System Studies of Unconventional Aircraft

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Workshop on Revolutionary Aircraft for Quiet Communities

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Introduction

• Advanced aircraft concept studies provide a vision of the possible – what could be, not necessarily what will be

• Future, unconventional aircraft concepts offer both opportunities and challenges from an aircraft noise perspective

• This presentation provides a glimpse of possible future aircraft based on ASAB and other NASA studies

• “Realism” of concepts presented varies from notional sketches to the output of conceptual design studies
Jet Transports: Over Wing Nacelle*

- New installation appears to eliminate drag penalty
- Easy clearance for large bypass engines
- Wing shielding of lower hemisphere engine noise
- No gaps in flaps (noise & performance benefit)
- Issues include maintenance access, cabin noise

*Shielding Effect is Approximately 4 EPNdB to Community for Pylon Mount, Fan Exit Dominates

Jet Transports: Blended Wing Body

• Typical over-body engine placement provides opportunity for noise shielding

• Improvement in aerodynamic efficiency compared to wing-body-tail configuration

• Key technical issues such as stability and control and non-circular pressure vessel continue to be worked

• Basic configuration for numerous low noise and/or high efficiency aircraft concepts
• Extension provides a noise shield between engines and observers on the ground.

• Length ranges from 1/2 to 3 times the fan exit diameter (largest extension possible to avoid tail strike on takeoff).

• Systems Impacts
  – Increased weight and drag due to larger “tail” area
  – Additional tail weight penalty due to retractable mechanism
  – Thrust reverser operation could be a problem

Low pressure ratio internally blown flap (IBF) for quiet powered lift and pitch control

Preliminary results indicate significant noise reduction

Systems Impacts
  - Increased overall propulsion system weight
  - Reduced engine efficiency
  - Increased maintenance costs
  - Increased noise from IBF?

Study conducted by Boeing under Revolutionary Aero-Space Engine Research (RASER) Contract

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*More at: [http://www-psao.grc.nasa.gov/presentations/CESTOL.ppt](http://www-psao.grc.nasa.gov/presentations/CESTOL.ppt)
Jet Transports: Notional Concepts

- Advanced Vehicle Configuration Workshop held at Langley in 2003
- Structured brainstorming of unconventional propulsion-airframe integration for low noise
- Qualitative assessment of concepts using Pugh Decision Matrix
Fuel Efficiency vs. Noise?

- Economic and environmental pressures could lead to a search for higher fuel efficiency
- Concepts for increased fuel efficiency may have negative noise implications...

- Noise challenges for unducted fan / propfan include airport noise, interior noise, and even cruise overflight noise
Striking an Environmental Balance…

• What is the right balance between fuel efficiency, emissions, and noise?
  – Pursue concepts which benefit all three areas?
  – Accept penalty in one area to realize significant gains in another?

• Ultimately the right balance depends on many external drivers, not just technology
Quiet Green Transport Concept A*

- Over-wing Engines
- Fuselage LH₂ Tanks
- Strut-Braced Wing
- Ultra-High Bypass Ratio H₂ Turbofan

- Steep Approach
- “Contrail Avoidance” Cruise

CO₂, CO, SOₓ, soot, hydrocarbons, contrails

Sound Exposure Level Contours

55 dBA Contour (Area –53%)

Community Noise (11 Study Airports)

Potential 90% Reduction*

* With Concept A benefit assumed for all aircraft types

Quiet Green Transport Concept B*

- Steep Approach
- “Contrail Avoidance” Cruise
- Distributed H₂ Fuel Cell Propulsion (H₂O only emission)
- Forward and Aft Noise Shielding
- Continuous Moldline Flaps
- Blended Wing Body
- Fuselage LH₂ Tanks

- Advanced technology (25-30 yr) fuel cell propulsion system
- 30% red. in structural, systems & equipment, fuel tank weight
- 15% red. in drag beyond current BWB designs

General Aviation: Civetta Concept*

Class: 4-seat, single engine
Wing Span: 39.0 ft
Wing Area: 162.5 ft²
Gross Weight: 3600 lb
Empty Weight: 2450 lb
Engine: Chevrolet LS-1 V8
Power: 300 hp
Cruise Speed: 163 kts
Landing Speed: 52 kts

General Aviation: Propeller Noise*

- Low noise propulsor studies performed by Hamilton-Standard in 1970-80’s
- Low noise propulsor is heavier, costlier, less efficient
- Quiet propeller is not retrofittable & requires a gearbox
- Quiet fan is not retrofittable but does not require a gearbox

“Time is money” principle provides a motivation for supersonic travel

Low bypass ratio engines make meeting airport noise regulations very challenging

Must fly supersonic over land to be economically viable
  - Sonic boom mitigation
  - Regulatory changes
• **Potential** civil, commercial, and military applications of unmanned aerial vehicles seem almost limitless

• Focus of current UAV debate largely on safety issues, could community noise be an obstacle as well?

• Many of the postulated missions could spread aircraft noise issues beyond airport communities
UAV: Border Eye Concept*

“Mothership”

- Originally designed for border surveillance
- Commercial uses? Automated package delivery?

*Developed by AVID, LLC under NASA Revolutionary Systems Concepts for Aeronautics (RSCA) project; NASA Technical Monitor Dennis Bartlett; presentation available at http://sacd.larc.nasa.gov/projects/RSCA.htm
UAV: “Aerobots”*

Small Package Delivery

Courier-Bot

Pizza Delivery

Summary

• ASAB, along with sister branches at other NASA Centers, continues to explore unconventional aircraft concepts
• New, unconventional aircraft concepts may mitigate or exasperate noise issues
• Future community noise concerns may extend beyond the airport area, e.g., small UAVs, sonic boom, propfan overflight
• Successful implementation of an unconventional concept depends as much or more on the market and regulatory environment as on the availability of technology

“Prediction is very difficult, especially if it’s about the future.”
Niels Bohr, physicist (1885 – 1962)