NASA-NOAA FEASIBILITY STUDY

Unmanned Aerial Survey of Marine Wildlife in the Aleutian Islands

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Background and Objective

The western stock of Steller sea lions and the Aleutian stock of harbor seals both experienced dramatic declines in abundance during the past few decades, particularly in the central and western Aleutian Islands. Both stocks have continued to decline in recent years, thus are a high priority for routine monitoring.

NOAA's Marine Mammal laboratory (MML) has conducted aerial surveys of marine mammals throughout coastal Alaska to monitor trends in population abundance and distribution for more than 20 years. These surveys have typically been conducted from a twin-engine aircraft, such as a DHC-6 Twin Otter, operated by NOAA pilots and crewmembers. Aerial surveys in the Aleutian Islands present significant challenges and higher risks due to their remoteness, rugged terrain, and extreme weather. To evaluate the feasibility of transitioning from manned to unmanned aerial surveys in this region, thereby reducing risks to NOAA personnel and high-value aircraft, we propose to conduct test survey flights in the Near Islands of Alaska using a medium-sized, fixed-wing UAV (NASA's SIERRA-B aircraft) with a nadir-aimed imaging payload.

Survey flights are planned to be conducted during daylight hours on days with VFR conditions and less than ~20 knot winds at altitudes of 800-1200 feet. Survey imagery, including thermal video and high-resolution color photos, would be collected at known Steller sea lion and harbor seal sites along the coastlines of Shemya, Nizki, Alaid, Agattu, and Attu Islands. The planning team will request approval and support from the US Air Force to conduct this project at Eareckson Air Station (Shemya Island, AK) during the month of September 2022 when weather conditions in the western Aleutian Islands are expected to be optimal.

Feasibility Areas

Prior to approval for the commencement of dedicated work on flight test preparation and execution, NASA and NOAA desired an internal assessment of the project's feasibility in the following areas: Technical, Legal, Logistics, Schedule, Cost, and Operational feasibility. Each section has highlighted the requirements, and evaluated how project plans to address or coordinate the successful execution of the mission.

Technical Feasibility

Goal 1: Evaluate the feasibility of transitioning from crewed to uncrewed aerial surveys of pinnipeds in remote areas of Alaska using a medium-range UAS.

- **Objective 1a:** Conduct initial beyond visual line-of-sight (BVLOS) UAS test flights in the Near Islands of Alaska (i.e., far western Aleutian Islands) during September 2022 when local weather conditions are expected to be optimal for flying. Collect imagery and flight data suitable for evaluating the UAS's ability to survey high priority pinniped sites safely and effectively around each island.
- **Objective 1b:** Conduct BVLOS UAS surveys of all known Steller sea lion and harbor seal sites in the Near Islands of Alaska during their pupping season (late June-early July). Collect survey imagery suitable for counting individuals and discerning age classes for use in population assessment models and stock assessment reports.

Goal 2: Advance the application of BVLOS UAS operations in the United States, and particularly within NOAA.

- **Objective 2a:** Develop a safety case for conducting BVLOS aerial surveys in the Near Islands of Alaska and obtain a Certificate of Waiver or Authorization (COA) from the FAA. This project would be a first-of-its-kind in the United States and, if successful, could open new opportunities for BVLOS UAS operations to others.
- **Objective 2b:** Provide NOAA's Uncrewed Systems Operation Center (UxSOC) personnel with an opportunity to gain experience with overseeing and implementing a large, interagency BVLOS mission using a medium range UAS. The UxSOC UAS Division currently specializes in small UAS platforms and 2 missions, but agency needs are becoming increasingly complex, and this project offers an ideal opportunity for exposure to larger platforms and more complex missions while meeting an agency need.

Legal Feasibility

In order to conduct this mission, NOAA has received permission to operate crewed aerial surveys using a NOAA Twin Otter aircraft from EAS in past years, and MML has already received permission to conduct UAS operations from EAS if the USPAI project is approved. Permissions are required from DoD for photography and drone usage, and the use of the taxiway and or runways for launch and recovery of UAS aircraft. Additionally, background checks may be required for permission to access the facilities. To address the legal aspects of the project NASA has been coordinating with each of the respective organizations to ensure permissions and approvals are conducted in a timely manner ahead of the flight test deployment.

