National Transonic Facility Public Geometry Release and Summary

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Outline

- Facility Overview
- History
- Key CRM Tests
- CRM Coordinate Transformations
- Geometry Files

Facility Overview

- **Closed circuit, pressurized, cryogenic facility**
- **Located at NASA Langley Research Center in Hampton, VA, USA**
- **Facilitates transonic, flight Reynolds number (Re) testing**
  - Mach 0.1 to 1.2
  - Re 4.0 million to 145 million/foot
    1.2 million to 44 million/meter
  - Temperature -250 to 130 deg F (-157 to 54 C; 116 to 328 K)
  - Can operate with dry, ambient air or with gaseous nitrogen

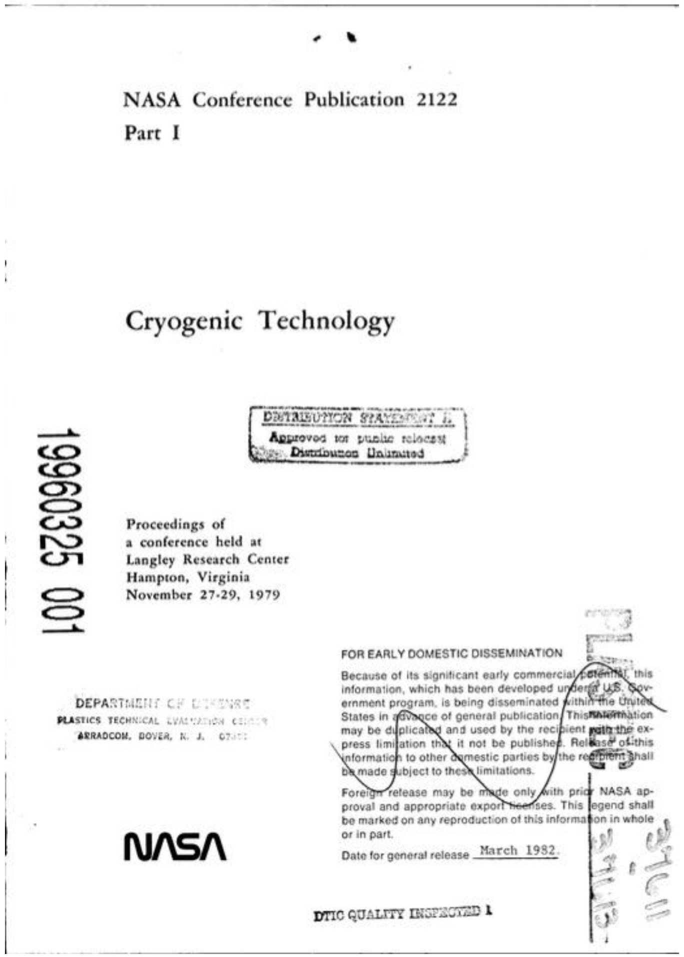
Source: NASA

Key Historical Dates

- **1960s** Facility needs identification
- **1970-1973** Conceptual design
- **1971-1973** Risk reduction facility tests
- **1974-1978** Detailed design
- **1976** Funding appropriated
- **1979** Construction started
- **1982** Construction complete
- **1984** Open for production
- **2001** Aerospace Sciences Meeting (first open discussion of capabilities)

History and Conceptual Design

- **Established an international need for high Reynolds number testing**
  - Desired for decades before construction
  - Interest from academia, industry, and government
- **Detailed facility requirements study formalized in 1971**
  - Matured by Department of Defense, NASA, commercial partners, and scientific advisory committees
  - Many workshops with partners and customers
- **Identified three ways to increase Reynolds number**
  1. Increase P_{total}
  2. High molecular weight fluid
  3. Reduce T_{total}


NASA Conference Publication 2122
Part I

Cryogenic Technology

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Proceedings of
a conference held at
Langley Research Center
Hampton, Virginia
November 27-29, 1979

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Date for general release March 1982

DEPARTMENT OF DEFENSE
PLASTICS TECHNICAL EVALUATION CENTER
ARRADCOM, DOVER, N. J.

NASA

DTIC QUALITY INSPECTED 1

Configuration Selection

- **Two final configurations candidates**
  - Short-run, high-pressure Ludwieg tube
  - Continuous-run cryogenic nitrogen facility
- **Cryo facility selected for five key reasons**
  1. Temperature has a large effect on Reynolds number at low temperatures
  2. High Reynolds numbers can be tested
  3. Reduced temperature → reduced speed of sound → decreased velocity → decreased fan power
  4. Cryo nitrogen is similar to ambient, high-altitude flight conditions
  5. Independent control of total pressure, total temperature and fan speed

Risk-Reduction Facilities

- **Two risk-reduction facilities constructed prior to NTF funding approval**
- **Low-speed cryogenic benchtop wind tunnel (1971)**
  - 7 inch by 11 inch (18 cm by 28 cm) test section
  - Low speed (up to Mach 0.2)
  - Operated down to 80 K (-316 F, -193 C)
  - Confirmed liquid nitrogen injectors can create cryo conditions
  - Identified requisite material behavior at cryo temperatures
- **Langley 0.3-Meter Transonic Cryogenic Tunnel (1973)**
  - Small-scale version of proposed NTF
  - Transonic, cryogenic
  - Designed to operate for 90 days; still in operation for technology-development experiments
- **Funding for NTF appropriated in 1976**

