NASA Ames Planetary Defense Integrated Product Team: An Overview

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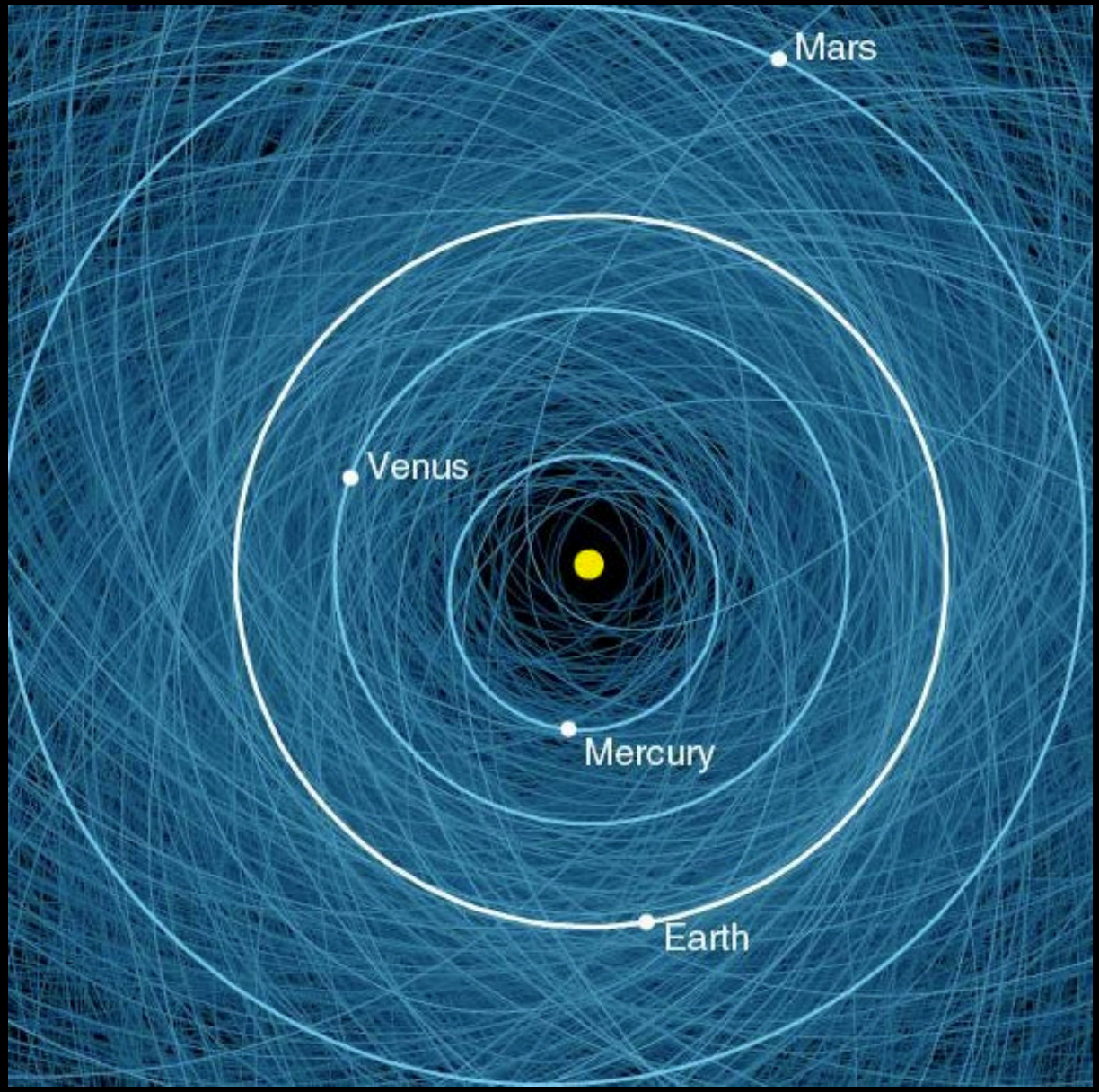
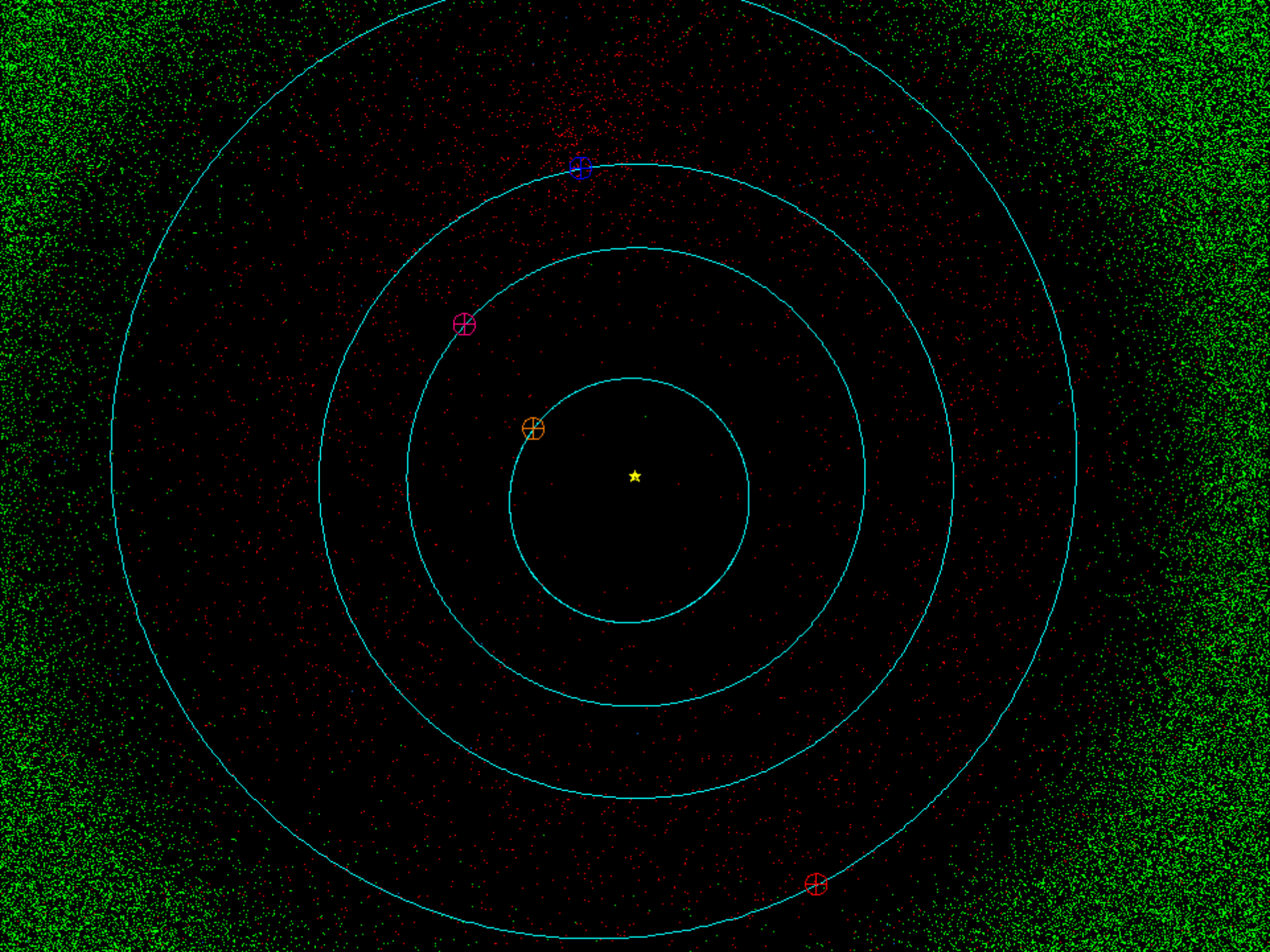
Orbits of Near Earth Objects (NEOs)



