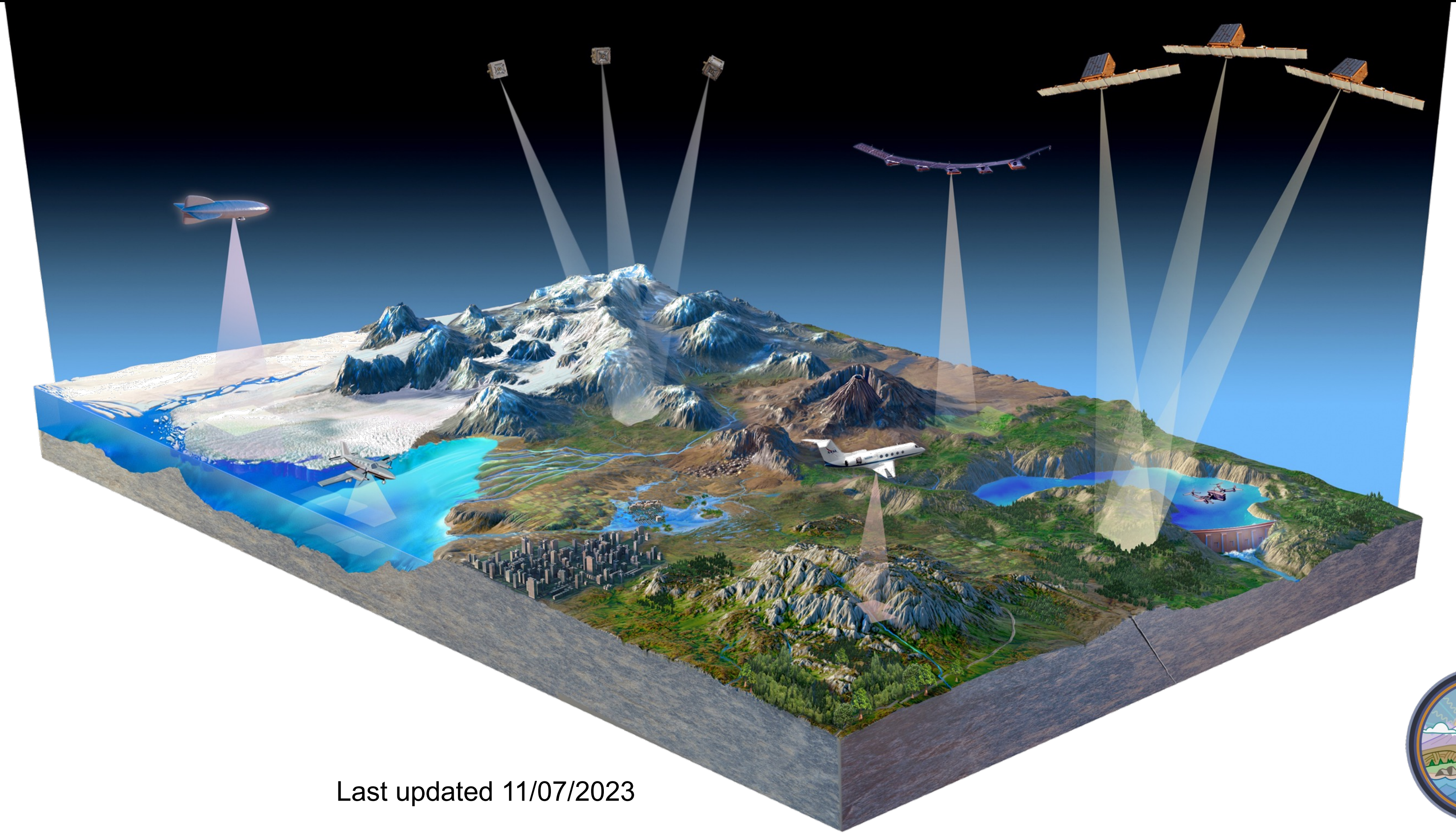
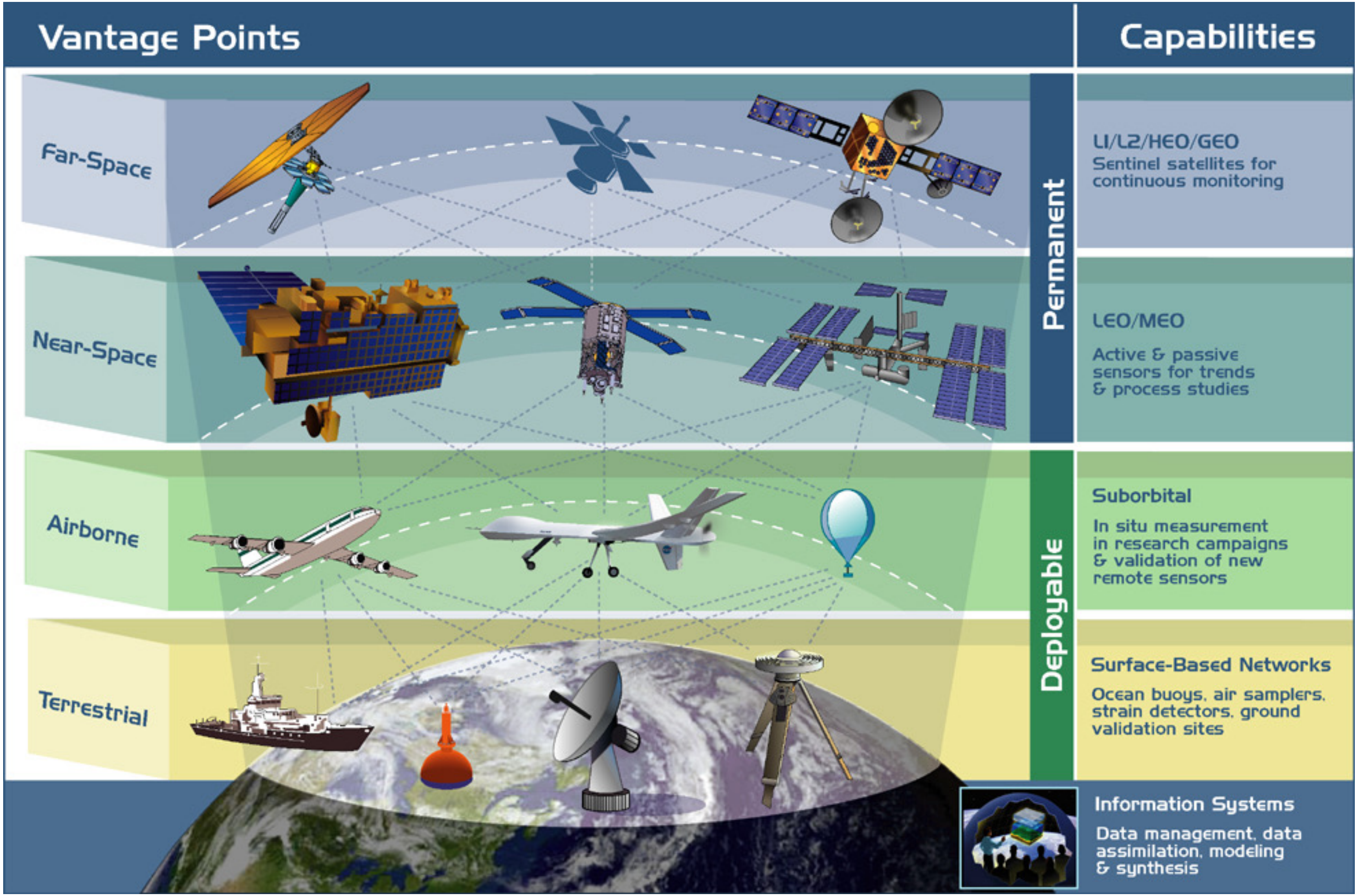
NASA's Surface Topography and Vegetation Study

