



**NOAA
FISHERIES**

Advanced UAS Sensor Development for Marine Mammal Monitoring

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Mission Concept Review

Agenda

- Welcome/Intro – JC
- Background – JC & KS
- CONOPS – KS
 - Mission Requirements + Operations
 - Data collected + Performance Metrics
- Performance Metrics – KS
 - Timeline, Milestones, & Deliverables
 - Cost schedule
- Risk Assessment & TDL – KS & JC
- UASPO Director's Comments – Phil Hall

Executive Summary

This project involves three objectives. The assessment of ...

- A medium endurance rotary wing UAS with ≥ 30 minute flight time
- A high resolution RGB camera and new thermal/RGB sensor
- Multi-spectral imaging (coordinating with NESDIS)

for surveying pinnipeds hauled out on land.



Mission Concept Review

Addressing RFP Objectives:

- “Evaluate observing strategies using medium endurance (i.e., > 30 minutes) rotary wing UAS”
- “Evaluate, test, calibrate, and validate UAS payloads”

Implications for NOAA Fisheries and other line offices:

- Evaluate new platform and sensors
- Multi-spectral imaging has not been assessed for pinnipeds
 - Creating protocol guidelines for assessing multi-spectral imaging: could be used across NOAA line offices

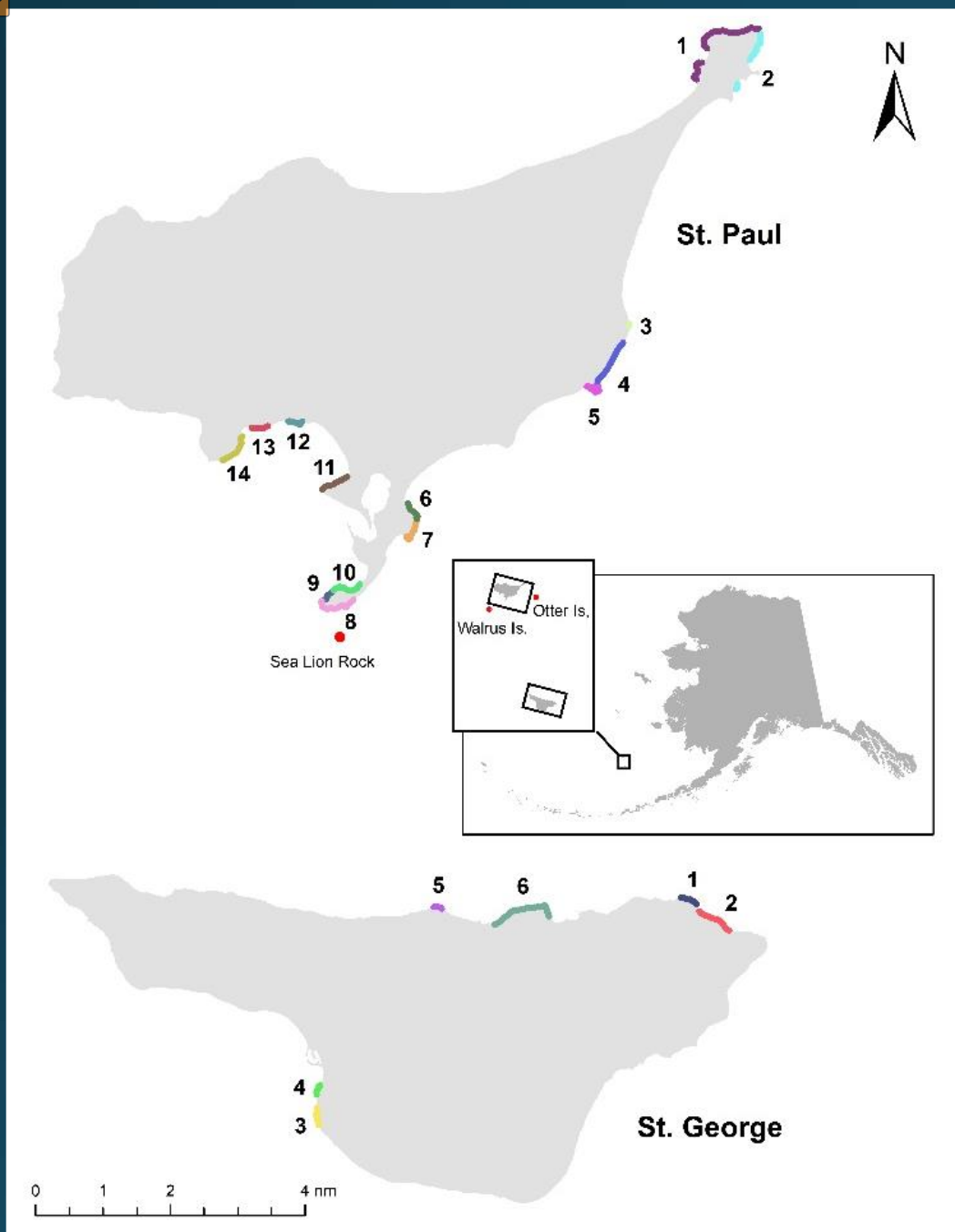
Northern Fur Seals

Background

- MMPA protected species in decline
- August abundance surveys are costly, time consuming, and cause large disturbances

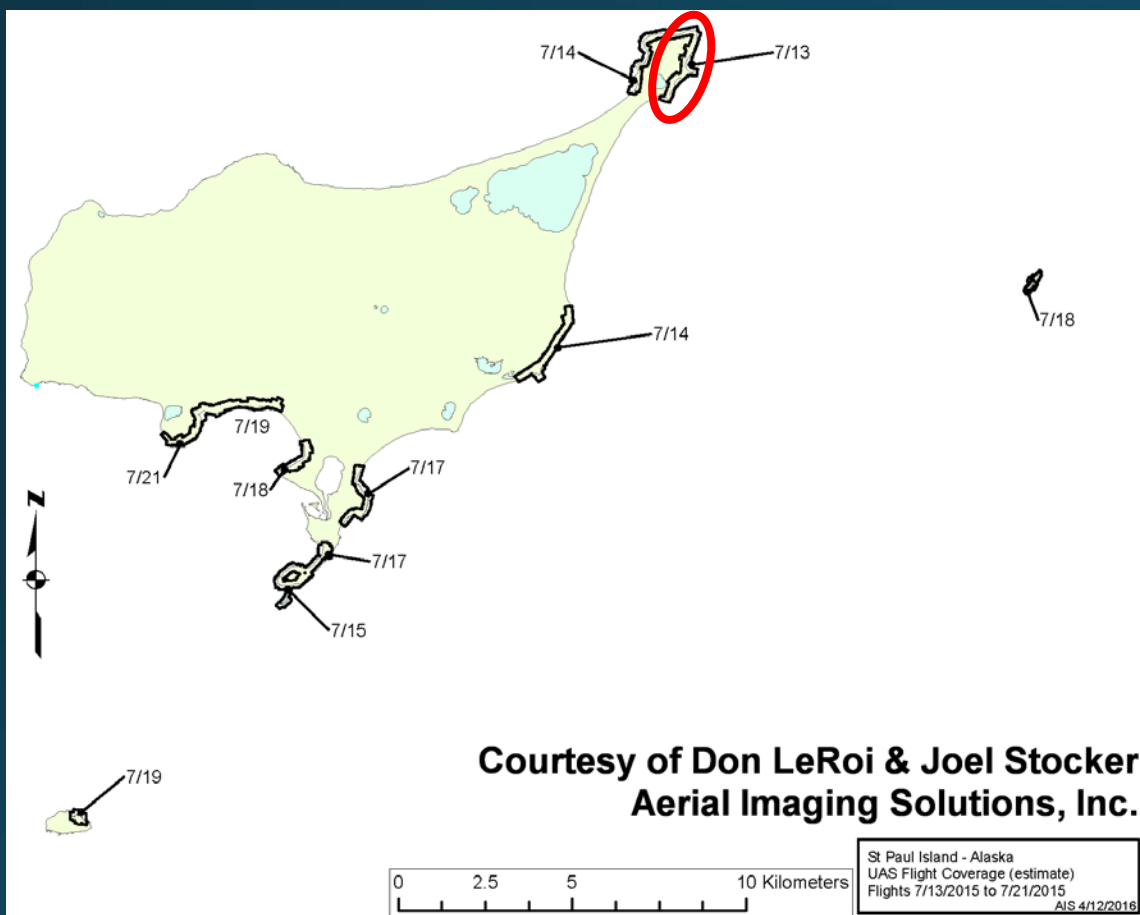


- Develop UAS-based strategy
 - We can now fly near these airfields and access all rookery sites!

