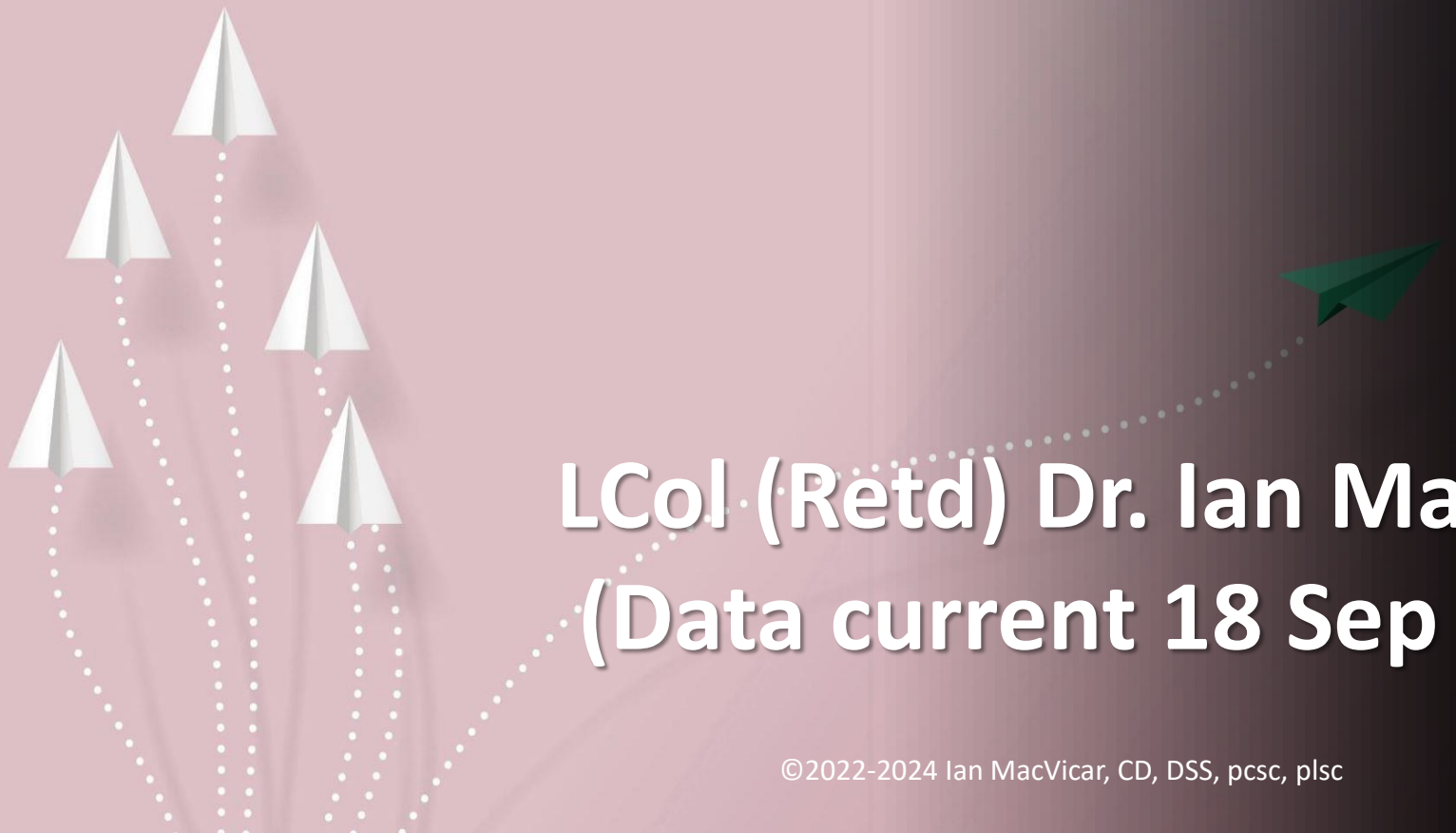
RUSI (NS) Distinguished Speaker Series 18 Sep 2024

UAS /"Drones" Employment to 2024 & Future Research Directions



LCol (Retd) Dr. Ian MacVicar

(Data current 18 Sep 2024)

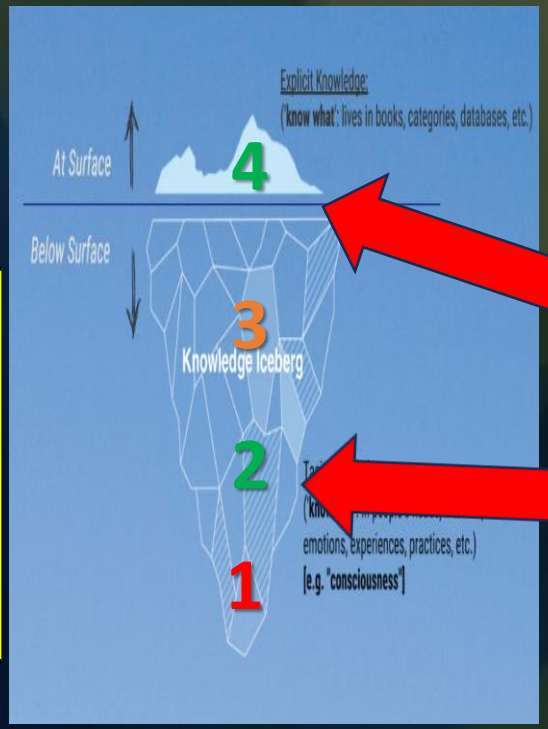
Synopsis

- Part 1: A - Civ Drone/B - Military UAS employment to date
- Part 2 – Ukraine Conflict analysis
- Part 3 – Future RDTE
- Part 4 – Implications for Canada/CAF

Limitations…

Concerns vehicles piloted by a remote pilot in real-time, and autonomous drones.

It does not address air vehicles flying a pre-programmed course, i.e., cruise missiles.



"Data dense"

AIM "Dwell" Time

Assumptions, given time

CHATHAM HOUSE RULES & …

Audience has foundational knowledgeable re UAV and UACV and is following open media press

Subject Matter Experts (SME)

Lurking …

Welcome but please don't slow presentation

Welcome to share your K in Q & A

BLUF

"Bottom Line Up Front"
WRT "Drones"

Not a new phenomenon, developed from aerial targets

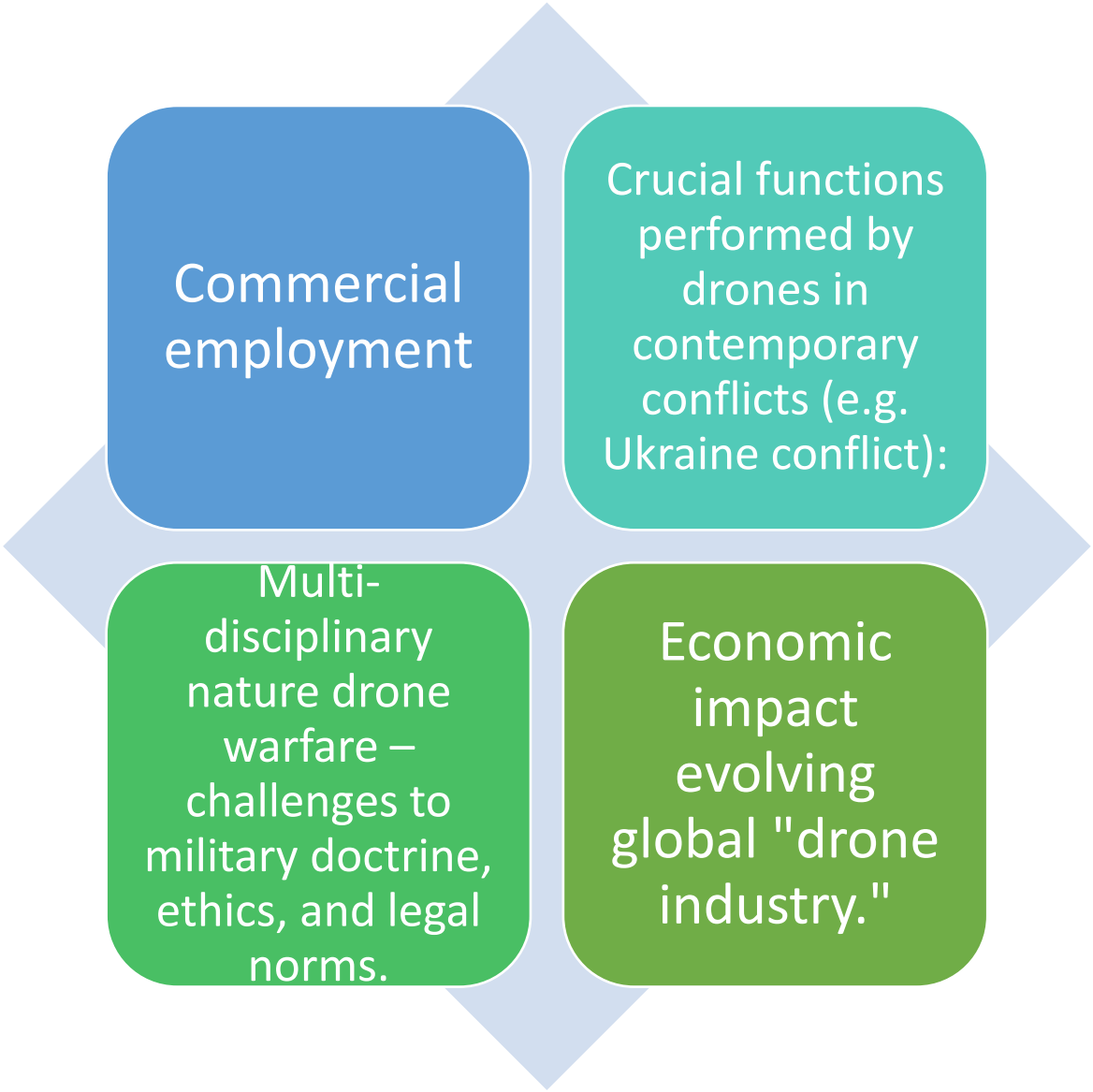
Dynamic expansion in employment in civilian world and in military

Driving change in warfare - all levels

Technology leads law

Technology accelerator in guidance, optics, sensors

4 X Take-aways Post Talk



“Kill Your Babies” - Shaving Wood Sculptures

Aspirations…in trimming this talk…

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Wanna Have Talks - Post this Talk?

- CUAS (Military) - Creativity
- cUAS (Civilian) – ATC, UTM, ROE
- Maritime UAS
- Uncrewed Ground Vehicles (UGV)
- Political Impact
- AI in promoting Full Sensor PED; Project MAVEN

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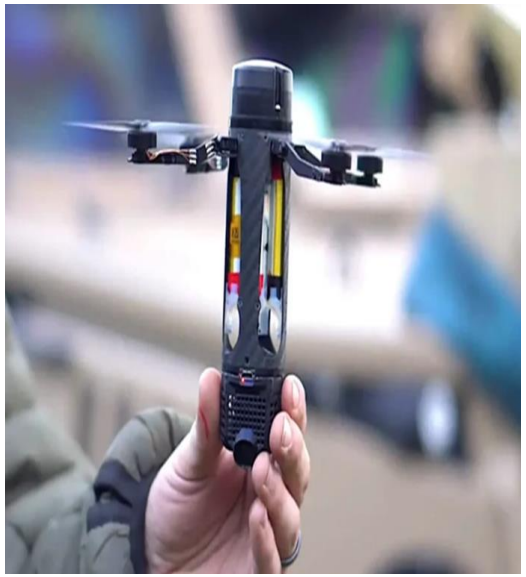
Wanna Have Regional Talks - Post this Talk?

- UAS RDTE - PRC
- UAS RDTE - Russia
- UAS RDTE - India
- UAS RDTE - Israel
- UAS RDTE - Iran
- **UAS RDTE – USA (in depth)**

Definitions

a.k.a. “Drones”



UA(C)Vs, UACS/UCAS, RPV, FPV

- **U**ncrewed
  - Unmanned
  - Uninhabited
- **A**erial
- **V**ehicles

- **U**ncrewed
- **A**erial
- **(C**ombat**)**
- **V**ehicles

- **U**ncrewed
- **A**erial
- **(C**ombat**)**
- **S**ystems

- **R**emotely **P**iloted **A**ircraft
- **R**emotely **P**iloted **V**ehicle

- **F**irst **P**erson **V**iew

NATO UAS CLASSIFICATION

Class	Category	Normal Employment	Normal Operating Altitude	Normal Mission Radius	Primary Supported Commander	Example Platform
Class III (> 600 kg)	Strike/ Combat *	Strategic/ National	Up to 65,000 ft MSL	Unlimited (BLOS)	Theatre	Reaper
	HALE	Strategic/ National	Up to 65,000 ft MSL	Unlimited (BLOS)	Theatre	Global Hawk
	MALE	Operational/ Theatre	Up to 45,000 ft MSL	Unlimited (BLOS)	JTF	Heron
Class II (150 kg - 600 kg)	Tactical	Tactical Formation	Up to 18,000 ft AGL	200 km (LOS)	Division, Brigade	Watchkeeper
Class I (< 150 kg)	Small (>15 kg)	Tactical Unit	Up to 5,000 ft AGL	50 km (LOS)	Battalion, Regiment	Scan Eagle
	Mini (<15 kg)	Tactical Sub-unit (manual or hand launch)	Up to 3,000 ft AGL	Up to 25 km (LOS)	Company, Platoon, Squad	Skylark
	Micro ** (<66 J)	Tactical Sub-unit (manual or hand launch)	Up to 200 ft AGL	Up to 5 km (LOS)	Platoon, Squad	Black Widow

PART 1: < 10 minutes

Civilian Industry Overview

Commercial Drones 2006-2013

- **Government**: disaster relief, border surveillance and wildfire fighting
- **Corporations**: inspect pipelines and spray pesticides on farms.
- FAA issues an average of two permits/year for next eight years – all that was requested.

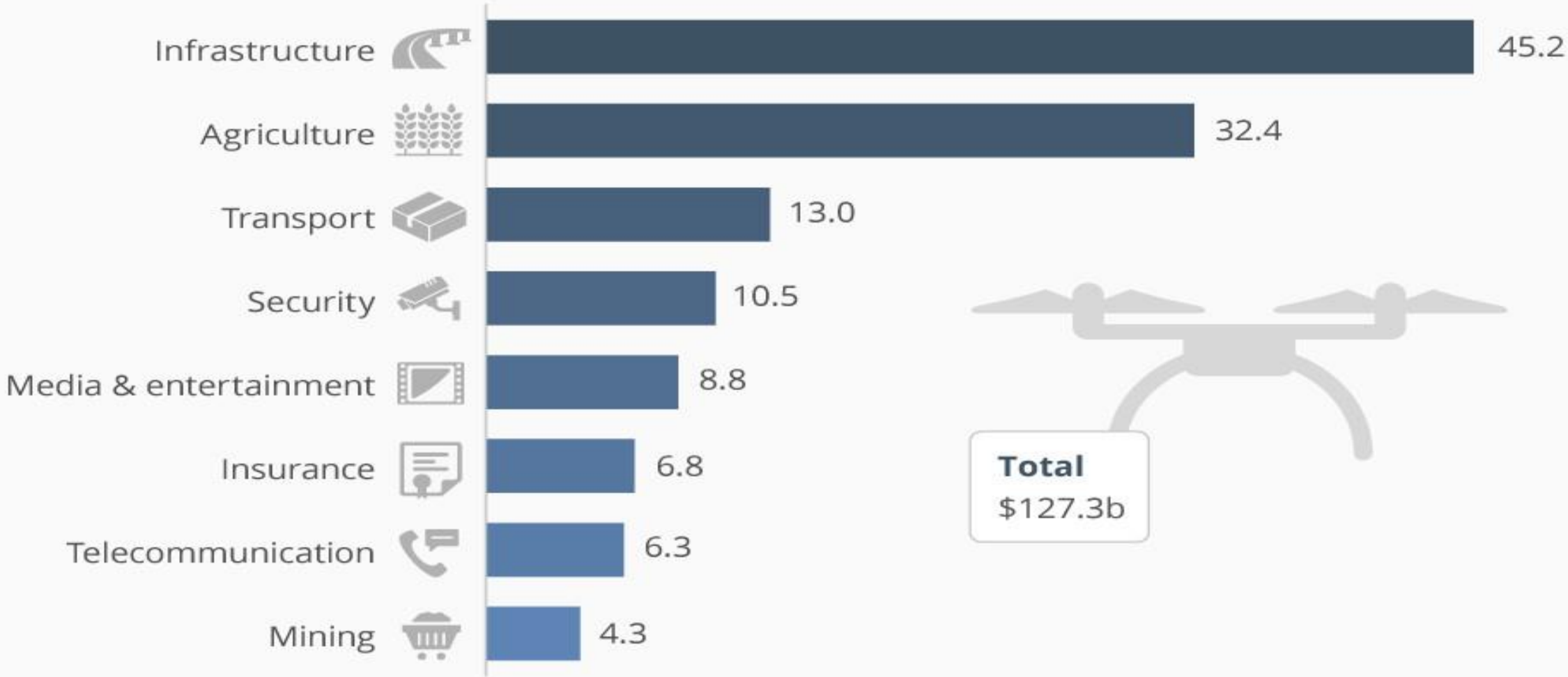
Commercial Employment /Sales Since 2015

Surveillance, cargo transport, specialized medical transport

Proprietary – Do NOT Copy

The Industries Where Drones Could Really Take Off

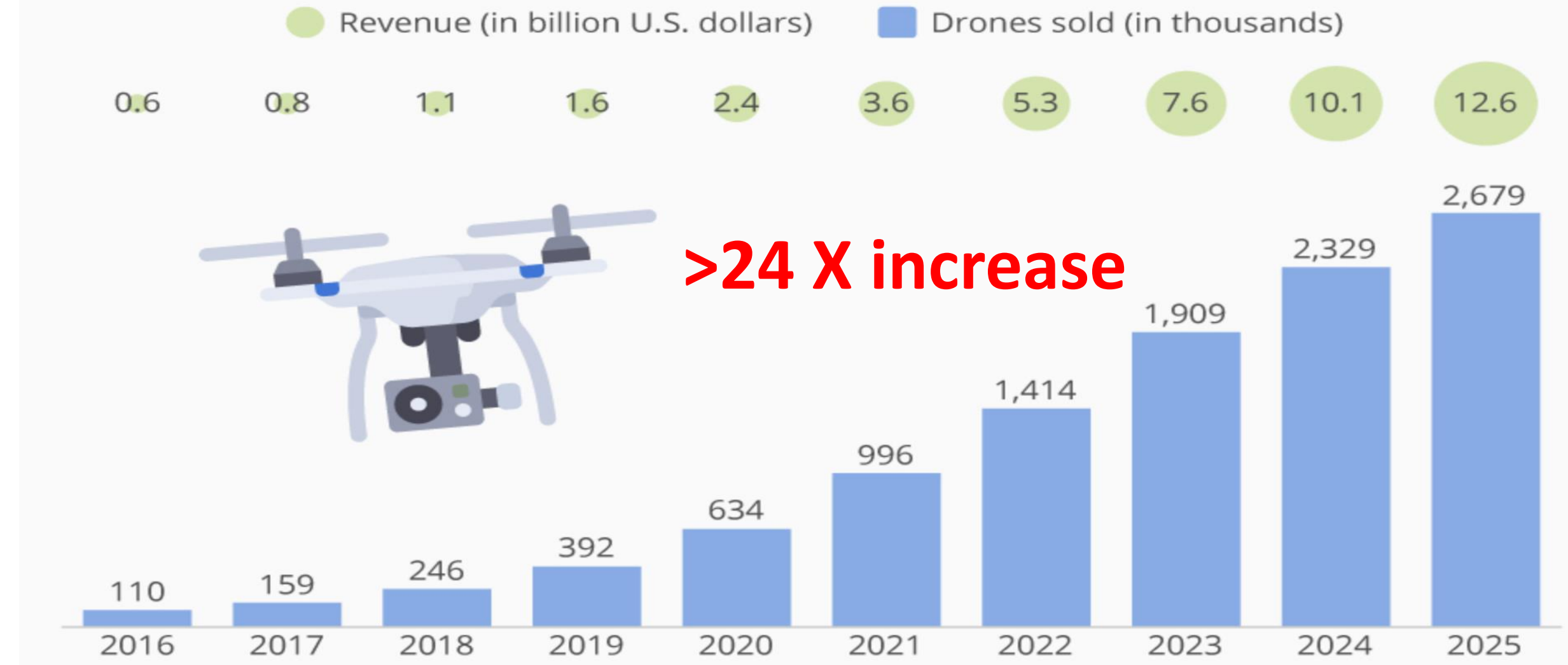
Value of drone powered solutions to industries in 2015 (billion U.S. dollars)



