Navy/UNOLS SCOAR Committee, Nov.1,2, 2023

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HEALY in Arctic 2023

# USCG UAS updates

- USCG UxS Strategy document released, April 2023, see: https://www.dco.uscg.mil/Portals/9/DCO%20Documents/2023%20Unmanned%20Systems%20Strategic%20Plan.pdf
- USCG hires three (HQ, PACAREA, and GoM) UAS coordinators
- USCG purchases >100 Parrot and Skydio drones…Parrots have high failure rate in operations, as also found by several other federal agencies…likely to be discontinued for CG use.
- USCG R&D Center purchases FlightWave Edge VTOL UAS, after approval on NSA "Blue UAS" list…delivery end of October…sea trials planned.
- White House "Implementation Plan for the 2022 National Strategy for the Arctic Region" released Oct. 18, 2023, see: https://www.whitehouse.gov/wp-content/uploads/2023/10/NSAR-Implementation-Plan.pdf , calling for UAS use in Arctic for data collection and Maritime Domain Awareness (MDA), including joint operations for foreign partners.
- CG "Arctic Strategic Outlook Implementation Plan" released, Oct. 2023, see: https://www.dco.uscg.mil/Portals/9/DCO%20Documents/2023%20Unmanned%20Systems%20Strategic%20Plan.pdf , calling for UAS Arctic use for environmental data & MDA.

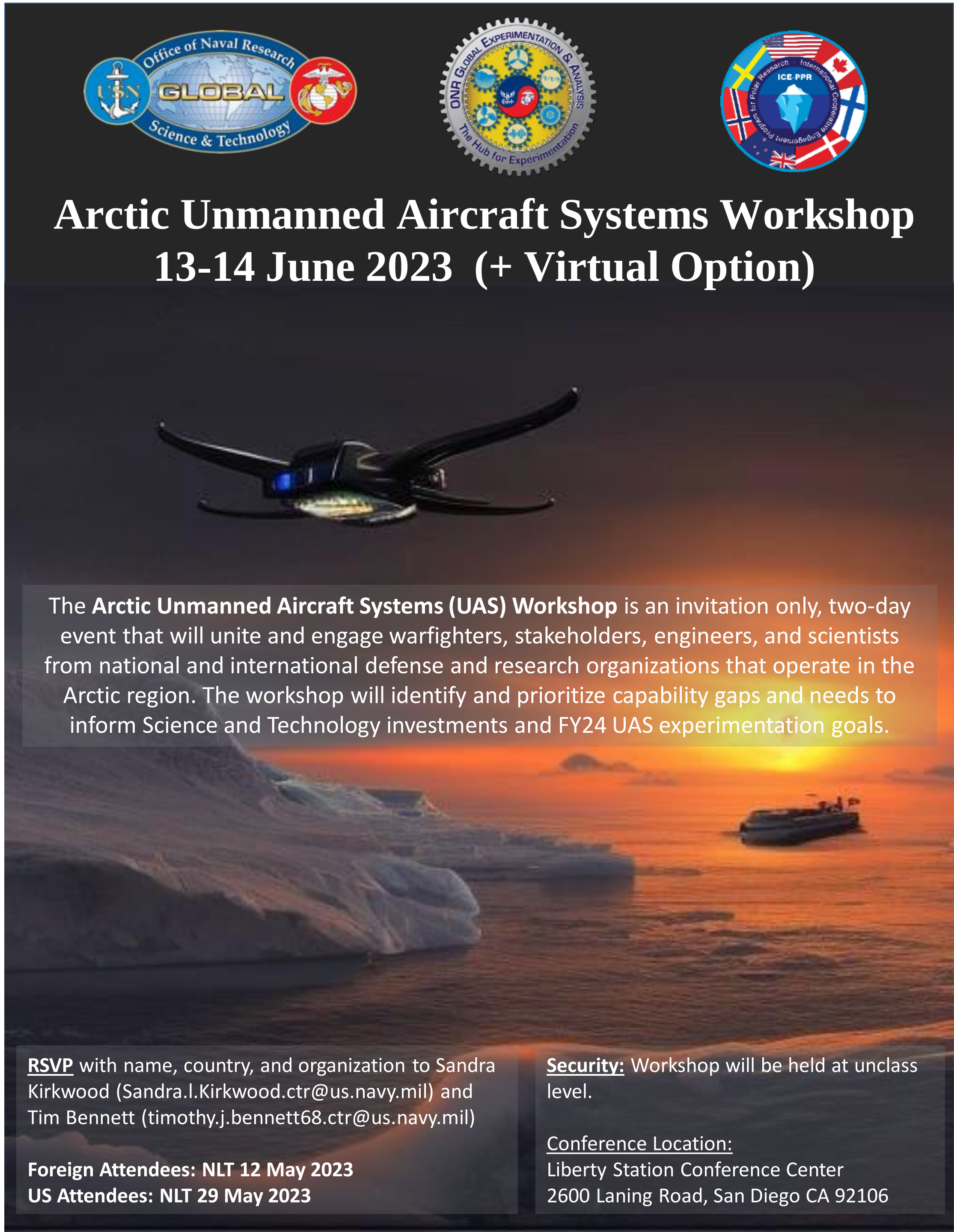
# PACAREA & Icebreaker UAS plans, 2024-2026

- 2024- plan for NASA VANILLA UAS with sea ice radar to operate out of Thule AFB, concurrent with NAVY MQ-9B Sea Guardian (“Predator”) in first Arctic deployment of this platform. Exercise goals: have SeaGuardian task VANILLA with areas to survey; transmit radar data from VANILLA to SeaGuardian for ML/AI processing of ice ridge detection. HEALY will not be in area concurrently, but if it were, goal would be for data transmission to HEALY. HEALY is tentatively planned to be operating in that area in 2024, 2025, pending CG approval. This is a heavy multiyear ice area (Lincoln Sea), where UAS sea ice data would be particularly useful.

