



PDC19 Impact Exercise: Probabilistic Asteroid Impact Risk Assessment

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NASA Ames Research Center

Asteroid Threat Assessment Project

IAA Planetary Defense Conference

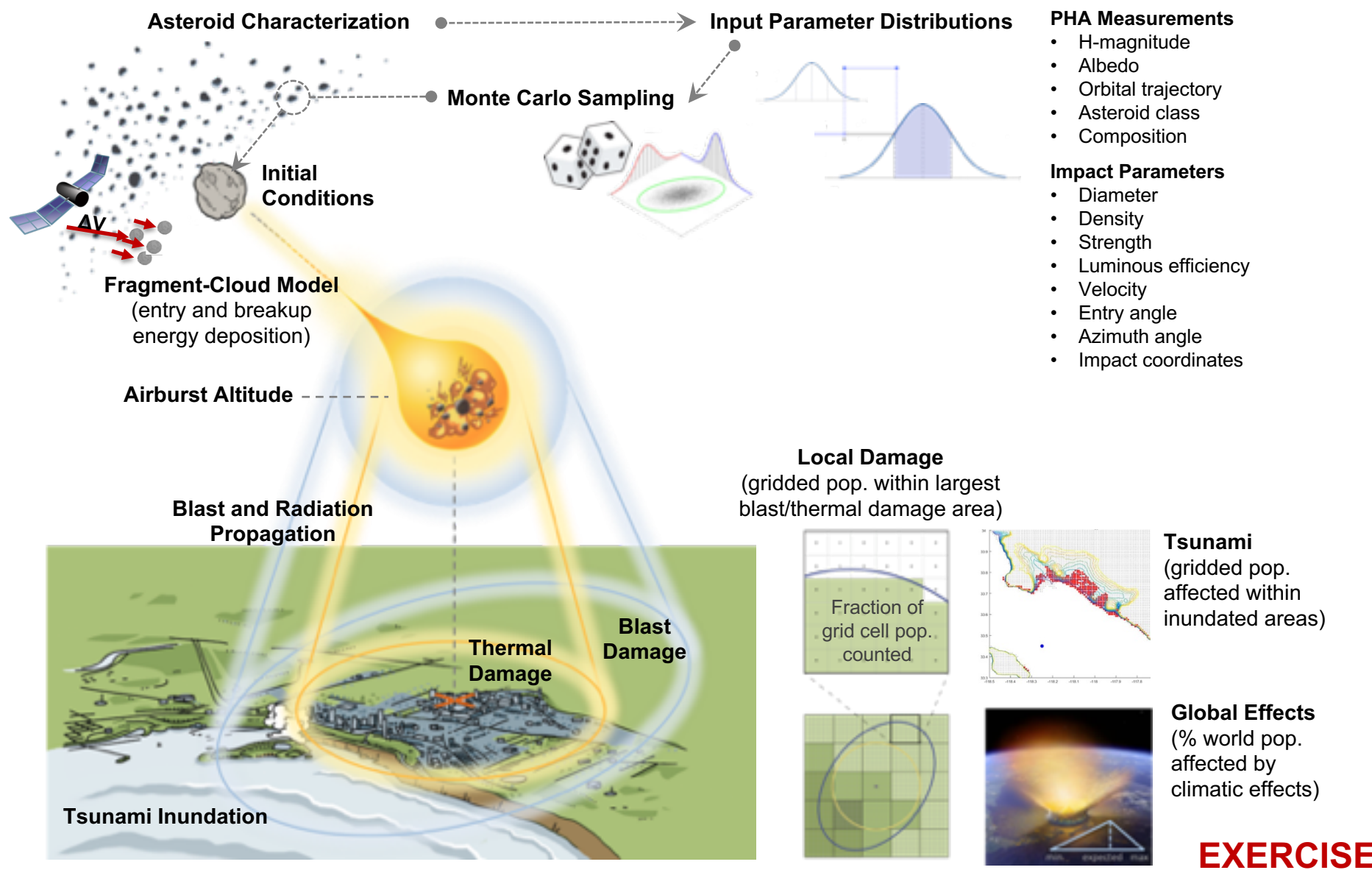
April 29 – May 3, 2019

College Park, MD





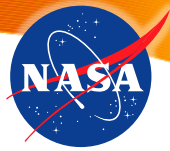
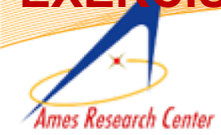
Probabilistic Asteroid Impact Risk (PAIR)



Local Ground Damage

- Local ground damage sources:
 - Blast overpressure
 - Thermal radiation
- Ground damage is assessed at four severity levels, with each level affecting different fractions of the population within that region
- For each damage level, the larger of the blast or thermal radius is used

Damage Level	Population fraction	Blast Threshold (psi)	Thermal Threshold
Serious	10%	1 psi – window breakage and some structural damage	2 nd degree burns
Severe	30%	2 psi – doors and windows blown out, widespread structural damage	3 rd degree burns
Critical	60%	4 psi – most residential structures collapse	cotton/denim clothing ignites
Unsurvivable	100%	10 psi – complete devastation	sand explodes, roll roofing ignites



29 July 2019

DAY 2



Impact Risk Summary

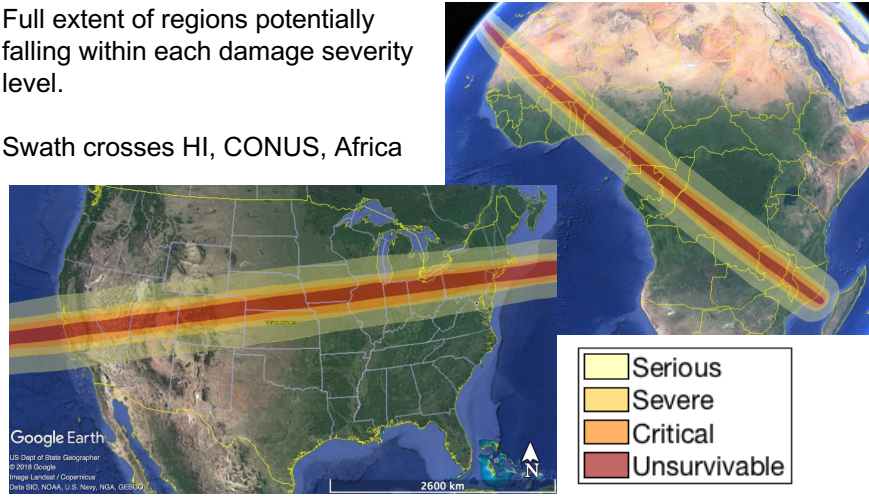
Characterization Summary & Updates

- Assessment date: 29 July 2019
- Potential impact date: 29 April 2027 (7.75 years)
- Earth impact probability: 10%
- Obtained albedo and size refinements from NEOWISE observation
- Diameter (m): 185 ± 45 (1- σ), range 114–492
- Energy (Mt): mean 340, range 46–5800,
- Type: Unknown. Type probabilities based on albedo, but all types remain possible.

Potential Damage Zone Map

Full extent of regions potentially falling within each damage severity level.

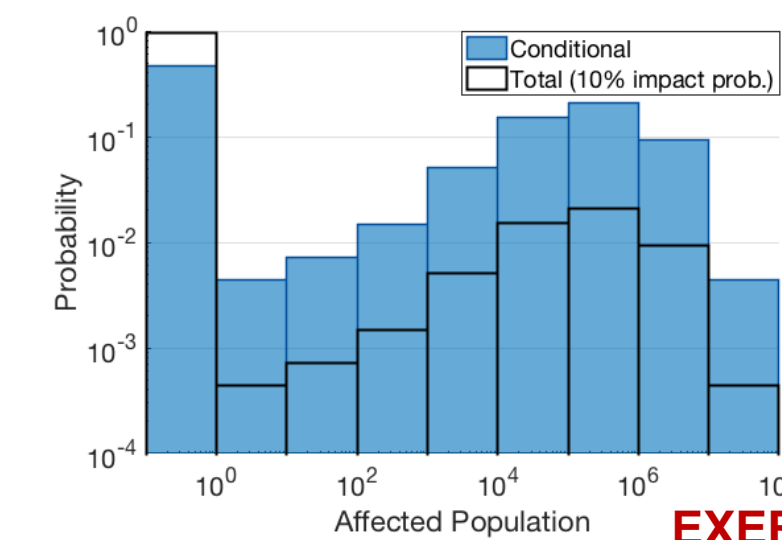
Swath crosses HI, CONUS, Africa



Hazard Summary

- Affected population: mean 375k, range 0–19M
- Airburst causing blast overpressure is primary hazard.
- Small risk of tsunami if impact is very large or near coast.

