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Computers and the Space Program: An Overview

Since the earliest days of the National Aeronautics and Space Administration, the American space program has been dependent on the data processing industry. Without the computer, there would have been no space program and, likewise, without the space program the main technological forces driving the computer industry forward would have been missing.

The exploration of space has demanded very large computer systems of great complexity, size, and speed. More importantly, space needs have required new flexibility in the use of computers, ranging from automated checkout functions to the real-time monitoring of space missions; from inventory management to simulated aircraft and spacecraft control; from computing planetary trajectories to modeling global weather patterns. Planetary space missions, with unyielding launch windows, have required, on schedule, advanced spacecraft and supporting equipment designed to meet rigid specifications. New kinds of computer systems have been needed with complex software programs requiring lead times as long as those required for the spacecraft.

Computers have played an indispensable role in the training of our astronauts and flight control teams. Computer-driven simulation systems have provided accurate representations of all aspects of each manned space mission. These simulation systems have allowed the astronauts and flight control teams to train for each mission in a realistic environment, to develop nominal activities and timelines, and to learn to react to the types of problems which might occur during flight. The use of digital computers allowed failure situations to be programmed and introduced into portions of the spacecraft or ground system simulation, which could be corrected or compensated for, allowing the training to continue. Training systems utilizing actual spacecraft hardware or analog simulation systems do not always provide this capability. These techniques of digital system simulation and failure introduction allowed the mission team to develop all the required air-to-ground interfaces, emphasizing the recognition of problem areas and the development and implementation of the resultant corrective actions, necessary for mission success.

The need for rapid progress has been relentless. In Project Mercury, ground-based computers were required only to determine booster cut-off conditions quickly and accurately, and for orbit determination and de-orbit computations. In Apollo, however, computers were used throughout the mission in real time to calculate the trajectory to the Moon and back, to compare three separate solutions for the lunar descent, and to record and analyze thousands of bits of telemetered spacecraft information and to compare this data with predicted values to detect trouble while monitoring the well-being of the crew.

For Mercury, the computer program ranged from 32000 to 65000 computer words; for Apollo, a 1250000 word program was needed while, at the same time, the speed of the computers had to be increased sevenfold. Without a new generation of computers, we could not have gone to the Moon. Without the forcing function of NASA's requirements, the industry would not have been able to exploit fully the inherent capabilities of their own machines to meet other requirements. Today, virtually every on-line, direct access, commercial computer system in the world reflects to some degree the space guidance and checkout requirements of some years ago.

Challenging the best talents of our nation in this way, to produce both hardware and the programming that make it useful, has helped the U.S. computer industry attain its present position. An impressive record was built on excellence of performance through continuing technological superiority. In a large measure it was the stimulus of the requirements of the space age and Apollo that brought about these technological advances in the computer industry.

For the Skylab program, the shoe was on the other foot. Skylab was a case of the computer industry coming to the aid of the space program with a data handling system that had been developed to meet commercial demands, such as the airline reservations programs. The experience in building those programs was just what we needed to solve the tremendous data handling and data capacity problems of Skylab. During the Skylab mission, computers provided 270 days of continuous spacecraft monitoring while processing and storing 25 million pieces of data per hour.

Already, space applications such as Earth resources remote sensing techniques have begun to pay dividends in such areas as geological exploration for minerals and energy fuels, understanding of ocean currents and the resulting fishing patterns, and urban planning to protect our ecological balance. At NASA, we have a cooperative project with the Department of Agriculture and the National Oceanic and Atmospheric Administration to develop more accurate techniques for global crop forecasting through analysis of remotely sensed data. This experiment alone, if successful, could contribute significantly to the world food supply by predicting crop yield and detecting major crop failures well in advance.

We now seem to be moving into a new era as we look forward to the Space Shuttle. This vehicle is completely dependent upon computers and will, I firmly believe, revolutionize space flight. Reducing the cost of flying will allow payloads to be flown which cover a spectrum of missions from science through applications and space manufacturing. It could well provide the means for helping to utilize solar energy from space. By beaming power from space to Earth, we may be able to validate new concepts for providing solar energy.

Looking forward to these new horizons, I believe the main technological thrust is going to be for large-scale data handling machines, probably a couple of orders of magnitude greater than Skylab. Scientists who want to use space as a base for looking back at the Earth with Earth resources instruments or looking outward for astronomical research, for example, are calling for higher and higher information resolution. That means a much higher bit rate than we have ever thought about before; in fact, I have heard estimates of between 50 and 150 megabits per second. With a capability of processing those data rates, we could have processed all the Skylab data in several hours. I foresee that the real demand on the computer in the next 10 years is going to be data reduction rather than the handling of computation cycles.

I am confident that the computer industry is aware of these coming demands and will be responsive to them. The challenge will be tough, both in terms of complexity and cost, but I have no doubt that it will be met.

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