"Rotorcraft – Back to the Future"

A Discussion of the Past, Present, and Future of Rotorcraft





Presented by:

Oris E. Davis, Jr.

Director, Southern Europe
International Business Development (IBD)
Boeing Defense, Space & Security (BDS)
The Boeing Company
Phone: +39-06-45217787
oris.e.davis@boeing.com

Presented at:

The National President of Associazione Arma Aeronautica (AAA), The Future of Rotary Wing Symposium
at the Center for High Defence Studies,Palazzo Salviati, Piazza della Rovere 83, Rome, Italy November 22, 2012

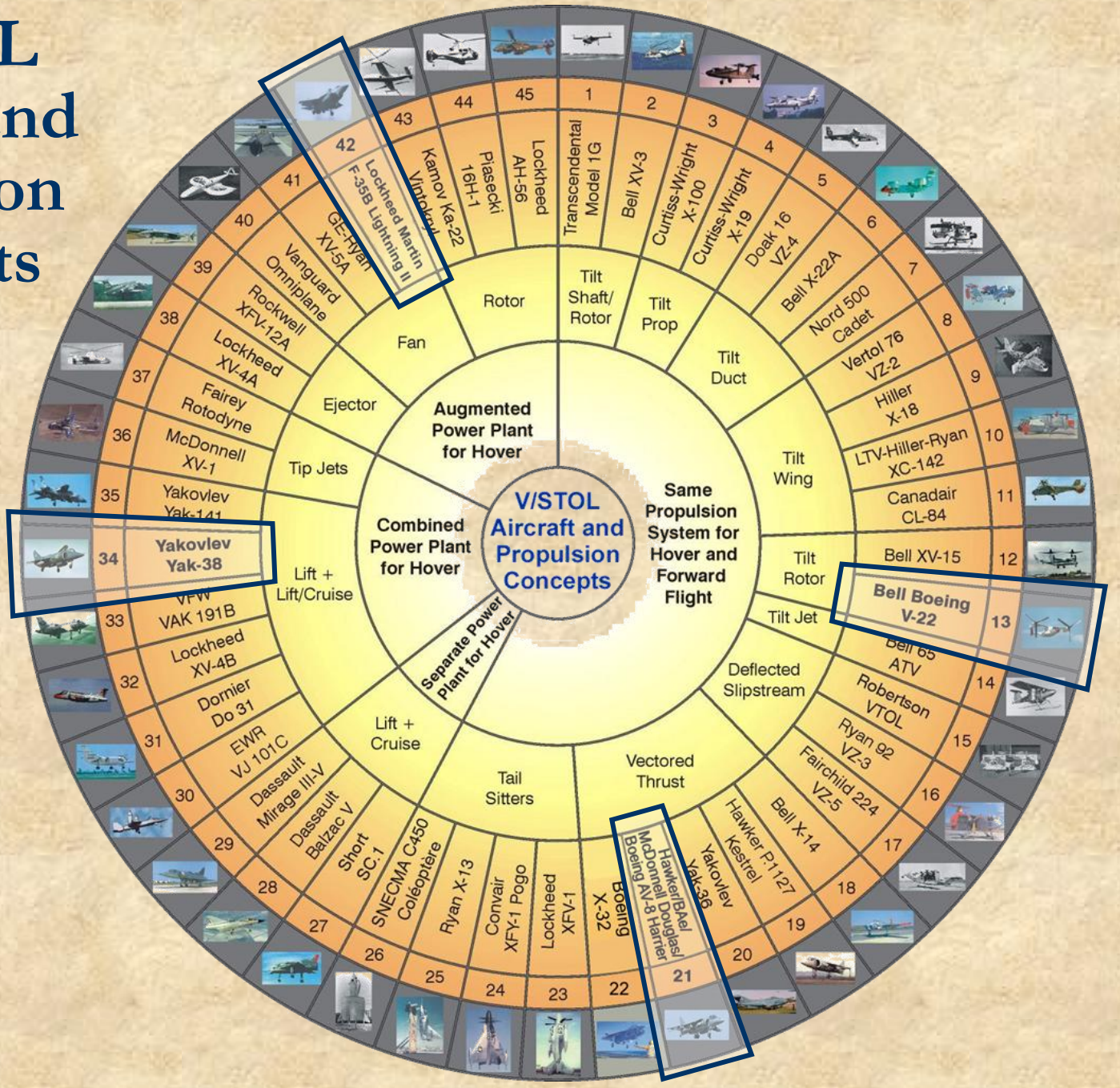
Previously Presented:

Steve Glusman
Director, Advanced Mobility
Advanced Boeing Military Aircraft
AHS Dinner Presentation
March 8, 2011 Towne House Restaurant, Media, PA
AIE Military Rotorcraft Conference
June 7, 2011 Washington, DC