Platform Group



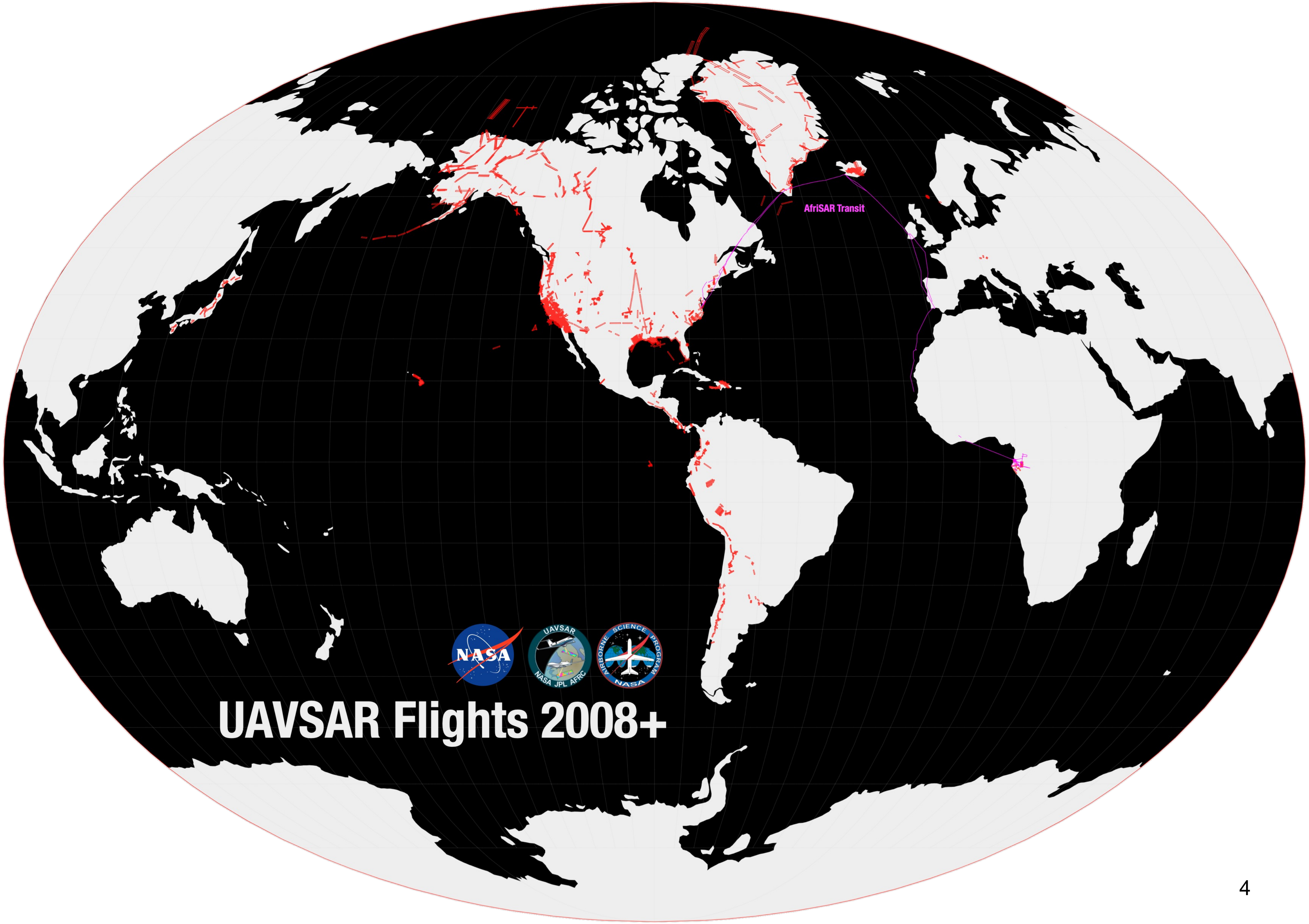
Matthew Fladeland
NASA Ames Research Center