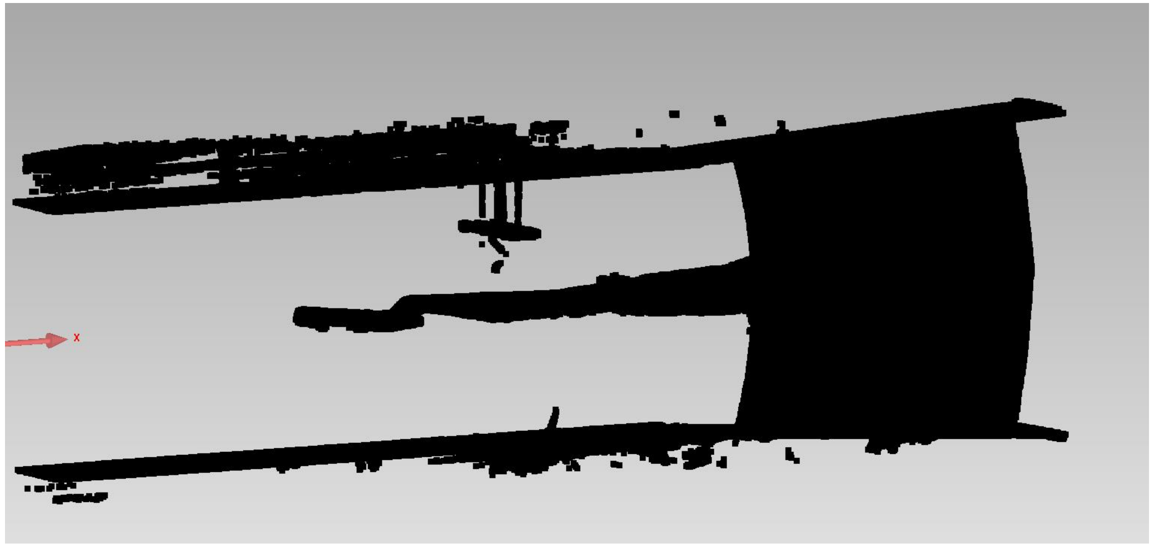
Test Environment Challenges

- **Materials advancements needed to ensure facility and model integrity**
- **Japan Steel material improvements**
  - Developed high-strength 9% Nickel maraging steel
  - Stronger materials and increased maximum part size than availably domestically
  - Urban legend that Japan Steel was used due to a domestic steel shortage
- **Samurai sword friendship gift**
  - Made with traditional techniques
  - Offered to NASA "... in hope that this sword would serve as a symbol of the international cooperation reflected in the National Transonic Facility"
  - Sword is on display in the NTF building

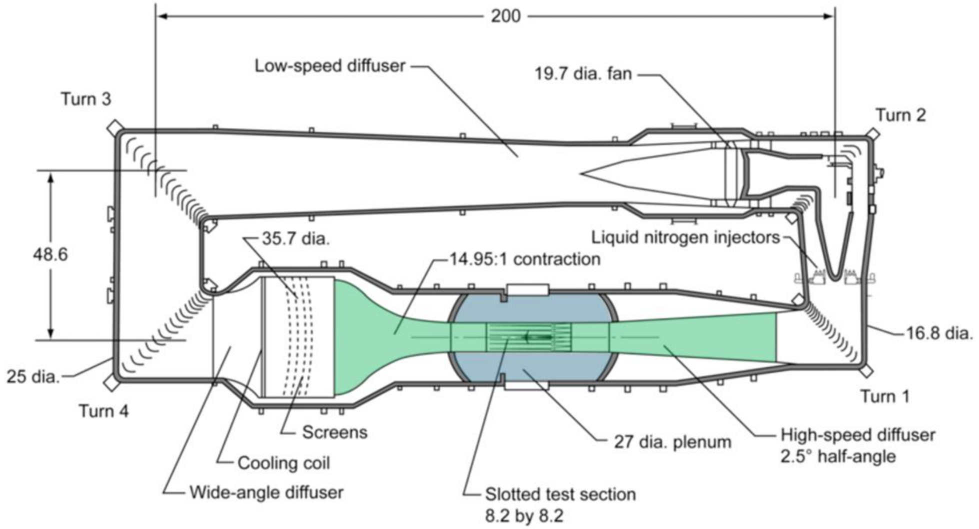
Source: NASA

Facility Digital Model

- **Detailed digital scan of NTF circuit was taken in the mid-2010s**
  - About 250 million points
  - Approximately 80% of the points are in the plenum
  - Significant work with GeoMagic used to generate CFD-ready surface geometry
- **High-speed leg geometry and model support hardware has been released**



Point cloud data



Tunnel circuit, high speed leg (green), and plenum (blue)

Key Common Research Model (CRM) Tests

- **CRM**
  - Original transonic tests performed in support of Drag Prediction Workshop IV
  - High-quality experimental data facilitated detailed CFD comparisons
  - Tests NTF-197, NTF-215, and NTF-229
- **CRM-HL**
  - Low-speed NTF test supplemented already-existing data sets
  - Special session Wednesday morning in Academy 415 (GT-10/APA-26)
  - Test NTF-237
- **CRM-NLF**
  - Designed with Crossflow-Attenuated Natural Laminar Flow (CATNLF) method
  - Temperature-sensitive paint used to visualize regions of laminar/turbulent flow
  - Test NTF-228

