A-STR AND AA-STR

Space

AUTONOMOUS STAR TRACKERS

The A-STR and AA-STR are medium Field of View (FOV) star trackers integrated in a single assembly with a radiation hardened design. The trackers feature robust and accurate three axis attitude determination with very low mass and power consumption for the class of instrument.

The star trackers are highly reliable and represent the latest technology in the field of autonomous attitude determination. Suitable for a broad range of missions, the trackers are utilised in the commercial market of telecommunication geostationary satellites (characterised by severe radiation orbits and long duration), in Earth observation satellites, scientific satellites and for interplanetary missions/probes.

Initial attitude acquisition can be performed without any prior information about the S/C orientation, solving the problem of the assembly becoming lost in space.

All operations are executed under microprocessor control by means of SW modules with in-flight reprogramming capability. The company constantly updates its star trackers with the latest technology, whilst also maintaining a reputation for highly reliable products.

Active Pixel Sensor (APS) CMOS technology is one of these advancements. The AA-STR is based on the HAS detector, and as such is the first star tracker to include CMOS technology, able to achieve TRL 8. The company is now building on this experience with these highly-integrated CMOS image sensors to study further miniaturisation of star trackers, with the goal being to make a “sensor-on-a-chip” device available in the near future. As part of this endeavour a mock-up unit, functionally representative of the “basic” architecture, has already been realised and follow on activities are currently ongoing.

A-STR AND AA-STR

The heritage of the A-STR and AA-STR star trackers stems from their predecessor, the High Resolution Star Tracker (HR-STR) that is successfully flying (or was flown) on ISO, SAX, SOHO (flying since December 1995), CASSINI, XMM, INTEGRAL, SAC-C, ROSETTA, MARS EXPRESS, VENUS EXPRESS and others.

All of these star trackers have performed flawlessly and have never placed their mission in jeopardy.

More than 100 A-STR FMs have been sold for GEO, LEO and inter-planetary missions since 2001 and more than 90 years of successful operations in space have been accumulated to the date.

The high performance of its CCD detector means that the A-STR can be used in extremely accurate pointing space telescopes and in agile (or spinning) satellites. This is achieved via the A-STR's dedicated operative modes that can be entered via telecommand.

For the ESA's Herschel telescope an "interlaced" tracking mode allows the attitude measurement accuracy to improve up to a factor 1.41. In the NASA PLUTO Kuiper Belt and in the ESA Plank Satellites, a TDI (Time Delay Integration) mode allows Lost in Space and accurate tracking with satellite spin rates up to 10 RPM.

The AA-STR is a high TRL-9 next generation product. The AA-STR, while offering similar performance and improved radiation capabilities with respect to CCD based star trackers, incorporates all the advantages of miniaturization and reduced weight, power and cost.

The AA-STR product is the next step in the company's star tracker products. It benefits from the successful flight experiences Galileo's customers have had with our earlier star trackers, some of which have been continuously operating in space for more than 10 years.

Our AA-STR product continues this evolutionary philosophy and takes advantage of the relatively new but now mature CMOS Active Pixel Sensor (APS) technology, resulting in the miniature AA-STR star tracker that is approximately two thirds the size, weight, power and cost of conventional CCD units belonging to the same "class".

The AA-STR, although it was initially developed for a GEO telecommunication spacecraft, has demonstrated a large flexibility and, despite having been presented on the market quite recently, has already found applications in scientific (Bepi Colombo - ESA, Astro-G - JAXA), Earth observation (PRISMA) and other commercial programs (AlphaBus, SpaceBus 4000).

We also develop and produce "custom" star trackers for unique spacecraft with highly demanding mission requirements. The SRU for JUNO, NASA's second New Frontiers Mission, has been designed to specifically cover the high-radiation environment of Jupiter and the need to work on board a spinning satellite (using TDI technique).

The JUNO SRU includes an optical head (duly radiation hardened to withstand the harsh environment of Jupiter) and an electronic unit, which will be mounted in a radiation protected area of the satellite (radiation vault).

The star sensor operations are based on the operating modes already developed for the star sensors of the New Horizon Pluto Kuiper Belt mission (by NASA) and Planck mission (by European Space Agency), with adaptations to cope with the severe radiation environment expected by JUNO.

