Quick Insight Brief: Using Artificial Intelligence to Maximize the Benefits of Drones for Nuclear Power Plants

Drones enable certain nuclear power plant operations to be conducted more safely and with reduced inspection costs. Additionally, the richer data provided by drones allows for more efficient and enhanced monitoring and inspections (though the cost of requiring additional data analysis must be considered). This Quick Insight Brief discusses how Artificial Intelligence (AI) solutions can be leveraged to maximize the benefits of drone applications by alleviating the burden on data analysis using the visual inspection of large concrete structures as an example.

RESEARCH QUESTIONS

This Quick Insight Brief focuses on the following research question:

- How can the industry maximize the benefits offered by drone technology?

KEY POINTS

- The industry can leverage drones to increase safety and reduce costs for several operational activities.
- The increased data quality provided by such approaches enhances monitoring capabilities and leads to more efficient and thorough inspections (though it will likely include increased data analysis costs).
- AI solutions can be leveraged to alleviate the extra burden of data analysis and maximize the benefit of such approaches.
- EPRI is continuously collaborating with utilities to identify and develop such solutions.

DRONES IN THE NUCLEAR POWER INDUSTRY

Unmanned Aerial Systems (UAS), or drones, bring considerable benefits to the nuclear power industry. By leveraging drone systems, utilities can:

- Enable safer operation since drones can be used to access areas that would otherwise pose safety risks to personnel
- Increase operation reliability through more efficient and thorough inspections, enhanced monitoring, and improved record management
- Reduce costs by optimizing manpower usage

They can be applied in a variety of applications, including, but not limited to:

- Construction
  - Building roofs and facades
  - Construction site surveys
- Inspection activities
  - Generic visual inspection of hard-to-reach components
  - Boiler inspections
  - Stack inspections
  - Sprinkler head inspections
  - Large concrete structures such as containment buildings and cooling towers
- Monitoring activities
  - Equipment rounds
  - Plant security patrols
  - Dry cask storage systems
- Measurement activities
  - Radiation mapping
  - Tank and liner thickness measurements

The numerous benefits and applications enable well-utilized drone programs to add considerable value to plant operations (see EPRI's UAS user's guide for nuclear power plants, 3002020913).

INSPECTION OF LARGE CONCRETE STRUCTURES

One application to consider is the inspection of large concrete structures, such as containment buildings and cooling towers. A recent EPRI study on its business case (3002021027) shows considerable advantages. Figure 1 provides a comparison between manual and drone inspections. In traditional manual inspections, cranes or lifts typically need to be used to access elevated areas of the containment building; drones can do so remotely without the need for the large equipment—and without exposing the personnel to the associated inherent safety risk.

The benefits for utilities using the drone approach include increased safety, the ability to leverage their own resources for inspections, and optimized labor usage. Utilities that typically rely on large equipment rentals or contractors can also realize significant cost reductions.

Figure 1 – Manual (Left) and drone (right) visual inspection of a containment structure

The Blessing and Curse of Data

Table 1 shows the impact of drone use on typical containment inspection activities. Time, labor, and cost-saving opportunities are noted in the captured tasks. However, one drawback is also evident: the increased burden of data analysis.

An advantage of the increased data quality and quantity provided by the drone approach is an improved inspection record. However, a disadvantage is that it comes at the cost of increased burden and time needed for analysis due to higher data quantity and complexity. This issue is not unique to this application; the increased burden of data analysis is a natural consequence of automated data-collection processes since they provide significantly more detailed data—simultaneously making inspections more thorough and providing better records.

Leveraging AI for Maximum Benefits

The increased data quality and quantity provided by drones is an opportunity to gain additional insights if leveraged correctly. In this case, the industry can leverage AI solutions to ease the burden of data analysis to maximize its benefits.

EPRI is supporting research to enable the utilities to do just that. Using the inspection of containment structures as an example, EPRI has developed machine vision models to autodetect defects in concrete structures. The Concrete Defect Detection Tool (CDDT) is currently available to EPRI members as a beta version. Through its web portal, users can 1) upload their datasets, 2) evaluate them with the model, and 3) review the results. Figure 2 shows some examples of drone images evaluated by the CDDT.

