Relevant links:

* UAS\_RFC\_Workshop\_Summary\_final.pdf <https://drive.google.com/open?id=0B6vqMOQTeLkIZVFQV21SemJWSTFrUnUtYk90QWloNDRiVU9v>
* UAS RFC Workshop Report\_030615\_gaw.docx  
  <https://drive.google.com/open?id=0B6vqMOQTeLkINkxiMDRhcnJ1UU9vdUJJRlBhTldjZWFPNG9N>

**Alaska Hydrology UAS Requirements**

This document will attempt to identify requirements for Unmanned Aircraft System observations to support NWS river and flood forecasting in Alaska. Due to the complex nature of river ice breakup and ice jam formation, current numerical models have little value to assist with hazard assessment during river ice breakup on large Alaskan rivers. Historically breakup flood forecasting has relied upon manned aerial reconnaissance flights to issue timely flood watches and warnings. These reconnaissance flights track river ice conditions (strength, extent and movement) at the reach scale (10’s to 100’s of miles) and also identify ice jams as they form. These qualitative observations are used to forecast the flood hazard and to issue timely flood warnings. These flights, also known as ‘Riverwatch’, have developed over decades and are proven to be the most cost effective method to provide these mission critical services. To be as valuable as the manned Riverwatch flights for drawing conclusions on flood threat and ice jam formation, any UAS mission would need to provide comparable imagery over hundreds of miles of river and provide imagery to RFC staff by the following morning.

Apart from spring river breakup, there are processes ranging from snowmelt volumes to glacial outburst flooding to normal open water conditions that could benefit from enhanced observing from UAS platforms. While there is less reliance on the Riverwatch program during the open water season, the APRFC does routinely task the Civil Air Patrol to perform airborne reconnaissance over flooded areas. These are flights where UAS capabilities could add considerable information for decision support.

We have identified the following observation requirements to meet the RFC breakup and open water season missions. UAS flights need to address these requirements cost effectively in order to reduce or possibly eliminate the need for manned aerial reconnaissance. Technology demonstrations are only useful to the extent that the mission technology and platform could be scaled to the size of the RFC’s areas of interest. The UAS flights also need to be flexible and responsive to changing conditions, i.e. if they are locked to a small area Certificate of Authority for airspace, and flood events are occurring elsewhere, that is of limited value. However, when serious events do occur at a site, manned air traffic may be a priority over UAS to evacuate people and bring in emergency responders.

## Pre-Breakup Snow Conditions

* 1. Key questions to answer:
     1. What are the pre-breakup snow conditions in terms of snow depth, snow water equivalent, and snow albedo?
  2. Frequency: weekly to twice weekly

## Reach Based Reconnaissance

* 1. Key questions to answer:
     1. What are the general ice conditions along the river reach, before and during the break up season?
        1. Ice coverage, thickness, type, velocity
        2. Spatial Ice strength (qualitative)
     2. Where is the breakup front?
        1. Or are there multiple fronts and open areas?
        2. Are conditions generally dynamic or thermally-driven?
        3. What is the downstream average velocity of the breakup front?
     3. Are any ice jams present along the reach?
        1. If so, how large are these ice jams (thickness and downriver length)?
        2. What is the relative strength of ice at these ice jams?
     4. Presence and severity of current flooding (breakup or open water season)?
        1. If so map the flooding extents.
        2. What are current water levels?
     5. Sediment movement and impacts on hydrology hazards?
     6. Groundwater contributions and impacts on low flow
     7. Use of soil moisture and active layer thickness conditions to predict overland flow
  2. Frequency: Weekly to Daily; data need to be available within a day, processed to ‘decision support’ quality level. Some areas need to be monitored repeatedly for changing conditions.
  3. Decision Support: Enough information for observer to provide expert opinion on:
     1. Expected ice jam duration and severity.
     2. Identification of ice jam release time and place
     3. Impacts of glacial outburst and other summer flooding

