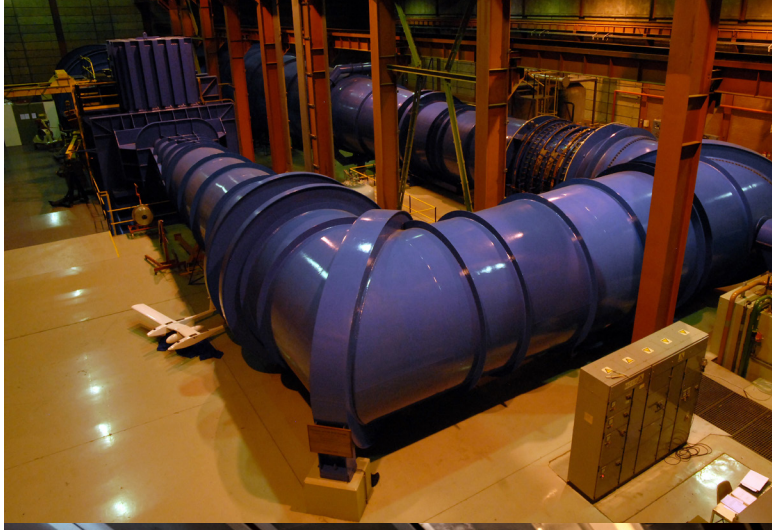
AEROSPACE RESEARCH, DEVELOPMENT AND SERVICES
at the CSIR

CSIR
Touching lives through innovation

The Council for Scientific and Industrial Research (CSIR) is the home of aerospace research and development in South Africa, with a track record in aeronautical excellence spanning more than 70 years. A range of aerospace services is provided to local and international clients by a dedicated team of engineers and technologists supported by world-class facilities, including a suite of wind tunnels, a computer cluster and laboratories for aeroelasticity, unmanned aircraft and aerostructures.

This hub of expertise supports activities in the following areas:

- Experimental Aerodynamics
- Aircraft Store Integration
- Airworthiness Engineering
- Systems Engineering
- Aeroelasticity and Flutter
- Modelling and Simulation
- Unmanned Aircraft Systems (UAS) and Aeronautical Design
- Propulsion Systems
- Spacecraft and Space Launcher Engineering
- Technology Demonstrators



Wind Tunnel Facilities at the CSIR

The CSIR has six wind tunnels and operates its four wind tunnels for the production of wind tunnel data for both local and international clients. These four tunnels, in order of test speed, are:

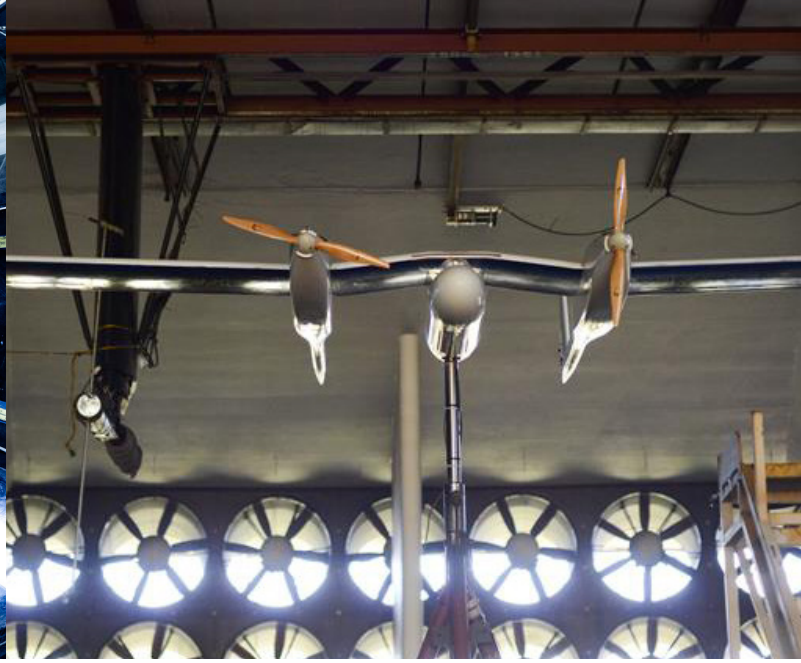
- Seven Metre Wind Tunnel (7mWT)
- Low Speed Wind Tunnel (LSWT)
- Medium Speed Wind Tunnel (MSWT)
- High Speed Wind Tunnel (HSWT)