Table 1 – Impact of drone-assistance on typical containment inspection activities

Task	Owner	Impact
Inspection planning tasks	Planner	Reduced by 50% due to elimination of high-risk activity
Prepare location for inspection	Maintenance/Contractor	Significantly reduced (no cranes, manbaskets, or scaffolding)
Perform structural inspection	Engineer	Reduced to two days per unit
Oversee inspection	Engineer	Reduced due to lower inspection time
Evaluate inspection results	Engineer	Additional task due to increased data quality
Large equipment and associated vendor labor	Contractor	Eliminated where applicable

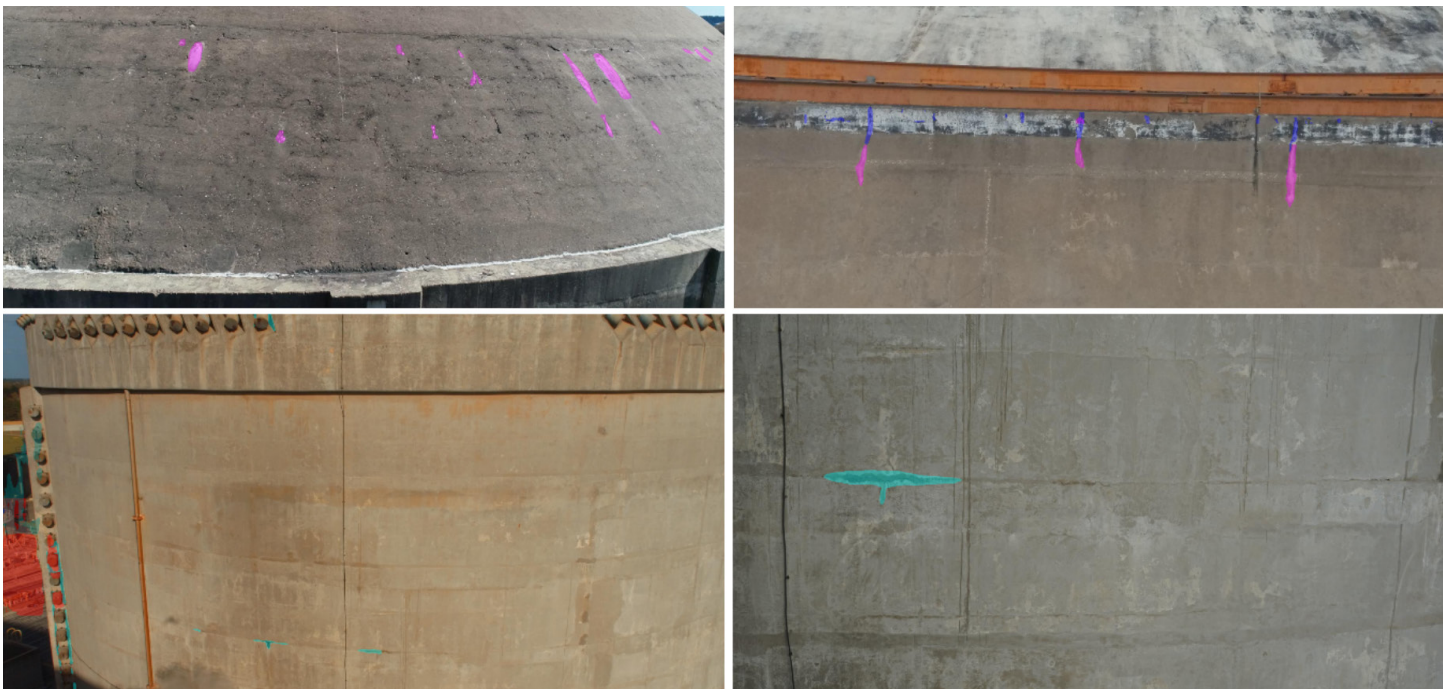

Figure 2 – Examples of drone images evaluated by CDDT. Color highlights indicate potential defects found by CDDT

By leveraging CDDT, utilities can realize the benefits of the increased data quality and inspection records while avoiding or minimizing the added burden on analysis that would otherwise be required. This is one example of how automated data collection processes—such as those enabled by drones—coupled with AI solutions can allow utilities to perform safer, more reliable, and more affordable operations.

