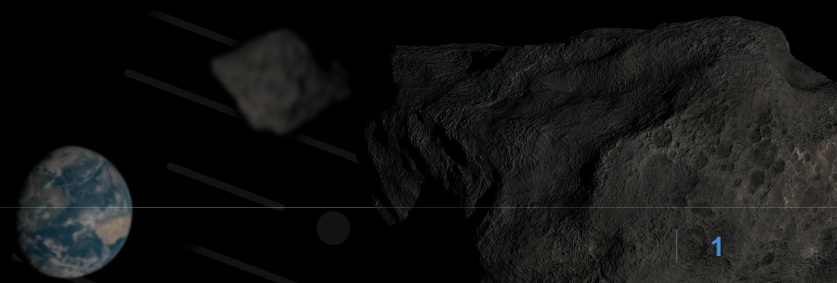
PLANETARY DEFENSE
INTERAGENCY
TABLETOP EXERCISE 4

Module 3
Final Preparedness & Readiness

10 August 2022
(Six Days Prior to Impact)

Anne Roberts-Smith
Module 3 Facilitator
Johns Hopkins Applied Physics Lab



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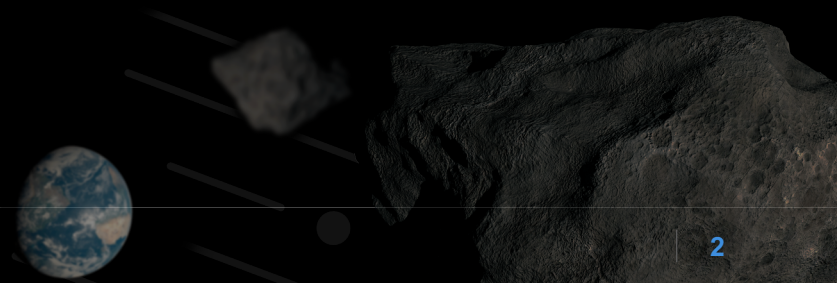
Module 3 Roadmap

In this module, we will:

- Provide more detailed information on the asteroid, its impact location, and potential damage
  - Discussions will focus on final preparations, how to respond at the local level, and what federal actions are required



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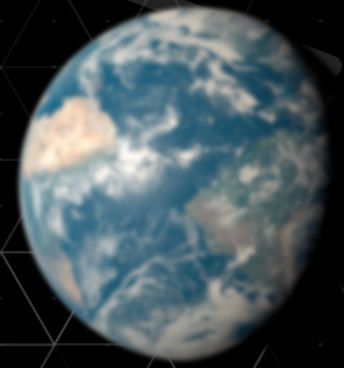

Module 3
Six Days to Impact

10 August 2022:
2022 TTX Detected by Radar; Potential Severity Downgraded

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

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Scenario Update: Module 3

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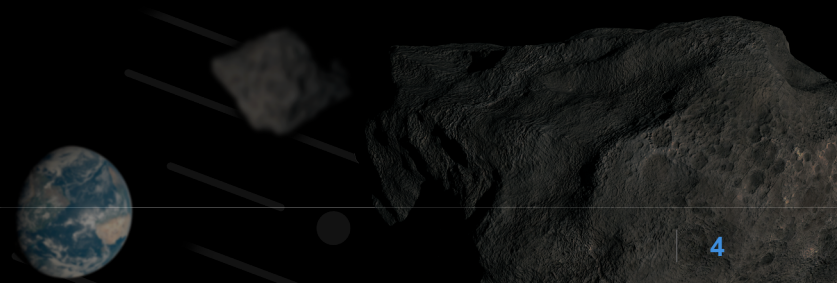
- Goldstone has been attempting to detect 2022 TTX for the last week but was unsuccessful until today, Aug. 10; now there are only 6 days until impact
- If the asteroid was at the large end of its size range, it would have been detected before now
- The radar measurements indicate that 2022 TTX is about 70 m (230 ft), toward the small end of the previous size range
- There is still some uncertainty in size: the most likely range is 60-80 m (200-260 ft)
- The radar data also contribute to another dramatic improvement in orbit accuracy, adding to the growing set of tracking data accumulated over the last two months; the expected impact location is now known to an accuracy of about 20 km
- Although the asteroid size is now much better constrained, large uncertainties still remain in other physical parameters, such as density



Module 3: Predicted Impact Region

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Shows the region in which 2022 TTX will impact, projected to the surface, not at the altitude of airburst

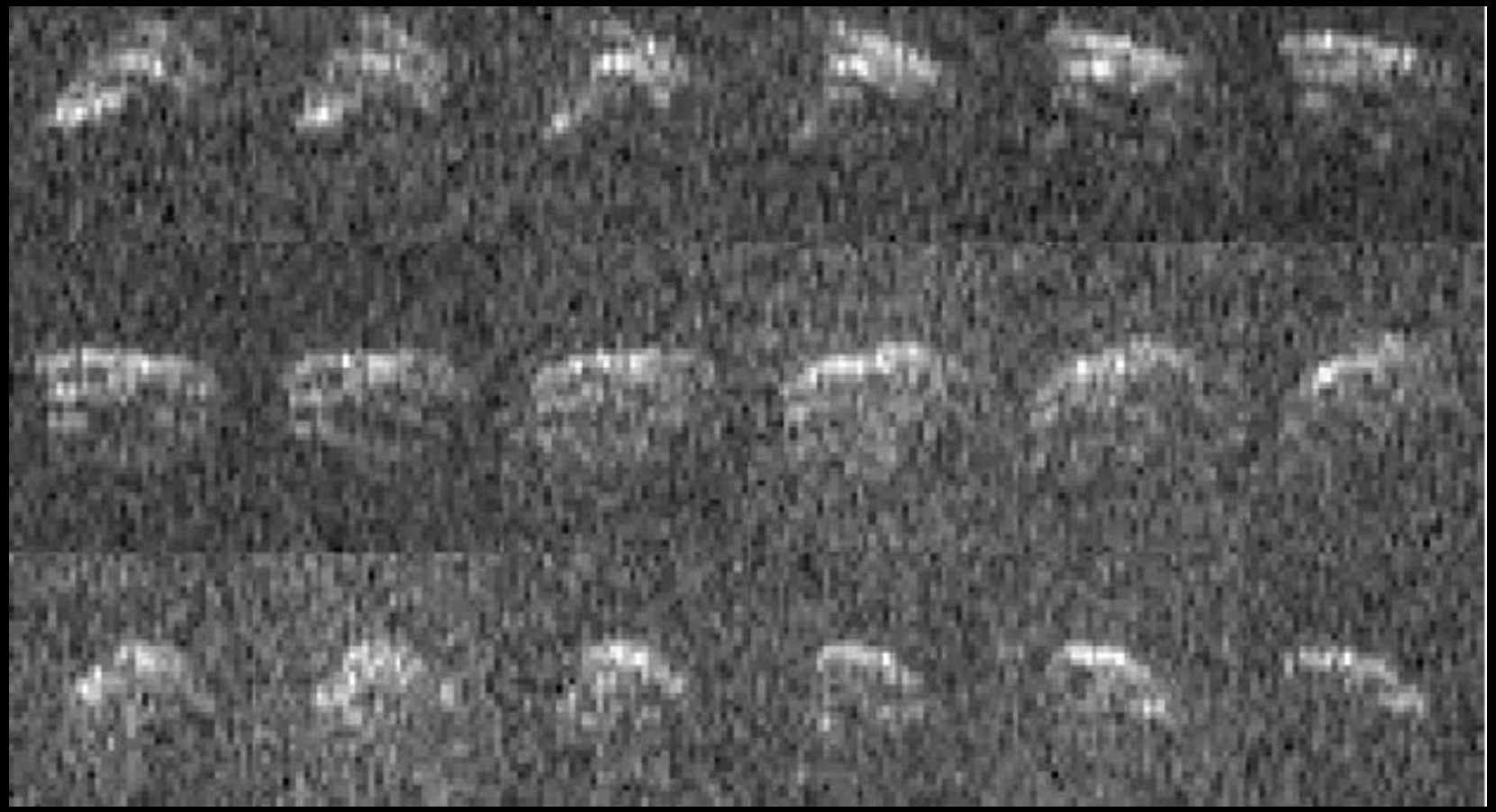
Impact date/time:
16 August 2022
2:02:10 pm EDT

