Unmanned Systems to Build Foundations on Mars (8.2)

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Problem

The problem is that Earth is not going to last forever, humanity needs to find a new home. Another problem is that political & financials obstacles are not going to allow humans to migrate to Mars despite Musk's push, unmanned systems solution is needed. Unmanned systems to build foundation on Mars is the solution and the gist of this paper.

Mars is among Earth's closest habitable neighbors at an approximate distance of 140 million miles away from the Earth. It is averagely half far from the sun as compared to the Earth and, therefore, has enough sunlight. Its atmosphere constitutes mainly carbon dioxide, nitrogen, and argon, which means that it can support plant growth by compressing its atmosphere. With the correlations between Mars and Earth identified above and the political and financial constraints on Earth, relocating to Mars constitutes an exit plan, which calls for the construction of unmanned robots on Mars to establish a foundation for human survival. Despite many people interpreting first manned flight to other planets as a matter of time and adventure, NASA team and Elon Musk are working towards the tantalizing prospect of building and colonizing Mars. However, the operation of the unmanned systems on Mars from the Earth will require a reliable transportation system as facilitated by the starship spacecraft and the super-heavy rocket and several controls gathered in a highly collaborative manner to implement building on Mars, which is addressed by some projects solving the issue of building on Mars including the Mars Ice House and foster + partners Mars Habitat.

Interoperability Development

Interoperability between unmanned construction systems on Mars, satellites, and end-users on Earth needs to be identified, classified, improved and maintained. Figure 1 exhibits all

proposed system communications between devices and compares to interoperability of Predator UAS.

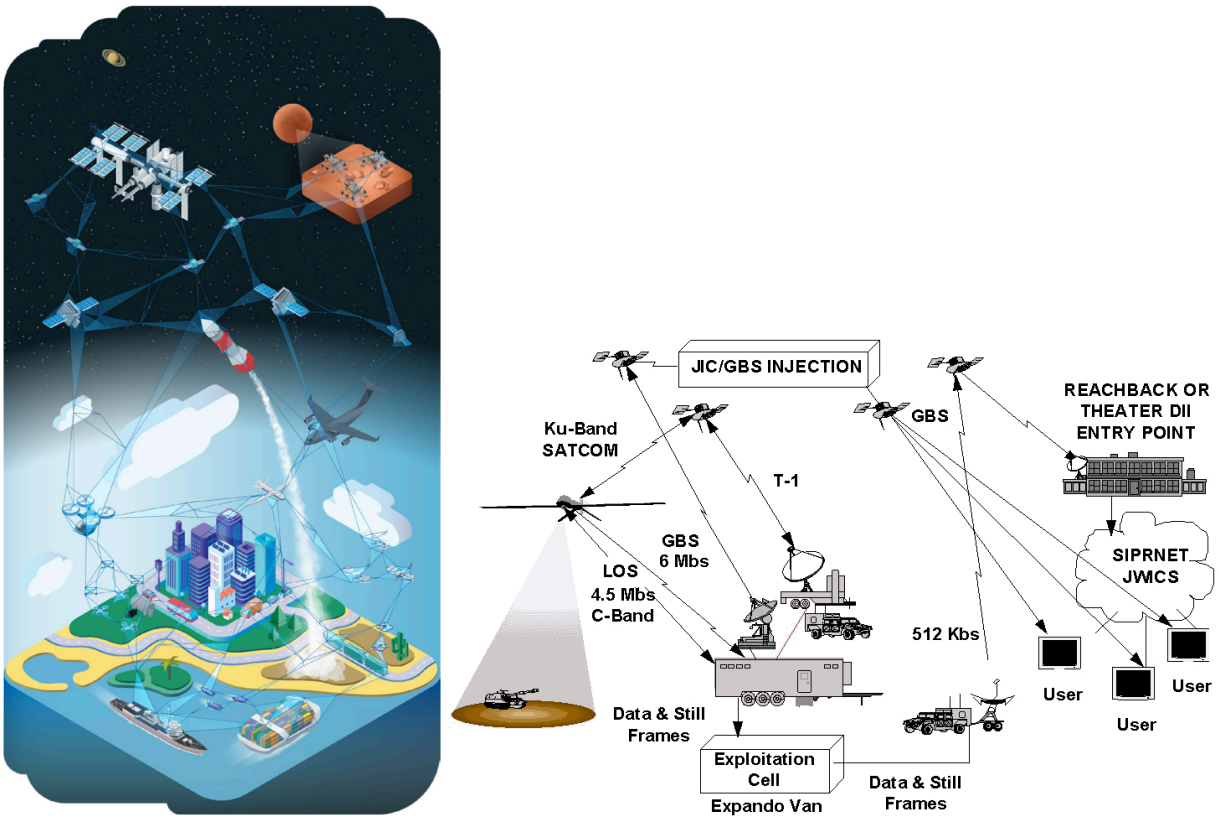

Figure 1: Mars & Predator Communications Schematic.

