Sun, Aug 17, 15:00-16:00, rm 431-432, 2025 Seattle WorldCon Panel SPA02 ***The Moon Is Nigh Cislunar Exploration in 2025***: "Lunar activity is ramping up, as several nations send spacecraft past the Moon, around the Moon, or onto the Moon in a new wave of exploration. Our panelists discuss recent, ongoing, and upcoming missions--then consider their significance in a bigger picture, expanding human knowledge of the Moon and extending lunar capabilities for further exploration or exploitation."

Bob Hranek (mod), **Dan Dubrick**, **David Brin**, **Michael Nayak**, **Michael Ravine**

[My career began with 6 years of USAF Computer Programming plus 34 more years as an Aerospace Systems Engineer. Since I was a Defense Contractor for the Intelligence Community, I'm usually depicted as representing *the Dark Side* on panels. Hence my 'Protogen' name plate, which fans of ***The Expanse*** will understand. That being said, I do NOT speak for ANY of my employers! My role on this panel is to add my Military-Industrial Aerospace experience. I OVERprepare for all my panels, so if you'd like my file regarding Cislunar Exploration, then just email me at BobHranek@gmail.com]

Background: Lunar Colonies: Could We Live On The Moon? NSS's good 52-min 2025/05 YouTube relevant for our panel.

1. Jim Lovell's answer about the utility of returning to the Moon: "Imagine if Christopher Columbus had come back from the New World and no one returned in his footsteps."
2. **Space Sample-Return Missions**
    a. 1969-72 six Apollos, totaling 382 Kg of lunar rocks, core samples, pebbles, sand & dust from lunar surface.
    b. 1970-76 USSR's Luna 16 (drilled 35cm down), 20, & 24, returned about 300g of lunar soil.
    c. 1999/02/07 NASA Stardust flyby of Wiki2 comet collected dust on silica panels, returning >10,000 particles, which included the amino-acid glycine.
    d. 2003 & 2014, JAXA Hayabusa 1 (crashed into asteroid Itokawa but returned 1,000s of particles) & 2 (2 rovers & 1 lander on asteroid Ryugu & a sample container returned 2020/12).
    e. 2016/09/08, Osiris-Rex mission launched, collected 250g of pebbles & dirt on 2020/10/20, returned to Earth on 2023/09/24 from asteroid Bennu. The black dust on returned capsule may be from Bennu as well.
    f. 2020/11/03 CNSA Chang'e 5 drilled 1m into Moon & returned 1.73 Kg of regolith to Earth 2020/12/16.
    g. 2024/05/03, CNSA Chang'e 6 Landed at Lunar South Pole & returned 1.93 Kg of samples to Earth 2024/6/25.
3. India's **Chandrayaan-3** landed on Moon 2023/08/23, completed South Polar objectives in Sep, & went inoperative.
    a. 1700 Kg lander was a significant achievement: India became the 4th nation to successfully land on Moon.
4. Japan's **Smart_Lander_for_Investigating_Moon** (**SLIM**) launched 2023/09/06 on H-IIA SLV from Tanegashima Space Center, entered Lunar orbit Oct 1st, landed 2024/01/19 near Shioli crater via Weak stability boundary like trajectory.
    a. Containing Lunar Excursion Vehicle (LEV)-1 hopper & SORA-Q baseball-sized transforming robot.
5. Lunar Station Corporation (MIT NewSpace, 2016 Startup), 2021/02/19, with some additional 2025 updates.
    a. NSA/NRO Working Group Briefing Slides.
    b. MoonHacker platform makes 3D Moon Rendering, Moon Navigational Services (MNS), [TRL8].
    c. 2020-2025, 30 Lunar Surface Missions to provide 3,750 TB of raw data.
    d. Intuitive Machines Nova-C **Odysseus** lunar lander, 2024/02/15, 1st launch.
    e. Firefly Aerospace Blue Ghost lunar lander, 2025/01/15, 1st launch.
    f. **Chinese Lunar Exploration Program (CLEP), Chang'e** Program by CNSA.
        i. 2007/10, High-definition 3D Moon Map.
        ii. 2010/10, More detailed 3D Moon Map.
        iii. 2013/12, Lunar Lander & Yutu rover.
        iv. 2018/12, Lunar Lander & Yutu-2 rover on far-side + Queqiao relay-sat & Longjiamg-1 & -2 microsats.
        v. 2020/11/23, Lunar sample mission returned 1731 grams to Earth 2020/12/16.
        vi. 2024/05/03, Landed at Lunar South Pole 6/1, returned 1935.3 grams of samples to Earth 6/25.
            1. Jinchan 5 Kg lunar rover took the photo of the lander shared online.
        vii. **2026**, Explore South Pole Resources.
        viii. **2027**, Use and develop Lunar Resources.
6. SpaceX initially cut off Ukraine's use of Starlink, degrading Ukraine's defense vs Russian War.