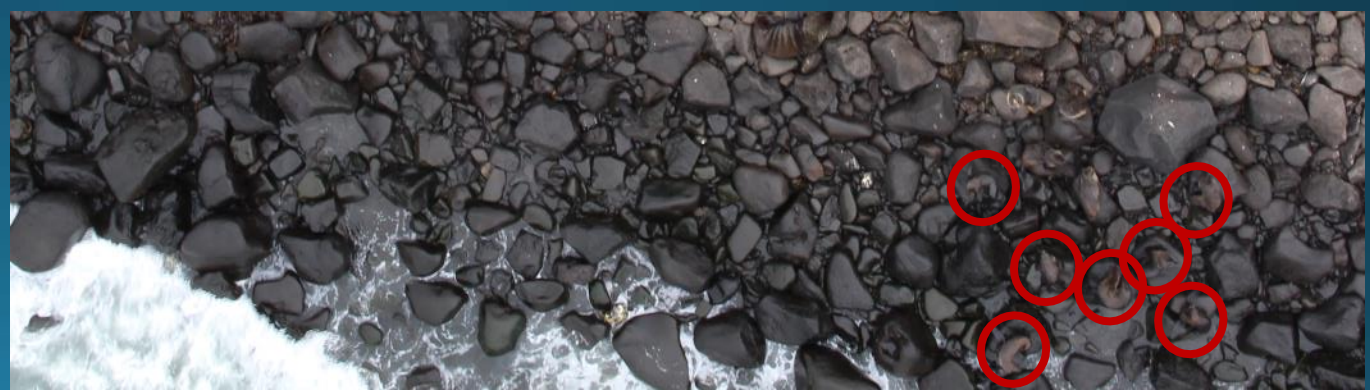


Northern Fur Seals

Pribilof Islands, Alaska



- 2015: Successfully flew St. Paul
 - 400 ft alt., 17 sites, 14 mi coastline, 7 survey days, 60 flights, 10 hours
- 2016 surveyed Morjovi at ~100 ft alt.
- Major challenges identified:
 - ID pups from background
 - Endurance/efficient surveying
 - High winds (non-vertical images)





Northern Fur Seals

Pribilof Islands, Alaska



Concept of Operations

Objective 1: Medium endurance rotary wing UAS, ≥ 30 min flight time



Low Risk:
Similar to
APH-22

APH-28

- 49 min flight time w/o payload
- “heavy-lift” version of APH-22
 - Same “guts” – flight controller/navigation
 - Gimbal sensor mount
- Larger motors/propellers
- Arms fold down
- Greater payload capacity
- Longer endurance = greater efficiency

Concept of Operations

Objective 2: High resolution RGB camera & thermal/RGB sensor



Low Risk:
Better resolution
than Olympus

Interchangeable payloads mounted to gimbal

1. Sony Alpha a7r II
 - Full-frame sensor (larger footprint)
 - Higher resolution (42.4 MP)
 - 2.5 x heavier than APH-22 sensor
2. FLIR DUO Pro R (pre-order now)
 - New thermal sensor
 - FLIR + RGB camera combined
 - Relatively higher resolution

Moderate Risk:
Have not tried
thermal on
SSL/NFS





Concept of Operations

Objective 3: Multi-spectral imaging assessment (with NESDIS)



Concept of Operations

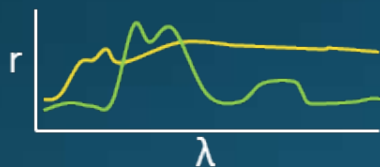
Objective 3: Multi-spectral imaging assessment (with NESDIS)



