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Final Report
ASSURE A28: Disaster Preparedness and Response Using UAS
Attachment 2 – Concept of Operations (CONOPS) for Earthquake and Tsunami

June 1, 2022

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TABLE OF ACRONYMS

ACUASI	Alaska for Unmanned Aircraft Systems Integration
ARTCC	Air Route Traffic Control Center
BVLOS	Beyond Visual Line of Sight
CONOP	Concept of Operation
DEM	Digital Elevation Model
DLI	Divert Land Immediately
EO	Electro-Optical
EVLOS	Extended Visual Line of Sight
FAA	Federal Aviation Administration
GCS	Ground Control Station
GEOJSON	Geographic JavaScript Object Notation
HD	High definition
IFR	Instrument Flight Rules
JPEG	Joint Photographic Experts Group
KML	Keyhole Markup Language
NAS	National Airspace System
NOTAM	Notice to Airmen
ORA	Operational Risk Assessment
PIC	Pilot in Command
RTB	Return to Base
SfM	Structure from Motion
SGI	Special Governmental Interest
SHP	Shape file
SOSC	System Operations Support Center
TFR	Temporary Flight Restriction
TIFF	Tag Image File Format
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 Take-Off and Landing

ATTACHMENT 2 - CONCEPT OF OPERATIONS (CONOPS) FOR EARTHQUAKE AND TSUNAMI

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). The CONOP is to be submitted by the lead organization for the mission.

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 **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)

Notes on a CONOP:

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 an overview fashion, 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)

Major Earthquake occurs in South Central Alaska that leads to a Tsunami warning for Seward, Alaska and the surrounding area

Operation

Large earthquake in South-Central Alaska with Tsunami warning and need to map inundation to Seward region

Duration of Operation

At least a day

(It will take time to get large UAS airborne, will need to map a large area, Small UAS #1 team will need to get to bridge collapse, Small UAS #2 team will need to be repaired to fly and map the impacted region in Seward)

Outcomes/Actionable intelligence

- Large UAS (Higher altitude observations and communications on disaster) - Adaptable mission to map the full extent of the disaster. Electro-Optical (EO) visible video data feedback to Ground Control Station (GCS) and piped into the operations center. GCS team in communications with the operations center and then small UAS #1 team for bridge inspection.

- Small UAS #1 (Bridge) - Mission readied and flown once bridge seen in large UAS data and flight is adaptable to focus on the collapsed bridge. EO video feed back to Pilot In Command (PIC) and piped into the operations center. Three-dimensional (3D) rendering of the bridge available soon after mission flown. Field of View of EO camera seen in the operations center so they can adapt flight as their needs.

- Small UAS #2 (Seward for Tsunami) - Mission readied once reports of Tsunami impacted the community. Local Part 107 pilot was prepared given the warning from Alaska Earthquake Center (AEC) and Tsunami Warning Center. EO and thermal video feeds back to PIC and piped into the operations center. PIC able to adapt routes at the needs of local EM and ground teams to support operations. 3D rendering of the community available after flight lands and processed data. Thermal imagery overlaid on the EO 3D Structure from Motion (SfM) model.

Metrics of success:

- Large UAS streams data back to the incident center to support assessment of full extent.
- Small UAS #1 streams back data to support those on ground to assess Tsunami Inundation.
- Small UAS #2 maps bridge and gets real-time videos back to the operations center.
- Small UAS #2 responds to needs from the operations on where observations are needed.
- Safe flight operations with two small UAS operating and data streaming back.
- Both small UAS flew under Part 107 and Visual Line Of Sight (VLOS) is maintained.
- Local Part 107 small UAS pilots respond to requests and data back to the EM Ops Center.

1.2 CONOP Quad Chart: Large earthquake in South-Central Alaska with Tsunami warning and need to map inundation to Seward region.

1.2.1 Mission Purpose/Objectives

Purpose: Large earthquake in South Central Alaska that impacts Anchorage to Palmer region; Tsunami warning and then inundation of coastline and impacts Seward; Bridge collapse along highway from Anchorage to Palmer and need to map.

Goals: Large UAS up and mapping impacted region to get data to emergency management operations center. Small UAS Part 107 pilots respond and provide data of impacted regions [Bridge and City of Seward] to show that they can be useful during disaster without needing to send EMs from Anchorage until needed. Small UAS support analysis of local infrastructure and safety assessment.

Objectives: Large UAS with real-time data to GCS and onto emergency management operations center used to detect bridge hazard and to target local finer scale mapping of impacted infrastructure. Small UAS #1 responds to and collects data for viewing at emergency management operations center. Small UAS #2 provided by Seward-based emergency management operations approved Part 107 pilot collects data over impacted areas and provides data back to local GCS and emergency response as well as feeds to State emergency management operations center. Evaluate how small UAS missions can respond to large UAS operations and data analysis. Evaluate how local 107 pilots can respond to needs of State and/or City agencies. Evaluate how local 107 pilots respond to Tsunami warnings and reports to map regions and feed data back to the State emergency management operations center.

1.2.2 Mission Procedures/Approach

Large UAS: High Altitude observations over disaster area

Early morning take-off from Anchorage

Beyond Visual Line Of Sight (BVLOS) operations

Flown from runway to the traverse up to Palmer

Route defined to cover main road networks and communities

Day of flying to reach site and provide high altitude eyes on disaster

Visual Flight Rules (VFR)/Instrument Flight Rules (IFR) conditions as will be BVLOS

Weather conditions: Pre-flight and during flight

Small UAS #1: Tsunami Inundation impact in Seward

Locally based Pilot approved for emergency management operations center

Part 107 waiver and Special Government Interest (SGI) waiver

Fly VLOS or extended-VLOS (EVLOS) under VFR conditions

Weather conditions: Pre-flight and during flight

Map the extent of impact to community and if possible, further across Bay

Small UAS #2: Bridge along highway between Anchorage and Palmer

Locally based Pilot approved by emergency management operations center

Pattern defined to map extent of damage seen in large UAS and any ground reports

VLOS with Part 107 waiver if needed based on time of day/location/altitude

VFR conditions

Weather conditions: Pre-flight and during flight

1.2.3 Mission Results

Observations: Recording of full extent of the damage of the earthquake to infrastructure and transportation networks across South Central Alaska. Data feeds back to emergency management operations center and determines there is a collapsed bridge on the highway that needs local small UAS mapping. Secondary tsunami warning that predicts inundation along the South-Central coastline. Seward reports Tsunami and local small UAS operations, maps damage, and feeds data back to their GCS as well as State operations center.

Real-time Mission Products: Electro-optical visible and where possible thermal data feeds back to GCS and operations center from all three UAS. Data displayed in geospatial interface to superimpose on other available data from state, federal, and local agencies.

