rate sensors using MEMS technology

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sea

System Engineering & Assessment Ltd

- SME founded in 1988
- space/marine/defence/transport
- >400 man years of space experience
- 200 staff (up to 50 staff working on space projects)
- located in Filton (Bristol) & Bath

background

- MEMS rate sensing widely applied in terrestrial applications.
- Volume markets (eg automotive) driving technology innovation, production processes and costs.
- Low to moderate performance sensors complement star sensor improvements

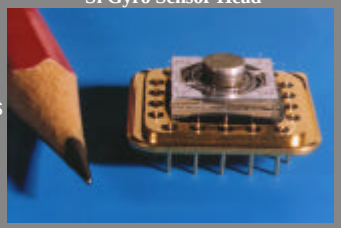
current study

- Team of SEA and BAE Systems studying
  - Requirements
  - Market
  - Technical Feasibility
  - Production Cost
- SEA addressing market and space electronics/qualification.
  BAE technology and design support.

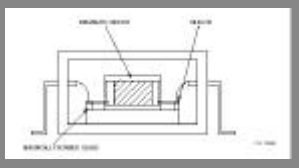
technology advantages

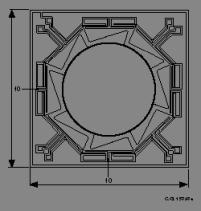
- Mass
- Power
- Volume
- Robustness

Si Gyro Sensor Head



configuration

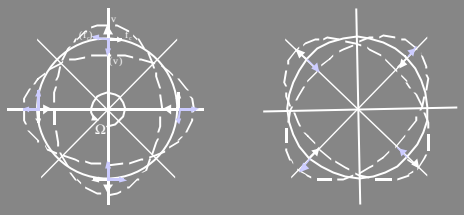




how does it work?

Carrier mode

Response mode



Vibration Cycle

needs

- EO
- Science
- Communications
- Navigation
- Launchers
- FDIR

forces driving market

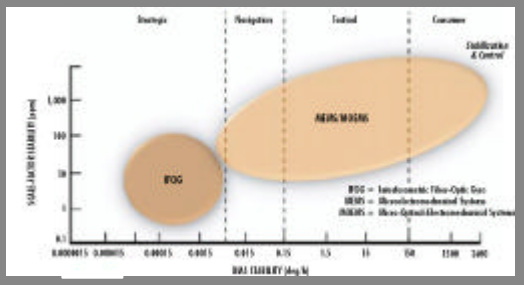
- Star sensor miniaturisation, performance and accommodation.
- Commercial EO requires better revisit/ higher resolution
- Launch technology relatively mature.
- Operations costs become significant

=>multiple, smaller spacecraft with high performance and robust operations

=>routine integration with star sensors for attitude measurement on all platforms

future performance

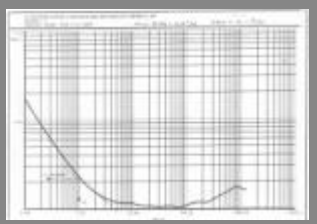
Draper Labs (US) prediction in 1998



Courtesy of Draper Labs

current performance

- Analogue electronic drive/compensation
- <10 deg/h bias instability (fixed conditions)
- 0.1 deg/s bias repeatability
- < 50 g
- <250 mW

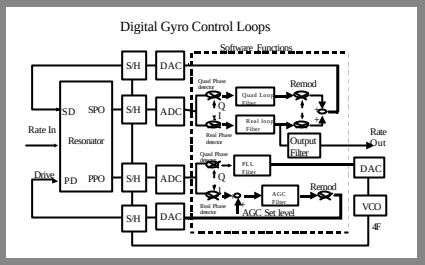


how do we get to the future?

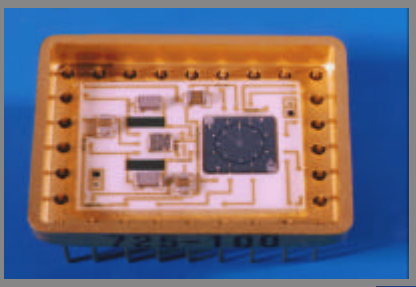
Potential improvements include:-

- Digital drive schemes
  - Better repeatability/ minimal ageing.
  - More sophisticated compensation schemes.
  - Removal of flicker.
- Electrostatic balancing.
  - Reduce frequency split
  - Rate integration mode.
- Larger resonator head
  - Process and frequency improvement
- 'Deep' compensations.
  - Multi-parameter calibration.

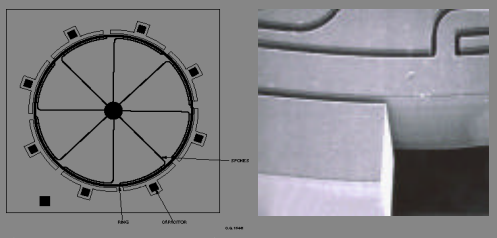
digital drive scheme



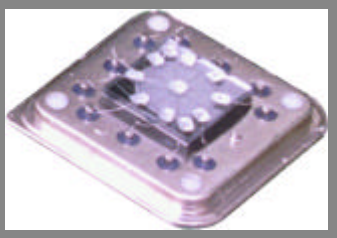
capacitive drive/pick-off



electro-static balancing



larger resonator head



deep compensations

- Application of digital drive scheme allows the measurement/ estimation of many control and compensation parameters.
- Applied to current sensors this approach has demonstrated 2 orders of magnitude improvement over ‘inherent bias’.

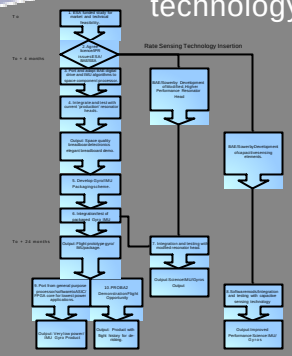
adaptation for space

- Limitation on digital technologies, however space applications do not (usually) require:
  - Large bandwidth (50 Hz plus)
  - Large Dynamic Range
  - Operations at 1000g
- These factors (and others) can be used to trade mass, power, performance and electronics selection.

industrial context

- ‘market pull’ and ‘technology push’ are not provided by the space industry.
- BAE are the world leader in this technology
- SEA are undertaking the adaptation required to meet the needs of space - radiation, electronics packaging and tuning
- BAE have provided a ‘low dynamic range/high performance’ design for SEA, but sensor technology is scalable for applications, digital drive is core function and key.
- SEA are working closely with BAE to offer this technology to the space industry.

technology route map



target specifications

Per 3 axis set:

mass < 0.5 kg

power < 3 W (ASIC version)

radiation : compatible with GEO

Performances:

Family of devices with bias from 10 deg/h to 0.1 deg/h

Availability: within 2 years as space qualified packages.

industrialisation

- SEA: lead plus electronics design
- BAE ISD: technology
- BAE SSD: packaging design/test and manufacturing

thanks

- To BAE for their excellent support on the current effort.
- To BNSC for supporting the precursor work.
- To ESA for supporting the current work.