Appendix A

LOS Operations
The flights to be executed on November 4th and 5th focus on the close-range inspection and imaging of facilities and will serve as a proof of concept demonstrating the logistical ability to fly a UAV at pump station 07 and stream low-latency, high definition video from the UAS to ground operations where it will be viewed live in Fairbanks and Anchorage using the Alyeska network.
Introduction

Purpose
The purpose of this document is to provide details of the mission goals, logistics planning, flight plan, and operations schedule to those involved.

The flights to be executed on November 4th and 5th focus on the close-range inspection and imaging of facilities and will serve as a proof of concept demonstrating the logistical ability to fly a UAV at pump station 07 and stream low-latency, high definition video from the UAS to ground operations where it will be viewed live in Fairbanks and Anchorage using the Alyeska network.

Background
The operation of unmanned aircraft systems (UAS) for monitoring of pipeline operations, patrolling the Right of Way (ROW), and facilities inspection is novel. Strict regulation of the technology by the Federal Aviation Administration has limited UAS research to industrial/academic research partnerships in remote locations of the United States where airspace can be more easily managed. This research partnership between the Alyeska Pipeline Service Company (APSC) and the University of Alaska Fairbanks (UAF) is funded by the US Department of Transportation.

Alyeska’s partnership on this project includes participation of staff as well as project cost-share in the form of survey and mapping data. The project’s principal investigator is Keith Cunningham, PhD of UAF’s Scenarios Network for Alaska and Arctic Planning and he is a close collaborator with the UAF Alaska Center for Unmanned Aircraft Systems Integration.

Dr. Cunningham has designed several mission scenarios to test UAS missions integrated with pipeline operations. Generically, these include a) the regular and persistent patrolling of the pipeline corridor and key facilities; b) the close-range inspection and imaging of facilities; c) and thermosiphon inspection to mitigate permafrost thaw and better understand geotechnical engineering in the Arctic. Integrating these three scenarios is the sharing of imaging and data across all levels of Alyeska’s business, from operations, inspection, engineering, integrity management, and executive decision making.

Goals
Research goals of the project are to understand the best practices for incorporating UAS into the daily business practices of a pipeline operator, providing real-time airborne situation awareness in order to augment the regular patrolling of the ROW, the inspection of facilities, and the closer collaboration of engineering, operations, and management in organizational decision support systems.

Mission Overview
Two mission scenarios will be demonstrated during the November 2014 operations. The first scenario will involve flying along the ROW. The second scenario will involve flying along a section of pipeline within the pump station.

Both mission scenarios will stream high-definition video from the aircraft to the Emergency Operations Centers (EOC) in Fairbanks and Anchorage. Using the voice conferencing a dialog between the two EOC will occur among engaged Alyeska observers. A designated Alyeska supervisor will communicate with the Flight Supervisor at the pump station regarding observed issues within the ROW. The Flight Supervisor will then relay instruction to the pilot regarding the stop and hover of the UAS as well as the gimbal control of the streaming video for detailed analysis of the imagery at the EOC.
Right of Way Patrol (ROW)

During this mission, the Ptarmigan UAS will operate above the ROW, flying northwest and southeast of the pump station, to inspect the ROW. The inspection will be for encroachments such as parked vehicles on and near the ROW, as well as indicators of spills and other hazards, i.e. erosion of stream crossings. The ROW patrol will be a collaborative exercise among the Emergency Operations Centers, UAS operations, and the staff working on site at the pump station. The intended results are a vertical integration of situation awareness data at multiple levels of the Alyeska organization leading to the real time decision making.
**Close-Range Inspection**

During this mission, UAF pilot and observer will operate the Ptarmigan UAS at a close distance to the above-ground pipeline, less than 50 ft. The close range inspection is for visual indication of any issues affecting the integrity of the facilities, which may include signs of corrosion, water in insulation, settling/deflection of the vertical support members (VSM), and even intentional damage from bullets.

