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

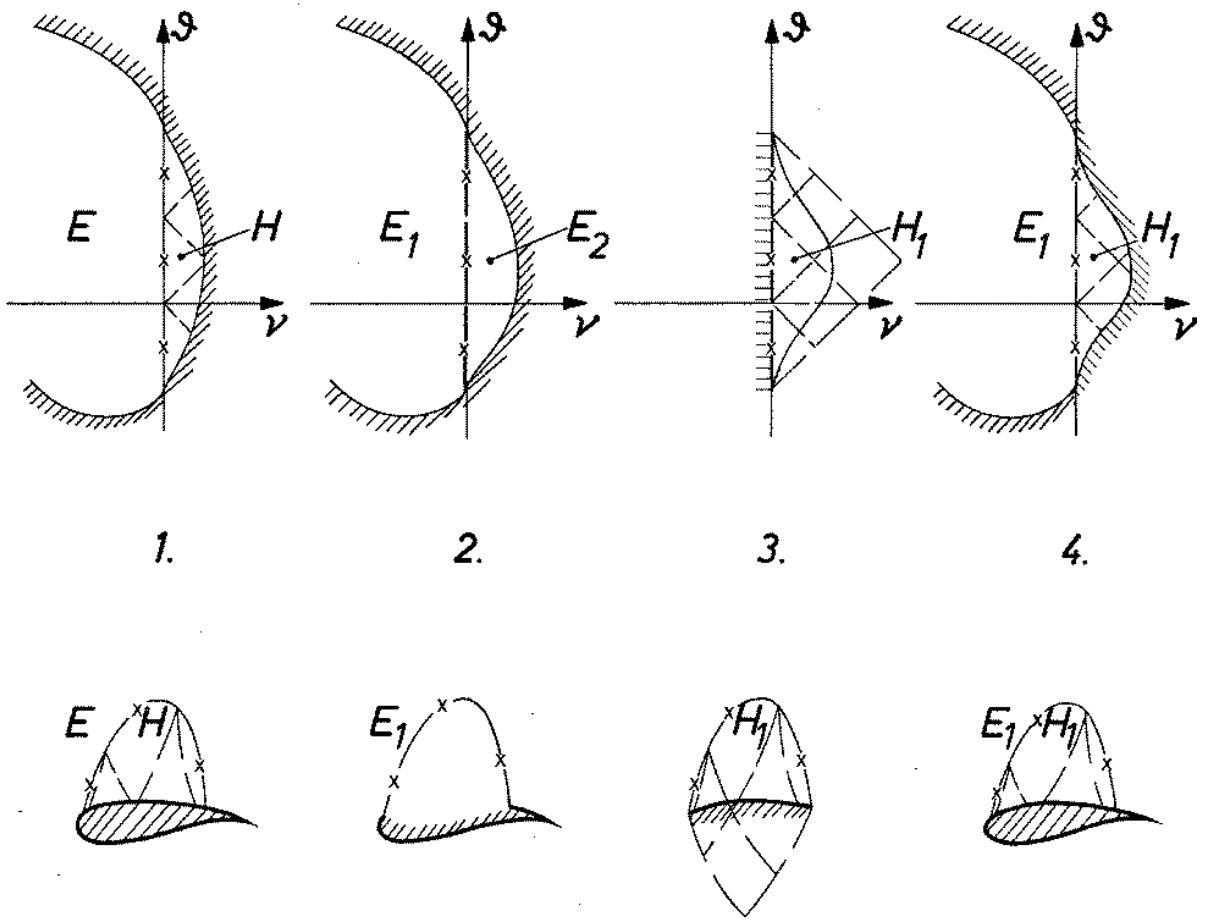
Fluid mechanics education with the computer arriving.

