Towards a Moon Base
Leaving Apollo's Legacy Behind

A Mars fly-by is actively promoted as a viable, practical goal, but NASA's two systems for travelling beyond low Earth orbit are not sufficient even to "return" to the Moon. Agency insiders admit that an international collaborative effort is needed to solve human deep-space exploration problems. The Apollo legacy is becoming irrelevant.

by Phil Kouts

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Don't worry. Matt Damon won't get stuck on Mars. NASA can't get him there.
— *Washington Post*, 2 October 2015[1]

Where From Here?

The US space agency NASA is currently awash with plans to travel to Mars, although none of the proposals includes a stopover on the Moon. As a result of the cancellation of the Constellation Program, travelling anywhere via the Moon is simply no longer on the cards. Moreover, the current Mars programs also do not indicate landing on the Martian surface in the foreseeable future. What, then, is the situation regarding human space exploration? Is it the case that human space travel is no longer of interest to the agency? Or has it all become far too dangerous?

The prospect of building a lunar outpost—so enthusiastically anticipated in 2005 (Arch. Study, 2005)—has now moved way beyond any practical proposals. Now the idea is to fly close to the Moon and Mars but without actually landing. So we appear to be even farther away from developing lunar bases than was the case 10 years ago.

Since the outset of the latest plan to return to the Moon, NASA has been working without interruption in two main areas: the Space Launch System (SLS) and the Crew Exploration Vehicle (CEV) known as Orion and also referred to as the Multi-Purpose Crew Vehicle (MPCV).[2] These two elements are easily recognisable as a later iteration/version of the infamous Saturn V rocket and the Apollo Command Module (CM). But there is little if any reliance on the seemingly proven Apollo technology with these new systems. (NEXUS, 2015) It is important to understand that, first, these two flight hardware elements will only be sufficient to fly *by* the Moon, but certainly not enough for any interplanetary deep-space journeys between Earth and Mars; and second, other necessary systems aren't included in NASA's current plans. So what actually can be achieved within the next 10 years or so?

Mars Incentives

Over the last few years, NASA has been actively generating interest in human missions to Mars with considerable passion and enthusiasm. The mainstream media repeat this in virtually all technically related as well as other unrelated magazines, newspapers and TV shows. The common angle is the new human exploration initiative on a grand scale, comparable maybe only to the legendary saga of the alleged Apollo Moon landings between 1969 and 1972. However, this time no Mars landing is foreseen for at least the next 20 or so years, i.e., not until after the mid-2030s when the agency hopes to send astronauts to fly by Mars.

While developing some fragments of the technical capability and hardware, NASA rightfully admits:

"…The most important challenge for human pioneering missions is keeping the crew safe for long-duration missions up to 1,100 days. Habitats and associated systems and supplies, including food, clothing, atmospheric gases, and human interfaces, represent a significant portion of any exploration architecture. Habitation includes both in-space transit and Mars surface capabilities." (Mars Strategy, 2015, p. 31)

The key element of the hardware is indicated by the term "habitat", which is in fact a mega-concept similar to the International Space Station (ISS) but in this case it is supposed to travel between the two planets.

So the technical problem is defined, but what about actual solutions and what are the likely steps for implementation? The US Government Accountability Office (GAO) states that NASA recently issued a strategy for its journey to Mars, but "the document does not provide additional details on future exploration missions making it difficult to understand NASA's vision for what type and how many missions it will take to get to Mars". (GAO, 2016, p. 17) There is no indication that NASA has any viable plans for developing this.

With the questionable goal of a Mars fly-by some time in the 2030s, the agency has secured a further few years of hopefully unchallenged existence, continuing to develop two basic elements, the SLS and Orion. However, the informational noise has converted Orion into a universal interplanetary vehicle that seems to be designed to deliver crews to Mars. Titles of recent publications announce, for example, "…Orion Heat Shield…Needed for Destination Mars" and "…Orion craft that could take man to Mars gets metallic heat shield". (AmericaSpace, 2015; Daily Mail, 2015)

Obviously, while Orion is a compulsory element for manned deep-space trips, it cannot sustain the many months of travel required to take astronauts to Mars. The truth is that primarily it is an Earth return vehicle which, according to its specifications, can serve as a temporary crew lifeboat for 21 days at most. Why, then, tell so many white lies to the public? Apparently the Mars mission proposal is being exploited far beyond the practicality of the situation, with the objective of covering up embarrassing aspects in the agency's capability and painting a picture way beyond the reality of the circumstances.

It seems that NASA is deliberately implementing its "incremental development strategy" which the agency has been warned about for some time. Evidently, the agency has postponed indefinitely the development of many life-support systems required for human-rated deep-space missions. "…For example, unless NASA begins a program to develop landers and surface systems, NASA astronauts will be limited to orbital missions using the MPCV." (NASA Audit, 2013, p. ii) Three years after this audit, NASA's strategy of leaving serious shortcomings in its plans remains largely unchanged.

