NASA Mini Moon Rover Payload

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| **Concept** | **Pros** | **Cons** |
| Ferritic material resource finding | Feels feasible and potential for innovation   * Not too difficult to miniaturize * Can work while fully contained in payload space (i.e. no deployables) * Would be continuously useful during rover operation | Might be a little difficult on the E&M side of things   * Precise feasibility can only be gauged through some E&M calculations |
| Miniaturization of solar cell prototype | Ambitious and potential for innovation   * Idea development could possibly pave the way for innovative new moon energy tech options * If small enough, a prototype could be “snuck” into another payload design or onto another moon-destined thing | Might not be best suited to a *rover* payload   * Dubious value as a *primary rover payload*, like concept seems better suited for moon-environment prototyping as a small hitchhiker on another thing going to the moon * Legally can’t use any patented solar cell designs |
| Lunar dust charge monitoring | * Concept would be continuously useful during rover’s life | * Need to research whether tech is reasonable to miniaturize |
| Solar “weather” monitoring | Potential to be very useful   * Concept would be continuously useful during rover’s life * Concept development could pave way for future lunar solar “weather station” tech | Not sure yet about its feasibility   * Need to research what tech exists to realize concept functionality * Need to research whether tech is reasonable to miniaturize |
| Experimenting/ prototyping with magnetic field generation | Ambitious and potential for innovation   * Concept development could pave way for future solar wind protection tech | Might not be possible   * Dubious about whether it’s possible to make a sufficiently strong yet small magnetic field generator |
| Mapping regolith resource composition | Ambitious and valuable   * Would be continuously useful during rover operation * Addresses a very valuable need | Not sure yet about its feasibility + dependent on deployable   * Would need to deploy something to scoop regolith into payload for processing |

Ranking:

Favourite ideas

* Finding ferrous resources/micro-particles!

Nixxed ideas

* Dust charge monitoring
* Solar wind monitoring

# Concept 1: Locating ferrous micro-particles - Kelsey

**Need:** Future lunar mining efforts need to know where ferrous materials are

**Available technology:**

Fluxgate magnetometers and magneto-inductance sensors are typically very small sensors that generate magnetic fields and sense how the fields change due to interaction with things like ferrous materials. Using E&M principles, could reasonably calculate the size of the smallest particle that could be sensed from a distance of 6.5 cm from the lunar surface.

<http://www.ti.com/lit/ds/symlink/drv425.pdf?HQS=TI-null-null-mousermode-df-pf-null-wwe&DCM=yes&ref_url=https%3A%2F%2Fwww.mouser.ca%2F&distId=26>

* Can operate within temperature range expected on lunar surface!
* Small 4mm x 4mm chip!

<https://www.aichi-mi.com/e-home-new/highly-sensitive-magnetometers/type-dh/>

* Small 35 x 11mm weak magnetic field sensor. Operating temperature range of -20 to +60 C

<https://www.mt.com/ca/en/home/library/know-how/product-inspection/metal-detector-sensitivity.html>

Fluxgate magnetometers are known to degrade over time: <https://www.nasa.gov/feature/goddard/2017/nasa-technologist-develops-self-calibrating-hybrid-space-magnetometer>

**Concept:** Drive around sensing magnetic fields of moon material, reporting locations of high magnetic field activity that could indicate locations of ferrous materials

**Anticipated benefits:** Knowing where high-abundance ferrous resource deposits are

# Concept 2: Miniaturization of a low weight/high efficiency solar cell prototype design to test on moon - Jordan

**Need:** Some guys developed a low weight/high efficiency solar cell prototype that holds the potential for being leading edge lunar solar power technology. Developing it into a payload-sized prototype could help pave the way for using the technology on a larger scale for generating moon power

**Previous research:**

The guys who designed the cell: <https://www.pv-magazine.com/2020/04/14/six-junction-iii-v-solar-cell-with-47-1-effiency/>

Their research paper - <https://www.researchgate.net/publication/340611789_Six-junction_III-V_solar_cells_with_471_conversion_efficiency_under_143_Suns_concentration>

**Available technology:**

Ful six-junction design was published less than a month ago

**Concept:**

Six-junction III-V GaAs solar cell with germanium substrate test on the moon

**Perceived benefits:**

More moon energy = more moon fun.

**Notes:** ~~Did they patent it? Shouldn’t use a patented design because of legal problems…~~ COULD NOT FIND A PATENT for six-junction. If we go ahead with this though there are many multilayer PV techs to try avoid.. Not like we’d be making millions off it anyway. <https://patents.justia.com/patents-by-us-classification/D13/102>

# Concept 3: Lunar dust charge monitoring - Kelsey

**Need:** Electrostatic charge of lunar dust influences how badly it “sticks” to equipment and future people. Charge varies daily, as influenced by solar wind intensity during the day.

When moon passes through earth’s magnetotail, it can generate big dust storms and electrostatic discharges on moon. Most importantly, magnetotail moves around a lot, and can sweep across moon many times as moon passes behind earth.

* <https://www.nasa.gov/topics/moonmars/features/magnetotail_080416.html>
* “The moon can be just sitting there in a quiet region of the magnetotail and then suddenly all this hot plasma goes sweeping by causing the nightside potential to spike to a kilovolt. Then it drops back again just as quickly.”
* “The roller coaster of charge would be at its most dizzying during solar and geomagnetic storms.”
* “No one can say for sure what happens on the moon when the magnetotail hits, because no one has been there at the crucial time.”