Coordinate Transformation Overview

- **Different models require different transformations**
  - Full-span, upper-swept strut mounted vehicle
  - Semispan, sidewall mounted vehicle

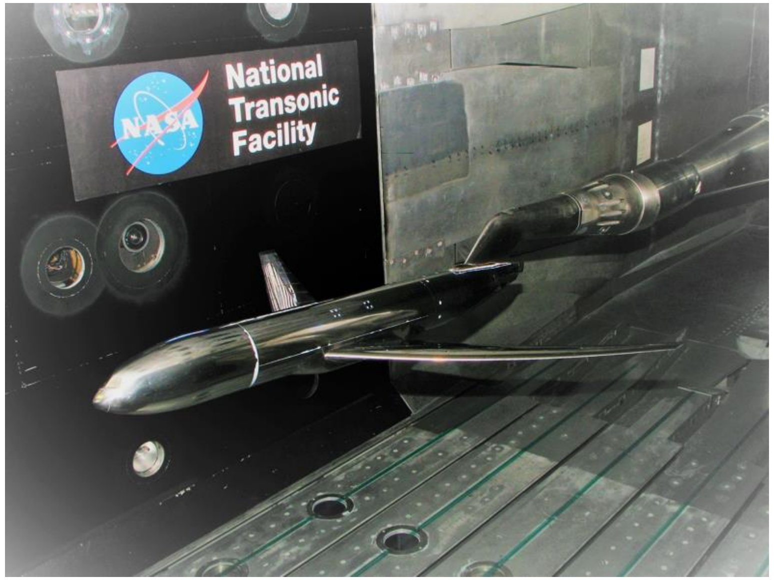
- **Four main steps**
  1. Rig the full-scale vehicle in the tunnel at model scale
  2. Add sidewall standoff, if necessary
  3. Rotate mounting hardware to achieve zero-deg alpha, if necessary
  4. Rotate vehicle and associated hardware for non-zero alpha

CRM Mounting Options

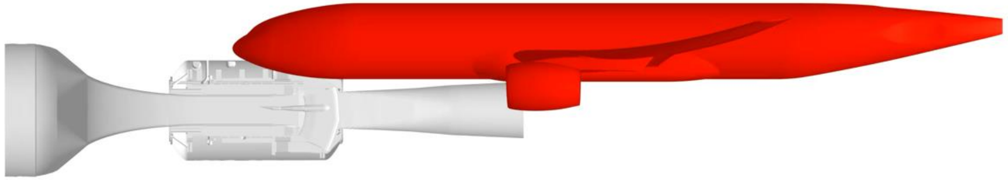
- **2.7% full-span**
  - Traditional CRM
  - CRM-HL (planned test)
  - Upper swept strut
- **5.2% semispan**
  - CRM-HL (GT-10/APA-26, Wednesday morning, Academy 415)
  - CRM-NLF
- **2.7% semispan CRM-HL (planned test)**
- **Coordinate transformations provided in the accompanying paper**
- **Two example transformations on the next two slides**

Full-Span 2.7% CRM Coordinate Transformations

- **Equations maintained from previously-listed information for consistency**
- **Transformations included in** `how_mounted_2p7.txt` **in CAD release**
  1. Scale vehicle
  2. Translate to model origin in the wind tunnel
  3. Rotate arc sector and upper-swept strut around y axis
  4. Rotate arc sector, upper-swept strut, and vehicle for non-zero alpha



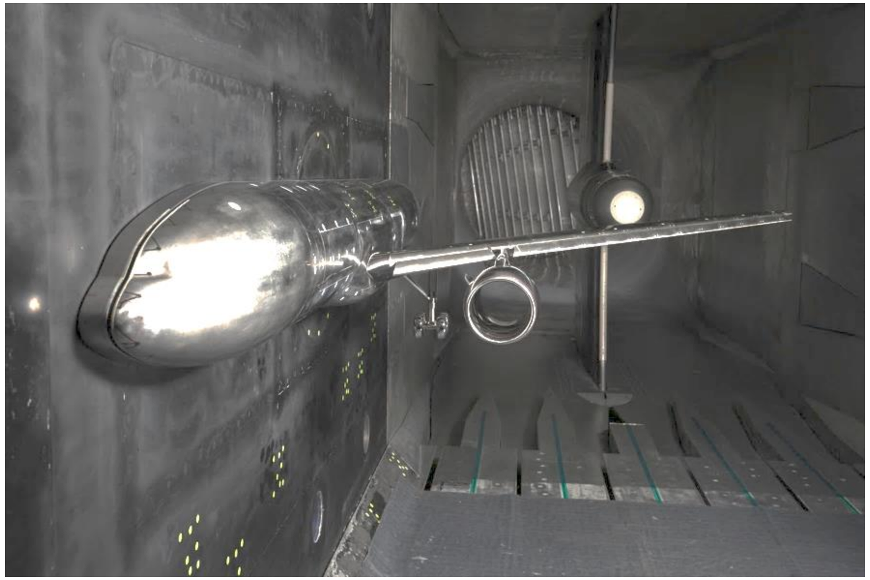
Source: NASA



Animation depicting coordinate transformations

Semispan 5.2% CRM Coordinate Transformations

- **Version 1.9 has new transformations from historically published transformations**
- **Transformations included in** `how_mounted_5p2semispan.txt` **in the CAD release**
  1. Translate and scale to wind tunnel model origin
  2. Add a standoff between the model and the wall
  3. Rotate vehicle for non-zero alpha



