DEEP SPACE GATEWAY CONCEPT SCIENCE WORKSHOP

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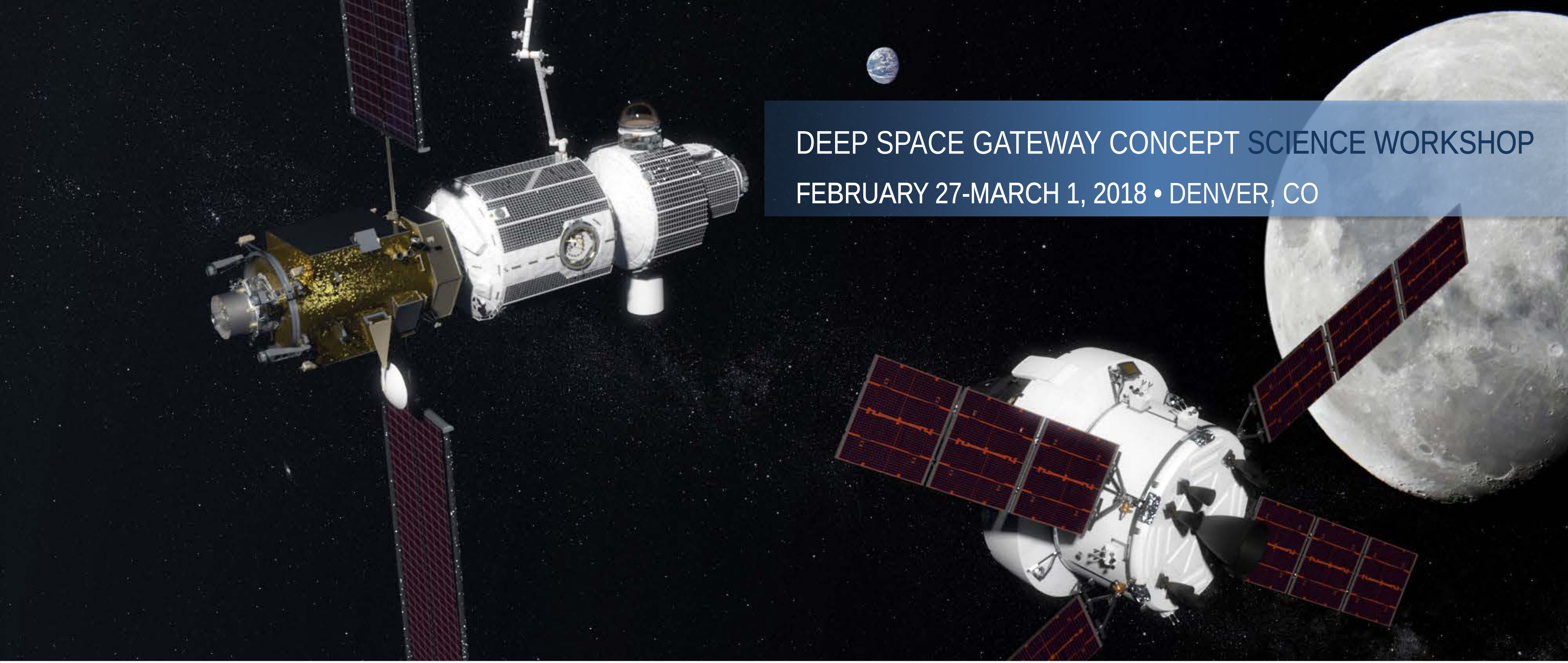