Source: PwC

Commercial Drones are Taking Off

Projected worldwide market growth for commercial drones



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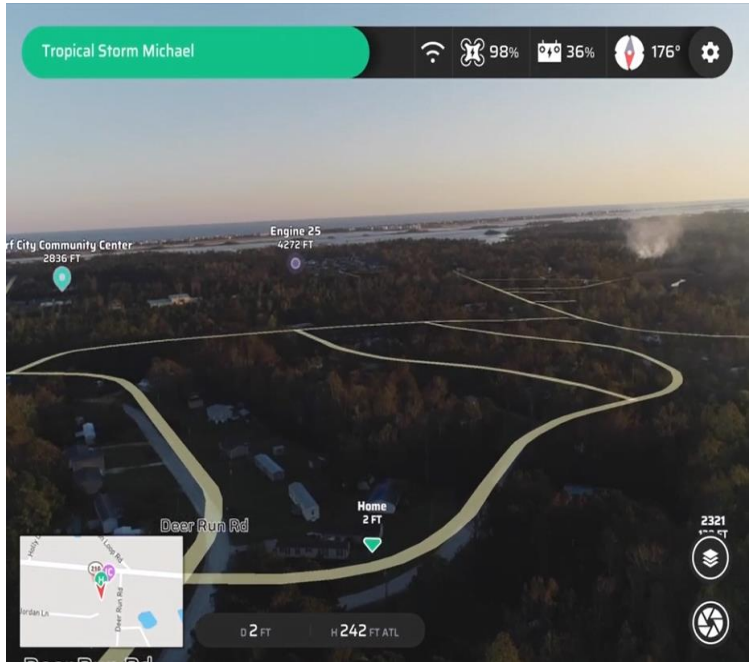


The "Detectives"
Civilian Applications (Growing)

- Policing/border patrols
- 24/7 routine industrial inspection, surveillance, mapping tools through a video-camera drone.
- Disaster response/3d mapping
- Real estate sales.
- **The "Deliverers" of:**
  - Grocery, medicine, AMAZON parcels
  - Refreshments to golfers.
  - Drugs (Criminal use).
- Transportation - evolving

Walmart Drone Delivery

- 30K drone deliveries in DFW since 2021
- 1.8M households

36

Walmart stores in the U.S. have drone delivery hubs operated by DroneUp, Flytrex and Zipline

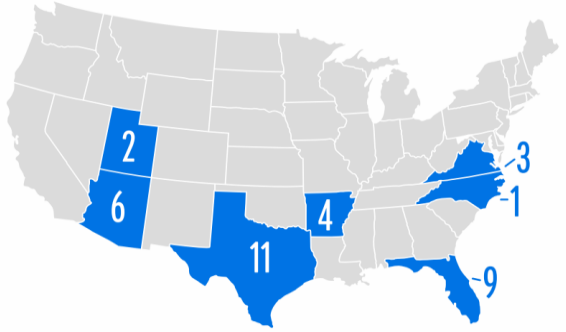
6,000+

Completed drone deliveries in 2022

5

Customer favorites delivered by drones are Great Value Cookies and Cream Ice Cream, 2lb Bag of Lemons, Rotisserie Chicken, Red Bull and Bounty Paper Towels

7 STATES OPERATING DRONE DELIVERY



30

Minutes or less for drone to deliver after ordering

+85%*

Of items in a Neighborhood Market meet the weight (10lb) and volume requirements to be delivered by drone

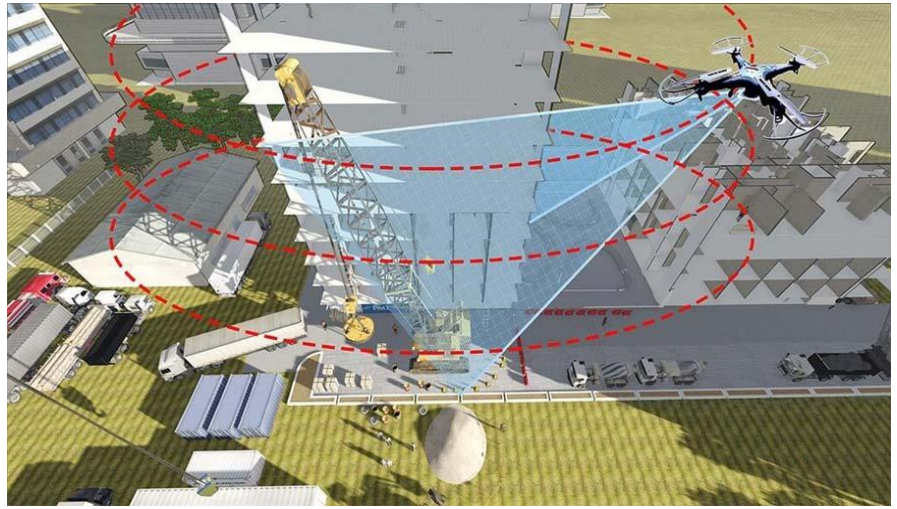
*While 85% of items in a NHM meet the weight requirements, Walmart and its partners currently offer up to 20,000 items available for drone delivery.

4,700

Stores located within 90% of the U.S. population, making Walmart uniquely positioned to offer drone delivery at scale

Walmart

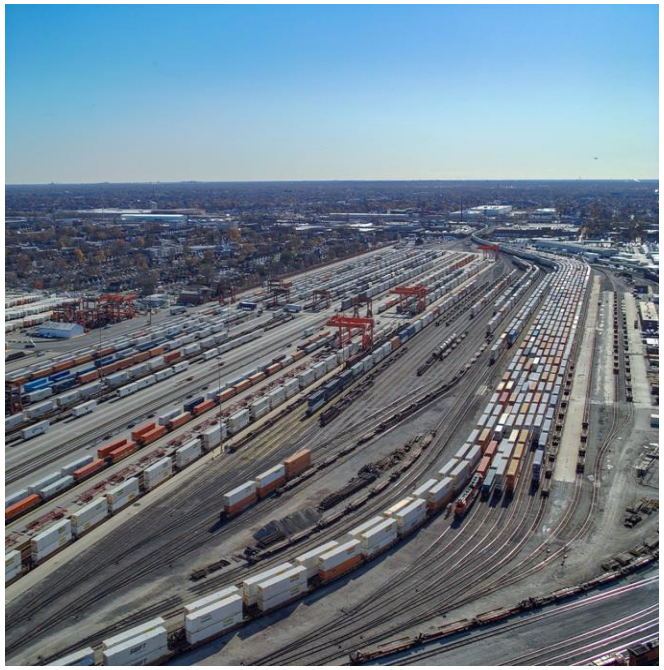
Civilian Applications (Growing)



- **Construction drones**: larger than normal drones, usually approx. 5 lbs., and have an average travel radius of 400 feet or more which allows contractors to be more ambitious with projects over a large space.
- **Safety drones** maintain safety on jobsites. Not only do they monitor jobsites to see potential hazardous areas, but they can detect numerous dangers.
- **Connectivity and Communication**
- **Aerial inspections of jobsites**; can save time and effort needed to manually inspect areas.

Drones shaping future of railroading

One of BNSF's first proof-of-concept **bridge inspection** drones, shown flying near East Glacier Park in Montana during 2015. This aircraft was an AR 180, which tested the effectiveness of both thermal and optical supplemental inspections. BNSF Railway



Routine drone overflight of BNSF's Corwith intermodal facility in Chicago displays how drones are utilized to provide **inventory management**, employee safety, and operational efficiency. BNSF Railway

- UAVs transforming industry into a faster, safer, and more sustainable line of work:
  - engineering-related track conditions
  - service interruptions
  - construction surveying
  - automated inventory of intermodal facilities
  - digital twins of bridges, towers, and other complex structures: Virtual recreations of railway assets for supplemental inspection, inventory, and analysis
  - Movement of right-of-way, change detection, vegetation, encroachment, and security.

Civilian Applications (Growing)

Marut AG 365 drone telanganatoday.com

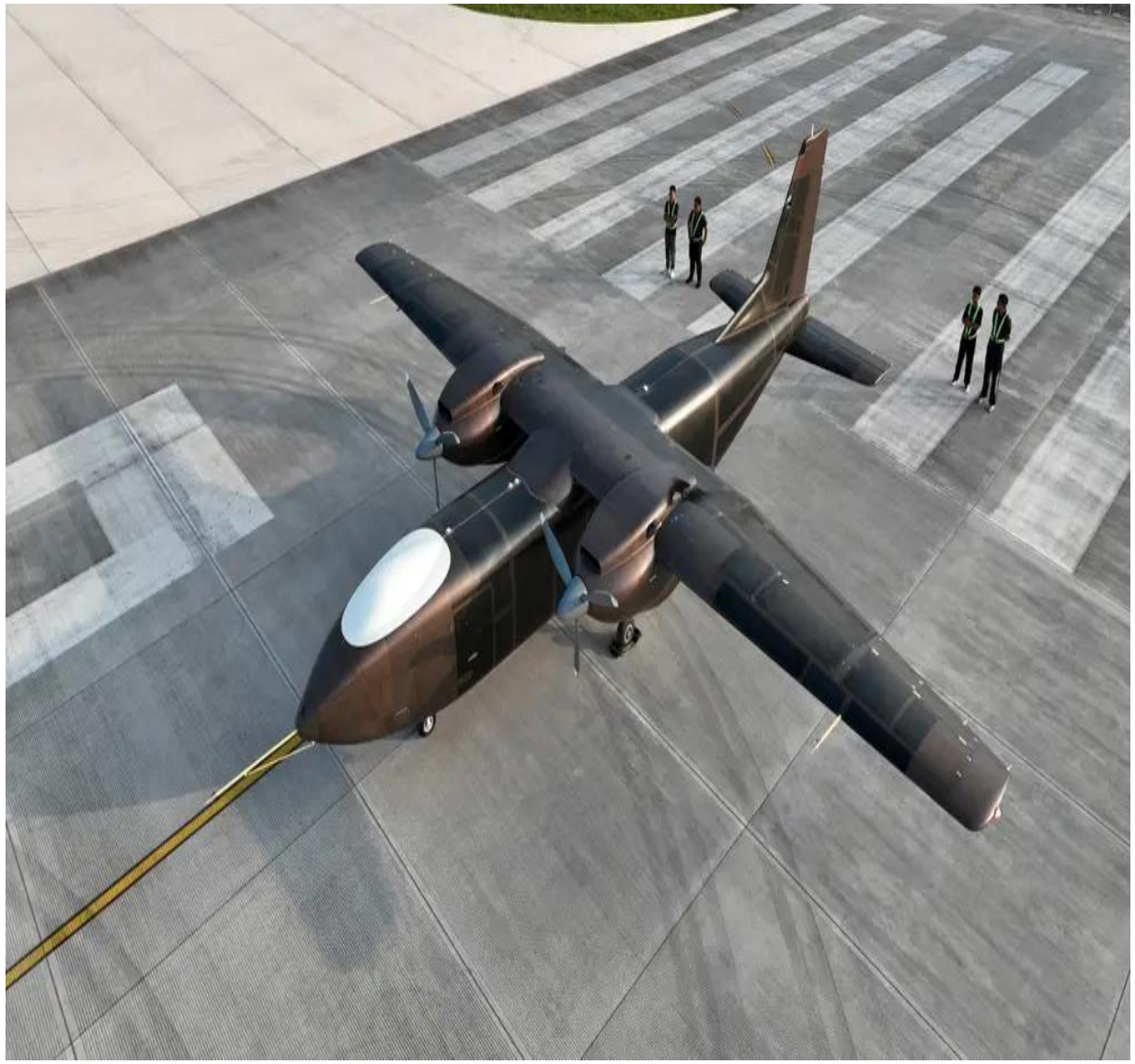
"Marut Drones has…its **vision of advancing agriculture. Manual spraying in agriculture have caused huge negative health impacts on operators**…these sprays is inhumane exposing the operator to chemicals and leading to cancers. A drone entrepreneur using this drone can earn anywhere between Rs.40000 and Rs.90, 000." ($USD 482 to $USD 1085)

- Marut Drones Founder, **Prem K. Vislawath**, 27 Dec 2022

"We have built the first multi-purpose drone. Our AG 365 is similar to tractors and one can do more than just spraying by changing attachment. This will give **better ROI to user and the drone can be used across year for different purposes in agriculture"."**

- Marut Drones Cofounder **Suraj Peddi,** 27 Dec 2022

Cargo UAV



China tested its largest unmanned cargo plane in Zigong, Sichuan province. REUTERS

- China tested its largest unmanned cargo aircraft, capable of carrying 4,400 pounds.
- Maiden flight lasted 20 minutes at Fengming General Aviation Airport in Sichuan.
- This aircraft advances China's "low-altitude economy," projected to be worth $279 billion by 2030.

Nepal to Clean Up Mt. Everest

Discarded climbing equipment and rubbish scattered around Camp 4 of Mount Everest, where decades of commercial mountaineering have left a trail of discarded waste. AFP

- 3 Aug 2024. two Nepalese agencies signed accord with private drone provider to clean-up mountains around Mount Everest.
  - Deal came after a Chinese DJI **FlyCart 30** airlifted 234 kgs cargo in an hour last April, between Everest's 5364m Base Camp and Camp I six kms away.
  - "It would have taken more than a dozen porters six hours to carry out such a task," an official said of the **Flycart**, which is fitted with cameras, radar and can airlift up to 30 kgs in a single sortie.
- Nepal estimates 50 tonnes of frozen trash including tents, oxygen tanks and ropes litter Mount Everest, as well as some 200 frozen bodies.

SAR

- 1 Sep 2024. TI SAR finds 3-year-old in 6-foot cornfield,
  - Fond Du Lac County, WI police locate missing boy in cornfield using TI UAV
- 16 Sep 2024. Little Rock, Ark – 10-year-old Louisiana girl safe after a south Arkansas company assist

Optronic systems

Gyro-stabilised optronic systems that can be delivered either as part of an unmanned aircraft system or as an independent product.

Multipurpose payload AC- 170/30/19T

Multipurpose payload AC-170/30/19T combines at once visual and thermal imaging matrices. This helps to reduce the camera weight and allows to receive twice as large the data during the flight, hence increasing the efficiency of air inspection.

On-board IR camera

Industrial camera with high sensitivity in low light conditions.

Professional thermal imaging camera AC-130/40T

The AC-130/40T possesses a function of real-time temperature measurement and when saving photos of an object each pixel of the picture contains information about temperature.

Multispectral camera

Enables images of the same area in different areas of the electromagnetic spectrum, revealing processes and phenomena that are difficult to detect in a visible spectrum image.

Payloads aerophotographic camera

Aerophotographic camera is designed to capture a series of image frames of the underlying terrain from the aircraft board and saving them on a solid-state recorder

Laser scanner

A device that sends out directional radiation catches the reflected

Radar station with active phased array

PRS provides operation of the system in three key modes:

detected objects in the relative coordinate system in logbooks;
– in the mode "meteo" – a map with place of location of the detected meteorological formations.

Aerial laser scanners

Aerial laser scanners are used for geodetic measurements during geotechnical investigations, surveying, cadastral and land management works.

Methane leakage laser sensor

Methane leakage laser sensor is mounted on the aircraft board while twenty-four-hour flying around of the infrastructure. It is designed for autonomous gas leakages search.

Transport module

The transport module is designed for transportation of cargo by air. The overall dimensions of the transport module may vary depending on the purpose of transportation.

Fire-fighting module

The fire-fighting module is designed for prompt extinguishing of local fires by dropping self-activating extinguishing modules Powder Fire Fighting Automatic Device (PFAD) Sphere FINFIRE. Capacity of the fire extinguishing system: 10 PFAD Sphere FINFIRE.

Multi-Mission

- High-precision aerial photography
- Multispectral photography
- Thermal imaging
- On-line monitoring
- In-line check at emergency situations
- Exploration works

- Firefighting
- Gas leaks
- Aerial LASER geodetic survey measurement
- Aerial LASER space measurement

History

Early Military Employment (Second World War)

Proprietary – Do NOT Copy

“The 3Ds” – Dull, Dirty, Dangerous (c.1944)

Interstate TDR-1 assault drone in flight, carrying an aerial torpedo. (Photo Credit: U.S. Navy/ Wikipedia/ Public Domain)

- Wood stretched over a metal frame
- Twin engines; removable cockpit so could be flown by a human when needed.
- Remote control by pilot in a following TBM Avenger.
- Impressive (c. 1944) technologies make this possible.
  - Television camera in TDR-1 nose, transmitting live feedback to a five-inch screen in the Avenger.
  - Picture quality poor but good enough for the TBM Avenger pilot to see large targets like ships.
- Saw combat July – November 1944

“Machines don’t get tired, don’t get sick, and carry out orders exactly as required.”

History

Recent Military Employment (Cold War)

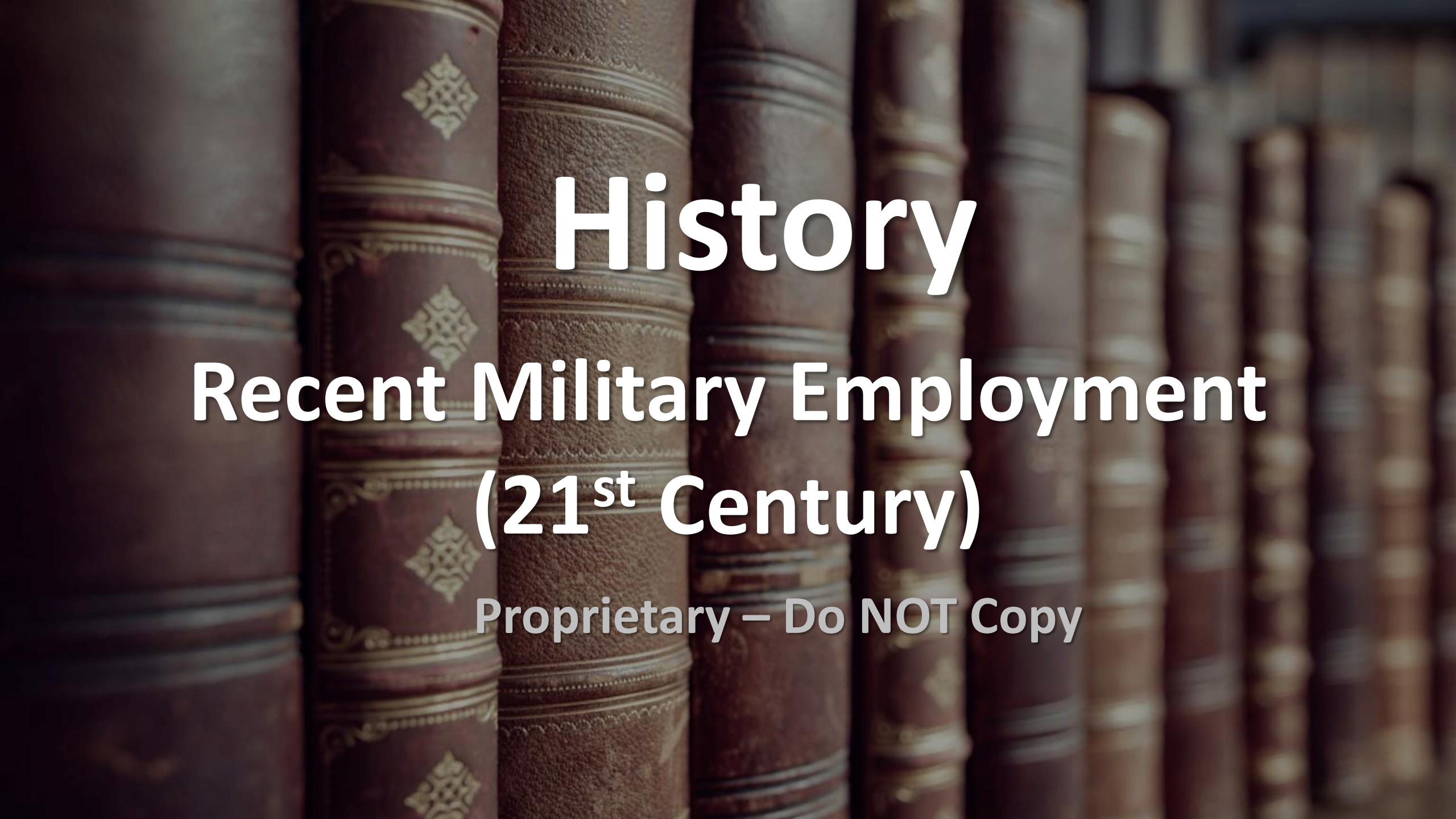
Proprietary – Do NOT Copy

Cold War ISR

General characteristics
- **Length:** 12 ft 2 in (3.71 m) (with booster)
- **Wingspan:** 3 ft 1 in (0.94 m)
- **Diameter:** 1 ft 1 in (0.33 m) (body diameter)
- **Empty weight:** 172.4 lb (78 kg)
- **Max takeoff weight:** 343 lb (156 kg) (with booster)
- **Powerplant:** 1 × Williams International WR2-6 turbojet, 125 lbf (0.56 kN) thrust
- **Powerplant:** 1 × BAJ Vickers Wagtail rocket booster, 5,000 lbf (22 kN) thrust

Performance
- **Maximum speed:** 460 mph (740 km/h, 400 kn)
- **Range:** 37 mi (60 km, 32 nmi)
- **Service ceiling:** 10,000 ft (3,000 m)

- **June 1963**. Sponsored by Canada and U.K., based on Canadair design, to evaluate and test the CL-89 drone, which had been developed by Canadair from the CL-85, a study for the carriage of dispatches. West Germany later joined, and although U.S.A. was invited to join, they declined.
- **November 1987**. Agreement signed between Canada, West Germany and France for production of the CL-289 system, (design started in 1974).
  - Larger with better range and payload than the CL-89. Intended to obtain corps level intelligence for NATO armies.



