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The upcoming re-entry of the OSIRIS-REx Return Capsule: Plans for a coordinated seismo-acoustic observational campaign

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Abstract #: 1229

1. Introduction

- Meteoroids and asteroids (>1 m in diameter) are of broad scientific interest, from planetary sciences to hypersonic physics. Upon entering dense regions of the Earth's atmosphere at hypervelocity, these objects undergo complex processes (e.g., sputtering, heating, ablation), resulting in a visual phenomenon called a meteor [1,2] (**Fig. 1**).

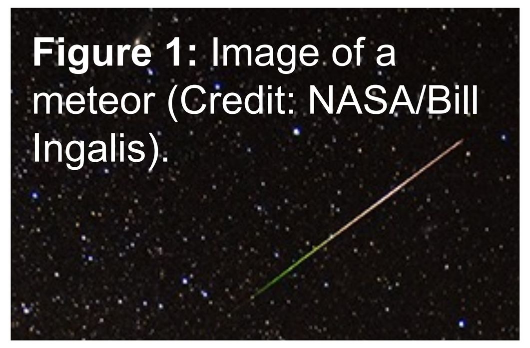

Figure 1: Image of a meteor (Credit: NASA/Bill Ingalis).

- In the transitional and continuum flow, sufficiently large and fast meteoroids generate shockwaves, which decay to very low frequency acoustic waves (below human hearing), or infrasound. Depending on atmospheric conditions and acoustic propagation paths, infrasound may reach the ground where it could be detected by very sensitive microphones [1,2].
- Impacts into the Earth's atmosphere, especially by asteroids in a meter-size range, are sporadic and unannounced, making it impractical to plan a dedicated multi-instrument observation campaign aimed at studying and characterizing these objects.
- Well-documented scientific observations of asteroids are relatively rare and generally happen by chance [3]. In these cases, many parameters of interest (e.g., composition, size, porosity, ablation rate, shock characteristics, hyperthermal chemical processes) remain poorly defined, and scientific analyses largely rely on assumptions and predictions from the theoretical domain [1,2].

2. Artificial meteors

- Since the end of the Apollo era, only four instances of an hypersonic re-entry of an artificial body from interplanetary space with an incident speed of 11-12 km/s have been observed and studied (**Table 1**). These were the Sample Return Capsules (SRCs) that brought physical samples of extraterrestrial material back to Earth (**Fig. 2**).

Table 1: List of SRC re-entries.

	Genesis[1]	Stardust[2]	Hayabusa 1[3]	Hayabusa 2[4]	OSIRIS-REx[5]
Date	8-Sep-04	15-Jan-06	13-Jun-10	5-Dec-20	24-Sep-23
Entry speed* (km/s)	11	12.9	12.2	12	~12
Entry angle (°)	8	8.2	12	12	~8
Landing site	UTTR	UTTR	WPA	WPA	UTTR
Mass (kg)	225	45.8	18	16	46
Diameter (m)	1.52	0.811	0.4	0.4	0.81

*at ~135 km altitude; [1]ReVelle, et al., 2005; [2]ReVelle & Edwards, 2007; [3]Yamamoto et al., 2011; [4]Sansom et al., 2022; [5]Lauretta et al., 2017

Figure 2: A render of the Stardust SRC re-entry (Image credit: NASA).

- Arriving from interplanetary space at hypervelocity, SRCs are considered artificial meteors [e.g., 4], and as such provide unprecedented and unique opportunities to perform detailed studies of meteor phenomena, test and calibrate sensors, and validate and improve models.
- **The next opportunity will present itself on 24 September 2023 with the re-entry of OSIRIS-REx SRC that will bring samples of the carbonaceous near-Earth asteroid Bennu** [5].

3. OSIRIS-REx

- The OSIRIS-REx asteroid sample return mission was launched in 2016 and it will return to Earth on **24 September 2023** [5]. In design and re-entry, the OSIRIS-REx SRC is nearly identical to that of the Stardust SRC (**Fig. 2**). Landing will take place in the morning hours local time over the region enclosed by an 80km x 20km ellipse at the Utah Test and Training Range (UTTR), Utah, USA [5].
- The SRC will arrive on a SW-NE trajectory (**Fig. 3**). The atmospheric interface will occur over Monterey, CA at 125 km altitude. The SRC will become luminous over Luning, NV, reaching the point of maximum heating at ~61 km altitude SW from Eureka, NV.
- The re-entry will consist of several flight phases, including the hypersonic, supersonic, main parachute, and landing phases, lasting ~14 minutes (**Fig. 4**).

