OBLIQUE-WING GLIDE-BACK BOOSTER
FOR
SHUTTLE REUSABLE FIRST STAGE

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Background and Motivation

• Current Shuttle SRB Falls in Ocean After Separation

• Any Fly-back Concept Eliminates Search/Recovery Cost And Reduces Processing Cost

• Most Fly-back Concepts Require Engine, Fuel To Return Fuel Wt Approx 30,000 Lb/Booster

• Glide-back Concept Offers Much Lower Weight, Lower Complexity

Can It Be Done?

Objective:

• Demonstrate Feasibility of Turn and Glide-Back Using Oblique Wing Deployed on Reusable First Stage
Ballistic Trajectory of Current Shuttle SRB

Apogee
3600 ft/s

Separation
4200 ft/s
Γ = 30°
The Oblique-Wing Glide Back Concept

- Oblique Wing Stows with Minimal Impact on Ascent Configuration

- Variable Sweep, High Aspect-ratio Wing Provides Very High L/D Over Wide Mach No. Range

- Minimum Weight For Variable Geometry
  - Continuous Spar, No Bending In Pivot

Conceptual Design Sizing, Layout

- Wing Sized to Fit Existing Shuttle SRB
  - Biggest Wing Gives Best Turn Performance, Min Landing Speed
  - Nominal SRB Weight, Trajectory Used for Initial Feasibility Study

- Adaptable to Liquid-Fueled Booster, Aft C.G. Issue
Variable Sweep Provides High Aerodynamic Efficiency Over Wide Mach Number Range

![Graph showing lift/drag ratio vs. Mach number for different sweep angles. The graph demonstrates high aerodynamic efficiency across a wide range of Mach numbers.](embed)

ARC code A  scs 7/99
geometry figure — To be improved —
Trajectory Simulation of Turn and Glide-back Requires Aero-Performance Model

- Typical Conceptual Design Studies Rely on Low-Fidelity Aero-Performance: CL\text{max}, CD Estimation

- Extensive Wind Tunnel Database on Representative Configuration Provides High-Credibility Aero Model

- Data for Mach 0.4 - 2.5 From F-8 Oblique Wing Development

- Stowed Geometry Aero Model From CFD
Stowed Oblique Wing Booster
AIRPLANE Aerodynamic Coefficients, $M = 4.00$

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AIRPLANE

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$C_L$ vs $\alpha$

$C_L$ vs $C_D$

$C_L$ vs $C_M$
Drag Corrections for Re, Base Drag, and Aspect Ratio

\[ CD_{ow-gb} = CD_{F8} - \Delta CD_{Re} + \Delta CD_{base} + \Delta CD_{AR} \]

Re Correction:
\[ @ H = 42,000 \quad \Delta CD_{Re} = 0.0045 \]
\[ @ H = 0 \quad \Delta CD_{Re} = 0.0037 \]

Base Drag:
\[ @ M > 1 \quad \Delta CD_{base} = 0.0185 \]
\[ @ M < 1 \quad \Delta CD_{base} = 0.0130 \]

AR Correction:
\[ @ AR=9.5 \quad \Delta CD_{AR} = 0.0020 \]

\[ @ M < 1 \quad CD_{ow-gb} = CD_{F8} + 0.01 \]
Conclusions

- Oblique Wing Stows on Booster with Minimum Impact on Ascent Configuration

- Successful Glide-back Trajectory Demonstrated

- Many Issues/Questions Remain

  - Increased Booster Length Improves performance

  - Aero-brake from Separation to Apogee

  - Base Drag Reduction

  - Wing Weight

  - Aft C.G. For Liquid Fueled Rocket

  Tentative answers exist.