OAK RIDGE National Laboratory

Update on Aircraft Impact Analysis Using FAA Radar Data

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Research Reactors Division

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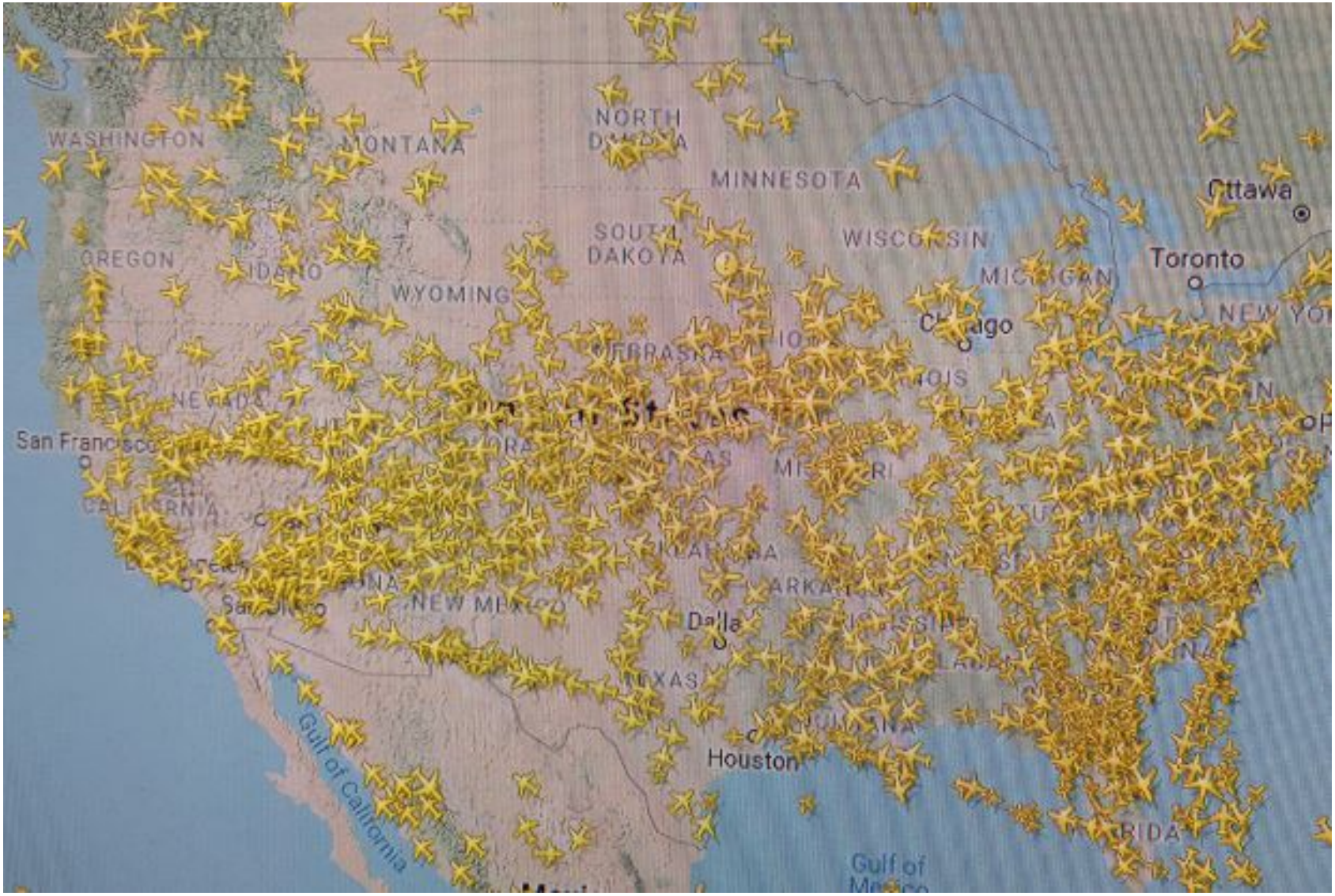
Publication ID: 137725

Radar Data

Flightradar24



Why FAA Radar Data

- **DOE-STD-3014**, NUREG 0800 Based on outdated Flight Data
  - AA Handbook, DNFSB Letter, recommend **updated analyses/data**
- Aircraft Fly point to point, GPS – no longer limited to Airways
- General Aviation often flies VFR – **no flight plan filed** – not IFR
- Airports do not maintain flight data – **tracked on radar**
- Airport radar picks up aircraft transponder signal
- Radar Data - updated source of local aircraft operations **local aircraft density** (aircraft hrs. of operation/mi^2)
- Aircraft density used to determine **local Crash Frequency**
- Crash Data often sparse in local DOE areas
  - expanding crash radius to include more crashes removes site crash effect

Radar Data

AIRCRAFT_ID	SOURCE_FACILITY	ACFT TYPE	USER CLASS	LATITUDE	LONGITUDE	ALTITUDE x100ft	TRACK_POINT TIME_UTC
N91963	ZTL	C182	G	35.8044	-84.4425	70	1:20:45 AM
N91963	ZTL	C182	G	35.8019	-84.4508	70	1:20:33 AM
N91963	ZTL	C182	G	35.8014	-84.46	69	1:20:20 AM
N91963	ZTL	C182	G	35.8014	-84.4786	69	1:20:08 AM
N91963	ZTL	C182	G	35.8014	-84.4878	69	1:19:55 AM
N49WF	ZTL	SR22	G	35.7983	-84.0075	10	2:35:25 AM
N49WF	ZTL	SR22	G	35.7983	-84.0075	10	2:35:12 AM
N49WF	ZTL	SR22	G	35.8039	-84.0006	10	2:35:00 AM
N49WF	ZTL	SR22	G	35.8097	-83.9936	10	2:34:48 AM
N49WF	ZTL	SR22	G	35.8161	-83.9858	10	2:34:36 AM
GTI8126	ZTL	B744	C	35.82	-83.9914	410	1:26:32 AM
GTI8126	ZTL	B744	C	35.7983	-84.015	410	1:26:19 AM
GTI8126	ZTL	B744	C	35.7772	-84.0389	410	1:26:07 AM
GTI8126	ZTL	B744	C	35.7561	-84.0631	410	1:25:55 AM
GTI8126	ZTL	B744	C	35.7344	-84.0867	410	1:25:42 AM
EDV4194	ZTL	CRJ9	C	35.7989	-84.0061	10	2:56:31 AM
EDV4194	ZTL	CRJ9	C	35.8056	-83.9981	10	2:56:19 AM
EDV4194	ZTL	CRJ9	C	35.8122	-83.99	10	2:56:06 AM
EDV4194	ZTL	CRJ9	C	35.8122	-83.99	10	2:55:54 AM
EDV4194	ZTL	CRJ9	C	35.8197	-83.9808	10	2:55:42 AM

Aircraft ID - used to confirm aircraft type , crash rate

C182 – Cessna 182 Skyline

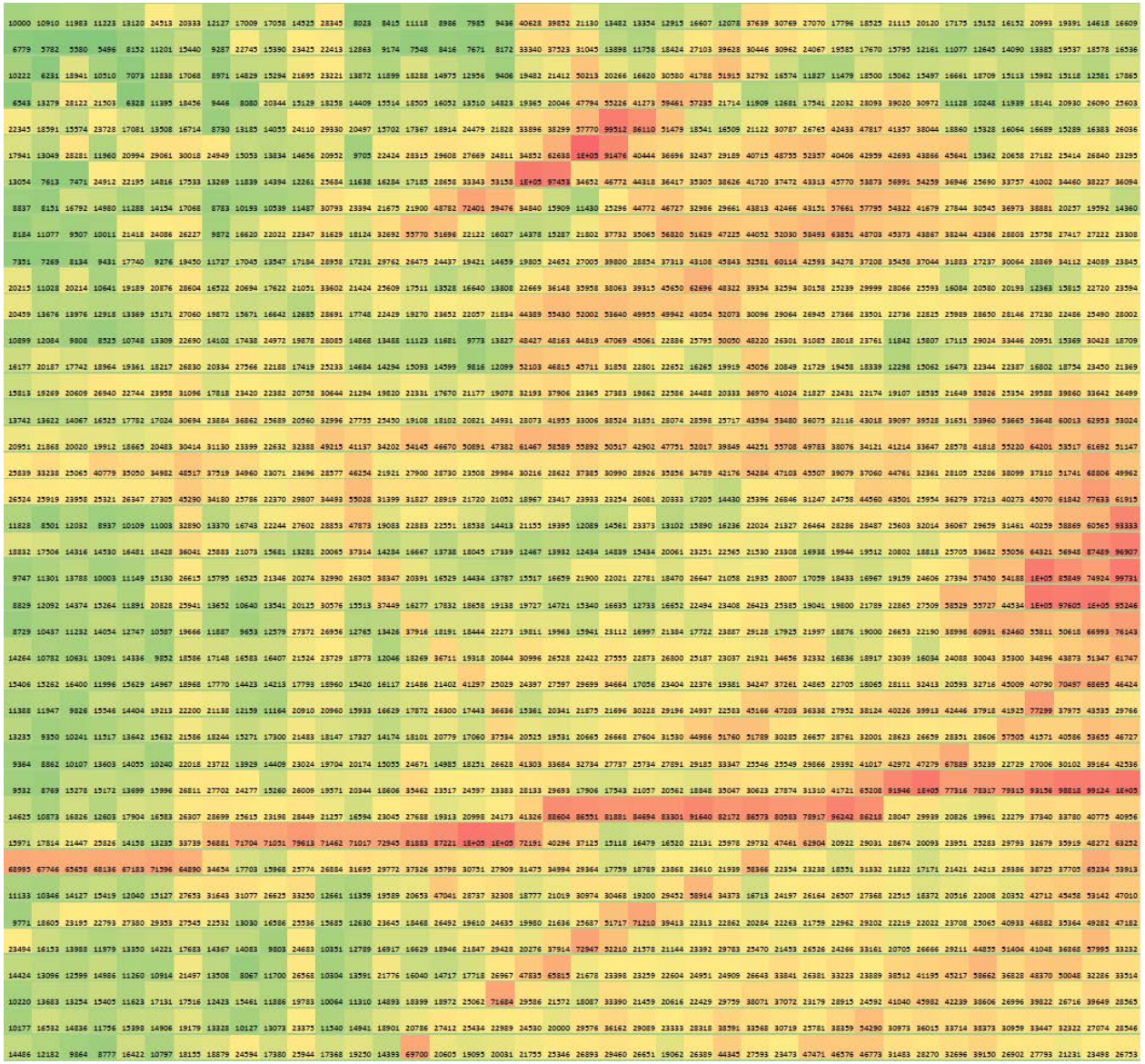
SR22 – Cirrus SR22

B744 – Boeing 747

CRJ9 - Canadian Regional Jet

Our First Attempt at Constructing a Flight Density Heat Map!

20 x 20-mi Heat Map of Local Aircraft Density in ½ mile Grid – ORNL (seconds)



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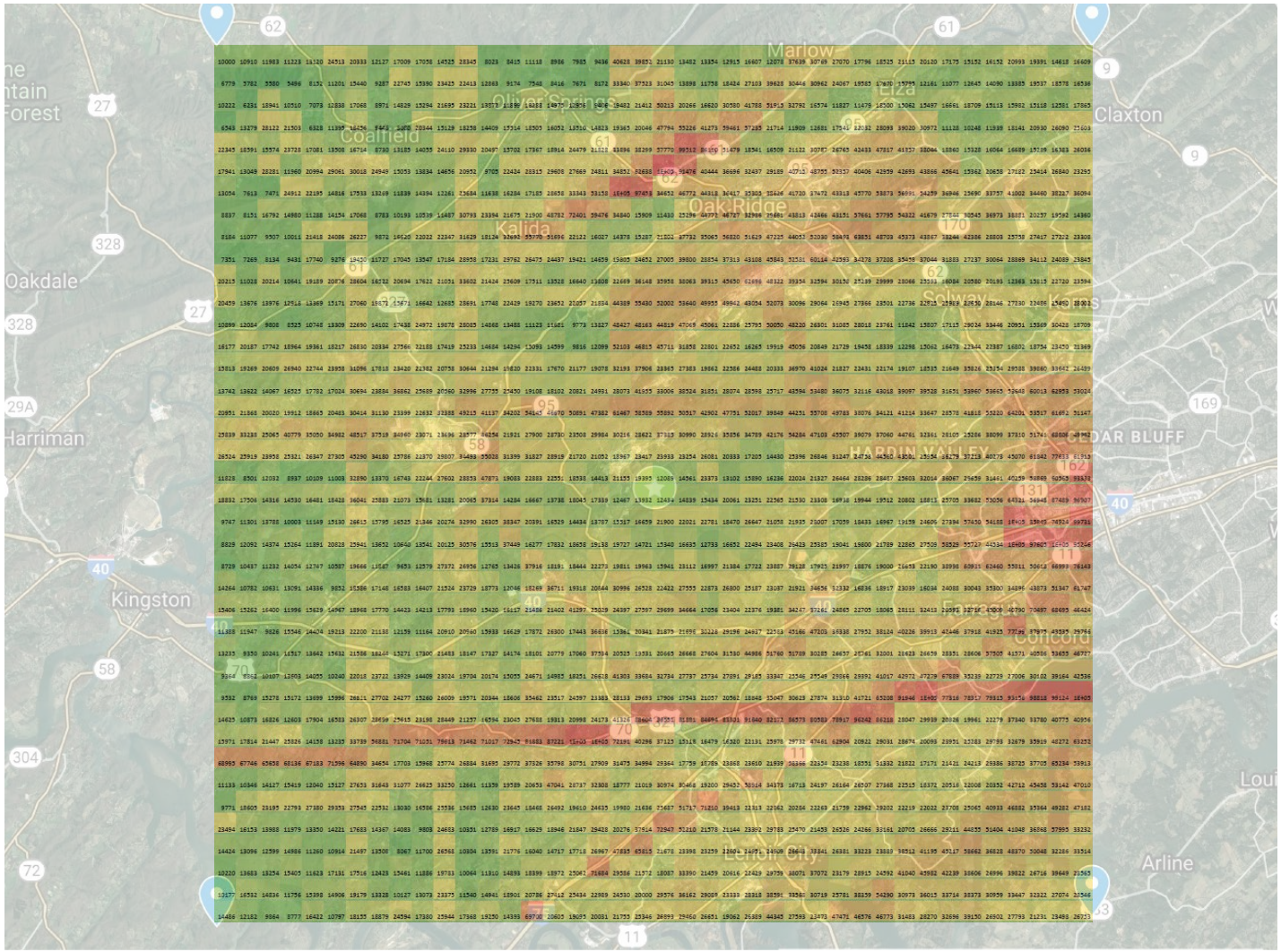
Excel Spreadsheet “Heat Map” + Google Maps = Our First Data Visualization!

