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Investigation of Range-Applicable Lightning Detection Systems

Darryl Randerson and Walter W. Schalk

Special Operations and Research Division
Las Vegas, Nevada

Air Resources Laboratory
Silver Spring, Maryland
March 2006

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ABSTRACT

An investigation of current operating lightning activity/potential monitoring systems was conducted. Ten Federal facilities were identified and contacted. Three facilities were visited. Four primary systems were identified across all facilities: Field Mills, Magnetic Direction Finders (MDF), the National Lightning Detection Network (NLDN), and Lightning Detection And Ranging (LDAR) systems. One facility employed all four systems, while two facilities use three of the systems. The primary capability used by these three facilities was the MDF system. These facilities did have field mills; however, the primary purpose was to determine the static electrical field and not to determine lightning activity or potential.

INVESTIGATION OF RANGE-APPLICABLE LIGHTNING DETECTION SYSTEMS

Darryl Randerson and Walter W. Schalk

ARL/SORD
Las Vegas, Nevada

1. Objective

To investigate current operating systems that detect lightning and are used to guard the safety of personnel, to protect property, and to help safeguard sensitive equipment.

2. Methodology

- Identify significant operational facilities that may have a requirement to monitor lightning activity or the potential for lightning strikes.
- Review technical literature and identify lightning detection and tracking systems.
- Contact the identified facilities to obtain information about their activity/potential monitoring systems. Make site visits where appropriate.
- Analyze data collected.
- Prepare draft report and present to Lightning Focus Group.
- Address comments.
- Prepare final report.

3. Findings

Table 1 lists the facilities that were contacted regarding lightning detection and monitoring systems. The facilities contacted ranged across the Federal community. A majority of the locations are DOE/NNSA sites; however, NASA, DOD, and NOAA are represented. Table 2 summarizes the lightning detection capabilities at these facilities. The capabilities fell into four categories; Field Mills, dedicated Magnetic Direction Finders (MDF), the National Lightning Detection Network (NLDN), and Lightning Detection And Ranging (LDAR) systems.

Table 3 lists technical characteristics of the four primary lightning detection systems used by the major Federal facilities contacted. The systems used at the NTS are shaded in blue.

Table 4 lists the number of sensors for each system installed at the facilities contacted.

Table 1: Facility and Contact Type

Facility/Organization	Federal Affiliation	E – mail	Telephone	Site Visit
Cape Canaveral / KSC	NASA	X	X	
PANTEX	DOE / NNSA	X	X	X
LANL / DX	DOE / NNSA	X	X	X
NTS	DOE / NNSA	NA	NA	NA
SRL	DOE / NNSA		X	
INEEL	DOE / NNSA		X	
Richland	DOE		X	
YMPO	BN / SAIC	X	X	
White Sands	DOD		X	
Severe Storms Lab	NOAA		X	
New Mexico Tech	NA			X

Table 2: Lightning Detection Capabilities at Major Facilities

Facility/Organization	Field Mills[1]	Dedicated MDF	NLDN	LDAR / LMA
Cape Canaveral / KSC	X	**X**	X	X
PANTEX	X	**X**	X	
LANL / DX	**X**		X	
NTS	X	**X**	X	
SRL	X		**X**	
INEEL				
Richland			**X**	
YMPO		**X**[2]	X	
White Sands			**X**	X[3]
Severe Storms Lab	NA	X	X	X
New Mexico Tech			X	X

RED denotes primary system used.
(1) Measures electric field strength
(2) Uses access to NTS MDF system
(3) LMA being installed

Of the eleven facilities listed in the tables, three standout as having a substantial total capability. These facilities are Cape Canaveral / KSC, PANTEX Plant, and the Nevada Test Site.

The most extensive lightning detection system is at Cape Canaveral / KSC in Florida. Their total capability uses all four of the systems outlined in this investigation. Each system has a primary purpose in support of KSC missions. The primary system for lightning activity information is the Magnetic Direction Finders (MDF). The KSC uses field mills in support of rocket launch activities to detect the static electricity field near the launch facility. A high static electrical field measurement can postpone a rocket launch. As explained by KSC personnel: The exhaust from a rocket is plasma-like which acts as a conductor and compresses the existing static field. If the existing static field is large enough, the rocket will create a lightning strike upon itself that can have very catastrophic effects.

Table 3: Technical Characteristics of the Primary Lightning Detection Systems (NTS Systems are in blue)

	Field Mills(1)	Dedicated MDF	NLDN	LDAR / LMA
Sensor Spacing	8 – 16 km	40 – 75 km	200 – 400 km	6 – 10 km
Effective Range	10 – 20 km	200 – 300 km	National	100 km
Lightning Detected	All (Flash Strength)	Cloud-to-Ground	Cloud-to-Ground	All
Flash Detection Efficiency	≥90%	95%	80% – 90%	≈100%
Location Accuracy	2 – 20 km	0.5 km	0.5 – 1.0 km	0.1 km
Peak Location Rate	80 – 85 min^{-1}	80 – 90 min^{-1}	800 min^{-1}	10,000 min^{-1}
Source	Commercial	Commercial	Commercial	Research
Operational	Yes	Yes	Yes	No
Customers	Few	Many	National	Limited
Approximate Cost Installed	$5,000 - $10,000 (each)	$350,000 (3 – 5 DFs)	NA	$400,000 - $600,000