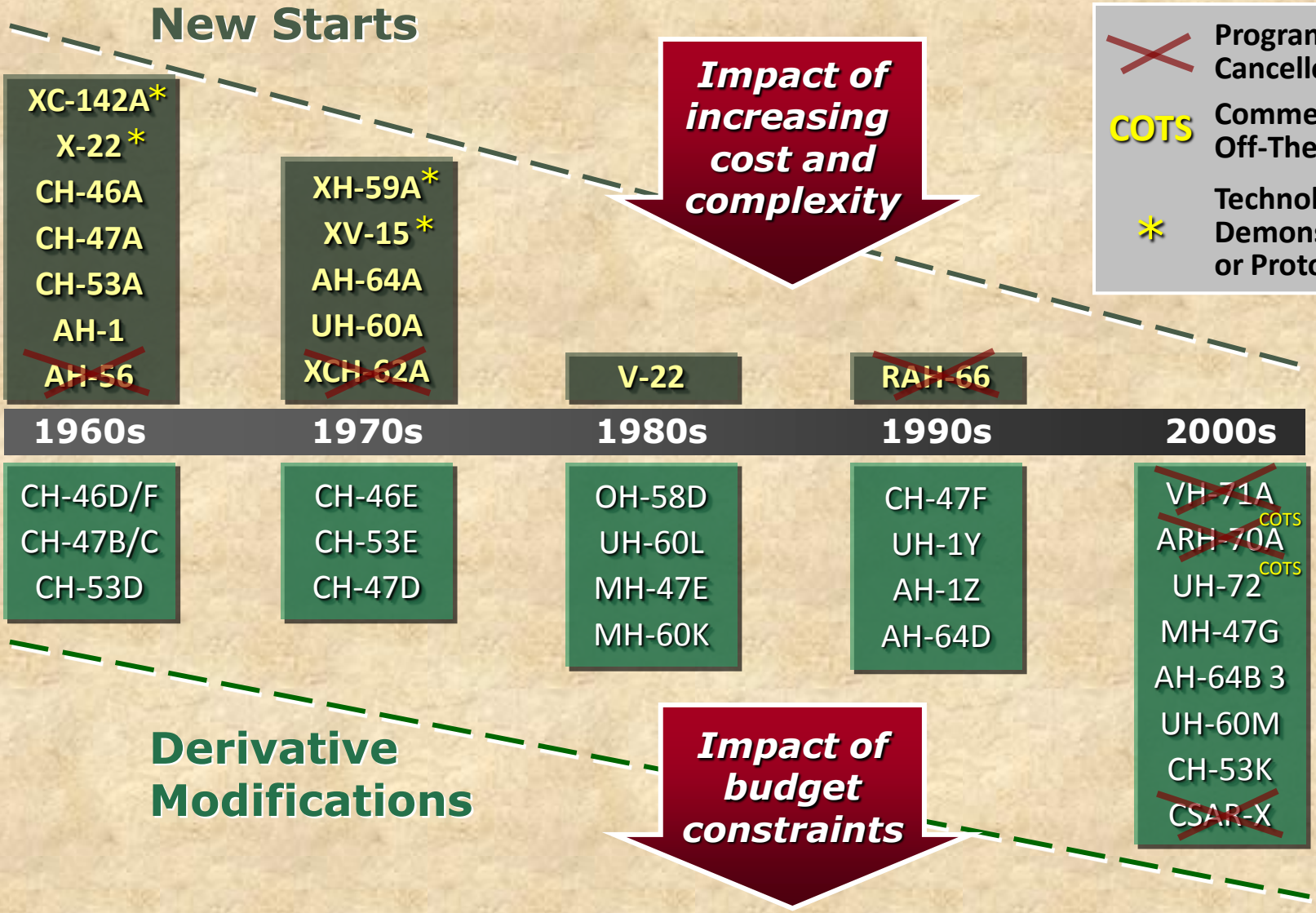
Hal Rosenstein
Chief Engineer, Advanced Mobility
Advanced Boeing Military Aircraft
Technical University of Munich
June 27, 2011 Munich, Germany

V/STOL Aircraft and Propulsion Concepts

- **We have done it all before**
- **Except for helicopters, only a handful of V/STOL concepts have reached production**



Competition Decreasing -- Derivative Modifications Increasing



U.S. Jet Fighter vs. Rotorcraft Generations

1940s | 1950s | 1960 | 1970s | 1980s | 1990 | 2000s | 2010s

1st Gen Fighters	2nd Gen Fighters	3rd Gen Fighters	4th Gen Fighters	5th Gen Fighters

- Subsonic
- Guns
- No radar

- Supersonic
- Radar
- Air-air missiles

- Maneuverability
- Adv. weapons integration

- Maneuverability
- Look down, shoot down capability

- Stealth
- Fly-by-wire
- Net centric
- Thrust vectoring

1st Gen Rotorcraft	2nd Gen Rotorcraft	3rd Gen Rotorcraft

- Piston engine
- Wood blades
- Vc <90kts

- Turbine engine
- Metal blades
- Vc ~130 kts

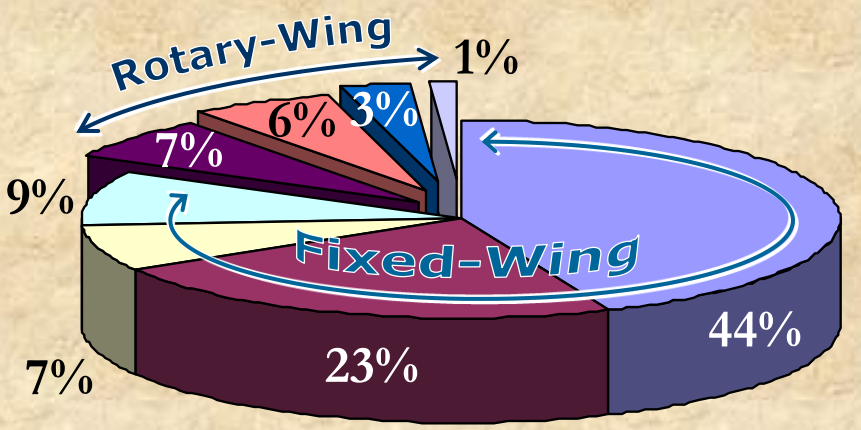
- Composite blades
- Survivability
- Adv. weapons integration
- Vc ~150 kts