    a. Illustrates the danger of relying on ANY commercial space infrastructure.
7. Psyche Spacecraft First-time achievements: Solar-electric (Xenon gas) propulsion in deep space, & optical communications experiment with near-IR laser providing 10-100x more bandwidth than RF communications.
    a. Unveiling the Mysteries of a Metal Asteroid, The Psyche Mission, Jordan Strickler, Ad Astra, NSS 2024-1, p23-27: "According to the *Harvard International Review*, Asterank, a scientific and economic database of over 600,000 asteroids, has ascertained that mining the 10 most economically viable asteroids-that is, those with the highest value and closest proximity to Earth-could yield a profit of approximately $1.5 trillion."
8. **Lunar Resonant Orbits**: like Interstellar Boundary Explorer (IBEX) are spirograph-like, such as 3:1 Spacecraft:Moon Earth-orbit resonance.
    a. Stable for 30-40 years, a Transiting Exoplanet Survey Satellite (TESS)-like orbit is possibly stable for 100 yrs!
    b. TESS was launched 2018/04/18, highly elliptical 13.7-day Cislunar orbit (2:1 Lunar resonance around Earth).
9. **Libration Point Orbits**: any quasiperiodic orbit around a Lagrange Point.
    a. There were 5 specific names listed of these, but adding those names adds nothing for this panel.
10. **Lunar Transfer Orbits**: Direct vs Phasing Loops, which offer low-energy transfers of 90-120 days.
    a. Weak Stability Boundary (WSB) Ballistic Lunar Transfer (BLT) trajectory, such as CAPSTONE mission's test of orbital stability for planned Lunar Gateway space station.
        i. Lunar Gateway planned orbit is 7-day near-rectilinear halo orbit (NRHO) around Moon, within 1,500 km over lunar north pole and 70,000 km from lunar south pole.
        ii. Allow expeditions to reach a low polar orbit with Δv of 730 m/s & ~12-hr transit time.
        iii. Orbital station-keeping would require less than 10 m/s of Δv per year.
        iv. Orbital inclination could be shifted with a relatively small Δv expenditure, allowing access to most of the lunar surface.
        v. Earth launches would perform a powered flyby of the Moon ($\Delta v \approx 180$ m/s) followed by a $\Delta v \approx$ 240 m/s NRHO insertion burn to dock with the Gateway at apoapsis.
            1. The total travel time would be 5 days, spend 11 days at Gateway, then return.
        vi. Crewed mission duration = 21 days and $\Delta v \approx 840$ m/s based on Orion's limits.
        vii. Another NRHO advantage is the minimal communications blackout with the Earth.
    b. Also used for improvised rescue of Asiasat-3 satellite whose launch stranded it in an incorrect orbit.
        i. A 3-5 month trajectory could have placed it in intended geosynchronous orbit, but Hughes engineers chose a quicker (few days) option that only eliminated 40° of its 51° inclination.
11. Distant Retrograde Orbit (**DRO**) between E-M L_1 & L_2, NOT to be confused with JWST's S-E L_2 orbit.
    a. Orbits in opposite direction to which the smaller body orbits the larger one.
    b. Facilitates low-delta-V orbital transfer back to Earth orbit.
    c. China's Chang'e 5 (CE-5) in DRO as part of China's Lunar Exploration Program (CLEP).
12. ORACLE USAF Cislunar Tracking up to 10x GEO distance, providing up to 1000x orbital tracking volume capability.
13. Please visit Astrogatorsguild.com for excellent visual renderings of the Cislunar trajectories we've discussed.
14. 2025/03/18, Firefly Aerospace's Blue Ghost 1 became 1st completely successful commercial Lunar mission & sent back 119 gigabytes of data after all 10 NASA payloads completed their 14 (Earth) days of operation.

