

Closed for Operations: Non-Interference Zones and the Cadence of the New Space Race

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Today's Inquires

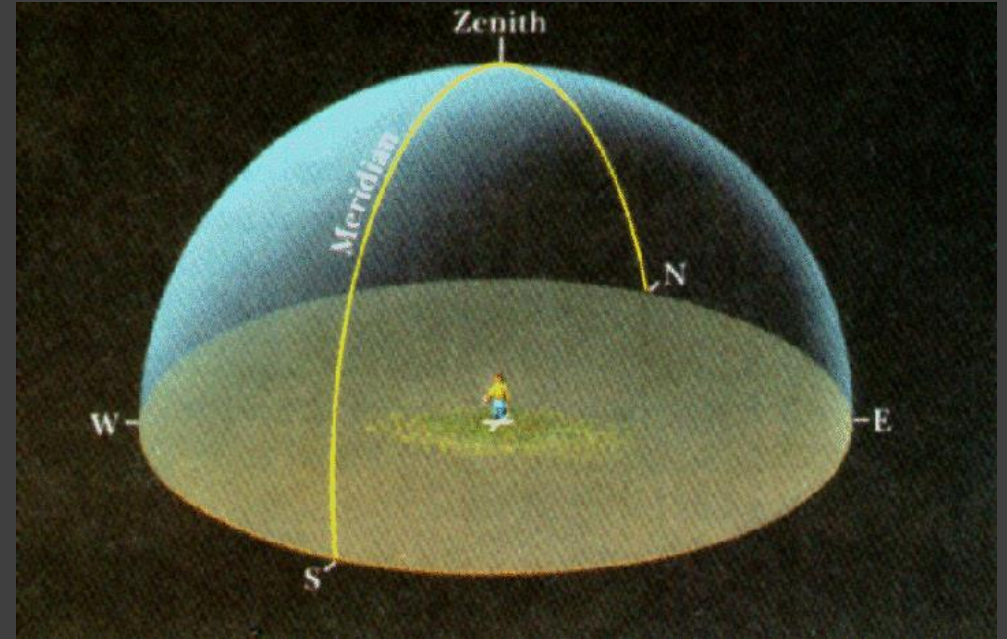
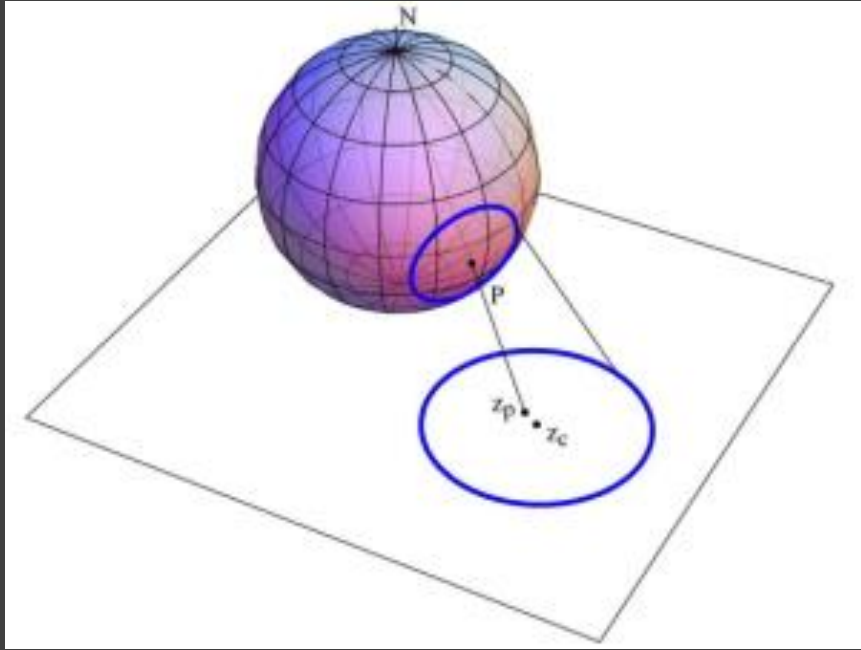
- What are non-interference zones for space activities?
- What benefits do non-interference zones provide?
- What are the limitations of non-interference zones?
- What issues arise from the use of non-interference zones?
- What do non-interference zones implicate for the future?