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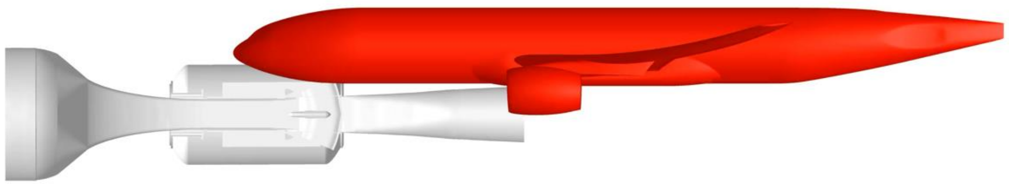
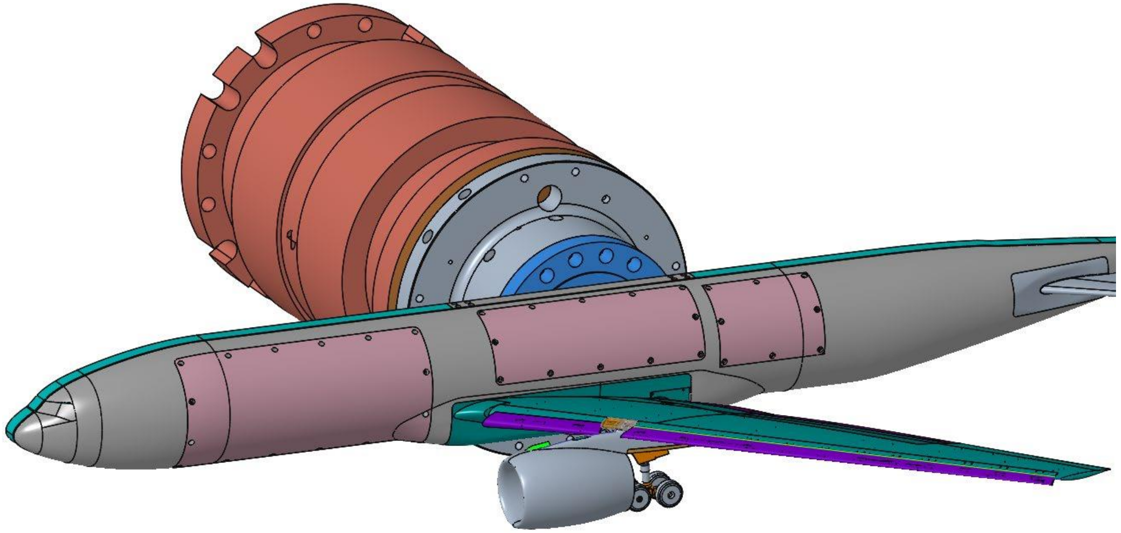
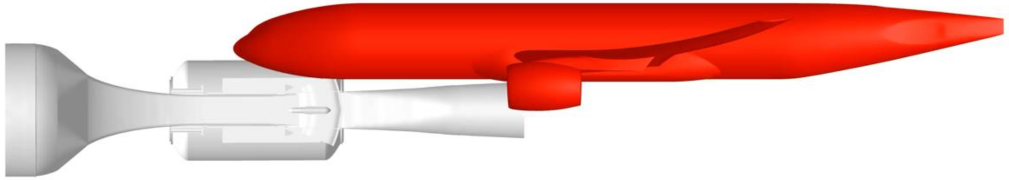