**Previous research:**

Lunar dust electrostatic charging:

* <https://www.nasa.gov/centers/johnson/pdf/486015main_StubbsSurfaceCharging.4070.pdf>
* <https://agupubs.onlinelibrary.wiley.com/doi/pdf/10.1029/2005RG000184>

**Available technology:**

Faraday cups have been used to measure charges of aerosols: <https://link-springer-com.ezproxy.library.uvic.ca/article/10.1007/s11814-010-0378-1>

Charge magnitudes are again measured using a Faraday cup: <https://agupubs.onlinelibrary.wiley.com/doi/pdf/10.1002/2017GL072909>

* “The magnitudes of charges on the dust particles were measured using a Faraday cup apparatus that consistsof an inner cup coaxially embedded in an outer cup (Figure 1). A voltage of ±3 kV was applied to the outer cup in order to accelerate -/+ charged dust particles from the surface to enter through a small hole (1 mm indiameter) into the inner cup where their image charges were measured with an electrometer.”

A very tiny Faraday cup: <https://www.tedpella.com/technote_html/651-TN.pdf>

* 2.5mm diameter, 2mm height
* (Looks like Faraday cups in general are very small)

**Concept:** Could...somehow use a faraday cup to measure electrostatic charge of moon dust.

**Perceived benefits:** Not sure what kinds of conclusions could be drawn from data or how, but it would still be useful data for understanding the electrostatic nature of the moon given that that’s currently a big unknown.

It could possibly help with making decisions about when to keep equipment and future people safe from ultra-sticky/ultra-charged dust days.

# Concept 4: Lunar “solar weather” monitoring - Kelsey

**Need:** Solar wind outbursts are a significant hazard to stuff on the moon, especially future humans, so being able to forecast dangerous solar events, particularly while away from a safe home base, can help prevent damage.

**Previous research:**

Measuring the solar wind with Faraday cups: “The conventional Faraday cup is applied for measurements of ion (or electron) flows from plasma boundaries” (wikipedia)

**Available technology:**

Idk :(

**Concept:**

**Perceived benefits:** Ability to make decisions about when to keep equipment and future people safe from high-radiation events

**Things that need to be answered:**

* How is the solar wind intensity measured?
  + Faraday cups?
* How do you draw conclusions from data collected?
* What kind of data needs to be collected to draw meaningful
* How would one measure the electrostatic charge?
  + “There are at least three instruments we can use to measuring static: electrostatic fieldmeters, Coulomb meters used with Faraday cups, and non-contacting electrostatic voltmeters”
  + <https://www.pffc-online.com/static-beat/8180-0401-measure-static-charge>

# Concept 5: Generating a magnetic field - Scott

**Need:** Lunar missions need protection from cosmic radiation

**Available technology:**

* Simple electromagnets can be used to produce magnetic fields
* A spin-off of the Faraday Effect means that a magnetic field can be produced by manipulating the polarization of light travelling through a magnetic material.
* It may be possible to focus the sun’s light rather than drawing power from the rover, thereby increasing the system’s sustainability.

**Concept:**

Send a team of three payloads: one generator and two solar weather stations (see Concept 3). Weather Station A (WS-A) remains near the generator while WS-B drives away and measures the decrease of magnetic protection / increase in radiation incidents relative to WS-A. If we want to determine the effectiveness of each method of producing magnetic fields, we could duplicate this experiment but with WS-A boasting an alternative generation technology.

**Anticipated benefits:**

* Having a better concept of how feasible it would be to generate a magnetic field during future missions.
* Knowing which, if either, form of generation technology is most efficient and effective.

**Some links:**

Manipulating light polarization

* <https://www.researchgate.net/publication/232257629_Manipulating_light_polarization_with_ultrathin_plasmonic_metasurfaces>

Transparent but magnetic and conductive materials

* <https://onlinelibrary.wiley.com/doi/abs/10.1002/pssa.201300560>

Inverse Faraday Effect

* <https://iopscience.iop.org/article/10.1088/1367-2630/18/7/072001/meta;jsessionid=AF404F195513DC69BA4777FF7E368CBF.c2.iopscience.cld.iop.org>

Magnetic shielding from galactic radiation

* <https://aip.scitation.org/doi/10.1063/1.5109560>

**Notes:** Concerns about ability to miniaturize

# Concept 6: Determining the chemical makeup of regolith (Aila)

**Need:** To assist in the locating of minerals and various valuable deposits on the lunar surface

**Previous research:**

- Device already has small version, just have to build a system to collect and process sample: <https://www.hamamatsu.com/resources/pdf/ssd/mini-spectro_kacc0002e.pdf>

- Example of evaluating iron: <https://carleton.ca/chemistry/wp-content/uploads/speclab.pdf>

- <http://www.liskeard.cornwall.sch.uk/images/Liskeard-Sixth-Form/Atomic-Absorption-Spectrometry.pdf>

- Efforts have been made (and were successful) to shrink mass spectrometers:

<https://cen.acs.org/analytical-chemistry/mass-spectrometry/Mini-mass-specs-still-looking/96/i22>

<https://en.wikipedia.org/wiki/Miniature_mass_spectrometer>

* NASA already has small mass spectrometers (sent to Mars) so if they wanted this technology on the moon they would have it
* Technology likely patented and inaccessible to us

**Available technology:**

**Concept:**

**Perceived benefits:**

**Notes:** Not sure if we’re allowed to extend a scooper collection tool