Compressible flow modeling of experimental results
Potential flow,
Poisson equations,

Analytical methods:
Singularities,
Mapping techniques,
Method of characteristics
Hodograph method

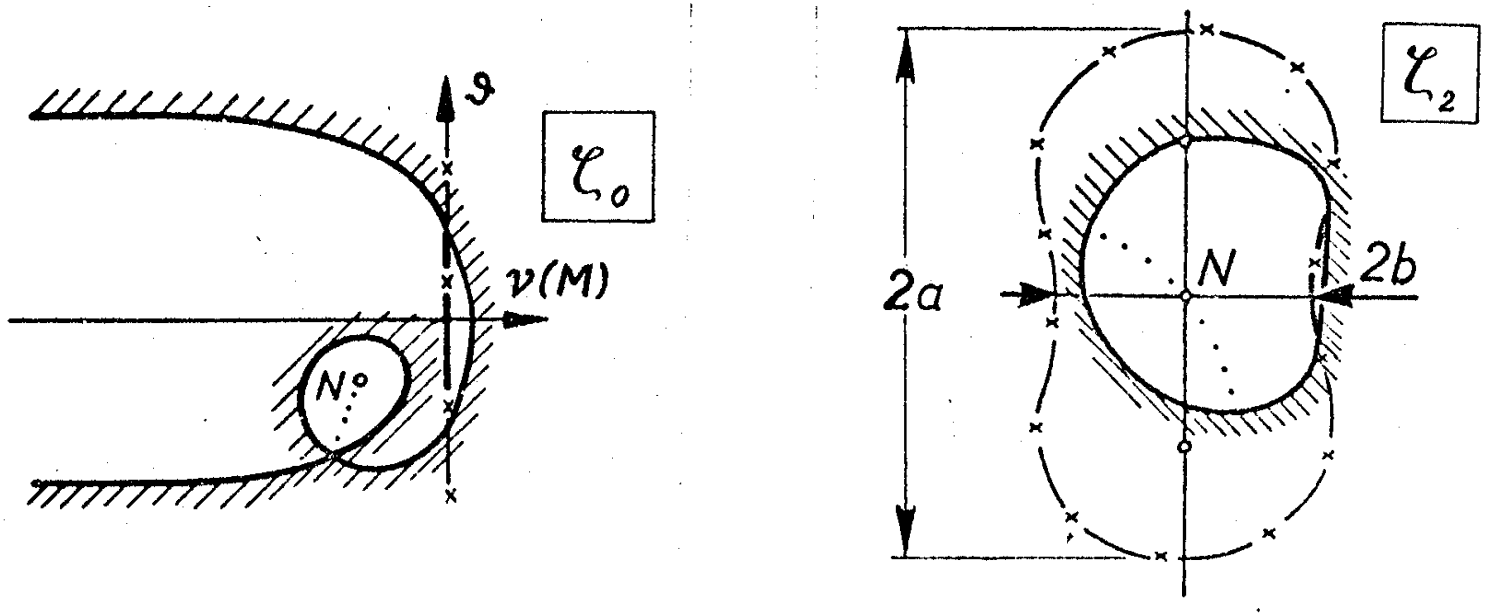
Learning by playing with classical tools of physics:
Rheoelectric analogy

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.