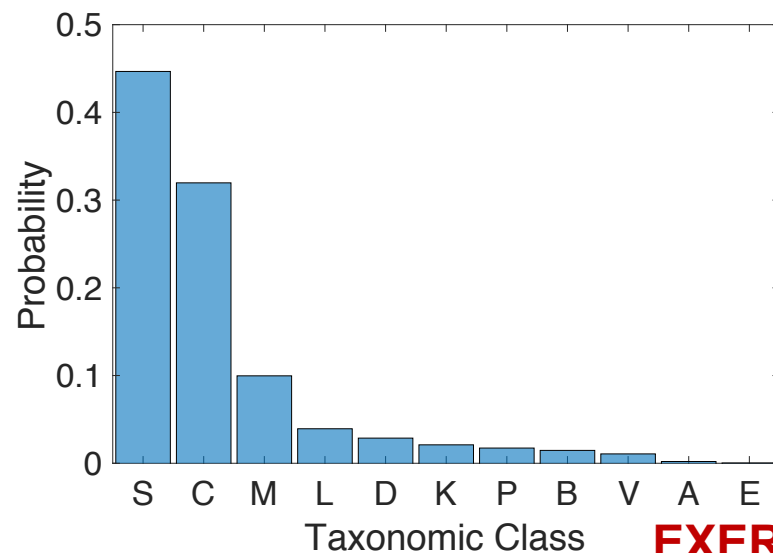
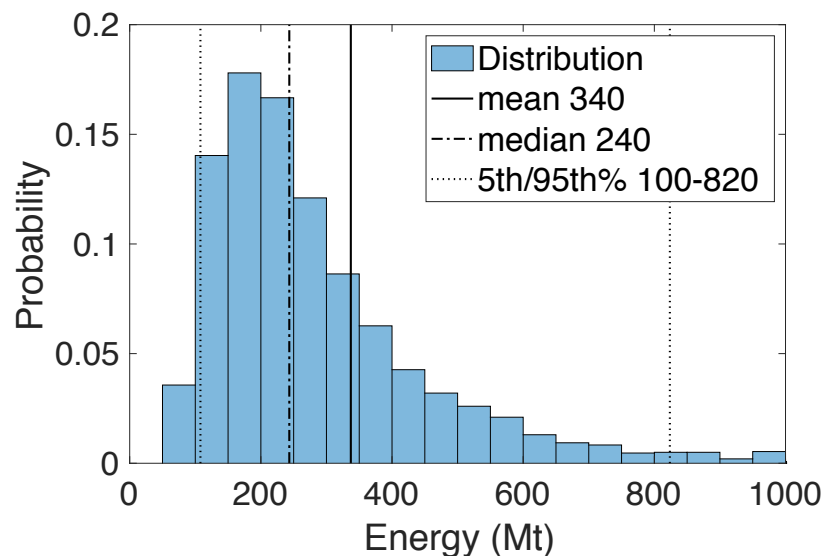
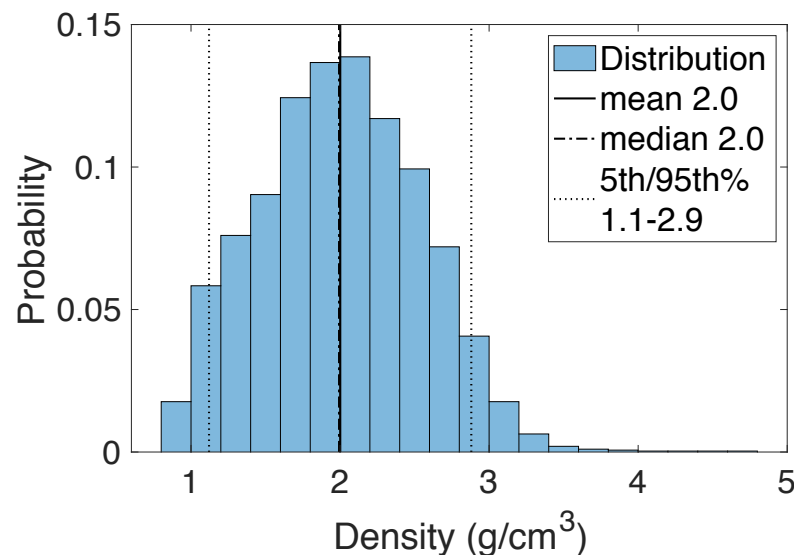
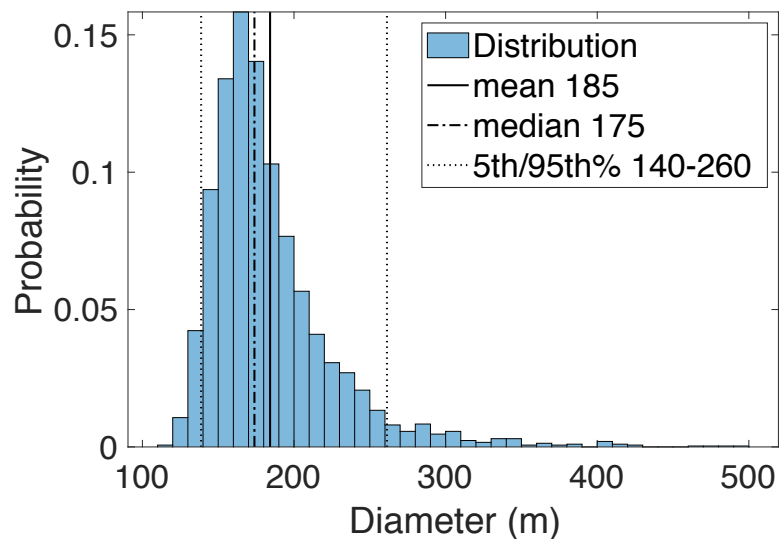
Affected Population Probabilities



Damage Levels	Mean Radius	Radius Range
Serious	137 km	46 – 419 km
Severe	72 km	14 – 207 km
Critical	43 km	0 – 137 km
Unsurvivable	19 km	0 – 56 km