Asteroid velocity:
15.54 km/s (34,700 mph)

Approach elevation:
64 deg (26 deg from vertical)

Approach direction:
37 deg (from NNE)

Sample Radar Images of 2022 TTX



(Actual images of 2013 ET)

- Now that 2022 TTX is within range of Goldstone, range/Doppler images can be taken that reveal the asteroid's size, shape, and surface roughness
- Images are taken repeatedly, as the asteroid rotates, providing different views of the asteroid's profile

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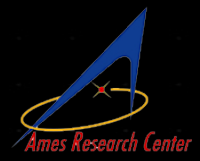

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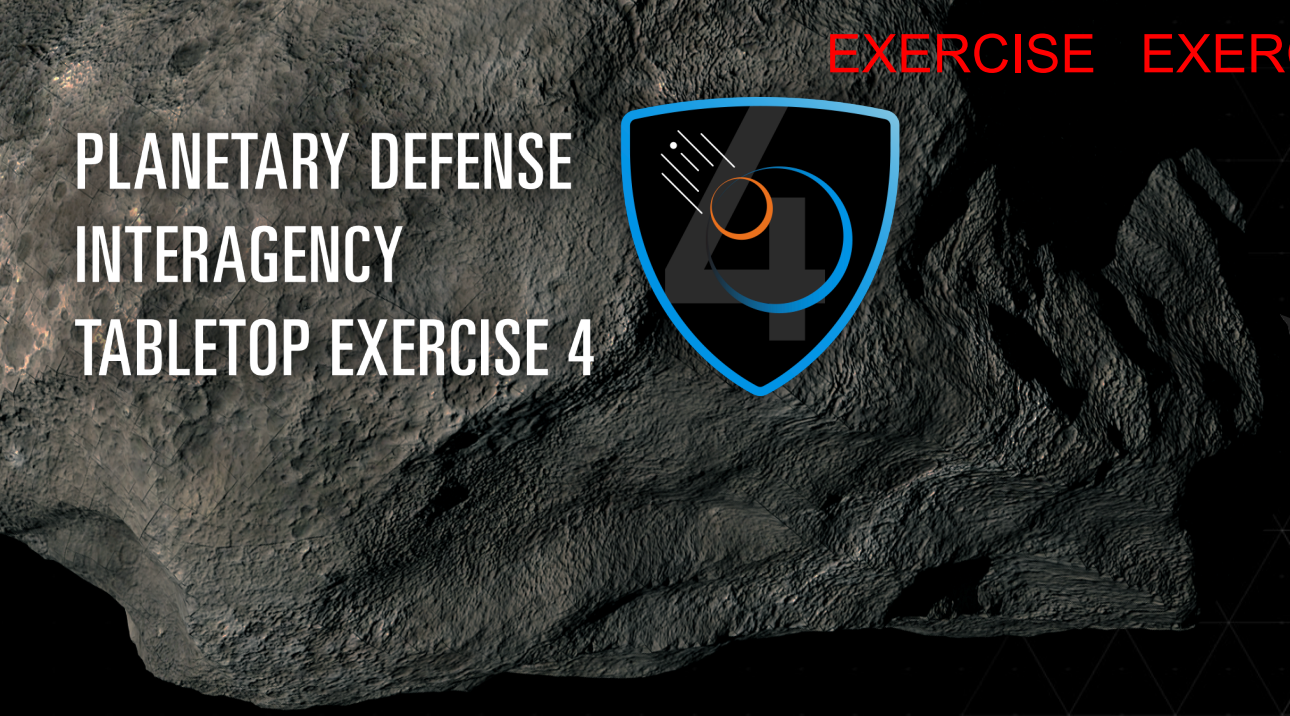

Asteroid Impact Risk: Module 3

6 days before impending impact over Forsyth county

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

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JOHNS HOPKINS
APPLIED PHYSICS LABORATORY

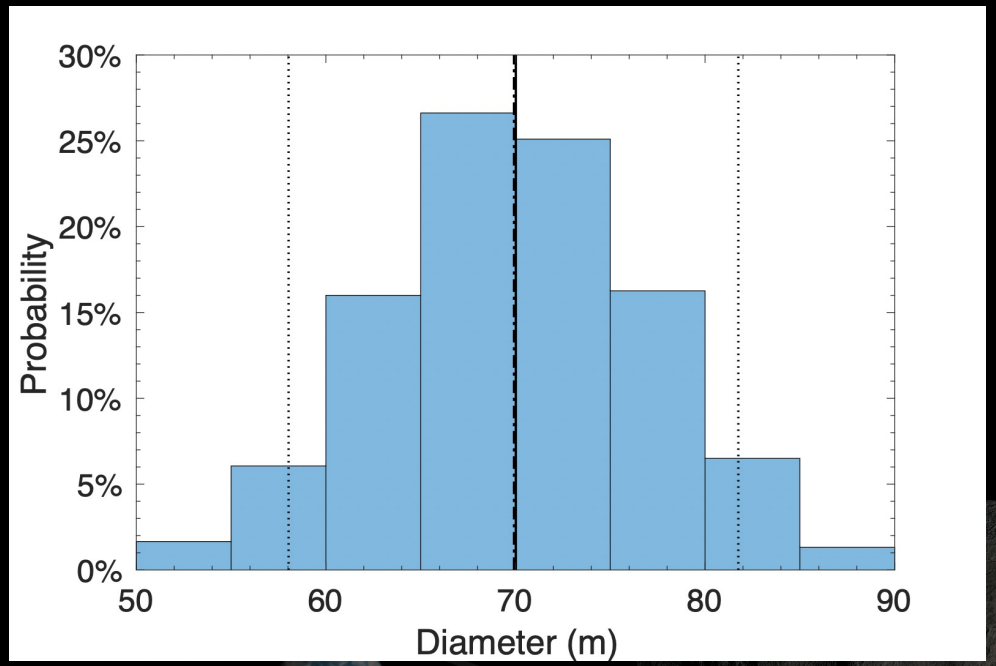
Asteroid Size & Properties

- Radar measurements from Goldstone estimate size to be ~70 m (230 ft) ± uncertainty
  - Potentially 50–90 m (170–290 ft),
  - Most likely 60–80 m (200–260 ft)
  - Type and physical properties remain unknown
- Effects on damage ranges:
  - More accurate size range reduces potential damage sizes significantly
  - However, substantial uncertainty in damage sizes remains due to unknown properties
  - Energy range still an order of magnitude due to unknown density
  - Structure and strength leave large uncertainties in potential breakup and resulting airburst altitude

