Final Report
ASSURE A28: Disaster Preparedness and Response Using UAS
Attachment 9 – Concept of Operations (CONOPS) for Wildland Fire #1

June 1, 2022

NOTICE

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TABLE OF ACRONYMS

ACUASI – Alaska for Unmanned Aircraft Systems Integration

BLM – Bureau of Land Management

BVLOS – Beyond Visual Line of Sight

CONOP – Concept of Operation

DAA – Detect and Avoid

DEM – Digital Elevation Model

DLI – Divert Land Immediately

EO – Electro-optical

EVLOS – Extended Visual Line of Sight

FAA – Federal Aviation Administration

FEMA – Federal Emergency Management Agency

FMV – Full Motion Video

FOV – Field of View

GCS – Ground Control Station

GEOJSON – Geographic JavaScript Object Notation

IFR – Instrument Flight Rules

JPEG – Photographic Experts Group

KML – Keyhole Markup Language

KMZ – Keyhole Markup Zipped

LAANC – Low Altitude Authorization and Notification Capability

LiDAR – Light Detection and Ranging

NAS – National Airspace System

NWS – National Weather Service

ORA – Operational Risk Assessment

PIC – Pilot in Command

RGB – Red, Green, Blue

RTB – Return to Base

RTL – Return to Land

SfM – Structure from Motion

SGI – Significant Governmental Interest

SHP – Shape file

SOSC – System Operations Support Center

sUAS – Small Unmanned Aircraft System

TFR – Temporary Flight Restriction

TIFF – Tag Image File Format

TIR – Thermal Infrared

UAF – University of Alaska Fairbanks

UAS – Uncrewed/Unmanned Aircraft System

USGS – United States Geological Survey

VFR – Visual Flight Rules

VLOS – Visual Line of Sight

VNIR – Visible and near-infrared

VO – Visual Observer

VTOL – Vertical Takeoff and Landing

ATTACHMENT 9 - CONCEPT OF OPERATIONS (CONOPS) FOR WILDLAND FIRE #1

Lead organization will demonstrate that the CONOP has been reviewed. The CONOP will be accepted if the document contains sufficient information to proceed to an operational risk assessment (ORA). <u>The CONOP is to be submitted by the lead organization for the mission.</u>

Approval by (Name/Org)	Title	Date	Approve Digital Signature

This CONOP will include all items needed to build out a successful mission. There will be sections included that are specific to each disaster response in the CONOP, such as under purpose of mission. Any specific information needed in the CONOP for a disaster response will be included before the summary section.

This CONOP document follows the "5-paragraph order" format, leveraged from the military operations world. The purpose is to allow operational team members to determine whether an applicant explicitly identifies key information that will be necessary for a subsequent **Operational Risk Assessment (ORA)**. These paragraphs spell out the acronym **S-M-E-A-C, for "Situation", "Mission", "Execution", "Administration & Logistics", "Command & Signal"**. This is known as the "SMEAC Sheet".

List of Revisions			
Revision Description	Approved by	Approve Digital Signature	Release Date (DD/MM/YY)

<u>Notes on a CONOP:</u>

The CONOP is viewed as an "evolving" document that records an analysis performed during the requirements generation process and should contain the following:

- A clear statement of the goals and objectives
- Strategies, tactics, policies, and constraints that describe how security will affect the program
- Organizations, activities, and interactions that describe who will participate and what these stakeholders do in that process
- A clear statement of the responsibilities and authority of the roles played in the process
- The specific operational processes, in overview fashion, that provide a process model in terms of when and in what order these operation processes take place, including such things as dependencies and concurrencies
- Processes for initiating the program, developing the products and components, maintaining the products, and components, and possibly for retiring the program and its products and components

CONOP:

- Narrate the processes to be followed
- Define the roles of the various stakeholders involved in the process
- Outline a methodology to realize the goals and objectives of the mission

1.1 Concept of Operation (CONOP)

Prescribed burn of land outside Tanacross

UAS required to monitor the burn as well as ignite the surface and repellant the fire once burn complete

Operation:

Collection of thermal and optical imagery and video of the prescribed burn as well as the application of a fire suppression payload. Site: Tanacross, Alaska with collaborators

Duration of Operation:

Few hours (sUAS airborne to map the region of the burn site and monitor the burn episode)

Outcomes/Actionable intelligence:

- sUAS #1 - Tethered watching from the side with an off-nadir ability to monitor events. Electro-optical (EO) and thermal video feed of the events support local operations. Data feeds through tether along with power to provide sustained operations. Location such that it can watch all operations and be used to evaluate effectiveness of missions.

- sUAS #2A, #2B, #2C (Team with sufficient batteries to support at least three missions) (Mapping landscape before (#2A), during (#2B) and post fire, #2C) - Imagery captured prior to ignition to evaluate the landscape and environment. Then sent up once the fire has been started to have eyes on the event from above and capture images to build a mosaic of the landscape. EO video feed back to Pilot In Command (PIC) and piped into the local operations team. 3D rendering of the landscape available soon after the mission flew. Field of View (FOV) of EO camera seen by the operations team so they can adapt flight as their needs. sUAS #2C flown after #3A mission to evaluate if the area needed to be burnt has been completed and that the retardant has been successful.

- sUAS #3A (ignition of land) - Ability to ignite the area for the prescribed burn so the team does not need to send personnel on the ground.

- sUAS #3B (Retardant sent out to put out fire) - Same original sUAS carries retardant that can be placed onto the burned area to stop the fire. sUAS #2C is mapping the region to assess the effectiveness of the retardant.

- sUAS #4A - #4D (Monitoring of UAS #2A and #2B) - Video feed supports the local operations team to assess effectiveness of the missions. Data back to local operations team so that they can communicate with PIC of UAS #3A, #2B, #3B, and #2C.

Metrics of success:

- sUAS #1: Stays airborne throughout, EO and Thermal Infrared (TIR) feeds back to ground control station (GCS), tether continues to support data being streamed back as well as power to prevent need for new batteries
- sUAS #4A - #4D: Stream data back to the ops center to support assessment of prescribed fire missions and allow other PICs to change flights in response to fire spread.
- sUAS #2A produces mosaicked maps in EO/Visible Near Infrared (VNIR)/TIR of the pre-fire landscape.
- sUAS #2A produce LiDAR point cloud observations to assess before #2B takes off
- sUAS #2C produce LiDAR point cloud to determine if prescribed burn safe to leave
- sUAS #3A drops of ignition cargo to start the prescribed burn at sites required.
- sUAS #2B streams back data to support those on ground to assess fire extent.
- sUAS #3B navigates to fire edge to suppress fire given data from sUAS #4C above.
- sUAS #2B responds to commands from the incident center to fire edge from #4C data.
- sUAS #3C maps the edge of the fire and data shows that fire has been suppressed and safe to end operations.
- sUAS flew under Part 107 and visual line of sight (VLOS) maintained.

1.2 CONOP Quad Chart: Collection of thermal and electro-optical imagery and video of the prescribed burn as well as the application of a fire suppression payload.

1.2.1 Mission Purpose/Objectives

Purpose: Prescribed burn at Tanacross, Alaska with ignition of fuels and suppression of fire

Goals: Get multiple sUAS operating in the same area, each taking on different roles. Demonstrate that sUAS can provide ignition and retardant material and also map the fire spread to minimize risk for manned aircraft and ground crews.