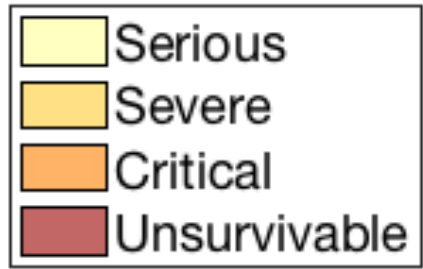
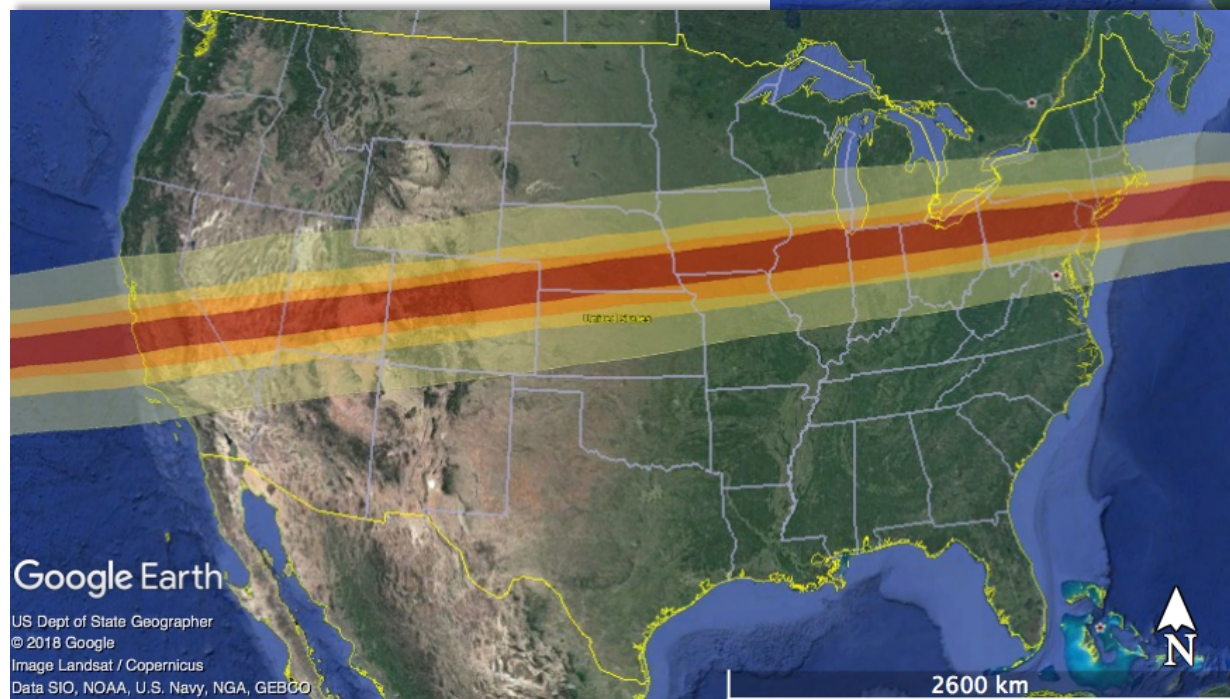
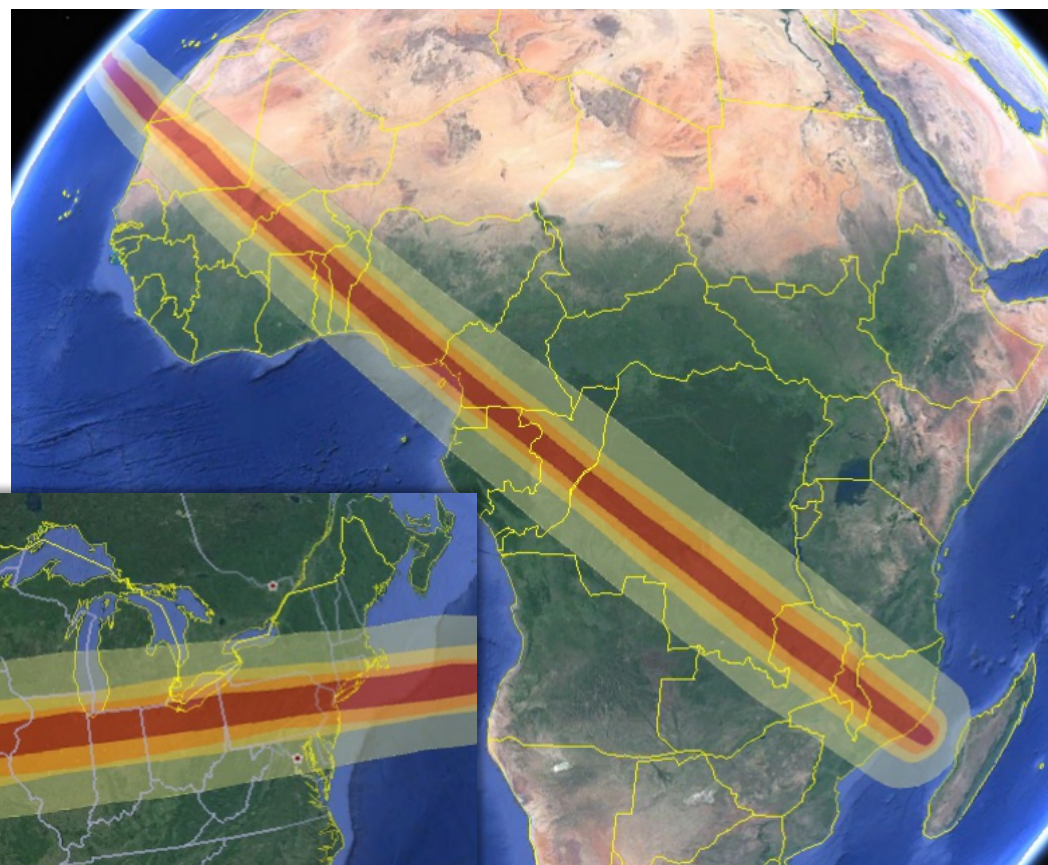
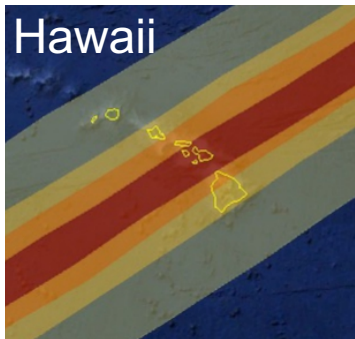
Asteroid Properties

- J. Dotson, Bayesian Inference of Physical Properties for Impact Scenarios (IAA-PDC-19-02-P12)





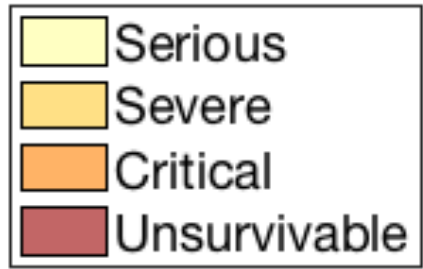
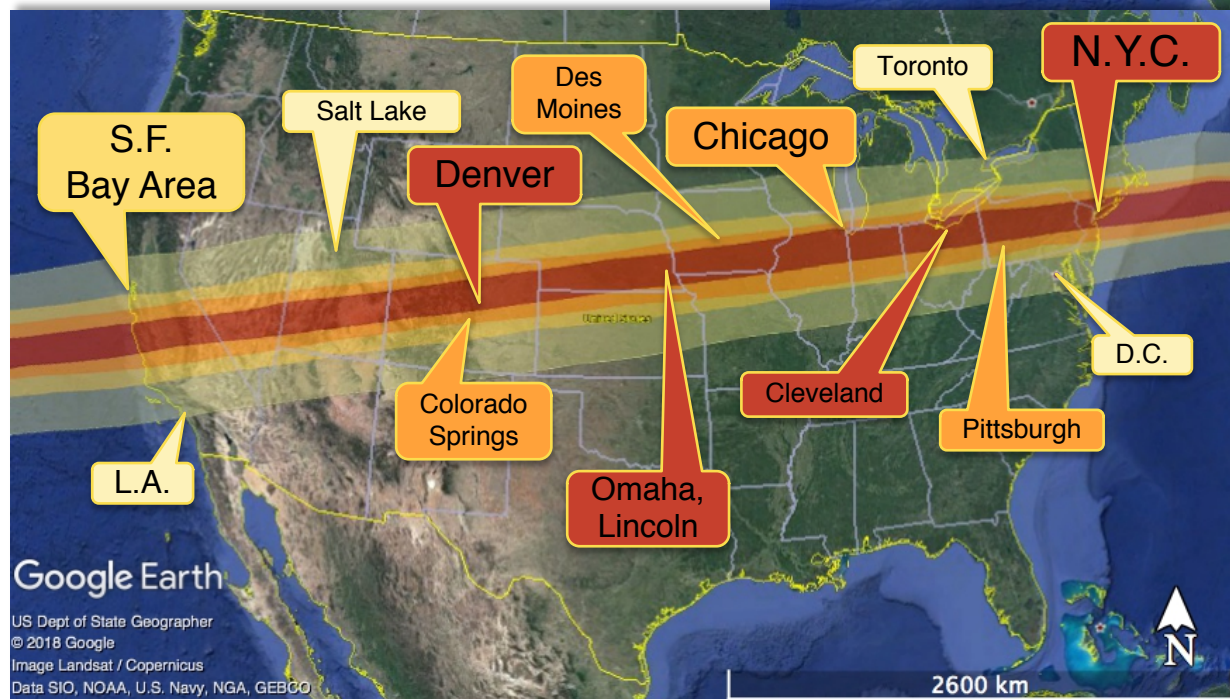
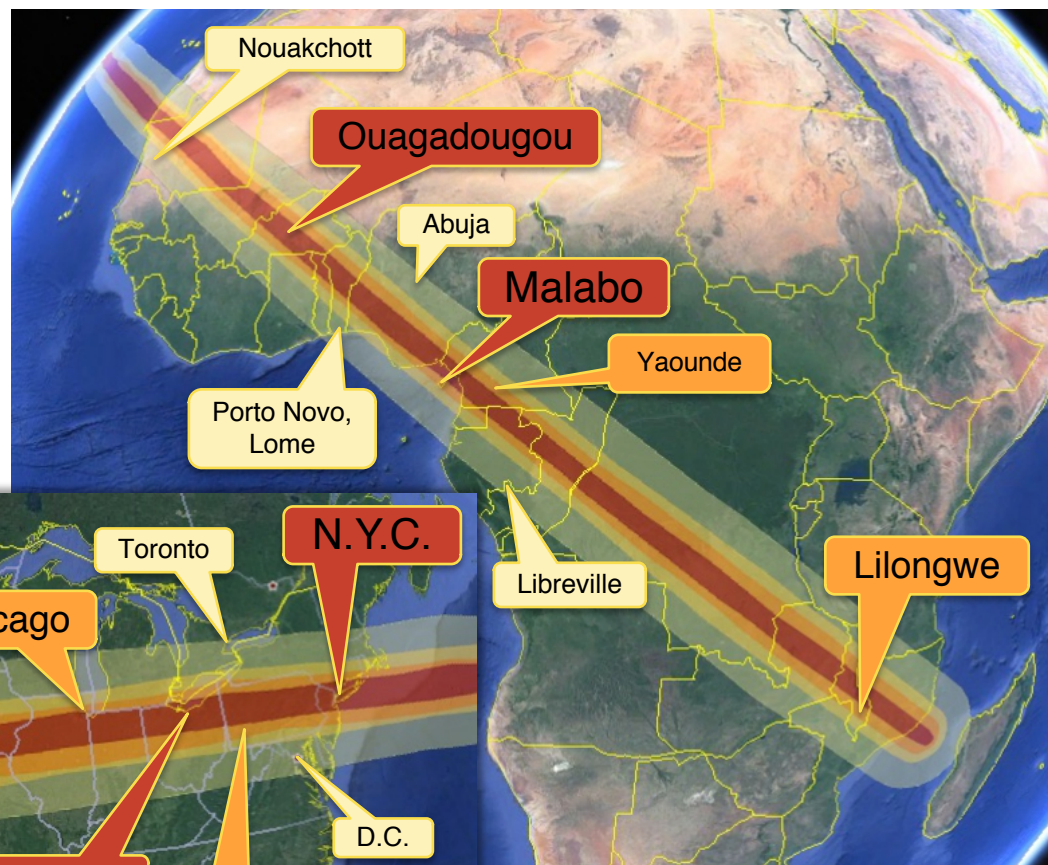
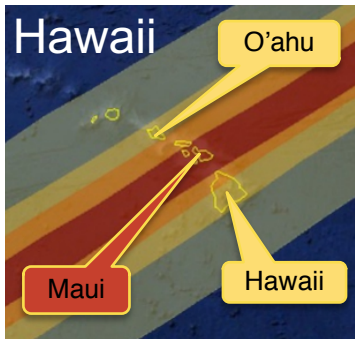
Potential Damage Swath