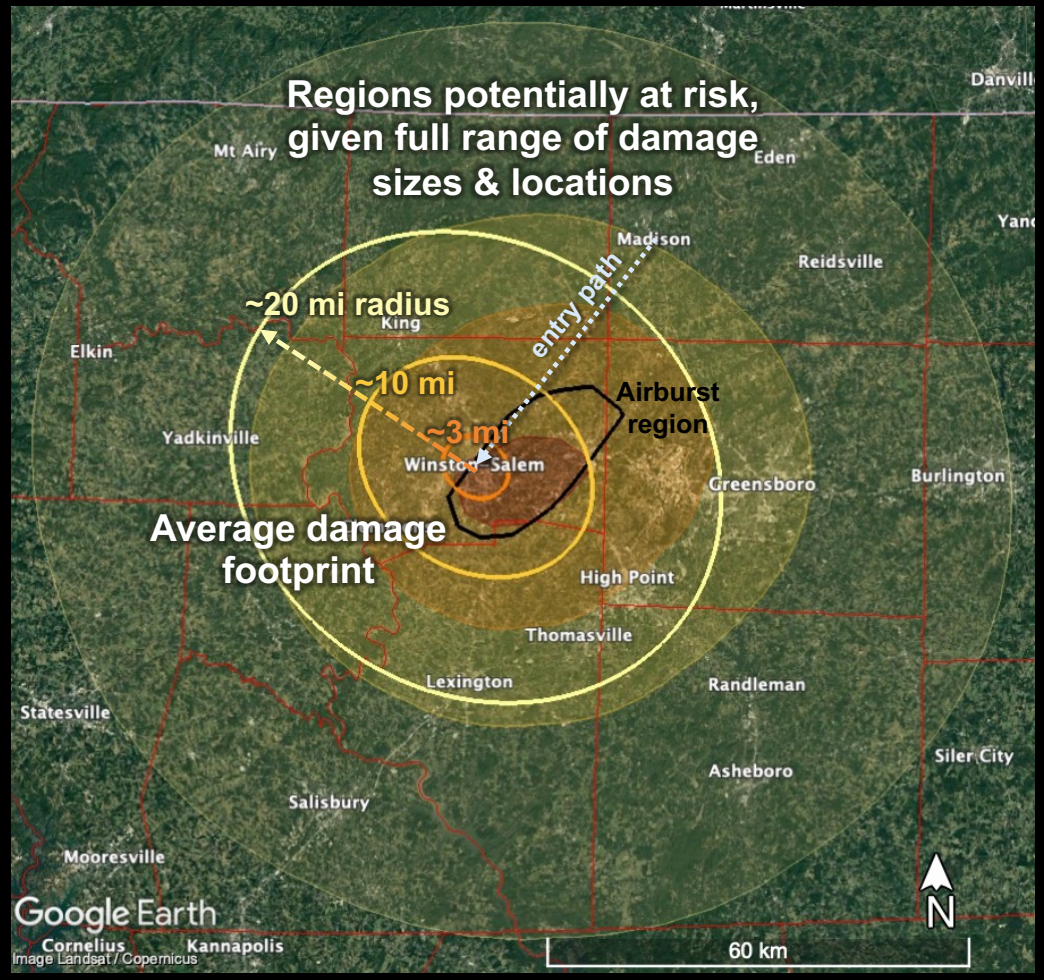
Asteroid Size Ranges

	Diameter	Energy
Range	50–90 m (170–290 ft)	3–30 Mt
Most likely range	60–80 m (200–260 ft)	6–14 Mt
Median	70 m (230 ft)	11 Mt

Asteroid Diameter Probabilities



Potential Risk Swath



Damage risk swath: Shaded swath areas bound potential at-risk regions given range of damage sizes and airburst/impact locations (black border). Rings show an average-sized damage footprint at a sample location.

Risk swath shows range of regions ***potentially*** at risk, including range of damage sizes and locations

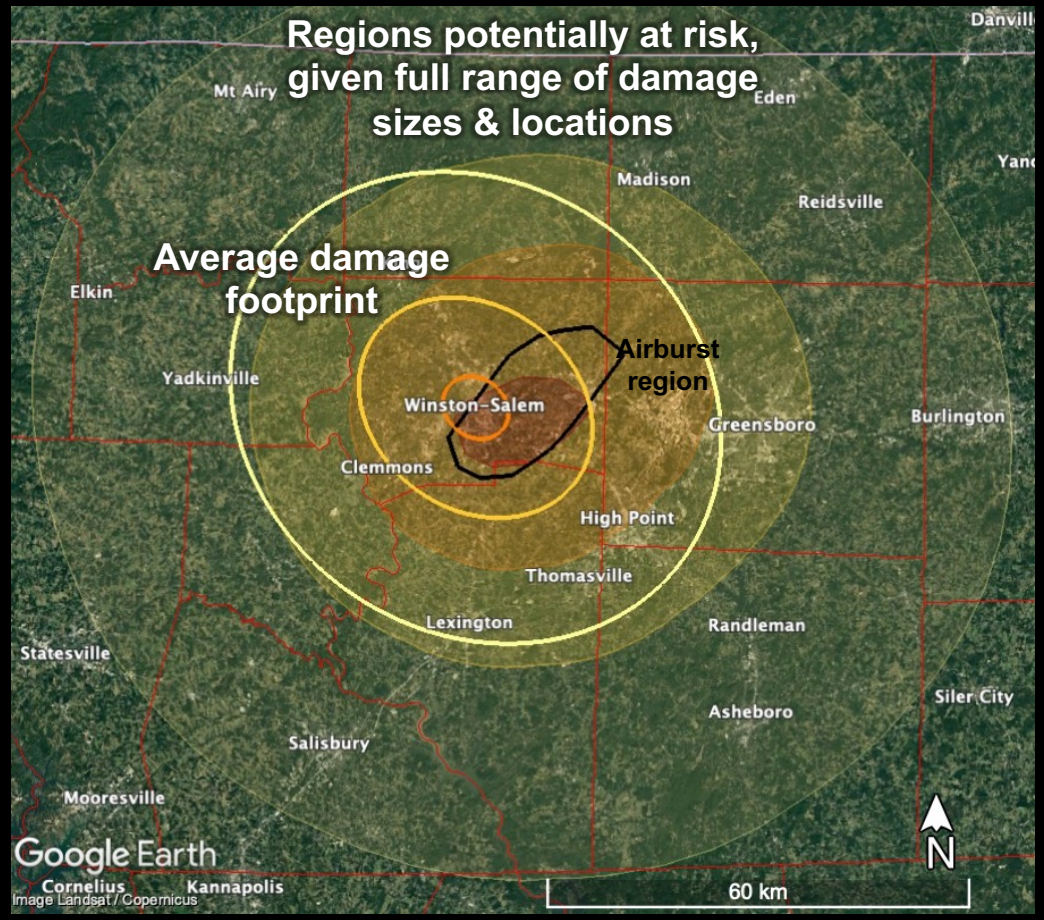
- Black outline shows range of potential airburst / impact points (damage-center locations)
- Shaded areas show potential at-risk regions given range of damage sizes and locations
- Rings show an average-sized damage footprint at a sample location

Damage radius sizes:

- Serious: 20 mi average (range 10–40 mi)
- Severe: 10 mi average (range 0–20 mi)
- Critical: 3 mi average (range 0–10 mi)
- Unsurvivable: 0 mi average (range <2 mi)

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

Likelihood of Damage Severities



Damage risk swath: Shaded swath areas bound potential at-risk regions given range of damage sizes and airburst/impact locations (black border). Rings show an average-sized damage footprint at a sample location.

- Serious and severe damage levels are very likely to occur over potentially large areas
- Higher damage levels are possible but less likely
- Critical levels: 45% chance of occurring
  - 75% chance radius will be under 5 mi
  - 95% chance radius will be under 10 mi
- Unsurvivable levels: 5% chance of occurring
  - under 1-2 miles in radius

Damage Level	Potential Blast Effects	Chance of Occurring	Damage Radius Range (miles)
Serious	Shattered windows, some structure damage	~100%	10–40 (avg. 20)
Severe	Widespread structure damage	~90%	0–20 (avg. 10)
Critical	Most residential structures collapse	~45%	0–10 (avg. 3)
Unsurvivable	Complete devastation	~5%	<2 (avg. 0)

