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Investigating the USACE Operational Condition Assessment Process Current and Future

Willie H. Brown and Jonathan K. Alt

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Abstract

The US Army Corps of Engineers operates, maintains, and manages more than \$232 billion worth of the Nation's water resource infrastructure and relies on the Operational Condition Assessment (OCA) process to determine the condition of the assets and their components. The sheer number of components, all of equal OCA scheduling priority, creates challenges in ensuring that assessments are conducted in a timely manner and that data generated are of sufficient quality to inform resource allocation decisions. This research applied methods from systems design to determine the OCA system "as-is" state and create a stakeholder-informed vision of a "to-be" state that addresses current system challenges. To meet its objective of providing current assessments of asset condition, the OCA system must provide four high-level functions: provide access to asset data, conduct assessments, determine asset risk, and prioritize and schedule assessments. The development of capabilities to provide these functions will facilitate the achievement of the OCA system to-be vision: a consistent view of asset condition and risk across the enterprise.

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Preface

This study was conducted for the Navigation Systems Research Program, Coastal Hydraulics Laboratory, US Army Engineer Research and Development Center, under Funding Account Code U4371811; AMSCO Code 031391. Ms. Morgan Johnston was the Program Manager for the Navigation Systems Research Program, and Mr. Peter Dodgion was the Program Manager for Asset Management, Headquarters, USACE.

The work was performed by the Institute for Systems Engineering Research (ISER), Computational Science and Engineering Division, Information Technology Laboratory (ITL), US Army Engineer Research and Development Center (ERDC), and the Hydrologic Systems Branch, Flood and Storm Protection Division, ERDC Coastal and Hydraulics Laboratory. At the time of publication of this report, Dr. Simon R. Goerger was ITL ISER Director; Dr. Jerry Ballard was ITL Computational Science and Engineering Division Chief; and Dr. Robert Wallace was the ERDC-ITL Technical Director for Engineered Resilient Systems. The Deputy Director of ERDC-ITL was Ms. Patti Duett, and the Director of ERDC-ITL was Dr. David Horner.

COL Teresa A. Schlosser was the Commander of ERDC, and the Director of ERDC was Dr. David W. Pittman.

1 Introduction

1.1 Background

The US Army Corps of Engineers (USACE) operates, maintains, and manages more than \$232 billion worth of the Nation's water resource assets — impacting American citizens on a daily basis. This infrastructure is declining in condition and functionality as it ages and receives less than optimal care. USACE uses an Operational Conditional Assessment (OCA) process to prioritize maintenance and repair of these structures. Condition is defined in terms of impact to performance, operation, or maintenance as well as the potential for failure, where failure is defined as loss of function. The OCA currently defines the impacts from condition in vague terms (e.g., “advanced state of degradation,” “potential to cause a functional failure,” “moderately affects,” and “substantially affects”). Although additional guidance is given for specific defects, inspectors interpret the terminology and apply them differently, leading to a variation in condition ratings and an inherently unreliable assessment system¹.

Additionally, the proper determination of condition is a function of the depth of inspection (e.g., level of access provided, use of tools, and nondestructive testing length of time spent inspecting) and the experience of the inspector (e.g., understanding system behavior as well as knowing where and how to look for defects). This often results in an inconsistent application of ratings. The USACE also conducts OCAs on all components at each operating project with no prioritization of components based on their criticality to the system's operation. The sheer number of components across the enterprise and qualitative nature of the assessments result in late identification of issues and a lack of confidence in the assessment process. The USACE Asset Management (AM) program seeks a greater understanding of the current state of the OCA process and its effectiveness in order to identify opportunities to improve the process through focused modernization efforts.

¹ Sauser, P. Unpublished. *Statement of Need: Increasing the Reliability of Condition Data Collection for Operational Condition Assessments of Hydraulic Structures*.

1.2 Objective

This study investigates the current state of the OCA process and envisions a potential future state. The team worked with stakeholders and arrived at the following problem statement:

To develop a roadmap for the modernization of the OCA process to improve the quality and timeliness of data generated by the assessment process and used to make resource allocation decisions to ensure risk associated with critical infrastructure assets is mitigated.