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Orion Today

Meanwhile, the first trial of the Orion CEV on 5 December 2014, the Exploration Flight Test 1 (EFT-1), was hailed as a success. The test flight had a re-entry velocity lower than that required to return from the Moon, with heat exposure for the thermal shield lower than that expected at the return. How significant, then, is such a test result?

With unprecedented openness, NASA has reported on various seemingly incremental changes to be made to the Orion capsule before its next test flight. On closer examination, it appears that NASA is now undertaking serious modifications to Orion.

It is clear that step by step NASA is learning small but vitally important lessons—as if it had never acquired any experience in this area.

The GAO noted recently that "[t]he Orion program continues to face design challenges, including redesigning the heat shield following the determination that the previous design used in the first flight test in December 2014 would not meet requirements for the first uncrewed flight". (GAO, 2016, p. 10)

The GAO obviously points to the unmanned Exploration Mission 1 (EM-1) flight around the Moon, initially planned for 2018. According to the Apollo record, such an unmanned flight was not needed in 1968 prior to the alleged flight of Apollo 8 straight to the Moon with a crew on board for the first time ever. Now, following 10 years of research and development (R&D), Orion, even without a crew, is deemed unready to undertake such a flight. Where is all that Apollo CM re-entry experience?

Re-entry Profile

Lockheed Martin has published a report which describes the landing coordinates of Orion's first test flight (Lockheed, 2015, p. 9) but remains silent on the distance Orion travelled from entry interface, the so-called "downrange". An estimate from the limited data available is that the downrange was just under 1,500 kilometres (km). Therefore it appears that Orion covered a slightly shorter distance than a typical Apollo return, having an initial velocity of 8.9 km per second—substantially lower than that required for a nominal

return, i.e., 11.2 km/sec. Yet it is apparently possible to generate an altitude versus traverse graph to estimate the re-entry profile. It appears that the descent profile was close to that identified for the Apollo CM as double-dip "direct" re-entry. (NEXUS, 2015) To some extent the trial seems to be a retro-look into the "virtual reality" of the past. Another aspect is that it was a trial of higher gravity loads for future crews than those recorded for the Apollo flights. Orion's maximum deceleration load, 8.2 *g*, was slightly greater compared to deceleration loads recorded for CM re-entries of Apollo 8, 10 and 11, the largest being 6.8 *g*. The report concludes that the next test, the EM-1, will introduce "several new capabilities" including skip re-entry. (Lockheed, 2015, p. 14)

It is important to note that today NASA specialists recognise that for NASA a skip re-entry is a new technique which is yet to be attempted. (NEXUS, 2015) However, on this topic there is a lot of confusion. For example, in his book Chris Kraft, Flight Director for NASA during the Apollo period, says about the Apollo 8 CM that "[*i*]*t had done a skip reentry* that bled off excess speed and energy, then dropped through the atmosphere and splashed down a few miles away in full view of television cameras". (Emphasis added.) (Kraft, 2001, p. 301)

By 2009, Kraft had polished and revised this initial distortion of the story, so it's evolved into this bold statement:

"Because the velocity is so high, if you tried to come in directly, the heat-shield requirements would be too great. So what we did was get them into the atmosphere, skip it out to kill off some of the velocity, and then bring it back in again. That made the total heat pulse on the heat shield of the spacecraft considerably lower." (Popular Mech., 2009)

This totally fabricated statement about the Apollo CM's performance of a skip re-entry, by one of the key players behind Apollo, is a classic example of how the Apollo mythology has been created and perfected over time. Surprisingly, this became a topic of rather unpleasant argument from Apollo astronauts at an Autographica conference, addressed to Chris Kraft personally. (Autographica, 2014)

The most impressive lunar return and re-entry claimed by NASA is, of course, Apollo 13's emergency return which allegedly demonstrated the robustness of NASA's approach and its ability to rearrange flight protocols promptly for a safe return. A trajectory adjustment "to aim a spacecraft 40,000 miles closer to Earth", as the dramatic narration goes, was achieved through just "the barest tweak of the vehicle's engine". (Lovell, 1994, p. 150) On their traverse to Earth, the Apollo 13 astronauts could not see the planet but nevertheless managed to fine tune the course by using a simple navigation chart (figure 1). This Apollo 13 navigation chart is now exhibited at the Bullock Texas State History Museum in Austin, Texas. We are supposed to believe that this was a sufficient guide for the manual precision adjustment of the spacecraft course in an emergency. The exhibit states that "[t]he astronauts completed a manual alignment using the Earth's terminator line (the line that separates the night and day on Earth)". This narration complements the story told by the Apollo 13 Commander, Jim Lovell, that the CM was "approaching the Earth from its nighttime side, meaning there would be nothing below in the critical moments before reentry but a dim mass where the planet ought to be" (Lovell, 1994, p. 304), i.e., there was no terminator line visible at the time due to the position of the planet.

So this commander's version of the adjustment process is even more amazing than the museum's one and could be compared to scoring a bull's-eye while being unable to see the actual target. To be fair, the Apollo 13 return navigation record comprises a variety of adjustments using stars and even the Sun; this is worthy of a separate article.

