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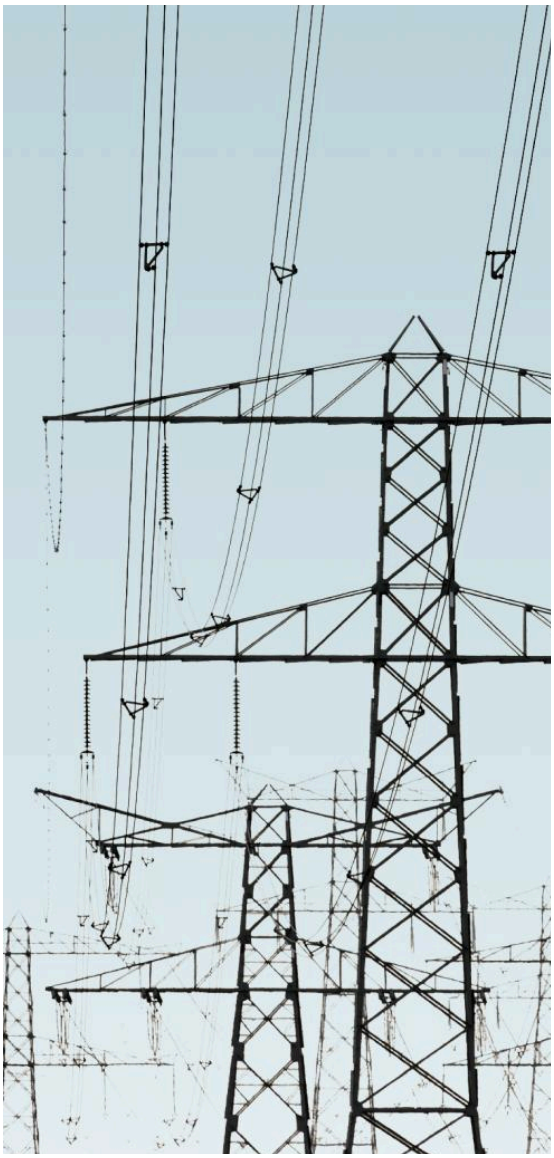

Utilities industry insights:

Future-proofing today: the path to condition-based maintenance

Table of contents

Introduction 2

Inefficiencies of traditional methods 3

Core differences and advantages vs. time-based maintenance 6

A story of timely, accurate insights 8

Emerging technologies in utility management 9

Enhanced data collection with drones 10

CBM implementation strategies 12

Develop a roadmap to condition-based maintenance 13

Common obstacles in transition to CBM 16

Risk mitigation strategies 18

Envisioning the future of utility maintenance 20

Continuous improvement and adaptation 21

Conclusion 23

About Skydio 23

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Introduction

In today's rapidly evolving energy landscape, utilities are at a crucial crossroads. A report from Carnegie Mellon University highlights, "The challenge with aging infrastructure in the utility sector is not just about reliability but also about adaptability to new technologies and changing environmental conditions." Faced with the dual challenges of an aging infrastructure and an increasingly unpredictable climate, the need for a more efficient and reliable utility infrastructure monitoring and inspection solution has never been more critical.

Risks of an aging workforce

The report from Carnegie Mellon also found that "Workers with physically demanding jobs, such as linemen, may not be able to continue working into their 60s... failing to maintain the skills of today's workforce by replacing retiring workers with competent substitutes... will increase stress to the power systems."

> "The electricity industry is facing an unprecedented array of challenges... in many utilities, half or more of the workforce will be eligible to retire within five years."
>
> **West Monroe 2024 Outlook: The Future of the Energy and Utilities Industry**

There is a vast reservoir of knowledge and experience held by long-time employees nearing retirement adding another layer of complexity to the already challenging task of utility management.

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Did you know?

AI can process and analyze inspection data, increasing defect detection rates and improving grid reliability. Early adopters have reported a 280% increase in inspection capacity using the same resources, a 37% increase in defect detection, and higher job satisfaction among maintenance inspectors. (Utility Analytics Institute)

Inefficiencies of traditional methods

Traditional time-based maintenance strategies — scheduling inspections and maintenance activities at predetermined intervals — miss the AI revolution that is powering innovative utility organizations into the future.

> “We are on the cusp of a digital revolution. Embracing new technology like drones and AI for condition-based maintenance not only improves efficiency but also ensures a more reliable and sustainable future.”

