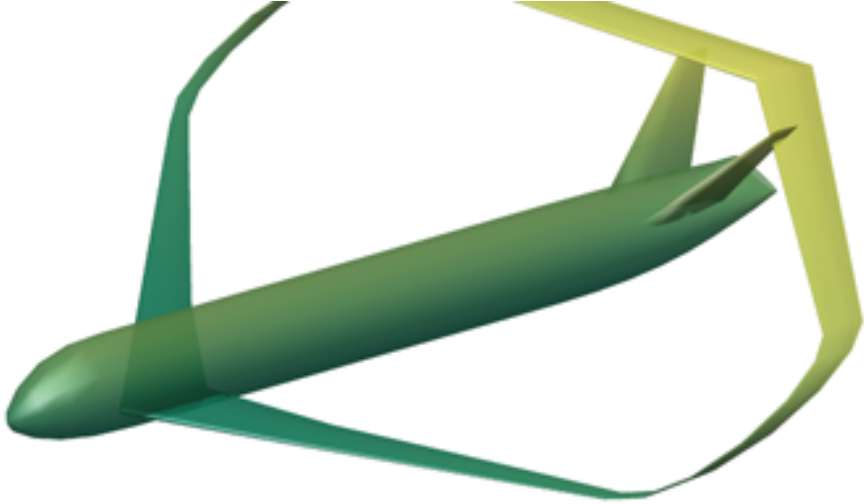
December 4-6, 2012

COLLABORATION
IN AIRCRAFT DESIGN
2nd CPACS / RCE SYMPOSIUM



Integrated Design Lab | HAMBURG

Design Challenge

DLR

Summary

- These slides elaborate on the design challenge for a new medium range civil transport aircraft
- The design challenge is part of the Collaboration in Aircraft Design series of CPACS/RCE Symposia organized by the German Aerospace Center (DLR)
- Results will be presented at the 3rd CPACS/RCE Symposium on 19th/20th September 2013 in Linköping, Sweden
- The design challenge is open for anyone interested in aircraft design and multi-disciplinary optimization

3rd CPACS/RCE Symposium

- 19th/20th of September 2013 in Linköping, Sweden
- The symposium is held in cooperation with CEAS 2013 Air & Space Conference
- It is possible (but not necessary) to hand in papers for the CEAS 2013 Air & Space Conference. The abstract deadline is the 15th of Feb 2013. Please refer to your design team for possible contents.

TLAR

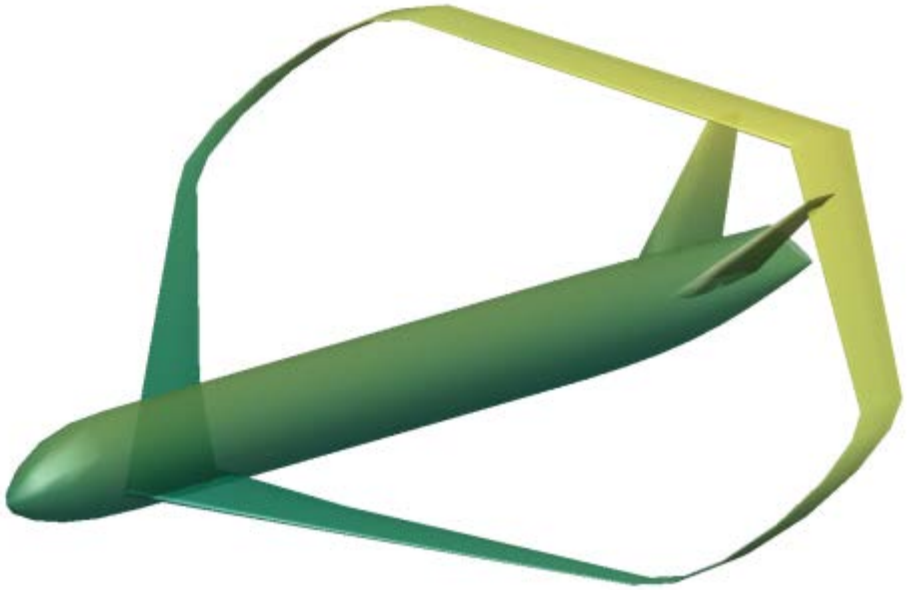
- The top-level aircraft requirements describe the overall design task for aircraft to be designed
- The overall goal is to reduce cash operating cost
- A method for estimation of cash operating cost for EIS 2025 will be made available by 02/13
- All requirements may be violated for good reason! Try to achieve as much reduction of cash operating cost as possible. This will not be possible without changing the rules of the game.