Why is all this so interesting in relation to Orion's development? The big question is: why does NASA need to learn the skip re-entry technique when it is on record that the agency has successfully demonstrated direct re-entry in the past? The answer is that we shouldn't undertake returning from deep-space missions using direct re-entry—as this would, in all probability, end up as a fatal disaster. (NEXUS, 2015)

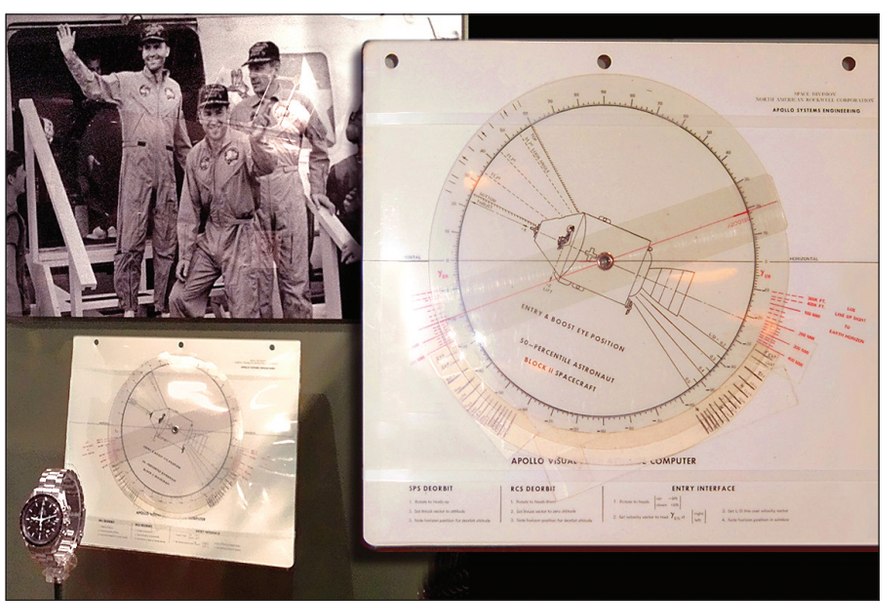

Figure 1: The Apollo 13 navigation chart named "Apollo Visual Pitch & Yaw Attitude Computer, 1960s", exhibited at Bullock Texas State History Museum, Austin, Texas. At the bottom left is the wristwatch allegedly used by the CM Pilot Jack Swigert to count the critical 14 seconds of burn time for the craft trajectory fine adjustment. (Photo by P. Kouts)

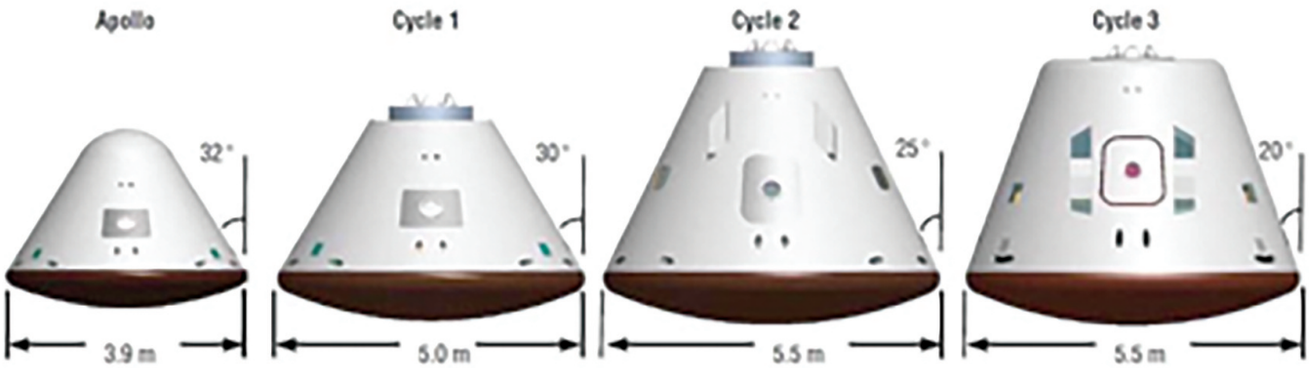

Figure 2: CEV crew module sizing progression as per the Architecture Study. The design and shape of the CEV CM evolved in four design cycles throughout the study, beginning with an Apollo derivative configuration 5.0 metres in diameter and a sidewall angle of 30 degrees (Arch. Study, 2005, p. 224), which is practically the configuration of Orion.

Aerodynamics

Regarding re-entry automation in the Apollo era, an expert engineer from MIT's Instrumental Laboratory, Dan Lickly[3], concluded in an interview in 2001 about the action of the astronauts at the crucial period of atmosphere re-entry: "'As far as I know, none of them ever touched a manual stick', on reentry, Lickly remembered, for 'they were so beat' after a two-week flight." (Digital Apollo, 2008, p. 160) So we have to conclude that all Apollo re-entries were performed in an automatic regime.