# PACAREA & Icebreaker UAS plans, 2024-2026

- ONR ICE-PPR (International Collaborative Engagement Program for Polar Research) convened June 13, 14, 2023 “Frozen Flyer” UAS in Arctic Workshop in San Diego, CA with goal of planning 2024 and 2025 UAS Arctic ops.  Plans are for initial North Dakota ops in winter 2023 to test selected airframe performance, followed by ops out of Utqiagvik/Barrow in 2024, and Greenland in 2025. NRL is lead. (See flier next slide)
- ONR ICE-PPR will conduct 2025 operations out of Thule, including ONR funded manned and unmanned aircraft flown by NORCE (Norway, Tromso) out of Svalbard to North Station, Greenland, and Thule to evaluate ice radar capabilities.

# Flier for ONR Arctic Unmanned Aircraft Workshop



# PACAREA & Icebreaker UAS plans, 2024-2026

- HEALY conducted joint operations with Norwegian Navy/CG ship AMUNDSEN in fall 2023 (pix lower right), and had port call and science workshop in Tromso, as first ever visit to this port. Given HEALY presence in Arctic in trans-polar route in 2024-2025, plans are to continue joint operations with foreign partner countries, including joint UAS operations.
- Plans are to attempt ship to ship and ship to UAS optical comms using optical systems from Cailabs (https://www.cailabs.com ) using OAM methods which have been demonstrated to have superior performance in turbulent air conditions (eg such as those over ice leads, ice edges). Spex on Cailabs system expected in early 2024, should be no problem for ships, TBD re UAS.

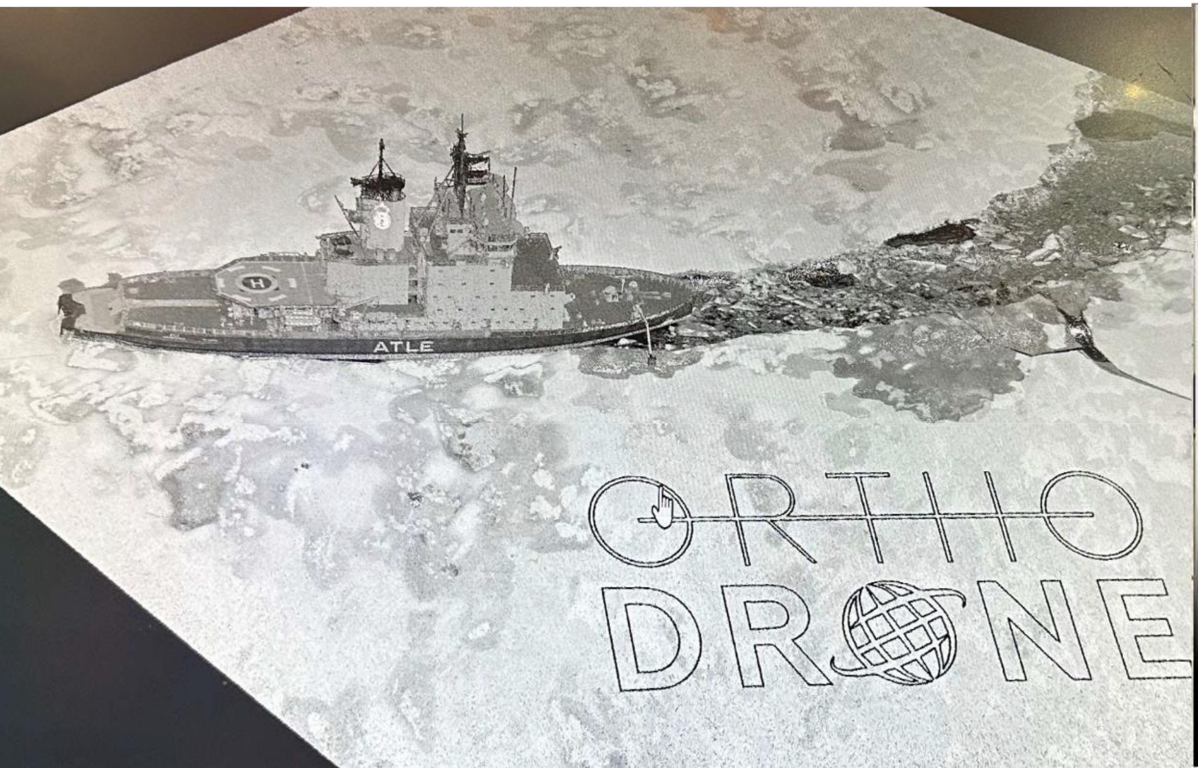
# Current & Projected Arctic UAS Mission & Operational Requirements

