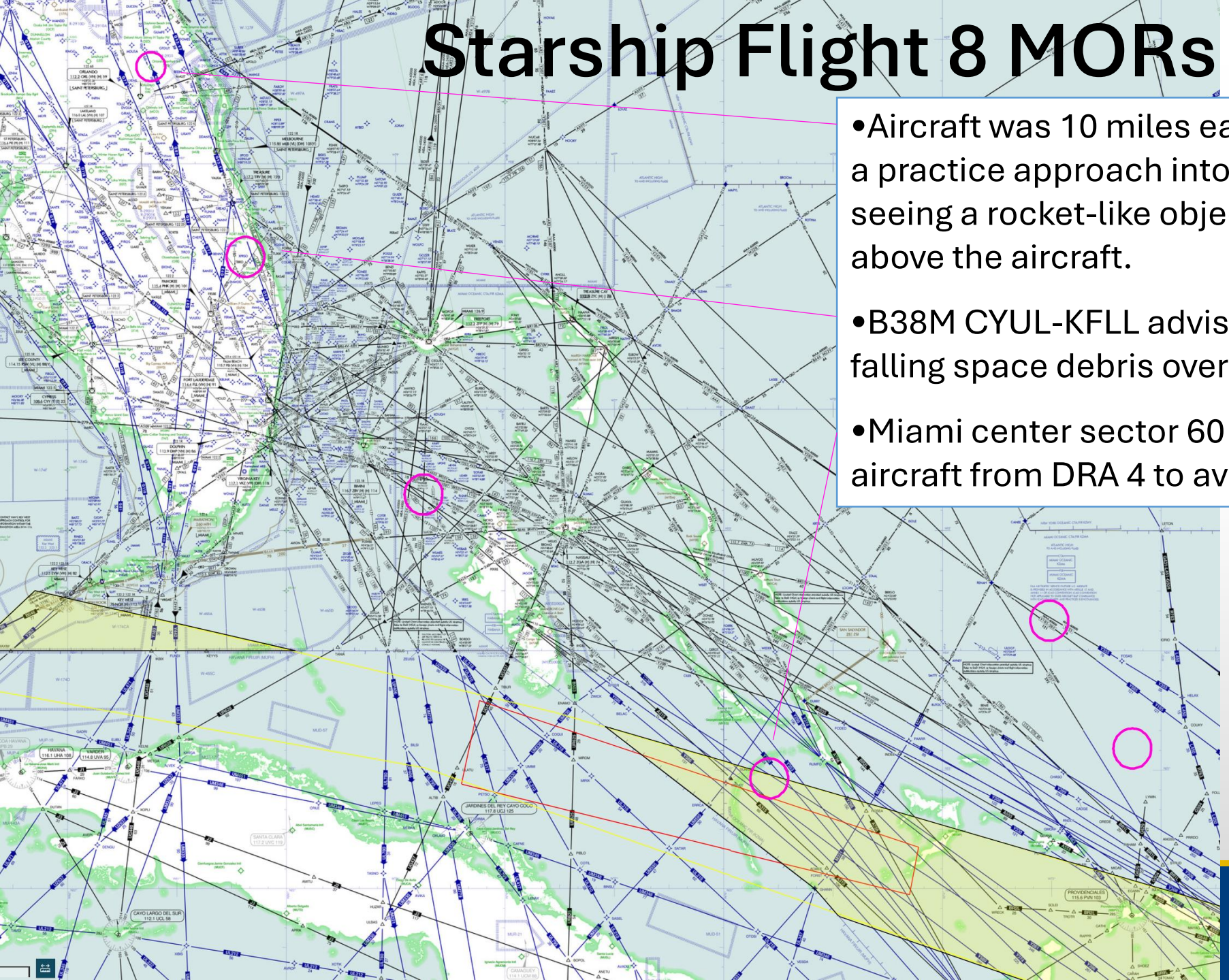
Launch Observation Guide

FAA ATO Space Operations (AJR-1800)