Objectives: sUAS #1 is a fixed location to support teams to get real-time analysis of missions as they are ongoing and to support teams to evaluate effectiveness of missions and the implementation of the operations. sUAS #2 provides pre, during, and post fire observations at lower altitude [Pre: electro-optical-near-infrared[NIR]/thermal infrared[TIR]/LiDAR; During: RGB/TIR; Post: RGB-NIR/TIR/LiDAR]. sUAS #4A - #4D provides the same altitude eyes on the missions. sUAS #3A is able to ignite the prescribed burn in a location that is difficult to access for ground teams. sUAS #3B can access the fire edge and release retardant to stop fire spread. Evaluate how sUAS missions can respond to other sUAS operations and data analysis. Evaluate how 107 pilots can respond to needs of a community and how Part 107 operations can provide full aspects of prescribed burn needs.

1.2.2 Mission Procedures/Approach

sUAS#1: Fixed tethered view of all of the missions

EO and TIR data shared through tethered system

Field of View allows full view of all operations [take-off, flight, and landings]; Fly VLOS or Extended Visual Line of Sight (EVLOS) under Visual Flight Rules (VFR) conditions; Will stay airborne until operations complete

sUAS #2A: 1st flight; VLOS operations

EO/VNIR/TIR camera with LiDAR; Provide real-time data and build mosaiced maps and 3D models

Post flight: LiDAR point clouds to assess local vegetation and canopy near to burn areas

Flown from launch site for use by all sUAS; Route defined to cover the area that will be burned ; VFR conditions as will be VLOS

sUAS - #3A and #4A [#3A - Carry fire ignition material; #4A - EO and TIR payload for eyes on the event]

Part 107 operations, flight #3A at higher altitude to view the full burn area

Fly VLOS or EVLOS under VFR conditions

sUAS - #2B and #4B [#2B - EO, VNIR, and TIR payload to map the fire; #4B - EO and TIR payload for eyes on the event]

Part 107 operations, flight #4B to view the full burn area

Flight #2B has defined pattern and also can move based on data from #3B

sUAS - #3B and #4C [#3B - Carry fire retardant material; #4C - EO and TIR payload for eyes on the event]

Part 107 operations, flight #4C to view the full burn area

Flight #3B will move to area needed for retardant based on data from #4B

sUAS - #2C and #4D [#2C - EO/VNIR/TIR camera with LiDAR; #4D - EO and TIR payload for eyes on the event]

#2C - Provide real-time data and build mosaiced maps and 3D models; Post flight: LiDAR point clouds to assess impact to vegetation and any canopy

#4D will watch how #2C maps the edge of fire and collects LiDAR data

#2C follows pattern based off data from flight #4C

1.2.3 Mission Results

Observations: Recording of full extent of fire spread. Data feeds back to operations center. sUAS #4 is a fixed and tethered system to provide red-green-blue electro-optical and thermal data to support post-mission evaluation of effectiveness of all flights, ground team effectiveness and operational timing. sUAS #2 is mapping the land before burn [with LiDAR to map any canopy/vegetation], the progression of the fire, and extent of the burned areas. sUAS #3 will release the ignition material and the retardant to stop the fire. sUAS #4 fly at same altitude as missions to watch the other flights and support the ops center to monitor the flights and connect to the PIC's of sUAS #2 and #3.

Real-time Mission Products: sUAS #1 - electro-optical visible data feeds through tether along with archived data for post mission evaluation. Visible and thermal data feedback to ground control station (GCS) and operations Ccnter from all. sUAS #4A - #4D to provide eyes on the missions. Data displayed in geospatial interface to superimpose on other available data from state, federal, and local agencies. sUAS #2A - #2C provide electro-optical visible, near-infrared (NIR), and thermal data real-time video feeds that can be assessed in operations center. Note that sUAS #2A and #2 for pre and post fire have sensors to map vegetation and landscape to determine pre landscape including any canopy and post impact on vegetation. sUAS #3A and #3B data shows release of ignition and retardant materials into the correct locations.

Post-Mission [fast response] Products: sUAS#1: Full motion video (FMV) of the missions with geo- and time-tagged data to compare to data from other sUAS and flight software. sUAS #2A - #2C: visible, NIR, and thermal videos of pre, during and post fire landscape [LiDAR point clouds for sUAS #2A and #2C]. Mosaiced maps with derived properties of landscape along with surface models where structure from motion (SfM) is possible. sUAS #3A and #3B: Videos in visible wavelengths of release of ignition and retardant with locations of released material. sUAS #4A - #4D: FMV footage of the operations from the same altitude that superimposes with the post processed data from sUAS #2A- #2C.

1.2.4 Mission Milestones

Outcomes/Actionable Intelligence

sUAS #1 - Tethered watching from the side with an off-nadir ability to monitor events. Electro-optical visible and thermal video feed of the events support local operations. Data feeds through tether along with power to provide sustained operations. Location such that it can watch all operations and be used to evaluate effectiveness of missions.

sUAS #2A, #2B, and #2C [Support at least three missions] [Mapping landscape before [#2A], during [#2B] and post fire, #2C] - Imagery captured prior to ignition to evaluate the landscap. Sent up once the fire started to have eyes on the event and capture images to build a mosaic of the landscape. Visible video feed back to PIC and sent back into the local operations team. Three-dimensional rendering of the landscape available soon after the mission flew. FOV of visible camera seen by operations team so they can adapt flight as their needs. sUAS #2C flown after #3A mission to evaluate if the area needed to be burnt has been completed and that the retardant has been successful.

sUAS #3A [ignition of land] - Ignite the area for the prescribed burn so the team does not need to send personnel on the ground.

sUAS #3B [Retardant] - Same sUAS carries retardant onto the burned area to stop the fire. sUAS #2C is mapping to assess the effectiveness of the retardant.

sUAS #4A - #4D [Monitoring of sUAS #2A and #2B] - Visible video of the events that supports the local operations team to assess effectiveness of the missions. Data back to operations team so that they can communicate with PIC of sUAS #3A, #2B, #3B, and #2C.

Metrics of success

sUAS #1: Stays airborne throughout, visible and thermal data feed to ground control station, tether support data being streamed back as well as power to prevent need for new batteries

sUAS #4A - #4D: Stream data back to support assessment of prescribed fire missions and allow other PIC's to change flights in response to fire spread.

sUAS #2A produces mosaicked maps in visible, near-infrared, and thermal of the pre-fire landscape.

sUAS #2A produce point cloud observations to assess before #2B takes offs

sUAS #2C produce point cloud to determine if prescribed burn safe to leave

sUAS #3A drops of ignition cargo to start the prescribed burn at sites required.

sUAS #2B streams back data to support those on ground to assess fire extent.

sUAS #3B navigates to fire edge to suppress fire given data from sUAS #4C above.

sUAS #2B responds to commands from the incident center to fire edge from sUAS #4C data.

sUAS #3C maps the edge of the fire and data shows that fire has been suppressed and safe to end operations.

1.3 Situation

1.3.1 Overview

<u>Purpose of the mission</u>: Prescribed burn of landscape at Tanacross, AK. sUAS support ground operations to ignite fire, map spread, suppress the burn area, and watch over missions for effectiveness.

<u>Goals</u>: Perform a prescribed burn of local landscape and want to perform ignition, mapping, and suppression all from a UAS. Minimize the need for ground teams to visit remote locations.

UAS mission Lead: University of Alaska Fairbanks (UAF) Alaska Center for Unmanned Aircraft Systems Integration (ACUASI) team with support from flight crews of three sUAS.

- Overall: ACUASI at operations hub. Communicate with flight team leads.

