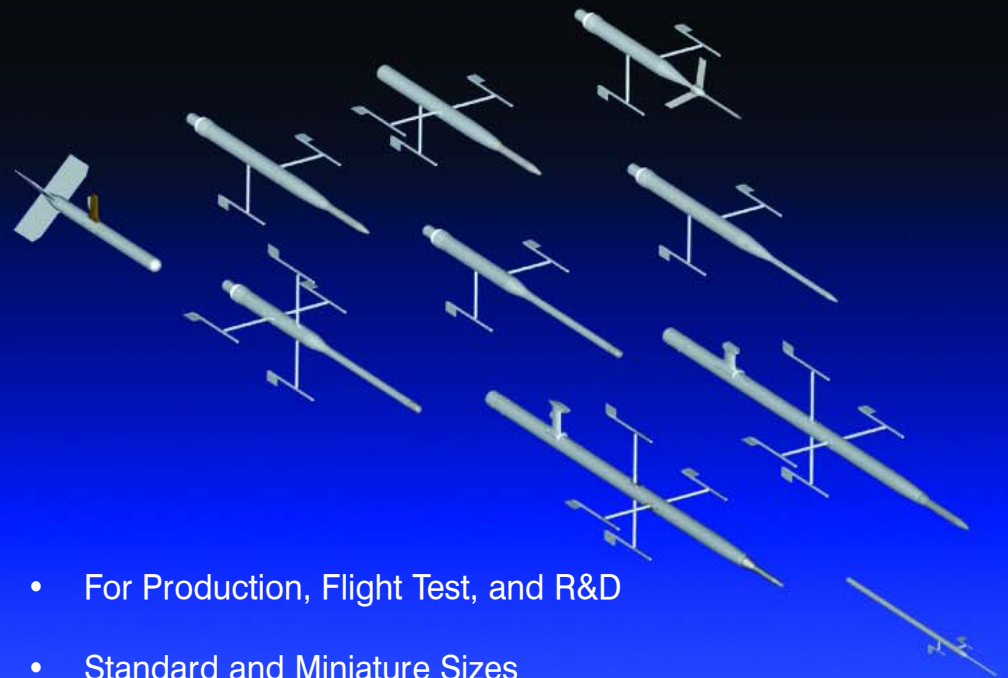
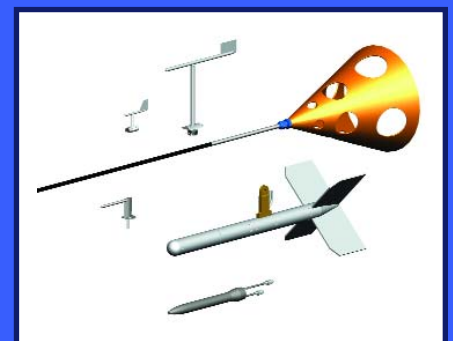


State-of-the-Art Air Data Products Solution Guide



- For Production, Flight Test, and R&D
- Standard and Miniature Sizes
- Angle of Attack and Sideslip
- Total and Static Pressures
- Total and Outside Air Temperature
- Off-the-Shelf and Custom Configurations
- Heated and Unheated
- Pitot/Static Tubes
- Trailing Cones/Trailing Bombs



Company Background

Table Of Contents

| | |
|---|----|
| Company Background | 2 |
| Product Summary | 2 |
| Technology Overview | 3 |
| Applications | 3 |
| Air Data Products | 4 |
| Product Matrix | 6 |
| Specifications | 8 |
| Support Equipment | 9 |
| Engineering Services | 10 |
| Next Steps | 10 |
| More Information | 11 |
| NASA Reference Publication 1046, Measurement of Aircraft Airspeed and Altitude | 11 |
| Position Transducers for Static, Dynamic, and Flight Testing | 11 |



Early use of the 100510 swivel-head air data boom on the NASA XV-15 tilt rotor aircraft. The 100510 product has become the de facto standard for rotary wing and high angle-of-attack air data collection.

Located near key flight test centers of NASA Dryden Flight Research Center, Edwards Air Force Base, China Lake Naval Test Center, USAF Plant 42, and Mojave Airport, SpaceAge Control was established in 1968 to design, develop, and manufacture pilot protection devices in support of space-based and high-performance test aircraft programs.

In 1973, the company was awarded a NASA contract to produce devices for obtaining angle of attack, angle of sideslip, and pressure information on test aircraft. Since 1973, SpaceAge Control has produced these devices, subsequently called air data booms, nose booms, or air data probes, for a broad array of flight test activities.