Last updated 11/07/2023

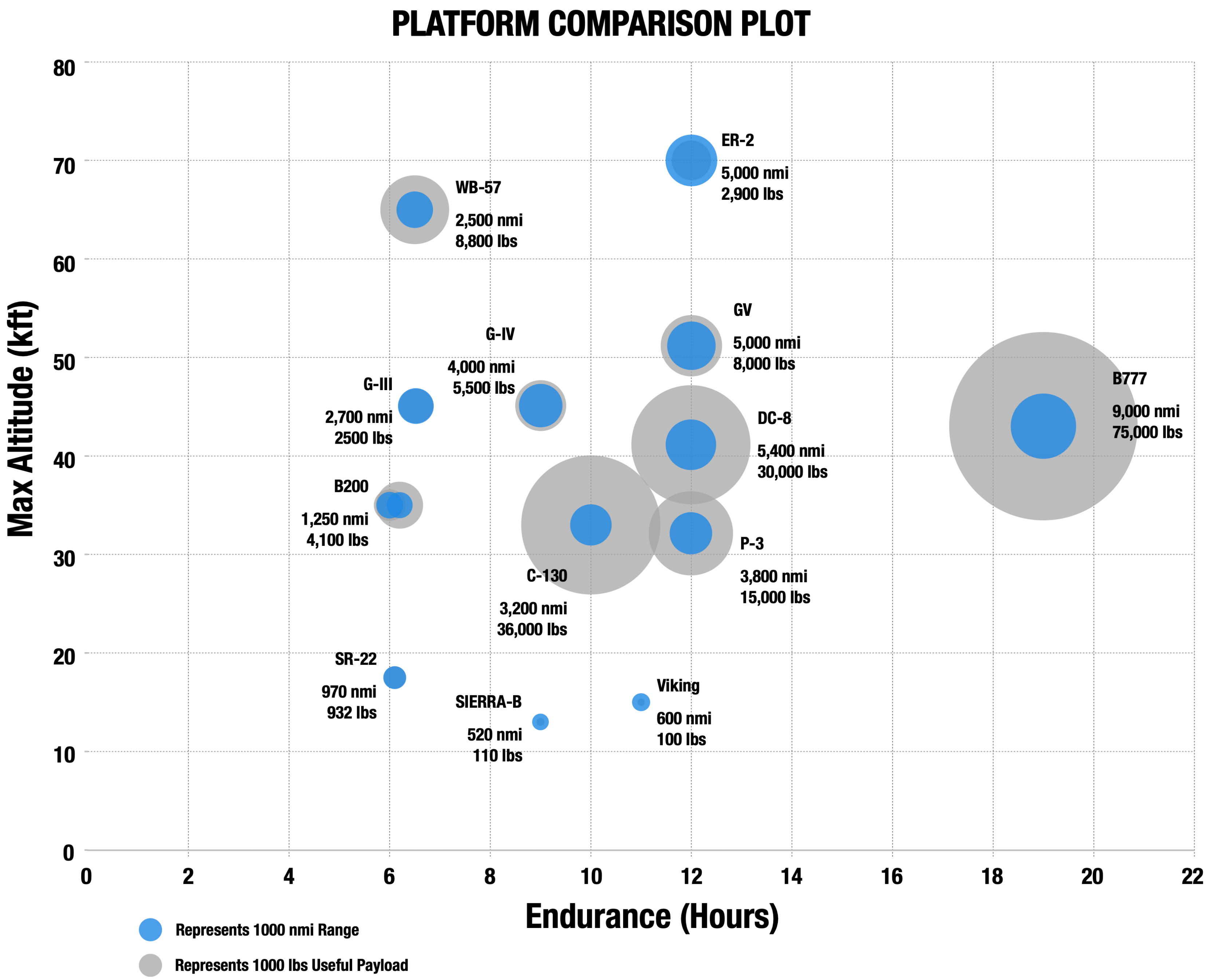


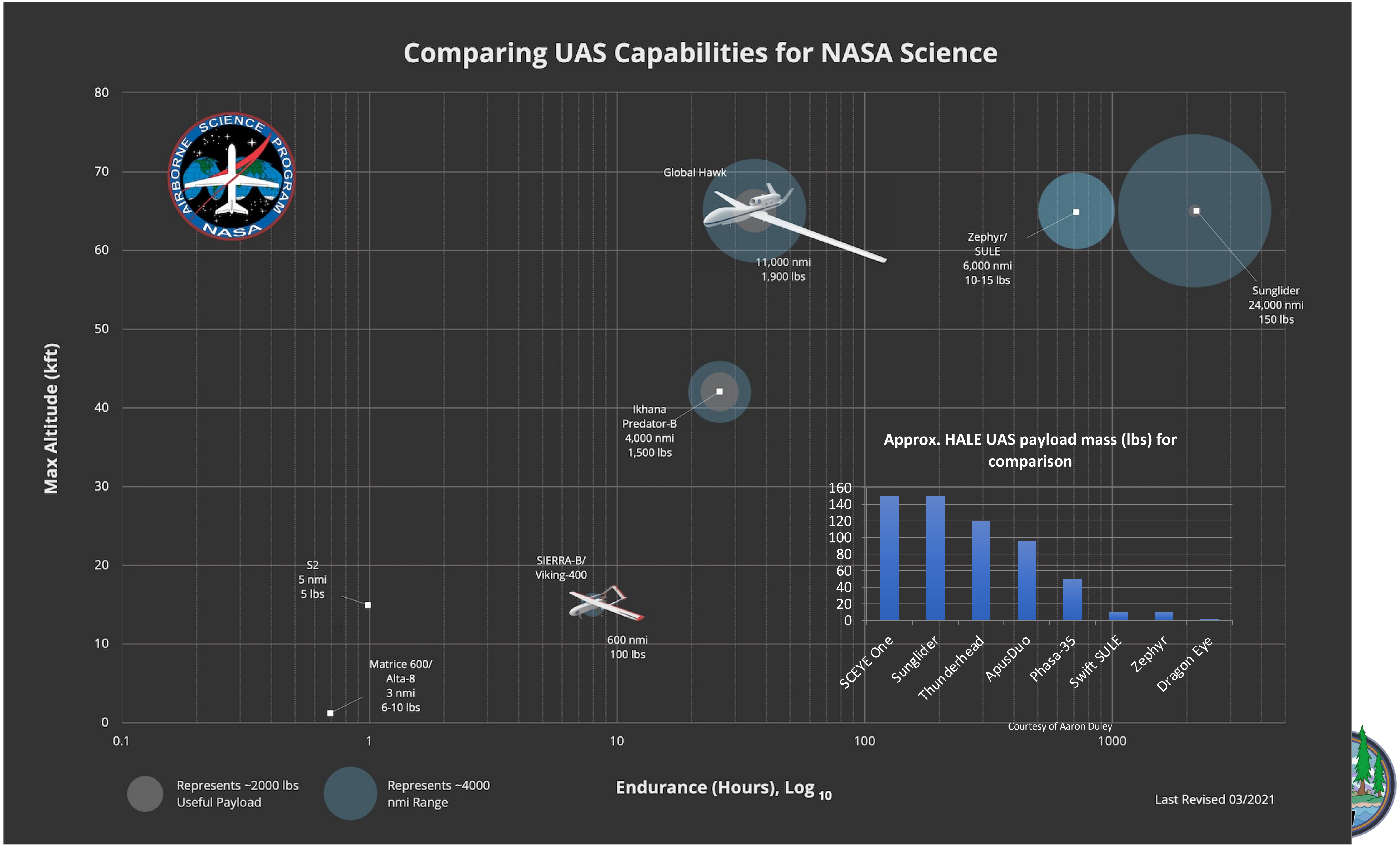
Vantage Points
Capabilities
Far-Space
Near-Space
Airborne
Terrestrial
Permanent
Deployable
L1/L2/HEO/GEO
Sentinel satellites for continuous monitoring
LEO/MEO
Active & passive sensors for trends & process studies
Suborbital
In situ measurement in research campaigns & validation of new remote sensors
Surface-Based Networks
Ocean buoys, air samplers, strain detectors, ground validation sites
Information Systems
Data management, data assimilation, modeling & synthesis