- Higher speed
- Fly-by-wire
- Composites
- Signature reduction
- Vc >170 kts

50 Years of DoD Aviation Investment

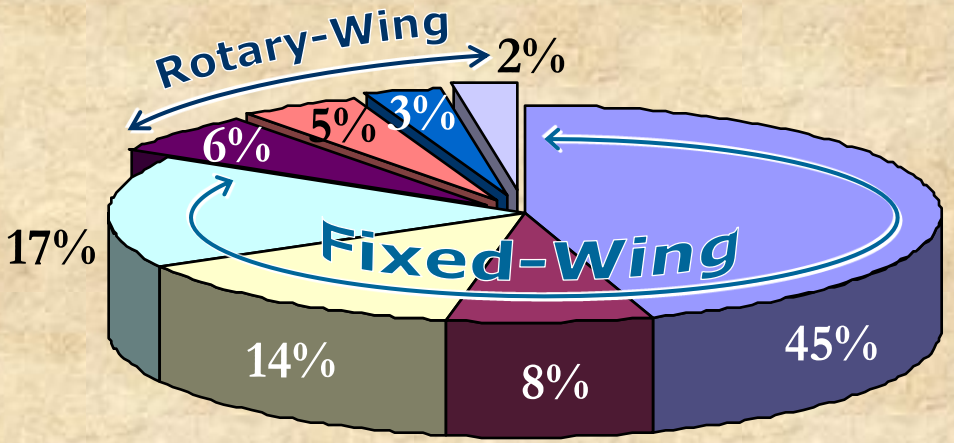
1960 – 2010

RDT&E



$ 321 B
(FY 2011 $)

Procurement



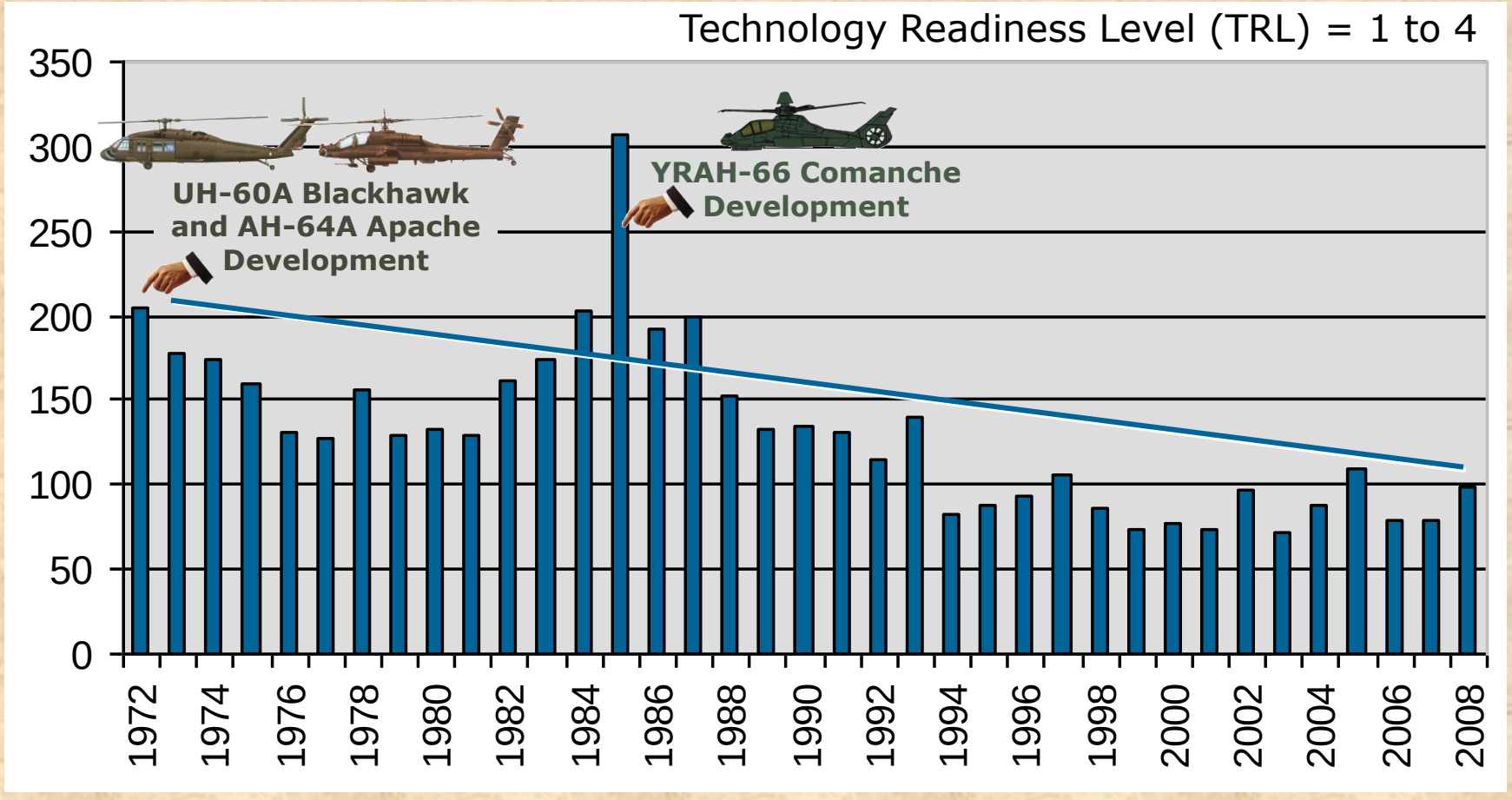
$ 926 B
(FY 2011 $)

