde Generating Station collaborated on a large-scale pilot of the performance tool as well as aspects of the integration platform for NextAxiom's electronic work management technology. The purpose of the pilot was to demonstrate the technology in a real-life capacity. The goal was to receive feedback on preferred functionality as well as opportunities for improvement.

The task used in the pilot was identified as a routine, low-risk task that had multiple decision points as well as opportunities to demonstrate the dynamic capabilities included in the tool. During the pilot, the task was executed by one of Palo Verde's turbine maintenance crews.

The instruction was converted through the NextAxiom conversion tool. Following conversion, the set of dynamic instruction and related documents reviewed by software specialists and supervisory operators at Palo Verde to ensure overall accuracy and integrity.

Before the pilot, INL researchers visited Palo Verde, where they presented the performance tool to field workers and senior leadership. The purpose was to gather initial feedback on the design of the field worker interface, address any questions and concerns, and spread awareness of these types of technology.

During the plant visit, the team captured positive feedback, such as that the capability to take notes on future steps was much received, as well as areas for improvements. A couple of examples of improvement items captured were the need to have multiple users working on the same instruction within a single session and the ability to prevent the user from unintentionally clicking through multiple steps while executing work.

The demonstration occurred on October 31, 2019, but planning began in August 2019. The task took place over the course of multiple night shifts. INL researchers were not able to follow the field workers as they were completing the task. Instead, the crew provided feedback to their supervisor by the end of the task. The feedback was then shared with the INL-NextAxiom team.

