Leveraging Consumer Drones for Wildland Fire Monitoring:

Validating the Positional and Thematic Accuracy of Small UAS Motion Imagery

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GEOG 596A

10 December 2021

Overview

- Background
- Problem Statement
- Methodology
- Research Plan

Image: M. Truong, BLM

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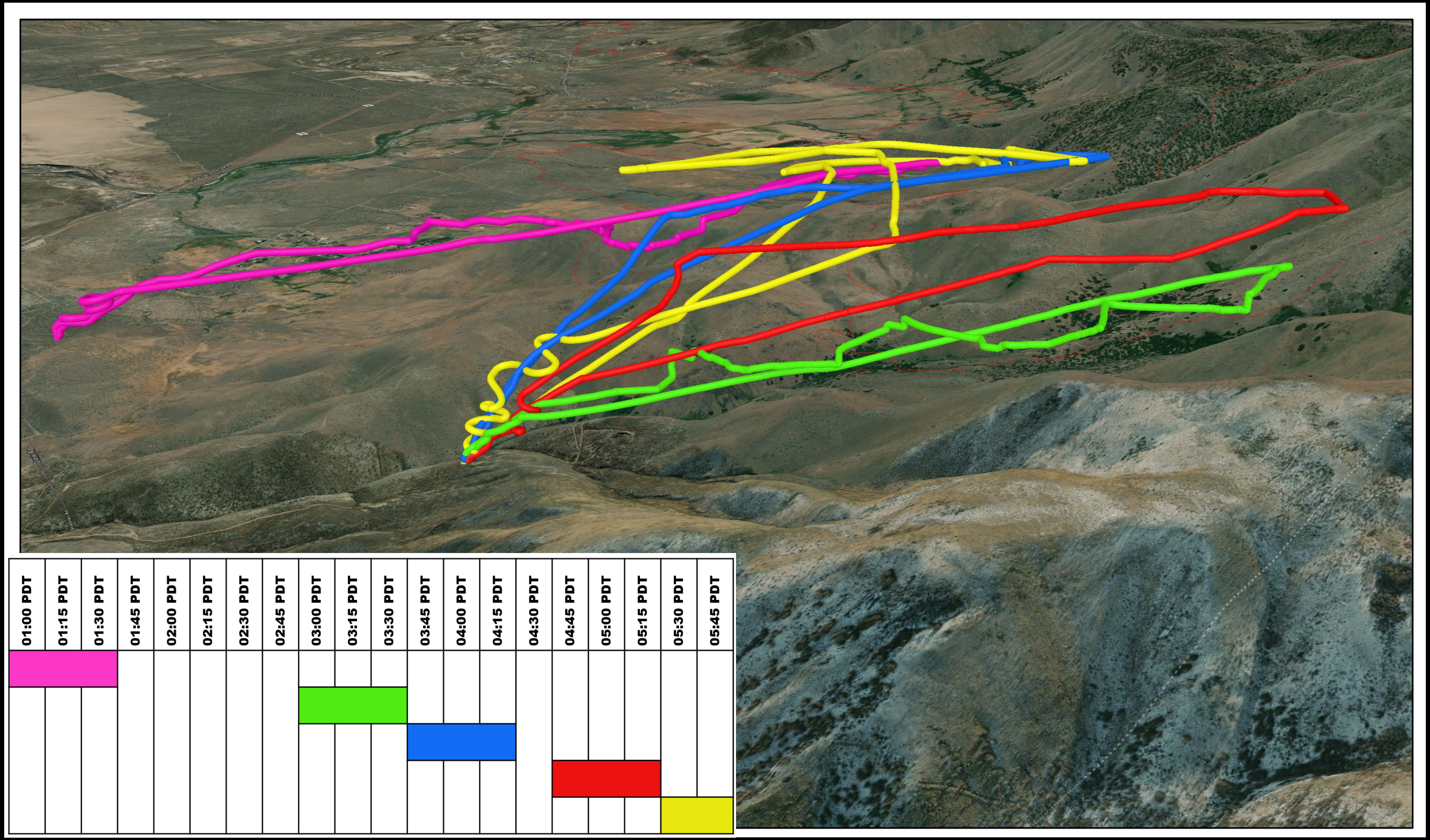
Image: L. Russell