- Fighter/Attack
- Bombers
- Transports - FW
- Other FW
- Utility/Assault RW
- Attack/Recon RW
- Cargo RW
- Other RW

83% / 17% investment split between fixed- and rotary-wing

US Army Aviation S&T Investment

Constant 2008 Dollars (Millions)



Downward trend in DoD rotorcraft investment over past 20 years!

A Look at Today

There hasn't been this much excitement in the rotorcraft industry since the 1960's

PIASECKI AIRCRAFT CORPORATION

EUROCOPTER

SIKORSKY AIRCRAFT

BOEING

Have we made progress?

Co-Axial Compound Helicopters

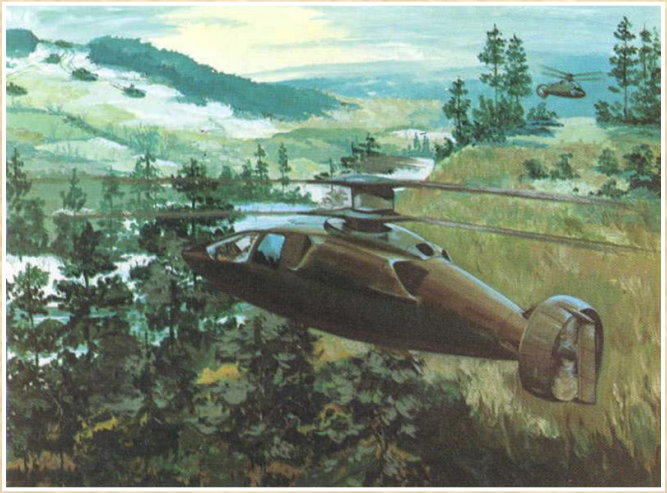
AVIATION WEEK & SPACE TECHNOLOGY, ANUARY 29, 1968

Sikorsky Light Anti-Submarine Attack Vehicle – LAAV Concept (1968)

SIKORSKY AIRCRAFT

Sikorsky XH-59A Advancing Blade Concept (ABC™) (1975)

SIKORSKY AIRCRAFT



Sikorsky LHX Concept (1982)

SIKORSKY AIRCRAFT

Sikorsky X2 Technology Demonstrator (2008)

Have we made progress?

Single Rotor Compound Helicopters

Bell UH-1 Model 533 HPH III – 274.6 knots (316.0 mph) (1969)

EUROCOPTER

Eurocopter X3 – 180 knots (207 mph) (2010)

Have we made progress?

Piasecki Compound Helicopters with the Vectored Thrust Ducted Propeller

Piasecki 16H-1 Pathfinder (1962)

Piasecki 16H-1A Pathfinder II (1966)

(2007)

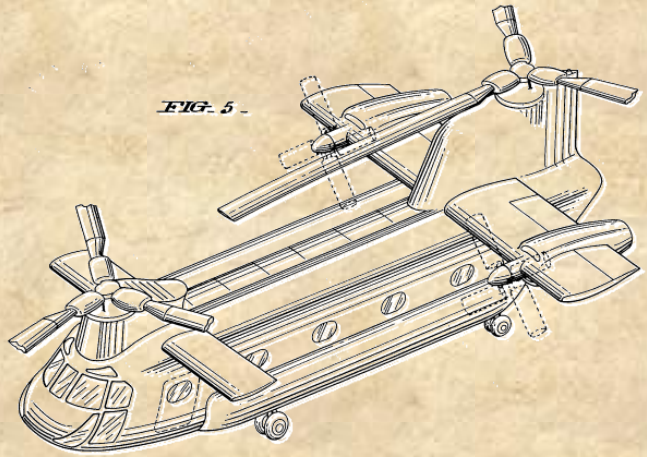
PIASECKI AIRCRAFT

X-49A SpeedHawk

PHOTOS: PIASECKI AIRCRAFT CORPORATION

Have we made progress?

Compound Tandem Rotor Helicopters



Chinook Compound Concept (1961)

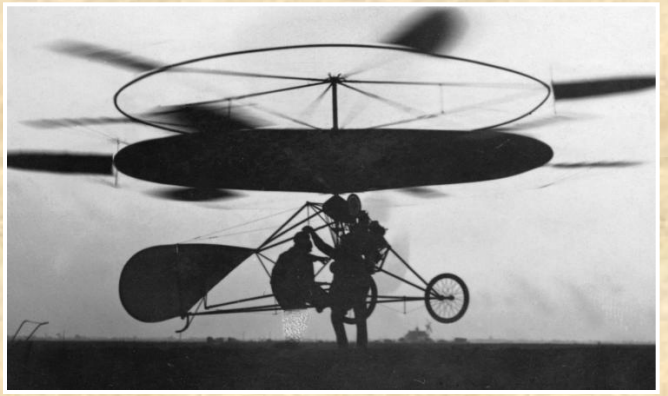
Unloaded Lift Offset Rotor – ULOR
(Ongoing Design Project)