Christina Park, Former Senior Director of Asset Intelligent Solutions, NYPA and Current Senior Director of Energy Strategy, Skydio

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The time-based maintenance (TBM) approach, driven by manufacturer recommendations or historical practices, is based on an assumed average lifespan of assets. While this method offers simplicity and routine, it leads to two significant inefficiencies:

Over-maintenance

Without proper insights into asset health, assets are sometimes serviced or replaced prematurely, leading to unnecessary expenditure.

Unexpected failures

This approach can miss early signs of wear and tear, resulting in sudden and unexpected breakdowns paired with costly and easily avoidable emergency response scenarios.

Extreme weather resiliency risks

The impact of climate change exacerbates these issues, introducing more unpredictability into the equation. Extreme weather events, such as storms, wildfires, and floods, are becoming more frequent and severe, threatening the resilience and reliability of utility infrastructures. These events not only pose immediate risks to the stability of power and utility systems but also place a significant strain on maintenance and inspection routines, which are already stretched thin under the time-based model.

The shift to condition-based maintenance

In light of these challenges, industry experts are increasingly recognizing the need to move towards condition-based maintenance (CBM). CBM represents a paradigm shift in asset management, focusing on the actual condition of assets to determine maintenance needs.

Unlike TBM, CBM leverages real-time data, advanced analytics, and cutting-edge technology, such as mounted or mobile camera sensors, to predict potential failures before they occur. The CBM approach allows for a timely and accurate understanding of asset conditions, enabling utilities to make informed data-driven maintenance decisions. By prioritizing interventions based on actual needs rather than predefined schedules, CBM can significantly enhance operational efficiency, reduce costs, and improve the reliability and longevity of utility assets.

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Did you know?

Drones minimize the need for utility workers to perform hazardous tasks, such as climbing high-voltage towers or working in difficult-to-reach areas. This reduction in direct exposure to dangerous environments significantly improves worker safety. (Utility Analytics Institute).

As the energy and utilities industry confronts unprecedented challenges, the shift to condition-based maintenance (CBM) emerges not just as a modern alternative, but as a necessary evolution in asset management. This guide provides an analysis of this pivotal transition, exploring the definitions, core differences, and advantages of CBM compared to traditional time-based maintenance (TBM), as well as highlighting the significance of timely, accurate insights over utility assets.

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Core differences and advantages vs. time-based maintenance

Prescriptive

Time-based maintenance strategies follow a set schedule based on manufacturer recommendations.

Predictive

CBM is predictive, focusing on preempting failures based on the current state of equipment. This shift from a prescriptive to a predictive approach is central to CBM’s effectiveness.

Data-driven decisions

CBM leverages data from IoT devices (i.e mounted cameras or drones) to provide a comprehensive view of asset health. This contrasts with TBM's reliance on historical data and generalized schedules.

Cost efficiency

CBM can significantly reduce costs by eliminating unnecessary maintenance. While TBM often leads to either over-maintenance or costly reactive maintenance, CBM ensures maintenance work is performed only when needed.

Extended asset life

Performing the right maintenance at the right time can extend asset life. Operating conditions for assets vary widely, which the one-size-fits-all approach of TBM doesn’t take into account. CBM works in two ways to extend asset life:

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- It prevents premature wear and tear caused by unnecessary interventions
- It catches issues early before larger problems emerge

Minimized downtime and disruptions

It accounts for the differences in operating conditions, which may vary widely by user. Environmental factors such as geography and climate will affect asset life, as well as the way the assets are operated.

Less downtime

CBM's predictive nature allows for better planning and scheduling of maintenance work, minimizing disruptions to operations, and resulting in reduced customer minutes interrupted (CMI), higher customer satisfaction, and reduced costs from unexpected overtime and emergency response.

Enhanced safety and reliability

With CBM, potential issues are identified and addressed before they escalate, enhancing the overall safety and reliability of the utility infrastructure.

Did you know?

Traditional helicopter inspections can cost upwards of $10,000 a day, whereas a fully equipped drone costs a fraction of that and poses no risk to human life in case of a crash. Drones not only reduce operational costs but also increase productivity, as they can perform more inspections per day than a human crew. For instance, while a typical lineman might complete two detailed climbing inspections per day, a drone can perform 10 to 20 inspections (The Utility Expo).

