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Light Water Reactor Sustainability Program

Status Report on the Development of Micro-Scheduling Software for the Advanced Outage Control Center Project

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Status Report on the Development of Micro-Scheduling Software for the Advanced Outage Control Center Project

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ABSTRACT

This report describes recent efforts made in developing a suite of outage technologies to support more effective schedule management. Currently, a master outage schedule is created months in advance using the plant's existing scheduling software (e.g., Primavera P6). Typically, during the outage, the latest version of the schedule is printed at the beginning of each shift. INL and its partners are developing technologies that will have capabilities such as Automatic Schedule Updating, Automatic Pending Support Notifications, and the ability to allocate and schedule outage support task resources on a sub-hour basis (e.g., outage Micro-Scheduling). The remaining sections of this report describe in more detail an overview of advanced outage functions, the scheduling challenges that occur during outages, how the outage scheduling technologies INL is developing helps address those challenges, and the latest developments on this task.

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ACRONYMS

AOCC	Advanced Outage Control Center
AWP	Automated Work Package
CBP	computer-based procedure
CSCW	Computer Supported Cooperative Work
DOE	Department of Energy
INL	Idaho National Laboratory
IT	Information Technology
LWRS	Light Water Reactor Sustainability
NPP	nuclear power plant
OCC	Outage Control Center
POE	power-over-ethernet
QC	Quality Control
R&D	research and development
U.S.	United States

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1. INTRODUCTION

The long-term viability of existing nuclear power plants (NPPs) in the United States (U.S.) is dependent on a number of factors, including maintaining high capacity factors, maintaining nuclear safety, and reducing operating costs, particularly those associated with refueling outages. Refueling outages typically take 20 to 30 days, and for existing light water NPPs in the U.S., the reactor cannot be in operation during the outage. Furthermore, given that many NPPs generate between $1 million to 1.5 million/day in revenue when in operation, there is considerable interest in shortening the length of refueling outages. Yet refueling outages are highly complex operations, involving multiple concurrent and dependent activities that are somewhat challenging to coordinate. Therefore, finding ways to improve refueling outage performance, while maintaining nuclear safety, has proven to be difficult.

The Advanced Outage Control Center (AOCC) project is a research and development (R&D) demonstration activity under the Light Water Reactor Sustainability (LWRS) Program. LWRS is an R&D program that works with industry R&D programs to establish technical foundations for the licensing and managing of long-term, safe, and economical operation of current NPPs. As such, the LWRS AOCC project has the goal of improving the management of commercial NPP refueling outages. To accomplish this goal, Idaho National Laboratory (INL) is developing an advanced outage control center (AOCC) that is specifically designed to maximize the usefulness of communication and collaboration technologies for outage coordination and problem resolution activities. The overall focus is on developing an AOCC with the ability to:

- Collaborate in real time to address emergent issues
- Effectively communicate outage status to all workers involved in the outage
- Effectively communicate discovered conditions in the field to the Outage Control Center (OCC)
- Provide real-time work status
- Provide automatic pending support notifications
- Provide real-time requirements monitoring.

INL has partnered with two commercial NPP utilities to develop a number of advanced outage management technologies. These outage management technologies have focused on both collaborative technologies for control centers and developing mobile technologies for NPP field workers.

This report describes recent efforts made in developing a suite of outage technologies to support more effective schedule management. Currently, a master outage schedule is created months in advance using the plant's existing scheduling software (e.g., Primavera P6). Typically, during the outage, the latest version of the schedule is printed at the beginning of each shift. INL and its partners are developing technologies that will have capabilities such as Automatic Schedule Updating, Automatic Pending Support Notifications, and the ability to allocate and schedule outage support task resources on a sub-hour basis (e.g., outage Micro-Scheduling). The remaining sections of this report describe in more detail: the scheduling challenges that occur during outages, how the outage scheduling technologies INL is developing helps address those challenges, and the latest developments on this task (e.g., work accomplished to date and the path forward)

1.1 Background on the Challenges of Outage Scheduling

Many outage activities are difficult to schedule with precision using existing technology, because the activities require additional task support resources to be introduced at fixed points in their progression. Examples of when additional task support resources are introduced into a primary outage task include quality control (QC) hold-point inspections, required operator actions during a maintenance activity, and temporarily lifting safety tags to support testing during maintenance (e.g., stroke a valve). Given the technologies currently in use, it is virtually impossible to precisely schedule when these additional task support resources will be needed, because the exact time depends on the work progress of the primary activity.