Target Signatures



Background Signatures



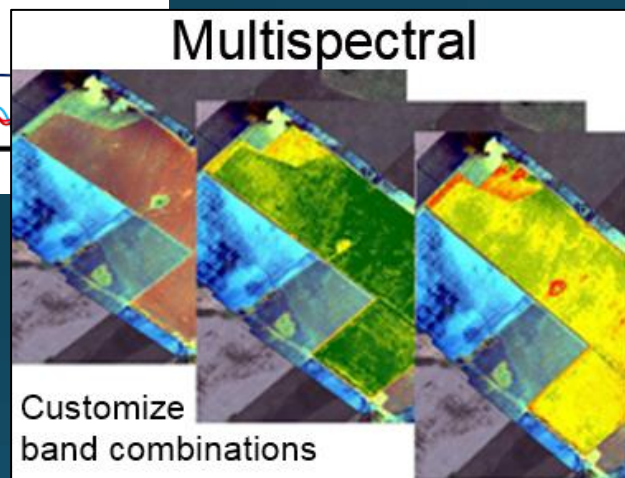
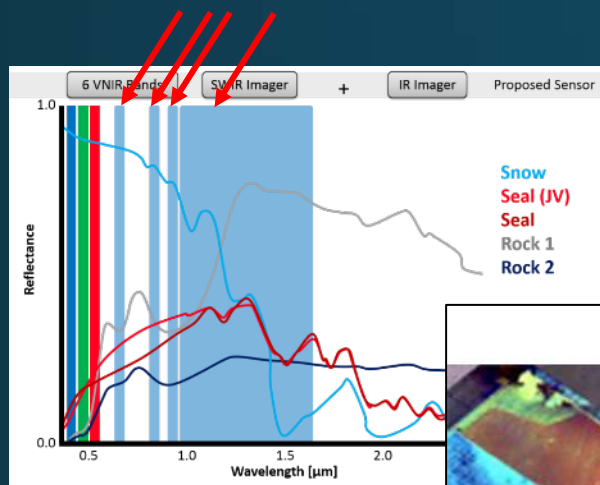
Signature Collection

- Borrow NESDIS hand spectrometer
- New England Aquarium (spring?)
 - Juvenile, adult female, sub-adult male
 - California sea lions + harbor seals?
- Alaska abundance trip (August)
 - Inflexible timing – biological window
 - Pups and potentially adult females
 - Adult males, opportunistically
 - Background: grass, rocks, sand, etc.

High Risk:
 Dependent on NESDIS'
 handheld spectrometer &
 Alaska travel

Concept of Operations

Objective 3: Multi-spectral imaging assessment (with NESDIS)



Very Low:
Conducted in lab & no
need to purchase \$27K+
sensors to assess

Modeling + simulation

Feasibility Assessment Report

- Identify right sensor/filter

Pros + Cons

- Pros: Don't need to buy sensors first to test feasibility
- Cons: If feasible, no time to purchase sensors for testing next summer

Concept of Operations

Next Steps: Multi-spectral sensor payload development



Desert



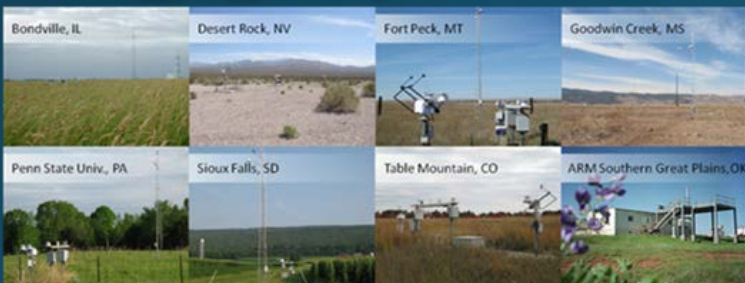
Open Ocean



Vegetation



Ground Based Autonomous Sites:
Surface Radiation Budget Network (SURFRAD)



Not completed within this proposal
however, preliminary work completed to submit new proposal

- Purchase sensor components, create sensor and interchangeable mount (for two different UAS – UMD and MML)
- NOAA Fisheries: Used for marine mammal surveys
- NESDIS: validate and ground truth satellite data

Performance Metrics

Objective 1 & 2: UAS & sensors assessment

Using APH-28 during **Steller sea lion Aleutian Islands** survey

- Successful ship and land-based flights with both sensors
- Counts across all sensor imagery w/in 5%
 - Distinguish SSLs in thermal imagery?
 - What about marked animals?

Opportunistic **surveys of NFS rookeries** during August abundance trip

- Survey >1 rookery with both sensors
- Counts across all sensor imagery w/in 5%
 - Distinguish NFS in thermal imagery?
- Compare UAS counts to ground counts

