

ITEM 13
Computers

Computers

Analogue computers, digital computers, or digital differential analyzers designed or modified for use in the systems in Item 1, having either of the following characteristics:

- (a) Rated for continuous operation at temperatures from below minus 45 degrees C to above plus 55 degrees C; or
- (b) Designed as ruggedized or “radiation hardened.”

Notes to Item 13:

Item 13 equipment may be exported as part of a manned aircraft or satellite or in quantities appropriate for replacement parts for manned aircraft.

Nature and Purpose: Most missiles use at least one computer, typically in the guidance set or integrated flight instrumentation system. Generally the guidance computer calculates missile velocity and position information from onboard reference sensors. It uses these data for comparison with the prescribed missile flight path and sends steering commands to correct for errors. Computers may also provide time references for the missile and give cutoff commands to the propulsion system and arming commands to the weapons payload at the appropriate flight times. Mission computers may also be used to store and execute preprogrammed flight profiles.

Method of Operation: Onboard analog or digital computers rapidly integrate the equations of motion for missile flight and compute the magnitude and duration of the commands necessary to maintain the missile flight path. The computers receive electrical signals from onboard sensors, perform the appropriate calculations, and send command signals to the various missile systems to try to match the preprogrammed flight path. These computer systems are powered by batteries (typically 28V) and use connecting cables to interface with the sensors and control systems.

Typical Missile-Related Uses: Most complete rocket systems and unmanned air vehicles (UAVs) including cruise missiles, have at least one ruggedized digital computer for navigation and control computations and digital integration of Inertial Measurement Unit (IMU) data. Many also use

Produced by companies in

- Canada
- China
- France
- Germany
- India
- Israel
- Italy
- Japan
- North Korea
- Russia
- South Africa
- South Korea
- Sweden
- Taiwan
- Ukraine
- United Kingdom
- United States



Figure 13-1: A global positioning system (GPS) aided inertial navigation system with integral guidance computer.

Other Uses: Most military and civilian aircraft, tactical missiles, and spacecraft require ruggedized computers that operate within the temperature extremes defined in the Annex. Long-lifetime spacecraft and satellites stationed in or near the radiation belts also have requirements for radiation hardening, but those requirements may be somewhat lower than the Annex specification.

Appearance (as manufactured): Computers configured for missiles and UAVs are usually housed in metal enclosures with integral heat sinks to dissipate power generated by high operating speeds, as shown for the inertial navigation system and guidance computer assembly in Figure 13-1. A ruggedized computer for aircraft, which is similar to rocket and UAV computers, with its printed circuit boards partially removed, is shown in Figure 13-2. A radiation-hardened digital signal processor (DSP), shown in Figure 13-3, is packaged on a single printed circuit board and is ideal for missile use. In these assemblies, the heat sinks are also augmented by water cooling. A radiation-hardened electronics assembly with liquid cooling connections is shown in Figure 13-4. Within such assemblies are a wide variety of ordinary looking electronic parts with wide use in commercial applications. A distinguishing characteristic (not unique to military use) is hermetically sealed metal and



Figure 13-2: A ruggedized computer for fighters, which is similar to a missile or an UAV computer.

Photo Credit: LITEF



Figure 13-3: A radiation-hardened digital signal processor.

ceramic components as opposed to more common plastic components (chips) found in commercial electronics. The cable interfaces feature rugged, circular connectors or small bolt-on connectors with shielded cables. The electronics are typically within an outer radio frequency (RF) Faraday cage enclosure, which may be hermetically sealed or vented to the ambient pressure. Pressurized vessels are used to help conduct heat to the case and heat-sink mounting of missiles and UAVs, which operate at high altitude. For applications requiring lightweight assemblies, the computers can be packaged in rugged plastic containers with metal coatings inside the plastic covers for RF shielding.

Appearance (as packaged): Electronic computer assemblies and parts typically weigh less than 25 kg. They are packaged in plastic bags, placed inside cardboard boxes, and packed in rubber foam or bubble wrap shock protection; box labels typically indicate the contents as electrostatic sensitive devices. Larger units integrated into a larger system and over 25 kg may be packed in metal or wooden boxes.

Photo Credit: The Charles Stark Draper Laboratory, Inc.



Figure 13-4: A radiation-hardened electronics assembly with liquid cooling.