The Future of Vertical Flight:

US and international military rotorcraft developments

Mike Hirschberg, Director of Strategy

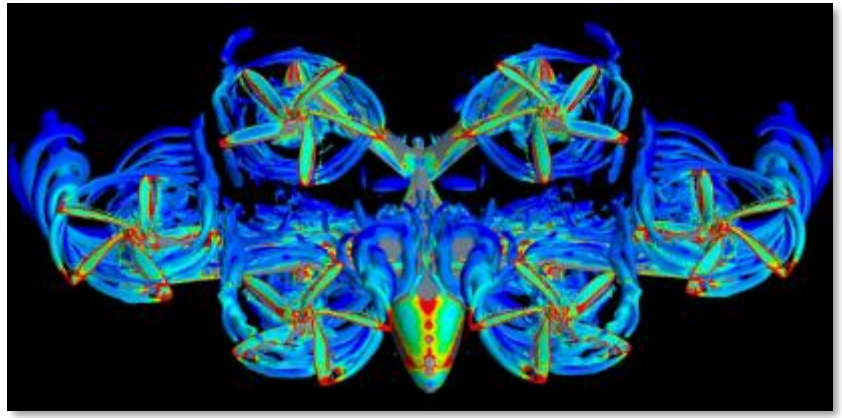
Vertical Flight Society **• www.vtol.org**

These slides at www.vtol.org/FVL

Vertical Flight Society
www.vtol.org

What is The Vertical Flight Society?

- The international **professional society for those working to advance vertical flight**
  - Founded in 1943 as the **American Helicopter Society (AHS)**
  - Everything from VTOL **MAVs/UAS** to **helicopters, eVTOL, etc.**
  - 6,400 individuals, 170 companies, 30 universities, etc.
- **Expands knowledge** about vertical flight technology and promotes its application around the world
- Advances **safety and acceptability**
- Advocates for vertical flight **R&D funding**
- Helps **educate and support** today's and tomorrow's vertical flight engineers and leaders
- **Brings together the community** — industry, academia and government agencies — to tackle the toughest challenges



CFD of Joby S4, Aug 2015

VFF Scholarship Winners at Forum 71, May 2015

Join us today: www.vtol.org

© Vertical Flight Society: CC-BY-SA 4.0

Vertical Flight Society
www.vtol.org

VTOL Innovators – Then and Now

© Vertical Flight Society: CC-BY-SA 4.0

Vertical Flight Society
www.vtol.org

An 80+ Year Legacy

- VFS has a long history of advocacy and leadership
  - Helped establish NASA-Army Joint Office, Nat'l Rotorcraft Technology Center (NRTC), Centers of Excellence, RITA/VLC
  - Worked with NASA and DoD to save the NFAC wind tunnel
- Provided major support to transformative initiatives
  - Joint Strike Fighter / F-35B STOVL
  - V-22 Osprey tiltrotor / civil tiltrotor
- Providing major foundational support to new transformative initiatives
  - Battery-, hybrid- and hydrogen-electric VTOL (eVTOL)
  - Future Vertical Lift (FVL)

NFAC 40 ft x 80 ft wind tunnel (NASA)

Bell V-280 Valor Tech Demonstrator (Bell)

Piasecki PA-890 H2helo concept (Piasecki)

VFS Works to Advance Vertical Flight!

© Vertical Flight Society: CC-BY-SA 4.0

Vertical Flight Society
www.vtol.org

circa 2011

US Military VTOL Capability Gaps

- **Performance shortfalls**
  - Speed, range, payload, endurance, altitude
- **Unexploited autonomy/collaboration**
  - Significantly increased mission effectiveness remains untapped
- **Unacceptable survivability & situational awareness shortfalls**
  - Safety and threat losses, no common picture
- **Costly sustainment**
  - Supportability, maintainability, reliability and availability

10 years of conflict and DoD studies reveal significant VTOL mission capability gaps

