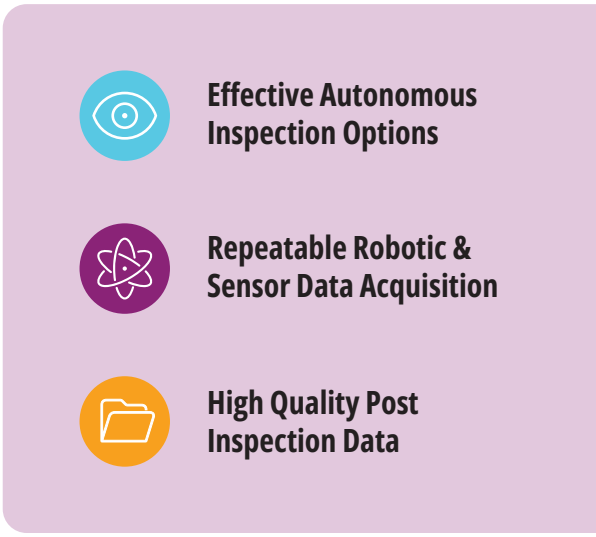
Autonomous Asset Inspections

A UNITI Specific Brief

ABSTRACT

Thread provides effective autonomous inspection options to utility, oil and gas, and renewable resource industries that require scheduled and on-demand asset assessments. Thread's flagship product, UNITI (Unified Inspection Technology Interface), enables rigorous and repeatable robotic and sensor data acquisition without the use of external contractors. Inspection quality increases with consistent and context aware imaging for timely defect identification. High quality, post inspection data that is asset-indexed enables defect alerting and long-term time-based analyses, such as measuring flaw or damage growth rates and implementing severity rating systems. Such analyses trigger effective asset management with enterprise-ready reporting, actionable insights, and integrated information that will enable a faster return-to-service. In-house and on-demand inspection-based data workflows raise the level of inspection standards because control of what is inspected and when it is necessary is now in complete control of the asset owner. This results in the ability to make decisions with unprecedented statistical precision for timely prevention of asset degradation and loss.



ENTERPRISE-SCALE ASSET INSPECTION yet to be realized

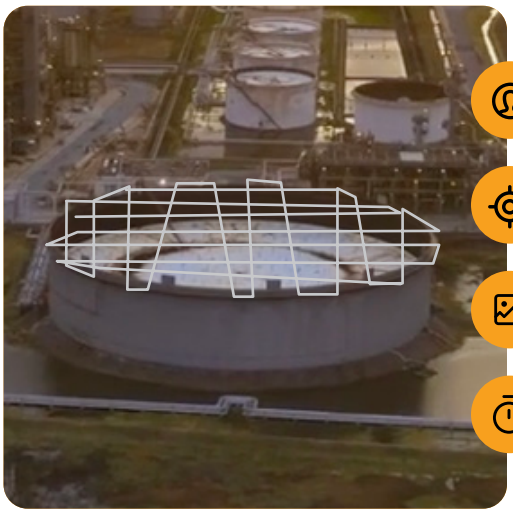
Utility and renewable resource industries struggle with proper asset inspections presently because of inconsistent monitoring and laborious methods of data interpretation and management. Timely and accurate asset condition assessments are essential for continuous functionality and minimized downtime. However, the significant cost and accuracy of inspection options available to customers currently result in meeting minimal regulatory or internal requirements, instead of an effective tool to enhance asset return on investment.

Methods that require in-person observations are inaccurate, time consuming, expensive, and are often dangerous. As a result, robotic data collection systems have become the norm in providing timely information to prevent losses, but available monitoring devices can have significant drawbacks. Ready-to-fly consumer drones were first launched in 2010 and were originally used sparingly in industry for various unplanned inspections, such as flare stack inspections. From these situations, the value of drone operations became apparent and consequently the use of drones increased, but in a limited manner due to functional inadequacies.

