A WORLD LEADER IN PRECISION

With over 90 years experience, you can trust us to offer accurate, reliable delivery. Every time.

- MEMS based inertial sensing systems
- Guidance systems for precision guided weapons
- Stability augmentation systems for vehicles and platforms
- Ground collision avoidance systems for aircraft
Navigation and aircraft protection

Best known for its fast-jet applications, the AIS TERPROM® technology has evolved into a family of related systems that can provide safety, awareness and operational effectiveness for a much wider range of aerial platforms.

TERPROM® is a digital terrain system that provides the platform aircraft with navigation, safety, situational awareness and ranging capabilities based on the integration of the platform’s navigation data with stored digital terrain and obstruction map data. It has been installed in a range of fast-jet types, including Typhoon, Tornado, F-16 and A-10.

TERPROM® references the actual terrain over which the aircraft is flying – based on readings from the radar altimeter – with a digital terrain database, and with inputs from the aircraft’s inertial and GPS systems, to give a highly accurate terrain-referenced navigation (TRN) function.

With the aircraft’s position fixed in relation to the local terrain, TERPROM® can be used in further ways. It provides predictive ground collision avoidance and obstruction warning, regardless of aircraft attitude. It can be used for terrain-following flight, with the advantages of being able to ‘see’ areas on the other side of high terrain that are blind to terrain-following radars, and with no forward radar emissions. It continues to perform even in areas where GPS is denied.

TERPROM® has significant applications in weapons delivery. It can be used as a passive ranging tool, while its elevation data can be employed to refine aimpoints for free-fall weapons. Ballistics computers see the world as flat, but TERPROM® adds the vital target height data required for accurate delivery.

 Expanded capabilities
TERPROM®’s abilities in the fast-jet world have been proven over years of successful operation, but AIS has evolved the technology to support other platforms, such as transports and helicopters. For the military transport world – as selected for the Boeing C-17 and C-130 AMP upgrade – AIS has developed new features for TERPROM®. They include a reactive ground proximity warning system (GPWS), as a backup for the predictive and warning functions for windshear, bank angle, and ILS glideslope deviation. Together, these developments result in a system that is compliant with the FAA Technical Standing Orders (TSOs) for GPWS and Terrain Awareness and Warning Systems (TAWS).

A Terrain Awareness Display can be generated on a head-down map to show surrounding terrain and obstructions as a colour-coded display, referenced to the aircraft’s altitude. This function is highly intuitive, showing ground higher than the aircraft in shades of yellow, orange and red, while terrain
beneath the aircraft is in shades of green. 

AIS further developed a rotary-wing TERPROM® system, tailored to nap-of-the-earth flight. The Advanced Terrain Avoidance Cueing function generates terrain/obstacle clearance data in three sectors: left, ahead and right of the current aircraft flightpath. This gives the pilot a clearer picture of the terrain, with the necessary data available for various course options.

A key growth area is the unmanned air vehicle sector. TERPROM® and its developments have obvious application to UAVs, particularly in the field of target location and weapons ranging.

**Further evolution**

AIS is working on a number of programmes to enhance the capability of TERPROM® and to widen its applications. Among the initiatives is the provision of higher resolution terrain databases to improve accuracy, awareness and operational functionality yet further, and active sensor integration. A variety of sensors, such as infra-red, laser, optical and millimetre-wave radar, can be integrated with TERPROM® to give greatly improved situational awareness and to enhance the performance of synthetic vision systems. Active sensors can provide positive detection of obstacles that may not be in the database, but they only have a limited field of view. When merged, the data from TERPROM® and the active sensor combine to give a robust and accurate view of the wider world around the platform. Active sensor integration is of particular value in the rotary-wing community, where wires and obstacles remain among the biggest threats to safety. Another area of concern is billowing dust, as encountered during operations in Iraq and Afghanistan.

Under its Low Visibility Landing programme, the UK MoD has launched a study to investigate means of greatly improving safety in ‘brown-out’ conditions. AIS – with its experience of TERPROM® and integration of other sensors – is a member of the LVL study team.

Several tests have been conducted with active sensors combined with high-resolution TERPROM®.

Active sensors also give the very useful capability of dynamic map building, with unmapped obstacles and terrain features being added to the map databases in real-time.

