Lunar Development Lab (LDL) Concept
Leading to the First Human Lunar Outpost

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• FDL is an applied AI research accelerator that uses interdisciplinary teams to solve challenging problems for space science and exploration.

• FDL is a PPP between NASA, SETI and the commercial sector with key partners in AI/ML such as, Google, Intel, IBM, and Nvidia.

• FDL is in its 4th year and has established an impressive success rate for research output. Research outcomes are regularly accepted to respected journals and scientific conferences.

• Over this time, FDL has developed 17 AI applications in heliophysics, exoplanet discovery, lunar exploration, astrobiology, earth science and planetary defense.
AI for Lunar Development and Exploration

NASA FDL has a growing suite of AI tools for lunar development and exploration:

- Automated crater identification for lunar mapping
- Rover localization using onboard cameras
- Co-operative robotic methodologies for polar prospecting/traverse planning

Challenges are chosen to identify closely with the National Space Exploration Campaign’s strategic goals, specifically:

- Lead the emplacement of capabilities that support lunar surface operations and facilitate missions beyond cislunar space

Partners in FDL’s past Lunar AI projects included:

- Intel, Google and HP
- Luxembourg Space Agency/Space Resources
- XPRIZE Foundation
Lunar Resource Mapping Challenge for 2019

FDL Opportunity

• It is estimated that billions of tons of metal (nickel-iron-cobalt) meteorite fragments could exist on the Moon. There also have not been any missions that specifically looked for evidence of M-class impactors.

• These lunar resources may be exploited through ISRU capabilities to build infrastructure on the Moon, such as lunar habitats.

• Higher resolution resource maps can aid mission planners to locate resources for ISRU in future robotic and human lunar missions.

FDL Challenge
Investigate existing data sets from multiple missions to develop a high-resolution resource map of potential metallic deposits from M-class impactors.

• LRO’s LROC WAC and NAC visible images
• LRO’s Diviner imaging radiometer datasets
• LRO’s Mini-RF data
• Clementine’s UV-VIS dataset
• CNSA Change’E-1 and Chang’E-2 microwave radiometer data
• ISRO Chandrayaan-1 Mini-SAR
• JAXA Kaguya Radar Sounder

Lunar Thermal Anomaly Distribution shows 266 hot/cold spots, from 60N to 60S (Zheng, et al, 2014)
Lunar Development Lab (LDL)

Purpose:
• To bring together experts from academia, industry and NASA in an accelerator environment to advance lunar development sufficiently that leads to a sustainable and economical human lunar outpost as well as the creation of a new thriving, cislunar economy.

Approach:
• Generate new design solutions, technologies and architectures leveraging lunar resources as much as possible.
• Develop design solutions and architectures for infrastructure systems including power generation and storage, communications, navigation, surface mobility and life support systems
• Build and test prototype hardware in a simulated environment to reduce technical and operational risk.
• Use AI and machine learning technologies and other advanced tools to quickly process data and optimize design solutions
• Use economic analysis tools to compare designs and architectures to work towards economic and sustainable solutions
Draft Challenge Areas

1. **Lunar architecture designs** which integrate lunar resources into the design of surface systems, human habitats and life support systems.

2. **Infrastructure system designs** for power generation, communications, navigation, thermal management, landing pads and radiation shielding.

3. **Lunar mining techniques** and resource production estimates for key raw elements, e.g. H2O, O2, Si, Ti, Al

4. **High-definition lunar resource mapping** and modelling of minerals, metals and rare-earth elements.

5. **Economic analysis of resource production techniques** and competing lunar architectures

6. **Lunar base radiation ‘safe haven’ architectures** which uses supercomputer simulations of lunar magnetic anomalies
Road From LDL to First Human Lunar Outpost

Integrated Design Solutions

Prototype Hardware and Ground Testing

Low-Cost Flight Demonstrations

Buildup of Initial Elements Human Lunar Outpost
Next Steps

- Define lunar resource challenge areas for initial LDL 1.0
- Establish public-private partnerships to help sponsor teams in an accelerator environment
- Select PI’s to lead research objectives challenge problems and technical team.
- Solicit highly-qualified and motivated researchers and mentors to participate in LDL 1.0
- Prepare data and tools that researchers will need to address challenge problems
- Implement LDL research sprint sessions by FY 2020
THANK YOU!

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