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An Operational System for Real-Time Lightning Display and Resource Protection

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The Meteorological And Range Safety Support (MARSS) System

Overview

- Data acquisition and display:
 - Four different lightning systems – LDAR, LPLWS, CGLSS, LLPS
 - Mesonet towers up to 300'
 - Multiple ASOS sites
 - Six 915 MHz DRWP/RASS units
 - Six MiniSODARs
 - One 50 MHz DRWP/RASS
 - AMPS Hi and low-res balloon soundings
 - External model data: LAPS analysis and MM5 (or RAMS) forecast grids
- Meteorological, hazard, and risk models

Data Sources: LDAR

The Lightning Detection and Ranging (LDAR) system:

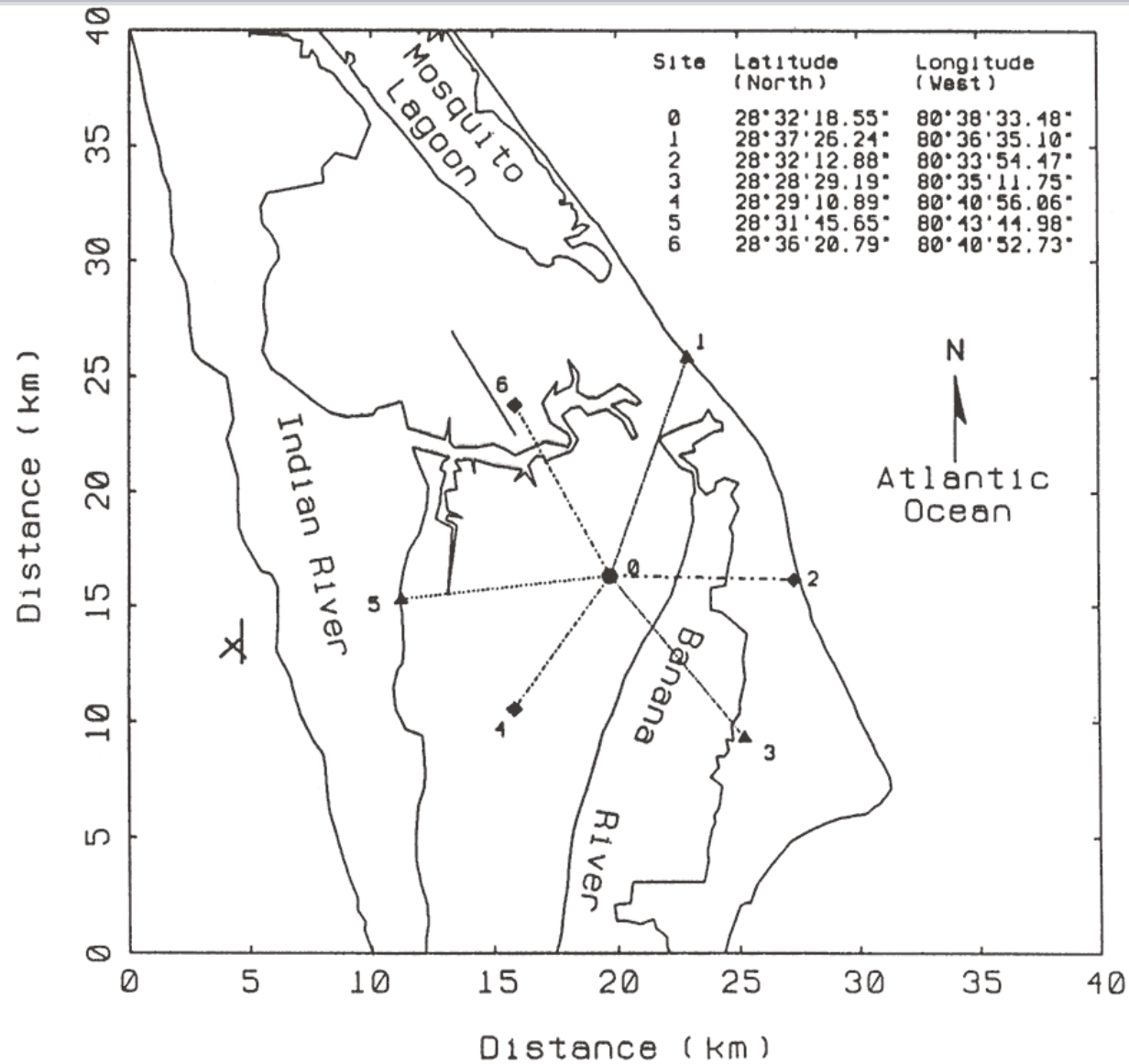
Located at the Kennedy Space Center. The center lat/long of the LDAR network is 28.5387 and -80.6428. All x, y, and z values represent distance (in meters) from this location. LDAR is a volumetric lightning mapping system providing near real-time location of lightning in support of Space Shuttle operations. It consists of seven antennas, microwave and land line communication between the outlying antennas and the central station, and a central processing facility located at the central station.

