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Module 1a

Early Mitigation Options

23 February 2022 (Six Months to Impact)

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Module 1 Roadmap

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- In Module 1, our scenario moves forward to 23 February 2022
- Module 1 will be split across both days of the TTX
- In Module 1a (Day 1), we will:
  - Provide updated impact predictions and damage risk assessment
    - Discussion will focus on communication of the asteroid threat
- In Module 1b (Day 2), we will:
  - Provide information on space mission mitigation options
    - Discussion will focus on capability gaps, legal and policy implications, and communication as our knowledge evolves

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INJECT 1.1

- Presentation from NASA Center for Near-Earth Object Studies on the latest observations of asteroid 2022 TTX as of 23 February 2022

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Impact Predictions: Module 1

Scenario Date: 23 February 2022
Impact Probability Increases to 71% and the CONUS Is at Risk

Paul Chodas, Davide Farnocchia & Ryan Park
Center for NEO Studies (CNEOS)
Jet Propulsion Laboratory, California Institute of Technology

Scenario Update: Module 1

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- **23 February 2022:** A week has passed since Module 0, and 2022 TTX has been tracked nightly by astronomers around the world, using large optical telescopes
  - The asteroid is currently about 37 million mi (60 million km) away
- The new observations, along with prediscovery observations from several days before discovery, have enabled a more accurate orbit to be determined for 2022 TTX
- The impact probability has jumped to 71%
- The predicted impact region has converged to a wide corridor spanning across the globe and passing across much of the continental U.S.
- The asteroid's size remains highly uncertain; based on its brightness, it's most likely in the range of 55–160 m (180–520 ft), but it could be as large as 440 m (1440 ft)
  - The asteroid will not be within range of Goldstone radar until August

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2022 TTX Uncertainty Region

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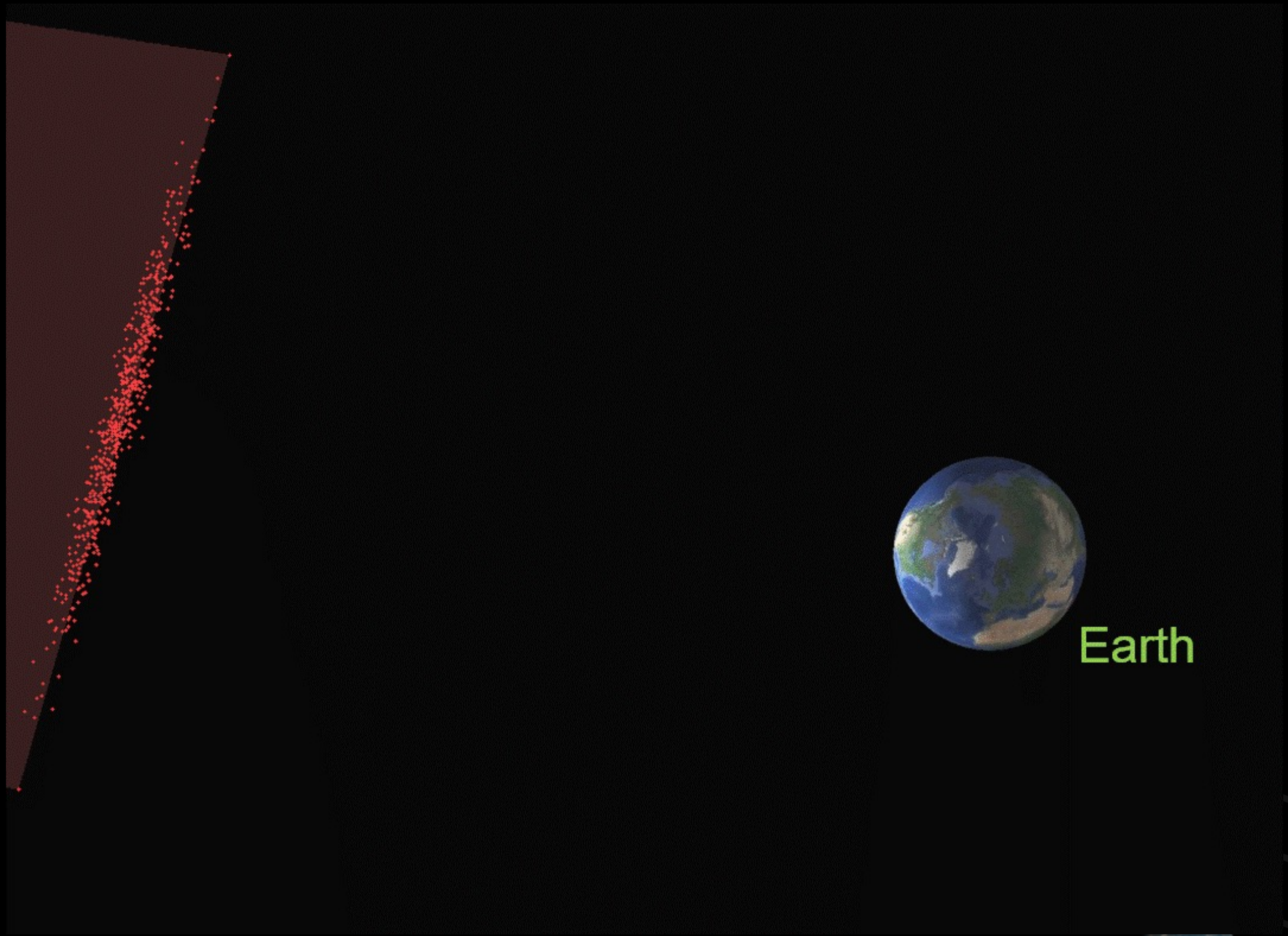

The red dots trace the uncertainty region, which encompasses all possible positions of the asteroid as it approaches Earth on Aug. 16

The shaded region shows the region swept by the uncertainty region

Half-hour time steps

Predicted Impact Region

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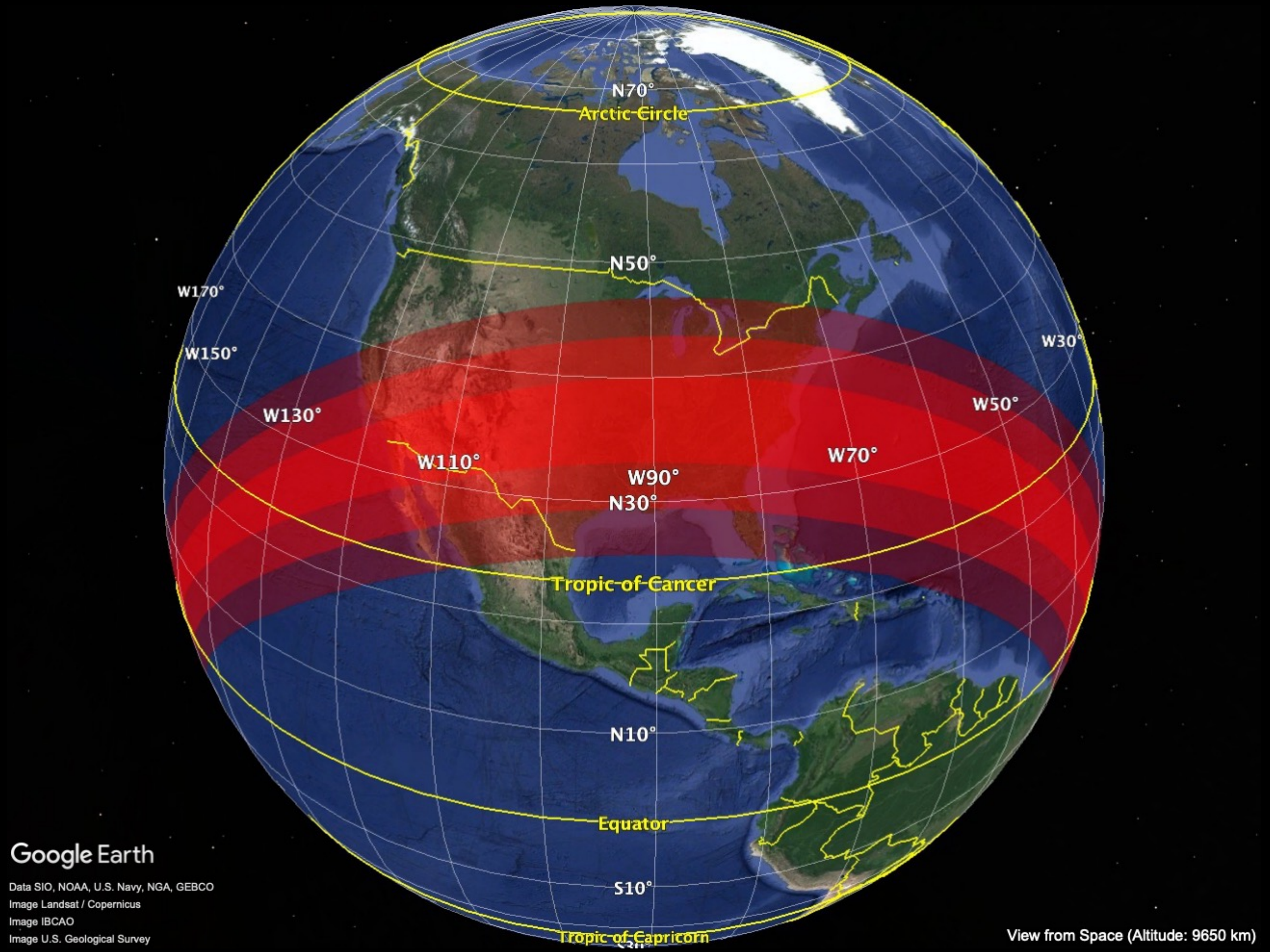

