China's 'Jade Rabbit' on the Moon: A "Wakeup Call"?

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Chang'e 3 and Yutu on the Moon

Last December's successful soft-landing on the lunar surface of the Chang'e 3 spacecraft along with its rover, dubbed *Yutu* or Jade Rabbit, was another milestone in the steady, measured evolution of China's space prowess. China had now become the third nation to demonstrate this technological capability, albeit the U.S. and the former Soviet Union had placed rovers on the lunar surface decades earlier.

The Chinese success was deservedly applauded in the U.S. and elsewhere. The U.S. has generally accepted successive Chinese space successes over the years appreciatively and with equanimity. Appropriately enough for the nation that has long been the clear leader in space exploration and unquestionably remains so. This latest development was especially arresting, however, in that it underscores just how far China's program has come. Moreover, it calls attention to China's focus on the Moon in particular, heralding the likelihood that China is going to be playing a significant role in lunar exploration.

The question then arises: might not this evolving reality of China now on the Moon suggest that the U.S. could be left behind in lunar exploration? Especially inasmuch as the U.S. seems to have lost official interest in the Moon in recent years.

Sure enough, voices soon began speaking out. For example, Gene Grush, the former propulsion and power division chief at the NASA Johnson Space Center, saw China's unmanned lunar rover as "a wakeup call" and explicitly counselled against ceding the Moon to China.[1] Similarly, in December 2013 Congressman Frank Wolf (R-Va) penned a personal letter to President Barack Obama noting that "As China prepares to send a series of increasingly advanced rovers to the Moon in preparation for what most observers believe will ultimately be human missions, many are asking why the U.S. is not using this opportunity to lead our international partners in an American-led return to the Moon." Wolf later (on April 28) gave a talk on this matter here at GWU, excerpts from which can be found in his subsequent article in the *Wall Street Journal* on May 5.[2]

That specific "wakeup call" lunar rover, the Jade Rabbit, actually fell short in completing its brief mission on the Moon's surface, but this minor glitch does not diminish the significance of China's accomplishment, nor will it in the least slow China's space program. As Congressman Wolf indicated, more sophisticated Chang'e unmanned missions are coming, including a challenging one in 2017 to extract soil and rock samples and return them to Earth.

So, what has been the response thus far, i.e., now several months after the celebrated Jade Rabbit began its trek on Mare Imbrium (the Sea of Showers)? Is this alleged wakeup call being at all heeded? Will the U.S., in fact, be ceding the Moon?

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[1] Gene Grush, "Special Series: Return to the moon, " *FoxNews.com*, March 18-21, 2014.
[2] Frank Wolf, "Squandering America's Leadership in Exploration," *The Wall Street Journal*, May 5, 2014.

Judging by the response thus far, the answer is still inconclusive. Although in the end it is unlikely that the U. S. will remain oblivious to the implicit challenge in one way or another.

For one thing, it appears that to this point the Chinese space program is not yet widely sensed as a serious threat to U.S. interests. The early expressions of concern about China on the Moon were, after all, not particularly anxious ones. What seems to be the case here is that China's latest space success as much as anything plays opportunely into what is a continuing argument in the U.S. over its own space objectives, particularly with regard to the human space program. Referencing China is simply meant to strengthen the hand of those seeking to restore the Moon as a destination for the U.S. space program. This is a big debate and one that has become notably politicized and heated. The idea seems to be to suggest a plausible international rivalry that might prompt the U.S. to take appropriate action.

The Moon as Human Spaceflight Destination Controversy

For frustrated lunar exploration advocates such an argument may seem justified in dealing with the current White House and NASA leadership, which have explicitly excluded the Moon as a NASA human space flight destination. This determination is seen, for example, in NASA Administrator Charles Bolden's reiteration of U.S. policy this May, several months after the supposed Jade Rabbit wakeup call. So, one can surmise that China's latest lunar achievement has done nothing to change the mind of the Obama Administration. This is not surprising. It was President Obama, after all, who cancelled the Moon-oriented Constellation program in 2010. It was he who announced to an unenthusiastic audience at the Kennedy Space Center that an asteroid would be a more suitable waypoint in a space program that did, however, retain Mars as the ultimate horizon destination. Since then, accordingly, a cost-conscious NASA has come up with the asteroid retrieval mission (ARM), with which it has sought to deflect attention from the Moon. As for those who have doubts about the investment in ARM, Bolden has suggested that they simply "get over it."![3]