History

Recent Military Employment (21st Century)

Early Version – In Service 1994-2018

RQ-1 Reconnaissance // MQ-1 Strike

Predator UAV (Air Force)

- First Flight: June 1994
- Over 30,000 flight hours
- System includes: 4 air vehicles, 1 ground station, and 1 communications system
- 12 systems planned

- Sensors: Synthetic Aperture Radar, Electo-Optical/Infrared, Video and Laser Designator
- Max Altitude: 25,000 feet
- Payload Weight: 450 lbs
- Endurance: 24+ hours
  - 14 hours at 400 nm
- Main operating base: Indian Springs AF Aux Field, NV
- Contractor: General Atomics Aeronautical Systems

RQ-1 / MQ-1 Predator

A US Air Force MQ-1 armed with AGM-114 Hellfire missiles

Role	Remote piloted aircraft/unmanned combat aerial vehicle
National origin	United States
Manufacturer	General Atomics Aeronautical Systems
First flight	3 July 1994; 28 years ago
Introduction	1 July 1995; 27 years ago
Retired	9 March 2018 (USAF)[1]
Status	In limited service
Primary users	United States Air Force (retired) Italian Air Force Turkish Air Force Royal Moroccan Air Force
Produced	1995–2018
Number built	360 (285 RQ-1, 75 MQ-1)[2]
Developed from	General Atomics Gnat
Variants	General Atomics MQ-1C Gray Eagle
Developed into	General Atomics MQ-9 Reaper

Military Employment of Drones

Tactical: find, fix, & kill enemy troops

Operational: disrupt enemy cohesion
- attack supply depots and transport hubs

Strategic: cripple enemy population
- destroy enemy power grid, dams, railways

Part 2: +/- 15 minutes

Ukraine Conflict

Advisory

Given the massive scope of the types, rapidly evolving capabilities, and quantities of drones employed by both Russia and Ukraine in the current conflict, **this section is illustrative rather than all inclusive**.

“Necessity is…

The Mother of Invention”

15-Year-Old Drone Pilot – ISR Employment (03:04)

$400 DIY Drone vs. $1m Tank (04:09)

Trench Clearing ROBOTYNE – Sep 2023 (30s)

UACV Strike vs. Russian MBT – 21 June 2024

Proliferation of Improvised Civilian Drones

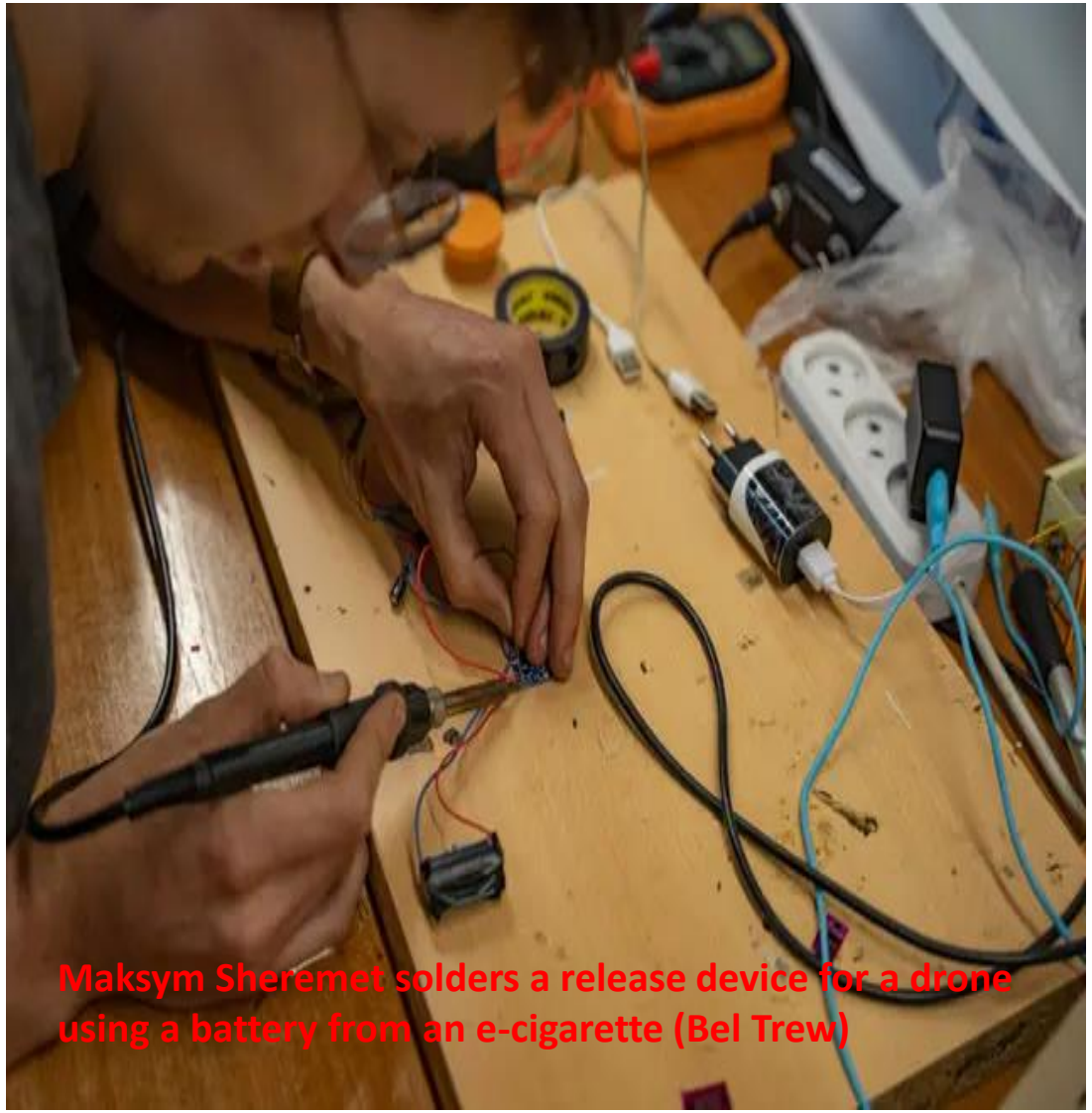
Improvised FPV kamikaze drone assembly in Ukraine. The same approach to building low-cost loitering ... [+]GLOBAL IMAGES UKRAINE VIA GETTY IMAGES

- Assembly is by low-skill workers. While some drones are highly adapted, the simplest are standard racing drones with extra batteries and a warhead attached.
- Volunteer groups in Ukraine and Russia assemble **thousands of these drones every month** in garages/backrooms from components bought from China at a cost of around $400 each.
  - *UA Position* 15 Sept 2023 report: four or five volunteers assemble 15 drones each day.

Civilian Drone Innovation

- Lithium polymer batteries power drone release systems so they can carry/drop items from medical supplies to grenades. Release systems built by 3D printers.
- “We started collecting e-cigarettes after the price of lithium batteries really rose a month ago…Lithium batteries used to cost $1 each but went up five times in price adding significantly to our costs… So we started powering dropping systems from the batteries in disposable e-cigarettes. It’s free, easy to repurpose and environmentally friendly because we are recycling.” (Maksym Sheremet, Drone Lab)

Civilian Drone Innovation



Maksym Sheremet solders a release device for a drone using a battery from an e-cigarette (Bel Trew)

- E-cigarettes have powerful batteries which are designed to be recharged. The disposable devices have no USB charging points and so are discarded sometimes after a single use.
- “You cannot put electric cigarettes in the trash because of the lithium battery, it is a serious fire risk and terrible for the environment…So our plan has benefits for the army, the environment and safety.”

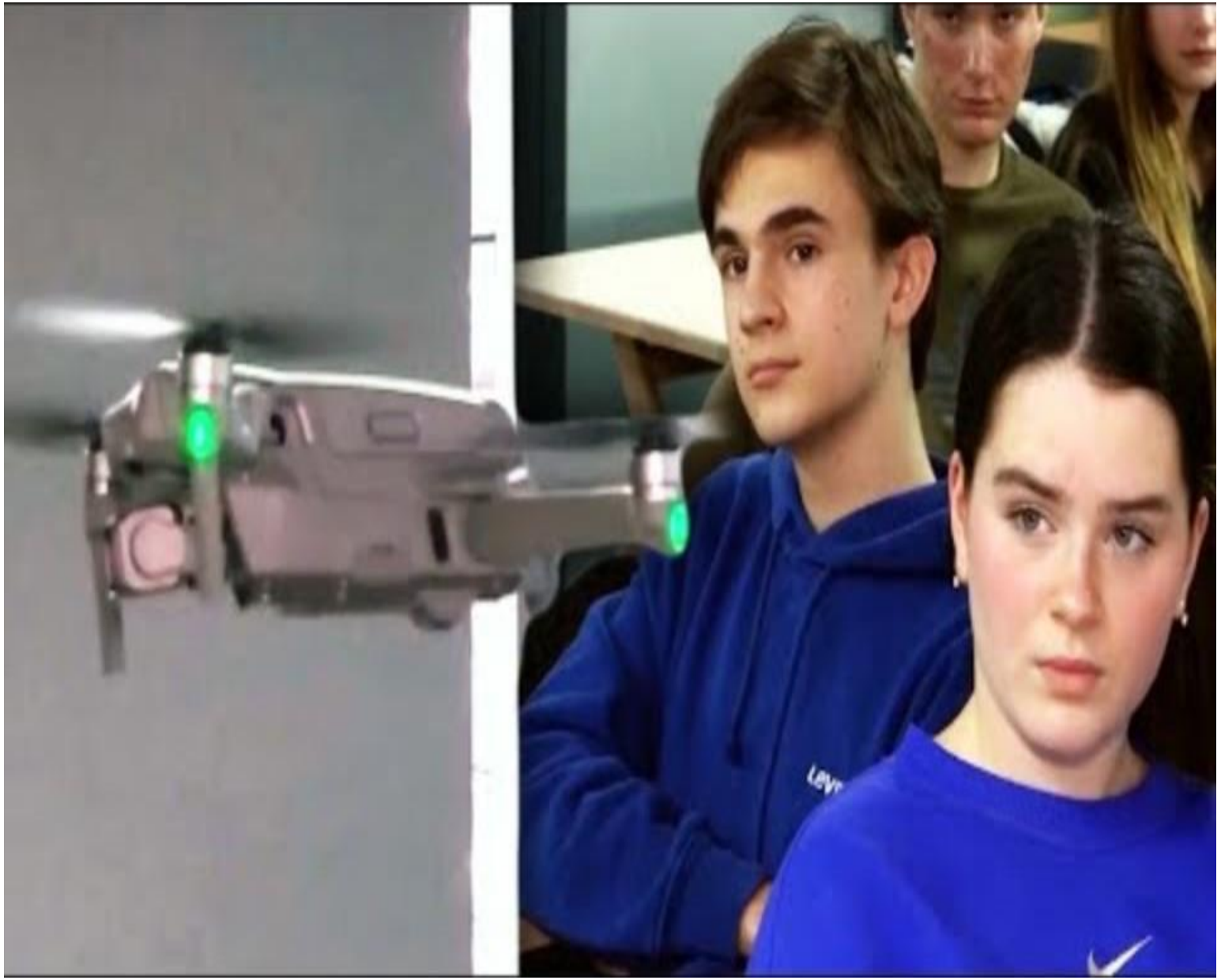
Charitable Drone Donations

https://prytulafoundation.org/en/home/support_page

- Sergey Prytula's Charitable Foundation bought 130 sets of **DJI Mavic 3** and **Air 2S Fly More Combo** quad-copters for the Armed Forces. (@serhiyprytula)
- Crowdfunding

High Schoolers in Ukraine Learn to Operate Drones (1m)

- School is meant to prepare students for the future.
- Lviv, Ukraine. High school students are preparing to live in a country at war with Russia.
- The *Defense of Ukraine* program has been added to the school curriculum at the centers of **National and Patriotic Education**.
- This class focused on how to operate drones, which have been crucial to Ukraine's defense on the battlefield.



Chuck Pfarrer | Indications & Warnings |
@ChuckPfarrer

MAKING LEMONADE: UKR's Minister for Digital Transformation @FedorovMykhailo writes that Moscow's invasion has turned Ukraine into a testing ground for new military technologies that are redefining the art of war, transforming the country into a defense tech superpower.

Ukraine's SHARK: Recon UAV Can Penetrate Hostile Airspace and Adjust HIMARS Fires.

The UKR Shark UAV was developed by UKRSPECSYSTEMS as a secure, long-range reconnaissance platform to spot HIMARS and other precision strike munitions.

The SHARK is designed to penetrate hostile airspace, and is strengthened against enemy Electronic Warfare measures

Maximum flight altitude: 2 km
Wingspan: 1.91 m

30x optical thermal & digital zoom

Secure uplink and downlinks permit targeting at ranges in excess of 60 km
Flight time: >2 hours. Max speed: 150 km/h

APPROX SCALE IN FEET
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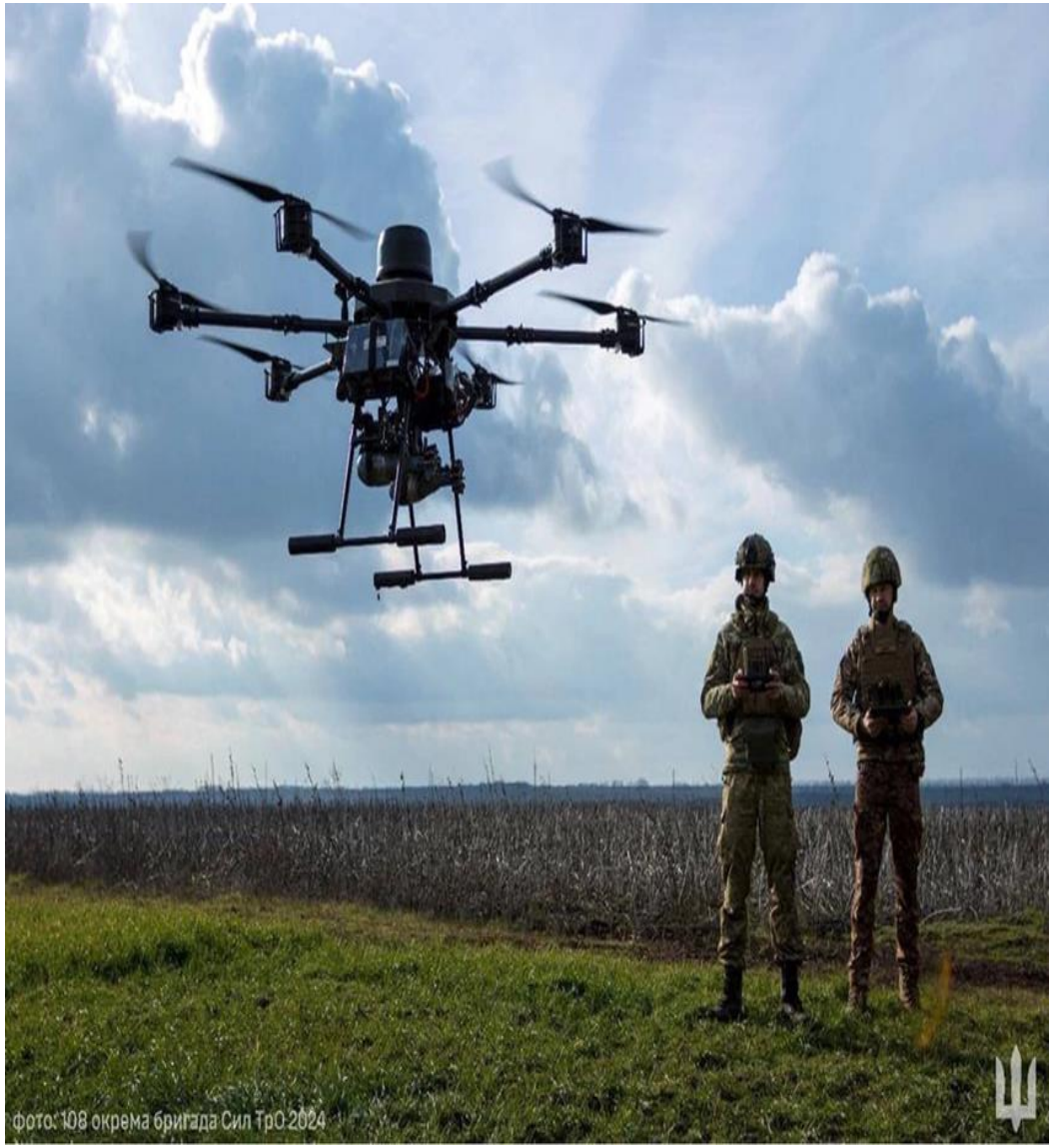
Multi-role SYPAQ PPDS for Ukraine (30s & 30s)

Baba Yaga Mother Ship – Feb 2024



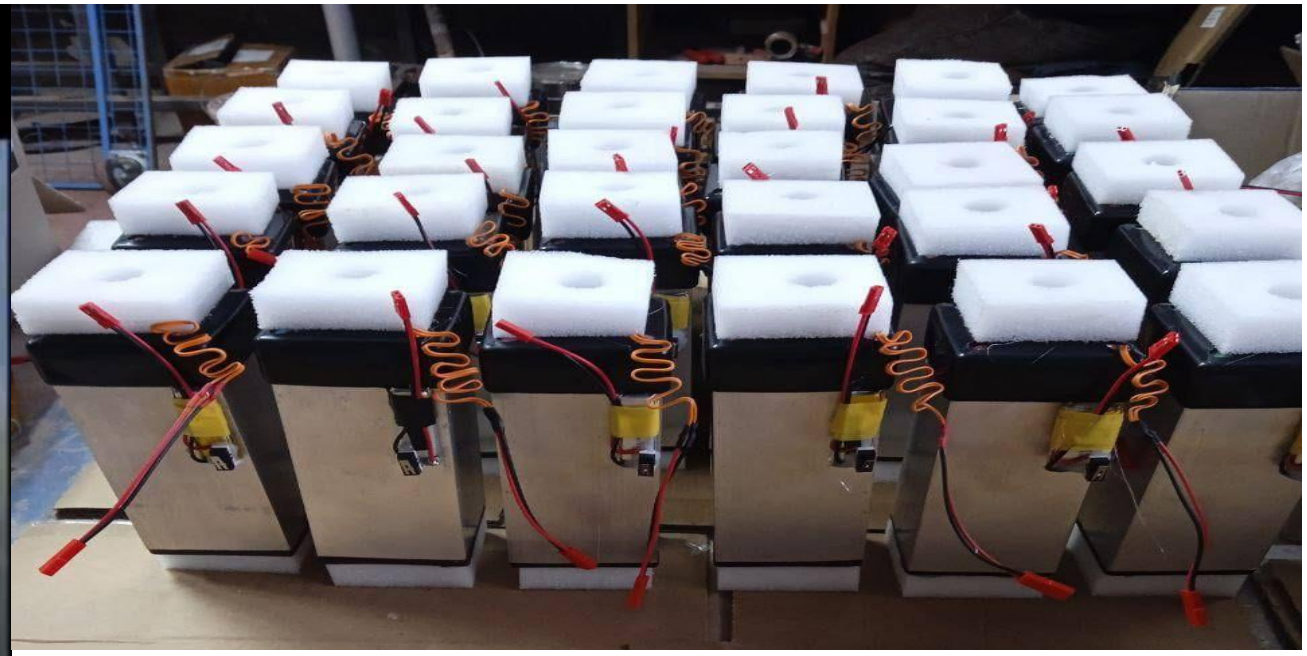
- "They use this giant, agricultural drone, it's the Baba Yaga, they use it as a **repeater,** like a **mother ship, for little FPV drones**, so they fly **into our rear area, 20 or 30 kilometers**, you have to be really careful, it's a very dangerous weapon. It's not easy to shoot them down. They (Ukrainian drone operators) use them most of the time at night, during dark periods of the day. They don't fly so fast but they have a lot of carrying capacity. Like four shots from a grenade launcher. And like I said, **they use them as repeaters to extend the range of the FPV drones,"**
  - Russian soldier to Kremlin-controlled *RIA Novosti* television channel in a report aired Feb. 13.
- Assessed TRL 9

Russian Dolls – Burya -20 Sep 2024

The Admiral, a Russian drone-carrying drone with two FPV drones slung underneath. Russian MoD via Twitter/X

- Mothership for FPV drones.
- Concept. Mothership uses machine vision to detect the target and transmit information to operator, who makes the decision to attack.
- Communication range of Burya-20 70 km from the ground control center.
- Takeoff weight: 50 kg,
- Payload: 15 kg
- Altitude: 3000 m
- Main camera operate effectively at 2000 m.
- Small-scale production.

