How does the product improve upon competitive products or technologies?

The AHA Framework represents a significant advance over traditional infrastructure risk analysis tools by enabling analysts to understand and manage risk in highly interconnected systems. Conventional hazard analysis platforms typically evaluate threats or infrastructure sectors independently, producing static assessments of individual systems. In contrast, AHA provides a dynamic, system-level view of cascading failures across multiple sectors and supply chains, something no other platform offers at this scale and adaptability.

At the core of this capability is AHA's dynamic dependency modeling framework, which continuously incorporates new information as infrastructure systems evolve. Rather than relying on static datasets or periodic assessments, AHA updates its models as new data sources and infrastructure changes become available, allowing analysts to maintain a current understanding of infrastructure relationships and potential vulnerabilities. AHA also improves on existing tools by integrating multiple critical infrastructure sectors into a single analytical environment. Many risk analysis platforms focus on a specific domain, such as energy or transportation. AHA, however, models dependencies across all sectors. This cross-sector integration allows analysts to identify vulnerabilities and cascading risks that would otherwise remain hidden when systems are analyzed separately. By combining several advanced analytical methods, such as function failure logic, time-dependent discrete-event modeling and reachability analysis, AHA predicts how disruptions propagate and presents recovery scenarios based on actionable insights for decision-makers.

In terms of visualization, AHA's linked map view and dependency graph give users a clear, intuitive understanding of complex dependencies, bridging the gap between technical analysis and operational decision-making. While designed for critical infrastructure resilience, AHA's approach to modeling complex systems has applications in cybersecurity, supply chain optimization, emergency management and even global economic risk analysis. In short, AHA doesn't just improve hazard analysis, it redefines it. It offers a planning tool for proactive resilience, safeguarding society against cascading failures that could otherwise cripple essential services and economies.

Figure 4: AHA's national-scale data provides sufficient detail and robustness to support meaningful local-level analysis.

"The commonsense approach AHA represents, connecting crucial aspects impacting critical infrastructure, filled a gap in nationwide understanding of cascading infrastructure impacts. One consistent theme we have heard from those with whom we have shared this technology is that it addressed a requirement they did not know they could resolve."

— Tristan Allen, Infrastructure & Industry Section Manager, State of Washington Military Department Emergency Management Division

What are the limitations of the product/service?

Like any analytical platform that models complex infrastructure systems, the effectiveness of the AHA Framework depends on the availability and accuracy of supporting data. Because much of the nation's critical infrastructure is privately owned, and sensitive operational information is not always publicly shared, some facility-level details must be validated with input from infrastructure owners, operators or subject matter experts.

AHA addresses this challenge through semiautonomous and autonomous data collection techniques that integrate information from public records, technical documents and other open sources. However, expert review is often required to verify certain operational details and refine dependency relationships for the most accurate analysis.

Localities with limited personnel and resources may also require collaboration with infrastructure partners or technical support to fully leverage AHA's analytical capabilities. In practice, this collaborative approach strengthens the resulting models by incorporating both automated data integration and expert knowledge. Likewise, AHA collects data that might not otherwise be available from utility partners. This saves time and effort by gathering information for analysis much more quickly than traditional, human-based processes.

Development of the AHA platform is ongoing. Current enhancements focus on improving the user interface, expanding visualization capabilities — including maps, dependency graphs and search functions — and further streamlining data integration. These improvements are intended to make the platform more accessible to a broader range of users while increasing the speed and clarity with which analysts can interpret complex infrastructure relationships.

INL Idaho National Laboratory

Provide a matrix demonstrating how key features compare to other products:

Technical Capability	AHA (INL)	Palantir Foundry / Gotham	ESRI ArcGIS (Geo Risk Tools)	FEMA Hazus	DTN / Weather Risk Platforms
Infrastructure Knowledge Model	✓	Partial	✗	✗	✗
Cross-Sector Infrastructure Integration	✓	Partial	Partial	✗ (hazard-specific)	✗
Dependency Profiles (Asset-Level I/O)	✓	✗	✗	✗	✗
Upstream/Downstream Dependency Analysis	✓	Partial	✗	✗	✗
Cascading Failure Modeling	✓	✗	✗	Partial (scenario-based)	✗
Time-Dependent / Discrete Event Simulation	✓	✗	✗	✗	✗
Functional Failure Logic Modeling	✓	✗	✗	✗	✗
Real-Time / Dynamic Model Updating	✓	✓	Partial	✗	✓
Machine Learning Data Integration	✓	✓	Partial	✗	✓
NLP for Unstructured Data Extraction	✓	✓	✗	✗	✗
Multi-Source Data Fusion (Structured + Unstructured)	✓	✓	Partial	✗	Partial
Infrastructure Ontology / Schema	✓	Partial	✗	✗	✗
Continuity of Operations Modeling	✓	✗	✗	✗	✗
Geospatial Mapping	✓	✓	✓	✓	✓
Infrastructure Gazetteer / Entity Resolution	✓	Partial	✗	✗	✗
Graph Analytics / Network Modeling	✓	✓	✗	✗	✗
Linked Graph + Map Visualization	✓	Partial	Partial	✗	✗
Scenario Design & Simulation	✓	Partial	✗	Partial	✗
Resilience Metrics / Impact Assessment	✓	Partial	✗	✗	Partial
Supply Chain Modeling Integration	✓	Partial	✗	✗	Partial
Emergency Response Prioritization	✓	✗	✗	Partial	✗
Data Confidentiality / Federated Analysis	✓	✓	✗	✗	✗

How does the product operate?

