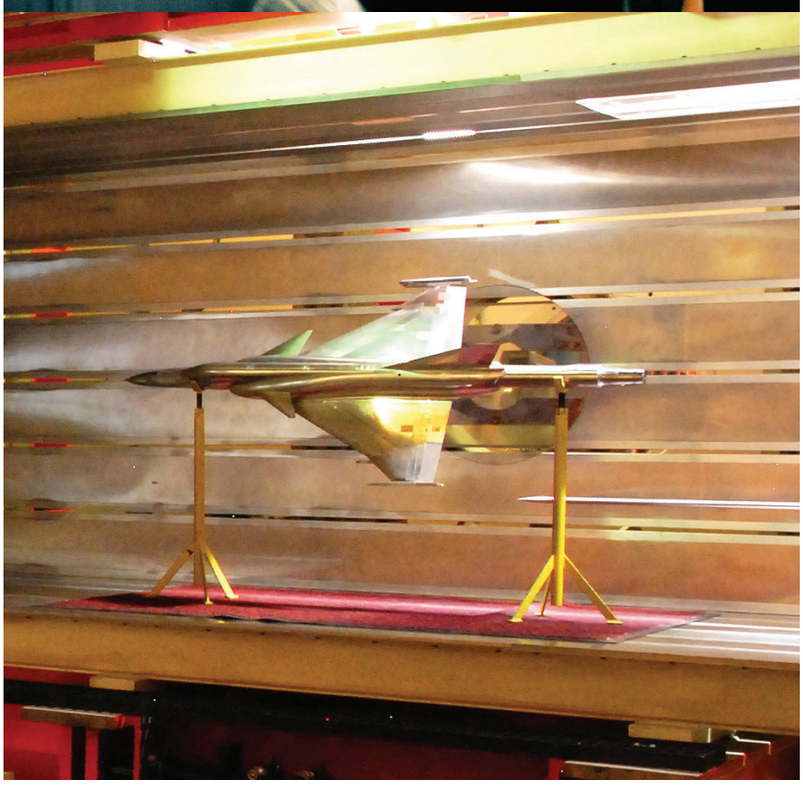
# CSIR ADVANCES IN **AERONAUTICAL RESEARCH AND DEVELOPMENT**

CSIR
Touching lives through innovation

The Council for Scientific and Industrial Research (CSIR) is the home of aeronautical research and development in South Africa, with a track record in aeronautical excellence spanning more than 50 years. The combination of talented engineers, scientists and technicians and modern facilities – including a suite of wind tunnels, aeroelastic and structural test facilities and computer clusters – has resulted in the existence of a hub of world-class aeronautical expertise at the CSIR.



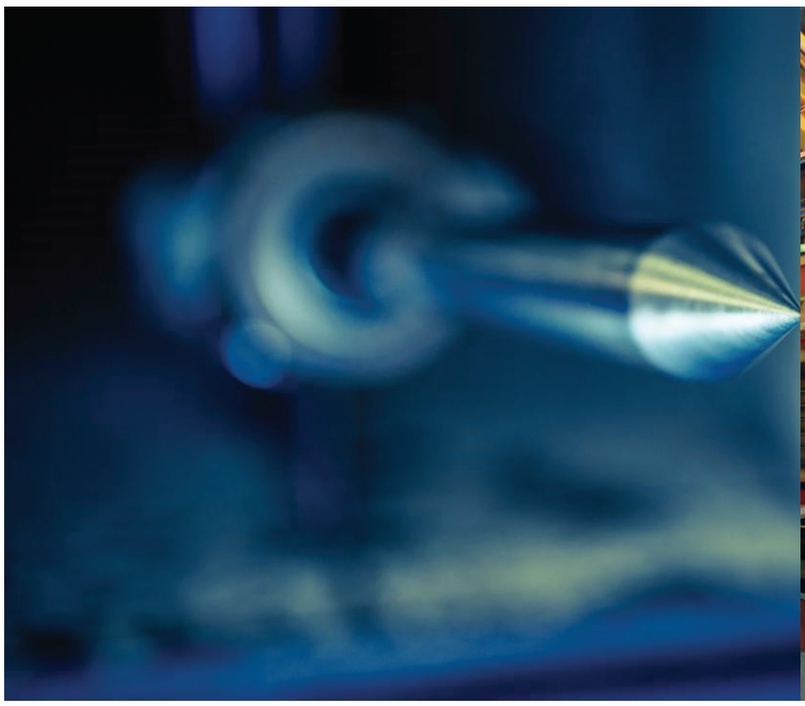
## This hub of expertise supports activities in the following areas:

- Systems Engineering
- Modelling and Simulation
- Experimental Aerodynamics
- Aeroelasticity and Flutter
- Store Integration
- Unmanned Aerial Vehicle (UAV) and Aeronautical Design
- Technology Demonstrators