© Vertical Flight Society: CC-BY-SA 4.0

circa 2011

Aging U.S. Military Fleet

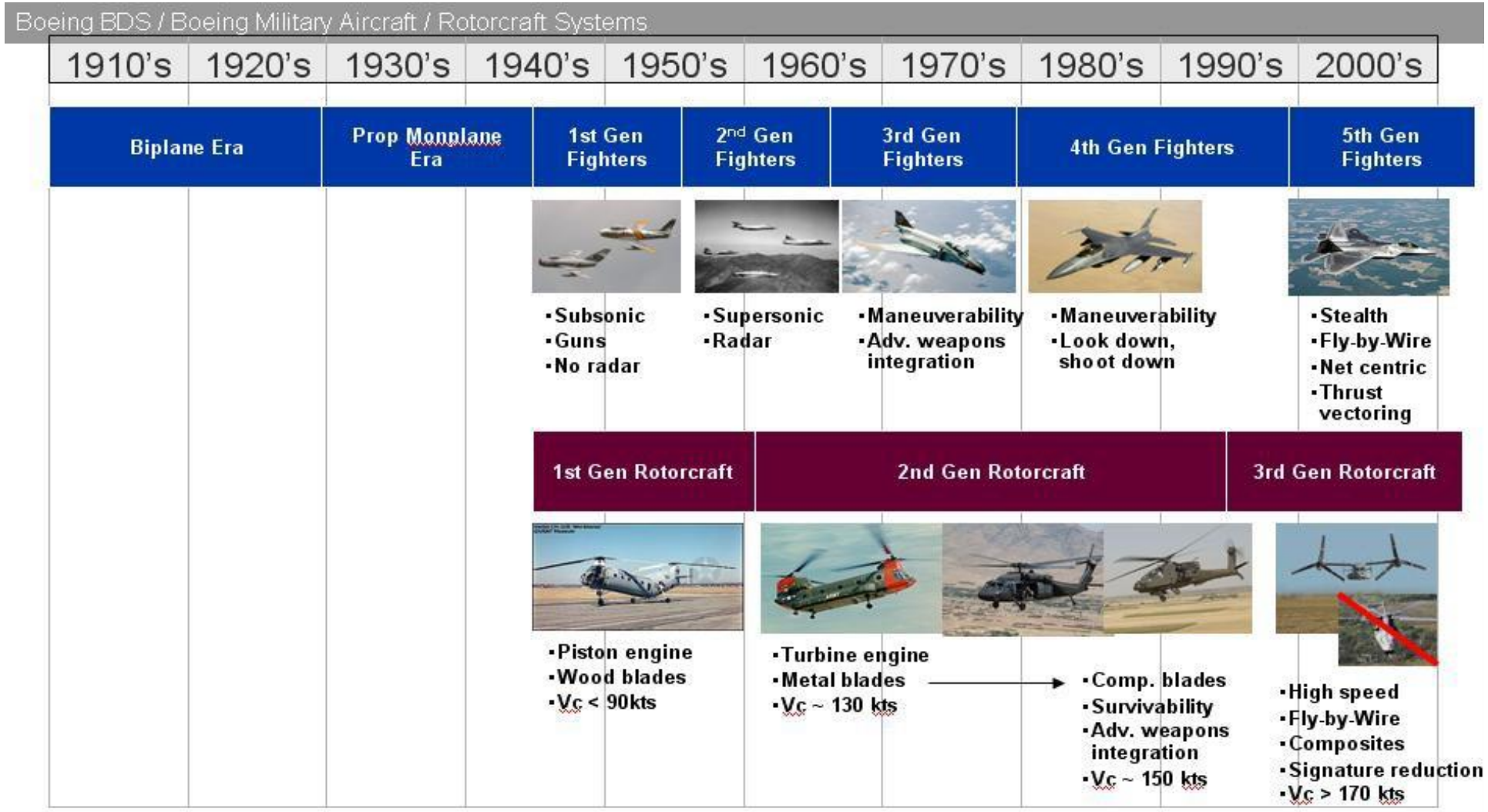
- V-22 was only all-new U.S. military rotorcraft design fielded in past 30 years
- All other deployed designs are 30-50 years old
  - UH-1 Huey first flight 1956; Chinook 1961; Black Hawk 1975; Apache 1976
  - OH-58 Kiowas in service from 1969 to 2017
  - Some 1960s airframes are still flying!
  - CH-53A Sea Stallion 1964; CH-53K operational April 2022