A Preliminary Point: Why go to the Moon? Or Mars? Or do anything in space?

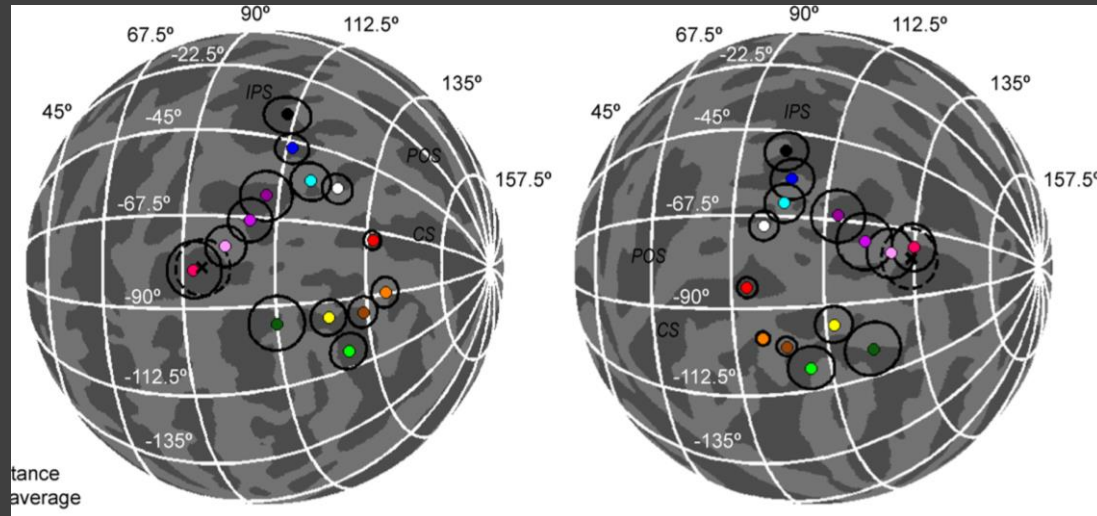
- *Space activities started with rights of overflight above national air space set under international law and custom/practice*
- Resources
- Science
- Technology Research & Development
- Prestige
- National Security and/or Foreign Policy
- Species survival and settlement
- Because it's there

What are non-interference zones for space activities?

- What exactly is a non-interference zone?
 - A volume of space around a space object that is exclusively controlled and/or operated within a fixed or at a relative location by the operators of the space object
 - Zone defined according to a variety of metrics including
 - Risk and technology failure analysis
 - Personal (Pc) and property (Ec) risk analyses - FAA
 - Legal requirements
 - Normative behavior of space operators
 - Provides operational safety and certainty regarding space activities
 - Provides a means for economic and risk management of operations
- Are all non-interference zones alike?
 - No!
 - ISS and spacecraft – NASA and FAA rules
 - Physical and electromagnetic interference separation distances – ITU/FCC rules
 - Spaceports – FAA and USAF rules



*For illustration purposes



NASA Keep Out Zones

Mission Profile

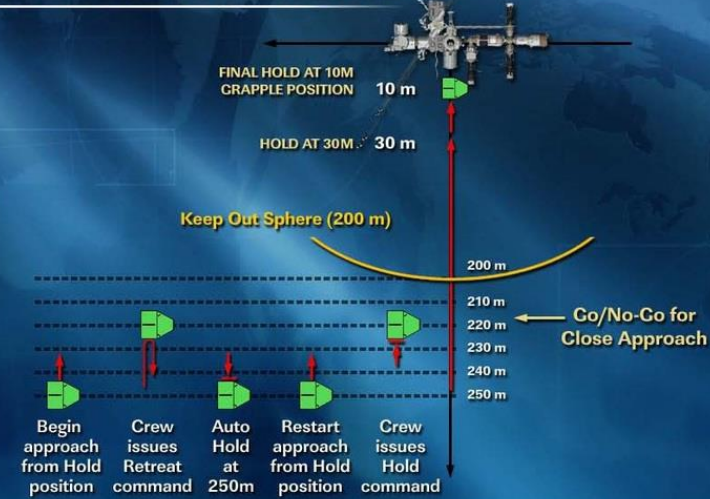
Nominal Mission: Fly around at 6.2 miles with fly-under at 1.6 miles



