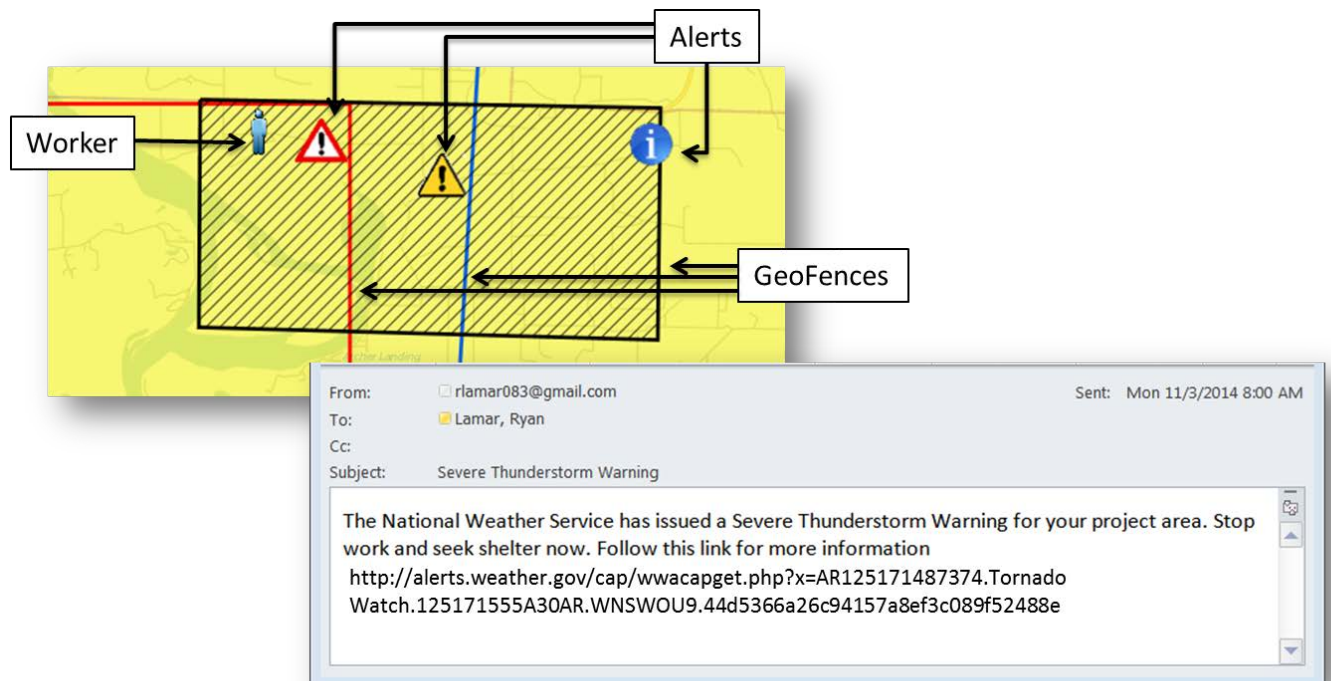


# IMPROVING HEALTH & SAFETY WITH ACCESS TO REAL-TIME EVENTS USING GEOEVENT PROCESSOR

## MGIS CAPSTONE PROJECT

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## EXECUTIVE SUMMARY

Today Environmental Health and Safety (EHS) programs and policies play a large role in corporate culture and identity. Keeping employees safe is paramount to helping ensure organizational success. Generally EHS programs aim to prevent accidents or incidents and to reduce adverse effects from operations on their employees and the environment (Wikipedia, 2014).

A key element affecting every organization is weather. Many organizations today maintain a global footprint and conduct work in local and remote areas of the world. Monitoring and tracking weather conditions in real-time has the potential to allow organizations to protect the safety of their employees and assets.

Though event based tracking and monitoring systems have been developed in the past they have often required complicated architecture, significant development, and coding to fulfill their purpose. Thus until recently, building and maintaining these systems has been costly for many organizations. In the Fall of 2013 ESRI released GeoEvent Processor, a new extension for ArcGIS Server, which promises to allow users to connect to “virtually any type of streaming data” in real-time, monitor and analyze that data, and send alerts / notifications to specified individuals when events occur (ESRI, 2014a).

This project evaluated how Geographic Information System (GIS) technology, namely GeoEvent Processor, coupled with weather warnings, watches, advisories and statement information provided by the National Weather Service (NWS) can be leveraged to determine if localized weather conditions pose a threat to business operations or workers. The project assessed the use of GeoEvent processor as a means to automatically consume weather data in-real time and process the weather data against known business operation locations to improve EHS.

During the course of the investigation six criteria were used to evaluate GeoEvent Processor. The criteria included; Extension Maturity, Privacy Issues, Data Schema & Workflows, Hardware / Software Requirements, External Services, and Additional Feature Detection. Although there are some enhancements that could be made to GeoEvent Processor, overall it proved effective in developing our weather alert tool.

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## 1.0 INTRODUCTION

Although there are many components to corporate Environmental Health and Safety (EHS) programs and policies, addressing safety with regards to weather related events is critical. Almost all industries are affected by the weather in one way or another. Transportation, Utilities, Oil and Gas can all be affected adversely by sudden or severe weather conditions. Heavy rain, snow or strong winds can cause airports to close and bring havoc to rail and roadways. Tornadoes, hurricanes, and lightning can cause severe damage to infrastructure and pose a serious threat to human life.

According to the National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center, between 1980 and 2013 there were 151 weather events where damages “reached or exceeded \$1 billion”. In 2013 alone there were over \$7 billion in damages and 109 deaths related to severe weather outbreaks (NOAA, 2014).

Organizations have a responsibility to keep not only their physical assets (structures, vehicles, etc.) safe, but also protect the health and safety of their employees and the public from any undue harm resulting from weather related events. Within the United States nearly all employees fall under the Occupational Safety and Health (OSH) Act which is administered by the U.S. Department of Labor’s (DOL) Occupational Safety and Health Administration (OSHA) (DOL, n.d. b). Additionally 27 States maintain their own Safety and Health programs which meet or exceed guidelines set-forth in the OSH Act (DOL, n.d. a).

Globally organizations working with the International Finance Corporation (IFC) must follow Health and Safety guidelines set-forth in the World Bank Group Environmental, Health and Safety Guidelines (EHS Guidelines) developed in 2007 (IFC, 2014). Section 3.7 defines guidelines for worker notification and communication systems (IFC, 2007).

The chance of damage to assets or injury to workers from severe weather can be substantially reduced or eliminated if organizations can alert potentially affected employees and assets of adverse weather conditions. According to a study done by the American Society of Safety Engineers in 2002 organizations with strong H&S programs can save money & improve employee productivity & morale. However the vast geographic area over which organizations operate and the localized nature and timing of weather events present organizations and EHS program managers with a unique set of challenges.