Animation depicting coordinate transformations

Semispan 2.7% CRM Coordinate Transformations

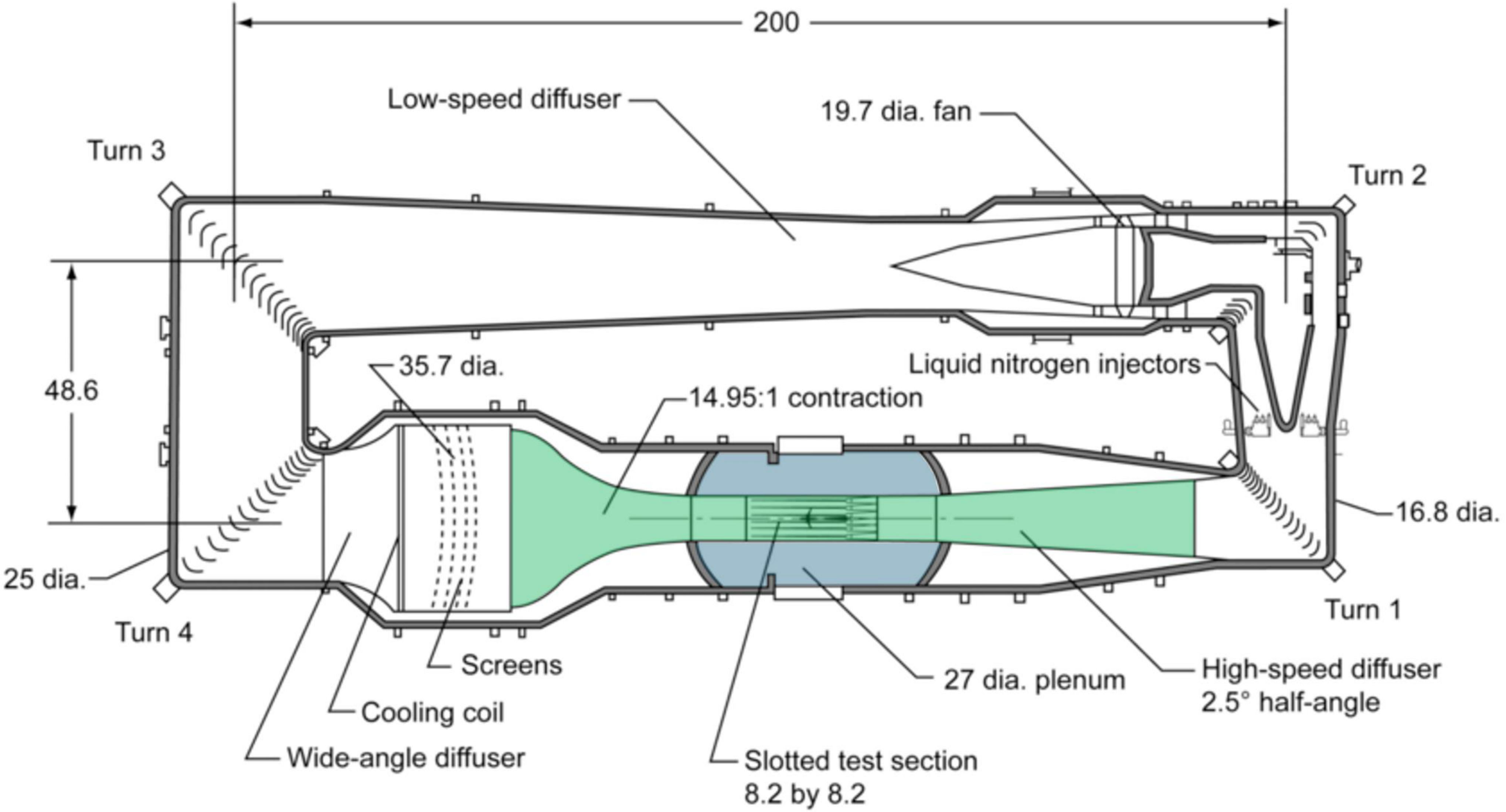
- **Version 1.9 has transformations not previously published**
- **Transformations included in** `how_mounted_2p7semispan.txt` **in the CAD release**
  1. Translate and scale to wind tunnel model origin
  2. Add a standoff between the model and the wall
  3. Rotate vehicle for non-zero alpha





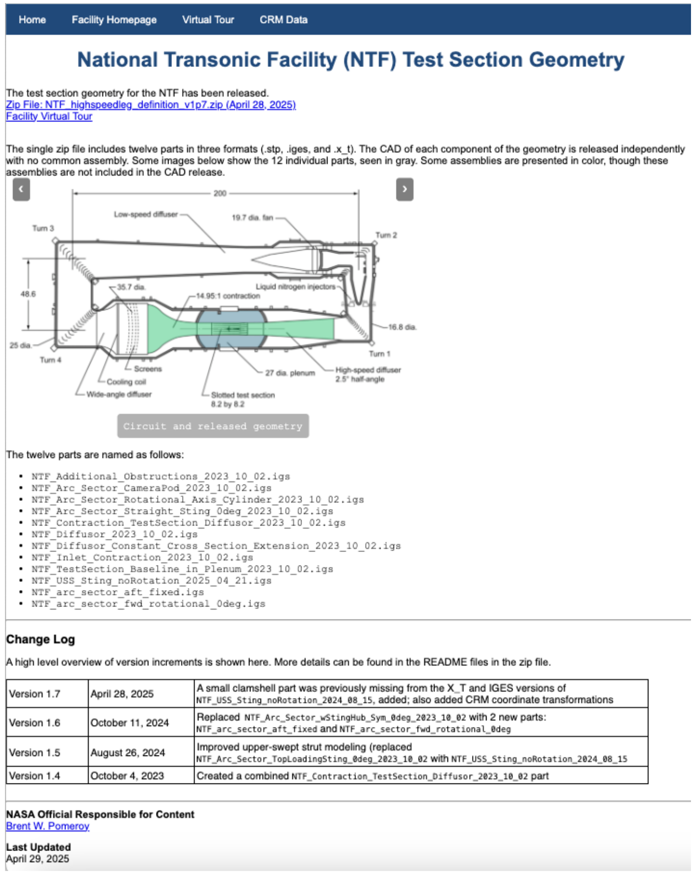
Animation depicting coordinate transformations

High-Speed Leg and Plenum



Geometry Download

- **Posted to the new DPW website (https://www.aiaa-dpw.org/ntf.html)**
- **Note the new domain**
- **Current version: v1.9 (June, 2025)**
- **Contains**
  - 12 files
  - .igs, .stp, and .x_t
  - All in inches



Home Facility Homepage Virtual Tour CRM Data

National Transonic Facility (NTF) Test Section Geometry

The test section geometry for the NTF has been released.
Zip File: NTF_highspeedleg_definition_v1p7.zip (April 28, 2025)
Facility Virtual Tour

The single zip file includes twelve parts in three formats (.stp, .iges, and .x_t). The CAD of each component of the geometry is released independently with no common assembly. Some images below show the 12 individual parts, seen in gray. Some assemblies are presented in color, though these assemblies are not included in the CAD release.

