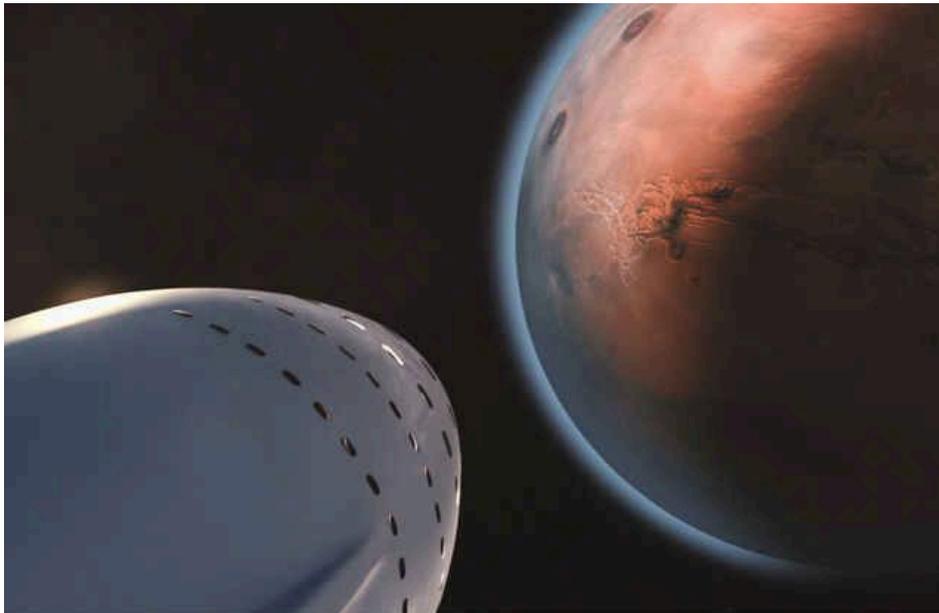


Dr. Bruce Damer's response to Elon Musk's Sept 28, 2016 announcement of SpaceX's Mars colonization plan

(responses posted on Facebook thread, edits made for clarity)

Find the full Facebook thread made public October 19, 2016 at:

https://www.facebook.com/bdamer/posts/10154379292095907?notif_t=like¬if_id=1476908199797001



I am sitting here very disappointed about Elon Musk's fantastical Mars colonization presentation yesterday. It deflated my hopes that he would be a mover for the development of a realistic sustainable architecture for extending human presence beyond the Earth. Sadly his plan recalls sci-fi visions before we knew about the trials and real engineering challenges of space travel. It resembles a Buck Rogers or Flash Gordon Saturday morning kid's serial and doesn't even approach the pre-spaceflight engineering thinking of Werner Von Braun's *Colliers* magazine articles of the early 1950s. Who on Earth was advising him on this? Where is a viable concept for fuel waystations? Where are the multiple backup systems and pre-emplaced infrastructure? Unless someone from SpaceX subsequently presents an approach grounded in reality, I consider that Elon and SpaceX may not actually be viable candidates for building humanity's future in the solar system.

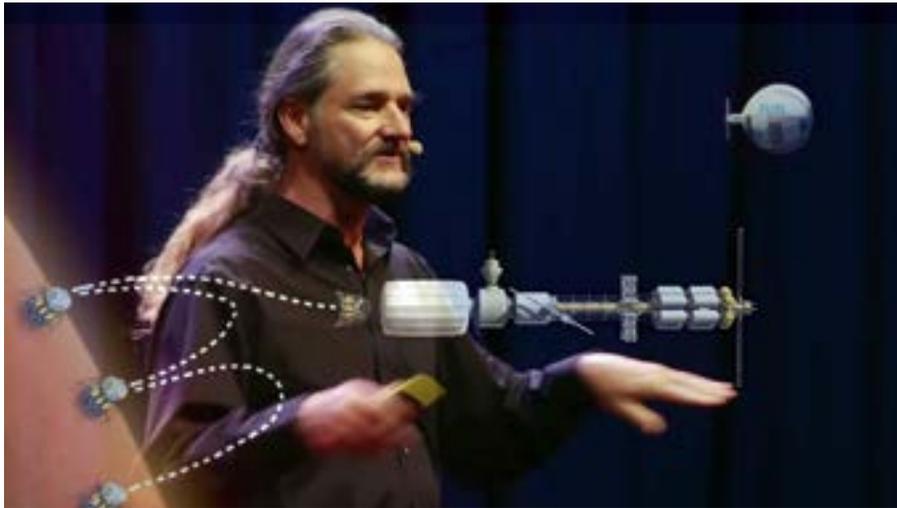
Some initial critique and common sense from our NASA colleague Chris McKay can be found in the following article:

<http://www.theverge.com/2016/9/28/13087110/spacex-elon-musk-mars-plan-habitat-radiation-funding-questions>

Responses to posts on the Facebook thread, please see original thread for others' comments:

Last year, after a personal quest of almost forty years of design concepts and fifteen years of mission simulation and design work for NASA and the space community (see www.digitalspace.com) I presented to the public a radical new spacecraft concept. If it works, this spacecraft could create a system of fuel stations by harvesting volatiles from asteroids containing water ice and other compounds. SHEPHERD (Secure Handling by Encapsulation of a Planetesimal Heading to Earth–moon Retrograde orbit Delivery) was developed in collaboration with SETI Institute asteroid astronomer Peter Jenniskens, and world-renowned balloon designer Julian Nott. SHEPHERD encapsulates asteroids in a fabric structure and handles them with introduced gas, not only to relocate them but to also extract resources including water and other volatiles, organics, metals and even serve as a bio-reactor to “farm” in space. Deployed in all of its variants, SHEPHERD would provide a sustainable architecture to support life and human activities well into the future, unlike one-off exploration approaches like Apollo and, as it seems, Elon's direct to Mars strategy. The gas extraction of resources from copious sources already in space is potentially much less fraught with difficulties and equipment breakdowns than planetary surface mining or atmospheric gas processing. As Gerard O'Neill wrote back in the 1970s, planetary surfaces may not actually be the best places for an expanding human civilization. He was the chief early proponent of large space-based colony structures. In addition, short sortie missions to multiple locations on Mars while crew resides in a clean, secure environment in orbit are a much safer and more scientifically valuable Mars mission design.

I invite you to take a look at the following 9 minute April 2015 TEDx talk on the SHEPHERD concept and the architecture it enables.



<https://www.youtube.com/watch?v=wLMHcUg36yc>

I am not questioning Elon's intelligence or his strong intention and will behind this Mars colonization vision. Nor am I questioning or casting doubt on the strong achievements of the SpaceX company in bringing a launch system to life in a breathtakingly short amount of time (with first stage return capability to boot). What I am concerned about is the severe overreach of

this proposal. For sixty years space exploration has progressed by small incremental steps to attainable goals, each with carefully designed and modest additions of capability. SpaceX's business has also followed this model, copying from earlier innovators to re-create a conventional booster and cargo/crew capsule. Using this incremental method, with extremely constrained budgets and careful engineering (and a lot of painful trial and error) humanity has just been able to land a one ton rover on Mars.

It seems to me that Elon could have presented a viable, incremental series of steps to get a small crew to Mars orbit to engage in valuable initial surface sortie missions, all based on Falcon 9 Heavy, and "Red Dragon" coupled with something like Robert Bigelow's inflatable crew habitats and a number of other proven technologies. The science and engineering community could then have gotten behind such an effort. The proposal he presented bypasses the logical, sensible and necessary steps for the first low risk missions of exploration climbing carefully up the technology spiral. Instead he goes straight to a grandiose "colonization/fun/tourist" effort with numerous unproven technologies such as Mars surface mining with atmospheric gas processing, the radiation problem glossed over, and an enormous Earth to Mars direct launcher.

This extremely high cost, high risk vehicle and unproven technologies are all offered for an uncertain or probably nonsensical goal of Mars colonization. Any form of human colonization outside of the Earth is decades or more likely, a century or more away. The sheer enormity of creating a sustainable colony on what is effectively a dead planet with a thin atmosphere, high radiation and viscous planetary dust storms defies common sense as a realizable objective. Decades of science and test missions must come before even considering this. And as Elon, SpaceX or any government would be unwilling to pay for such a grandiose "fantasy" (yes, I would call this a "fantasy") it is counterproductive to even present it in the first place.