At any given time only very small portions of an organization’s operations may be impacted by localized weather events such as thunderstorms, tornadoes, or flooding and operations throughout the rest of the organization can continue without risk. With such large geographic footprints many organizations require a method for organizing and processing important information regarding weather conditions in a timely and efficient manner. Businesses need to be able to evaluate weather conditions across their work sites and send targeted alerts to affected business operations without disrupting work in other locations.

## 2.0 PROJECT OBJECTIVES

With these challenges in mind the objective of this project was to evaluate ESRI's GeoEvent Processor extension for monitoring worker locations and to develop an effective weather alert system that provides targeted advanced warning of severe weather conditions to the organization. Specifically the project evaluated the GeoEvent Processor workflow including connecting to input data streams, analyzing data, and publishing outputs, with respect to six criteria.

- Extension Maturity,
- Privacy Issues,
- Data Schema & Workflows,
- Hardware / Software Requirements,
- External Services, and
- Additional Feature Detection.

The ideal system will monitor areas of interest (AOI) (e.g. project boundaries and severe weather extents) and check those against worker locations. When a worker enters or leaves an AOI the system should send out targeted alerts / notifications. The system should also include a mapping interface to display worker locations, AOI's, and alert / notification information.

The sections below provide a description of GeoEvent Processor and it's key components, discuss the methodology used to develop the project, a description of the tool developed, and an overall evaluation of GeoEvent Processor with relation to this project.

## 3.0 GEOEVENT PROCESSOR

GeoEvent Processor is a new extension for ArcGIS Server released with ArcGIS 10.2, which allows users to connect to almost any type of streaming data, perform analysis on that data based on defined parameters, and then send alerts to key personnel and/or update maps (ESRI 2014a).

The GeoEvent Processor workflow is managed using the GeoEvent Processor Manager. The GeoEvent Processor Manger is similar to the ArcGIS Server Manager and is the application used to “create and configure inputs and outputs, design, and publish GeoEvent Services, and configure GeoEvent Definitions used to interpret incoming GeoEvents” (ESRI, 2014e) (Figure 1).

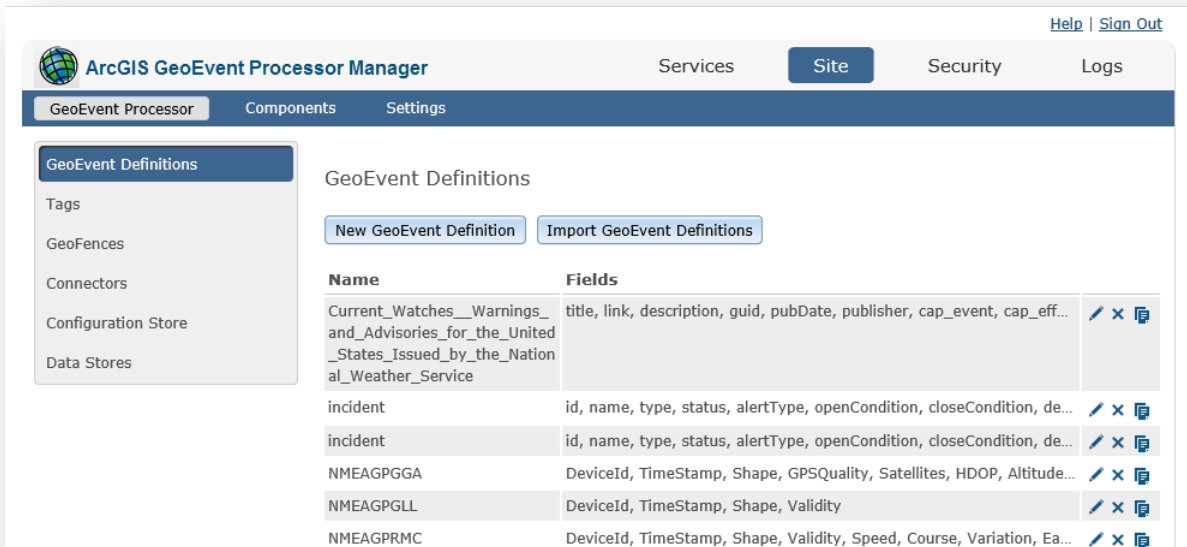


Figure 1 - GeoEvent Processor Manager

GeoEvents contain information about things that happen and where they happened, such as a Tweet with a GPS location. Input connectors receive and interpret GeoEvents. GeoEvent Services organize the incoming GeoEvents, perform analysis, and route the results to the appropriate Output Connector (Figure 2).



Figure 2 - GeoEvent Processor Workflow

Within the GeoEvent Service, GeoFences, Processors, and Filters perform the analysis. GeoFences are virtual polygon boundaries used to define areas of interest (Rouse, 2013). GeoFences can be defined by the user and represent areas that the user wishes to monitor such as project boundaries, or severe weather extents. Processors perform actions against GeoEvents such as adding, removing, or calculating new fields (ESRI 2014b). Filters are used to check incoming GeoEvent attributes (ESRI 2014b). A filter can monitor attributes such as vehicle speed, trip duration, or flight altitude. After a GeoEvent has been

analyzed, Output Connectors push the results to the appropriate output (i.e. e-mail, text message, and / or update feature service, etc.) for end users to consume (ESRI 2014b).

GeoEvent Definitions define the “expected schema for event data (input) being received and allow GeoEvent Processors to interpret the event data and construct the GeoEvent.” (ESRI, 2014e) In other words the GeoEvent Definition must exactly match the input data schema being received.

Data stores contain a list of registered system folders and ArcGIS Server instances which contain source data for inputs, GeoFences, and outputs (ESRI 2014b).

## 4.0 APPROACH

To meet the objectives described in section 2.0 a GIS based system using a combination of ESRI GeoEvent Processor, ArcGIS Server, Operations Dashboard, and ArcGIS Online for Organizations was tested. The projects overall architecture is shown in Figure 3.