Circuit and released geometry

The twelve parts are named as follows:

- NTF_Additional_Obstructions_2023_10_02.igs
- NTF_Arc_Sector_CameraPod_2023_10_02.igs
- NTF_Arc_Sector_Rotational_Axis_Cylinder_2023_10_02.igs
- NTF_Arc_Sector_Straight_Sting_0deg_2023_10_02.igs
- NTF_Contraction_TestSection_Diffusor_2023_10_02.igs
- NTF_Diffusor_2023_10_02.igs
- NTF_Diffusor_Constant_Cross_Section_Extension_2023_10_02.igs
- NTF_Inlet_Contraction_2023_10_02.igs
- NTF_TestSection_Baseline_in_Plenum_2023_10_02.igs
- NTF_USS_Sting_noRotation_2025_04_21.igs
- NTF_arc_sector_aft_fixed.igs
- NTF_arc_sector_fwd_rotational_0deg.igs

Change Log

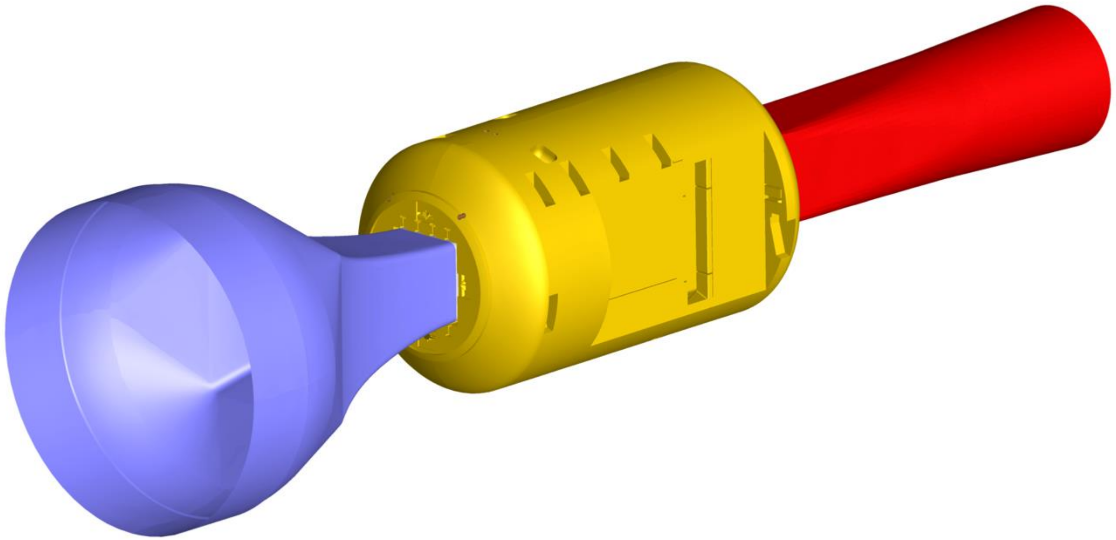
A high level overview of version increments is shown here. More details can be found in the README files in the zip file.

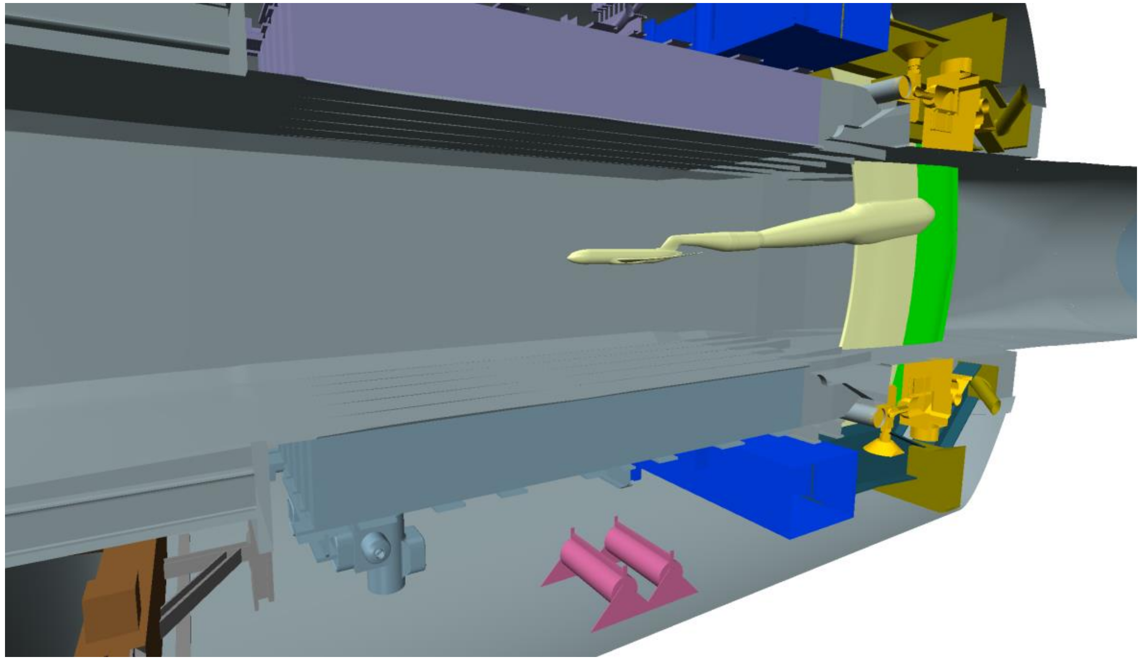
Version 1.7	April 28, 2025	A small clamshell part was previously missing from the X_T and IGES versions of NTF_USS_Sting_noRotation_2024_08_15, added; also added CRM coordinate transformations
Version 1.6	October 11, 2024	Replaced NTF_Arc_Sector_wStingHub_Sym_0deg_2023_10_02 with 2 new parts: NTF_arc_sector_aft_fixed and NTF_arc_sector_fwd_rotational_0deg
Version 1.5	August 26, 2024	Improved upper-swept strut modeling (replaced NTF_Arc_Sector_TopLoadingSting_0deg_2023_10_02 with NTF_USS_Sting_noRotation_2024_08_15
Version 1.4	October 4, 2023	Created a combined NTF_Contraction_TestSection_Diffusor_2023_10_02 part