108th Territorial Defence Bde – “No Chance Company of Strike Drones” (45s)



- Thermite, combustion temp 2400 deg C
- Most powerful 13-inch FPV drones can carry 8 kgs payload to 5 kms
- Typical, 1 kg square metal case to prevent roll

11 June 2024 – Unmanned Systems Forces (USF)

Ukrainian Col. Vadym Sukharevskyi unveils the emblem for the Unmanned Systems Forces in Kyiv, Ukraine. -Natalia Kushnir/ABC News

- "By creating the USF, we began to prepare for the war of the future, not for the war of the past,"

- Col. Vadym Sukharevskyi. Comd USF

- Comd explained that UAF units which already have UAV control units, will **not be subordinated to the new command**, so as **not to disrupt the established system of work and not to create chaos.**

Palianytsia (01:30)

- 24 August 2024. (Independence Day). President Zelenskyy announces Ukrainian forces struck the Russian army in the Crimean Peninsula with the new weapon - a rocket drone named 'Palianytsia.'

Kursk Offensive (6 Aug 2024...

Ukrainian miliary members carry a reconnaissance drone at a position in Ukraine's Sumy region, near the Russian border, on Sunday 11 Aug 2024.
- (Roman Pilpey/AFP/Getty Images)

- "It's a creeping barrage of jammers and drones."

- Journalist David Axe, in newsletter *Trench Art*.

- Unclear how much planning was needed for the Kursk offensive, and also to what degree Ukraine has been able to integrate its drone-and-jamming tactics with planned manoeuvres.

- Nick Reynolds, Research Fellow Land Warfare, RUSI (UK)

- Ukraine launches UACV strikes in Russia ahead of state elections 6-8 Sept 2024 to embarrass President Putin.

“Pontus Interruptus” in Kursk Oblast

SOPA Images/LightRocket via Getty Images

In this image released by the Ukrainian Armed Forces on Sunday, August 18, 2024, smoke rises from what was described as the destruction of a crucial bridge in Russia's Kursk region. (Armed Forces of Ukraine via AP) [-] ASSOCIATED PRESS

- One of most difficult operations in war
  - Unstable banks/current, i.e. maintenance hungry
  - Limited specialist troops reqr
  - Identifiable static fragile chokepoint tgts
  - e.g. May 2022. RF lost BTG Siverski Donets River
- RU face similar difficulties building pontoon bridges SEIM River, Kursk Oblast
- Degree of far bank control needed by crossing force to succeed by reducing direct and observed indirect fire no longer as great.
- **UAS strike well beyond far bank, offer continual ISR, TI sense through smoke obscurants, track unit movement thru RF, AI sense sharp geo-features reqr less human control.**
- **BLUF – RU loses MSRs, limits off/def ops**

Drone Impact Overview

- Ukraine conflict illustrates widescale employment of Unmanned Aerial Systems (UAS) spurring:
  - Widescale rapid expansion of UAS RDTE, industrial innovation, Capability Development; and,
  - Re-assessment networked info management in congested battlespace and in densest part of RF spectrum (8-18 GHz).
- Political fallout re targeting varies and is evolving.

Naysayer? (26 Nov 2022)

- RPAs are very vulnerable when opposed by layered AD, and **would have a limited impact on the battlespace.**
- Must wait for entire context and conditions to become clearer before reaching definitive conclusions.
- Initial observations of UAS employment in Ukraine seem to contradict ACM Chaudhari, however his general point on the need for a detailed evaluation using a mature Lessons Learned (LL) and Lessons Applied (LA) process is valid.

Indian Chief of Air Staff
ACM Vivek Ram Chaudhari

Military LL thus far

1) **Large, hi-tech expensive drones don't last due to:**

   a) Deception – smoke hides target from observers

   b) Electronic Warfare (EW) – disrupt radio emissions essential for communication, navigation and weapon guidance.

   c) Kinetic attack – rocket, gun, laser

   BLUF – the drone employer will exhaust their available supply within months

2) **Quantity has a quality all its own** - Ukraine lost 90% of all drones between February and July 2022 – highlighting the advantage of cheap, simple, plentiful drones

   BLUF – a consistent supply will keep the drone employer in the fight.

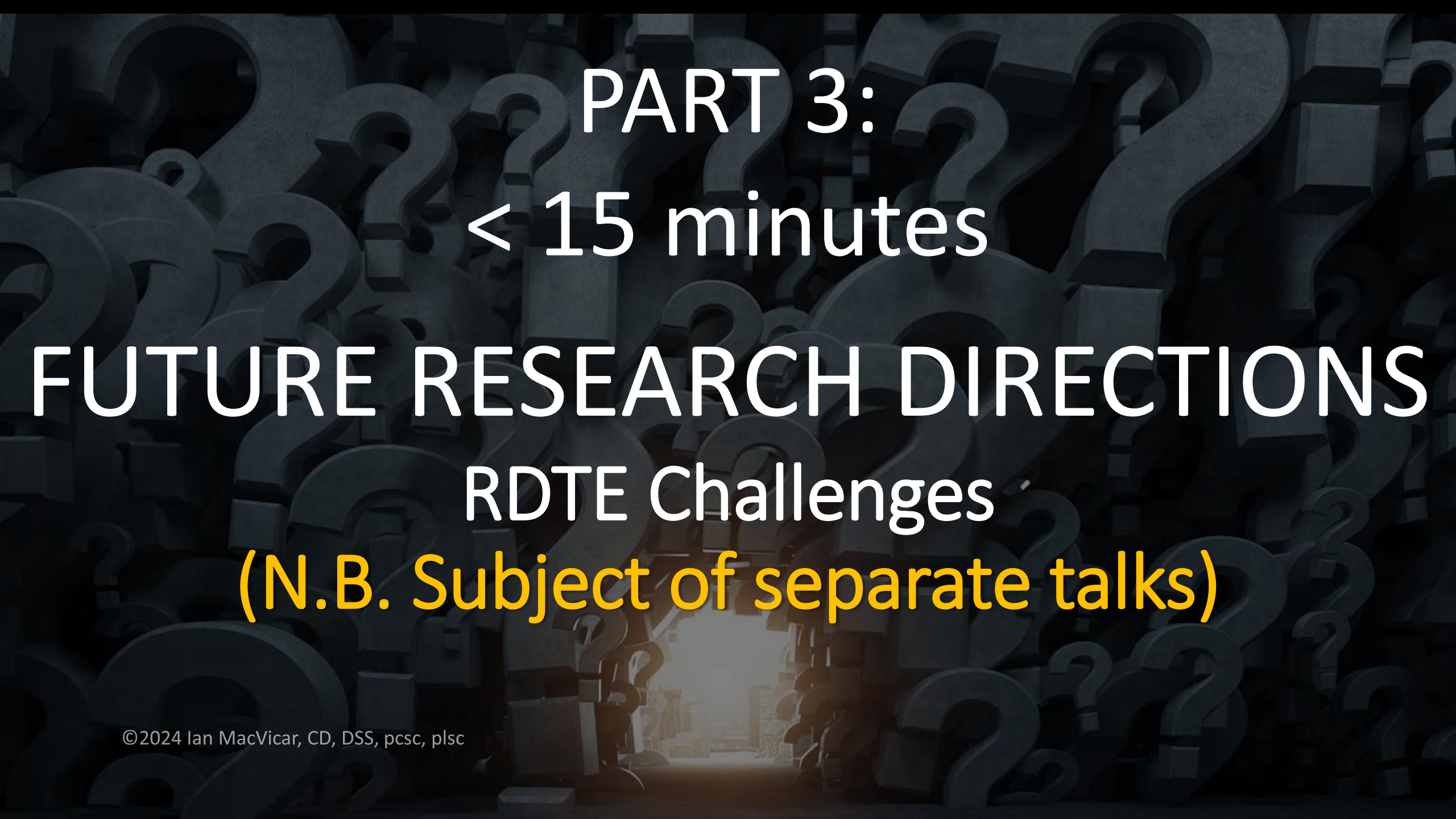
3) **Ease of customization** – is driving rapid evolution

Best Innovators?

"It's easy to sit at the Pentagon thinking that you have great ideas for innovation, but you know who the best innovators are?

- The people who have to innovate or they're going to die the next day. The battlefield innovation that's occurring in Ukraine is unprecedented."

-Andrew Evans, Director Army ISR Task Force

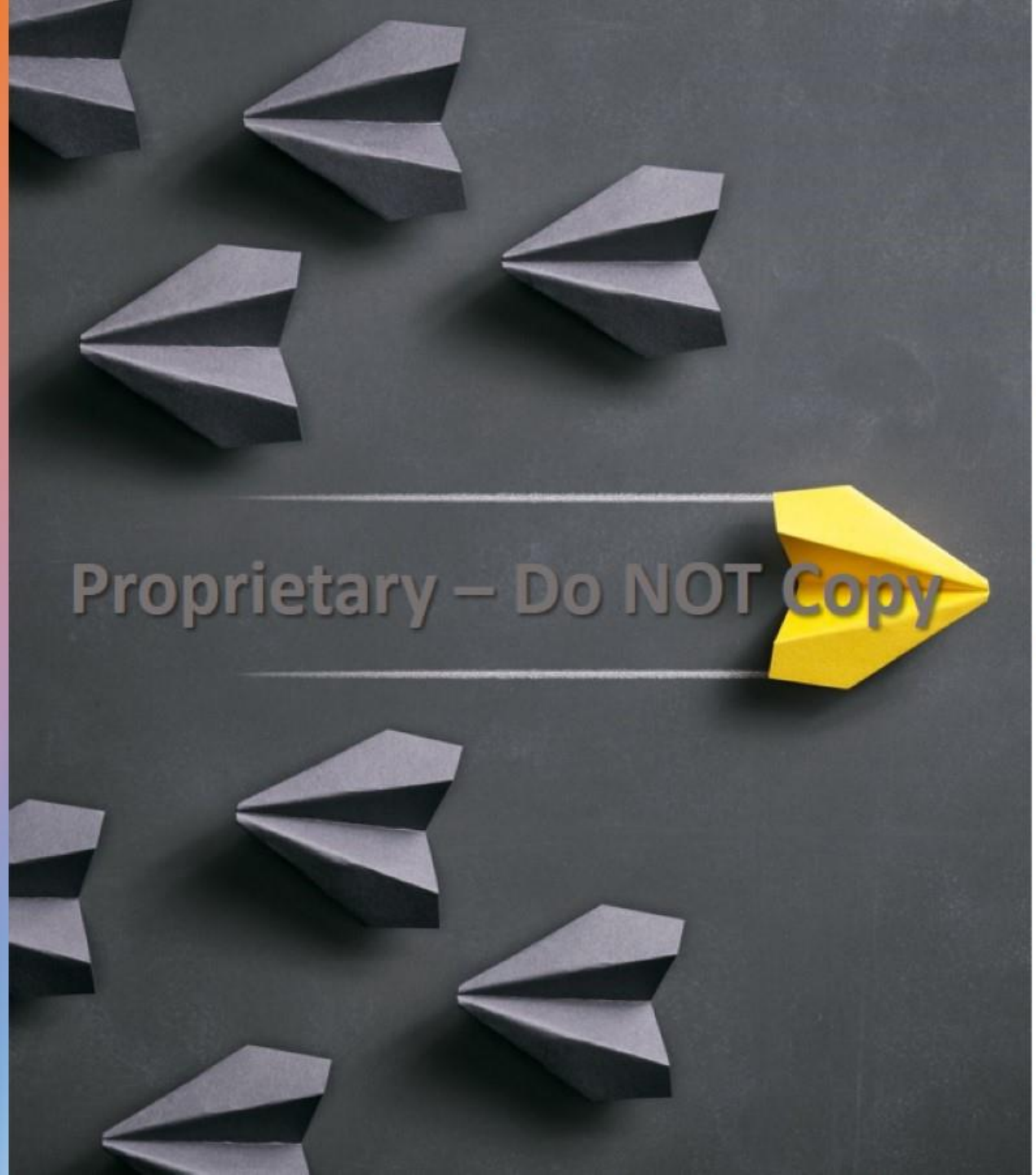


PART 3:
< 15 minutes

FUTURE RESEARCH DIRECTIONS

RDTE Challenges

(N.B. Subject of separate talks)



Flight Domain

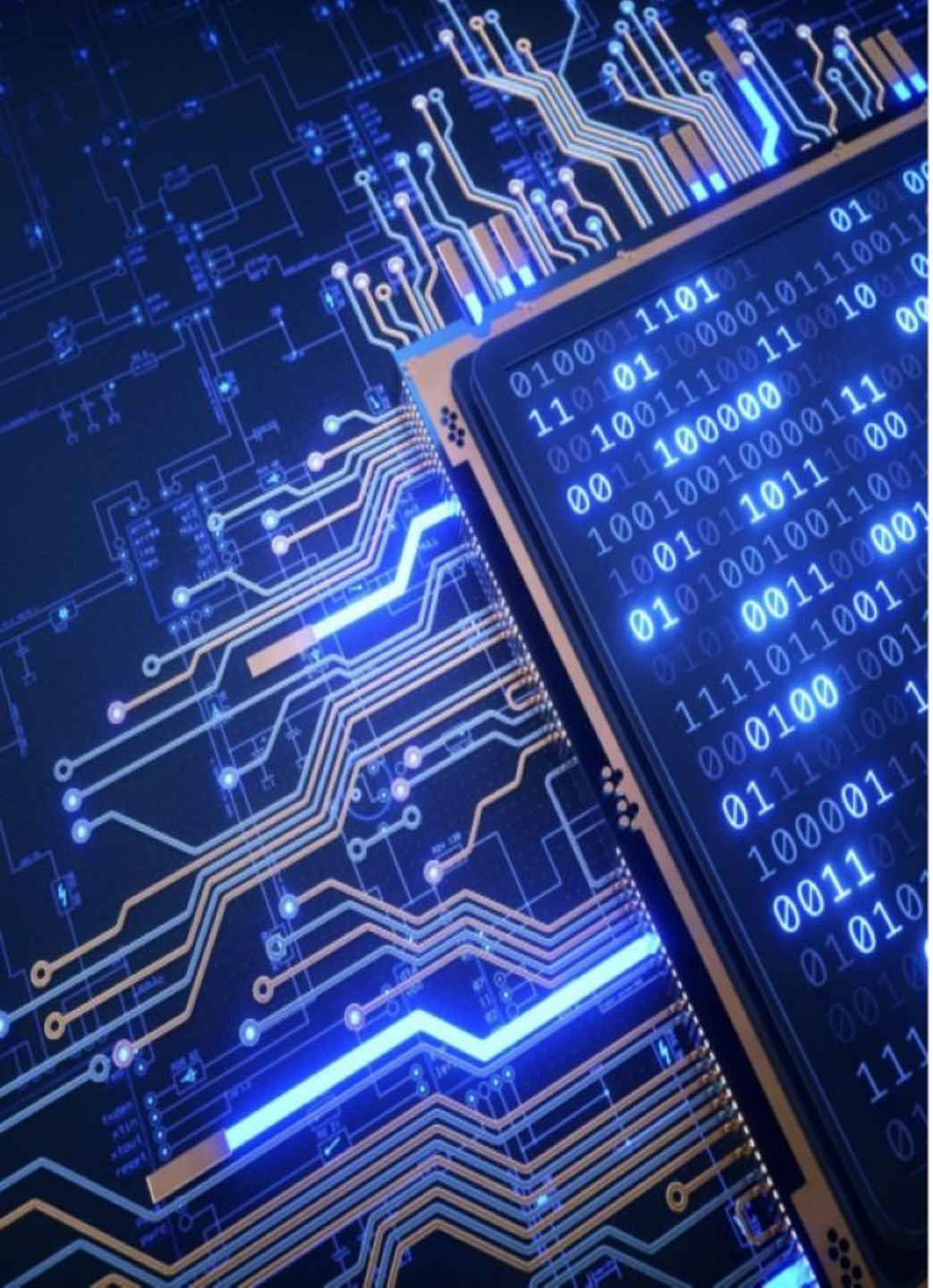
- Wind resistance
- Omnidirectional obstacle sensing
- Remote ID (RID)
- Adaptive morphing engines to reduce air resistance, optimize fuel efficiency, i.e. “scramjet”, or supersonic combustion ramjet engines.

Guidance Domain

- Autonomous drones
- Integrated Wide Area Network (WAN) Systems
- Omnidirectional obstacle sensing
- Self-organizing UAV & Traffic Management
- Remote ID (RID)
- Private ownership of networks, e.g. Starlink and Elon Musk

Autonomous Object Recognition (00:36)

- Facilitates terminal guidance if drone being jammed.
- Expensive, aval on U.S. built *Switchblade 300* ($50K ea)
- Russian *Ovod* (Gadfly) AI
- Ukrainian *Scalpel* ($1K ea)
- Not yet commonplace on low-end systems.
- Possible solutions:
- Freq hopping radios
- Replace GPS with optical navigation



Information Management Domain

- Target triage (i.e. HPTLs) leading to…
- …Information Management in a congested battlespace can overwhelm commanders and staffs with too much information and paralyze decision-making.
- Frequency management working in the densest part of the RF Spectrum.

X Band – 8 to 12 GHz and Ku Band – 12 to 18 GHz

Ex VANGUARD Series (2021…)

Swarming capabilities demo at Ex VANGUARD 2023
U.S. Army photo Aaron Duerk

- U.S. Army to assess **emerging capabilities** for swarming, medium-sized UAS during Ex **Vanguard 2024** Fort Huachuca 8-21 Sep 2024.
  - Autonomous aircraft will be capable of alerting humans to high-priority threats.

"There's what I'll describe as an insatiable demand for airborne ISR collection capability across all the combatant commands."

Andrew Evans

DIRECTOR, INTELLIGENCE, SURVEILLANCE AND RECONNAISSANCE TASK FORCE, U.S. ARMY

Project CONVERGENCE (PC) 2024 Scenario

US Army soldiers with the 101st Airborne Division work inside a command post 22 Aug 2024 during a rotation at the Joint Readiness Training Center. (Breaking Defense/ Ashley Roque)

- How command and control nodes from all five services can **penetrate** an integrated AD system network resembling those currently being used by Russia in Ukraine.
- Then joint force **sustain a land campaign against a hybrid threat** much like the one "you're seeing in living color right now in Ukraine,"
  - Col. Tobin Magsig, Special Assistant to Commander of Army Futures Command.
- Canada an observer

RDTE

Measuring Success

Capability Development Horizons

Technology Readiness Levels

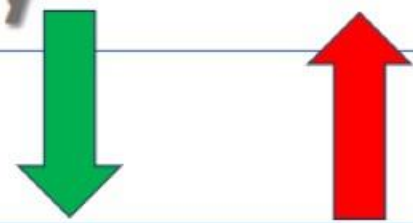
Capability Development Horizons

0 – less than 1 year away

1 – 1 to 5 years out

2 – 6 to 10 years out

3 – 10 to 20 years out



Often a Sliding Scale, – ever dependent on Cost, Schedule and Scope (and $M-$B) in competition with competing needs in a politicized environment

U.S. DoD Technology Readiness Levels (TRL)

TRL 9: System proven through successful mission operations

TRL 8: System completed/qualified through test and demonstration

TRL 7: Prototype demonstration in an operational environment

TRL 6: System/subsystem model or prototype demonstration in a relevant environment

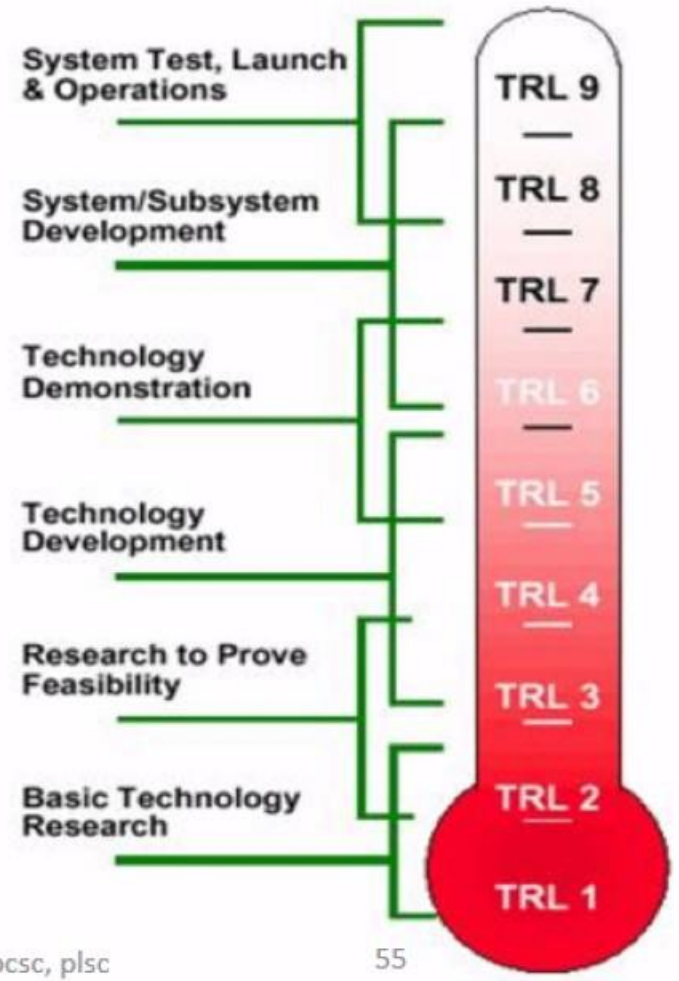
TRL 5: Component and/or breadboard validation in a relevant environment.

TRL 4: Component and/or breadboard validation in a laboratory environment

TRL 3: Analytical and experimental critical function and/or characteristic proof of concept. Active R & D.