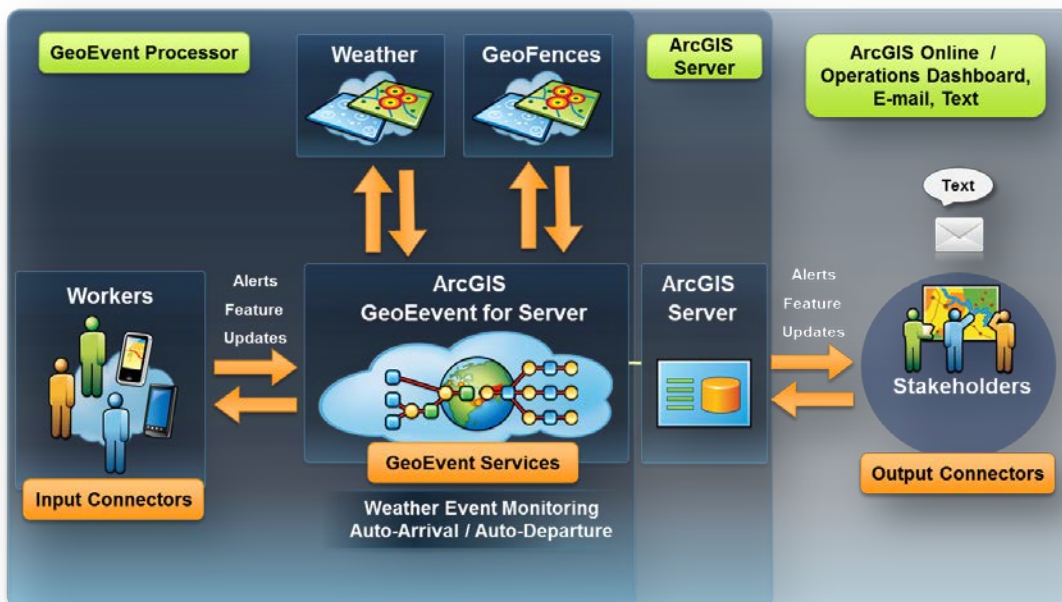


Figure 3 - Weather Monitor High Level Workflow

Looking at Figure 3 the GeoEvent workflow begins with worker location coordinates (GeoEvent) along the far left of the diagram. Input connectors receive the coordinate data and move the GeoEvent to the GeoEvent Service. Within the GeoEvent Service the GeoEvent is analyzed against the various processors, filters, and GeoFences developed for the project. Once the GeoEvent has been analyzed it is then transformed and shared with stakeholders. Output Connectors handle transforming the GeoEvent into the required output format, including email, and updating a feature service.

The mapping component of the Weather Monitor System is accessed through Operations Dashboard. Applications such as Operations Dashboard are specifically designed to integrate maps, charts, and graphs to provide a common view of real-time data feeds. The Operations Dashboard can be shared within the organization and accessed through any web client (e.g. Internet Explorer).

## 4.1 Preparation

A local system file folder and ArcGIS Server were registered with the data store. The local system file folder, “inputs”, holds the .CSV file(s) that contain the GeoEvent data for this project. Each .CSV file contains attributes for; Time, Latitude, Longitude, Elevation, Accuracy, Bearing, Speed, and Worker ID. The local ArcGIS Server contains the feature services used to represent the project GeoFences (Figure 4).

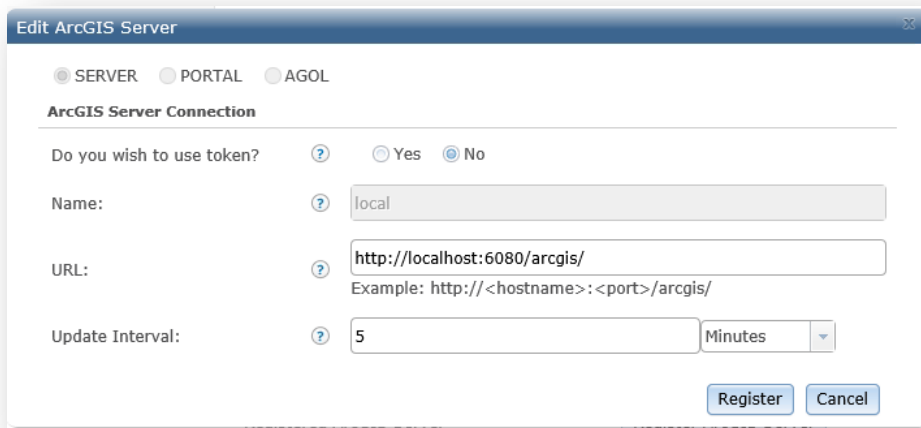
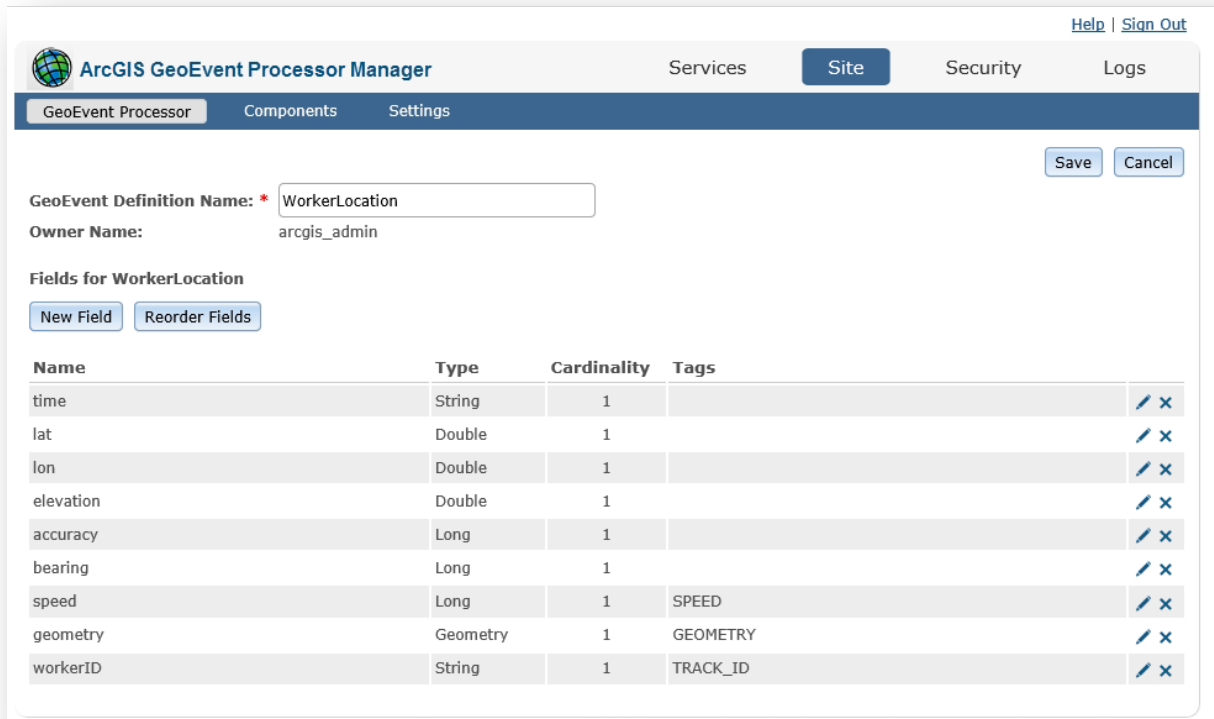


Figure 4 - Registering a ArcGIS Server with GeoEvent Processor

GeoEvent Definitions for worker locations, alerts, thunderstorm warnings, and tornado warnings were developed and established with the GeoEvent Processor Manager. The GeoEvent Definition for worker locations is shown in Figure 5. As described in section 3.0 the GeoEvent Definition identifies the attribute fields and data types for a given GeoEvent. The data type “Geometry” contains the spatial information (XY coordinates) needed to plot the GeoEvent. The tag “Track\_ID” is given to the field that contains the unique identifier for each record in a GeoEvent.