Federal Aviation Administration

Starship Flight 8 MORs

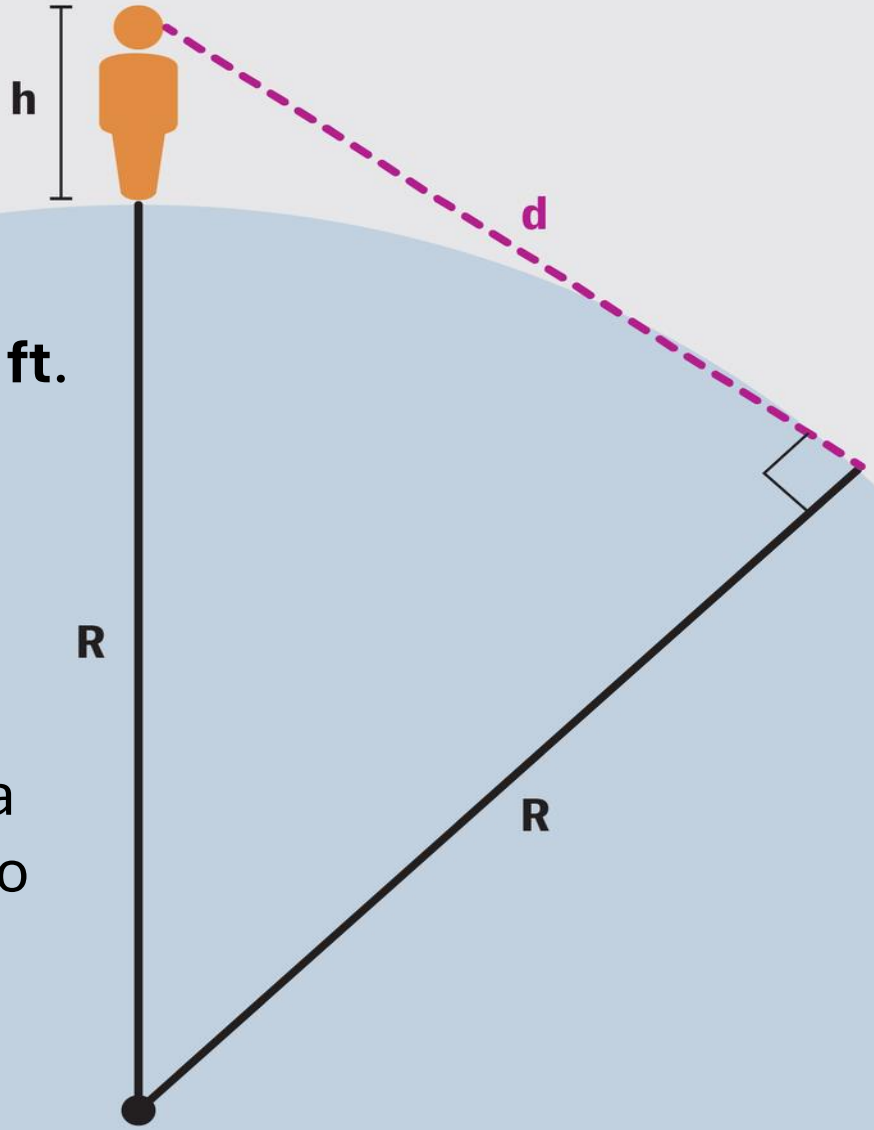


- Aircraft was 10 miles east of SFB at 2500 conducting a practice approach into SFB. The pilot reported seeing a rocket-like object explode about 200 feet above the aircraft.
- B38M CYUL-KFLL advised Miami center sector 20 of falling space debris over the Bahamas.
- Miami center sector 60 issued vector H360 to clear aircraft from DRA 4 to avoid falling space debris.

Horizon Distance

The Starship breakup occurred at an altitude (“h”) of approximately **439,000 ft**.