"The Orion entry guidance algorithm is generally based on the Apollo algorithm", so during its re-entry Orion made a number of rather abrupt ("instantaneous") bank angle reversals for descent control (Lockheed, 2015, p. 8) similar to those described in the Apollo mission reports. As always, the Apollo record on this topic is impeccable so no physiological problems were ever encountered by the crews. However, it is quite likely that these manoeuvres could cause physiological problems for the crew, so it is not surprising that a series of tests is now proposed for investigating adverse effects that crews may experience during re-entry. See the section below on "dummies in helmets".

Figure 3: Russian Soyuz capsule exhibited at the Chabot Space & Science Center near San Francisco, California. (Photo by P. Kouts)

To understand NASA's current technical level, a thorough study of 2005 regarding the agency's capabilities remains the most comprehensive source of data. (Arch. Study, 2005) Regarding a CM return from beyond low Earth orbit (LEO), it is unambiguously stated that there is an important feature, monostability, of the re-entry module which "implies that the vehicle has only one stable trim angle-of-attack in atmospheric flight". This would guarantee that the vehicle reached its desired heat shield forward attitude passively, without assistance from the module control system.

"The Apollo capsule was not able to achieve monostability due to the inability to place the CG [centre of gravity] close enough to the heat shield. Conversely, the Soyuz vehicle is monostable, with claims that it is able to achieve its desired trim attitude and a successful reentry with initial tumble rates of up to 2 deg/sec." (Arch. Study, 2005, p. 261)

Aerodynamic stability analysis in the

study entails the need "to reorient the vehicle from an 'apex forward' to a 'heat shield forward' configuration for entry" due to the danger that "…the CEV CM, much like the Apollo Command Module, may be bi-stable and have a secondary trim point where the vehicle apex points during entry in the direction of the velocity vector. Such an orientation is clearly undesirable, as the CEV would be unable to withstand the intense heat of atmospheric entry. If the vehicle's CG can be lowered close enough to the aft heat shield, this trim point can be eliminated and the vehicle will have a single trim point (monostable) where the heat shield points toward the velocity vector." (Arch. Study, 2005, p. 231) It is clear that the Apollo CM did not have this important feature. To what degree, then, was it dangerous to fly home in such a vehicle? The modern trials of the Orion CEV still have to answer this, some 45-plus years after the acclaimed Apollo re-entries that were reported as perfect every time.

"The design and shape of the CEV CM evolved in four design cycles throughout the study, beginning with an Apollo derivative configuration 5 m in diameter and a sidewall angle of 30-deg." (Arch. Study, 2005, p. 223) This Cycle 1 shape is practically the configuration of Orion (figure 2). The further evolvement of the Apollo CM converts Orion's shape into that in Cycle 3 (figure 2), closer to a Soyuz configuration (figure 3) which is more likely to survive re-entry.

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Furthermore, NASA, at the Langley Research Center, is going to evaluate the Orion spacecraft and crew safety when returning from deep-space missions, simulating splashdown scenarios "by dropping a mockup of Orion, coupled with the heat shield from the spacecraft's first flight". It is contemplated that a helmet on an astronaut's head may have some adverse influence due to its weight. "Lateral loads contribute to throwing your head side to side so there's an advantage to understanding how the test dummies respond with and without the helmet." (Langley, 2016)

This simplistic set of tests raises inevitable questions as to whether anything at all was ever learned in this regard from Apollo. If, at face value, experimenting with splashdown effects seems to be trivial and out of date, then the suggestion that NASA specialists are concerned that astronauts can suffer due to gravity overloads at re-entry—especially during bank angle manoeuvring, as described above, following several days of exposure to zero gravity—makes complete sense. Then it becomes clear that such experiments with dummies in helmets are really important and necessary. Again, one must note that from any perspective there is little or no reliance on any prior Apollo experience.

Moreover, engineers consider this testing as "one of many steps required to ensure Orion will meet the demands of sending humans to deep space for the first time". (Langley, 2016) A similar review concludes that Orion will "return home faster and hotter than ever before". (Ins and Outs, 2016) What does this mean? Is it possible to make such statements without implying that the Apollo flights did not happen?

Thermal Shielding

The fundamental problem with the heat shield is its integrity and ability to withstand various extreme conditions. It was recognised before the test flight that the Orion heat shield will be made of "…a material known as Avcoat, which was also used on Apollo spacecraft, …to serve as a protective barrier during re-entry into the Earth's atmosphere. Unfortunately, the material has shown tendencies to crack under thermal conditions similar to those the capsule will experience during the mission in the deep space environment prior to reentering the Earth's atmosphere." (NASA Audit, 2013, p. 14)

Not surprisingly, after the test flight the engineers admitted that at the shield manufacturing stage they had already "determined that the strength of the Avcoat/honeycomb structure was below expectations". Further, they contemplated that although the heat shield worked as expected for the first limited test, "the EM-1 Orion will experience colder temperatures in space and hotter temperatures upon reentry, requiring a stronger heat shield". (Orion Update, 2015)

Obviously, nothing has been retained in this regard as valuable know-how from the Apollo period, so another interim unmanned test will be of real value. Given the time span from 2005 to 2018 for the cautious, unmanned trials as planned for Orion, it is hard to see any reliance on knowledge acquired during the Apollo era.