I don't buy the argument that an "exciting vision has to be sold first". The risk you run is that such visions distract people by giving them unrealistic expectations. The hype collapses after a few years when no progress is made, and then the science and engineering community pays the price. And just because you can show impressive computer graphics does not make something viable or even desirable.

So, I hate to say this, but for a man in your position, Elon, *you did a great disservice, instead of a good service, to the enterprise of space yesterday.*

Thanks *Evan Ldb*. I would also agree with *Jeh Cranfill* on not discounting Elon and his team, but this is not off to a good start. Ambitious space projects are usually more grounded in what is known and achievable, without resorting to "fun times to be had by all on the way to Mars" (a central theme of Elon's presentation). The first and subsequent human missions to Mars are going to be serious affairs with ever vigilant crews facing multiple breakdowns and challenges in cramped quarters. Anything else is magical thinking.

Please understand that I am as much into visionary space stuff as many of you, and I congratulate Elon for building a great company that actually delivers payloads to orbit (and soon we hope, beyond). I want to clarify that my beef is the order of his presentation: leading with an audacious colonization effort without discussing the long phase of precursor development. A NASA colleague informed me privately just now that Elon's team does have a handle on approaches to earlier missions before a full out colonization effort. I feel however that the full scope of precursor missions or at least a listing of the extant issues should be presented long before a colonization concept. I am and always will be an engineer looking for viable paths forward. I am also looking for honesty and simply taking some time to list the known challenges might have offered a valuable disclaimer to avoid criticism from serious mission people. Perhaps he has got the cart before the horse on this one.

From my ex-NASA friend and colleague *Michael Sims* over in another thread:

Bruce, let me take an alternative perspective. Musk is a bright guy and he wouldn't try to tell us about getting to Mars and then not tell us about getting to Mars. The problem is that he (quite intentionally I'm sure) did something different than I thought he was going to do and that many people still think he was trying to do. As he said before the talk he was talking about Solar System colonization - and not about the next few missions to Mars. He's got plans for those but he just wasn't talking about that. I think what he did was much more brilliant and useful. What he did was define his vision for our goal very clearly so that we would have that vision to measure our activities against. So, beginning at the end - the vision is a species (and our biota) that have human access to the whole system and he defined the size of viable colonization as roughly a million people off planet. That is a von Braun level of insight IMHO. Then, how do we get there? First we need to move lots of people and equipment from Earth to the rest of the Solar System. But how is that possible? Well it's only possible if we do that very, very cheaply. Elon Musk suggested \$200K for a trip to Mars - about like some US houses. There are probably a million people that can afford that cost and would want to go. He also presented some plans for larger vehicles that might get us there. Clearly that's a work in process but it's not crazy. It's what we need to think about to accomplish his goal of a solar system wide species. And then he stopped the story. Probably a few reasons for stopping there but the best one is that he was laying out a vision without distracting us with short term details. And taking this perspective - by explicitly laying out the vision to judge our efforts against - one can see why plans like the Mars Direct would be passed over in favor of his general scheme for beginning Mars exploration. He didn't present plans for cheaper, short-term alternatives, how to handle radiation and zero-g because that's not what he wanted to convey. In the world of getting humans to Mars we have continually tried the bottom up approach - let's see what we can do now (e.g., how to manage radiation, health issues, etc.) and then we'll lay out a plan for how to explore. It hasn't gotten us very far. Musk is saying and I believe it that it's because we have been guided by puny goals - just to not kill many of us on the way. His goal is audacious and has the nice effect that it gives us a great risk posture for the likely eventually extermination event for Earth.

