



**HUMMINGBIRDSCHARM (HsC)
in MARS Neighborhood**



HUMMINGBIRDSCHARM

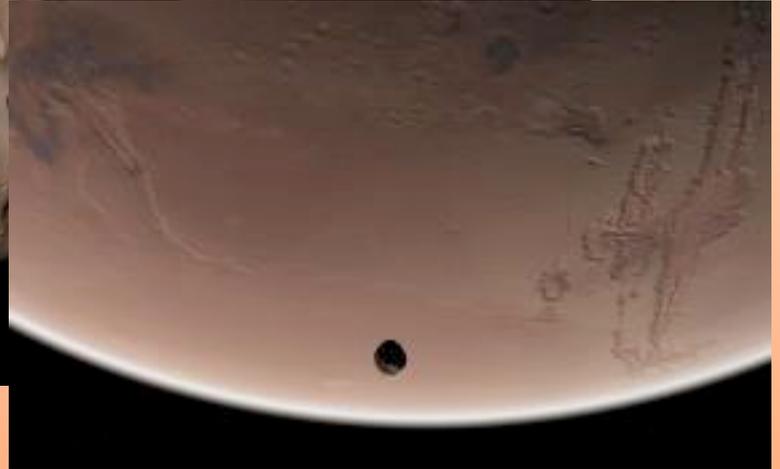
HsC / Guidance

OBSERVE

TOUCH

EARLY

OFTEN



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Objectives

-Globally Determine Target Characteristics

***Physical, Elemental/Mineral / Molecular/Isotopic
Surface Morphologies
Ground Truth for Existing Data and Models***

-Provide Detail Visuals at Target

***Imagining Over Entire Target
Variety of Stand-Off Distances / Separations Available
between Multiple Vehicles and the Target Body
Imaging of the Surface TAGS by ObsCOMM***

-Characterize Composition and Processes at Target Via both Visual and Tactile Systems

-Target Composition and Structure are TOP Priorities Visual / Tactile / Radar / Instrument Suite



HUMMINGBIRDSCHARM

Drivers in Design/Methods

Overwhelmingly Cost Effective (OCE)

LV Cost - FALCON 9 (Equivalents,,)

Simple Bus Designs/Same Design for each SC

Low Cost to Allow for “Many-Offs”

Reach Max # of Targets

Multiple Vehicles to Selected Targets (thus the CHARM)

TOUCH & GO Vehicle/TAGS (Sampling, Instruments)

Observer and Prime Comm/ObsCOMM (Instruments)

