U.S. Air Force Manned Orbiting Laboratory: Atmosphere Research

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In the early 1960s, the space race included U.S. Air Force (USAF) efforts to place two men in an orbiting vehicle. "The Manned Orbiting Laboratory, or MOL as it was known, promised to use space for the first time as a manned reconnaissance vantage point."[8] The program required considerable research related to human activity, health, and survival in space and the Aerospace Medical Division at Brooks AFB, TX, was the site of most of that early effort. Expansion of the Brooks research capability to be used in support of the U.S. Space Program and the USAF was dedicated by President John F. Kennedy in November 1963. Following the dedication, he accepted an invitation to see some ongoing altitude chamber research (**Fig. 1**).[11]

The MOL design concept[11] (**Fig. 2**) would enable the two-man crew to have enough space for one to operate the reconnaissance equipment while the other rested. A 5 psia, 100% oxygen environment like the Gemini capsule and the planned 2-week Apollo missions were believed to involve issues with aural and pulmonary atelectasis and other physiological issues. Since the USAF's 30-d Manned Orbiting Laboratory (MOL) missions would exceed the NASA 2-week mission duration, USAF research investigated a two-gas mixture to eliminate those issues.

Among the inert gases considered, helium (He) was chosen due to its very low solubility in human tissue and fluids as compared with nitrogen. Also, He lacks the undesirable physiological or narcotic effects of other inert gases and was also found to have more effectiveness at reducing atelectatic tendency.[9] Including He in the breathing mix would achieve a reduction of oxygen concentration, providing greater safety from fire hazards. Initial research with a mixture of 50% O_2 and 50% He at 395 mmHg (17,000 ft, 7.6 psia) indicated that such a breathing mixture at that pressure would "…not present any severe communication problems."[3,4] This contrasts with well-known communication problems at much higher partial pressures of He, particularly during hyperbaric exposures. Reduction in the level of oxygen from 100 to 50% at 395 mmHg also provided much better fire protection. However, there were many more questions regarding use of He in the MOL atmosphere.

Because of its greater thermal conductivity, He may be the best for maintaining insulation temperature below the ignition point, even at relatively low oxygen concentrations in potential overheat conditions. This property also affects human thermoregulation as He facilitates more rapid body heat transfer to the environment during expiration and from body surfaces.[9]

The He atom's atomic mass is 4.0 vs. 14.0 for a nitrogen molecule, raising questions about the leak rate of He from the vehicle. Evaluation of loss rate for both gases concluded that "…there is no valid reason for excluding He-O_2 atmospheres from consideration."[12] Another issue was the human physiological effects while breathing a two-gas atmosphere of oxygen and He. Human exposures lasting 56 d in a test atmosphere of 258 mmHg (27,000 ft, 5 psia) consisting of 176 mmHg O_2 and 83 mmHg of He[6] (the proposed two-gas atmosphere) included sampling and analysis of selected blood enzyme values. Findings determined that all values "…were well within the normal range" and that "man appears to tolerate this atmosphere quite well."[1] "Speech intelligibility would not, in an operational situation, be significantly different from that in air and as such would be estimated satisfactory so long as the level of ambient noise in the speech frequency range was not greater than the speech level nor sufficiently loud to overdrive the human auditory system." However, communication ability (speech quality) in 30% He was judged to deteriorate with increased duration of exposure.[7] Renal function was also tested in this 258 mmHg atmosphere and there was "…no adverse effect on renal function."[5] "No physiologic data have been found that would indicate that He should not be considered for use as a diluent gas in spacecraft atmospheres."[12] "There is no positive indication at this time that nitrogen is essential for human metabolism."[12] Zeft et al.[13] found "…no significant medical abnormalities developed that could be directly attributed to the oxygen-helium, 258 mmHg environmental conditions."

Another important issue was susceptibility to decompression sickness after adapting to the proposed two-gas vehicle atmosphere. A further decompression from a 258 mmHg vehicle atmosphere to the space suit atmosphere of 100% oxygen at 178.7 mmHg (35,000 ft, 3.5 psia) may be necessary if there was need to depart the vehicle for any reason. Beard et al.[2] stated "…it appears that the occurrence of bends with decompressions from 5 psia would be scarcely affected by the kind of inert gas." At the space suit pressure of 178.7 mmHg, even with 100% oxygen, hypoxia would be an issue.

Termination of the MOL program in the second week of June of 1969[8] included an immediate stoppage of the ongoing research at Brooks AFB on physiological effects of a two-gas atmosphere. Fortunately, many of the researchers published their highly credible research findings in *Aerospace Medicine* and other publications. Their detailed efforts and publications have not been wasted. Their work involving use of He as a diluent in space cabin atmospheres has provided the basis for a hypothesized breathing gas mixture for long-duration spaceflight or extraterrestrial habitats.[10] Without the stimulus of the MOL researchers' extensive efforts and publications, the idea may never have been conceived.

From SARC, Bandera, TX; Space Center Houston, Houston, TX; and Paris, TX.