Google Earth
US Dept of State Geographer
© 2018 Google
Image Landsat / Copernicus
Data SIO, NOAA, U.S. Navy, NGA, GEBCO

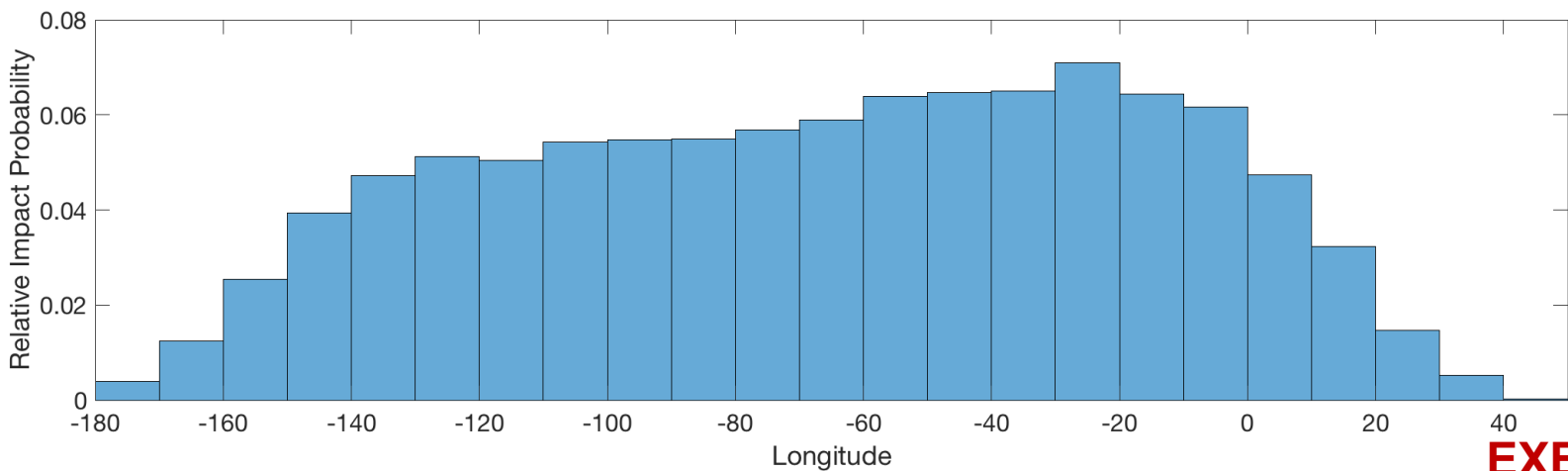
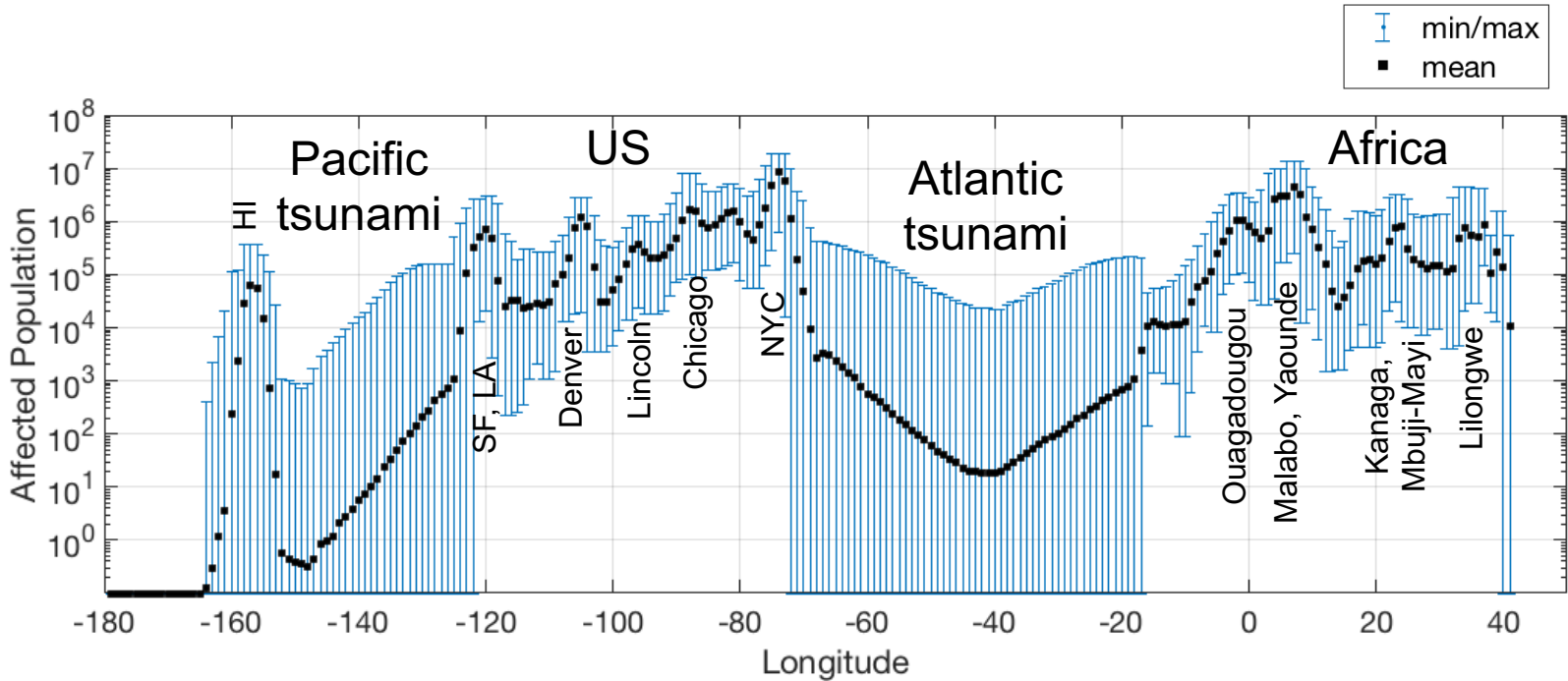