The operational platforms for drone use are constrained by the requirement for a high degree of operator skill. This requirement limits the practical use of drones to higher value inspection activities that can be scheduled in advance with an outside service provider. At present, many oil and gas companies working to implement an internal inspection program attempt to use consumer software to manage the skill barrier, but this solution generates a large amount of raw data that can be too burdensome and costly to review, which reduces the capture platform efficiency. In addition, the result may not provide the necessary consistency for objective comparisons over time. Software tools of today for automated robotic data collection were built to rely on waypoints for mapping and modeling missions. This method forces users to struggle with employing these limited and cumbersome tools in workflows that need to be scalable across regional, national and international enterprise operations. Implementation in this manner is simply not possible because the data generated is scattered and typically one-time-use (throw away) and lacks leverage across organizations and common approaches to asset modalities. As a result, enterprise level use of drones and other robotic systems to provide valuable inspection-based insights, both regularly and on an as-needed basis, is not a viable option.

TOO MANY TANKS
an inspection attempt

External floating roof tanks at a major resource oil and gas operator required weekly inspections to monitor condition and inspect for issues that could lead to a release of product. The operator used a commercial data capture tool to execute an automated flight with comprehensive coverage which ultimately ended with an irregular surface pattern that was then used to generate a mesh model. To produce a model of sufficient quality for the review of observations for each tank involved a 60-minute flight time that generated approximately 3000 images. Even though the data was more detailed, the project failed because manual review was unwieldy and led to an inefficient and expensive analytical workflow that could not be scaled to cover the existing assets of more than 50 tanks.



Reliability engineers require accurate and consistent imagery collected over time to either provide a basis for a design modification program or to establish an asset service or life cycle schedule. Effective original equipment manufacturer production ideas and operator maintenance schedules that increase asset lifespan — maximizing the return on investment — are only as good as the information available on asset performance. This essential information is grossly inadequate at this time but recent technological advances by Thread in automated asset inspections have solved the problem and made the solution available industry wide.

UNITI DELIVERS THE AUTOMATED SOLUTION

Thread is leading the movement toward automated robotic data collection for delivery of accurate asset inspection insights by releasing UNITI as the world's first digital asset catalog — the missing connection within the data-capture-to-analytics workflow in enterprise scale operations. The unique and compelling attributes of UNITI include, 1) an autonomous mission control, 2) consistent and historically valid results, and 3) immediately actionable analytics.

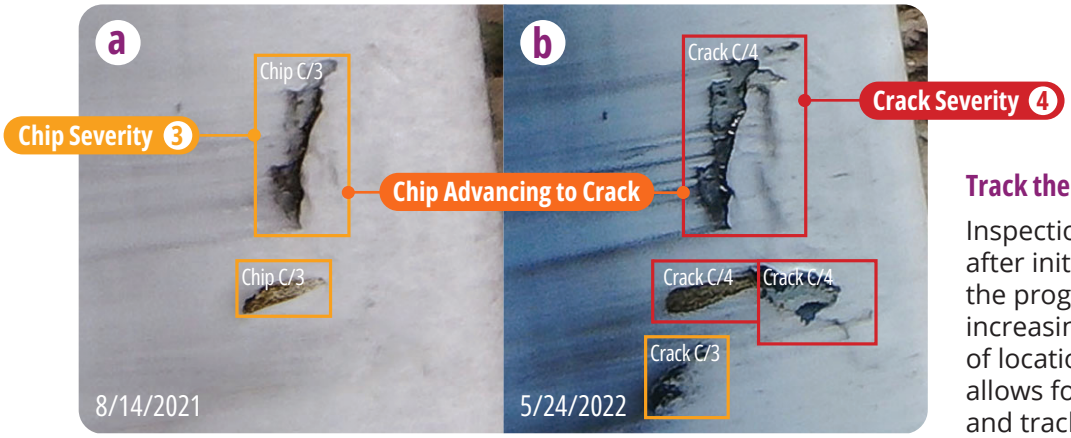
1 Autonomous Inspection Mission Control

UNITI is an enterprise-scale autonomous drone inspection system that takes a significant step away from the use of manual operations that require highly skilled operators. Drone service providers (DSP) struggle with asset inspections that require a timely response to perceived threats to infrastructure from product or asset flaws and damage. Efficient assessments require a level of drone operator precision that is currently unavailable with DSPs because of the inherent limitations on operator skill and is independent of flight pilot skill — manual operators simply cannot match the image alignment and quality generated by UNITI. In most cases within the product or asset inspection industry, use of a robotic monitoring system is too difficult for customers to perform, which is a loss of infrastructure control. Thread provides you with the opportunity for first-hand knowledge of asset condition by enabling in-house and on-demand autonomous inspections — independent of flight experience level — for your own push button robotic monitoring system.