1 – UAS for sea ice reconnaissance: ships do @10 knots in ice, so in a 12 hour half day, steam at @120nmi, say @100nmi. Proposal is to do ship UAS LARS (launch & recovery) in morning and evening to do surveillance for the @100nmi ship will steam in next 12 hours. So, want UAS with @200 nmi range (100 out, 100 back). This is the ideal; am OK with just ‘better than what we have now’.
2 – Need BVLOS UAS ops & OTH (over the horizon) comms. Our ship mast is 96’ ASL, but comms antenna mounts @90’ ASL so LOS radio comms of @21.6km=11.7nmi (or LOS visual of 18.7km= 10.1nmi ). For calculations, see: https://www.everythingrf.com/rf-calculators/line-of-sight-calculator . For a ship - tethered (or untethered) UAS at 400’ altitude your radio range is 24.6nmi, or 21.3nm visual LOS. This means for BLOS comms either have to use: 1) sat comms; 2) tethered UAS at @400’; or, 3) a second UAS as a comms node flying at 400’. This will give you a range of >100nmi.
3 – Alternately, use long-range radio comms systems like RadioNor (https://radionor.no/ ) on UAS, which while not small (@300g=@0.7lbs), gives you @300km (>150nmi) range. Good option…
4 – Want a VTOL UAS for ship LARS, and useful if it can hover to study conditions/sites of interest (eg icebergs, ridges, other vessels of interest, oil spills, etc.).
5 – One key operational requirement will be to measure ice ridge/keel height/depth per adage: “Ice doesn’t stop ships, ice ridges/keels stop ships”. In some cases useful to also measure snow depth atop ice. For research studies helpful to also measure sea ice brine channel volume (directly correlates with sea ice algal productivity). Sensor technologies for this are discussed in Topic 5.
6 – Again, UAS methods that can measure sea ice/iceberg drift are particularly useful for ship operators.

# Current Capabilities for Arctic Operations

1 – Quadcopters lack range for effective sea ice surveillance but can be useful for vertical profiling of atmospheric conditions (wind speed, icing conditions, gas/heat fluxes).
2 – VTOL UAS designs such as V-BAT were demonstrated for ship launch/recovery in 2022 Bahrain Task Force 59 exercises. However, large their 'sail' area complicates transition from horizontal to vertical flight when ship superstructure turbulence in wind speeds above 25 knots occurs routinely in polar regions. Also lacks ability to hover well (energy efficiently).
3 – VTOL UAS with a 'hybrid' design, ie H-shape design with endpoint quadcopter props that freeze in place after takeoff, and are replaced by a pusher prop for forward motion once aloft are one current ship operating VTOL UAS standard, as exemplified by the formerly Latitude Engineering (now Boeing) HQ-60 and HQ-90 "H"-shaped designs (see: https://www.unmannedsystemstechnology.com/2016/09/latitude-engineering-hq-60-uav-sets-newflight-record/ ), now in several other COTS variants.
4- Another VTOL design is the "mini-Osprey"design, where propellers rotate from vertical to horizontal following take-off. Both this and H-hybrid design also accommodate hovering. Early example of former is Flightwave Edge (see: https://www.flightwave.aero/ ), notable for having 'blended controls', checking once a second to see if it is plane or quadcopter, so if flipped by wind gusts, within seconds automatically rights itself to resumes altitude and mission. Most VTOL UAS don't have this capability so are at risk of mission failure gusting winds >45 knots. A feature to look for! Further VTOL UAS examples listed in Topic 4.
5 – Currently, comms for S-UAS limited to radio or Iridium CERTUS. Starlink for S-UAS does not yet exist, so can transmit real-time video, but not higher bandwidth sensor data (hyperspectral, lidar, SAR, I-SAR, other radars).

Orthodrone (https://www.orthodrone.com/ ) VTOL UAS from AUVSI XPONENTIAL 2023, showing March 2020 Swedish Icebreaker ATLE test of UAS lidar for sea ice recon, Bay of Bothnia. In 2023 will do UAS data integration on ship's bridge. URL of the 2020 trip using Avartek Boxer Hybrid (not current UAS version), see:
https://www.youtube.com/watch?v=N0G7rCbpAAM
Video of current version shows UAS itself as gimbal, so in wind gusts props and support arms move, (mostly) drone body does not, see: https://www.youtube.com/watch?v=HWZL48MtXMk
Uses fuel, not batteries: flight time ">2 hours" (NFI re speed, range, other spex; but"min. speed 4m/sec=14.4km/hrx2=28.8km=17.9mi range at slowest speed…NFI re typical speed)
Cost: @$100K
Country of origin: Germany
See additional pix next slide.