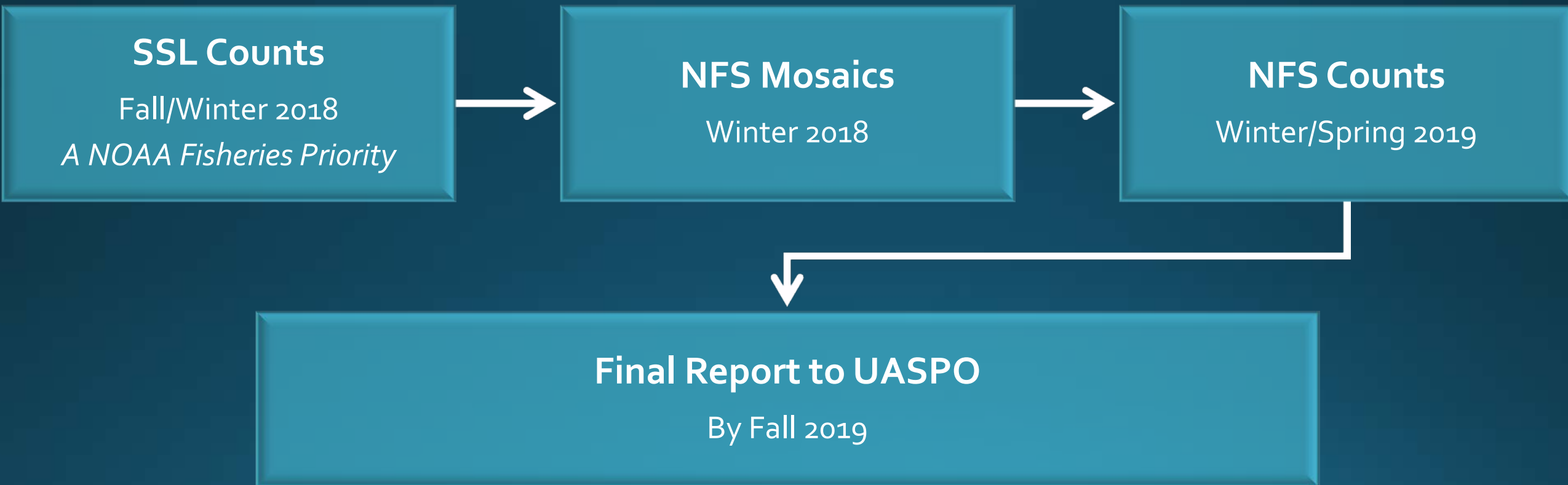
Timeline & Milestones

Objective 1 & 2: UAS & sensors assessment



Timeline & Milestones

Objective 1 & 2: UAS & sensors assessment





Performance Metrics

Objective 3: Multi-spectral imaging assessment

Aquarium visit:

- Collect spectral signatures of NFS (juvenile/sub-adult male; and other marine mammals?)
- Train MML staff in assisting with handheld spectrometer
- Outreach

Alaska abundance trip: Collect spectral signatures

- Target: pup and adult female. Opportunistically: juv and adult male
- Background: grass, sand, pebbles, boulders, etc.

Summary of results:

- Aquarium summary report & insights
- Feasibility Assessment Report

Timeline & Milestones

Objective 3: Multi-spectral imaging assessment



*Aquarium visit & FAR scheduling is fairly flexible

Timeline & Milestones

Cost Schedule

Funding total: \$172,150 (FY17 \$37,000, FY18 \$135,150)

Cost	Description
\$63,655	2 x APH-28 + Sony systems, FLIR sensor NFS rookery mosaic with 2015 images for flight planning (\$1,500)
\$76,693	Multi-spectral imaging assessment contract
\$9,824	NOAA link fee (7%) for contracting
\$6,000	2 x travel to Alaska for UAS flights and signature collection
\$4,300	MML travel for acceptance flight + manufacturer training
\$4,300	MML travel for Aquarium visit
\$3,000	Pix4D training + MML travel
\$4,300	Equipment (batteries, cases, tripod, SD cards, etc.)



Deliverables

1. **Monthly & Annual Progress Reports**
2. **Final Report** at the end of the performance period
 - flight test and sensor protocols and results will be provided
 - Critical steps for moving TRLs will be identified
3. Optional: **Feasibility Assessment Report** can be provided or summarized in our **Final Report** (depending on what UASPO prefers)
 - This report will outline the steps taken, address the effectiveness of multi-spectral imaging for identifying NFS from the background, and guidance for next steps, including sensor and other equipment necessary

Risk Assessment

Objective 2: RGB and thermal sensor integration

Low to Moderate: Acquiring Sony + FLIR DUO Pro R sensors

Status: The procurement process for both sensors has begun. The contractor is confident that these sensors can be interchangeable in a gimbal mount. The FLIR is new technology that will be released soon.

Mediation: We are confident the Sony camera will be operational and ready for testing. If for some reason there is a delay in the procurement or integration of the FLIR sensor we may have to hold off on testing to another opportunity.

Risk Assessment

Objective 1 & 2: UAS – sensor testing

Moderate: Flight missions and spectral measurement collection during abundance trip (August)

Status: Our August abundance trip timing is inflexible and delays getting gear/crew to the island are common, as well as weather delays (fog & low ceilings). The abundance assessment work is also high priority during this time.