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A story of timely, accurate insights

Consider the case of a major utility company facing frequent outages due to transformer failures. Under their TBM regime, transformers were scheduled for maintenance every two years. However, this interval was not aligned with the actual wear and tear experienced by the transformers, leading to unexpected failures.

The company decided to shift to a CBM strategy, installing sensors to monitor transformer temperature, oil quality, and electrical currents in real time. This move allowed them to gather critical data reflecting the actual condition of each transformer.

One summer, the sensors detected an abnormal rise in the temperature of a particular transformer. Though it wasn't due for maintenance for another six months under the TBM schedule, the data indicated an imminent risk of failure. Thanks to the insights provided by CBM, the utility was able to proactively address the issue, replacing a faulty component and averting a potential outage. The downstream effects of an unplanned outage are not limited to just the immediate downtime and labor, but the cost of a replacement and the potential supply chain considerations of how long it takes to get a replacement must be accounted for, which is impossible without a clear picture of utility infrastructure.

This incident underscored the importance of timely, accurate insights into utility asset health. The utility not only prevented a significant disruption but also saved considerable costs that would have been incurred in an emergency response. The transition to CBM transformed their approach from reactive to proactive, aligning maintenance activities with actual asset conditions and needs.

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Emerging technologies in utility management

One of the most impactful technologies in recent years has been the rapid development of camera sensors and AI algorithms for autonomous data capture and processing.

> “The field of infrastructure inspection is evolving and expanding faster than ever before with new technologies such as robotics, augmented reality, and deep learning revolutionizing the ways we can monitor and evaluate structural systems.”
>
> **MPDI**

Artificial intelligence can now handle both data-capture & data-processing processes, giving utility organizations constant visibility into their most valuable assets with the added benefit of distributing their workforce where they can be most impactful and allow robots to handle the rest of the dull, dirty, or mundane work.

Did you know?

AI is already showing real-world impact in the power and utilities sector by improving power generation, reducing energy costs, and advancing scientific breakthroughs. Innovations such as smart grid chips, AI-powered solar forecasting, and AI-driven monitoring of utility poles exemplify how AI is revolutionizing the utility industry (NVIDIA).

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Enhanced data collection with drones

The introduction of AI-powered technology tailored to the specific needs of the utility industry changes the game entirely. Drones offer significant advantages for utility maintenance that cannot be attained through other methods.

> “Drones play a crucial role in managing renewable energy sources by optimizing equipment management and forecasting energy production based on environmental conditions, thereby contributing to a more sustainable energy landscape.”

AnalyticsSteps

Accessibility and coverage

Drones can easily access remote, hard-to-reach, and dangerous areas, providing comprehensive coverage without the need for physical human presence.

Data quality

High-resolution cameras and sensors on drones capture detailed, accurate data, offering a clearer objective record of asset conditions.

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Safety

Drones eliminate the need for human workers to be exposed to hazardous conditions, significantly reducing the risk of accidents.

Cost-effectiveness

Utilizing drones for inspections can be more cost-effective than traditional methods, especially considering the number of people needed for manual inspection and the time spent driving to sites and setting up before you can conduct an inspection.

Time efficiency

Drones can cover large areas in a fraction of the time it would take for ground crews, leading to faster decision-making and maintenance response.

Improved visibility

Drones offer improved insights from more frequent and repetitive inspections. Utilizing docked drones that can be piloted remotely or flown fully autonomously takes these insights to the next level by providing constant visibility via ad-hoc, scheduled, or random inspections of critical assets.

> “Routine maintenance inspection of assets and transmission structures by sUAS can reduce inspection time, increase data collection, expand inspection areas, and improve inspection safety compared to visual inspection.”

Pinnacl X

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CBM implementation strategies

Implementing CBM, particularly through the integration of advanced drones and data analytics, requires a comprehensive strategy that considers the organization's current state, its readiness for change, and the steps needed for a successful transition. Here’s what to keep top of mind as your organization begins your transition:

Assess organizational readiness

Before embarking on the journey to CBM, it's crucial to assess the organization's readiness for this shift. This involves understanding the current maintenance culture, technological landscape, and the organization's appetite for change. Key questions to consider include the level of openness to new processes among staff, existing data management practices, and the organization’s historical approach to maintenance. This assessment helps in identifying potential resistance, training needs, and areas where additional resources might be required.

