AIAA CFD Drag Prediction Workshop

Wind Tunnel Data

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Purpose

- To provide further discussion on the wind tunnel data used for reference in this workshop
  - based primarily on description in AGARD AR-303, Vol. II - G.Redeker
  - Highlight some of the challenges for test-to-test & facility-to-facility comparisons

Initial Thoughts

- One model - Three facilities
- Good agreement from facility to facility is challenging
  - facility differences, including model mounting
  - Instrumentation differences
  - Data acquisition, reduction, and “correction” differences
  - Repeatability of “unchanged” items
    - Model part fit, transition grit application, filler, etc.

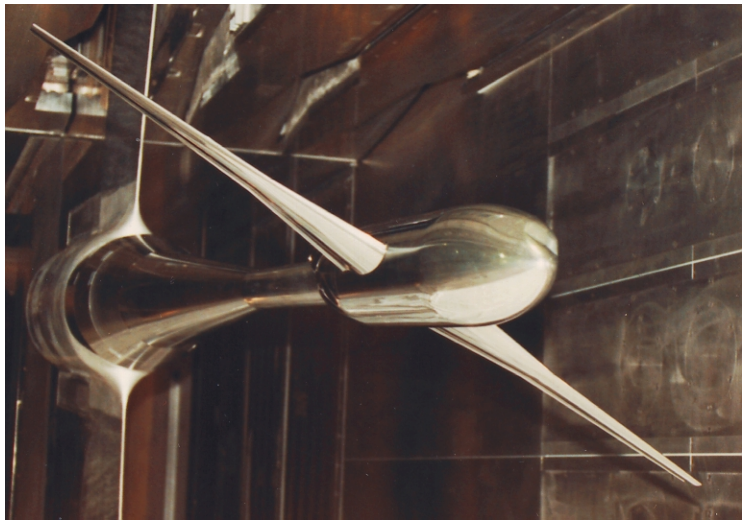
Wind Tunnel Facilities

- 3 facilities, single model
  - some general differences

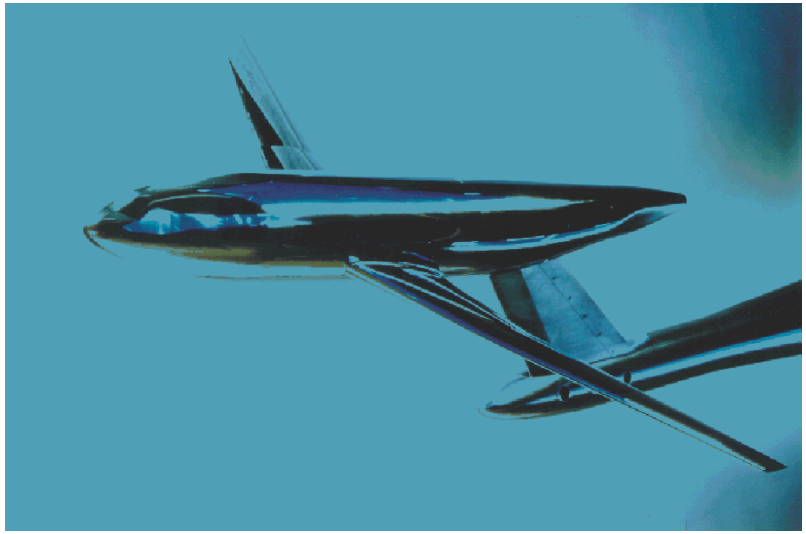
Facility ->	DRA 8' x 8' Bedford	NLR - HST	ONERA - S2MA
Test Section Dim. (m)	2.44W x 2.44H x 14L	2.00W x 1.60H x 2.70L	1.75W x 1.77H x 5.40L
Acs (m^2)	5.954	3.2	3.098
Max Model Blockage	0.44%	0.81%	0.84%
Wing Area/Acs	2.44%	4.54%	4.69%
Model Span/A,width	47.99%	58.55%	66.91%
Walls	Solid	12% open ceiling & floor solid side walls	Perforated ceiling & floor 6% geometric porosity max solid side walls
Model mount	straight sting	NLR Z sting	ONERA Z sting
Flow Angularity	~0.03 deg measured upr/inv	~0.2 deg measured upr/inv	not reported measured upr/inv