The following two questions guided this work:

- What is the current state of the OCA process (“as-is” state)?
- What opportunities exist to improve the OCA process (“to-be” state) through modernization?

1.3 Approach

This study consists of a literature review of the OCA process, stakeholder interviews (Appendix A) (Table 2), and gathering various data sources (Appendix B). A literature review of relevant USACE literature yielded a general understanding of the mechanics of the OCA process. Then, to understand the process in greater detail, the researchers interviewed 13 people from six different USACE organizations: Asset Management (AM), Flood Risk Management (FRM), Facilities and Equipment Maintenance (FEM), Inland Navigation (INAV), the Great Lakes and Ohio River Division (LRD), and the US Army Engineer Research and Development Center (ERDC). Instead of investigating the entire OCA process, the research sponsor focused the effort on the FRM business line. Many of the specific findings are FRM-centric but are illustrative of the challenges that exist across business lines. These interviews and data sources revealed a well-defined picture of the current OCA process and helped build a stakeholder-defined vision of what the OCA process could be. The researchers then documented the functional requirements to achieve the vision in a strategic roadmap and developed a project management plan for Fiscal Year (FY) 21–23 to make the first steps toward realizing the OCA to-be state. The general flow of the process is depicted in Figure 1.

Figure 1. OCA study approach.

The study was further scoped through an agreed-upon set of constraints, limitations, and assumptions.

Constraints. A restriction imposed by the study sponsor that limit the study team’s options in conducting the study.

- This study began in April 1, 2020, and had to be complete by September 30, 2020.
- Sponsors focused initial efforts on assets associated with FRM.
- Any recommendations made had to be solutions-agnostic.

Limitations. Factors that impact the study team’s ability to fully investigate the study issues.

- Because of COVID-19, travel was restricted.
- Access to condition data was limited to data pulled from the OCA reporting system.

Assumptions. A statement related to the study that is taken as true in the absence of facts, often to accommodate a limitation.

- Focusing on the FRM business line would provide sufficient picture of the as-is state of the OCA process.
- Access to subject matter experts would be sufficient to develop a vision for the to-be state.

1.4 Scope

This special report has a three-fold purpose:

1. Describe the as-is state of the system that enables the OCA process generally and how the data generated through the process are used to inform maintenance, repair, and replacement (MR&R) resource-allocation decisions.

2. Envision the to-be state of the system that enables the OCA process including conducting OCAs, data strategy, determining asset risk, and scheduling and prioritizing OCAs.
3. Outline the functional requirements to achieve the OCA to-be state through a set of high-level strategic objectives for the enterprise and a more detailed description of the first work unit to begin enabling the achievement of two of these objectives.

In addition to giving a high-level description of the purpose of this document, the preceding three bullets also outline the flow of the document and map to the sequence of the study approach. First, the current OCA process is described both in terms of the how OCA data are generated and used. Second, the stakeholder-defined vision of a modernized OCA process is given. Third, the functional requirements to achieve the modernized OCA process are outlined.

2 OCA “as-is” State

2.1 OCA mechanics

2.1.1 Terms of reference

Before analyzing the OCA process and its impact on resource allocation, it is helpful to explain the OCA infrastructure hierarchy and to define what is meant by “operational condition” and “assessment.” Figure 2 displays the OCA infrastructure hierarchy. In this hierarchy, the highest level is called an *operating project* (e.g., a dam). These operating projects decompose into systems, subsystems, and finally components. OCAs are performed at the component level.

Figure 2. OCA infrastructure hierarchy.

The operational condition of a component refers to (1) the “condition state, specifically, the degree of severity of an observed and/or documented deficiency” and (2) “the level or degree to which a deficiency degrades the component’s performance, alters operational procedures, and/or increases its maintenance requirements.” Assessment refers to “the use of existing data, as much as possible, to accurately determine the

asset's operability and readiness." (USACE 2019) Note that although OCAs often involve visual inspection, visual inspection is not required.

