PD TTX4
23–24 February 2022

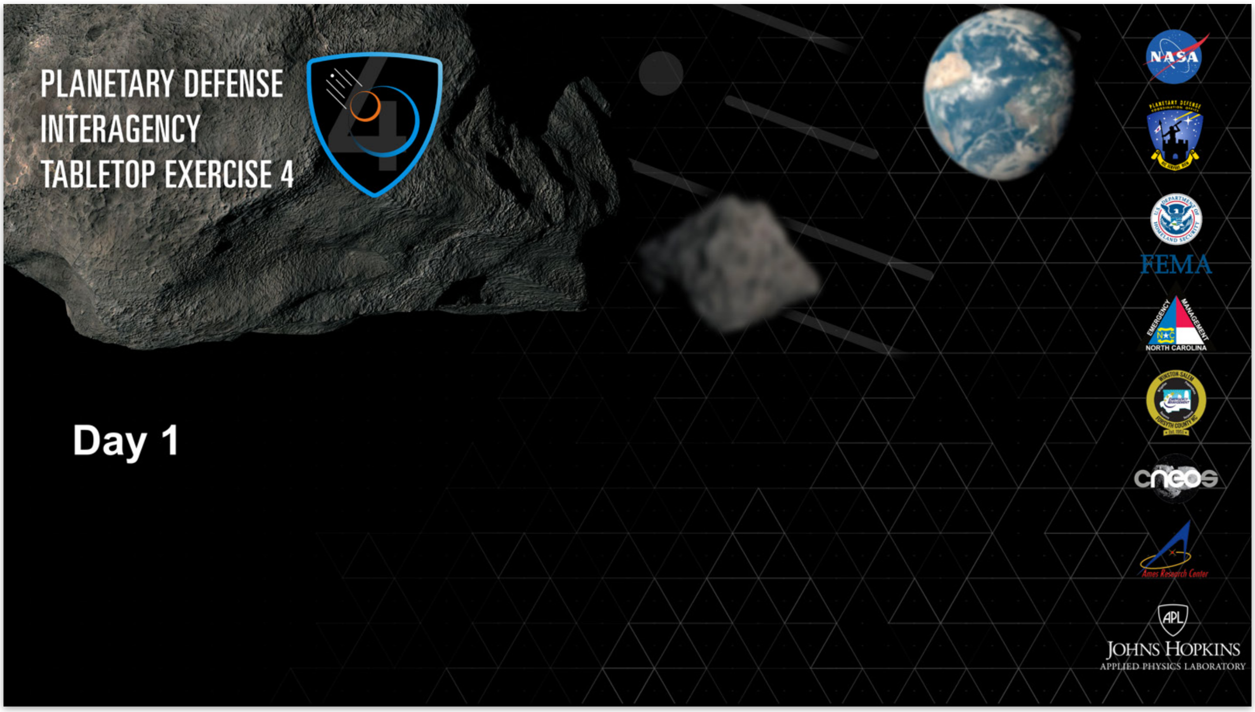
After Action Report

Appendix C: Presentation Slides

This appendix contains static versions of the as-presented slides from the 4th Planetary Defense (PD) Interagency Tabletop Exercise (TTX). The actual slides in some cases contained animations to better inform or describe the scenario.

Table of Contents

C.1 Introductory Material




Agenda
PLANETARY DEFENSE
INTERAGENCY
TABLETOP EXERCISE 4
• Welcome
• Few words from our sponsor
- Lindley Johnson, NASA Planetary Defense Coordination Officer
• Few words from our TTX Director
- L.A. Lewis, NASA PDCO FEMA Detailee
• Why we are here
• Objectives
• What to expect
PD TTX 4 – Module 0
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Why We Are Here
PLANETARY DEFENSE
INTERAGENCY
TABLETOP EXERCISE 4
• What would we do if we knew a sizable asteroid was headed our way?
• Do we understand everyone's roles in this scenario?
• After we're done, what can do well ahead of time to be better prepared for this?
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Objectives

PLANETARY DEFENSE INTERAGENCY TABLETOP EXERCISE 4

1. *Increase the understanding* by personnel and U.S. government institutions of near-Earth object (NEO) threats and their roles in mitigating that threat
   - Opportunity to understand what the role of USSPACECOM is
2. *Test methods of communicating* information both to and among decision-makers
3. *Exercise post-impact protocols*, including involvement of local government

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Structure of the TTX

PLANETARY DEFENSE INTERAGENCY TABLETOP EXERCISE 4

- Set of “Planetary Defense 101” short briefs
- TTX broken into five “modules,” numbered 0–4
  - Each module represents a different segment of time between discovery of the asteroid through post-impact protocols

Module	Description
0	Quick briefing of the read-ahead materials
1	6 months before impact
2	2 months before impact
3	6 days before impact
4	Post-impact response and recovery

- Module structure
  - Series of injects (either new information presented or questions posed) resulting in Q&A or discussion
  - Hot wash with Participant Feedback Forms (PFFs)

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Agenda for Day 1

PLANETARY DEFENSE INTERAGENCY TABLETOP EXERCISE 4

Day 1	Start (EST)	Stop (EST)	Duration	Activity
23-Feb	12:30	13:00	0:30	Arrival and Check-in *for any in-person people*
	13:00	13:20	0:20	Welcome, Objectives, What to Expect
	13:20	13:35	0:15	Technical logistics
	13:35	13:55	0:20	Introduction to Planetary Defense 101
	13:55	14:10	0:15	Why Planetary Defense 101
	14:10	14:30	0:20	Asteroid Detection and Tracking 101
	14:30	14:45	0:15	Break
	14:45	15:00	0:15	Asteroid Damage Modeling 101
	15:00	15:15	0:15	Space Mitigation Strategies 101
	15:15	15:30	0:15	***Module 0***: Background, Initial Detection
	15:30	15:40	0:10	Pre-exercise Participant Feedback
	15:40	16:30	0:50	***Module 1a***: Early Detection & Mitigation
	16:30	16:45	0:15	Debrief Day 1

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Agenda for Day 2

PLANETARY DEFENSE INTERAGENCY TABLETOP EXERCISE 4

Day 2	Start (EST)	Stop (EST)	Duration	Activity
24-Feb	7:00	8:00	1:00	Arrival and Check-in (continental breakfast served)
	8:00	8:30	0:30	Welcome, Objectives, What to Expect
	8:30	9:30	1:00	***Module 1b***: Continue Early Detection Discussion
	9:30	9:45	0:15	Break
	9:45	11:35	1:50	***Module 2***: Early Preparedness
	11:35	12:35	1:00	Lunch
	12:35	14:25	1:50	***Module 3***: Final Preparedness and Readiness
	14:25	14:40	0:15	Break
	14:40	16:30	1:50	***Module 4***: Response and Transition to Recovery
	16:30	17:00	0:30	Debrief, capture comments

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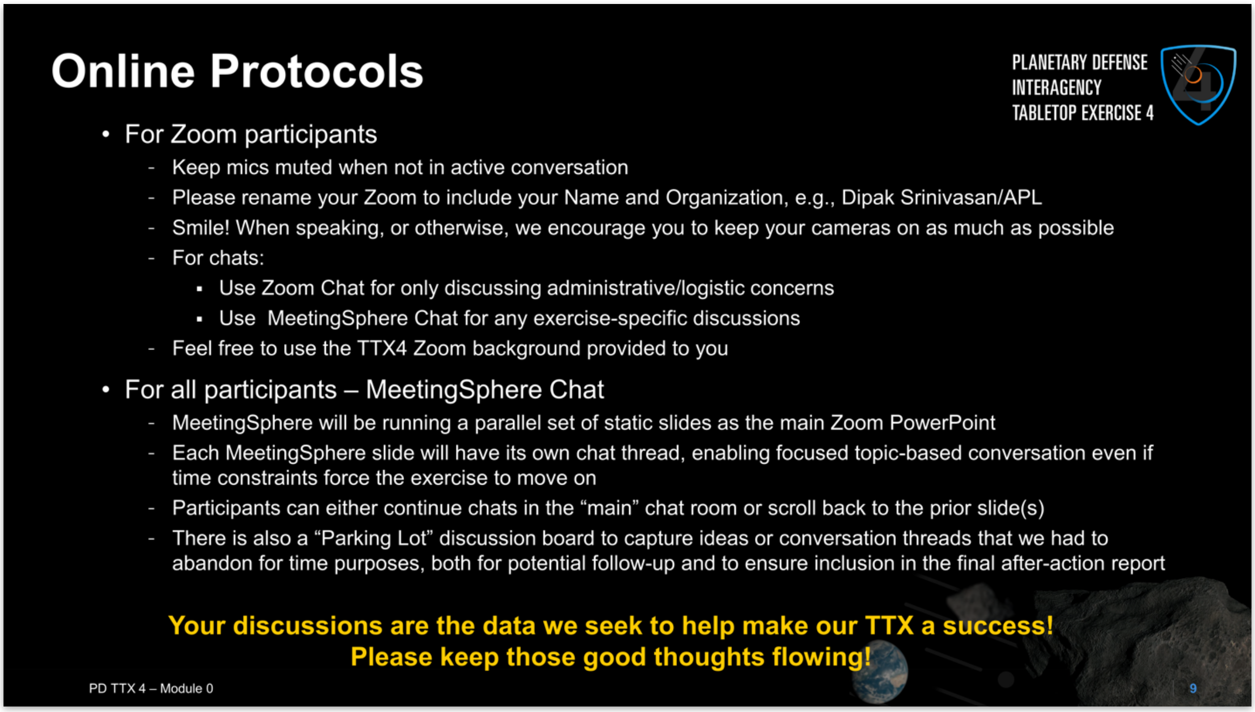
Online Protocols
PLANETARY DEFENSE
INTERAGENCY
TABLETOP EXERCISE 4
• For Zoom participants
- Keep mics muted when not in active conversation
- Please rename your Zoom to include your Name and Organization, e.g., Dipak Srinivasan/APL
- Smile! When speaking, or otherwise, we encourage you to keep your cameras on as much as possible
- For chats:
▪ Use Zoom Chat for only discussing administrative/logistic concerns
▪ Use MeetingSphere Chat for any exercise-specific discussions
- Feel free to use the TTX4 Zoom background provided to you
• For all participants – MeetingSphere Chat
- MeetingSphere will be running a parallel set of static slides as the main Zoom PowerPoint
- Each MeetingSphere slide will have its own chat thread, enabling focused topic-based conversation even if time constraints force the exercise to move on
- Participants can either continue chats in the "main" chat room or scroll back to the prior slide(s)
- There is also a "Parking Lot" discussion board to capture ideas or conversation threads that we had to abandon for time purposes, both for potential follow-up and to ensure inclusion in the final after-action report
Your discussions are the data we seek to help make our TTX a success!
Please keep those good thoughts flowing!
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PLANETARY DEFENSE
INTERAGENCY
TABLETOP EXERCISE 4
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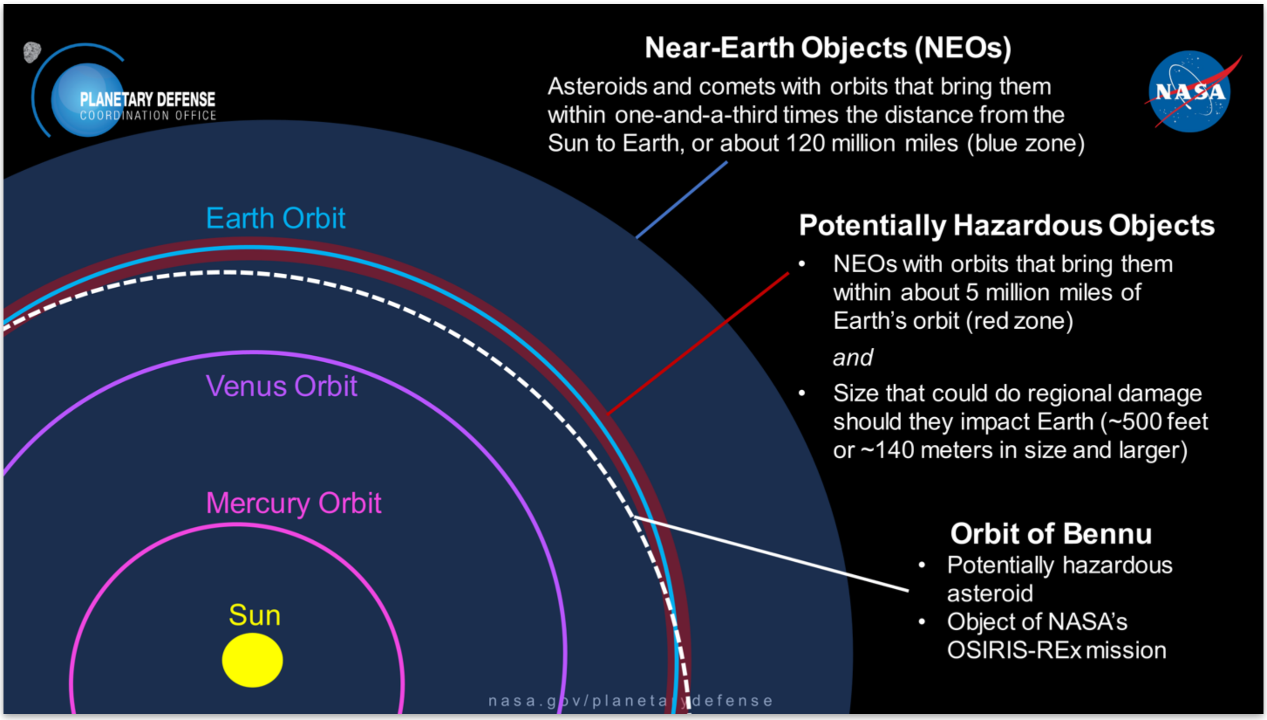
FEMA
APL
JOHNS HOPKINS
APPLIED PHYSICS LABORATORY
cneos
Ames Research Center
NORTH CAROLINA

C.2 Planetary Defense 101 and Module 0

Slide 1

Slide 2

Slide 3



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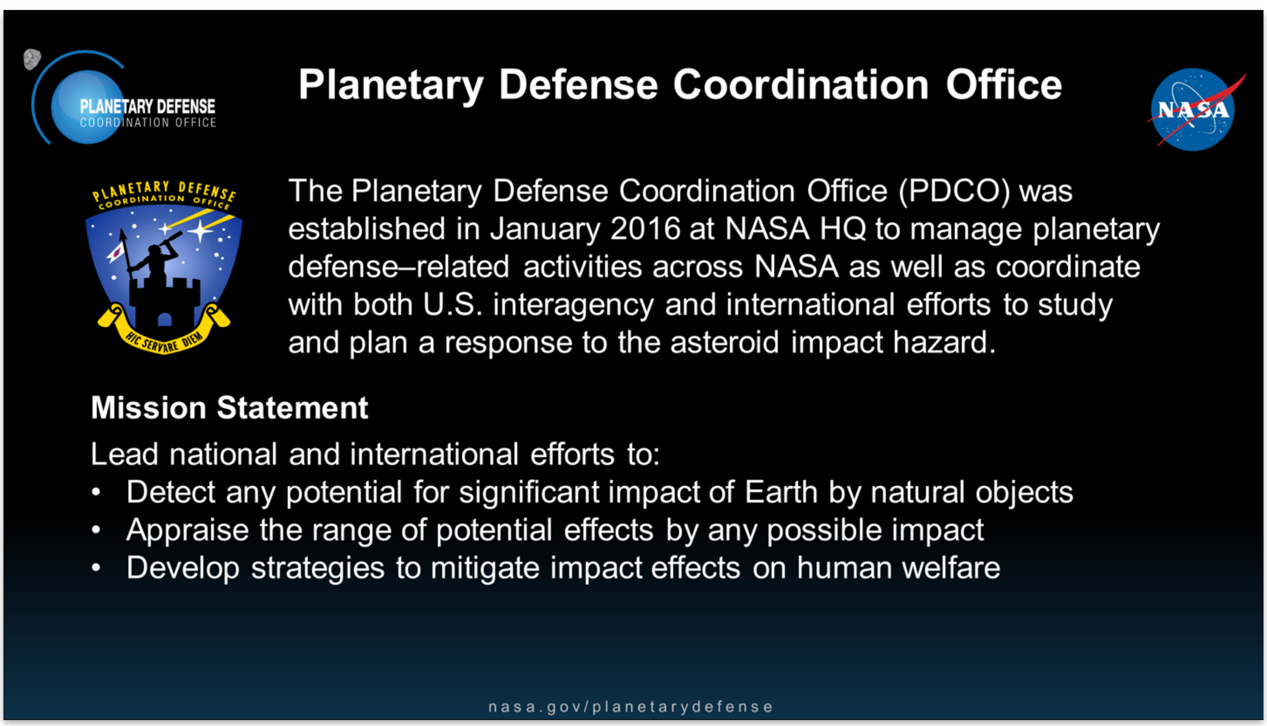

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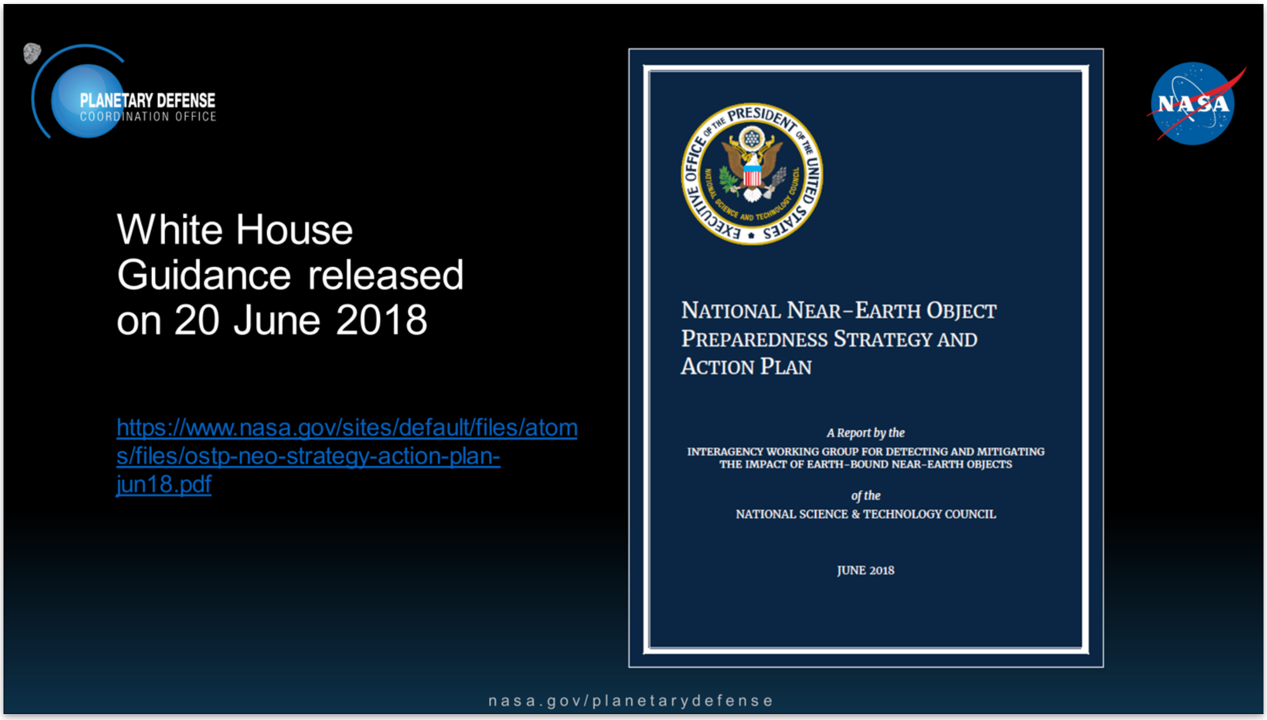

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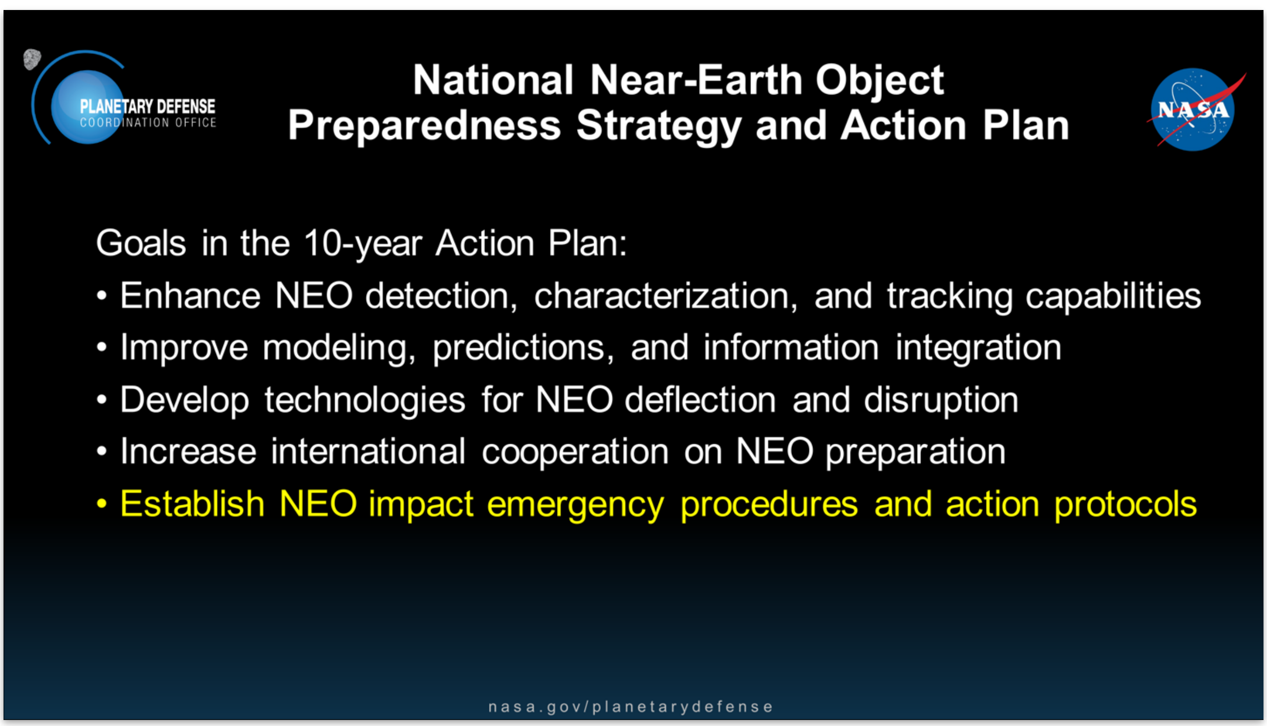

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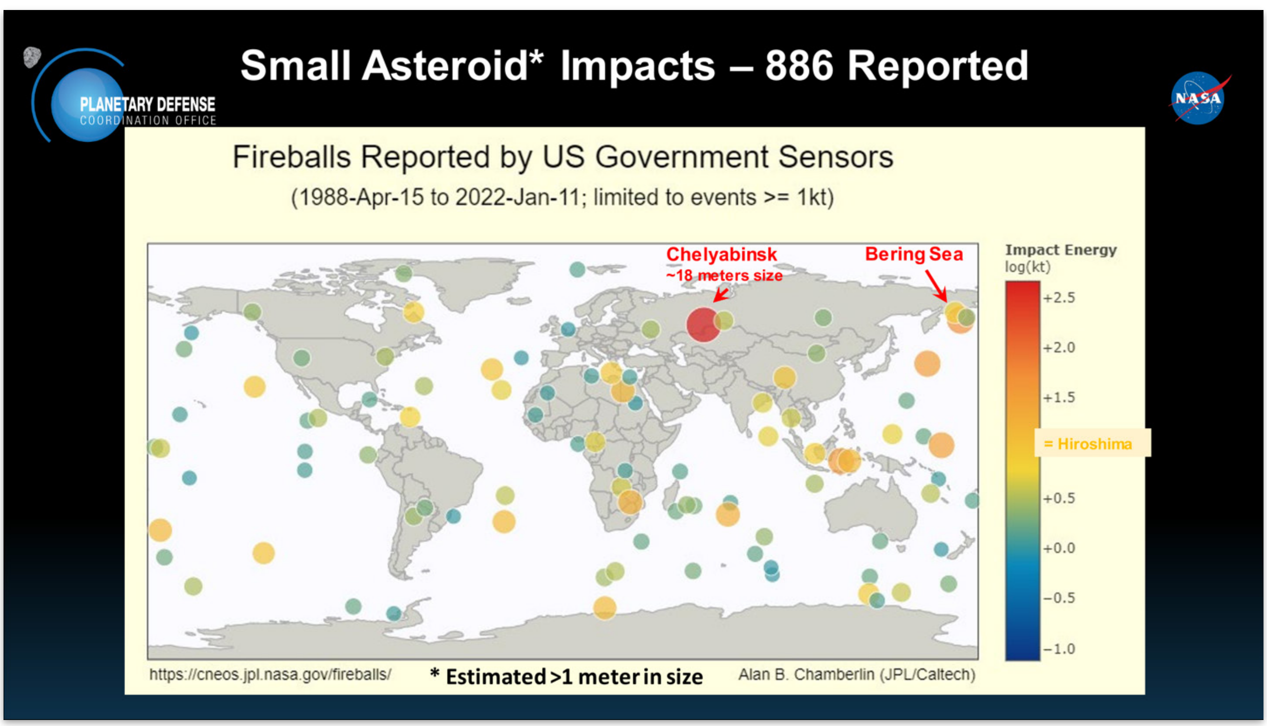

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PLANETARY DEFENSE COORDINATION OFFICE

Asteroid Impact Relative Energy

Diameter of Impacting Asteroid	Type of Event	Approximate Impact Energy (MT)	Average Time Between Impacts (Years)	
5 m (16 ft)	Bolide	0.01	1	Protected by atmosphere
10 m (33 ft)	Superbolide	0.1	10	
25 m (80 ft)	Major Airburst	1	100	Still vulnerable
50 m (160 ft)	Local Scale Devastation	10	1000	
140 m (460 ft)	Regional Scale Devastation	300	20,000	Working on it!
300 m (1000 ft)	Continent Scale Devastation	2,000	70,000	
600 m (2000 ft)	Below Global Catastrophe Threshold	20,000	200,000	
1 km (3300 ft)	Possible Global Catastrophe	100,000	700,000	
5 km (3 mi)	Above Global Catastrophe Threshold	10,000,000	30 million	Found them all!
10 km (6 mi)	Mass Extinction	100,000,000	100 million	

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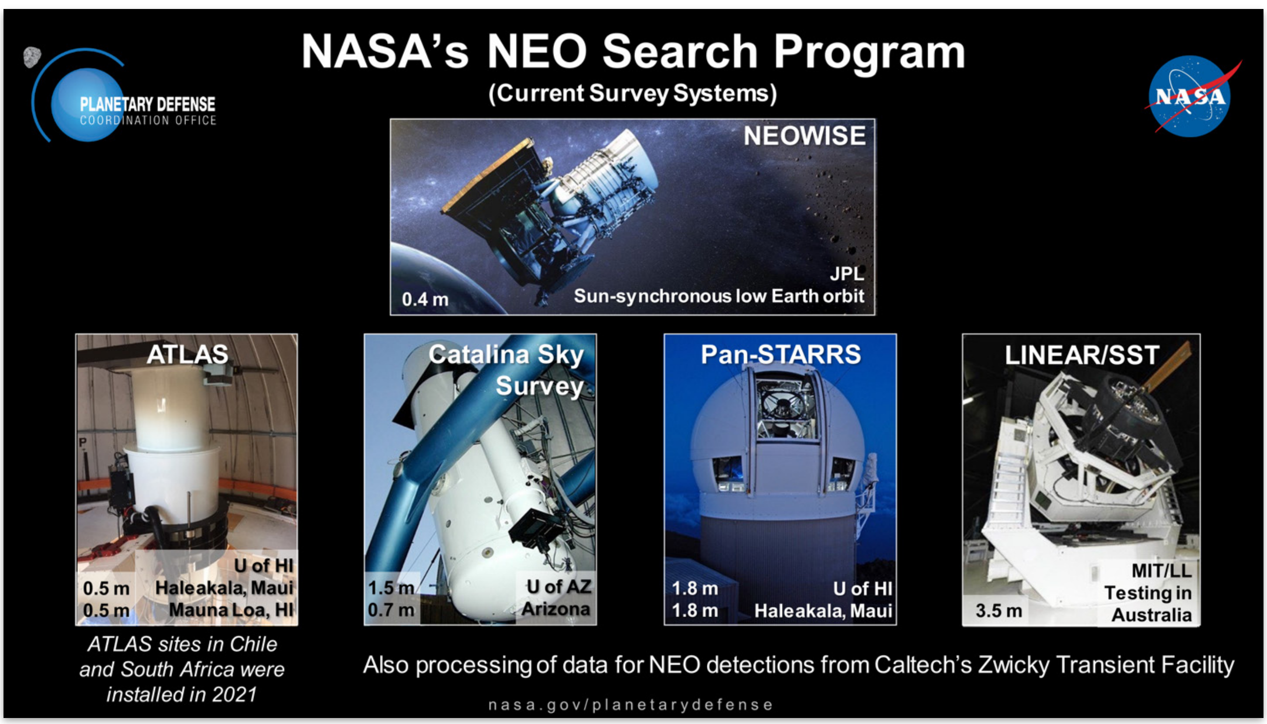

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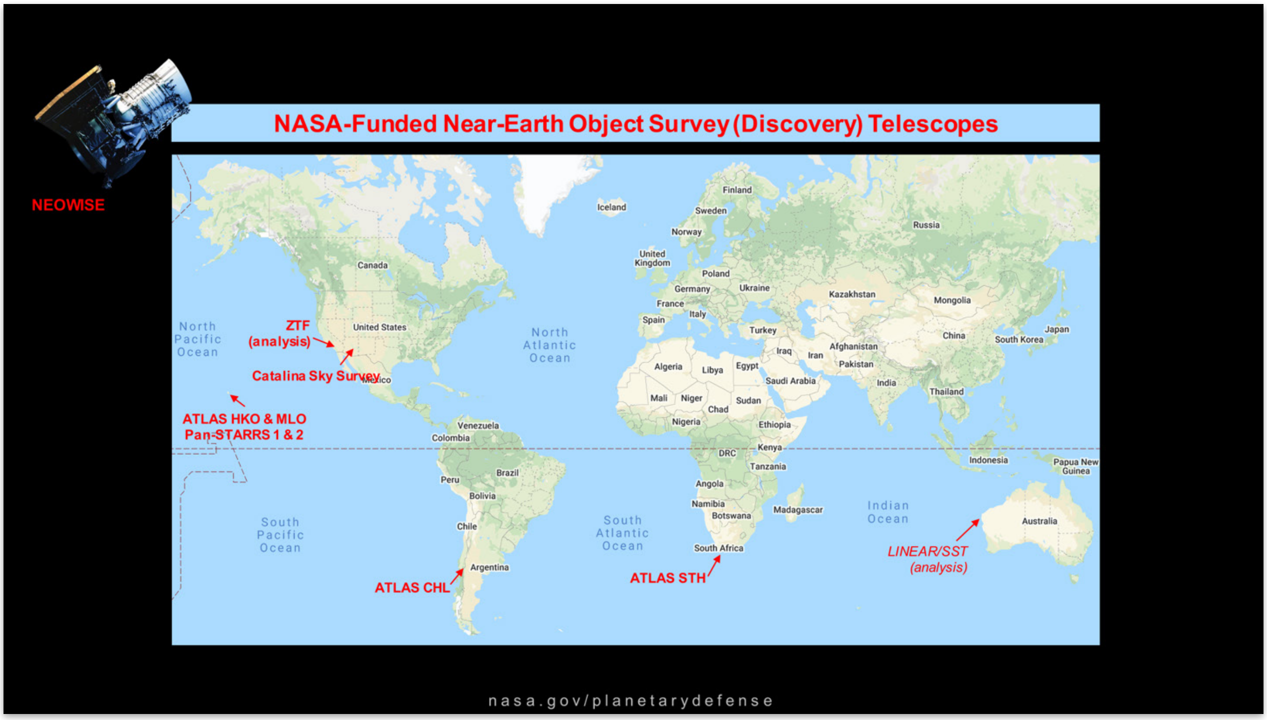

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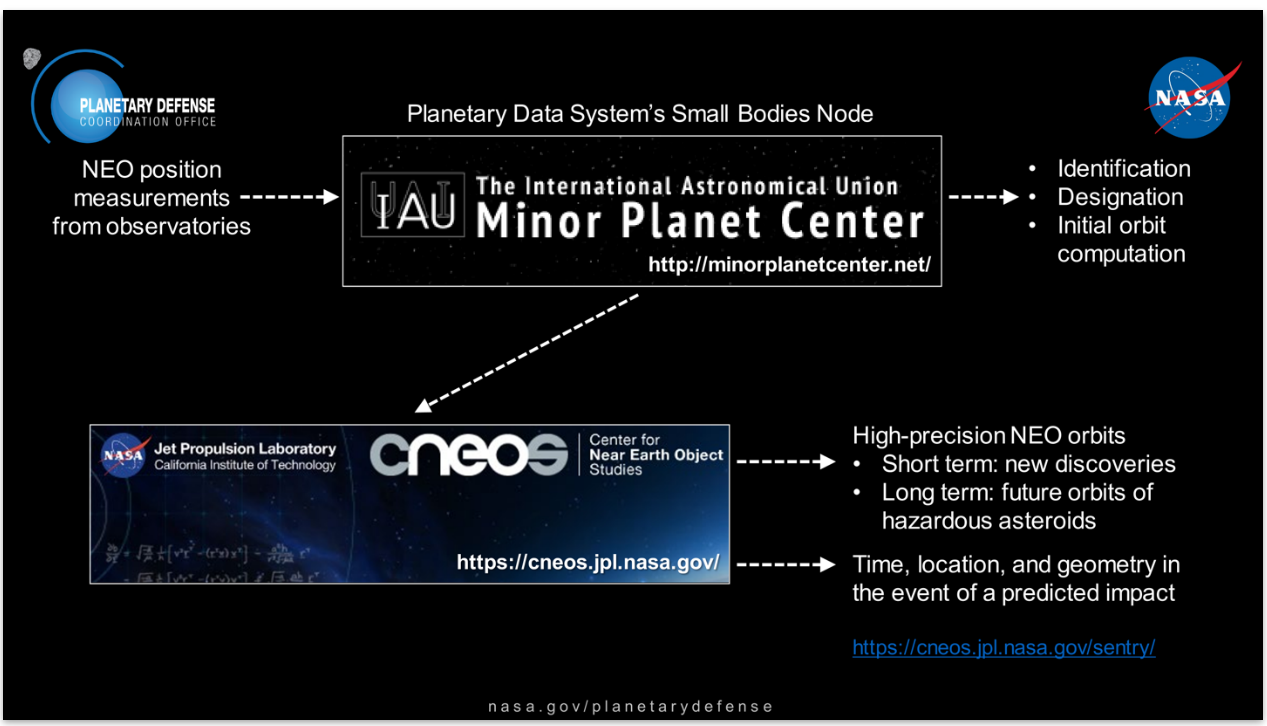

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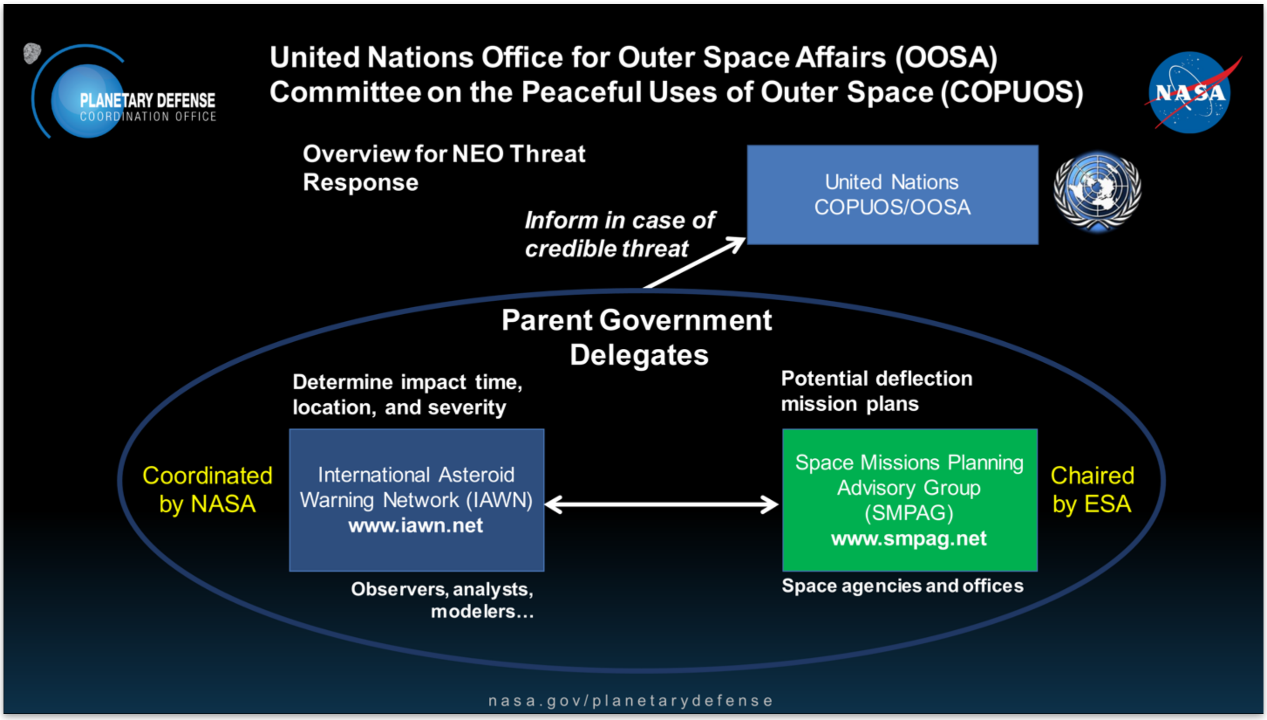

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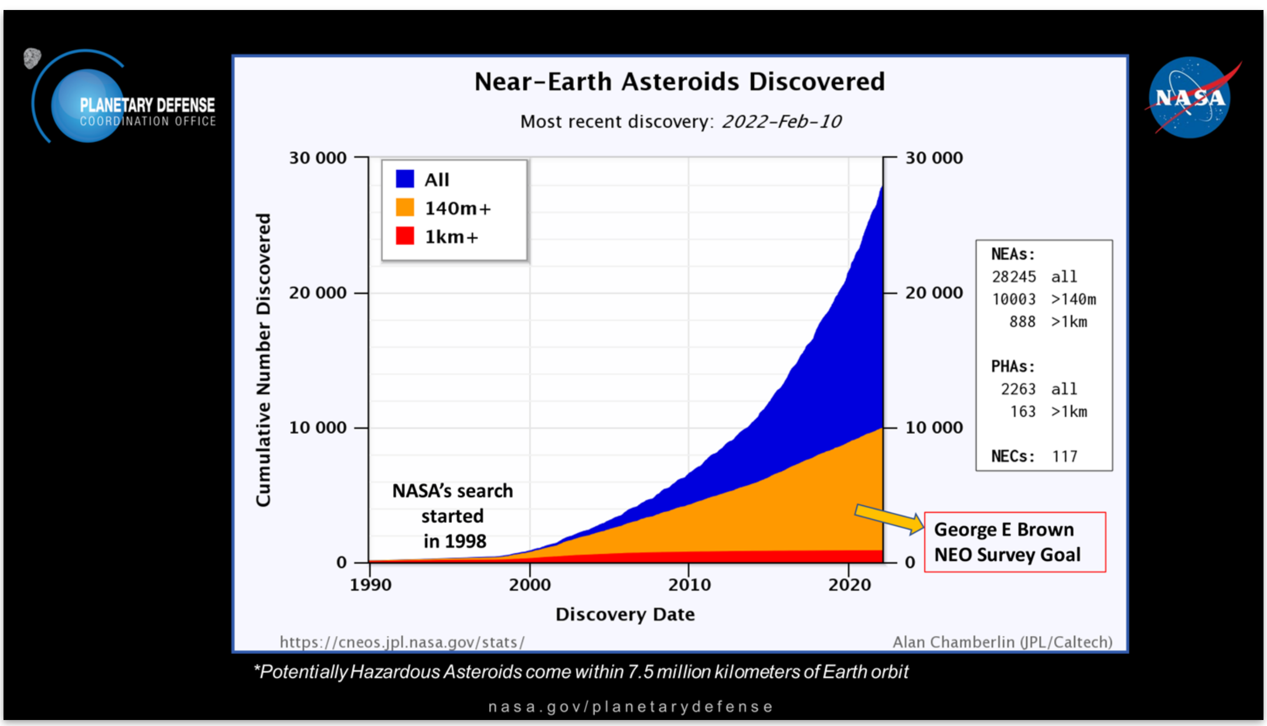

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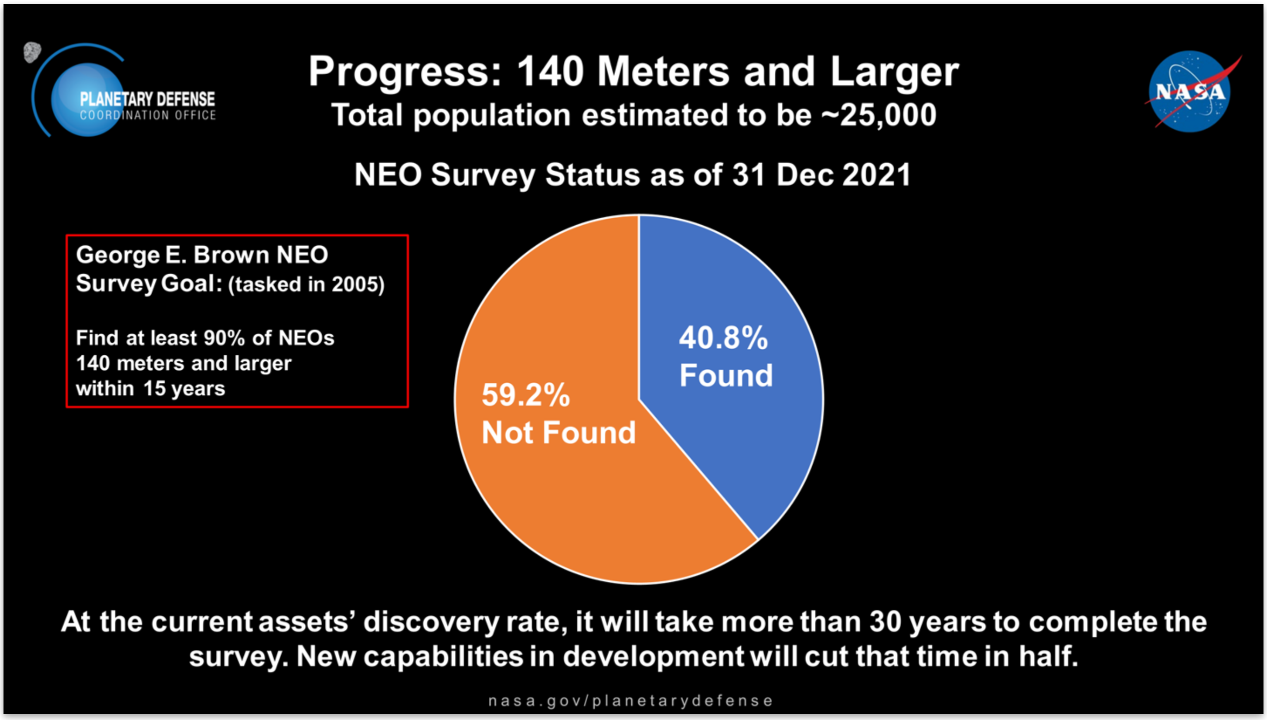

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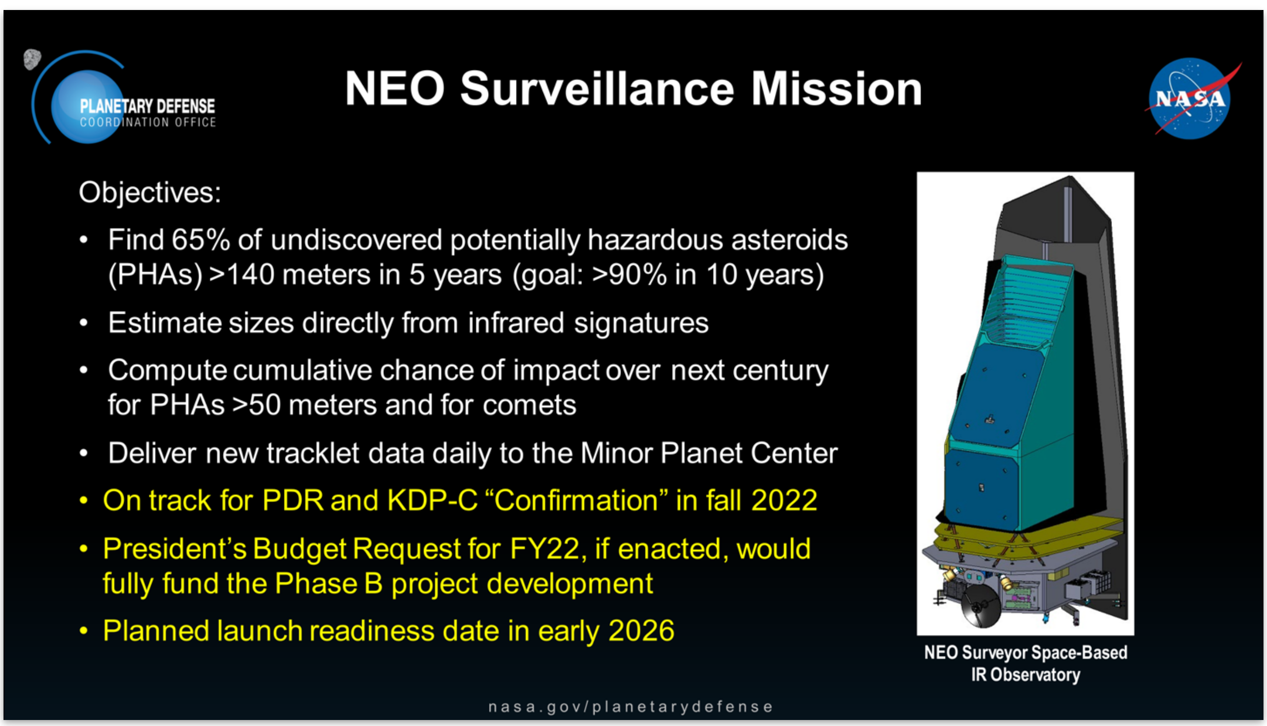

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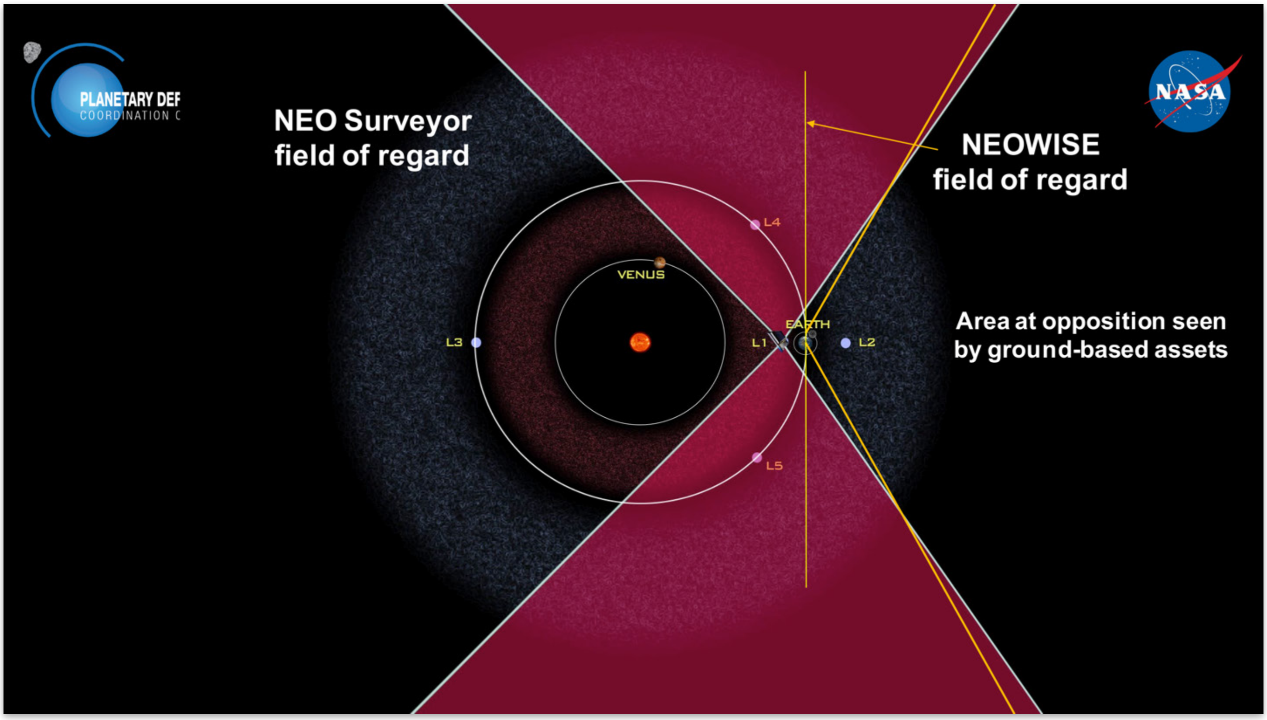

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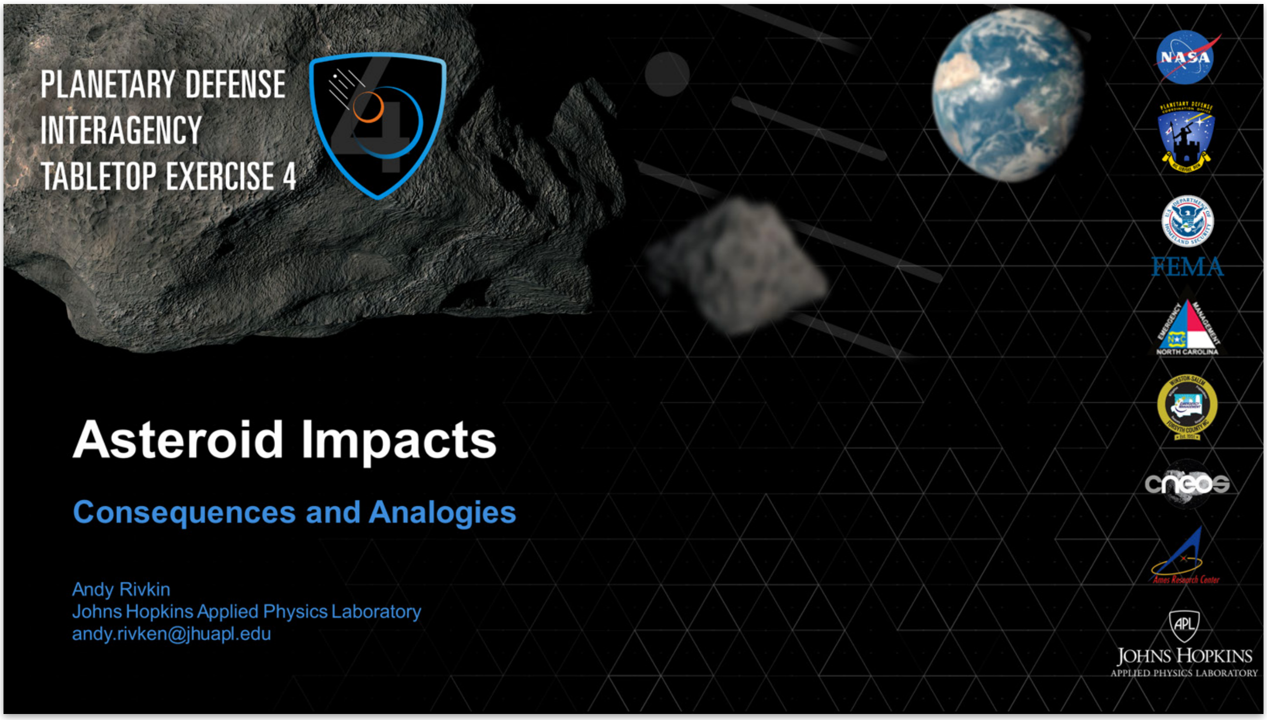

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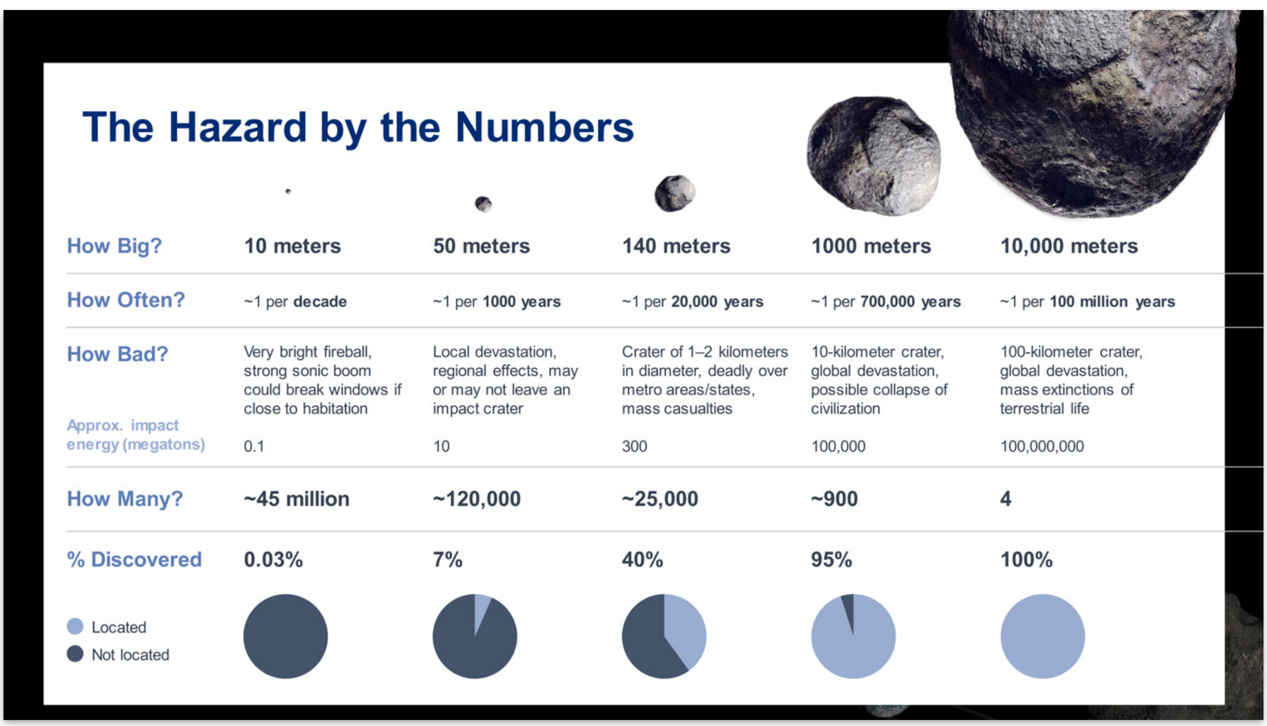

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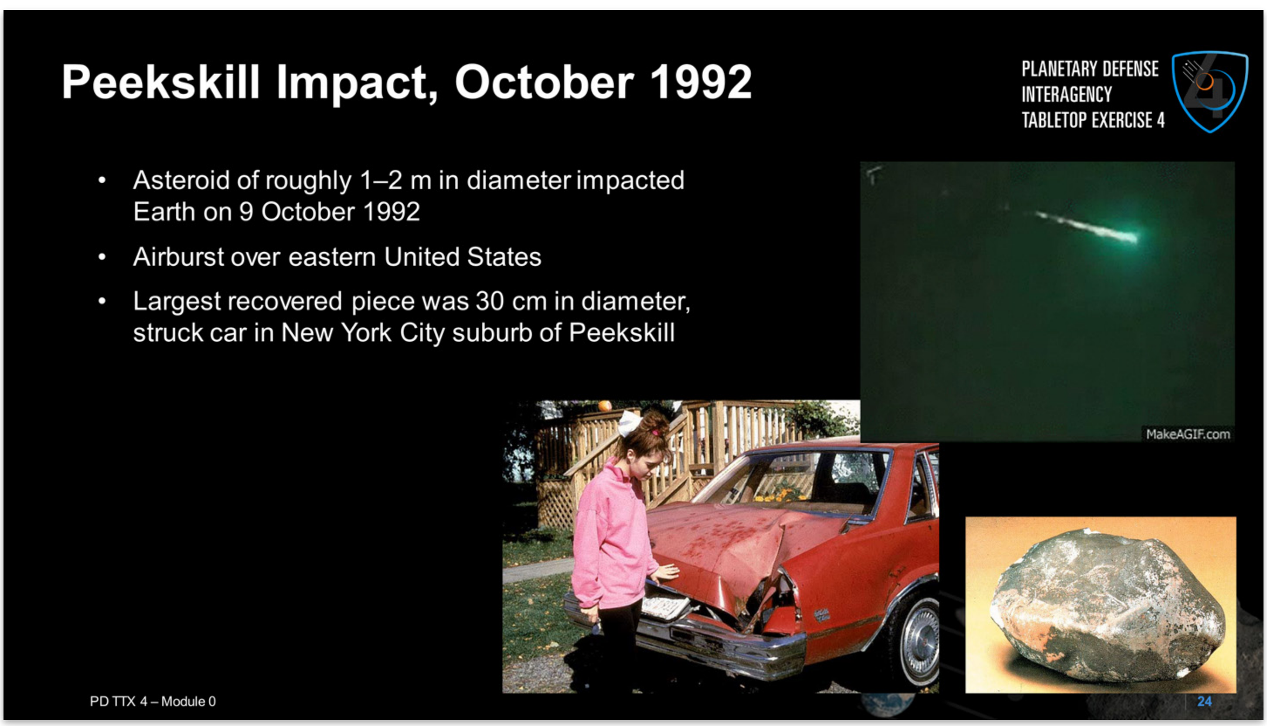

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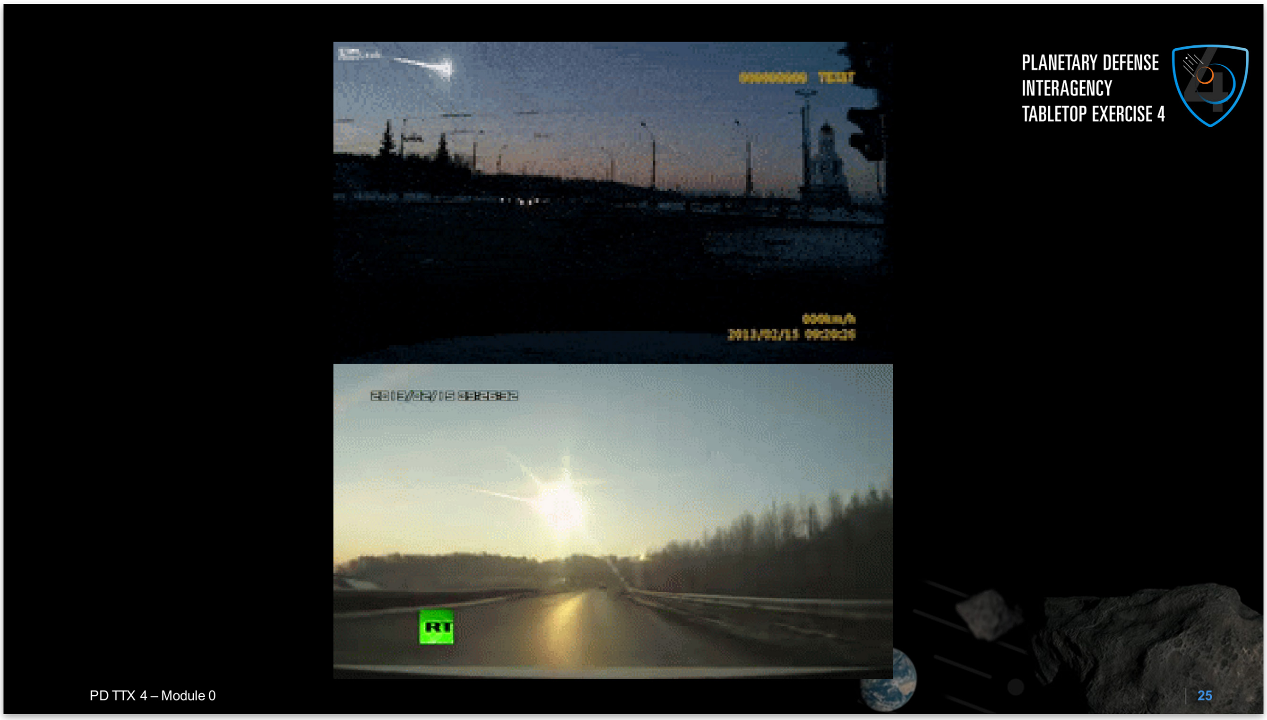

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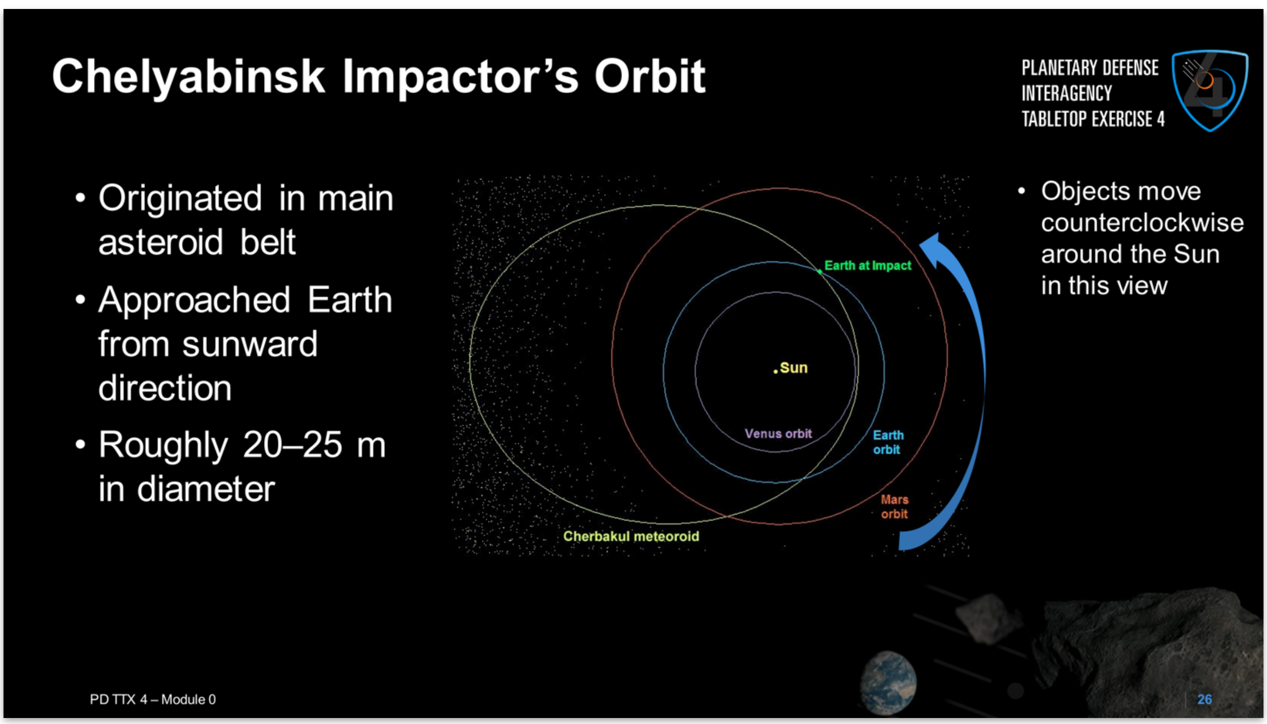

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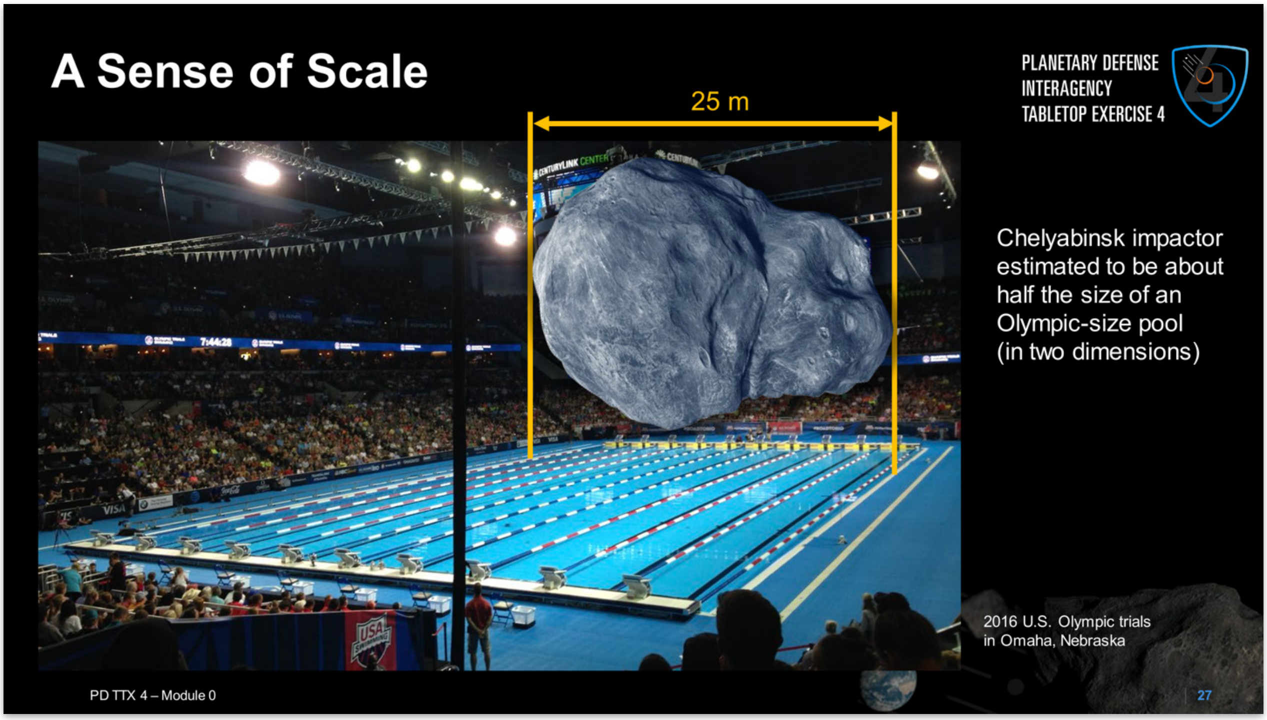

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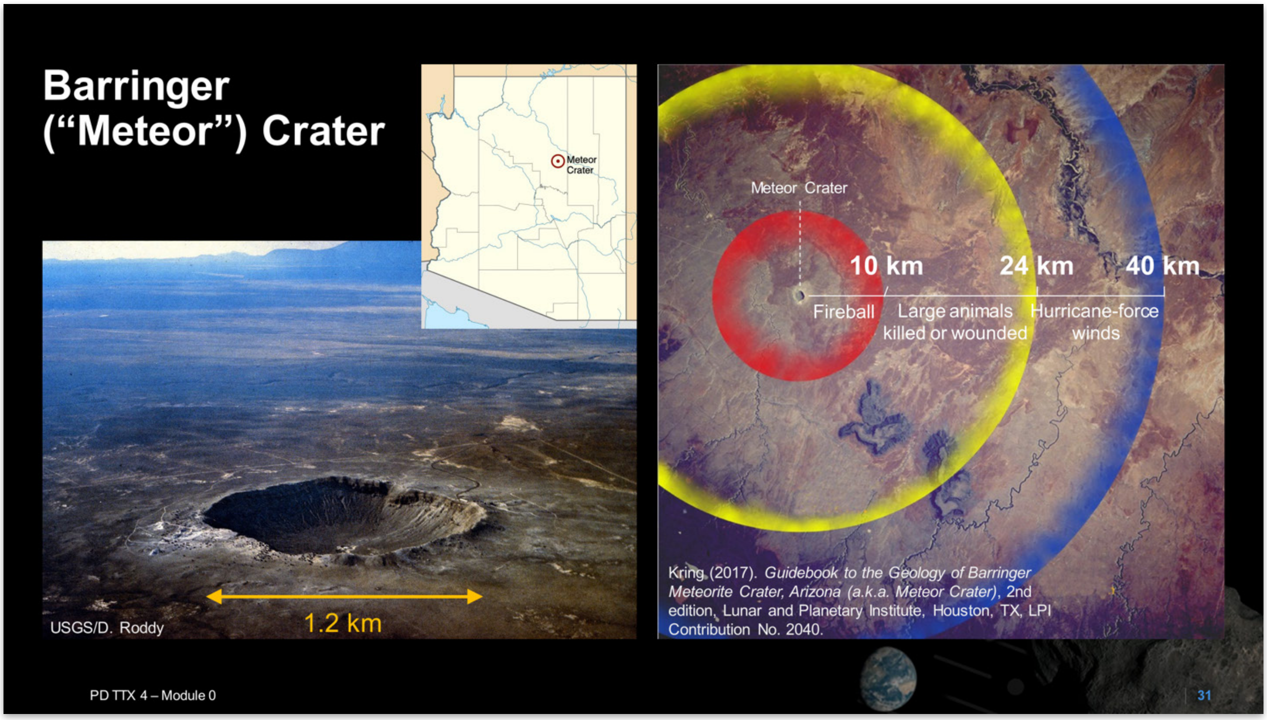