© Vertical Flight Society: CC-BY-SA 4.0

Vertical Flight Society
www.vtol.org

Boeing 2009 Slide

Comparison of Fighter & Rotorcraft Generations



Source: Boeing Rotorcraft @ VFS Forum 65 (2009)

© Vertical Flight Society: CC-BY-SA 4.0

Vertical Flight Society
www.vtol.org

circa 2010

Rotorcraft Generations

Modified from slide presented on Rotorcraft Generations at AHS Forum 66 in Phoenix, AZ, 12 May 2010.

R-5, H-21

Airspeed <100 kt
Reciprocating Engines
Wood Blades Mechanical Controls No Survivability

1st Gen

1945-1960

CH-47A, UH-1, CH-53

Airspeed <130 kt
Turboshaft Engines
Metal Blades
Automatic Flight Control Systems
Metal Structure
Reduced Vulnerability
Passive Survivability Countermeasures
Crashworthiness Standards Defined

2nd Gen

1960-1975

UH-60A, AH-64A

Airspeed >150 kt
Increased Engine Power
Composite Blades
Reduced IR Signatures
Improved Crash Safety
Active Survivability Countermeasures

3rd Gen

1975-1990

V-22, UH-60M, AH-64E
CH-47-II, A/UH-1Y/Z

Airspeed >150 kt
More Efficient and Powerful Engines
Limited Composite Structures
Adv Flight Controls
Adv Blade Design
Avionics Sensor Fusion
Reduced RF & Acoustic Signatures

3rd+ Gen

1990-2015

~~RAH-66~~, CH-53K

Airspeed >170 kt
More Efficient and Powerful Engines
Extensive Composites
Digital Fly By Wire
Adv Blade Design
Avionics Sensor Fusion
Reduced RF and Acoustic Signatures
Intelligent Survivability
Adv Countermeasures
Active Crash Safety Systems

4th Gen

2015-2030

FVL, MUX, FUAS

Airspeed >200 kt
Long range/endurance
High efficiency & high power/weight engines
Novel Configurations
Open System Architecture
Individual Blade Control?
Thrust Augmentation?
Adaptive Controls?
Signature Reductions
Optionally Piloted
Digital Interoperability

5th Gen

2030-

© Vertical Flight Society: CC-BY-SA 4.0

circa 2010

Rotorcraft Generations

Adapted from slide presented on Rotorcraft Generations at AHS Forum 66 in Phoenix, AZ, 12 May 2010.

~~RAH-66~~, CH-53K

- Airspeed >170 kt
- More Efficient and Powerful Engines
- Extensive Composites
- Digital Fly By Wire
- Adv Blade Design
- Avionics Sensor Fusion
- Reduced RF and Acoustic Signatures
- Intelligent Survivability
- Adv Countermeasures
- Active Crash Safety Systems

4th Gen

2015-2030

FVL

- Airspeed >200 kt
- Long range/endurance
- High efficiency & high power/weight engines
- Novel Configurations
- Open System Architecture
- Individual Blade Control?
- Thrust Augmentation?
- Adaptive Controls?
- Signature Reductions
- Optionally Piloted
- Digital Interoperability

5th Gen

2030-20??

© Vertical Flight Society: CC-BY-SA 4.0

circa 2014

FVL Family of Systems

Light	Medium	Heavy

- Cockpit
- FACE/JCA
- Training
- Requirements
- Reduced overhead
- Mission flexibility