- sUAS #1 - PIC with Visual Observer (VO), tethered sUAS
    - EO visible TIR sensor
    - Watch and evaluate effectiveness of missions, Fixed location

- sUAS #2A, #2B, #2C - PIC with (VO, Part 107 remote pilot, PIC in comms to lead all ops
    - EO visible and VNIR sensor
    - Map landscape pre, during, and post fire

- sUAS #3A and #3B: PIC with VO, Part 107 remote pilot, PIC in comms to lead all ops
    - Ignition and suppression payloads for prescribed burn

- sUAS #4A - #4D: PIC with VO, Part 107 remote pilot, PIC in comms to lead all ops
    - EO visible high resolution to follow operations
    - Manually move based on needs

1.3.2 Location

Location

Tanacross, Alaska

Latitude: 63.370772°N

Longitude: 143.3329861°W

All Maps in Appendix 3

1.3.3 Systems

Location: Central Operation

- Based at safe perimeter from the launch sites so can watch the operations
- Coordination with flight teams
- ACUASI: Director of Operations Adkins
- Bureau of Land Management (BLM), Local community, Doyon, and Prescribed burn representatives

sUAS #1

- Vertical Takeoff and Landing (VTOL) system on a tether
- Continuous operations throughout all missions

- Pilots and Crew
  - Part 107 PIC with VO
- Minimum Payload
  - EO visible and TIR to support observations on all missions
  - Off-nadir capability to adapt to a need with FOV can see all operations
- Tether allows data feeds streamed back in real-time as well as power to UAS

sUAS #2A/2B/2C

- VTOL system with endurance for 45 minutes per flight
- Pilots and Crew
  - Part 107 PIC + VOs with aircraft for rapid response (Approved for Ops)
  - VTOL support take-off and landing to map area for burn
  - Engineering support (if possible as VO)
- Minimum Payload
  - EO and VNIR (fuel mapping) and thermal (fire mapping)
  - LiDAR added for mapping of landscape and tree canopy
- Sufficient battery capacity for multiple flights
- FAA waiver to get a higher altitude, > 400 ft

sUAS #3A/3B

- VTOL system with endurance for 45 minutes per flight)
- Pilots and Crew
  - Part 107 PIC + VOs with aircraft for rapid response
- sUAS flies to area where Ops team would like burn to start
- Minimum Payload
  - Ignite material to start the fire
  - EO visible and TIR for real-time video feed to check material ignited

sUAS #4A/4B/4C/4D

- VTOL system with endurance for 45 minutes per flight
- Pilots and Crew
  - Part 107 PIC + VOs with aircraft for rapid response (Approved for Ops)
  - Engineering support (if possible as VO)
- Minimum Payload
  - EO to provide high resolution data of the event
- Sufficient battery capacity for multiple flights
- FAA waiver to get a higher altitude > 400 ft.

Missions Order

- sUAS #1 Tethered sUAS that watches all missions for evaluation

- sUAS #2A Prior to burn mapping of landscape
- sUAS #3A + #4A Fire Ignition + mission watching overhead
- sUAS #2B + #4B Fire mapping + mission watching overhead
- sUAS #3B + #4C Fire Suppression + mission watching overhead
- sUAS #2C + #4D Fire analysis + mission watching overhead
- sUAS #1 Lands after all other missions completed

1.4 Mission

Disaster:

Prescribed burn at Tanacross, Alaska with ignition of fuels and suppression of fire

Observations

Recording of full extent of fire spread. Data feeds back to the operations center. sUAS #1 is a fixed and tethered system to provide red-green-blue (RGB) visible and thermal data to support post-mission evaluation of effectiveness of all flights, ground team effectiveness and CONOPs timing. sUAS #2 is mapping the land before burn (with LiDAR to map any canopy/vegetation), the progression of the fire, and extent of the burned areas. sUAS #3 will release the ignition material and the retardant to stop the fire. sUAS #4 fly at same altitude as missions to watch the other flights and support the ops center to monitor the flights and connect to the PICs of sUAS #2 and #3.

Preparedness and Response mission:

Organization is running a prescribed burn and needs to access remote locations. Needs to assess the area before burn, the spread of the fire, and if the burn has been successful.

Stakeholders:

Doyon as this is of interest for their prescribed burns; Community of Tanacross, National Weather Service (NWS) as responsible for prediction of smoke from any wildland fire; BLM as State organization.

Goals:

Get multiple sUAS operating in the same area, each taking on different roles. Demonstrate that sUAS can provide ignition and retardant material and map the fire spread to minimize risk for manned aircraft and ground crews.

Objectives:

sUAS #1 is a fixed location to support teams to get real-time analysis of missions as they are ongoing and to support teams to evaluate effectiveness of missions and the implementation of the CONOPs. sUAS #2 provides pre, during, and post fire observations at lower altitude (Pre: RGB-VNIR/TIR/LiDAR; During: RGB/TIR; Post: RGB-VNIR/TIR/LiDAR). sUAS #4A - #4D provides the same altitude eyes on the missions. sUAS #3A can ignite the prescribed burn in a location that is difficult to access for ground teams. sUAS #3B can access the fire edge and release retardant to stop fire spread. Evaluate how sUAS missions can respond to other sUAS operations and data analysis. Evaluate how 107 pilots can respond to needs of a community and how Part 107 operations can provide full aspects of prescribed burn needs.

Real-time Mission Products:

- sUAS #1 - RGB and EO feeds through tether along with archived data for post mission evaluation.
- EO and thermal data feedback to GCS and operation center from all sUAS #4A - #4D to provide observations on the missions.
- Data displayed in geospatial interface to superimpose on other available data from state, federal, and local agencies.
- UAS #2A - #2C EO, VNIR, and thermal data real-time video feeds that can be assessed in Ops Center. Note that #2A and #2 for pre and post fire have LiDAR to map vegetation and landscape to determine pre landscape including any canopy and post impact on vegetation.
- sUAS #3A and #3B data shows release of ignition and retardant materials into the correct locations.

Post-Mission (fast response) Products:

- sUAS#1: Full field of view (FOV) of the missions with geo- and time-tagged data to compare to data from other sUAS and flight software.
- sUAS #2A - #2C: EO, VNIR, and thermal videos of pre, during and post fire landscape (LiDAR point clouds for #2A and #2C).
- Mosaiced maps with derived properties of landscape along with digital elevation model (DEM) and three-dimensional (3D) models where Structure From Motion (SfM) is possible.
- sUAS #3A and #3B: Videos in optical wavelengths of release of ignition and retardant with GPS locations of released material.
- sUAS #4A - #4D: Full Motion Video (FMV) footage of the operations from the same altitude that superimposes with the post processed data from sUAS #2A- #2C.

1.5 Execution

1.5.1 Operations Plan

Multiple sUAS used for the disaster response, each with their own mission sets.

sUAS - #1

- Setup before operations below commences
- Support as a fixed tethered view of all the missions
- EO visible and TIR data shared through tethered system
- Field of View allows full analysis of all other operations (take-off, flight, and landings)
- Fly VLOS under VFR conditions
- Stays tethered and provided observations throughout all other operations
- Follow pre-flight, during, and post-flight checklist for sUAS, need for VO per aircraft

sUAS - #2(A)

- 1st flight for this sUAS VLOS operations
- EO/VNIR/TIR camera with LiDAR

- Provide real-time data and build mosaiced maps and 3D models
- Post flight: LiDAR point clouds to assess local vegetation and canopy near to burn areas
- Flown from launch site for use by all sUAS
- Route defined to cover the area that will be burned
- VFR conditions and VLOS operations
- Follow preflight, during, and post-flight checklist for sUAS, VO per aircraft

<u>sUAS - #3A and #4A</u>

- Flown together
- UAS #3A: Carry fire ignition material
- UAS #4A: EO and TIR payload for observations on the event
- Part 107 operations
- UAS #3A at higher altitude to view the full burn area
- Fly VLOS or EVLOS under VFR conditions
- Follow preflight, during, and post-flight checklist for sUAS, need for VO per aircraft