2.1.2 OCA process overview

When a full OCA is conducted, it includes each component of a given operating project. In the FRM business line alone, there are 128,698 components, leading to assessment reliability and consistency issues. To determine condition ratings, OCA teams leverage existing data, from various sources, to justify their ratings. These data can include annual condition inspections, bridge inspections, engineering reports and analyses, FEM data, hydraulic steel structure inspections, periodic inspections, risk and reliability investigations, risk analysis evaluations, security reports, performance data, and underwater inspections. Significant variability exists in the data available for each Operating Project and the data made use of by the OCA teams. Additionally, OCA teams often perform an onsite walk-around and interview project staff. The condition ratings range from A (Excellent) to CF (Completely Failed). Table 1 displays the rating scale and the definitions for each rating (USACE 2019).

Table 1. OCA rating scale and definitions (USACE 2019).

Rating		Descriptor	Definition	Notes
A	9	Excellent	Component was recently put into service and shows no signs of wear.	Ratings DO NOT require comments.
A-	8			
B	7	Good	Component performs its intended function. Any deficiencies are normal wear and not actively progressing at a greater rate than normal wear.	
B-	6			
C	5	Fair	Component has a deficiency that is beginning ¹ to affect its performance, operational procedures, and/or maintenance requirements.	Ratings DO require justification comments and will be verified during the assessment.
C-	4		AND/OR Component is beginning to show a greater rate of change in degradation that has the potential to cause a functional failure.	
D	3	Poor	Component has a deficiency that increasingly ² or moderately ³ affects its performance, operational procedure, and/or maintenance requirements.	
D-	2		AND/OR Component has a clear mode of failure due to an advanced state of degradation likely with an accelerating trend.	
F	1	Failing	Component has a deficiency that substantially ⁴ affects its performance, operational procedures, and/or maintenance requirements and is approaching complete failure.	
			AND/OR Component is clearly in the final stage of degradation trending toward complete failure (imminent failure).	
CF	0	Completely Failed	Component is completely failed and does not perform its intended function.	
			AND/OR Component is red-tagged.	
Minus OCA Rating Definition				
The minus OLCA ratings (A-, B-, C-, and D-) are for components that meet the definition of a particular OCA rating but may be showing initial signs of the next lower OCA rating.				

Note that only ratings below a B require written comments documenting a component's deficiencies. These comments describe the deficiency's impact on operations, maintenance, and performance along with data sources used to identify the deficiency (e.g., periodic inspection report). These ratings along with supporting documentation are submitted to the Major Subordinate Command Regional Asset Manager where disputes are resolved (USACE 2019). Upon completion of that process, approved data entry personnel post the rating results to the OCA database.

2.1.3 Insights from OCA data

As part of the OCA system, operating projects are decomposed into systems, and their components are tracked in a database that OCA teams update with the results of completed OCAs. During exploratory data analysis of this data set, the team found that the overwhelming majority of OCA ratings were in the “B” category, which corresponded with comments from stakeholders. These data also provided understanding of the full scale of the problem. As an example, Figure 3 shows how the Sardis Dam, one of 21 operating projects in the Vicksburg District, decomposes into 16 systems and 92 subsystems, with 742 components that all require an OCA. To illustrate what these layers represent, Figure 4 shows a single strand from operating project to components.

Figure 3. Sardis Dam OCA decomposition.

Figure 4. Sardis Dam example system, subsystem, and components.

2.2 Guiding questions

How are operating projects currently scheduled for an OCA?

Full OCAs must be scheduled at a maximum of every 5 years. Some Major Subordinate Commands meet that requirement by doing OCAs every 5 years, but others do them more frequently. Additionally, zero components or operating projects receive scheduling priority because risk has not been determined at the operating-project level, and risk drivers have not been identified at the component level.

How is risk currently assessed and considered in the OCA process?

Risk scores have not been determined for USACE operating projects, and risk drivers have not been identified for components. Therefore, there are no relevant risk scores to inform the OCA process.

How are the results used in conjunction with risk data to inform resource decisions?