Off-the-Shelf hardware added to robot to configure autonomous inspection. User presses launch from controller.

2 Accurate, Repeatable, And Historically Valid Inspection Results

UNITI is an industry-independent robotics software platform that provides accurate, location-specific imagery that can be used in comparisons and long-term monitoring to identify asset flaws and damage. Data collection from independent service providers is inconsistent by nature due to a lack of properly tracked and synthesized imagery leadings to complications in identifying progressive problems that can lead to asset failure. UNITI employs the scientific method as the basis of operations by providing the consistent empirical evidence that is required to minimize or eliminate cognitive inferences or human bias that may compromise data analyses. The current system precision for successive 3-square-meter images is a positional placement within ±1 degree and an edge overlap of less than 25 cm, which is less than 1% of the area covered in each image. Replicated imagery from proper robot (drone) placement minimizes existing sources of error in burdensome spatial and temporal comparisons, effectively establishing a dependable, location-specific history of product or asset condition with no inadvertent bias.



Track the Crack

Inspection data captured 9 months after initial inspection (a) shows the progression of asset damage increasing in severity (b). The accuracy of location-specific image capture allows for the objective comparison and tracking of increasing damage.

3 Actionable Data Analytics

UNITI is the hardware independent link between data capture and data analytics that circumvents this limitation by utilizing the existing integrated computer resource of your robotic system in concert with cloud-based data management. It is the integration of workflow defined metadata with asset image capture that establishes a framework for consistent, location-specific comparisons and enables the application of machine learning from the data synthesis. The solution to the data glut in any automated robotic inspection program is to capture data that is ready for analytical tool consumption by creating contextualized information about the object during inspection. Images must be optimized by minimizing overlap, eliminating duplicates, and ensuring consistency between automated flight sessions — identical images are nearly impossible for even the best drone operators. This discrepancy is resolved by incorporating analytical capture data requirements with the automated flight templates for replication and reduced operator training requirements. Hence, the contextualized product or asset data can be stored in a single location and is accessible via the application programming interface as a data package that is ready for integration with inspection insights that are immediately available for analyst review.

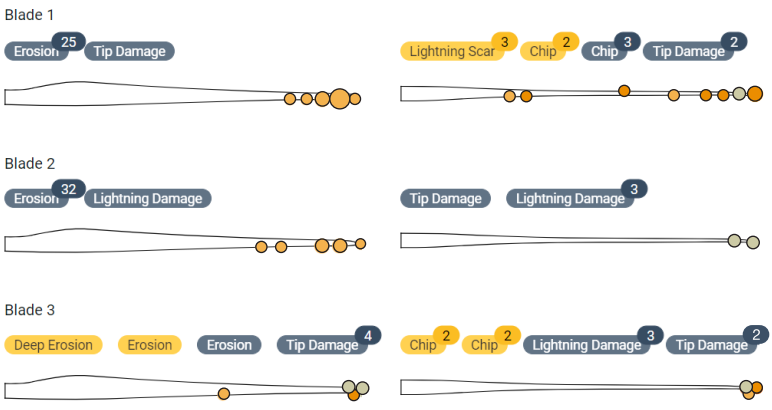
Inspection Details:

Inspection Date:	8/1/2022
Time of Inspection:	6:53:07 AM PDT

Asset Details

Model:	V120
Hub Height:	80
Latitude:	
Longitude:	
Altitude:	Unknown

Description	Severity	Intervention Description	Recommended Action
Very Serious	5	Immediate intervention required to prevent further damage.	Shutdown turbine; Immediate repair
Serious	4	Blade must be repaired in the next 3 months or during next inspection, whichever occurs first.	Repair within 3 months; Monitor monthly
Not Serious	3	Intervention is done during planned inspection of the turbine.	Repair within 6 months; Monitor every 3 months
Major Cosmetic	2	Intervention is only done if there are other damages on the blade.	No action; Monitor at next inspection
Cosmetic	1	No intervention required.	No action



Burdensome Data Be Gone

Inspection insights are recommended as actions according to the manufacturer.

