

HYPOTHETICAL EXERCISE ONLY

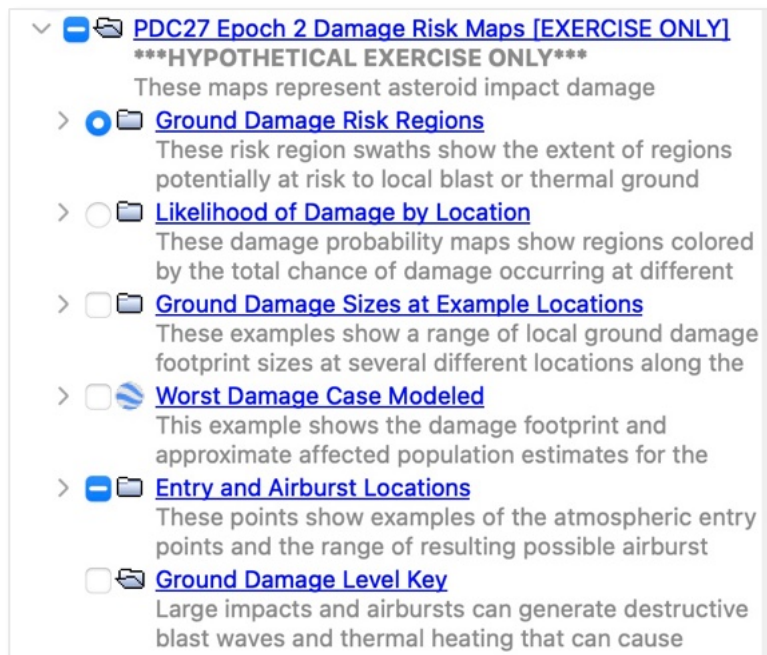
PDC27 Epoch 2 Damage Risk Maps Guide Document

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This document provides a content guide for the Google Earth KMZ package of damage risk maps produced for Epoch 2 of the 2027 Planetary Defense Conference hypothetical impact exercise. The associated Google Earth package is available for download from the [CNEOS PDC27 Scenario Epoch 2 Website](#). The following sections provide screenshots and informational blurbs for each type of damage map included in the package.

Damage risk map package contents and folder structure:

- Damage Risk Map Overview
- Ground Damage Level Key
- Airburst/Impact Region
- Ground Damage Risk Regions
- Likelihood of Damage by Location
- Ground Damage Sizes at Example Locations
- Worst Damage Case Modeled
- Entry and Airburst Locations



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PDC27 Epoch 2 Damage Risk Maps [EXERCISE ONLY]

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These maps represent asteroid impact damage estimates modeled for the **PDC27 Hypothetical Asteroid Impact Exercise**, as part of the 10th IAA Planetary Defense Conference (PDC 2027). This exercise assesses a realistic but fictitious hypothetical scenario, not a real asteroid threat.

DAMAGE RISK MAP OVERVIEW & CONTENTS:

These damage risk maps represent the potential range of local ground damage that could occur given the uncertain ranges of potential asteroid sizes, properties, and impact locations in the current scenario. This map set includes damage risk swaths covering the combined extent of regions that could potentially be at risk to damage, maps of the likelihood of damage across different locations, and examples of various damage footprint sizes over sample locations. These different risk region and footprint examples can be displayed or hidden on the globe map by expanding and selecting different elements in the navigation panel folders. Information on each example set can be seen by clicking on the folder title in the navigation panel, which will display a pop-up text box.

*** Tip:** These maps work most reliably using the freely available Google Earth Pro desktop app. Functionality may vary by browser, OS, or internet connection if using the Google Earth web app.

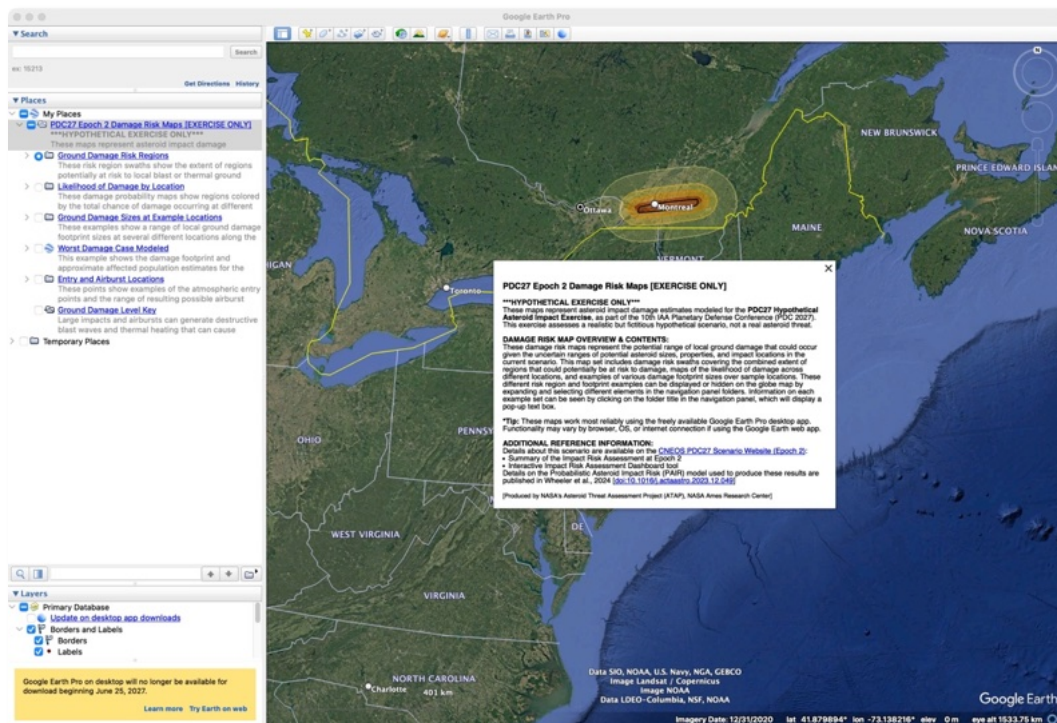
ADDITIONAL REFERENCE INFORMATION:

Details about this scenario are available on the [CNEOS PDC27 Scenario Website \(Epoch 2\)](#):

- Summary of the Impact Risk Assessment at Epoch 2
- Interactive Impact Risk Assessment Dashboard tool

Details on the Probabilistic Asteroid Impact Risk (PAIR) model used to produce these results are published in [Wheeler et al., 2024 \[doi:10.1016/j.actaastro.2023.12.049\]](#)

[Produced by NASA's Asteroid Threat Assessment Project (ATAP), NASA Ames Research Center]



