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EMERGENCY MANAGEMENT USE CASE

Research Title:	**Use of the Houston Lightning Mapping Array to aid in mitigating lightning strike damage to life and property**
Author(s):	Timothy Logan
Description:	Lightning is not only a reliable predictor of the strength of thunderstorms but also poses a serious risk to life and property. Though it is difficult to predict where a lightning strike can occur, it is possible to track the evolution and behavior of storms through the amount of lightning being produced. In addition, areas that suffer from lightning strikes which cause power loss and structural fires can be identified by careful analysis of storm coverage/extent and lightning location (e.g., edge of storm vs. inner core of storm). The Houston Lightning Mapping Array (HLMA) consists of a network of sensors which detect electrical cloud impulse events which constitute a lightning flash in three dimensions and time of event. The HLMA has a range of 100 km for near 100% detection of lightning and up to 400 km for general lightning detection. Note that this range includes virtually all of the Houston Metropolitan Area, the immediate Texas/Louisiana Gulf Coasts (from Lake Charles to Corpus Christi), and a large portion of the Gulf of Mexico. To the north, coverage exists as far north as Waco and Shreveport. The HLMA reports lightning activity every minute and is publicly available via the internet on many electronic devices.
When Applied:	The use case will be applied in instances of forecasted and ongoing thunderstorm activity that has the potential to cause infrastructure damage within the domain of the HLMA.
Who Applies:	The use case applies to County Fire Marshall, County Office of Emergency Management, Police and Fire Departments, School Districts, Parks and Recreation, Petrochemical Facilities.
Disaster Type:	The use case would be applied to the following disaster types: thunderstorms, hail, tornadoes, severe wind events, hurricanes, and flooding.
Infrastructure Affected:	Affected infrastructure includes residential/manufactured/mobile homes, businesses, schools/parks/campgrounds, high altitude towers/tall free-standing structures, and farms (e.g., pets, livestock, etc).
Industry Affected:	Industries affected include petrochemical, energy, agriculture, telecommunications, transportation, and aviation.
Where Applied:	The use case is applied to geographic locations such as the immediate coast, up to 300 km in the Gulf of Mexico (Texas Gulf Coast), flood and tornado prone areas, and low-income urban/rural communities in

	Southeast Texas ill-equipped to withstand strong storms (e.g., mobile homes and trailer parks).
Agency Affected:	The use case can be targeted to specific local and state authorities which manage emergency and disaster mitigation efforts such as the Harris, Montgomery, Brazos, Kendall, Bell, and McLennan County Fire Marshall offices.
VOAD Affected:	n/a
Who/What Affected:	The impacts for the implementation of the use case would be assisting and notifying first responders and fire/rescue personnel of impending lightning activity.
How Affected:	Lightning activity can damage homes and businesses. This is detrimental especially when storms occur overnight as people are sleeping and may not be aware that their structure was struck. Fires resulting from lightning strikes often take hours before completely engulfing a structure.
Timing of Application:	The use case would be applied prognostically before a storm event, and then the HLMA would provide near real-time lightning activity information to concerned parties and stakeholders.
Critical Points:	The critical points of the use case involve using the HLMA to identify developing storms that may harm vulnerable populations and infrastructure, rapidly notify and guide first responders and emergency agencies, improve communication between the science community and emergency responder community to target and mitigate the damage prone areas, and work with the public in issuing advisories/warnings.
What Benefit:	Benefits of the use case include: lowering the number of casualties/deaths/injuries to unsuspecting populations who are caught in a severe weather event, shortening the response time of emergency personnel to a structure that caught fire as a result of a lightning strike, issuance of impending storm and possible flooding advisories at the neighborhood level. This will help first responders discern the best possible route to avoid compromised roads during extreme thunderstorm and lightning events.
Where Used:	The HLMA has been used on several occasions to identify lightning strike information to assist the Harris, Montgomery, Kendall, Bell, Brazos, and McLennan Fire Marshalls in instances of structural fires (forensic meteorology). Information on the time and location of strike relative to the fire report, as well as peak current (maximum amount of electric current capable of heating building material), temperature of the lightning strike (in BTUs), and the interaction with the structure (melting wires, burning wood, etc.) were also included in the report.