The LDAR central station located at antenna #1 is surrounded by six additional antennas arranged in a hexagonal pattern from 6 to 10 km away. Each site is comprised of an antenna to detect the 66 MHz VHF pulse of an intra-cloud event, and an electric field detector which monitors the electric field change (K change) associated with a cloud to ground strike. Data arrives at the central site from the six outlying antennas on a continual basis via either microwave or land line transmission at a rate of 6 MHz. With a time resolution of 10 nanoseconds, the time and amplitude of the peak signal are input to the central workstation from each antenna for event calculation.

LDAR Antenna



LDAR Antenna Locations



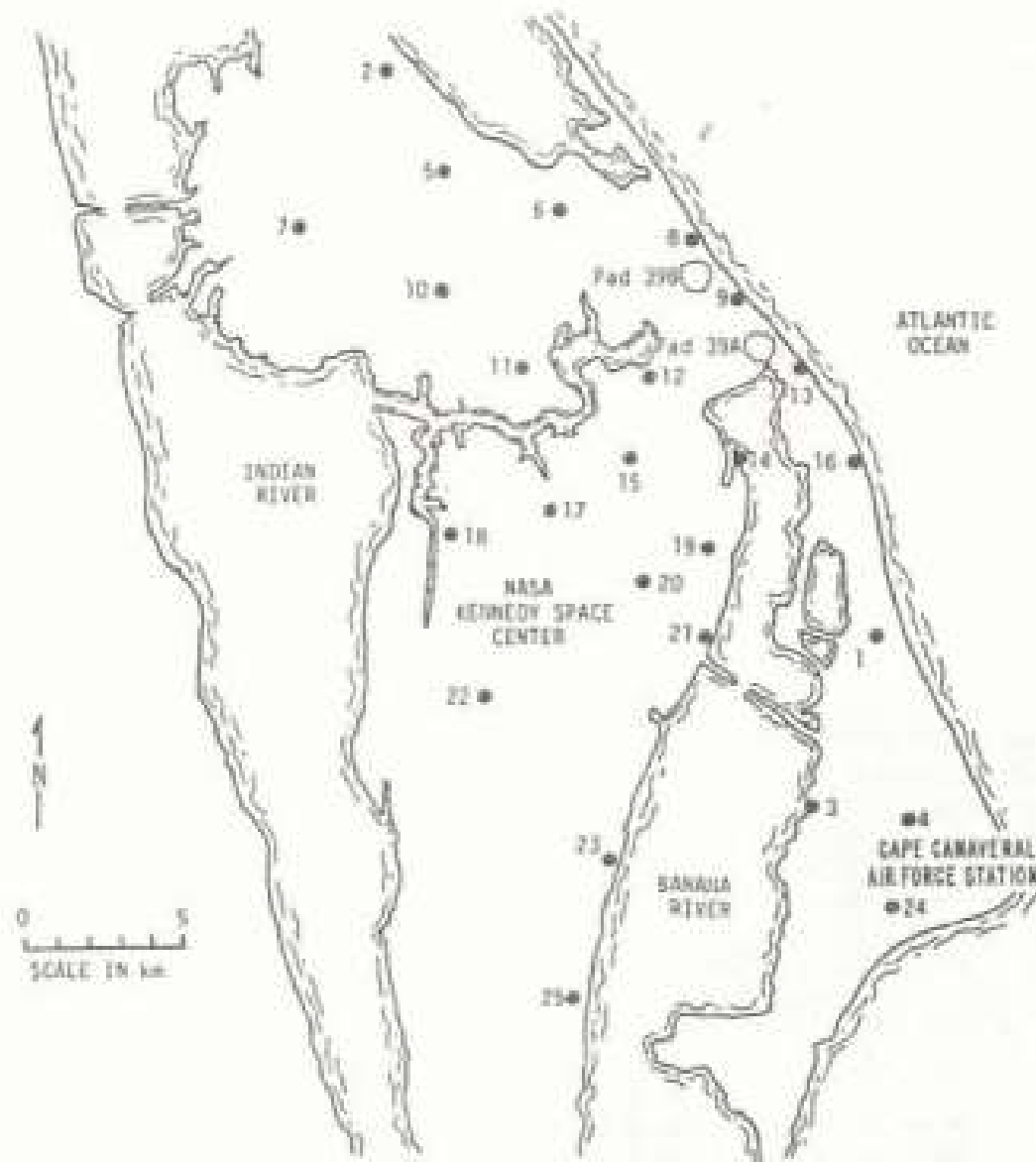
Data Sources: LPLWS

An array of 31 Advanced Ground-Based Field Mills (AGBFM) comprise the LPLWS used to provide an early warning of the onset of cloud electrification that precedes the occurrence of lightning. The AGBFMs operate continuously year-round in the hostile marine environment of the south Florida coast and measure electric fields to +/- 32kv/m with a sensitivity of 4 v/m (14-bits) over a DC to 10Hz bandwidth. The inverted configuration preserves accuracy during intense precipitation.

LPLWS Field Mill Sensor



Field Mill Sensor Locations



Data Sources: CGLSS/LLPS

The LLPS at Vandenberg AFB consists of four Advanced Lightning Direction Finders (ALDFs) and an Advance Position Analyzer (APA) which locates cloud to ground lightning using magnetic and time of arrival direction finding. The original ALDF sensors were recently upgraded to the Improved Accuracy from Combined Technology-Enhanced Sensitivity (IMPACT-ES) Sensors.

The Cloud-to-Ground Lightning Surveillance System (CGLSS) at KSC/CCAFS/PAFB is an earlier version of the same LP2000 system above (LLPS), both of which were provided by Global Atmospheric, Inc.

ALDF Lightning Sensor



LLPS Lightning Processor and Sensor Comm Rack



Functional Data Requirements

MARSS Functional Allocation (Input)

