- Chapter Two -
- Computers On Board The Apollo Spacecraft -

The need for an on-board computer

[28] The Apollo lunar landing program presented a tremendous managerial and technical challenge to NASA. Navigating from the earth to the moon and the need for a certain amount of spacecraft autonomy dictated the use of a computer to assist in solving the navigation, guidance, and flight control problems inherent in such missions. Before President John F. Kennedy publicly committed the United States to a "national goal" of landing a man on the moon, it was necessary to determine the feasibility of guiding a spacecraft to a landing from a quarter of a million miles away. The availability of a capable computer was a key factor in making that determination.

The Instrumentation Laboratory of the Massachusetts Institute of Technology (MIT) had been working on small computers for aerospace use since the late 1950s. Dr. Raymond Alonso designed such a device in 1958-1959[1]. Soon after, Eldon Hall designed a computer for an unmanned mission to photograph Mars and return[2]. That computer could be interfaced with both inertial and optical sensors. In addition, MIT was gaining practical experience as the prime contractor for the guidance system of the Polaris missile. In early 1961, Robert G. Chilton at NASA-Langley Space Center and Milton Trageser at MIT set the basic configuration for the Apollo guidance system[3]. An on-board digital computer was part of the design. The existence of these preliminary studies and the confidence of C. Stark Draper, then director of the Instrumentation Lab that now bears his name, contributed to NASA's belief that the lunar landing program was possible from the guidance standpoint.

The presence of a computer in the Apollo spacecraft was justified for several reasons. Three were given early in the program: (a) to avoid hostile jamming, (b) to prepare for later long-duration (planetary) manned missions, and (c) to prevent saturation of ground stations in the event of multiple missions in space simultaneously[4]. Yet none of these became a primary justification. Rather, it was the reality of physics expressed in the 1.5-second time delay in a signal path from the earth to the moon and back that provided the motivation for a computer in the lunar landing vehicle. With the dangerous landing conditions that were expected, which would require quick decision making and feedback, NASA wanted less reliance on ground-based computing[5]. The choice, later in the program, of the lunar orbit rendezvous method over direct flight to the moon, further justified an on-board computer since the lunar orbit insertion would take place on the far side of the moon, out of contact with the earth[6]. These considerations and the consensus among MIT people that autonomy was desirable ensured the place of a computer in the Apollo vehicle.

Despite the apparent desire for autonomy expressed early in the [29] program, as the mission profile was refined and the realities of building the actual spacecraft and planning for its use became more immediate, the role of the computer changed. The ground computers became the prime determiners of the vehicle's position in three-dimensional space "at all times" (except during maneuvers) in the missions[7]. Planners even decided to calculate the lunar orbit insertion burn on the ground and then transmit the solution to the spacecraft computer, which somewhat negated one of the reasons for having it. Ultimately, the actual Apollo spacecraft was only autonomous in the sense it could return safely to earth without help from the ground[8].

Even with its autonomous role reduced, the Apollo on-board computer system was integrated so fully into the spacecraft that designers called it "the fourth crew member"[9]. Not only did it have navigation functions, but also system management functions governing the guidance and navigation components. It served as the primary source of timing signals for 20 spacecraft systems[10]. The Apollo computer system did not have as long a list of responsibilities as later spacecraft computers, but it still handled a large number of tasks and was the object of constant attention from the crew.