Today, SpaceAge Control air data products are used by virtually every commercial, general aviation, and military aircraft company as well as a range of auto racing teams and auto manufacturers. The company also designs and markets precision miniature and sub-miniature position transducers for measuring aircraft component movement such as flight control surfaces, landing gear, and aircraft control systems.

Designed for the precise and reliable air data acquisition needs of flight test aircraft programs, SpaceAge Control air data products have proven their value around the world for over 30 years. With a broad customer base of military, defense contractor, government, commercial, research, automotive, racing, and academic users, SpaceAge Control air data products can be tailored for each application.

Product Summary

Specific SpaceAge Control air data products adhere to designs and specifications set by NASA and NASA's predecessor organization, NACA. These types of products have been used by NASA on a wide range of flight test activities ranging from the X-1 to the X-40A. SpaceAge Control, NASA/NACA, and third-party wind tunnel and performance reports on these designs are available on request.

Air data products obtain aircraft angle of attack (AOA, alpha), sideslip (AOS, beta), static pressure, total pressure (pitot static), outside air temperature (OAT), and total air temperature (TAT). Typical names for these devices are nose booms, wing booms, nosebooms, air data probes, pitot probes, pitot static probes, trailing cones, and trailing bombs. These products provide pressure and airflow direction data to data acquisition and air data computers for computation of aircraft orientation, airspeed, altitude, and related information.

Special configurations can be produced including those incorporating solo vanes, dual vanes, mounting adapters, and mounting extenders.

To view selected applications of these products mounted on aircraft, visit www.spaceagecontrol.com/adpgal.htm.

Technology Overview

Air data booms and related products such as trailing bombs and trailing cones measure a range of parameters collectively known as "air data." This air data is generally comprised of:

P_t **total pressure:** the sum of local atmospheric pressures plus dynamic (operating (ram or impact)) pressures. Algebraically, total pressure (P_t) equals the sum of static pressure (P_s) plus impact pressure (q_c)

$$P_t = P_s + q_c$$

P_s **static pressure:** the absolute pressure of still air surrounding a body; the atmospheric pressure at the flight level of the aircraft

q_c **impact pressure:** a calculated value (q_c), it is the difference between total pressure and static pressure; it is the pressure created by the forward speed of the aircraft

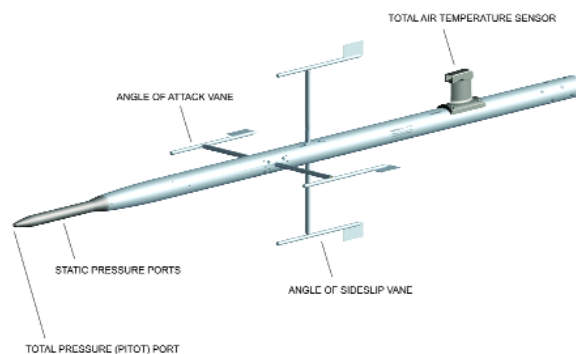
α **angle of attack:** the angle measured in the XZ plane between the X axis and the relative air flow; also designated as AOA, alpha, or α ; angle of attack is not the same concept as "pitch" which indicates the rotation of the aircraft relative to three imaginary lines running through an airplane and intersecting at right angles at the airplane's center of gravity

β **angle of sideslip:** the angle measured in the XY plane between the Y axis and the relative air flow; also designated as AOS, beta, or β ; angle of sideslip is not the same concept as "yaw" which indicates the rotation of the aircraft relative to three imaginary lines running through an airplane and intersecting at right angles at the airplane's center of gravity

T_T **total air temperature:** the temperature of an airflow measured as the airflow is brought to rest without removal or addition of heat; also designated as TAT or T_T

OAT **outside air temperature:** the temperature of the static outside temperature without the effects of airspeed; also designated as OAT

The above parameters allow a number of other parameters to be calculated such as airspeed, altitude, true airspeed, and Mach number.



For a complete introduction to airspeed and altitude measurement, please request NASA Publication 1046 at www.spaceagecontrol.com/req1046.htm.