NASA
National Aeronautics and Space Administration
Airborne Science Program
AIRBORNE SCIENCE PROGRAM
NASA



AfriSAR Transit
NASA
UAVSAR
NASA JPL AFRC
AIRBORNE SCIENCE PROGRAM
NASA
UAVSAR Flights 2008+
STV


PLATFORM COMPARISON PLOT
Max Altitude (kft)
Endurance (Hours)
80
70
60
50
40
30
20
10
0
0
2
4
6
8
10
12
14
16
18
20
22
ER-2
5,000 nmi
2,900 lbs
WB-57
2,500 nmi
8,800 lbs
GV
5,000 nmi
8,000 lbs
G-IV
4,000 nmi
5,500 lbs
G-III
2,700 nmi
2500 lbs
B777
9,000 nmi
75,000 lbs
DC-8
5,400 nmi
30,000 lbs
B200
1,250 nmi
4,100 lbs
P-3
3,800 nmi
15,000 lbs
C-130
3,200 nmi
36,000 lbs
SR-22
970 nmi
932 lbs
Viking
600 nmi
100 lbs
SIERRA-B
520 nmi
110 lbs
Represents 1000 nmi Range
Represents 1000 lbs Useful Payload

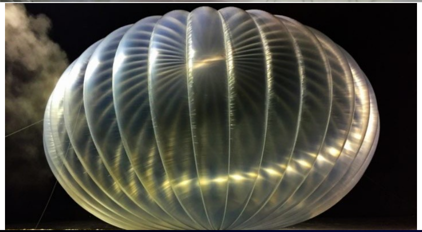

Comparing UAS Capabilities for NASA Science
Max Altitude (kft)
80
70
60
50
40
30
20
10
0
0.1
1
10
100
1000
Endurance (Hours), Log 10
AIRBORNE SCIENCE PROGRAM NASA
Global Hawk
11,000 nmi
1,900 lbs
Zephyr/
SULE
6,000 nmi
10-15 lbs
Sunglider
24,000 nmi
150 lbs
Ikhana
Predator-B
4,000 nmi
1,500 lbs
S2
5 nmi
5 lbs
SIERRA-B/
Viking-400
600 nmi
100 lbs
Matrice 600/
Alta-8
3 nmi
6-10 lbs
Approx. HALE UAS payload mass (lbs) for comparison
160
140
120
100
80
60
40
20
0
SCEYE One
Sunglider
Thunderhead
ApusDuo
Phasa-35
Swift SULE
Zephyr
Dragon Eye
Courtesy of Aaron Duley
Represents ~2000 lbs Useful Payload
Represents ~4000 nmi Range
Last Revised 03/2021

HAPSMOBILE Sunglider

Capability: payload 150 lbs; 260 ft wingspan; 6 month endurance;
Status: Stratospheric flight testing at SpacePort; recently renewed 5-yr agreement between Aeroenvironement and Softbank

SCEYE One

Capability: 100+lb payload; 10kw Power; station-keeping @ 65kft for 6+ months
Status: Subscale prototypes flown; 2021 stratospheric testflight; CRADA with USGS



Aerostar Thunderhead

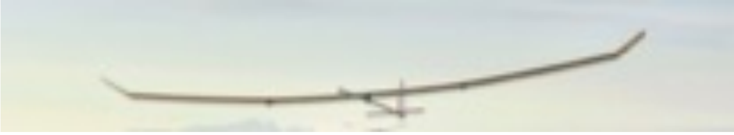
Capability: ~80lb payload (125 incl gondola); station-keeping within 50-60miles for 90+ days
Status: Operational station-keeping balloon; no COA constraints on operating locations

Airbus Zephyr Program

Capability: ~10-20lb payload; GTOW 165lbs and 71ft wingspan; 28 days (world record)
Status: Operational; new ops base in Australia; Zephyr-T under development with ~50lb payload