HSWT

Facility	Trisonic, blowdown wind tunnel
Mach Number Range	0.6 to 4.3
Test Section	0.45 x 0.45 m
Stagnation Pressure Range	70 to 1 200 kPa
Reynolds Number Range	2 x 10^7 / m to 2 x 10^8 / m 185 x 10^6 / m at Mach 2.0
Support System	**Pitch sector with** Standard pitch range: ±15° Roll range: ±180° Wall installation
Standard Test Capabilities	• Static force testing with models sting mounted on internal strain-gauge balances • Pressure measurements • Isolated inlet testing • Installed inlet testing • Free-spin projectiles • Drop testing
Standard Flow Visualisation	Colour Schlieren video

MSWT

Facility	Continuous, closed-circuit, variable density wind tunnel
Mach Number Range	0.2 to 1.4
Test Section	1.5 x 1.5 x 4.5 m
Stagnation Pressure Range	20 kPa to 250 kPa
Reynolds Number Range	31 x 10^6 / m at Mach 0.8
Support System	**Pitch Sector with** Standard AoA range: -10° to 30° Roll range: ±180° **Side Wall Support with** AoA range: -30° to 30° **Captive Trajectory System with** Pitch range: ±45° Yaw range: ±45° Roll range: ±180° Axial (X) range: ±560 mm Lateral (Y) range: ±410 mm Vertical (Z) range: ±525 mm
Standard Test Capabilities	• Static force testing with models sting mounted on internal strain-gauge balances • Half-model tests on specialised balance • Pressure measurements • Inlet testing • Store release tests (grid, flow field measurement and captive trajectory)
Standard flow visualisation	Oil Flow Tufts



LSWT

Facility	Continuous, atmospheric, closed-circuit wind tunnel
Mach Number Range	0 to 0.33 (120 m/s)
Test Section	2.14 x 1.53 x 5.2 m
Stagnation Pressure Range	Atmospheric
Reynolds Number Range	6.6 x 10^6 / m at 120 m/s
Support Systems	Pitch Sector with Standard AoA range: -27° to 20° Overhead Support on Turntable Standard AoA range: 40° Yaw Table Standard Yaw range: -180°to ±180°
Standard Test Capabilities	Static force testing with models sting mounted on either • An internal strain-gauge balance or the overhead balance • Pressure measurements
Standard Flow Visualisation	Oil flow Tufts

7mWT

Facility	Continuous, Eiffel wind tunnel
Speed	2 to 32 m/s
Test Section	7.5 x 6.5 x 13 m
Stagnation Pressure Range	Atmospheric
Reynolds Number Range	N/A
Support Systems	Various
Standard Test Capabilities	• Static force testing • Flow field surveys • Full-scale UAV tests • Engine-on testing for UAVs
Standard Flow Visualisation	Smoke trace Tufts

Aeroelasticity and Flutter

The CSIR is a leader in aeroelasticity technology and has cleared more than 200 aircraft configurations for the South African Air Force (SAAF), as well as for local and international clients since the 1970s. The flutter clearance capability at the CSIR was established to support of the SAAF in 1978. At the time, the SAAF needed to carry different store combinations on, mainly, the Mirage F1, and the CSIR performed several hundred flutter clearances for the SAAF. The CSIR has developed its own Ground Vibration Test (GVT) systems since 1991 and its own full suite of flutter clearance software. As the military demand decreased, the CSIR started serving the civilian market. Apart from a novel CAN bus-based GVT system, the CSIR developed smart support systems for ground vibration testing of light aircraft and in-flight excitation systems for flutter flight testing of light to supersonic aircraft.

It has a full range of aeroelasticity-related capabilities including:

- GVT and modal analysis
- Finite element modelling
- Unsteady aerodynamics analysis
- Flutter analysis
- Flutter excitation systems to support flight testing

Flutter Excitation System

The purpose of a flutter exciter is to impart a vibration into a structure. Installed on the flight test aircraft, it provides an energy input for an aircraft structure to excite all the natural modes. These structural vibrations are measured by accelerometers and the responses are used to determine if flutter onset is likely or not. A flutter excitation system improves the signal-to-noise ratio of the accelerometer responses and provides higher fidelity structural data. The flutter exciter used by the CSIR is based on an annular wing concept. The annular wing excitation system provides excitation over a programmable frequency range and duration. It is used on civilian and high-speed military aircraft.

Store Integration

The CSIR has the capability to integrate a client's store with any aircraft. This includes functional integration as well as compatibility evaluation for airworthiness certification. A systems engineering approach is followed that complies with all the aspects of military airworthiness standards such as MIL-HDBK-1763. The CSIR has expertise in these aspects of store integration and also provides store integration training:

- **Store-Aircraft Integration Specification and Integration Management**

  The CSIR has extensive experience with store integration with fast-jets and other aircraft and can assist with developing full specifications for store integration, defining the interfaces and environments for the configurations and providing a basis for airworthiness assessment. The CSIR assists clients with preparing the data pack justifying the airworthiness of the aircraft store configurations.