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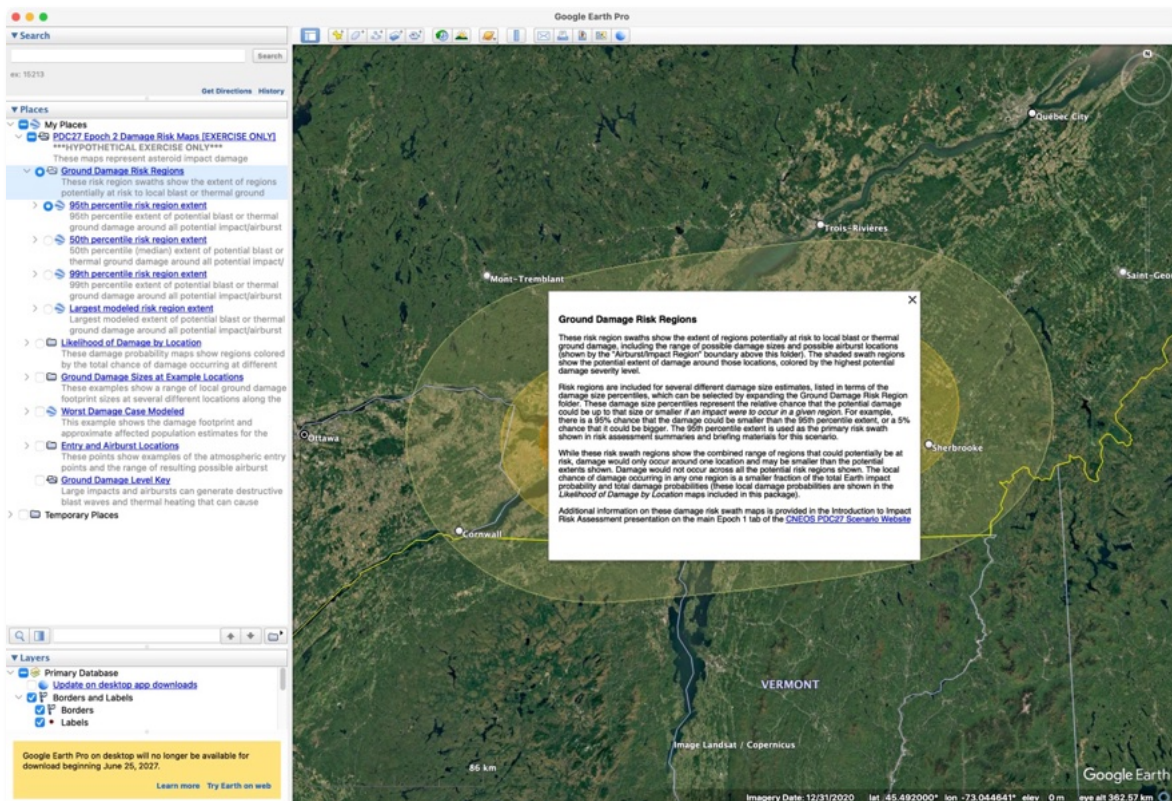
Ground Damage Risk Regions

These risk region swaths show the extent of regions potentially at risk to local blast or thermal ground damage, including the range of possible damage sizes and possible airburst locations (shown by the "Airburst/Impact Region" boundary above this folder). The shaded swath regions show the potential extent of damage around those locations, colored by the highest potential damage severity level.

Risk regions are included for several different damage size estimates, listed in terms of the damage size percentiles, which can be selected by expanding the Ground Damage Risk Region folder. These damage size percentiles represent the relative chance that the potential damage could be up to that size or smaller *if an impact were to occur in a given region*. For example, there is a 95% chance that the damage could be smaller than the 95th percentile extent, or a 5% chance that it could be bigger. The 95th percentile extent is used as the primary risk region swath shown in risk assessment summaries and briefing materials for this scenario.

While these risk swath regions show the combined range of regions that could potentially be at risk, damage would only occur around one location and may be smaller than the potential extents shown. Damage would not occur across all the potential risk regions shown. The local chance of damage occurring in any one region is a smaller fraction of the total Earth impact probability and total damage probabilities (these local damage probabilities are shown in the *Likelihood of Damage by Location* maps included in this package).

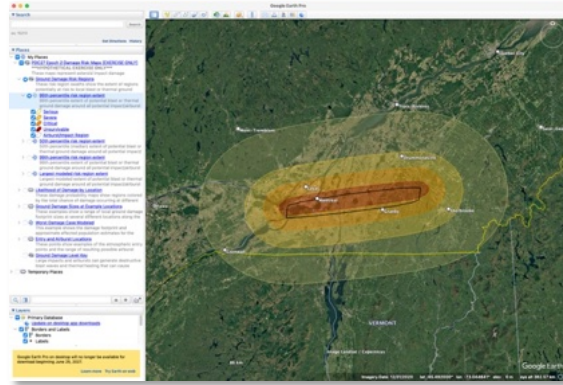
Additional information on these damage risk swath maps is provided in the Introduction to Impact Risk Assessment presentation on the main Epoch 1 tab of the [CNEOS PDC27 Scenario Website](#)



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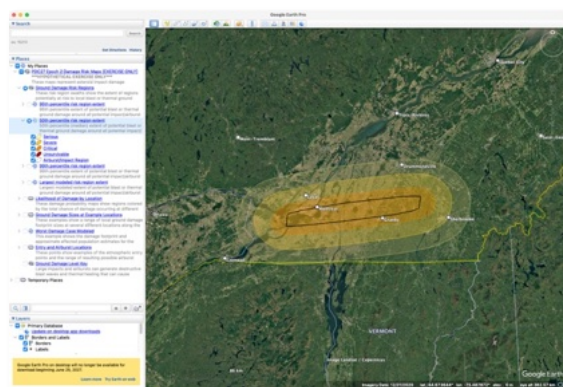
95th percentile risk region extent

95th percentile extent of potential blast or thermal ground damage around all potential impact/airburst locations. The 95th percentile damage extents represent damage sizes that are larger than 95% of the range of modeled cases. There is a 95% chance that damage could be up to this size or smaller, and a 5% chance that it could be bigger. This 95th percentile region is used as the primary risk region swath shown in risk assessment summaries and briefing materials for this scenario.



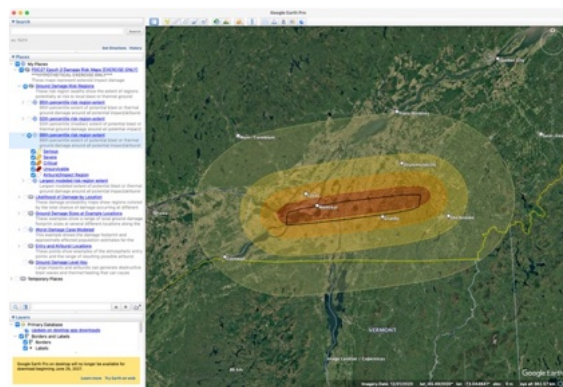
50th percentile risk region extent

50th percentile (median) extent of potential blast or thermal ground damage around all potential impact/airburst locations. The median 50th percentile damage extents represent damage sizes that are larger than 50% of the range of modeled cases. There is a 50% chance that damage could be up to this size or smaller, and a 50% chance that it could be bigger.