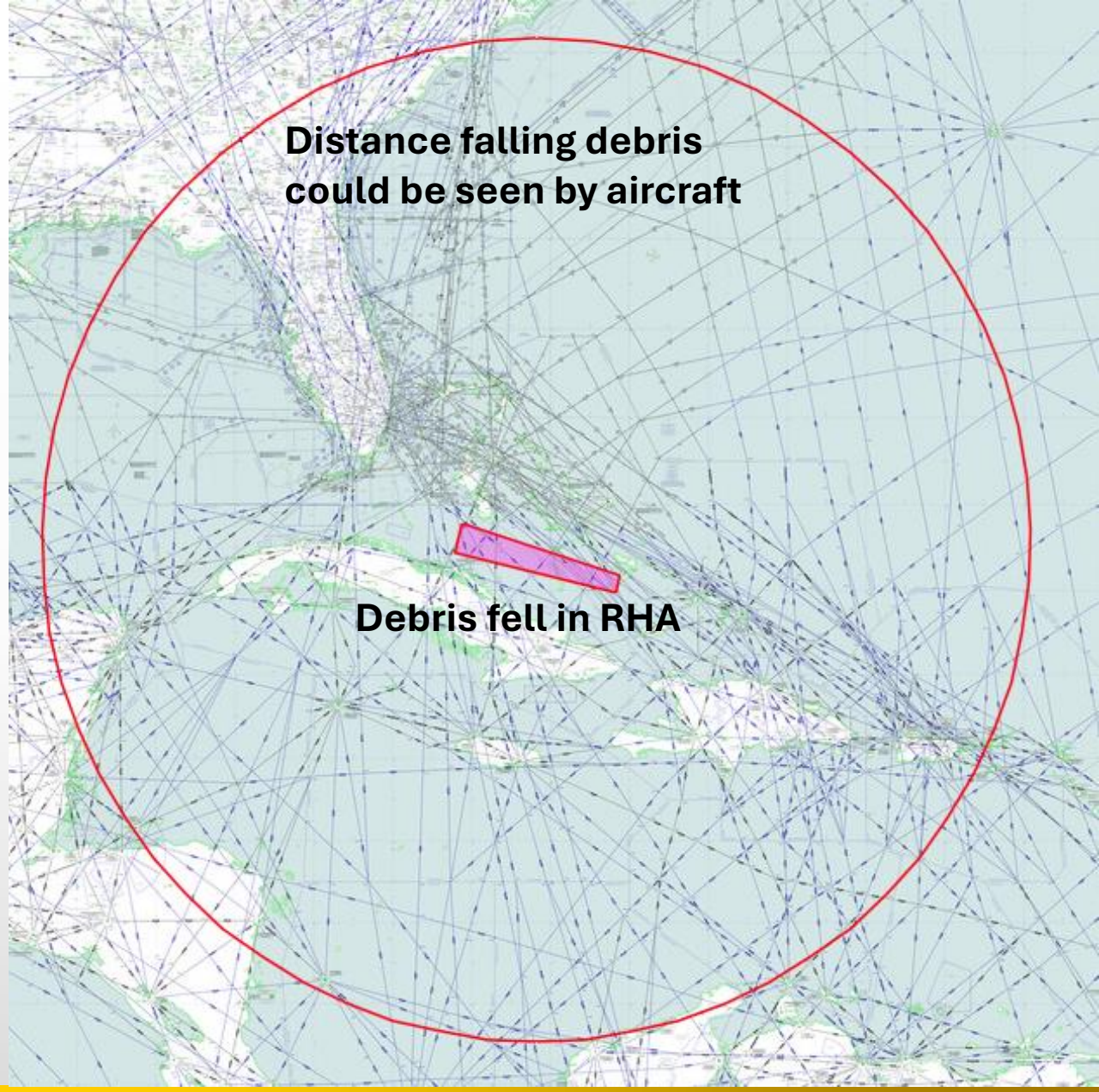
The Starship breakup would be visible a distance (“d”) of over **800 miles** away to an observer on the ground.