ROLE PLAYING Concept: the Surrogate Astronaut

Reduced Complexity Across ALL Systems/Subsystems

Minimize # of Deployments, Mechanisms

Reduced Complexity in Instruments

Simple TAGS Sampling

Single-string Hummingbirds

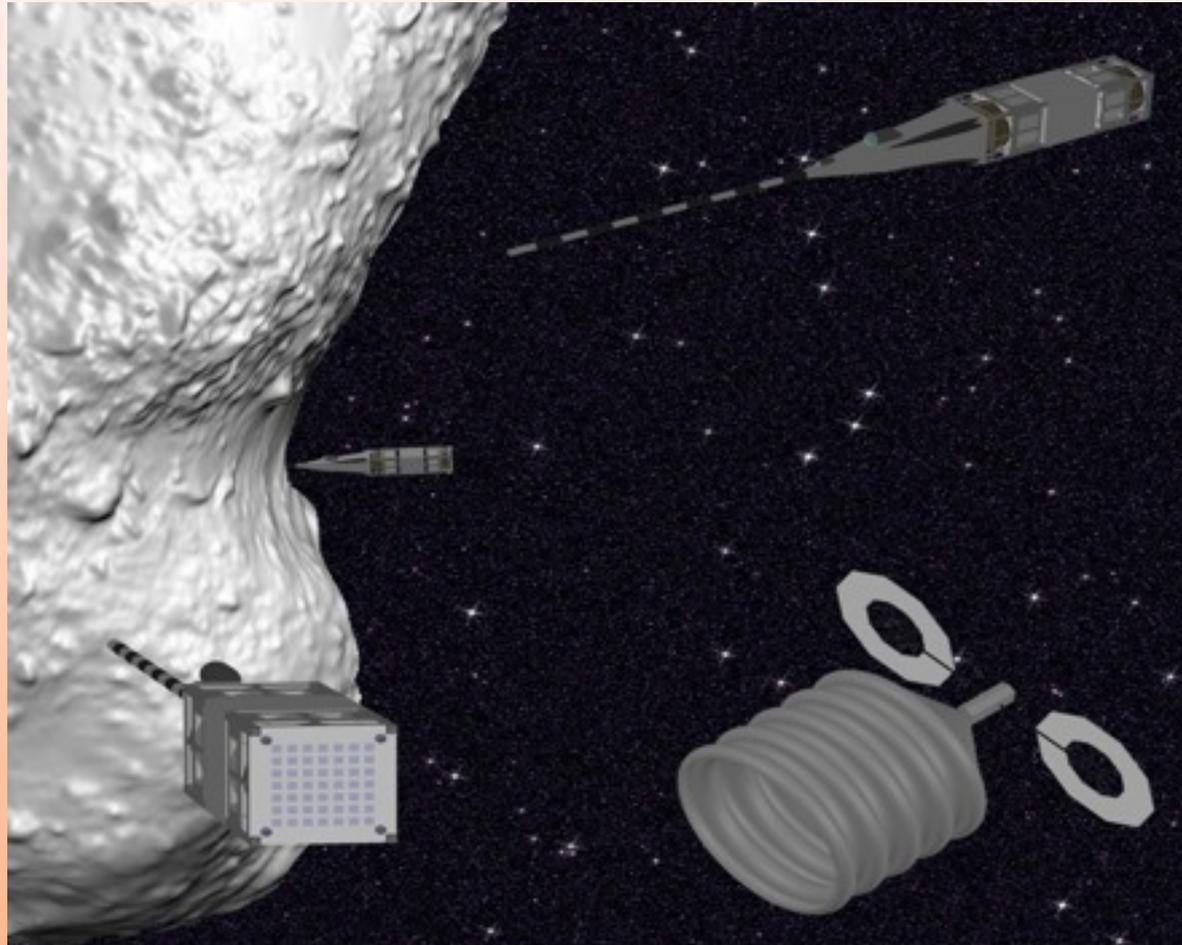
Multiple Birds Bring Redundancy



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Mission Scenarios: NEO/NEA, Mars Moons, Lunar



Asteroid Redirect Mission Scenario



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HsC Evolution / Continued Development / Surface Contact

PROBE (Mechanical Properties Characterization)

- Fixed Probe: Only Limited by Config with Delivery Spacecraft
- Simple Deployable Probe: Whip Antenna, other,
 - **Limited Probe Diameter. Possible Stowage Issues*
- Simple Deployable Probe: Hinged Rigid Probe
 - **Length Limited to HsC Main Body Dimension*
- Extendable Probe: Nested Segements
 - **Inherently Limited Axial Force Available due to Mating Segments*
 - **Concerns with Mechanical Deployment, Segment to Segment*
- Reel Deployment: Small Stowed Form Factor
 - **Unknowns: Rigidity of Deployed Probe*



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HsC Evolution / Continued Development / Surface Contact

PROBE SENSOR OPTIONS (in addition to Mechanical)

-Thermal Profiles

- *Relatively Simple Measurement while in Contact with the Surface
- *Temperature Sensors down the Length of the HsC Contact Probe

-Thermal Conductivity

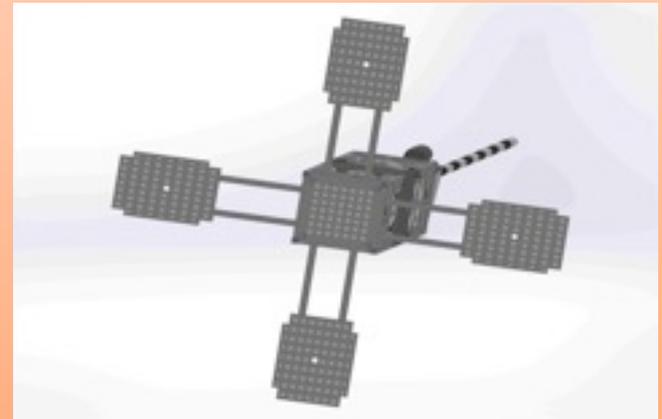
- *Options to Perform Conductivity while in Routine HsC Contact
- *Additional Testing could be performed in HsC Secondary Operations
 - IE, *We Embed the HsC Vehicle into the Surface after Primary Touch and Go Operations*

-Surface Electrical Properties/Electrical Conductivity

- *Options similar to those applied for Thermal Props

-Spectroscopy

- *Options include Utilization of Fiber Optics Embedded down the Length of the Probe
- *Sources and Sensors Mounted back in the HsC Vehicle Bus
- *Sample Collection
- *Compact XRD/XRF
- *OTHER,,,



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HsC Evolution / Continued Development / Surface Contact

Some Other Probe Possibilities



Low Power, Scalable Dust Collection Tool

**NASA Goddard / Fred Minetto*



MIA, Miniature In-Situ Analyzer

MIA provides XRD/XRF/Imager/RAMAN

--No Sample Prep Required

**MICA mockup under a 1U Section of HsC Model*

**Provided by Space Science Institute/N-Sci*



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HsC Evolves / Continued Development / Surface Contact

EXTRACTION OPTIONS

- Maneuvering Thrusters
 - *Low Thrust. Must Budget for Extraction*
- Dedicated High Thrust Propulsion
 - *High Added Mass*
- Mechanical Pusher: Push OFF
 - *Complex Mechanical System, Other Complexities (Surface Features)*
- Mechanical Hammer: Internal Percussive Mechanism
 - *Relatively Simple. Mass Added to the System*
- Leave Penetrator Behind
 - *Separable Probe or Leave SC Embedded in Surface*



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HsC Evolution/ Continued Development / Missions Scenarios

- The Prime Directive of the HsC Effort
- Missions to a Variety of Targets/Building the Characterization Data Base - an OPERATION CHARACTERIZATION



