**PROPOSED TORNADO / THUNDERSTORM HAZARD**

**MOBILE PHONE ALERT APPLICATION**

A.)OVERVIEW OF PROPOSED PRODUCT

The idea is to create a smartphone application that will provide a visual display to the user consisting of his/her location (or other locations of his/her choosing) relative to the location(s) of any of the following thunderstorm hazards:

1. Lightning
2. Hail
3. Flooding
4. Strong winds in excess of 50kts (considered ‘severe’ winds)
5. An area of rapid rotation, indicative of a tornado

The smartphone application is to incorporate visual elements of information as currently provided by smartphone applications developed by *TheWeatherSphere*1and *MyWarn*2*,* and as currently provided by *GRLevel 2* and *GRLevel 3* software3. The application is intended to be made available to Droid, iphone, and the Windows mobile devices.

B.)REQUIRED DATA

The proposed product would incorporate or import the following forms of real-time data into the smartphone application (users are to be allowed to adjust or turn on / off various data layers, which is explained later):

1. **GPS data**: The application should be set to track the GPS location of the user’s smartphone, but the user should also be given the option to track the locations of other smartphone devices at the user’s discretion (up to 20 if possible).
2. **Mapping / satellite data**, which includes road networks, building footprints, and topography of a given location (similar to what is shown on Google maps).
3. **Weather advisories issued by:**
   1. The Storm Prediction Center4: These would include Tornado, Severe Thunderstorm, and Flash Flood ‘Watch’ products issued by the Storm Prediction Center. Watches are generally aligned along U.S. county borders. In addition, the Storm Prediction Center issues Mesoscale discussion statements, which are hazardous weather outlook statements for a local region of the U.S.
   2. Local National Weather Service office5: These would include area forecast discussions, hazardous weather outlook statements, or severe weather warning statements issued by the forecasting office that covers the metropolitan region where the user’s smartphone is located.
4. **Radar data**, which visually illustrates a thunderstorm, can be acquired at any of the 100+ nationwide National Weather Service office stations6. The radar data that is available to the public includes the following:
   1. Reflectivity data; radiation beams emitted from a radar dish are dispersed and scattered upon striking a particulate of a certain size. The magnitude of the scattered beams that return to the radar dish are classified according to decibel levels relative to reflectivity (dbZ); the returned decibel readings then produce color-coded radar echoes, with warmer colors representing larger particulates, or more specifically, larger raindrops, hail, and / or heavy rainfall (Exhibit A).
   2. Wind velocity data; current radar technology captures inbound and outbound winds at various magnitudes. Inbound winds are represented by green colors (Exhibit A), whereas outbound winds are represented by red colors. Brighter inbound and outbound colors are indicative of higher velocity measurements.
   3. Vertically Integrated Liquid: radar technology captures reflectivity data and converts measurements into water equivalent values; higher measurements typically correspond to hail cores (Exhibit B).7

Radar technology additionally allows forecasters to track the velocities of parent thunderstorms, and therefore allows for time estimates as to when thunderstorms may impact a specific area.

1. **Real-time Lightning Data**: Lightning data may potentially be retrieved from any of the links found on the NWA Remote Sensing Committee web page8. Lightning is initially sensed by instruments mounted on orbiting satellites, which allows for lightning strike data to be subsequently collected and georeferenced. The *Weatherbug* is an example of a mobile phone application which performs this function; it georeferences a person’s location relative to a lightning strike, and provides real-time updates of distance and time for a lightning strike relative to an individual’s location (Exhibit C).
2. **Storm spotter reports**: Websites such as *spotternetwork.org* 9 allow for storm spotter reports to be compiled when a severe weather event is in progress for a certain location. Reports would include:
   1. Damage from straight-line winds
   2. Hail
   3. Tornado or funnel cloud

Weather software programs that compile such reports typically feature icons representing severe wind, severe hail, or tornado reports; these icons pop-up when severe reports are logged (Exhibit D).

