Advanced development for canceled Apollo missions

From the beginning of the Apollo contract, NASA recognized that the development of the initial suit system was only a first step for lunar surface exploration. It was believed that effective exploration would require a more specialized spacesuit than the initial system recounted in Chapter 6. This began with NASA funding Litton Corporation for advanced pressure suit development in 1962. In 1963, NASA’s Manned Spacecraft Center (MSC) located in Houston, Texas, started developing requirements for a later Apollo suit system that was to commence operation in the 1970–1973 timeframe. For these later missions, NASA was planning for extended stays leading to bases to permit extensive study of lunar geography. Also in 1963, NASA’s Ames Research Center located at Moffett Field, California, was tasked with advanced spacesuit development.

To understand the state of potential advanced suit technologies in 1963, it may be helpful to reflect on the suit technology approaches available and the effects of internal pressure on these systems. When a fabric suit is pressurized, it not only tends to become stiffer (hard) and hence less mobile, it also tends to change shape. This can be demonstrated by blowing into the sleeve of a latex dishwashing glove and sealing it. If you collapse the sleeve, the air pressure in the glove increases, the palm area of the glove tries to assume a round shape and the glove stiffens, and all of these tendencies resist efforts to grasp a tool. While pressure gloves are designed to generally retain shape and have features to enhance pressurized mobility, they present an area of great challenge. Minor shape changes can cause hard contacts that could result in bruising and even nerve damage. The same analogy applies to pressure suit arms, legs, and torso. As outlined in Section 7.1, most of the advanced approaches in 1963–1965 controlled shapes by using hard-shell segments in non-flex areas coupled with more effective mobility elements.

In 1965, the advanced extravehicular activity (EVA) suits gained a specific place in the Apollo program, the Block III vehicle system, and a timetable for implementation. Following this, the number of organizations involved in advanced suit development expanded. The development of advanced suits was not only of interest to NASA but also to the growing number of international groups who were also exploring cooperative agreements.
development grew to include International Latex, Hamilton Standard, David Clark Company, AiResearch, NASA’s Manned Spacecraft Center, and Webb Associates. These organizational endeavors are discussed by manufacturer in Section 7.2. While such efforts did not result in a single design model reaching space service, they would have far-reaching effects (see Section 7.3).

7.1 EARLY ADVANCED SUITS (1962–1965)

There was a window of opportunity for “advanced suits” to have been part of the original lunar missions. Pressure suit mobility and durability in the first two years of the Apollo program for the initial lunar missions did not progress as rapidly as was planned. If the parallel, advanced suit development had reached technical maturity during this period, the suit systems used on the Moon might have been dramatically different. However, this would have required either finding more volume and vehicle lift capacity for an additional, more advanced EVA suit system, or the more advanced suit system would have needed to additionally support intravehicular activity (IVA) functions, such as launch and entry. IVA suits were required to provide comfort for hours while waiting to launch and under multi-g launch loads. IVA also meant performing in extremely cramped spacecraft cabins and potential emergency pre-launch egress conditions. While advanced suit progress was made during 1963–1965, this path had much greater technical challenge and would take longer to reach an acceptable design prototype level.

The greatest amount of advanced development during this period came from Litton’s Aerospace Division, whose work was based on earlier developments. In the 1950s, Litton’s Dr. Sigfried Hansen developed a concept that looked something like the Tin Man in the *Wizard Of Oz* (Figure 6.1.1A) to facilitate real time vacuum tube development inside a vacuum chamber. The concept used human-shaped metallic sections where the human body does not bend, and attempted to create constant volume mobility joints where mobility was required. Constant volume is the ideal because if the joint does not change volume during movement and the center of pressure remains coincident with the center of rotation, there would be essentially no effort to move or hold position. Litton’s first attempt was the Mark I pressure suit. This “hybrid” suit had a “hard” metallic upper torso and “soft” fabric hips and legs. The upper torso featured a “slash” or “bandolier” side entry body seal closure. The body seal closure effectively sealed the pressurized environment inside, unlike the constantly leaking zipper entry systems of the time.

The Mark I featured gimbaled mobility joints (cardanic linkages) that provided more mobility in most areas than the aviation-based pressure suits of the time. The U.S. Air Force was the first to see potential in this odd-looking design, and provided test personnel and technical participation from almost the beginning. By 1960, NASA had also expressed interest in this approach, even though its mobility was still inadequate for any of the then proposed space missions and the suit system did not meet the dual-purpose nature of the early NASA programs.