Shall #	Source	Frequency 3.1.1.2	Input Format 3.1.1.1	Source	Interface	QC 3.1.2.2	ARC 3.1.3.2	DISS 3.1.4.2	LDM 3.1.5.2
1	Tower	1 min	Ref Doc. (LDAD)	RSA IIA Weather Interface	RSA_WX_INF	X	X	X	X
2	AMPS (upper air sounding)	5 min	Ref Doc. (BUFR)	RSA IIA Weather Interface	RSA_WX_INF		X	X	
3	50 MHz RWP	3 min	Ref Doc. (LDAD)	RSA IIA Weather Interface	RSA_WX_INF	*	X	X	X
4	915 MHz RWP	1 set of 5 instruments in 15 min	Ref Doc. (LDAD)	RSA IIA Weather Interface	RSA_WX_INF	X	X	X	X
5	RASS 915 MHz	1 set of 5 instruments in 15 min	Ref Doc. (LDAD)	RSA IIA Weather Interface	RSA_WX_INF	X	X	X	X
6	Sodar	1 min	Ref Doc. (LDAD)	RSA IIA Weather Interface	RSA_WX_INF	X	X	X	X
7	Local Surface Observations	1 min	Ref Doc. (LDAD)	RSA IIA Weather Interface	RSA_WX_INF	X	X	X	X
8	LLPS	100 pts/min	(ASCII)	LLPS Interface	UALF_INF		X	X	X
9	CGLSS	100 pts/min	(ASCII)	CGLSS Interface	UALF_INF		X	X	X
10	LPLWS Center of Charge	100 pts/min	(ASCII)	LPLWS Interface	LPLWS_INF		X	X	X
11	LPLWS Field Mill Grid	5 min	(ASCII)	LPLWS Interface	LPLWS_INF		X	X	X
12	LPLWS Field Mill Value Table	1 min	(ASCII)	LPLWS Interface	LPLWS_INF		X	X	X
13	LDAR	>1000000 pts/min	(ASCII)	LDAR Interface	LDAR_INF		X	X	X
16	MM5 Forecast model	1 grid every 5 min	NetCDF	AWIPS Interface	AWIPS_INF			X	
17	LAPS	5 min	NetCDF	AWIPS Interface	AWIPS_INF		X	X	
18	REEDM	4 sets in 5 min	ASCII	MDS Interface	PPR_MDS_MOD_I NT		X	X	
19	BLASTI	4 sets in 5 min	ASCII	MDS Interface	PPR_MDS_MOD_I NT		X	X	
20	BLASTM	4 sets in 5 min	ASCII	MDS Interface	PPR_MDS_MOD_I NT		X	X	
21	BLASTO	4 sets in 5 min	ASCII	MDS Interface	PPR_MDS_MOD_I NT		X	X	

Lightning Data Elements

MARSS-LIGHTNING Data Elements

Data Element	Units of Measure	Range	Accuracy	Precision
Latitude	Degrees	-90 - 90	0.1 degree	7
Longitude	Degrees	-180 - 180	0.1 degree	7
Normalized Strength	volts/m ³	0 - 3000	1 volt/ m ³	6

MARSS-LPLWS-GRID Data Elements

Data Element	Units of Measure	Range	Accuracy	Precision
Grid Value	volts/m ³	-30000-30000	1 volt/ m ³	6