Interoperability control will be engineered and organized into a coherent flow tables between hardware, end-users, sensors, lasers, python programed software, gyroscopes, quality assurance standards, frequency channels, batteries, and other fuel sources. It is also imperative to consider situational awareness, positional coordinates, weather conditions, speeds, accelerations, mountings, C3, LOS, metadata from telemetry interpretation and prediction, densities of martian geo material, risk analysis during malfunction and mitigations. Innovation in the realm of

physics also needs to be taken into an account to forecast potential cost savings. Improvement in hardware sensors on board the unmanned martian concrete mixer/pourer (UCMP) machine need to be able to function in martian temperatures ranges -220F to +70F, as well as survive the vacuum of space during the trip to Mars. Sensors also need to survive enormous vibration at 5 million pounds of thrust that is generated by Falcon Heavy or SN9 rocket at lift off in Cape Canaveral, Florida.

Stabilization of flight is another area where innovation in interoperability shall be studied further. Blurry pictures are being transmitted due to turbulent flight or an unforeseen vibration caused by a gust of wind for example. Various smart gyroscopes with clever python/ai coding are being developed and allowing for the images to be captured via drone and transmitted to the user on the ground in better resolution. Dajiang company is leading the way in development of stabilizing camera in flight so it is better equipped in spotting moving objects on the ground both in visible and IR spectrum. However, on Earth government decided to ground these drones, but on Mars since it is still financially speaking and politically restricted to send humans to mars, proposed unmanned systems will fly and work to build foundations autonomously on Mars without any political restrictions. There will be policing or quality assurance drones that will work independently from the main motherboard and will communicate with the users on Earth directly.

Lasers for drones for construction and surveying purposes is another area of research that needs to be looked at. Drones are seeing advancements in technology and present an interesting

development of drones with lasers that cut matter with precision and accuracy from thousands feet away from the target, they can weld construction metal structural beams together via arc welding while in flight. They can also use those laser to measure differences in slopes on martian terrain for surveying purposes.

Rethinking sources of energy for nano drones is another aspect to this saga. From Lithium batteries to solar panels, advancement in fuel efficiency will take unmanned systems to use liquid Hydrogen. Phanton Eye is the first UAS that is already operating on liquid Hydrogen. Martian motherboard coded in ai/python will assemble and dis-assemble nano drone for different construction phases. Swarm of drones will operate on ultrasonic as well as internal electromagnetic fields powered by the laser coming from the ai motherboard on Mars. Nano drones will scout the most flat martian terrain, will crush the basalt, bring the geo-material to the hopper and will disassemble in mid flight to fly through tight squeeze areas and then re-assemble in mid flight to continue working like the army of flying ants on mars.

Flying through hard weather presents challenges for proposed system. Rain, dust storm, high wind, humid & freezing conditions, bright solar light, sun's rays also need innovative interoperability improvements on Mars. Novadem XM-70 is good example of innovative drone that flies through storms here on Earth.

Policing the construction drones on Mars via quality assurance drones is the last topic for this R&D. Several drones will be manufactured on mars for surveying, and quality control missions.

Basic capacities those administrator unmanned systems will report are approved construction data, and determination where to alter design or construction practices if necessary. They will also sort through uncertain/clashing data, build up trust and validity with each other, keep up adequate group attention to empower compelling coordination. In the event of a construction drone malfunction, these policing drones will adjust the requirement for sharing metadata against the risk of failures, these drones will select proper correspondence modalities for sharing data with Earth users and prompt other construction drones to evolve to save time/energy/materials. These QA/QC flying vehicles shall not be more than 15 pounds and they will report of any deviation among construction drones, they will identify odd patterns and relay information back to users on Earth directly. VINS-RGBD framework is already paving the wave for such frameworks to collaborate together and identify anomaly in Visual Inertial Odometry (VIO).

The numerous controls to implement building on Mars primarily entail interoperability development, which generally includes the improvement of duration messages take from Mars to Earth, stabilizing of flight, lasers for drones, energy sources for nano drones, and flying via hard weather of Mars. Presently, a signal takes six minutes to reach the Earth from Mars through satellites that utilize the speed of light. However, with the development in the telecommunication arena and the quantum entanglement that surpasses the speed of light, the innovative technology can reduce the duration to milliseconds (Federation of American Scientists, n.d.). The improvement of the sensor hardware also constitutes an integral part of building on Mars. Blurry pictures caused by destabilized imager by a gust of wind for example are the major obstacle to stabilized flight. However, a variety of smart gyroscopes with intelligent python coding are being

developed to overcome the situation by allowing for the images to be captured through drones and transferred to the operator on Earth in improved resolution.