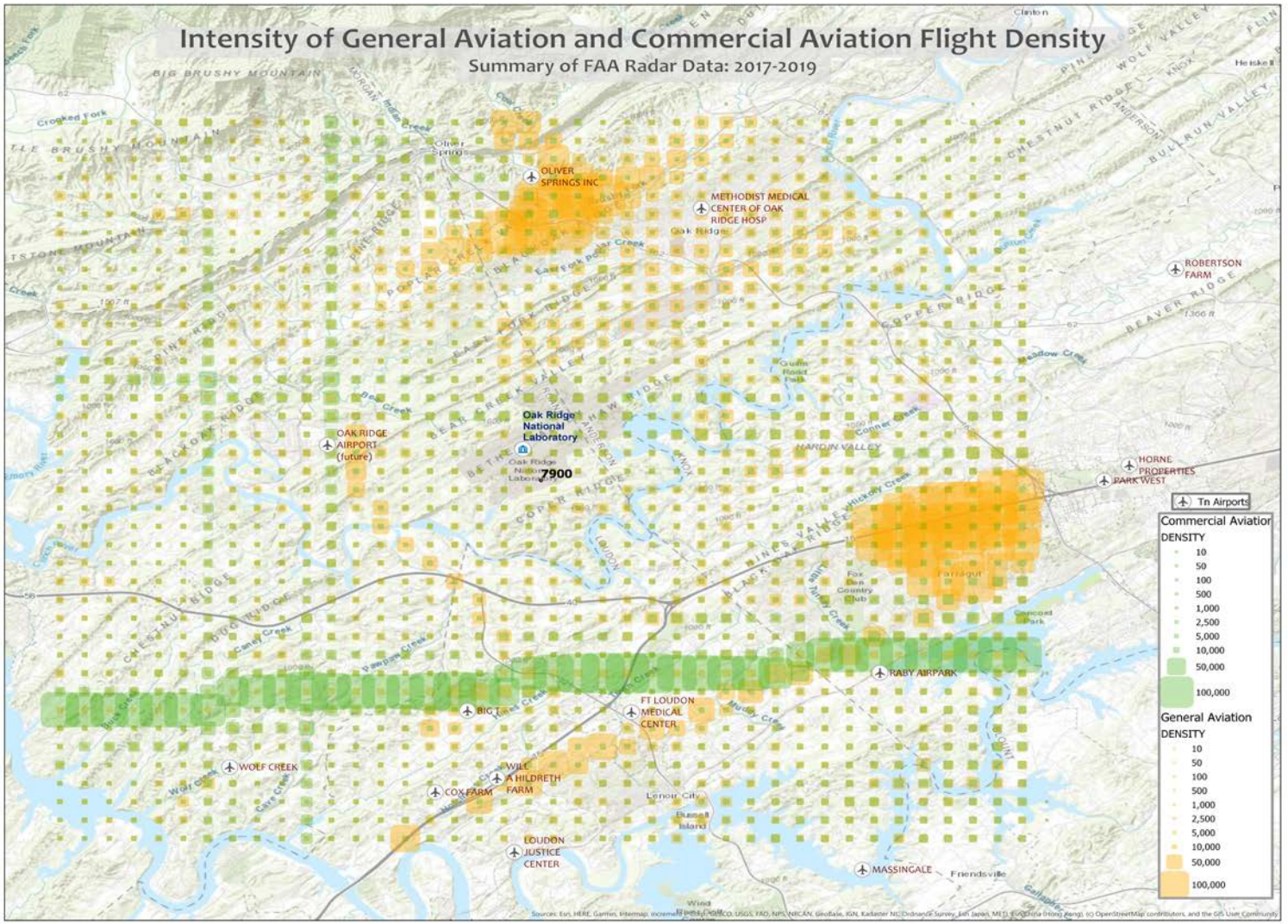
Map Underlay - 20 x 20 mi Heat Map Local Aircraft Density ½ mile Grid – ORNL (seconds)



Update on **Aircraft Analysis Methodology**

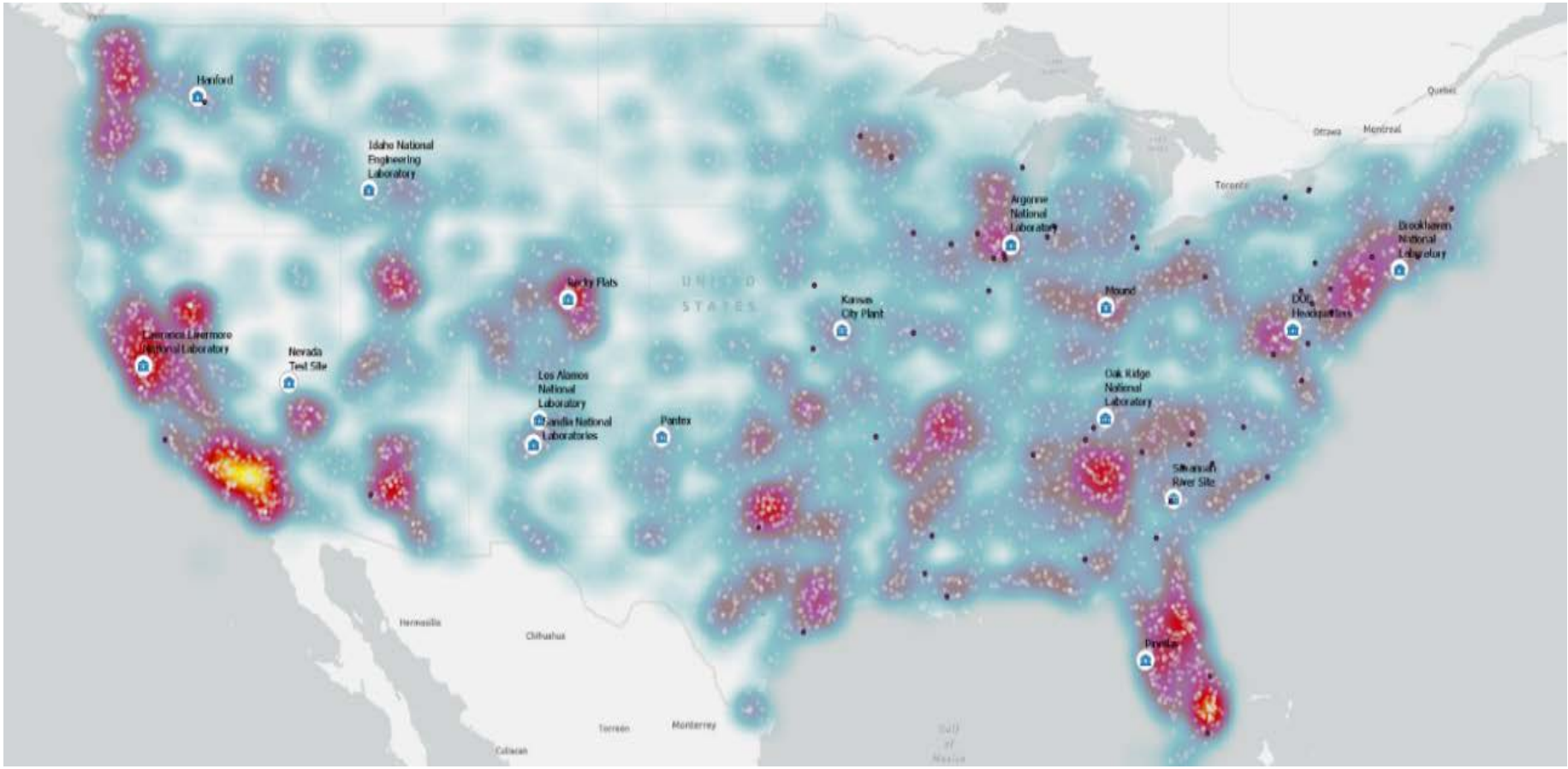
- **NRC participation** added to AAM Team (NUREG 0800)
  - Provided NUREG 0800 Data Source – WASH-1400 (1975)
    (1964 to 1968 flight data – fatal crash basis – 3,993 fatal accidents)
- **GIS Heat Mapping** Application (Geographic Information System)
  - Map NTSB Crash Data , FAA Radar Data
- **FAA/MCAID Approval** for **Military Radar Data**
  - Unfiltered Radar Data - 213 Types of Military Aircraft, 7% of ORNL Data
- **SQA** of **ATAP** Initiated – Aerial Tracking Analysis Platform
  - V&V initiated, LLNL – C. Zampella
- **New FAA Data** Received – including unfiltered Military Aircraft
  - Atlanta Hartsfield-Jackson International Airport
  - Argonne National Laboratory
  - Hanford Site
  - Lawrence Livermore National Laboratory:
  - Pantex Plant
  - Savannah River Site

When We Finally Got GIS Help…

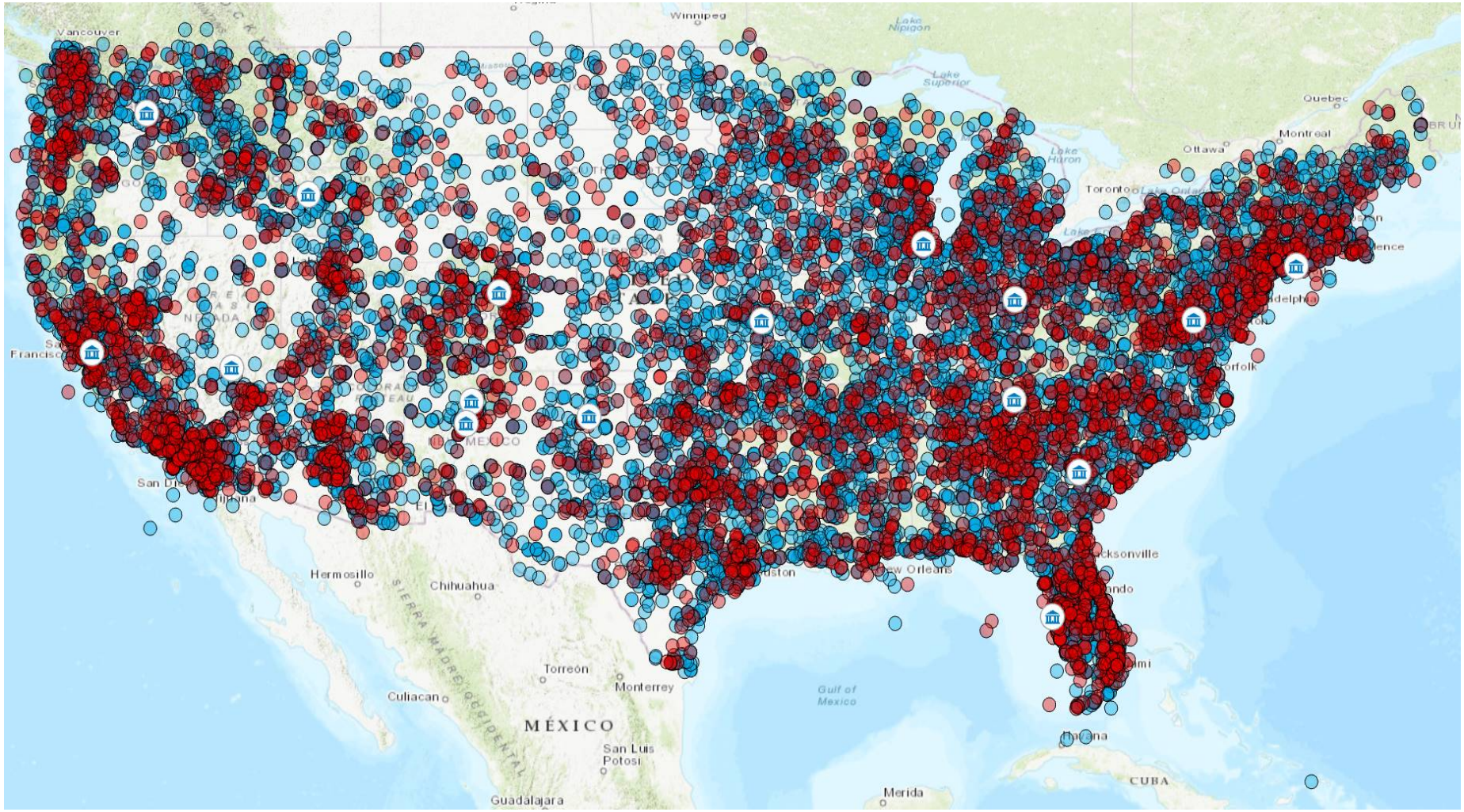


GIS Heat Map of General Aviation Crashes: Non-Airport Events

(1/2000 - 10/2018) (ArcGIS Pro)