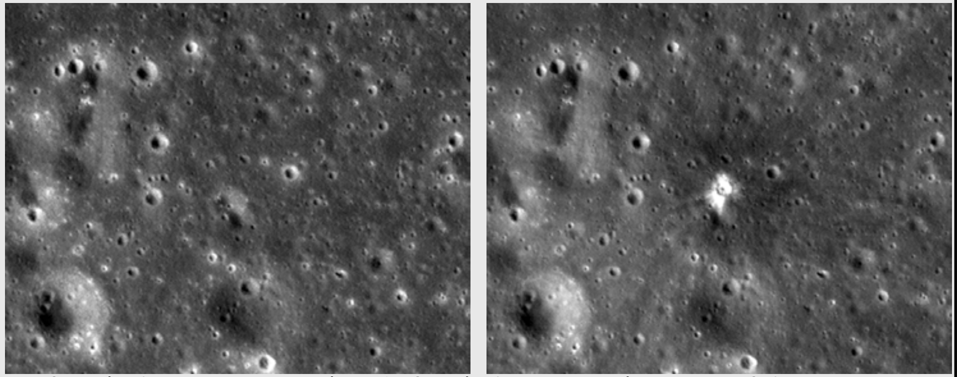
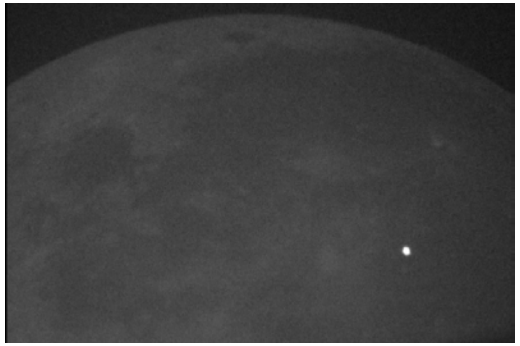
Impact Flash Monitoring Facility on the Deep Space Gateway

February 27, 2018

Debra Needham, Research Scientist, NASA/MSFC[1],

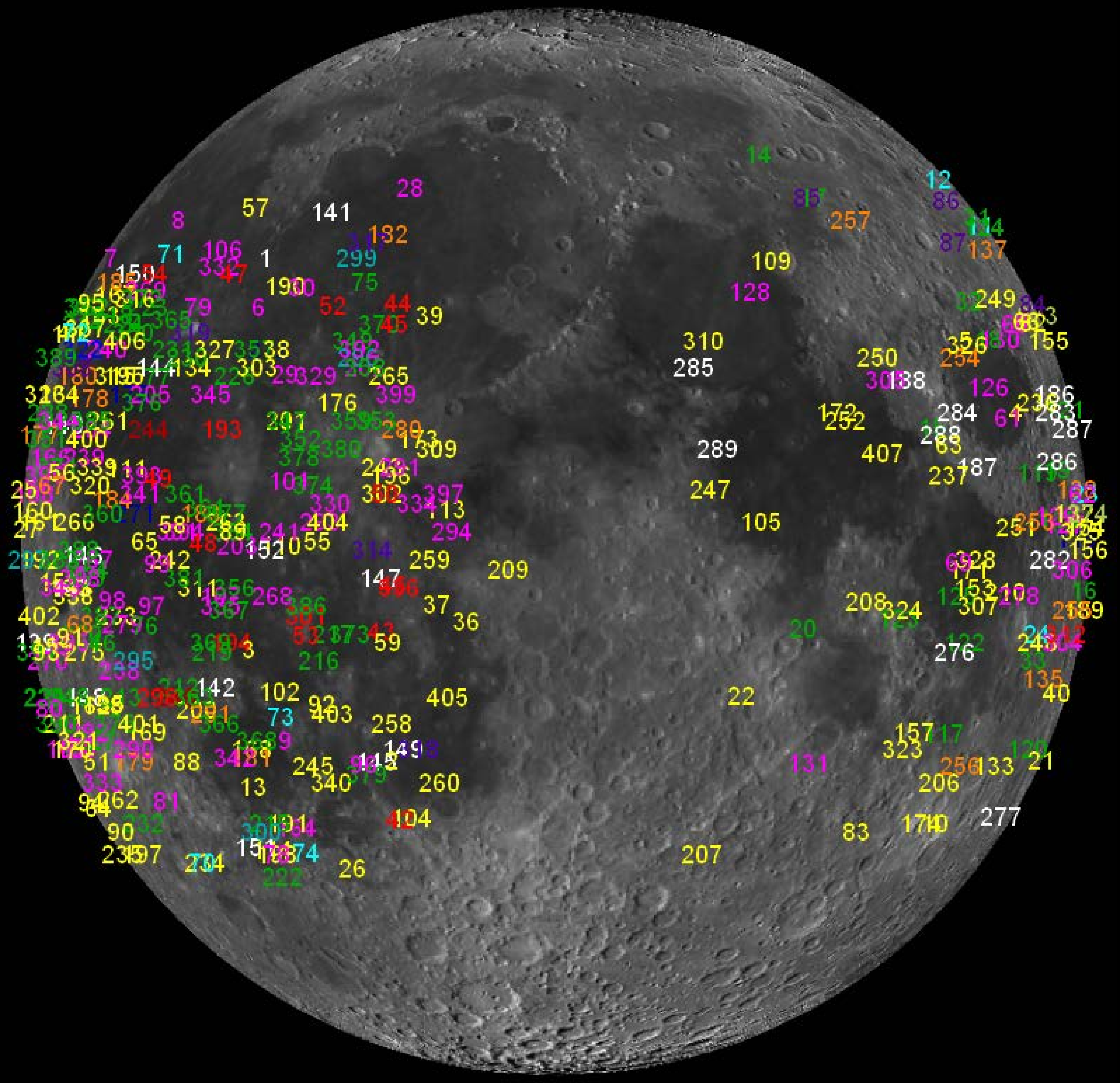
with Danielle Moser[1], Robert Suggs[1], William Cooke[1], David Kring[2], Clive Neal[3], and Caleb Fassett[1]; [2]CLSE/LPI/USRA/NASA JSC; [3]University of Notre Dame