Shows the region where the 2022 TTX might impact on 16 August 2022, based on the latest orbit solution

Region extends from the mid-South Pacific, across North America, to mid-South Atlantic

The intensity of the red shading indicates the relative probability

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Predicted Impact Region

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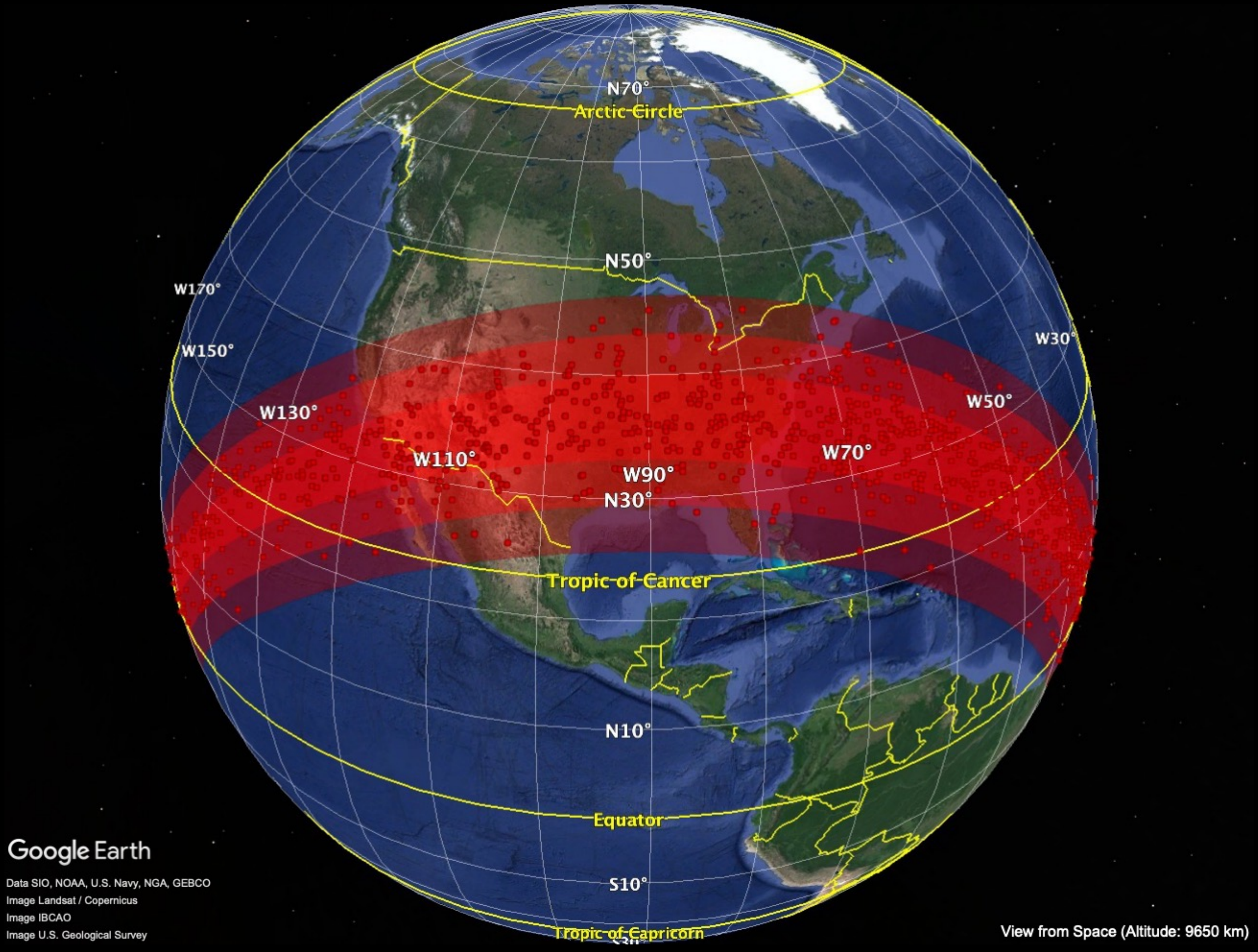

Shows the region where the 2022 TTX might impact on 16 August 2022, based on the latest orbit solution

Region extends from the mid-South Pacific, across North America, to mid-South Atlantic

The intensity of the red shading indicates the relative probability

With 980 sample impact cases

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Predicted U.S. Impact Region

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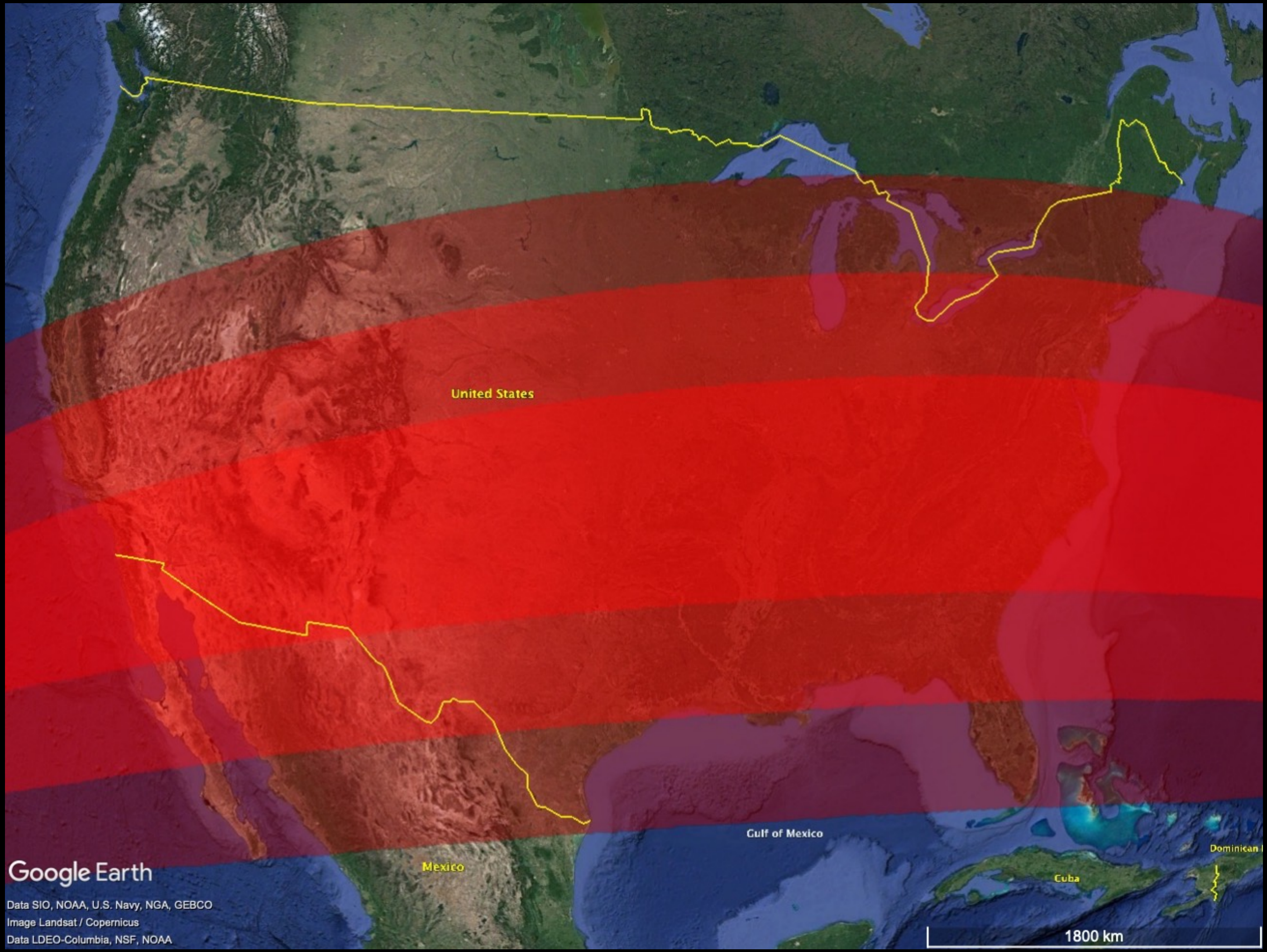

Shows the region where the 2022 TTX might impact on 16 August 2022, based on the latest orbit solution

