Intrinsyx Technologies Corporation

An Engineering and Information Technologies Organization

Position Paper

Tools and Capabilities for Space Development

February 11, 2008

Christopher A. Leidich
Director, Engineering
Intrinsyx Technologies Corporation
Christopher.A.Leidich@nasa.gov
cleidich@intrinsyx.com
650-604-6863 office
650-823-0925 mobile

Tools and Capabilities for Space Development

Threats and Needs in the Earth - Moon – Mars Neighborhood

Globalization has led to some unexpected surprises – one year ago China tested a missile by shooting up one of its own weather satellites. This has resulted in the worst-ever cloud of man-made debris in space, now a known threat forcing some satellites to be moved periodically to avoid the shrapnel.[1] Currently, sovereign-wealth funds are large, growing fast, and they are available to many countries (including hostile nations) - that can enable increased access to space.

At the end of January 2008, Asteroid 2007 TU24 came within about 344,370 miles of hitting Earth.[2] A day earlier, Asteroid 2007 WDS came within about 13,700 miles of hitting Mars.[3] An asteroid expected to fly past Earth in 2029 will be visible to the naked eye.[4] It is not if but "when" our Earth & our Moon will be hit again by a very large object. On average, 33 metric tons (73,000 lbs) of meteoroids & showers of meteoroids hit Earth every day, the vast majority of which harmlessly burns up high in the atmosphere, never making it to the ground.[5] The Moon and man-made space assets, however, have no protection from meteoroids.

There is also an immense amount of rubbish from man-made satellites (space junk) orbiting the Earth. There may be over a million pieces of space junk currently orbiting the Earth. However, all but 9,000 pieces of this junk are smaller than a tennis ball. This junk could be anything from jettisoned rocket stages or satellite fragments down to loosened paint chips.[6]

The US must further extend its leadership role to monitor (and possibly intervene as required) in the Earth-Moon-Mars neighborhood. The US must take the lead developing the capability of "re-directing" undesirable objects that pose a threat to Earth & critical orbital domains. On this issue, NASA needs to collaborate with other key organizations like DARPA, DHS, IARPA, and International Partners like Russia, India, China, ESA, and Japan.

The US must leverage and further develop expertise in robotics, satellites & information technology - to significantly improve effective surveillance and enable effective teleoperations & future capabilities in the Earth-Moon neighborhood. NASA/Ames Research Center and other key significant partners possess valuable skills for defining and developing tools & solutions to lessen space threats and better enable space development.

Tools and Capabilities – Virtual Environment Knowledge Database

Using all available data there should a collaborative development (involving NASA and other key significant partners) of a secure, Virtual Environment Knowledge Database offering a "gods-eye" view of all pertinent solar system non-manmade objects and manmade assets (of course there should be a military only version). A COTS software tool that is a great start in this direction is the Satellite Tool Kit® (STK) that provides a powerful astrodynamic and geometric engine for simulating and analyzing interactions among satellites, launch vehicles, missiles, aircraft, and ground vehicles.[7]

This Virtual Environment Knowledge Database should include activities & assets on the Moon, Mars, International Space Station (ISS) and asteroids. This tool would allow: visualization of reality, simulated reality & augmented reality (combined real-world and computer-generated data). A temporal adjustment should be available to cover the past & allow best known predictions for the future (e.g., the progress of Mars or asteroid activities).

Getting the big picture… As part of the Virtual Environment Knowledge Database, significant development in data and information visualization needs to be revolutionized - we need a simulated reality facility. The fictional holodeck on Star Trek is an example.

We need the creation of a complete database of all past, present & future planned civilian spacecraft. The knowledge of space scientists & engineers is significant. It is essential to capture past information & knowledge and integrate with the present and future. The development of a truly comprehensive knowledge database would be invaluable for NASA and other key agencies. This knowledge database would benefit the current & future generation of engineers and scientists.

This Virtual Environment Knowledge Database should include search technology via voice or other input including the use of Artificial Intelligence (AI) & "artificial" AI. Because of the quick Earth-Moon round-trip light time, artificial AI will complement AI. For example, future Astronauts should be able to use artificial AI and be able to search for information verbally via speech recognition and get rapid response back from a combination of computers & humans. Artificial AI is already used by amazon.com. They use a program called Amazon Mechanical Turk, through which a computer can ask humans to perform human intelligence tasks that it can't do itself such as evaluate beauty, translate text and find specific objects in photos.