TRL 2: Technology concept and/or application formulated

TRL 1: Basic principles observed and reported



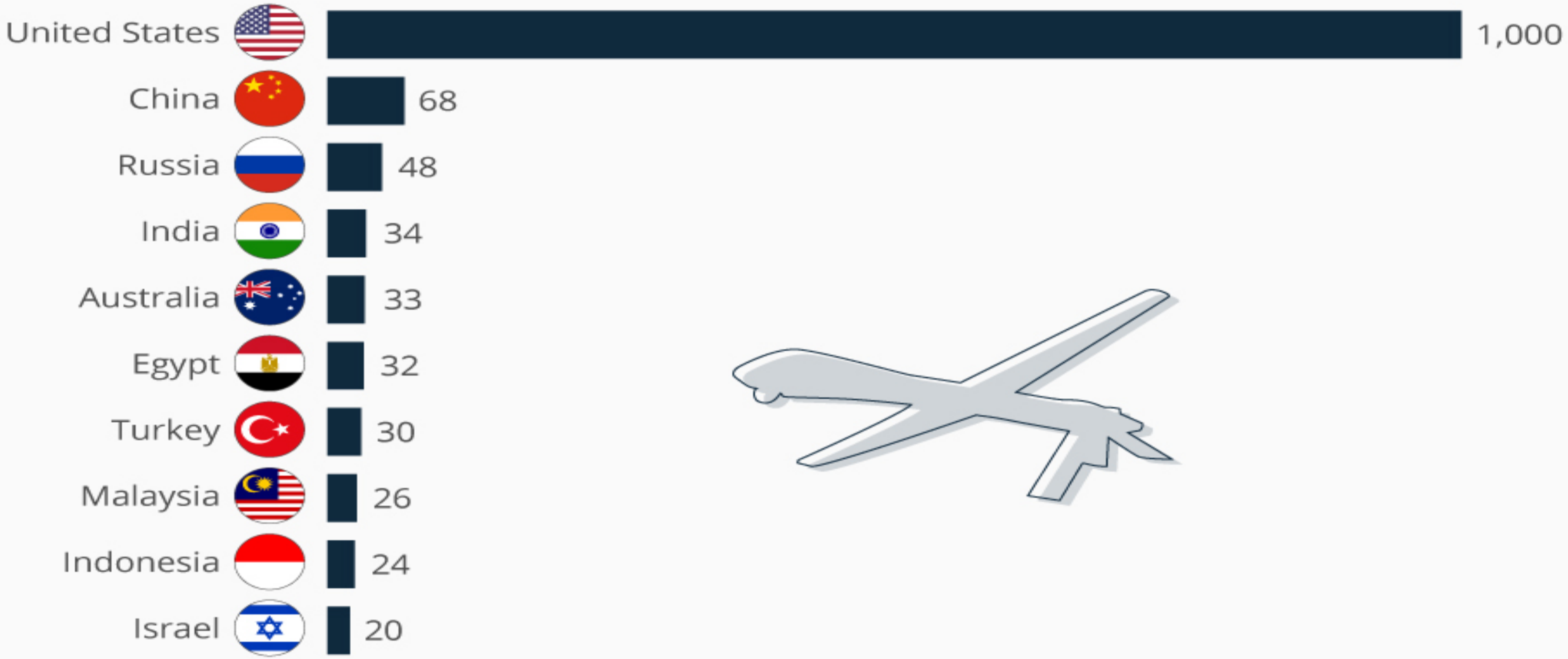
Military UAS

Q. Are we in a drone “arms race”?

If so – do we invest in the sprint, the 5km, 10km, the Half or the Full Marathon?

The Countries Set To Dominate Drone Warfare

Total forecast purchases of weaponized military drones up to 2028



Source: Jane's Markets Forecast via The Guardian

Capability Development

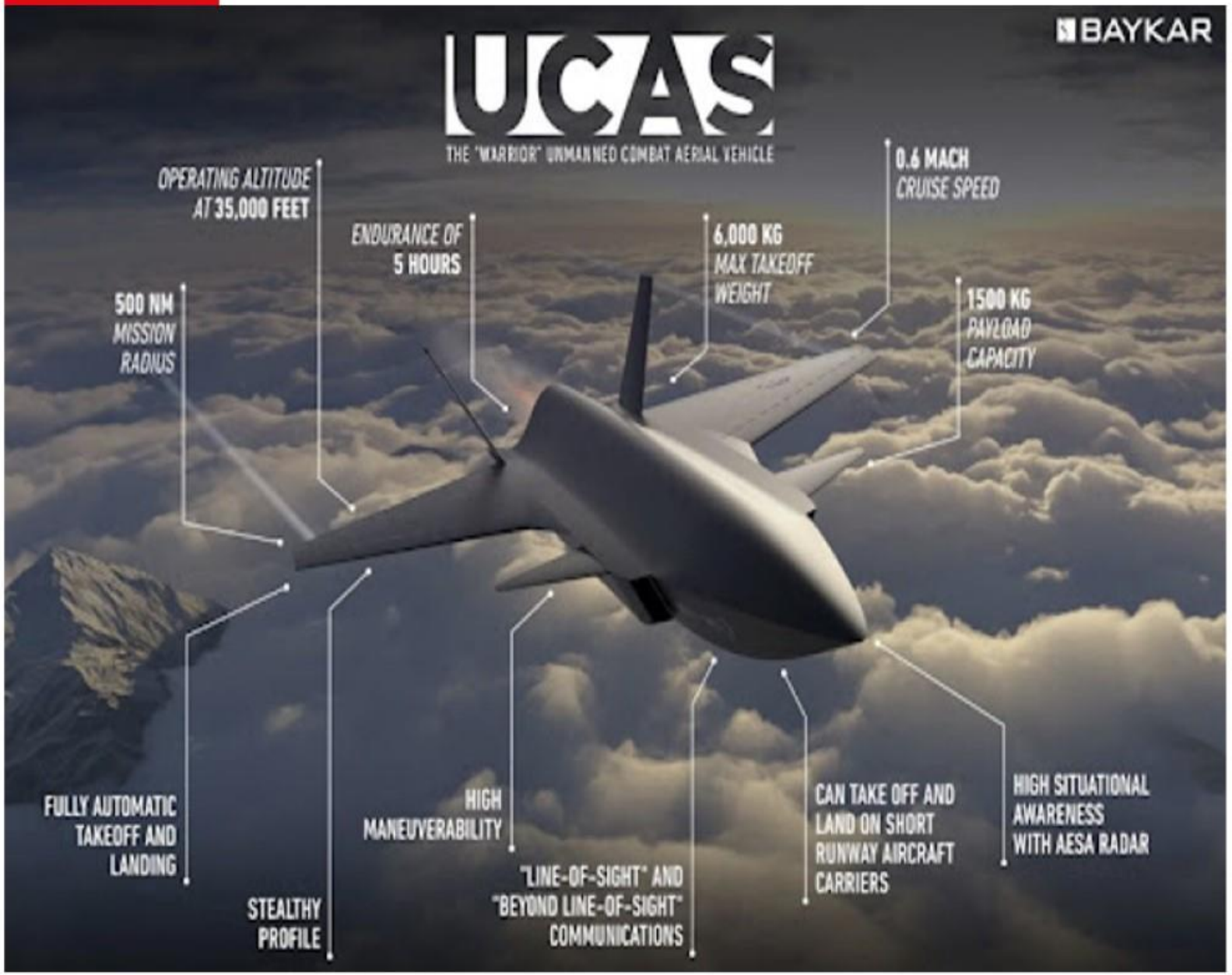
Horizon 0

- "Sprint"

Present to 1 Year

TRLs 8-9?

Kizilelma



- Taxi tests, 22 Nov 2022.
- Turkish media announced that end of November or in early December, first flight of the unmanned combat aircraft.
- Must verify if whether Kizilelma UCAS is able to fly to reach supersonic speeds or Mach 1.
- Quantum leap ahead of quadcopters…
- IOC 2025, assessed TRL 8

Loyal Wingman

Boeing MQ-28A *Ghost Bat* during a high-speed taxi test Australia, 2020

- Boeing MQ-28A ***Ghost Bat*** first combat aircraft designed and developed in Australia in over 50 yrs.
  - First flight: 27 February 2021
  - Introduction: 2024-25 (planned)
  - Range: 3,700 km (2,300 mi, 2,000 nmi)
  - Combat range: 1,700 km (1,000 mi, 900 nmi)
- one role - utilize **Manned-Unmanned Teaming (MUM-T) concept** to support and protect manned Royal Australian Air Force (RAAF) aircraft, such as the F-35A, F/A-18F, E-7A, and KC-30A while they conduct operations.
- Project – 10 UCAV, $A600M
- Assessed TRL 8

MQ-9B SeaGuardian at RIMPAC 2024

MQ-9B SeaGuardian UAS (GA-ASI photo)

"For RIMPAC, the MQ-9B effectively passed ISR&T information to various surface and air units, such as the **Nimitz-class carrier** USS Carl Vinson, **Guided Missile Destroyers** (DDGs), **Littoral Combat Ships** (LCS), **frigates**, **patrol boats, P-8s, P-3s, and numerous other U.S. and foreign units** that took part in the exercise,."

- David R. Alexander, GA-ASI President

- RT ISR&T data feeds to U.S. Pacific Fleet Command Center using SIGINT parametrics and full-motion video to the watch floor and intelligence centers for RT dynamic tasking.
- e.g. internal payload can search ocean's surface and depths in support of Fleet Operations.
- SeaGuardian showcased all operational payloads, including SeaVue, SNC's Electronic Support Measures (**ESM**) solution, an Automatic Identification System (**AIS**), and a self-contained Anti-Submarine Warfare (**ASW**) system.

World's 1st Unmanned Air Warfare Center launched aboard *USS George HW Bush* (CVN 77)

US Navy installing MQ-25 on USS George HW Bush.
US Navy

- Unmanned Air Warfare Center (UAWC) will control future **MQ-25 Stingray** airborne **(tanker)** operations to provide an **aerial refueling capability** that extends the range, operational capability, and lethality of carrier-based crewed aircraft and **Collaborative Combat Aircraft** (UACV).
- IOC on CVNs 70, 71, 76 beginning in FY2025.

U.S. Army Cancels Future Attack Recce Aircraft

The Sikorski Raider X prototype. (Photo: Sikorski/Lockheed Martin)

The Bell 360 Invictus prototype. (Photo: Bell)

- Along with FARA, U.S. Army will end UH-60V Black Hawk program, postpone the Improved Turbine Engine Program production and retire legacy UAS, i.e. RQ-7 Shadow and RQ-11 Raven.
- **Sunk costs**: $2B+, plus more than $500M in contractor funding.
- "We are learning from the battlefield—especially in Ukraine-that **aerial reconnaissance has fundamentally changed."**
  - Army Chief of Staff General Randy George
  - "May be true, or an excuse more of a fig leaf to cover up the Army's troubles in fielding a scout/attack helicopter."

Capability Development

Horizon 1 - "5K"

1-5 Years

TRLs 5-7?

USN Project LOCUST, 2017

ONR - Low-Cost UAV Swarming Technology (LOCUST)

- Office of Naval Research has developed the **Low-Cost UAV Swarming Technology** (LOCUST) program, which fires small UAVs from a tube-based launcher.
- Operation of a swarm is “akin to that of a large flock of birds or insects working under three core principles: **direction, distance and separation.”**
  - Professor Chris Baber, Chair of Pervasive and Ubiquitous Computing, University of Birmingham.

N.B. Barber’s comment refers to the direction they travel (following a leading UAV), the distance to be maintained between members of the swarm and ensuring the separation of each UAV's payload sensor to cover a different area and avoid duplication of coverage (this balance is key to ensuring the swarm works).

Collaborative Combat Aircraft (CCA)

- a.k.a. Skyborg Project
- Unlike conventional UACVs, CCA incorporates artificial intelligence (AI), denoted an "autonomy package", increasing its survivability on the battlefield.
- Expected to cost much less than a manned aircraft with similar capabilities.
- **USAF plans spending $6+B on CCA programs 2023 - 2028.**
- Success of the CCA program may lessen need for additional manned squadrons.
- Elevate role of human pilots to mission commanders

“Maiden flight for the XQ-67A Loyal Wingman – the drone built like a car”(28 Feb 2024)

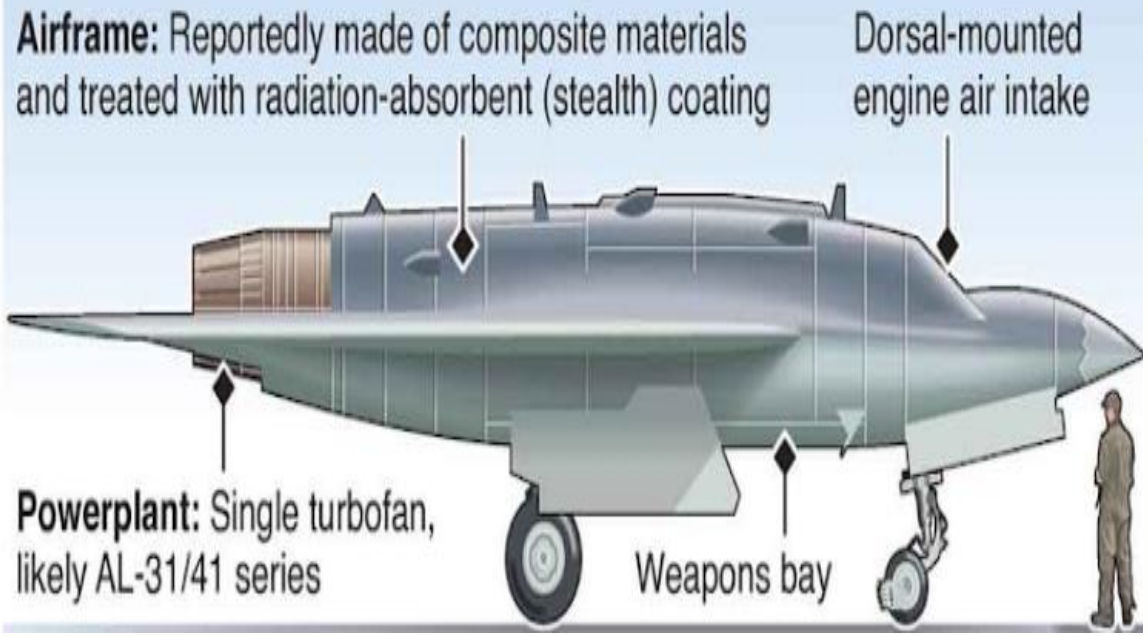
The XQ-67A in flight AFRL

- According to Air Force Research Laboratory (AFRL), first flight of the XQ-67A took place at the General Atomics Gray Butte Flight Operations Facility near Palmdale, California.
- Purpose: general design development and a specific emphasis on the Off Board Sensing Station.
- When the airframe is deemed ready, sensors, autonomous avionics and other systems and payloads (e.g. OBWS) will be installed.

CONSIDER MULTI-DISCIPLINARY DIME-FIL CONTEXT

- Diplomatic
- Informational
- Military
- Economic
- Financial
- Intelligence
- Law Enforcement

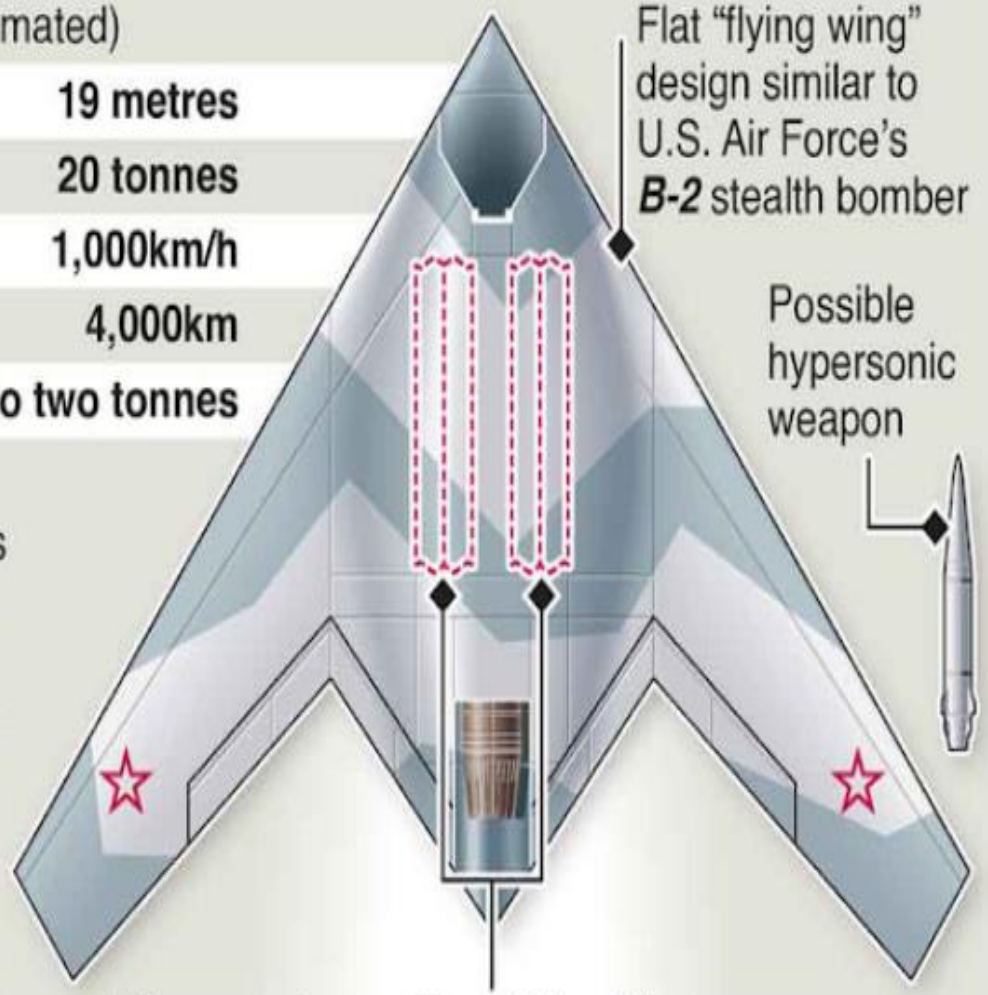
SUKHOI S-70 OKHOTNIK-B (HUNTER-B)



SPECIFICATIONS (estimated)	
Wingspan	**19 metres**
Take-off weight	**20 tonnes**
Maximum speed	**1,000km/h**
Range	**4,000km**
Payload	**Up to two tonnes**

Armament
Air-to-surface missiles and array of bombs carried inside ventral bay or bays to reduce drone's visibility on enemy radar

"Fully robotized" vehicle capable of making independent combat decisions – only requiring human operator to deploy weapons



Weapons bays: Should be able to carry most, if not all, missiles and munitions being developed for Russia's ***Su-57*** multirole aircraft, including hypersonic missile with characteristics similar to ***Kh-47M2 Kinzhal***

Sources: GlobalSecurity, Jane's 360, The National Interest

RF S-70B Okhotnik (Hunter) UACV (Drone)

- Prototype stage – only 2 exist
  - Sukhoi – MiG cooperation
  - 6G aircraft?
- First flight 2019, IOC by 2024
- Stealth advertised, assessed doubtful:
  - Exhaust signature (Thermal)
  - Data gathering capabilities (ELINT)
- Guided air-surface missile tests 2022
- Western sanctions/export controls = Russian companies cannot get parts/ electronics.
  - Likely adverse affect on design, development, and production of S-70B.

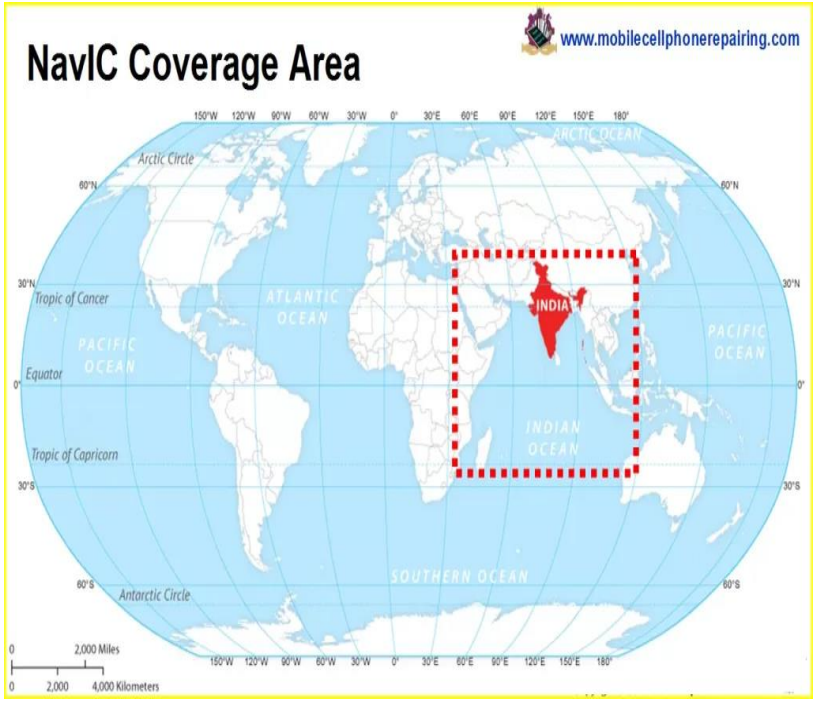
Speed: Unknown
Altitude: Unknown
Range: 6000 Kms to 4000 kms (combat)
Payload: 2K kg, air-surface missiles?