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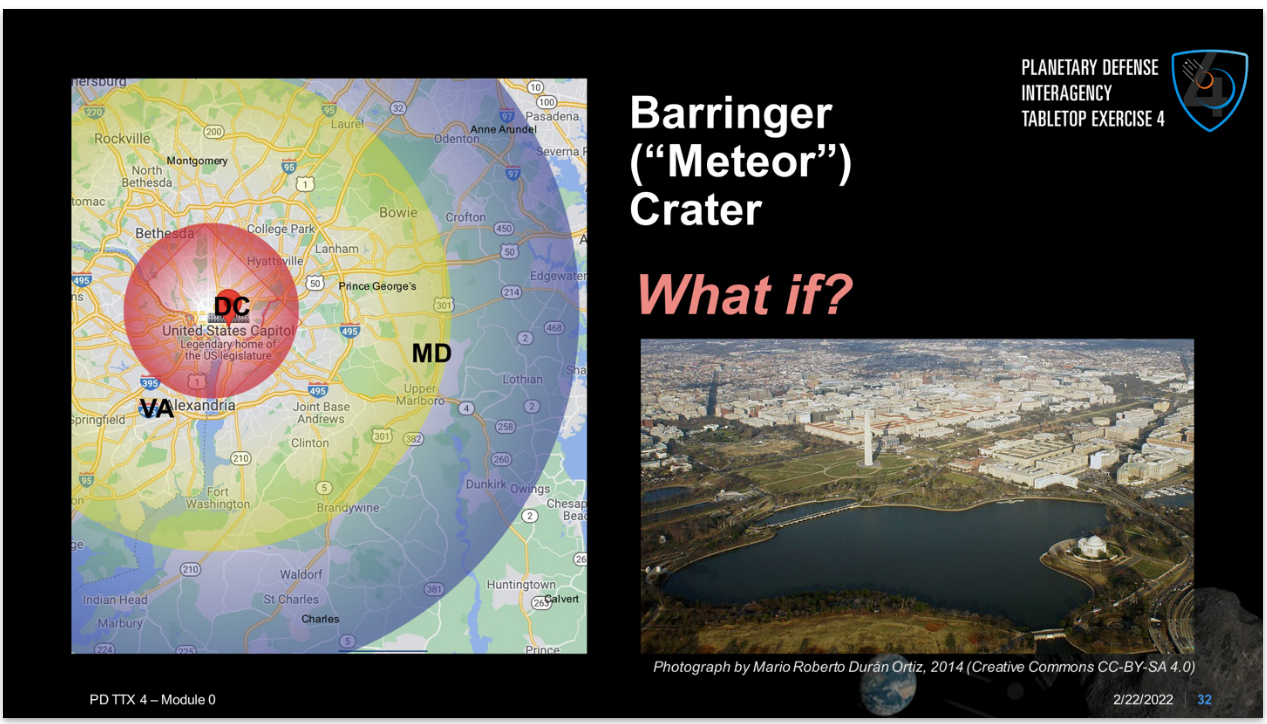

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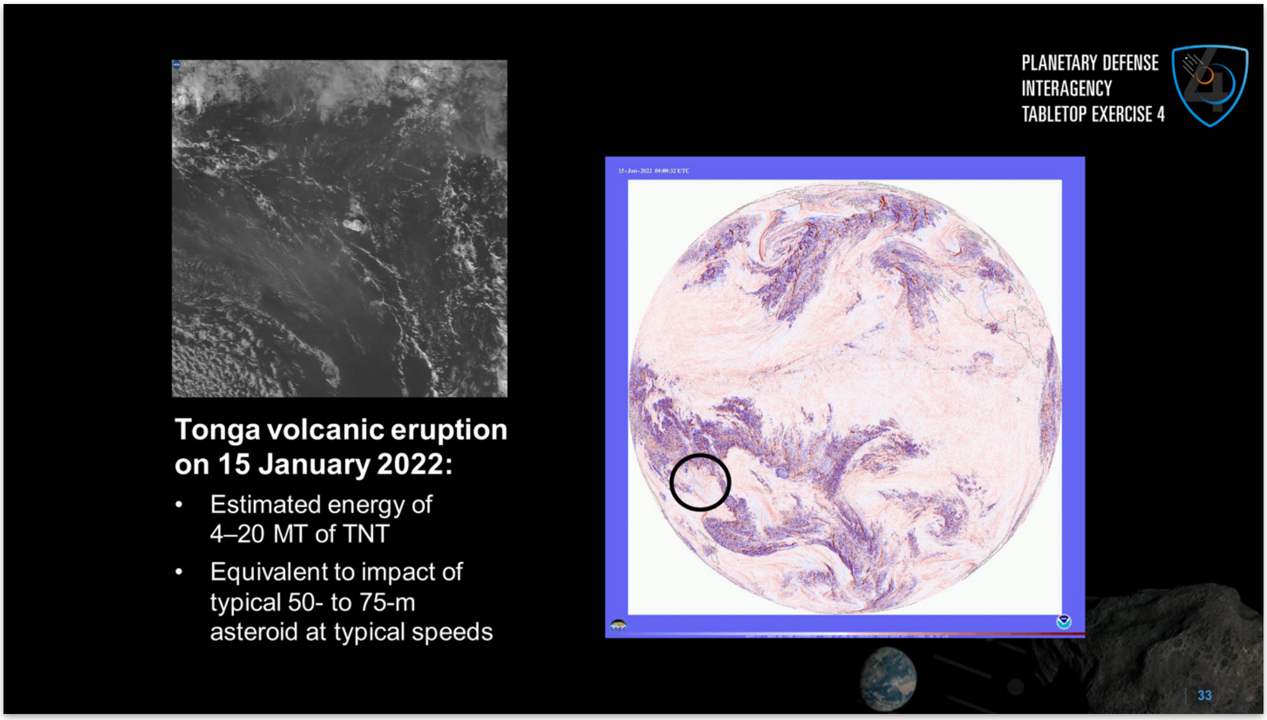

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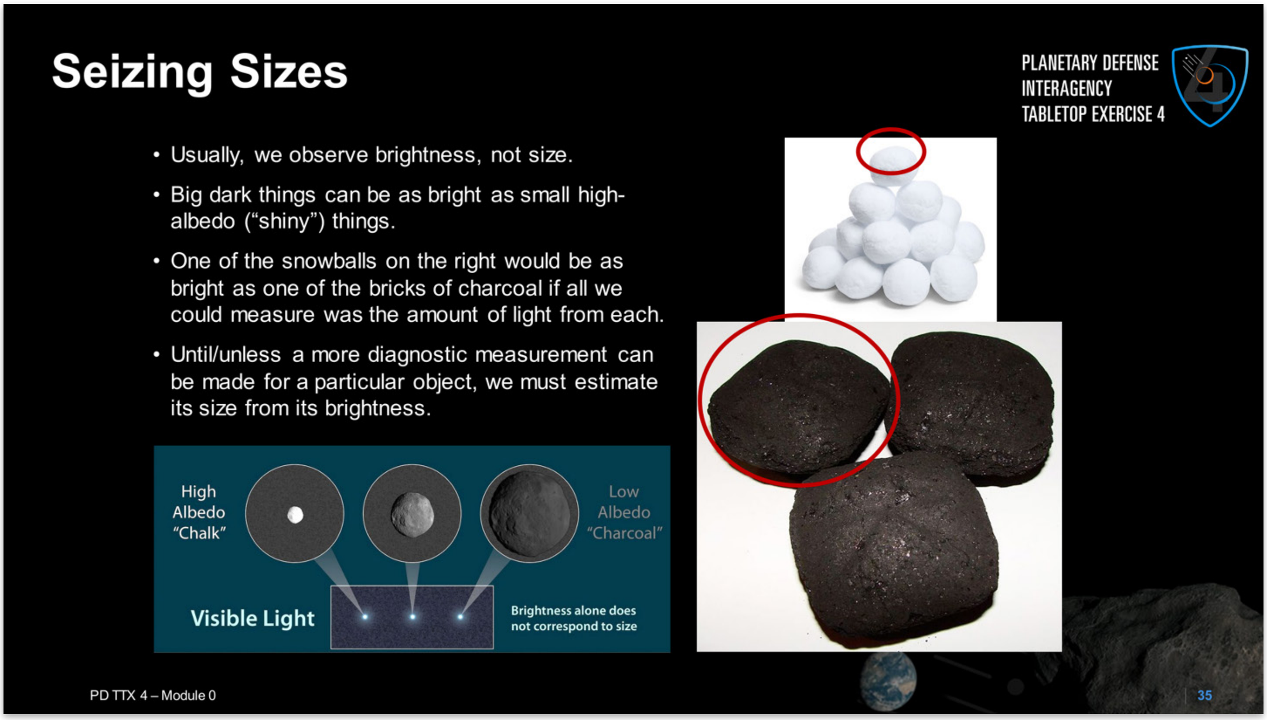

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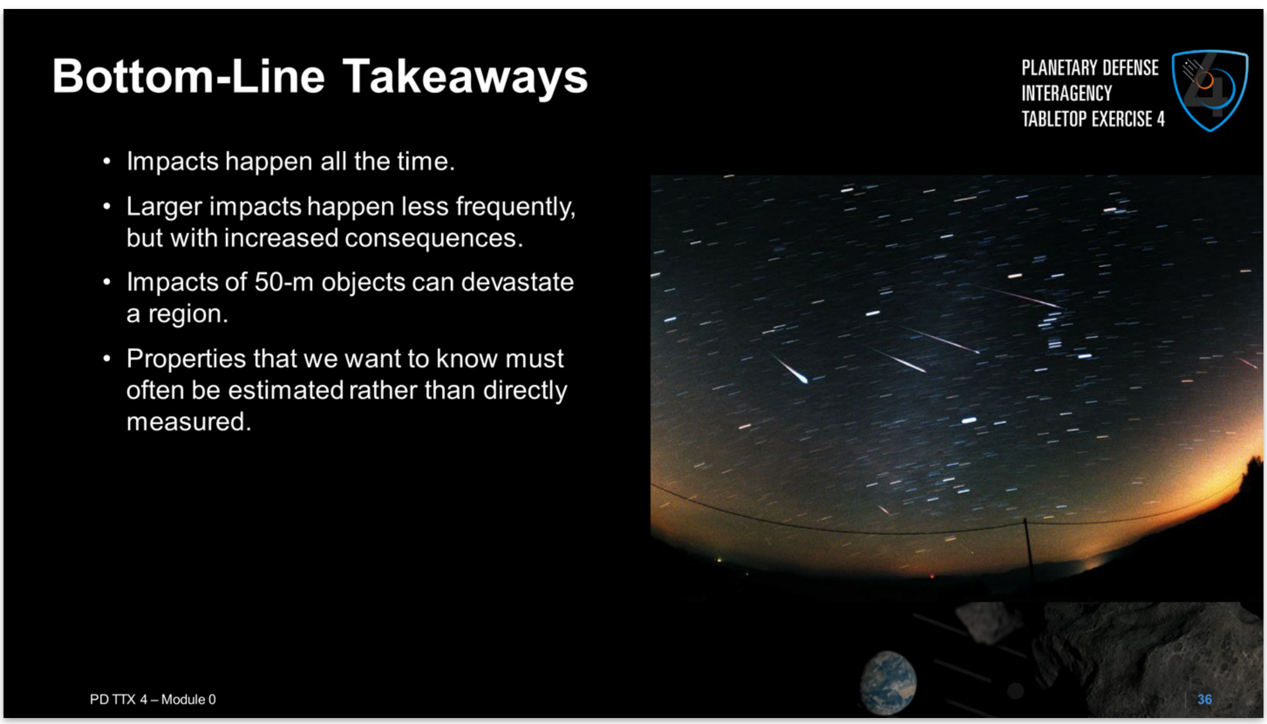

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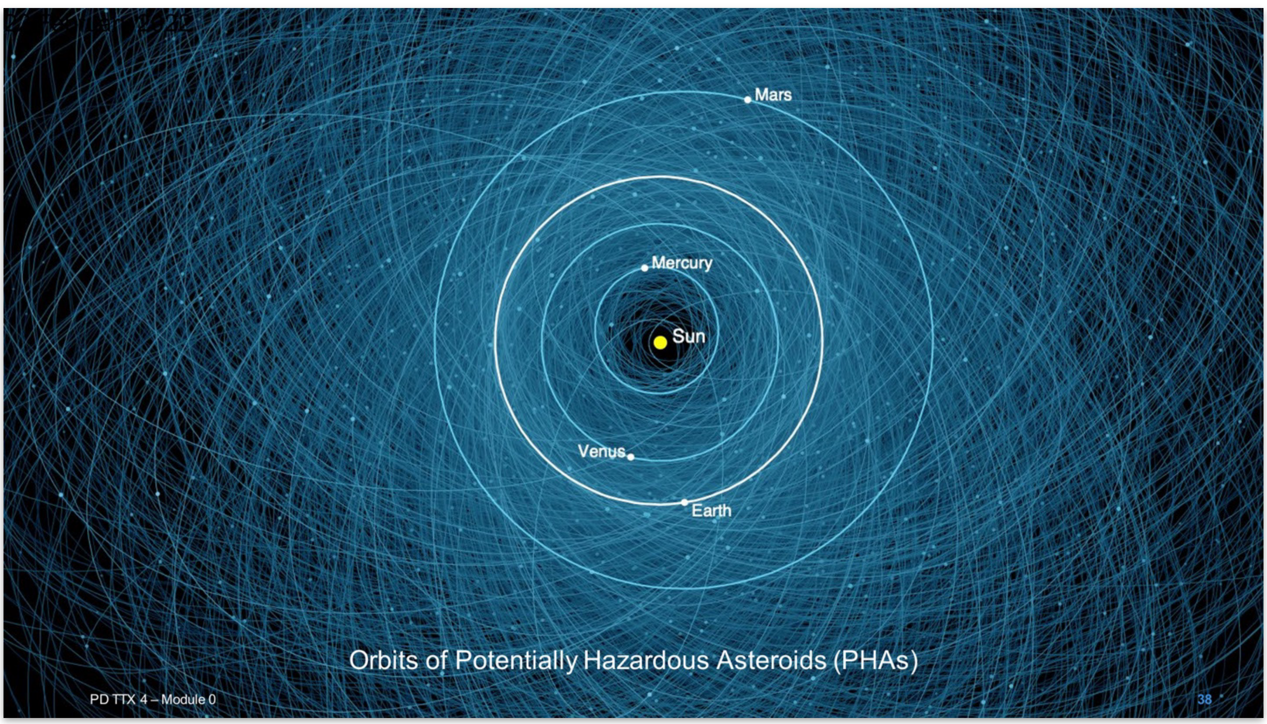

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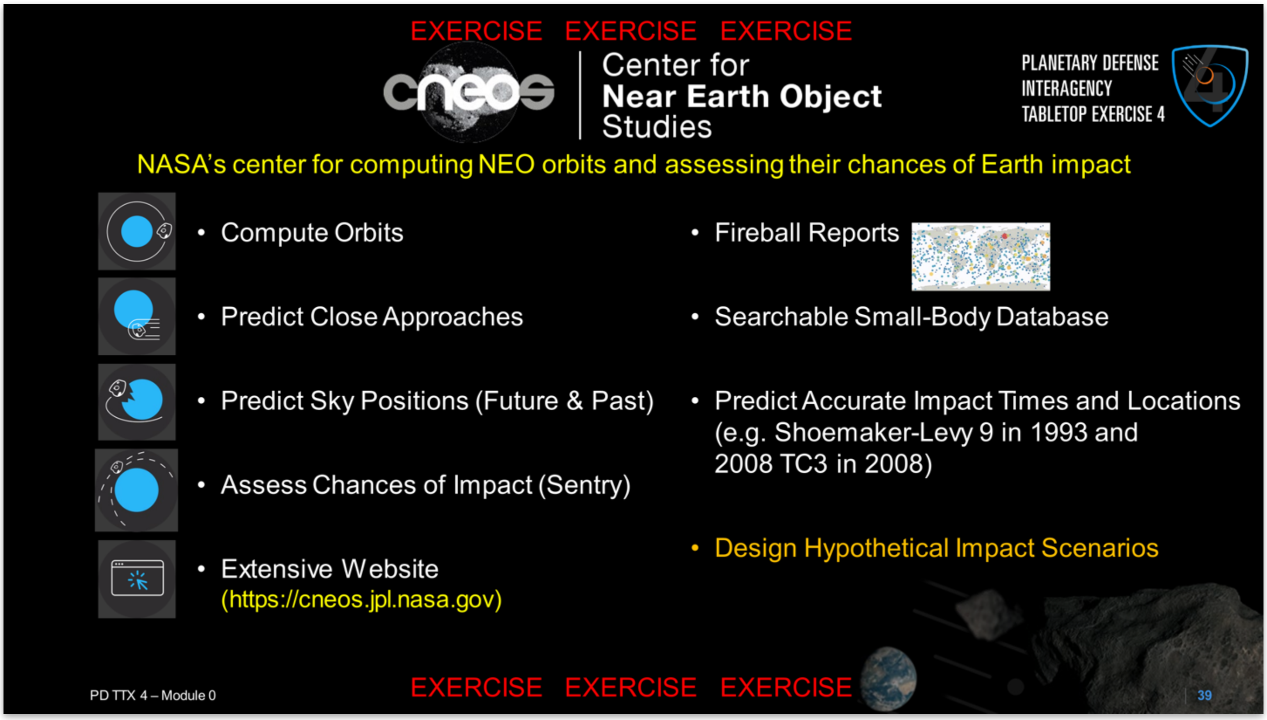

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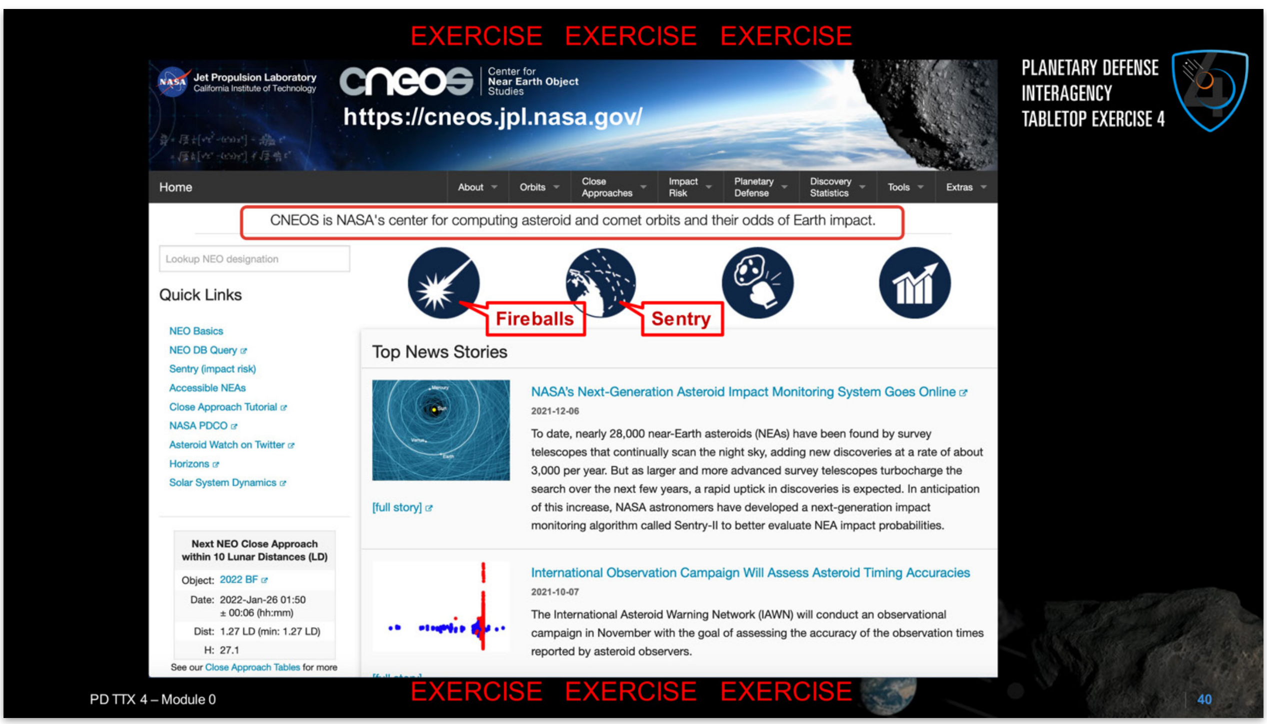

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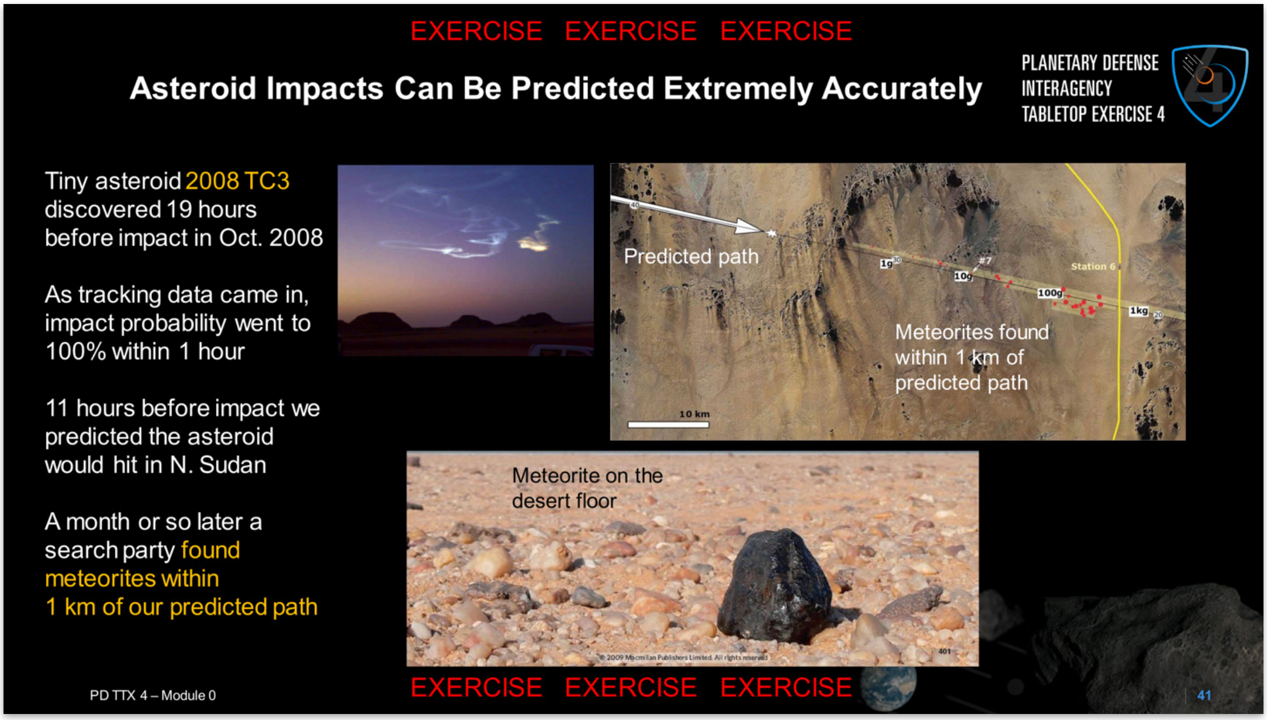

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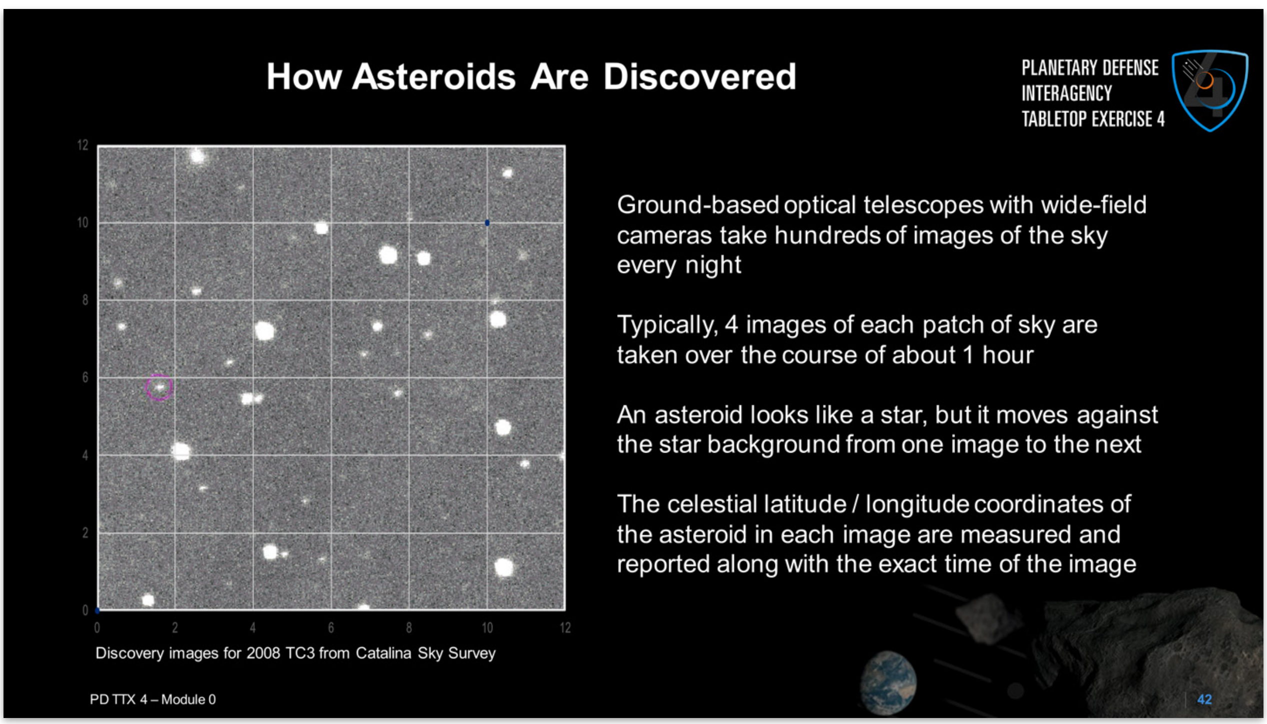

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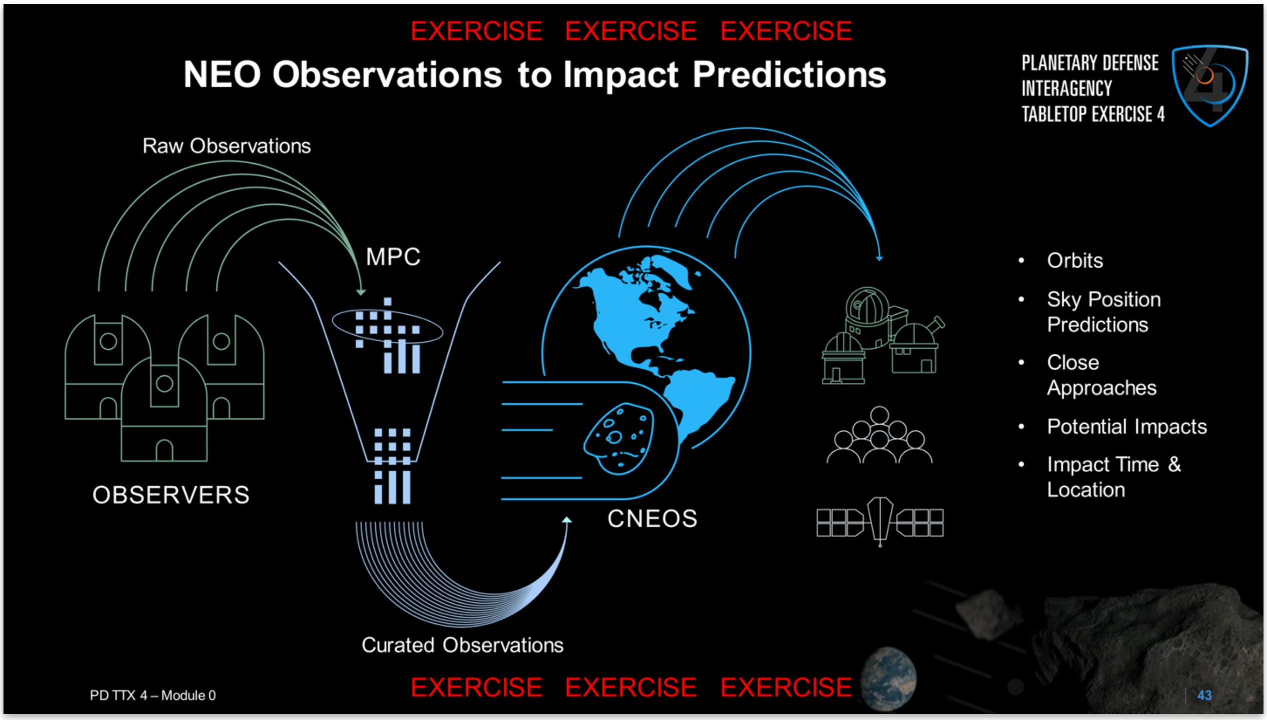

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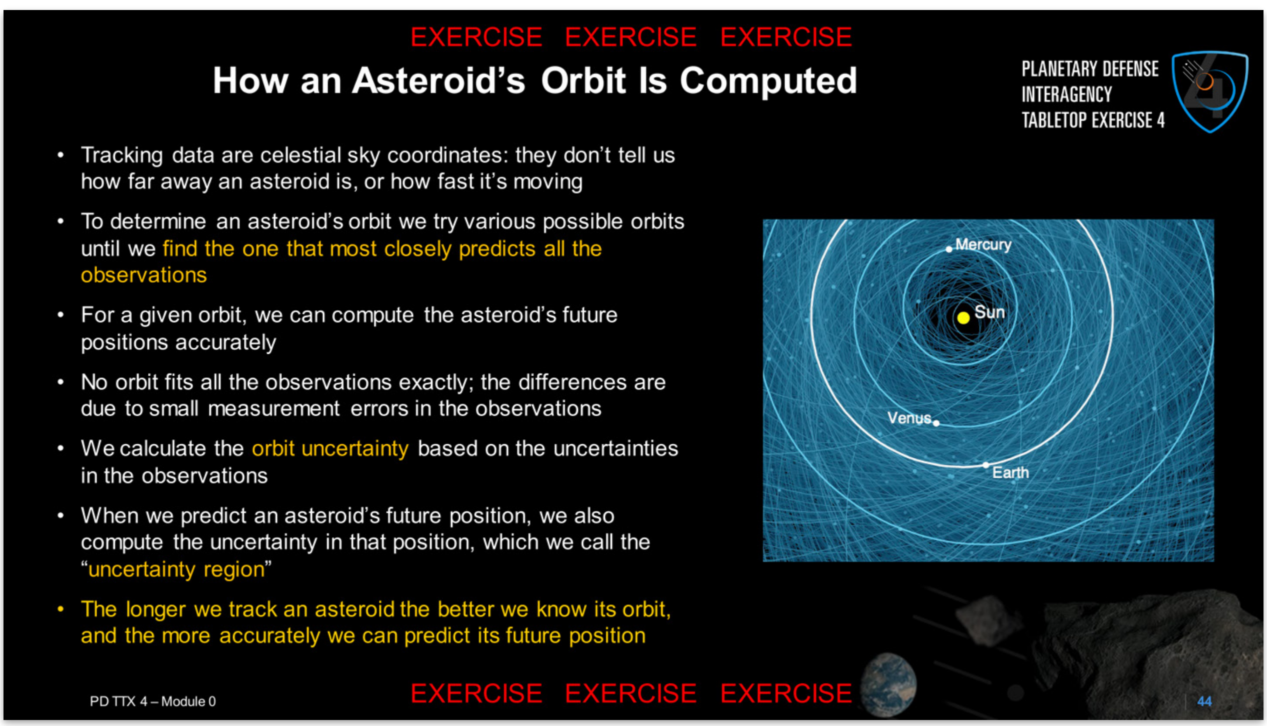

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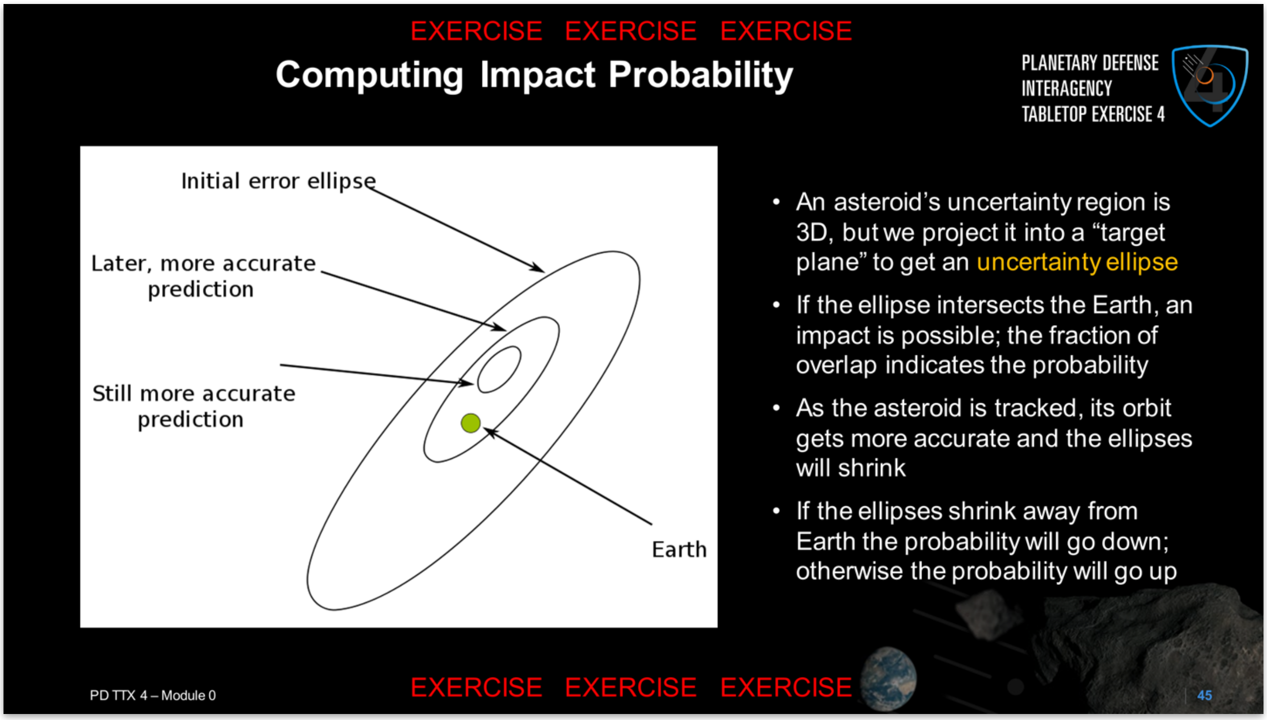

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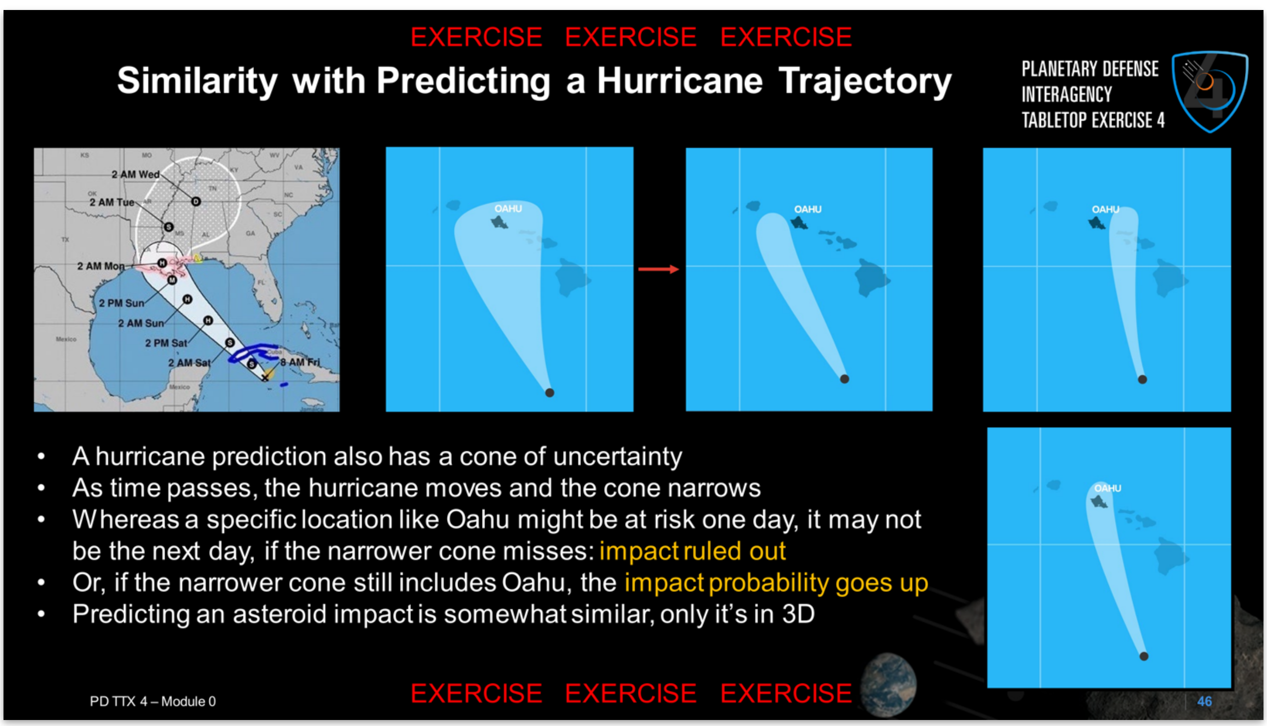

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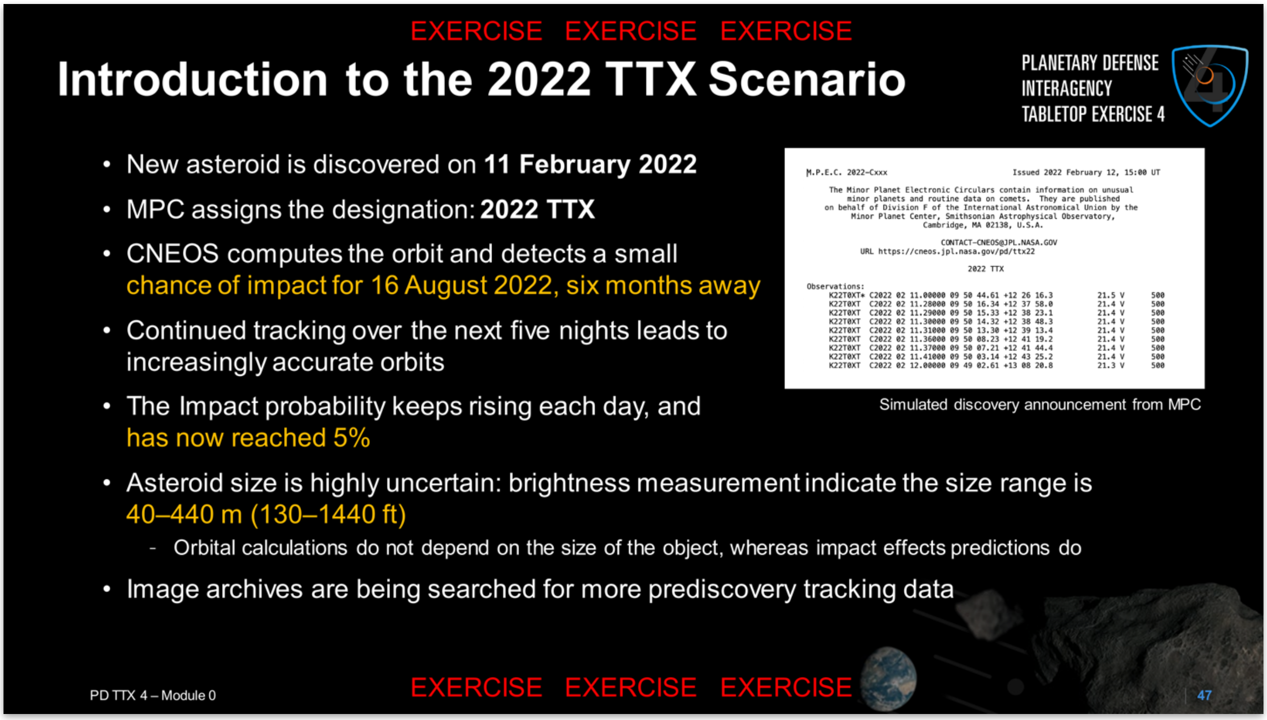

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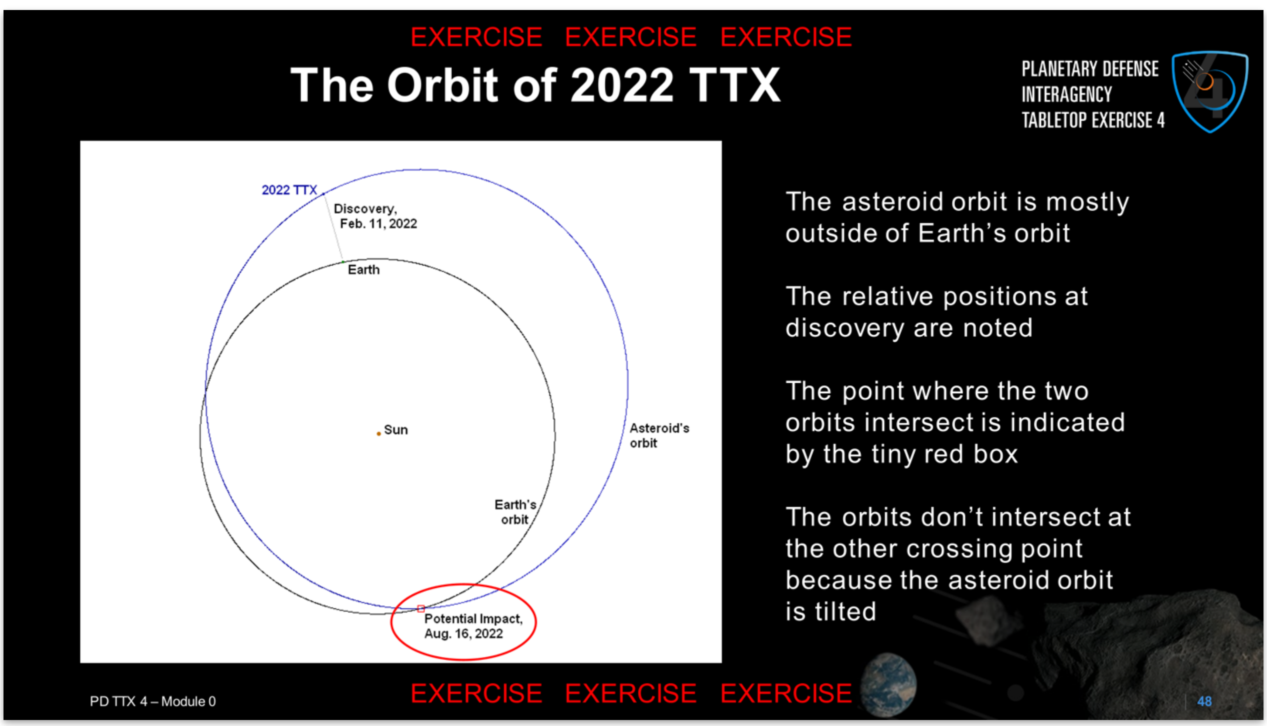

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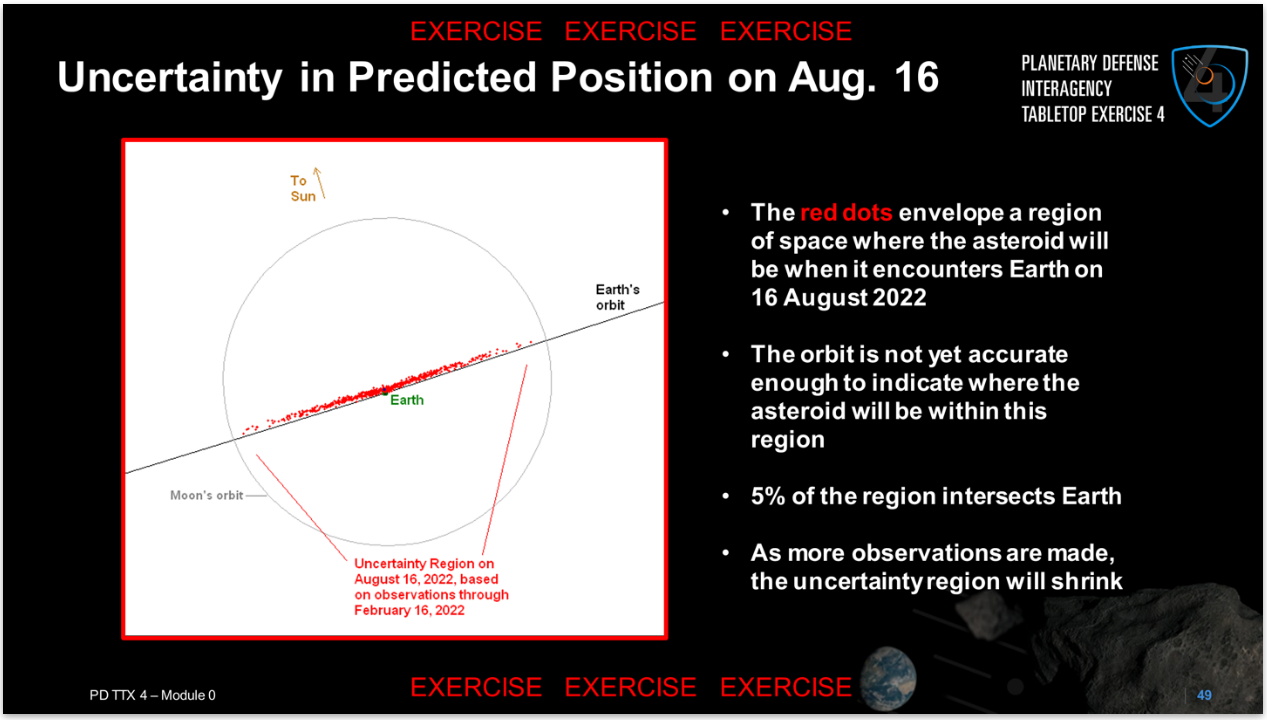

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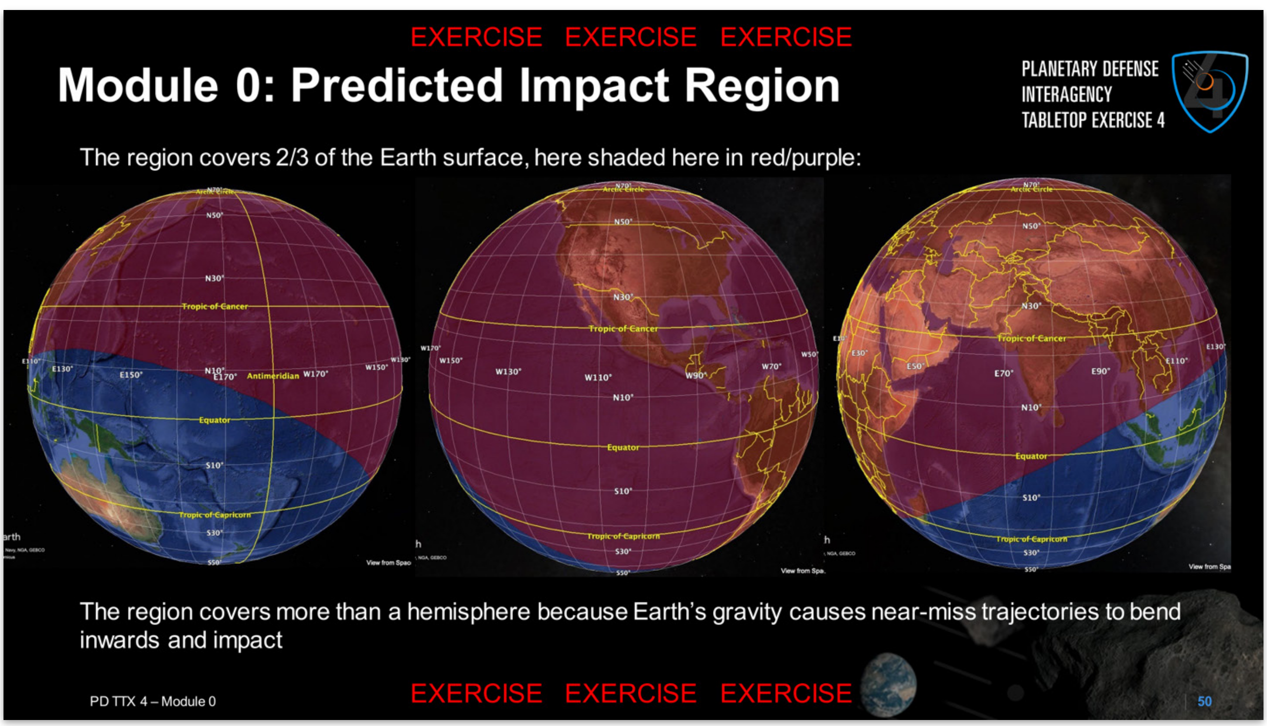

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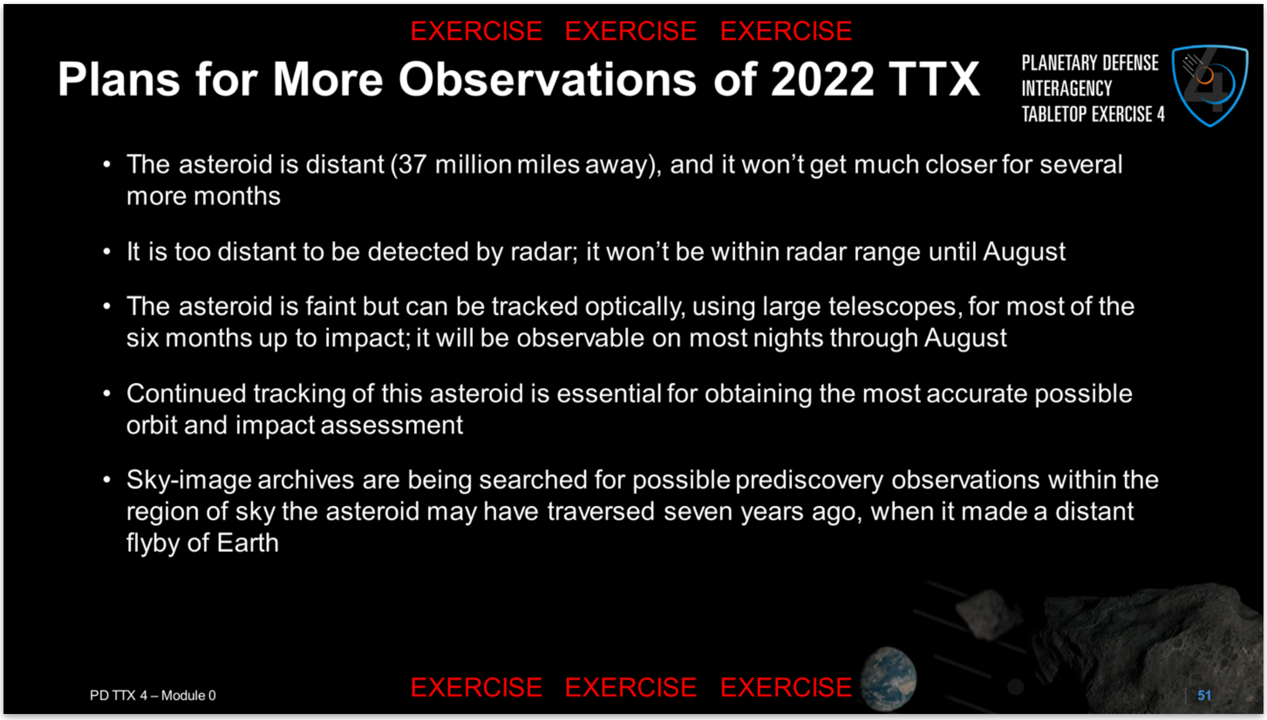

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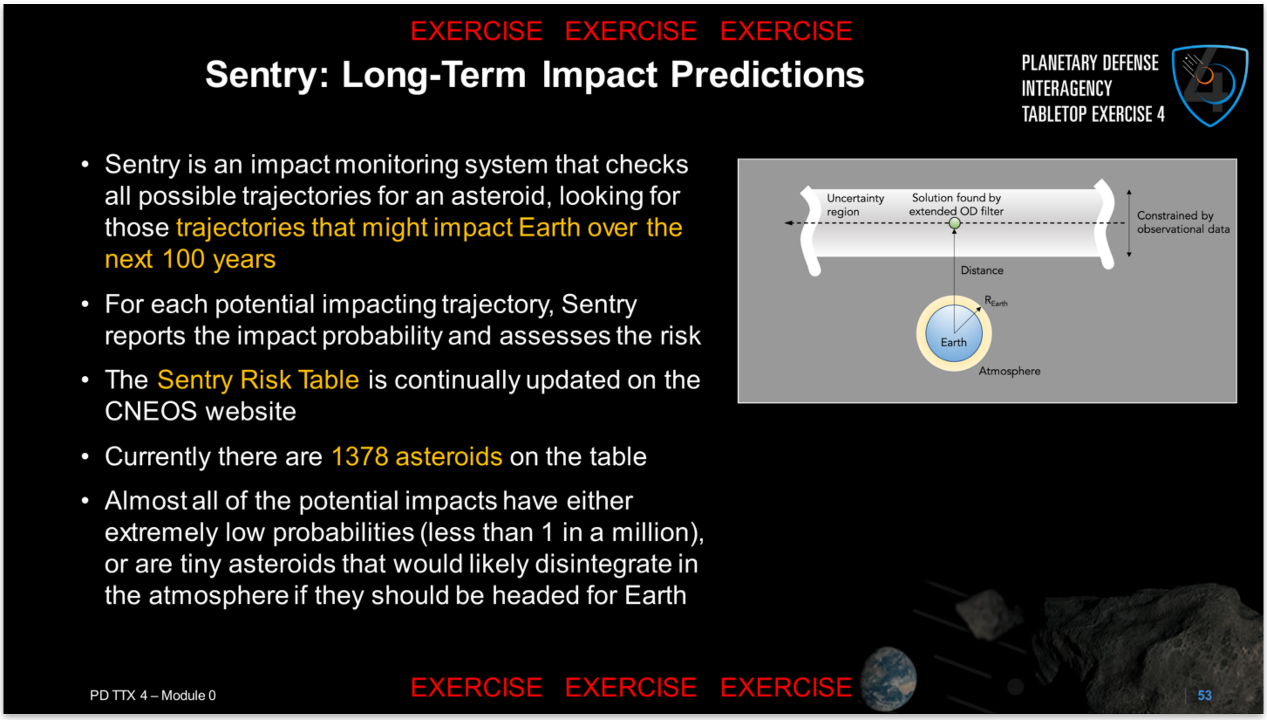

- Comments on slide 53
- test (#1 | Aaron Chrietzberg)

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C.3 Module 0b: Planetary Defense Briefing – Part 2

Slide 1

Slide 2

Outline

PLANETARY DEFENSE INTERAGENCY TABLETOP EXERCISE 4

- What is asteroid impact risk assessment?
- Asteroid properties and uncertainties
- Impact hazards and damage effects
- Risk assessment modeling for specific impact scenarios
- Impact risk assessment result examples

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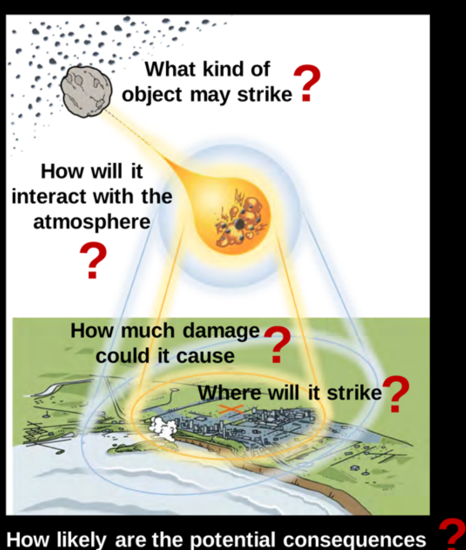
Slide 3

What Is Asteroid Impact Risk Assessment?

PLANETARY DEFENSE INTERAGENCY TABLETOP EXERCISE 4



- Risk assessment evaluates both the range and likelihood of potential outcomes, given the level of uncertainty or knowledge of the factors
- Evaluating asteroid impact risks involves large uncertainties across all aspects of the problem:
  - Impact probability, potential impact locations, entry trajectories (speed, entry angle)
  - Initial asteroid sizes and properties (density, strength, structure, composition, shape, etc.)
  - Atmospheric entry, breakup, airburst or impact behavior
  - Severity and range of resulting hazards
  - Population and infrastructure within damage regions
- Some uncertainties shrink as we gain knowledge over time (impact locations, asteroid size), while some remain unknown (specific asteroid properties, entry/breakup behavior, damage uncertainties)

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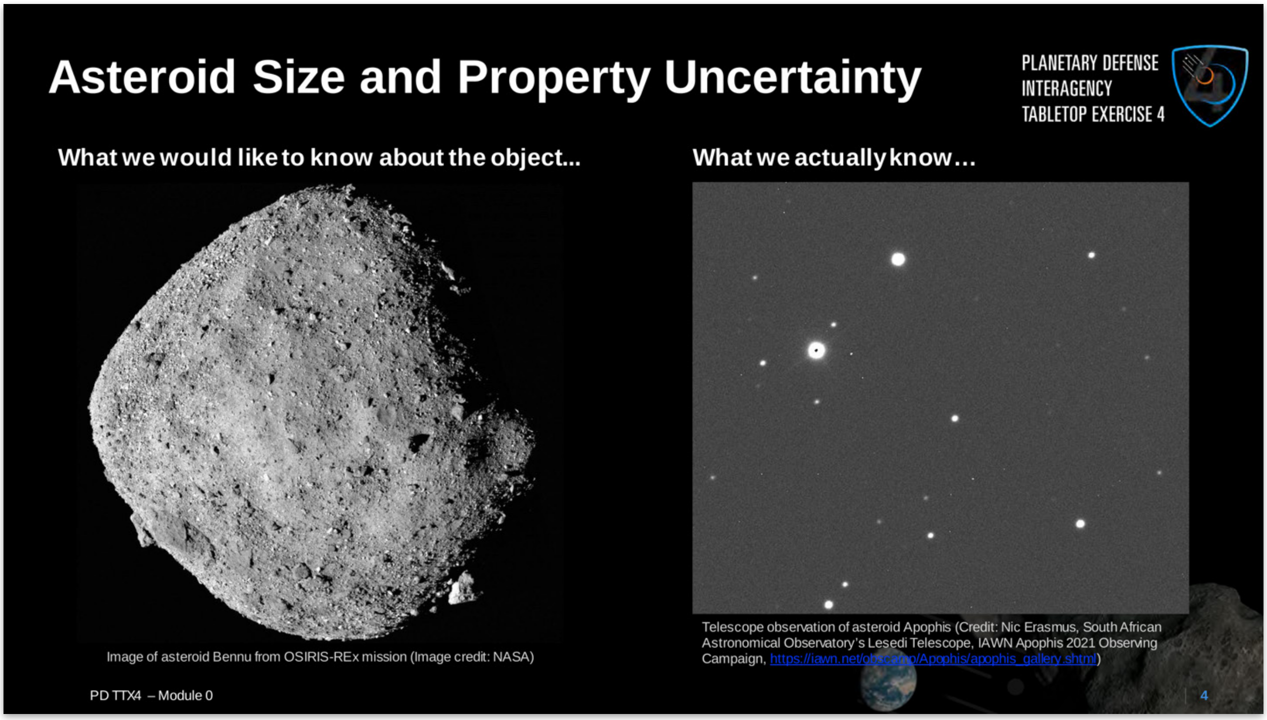
Slide 4



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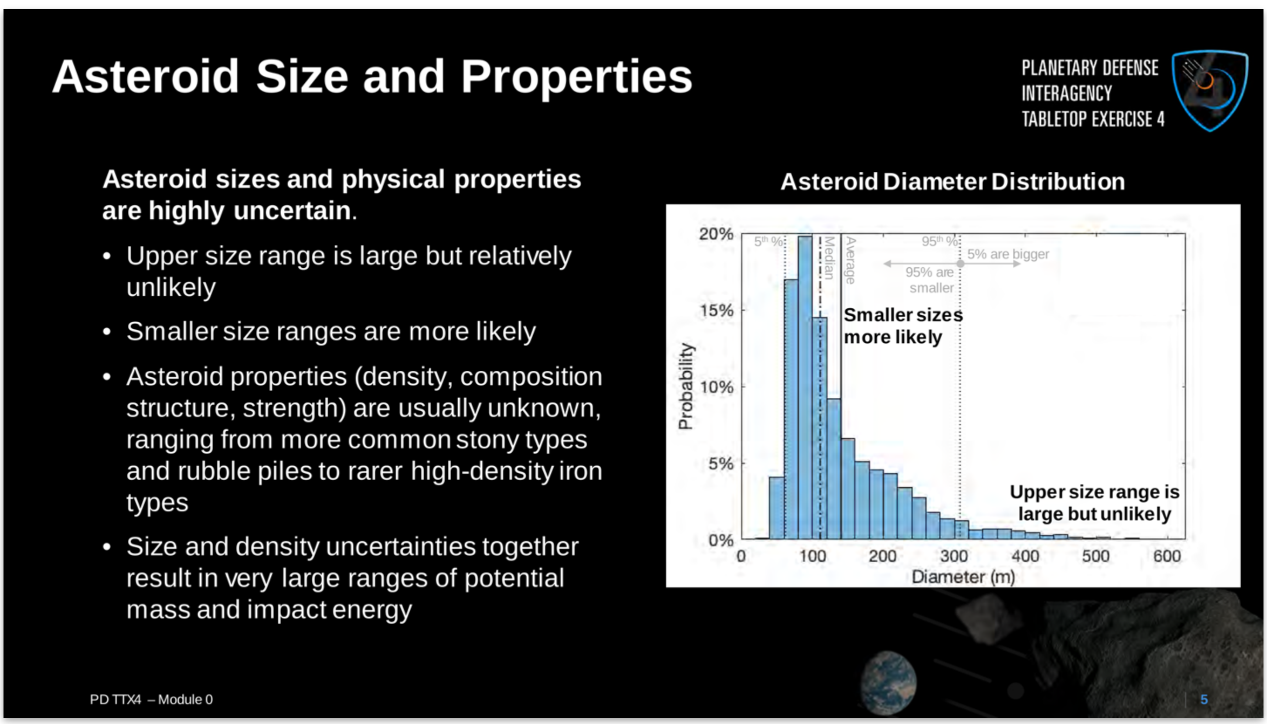

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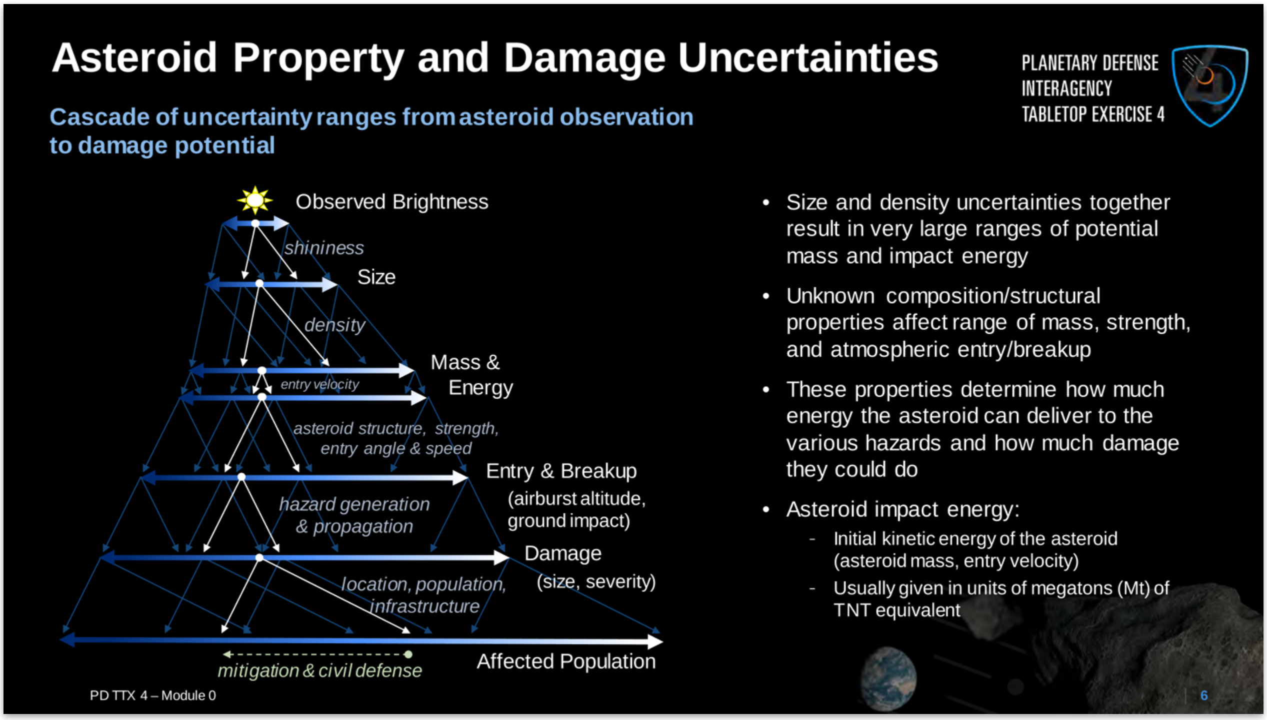

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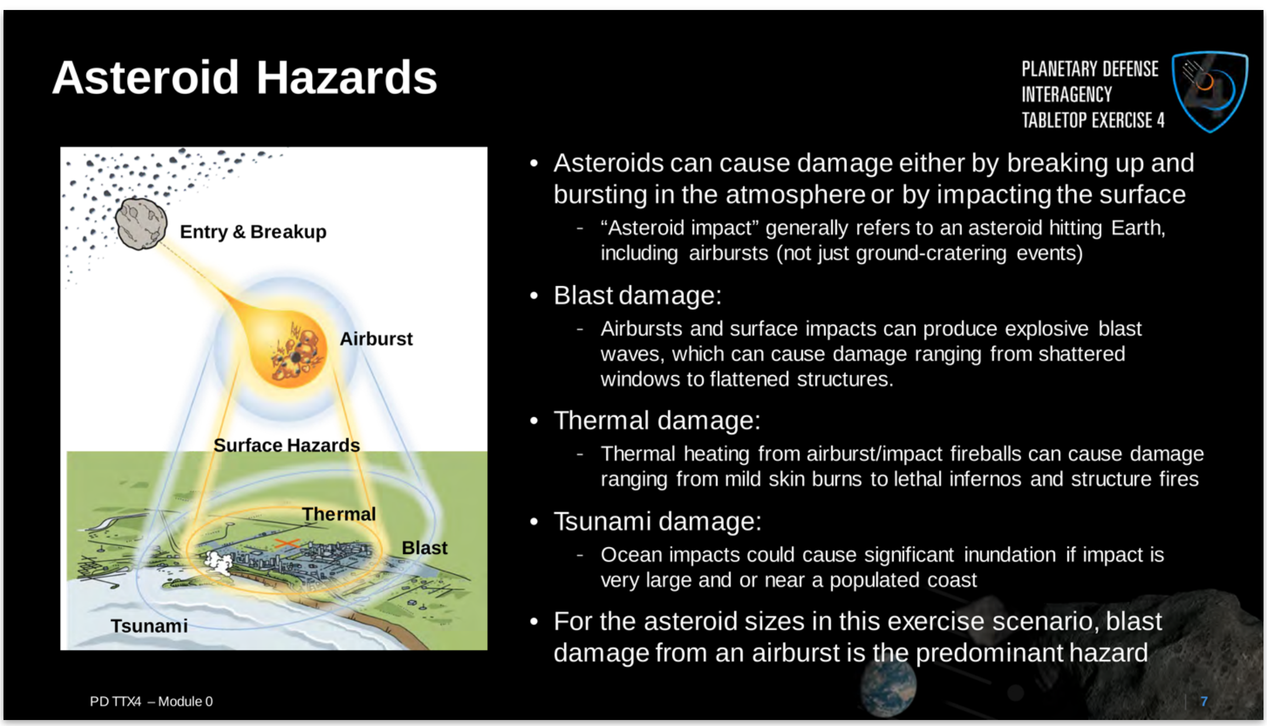