Dajiang is among the companies striving to produce such stabilized cameras in flight that can spot objects in motion on the ground both in the visible and IR spectrum. The construction is also well-catered to by the development in laser technology with an amazing production of drones with lasers that can cut objects with accuracy from thousands of feet away from the target. They can weld the building metal structural beams together through arc welding while in flight. The construction on Mars will necessitate an enormous quantity of energy that is catered to by lithium batteries, solar panels, and Phanton Eye that operates on liquid Hydrogen, facilitated by the advancement in fuel efficiency. The swarm of drones will use ultrasonic and internal electromagnetic fields sourced by laser emanating from the ai motherboard on Mars. Dust storms, strong wind, humid and freezing conditions, and strong rays of the sun on Mars make its weather condition harsh for easy flights. However, the innovative interoperability improvements on Mars evidenced by the development of Novadem XM-70, an innovative drone that flies via storms on Earth, will facilitate easy flying through the harsh weather. Therefore, with the general advancement in technology as discussed above, the transmission of data between Mars and Earth, the sensing aspect, stabilized flight, sufficient energy, and flying through the hard weather is no longer a bother regarding building on Mars.

In terms of improving time for messages from Mars to Earth, currently in takes 6 minutes for signal from Mars to reach to Earth via satellites via speed of light. With the advancement in telecommunication realm and quantum entanglement at the faster than speed of light (FLT), there by surpassing the speed of light, innovative technology could cut that time down to milliseconds.

Spinning opposing electors one on Earth, the other one on Mars, since they share quantum state on Earth if one will be delivered to Mars it will show same information once transported to Mars. Two particle have same information, distance does not matter. Although it has not been proven yet, but this is definitely an area of advancement.

Existing Proposals

Foster + Partners is a company that has joined the race to build on Mars and has already established a New Mexico, Spaceport America, purposely for private space travel companies. The company has developed an idea about producing a human habitat constructed by robots (Foster + Partners, n.d.). The idea utilizes 3D printing and semi-autonomous robots with materials being regolith that is mainly loose rocks, dust, and soil on Mars' ground (Foster + Partners, n.d.). The proposal scrutinizes numerous aspects of the project ranging from deployment to construction and operations. The habitat will be supplied in two phases before the astronauts' arrival (Foster + Partners, n.d.). Firstly, semi-autonomous robots will choose the most appropriate site and dig a crater of one and a half meters deep followed by the delivery of the inflatable elements that will lie on the dug crater to establish the settlement's core (Foster + Partners, n.d.). The system is designed to embrace flexibility to change due to unanticipated challenges by employing minimal human input and hinging upon the rules and objectives instead of the closely defined instructions.

The creation of structures fundamentally from the Martian ice is another possibility under investigation. The Mars Ice House project has developed a mechanism to turn subsurface

Martian ice into vapor (Construction Industry Data, n.d.). The vapor is then converted into liquid water and applied to print solid structures in an environment that is cold enough to turn to sold ice immediately (Construction Industry Data, n.d.). The construction is projected to commence before the arrival of astronauts using digital procession techniques and semi-autonomous machines (Construction Industry Data, n.d.). Therefore, the Mars Ice House project has managed to define a deployment and construction sequence comprising the utilization of a forecasted Mars descent vehicle, a deployable membrane, and semi-autonomous robotic printers to harness and accumulate subsurface water ice.

Reachback or Theater DII Entry Point as exhibited in Figure 1 will be constructed or leased in Cape Canaveral, Florida for the purposes of this unmanned martian mission. Users will be all authorized individuals working from homes or offices depending on COVID restrictions. Garmin GNC 255 will be providing radio control, navigation features, and will look up frequencies and display on the user's screens so that communication will be in the correct frequency There shall be two channels, stand-by frequency will be used when the center frequency is occupied or in the event of emergencies. Grumman LN-200 IMU is a fiber optic gyro that will measure angle and velocities in the fixed martian coordinate system. Interoperability will also consist of ViaSat airborne modem transfer (AMT) that will allow for satellite communication technology between martian terrain and UASs, similar to what is used in US Navy today. EmerLinks III will allow earth based user to view video and images captured on Mars by unmanned construction robots and quality assurance/surveying drones, Miles Tek will provide connectivity to 5G network on Mars via ethernet, cabling, connectors, adapters, switching devices to connect all the unmanned systems on Mars. The signal from the drone on

Mars will travel from AMT to MMT to SMT to ISS to GMT here on Earth, providing clear images/videos of various construction and quality control phases of the very first foundation construction on Mars.