Potential Damage Swath



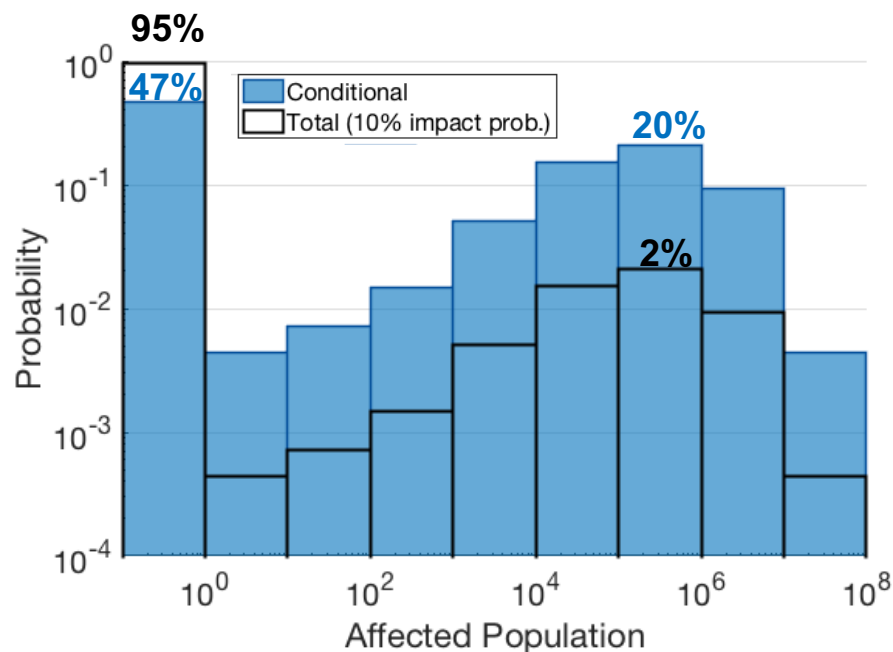


Population Risk along the Swath

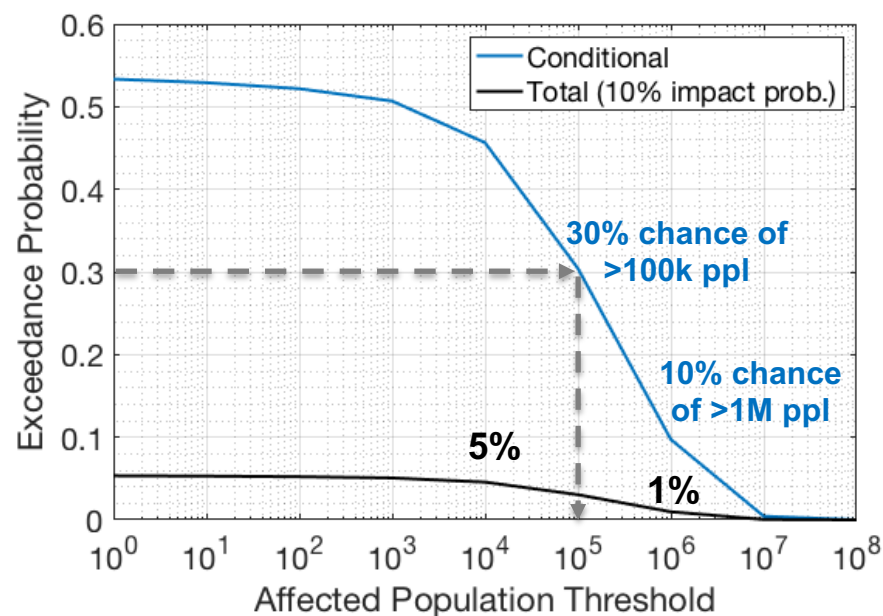


Affected Population Probabilities

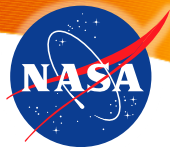
Population risk histogram:
probabilities of different population ranges being affected



Damage exceedance probabilities:
Likelihood of a certain number of people or more being affected

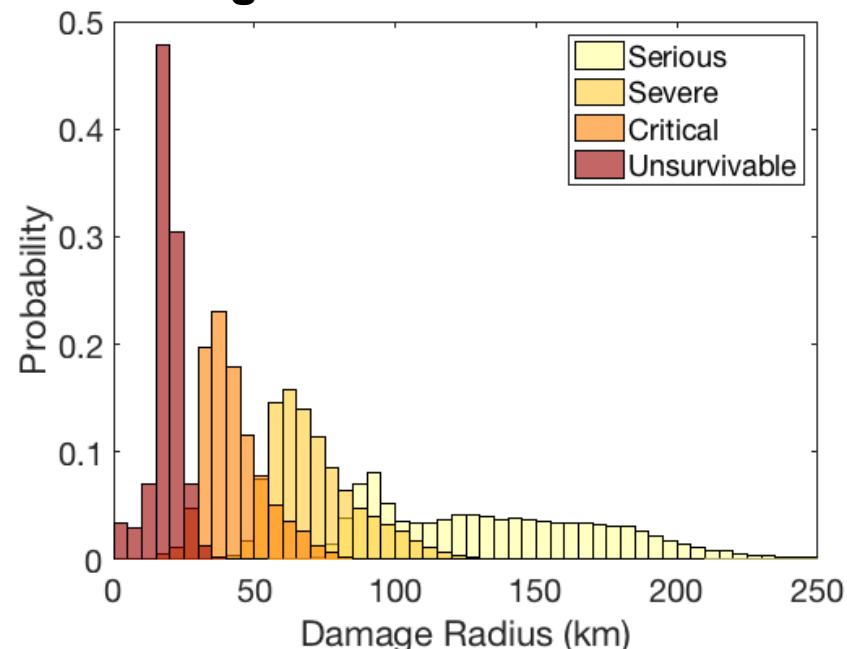


- **Probability of Earth strike: 10%**
- **Total probabilities:** account for chance that asteroid misses Earth (90%)
- **Conditional probabilities:** probabilities *if* an Earth strike occurs

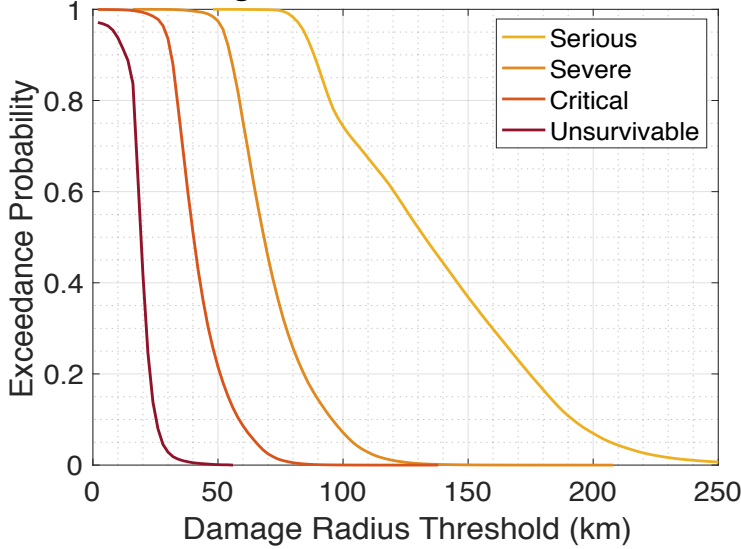


Hazard & Damage Probabilities

Damage Radius Probabilities

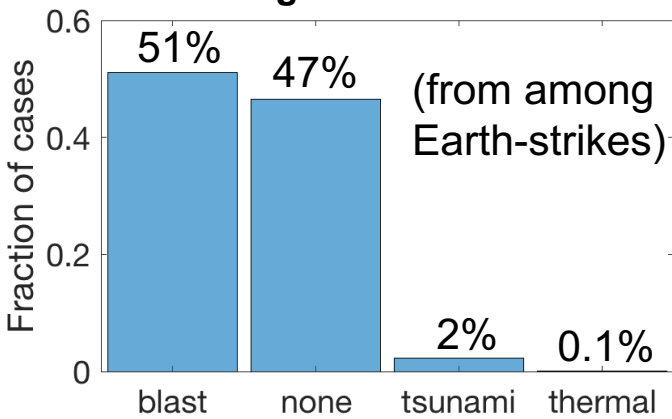


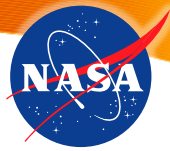
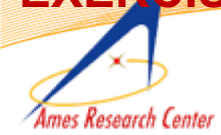
Damage Exceedance Probabilities



Damage Levels	Mean Radius (km)	Radius Range (km)
Serious	137	46 – 419
Severe	72	14 – 207
Critical	43	0 – 137
Unsurvivable	19	0 – 56

Driving Hazard Sources





30 December 2021

DAY 3



Probabilistic Asteroid Impact Risk

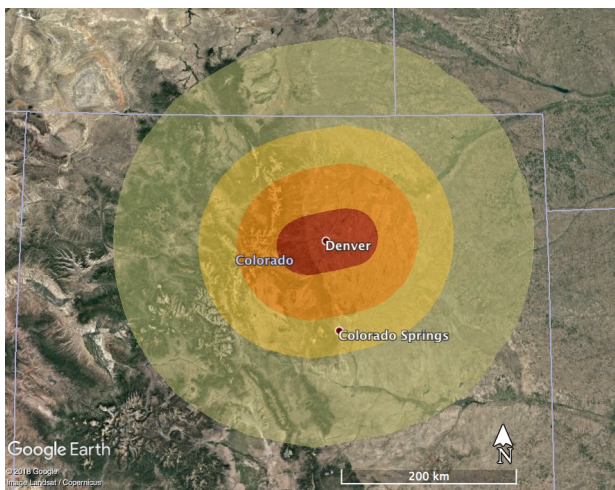


NASA Ames, Asteroid Threat Assessment Project

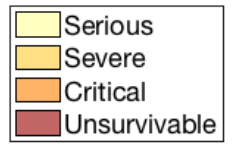
Characterization Summary & Updates

- Assessment date: 30 December 2021
- Impact date: 29 April 2027 (5.3 years)
- Earth impact probability: 100%, Denver area
- Size, shape, and class from flyby mission.
- Diameter (m): 180 ± 20 (1- σ), range 110–250
- Energy (Mt): mean 290, range 52–943,
- Type: S class, contact binary with 2:1:1 shape

