Inertial Systems
for Military Aircraft

INERTIAL NAVIGATION
HEADING AND ATTITUDE SYSTEMS
COMPUTING
DISPLAYS
Elliott experience covers...

DIGITAL INERTIAL NAVIGATION SYSTEMS
ATTITUDE AND HEADING REFERENCE SYSTEMS
DOPPLER-INERTIAL HYBRID NAVIGATION SYSTEMS
DIGITAL WEAPON AIMING SYSTEMS
NAVIGATION DISPLAYS AND CONTROLS
SHIPS INERTIAL NAVIGATION SYSTEMS

With extensive facilities for...

RESEARCH AND DEVELOPMENT
SYSTEMS MANAGEMENT
QUALITY ASSURANCE
PRODUCTION
SUPPORT

...under one roof

a decade of Advanced Airborne Inertial Systems

1960 – Blue Steel
Elliott built the first production inertial navigation system in Europe for terminal guidance of Blue Steel and navigation of the carrier aircraft.

1965 – Nimrod
Elliott E3 provides the Attitude and Heading Reference System for the most advanced maritime warfare system in the world.

1970 – Jaguar
Elliott digital inertial navigation and weapon aiming system is at the heart of Jaguar’s advanced avionics systems.

Future Developments

Variants of the present digital navigation and weapon aiming system can be provided without penalties of extensive development. These include the E3R Inertial Navigation System and the E3R(M) system.
E3 Heading Reference System for the HS Nimrod MR1

**E3 Heading Reference System for the HS Nimrod MR1**

**Characteristics**

<table>
<thead>
<tr>
<th>Unit</th>
<th>Dimensions (cm)</th>
<th>Wt (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLATFORM (with mounting)</td>
<td>21.5 diam. x 33.0L</td>
<td>13.8</td>
</tr>
<tr>
<td>POWER SUPPLY UNIT</td>
<td>12.5 W x 49.6L x 19.4H (1/4 ATR Short)</td>
<td>11.3</td>
</tr>
<tr>
<td>PLATFORM COMPUTER No. 1</td>
<td>12.6W x 49.6L x 19.4H (1/2 ATR Long)</td>
<td>10.2</td>
</tr>
<tr>
<td>PLATFORM COMPUTER No. 2</td>
<td>1/2 ATR Long</td>
<td>8.1</td>
</tr>
<tr>
<td>GROUND SPEED RESOLVER</td>
<td>40.7W x 38.1L x 25.4H</td>
<td>20.8</td>
</tr>
<tr>
<td>CONTROL PANEL</td>
<td>20.0W x 15.1L x 12.7H</td>
<td>1.9</td>
</tr>
</tbody>
</table>

**Main Features**

LOW AZIMUTH DRIFT 0.1° hr.
E3 provides a true Heading reference with automatic compensation for earth’s rotation and aircraft motion.

VERY ACCURATE VERTICAL >0.1° error
Irrespective of aircraft manoeuvres; an essential feature of a precision heading reference achieved by Schuler tuning.

ACCURATE INITIAL ALIGNMENT
Within ± 0.15° using the Elliott Runway Alignment Technique.

DOPPLER/INERTIAL MIXING giving:
- Excellent dynamic response of the inertial system
- Long term accuracy of Doppler velocity
- Doppler velocity damping of Schuler oscillations

ACCURATE VELOCITY AND POSITION DATA
At all times including attack phase when doppler cuts out in turns and system reverts to pure I.N. mode.

