

TESTIMONY OF APOLLO 11 ASTRONAUT DR. BUZZ ALDRIN
BEFORE THE SENATE SUBCOMMITTEE ON SPACE, SCIENCE AND COMPETITIVENESS
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Senator Cruz, Members of the Senate Subcommittee on Space, Science and Competitiveness, I want to thank the Committee for the opportunity to speak with you about the future of the American human spaceflight enterprise. This is truly an honor, and I applaud you for raising this issue so early in this session.

Some of you may wonder why an 85 year old former Astronaut is here, testifying in Washington DC, rather than playing golf in Florida. Well, in the first place, while I do live in Florida, I am a truly horrible golfer. I am a much better orbital dynamicist. But more importantly, I love my country and I believe the future of the American space program is one of the most important issues we face as a nation. We are at an important inflection point in our nation's space program. Over the next few years we must choose whether we are to go forward as a nation and lead the extension of global civilization to a permanent presence beyond Low Earth Orbit, or to allow American leadership in space to erode over the next decades.

America must be the world leader in human spaceflight. There is no other policy area which so clearly demonstrates American values of innovation and enterprise than human spaceflight. I have dedicated the last 50 years of my life to this proposition and I do not intend to stop any time soon. I think there is broad agreement in the space community and the panelists you are hearing from today on this point.

There is decidedly less agreement on how we should do this. We do not have long to decide, and this Subcommittee will play a critical role in setting the agenda for this decision. I hope that my testimony today can contribute to this process. I think it will come as no surprise to Members of the Subcommittee and my fellow panelists that I have my own opinions.

Allow me to begin with a question: What do we mean when we talk about American leadership?

American leadership is more than simply getting one step ahead of our global competitors. American leadership is inspiring the world by consistently doing what no other nation is capable of doing. We demonstrated that for a brief time 45 years ago. I do not believe we have done it since.

I believe it begins with a bi-partisan Congressional and Administration commitment to sustained leadership. If we wish to retain American leadership in space, I believe that early in the next administration, the nation must commit to developing a permanent presence on Mars. Another Apollo like mission to put flags and footprints on Mars does not ensure sustained leadership, and restarting a failed constellation program will only require one small step for China to catch up.

I have spent much of the time since I landed on the Moon thinking and writing about the future of the American space program. But we cannot get there with conventional thinking. The architectures I have developed are driven by several technical principles which I believe are essential to achieving this goal. These principles are part of what I call my Unified Space Vision.

- 1) Development of the commercial space transportation sector to provide crew and cargo transportation systems. Current programs for commercializing crew and cargo transportation to the International Space Station could lead to augmenting and expanding that commercial capability to transport mixed crews with lifeboat rotations to control stations in the vicinity of the Moon.
- 2) The US should lead commercial and support international development of the Moon with extensive telerobotic complex engineering assembly of habitation structures and scientific and commercial rovers in order to provide necessary fuel resources and develop reliable systems for Mars. We should participate in lunar development but avoid getting our human spaceflight budget captured by lunar gravities expensive consumption of funds to create, support, and sustain human landings. Let's establish a lunar infrastructure which can be commercially self-sustaining, relying on bartered visits to the surface on international landers. This makes far more economic

sense for scientific and commercial activities.

- 3) Reduce the cost of sustaining a presence on Mars by deploying cycling spacecraft which perpetually orbits between Earth and Mars only requiring small trim propulsion. The primary cost of getting to Mars is the fuel required to send a complex base of habitable structures to Mars. Each successive mission would redundantly send astronaut pioneers in Mars landers of increasing capacity. The majority of the mass including radio mitigation would remain in orbit between Earth and Mars.
- 4) Focus on sending people to Mars to stay. The huge cost driver for Mars missions is the cost of bringing everyone back home after a relatively brief stay. I envision a program of settlement that schedules most of the crews who go to Mars will remain and establish a permanent settlement there. Naturally, we have to develop the Inbound Cyclor as a means to bring people home who need to return for whatever reason. But the cost of effectively sending an entire launch system to return everyone home on every mission can make the whole venture prohibitively expensive.

These are the basic principles. Let me turn briefly to just a few notes from my Unified Space Vision on just how we would execute this program and establish a permanent presence on Mars before 2040.