Future Missions: What we have Wrong about Living on the Moon, SPACE ARCHITECTURE DamiLee's cute 23-min starter.

15. Blue Origin's Blue Moon Mark 1 is designed to land up to 3000 kg on moon & is scheduled to transport liquid hydrogen & oxygen to lunar orbit by the end of 2025. Mark 2 will transport up 20000 kg reusably or 30000 kg 1-way.
16. Space Capstone Publication, SPACEPOWER, Doctrine for Space Forces, USSF, 2025/04/04, 51 pgs.
    a. For US definition of The Space Domain, National Spacepower, Military Spacepower, Employment of Space Forces, and Military Space Forces.
    b. 3 Cornerstone Responsibilities: Preserve Freedom of Action in Space; Enable Joint Lethality and Effectiveness; and Provide Independent Options. (page xiv of 2020/08/10 doc)
    c. 5 Core Competencies: Space Security; Combat Power Projection; Space Mobility and Logistics; Information Mobility; and Space Domain Awareness (SDA).

d. 7 Spacepower Disciplines: Orbital Warfare; Space Electromagnetic Warfare; Space Battle Management; Space Access and Sustainment; Military Intelligence; Cyber Operations; and Engineering/Acquisitions.
e. Cislunar Regime defined as from GEO to 2nd Earth-Moon Lagrange point.