**Output Data**

ACCURATE HEADING FOR USE BY AIRCRAFT SYSTEMS –
- E.C.M. Navigator’s Compass Repeater
- Digital Computer True Heading Repeater

VERY ACCURATE VERTICAL FOR USE BY AIRCRAFT SYSTEMS –
- Autopilot
- Radar

RESOLVED GROUND SPEED FOR USE BY AIRCRAFT SYSTEMS –
- Digital Computer Spherical Data Computer
- Wind Computer Radar

INERTIAL GROUND SPEED AND DRIFT FOR AUTOMATIC WIND COMPUTING

INERTIAL VELOCITIES FOR DOPPLER/INERTIA MIXING
A fully automatic rapid azimuth alignment technique. Only restraint is the requirement to keep the aircraft close to the runway centreline at the beginning and end of the takeoff run.
The apparent distance travelled across the runway due to initial heading error is used to correct the platform heading.
Navigation and Weapon Aiming System for the Jaguar

**CHARACTERISTICS**

<table>
<thead>
<tr>
<th>Sub System</th>
<th>Unit</th>
<th>Dimensions (cm.)</th>
<th>Wt.(Kg.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>INERTIAL VELOCITY SENSOR</td>
<td>PLATFORM (with mounting)</td>
<td>33.8W x 39.7L x 26.5H</td>
<td>23.6</td>
</tr>
<tr>
<td></td>
<td>POWER SUPPLY UNIT</td>
<td>% ATR (Short)</td>
<td>15.4</td>
</tr>
<tr>
<td></td>
<td>PLATFORM ELECTRONS UNIT</td>
<td>% ATR (Short)</td>
<td>9.5</td>
</tr>
<tr>
<td>CENTRAL COMPUTING SYSTEM</td>
<td>INTERFACE UNIT</td>
<td>25.9W x 32.0L x 19.4H (1 ATR Short)</td>
<td>16.2</td>
</tr>
<tr>
<td></td>
<td>920M COMPUTER</td>
<td>% ATR (Short)</td>
<td>14.0</td>
</tr>
<tr>
<td>DISPLAYS AND CONTROLS</td>
<td>PROJECTED MAP DISPLAY</td>
<td>18.8W x 45.8L x 18.8H</td>
<td>10.4</td>
</tr>
<tr>
<td></td>
<td>NAVIGATION CONTROL UNIT</td>
<td>18.8W x 17.0L x 11.5H</td>
<td>3.3</td>
</tr>
<tr>
<td></td>
<td>HAND CONTROLLER</td>
<td>6.1W x 14.5L x 19.8H</td>
<td>0.8</td>
</tr>
</tbody>
</table>

**MAIN FEATURES**

- **HIGH ACCURACY**
  Precise velocity and attitude data essential for weapon delivery. Navigation accuracy better than 2nm/hr. C.E.P.

- **FLEXIBILITY**
  Changes in operational requirements for new weapons, sensors and displays can be accommodated primarily by software modifications.

- **RELIABILITY**
  All digital computation and use of rotational averaging techniques lead to high reliability and elimination of soft failures.

- **EASE OF MAINTENANCE**
  First line testing entirely by computer programme. Automatic bias calibration. Extensive in flight monitoring.

- **SELF ALIGNMENT**

- **LOW COST COMPONENTS**
  E3R Rotational Averaging technique enables low-cost inertial components to be used and minimises stability problems.

- **ACCURATE DATA AT ALL TIMES**
  Inertial system gives output independent of attitude or position. It’s self contained nature precludes jamming or interference.

- **INTEGRATED DISPLAYS**
  Presentation of data on headup display, projected map display and navigation controls minimises pilot workload and interpretation.

**OUTPUT DATA**

- Aircraft present position displayed both as a topographical display and by means of numerical readouts.
- Steering signals to maintain pre-planned and pre-selected routes.
- Steering instructions to give maximum assistance in target acquisition.
- Information on the relative position of aircraft and target and release point for weapons.
- Aircraft attitude, velocity and heading.
The Inertial Velocity Sensor

**E3R PLATFORM (in mounting cradle)**

This is a pure inertial, fully manoeuvrable platform incorporating 3 single-degree-of-freedom gyro's and 3 accelerometers. A Rotational Averaging Technique confers upon the system an accuracy in excess of that normally obtainable from the unsophisticated components used.

**PLATFORM ELECTRONICS UNIT**

Contains the necessary circuits to convert analogue inputs of horizontal and vertical acceleration into digital form for transmission to the digital computer. Platform correction terms are also generated within this unit.

