The ERAU Applied Meteorology program at Daytona Beach is interested in providing a new lightning data feed to the Unidata IDD. Provided below is a brief overview of some of the more noteworthy features and performance capabilities of the United States Precision Lightning Network (USPLN – www.uspln.com). Also addressed are related issues such as data access, format and policies related to its use within the educational and research communities.

**Noteworthy features and performance capabilities of the USPLN**

- Basic data set provides for coverage of the contiguous 48 United States, adjacent land and maritime areas outward to 500 km and the East Central Caribbean Sea in the area of Puerto Rico and the U.S. Virgin Islands.
- Unlike the NLDN data set, the data reported by the USPLN includes individual stroke detected within CG flashes is reported in real-time. See supplementary materials that give two examples of proven advantages of having access to individual stroke reports in real-time.
- Detection Efficiency (DE) and Location Accuracy (LA) of CG stroke data are 95% and 250m, respectively.
- Latitude, Longitude and time reports are given to the 4th decimal place.
- The actual location of CG stroke reports represents the actual Point-of-Impact of the event. Through use of proprietary low frequency detection methods and waveform discrimination the system can calculate the location where the stroke hits the ground or an object attached to it.
- Cloud flashes detected by the USPLN are also reported in real-time. While the three (3) reportable types of cloud flashes (CC, IC, and CA) are reported, no distinction is made as to their specific type.
- LA and DE of cloud flashes is dependant upon the location of the event within the network geometry as well as the distance from the event to participating sensors.
- Access shall also be provided to experimental CG flash reports that are based on detection of sky-wave pulses that are beyond 500-800 km from the mainland of the United States and are using algorithms currently under test. These reports extend well into Northern South America, Canada, the mid-Pacific and mid-Atlantic oceans, Caribbean Sea and Gulf of Mexico.

**Data Access and Format**

- Initial plan is to deliver data in 1-minute packets to the end user’s LDM in real-time from ERAU-DB.
- Format of the data is typically in GIS, ASCII or another form defined that may be requested by Unidata. If the user desires packets to be of longer duration, then such a request can be readily accommodated.

**Policies and Commitment**

- Naturally, there will be some policies that would apply to data access and use where there is direct or possible conflict with existing or potential user base supported by WDT and its many distributors. The existing policy for the NLDN data feed will be used as a model for the USPLN feed.
- At one time or another, technical personnel within WDT have been actively involved in the education and research communities. Many of these personnel have graduate degrees in meteorology and/or related sciences, as well as additional degrees in business, computer systems and engineering.
- WDT is in the process of developing a Grant program that is specifically directed towards further study of data quality and the role of lightning stroke and cloud data within other meteorological data sets in support of innovative approaches and new procedures for analyzing and forecasting such deadly events.

# Rationale & Advantages of Detecting and Reporting Lightning Strokes Versus Flashes

## 1. Early Phase of USPLN

During the planning and developmental design of the USPLN it was not surprising to find out that many people felt that a report reflecting only the flash location, along with a multiplicity value was insufficient for their applications and as such, was considered to be an incomplete report. One of the reasons this was not a surprise was that if one takes into consideration the results of many scientific studies previously addressed in this proposal, as well as published papers that clearly state that a very high percentage of strokes within a given flash strike the ground at a distance from the initial stroke and in many cases up to 10 kilometers away. In addition, there are a number of more recent professional papers by Murphy, Cummins, et al, which more or less note that flash data was best used for trending and stroke data was more for use in investigating specific events.

## 2. Validating the Decision

One of the more detailed comparisons of stroke versus flash data was carried out by Saba et al. *(Monitoring the Performance of the Lightning Detection Network by Means of a High Speed Camera, ILDC 2004, ref #63, )* using high speed cameras. In this work, which was carried out in the vicinity of Vaisala IMPACT sensors, several interesting facts were reported.

a. From 254 monitored time intervals between strokes of positive and negative flashes, the mean value was 66 msec, with a min of 6 msec and a max of 782 msec.

b. The reason why negative flashes have a flash detection higher than positive and negative strokes combined, can be explained by the fact that by convention, a flash is considered to be detected if any of its strokes is detected

c. The maximum distance between strokes observed was more than 8 km and the average maximum distance was 2.4 km. (These data are shown in Figure 1 below.)

d. Nearly all Lightning Detection networks consider that strokes comprise a single flash if each stroke occurs within 500 msec of the previous one.