“Russia Buys “Sensitive” Goods From New Delhi Despite Embargo” – 6 Sep 2024

Indian Prime Minister Narendra Modi shakes hands with Russian President Vladimir Putin during talks in Moscow, Russia, July 9, 2024.
Credit: Indian Ministry of External Affairs

- British ***Financial Times*** report:
- Russia and Indian partners trade in dual-use technologies, sanction targets from Western countries.
- Components included parts for “telecommunication, server, and other complex electronic equipment.”
- Indian company, Innovio Ventures, supplied at least US $4.9 m worth of electronics, including drones, to Russia and shipped another US $600K worth of goods via Kyrgyzstan.
- Stockholm International Peace Research Institute suggests that in the last two decades, Russia supplied 65 % of Indian weapons valued at US $60 b.
  - jointly manufacturing the BrahMos cruise missile and plan to produce AK-203 rifles in India.
- “Make in India” policy emph independence...but...

Why NavIC GPS App Was Built



- 1999. Pakistan seizes positions in Kargil. Indian military sought US GPS data for region, but US denied it. Kargil experience made India realize its importance.
- 2007. Indian Space Rsch Org NavIC App Announcement
  - 2012. FOC did not happen due to various constraints. 2013. First of nine satellites sent into orbit.
  - 15 August 2018. PM Narendra Modi announces launch of NavIC App on 72nd Independence Day celebration.
  - NavIC system uses S and L bands, GPS uses L band. IRNSS claims helps NavIC to be more accurate than GPS.
- **Primary Service Area (PSA)**: All India
- **Extended Service Area** lies between PSA and area enclosed by the rectangle from Latitude 30 deg S to 50 deg N, Longitude 30 deg E to 130 deg E.

'Swadeshi' Kamikaze drones (LM)

"India is developing these **fully indigenous** kamikaze drones; they are a game-changing 21st-century new-age war machine.“ (Dr. Abhay Pashilkar, Director NAL)

- Council of Scientific and Industrial Research (CSIR) National Aerospace Laboratories (NAL)
- Range: 1,000 kms
- Payload: 25 kgs
- Endurance: 9 hrs
- Indian NAViC system, UAVs can navigate and acquire targets even in areas where **GPS signals are jammed or unavailable**
  - Indian Regional Navigation Satellite System (IRNSS), officially known as NAVIC, (NAVigation with Indian Constellation).
  - Std Positioning Service & Restricted Service
  - IOC 2013, nine satellites, FOC 2018

India's first indigenous UACV FWD 200B – May 2024

India's first unmanned bomber UAV (Photo/FWDA)

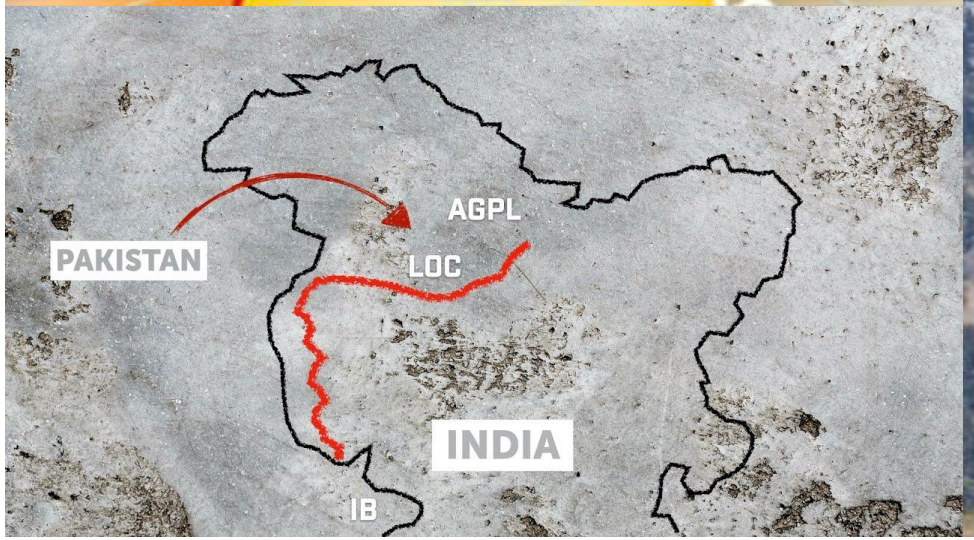
- Launch after setbacks with international suppliers, including Turkey's refusal to sell the Bayraktar UAV and a delay in the US Predator MQ-9 drone deal, and cost just a tenth of imported US drones.
- MALE, MTOW 102 kg, payload 30 kgs,
- Cruise – 12K ft at 152 kph,
- Max alt 15K ft, max speed 250 kph
- Endurance 7 hrs, rge 800 kms
- VSTOL – 300m
- Role – ISR and strike
- Wingspan – 5m, FWDA plans a 12m version

U.S. Sanctions vs. India – 7 Sep 2024

Moscow losing ~$175m (£140m)/day from fossil fuel export sanctions, IAW Centre for Research on Energy and Clean Air study. Major Russian banks also removed from SWIFT international financial messaging system.

- U.S. sanctions on Indian Gotik Shipping Co and Plio Energy Cargo Shipping, for alleged involvement in "Arctic LNG-2" project by Russia's NOVATEK .
  - Part of broader effort to limit Russian LNG exports amid other sanctions.
- Amidst global political tensions, Indian government may face a tough decision: continue cooperation with Russia or consider potential consequences of worsening relations with the West.

Context – LOC Surveillance



- India, Pakistan, China disputed KASHMIR border region
- High Altitude capabilities
- UAS replace human observers

India to obtain MQ-9B October 2024

- India poised to finalize a $3.9 b deal with USA for 31 MQ-9B Predator drones Oct 2024.
- UAV to be assembled locally, with over 30% of components sourced from Indian companies.
- Aim - to enhance India's surveillance and defense capabilities in the Indian Ocean Region and along land borders.

Image courtesy of Edge Hill University and Army Technology

Project ATRACT

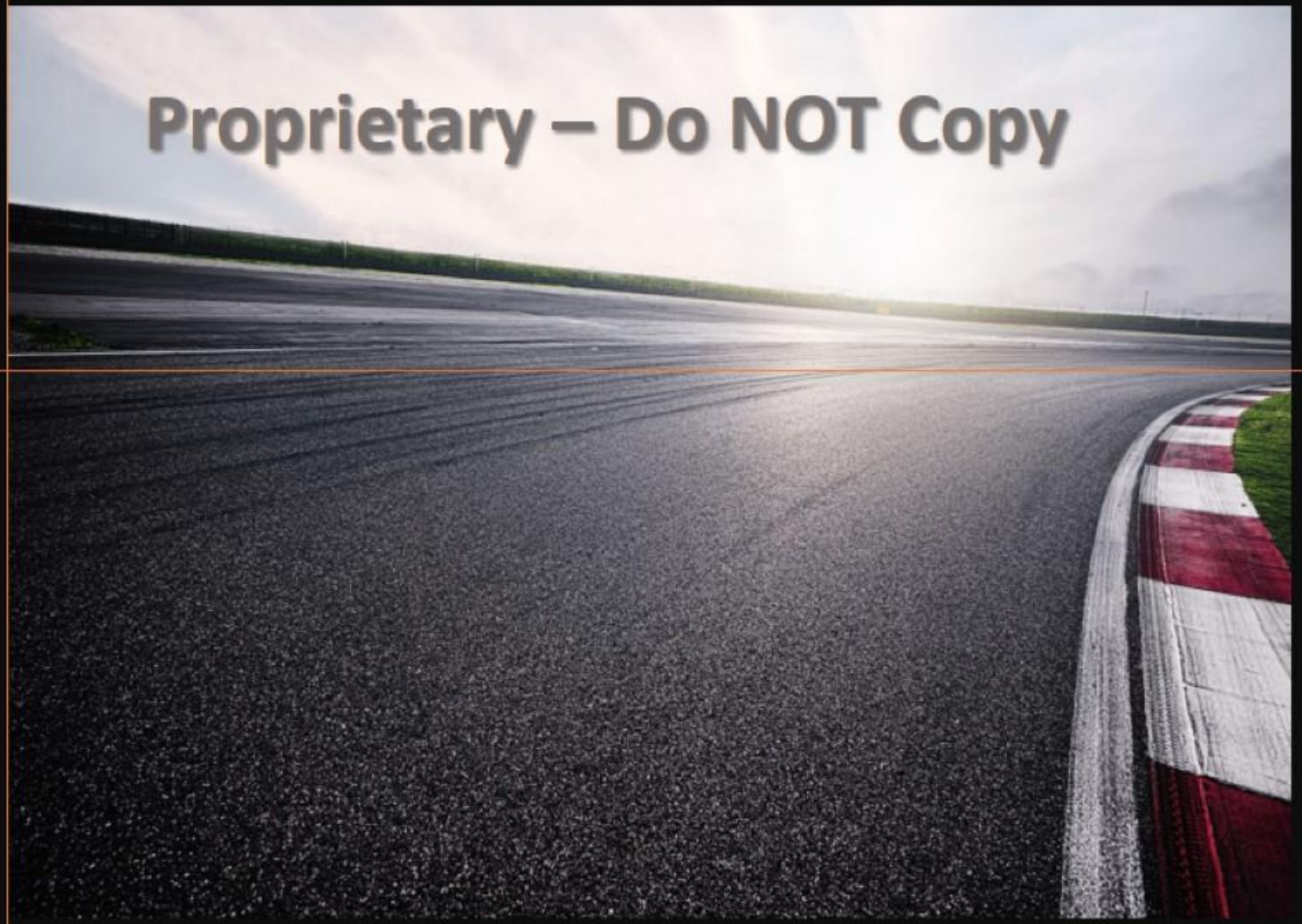
- **Context**: Ukraine conflict illustrates low helicopter survivability
- ***A Trustworthy Robotic Autonomous*** *system to support* ***Casualty Triage***, seeks to create a Robotics and Autonomous System employing aerial drones that can speed up triage in crucial post-trauma minutes that shape survival on the battlefield.
  - **Goal**. Aid first responders in making critical decisions in the "*platinum ten minutes*" post trauma.
- Edge Hill University, supported by Loughborough University, University of Brighton, and University of Portsmouth.
- £850K+ provided by Engineering and Physical Science Research Council of UK Research and Innovation.

U.S. LongShot Program

LongShot Air-To-Air Combat Drone Bid Won By General Atomics © GA-ASI, © Provided by The Drive

- Defense Advanced Research Projects Agency (DARPA) FY21, requests $2M to begin conceptual design work.
- DARPA selects General Atomics to build an air-launchable UAV capable of firing air-to-air missiles as part of its LongShot program.
  - Could give fighters and bombers new flexibility to engage aerial threats across longer distances.
  - General Atomics hopes to begin flight testing before end 2023.
  - First flight tests forecast December 2023
- Assessed TRL 7

Capability Development



Horizon 2
"The 10K"

6-10 Years
TRLs 4-6?

Russia's Loyal Wingman: *Grom* (Thunder)

Grom UAV. 5/5 pic.twitter.com/4dnjP19ZHw
— Michael Jerdev (@MuxelAero) August 12, 2024

- Seen *Army 2024* defense exhibition, Moscow region 12-14 August.
- Delta wing, conventional tail section with horizontal stabilizers and a vertical fin.
  - Fin mounts fairing at the top, perhaps containing satellite communications antenna as found on some business jets,
  - 2nd fairing located root of fin, a far more common feature on tactical aircraft, often containing a landing chute and/or EW gear.
  - Arms: 2K (4,409 lbs), including **laser-, satellite-, and TV-guided bombs and missiles**. Guided and unguided bombs and missiles of 100, 250, and 500 kgs (220, 551, and 1,102 lbs) will form armory, including anti-radiation missiles.
  - Internal bomb bay, four hard points

Lockheed Martin Skunk Works design for USAF and NASA - the X-56A (Model BSE)

X-56A in flight over Edwards AFB
(Image credit: Lockheed Martin)

- Istari Digital Flyer Øne initiative
- Digital model twin can be reliably certified for flight before the physical aircraft is built = new std in RDTE.
  - Digital certification routine in Formula 1 racing, where thousands of digital cars are designed and tested each season without ever being physically built.
- Passed Critical Design Review August 2024
- "It's not as futuristic as it sounds. For a new aircraft variant, if the structure and flight dynamics can be simulated accurately, physical prototypes become the slow lane. **Hardware as software is the fast lane."**
  - Dr. Will Roper, Istari Digital's Founder and CEO

Capability Development

DARPA unveils 6 new ANCILLARY designs

Ancillary design concept renderings, clockwise from lower left: Sikorsky, Karem Aircraft, Griffon Aerospace, Method Aeronautics, AeroVironment, Northrop Grumman. (Image credit: DARPA)

- Advanced Aircraft Infrastructure-less Launch And Recovery (ANCILLARY)
- **Uncrewed VTOL military aircraft**, negate need for a runway, meaning can be launched more easily.
- (Experimental) X-planes able to operate in adverse weather conditions without supporting groundcrew or infrastructure, which would enable them to operate in a wider range of battlefield environments.
- 2026 test flights

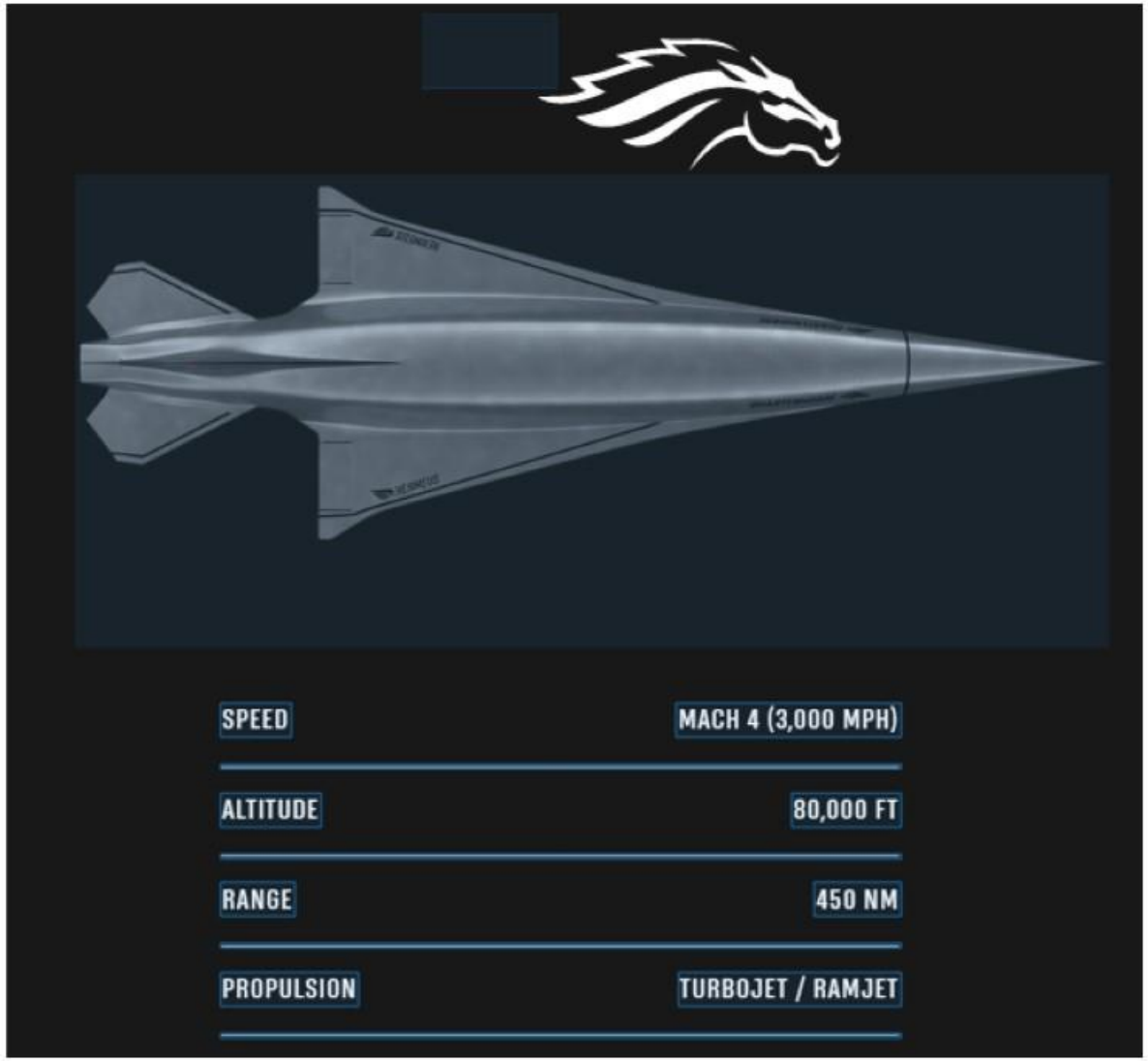
Project REPLICATOR – "Attritable drones"

Deputy Secretary of Defense Kathleen Hicks speaks at the National Defense Industrial Association's Emerging Technologies conference Monday, August 28, 2023 in Washington. (Courtesy NDIA/EPNAC.)

- Response to China's numerical advantage in UAS – in 18-24 months.
- "Replicator will galvanize progress in the too-slow shift of U.S. military innovation to leverage platforms that are small, smart, cheap, and many."
- **AI crucial to "attritable" aircraft concept.**
- U.S. DoD requested $1.8B for AI for FY2024, for more than 685 related projects as of 2021. Replicator intends to pull those investments together and scale production.
- Unknown what types of systems "Replicator" will produce and what missions they will undertake.

ASSESSMENT – TRL 1-2, Horizon 2-3

Hermeus *Quarterhorse*

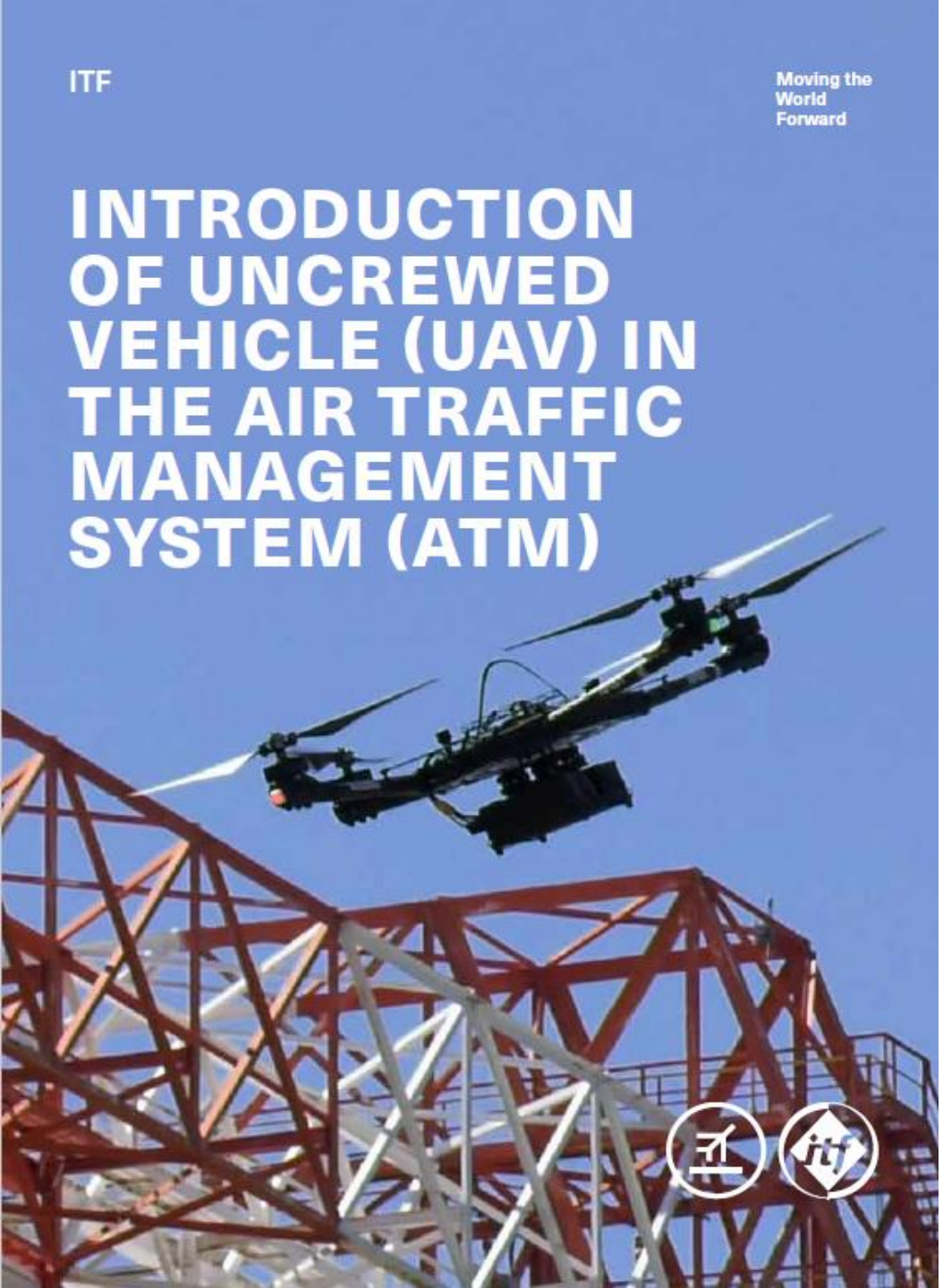


- **<u>Remotely piloted</u>** high-speed aircraft.
- "Sprinting short distances."
- Goal of *Quarterhorse*: to validate *Chimera* engine in-flight and touch **Mach 4 speeds** – breaking the nearly 50-year-old airspeed record held by the legendary SR-71.
- Anticipated flight 2024