Probability of impact within CONUS is about 19%

The intensity of the red shading indicates the relative probability

Predicted U.S. Impact Region

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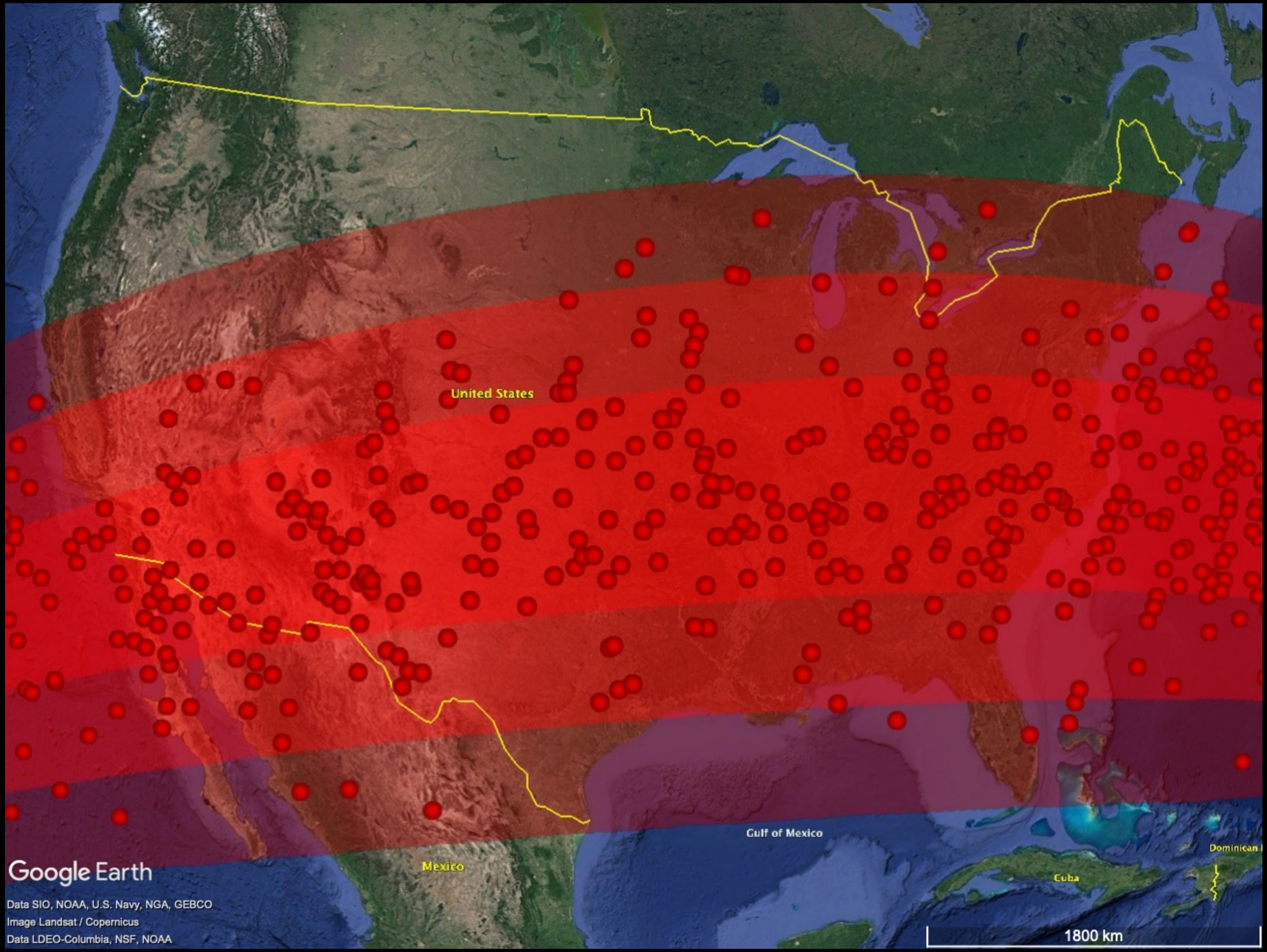

Shows the region where the 2022 TTX might impact on 16 August 2022, based on the latest orbit solution

Probability of impact within CONUS is about 19%

The intensity of the red shading indicates the relative probability

With sample impact cases

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- Presentation from NASA Asteroid Threat Assessment Project on the impact damage risk from 2022 TTX

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Asteroid Impact Risk: Module 1

71% chance of Earth impact in under 6 months

Lorien Wheeler
Jessie Dotson, Michael Aftosmis, Eric Stern, Donovan Mathias
Asteroid Threat Assessment Project (ATAP)
NASA Ames Research Center

Asteroid Size & Properties

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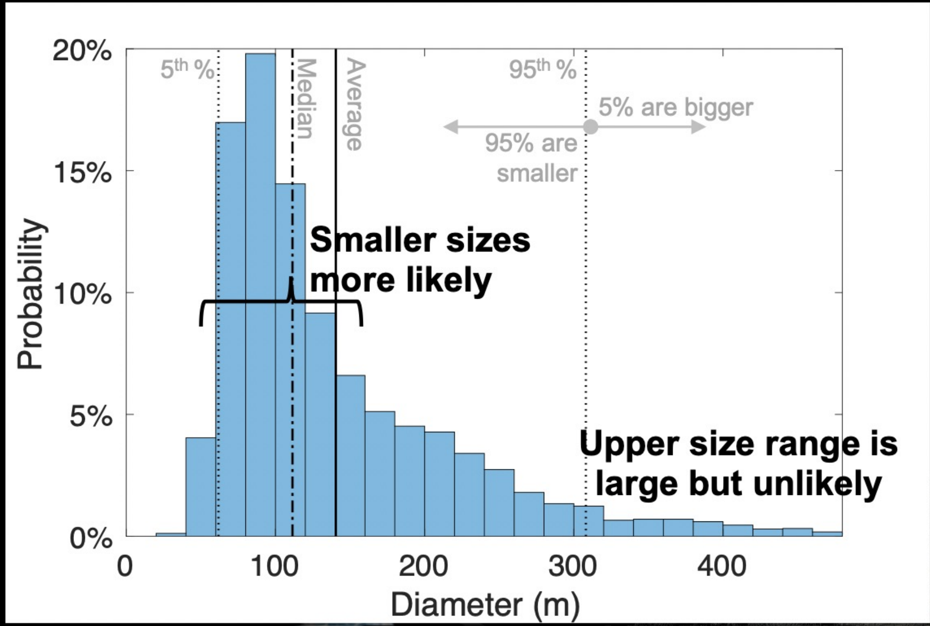
- **Asteroid size is highly uncertain**
  - Ranging from smaller objects that would pose little threat to objects hundreds of meters across with gigatons of impact energy
  - Upper size range is large but unlikely
  - Smaller size ranges are more likely
- Asteroid type and properties are unknown
  - Wide ranges of densities, strengths, structures, compositions
  - Ranging from more common stony types and rubble piles to rarer high-density iron types
- Size and property uncertainties result in ***very large*** ranges of potential mass, energy, and damage

Asteroid Size Ranges

	Diameter	Energy
Range	40–440 m (130–1440 ft)	1–3000 Mt
Most likely range	55–160 m (180–520 ft)	2–100 Mt
Median	110 m (360 ft)	46 Mt

Asteroid Diameter Probabilities



Potential Risk Swath

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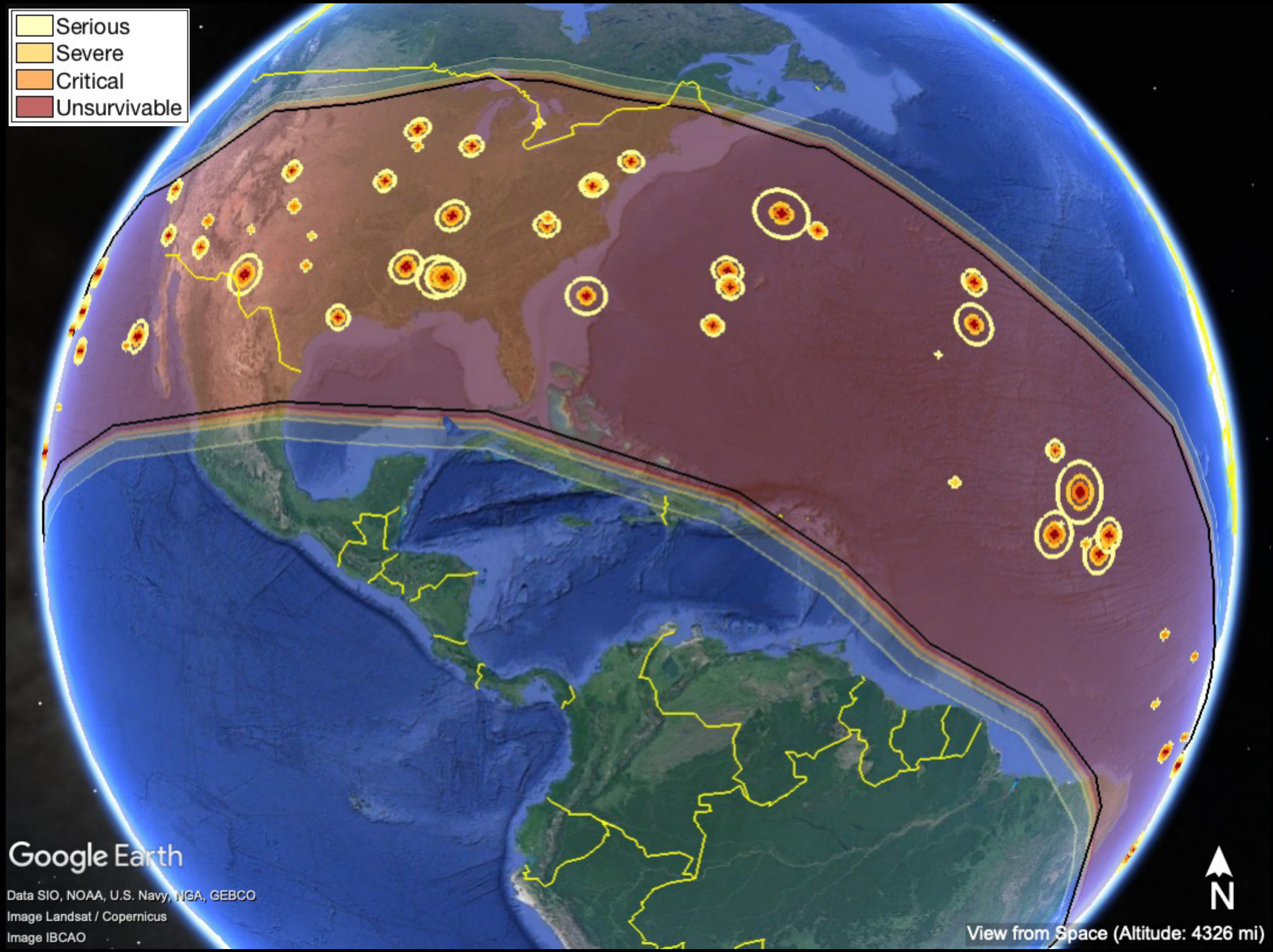