NASA systematically reports on Orion in a seemingly transparent manner, but an unbiased observer can see much ado about nothing created for the sake of gaining more time while learning key things which were supposed to be routine in the past. Following the only test flight of the capsule, the complexity of the thermal shielding was revealed through newly learned details. Two other examples illustrate the picture.

In particular, there were problems with "…[t]he compression pads [which] fill in the joints on the heat shield between Orion's CM and SM [Service Module]. Their purpose is to carry the structural loads generated during launch, space operations, and pyroshock separation (explosive bolts) of the two modules. …New

and more resilient thermal insulating compression pads…are needed because the current 2-D pads used on Orion's recently completed maiden test flight…are only suitable for Earth orbit return." Lockheed Martin's Orion Program Manager Mike Hawes[4] clarifies that these pads produce "the risk that you can get separation in the layers when you are using those kinds of 2-D forms that are just all layered together". An "innovative 3-D woven material" has been developed as "a direct result of lessons learned from Orion's inaugural mission". (AmericaSpace, 2015)

It is incredible to think that this lesson wasn't learned some 45 years ago. What about the same issues on separation of the same Apollo hardware elements?

Another upgrade relates to the so-called grid of tiles on the walls of the CEV capsule, known as the back shell and used for the protection of Space Shuttles. After the test flight it was decided that "the craft will be equipped with a silver, metallic-based thermal control coating which will be bonded to the crew module's back shell tiles". This coating "will reduce heat loss when Orion experiences colder temperatures, and limit high temperatures from when the spacecraft faces the sun". (Daily Mail, 2015)

Orion is benefiting from protection far greater than that of the Apollo CMs which allegedly operated faultlessly.

Given all the above, one could conclude that for an Apollo-type CM the probability of a safe return on re-entry would be similar to that of walking through pouring rain while dodging droplets in the hope of staying dry. No chance.

NASA is continuing to find new critical aspects for further R&D around Orion, predominantly not because of tighter requirements, e.g., safety, but simply because the agency has at last started to receive genuine information on the real requirements for flights beyond LEO. However, NASA seems to be reluctant to become the first to face the unpredictable and likely hostile circumstances of having humans travel out into deep space. Therefore, the easiest and safest scenario would be for the agency to procrastinate and postpone its actual trials.

Considering the outcome of the first test flight, it is not at all clear how NASA is actually going to test its skip re-entry planned for the EM-1, now just two years away. Lately the GAO has indicated the "launch readiness date" for Orion as April 2023, which could mean that the first crewed flight with the EM-2 has already slipped back two years from the earlier pencilled year of 2021. (GAO, 2016, p. 5)

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Radiation Doses

The actual record of radiation levels inside the Orion CEV during the test flight on 5 December 2014 states that the maximum absorbed dose rate due to passing through the Van Allen radiation belts "was found to be about 1 mGy/min[5] [milligrays per minute], 20 times the alarm level for the ISS". (Radiation Report, 2015, p. 39)

This report further explains that the cumulative absorbed radiation doses measured on the Orion CEV during the EFT-1 mission in December 2014 were about three orders of magnitude or 1,000 times larger than the cumulative absorbed dose as measured during the same period by detectors on board the ISS. Most certainly, the "data provided a preview of the radiation environment that the crew will encounter while transiting the trapped radiation belts on future exploration missions". (Radiation Report, 2015, p. 39)

It is important to note again that no reference is made to Apollo data, including data on the impact of cosmic radiation, which would have been even richer in detail and more diverse. The Orion test is evolving as if no previous experience and/or data have ever been acquired beyond LEO.

The data for the total absorbed doses in each Apollo mission, reproduced from NASA reports (Bennett, 2015), appears to be below the doses recorded by radiation sensors aboard the Orion CEV during its flight that lasted just four-and-a-half hours. In particular, the cumulative radiation doses for each of the Apollo 8 to Apollo 17 lunar missions except Apollo 14 are recorded as not more than 5.80 mGy (Bennett, 2015), compared to 13.5 to 17.9 mGy recorded during the EFT-1 in December 2014. (Radiation Report, 2015, p. 23) While the 11.40 mGy cumulative dose (Bennett, 2015) claimed for Apollo 14 is the highest among the Apollo missions, it is still less than that recorded in the Orion CEV data. The lack of comparison and analysis in current radiation research indicates that today's NASA specialists are distancing themselves from the doubtful Apollo legacy. The Apollo data in figure 4 is interspersed among LEO missions (Radiation Carcinogenesis, 2009, p. 141). It is unsurprising that it is considered by specialists to be inconclusive.

Professionals recognise that high doses of radiation can induce significant radiation sickness and even fatality.