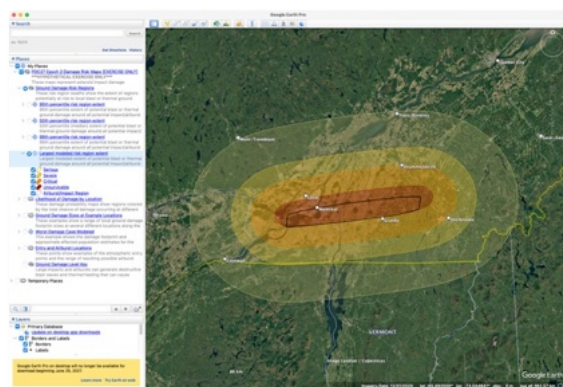
99th percentile risk region extent

99th percentile extent of potential blast or thermal ground damage around all potential impact/airburst locations. The 99th percentile damage extents represent damage sizes that are larger than 99% of the range of modeled cases. There is a 99% chance that damage could be up to this size or smaller, and a 1% chance that it could be bigger.



Largest modeled risk region extent

Largest modeled extent of potential blast or thermal ground damage around all potential impact/airburst locations. This represents the largest damage case modeled from among the sampled set of asteroid and entry properties. These largest damage areas are much less likely than the median sized damage estimates but also may not necessarily represent theoretical maximums given all the uncertainties involved in estimating asteroid damage.



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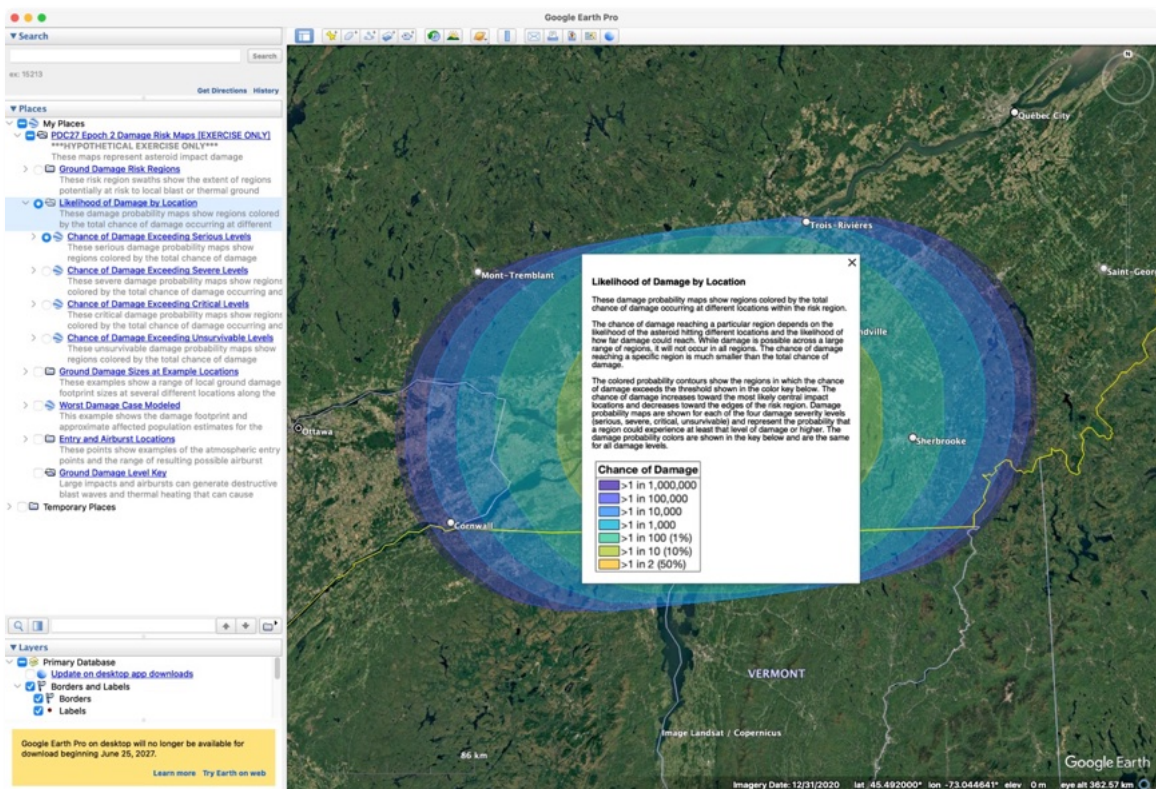
Likelihood of Damage by Location

These damage probability maps show regions colored by the total chance of damage occurring at different locations within the risk region.

The chance of damage reaching a particular region depends on the likelihood of the asteroid hitting different locations and the likelihood of how far damage could reach. While damage is possible across a large range of regions, it will not occur in all regions. The chance of damage reaching a specific region is much smaller than the total chance of damage.

The colored probability contours show the regions in which the chance of damage exceeds the threshold shown in the color key below. The chance of damage increases toward the most likely central impact locations and decreases toward the edges of the risk region. Damage probability maps are shown for each of the four damage severity levels (serious, severe, critical, unsurvivable) and represent the probability that a region could experience at least that level of damage or higher. The damage probability colors are shown in the key below and are the same for all damage levels.

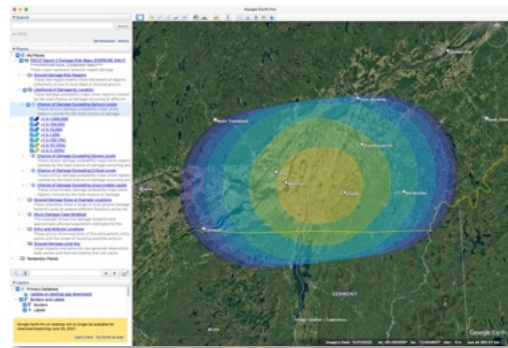
Chance of Damage	
	>1 in 1,000,000
	>1 in 100,000
	>1 in 10,000
	>1 in 1,000
	>1 in 100 (1%)
	>1 in 10 (10%)
	>1 in 2 (50%)



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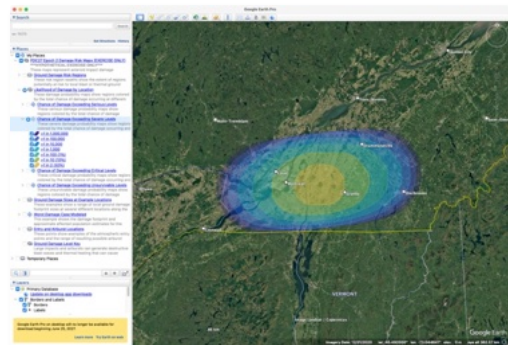
Chance of Damage Exceeding Serious Levels

These serious damage probability maps show regions colored by the total chance of damage occurring and reaching at least serious damage levels at the locations within the risk region. Serious damage effects include blown out windows and doors and some structural damage, caused by a blast overpressure of 1 psi or more. The colored probability contours show the regions in which the likelihood of serious damage exceeds the minimum thresholds shown in the color key. Higher damage levels are also possible within some of these regions.



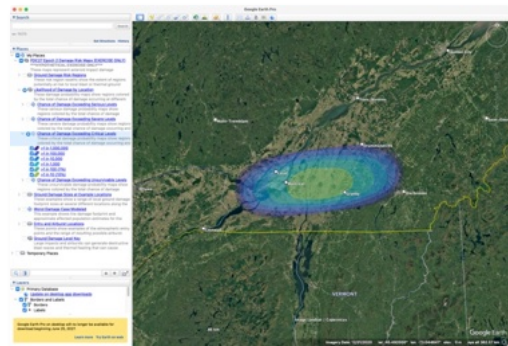
Chance of Damage Exceeding Severe Levels

These severe damage probability maps show regions colored by the total chance of damage occurring and reaching at least severe damage levels at the locations within the risk region. Severe damage effects include widespread structural damage, caused by a blast overpressure of 2 psi or more. The colored probability contours show the regions in which the likelihood of severe damage exceeds the minimum thresholds shown in the color key. Higher damage levels are also possible within some of these regions.