Airburst Blast Simulation

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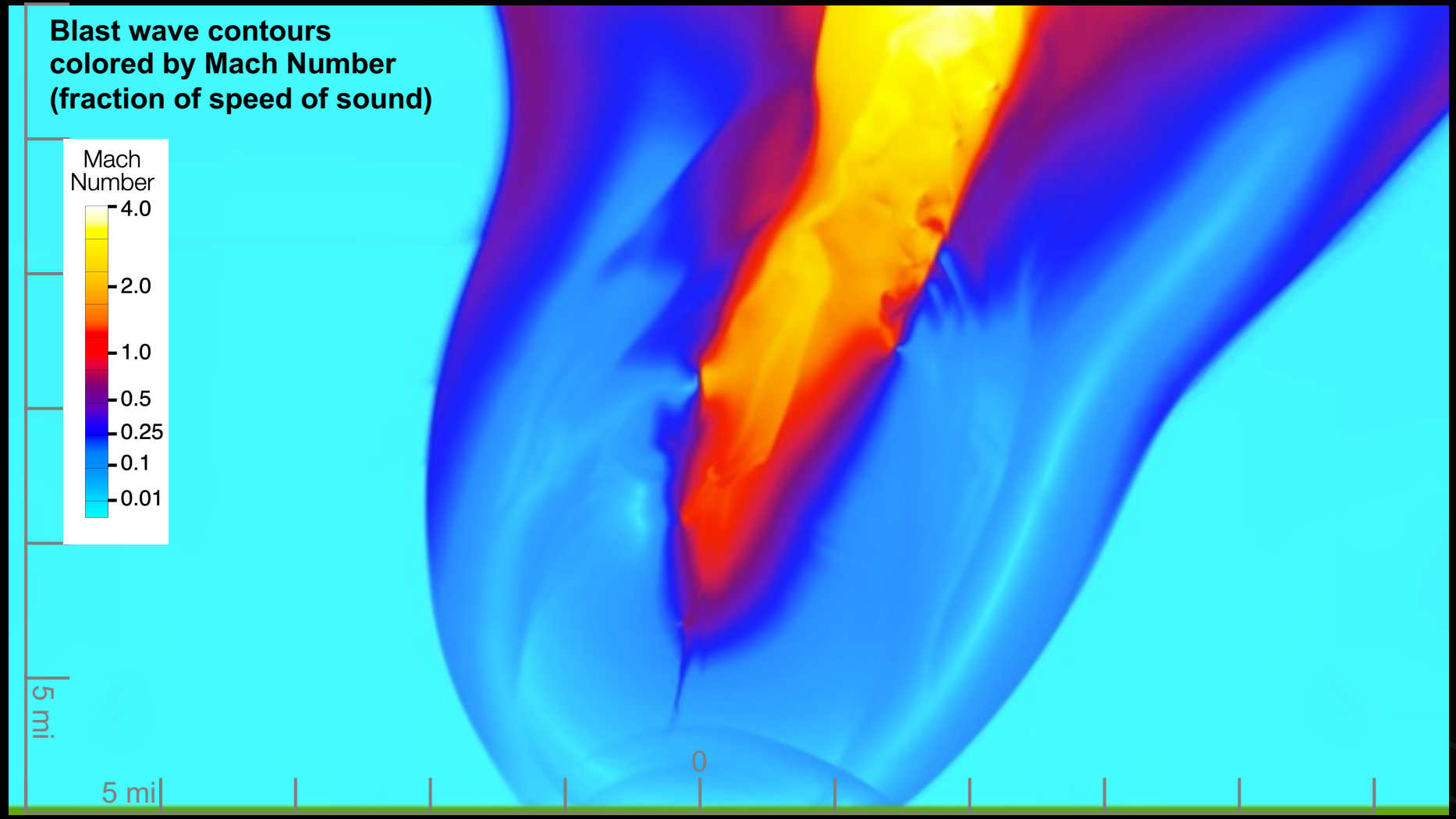

Simulation of nominal radar size case:

- 70 m (230 ft) diameter
- 11.3 Mt energy
- Typical stony-type asteroid properties assumed
- Entry velocity 15.5 km/s (~35k mph)
- Entry angle 65°
- Effective airburst altitude ~12.5 km (~8 mi)

Cart3D Computational Fluid Dynamics Simulation. Credit: **Michael Aftosmis**, ATAP, NASA Ames

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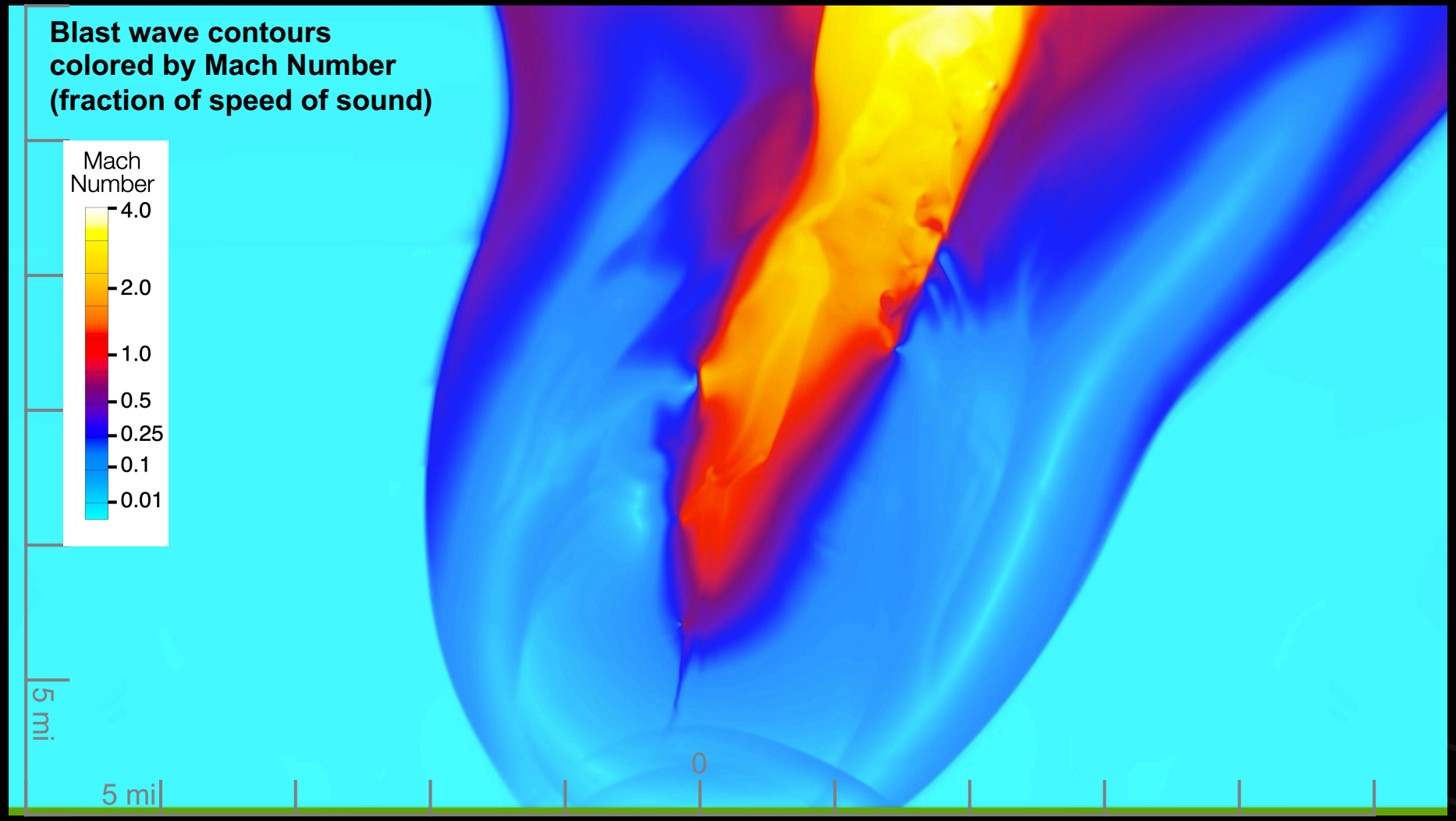
Airburst Blast Simulation Movie



Cart3D Computational Fluid Dynamics Simulation. Credit: **Michael Aftosmis**, ATAP, NASA Ames

Blast Process:

- **Entry:** Shockwaves emanate from the entry path as the asteroid enters at high speeds
- **Airburst:** Asteroid disrupts catastrophically under high aerodynamic pressures, producing an explosion-like blast
- **Ground damage:** Shock front reflects off the ground and sends a powerful overpressure wave outward across the ground. *Damage is caused by the **pressure** wave (**not** windspeed)*

Impact Risk Summary: Module 3

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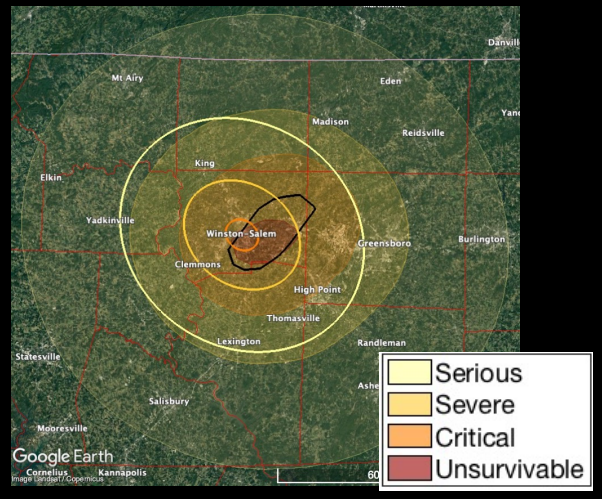
Asteroid Characterization Summary