Another image of the Orthodrone VTOL UAS from 2023 XPONENTIAL

VTOL UAS from XPONENTIAL 2023

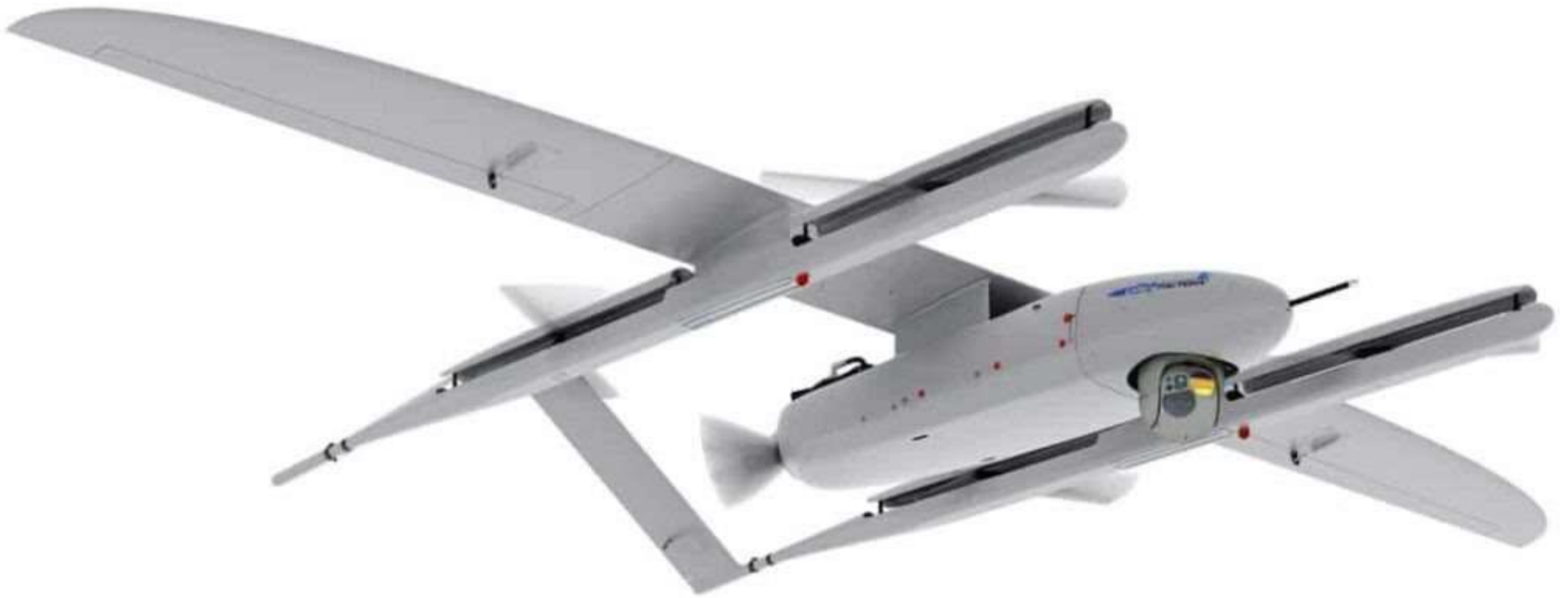
1 – Autel Dragonfish: vertically tilting rotors for take-off. Three models.
See:https://www.autelrobotics.com/productdetail/dragonfish-series-drones.html
Top model flight time 130-160 min, typically 15m/sec, range: 117-144km=63-76nmi
Speed: 0-17m/sec (rotors);17-30m/sec fixed wing.
Wind resistance (fixed wing) 15m/sec (=33mph).
Features: 1) Automatic transition to quadcopter if flipped in flight as plane; 2) Automated take-off & landing; 3) 50X and 240X optical zoom; 4) Image transmission to 18.6km (11.5mi).
Payload: 2.5kg.
Price: @$90K.
Country of origin:
China

VTOL UAS from XPONENTIAL 2023

2 – Mugin EV350, hybrid “H” design, see: https://www.muginuav.com
Three electric VTOLs:
EV350 - 3 hours w/ 3kg payload
EV460 – 2 hours w/ 8kg payload
Cost: $10K
Cruise speed: 20m/sec
Max speed: 30m/sec
Stall speed 16m/sec
Range: 2 hours, 180km (=97nmi)
EV6000 – 10 hours w/ 25kg payload
One gas VTOL:
EV4720 = 4 hours w/ 8 kg payload (NFI re speed/spex)
Country of origin: China

# VTOL UAS from XPONENTIAL 2023

Edge Autonomy Penguin C Mk 2 VTOL UAS (two other versions)
12+ flight hours, to 180km (97nmi) range
Power: fuel injected fuel cell engine with unique microtubular design for
redundancy
Parachute for emergency landing
Automated LARS
Automated target tracking
Silvus dual S and C band comms
Cruise speed: 30 knots, max speed 65 knots
Payload: 9.9 lbs
Operates in 30 knot winds (15m/sec)
Country of origin: US
Cost: starts @$17K



# VTOL UAS from XPONENTIAL 2023

Narma AF200 Ranger dual tilt rotor, see:
https://www.narma.co.kr/
Power: Li-ion batteries
Payload: 5kg
Comms: cell & RF data/video
Flight time: 50 min @20m/sec = 33 nmi
Max speed: 30m/sec
Auto LARS, landing w/in 1.5m
Cost: unspecified online, @<$30K if I recall
Country of origin: S. Korea