Dragon Rendezvous with ISS



Demonstration Maneuvers



*NASA images

Terrestrial Example

New Zealand's Ministry of Business, Innovation and Employment Regulation

16A

NON-INTERFERENCE ZONES AROUND PETROLEUM AND MINERAL EXPLORATION AND PRODUCTION ACTIVITIES

1. The Chief Executive of the Ministry of Business, Innovation and Employment can specify a non-interference zone around prospecting, exploration, or mining activities that are authorised under a permit granted under the *Crown Minerals Act 1991*.
2. It is an offence to enter a non-interference zone without reasonable excuse. A fine of up to \$10,000 may be imposed for doing so. Enforcement officers can:
 - (a) Arrest people entering, or attempting to enter, a zone;
 - (b) Prevent ships or people entering a zone;
 - (c) Stop and detain a ship in a zone; and
 - (d) Remove ships or people from a zone.
3. The zone is specified by a notice published in a fortnightly edition of *New Zealand Notices to Mariners*.
4. A notice will specify:
 - (a) The activity to which the non-interference zone relates;
 - (b) The locality of the activity;
 - (c) The area of the non-interference zone (which can be up to 500 metres from the outer edge of the structure or ship, or any attached equipment, to which the activities relates); and
 - (d) The time period for which the notice takes effect.
5. The non-interference zone can be applied within the territorial sea or the exclusive economic zone, or on or above the continental shelf.
6. The relevant sections of the *Crown Minerals Act 1991* are Sections 101A to 101C.
7. Under Section 101B(1) a person also commits an offence if the person intentionally damages or interferes with any structure or ship, or attached equipment, that is used in relation to offshore prospecting, exploration, or mining operations. A non-interference zone does not apply to this offence. An individual convicted of this offence is liable to imprisonment of up to 12 months or a fine of up to \$50,000; a company is liable for a fine of up to \$100,000.

Legal considerations: Outer Space Treaty (1967)

- **Outer Space Treaty (Article I) (Exploration and Use)**
 - The exploration and use of outer space, including the moon and other celestial bodies, shall be carried out for the **benefit and in the interests of all countries**, irrespective of their degree of economic or scientific development, and shall be the province of all mankind.
 - **Outer space, including the moon and other celestial bodies, shall be free for exploration and use by all States without discrimination of any kind, on a basis of equality and in accordance with international law, and there shall be free access to all areas of celestial bodies.**
 - **There shall be freedom of scientific investigation in outer space, including the moon and other celestial bodies, and States shall facilitate and encourage international co-operation in such investigation.**
- **Outer Space Treaty (Article II) (Prohibition on national appropriation of space)**
 - Outer space, including the moon and other celestial bodies, is **not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means.**
- **Outer Space Treaty (Article III) (All International law applies)**
 - States Parties to the Treaty **shall carry on activities in the exploration and use of outer space, including the moon and other celestial bodies, in accordance with international law**, including the Charter of the United Nations, in the interest of maintaining international peace and security and promoting international co-operation and understanding.
- **Outer Space Treaty (Article IV) (Assistance for distress)**
 - States Parties to the Treaty **shall regard astronauts as envoys of mankind** in outer space and **shall render to them all possible assistance in the event of accident, distress, or emergency landing** on the territory of another State Party or on the high seas...

Legal considerations: Outer Space Treaty (1967)

- **Outer Space Treaty (Article VI) (Authorization and continuing supervision of space activities)**
 - States Parties to the Treaty shall bear **international responsibility for national activities in outer space, including the moon and other celestial bodies, whether such activities are carried on by governmental agencies or by non-governmental entities, and for assuring that national activities are carried out in conformity with the ... Treaty.** The activities of non-governmental entities in outer space, including the moon and other celestial bodies, **shall require authorization and continuing supervision** by the appropriate State Party to the Treaty.
- **Outer Space Treaty (Article IX) (Mutual assistance, due regard, interference and contamination)**
 - In the exploration and use of outer space, including the moon and other celestial bodies, States Parties to the Treaty shall be guided by the **principle of co-operation and mutual assistance and shall conduct all their activities in outer space, including the moon and other celestial bodies, with due regard to the corresponding interests of all other States Parties to the Treaty.** States Parties to the Treaty shall pursue studies of outer space... **and conduct exploration of them so as to avoid their harmful contamination** ... If a State Party to the Treaty has reason to believe that an activity or experiment planned by it or its nationals in outer space... **would cause potentially harmful interference with activities of other States Parties** in the peaceful exploration and use of outer space, ... it shall **undertake appropriate international consultations** before proceeding with any such activity or experiment.
- **Outer Space Treaty (Article XI) (Notification)**
 - In order to promote international co-operation in the peaceful exploration and use of outer space, States Parties to the Treaty conducting activities in outer space, including the moon and other celestial bodies, **agree to inform** the Secretary-General of the United Nations as well as the public and the international scientific community, **to the greatest extent feasible and practicable**, of the **nature, conduct, locations and results of such activities.** On receiving the said information, the Secretary-General of the United Nations should be prepared to disseminate it immediately and effectively.