Map: L. Russell

Location Data for Aircraft Position Only

Image: L. Russell

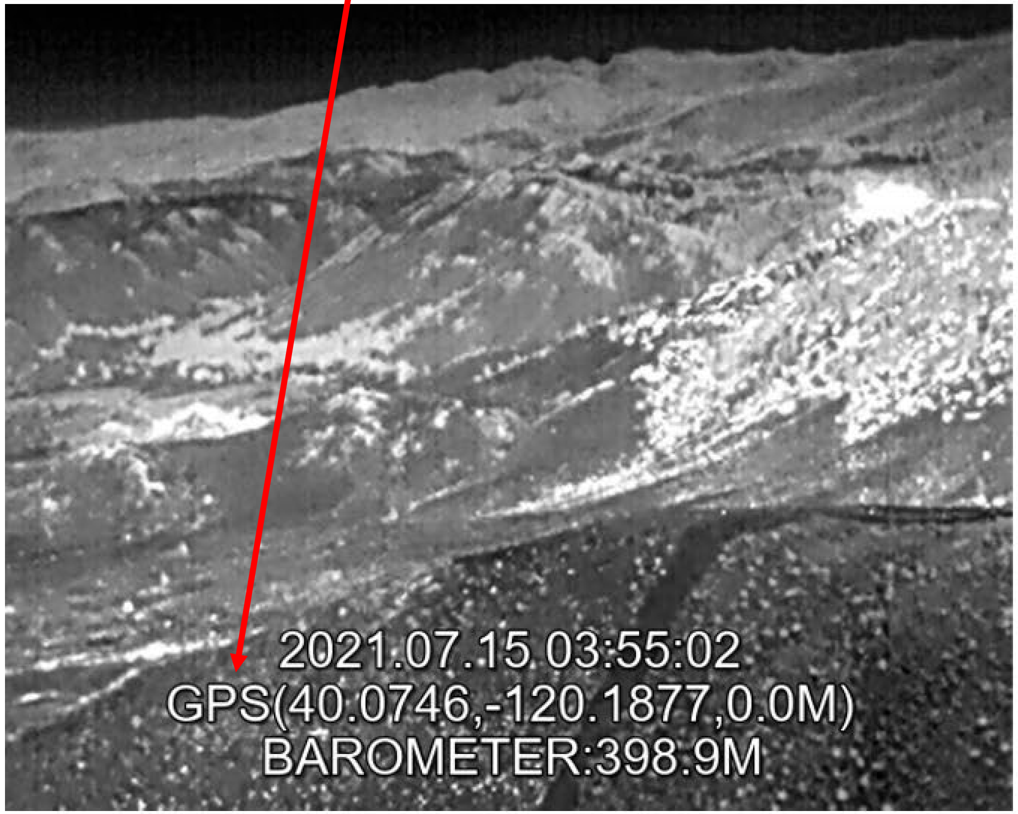


Image: BLM National UAS Program

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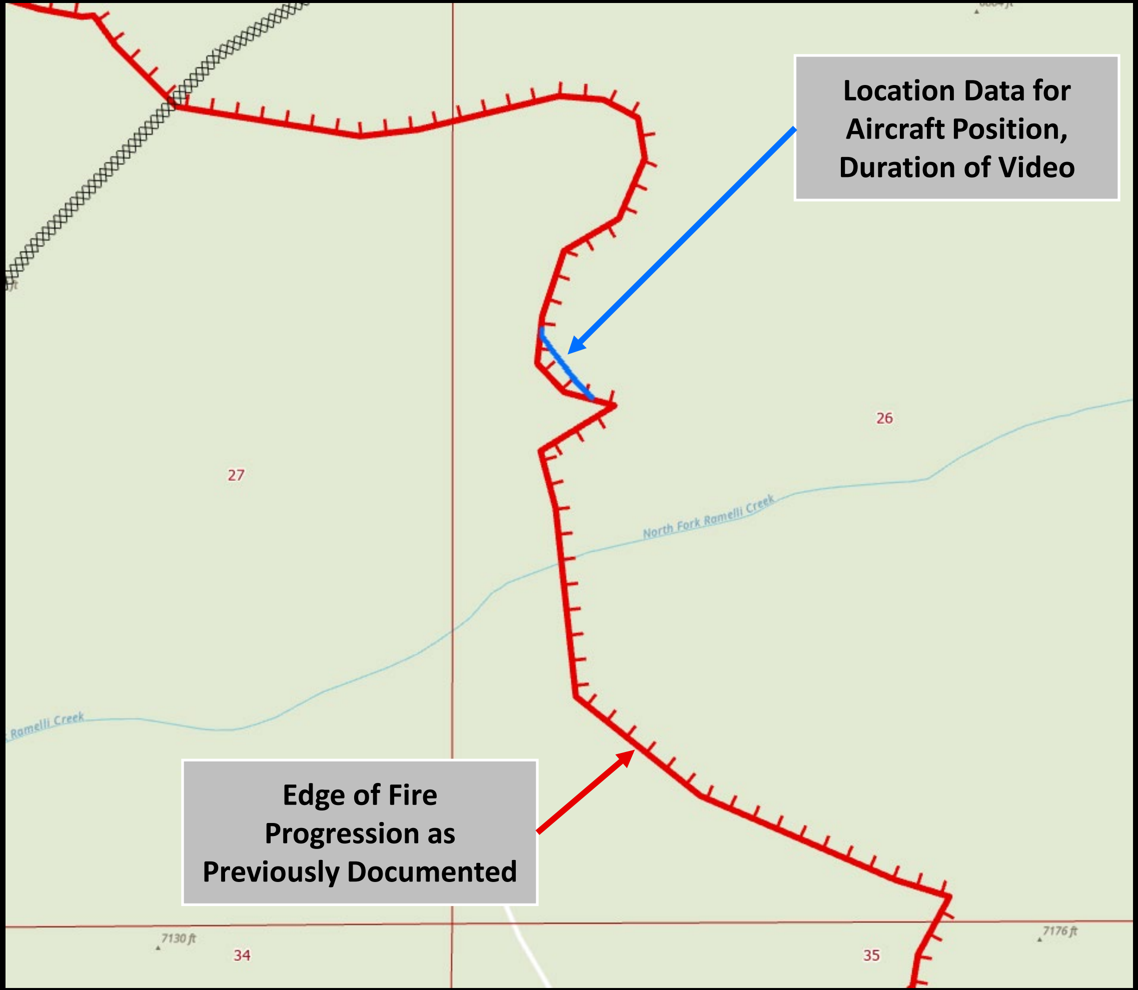
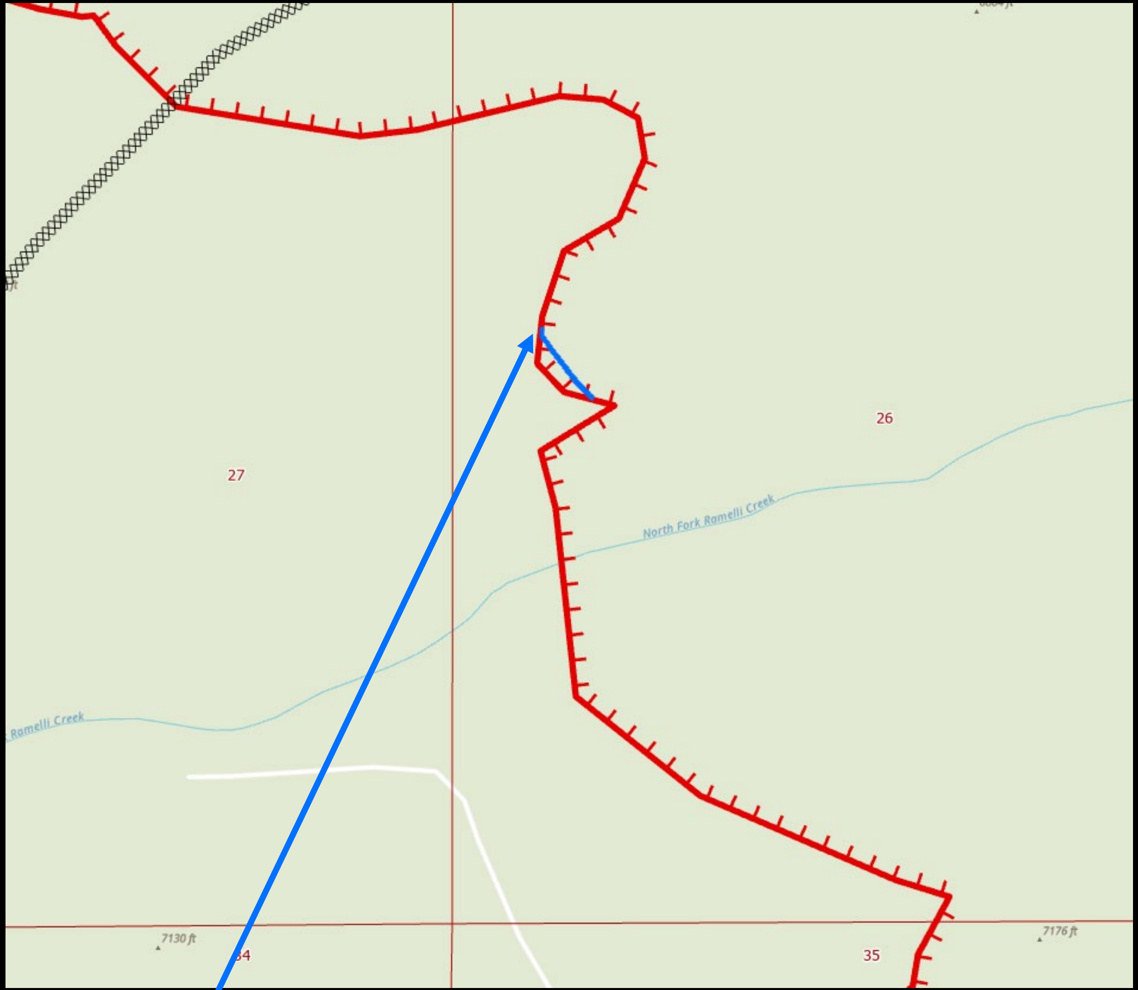


Map: L. Russell

Current techniques for tactical fire perimeter mapping using sUAS involve a painstaking manual process… the pilot must 1) navigate the aircraft to the fire's edge; 2) utilize the thermal IR sensor in a nadir position to orient the aircraft above the fire's edge, and 3) "trace" the edge by piloting the aircraft along it with using the video data as a visual reference.