Damage risk swath: Shows extent of regions potentially at risk to local ground damage, given ranges of potential damage sizes and locations (not representative of likelihood).

Damage risk swath:

- Shaded swath areas show regions ***potentially*** at-risk, given range of damage sizes and locations.
- Rings show a random sampling of individual potential damage footprints.

Extent of current risk region:

- Crosses U.S., Mexico, SE Canada, Antilles, E. Brazil. Water impacts also near Hawaii, S. Pacific, W. Africa.
- Swath width/length is due to range of unknown impact locations, **not** expected damage sizes
- Range of locations will shrink as observations refine the orbital data

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U.S. Potential Risk Swath

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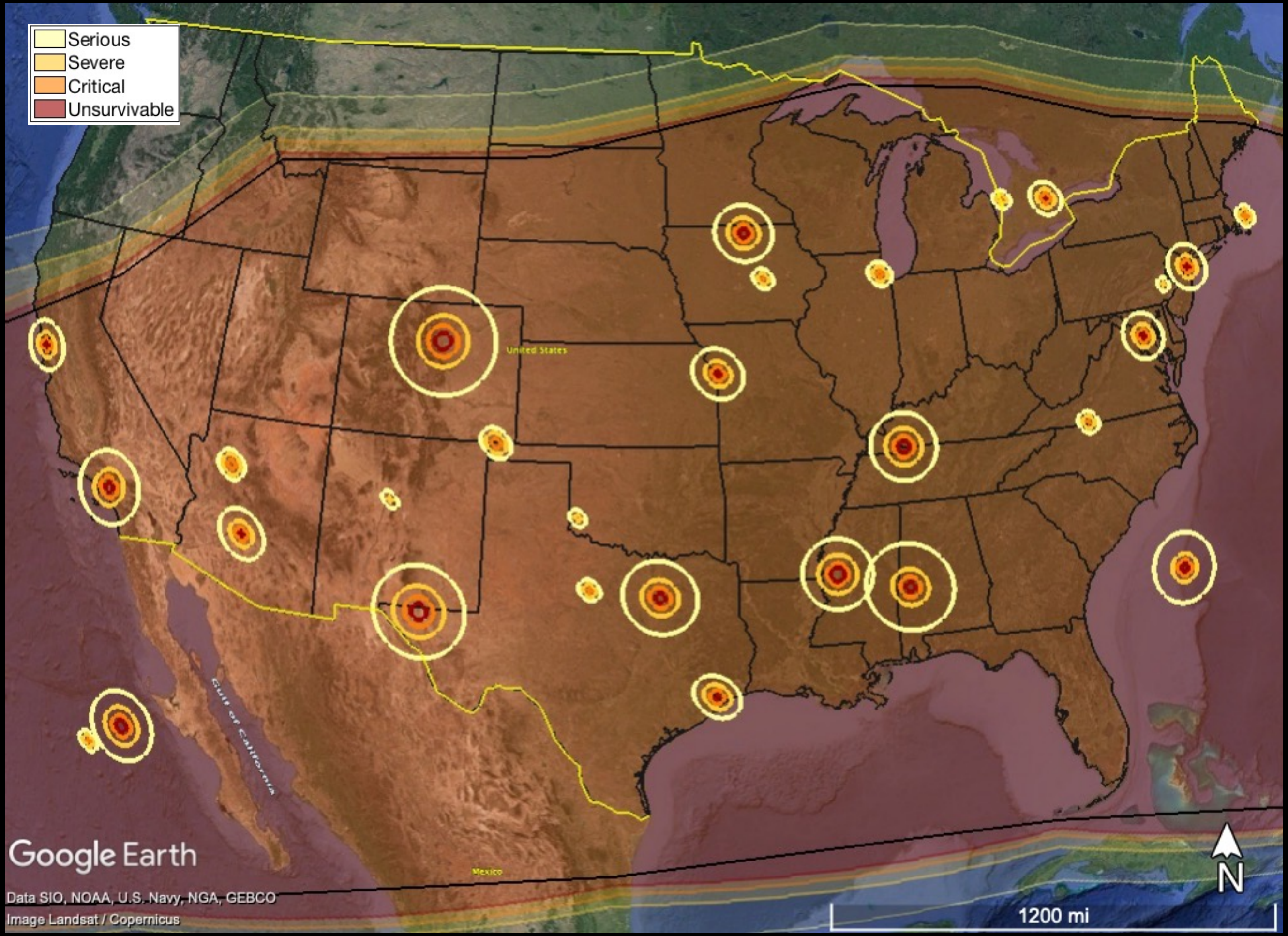

Damage risk swath: Shows extent of regions potentially at risk to local ground damage, given ranges of potential damage sizes and locations (not representative of likelihood). Rings show range of damage sizes at random locations.

U.S. Impact Damage Risk:

- ~26% chance of U.S. damage among Earth-impacting cases (~19% total chance)

Wide range of damage sizes and severities

- Damage severities could range from shattered windows to unsurvivable blasts
- Outer damage radius ranges:
  - Potential range: 0–120 mi
  - Most likely range: 12–70 mi
  - Average: 50 mi

Damage Level	Description
Serious	Shattered windows, some minor structure damage
Severe	Widespread structure damage, doors blown out
Critical	Most residential structures collapse
Unsurvivable	Complete devastation

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U.S. Potential Risk Swath

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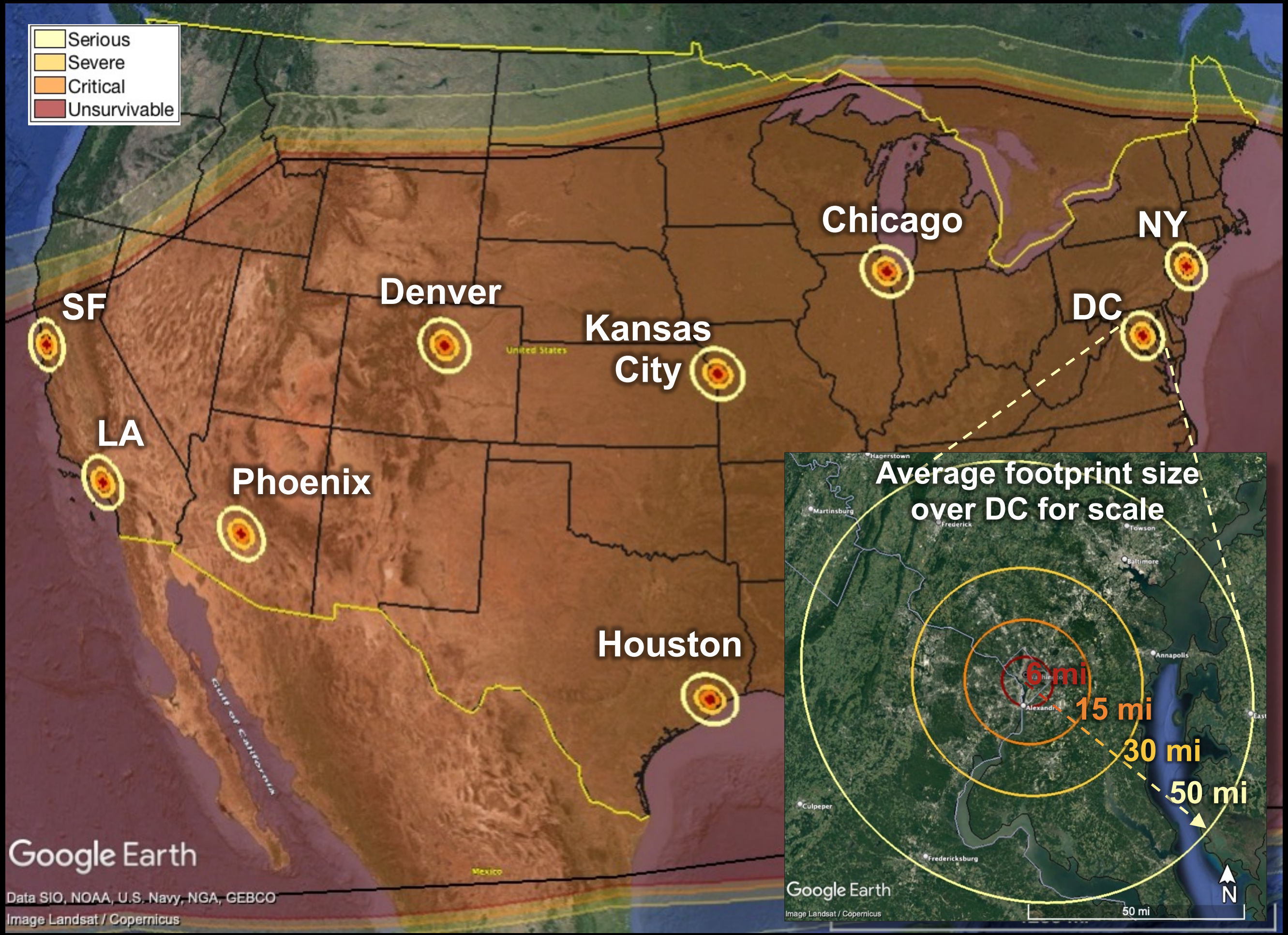

