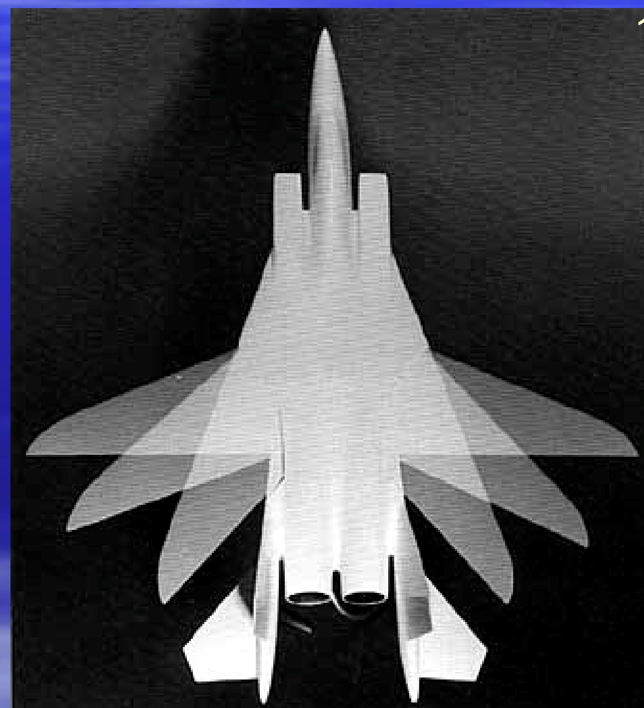
Aerial Metamorphosis:
Variable Sweep Wings



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Outline

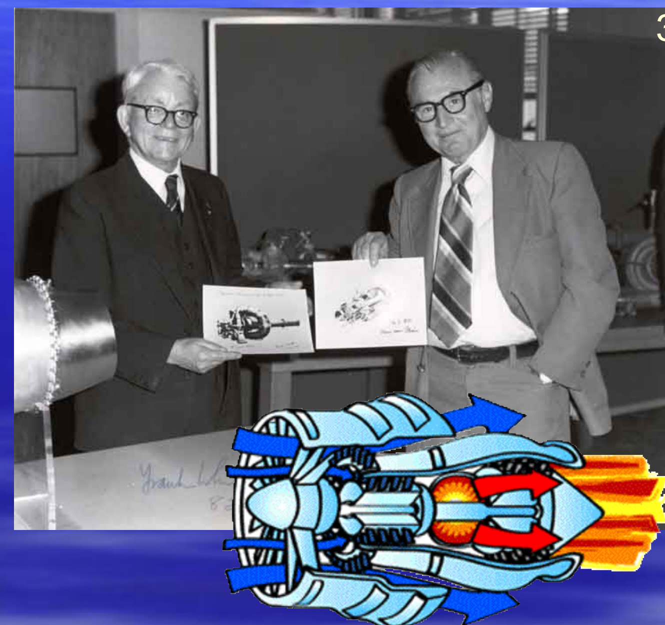
- The Jet Age
  - Aerodynamic Lift At Supersonic Speed
  - Increasing Critical Mach Number
- In-Flight Optimization
  - Pivoting Around Stall
  - Variable Sweep – Variable Mission
- Variable Sweep Aircraft

The Jet Age

- Advances in propulsion in 1930's made sustained high-subsonic, transonic, and supersonic flight possible

http://www.acepilots.com/planes/p51_mustang.html

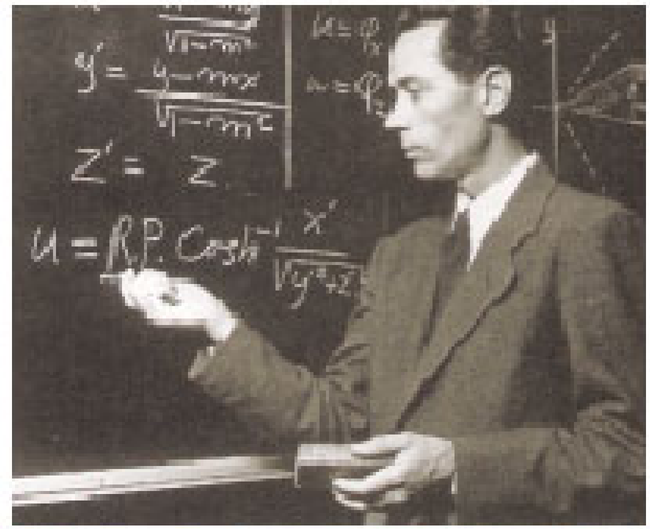
http://www.acepilots.com/planes/p38_lightning.html

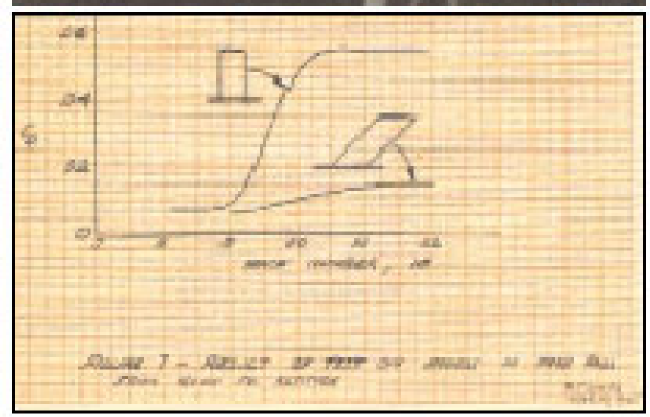


- High-speed WWII era aircraft typically had strait wings and thickness ratios of 14 to 18 percent