PAX	190 all economy @ 30“ pitch 100 kg/pax payload capacity for high density layout @ 28“ pitch
Range	2000 NM (90% of flights within Europe and USA < 500 NM range). Technical means to enable up to 2900 NM range
TOFL	2000 m, SL, MTOW, ISA +15° C
LDGFL	1500 m, SL, MLW, ISA +15° C
Mach	0,79
Initial Climb/ Max. Altitude	FL 350 FL 410
Span	Max. 36m or technical means to achieve ICAO class C
Noise	-5 dB cum. vs. Chapter 4
Fuelburn	-25% versus A320 (CFM) 2009
Emissions	Near zero emissions at gate and during taxi
CoC	-35% versus A320 (CFM) 2009

Design Teams

- Four different configurations have been discussed at the 2nd CPACS/RCE Symposium in Dec 2012.
- For each configuration preliminary information and points of contact are given. Feel free to get into contact with us for any given configuration
- The design challenge is open for additional technologies, configurations or means to reduce cash operating cost
- A preliminary work schedule will be created by end of Jan 2012.

Box Wing



Less Aircraft

Box Wing

Cost impact

Operational Cost

Mass per available seat

REQUIREMENTS
- NO REQ SEEMS PARTICULARLY CHALLENGING

- CONFIG SEEMS PARTICULARLY SUITABLE TO GIVEN REQS

MOTIVATION: → MORE L/D
- INDUCED DRAG REDUCTION
- LOWER INSTALLED THRUST (LIFT TO NACELLE)

ISSUES:
- STRUCTURAL PENALTY
- OFF DESIGN ON C_{Di}

- FUEL STORAGE (STRUCTURAL ARCHITECTURE)
- "MORE INTEGRATED" DESIGN (MORE DIFFICULT TO DESIGN)

- LAT. STABILITY ON THE GROUND
- LAND. GEAR INTEGRATION

Stability & control characteristics

- MAINTAINANCE: ACCESSIBILITY; MORE "MOVABLE COMPONENTS" ON WINGS → & SYSTEMS

- GROUND HANDLING (REFUELLING?)

- SAFETY ISSUE IN CASE OF WING TANKS ON FIRE

Higher manufacturing costs → RC

- INVESTIGATE ALTERNATIVE BOX WING CONFIGS
  - STAGGER
  - WING SEPARATION
  - WING ATTACH. FUS.

- AERO TOOLS VALIDATION (DO CONV. TOOLS SUFFICE?)

MORE SOPHISTIC.
- AEROELASTICS TO BE USED ALREADY IN CONC./PRELIM. DESIGN

AirLive ... required.