All Fatal (Red) / Non-Fatal (Blue) GA crashes since 2000



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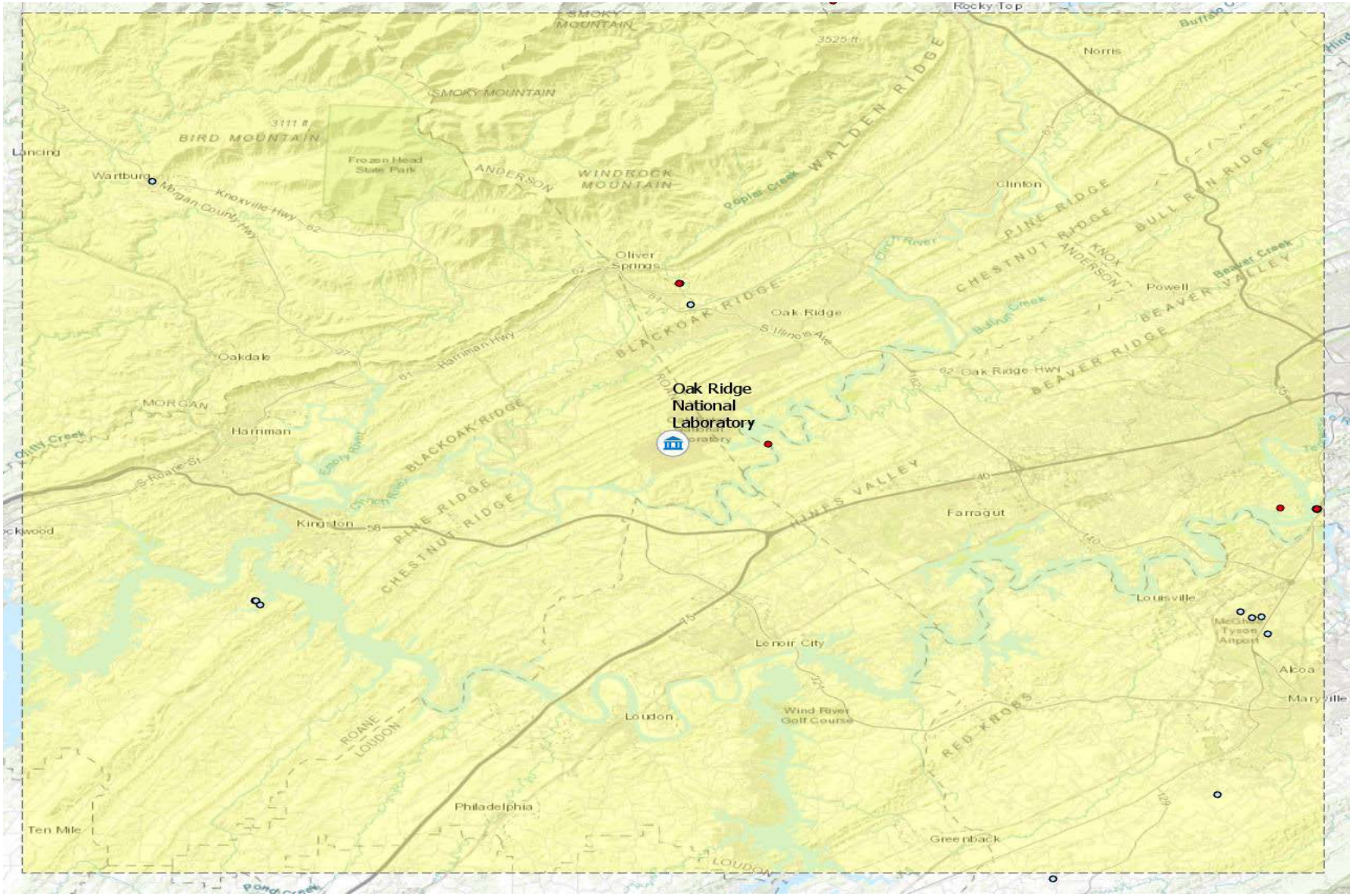
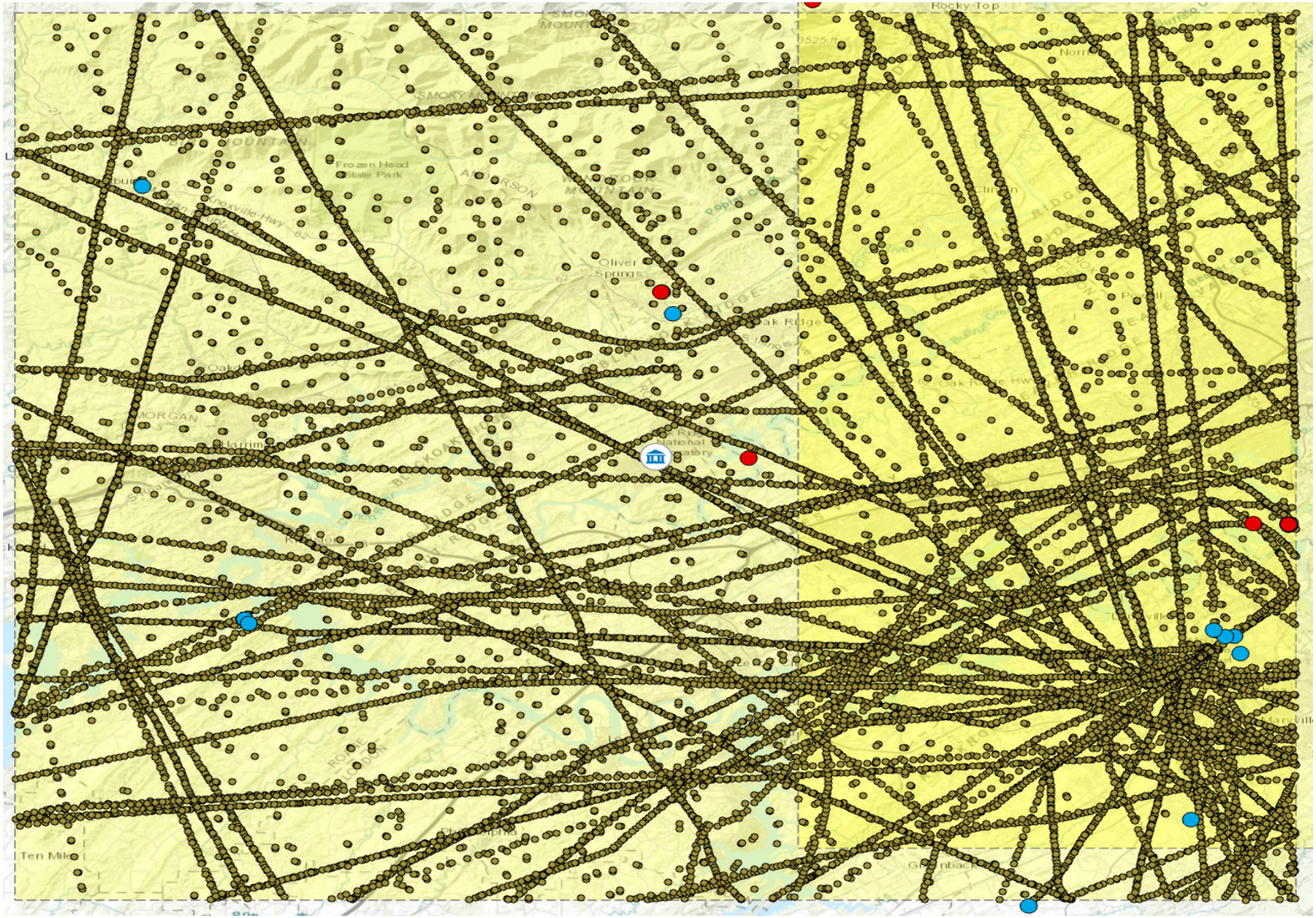
w/ NTSB Crash Data (2000-2018)

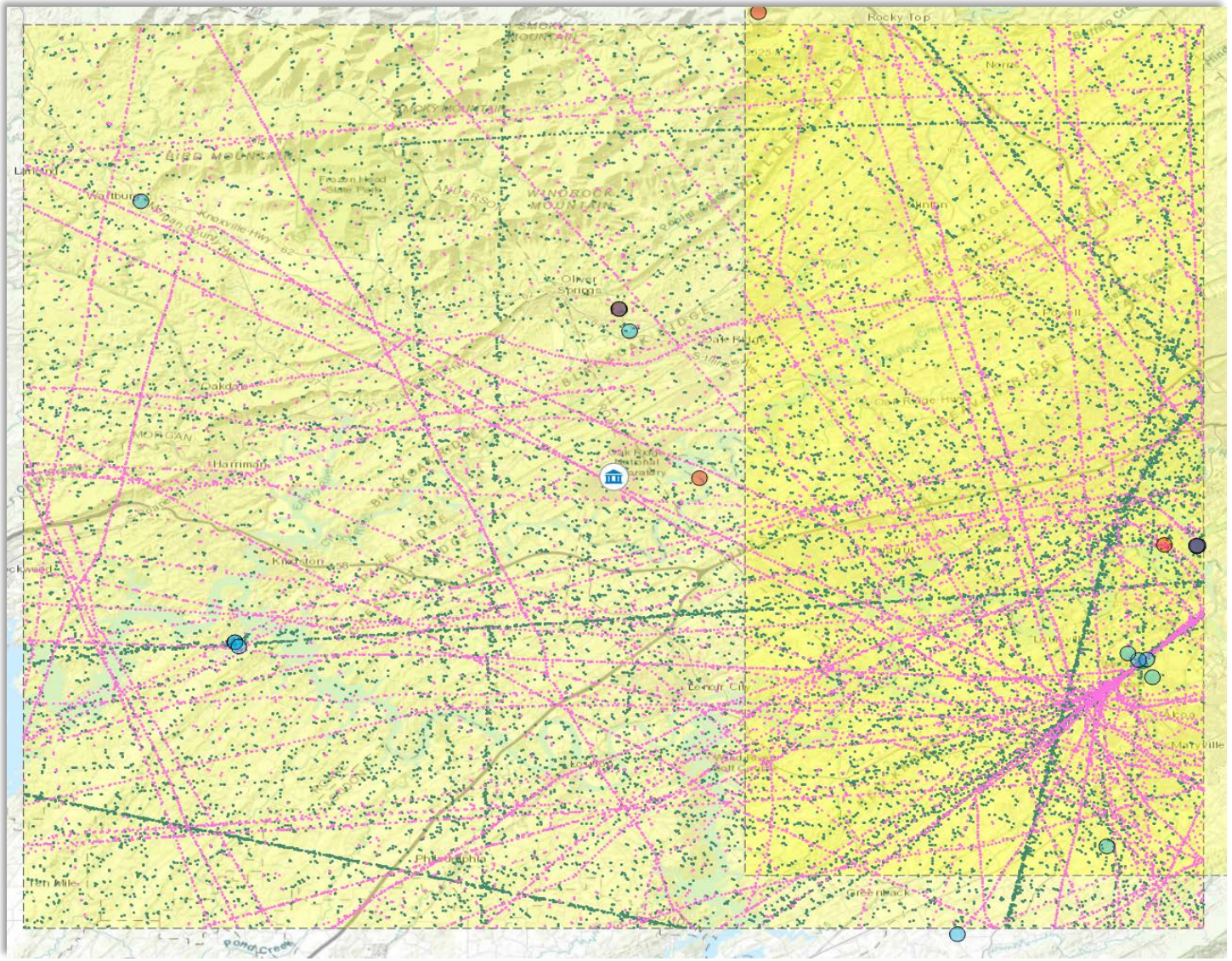


40 x 40-mi Grid Centered on ORNL , GA IFR data (June 30, 2018)



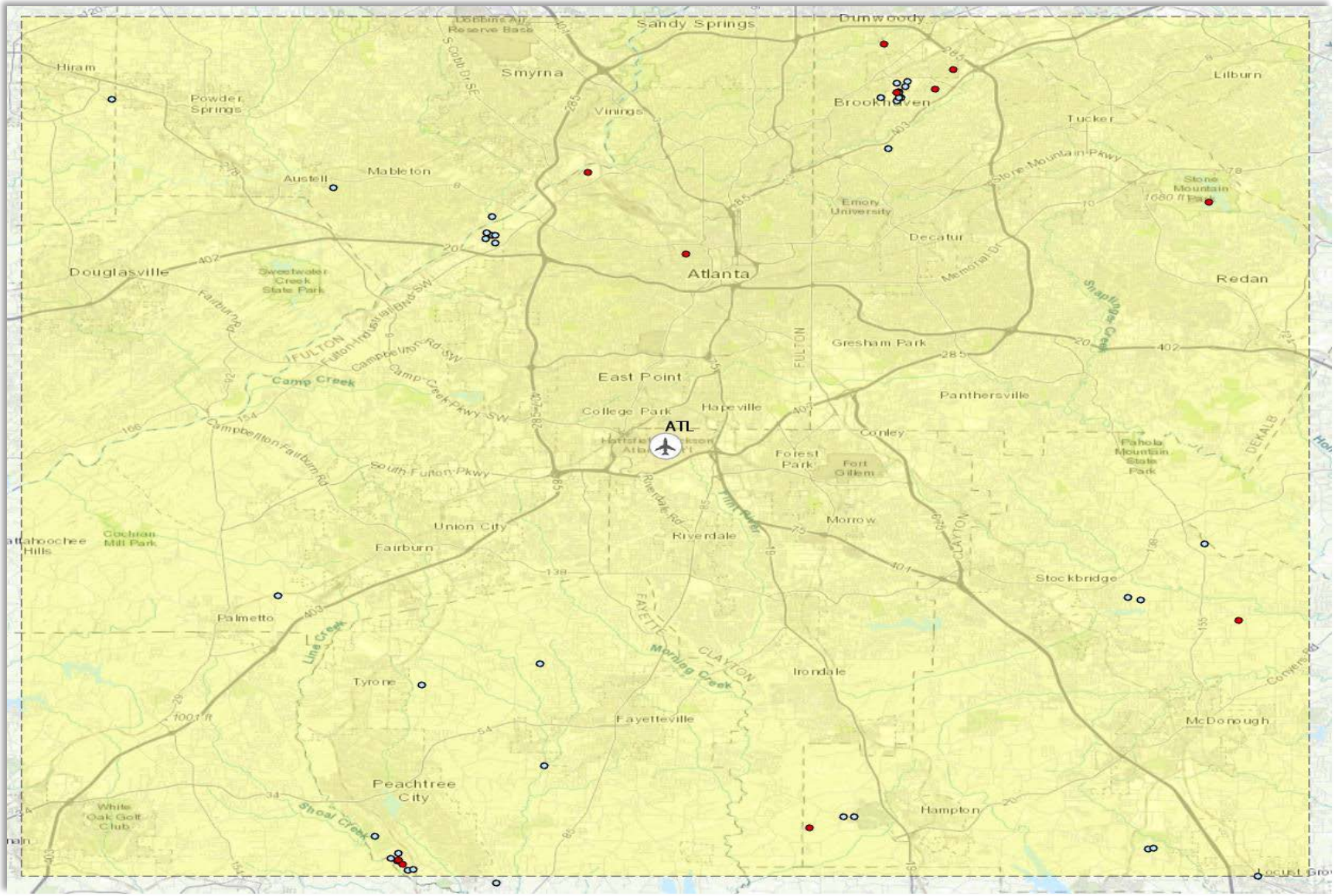
40 x 40-mi Grid Centered on ORNL (June 30, 2018)