<u>sUAS - #2B and #4B</u>

- Flown together
- UAS #2B: EO, VNIR, and TIR payload to map the fire
- UAS #4B: EO and TIR payload for observations on the event
- Part 107 operations
- UAS #4B to view the full burn area
- UAS #2B has defined pattern and can move based on data from #3B
- Fly VLOS or EVLOS under VFR conditions
- Follow preflight, during, and post-flight checklist for sUAS, need for VO per aircraft

<u>sUAS - #3B and #4C</u>

- Flown together
- UAS #3B: Carry fire retardant material
- UAS #4C: EO and TIR payload for observations on the event
- Part 107 operation
- UAS #4C to view the full burn area
- UAS #3B will move to area needed for retardant based on data from #4B
- Follow preflight, during, and post-flight checklist for sUAS, need for VO per aircraft

<u>sUAS - #2C and #4D</u>

- Flown together
- UAS #2C: EO/VNIR/TIR camera with LiDAR
- UAS #2C: Provide real-time data and build mosaiced maps and 3D models
- UAS #2C: Post flight: LiDAR point clouds to assess impact to vegetation and any canopy
- UAS #4D: EO and TIR payload for eyes on the event
- UAS #4D will watch how UAS #2C maps the edge of fire and collects LiDAR data
- UAS #2C follows pattern based on data from UAS #4C
- UAS #4D manual routes to watch over Flight #2C

- Fly VLOS or EVLOS under VFR conditions
- Follow preflight, during, and post-flight checklist for sUAS, need for VO per aircraft

1.5.2 Data collection, processing, and dissemination

sUAS #1

Tethered sUAS to monitor all missions

- Data in flight:
    - High Precision GPS locations and time synchronization
    - Flight routes and logs
    - Geotagged EO and TIR imagery over landscape
    - Optical and TIR data streamed to GCS and onto operations center
    - On-board storage of data, downloaded upon landing and processed
- Products post flight:
    - Geotagged video with overlaid field of view on geospatial visualization tool
    - Time tagged video to follow missions and compare to other sUAS data

sUAS #2A, #2B, #2C

Pre, during and post mapping of landscape and fire

- Data in flight:
    - High Precision GPS locations and time synchronization
    - Flight routes and logs
    - Geotagged EO, VNIR, TIR imagery over landscape
    - UAS #2A and #2C: High precision LiDAR data to build point cloud maps
    - Optical setup to support SfM processing from data
    - Optical data streamed to GCS and onto operations center
    - On-board storage of data, downloaded upon landing and processed
- Products post flight:
    - Geotagged video with overlaid field of view on geospatial visualization tool
    - Orthomosaic of EO, VNIR, and TIR data in geospatial visualization tool
    - UAS #2A and #2C - LiDAR point clouds
    - DEM of impacted zone from the prescribed burn

sUAS #3A and #3B

Ignition and retardant material cargo

- Data in flight:
    - High Precision GPS locations and time synchronization
    - Flight routes and logs
    - Geotagged optical imagery of route
    - Optical data streamed to PIC, GCS, and operations to show payload being dropped
    - On-board storage of data, downloaded upon landing and processed
- Products post flight:

- FMV of the optical video feed to show ignition and retardant being used

sUAS #4A - #4D

Same altitude observations on the missions as UAS #2 and #3, manually move based on needs

- Data in flight:
  - High Precision GPS locations and time synchronization
  - Flight routes and logs
  - Geotagged optical and thermal infrared imagery of missions
  - Optical data streamed to PIC and onto GCS
  - On-board storage of data, downloaded and processed
- Products post flight:
  FMV and orthomosaic of visible and thermal data

1.6 Administration & Logistics

1.6.1 Planning and local logistics

sUAS team will have accommodation at a hotel nearby to Tanacross. This will provide overnight lodging before and after each flight day. Also, it will allow them to store no mission required equipment to optimize the equipment taken with them for the daily missions. UAS mission teams will ensure that all required waivers are in place to support flight operations. If TFR in place, the flight team lead will liaise with the event air boss to ensure permissions set up to allow sUAS to fly into TFR.

Any required Part 107 waivers will be in place before missions start. SGI waiver will be submitted to support all sUAS missions to ensure that sufficient permissions are acquired, if needed, so that they do not need to be submitted during the missions and any time lost. sUAS #1 will be tethered to provide a fixed location for operations. sUAS pilot in command and UAS missions lead will liaise with the emergency operations center to define allowed locations for tethered UAS. From these site selections, the most effective location to support ground operations and acquire data of the events will be chosen.

All required communications will occur between all PICs and local air traffic control tower. All NOTAM's will be provided to the wider aviation community.

1.6.2 Hazards/Risk

The following information provides specific hazards that may occur from supporting the emergency response to the prescribed burn wildland fire event.

Hazard #1: Toxic ash and gases

- Risk: This hazard can be caused by the wildland fire ash concentrations impact to the aircraft and visibility leads to Instrument Flight Rules (IFR) only conditions. Possible effects resulting from this hazard are a loss of aircraft performance and ability to continue mission.
- Mitigation: The Pilot in Command will perform controlled flight operations to move the aircraft away from the toxic level of ash and gases. The PIC will assess if the levels of ash and gas in the atmosphere limit the ability of the UAS to operate and the crew to continue to

operate. The PIC will determine if a Return To Base (RTB) or Return to Landing (RTL) is required or if the aircraft can continue its operations. The mission PIC will invoke a Divert Land Immediately (DLI), which suspends the onward flight path and commands the UAS to land at a designated landing zone, in a controlled manner at the maximum safe descent rate.

Hazard #2: Severe weather conditions

- Risk: This hazard is a result of atmospheric conditions that change so there is a no-go for flight operations and with wildland fire #1 a no-go on the burn. Possible effects are a stop in flight operations and an aircraft that must rapidly RTL or end flight and the team left waiting and unable to complete their mission.
- Mitigation: During flight, if weather conditions deteriorate suddenly, the PIC assess if DLI is required or if they can invoke RTB resulting in a suspension of the onward flight path. DLI will ensure that the flight lands safely as close as possible to the original location. If the PIC can determine that flight can still operate with the RTB in place, then the UAS will follow this pattern, i.e., its launch/landing point. If this is not possible given the weather conditions, the mission will use the defined landing zones developed in the CONOP for divert land immediately. If there are multiple UAS flights at the same time and in the same airspace supporting a disaster response, then pre-mission coordination on each flights alternative landing zones will occur to mitigate any mid-air collisions from DLI or RTB flights.

Hazard #3: Loss of time synchronization between UAS used in response

- Risk: This hazard would be caused by incorrect timing of missions (multiple aircraft) to match through centralized communications. Possible effects are aircraft taking off at the wrong time and data not comparable for evaluation of the disaster event.
- Mitigation: Before all the missions start, the flight crews will ensure that aircraft systems and GCSs are synchronized so that data can be compared. Between flights, the crew will re-assess the time synchronization of their systems and be in communications with the central team to ensure operations occur at the time specified in the CONOP.

Hazard #4: Crew unable to ensure safe operations over people and/or property

- Risk: This hazard comes from the flight crew being unable to ensure safe flight operations when there are people and/or property below the flight route. Possible effects are a crash of the UAS with people/property or a need to RTB because the PIC cannot ensure safe flight operations.
- Mitigation: Before the mission starts, the PIC will define all the backup landing zones in case there is an issue with the flight operations. The VO will continue to track the aircraft and airspace and inform the PIC if they are unable to continue this role. If there is a loss of the aircraft by the VO, then the PIC will invoke a DLI or RTB depending on the location and proximity to people and property. The flight mission will have all required permissions to allow them to fly over people and the environment below the flight path.

Hazard #5: Loss of communications between multiple UAS flight crews

- Risk: This hazard comes from multiple sUAS flying at the same time in proximity and a lack of communications between each flight crew. Possible effects are a crash of the sUAS as flight routes cross, a near miss as some flight routes are manual while others are automated, or a RTB or rapid descent of a UAS to prevent a crash or near miss and continue safe operations for all UAS.