## Wind Tunnel Facilities at the CSIR

The CSIR operates four wind tunnels for the production of wind tunnel data for its clients. These four tunnels, in order of test speed, are designated as the:

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




## HSWT

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|---|---|
| **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<br>185 x $10^6$ / m at Mach 2.0 |
| **Support System** | **Pitch sector with**<br>Standard Pitch Range: +/-15°<br>Roll Range: +/- 180°<br>Wall Installation |
| **Standard Test Capabilities** | • Routine static force testing with models sting mounted on internal strain-gauge balances<br>• Pressure measurements<br>• Isolated inlet testing<br>• Installed inlet testing<br>• Free-spin projectiles<br>• Drop testing |
| **Standard Flow Visualisation** | Colour Schlieren video |

## MSWT

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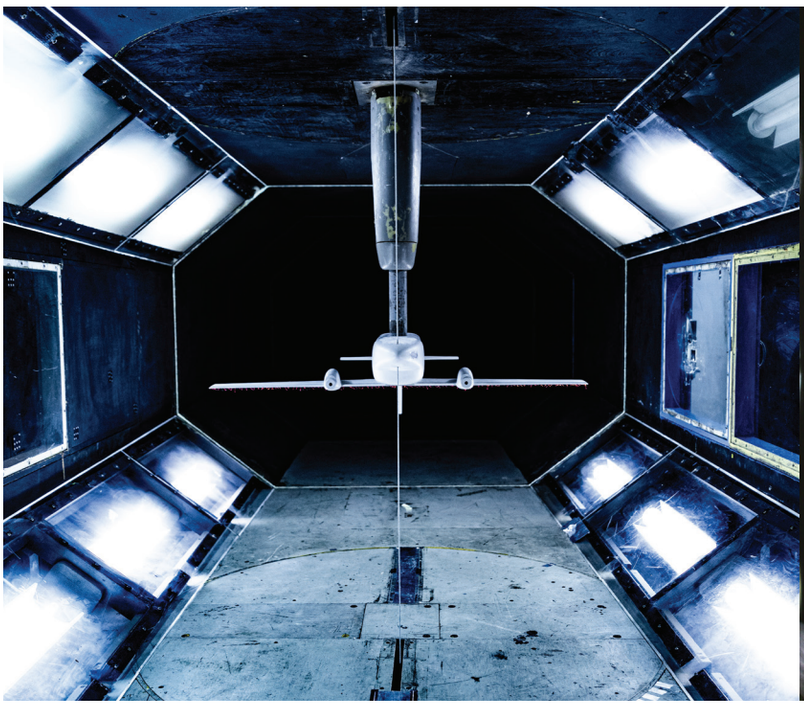
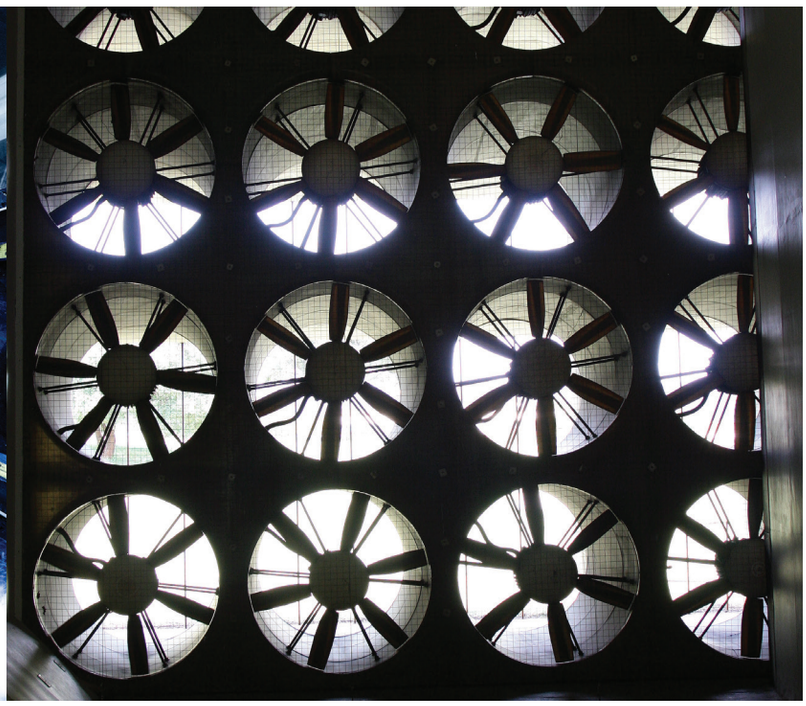
| **Facility** | Continuous, closed-circuit, variable density wind tunnel |
| **Mach Number Range** | 0.2 to 1.4 |
| **Test Section** | 1.5 x 1.5 x 4.5 m |
| **Stagnation Pressure Range** | 20 kPa to 250 kPa |
| **Reynolds Number Range** | 31 x $10^6$ / m at Mach 0.8 |
| **Support System** | **Pitch sector with**<br>Standard AoA Range: -10° to 30°<br>**Side Wall Support with**<br>AoA Range: -30° to 30°<br>**Captive Trajectory System with**<br>Pitch Range: +45° Axial (X) Range: +560 mm<br>Yaw Range: +45° Lateral (Y) Range: +410 mm<br>Roll Range: +180° Vertical (Z) Range: +525 mm |
| **Standard Test Capabilities** | • Routine static force testing with models sting mounted on internal strain-gauge balances<br>• Pressure measurements<br>• Store release tests (grid, flow field measurement and captive trajectory) |
| **Standard Flow Visualisation** | N/A |