*Commercial (**Dark Green**), GA (**Pink**) IFR data*

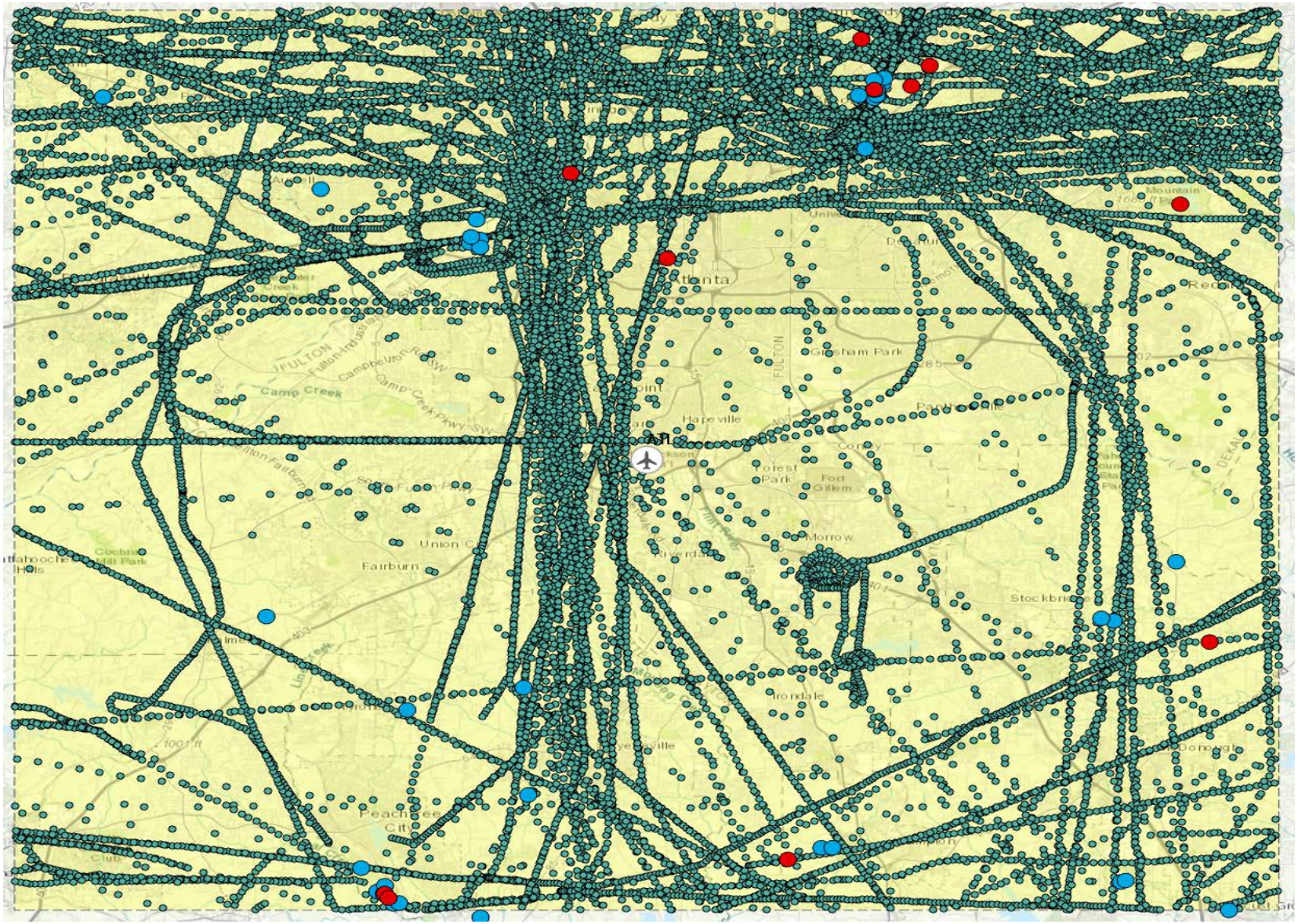


Atlanta Hartsfield-Jackson Airport

w/ NTSB GA Crash Data (2000-2018)

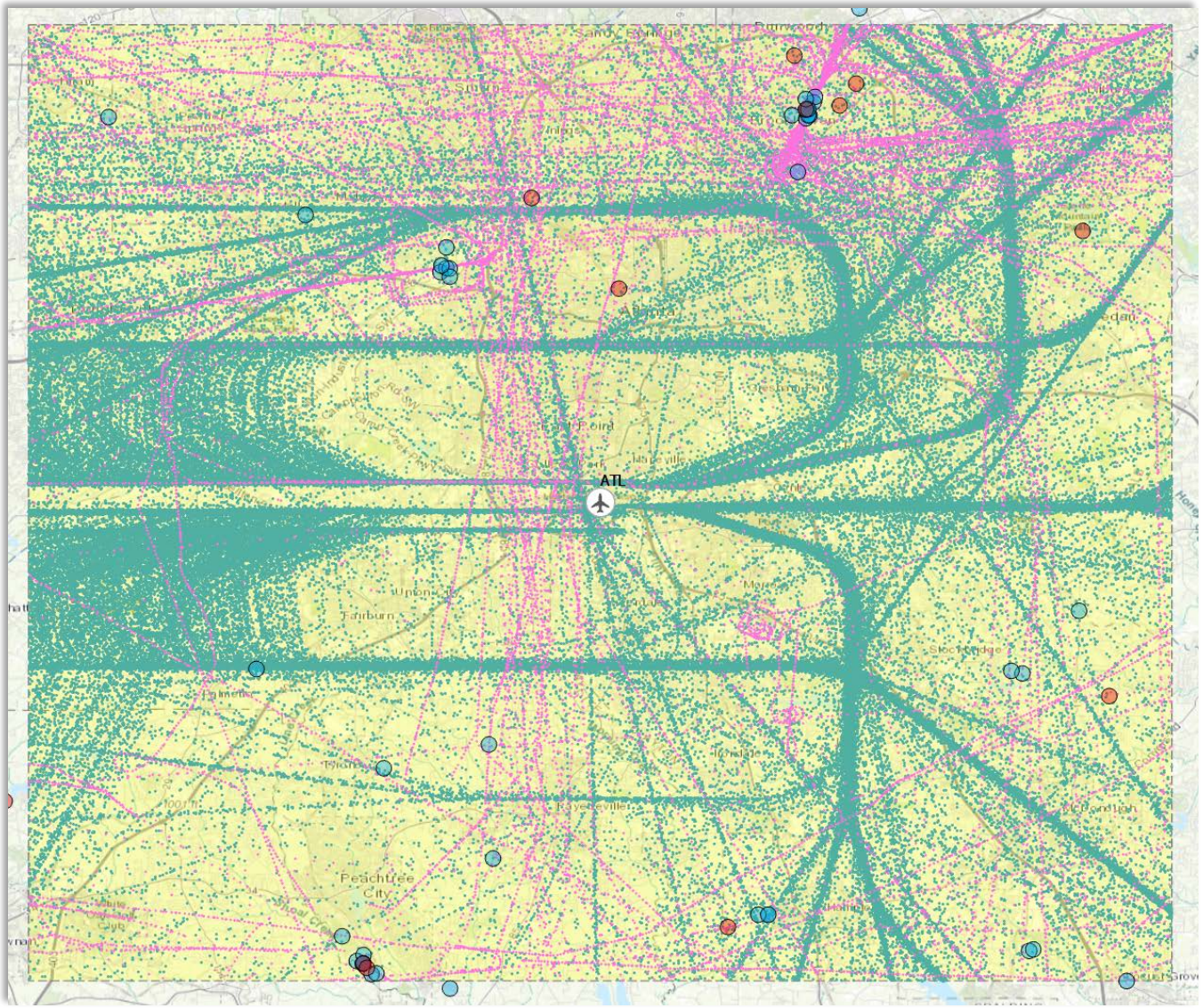


40 x 40-mi Grid Centered on Atlanta Hartsfield-Jackson Airport
GA IFR data (June 30, 2018)

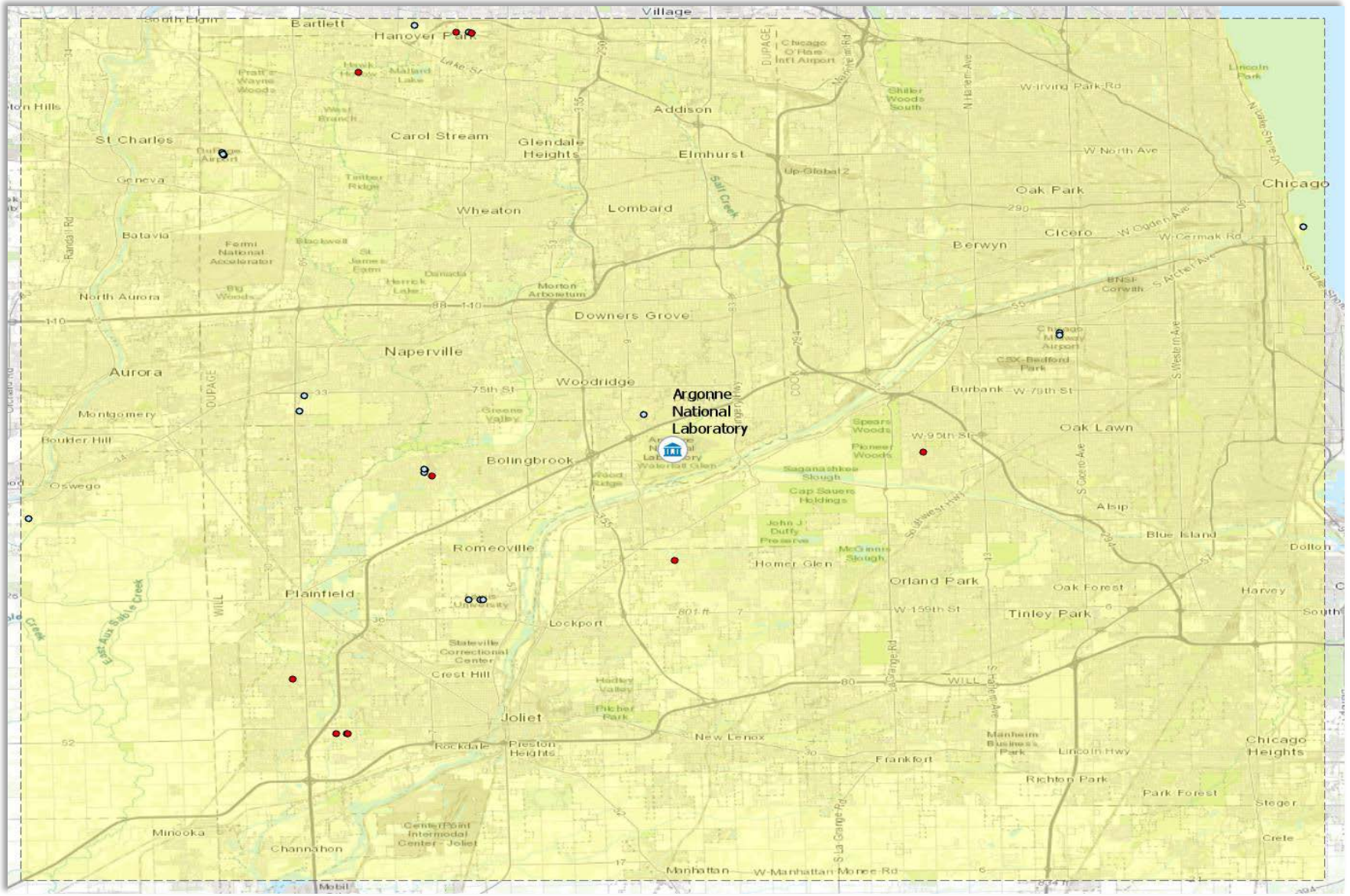


40 x 40-mi Grid Centered on Atlanta Hartsfield-Jackson Airport (June 30, 2018)

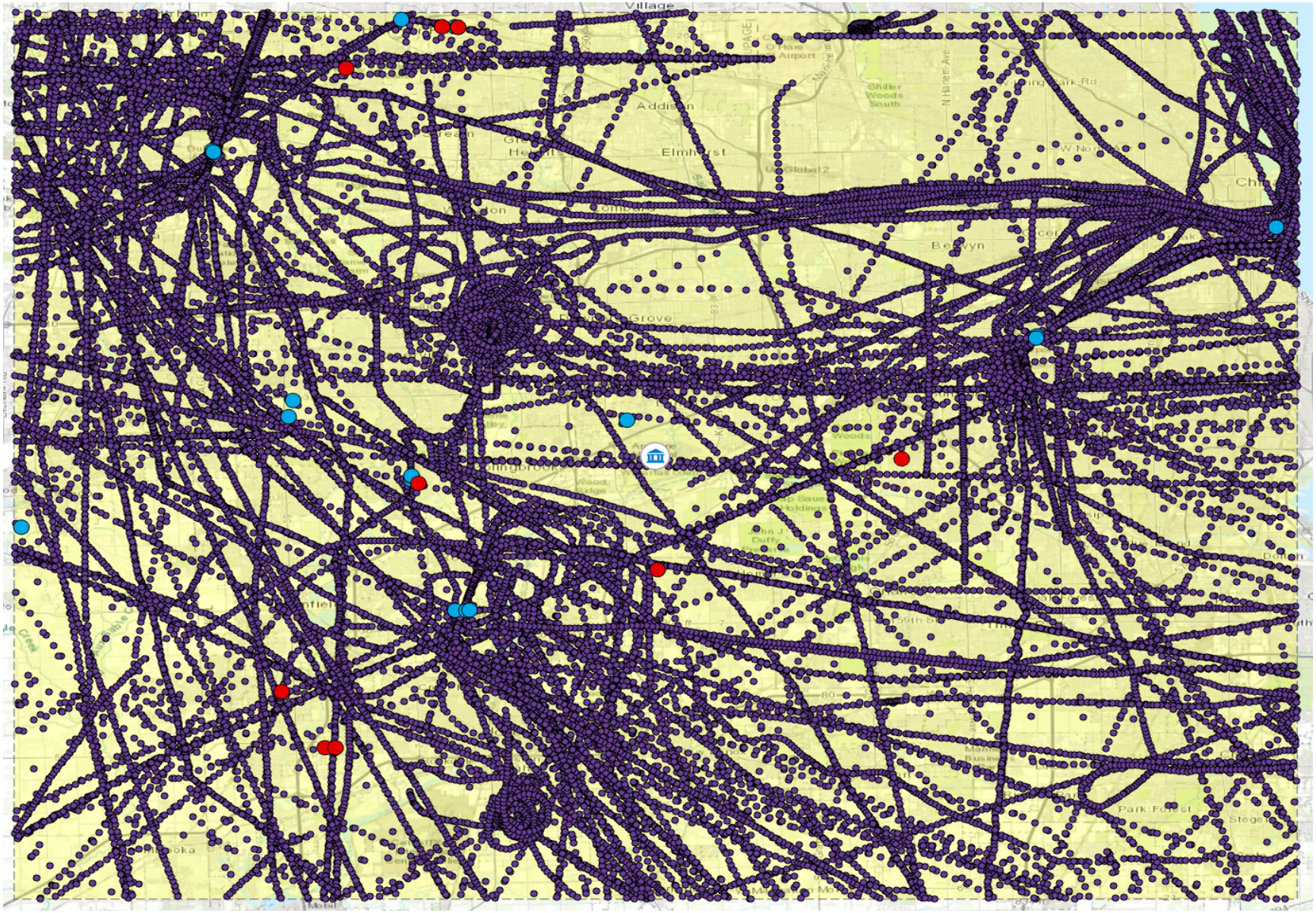
*Commercial (**Teal**), GA (**Pink**) IFR data*



Argonne National Laboratory
w/ NTSB GA Crash Data (2000-2018)