CH-46 Tandem Wing Compound
(mid-1960s)

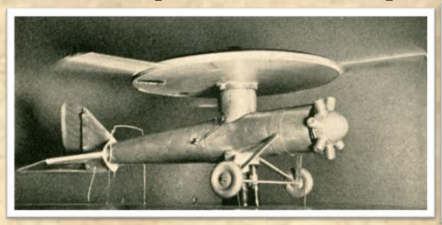
Model 347 Tandem Compound
(early 1970s)

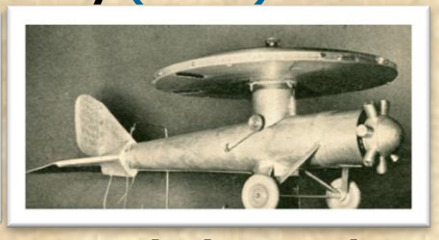
Have we made progress?

Disc Rotors



Jacob Ellehammer – first 'Disc-Rotor Helicopter' concept to fly (1912)





Ellehammer –Disc-Rotor wind tunnel model and test (1935)

Jonathon Caldwell – 'Disc-Rotor Plane' (1934)

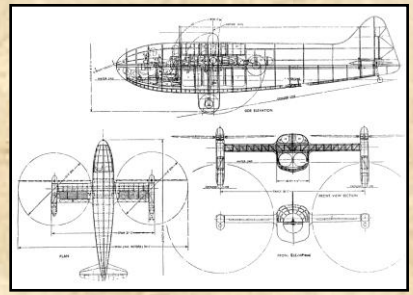
Boeing/DARPA Disc Rotor (Ongoing Design Project)

SOURCE: 100 YEARS OF DISC-ROTOR RESEARCH - A BRIEF HISTORY, ANGELO N. COLLINS and MICHAEL J. HIRSCHBERG, Presented at the International Powered Lift Conference, October 5-7, 2010, Philadelphia, PA

Have we made progress?

YES!!!

Tilt Rotors



Baynes "Heliplane" (1938)

JAY HENDRICKSON PLATT-LEPAGE AIRCRAFT ARCHIVES

Platt-LePage Tilt Rotor Design (1940s)

HOWARD LEVY PHOTO

Transcendental Model 1-G (1954)

Bell XV-3 (1955)

HOWARD LEVY PHOTO

Transcendental Model 2 (1957)

NASA AMES PHOTO

Bell XV-15 (1977)

USMC/Bell Boeing MV-22B Osprey (1989)

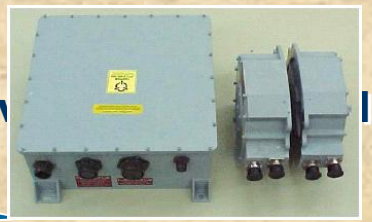
In production and operational with the U.S. Marine Corps and U.S. Air Force, the V-22 recently surpassed 100,000 flight hours!

What is going on?

"Recent" Technology Advancements

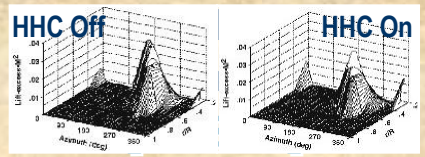
- **For the most part, it is not the configurations that are advancing …. it's the Technology Enablers**

All-c posite rotorcraft

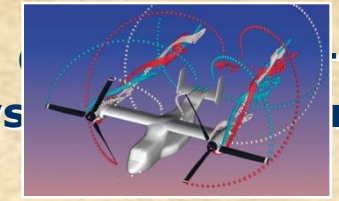


Advanced airf nd
blade ti s
0s]

Optimal Coned Rotor
[ea 0s]



Analys niques



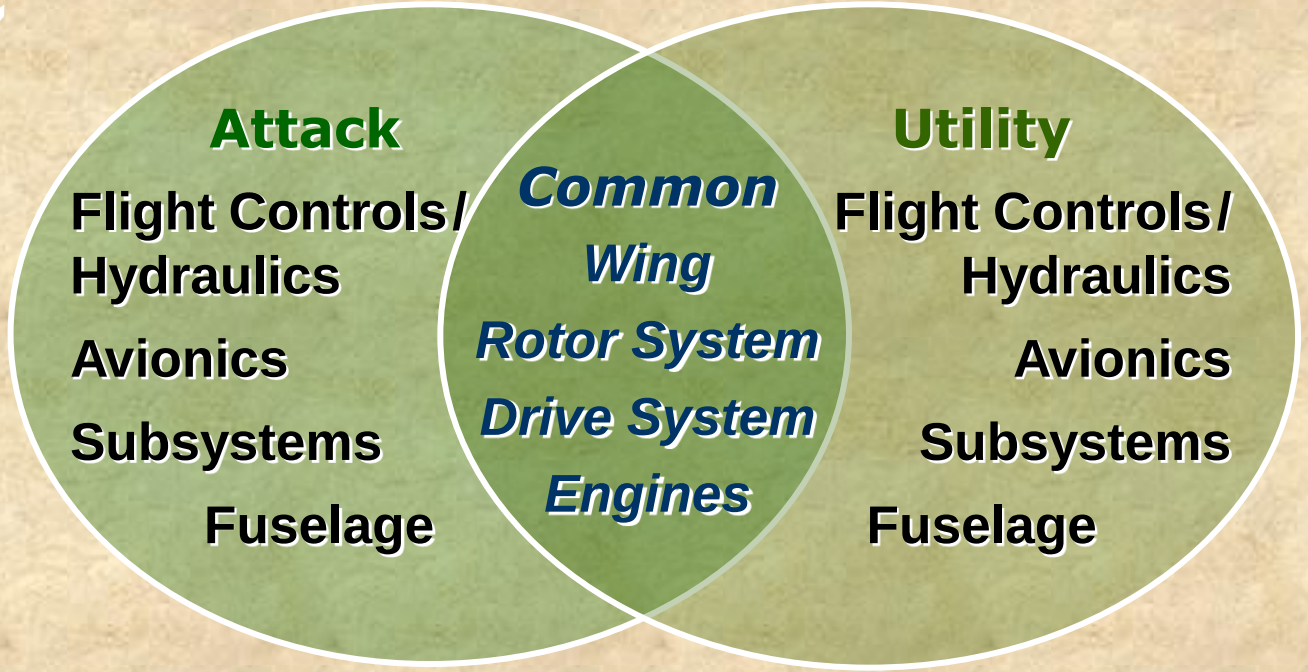
What technology breakthroughs have been demonstrated in this decade?