software.DLR.de

Box Wing

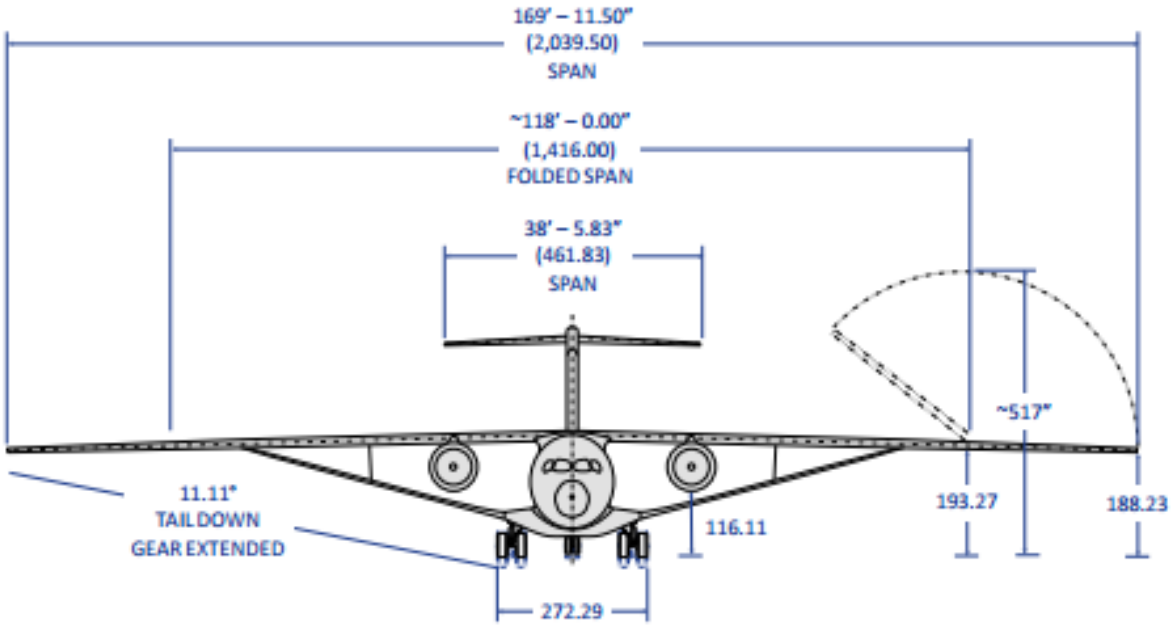
- Ground handling issues
- Amount of storable fuel
- Maintenance issues
- Safety (ground fire)

- Reduced induced drag
- Lesser fuel burn
- Less thrust, less noise
- Fits requirements

Design Team Partners: TU Delft, RWTH Aachen, University Linköping, DLR

Point of Contact: K. Risse, RWTH Aachen, F. Dorbath, DLR

Strut Braced Wing



Picture, NASA Subsonic Ultra Green Aircraft Research

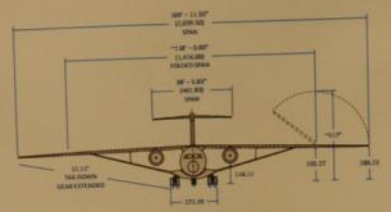
Critical:
→ Fuel Volume
→ Landing Gear Integration
Strut Integration:
→ avoid compression
→ cable ?
→ shock in strut attachment to w
Strut as Wing
→ Leading to Joint Wing
→ " to Box Wing

1

Reason for Cost Reduction:
→ fuel reduction → ground handling ?
→ drag "
→ mass "
Foldable Wing
→ SBW better to take the hinge moment
→ no hydraulics outside of hinge
Multi Use of Strut:
→ fuel storge
→ Lift generation
→ high lift "