All Air Vehicles have common…

- Sustaining
- Maintaining
- Repair parts and components

Capability Set 1	Capability Set 2	Capability Set 3	Capability Set 4	Capability Set 5
Missions:	**Missions:**	**Missions:**	**Missions:**	**Missions:**
• Reconnaissance • Attack • Security • CCA/CAS • Surface Warfare • Direct Action • Maritime Interdiction Operations	• Reconnaissance/Attack • Security • CCA/CAS • MEDEVAC • Surface Warfare • Direct Action • Anti Submarine Warfare • CSAR • Maritime Interdiction Operations • Mine/Counter Mine	• Mine/Counter Mine • MEDEVAC • Air Assault • Logistics • HA/DR • Amphibious Assault • NEO	• MEDEVAC • Air Assault • Logistics • HA/DR • Amphibious Assault • NEO	• MEDEVAC • Air Assault • Logistics • HA/DR • Amphibious Assault • NEO
• Army • Marines • US Special Operations • Navy • Coast Guard • (DHS)	• Army • Marines • US Special Operations • Navy • Coast Guard • (DHS)	• Army • Marines • US Special Operations • Navy • Coast Guard • (DHS)	• Army • Marines • US Special Operations • Navy	• Army • Marines • US Special Operations • Navy

© Vertical Flight Society: CC-BY-SA 4.0

Vertical Flight Society
www.vtol.org

circa 2022

Future Vertical Lift (FVL)

- **5 Capability Sets from Light to Ultra Heavy**
  - Plus advanced unmanned programs
- **Joint Multi-Role (JMR) Technology Demonstrations – 30,000 lb-class (13.6 t)**
  - Bell V-280 Valor ~~vs. Sikorsky-Boeing SB>1 Defiant~~
  - *US industry invested ~$1B in JMR at 4:1 gov't spending*
- **Other Capability Sets**
  - **CS1** (Light): ~~Army's Future Attack Reconnaissance Aircraft (**FARA**) to replace Kiowa Warriors~~
  - **CS2** (Medium Light): Navy to replace Seahawks and Fire Scouts with **FVL Maritime Strike**
  - **CS3** (Medium heavy): Army's Future Long-Range Assault Aircraft (**FLRAA**) to replace Black Hawks; ~~Attack/Utility Replacement Aircraft (**AURA**)~~ *Future Vertical Lift Family of Systems (**FVL FoS**)*

Sikorsky-Boeing SB>1
FVL CS3 Concepts

Sikorsky-Boeing SB>1 JMR Demonstrator

www.vtol.org/FVL

© Vertical Flight Society: CC-BY-SA 4.0

Vertical Flight Society
www.vtol.org

Bell V-280 Valor JMR Demonstrator

US Army March 2018 Announcement: Future Attack Reconnaissance Aircraft (FARA)

- www.vtol.org/cft and www.vtol.org/fara

© Vertical Flight Society: CC-BY-SA 4.0

US Army original vision: Future Attack Reconnaissance Aircraft (FARA)

- Announced March 2018
- Solicitation released Oct. 3; proposals submitted Dec. 18
- 8 proposals submitted:
  - ~~Airbus Helicopter~~
  - AVX Aircraft/L3Harris
  - Bell
  - Boeing
  - ~~Hi-Lite Aircraft~~
  - Karem Aircraft/Northrop/Raytheon
  - ~~MD Helicopters~~
  - Sikorsky Aircraft
- 5 contract awards April 2019
- 2 prototypes – flights in FY22Q1

- $750M in government funding + $375M contractor funding = $1.1B each
- Smaller, slower than Capability Set 3 assault aircraft
  - ~14,000 lb (6.5 t) and 40 ft (12.2 m) rotor diameter and width
  - >180 kt cruise
- Operational by 2028
- Improved Turbine Engine (ITE)
  - GE T901 @ 3,000 shp selected over ATEC (Honeywell/PW) T900
  - Most advanced turboshaft ever
  - 25% sfc reduction, 20% longer life
  - 10,000 engines for Black Hawk, Apache

© Vertical Flight Society: CC-BY-SA 4.0

Vertical Flight Society
www.vtol.org

Future Attack Reconnaissance Aircraft (FARA)

www.vtol.org/FVL

© Vertical Flight Society: CC-BY-SA 4.0

Vertical Flight Society
www.vtol.org

circa 2022

Future Vertical Lift (FVL)