**POWER SUPPLY UNIT**

Accepting raw aircraft power, the power supply unit generates all the stabilised supplies and precision frequencies required by the inertial system. In addition it contains the sequence and protection unit.
Central Computing System

920M DIGITAL COMPUTER
The MCS 920M is a microminiature general purpose digital computer operating in the parallel mode. It has a random access, 8192 word, 18 bit store with a 2μs cycle time. In addition to performing navigation and weapon aiming calculators, the computer caters for in-flight monitoring, initial alignment and in situ first line system testing.

INTERFACE UNIT
Enables the digital computer to receive and transmit information from and to other units in the aircraft in compatible signal form. It also supplies the power for the computer and navigation control unit.

Displays and Controls

PROJECTED MAP DISPLAY
The pilot has a continuous reference to the aircraft present position and track superimposed on the projected image of air topographical maps. He may also select a destination (waypoint) to be displayed. Automatic frame changing is provided and aircraft position is continuously updated by a closed loop drive system. Two scales are available on selection. Meridian convergence and curvature of parallels are compensated for in the digital computer. An area approximately 750 x 750nm is contained in a single cassette of 35mm coloured film.

NAVIGATION CONTROL UNIT
The Navigation Control Unit enables the operator to control the navigation system through switch-on, alignment, waypoint setting and selection, fixing and reversionary operation. This unit provides read-outs of navigation data and system malfunction indications. 12 waypoints may be inserted as well as information on wind, offsets, heading etc. 20 quantities may be displayed, including latitude, longitude, heading, groundspeed and magnetic variation or other information as required.

HAND CONTROLLER
The Hand Controller is used for fix correcting and waypoint setting in conjunction with the Projected Map Display. It is also used during weapon aiming.

OTHER DISPLAYS
Other displays associated with the Navigation and Weapon Aiming System are a Head-Up Display and a Horizontal Situation Indicator. These provide steering, situation and weapon aiming information to the pilot from data calculated by the digital computer.
E3R System Options...

E3R INERTIAL NAVIGATION SYSTEM
FOR USE WITHIN DISTRIBUTED COMPUTING AVIONICS SYSTEMS

102C DIGITAL COMPUTER
The 102C is a modular microminiature digital computer with integral interface and power supplies. The store module for this application has a combined fixed and data storage capacity of approximately 4000 words of 12 bit length. Computations performed include navigation, steering, alignment and in-flight monitoring.
Dimensions: ¾ ATR long.
Weight: 13.5Kg.

E3R (M) PLATFORM (in Cradle)
Dimensions: 26.6W x 33.8L x 26.5H
Weight: 20.4 Kg.

This system offers the flexibility and cost-effectiveness of the existing E3R systems with small size and weight. It also leads the way towards further developments in miniature platform systems.

E3R (M) INERTIAL NAVIGATION SYSTEM USES BASIC E3R PLATFORM TECHNOLOGY COUPLED WITH LSI/MSI ELECTRONICS AND COMPUTING.

ELECTRONICS UNIT
Dimensions: 25.9W x 49.6L x 19.4H (1ATR long)
Weight: 18.2Kg.
ELLIOTT HAVE PRODUCED INERTIAL SYSTEMS FOR USE ON:

- SHIPS
  - SMALL CRAFT WITH ROYAL NAVY
  - WESSEX 2

- HELICOPTERS

- AIRCRAFT
  - JAVELIN,
  - COMET 4,
  - BOEING 707,
  - NIMROD,
  - VARSITY,
  - CANBERRA,
  - JAGUAR

- HOVERCRAFT
  - SRN 3

- MISSILES
  - BLUE STEEL

- LAND
  - TRIALS VEHICLES

NO OTHER SINGLE TYPE OF INERTIAL SYSTEM HAS HAD A WIDER VARIETY OF APPLICATIONS THAN THE ELLIOTT E3.