2

Strut Braced Wing



Engine Integr.
→ probably normal pos.
Investigate Airport Constraints
Negotiate

3

Foldable Wing used also as Winglet

4

2 Struts:
Forward / Rear Spar

5

Strut Braced Aircraft

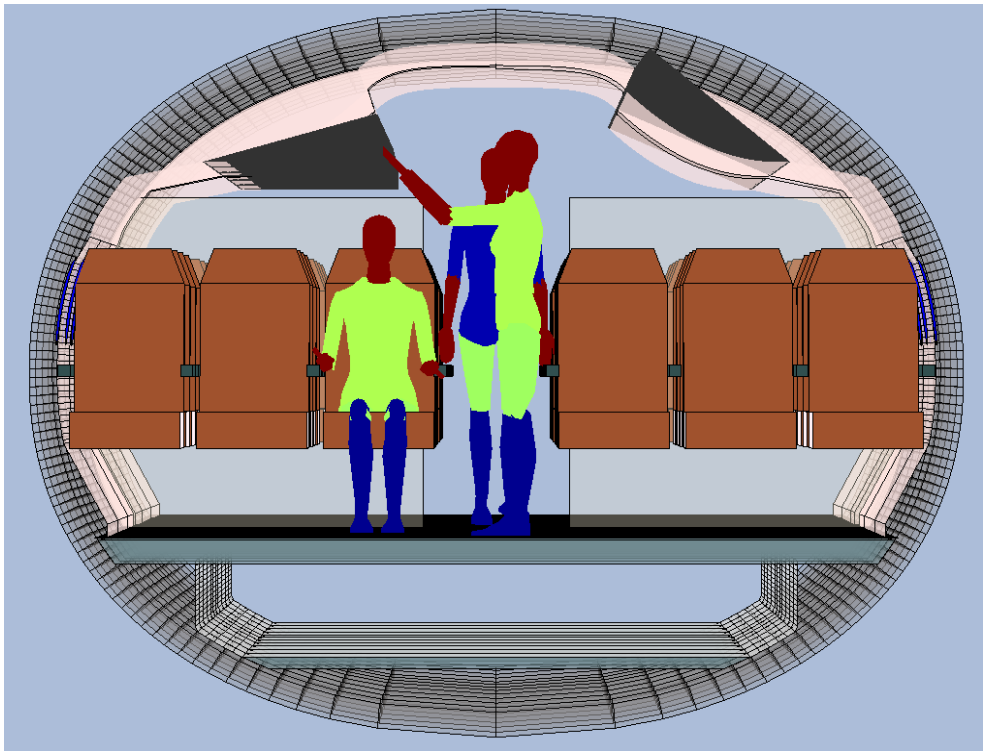
- Amount of storable fuel
- Flutter analysis
- Strut attachment
- Interference drag
- Landing gear integration

- Reduced induced drag
- Reduced wing mass
- Combination with foldable wings

Design Team Partners: KTH Stockholm, HAW Hamburg, CFSE Lausanne, DLR

Point of Contact: D. Scholz, HAW Hamburg, E. Moerland, DLR

ULD Less Aircraft




ULD
Cargo Less Aircraft
Technical Challenges
Non - circular cross section
Analysis of Turnaround Advantage
Does not cover 100 % of market.
Engine Placement
[Potential] Advantages
Different use of lower deck.
Ground Handling
Less wetted area ⇒ CD0
Enable new revenue potential
Different Cabin Product
Fuselage Mass
Cost impact
Operational Cost
Mass per available seat
AirLive model required.