This flight mission will be within the perimeter of the pump station. The northern portion of the pipeline is above ground permitting close range inspection from multiple look angles. A safe stand-off distance for the hovering UAS will be determined by the UAS pilot/operators and Alyeska safety staff.

The streaming video will be displayed at the Fairbanks and Anchorage EOC but the goal of the flight is to collect overlapping, high-resolution images of the above ground facility. A designated Alyeska supervisor with expertise in facility inspection will communicate with the Flight Supervisor at the pump station regarding observed issues from the real-time imaging, such as corrosion, settling, and staining. The EOC observer can instruct the UAS Operator/Pilot to collect more detailed imagery, possibly at a closer range and from multiple angles.
Safety
Safety is paramount on any APSC activity. A Job Hazard Analysis (JHA) has been completed for this project, including UAS operations for November 4th and 5th. See JHA for a complete breakdown of hazard mitigations.
Critical Mission Component Descriptions

Aircraft
The Ptarmigan UAS - A vertical takeoff and land (VTOL) aircraft with 6 rotors capable of lifting up to 1.5 kg payloads. A system description document is available for review and will also be on-site during operations.

Payload
The payload consists of a wireless video system and high definition camera. The DJI Lightbridge HD video system integrated to the Ptarmigan provides video from a source onboard the aircraft to a ground receiver. The modified GoPro camera on stabilization gimbal will provide video to the Lightbridge video system.

Ground Control System
The standard ground control system for Ptarmigan Operations will be used. The standard ground control system consists of a Manual Control Console (MCC) and Ground Control Station (GCS) laptop. This provides control redundancy as the pilot can command the aircraft using either device.

Saved Mission & Flight Logs
Flight mission logs from the UAS will be saved for analysis and programming of future missions.

Data/Imagery Telemetry
The Lightbridge ground unit receiving video will be a non-integral part of the ground station. The video from the Lightbridge is not considered to be a part of the control system and operations using the video for navigation are not permitted. The video from the Lightbridge will be rebroadcast using Alyeska’s short range HD Flow video link to a network interface unit so the video can be used as a teleconference input on Alyeska’s intranet.

Airspace Management
Operators will comply with all directives in the Certificate of Authorization (COA) from the FAA. The COA authorizes the ACUAS! Ptarmigan aircraft to operate in the vicinity of pump station 07 up to 200 ft. above ground level (AGL).
# Participants