- **5 Capability Sets from Light to Ultra Heavy**
  - Plus advanced unmanned programs
- **Joint Multi-Role (JMR) Technology Demonstrations – 30,000 lb-class (13.6 t)**
  - Bell V-280 Valor ~~vs. Sikorsky-Boeing SB>1 Defiant~~
  - *US industry invested ~$1B in JMR at 4:1 gov't spending*
- **Additional Capability Sets underway**
  - **CS1** (Light): ~~Army's Future Attack Reconnaissance Aircraft (**FARA**) to replace Kiowa Warriors~~
  - **CS2** (Medium Light): Navy to replace Seahawks and Fire Scouts with **FVL Maritime Strike**
  - **CS3** (Medium heavy): Army's Future Long-Range Assault Aircraft (**FLRAA**) to replace Black Hawks; ~~Attack/Utility Replacement Aircraft (**AURA**)~~ *Future Vertical Lift Family of Systems (**FVL FoS**)*

Sikorsky-Boeing SB>1
FVL CS3 Concepts

Sikorsky-Boeing SB>1 JMR Demonstrator

www.vtol.org/FVL

© Vertical Flight Society: CC-BY-SA 4.0

Vertical Flight Society
www.vtol.org

Compounds & Tiltrotors

Sikorsky-Boeing S-100 SB>1 Defiant™ (2019)

30,000 lb (13.6 t) class

Sikorsky S-102 Raider X™ (2024)

14,000 lb (6.35 t)

Sikorsky S-97 Raider™ (2015)

11,000 lb (5 t)

Sikorsky S-94 X2 Technology™ Demonstrator (2008)

5,500 lb (2.5 t)

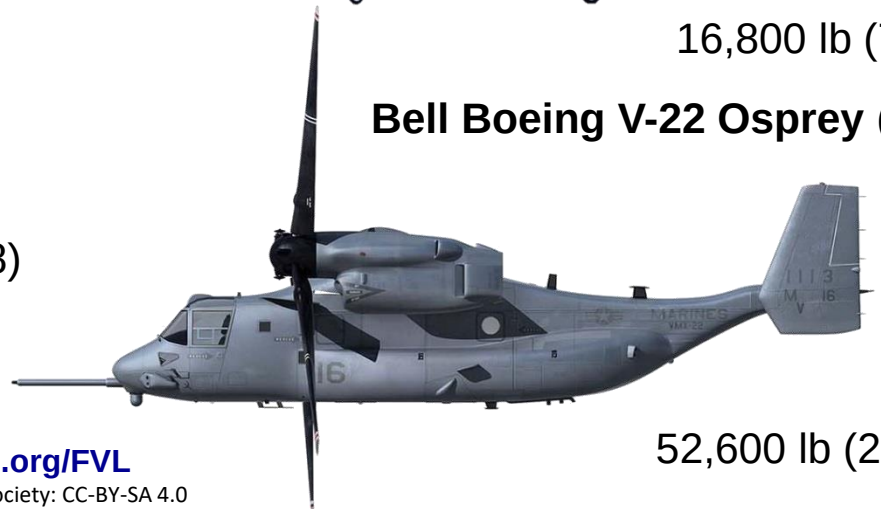
Bell Helicopter V-280 Valor (2017)

30,000 lb (13.6 t) class

Leonardo (with Bell) AW609 (2003)

16,800 lb (7.6 t)

Bell Boeing V-22 Osprey (1989)



52,600 lb (23.8 t)

www.vtol.org/FVL

© Vertical Flight Society: CC-BY-SA 4.0

VFS graphic

Vertical Flight Society
www.vtol.org

Compounds & Tiltrotors

Sikorsky-Boeing S-100 SB>1 Defiant™ (2019)

30,000 lb (13.6 t) class

Sikorsky S-102 Raider X™ (2024)

14,000 lb (6.35 t)

Sikorsky S-97 Raider™ (2015)

11,000 lb (5 t)

Sikorsky S-94 X2 Technology™ Demonstrator (2008)

5,500 lb (2.5 t)

