VARIABLE SWEEP

A History, A Function and A Future???

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Overview

- Motivation for Variable Sweep
- History
  - Dr. Albert Betz and the P-1011
  - Bell Aircraft and the X-5
  - F-10F Jaguar
  - TFX Program and the F-111
- The F-14 and Comparisons
  - Analysis
  - Drawbacks
- Current Usages
- Future Planes
- Questions

Motivation for Variable Sweep

Benefits

- Fixed wing aircraft are based upon an intrinsic compromise
- Sweeping the wing allows an optimization of all or most facets of a given mission

http://www.darpa.mil

Benefits, cont.

- Longer, Unswept Wings:
  - Long loiter, low landing speed good subsonic maneuvering, improved take-off characteristics
- Shorter, Swept Wings:
  - Delays wing-flow breakdown, increases critical Mach number, save weight for high Mach number maneuvering.

http://www.fas.org

Drawbacks

- Stability problems arise due to AC shift in supersonic regime.
- Mechanically complex wingboxes
- COST

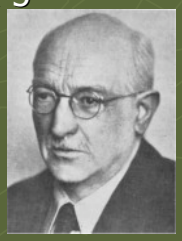
History: The Beginning

- Experiments began in France in 1911
- Dr. Busemann presents the first theoretical concept for a practical moveable wing in 1935 at Volta conference
- After WWII, he is brought to the US and joins NACA Langley

http://home.comcast.net/~robert.culp/

History: The First Prototype

- Dr. Betz of the Gottingen Aerodynamics Research Institute develops the Messerschmitt P-1101 in 1942
- Lacked true variable geometry
- Powered by one Junkers Jumo 004B turbojet but later captured by Americans and fitted with an Allison J35 turbojet
- The P-1101 was damaged in its only attempt to takeoff but paved the way for the X-5



www.bol.ucla.edu/ ~frank/jc.html histaviation.com/AVA.html

History: The Bell X-5

www.pilotfriend.com

- First aircraft to vary wing sweepback in flight
- Developed for USAF and NACA
- Small and designed strictly for research

- Unlike other X Planes, the X-5 could takeoff and land on its own and vary its wing sweep several times in flight if needed
- Gearboxes and jackscrews were used to both change the wing sweep and change the location of the wing box

History: Specifications of the X-5

Length	36 feet
Swept-Back Span	19 feet
Thrust	4,900 lbs*
Max Speed	Mach 0.91

*Allison J35-A-17

www.edwards.af.mil/history/

History: The Doomed F-10F Jaguar

- First VS aircraft to be developed considering production and flight operations
  - US Navy was concerned that launching planes from carrier decks would become impossible due to growing weights of jet fighters
  - Demands for high speed performance led to configurations that where not good in take-off
- Presented the same stall characteristics as the X-5
- The design was doomed by the Westinghouse J40 Turbojet
  - Developed only 6800 lbf thrust rather then the anticipated 11000 lbf
  - Prone to Engine related problems
- Despite all this, the wing-sweep mechanism was the only feature to work as designed
  - This was used on later American variable sweep aircraft
  - Navy still canceled program and an order for 100 production aircraft

History: F-10F Jaguar

entertaining to fly "because there was so much wrong with it."

--Corwin "Corky" Meyer

Wings swept from 13.5 degrees to 42.5 degrees

http://www.airwar.ru

Crew: one pilot
Length: 55 ft 9.6 in
Wingspan: 50 ft 8 in, 36 ft 8
Height: 16 ft 3 in
Wing area: 466.9 ft_, 450 ft_
Empty weight: 20,425 lb
Maximum gross takeoff weight: 35,450 lb
Powerplant: 1_ Westinghouse XJ40-W-8 turbojet, 6,800 lbf
Maximum speed: 710 mph
Range: 1,670 miles
Thrust/weight: 0.19:1

History: TFX Program Roots

- In 1959, engineers at NASA Langley devised the two pivot variable sweep concept
- In the late 1950s the USAF TAC submitted specifications for a plane to replace the F-105
  - Carry nuclear weapons internally
  - Fly transatlantic routes without refueling
  - Operate from semi prepared fields
  - Mach 2.5 at high altitudes
  - High subsonic speeds at low altitudes
  - John Stack (1959) suggest variable sweep as a means to meet requirements
- Also, in 1957 the US Navy requested industry responses for the design of a low altitude strike fighter
  - Stack briefs on the capabilities of VS to surpass British Designs

History: McNamara Creates TFX

- 1960: Both the USN and USAF were wanting to develop new fighter aircraft
- Secretary of Defense, Robert McNamara, creates the Tactical Fighter Experimental (TFX) Program
  - Single aircraft for both the Navy and the Air Force (led by the USAF)
  - Combined the needs of the AF with that of the Navy's need for fleet defense and the Army's need for close air support
  - McNamara defines requirements when two sides cannot agree
  - October of 1961, the RFP is release to the industry
- Boeing wins all four stages of the competition but McNamara awards the contract to General Dynamics and Grumman Team on 24 Nov 1962

History: VS is the Key to TFX

New developments in engine performance and in aerodynamics, particularly the variable-geometry wing concept evolved by NASA, now make it possible to develop a tactical fighter that can operate from aircraft carriers as well as from much shorter and cruder runways, and yet can carry the heavy conventional ordnance loads needed in limited war.