- We can begin as soon as 2018 with the launch of an inflatable 1st generation exploration module (XM) to a low earth orbit station with Orion or Dragon. Then hopefully one of these spacecraft to be launched with another inflatable XM will be transported to the near libration point, L-1 of the Moon in July 2019 for the Apollo 11 50th Anniversary! The purpose of these flights is to test exploration modules and to provide locations from which to remotely construct international lunar bases. These lunar activities will provide the necessary experience to later remotely construct (from Earth and then from Phobos) a base on Mars. They also provide the basis for extended international and commercial lunar operations, including in situ resource utilization, as well as a capability for future human missions to asteroids. I believe that the development of commercially provided resources from space will be critical to enabling human missions to Mars.

- As we begin to develop our capabilities on the Moon, sometime between 2020 and 2030, I envision a one year Orion mission with an inflatable to an in-orbit asteroid that arrives a few days before a complex sampling robotic spacecraft arrives from a slow, fuel saving solar electric propulsion transit of 1.5 years. This would give 60 days for a crew including scientists, asteroid mining and the robotic experts. This mission would also enable us to further test human spaceflight systems in deep space.
- In 2031 an Orion with a rigid 2nd generation exploration module will join the inflatable at LEO, L-1, and L-2, and will then land on the Moon as a lunar habitat.
- Once the lunar bases have been established, beginning in 2028 (before first humans are sent to Mars) and through 2034—nine unoccupied 3rd generation exploration modules, will be launched to Mars and two XM habitats sent to Phobos.
- In 2031 an Orion with a rigid XM will be launched on an “Inspiration Venus” one year flyby of Venus mission with a crew of two women. On return to Earth we will perform two aerocapture maneuvers before reentry.
- One of defining highlights of the mission architecture is the use of “cyclers” spacecraft that would travel between Earth and Mars perpetually every synodic period. (A synodic period is the time that the orbits of the Earth and Mars bring the planets closest together--about every twenty six months.) My architectures features two cyclers. The larger capacity outbound cycler (heading from Earth to Mars) and the smaller inbound cycler (traveling back from Mars to Earth) alternately encounters Earth roughly every four and a half years.
- The first outbound cycler will be intercepted by three smaller landers with one crew member each. One unmanned lander lands on Mars to demonstrate and checkout Mars landing procedures, and two landers land on Phobos with three crew members. The Phobos crew will remotely connect up to nine surface modules telerobotically, using techniques developed at the Earth-Moon libration facilities. These XM habitats are low thrust transported and landed five years before the 1st outbound cycler reaches Mars. Then the XMs are transported by rovers slowly from dispersed landing locations by long delayed control from Earth to within a few feet of each

other at the desired base location.

- When the first outbound cycluser crew of three is cleared to land, the crew transfers from Phobos to the Mars surface. If the crew is not cleared to land, then they could return to Earth with an inflatable module and a Mars lander and storable propulsion system, all stationed on Phobos or by intercepting the first inbound cycluser for its return to Earth.
- The second outbound cycluser transit to Mars carries three landers with a total of nine crew members. One lander with three crew members replaces the original three crew members on Phobos. The remaining two landers land on Mars with a total of 6 crew members establishing the first permanent settlement on Mars
- The Inbound Cycluser when not used for crew return can be intercepted to return high value cargo. The lander capacity could be increased to six. Also a second outbound cycluser can be introduced to make transits every synodic period instead of every other.
- Every four and a half years the population of Mars will continue to grow as recurring outbound cyclusers bring additional crews of up to 9 new inhabitants. The list of potential tasks the surface inhabitants of 18 might accomplish is far too long to enumerate in my remaining time, but I would just note that Steven Squires, the Principle Investigator of the Mars Pathfinder mission once said that a single crew could accomplish in one week what took two rovers five years to do.

Over the coming months you will listen to a great deal of how hard and expensive it is to go to Mars just once, let alone stay there. But, in closing I encourage you to think about the ability of free markets in space to reduce the cost and power of American ingenuity to solve the most difficult technical challenges. In my opinion there is no more convincing way to demonstrate American leadership for the remainder of this century than to use 20 July 2019 to commit to and execute a permanent presence on Mars.

I thank you for your time and look forward to this committee's leadership.