C.) USER ALERT SETTINGS

With the six above forms of data being made available to the user, the user should be given the options of being alerted to any weather bulletins that may impact his / her location with respect to the issuing of weather watches, advisories, outlooks, or warnings. The user should have the option to turn these items on or off at his / her discretion. For reference, the user should have menu options similar to those displayed by MyWarn and TheWeatherSphere (Exhibits E and F):

The user of the smartphone may configure settings that would cause the mobile phone application to warn the user via an alarm when a weather bulletin is issued under the following circumstances:

1. when a bulletin is issued for an area that is within a certain distance of the user’s location (distance being set by the user),
2. when a bulletin is issued for a location that is within the monitoring area of a local National Weather Service office branch, and the monitoring area is where the user is located
3. when the above two situations apply with respect to a specific address or GPS location of another individual, which may be set by the user.

In any of these cases, the location settings pertaining to alerts may be set to the user’s discretion. The weather bulletins would include one or more of the following:

1. a severe thunderstorm or tornado watch is issued by the Storm Prediction Center.
2. a severe thunderstorm or tornado warning statement is issued by a National Weather Service office.
3. a hazardous weather outlook statement is issued by a National Weather Service office.
4. A mesoscale discussion statement is issued by the Storm Prediction Center.

At this point, if a severe weather event is in progress, the user would be redirected to a visual display showing his or her distance relative to the thunderstorm hazard along with text information that relays various thunderstorm hazard attribute information; the information provided on the visual display screen would specifically indicate how and when a thunderstorm hazard may impact a specific location (i.e. the user’s location, the location of a relative of the user, specific address locations, etc.) This is explained further in Section D below:

D.) VISUAL DISPLAY OF DATA

If a severe weather event is in progress, the user should be provided with a visual display that would incorporate the following data layers that may be turned on or off at his / her discretion (visual references are provided where noted below):

1. **A display of the user’s smartphone GPS location**
2. **A display of other desired smartphone GPS locations or specific place locations, as programmed by the user**
3. **A display of the radar image of an incoming thunderstorm (either reflectivity, velocity, or VIL mode)**
4. **A display of road networks and building footprints**
5. **A display of an overhead image of the area, which may include satellite imagery, as shown on Google Earth**
6. **A display of severe thunderstorm, flooding, or tornado warning polygon**

A severe thunderstorm warning is typically characterized by a yellow polygon, a tornado warning characterized by a red polygon, and a flash flood warning is characterized by a green polygon (although the colors may vary).

1. **A display of a tornado, flood, or severe thunderstorm watch polygon**
2. **A display of the location of the severe weather hazard, as represented by the following:**
   1. The location of a tornado on the ground is defined by velocity “couplets”, which pertain to the radar velocity image (initially displayed in Exhibit A). Where there are very strong inbound winds next to very strong outbound winds, this is indicative of rotation. A tornadic thunderstorm feature that typically is also present when there is a velocity couplet is a feature known as a “hook” echo on the dbZ reflectivity image; this is a “tail” feature typically found on the southwest side of a tornadic thunderstorm, and is indicative of falling precipitation wrapping around a tornado that is either developing or already on the ground.

A *“TVS” (Tornado Vortex Signature)* is an upside-down triangular symbol that is generated on radar when rotating wind velocities reach a certain threshold that is indicative of strong enough rotation to suggest possible tornado formation (Exhibit G); also see9.

A tornado warning may be issued without a TVS; the area of greatest rotation should subsequently become highlighted to mark the location for the user.

* 1. The location of “severe” straight-line winds, which are defined by inbound or outbound velocities that reach or exceed 50 nautical miles per hour.
  2. The location of large hail (where VIL measurements are indicative of 1”+ hail).

A hail algorithm is a triangle feature that is generated over areas when probability for hail reaches a specific threshold (Exhibit G); these parameters were developed by the National Weather Service’s Next Generation Radar program (NEXRAD), and are explained in 10.