-- Secretary of Defense, Robert McNamara

http://ivizlab.sfu.ca

http://www.europa.com

History: The F-111 A/B

- Due to the support of NASA, Langley, Ames, Glenn and Dryden, the development of the F-111 was well documented
  - Polhamus coordinated tunnel test and meetings with the DOD, industry and even the Senate
  - Over 15 Wind tunnels were used for testing (22,000 Hrs)
- Two versions were to be built
  - F-111A for the Air Force
  - F-111B for the Navy
- 15 October 1964: The F-111 was rolled out

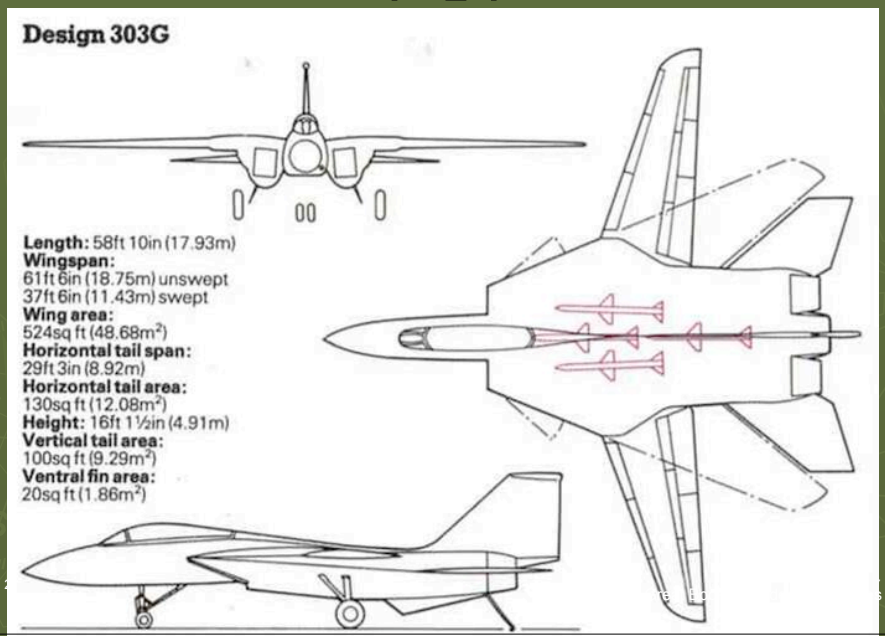
History: The F-111 A/B (cont)

- Early test showed very positive results of the VS wing system
- It was also judged to be underpowered and sluggish
  - Engines also exhibited violent stalling and surging characteristics
  - During early service had numerous problems, including large cracks in the gearbox used to move the wings

http://www.pilotfriend.com

- The Navy cancels its portion of the program in August 1968 finding the plane to be too heavy
- The F-111 saw service in Vietnam and the Gulf War
  - Greatest success may have been at El Dorado Canyon in mid-April 1986 against Libya's terrorist government

F-14



F-14

- Wing Characteristics:
  - NACA 64-A2
  - Thickness ratio ranging from 10.65% at the root to 7% at the tip.
  - Wing Area = 541 ft^2
  - "Pancake"
  - Sweeps from a minimum of 20° to 68° at a rate of 7.5°/sec in level flight (4°/sec at a 7.5g loading)
    - Can sweep up to 75° to reduce space taken up on carriers

Sweeping modes

- Mach Sweep Programmer (MSP)
  - Automatic
    - Used extensively, computer controls sweep
  - Manual
    - Pilot can override computer.
  - Emergency
    - Pilot has complete control
  - Ground Attack
    - Locked sweep

Wing Planform Vs. Range/Endurance

- Unswept:
  - Planform Area = 521.8 ft^2, AR=7.3
- Swept:
  - Planform Area = 281.8 ft^2, AR = 5.0

- Under equal flight conditions, the unswept wing will experience a 54% increase in range and endurance.

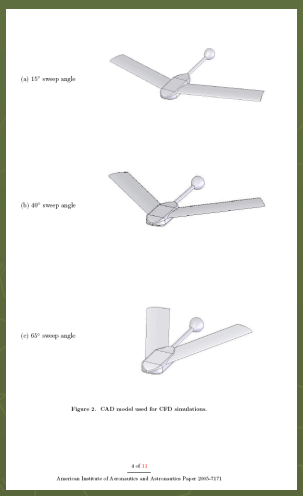
Current Variable Sweep Aircraft

- American
  - F-14
  - B-1B
- European
  - Tornado
- Russian
  - Mig-23
  - Mig-27
  - Su-24
  - Tu-22M
  - Tu-160