This creates a difficult allocation problem for these task support resources in that they must react quickly to a moving start time, based on the progress of the primary outage activity. For critical path activities, they are sometimes deployed early so they are immediately available when needed. This creates a lot of unproductive wait time for these expensive task support resources. For noncritical path activities, they rely on an early warning notification from either the OCC, or job supervisor to be ready at a certain time. If subsequent delays exist in the primary activity, unproductive wait time or concurrent demands that are greater than what a given task support resource can meet will be additional delays until the primary activities can be accommodated in prioritized sequence.

Furthermore, even if the allocation of these support resources is resolved to the general satisfaction of the parties involved, there is no assurance that they were allocated in a manner that produced the greatest overall outage schedule progress. The reason is that the task of managing this real-time resource allocation problem is typically handled in the OCC in a "silo'd" manner. That is, a coordinator in the OCC for each type of resource (e.g., Reactor Protection coverage, safety tagging, QC) manages that resource independently, often without full awareness of how other coordinators are managing their resources. While the coordinator generally assigns support resources based on the known schedule priorities (e.g., the known critical path), it is an unoptimized solution, because no one coordinator can predict the total schedule effect of delaying certain activities. This is true when combined with other work delays that a given activity might experience. It is often seen in retrospect that resources were allocated to the wrong activities, and that a near-critical path activity moved onto the critical path because of the cascaded effect of multiple delays.

Even for the bulk outage activities (e.g., general valve maintenance) that are not near-critical path, there tends to be a general schedule creep because of small delays in either the activities themselves, or in the availability of required task support resources. This schedule creep phenomenon for these bulk schedule activities is well known to outage managers and is typically monitored with "burn-down curves." These delays create a "bow wave," where task support resources needed near the end of the work windows for these routine outage activities (where work windows are defined by mode changes, system drains/fills, train/division swaps, etc.). At this point, the bow wave overwhelms certain tasks support resources such as clearing tags at a system level, running operational tests, and realigning systems. This is one of the typical ways that routine bulk outage activities end up impacting the critical path.

In summary, the optimized allocation of outage task support resources is impaired by the:

- Ability to accurately predict in the outage schedule of when a support task will be needed at a precision of a fraction of an hour.
- Ability to have of real-time, efficient communications from the job site in apprising the OCC of small gains or delays in the work progress affecting the timing of the allocation of task support resources.
- Inability to compute the combined effect of real-time progress gains or losses for a given activity with the competing needs for task support resources from multiple primary activities.

- Inability to optimize limited task support resources in consideration of the total outage impact. Automatic allocation to the critical path activities might not be the best decision if a critical path activity has some flexibility in the sequence of tasks.
- Inability to quickly redirect task support resources in view of major schedule upsets (e.g., emergent critical work, significant schedule delay in the critical path activity)

Figure 1. Typical Current Outage Control Center.

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2. OVERVIEW OF ADVANCED OUTAGE FUNCTIONS

2.1 Advanced Outage Functions

Depending on the level of information technology (IT) infrastructure available and the level of integration with existing processes, various AOCC functions will more likely become available. The AOCC functions that can be enabled by technology improvements include but are not limited to:

- Real-Time Collaboration for Emergent Issues—Using multi-touch boards and high quality audio and video conferencing equipment deployed in various coordination centers, staff will be able to simultaneously work on complex problems by sharing real-time pictures, diagrams, schedule information and notes. This technology will also facilitate communicating the product of the collaboration effort to the OCC, subject matter experts or other managers. An electronic record of the resolution of the issue will also assist in knowledge management and future use of the information. The use of technology has the potential to reduce the need for face-to-face meetings, saving time, and the richer data may increase the level of comprehension of complex problems.
- Real-Time Work Status—The use of computer-based procedures (CBPs) will allow OCC staff instant status of work packages and procedures. The system will allow outage managers to call up and view the actual steps of a procedure as they are signed off or to simply notify the OCC automatically when certain tasks are completed. When tied into scheduling software, it will provide a real-time picture of schedule adherence. Portable wireless cameras installed near critical job sites will also allow outage managers to monitor job status without relying on field workers to call in status updates.
- Automatic Pending Support Notifications—Utilizing embedded triggers in CBPs and AWPs; notifications to support staff can be automatically routed to required personnel via calendar, text or email notifications at predetermined time points alerting them of pending tasking that require their support. For example, a trigger may be set 30 minutes prior to a quality control (QC) hold point notifying the assigned QC inspector of an upcoming required inspection. If the first resource (QC Inspector) is unable to provide support in a reasonable time frame they could reject the notification and a follow-on notification would go to the next resource, and so on until a resource accepts it. Automated notifications will allow for more efficient resource allocation and real-time planning by staff.
- Improved Communication of Discovered Conditions From the Field—Using mobile technologies, field workers identifying issues in the field would be able to set up an instant video conference with the OCC or a supervisor in the field at the point of the problem. This would provide OCC staff with eyes on the issue and an instant understanding of the nature of the issue and allow further interaction between outage managers and the person discovering the issue. Further interaction may include directing the worker to send back additional video footage or an annotated photograph of the surrounding area, component, or more carefully describing some aspect of the problem.
- More Efficient Dissemination of Information from the OCC – Utilizing advanced conferencing software and multi-touch boards, OCC managers can establish interactive status briefings in which stakeholders may participate from any location, on site or off, using a variety of devices including desktop computers, laptops, smart phones, and tablet computers.
- Real-Time Requirements Monitor—Utilizing a combination of information pulled from the status of procedures, real-time plant status from the plant computer and plant logs, the OCC managers will be able to more easily display status and readiness for key activities or tasks.
- Mobile Alerts—Utilizing a messaging system similar to instant messaging used by most smart phones, NPP personnel could be updated by the OCC managers when important milestones are met or plant conditions change. Alerts for such events as window closures, plant risk level changes,

protected system changes, industrial or radiological hazards, etc. These messages would consist of a simple statement of the condition, but also provide more detailed information for those that require it through use of an information icon. These alerts could be also sent to handheld devices, desktop computers and large screen displays throughout the plant.

2.2 Available Technologies

Several technologies have shown promise at NPPs for improving the collective situational awareness of the organization. Typically these technologies are combined to support the advanced outage functions described above but may be implemented individually or as part of some nonoutage process improvement. Many of these technologies have been evaluated at INL or are currently being evaluated at pilot project utilities.

2.2.1 Touch Enabled Interactive Displays

Use of large format touch enabled interactive displays (60” to 80”) may be used to support team collaboration both face to face and remotely. Touch screens are usually combined with one of the collaboration software packages described in the next section. To fully support remote collaboration, webcams and microphones should be added as well. In an AOCC, multiple large screen monitors can be used to display information. Only one or two need to be touch displays depending on the function allocation. Most of the static information that is currently displayed in OCCs is on dry erase boards and printed paper that could be easily displayed on high quality monitors. Use of collaboration software allows information displayed in the OCC to be viewed and updated from any location, improving the site’s collective situational awareness while minimizing low value work required maintaining static displays. In addition, these displays may be used to provide visual content to routine briefings and facilitate remote participation and sharing of routine and nonroutine briefings. Figure 2 shows a video wall that is currently installed at Palo Verde. Large monitors and collaboration software have replaced the previously used whiteboards and paper schedules.