- Assessment date: 10 August 2022 (T-6 days)
- Impact date: 16 August 2022, impact time ~14:02 EDT
- Refined asteroid size estimates from Goldstone Radar measurements. Other properties still unknown, leaving uncertainty in mass, energy, and entry/airburst factors
- Diameter: 70 m (230 ft) radar size estimate, potentially 50–90 m (170–290 ft), most likely range 60–80 m (200–260 ft)
- Energy: 3–30 Mt (megatons), most likely range 6–14 Mt, median 11 Mt



Risk Region Swath

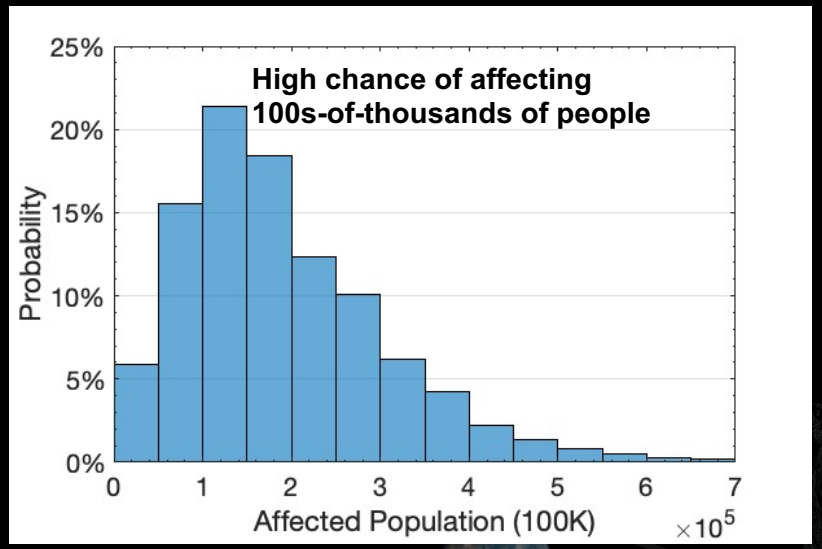
Range of regions potentially at risk to ground damage, given range of potential damage sizes and impact locations.

Rings show an average damage footprint size at a sample location

Black border shows range of potential airburst locations

Impact Hazard Summary

- High chance of damage affecting hundreds of thousands of people in Forsyth and potentially surrounding NC counties
- Primary hazard: Airburst causing blast damage, ranging from shattered windows and structural damage to potentially unsurvivable levels
- Damage region radii: 10–40 mi, most likely range 15–25 mi, median size ~20 mi
- Affected population: tens to hundreds of thousands, 190k avg risk, 80% chance of >100k people, 40% >200k, 15% >300k, 5% >400k



Population Risk

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

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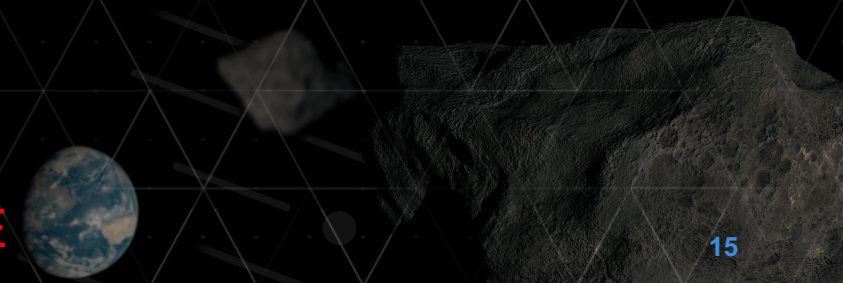
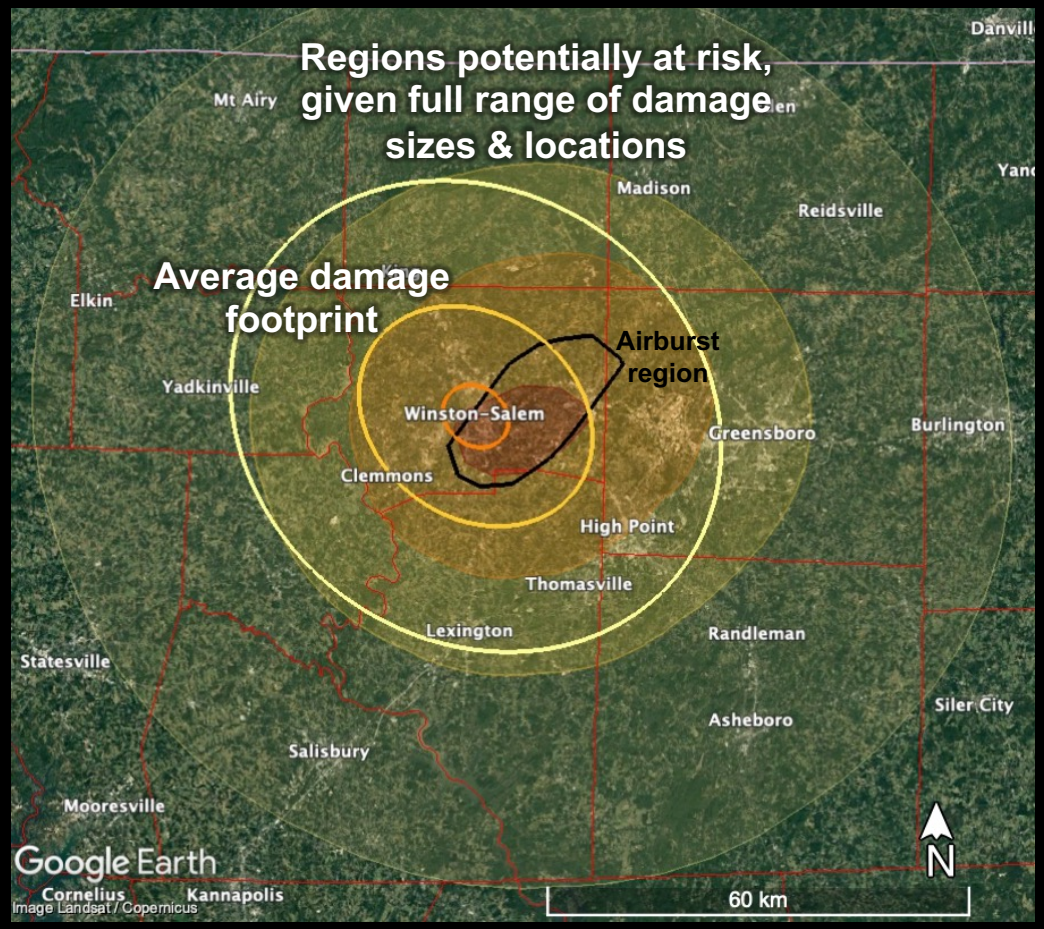
Module 3 Impact Risk Backup