Courtesy: NEO Program office / JPL

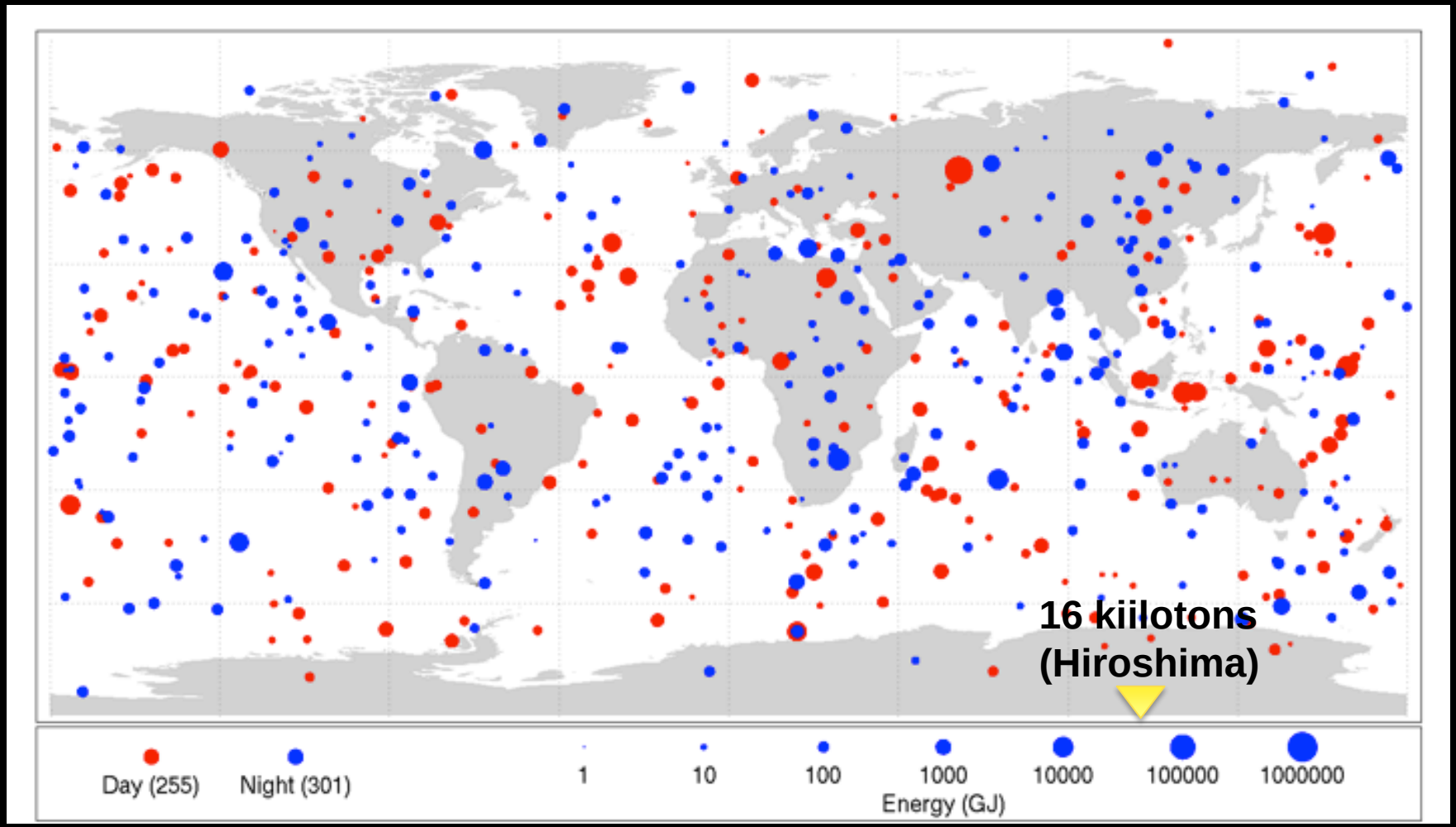


Feb 15, 2013

Satellite Observations of Bolides

Bolide Events 1994 - 2013

556/19 ~ 29 events per year



NEO impacts are not isolated events

NEO Impact Energy, Frequency & Survey Status*

Type of Event	Diameter of NEO	Approximate Energy	Average Interval	Currently Surveyed
Airburst*	**<30 meters**	**<5 MT**	**1-50 years**	**<< 1%**
Local **	**>30 meters**	**>5 MT**	**250-500 years**	**< 1%**
Regional	**140 meters**	**~300 MT**	**30,000 years**	**< 10%**
Continental	300 meters	~2,000 MT	100,000 years	~ 60%
Global	1 KM	~100,000 MT	700,000 years	~ 95%
Extinction	10 KM	~100 million MT	100 million yrs	> 95%

*** February 2013 – Chelyabinsk, ~17-20 Meters, ~500-550 KTs**
**** June 1908 – Tunguska, 30-50 meters, ~5-15 MT**

Small NEOs can offer a "powerful punch," and can be a total surprise

Planetary Defense Integrated Product Team

Objective: Develop Predictive Impact Assessment Tools to Support Decision Makers In the Event of a pending impact by a Potentially Hazardous Asteroid (PHA).

Approach: Characterize PHAs, Leverage NASA and DoE Codes to Conduct Physics-Based Simulations of Meteor Entry/Breakup, Surface Damage and Bound Associated Risks.

Tasks, Products & Interactions

1. Characterization

Properties, Test cases

Trajectory (JPL/MPC)