Horizon Distance

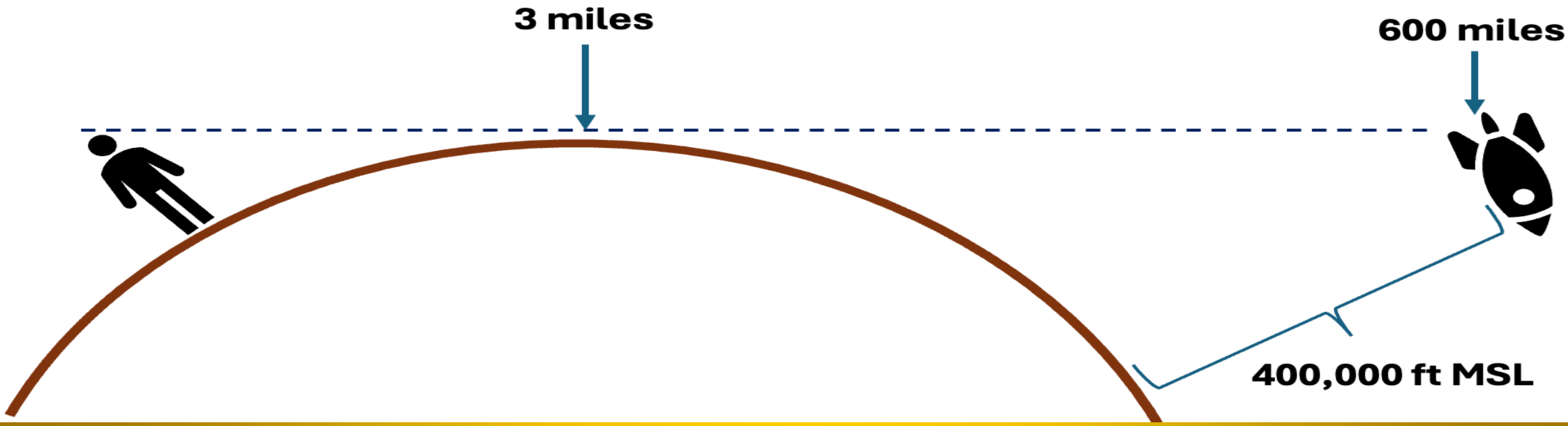
The distance estimate for the visible range of the break-up is over **850 nautical miles** for aircraft.

Rocket viewing distance from Surface and 35,000 ft		
Rocket altitude (feet MSL)	From Surface (nmi)	From FL350 (nmi)
0	3	199
50,000	241	437
100,000	339	536
200,000	478	675
400,000	676	872
500,000	755	952



Distance Illusion

When rockets or debris re-enter the atmosphere, to many viewers this can appear to be occurring very close to the observer at the horizon line but is actually hundreds of miles away. The example below illustrates this issue; the rocket appears to touch the ground to the observer only 3 mi away but is actually 400,000 ft above earth and 600 mi away from the observer as it disappears over the horizon.



Distance Illusion

Lightning at Night for Pilots: It can be easy to misjudge distances to tall thunderstorms with lightning at night. The storms can be seen for hundreds of miles but appear closer, due to (1) the combined height of the storm & observer and (2) point-source bright light, which can make estimating distance inaccurate. Rockets or debris are also a point-source bright light against a dark background. Pilots may also experience a similar point-light illusion in their careers, called the black hole effect, by landing at dark airports bordering city lights.

Atmospheric Turbulence: Turbulent air can cause objects to appear to shimmer or twinkle, further distorting the perception of distance.

Aerial Perspective: The way objects appear to fade and become less defined as they recede into the distance, due to atmospheric scattering and absorption of light, also contributes to the illusion of distance.

Weather

How does weather affect rocket viewing?

- In clear weather, rockets or re-entering debris can appear to ‘touch’ the horizon as they descend from high altitude, giving an illusion of appearing closer than they are.

- Low sun angles provide optimal light on rockets, allowing for viewing from far away.

- Similarly, rockets illuminated on ascent around sunrise or sunset commonly appear as a ‘jellyfish’ shape and can be seen for hundreds of miles away, as shown in the figure to the right.