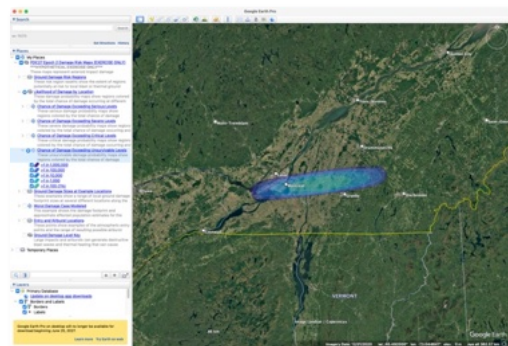
Chance of Damage Exceeding Critical Levels

These critical damage probability maps show regions colored by the total chance of damage occurring and reaching at least critical damage levels at the locations within the risk region. Critical damage effects include collapse of most residential structures, caused by a blast overpressure of 4 psi or more. The colored probability contours show the regions in which the likelihood of critical damage exceeds the minimum thresholds shown in the color key. Higher damage levels are also possible within some of these regions.



Chance of Damage Exceeding Unsurvivable Levels

These unsurvivable damage probability maps show regions colored by the total chance of damage occurring and reaching unsurvivable damage levels at the locations within the risk region. Unsurvivable damage is a blast overpressure of 10 psi or more that would flatten reinforced concrete structures. The colored probability contours show the regions in



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which the likelihood of unsurvivable damage exceeds the minimum thresholds shown in the color key.

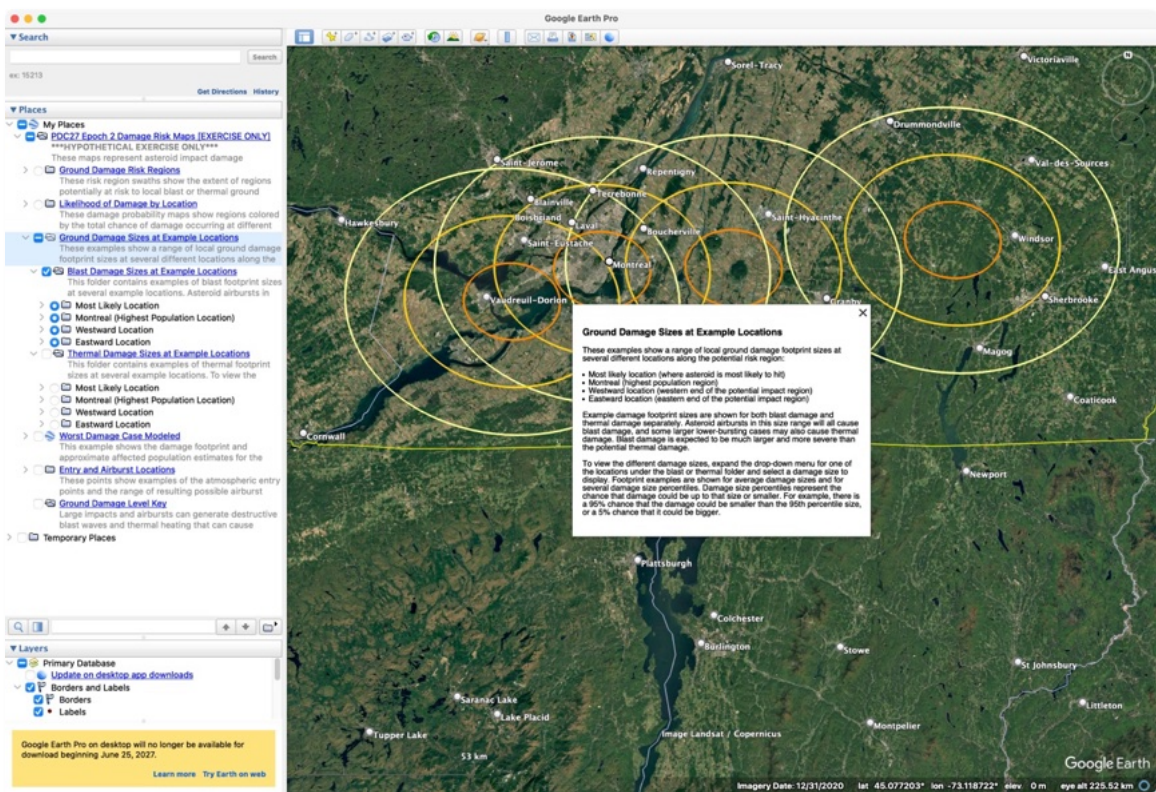
Ground Damage Sizes at Example Locations

These examples show a range of local ground damage footprint sizes at several different locations along the potential risk region:

- Most likely location (where asteroid is most likely to hit)
- Montreal (highest population region)
- Westward location (western end of the potential impact region)
- Eastward location (eastern end of the potential impact region)

Example damage footprint sizes are shown for both blast damage and thermal damage separately. Asteroid airbursts in this size range will all cause blast damage, and some larger lower-bursting cases may also cause thermal damage. Blast damage is expected to be much larger and more severe than the potential thermal damage.

To view the different damage sizes, expand the drop-down menu for one of the locations under the blast or thermal folder and select a damage size to display. Footprint examples are shown for average damage sizes and for several damage size percentiles. Damage size percentiles represent the chance that damage could be up to that size or smaller. For example, there is a 95% chance that the damage could be smaller than the 95th percentile size, or a 5% chance that it could be bigger.