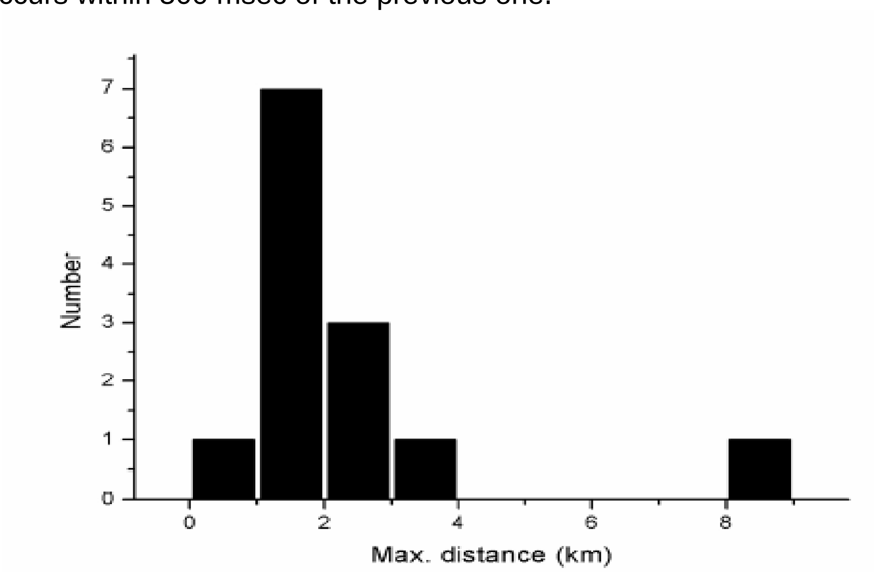


**Figure 1: Maximum distance between strokes**

## 3. Network Verification (Internal Analysis)

Many are of the opinion that it is important to report individual strokes because not to do so could result in serious consequences due to the absence of a particular report or false locations. To understand the value of having access to stroke data, Table 1 below shows actual data from a 12 stroke lightning flash as reported by the USPLN.

| Stroke # | Time | Long | Lat | Delta Km |
|---|---|---|---|---|
| 1 | 2:11:40 | -102.954 | 36.51115 | 0.09 |
| 2 | 2:11:40 | -102.954 | 36.51286 | 0.19 |
| 3 | 2:11:40 | -102.953 | 36.51569 | 0.33 |
| 4 | 2:11:40 | -102.933 | 36.54336 | 3.81 |
| 5 | 2:11:40 | -102.933 | 36.54347 | 0.06 |
| 6 | 2:11:40 | -102.932 | 36.54478 | 0.18 |
| 7 | 2:11:40 | -102.932 | 36.54531 | 0.06 |
| 8 | 2:11:40 | -102.932 | 36.54555 | 0.05 |
| 9 | 2:11:40 | -102.931 | 36.54618 | 0.08 |
| 10 | 2:11:40 | -102.931 | 36.54625 | 0.04 |
| 11 | 2:11:40 | -102.931 | 36.54649 | 0.04 |
| 12 | 2:11:40 | -102.931 | 36.5474 | 0.13 |

**Table 1: A Lightning Flash consisting of 12 strokes separated by as much as 3.8 km.**

In Table 1 it is clear that three strokes occurred at one location (yellow) and then 9 subsequent return strokes (blue), commencing some 100 milliseconds later, were located some 3.8 km distant. One could suggest that the strokes at the two locations were connected in the cloud or maybe they were connected below the cloud. The separation distance certainly indicates that they are within the same cell and probably connected to the same electrical channel. However, as the distance between the stroke center increases it may become increasingly questionable as to whether the strokes are connected or not.

If a system only reports flash data in real-time, the location of the first stroke in a flash is identified, and then, depending on angular measurements and timing, the number of potential strokes from that flash are counted, but not located. Therefore, in the example shown, this would result in a location error of almost 4 km for several strokes.

Now let us assume that in a flash, only one stroke occurred at the initial strike point, and the subsequent ones were maybe 7 km distance, or perhaps that the first strokes were at one location and the last one at a different location some 7 km away. In a “flash-only” environment it would be basically impossible to determine if these were from one or two flashes, or for that matter to calculate the accurate location.

One can easily see from the above data that without the ability to monitor and locate strokes, the resulting errors in location and identification could at times be rather large and serve as a source of incomplete or less reliable information, especially when performing critical analysis affecting a broad range of applications, from weather forecasting, to power system and safety needs.

## 4. Network Verification (Independent Sources)

Provided below are two recent examples of the quality and accuracy of the USPLN as well as the value of having stroke instead of flash data.