* 1. The location of a cloud-to-ground lightning strike

1. **A display of the general track of the severe weather hazard (which generally complements the velocity of the parent thunderstorm.) (Exhibit H).**
2. **A display of storm spotter reports (Exhibit D for reference):**

a. A straight-line wind symbol is displayed when there is a report of wind gusts exceeding 50 kts.

b. A hail icon is displayed when there is a report of hail 1” in diameter or greater.

c. A tornado symbol is displayed when there is a spotter report of a tornado or funnel cloud.

1. **A display of the potential damage swath of the severe weather hazard, given its movement during one particular radar scan (Exhibit I):**

The display would correspond to the width of the tornado couplet, or swath of damaging winds, as indicated by velocity measurements on radar, or areas where vertically integrated liquid measurements are indicative of hail that is 1”+ in diameter. The width and distance of the potential damage swath would also be provided to the user via text.

1. **A text display of the smartphone distance relative to the severe weather feature (the tornado, large hail, or damaging winds) (Exhibit I).**
2. **A text display of the estimated time the user has relative to the severe weather feature before it arrives at his/her location (Exhibit I).**
3. **A text display of the width of the potential damage swath of the severe weather feature**

When integrating these data layers together, ideally, the visual product that the user should see on his or her smartphone should combine the elements described above and displayed in Exhibits E-I.

Current mobile phone application products that most closely resemble the desired final product being proposed here are products designed by *TheWeatherSphere* and *MyWarn* (Exhibit J). Ideally, the proposed smartphone application product would also be incorporating elements displayed by *GRLevel 2/3* software (Exhibits D, G, H).

E.) USER OPTIONS FOR THE VISUAL DISPLAY

With respect to the data layers explained in section D above, the proposed mobile phone application is to give the user the option of superimposing as many of these layers of data as he or she chooses, and to have the option to turn any of the above data layers on and off at any given time.

In particular, the user should have the option to program his / her GPS tracker, in addition to the GPS locations of any other mobile devices he / she has programmed into the application to automatically shut off when there are no weather statements in effect, or there are no thunderstorm hazard features present within a specified distance of the user’s smartphone location.

The user also should have the ability to ‘zoom in’ and ‘zoom out’ of any given location while in the visual display mode; this may correspond to the current location of the user, the location of his / her loved ones, or of any location within the United States; should the user turn on various data layers that may not be available to a specific location at a given moment, the application should provide a displayed text informing the user indicating that the data of the respective layer is not available.

Lastly, the user should have the option of adjusting transparency settings for radar imagery of a thunderstorm, as displayed in Exhibit K.

F.) REFERENCES:

1.) Weathersphere. (2013). Accessed at http://weathersphere.com/ [24 May 2013]

2.) MyWarn. (2013). Accessed at: http://www.mywarn.com/ [24 May 2013]

3.) GRLevelX. (2013). Accessed at: http://www.grlevelx.com/ [24 May 2013]

4.) Storm Prediction Center (2013). Accessed at: http://www.spc.noaa.gov/products/watch/ [24 May 2013]

5.) National Weather Service (2013). Accessed at: http://forecast.weather.gov/MapClick.php?x=222&y=150&site=cle&zmx=1&zmy=1&map\_x=221.5&map\_y=150 [24 May 2013]

6.) National Doppler Radar Sites (2013). Accessed at: http://radar.weather.gov/ [24 May 2013]

7.) Vertically Integrated Liquid Density as an Indicator of Hail Size (2013). Accessed at: http://www.srh.noaa.gov/ohx/?n=vildensity [24 May 2013]

8.) Lightning Detection – NWA Remote Sensing Committee (2013). Accessed at: http://www.nwas.org/committees/rs/ltng.html [24 May 2013]

9.) Tornado Vortex Signature (2013). Accessed at: http://w1.weather.gov/glossary/index.php?word=tornado+vortex+signature [25 May 2013].

10.) Kessinger, C. and Brandes, E. (1995). “A Comparison of Hail Detection Algorithms.” Accessed at: http://www.rap.ucar.edu/staff/kessinge/cjk\_faa1995.html [25 May 2013].

11.) COD Storm Chase Tracer. (2013). Accessed at: http://weather.cod.edu/chasing/tracker/