



LOCKHEED MARTIN ARIES™

AUTOMATED RAPID INFRASTRUCTURE EVALUATION SYSTEM



Conventional Damage Assessment



Slow Response Time
Impassable Roads

Lockheed Martin ARIES™ Damage Assessment



Fast Accurate Evaluation Post Event,
No Dependency on Passable Roads



Right Crew Size
Right Materials

STORM RECOVERY–DAMAGE ASSESSMENT

The current process of assessing storm damage to utility infrastructure involves visual inspection: ground-based crews driving along circuits at speeds of 5–10 mph in hazardous conditions, manually entering damage findings into handheld computing devices. Not only is this process tedious and time-consuming, but resulting information is often subjective, incomplete, and sometimes inaccurate.



A NEW APPROACH: LOCKHEED MARTIN ARIES™

Solving these issues is Lockheed Martin Automated Rapid Infrastructure Evaluation System (Lockheed Martin ARIES™) technology. The system consists of an aerial LiDAR data collection process, the output from which is fed into data analytics algorithms to produce fast and accurate post-storm assessment results of electric utility infrastructure. In addition to damage assessment, the system's analytics also detect floodwaters using aerial LiDAR data and identify impacted utility infrastructure.

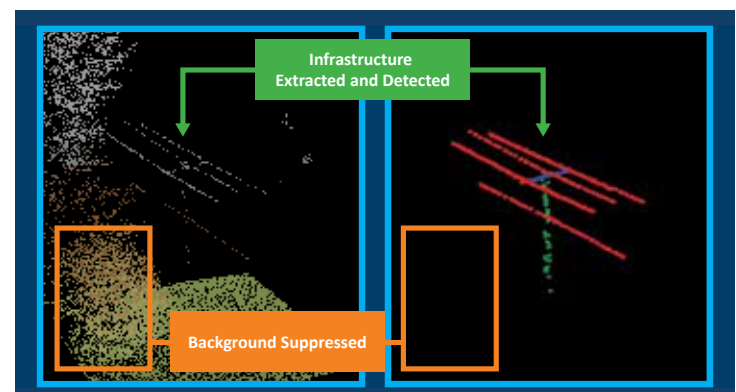
- **Fast:** Data can be collected and processed over an area up to 500 square miles within 24 hours.
- **Accessible:** Compatible with a large portfolio of standard commercial LiDAR sensors.
- **On-Demand:** Does not require a LiDAR data baseline to be captured in advance.
- **Comprehensive:** Automatically assesses damage to electric distribution and transmission systems. Identifies locations of water and associated impacted infrastructure.
- **Integrated:** Generates assessment reports aligned with the utility's GIS data.

HOW IT WORKS

LiDAR data collected from an airborne platform is processed through Lockheed Martin ARIES™ data analytics algorithms, which detect and assess electric distribution and transmission assets along a circuit using only asset location and connection information from the utility's GIS data as initial guidance. The automated output quickly provides the locations and details of damage and floodwaters, enabling a more focused response, proper crew resourcing, and accurate materials procurement.



An aerial LiDAR collection helicopter flies over damaged infrastructure, producing a three-dimensional "point cloud" representation that is automatically processed through the system's data analytics algorithms to determine an assessment.



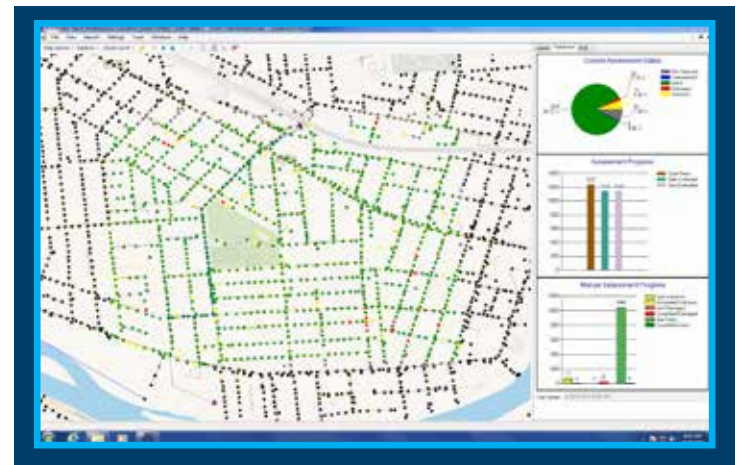
Using the raw LiDAR point cloud, Lockheed Martin ARIES™ algorithms automatically extract, classify, and assess assets of interest, leveraging the utility's GIS data of pole locations as initial guidance.