Evaluate current maintenance practices and infrastructure

A thorough evaluation of the current maintenance practices and infrastructure sets the baseline for the CBM implementation. This step involves reviewing existing maintenance schedules, methods, and tools, as well as the condition and age of the current infrastructure. It's important to document the frequency and causes of equipment failures, maintenance costs, and any downtime impacts. This evaluation not only highlights the limitations of current practices but also underscores the areas where CBM can bring the most significant improvements and establishes a baseline to help calculate the ROI by measuring current and future state.

Identify areas for immediate improvement

Based on the evaluation, identify areas where CBM can yield immediate improvements, especially those that are already lean on staff and facing expanding regulatory compliance requirements. Getting creative is essential in these areas which is why innovative utilities are looking to technology.

Other areas needing immediate improvement may include assets that are critical to operations, have a high failure rate, or are costly to maintain. Prioritizing these areas can provide quick wins, demonstrate the value of CBM, and build momentum for wider implementation across the organization.

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Did you know?

The use of drones can dramatically increase the efficiency of infrastructure inspections. For instance, Pedernales Electric Cooperative experienced a substantial reduction in customer interruptions by leveraging drone technology for predictive maintenance, showcasing the potential for drones to significantly improve key performance metrics such as reliability and cost control (UAV Recon).

Develop a roadmap to condition-based maintenance

Creating a roadmap to CBM involves outlining the steps needed to transition from time-based to condition-based strategies. This roadmap should include:

Technology acquisition

Selecting and acquiring the necessary technology and analytics software that aligns with organizational needs.

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Integration with existing systems

Planning how new technologies will integrate with existing maintenance management systems to ensure seamless data flow and analysis.

Infrastructure modifications

Making any necessary changes to the infrastructure to accommodate new technologies, such as installing drone docking stations or enhancing network capabilities for data transmission.

Integrating technology into existing systems

Integrating advanced AI-powered technology and analytics into existing systems should be a phased process and should focus on:

- **Pilot program:** Start with a pilot program in one of the identified priority areas. Use this as a learning opportunity to refine processes and integration strategies.
- **Data collection and analysis:** Establish procedures for drone flights, data collection, and analysis. Ensure data captured is accurately fed into analytics software and interpreted correctly.
- **Feedback loop:** Create a feedback loop where insights from data analysis inform maintenance decisions and schedules.

Training and capacity building for staff

The success of CBM implementation heavily relies on the staff's ability to adapt to new technologies and processes. This requires:

Technical training

Providing comprehensive training on operating drones, using analytics software, and interpreting data.

Change management

Supporting staff through change management programs to help them understand the benefits of CBM and address any resistance to new technologies.

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Continuous learning

Establishing ongoing learning and development programs to keep pace with evolving technologies and practices in CBM.

Did you know?

Drones offer scalable and flexible solutions for utility infrastructure monitoring. They can be deployed quickly in response to emerging issues or for routine inspections, and their use can be scaled up or down based on the specific needs of the utility. This flexibility allows utilities to efficiently allocate resources and adapt to changing conditions or requirements. (The Utility Expo)

Implementing CBM through the integration of advanced drones and data analytics is a transformative process, requiring thoughtful planning, assessment, and training. By systematically evaluating the current state, identifying improvement areas, and developing a detailed roadmap for integration, utilities can effectively transition to a more efficient, data-driven maintenance strategy. The key to success lies in embracing technological advancements, fostering organizational change, and building the capacity of staff to adapt to these new paradigms.

> “Small Unmanned Aerial Systems (sUAS) offer the capability to inspect transmission and distribution lines, substations, facilities, and right-of-ways remotely, providing video and photographic images for electrical and mechanical component maintenance and failure analysis.”
>
> **Pinnacl X**

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Common obstacles in transition to CBM

The transition to condition-based maintenance (CBM) in the utility sector, while advantageous, presents several challenges. Addressing these effectively is crucial for mitigating risks and ensuring the success of the transition. Common obstacles to look out for on the path to CBM:

Resistance to change

Ingrained practices and comfort with the status quo can lead to resistance among staff.

Technical complexity

The integration of advanced technologies like AI-powered drones and data analytics can be daunting without the right support.

Budget constraints

Allocating funds for new technologies and training can be challenging, especially in budget-conscious environments.

Data overload

Managing and interpreting the large volumes of data generated by CBM technologies can be overwhelming and requires a technology platform that integrates with current workflows.