Accurate terrain database technology has obvious military applications, but can also become an important part of civilian helicopter operations. The safety aspect offered by TERPROM®, especially ground and obstacle avoidance, is available at a low cost compared to the lives and aircraft it could save.
MEMS Inertial Sensors

Atlantic Inertial Systems is a world leader in providing inertial systems for precision navigation and guidance. Its latest MEMS-based devices open up new possibilities for inertial guidance of ever smaller platforms – with high reliability and at low cost.

Inertial technology – the ability to measure tiny rotational and linear accelerations – is the bedrock of modern precision navigation and guidance systems. While radar, laser or GPS can all provide the required precision, it is the inertial system that provides the continuity when other sensors cannot work, or are degraded or jammed, and it can also be used on its own.

AIS has a long pedigree of providing inertial sensors for military and commercial uses. Today, its development efforts are focused on Micro Electro-Mechanical Systems (MEMS), and AIS was the first company to harness this technology for inertial guidance. Its initial MEMS product – the SiIMU01® – was the first MEMS inertial measurement unit (IMU) to enter service, and volume production.

MEMS sensors

AIS produces a range of sensors using MEMS, and is working on important developments. MEMS units are based on silicon vibrating structure gyro (SiVSG) rate sensors, each smaller than the size of a fingertip. A single rate sensor, together with its control and power electronics, can be packaged to provide a single-axis device. More importantly, three of these rate sensors can be mounted along with three MEMS accelerometers to provide a complete IMU with six degrees of freedom. While the first-generation SiIMU01® has a volume of about seven cubic inches, the second-generation SiIMU02® unit is only 4 cubic inches in size. It is roughly cylindrical and weighs less than 250g. IMUs are produced as stand-alone units providing angular rate and acceleration information. AIS has also devised an integrated MEMS INS/GPS unit – SiNAV02® – with the second-generation IMU combined with a GPS receiver and a Modular Integrated Kalman filter, providing tactical free-inertial performance and navigation accuracy.

MEMS advantages

The nature of MEMS technology allows inertial sensors to be made extremely small, greatly reducing the size of the overall IMU. In turn, that allows inertial guidance to be applied to much smaller projectiles than is possible with conventional spinning wheel gyros. Another key advantage is an inherent tolerance of extreme loads. AIS MEMS sensors have been successfully tested at accelerations of up to 23,000g, allowing the company to offer the world’s first gun-hard MEMS IMU. Trials have been undertaken from a variety of weapons, including a 105-mm light field gun, 155-mm rifled howitzers and a 5-inch naval gun.

Another key benefit of MEMS technology is its suitability for mass production, resulting in low cost. This is a very important factor in today’s economic climate, particularly when comparing the cost of weapons against their likely effects. The MEMS IMU also delivers on required performance, with the added benefit of much faster start-up times than traditional inertial systems.
MEMS applications

Today’s military forces increasingly demand precision attack capability to increase kill probability and reduce collateral damage. Inertial/GPS-guided bombs have become the standard air attack weapon, and now the military is looking for similar kinds of precision from ever smaller weapons. Small size and the ability to perform when exposed to high shock and vibration allows MEMS-based IMUs to be incorporated into artillery shells and mortars, and to give precision guidance to small-calibre rockets.

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The company’s first MEMS IMU is incorporated into the Saab NLAW anti-tank weapon, MBDA Seawolf naval ship defence missile and the Raytheon Rolling Airframe Missile. In the latter application the IMU incorporates an innovative rate integrating gyro in the roll channel, providing exceptional scale factor performance at high spin rates.

In December 2006 AIS began delivering second-generation SiMU02® units for the BAE Systems APKWS 70-mm guided rocket programme. The IMU was also selected by Denel for the A-Darter air-to-air missile, Raytheon for the NLAW.

ERGM II maritime precision attack system and for a range of international guided rocket and bomb applications. Recently, AIS has provided the IMU for the Raytheon Excalibur programme. This is a 155-mm precision guided artillery shell, requiring the unique gun-hard capabilities of the AIS IMU. There is also increasing interest in AIS MEMS technology for UAV and stabilized platform applications.

AIS continues to refine its current products, while developing the systems of tomorrow. The company is involved in the UK’s Team Complex Weapons, notably as part of the Fire Shadow Loitering Munition and Common Anti-air Modular Missile programmes, and also Team ImpaQt, which is also developing guided 155-mm projectiles.