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Additional Research:	Additional research will be needed to develop maps of hotspots of lightning activity collocated with vulnerable communities and infrastructure. A frequency of occurrence of structures being struck by lightning in various communities within the HLMA domain should also be studied. Finally, best practices on improving the communication between lightning scientists and first responders should be investigated.
Additional Information:	Dr. Timothy Logan maintains the HLMA website which outputs real-time data (https://lightning.geos.tamu.edu/hlma) as well as Dr. Logan's Texas A&M University People Page (https://atmo.tamu.edu/people/profiles/faculty/logantim.html) and HLMA information website (https://atmo.tamu.edu/facilities-resources/lightning/index.html). Additional information is available on the National Oceanographic and Atmospheric Administration (NOAA) website (https://www.noaa.gov/jetstream/lightning).
Expert Contact:	Timothy Logan, Texas A&M University (HLMA) Eric Bruning, Texas Tech University (WTLMA)
Original Research:	Original research includes two papers on lightning development and lightning-precipitation relationships during Hurricane Harvey: -Anomalous Lightning Behavior during the 26-27 August 2007 Northern Great Plains Severe Weather Event. J. Geophys. Res. Atmos., 123, https://doi.org/10.1002/2017JD027750 -An analysis of the performance of the Houston Lightning Mapping Array during an intense period of convection during Tropical Storm Harvey, J. Geophys. Res. Atmos., 126, e2020JD033270. https://doi.org/10.1029/2020JD033270. Special Issue: The Three Major Hurricanes of 2017: Harvey, Irma, and Maria
What Risks:	The HLMA sensors are self-contained and are considered "listening" devices which output no electrical noise or interference. The sensors are prone to electrical noise/interference, however. In addition, the range of the sensors is limited because they listen on VHF bands which signal rapidly degrades with distance. For example, the lightning detection efficiency in near 100% within 100 km of downtown Houston. After 400 km, roughly 60-70% of the total lightning is detected. In addition, no ground strike information can be obtained outside of 100 km, but lightning activity can still indicate the possibility of ground strikes. In a case of storm more than 100 km away, ground strike information from the Vaisala National Lightning Detection Network (NLDN) is typically used in conjunction with the HLMA.
Partner Agencies/Jurisdictions:	County Offices of Emergency Management, County Fire Marshalls, Police/Sheriff/Constable, Parks Directors, Forest Rangers, and other first responder agencies.
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Research with a Technology Component Should Respond to the Following Questions

Research Requested:	The Houston Lightning Mapping Array (HLMA) currently consists of a network of 10 active sensors. The HLMA maps a complete lightning flash from initiation to ground or cloud with at least 5 sensors reporting data. Emergency managers outside of the 100 km radius of detection would benefit from the addition of more HLMA sensors to extend the radius of detection for more coverage of ground strikes (e.g., Bell, McLennan, and Brazos County Fire Marshalls).
Why Better:	Lightning mapping arrays (LMAs) have an advantage over other ground-based and space-based lightning networks in that a three-dimensional picture of a lightning flash can be generated and overlaid on a map. In addition, HLMA information can be provided free of charge on the HLMA website while other networks charge a fee or subscription service.
Reliability:	The sensors are reliable under most extreme conditions (severe storms, extreme heat, extreme cold). However, during extended periods of cloud cover, the batteries may not fully charge, and network operability will decline.
Support Needed:	Support such as new sensor boards and connections, hard disk storage, batteries, telecommunication charges, and routine site maintenance and upkeep (pests, light construction/demolition) would be needed to ensure continuous operation.
Citizen Impact:	The sensors are in secluded areas away from human traffic and are enclosed in fenced areas. There are no negative impacts to the public anticipated.
Training Required:	Training would be minimal since the data are processed by the Texas A&M server and Dr. Logan. Anyone can be taught how to output the data on a chart (Excel or Matlab) or map (ArcGIS or Google Earth) with relative ease.
Public Accountability:	The data are stored on secured servers and no public information would be shared. The data are most certainly available to all stakeholders in this Use Case in a readable format.

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Please Note: Questions or suggestions regarding the Use Case Template may be directed to Dr. MacGregor Stephenson at the Texas Division of Emergency Management at macgregor.stephenson@tdem.texas.gov.