Mediation: One APH-28 system will be shipped to Island well in advance and I will hand-carry thermal sensor. If we have delays in getting other gear/crew on island or inclement weather during our time available to survey we will be unable to do our work. We also are restricted to the biological window (pups are born July and molt in September).

Risk Assessment

Objective 3: Multi-spectral imaging assessment

High: Spectral measurement collection

Status: The contract procurement process has begun. The aquarium visit is flexible and short. The August Alaska trip is fixed and susceptible to weather delays.

Mediation: If we have delays in getting gear/crew on island or inclement weather during our time available to survey we will be unable to do our work. We also are restricted to the biological window (pups are born July and molt in September). Therefore we would have to put off until another opportunity.

Risk Assessment

Objective 3: Multi-spectral imaging assessment

High: Obtaining handheld spectrometer for spectral measurements

Status: Borrow the instrument from NESDIS? Rent an instrument?

Mediation: Currently, we are in discussions with NESDIS for borrowing the instrument (uncertain). This was apart of our original proposal as we were going to provide funds to contract through NESDIS however, not possible (which is why our FY17 funds fell through last year).

The instrument costs >\$80,000 so purchasing is not a viable option. We are waiting on an estimate for renting the instrument.

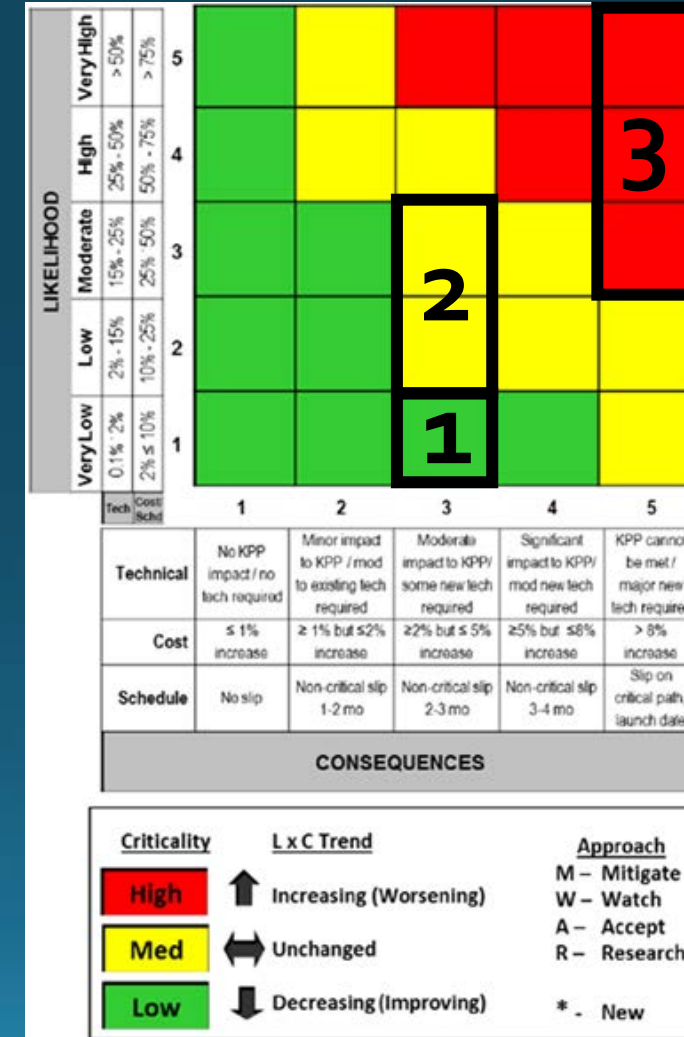
If there are any delays getting this instrument to the island, we may not be able to conduct this work.

Risk Assessment

Technology Readiness Level

Transition Index	Technology Readiness Level	Description
Research	TRL 1	Basic or fundamental research
Research	TRL 2	Technology concept and/or application
Development	TRL 3	Proof-of-concept
Development	TRL 4	Concept validated in laboratory
Development	TRL 5	Concept validated in relevant environment
Demonstration	TRL 6	Prototype demonstration in relevant environment
Demonstration	TRL 7	Prototype demonstration in operational environment
Demonstration	TRL 8	System demonstration in an operational environment
Application	TRL 9	System totally operational

- Objective 1 – UAS
- Objective 2 – RGB + thermal/RGB sensors
- Objective 3 – Multi-spectral imaging





Thank You!