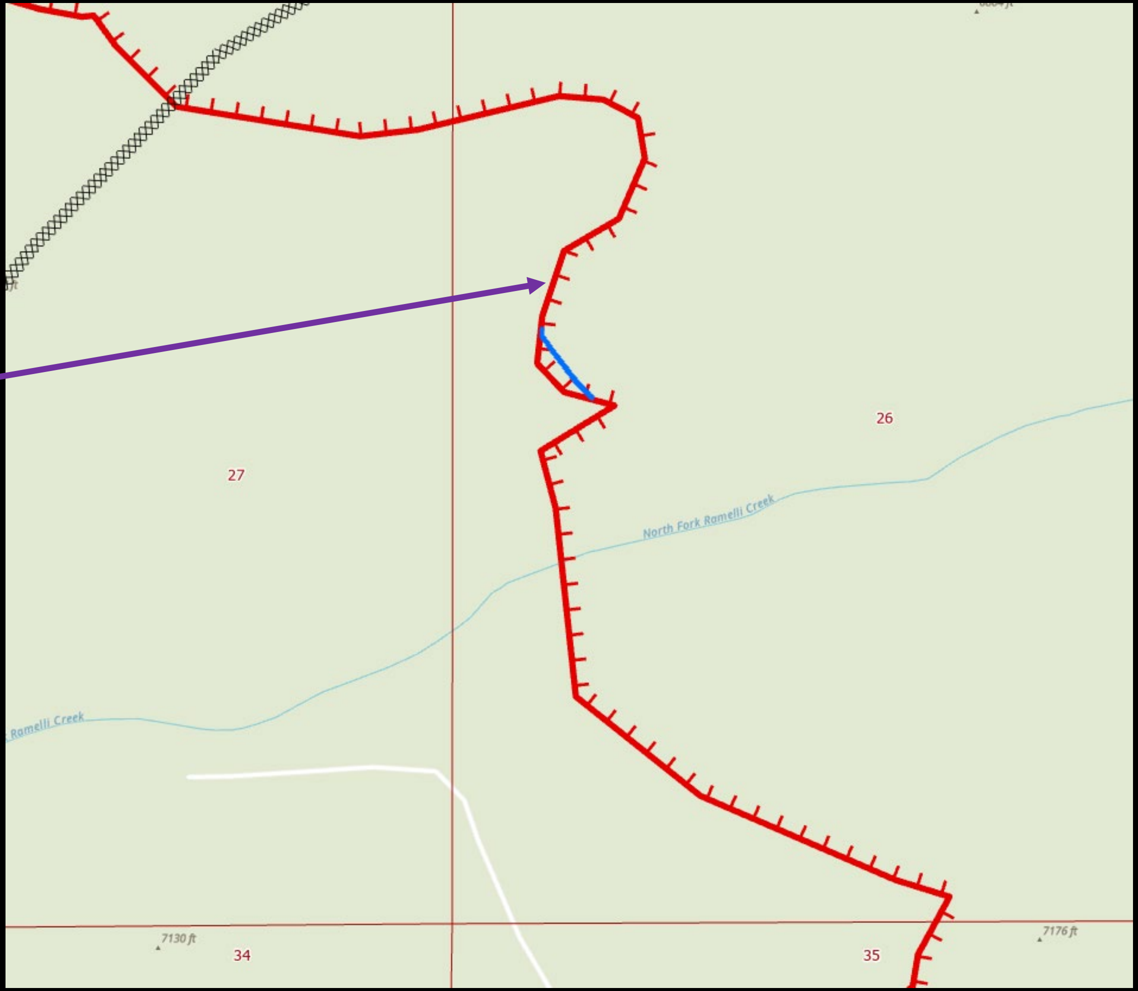
Image: BLM National UAS Program



Map: L. Russell

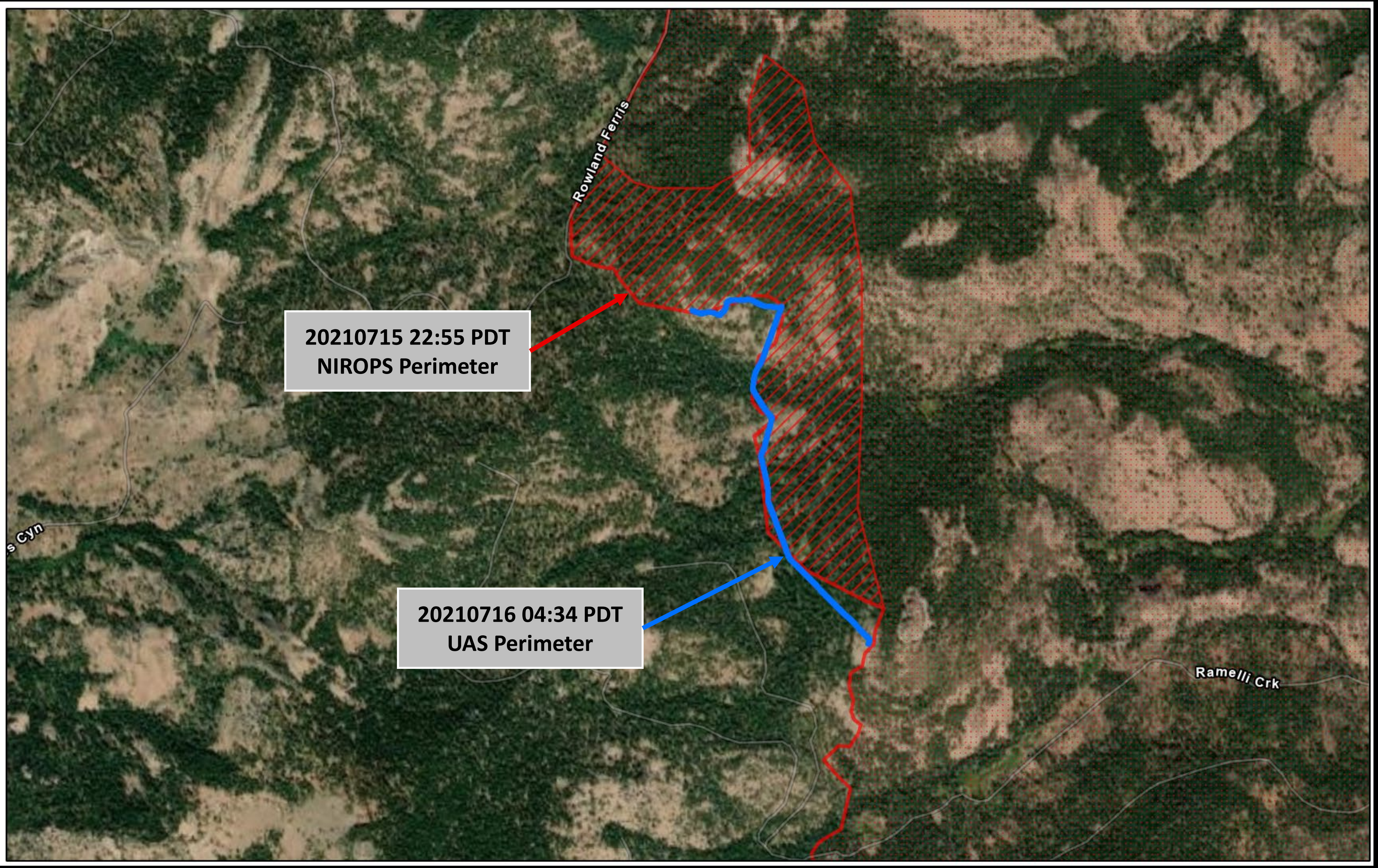
This video frame was captured when the aircraft was located here…

Image: BLM National UAS Program

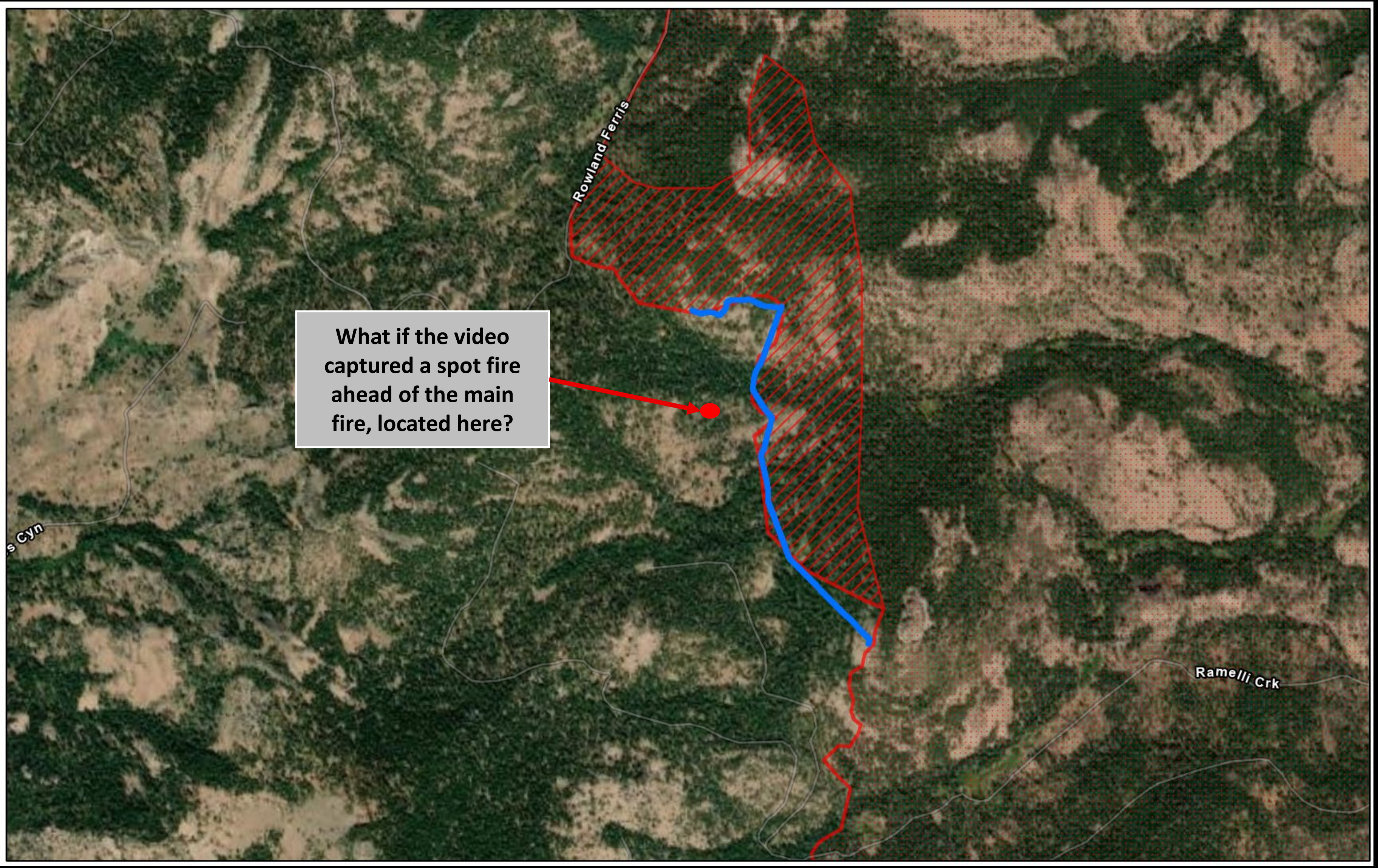


Map: L. Russell

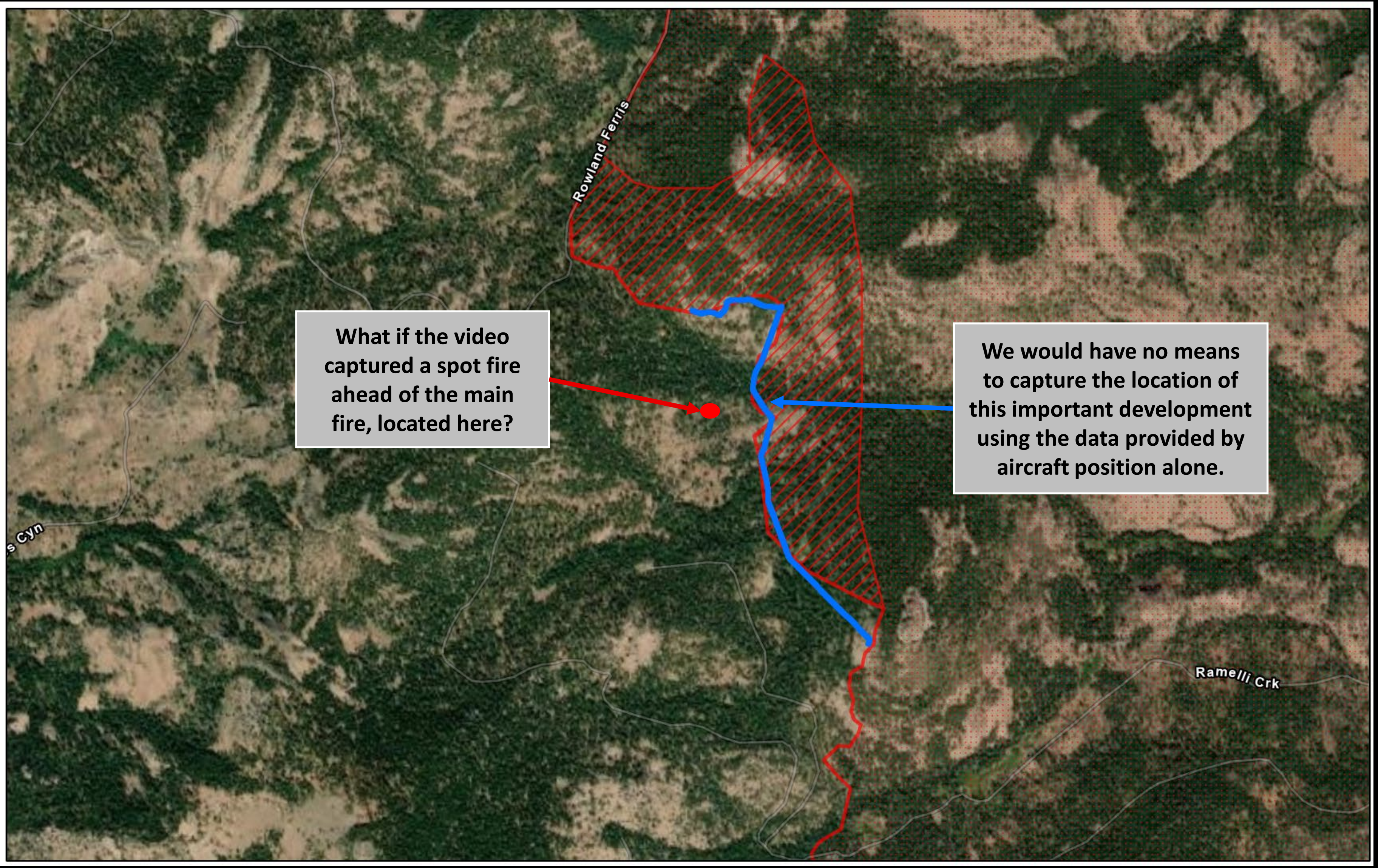
This video frame was captured when the aircraft was located here… But the sensor is capturing data at an oblique perspective, which means the principle point of the image is actually located closer to here…