2. Physics-based entry & breakup

Hi-fidelity simulations

Near-field energy deposition

3. Surface damage effects

Winds/overpressure

Land, tsunami

4. PHA Risk Assessment: Min. size and time req'd for mitigation. Max. size where civil defense is OK

Predicted impact assessment tools

Decision Makers

Mitigation

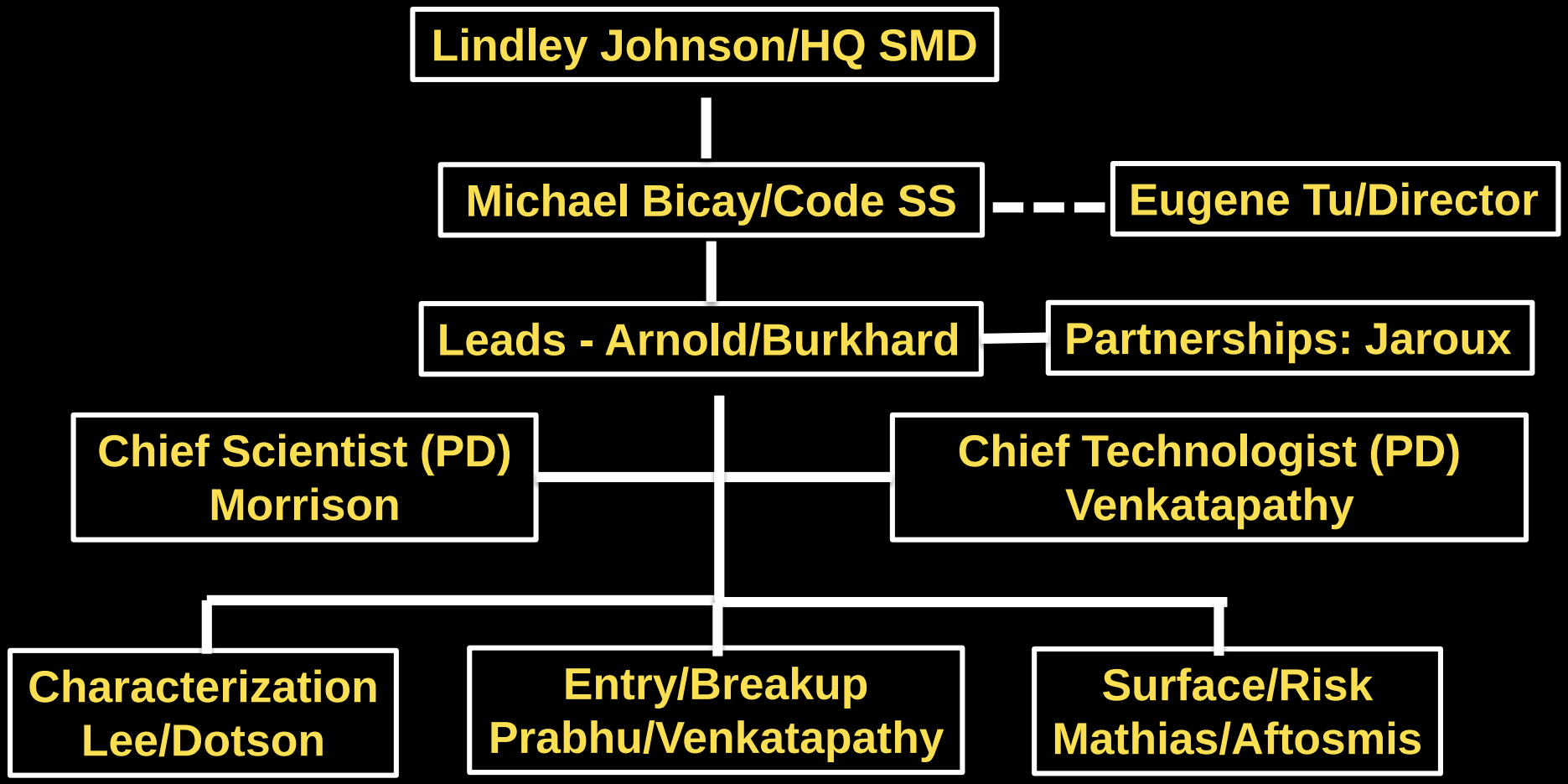
Summary

- A new project in Planetary Defense is underway at NASA with the objective to provide decision makers bounded risk assessments in the event of a pending PHA strike.

- Codes from NASA's activity for entry capsule design is one basis for the new work. Following presentation by Venkatapathy, et al. highlights preliminary results.

- Developments for higher entry speeds (> 12 km/s) will be of benefit to future human Mars return and robotic sample return missions.

Planetary Defense Integrated Product Team



Backup

Task I: Characterization

- Collect physical properties of PHAs from literature and from in-house study of meteorites, ground-based observations, and eventually, in-situ measurements.

- Focus is on needs for simulation of entry/breakup, risk assessment and kinetic mitigation (impact and nuclear stand-off – Collaboration with LLNL).

- Modeling of PHAs as they exist in the space environment.

- Products: Test Cases, Web Site with properties data base.

Task 2: Atmospheric Entry and Breakup