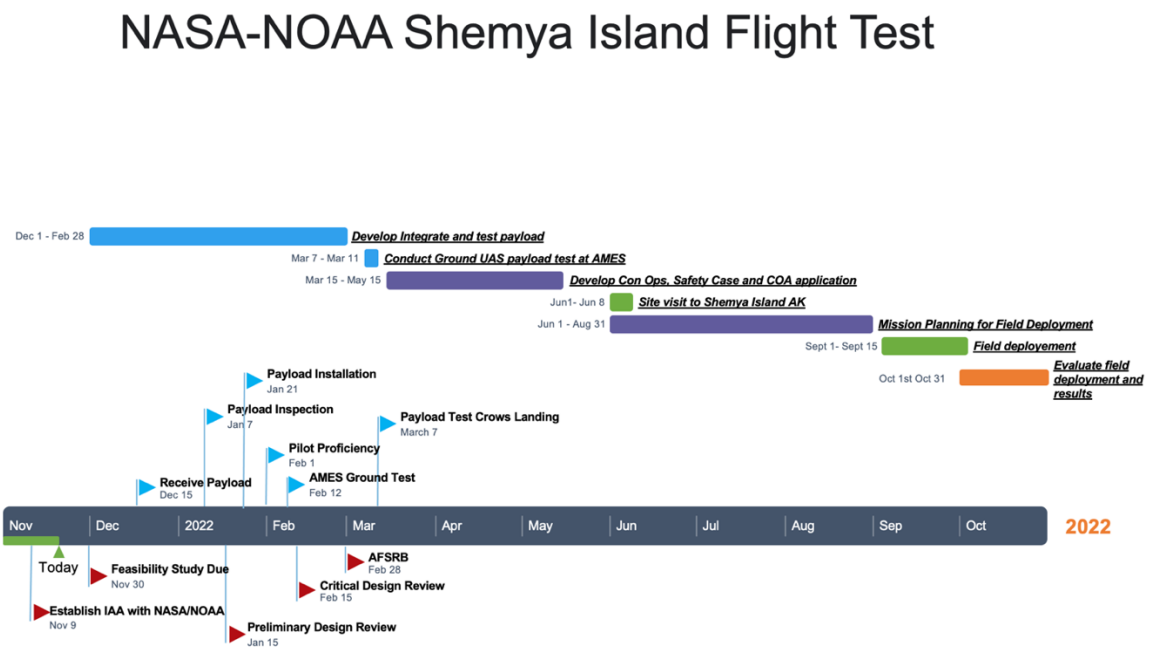
Logistics

Being in a remote area of the Aleutian Islands, operations conducted from Shemya will require a great deal of coordination in order to support the mission.

- **Cargo transport** – Coordination to ship the UAV and all other necessary equipment (packed in two large gear trailers) to/from EAS will be sought via the regularly scheduled C-130 cargo flights. Contact has been made with the JBER Traffic Management Office to request info on costs and required lead times for shipping.
- **Personnel transport** – Transportation of our field team (composed of 6-10 NASA personnel and 2-4 NOAA personnel; exact numbers TBD) to/from EAS via the regularly scheduled personnel "rotator" flights.
- **Lodging and meals** – Lodging and meals for 8-14 people (exact numbers TBD) during our stay at EAS.
- **Hangar space** –The SIERRA-B aircraft will require storage (length x width = 13 x 20 ft) and our two gear trailers (25 x 9 ft and 20 x 10 ft). If hangar space is limited, the gear trailers could potentially be stored in a separate building or perhaps parked outdoors near the hangars.

- **Office space** Work areas and office spaces are required and available in or near the hangars. The Airport Manager has mentioned empty offices/ready rooms attached to Hangar 7 which could potentially be available for use.
- **Fuel** – The SIERRA-B uses 100LL (Avgas). If this is not available at EAS, we will need to ship to test location
- **Vehicles** – A vehicle will be required for shuttling the field team between the living quarters and airport on an irregular basis, and perhaps for repositioning equipment or the gear trailers as needed.
- **Coordination** – Coordination with the EAS Airport Manager and other staff will be required to deconflict with any local air traffic during UAS flight operations. Also, personnel transportation to Eareckson Air Station will require approvals from a OIIR DoD Liaison.