VTOL UAS from XPONENTIAL 2023

Spright: https://sprightuas.com/ tilt rotor (focused on medical delivery, holder of US BVLOS range for that)
Power: hybrid electric or all electric
Range: to 60 mi
Speed: to 60mph
Wind resistance: to 45 mph
Feature: Auto LARS
Payload: 88 lbs
Cost: NFI
Country of origin: US (joint w Swiss UAS co)

# VTOL UAS from XPONENTIAL 2023

Zephyr, hybrid VTOL UAS ARK-350, see: https://zephyrsys.com/
(two other models "coming soon"
Note: Under Army contract
Power: Hydrogen fuel cell, variable pitch propeller
Range: 150mi (3.5 hr w payload at 20m/sec[=44mph]= 150mi)
Payload: 35 lbs
Wind resistance 5.5-7.9m/sec (=12-17mph)
Price: @$35K
Country of origin: US

# VTOL UAS from XPONENTIAL 2023

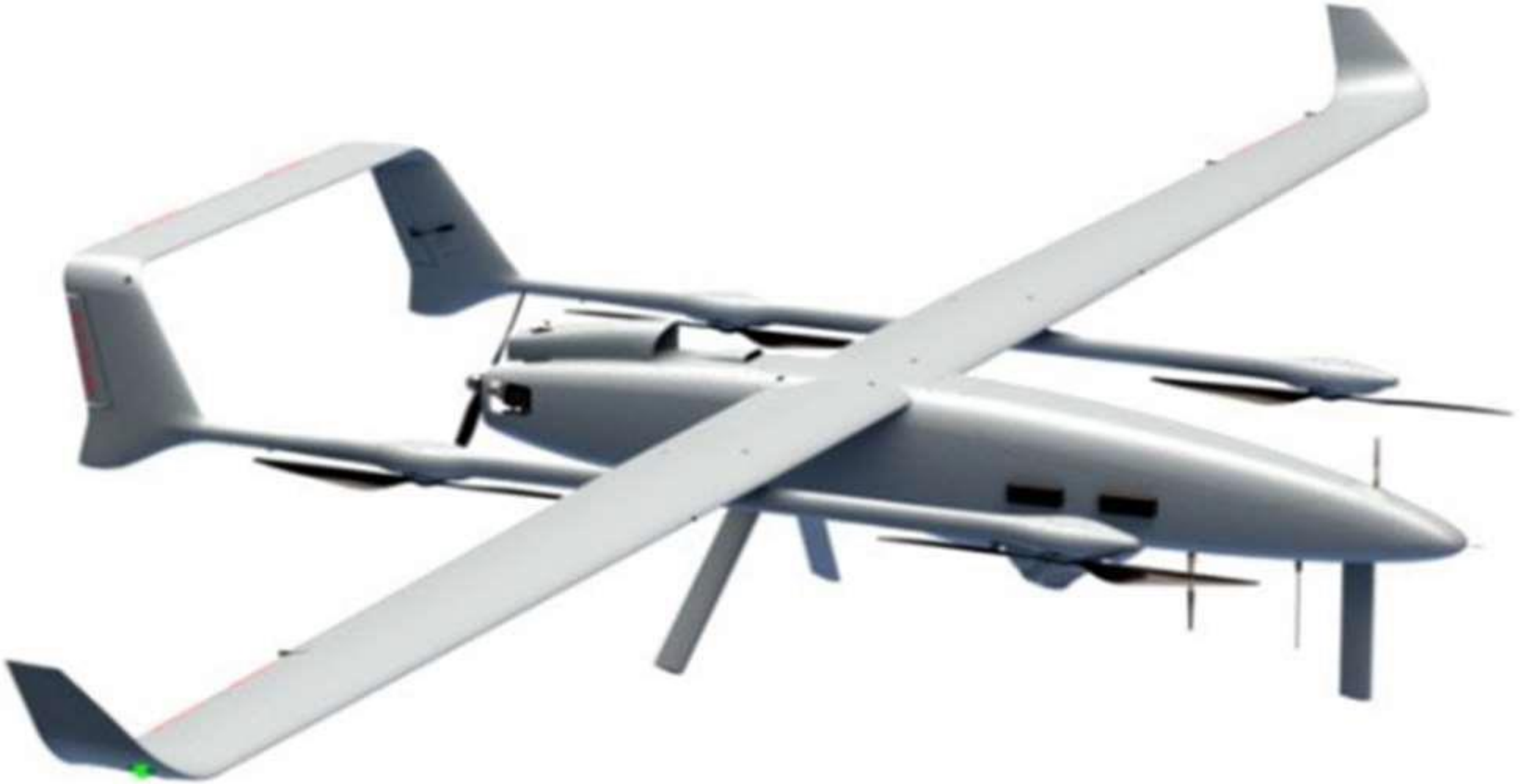
ESEN Gokuhn, https://www.esensi.com.tr/en/product/gokhunuas
Hybrid VTOL w pusher prop
Engine: two stroke gasoline/heavy fuel, fuel-injected, 15 HP, w 2kW power available
Flight time: up to 16 hrs w 4 kg payload (can take up to 12kg payload)
Range: >150km (80nmi)
Cruise speed: 52-85 knots
Wind speed limits: 40 knots
Comms: S and L band, 10Mbps
Country of origin: Turkey
Features: visual non-GPS navigation; simultaneous operation of 2 different payloads; NATO AEP-83 and AEP-84 compliant; redundancy of key systems; ground and aircraft traffic collision avoidance.