Potential Damage Zone Map



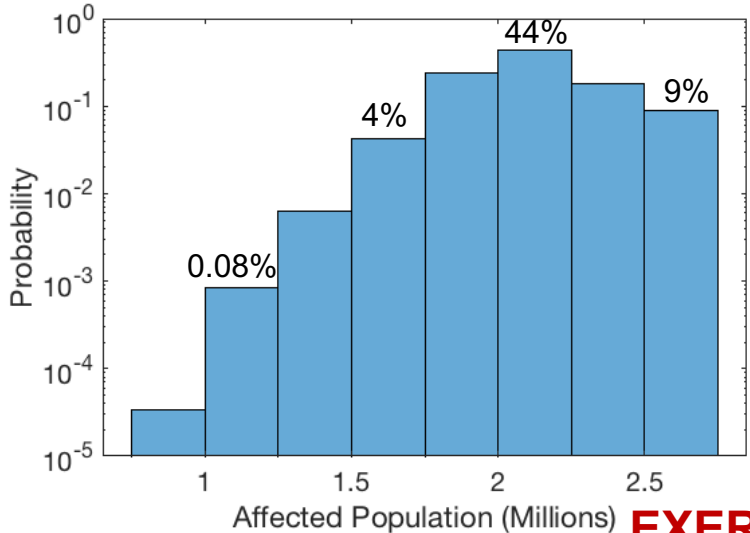
Full extent of regions potentially falling within each damage severity level.



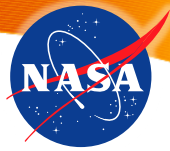
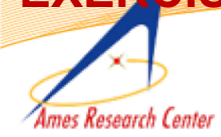
Risk Summary

- Affected population: mean 2.1M, range 826k–2.73M
- Likely airburst at ~6-8 km altitude (max 18 km).
- Blast overpressure is primary hazard, reaching at least critical damage levels (>4 psi)

Affected Population Probabilities



Damage Levels	Mean Radius	Radius Range
Serious	150 km	72 – 220 km
Severe	72 km	47 – 120 km
Critical	43 km	24 – 79 km
Unsurvivable	20 km	0 – 35 km

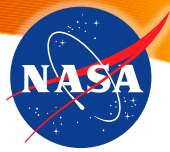


3 September 2024

DAY 4



Impact Risk Summary



Characterization Summary & Updates

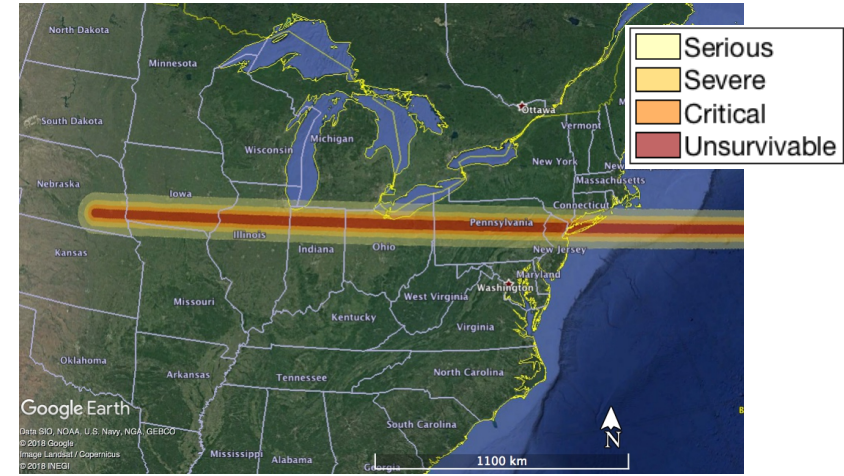
- Assessment date: 3 September 2024
- Impact date: 29 April 2027 (~2.7 years)
- Earth impact probability: 100%,
- Disrupted fragment expected to strike between East Nebraska to mid-Atlantic
- Diameter (m): 65 ± 15 (1- σ), full range 12–117
- Energy: mean 15 Mt, range 57 kt – 80 Mt,
- Type: Disrupted fragment from S-class contact binary

Risk Summary

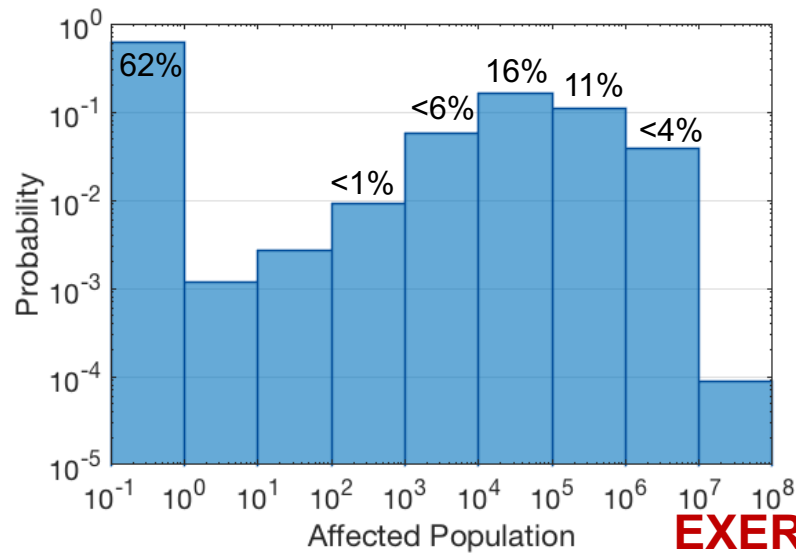
- Affected population: mean 146k, range 0–11.5M
- Likely airburst at ~16 km altitude (6.5–36 km).
- Blast overpressure is primary hazard.
- Damage out to ~84 km if larger, lower burst
- Little-to-no damage if burst is small & high

Damage Levels	Mean Radius	Radius Range
Serious	38 km	0 – 84 km
Severe	16 km	0 – 53 km
Critical	5.4 km	0 – 33 km
Unsurvivable	0.6 km	0 – 17 km