Thus it is that Gene Grush's comments mentioned above were expressed in a five-part series of articles that he published in March, advocating that the U.S. reassert its space leadership by restoring the Moon as a destination and ultimately build a base there. His argument did indicate that otherwise China might well inherit such leadership of a possible international lunar mission, for which there is widespread interest. Incidentally, he did not preclude American cooperation with China among others in such a venture. As for Representative Wolf, as chairman (retiring) of the House Appropriations Committee, he is a leader in Congress pushing for the Moon as a NASA destination. But he is not, to put it mildly, a champion of cooperation with China and is largely responsible for NASA's inability to have an official space program relationship with China.

The argument over the Moon as a destination for the U.S. space program continues unabated. It is an oversimplification to see it merely as a Republican-Democrat tiff. It has

[3] Dan Leone, "Bolden: Don't like Asteroid Mission: Get Over It!" *Space News*, April 23, 2014.

become that, for sure, but it is much broader and more complicated.[4] The advocates for the lunar destination are numerous and include many knowledgeable space luminaries, and they present a very compelling case. Among the advocates are the first and last American astronauts who walked the lunar surface. The late Neil Armstrong, who generally eschewed public attention, made no bones about his preference in this regard, and about his concern over the direction of the space program otherwise. He was joined in this by Eugene Cernan, who has long deplored the fact that he is still the last person to have walked on the Moon. The former director of George Washington University's Space Policy Institute John Logsdon has asserted: "I frankly don't think anyone would be pushing asteroid redirect if the U.S. embraced a return to the moon." He noted that "The rest of the world is focused on going to the moon. We're the only country that's out of sync with that."[5]

Underscoring that point, it is worth keeping in mind that in 2016 the Russians plan to soft-land their Luna-25, a more sophisticated lander consisting of five modules.[6] And less than a month ago, Oleg Ostapenko, the head of Roscosmos, announced plans to launch a full-scale Moon exploration program in the late 2020s or early 2030s. Work is already underway, he said, on a new manned spacecraft together with new heavy and super-heavy carrier rockets.[7] Whether the Russians can adhere to or fulfill this plan remains to be seen, but they do seem to be aiming to return to space and to the Moon itself in a big way.

Adding coals to the fire, this June the National Research Council's Committee on Human Spaceflight released its final report, fulfilling the task it had received from Congress in 2010. This important blue-ribbon report explicitly kept the door open for a return to the Moon on the pathway to Mars. It did not directly criticize the ARM program, but saw it as an expensive distraction. Importantly, it extolled the need for the U.S. to provide leadership in an international space exploration program, and also (incidentally) suggested the need to keep open the possibility of including China in such cooperation.[8] In short, this blue-ribbon report lends support for the pro-lunar advocates, even suggesting the building of a lunar base.

And there continue to appear other strong voices supporting a return to the Moon, including an informative three part series of articles by science writer Eric Berger, who sees the U.S. as having sufficient existing technology to get the job accomplished soon.[9] Peter J. Turchi's letter to the editor in *Aerospace America* in May explicitly made the case both to achieve the technical goals of an established lunar based Advanced Space

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[4] See, e.g., "Mars Mission: Obama Wants an Asteroid. Republicans Want the Moon," *NationalJournal.com*, July 3, 2014.
[5] *Ibid.*
[6] See Boris Pavlischev, Moscow, "Moon Plays Trick on Jade Rabbit," *Voice of Russia*, *Space Daily*, Online, February 4, 2014.
[7] "Russia to Launch Full-Scale Moon Exploration Next Decade," Zvyozdny Gorodok (Moscow Region), RIA Novosti, September 23, 2014.
[8] See Jeff Foust, "NRC co-chairs reiterate call for national commitment and sustained funding for human space exploration," *Space Politics*, June 25, 2014.
[9] Eric Berger, "Adrift: Parts 1-3," *Houston Chronicle*, June 22, 2014.