Aerodynamic Lift At Supersonic Speed[2]

- 1935 Adolf Busemann, Aviation Research Organization, Germany
- 1941 Michael Gluhareff, Sikorsky chief of design
- 1945 Robert T. Jones, NACA Langley aerodynamicist

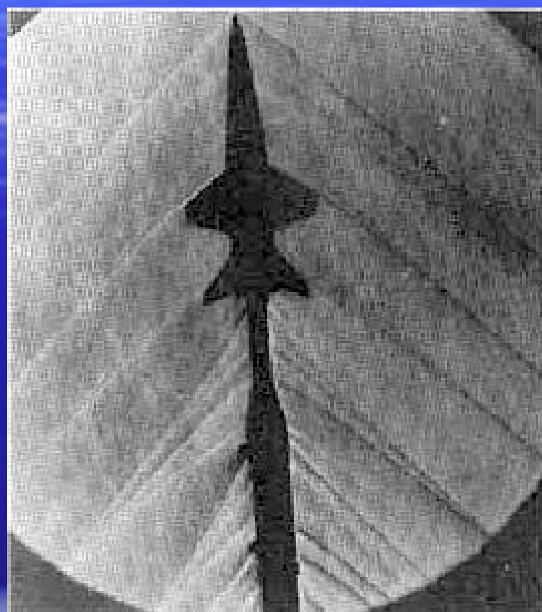




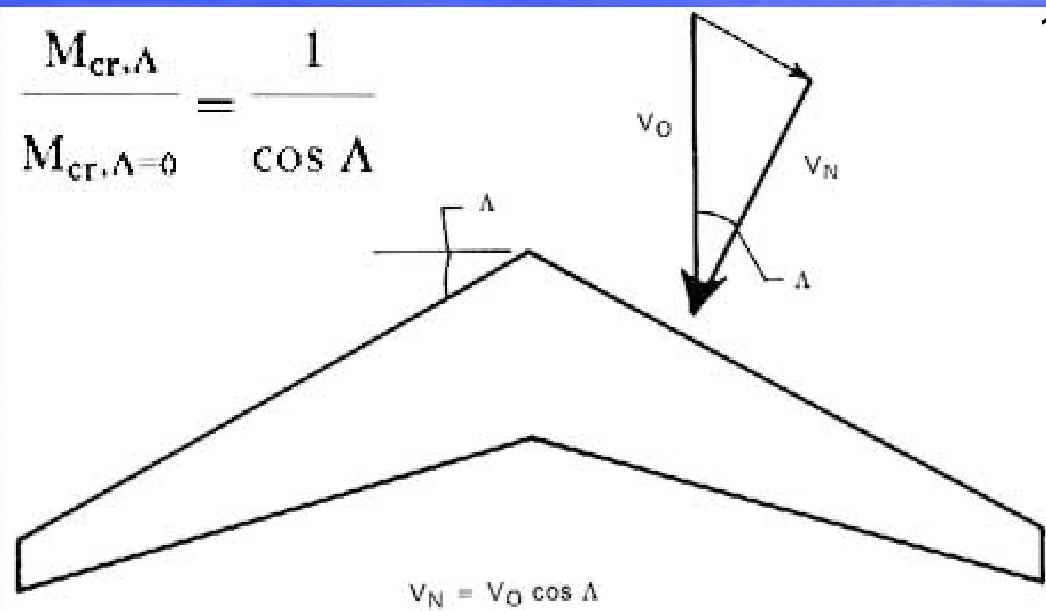
http://www.hiller.org/about-us/briefings-journal/briefings/2000q4.pdf