Future developments

AIS’s current MEMS products have greatly reduced the size and cost of an IMU. However, all inertial products suffer from drift over time. This is not an issue with short duration applications such as artillery shells, short range missiles and rockets. Now AIS is working on a MEMS IMU that offers high levels of performance on long endurance weapons in the tactical arena. This Tactical SiMU will combine the rugged, low cost and size advantages of MEMS IMUs with high levels of accuracy over long distance and time - and is positioned not only to allow the development of new weapons but also to modernize existing missiles that use older, more expensive technology.

MEMS resonating ring sensor

At the heart of the MEMS units are sensors that use Coriolis forces to measure angular rates. The sensor comprises an ultra-thin silicon ring approximately 6 mm in diameter. The ring is mounted in a magnetic field and is vibrated resonantly. When angular motion is applied secondary vibrations are created, whose amplitude is proportional to the rate of rotation. A secondary drive is applied to oppose these secondary vibrations, and the amount of force needed to null them can be measured. The required force is converted into a measure of the angular motion.
Spinning wheel inertial sensors

AIS is not only a world leader in terms of the latest MEMS-based technology, but is also one of the largest producers of traditional gyros and inertial systems in the world, with over 4 million delivered to date. The armed forces of the United States are the largest military consumers of inertial products, and AIS is one of the biggest suppliers. Its Cheshire, Connecticut, facility has unparalleled expertise in the high-volume production of gyros, accelerometers and associated precision instruments. AIS products are integral to the performance and success of many of the biggest US platform and weapons programmes.

These products consist primarily of spinning mass inertial sensors. The product portfolio is suited to the requirements of varied applications, and ranges from single-axis rate gyros to complete inertial measurement units. AIS also manufactures a range of sensors incorporating Rotating PZT (piezo) technology. This is a spinning wheel device that has two axes of rate measurement and two accelerometers. It combines the precision of spinning wheel gyros with some of the benefits of solid-state sensors. Rotating PZT sensors are included in several high-profile air-launched missile systems.

Product applications

In the land arena AIS spinning wheel gyros have a number of applications to fighting vehicles. They include gun, sight and target stabilization, and the relative positioning of gun, hull and turret. Vehicles with AIS systems include the M1 Abrams main battle tank, Bradley fighting vehicle, Stryker armoured combat vehicle, Light Armoured Vehicle, Avenger and the Korean K1 main battle tank. AIS gyro assemblies are included in many US fixed-wing platforms, from the C-5 Galaxy outsise transport to F-22 stealth fighters. The systems are used in the flight control system, radar and targeting pod stabilization, and attitude heading and reference systems. Among the applications are the Litening targeting pod used by a variety of attack aircraft, and the MTS turret employed by the Predator and Reaper UAVs. Sweden’s Gripen multi-role fighter also uses AIS gyros.

Rotary-wing applications include stability augmentation, sighting, targeting and camera stabilization systems, with platforms including the Black Hawk, Seahawk, Apache, Cobra, Chinook and Kiowa Warrior. Key systems include the Apache’s TADS and MTADS/Arrowhead targeting systems. AIS gyros are on board numerous missile systems. Both US state-of-the-art air-to-air weapons – the AIM-9X Sidewinder and AIM-120 AMRAAM – have AIS inertial measurement units with Rotating PZT sensors. This technology is also in the Evolved Sea Sparrow Missile (ESSM) maritime air defence weapon, AGM-158 Joint Air-to-Surface Standoff Missile (JASSM), Paveway laser-guided bomb family,
Wind-Corrected Munition Dispenser, Starstreak short-range surface-to-air missile, Javelin man-launched anti-tank weapon, BAT/Viper Strike weapons, and in the Brimstone and Longbow programmes.

One of AIS’s most important products has been the two-axis gas-activated fast-start free gyro used in the TOW and Hellfire air-launched anti-tank weapons, of which over 1 million have been delivered.

Other key missile programmes for which AIS has provided gyros and IMUs are the Harpoon anti-ship weapon, Patriot surface-to-air missile and Mk 54 Lightweight Hybrid Torpedo. Overseas programmes include the Israeli Spike anti-tank weapon and Korean Chun-ma SAM.

AIS products also feature in the guidance and flight control systems of the most important US space-based programmes, such as the Atlas, Delta and Titan launch vehicles, and the Space Shuttle. The company also provided guidance systems for the Minuteman and Peacekeeper ICBMs.