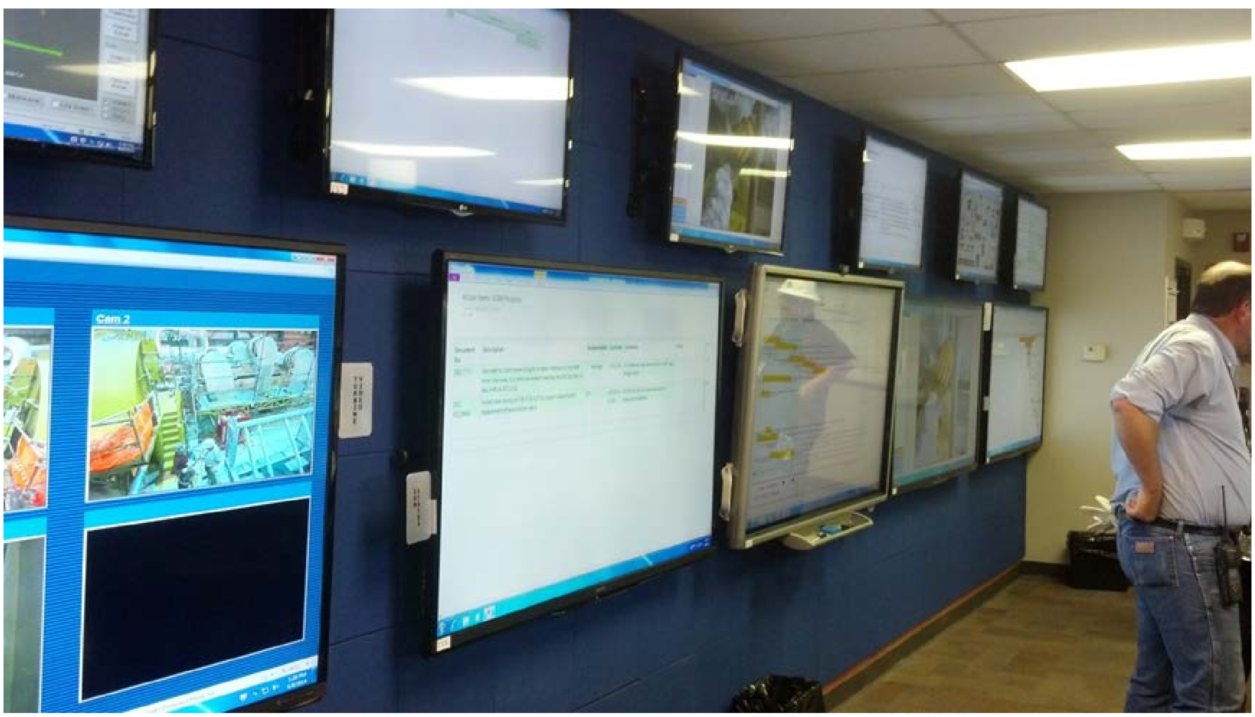


Figure 2. Palo Verde OCC Video Wall.

2.2.2 Collaboration Software

Collaboration software, also known as groupware, can be an effective tool for outage communication. Collaboration software is one element of a larger topic of Computer Supported Cooperative Work (CSCW). CSCW combines the understanding of the way people work in groups with the enabling technologies of computer networking, associated hardware, software, services, and techniques. First introduced in 1984, CSCW provides two approaches—technology-centric or work-centric viewpoints to support groups of individuals collaborating from different locations. The technology-centric approach emphasizes the design and implementation of computer technology aimed at supporting groups working together, while the work-centric approach is geared at the design and implementation of computer systems supporting group collaboration.

Several collaboration software package options are available to support the AOCC function described in Section 2.1. Some collaboration software supports real-time collaboration, while others support near real-time collaboration. Typically, real-time collaboration requires more expensive software and near real-time is probably adequate for most applications. A combination of near real-time software for bulk work and specialized real-time capable software for intensive collaborations may be optimal.

2.2.3 Mobile Worker Devices

Mobile worker devices include any number of hand-held electronic devices that provide information to and allow interaction with field workers. In the AOCC concept, mobile worker devices will support CBPs and automated work packages (AWPs) described in Section 4.2.5 as well as providing voice and video communication capability. A number of form factors are available depending on the specific end users need, but typically a mid-sized tablet computer with an embedded camera and WiFi capability is sufficient. The embedded camera may be used to scan barcodes for component verification as well as support rich data transfer from the field to the OCC. Various rugged devices are an option or rugged cases may be used to protect consumer models.

2.2.4 Remote Cameras

High quality video images are an effective form of communication. Real-time video feeds of an issue or ongoing work can convey much more information than a static picture or voice report. Remote video cameras are currently used in several areas during NPP outages. Currently, these cameras are used to monitor outage progress in containment, on the refuel floor, and in the turbine building. These cameras are typically power-over-ethernet (POE) type cameras that are set up at the beginning of the outage and remain in place for the duration of the outage. If Wi-Fi is available, Wi-Fi-enabled cameras could be used to provide temporary activity monitoring in locations not observable by the POE cameras typically installed. In addition, battery packs could be used to provide completely wireless video monitoring capability. Another option is to use helmet mounted video cameras to stream a video signal to the OCC or other satellite center to obtain rich information about an issue or job.