Managing the change to new technologies

The promise of AI-powered drones is immense: real-time data collection, the ability to access and inspect hard-to-reach assets, and the reduction of risk in hazardous environments. However, this new technology also brings concerns – the need for new skills, the integration with existing systems and the fear of the unknown. Be prepared to tackle the following challenges within your organization:

Effective communication

Communicate the benefits of CBM to all stakeholders, emphasizing long-term gains over short-term disruptions.

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Stakeholder engagement

Involve staff at all levels and departments in the planning and implementation process to foster a sense of ownership and acceptance.

Phased implementation

Start with pilot projects or specific areas before a full-scale rollout to demonstrate effectiveness and iron out issues.

The real potential of drones powered by artificial intelligence is being realized over time. The synergy between asset management capabilities and the extensive, precise data collection technology available today propels utilities into a new era of maintenance strategy — one that is proactive, efficient, and driven by real-time conditions rather than a predetermined schedule.

Ensuring data security and compliance

As we harness these sophisticated new tools to gather vast amounts of data and derive actionable insights, the imperative to protect and manage this data responsibly becomes increasingly paramount. Ensuring the integrity and security of this data not only aligns with regulatory standards and protects critical infrastructure from those who might harm it but also forms the bedrock of trust and reliability in these advanced systems. As we navigate this transition, let us delve into the strategies and measures essential for maintaining the highest standards of data security and compliance in the era of digital utility management.

Robust security protocols

Implement stringent cybersecurity measures to protect data collected through drones and IoT devices.

Compliance with regulations

Stay abreast of industry standards and regulations to ensure that data handling and maintenance practices are compliant.

Regular audits and updates

Conduct regular security audits and update protocols as needed to guard against evolving cyber threats.

U.S. trusted sources

Vendors trusted by state and federal agencies offer products with robust security (SOC2-Type2, NDAA) to protect against cyber threats, safeguarding critical infrastructure and sensitive customer data.

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Did you know?

The adoption of drones for infrastructure inspections helps mitigate corporate and governmental risks by improving safety records and compliance with environmental regulations. This, in turn, can lead to reduced insurance costs and better data reporting (Roads and Bridges).

Risk mitigation strategies

Safeguarding utilities involves a multi-faceted approach, with each layer of security and compliance serving as a building block for a robust and resilient risk management framework. Risk mitigation should focus on:

Comprehensive risk assessment

Regularly assess potential risks associated with CBM technologies and data management.

Redundancy and backups

Ensure that critical data is backed up and that there are contingency plans in case of technology failures.

Staff training

Equip staff with the necessary skills to handle new technologies and interpret CBM data effectively.

Proactive planning

The ability to proactively plan for emergencies and unexpected issues is not just a precaution, it's a necessity. Utilities must adapt to be prepared for the unforeseen. From natural disasters to technological failures, utility companies can build resilience and agility into their operations, ensuring they can respond quickly and effectively to any emergency, safeguarding both their infrastructure and the communities they serve by following these guidelines:

Emergency response

Develop and regularly update emergency response plans that incorporate scenarios where CBM technologies play a key role.

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Simulations

Conduct regular drills and simulations to prepare staff for handling emergencies with these new technologies.

Leveraging Data for Predictive Maintenance and Risk Assessment

By effectively utilizing data, utilities can not only anticipate but also strategically address the myriad challenges they face, thereby ensuring greater resilience and efficiency in their operations. To maximize your organization's data usefully, you'll need to evaluate the following workflows within your organization:

Advanced analytics tools

Advanced data analytics tools to interpret data effectively and identify trends and potential failure points.

Continuous monitoring

Implement continuous monitoring of assets to detect early signs of wear or failure.

Feedback loops

Create feedback loops where data insights inform maintenance decisions, and the results of those decisions further refine data analysis algorithms.

Did you know?

Drones contribute to the reliability of essential services by enabling more frequent inspections and providing better data. They play a crucial role in identifying issues like vegetation encroachment, equipment wear, and potential wildfire fuels, thus improving public safety and the reliability of water, energy, and transportation systems (Roads and Bridges).