I would like to add note or two to Michael Sims' cogent comments above. We have actually got very far on Mars exploration thanks to efforts of many in the robotic exploration program (as toiled on by Michael Sims, Chris McKay, Steve Squyres, Carol Stoker and many, many others). Serious planning for human missions to Mars have had many false starts over the years because governments (and companies) rightfully balk at the huge long term commitments to develop the technologies and run test flights with ever extending range (to asteroids for example). I don't think that these costs, risks and time frames are somehow magically reduced by a speech and fancy computer graphics even from a powerful personality like Elon Musk.

What this comes down to is that I don't think that it is helpful to put forth a Mars surface colonization agenda. I believe it is the wrong story to tell right now. As Gerard O'Neill opined in the 70s, a planetary surface might not be the right place for an expanding human civilization. We just don't know where we should invest on that score. Despite its flaws, *The Martian* movie did present some of the difficulties of operating on the Martian surface. Apollo missions met similar challenges with steep temperature gradients, dust and radiation limiting the duration of mission activity to days.

So I would offer that the fragile, underfunded and often misunderstood space exploration enterprise needs to stay conservative, to stick with what has worked to allow it to make steady progress in a stepwise fashion for the past sixty years. The entry of a charismatic personality with a personal agenda is *not necessarily aligned with the best interests of this enterprise*. If SpaceX has a bad quarter, or another accident, or fails to win a contract, or changes management, its focus will change. No company is capable of making the continuous multi-decade investment necessary to realize even a small fraction of these goals. Public-private partnerships also have their limits and time frames. Any billionaire with deep pockets also has his or her limits.

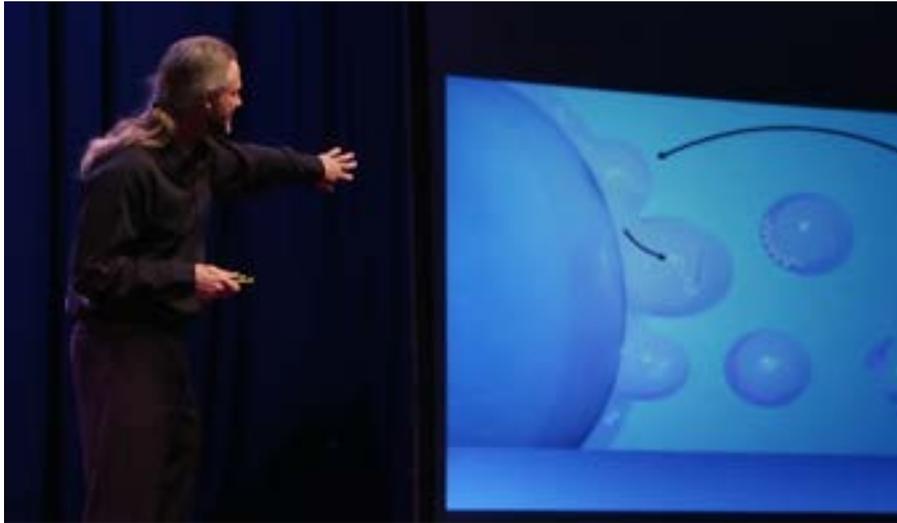
In conclusion I don't think we can put the cart before the horse. We need to proceed as we have done in the past and we may have no other option. We are nowhere near to sending people to Mars but let's cheer SpaceX if within the next decade they are able to send a remote controlled uncrewed Dragon to Mars orbit and another to the surface (at its own cost or with NASA help). If this happens it will open all of our imaginations. Adding people, supplies, living quarters, shielding, and return fuel to this Red Dragon will make it much bigger, costlier and give us all an idea of a real road map for such a modest but high risk mission, perhaps still possible in some of our lifetimes. Colonization, or perhaps more accurately longer term surface stays, may come up as a real possibility in the lifetimes of some of our grandchildren.

Perhaps in the end *Nature will reward courage*.