Increasing Critical Mach Number

http://www.eng.vt.edu/fluids/msc/gallery/shocks/p25b.htm

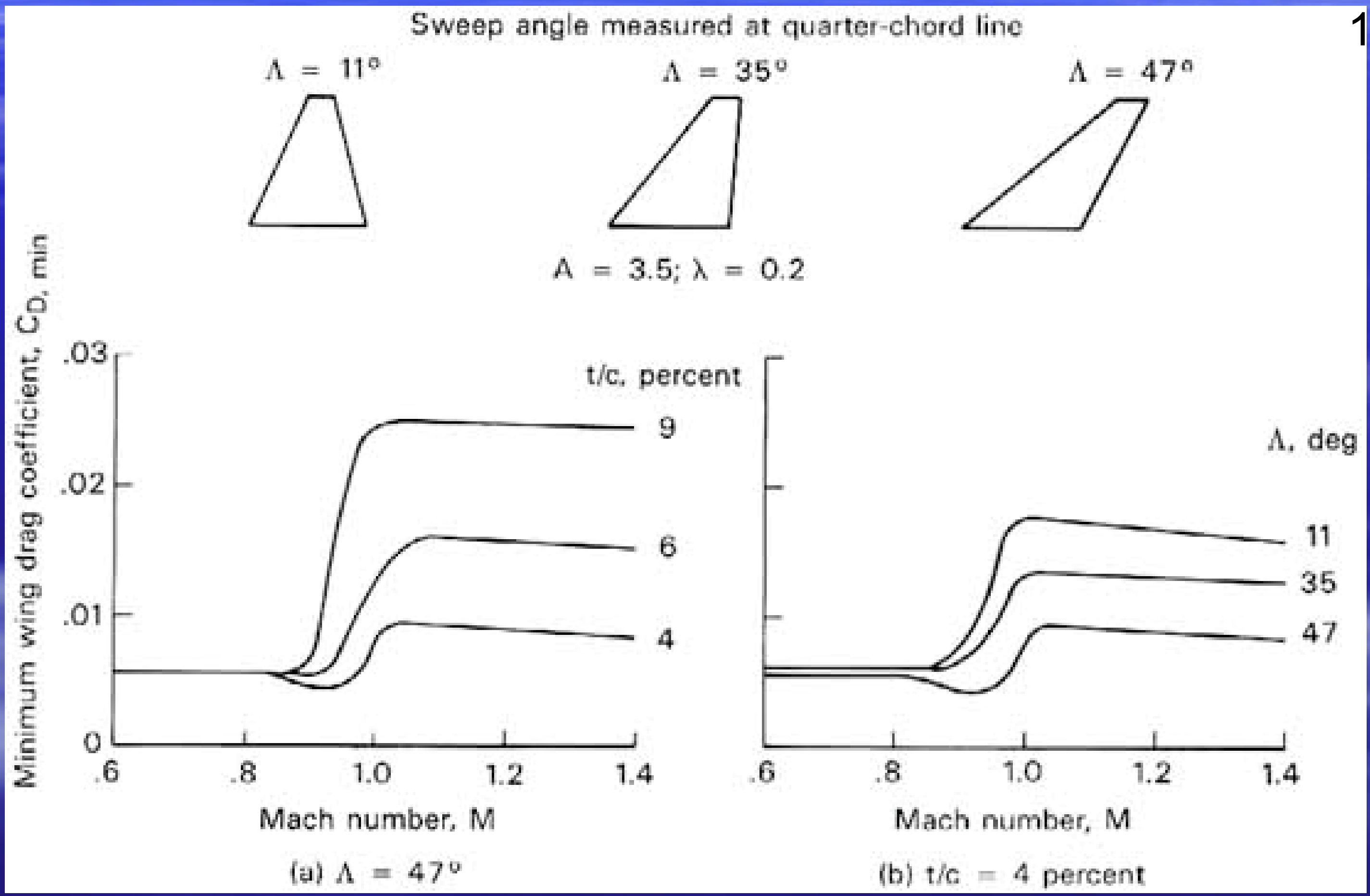


$$\frac{M_{cr,\Lambda}}{M_{cr,\Lambda=0}} = \frac{1}{\cos \Lambda}$$



- Independence of velocity components is true only for invisid flow
- Overestimates $M_{cr,\Lambda}$