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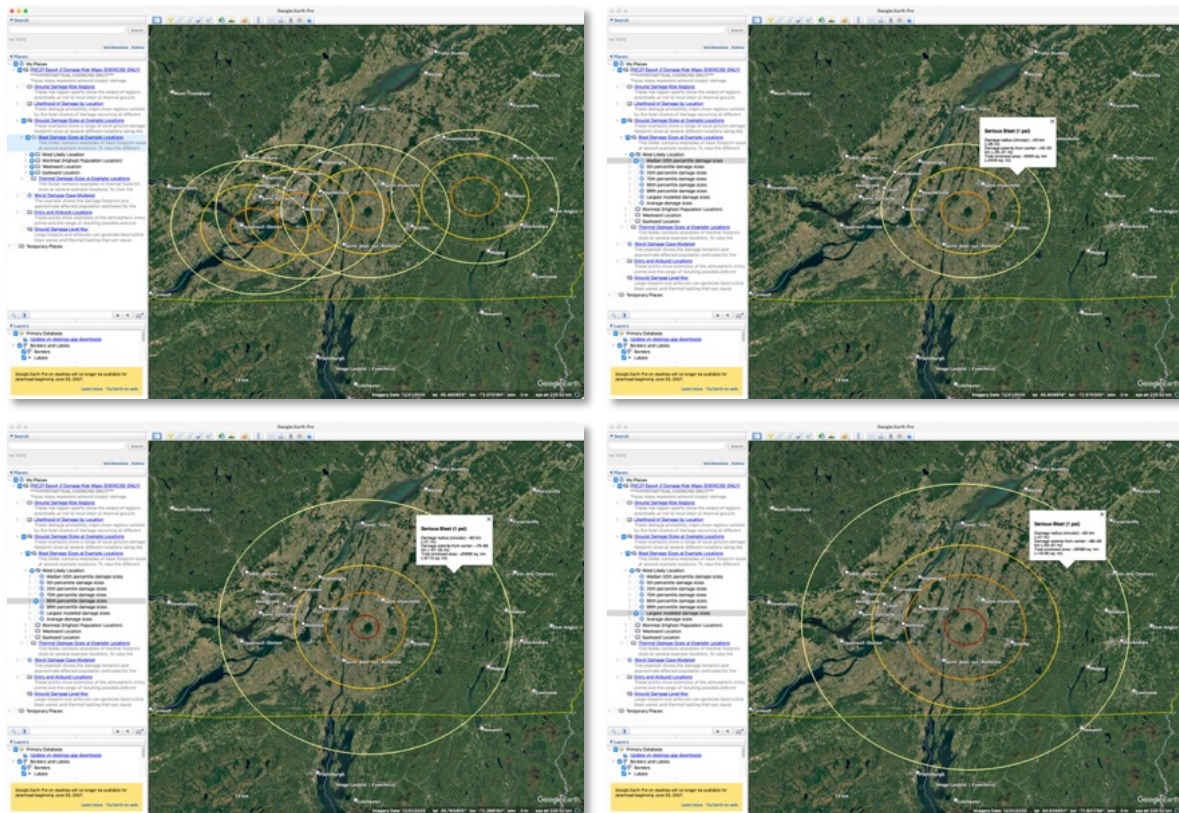
Blast Damage Sizes at Example Locations

This folder contains examples of blast footprint sizes at several example locations. To view the different blast footprint sizes, expand the drop-down menu for one of the locations and select a damage size to display. Footprint examples are shown for average damage sizes, median damage sizes, and for several other damage size percentiles. Damage size percentiles represent the chance that damage could be up to that size or smaller (for example, there is a 95% chance that the damage could be up to that size or smaller, or a 5% chance that it could be bigger).

The colored rings of each footprint represent the potential blast damage severity levels shown in the color key below. For each footprint example, clicking on the individual damage level rings will display a popup with additional information.

	Damage Level Description	Relative Severity
Serious	Shattered windows, some structure damage	10%
Severe	Widespread structure damage	30%
Critical	Most residential structures collapse	60%
Unsurvivable	Devastation, reinforced structures collapse	100%

Screenshots of median blast damage sizes at all example locations, and individual median, 95th percentile, and largest modeled blast damage sizes at the central most likely location:



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Thermal Damage Sizes at Example Locations

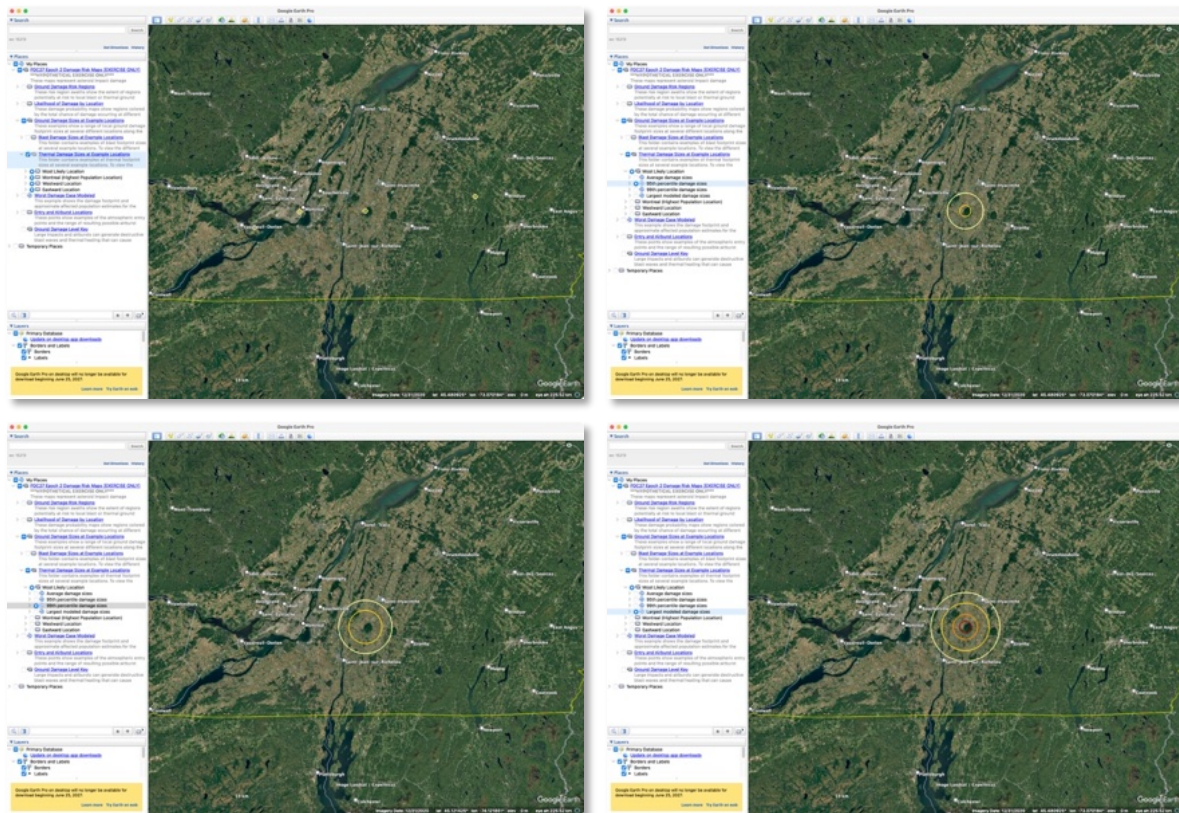
This folder contains examples of thermal footprint sizes at several example locations. To view the different thermal footprint sizes, expand the drop-down menu for one of the locations and select a damage size to display. Footprint examples are shown for average damage sizes and for several damage size percentiles. Damage size percentiles represent the chance that damage could be up to that size or smaller (for example, there is a 95% chance that the damage could be smaller than the 95th percentile size, or a 5% chance that it could be bigger).

The colored rings of each footprint represent the potential thermal damage severity levels shown in the color key below. For each footprint example, clicking on the individual damage level rings will display a popup with additional information about the damage area.

Note that most airburst sizes in this scenario are not expected to cause significant thermal damage, and blast damage is expected to be much larger and more severe for all cases. Because most cases modeled cause no thermal damage in this scenario, thermal damage size examples are only shown for the average and higher percentile sizes (lower percentile sizes are 0).