WIND Case Study with Xcel Energy

UNITI has current applications in wind product management that exemplify the utility, efficiency, and cost efficacy as an end-to-end automated workflow package. Turbine blade assessments require intersessional image comparisons and yet each inspection is simply not comparable due to inconsistent image location, distance, size and resolution. This leads to cumbersome and subjective comparisons of disparate data and missed opportunities to capture problems before failure. UNITI provides analyst ready data packages that contain directly comparable imagery through time and space for current and long-term asset monitoring. As an example, this approach not only produces consistent data, but tremendous gains in productivity are realized. In a single day at a Nova Scotia based wind farm a newly trained customer drone operator was able to complete 20 full wind turbine inspections with a single drone which produced automated organization, defect identification, and wind turbine asset health analysis for operational review. Wind turbines are a rapidly advancing energy solution that requires near-constant operation with minimal downtime for inspections and maintenance.

No SD Card **Push-Button Simple**

ADVANCED DATA ACQUISITION AND Management As a Unified Solution

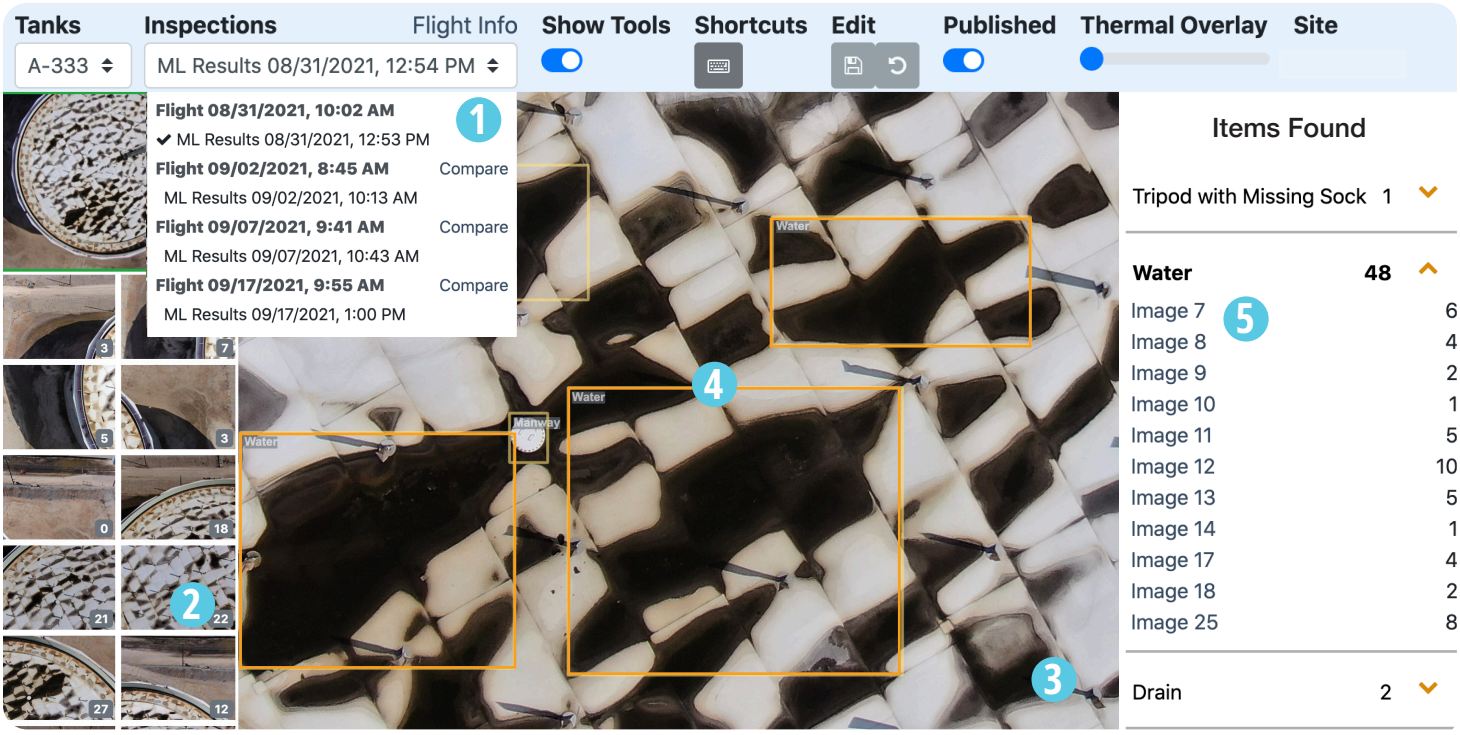
Thread provides an essential element that is missing in the asset monitoring industry by using state-of-the-art image location tracking and edge computing to minimize or alleviate follow up inspections due to a lack of information or inconsistent data collection. Organization and contextualization of successive asset images in time and space for proper inspection and analysis requires a level of consistency that is unavailable using conventional methods. Use of edge computing for real time situational awareness and accurate positioning is integral to the Thread survey system and enables precise repositioning of your monitoring robotics between inspection sessions, that allows for immediate image comparisons in adaptive machine learning and vision (*see 'Track the Crack'; page 3*). Hence, asset or product defects and other forms of degradation are detected and modeled effectively using the accurate monitoring imagery to pinpoint weaknesses or flaws prior to failure.