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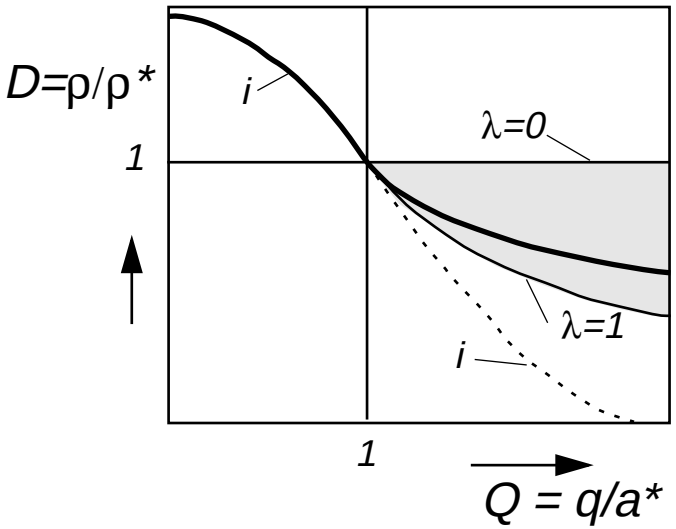
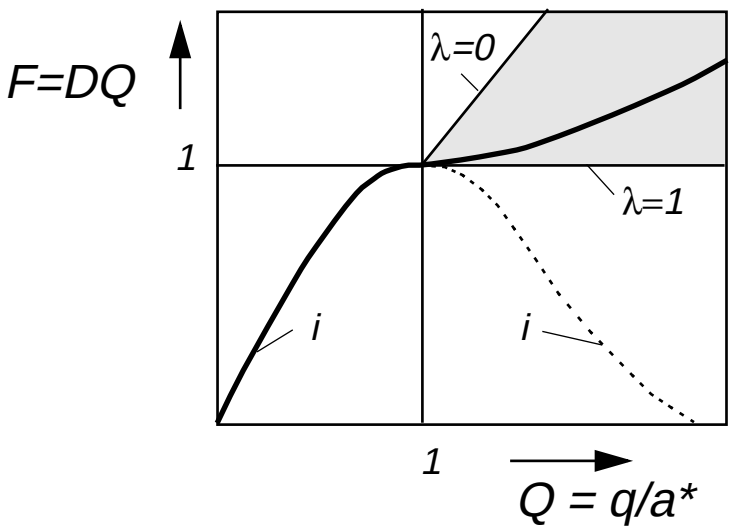
*.... a controlled heating / cooling in the flow field where q > a**

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

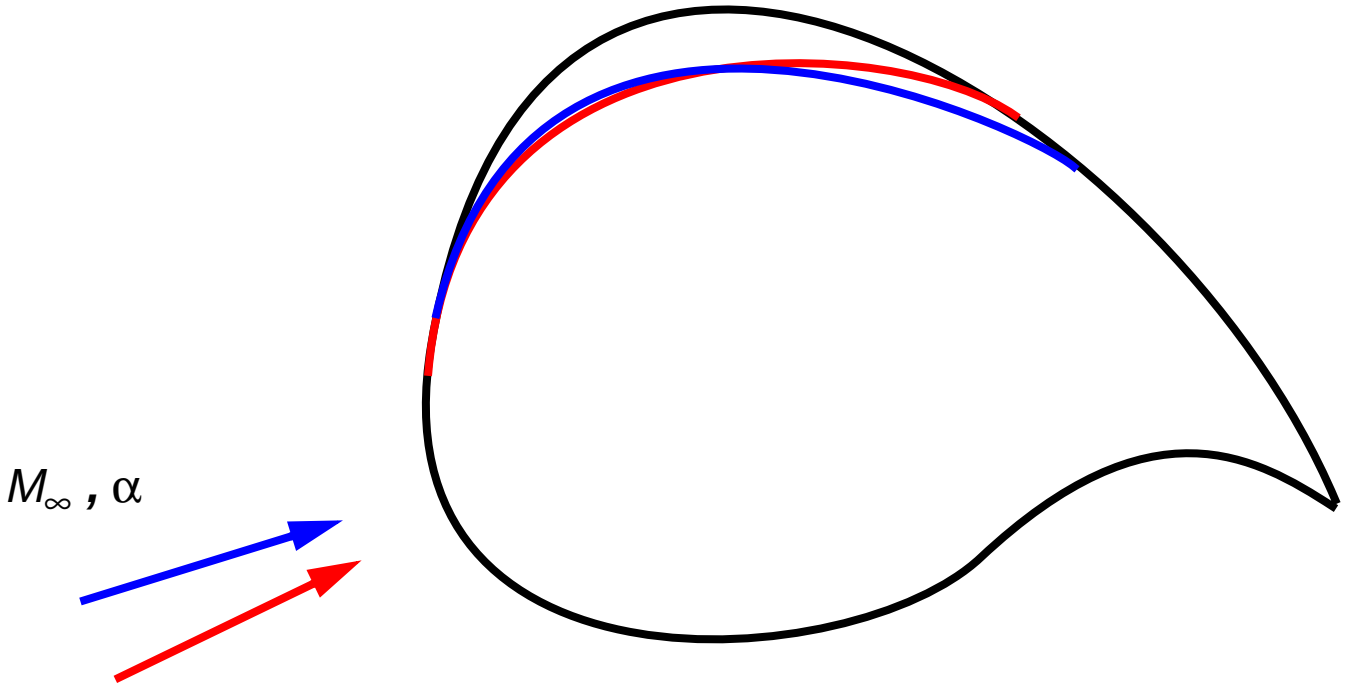
*K-Ying **Fung** (1978): TSP codes, FLO 6 2D airfoils, FLO 22 3D wings*
*Jong **Yu** (1979): FLO27, FLO 28 3D wing - body*
*Howard **Nebeck** (1981): Grumfoil, 2D airfoils*
*Albrecht **Eberle** (1981): MBB code, 3D wings*
*Phil **Beauchamp** (1982): NASA Lewis code, 2D Turbo-cascades*
*George **Dulikravich** (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