Prismatic/BAE Systems

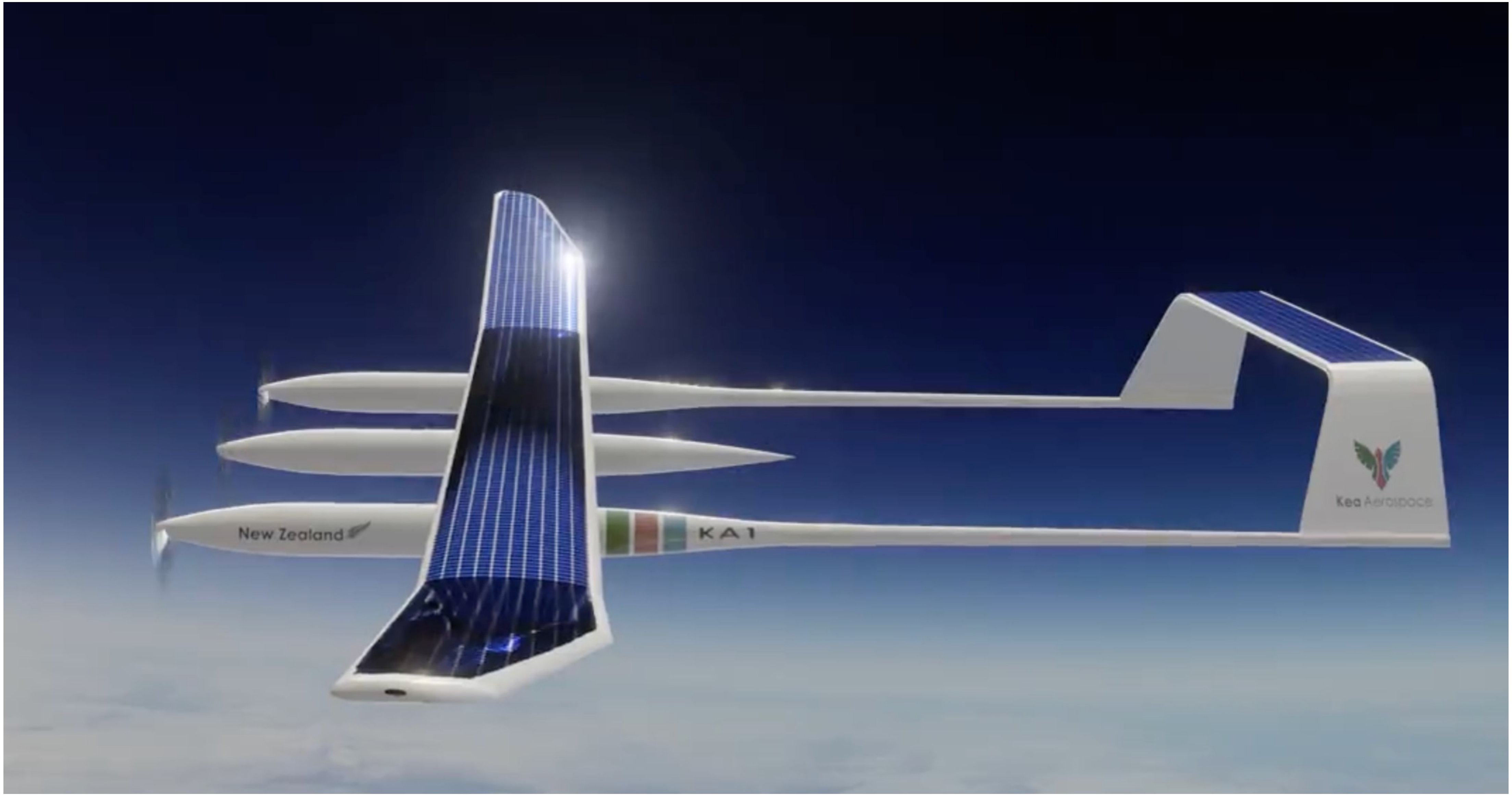
Capability: 30lb payload ; 300+lb GTOW; 100+ft wingspan;1 year endurance
Status: 2 Prototypes produced; successful stratospheric flights in 2020; $1.5B in investment by BAE Systems starting in 2018.



Swift SULE

Capability: 175+lb GTOW; 72 ft wingspan; 12lb payload; 30+day endurance
Status: 1 Prototypes produced; 3 successful low alt flights in 2020,2021; USFS Phase II and NASA Phase IIE planned for 2022 w/ IR and MWIR payloads

SCEYE Airship launching from NM last Friday



Kea Aerospace “Atmos” in New Zealand

HALE-X – A USFS-NASA partnership with Swift Engineering to demonstrate sustained IR imagery for weeks to months with next generation solar-electric uncrewed aircraft systems UAS

Overview: HALE-X (High Altitude Long Endurance eXperiment) is an innovative partnership between the US Forest Service, NASA and Swift Engineering designed to test high altitude UAS capabilities for providing persistent, real-time mapping and intelligence over a wildfire incident. Platform and payload testing is scheduled to occur during summer 2021 at SpacePort America and adjacent airspace in New Mexico.

Background: A HALE (High Altitude Long Endurance) UAS (Uncrewed Aircraft System) that can loiter for weeks, months or the duration of an incident can provide many significant benefits over currently available technologies. The US Forest Service is interested in evaluating the feasibility of using High Altitude Long Endurance (HALE) systems to collect and provide Incident Awareness and Assessment (IAA) data on wildfire incidents. Real time imagery of fire perimeters will provide greater situational awareness, while enhanced communications capabilities can provide an important data link to remote areas. A strategic network of geographically prepositioned HALE platforms would allow existing aircraft to be reprioritized to other areas. Additionally, sensor payloads are highly configurable with the intent of accommodating multiple data collection missions during operational flights.

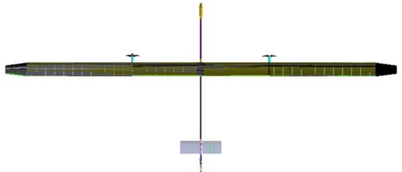
Capability: The HALE-X platform, developed by Swift Engineering through a Small Business Innovation Research (SBIR) grant administered by Ames Research Center, completed its maiden flight and successful flight trials at New Mexico's Spaceport America in July 2020. The 72-foot solar-powered air vehicle weighs less than 180 pounds and can safely carry up to 15-pound payloads for missions.

Mission: In collaboration with NASA Ames and Swift, the Forest Service awarded a Phase III contract to conduct a demonstration flight over an active wildfire and capture high resolution Infrared and visible imagery. The flight will be the first of its kind, occurring in the National Airspace over southwest New Mexico in the summer of 2021. The Forest Service entered into an Interagency Agreement with NASA to facilitate the airworthiness and flight safety reviews and assist in securing the mission's Certificate of Authorization (COA) from the FAA. NASA will maintain operational control of the mission. The scheduled mission will originate at Spaceport America where it will climb to operational altitude and perform system check out prior to 10-day loitering flight in the National Airspace System over wildfires and or prescribed burns to evaluate the resultant data products and aircraft performance. The team is also coordinating with the NASA ARMD ATM-x/ETM project regarding future concepts-of-operations.