Unmanned Systems and Interoperability

The journey to Mars and back is catered to by the developments of the starship spacecraft and the super-heavy rocket. Both utilize a reusable transport system that refills on-orbit and powers them using Mars' natural water and carbon dioxide to refuel on the Mars' surface (SpaceX, n.d.). The refilling on-orbit facilitates the transmission of about a hundred tons to Mars. If the tanker ship achieves high capability of reusability, the propellant will account for almost the entire cost since oxygen and methane are quite cheap (SpaceX, n.d.). The starship will venture into Mars' atmosphere at 7.5 kilometers per second and slow up aerodynamically (SpaceX, n.d.). The vehicle is designed to endure diverse entries of heat with some ablation of the heat shield since it will be venturing into Mars' hot atmosphere (SpaceX, n.d.). Therefore, with the starship spacecraft and the super-heavy rocket, the transportation of any building materials in bulky and other necessary travels is guaranteed and within a short duration of time following is supersonic speed. MTS-B EO/IR Lynx Multi-mode Radar Multi-mode maritime radar Automated Identification System (AIS) SIGINT/ESM system will be used for communications relays. Robotic unmanned foundation construction system on Mars, which later could be used here back on Earth to construct foundations for residential/commercial buildings will be running off 5G network technology. Intuitive Machines already in talks to set up network on the moon. The process of foundation construction will be orchestrated by the main

motherboard which will control construction UAS, surveying drones and QA/QC/policing drone. Machines will construct a concrete plant on Mars, mine, grind, sieve, dig footings, pour concrete and even test a sample of 6”x12” cylinder for compressive strength. Machines will be sent via Elon’s Falcon Heavy rocket from the 39b launchpad in Cape Canaveral, Florida in July 2022. The rocket will enter into Earth’s orbit, then Sun’s orbit and 7 months later, the rocket will enter into Mars’ orbits. Figure 2 exhibit orbits through which unmanned foundation builder system (UFBS) in the rocket needs to travel to reach Mars.

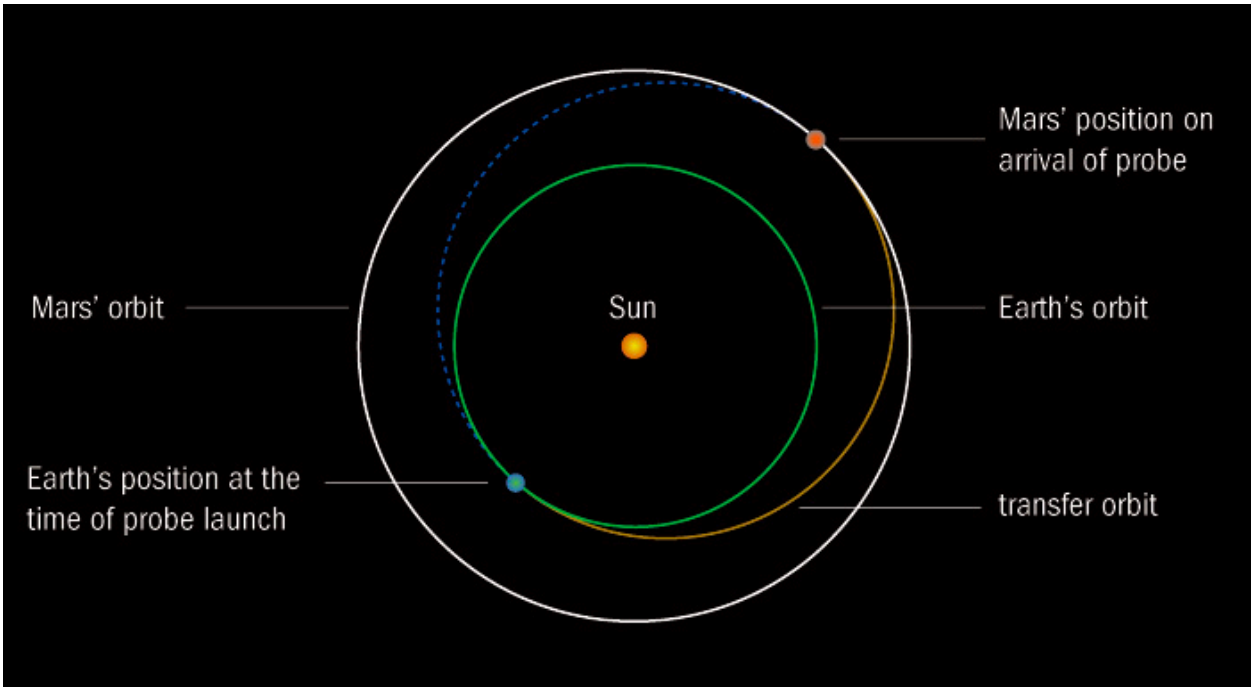

Figure 2. Path to Mars.