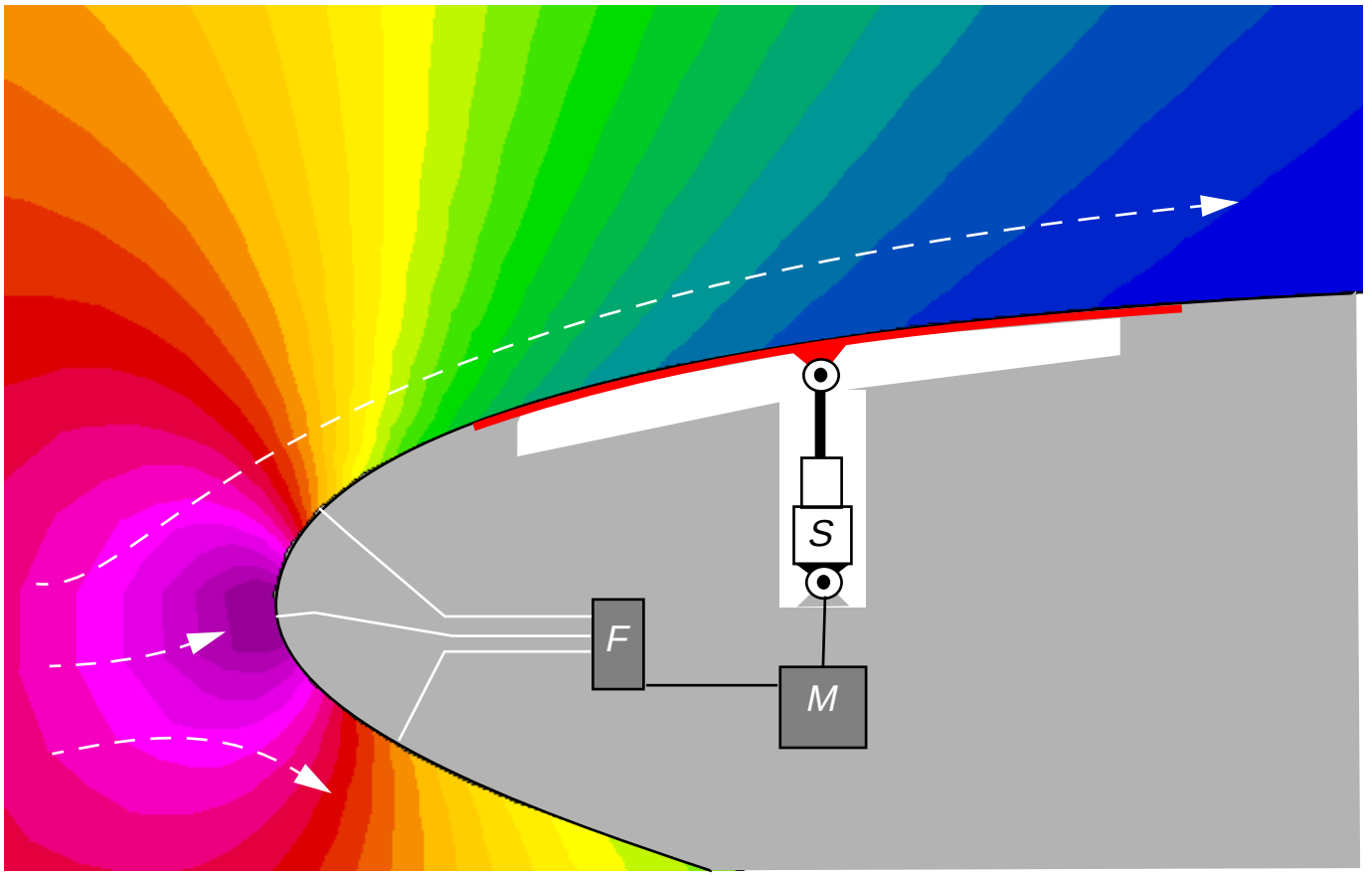
from theory to practical concepts



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)

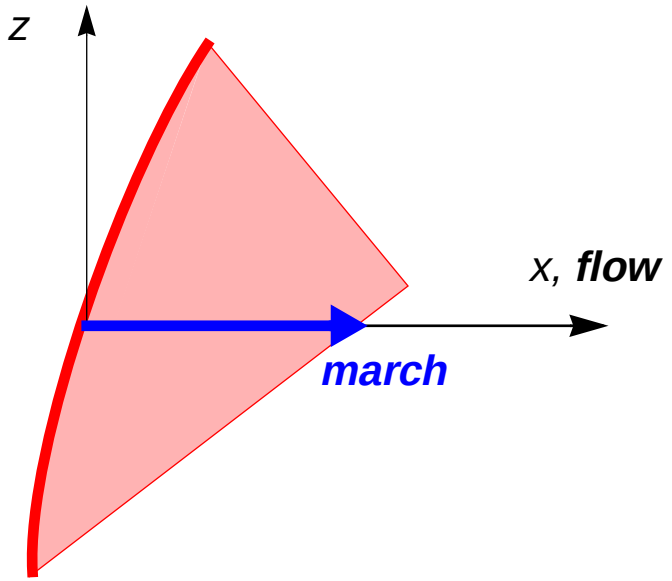