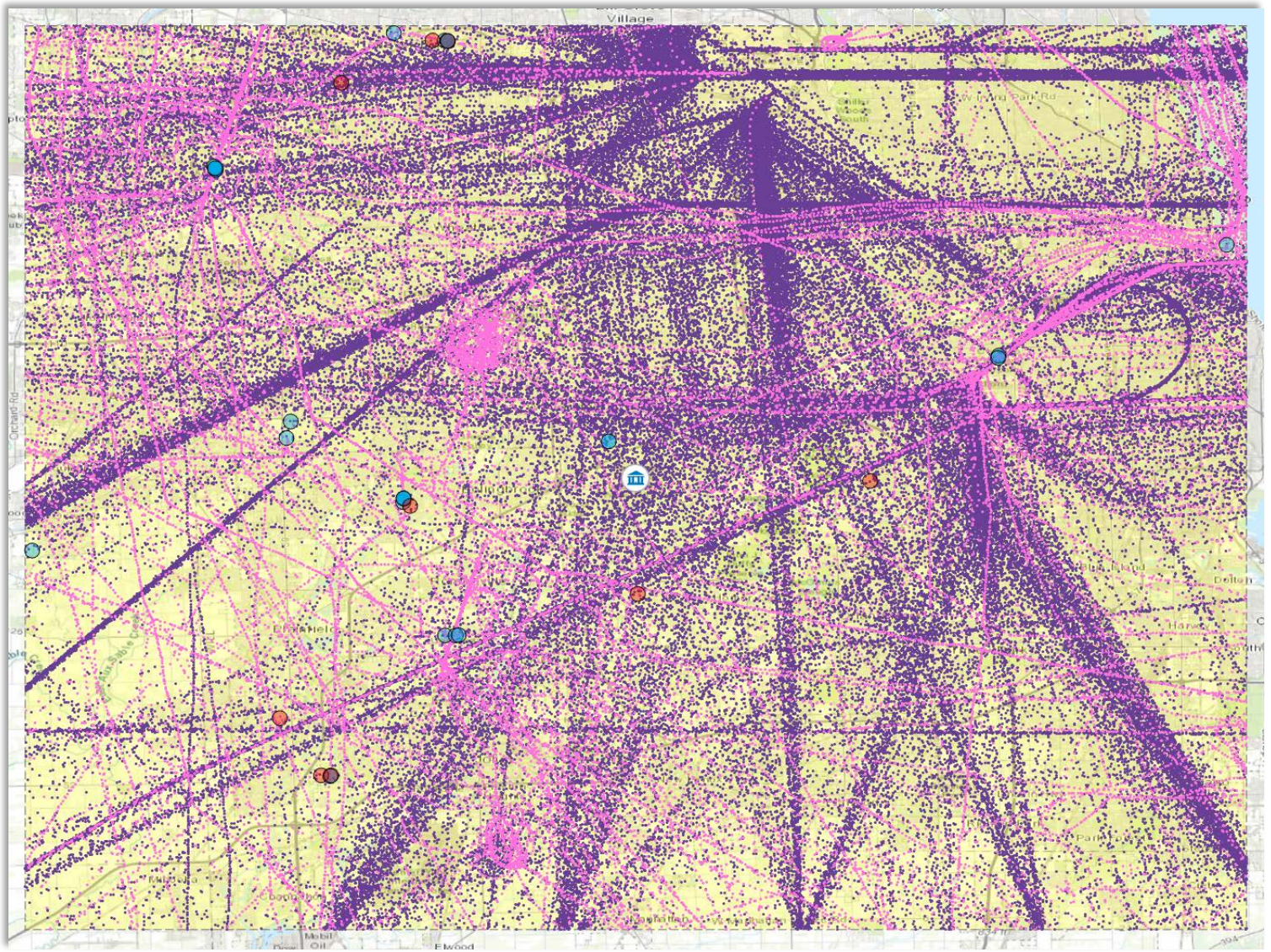


40 x 40-mi Grid Centered on ANL , GA IFR data (June 30, 2018)



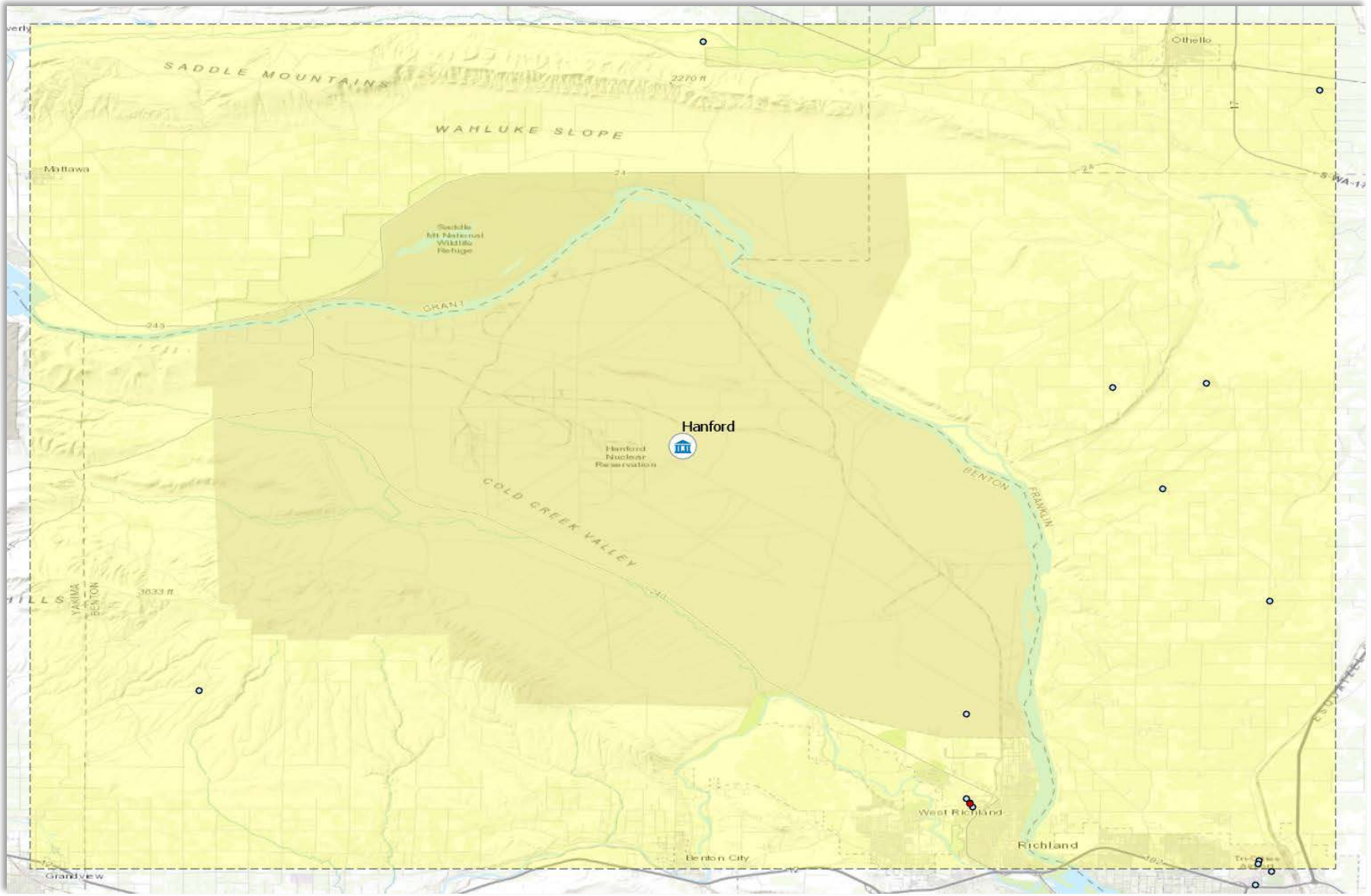
40 x 40-mi Grid Centered on ANL (June 30, 2018)

*Commercial (**Violet**), GA (**Pink**) IFR data*



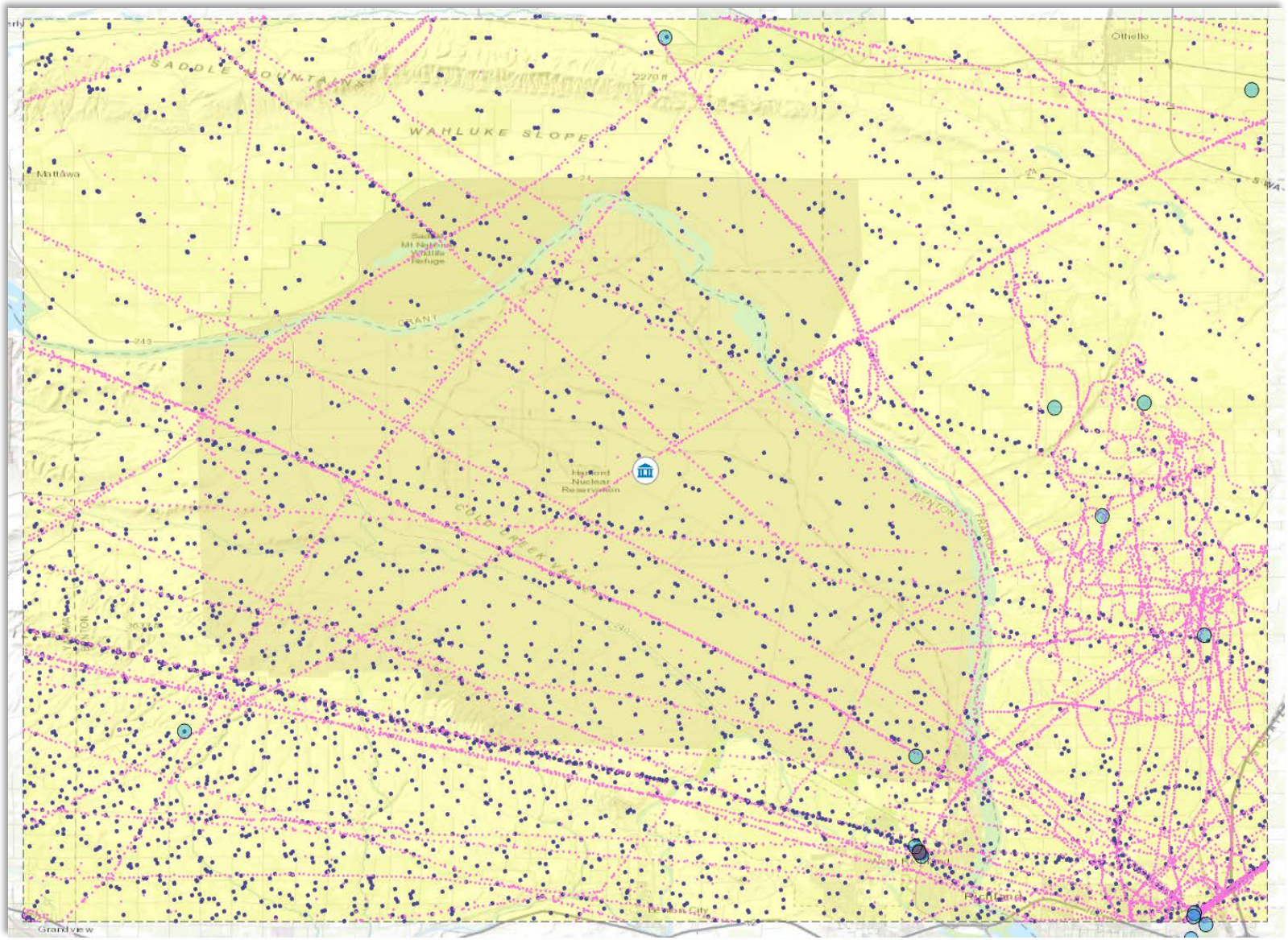
Hanford Site

w/ NTSB GA Crash Data (2000-2018)



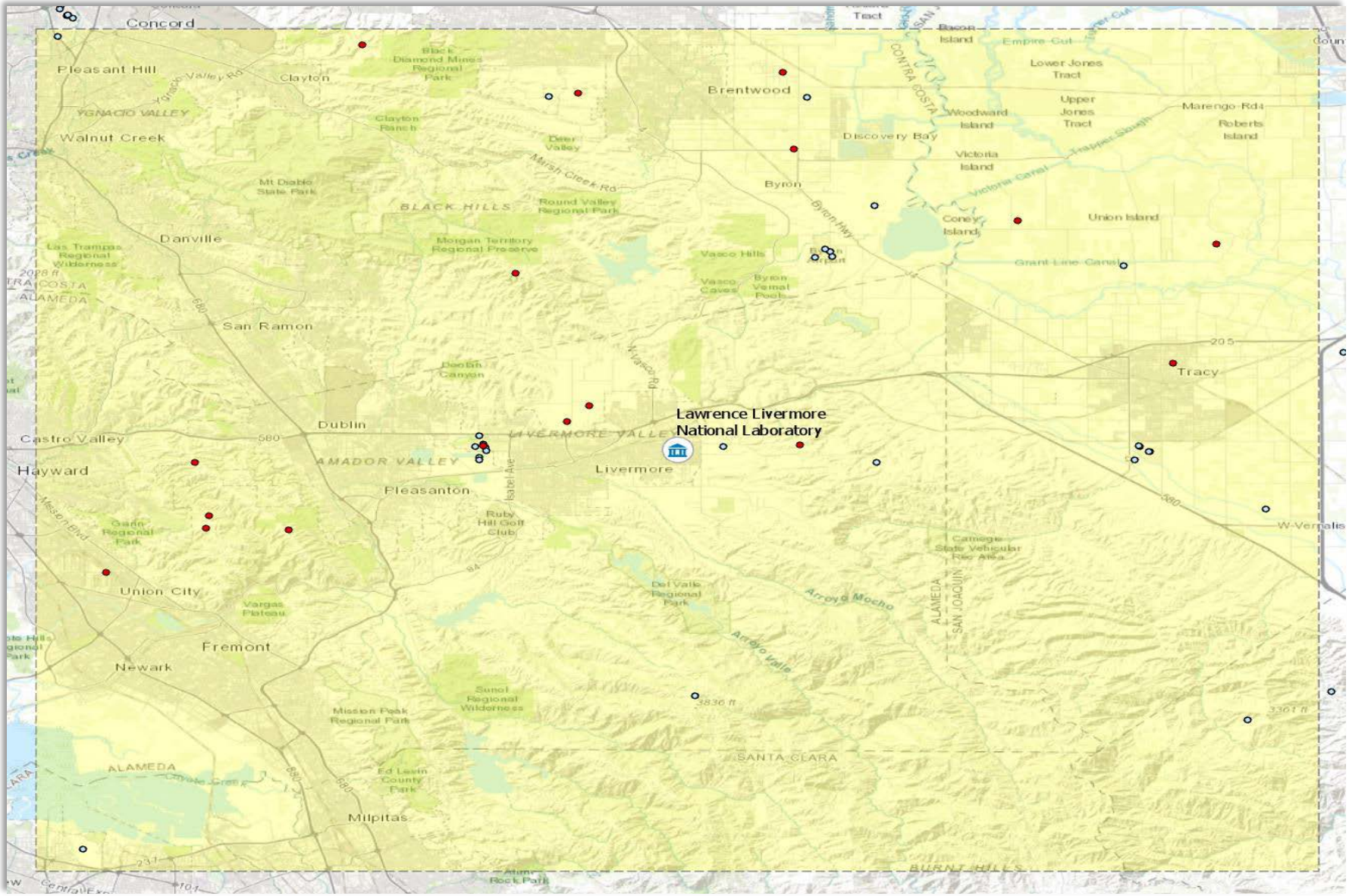
40 x 40-mi Grid Centered on Hanford Site (June 30, 2018)