Specifically, the OCA ratings comprise the condition leg of the 5×5 relative risk matrix, which is tied to maintenance work packages and not to inherent component qualities. This is a data field in the Civil Works Integrated Funding Database, which is a budget tool used at Headquarters, USACE (HQUSACE), to fund projects through Civil Works (CW). However, this answer requires further explanation. Work packages are created across the USACE-CW enterprise to request funding for operating project MR&R not commonly performed. When these work packages reach HQUSACE, decisions are made as to what MR&R work packages get funded. Each work package will propose MR&R on a certain operating project, which will contain numerous components. Additionally, each work package has a 5×5 relative risk matrix containing a condition leg and a consequence leg. The condition leg of the matrix is an A–F rating, and OCA ratings are used to fill this condition leg. This system creates an irreconcilable mismatch in that the work package is at the project level, but the OCA ratings are at the component level, which begs the following question: “How does one fill the condition leg of the matrix?” Official guidance mandates that the dominant component’s OCA rating be used, but this subjective choice leaves room for drastically different scores for the same work package as demonstrated in Figure 5 (USACE 2020).

Figure 5. OCA impact on CW resource allocation.

MR&R Work Package	5 x 5 Relative Risk Matrix	Civil Works Integrated Funding Database
<u>Component Ratings</u> Component 1 - A Component 2 - B Component 3 - D Component 4 - B Component 5 - B	Condition Leg F D C B A I 1 3 6 10 15 II 2 5 9 14 19 III 4 8 13 18 22 IV 7 12 17 21 24 V 11 16 20 23 25	<u>Work Package xxxx</u> Factor A: xxxx Factor B: xxxx Factor C: xxxx 5 x 5 RRM Score - 22 or 8 Factor E: xxxx

For example, if one person considers Component 1 to be the dominant component and another person considers Component 3 to the dominant component, then their resulting risk scores will be very different. If the consequence level is a III, then one work package will receive a risk score of 22 and the other a risk score of 8 despite the reality that these are identical work packages. This difference in risk scores has implications on whether or not this work package will get funded.

3 OCA “to-be” State

Informed by and understanding of the as-is state and the objectives of the system and guided by stakeholder input, the team developed a vision for the to-be state of the system.

Vision: A consistent view of asset condition and risk across the enterprise

This vision requires transparency, consistency, and traceability.

Transparency means that asset data are systematically collected and maintained across the enterprise to inform a common operating picture for USACE decision makers and data-driven resource decisions to mitigate risk.

Consistency means that common asset data are made available to OCA teams to enable consistent OCA processes across the enterprise.

Traceability means that asset risk and resource decisions can be traced back to component risk and condition assessments informed by the OCA process.

For the OCA process to more effectively provide a current assessment of asset condition, four major work areas need to be addressed to implement or improve the functions that comprise the OCA system: (1) providing data access, (2) conducting assessments, (3) determining asset risk, and (4) prioritizing and scheduling. The columns in Figure 6 map to these work areas.

Figure 6. High-level OCA system functional decomposition.

The columns on the left represent functions that require operational changes to the AM program. “Provide Access to Asset Data” speaks to an enterprise-level data strategy in which asset data are highly valued as an enterprise commodity. Those data are systematically collected, managed, provisioned for reuse, and governed. “Conduct OCA” speaks to the manner in which OCAs are conducted. This means that assessors have a consistent, intuitive picture of all asset data and knowledge of the critical components that contribute to flood risk. The technologies and procedures used in assessing component conditions should be reliable, and the component condition ratings should receive concurrence from operating project staff, regional asset managers, and other pertinent personnel.

The columns on the right require research to develop methods of determining asset risk and a framework for scheduling OCAs based on risk. “Determine Asset Risk” speaks to the need to understand the risk associated with the various components of each operating project. This requires data on the likelihood and consequence of operating project failure. Last, “Schedule OCA” speaks to a prioritized scheduling framework. Instead of interval-based scheduling, AM could develop a scheduling framework in which assets and components that contribute to more risk receive higher scheduling priority.