Applications

SpaceAge Control air data products are designed and manufactured specifically for production and test operations. These products have been used on a broad range of air and land vehicles including:

- Military fighter, attack, and cargo aircraft
- Commercial and transport aircraft
- Trainers
- Drones/RPVs/UAVs
- Helicopters
- Racing aircraft
- General aviation
- Experimental/R&D/Academia
- Automotive/Racing
- High-speed rail

For additional background information on air data measurement, you may want to review these publications:

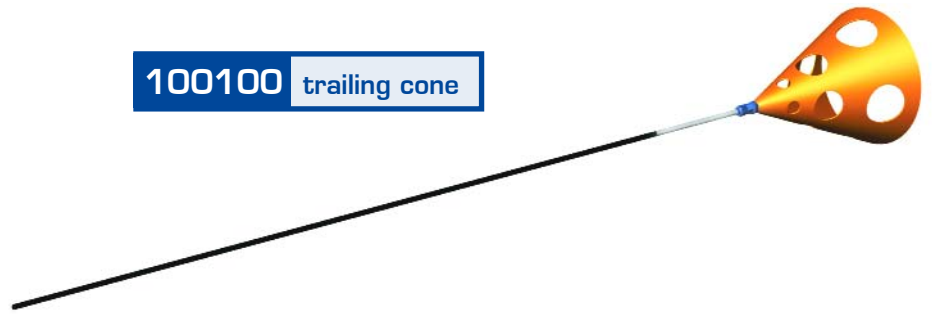
- *Airdata Measurement and Calibration*
- *Measurement of Static Pressure on Aircraft*
- *Investigation of the Fuselage Interference on a Pitot-Static Tube Extending Forward from the Nose of the Fuselage*
- *Accuracy of Airspeed Measurements and Flight Calibration Procedures*
- *Wind-Tunnel Calibration of a Combined Pitot-Static Tube and Vane-Type Flow-Angularity Indicator at Mach Numbers of 1.61 and 2.01*
- *The Measurement of Air Speed in Airplanes*
- *Summary of Methods of Measuring Angle of Attack on Aircraft*
- *Precision Pressure Transducers for Air Data Measurements*

These publications are available for review and download at:

www.spaceagecontrol.com/litroom2.htm.

Air Data Products

100100 trailing cone



100400 mini air data boom



100510 swivel-head air data boom



100600 unheated, straight-nose air data boom



100700 heated, straight-nose air data boom



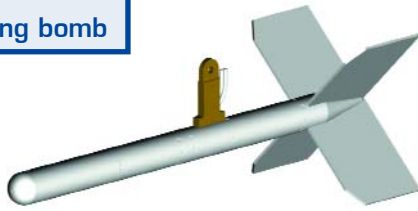
100700-02 heated, straight-nose air data boom



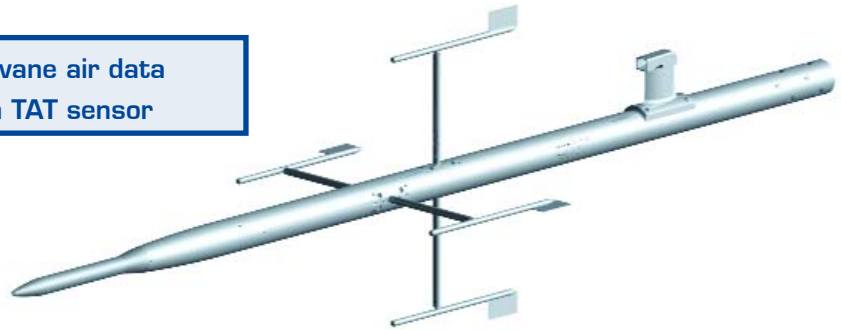
Images not shown to scale.

Air Data Products

100800 trailing bomb



100900 heated, 4-vane air data boom with TAT sensor



100386 miniature vane assembly



101000 hovervane



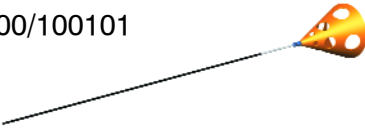






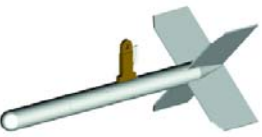



300933 pitot-static probe (L-shaped, unheated)