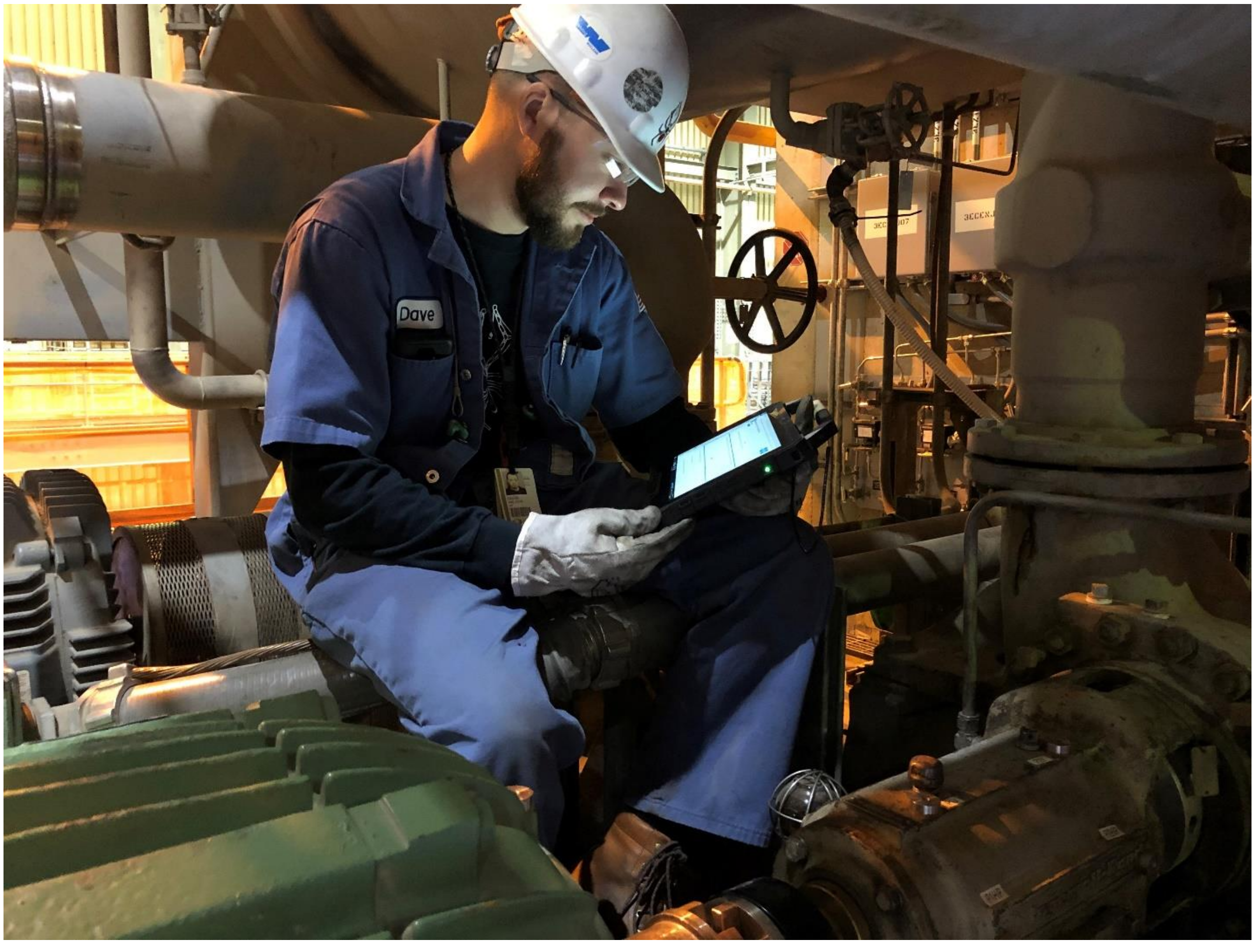

Figure 1. A Palo Verde field worker uses the performance tool to conduct his task.

Below are quotes from the maintenance crew who participated in the pilot when asked about their impressions of the performance tool:

- This is by far the most user-friendly interface I have used yet.
- The interface is incredibly simple and easy to use.
- Having the applicable procedure attached in the step is very handy.
- I really appreciate the camera feature and the ability to save photos directly to the work order so easily.
- From a leader’s perspective, the monitoring tool works well.
- Overall, I feel this platform is very close to a live dynamic instruction.

The crew also identified improvement opportunities, such as the ability to edit photos by using a pen tool or some way to pinpoint specifics in the photo, making sure the number pad is the visible keyboard for steps that require numeric input, and the need to easily rotate the camera from portrait to landscape modes.

In summary, the main insights gained from the pilot activities at Palo Verde were that:

1. the user interface received positive feedback and was regarded as user friendly and simple to navigate
2. the inclusion of additional applicable information within the instruction set was well received
3. additional capabilities, such as a built-in camera to take photos while completing a task, were regarded as beneficial and easy to use
4. leaders stated that the monitoring capability worked well, and that the performance tool would integrate nicely into an EWP solution.

7. INDUSTRY ENGAGEMENTS

One important aspect of TCF projects is to develop a strategy for industry engagements, which includes the strategy to raise industry awareness for the technology being developed as well as a commercialization strategy. This section will describe two of the main industry engagement activities conducted as part of the INL-NextAxiom project (i.e., the Dynamic Instructions Symposium and the DIRECTOR initiative) and briefly describe the effort's commercialization strategy. In addition to these activities, the researchers participated in multiple industry conferences and working group meetings where EWPs and dynamic instructions were the primary topics discussed.

7.1 Dynamic Instructions Symposium

INL and NextAxiom cohosted a Dynamic Instructions Symposium in Monterey, CA, November 13–14, 2019. The goal was to explore technology enabling dynamic instructions for field workers and discuss lessons learned and insights from first movers in the industry. The symposium participants discussed and collaborated on their plans for future implementations. In addition, INL and NextAxiom presented their joint commercialization effort. The agenda is in Appendix A—Agenda for Dynamic Instructions Symposium.

The symposium had thirty-two participants from fifteen different companies. The represented organizations were made up of six EWP and/or dynamic instructions vendors, four commercial nuclear utilities (out of them one was international), three national laboratories, EPRI, and PPA. Table 3. The participating organizations at the symposium. provides a list of all participating organizations. The participants' roles at their organizations and the distribution of these roles amongst the participants are illustrated in Figure 2.

Table 3. The participating organizations at the symposium.

Vendors	Utilities	Research Organizations	Standards Organization
ABB	APS	EPRI	PPA
DataGlance	Exelon	INL	
Honeywell FM&T	Ontario Power Generation	Los Alamos National Laboratory	
Lean Power	Southern Nuclear Company	Sandia National Laboratories	
Leidos			
NextAxiom			