*Commercial (**Violet**), GA (**Pink**) IFR data*

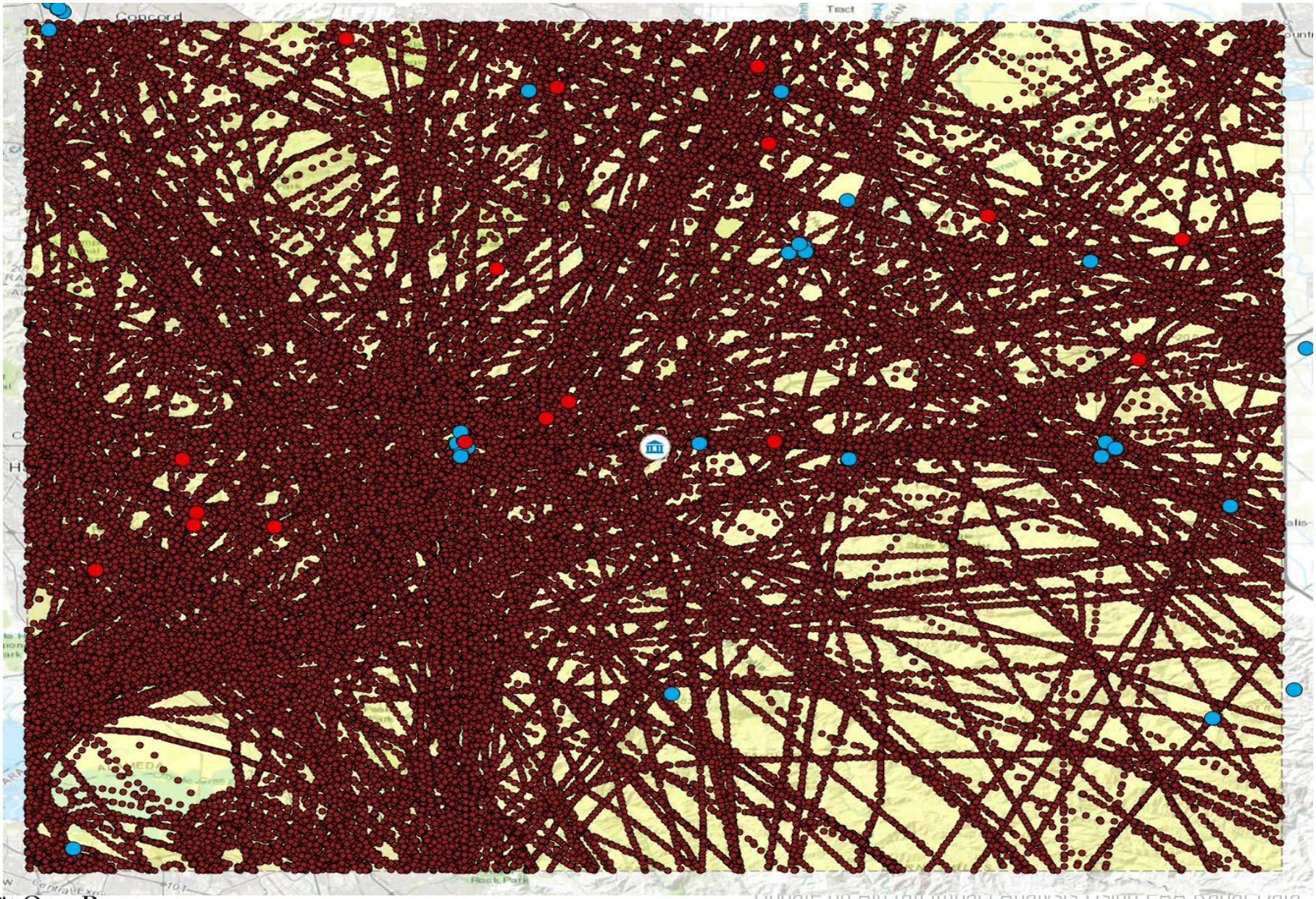


Lawrence Livermore National Laboratory

w/ NTSB GA Crash Data (2000-2018)

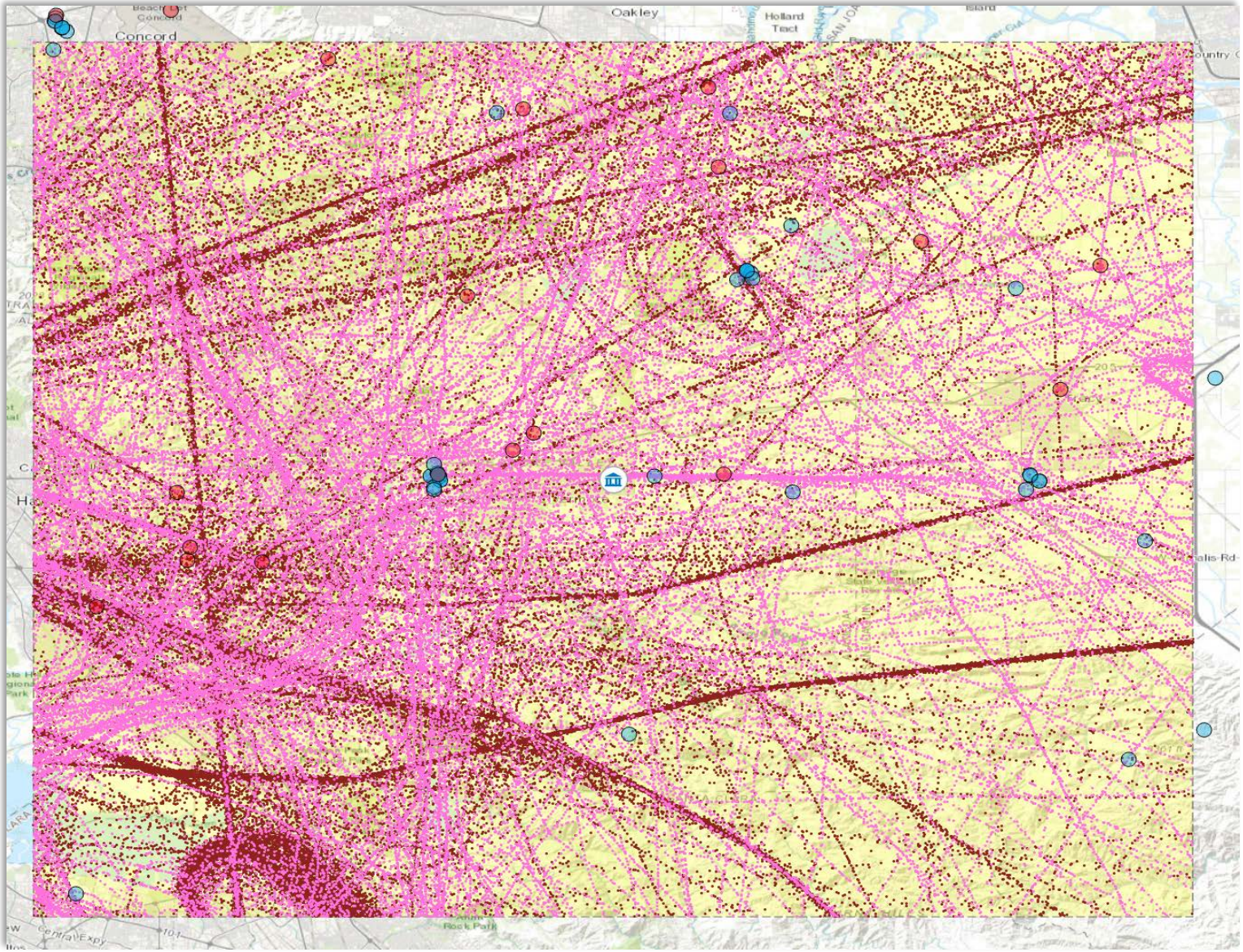


40 x 40-mi Grid Centered on LLNL , *GA IFR data (June 30, 2018)*



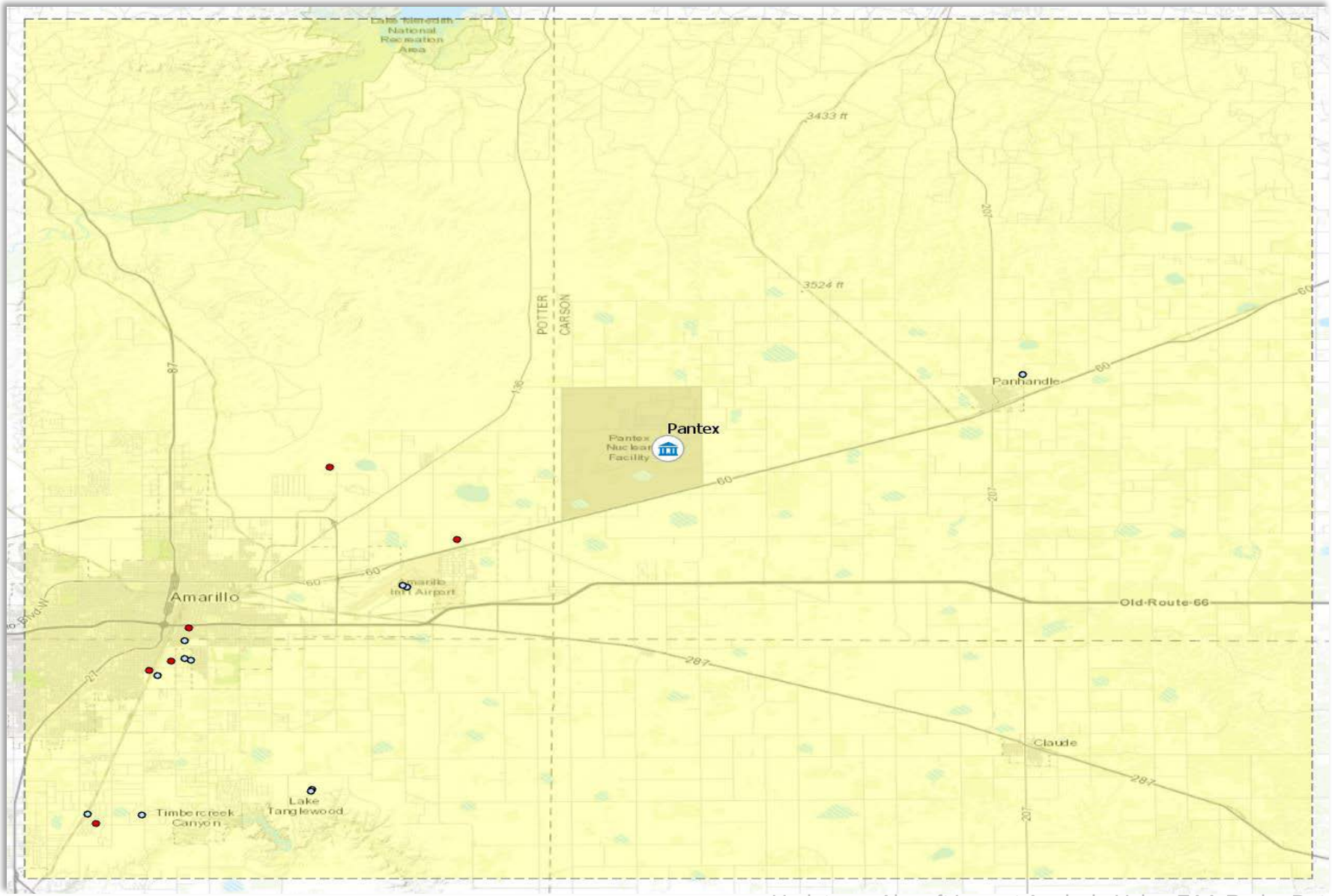
40 x 40-mi Grid - LLNL (June 30, 2018)

*Commercial (**Red**), GA (**Pink**) IFR data*

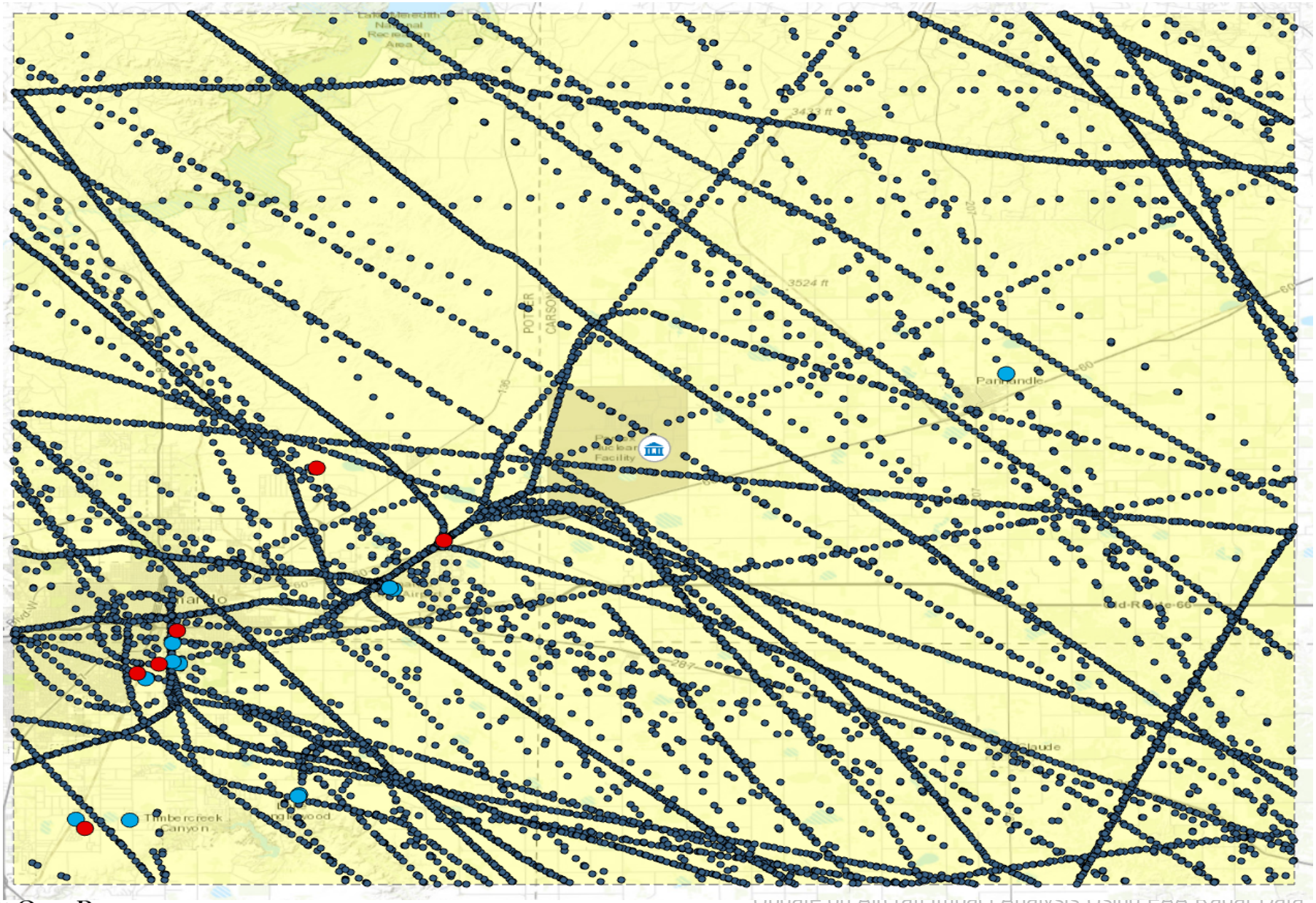


Pantex Site

w/ NTSB GA Crash data (2000-2018)