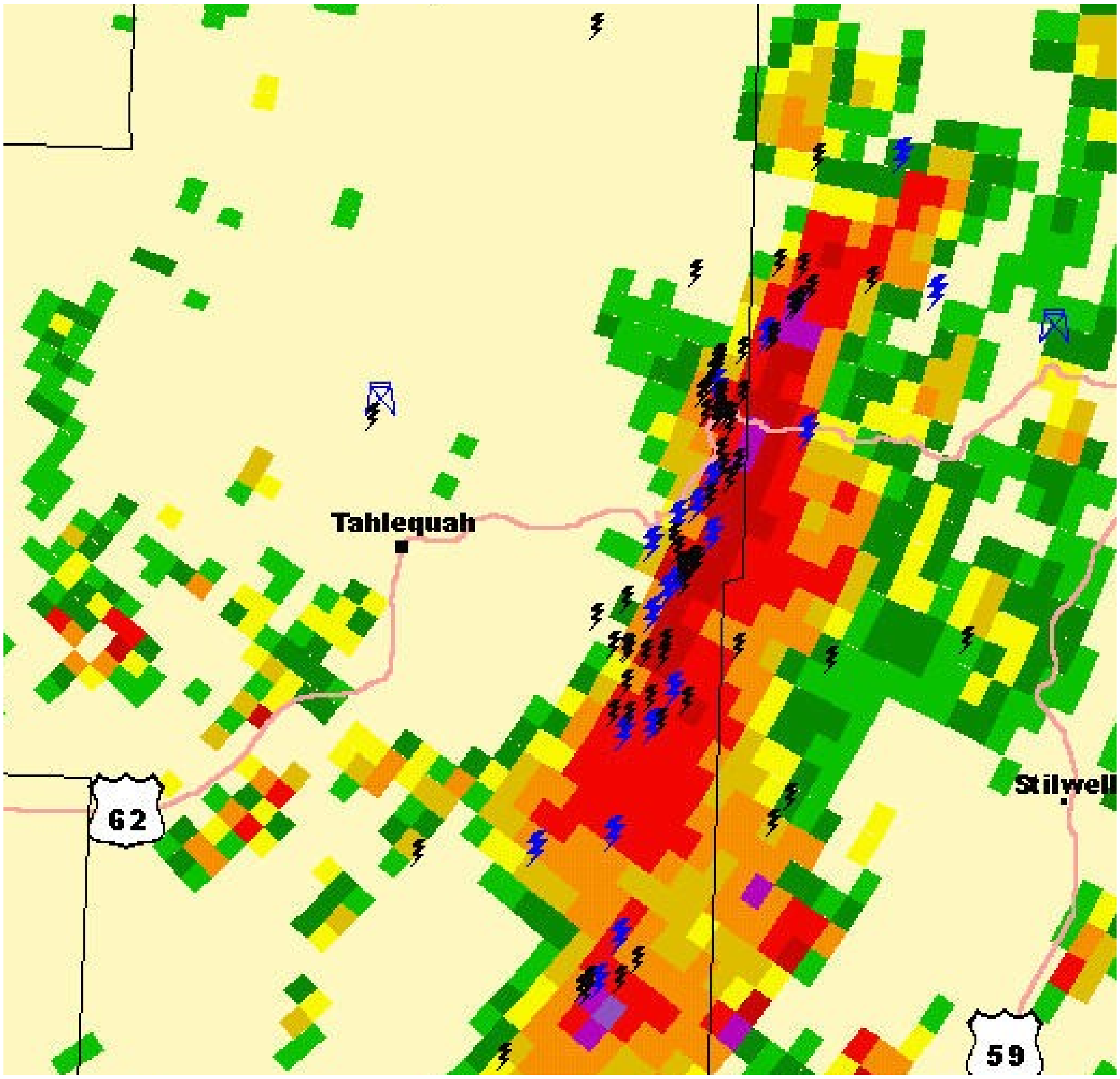


**Figure 2**

**a. Source: Oklahoma Climatologically Survey/Oklahoma Mesonet.**

The Oklahoma Climatologically Survey/Oklahoma Mesonet, a customer of the USPLN, provided an example where one of their Mesonet sites (indicated by the blue tower North of Tahlequah) was struck by lightning and severely damaged. The event occurred at 0945 UTC on 4/11/2005.

Stroke detection data from the USPLN are plotted in black and flash detections from the NLDN are plotted in blue. These data are from 0940-0950 UTC on 4/11/2005. The NEXRAD reflectivity data shown was valid at 0947 UTC on 4/11/2005. The overall Image represents roughly a 40 km x 40 km square area.