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AEROSPACE MEDICINE HISTORY, *continued*

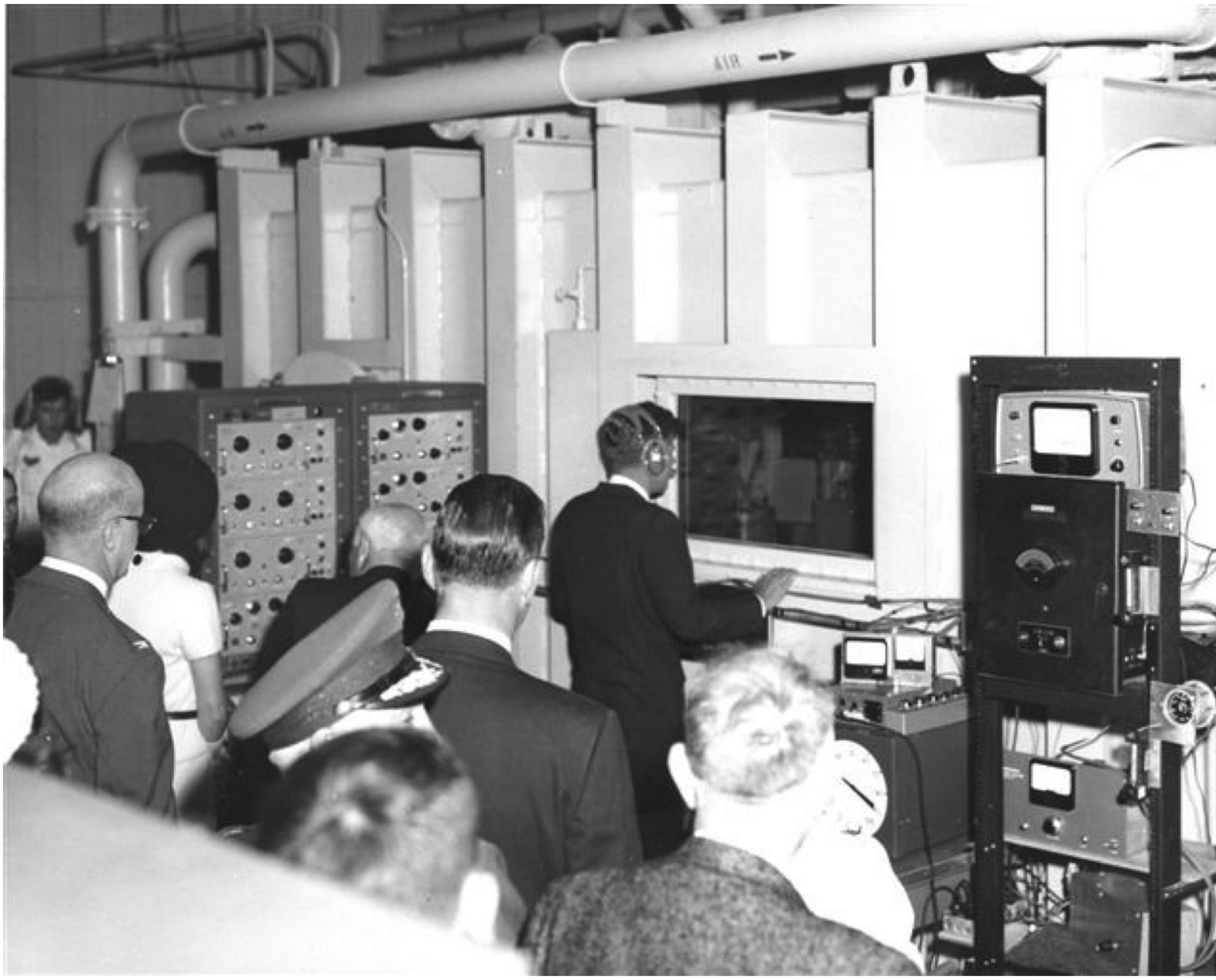

Fig. 1. President John F. Kennedy looking into Chamber C at Brooks AFB after his dedication of the Aerospace Medical Division and speaking with the research subjects.

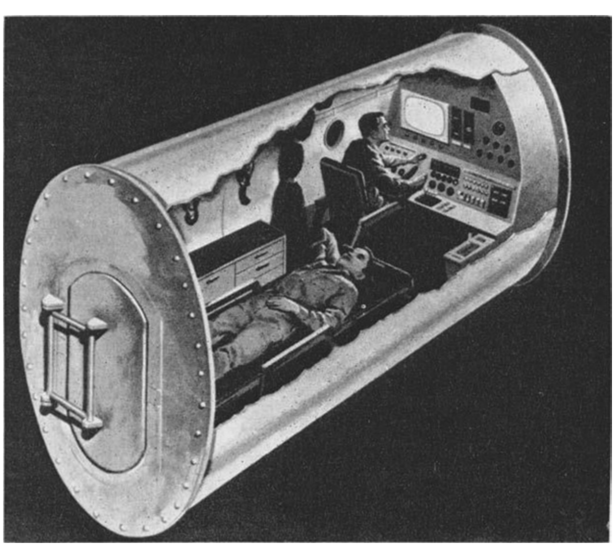

Fig. 2. MOL design concept.[11]

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