VTOL UAS from XPONENTIAL 2023

IdeaForge Switch: https://ideaforgetech.com/security-and-surveillance/switch-uav
Power: battery powered
Endurance: 2 hours;
Speed: 13 m/sec
Range: 15 km (8nmi)
Wind resistance: 40 kmph (12 mph)
Cost: @$11K
Country of origin: India
Features: automated LARS; moving target indicator; terrain tracking/avoidance;
used by Indian Army

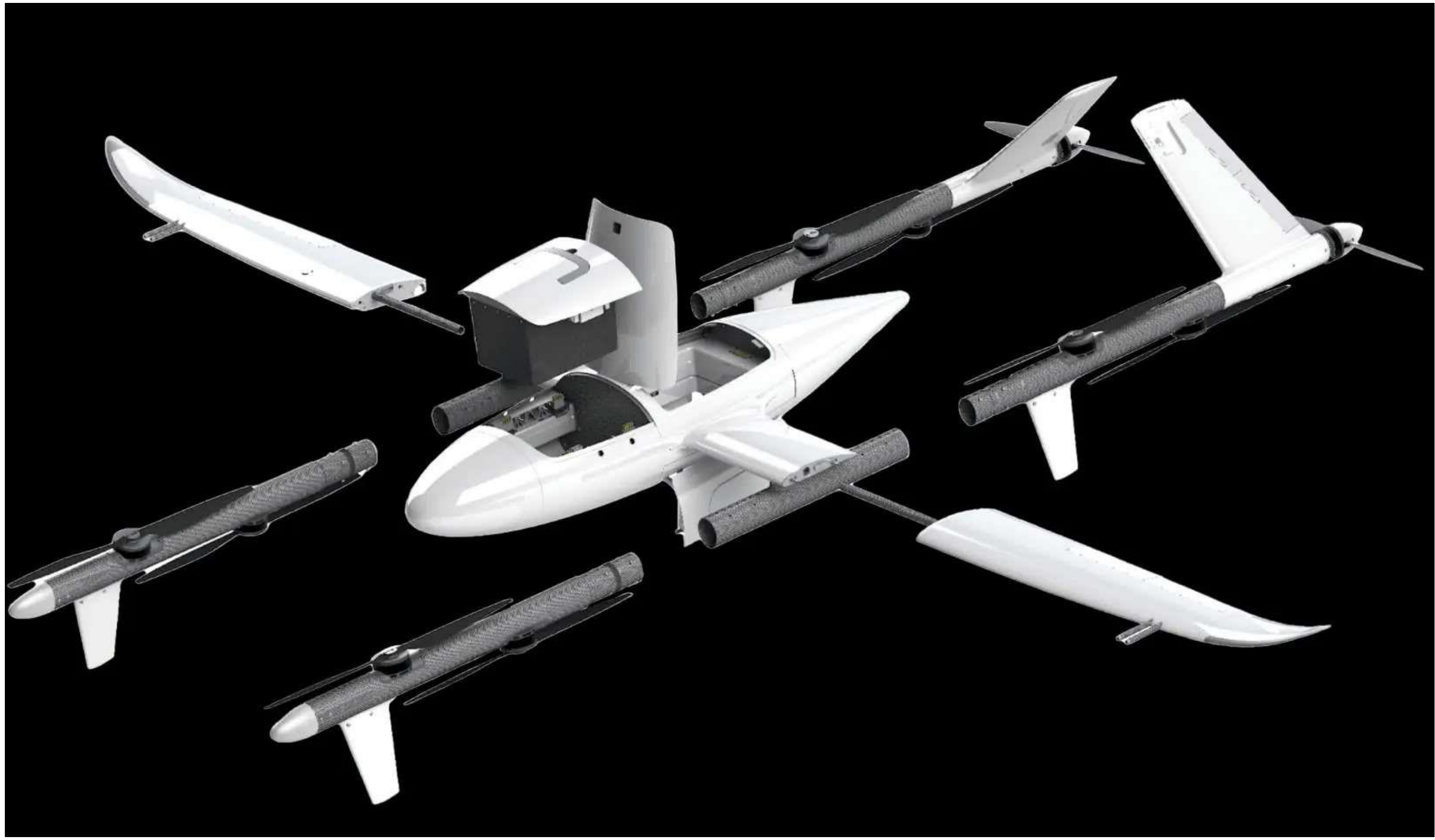
VTOL UAS from XPONENTIAL 2023

IAI Bluebird Aero Systems ThunderB: https://bluebird-uav.com/
, 'H'-Hybrid with pusher prop
Power: Electric motor (battery)
Comms Range: 150km (80nmi)
Endurance: 12 hrs
Payload: 77 lbs
Cost: NFI
Country of origin: Israel
Features: re-usable parachute and airbag; resistant to GPS jamming; numerous international customers



# VTOL UAS from XPONENTIAL 2023

Swoop Aero Kite UAS & Aviary Docking System:
https://swoop.aero/ , twin pusher
props at ends of H-frame
Power: battery
Range: 175 km (94 nmi)
Payloads: 3-5 kg
Cost: NFI
Country of origin: Australia
Features: parachute; operates in heavy rain;
detect & avoid technology; payload
access from above & below (ie can drop payload);
focus on medical deliveries