- Mitigation: Before the mission, each PIC will check their communications between their flight location and the centralized mission team and with the other PICs and their flight crew. The different UAS flight teams will ensure that each is aware of the communication frequencies to use and the call signs and terms that each team will be using. Each flight team will be able to see the location of the other UAS in their flight management software and if needed can communicate through the centralized mission team. One flight team member will be able to communicate with the other teams and will not take on the PIC or VO role for the flight. Each team will have backups in case their communications drop with the operational radio and if these fail, they will perform a DLI or RTB that will demonstrate to the other operational teams that their communications are broken and cannot perform safe operations.

Hazard #6: Loss of power and data transfer to tethered UAS

- Risk: This hazard comes from a lack of continued power and data transfer across the UAS tether. Possible effects are that the tethered UAS must descend to obtain new batteries as power and mission loses the capabilities that the UAS provides.
- Mitigation: Before the mission starts, the PIC for the tethered UAS will perform safety checks for the tethering system and check that power and data can be received by the aircraft and data sent back to the ground station. If there is a drop in power and data transfer, the PIC and their flight team will monitor the issue. Once it reaches close to their safety limits, the aircraft will descend with sufficient power to ensure a safe landing. All data collected will be removed from the onboard sensors and the power issue evaluated. If possible, the aircraft will return to its tethered altitude to provide the support needed.

Hazard #7: Tether breaks on the sUAS

- Risk: This hazard comes from a broken tether between the ground station and the airborne platform. Possible effects are a free flying UAS, that should be tethered to the ground, and does not have a pre-defined flight route and therefore is in fly-away mode.
- Mitigation: The PIC for the mission will take over manual control of the aircraft and either perform a DLI or RTB for the aircraft. The flight crew will use a sUAS that can be both a tethered UAS with data transfer and power provided by the tethered as well as a mobile UAS that can be manually controlled by the flight PIC. The flight crew will have a VO that can act if the aircraft does fly away from its tether and will communicate with the PIC.

1.6.3 Community outreach and connections

- All Operations: Tanacross community and airport through incident command team or a statewide operations center if one that has been setup. BLM and Doyon for prescribed burn location.
- sUAS: Four missions. Coordination between flight teams on who will fly each mission

1.6.4 Disaster response mission specific information

- October 26 - 31, 2020 - Woodpile debris burn to reduce wildfire danger - AKfireinfo.com

- Spot forecast for Tanacross region from National Weather Service (NWS). This is downloaded to the flight checklist documentation for each crew and GCS.

1.6.5 Mission Summary

Disaster:

Prescribed burn of landscape at Tanacross, AK. sUAS support ground operations to ignite fire, map spread, suppress the burn area, and watch over missions for effectiveness.

Objectives:

sUAS #1 is a fixed location to support teams to get real-time analysis of missions as they are ongoing and to support teams to evaluate effectiveness of missions and the implementation of the CONOPs. sUAS #2 provides pre, during, and post fire observations at lower altitude (Pre: RGB-VNIR/TIR/LiDAR; During: RGB/TIR; Post: RGB-VNIR/TIR/LiDAR). sUAS #4A - #4D provides the same altitude eyes on the missions. sUAS #3A can ignite the prescribed burn in a location that is difficult to access for ground teams. sUAS #3B can access the fire edge and release retardant to stop fire spread. Evaluate how sUAS missions can respond to other sUAS operations and data analysis. Evaluate how Part 107 pilots can respond to needs of a community and how Part 107 operations can provide full aspects of prescribed burn needs.

Flight Missions:

sUAS #1: Tethered mission that is airborne before any other operations start. sUAS #1 will stay airborne throughout all others and support evaluation of the effectiveness of the other mission's Lower altitude sUAS (#4A - #4D) flown to provide an overview of prescribed burn operations that can move around and watch. Two other sUAS missions to be flown: (1) UAS #2A - #2C: collect EO/VNIR/TIR data over landscape pre, during, and post prescribed burn (UAS #2A and #2C with LiDAR) and (2) UAS #3A and #3B: use sUAS to carry ignition and retardant cargo to set off the burn and suppress the resulting fire once complete.

Metrics of success:

- sUAS #1: Stays airborne throughout, EO and TIR feeds back to GCS, tether continues to support data being streamed back as well as power to prevent need for new batteries
- sUAS #4A - #4D: Stream data back to support assessment of prescribed fire missions and allow other PICs to change flights in response to fire spread.
- sUAS #2A mosaicked maps in EO/VNIR/TIR of the pre-fire landscape.
- sUAS #2A produce LiDAR point cloud observations to assess before #2B takes off
- UAS #2C produce LiDAR point cloud to determine if prescribed burn safe to leave
- UAS #3A drops of ignition cargo to start the prescribed burn at sites required.
- UAS #2B streams back data to support those on ground to assess fire extent.
- UAS #3B navigates to fire edge to suppress fire given data from sUAS #4C above.
- UAS #2B responds to commands from the incident center to fire edge from #4C data.
- UAS #3C maps the edge of the fire and shows that fire is suppressed.
- sUAS flew under Part 107 and VLOS maintained.

1.7 Command & Signal

Aim: *This section should provide an overview of the command and communication systems to be used. This supports anyone reviewing and evaluating the CONOP to efficiently assess those sufficient communications are in place to connect the UAS flight crew with additional organizations connected to and supporting the disaster response and/or preparedness.*

For some of the details included in this section, the plans will cross reference to the ORA, as they will be mitigation plans to ensure safe flight operations and minimize the risk of hazards that can impact flight operations.

Include details on:

- Type of communications tools used to connect PIC, Observer, and other crew members
- Security measures in place to protect the flight crew
- Hand-off process, where appropriate, between the PIC and visual observer(s)
- Flight team lost link and emergency procedures to ensure safe flight operations
- Communication tools use to connect the flight team and local ATC
- Note: for each communication tool to be used, this section should also include signals used such as radio frequencies, flight control frequencies, etc.

1.8 Supplementary appendices to accompany CONOP

1.8.1 Appendix 1: Operational Details – One Pager

Mission and Disaster Preparedness/Response

Collection of thermal and electro-optical imagery and video of the prescribed burn as well as the application of a fire suppression payload.

Mission Purpose/Objectives

Purpose : Prescribed burn at Tanacross, Alaska with ignition of fuels and suppression of fire

Goals : Get multiple small UAS operating in the same area, each taking on different roles. Demonstrate that small UAS can provide ignition and retardant material and also map the fire spread to minimize risk for manned aircraft and ground crews.

Objectives : Small UAS #1 is a fixed location to support teams to get real-time analysis of missions as they are ongoing and to support teams to evaluate effectiveness of missions and the implementation of the operations. Small UAS #2 provides pre, during, and post fire observations at lower altitude [Pre: electro-optical-near-infrared[NIR]/thermal infared[TIR]/LiDAR; During: RGB/TIR; Post: RGB-NIR/TIR/LiDAR]. Small UAS #4A - #4D provides the same altitude eyes on the missions. Small UAS #3A is able to ignite the prescribed burn in a location that is difficult to access for ground teams. Small UAS #3B can access the fire edge and release retardant to stop fire spread. Evaluate how small UAS missions can respond to other small UAS operations and data analysis. Evaluate how 107 pilots can respond to needs of a community and how Part 107 operations can provide full aspects of prescribed burn needs.