Potential Risk Swath



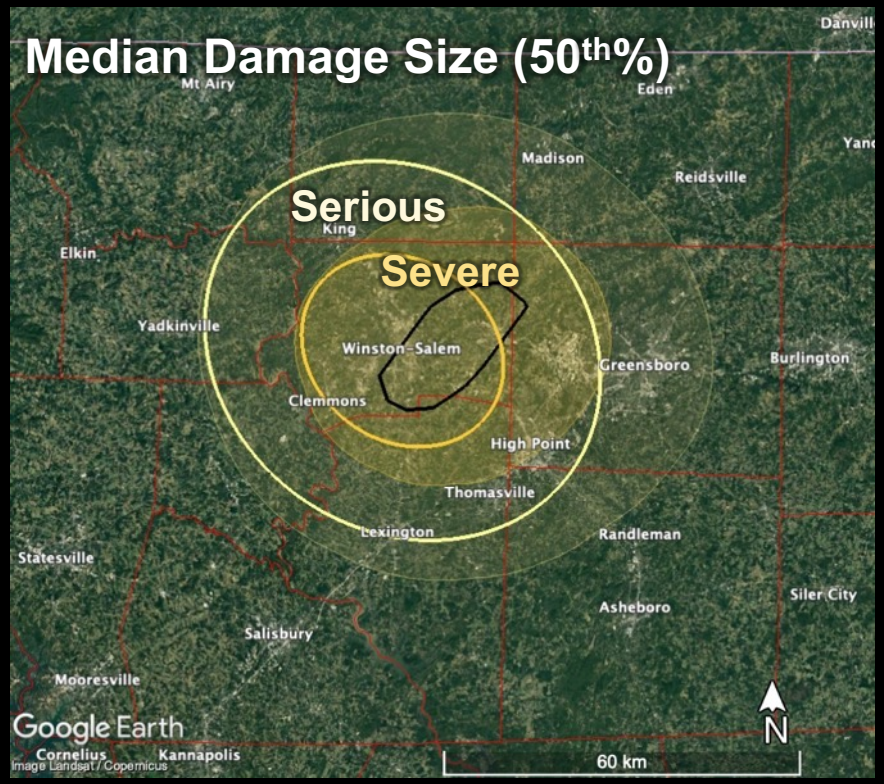
Damage risk swath: Shaded swath areas bound potential at-risk regions given range of damage sizes and airburst/impact locations (black border). Rings show an average-sized damage footprint at a sample location.

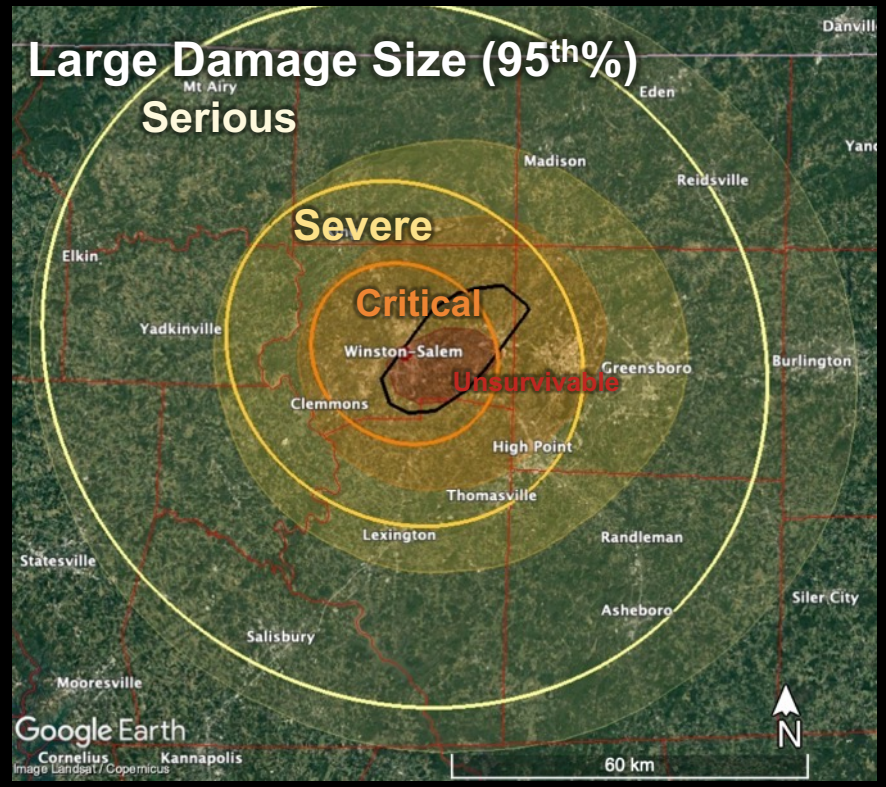
Likelihood of Damage Severities:

- Serious and severe damage levels are very likely to occur over large areas
- Higher damage levels are possible but less likely
- Critical levels are possible but less likely:
  - 45% chance of occurring
  - 75% chance radius will be under 5 mi
  - 95% chance radius will be under 10 mi
- Unsurvivable levels are very unlikely:
  - 5% chance of occurring
  - under 1-2 mi in radius

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

Damage Sizes with Location Ranges





- Serious and severe damage levels very likely, higher damage levels possible but less likely
- Critical levels are possible but much less likely (45% chance of occurring, 75% chance radius will be under 5 mi, 95% chance <10 mi)
- Unsurvivable levels very unlikely (5% chance of occurring in small areas under 1-2 mi in radius)

Local Ground Damage Radius Sizes (miles)

Damage Level	Mean	Min	5th %	25th %	**50th %**	75th %	**95th %**
Serious	21	0	12	17	20	23	37
Severe	10	0	0	7	10	14	18
Critical	3	0	0	0	0	5	10
Unsurvivable	0	0	0	0	0	0	1

	Damage Level Description
	Window breakage, some minor structure damage
	Widespread structure damage, doors/windows blown out
	Most residential structures collapse
	Complete devastation

*Percentiles give the chance that the damage region could be up to the given size or smaller

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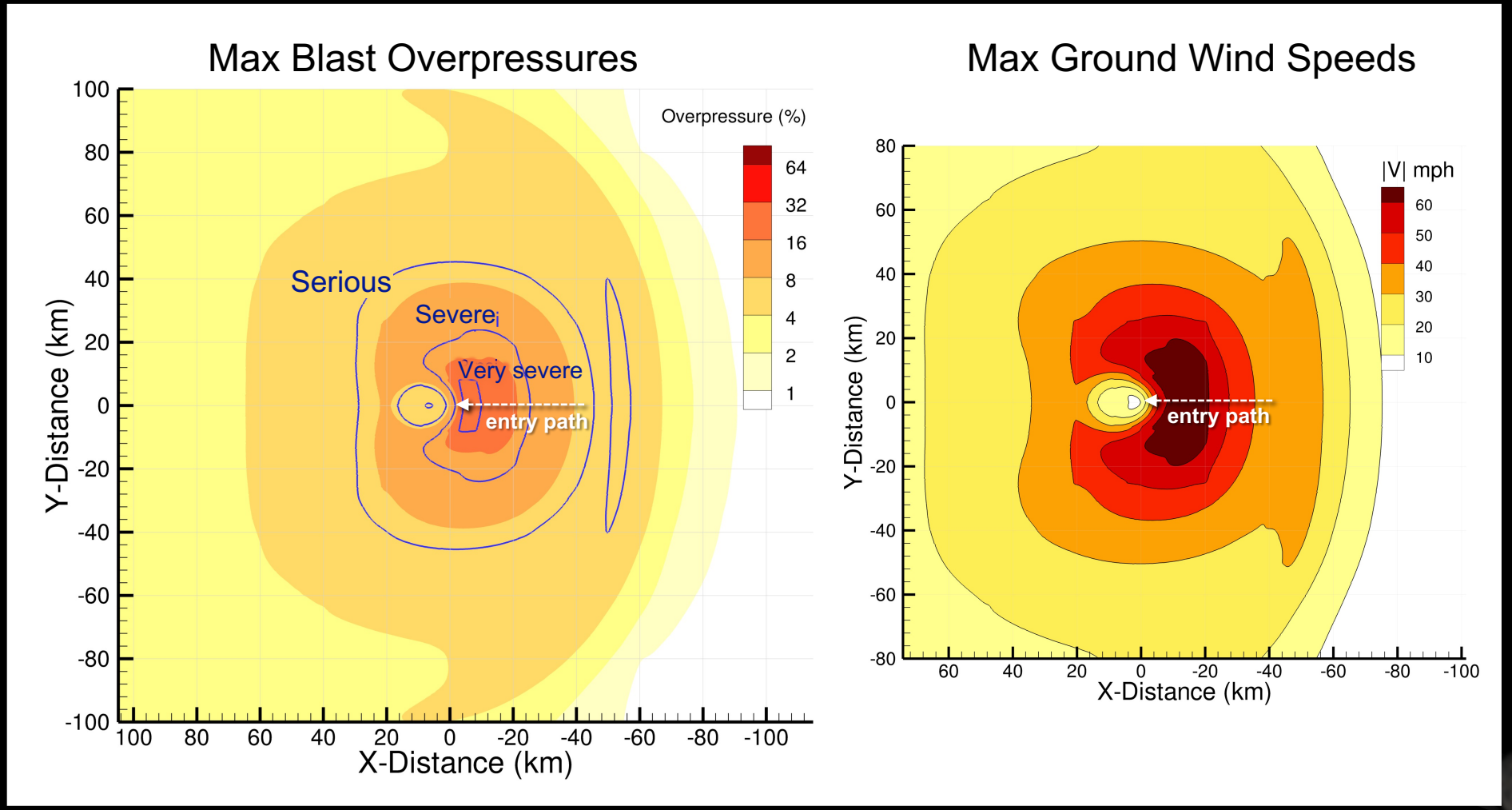
Blast Simulation Ground Footprint