Instrument Function Statement and Gateway Usage

STATEMENT	INSTRUMENT/CONCEPT DETAILS
FUNCTION STATEMENT  Before (February 12, 2012) and after (July 28, 2013) images of the new crater formed during the impact flash event of March 17, 2013	Leveraging existing expertise at MSFC, we propose an impact flash monitoring facility mounted to the Gateway exterior to constrain the contemporary impact flux at the Moon. This system requires a pointing platform and either two independent optical systems or one optical system with a beamsplitter feeding two cameras to eliminate false detections from cosmic ray effects. A dichroic beamsplitter would allow simultaneous measurements in two colors, yielding impact temperature in addition to flash detection.
WHY IS THE GATEWAY OPTIMAL FOR THIS INSTRUMENT/RESEARCH?  March 17, 2013 impact flash detected by the MSFC Meteoroid Environment Office Lunar Impact Monitoring Program from Earth.	Aboard the Gateway, this facility will vastly expand the coverage of similar observations made from Earth by exploiting continuous cloudless viewing conditions, increase the number of detected flash events, enable detection of much dimmer flash events (e.g., smaller, less energetic impacts), and expand detection coverage to include the lunar farside. The longevity of observations facilitated by the Gateway will enhance detections of shower and sporadic impact events and improve our assessments of the impact flux, seismic sources, and hazards to crew in cislunar space.

Instrument Function Statement and Gateway Usage

2005–2017 MEO Impact Candidates



Map of 400+ detections MSFC has recorded over the course of 12 years.

Observing facility at MSFC, operational from May 2006-present: Two observatory domes, a 15 meter (50 ft) tower with a roll-off roof, and an operations center with laboratory space.