2.2.5 Computer-based Procedures/Automated Work Packages

CBP projects are starting to emerge in US NPPs. When CBPs and AWPs are implemented, and when Wi-Fi connectivity is available, several of the more powerful advanced outage functions described in Section 4.1 become possible. AWPs, combined with mobile worker devices and plant wide Wi-Fi, will allow real-time work status to be passively collected and displayed in an AOCC. Flags built into the AWPs and CBPs may be used to notify support staff of pending requirements via mobile worker devices.

2.2.6 Plant Wide Wireless Networks

Many of the advanced outage functions described in Section 4.1 require connectivity via Wi-Fi. Plant wide Wi-Fi will enable connection of mobile workers to the OCC, allow real-time status updates from CBPs and EWPs, allow the use of streaming wireless video feeds, and support VoIP communication options. Plant wide Wi-Fi has numerous applications outside of outage management, and plants are not likely to install plant wide Wi-Fi just for outage management. However, some NPPs install temporary Wi-Fi in containment and other strategic locations during refueling outages. Several NPPs in the US have installed or have current projects to install plant wide Wi-Fi capability. For technical information regarding Wi-Fi installation in a NPP, refer to EPRI's Implementation Guideline for Wireless Networks and Wireless Equipment Condition Monitoring.

2.3 Functions vs. Available Technologies

In selecting individual technologies or advanced outage functions for implementation, it will be important to identify and catalog the entire IT infrastructure that will be required to support the proposed changes. Table 1 links these advanced OCC functions with the required enabling technologies. Some functions may be partially available without the enabling technology, but the full capability may not be realized until the IT infrastructure is improved. Because other factors will likely be driving IT infrastructure upgrades, those existing plans should be considered when developing a technology deployment plan.

Table 1. AOCC Functions vs. Available Technologies.

	AOCC Functions and Features						
Enabling Technologies	Information Inflow	Collaboration Within OCC	Collaboration With Groups Outside OCC	Real-Time Work Status	Real-Time Requirements Monitor	Automated Pending Support Routing	Information Outflow
Interactive Displays (Multi-touch Boards)	X	X	X	X	X	X	X
Mobile Technologies (Handheld Tablets)	X		X	X	X	X	X
Computer Based Procedures	X			X	X	X	X
Automated Work Packages	X			X	X	X	X
High Quality Video Conferencing	X		X				X
Conferencing Integration Software	X		X				X
Plant-Wide Wireless Network Coverage	X		X	X	X	X	X

3. AOCC SCHEDULING TECHNOLOGIES

The advanced OCC functions Real-Time Work Status, Real-Time Requirements Monitor, and Automated Pending Support Routing are related and require additional development to implement. The currently available scheduling software does not support the integration of these tasks. INL is working with a software vendor to demonstrate the value of these concepts.

3.1 Proposed Technologies

The AOCC scheduling technologies that INL is developing supports the automated work package life cycle across the evolution of the task (e.g., identification of work, plan, schedule, field execution, review and verification, and work order close out). The suite is being developed to include:

1. Automatic Schedule Updating—A dashboard that would be monitored in the OCC and by shop supervisors to monitor real time work completion. The dashboard would have a Gantt chart visual display of the work for the shift. The tasks represented on the display would each have a corresponding AWP. As each AWP is issued, the outside border of the bar on the Gantt chart would change color to indicate the job is at working status. As the AWP is completed, triggers at various points in the AWP would update the bar on the Gantt chart; for example at approximately 25%, 50% and 75% completion and the bar would fill in. When the job is complete, the bar on the Gantt chart would again change color. As the duration of the completion of each task changes, the successors on the display would move indicating the shift in the schedule. (For example, a job was scheduled for 3 hours takes 4 hours to complete, the successor start times would begin to shift.
2. Automatic Pending Support Notifications—Frequently within a work package, support is required from some organization not primarily responsible for the work, for example: QC, Security, Operation, or Health Physics. Using triggers embedded in the AWP, notifications would be sent to a work pool at some reasonable lead time (e.g., 1 hour), prior to when the support will be required. The request would be sent to the pool of workers signed in at the time to their mobile device (described in more detail below, a qualified worker would electronically accept the assignment and go to the location of the work.
3. Micro-Scheduling—The current practice is to print the latest version of the outage schedule once per shift. Task support resources are identified, but assigned to activities as a whole, not specifically when the support will be required inside the activity. The burden is on the supervisor to constantly realign resources to provide support when it is actually needed. The outage Micro-Scheduling technology being developed by INL and others allows for the real-time fine-tuning of the outage schedule, based on changes to the actual progress of the primary outage activities. This fine-tuning helps ensure that support task resources are optimally deployed with the least amount of delay and unproductive use of resources. Specifically, a task support resource allocation model for each outage shift would be developed based on the work scheduled for that shift. Each needed support task would be identified from the primary activity procedures as a schedule lag from the start time of the job. For instance, a QC hold point inspection in a 4-hour valve maintenance activity could be estimated to occur 2.25 hours after start time. These models would only have to be set up one time for a given primary activity.
4. A wirelessly connected hand-held device or field deployable heads up display. In the context of scheduling task support resources for a primary activity, the hand-held device would alert the job supervisor and/or lead technician and provide a time estimated for when the task support resource will be needed for the primary task. These alerts would work similarly to how Outlook provides schedule alerts for imminent calendar items. The supervisor could easily adjust the times the task support resource is needed based on real-time knowledge of job progress, and communicate this adjustment back to the task support resource allocation model. At the same time, these schedule adjustments