100486 vane assembly



Product Matrix

| Part Number | Name | Standard Outputs | Approximate Size (Inches (mm)) | Approximate Mass | |
|---------------|---|---|---|-------------------|--|
| 100100/100101 |  trailing cone | static | 800 (long) x 10 (dia.) (21590 x 254) | 70 oz 2.00 kg | |
| 101100 |  micro air data boom | total static AOA AOS | 18 (long) x 2 (dia.) (457 x 51) | 5 oz 142 g | |
| 100400 |  mini air data boom | total static AOA AOS | 30 (long) x 3 (dia.) (762 x 76) | 6 oz 170 g | |
| 100510 |  swivel-head air data boom | total static AOA AOS | 28 (long) x 8 (dia.) (711 x 203) | 41 oz 1.16 kg | |
| 100600 |  unheated, straight-nose air data boom (NACA standard design) | total static AOA AOS | 33 (long) x 8 (dia.) (838 x 203) | 56 oz 1.59 kg | |
| 100700 |  heated, straight-nose air data boom | total static AOA AOS | 35 (long) x 8 (dia.) (889 x 203) | 56 oz 1.59 kg | |
| 100700-02 |  heated, straight-nose air data boom | total static AOA AOS | 30 (long) x 8 (dia.) (762 x 203) | 56 oz 1.59 kg | |
| 100800 |  trailing bomb | total static | 22 (long) x 10 (dia.) (559 x 254) | 170 oz 4.82 kg | |
| 100900 |  heated, 4-vane air data boom with TAT sensor | total static AOA (2) AOS (2) total air temperature | 57 (long) x 16 (dia.) (1450 x 406) | 200 oz 5.44 kg | |
| 100386 |  miniature vane assembly | AOA or AOS | 1.5 x 3.3 x 0.5 (38 x 84 x 13) | 0.6 oz 15 g | |
| 100486 |  vane assembly | AOA or AOS | 9 x 9 x 1 (229 x 229 x 25) | 7 oz 188 g | |

All specifications are subject to change without prior notice.

| Nominal Max Airspeed | Heated or Unheated Total/Static Ports | Data Sheet Location | Typical Aircraft | Typical Product Use |
|----------------------|---------------------------------------|---|--|---|
| Mach 0.9+ | unheated | www.spaceagecontrol.com/s002b.htm & s002b1.htm | business & commercial jets, transports, trainers, UAVs |  |
| 200 knots | unheated | www.spaceagecontrol.com/s002l.htm | UAVs, drones, RPVs, experimental, light aircraft |  |
| 340+ knots | unheated | www.spaceagecontrol.com/s002c.htm | UAVs, drones, RPVs, general aviation, academia, automotive, rail, racing |  |
| 500 knots | unheated | www.spaceagecontrol.com/s002d.htm | rotary wing aircraft, STOL/VSTOL aircraft, business jets |  |
| Mach 2.5+ | unheated | www.spaceagecontrol.com/s002e.htm | very high-speed aircraft, non-icing conditions |  |
| Mach 2.5+ | heated | www.spaceagecontrol.com/s002f.htm | very high-speed aircraft, icing conditions |  |
| Mach 1.5+ | heated | www.spaceagecontrol.com/s002g.htm | high-speed aircraft, icing conditions |  |
| 200 knots | unheated | www.spaceagecontrol.com/s002h.htm | rotary wing aircraft, slow-flight aircraft |  |
| Mach 1.5+ | heated | www.spaceagecontrol.com/s002i.htm | high-speed aircraft, icing conditions |  |
| 400+ knots | not applicable | www.spaceagecontrol.com/s002j.htm | UAVs, drones, RPVs, general aviation, academia, automotive, rail, racing |  |
| Mach 2.5+ | not applicable | www.spaceagecontrol.com/s002k.htm | broad range |  |

* Photo credit: Judson P. Brohmer, National Test Pilot School, www.ntps.com

Vane Sensor Specifications



100400 air data boom

| | |
|-----------------------------|---------------------------------------|
| Type | conductive plastic |
| Resistance | 1.5K ohms |
| Resistance Tolerance | ±15% |
| Independent Linearity | ±5% |
| Electrical Travel | 60° (other options available) |
| Mechanical Travel | 360° continuous |
| Power Rating at 70° C | 0.5 Watt |
| Mechanical Life | 100 million shaft revolutions minimum |
| Operating Temperature Range | -65° to +125° C |

100510, 100600, 100700, and 100700-02 air data booms

| | |
|-----------------------------|---------------------------------------|
| Type | dual conductive plastic |
| Resistance | 5K ohms |
| Resistance Tolerance | ±10% |
| Independent Linearity | ±0.5% |
| Electrical Travel | 340° (±1°) from center tap |
| Mechanical Travel | 360° continuous |
| Power Rating at 70° C | 1.0 Watt |
| Mechanical Life | 100 million shaft revolutions minimum |
| Operating Temperature Range | -65° to +125° C |

Potentiometers are supplied with center taps that are aligned for 0° angle of attack and sideslip. User-specified potentiometers, synchros, and resolvers may also be incorporated.