Much of America's infrastructure, particularly the electric power grid, is privately owned. Owners and operators of infrastructure are under no legal obligation — and are frequently unwilling — to share information about their assets. As a result, infrastructure systems are often understood only in fragmented pieces. Without a comprehensive view of these interconnected systems, disruptions to energy, water, transportation and supply chains can trigger cascading failures with severe consequences for public safety, economic stability and national security.

The AHA Framework tool developed by Idaho National Laboratory addresses this challenge by enabling analysts to put those pieces together despite incomplete or fragmented information. It delivers significant social and economic benefits by providing a dynamic, data-driven platform that identifies cross-sector dependencies, modeling failure propagation across critical systems. As an independent clearing house, it maintains confidentiality while improving emergency preparedness and response. It supports continuity of essential services — such as power, water and healthcare — ensuring public safety and well-being during crises. It enables informed decision-making for government agencies and emergency managers, fostering coordinated and effective disaster response.

AHA analysts develop reference models for infrastructure assets by consulting engineering manuals and subject matter experts across multiple sectors. These dependency profiles identify the key commodities and services required for operation, as well as those provided by the asset, including electricity, water, communications, and other critical inputs and outputs. AHA is flexible enough to capture new infrastructure types, dependency types and properties, as well as information related to organizational and mission support.

Using these dependency profiles as a guideline, AHA leverages multisource analysis and machine learning to collect, integrate and store information from various facilities and systems and build a model of essential infrastructure in an area of interest. These sources might include a structured database that details substations served by a specific power plant, as well as unstructured information such as newspaper articles or incident reports from a website. With unstructured sources, AHA uses natural language processing in which algorithms are taught to recognize patterns in human language texts and extract information from them. Not only can AHA analyze and translate many different styles of writing, it can also employ optical character recognition to convert different types of documents — PDFs, Word documents, maps — into machine-readable media.

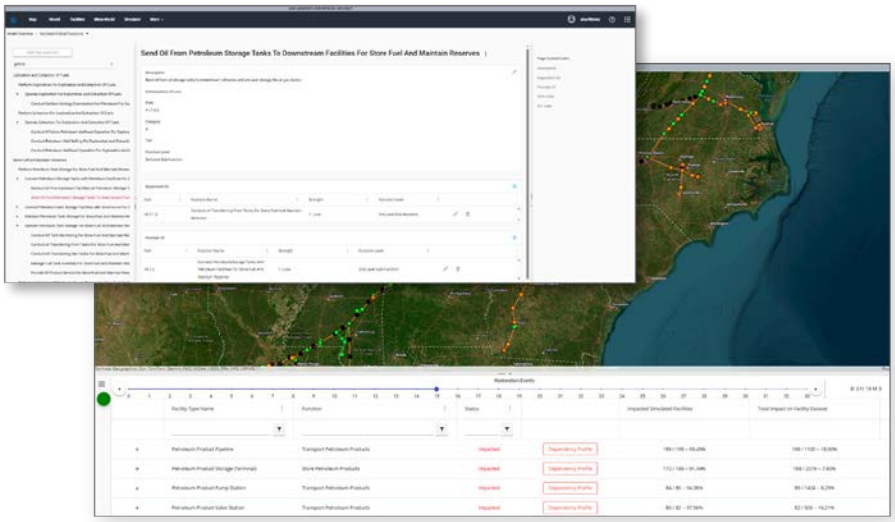

Figure 3: Cascading-effects simulation of the Colonial Pipeline shutdown, with the timeline and impact fractions showing how facility disruptions evolve over time. The foreground links infrastructure assets to National Critical Functions, allowing direct identification of which NCFs are affected.

Once the dependency profiles have been populated with the results of analysis, users can leverage AHA to design realistic incident scenarios. AHA can simulate plausible cascading events, allowing stakeholders to clearly visualize the consequences of a disaster and then develop strategies for lessening its effects. In doing so, AHA helps planners identify vulnerabilities, test mitigation strategies and correct gaps in preparedness planning.

A key innovation of AHA is its ability to transform disparate and incomplete data into an intuitive, actionable representation of complex infrastructure systems. Machine learning and artificial intelligence allow it to collect and document data, documenting changes over time as infrastructure is expanded or upgraded with new technologies. AHA accomplishes that flexibility with modern style databases and dynamic knowledge management techniques.

