

From Gasdynamic Models to High Speed Design: A learning Process

A contribution in memory of working with Richard Seebass

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Motivation

Thinking of the past 30 years' work, remembering a friend.

- 1. Classical tools for modern aerodynamics (1972)*
- 2. New tricks for transonics (1976)*
- 3. Let the wing change its shape (1980)*
- 4. Inverse supersonics (1987)*
- 5. Geometry for innovations (1991)*
- 6. What is left of the tricks? (1996)*

Transonics in the 1970's

Fluid mechanics education with the computer arriving.

Compressible flow modeling of experimental results

Potential flow,

Poisson equations,

Analytical methods:

Singularities,

Mapping techniques,

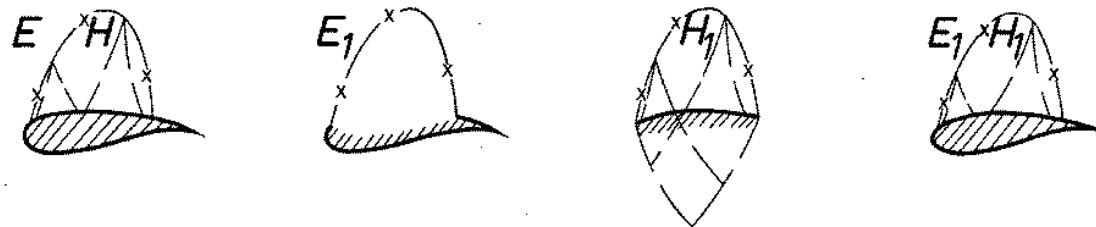
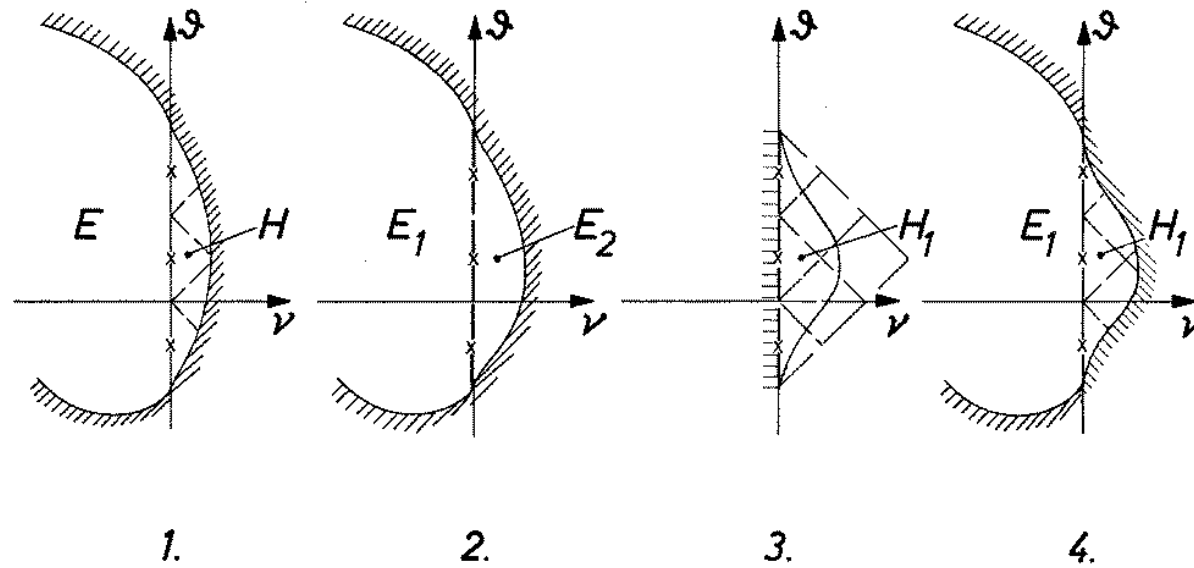
Method of characteristics

Hodograph method

Learning by playing with classical tools of physics:

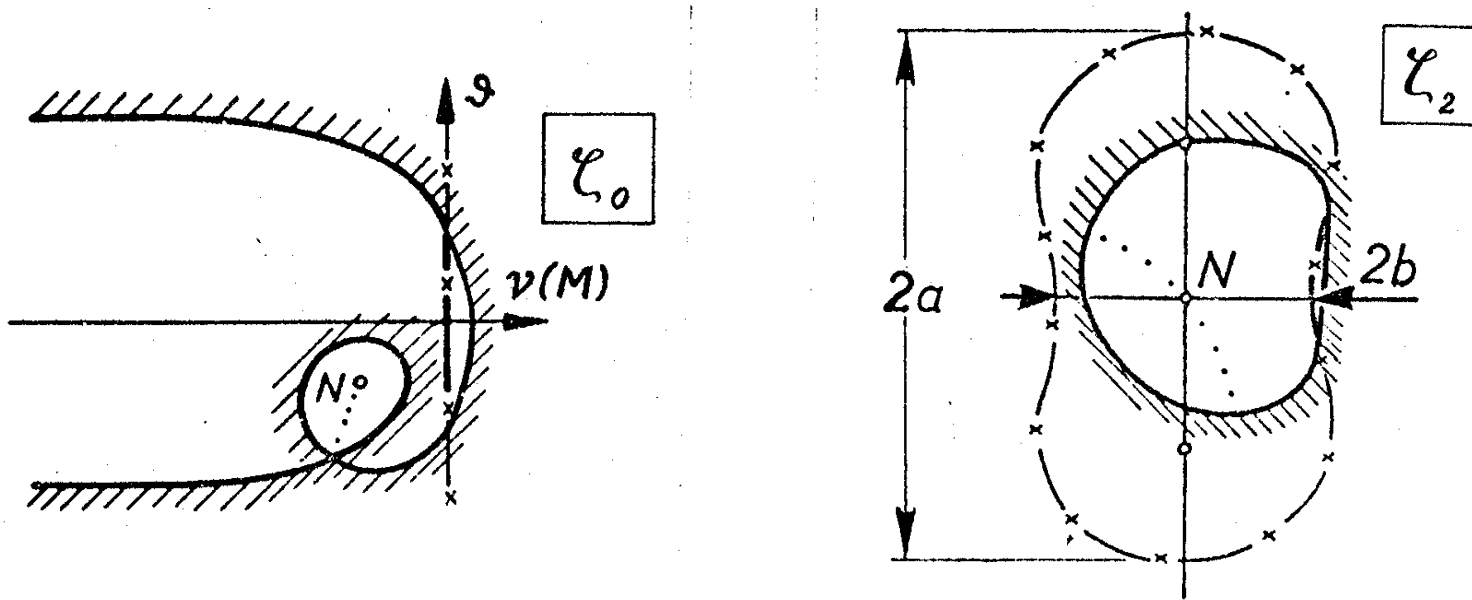
Rheoelectric analogy

Elliptic continuation in a hodograph plane



Rheo-electric hodograph plane

from the analog set-up to a Poisson boundary value problem



Theses: Albrecht **Eberle**, Ahmed **Hassan**

Gasdynamic models for design

From 'Elliptic Continuation' to 'Fictitious Gas'

A sign change in the hodograph equations means...

....a modified density - velocity relation in the non-linear potential equation,

....a balanced momentum and energy addition/removal in the Euler equations,

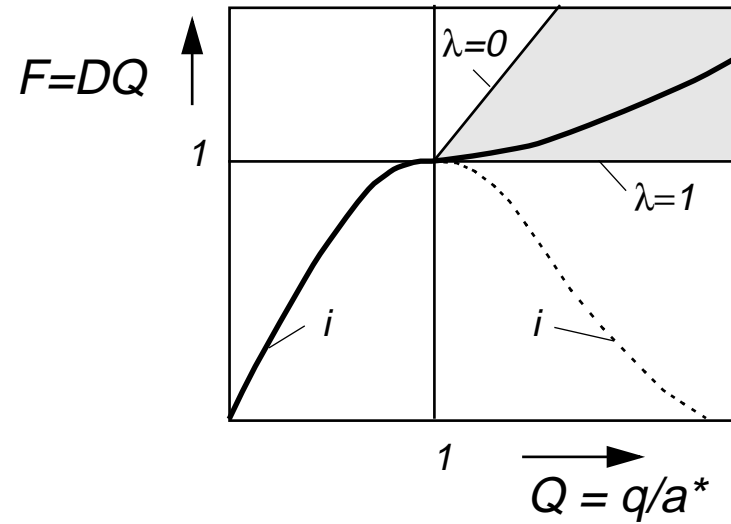
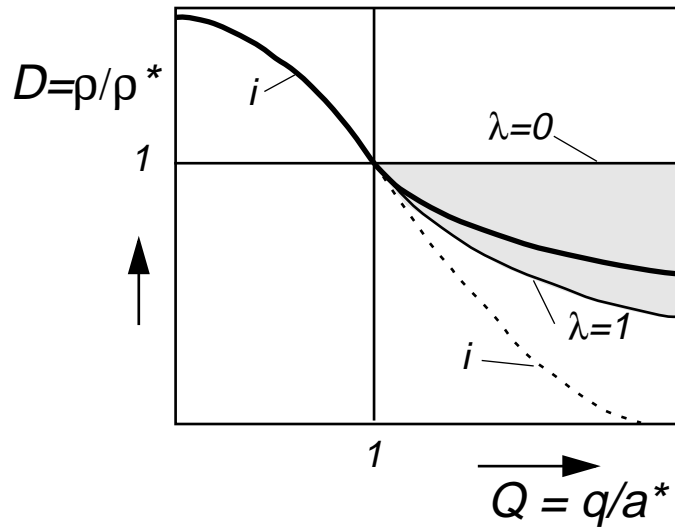
... that CFD codes can be converted to become design tools.