Ground footprints from simulation of nominal radar size case:

- Peak Overpressure is 23.4% (3.44 psi) (Severe 2-4 psi level)
- Max wind speed is 29.4 m/s (65.7 mph)
- Serious (>1 psi) region: ~18-37 mi radius, ~2600 sq. mi. enclosed area
- Severe (>2 psi) region: ~10-15 mi radius, ~425 sq. mi. area
- Very sever (3-3.5 psi): ~2-6 mi, ~38 sq. mi.

Cart3D Computational Fluid Dynamics Simulation. Credit: **Michael Aftosmis**, ATAP, NASA Ames

Inject 3.1: Six Days Out – Key Considerations

- Are you able to interpret the visuals and data you have seen?
  - With this information are you able to communicate complex information to both key decision makers and the public?
- Is the information you received sufficient to make decisions related to evacuation and public messaging?
- Given the unique nature of the threat, what gaps do you see in your current resources?
- Which agencies could provide ongoing consultation to the state and locals? How would that occur?
- At this point in the timeline, do you understand:
  - What types of casualties to expect?
  - What the environmental impacts might be?

Inject 3.2: Social Media & Misinformation

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Local news in Central North Carolina is reporting a growing number of social media posts claiming that the asteroid is a government hoax.

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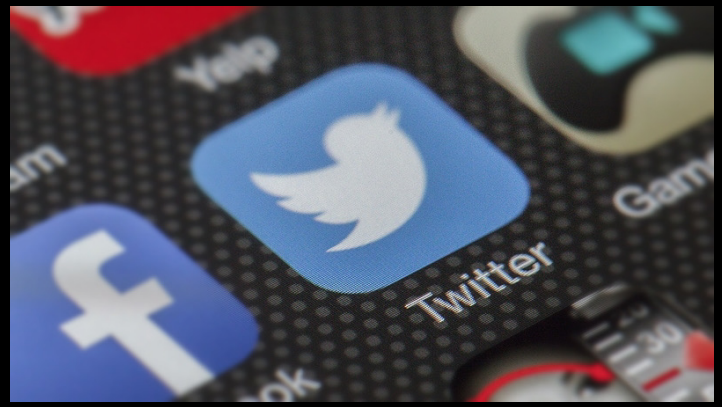
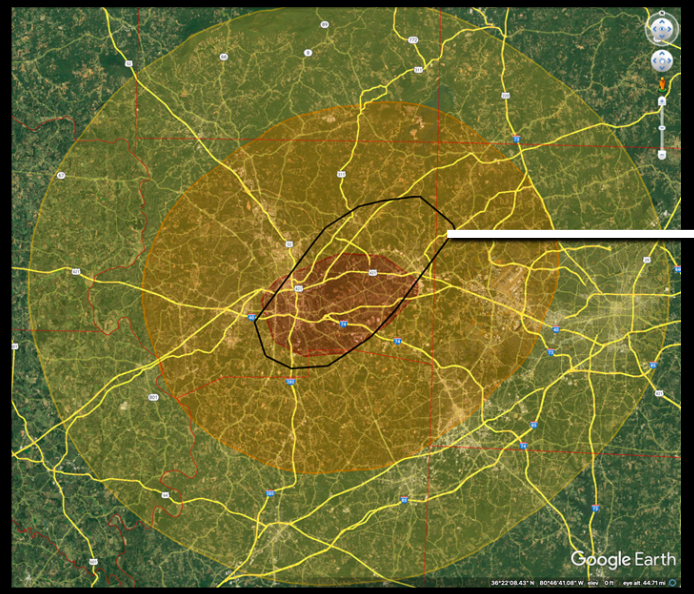


Inject 3.2: Social Media & Misinformation

- At this point in the scenario, who is the most trusted person/entity to provide information and update the public?
- Do state and local agencies have enough information to field questions?
  - What additional expertise is needed?
- How do you ensure continuity of messaging?
- What ongoing information is available to the general public and through what means?
- Are there concerns regarding foreign manipulation and the source of the misinformation?

Inject 3.3

There are a number of critical infrastructures in the potential risk swath including major highways, power substations, and communications towers.



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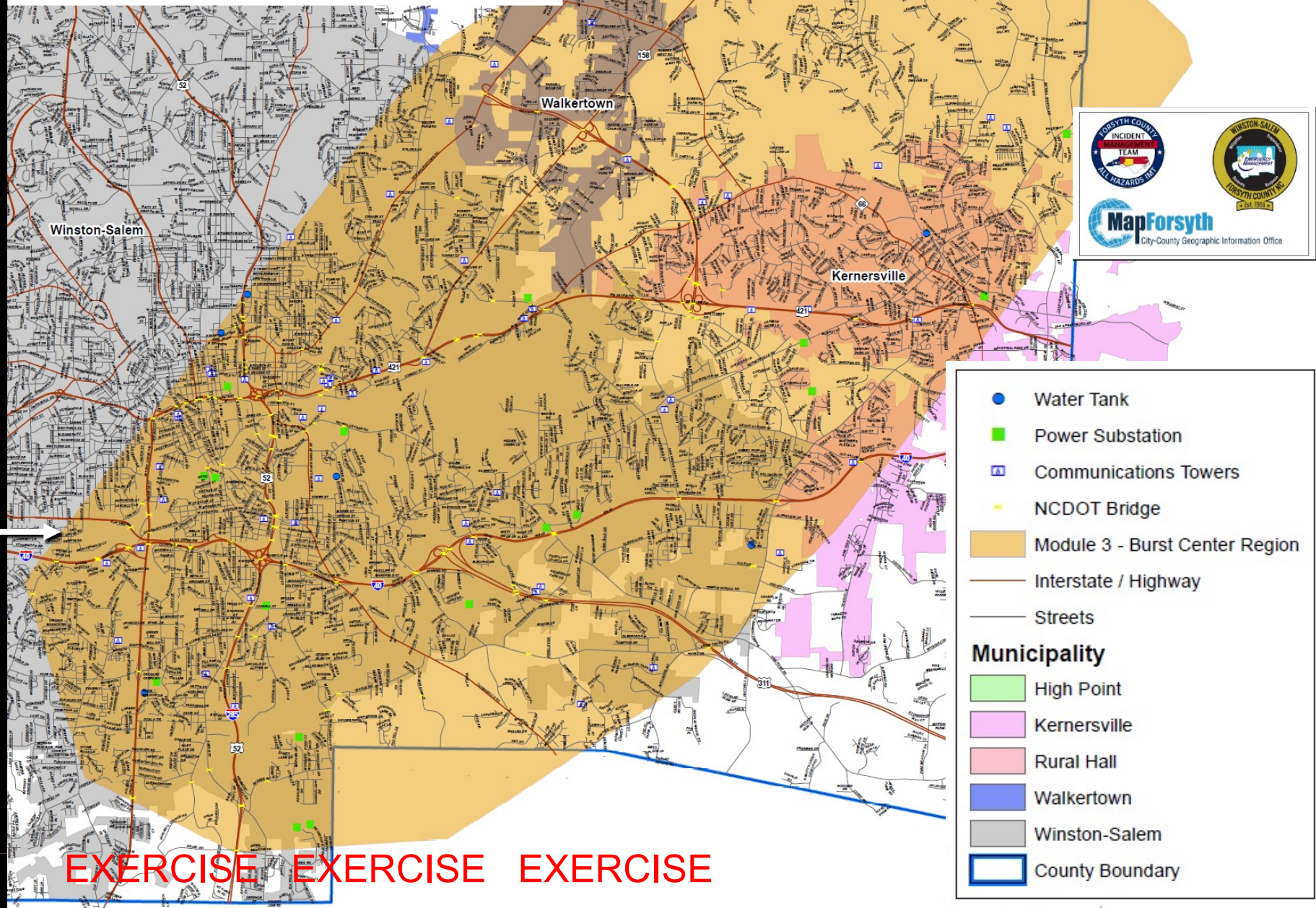
Module 3 – Burst Center Region
Select Critical Infrastructure Impacted



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Inject 3.3: Impacts to Infrastructure

- Based on the key infrastructure in the impacted area, what state and federal resources are being moved to the designated staging areas?
- What are your immediate concerns regarding continuity of government, emergency communications, security, and evacuation planning?
- What federal assistance do state and local organizations need?
- Are there executive actions that must be made to activate resources?