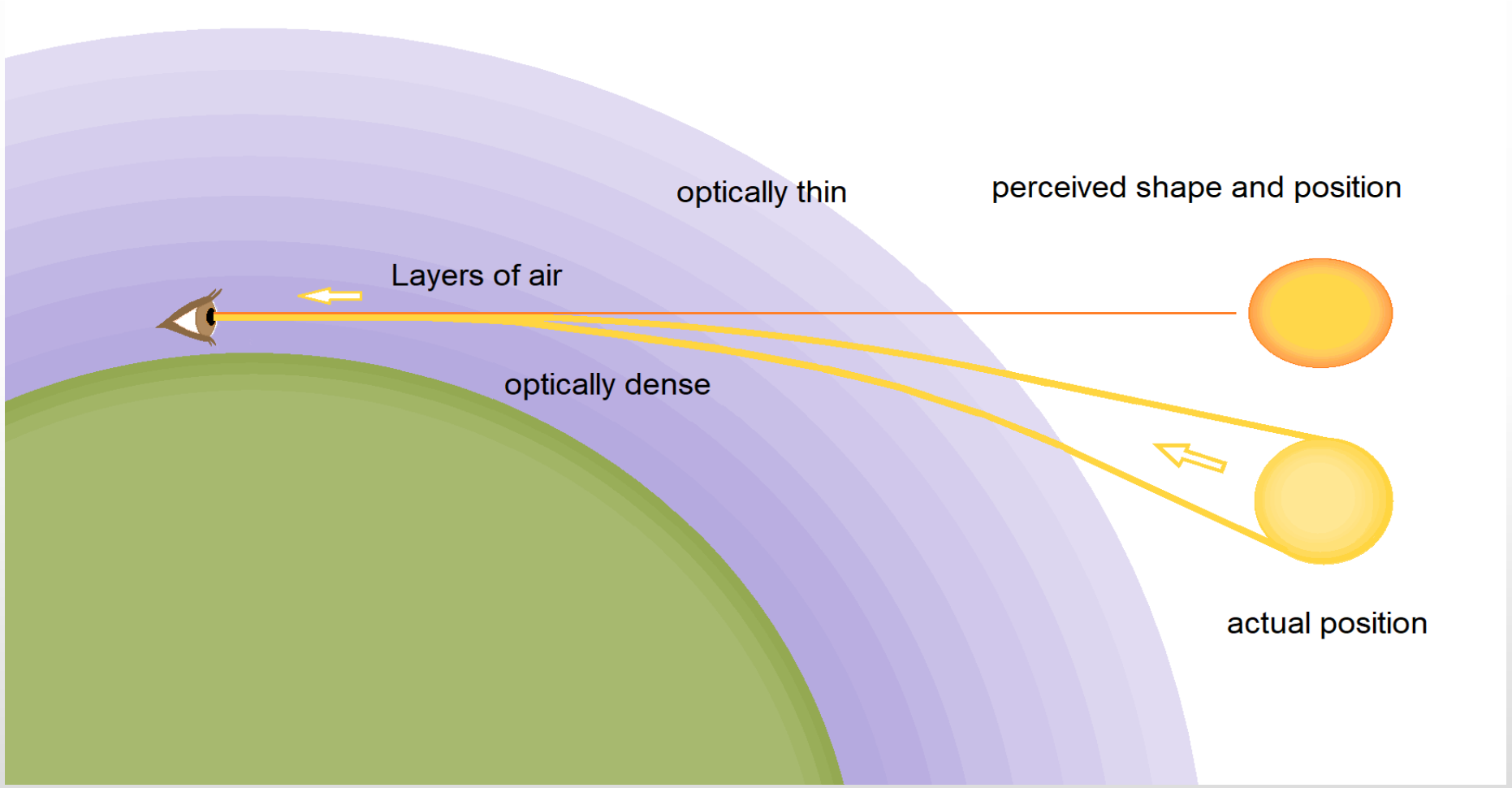
Refraction

Refraction distance illusions, like **mirages** and **looming**, occur when light bends as it travels through air layers of varying densities, creating the illusion of objects being closer to or further away from their actual position.