THE FUTURE OF DAMAGE ASSESSMENT

Preceding a major storm event, initial preparations are made to ready the system and notify flight crews of potential deployment depending on the anticipated storm track and intensity. Following the storm, the damage assessment coordinator identifies the data collection area on a digital map display. The selected area is matched against the utility's available GIS data. The system then generates a list of flight waypoints based on locations of selected assets, which can be provided to the flight crew.

To cover large areas in a short time, the system supports concurrent use of multiple helicopters for data collection. When the helicopter lands, the storage media used to collect data during the flight is removed and readied for analysis. The helicopter crew can then refuel the helicopter, upload and review the next set of flight waypoints, install fresh storage media, and continue flights to survey routes until all required data is collected.

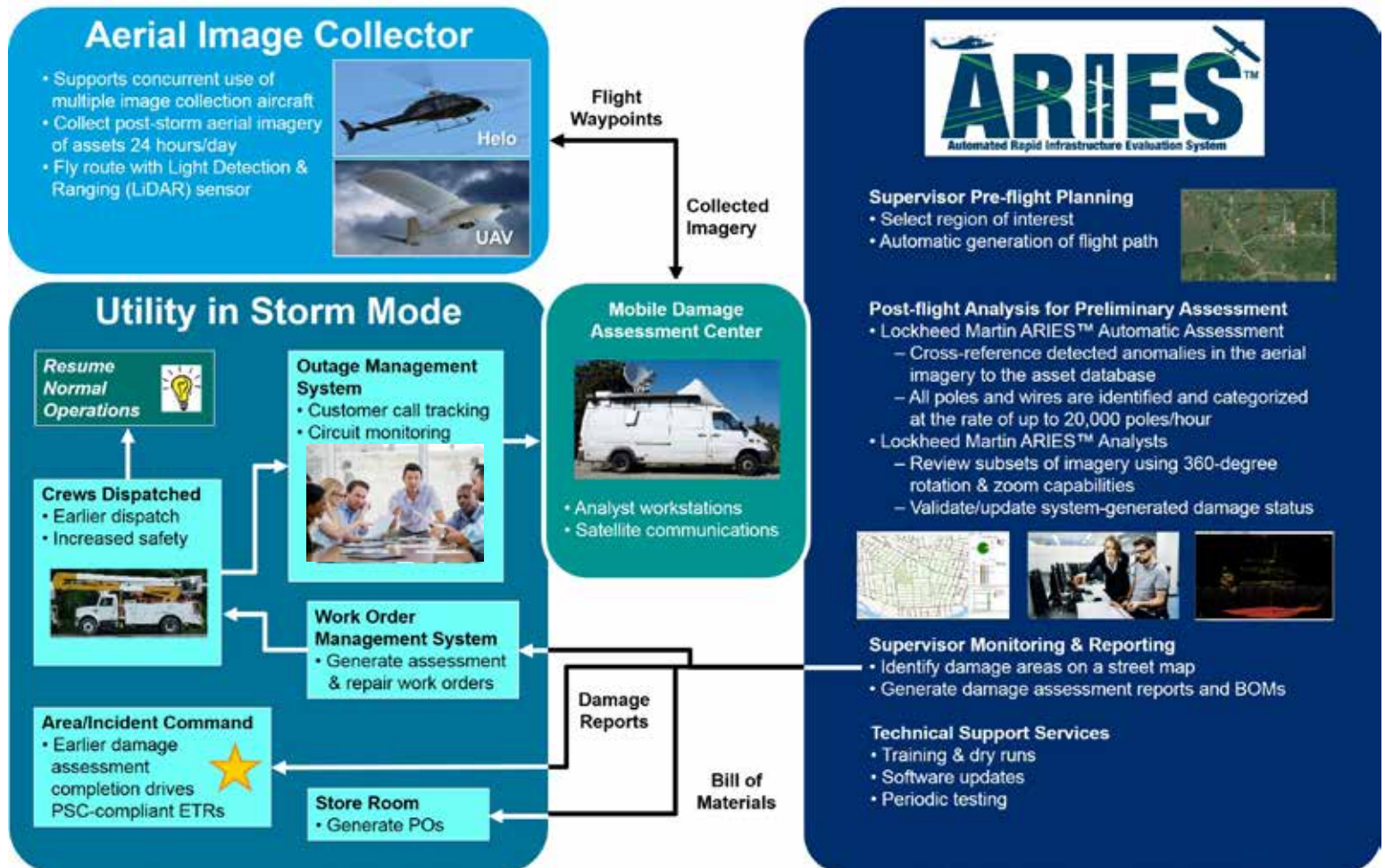
When data is moved from the storage media into the system, it tracks which utility assets were flown and automatically assesses those assets. Real-time status is displayed hierarchically on a heat map, showing relative damage severity across a geographic area using various color codes for assessed assets. In addition, assessment reports referenced to the utility's GIS data can be generated and exported so that damage can be quantified with ease, allowing rapid procurement and deployment of resources and materials.