Support activities and MEMS technology
Like its UK-based cousin, the US arm of AIS provides extensive support and servicing provisions for its products. These are principally conducted at the Heath, Ohio, facility. This location is responsible for the repair and overhaul of the guidance elements of the USAF’s strategic missile assets, and was recently awarded a contract to design and implement a Minuteman Enhanced Reliability Accelerometer for the ICBM force.

The development of MEMS-based instruments within AIS allows the company to exploit the advantages they offer as the large US market begins to embrace the new technology. There are certainly opportunities to introduce MEMS sensors to existing platforms as they are modified and overhauled, as well as installation in new platforms.

Opening the door for MEMS in the US is the Raytheon/Bofors Defence Excalibur 155-mm guided artillery projectile. The gun-hard capabilities of its AIS IMU have greatly impressed the US Army, and more than 30,000 rounds are expected to be ordered. While MEMS sensors are gaining a foothold in the US market, AIS continues to refine its traditional products, and produce them in vast quantity to satisfy the increasing demands for precision warfare capability.

AMRAAM

INSTRUMENT AND IMU DELIVERIES TO DATE
→ 1,350,000 Single-Axis Rate Gyros (Rate and G5)
→ 350,000 Rate Integrating Gyros (G6 and G6G)
→ 25,000 Tuned Rotor Gyros – Two-Axis Rate Integrating Gyros (DT6)
→ 7,000 STARS – Two-Axis Rate Sensors
→ 55,500 Multisensors – Two-Axis Rate Sensors
→ 1,000,000 Gas Activated Gyro – Two-Axis Fast-Start Free Gyros (TOW and Hellfire)
→ 9,000 AMRAAM IRUs
→ 30,000 IMUs – WCMD, JASSM, Longbow, Brimstone & BAT (Multisensor)
→ 6,750 IMUs – Longbow & AIM-9X (STAARS)
→ Over 15,000 MEMS in use on a range of military & aerospace applications
→ 5,000 on RAM, Seawolf, NLAW
→ 10,000 on A400M, anti tank weapons, missiles, simulators, space and marine applications.

F-22 uses AIS sensors in its flight control system

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→ 1,350,000 Single-Axis Rate Gyros (Rate and G5)
→ 350,000 Rate Integrating Gyros (G6 and G6G)
→ 25,000 Tuned Rotor Gyros – Two-Axis Rate Integrating Gyros (DT6)
→ 7,000 STARS – Two-Axis Rate Sensors
→ 55,500 Multisensors – Two-Axis Rate Sensors
→ 1,000,000 Gas Activated Gyro – Two-Axis Fast-Start Free Gyros (TOW and Hellfire)
→ 9,000 AMRAAM IRUs
→ 30,000 IMUs – WCMD, JASSM, Longbow, Brimstone & BAT (Multisensor)
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Atlantic Inertial Systems

AIS supplies mission-critical hardware in the fields of inertial measurement and navigation. The company produces gyroscopes suitable for any application, and its products are aboard a wide range of military hardware, from main battle tanks to the F-22 Raptor. It also supplies tactical-grade inertial measurement units to a number of important programmes. Through its production facilities and development laboratories, AIS possesses significant capabilities in the areas of systems and applications engineering, mission simulation and production capacity.

The company’s experience and capabilities allow it to solve complex problems in the guidance and navigation arena, and it stands ready to offer reliable solutions for a wide range of programmes – at low non-recurring cost and over short development timespans.

F-16

Company profile

Atlantic Inertial Systems currently supplies to over 250 programmes in 28 countries. As a Tier 2 supplier, most of its business is with prime contractors, and it counts most of the major Western manufacturing groups among its customers. Acquired in December 2009, AIS is owned by Goodrich Corporation. Goodrich is one of the largest worldwide aerospace and defense suppliers, providing a range of proprietary flight-critical systems and products. AIS provides Goodrich with a high growth platform in the defence market, building on existing Goodrich capabilities.

AIS’ portfolio of inertial sensors complements Goodrich’s guidance, control and navigation systems. Combining engineering strengths and technology will enable support to customers world wide, across the full spectrum of guidance and control systems.

AIS has facilities in the US (Cheshire CT, Heath Ohio, Totowa New Jersey) and the UK (Plymouth). Atlantic Inertial Systems Ltd in the UK also has a joint venture with Sumitomo Precision products. Known as Silicon Sensing Systems, the JV manufactures the MEMS rate sensors in Japan.

LONG-STANDING HERITAGE

AIS brings to the table a rich wealth of experience drawn from the impressive pedigree of its UK and US roots.