<table>
<thead>
<tr>
<th>Name</th>
<th>Role</th>
<th>Email</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ben Neubauer</td>
<td>Pilot</td>
<td><a href="mailto:b.e.neubauer@noremsol.com">b.e.neubauer@noremsol.com</a></td>
<td>Pump Station 7</td>
</tr>
<tr>
<td>Corey Upton</td>
<td>Flight Supervisor</td>
<td><a href="mailto:c.upton@noremsol.com">c.upton@noremsol.com</a></td>
<td>Pump Station 7</td>
</tr>
<tr>
<td>Sam Vanderwaal</td>
<td>Observer</td>
<td><a href="mailto:s.vanderwaal@noremsol.com">s.vanderwaal@noremsol.com</a></td>
<td>Pump Station 7</td>
</tr>
<tr>
<td>Keith W. Cunningham</td>
<td>QOS Monitor</td>
<td><a href="mailto:kwcunningham@alaska.edu">kwcunningham@alaska.edu</a></td>
<td>Pump Station 7</td>
</tr>
<tr>
<td>Bruce Crevensten</td>
<td>Control Station Monitor</td>
<td><a href="mailto:becrevensten@alaska.edu">becrevensten@alaska.edu</a></td>
<td>Not Participating</td>
</tr>
<tr>
<td>Ray Wilson</td>
<td>Control Station Support:</td>
<td><a href="mailto:rayjan.wilson@alaska.edu">rayjan.wilson@alaska.edu</a></td>
<td>Pump Station 7</td>
</tr>
<tr>
<td>Kristin Timm</td>
<td>Field Videography</td>
<td><a href="mailto:kmtimm@alaska.edu">kmtimm@alaska.edu</a></td>
<td>Not participating</td>
</tr>
<tr>
<td>Jacques Cloutier</td>
<td>Alyeska Exercise Liaison</td>
<td><a href="mailto:Jacques.Cloutier@alyeska-pipeline.com">Jacques.Cloutier@alyeska-pipeline.com</a></td>
<td>Pump Station 7</td>
</tr>
<tr>
<td>Frank Wuttig</td>
<td>Alyeska Exercise Logistics</td>
<td><a href="mailto:frank.wuttig@alyeska-pipeline.com">frank.wuttig@alyeska-pipeline.com</a></td>
<td>Pump Station 7</td>
</tr>
<tr>
<td>Lori Howard/Wes Wilson</td>
<td>PS7 O&amp;M Supervisors</td>
<td></td>
<td>Pump Station 7</td>
</tr>
<tr>
<td>Chuck Southerland</td>
<td></td>
<td><a href="mailto:Chuck.Southerland@alyeska-pipeline.com">Chuck.Southerland@alyeska-pipeline.com</a></td>
<td>Fairbanks Anchorage EOC</td>
</tr>
<tr>
<td>Tom Webb</td>
<td></td>
<td><a href="mailto:Tom.Webb@alyeska-pipeline.com">Tom.Webb@alyeska-pipeline.com</a></td>
<td>Alyeska Anchorage EOC</td>
</tr>
<tr>
<td>Seth Scavette</td>
<td>Network Security (WiPro)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dana Orr</td>
<td>Network Security (WiPro)</td>
<td><a href="mailto:dana.orr@alyeska-pipeline.com">dana.orr@alyeska-pipeline.com</a></td>
<td></td>
</tr>
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Operations Plan

Operations will be on the 4th and 5th of November weather permitting. Operations on each day will be identical.

Flight Operations
The Pilot in Command (PIC) and Visual Observer are required for flight operations of the Ptarmigan UAS. The PIC and Observer will operate from the top of the relief valve shelter structure shown in the image. The required equipment for operations will be hoisted up to the operation platform. This includes the Lightbridge ground unit and HD Flow short-range video transmitter. These units will be mounted to the safety railings as needed for adequate wireless reception.

During all critical stages of flight, defined as any time when the aircraft is powered, interruptions to the PIC and Visual Observer will be minimized.

The Ptarmigan will be operated using the Ground Control Station (GCS) with satellite imagery pre-cached from Google Maps. The Ptarmigan launch and recovery point will be from an unobstructed area near each ROW gate depending on the direction to be flown.
Communication Operations

The network interface box and HD Flow short-range video receiver will be located on the pad close to the relief valve shelter structure. If possible, this equipment will remain on the tailgate of a vehicle parked in the location with the network box shown in the image.

The Flight Supervisor and Alyeska Supervisor will communicate with Anchorage and Fairbanks EOC and the Flight Supervisor will relay any required instructions to the PIC and Observer.
Transportation

In an effort to reduce any confusion prior to departure, this section will discuss transportation to and from Pump Station 7. All personnel are required to have arctic gear in the vehicle. This gear is quite bulky, and requires significant space, so in order to reduce possible obstructed views; multiple vehicles will be taken to the site.

1. APSC (4x4 Crew Cab): Frank Wuttig and Jacques Cloutier
2. WiPro (Vehicle Unknown): Kevin Churches and Wing Tham
3. UAF (Personal 4x4): Ben Neubauer, Corey Upton, Samuel Vanderwaal
4. UAF (Vehicle Unknown): Keith Cunningham, Ray Wilson
Flight Process

Aircraft Preflight
Using required checklists, the Ptarmigan will have a pre-flight inspection before each flight by the PIC, Observer, or Flight Supervisor. This will occur prior to each flight and includes powering the aircraft.