## Community Based Short Reach Reconnaissance

* 1. Ad hoc, as needed basis, with certain communities particularly susceptible
  2. Key questions to answers:
     1. Similar to reach based reconnaissance
     2. Are there any local ice jams?
     3. Are water levels elevated either upstream or downstream of the community?
     4. Is there any out-of-bank flow upstream or downstream from the community?
     5. During a flood what areas of the community are inundated?
     6. What is the size and severity of a local ice jam?
     7. What is the approximate size of sheets/pans/chunks?
     8. What are the impacts of regional Aufeis building on infrastructure?
     9. What are glacial dammed lake conditions and evidence of growing flood hazards?
     10. Can we map communities pre-flood to estimate likely inundation during events?
  3. Frequency: Weekly to Daily
  4. If a jam forms upstream or downstream from a community, reconnaissance flights are required to assess the direct flooding threat either due to backwater or the subsequent flood water wave after the ice jam releases. UAS flights at the community level would typically cover twenty miles or less and would provide similar information to the reach based observations above.
  5. During low flow conditions, topographic mapping would be valuable for predicting inundation and flood impacts.

## Index observations

* 1. Key questions to answers:
     1. What is the ice strength over time at the index location?
     2. Has the ice moved or shifted at the index location?
     3. What are ice/water levels over time at the index location?
        1. Any lifting or hinge cracks?
  2. Detailed ice conditions at key locations.
     1. Measure ice texture and movement.
     2. Presence and extent of hinge cracks.
     3. Ice movement
     4. Ice type: sheets/pancakes/jumble
     5. Vertical ice displacement
  3. Which sites are important to observe because they are subject to rapid hydrologic change and have a major societal impact ?
  4. Frequency: Weekly to sub-daily
  5. While not actively utilized during the Riverwatch program a correlation between observations at index sites (i.e. specific transects) could be useful to better understanding river ice dynamics. This information could potentially be extrapolated to some degree upstream and downstream but would still require reached based observations to identify local ice jam hazards. One potential use of index observations would be to reduce the number of reach based missions by supplementing with index observations. Repetitive images could be used to estimate surface channel velocities.

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UAS sensors used to meet these requirements could include:

1. Nadir, orthorectified, mosaicked true color still images
   1. Uses: Qualitative ice measurements, quantitative estimates of extent, inundation, change detection
   2. Required resolution: 5-50 cm
2. Georeferenced video
   1. Uses: Estimating river and ice velocities
   2. Required resolution: 0.5-1 m
3. Orthorectified infrared images
   1. Uses: Identification of groundwater contributions and aufeis flooding
   2. Required resolution: 0.2 - 1 m
4. Oblique imagery:
   1. Uses: showing observers, who can better see landmarks in obliques and estimates of inundation, and flood impacts
   2. Required resolution: 1-5 m
5. Synthetic Aperture Radar (SAR) imagery (Polarimetric, L and/or C band)
   1. Uses: Ice cover and grounding, see through clouds to ice conditions
   2. Required resolution: 0.3-1 m
6. Electro-magnetic measurements
   1. Uses: Ice thickness
   2. Required resolution: 0.5-1 m
7. Gamma-ray measurements
   1. Uses: Snow water equivalent loading, pre-snow calibration
   2. Required resolution: 10-500 m
8. Snow Radar and/or Lidar
   1. Uses: Snow water equivalent/depth
   2. Required resolution: 500-1000 m
9. Laser altimeter transects and laser river surface profiles:
   1. Uses: water levels at vertically-referenced sites, ice roughness and vertical displacement
   2. Required resolution: 0.5-1 m
10. Digital elevation models (generated from Lidar, radar, or EO imagery):
    1. Uses: low-flow topography, snow loading, ice conditions, inundation, flood impacts, aufeis buildup
    2. Required resolution: 0.1-1 m

11. Soil moisture from active/passive radar

1. Uses: distributed modeling assimilation to predict overland flow and antecedent fire conditions
2. Required resolution: 10-100 m