Damage risk swath: Shows extent of regions potentially at risk to local ground damage, given ranges of potential damage sizes and impact locations (not representative of likelihood). Rings show average-sized damage footprints at example locations.

U.S. Impact Damage Risk:

- ~26% chance of U.S. damage among Earth-impacting cases (~19% total chance)

Wide range of damage sizes and severities

- Damage severities could range from shattered windows to unsurvivable blasts
- **Average U.S. Blast Footprint Radii:**
  - Serious: ~50 mi
  - Severe: ~30 mi
  - Critical: ~15 mi
  - Unsurvivable: ~6 mi

Damage Level	Description
Serious	Shattered windows, some minor structure damage
Severe	Widespread structure damage, doors blown out
Critical	Most residential structures collapse
Unsurvivable	Complete devastation

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Hazard Sources

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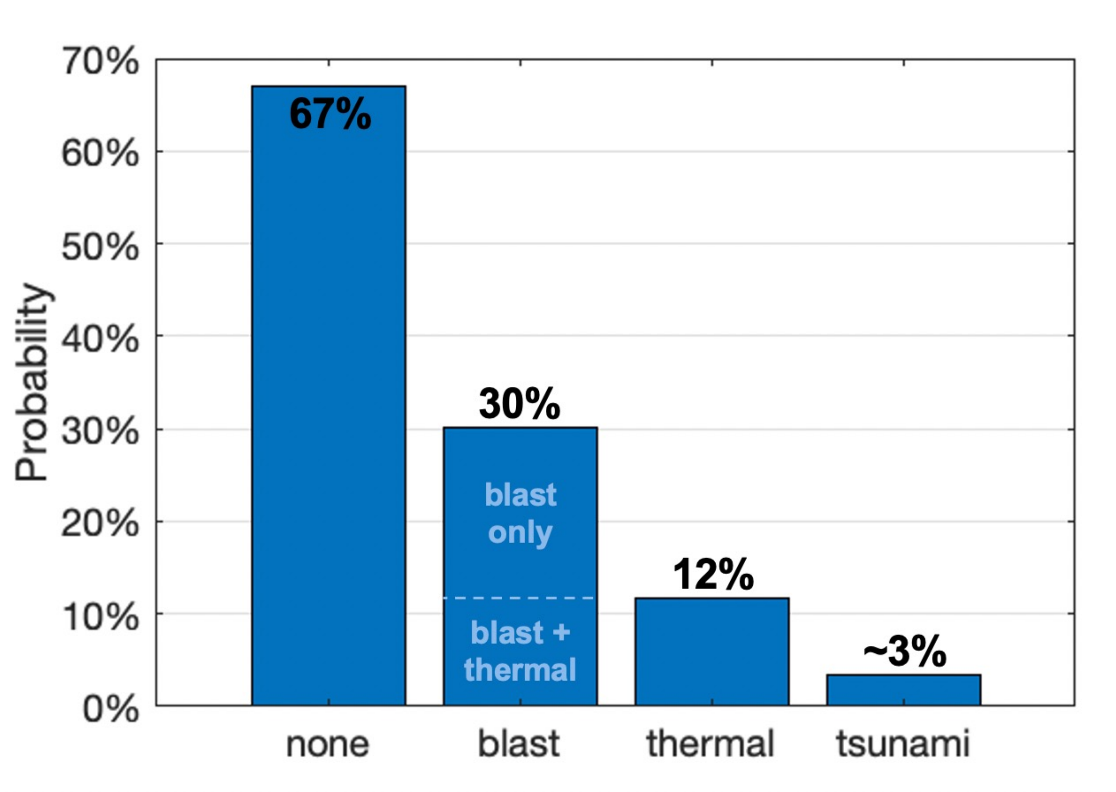
Relative hazard probabilities among Earth-impacting cases (71% Earth-impact):

- No damage occurs in ~67% of Earth-impact cases
- Blast damage is the largest hazard source in ~30% of Earth-impact cases
- Thermal damage also occurs in ~12% of cases, but it is smaller and less severe than accompanying blast damage in nearly all cases
- Risk of tsunami damage is low, occurring in ~3% of impact cases (5% of ocean cases), but the largest water impacts could cause significant damage if near populated coasts
- No global-scale climatic effects are expected, but potential for regional environmental effects from larger impacts is unknown

Hazard Occurrence Probabilities
(among 71% Earth-impacting cases)



* A single impact event can cause multiples hazards (such as blast + thermal, or tsunami + blast for near-shore cases).
Sum of all hazard occurrence probabilities may exceed 100%.

Impact Risk Summary: Module 1

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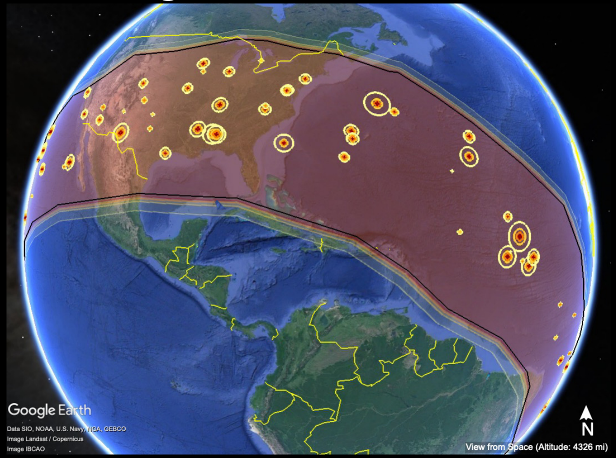
Asteroid Characterization Summary

- Assessment date: 23 February 2022 (T- <6 months)
- Potential impact date: 16 August 2022
- Earth-impact probability: 71%
- Large uncertainties in asteroid size, energy, and other properties
- Diameter: 40–440 m (130–1440 ft), most likely ~55–160 m (180–520 ft), median size 110 m (360 ft)
- Energy: 1–3000 megatons (Mt), most likely ~2–100 Mt, median 46 Mt

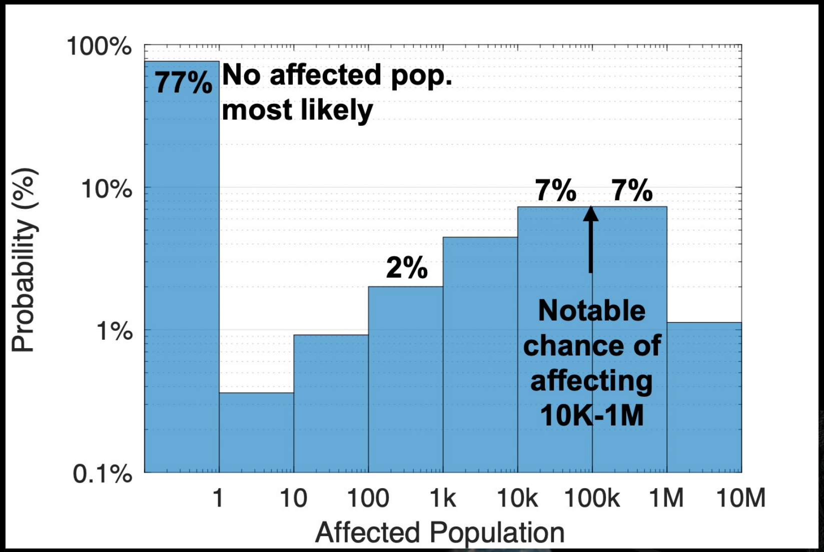
Risk Region Swath



Regions potentially at risk, given range of potential damage locations and sizes. Average-sized damage footprints are shown over sample U.S. cities.