Expansion and recompression shoulder bumps (ESB, RSB; 1998)

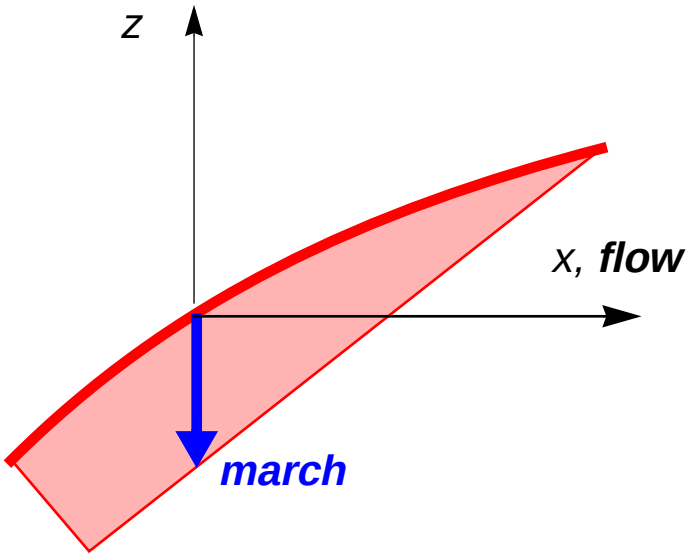
European cooperative project (EREA, 1999 - ....)