.... a controlled heating / cooling in the flow field where $q > a^$*

Parametric Fictitious Gas

Density - velocity relation

$$D_f = \left(1 + \frac{1}{\lambda}(Q - 1) \right)^{-\lambda}$$



Converting CFD analysis codes to become design tools

Partners and / or Thesis students

K-Ying Fung (1978): TSP codes, FLO 6 2D airfoils, FLO 22 3D wings

Jong Yu (1979): FLO27, FLO 28 3D wing - body

Howard Nebeck (1981): Grumfoil, 2D airfoils

Albrecht Eberle (1981): MBB code, 3D wings

Phil Beauchamp (1982): NASA Lewis code, 2D Turbo-cascades

George Dulikravich (1982): Cas22, 2D Turbo-cascades

Sri Sritharan (1982): 2D code for conical crossflow design

.....

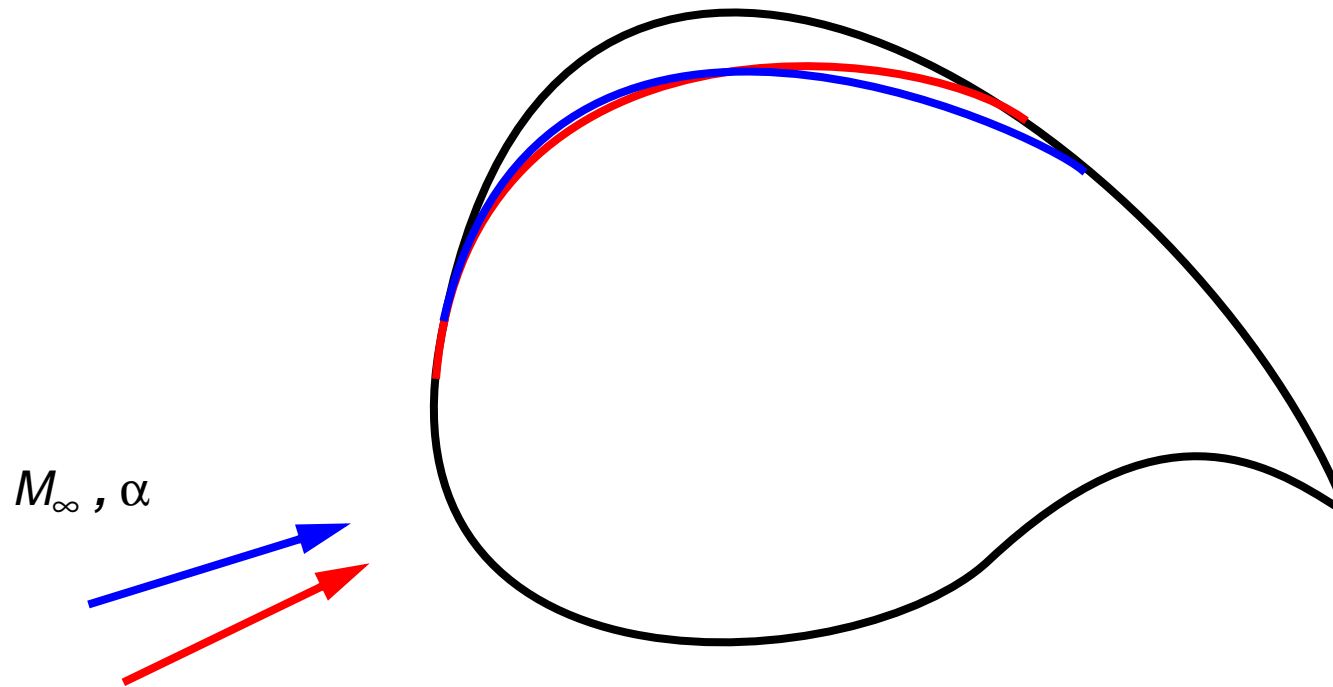
Pei Li: DLR-Cevcats 2D airfoils (1992), CFL3D 3D wings (1995)