ULD Less Aircraft

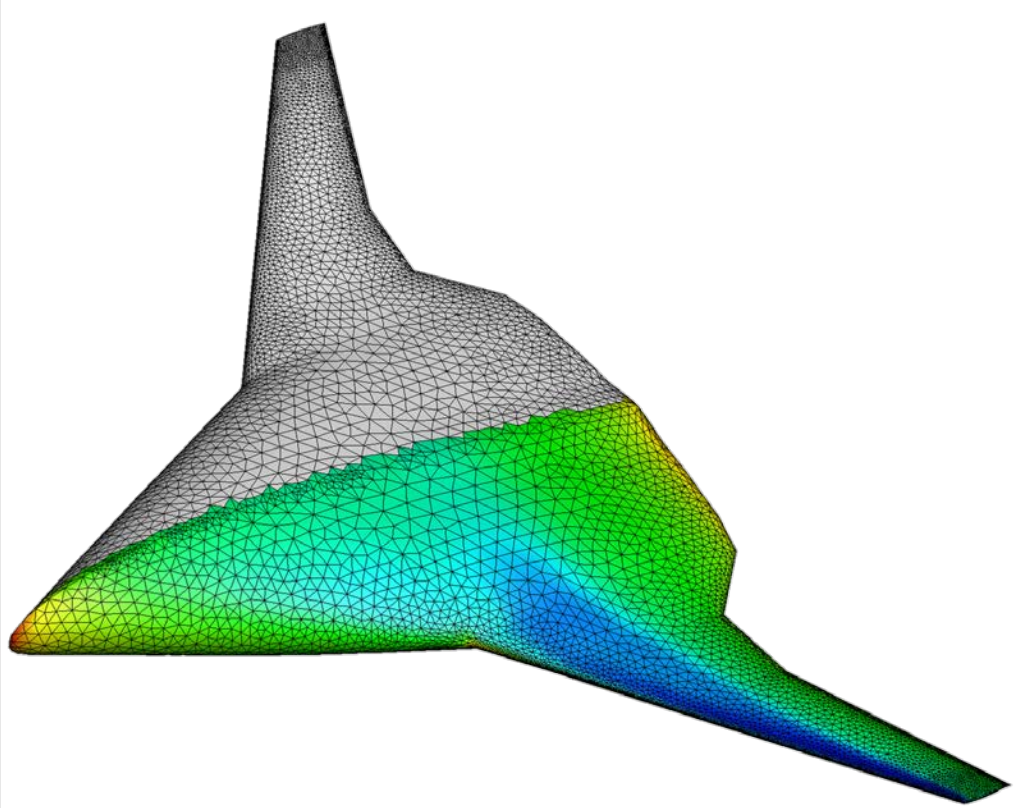
- Turnaround advantage
- Reduction in ground fees
- Possible additional revenues
- Unused fuselage volume

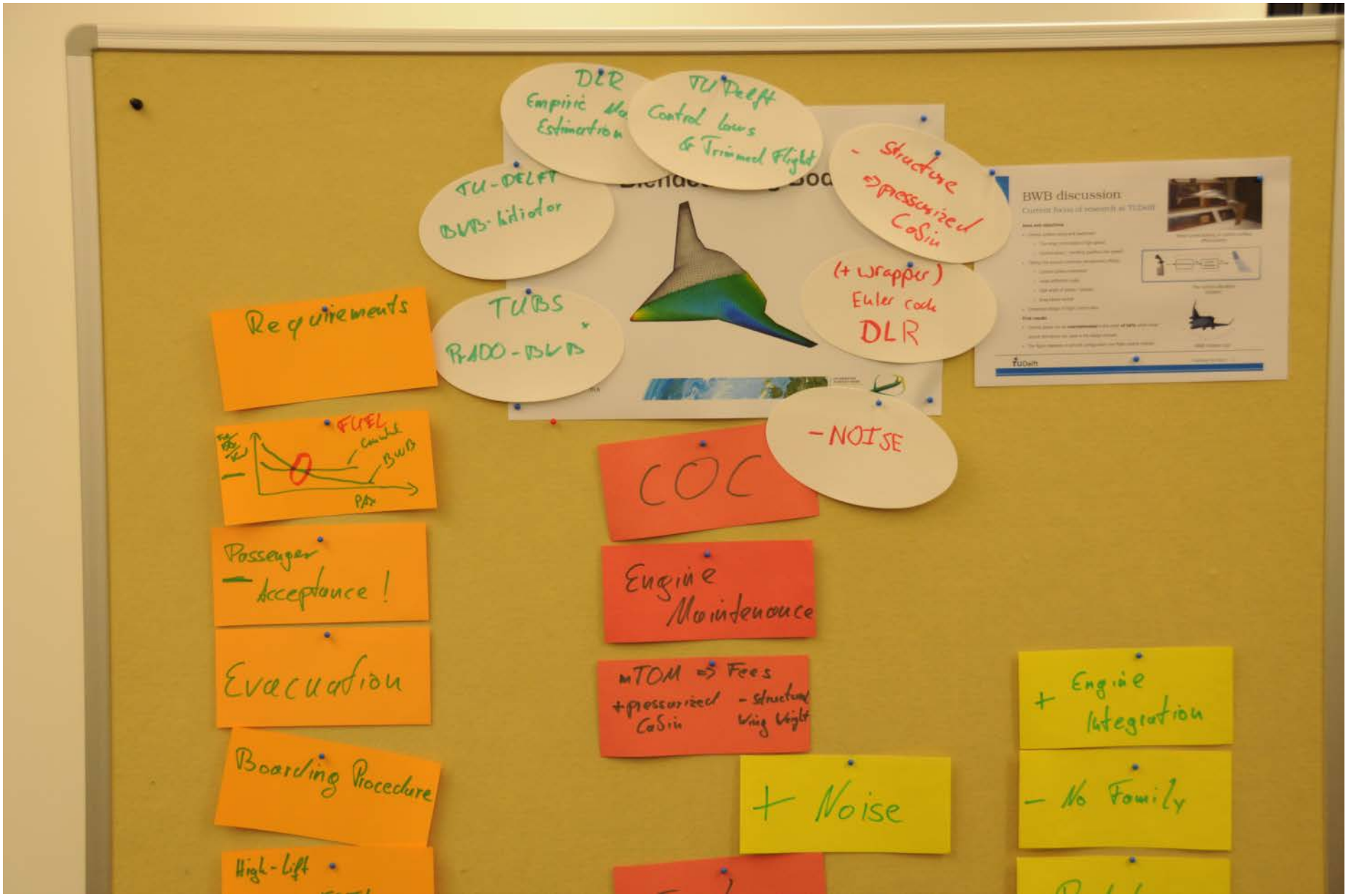
- Towards alternate payload accommodation
  - Seating concepts
  - Service level
  - Cargo and baggage stowage
- Integration with other concepts