**Figure 5 - GeoEvent Definition**

GeoFences were created from feature services on the local ArcGIS Server for project boundaries, thunderstorm warnings, tornado warnings, and National Weather Service (NWS) public alerts. The project boundaries feature service contains the AOIs defined by the project and were preloaded into the system or generated “on-the-fly” through ArcMap or the Operations Dashboard.

To generate the thunderstorm warnings, tornado warnings, and NWS public alerts GeoFences, a Python script was developed to monitor the GIS Rest services application programming interface (API) for each feature and return a .JSON file (Figure 6). URL links to the Rest services are provided in the Reference section of this document.

```

import urllib
#import time
#timestr = time.strftime("%Y%m%d_%H%M%S")
f = "NOAA_Warnings.json"# + timestr + ".json"
r = urllib.urlopen(r"http://tmservices1.esri.com/arcgis/rest/services/"\
                  "LiveFeeds/Weather_Warnings_Watches_Advisories_Statements/"\
                  "MapServer/0/query?f=json&where=1%3D1&outFields=EVENT,objectid,"\
                  "inc_desc&outSR=4326&maxAllowableOffset=0")
values = r.read()

if values.find("Unable to complete Query operation") <> -1:
    print "Unable to complete Query operation."
else:
    print "OK"
    jsonFile = open(r"C:\GeoEvent\Input\NOAA_Warnings\\" + f, "w")
    jsonFile.write(values)
    jsonFile.close()

```

Figure 6 - Python Script 1 Fetch .JSON

Another Python script converts the .JSON file to a Feature Class, deletes the old Feature Class, and updates the registered ArcGIS Server with the new Feature Class (Figure 7).

```

# NWS_Public_Alerts_json_to_FC.py
# Created on: 2014-10-01 20:04:36.00000
# (generated by ArcGIS/ModelBuilder)
# Description:
# -----

# Import arcpy module
import arcpy

# Local variables:
NWS_Public_Alerts_json = "C:\\GeoEvent\\Input\\NOAA_Warnings\\NWS_Public_Alerts.json"
SDE102_DBO_NWS_Public_Alerts = "Database Connections\\Connection to mis1-vm-db.sde\\"/
                              "SDE102.DBO.WeatherMonitor_1\\SDE102.DBO.NWS_Public_Alerts"
NWS_Public_Alerts_shp_2_ = "C:\\GeoEvent\\Input\\NOAA_Warnings\\NWS_Public_Alerts.shp"
NWS_Public_Alerts_shp = "C:\\GeoEvent\\Input\\NOAA_Warnings\\NWS_Public_Alerts.shp"
SDE102_DBO_NWS_Public_Alerts_4_ = "Database Connections\\Connection to mis1-vm-db.sde\\"/
                              "SDE102.DBO.WeatherMonitor_1\\SDE102.DBO.NWS_Public_Alerts"

# Process: Delete
arcpy.Delete_management(NWS_Public_Alerts_shp_2_, "ShapeFile")

# Process: JSON To Features
arcpy.JSONToFeatures_conversion(NWS_Public_Alerts_json, NWS_Public_Alerts_shp)

# Process: Delete Features
arcpy.DeleteFeatures_management(SDE102_DBO_NWS_Public_Alerts)

# Process: Append
arcpy.Append_management("C:\\GeoEvent\\Input\\NOAA_Warnings\\NWS_Public_Alerts.shp",
                        SDE102_DBO_NWS_Public_Alerts_4_, "TEST", "", "")

```

Figure 7 - Python Script 2 Convert .JSON to Feature Class

Using Windows Task Scheduler the Python scripts were set-up to run every 5 minutes. GeoEvent Processor checks the registered ArcGIS Server at 5 minute intervals and updates the GeoFences with the latest warning data. Figure 8 shows the workflow for updating GeoFences.

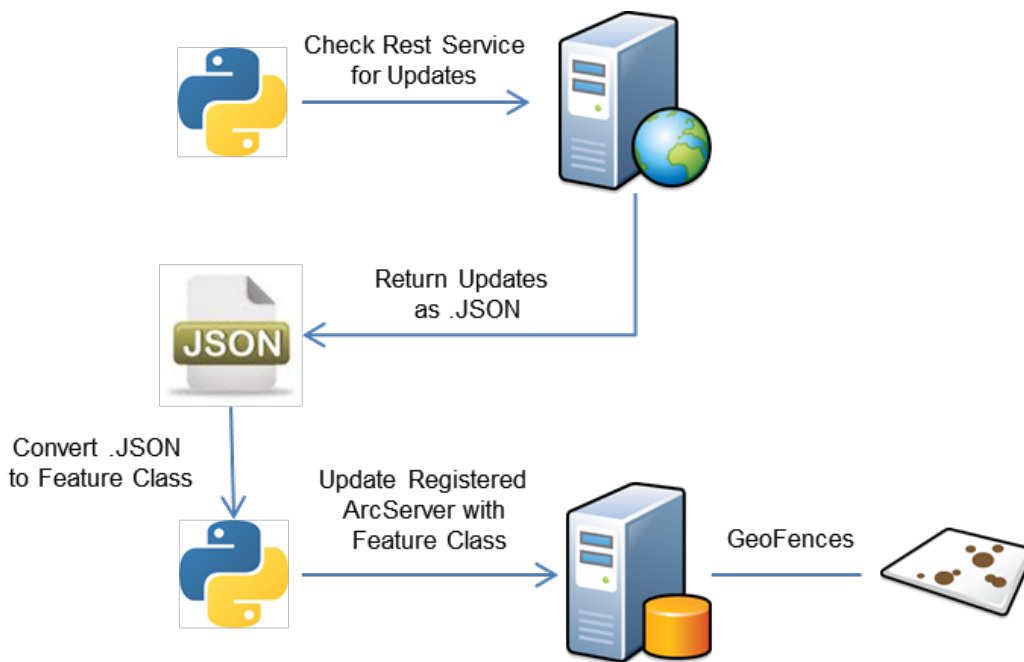


Figure 8 - Update GeoFence Workflow

## 4.2 Inputs

Location information was collected from worker cell phones using GPS Logger. GPS Logger is a free application (App) that allows users to collect GPS location information and automatically send the data to user specified locations including e-mail, FTP, and Dropbox at defined intervals (Mendhak, 2014) (Figure 9).