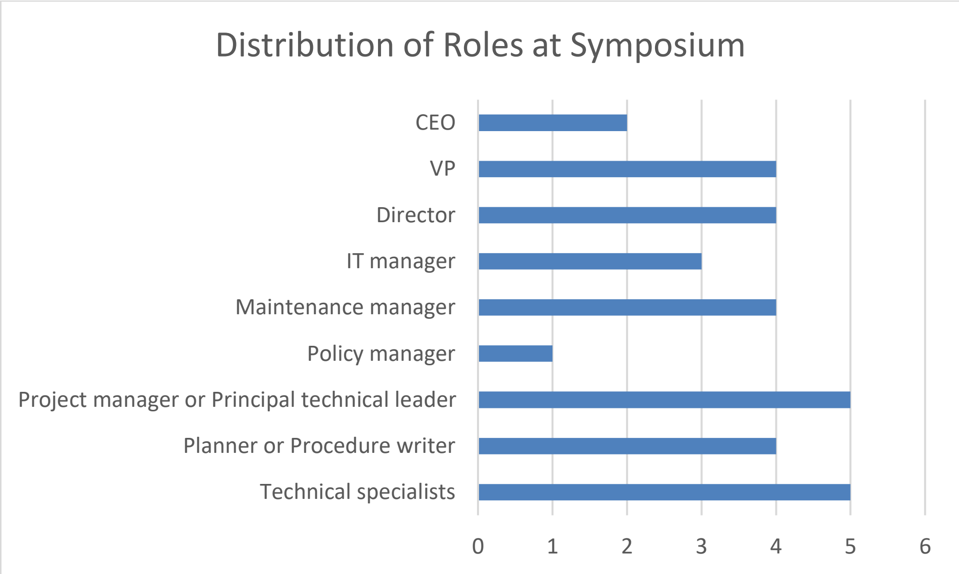

Figure 2. Distribution of roles amongst symposium participants.

There were three panel discussions throughout the symposium: a technical panel, a vendor panel, and a business panel. Topic specific questions were shared with the panelists before the symposium to help them understand the scope of the panel topic. The intent was not for the panelists to prepare answers to all questions. The panel discussions were highly interactive, where the audience were asking questions as well as taking an active part of the discussions.

The focus of the technical panel was to discuss the future of dynamic instructions for mobile work execution. The panelists were an IT manager from Exelon, IT business relations manager from APS, and a senior solutions architect from Southern Company. Table 4. Examples of questions for the technical panel contains examples of questions that were shared with the panel before the symposium.

Table 4. Examples of questions for the technical panel.

Questions for the Technical Panel
What must first occur in an institution to successfully advance from paper-based procedures to dynamic instructions?
How has the technology/process changed in the past 5 years for mobile field workers? What do you predict will happen in the next 5 to 10 years?
What is the biggest challenge right now in transitioning from current paper-based and electronic work packages to dynamic instructions?
As an individual in your organization, how can you most substantially influence the introduction of dynamic instructions to your organization?

From a technology standpoint, what is one piece of practical advice you would give to a utility considering the transition to dynamic instructions?
What is the question you are most tired of hearing on this subject, and what would you like to say about it so that you never have to answer it again?

The vendor panel discussed the marketplace demand for dynamic instructions solutions. The panelists were the chief executive officer from DataGlance, the vice president from Lean Power, and the vice president of technology from NextAxiom. Examples of questions provided to the vendor panel are in Table 5. Examples of questions for the vendor panel.

Table 5. Examples of questions for the vendor panel

Questions for the Vendor Panel
What positive effects will dynamic instructions technology have on nuclear work management?
What utility (in your opinion) has made the biggest advancements in dynamic instructions and what are they doing?
As a vendor, what are common misconceptions people have regarding dynamic instructions? How can we combat these misconceptions and communicate more effectively?
What's the question you are most tired of hearing on this subject, and what would you like to say about it so that you never have to answer it again?
What are the best resources for people who want to dive in deeper towards Dynamic Procedures?
What main characteristic sets your company apart from other electronic work package/dynamic instructions vendors?

The manager of maintenance programs at Ontario Power Generation, the maintenance manager for Los Alamos National Laboratory, and the project manager for mobile work packages at INL were the panelists on the business panel. The goal of this panel was to discuss both perceived and actual savings, benefits, and barriers of dynamic instructions. Table 6. Examples of questions for the business panel provides examples of questions shared with the panel before the symposium.

Table 6. Examples of questions for the business panel.