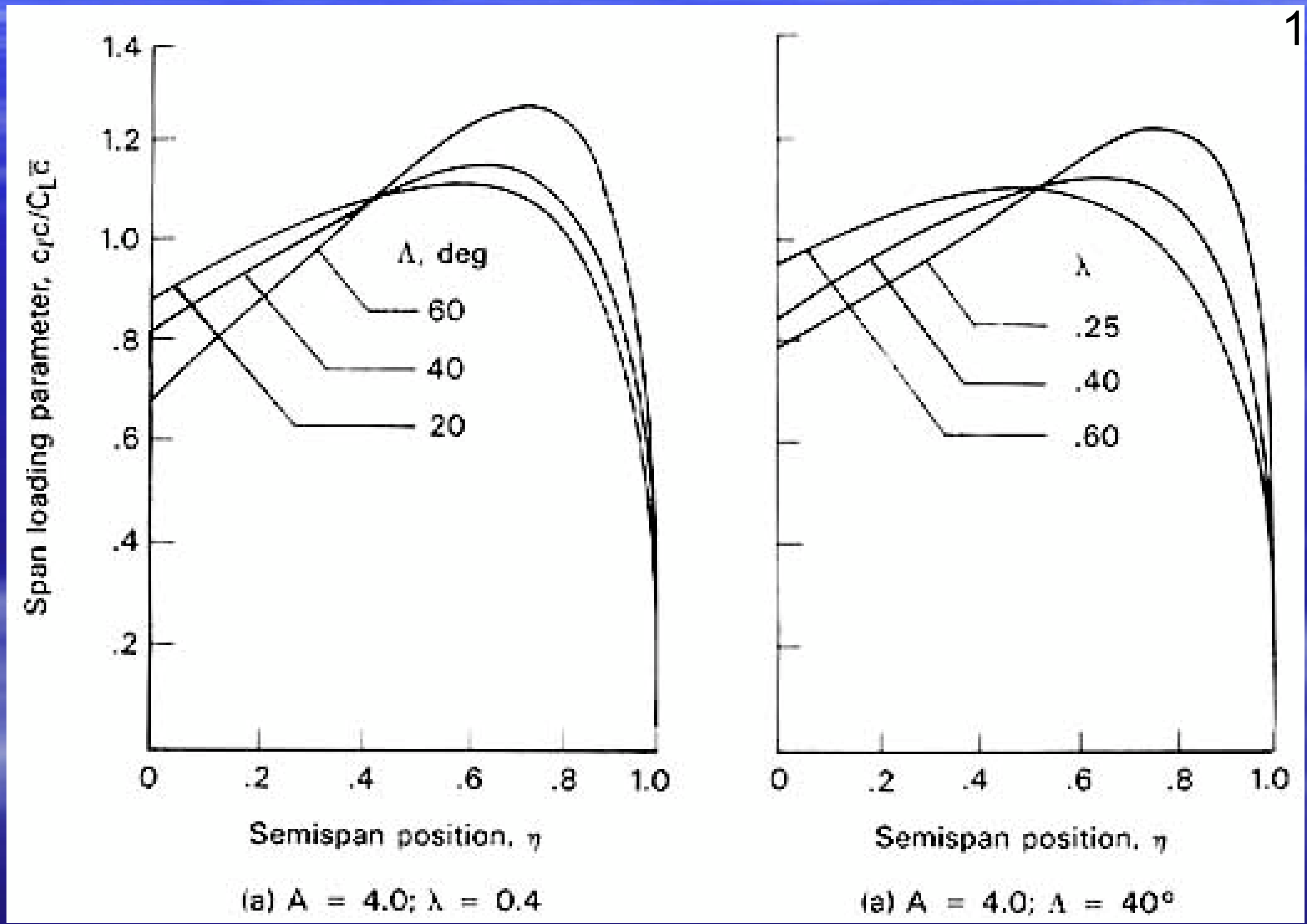
Thickness Ratio and Sweep Angle



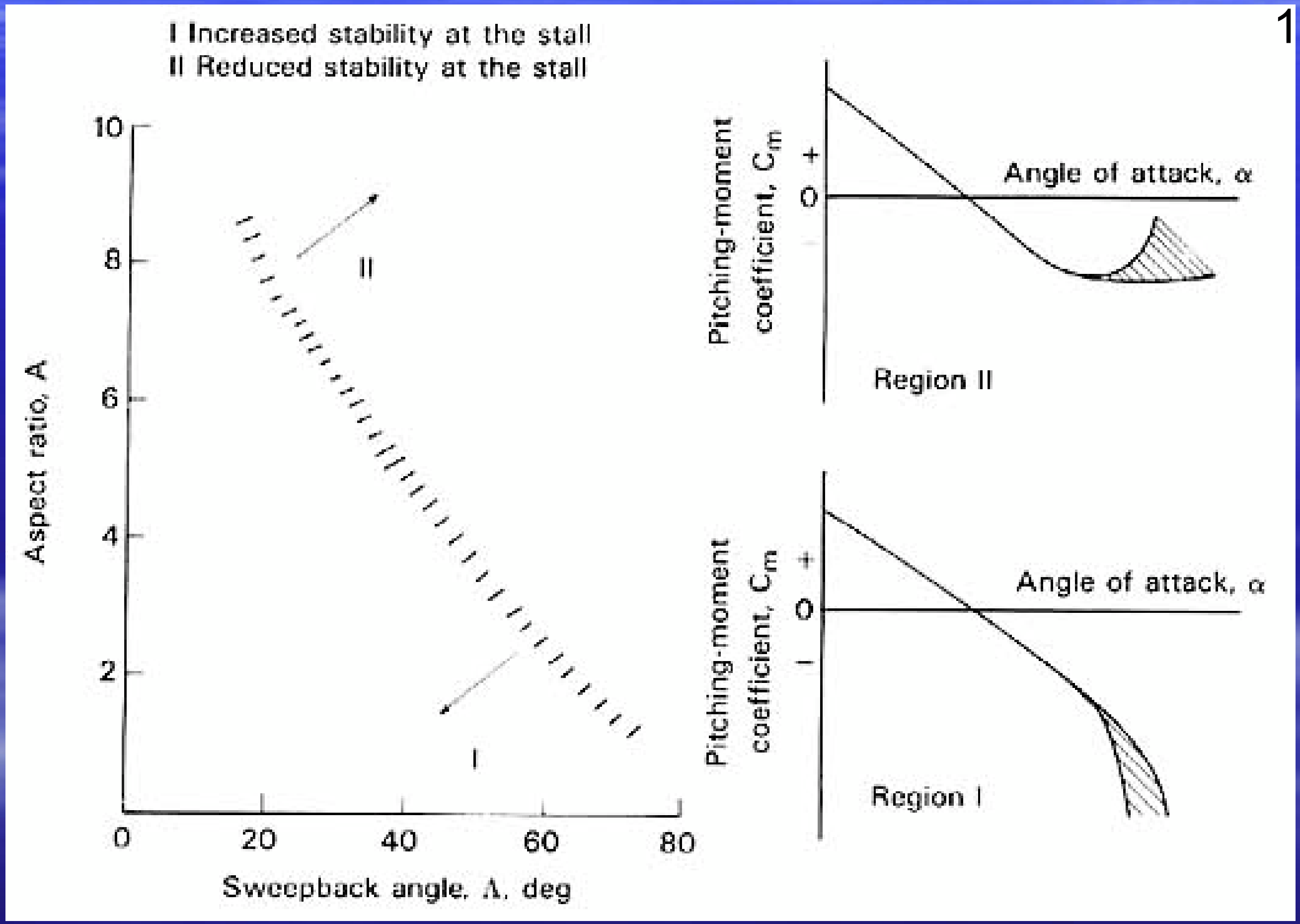
Problems At Stall

- Serious S&C problems at high α near stall
- NACA Bell L-39 swept wing flight study