GPS coordinate and attribute data was collected every 5 minutes and sent as a .CSV file to an FTP site. GPS Logger collects the following data fields: Time, Latitude, Longitude, Elevation, Accuracy, Bearing and Speed.

To uniquely identify the input .CSV files, each .CSV file was given a custom file name that included the worker ID, device serial number, year, month, day, hour, and minute (e.g. Worker02U243E42201410051330.csv)

In preparation for input into GeoEvent Processor the .CSV file was modified and moved to the registered local data store folder "inputs". A Python script was developed that automatically adds a

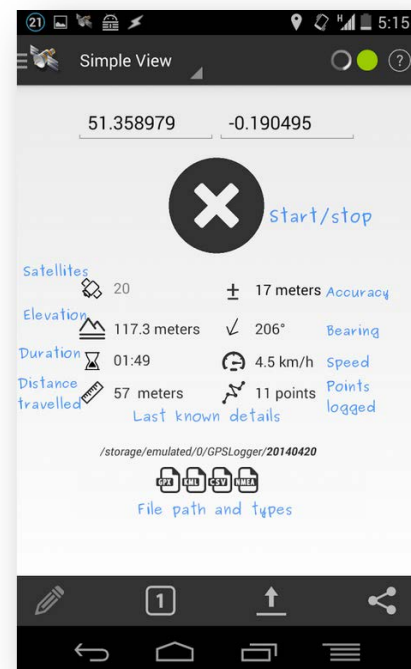


Figure 9 - GPS Logger (Retrieved from <https://play.google.com/store/apps/details?id=com.mendhak.gpslogger&hl=en> December 7th 2014)

new column containing the worker ID, removes the column heading names, and moves the .CSV file to the registered “inputs” folder. The Python script was deployed at 5 minute intervals using Windows Task Scheduler (Figure 10).

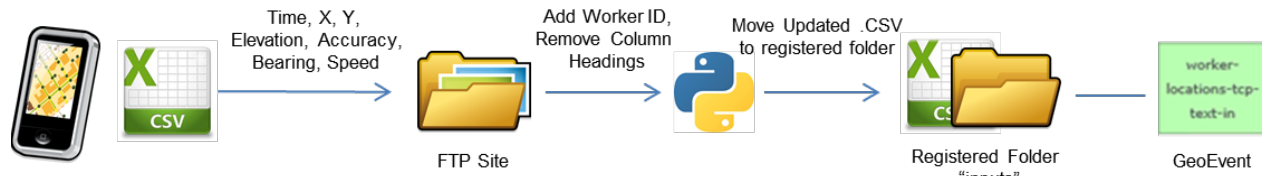


Figure 10 – Input GeoEvent Workflow

### 4.3 GeoEvent Services

The GeoEvent Service Designer, a tool similar to model builder, is used to connect the incoming GeoEvent(s) to Filtering and Processing rules and then route the results to the appropriate outputs as the GeoEvent are streamed into the system (Figure 11).

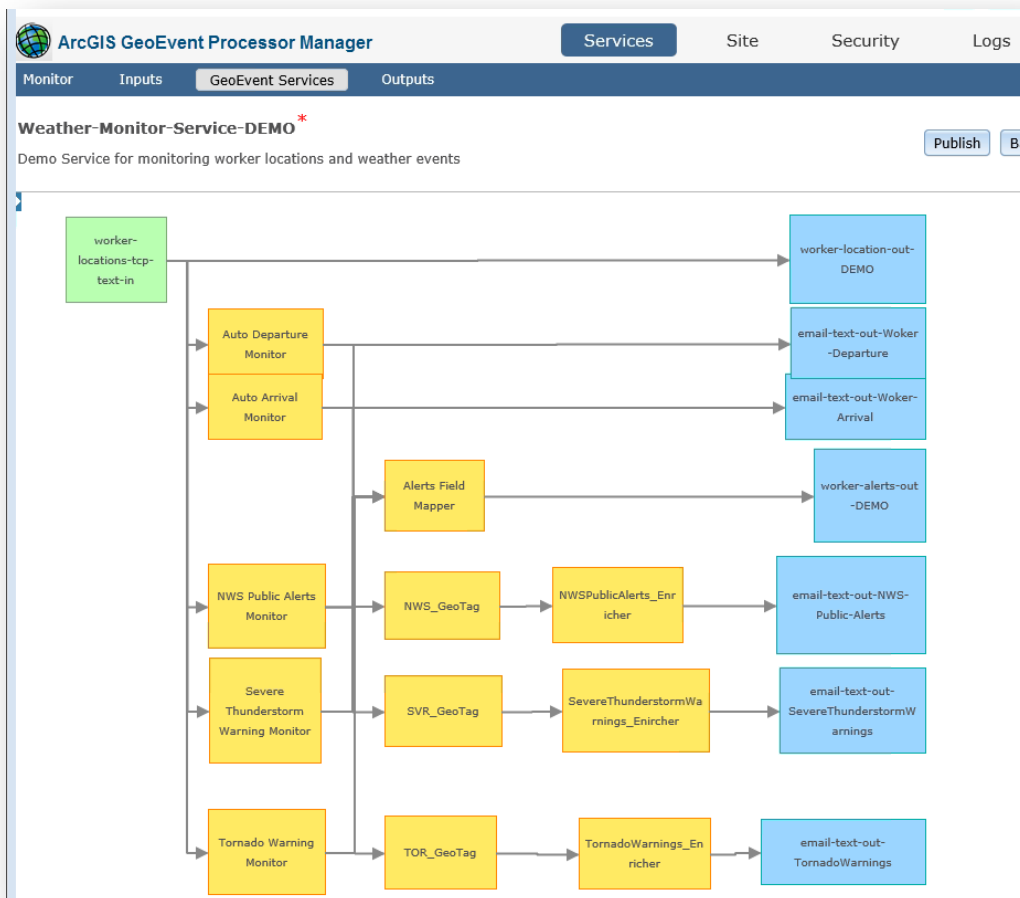


Figure 11 - GeoEvent Service Designer (Green = Input, Yellow = Processors, and Filters, Blue = Outputs)

Incident Detector Processors check worker locations geometry (XY's) against the GeoFences. When the geometry ENTERS or EXITS a particular GeoFence, it triggers GeoEvent Processor to issue an alert. The severity of the alerts are: Notification, Warning, or Urgent. The following Incident Detectors were defined for this project:

- Auto Arrival Monitor – checks for when worker location geometry (XY) ENTERS the project boundary GeoFences and issues a Notification level alert.
- Auto Departure Monitor – checks for when worker location geometry (XY) EXITS the project boundary GeoFences and issues a Notification level alert.
- NWS Public Alerts Monitor – checks for when worker location geometry (XY) ENTERS the NWS Public Alerts GeoFences and issues a Notification level alert.
- Severe Thunderstorm Warning Monitor – checks for when worker location geometry (XY) ENTERS the Severe Thunderstorm GeoFences and issues a Warning level alert.
- Tornado Warning Monitor – checks for when worker location geometry (XY) ENTERS Tornado Warnings GeoFences and issues an Urgent level alert.