17. **China's International Lunar Research Station (ILRS) by 2035**, with Russia, Venezuela, Pakistan, UAE, South Africa, Azerbaijan, & Belarus, or Russia on its own by 2040? ILRS construction planned for 2026-2035.
    a. 2024/04, Thailand & Nicaragua signed on to the ILRS project, followed by Serbia in May.
    b. Russia To Cancel Zeus Space Tug, Refocus Space Nuclear Power Efforts, AWST 2024 07 12.
        i. Zeus Space Tug cancelled due to financial hurdles & lack of suitable missions.
        ii. Offers the Zeus nuclear power unit for ILRS use.
    c. 2024/03/20 China tests nuclear-powered engine for Mars spaceship in Scientia Sinica Technologica.
    d. Chinese systems integration is currently the best, they have consistent & reliable funding once they decide on a goal, & they will take the best of all the technologies we've discussed & actually implement them.
    e. 2025/07/17, Chinese scientists found a way to extract water, oxygen, & rocket fuel from Moon dust.
        i. "The 1-step integration of lunar H2O extraction & photothermal CO2 catalysis could enhance energy utilization efficiency & decrease the cost & complexity of infrastructure development."
        ii. Important because it costs $83,000 to transport 1 gallon of water from Earth to the moon, & each astronaut would be expected to drink 4 gallons of water per day. TBD, is this method cost-effective?
18. REVAMPING THE X-PLANE, 6 new X-plane projects, AWST 2023 Sep18-Oct1, p 40-41.
    a. P 50-52 ORBITAL OUTPOSTS.
19. 2025/07/25, Italy Awards Thales Alenia Space Lunar Outpost Design Contract for launch in 2033.
    a. This Multi-Purpose Habitation (MPH) module is part of Artemis & designed for at least 10 years of operation.
20. Artemis summary, from The Planetary Report, Sep 2023, p15, with 2025 edits, including support missions.
    a. Contributing Space Agencies/Nations: NASA/US, European Space Agency, CSA/Canada, JAXA/Japan, CNES/France, DLR/Germany, ISRO/India, ASI/Italy, ISA/Israel, KARI/Korea, UAESA/United Arab Emirates.
    b. Commercial Partners: SpaceX, Blue Origin, Astrobotic, Firefly, Intuitive Machines, Axiom.
    c. COST to 1st Landing, U.S. Contribution: $100 Billion from 2012-2025 (Apollo was $272 Billion 2020 adjusted).
    d. Architecture: Orion & Service Module, SLS Block 1A & 1B, Gateway Station, Blue Origin Lunar Lander, Commercial Payload Landers, Commercial Spacesuits.
    e. 2024/04, 39 nations currently signed on.
    f. Artemis 1, launched 2022/11/16, successful 25-day uncrewed lunar orbit & return.
    g. Astrobotic Technology's Griffin lunar lander, 2025/09, to land in Moon's south polar region.
    h. Intuitive Machines Nova-C, 2025/10, 3rd launch of their lunar lander.
    i. Starship HLS, 2025, uncrewed Human Landing System (HLS) Demo landing mission.
    j. Artemis 2, early 2026, 4-person 8-day lunar flyby.
    k. Power & Propulsion Element+Habitation and Logistics Outpost, 2027 launch, 2 Lunar Gateway modules.
    l. Artemis 3, mid 2027, start of 30-day missions, 4-person lunar orbit & 2-person lunar landing.
    m. 2028 Demos of Lunar Surface Power; Lunar Surface Scaled Construction; ISRU Pilot Excavator; ISRU Subscale.
    n. Artemis 4, 2028/09, delivery of I-HAB module to Lunar Gateway, followed by a 2-person lunar landing.
    o. Blue Moon, 2028, uncrewed HLS Demo landing mission.
    p. Artemis 5, 2030/03, delivery of ESPRIT to Lunar Gateway + 2-person lunar landing with Lunar Terrain Vehicle.
    q. Artemis 6, 2031/03, delivery of Crew and Science Airlock module to Lunar Gateway, + lunar landing.
    r. Artemis 7, 2032/03, lunar landing with delivery of Habitable Mobility Platform (Lunar Cruiser) to the surface.
    s. 2032 Demos of Lunar Surface Scaled Construction; Autonomous Robotics; Deployable Hopper; ISRU.
    t. Fission Surface Power Demo, 2032.
    u. Artemis 8, 2033, ~60-day, delivery of lunar surface logistics & the Foundational Surface Habitat.
    v. Artemis 9, 2034, ~60-day, lunar landing with delivery of additional lunar surface logistics.
    w. Artemis 10, 2035, lunar landing – a long-term (<180 days) stay with delivery of lunar surface logistics.
    x. 2025 NASA's workforce is set to shrink by about 20% is NOT going to HELP the U.S. attain ANY of its space goals.