They acknowledge that while lower doses of radiation can induce milder physiological symptoms, both high

and low doses pose operational risks that are equally critical and possibly life-threatening:

"…Both scenarios have the potential to seriously affect crew health and/or prevent the completion of mission objectives. Radiation protection must be provided in the form of predictive models, shielding, and biological countermeasures when traveling outside of the protective magnetosphere of the Earth. Unfortunately, the development of these tools is hindered by a lack of relevant space radiation research. Most radiation studies focus on radiation species and doses that are unlike the radiation that is encountered in space." (Radiation Syndromes, 2009, p. 186)

The radiation researchers conclude that "[t]here is therefore a pressing need for research that accurately reflects the radiation risks that are native to the space environment and that facilitate the development of both improved risk assessment and effective radioprotective strategies". (Radiation Syndromes, 2009, p. 186)

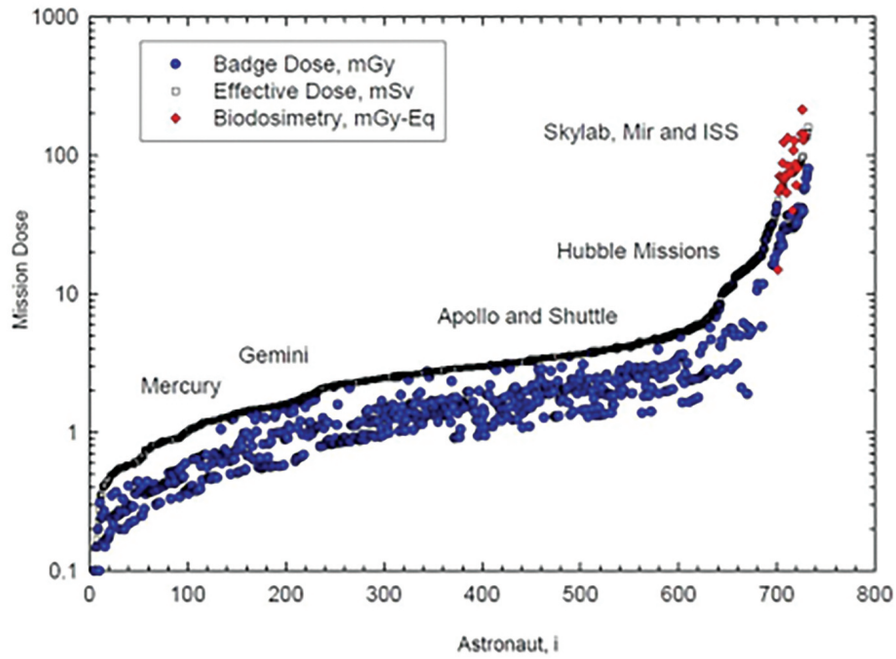

Figure 4: Summary of mission dosimetry for astronauts on all NASA space missions (Radiation Carcinogenesis, 2009, p. 141). "Badge dose" is a dose recorded on an individual dosimeter carried on the astronaut's person.

It is clear that the alleged Apollo radiation data does not meet the criteria for the space environment beyond LEO and therefore is not relevant.

NASA has produced a seven-minute educational clip—which has received an international award—where a NASA engineer admits that its astronauts can't travel safely through the Van Allen belts. (Trial By Fire, 2014) Around the three-minute mark, the engineer states:

03:00: "As we get further away from Earth we'll pass through the Van Allen belts, an area of dangerous radiation."

03:11: "Radiation like this can harm the guidance systems, onboard computers or other electronics on Orion."

03:18: "Naturally, we have to pass through this dangerous zone twice: once up and once back."

03:26: "But Orion has protection. Shielding will be put to the test as the vehicle cuts through the waves of radiation. Sensors aboard will record radiation levels for scientists to study."

03:36: "We must solve these challenges before we send people through this region of space."

But surely, weren't all these challenges already solved when NASA sent astronauts through this region numerous times over 45 years ago?

It is a matter of fact that the unmanned test of 2014 was the very first trial of an entirely new vehicle in this uncharted area.

Moon Base Perspectives

There are no indications that NASA is going to plan and develop a lunar outpost for at least 10 to 15 years. The latter figure is in line with NASA's promise to visit Mars, while any plans for a Moon base remain dormant. On the other hand, in a period of exceptional enthusiasm earlier in the Constellation Program, several proposals were made whereby it would be better to build a base on the Moon first. One of the Apollo astronauts, Harrison Schmitt, admits in his book that "the world and the United States did not build on the promise of Apollo". (Schmitt, 2006, p. 19) However, inspired by the Constellation Program, he was optimistically focused on the potential of helium-3 as a highly valuable fuel for power generation and therefore he envisaged that by 2030 "there should be a permanent settlement on the Moon, with commercial operations producing helium-3 fuel for a growing terrestrial fusion power industry". (Schmitt, 2006, p. 327) After 10 years of optimistic thinking, there are still no plans for a settlement on the Moon: the scope of NASA's human exploration continues as set out in 2010.

Furthermore, NASA has been forced to develop a human-rated space facility as a result of the clear dominance of Russia in this area. Switching from Soyuz flights to a national delivery vehicle was planned to be accomplished by 2012, but NASA has extended its contract with Roscosmos (the Russian space agency) to transport US astronauts to the ISS to beyond 2018. (Seats on Soyuz, 2015) The risk of crew loss in the Orion CEV for an ISS destination was estimated as 2.2% in 2012, down to 0.1% in 2016, beating the Soyuz 0.5%

benchmark of 2010. (Arch. Study, 2005, p. 581) In 2005 it seemed a realistic plan to develop a CEV for LEO destinations within some seven years (compare this to the length of the Apollo program) and then to go beyond LEO starting from 2017. Instead, only one unmanned test flight has taken place to date.