A further decomposition of these functions would lead to the identification of measures of effectiveness for each. This would inform an assessment process to assist OCA operations in measuring progress as changes are implemented. The next section provides greater definition of the strategic objectives and outlines, at a high level, how the researchers, in conjunction with a team from the Institute for Water Resources (IWR), plan to develop a scalable methodology to determine asset risk across the AM enterprise and then use that risk data to develop an OCA prioritization and scheduling framework.

4 Future OCA Functional Requirements

4.1 Strategic objectives to achieve modernized OCA

To achieve the aforementioned vision of a transparent, consistent, and traceable risk-based OCA system, the following four strategic objectives must be addressed:

Provide Access to Asset Data. The asset management community must collect, manage, provision for re-use, and provide governance over authoritative data describing assets, and their current status, within the portfolio to provide stakeholders and decision makers with a single consistent repository of data to inform analysis and subsequent resourcing decisions.

Modernize Conduct of OCA. As part of the data collection process, the asset management community must modernize the manner in which OCAs are conducted to systematically make better use of available data and to ensure that the OCA process generates objective, high-quality data to inform risk and support decision makers.

Determine Asset Risk. The asset management community must develop an understanding of the relative importance of each asset, and their critical components, to the performance of the system and the likelihood that the asset will perform as expected in its current condition.

Develop OCA Prioritization and Scheduling Framework. The asset management community must develop a risk-based prioritization and scheduling framework that enables resources and OCAs to be focused on the greatest sources of risk to the enterprise.

4.2 Determining operating project risk, FY21–23

The purpose of FY21–23 work is to develop an enterprise framework for risk-based prioritization of OCA. Currently, OCAs are conducted each year without a risk-based prioritization method resulting in the expenditure of resources to assess assets that pose no risk to the enterprise. In particular, this work is intended to help decision makers understand which FRM operating project components require an OCA based on their contribution

to overall risk and current component condition. To determine risk, likelihood of failure data and consequence data are required.

$$\text{Risk} = (\text{consequence} \mid \text{hazard}) \times (\text{likelihood of failure} \mid \text{component condition})$$

The researchers will conduct a literature review and elicit feedback from operating project staff to develop a methodology to determine the operating project-level likelihood of failure based on the likelihood of failure of the components that make up the operating project as is demonstrated in Figure 7.

Figure 7. Determining likelihood of failure based on component condition.

The team at IWR is modeling the *watershed-level consequences* of an operating project failing to perform at full operating capability at the watershed level because these operating projects work as a part of a larger FRM system within a given watershed. The systems that comprise operating projects with the most direct impact on the functioning of the watershed FRM system are those that impact the flow of water — gates. Modeling the FRM system performance in the context of the watershed in which it functions can provide insight into the contribution of each gate to the overall FRM system’s ability to control the flow of water in the watershed — the consequences — under various environmental conditions. The performance of each gate as a function of the OCA-informed condition of its components will be modeled to determine the probability that the gate will function as intended. Having consequence data at the gate level and likelihood of failure data at the gate level enables the determination of risk at the gate level. The collaboration of these two modeling efforts to produce gate-level risk is demonstrated in Figure 8. A methodology will be

developed to aggregate gate-level risk to the operating-project level. With a greater understanding of component risk drivers and operating project-level risk, the researchers will develop a methodology to prioritize the conduct of OCAs.

Figure 8. Determining FRM risk.

5 Conclusions

The USACE water resource assets impact the daily lives of American citizens, and these assets are in decline. Although the OCA system provides a defined process by which these assets are assessed, the process lacks consistency leading to unreliable condition ratings. These condition ratings then factor into a subjective work package proposal process used to fund CW MR&R across the enterprise. The findings in this study confirm the USACE position that the system needs modernization. The vision of a modernized OCA is a consistent view of asset condition and risk across the enterprise. To achieve this vision of a modernized and improved OCA system, four major work areas need to be addressed: (1) providing data access, (2) conduct of assessments, (3) determining asset risk, and (4) prioritization and scheduling. With an initial focus on the FRM business line, the next step is to develop a scalable and generalizable methodology to determine operating project probability of failure using component-level OCA condition ratings. Combining this probability failure data with the IWR consequence data will provide FRM with meaningful risk data, enabling prioritized OCA scheduling and more effective CW MR&R resource allocation.