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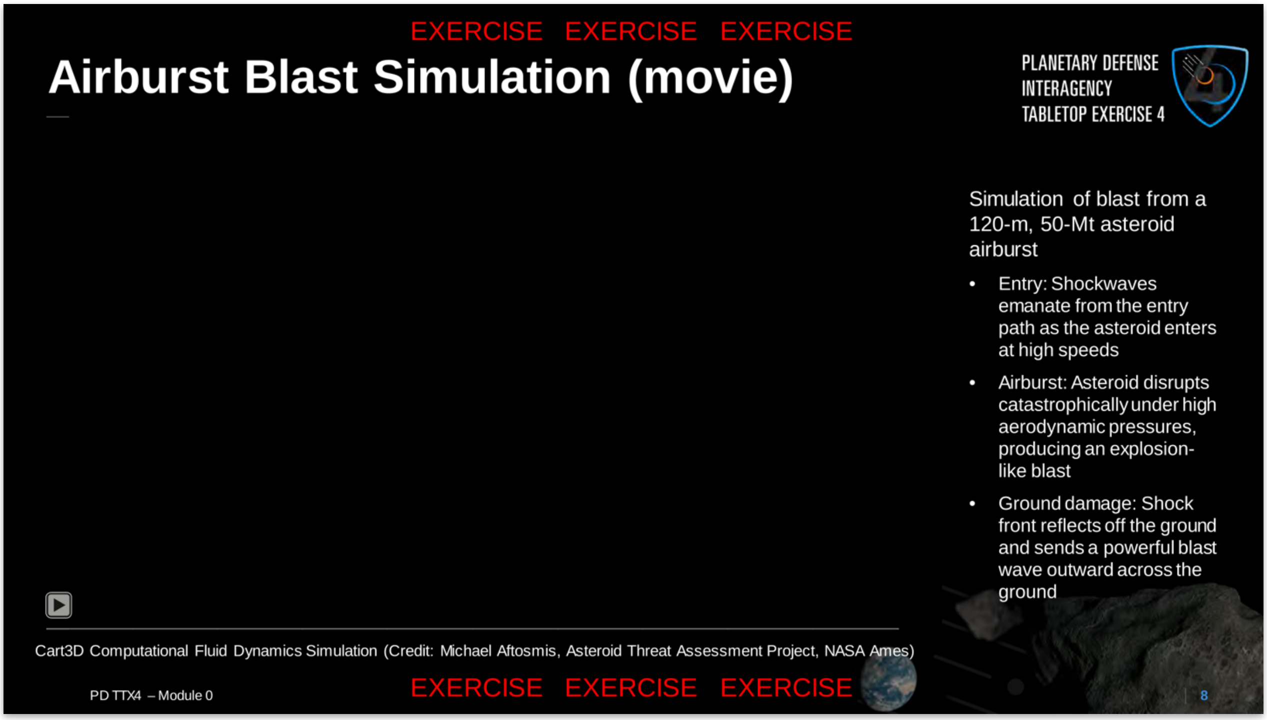

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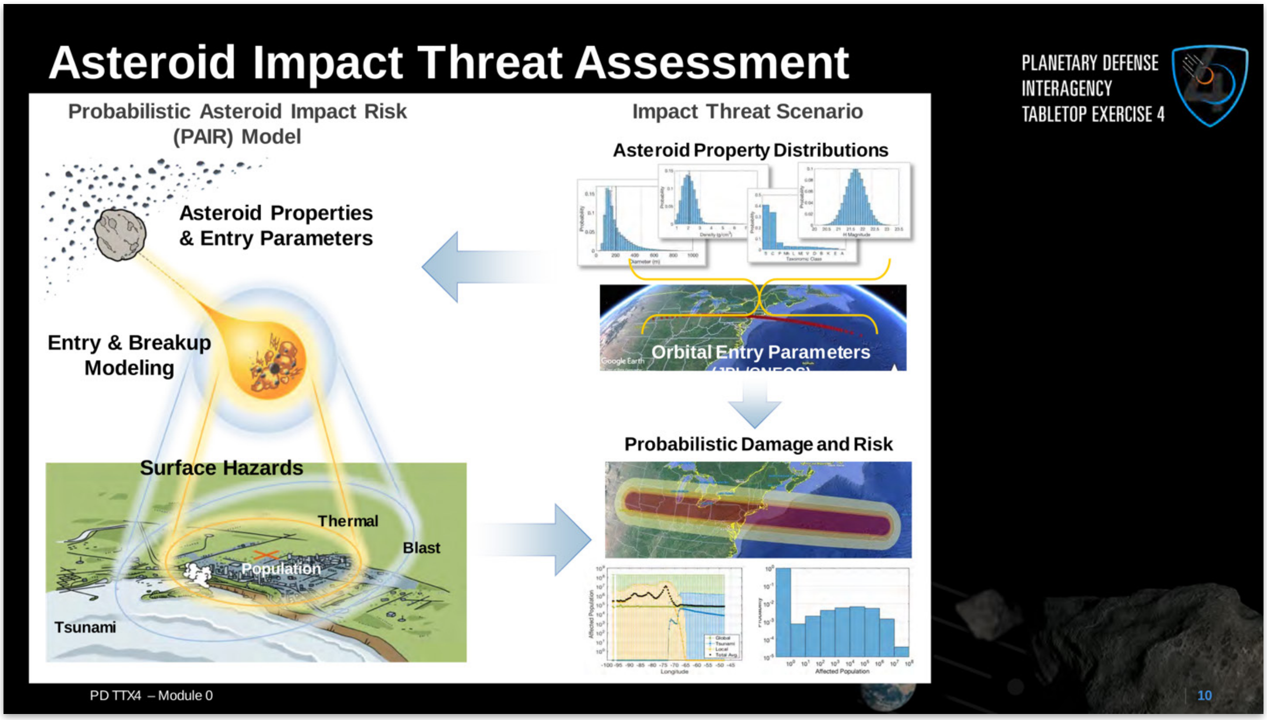
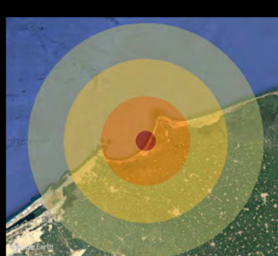


Slide 11

Local Ground Damage Severity Levels

PLANETARY DEFENSE INTERAGENCY TABLETOP EXERCISE 4

- Blast and thermal damage are assessed independently at four severity levels
  - For each damage level, the **larger** of the associated blast or thermal damage is used to determine the area and affected population for that level
  - Damage regions indicate ***either*** blast or thermal effects could exceed the given severity, ***not*** the occurrence of both effects within the entire region
- **Blast** is the predominant hazard for most asteroid sizes
  - Blast tends to be larger and more severe than the potential thermal damage in most cases
  - Blast areas usually define the larger risk regions for emergency response planning



Damage Level	Potential Blast Damage Effects	Potential Thermal Damage Effects
Serious	**Shattered windows, some structural damage**	Second-degree burns
Severe	**Widespread structural damage, doors and windows blown out**	Third-degree burns
Critical	**Most residential structures collapse**	Clothing ignition
Unsurvivable	**Complete devastation**	Structure ignition, incineration

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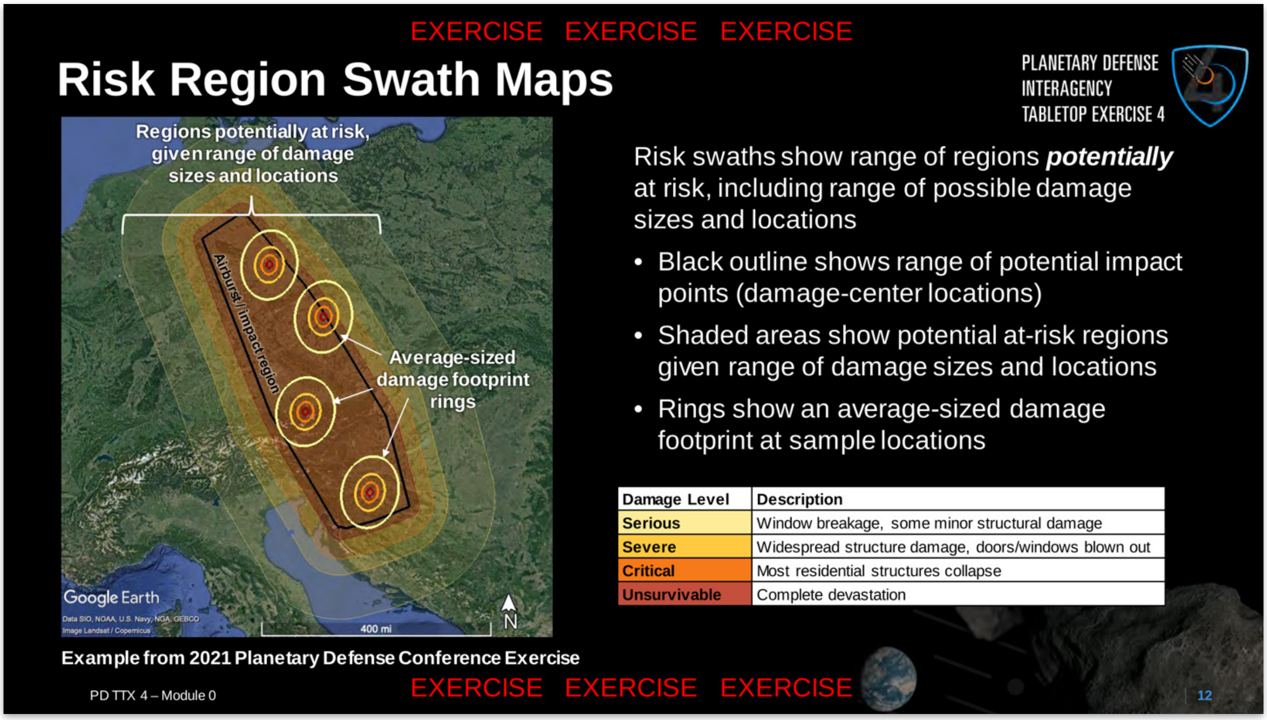
Slide 12



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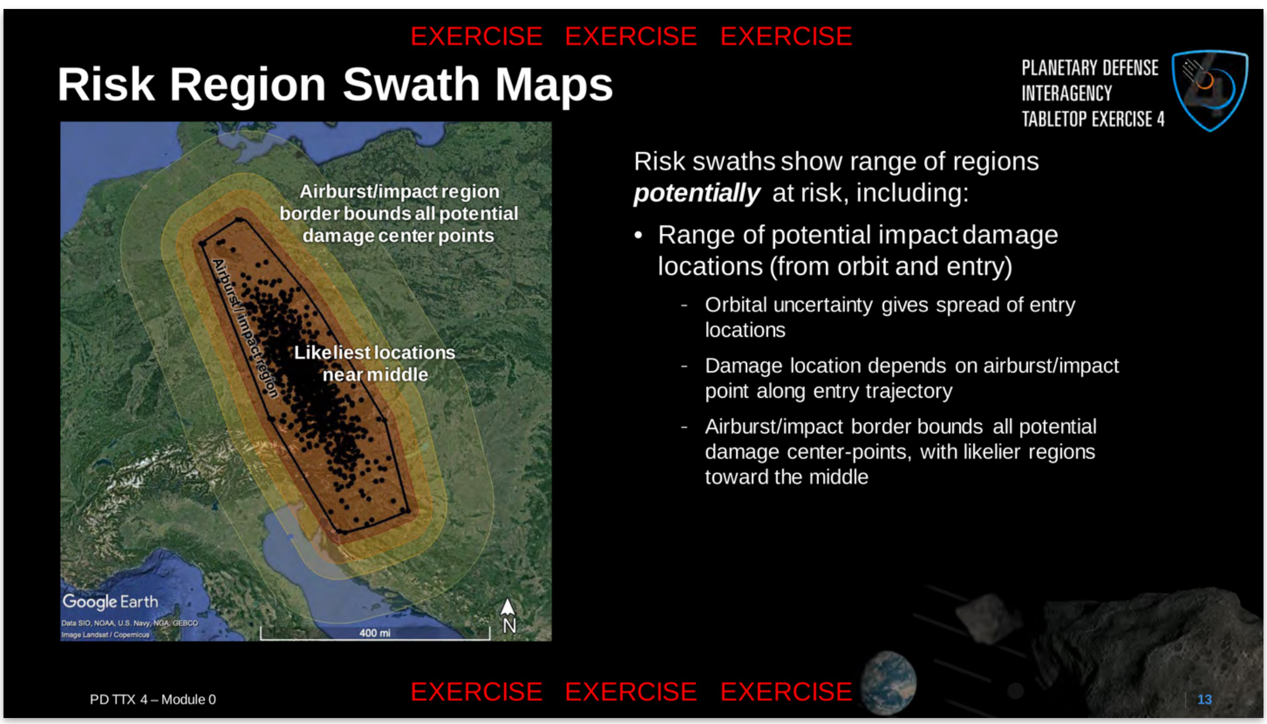

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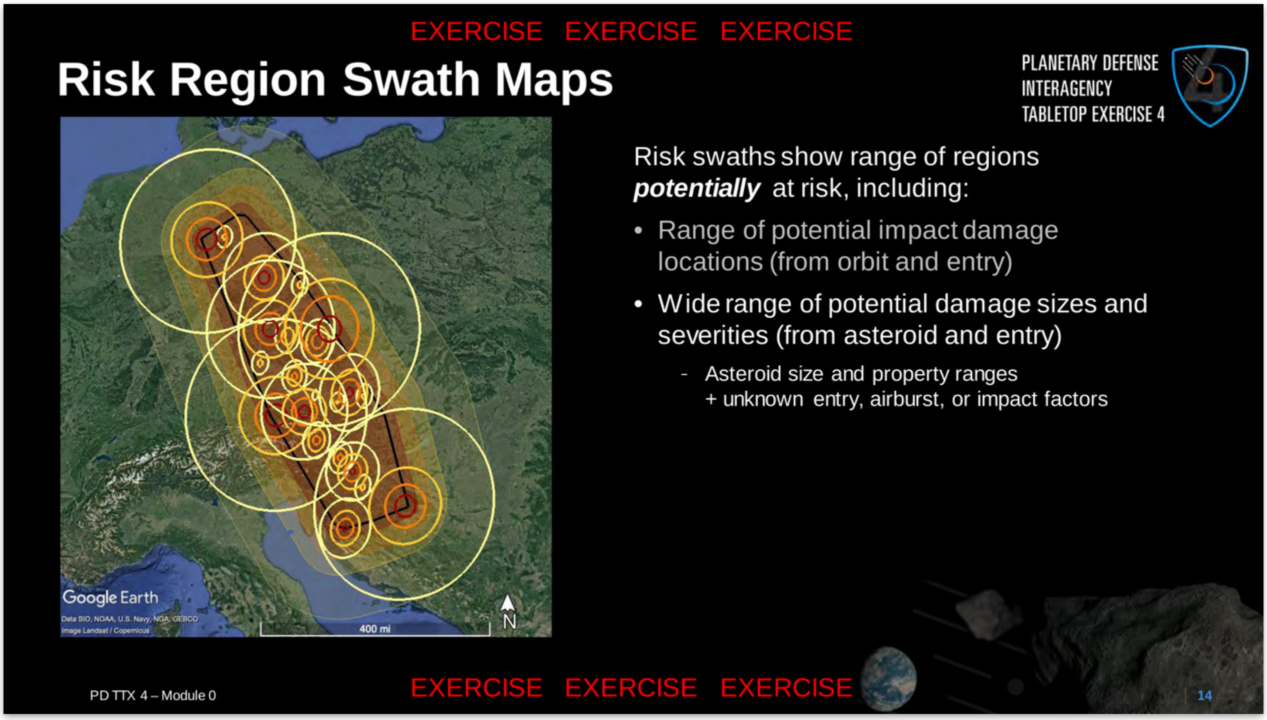

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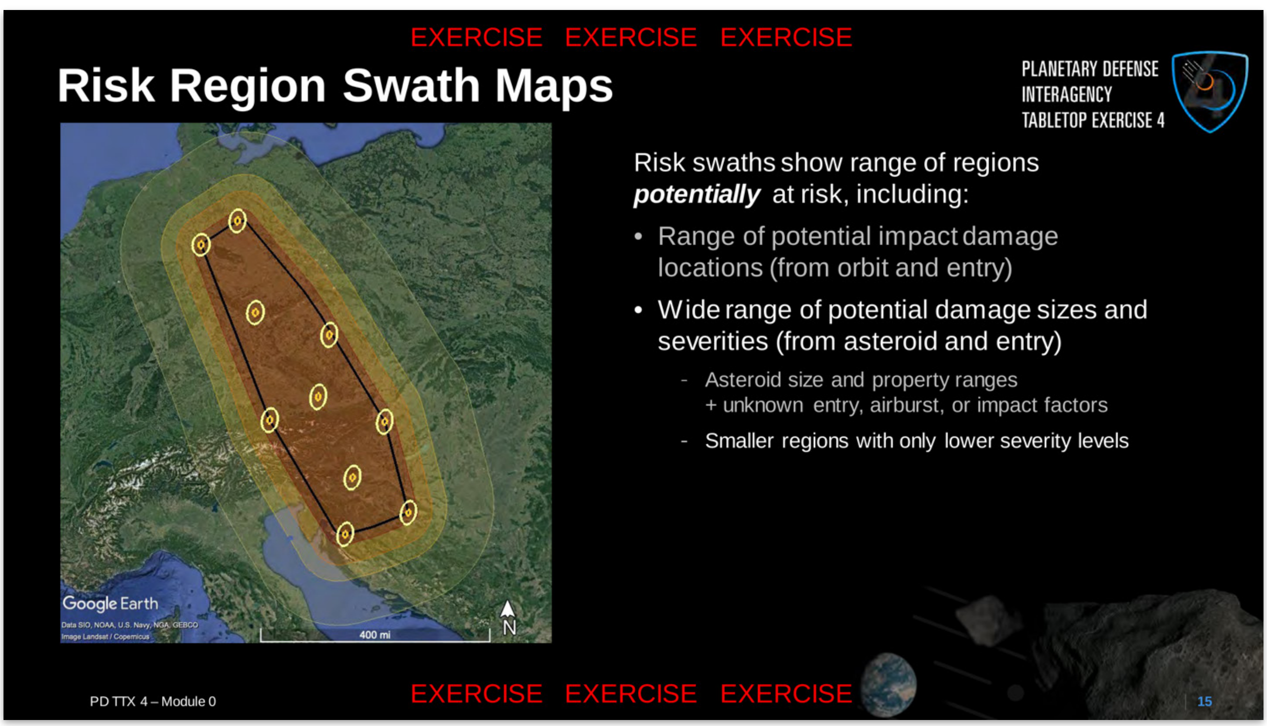

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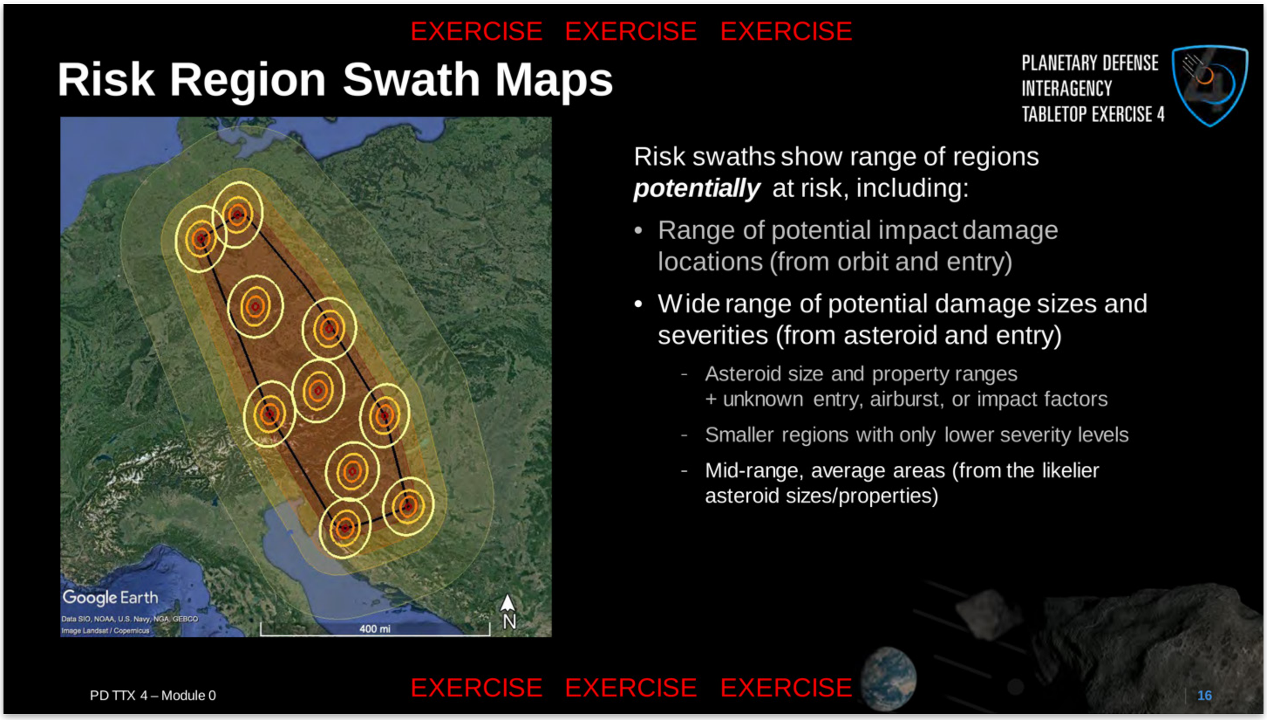

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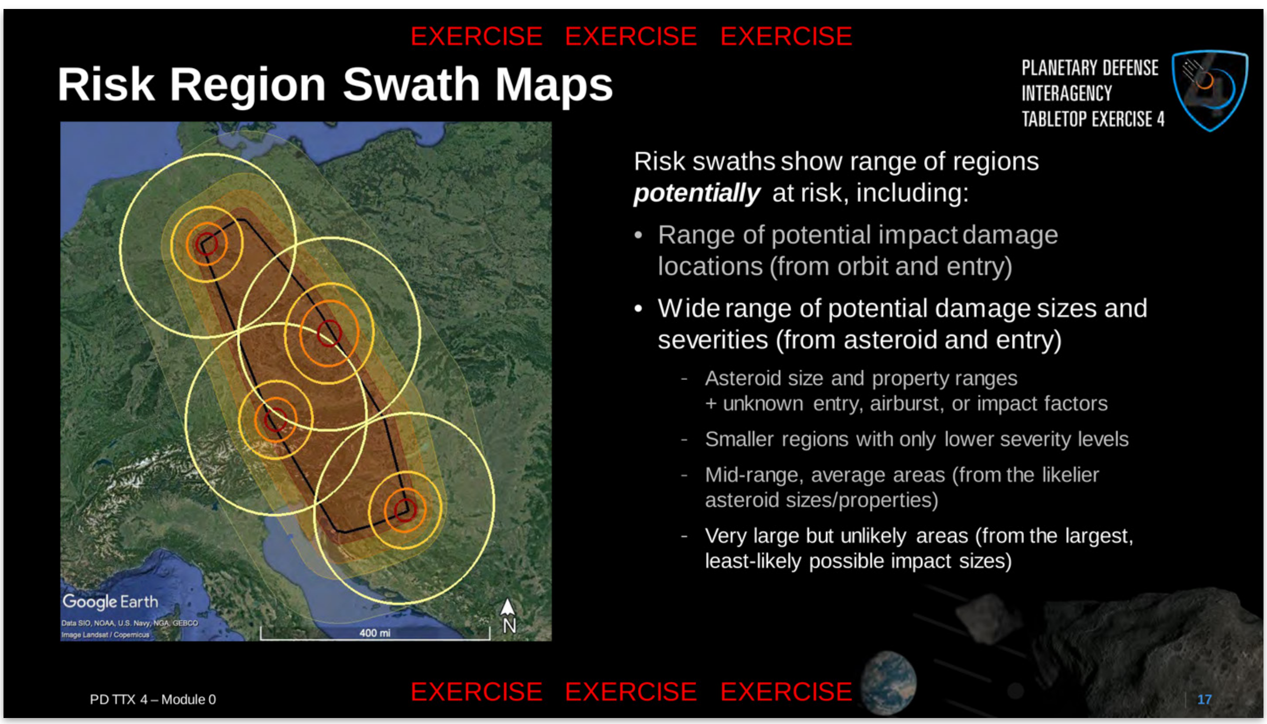

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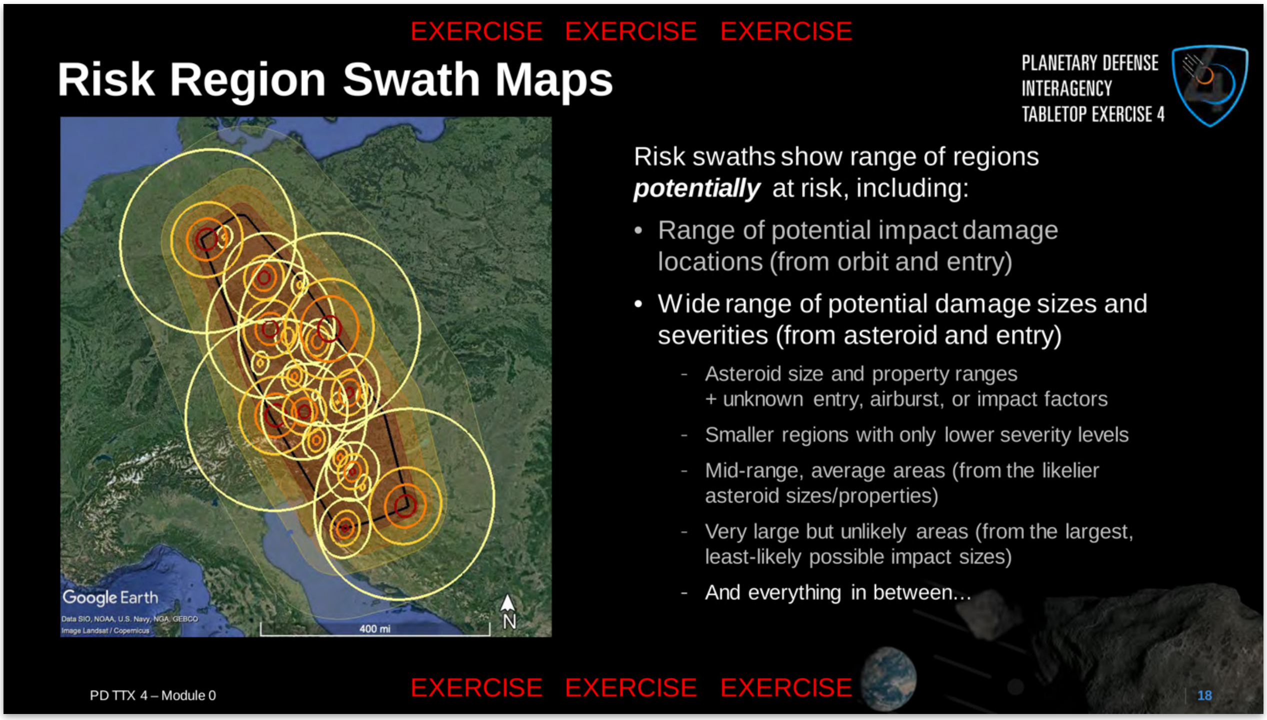

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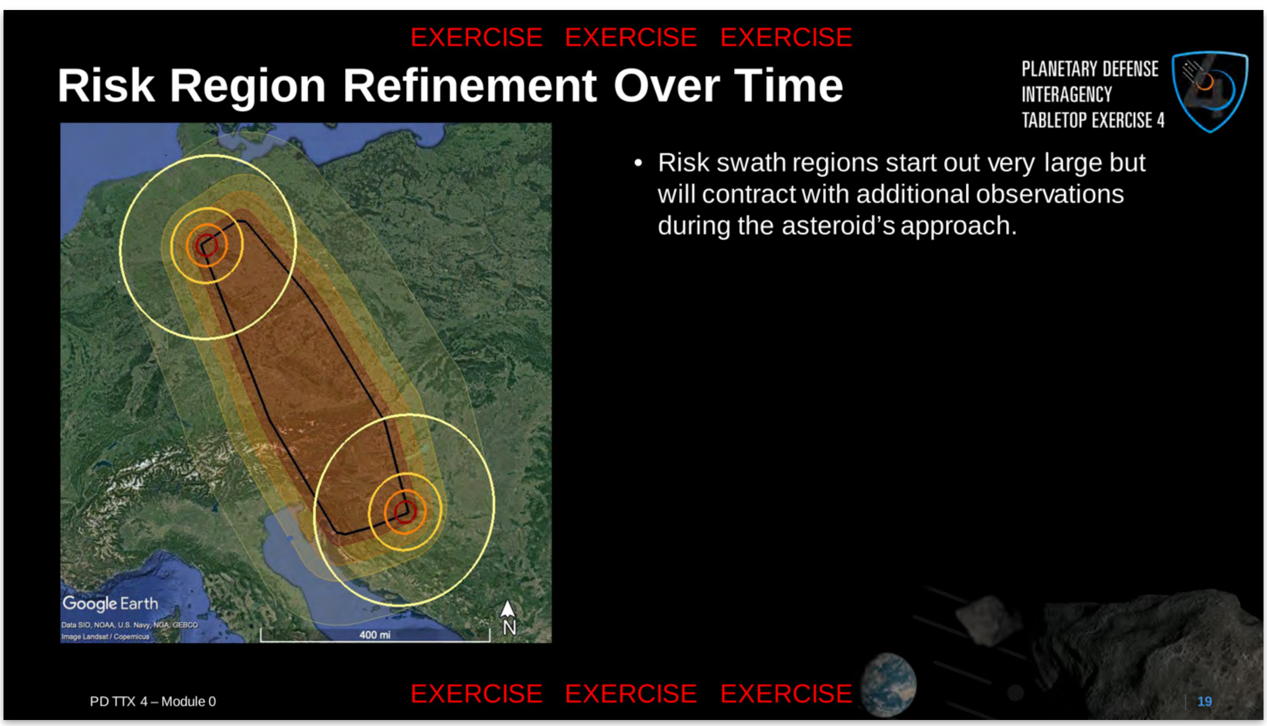

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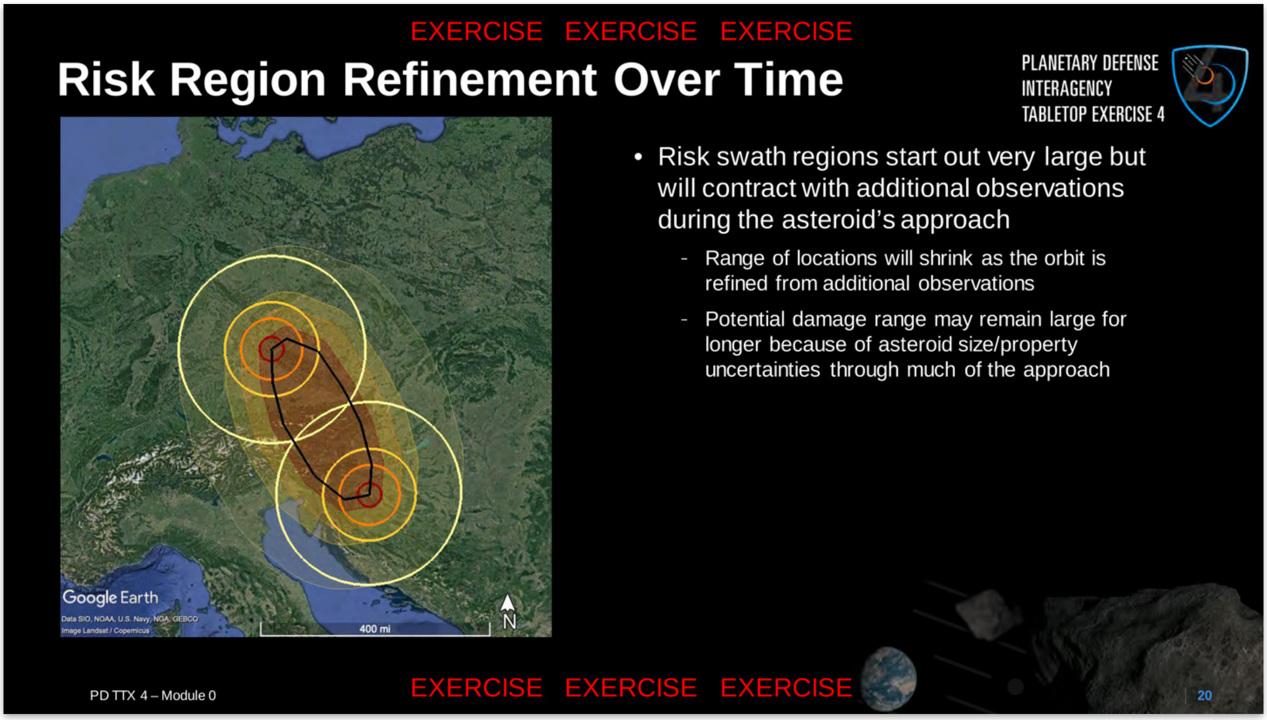

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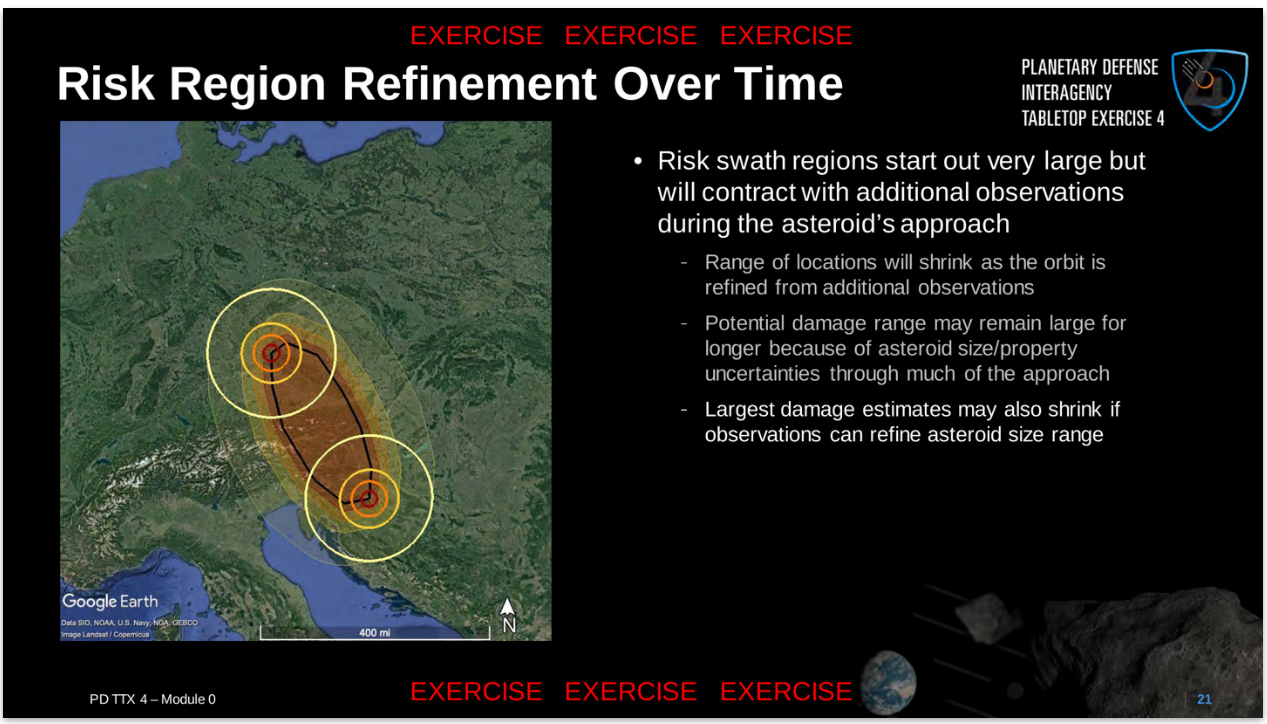

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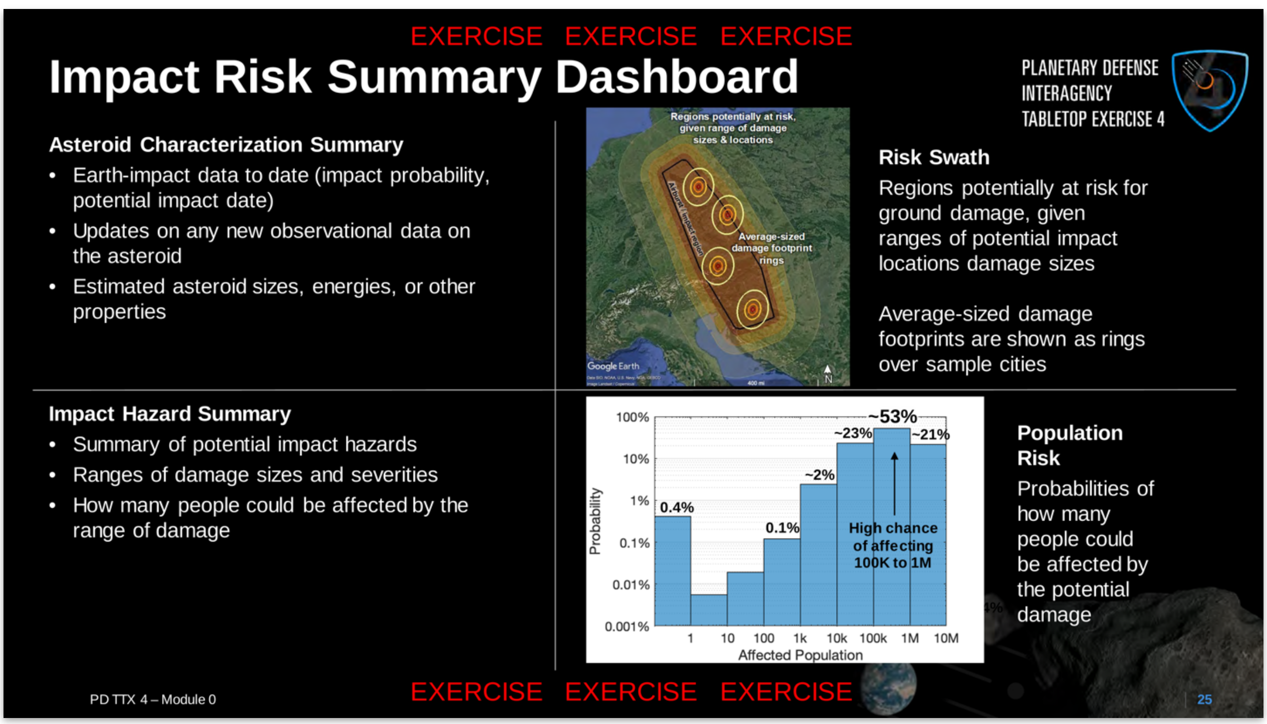

Slide 1

- Comments on slide 1
- test (#2 | Aaron Chrietzberg)

Slide 2

Planetary Defense Mission Types

PLANETARY DEFENSE
INTERAGENCY
TABLETOP EXERCISE 4

- **Reconnaissance**
  - Spacecraft collects data about the asteroid/comet (orbit, physical properties such as size, mass, etc.) and ascertains whether the object is indeed on an Earth impact trajectory.
  - A reconnaissance mission could include systems for asteroid/comet deflection or disruption, as an alternative to launching additional deflection/disruption spacecraft later. For example, a reconnaissance mission might carry a nuclear explosive device (NED) in case it is needed.
- **Deflection**
  - Spacecraft changes the asteroid/comet's speed around the Sun in a way that prevents Earth impact.
  - Deflection generally requires longer warning times than disruption.
- **Disruption**
  - Spacecraft carries an NED to the asteroid/comet that is sufficient to robustly disrupt the object.
  - Robust disruption means breaking the asteroid/comet into many small and widely scattered fragments, such that the fragments do not pose a threat to Earth's surface or orbital assets.
  - Robust disruption is possible with a short warning time, provided adequate infrastructure for rapidly launching a mission is in place.

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Slide 3

Reconnaissance Missions

PLANETARY DEFENSE
INTERAGENCY
TABLETOP EXERCISE 4

- Reconnaissance ideally precedes deflection/disruption, when circumstances permit.
- A flyby mission is usually easier to execute than a rendezvous mission, but it provides less benefit.

Y+ = Yes, Excellent Y = Yes, Good P = Partial N = No

Capability	Flyby Reconnaissance	Rendezvous Reconnaissance
Improve Asteroid Orbit Estimate	Y	Y+
Reduce Uncertainties in Asteroid Earth Impact Location	Y	Y+
Reduce Uncertainties in Asteroid Earth Impact Probability	Y	Y+
Estimate Asteroid Mass	N	Y
Observe Asteroid Shape	P	Y+
Estimate Asteroid Size	P	Y+
Estimate Asteroid Rotation State	P	Y+
Observe Asteroid Composition and Other Details	P	Y+
Carry Along Asteroid Deflection Mechanism	Y	Y
Continue Monitoring Asteroid After Deflection Attempt	N	Y

PD TTX 4 – Module 0 3

Slide 4

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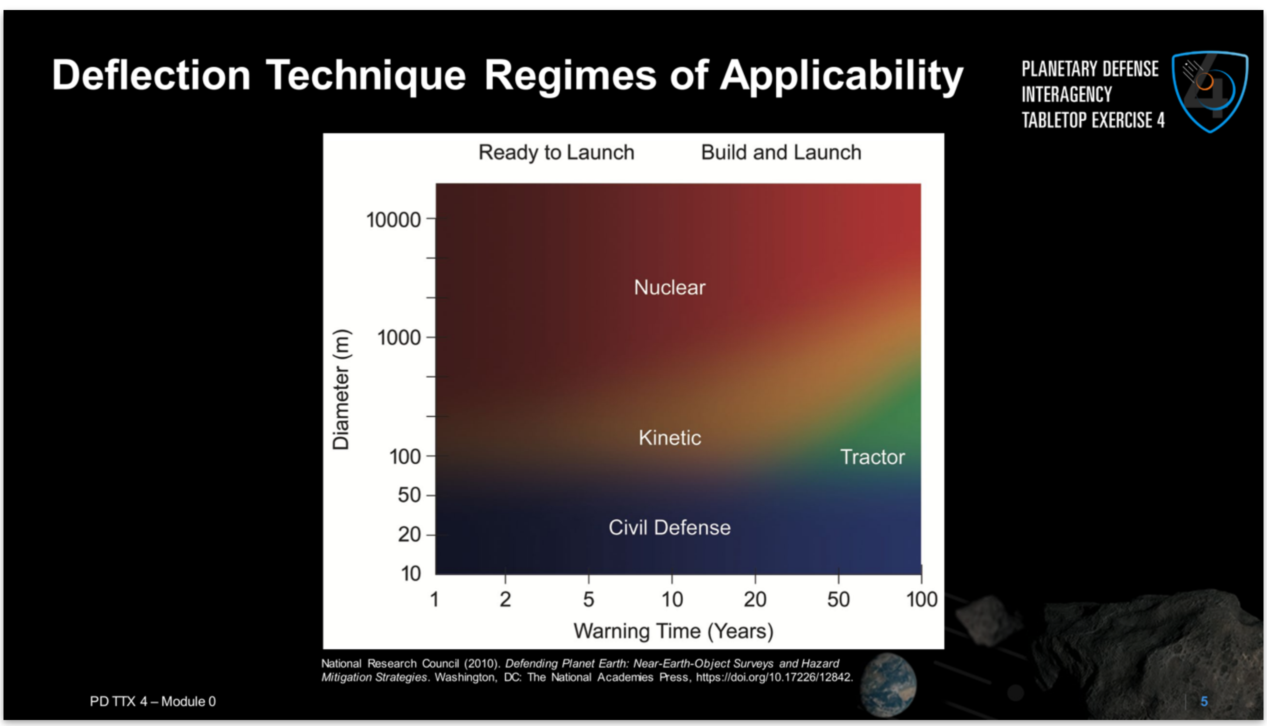

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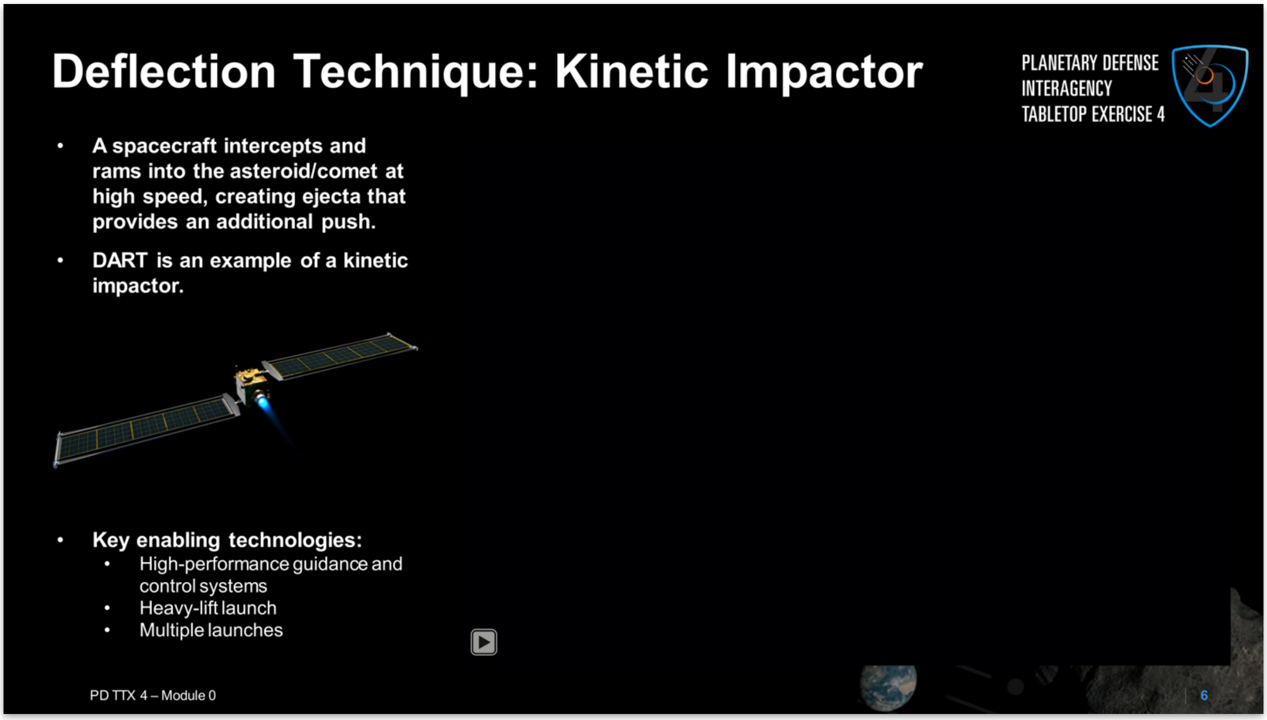

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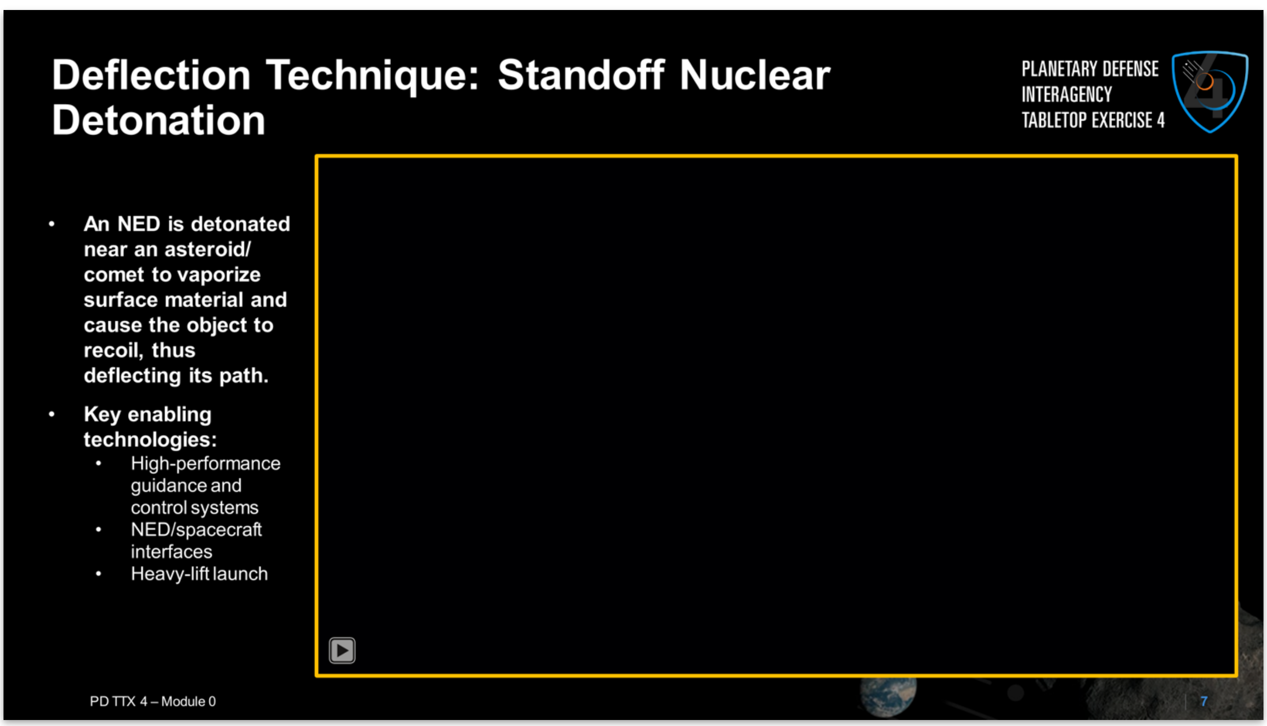


Slide 8

Disruption Technique: Standoff Nuclear Detonation

PLANETARY DEFENSE INTERAGENCY TABLETOP EXERCISE 4

- **The NED yield and detonation distance are chosen to create a strong shock that breaks the object up into small and widely scattered fragments.**
- **Key enabling technologies:**
    - High-performance guidance and control systems
    - NED/spacecraft interfaces
    - Heavy-lift launch

PD TTX 4 – Module 0 | 8

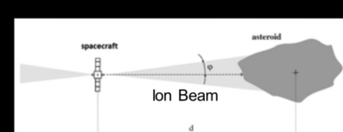
Slide 9

Other Deflection Techniques

PLANETARY DEFENSE INTERAGENCY TABLETOP EXERCISE 4

- **Gravity Tractor**
    - A rendezvoused spacecraft station-keeps near the asteroid/comet so that the spacecraft's gravity gradually nudges the object over time.
        - *Key enabling technologies: high-efficiency solar electric propulsion systems, heavy-lift launch, multiple launches*
- **Enhanced Gravity Tractor**
    - A rendezvoused spacecraft collects a substantial mass from the asteroid/comet (e.g., a boulder) to increase the spacecraft's gravity before it begins station-keeping as a gravity tractor. This allows the spacecraft to deflect the asteroid more quickly than it would otherwise, but it requires more propellant and is still a gradual process.
        - *Key enabling technologies: high-efficiency solar electric propulsion systems, heavy-lift launch, multiple launches, advanced robotics*
- **Ion Beam Deflection**
    - A rendezvoused spacecraft station-keeps near the asteroid/comet and aims its ion thruster exhaust at the object to gradually nudge it over time.
        - *Key enabling technologies: high-efficiency solar electric propulsion systems, heavy-lift launch, multiple launches*

Gravity Tractor



Ion Beam

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Slide 10

Rendezvous vs. Intercept/Flyby

PLANETARY DEFENSE INTERAGENCY TABLETOP EXERCISE 4

- **Rendezvous:** The spacecraft expends propellant to stop at the asteroid/comet and remain there.
- **Flyby/Intercept:** The spacecraft approaches the asteroid/comet at high relative speed and passes by it rapidly or hits it.
- Some kinds of missions require rendezvous, while some require intercept.
- Some kinds of missions can be either rendezvous or intercept.
- Intercept mission opportunities are often available earlier in the scenario timeline (and more frequently) than rendezvous mission opportunities (if any).
- Rendezvous is generally preferred when possible (except for kinetic impactors, of course).

Mission Type	Rendezvous	Flyby/Intercept	Rapid Response (less than 5 years of warning)
Reconnaissance	✓	✓	✓
Kinetic Impactor Deflection		✓	?
NED Deflection	✓	✓	✓
NED Disruption	✓	✓	✓
Gravity Tractor/Ion Beam	✓		

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Slide 11

Launch Considerations

PLANETARY DEFENSE INTERAGENCY TABLETOP EXERCISE 4

- Launch vehicle availability will likely be a challenge during rapid response scenarios (e.g., <1 year of warning).
- Multiple launches may be required to deliver sufficient mass for deflection or disruption.
- Additional launches may be desired for redundancy.
- Additional interfaces and protocols would be needed if launching an NED.

DART Launch
November 24, 2021
Image credit: NASA HQ

PD TTX 4 – Module 0 11

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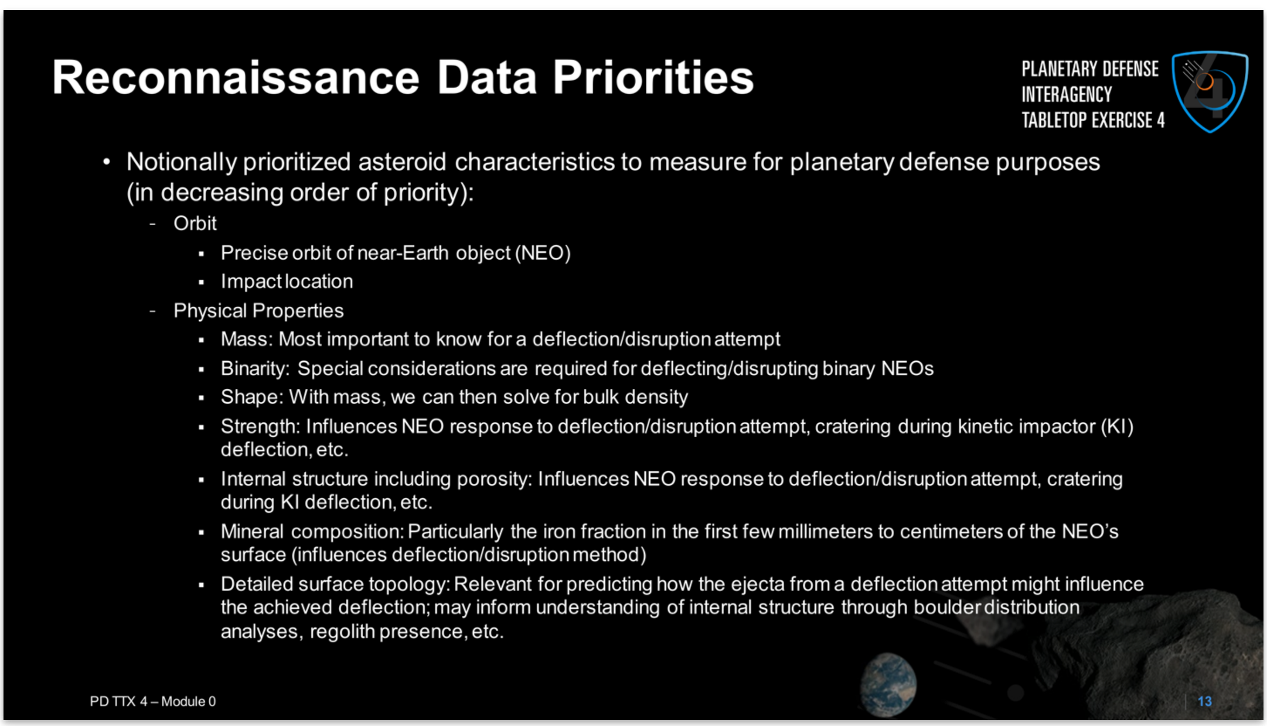

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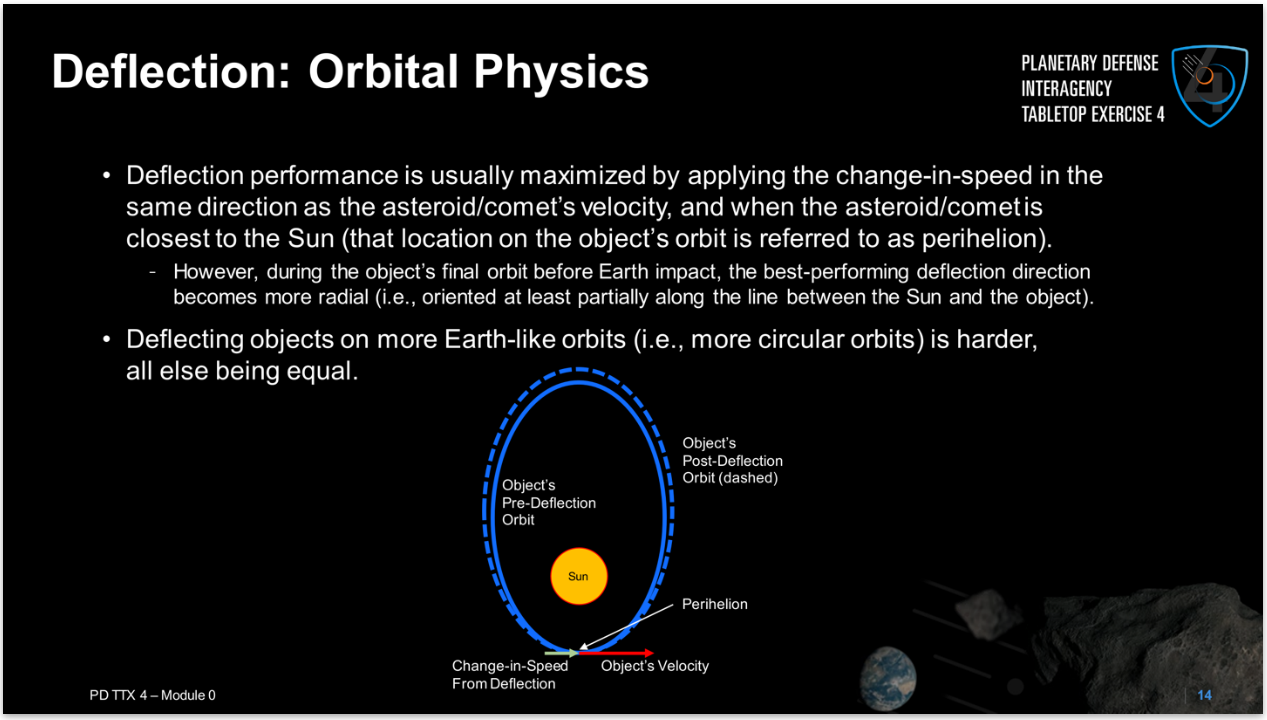

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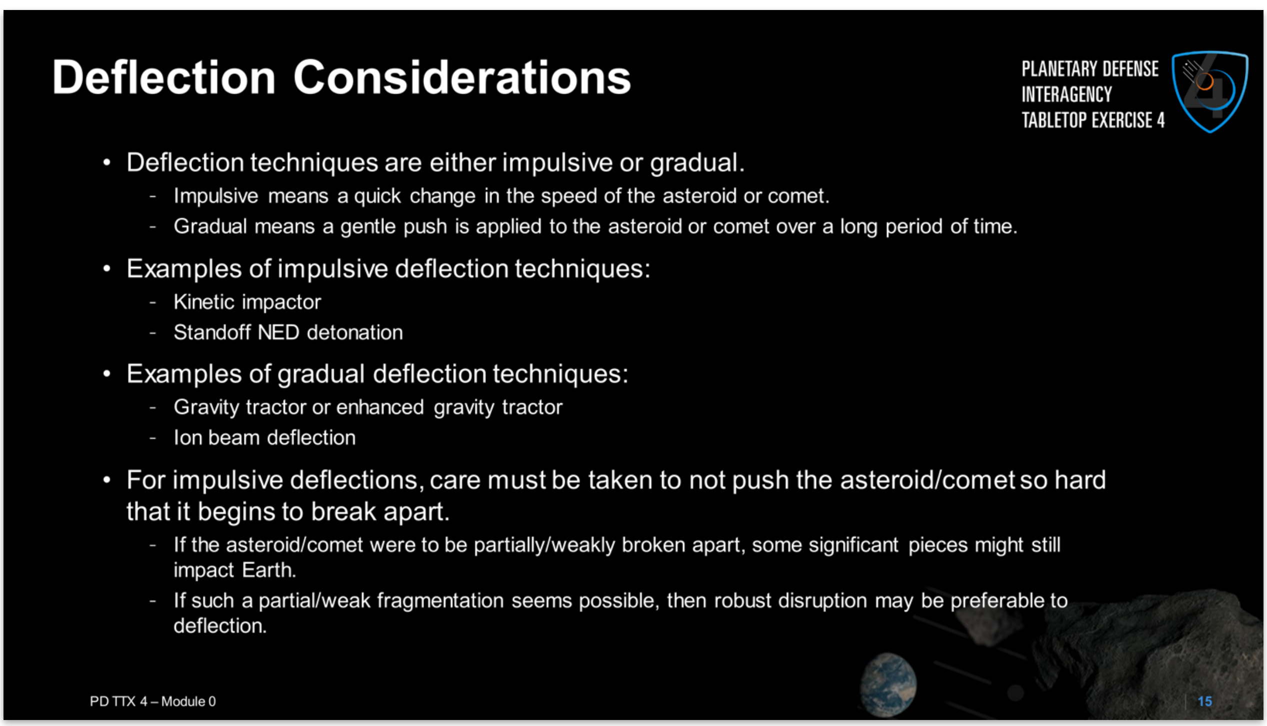

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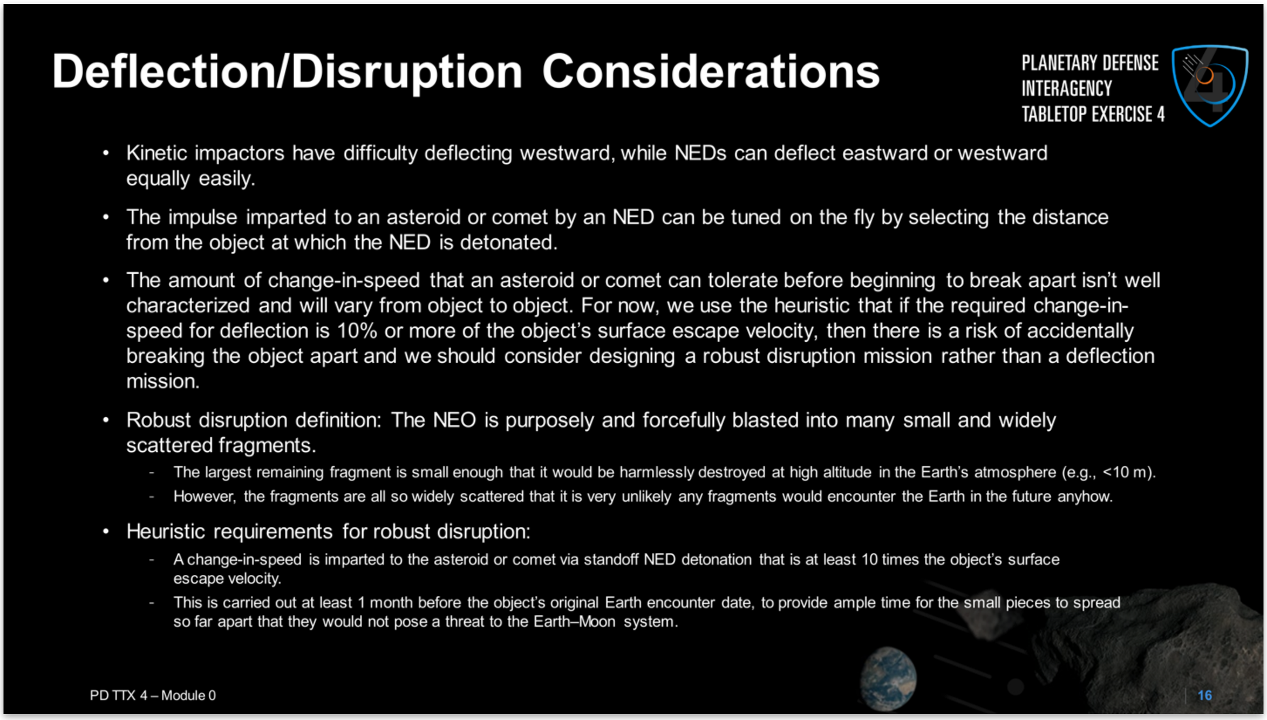

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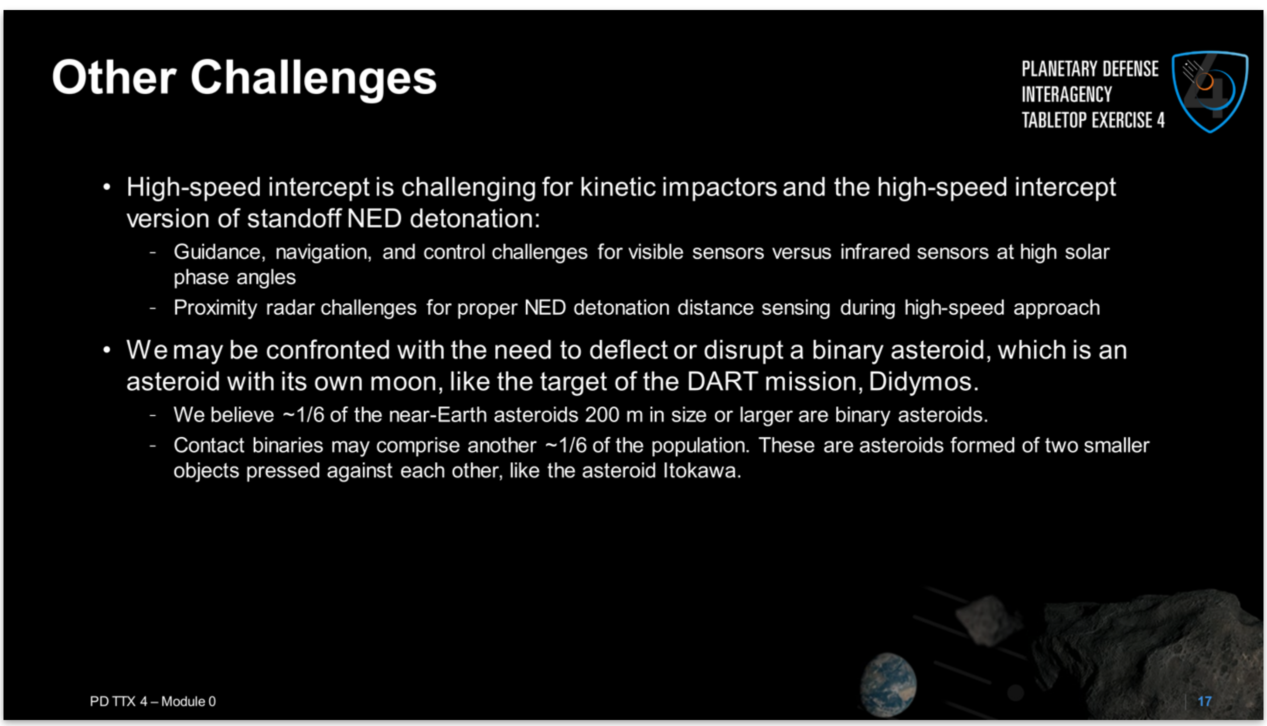

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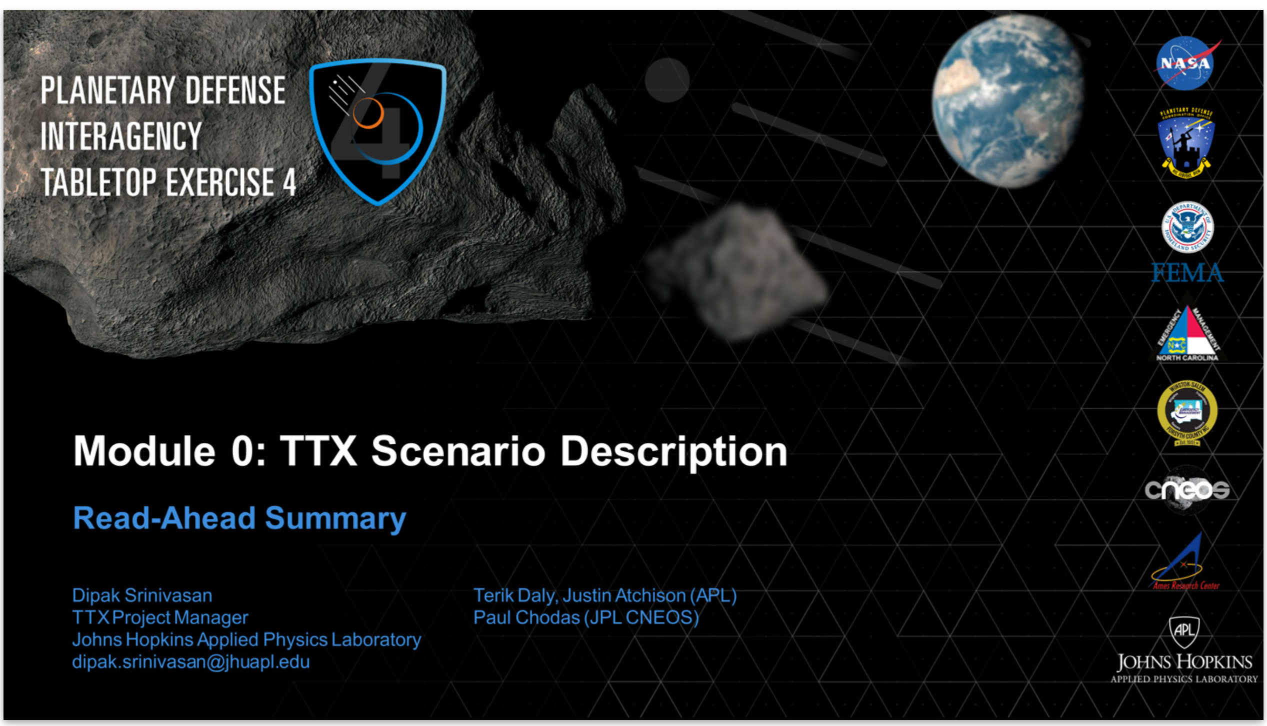