Post-Mission [fast response] Products: Large UAS: Geospatial located video feeds to show field of view to analyze for impact to infrastructure. Small UAS #1 @ Seward: Optical videos of impact to the community and coastline and where possible thermal data. surface and three-dimensional (3D) models where SfM is possible to assess damage. Small UAS #2 @ bridge: Orthomosaics in optical wavelengths of bridge and surrounding area as 3D models where SfM is possible to assess damage.

1.2.4 Mission Milestones

Outcomes/Actionable Intelligence

Large UAS [Higher altitude eyes and coms on disaster] - Adaptable mission to map the full extent of the disaster. Electro-optical video data feedback to GC) and piped into emergency management operations center. GCS team in communications with emergency management operations center and then small lUAS #1 team for bridge inspection.

Small UAS #1 [Bridge] - Mission readied and flown once bridge seen in large UAS data and flight had adaptable to focus on the collapsed bridge. Electro-optical video feed back to pilot in command and piped into the emergency management operations center. 3D rendering of the bridge available soon after mission flown. Field of view of electro-optical camera seen in emergency management operations center so they can adapt flight as their needs.

Small UAS #2 [Seward for Tsunami] - Mission readied once reports of Tsunami impacted the community. EO and thermal video feeds back to PIC and piped into emergency management

operations center. PIC able to adapt routes at the needs of local emergency management and ground teams to support operations. 3D rendering of the community available after flight lands and processed data. Thermal imagery overlaid on the 3D model of the landscape.

Metrics of success

Large UAS streams data back to the incident center to support assessment of full extent

Small UAS #1 streams back data to support those on ground to assess Tsunami Inundation

Small UAS #2 maps bridge and gets real-time videos back to the emergency management operations center

Small UAS #2 PIC responds to commands from the incident center on where obs. are needed

Safe flight operations with two small UAS operating and data streaming back

Both small UAS flew under Part 107 and VLOS is maintained

Local Part 107 small UAS pilots respond to requests and data back to the emergency management operations center

1.3 Situation

1.3.1 Overview

Purpose of the mission: Large earthquake in Anchorage, Alaska with Tsunami warning and impact to Seward, Alaska. UAS support is required to map the extent of the earthquake, assess safety of local infrastructure, and at the same time respond to another hazard in a small community, Seward, Alaska.

Goals: Get large UAS up and mapping impacted region to get data to operations center; Local small UAS Part 107 pilots able to respond and provide data of impacted regions (Bridge and City of Seward) to show that they can be useful during disaster without needing to send emergency managers and UAS operators from Anchorage until needed.

UAS mission Lead: University of Alaska Fairbanks (UAF) Alaska Center for Unmanned Aircraft Systems Integration (ACUASI) team.

Large UAS: High altitude observations of the event

- Flight team with crew, starting from Anchorage International Airport
- EO visible and thermal sensors onboard
- Stays at higher altitudes throughout the event

Small UAS #1: Mapping impacted bridge as detected in large UAS data

- Pilot in command and Visual Observer (VO)
- EO visible and thermal sensors
- Data feeds through ground control station to operations center and on-the-ground teams

Small UAS #2: Mapping the impact of the Tsunami on the City of Seward

- Pilot in command and VO
- EO visible sensor along with thermal sensor to provide observations of surrounding area

1.3.2 Location

Locations

Ted Stevens Anchorage International Airport, Alaska

Latitude: 61.1740847° N Longitude: 149.9981375° W

IATA: ANC ICAO: PANC FAA LID: ANC

https://www.airnav.com/airport/PANC

Seward, Alaska

Latitude: 60.1048° N Longitude: 149.4421° W

All maps in Appendix 3

1.3.3 Systems

Central Operations

- Coordination of flight teams: Anchorage/Alaska emergency operations center or airport
- UAF lead points of contact for large UAS operations
- Seward representatives as impacted community and to support locations for small UAS #1
- Operations: Air Boss along with Federal Aviation Administration (FAA) and Federal Emergency Management Agency representatives

Large UAS

- SeaHunter/Sentry type
- Ted Stevens Anchorage International Airport, Alaska (PANC)
- Endurance for multiple hours per flight, up to 4 hours per mission
- Pilots and support crew for large UAS
    - External Pilot, Crew Chief, Internal Pilot, and Supplemental Pilot
    - Additional operator to manage data feed from onboard payload
- Minimum Payload
    - EO feed is sent back GCS and onto operations center
    - Thermal payload integrated for nadir viewing
- Products: Classification of full extent of damage that leads to data on the bridge collapse

Small UAS #1

- Vertical Takeoff and Landing (VTOL)
- Endurance for 45 minutes per flight
- Flight team
    - PIC and VOs including sensor engineering support
    - Approved local Part 107 operator with aircraft for rapid response
    - Engineering support so can come back for fix between flights
- Minimum payload
    - Integrated EO and thermal sensor: Nadir viewing with pointable system
- Sufficient battery capacity for multiple flights or ½ of operations
- May need a waiver to get a higher altitude, > 400 ft.

Small UAS #2

- VTOL
- Endurance for 45 minutes per flight
- Flight team
    - PIC and VOs including sensor engineering support
    - Approved local Part 107 operator with aircraft for rapid response
    - Engineering support so can come back for fix between flights
- Minimum payload
    - Integrated EO and thermal sensor: Nadir viewing with pointable system
- Sufficient battery capacity for multiple flights or ½ of operations
- May need a waiver to get a higher altitude, > 400 ft.
- Post-flight: Digital Elevation Model (DEM) and three-dimensional (3D) model of bridge

1.4 Mission

Disaster:

Large earthquake in South Central Alaska that impacts Anchorage to Palmer region; Tsunami warning and then inundation of coastline and impacts Seward; Bridge collapse along highway from Anchorage to Palmer and need to map.

Observations

Recording of full extent of the damage of the earthquake to infrastructure and transportation networks across South Central Alaska. Data feeds back to the operations center and determines there is a collapsed bridge on the highway that needs local small UAS mapping. Secondary tsunami warning that predicts inundation along the South-Central coastline. Seward reports Tsunami and local small UAS operations, maps damage, and feeds data back to GCS as well as the State operations center in Anchorage.

Response mission:

As the large earthquake is over, there could be some smaller aftershocks, need to map damage from the main earthquake and significant tsunami inundation.

Stakeholders:

Department of Transportation in Anchorage for road network assessment. City of Seward to map full extent of damage without risking personnel. State of Alaska to assess full damage and best places to send resources. State operations center to get real-time data feeds into decision makers hands.

Goals:

Get large UAS up and mapping impacted regions to get data to the operations center. Local small UAS Part 107 pilots are able to respond and provide data of impacted regions (Bridge and City of Seward) to show that they can be useful during disaster without needing to send emergency managers and UAS operators from Anchorage until needed.