Insights from the architecture of UNITI — from the asset mission plan to data capture and processing to defect tagging and report generation — are generated from edge computing and an autonomous cloud-based process for timely consideration of information and a strong basis for effective asset management. Hence, use of the *in situ* robotic observations and measurements in edge computing provides analyst-ready-information with confidence for statistical evaluations, modeling in real-time, and direct application of machine learning tools.

While asset monitoring services that are offered to industry owner-operators may overpromise and under deliver due to logistical limitations, Thread puts their customers in the position of understanding their asset wear-and-tear from an in-house system before it becomes a problem. Operational issues, such as heat-related malfunction (thermal imaging), weather dependent problems (water damage or lightning strikes), or placement of protective measures (loss of insulating covers) are additional factors that can be integrated considerations for your autonomous asset inspections using UNITI. Thread is unlike other robotics software solution providers because it is not industry specific.

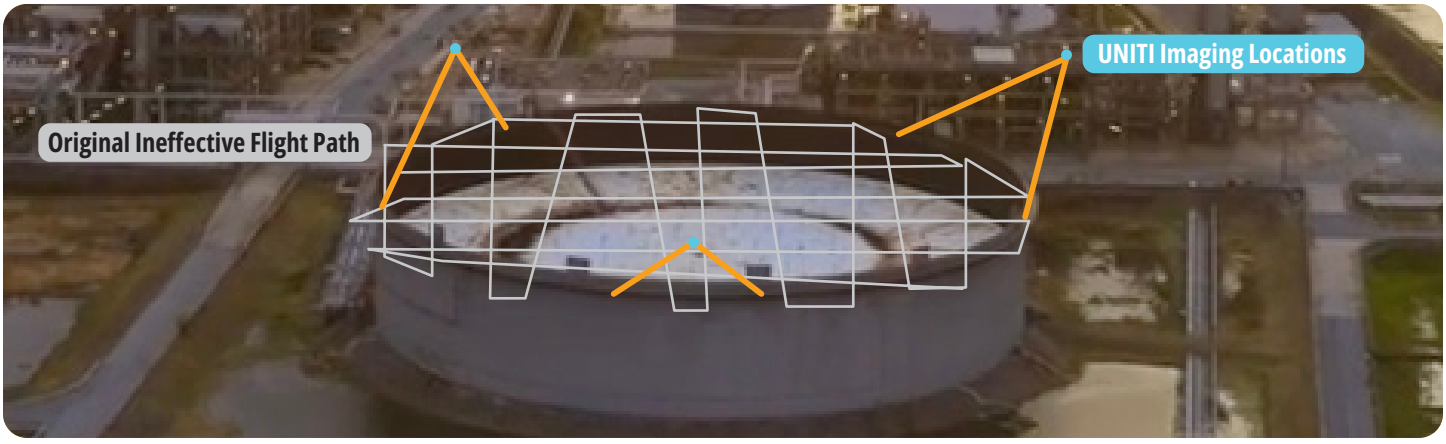
Tangible tank assessments – UNITI solved the proper monitoring problem for external floating roof tanks by allowing the development of an enterprise-scale tank inspection operation. Project alignments were performed remotely using simulation routines in under 3 months. The resultant template allowed deployment of an inspection operation on any of the operator tanks in under 10 minutes. Each flight duration was short (~5 minutes) and generated just 35 images per tank — by comparison with the original failed operation this was a drastic 99% reduction in the number of images generated (~3000). The insights