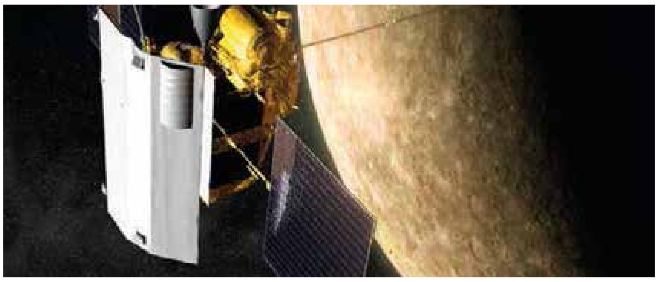
TECHNICAL CHARACTERISTICS

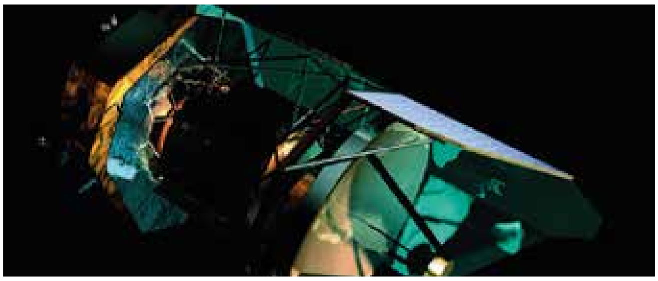
Operating principle

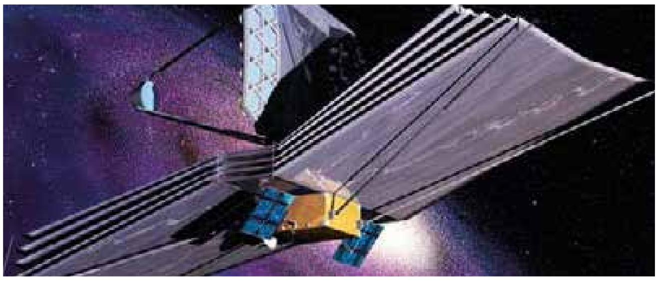
- Embedded star catalogues and algorithms for pattern recognition and attitude estimation.

Operating modes

- Autonomous attitude acquisition mode
- Tracking mode
  - Automatic after acquisition mode or by AOCS telecommand to resume attitude without passing through acquisition phase.







A-STR AND AA-STR

Characteristics	A-STR	AA-STR
Detector	MPP CCD	HAS APS
FOV	16.4 x 16.4°	20 x 20°
Dynamic range	1.5Mi to 5.5Mi	1.5Mi to 5.5Mi
Number of Tracked Stars	Up to 10	Up to 15
Tracking rate	Up to 2°/sec	Up to 2°/sec
Acquisition time (from Lost in Space)	Lower than 6 sec.	Lower than 9 sec.
SEU Tolerance	up to 17000 protons/cm^2/sec (depending on SW settings)	up to 170000 protons/cm^2/sec (depending on SW settings)
Update rate	10Hz, 4Hz	10Hz, 8Hz, 5Hz, 4Hz
Accuracy (3sigma; EOL; full temperature range; 10Hz updated rate)		
Bias (Gaussian distribution)	8.25 arcsec (pitch/yaw) 11.1 (roll)	8.25 arcsec (pitch/yaw) 11.1 (roll)
Low Frequency Error (FOV error)	<3.6 arcsec (pitch & yaw) <21 arcsec (roll)	<3.3 arcsec(pitch & yaw) <15.6 arcsec (roll)
NEA (random error) @0.1°/sec tracking rate	<6 arcsec (pitch & yaw) <63 arcsec (roll)	<6 arcsec (pitch & yaw) <49.4 arcsec (roll)
NEA (random error) @0.5°/sec tracking rate	<7.5 arcsec (pitch & yaw) <78 arcsec roll	<8.4 arcsec (pitch & yaw) <68.2 arcsec (roll)
NEA (random error) @ 2°/sec tracking rate	<25 arcsec (pitch & yaw) <230 arcsec roll	<34 arcsec (pitch & yaw) <288 arcsec (roll)
Data interfaces		
Telecommand & Telemetry	MIL-STD-1553B; RS 422	MIL-STD-1553B; RS 422
Interface for EGSE	Custom	Custom
Mechanical interfaces		
Size (L x W x H)	195mm x 175mm x 290.5mm (40 deg SEA baffle)	164mm x 156mm x 348mm (25 deg SEA baffle)
Mass	3.55kg with 40° SEA baffle GEO orbit radiation shielding	2.6kg with 26° SEA baffle GEO orbit radiation shielding
Electrical interfaces		
Power Supply	20V to 50V	60V to 110V, 20V to 52V
Power consumption	8.9W @ 20°C 13.5W @ 60°C	5.6W @ 20°C 12.6W @ 60°C
Environmental conditions		
Operational temperature	-30°C to +60°C	-30°C to +60°C
Storage temperature	-35°C to +70°C	-35°C to +65°C
Pressure	Ambient or space vacuum	Ambient or space vacuum
Vibrations levels	Design level Higher than 22g rms Qualification level 17.5g rms all axis Shock: 2000g	Design level Higher than 22g rms Qualification level 17.03g rms all axis Shock: 2000g
Lifetime	18 years in GEO orbit	18 years in GEO orbit
Reliability	1346 fits with Level 1 parts 2415 fits with Level 2 parts	850 fits with Level 1 parts 1950 fits with Level 2 parts

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