- Leverage NASA re-entry codes: Flow solver (DPLR), Radiation solver (NEQAIR) for conditions up to 20 km/s and 300 bar.
- Modify materials response codes FIAT and TITAN and data bases to account for meteor ablation.
- Apply Thermo-structural code MARC to account for fracture and fragmentation of meteors.
- Validate simulations: Comparison to observed meteor entries: light curves, decelerations, and deduced near-field energy deposition. Ground test.

Product: Near Field Energy Deposition

Task 3: Surface Damage

- **Modify NASA flow solver Cart3D to account for exponential**
- **atmosphere, hydrostatic equilibrium and develop subroutines to capture surface overpressures and wind profiles.**

- **Couple Cart3D to GEOCLAW code to simulate tsunami for given ocean topography.**

- **Computationally propagate near field disturbances from Task 2 to the surface.**

Products: Damage to surface (land/water) and cratering.

Task 4: Risk

- Apply NASA risk assessment modeling code to analyze/ bound PHA threats.
- Run set of test cases from Task 1 accounting for uncertainty in properties data base.
- Calculate casualties based on damage area simulated from Task 3 for either the average world or gridded populations.
- Evaluate relative sensitivity of input data and level of simulation fidelity. Use this information to prioritize focus of efforts in Tasks 1, 2 and 3.

Product: Predicted impact assessment tools