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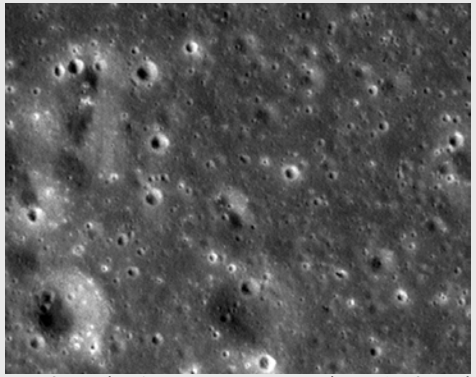
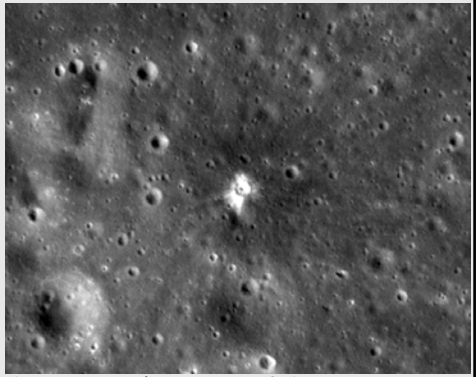
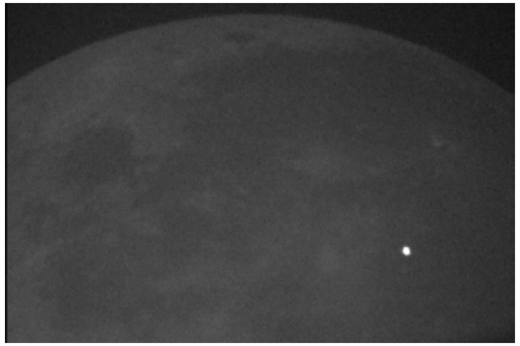
FUNCTION STATEMENT   Before (February 12, 2012) and after (July 28, 2013) images of the new crater formed during the impact flash event of March 17, 2013	Leveraging existing expertise at MSFC, we propose an impact flash monitoring facility mounted to the Gateway exterior to constrain the contemporary impact flux at the Moon. This system requires a pointing platform and either two independent optical systems or one optical system with a beamsplitter feeding two cameras to eliminate false detections from cosmic ray effects. A dichroic beamsplitter would allow simultaneous measurements in two colors, yielding impact temperature in addition to flash detection.
WHY IS THE GATEWAY OPTIMAL FOR THIS INSTRUMENT/RESEARCH?  March 17, 2013 impact flash detected by the MSFC Meteoroid Environment Office Lunar Impact Monitoring Program from Earth.	Aboard the Gateway, this facility will vastly expand the coverage of similar observations made from Earth by exploiting continuous cloudless viewing conditions, increase the number of detected flash events, enable detection of much dimmer flash events (e.g., smaller, less energetic impacts), and expand detection coverage to include the lunar farside. The longevity of observations facilitated by the Gateway will enhance detections of shower and sporadic impact events and improve our assessments of the impact flux, seismic sources, and hazards to crew in cislunar space.

Basic Instrument Parameters

PARAMETER	INSTRUMENT ESTIMATE & ANY COMMENTS
MASS (KG)	~10 kg for cameras;
VOLUME (M)	~0.2 m x 0.2 m x 0.1 m
POWER (W)	Peak: ~9 W; Average ~5 W
THERMAL REQUIREMENTS	~ -30˚C to +70˚C for COTS, could be broader for custom space-rated cameras
DAILY DATA VOLUME	~120 images/day at 5 MB/image => 0.6 GB/day (assuming onboard flash detection)
CURRENT TRL	Depending on camera system selected, TRL ranges from ~3 to 9
WAG COST & BASIS	
DURATION OF EXPERIMENT	Continuous
OTHER PARAMETERS	

Instrument Gateway Usage

USAGE	INSTRUMENT REQUIREMENTS & COMMENTS
ORBIT CONSIDERATIONS	Earth-Moon L2 ideal; any lunar-centric orbit will work but complexities may increase
FIELD OF VIEW REQUIREMENTS	Moon in view during operation; maximizing lunar night views is preferable.
REQUIRES USE OF AIRLOCK	Only for installation.
CREW INTERACTION REQUIRED?	Only for installation.
WILL ASTRONAUT PRESENCE BE DISRUPTIVE?	No
DOES THE INSTRUMENT PRESENT A RISK TO THE CREW	No
OTHER CONSUMABLES REQUIRED	None
SPECIAL SAMPLE HANDLING REQUIREMENTS	None
NEED FOR TELEROBOTICS?	Only for installation and maintenance.
OTHER REQUIREMENTS OF THE GATEWAY?	