Potential Damage Zone Map

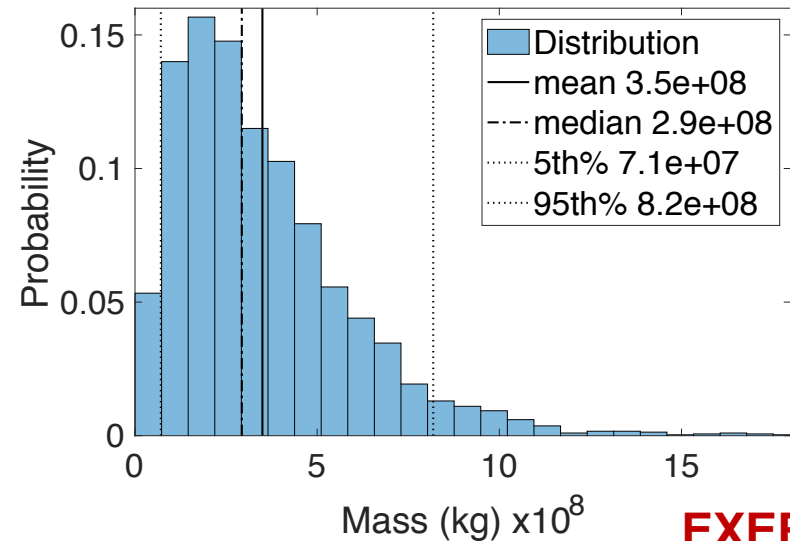
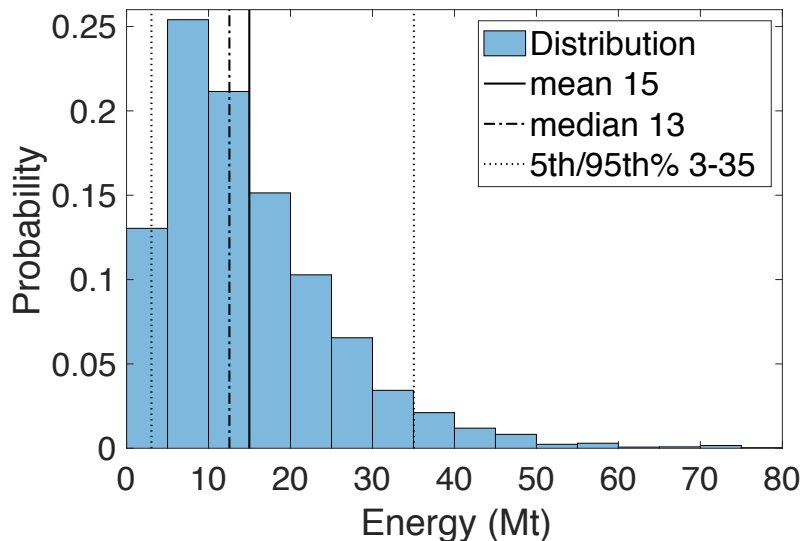
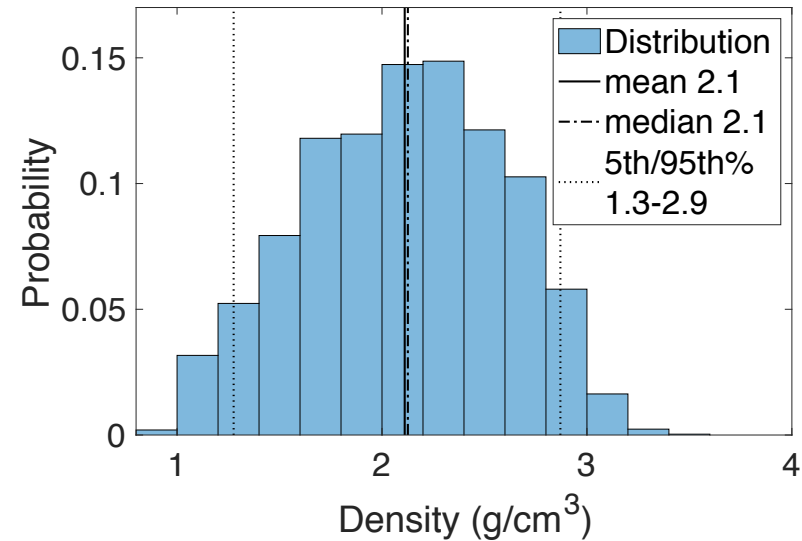
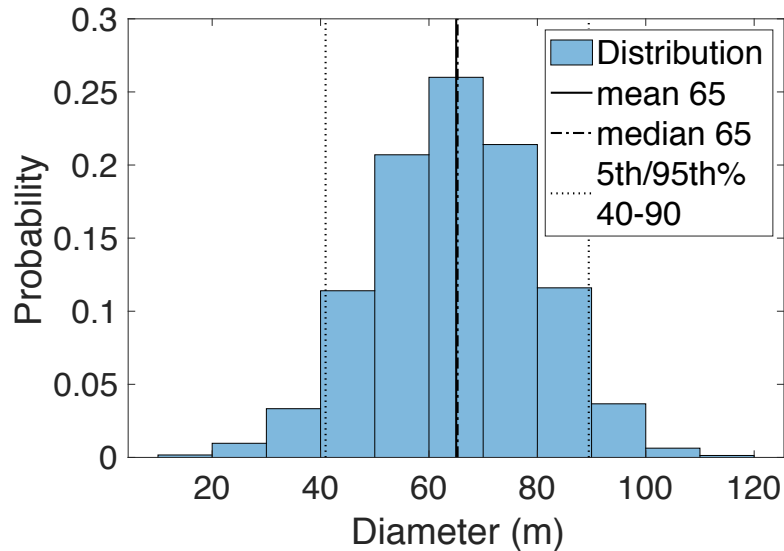


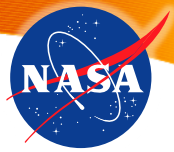
Affected Population Probabilities



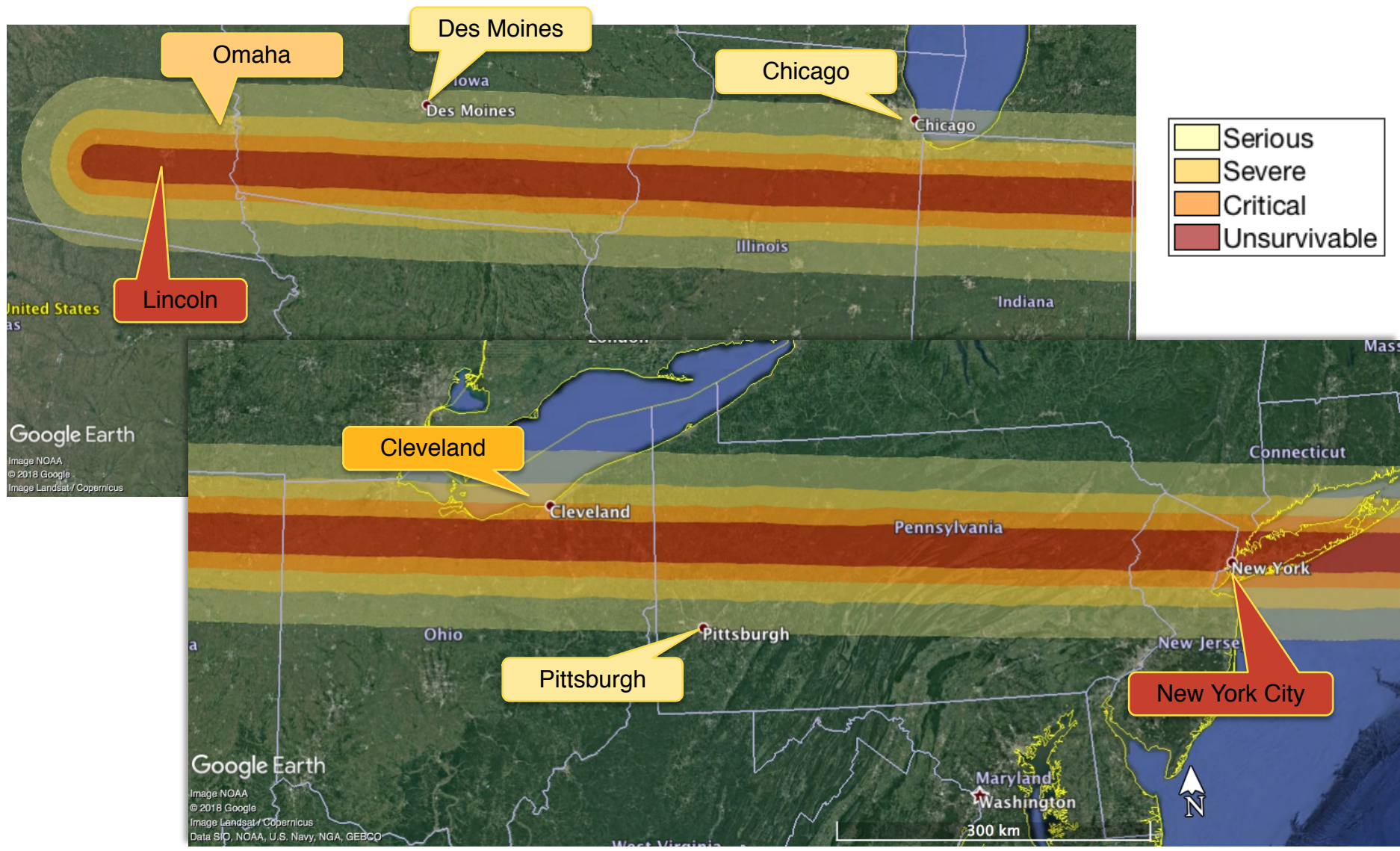
Asteroid Properties

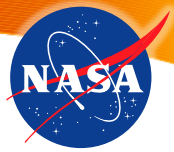
- J. Dotson, Bayesian Inference of Physical Properties for Impact Scenarios (IAA-PDC-19-02-P12)