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HsC Evolution/ Continued Development / Missions Scenarios

NEO/NEA and MARS MOONS Characterization Needs are Consistent

(From the Pascal Lee Presentation: Phobos, Deimos Sample Return)

-Phobos & Deimos Are Not Likely What They Seem to Be

**Remote Sensing Has Hit an Impasse*

-GRAB-N-GO is Not an Assured Way of Sampling These Targets Properly

**In-Situ, In-Contact Characterization is Required*

-Analysis of Boulders & Regolith of Phobos and Deimos is Required

**to “Get to the Bottom” of What They ARE*

**Determine How the Moons Relate to Each Other and to Mars*

THE CAPABILITIES of HsC Meet the Needs at PHOBOS & DEIMOS

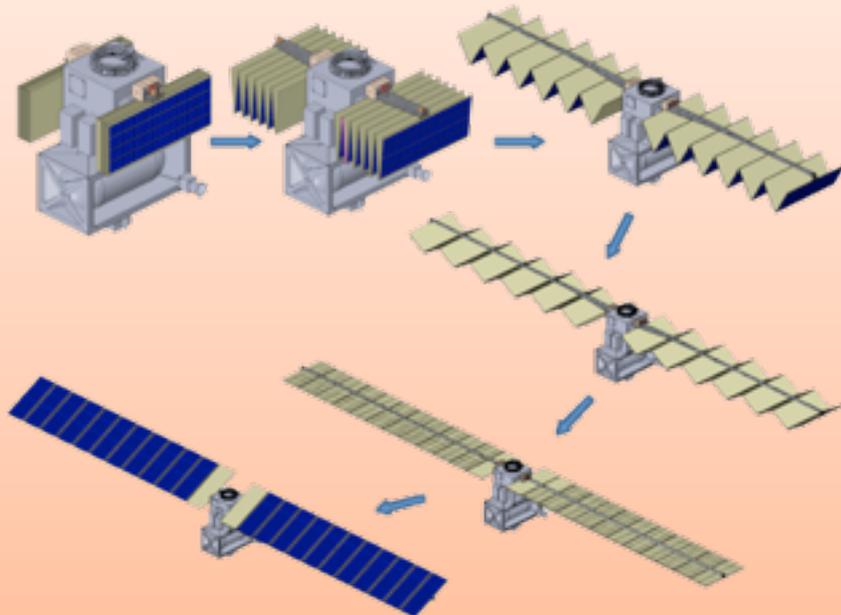


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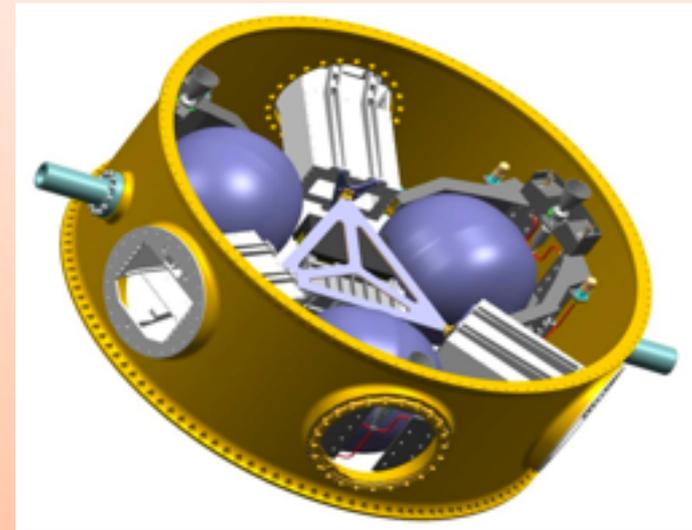
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HsC Evolution / Continued Development / Missions Scenarios

Operation Characterization : GO “DEEP” Missions



**Working with ExoTERRA
SoIRIDER Option**



**Working with MOOG
Aerospace
Smart ESPA Option**

**Working to Develop HUMMINGBIRD
Habitat Options**



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HsC Evolves / Continued Development / HsC Activities

Status of Current Activities:

-NASA SBIR 2014 (contract # NNX14CK06P)

**Title: Subsurface Access, Characterization, Acquisition, Transport, Storage and Delivery in MicroGravity*

**HsC Related Developments: Study Contact Probe Designs and Interaction with Regolith*

-NSci Space Act Agreement with NASA

**Johnson Space Center / Astromaterials Research & Exploration Systems*

**SAA-KA-14-18117*

**For Asteroid Exploration Concept Development*

**Joint Activities include Proposals to ROSES/PSTAR and ROSES/PICASSO*

-ARM BAA Trade Study Appendix C / SubContract to ExoTERRA

**N-Sci working Asteroid Characterization Suite Input to Study*

-SSERVI

**Institute for Modeling Plasma, Atmospheres and Cosmic Dust; University of Colorado, PI Mihaly Horanyi*

**N-Sci Industry Partners*

-MOOG Aerospace

**Continued Evolution of Concepts for HsC Mission Scenarios ; MotherBird and HsC Habitat Concepts,,,*