Autonomous rocket with UFBS payload on board will land in Vastitas Borealis near the ice caps. Machines will obtain and melt the sample icecaps in order to use that water to mix with cement and crushed basalt to make very first concrete mix on Mars via these proposed unmanned systems that will operate orders from the main motherboard. A sample geotechnical unmanned

system will be constructed in Cape Canaveral, it will crush basalt, melt ice, use sand, cement, water, and gravel, then pour cement into an excavated hole. Machines will perform standard penetration test, obtain N-values, and calculate for exact dimension of required size footing with a safety factor of 3. QA/QC/policing drones will fly autonomously scanning for the best martian terrain to build the first ever foundation for Elon's reusable rockets to land there. Another Machine will level the concrete and make a groove in order to prevent cracks. Figure 3 exhibits approximate location within the vicinity of Vastitas Borealis where the rocket with all of the unmanned systems and equipment on board will land.

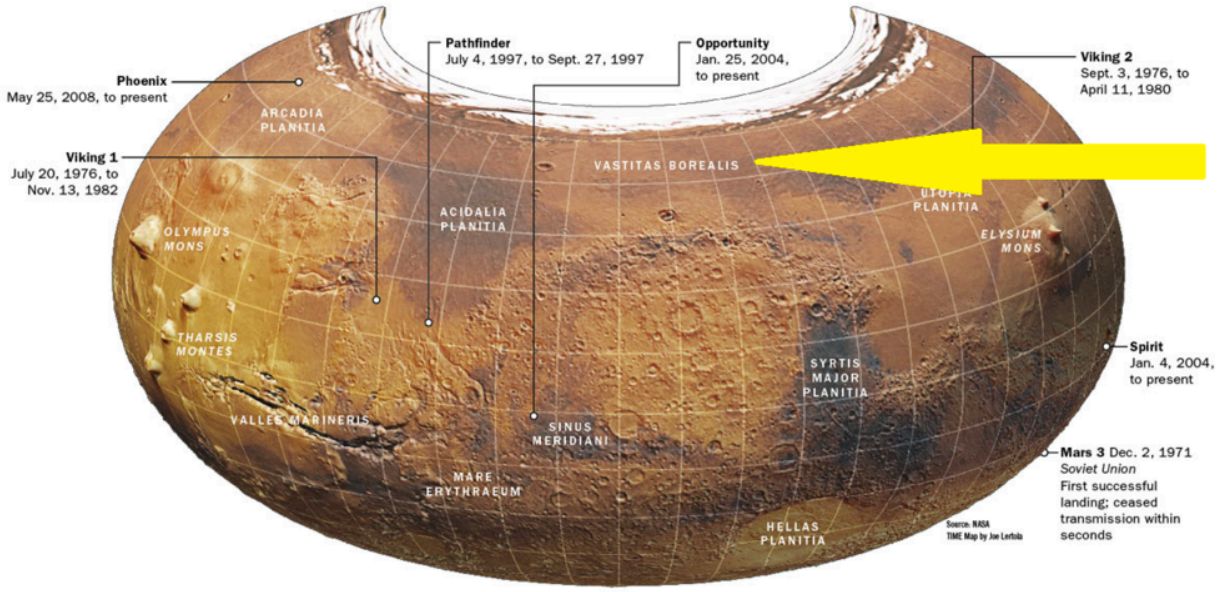

Figure 3. Map of Vastitas Borealis near martian ice caps.

Figure 4 exhibits a proposed de-icer unmanned system which will grab a block of martian ice and melt it into the red container, the red container is then transported to an unmanned autonomous mill. The interoperability between these systems needs to be programed, tested and

checked. An unmanned ground jack device will be manufactured on mars by the lead on the main motherboard to test martian soil for the moisture content, friction angle, shear strength. All these parameters are the vital key for foundation design in geotechnical engineering. Figure 5 exhibits a prototype of a ground jack penetrometer that will be hydraulically driven into the ground at desired depth and sensors on the cone tip will transfer meta data to a smart phone here on earth or to the main mother board work station, which will send these parameter to Earth users via satellite in martian orbit, to ISS to ground control users here on Earth. This device can be used here on earth for testing in-situ soil for further foundation designs. Patent pending.