Impact Hazard Summary

- Potential damage sizes and locations are very uncertain
- No damage is most likely (~77% chance) with moderate chance of large damage areas affecting 10k–1M people
- Primary hazard: Blast damage, ranging from blown out windows, to structure damage, to potentially unsurvivable levels
- Damage radii: 0–120 mi, most likely range 12–70 mi, median 40 mi
- Tsunami damage is unlikely and mostly minor
- Affected population: 0–millions, 50k total average risk, 20% chance of affecting >1k ppl, 16% >10k, 8% >100k, 1% >1M



Population Risk

Probabilities of how many people could be affected by the potential damage

(total probabilities including 71% Earth-impact probability)

Module 1 Risk Backup

Potential Risk Swath

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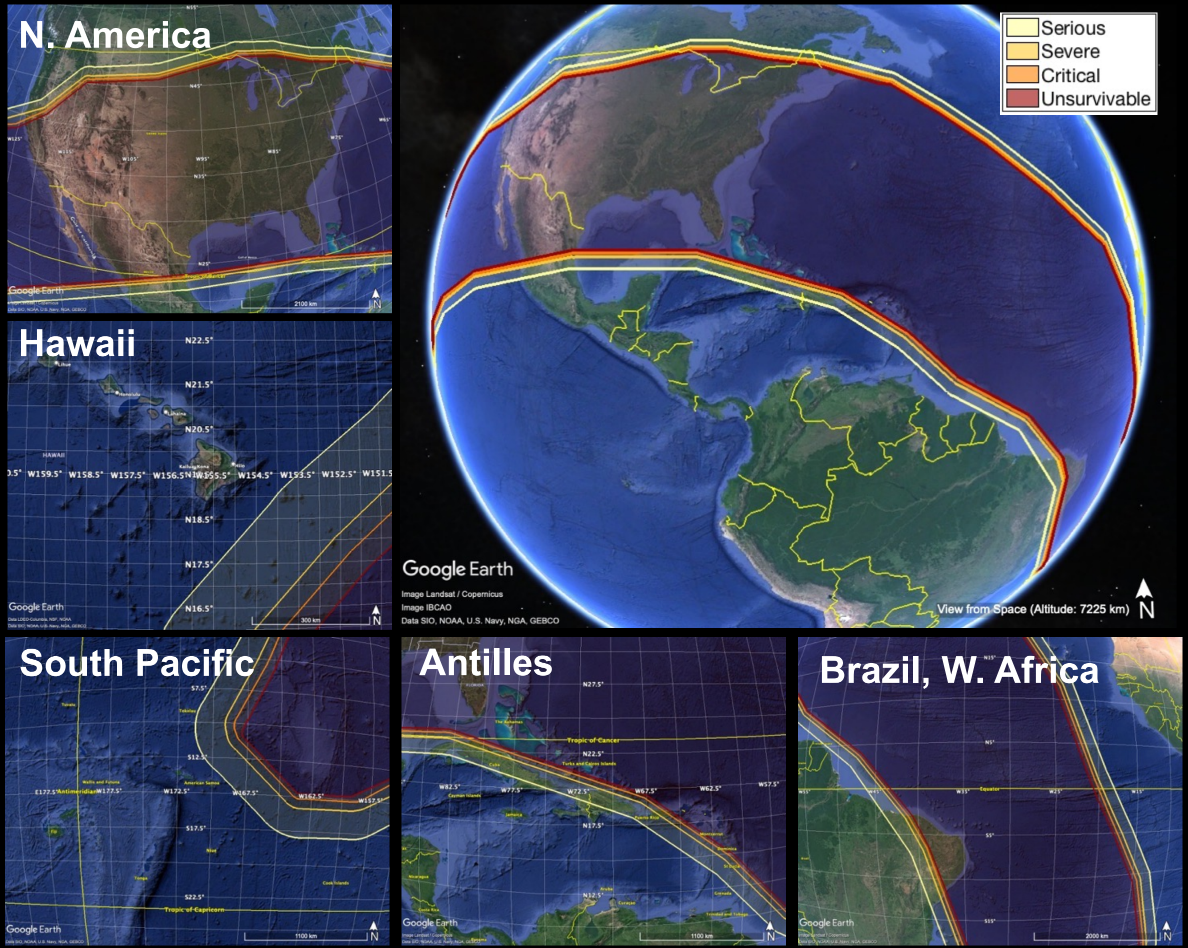

Damage risk swath: Shows extent of regions potentially at risk to local ground damage, given ranges of potential damage sizes and impact locations (not representative of likelihood).

Extent of risk region:

- >24,000 km (>15,000 mi) long,
  ~3000 km (~1900 mi) across at widest extents.
- Crosses U.S, Mexico, SE Canada, Antilles, E. Brazil. Water impacts also near Hawaii, S. Pacific, W. Africa.
- Swath width due to impact location uncertainty, not likely damage size

Impact hazard risks:
(among Earth-impact cases)

- ~67% chance of impact causing ***no*** population damage
- ~30% chance of blast damage to populated areas
- ~70% chance of ocean impact, but only ~3% chance of tsunami damage to populated areas (5% of ocean strikes cases)

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U.S. Damage Footprint Sizes

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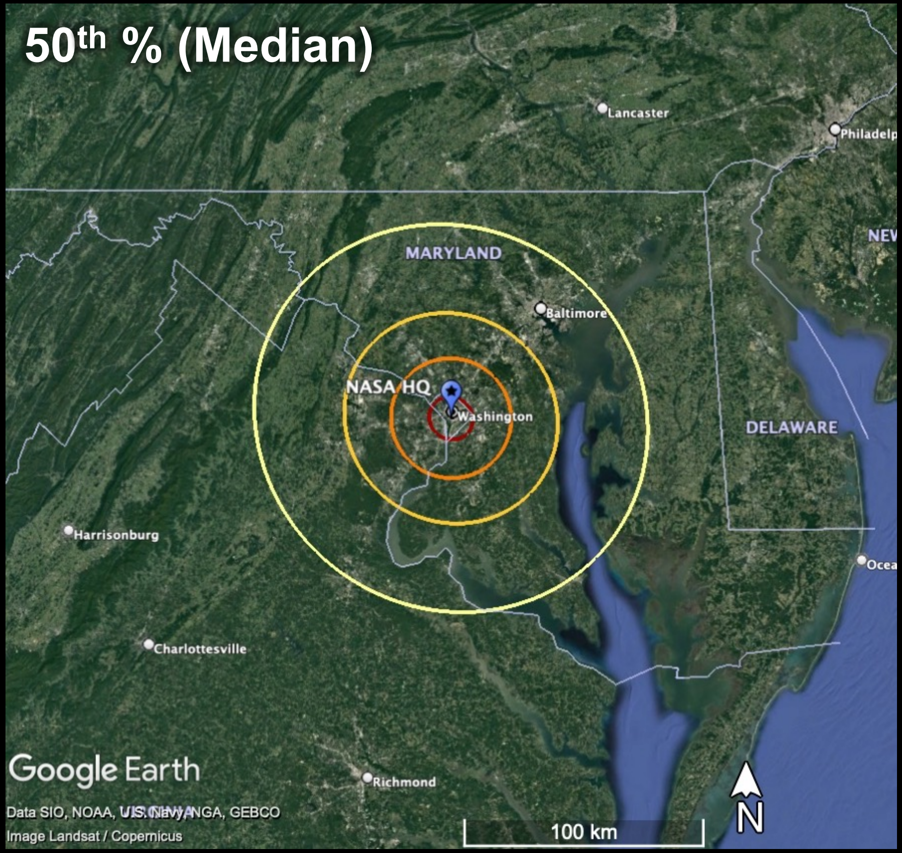