Legal considerations: Federal Aviation Administration's Office of Commercial Space Transportation Regulations

- FAA launch vehicle and spaceport licensing for commercial entities
 - Launch license (one and done)
 - Reentry license (up and coming back)
 - Spaceport license
- Commercial entities may ask the government for a review under FAA regs
 - Policy Review
 - Must have submitted launch license application to ask for policy review
 - Payload Review Request
 - Can ask anytime and at any point in the pre-launch license application phase, but a review shall be conducted if a launch license is submitted by LV company for commercial payloads

Legal considerations: Federal Aviation Administration's Office of Commercial Space Transportation Regulations

51 USC §50904. Restrictions on launches, operations, and reentries

(a) Requirement.—A license issued or transferred under this chapter, or a permit, is required for the following:

(1) for a person to launch a launch vehicle or to operate a launch site or reentry site, or to reenter a reentry vehicle, in the United States.

(2) for a citizen of the United States (as defined in section 50902(1)(A) or (B) of this title) to launch a launch vehicle or to operate a launch site or reentry site, or to reenter a reentry vehicle, outside the United States.

(3) for a citizen of the United States (as defined in section 50902(1)(C) of this title) to launch a launch vehicle or to operate a launch site or reentry site, or to reenter a reentry vehicle, outside the United States and outside the territory of a foreign country unless there is an agreement between the United States Government and the government of the foreign country providing that the government of the foreign country has jurisdiction over the launch or operation or reentry.

(4) for a citizen of the United States (as defined in section 50902(1)(C) of this title) to launch a launch vehicle or to operate a launch site or reentry site, or to reenter a reentry vehicle, in the territory of a foreign country if there is an agreement between the United States Government and the government of the foreign country providing that the United States Government has jurisdiction over the launch or operation or reentry.

Notwithstanding this subsection, a permit shall not authorize a person to operate a launch site or reentry site.

(b) Compliance With Payload Requirements.—The holder of a license or permit under this chapter may launch or reenter a payload only if the payload complies with all requirements of the laws of the United States related to launching or reentering a payload.

(c) Preventing Launches and Reentries.—The Secretary of Transportation shall establish whether all required licenses, authorizations, and permits required for a payload have been obtained. If no license, authorization, or permit is required, the Secretary may prevent the launch or reentry if the Secretary decides the launch or reentry would jeopardize the public health and safety, safety of property, or national security or foreign policy interest of the United States.

(d) Single License or Permit.—The Secretary of Transportation shall ensure that only 1 license or permit is required from the Department of Transportation to conduct activities involving crew, government astronauts, or space flight participants, including launch and reentry, for which a license or permit is required under this chapter. The Secretary shall ensure that all Department of Transportation regulations relevant to the licensed or permitted activity are satisfied.

Legal considerations: Federal Aviation Administration's Office of Commercial Space Transportation Regulations

14 CFR § 415.57 Payload review.

(a) **Timing.** A payload review may be conducted as part of a license application review or may be requested by a payload owner or operator in advance of or apart from a license application.

(b) Interagency consultation. The FAA consults with other agencies to determine whether launch of a proposed payload or payload class would present any issues affecting public health and safety, safety of property, U.S. national security or foreign policy interests, or international obligations of the United States.

(1) The FAA consults with the Department of Defense to determine whether launch of a proposed payload or payload class would present any issues affecting U.S. national security.

(2) The FAA consults with the Department of State to determine whether launch of a proposed payload or payload class would present any issues affecting U.S. foreign policy interests or international obligations.

