CHARMING APOPHIS - HUMMINGBIRDsCHARM (HsC) INTERVIEW WITH APOPHIS

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INTRODUCTION: Apophis is coming for a quick visit in our neighborhood. Clearly, a wide range of scientific activities will be focused on this event. The possibilities are an open book, at least for the moment. The realities will settle with time with regard to what can be accomplished at this target.We submit our chapter to this open book for consideration.

BACKGROUND/HsC: The HUMMINGBIRDsCHARM (HsC) is developed as a system of multiple missions to a variety of targets. The "charming" aspect of this concept is the requirement that we send multiple vehicles to each target. A gathering of Hummingbirds is in fact called a Charm. The HsC missions are intended to meet the clear guidance driven by the NEO/NEA communities; "Observe & Touch" and provide this capability "Early & Often". There are several excellent mission concepts coming forth to meet the remote "observational" need, for example NeoCAM. The HsC missions are intended to meet the "tactile", "touch" component of the guidance "quartet"; OBSERVE-TOUCH-EARLY-OFTEN. "Early" and "often" drives the need for Overwhelmingly Cost Effective (OCE) systems requiring simplification and reduced complexity and necessitates that there need be a "many-off", production mode approach implemented in spacecraft design, build, and availability. HsC is highly motivated by the concept of providing a "service" to the NEO/NEA communities. HsC enables unique opportunities at each target in providing complete characterizations of target properties. Each "charm" includes a Touch & Go vehicle(s) (TAGs) that "flit" in close to the target to provide up-close visual and tactile data along with an Observer/ Communications (Primary Vehicle or ObsComm), vehicle that relays both TAGs and ObsComm video along with instrument data streams from all vehicles. The ability to "flit" and move to different locations is important as surface properties on a given target will differ depending on location.
Modern technologies in avionics for spacecraft control, communications, and navigation permit the Hummingbirds to be small enough that multi-spacecraft missions can be launched on the more moderate-sized rockets. Since the Hummingbird vehicle designs are identical, no redundancy is implemented in their design, thus reducing the cost of implementing that complexity.

Base HsC Mission Objectives - NEO/NEA: The HsC mission objectives were originally established in order to meet the needs of the NEO/NEA community. The SKGs established by various interested parties (eg, Planetary Defense, Mining, ISRU, Science) and at various meetings and workshops (eg, SBAG & TargetNEO) were given high priority in the development of this concept. The Observe-Touch-Early-Often guidance was derived exactly from our education at these meetings and interaction with the community and these drive our requirements approach for HsC.
1) Globally Determine Target Characteristics - Physical, GeoTech, Surface Morphologies, Provide Ground Truth for Existing Data and Models
2) Provide Detail Visuals at Target - Imaging Over Entire Target Including Various Stand Off Distances
3) Characterize Composition and Target Processes - Uses Visual, Optical, and Tactile Systems (eg, Hyperspectral Imager and Instrumented Hummingbird Probe, other,)
4) Surface & Internal Structure - Using a Variety of Sensors Available (eg, Lidar, BiStatic Radar, etc.)
Various instrument groupings have been suggested over time and as new innovations come along. New ideas include HsC Darts (probe and sample collection) to electrostatic mechanisms for sample collection. Certainly, instrument groupings similar to other Comet/Asteroid encounter missions are of interest and there has been some standardization that has occurred.
This is the big picture concept for HsC, that is, using identical sensors and systems at multiple targets and a variety of target types. This is the key feature of an HsC concept. Whatever the final Instrument & Probe grouping, we send identical systems to every target. But what of Apophis, this single mission to Apophis, and application of HsC type mission at Apopohis?

HsC at Apophis - What Can Be Done/Where Does HsC Fit (Flit) In: A wide range of missions are being conceived as potentials for the Apophis visit. Dan Scheeres and others have presented ideas for mission profiles that just might work at Apophis. FlyBy and Rendezvous missions have been presented. If the dynamics allow for a rendezvous then there is potential for an HsC primary vehicle rendezvous and "potential" for release of multiple Hummingbirds. This would be detailed remote sensing with the ability to explore the surface but short of sample return. The Dart mission is a contact mission as are O-Rex an Hayabusa. Dart contact is extreme. O-Rex and Hayabusa both provided surface sample collection surface contact. HsC at Apophis can provide a global picture, remote and tactile observations. This HsC information, along with data from these missions will continue to fill the Observe & Touch guidance, fill those SKG bins.

Outlook: We have some work to do as do all the concepts considering a mission to Apophis. What is a best version, best match of HsC capabilities with our visitor? How do we best cooperate with this target. The good news being that we have a target and moreover a target that is coming to us. Something that has always come up in HsC discussions is the question about target. Where we going?? We've got a target. We get to play catcher instead of pitcher. Pitcher is harder.
Lastly, we get a great opportunity to play out "real In-Situ" characterization" scenarios at Apophis with an eye to the future HsC missions to multiple targets. We need not create a scenario or artificial target for demo, we've got the real thing.