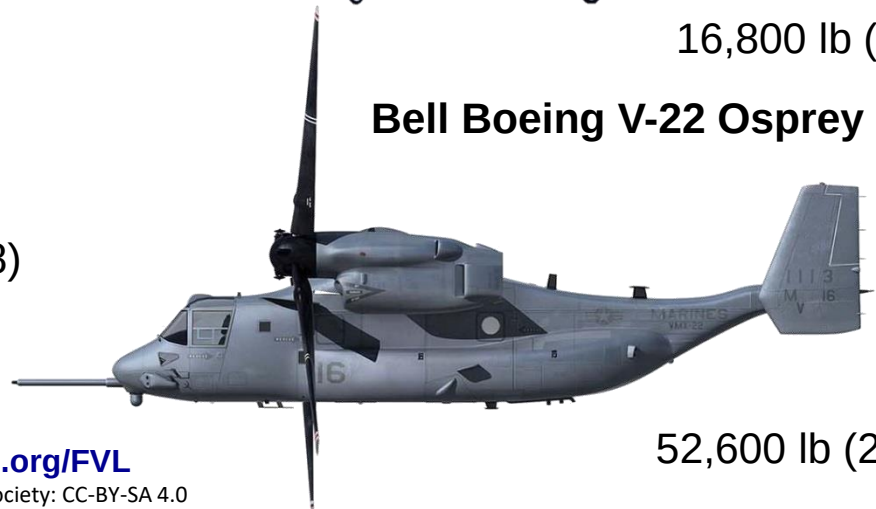
Bell Helicopter V-280 Valor (2017)

30,000 lb (13.6 t) class

Leonardo (with Bell) AW609 (2003)

16,800 lb (7.6 t)

Bell Boeing V-22 Osprey (1989)



52,600 lb (23.8 t)