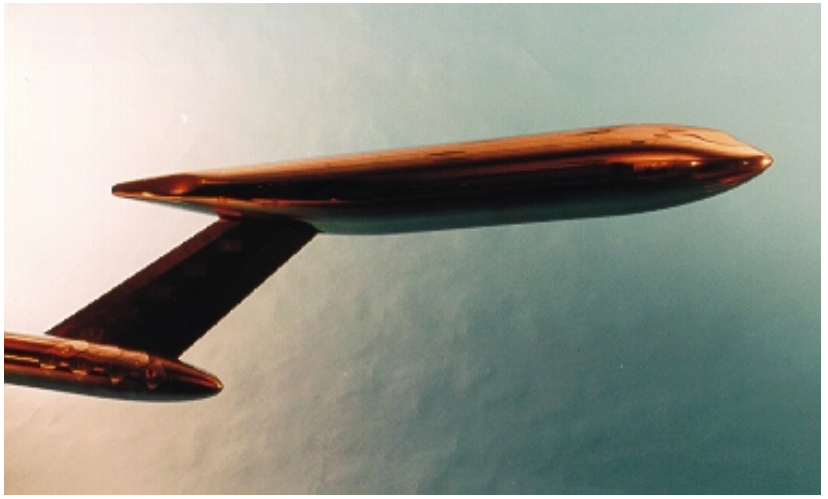
ETW Reference Model (DLR-F4)

From J.Quest



- ETW model
  - ~22.5% larger than used at DRA, NLR, & ONERA
- Multiple mounts
  - similar to those used in other WT