GCS Preflight
Using required checklists, the Ptarmigan GCS will connect to the aircraft and link status, operation parameters and other conditions will be checked. This will occur prior to each flight and includes arming the aircraft for takeoff.

Flight Plan
All flights will be conducted to comply with the Certificate of Authorization (COA) provided by the FAA which is available for review on request and will also be on site during operations. All flights will remain line-of-sight between the aircraft and PIC/Observer. Altitudes will be determined at the discretion of the PIC with the safety of personnel, aircraft, and property in mind and will not exceed 150 ft AGL.

Multiple flights will be conducted to determine optimal altitudes for inspection. The flight supervisor will relay requests from the EOC to the PIC. Aircraft maneuvers will be at PIC discretion to maintain safety and compliance with regulations.

Due to the sun’s low elevation angle, flights to the southeast will be conducted after 2:00pm AKST when the sun is close to perpendicular (75° to the right) to the line-of-sight direction between PIC and aircraft (see image). Flights will be completed by 3:45pm AKST (30 minutes prior to sunset).

![Google Image with Sunangle Table](image-url)
Each phase of flight will include a pre-flight briefing including a summary of flight and a number of safety items. Briefing will be given by the PIC or Flight Supervisor and all personnel directly involved with the flight are required to attend.

**Phase I – Verification of aircraft and payload operation**
A short flight will be conducted from the northwest launch/recovery area to verify line-of-sight operations from the operator location and successful video transmission in flight.

**Phase II – Northwest ROW flights**
Flight operations above the ROW to the northwest of pump station 7 will be conducted. Using GPS and visual navigation, the PIC will navigate along the ROW maintaining line-of-sight. Video transmission range will likely limit the distance traveled along the ROW.

Flights to the northwest along the ROW will be repeated until adequate data has been captured.

**Phase III – Northern Close-Range Inspection**
Flight operations within the pump station perimeter will be conducted with direction from the Alyeska Supervisor. Inspection distance will be at discretion of PIC who will ensure that a minimum safe distance is maintained.

**Phase IV – Southeast ROW flights**
A short flight will be conducted from the southwest launch/recovery area to verify line-of-sight operations from the operator location and successful video transmission in flight.

**Phase V – Southeast ROW flights**
Flight operations above the ROW to the southeast of pump station 7 will be conducted. Using GPS and visual navigation, the PIC will navigate along the ROW maintaining line-of-sight. Video transmission range will likely limit the distance traveled along the ROW.

The video feed from the aircraft will be used by the PIC and Observer as a situational awareness tool however it is not a flight navigation system and critical navigation decisions are not permitted to be made using the video feed as a primary source of information.

**Outcome Summary**

**Right of Way (ROW) Patrol**
Best practices documentation, including video captured of the EOC observers will be prepared. The documentation will create a storyline involving the following:

- Preparation, safety check, and launch of UAS
- Supervisory control of Flight Supervisor and Pilot to initiate ROW patrol
- Pilot begins patrol at optimal altitude
- EOC supervisor requests the Flight Supervisor/Pilot to stop, hover, pan camera
- Flight Supervisor/Pilot communicated with EOC status of aircraft battery level
- Aircraft reaches end of patrol and Pilot instructs UAS to return and land
- Mission debriefing via EOC to EOC to Observer/Pilot field teleconference

**Close-Range Inspection**
Documentation of the preliminary best practices for facilities inspection will be prepared. The mission storyline and document/video organization will be the following:

- Preparation, safety check, and launch of UAS
- Supervisor control of Flight Supervisor and Pilot to initiate ROW patrol
- EOC supervisor requests the Flight Supervisor/Pilot to stop, hover, pan camera, and collect additional imagery
- EOC supervisor request the Flight Supervisor/Pilot to resume image capture
- Five imaging strips will be collected, two from each side of the pipeline and one from overhead
- UAS landing
- Data retrieval from UAS
- Mission debriefing via EOC to EOC to Observer/Pilot field teleconference

Risk Analysis

Flight Risk Analysis:
UAF Operations and Engineering personnel, in conjunction with Alyeska, conducted a Preliminary Hazard Analysis of the operation.