By revealing hidden dependencies and vulnerabilities before disruptions occur, AHA enables proactive mitigation strategies that reduce economic losses and protect critical supply chains and industrial operations. The framework strengthens national and regional infrastructure resilience by safeguarding essential services and protecting billions of dollars in infrastructure assets and economic activity.

What does this product or technology do?

When the average person thinks of the Super Bowl, they're probably thinking of touchdowns and interceptions, nachos and chicken wings, friends, family and fun. For critical infrastructure security specialists, however, it's a whole different ballgame. While most viewers are evaluating the commercials, they are focused on what it takes to keep the event, fans and city safe.

The AHA Framework is an indispensable tool in making sure that bad actors can't ruin the big game — or your morning commute to work, for that matter. Developed at Idaho National Laboratory, AHA helps emergency response managers anticipate the effects of any disruption to critical infrastructure and provides actionable insight on how to respond. At the heart of the AHA software tool is a framework and methodology that maps the relationships between vital infrastructure assets and the services they depend on, allowing planners to understand how failures in one system can cascade across others. Analyzing all connections, AHA uses advanced geospatial mapping tools to pinpoint physical assets, then charts the dependencies, e.g., where a hospital gets its water from, or which transportation routes are most used in emergency responses.

For Super Bowl events, analysts have used AHA to map the critical infrastructure surrounding the host city. In Santa Clara this year, AHA was used to map critical infrastructure: water treatment plants, emergency communications, electrical substations and public transportation. Every infrastructure network across the country has unique features and idiosyncrasies. In the case of Santa Clara, while 70,000 guests watched Super Bowl LX in Levi's Stadium, the Santa Clara Valley Water District kept the game lit by recycling and cleaning municipal wastewater and pumping it out through pipelines to cool power plants. Imagine if a cyberattack or earthquake shut down the power grid and pumping stations. Without proper planning and preparation, it would be a disaster. AHA is an innovation that helps cities and states prepare for emergencies and, once they occur, cope with them in real time.

Figure 2: Analysts use the AHA tool to holistically examine energy infrastructures for vulnerabilities and potential mitigations before natural or man-made disasters occur

"What distinguishes AHA is not merely its modeling capability, but its operational utility. … It enhances continuity-of-operations planning, improves disaster preparedness modeling, and provides both analysts and senior decision-makers with a common operating picture grounded in reality."

— Joshua J. Dawson, Lieutenant Colonel, U.S. Army; Executive Officer, Army Cyber Institute, USM

Using intuitive queries, AHA helps emergency managers reach into extensive and disparate government and public databases to populate the framework with information about facilities and dependencies. AHA includes a unique feature that can identify and map potential cascading impacts to essential services. Emergency managers can use AHA to map and model the effects of natural and manmade incidents before a disaster strikes, enabling effective mitigation planning.

In the case of the pumping station, AHA's dependency model would help managers determine which essential services to recover, allowing emergency crews to respond more quickly and efficiently. AHA has been developed and tested on water, wastewater, communications and energy (electrical, oil, natural gas and petroleum), and critical manufacturing sectors. At the highest level, AHA methodology has been incorporated into a national-level Department of Homeland Security critical infrastructure portal. Across the U.S., states, counties and municipalities are recognizing its value at tracking infrastructure at all hours.

All Hazards Analysis (AHA)

Product/category
- Software/Services

Primary submitting organization:
Idaho National Laboratory

Product/services brand name:
All Hazards Analysis (AHA)

When product was introduced to the market:
June 2019

Abstract:
The All Hazards Analysis tool employs machine learning and natural language processing to help analysts identify infrastructure interdependencies. By modeling how failures can propagate, it helps utilities and public entities plan for emergencies and mitigate their effects on essential services such as power, water and healthcare during crisis situations.

Executive summary:
American infrastructure is more interconnected than ever. But because many assets are privately owned, forming a detailed picture is difficult. Disruptions to energy, water, transportation and supply chains can lead to cascading failures that threaten public safety, economic stability and national security. The All Hazards Analysis (AHA) tool, developed by Idaho National Laboratory, uses function-failure modeling with cascading impacts to help analysts assemble the disparate pieces of the American infrastructure puzzle into a comprehensive whole. AHA is a dynamic, data-driven platform that identifies sector dependencies and models how failures can propagate. It maintains confidentiality while enhancing emergency preparedness and continuity of essential services like power, water and healthcare during crises.

Figure 1: Electrical transmission systems in and around Colorado are visualized through the AHA map interface, which supports analysis of critical infrastructure facilities and their dependencies.

AHA integrates facility and systems information from various sources, including structured databases and unstructured text such as articles and reports. AHA then develops dependency profiles and models for facilities, allowing emergency managers to simulate incident scenarios and visualize disaster consequences to improve planning. The technology's flexibility enables it to document changes over time, support new infrastructure types, and use modern databases and dynamic knowledge management. Economically, AHA minimizes losses by identifying vulnerabilities, protecting supply chains and strengthening infrastructure resilience to safeguard assets and economic activity.

Additional supporting materials:
AHA Whitepaper

Videos:
AHA 2026

AHA demo

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