Questions for the Business Panel
How has the technology/process changed in the past 5 years for mobile field workers? What do you predict will happen in the next 5 to 10 years?
What is the biggest challenge right now in transitioning from current paper-based and electronic work packages to dynamic instructions?
What are the most critical changes the industry must make to face the future effectively?
What do you consider to be the first phase of transitioning to dynamic instructions? What do you think the best outcome would be for this first phase?
What types of quantitative return on investments would result from a successful transition to dynamic instructions?
What types of qualitative return on investments would result from a successful transition to dynamic instructions?

7.1.1 Summary of Symposium Discussions

The symposium brought vendors and customers together in a context where an open dialogue between the two was both encouraged and achieved. This section is an attempt to summarize two days' worth of productive panel discussions from the panel discussions, presentations, and beyond.

The EWP solutions have opened doors for the dynamic instructions solutions at the nuclear power plants. Before EWPs, workers sometimes had a hard time visualizing different approaches to work management and procedure use and adherence. It proved difficult for them to get a sense of what they could and should be asking for in terms of new functionality. By using EWP solutions, the workers were able to get hands on experience with electronic procedures, which in turn helped them start to think about other functionality that could be useful to them as they conduct work in the plant.

Another topic many participants felt strongly about was the desire to have vendors provide a “grocery list” of all possible functionality and data points in the dynamic instruction solution. That list would help the customer get a better understanding of what is currently available and possible. Such lists would also be very helpful when comparing the different products and vendors.

When pursuing a dynamic instruction or dynamic instructions solution, one cannot use the same return on investment plan and business case as was used to deploy an EWP solution. The business case for an EWP is commonly centered on decreasing operation and maintenance costs, which was largely driven by the nuclear promise (NEI 2016). Instead, the business case for dynamic instructions will have to focus on risk management and risk reduction. Incident avoidance will be the key factor. Considering the high retirement rate in the industry and the unfortunate high turnover of younger staff, the risk of human error will likely keep increasing. In other words, the risk or threat of something going wrong will be more important than the reduction of headcount for this type of business case.

Other factors that will be important for the business case are the validation of roles and responsibilities as the user signs into the application and/or a specific step and the access to a real-time informed schedule and tracking of the critical path. Data analytics will be invaluable when identifying bottlenecks and resolutions.

One question that was discussed at length was how to make a business case or justification for dynamic instructions for facilities where devices and cameras are restricted or not at all allowed. There seemed to be to main approaches to this topic amongst the participants:

1. Most work is conducted outside the restricted areas, hence there would still be great benefits to be gained with a dynamic instructions solution even if paper were still used in the restricted areas.
2. For organizations where most of the facilities have restricted or do not allow devices, there will unfortunately not be a business case.

As the industry moves forward with dynamic instructions, there is a need to define a common language and definitions for all the terms that are used, such as EWP, dynamic instructions, smart documents, and dynamic instructions. The participants concluded that the best way to frame the EWP solutions is as the platform that most organizations will use to deploy dynamic instructions.

There is also a need for a standardized information structure or model for the metadata used for the dynamic instructions solutions. This will minimize the risk for a utility to become too closely tied to one particular vendor. It will also open up the model for easy addition of potential new applications or functionality if needed later on. A common information model is currently being developed in the DIRECTOR initiative described below.

The business panel was asked the question of what would keep them up at night after deploying a dynamic instructions solution. The first risk discussed was not conducting enough testing before going live, either due to not fully understanding everything that needs to be tested or due to changes in the business environment leading to the vendor not being able to conduct adequate testing. The second risk discussed was lacking infrastructure due to IT, security, or other organizations holding back the progress.

7.2 Dynamic Instructions Editing Tool Requirements Initiative

The DIRECTOR initiative was launched by INL in January 2019 to understand and address the industry's needs around dynamic work instructions. DIRECTOR's original purpose was to identify utility generic functional requirements for editing and authoring tools for dynamic instructions.

7.2.1 Background—The NEWPER Initiative

DIRECTOR is a follow-on initiative to the Nuclear Electronic Work Packages–Enterprise Requirements (NEWPER) initiative, which was led by the Nuclear Information Technology Strategic Leadership group and facilitated by INL researchers. The NEWPER initiative brought stakeholders together to identify utility functional requirements for smart documents. NEWPER members defined four different levels of smart documents showed in Table 7. Summary of smart documents levels used in NEWPER (Oxstrand 2016) below. The adaptive level corresponds to dynamic instructions.

Table 7. Summary of smart documents levels used in NEWPER (Oxstrand 2016).