generated by UNITI were also uniquely available the same day through cloud-based analytics in the form of a analyst-ready report. Ultimately, UNITI created a basis for unlimited inspections with no additional cost as a fly-on-demand system that was established as an in-house, push-button operation.



Ready for Review

Insights generated by UNITI displaying the issues found on the infrastructure. **1.** Compare imagery from prior inspections to track damage progression or longevity of maintenance repair. **2.** Number of objects identified per frame. **3.** Ability to zoom in/out and manipulate image exposure of each frame. **4.** Issue found and classified by ML. **5.** Efficient navigation review with linked images associated with similar classifications.



Better Inspections, Better Data Management

Thread: 5-minute flight time generating ~35 images per tank.

Other companies: 60-minute flight time generating ~3,000 images per tank.

UNITI data is context aware — directly associated with the real-world asset at the moment of capture — in a software system that creates and relies on a rules-based mission. The selected asset workflow depends on robotic hardware sensors to detect the asset and use the information to generate mission-specific details for fully automated assessments. UNITI integrates asset-based templates that enable scaling of robotic monitoring systems to an enterprise level. Use of a hardware-in-the-loop simulation shortens development time, increases efficacy and confidence, and reduces cost by eliminating the need for observation-based positioning and reassessments of the robotic system between multiple resource structures. UNITI is a fully automated asset assessment pipeline from inspection to insight at the press of a button.

Thread provides the best approach for asset inspection and monitoring — independent of your position as an OEM, owner-operator, or inspection service provider — by providing you with the opportunity to place your robotics program into a sustainable in-house operation that is scalable to the size and shape of your industry assessment needs.

SUMMING IT UP
Actionable Insights

UNITI addresses the fundamental need for data that is reliable and actionable. Significant deficiencies exist in current asset inspection programs that range from inspection inefficiency due to skill level requirements for robotic mission operations to the generation of results that are analyst-review-ready for precise intersessional inspection comparisons. Thread provides the image accuracy and consistency necessary for machine vision and learning to effectively identify asset defects that are flagged for human review without cognitive bias. UNITI customers thus far have repeatedly highlighted how UNITI overcomes the deficits of the previous approach by yielding exceptional data that enables execution of additional missions that are timely and when suspected problems arise — immediate context qualified and systematically quantifiable imagery of a specific defect area is attainable with high precision and accuracy. UNITI thus enables rigorous and repeatable robotic and sensor data acquisition with little to no operator experience, while generating usable data that is consumed in the first asset inspection data catalog of its kind. Such analyses trigger effective asset management with enterprise-ready reporting, actionable insights, and integrated information that will enable a faster return-to-service. In-house and on-demand inspection-based data workflows raise the level of inspection standards because control of what is inspected and when it is necessary is now in complete control of the asset owner. This process results in the ability to make decisions with unprecedented statistical precision for timely prevention of asset degradation and loss. Thread has achieved a significant leap forward in transforming the ability of utility, oil and gas, and renewable resource industries to increase inspection frequency and quality with the integrated data required to effectively manage asset life cycles.