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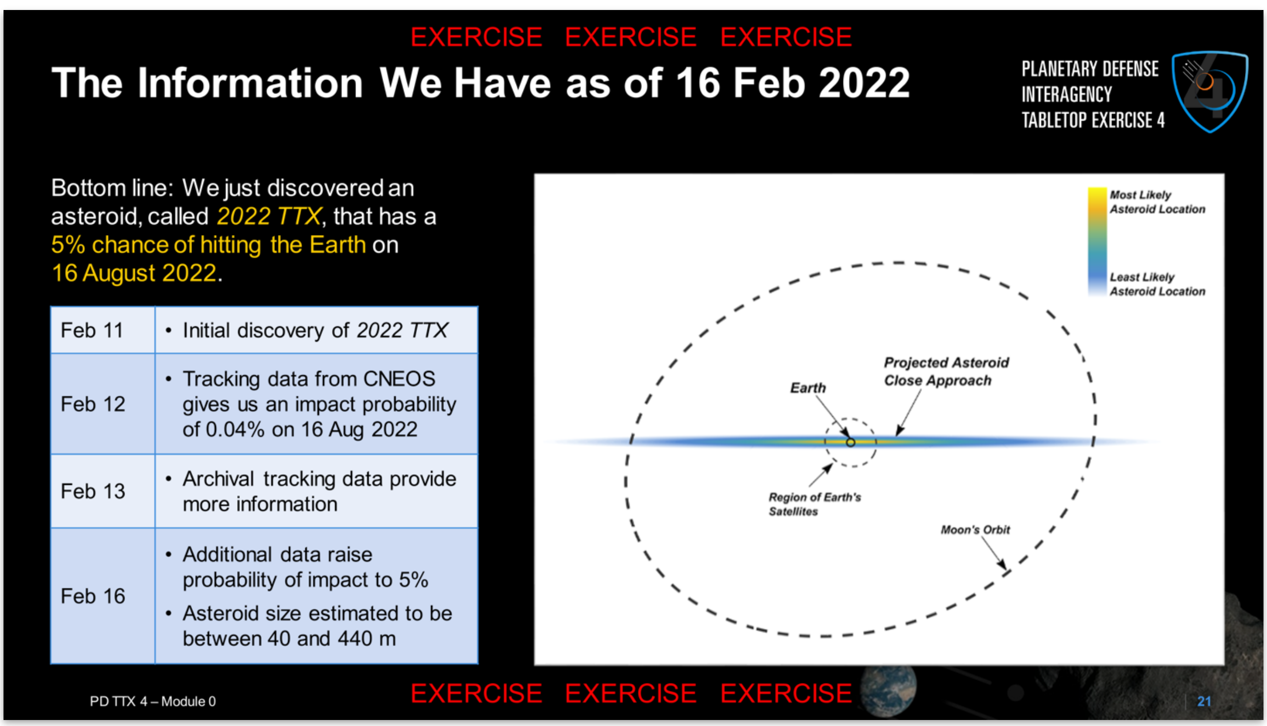

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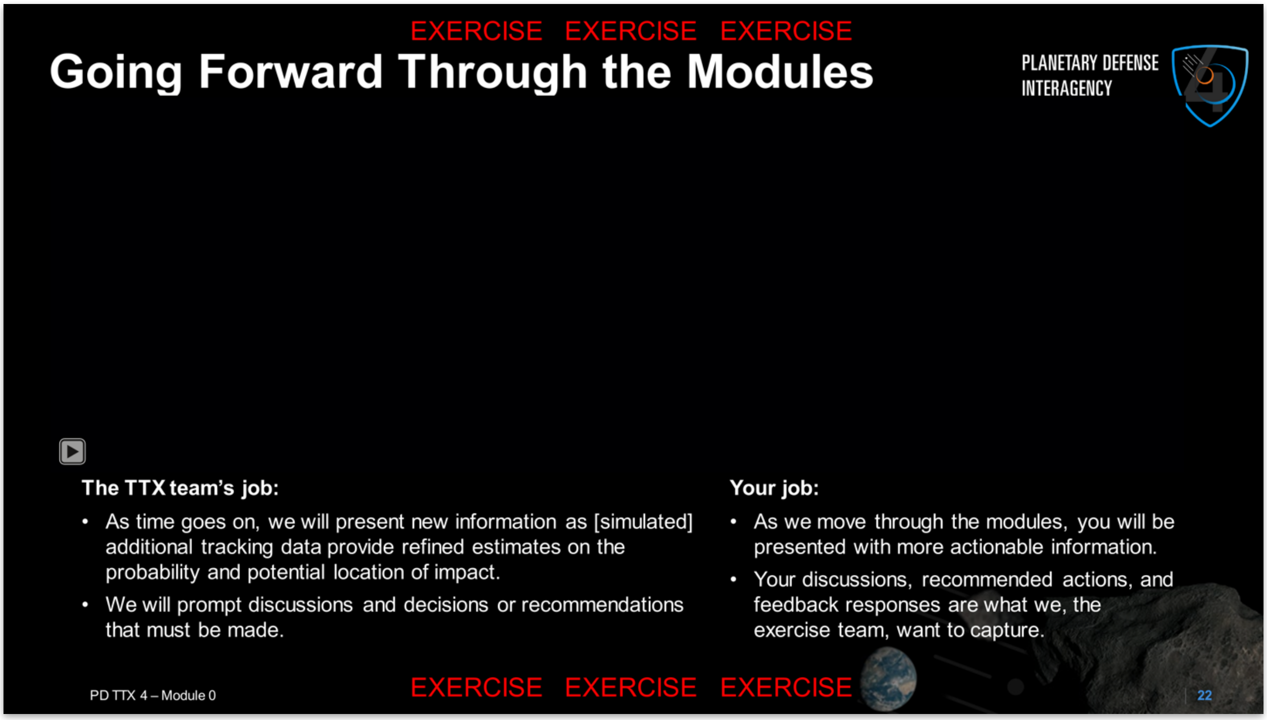

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C.4 Module 1

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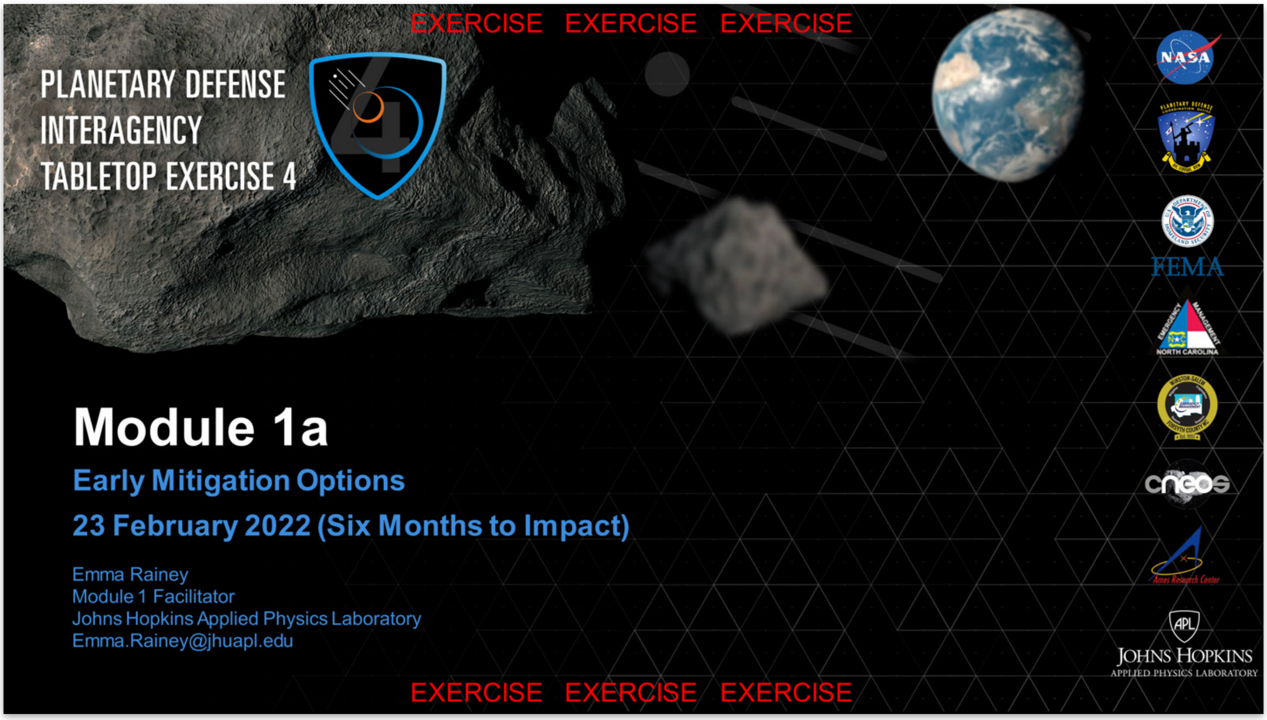

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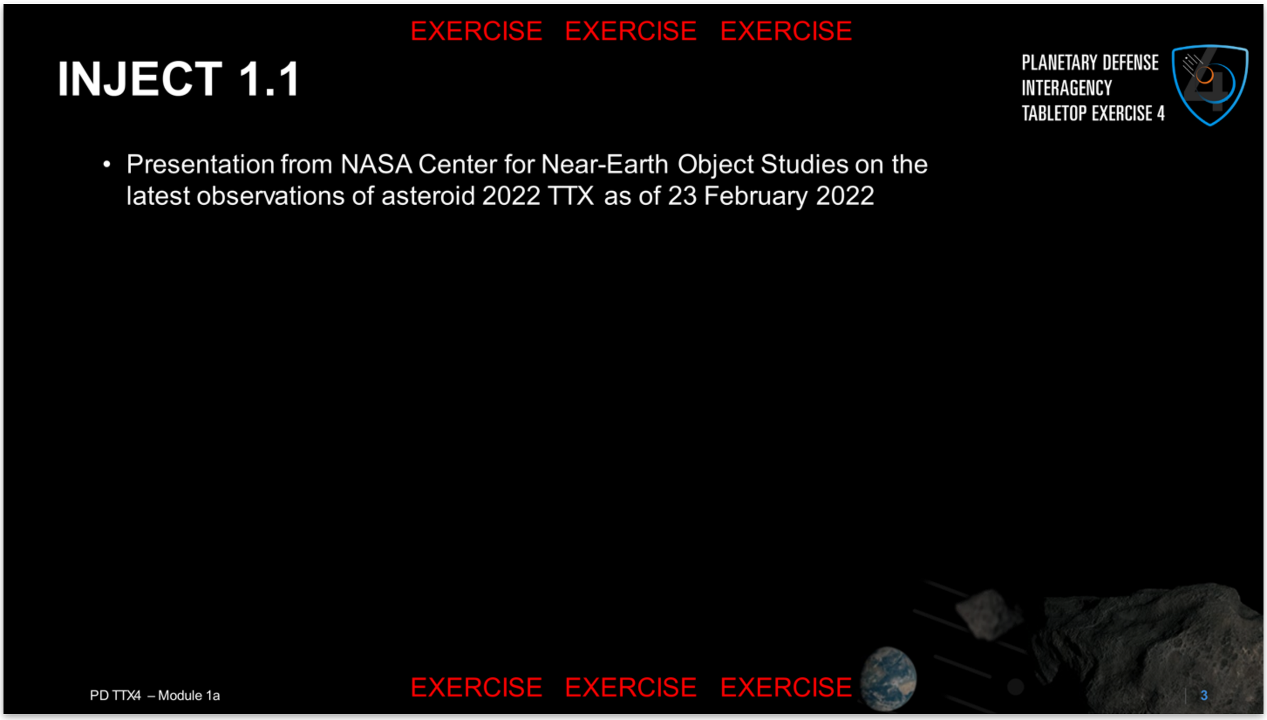

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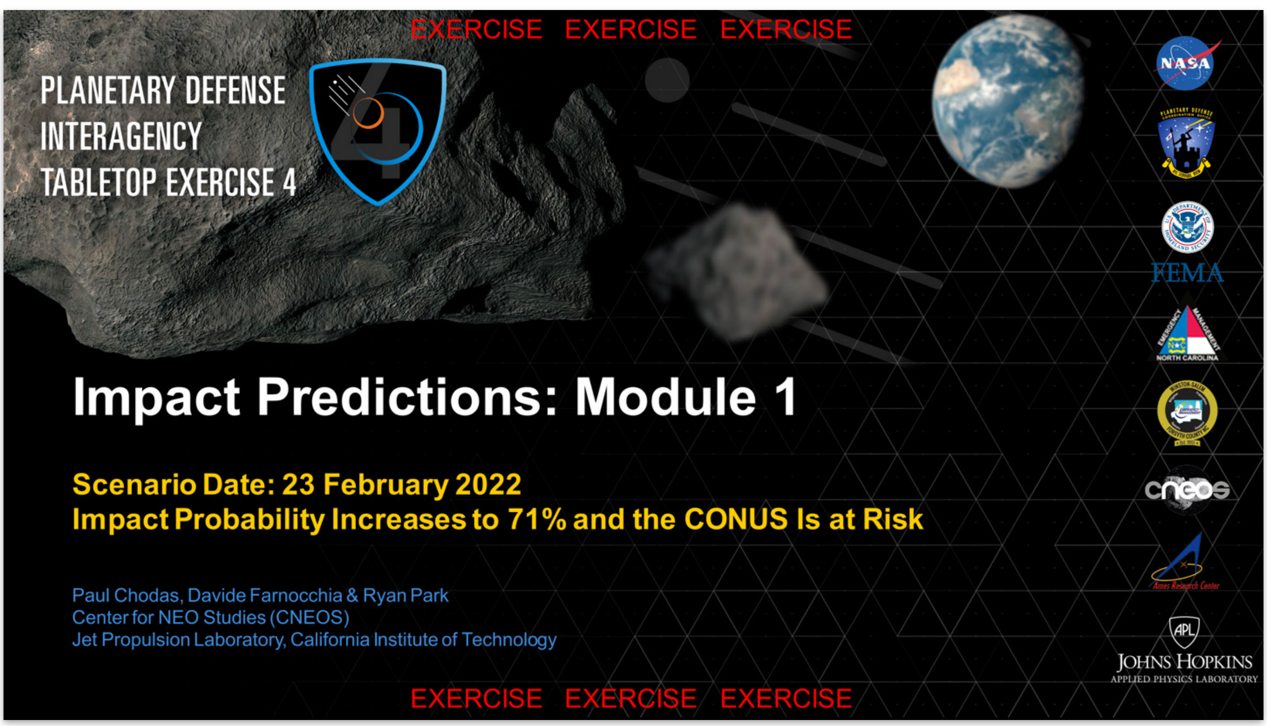

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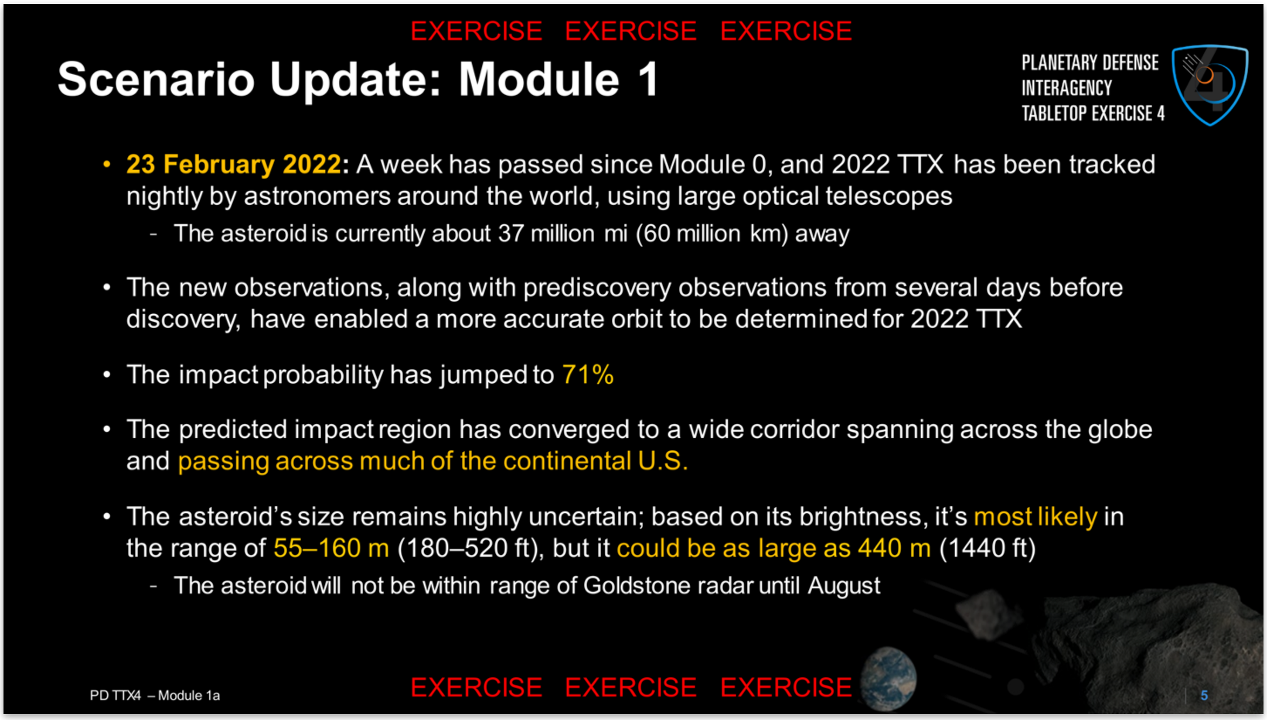

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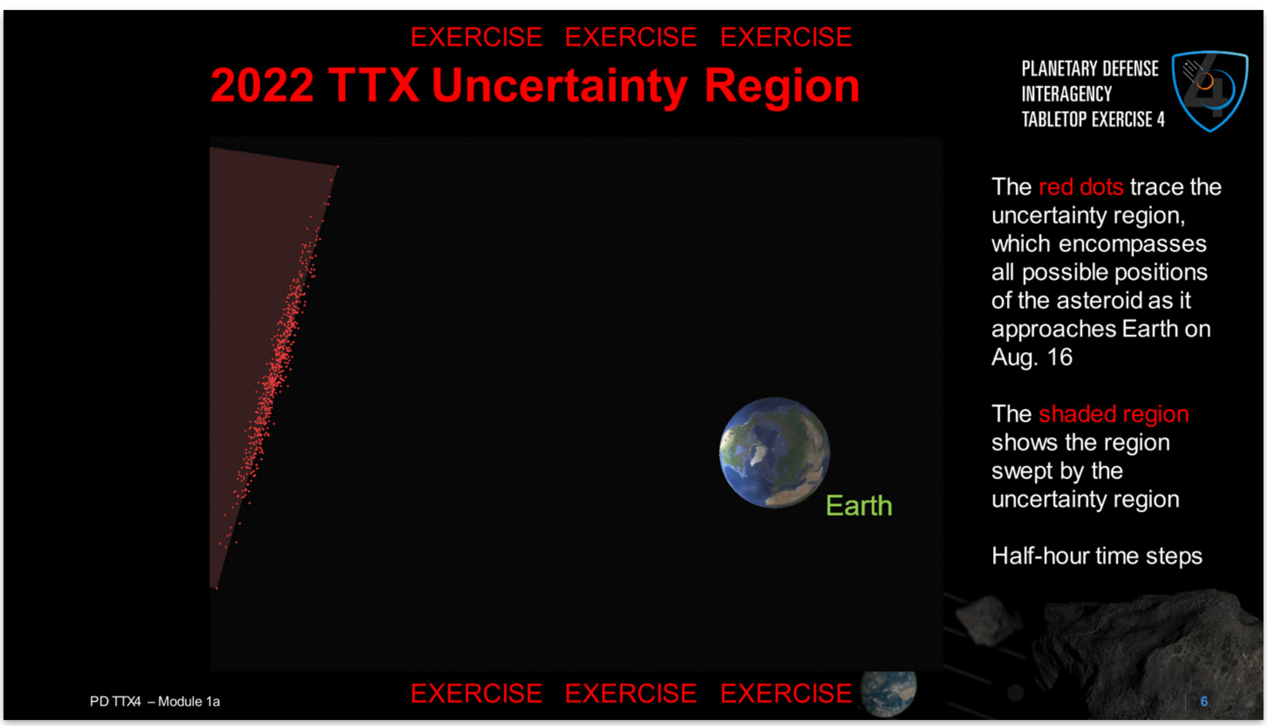

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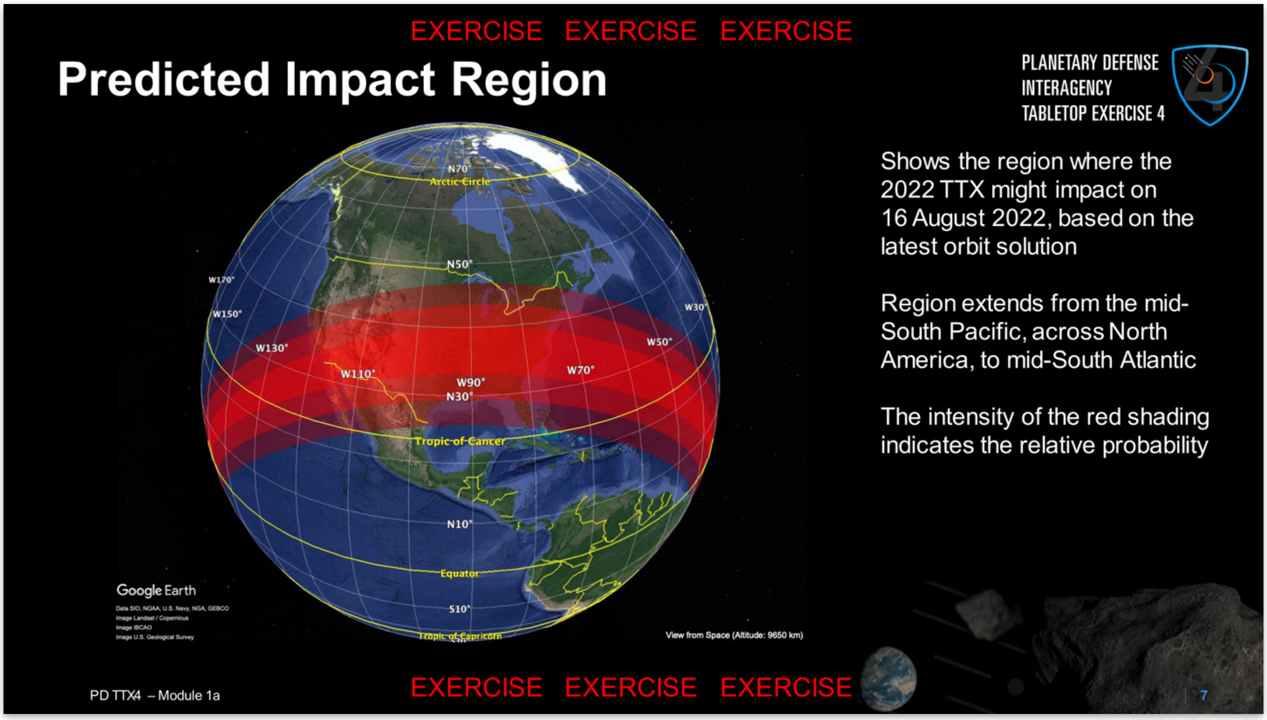

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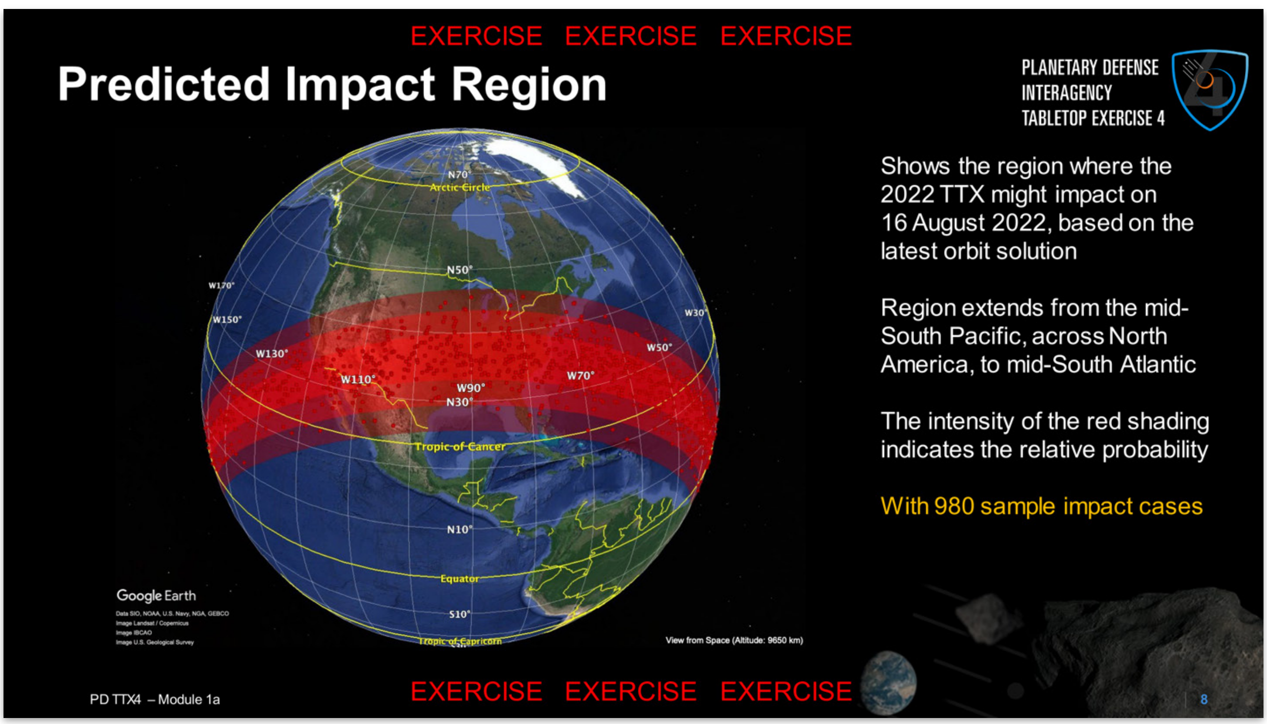

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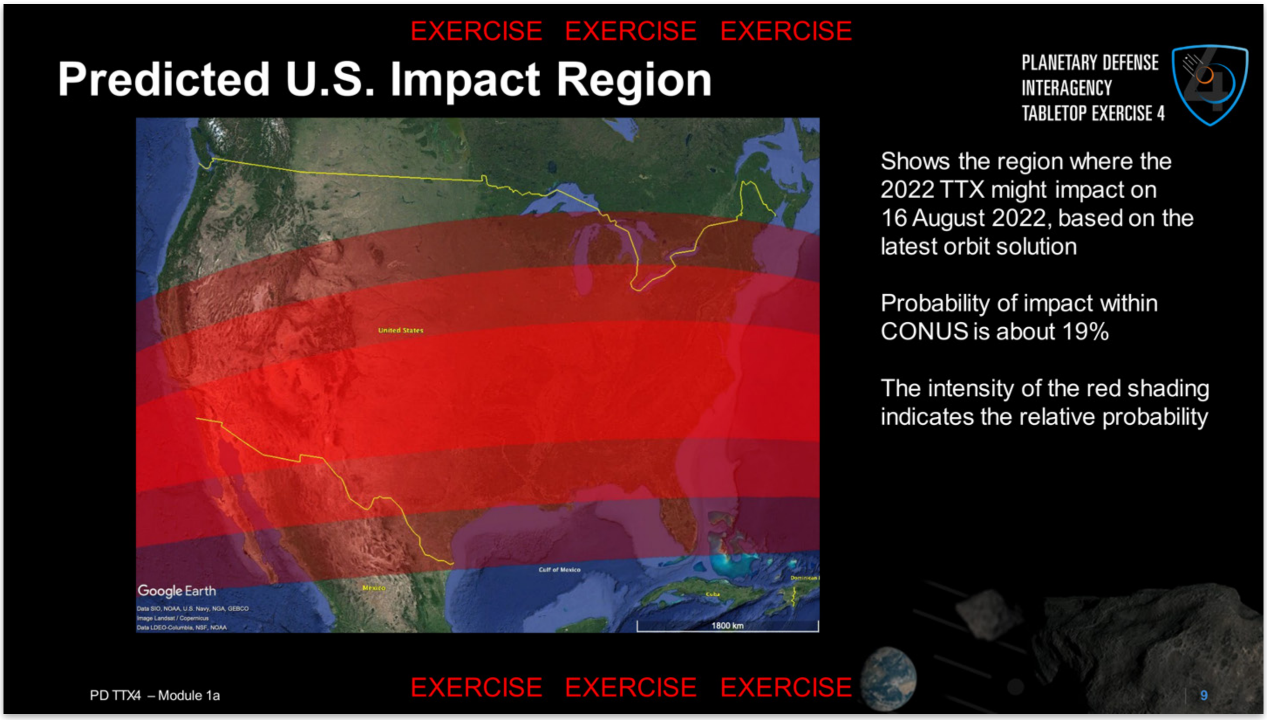

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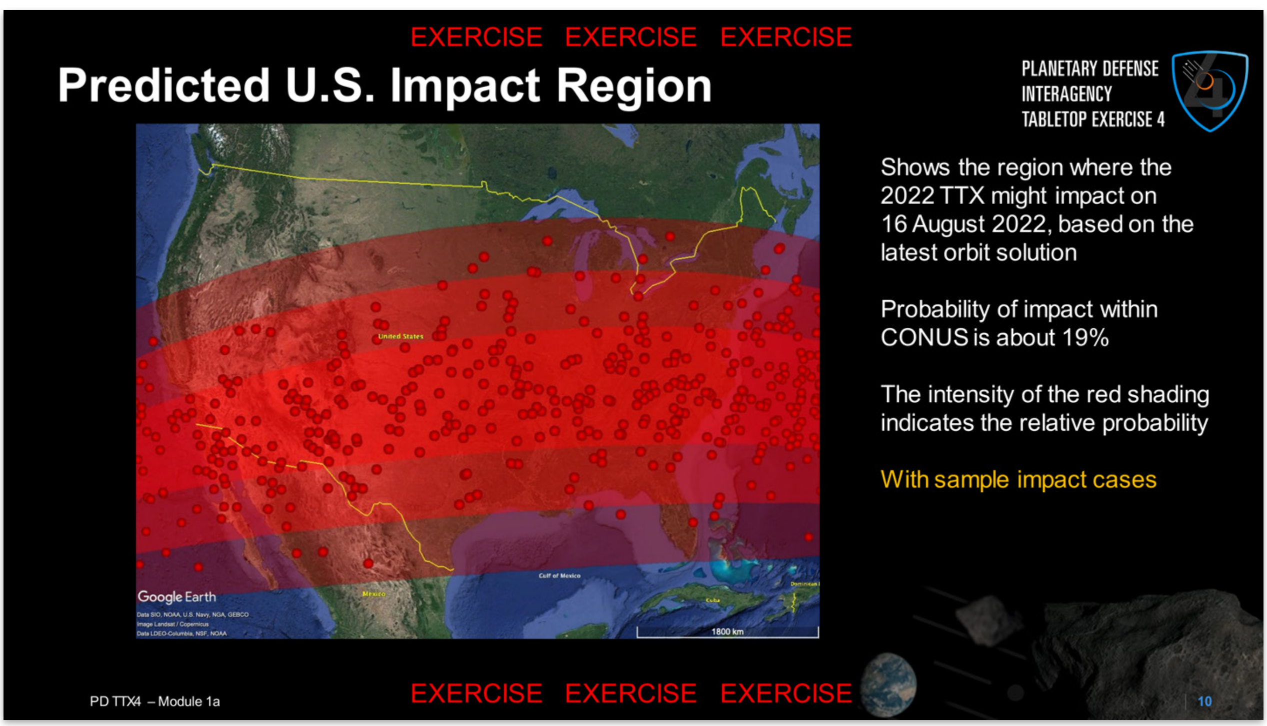

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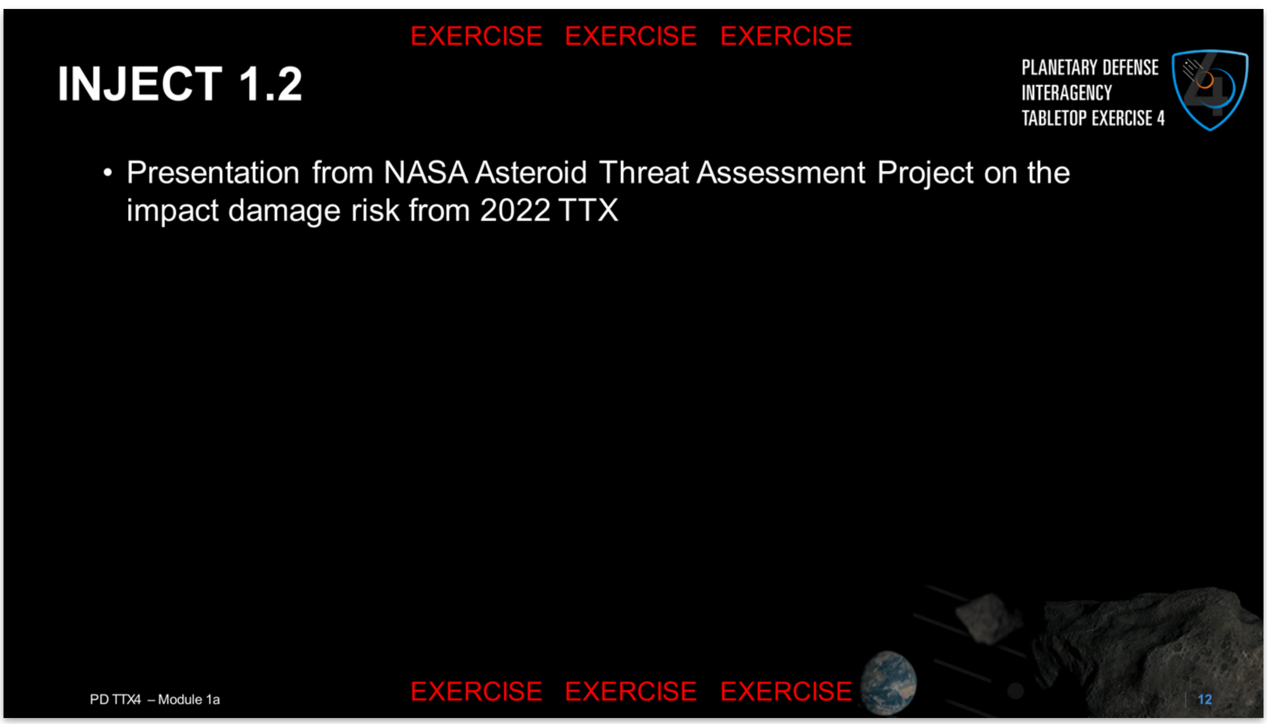

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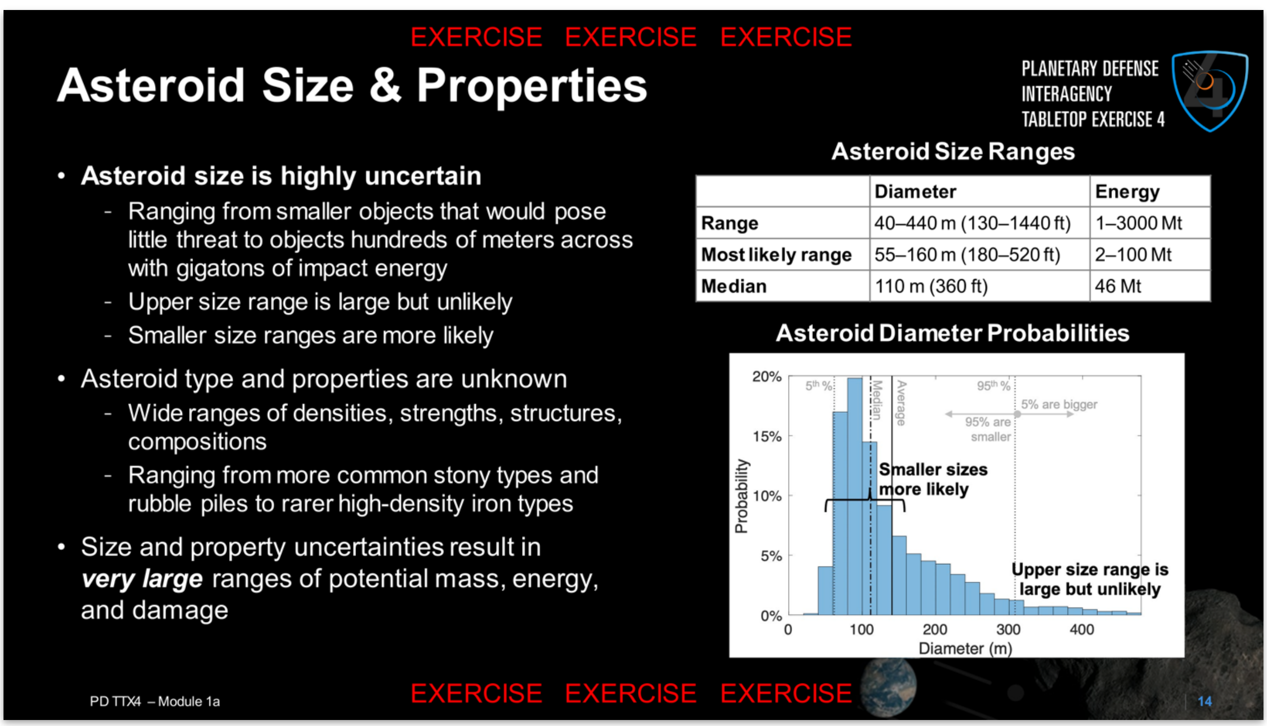

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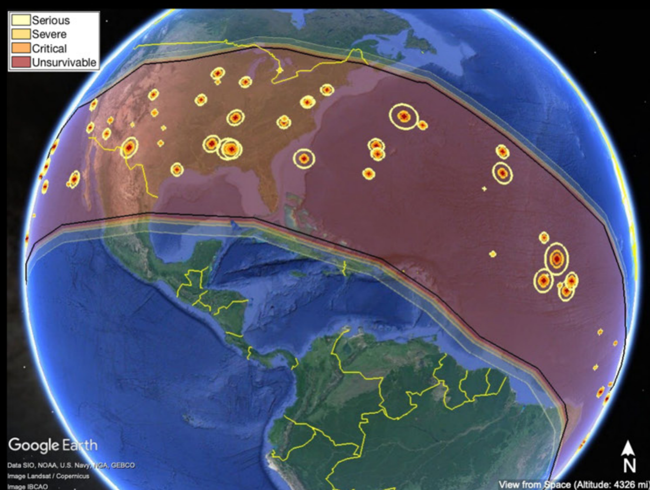
EXERCISE EXERCISE EXERCISE

Potential Risk Swath

PLANETARY DEFENSE INTERAGENCY TABLETOP EXERCISE 4



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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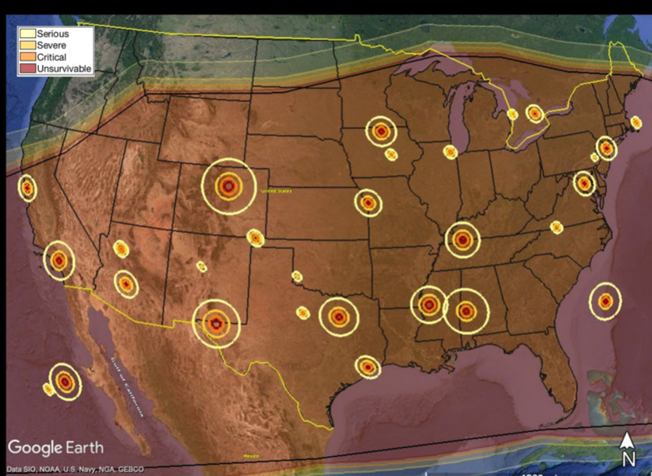
EXERCISE EXERCISE EXERCISE

U.S. Potential Risk Swath

PLANETARY DEFENSE INTERAGENCY TABLETOP EXERCISE 4



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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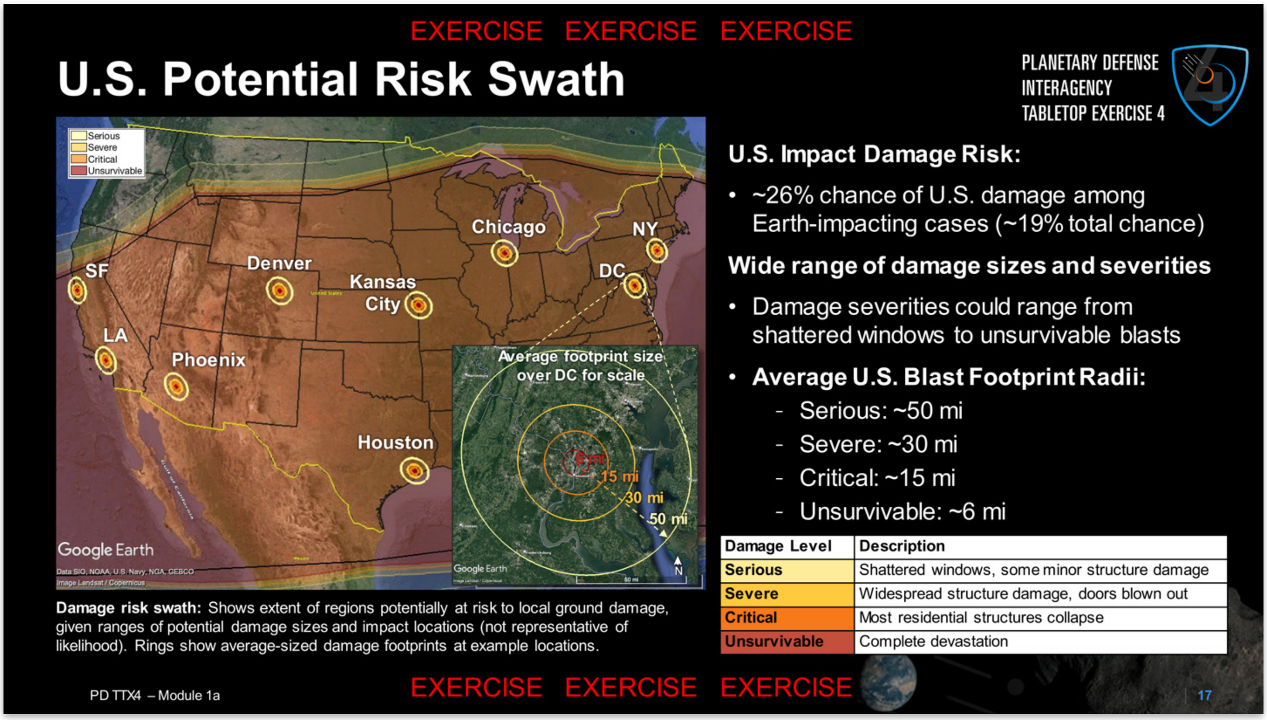

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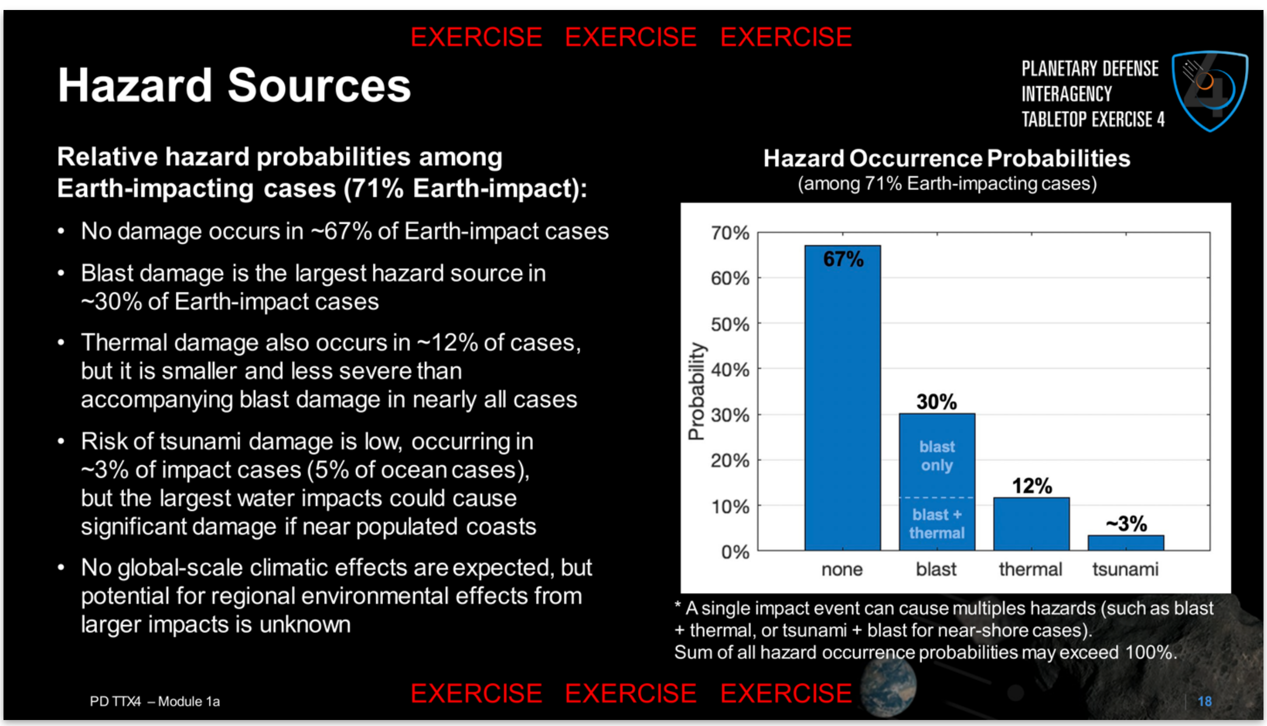

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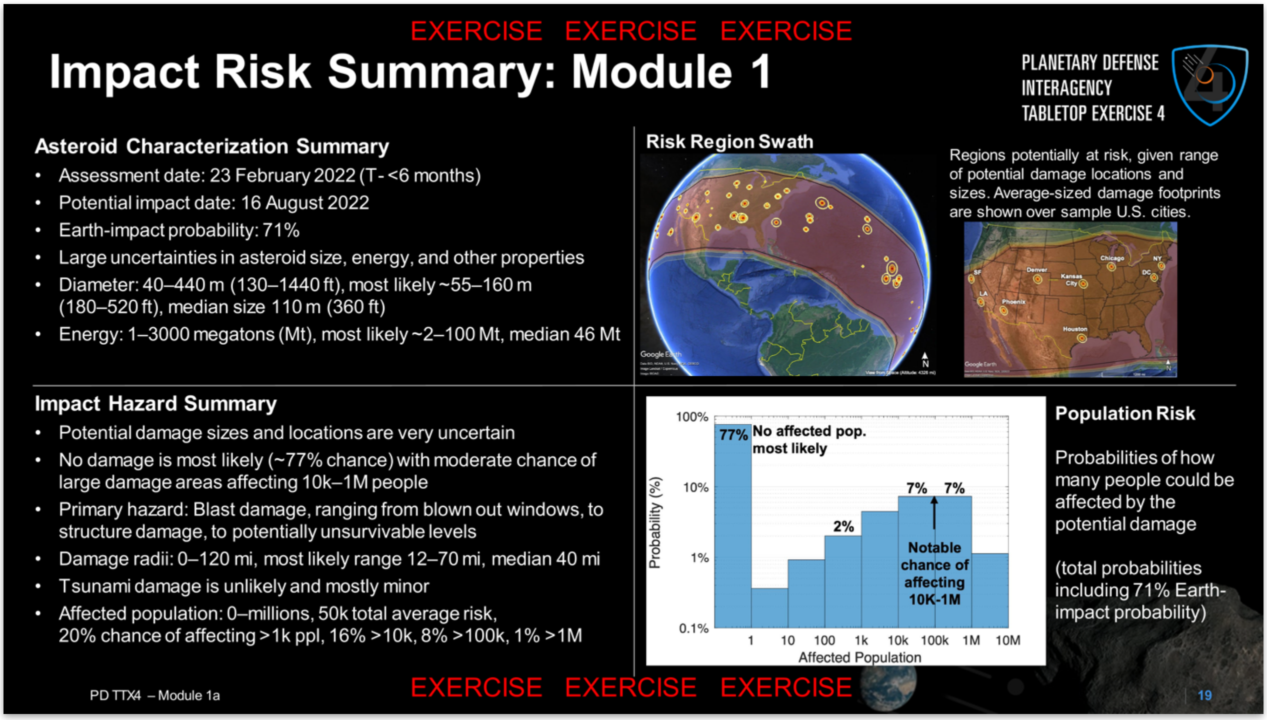

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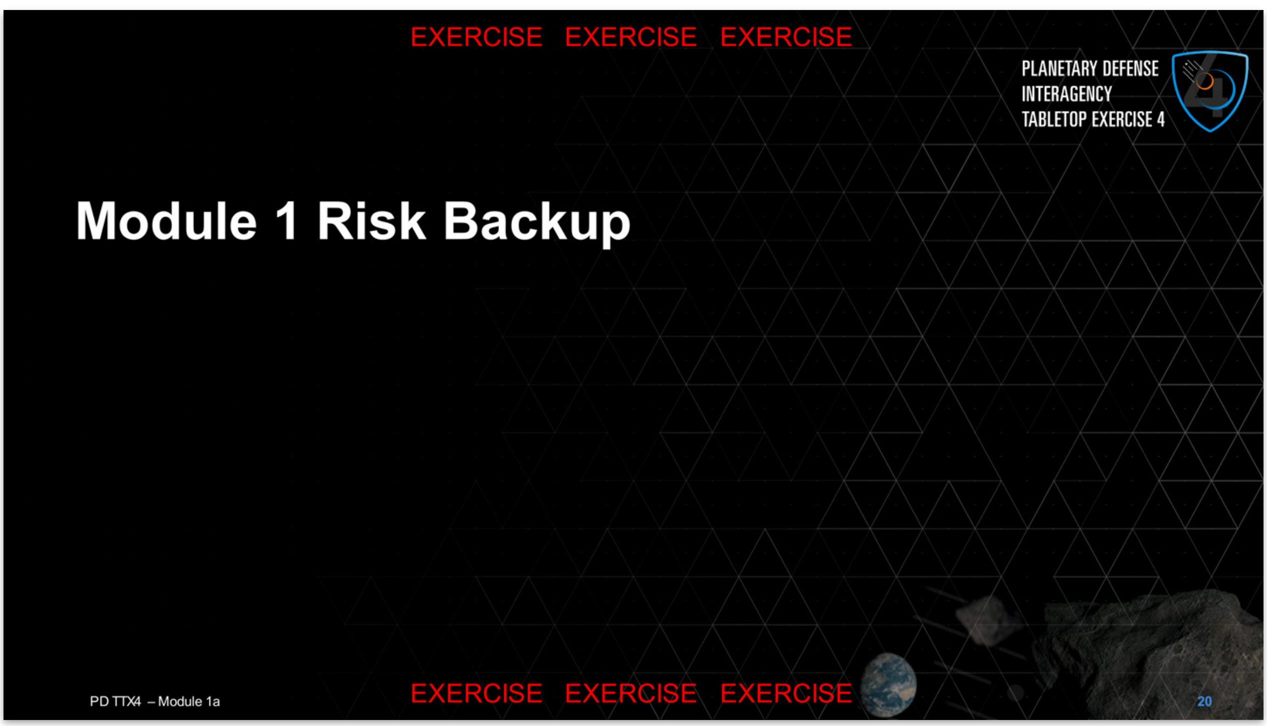

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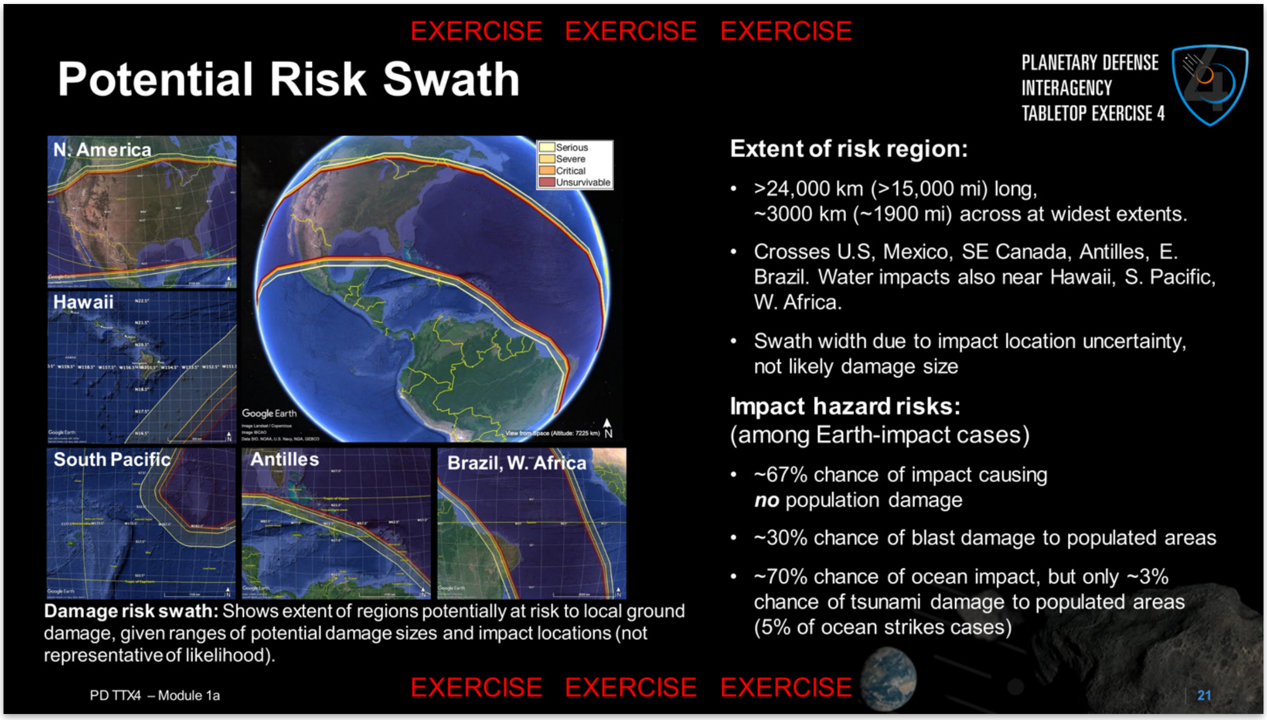

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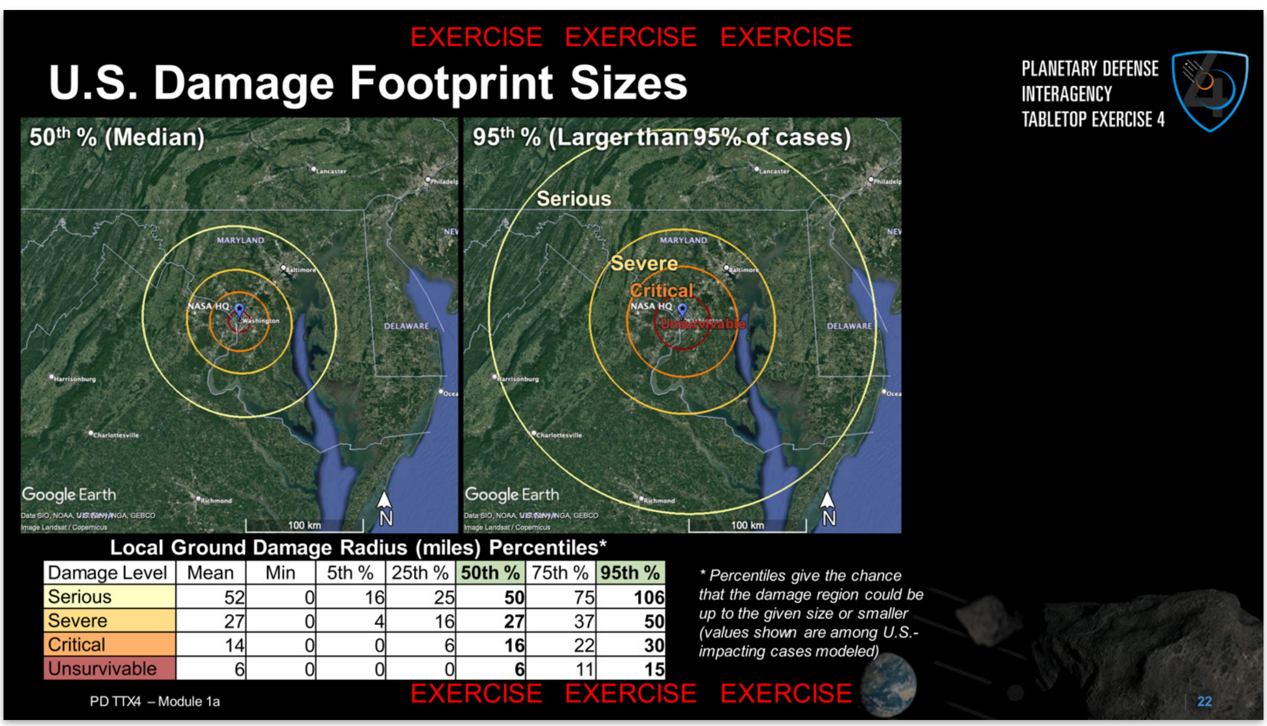

Damage Level	Mean	Min	5th %	25th %	50th %	75th %	95th %
Serious	52	0	16	25	50	75	106
Severe	27	0	4	16	27	37	50
Critical	14	0	0	6	16	22	30
Unsurvivable	6	0	0	0	6	11	15

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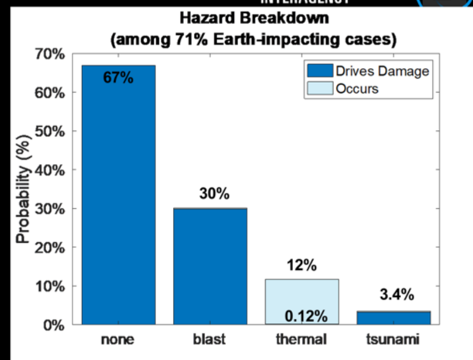
EXERCISE EXERCISE EXERCISE

PLANETARY DEFENSE INTERAGENCY

Hazard Sources

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

PD TTX4 – Module 1a

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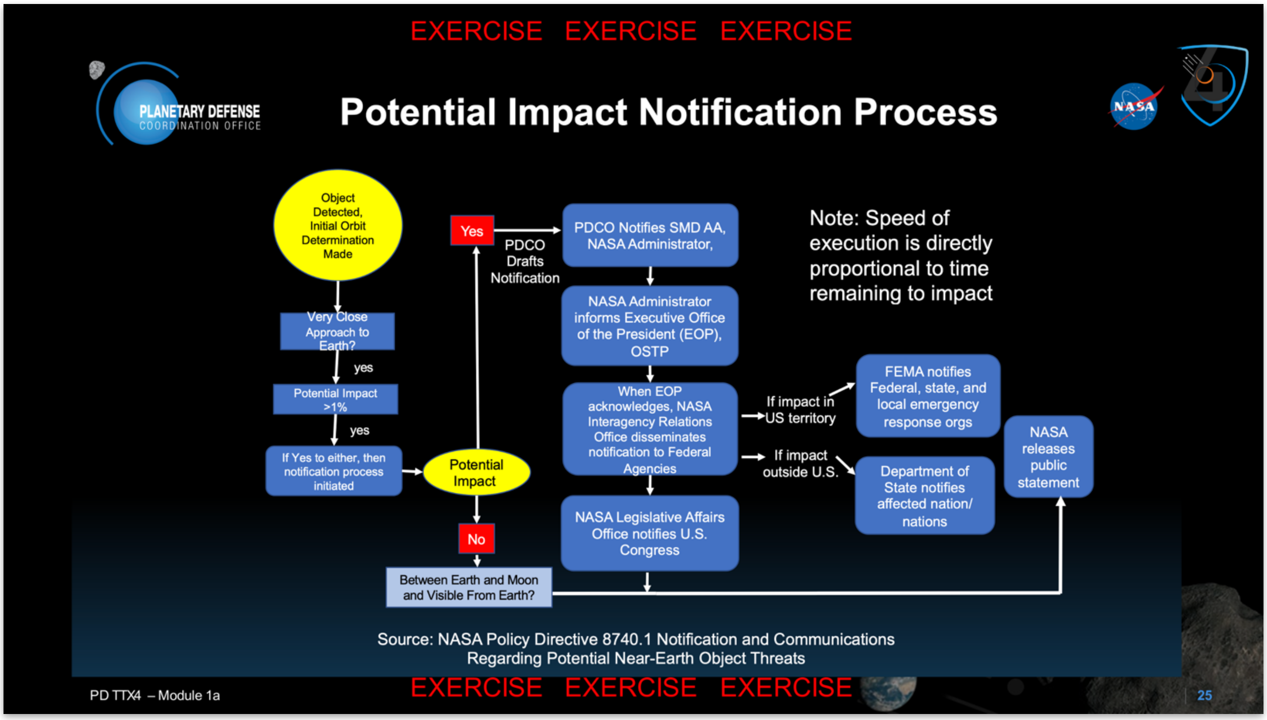

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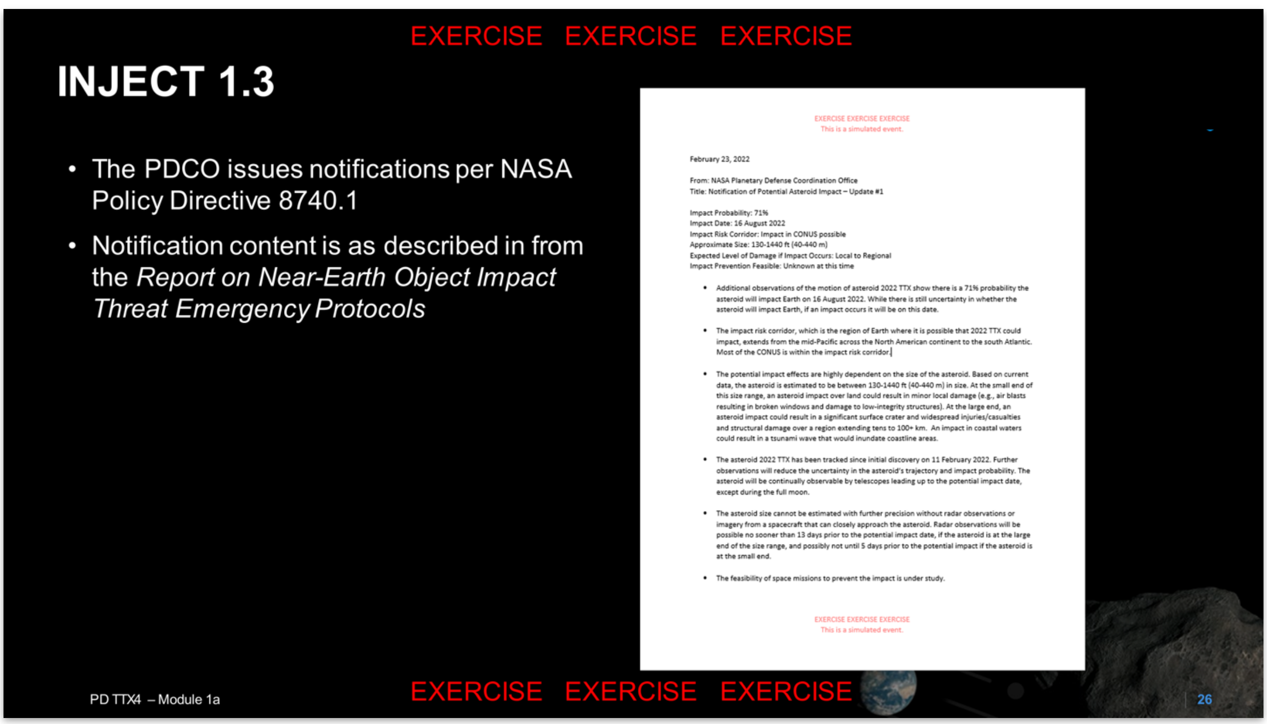

EXERCISE EXERCISE EXERCISE
This is a simulated event.

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.

