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
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- 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

History: The Bell X-5

- 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

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Length</td>
<td>36 feet</td>
</tr>
<tr>
<td>Swept-Back Span</td>
<td>19 feet</td>
</tr>
<tr>
<td>Thrust</td>
<td>4,900 lbs*</td>
</tr>
<tr>
<td>Max Speed</td>
<td>Mach 0.91</td>
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</tbody>
</table>

*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 were 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 than 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

24 March 2006
AOE 4124
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 ft², 450 ft²
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 released 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
- 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

http://www.pilotfriend.com
F-14

Wing Characteristics:

- NACA 64-A2
- Thickness ratio ranging from 10.65% at the root to 7% at the tip.
- Wing Area = 541 ft²
- “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

Future of Variable Sweep

- 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.

http://www.leuchars.raf.mod.uk
http://www.centurychina.com
http://recuv.colorado.edu:8080/
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)

http://www.afrlhorizons.com/Briefs/Jan05/VAH0502.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.

http://www.aer.bris.ac.uk/research/morphing/morph-intro.html
Morphing Aircraft Concept NASA
Active Aeroelastic Wing (AAW) technology


Questions???
References:
http://recuv.colorado.edu:8080/plone-site/pubandpres/AIAAInfotech-
MAVSweepWing1.pdf
http://www.area51zone.com/aircraft/switchblade.shtml
http://www.afrihorizons.com/Briefs/Jul05/VAH0502.html
http://www.aer.bris.ac.uk/research/morphing/morph-intro.html
http://www.edwards.af.mil/history/docs_html
http://www.f-111.net/articles/Langley-TACT-Develomnt.htm
http://www.findarticles.com/p/articles/mi_qa3897/is_199806/ai_n8797861/pg_3
http://www.globalsecurity.org
http://www.pilotfriend.com
http://en.wikipedia.org

Spick, Mike. The Great Book of Modern Warplanes. London: Salamander