Level	Summary
Basic (Active Fields)	The document has fields for recording input such as text, dates, numbers, and equipment status.
Moderate (Automatic Population of Data)	The document incorporates additional functionalities, such as form field data "type" validation (e.g. date, text, number, and signature) of data entered and/or self-populated basic document information (usually from existing host application meta data) on the form when the user first opens it.
Advanced (Data Transmission)	The document provides the capability to transmit data entered into other data systems.
Adaptive (Dynamic/Variable Fields)	The document uses variable (i.e., dynamic) field options based on previously completed data entries or links to other electronic documents or media.

The NEWPER initiative was launched in 2015, and the final report was published in September 2017. NEWPER had 119 members from thirty-three different organizations. Almost 50% of NEWPER's members worked at nuclear utilities. The remaining members were fairly evenly split between vendors and research organizations (both national and international). Figure 3 illustrates the distribution between the members in NEWPER.

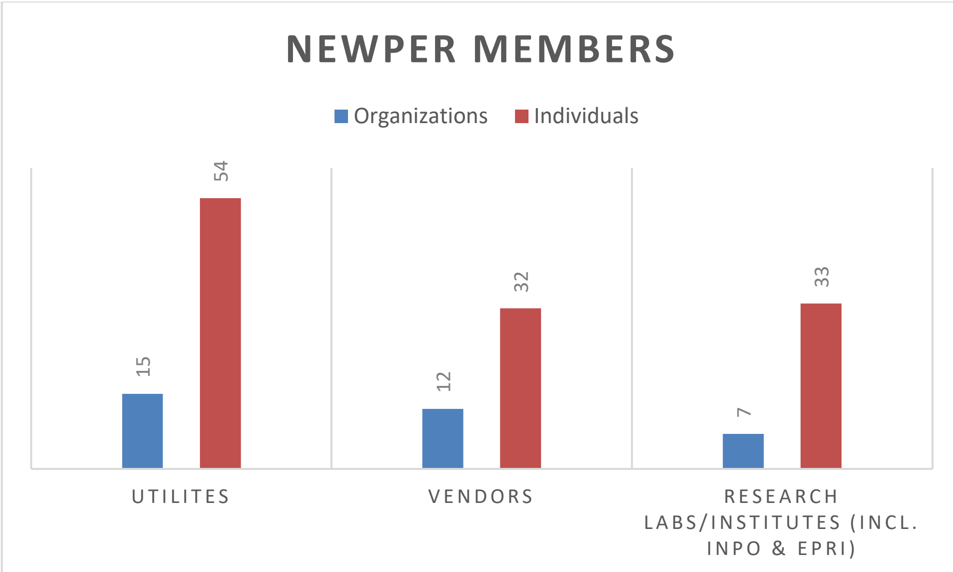

Figure 3. Distribution of NEWPER's 119 members.

The NEWPER initiative published two reports throughout its lifespan. The functional requirements for the two first levels of smart documents, basic and moderate, were addressed in the report "Functional Requirements for an Electronic Work Package System" (Oxstrand 2016). The requirements identified for the advanced and adaptive levels of smart documents were published in the report "PPA.AP-907-005.001, Functional Requirements for Advanced and Adaptive Smart Documents" (Oxstrand & Hargrett 2017).

7.2.2 Organization of the DIRECTOR Initiative

As mentioned above, the DIRECTOR initiative's intent was to address the functional requirements and design specification for editing and authoring tools. However, to ensure that DIRECTOR is aligned with its members' concerns and questions, an initial survey was conducted. The thirty-six surveyed participants were asked what topics they were would like to see addressed. Their responses showed that, in addition to drafting requirements, there were multiple topics of interest.

In response to this member feedback, and understanding the value of applying the experience and lessons learned from others to resolve concerns that might arise in their own organizations, the scope of the DIRECTOR initiative was broadened to include these eight Topic Area Groups (TAGs):

- TAG 1: Overall transition strategy from paper to dynamic instructions
- TAG 2: Conversion of existing documents
- TAG 3: Creating new dynamic instructions and documents
- TAG 4: Approval process and change management
- TAG 5: Utility generic selection criteria for editing tool
- TAG 6: Dashboard requirements
- TAG 7: Advanced technologies and dynamic smart documents
- TAG 8: Utility generic data structure for dynamic instructions.