NASA Official Responsible for Content
Brent W. Pomeroy

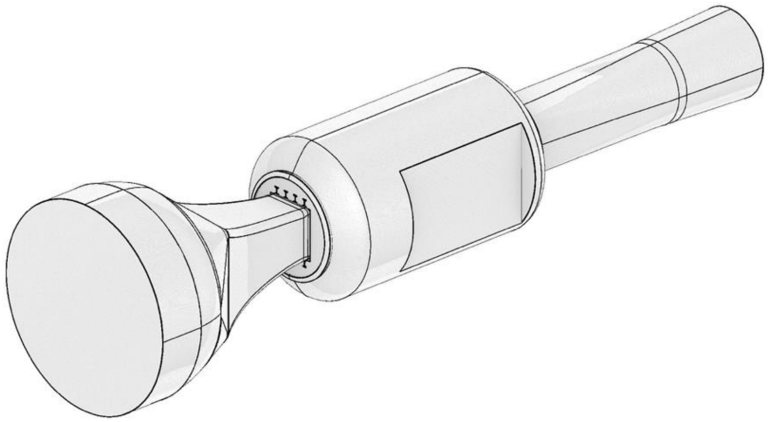
Last Updated
April 29, 2025

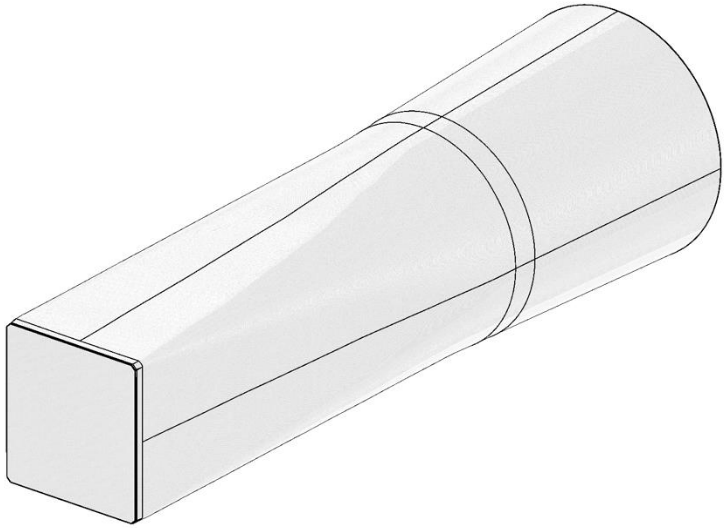
Geometry Overview

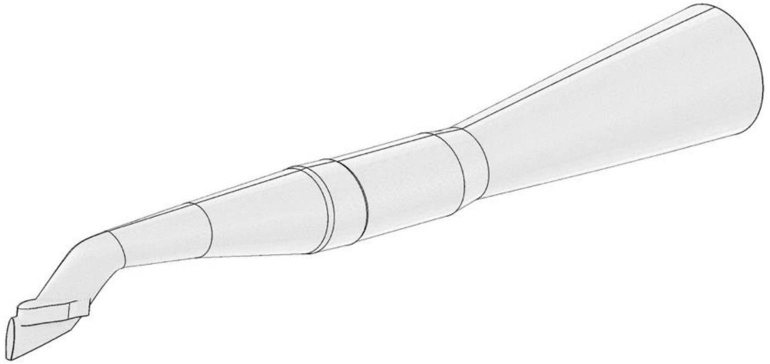


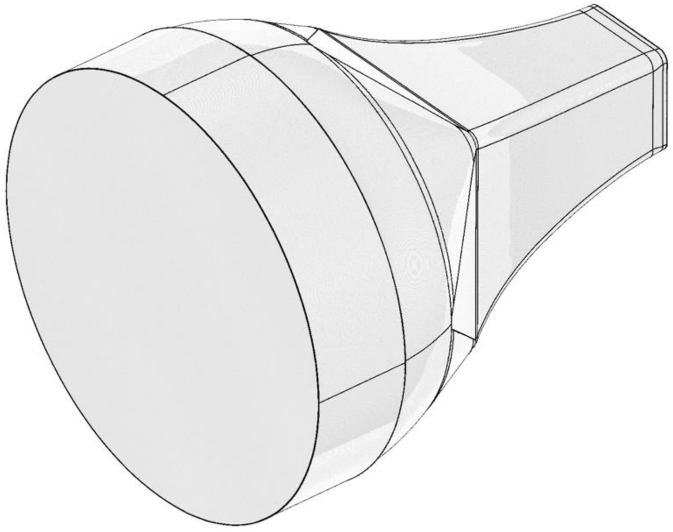


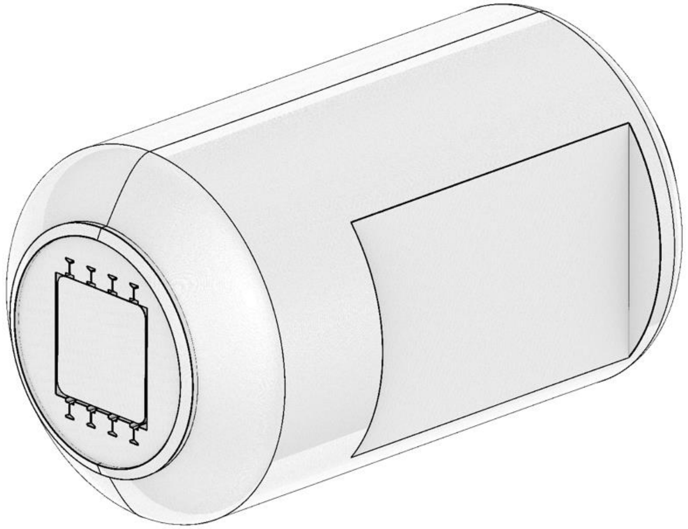
Geometry Files (1/2)





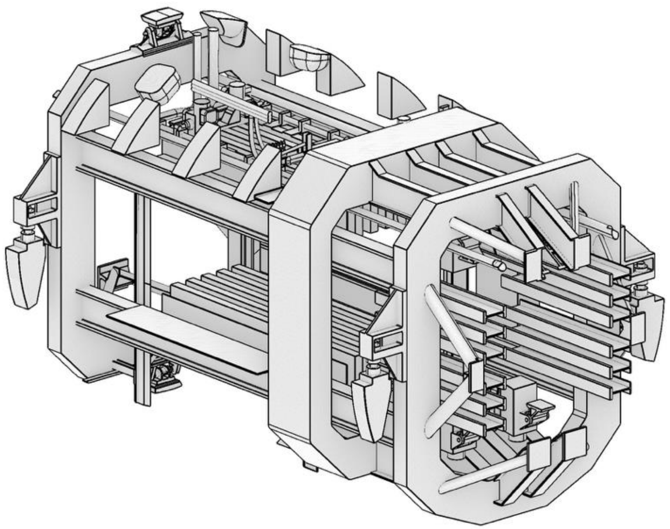


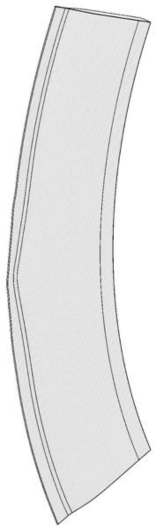


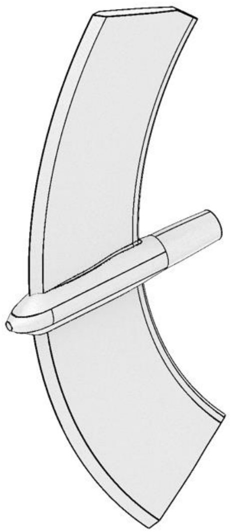


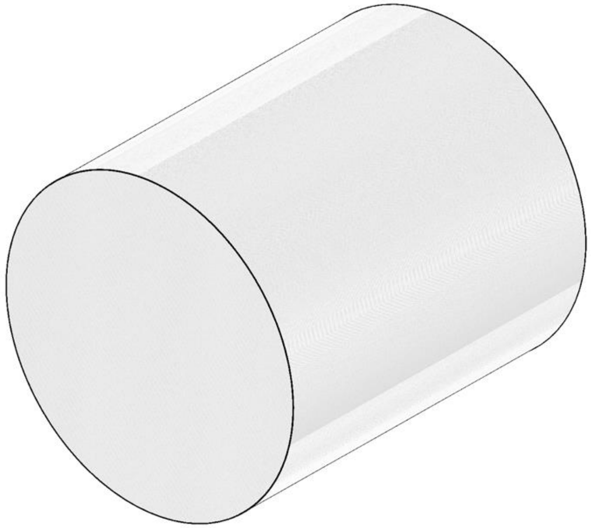
Note: The diffuser extension is not part of the NTF. It is provided in the CAD so boundary conditions can be applied further away from the test section. This may be desired to avoid potential numerical problems at the end of the diffusor. Use is optional.

Geometry Files (2/2)









DPW-8/AePW-4 Usage

- **Test case for Test Environments Working Group**
- **Consistent shift of CFD results relative to experimental data**
- **Multiple items may cause the differences**
  - Wall effects?
  - Tare and interference?
  - Physical geometry differences?
  - Freestream (i.e., inlet) conditions?
- **Complex geometry will require meticulous preparation and careful gridding**

Conclusions

- NTF has a storied history of tests, including three CRM configurations
- Detailed digitization of NTF circuit
- Publicly available high-speed leg CAD has been released (v1.9) at https://www.aiaa-dpw.org/ntf.html
- Test case of interest for DPW-8/AePW-4 Test Environment Working Group

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- Courtney Winski
- Andy Kwok

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