Wolfgang Geissler, (1996): 2D steady / unsteady N/S code

Markus Trenker (2001): 2D steady / unsteady design software

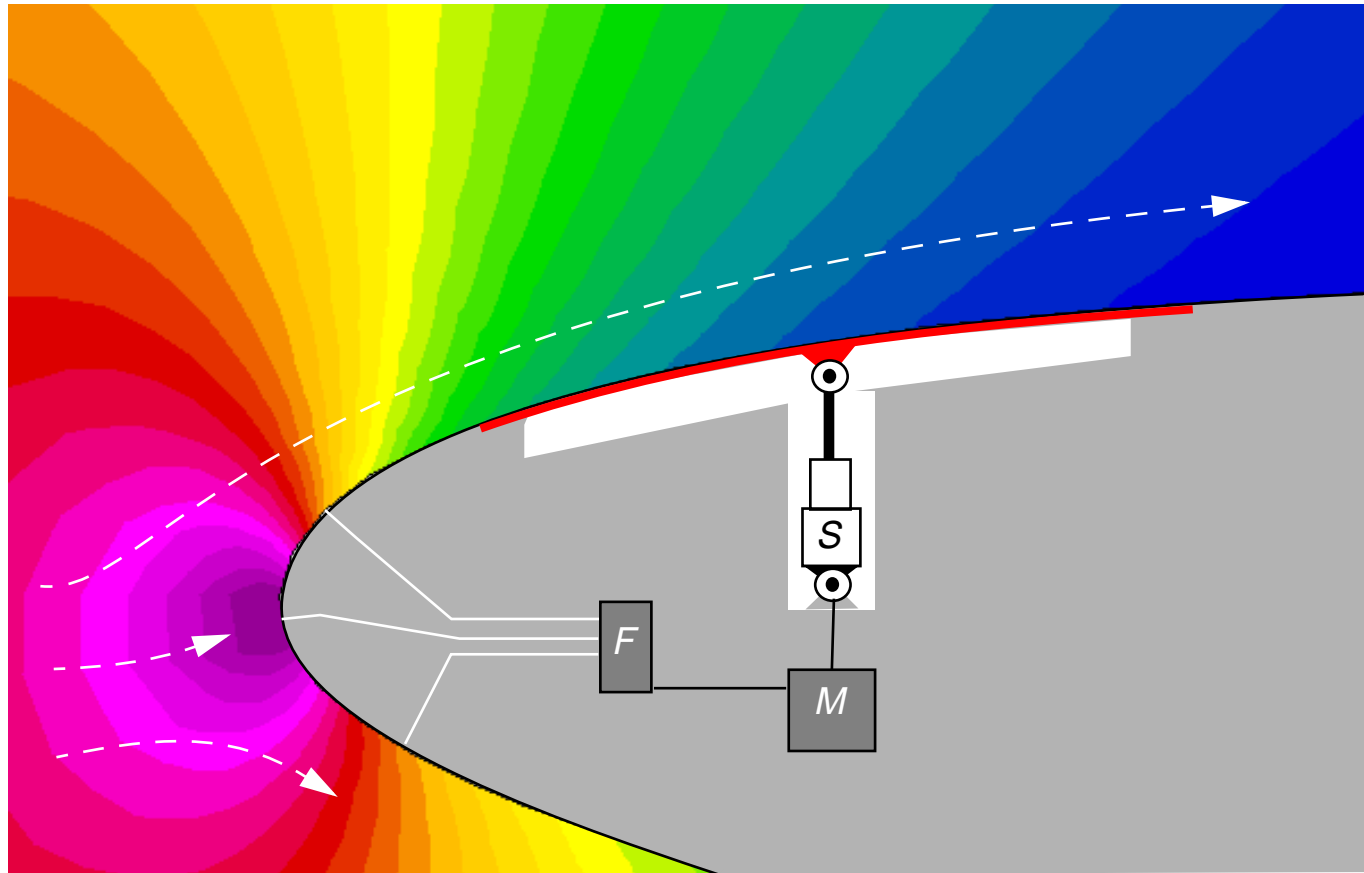
Adaptive Transonic Configurations

from theory to practical concepts



From one given airfoil, series of shock-free shapes have been obtained for varying operating conditions.....