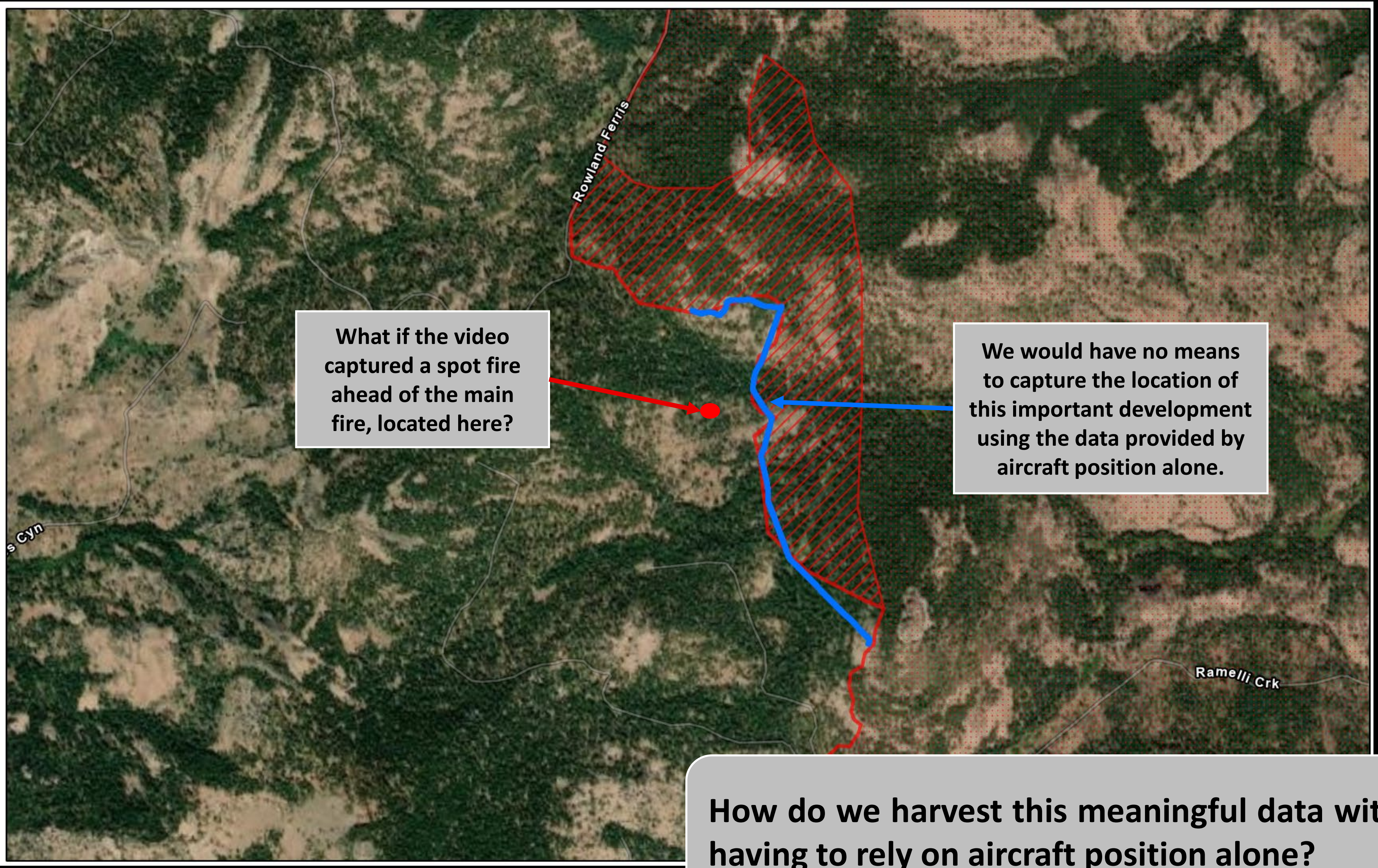
Map: L. Russell



Map: L. Russell

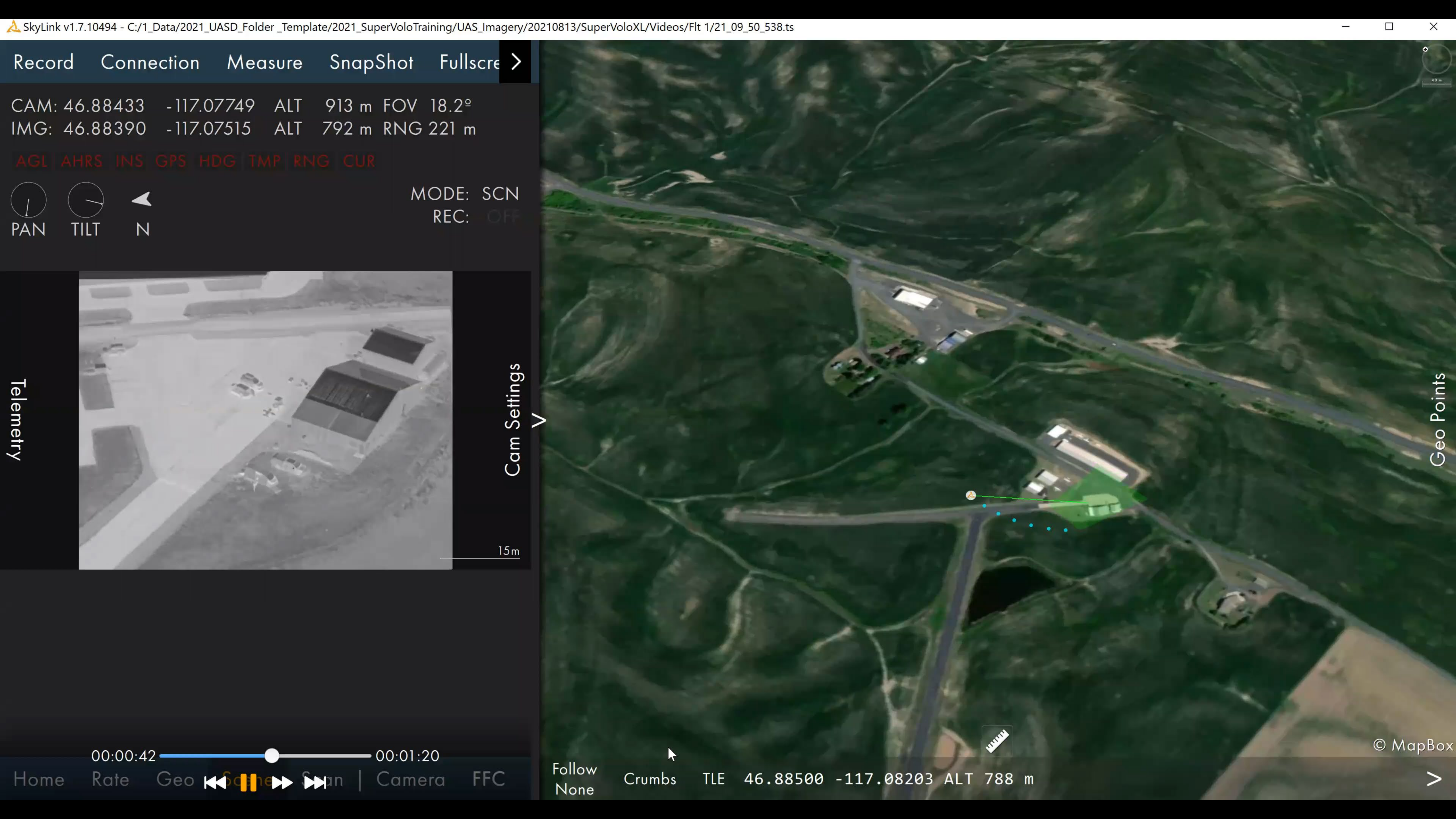


Map: L. Russell



How do we harvest this meaningful data without having to rely on aircraft position alone?