- This bending of light is due to the fact that light travels slower in cooler, denser air than in warmer, less dense air.
- **Mirages** (like the 'oasis' mirage) occur when light from the sky bends upward toward the viewer, making it appear as if there is water on the ground.
- **Looming** is the opposite of a mirage, where objects appear to be higher or closer than they actually are.
- **Looming** occurs when light rays from below the horizon are bent upwards, making objects that would normally be below the horizon appear to be lifted into the sky.

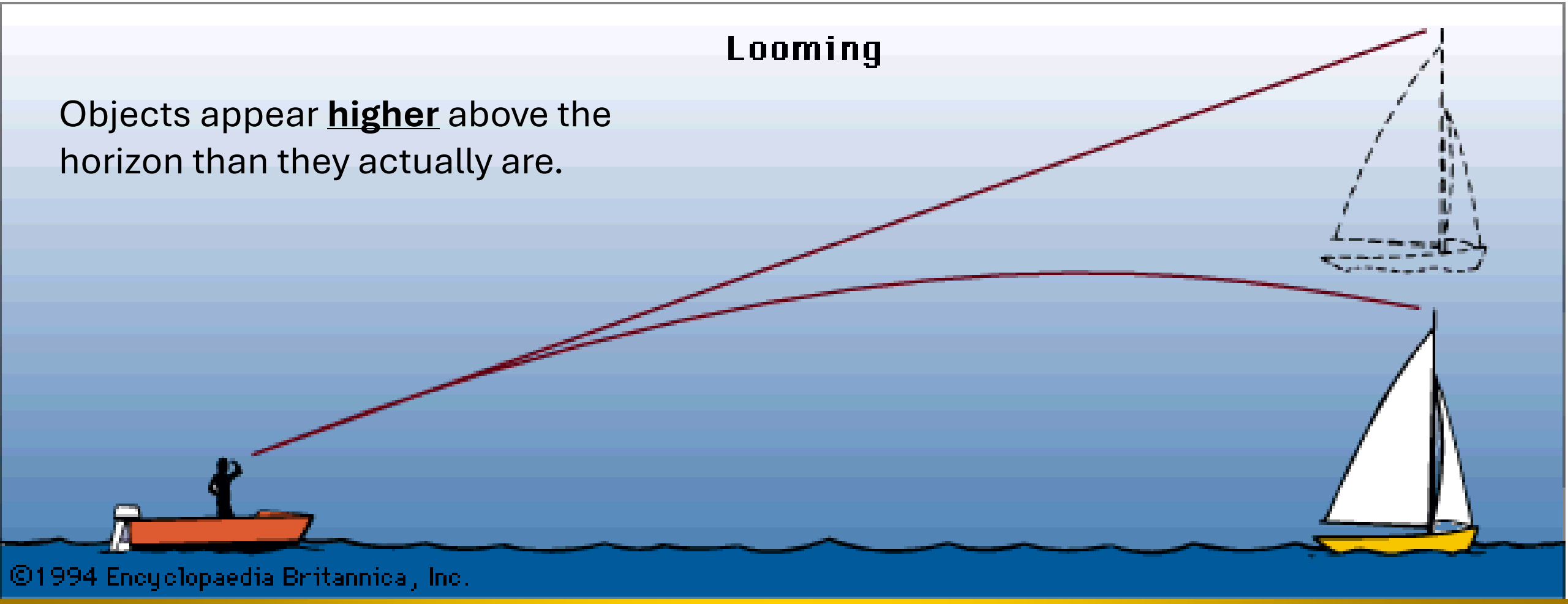
Refraction

Sunset and Sunrise: Shift in the perceived position of the sun due to atmospheric refraction