Propulsion Laboratory, and to reassert U.S.-based capability for crew launch and return missions.[10]

In the meantime, progress is being made on the huge, expensive Space Launch System (SLS) and Orion space capsule programs, both preferences of Congress, not of NASA in this administration. The SLS has now advanced further along than did the Constitution program (the Ares rocket) at the time of its cancellation. Encouraging…except that the Government Accountability Office claims that NASA and its contracting partners are unlikely to meet their goal of a December 2017 test flight; NASA's allotted spending figures, it is said, are not realistic.[11]

In any case, officially speaking, the administration and NASA leadership remain unmoved on the destination issue. The Moon is simply not on their agenda. And while there are fewer supporters for their agenda, there are indeed some, as might be expected. The administration in power does have influence, especially in a NASA beholden to it, and there are those who follow on a partisan basis. Moreover, the idea of asteroid missions is inherently interesting, even if it is for many a distraction, and especially so the more limited mission of asteroid retrieval. The argument does not let up.

Clearly, the U.S. space program remains in disarray, even as so many fascinating developments continue to take place, mostly robotic achievements that highlight the technological edge and experience that the U.S. possesses. In these circumstances, a change of political administrations may be required in order to restore the Moon as the logical stepping stone either as a goal in itself or as part of a program that will eventually lead to a manned mission to Mars. But even with such a political change there is no guarantee that a policy reversal would come about. A new administration will have its own priorities, and budgetary restraints are not likely to get much better anytime soon.

Accumulating Lunar Information and Interest

However, having said all this, it is worth keeping in mind that the U.S. has accumulated a great deal of information about the Moon and it is not at all being lost sight of. Remember, less than two years ago, at the end of December 2011 and the first of January 2012 NASA launched the twin lunar satellites of the GRAIL (Gravity Recovery and Interior Laboratory) program, which, after successfully measuring lunar gravity from crust to core were both crashed into the lunar surface by the end of 2012.[12] Then the LADEE (Lunar Atmosphere and Dust Environment Exploration) mission, launched in September 2013, productively examined the lunar atmosphere for six months before being crashed into the Moon's far side this April. Fortuitously, LADEE was on hand to take into account the dustup created by the landing of Chang'e-3.[13] And still operational

[10] Peter J. Turchi, "The case for returning to the moon," *Aerospace America* (May 2014); 3.
[11] Brooks Hays, Washington, *UPI*, July 232014.
[12] See the account by Sami Asmar, the co-investigator for GRAIL at NASA's Jet Propulsion Laboratory, "The Grail Mission Explores the Moon Crust to Core," *Ad Astra* (Summer 2013): 38-41.
[13] Leonard David, "NASA Moon Probe Will Bite the Lunar Dust Soon: What It Taught Us," *SPACE.com* (April 17, 2014).

is NASA's invaluable Lunar Reconnaissance Orbiter (LRO) that began its painstaking low altitude mapping chore in June 2009. It did so at the outset along with an initially accompanying LACROSS (Lunar Crater Observation and Sensing Satellite) mission that was soon crashed intentionally into a dark crater.

But all of these missions constituted NASA's Lunar Precursor Robotic Program (that is precursor to an expected human return to the Moon). And all of this had been initiated as part of the Vision for Space Exploration Program of 2004 that was then discarded in 2010 by the present administration. Now, with the Moon no longer an official destination for U.S. human spaceflight, there seems to be less urgency in accumulating invaluable lunar specific data.