Joint Multi-Role (JMR) Program

A generational leap desired in range *and* speed – all at 6,000 ft/95°F

Joint Multi-Role (JMR) Program
(continued)

Maximize commonality to improve affordability



JMR program appears to be the future of DoD Vertical Lift

Back to the Future – Prototyping
[e.g. Opportunity]

Model 347→Fly-by-Wire

SIKORSKY AIRCRAFT

XH-59A→Advancing Blade Concept

SIKORSKY AIRCRAFT

X2→Speed, maneuverability

XV-15→V-22

Model 360→V-22 composite airframe

PIASECKI AIRCRAFT CORP.

X-49A→Speed

ARTI→RAH-66

S-76B Fantail→RAH-66 anti-torque system

EUROCOPTER

X3→Speed

Hurdles

- **Existing fleet modernization programs:**

Bell Boeing
V-22 Osprey

Boeing
AH-64D Apache

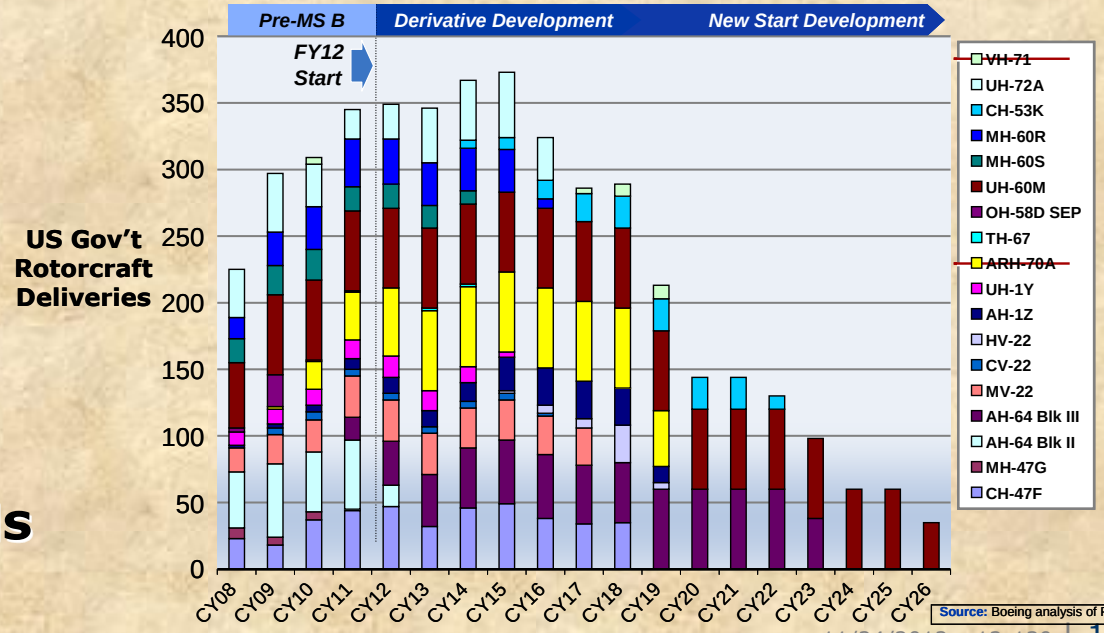
Boeing
CH-47F Chinook

SIKORSKY AIRCRAFT

Sikorsky
UH-60M
Black Hawk

- **Fixed-wing emphasis**
- **Customers collaboration**
- **International competition**
- **Possible loss of critical skills**