Assessment results are organized into a decision support tool with graphical user interface that highlights the hardest-hit areas, enabling a utility to assess damage quickly and accurately, distribute appropriate resources, and resume normal operations as quickly as possible.



When the post-storm LiDAR gathering helicopter comes back for refueling, the collected data is fed into Lockheed Martin ARIES™ to immediately begin rapid, automatic damage assessment.



LOCKHEED MARTIN ARIES™ FEATURES AND BENEFITS

| Lockheed Martin ARIES™ Feature | Benefit |
|--|---|
| Rapid Damage Assessment | <ul style="list-style-type: none"> • Faster, less expensive post-storm electric grid restoration now and in the future due to population expansion <ul style="list-style-type: none"> – Helps conserve storm reserves and preserves cushion for next storm strike – Prevents reducing earnings to pay off deferred storm costs • Lowers perceived risk and prevents negative reaction from Wall Street, shareholders, index providers, and credit raters (such as Standard & Poor's®, Moody's®, etc.) • Prevents negative customer perception caused by special surcharges on bills to cover storm costs (if applicable) |
| Remote and Centralized Damage Assessment in a Controlled Environment | <ul style="list-style-type: none"> • Increased safety and comfort, reduced transportation and labor costs for assessment crews • Minimizes size of initial assessment team |
| System-generated, optimized flight waypoints based on location of selected assets | <ul style="list-style-type: none"> • Pre-established flight path digitally transferred to pilot onboard aircraft enables image collection to begin immediately and more efficiently • Optimized flight path via analysis of pole locations and sensor characteristics |
| Use of LiDAR remote sensing technology to capture post-storm imagery of assets | <ul style="list-style-type: none"> • Current and accurate state and exact location of assets • Visibility of assets in/around vegetation • Effective in both rural and urban environments • Independent of lighting; enables 24 hour operation |
| Automated Rapid Initial Damage Assessment using Advanced Data and Image Analytics | <ul style="list-style-type: none"> • Faster, more accurate detection and status categorization (intact, damaged, or unknown) of utility poles, wires, and flood waters • Faster ETR issuance in order to meet state regulatory mandates • Comprehensive system coverage including hard-to-reach / inaccessible areas • Reduced transportation and labor costs • Enables data to be collected and processed over an area up to 500 square miles within 24 hours (using a single aircraft) • Earlier identification of downed wires promotes increased public safety • Dedicated wire guards dispatched sooner in a more organized fashion • Expedited repair crew resourcing and deployment • Earlier damage inventory and BOM generation |
| Cross-Referencing of Post-Storm Aerial Images to Expected Configurations from the Utility GIS Database | <ul style="list-style-type: none"> • Eliminates need for pre-storm baseline flight/imagery of service area • Rapidly compares expected conditions to detected damage • Enables generation of customized, on-demand reports <ul style="list-style-type: none"> – Reports can be used to correct location accuracy of the GIS database |
| Configurable thresholds for automated damage detection | <ul style="list-style-type: none"> • Alignment of damage assessment criteria to accommodate specific utility decision points |