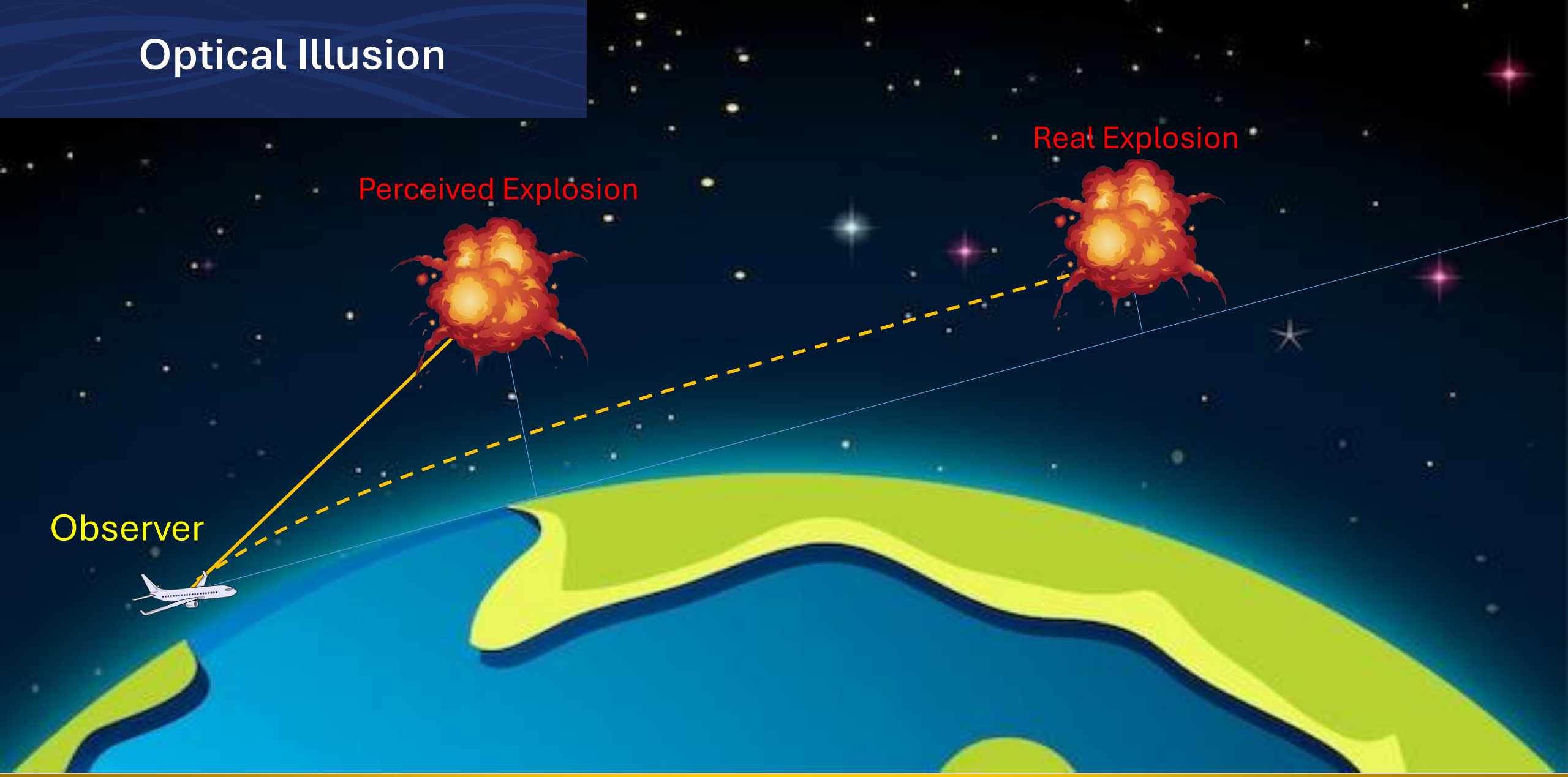


Looming

The brain always interprets light as traveling in a straight line.