Inject 3.4
FAST FORWARD: 24 hours to Impact

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Inject 3.4: 24 Hours to Impact

With 24 hours remaining:

- What are the top three priorities for the next 24 hours?
- Approximately 20% of residents have refused to (or cannot) evacuate. How does this influence your next steps?
- What security needs are you anticipating given the level of interest from media and the general population? What supplemental security resources do you have access to? What federal resources are available in the field?

Participant Feedback for Module 3

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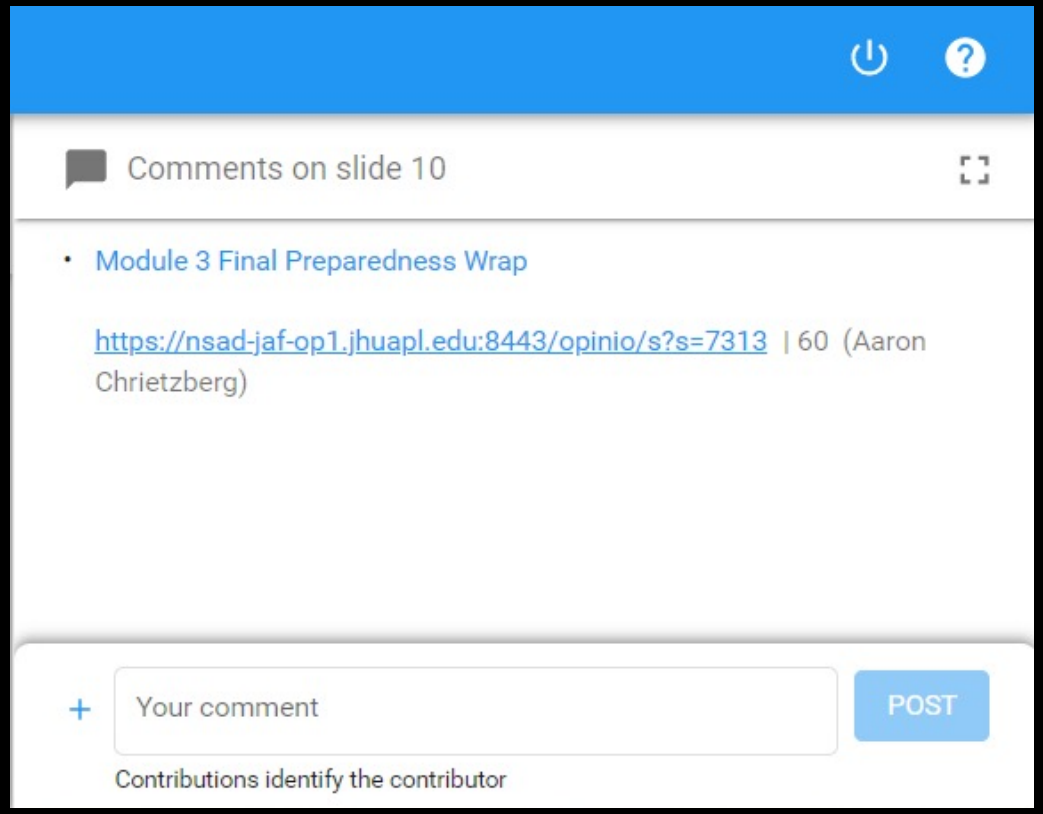

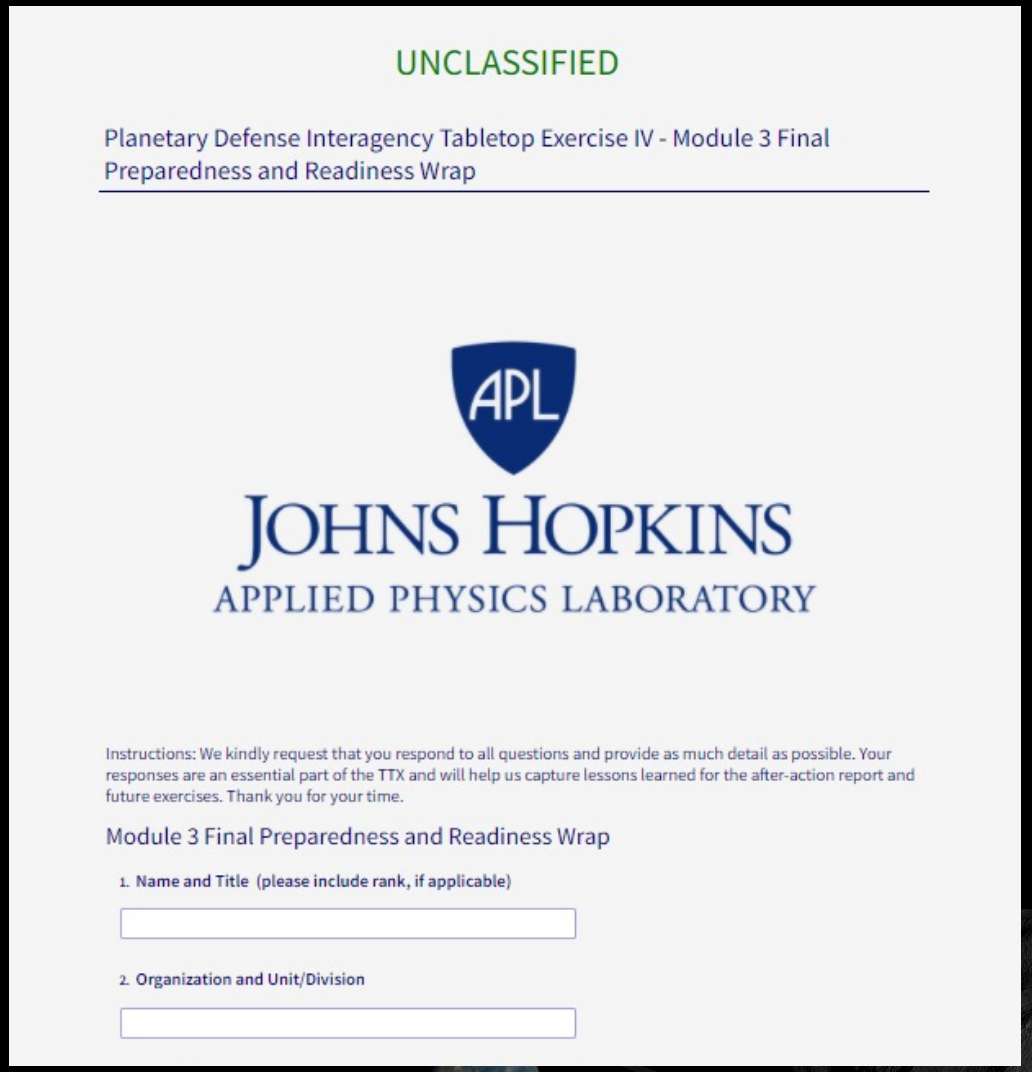
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Planetary Defense Interagency Tabletop Exercise IV - Module 3 Final Preparedness and Readiness Wrap

APL
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 3 Final Preparedness and Readiness Wrap

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

2. Organization and Unit/Division