References and Status of Work in this Field

- **Suggs, R. M., Cooke, W. J., Suggs, R. J., Swift, W. R., and Hollon, N. (2008) The NASA Lunar Impact Monitoring Program. Earth, Moon, and Planets, 102(1-4), 293-298.**
- **Suggs, R. M., Moser, D. E., Cooke, W. J., and Suggs, R. J. (2014) The flux of kilogram-sized meteoroids from lunar impact monitoring. Icarus, 238, 23-36.**
- **Robinson, M. S., et al. (2015) New crater on the Moon and a swarm of secondaries. Icarus, 252, 229-235.**
- **Speyerer, E. J., Povilaitis, R. Z., Robinson, M. S., Thomas, P. C., and Wagner, R. V. (2016) Quantifying crater production and regolith overturn on the Moon with temporal imaging. Nature, 538, 215-218.**
- **Bonanos, A. Z., et al. (2018) NELIOTA: First temperature measurement of lunar impact flashes. Astronomy and Astrophysics, DOI https://doi.org/10.1051/0004-6361/201732109**
- **Ikari, S., et al. (2017) EQUULEUS: Mission to Earth – Moon Lagrange Point by a 6U Deep Space CubeSat. Small Satellite Conference abstract.**

  - A similar facility is scheduled to fly on EM-1 (JAXA's DEtection camera for Lunar impact PHenomena IN 6U Spacecraft, DELPHINUS, a part of EQUilibriUm Lunar-Earth point 6U Spacecraft, EQUULEUS, 6 months operations)

Backup/Additional Information

- **Observing facilities:** Observations are conducted at NASA Marshall Space Flight Center in Huntsville, Alabama at the Automated Lunar and Meteor Observatory (ALaMO).
  - Operations from May 2006 – present.
  - Two observatory domes, a 15 meter (50 ft) tower with a roll-off roof, and an operations center with laboratory space (right).
  - A second observatory in Chickamauga, Georgia (Walker County) operated Sept 15, 2007 – June 2011. The facility consisted of a ground level building with a roll-off roof. This observatory was run remotely from Marshall Space Flight Center.
  - A fourth 14 inch telescope operated at New Mexico Skies Observatory October 2011 – Sept 2012.

Backup/Additional Information

- **Lunar impact rate:** On average, 33 metric tons (73,000 lbs) of meteoroids hit Earth every day, the vast majority of which ablates high in the atmosphere, never making it to the ground. The Moon, however, has little or no atmosphere, so meteoroids have nothing to stop them from striking the surface.
  - On average, MEO observes an impact flash on the Moon every 2 hours.
  - The slowest of these rocks travels at 20 km/sec (45,000 mph); the fastest travels at over 72 km/sec (160,000 mph). At such speeds even a small meteoroid has incredible energy -- one with a mass of only 5 kg (10 lbs) can excavate a crater over 9 meters (30 ft) across, hurling 75 metric tons (165,000 lbs) of lunar soil and rock on ballistic trajectories above the lunar surface.
  - The lunar impact rate in this mass range is difficult to determine due to the large observational collecting area and long time-on-target required for adequate number statistics.
  - Our current observing program is complete down to about 9th magnitude. The limiting magnitude of 9.0 corresponds to a kinetic energy of 1.05×10^{7} J (assuming luminous efficiency of 1.29×10^{-3} for a 24 km/s impact).
  - An orbiting system may be able to detect smaller impacts that produce dimmer flashes down to 11th magnitude.