21. **Blue Origin's** "Blue Ring" multiuse space platform for 2025, AWST, Oct 30-Nov 12, p36.
    a. To host, deploy, & refuel >6.660 lb payloads even beyond Cislunar space.
    b. Host/deploy 12x 1,100 lb satellites on generic ESPA (15" diam) & ESPA Grande (24" diam) ports.
    c. Can also anchor a 2-ton satellite on top deck.
    d. Hybrid chemical (high-thrust) & solar-electric (high efficiency/high specific impulse xenon gas) propulsion.
22. **Going Nuclear**, AW&ST 2023/08/14, p16+, Demonstration Rocket for Agile Cislunar Operations (**DRACO**) was set for 2026/02 launch, BWX Advanced Technologies (BWXT) nuclear engineering company's reactor using 2000 Kg of 20 °K Liquid H2, 100 Kg U-235 (20% purity), to 2700 °K in <1 sec to provide 700-850 I_{sp} for a couple months of in Earth orbit (700-2000 Km circular) testing. About same I_{sp} as Chemical Rocket's thrust with about twice the efficiency.
    a. Why cancelled: the decreased cost of conventional launch (like SpaceX) & **DRACO** cost overruns.
    b. 2025/02/06 ESA's **Alumni** NTP engine may pick up where **DRACO** left off.
23. Overview of **Space Nuclear Propulsion & Power** (**SNPP**), 2024/12
    a. 16 slides containing **excellent** summaries of concepts, histories, & technologies that could have cislunar use.
    b. Lunar surface, where 354 hours of night make having a continuous source of power better than storing 354 hours of solar power in batteries. If base is completely underground, then no risk due to solar panel damage.
    c. Advantageous for cislunar operations that may require frequent high-delta-V maneuvers.
    d. Advantageous for cislunar operations that want to reduce observability of large solar panels.
    e. Duffy to announce lunar nuclear reactor, 2025/08/04, soliciting proposals for 100 kW reactor by 2030.
24. U.S. Grapples With Barriers To Rapid Space Maneuvering, 2025/07/24 AWST, first focus of article is Chinese docking together on orbit in geosynchronous Earth orbit, & recent X-37 operations, but includes the following about NTP:
    a. "Congress rejects NASA plans to defund nuclear propulsion research", "Senate Appropriations Committee included "no less than" $110 million for NASA to develop, produce and demonstrate NTP systems in its 2026 spending bill markup as well as $10 million to establish a national nuclear propulsion center of excellence."
25. USSF-36 To Test **Laser Links** & **Quantum inertial navigation Sensor** on new X-37B Mission, >8/21 launch, 2025/07/28.
26. **The Road to a Sustainable Space Industry**, by Karen Jones, 2023/10/17.
    a. Use Environmental life-cycle assessments (E-LCA) towards a Circular (reusable) Economy.
27. **Lunar Gold Rush, There's Treasure in Those Poles!** 12-min YouTube & Leonard David in Ad Astra 2023-q3, p22-26.
    a. Nearly continuous solar power access + volatiles in permanently shadowed regions (PSRs) = high priority!
    b. Depending on what treaty & interpretation is used, areas could be "claimed" by landing/takeoff exclusion 'safety zones' being established by whoever sets up permanent equipment in the 'best' locations.
        i. Distribution of water & ease of extracting that water may be very different PSR to PSR.
        ii. There's no definition of how far is 'safe' regarding landing & launching away from other sites.
    c. Max temp of a PSR must not exceed 110 K (-262 C) to prevent water sublimination.
    d. Some PSRs may actually be so cold that other 'polluting' volatiles frozen too, making water extraction harder.
        i. This cannot be accurately accounted for until several PSRs are measured directly.
    e. Scientists worry about South Pole (current missions) rocket contamination, so they want to study North pole.
        i. Trying to get UN Committee on the Peaceful Uses of Outer Space (COPUOS) to consider these issues.
    f. Lawyer & Pres of ***For All Moonkind*** Michelle Hanlon has submitted views to UN re space resource utilization.
    g. These precedents and rules should be made and codified now, BEFORE a land-grab for resources starts.
28. **A Wild Ride, The Next 10 Years, Challenges & Opportunities of the New Era in Space**, John F Kross, Ad Astra 2023-q3, p29-36.
    a. *Artemiss or Hit?* SLS/Orion missions Artemis II, III, & IV projected at $4.1 Billion each at rate of 1 launch/year.
        i. The 'irregular cadence' & huge cost of Artemis missions makes long-term viability of the SLS unlikely.
    b. NASA has contracted the Falcon Heavy for the first 2 parts of the Lunar Gateway station (Power & Propulsion + Logistics Outpost) to near-rectilinear halo orbit around Moon for a total of $332 million.
    c. "We are on the cusp of seeing an opportunity of mass to orbit go from $2000 a Kg to $200 a Kg", Gary Henry.
        i. SpaceX adds: If Elon's Starship works as advertised, then "you're at $20 per Kg".
    d. SpaceX Starlink >7600 smallsat constellation provided broadband service to 4,000,000 subscribers in 2024.
    e. SpaceX launched 157 tons to orbit in 2022's 4th quarter, twice China's total payload mass.
    f. NASA awarded SpaceX, ULA, & LM 'tipping point' contracts to advance orbital cryogenic propellent depots.