Each TAG assigned one lead or two co-leads responsible for hosting teleconferences to discuss their specific topic and for making sure that the TAG discussions result in a tangible write-up. The DIRECTOR members may be involved in as many TAGs as they would like.

The TAG leads are part of the DIRECTOR core team, which have monthly meetings where the status of each TAG is shared and any potential issues or roadblocks are addressed. The core team is also responsible for finalizing reports and proposing, planning, and hosting face-to-face meetings.

As the TAGs addressed their scope and specific issues, it became clear that there was a potential for overlap between TAGs. Also, some TAGs were of the most immediate interest to the participants. To accommodate this, the TAGs were slightly reorganized and renumbered. Five were prioritized for active work, and two were put on hold. The list of active TAGs is:

- TAG 1: Overall transition strategy from paper to dynamic instructions, including approval process and change management
- TAG 2: Conversion of existing documents
- TAG 3: Creating and editing dynamic instructions and documents
- TAG 5: Utility generic selection criteria for editing tool
- TAG 8: Utility generic data structure for dynamic instructions, including a common dynamic instructions model.

The original TAG 4, Approval/Change Management, was incorporated into TAG 1. TAGs that are deferred until an agreed-upon resumption time are TAG 6, Dashboard requirements, and TAG 7, Advanced technologies and dynamic smart documents.

TAG 1, Strategy, focuses on the strategy needed to transition the work process from paper-based to dynamic instructions. The goal is to identify the customer for the transition strategy and the need for a graded approach. It is deemed unlikely that all instructions will be converted from paper to dynamic all at once, hence a graded approach to conversion and the reality of working with a mix of paper and dynamic instructions need to be carefully addressed. The goal of this TAG is to produce a guidance document to help members effectively implement dynamic instructions. This will address how to determine the graded conversion approach, how dynamic instructions will fit into existing EWP architecture, the training and skills needed for writers of dynamic instructions, and the approval process and change management requirements for dynamic instructions.

TAG 2, Conversion, is focused on the conversion of the existing paper documents to dynamic instructions. The TAG covers several critical issues, such as the structure levels of plant documents, criteria of conversion tool, the conversion scope, and support needed to make conversion decisions. The TAG will provide the functional requirements for the conversion as well as guidance to minimize the initial reluctance to the digitalization phase and maximize the future benefits.

TAG 3, Creating and Editing, is to provide functional requirements for the editing and authoring tool needed for dynamic instructions.

TAG 5, Tool Selection, aims to define selection criteria for a dynamic instructions application to meet business needs. Considerations include functionality, price, performance, vendor viability, training required, vendor services, scalability, support and services, interoperability, and the product’s position in the market. The TAG will consider the project and return on investment statements, or impact of such on the selection, and will identify the general basis for tool selection.

TAG 8, Data Structure, aims to define a high-level data structure for dynamic instructions. This model is called the common dynamic instructions model. The model will be provided and described in detail in the final publication.

7.2.3 DIRECTOR Members

As of this report, the initiative has 191 members from sixty-five organizations. Twenty-five power generating utilities (mostly nuclear), twenty-one different vendors, and fifteen research organizations are among them. The number of individual members for each organization type is shown in Figure 4. Less than a handful of members prefer not to specify which company they represent and/or they work as self-employed consultants.