Map: L. Russell


SkyLink v1.7.10494 - C:/1_Data/2021_UASD_Folder _Template/2021_SuperVoloTraining/UAS_Imagery/20210813/SuperVoloXL/Videos/Flt 1/21_09_50_538.ts
Record
Connection
Measure
SnapShot
Fullscre
CAM: 46.88433 -117.07749 ALT 913 m FOV 18.2º
IMG: 46.88390 -117.07515 ALT 792 m RNG 221 m
AGL AHRS INS GPS HDG TMP RNG CUR
PAN
TILT
N
MODE: SCN
REC: OFF
Telemetry
Cam Settings
15m
00:00:42
00:01:20
Home
Rate
Geo
Camera
FFC
Follow
None
Crumbs
TLE 46.88500 -117.08203 ALT 788 m
Geo Points
© MapBox

Problem Statement

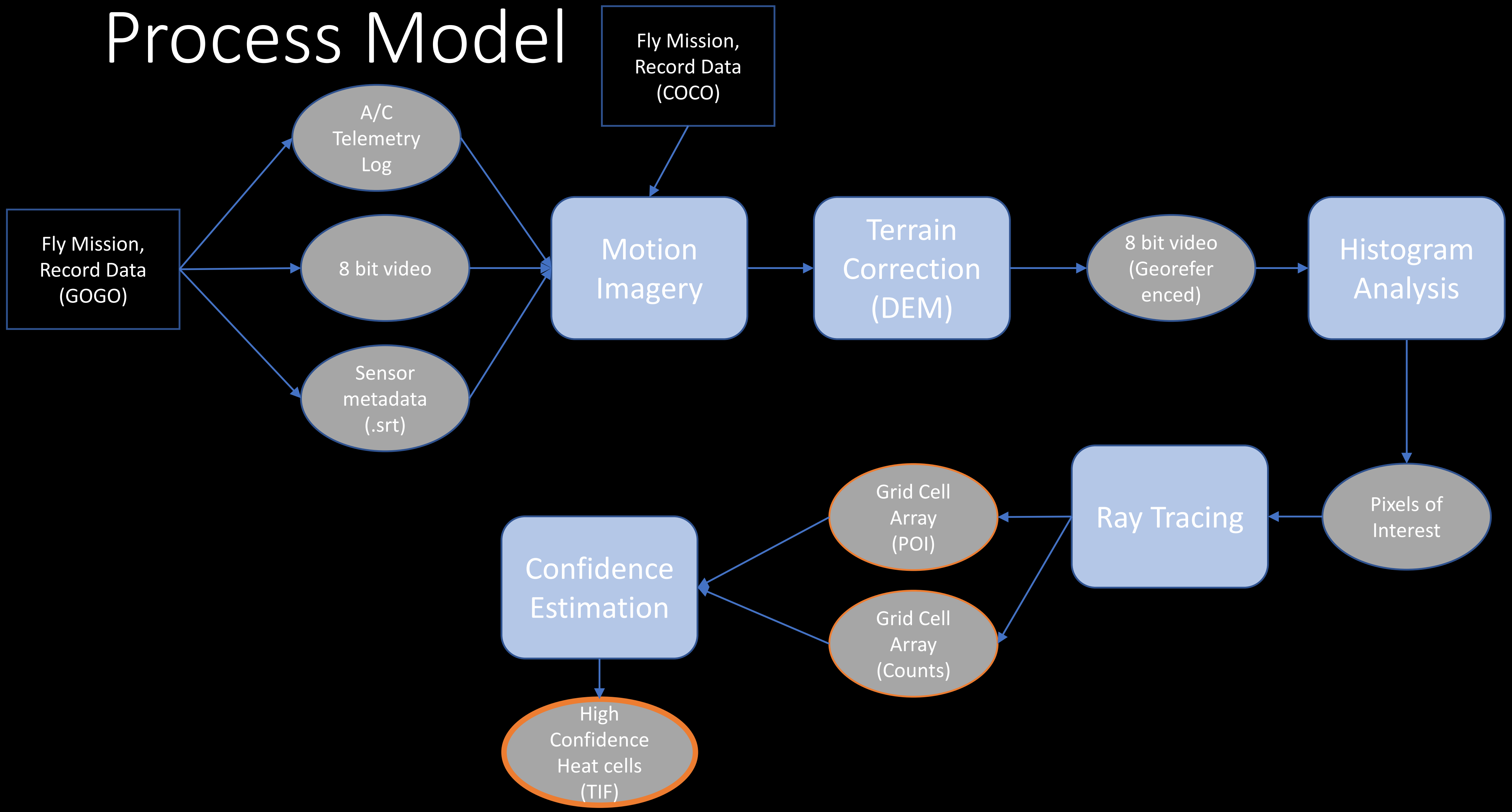
- No standardized process exists for generating motion imagery from fireline sUAS data. This project proposes such a process, and seeks to execute it on sample data in order investigate the following questions:
  - Is it possible to generate timely georeferenced videographic data (i.e., motion imagery) that meets acceptable standards of positional accuracy?
  - Is it possible to extract meaningful feature data depicting the presence of fire (e.g., perimeter, progression, heat polygons, et cetera) that meet acceptable standards of thematic accuracy?

Methodology

Phase 1:
Develop Workflow

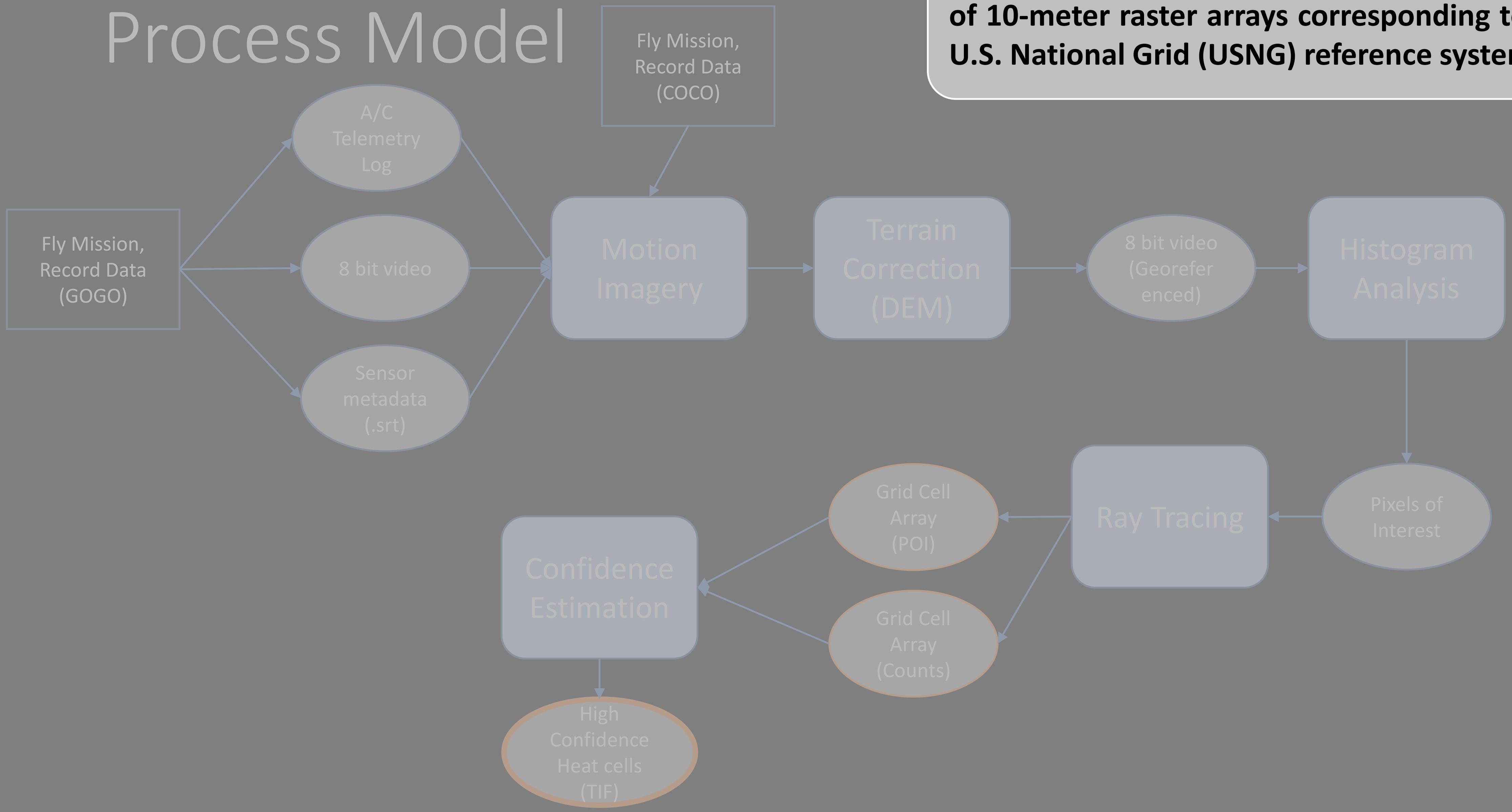
- Visualization
- User interface
- Projection
- Terrain correction
- Feature extraction
- Outputs