Objectives:

Large UAS with real-time data to GCS and onto operations center that is used to detect bridge hazard to target local finer scale mapping of impacted infrastructure. Small UAS #1 able to respond and collect data that is viewed by the Department of Transportation at the Department of Transportation, pilot approved for emergency operations. Small UAS #2 provided by Seward-based approved Part 107 pilot collects data over impacted areas and provides it to local GCS and emergency response as well as feeds to the operations center. Evaluate how small UAS missions can respond to large UAS operations and data analysis. Evaluate how local 107 pilots can respond to needs of State and/or City agencies. Evaluate how local 107 pilots respond to tsunami warnings and reports to map regions and feed data back to the operations center.

Mission Products

EO and where possible thermal data feeds back to GCS and operations center from all three UAS. Data displayed in geospatial interface to superimpose on other available data from state, federal, and local agencies.

Post-Mission (fast response) Products:

- Large UAS: Geo-located videos to show field of view to analyze for impact to infrastructure
- Small UAS #1 at the bridge: Orthomosaics in optical wavelengths of bridge and surrounding area as 3D models where structure from motion (SfM) is possible to assess damage.
- Small UAS #2 at Seward: Optical videos of impact to the community and coastline and where possible thermal data. DEM models where SfM is possible to assess damage.

1.5 Execution

1.5.1 Operations Plan

Large UAS supports the event and 2 small UAS at lower altitudes, with their specific missions. One in Seward to map the Tsunami impact and surrounding land and one flown in Anchorage-Palmer region to provide data on the impacted bridge and local infrastructure.

1st flight - Will take time to respond, provide large scale mapping of extent

Large UAS

- Early morning take-off from Anchorage
- BVLOS operations
- Flown from runway to the traverse up to Palmer
- Route defined to cover main road networks and communities
- Day of flying to reach site and provide high altitude eyes on disaster
- VFR or IFR conditions as will be BVLOS
- Weather conditions: Pre-flight and during flight
- Follow pre-flight, during, and post-flight checklist for large UAS like SeaHunter/Sentry

2nd flight - Map the collapsed bridge and local area

Small UAS #2

- Bridge along highway between Anchorage and Palmer
- Locally based pilot approved for operations
- Pattern defined by Department of Transportation to map extent of damage
- VLOS with Part 107 waiver if needed based on time of day/location/altitude
- VFR conditions

- Weather conditions: Pre-flight and during flight
- Follow pre-flight, during, and post-flight checklist for small UAS, need for VO

3rd flight - Assess issue at Seward given Tsunami warning after earthquake

Small UAS #2

- Tsunami Inundation impact in Seward
- Locally based Pilot approved for operations
- Part 107 waiver and SGI
- Fly VLOS or EVLOS under VFR conditions
- Weather conditions: Pre-flight and during flight
- Map the extent of impact to community and if possible, further across Bay
- Follow pre-flight, during, and post-flight checklist for small UAS, need for VO

1.5.2 Data collection, processing, and dissemination

Large UAS - Full extent of disaster

- Data in flight:
    - High Precision locations and time synchronization of flight
    - Flight routes and logs from crew
    - Geotagged optical and thermal infrared imagery
    - Decimeter res. visible data from High Definition (HD) multi-megapixel camera
    - Broadband thermal infrared [7 - 13 μm] data: Minimum 640 x 480 resolution
    - Optical setup supports overlay videos onto visualization tool [Full Motion Video]
    - Optical and thermal setup to support SfM from data and streamed to GCS
    - On-board storage of data, downloaded upon landing and processed
- Products post flight:
    - Geotagged videos with overlaid field of view on geospatial visualization tool
    - Mosaicked maps from optical, Visible and Near-Infrared (VNIR), and thermal data
    - DEM of impacted South-Central Alaska from earthquake

Small UAS #1 - Bridge collapse assessment

- Data in flight:
    - High Precision locations and time synchronization of flight
    - Flight routes and logs from crew
    - Geotagged optical and thermal infrared imagery
    - Decimeter res. visible data from HD multi-megapixel camera
    - Broadband thermal infrared [7 - 13 μm] data: Minimum 640 x 480 resolution
    - Optical setup supports overlay videos onto visualization tool [Full Motion Video]
    - Optical and thermal setup to support SfM from data and streamed to GCS
    - On-board storage of data, downloaded upon landing and processed
- Products post flight:
    - Geotagged videos with overlaid field of view on geospatial visualization tool
    - Mosaicked maps from optical, VNIR, and thermal data
    - DEM of the region to show any collapsed roads and landscape

- 3D model visualization of impacted bridge and local road network

Small UAS #2 - Seward community impacted by Tsunami

- Data in flight:
  - High Precision locations and time synchronization of flight
  - Flight routes and logs from crew
  - Geotagged optical and thermal infrared imagery
  - Decimeter res. visible data from HD multi-megapixel camera
  - Broadband thermal infrared [7 - 13 μm] data: Minimum 640 x 480 resolution
  - Optical setup supports overlay videos onto visualization tool [Full Motion Video]
  - Optical and thermal setup to support SfM from data and streamed to GCS
  - On-board storage of data, downloaded upon landing and processed
- Products post flight:
  - Geotagged videos with overlaid field of view on geospatial visualization tool
  - Mosaicked maps from optical and thermal data
  - DEM of the region to show any collapsed infrastructure and landscape
  - 3D model visualization of impacted community from Tsunami

1.6 Administration & Logistics

1.6.1 Planning and local logistics

Large UAS team will have accommodation at a hotel nearby the launching airport. 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. Large UAS team will work with launching airport to acquire runway access and set up location for their ground control station. UAS mission teams will ensure that all required waivers are in place to support flight operations. Large UAS will have all permissions to fly from launching airport and within the National Airspace System (NAS) to the terrorism event. If a Temporary Flight Restriction (TFR) in place, the flight team lead will liaise with the event air boss to ensure permissions set up to allow large UAS to fly into TFR. For small UAS, any required Part 107 waivers will be in place before missions start. SGI waiver will be submitted to support all small UAS 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. Flight teams will have their own vehicle and radio/cell communications so that they can move to needed locations. All waivers and permissions in place to support them in any location across western Anchorage and towards Seward. All required communications will occur between all PICs and local air traffic control tower. All Notices to Airmen (NOTAMs) will be provided to the wider aviation community.