Instrumentation

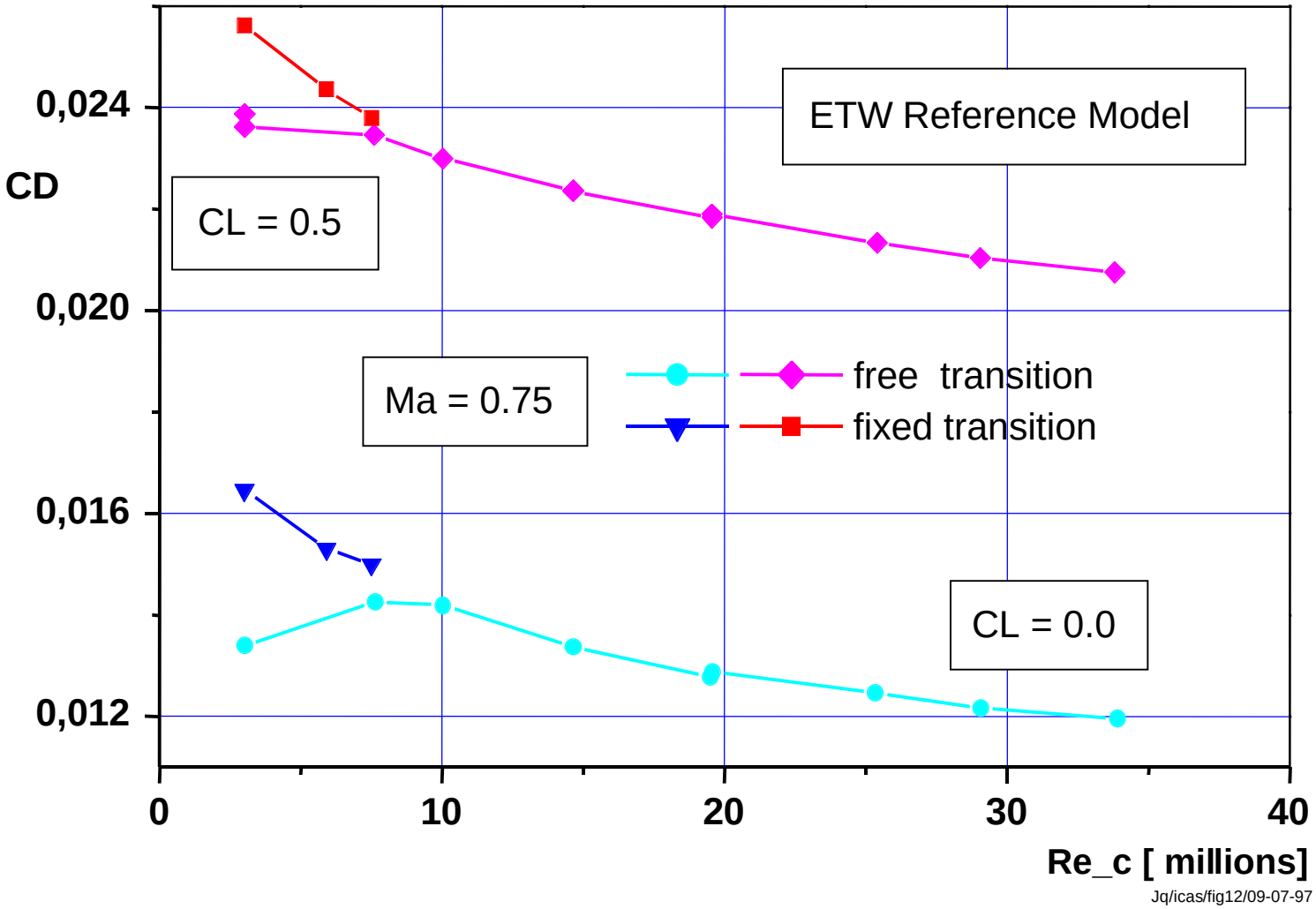
Facility ->	DRA 8' x 8' Bedford	NLR - HST	ONERA - S2MA
Model position	support angle + bending ±0.005 deg	support angle + bending ±0.02 deg	onboard & support ang + bending ±0.02 deg
Model Pressures	nominally the same in each facility		
Force & Moment	different balances used in each facility, primary components below		
NF, max (N)	7100	9220	20000
AF, max (N)	670	930	1700
PM, max (Nm)	750	461	1700

Experimental Procedures & Corrections

- "Data are corrected to free-air condition"
- Transition fixed similarly (loc, size, type)
- Corrections handled differently between facilities
  - Lift interference & blockage (various methods)
    - ONERA corrections at design pt: ΔM = -0.0001, ΔCD = -5.9 counts
  - Model support (various methods)
    - ONERA corrections at design pt: ΔCD = +19.2 counts
  - Aeroelastic deformation (all refer to NLR estimate of wing deformation)
    - Workshop grids based on NLR estimate of deformation
    - My experience in NTF --> CDvCL not affected, but CLvAoA and CLvCM are
  - Buoyancy
    - Body alone or clear-tunnel based
    - ONERA correction to ΔCD = +7.1 counts, as an example

Variation of Drag w/ Rn (ETW)

From J.Quest



Jq/icas/fig12/09-07-97

Experimental Data

- Documented Accuracy Assessment

Facility ->	DRA 8' x 8' Bedford	NLR - HST	ONERA - S2MA
angle of attack	±0.01 deg	< ±0.02 deg	±0.02 deg
Mach	±0.001	< ±0.002	±0.001
CL	±0.004	< ±0.005	±0.006
CD	±0.0004	< ±0.0005	±0.0004
CM	±0.001	< ±0.002	±0.0014
CP	±0.002	< ±0.005	±0.001

Concluding Remarks

- More detail can be found in AGARD AR 303
- Numerous issues make facility-to-facility comparisons a challenging proposition
- There is noticeable data scatter between facilities
- All in all, the general agreement is pretty good
- 'Apples to apples' comparison between CFD & Experiment is often not as easy to achieve as it sounds