www.vtol.org/FVL

© Vertical Flight Society: CC-BY-SA 4.0

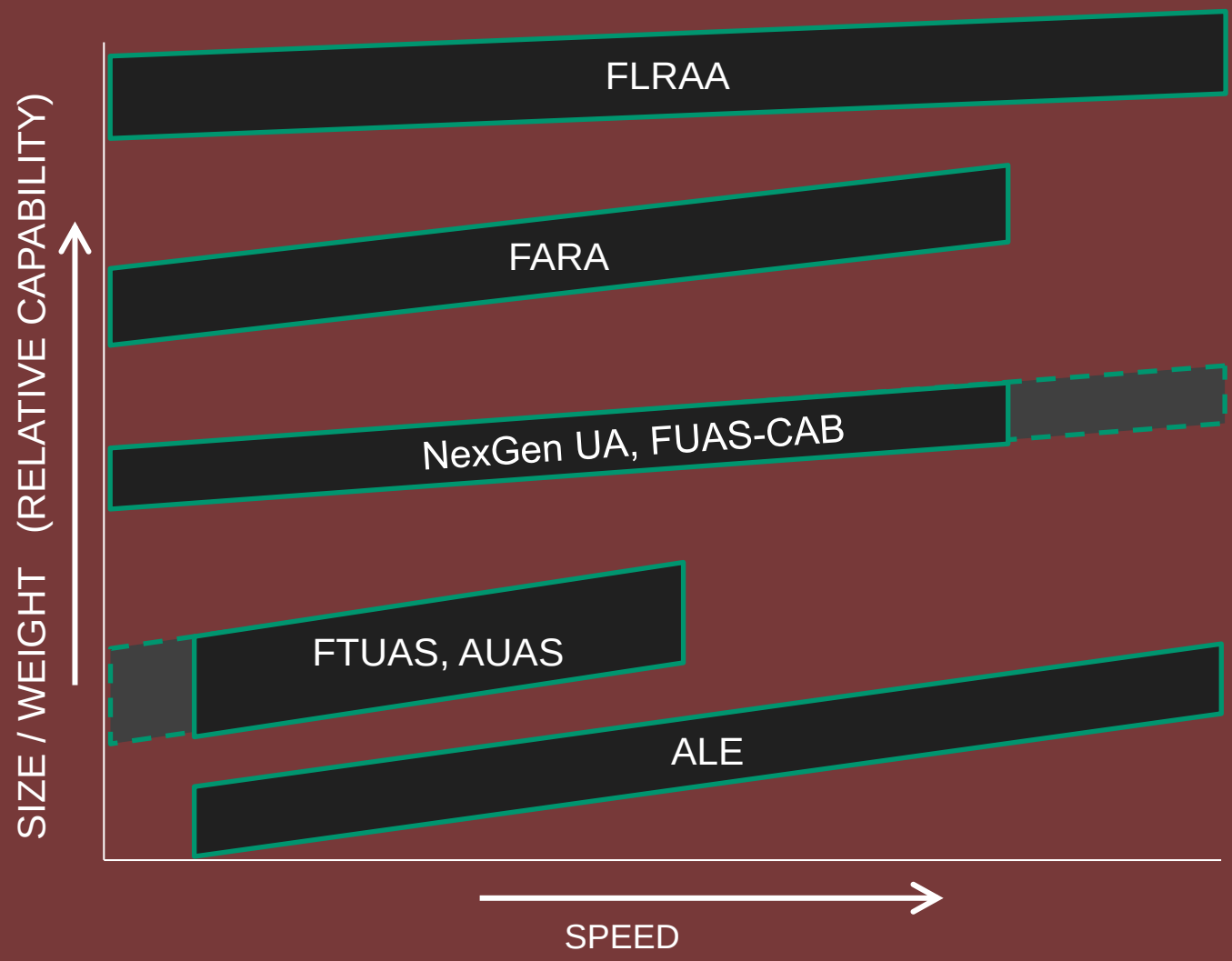
VFS graphic

Circa 2020

US Army Aviaiton: Relative Capability Bins

Increasing:

- Performance (Range, Endurance)
- Useful Load
- Resident Autonomy
- Achievable Effects (Lethal, MFEW)
- Cost / Complexity