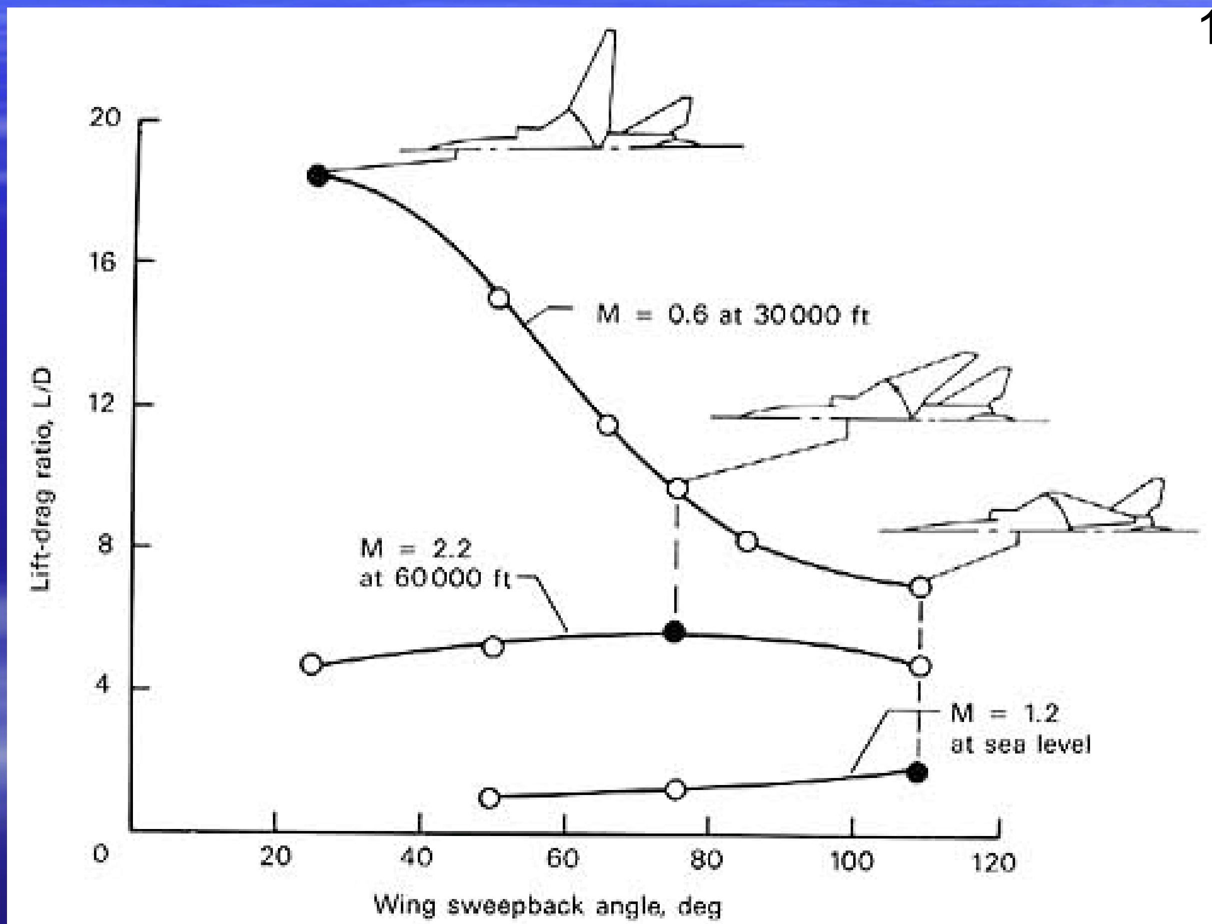
Effect On Span Loading



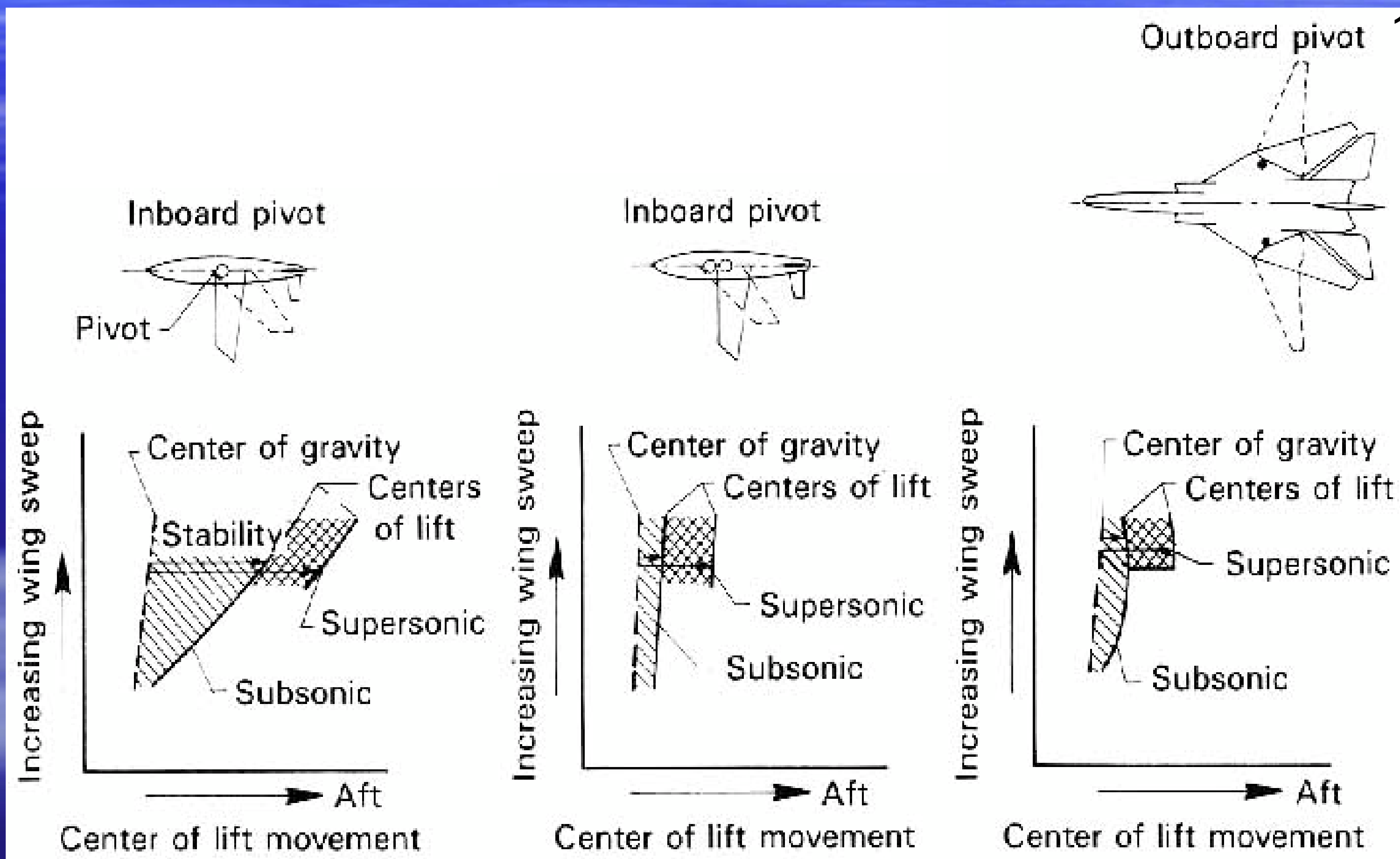
Stall Stability Boundary



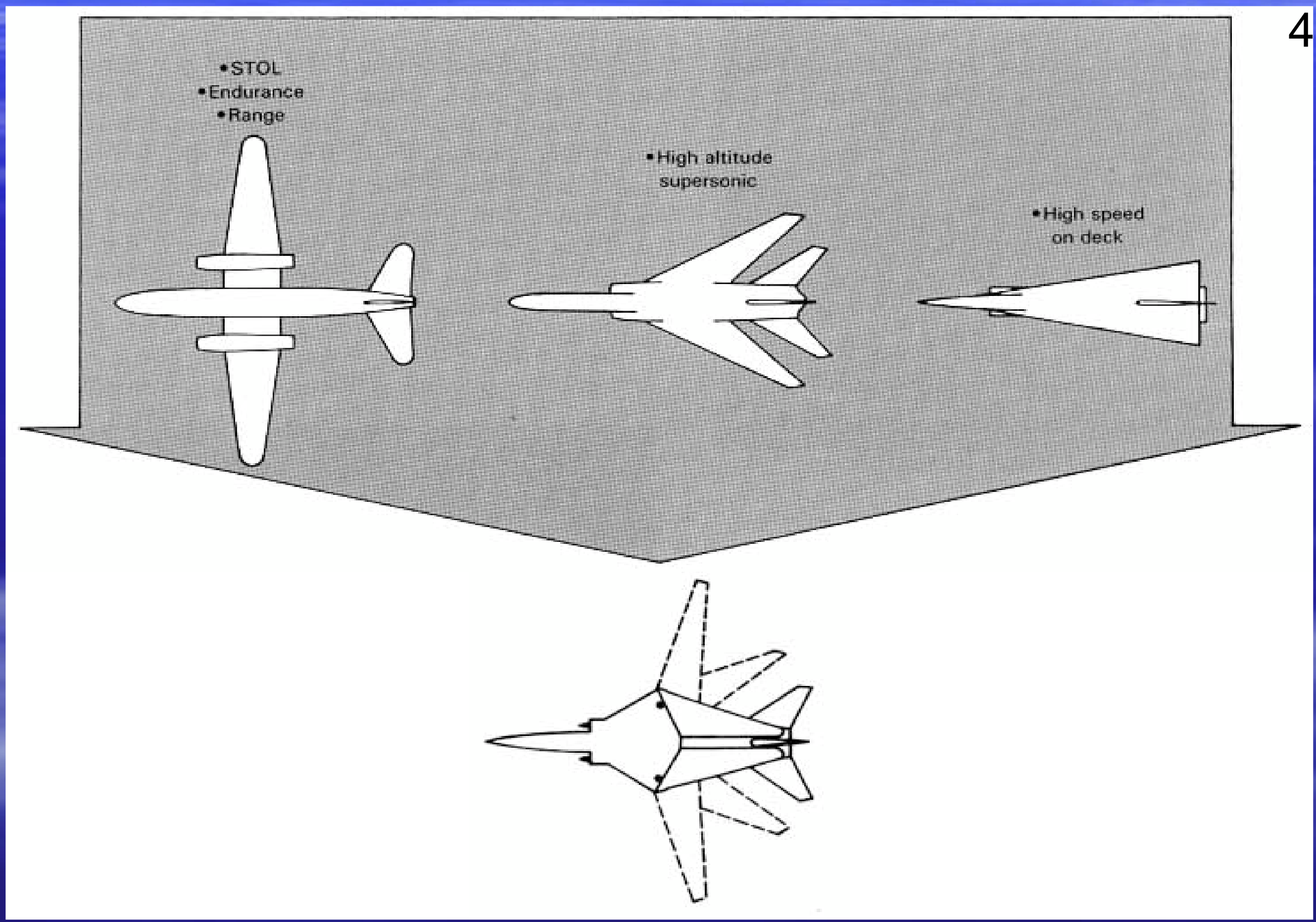
In-Flight Optimization



Pivoting Around Stability



Variable Sweep – Variable Mission



Variable Sweep Aircraft

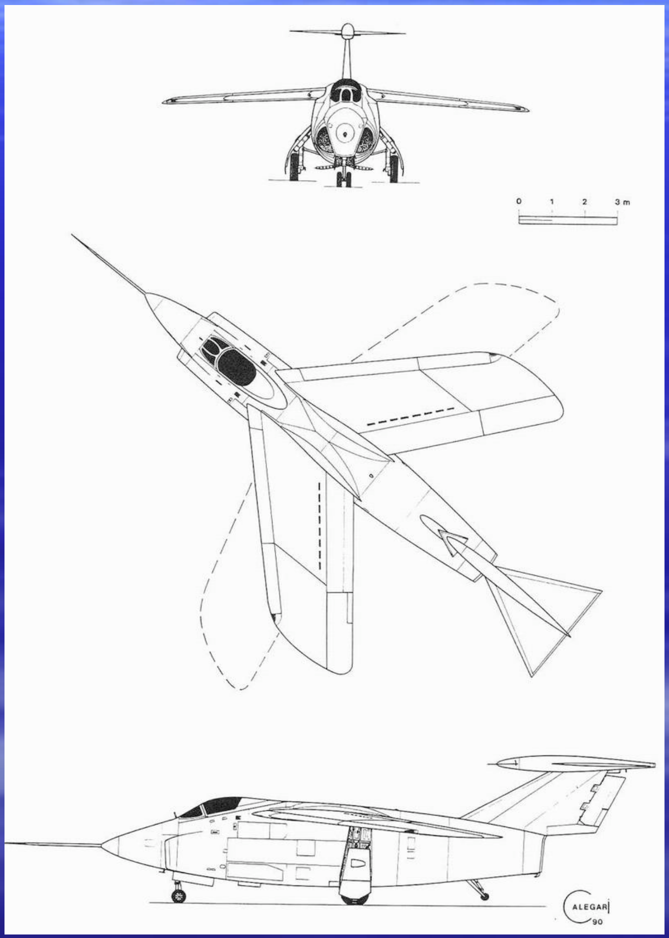
Bell X-5

- Sweep varied from 20° to 60°
- Mach 0.81 showed dramatic performance differences for varied sweep