## LSWT

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| **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 System** | **Pitch sector with**<br>Standard AoA Range: -27° to 20°<br>**Overhead Support on Turntable**<br>Standard AoA Range: 40°<br>**Yaw Table**<br>Standard Yaw Range: -180° - 180° |
| **Standard Test Capabilities** | • Routine static force testing with models sting mounted on either an internal strain-gauge balance or the overhead balance<br>• Pressure measurements |
| **Standard Flow Visualisation** | Oil flow<br>Tufts |

## 7m WT

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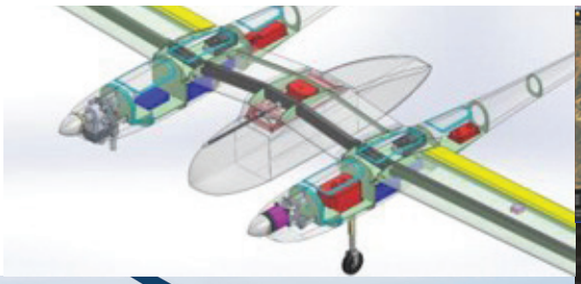
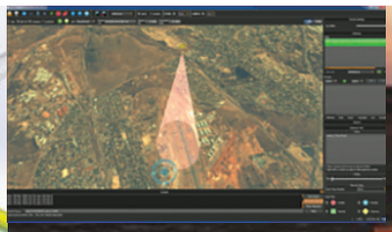
| **Facility** | Continuous, Eiffel wind tunnel |
| **Speed Range** | 2 to 32 m/s |
| **Test Section** | 7.5 x 6.5 x 13 m |
| **Stagnation Pressure Range** | Atmospheric |
| **Reynolds Number Range** | N/A |
| **Support System** | Various |
| **Standard Test Capabilities** | • Routine static force testing<br>• Flow field surveys<br>• Full-scale UAV tests<br>• Engine-on testing for UAVs |
| **Standard Flow Visu-alisation** | Smoke trace<br>Tufts |







## Aeroelasticity and Flutter

The flutter clearance capability at the CSIR was established to support of the South African Air Force (SAAF) from 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 developed its own ground vibration test (GVT) systems from 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.

The CSIR is a leader in aeroelasticity technology and has cleared more than 200 aircraft configurations for the SAAF, as well as local and international clients since the 1970s.

## 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

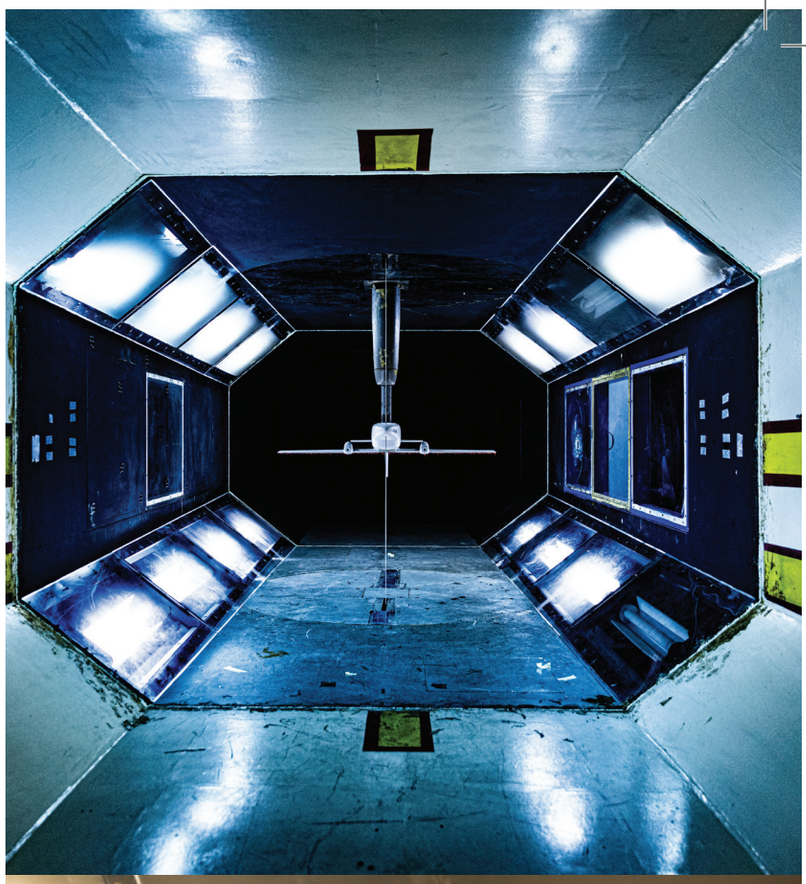
The purpose of a flutter exciter is to impart a vibration into a structure. Installed on the flight test aircraft, it provides an energy input for an aircraft structure to excite all the natural modes. These structural vibrations are measured by accelerometers and the responses are used to determine 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.