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Mission Results

Observations : Recording of full extent of fire spread. Data feeds back to operations center. Small UAS #4 is a fixed and tethered system to provide red-green-blue electro-optical and thermal data to support post-mission evaluation of effectiveness of all flights, ground team effectiveness and operational timing. Small UAS #2 is mapping the land before burn [with LiDAR to map any canopy/vegetation], the progression of the fire, and extent of the burned areas. Small UAS #3 will release the ignition material and the retardant to stop the fire. Small UAS #4 fly at same altitude as missions to watch the other flights and support the ops center to monitor the flights and connect to the pilots in command (PIC's) of small UAS #2 and #3.

Real-time Mission Products : Small UAS #1 - electro-optical visible data feeds through tether along with archived data for post mission evaluation. Visible and thermal data feed back to ground control station (GCS) and operations Center from all. Small UAS #4A - #4D to provide eyes on the missions. Data displayed in geospatial interface to superimpose on other available data from state, federal, and local agencies. Small UAS #2A - #2C provide electro-optical visible, near-infrared (NIR), and thermal data real-time video feeds that can be assessed in operations center. Note that small UAS #2A and #2 for pre and post fire have sensors to map vegetation and landscape to determine pre landscape including any canopy and post impact on vegetation. Small UAS #3A and #3B data shows release of ignition and retardant materials into the correct locations.

Post-Mission [fast response] Products : Small UAS#1: Full full motion video (FMV) of the missions with geo- and time-tagged data to compare to data from other small UAS and flight software. Small UAS #2A - #2C: visible, NIR, and thermal videos of pre, during and post fire landscape [LiDAR point clouds for small UAS #2A and #2C]. Mosaiced maps with derived properties of landscape along with surface models where structure from motion (SfM) is possible. Small UAS #3A and #3B: Videos in visible wavelengths of release of ignition and retardant with locations of released material. Small UAS #4A - #4D: Full motion video (FMV) footage of the operations from the same altitude that superimposes with the post processed data from small UAS #2A- #2C.

Mission Procedures/Approach

sUAS#1 : Fixed tethered view of all of the missions
EO and TIR data shared through tethered system
Field of View allows full view of all operations [take-off, flight, and landings]; Fly VLOS or EVLOS under VFR conditions; Will stay airborne until operations complete

sUAS #2A : 1st flight; VLOS operations
EO/VNIR/TIR camera with LiDAR; Provide real-time data and build mosaiced maps and 3D models
Post flight: LiDAR point clouds to assess local vegetation and canopy near to burn areas
Flown from launch site for use by all sUAS; Route defined to cover the area that will be burned ; VFR conditions as will be VLOS

sUAS - #3A and #4A [#3A - Carry fire ignition material; #4A - EO and TIR payload for eyes on the event]
Part 107 operations, flight #3A at higher altitude to view the full burn area
Fly VLOS or EVLOS under VFR conditions

sUAS - #2B and #4B [#2B - EO, VNIR, and TIR payload to map the fire; #4B - EO and TIR payload for eyes on the event]
Part 107 operations, flight #4B to view the full burn area
Flight #2B has defined pattern and also can move based on data from #3B

sUAS - #3B and #4C [#3B - Carry fire retardant material; #4C - EO and TIR payload for eyes on the event]
Part 107 operations, flight #4C to view the full burn area
Flight #3B will move to area needed for retardant based on data from #4B

sUAS - #2C and #4D [#2C - EO/VNIR/TIR camera with LiDAR; #4D - EO and TIR payload for eyes on the event]
#2C - Provide real-time data and build mosaiced maps and 3D models; Post flight: LiDAR point clouds to assess impact to vegetation and any canopy
#4D will watch how #2C maps the edge of fire and collects LiDAR data

Mission Milestones

Outcomes/Actionable Intelligence
Small UAS #1 - Tethered watching from the side with an off-nadir ability to monitor events. Electro-optical visible and thermal video feed of the events support local operations. Data feeds through tether along with power to provide sustained operations. Location such that it can watch all operations and be used to evaluate effectiveness of missions.

Small UAS #2A, #2B, and #2C [Support at least three missions] [Mapping landscape before [#2A], during [#2B] and post fire, #2C] - Imagery captured prior to ignition to evaluate the landscap. Sent up once the fire started to have eyes on the event and capture images to build a mosaic of the landscape. Visible video feed back to pilot in command (PIC) and sent back into the local operations team. Three-dimensional rendering of the landscape available soon after the mission flew. FOV of visible camera seen by operations team so they can adapt flight as their needs. Small UAS #2C flown after #3A mission to evaluate if the area needed to be burnt has been completed and that the retardant has been successful.

Small UAS #3A [ignition of land] - Ignite the area for the prescribed burn so the team does not need to send personnel on the ground.

Small UAS #3B [Retardant] - Same sUAS carries retardant on to the burned area to stop the fire. Small UAS #2C is mapping to assess the effectiveness of the retardant.

Small UAS #4A - #4D [Monitoring of small UAS #2A and #2B] - Visible video of the events that supports the local operations team to assess effectiveness of the missions. Data back to operations team so that they can communicate with PIC of small UAS #3A, #2B, #3B, and #2C.

Metrics of success
Small UAS #1: Stays airborne through out, visible and thermal data feed to ground control station, tether support data being streamed back as well as power to prevent need for new batteries
Small UAS #4A - #4D: Stream data back to support assessment of prescribed fire missions and allow other PIC's to change flights in response to fire spread.
Smal UAS #2A produces mosaicked maps in visible, near-infrared, and thermal of the pre-fire landscape.
Small UAS #2A produce point cloud observations to assess before #2B takes offs
Small UAS #2C produce point cloud to determine if prescribed burn safe to leave
Small UAS #3A drops of ignition cargo to start the prescribed burn at sites required.
Small UAS #2B streams back data to support those on ground to assess fire extent.
Small UAS #3B navigates to fire edge to suppress fire given data from small UAS #4C above.

1.8.2 Appendix 2: Flight Checklists

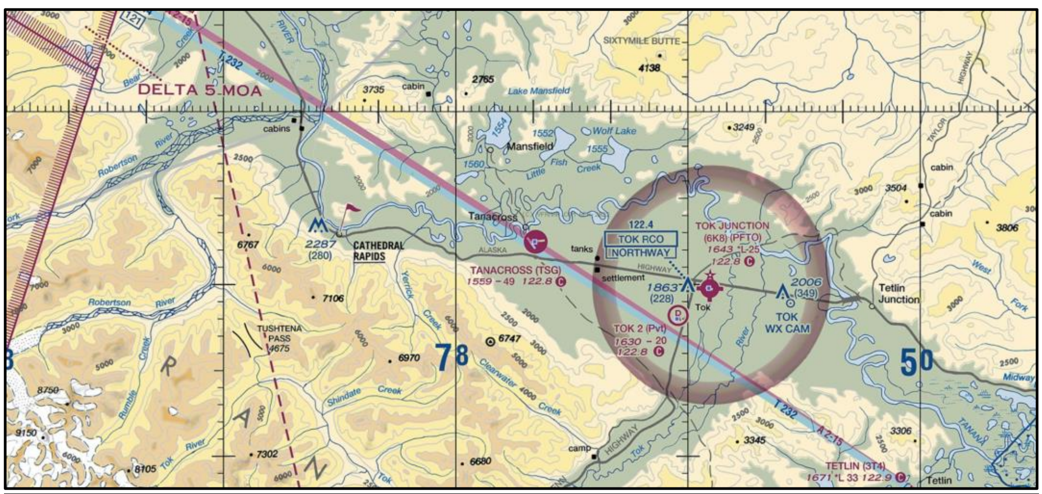
<u>*Aim:*</u> *This appendix collects all flight checklists the mission team would complete pre-, during, and post-flight while at the mission location as well as pre- and post-operation before arriving and after leaving the mission location. Each flight checklist is included in a supplementary document. These checklists are to supplement the maintenance checklists that would go with the organization leading the missions for the disaster response and/or preparedness that they use to ensure the safety of their aircraft and equipment. These maintenance checklists will likely be a part of the organization's own safety assessment process.*