LOCKHEED MARTIN ARIES™ FEATURES AND BENEFITS CONTINUED

| Lockheed Martin ARIES™ Feature | Benefit |
|---|--|
| Role-based damage assessment views (supervisor and analyst views) | <ul style="list-style-type: none"> • Simultaneous supervisory planning and monitoring and analyst confirmation and assessment of assets • Data access and functional control associated with role |
| Customized display of utility service area, assets, and assessment results overlaid on digital map using various color codes | <ul style="list-style-type: none"> • Asset information view tailored to specific customer needs • Easier and faster definition of area to be assessed • Enhanced, immediate visualization of damage clusters provided to all appropriate levels of the organization • Eliminates sole dependence on paper maps for assessment planning and reporting • Reduces time and effort to manually highlight and markup paper maps and convert markups to digital input for multiple systems |
| Automated rapid queueing of images in the area of interest pushed to analysts for assessment of unknown assets | <ul style="list-style-type: none"> • Eliminates need for human assessment of all assets (such as system-identified intact poles), reducing assessment timeline and effort • Provides additional damage assessment definition & accuracy |
| Streamlined workflow management with pre-established drop-down assessment categories and required completion criteria | <ul style="list-style-type: none"> • Consistent, predictable, objective, complete, & accurate assessment method & results provided almost immediately |
| Simultaneous display of 3D LiDAR imagery with 360° rotation and zoom capabilities alongside real-world, color aerial photograph | <ul style="list-style-type: none"> • Multi-sensory information for faster decision making • Closer inspection of damage in more finite detail from multiple different angles • Provides additional context of directly associated damage |
| Multiple analysts simultaneously confirming & assessing assets | <ul style="list-style-type: none"> • Increased assessment speed • Eliminates extraneous documentation • Standardizes assessment results for statistical reporting |
| On-Demand report generation & distribution | <ul style="list-style-type: none"> • Provides ability to make critical resource decisions earlier in a storm event |
| Standardized reports with varying levels of detail | <ul style="list-style-type: none"> • Streamlined reporting to various target audiences (i.e. executives vs. field operations) • Enables supervisor to perform real-time trend analysis at a glance • Repair efforts can be quantified and prioritized efficiently • Provides greater visibility to and real-time communication with: <ul style="list-style-type: none"> – Area Command for regulatory reporting & press releases – Work Order Management Systems (with integration) – Procurement Management for PO generation |
| Floodwater detection mode | <ul style="list-style-type: none"> • Automatic identification of flooded areas facilitates: <ul style="list-style-type: none"> – Focused shutdown of gas and/or electric infrastructure – Prioritization of vulnerable low-pressure gas system components – Capture of affected customers (type & count) – Identification of blocked/flooded vs accessible roads • Supports subsequent flights to monitor changing conditions for re-energizing gas systems |

LOCKHEED MARTIN ARIES™ PRODUCT ENHANCEMENTS

Flood Prediction

- High-resolution prediction of flood impacts to electric and gas infrastructure based on elevation data augmented with LiDAR data, storm predictions, and forecasted river levels
- Use Lockheed Martin ARIES™ to preemptively determine which gas services to shut off and when in order to avoid damage and safety issues
- User can:
 - Generate multiple flood scenarios by entering forecasted river gage levels into pre-calibrated models
 - View extent of predicted flooding as a layer on a map
 - View customer locations as a layer on a map
 - Generate a report listing all customers within the predicted flood area
 - Compare results of two scenarios to announce the differences between the two

Vegetation Management

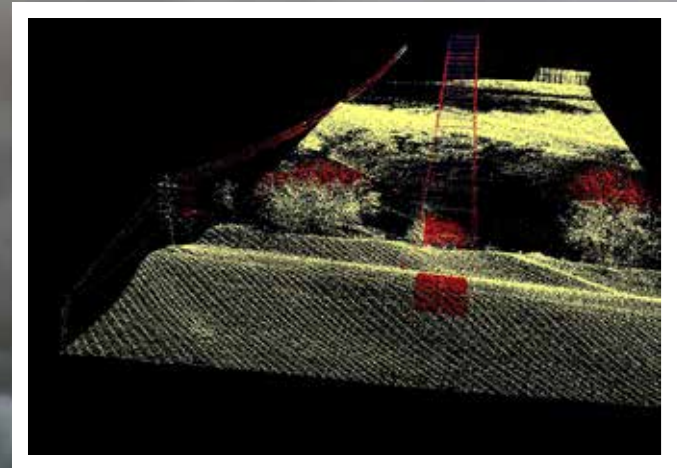
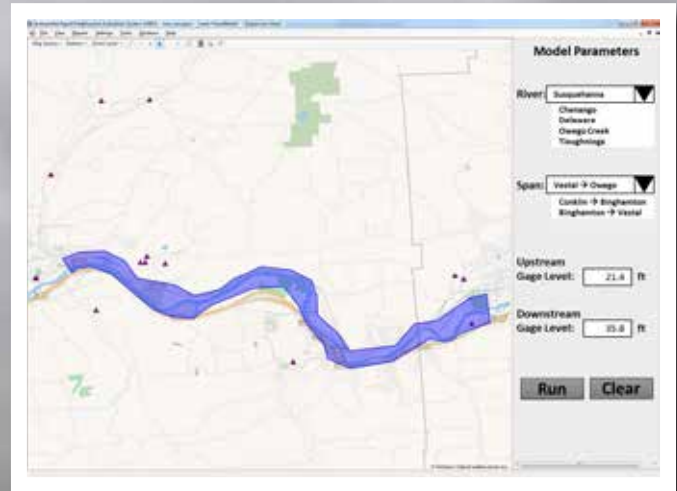
- Automatic detection of encroachment upon transmission, distribution, and gas lines based on pre-established clearance thresholds
- Integrated work order, time, and invoicing management systems