© Vertical Flight Society: CC-BY-SA 4.0

Vertical Flight Society
www.vtol.org

NATO NGRC Project
Next-Generation Rotorcraft Capabilities

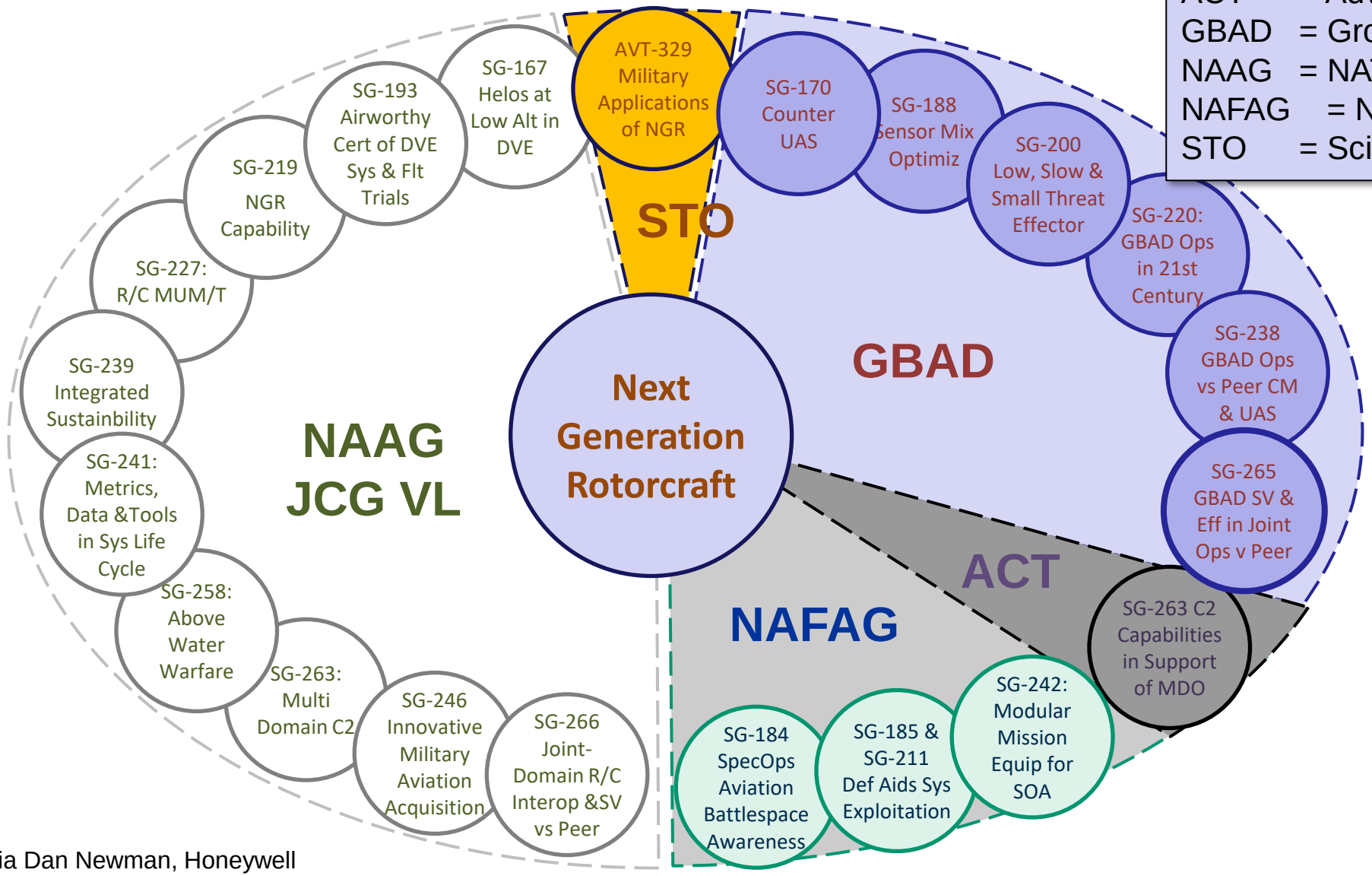
NATO OTAN

- 900+ NATO medium helicopters reaching end of life cycle in 2035–40
- Initial talks in 2012. Now 10+ years of studies and agreements completed.
- On June 16, 2022, France, Germany, Greece, Italy, the Netherlands and the UK pledged €26.7M to initiate concept development
  - Canada now joined; Spain and other countries interested
  - US participating as observers
- Industry Day May 2021 “Required Attributes”
  - MTOW 22,000–37,500 lb (10–17 metric tons)
  - 220 kt+ top speed (not less than 180 kt)
  - 900 nm unrefueled range
  - Endurance of 5+ hours (8 hours with extra tanks)
  - **Deploy for 6-9 months on a Frigate (FF) or Destroyer (DD)**

© Vertical Flight Society: CC-BY-SA 4.0

NATO & NIAG Studies on NGRC

ACT = Advanced Concept Transformation
GBAD = Ground Based Air Defense
NAAG = NATO Army Armaments Group
NAFAG = NATO Air Force Armaments Group
STO = Science & Technology Organization



via Dan Newman, Honeywell

© Vertical Flight Society: CC-BY-SA 4.0


CSX 82069

International Developments
Italy: Leonardo AW249

Vertical Flight Society
www.vtol.org

International Developments: Turkish Aerospace

11,200 lb (5.1-t) T129 ATAK
(based on AW129)

25,300-lb (11.5-t) T929 ATAK 2
first flight April 28, 2023

“10-Ton” T925 transport mockup
at the Paris Air Show (AvWeek)

© Vertical Flight Society: CC-BY-SA 4.0

Summary

- **Future Vertical Lift**
  - **US Army's FLRAA is transformative**
    - **Modular Open Systems Approach (MOSA) is important**
    - **Potential UAS development**
  - **USN and USMC planning development programs**
- **Other allied nations planning military developments**
- **VFS is the global Vertical Flight Society**
  - We are helping to shape the future of vertical flight!
  - $Billions going into new rotorcraft
  - Find out more at **www.vtol.org** and join us!

© GANNETT FLEMING | UBER