Nevertheless, there remain numerous scientists and other supporters of the goal of returning to the Moon both within NASA and in the larger space community. To ignore the Moon just doesn't make sense to many such knowledgeable and concerned enthusiasts. Some boldly continue thinking Moon first and thoughtfully ponder the amassing information to which they have access and labor to interpret. There is, for example, an active unofficial working group at NASA Ames in Silicon Valley. It recently made a persuasive public presentation seeking to demonstrate that an *affordable* Moon base is achievable.[14]

New Space Lunar Missions

Moreover--**and this is big and significant and probably game-changing**--even if the U.S. is not for the moment officially interested in returning to the Moon in any big way, there are on the private, commercial side some fascinating things underway. What is going on is nothing short of amazing and should not be underestimated. Space writer Anthony Young uses Malcolm Gladwell's tipping point concept to suggest that we are approaching such a moment "with respect to commercial lunar exploration and the potential of resource utilization providing," as he puts it, "an improved quality of life on Earth and an array of new industries not even imagined yet."[15] This momentous moment includes developments that build on the significant but nonmonetary cooperation of NASA itself and on the extraordinarily timely and fortuitous challenge of the Google Lunar X Prize.

First, NASA's Lunar CATALYST (Lunar Cargo Transportation and Landing by Soft Touchdown) program had been explicitly designed to encourage the development of robotic lunar landers that can be integrated with U.S. commercial launch capabilities to deliver payloads to the lunar surface. Three small companies have been granted no-funds-exchanged Space Act Agreement (SAA) partnerships in this program: Astrobotic Technology of Pittsburgh, Pennsylvania, Masten Space Systems of Mojave, California, and Moon Express, Inc. of Mountain View, California. They are, respectively, producing the Griffin Lander, the XEUS Lander, and the MX-1 Lander.

[14] This was the topic of their presentation at a meeting of the Space Society of Silicon Valley in Mountain View, California on August 13, 2014.
[15] Anthony Young, "The commercial race back to the Moon," *thespacereview.com*, June 9, 2014.

But it is the Google Lunar X-Prize (GLXP) that is stirring the most excitement in the space community, particularly among New Space enthusiasts. The GLXP's Internet home page flatly says it all: "We're going back to the Moon. For good." This is being done, it explains: "In the spirit of Charles Lindbergh, we want to break open Space the same way he broke open aviation. Join us---as we open up the Moon, and create an epic future in space for all of us!"

The Google Prize entries include the three SAA partnerships, but total overall as many as eighteen small private companies from around the world that are planning to compete for its prestigious prize of up to $30 million that is to be awarded the top winner. We can be sure that much of the world will be watching as something suggestively akin to a NASCAR race takes place en route to the lunar surface. Some of the participating rovers who make it there will emerge from a lunar lander (e.g., courtesy of Masten and Astrobotic), presumably more or less line up abreast, and then on signal, commence racing for the prize. The winning rover must be the first to traverse a distance of 500 meters (1,640 feet) and then transmit high definition video and images of the landing and the completion of the mobile requirement. A supplemental distance prize will go to the first rover that continues to travel a full five kilometers (3.1 miles). All of this is to be completed before December 31, 2015 (the deadline requirement of the Google Prize).

For some of these private companies the main motivation is less the glory of winning the prize in this first lunar contest, and more the prospect of substantial profits ahead. That is, if they can expeditiously find, extract, and return to Earth the most desirable of the Moon's abundantly available valuable resources. This includes precious metals, rare earth elements, and Helium-3.

China Moves On

As for China's lunar program, whether or not the U.S. *officially* responds to the implicit challenge it poses, it can be expected on its own to register continued successes. It will do so on the basis of incrementally accumulating experience, with eager public and official support for the ever-widening pertinent infrastructure and financial requirements to get the job done. It is worth noting that the new, fourth, space launch center (at Wenchang, on Hainan Island) is now finally operational.[16] This favorable site will enable more efficient launches and will greatly enhance the Chinese public's keen appreciation for space activities.