g. NASA's funding 4 teams via the Commercial LEO Destinations initiative: (1) signed a contract with Axiom Space to install a commercial module on ISS, which will become a free-flyer when ISS is decommissioned; (2) Nanoracks (Starlab); (3) Blue Origin (Orbital Reef); & (4) Northrup Grumman's station.
h. NASA's published predictions of commercial station specs: conduct 130-250experiments/year, requiring 3000 to 4000 hours of crew time, & up to 50 Kw of power.
i. Biotechnology market has been proposed as a business case, but ultra-purity circuit boards might be better.
j. **CHINA**: had 80 'commercial' space companies in 2019 & may 'become a major global competitor by 2030.'
    i. Chinese companies attracted 35% of all space investments 4th quarter of 2022 vs 41% for US.
    ii. CSA declared Taikonauts would step onto the lunar surface in 2029 (before PRC's 80th anniversary).

29. **Intelligence of The Artificial Kind, AI and the Space Enterprise**, John K. Kross, Ad Astra (NSS), 2024 Q2, p14-21.
    a. Cooperative Autonomous Distributed Robotic Exploration (CADRE), 3 small 2024 self-directed lunar rovers.
    b. NASA's 2024/11 Volatiles Investigating Polar Exploration Rover (VIPER) will be landed & operated with AI.
        i. **NASA Cancels VIPER Lunar Rover, Citing Schedule and Cost Issues**, Irene Klotz & Mark Carreau, AW&ST, 2024 07 29-08 11, p31. (Resource Prospector mission cancelled in 2018.)
        ii. VIPER was assembled at Johnson Space Center but didn't progress to system environmental testing.
            1. VIPER's science instruments are planned for reuse on other missions.
30. **Surviving Space, Artificial Gravity will be Critical to Long-Term Space Travel & Settlement**, Mark Armstrong, Ad Astra 2023-q3, p38-41.
    a. Visual Impairment & Intercranial Pressure (VIIP) syndrome affects high % (men only), & can be permanent.
    b. Beyond the Van Allen belts, a solar flare can inflict 30-40 roentgens (rems). Nuclear workers have received up to 74 rem with no observed ill effects, but 100 rems increased cancer risk by 1.8% over 30 years (estimated).
        i. A water-blanketed ***shelter*** can mitigate some danger, depending on design & threat duration.
    c. 1 G may be impractical, a 1/3 G (Mars like) or 1/6 G (Lunar) station would be much easier to engineer.
31. **A Cislunar Fizz, Please, Social Drinking in Space**, Colleen Mcleod Garner, Ad Astra 2023-q3, p 42-43.
    a. Lack of gravity makes it harder for alcohol to settle in stomach, leading to faster absorption by the body.
    b. Metabolic rate can decrease in space, which can cause alcohol to remain in body for longer.
    c. Microgravity adds danger to losing motor coordination due to alcohol consumption.
    d. Social drinking can be a relaxation technique and it can lead to dangerous interpersonal conflicts.
    e. Most space agencies prefer to prohibit alcohol to avoid preventable accidents, but this will change as tourism and longer duration missions become the norm.
32. **Everyone's Gone To The Moon…, Traffic Jam or Part of the Plan?**, John F. Kross, Ad Astra, , NSS 2024-1, p42-49.
    a. 'Bao Weimin, a senior CASC official, has called for a cislunar "space economic zone" to generate $10 trillion a year in wealth for China by 2050. [] Lieutenant General Zhang Yulin, deputy chief of armament development, has declared that "Earth-Moon space will be strategically important for [rejuvenation of] Chinese nation."'
33. Life on the moon: Lockheed Martin shares exploration vision for 2044, 2024/08/06, by Samantha Mathewson.
    a. 6-month Lunar mission "during which lunar resources are harvested, produced stored & distributed."
    b. Power "from nuclear fission reactors, solar farms, fuel cells and flow batteries."
    c. "Developing water-based propellants on the moon means that spacecraft can launch empty — and for lower cost — and refuel in lunar orbit using propellants produced from icy regolith."
    d. A well-made 7-minute video is included, but overoptimistic, that the funding will actually happen.
    e. 32-page novella: "describes a 'Martian gas station' in orbit above Mars, at which interplanetary transit vehicles arrive from Luna every 26 months with water supplies that can be turned into propellants."
34. Aurora Delivers Critical Components for NASA's Gateway Lunar Space Station, 2025/06/24, work continues.
35. Canadian Space Agency Funds 18-month $10.6 million Lunar Rover Development with 10-yr design life, 2025/07/29.
36. NASA Awards Firefly Aerospace $176.7 million 4th Lunar Lander Mission Contract, 2025/07/30.
37. Useful References:
    a. **Trajectory Modeling and Cislunar Space Series**, Ansys Government Initiatives, 68 slides, 2023/03/06.
    b. SpaceGold, Lunar Station, and Planex Unite to Locate Metal-Rich Regions on the Moon for Space Mining Operation, 2023/04/13.