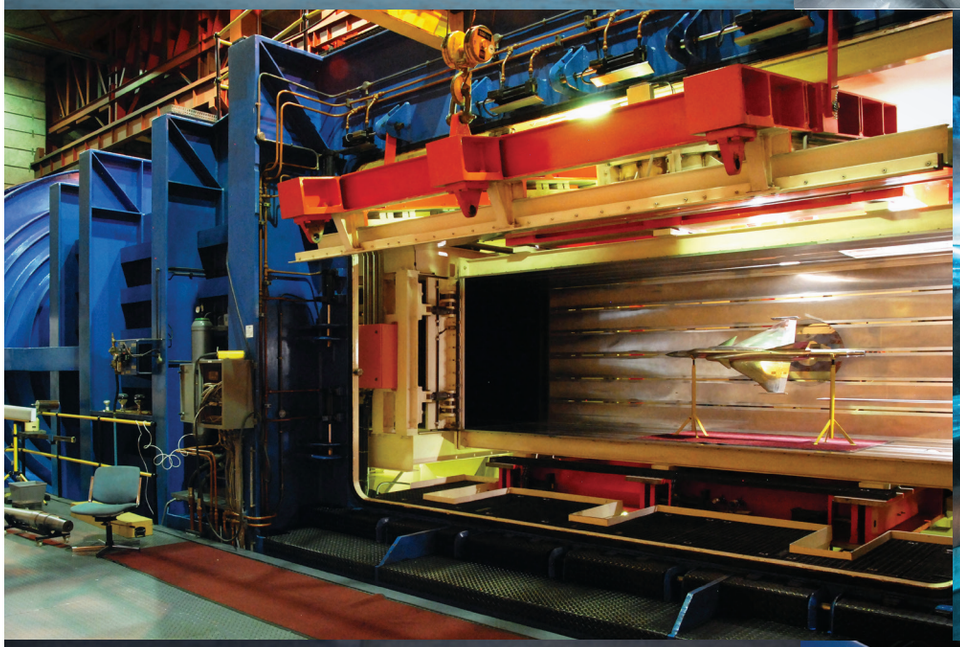
## Unmanned Aircraft Systems

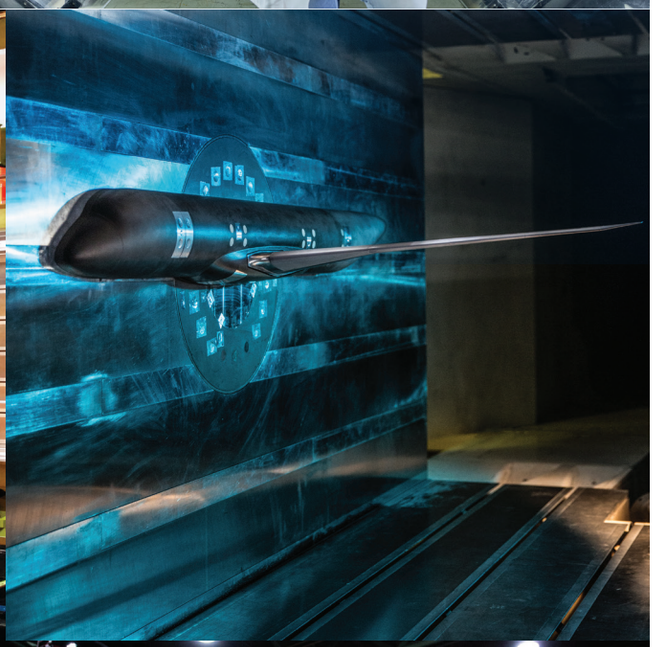
The CSIR has been supporting the development and application of unmanned aircraft systems (UAS) in South Africa since the early 1980s. Developing and implementing UAS solutions is a complex exercise. A wide range of regulatory, physical, technical, operational and logistic issues must be solved for sustainable 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 complex 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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