- Short field landing and take off
- High rate of climb
- Good loiter capability

http://users.dbscorp.net/jmustain/x5.htm

Grumman XF10F-1

- Sweep varied from 13.5° to 42.5°
- Goals:
  - Reduce transonic drag
  - Low speed takeoff / landing for carrier use



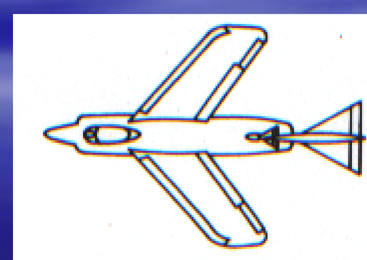
http://jpcolliat.free.fr/xf10/xf10.php3

XF10F-1 VS F3H-1

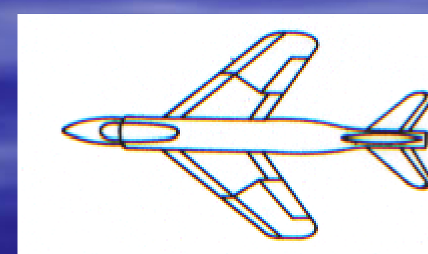
- Variable sweep provided:
  - Reduced landing speed
  - Higher max speed
  - Increased Range

	XF10F-1	F3H-1	
Weight	27,351	25,650	lbs
Wing area	467 - 450	442	ft^2
Span	36.8 - 50.6	35.3	ft
Stall speed	78	96	knots
Max speed	617	592	knots
Range	1450	1025	miles

XF10F-1



F3H-1



"Variable Sweep Wing Design"

General Dynamics F-111

- Navy: carrier based
- Air force: long range
- Combination of requirements led to variable sweep design
- Sweep varied from 16° to 72.5°