Proprietary – Do NOT Copy

Hermeus *Darkhorse*

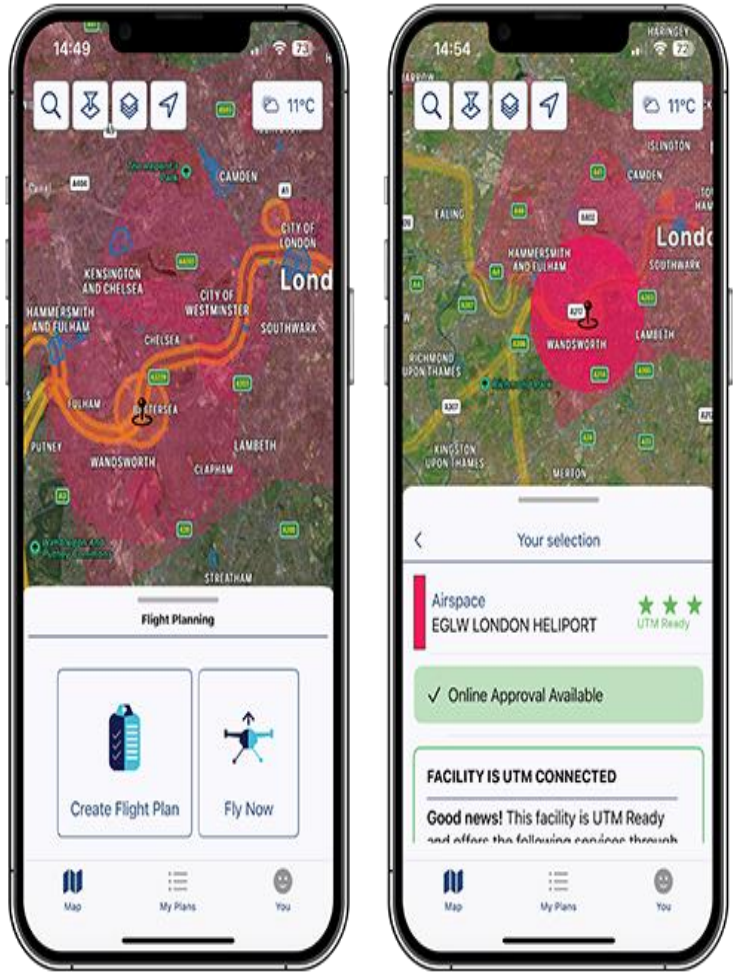
- Hypersonic UAS for defense and intelligence customers.
- Multi-mission flexibility/fully reusable.
- Major technological leap. Sustained hypersonic flight is a capability that no other country in the world has.
- Anticipated flight 2025.

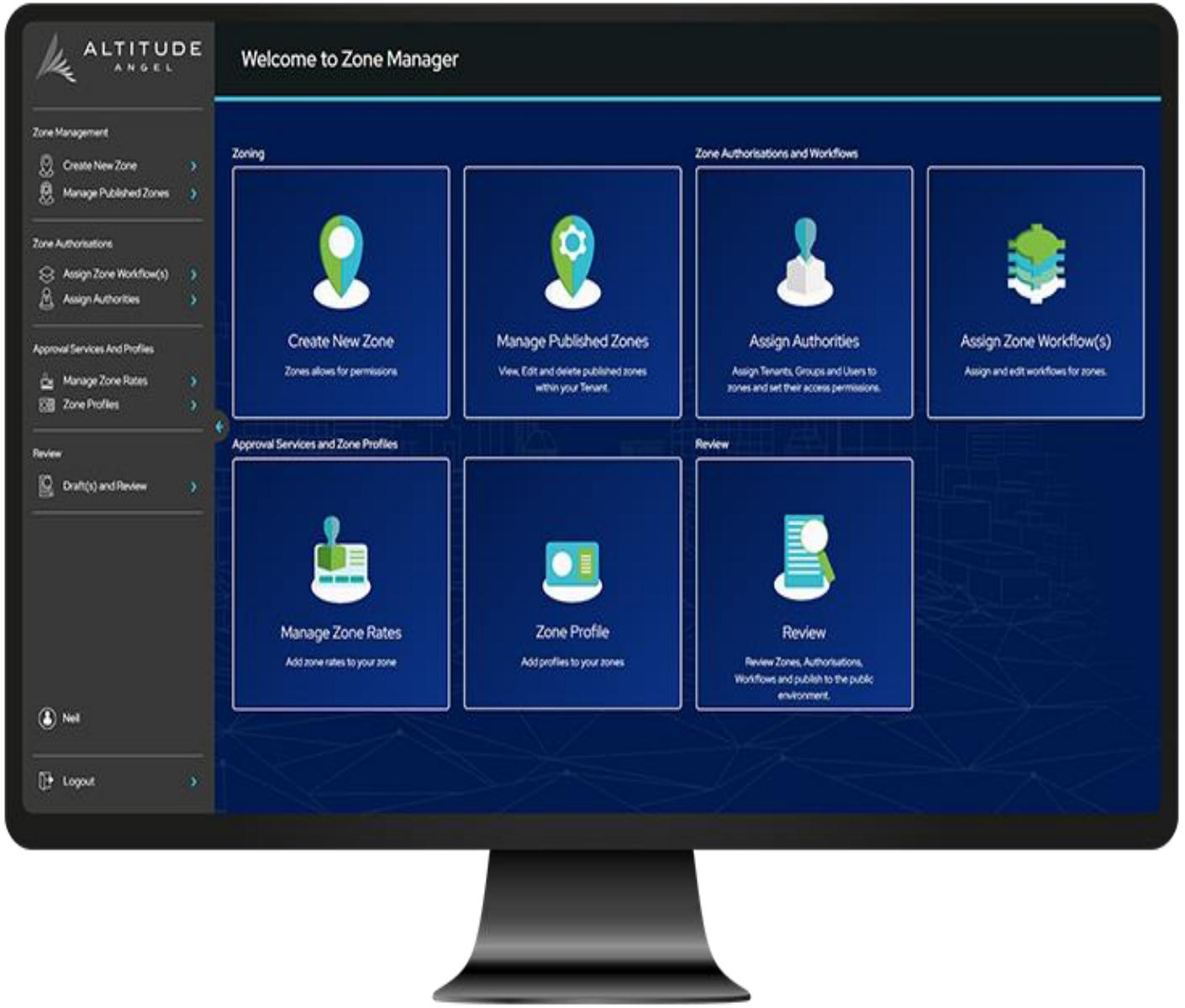


UTM - Uncrewed Traffic Management

a.k.a. “unmanned”

GuardianUTM - cloud-based SaaS solution





US National Public Safety cUAS Hub – March 2024

- Air domain awareness top DHS priority (DHS cUAS analyst) **Mary Rupert**.

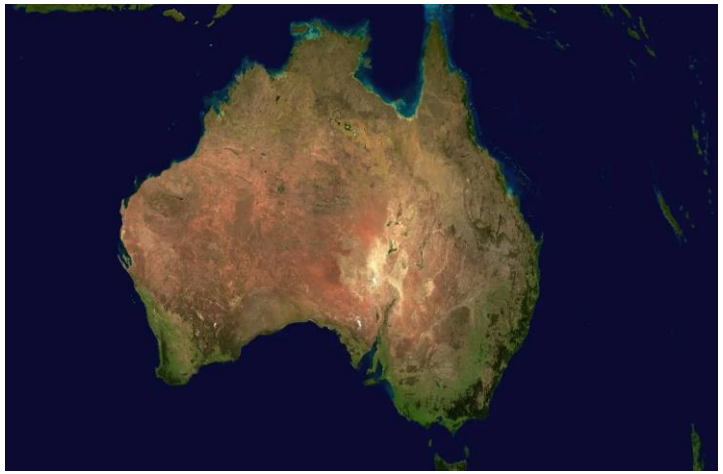
"We cannot set our security network up without **UTM** and airspace awareness… How can we protect our airspace if we can't even see what's out there?"

Re dark drones (disabled RF):

"It's always going to have to be a layered approach… There's no one thing that will detect all drones… and you need to also look at tools that show crewed aircraft." (**Tom Adams** cUAS Hub Co-Architect)

A layered approach implies multiple technologies: ground-based tools **like radar, acoustic tools, and software that can put all of that information into an understandable format.**

Frequentis to create UTM for 60M drones by 2043



- Air Services Australia est. from 2024 of 1.5M/ann
- **Frequentis Australasia** to create Flight Information Management System (FIMS) core of Australia's Uncrewed Aircraft Systems Traffic Management (UTM) ecosystem.
  - Enable Airservices to share flight information between ATC, aircraft, and UAS airspace users.
- "Frequentis is the only company worldwide to have successfully delivered UTM solutions to multiple Air Navigation Service Providers. This strategic partnership with Airservices Australia represents another important milestone in our mission to support the Australian airspace ecosystem with safe, efficient and compliant integration of drones while fostering innovation and economic growth." (Martin Rampl, Managing Director, Frequentis Australia)

airservices australia

FREQUENTIS

FOR A SAFER WORLD

PART IV

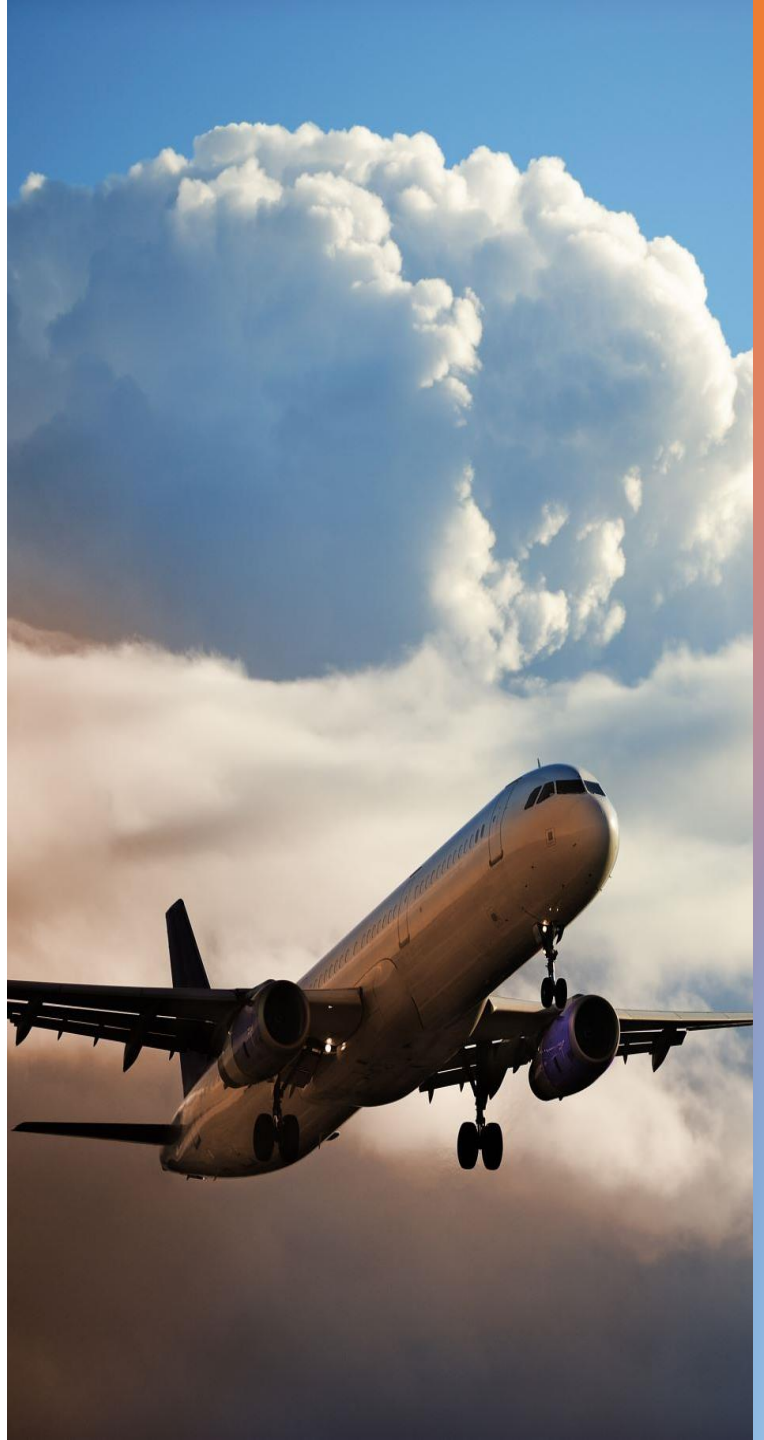
IMPLICATIONS FOR CANADA

AND FOR THE CAF

YOUR INPUT IN Q &A svp!

Transport Canada Definitions

- **Unoccupied Aircraft System.** A UAS is a power-driven aircraft that is designed to fly without a human operator on board and all of the equipment and personnel necessary to control the unmanned aircraft (e.g., a drone).
- **Class 1 Unoccupied Aircraft System**. A Class 1 UAS is a UAS weighing between **250 grams and 15 kilograms.**
- **Sub-micro Unoccupied Aircraft System**. A sub-micro unoccupied aircraft system is a UAS **weighing 250 grams or less**.



Drone site selection tool:

https://nrc.canada.ca/en/drone-tool/

- **Drone Site Selection Tool** loads the map data for all of Canada simultaneously, and renders it using the **Google Maps API**.
- FAQ 1. If an area is not covered by a coloured shape is it legal to fly my drone there?
- Not necessarily. The Drone site selection tool shows known locations of airports/ heliports and airspace on its map. The legality of a particular operation may be influenced by the laws of several jurisdictions, including municipal, provincial, property access rights, and privacy etc...
- The operation of a remotely piloted aircraft system (RPAS) in accordance with this web-tool **does not imply** the operator is compliant with Transport Canada's regulatory requirements.

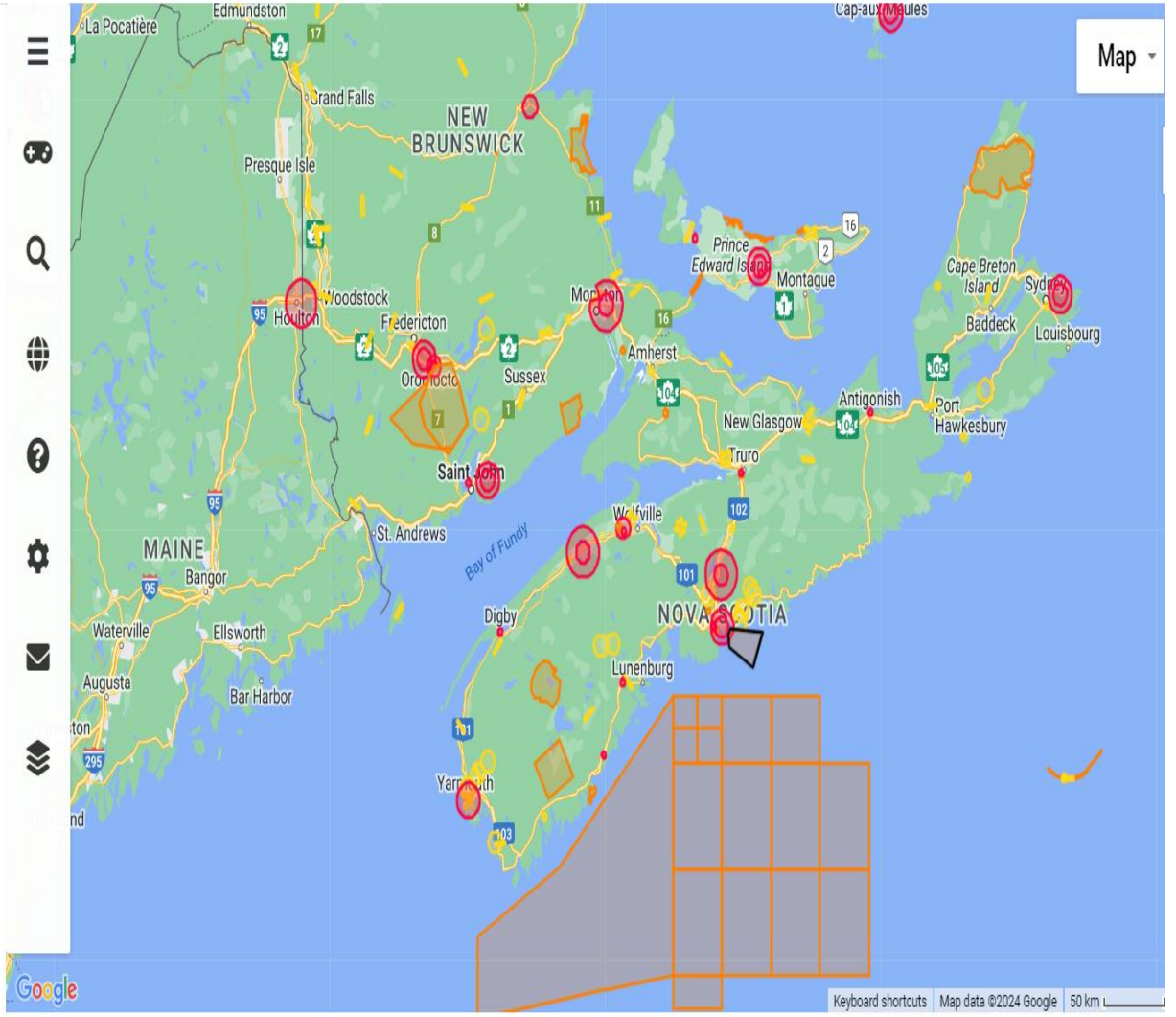


Image description - Map: Drone site selection tool

▶ Image description - Map: Drone site selection tool

Civilian UAS-CE, ALMA, QC -2019

UAS CE main building.

- **Qualia Pre-Qualification Centre** in Alma, Saguenay–Lac-Saint-Jean region:
  - $1.6m pre-qualification training
  - RPAS R&D, training & qualification test site
  - Quebec's Aerospace Strategy 2016-2026 to develop the drone sector and its civilian applications.
  - 5,000-foot paved runway, automated weather information system, navigation systems and other drone testing facilities.
  - UAS-CE has access to one of the only areas in Canada where drone flights can be conducted beyond visual range(BVLOS).