Continuous Collaboration and Improvement

CDDT's development continues as a collaborative effort. EPRI continues to receive inspection data from member utilities to further train future iterations of the model. For example, though currently trained only on containment buildings, EPRI member utilities have provided data on cooling towers that can be used to expand the CDDT's applicability to these structures.

Additionally, EPRI and collaborators are targeting a field demonstration of a real-time implementation of CDDT, where the model is run onboard the drone itself, providing live information on the defects found to the inspectors, who can then direct the pilots to the identified regions of interest. Such an approach would enable on-site, live data analysis and generate detailed inspection records for post-inspection review as desired.

SUMMARY

Drones enable remote or automated activities such as data collection that lead to numerous benefits to the nuclear power industry, including increased safety, optimized resource usage, and reduced costs, all while enabling more efficient and thorough inspections or enhanced monitoring capabilities. However, the larger amounts of data collected mean utilities need to prepare for the analysis of significantly larger volumes of data that will likely lead to an increased burden in cost and time to perform the necessary data analysis.

The industry can leverage AI solutions to assist in data analysis to maximize the benefits of drone usage. EPRI continuously collaborates with member utilities to identify use cases and develop such solutions. The Concrete Defect Detection Tool is the first example available to the Nuclear industry. Research continues both to improve current tools as well as to develop other applications across multiple EPRI sectors (see Additional EPRI Resources).

ADDITIONAL EPRI RESOURCES

Refer to the following EPRI resources for additional information on this topic and other ways AI can be leveraged to benefit the electric power industry.

- *Concrete Defect Detection Tool (CDDT) v1.0 Beta*. EPRI, Palo Alto, CA: 2022. 3002021063.
- *Plant Modernization Business Case: Drone Inspections of Containment Structures*. EPRI, Palo Alto, CA: 2021. 3002021027.
- *Unmanned Aircraft System (UAS) User's Guide for Nuclear Power Plants: Implementation Guidance, Technologies, and Applications, and Cost Savings Opportunities*. EPRI, Palo Alto, CA: 2021. 3002020913.
- *Automated Analysis of Remote Visual Inspection of Containment Buildings*. EPRI, Palo Alto, CA: 2020. 3002018419.
- *Autonomous Indoor Radiation Survey and Inspection Drone Demonstration at Peach Bottom*. EPRI, Palo Alto, CA: 2020. 3002018409.
- Reducing Condenser Inspection Costs Using Unmanned Aerial Vehicles (UAV) (MTA-MA-020)
- *Quick Insight Brief: Leveraging Artificial Intelligence for Nondestructive Evaluation*. EPRI, Palo Alto, CA: 2021. 3002021074.
- *Quick Insight Brief: Leveraging Artificial Intelligence for the Nuclear Energy Sector*. EPRI, Palo Alto, CA: 2021. 3002021067..
- *Drone Imagery for Utility Inspection: Distribution Systems, Power Delivery, and Utilization, Overhead Inspection Technologies*. EPRI, Palo Alto, CA: 2022. 3002024059.
- *State-of-the-Art of Processing Inspection Imagery*. EPRI, Palo Alto, CA: 2021. 3002021459.
- *Unmanned Aircraft Systems (UAS) Automation Technologies for Transmission Inspection: Image Prediction Testing*. EPRI, Palo Alto, CA: 2019. 3002016958.

For further information, contact Thiago Seuaciuc-Osorio, Principal Technical Leader, tsosorio@epri.com.

To learn more about EPRI's AI initiative, visit ai.epri.com.

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EPRI
3420 Hillview Avenue, Palo Alto, California 94304-1338 USA
800.313.3774 • 650.855.2121 • askepri@epri.com • www.epri.com