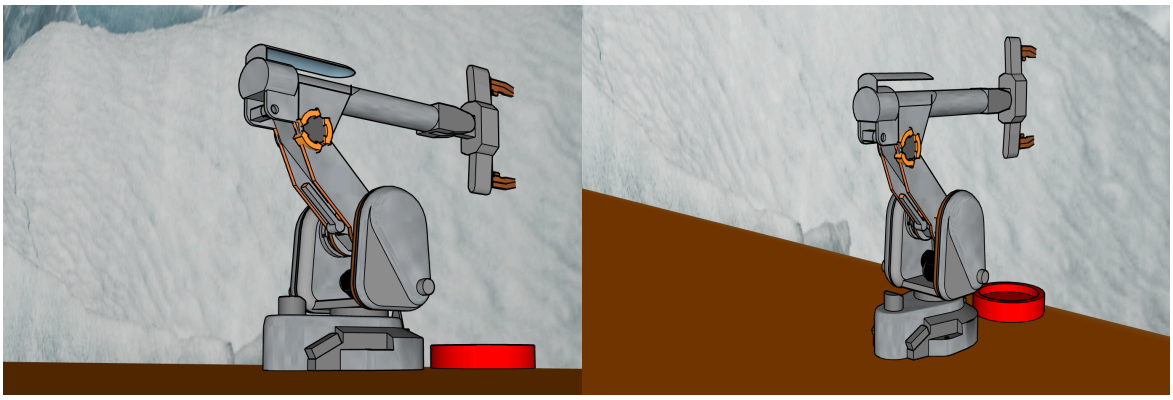

Figure 4. Illustration of unmanned Martian Ice Melter, proposed design.

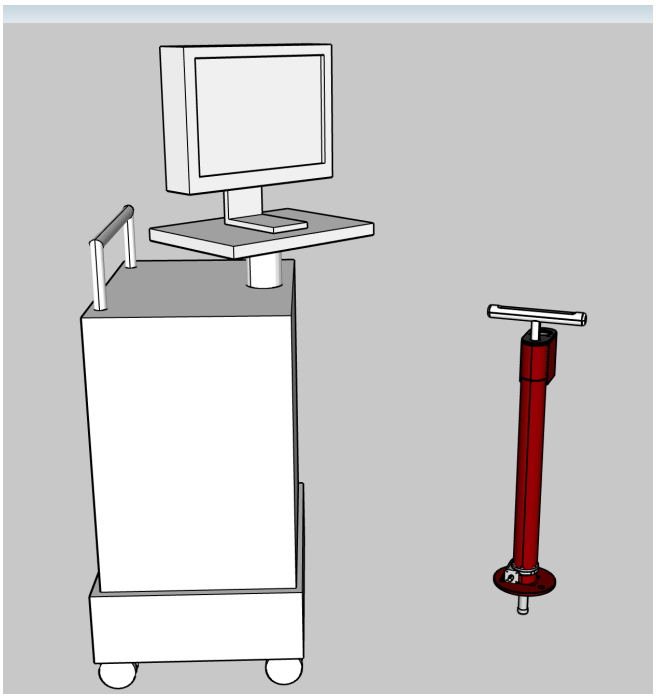

Figure 5. Prototype of hydraulic ground sensor, proposed design.

Figure 6 exhibits a proposed design of unmanned system which will gather water, crushed basalt sand, gravel and will pour a circular column on top of a square foundation footing. This unmanned concrete mixer/pourer (UCMP) machine will also be able to pour slabs 1 cubic foot at a time per hour. De-icer machine will be transported and placed near polar caps by UCMP. On board UCMP is a motherboard coded in python with an antenna receiver, allowing users on Earth to alter code between slab and column footing functions, which communicates with satellite orbiting Mars via International Space Station (ISS). Currently this is being re-designed for full autonomy and interoperability is being designed. The hopper will be loaded by unmanned excavator with basalt rock from a nearby quarry. The hopper will grind, sieve the #57 stone, fine, course sands and will manufacture martian cement, pozolonic reactions will occur during the mixture process similar to the chemical reaction here on Earth. On board this unmanned hopper there will be a navigation system that will be followed by the ACI and ASTM codes. This python

programmed maverick machine will determine the compressive strength of freshly maid concrete and also perform a compression strength test and send results back to Earth for further analysis. Excavated soil on Earth via this robot will be melted and cured into bricks to use for walls later on. Contract will be written with an Earth lot owner to rent this machine and pour foundation given present kips/loading of the desired structural loads. Machine will perform Standard Penetration Test, calculate for depth and width of a footing, will excavate, reuse soils, place rebar and pour concrete that it will mix in the hopper. Estimated time for entire foundation for a typical 2 story house 100 feet by 80 feet perimeter is 24 hours.