100900 air data boom

| | |
|-----------------------------|---------------------------------------|
| Type | conductive plastic |
| Resistance | 5K ohms |
| Resistance Tolerance | ±10% |
| Independent Linearity | ±0.5% |
| Electrical Travel | 340° |
| Mechanical Travel | 360° continuous |
| Power Rating at 70° C | 1.0 Watt |
| Mechanical Life | 100 million shaft revolutions minimum |
| Operating Temperature Range | -65° to +125° C |

User-specified potentiometers, synchros, encoders, and resolvers may also be incorporated.

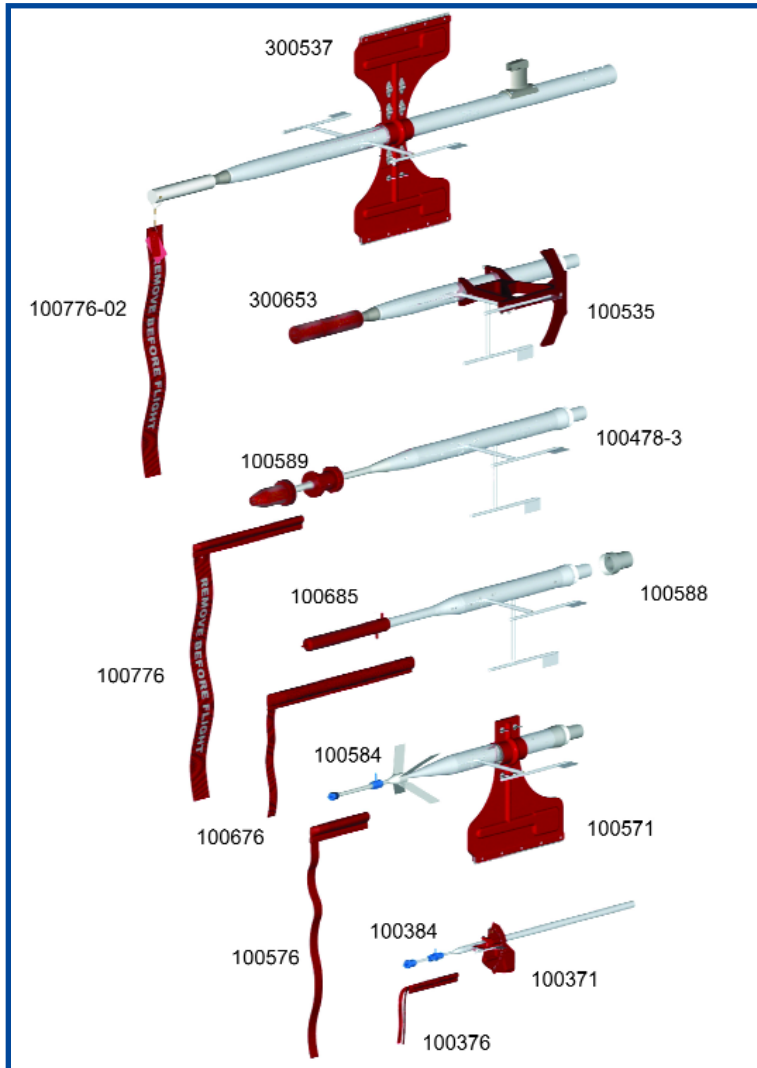
Other Specifications

All electrical cables are supplied without connectors. All air data booms can be supplied without one or all vanes and with total air temperature or outside air temperature sensors. For additional information or to request installation drawings, please contact us. Or, visit our Web site at:

www.spaceagecontrol.com/adpmain.htm

Support Equipment

Available support equipment for the air data products is outlined below. Please contact us if you need recommendations for pressure transducers, air data test sets, or air data computers.



test fixture set - seals static and total pressure ports for leak testing; with user-provided air data test set and pressure transducers, can also be used to calibrate the total and static pressure system

total probe cover - protects the total and static ports from debris; serves as a visual warning indicator to personnel in the area

vane cover - prevents the vanes from being rotated; serves as a visual warning indicator to personnel in the area

vane calibration fixture - provides a visual scale that is mounted on the air data boom and that is aligned with the vane fin to allow calibration of the vanes

boom adapter - provides a threaded mounting point for quick installation and removal from the application; provided standard with the 100510, 100600, 100700, and 100700-02 air data booms