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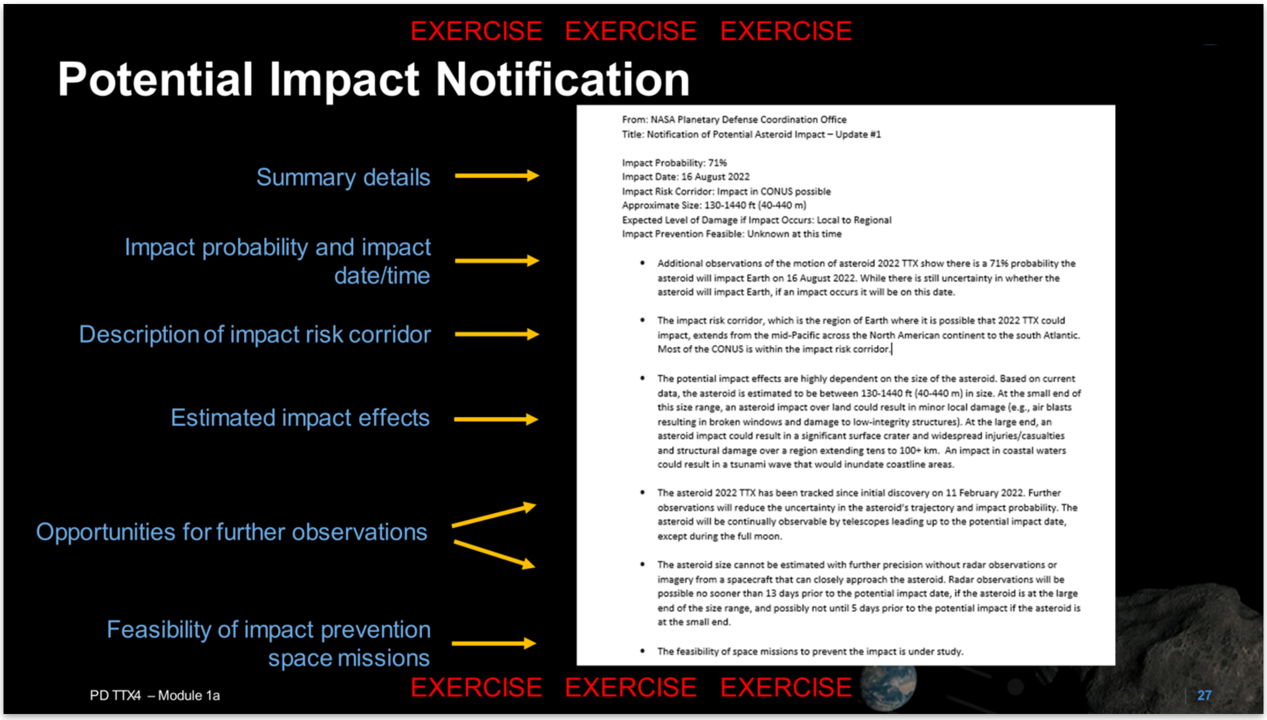

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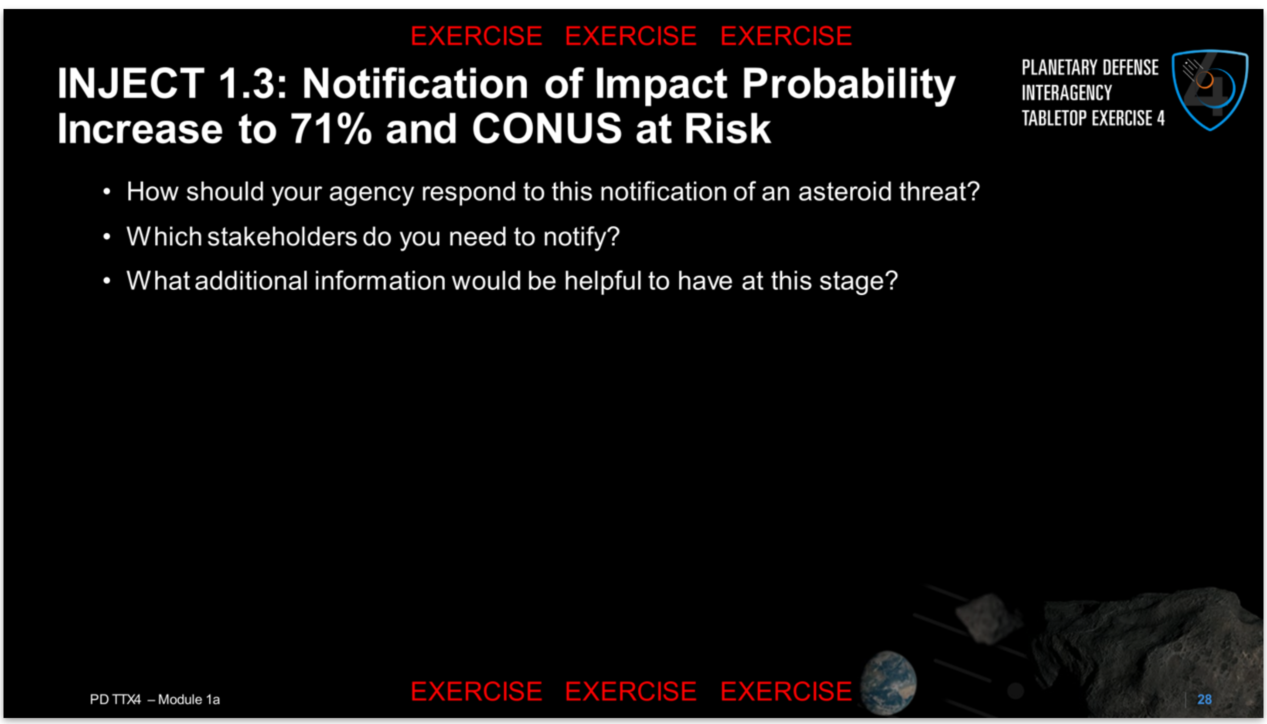

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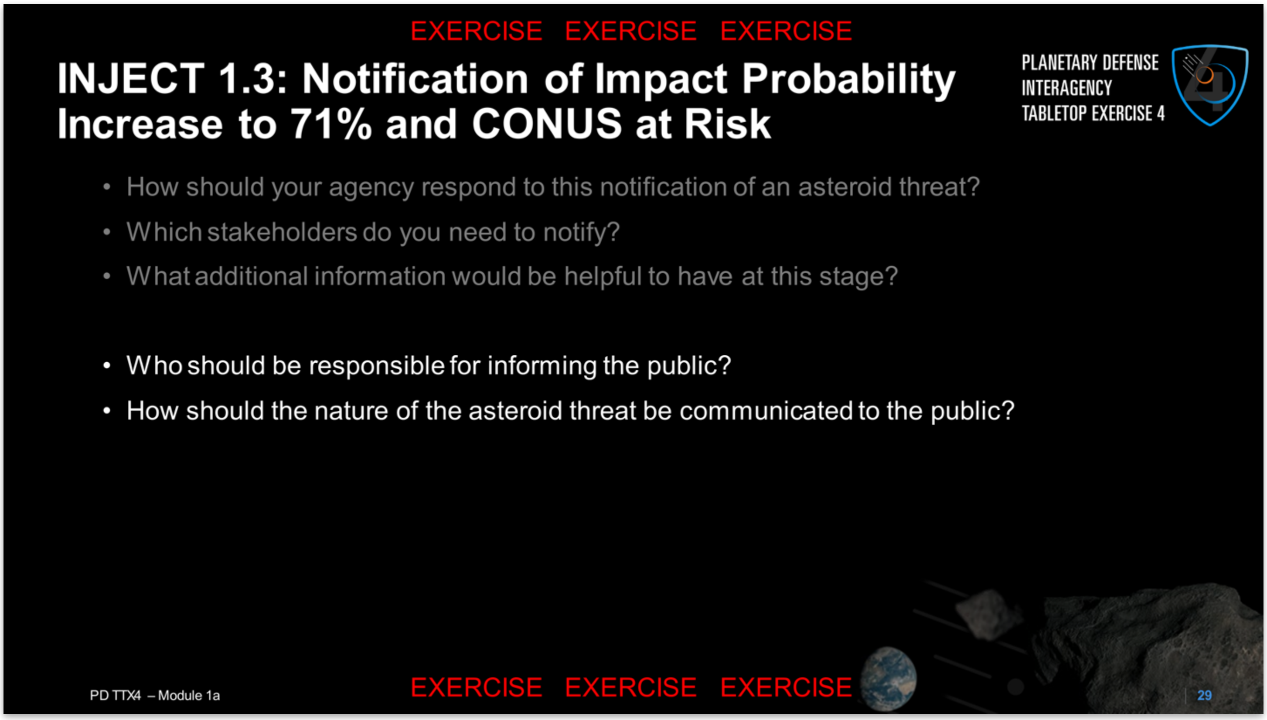

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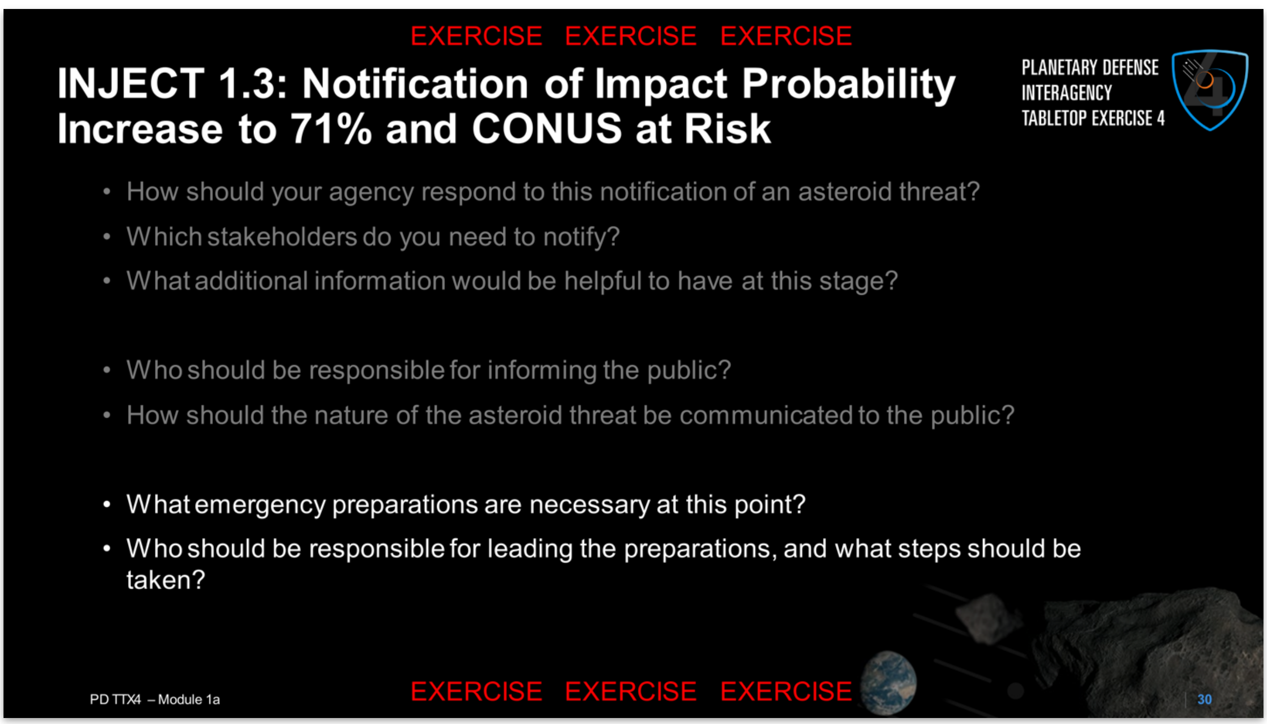

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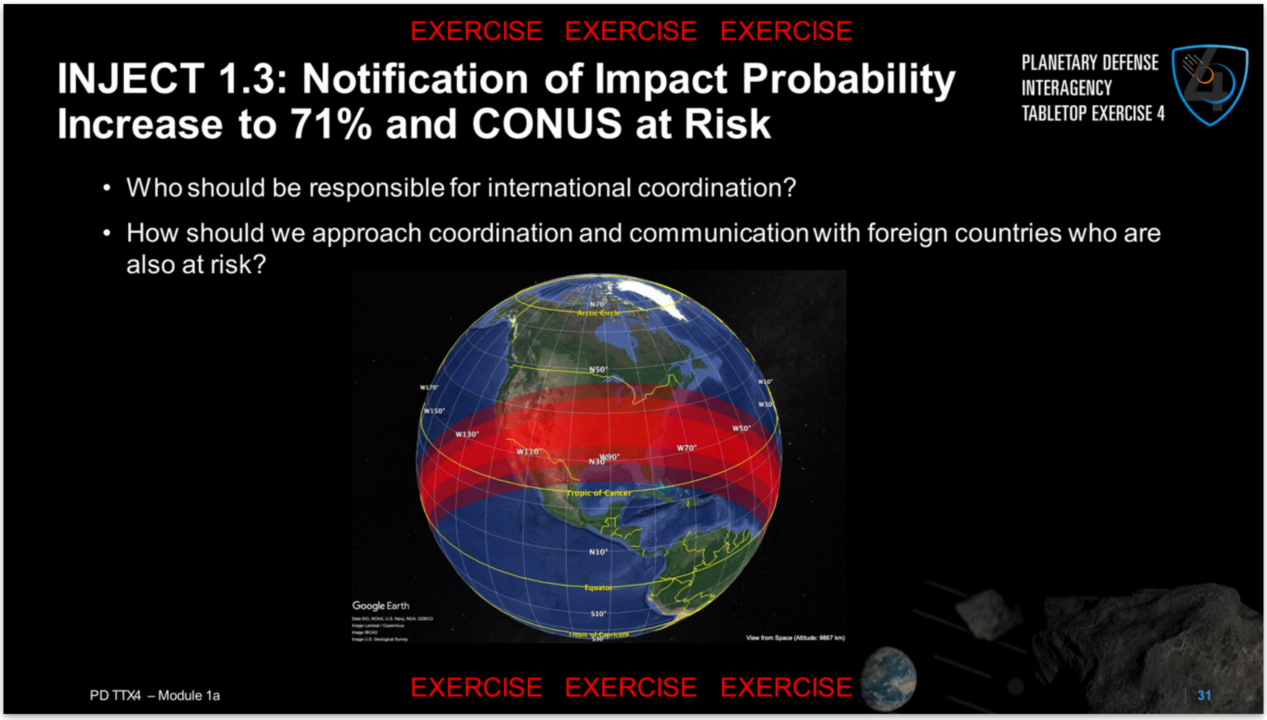

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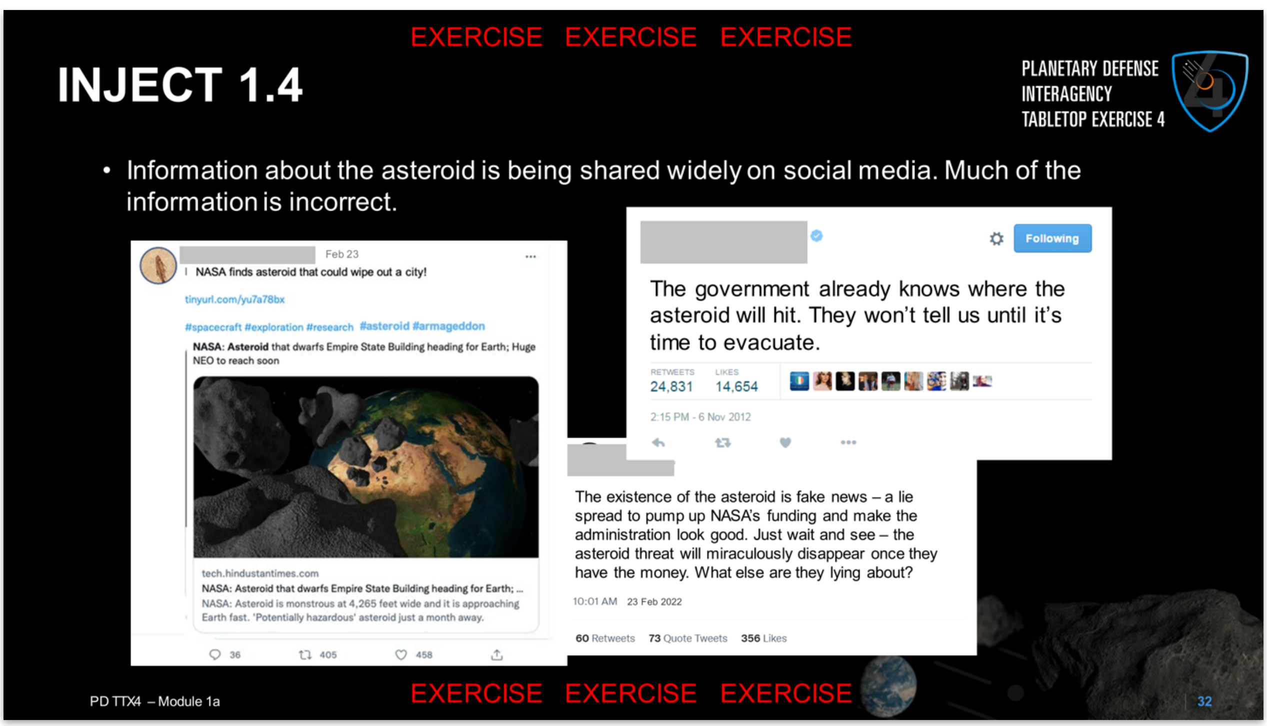

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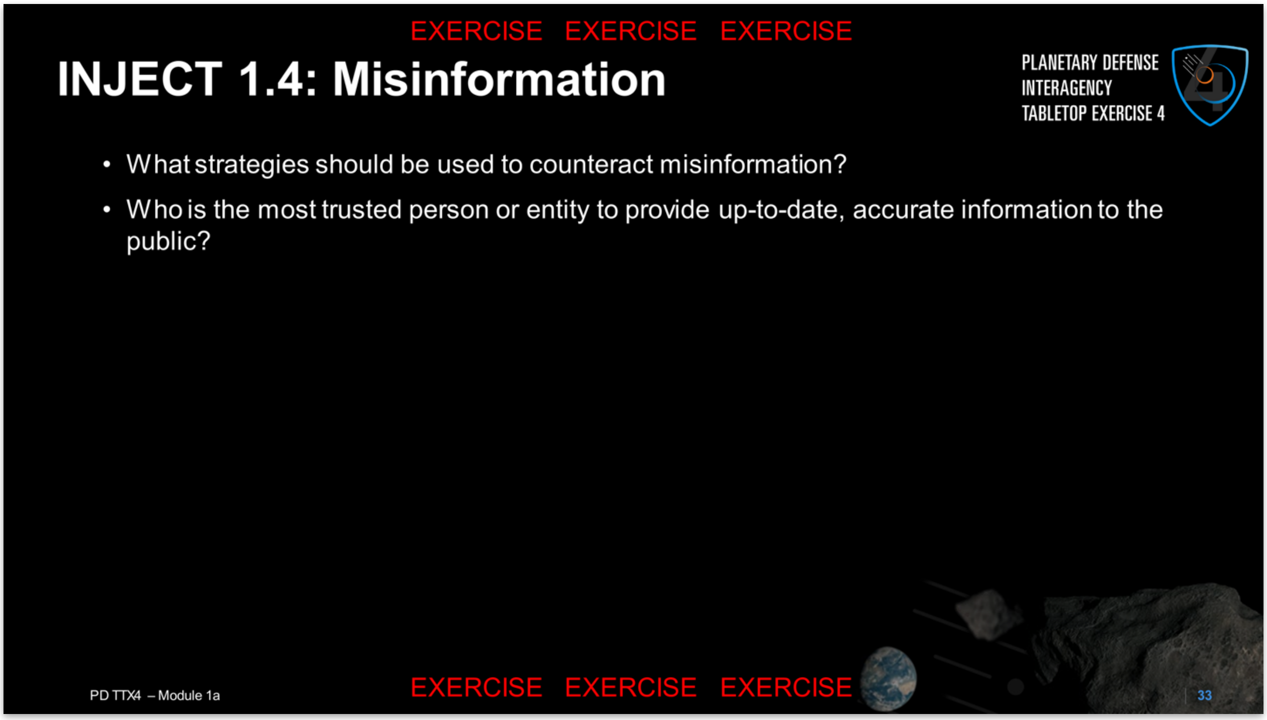

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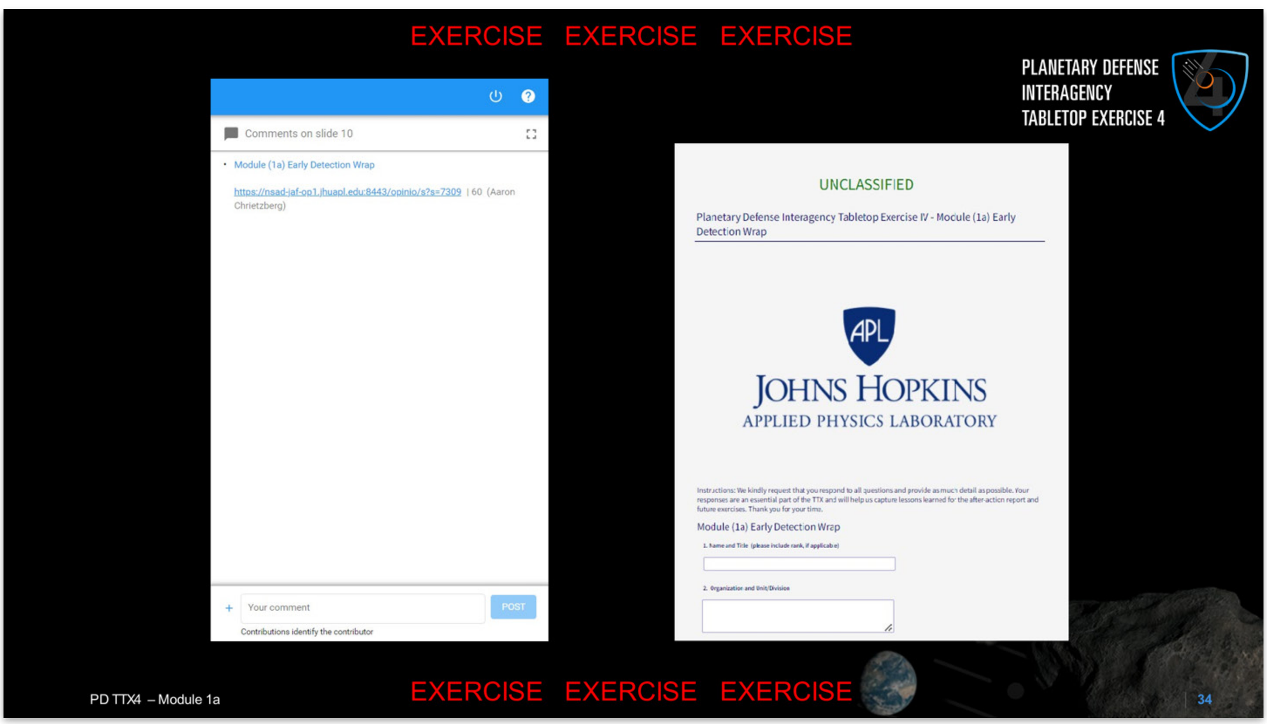

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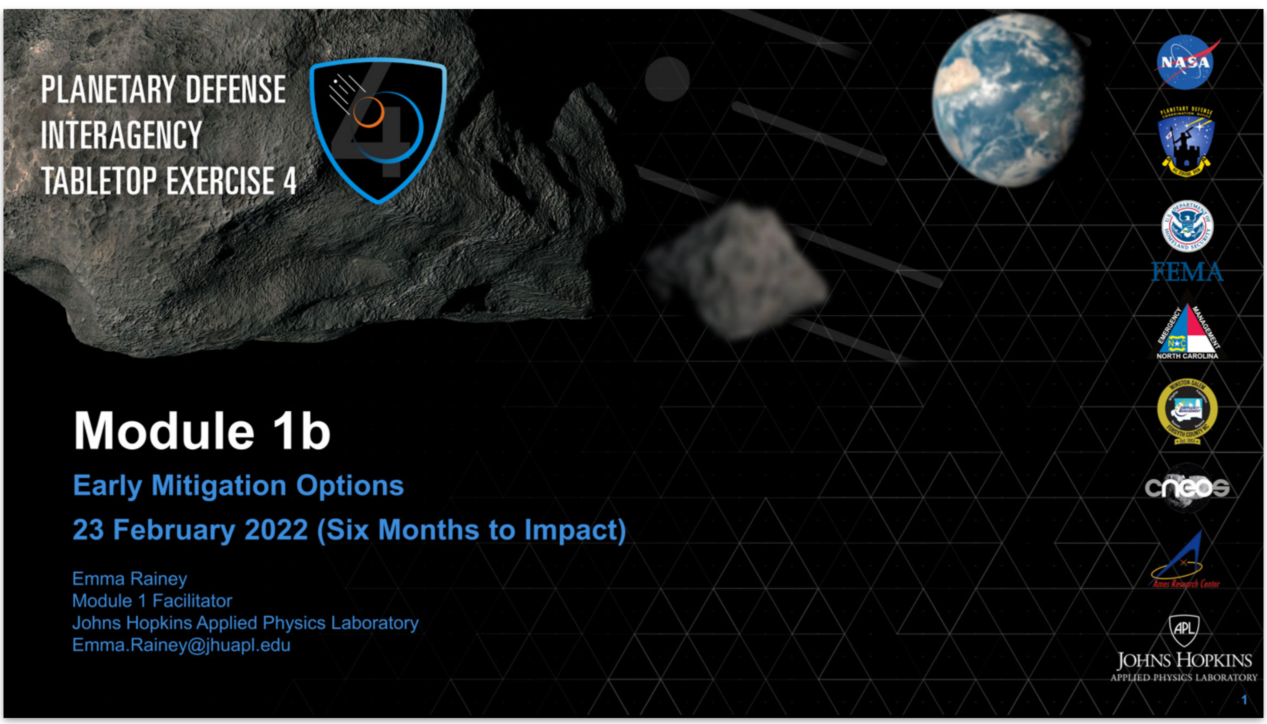

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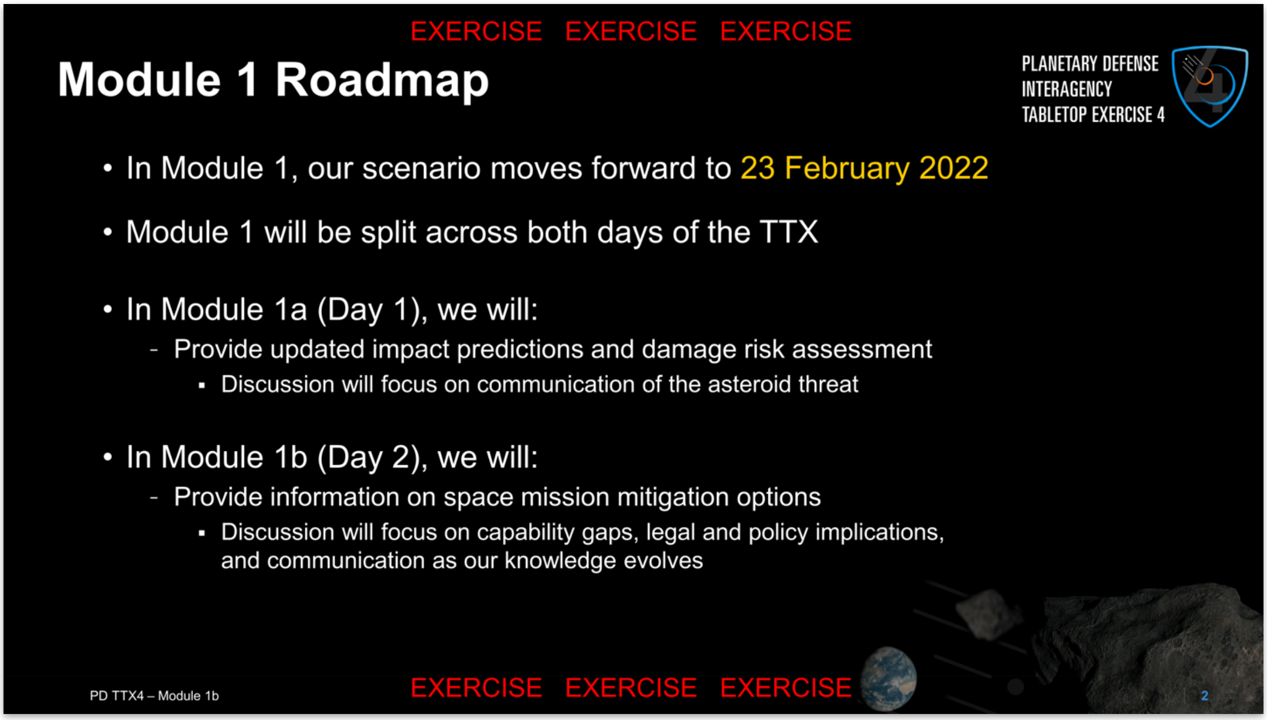

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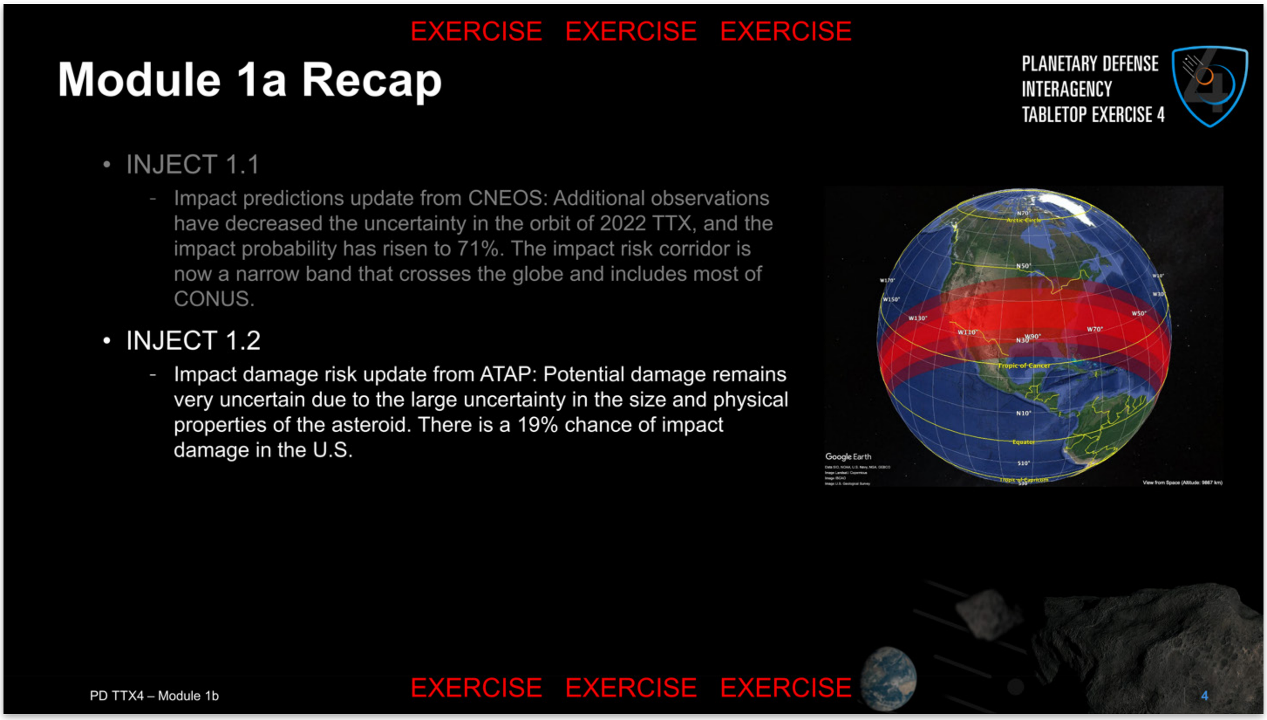

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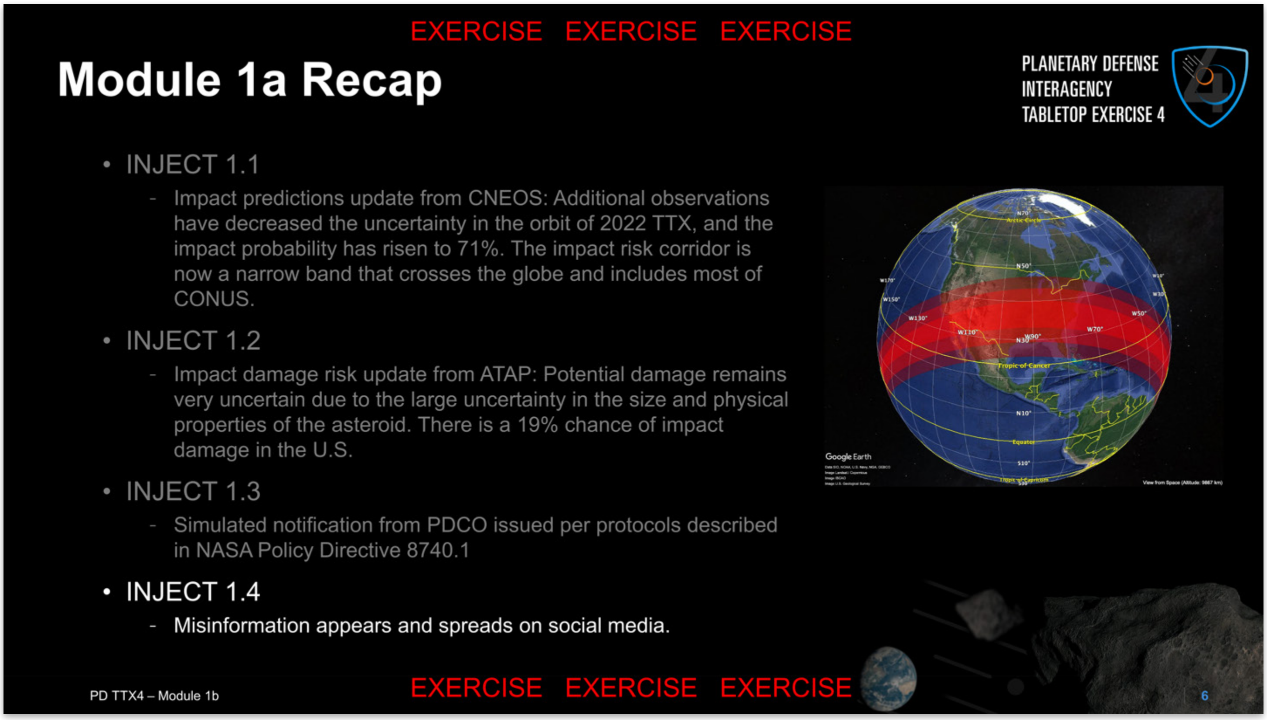

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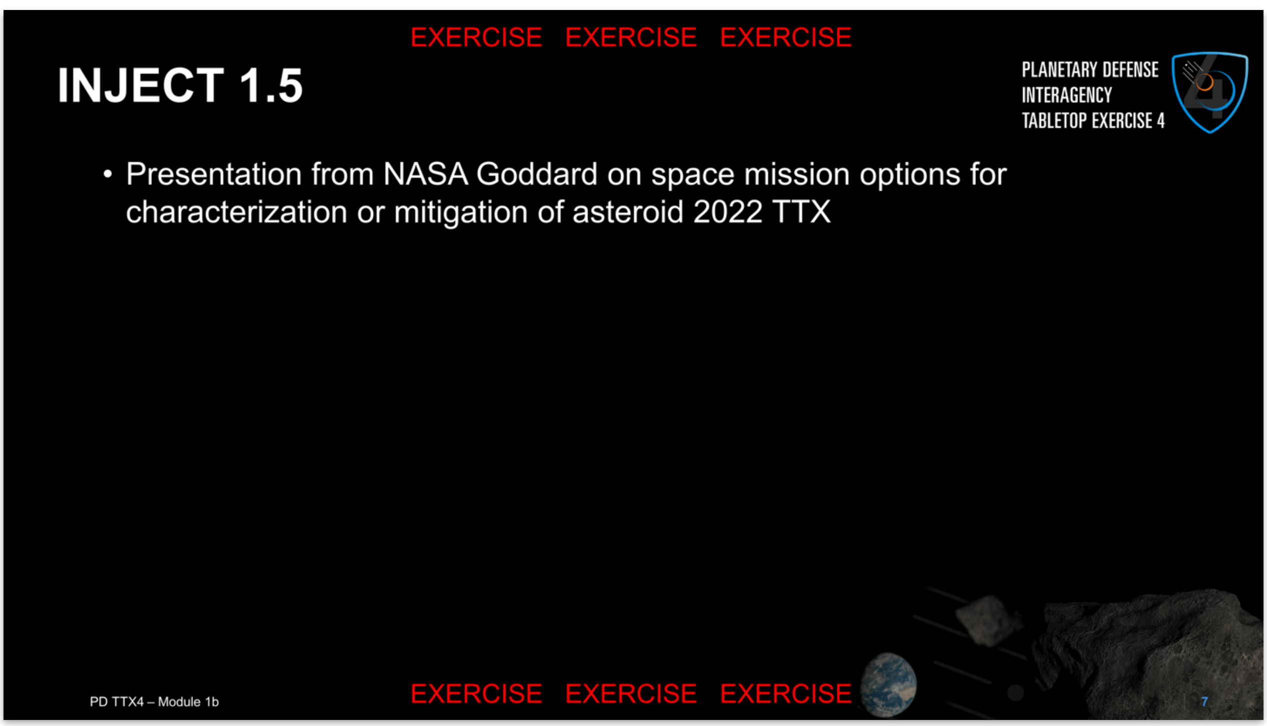

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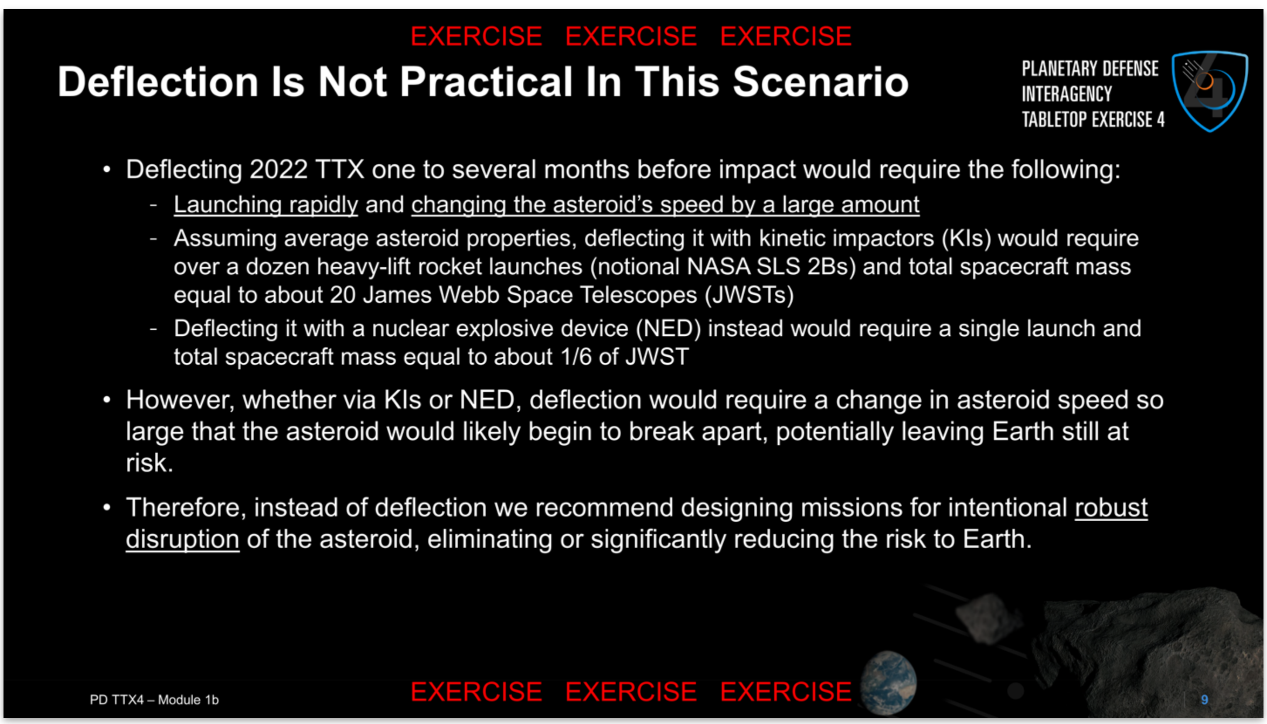

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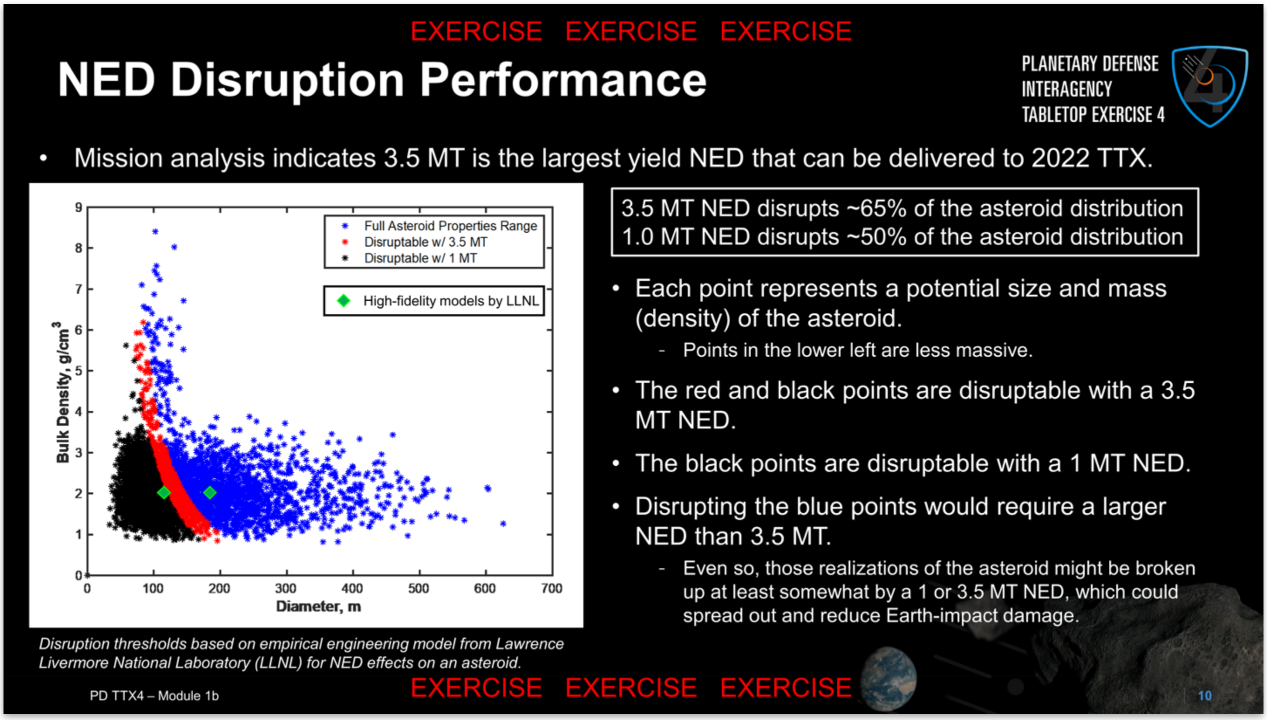

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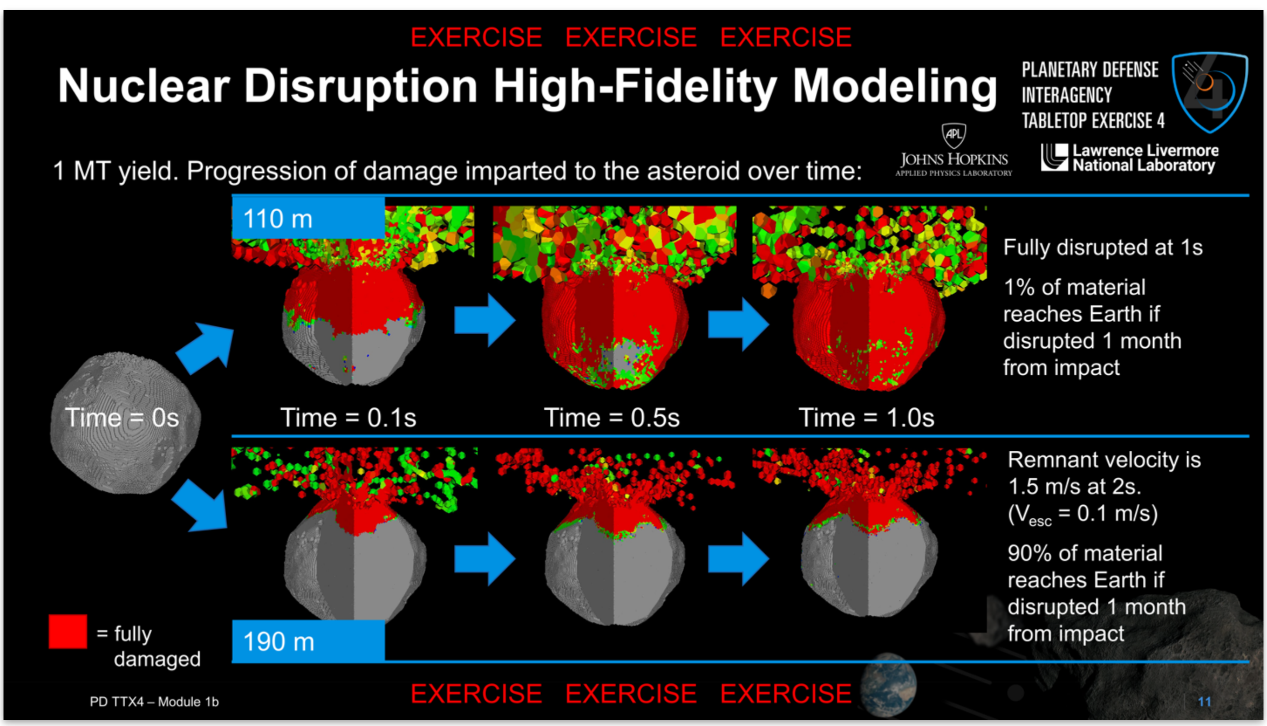

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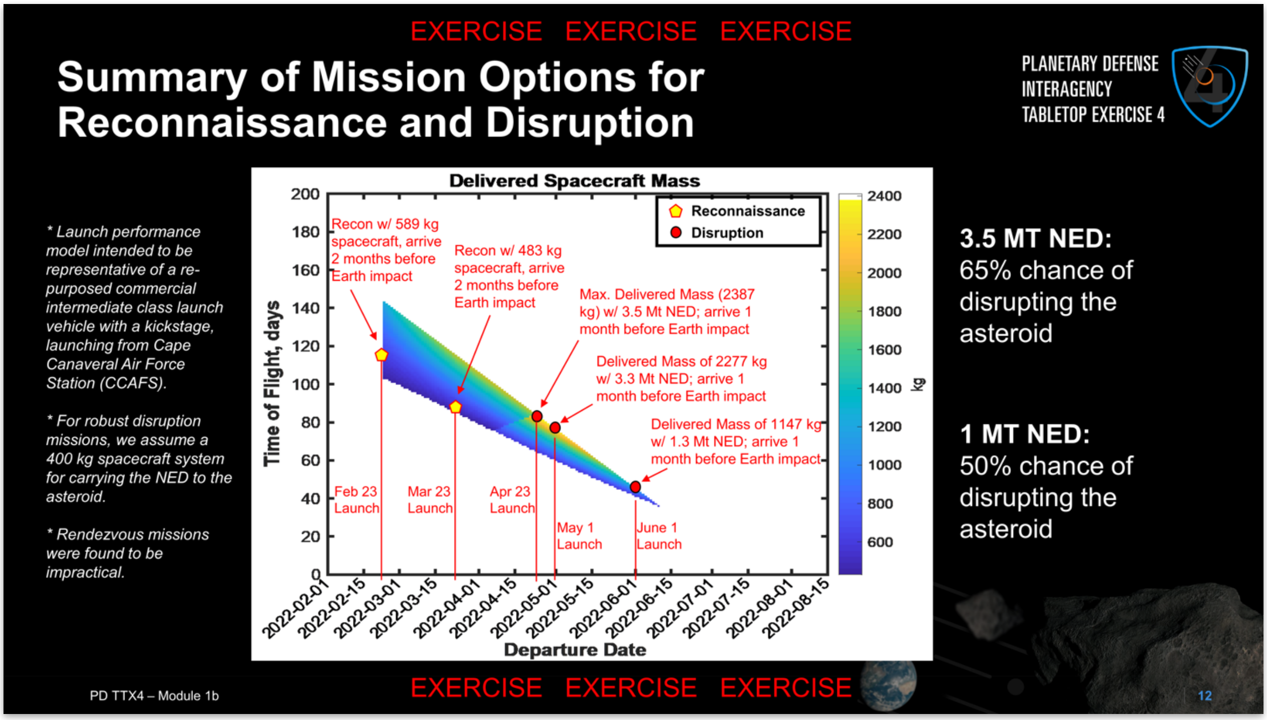

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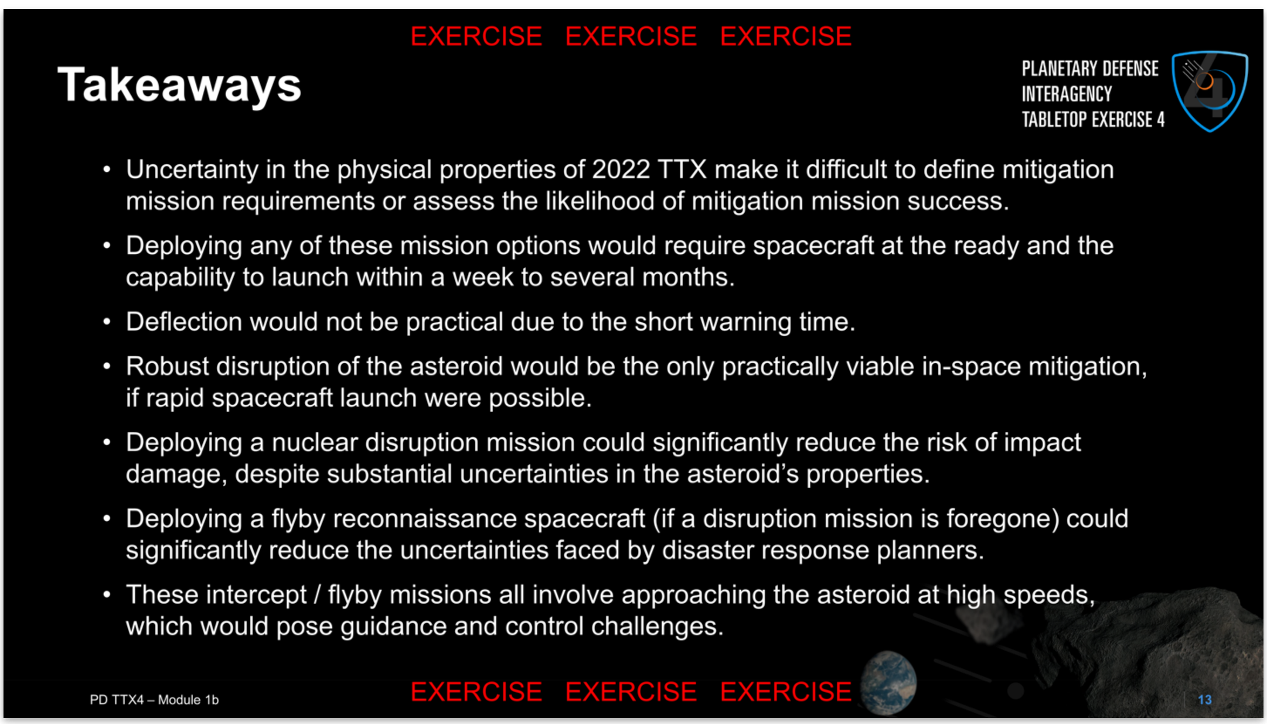

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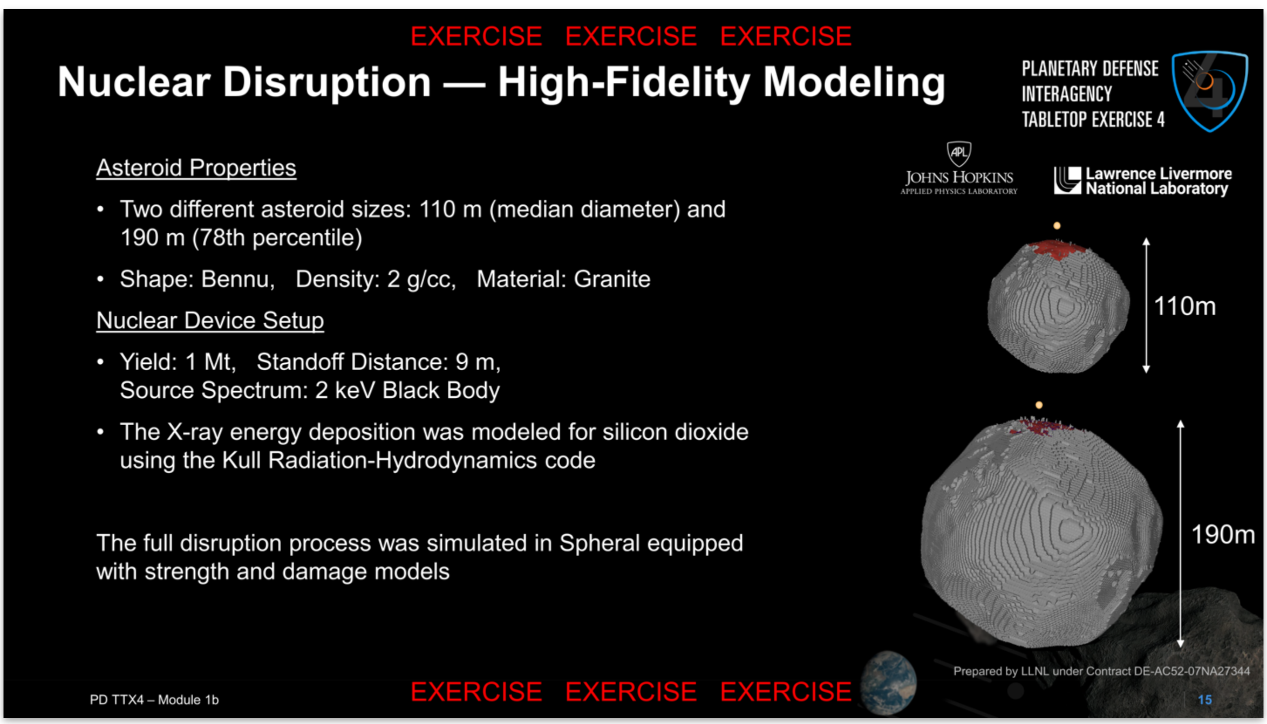

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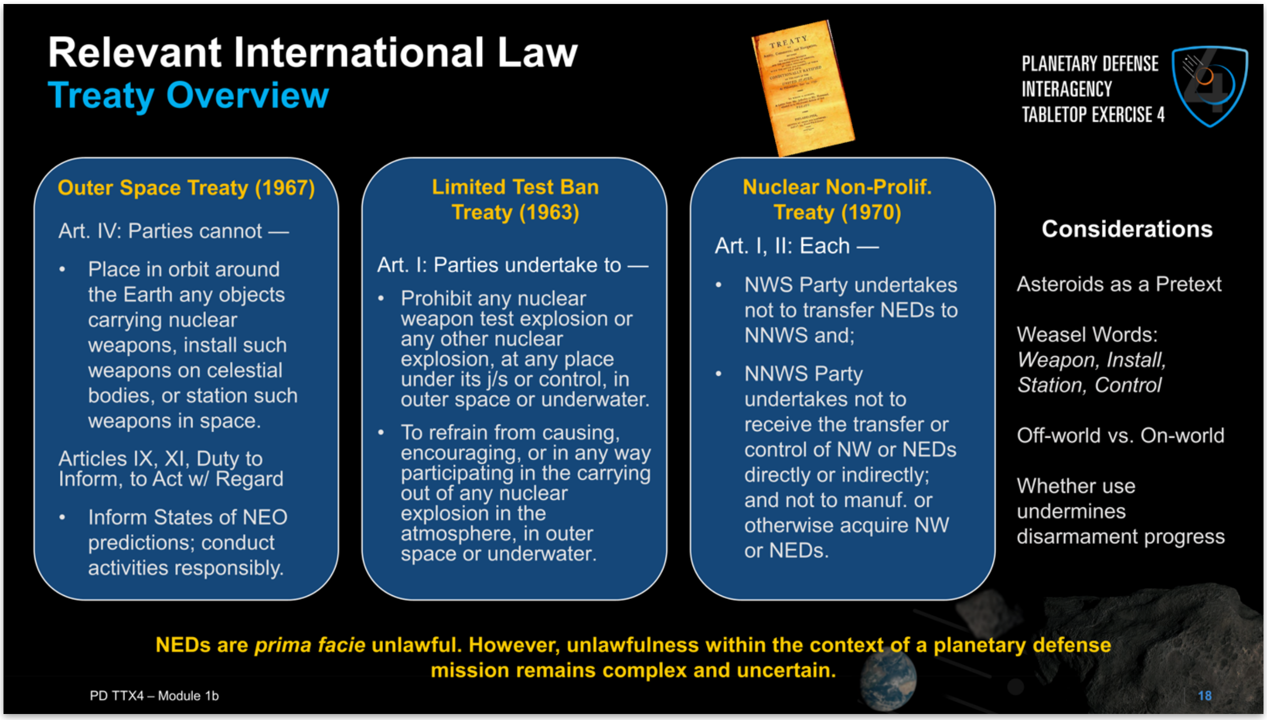

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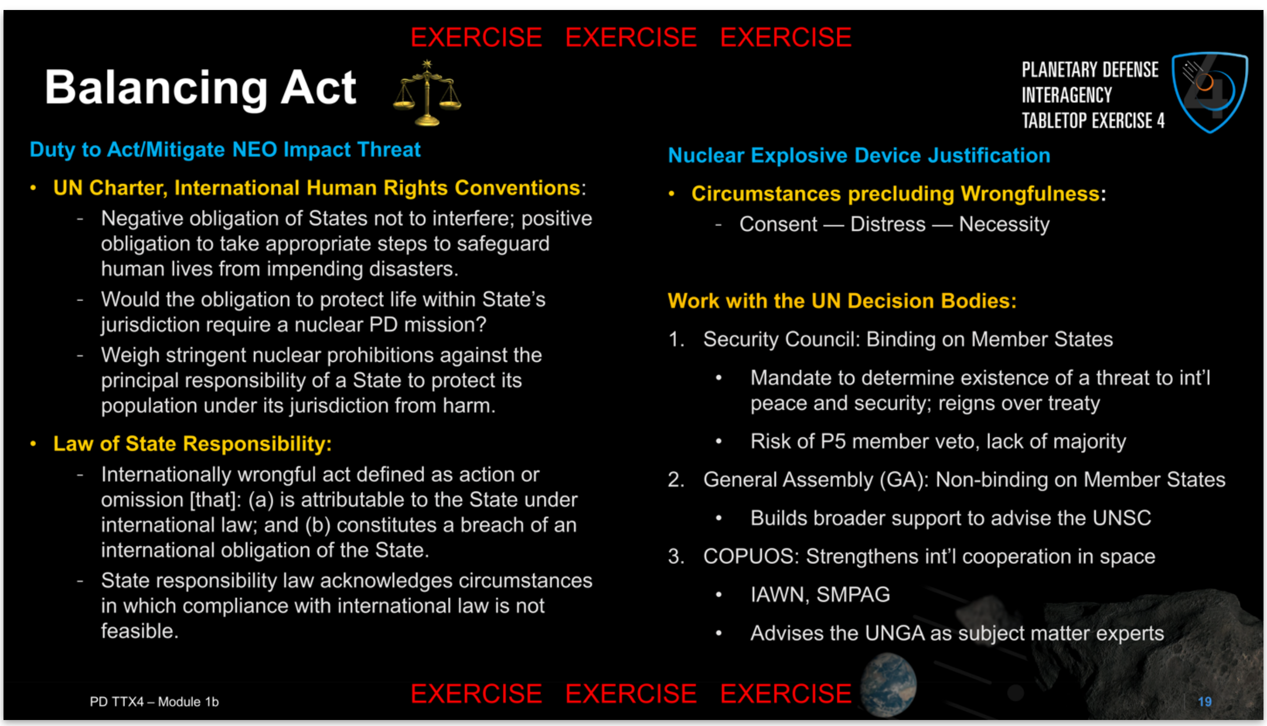

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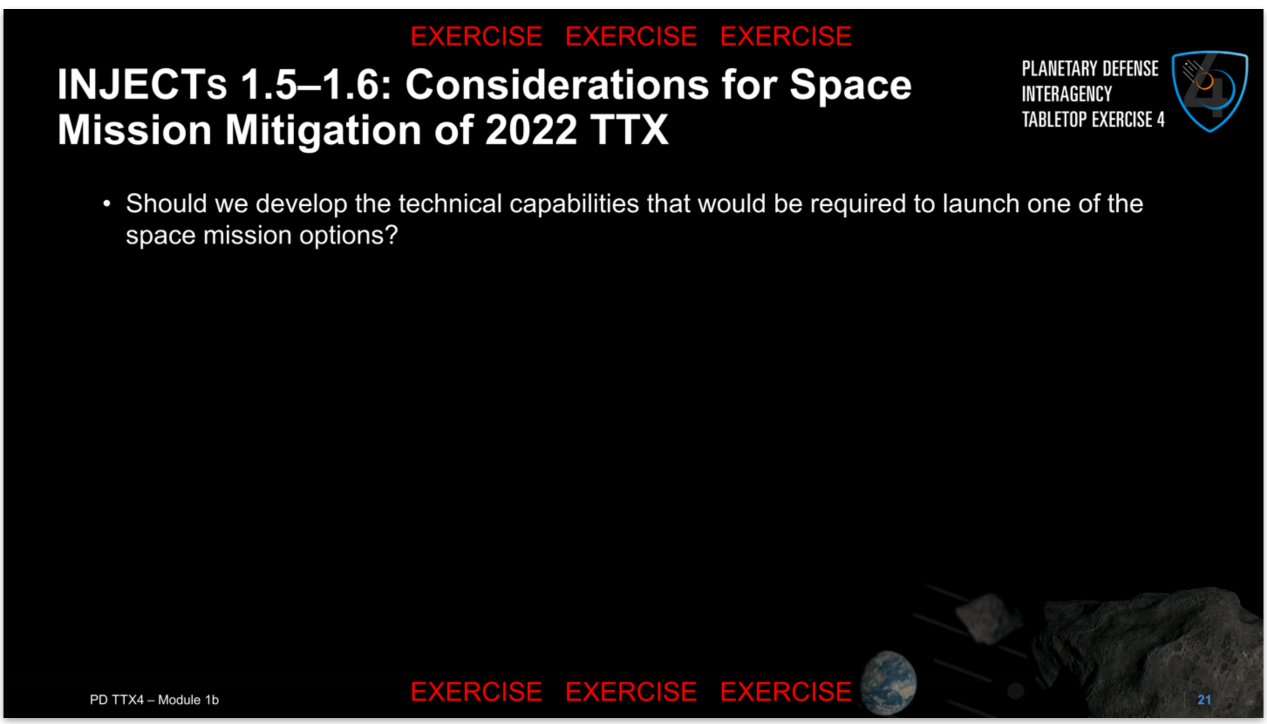

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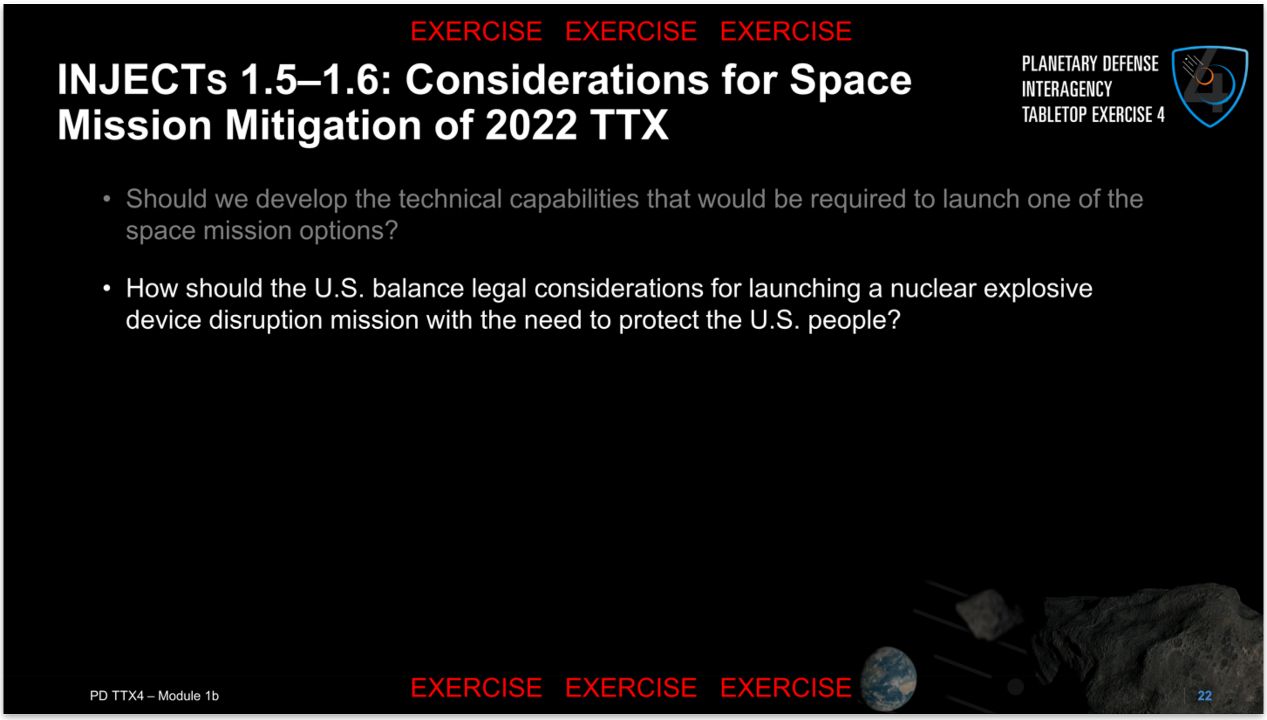

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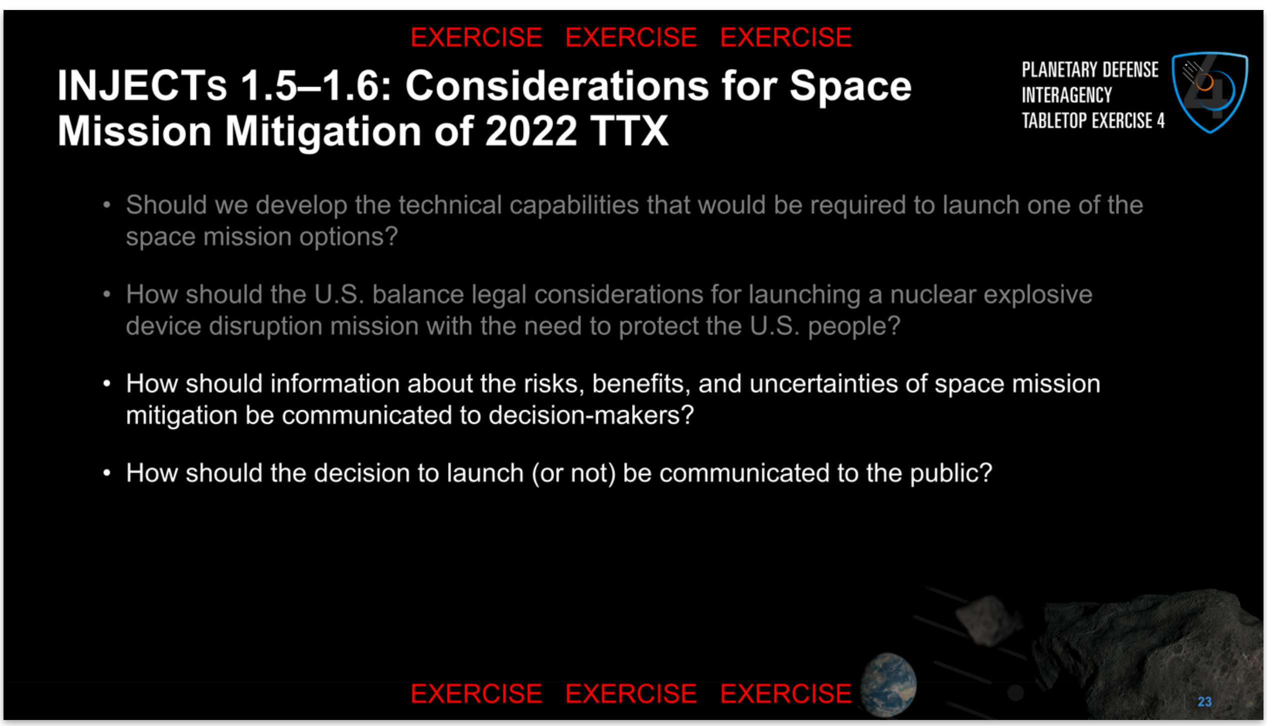

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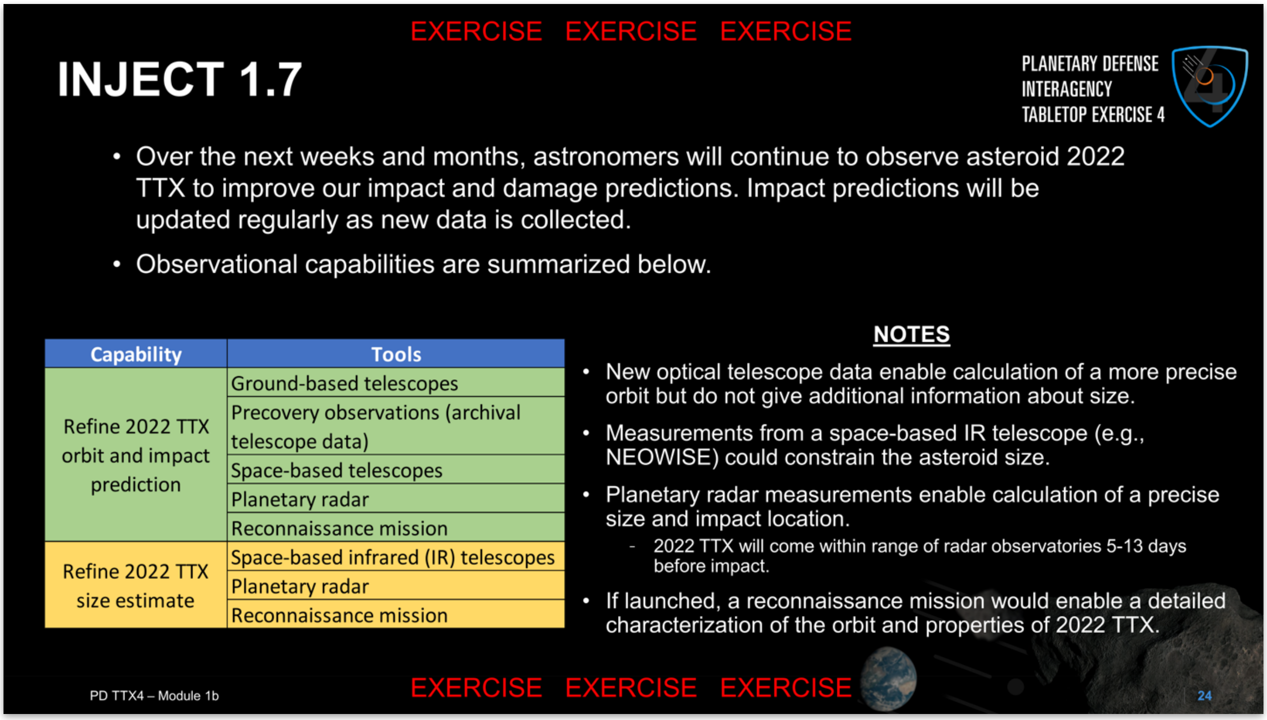

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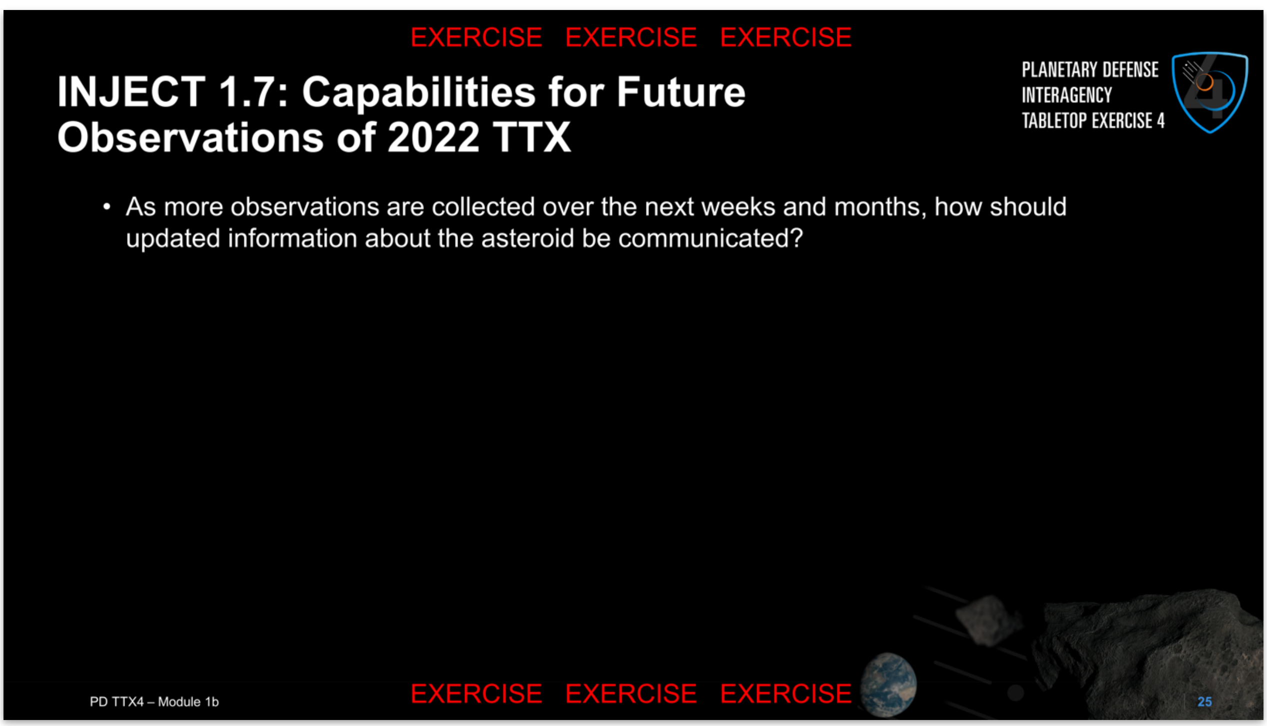