Schedule Feasibility



Currently the project has identified major milestones for various concurrent efforts. Payload assembly, testing and integration, pilot proficiency, flight testing, airworthiness approvals, and site visits have been determined and scheduled as shown above. NASA and NOAA MML will conduct a 22-day deployment to EAS (Shemya Island, AK) for BVLOS test flights in the Near Islands of Alaska during September 2022, when weather conditions are expected to be optimal for flying. This deployment will include 6 days of travel and up to 16 days of flight operations. The Payload design is planned to be finalized by mid-December, allowing the engineering team to begin ordering parts to assemble the payload. Once the payload is assembled subsequent reviews will be scheduled prior to integrating it to the Sierra B aircraft. Following the installation and ground tests, flights at Crows Landing and eventually Alaska will take place.

Cost feasibility

This is a five-year agreement and describes scientific and technical activities to be undertaken by NASA through the Ames Research Center (ARC) in support of the Office of Marine and Aviation Operations (OMAO), National Oceanic and Atmospheric Administration's (NOAA's) Oceanic, United States Department of Commerce. This agreement is part of a larger cooperative effort by NOAA and NASA to plan and execute airborne science missions using UAS technology for research and development operations of interest to NOAA and NASA. The information and experience gained from these UAS missions will be of mutual benefit to both Parties and will provide substantial value through development of new and upgraded capabilities into NOAA and NASA research and operational systems. This specific agreement covers activities related to resource contributions provided by NOAA to NASA in support of unmanned aircraft systems operational and research requirements.

The project has been organized into multiple phases and deployments. The first phase of the project is to deliver a feasibility report to showcase the cost estimate that considers the technical, legal, logistical, schedule, and cost-related aspects of the project that will showcase the summary and success criteria of the mission . Once the feasibility study has been presented and approved, the project will advance to Phase 2 where the procurement, integration and testing of the payload will be developed and tested. Deployment 1 will be at Crows Landing in California to prepare for the live test in Alaska. deployment 2 which will consist of planning for the site visit, logistics and shipping of the Sierra B to Shemya island to conduct the flight mission. Deployment 2 is the actual flight mission itself; the project is planning for a 2-3 week deployment. Afterwards the team will assess the data from the mission and will assess future deployments to Alaska Phase 3)

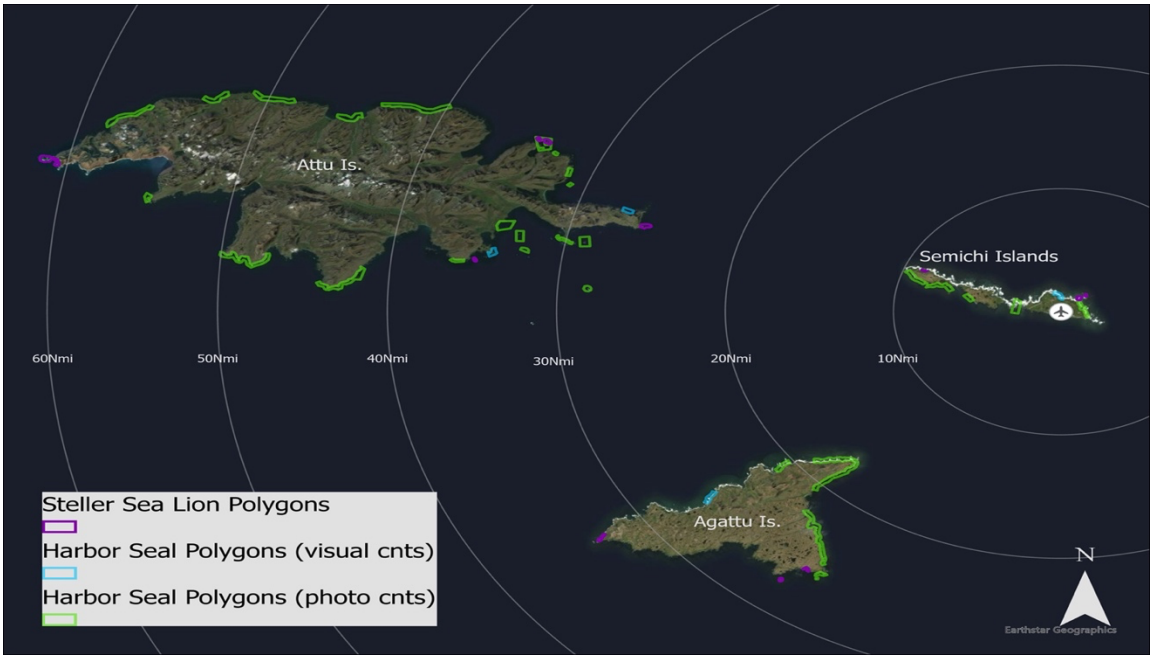
<u>NOAA requires NASA/ARC to perform the following activities:</u>