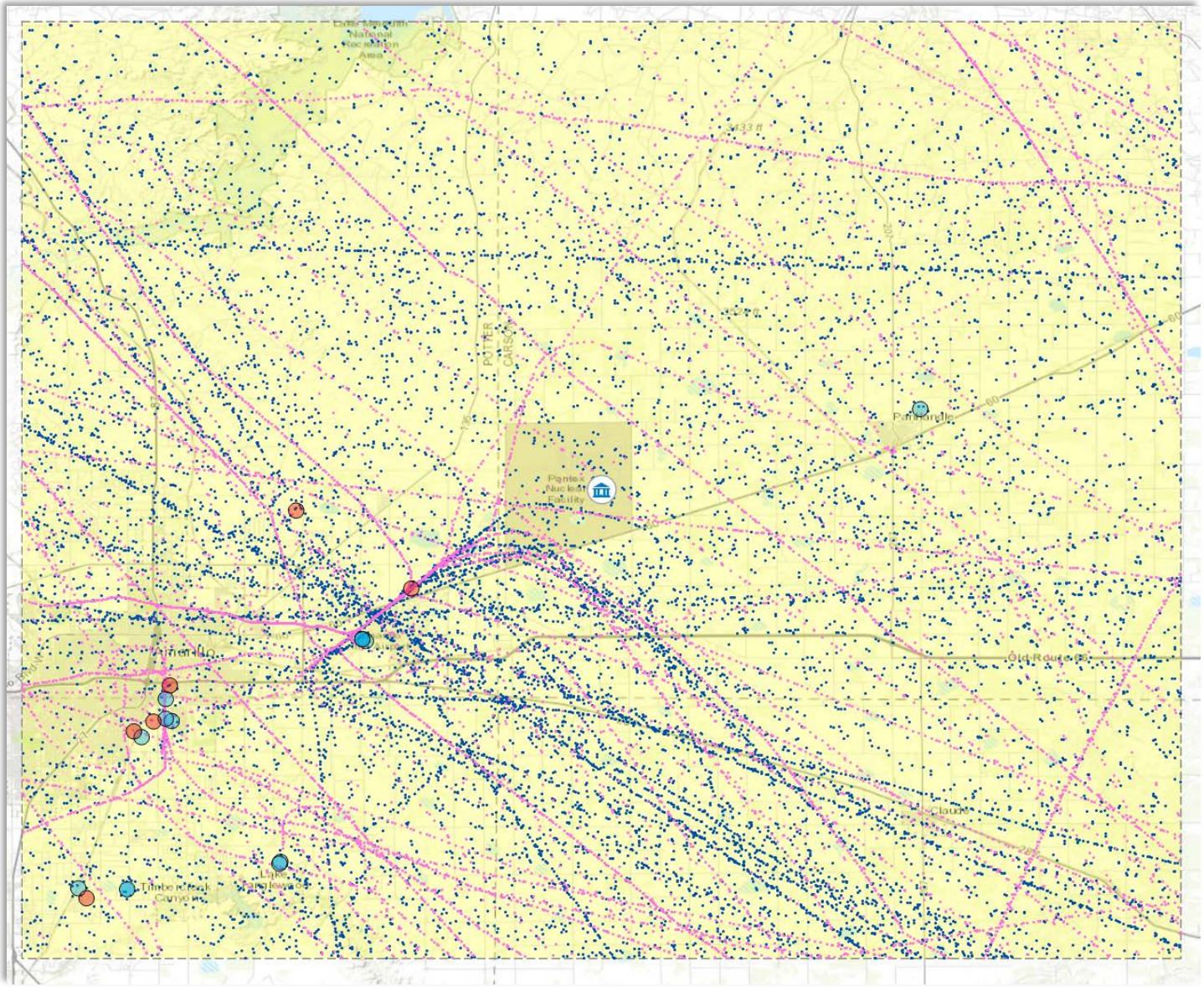


40 x 40-mi Grid Centered on Pantex Site , *GA IFR data (June 30, 2018)*



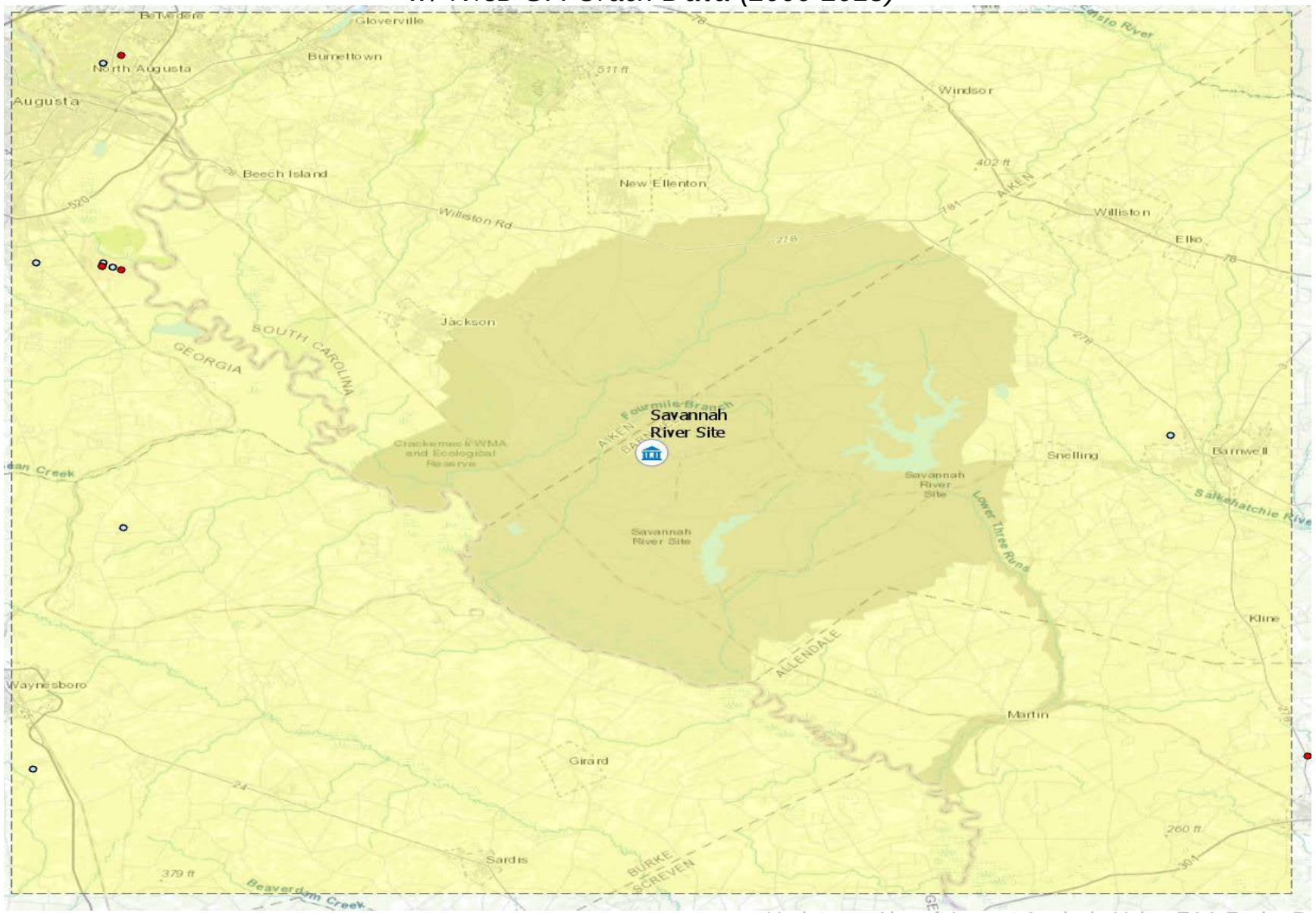
40 x 40-mi Grid Centered on Pantex Site, *(June 30, 2018)*

*Commercial (**Dark Blue**), GA (**Pink**) IFR data*



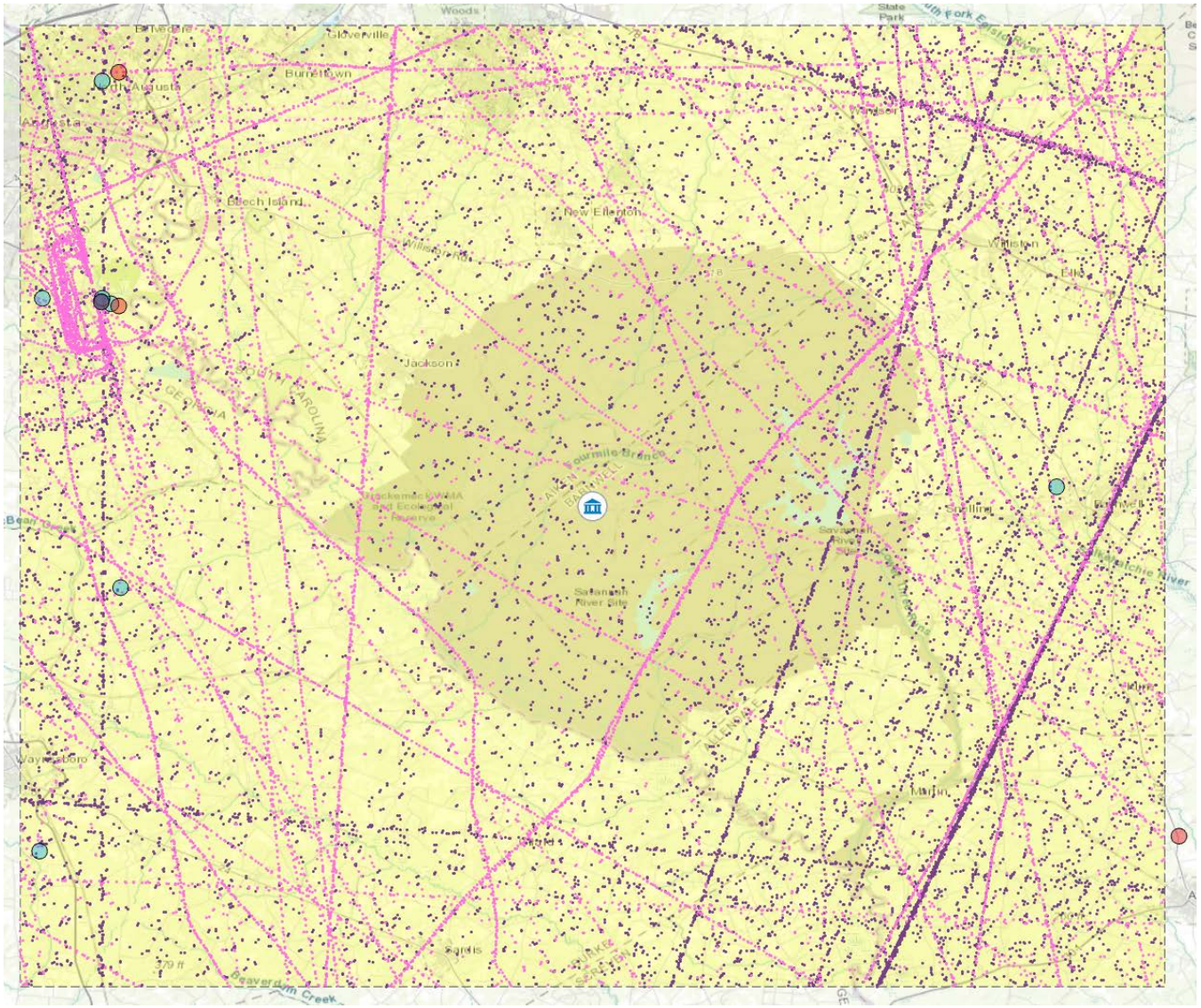
Savannah River Site

w/ NTSB GA Crash Data (2000-2018)



40 x 40-mi Grid Centered on SRS, *(June 30, 2018)*

*Commercial (**Violet**), GA (**Pink**) IFR data*



Interesting Flights

Aircraft Description

Serial Number	515	**Status**	Valid
Manufacturer Name	DEHAVILLAND	**Certificate Issue Date**	10/29/1993
Model	DHC-6-300	**Expiration Date**	07/31/2021
Type Aircraft	Fixed Wing Multi-Engine	**Type Engine**	Turbo-prop
Pending Number Change	None	**Dealer**	No
Date Change Authorized	None	**Mode S Code (base 8 / oct)**	51472022
MFR Year	1976	**Mode S Code (base 16 / hex)**	A67412
Type Registration	Corporation	**Fractional Owner**	NO