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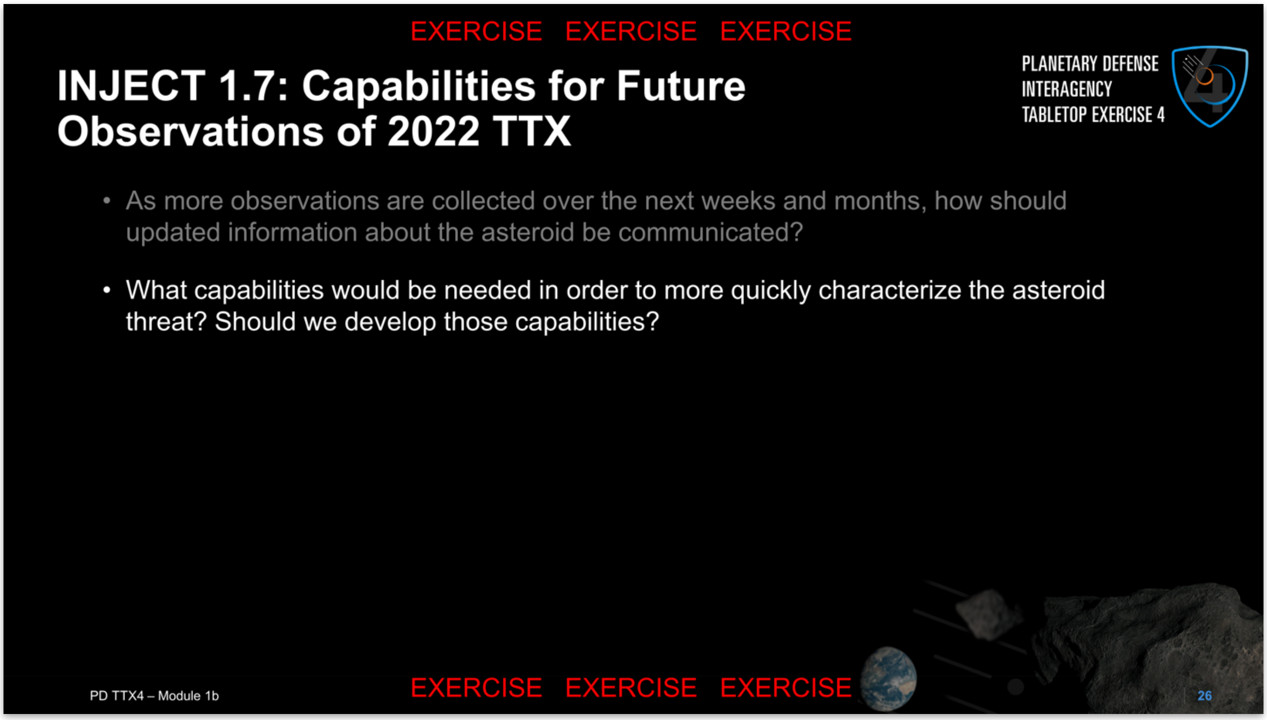

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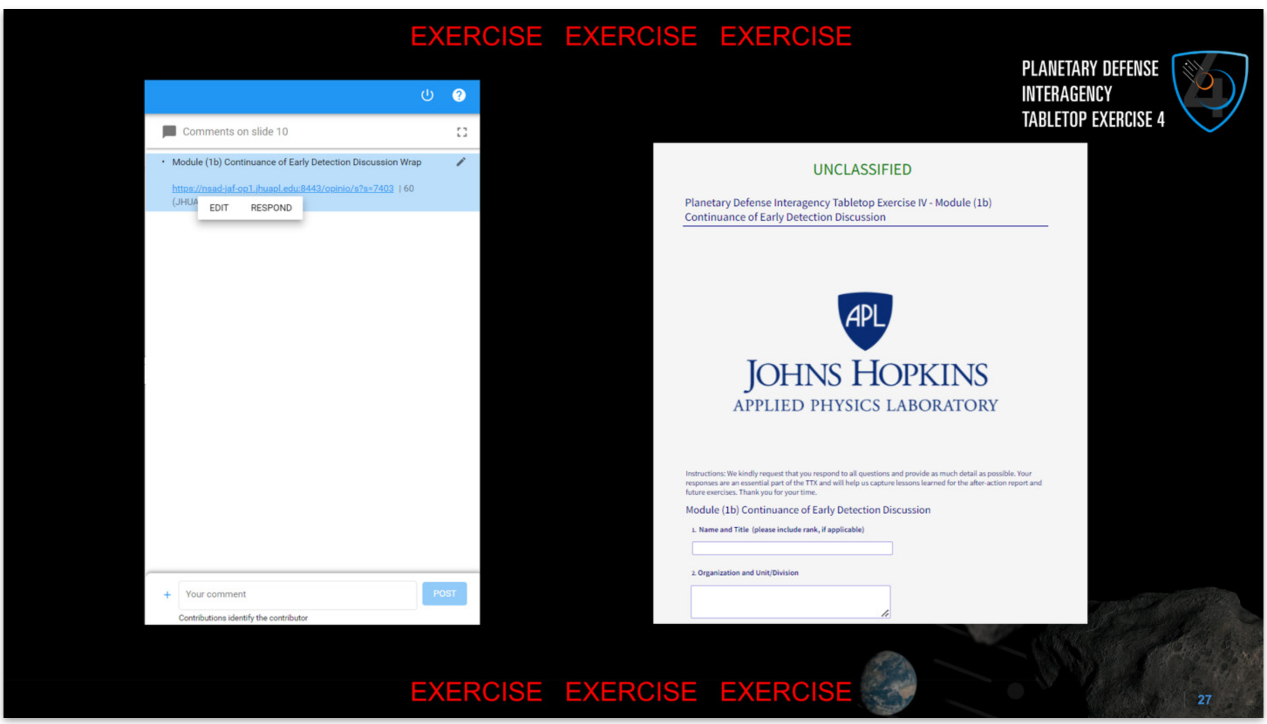

C.5 Module 2

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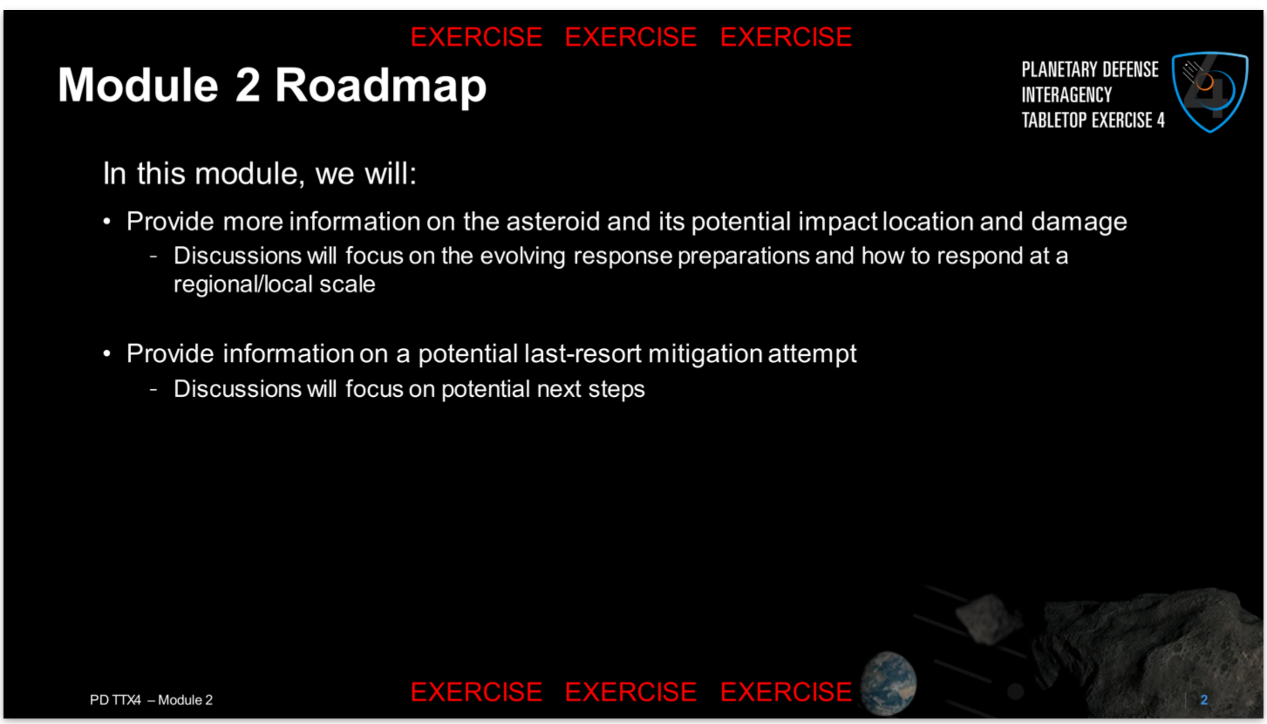

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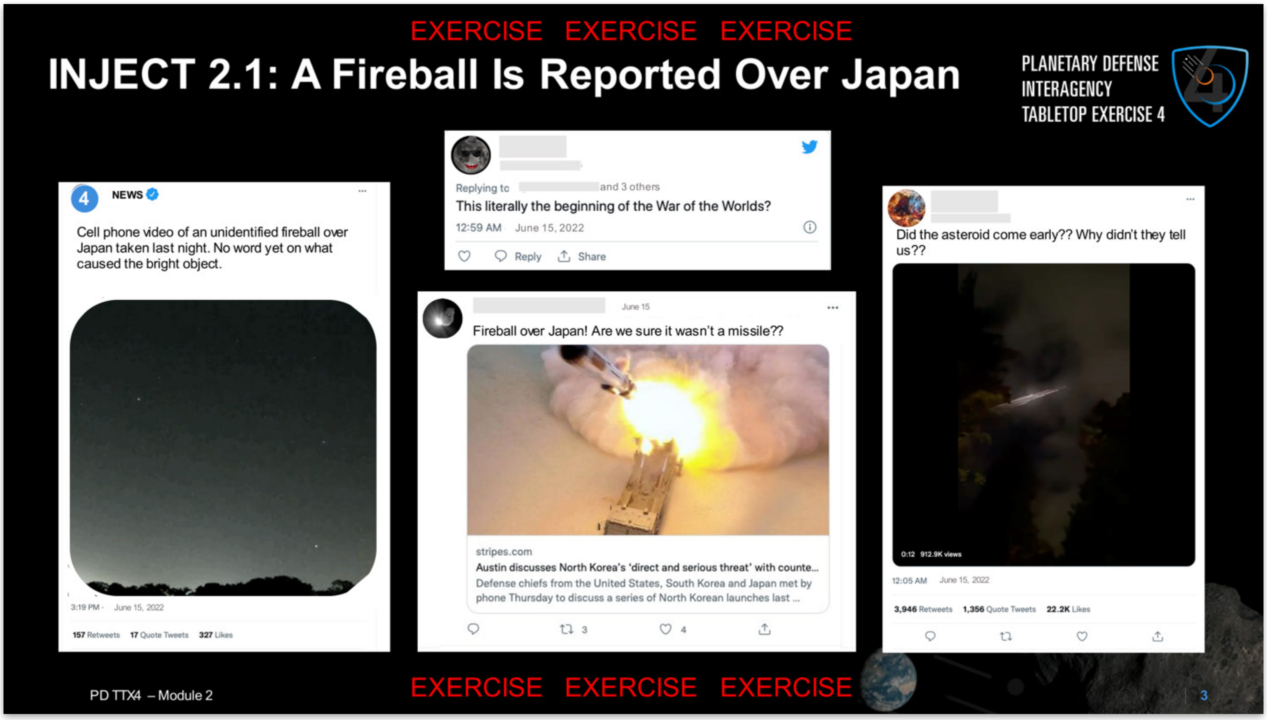

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EXERCISE EXERCISE EXERCISE

Scenario Update: Module 2

PLANETARY DEFENSE INTERAGENCY TABLETOP EXERCISE 4

- New tracking data for 2022 TTX, now spanning 7 years, have produced a much more accurate orbit for the asteroid, enabling very precise predictions of the impact
- The asteroid is now 100% certain to impact, and the predicted impact location is N. Carolina
- The most important new data were “prediscovery” detections of the asteroid from sky images taken in 2015, when 2022 TTX made a distant flyby of Earth
- Astronomers worldwide have continued tracking the asteroid at every opportunity over the last 4 months, contributing close to a hundred new observations
- 2022 TTX passed through the sky region where the NEOWISE spacecraft points its infrared telescope, but the asteroid was not detected
- If the asteroid is at the large end of its size range, larger than about 340 m (1100 ft), it should have been detected by NEOWISE; since it was not, the large end of the size range can be revised down somewhat to a new size range of 40–340 m (130–1100 ft)

PD TTX4 – Module 2 EXERCISE EXERCISE EXERCISE 7

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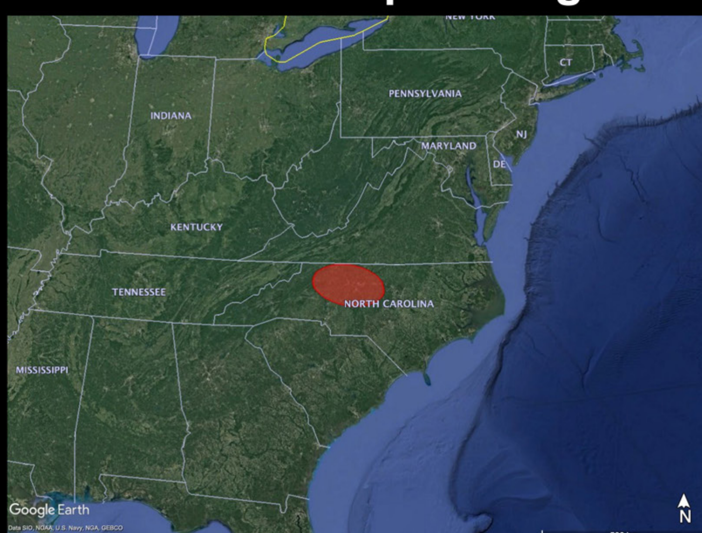
EXERCISE EXERCISE EXERCISE

Predicted Impact Region

PLANETARY DEFENSE INTERAGENCY TABLETOP EXERCISE 4



Shows the region where the 2022 TTX will impact

The impact will occur at: 16 August 2022 at 2:02:10 pm EDT

The asteroid will impact at a velocity of 15.5 km/s or 35,000 mph

This is not the same as the damage region

PD TTX4 – Module 2 EXERCISE EXERCISE EXERCISE 8

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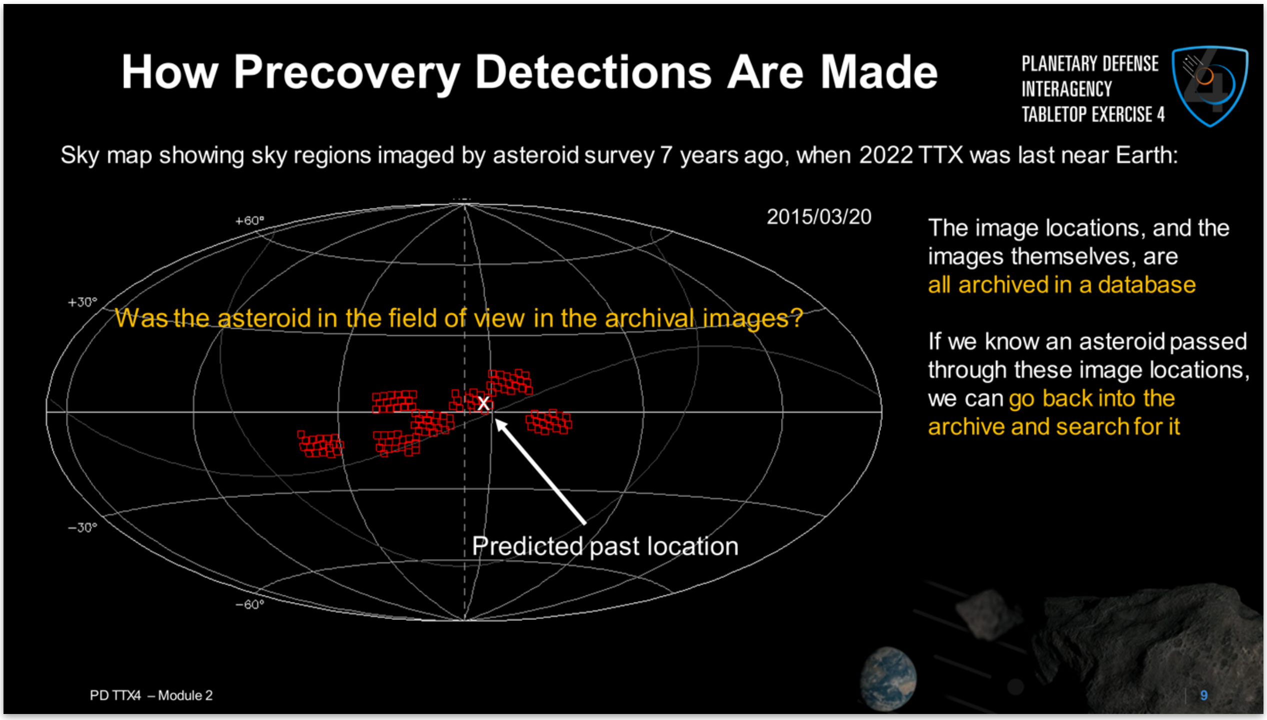

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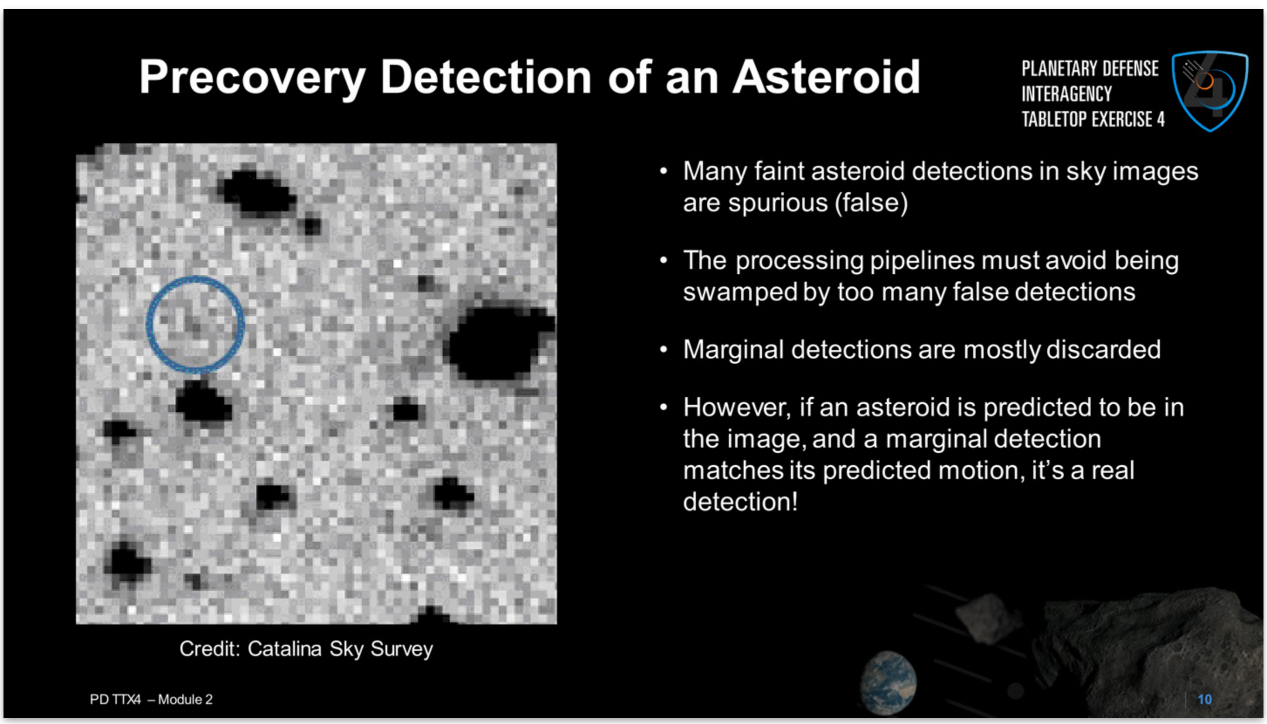

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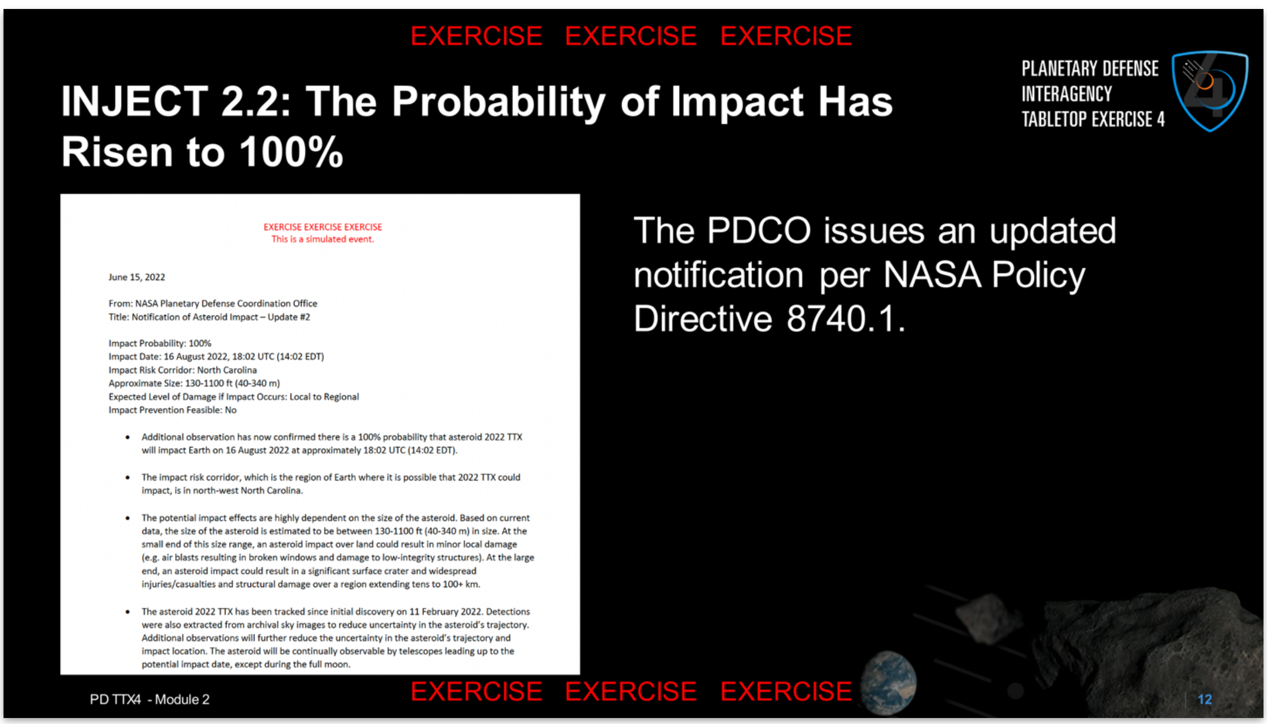

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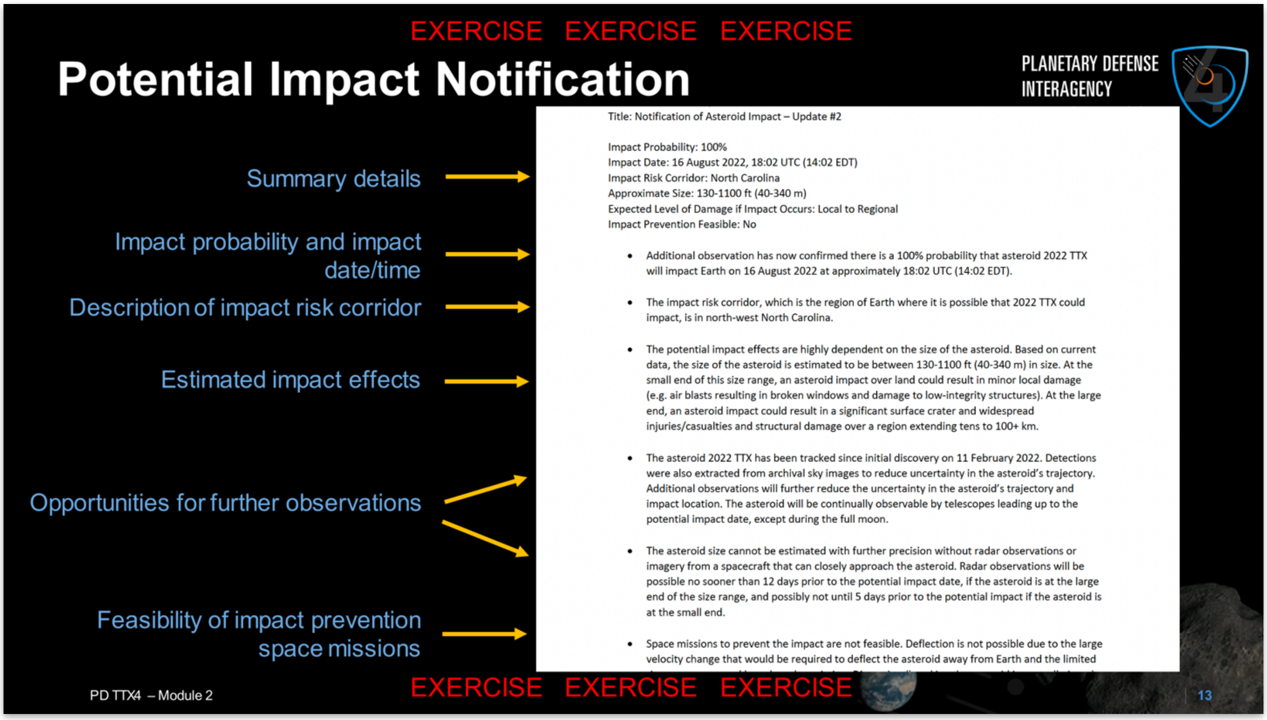

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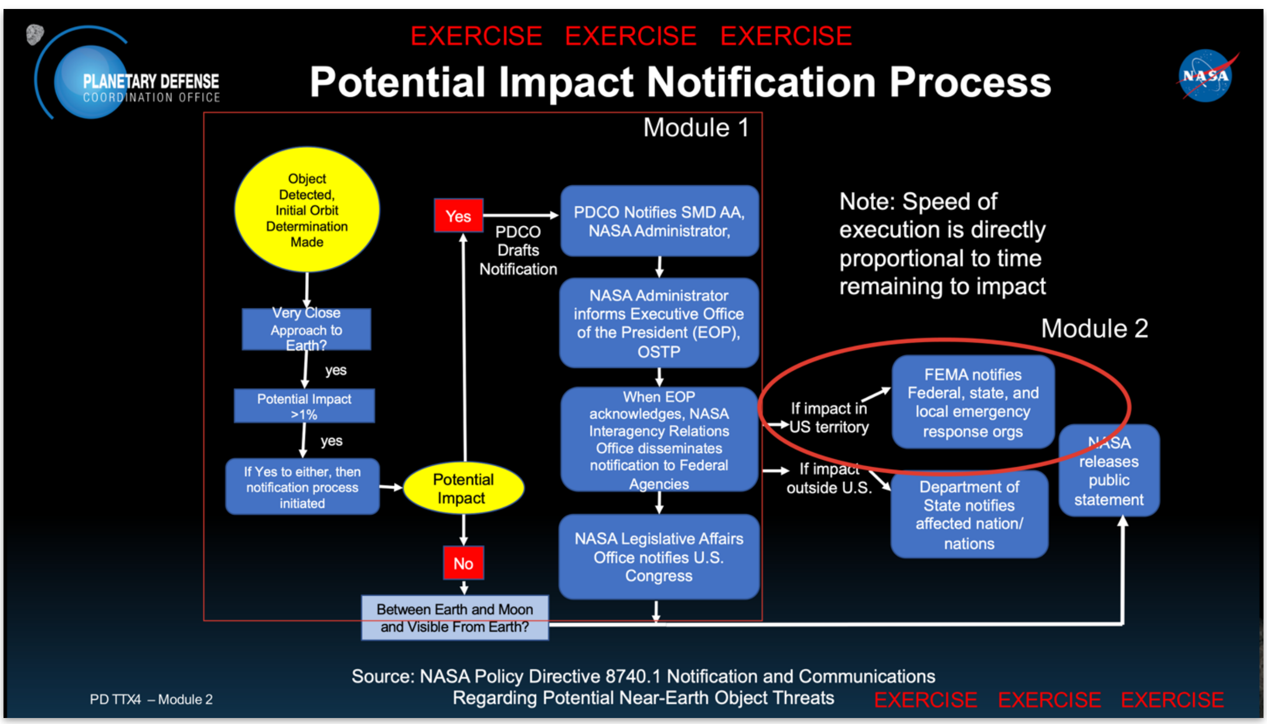

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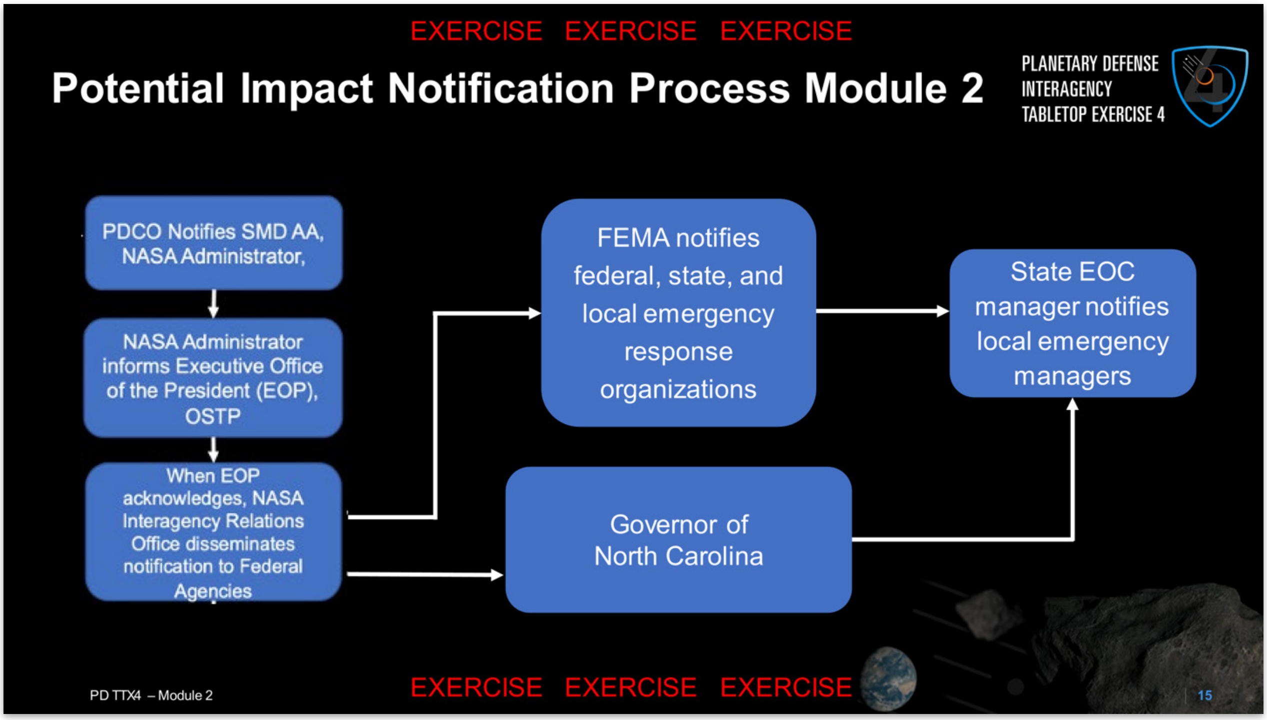

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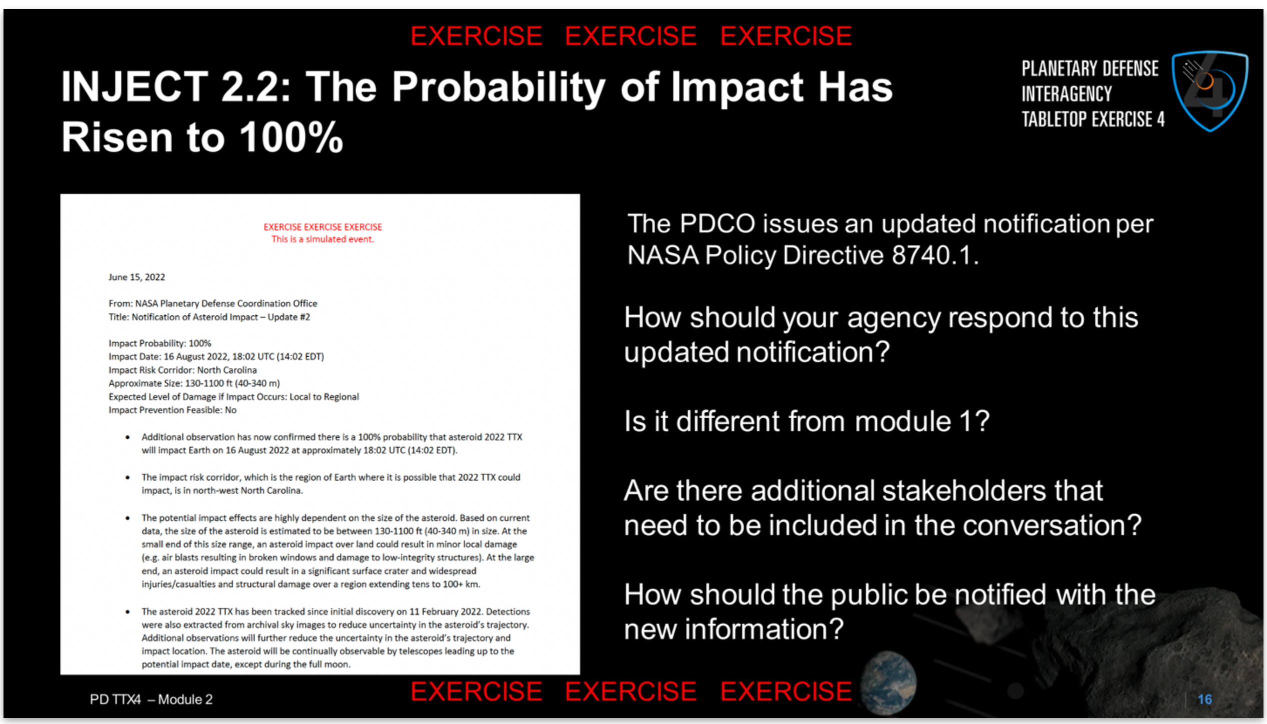

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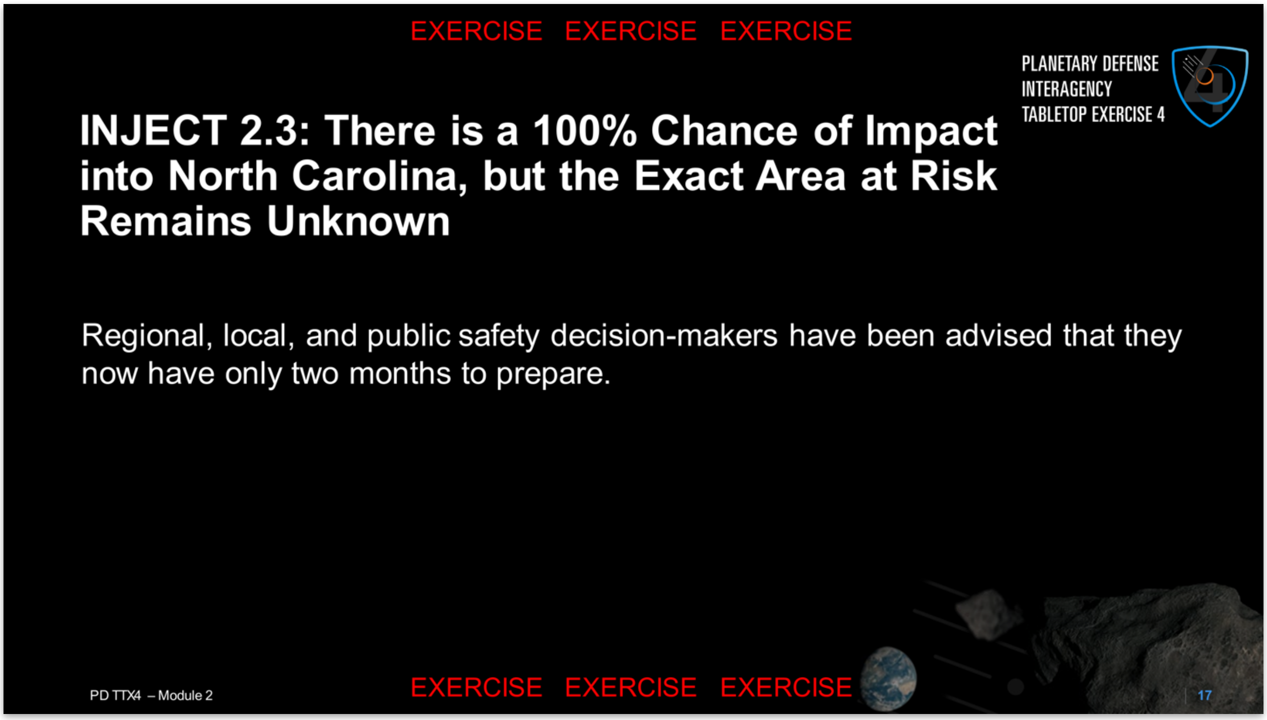

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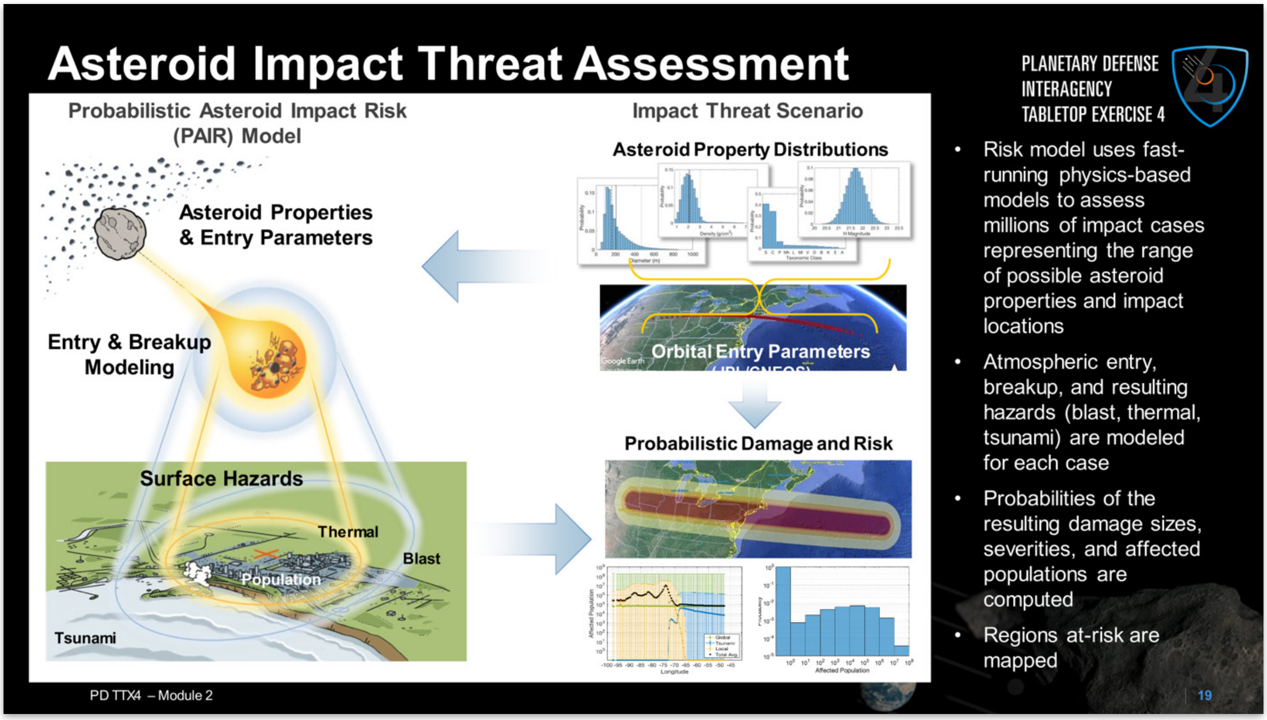

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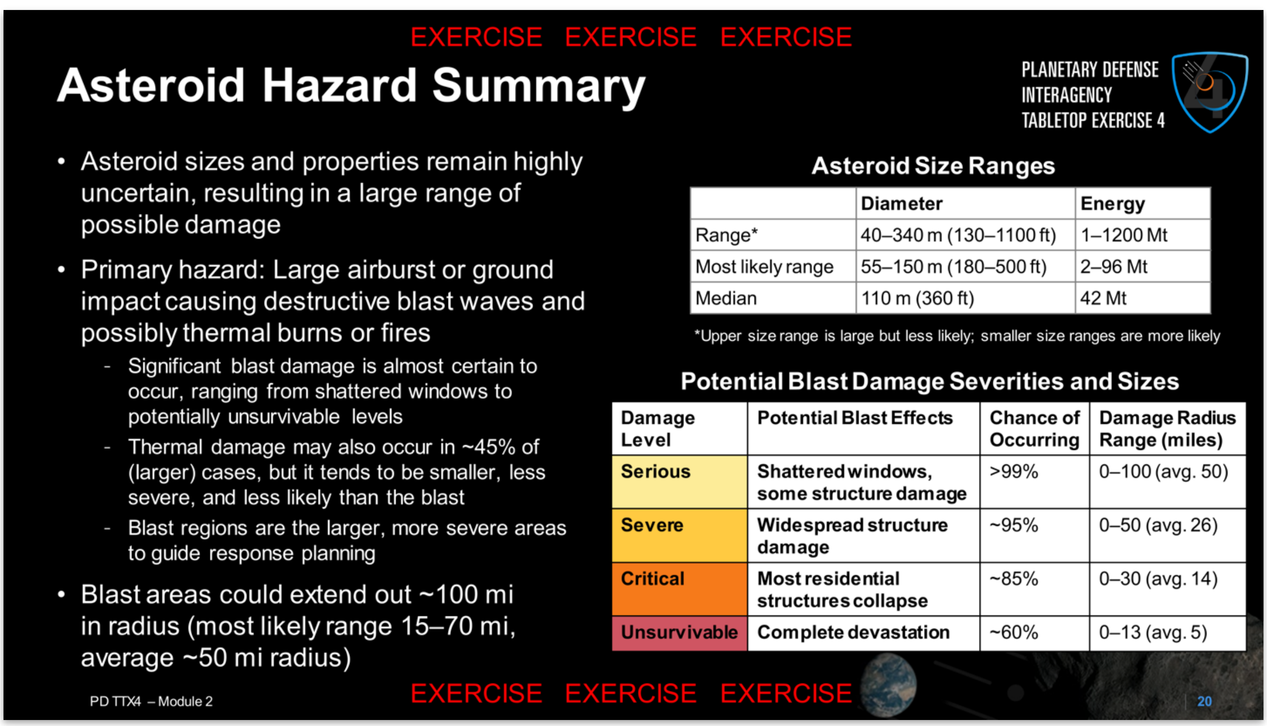

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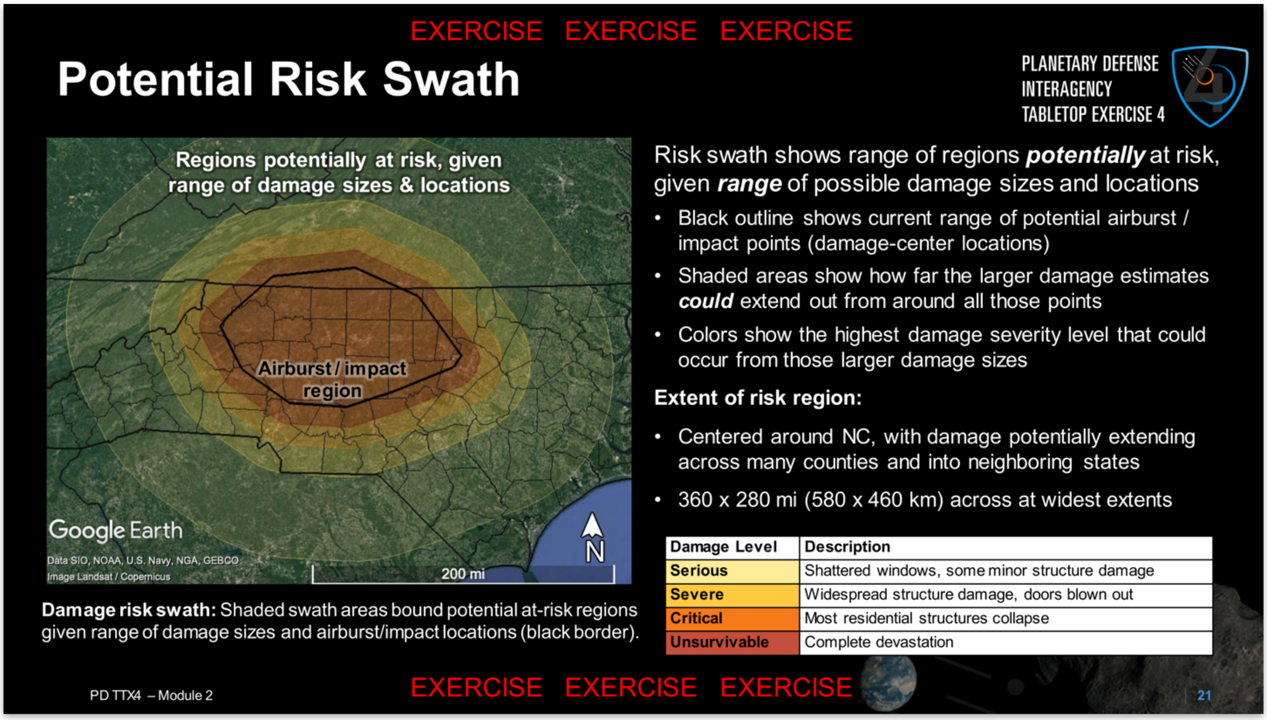

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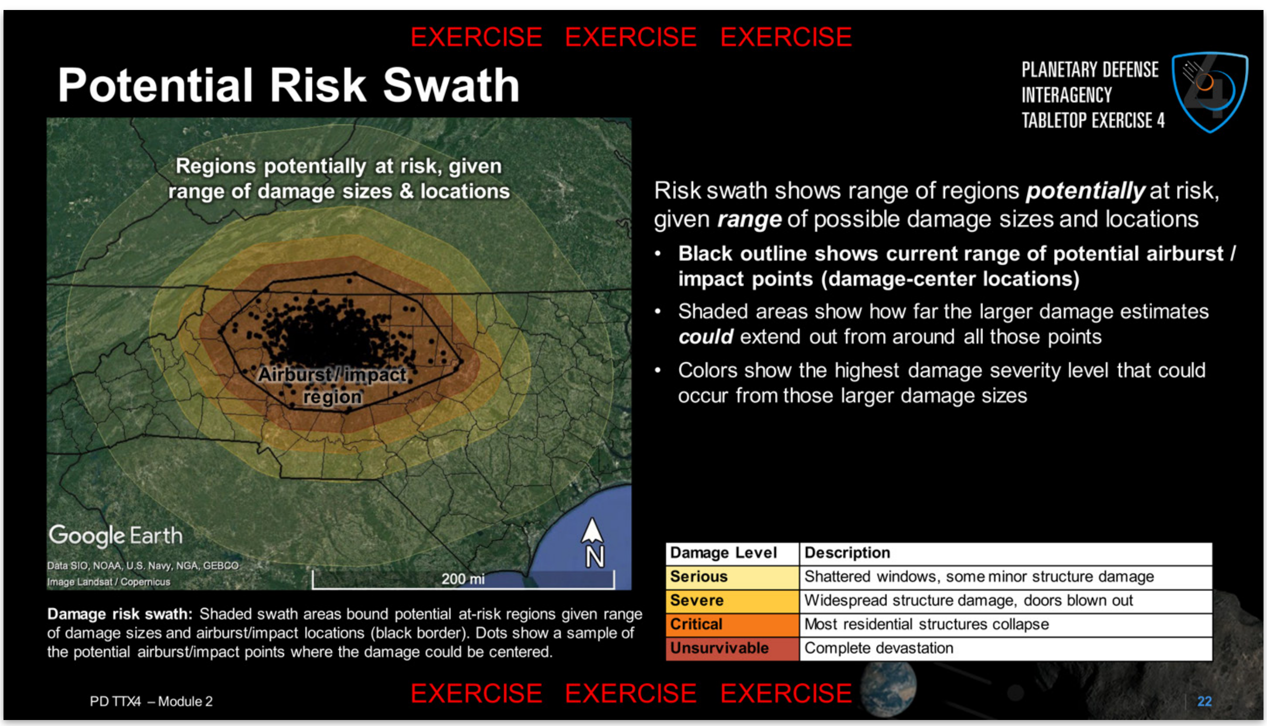

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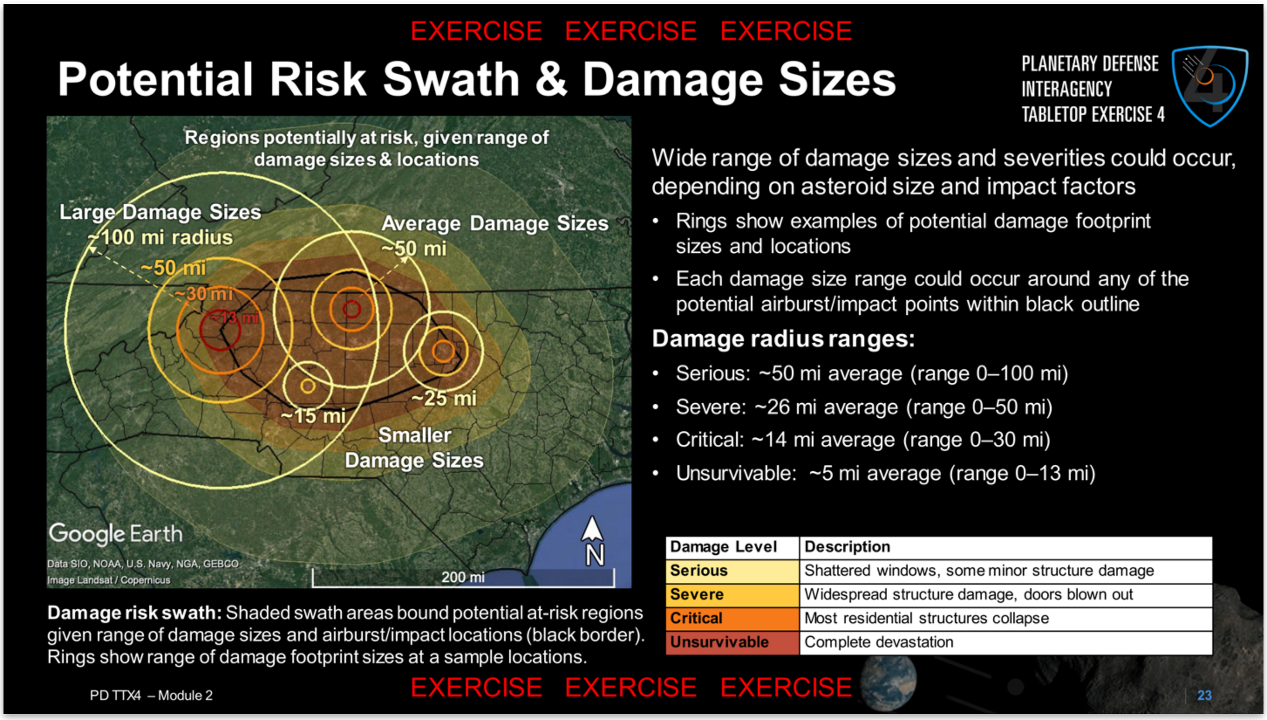

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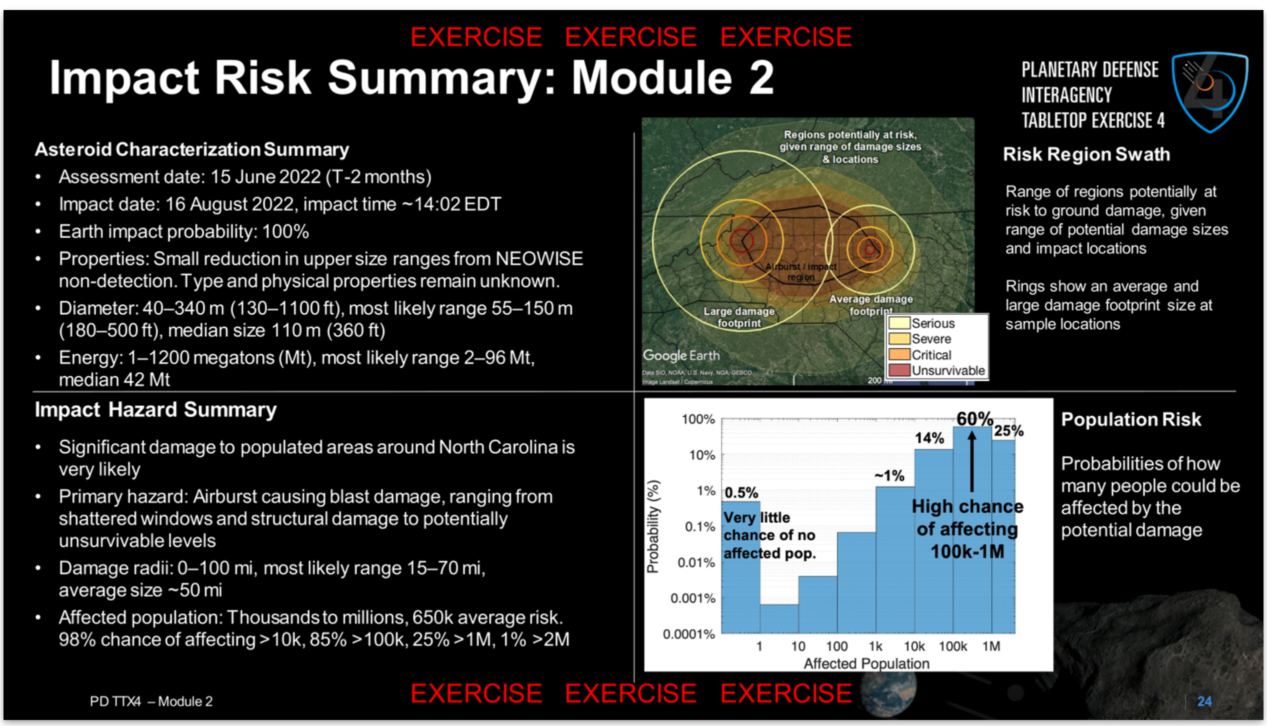

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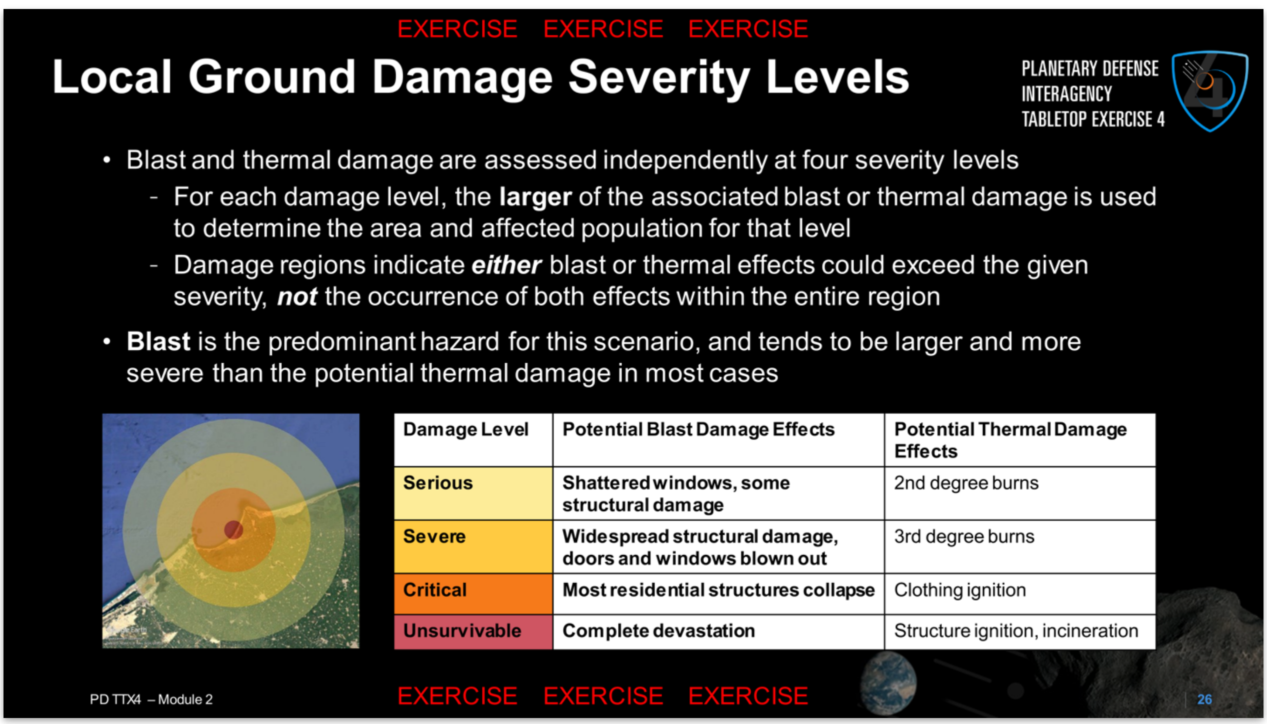

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EXERCISE EXERCISE EXERCISE

Asteroid Size & Properties

PLANETARY DEFENSE INTERAGENCY TABLETOP EXERCISE 4

Asteroid sizes and properties remain highly uncertain

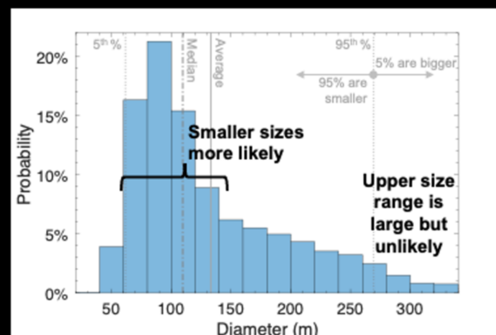
- Small reduction in upper size ranges from NEOWISE non-detection, but primary size probabilities remain similar
- Upper size range is large but relatively unlikely
- Smaller size ranges are more likely
- Type and properties are unknown, ranging from more common stony types and rubble piles to rarer high-density iron types
- Size and density uncertainties result in very large ranges of potential mass and impact energy

Large range of possible asteroid size and energy result in large range of possible damage

Asteroid Size Ranges

	Diameter	Energy
Range	40–340 m (130–1100 ft)	1–1200 Mt
Most likely range	55–150 m (180–500 ft)	2–96 Mt
Median	110 m (360 ft)	42 Mt

Asteroid Diameter Probabilities



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EXERCISE EXERCISE EXERCISE

Hazard Summary

PLANETARY DEFENSE INTERAGENCY TABLETOP EXERCISE 4

- Asteroid sizes and properties remain highly uncertain, resulting in a large range of possible damage sizes and severities
- Primary hazard: Large airburst or ground impact causing destructive blast waves and possibly thermal heat damage
  - Significant blast damage is almost certain to occur, ranging from shattered windows to potentially unsurvivable levels
  - Thermal damage may also occur, but tends to be less likely, smaller, and less severe than the blast damage
- **Outer blast damage areas could extend out ~100 mi in radius** (most likely 15–70 mi, average ~50 mi radius)

Potential Blast Damage Severities and Sizes

Damage Level	Potential Blast Effects	Chance of Occurring	Damage Radius Range (miles)
Serious	Shattered windows, some structure damage	>99%	0–100 (avg. 50)
Severe	Widespread structure damage	96%	0–47 (avg. 26)
Critical	Most residential structures collapse	86%	0–28 (avg. 14)
Unsurvivable	Complete devastation	61%	0–13 (avg. 5)

Potential Thermal Damage Severities and Sizes

Damage Level	Potential Thermal Effects	Chance of Occurring	Damage Radius Range (miles)
Serious	2nd degree burns	44%	0–22 (avg. 5)
Severe	3rd degree burns	37%	0–17 (avg. 4)
Critical	Clothing ignition	28%	0–12 (avg. 2)
Unsurvivable	Structure ignition	24%	0–10 (avg. ~1)

PD TTX4 – Module 2 EXERCISE EXERCISE EXERCISE 28

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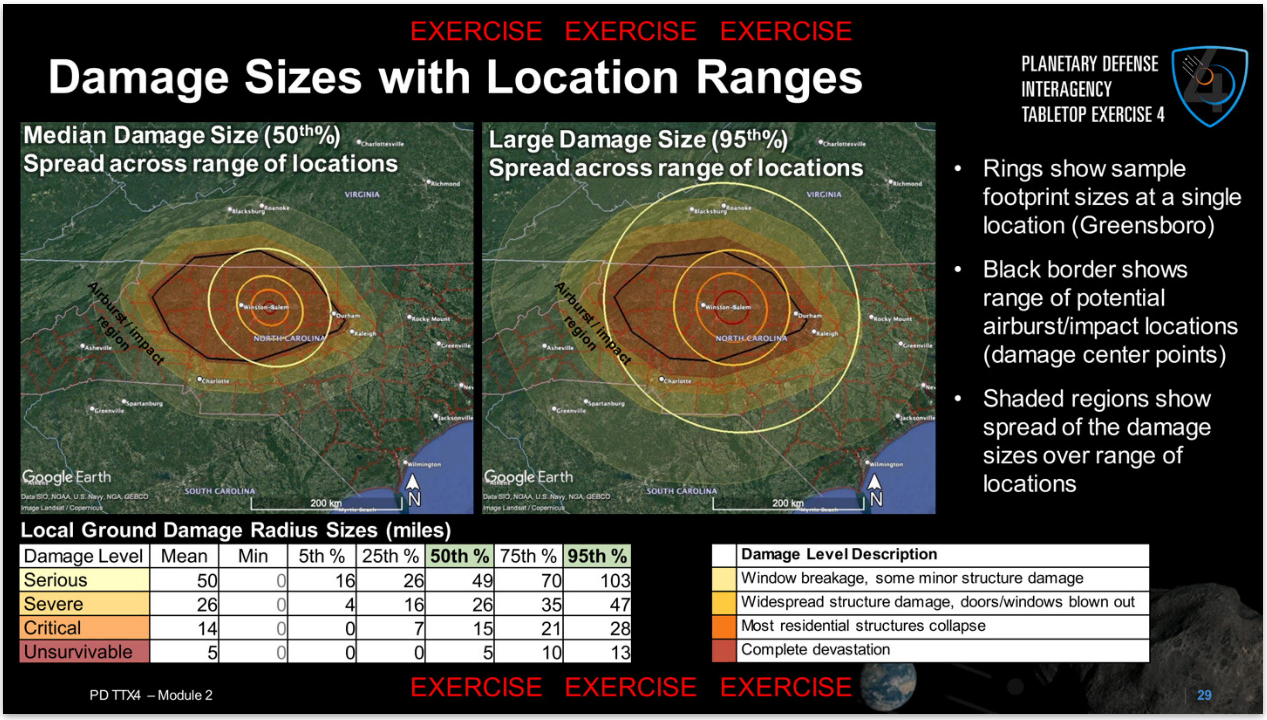

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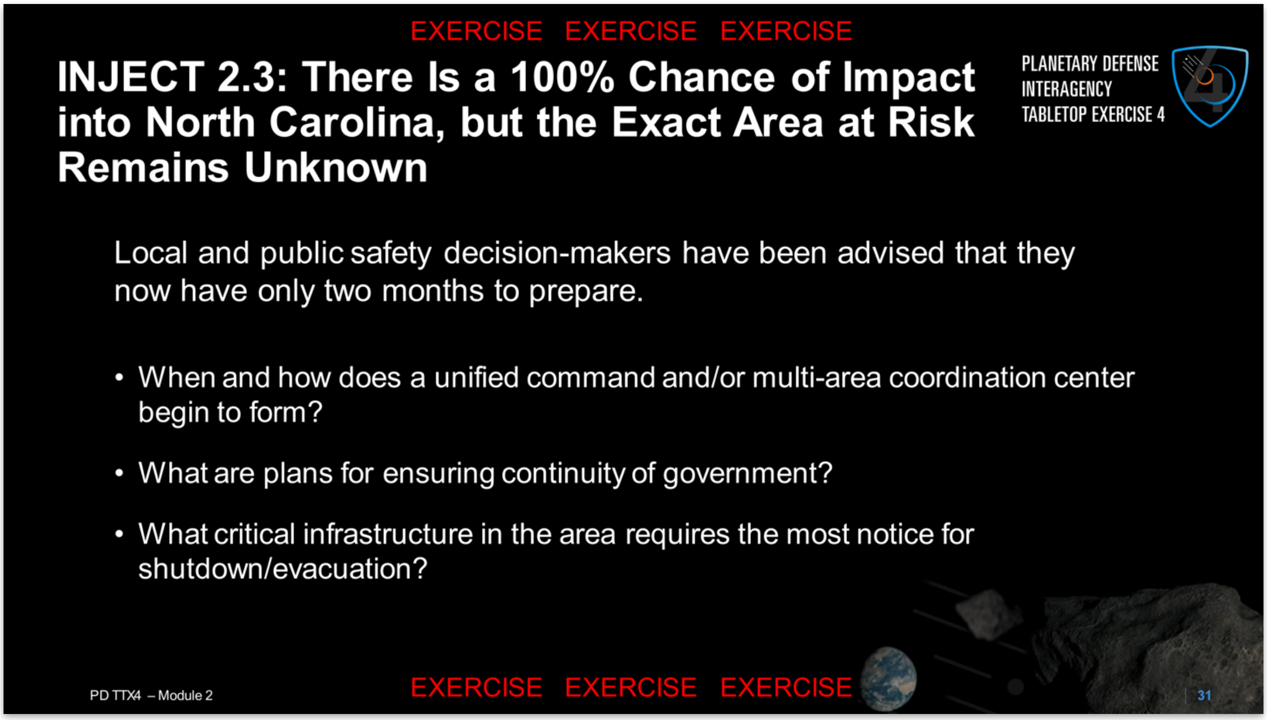

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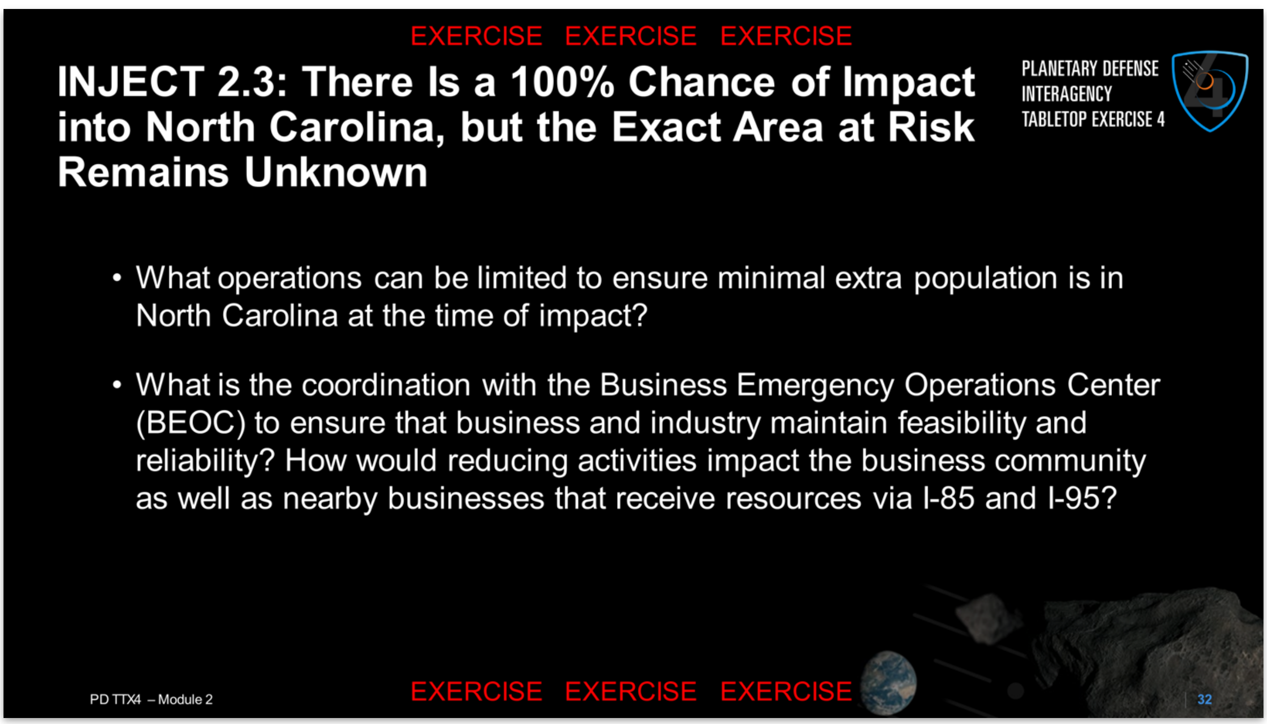