For GeoEvent Processor to correctly update the alerts feature service Output, the incoming GeoEvent Definition (data schema) must match exactly to the alerts feature service data schema. A Field Mapper Processor, “Alerts Field Mapper”, was used to align the input data schema with the alerts output data schema (Figure 11).

GeoTagger Processors append GeoFence attributes to GeoEvents based on spatial relationships and create a new GeoEvent Definition. For example, if a GeoEvents geometry is within a GeoFence the containing GeoFences name can be appended as a new attribute value. The following GeoTagger Processors were used:

- NWS GeoTag – appends the OBJECTID attributes from the NWS Public Alerts GeoFences to the GeoEvent.
- SVR GeoTag – appends the OBJECTID attributes from the Severe Thunderstorm Warning GeoFences to the GeoEvent.
- TOR GeoTag – appends the OBJECTID attributes from the Tornado Warning GeoFences to the GeoEvent.

Field Enricher (feature service) Processors perform join operations. Using a Field Enricher (feature service) Processor, attributes from a GeoFence can be joined to a GeoEvent. The joined attribute information can then be made available to the end user. Three Field Enricher (feature service) Processors were developed for this project:

- NWS Public Alerts Enricher – joins attribute information (EVENT, INC\_DESC, and INC\_LINK) to the GeoEvent. The join is performed based on the OBJECTID and results in a new GeoEvent Definition. The EVENT attribute provides information on the type of

Public Alert (e.g. Flood Advisory, Tornado Watch, etc.). INC\_DESC contains the NWS description of the event, and INC\_LINK contains the link to the alert statement online.

- Severe Thunderstorm Warnings Enricher – joins attribute information (WFILE) to the GeoEvent. The join is performed based on the OBJECTID and results in a new GeoEvent Definition. WFILE contains a link to the NWS Severe Thunderstorm statement online.
- Tornado Warnings Enricher – joins attribute information (WFILE) to the GeoEvent. The join is performed based on the OBJECTID and results in a new GeoEvent Definition. WFILE contains a link to the NWS Tornado Warning statement online.

## 4.4 Outputs

Two types of Outputs were used for this project: Update a Feature, and Send an Email. All Outputs are shown in Figure 11 as blue boxes. The Update a Feature Service Outputs includes the following:

- Worker-location-out-DEMO – updates the worker location feature service with the XY coordinate information provided from the input .CSV file
- Worker-alerts-out-DEMO – updates the alerts feature service and is symbolized based on the severity of the alert as described in Section 4.3 of this document.

The resulting updated worker locations and alerts are symbolized on an Operations Dashboard (Dashboard)

map. Worker locations are symbolized with a worker icon, while alerts are symbolized based on their severity (Figure 12).

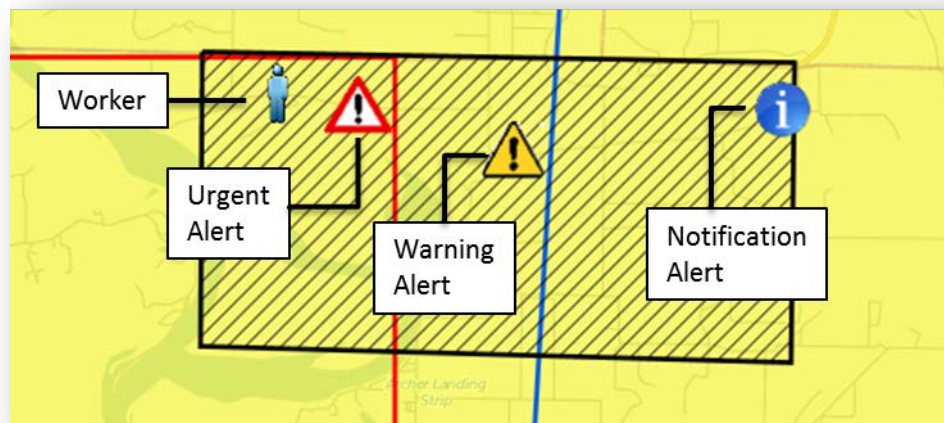


Figure 12 - Symbolizing Worker and Alert Features

In addition to displaying the worker locations and alerts on a map, information is also passed along to the project managers and field workers via email (Figure 13). The email notifications include the type of warning (i.e. Severe Thunderstorm), and a URL link to the official alert from the National Weather Service. The following email Outputs were defined for this project:

- Email-text-out-Worker-Arrival – sends an email to the Project Manager (PM) when the worker location geometry ENTERS a Project Boundary GeoFence.

- Email-text-out-Worker-Departure – sends an email to the PM when the worker location geometry EXITS a Project Boundary GeoFence.
- Email-text-out-NWS-Public-Alerts – sends an email containing the EVENT, INC-DESC, and INC\_LINK attributes to the PM and field workers.
- Email-text-out-SevereThunderstormWarnings – sends an email containing the WFILE attribute information to the PM and field workers.
- Email-text-out-TornadoWarnings – sends an email containing the WFILE attribute information to the PM and the field workers.