While the determination of risk scores will greatly improve the utility of OCA data, more work is needed to improve the OCA process. To ensure that the first objective, providing access to asset data, is attained, it is recommended that the USACE AM program develop an enterprise-level data strategy that provides a vision for how the organization will (1) allow users to identify the existence of data; (2) collect and store data to facilitate use, shared access, and processing; (3) provision data for reuse and sharing and provide rules and guidelines for data access at scale; (4) process data from disparate systems to provide a consistent data view; and (5) develop data policies to govern how the organization will capture, manage, and use information for disparate sources (Klingensmith and Alt 2020).

In support of the second objective, conduct OCA, it is recommended that USACE identify existing initiatives within USACE that collect data from mechanisms not traditionally used to inform operating-project or component status (such as sensors, inspections, maintenance, or testing). The data generated by these sensors possess the potential to inform component probability-of-failure estimates. Last, inconsistent human

actions, such as visual inspections and application of testing and monitoring equipment, result in inconsistent and unreliable condition assessments. This variability can include inconsistent procedures, inaccurate data interpretation, improper equipment calibration, and lack of experience. It is recommended that research be conducted to understand these human factors and how they influence the OCA process¹.

¹ Sauser, P. Unpublished. *Statement of Need: Reliable Inspection and Monitoring Techniques for Hydraulic Structures*.

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- USACE. 2020. *Civil Works Direct Program Development Policy Guidance*. Engineer Circular No. 11-2-222. Washington, DC: Department of the Army, US Army Corps of Engineers.

Appendix A: Interviews

Table 2. The stakeholder interviews that informed the “as-is” and “to-be” states.

Organization	People	Date
AM and ERDC-Coastal and Hydraulics Laboratory (CHL)	Peter Dodgion (AM), Chris Westbrook (AM), Matt Smith (ERDC-CHL)	05/20/2020
ERDC-Information Technology Laboratory	James Stinson	05/27/2020
AM	Joe Dziuk	05/27/2020
INAV	Andy Harkness	05/28/2020
LRD	Dan Cox	06/30/2020
FRM	Lisa Kiefel and Jeff Jensen	06/30/2020
FEM	Lisa Lund, Kerry Brink, Michael Brehm, Sharon Ramsey	07/16/2020
LRD	Dan Cox	07/17/2020
ERDC-CHL	Matt Smith	07/24/2020
FEM	Lisa Lund	08/05/2020

Appendix B: Tools and Data Sources

Data Sources

- FRM OCA Data
- FRM FEM Maintenance Data
- FRM Fault Trees (2017)
- National FRM OCA Component List
- National INAV Component List

FRM Operational Risk Assessment (ORA) Tool Resources

- Past Attempts at an FRM ORA Tool
 - Conemaugh Dam
 - John W. Flanagan Dam
 - Senecaville Dam
- FAQs on FRM ORA
- Notional FRM ORA Tool Slides

Other Resources

- OCA-FRM Integration Plan PMP
- INAV ORA Risk Calculation Walkthrough Files
- Sample INAV ORA Budget Workbook, Pittsburgh District

Acronyms and Abbreviations

AM	Asset Management
CW	Civil Works
CHL	Coastal and Hydraulics Laboratory
ERDC	US Army Engineer Research and Development Center
FEM	Facilities and Equipment Maintenance
FRM	Flood Risk Management
FY	Fiscal Year
HQUSACE	Headquarters, US Army Corps of Engineers
INAV	Inland Navigation
IWR	Institute for Water Resources
LRD	Great Lakes and Ohio River Division
MR&R	maintenance, repair, and replacement
OCA	Operational Conditional Assessment
ORA	Operational Risk Assessment
USACE	US Army Corps of Engineers

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