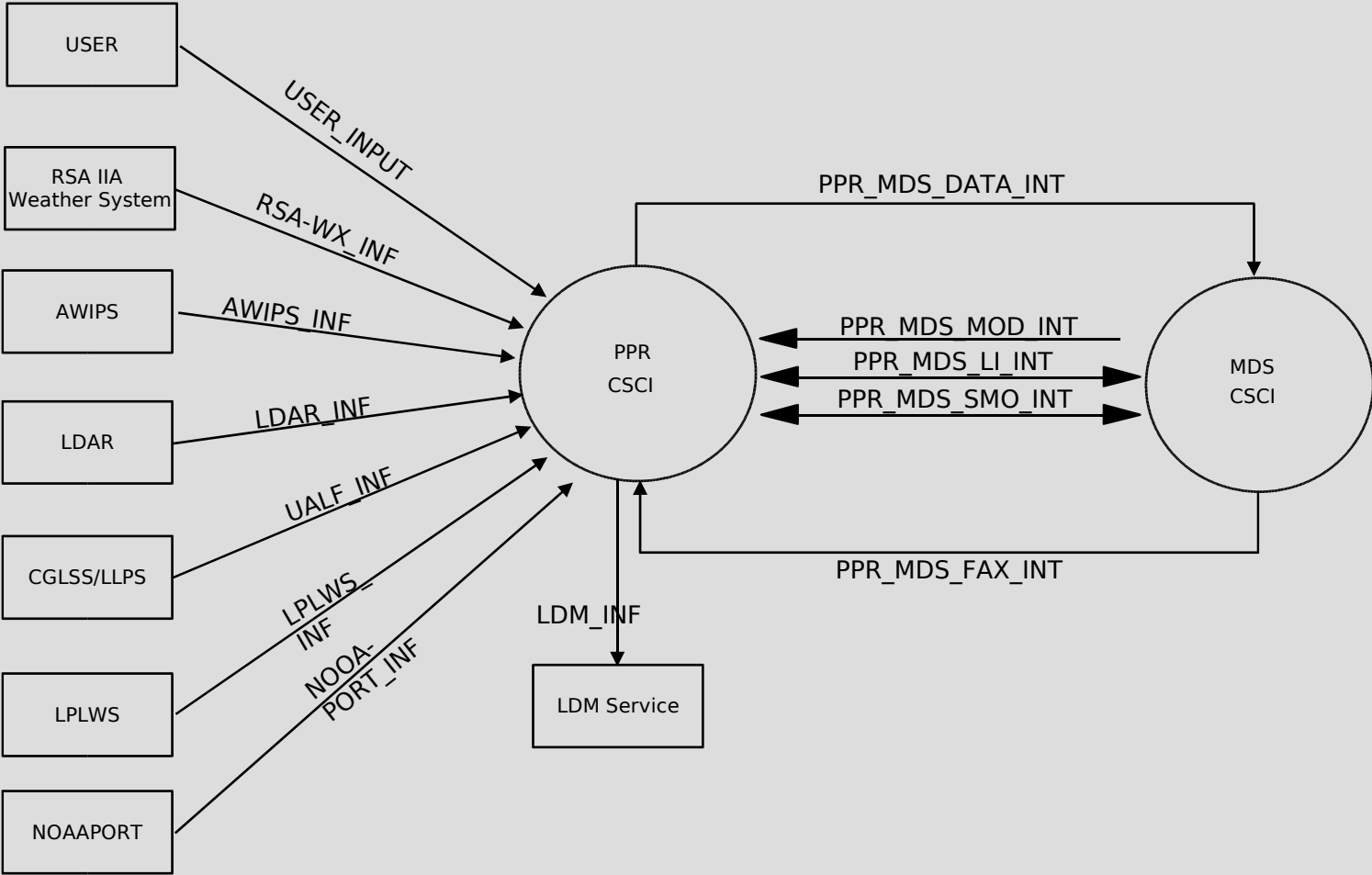
MARSS-LPLWS-MILL-VALUES Data Elements

Data Element	Units of Measure	Range	Accuracy	Precision
Mill Value	volts/m ³	-30000-30000	1 volt/ m ³	6

MARSS-LDAR Data Elements

Data Element	Units of Measure	Range	Accuracy	Precision
X, Y, Z	meters	-100000 – 100000	100 m	7

Data Interfaces



LDAR Format

```
23 16 53 33 69511      857  -57520  3730
23 16 53 33 71210     -1984 -56410  4863
23 16 53 33 75900      625  -55021  3413
23 16 53 33 76303      580  -55764  4193
23 16 53 33 80922     -497  -57109  4349
```