Configuration adaption controlled by flow quality



Adaptive airfoils and wings

ideas, concepts and projects

Trying to obtain a US patent (1979)

Experiments with series of varying airfoils (~ 1984)

Concepts of flow control in the transonic regime (since ~1990)

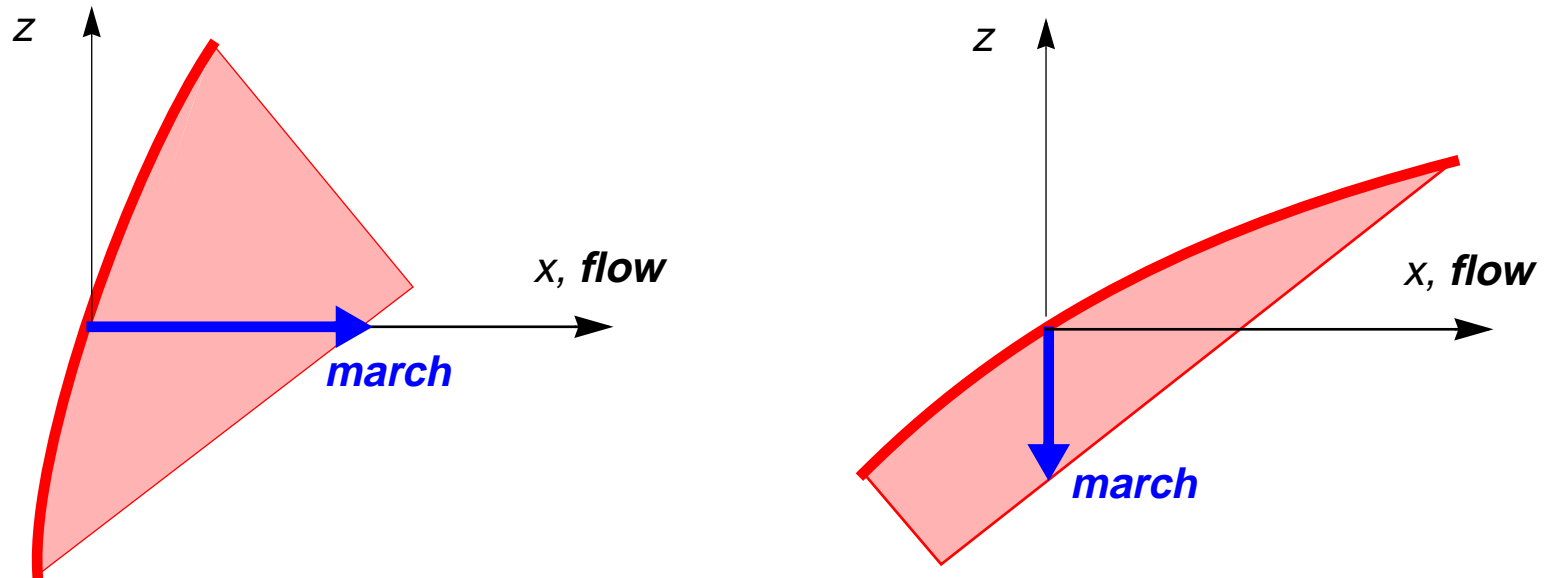
Expansion and recompression shoulder bumps (ESB, RSB; 1998)

European cooperative project (EREA, 1999 -)

Helicopter rotors with adaptive devices (since 2000)