Postscript: the origin and purpose of life, linked to a sustainable presence in space

Yes *Jason Keehn*, the theme of my other TEDx talk is on the origin of life. As you will see at the end, in its bio-reactor variant, SHEPHERD is potentially a mechanism for creating Earth's double, like a kind of planetary cell division. In fact, if we want to live sustainably in the solar

system, we must bring some part of the biosphere with us. In this way we will enable a path forward for complex, intelligent life, which evolved on the Earth against all odds over four billion years. Would this not be a real purpose and a great mission for humanity that honors the rarity and beautiful outcome of our biosphere? And lastly, I offer that the project of learning to build space-based habitats and biospheres to sustain them will teach us how to better manage our home biosphere, the Earth. Find the link to this TEDx talk below:



In the Beginning: The Origin & Purpose of Life | Dr. Bruce Damer | TEDxSantaCruz

Are we compelled to become an interplanetary species?

Scientist and designer Bruce Damer thinks so. In this philosophical talk he elaborates on a new theory of the origin of life, and makes the case that the future of all life on earth lies in complete, and radical, collaboration.

<https://www.youtube.com/watch?v=6qiW4aUqtvA>

Concluding remarks and call for support

Thank you all for your comments, critique, and confidence and for just taking a look. If you would like to be involved, I really need a team to join Peter Jenniskens, Julian Nott and myself to test and develop the idea of SHEPHERD further. If we can build a strong case we can conceivably walk in the door for a meeting with Elon, or Elon's team or anyone willing to listen. This idea is right now just a concept on paper but it is an informed concept. Our team has expertise in the properties of asteroids, spacecraft and mission design, and the engineering of balloon enclosures.

Note: the SHEPHERD concept was proposed for funding to NASA under the Asteroid Redirect Mission (ARM) program in April of 2014. Please see the link to the technical proposal and a later NewSpace Journal article below.

Offer to present

Our vision is also informed by the passionate belief that we can unlock space-based resources for a truly sustainable architecture and the future economic viability of human presence in the solar system. We put forth that this one invention, SHEPHERD, may be the key to accomplishing that. The three co-inventors can't move this to the next step but an expanded team could. Earth-based research needs to be funded and test flights flown with released targets in low Earth orbit. We need fifteen years or so to prove the viability of this concept before then bringing an nearby small space rock back to LEO for science. When that is accomplished we may have a clearer idea of a path forward to encapsulate, relocate, and harvest resources from larger objects farther out, for science and the provisioning of fuel and other resources at key waypoints. Then and only then will we be ready to "go forth".

I am happy to go forth anywhere to give the talk, and tell the story of SHEPHERD.

This thread is an appeal to anyone out there who is drawn to this. My most concise telling is my nine minute TEDx talk:

<https://www.youtube.com/watch?v=wLMHcUg36yc>

Feel free to reach me directly at my email address bdamer@digitalspace.com.

Final posting Oct 19, 2016: for another view, here is science fiction author Kim Stanley Robinson's take on Elon's announcement:

Kim Stanley Robinson says Elon Musk's Mars plan is a "1920s science-fiction cliché"

<http://boingboing.net/2016/10/17/kim-stanley-robinson-says-elon.html>

Additional Resources

SHEPHERD paper in NewSpace Journal (March 2015):

<http://online.liebertpub.com/doi/abs/10.1089/space.2014.0024>

Direct link to PDF of SHEPHERD paper:

<http://www.digitalspace.com/papers/SHEPHERD/Jenniskens-Damer-et-al-SHEPHERDspace20140024.pdf>

BAA funding proposal to NASA for the Asteroid Redirect Mission (ARM) in April 2014:

<http://www.digitalspace.com/papers/SHEPHERD/SHEPHERD-12-BAA-Proposal-NASA.pdf>

NASA Future in Space Operations (FISO) telecom presentation of SHEPHERD by Jenniskens & Damer (June 2015):

<http://spaceref.com/missions-and-programs/nasa/nasa-fiso-presentation-shepherd---a-concept-for-gentle-asteroid-retrieval-with-a-gas-filled-enclosur.html>

Longer SHEPHERD talk at Santa Cruz Del Mar Theater, Santa Cruz (December 2015):
<https://www.youtube.com/watch?v=BPPONPS4MS8>

DigitalSpace mission simulation and design work for NASA (1999-2013):
<http://www.digitalspace.com>

Dr. Bruce Damer's personal site:
<http://www.damer.com>

Dr. Bruce Damer contact: bdamer@digitalspace.com

End.