	Thermal Damage Description	Relative Severity
Serious	2 nd degree burns	10%
Severe	3 rd degree burns	30%
Critical	Clothing ignites	60%
Unsurvivable	Incineration, structures ignite	100%

Screenshots of average thermal damage sizes at all example locations, and individual 95th percentile, 99th percentile, and largest modeled thermal sizes at the most likely location:



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Worst Damage Case Modeled

This example shows a damage footprint and approximate affected population estimates for the worst damage case modeled in the current scenario set. Additional details can be seen by clicking on each damage level or airburst/entry point marker on the map or navigation pane. (Tip: hiding the risk swath layer can make it easier to click on specific damage footprint areas).

Damage estimates:

- Total estimated population in damage area: ~5.5M people
- Affected population damage estimate: ~3.4M people
- Damage area: ~26,300 sq. km (~10,100 sq. mi)
- Damage level radii: serious ~90 km, severe ~50 km, critical ~35 km, unsurvivable ~11 km

Asteroid Properties:

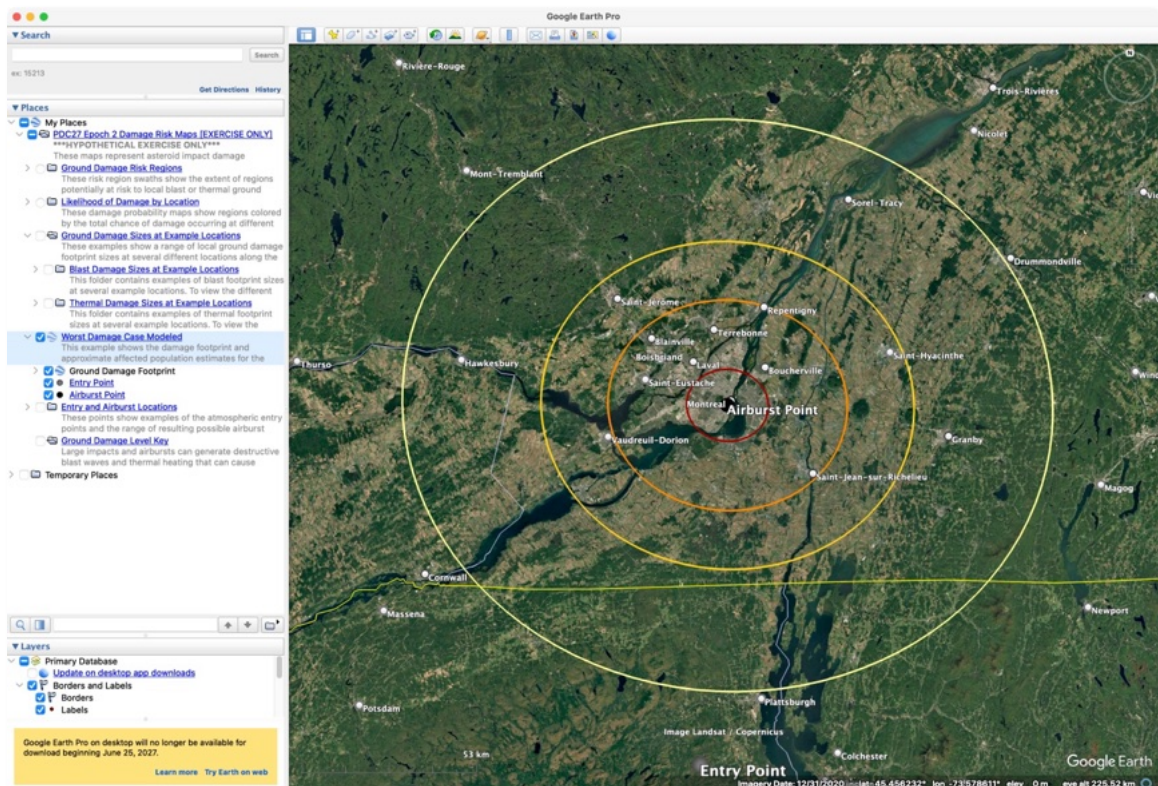
- Diameter: 85m
- Energy: 45 Mt
- Mass: 1.2×10^9 kg

Entry Properties:

- Entry angle: 56°
- Entry velocity 17.97 km/s
- Entry flight heading 5° (northward)

Effective Airburst Estimate:

- Altitude ~8 km (5 mi)
- Yield energy ~45 Mt



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Worst Case Damage Level Details:

Serious Damage

Serious Blast Level: 1-2 psi overpressure,
10% affected population severity

Damage radius (circular): ~91 km (~57 mi)
Damage extents from center: ~86–98 km
(~53–61 mi)

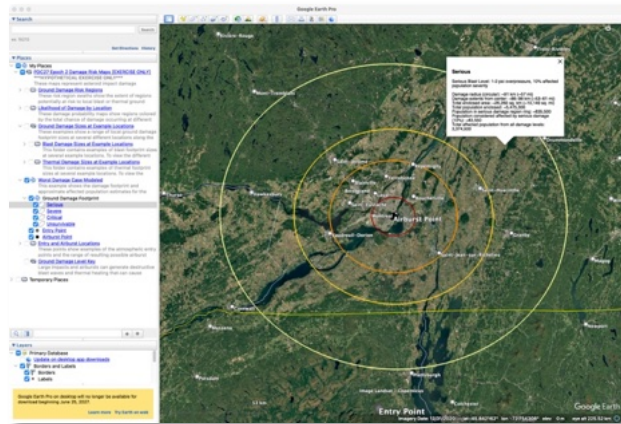
Total enclosed area: ~26,260 sq. km
(~10,140 sq. mi)

Total population enclosed: ~5,475,300

Population in serious damage region ring:
~835,500

Population considered affected by serious
damage (10%): ~83,550

Total affected population from all damage
levels: 3,374,500



Severe Damage

Severe Blast Level: 2-4 psi overpressure,
30% affected population severity

Damage radius (circular): ~52 km (~32 mi)
Damage extents from center: ~49–56 km
(~30–35 mi)

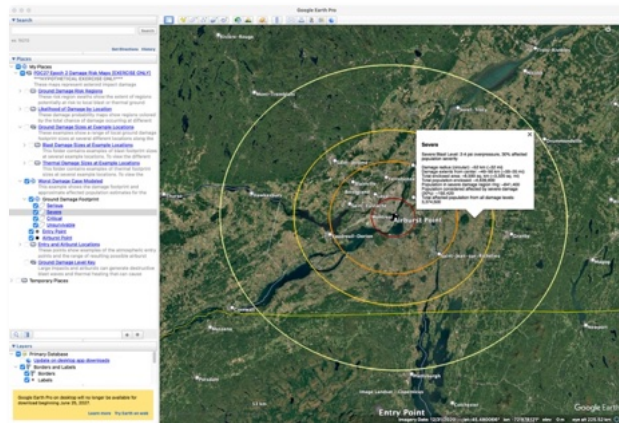
Total enclosed area: ~8,590 sq. km
(~3,320 sq. mi)

Total population enclosed: ~4,639,800

Population in severe damage region ring:
~641,400

Population considered affected by severe
damage (30%): ~192,420

Total affected population from all damage
levels: 3,374,500



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Critical Damage

Critical Blast Level: 4-10 psi overpressure,
60% affected population severity

Damage radius (circular): ~34 km (~21 mi)