The shift to condition-based maintenance, although not without its challenges, presents a strong and clear path toward enhanced operational efficiency and reduced risks in the utility sector. By addressing common obstacles, embracing change management, ensuring data security and compliance, and leveraging data for predictive maintenance, utilities can not only mitigate the risks of failure but also set a new standard for maintenance and asset management. This proactive and data-driven approach positions utilities to effectively respond to emergencies and unexpected issues, ensuring sustained reliability and safety of essential services.

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Envisioning the future of utility maintenance

In the long term, CBM and the integration of advanced technologies promise substantial benefits for organizations in the energy and utility space. CBM powered by technologies like AI-powered drones promises benefits to your organization, including:

Enhanced operational efficiency

CBM enables utilities to optimize their maintenance schedules, focusing resources where and when they are needed most. This efficiency transcends into reduced downtime, minimized disruptions, and significant cost savings over time.

> “When Hurricane Irma hit South Florida in 2017, it took 10 days to restore electricity and light, compared to the 18 days it took to recover from Hurricane Wilma. This fact illustrates drones’ role in enhancing the resiliency of power systems during extreme weather events.”
>
> **AnalyticsSteps**

Increased asset lifespan

By identifying and addressing maintenance needs based on the actual condition of assets, CBM extends their usable life. This proactive approach prevents the premature aging of infrastructure, ensuring long-term serviceability.

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Improved safety and reliability

The predictive nature of CBM enhances the safety of both the infrastructure and the workforce. By foreseeing potential failures and mitigating risks proactively, CBM contributes to a more reliable utility network, which is essential for modern society.

Data-driven decision-making

The wealth of data generated and analyzed provides utilities with deep insights into their operations. This data-driven approach facilitates informed decision-making, aligning maintenance strategies with business objectives and customer needs.

Continuous improvement and adaptation

As we embrace the profound insights and efficiencies unlocked by condition-based maintenance, it is crucial to recognize that this is not the final destination, but rather a significant milestone in our ongoing journey. The future of utility maintenance, illuminated by CBM, paves the way for an even more dynamic and responsive approach.

This approach hinges not just on the technologies we adopt today, but on a commitment to continuous improvement and adaptability in the face of an ever-evolving technological landscape. As you step into this future, the importance of refining, enhancing, and adapting your strategies becomes paramount, ensuring your organization stays at the forefront of innovation and efficiency by:

Embracing technological advancements

The future of utility maintenance is inextricably linked with technological innovation. Continuous improvement in CBM strategies will involve adopting new technologies as they emerge, such as more advanced drone capabilities, sophisticated data analytics, and IoT integrations.

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Did you know?

The advent of connected drones, especially with 5G technology, enables autonomous Beyond Visual Line of Sight (BVLOS) inspections, significantly speeding up the inspection of vast infrastructures like bridges, dams, and pipelines, and ensuring timely maintenance and risk management (Roads and Bridges).

Cultivating a culture of adaptation

As the utility sector evolves, so must the mindset of those within it. Fostering a culture that values adaptation and continuous learning will be key to staying ahead in a rapidly changing environment.

Regularly revisiting and revising strategies

The dynamic nature of technology and the evolving demands of the energy sector necessitate a regular reassessment of maintenance strategies. Utilities must remain agile, adapting their approaches in line with discoveries, regulatory changes, and shifting market dynamics.

Collaborative innovation

The path forward will also be shaped by collaborative efforts across the industry. Sharing best practices, lessons learned, and innovative solutions will propel the entire sector towards greater efficiency and resilience.

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Conclusion

As we look to the future, CBM will play a critical role in shaping the landscape of utilities maintenance. Dr. Linda Wright, an energy analyst, remarks, “This proactive and data-driven approach positions utilities to effectively respond to emergencies and unexpected issues, ensuring sustained reliability and safety of essential services.” This era of unprecedented change signals a new dawn for the utility sector, illuminated by the insights and efficiencies of condition-based maintenance.

The advent of advanced AI-powered drones tailored for infrastructure inspection and monitoring promises to revolutionize utility maintenance strategies, allowing for more frequent and precise data collection, minimal human intervention, and a profound shift toward predictive analytics. Ultimately, the integration of docked drones and remote technologies will enhance operational efficiency, reduce costs, and elevate the safety standards within the utility sector.

About Skydio

Skydio works with some of the largest energy and utility companies on the path to condition-based maintenance, sharing deep industry expertise along with providing a solution that includes AI-powered drone technology, integrations to existing maintenance infrastructure, and an array of services to support a successful journey.

Learn more at Skydio.com.

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