c. **https://lunarstation.space/** NASA WG, 12 slides, 2021/02/19.
d. **A Primer on Cislunar Space**, USAF Research Laboratory, 23 pages, 2021/05/03.
e. **Space Strategy at a Crossroads**, Opportunities & Challenges for 21st Century Competition, edited by Ben Bahney, Center for Global Security Research, Lawrence Livermore National Laboratory, 66 pages, 2020/05.
f. Journal of DoD Research & Engineering, Vol 6, Issue 2, NRL Special Edition – ADC201221. 135 pgs, 2023/06.
g. DIA Challenges to Security in Space, Space Reliance in an Era of Competition & Expansion, 80 pages, 2022.
h. Global Counterspace Capabilities Report, Secure World Foundation webpage, 2023.
i. Global Counterspace Capabilities, Secure World Foundation, 237 pages, 2021/04.
j. Enhancing Assessments of Space Mission Assurance, RAND Corporation, 118 pages, 2020.
k. Space Threat Assessment, Center for Strategic & International Studies (CSIS) Aerospace Security Project, 41 pgs, 2021/04.
l. Defense Against The Dark Arts In Space, Protecting Space Systems from Counterspace Weapons, CSIS, 53 pgs, 2021/02.
m. Counterspace Operations, USAF Doctrine Publication 3-14, 38 pages, 2018/08/27.
n. (U) Weapons and Counterproliferation Mission Center (*WCPMC*) **Space 101: Counterspace Taxonomy**, vol 8, 52 pgs, 2018/04.
o. Space Landfill: How to Remove & Prevent Space Debris by Geoff Crowley, 2024/06/20. ~6000 tons in LEO.
p. Estimated-concentration-of-3He-parts-per-billion-by-mass-in-lunar-regolith = ~4.2 ppb or 0.007 g/m^3.
    i. NASA's Lunar 3He Mining Concepts & Prospective 3He-rich Lunar Sites have been proposed.
q. NASA's Magnetic Dust Filtration System (MDFS) is a key technology required for lunar colonization.

38. PANEL DISCUSSION:
    a. What surprises you most about Cislunar Exploration?
        i. I could not find detailed proposals about using magnets to collect iron from lunar regolith.
    b. What year do you believe there will be a permanently occupied Lunar Base? By what countries?
    c. Do you believe Lunar Colonization is a 1st priority? Or should some other goal (Mars?) come first?
    d. What do you believe are the biggest obstacles to Lunar Colonization? And how can those be overcome?
    e. ESA called for establishment of Coordinated Lunar Time in 2023, are you for or against this idea?
        i. NASA started work on Coordinated Lunar Time April 2024.
    f. What innovations do each of you anticipate will become a near-term reality for Cislunar development?
        i. **David Brin**: what NASA NIAC innovations can you share from your 12 years of experience there?
            1. Details of NIAC studies on the difficulty of refining lunar ores.
        ii. **Michael Nayak**: what DARPA technologies show the best promise for Cislunar use?
        iii. **Michael Ravine**: does Malin Space Science Systems have implementations for Cislunar use soon?
            1. Details of his cameras for deep space missions, such as LRO camera, Shadowcam, 3rd Firefly Blue Ghost lander Heimdall Camera, & Orion's Docking Camera (Mike has a model of this).
            2. 4-min YouTube of How NASA's Orion Spacecraft Docks in Space.