Inventory Auditing

- LiDAR aided automatic classification of pole attachments and entry into utility asset database
- Automatically update/correct pole locations and configurations in the asset database
- Automatically obtain a detailed inventory of pole attachments (including foreign attachments)
- Generate detailed physical circuit layouts
- Line classification (Transmission, primary, secondary, guy wire, phone, cable, etc)
- Line Following / Phasing
- Sensor is primarily LiDAR & EO collection from a ground vehicle
- Aerial collection can be used to cover lines/poles not located on/near roadways

UAV-Based Operations

- Platform agnostic operational concept and data analytics software enables the solution to be easily extensible to UAV-based platforms to meet evolving needs
- Adaptable to other sensor technology



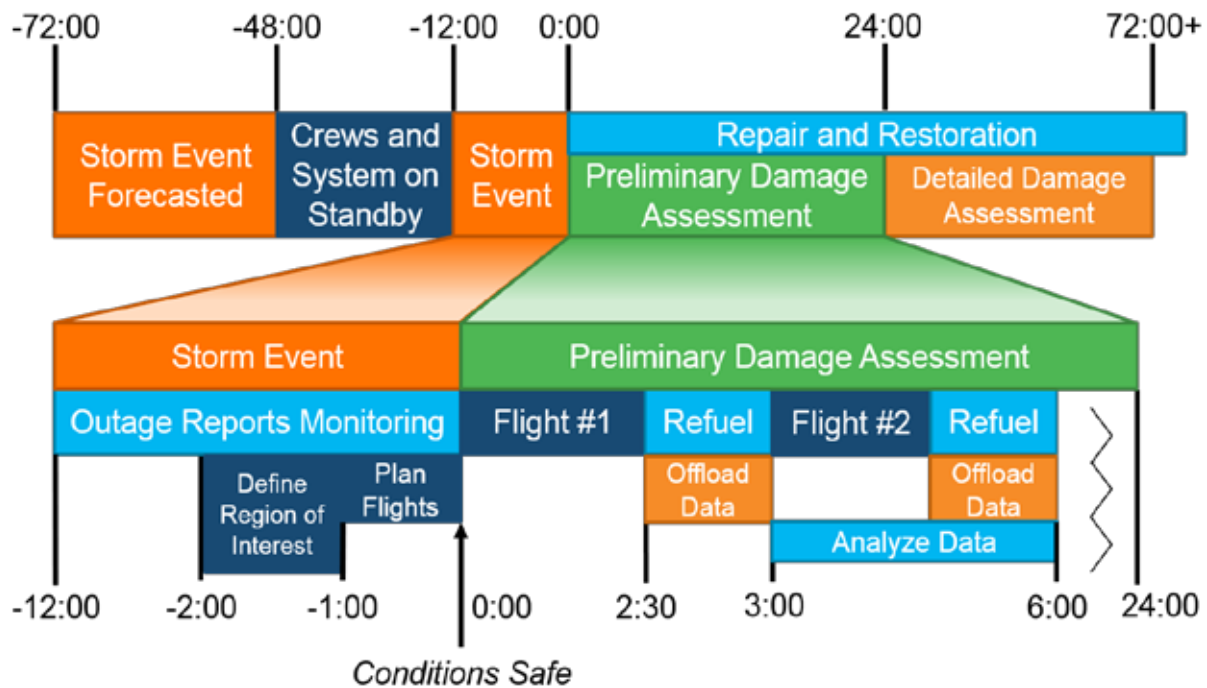
LOCKHEED MARTIN ARIES™ VALUE PROPOSITION

Automated damage assessment reduces preliminary assessment time by 75% and:

- Reduces total storm costs
- Increases revenues due to shorter outage durations
- Can be operated by a small team in a centralized location near the storm area
- Promotes personnel safety by reducing exposure to hazardous conditions
- Enables fast and accurate evaluation post-event
 - Data to be collected and processed over an area up to 500 square miles within 24 hours; timeline can be compressed using multiple helicopters
- Eliminates dependency on passable roads
- Facilitates PSC reporting compliance of ETRs
- Rapidly determines right crew size and materials



Lockheed Martin ARIES™ Team supporting AVANGRID®'s Preliminary Damage Assessment Dry Run at the Greater Binghamton Airport.



Lockheed Martin ARIES™ technology drastically shortens the preliminary damage assessment timeline by performing automated analysis and assessment in parallel with LiDAR data collection flights.

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WE'RE ENGINEERING A BETTER TOMORROW

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