The US Industry Faces a Precarious Future



Source: Boeing analysis of PB09

Exciting projects are already under-way

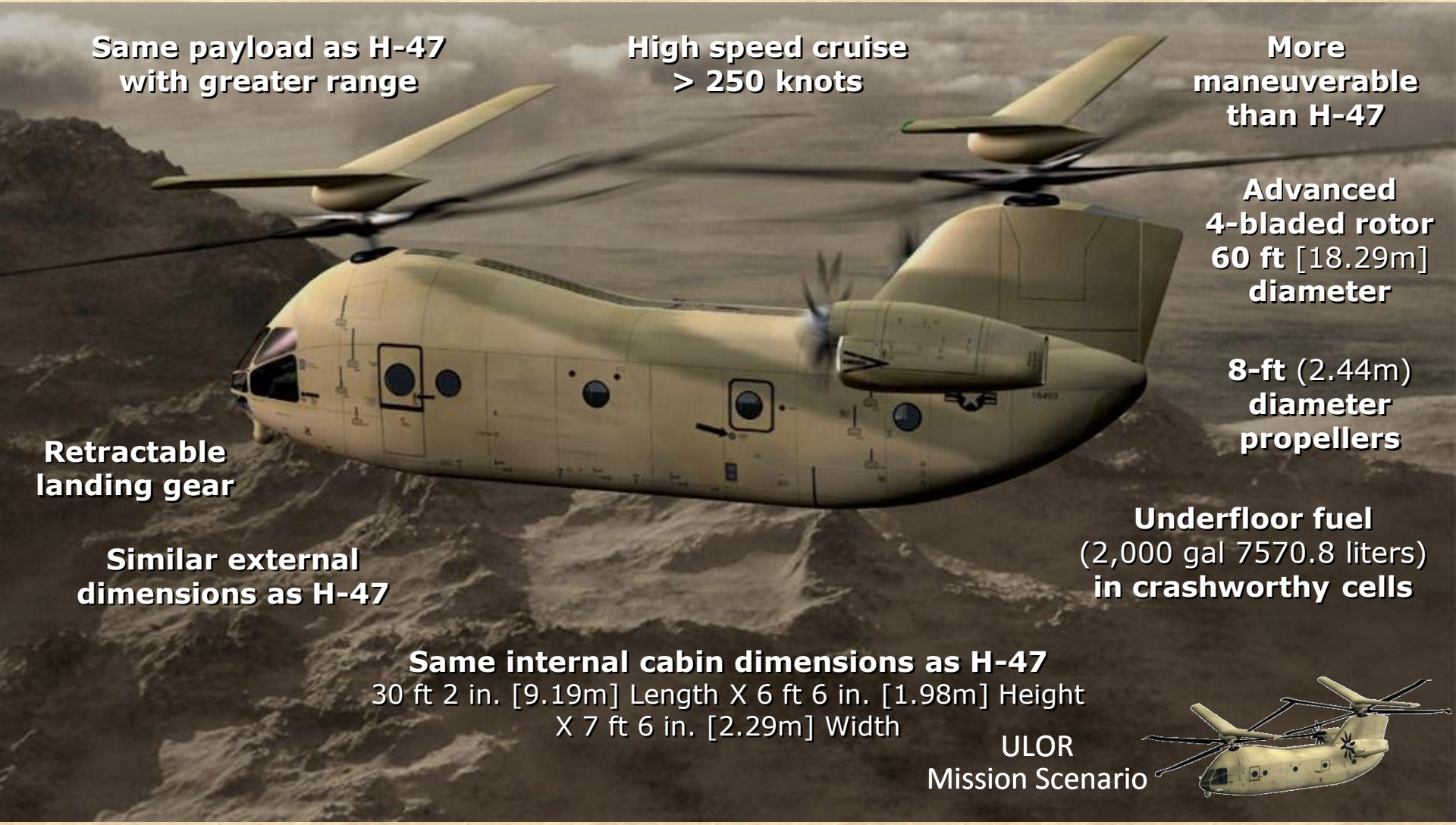
Unloaded Lift Offset Rotor – ULOR

DARPA Mission Adaptive Rotor – MAR

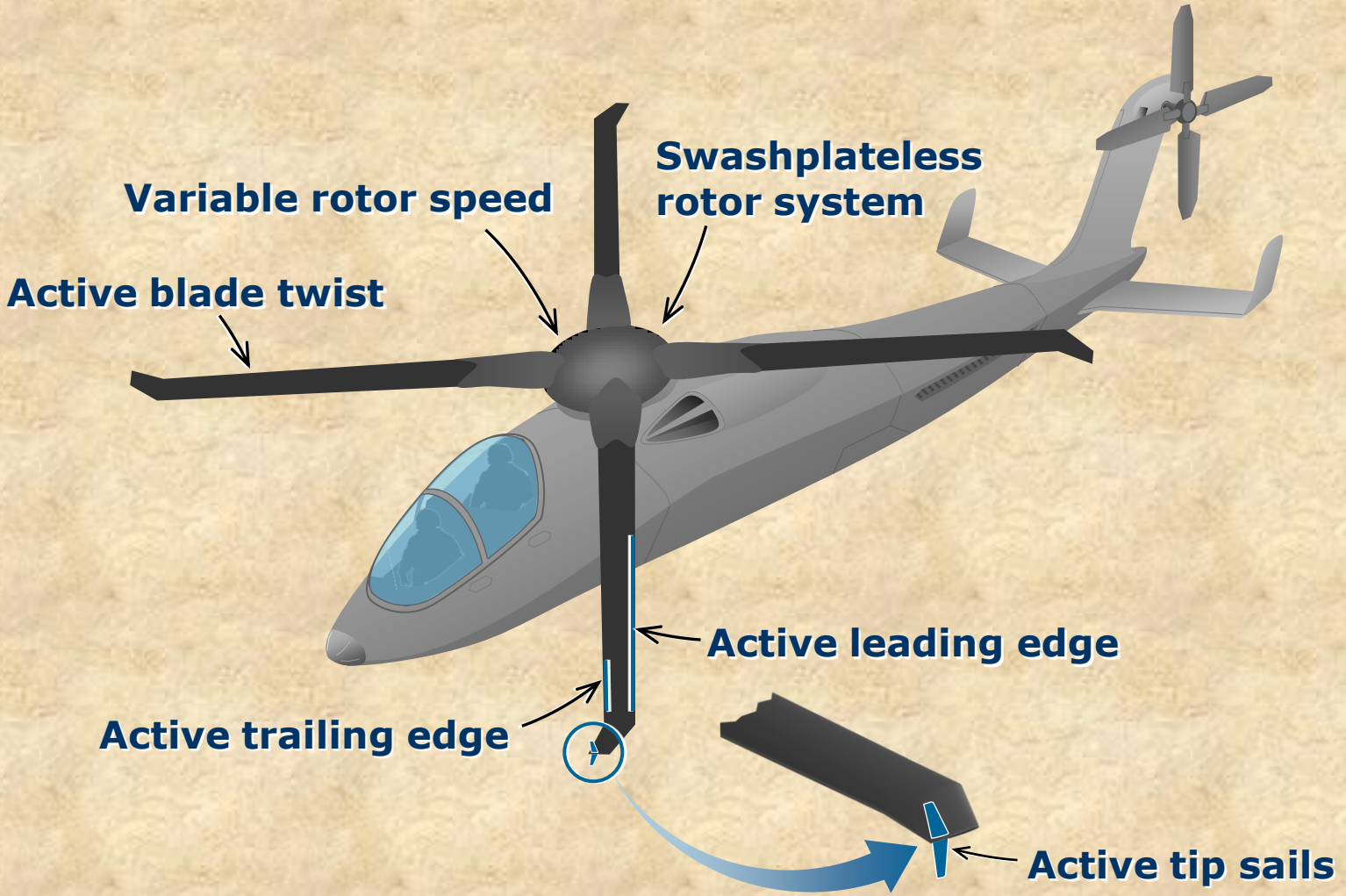
DARPA Disc Rotor

ULOR Configuration Features

Unloaded Lift Offset Rotor – ULOR



Boeing/DARPA
Edgewise Mission Adaptive Rotor (eMAR)
Features on a Notional New Design Rotorcraft



DARPA/Boeing/VPI
Disc Rotor Concept Study

- **High-speed VTOL/troop assault**
- **(2) turboshaft engines or turboshaft/turbofan combination**