1. Conduct a project feasibility study and cost estimate
2. Phases 1 & 2 perform payload mounting, integration, & testing, & conduct local UAS/payload test flights. Provide mission planning, management, engineering, & review services
3. Crows Landing deployment, testing the set up prior to Alaska
4. Conduct a site Visit to Alaska
5. Conduct field deployments to evaluate beyond visual line-of-sight (BVLOS) UAS capabilities for pinniped surveys in the Aleutian Islands of Alaska

Line Item	Total Cost
Mission Phase 1 & 2 Prep	**$349,563**
Deployment 1: Crows Landing Test Prep	**$90,480**
Site Visit: AK	**$41,466**
Deployment 2: AK	**$651,018**
Mission Phase 3 Prep	**$65,068**
Deployment 3: AK	**$732,135**
Total Mission Costs	**$1,929,730**

Operational Feasibility

The UAS operations will be conducted BVLOS. Currently it is estimated that 30 flight hours are required to achieve Objective 1a. Specific flight profiles are being determined to best optimize the range/endurance of the operations. The Sierra aircraft will be launched and recovered from Shemya island and conduct operations over Shemya itself as well as Attu and Agattu Island. NOAA has created areas of intended flights seen below. Depending on wind and weather, the team will determine which flight profiles to conduct on a given day.



NASA Sierra B Platform

NASA has planned to operate the SIERRA-B medium-range, fixed-wing UASs that appears to be capable of conducting these missions. NASA/ARC also has the personnel and expertise to provide end-to-end support for all phases of UAS missions, including payload design and integration, airworthiness and flight safety reviews, Certificate of Waiver or Authorization (COA) application development, deployment planning, and flight operations. The mission includes the safe and successful automated flight operations over designated survey areas at a target altitude of 1,000 ft, and photograph 100% of each survey area with overlapping, high-resolution imagery.

	NASA SIERRA-B
Type:	UAS, Fixed wing, single engine pusher
Duration:	9 hours (payload & weather dependent)
Useful Payload:	110 lbs
Gross Take-off Weight:	480 lbs
Max Altitude:	13,000 ft.
Air Speed:	60 knots
Range:	527 Nmi
Power:	2416 Amps @ 24 V DC

Payload Integration and Process

Payload Integration is a key item as the Sierra B aircraft will have to be fitted with new sensors and cameras in order to successfully carry out the mission. NOAA will coordinate supplying NASA with the payload set up to allow integration and testing prior to the field test. Pilot proficiency and payload tests will be conducted at Crows Landing in California, prior to deployment. This effort will allow the NOAA team to inspect the data recovered from the test to determine if the aircraft payload set up is acceptable to gather data in the field.

Payload Components

Payload components	Voltage req	Amp req	Watts cont.	Weight(kg)	Weight(lb)
FLIR A645SC 25 [Thermal1]	24	1	24	0.90	1.98
FLIR A645SC 25 [Thermal2]	24	1	24	0.90	1.98
FLIR A645SC 25 [Thermal3]	24	1	24	0.90	1.98
GT6600C [EO1]	12	0.675	8.1	0.37	0.82
GT6600C [EO2]	12	0.675	8.1	0.37	0.82
GT6600C [EO3]	12	0.675	8.1	0.37	0.82
POS AVX210 (IMU	24	0.145833333	3.5	0.66	1.46
LPC-490 [Computer1]	24	3	72	1.81	4.00
LPC-490 [Computer2]	24	3	72	1.81	4.00
LPC-490 [Computer3]	24	3	72	1.81	4.00
USB Ext SSD Hard Drive	12	1.5	18	0.18	0.40
USB Ext SSD Hard Drive	12	1.5	18	0.18	0.40
USB Ext SSD Hard Drive	12	1.5	18	0.18	0.40
Power Distb board?	24	0.1	2.4	0.23	0.50