RPAS Traffic Management

2021 - VLOS

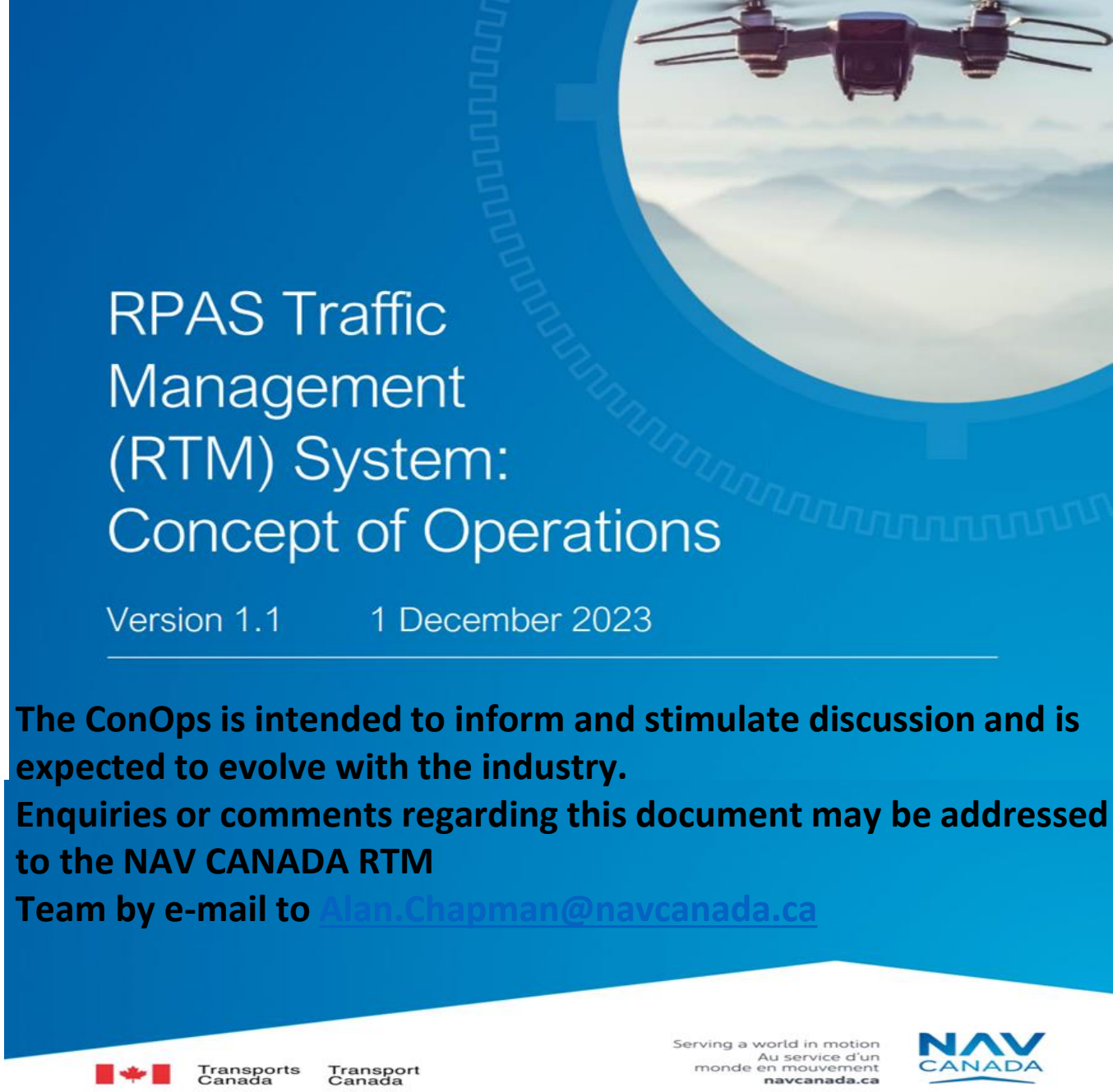
- Operators fly their drones within visual line of sight (VLOS) with the help of NAV Drone, which lets them access important information, schedule flights, and request permission to fly in controlled airspace.
  - Commercial uses, e.g. direct delivery of consumer goods, long-range inspections and land surveys, and even the rapid transport of life-saving transplant organs.
- Larger drones that carry necessary navigation, communications and surveillance equipment can generally integrate into existing air traffic management (ATM). **Small and low-level drones, however, pose very different challenges.**

2024+ - BVLOS

- To prepare for this, NAV CANADA is developing drone traffic management services to monitor drone operations and ensure **safe integration with the Canadian aviation ecosystem**.
- ConOps 1.1 1 Dec 2023 released:
  - This document is a starting point, and will continue to evolve, but it already gives a clear image of what the future might hold.

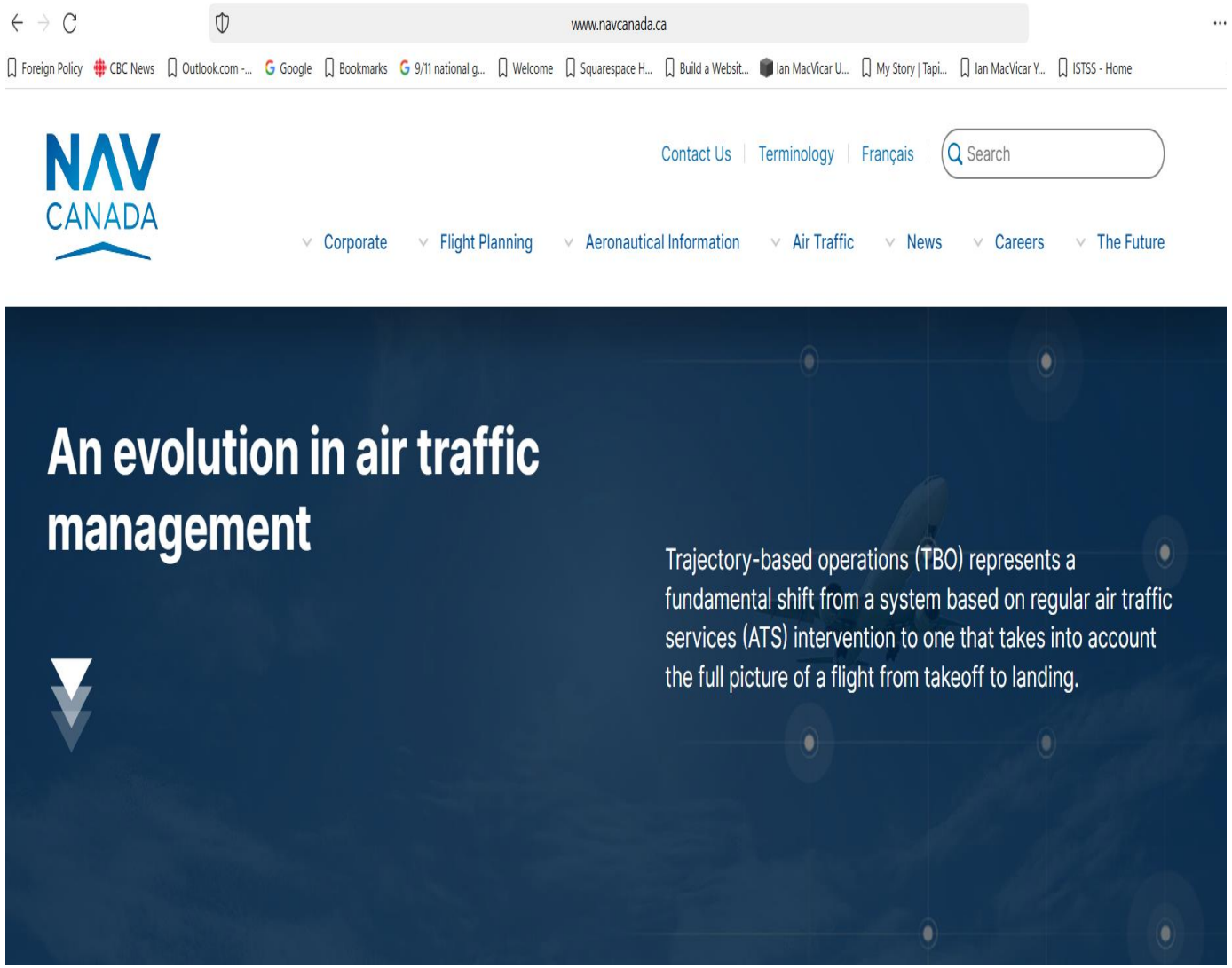
External Governance

- Public perception
- Socio-cultural norms and values
- Legislation and regulations
- Funding agency requirements
- Scientific and peer review
- Ethics and privacy review



Trajectory-based operations (TBO)

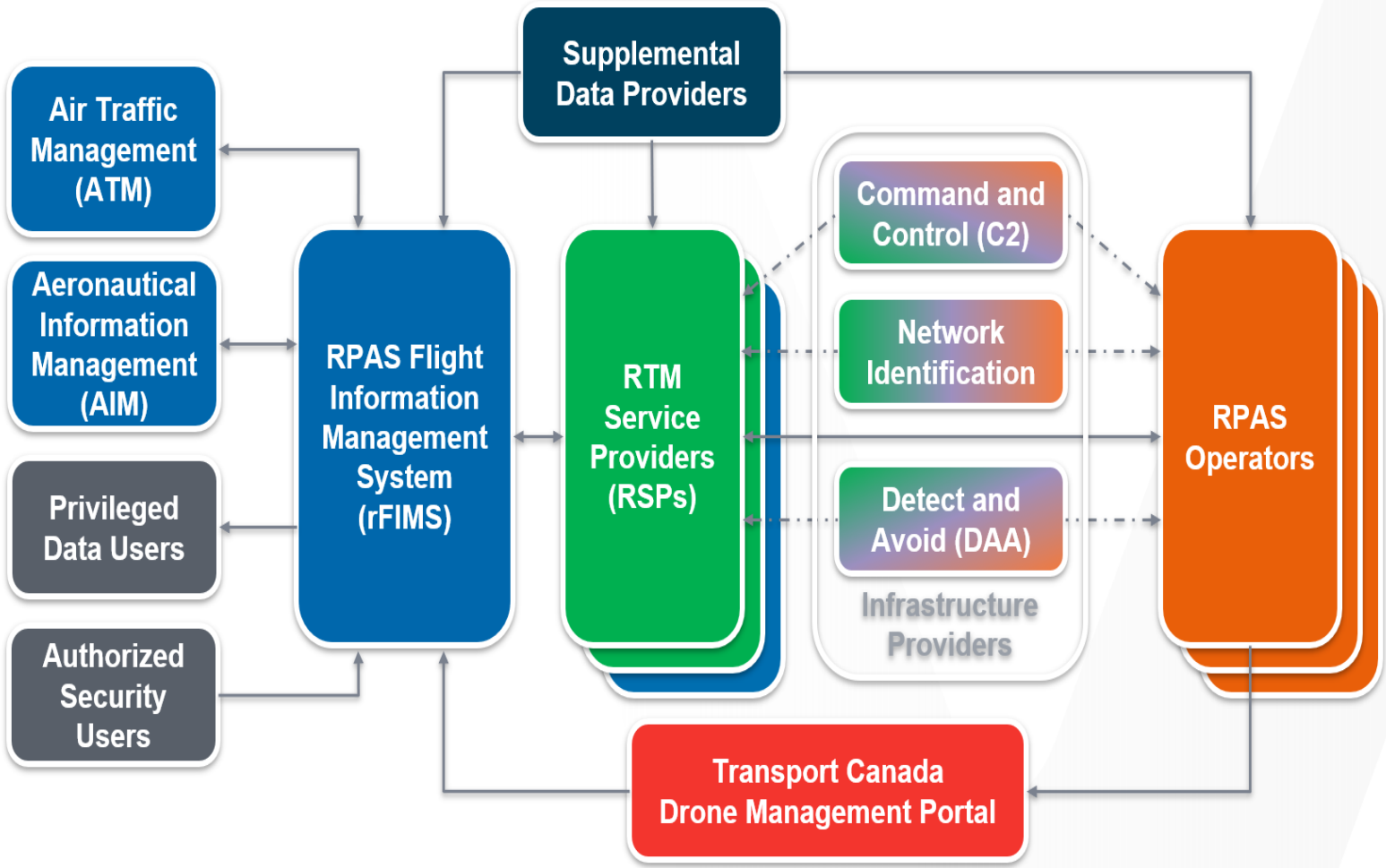
- https://www.navcanada.ca/en/our-strategic-direction/trajectory-based-operations.aspx



RPAS Flight Information Management System (rFIMS)

- **RPAS Operators** will interact with RTM Service Providers to plan and conduct RPAS operations, having registered through the Drone Management Portal as required.
- **RTM Service Providers** (RSPs) will assist Operators with flight plans, submit and receive information to and from rFIMS, and relay key information back to Operators. In many cases, this role can be filled by third parties.
- **rFIMS** will draw data from a range of sources and interact with other airspace management entities to provide critical management, planning, tracking, monitoring, and conflict detection functions.

RTM Ecosystem **FUTURE>>>2027…2030…**



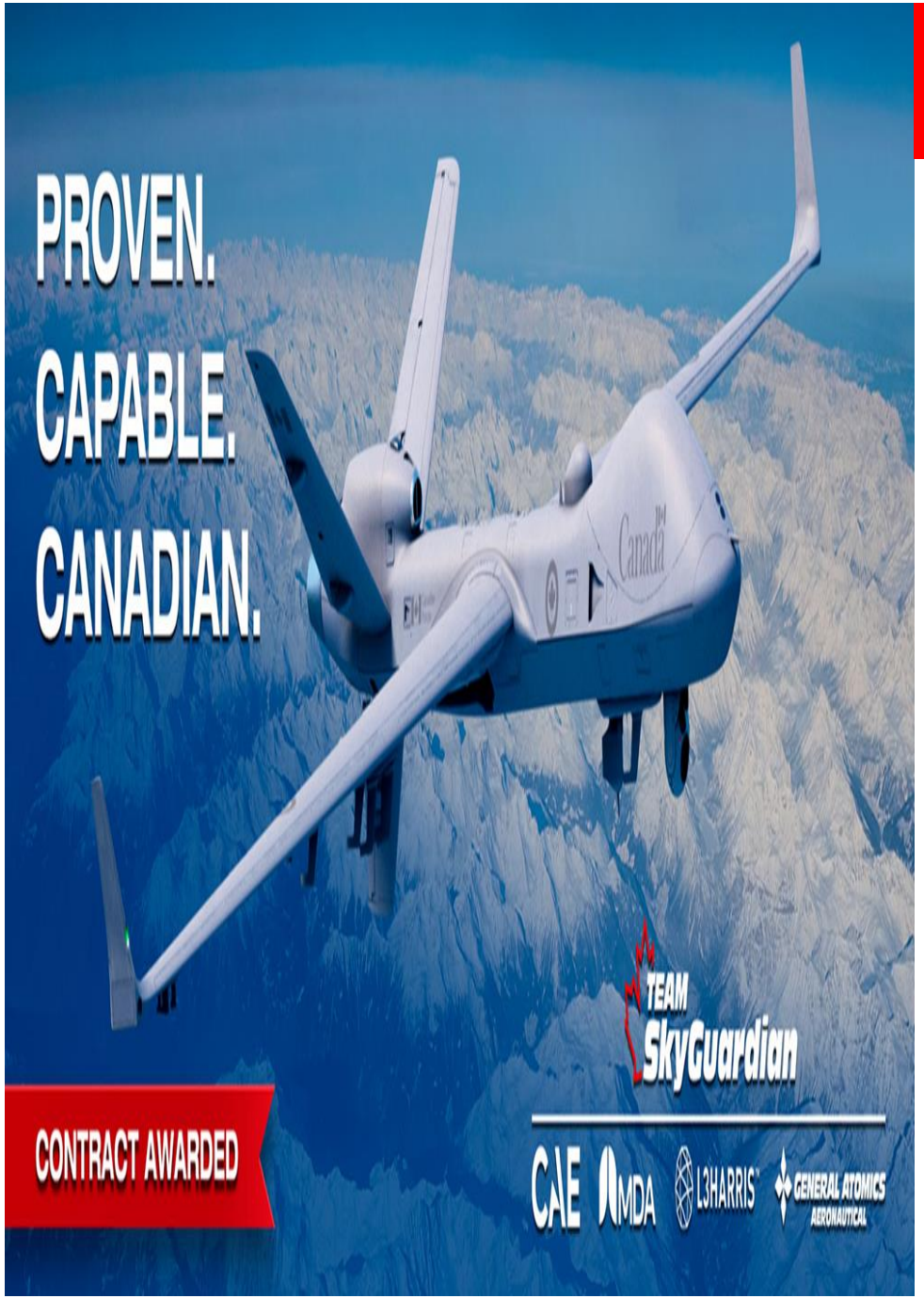
A diagram of the proposed RTM Ecosystem

CAF J-UAS WG

- JUAS WG (60 pers) operated 2017-Fall 2022
  - Periodic CCG and TC input
  - CAF Med Branch – on physical, mental, characteristics to become UAV operator
    - Don’t need aircrew medical status, did cannabis study, PTSD for remote operators
    - Share info with **DRDC CORA** (now Dir Gen Mil Pers Research & Analysis (**DGMPRA**))
    - Work with NATO L3 J-UAS Cap Dev WG
  - WG stalled, Sharepoint no longer being updated
- Differing service constraints/restraints:
  - RCN – cannot add new specialized trade with one PCF function to undermanned ships
  - SOF – Army – small teams, immediate battlefield surveillance focus
  - RCAF – prefer large platforms
- **Source: former DND/CAF member**

CAF RPAS Capability – 19 Dec 2023

- $2.49 b, COTS contract **General Atomics Aeronautical Systems**, Inc, with some specific components acquired through a Foreign Military Sale with U.S.
- **Partners – "Team Sky Guardian Canada": CAE, MDA Ltd., and L3Harris Technologies**
- **First delivery 2028 and FOC by 2033**



Why SkyGuardian?

- “Canada’s vast territory and complex terrains, including in the Arctic, require a cost-effective multi-mission RPA solution that can endure long periods on station, withstand harsh weather environments, and safely operate in civil airspace. MQ-9B SkyGuardian delivers those critical capabilities and more.”

- MQ-9B is the next generation of RPAS, delivering exceptionally long endurance and range, with auto takeoff and landing under SATCOM-only control.

CAF RPAS Capability – 19 Dec 2023

MQ-9B SkyGuardian RPAS from GA-ASI

- 11 RPA; six ground control stations;
- a new ground control centre (Ottawa);
- two new aircraft hangars;
- initial weapons; sustainment services;
- training solution including training devices, mission crew and technician courseware;
- supporting information management and technology;
- associated work and equipment.

CAF RPAS Personnel Structure

- 55 CAF/DND personnel stationed at 14 Wing Greenwood, NS
- 25 personnel at 19 Wing Comox, BC; and
- 160 personnel at Ground Control Centre in Ottawa
- CoE/schoolhouse? **TBC**

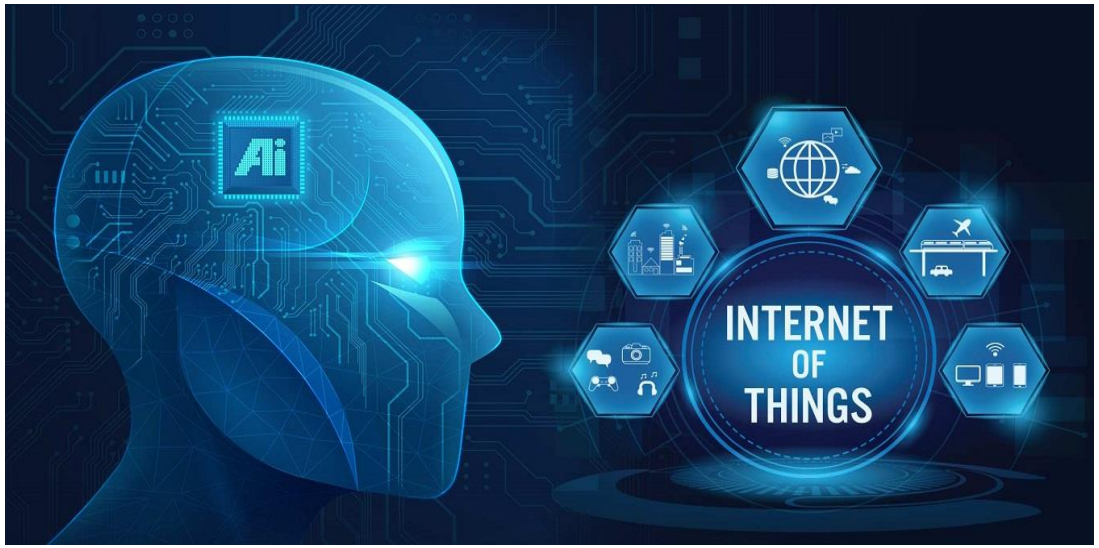
CAF Military Interface

- Canada continue to attend U.S. Project CONVERGENCE (AI) series of exercises.
- Inoperability with US forces paramount which will lead to interoperability with: 1) NATO; 2) Australia, Japan, RoK navies and 3) support regional NORAD ops
- Continue to attend NATO L3 JUAS WG
- Re-activate CAF JUAS WG:
  - Consider doctrine for each services' unique op reqrs
- Designate CAF CoE
- ???

DND/CAF GC Interface

- Work with TC for ATC/ATM-UTM integration
- Consider need for access to sensor data for agencies with a security role; i.e. CSIS, CCG, CBSA, RCMP, and TC
- ???

CAF Civilian Industry Interface



- DRDC continue cap dev demos, e.g. c-UAS FTX DRDC Suffield, August 2024
- RMC and other civ university PG RDTE sponsorship in engineering, Human Factors, AI and sensor integration
- ???

Spiri Robotics – Halifax, NS

Patrick Edwards-Daugherty, CEO

- "We're getting involved in environmental monitoring for things like spills and emergencies, so we're getting into **emergency management at the local level**...where you might have a hurricane that you have to recover from. Another one we're getting into, broadly speaking, is the protection of land and maritime borders." (*The Chronicle Herald*, 22 Feb 2024)
- **Working on c-drone operations and battlefield surveillance.**

Psychological & Social Factors

Individual & Group

Human Factors Considerations

- Universality of Service
- Military Identity:
  - Issue - Flight suits worn by remote drone operators thousands of kms away from battlespace
    - Not soldiers
    - Connection to institution
- PTSD in a remote kill chain
- Fights over narrative not territory (Alan Okros, CDA, 2023)

Human-Drone Trust Building

- When multiple autonomous systems are involved, i.e. UAV swarms, judging reliability becomes significantly more complex.
- This complexity introduces the risk of the pull-down effect, where trust in all system components is reduced due to the unreliability of a single element.

Future?

https://mx.pinterest.com/pin/308426274487031822/

Wanna Have RDTE Talks - Post this Talk?

- Propulsion
- Guidance
- Info Management
- Collaborative Combat Aircraft
- Hypersonic
- 20th Century History

https://mx.pinterest.com/pin/308426274487031822/

Wanna Have Legal Talks - Post this Talk?

- Anticipatory Governance - LOAC
- Human in Loop & ROE
- Criminal Employment
- Civilian pilots in conflict zones
- Child Soldiers
- Dual-Use RDTE & Civ Employee Rights

Questions, Comments, or Concerns?