...

```
dd hh mm ss  lllllll  xxxxxxxx  yyyyyyyy  zzzzzz
```

dd = day of the month

hh = hour of day UTC

mm = minute

ss = second

lllll = microsecond

xxxxxxx = distance in meters from site #1 in the X (+ to the east) direction

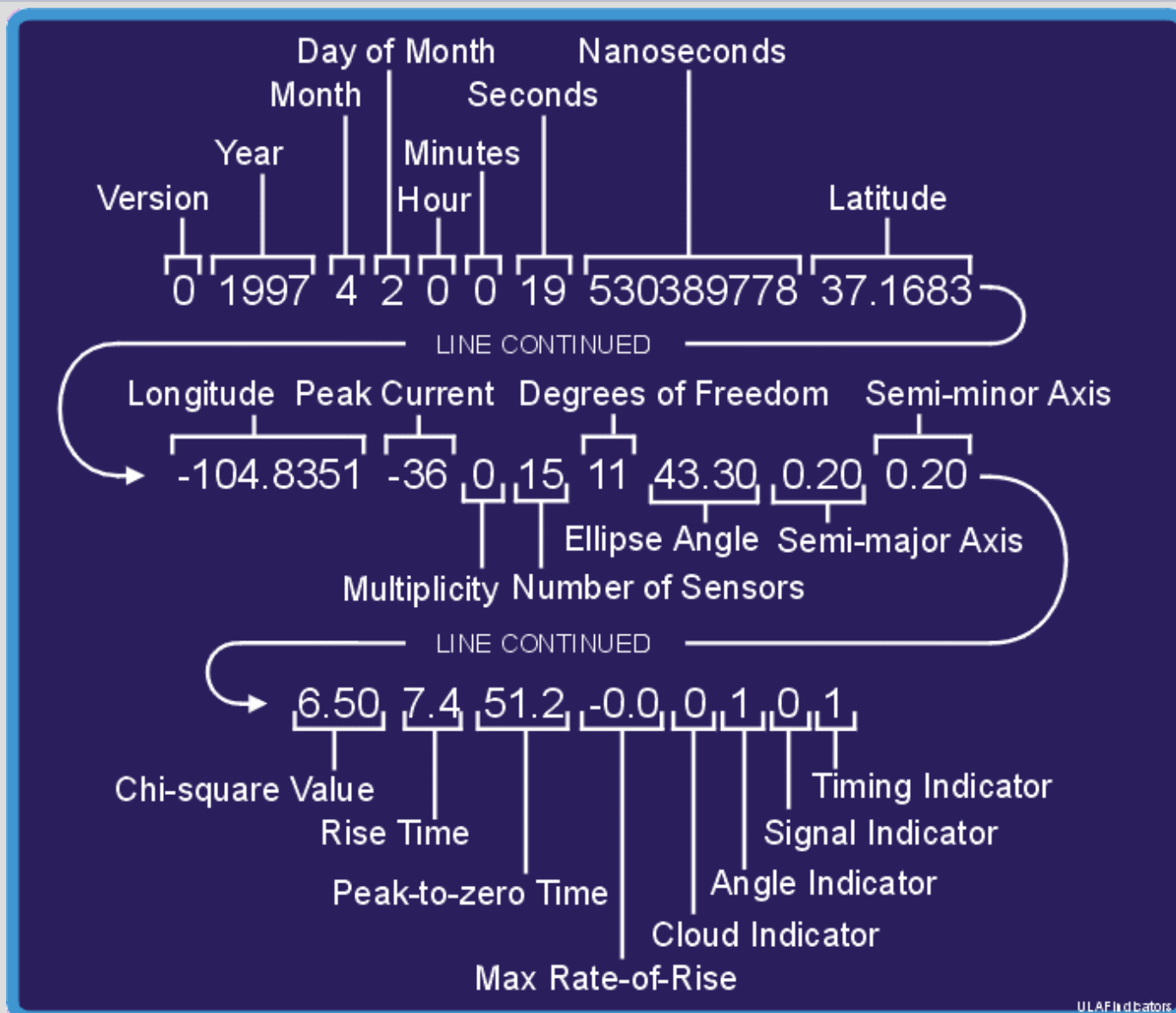
yyyyyyy = distance in meters from site #1 in the Y (+ to the north) direction

zzzzzz = distance in meters above the surface of the Earth

LPLWS Format

- LPLWS produces 3 types of data sets
 - Field Mill Grid data, Field Mill Value Table data, and Field Mill Center of Charge data
 - All ASCII formats
 - Gridded charge values in volts/m
 - Field Mill values in volts/m
 - Center of charge values in volts/m³
 - All records contain latitude, longitude, and time