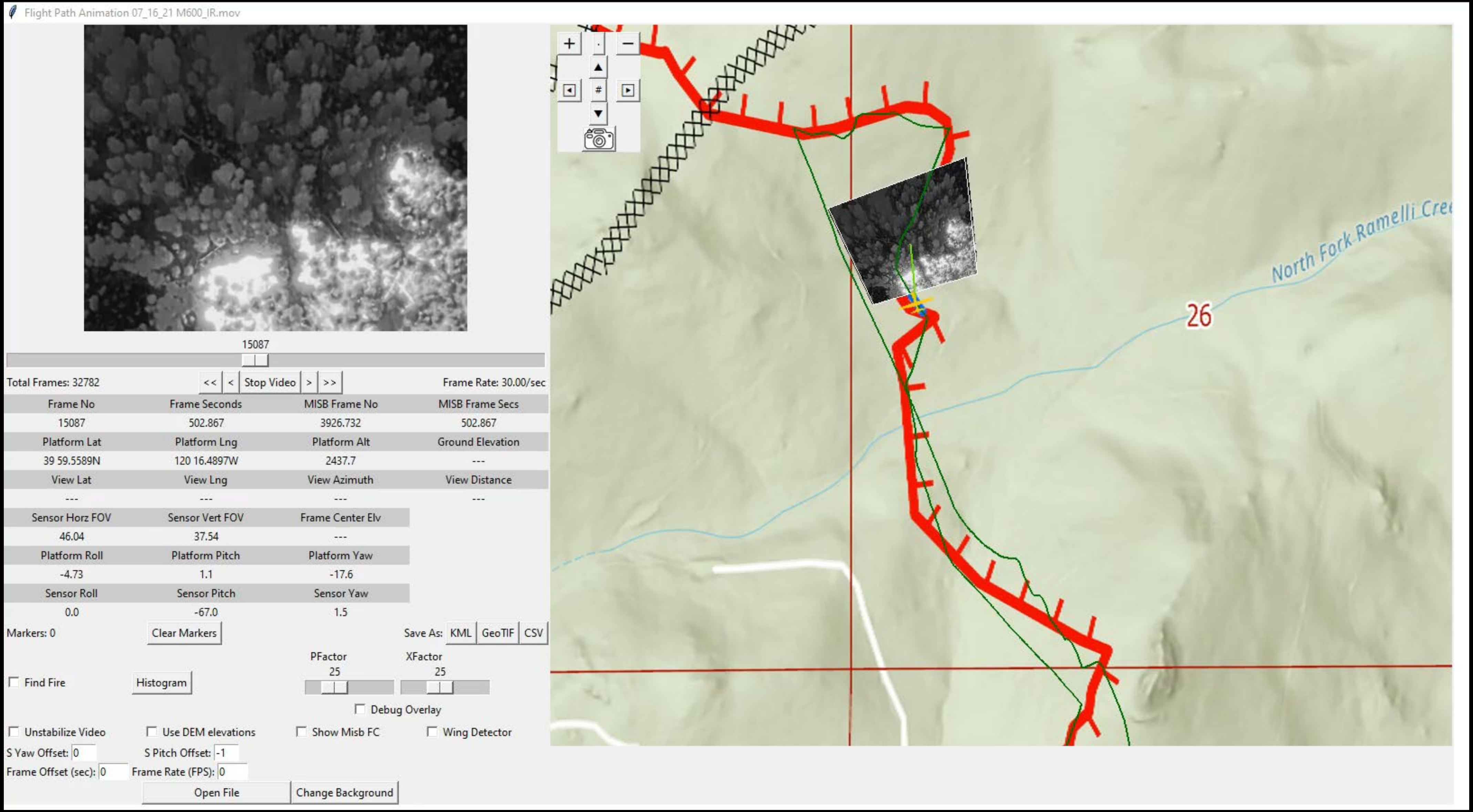
Process Model



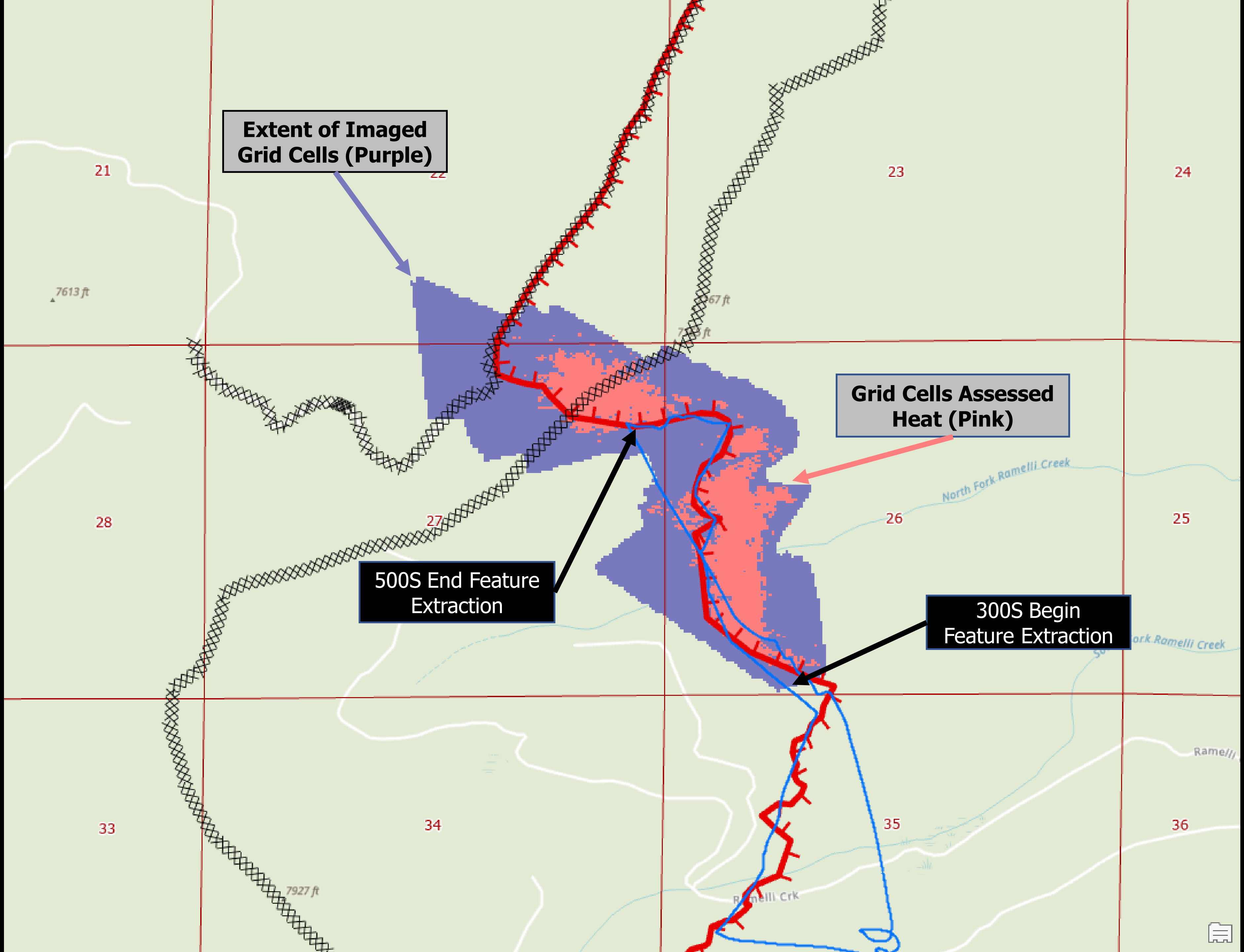
Process Model

The output of this complicated process is a set of 10-meter raster arrays corresponding to the U.S. National Grid (USNG) reference system.

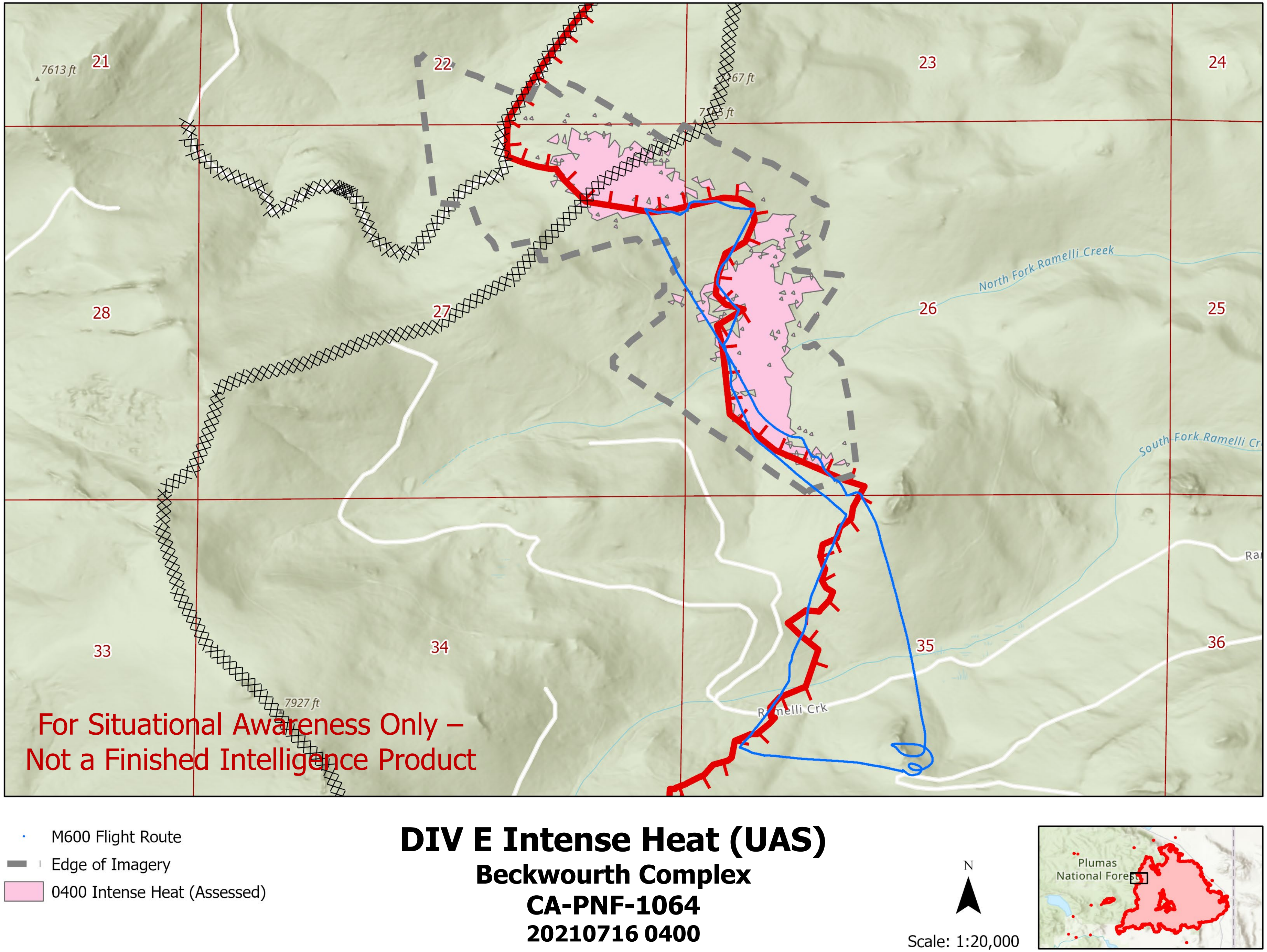




We use aircraft and sensor telemetry metadata, combined with elevation data, in order to georeferenced and terrain correct each video frame.