As shown, there are significantly more USPLN detected stroke reports than flashes detected by the NLDN. More importantly, the lightning stroke that struck the tower at the Oklahoma Mesonet site was reported by the USPLN and, as noted, occurred roughly 10 km away from the core of the storm as depicted by the NEXRAD. <u>This event was neither detected or reported by the NLDN</u>.

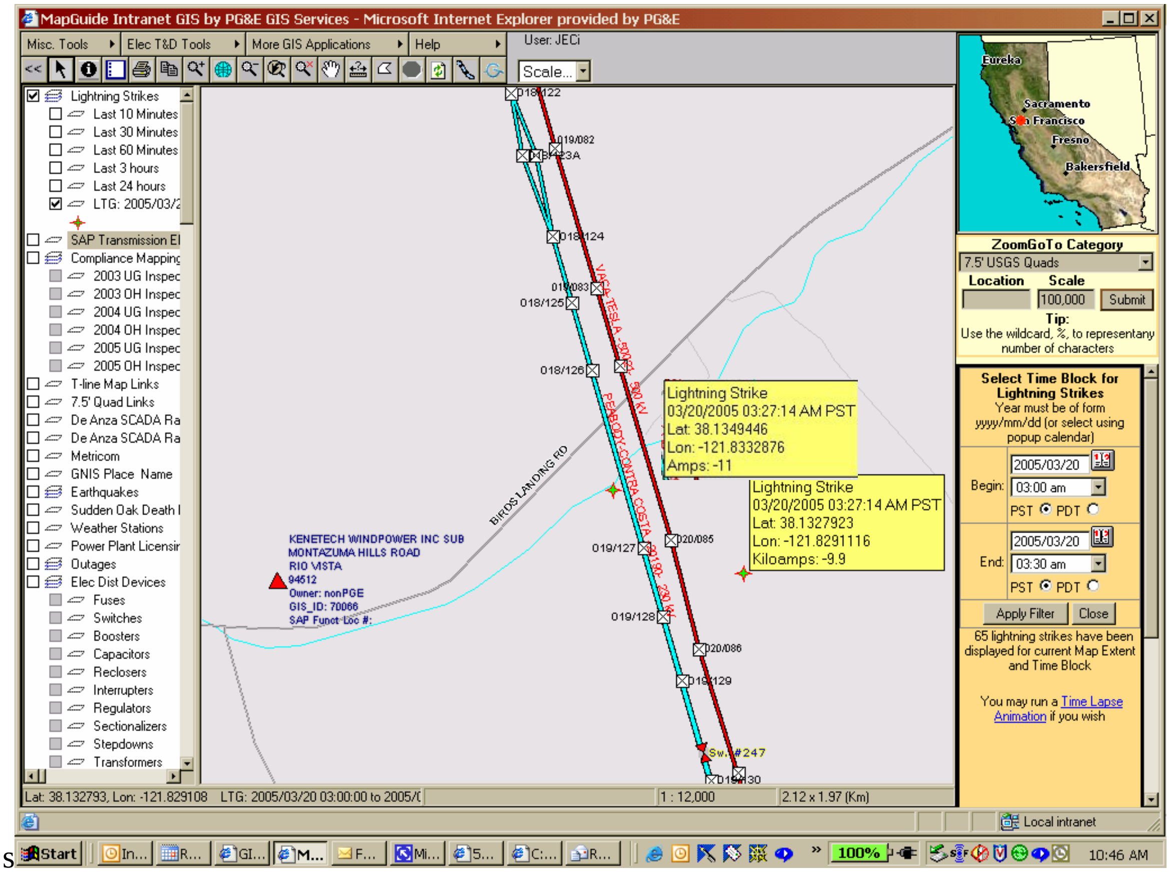


**Figure 3**

**b. Source: Pacific Gas & Electric**

While lightning activity along the cost of California has been historically rare during the Month of March, the many storms that have frequented the state this year are not only above average, they have caused substantial damage to many facilities due to high winds and lightning.

Shown below is a snapshot of the system used by Pacific Gas & Electric (PG&E), a USPLN customer for tracking line faults and correlating such information with weather data and other data sets.

The narrative below provides further insight as to the value of stroke data.

(1) On the morning of 03/20/05 PST PG&E reported that a lightning stroke had caused a power disruption. To restore the point of disruption, flashed insulators had to be replaced on the two towers (018/126 and 019/127) which are located north and south, respectively, of the location where the stroke was detected. The stroke reported was a negative polarity event with -11KAmp of current.

(2) This example not only shows the real-time capability of the USPLN to detect strokes (not flashes) and pinpoint their location with great accuracy. The two strokes shown were part of the same flash. Information is not available to confirm whether or not this event was detected by the NLDN