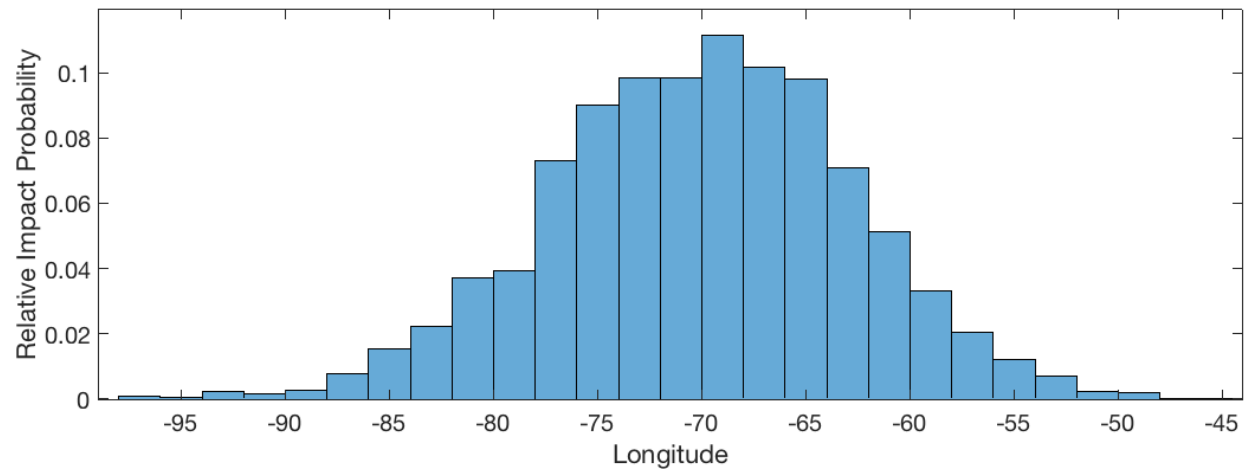
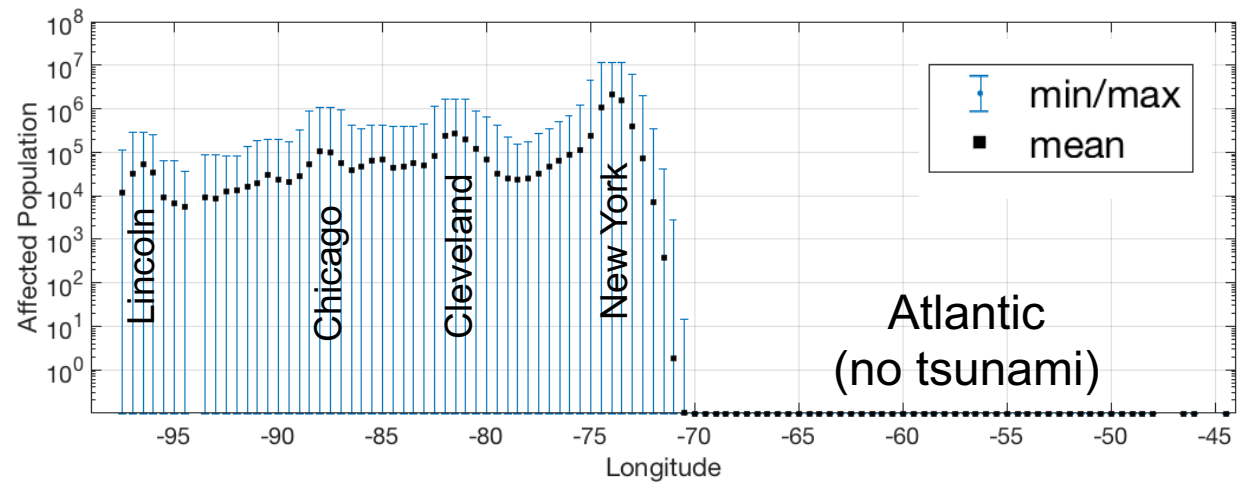


Risk Swath



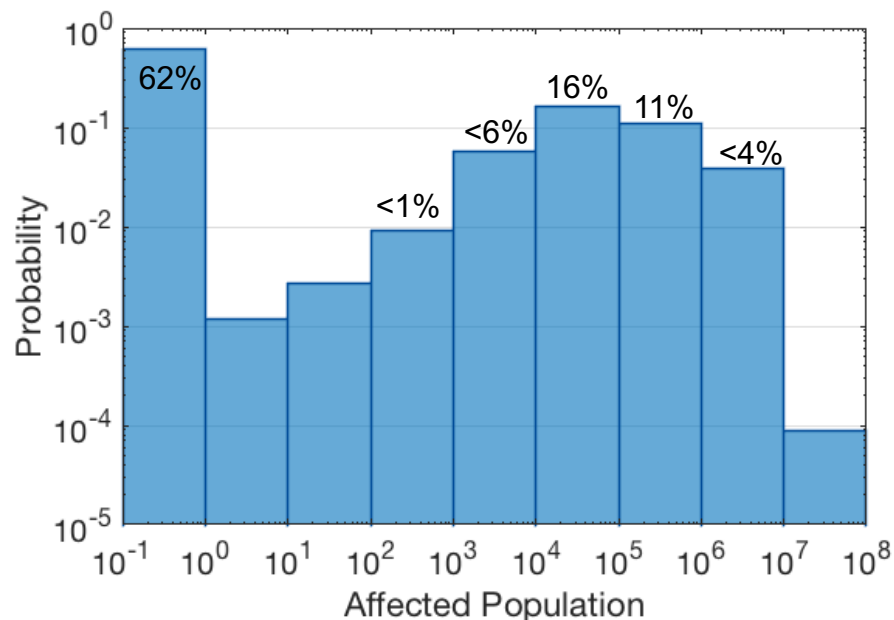


Affected Population Ranges and Impact Risk Along Swath

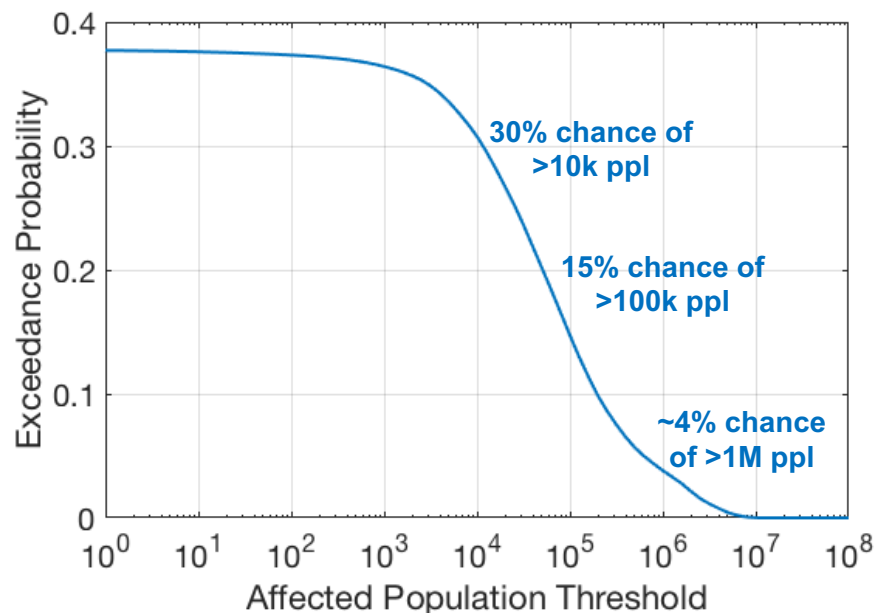


Affected Population Probabilities

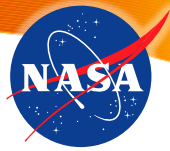
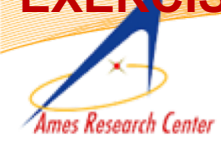
Population risk histogram:
probabilities of different population ranges being affected



Damage exceedance probabilities:
Likelihood of a certain number of people or more being affected



- **No damage** most likely, followed by **10-100k** people
- Maximum affected population: **11.5 million** people



19 April 2027

DAY 5



Probabilistic Asteroid Impact Risk

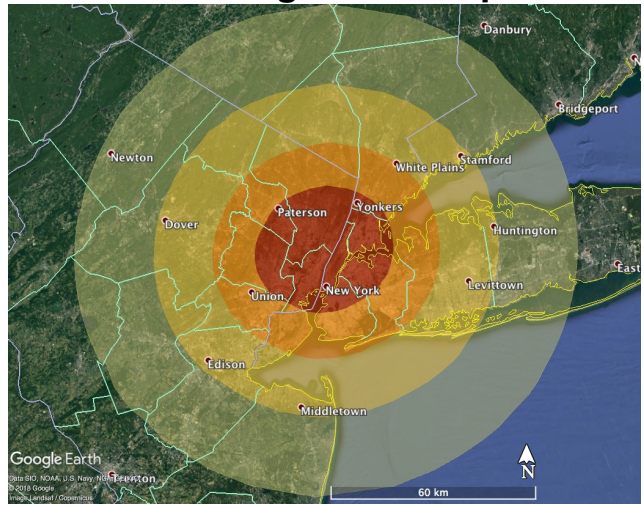


NASA Ames, Asteroid Threat Assessment Project

Characterization Summary & Updates

- Assessment date: 19 April 2027
- Impact date: 29 April 2027 (10 days)
- Earth impact probability: 100%, New York Area
- Diameter (m): 60 ± 10 (1- σ), range 26–93
- Energy: mean 11 Mt, range 650 kt – 46 Mt,
- Type: S class, remaining chunk of disrupted contact binary.

Potential Damage Zone Map



Full extent of regions potentially falling within each damage severity level.



Risk Summary

- Affected population: mean 2.4M, range 0–10.2M
- Likely airburst at ~16 km altitude (8–29 km).
- Blast overpressure is primary hazard.
- Damage out to ~70 km if larger, lower burst
- Little-to-no damage if burst is small & high

Damage Levels	Mean Radius	Radius Range
Serious	33 km	0 – 68 km
Severe	13 km	0 – 45 km
Critical	3 km	0 – 28 km
Unsurvivable	0.1 km	0 – 15 km

Affected Population Probabilities