Map: L. Russell



DIV E Intense Heat (UAS)

Beckwourth Complex
CA-PNF-1064
20210716 0400

Map: L. Russell

Methodology

Phase 1:
Develop Workflow

Phase 2:
Execute the Workflow on Sample Data; Generate Outputs

- Visualization
- User interface
- Projection
- Terrain correction
- Feature extraction
- Define outputs

- Identify sample datasets
- Execute the workflow
- Generate outputs
- Post-process outputs
- Generate source data for accuracy assessment

Phase 2: What makes a good sample dataset for positional accuracy assessment?

- **Permanent/semi-permanent photo-identifiable features**
- **Daytime EO**

Image: G. Dustin

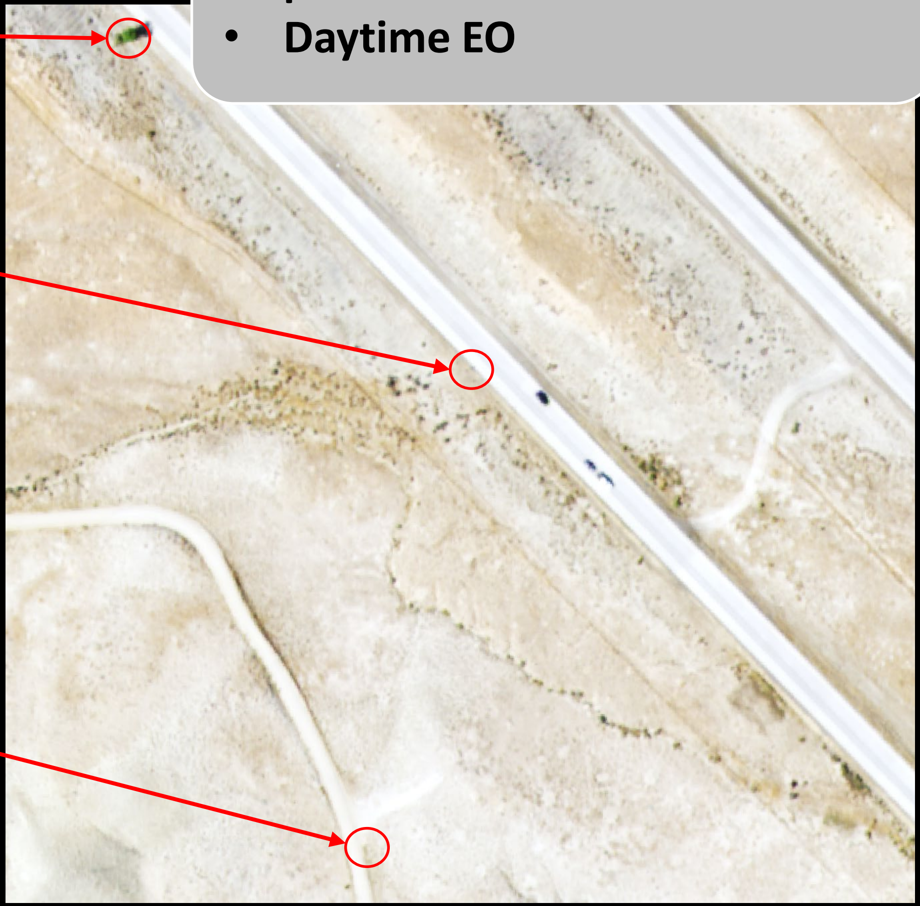


Image: NAIP

Phase 2: What makes a good sample dataset for thematic accuracy assessment?

- **Daytime EO and IR video**
- **Early morning hours**
- **Discernible flame front**

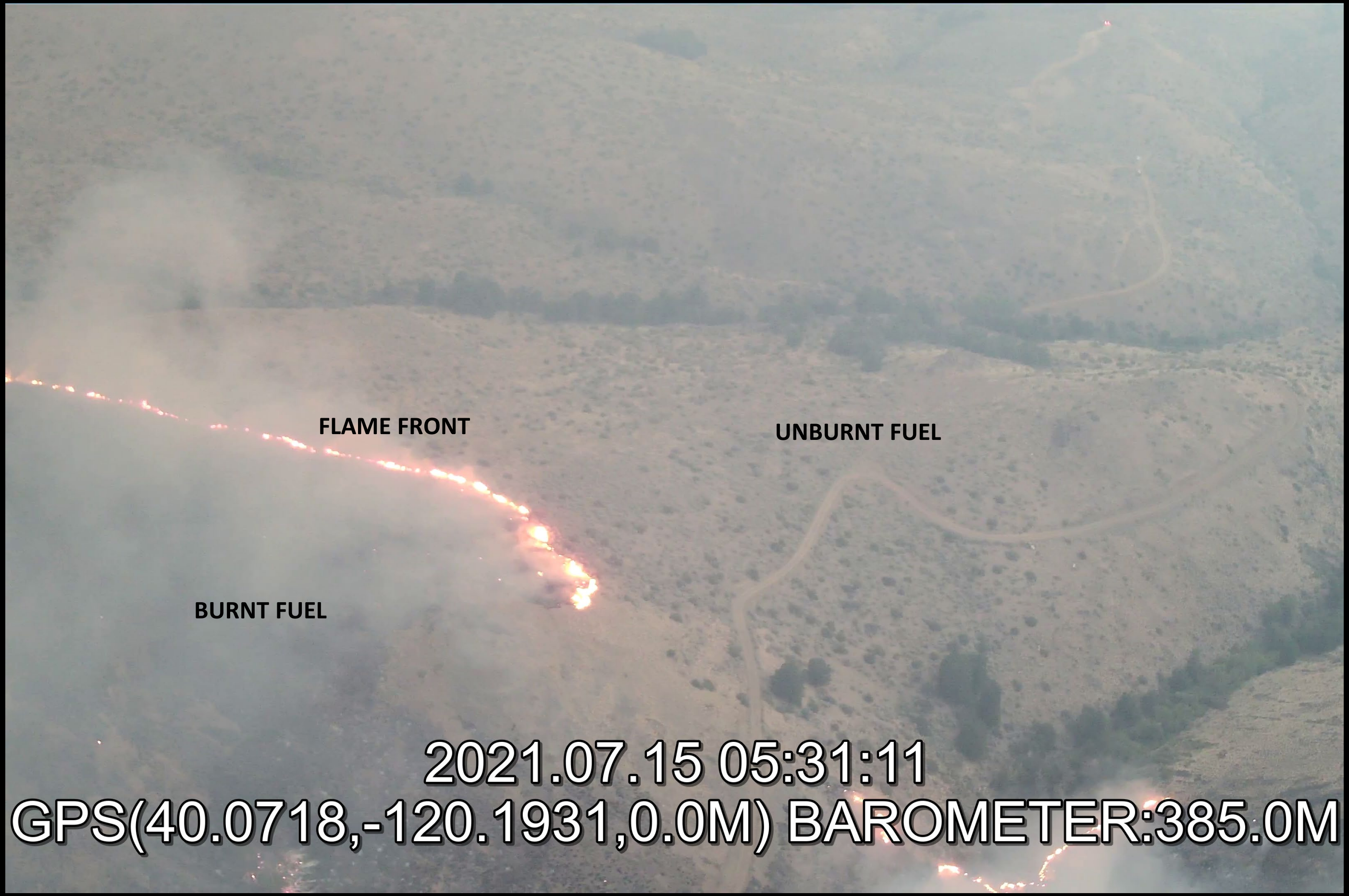


Image: BLM National UAS Program

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Methodology

Phase 1: Develop Workflow → **Phase 2: Execute the Workflow on Sample Data; Generate Outputs** → **Phase 3: Assess the Positional and Thematic Accuracy of the Outputs**

Phase 1: Develop Workflow

- Visualization
- User interface
- Projection
- Terrain correction
- Feature extraction
- Outputs

Phase 2: Execute the Workflow on Sample Data; Generate Outputs

- Execute the workflow
- Generate outputs
- Post-process outputs
- Generate source data for accuracy assessment

Phase 3: Assess the Positional and Thematic Accuracy of the Outputs

- Assess positional accuracy
- Farm out thematic accuracy assessment to volunteers
- Calculate statistics and error matrices

Phase 3: How do we perform positional accuracy assessment on motion imagery?

Image: Atlas United LLC

Plot photo-identifiable checkpoints in successive frames of motion imagery, then calculate NMAS CE90 statistics.

Image: ESRI

Phase 3: How do we perform thematic accuracy assessment on motion imagery?

Image: BLM National UAS Program

Identify a stratified random sample of heat and non-heat grid squares in processed dataset. Back-project each grid square to video, edit clips together, and disseminate to accuracy assessors for visual interpretation.