The current R&D program continues to be focused on the SLS and the Orion CEV, both necessary for deep-space journeys but would also be suitable for visits to the Moon. However, the two systems are not sufficient for a Moon landing because other systems are also required. NASA is no longer considering Moon-landing options since most likely the agency has understood the very high risks associated with lunar landings and takeoffs from "deep" gravity wells. So these tasks have been postponed indefinitely.

As if responding to a recent publication (NEXUS, 2015), NexGen Space, in a study part-funded by NASA, proposes a surprising idea of the so-called Evolvable Lunar Architecture (ELA, 2015), focused on establishing industrial bases on the Moon within some 10 to 12 years following the first future human visit to the Moon envisaged in the ELA. While not deeply technical, the ELA initiative is still bridging ideas in the Architecture Study of 2005 by suggesting a novel administrative strategy which might circumvent NASA's current policy and plans. The problem is that the initiative is funded by NASA and addresses the agency's masters. The timing of the ELA is conditional upon acceptance of the initiative by the agency and/or by the US government, so the implementation commencement date is still uncertain until the concept is endorsed and adopted.

Yet the ELA initiative is a revolutionary development in that it openly admits that "NASA managers and executives find that their options are eliminated or severely constrained by politics". The question is: what kind of politics dominates so badly and destructively? The document clarifies that "[f]rom the perspective of industry, the U.S. Government is difficult (at best) to develop a long-term partnership with. It costs industry a lot, in…time, money and lost opportunities, to get to a signed contract. Even then the commercial partner cannot be sure the government will not terminate for convenience. Further, every change in the White House, in the Congress, and in NASA's leadership is a source of risk for a commercial partner." (ELA, 2015, p. 84)

Why is NASA so concerned, and what would be revealed at the sites claimed to contain genuine Apollo landing platforms and lunar rovers? Why would it be so undesirable for NASA's relics to be examined by independent observers?

As a fundamental solution, the ELA's proponents intend to establish an International Lunar Authority (ELA, 2015, p. 82) independent of governments, thereby allowing flexibility and stimulating competition which in turn would present a cheaper solution for eventually landing humans on the Moon.

Ironically, by criticising those to whom the initiative might appeal, the ELA proposition doesn't ease but rather inflates the tension. Such a revolutionary initiative could never be accepted without a powerful triggering event. When evaluating lunar plans and talking about "a return of humans to the surface of the Moon" (ELA, 2015, Executive Summary), ELA proponents remain in a state of pre-revolutionary compromise with their opponent. The triggering event that is needed is an authoritative recognition of the fact that the Apollo Moon landings *never* happened.

It is also evident that NASA doesn't even want to be the first on the Moon because its attempts will initially put crews at the calibre of risk that the agency faced during the *Challenger* and *Columbia* Space Shuttle disasters. In all probability NASA is watching its two major rivals, the Russian and the Chinese space agencies. These two key players are, in principle, capable of attempting to execute Moon landings, and there is much media discussion over what they are considering doing as an eventual response to the acclaimed American accomplishment. In any event, NASA would rather wait and learn from the experiences of other teams as to what the actual solutions, whether technical or biomedical, might be. If Russian cosmonauts or Chinese taikonauts attempt future Moon landings, it is very likely that their initial attempts will be unsuccessful. Therefore, depending on what happens, NASA could offer its support and collaboration and then join the effort and/or formulate its own program, all without losing face.

It would be fair to say that NASA insiders have started to recognise that streamlining R&D in the area of human space exploration would be achieved far more easily through unprejudiced international collaboration.

Just recently, a noteworthy appeal from former NASA astronaut Leroy Chiao and Space Foundation CEO Elliot Pulham[6] divulged that "one of the most ill-considered comments to color our discussion, has been 'Been there,

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done that'", obviously referring to President Obama's argument of 2010 on closing the lunar visitation program. They conclude that the comment, though without such intent, "flippantly discounted a unique American accomplishment and a unique body of knowledge that the U.S. can bring to the human experience". (Politics of Space, 2016) This bitterly echoes the key concerns in the ELA document pointing to a problem bigger than NASA's inability to plan and execute.

It appears that NASA operates within a catch-22 paradigm: the agency cannot move forward without recognition of its true experiences accumulated in the area of human space exploration, primarily the Apollo legacy, whatever that may be, while on the other hand it cannot reveal the truth about Apollo for various political reasons.

Lunar Trespass Warning

Regarding the Apollo legacy, we know of only a few low-resolution photographs published by NASA as a reluctant response to public requests for Apollo landing site images, while there are no photographs taken by independent observers.