<u>Include details on:</u>

- Before CONOP development: Site Survey (details on assessment of mission location)
- Before Operations: Mission checklist (complete at home for lead organization)
- Pre-deployment: Checklist to complete prior to leaving for mission site
- Deployment: Checklists for flight operations, once arrived at mission site
- Pre-flight: Checklist to follow prior to flight including example of flight readiness review
- Post-flight: Checklists to follow including log sheet
- Post-mission: Checklists to follow at the end of all flights for the mission

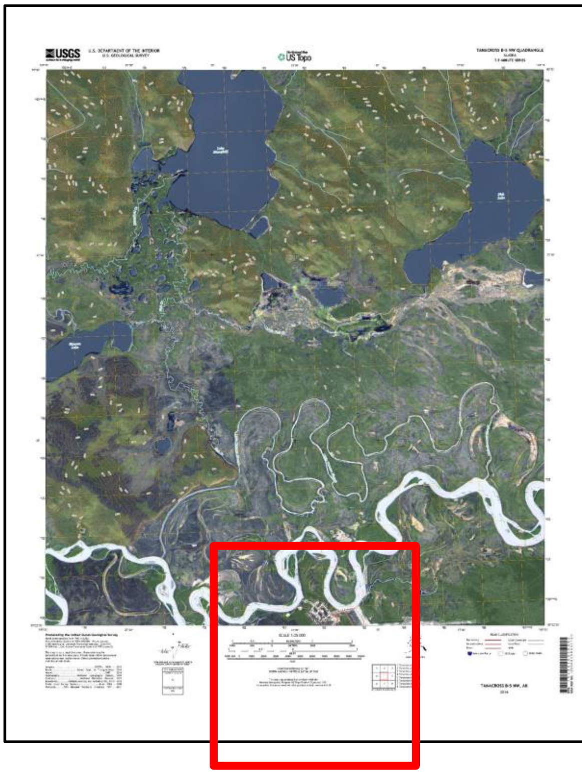
1.8.3 Appendix 3: Additional Requirements

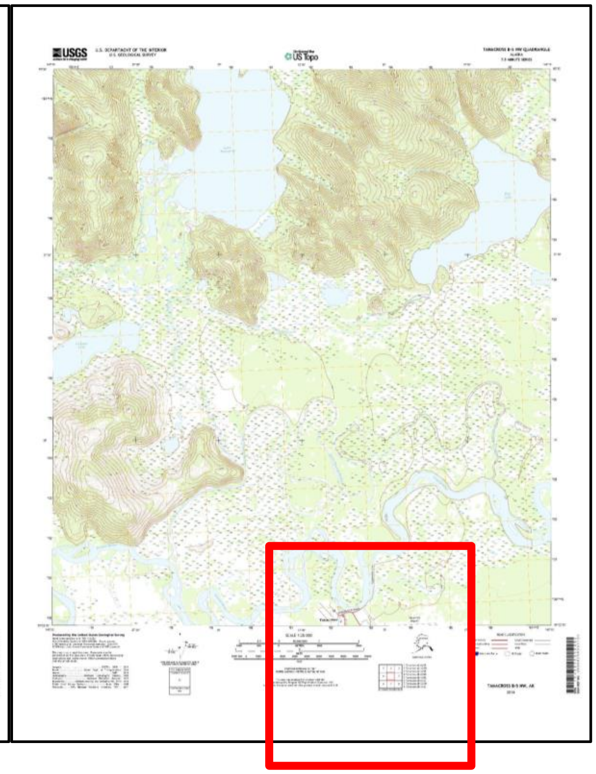
Sectional charts



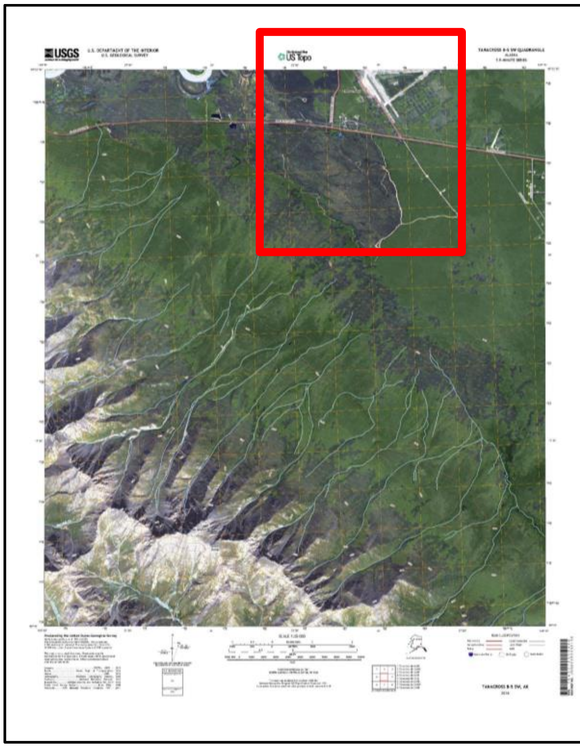
United States Geological Survey (USGS) 7.5-minute topographic map

