ITEM 16
Modeling and Design Software

Modeling and Design Software

Specially designed software, or specially designed software with related specially designed hybrid (combined analogue/digital) computers, for modelling, simulation, or design integration of the systems in Item 1 and Item 2.

Note to Item 16:
The modeling includes in particular the aerodynamic and thermodynamic analysis of the systems.

Produced by companies in

- Australia
- Brazil
- Canada
- China
- France
- Germany
- India
- Israel
- Italy
- Japan
- Norway
- Russia
- South Africa
- South Korea
- Sweden
- Ukraine
- United Kingdom
- United States

Nature and Purpose: Modeling, simulation, and design integration software tools permit the designer to build and fly a missile using a computer. Numerous design changes and flight environments can be investigated by using these tools and thereby avoiding the expense of building, testing, and redesigning actual hardware. This modeling capability dramatically decreases the cost and time required to develop a rocket or an unmanned air vehicle (UAV). Various computer-generated codes have a critical role in designing a missile with desired performance capability, especially for longer range missiles. Using a full library of software models to validate performance in the design stage leads to missiles with the most appropriate, mission related trade-offs, including range and payload capabilities.

Hybrid computers combine analog and digital components to exploit the advantages of each. They are useful in situations in which data rates are extremely high and the signal-to-noise ratio is low, such as focal plane arrays in advanced sensors. These conditions may be stressing to purely digital computers because such computers cannot always keep up with the data stream, and the low signal strength sometimes does not create the clear "1" or "0" required by a digital device. Thus, analog circuitry is sometimes used to collect and process the output of the sensor before digitizing the data.

Method of Operation: Most missile design software models represent the physics of missile operation. Modern aerodynamic models may offer a highly accurate treatment of flows internal and external to the missile and can be tailored to the specific missile geometry under evaluation.

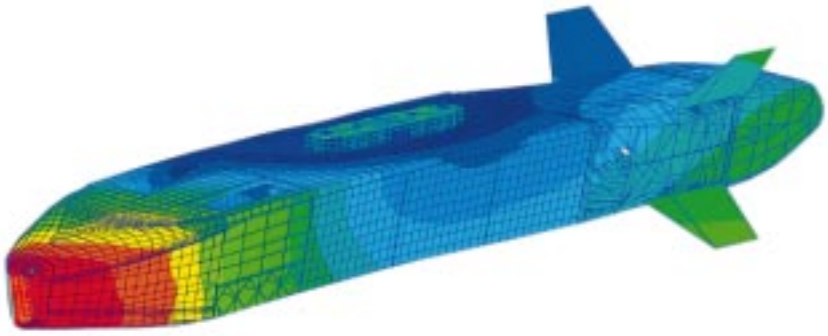

Figure 16-1:
The output of a finite-element missile structures code showing relative deformation across a missile body.

Thermodynamic models predict both the frictional heating and chemical reactions involved in missile propulsion and thermal protection, and the resulting flow of heat into critical missile components. Applications of finite element models in designing missile structures are now common, as are applications of models combining guidance hardware and missile controls to test performance. An example of the output of a structures code is shown in Figure 16-1. Once designed, subsystem hardware is frequently tested by means of hardware-in-the-loop simulators. These simulators may range from straightforward actuation of mechanical linkages on a rocket nozzle during simulated test firing to highly sophisticated laboratory assemblies involving the measurement of the responses of complex subsystems such as guidance and control.

Typical Missile-Related Uses: Missile design software may be applied early in the design process to define overall configurations, thrust capabilities, aerodynamic flight loads, structural requirements, thermal insulation requirements, and the guidance or control requirements of candidate design concepts, or models. Subsystem hardware designs based on these models are performance tested, often with simulation software in-the-loop, to validate their capabilities and to refine the models to make them more design specific. The computer then combines these design-specific models in order to represent an integrated rocket or UAV system in flight and to confirm its design capabilities before actual flight testing. This modeling approach eliminates much of the need for expensive iterative flight testing.

Other Uses: Many of the more fundamental software models used in rocket systems or UAV design are commonly used commercially. A popular structural model, NASTRAN, is used in designing trucks and building bridges. Thermodynamic codes such as SINDA are used in satellite and power plant design. Flight motion computers have wide applications for pilot training and other flight simulators.