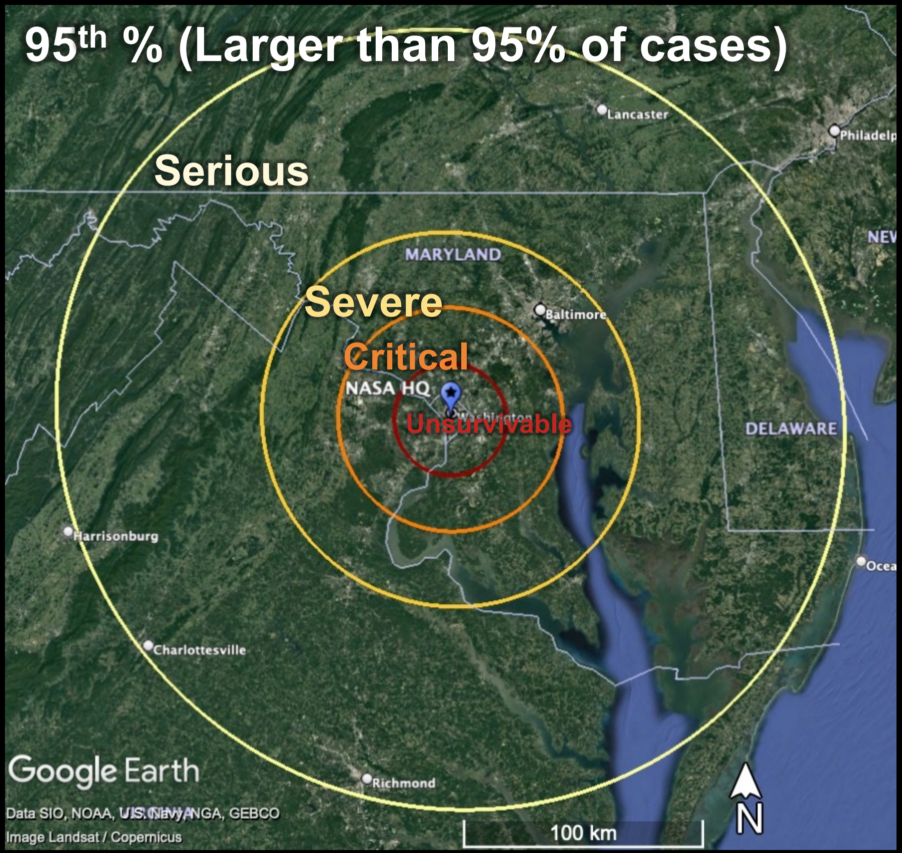

Local Ground Damage Radius (miles) Percentiles*

Damage Level	Mean	Min	5th %	25th %	**50th %**	75th %	**95th %**
Serious	52	0	16	25	**50**	75	**106**
Severe	27	0	4	16	**27**	37	**50**
Critical	14	0	0	6	**16**	22	**30**
Unsurvivable	6	0	0	0	**6**	11	**15**

** Percentiles give the chance that the damage region could be up to the given size or smaller (values shown are among U.S.-impacting cases modeled)*

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Hazard Sources

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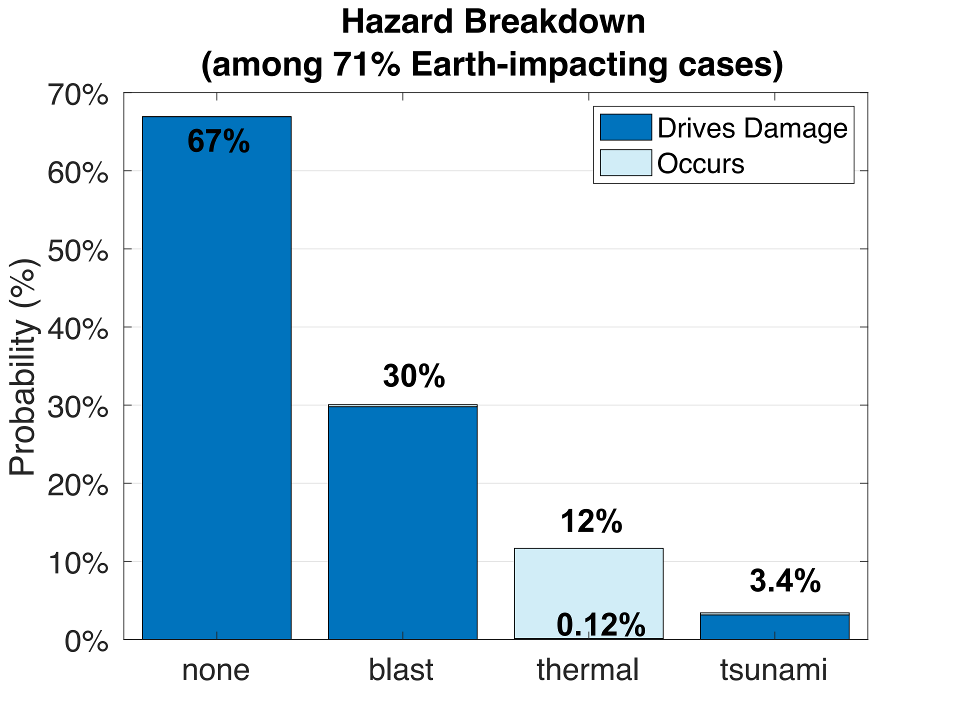
Relative hazard probabilities among 71% Earth-impacting cases:

- No damage occurs in ~67% of cases
- Blast damage is the predominant hazard source in ~30% of Earth-impact cases
- Thermal damage also occurs in ~12% of cases, but it is smaller and less severe than accompanying blast damage in nearly all cases
- Risk of tsunami is low, occurring in ~3% of impact cases, but the largest water impacts could affect hundreds-of-thousands of people if near a high-population coast.
- No global effects expected, but potential for regional environmental effects from larger impacts is unknown



Hazard Source	Occurrence Probability	Affected Population Ranges			
		Average	75th %	95th %	Full Range Modeled
No Damage	67%	0	0	0	0
Blast	30%	71K	2.7K	389K	0–16.5M
Thermal	12%	5.5K	0	3K	0–20M
Tsunami	3.4%	820	0	0	0–766K

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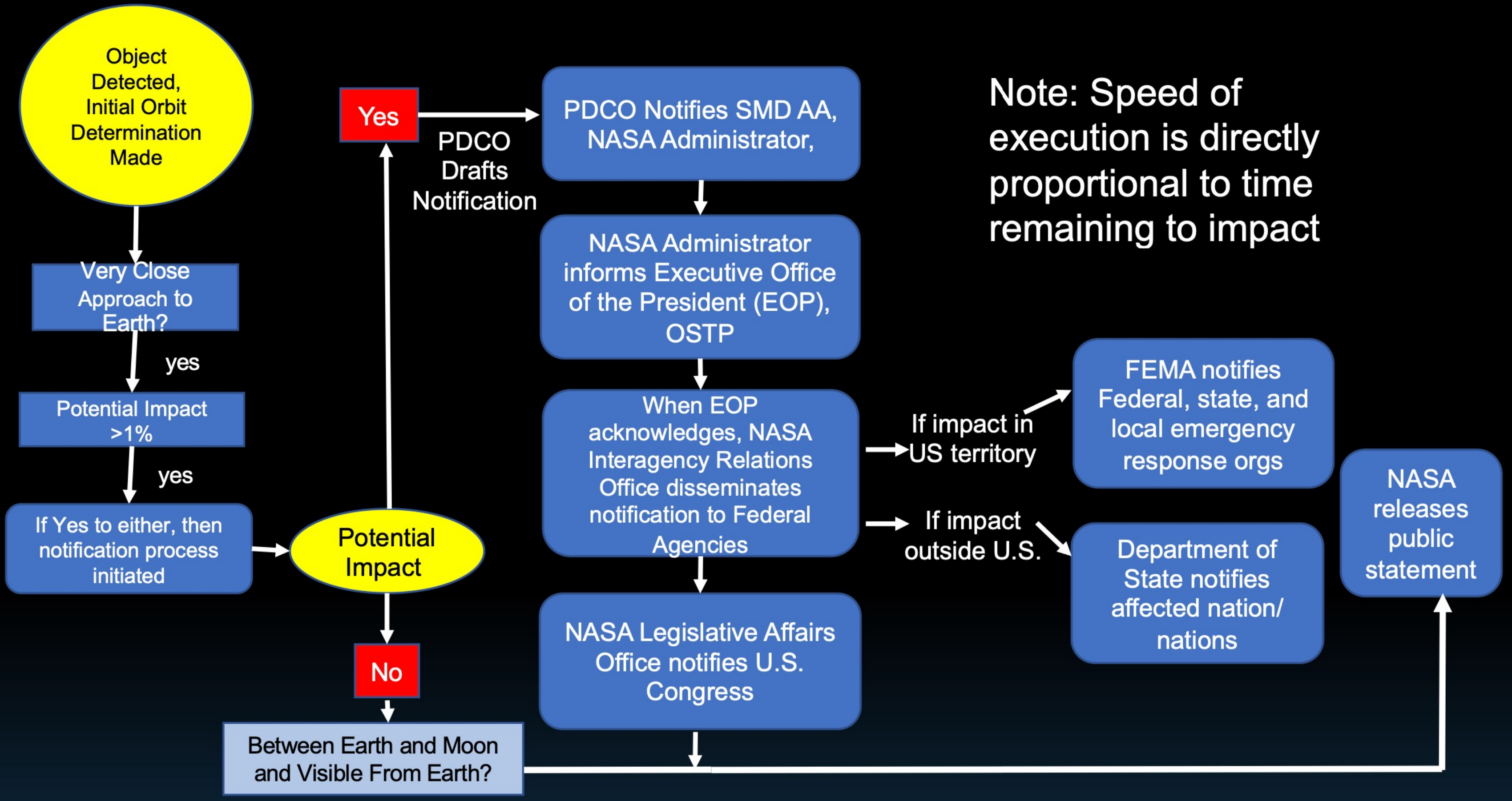
PLANETARY DEFENSE COORDINATION OFFICE

Potential Impact Notification Process



Note: Speed of execution is directly proportional to time remaining to impact

Source: NASA Policy Directive 8740.1 Notification and Communications Regarding Potential Near-Earth Object Threats

INJECT 1.3

- The PDCO issues notifications per NASA Policy Directive 8740.1
- Notification content is as described in from the *Report on Near-Earth Object Impact Threat Emergency Protocols*

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This is a simulated event.