NTS Systems are shaded blue.
(1) Measures electric field strength

At the Nevada Test Site (NTS), the MDF capability is also the primary site safety system for detecting and tracking lightning activity. NTS procedures for personnel and operational safety are linked to information received from these lightning sensors and interpreted by National

Oceanic and Atmospheric Administration (NOAA) ARL/SORD staff. The primary function of field mills on the NTS is to detect the static electrical field in the environment surrounding explosive and hazardous materials. In addition, SORD meteorologists have the following assets to assist in the prediction of thunderstorm activity and detect and track lightning:

- NOAA NEXRAD RADAR,
- NOAA weather satellite imagery (GOES West),
- SORD NTS weather network,
- SORD upper-air sounding system (GPS and NOAA microARTS),
- DRA surface weather observations, and
- Local/national atmospheric stability/thunderstorm prediction parameters.

The PANTEX Plant in Amarillo, TX, employs the same capabilities as the NTS. The primary capability for site safety is the MDF system. Plant procedures for personnel and operational safety are linked to information received from these lightning sensors. PANTEX also uses field mills. The primary function of the field mills is to detect the static electrical field in the environment surrounding the movement and disassembly/assembly of hazardous materials.

Table 4: Lightning Detection and Tracking Sensors for Major Facilities

Facility/Organization	Field Mills(1)	Dedicated MDF	NLDN	LDAR / LMA
Cape Canaveral / KSC	31	**5**	105	7
PANTEX	3	**4**	105	
LANL / DX	**6**		105	
NTS	6	**6**	105	
SRL	1		**105**	
INEEL				
Richland			**105**	
YMPO		**6**	105	
White Sands			**105**	1
Severe Storms Lab	NA	1	105	1
Lightning Research Center, AZ				

RED denotes primary system used.
(1) Measures electric field strength

Four different lightning activity/potential monitoring systems have been identified. After gathering information from the various sites, benefits and shortcomings of each system can be identified. Table 5 displays this analysis.

Table 5: Benefits and Shortcomings of the Four Primary Lightning Detection/Potential Systems

System	Benefits	Shortcomings
MDF and LDAR	- Indicates when the atmosphere is becoming electrically active - Displays electrical activity on maps as occurring - Indicates the movement of electrical activity - Indicates the amount of electrical activity - Indicates the trend of electrical activity - Indicates when the electrical activity is diminishing - Detection capability covers a large area, allowing time to assess local safety issues and provide warnings	- High Cost - Need at least 2 DFs; 3 preferred - Limited range (< 300 km) - Requires professional interpretation
Field Mills	- Low Cost - Easy to Use - Detect all electrical discharges - Detect electrical potential	- Limited Range (not much better than eyes and ears) - Limited display capabilities - Threshold must be identified - False-positive alerts
NLDN	- Low cost - Low maintenance - Easy to Use - Indicates when the atmosphere is becoming electrically active - Displays electrical activity on maps as occurring - Indicates the movement of electrical activity - Indicates the amount of electrical activity - Indicates the trend of electrical activity - Indicates when the electrical activity is diminishing - Detection capability covers a large area, allowing time to assess local safety issues and provide warnings	- Not site specific - Limited accuracy

4. Summary

After investigating the capabilities and systems employed by ten federal operational facilities, four primary capabilities were identified. One facility, Cape Canaveral / KSC, used all four, while two facilities, NTS and PANTEX, used three. The site missions of the NTS and PANTEX have some general similarities, but contrast greatly with the Cape Canaveral / KSC mission. However, the over-arching purpose is for personnel and operational safety. The primary system at all three facilities was the MDF capability. While these three facilities do use field mills, the purpose of the information received from them was neither to determine lightning activity nor potential, but rather to measure the static electric field in explosive and hazardous material areas.

Field mills are used at one facility, LANL, as the primary system. Overall, four facilities use MDFs as the primary system, and three use the NLDN. The LDAR/LMA is a research grade system that is being evaluated and is not available commercially. Based on conversations with system developers, the addition of an LDAR/LMA system to the NTS might increase the lightning detection envelope by 5 to 10 minutes.

Activities completed and final comments:

- Assessed lightning detection and tracking systems at 10 major federal facilities
- Four different systems/networks were identified
- Compared the NTS system with those at other facilities
- Field mills serve as the primary lightning detection system at only one site, LANL
- Number of field mills at NTS is adequate to meet operational needs
- The MDF system is the primary system at 4 sites and the NLDN is primary at 3 facilities
- The LDAR/LMA is primarily a research grade system that is being evaluated and is not in commercial production
- Addition of LDAR/LMA might increase lightning detection safety envelop by 5 to 10 min.
- Recommend reanalysis when LDAR/LMA system becomes operational and available**.**
- The NTS MDF system was designed to provide very high resolution on the NTS (within 0.25 km), provide high sensitivity (detect 95 to 98% of cloud-to-ground lightning), and streamline data flow to customers.