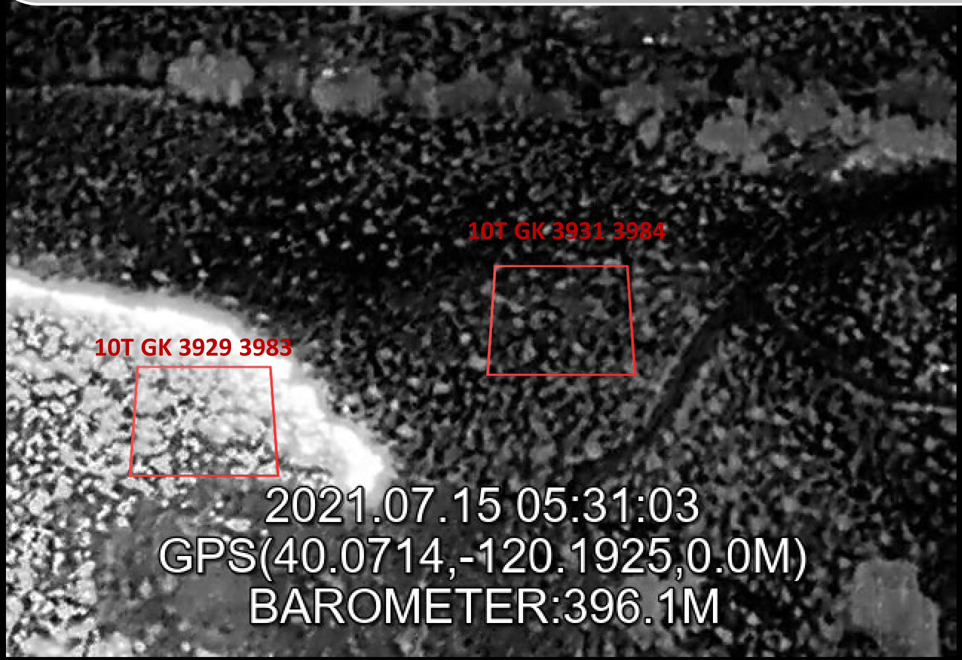
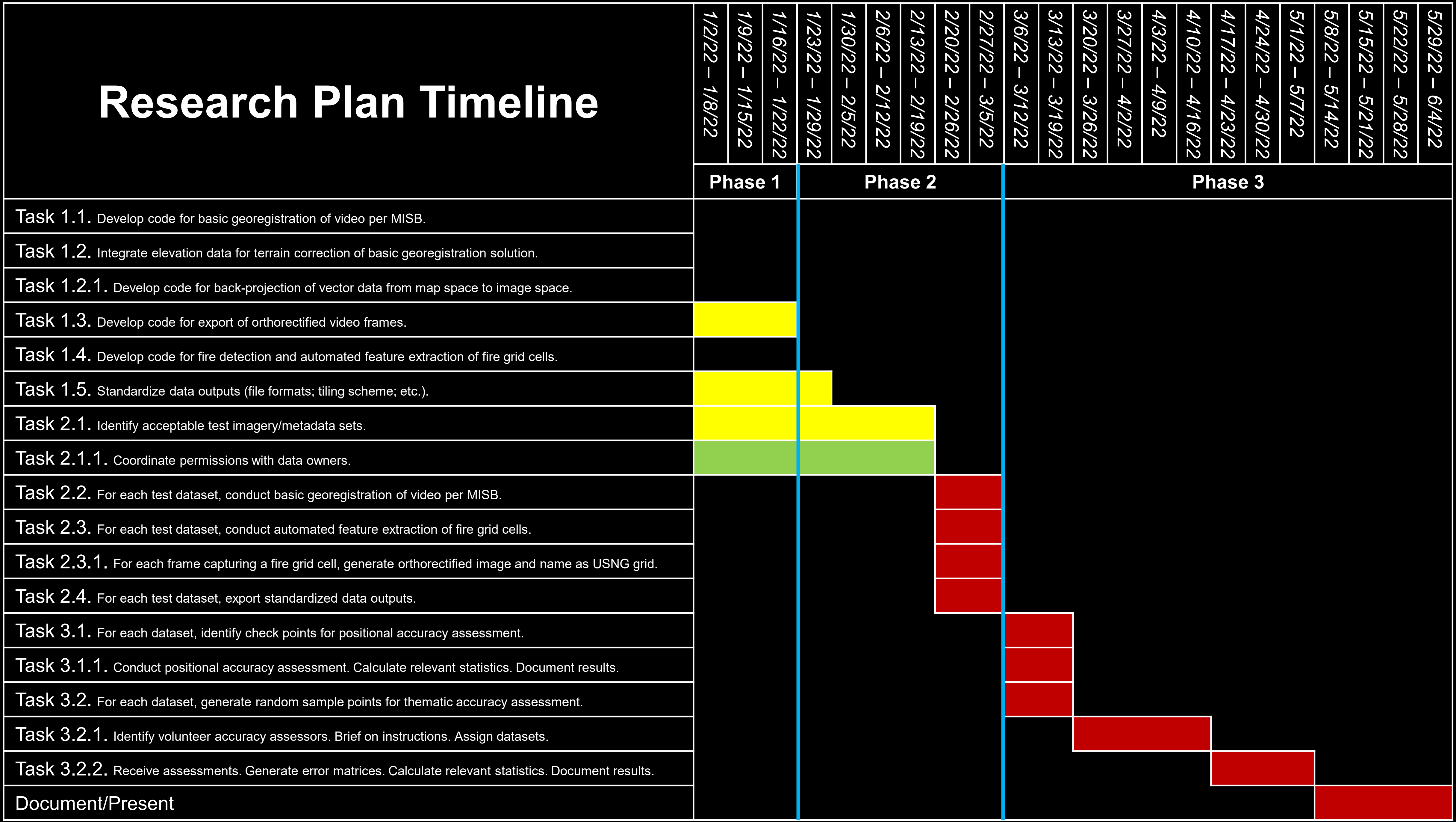


Image: BLM National UAS Program

Research Plan: Strategy-to-Task

Phase 1: Develop the Workflow	Phase 2: Test Workflow Across 3+ Imagery/Metadata sets	Phase 3: Conduct Accuracy Assessment
1.1. Develop code for basic georegistration of video per MISB.	2.1. Identify acceptable test imagery/metadata sets.	3.1. For each dataset, identify check points for positional accuracy assessment.
1.2. Integrate elevation data for terrain correction of basic georegistration solution.	2.1.1. Coordinate permissions with data owners.	3.1.1. Conduct positional accuracy assessment. Calculate relevant statistics. Document results.
1.2.1. Develop code for back-projection of vector data from map space to image space.	2.2. For each test dataset, conduct basic georegistration of video per MISB.	3.2. For each dataset, generate random sample points for thematic accuracy assessment.
1.3. Develop code for export of orthorectified video frames.	2.2.1. For each test dataset, terrain correct basic georegistration solution.	3.2.1. Identify volunteer accuracy assessors. Brief on instructions. Assign datasets.
1.4. Develop code for fire detection and automated feature extraction of fire grid cells.	2.3. For each test dataset, conduct automated feature extraction of fire grid cells.	3.2.2. Receive assessments. Generate error matrices. Calculate relevant statistics. Document results.
1.5. Standardize data outputs (file formats; tiling scheme; etc.).	2.3.1. For each frame capturing a fire grid cell, generate orthorectified image and name according to USNG grid coordinate.	
	2.4. For each test dataset, export standardized data outputs.	



Research Plan Timeline
1/2/22 – 1/8/22
1/9/22 – 1/15/22
1/16/22 – 1/22/22
1/23/22 – 1/29/22
1/30/22 – 2/5/22
2/6/22 – 2/12/22
2/13/22 – 2/19/22
2/20/22 – 2/26/22
2/27/22 – 3/5/22
3/6/22 – 3/12/22
3/13/22 – 3/19/22
3/20/22 – 3/26/22
3/27/22 – 4/2/22
4/3/22 – 4/9/22
4/10/22 – 4/16/22
4/17/22 – 4/23/22
4/24/22 – 4/30/22
5/1/22 – 5/7/22
5/8/22 – 5/14/22
5/15/22 – 5/21/22
5/22/22 – 5/28/22
5/29/22 – 6/4/22
Phase 1
Phase 2
Phase 3
Task 1.1. Develop code for basic georegistration of video per MISB.
Task 1.2. Integrate elevation data for terrain correction of basic georegistration solution.
Task 1.2.1. Develop code for back-projection of vector data from map space to image space.
Task 1.3. Develop code for export of orthorectified video frames.
Task 1.4. Develop code for fire detection and automated feature extraction of fire grid cells.
Task 1.5. Standardize data outputs (file formats; tiling scheme; etc.).
Task 2.1. Identify acceptable test imagery/metadata sets.
Task 2.1.1. Coordinate permissions with data owners.
Task 2.2. For each test dataset, conduct basic georegistration of video per MISB.
Task 2.3. For each test dataset, conduct automated feature extraction of fire grid cells.
Task 2.3.1. For each frame capturing a fire grid cell, generate orthorectified image and name as USNG grid.
Task 2.4. For each test dataset, export standardized data outputs.
Task 3.1. For each dataset, identify check points for positional accuracy assessment.
Task 3.1.1. Conduct positional accuracy assessment. Calculate relevant statistics. Document results.
Task 3.2. For each dataset, generate random sample points for thematic accuracy assessment.
Task 3.2.1. Identify volunteer accuracy assessors. Brief on instructions. Assign datasets.
Task 3.2.2. Receive assessments. Generate error matrices. Calculate relevant statistics. Document results.
Document/Present

Summary

- Background
- Problem Statement
- Methodology
- Research Plan

Questions?

- Feel free to contact me at lbr5286@psu.edu with feedback.