- **Store Separation Analysis**

  Stores that are individually stable can behave differently in the flow field of an aircraft. This can result in unexpected dynamics with the store possibly colliding with the aircraft. It is essential to verify that stores can be released safely over the specified release and jettison envelopes.
  Store separation analyses are complex and require advanced computational and experimental tools. The CSIR has developed store separation analysis tools in-house and leads the field in South Africa. These tools include:
    - Computational Fluid Dynamics (CFD) codes
    - The Medium Speed Wind Tunnel (MSWT) fitted with a Captive Trajectory System (CTS)
    - The ARUV panel code tailored for store separation analyses
    - Extensively validated analysis tools

- **Aeroelastic (Flutter) Compatibility**

- **Carriage Loads Analysis**

  Stores exert loads on the aircraft structure while it is being carried. These loads include:
    - Aerodynamic
    - Manoeuvre
    - Landing
    - Ejection

  It is important to ensure that aircraft structures are not overstressed at any point. The CSIR performs analyses in compliance with the required regulations using a range of aerodynamic, simulation and dynamics tools.

- **Performance and Handling Analysis**

  Carrying a store affects the performance and handling of the aircraft. It is important to compare the actual drag and performance envelopes against the specifications for the configurations with the store. It is also necessary to ensure that the aircraft is controllable and has acceptable handling in all phases of flight. The CSIR performs analyses in compliance with regulations.

- **Flight Test Specification, Execution and Analysis**

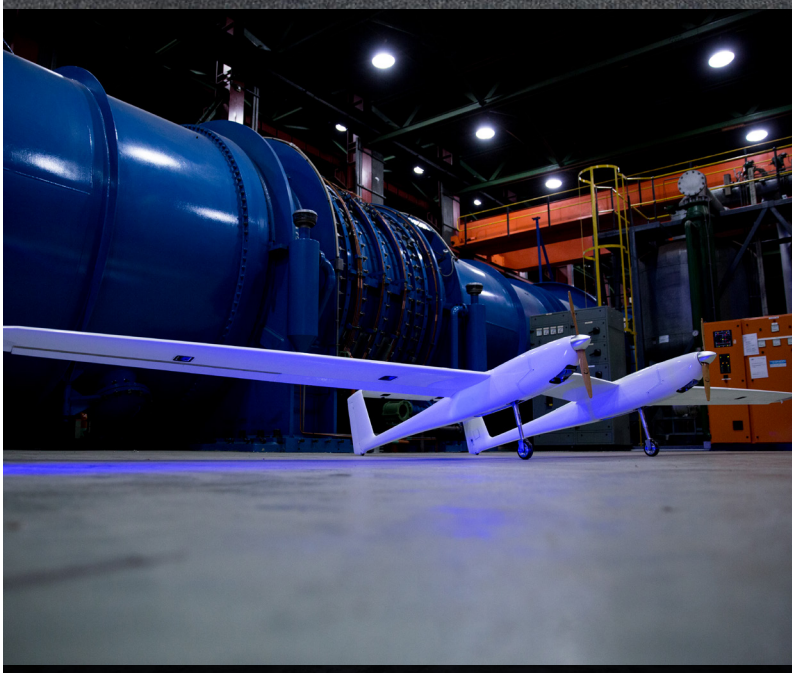
  The CSIR prepares flight test specifications for store integration programs, arranges and oversees flight tests and processes flight test data.

Unmanned Aircraft Systems

The CSIR has supported the development and application of Unmanned Aircraft Systems (UAS) in South Africa since the 1970s. The CSIR is active in developing novel UAS solutions addressing different propulsion systems, take-off and landing methods, control concepts and regulations. Developing and implementing UAS solutions is a complex exercise. A wide range of regulatory, physical, technical, operational and logistic issues must be solved for sustainable UAS operations.

The CSIR offers services and collaboration in the following areas:

- Development and proving of new UAS technologies
- Development of airframes
- Characterising airframes:
    - Wind-tunnel testing (the CSIR has the largest wind-tunnel facility in the southern hemisphere)
    - Computational fluid dynamics
    - Flight testing
- Aeroelastic and flutter analyses and testing
- Engine testing
- Flight control systems
- Modelling and simulation
- Trade studies and optimisation
- Payload selection and integration



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