Cross marching

Inverse design based on method of characteristics



Extending the Waverider concept

*Inverse design from given shock shapes
2 new methods*

*Arbitrary 3D shock waves prescribed:
Euler inverse 3D marching required*

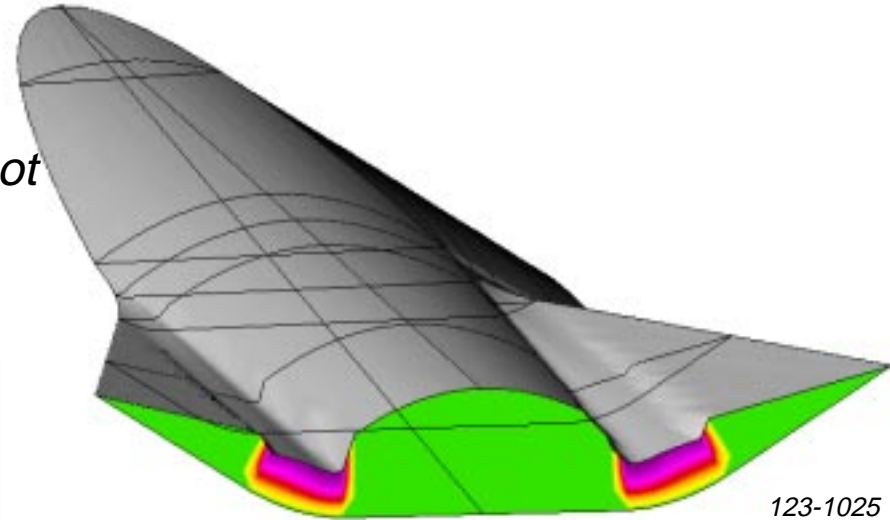
*Known flow fields used:
(Plane, Cone flow --> common knowledge by 1987)
Osculating Cones (OC) concept*

*Theses and partners in research:
Kevin **Jones** (1994): Arbitrary 3D shock waves
Ken **Center** (1995): OC Interactive design software
Thino **Eggers** (1996): OC case design and experimental studies
YiJi **Qian** (1998): OC concept extended to "OA", curved shocks*

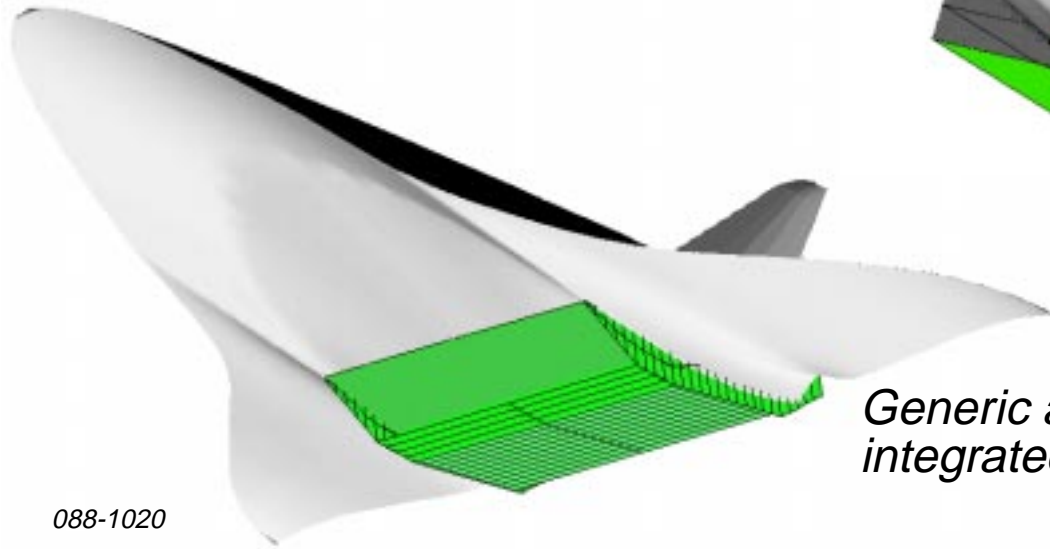
Complex configurations

integrating the waverider concept

OC waverider forebody with given shock, defining inlet, wing root



123-1025



088-1020

Generic aerospace plane with integrated propulsion unit

The Oblique Flying Wing

Germany's Max-Planck Research Award (1991-1996)

"for outstanding international research cooperation"

to Seebass & Sobieczky

Research Associate Pei Li

Seebass' Durand lecture

*Joint work on the aerodynamics and aeroacoustics
of OFW aircraft*

Symposium and book:

'New Design Concepts for High Speed Transport'

CISM lecture series No 366, Springer Wien New York

Conclusions

How much of our work results will last?

Learning from our past results sparked our new ideas.

Classical modelling still needed for education of next generation engineers.

The aerodynamic knowledge base is now accelerating automated optimization.

*Improving future air transport will need substantial innovations,
including novel aircraft configurations.*

Richard Seebass' legacy is a guide to such goals.

<http://www.as.go.dlr.de/~helmut>