Optical Illusion

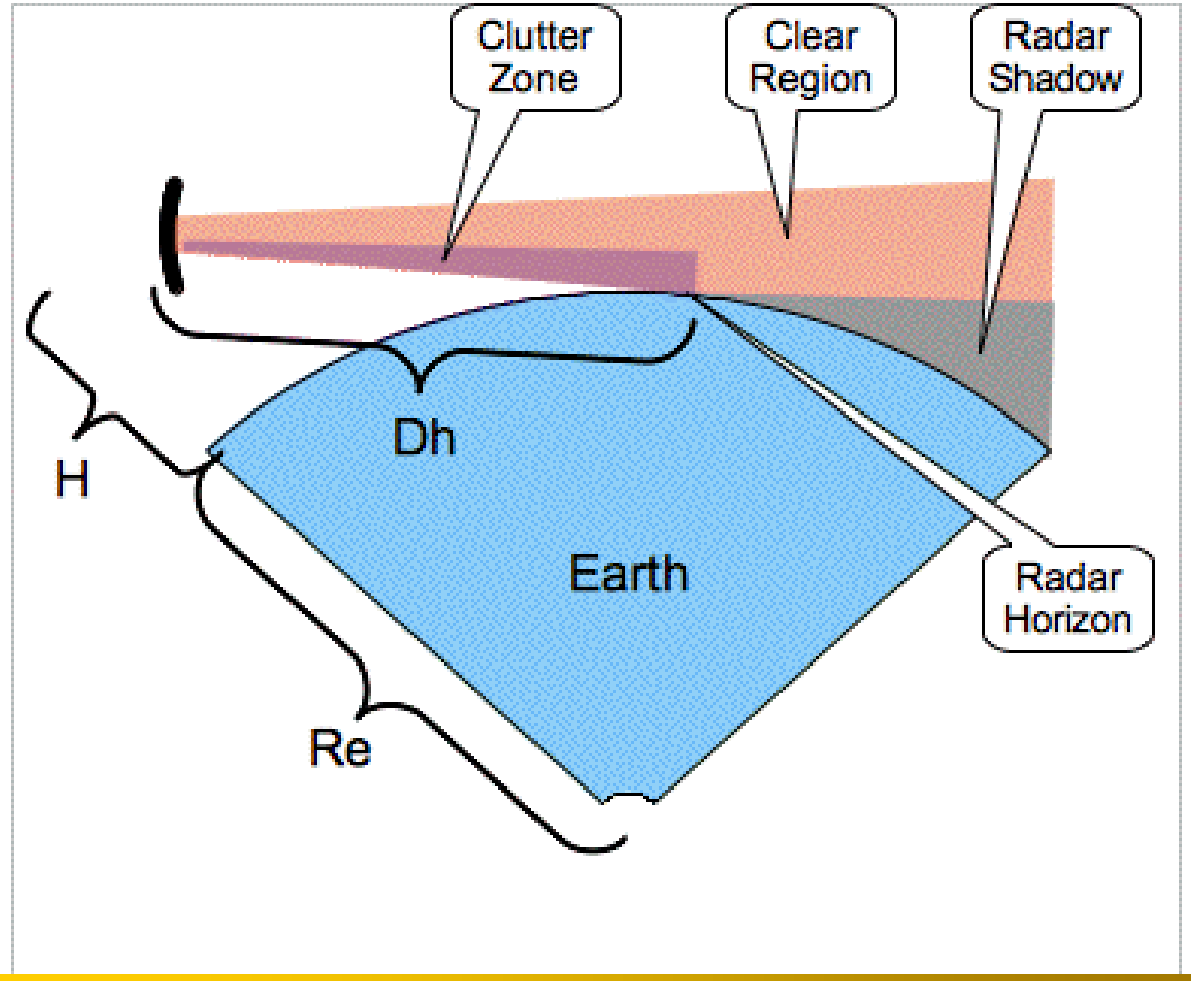


RADAR

RADAR waves follow the same rules as visible light waves.

It is **extremely difficult** to accurately determine the distance to objects when RADAR waves are being bent.

When RADAR are looking at objects beyond their effective range, distance estimates become unreliable.



Summary

Remember:

- Debris may appear to be very close, but could be hundreds of miles away.
- The height of the space vehicle, lighting, and atmospheric effects can make estimating distance inaccurate.

During/after an anomaly, please note:

- The ATO Space Operations hotline is the authority regarding DRA activation and deactivation.
- The pre-mission safety products cover a wide range of failure possibilities while the Refined Hazard Area (RHA) is calculated from the last known position and heading.
- The release of airspace after an anomaly is based on the RHA.
- The malfunction time you are provided in advance of the mission may be different than what is used following an actual anomaly.