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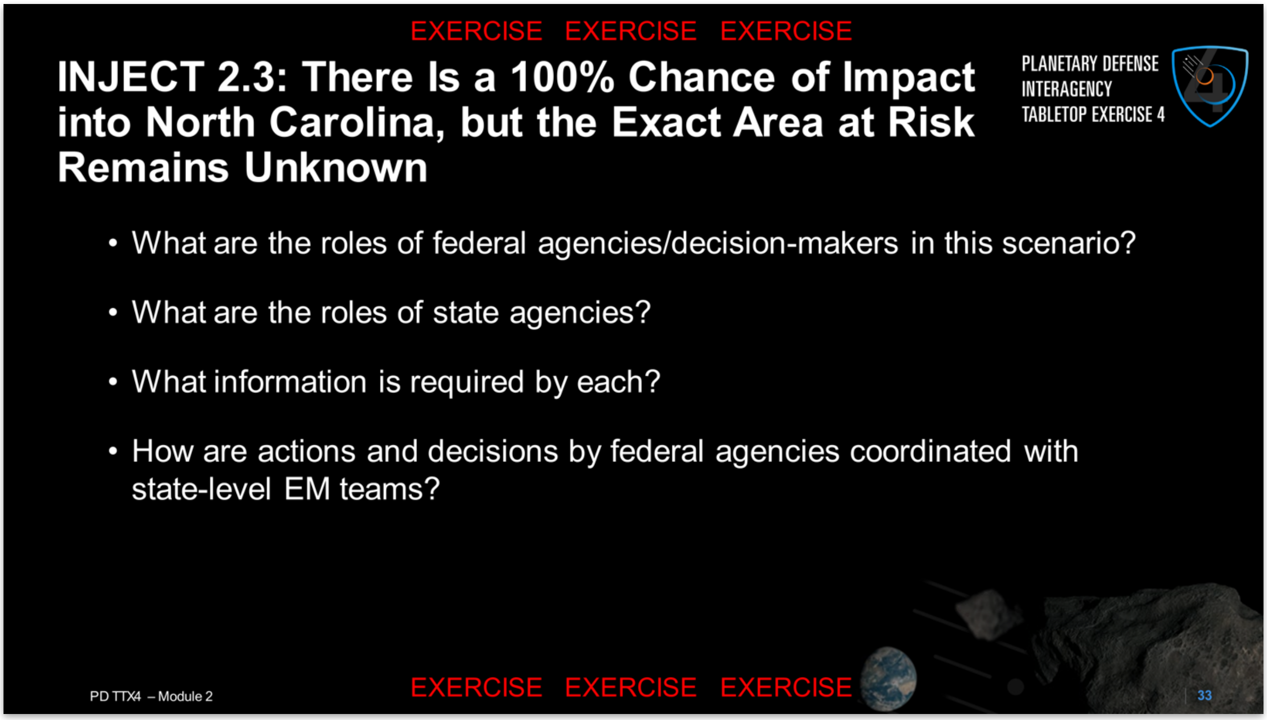

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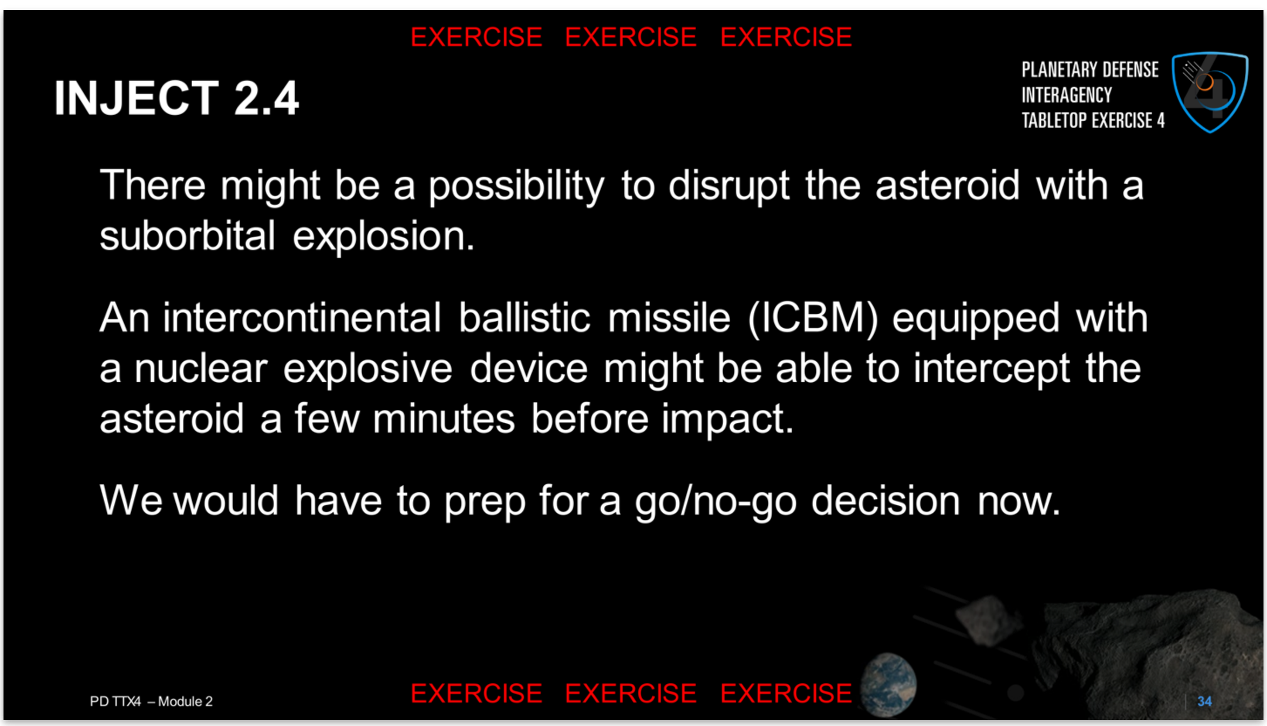

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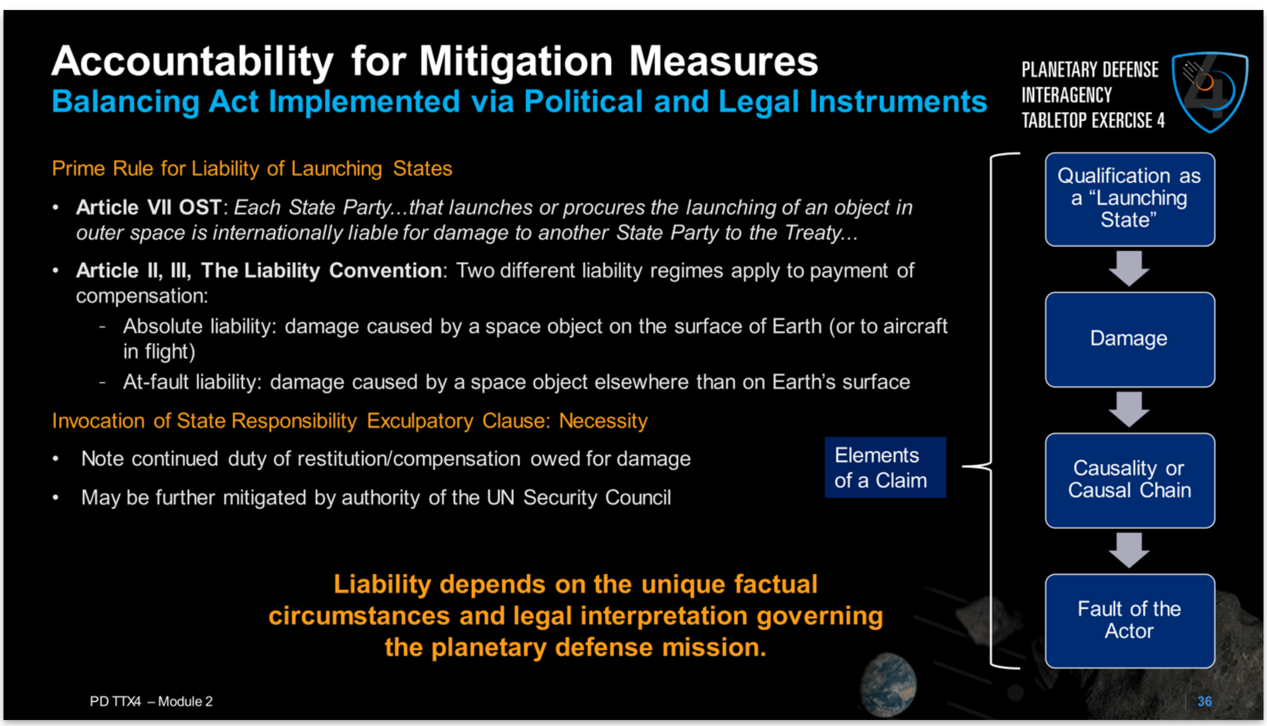

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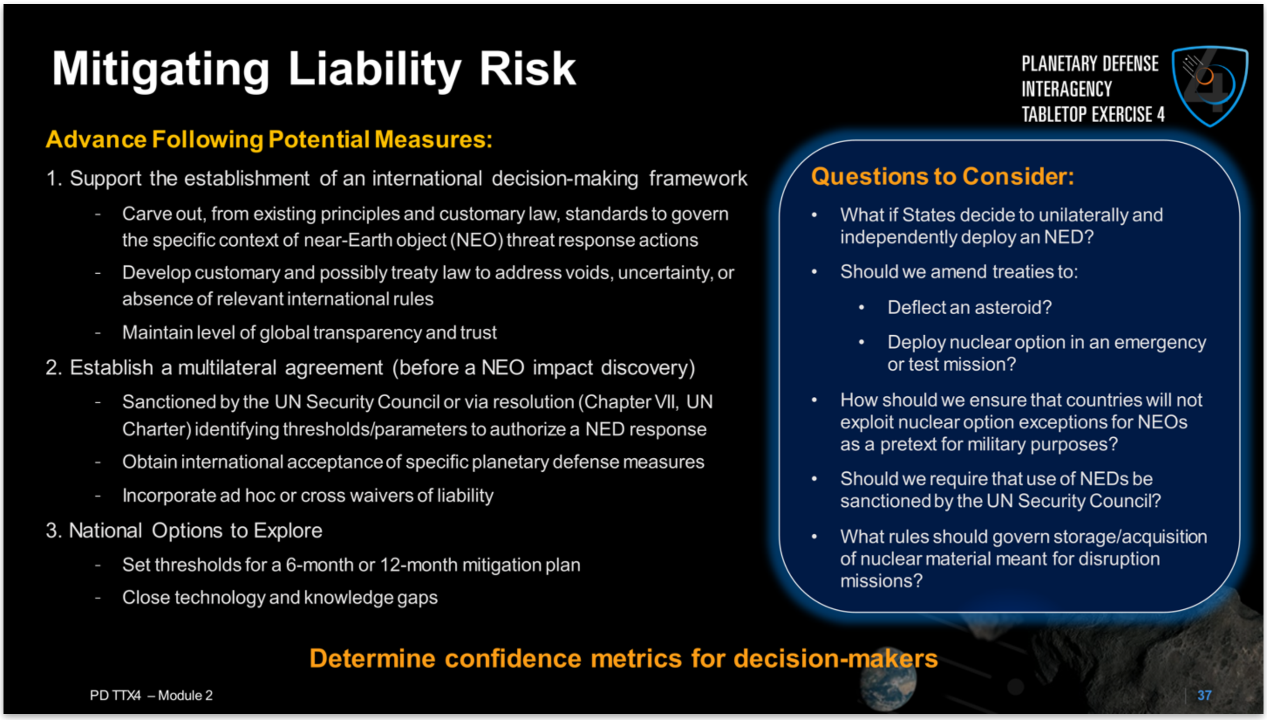

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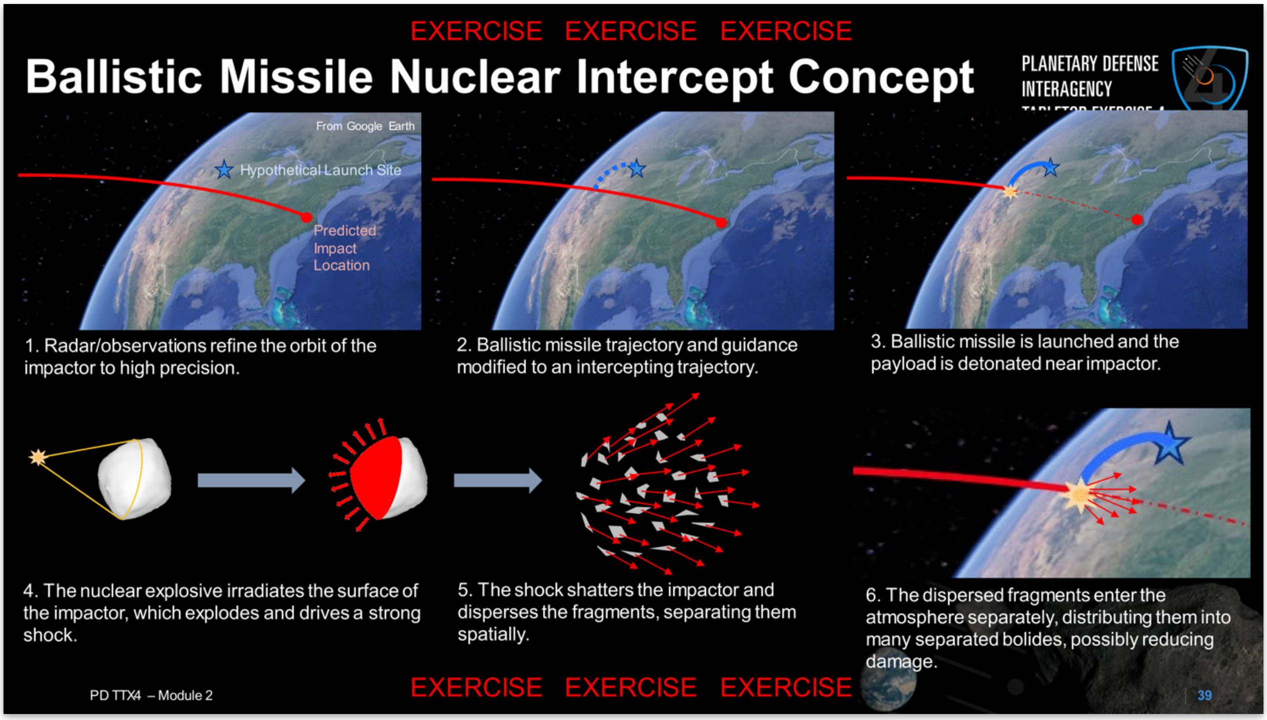

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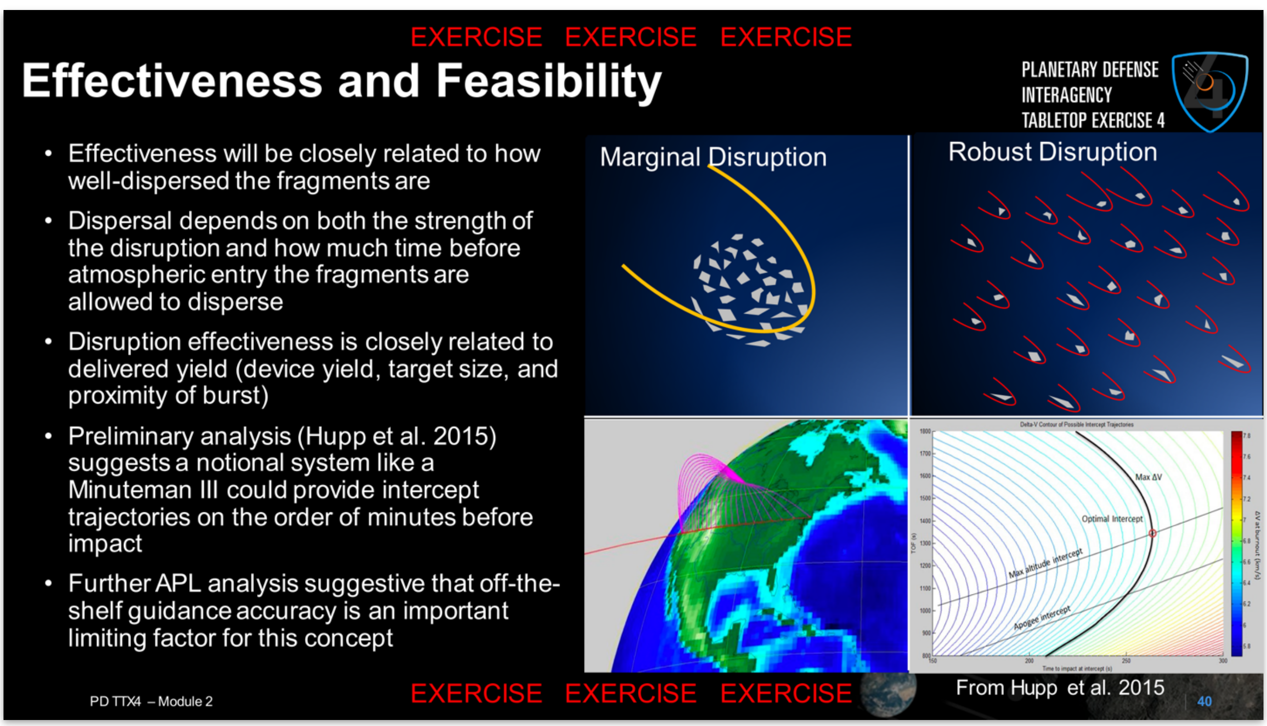

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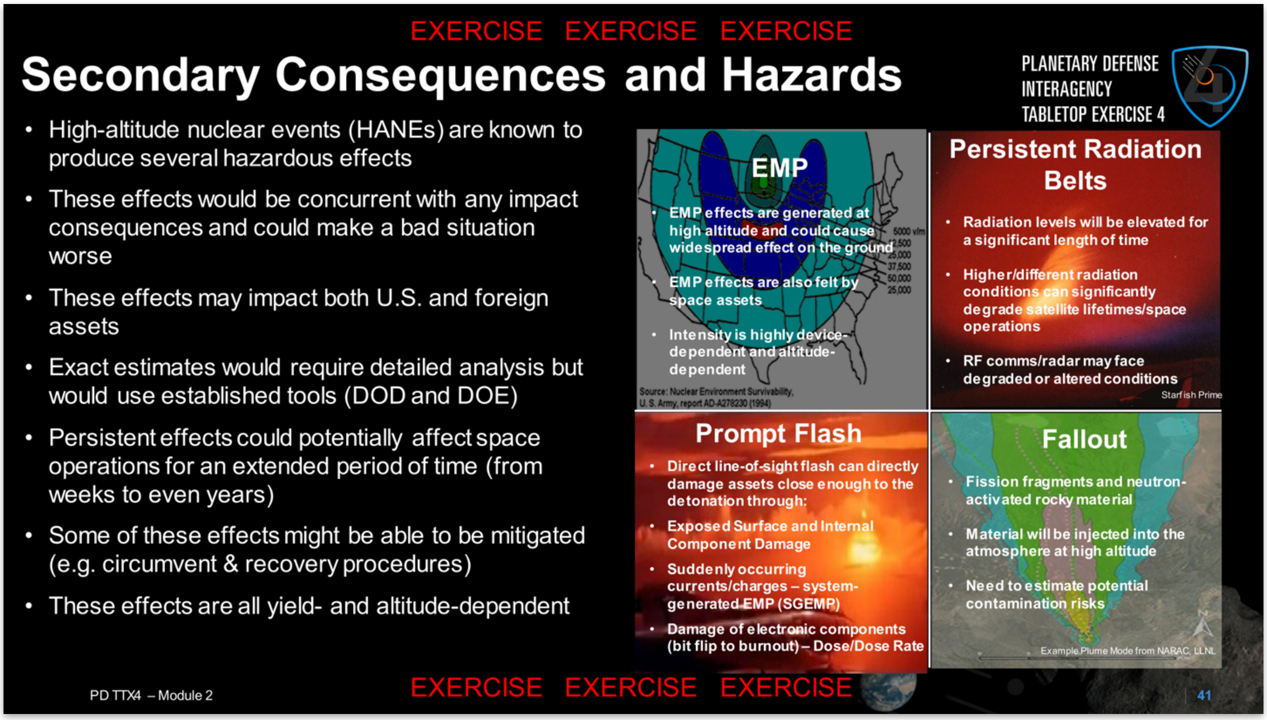

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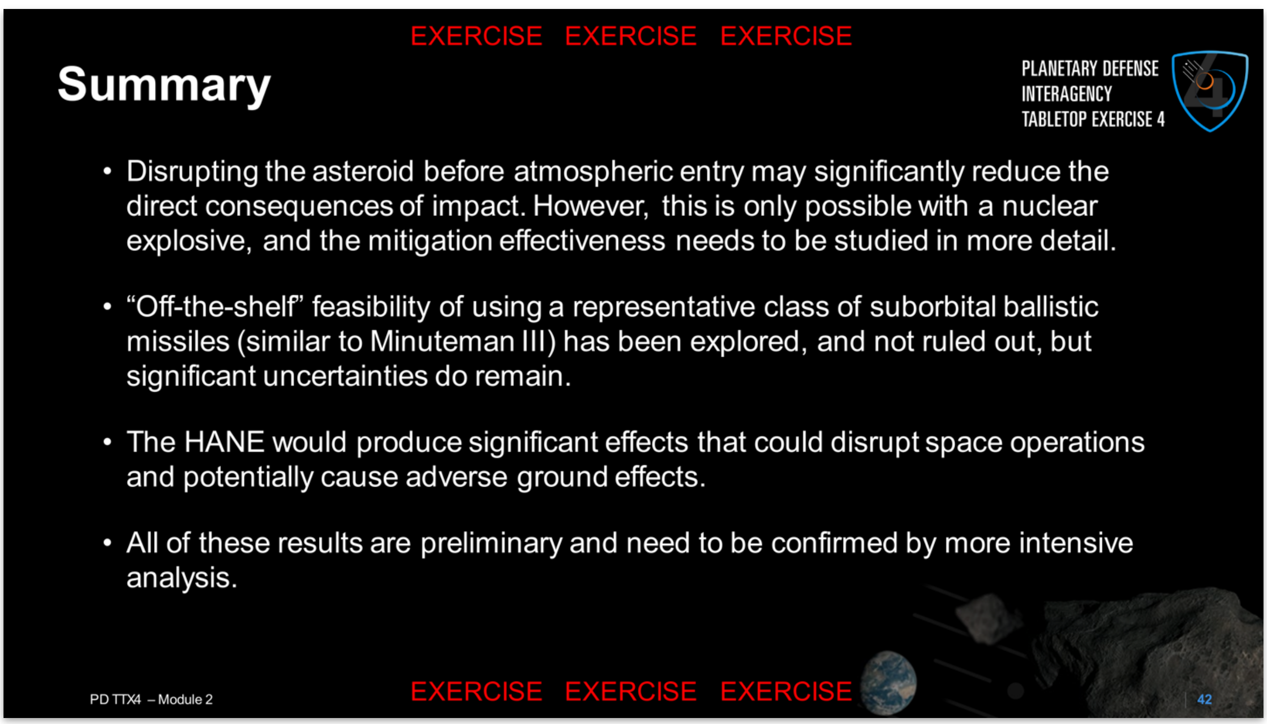

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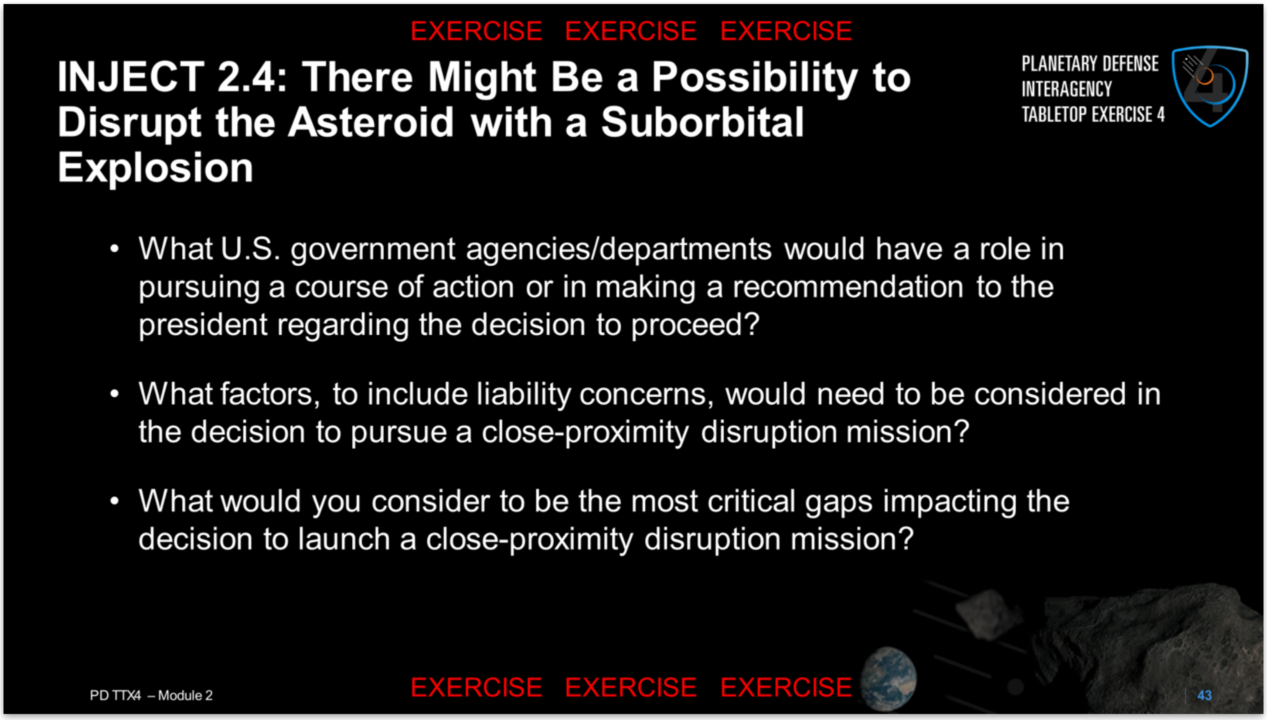

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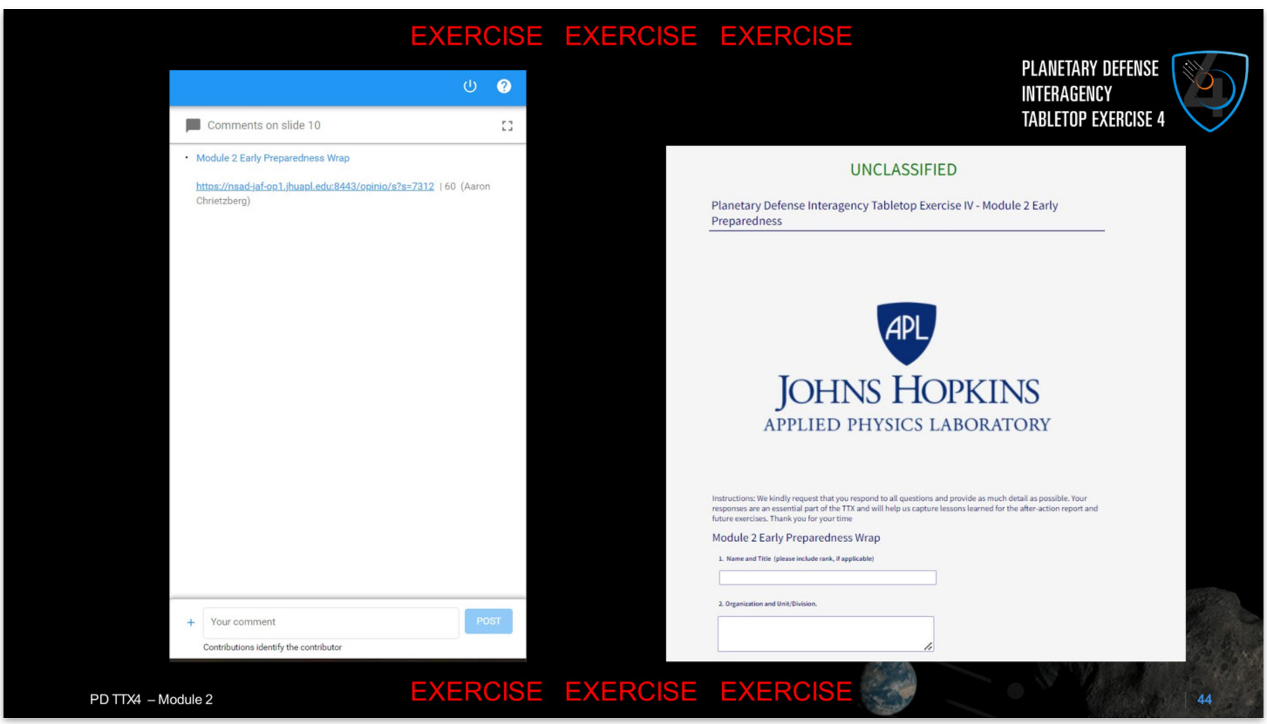

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C.6 Module 3

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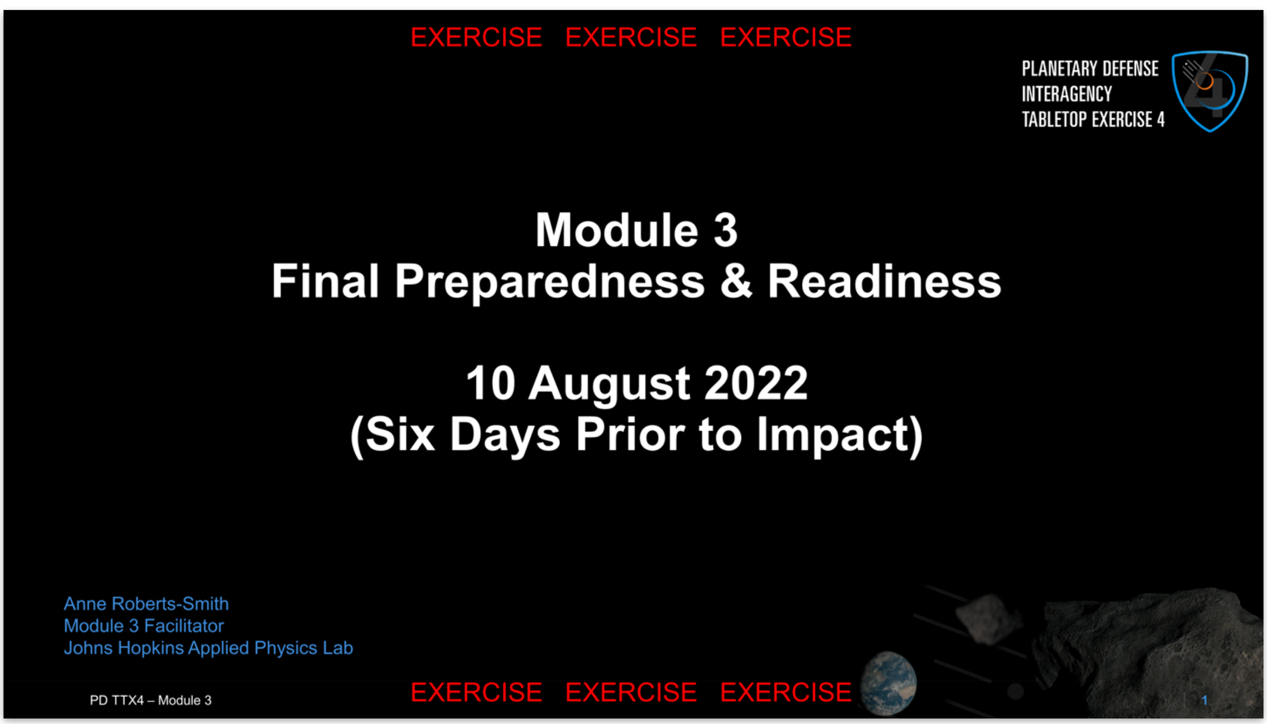

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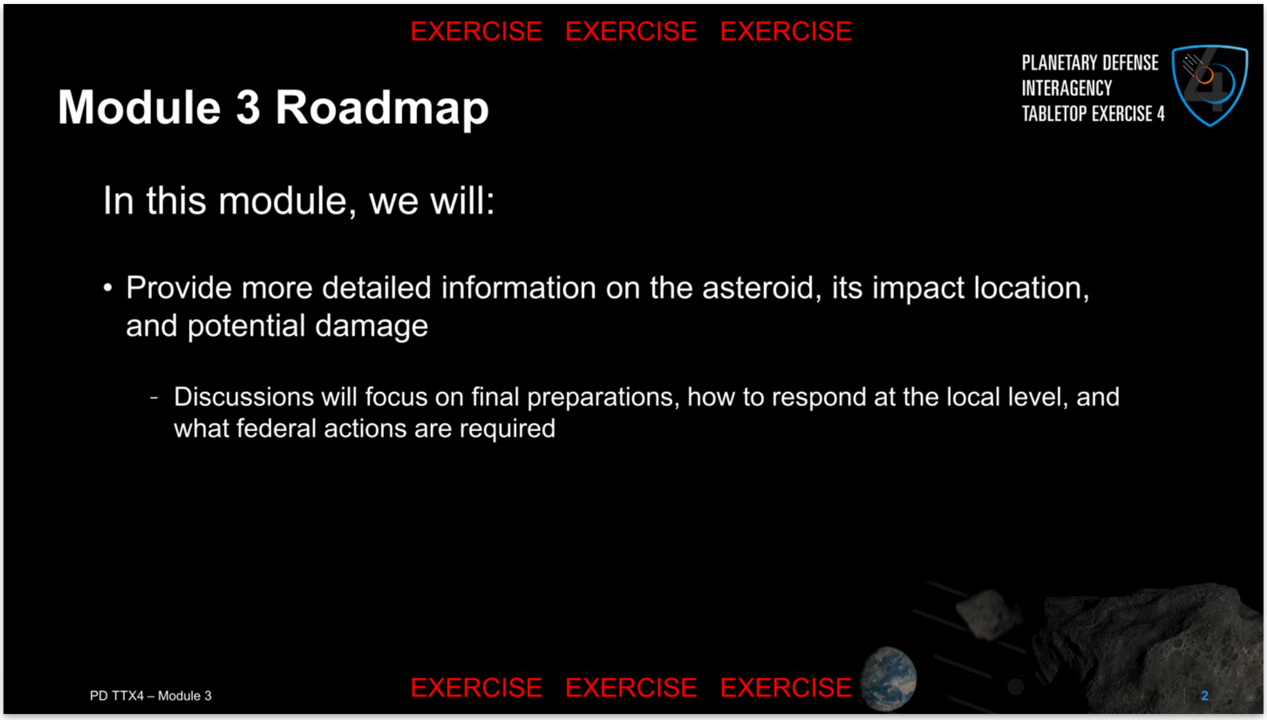

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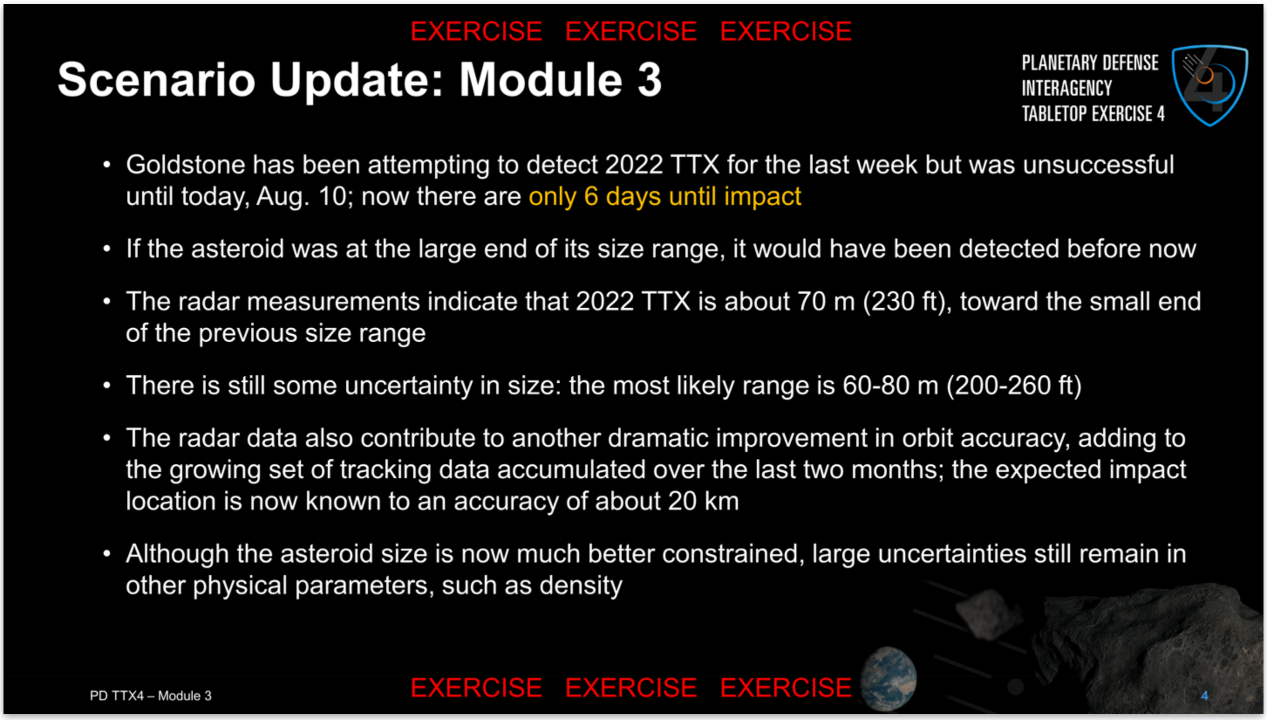

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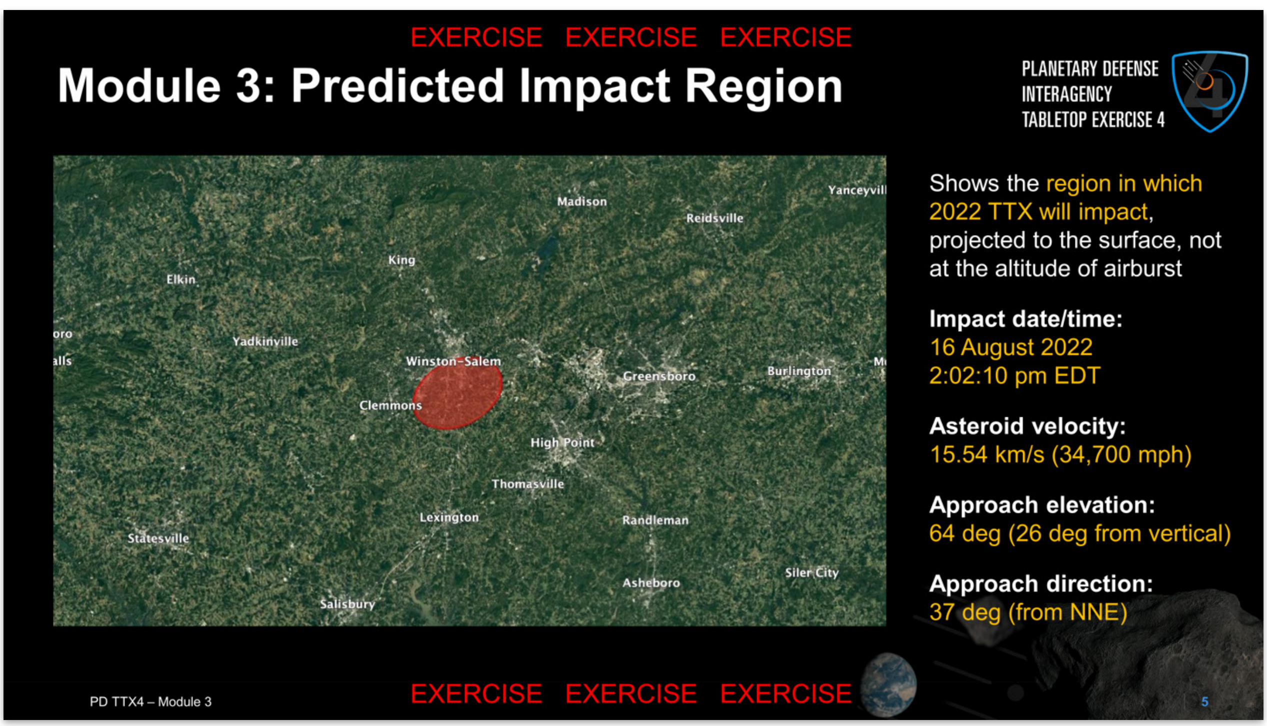

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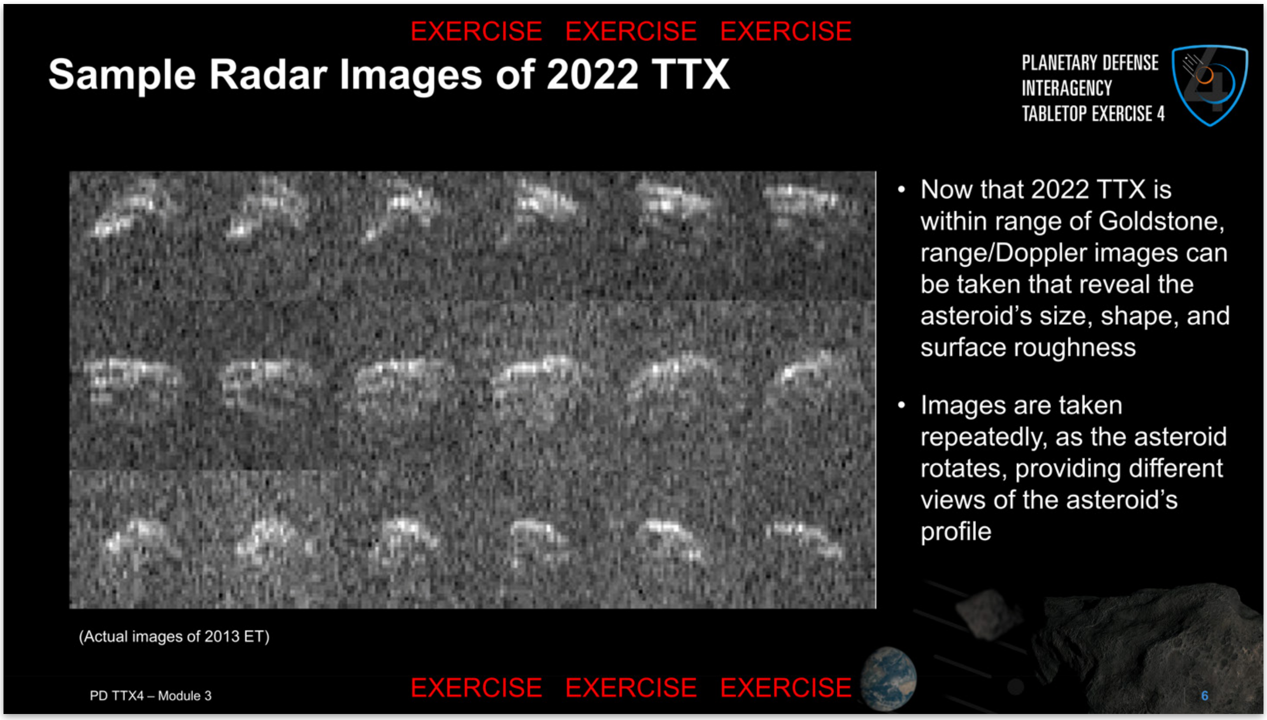

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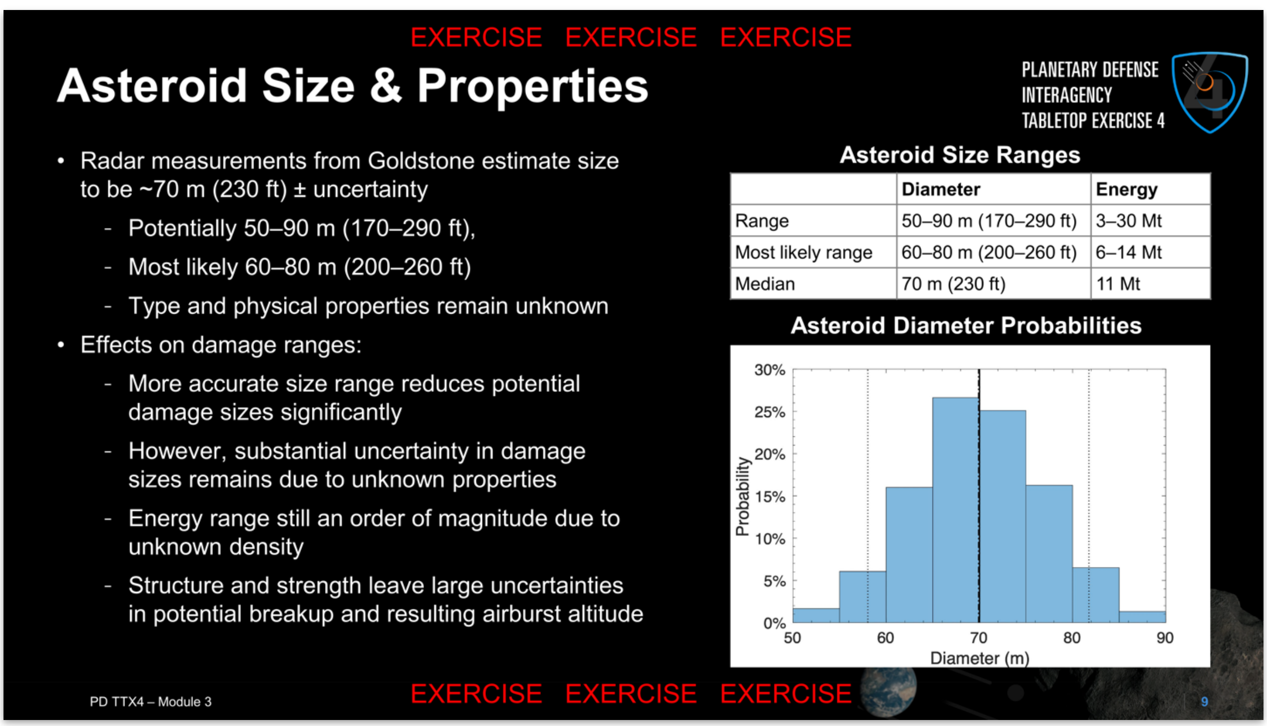

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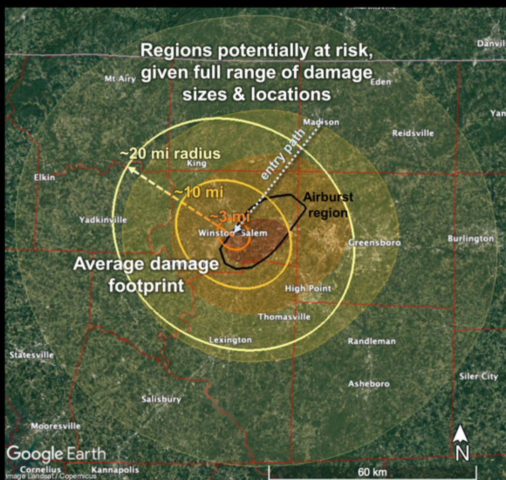
EXERCISE EXERCISE EXERCISE

Potential Risk Swath

PLANETARY DEFENSE INTERAGENCY TABLETOP EXERCISE 4



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

PD TTX4 – Module 3

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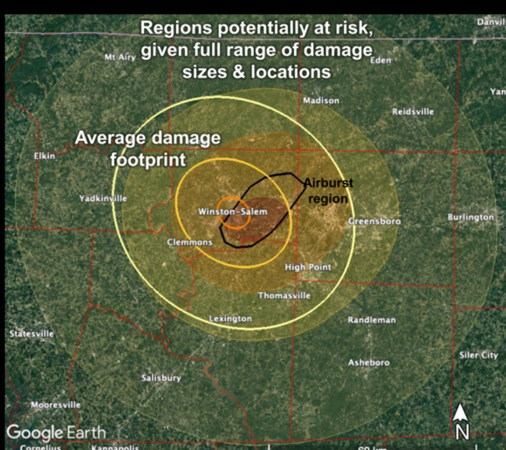
Likelihood of Damage Severities

PLANETARY DEFENSE INTERAGENCY TABLETOP EXERCISE 4



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)

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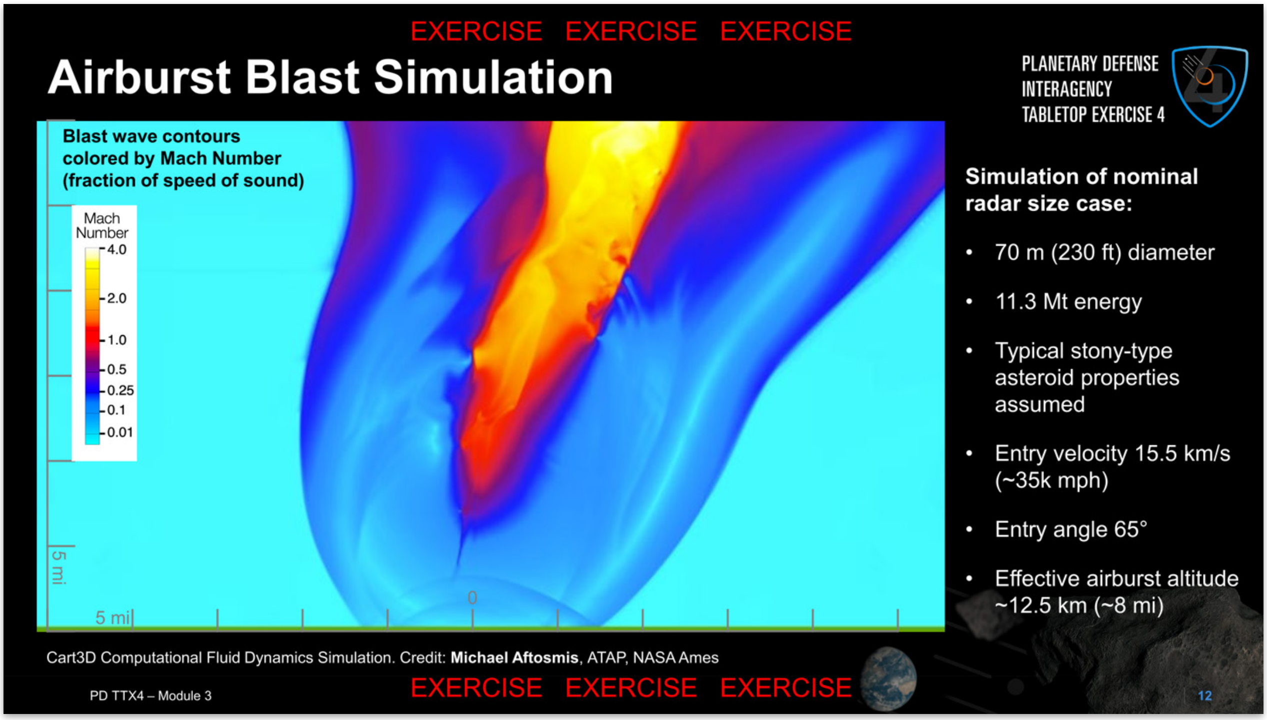

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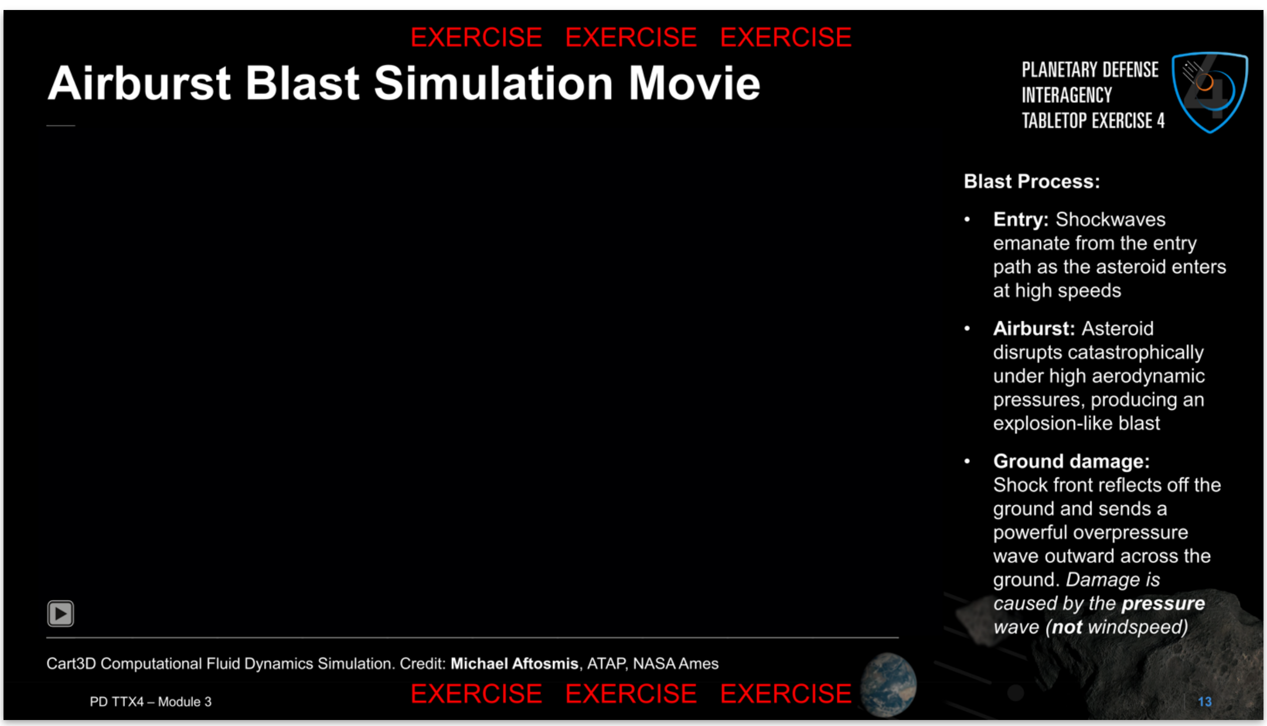

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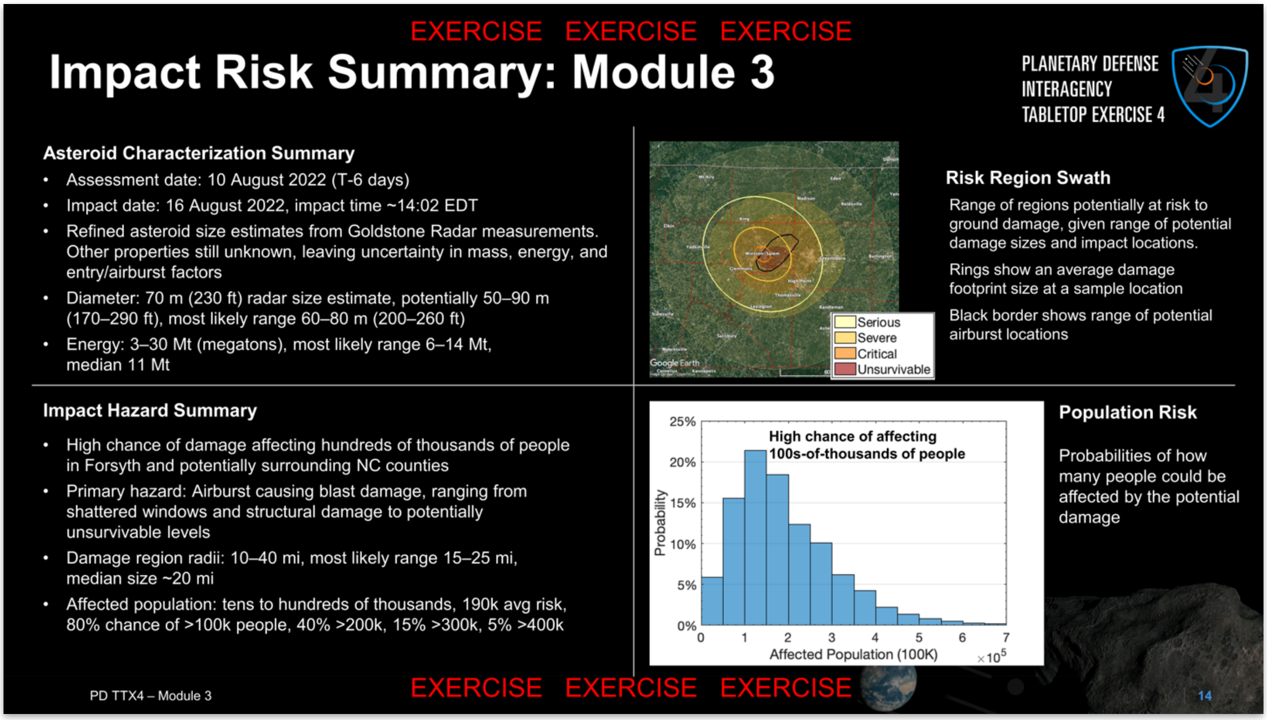

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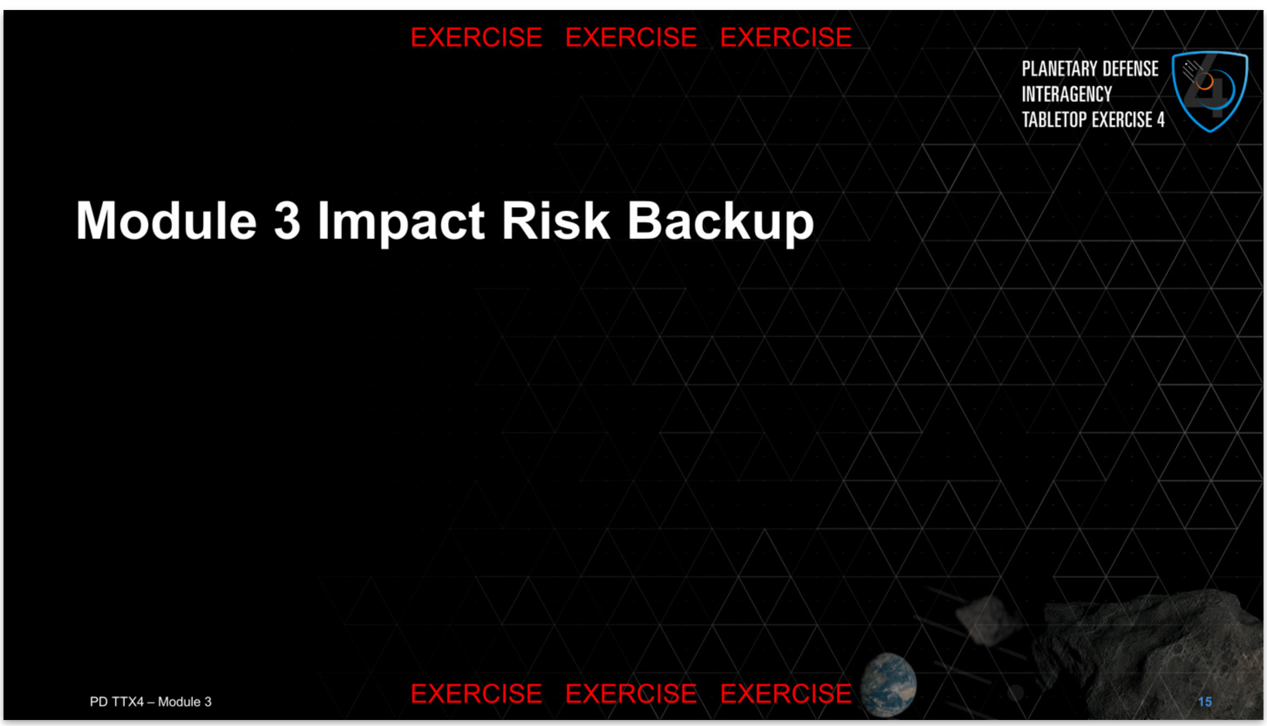

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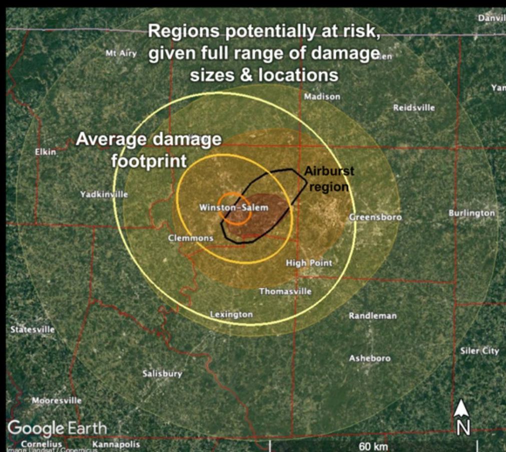
Potential Risk Swath

PLANETARY DEFENSE INTERAGENCY TABLETOP EXERCISE 4



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

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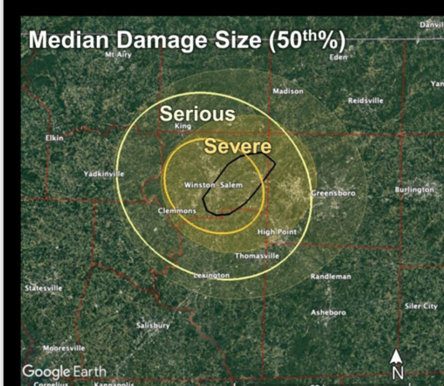
Damage Sizes with Location Ranges

PLANETARY DEFENSE INTERAGENCY TABLETOP EXERCISE 4



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

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

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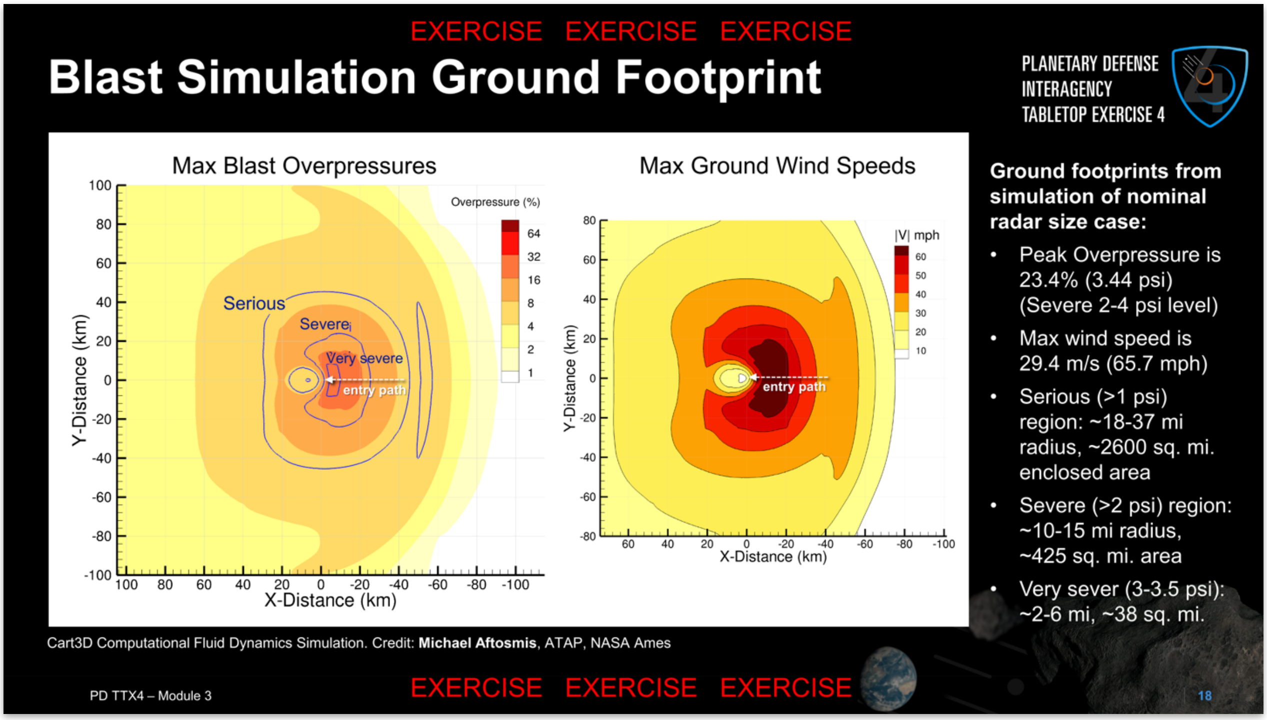

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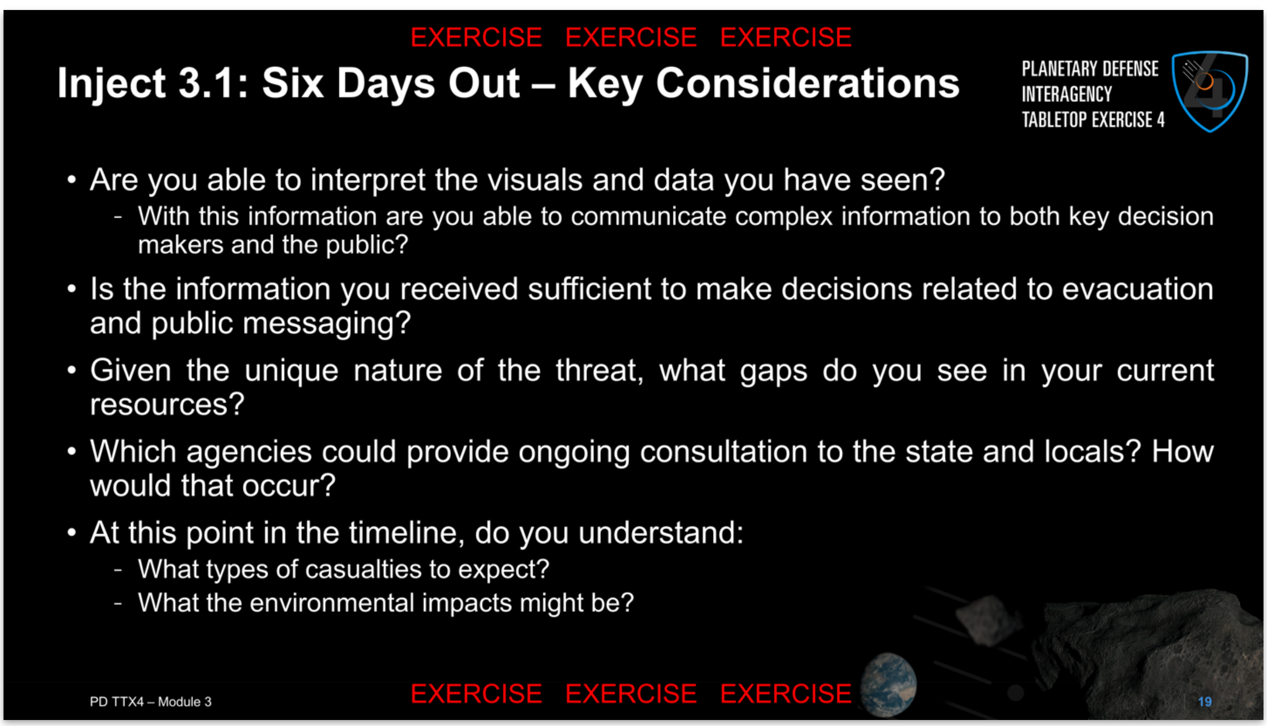

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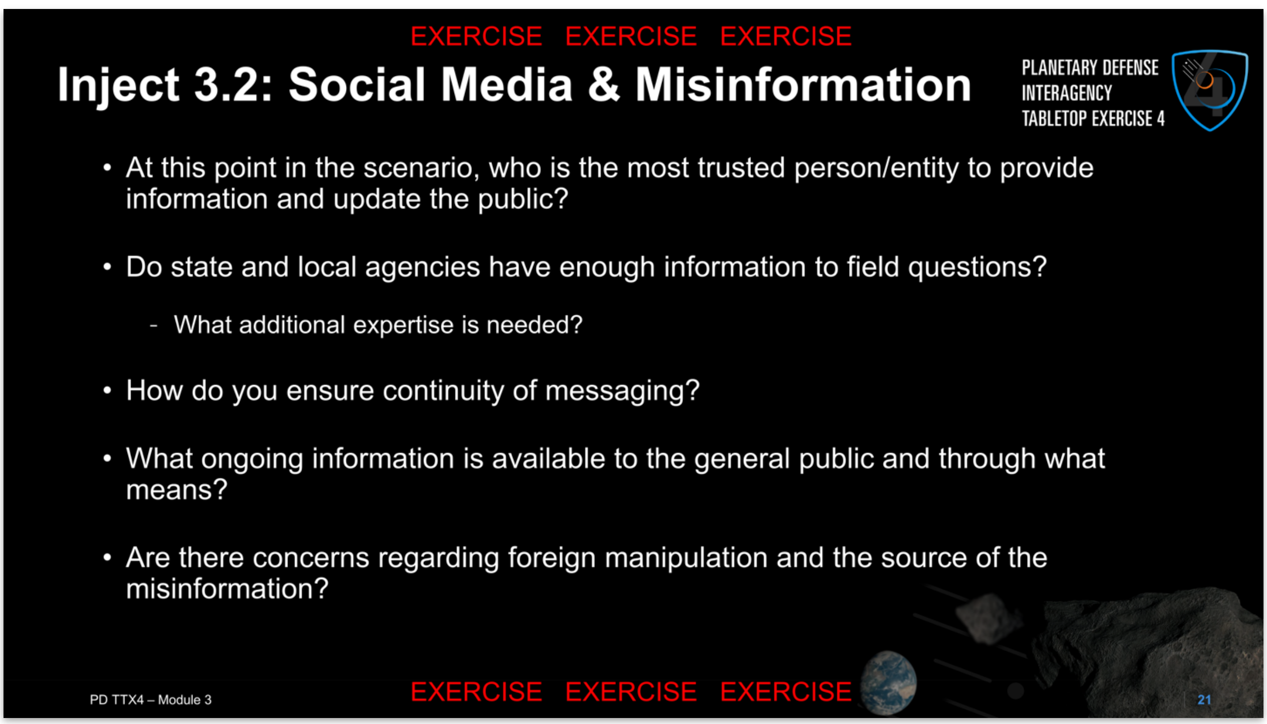