would also be communicated to the overall outage network schedule software as a new expected time of completion for the activity. This, in turn, would allow real-time management of the outage schedule, rather than getting these kinds of updates once or twice a shift. These mobile devices are designed to have the following functional capabilities:

- Bar code scanning.
- Built-in camera for documenting the condition of equipment prior to and after maintenance work has been performed.
- Voice recognition to transcribe spoken words to text for documentation and/or annotation of existing files.
- Virtual keyboard for manual data entry.
- Annotation of PDFs with checkmarks/circle-slash (for place keeping), free hand drawings, and text. Annotations automatically includes audit tracking information (e.g., date and time stamp).
- Wireless connectivity to the Micro-Scheduling system in the OCC. If not within range of the network, the device can store the information to be transmitted to the system later.
- A graphical user interface (GUI), or human system interface that conforms to human factors best practices. The GUI is customized to the user and his or her credentials (e.g., supervisor vs. maintenance technician).
- Automatic consolidation of multiple, related work packages for activities requiring multiple field technicians to perform separate but related work tasks. This simplifies the consolidation of data at the completion of the evolution.
- Notification to the field workers when their individual task within a work package has dependencies with other tasks.
- Notification to the field workers when their individual task within a work package has been changed, or they have been reassigned.
- A task-based Gantt Chart dashboard to provide field workers with an overview of the activities involved in the work package.
- Fully searchable.
- Ability to print work packages, if necessary.
- Notification to the advanced OCC when field workers Check-in/Check-out a hand-held device.