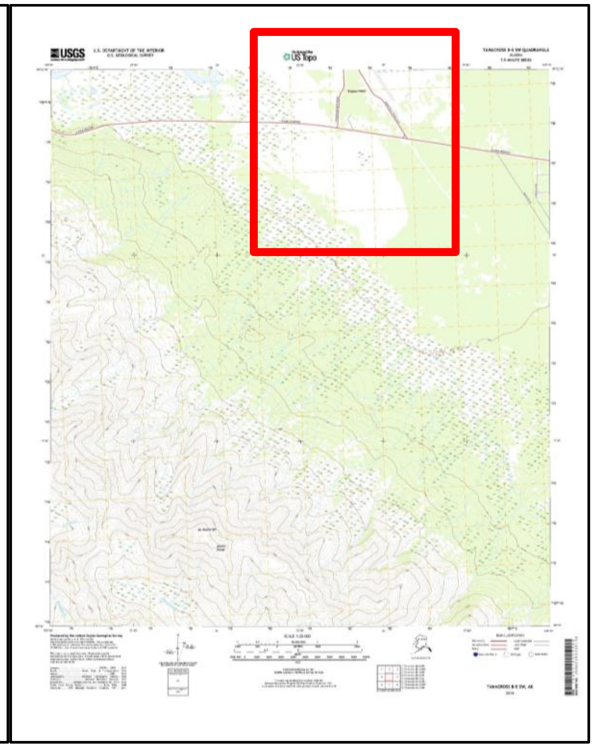
Tanacross region - Tanacross B-5 NW



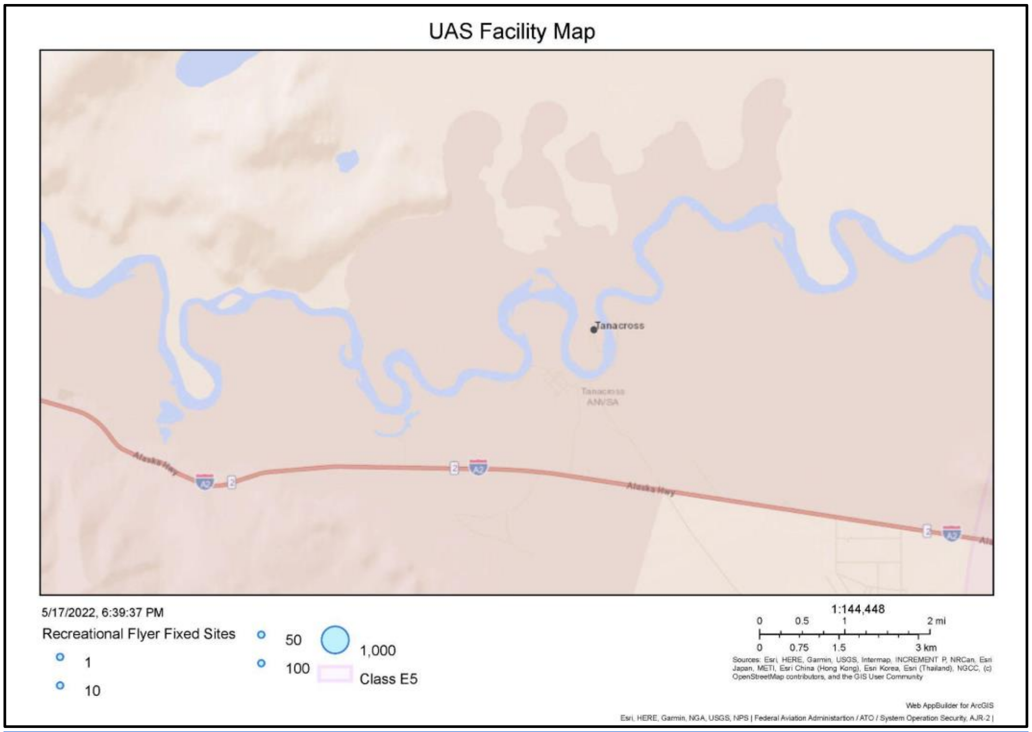


Tanacross region - Tanacross B-5 SW





Low Altitude Authorization and Notification Capability (LAANC) Facility Maps



1.8.4 Appendix 4: Special Government Interests (SGI) Process Documentation

- FAA Order JO7200.23B
  Processing of UAS Requests. Effective: July 14, 2020
  - Page 16 to 19: Chapter 6. 14CFR Part 91, COA Processing
  - Page 17 – SGI information: The Special Government Interests (SGI) process will be managed by Systems Operations Security as per FAA Order JO 7210.3
- FAA Order JO7210.3CC

Facility Operation and Administration. Effective: June 17, 2021

  - Page 469: Section 21-5-4. UAS SGI Addendum Request Process and Coordination
  - System Operations Support Center (SOSC) Contact Phone Number - 202-267-8276
- FAA Request Form for Expedited SGI Waiver or Authorization for UAS Operation – Form # SOSC 2020/02/20 1125Z

1.8.5 Appendix 5: Data Archive Plan

Processing specifications

- Imagery and video collected at maximum resolution
- Sufficient overlap to support Structure from Motion processed
- Full motion video captured where possible from available payload

File formats

- Detailed descriptions: https://www.ogc.org/docs/is
- Electro-optical visible and multispectral visible - near-infrared imagery
    - Joint Photographic Experts Group (JPEG): containing lossy and compressed data
    - Tag Image File Format (TIFF): store raster graphics and image information
- Broadband thermal infrared imagery
    - Radiometric JPEG: JPEG and TIFF for thermal data
    - Stores Temperature data as well as RGB JPEG of thermal data
- Electro-optical visible and multispectral visible - near-infrared video
    - MPEG-4 format (MP4, note MOV from EO visible on dual camera system)
    - High compression international audio-visual coding standard
- Broadband thermal infrared video
    - SEQ/FFF - Proprietary FLIR video formats that store images and thermal data
    - MOV - MPEG 4 video container file
- Point clouds - LiDAR data
    - LAS (binary file format) or LAZ (compressed LAS file)
- Geospatial data - GEOTIFF
    - Standard file for GIS with embedded geolocation data
- Google Keyhole Markup Language (KML)
    - KML (default Google Earth geospatial format)
    - KMZ (compressed KML file format)
- Geographic JavaScript Object Notation (GEOJSON)
    - GEOJSON (coordinates as text in JavaScript Object Notation form
- Shapefile (SHP)
    - SHP (feature geometry), SHX (shape index position), DBF (attribute data)
    - PRJ (projection system metadata), XML (associated metadata)

Data archiving locations

- In-Flight:
    - Onboard storage of all data as well as through specific GCS
    - Data streamed through GCS to operations center to support secondary archive
- Post-Flight:
    - Online secure file storage per UAS and per mission (password protected)
    - Folders for raw sensor data as well as flight logs and route data

Folders to store post-processed data and all planning documents

1.8.6 Appendix 6: Rationale behind each section in CONOP

Situation

High level situation awareness and sufficient information to clearly define each element.

Template items

- *Organization's business (manufacturer, operator, system integrator, etc.).*

- *Geographic operating boundaries (lack of specifics implies very broad National Airspace System (NAS) access).*
- *Describe if launch/ fly/ recover only over private property with owner's permission.*
- *Define the minimum and maximum operating altitude of the vehicle.*
- *Describe if operating within or beyond Visual Line of Sight (VLOS).*
- *Define command and control link.*
- *Provide details on dimensions and materials for vehicle design.*
- *Identify the vehicle's maximum cruise speed and maximum operating gross weight.*
- *Describe Proposed Airspace Classes (A, B, C, D, E, F, etc.).*
- *Define the Proposed Operating Airspace (character aspects – regardless of class).*
- *Describe location of the control station.*

Mission:

Sufficient, clear, and concise statement of what the flight team and lead organization and/or stakeholders for the disaster response mission request want to accomplish. Provide the most important large-scale information and provide sufficient information and clearly define each element.

- *Describe the intended mission of the UAS (surveillance, response, preparedness, etc.).*

Execution:

Thoroughly state how you will "execute" the mission and provide sufficient information and clearly define each element.

- *Identify Airspace Considerations (peculiarities and congestion, special use, etc.)*
- *Give information on Launch and Recovery Details / Location(s)*
- *Identify and describe the vehicle's proximity to people, infrastructure, and surface vehicles*
- *Identify and describe the vehicle's proximity to other NAS users*
- *Identify whether you want to Flight into Known Icing (FIKI)*
- *Identify meteorological conditions you want to operate in Visual / Instrument conditions*
- *Identify the flight rules you want to operate in Visual / Instrument Flight Rules*
- *Describe whether your geographic and airspace boundaries are physically contiguous*
- *Identify Automation Level (occasional autopilot, 100% autonomous, manual control, etc.)*

- *Identify minimum crew and support personnel*
- *Identify the role(s) of the crew and support personnel*
- *Identify whether you will fly over people not involved in the operation*
- *Identify any requests for airspace be blocked off for your exclusive use*
- *Identify your operator/vehicle ratio (1:1, etc.)*
- *Identify day and/or night operations*
- *Describe your plan for safety of Operator(s) and Observer(s)*
- *Describe the training level of each team member*

Command & Signal:

Sufficiently provide information of their plans involving command and communication functions between different portions of the UAS and stakeholders. Clearly describe how you will command and signal amongst the various components of the entire system (vehicle, control station, control link, observers, etc.)

- *Describe Communication between Operator, Observer, Crew Members (visual, radio, etc.)*
- *Describe the Electronic Security of the Control Link*
- *Describe the Physical Security of the operator and control station*
- *Describe real time situational awareness features*
- *Describe the # of operators, and hand-off between control*
- *Describe Lost Link Procedures or loss of Positive Control*
- *Describe Communication Expectations with Air Traffic Control*
- *Describe Emergency Procedures*

Administration & Logistics:

Adequately provide the information or instructions pertaining to how and with whom they will coordinate to conduct the operations.

- *Details on Community Outreach (Flying / Non-Flying Public, municipalities, airports, etc.)*
- *Describe when if flight routes will be filed with Air Traffic Control (VFR / IFR)*
- *Identify Liaisons with Air Traffic Control*
- *Identify MISHAP Reporting Procedures*

- *Identify when NOTAMs will be posted*