1.6.2 Hazards/Risk

Hazard #1: 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 of the missions start, the flight crews will ensure that aircraft systems and GCS's 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 #2: Large UAS is unable to stay airborne or takes too long to launch

- Risk: This hazard comes from the time taken to get the large UAS airborne to collect data thus limiting observations of the event. It can be caused by a need to refuel and therefore no high-altitude observations of the response. Possible effects are no higher altitude data to keep eyes on the full extent of the event and/or act as a communications hub.
- Mitigation: The large UAS team will react as quickly as they are requested to support the disaster response. They will know the available airports that they can use for their flight operations and will have their own flight checklists for flight operations. The large UAS team that assets are closest to the disaster response will be contacted first to ensure fast response. The disaster response team will know the available large UAS teams that are approved to support a disaster response. The large UAS flight crew will inform the ICS lead/air boss on their currently available fuel and time that they can stay airborne.

Hazard #3: Crew unable to provide visual observations for small UAS flight

- Risk: This hazard comes from a required flight time of the small UAS missions extending beyond the visual observation capabilities of the crew and there is no VLOS plan in place. Possible effects are that a mission has to end and cannot support operations or a small UAS cannot be tracked and so a Return to Base (RTB) is required to ensure the crew can keep a visual on it and airspace.
- Mitigation: Before the mission starts, the PIC will determine the maximum distance that a VO can see to ensure VLOS operations based on the conditions at the time of flight. The VO will continue to stay in communication with the PIC to ensure that they can confirm that they can see the aircraft and the airspace around the operations. If there is a deviation of the planned flight route, then the PIC will ensure that the VO can still see the aircraft and if no onboard detect and avoid system is in place and no waiver to allow BVLOS operations then the new route will not occur and the aircraft will stay on its course that ensure VLOS operations.

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 of 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 Divert Land Immediately (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 power and navigational connection to large UAS in NAS

- Risk: This hazard comes from a loss of power and control of the large UAS providing higher altitude eyes on the response. Possible effects are no higher altitude data to keep eyes on the

full extent of the event and/or act as a communications hub and a RTB or uncontrolled descent of the UAS.

- Mitigation: Mitigation would include assigning ditch points for the UAS in the CONOP so the team is prepared for safe landings, if unable to return to home. The crew member responsible for mission team safety and the ground control station will inform the PIC or mission manager on loss of power. Depending on the vehicle capabilities, it may not be possible to reach a prescribed ditch point during a power loss. However, if the vehicle can reach the ditch point, these points should be monitored for pedestrian/ground traffic to ensure safe landing is possible. VO's in place for VLOS operations will be used to support the PIC in understanding any risks on the ground below the aircraft's location when power is lost. 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 flight's alternative landing zones will occur to mitigate any mid-air collisions from DLI or RTB flights.

1.6.3 Community outreach and connections

- All Operations: City of Seward, Incident command team if a statewide operations center has been set up, FAA Anchorage Air Route Traffic Control Center (ARTCC), education to local community on dangers of recreational UAS operations during response.
- Large UAS: Communications with launching airport for large UAS [Anchorage International airport] and Department of Defense Joint-Base Elmendorf-Richardson given routes around Anchorage and their potential airspace
- Small UAS #1: Department of Transportation to set up the necessary access for the takeoff and landing site.
- Small UAS #2: City of Seward and local approved Part 107 pilots to obtain systems and launch sites.

1.6.4 Disaster response mission specific information

United States Geological Survey (USGS) details on the 1964 earthquake and subsequent Tsunami - https://earthquake.usgs.gov/earthquakes/events/alaska1964/

Alaska Earthquake Center Tsunami Risk Reduction for Alaska tools - https://earthquake.alaska.edu/tsunamis

Alaska Division of Natural Resources Geological and Geophysical Surveys Tsunami Inundation Mapping information - https://dggs.alaska.gov/pubs/tsunami

1.6.5 Mission Summary

Disaster:

Large earthquake in South Central Alaska that impacts Anchorage to Palmer region; Tsunami warning and then inundation of coastline and impacts Seward; Bridge collapse along highway from Anchorage to Palmer and need to map.

Objectives:

Large UAS with real-time data to GCS and onto operations center that is used to detect bridge hazard to target local finer scale mapping of impacted infrastructure. Small UAS #1 able to respond and collect data that is viewed by the Department of Transportation at the Department of Transportation, pilot approved for emergency operations. Small UAS #2 provided by Seward-based approved Part 107 pilot collects data over impacted areas and provides it to local GCS and

emergency response as well as feeds to the operations center. Evaluate how small UAS missions can respond to large UAS operations and data analysis. Evaluate how local 107 pilots can respond to needs of State and/or City agencies. Evaluate how local 107 pilots respond to tsunami warnings and reports to map regions and feed data back to the operations center.

Flight Missions:

Large UAS flown to provide an overview of the full disaster extent. Two small UAS would be flown to: (1) collect data of a collapsed bridge that was seen in large UAS, and data requested by Department of Transportation, and (2) collect data over Seward that had Tsunami warning and then inundation.

Metrics of success:

- Large UAS streams data back to the incident center to support assessment of full extent.
- Small UAS #1 streams back data to support those on ground to assess Tsunami Inundation.
- Small UAS #2 maps bridge and gets real-time videos back to the operations center.
- Small UAS #2 responds to needs from the operations on where observations are needed.
- Safe flight operations with two small UAS operating and data streaming back.
- Both small UAS flew under Part 107 and VLOS is maintained.
- Local Part 107 small UAS pilots respond to requests and data back to the EM Ops Center.

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 that 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

Large earthquake in South Central Alaska with Tsunami warning and need to map inundation to Seward region.

Mission Purpose/Objectives

Purpose : Large earthquake in South Central Alaska that impacts Anchorage to Palmer region; Tsunami warning and then inundation of coastline and impacts Seward; Bridge collapse along highway from Anchorage to Palmer and need to map.

Goals : Large UAS up and mapping impacted region to get data to emergency management operations center. Small UAS Part 107 pilots respond and provide data of impacted regions [Bridge and City of Seward] to show that they can be useful during disaster without needing to send EMs from Anchorage until needed. Small UAS support analysis of local infrastructure and safety assessment.

Objectives : Large UAS with real-time data to ground control station (GCS) and onto emergency management operations center used to detect bridge hazard and to target local finer scale mapping of impacted infrastructure. Small UAS #1 responds to and collects data for viewing at emergency management operations center. Small UAS #2 provided by Seward-based emergency management operations approved Part 107 pilot collects data over impacted areas and provides data back to local GCS and emergency response as well as feeds to State emergency management operations center. Evaluate how small UAS missions can respond to large UAS operations and data analysis. Evaluate how local 107 pilots can respond to needs of State and/or City agencies. Evaluate how local 107 pilots respond to Tsunami warnings and reports to map regions and feed data back to the State emergency management operations center.