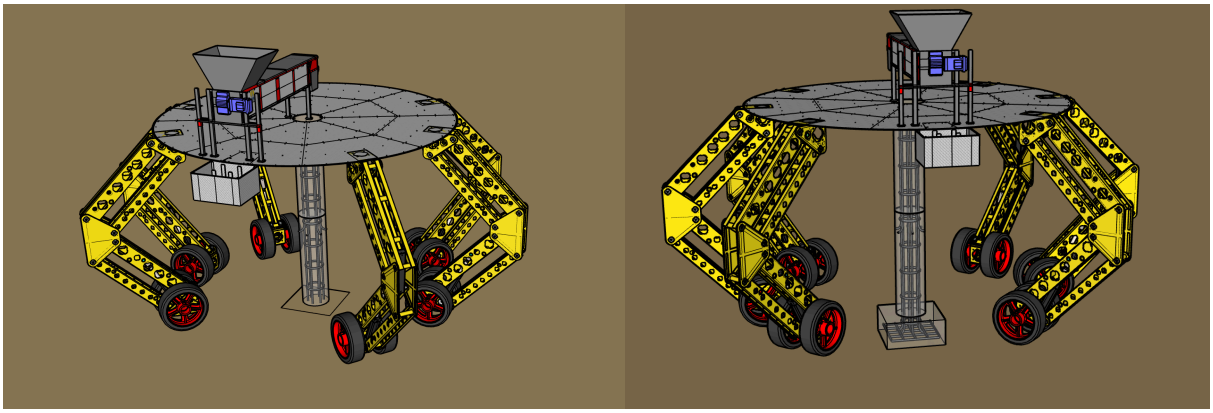

Figure 6. Illustration on footing installer unmanned system, proposed design.

Political Interoperability

It is important to note that political interoperability is a key to the success of this unmanned mission. Congress that would confine the homegrown utilization of robots here on Earth via the use of the Fourth Amendment: “The right of the people to be secure in their persons, houses, papers, and effects, against unreasonable searches and seizures, shall not be violated, and no

Warrants shall issue, but upon probable cause, supported by Oath or affirmation, and particularly describing the place to be searched, and the persons or things to be seized." On Mars, there are no people to monitor and no problems from people regarding too much monitoring, only drones, which would ultimately solve the problem of political interoperability. There will be unmanned "martian congressional" oversight via monitoring QA/QC drones. The operational hypothesis will utilize this current innovation to expand martian security while improving martian area endeavors.

Bill in Congress would expect police to tell the FAA how they would limit the assortment and maintenance of information inconsequential to the examination of a wrongdoing. During a pursuit, the utilization of a drone drastically builds security and leads to effective capture of the suspect. On Mars, if the construction drone is malfunctioning, QA/QC drones will send the data to the user on Earth to re-code the construction drone. Similar interoperability will be used on Mars; however, not between humans but between unmanned systems.

Conclusion

Building on Mars requires critical consideration of interoperability developments and innovations, a reliable transportation system, and several controls gathered in a collaborative manner to implement building on Mars. The interoperability development generally includes the improvement of duration information takes to and from Mars, stabilizing of flight, lasers for drones, energy sources for nano drones, and flying via hard weather of Mars. The development in the telecommunication arena and the quantum entanglement that surpasses the speed of light reduces the duration a message takes to and from Mars to milliseconds. Stabilized flights will be

ensured by the production of a variety of smart gyroscopes with intelligent python\ai coding to allow capturing images through drone and in improved resolution. The enormous energy for construction is catered to by lithium batteries, solar panels, and Phanton Eye that operates on liquid Hydrogen. The development of Novadem XM-70 will facilitate easy flying through the harsh weather on Mars. The controls to implement building on Mars is facilitated by projects such as Foster + Partners, which has developed an idea about producing a human habitat constructed by robots, and the Mars Ice House, whose objective is to develop a way to turn subsurface Martian ice into vapor for creation of structures. Finally, the starship spacecraft and the super-heavy rocket has availed a reusable transportation system to deliver building materials and necessary travels within a short duration of time following their high speed. Due to political and financial constraints here on Earth, people will not be on Mars for sometime, proposed design puts unmanned robots on Mars to construct foundation for when humans will finally arrive. From users here on Earth to the final concrete curing on mars, a lot of controls will be gathered in a very delicate ensemble to execute human's giant construction leap towards building on other planets.

References

Lorek, S. (2019). SpaceX to Mars City: How to Build on Mars. Trimble. Retrieved from https://constructible.trimble.com/construction-industry/spacex-to-Mars-city-how-to-build-on-Mars

Foster + Partners (n.d.). Architecture projects. Retrieved February from https://www.fosterandpartners.com/projects/Mars-habitat/

Federation of American Scientists (n.d.). Section 6 - communication integration and interoperability. Retrieved from https://fas.org/irp/doddir/usaf/conops_uav/part06.htm

SpaceX (n.d.). Mars & beyond. Retrieved from https://www.spacex.com/human-spaceflight/Mars/

R. Bloss, "Unmanned vehicles while becoming smaller and smarter are addressing new applications in medical, agriculture, in addition to military and security," Industrial Robot: An International Journal, vol. 41, no. 1, pp. 82-86, 2014. https://www.mdpi.com/1424-8220/19/10/2251/htm

Richard M Thompson II. Drones in Domestic Surveillance Operations: Fourth Amendment Implications and Legislative Responses. Congressional Research Service Report for Congress, 2012. last accessed: 19 February 2014. URL: http://www.fas.org/sgp/crs/natsec/R42701.pdf

Defense World (2019, February 13). France Gets 27 Novadem NX70 Micro Drones. https://www.defenseworld.net/news/25457/France_Gets_27_Novadem_NX70_Micro_Drones#.YBCco3dKhpI

NASA (2015, March 15). Is Warp drive real? https://www.nasa.gov/centers/glenn/technology/warp/warp.html

Cheng, Y., Johnson, A., and Matthies, L. 2005. MER-DIMES: A planetary landing application of computer vision. In IEEE Conf. on Computer Vision and Pattern Recognition, San Diego, pp. 806–813.