# VTOL UAS from XPONENTIAL 2023

Vayu Aerospace, G1-Mk II, https://vayuaerospace.com/ , H-frame w pusher
prop, 8 electric motors for take-off, gas motor for flight
Power: 13 Elecjet AX 31AH solid state batteries (w 2.5X energy of Li ion
batteries), are fire resistant
Payload: 24.2 lbs
Flight Time: 10-20 hours depending on payload
Range: to 1200 mi
Max speed: 67 mph
Cost: NFI
Country of origin: USA

VTOL UAS from XPONENTIAL 2023

Hiveground (HG) Vetal: https://www.hiveground.
Tail-sitter design
Power: battery
Payload: 800g (1.7 lbs)
Endurance: 60 min
Max Speed: 90 km/hr (55mph)
Range: 55 mi
Wind resistance: 15m/sec (33mph)
Cost: @$23,000
Country of origin: Thailand
Features: onboard 4G/5G for longer BVLOS ops; can operate in stealth mode w/o comms; designed to land on moving objects (ships, trucks, etc.)

VTOL UAS from XPONENTIAL 2023

Aurora [Boeing] Skiron-X, https://www.aurora.aero/small-uas/ ,
H-VTOL
design, tail pusher prop
Power: Li ion battery
Payload: 3.2 lbs
Endurance: 180min. (flight); 25min. (hover)
Range: 110 nmi
Max speed: 26m/sec (58mph)
Cruise speed: 19m/sec (42mph)
Cost: NFI
Country of origin: USA

VTOL UAS from XPONENTIAL 2023

Skydio 2+, Skydio dock: https://www.skydio.com/defense
Doghouse for their UAS (which is CG approved)
Endurance: 27 min.
Flight Speed: 36 mph
Range: 6km
Cost: UAS $1100+ / Dock $7K
Country of origin: USA
Features: 360o view w six 4K cameras, good for 3D mapping; has tracking capability (tracking filmer)
Dock allows unmanned outdoor use.

# VTOL UAS from XPONENTIAL 2023

C-Astral Aerospace SQA-eVTOL, https://www.castral.com/en/unmanned-systems/sqa-evtol
Power: Li-PO Battery
Payload: camera (NFI)
Endurance: 2.5 hr
Range: 160 km (86nmi)
Comms range: 40km (20.5nmi)
Max speed: 24m/sec 54mph); cruise 18m/sec (40mph)
Cost: NFI
Country of origin: Slovenia
Features: parachute; GPS jamming resistant; target tracking

# VTOL UAS from XPONENTIAL 2023

Precision general UAS:
https://www.flyprecision.com/unmanned/ , H-w pusher prop
Spektreworks Cobalt 110:
https://www.34northdrones.com/product/spektreworkscobalt-110-g-vtol/
Spektreworks Cobalt 55:
https://www.34northdrones.com/product/spektreworkscobalt-g-55-vtol/
Power: fuel-injected engine
Payload: 20 lbs / 10 lbs
Endurance: 10 hrs / 4-6 hr (5 min hovering)
Range: 500 nmi/ 100 nmi
Max speed: 65 knots (75mph)
Cruising speed: 50 knots (57mph)
Cost: All are on GSA schedule
Country of origin: Oregon

VTOL UAS from XPONENTIAL 2023

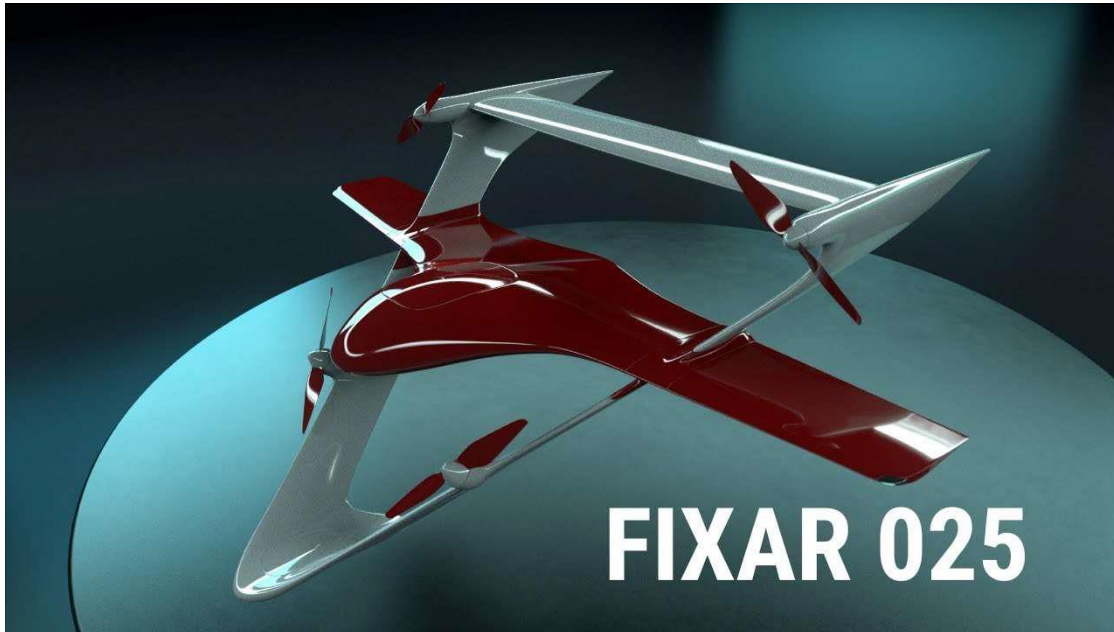
Censys Sentaero 5, https://censystech.com/ ,
mini-Osprey design
Power: battery
Payload: NFI
Flight Time: 1.2 hr
Range: 55 mi
Cruise speed: 40mph
Max speed: 53mph
Wind resistance: 20 steady-25mph gusts
Cost: $15(-40)K
Country of origin: USA
Features: aircraft can be leased