Appearance (as manufactured): Software for missile design is physically indistinguishable from commercial software. It is contained on the same computer disks or CD-ROMs, etc. Missile analog/hybrid computers are custom electronics generally smaller than a breadbox. Flight motion computers are cabinets with commercial standard electronics racks. A hardware-in-the-loop missile simulator testbed for a missile with high accuracy requirements is shown in Figure 16-2. Alternatively, missile software and specialized flight dynamics models can be loaded on a pure digital, real-time computer (flight emulator), as shown in the lower portion of Figure 16-2. Real-time models can be used to replace the test article hardware in the loop.

Appearance (as packaged): Typical packaging schemes for missile simulation and software test equipment are shown in Figure 16-3. Custom electronics like the analog/hybrid computers may be packaged in a variety of ways, including trunk containers used for shipping sensitive instruments and computer monitors. Flight motion computers are generally shipped like other electronic equipment. Other flight simulator hardware, including flight motion tables, may be packed in wooden crates for shipment. Models and real-time software look like any other software product and are packaged in cardboard boxes, possibly in shrink wrap (if commercial/new) or on unmarked standard transfer media, such as floppy disks, CD-ROMs, or 1/4″ magnetic tape cartridges.

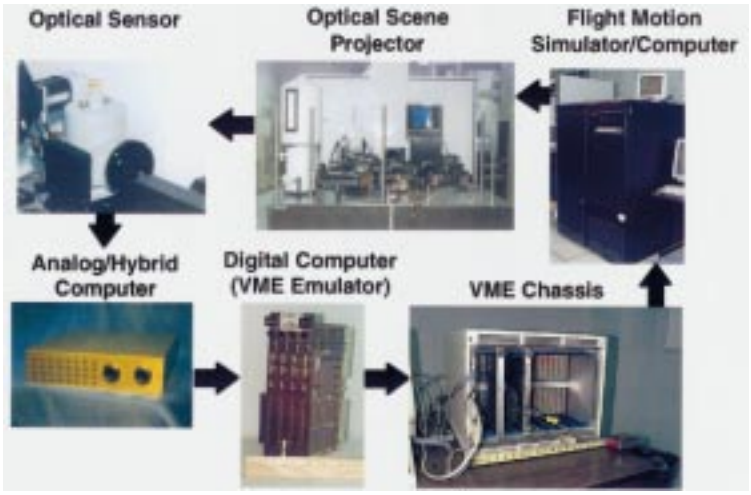

Figure 16-2: Hardware-in-the-loop missile hardware simulation.

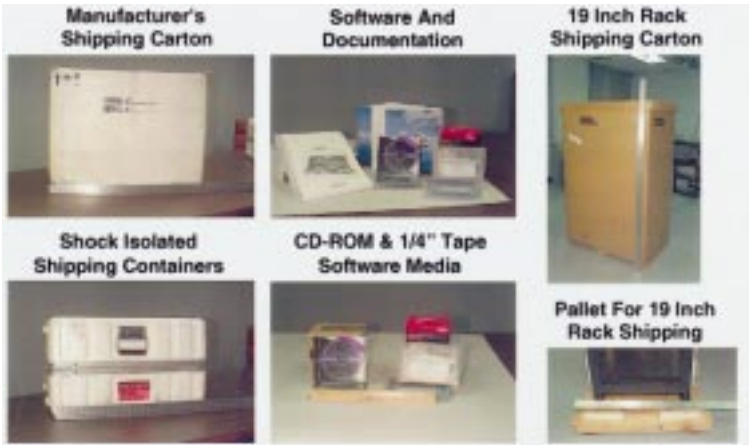

Figure 16-3: Packaged missile simulator equipment and software appearance.

Additional Information: High speed digital computers based on industry bus standard definitions such as Virtual Machine Europa, Multibus, and Futurebus+, provide considerable leverage for developing real-time missile flight software. These commercial standards are fast enough to support real-time missile performance simulations. The flight motion computer is the essential integrator that makes these commercial computers useful as emulators for missile software development and testing. Flight motion computers have specialized operating systems that enable them to act as simulation controllers and flight performance data loggers.