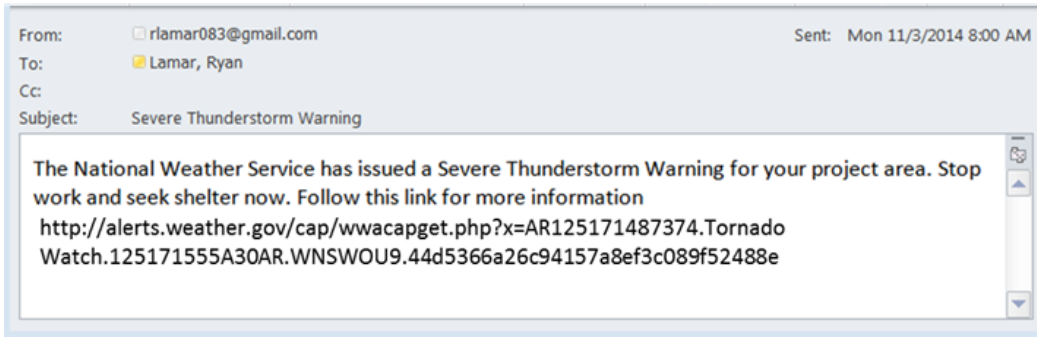
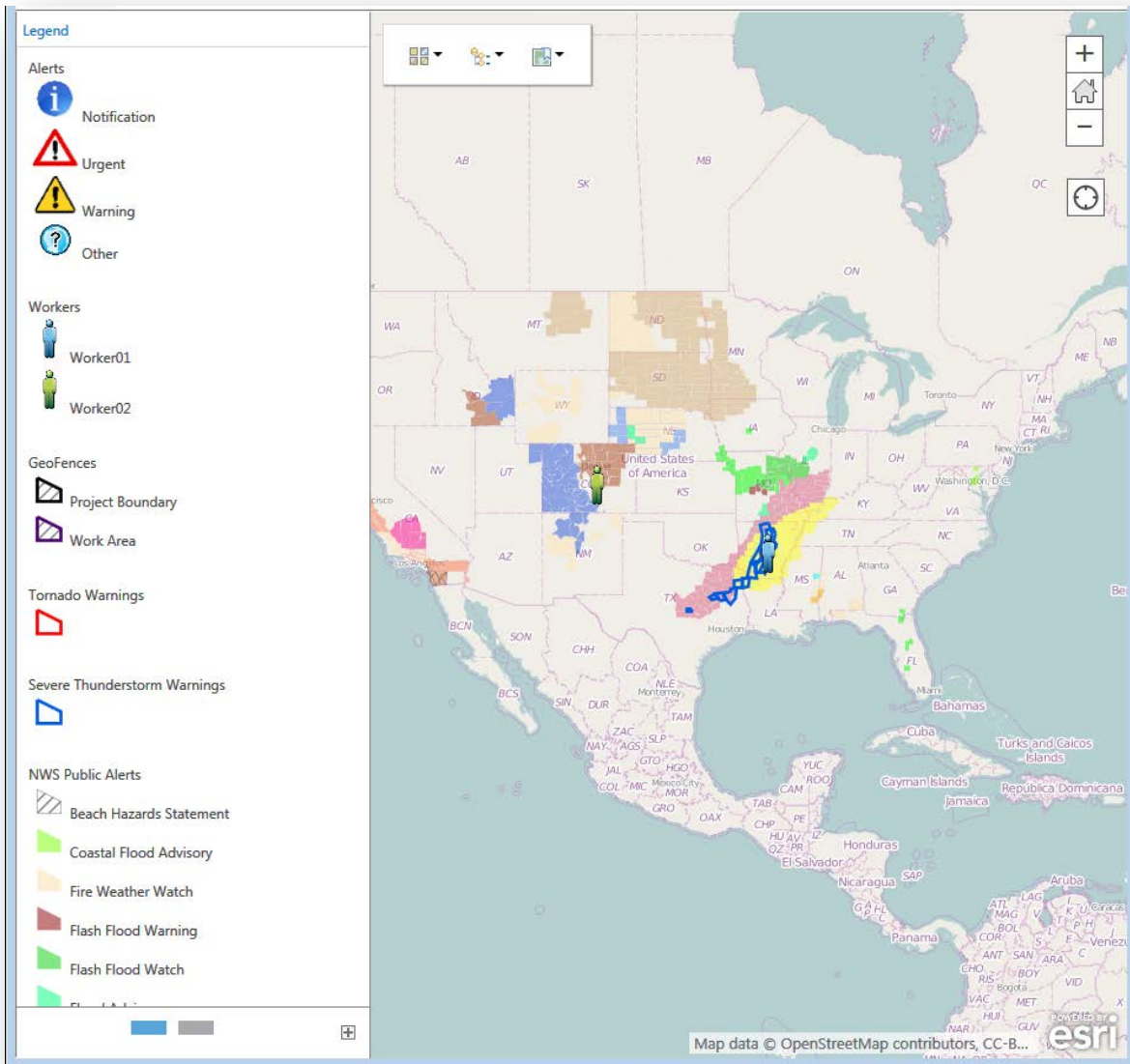


Figure 13 – Email Notifications

## 5.0 INTERACTING WITH THE SYSTEM

An Operations Dashboard was developed to interactively display the project layers, worker locations, and alerts (Figure 14). The Dashboard serves as the primary portal for monitoring weather conditions, checking for updates, and evaluating the safety of field workers. To maintain confidentiality regarding worker locations, the Dashboard is accessed via a web link and only made available to employees within an organization’s ArcGIS Online subscription. Additional users can be added on a case by case basis.



**Figure 13 - Weather Monitor Operations Dashboard**

Alerts, Worker Locations, GeoFences, Tornado Warnings, Severe Thunderstorm Warnings, and NWS Public Alert features are all clearly and prominently symbolized on the map. As shown in Figure 15, additional information associated with any of the project layers can be accessed by clicking on the feature on the map. A popup will appear displaying the feature attributes.



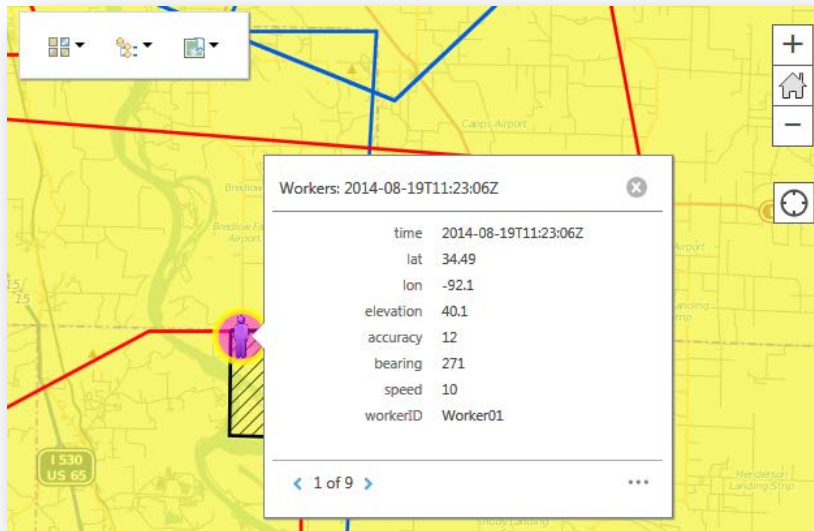


Figure 14 - Feature Attributes

## 6.0 EVALUTATION RESULTS

As anticipated, the system developed provides an automated and somewhat flexible means for monitoring changing weather conditions, and continuously evaluate the safety and wellbeing of field workers. Though the system technically meets the stated project objectives, working with GeoEvent Processor was not as easy as originally expected. Table 1 provides a breakdown of the evaluation.