Mission Results

Observations : Recording of full extent of the damage of the earthquake to infrastructure and transportation networks across South Central Alaska. Data feeds back to emergency management operations center and determines there is a collapsed bridge on the highway that needs local small UAS mapping. Secondary tsunami warning that predicts inundation along the South Central coastline. Seward reports Tsunami and local small UAS operations, maps damage, and feeds data back to their ground control station (GCS) as well as State operations center.

Real-time Mission Products: Electro-optical visible and where possible thermal data feeds back to GCS and operations center from all three UAS. Data displayed in geospatial interface to superimpose on other available data from state, federal, and local agencies.

Post-Mission [fast response] Products: Large UAS: Geospatial located video feeds to show field of view to analyze for impact to infrastructure. Small UAS #1 @ Seward: Optical videos of impact to the community and coastline and where possible thermal data. surface and three-dimensional (3D) models where structure from motion (SfM) is possible to assess damage. Small UAS #2 @ bridge: Orthomosaics in optical wavelengths of bridge and surrounding area as 3D models where SfM is possible to assess damage.

Mission Procedures/Approach

Large UAS: High Altitude observations over disaster area
Early morning take-off from Anchorage
Beyond line of sight (BVLOS) operations
Flown from runway to the traverse up to Palmer
Route defined to cover main road networks and communities
Day of flying to reach site and provide high altitude eyes on disaster
Visual Flight Rules (VFR)/Instrument Flight Rules (IFR) conditions as will be BVLOS
Weather conditions: Pre-flight and during flight

Small UAS #1 : Tsunami inundation impact in Seward
Locally based Pilot approved for emergency management operations center
Part 107 waiver and special government interest (SGI) waiver
Fly visual line of sight (VLOS) or extended-VLOS (EVLOS) under VFR conditions
Weather conditions: Pre-flight and during flight
Map the extent of impact to community and if possible, further across Bay

Small UAS #2 : Bridge along highway between Anchorage and Palmer
Locally based Pilot approved by emergency management operations center
Pattern defined to map extent of damage seen in large UAS and any ground reports
VLOS with Part 107 waiver if needed based on time of day/location/altitude
VFR conditions
Weather conditions: Pre-flight and during flight

Mission Milestones

Outcomes/Actionable Intelligence
Large UAS [Higher altitude eyes and coms on disaster] - Adaptable mission to map the full extent of the disaster. Electro-optical video data feedback to ground control station (GCS) and piped into emergency management operations center. GCS team in communications with emergency management operations center and then smallUAS #1 team for bridge inspection.

Small UAS #1 [Bridge] - Mission readied and flown once bridge seen in large UAS data and flight had adaptable to focus on the collapsed bridge. Electro-optical video feed back to pilot in command and piped into the emergency management operations center. 3D rendering of the bridge available soon after mission flown. Field of view (FOV) of electro-optical camera seen in emergency management operations center so they can adapt flight as their needs.

Small UAS #2 [Seward for Tsunami] - Mission readied once reports of Tsunami impacted the community. Electro-optial and thermal video feeds back to PIC and piped into emergency management operations center. PIC able to adapt routes at the needs of local emergency management and ground teams to support operations. 3D rendering of the community available after flight lands and processed data. Thermal imagery overlaid on the 3D model of the landscape.

Metrics of success
Large UAS streams data back to the incident center to support assessment of full extent
Small UAS #1 streams back data to support those on ground to assess Tsunami inundation
Small UAS #2 maps bridge and gets real-time videos back to the emergency management operations center
Small UAS #2 PIC responds to commands from the incident center on where obs. are needed
Safe flight operations with two small UAS operating and data streaming back
Both small UAS flew under Part 107 and VLOS is maintained

1.8.2 Appendix 2: Flight Checklists

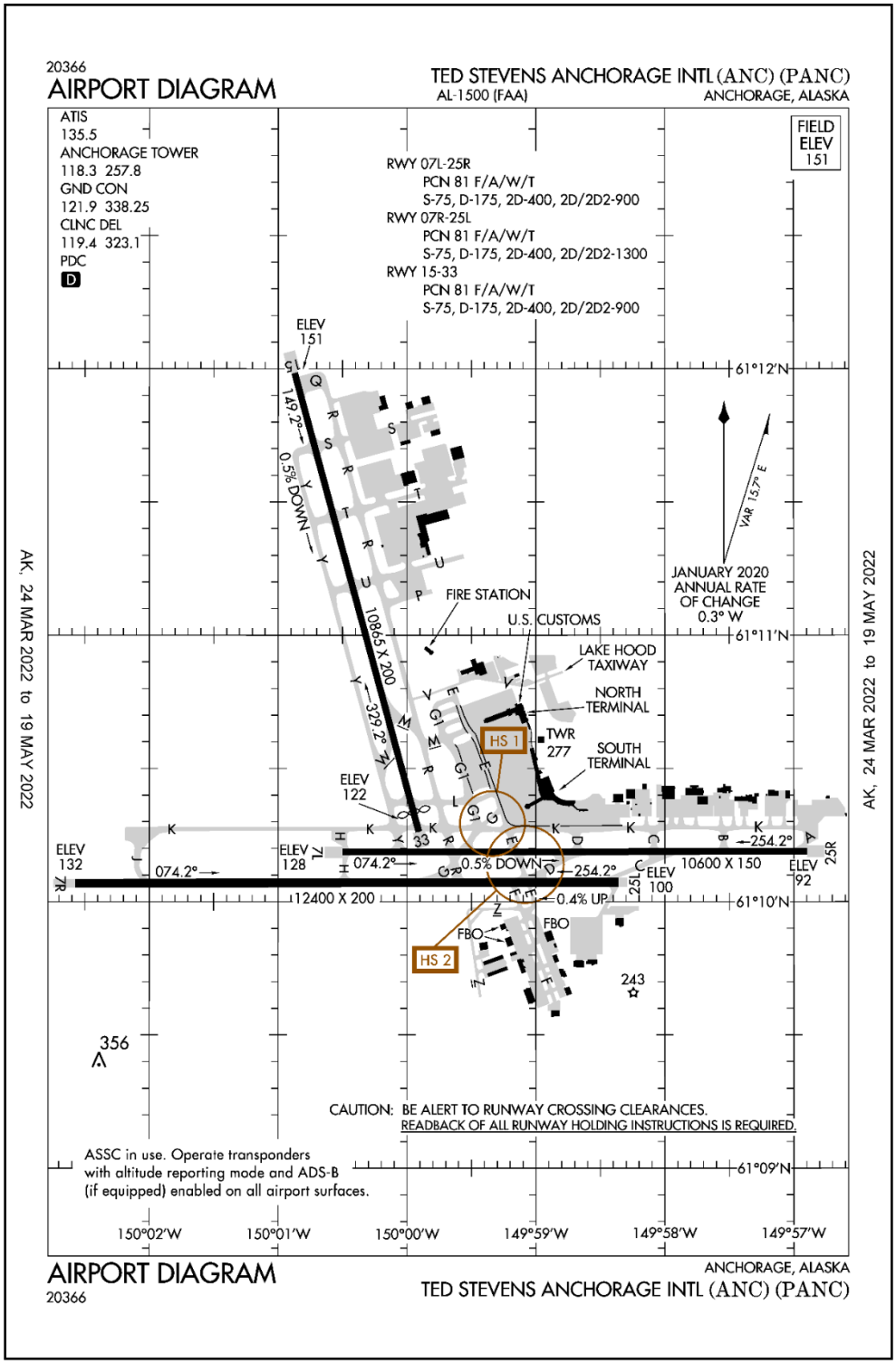
Aim: This appendix collects all flight checklists the mission team would complete pre-, during, and post-flight while at the mission location as well as pre- and post-operation before arriving and after leaving the mission location. Each flight checklist is included in a supplementary document. These 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.