Desired Altitude – 1000’

- Potential range = 500-1200 ft; Preferred range = 800-1000 ft

Desired Ground Speed

- Payload should operate successfully if the flights are less than 100 knots; 55-65 knot range should work well. Flying at a relatively constant airspeed during survey passes would be optimal

Noise Considerations

- A goal to aim for is keeping UAS noise levels < 60 dB (at sea level, from survey altitudes). We will analyze survey imagery for pinniped disturbance and adjust survey altitudes, if needed

Sensitivity to Vibration

- To be tested at crows landing to determine if and vibrations affect the camera quality

Radar Coverage

- Required for beyond radio line-of-sight operations, includes most if not all of Attu and Agattu Islands

Lost link

- The Sierra B is outfitted with a Return to Launch capability if the link is lost. The vehicle will return to the point of origin and circle until the link is manually picked up from the GCS. The vehicle then will perform a controlled decent to the point of take-off for a recovery.

Approvals:

The following approvals will have to be made prior to operating in Shemya:

- Station Use (DoD)
- Airspace (DoD/FAA)
- Spectrum Management (DoD)
- Aircraft and Instruments (DoD)
- COA modifications (FAA)
- Airworthiness, FRR (NASA)
- Science Mission (NOAA)

Coordination

Coordination between the approval agency and the following will have to be done to ensure a safe operating environment

- COA Coverage for Operations
- DoD Airspace Approval & Coordination, NOTAMS
- Other Special Approvals (Wildlife Protection, Marine Sanctuary, State, Local, etc.)
- Produce an operations safety plan
- Conduct flight readiness reviews
- Permission to be on Station and use facilities
- Air Traffic Control
- Aircraft Approval
- Spectrum Approval
- Aerial Photography/Sensor/Data Approval

Weather Analysis

The Aleutian Islands have been home to notoriously bad weather in past years. The MML's crewed aerial surveys in the Aleutian Islands have often been grounded by high winds, low cloud ceilings, and/or fog, sometimes for several days at a time. Furthermore, the wind tolerances and weather restrictions for operating a medium-range UAS are even lower than those of a crewed aircraft, such as NOAA's Twin Otter. Mitigation of weather issues, based on analysis of past METAR weather observations from EAS indicate September is the best time for flying UAS's.

Summary of daytime (9a-9p local) METAR observations at Eareckson Air Station (Shemya, Alaska) during 2000-2018.

	May			June			July			August			September		
	early	mid	late	early	mid	late	early	mid	late	early	mid	late	early	mid	late
Number of METAR obs	2981	2827	3182	2850	2901	3234	3307	3511	3919	3548	3311	3641	3035	2573	2474
Avg temp (F)	38	40	41	42	44	45	47	48	50	52	52	52	52	50	49
Avg rel humidity (%)	86	85	89	90	92	94	96	93	96	95	94	93	90	88	86
Avg ceiling height (ft)*	1367	1399	1033	834	687	547	465	457	419	564	750	797	1255	1694	1930
Avg visibility (mi)	7.3	8.1	6.9	6.4	6.7	5.4	4.6	4.6	4.0	4.2	5.4	5.2	6.3	6.9	7.3
Avg wind speed (kt)	16.0	14.2	15.0	13.4	13.4	11.7	11.6	10.5	10.8	11.0	12.0	13.5	14.7	15.3	15.7
Avg wind gust speed (kt)	30.4	28.1	30.2	30.0	28.0	26.6	26.1	28.0	26.8	26.7	26.7	27.1	28.4	29.6	30.4
Sky Cover of lowest layer															
% obs = clear (0/8ths cover)	3%	3%	2%	2%	2%	1%	1%	1%	1%	1%	1%	3%	4%	7%	7%
% obs = few (1-2/8ths)	21%	23%	15%	11%	7%	7%	5%	4%	6%	6%	11%	13%	17%	25%	30%
% obs = scattered (3-4/8ths)	14%	16%	14%	11%	9%	8%	6%	6%	7%	8%	10%	9%	14%	16%	19%
% obs = broken (5-7/8ths)	21%	19%	21%	17%	18%	15%	12%	14%	14%	15%	16%	17%	18%	18%	19%
% obs = overcast (8/8ths)	38%	34%	44%	50%	55%	56%	56%	53%	47%	47%	43%	39%	35%	29%	22%
% obs = indefinite (fog/rain)	4%	3%	5%	8%	8%	13%	20%	22%	25%	22%	18%	19%	11%	6%	3%
Most frequent Wx Codes															
% obs = no significant Wx	61%	76%	64%	56%	59%	43%	34%	35%	29%	31%	47%	39%	53%	58%	63%
% obs = rain	9%	4%	7%	5%	4%	5%	4%	4%	3%	2%	2%	4%	4%	8%	8%
% obs = mist	13%	10%	16%	24%	20%	32%	40%	39%	42%	41%	32%	33%	23%	20%	16%
% obs = rain & mist	6%	4%	7%	6%	7%	7%	6%	4%	5%	6%	3%	6%	8%	7%	8%
% obs = fog	2%	1%	3%	5%	7%	9%	12%	14%	17%	16%	13%	13%	6%	3%	2%
Go/No Go															
% obs with "GO" conditions**	22%	31%	18%	13%	13%	8%	6%	8%	5%	8%	13%	13%	17%	28%	34%