Swift Engineering Inc Flight Ops Team

Contacts:

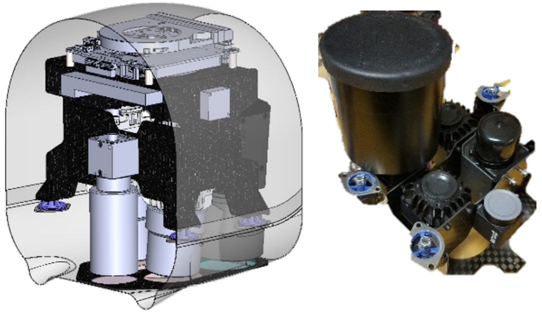
Sean Triplett – Tools and Technology Team Lead, USFS Fire & Aviation Aviation Management
Hamed Khalkani – VP of Engineering, Swift Engineering, Inc.
Matt Fladeland – Airborne Science, NASA Ames Research Center



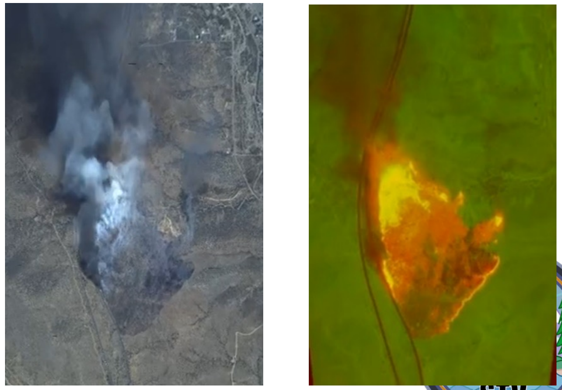
72' wingspan designed to enable shipping in standard shipping containers for rapid response

First Flight – July 2020

Gross Take-off weight – 175 lbs
Payload mass – 15-20 lbs
Operating Altitude – 55,000-65,000 ft
Endurance – 30+day design



5-camera Imaging Payload for 2021 flight



Example data of imaging fire front through smoke

S16.04-1968 - Integrated Flight Validation of HALE UAP Avionics & Propulsion Systems for Science Missions

PI: James Stewart , Electra Aero Inc - Falls Church, VA

SBIR·STTR America's Seed Fund™ POWERED BY NASA

NON-PROPRIETARY DATA

IDENTIFICATION AND SIGNIFICANCE OF INNOVATION

The Stratospheric Airborne Climate Observing System (SACOS) is a solar powered, high altitude, long endurance (HALE) UAS that will be capable of remaining aloft up to a year at altitudes up to 85,000 feet to host active and passive payloads for climate science. The goal of the vehicle is to be a platform for instruments that have been under development at Harvard University for decades to collect in-situ and remotely sensed data that is crucial to strengthen the critical links between theory and global climate models. These small scale, yet highly sensitive instruments will help further our understanding of the physics that is so critical to ultimately developing science-based national and international economic policies to combat global climate change and address risks.

TECHNICAL OBJECTIVES AND PROPOSED DELIVERABLES

Objective 1 – Objective Aircraft Development. Complete the evaluation of the science sensor payloads and define the mechanical, electrical, and software interface into the SACOS concept to minimize weight (similar to the modular experiment interface panel). Refine the Objective Aircraft sizing point and complete the conceptual design (airframe, avionics, propulsion, etc.) for that vehicle. Present a Concept Design Review (CoDR) on the results.

Objective 2 – Propulsion and Avionics Development.
Procure and ground test an integrated battery pack (4 modules) including Avionics-BMS systems and interface to allow for integrated testing on the Dawn One demonstrator aircraft. Test charge/discharge/SOC management across packs in charge/discharge representing diurnal cycles. Procure and test the avionics architecture and integrate onto the copper bird for testing. Build and test objective aircraft HILSIM (including vehicle model) and test interface with copper bird.

Objective 3 – System Integration and Flight Testing.
Integrate avionics package into subscale surrogate aircraft to test “up and away” avionics package and reduce test risk on the objective aircraft. Integrate new avionics package and propulsion into Dawn One aircraft and complete ground test. Conduct low-altitude flight test of the new technologies on the aircraft. Document lessons and findings during testing.

TRL

Estimated

1 2 3 4 5 6 7 8 9 (estimated TRL: 3–4)

IMAGE TITLE: Electra "SACOS" HALE UAS

NASA APPLICATIONS

Numerous climate science related missions identified by stakeholder engagements with the NASA Airborne Science Program (Matt Fladeland), Cryospheric Science Program (Thorsten Markus), and NASA Goddard (Dave Harding).

NON-NASA APPLICATIONS

Science Missions: High Latitude Ice Observations (Antarctic Ice Shelf Collapse Forecasting, Greenland Glacier Flow Prediction), Direct Stratospheric Sampling (Sampling of Stratospheric Aerosols, In-situ Measurement of Storm Driven Stratospheric Chemistry), Drought, Wildfire, and Flood Monitoring (Coastal Flood Monitoring, Drought and Wildfire Prediction), Oceanic Surface and Cyclone Monitoring.

FIRM CONTACTS

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PHONE: (248) 860-5606

Strategic Tac Radio and Tac Overwatch (STRATO): Last Mile Communications and Realtime Observation Stratospheric Platforms for wildland fire.

- The USFS requires solutions for last mile connectivity to push data to the incident command center and staff on the fire-line
  - Improve incident response through low latency situational awareness
  - Adapt to quickly changing fires to save life and property
  - FirstNet tethered balloons provide limited coverage, are difficult to deploy and move
- NASA ARMD and SMD are formulating multi-year Programs to use NASA tools and technology for improving observations, models, and response to wildfires.
  - Improved models and observations rely on last mile connectivity to have an impact on management
  - Models also need data out for *a priori* state variables and to re-initialize
- This joint effort is intended to baseline the best available technology for providing persistent communications to a remote fire management team
  - Enable NIFC/USDA/USFS to understand the cost and complexity of contracting for this service
  - Identify opportunities to improve the capability for NASA Science and Applications

HAPS Access to Airspace

Fixed wing UAS –

- FAA PART 107 Operations;
- Experimental Aircraft Certification;
- Certificate of Authorization required for access to National Airspace System
- Beyond Visual Line of Site waiver required; one operator per vehicle

Balloon/Airship –

- FAA PART 101 operations;
- Vehicle must collapse with payload recovery through gondola with parachute;
- No COA required