LLPS/CGLSS (UALF) Format



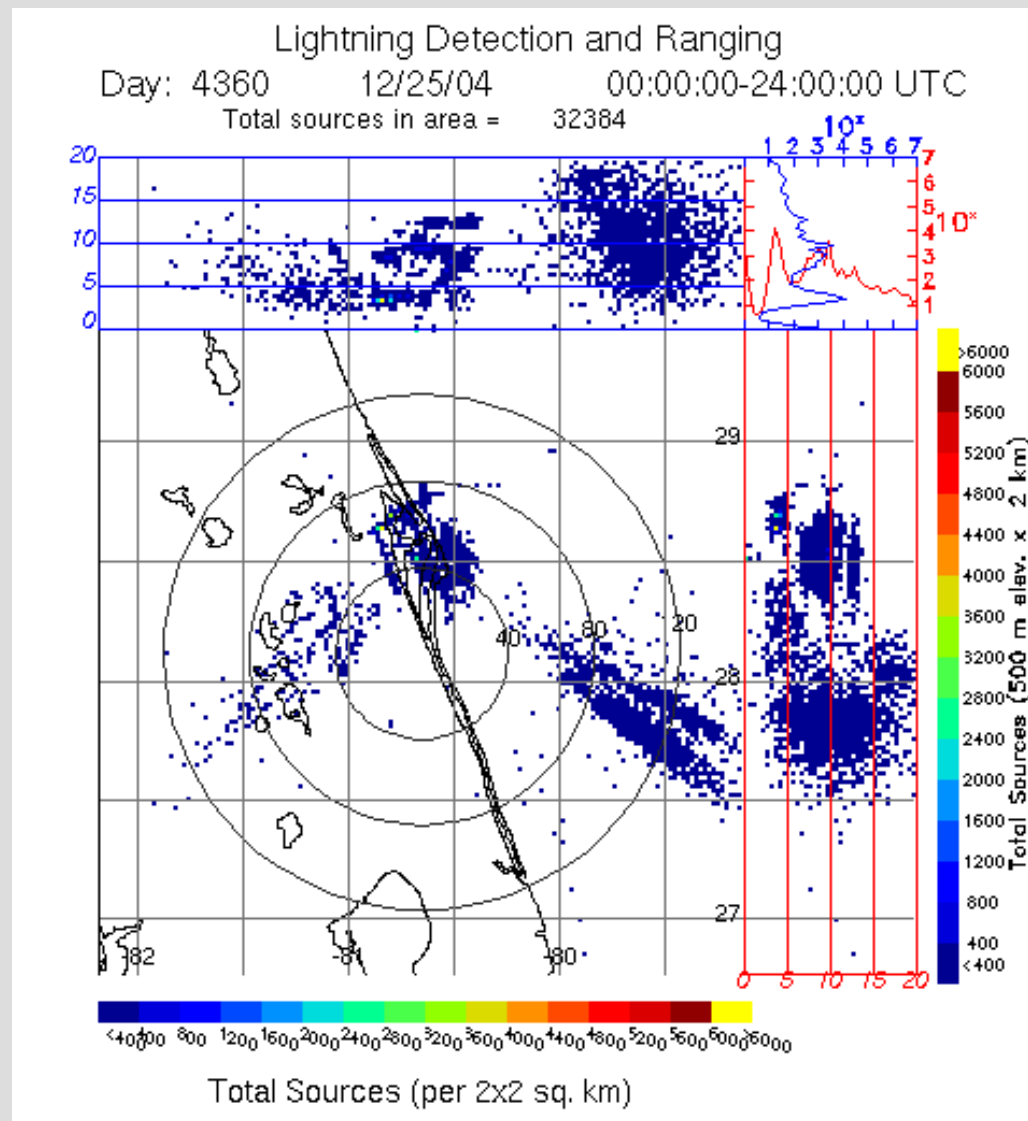
Real-time Data Ingest

- LLPS and CGLSS
 - APAs based on Sun Solaris
 - Multiple display and transport options
 - Displays and sensors use 16-port serial breakout box
 - MARSS physical interface uses Digiport EtherLite 8 serial/IP connection
- LPLWS
 - Also RS-232 serial interface (ASCII format)
- LDAR
 - Custom network based on OSPF variant
 - Requires dedicated Linux protocol converter