3.2 Status of AOCC Scheduling Technologies Demonstration Activities

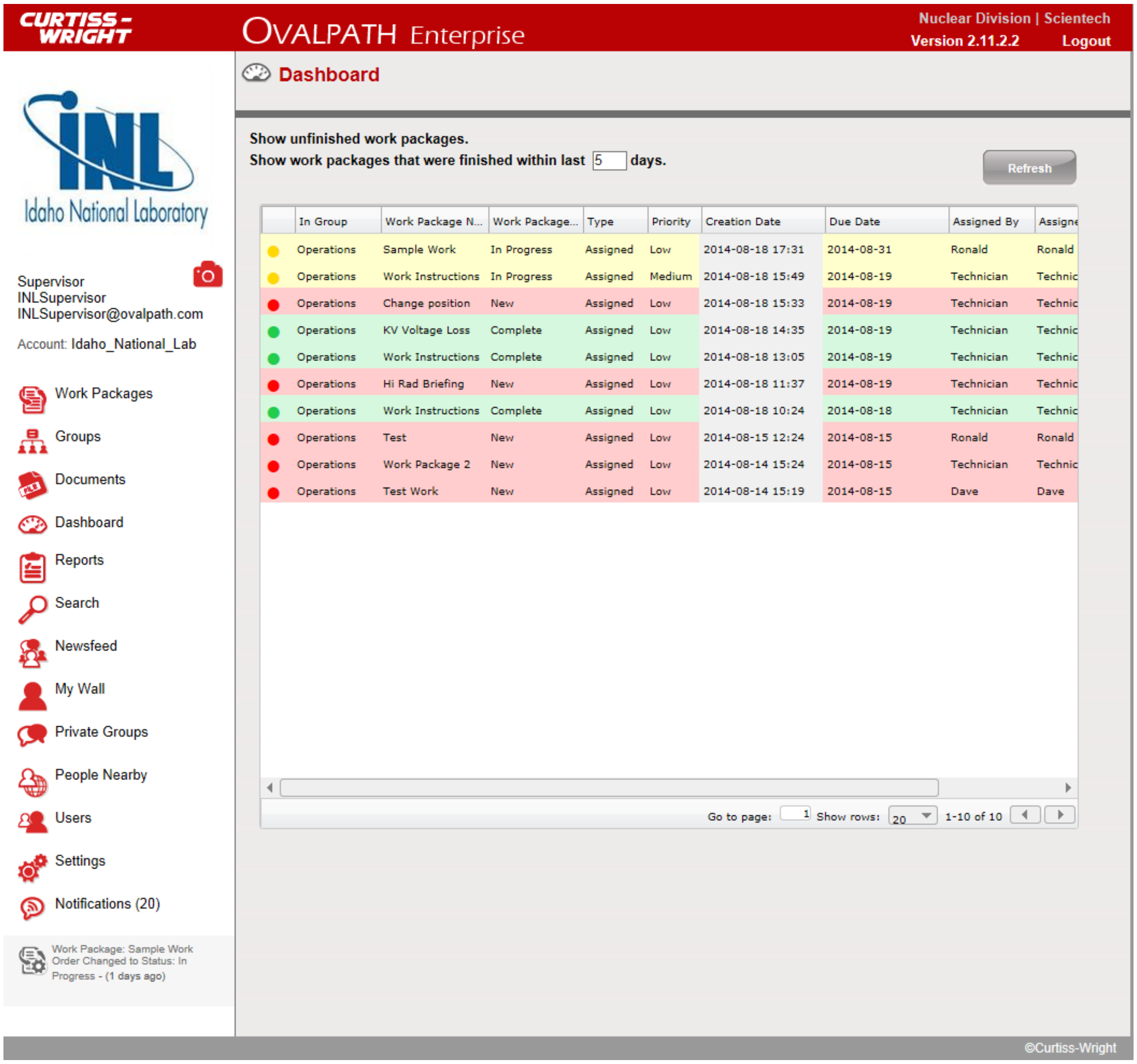
INL is working with Scientech (Curtiss-Wright) to demonstrate key advanced outage management concepts utilizing the Ovalpath software framework. The use of the Ovalpath platform would be limited to technology demonstrations only. To accomplish this demonstration, several modifications to the existing Ovalpath platform are required as the software is not currently capable of the required level of task planning and display. The demonstration will likely include some parts that occur in real time, with real time feedback between AWPs on portable devices and the dashboard and some parts that will be time compressed to show work completion throughout the day. In this case, the system will show a time bar that is moving through time with the dashboard dynamically updating as if AWPs are being signed in, worked, and completed. Specific tasks required to accomplish this demonstration include:

- Development of an outage management dashboard. The dashboard would have a portion of the display that shows a Gantt chart representation of the schedule; in reality, the portion of the schedule that is displayed would be user definable. Another portion of the dashboard (micro-scheduling) should show for a particular work group, the total required resources to support work based on the scheduled work packages throughout the day and be color coded as resources are challenged. A time bar for controlling the time compression aspect of the demo at the bottom, this would not be in an actual dashboard, just for demonstration purposes.

- Development of a dummy schedule for the day, with approximately 40 activities. Each activity will have to be linked through predecessors with start times and durations assigned. Some of the activities will have specific resources assigned to them with a delta start time and duration to support the micro-scheduling dashboard portion. In reality, this schedule would need to be imported from the plants scheduling software, such as Primavera P6.
- Development of several AWPs for some of the activities to interact with the dashboard. For example, an AWP for the first activity on the schedule with 10 simple tasks. Triggers in the AWP would then update the Gantt chart portion of the dashboard in real time. Another AWP would be created for an activity that requires a support. A trigger in the AWP would automatically send a pending support notification to the work pool for assignment. When the support task is completed, the AWP should update the micro-scheduling display and reduce the resource requirement accordingly.
- Creation of a time compression tool for demonstration purposes only. The tool should step through the day starting activities, working them and completing them. The Gantt chart should react to each activity as it changes. The actual durations for the activities should be different for some of the tasks than the scheduled durations. The successor activities in the dashboard display should update with the new scheduled start times based on shifts in schedule. As the support activities shift, the micro-scheduling portion of the dashboard will change as the time support resources are required updates. The simulation should create a situation where the planned schedule was achievable with resources available, but at some time due to schedule slip, required resources will exceed those available. The dashboard should change to a red color and give a warning.