February 23, 2022

From: NASA Planetary Defense Coordination Office
Title: Notification of Potential Asteroid Impact – Update #1

Impact Probability: 71%
Impact Date: 16 August 2022
Impact Risk Corridor: Impact in CONUS possible
Approximate Size: 130-1440 ft (40-440 m)
Expected Level of Damage if Impact Occurs: Local to Regional
Impact Prevention Feasible: Unknown at this time

- Additional observations of the motion of asteroid 2022 TTX show there is a 71% probability the asteroid will impact Earth on 16 August 2022. While there is still uncertainty in whether the asteroid will impact Earth, if an impact occurs it will be on this date.
- The impact risk corridor, which is the region of Earth where it is possible that 2022 TTX could impact, extends from the mid-Pacific across the North American continent to the south Atlantic. Most of the CONUS is within the impact risk corridor.
- The potential impact effects are highly dependent on the size of the asteroid. Based on current data, the asteroid is estimated to be between 130-1440 ft (40-440 m) in size. At the small end of this size range, an asteroid impact over land could result in minor local damage (e.g., air blasts resulting in broken windows and damage to low-integrity structures). At the large end, an asteroid impact could result in a significant surface crater and widespread injuries/casualties and structural damage over a region extending tens to 100+ km. An impact in coastal waters could result in a tsunami wave that would inundate coastline areas.
- The asteroid 2022 TTX has been tracked since initial discovery on 11 February 2022. Further observations will reduce the uncertainty in the asteroid's trajectory and impact probability. The asteroid will be continually observable by telescopes leading up to the potential impact date, except during the full moon.
- The asteroid size cannot be estimated with further precision without radar observations or imagery from a spacecraft that can closely approach the asteroid. Radar observations will be possible no sooner than 13 days prior to the potential impact date, if the asteroid is at the large end of the size range, and possibly not until 5 days prior to the potential impact if the asteroid is at the small end.
- The feasibility of space missions to prevent the impact is under study.

EXERCISE EXERCISE EXERCISE
This is a simulated event.

Potential Impact Notification

Summary details →

Impact probability and impact date/time →

Description of impact risk corridor →

Estimated impact effects →

Opportunities for further observations →

Feasibility of impact prevention space missions →

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- The feasibility of space missions to prevent the impact is under study.

INJECT 1.3: Notification of Impact Probability Increase to 71% and CONUS at Risk

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- How should your agency respond to this notification of an asteroid threat?
- Which stakeholders do you need to notify?
- What additional information would be helpful to have at this stage?

INJECT 1.3: Notification of Impact Probability Increase to 71% and CONUS at Risk

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- How should your agency respond to this notification of an asteroid threat?
- Which stakeholders do you need to notify?
- What additional information would be helpful to have at this stage?

- Who should be responsible for informing the public?
- How should the nature of the asteroid threat be communicated to the public?

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INJECT 1.3: Notification of Impact Probability Increase to 71% and CONUS at Risk

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- How should your agency respond to this notification of an asteroid threat?
- Which stakeholders do you need to notify?
- What additional information would be helpful to have at this stage?

- Who should be responsible for informing the public?
- How should the nature of the asteroid threat be communicated to the public?

- What emergency preparations are necessary at this point?
- Who should be responsible for leading the preparations, and what steps should be taken?

INJECT 1.3: Notification of Impact Probability Increase to 71% and CONUS at Risk

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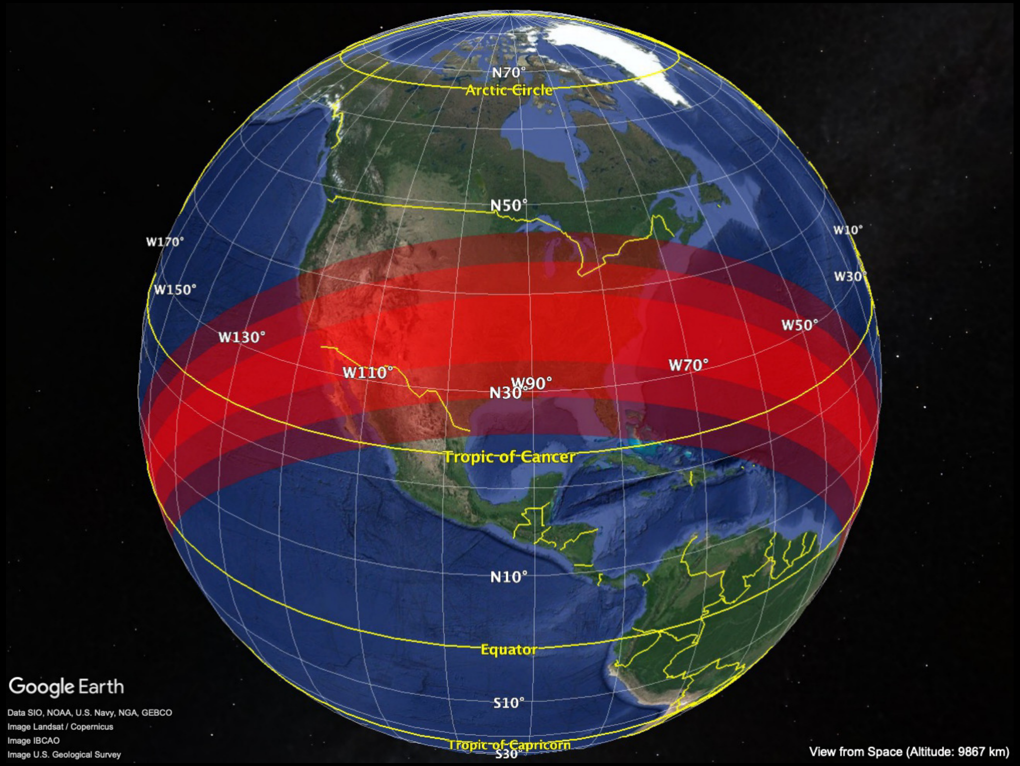
- Who should be responsible for international coordination?
- How should we approach coordination and communication with foreign countries who are also at risk?



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INJECT 1.4

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- Information about the asteroid is being shared widely on social media. Much of the information is incorrect.

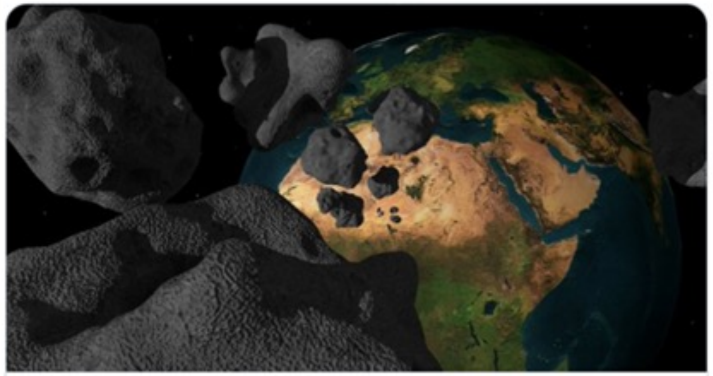
Feb 23 ···

NASA finds asteroid that could wipe out a city!

tinyurl.com/yu7a78bx

#spacecraft #exploration #research #asteroid #armageddon

NASA: Asteroid that dwarfs Empire State Building heading for Earth; Huge NEO to reach soon



tech.hindustantimes.com

NASA: Asteroid that dwarfs Empire State Building heading for Earth; ...

NASA: Asteroid is monstrous at 4,265 feet wide and it is approaching Earth fast. 'Potentially hazardous' asteroid just a month away.

36 405 458

Following

The government already knows where the asteroid will hit. They won't tell us until it's time to evacuate.

RETWEETS 24,831 LIKES 14,654

2:15 PM - 6 Nov 2012

The existence of the asteroid is fake news – a lie spread to pump up NASA's funding and make the administration look good. Just wait and see – the asteroid threat will miraculously disappear once they have the money. What else are they lying about?

10:01 AM 23 Feb 2022

60 Retweets 73 Quote Tweets 356 Likes

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INJECT 1.4: Misinformation

- What strategies should be used to counteract misinformation?
- Who is the most trusted person or entity to provide up-to-date, accurate information to the public?

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Comments on slide 10

- Module (1a) Early Detection Wrap

  https://nsad-jaf-op1.jhuapl.edu:8443/opinio/s?s=7309 | 60 (Aaron Chrietzberg)

Your comment

POST

Contributions identify the contributor

UNCLASSIFIED

Planetary Defense Interagency Tabletop Exercise IV - Module (1a) Early Detection Wrap

JOHNS HOPKINS
APPLIED PHYSICS LABORATORY

Instructions: We kindly request that you respond to all questions and provide as much detail as possible. Your responses are an essential part of the TTX and will help us capture lessons learned for the after-action report and future exercises. Thank you for your time.

Module (1a) Early Detection Wrap

1. Name and Title (please include rank, if applicable)

2. Organization and Unit/Division

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