Include details on:

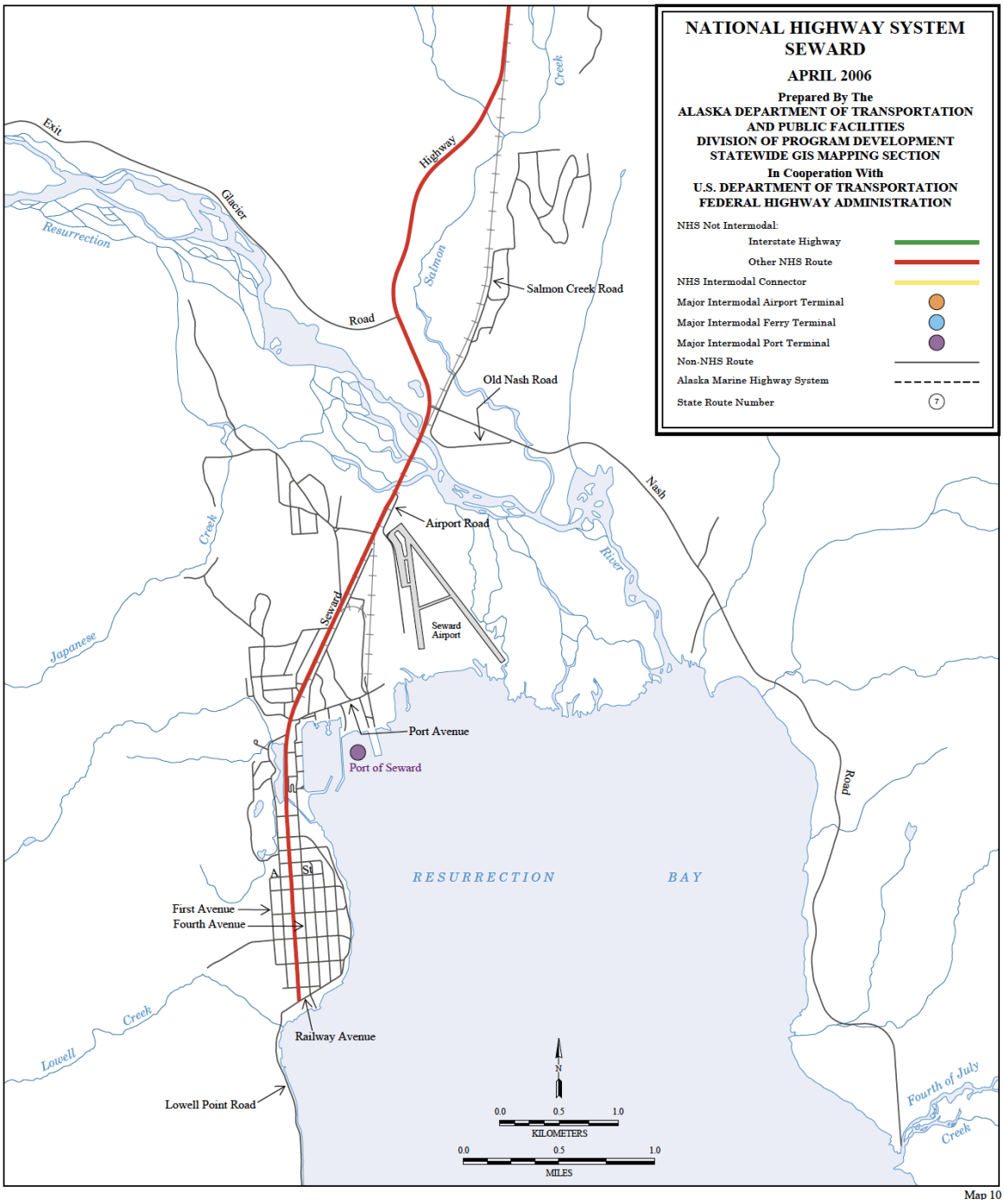
- Before CONOP development: Site Survey (details on assessment of mission location)
- Before Operations: Mission checklist (complete at home for lead organization)
- Pre-deployment: Checklist to complete prior to leaving for mission site
- Deployment: Checklists for flight operations, once arrived at 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

Anchorage airport map



Map of Seward, Alaska:



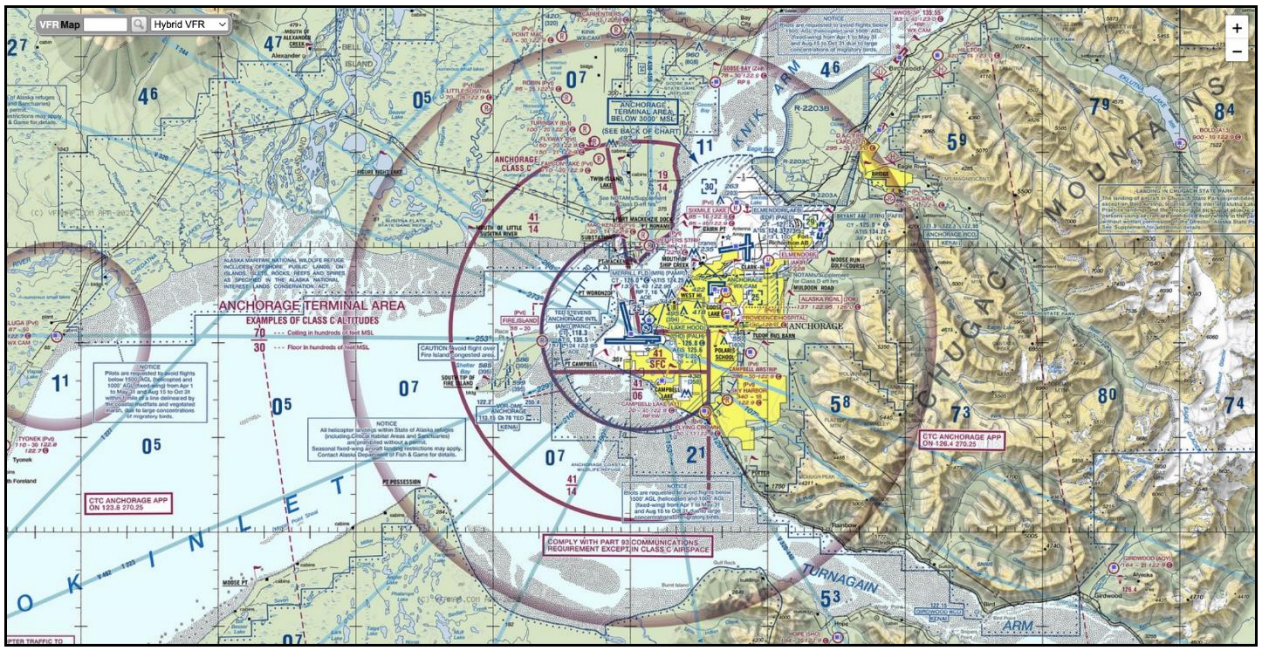
Map 10

Page 12 in https://dot.alaska.gov/stwddes/gis/dataproducts/NHS_MapSet2006final.pdf

Sectional Charts

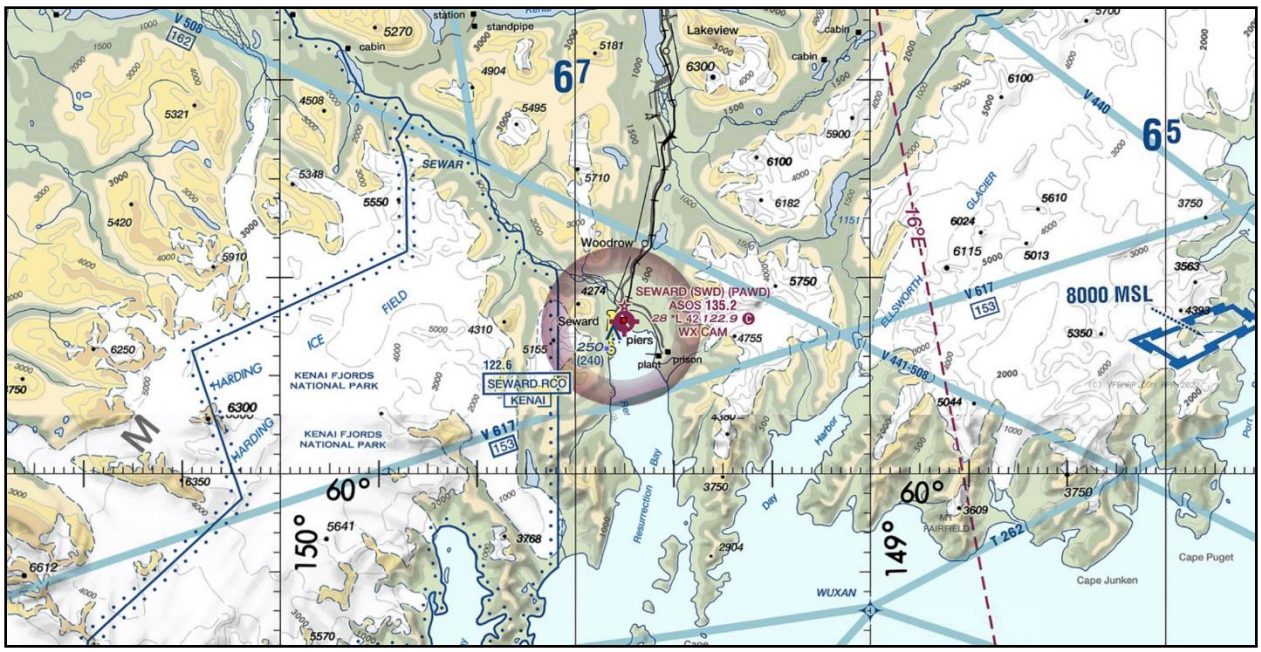
Anchorage Airport and vicinity

http://vfrmap.com/?type=vfrc&lat=61.174&lon=-149.998&zoom=10&api_key=763xxE1MJHyhr48DlAP2qQ



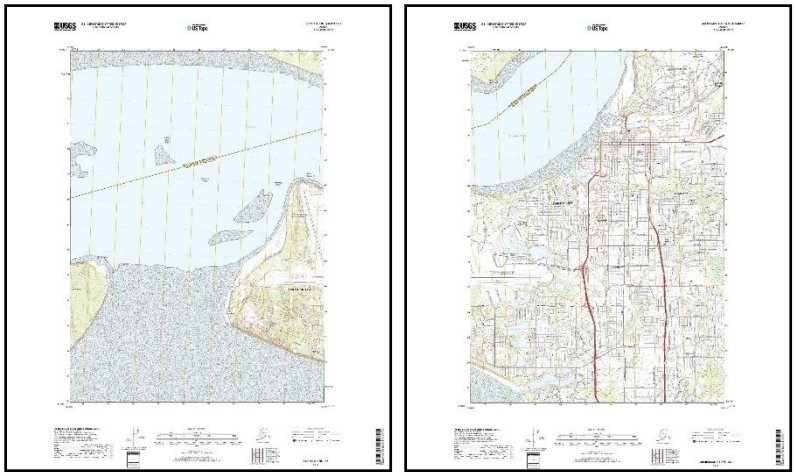
Seward and vicinity

http://vfrmap.com/?type=vfrc&lat=61.174&lon=-149.998&zoom=10&api_key=763xxE1MJHyhr48DlAP2qQ