INL has provided initial concepts for the layout and function of the dashboard and will work with Scientech to improve it. Scientech has provided INL with a custom web-based version of its Ovalpath platform to support AOCC capability demonstrations (Figure 2). The platform has already been modified to support INL users and has a number of sample AWPs loaded into it. Scientech is currently developing the additional capability INL has requested into the software. The time compression capability was not included in the initial contract due to cost considerations, but may be added in the future if desired. Because the platform is web based, it will be possible to build a scripted demonstration that can be run from a laptop computer from any location, allowing INL to include the demo during utility visits or working group meetings. The entire scripted portion of the demonstration is expected to be 30 to 45 minutes, so that with questions, the entire demonstration can be shown in 1 hour.

The platform will also provide the ability to demonstrate the concepts during an actual outage at a participating utility by creating a dummy AWP that would track the status of a number of linked key activities that are occurring in an area with Wi-Fi coverage. An example would be for major main turbine or generator work. The system would not replace the current paper-based work orders, but the supervisor could use a small hand-held device to update the system with the real-time status being displayed in the OCC.



In Group	Work Package N...	Work Package...	Type	Priority	Creation Date	Due Date	Assigned By	Assigne
Operations	Sample Work	In Progress	Assigned	Low	2014-08-18 17:31	2014-08-31	Ronald	Ronald
Operations	Work Instructions	In Progress	Assigned	Medium	2014-08-18 15:49	2014-08-19	Technician	Technic
Operations	Change position	New	Assigned	Low	2014-08-18 15:33	2014-08-19	Technician	Technic
Operations	KV Voltage Loss	Complete	Assigned	Low	2014-08-18 14:35	2014-08-19	Technician	Technic
Operations	Work Instructions	Complete	Assigned	Low	2014-08-18 13:05	2014-08-19	Technician	Technic
Operations	Hi Rad Briefing	New	Assigned	Low	2014-08-18 11:37	2014-08-19	Technician	Technic
Operations	Work Instructions	Complete	Assigned	Low	2014-08-18 10:24	2014-08-18	Technician	Technic
Operations	Test	New	Assigned	Low	2014-08-15 12:24	2014-08-15	Ronald	Ronald
Operations	Work Package 2	New	Assigned	Low	2014-08-14 15:24	2014-08-15	Technician	Technic
Operations	Test Work	New	Assigned	Low	2014-08-14 15:19	2014-08-15	Dave	Dave

Figure 3. Current INL Ovalpath Platform Example.

4. CONCLUSION

The AOCC scheduling technologies being developed by INL and others have a number of advantages over manually routed, paper-based, work packages. Built into these AOCC technologies are the following capabilities:

- Real-time optimization software that efficiently allocates all task support resources based on overall schedule impact (e.g., performing multiple in-containment activities based on a single dress-out.). This software, working with the outage network schedule software, would suggest alternative schedules (where there is flexibility) that would minimize delays to activities in order to keep field crews as productive as possible. The software would also communicate the estimated arrival time of the task support resources to personnel involved in-progress activities (via hand-held).
- Real-time status, via graphical depiction, on a desktop display or Smart Board to OCC and warning communications center managers and coordinators.
- Real-time decision support algorithms that outage managers and coordinators can use to make decisions on resource allocations, and schedule alternatives for concurrence, rejection, or modification.

Given these capabilities, the anticipated savings include, but are not limited to:

- Critical path time savings—shortening the overall outage by eliminating unnecessary job delays caused by unoptimized resource allocations and improving situational awareness for outage managers and coordinators.
- Reduced unproductive time for primary outage activities (e.g., maintenance, testing, and modifications) because of more effective scheduling of task support resources.
- Reduced unproductive time for task support resources because of more efficient scheduling and rapid transitioning to the next most critical job.
- More productive OCC management resulting from optimization software that will perform what is now a difficult manual optimization and communication function.