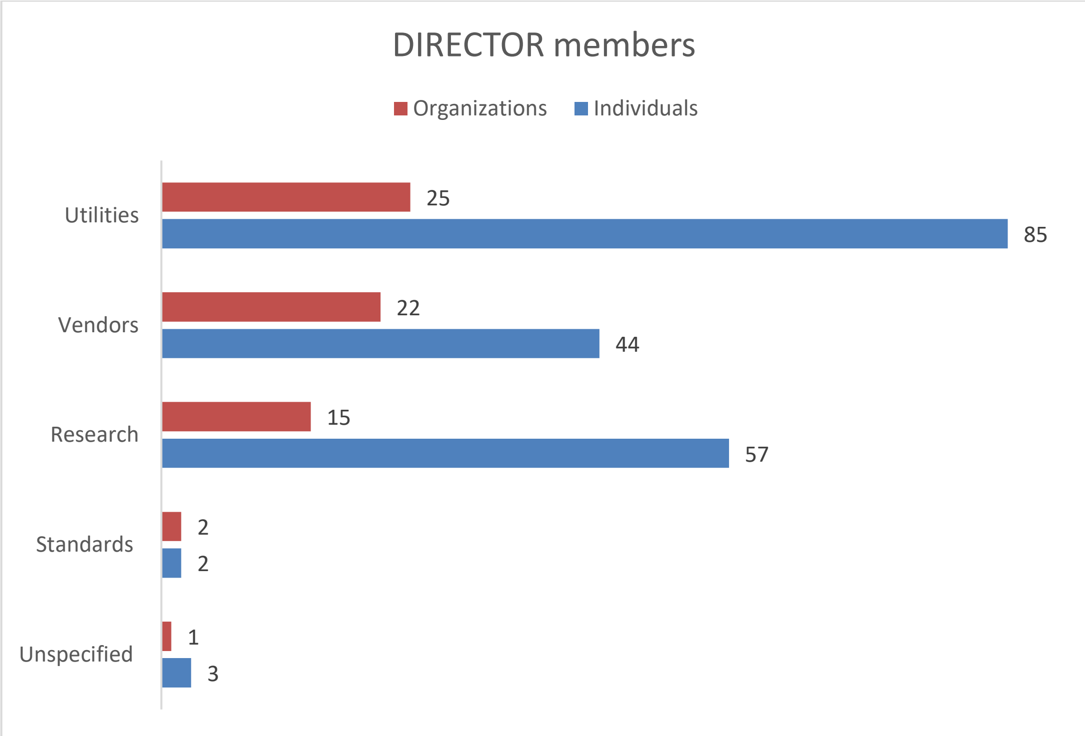

Figure 4. The amount of DIRECTOR member organizations and individual members.

7.2.4 Face-to-Face Workshop

In June 2019, a face-to-face workshop was conducted during the Procedure Professionals Association (PPA) annual symposium in Kissimmee, Florida. The DIRECTOR initiative had a three-hour block allocated for the workshop during the symposium. All symposium participants were invited to participate in the workshop as well.

The workshop had two main goals:

1. To educate the PPA participants in the research and initiatives dedicated to the transition to dynamic instructions in the nuclear industry
2. To gather procedure writers' feedback and insights on the topics addressed in DIRECTOR.

The format of the workshop was three sets of forty-five-minute-long breakout discussions where the TAGs hosted group discussions focused on a limited number of topics per TAG. The format allowed participants to participate in three different TAG discussions throughout the workshop.

The workshop had 100 participants, of which sixty-seven were new to the DIRECTOR initiative. More than half of the participants represented nuclear utilities. For more details about the insights gained from the workshop, see the report DIRECTOR Workshop Summary Report (Hill et al. 2020).

7.2.5 Planned Activities for DIRECTOR

Two additional opportunities for face-to-face interactions for DIRECTOR members were planned for the spring and summer of 2020. The initiative was invited back to the PPA annual symposium. The plan was to conduct a rapid-fire session during the general session on day one of the symposium. Each TAG would get a couple of minutes to present their scope, goals, and the value for PPA's participants. Additionally, a poster session where PPA participants would be able to interact with all the TAGs and the

DIRECTOR representatives was planned for the symposium. Unfortunately, the PPA symposium for 2020 was cancelled due to the COVID-19 pandemic.

DIRECTOR also planned for a working meeting to finalize the remaining items and close-out the ongoing five TAGs. The outcome of the working meeting was to be a draft report. The future of DIRECTOR and what topics to tackle would also be discussed. This meeting, initially planned to be hosted by Los Alamos National Laboratory in April 2020, was also postponed due to COVID-19. DIRECTOR representatives now intend to hold this meeting later this summer or fall, depending on when it is appropriate and safe.

The report that will describe the DIRECTOR activities and their outcomes is currently planned to be published late summer or early fall 2020.

8. PATH FORWARD

After jointly developing a procedure tool prototype for field workers that was successfully demonstrated at the Dynamic Instructions Symposium and in the pilot at a nuclear plant, NextAxiom continued its separate and distinct development efforts to build its DIP software. DIP is a complete platform that includes analytics, authoring, conversion, execution, monitoring, and workflows for dynamic instruction/procedures. The DIP technology is based on a provisional NextAxiom patent for dynamic instructions and upon its proven hyperService® Platform software used by numerous nuclear operators.

Since this project concluded at the end of 2019, the nuclear industry has continued to move towards adopting and deploying smart forms and dynamic instructions to enable individual initiative for digital work execution.