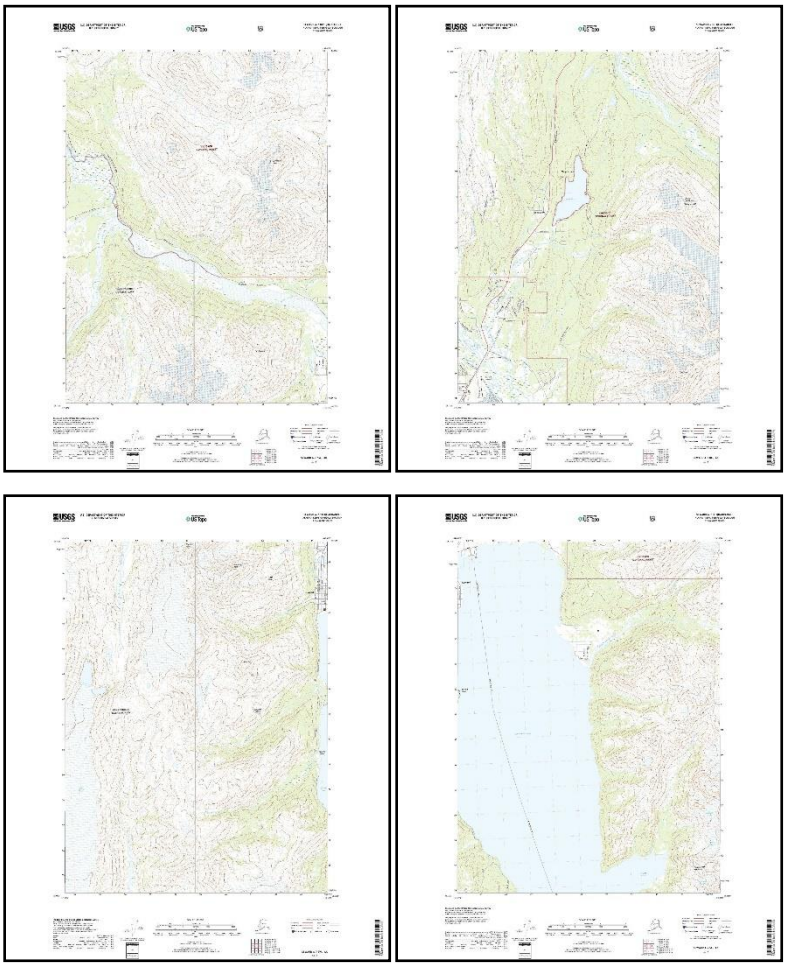


United States Geological Survey (USGS) 7.5-minute topographic map

Anchorage airport and its vicinity

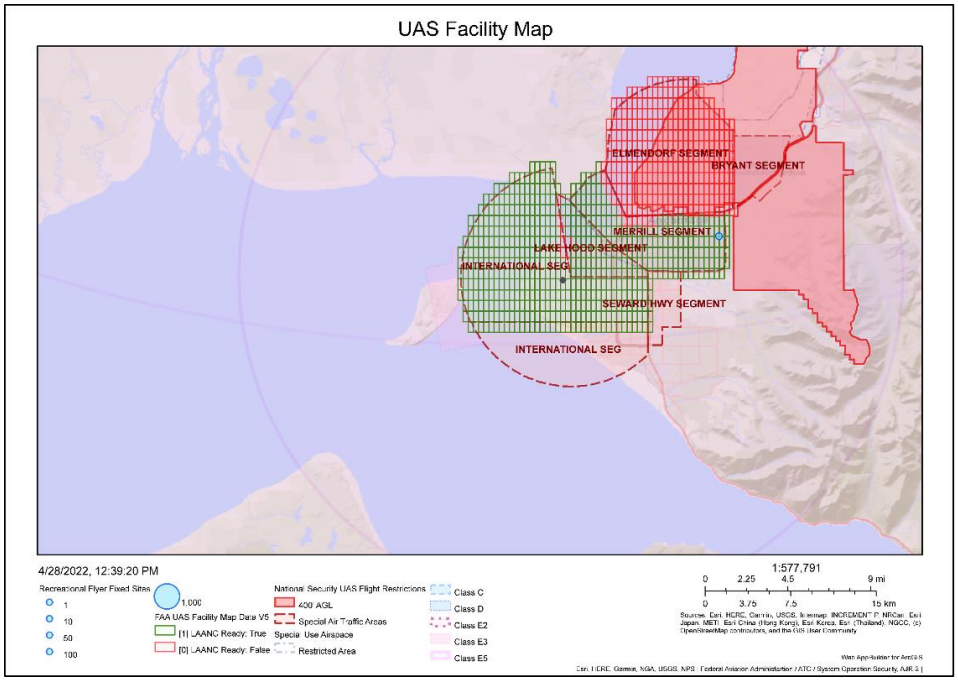


Seward and region

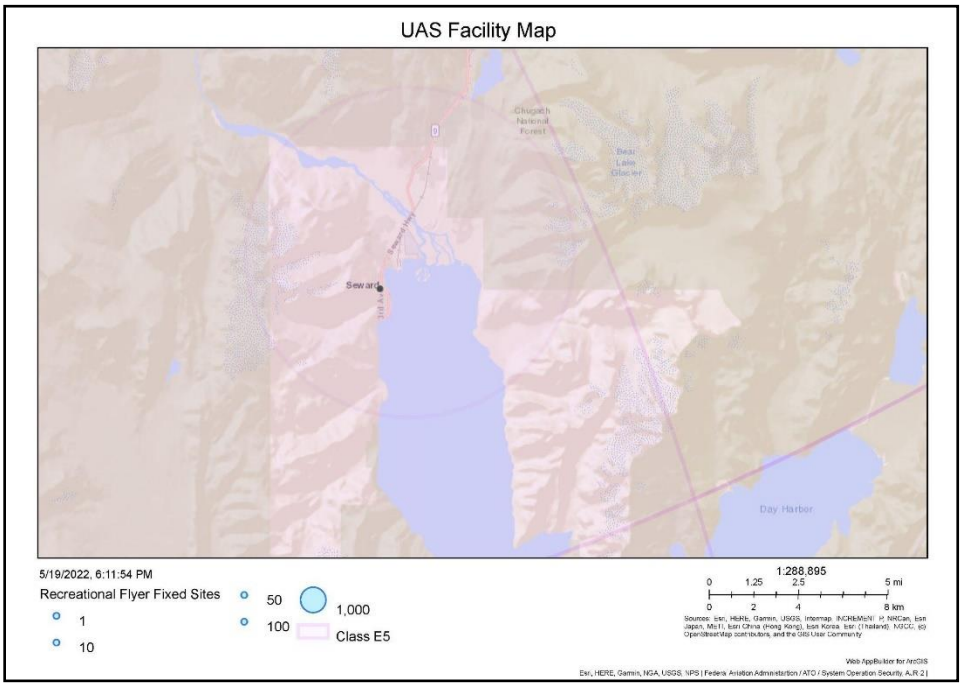


Low Altitude Authorization and Notification Capability Facility Maps

Anchorage Airport and vicinity



Seward and surrounding region



Tsunami Potential for Seward

Figure 22. Observed 1964 inundation line (from Lemke, 1967) and calculated inundation lines from tectonic and landslide sources at Seward.

From Figure 22 in Suleimani et al (2010)

Reference: Suleimani, E. N., West, D. J., Combellick, D. A., and Hansen, R. A., 2010. Tsunami inundation maps of Seward and northern Resurrection Bay, Alaska. 55pg, https://dggs.alaska.gov/webpubs/dggs/ri/text/ri2010_001.pdf

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 red green blue 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 – Light Detection and Ranging 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)
    - Keyhole Markup Zipped (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 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 BVLOS.*
- *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*

1.9 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*