http://www.globalsecurity.org/military/systems/aircraft/f-111-pics.htm

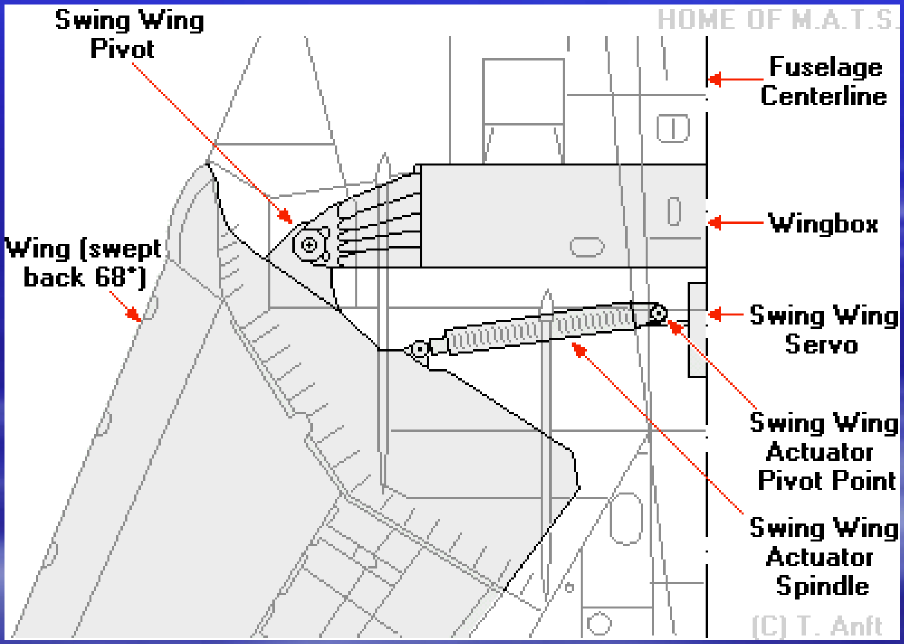
Grumman F-14

- Carrier based air defense
- Low speed take off / landing
- Capable of Mach 2.4
- Sweep varied from 20° to 68°

http://www.anft.net/f-14/f14-detail-wsm-04.htm

F-14 Sweep Mechanism

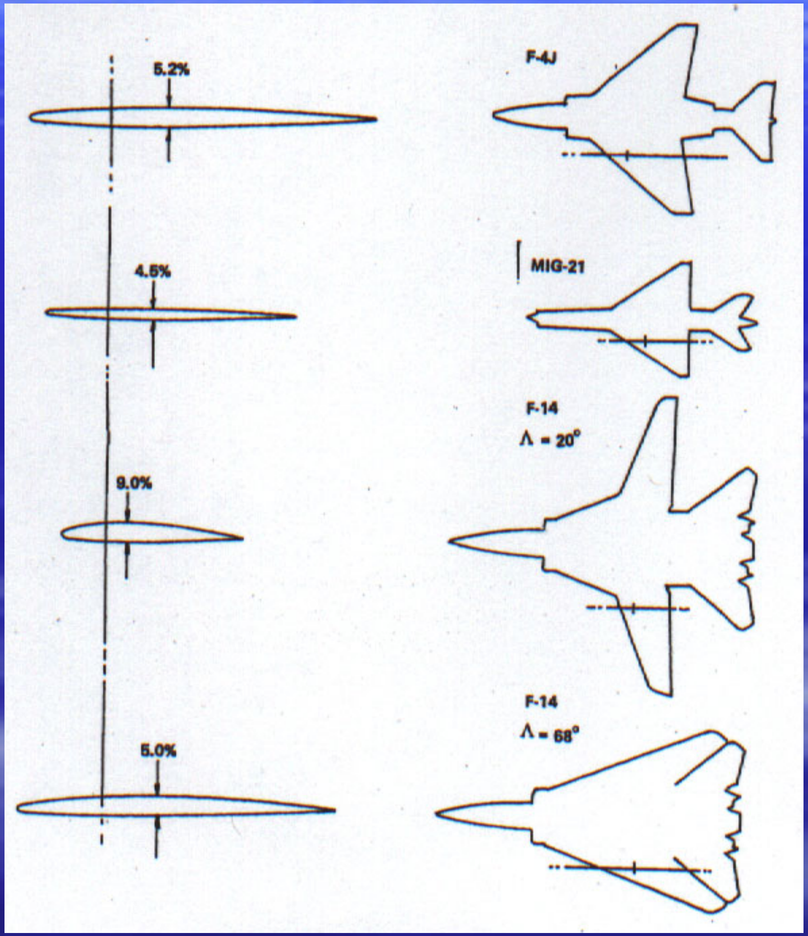
- Disadvantages:
  - Added complexity
  - Added weight
- Really add weight?
  - Larger wing area
  - Larger engines



http://www.anft.net/f-14/f14-detail-wsm-04.htm

F-14 Sweep Benefits

- Combines low and high speed performance
  - Airfoil for subsonic and supersonic
  - Reduced drag to weight ratio
  - Lower thrust to weight required



"Variable Sweep Wing Design"

Rockwell International B-1

- Sweep varied from 15° to 67.5°
- Forward swept:
  - Takeoff / landing
  - High altitude cruise
- Aft swept:
  - High subsonic flight
  - Supersonic flight

http://www.globalsecurity.org/wmd/systems/b-1.htm

Switchblade

- Possible design of forward variable sweep
- Leading edge becomes trailing edge
- Thought to be the now unveiled Boeing bird of pray

http://www.area51zone.com/aircraft/switchblade.shtml

References

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8. http://www.globalsecurity.org/military/systems/aircraft/f-111-design.htm
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10. http://www.globalsecurity.org/military/systems/aircraft/f-14.htm
11. "Variable Sweep Wing Design" by: Robert W. Kress
12. Bullets and lower right figure courtesy of http://www.bestanimations.com/Military/Planes/F-14/F-14.html
13. Virginia Tech logo courtesy of http://filebox.vt.edu/vaes/HRAREC/images/

Questions?

http://www.3dmodelworks.com/redir.asp?Page=thumb-show.asp%3FMODEL%3D706

Cool Picture

Free Flight F-111