Moreover, instead of looking closely at its own lunar landing experience, amazingly NASA is not interested in learning about what may have happened to the Apollo equipment left on the Moon. It would be natural to monitor each landing site, e.g., with high-resolution cameras or one of its own mini-robots similar to those operating on Mars, and record any changes due to possible meteorite strikes, activity of the Sun and the solar wind, etc. On the contrary, the agency has issued a warning to all potentially interested parties not to approach the acclaimed landing sites. (Lunar Artifacts, 2011) Taken together with the decision to cancel all programs for returning to the Moon, this suggests a recognition that things have gone seriously awry within NASA.

This NASA warning declares that "[t]he AB [Artifact Boundary] will be established to specifically encompass all artifacts at a particular site to prohibit interaction/visitation within that area in order to protect the artifacts of interest: descent stage, lunar rover, flag, Apollo Lunar Surface Experiments Package (ALSEP) experiments, etc." (Lunar Artifacts, 2011, p. 8)

The document was widely discussed on the Google Lunar XPRIZE website dedicated to a competition for the development of an unmanned mission to the Moon with a mini-robot which, after landing, would be capable of covering a distance not less than 500

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metres on the lunar surface. Apparently, NASA is concerned that such a mission might send a robot too near to any infamous Apollo landing sites and disturb the resting place of the US achievements.

"The 2.0 km exclusion radius applies to the descent/approach path of the visiting vehicle…" (Lunar Artifacts, 2011, p. 10) So it is prohibited to land closer than 2.0 km to any Apollo landing gear—assuming, of course, it is actually there.

Throughout the document, there are expressions such as "exclusion zones", "buffer distance", "prohibiting visits to any part of the site", "restricted from close inspection by visiting robotic systems", etc.

Why is NASA so concerned, and what would be revealed at the sites claimed to contain genuine Apollo landing platforms and lunar rovers? Why would it be so undesirable for NASA's relics to be examined by independent observers?

The Burden of Apollo

This is the third article in a series questioning NASA's reluctance to develop a Moon base. The first article reviewed two major NASA documents, its Architecture Study of 2005 and the so-called Augustine Report of 2009. (NEXUS, 2014) If the former was enthusiastic and constructive about Moon bases, the latter actually derailed such ideas and mainly advocated abandonment of the Constellation Program.

The first article also demonstrated that the Architecture Study has finally lifted the taboo on criticism of the Apollo hardware.

Soon after the second article was published (NEXUS, 2015), a new collaborative report, focused in line with the article's key suggestions, was released (ELA, 2015). This new report puts the Moon base idea back on track, proposing a truly independent International Lunar Authority—one that NASA will never accept due to its potential to undermine the agency's position.

Further, the recent appeal from Chiao and Pulham confirms that "[t]here are numerous technical, operational and programmatic reasons…to go back to the Moon, as part of the effort to send astronauts to Mars". (Politics of Space, 2016) These two noteworthy documents establish the right framework, but both stop just short of pointing to NASA's main problem: the burden of Apollo.

The Apollo legend continues to be a major hindrance to any further development in the exploration of space. Decades have been lost under NASA's assumed superiority in human space exploration because other agencies have delayed replication on the assumption that the leader has already achieved success. A new generation of NASA specialists has finally admitted that much necessary work is still to be undertaken.

NASA's successes in unmanned space programs are undisputed, while the situation with human space exploration is quite the opposite. With the cancellation of the Constellation Program, profound shortcomings were revealed in NASA's capabilities of flying crewed missions.

Work completed by NASA within the last 10 years on the Orion CEV has shown that the agency is developing an entirely new vehicle based on little previous experience.

It is fair to conclude that no Apollo Command Modules were ever capable of safely returning crews to Earth from deep space. This fact alone should be sufficient for us to infer that all the Apollo landings were faked.

The Orion data on radiation acquired beyond LEO further supports this upsetting conclusion, as the claimed Apollo radiation data is totally irrelevant.

Over the last decade, the question as to whether the alleged Apollo missions were a stepping stone for human progress has received a rather negative answer. Considerable resources are still being wasted supporting the Apollo story. While the US Government Accountability Office is doing a great job monitoring and guiding NASA's programs, it's not sufficient due to the shackles of the Apollo mythology.

All financial investments in this area will be ineffective until the technical and biomedical difficulties are examined as they truly are. Only then will President Kennedy's 1963 bold recommendation to consolidate international efforts to land on the Moon be finally upheld.

A new era in space exploration will only begin after the recognition that the entire Apollo story is a tool of the past, devised to win a political race—as suggested in the film *Interstellar*.[7] ∞

About the Author:
Phil Kouts lives and works in New Zealand. He has a PhD in applied physics and gained considerable experience in applied research, working as a research fellow in universities in the UK and as an R&D manager in private companies. He writes under a pseudonym to differentiate his professional occupation from his interests. His articles "Towards a Moon Base: Has Anything Been Learned from Apollo?" and "Is There Any Hope for a Moon Base?" were published in NEXUS 22/03 (April–May 2015) and 21/05 (August–September 2014) respectively. Phil Kouts can be emailed at philkuts@gmail.com.

Editor's Note:
Due to space constraints we are unable to include the endnotes and references accompanying Phil Kouts' article. To see these and to access hyperlinked sources, go to the website http://www.aulis.com.