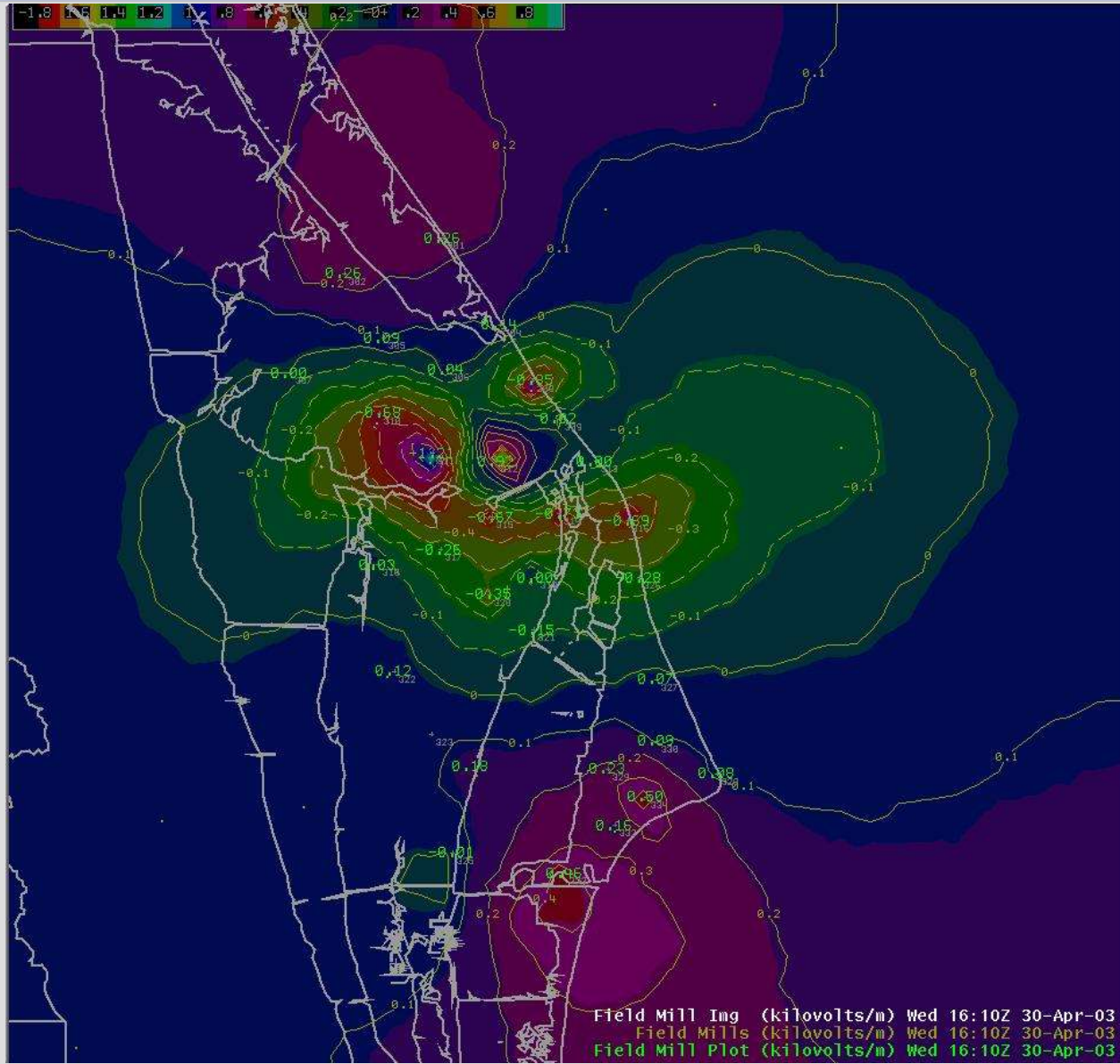
Data Processing

- All lightning data arrives in real-time
- Potential data rates
 - LPLWS center of charge: 1000 pts/min
 - LLPS strike data: 1000 pts/min
 - CGLSS strike data: 1000 pts/min
 - LDAR: 20,000 pts/flash
- All strike data is binned into one-minute packets and sent to MDS for display
- All lightning data is also exported via LDM to RSA weather system

LDAR Data (MSFC)



LPLWS Field Mill Data in D2D



MARSS Lightning Strike Map Layer



Motivation