Damage extents from center: ~31–36 km
(~20–22 mi)

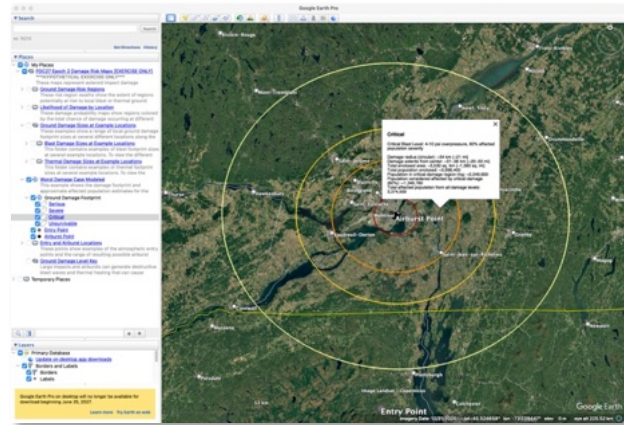
Total enclosed area: ~3,530 sq. km (~1,360
sq. mi)

Total population enclosed: ~3,998,400

Population in critical damage region ring:
~2,249,600

Population considered affected by critical
damage (60%): ~1,349,760

Total affected population from all damage
levels: 3,374,500



Unsurvivable Damage

Unsurvivable Blast Level: >10 psi
overpressure, 100% affected population
severity

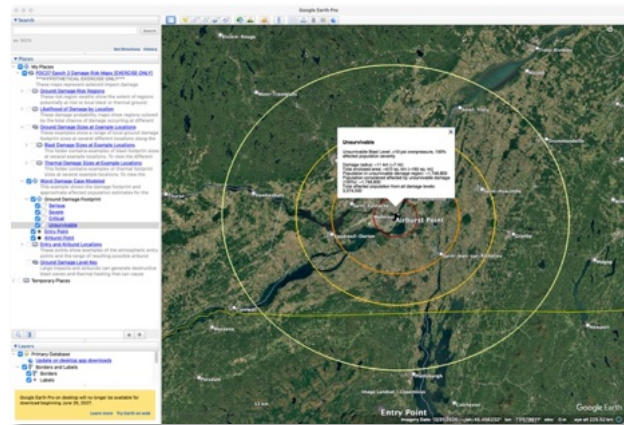
Damage radius: ~11 km (~7 mi)

Total enclosed area: ~410 sq. km (~160 sq.
mi)

Population in unsurvivable damage region:
~1,748,800

Population considered affected by
unsurvivable damage (100%): ~1,748,800

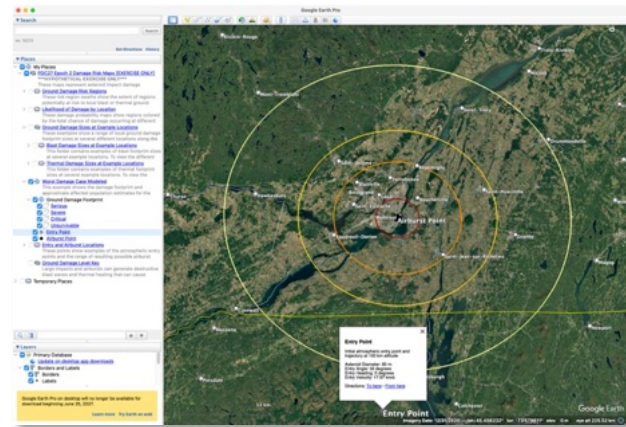
Total affected population from all damage
levels: 3,374,500



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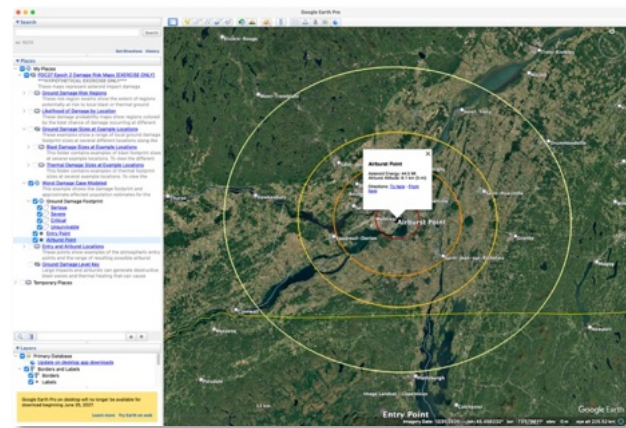
Entry Point

Asteroid Diameter: 85 m
Entry Angle: 56 degrees
Entry Heading: 5 degrees
Entry Velocity: 17.97 km/s



Airburst Point

Asteroid Energy: 44.5 Mt
Airburst Altitude: 8.1 km (5 mi)



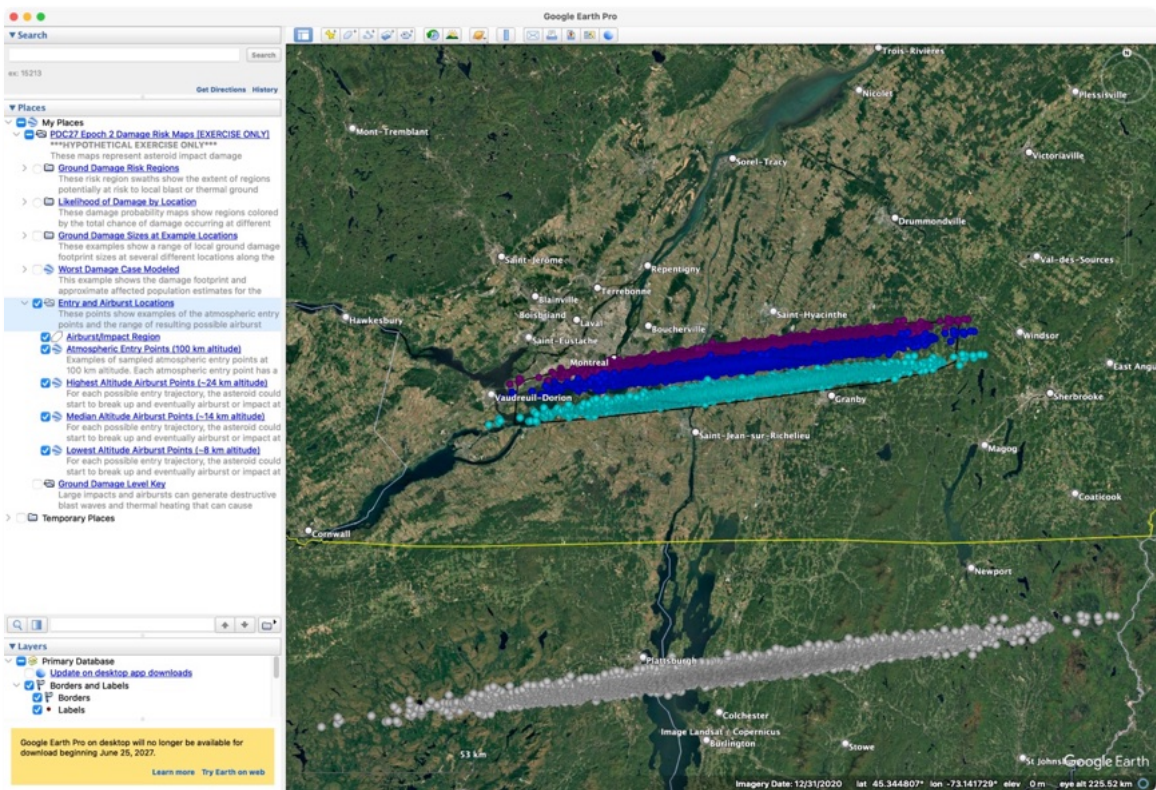
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Entry and Airburst Locations

These points show examples of the atmospheric entry points and the range of resulting possible airburst locations modeled. Each atmospheric entry point has a given entry angle and velocity determined by the asteroid's orbital trajectory. For each possible entry trajectory, the asteroid could start to break up and eventually airburst or impact at different locations along the entry trajectory, depending on the asteroid's properties.