Upper E Traffic Management – NASA ARMD and FAA are working on an airspace management system for FL600 and above to improve coordination and deconfliction. ASP has supported with science use cases and connections to aircraft operators

STRATO PROJECT OVERVIEW

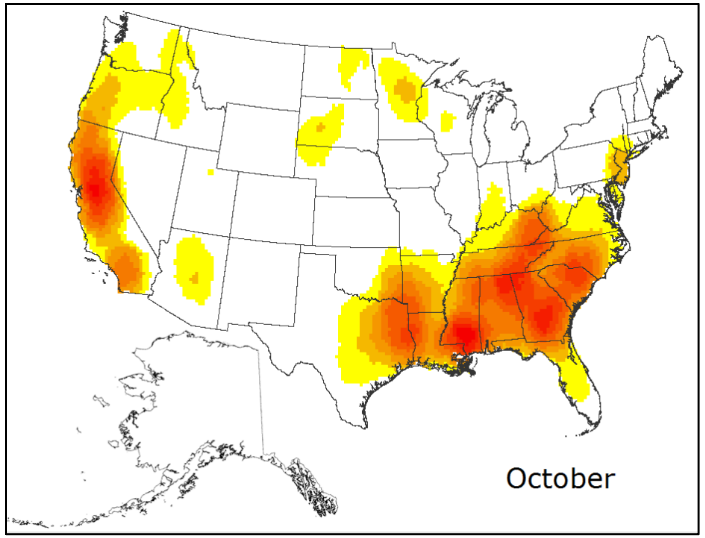
National Interagency Fire Center (NIFC)

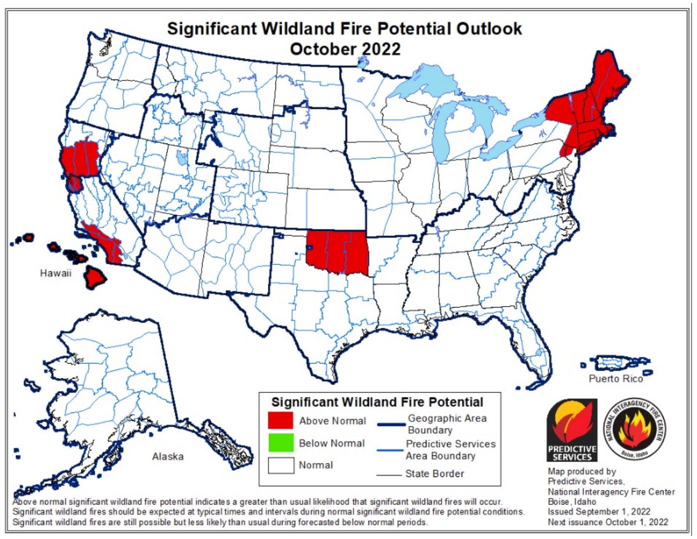
Strategic Tactical Radio and Tactical Overwatch (STRATO)

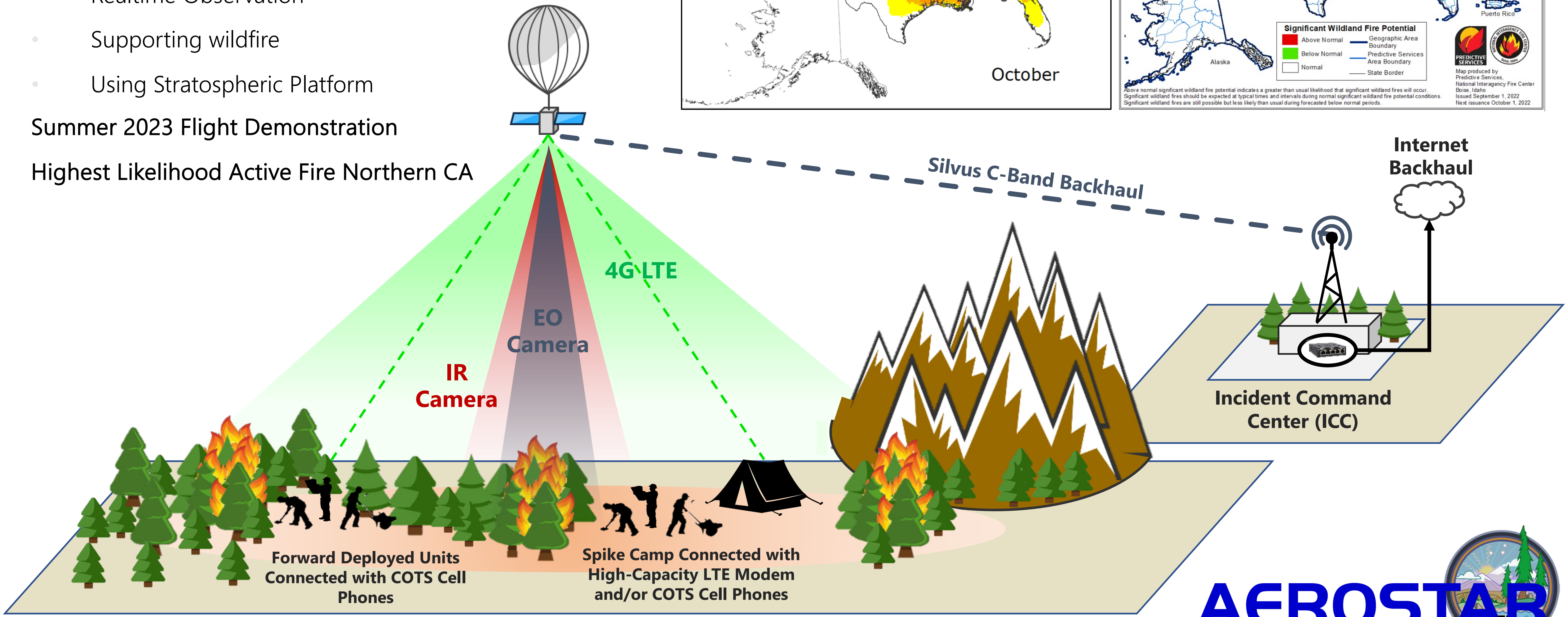
- Last Mile Communications
- Realtime Observation
- Supporting wildfire
- Using Stratospheric Platform