http://www.leuchars.raf.mod.uk

http://www.centurychina.com

Future of Variable Sweep

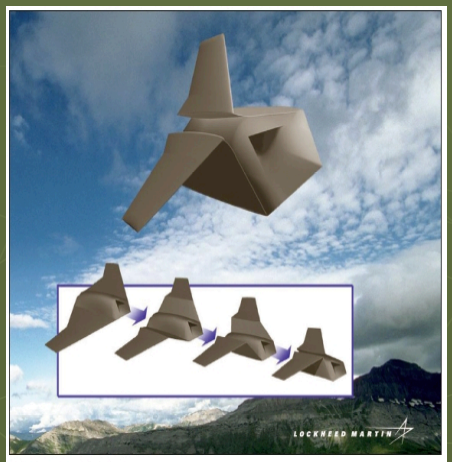


http://recuv.colorado.edu:8080/

- Micro Air Vehicle
  - Deployed into unsafe or toxic conditions for humans.
  - Launched from a tube.
  - High speed flight to designated area.
  - Low speed loiter to collect necessary data.

Future of Variable Sweep

- Morphing Wing
  - One primary advantage would be the increased cost effectiveness of aircraft through eliminating the need for multiple, expensive, mission specific aircraft
- Z-wing by Lockheed
  - to be the future of variable sweep (Variable Geometry)



Z-wing morphing wing concept

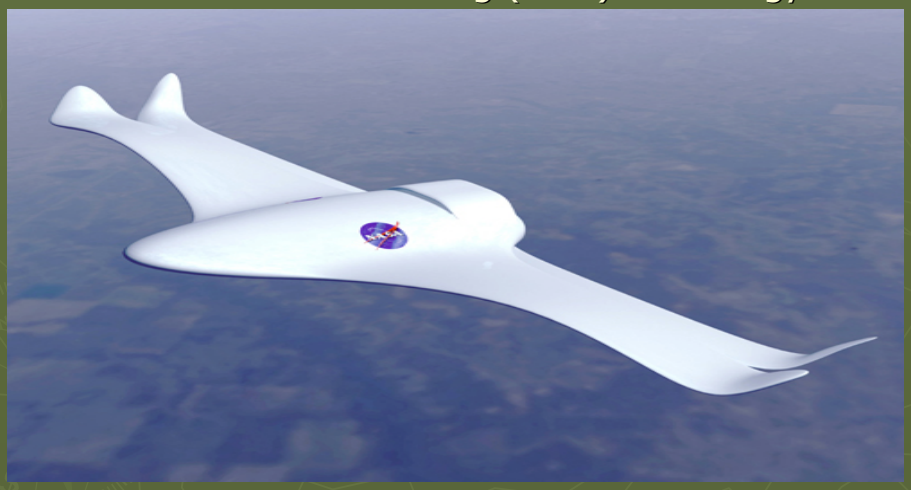
http://www.afrlhorizons.com/Briefs/Jun05/VAH0502.html

http://www.aer.bris.ac.uk/research/morphing/morph-intro.html

There are typically four applications of morphing:

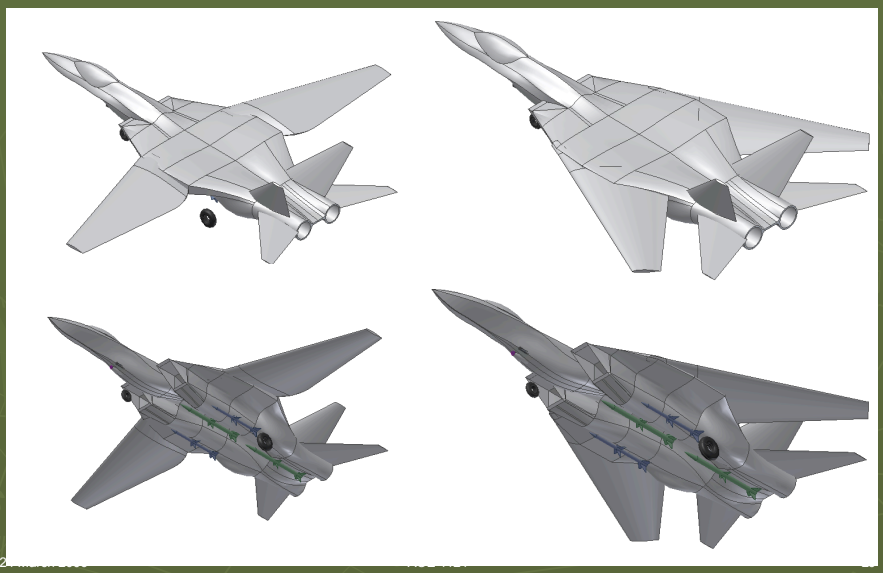
- improve aircraft performance to expand its flight envelope;
- replace conventional control surfaces for flight control to improve performance and stealth;
- reduce drag to improve range;
- and reduce vibration or control flutter.

Morphing Aircraft Concept NASA
Active Aeroelastic Wing (AAW) technology



http://www.dfrc.nasa.gov/Newsroom/X-Press/stories/043001/new_morph.html

Questions???



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