VTOL UAS from XPONENTIAL 2023

Velos V3 unmanned helicopter: https://velos-rotors.com/
Power: battery
Payload: to 10 kg
Endurance: 30-90 min.
Range: 60min@30mph=30mi; 90min@40mph=60mi
Cruise speed: 30-70kmph (@20-40mph)
Max speed: 130kmph (@80mph)
Cost: NFI
Country of origin: Greece
Features: obstacle

VTOL UAS from XPONENTIAL 2023

Fixar, two models 07 and 25, https://fixar.pro/
https://fixar.pro/products/fixar007/
https://fixar.pro/products/fixar-025/
Power: battery
Payload: 4.4 lb/22 lb
Flight Time: 1 hr / 3.5 hr
Range: 60 km (max dist. 120km) / 93mi (max dist. 186mi)
Max speed: 75mi/hr
Cruise speed: 40-45mi/hr
Wind tolerance: 33 mph
Cost: $20.4K / NFI
Country of origin: Latvia
Features: automated LARS

# VTOL UAS from XPONENTIAL 2023

Sky Drones Skylane 250 & 350 VTOLs, https://sky-drones.com/skylane
Power: battery
Payload: 1.2kg(2.6lbs) / 7kg(15.4lbs)
Flight Time: 4 hr / 5 hr
Range: 300+km (162nmi)
Cruising speed: 100km/hr (62mph)
Max speed: 26/28mps (58/62mph)
Wind resistance: 13.8m/sec (30mph)
Cost: NFI
Country of origin: UK

# VTOL UAS from XPONENTIAL 2023

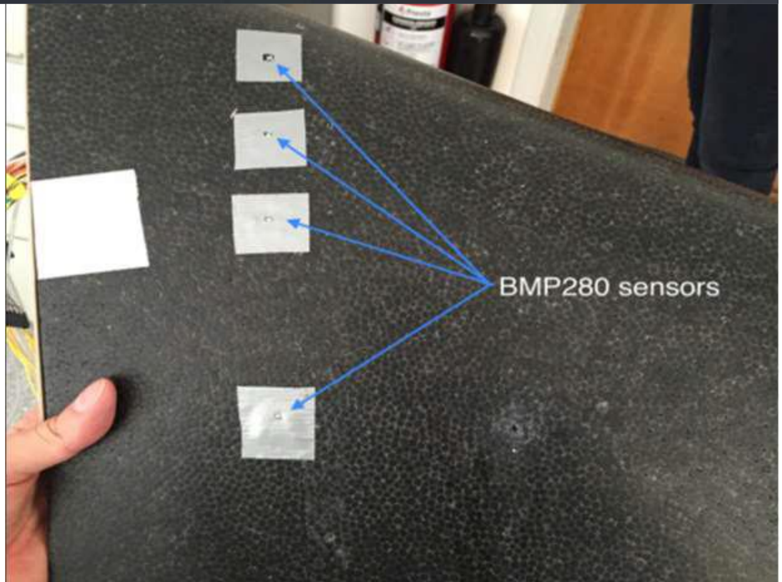
Flightwave Edge https://www.flightwave.aero/ , mini-Osprey design
Power: Li ion battery
Payload: 0.76 lbs
Flight Time: 2 hours
Range: 66mi
Cruise speed: 33mph
Max speed: 65mph
Wind resistance: 40mph
Cost: $10K
Country of origin: USA
Features: blended controls = auto-corrects if flipped by turbulence

VTOL UAS from XPONENTIAL 2023

Tetra Drones (www.tetradrones.co.uk/ ) are designed to both fly, and get in the water and take samples.


New UAS sensor methods: wind speed & direction…

Kasper Trolle Borup (NTNU) has developed a fixed wing UAS with multiple pitot
tubes across the wingspan, which allows it to measure wind speed and direction
while flying. This elegant solution is an improvement to the alternative of using
multiple UAS to do this.
See: "A Machine Learning Approach for Estimating Air Data Parameters of Small
Fixed-Wing UAVs Using Distributed Pressure Sensors." IEEE Trans. Aerospace &
Electronic Systems, 2019. DOI: 10.1109/Taes.2019.2945383.



# UAS SAR Iceberg Detection

Location: around Lovenoyane Islands (white), Kongsfjord, Svalbard, showing two different screening/visualization options to discriminate icebergs from sea ice (V. Akhari & C. Brekke, IEEE Trans. Geosci. & Remote Sensing, 2018)