Design Team Partners: RWTH Aachen, DLR, NASA (over wing nacelles)

Point of Contact: J. Fuchte, DLR

Blended Wing Body




DLR
Empiric
Estimation
TU Delft
Control laws
& Trimmed Flight
TU-DELFT
BWB-Editor
- Structure
⇒ pressurized
CaSin
TUBS
PrADO - BWB
(+ wrapper)
Euler code
DLR
BWB discussion
Requirements
FUEL
BWB
PAX
- NOISE
COC
Passenger
- Acceptance !
Engine
Maintenance
Evacuation
mTOM ⇒ Fees
+ pressurized
CaSin
- structural
Wing Weight
+ Engine
Integration
Boarding Procedure
+ Noise
- No Family
High-Lift


Acceptance !
Evacuation
Boarding Procedure
High-lift
=> TOFL
=> LPFL
Ma ↓ ICA ↑
HQ
Stability Margin
relaxed
Maintenance
MTOM => Fees
+pressurized Cabin
- structural Wing Weight
+ Noise
+ Fuel
Potential for rising Fuel Price
Maintenance of Control System
Rise in Ground Handling
Infrastructure
=> Maintenance
+ Engine Integration
- No Family
- Production Cost
Development - Cost
+ Volume
=> Cargo, Fuel
Hydrogen

Blended Wing Body

- Not a medium range competitor
- Passenger accommodation
- Safety (ditching)
- Boarding procedure
- Weight estimation of pressurized cabin
- Lesser fuel burn
- Less thrust, better shielding less noise
- Adjustment of stability margin

Design Team Partners: TU Delft, TU Braunscheig, DLR

Point of Contact: P. Ciampa, DLR, M. Voskuijl, TU Delft

We like to thank all attendees of the 2nd CPACS/RCE Symposium for their contribution. We are very happy about the broad interest in Collaboration in Aircraft Design!

We are looking forward to the 3rd Symposium and the results of the Design Challenge. This an ongoing process, feel free to ask any questions and get into contact with us.

Björn Nagel and Daniel Böhnke