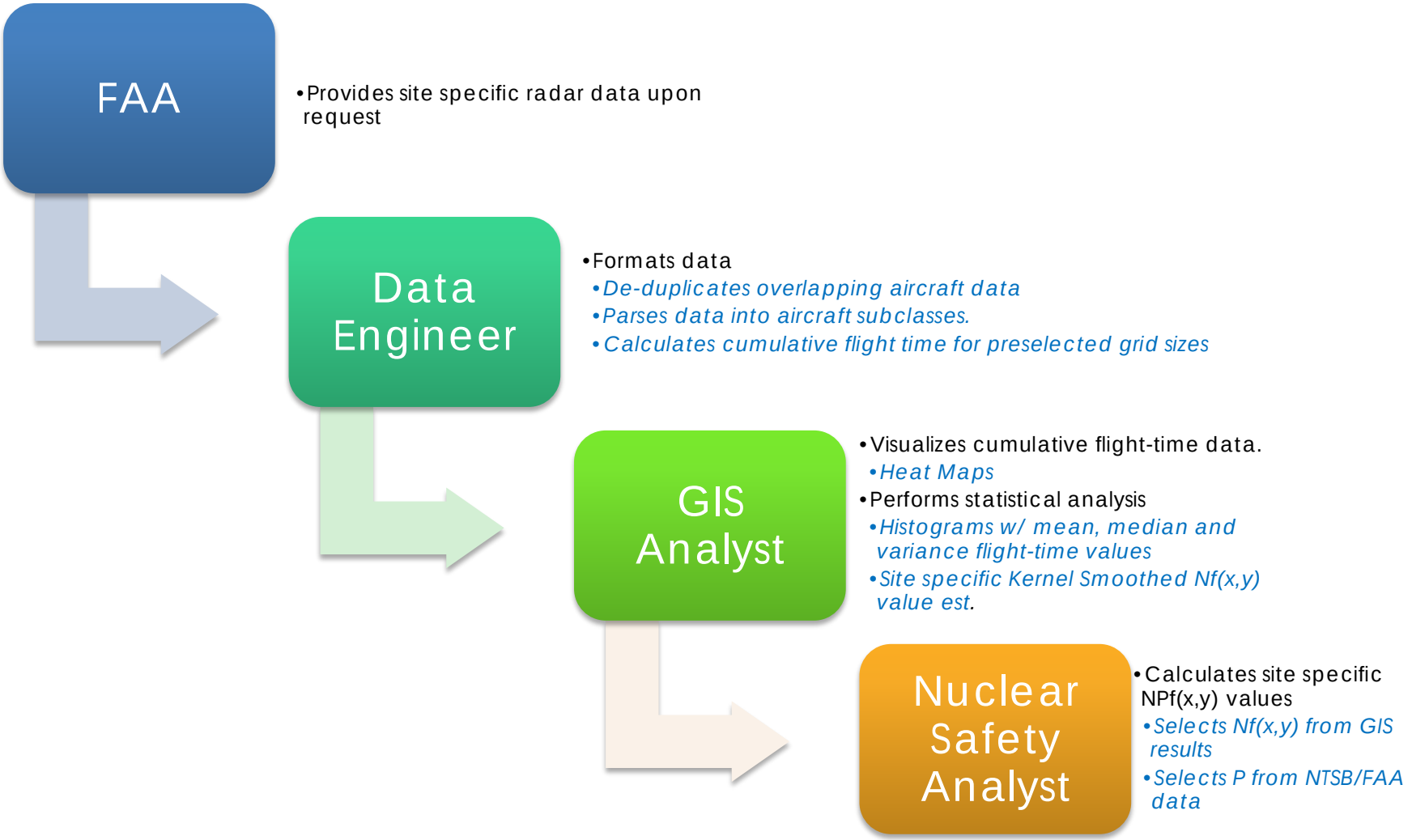
Registered Owner

Name	TWIN OTTER INTERNATIONAL LTD		
Street	PO BOX 570337		
City	LAS VEGAS	**State**	NEVADA
County	CLARK	**Zip Code**	89157-0337
Country	UNITED STATES		

Airworthiness

Engine Manufacturer	P&W CANADA	**Classification**	Restricted
Engine Model	PT6A-27	**Category**	Aerial Surveying
A/W Date	11/09/2017	**Exception Code**	No

Workflow for Processing FAA Radar Data



Obtaining and Preparing the Radar Data

- Radar Data comes from FAA.
  - One data file per day for IFR operations
  - One data file per day for VFR operations
  - A total of 1,460 data files (for 2 yrs radar data)
  - Approx. 6 Gigabytes of data
- Data Engineer complies results in ATAP software application
  - ATAP performs the following data compilation tasks:
    - De-duplicates data (data originates from multiple overlapping radar sites)
    - Subgroups data into aircraft categories
    - Computes cumulative residence time (flight-seconds) in predetermined grid size.
  - Compiled data then transmitted to analysts.

Analyzing the Radar Data

- GIS Analyst
  - Uploads flight-second summary data into GIS software application.
  - Generates heat maps, flight density histograms, and kernel smoothing density maps.
  - Output from GIS analysis: flight-hours per year per mile^2.
- Nuclear Safety Analyst
  - Use GIS results along with contemporary aircraft crash probability [crashes/flight-hr] from NTSB and/or FAA to calculate site specific values for NPf(x,y).
    - New NPf(x,y) values can be used to revise Tables B-14 and B-15 in STD-3014.

Four-Factor Formula

$$F = \sum N \cdot P \cdot f(x,y) \cdot A$$

- F = Est. annual aircraft impact frequency; [Crashes/Yr]
- N = Est. annual no. of aircraft operation; [Ops/Yr]
- P = Aircraft Crash Rate; [Crashes/Ops]
- f(x,y) = Aircraft crash location conditional probability; [1/mi^2]
- A = Facility specific Effective Impact Area; [mi^2]

- $N \cdot P \cdot f(x,y) = P \cdot \left(N \cdot f(x,y)\right)$ = [Crashes/Ops] [Ops/Yr · 1/mi^2]

Radar data allows quantifying hours of operation in local area:

Local Aircraft Density = $N \cdot f(x,y)$; [Ops/(yr-mi^2)]

If using radar data, local density expressed as; [Flight-hrs/(yr-mi^2)]

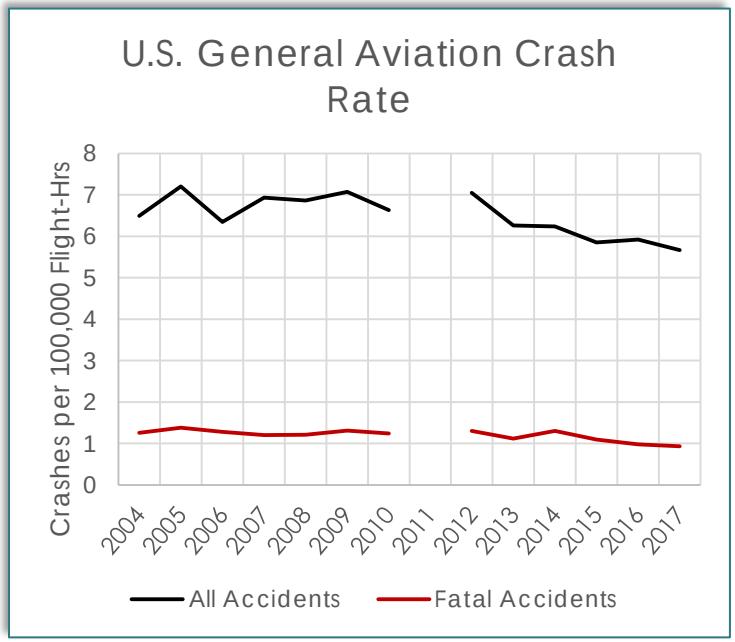
Crash Rate

- P is determined from National crash rate data
- NTSB Crash Reports for Part 121, Part 135, Part 91
  (Commercial, Charter/Air Taxi, and General Aviation)

  - Commercial - Accidents/flight hr , Accidents/flight mile, Accidents/departure
    - ~ **3.88 E-8** Fatal Accidents/Flight hr (last 10 years)
  - Charter/Air Taxi - Accidents/flight hr
    - ~ **2.94 E-6** Fatal Accidents/Flight hr (2007-2017, excluding 2011)
  - General Aviation - Accidents/flight hr
    - ~ **1.18 E-5** Fatal Accidents/Flight hr (2007-2017, excluding 2011)

US General Aviation Crash Rate (2004 – 2017)

	Accidents		Fatalities			Accidents per 100,000 Flight Hours[b]	
Year	All	Fatal	Total	Aboard	Flight Hours[a]	All	Fatal
2004	1,619	314	559	559	24,888,000	6.493	1.262
2005	1,671	321	563	558	23,167,712	7.204	1.381
2006[c]	1,523	308	706	547	23,962,936	6.347	1.281
2007	1,654	288	496	491	23,818,668	6.936	1.201
2008	1,568	277	496	487	22,804,648	6.867	1.215
2009	1,480	275	479	470	20,861,866	7.075	1.313
2010	1,441	271	458	455	21,688,409	6.630	1.240
2011	1,471	270	458	447	-	-	-
2012	1,472	273	438	438	20,880,993	7.045	1.303
2013	1,223	221	390	386	19,492,356	6.259	1.118
2014	1,224	256	423	413	19,617,389	6.239	1.305
2015	1,211	230	378	375	20,576,000	5.851	1.098
2016	1,267	213	386	379	21,333,747	5.925	0.984
2017[d,e]	1,233	**203**	330	330	**21,702,719**	5.667	**0.931**



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Processing Radar Data - Basic Steps

- ATAP Software (Developed by ORNL)
  - Open/Transfer all files to SQL database & perform Data De-duplication (very important!)
  - Sort data into 3 aircraft types by User Class

    C = Commercial (all Part 121),
    T = Air Taxi (Part 135),
    F = Freight (Part 135),
    G = General Aviation (Part 91 and Part 135),
    M = Military,
    O = other
  - Sum hours of operation for each of 4 main types

    Commercial, Air Taxi, General Aviation, Military
  - Sort data into local area bin coordinates – Longitude/Lattitude
- Import Summary Data to GIS software
  - Data Visualization
  - Statistical Processing
- Data Processing Details – SQA / Confirmation in Process

Example Calculation – General Aviation Radar Data

General Aviation Summary									
ORNL Bin size	Dist. from ORNL center (mi)	Total Flight hours	Total Flights in Bin	Bin Flight hours / mi^2	Bin Flights / mi^2	CONUS Crash Rate fatal crashes/ hour flown	ORNL Site Crash density (crashes /mi^2 yr)	ORNL Facility Effective Area (mi^2)	ORNL Facility Aircraft Crash Frequency
1 mi x 1 mi	0.5	6.3625	713	6.3625	713.00	1.18E-05	7.51E-05	3.7540E-03	2.82E-07
2 mi x 2 mi	1	22.9611	1,656	5.7403	414.00	1.18E-05	6.77E-05	3.7540E-03	2.54E-07
5 mi x 5 mi	2.5	183.8350	4,446	7.3534	177.84	1.18E-05	8.68E-05	3.7540E-03	3.25E-07
10 mi x 10 mi	5	572.3214	9,135	5.7232	91.35	1.18E-05	6.75E-05	3.7540E-03	2.53E-07
20 mi x 20 mi	10	2177.0786	19,542	5.4427	48.86	1.18E-05	6.42E-05	3.7540E-03	2.41E-07

Analytical Issues

- Aircraft Type filtering criteria
  - Aircraft weight vs. User Class
- Criteria for determining bin sizes for representative conservative local area aircraft density
  - Averaging flight density across the entire data set vs. location specific flight density determinations
  - *Granularity of data:* How small can a bin be and still be a viable assessment of flight density compared to neighbor bins
- GIS interface with ATAP application
  - Data visualization (e.g., heat maps) vs. computational analysis
  - Use as data validation tool and identification of anaomolies

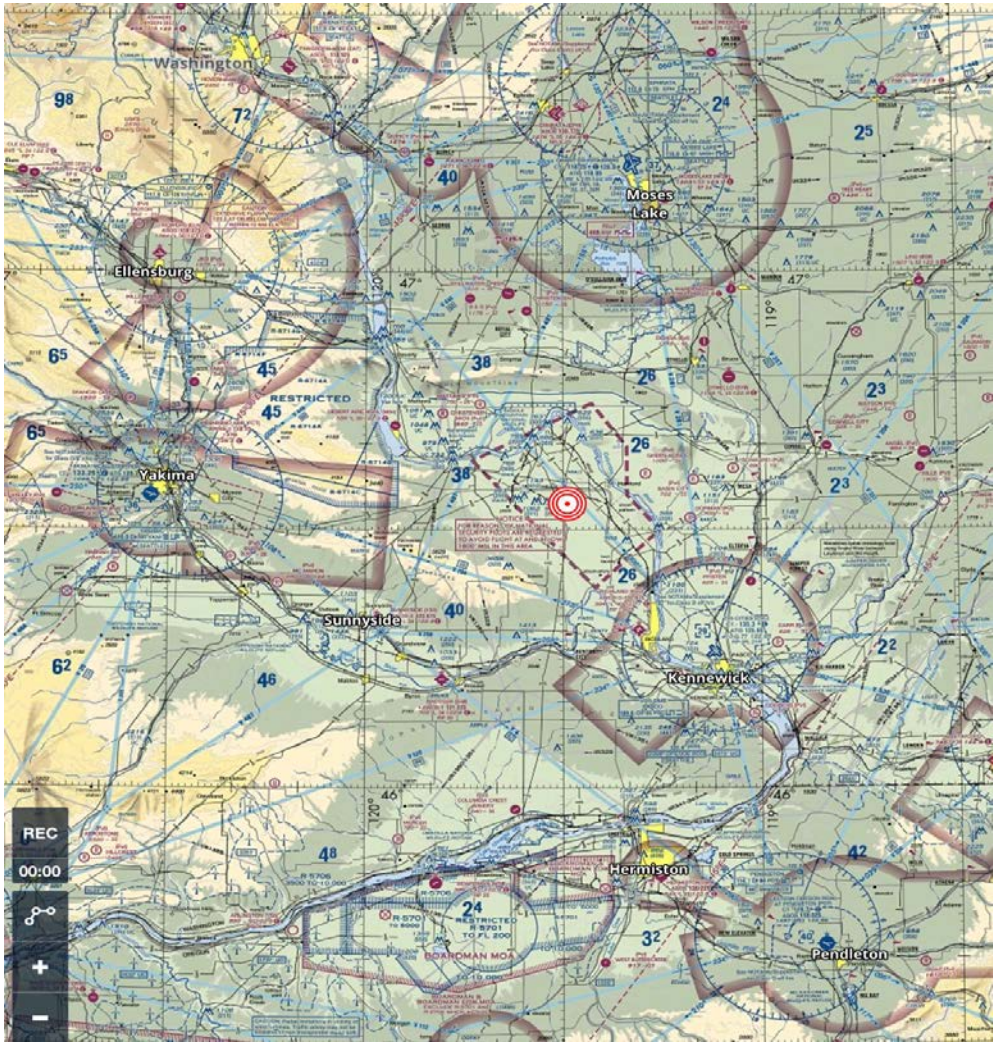
Other Radar Issues and Capabilities

- Correlation of Aircraft Crash Rate and Aircraft Density
  - Localized crash rates vs. National Avg. crash rates
- Discrimination of Airport Operations vs. Non-Airport Operations
- Aircraft Performance Parameter Analyses
  - Vector Analysis (Flight towards / away from facility)
  - Aircraft Velocity Profiles
  - Impact Angle Assessment
- Airspace Restriction Designation, Implementation, and Monitoring
- Military Aircraft Data – FAA Request

HANFORD RESERVATION
46.5507 N/119.4890 W

Airspace over the Hanford Reservation is designated as National Security Airspace. There is no restriction against flight in this airspace. Pilots are ”requested” to avoid flight at and below 1800’ MSL. As Hanford sits approx. 700’ above sea level aircraft can fly as low as 1100’ above the ground over the reservation.

The closest restricted airspace lies well south of Hanford adjacent to the town of Hermiston and is part of the US Navy’s Pacific Northwest Operating area. It includes a bombing range.



Path Forward

- Use Aircraft Density to Determine $N \cdot P \cdot f(x,y)$ values for each DOE Site (Table B-14, B-15)
  - Request data from FAA – 2 years for each Site
  - Generate Site Heat Maps
  - Determine Representative Bin Size for each Site
  - Calculate $N \cdot P \cdot f(x,y)$ values
- Correlate Aircraft Density with Crash Data
- Refine algorithms for determining flight density of GA, Commercial, Air Taxi, and Military aircraft.
- Refine/Define DOE-STD-3014 Update Approach
- NRC Input – NUREG 0800 Update or Endorse STD-3014

Questions??

- Thanks!