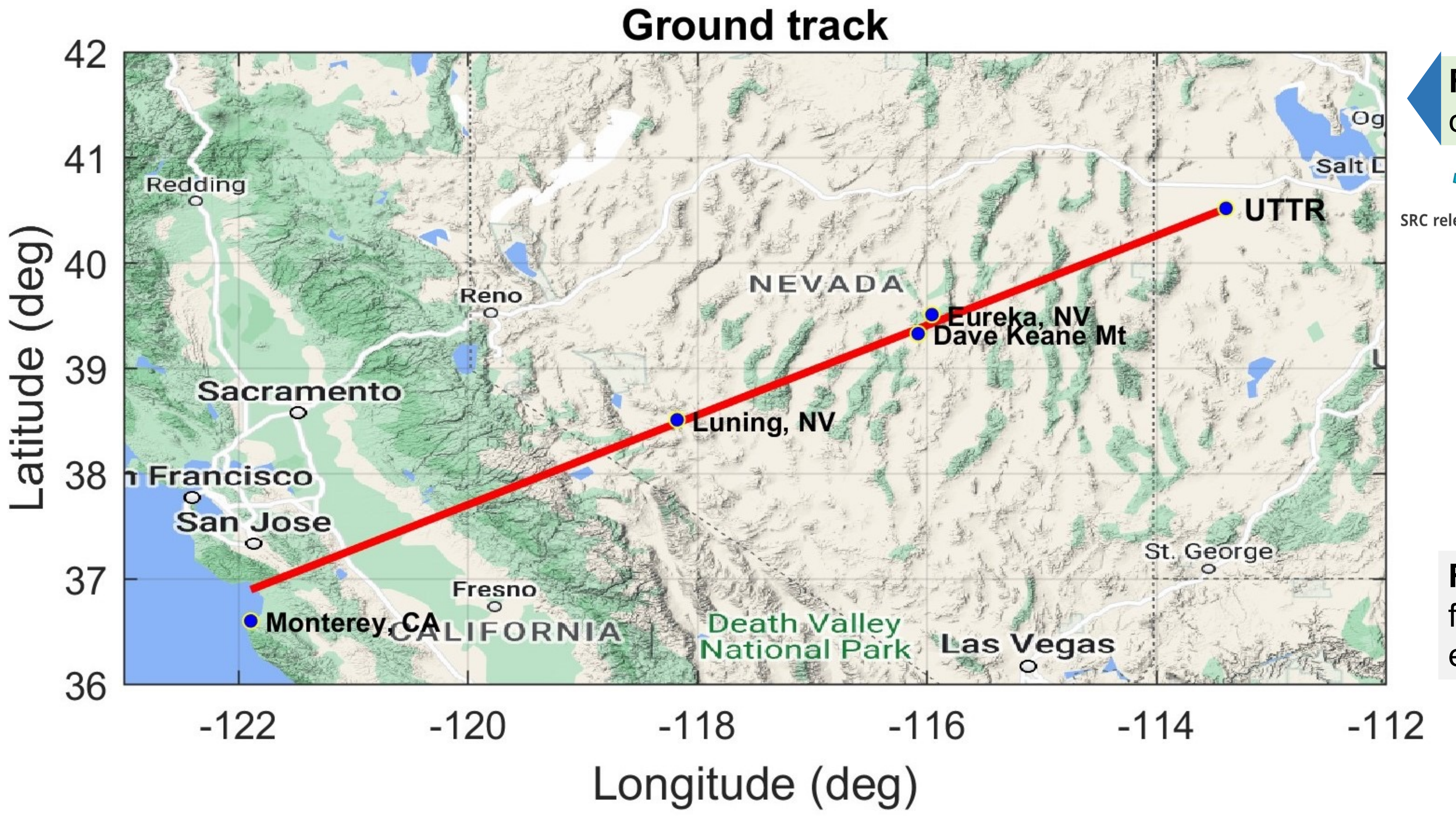

Figure 3: Ground track. The direction of travel is NE.

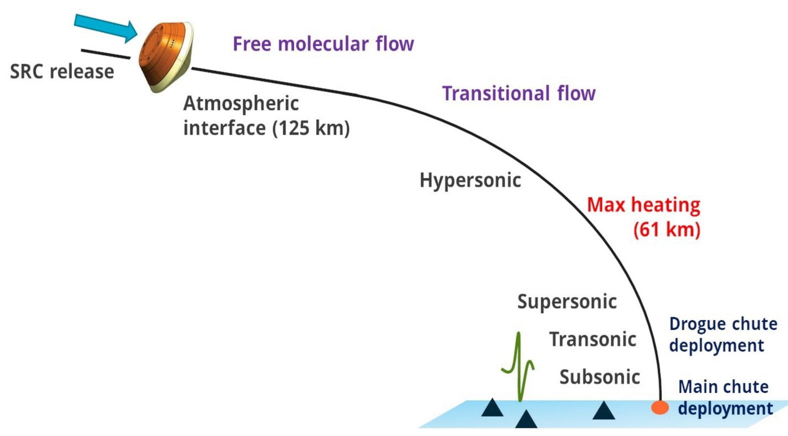

Figure 4: Diagram showing different flight regimes related to the SRC re-entry.

4. Seismo-acoustic observational campaign

- The OSIRIS-REx re-entry presents an exceptional opportunity to observe a well-defined artificial meteor, to perform detailed studies of hypersonic entry and event characterization, to test sensors, and validate and improve models.
- Sandia National Laboratories (SNL) will lead a seismo-acoustic observational campaign with the aim to capture infrasound and seismic signals generated by the OSIRIS-REx SRC during the re-entry. The instruments will include infrasound and seismic sensors strategically positioned in the immediate and extended region around the projected re-entry trajectory to maximize the scientific output. Data collected during this observational campaign will be made freely available to the broad scientific community following publication.

References

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