Time periods: early = days 1-10; mid = days 11-20; late = days 21-30 or 31.

* Height of lowest cloud layer, if present (i.e., does not include "clear" sky cover conditions).

** Defined as: 1) Sky cover = clear OR Ceiling ≥1000 feet, AND 2) Visibility ≥1 mile, AND 3) Wind speed ≤ 15 knots, AND 4) Wx ≠ rain, mist, rain&mist, or fog.

Risk

As with any flight operation, there are inherent risks in performing the missions and in its ultimate success. However, the assessment of identified risks for the Shemya deployment has deemed that none of the risks are prohibitive and that mitigations are either in place or planned. The following are risks that have been identified as part of the feasibility assessment of the Project:

Risk	Description	Mitigation
Weather	Weather in the Aleutians is generally rough and not conducive to flight with respect to winds and precipitation for much of the year.	NOAA scientists have conducted analyses of weather data for the previous 20 years and have determined that the month of September provides the best flight conditions. Consequently, the current schedule reflects the result and includes a 16-day flight opportunity window.
DoD/Unplanned Priorities	There may be situations where the DoD or other entities will need to prioritize their missions and airspace use over those of NASA/NOAA.	The use of DoD facilities to support the NASA/NOAA flights means that the operations will likely have lower priority. However, the length of the flight window should provide enough buffer to account for times at which the airspace is in use by the DoD or other entities.
FAA COA	FAA may not grant a COA to conduct BVLOS UAS operations in the Near Islands as proposed, or the COA will be too restrictive.	Selected extremely remote operating area for minimal risk. Airspace use is also very limited and well understood due to USAF control, and we will be coordinating closely with FAA and USAF.
Cost Overruns	The possibility exists for cost variability or unforeseen requirements that result in budget shortfalls.	NASA and NOAA to work together to understand the consequence of cost overrun(s) and that the customer is either able to provide additional funds or is comfortable accepting reduced mission capabilities as a result.
COVID Restrictions	The evolving nature of the pandemic and its impact to work	This risk is not limited to this effort and is largely out of our

	and travel have the potential to affect mission execution.	control. However, we will be monitoring the situation and ensuring that all protocols are known and followed throughout the planning and execution process for full compliance.
Parts and Sensor Availability	Current supply chain complications have the potential to negatively impact availability of parts and sensors needed for mission performance	Prioritized needs and timelines with back-up alternatives where appropriate and delineation between base requirements and stretch goals.

Recommendation

In summary, NASA will integrate a payload from NOAA onto the Sierra to conduct BLVOS UAS missions over Shemya and Attu islands. These operations are planned to be conducted in September 2022 for optimal weather conditions. Based on the feasibility assessment, we have concluded that there are no major risk items that would preclude successful completion of the project. A schedule has been created with milestones and deliverables that provide enough time for payload development, integration, review, testing and deployment. Although we have identified a number of risk items, each has been summarily addressed through planned mitigations that will enable continued progress and execution. NASA has already established coordination with involved stakeholders and organizations for payload testing, permissions for operating in the proposed area, as well as logistical planning for supporting mission personnel on the island. The NASA and NOAA teams have deemed this mission feasible and recommend proceeding to the subsequent tasks and task orders.