Table 1 - GeoEvent Processor Evaluation

Criteria	Ranking		
	Needs Improvement	Neutral	Meets Expectations
Extension Maturity		✓	
Privacy Issues		✓	
Data Schema & Workflows			✓
Hardware / Software Requirements			✓
External Services	✓		
Additional Feature Detection	✓		

The criteria ranking categories are;

- Needs Improvement – Criteria does not perform at an acceptable level or is inconsistent in it's performance and needs improvement to meet expectations.

- Neutral – Criteria neither needs improvement nor does it quite meet expectations.
- Meets Expectations – Criteria performed as expected and documented.

As a new extension GeoEvent Processor has only been out for a little more than one year. During the investigations we could only find a few good use cases. Rochester Public Utilities in NY has been successfully using GeoEvent Processor as part of their network fleet with Verizon Wireless to provide better service to their customers (Verizon 2013). The user community is small, but growing and ESRI provides several resources for learning GeoEvent Processor including self-paced tutorials (ESRI 2014e). Taking into account these elements, we gave Extension Maturity criterion a neutral rating.

Going into the project we were concerned that privacy may be a problem. Tracking worker locations may make some employees feel a bit uneasy. However for the most part this seemed to be a non-issue. Several factors worked in our favor. Many employees already download apps on their phones that track location information and use it for other purposes, so one more app wasn't a big deal. In addition, with an explanation of the purpose of what we were doing with the data, most users were happy to participate in a system that helps improve health and safety within the organization. Based on our interactions with employees during the project Privacy Issues criterion doesn't appear to be a problem, nor does it need improvement, thus it has a neutral rating.

Understanding your data's schema and developing your proposed workflow are essential when working with GeoEvent Processor. The input data schema and output data schema are critical for understanding how your GeoEvent Services will work and what types of processors and/or filters you need to apply. This point is well made and reinforced throughout the tutorials, though it may be easy to overlook when working with tutorial data. Based on the documentation and reinforcement presented we felt that the Data Schema & Workflow criterion meets expectations.

Even though we in the GIS field may see access to GIS technology as common not all organizations have the resources or technical know-how to implement this type of project. Still the hardware and software requirements for using GeoEvent Processor are well stated and documented, which led us to conclude that the Hardware / Software Requirements criterion also meets expectations.

Working with external services is the cornerstone for working with GeoEvent Processor. Unfortunately it is also the component that caused the most difficulties when developing this project. Several problems related to external services evolved over the course of the project.

1. Stability of external services
2. Ability to pass attributes from a GeoFence to a Feature Service, and
3. Data "freshness" (How old the data is)

As a consumer of external services you may not have control over the resources being used to gather, maintain, or share the data you are trying to access. If a service you are trying to access goes down, or if the service generates a larger result than anticipated it may cause your GeoEvent Services to not function properly or at all.

In our case, we discovered that when working with GeoFence requests to external ArcGIS services, if a request returns an error from the host service, GeoEvent Processor does not know how to interpret the error and will drop the entire GeoFence layer from its GeoFence cache. Thus, even though we could visually see the representation of the GeoFences on the map the GeoFence boundaries did not exist in the GeoEvent Service. Consequently when the workers entered the GeoFences no alerts were triggered. Figure 8 in Section 4.1 describes the methodology developed to overcome this limitation with GeoEvent Processor. The Python Script being used to make the request to the external service (Figure 6) contains the logic to handle an error without causing GeoEvent Processor to drop the GeoFence cache.

Typically the features being used to represent a GeoFence contain attribute information that may be important to pass along to the end consumer. Presently GeoEvent Processor only recognizes the geometry of a GeoFence and does not maintain the GeoFences' associated attributes. Only attributes from a Feature Service can be passed to Outputs. Figure 7 shows the Python Script developed to convert the .JSON request file to a local Feature Service. Using a series of GeoTagger and Field Mapper Processors, we were then able to join the attributes from the GeoFence layer to the GeoEvent so that they may be passed along to the Output. Section 4.3 describes the process for joining the attribute information.

External services may also determine how often your GeoEvent Services should be updated. For this project the "refresh" time was set to 5 minute intervals to accommodate capturing the most current NWS Public Alerts. According to the REST Service description, the NWS Public Alerts service is refreshed and updated every 5 minutes (ESRI, 2014i), therefore capturing worker location information at more frequent intervals wouldn't yield any benefit. Additionally, the Severe Thunderstorm Warning and Tornado Warning information is only updated on an hourly basis (ESRI, 2014j).

Based on the difficulties described above, we feel that working with External Services is an area that GeoEvent Processor needs improvement in. During the project we were able to work with ESRI to develop an Enhancement Request to "allow GeoFences to contain attribution as well as geometry (Support 2014). This should allow attributes to be passed from a GeoFence to an Output without having to create a separate standalone Feature Service. In the future we would like to submit an Enhancement Request for GeoEvent Processor to properly handle errors from external services and not drop GeoFence layers from the GeoFence cache.

The initial work plan that was proposed called for developing two potential use cases, static and predictive, and to evaluate the use of nowcasting technology as a means for enhancing the predictive analysis. The predictive case analysis and evaluation of nowcasting technology in the initial work plan

relied upon being able to use GeoEvent Processor to assess intersecting polygons. However, due to limitations with the technology the project goals had to be modified.

The current release of GeoEvent Processor (ArcGIS 10.2.x) does not support polygon on polygon detection unless one polygon fits wholly within the other. However ESRI has posted that this functionality along with a list of others will be available with the release of ArcGIS 10.3 (LaMar, 2014).

Though it is good to know that ESRI does plan on adding additional feature detection in future releases, we still rated the Additional Feature Detection criterion as needing improvement.

## **7.0 CLOSING**

Consuming live data streams is not a new concept in GIS, but it has traditionally been somewhat difficult to accomplish. GeoEvent Processor is designed to simplify working with streams of data. Our investigations confirmed that GeoEvent Processor offers a relatively simplified approach for working real-time data streams, such as worker locations, and weather warning services. However working with more complicated data streams, or data streams with Input / Output connectors not yet developed still requires a healthy knowledge of programming.

It is anticipated that the GeoEvent Processor Extension will continue to evolve and improve with subsequent releases of the ArcGIS Platform. Despite some of the challenges encountered during this project, the GeoEvent Processor Extension is worth the investment if you are planning on working with real-time data.

A tutorial and associated data files for developing the Weather Monitor Service are available on GitHub through the following link <https://github.com/lamar083/GeoEvent-Processor>.

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