NPR (2020, January 29). Interior Department Grounds Chinese-Made Drones, Months After It Approved Them https://www.npr.org/2020/01/29/800890201/interior-department-grounds-all-of-its-drones-citing-cybersecurity-other-concern

Popular Mechanics (2013, February 28). See Boeing's Hydrogen-Powered Phantom Eye Take Flight https://www.popularmechanics.com/flight/drones/a8696/see-boeings-hydrogen-powered-phantom-eye-take-flight-15155089/

Defense World (2019, February 13). France Gets 27 Novadem NX70 Micro Drones. https://www.defenseworld.net/news/25457/France_Gets_27_Novadem_NX70_Micro_Drones#.YBCco3dKhpI

Reuters (2019, October 19). Got any signal up here? Nokia to build mobile network on the moon https://www.reuters.com/article/uk-nokia-nasa-moon-idUKKBN27418G

Northrop Grumman (2020, October 27). LN-200 FOG Family Advanced Airborne IMU/AHRS https://www.northropgrumman.com/what-we-do/air/ln-200-fog-family-advanced-airborne-imu-ahrs/

EL-IIITM Configuration and Operation Guide (2010, October 20). EnerLinksIIITM Video Data Link Configuration and Operation Guide https://apps.fcc.gov/els/GetAtt.html?id=172422&x=.

Federation of American Scientist (1996, December 3). Section 6 - communication integration and interoperability https://fas.org/irp/doddir/usaf/conops_UAS/part06.htm

Rook Andalas (2018, March 26). Mar 21 To Mars or Bust - Water on the Red Planet https://www.rookandalus.com/blogs/2018/2/12/to-mars-or-bust-part-v

File: 12+x+12+x+6+polycarbonte+guarding+enclosure.skp https://3dwarehouse.sketchup.com/user/152249875465137892975937 6/mk-Profiles?tab=products

Luxorion. Space Communications with Mars. http://www.astrosurf.com/luxorion/qsl-mars-communication3.htm

Robotics and Autonomous Systems - Ground (RAS-G) Interoperability Profile (IOP) (Version 2.0 ed.). Warren, MI, USA: US Army Project Manager, Force Projection (PM FP). 2016. https://ndiastorage.blob.core.usgovcloudapi.net/ndia/2016/GRCCE/Mazzara.pdf

https://noblis.org/wp-content/uploads/2019/09/10_AAS_Challenge-Interoperability.pdf

Boiney, L. Team Decision Making in Time-Sensitive Environments. In Proceedings of the 2005 Command and Control Research and Technology Symposium. Department of Defense Command and Control Research Program: McLean, VA, June 2005. https://apps.dtic.mil/sti/pdfs/ADA463813.pdf

Todd Humphreys. Statement on the Vulnerability of Civil Unmanned Aerial Vehicles and Other Systems to Civil GPS Spoofing. University of Texas at Austin, 18 July 2012. last accessed: 19 February 2014. URL: http: //rnl.ae.utexas.edu/images/stories/files/papers/Testimony-Humphreys.pdf

R. Bloss, “Unmanned vehicles while becoming smaller and smarter are addressing new applications in medical, agriculture, in addition to military and security,” Industrial Robot: An International Journal, vol. 41, no. 1, pp. 82-86, 2014. https://www.mdpi.com/1424-8220/19/10/2251/htm

Richard M Thompson II. Drones in Domestic Surveillance Operations: Fourth Amendment Implications and Legislative Responses. Congressional Research Service Report for Congress, 2012. last accessed: 19 February 2014. URL: http://www.fas.org/sgp/crs/natsec/R42701.pdf

John A. Wallace. Integrating Unmanned Aircraft Systems into Modern Policing in an Urban Environment. Master's thesis, Monterey, California. Naval Postgraduate School, 2012. last accessed: 19 February 2014. URL: https://calhoun.nps.edu/public/handle/10945/17474.

Homeland Security News Wire. "UASs Law-enforcement Technology." Homeland Security News Wire. August 8, 2012. http://www.homelandsecuritynewswire.com/dr20120808-drones-used-by-police-firefighters-raise-privacy-concerns

Solosky, Kenneth. "A Primer on Police Aviation." PoliceOne.com. September 27, 2008. http://www.policeone.com/police-technology/articles/1737278-Aprimer-on-police-aviation/