> The greatest gain from space travel consists in the extension of our knowledge. In a hundred years this newly won knowledge will pay huge and unexpected dividends.
> *Wernher von Braun*

Tools and Capabilities – Advanced Robots

The Earth-Moon distance is only about a quarter million miles. Teleoperated robots are the perfect tool within the Earth-Moon neighborhood because the round trip light time is very small - roughly 3 seconds. We should develop advanced robots teleoperated by humans to perform key tasks such as:

a) Mining and processing key resources on near earth asteroids and the Moon such as soil and water
b) Re-directing objects (like asteroids headed towards Earth) and/or capturing objects (like resource rich asteroids) in space
c) Capturing/Transforming Asteroids - a captured asteroid could be transformed into a rotating space station/mother-ship with a propulsion system for orbit around Mars or as an outpost, e.g., between the Earth & Moon or at a Lagrangian point
d) Implementing Lunar and large asteroid construction projects such as: underground habitat centers including hotels; surface & subsurface railways; space-ports including electromagnetic rail launchers; and facilities for the collection/production and distribution of things such as: electrical power, water and fuel
e) Packing & unpacking cargo vehicles
f) Building/fixing/servicing other robots and other assets such as: small satellites and astrophysical observatories

The combination of real world and computer generated data (augmented reality) could and should include real actions of teleoperated robots using the Virtual Environment Knowledge Database tool. Imagine a builder using the Virtual Environment Knowledge Database tool on a computer in the Silicon Valley or by an astronaut onboard the ISS actually doing real space construction on an asteroid with a teleoperated robot. Having teleoperated robots doing specific tasks lowers costs and eliminates safety issues by having these tasks done by astronauts at the construction site.

We should develop self-replicating robots using evolutionary strategies. These robots could initially be self-assembling and eventually self-fabricating. In large numbers, these robots would be essential for planetary engineering. These kind of robots would really lower the cost of making & servicing satellites.

The ability to affordably replace damaged or inoperable space systems on short notice with satellites and low-cost launchers is currently not possible. The use of space to support tactical operations (scientific, commercial or military) is largely not possible. Our launch/satellite industry deployment methods need to be moved from an artisan-like environment to a production-oriented, agile environment.

Advanced robots will enable human occupied facilities at locations such as the Moon and asteroids to be more self-reliant and "live off the land" as much as possible. Surface activities done by teleoperated robots will be cheaper & safer than being performed by humans.

CONCLUSION

It is surprising that NASA is being so under-funded to do so many things - all in a time when so many countries are launching satellites and where India, China, Japan and Europe have launched, or are planning to launch spacecraft to the Moon and places beyond.

Europe's Small Mission for Advanced Research and Technology (SMART)-1 spacecraft was orbiting the Moon beginning in November 2004 and successfully impacted the Moon at 0542 GMT, September 3, 2006. One observation of this impact is at www.cfht.hawaii.edu/News/Smart1.

"Smart 1 will now rest in peace on the Moon. We are now collaborating with the international community, preparing the way for the future exploration of the Moon - the next fleet of orbiters, landers; leading to robotic villages and human bases."
Spoken on 9/3/06, by Professor Bernard Foing the missions project scientist from ESA

In the "space race" of the early 1960s, when reporters asked Wernher von Braun what he expected to find on the Moon, he jokingly replied: "Russians." Nowadays, his answer would likey be: "Indians, Chinese, Japanese and Europeans." [8] India, China, Japan & Europe all have plans for sending humans to the Moon. Their goals will include tasks ranging from mapping minerals to seeking ice from which future astronauts might extract drinking water. More distant goals include looking for a mineral called ilmenite that some experts think is rich in an isotope called helium-3. *In theory, that isotope could be shipped to Earth and burned in futuristic nuclear fusion reactors".* [8] Shouldn't the United States be retrieving this mineral first?

For the benefit of America and all of mankind, NASA should be funded to collaborate with key significant partners to enable greatly improved situational awareness in the Earth - Moon – Mars neighborhood and to establish the tools & capabilities to enable space development and elimination of significant hazards.

REFERENCES

[1] "Dangerous Driving in the Heavens," The Economist, January 19th-25th 2008, Page 13

[2] http://neo.jpl.nasa.gov/news/news157.html

[3] http://www.itwire.com/content/view/16437/1066/

[4] http://www.space.com/spacewatch/050204_2004_mn4.html

[5] http://www.nasa.gov/centers/marshall/news/lunar/program_overview.html

[6] http://www.bbc.co.uk/science/space/solarsystem/earth/spacejunk.shtml

[7] http://www.mathworks.com/products/connections/product_main.html?prod_id=284&prod_name=Satellite%20Tool%20Kit%20(STK)

[8] "World's nations will shoot for the Moon in the next decade" - Keay Davidson, Chronicle Science Writer Sunday, March 5, 2006