Assumptions made in the Flight Risk Analysis include:
- The UAS flight control and flight termination systems will function correctly.
- Manned aircraft will not operate below 500 ft AGL in the vicinity of the operational area.
- Unauthorized personnel and vehicles will not be allowed within the confines of the operational area.

The following hazards were identified in descending order of magnitude:
1. Loss of navigation control.
2. UAS PIC loses visual contact with UAV.
3. Loss of voice communications between PIC and ATC.
4. Loss of voice communications between PIC and Observer(s).

The Preliminary Hazard Analysis Worksheet and Risk Matrix diagram is attached.
Schedule

This section will outline the schedule of activities pertaining to this exercise.

Tuesday October 28, 2014: Final revisions to JLA and this document are due.

November 1, 2014: Evaluation of weather and deployment readiness – Go/No-Go Decision and file NOTAM

November 4-5, 2014: Actual Flight Days determine by COA and weather. Both operation days will maintain the same tentative schedule below.

- **0830**: Depart ACUASI (3330 Industrial Avenue, Fairbanks) for Pump Station 7
- **1000**: Arrive at Pump Station 7
- **1000-1100**: Site Orientation & Setup
  - Discuss exercise with pump station personnel
  - Set up GCS and required operations equipment on relief valve shelter building
  - Set up network interface on tailgate in proposed location
- **1100-1200**: Ground Control System and & Communications test
  - Verify telemetry operational
  - Verify Lightbridge equipment on APSC network
  - Live video feed from UAS to off-site locations
    - FEOC
    - AEOC
    - ACUASI
- **1150-1200**: Activate NOTAM
- **1200-1245**: Lunch
- **1245-1300**: Pre-Flight Briefing
- **1300-1400**: Right of Way (ROW) Patrol Flights to northwest
- **1400-1500**: Right of Way (ROW) Patrol Flights to southeast
- **1500-1545**: Close-Range Inspection Flights if time permits
- **1545-1600**: Post-Flight Briefing
- **1600-1700**: Mission Tear Down
  - Meet in PLQ for Post Exercise Discussion
    - Improvements required
    - What went well?
- **1700-1800**: Return to Fairbanks
Mission Checklist – UAS

1. ACUASI Ptarmigan (pre-assembled with payload) – Serial# PTAR2
   1.1. Manual Control Console (MCC) for PTAR2
   1.2. Ground Control Station (GCS) Radio for PTAR2
   1.3. USB cable (mini) for GCS Radio
   1.4. GCS Laptop
   1.5. Lightbridge Ground Station
   1.6. Spare Aircraft Batteries
   1.7. Spare Aircraft Propellers

2. Communications Kit Bag
   2.1. x3 Sportsman UHF Radios
       2.1.1. Chargers
   2.2. Aviation Band handheld VHF Radio
   2.3. Satellite Phone

3. Other Mission Support Equipment
   3.1. 50’ Extension Cord
   3.2. HDMI Cable for Lightbridge
   3.3. HD Flow transmitter and receiver kit (Alyeska Equipment)
   3.4. Folding Table
   3.5. Hoist rope
   3.6. 20x70mm Binoculars (Leonard’s Personal Equipment)
   3.7. Antenna tripod or railing mounts

4. Safety Equipment
   4.1. x2 Hard Hat
   4.2. x2 Pairs Gloves (Large)
   4.3. x2 Safety Vest
   4.4. x2 Safety Glasses/Goggles
   4.5. x1 Fire Extinguisher
   4.6. x1 Small First Aid Kit
   4.7. Arctic Emergency Gear

5. Documentation
   5.1. Certificate of Authorization Binder with attachment documents
       5.1.1. Crewmember Certifications
       5.1.2. Sectional Chart
       5.1.3. GPS RAIM Prediction
   5.2. Aircraft specific flight log, maintenance log, and configuration log binder Checklists