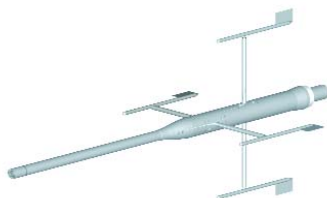
nut and sleeve - interfaces to the 100478-3 boom adapter allowing installation and removal of the air data boom from the aircraft; an optional item

| Air Data Boom | Vane Calibration Fixture | Probe Cover | Vane Cover | Test Fixture Set | Boom Adapter | Nut and Sleeve | Vane Assembly |
|---------------|--------------------------|-------------|------------|------------------|--------------|----------------|---------------|
| 100400 | 100335 | 100376 | 100371 | 100384 | NA | NA | 100386 |
| 100510 | 100535 | 100576 | 100571 | 100584 | 100478-3 | 100588 | 100486 |
| 100600 | 100535 | 100676 | 100571 | 100685 | 100478-3 | 100588 | 100486 |
| 100700 | 100535 | 100776 | 100571 | 100589 | 100478-3 | 100588 | 100486 |
| 100700-02 | 100535 | 100776-02 | 100571 | 300653 | 100478-3 | 100588 | 100486 |
| 100900 | 100535 | 100776-02 | 300537 | 300653 | NA | NA | NA |

Engineering Services

If you have special requirements requiring engineering services, we can assist you. Our range of services include:

- environmental test and qualification to U.S. and worldwide standards
- static and dynamic structural analysis
- customizations such as TAT and OAT sensor additions, redundant or dual vanes, and special mounting hardware



100600-01 air data boom with 4 independent vanes and high-speed unheated probe rated to Mach 2.6+



100700-03 air data boom with synchro vane sensors, dual vanes, and TAT sensor

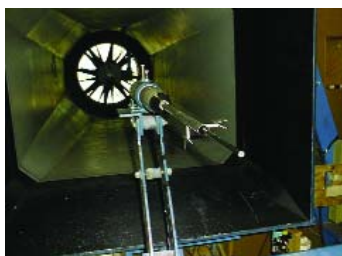


100700-04 air data boom with dual angle of attack vanes for redundancy and heated probe temperature sensor to verify operation



100700-05 air data boom designed and tested for low-mass, long-life, and extreme environmental conditions; note the small cross-sectional area

- wind tunnel testing



100400 mini air data boom with low-speed wind tunnel test suite in progress



300643 heated probe undergoing low- and high-speed wind tunnel testing

- recommendations for pressure transducers, air data test sets, and air data computers

Next Steps

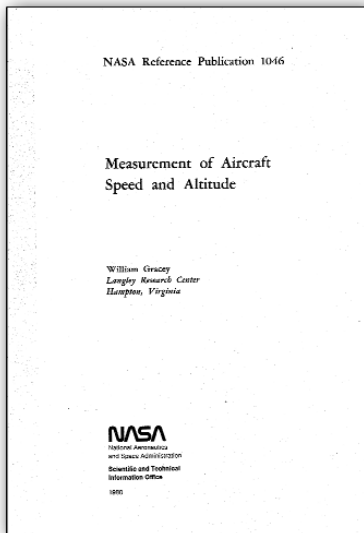
To order or for application assistance, please contact us. We will respond immediately.

We also provide replacement, calibration, modification, and repair services for your existing air data products. Please contact us if you have requirements for these services.

More Information

For complete information on air data products including fully-dimensioned installation drawings, contact us by phone, fax, e-mail, or web.

NASA Reference Publication 1046, Measurement of Aircraft Airspeed and Altitude



Would you like to qualify for a free copy of NASA's 316-page document on air data measurement (NASA Reference Publication 1046, Measurement of Aircraft Airspeed and Altitude)?

If so, complete our Web form at www.spaceagecontrol.com/req1046.htm and you will be qualified for a FREE downloadable (electronic) copy. This publication provides a wealth of information on how to accurately obtain air data from aircraft. This publication is a \$56.00 value.

Position Transducers for Static, Dynamic, and Flight Testing

Need flight-proven, reliable position transducers for static, dynamic, and flight testing? Consider using rugged, miniature position transducers that feature broad operating temperature ranges, easy installation, high repeatability, and tested performance to DO-160D (ED-14D) and MIL-STD-810E.

For more information, visit www.spaceagecontrol.com/ptmain.htm.