The initial atmospheric entry points at 100 km altitude are shown in gray, along with examples of the corresponding airburst locations for the highest altitude (teal), median altitude (dark blue), and lowest altitude (purple) airburst cases modeled for this scenario.

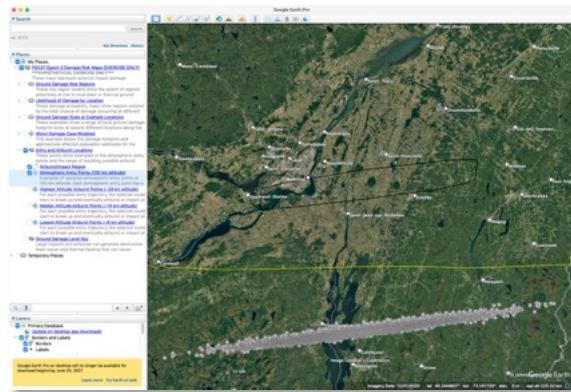
Note that the points are plotted at their different entry or airburst altitudes, so higher points appear closer and the navigation view angle will change the perspective of where on the map the points appear to be over.



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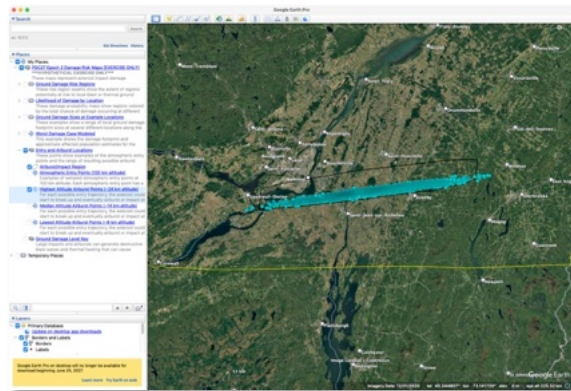
Atmospheric Entry Points (100 km altitude)

Examples of sampled atmospheric entry points at 100 km altitude. Each atmospheric entry point has a given entry angle and velocity determined by the asteroid's orbital trajectory. For each possible entry trajectory, the asteroid could start to break up and eventually airburst or impact at different points along the entry trajectory, depending on the asteroid's properties.



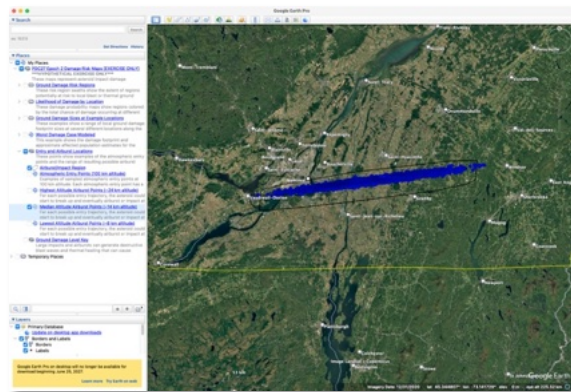
Highest Altitude Airburst Points (~24 km altitude)

For each possible entry trajectory, the asteroid could start to break up and eventually airburst or impact at different points along the entry trajectory, depending on the asteroid's properties. These points show examples of the highest-altitude airburst locations modeled (at 24 km altitude for this scenario) from the range of sampled entry points.



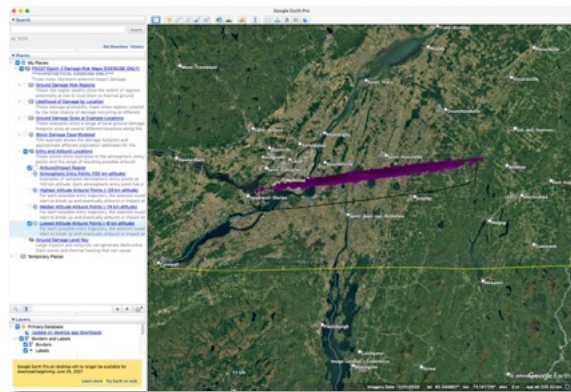
Median Altitude Airburst Points (~14 km altitude)

For each possible entry trajectory, the asteroid could start to break up and eventually airburst or impact at different points along the entry trajectory, depending on the asteroid's properties. These points show examples of median-altitude airburst locations modeled (at 14 km altitude for this scenario) from the range of sampled entry points.



Lowest Altitude Airburst Points (~8 km altitude)

For each possible entry trajectory, the asteroid could start to break up and eventually airburst or impact at different points along the entry trajectory, depending on the asteroid's properties. These points show examples of the lowest-altitude airburst locations modeled (at 8 km altitude for this scenario) from the range of sampled entry points.

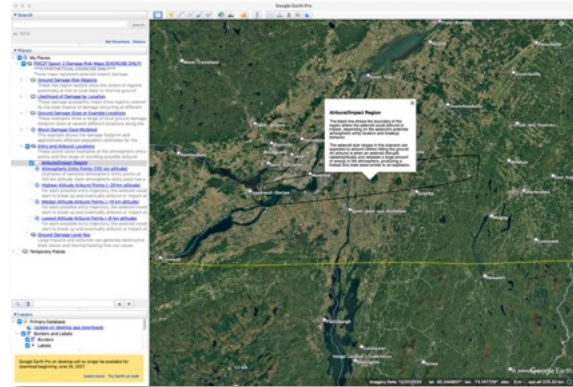


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Airburst/Impact Region

The black line shows the boundary of the region where the asteroid could airburst or impact, depending on the asteroid's potential atmospheric entry location and breakup behavior.

The asteroid size ranges in this scenario are expected to airburst before hitting the ground. An airburst is when an asteroid disrupts catastrophically and releases a large amount of energy in the atmosphere, producing a fireball and blast wave similar to an explosion.



Ground Damage Level Key

Large impacts and airbursts can generate destructive blast waves and thermal heating that can cause various levels of injury, fatalities, structural damage, and/or fires extending far around the impact location. Blast damage from a large airburst is the predominant hazard for the asteroid sizes in this scenario. Damage sizes are estimated for four damage severity levels described below.

	Damage Level Description	Relative Severity
Serious	Shattered windows, some structure damage	10%
Severe	Widespread structure damage	30%
Critical	Most residential structures collapse	60%
Unsurvivable	Devastation, reinforced structures collapse	100%