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*

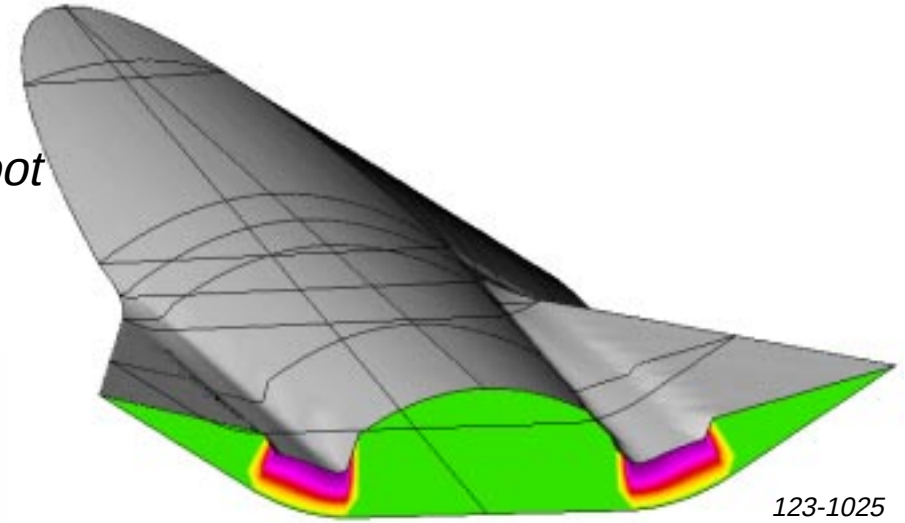
*Thino **Eggers** (1996): OC case design and experimental studies*

*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



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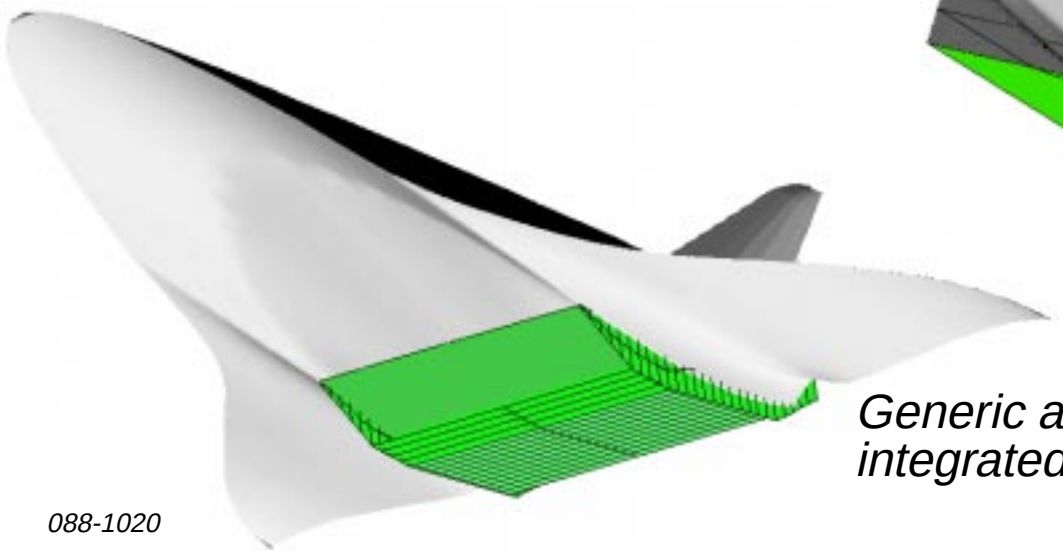

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Generic aerospace plane with integrated propulsion unit

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 NewYork

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