Summer 2023 Flight Demonstration

Highest Likelihood Active Fire Northern CA

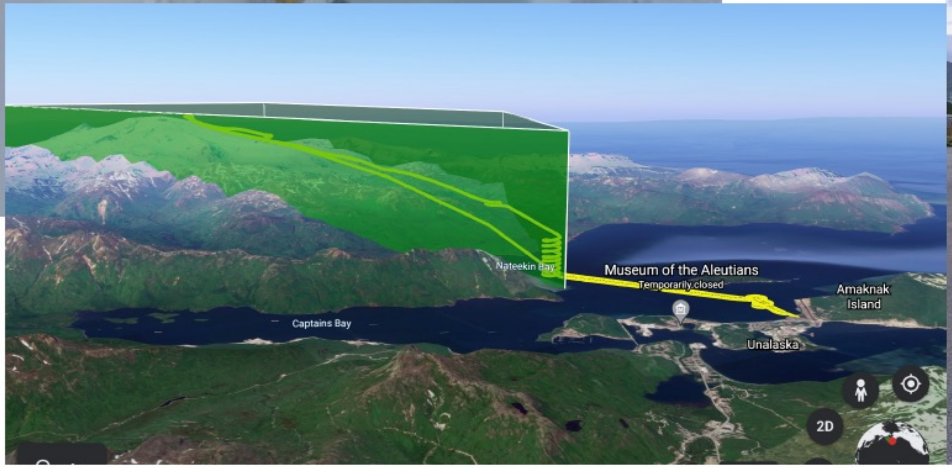






AEROSTAR

NASA/USGS exploring volcanoes w/ Uncrewed Aircraft



Black Swift TECHNOLOGIES

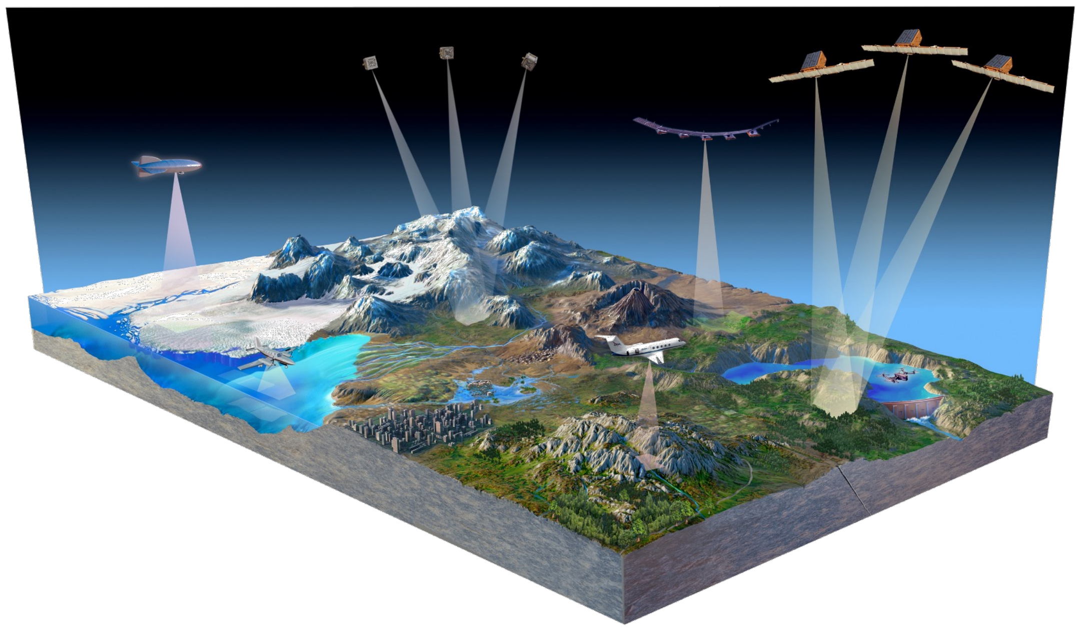
USGS science for a changing world

Platform Questions

What are the minimum set of optimal platforms that can satisfy STV science goals?

Sub questions

1. **What are the payloads and conops to meet observing system requirements from the architecture team?**
2. **What are the mass, power, data storage and telemetry requirements?**
3. **What are the science observables that cannot be accomplished with a satellite-only approach?**
4. **What data products require low latency delivery?**
5. **What interoperability between systems is required and at what time interval?**



STV Platform Group Goals (DRAFT)

Support instrument, science and architecture teams with Platform capabilities and constraints

Sub goals

1) Provide access to modified aircraft through entire life-cycle from instrument development through product validation.
    1) Updated database of aircraft providers and specifications
    2) Develop database of STV ”airborne simulators” (eg. CASALS, LVIS, AirSAR NG)

2) Catalog TRL 6 or higher platforms to inform architecture and payload groups

3) Support development of flight campaigns to evaluate and compare technologies.

STV Platform Group - Capability Gaps

Identify and mature technologies to improve surface and vegetation observations.

1) Are new capabilities needed from spacecraft buses or science aircraft to support STV observations?

2) What role will ground sensors (eg. Fixed cameras) and SUAS/drones play?

3) How important is HAPS maturation, testing, and airspace access?

4) What data is needed to expanding OSSEs to include suborbital measurements?

5) Are current airborne onboard data processing and telemetry system sufficient?

Platform inputs to Experiments

Support instrument development, flight testing, and concepts-of-operations

Airborne campaigns -

- instrument testbeds and measurement intercomparisons
- Platform capability assessments for new platforms
- onboard computing and communications testbeds for “tip and cue” conops
- Need to define when

Example Targets for Airborne focus

- Fast changing regions – volcanoes, regions w/ deforestation, pre-, post- hurricane observations
- Coastal zones are often difficult to observe at proper spatial and temporal resolutions
- Marginal ice zones and glaciers

Summary

- What platforms does STV need from incubation through Phase A and into operations?

- Many potential “game changing” platform technologies will likely be operational during STV time-frame

- Thoughts about future activities
  - Leverage existing airborne platforms and instruments to refine data acquisition strategies and data fusion workflows.
  - Airborne campaigns for evaluating proper complementary use cases
  - Identify ”hot spot” targets needed for planning HAPS or other airborne complementary measurements to STV satellites
  - Thinking about how to handle very high spatial and temporal resolution data products (100x measurements per day)