The established lunar program, followed to this point, consists of three successive phases using Shenzhou spacecraft with the Chang'e designation. Thus Phase One saw the orbiting of the Moon, first with Chang'e-1, the first spacecraft to do so (and which was then sent into deeper space), followed by the second lunar orbiter Chang'e-2 that was then intentionally crashed into the lunar surface. Phase Two has now seen the celebrated soft landing accomplished by Chang'e-3's that now operates on the lunar surface. This

[16] Staff writers, Beijing, "China completes construction of advanced space launch facility," *Space Daily*, September 12, 2014, online.

current second phase will also include the flight of Chang'e-4, that is to be launched shortly and will test equipment to be used on the next mission. This will be Chang'e-5, which in 2017 begins Phase Three as it conducts the more complex sample return mission. If this is successful, Phase Three will have been completed in one fell swoop. And if all goes well, Ye Peijian, senior adviser to the China Academy of Space Technology, told CCTV recently "we'll study and move to possible manned missions."[17]

However, for now, the sequence of planned missions has become a bit confused. It appears, for example, that Chang'e-4 is modified in a way that heralds preparation for a probable manned circumlunar mission to be undertaken within the next decade and is thus less clearly seen as simply the forerunner for the 2017 sample return mission.[18] It has been estimated that China could in fact undertake such a circumlunar mission with a single astronaut aboard with technologies already available.[19] This means they could do so within the next few years without having to wait for the full vetting of the big new Long March 5 rocket. It would be a feat that would surely grab global attention.

Remember, too, that China will be building its own new space station shortly (currently scheduled for 2020). And China is already planning on missions to Mars. Ouyang Ziyuan of the Chinese Academy of Sciences and one of the chief scientists of China's Lunar Exploration Program says that China plans to land a rover on Mars in 2020 and to collect samples a decade later.[20] China's Mars program had actually begun in earnest in 2009 but was interrupted when its probe, Yinghuo-1, crashed aboard the ill-fated host Russian spacecraft, Fobos-Grunt in 2011. It is frustrating for China that India has now won the Asian robotic space race to Mars, having placed its MOM spacecraft in Martian orbit just last month.

Finally, it may be that however well the Chinese lunar exploration program is currently planned and however well it may productively pay off, it is likely that the Chinese will also be taking into account what happens in New Space-style commercial activity on the lunar surface. Therefore, it is not just a matter of the U.S. being stimulated to turn its attention to the Moon once again, the underlying theme of this paper.

Rather, it may be that if the private commercial ventures prove successful, the main challenge will become that of competition from private companies. Profits being involved, this private competition could become fierce. Thus, it becomes a matter of what China's own response will be to this new kind of wakeup call!

Remember, too, that in this presentation we have been referring only to the small private space companies that are caught up in this new race to the Moon. They do so in the shadow of much better endowed private space ventures these days, such as Boeing, Space-X, and ULA/Blue Origin, not to mention the likes of Sierra Nevada, XCOR, and

[17] Leonard David, "China Plans To Launch Recoverable Lunar Orbiter Prototype This Year," *SpaceNews* (September 8, 2014): 14.
[18] See Morris Jones, "Are China's Astronauts Moonbound(?)" *Space Daily*, Online, July 1, 2014.
[19] Morris Jones, "China's Fast Track to Circumlunar Mission," *Space Daily*, Online, July 16, 2014.
[20] Staff writers, RIA Novosti, Moscow, *Space Daily.com*, July 1, 2014,

Virgin Galactic, among others that could similarly set sights on the Moon. There is an incredible amount of energy, imagination, and MONEY coming to bear in the private commercial sector, and often with strategic government (read NASA expertise) partnerships or other support as well. If the U.S. wants to restore its leadership role on the Moon it surely can do so.

Incidentally, some interesting international cooperation is already underway in this new era of lunar exploration. A number of entries from foreign countries are hitching a ride aboard the commercial space craft and lander next October, although a Chinese entry is not among them. Even so, at least one of the international GLXP entries (the Barcelona Moon Team lander/rover) intends to be inserted into lunar orbit courtesy of a Chinese Long March 3C rocket to be launched from Launch Complex 2 at the Xichang Satellite Launch Center in Sichuan (as was Chang'e-3 last December). So far, this launch is slated for June 2015. It is worth noting that this date is earlier than the projected Fall/Winter 2015 landings of some of the other entries, although it is worth keeping in mind that this very competitive situation is undoubtedly quite fluid.

But, as things look at this particular moment, it could just be that the winner of the GLXP might turn out to be the contest competitor that was carried to the Moon on a Chinese Long Mach rocket?! This is not a prediction…just an ironical possibility.

The End