At the time of this report a major nuclear utility in the U.S. is in the early stages of deploying NextAxiom’s DIP solution, while another nuclear utility just completed negotiations with NextAxiom to begin its implementation of the DIP workflow technology. Additionally, a third nuclear utility has decided to pilot the DIP solution, and two national laboratories are in the planning stages for pilots. One nuclear utility piloted the technology in late 2019 and is now requesting pricing information.

In addition to these NextAxiom specific activities, Ontario Power Generation (OPG) has issued a request for proposals for a dynamic instructions solution. OPG as well as the two nuclear utilities that are in the process of deploying NextAxiom’s technology are each planning an aggressive schedule to get the technology into the hands of the end users in 2020.

Since the initiation of the INL-NextAxiom TCF project, the INL researchers have been awarded two additional TCF efforts related to dynamic instructions. In 2018, the team was awarded a TCF project in partnership with Lean Power, another dynamic instruction vendor. The scope of this TCF effort is to develop a smart scheduling tool and a dashboard application that can be used as a plug-in to Lean Power’s solution as well as most other dynamic instructions solutions. The second TCF was awarded in 2019 and is in partnership with GSE Systems. The scope of that effort is to leverage the dynamic instructions knowledge at INL and the GSE control room simulator expertise to design and develop a decisions support tool for control room operators.

As mentioned in the section above, the DIRECTOR initiative is ongoing and intends to continue through the publishing of a report describing the functional requirements, design specifications, and guidance developed by the current TAGs. A publish projection date has been established for the late summer or early fall of 2020. If there is a desire and identified need to address new topics, the initiative will continue beyond fall of 2020.

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Appendix A—Agenda for Dynamic Instructions Symposium

AGENDA

DYNAMIC INSTRUCTIONS SYMPOSIUM

November 14-15, 2019 • Intercontinental Clement Hotel Monterey, CA

WEDNESDAY, NOVEMBER 13, 2019

TIME	TOPIC
6:00 - 8:00 pm	Reception

THURSDAY, NOVEMBER 14, 2019

TIME	TOPIC	PRESENTER
7:30 am	Registration/Continental Breakfast	
8:30 am	Welcome, Safety Message, Antitrust Guidelines and Agenda Review	*John Manoogian, NxA*
8:40 am	Introductions, and Objective of Meeting	*All*
9:00 am	Keynote: Supporting innovation and technology deployment through private-public partnerships	*Bruce Hallbert, INL*
10:00 am	Break	
10:15 am	Dynamic Instructions - The Journey from Research Concept to Industry Deployment	*Johanna Oxstrand, INL*
11:00 am	Technical Panel – Future of Dynamic Instructions for Mobile Work Execution	*APS, Exelon, PPA, LANL*
12:00 pm	Lunch	
1:00 pm	Palo Verde Nuclear Experience with Dynamic Instructions	*Carlos Williams, PVGS* *Mark Johnson, PVGS*
2:30 pm	Break	
3:00 pm	Integrating Maintenance Technology Innovations with Electronic Work Packages	*Fred Berl, Adam Smith, & Dennis Vigil, LANL*
4:15 pm	Vendor Panel – Marketplace Demand for Dynamic Instructions Solutions	*DataGlance, Lean Power, NextAxiom*
5:00 pm	Adjourn	
5:30 pm	Reception and Dinner	

FRIDAY, NOVEMBER 15, 2019

TIME	TOPIC	PRESENTER
7:30 am	Continental Breakfast	
8:30 am	Business Panel: Perceived Savings/Benefits and Barriers. How soon could your ROI be realized?	*Moderator: Andy Zetlan, ABB*
9:30 am	NextAxiom / Idaho National Laboratory CRADA Live Demo: Performance Tool & Monitor	*Ronnie Williams, NxA*
10:45 am	Break	
11:00 am	NextAxiom Vision for Dynamic Instructions and the introduction of the Interactive Instructions Platform (IIP)	*Ash Massoudi, NxA* *Sandy Zylka, NxA*
12:00 pm	Lunch	
1:00 pm	A Utility Perspective on Smart Procedure Implementation	*Eric Jurotich, SNC*
2:00 pm	The Impact of Digitalization in the Nuclear Industry	Andy Zetlan, ABB
2:45 pm	Meeting Wrap-up	*All*
3:00 pm	Adjourn	