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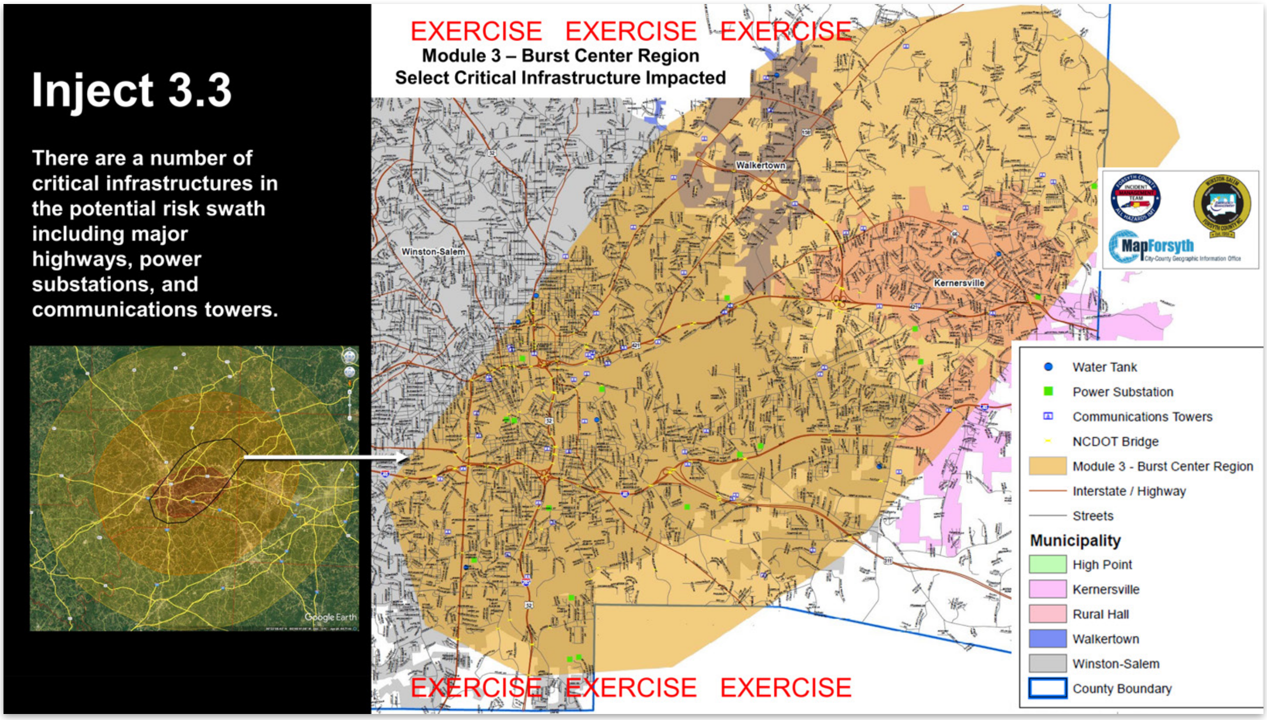

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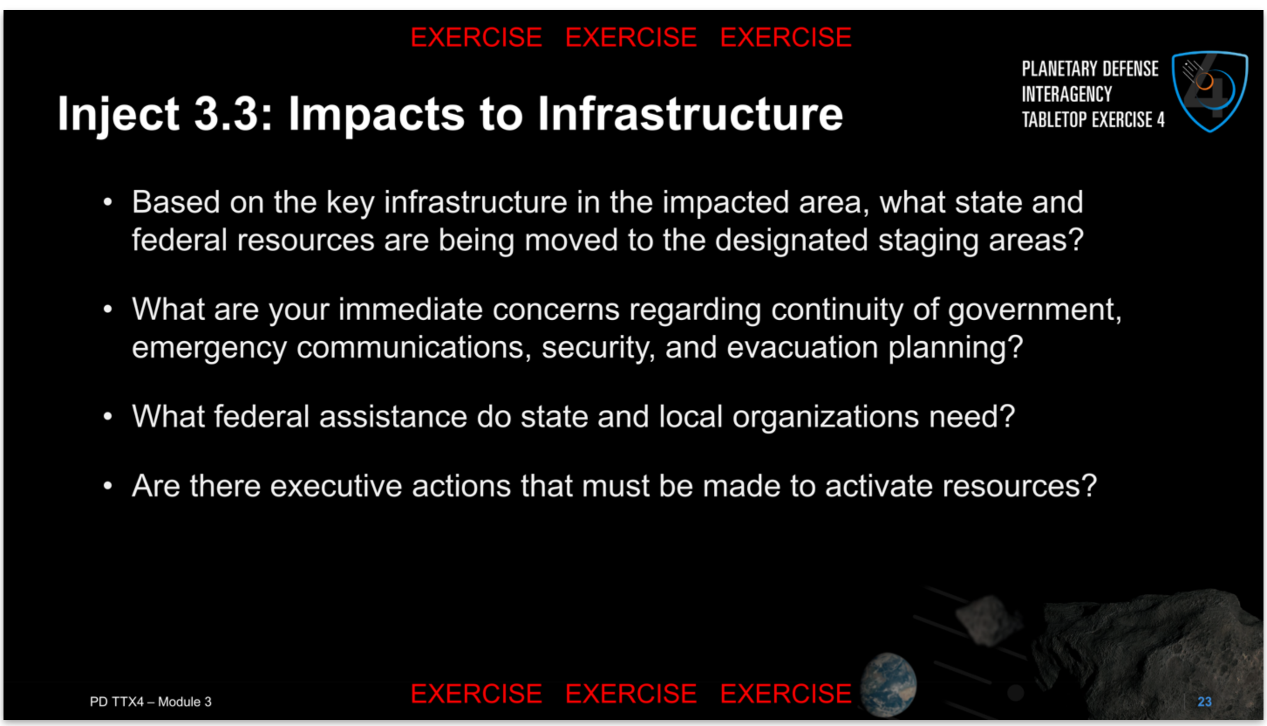

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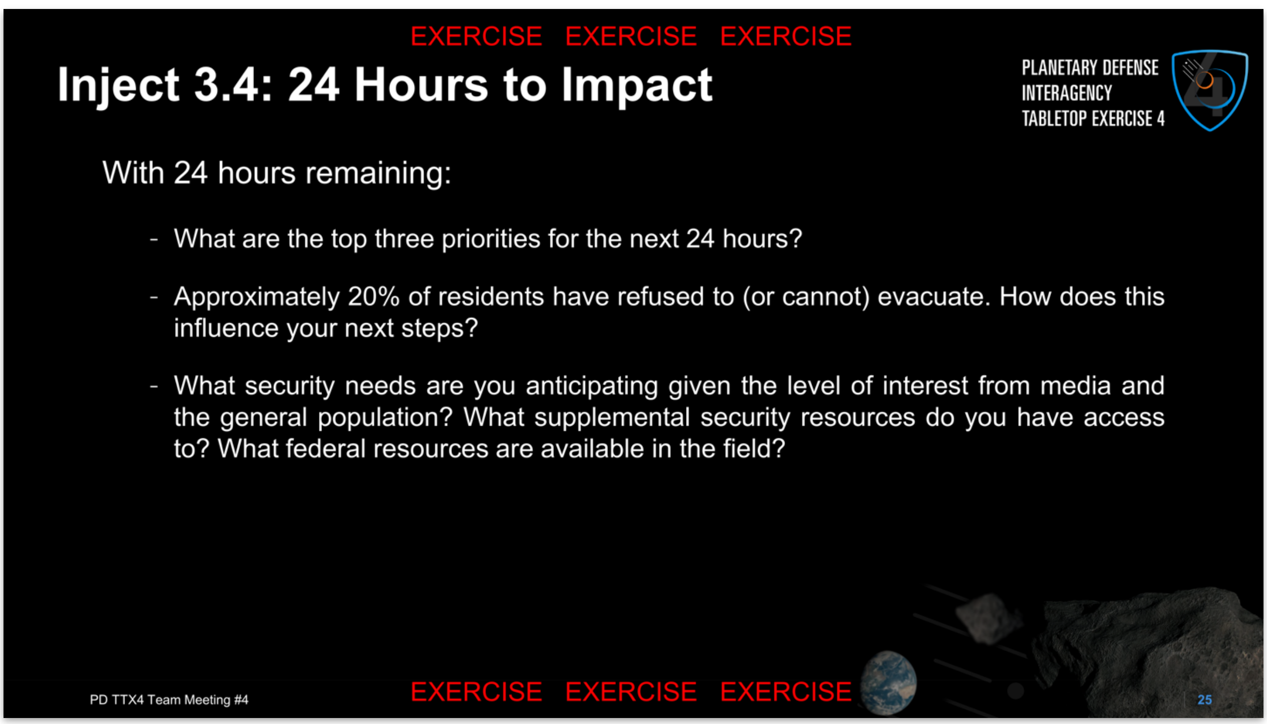

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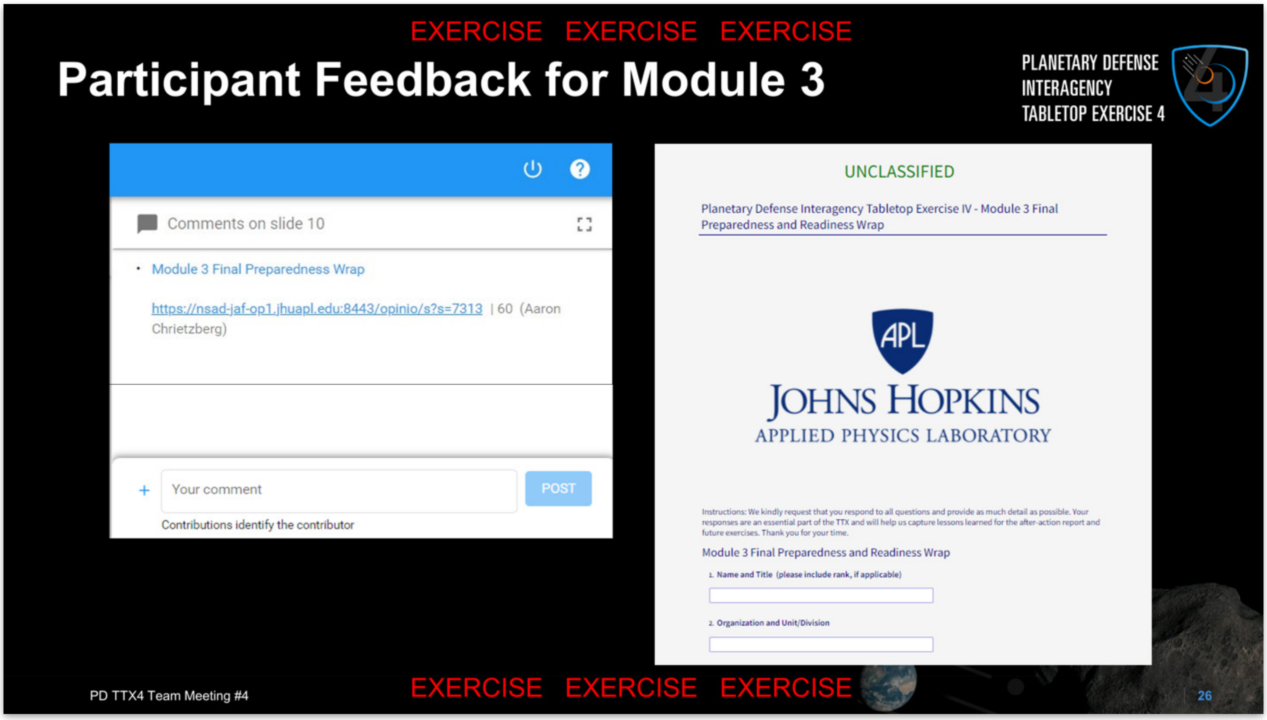

C.7 Module 4

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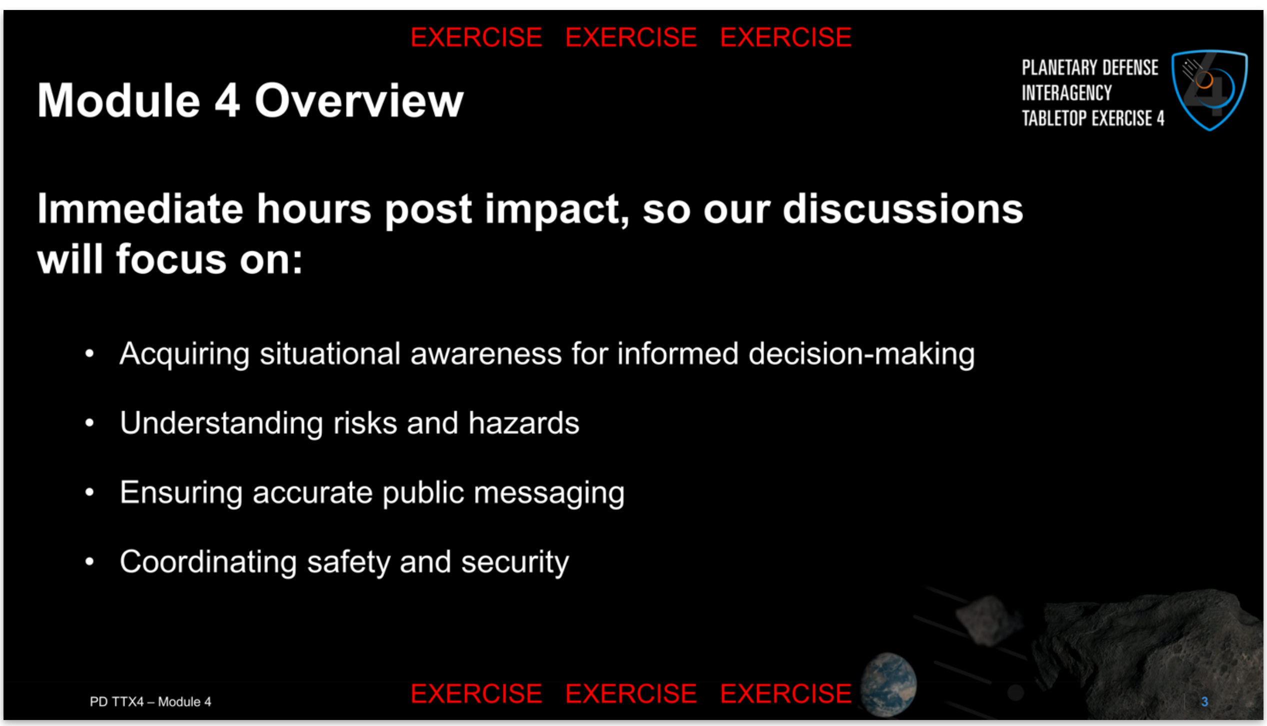

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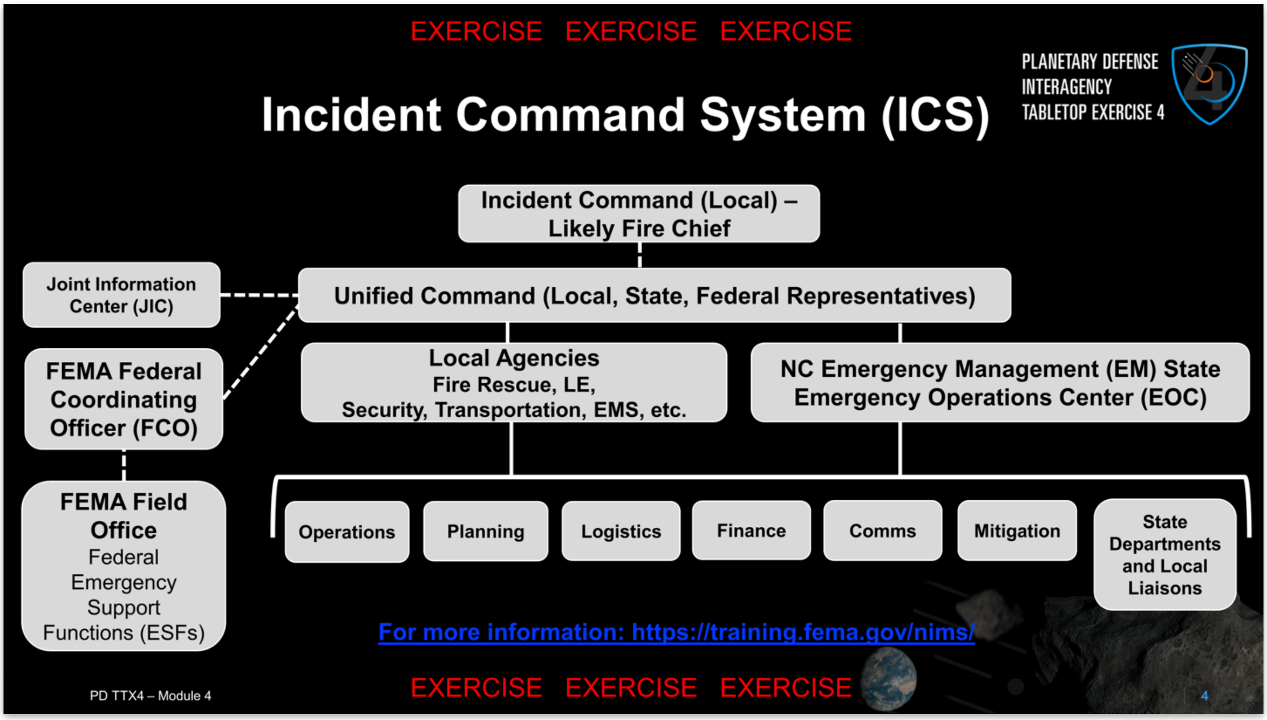

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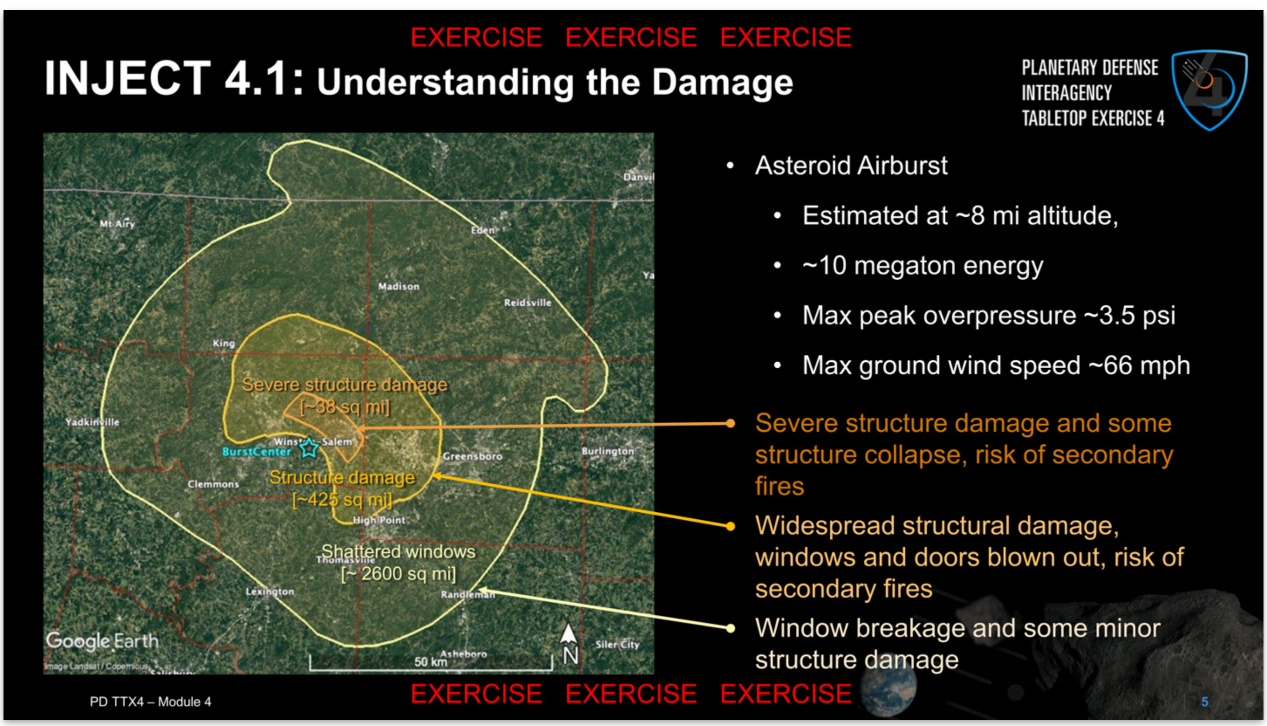

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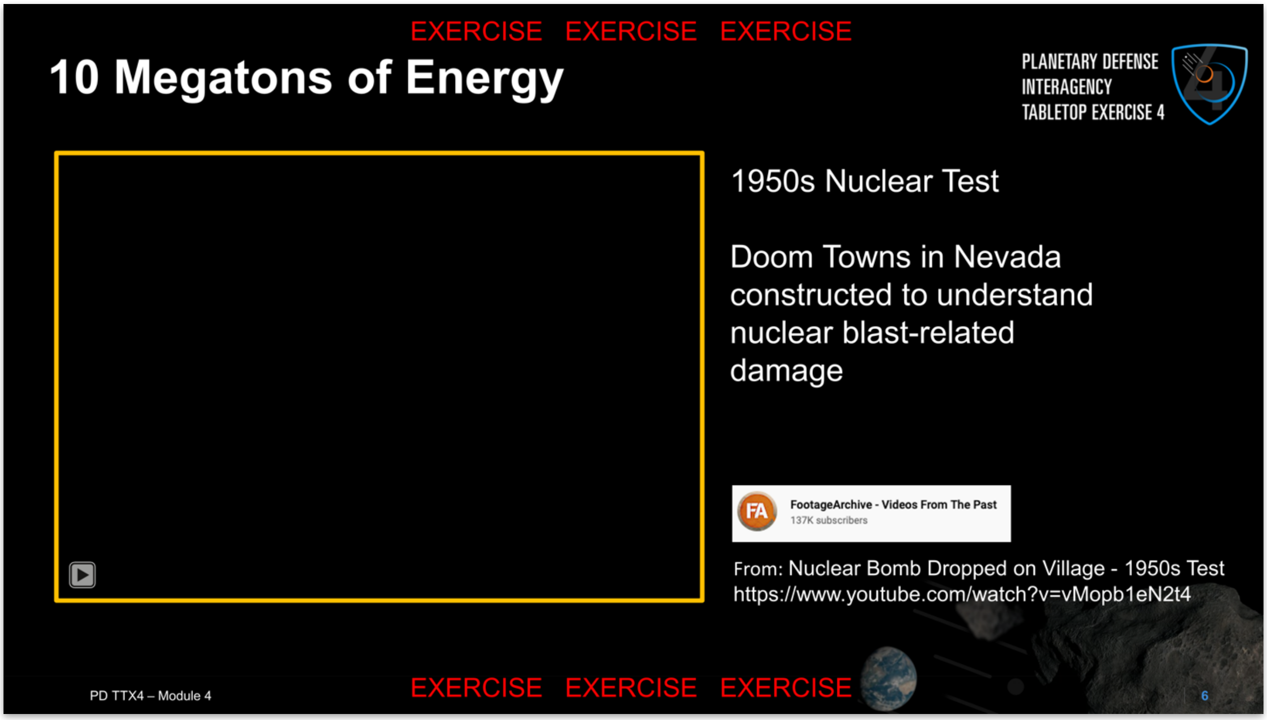

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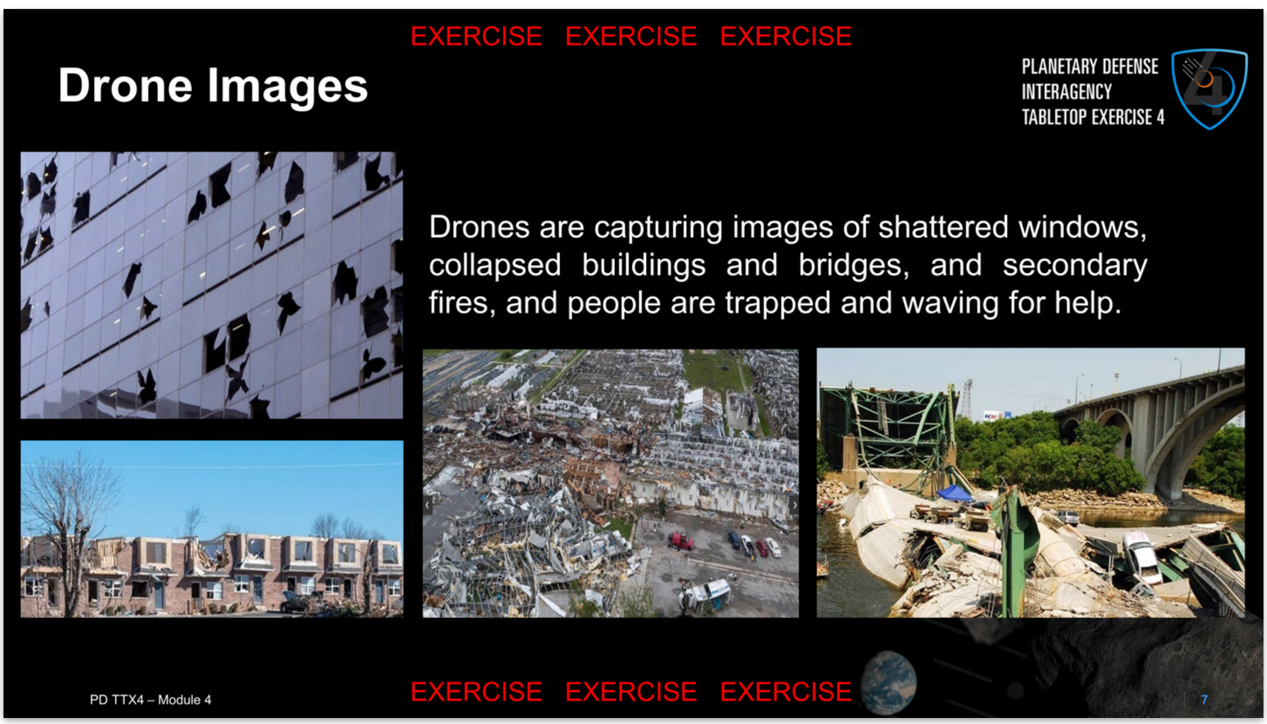

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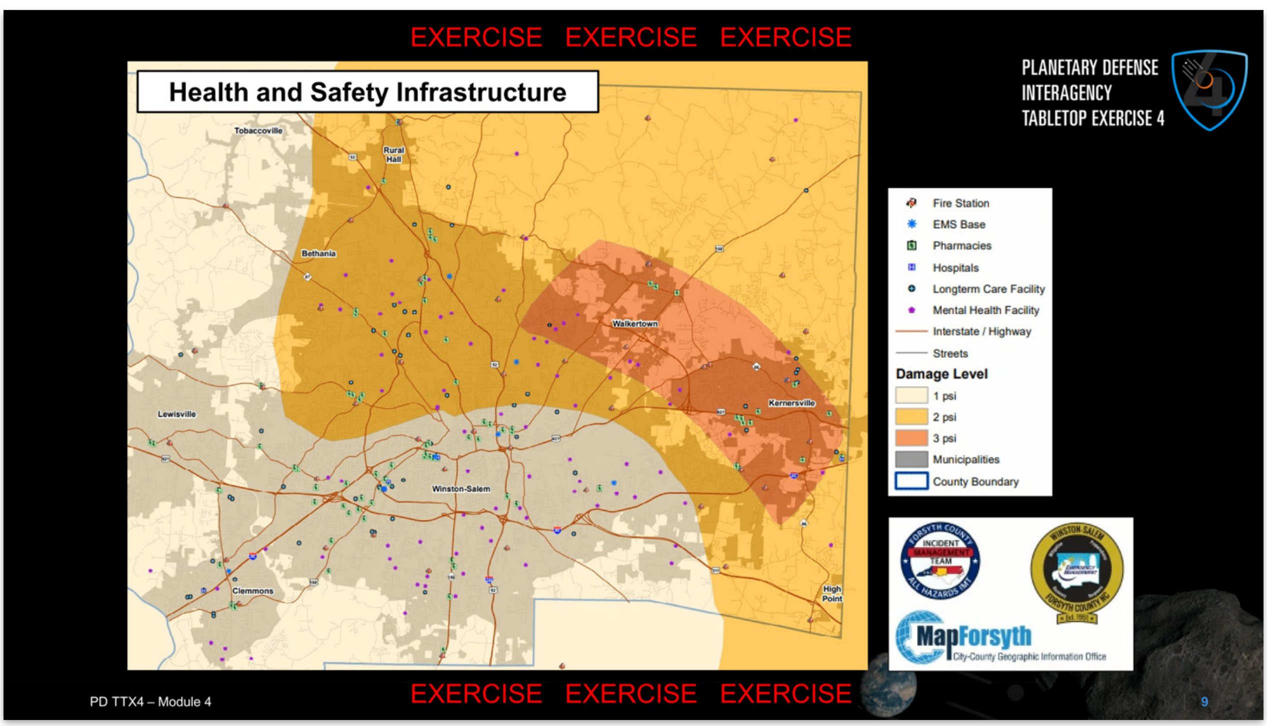

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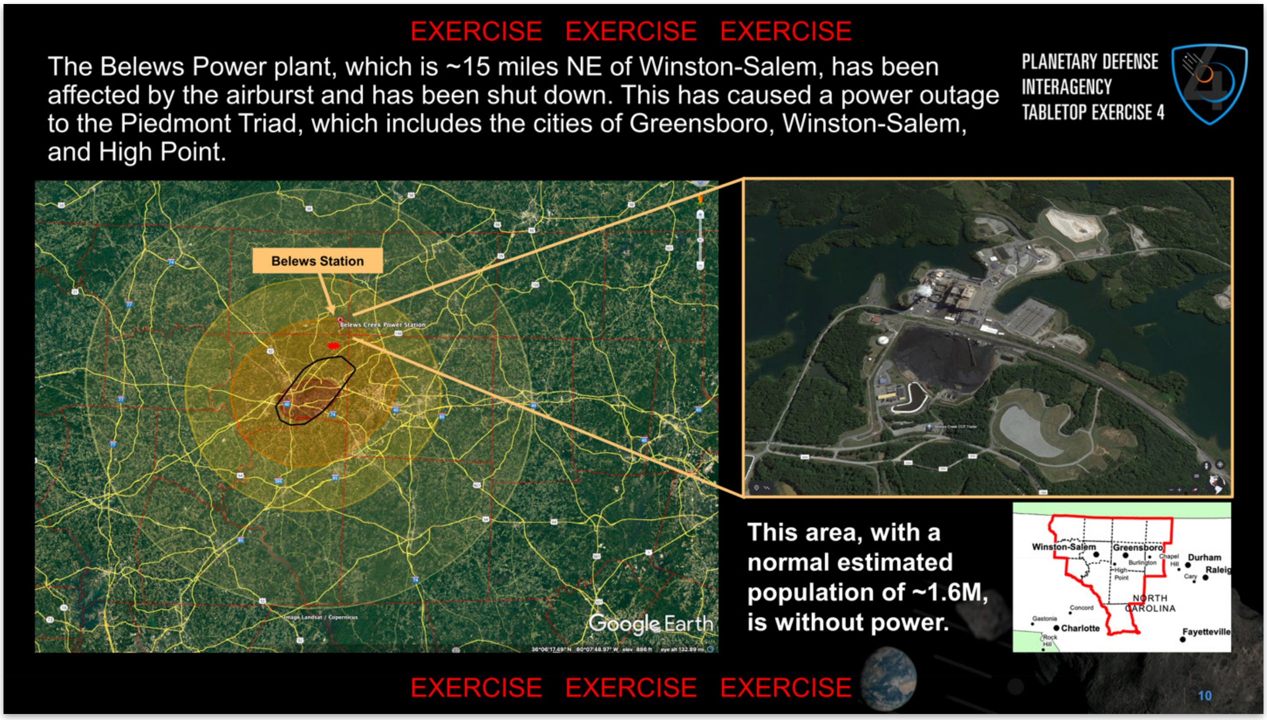

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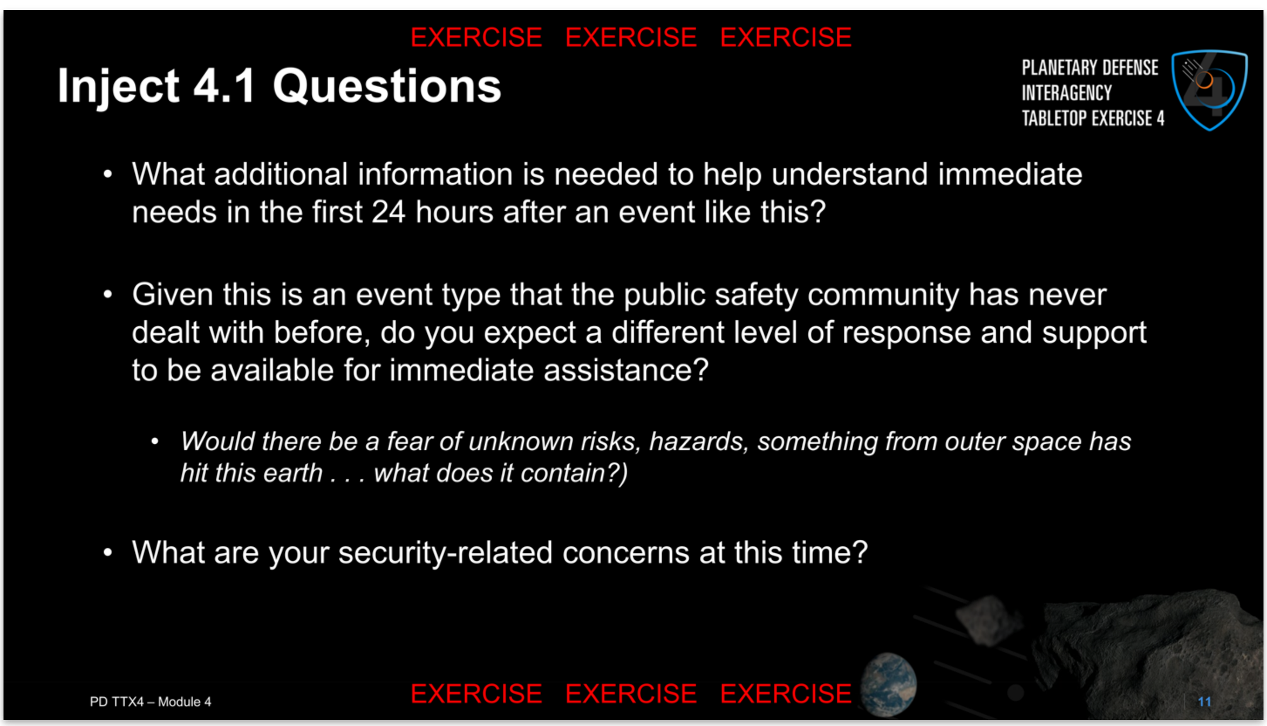

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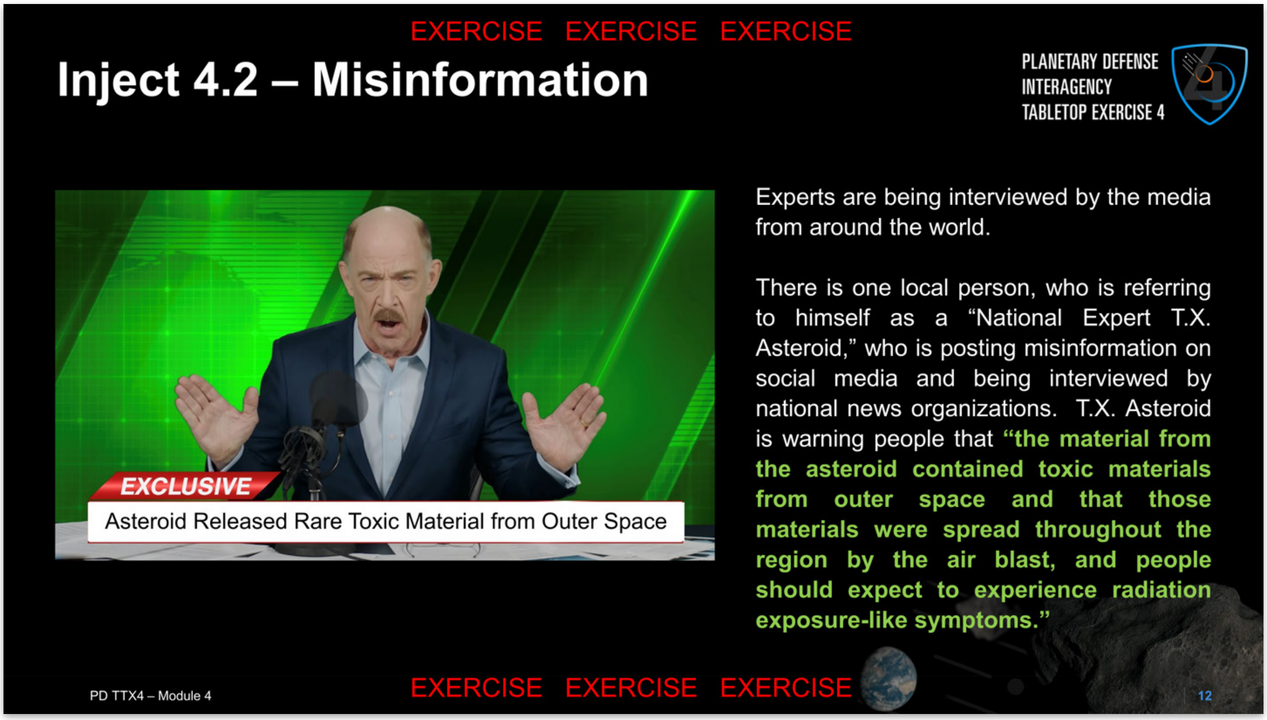

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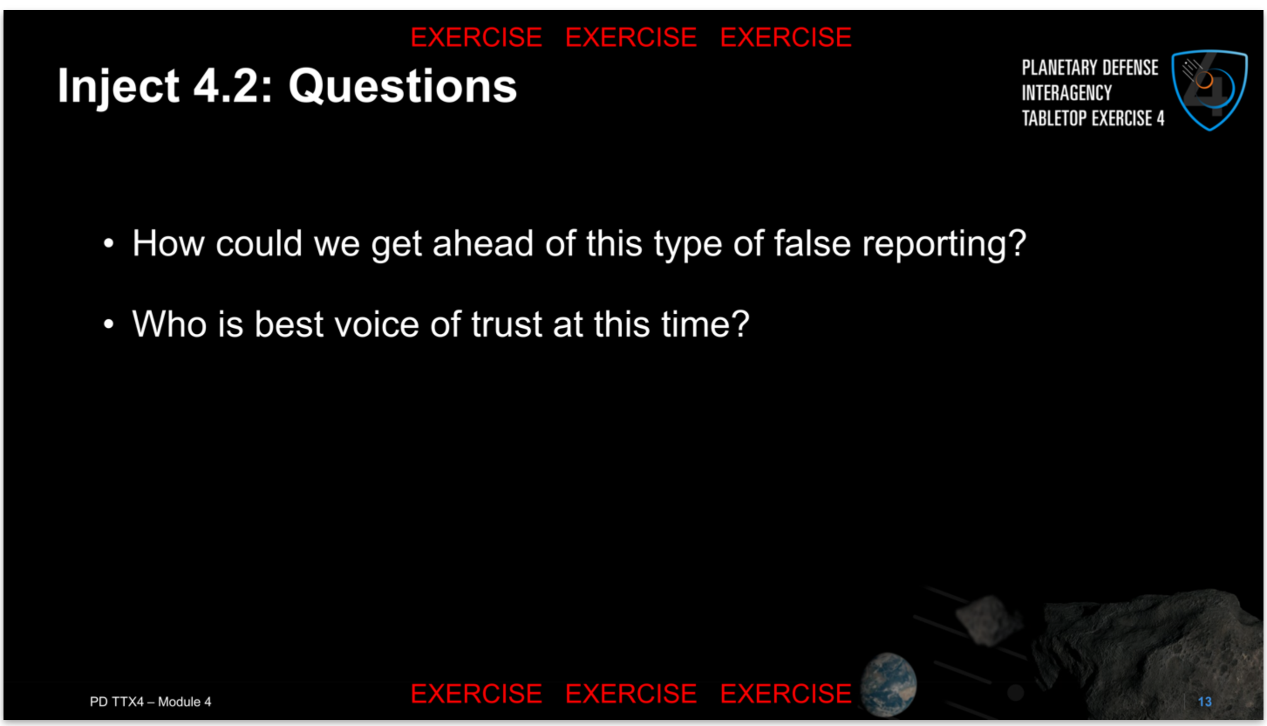

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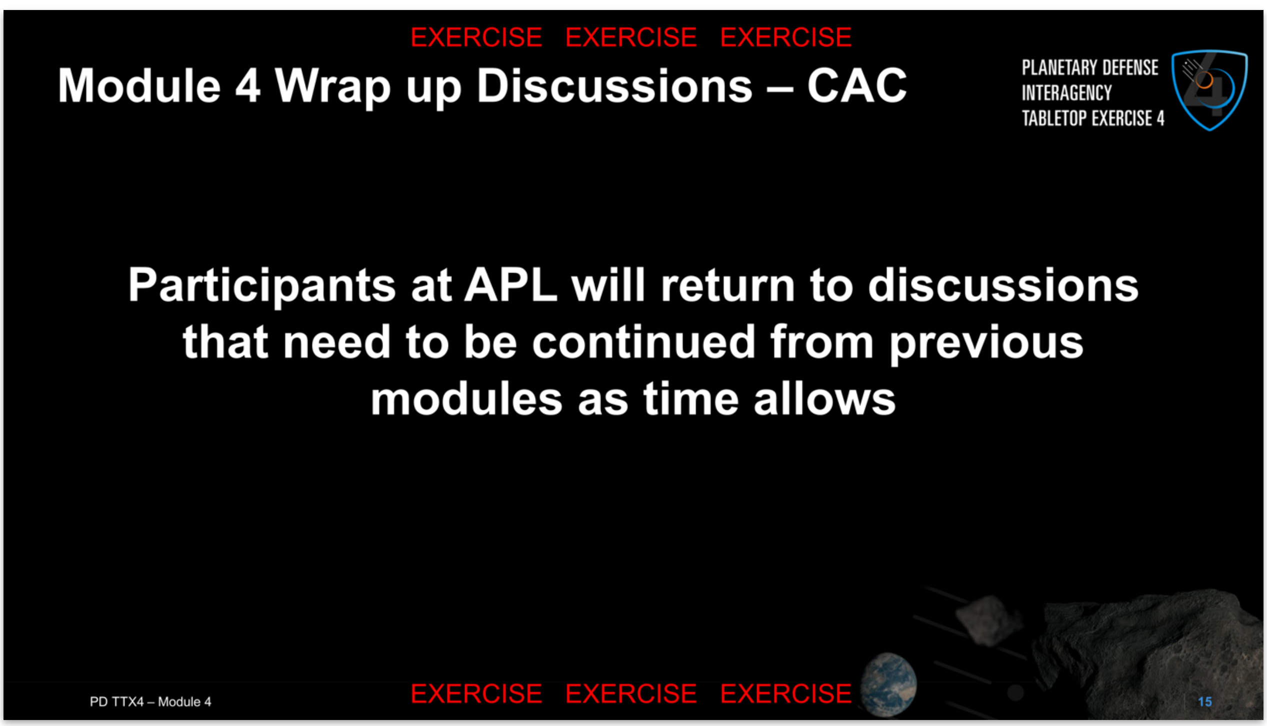

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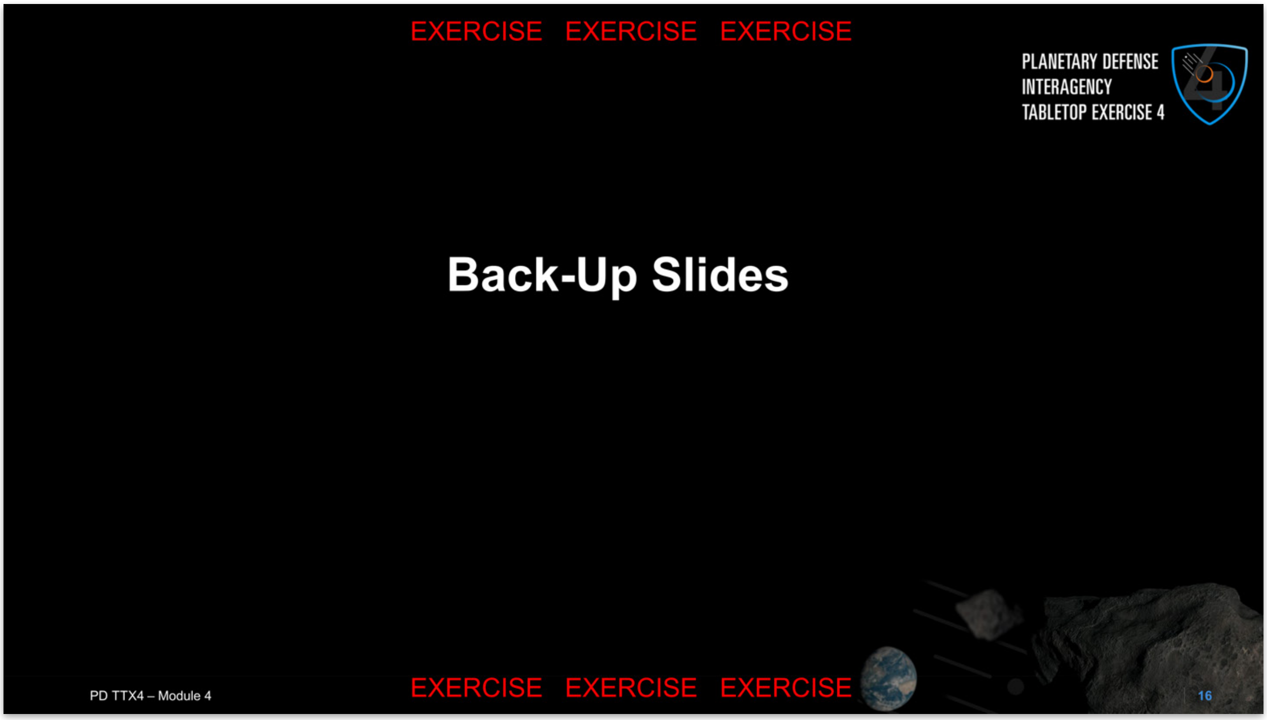

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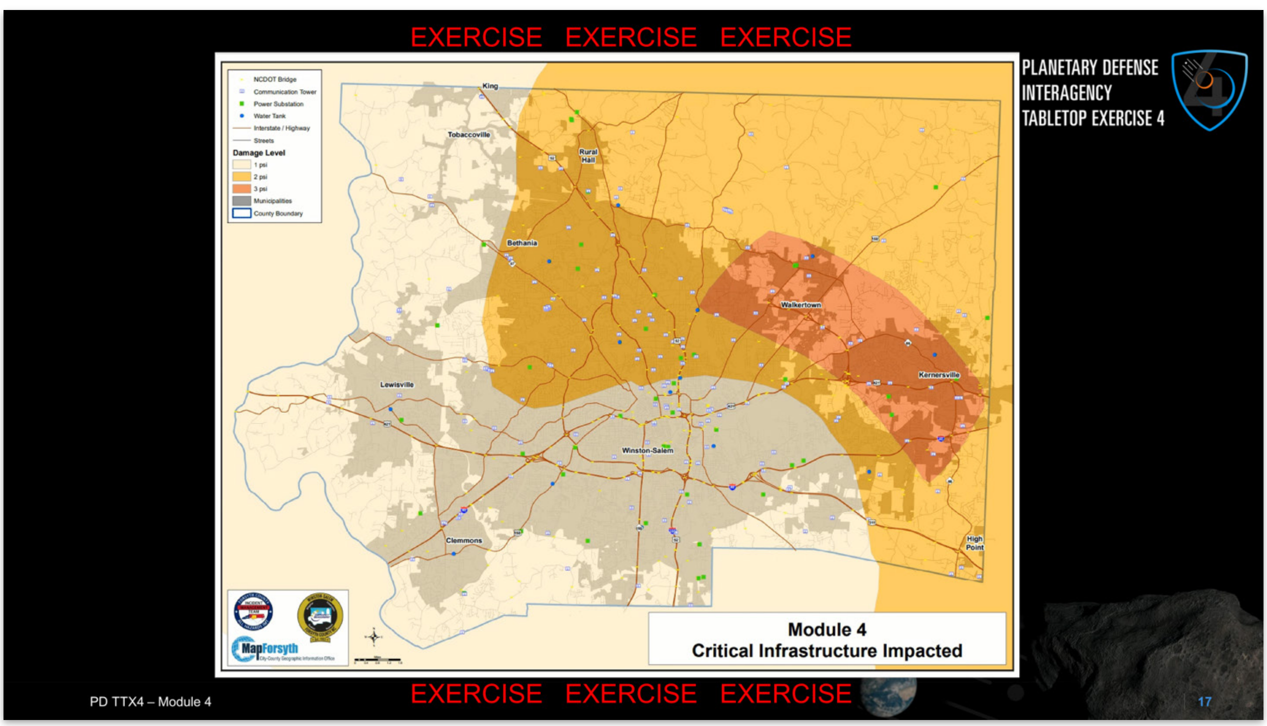

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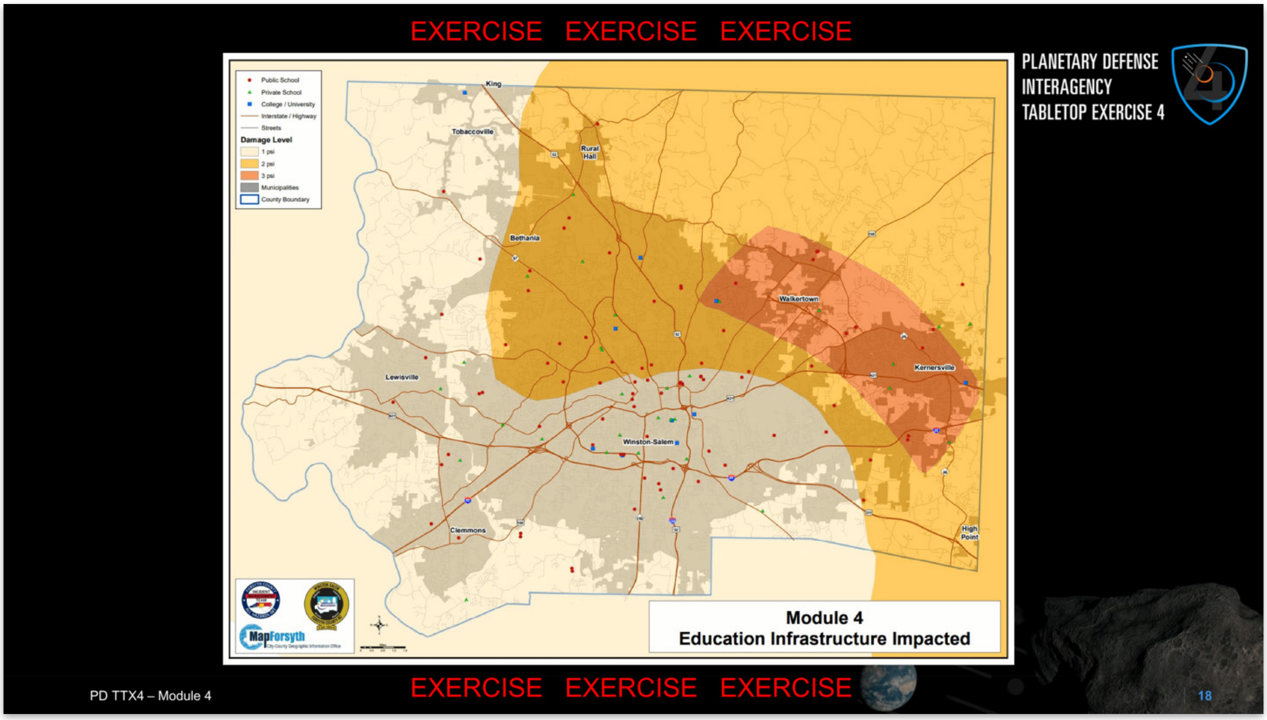

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PLANETARY DEFENSE INTERAGENCY TABLETOP EXERCISE 4

Module 4 - Final Damage Footprint
Infrastructure / Critical Facilities Damaged

3 psi			
Facility Type	Count Impacted	Total Number in County	Percent of Total Impacted
Airport	0	1	0.00%
Animal Clinic	5	35	14.29%
Bridge (NC DOT)	30	310	9.68%
Bus Station	0	1	0.00%
Child Day Care	23	169	13.61%
College/University Campus	2	10	20.00%
Communications Tower	16	172	9.30%
Electric Power Substation	5	44	11.36%
Emergency Management Office	0	1	0.00%
EMS Base/Station	2	11	18.18%
Entertainment Facility (ie Stadium, Theater, Shopping etc)	1	18	5.56%
Fire Station	8	46	17.39%
Government Admin Buildings	2	17	11.76%
Grocery Store/Food Retailer	10	84	11.90%
High Hazard Dam	4	50	8.00%
Hospital	0	5	0.00%
Long-term Care Facility	6	49	12.24%
Mental Health Facility	9	85	10.59%
Pharmacies	13	88	14.77%
Private School	5	31	16.13%
Public School	10	81	12.35%
Retirement Community	1	8	12.50%
Water Tank	2	15	13.33%
WSFCS Admin Facility	1	6	16.67%

Module 4 - Final Damage Footprint
Infrastructure / Critical Facilities Damaged

2 psi			
Facility Type	Count Impacted	Total Number in County	Percent of Total Impacted
Airport	1	1	100.00%
Animal Clinic	16	35	45.71%
Bridge (NC DOT)	117	310	37.74%
Bus Station	0	1	0.00%
Child Day Care	90	169	53.25%
College/University Campus	4	10	40.00%
Communications Tower	94	172	54.65%
Electric Power Substation	19	44	43.18%
Emergency Management Office	0	1	0.00%
EMS Base/Station	5	11	45.45%
Entertainment Facility (ie Stadium, Theater, Shopping etc)	10	18	55.56%
Fire Station	26	46	56.52%
Government Admin Buildings	5	17	29.41%
Grocery Store/Food Retailer	39	84	46.43%
High Hazard Dam	21	50	42.00%
Hospital	1	5	20.00%
Long-term Care Facility	22	49	44.90%
Mental Health Facility	40	85	47.06%
Pharmacies	62	88	70.45%
Private School	13	31	41.94%
Public School	36	81	44.44%
Retirement Community	4	8	50.00%
Water Tank	8	15	53.33%
WSFCS Admin Facility	5	6	83.33%

PD TTX4 – Module 4

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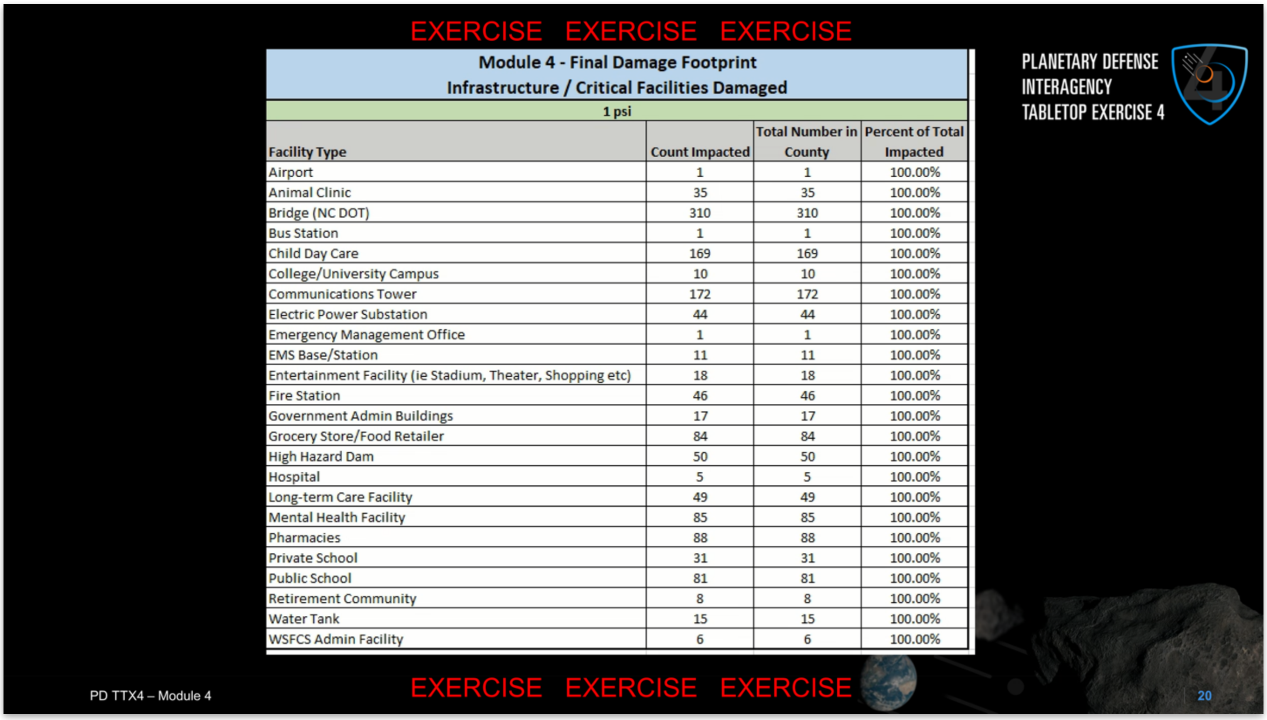

Module 4 - Final Damage Footprint
Infrastructure / Critical Facilities Damaged

1 psi

Facility Type	Count Impacted	Total Number in County	Percent of Total Impacted
Airport	1	1	100.00%
Animal Clinic	35	35	100.00%
Bridge (NC DOT)	310	310	100.00%
Bus Station	1	1	100.00%
Child Day Care	169	169	100.00%
College/University Campus	10	10	100.00%
Communications Tower	172	172	100.00%
Electric Power Substation	44	44	100.00%
Emergency Management Office	1	1	100.00%
EMS Base/Station	11	11	100.00%
Entertainment Facility (ie Stadium, Theater, Shopping etc)	18	18	100.00%
Fire Station	46	46	100.00%
Government Admin Buildings	17	17	100.00%
Grocery Store/Food Retailer	84	84	100.00%
High Hazard Dam	50	50	100.00%
Hospital	5	5	100.00%
Long-term Care Facility	49	49	100.00%
Mental Health Facility	85	85	100.00%
Pharmacies	88	88	100.00%
Private School	31	31	100.00%
Public School	81	81	100.00%
Retirement Community	8	8	100.00%
Water Tank	15	15	100.00%
WSFCS Admin Facility	6	6	100.00%

C.8 Closing

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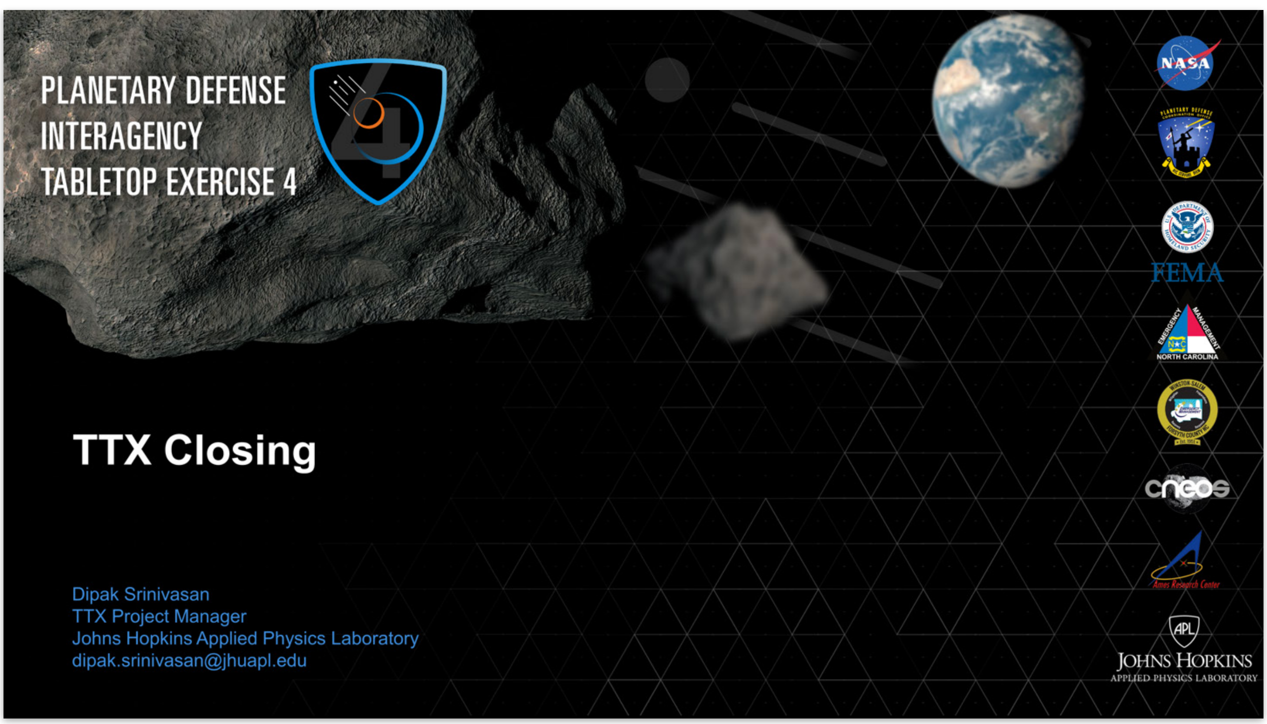

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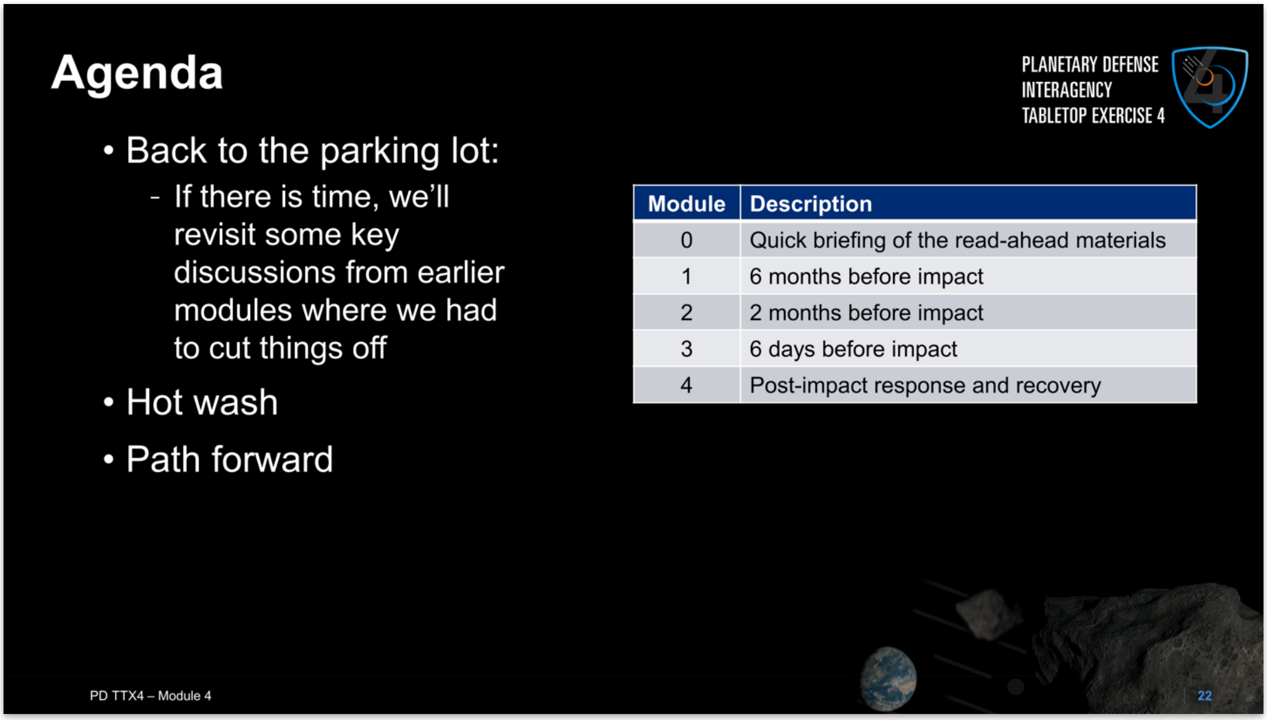

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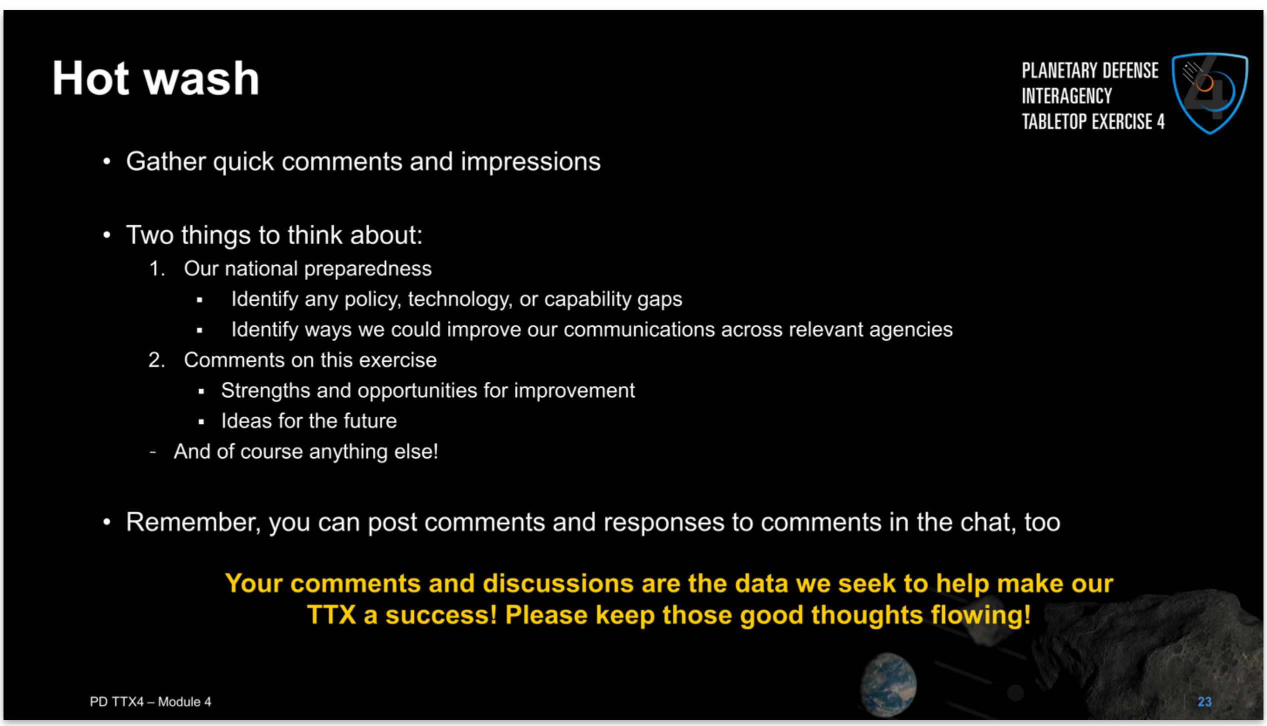

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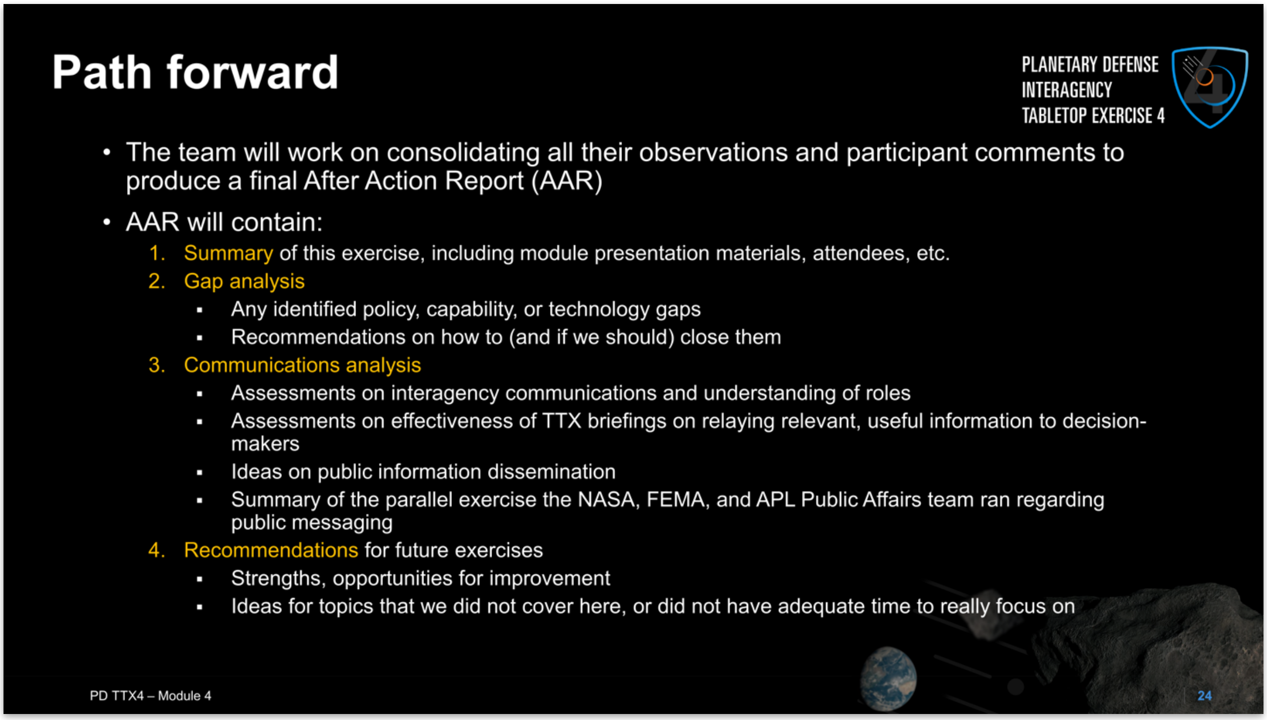

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