- **Unique 350+ knots speed capability**

DiscRotor Mission Scenario

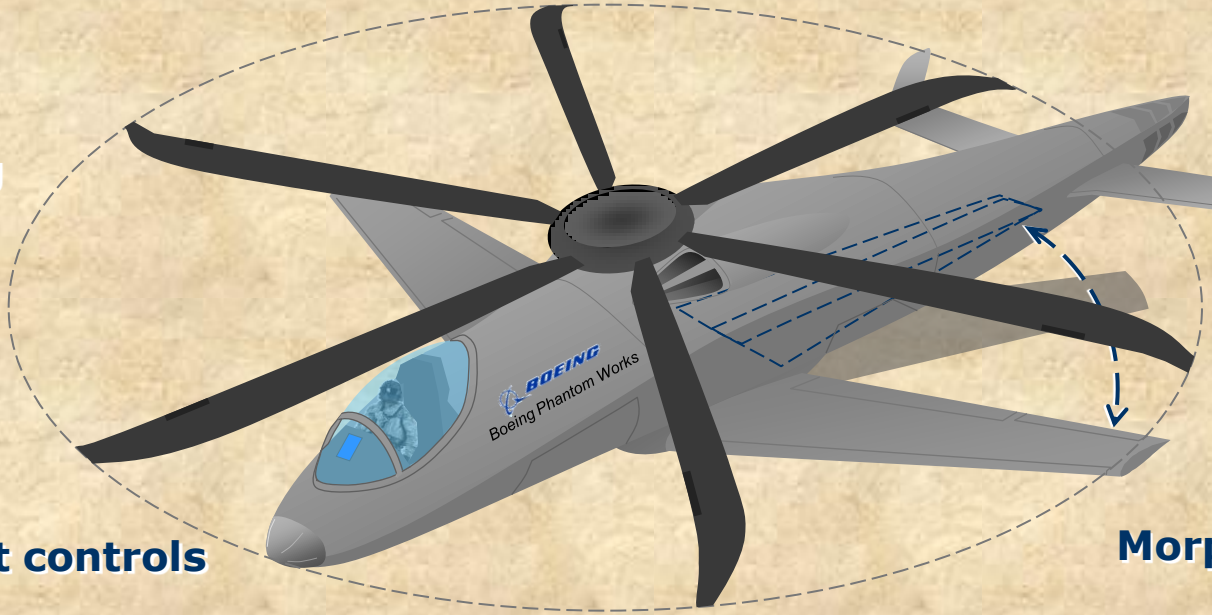
What will next generation rotorcraft look like?

Mission Adaptive Rotor technologies

Active drag reduction

Ultra-low vibration and noise

Adaptive self-healing structures



Next generation advanced NOTAR

Next generation digital flight controls

Morphing wings

Single-pilot crew station

Advanced engine and hybrid propulsion technologies

Technology Demonstrators and Prototypes have worked *very* well in the past...

Parting Comments

Questions?

Thank you.


BOEING