(3) The FAA consults with other federal agencies, including the National Aeronautics and Space Administration, authorized to address issues identified under paragraph (b) of this section associated with an applicant's launch proposal.

(c) The FAA advises a person requesting a payload determination, in writing, of any issue raised during a payload review that would impede issuance of a license to launch that payload or payload class. The person requesting payload review may respond, in writing, or revise its application.

Who wants non-interference zones?

- Bigelow Aerospace Payload Review Request (Dec 2013)
 - Asked FAA whether it would prohibit a Bigelow habitat module from being launched to the surface of the Moon
- Moon Express Payload Review Request (2015)
 - Ask FAA whether it would prohibit Moon Express from launching a lunar lander to the surface of the Moon

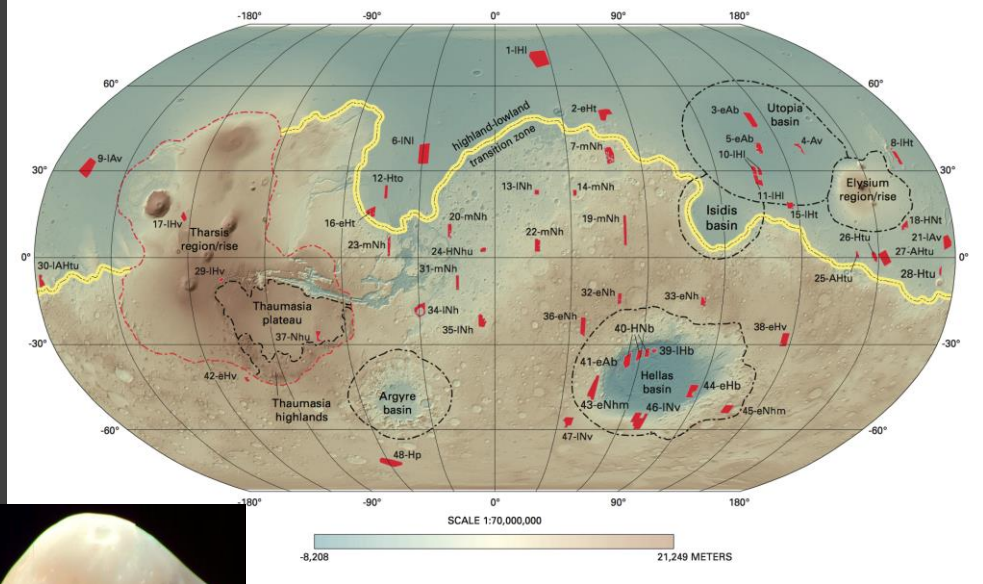
What is the USG position on non-interference zones?

- **Bigelow Aerospace Payload Review Determination (Dec 22, 2014)**

- [w]e recognize the private sector's need to protect its assets and personnel on the Moon or on other celestial bodies. **Supporting non-interference for private sector operations will enhance safety and only add to the long history of preserving ownership interests in hardware and equipment.** Per Congressional guidance, we intend to leverage the FAA's existing launch licensing authority to encourage private sector investments in space systems by ensuring that commercial activities can be conducted on a non-interference basis.

- **Moon Express Payload Review Determination (Aug 3, 2016)**

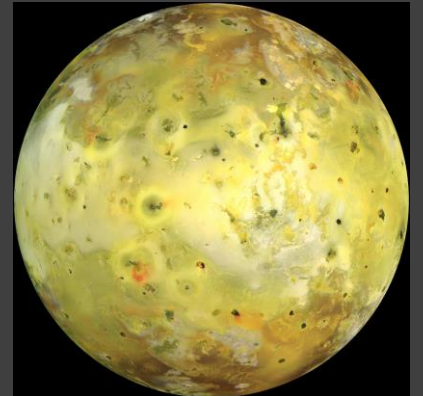
- The FAA made a favorable payload determination for this particular mission, however, not all non-traditional space missions may lend themselves to favorable payload determinations under the payload review ... **Future missions may require additional authority** to be provided to the FAA to ensure conformity with the Outer Space Treaty. Suggested language for legislative relief and the relative merits and needs has been transmitted to Congress in compliance with Section 108 of the Commercial Space Launch Competitiveness Act (Public Law 114-90). In the absence of legislative relief, the FAA will continue to work with the commercial space industry to provide support for non-traditional missions on a case-by-case basis when the law permits.



MARS

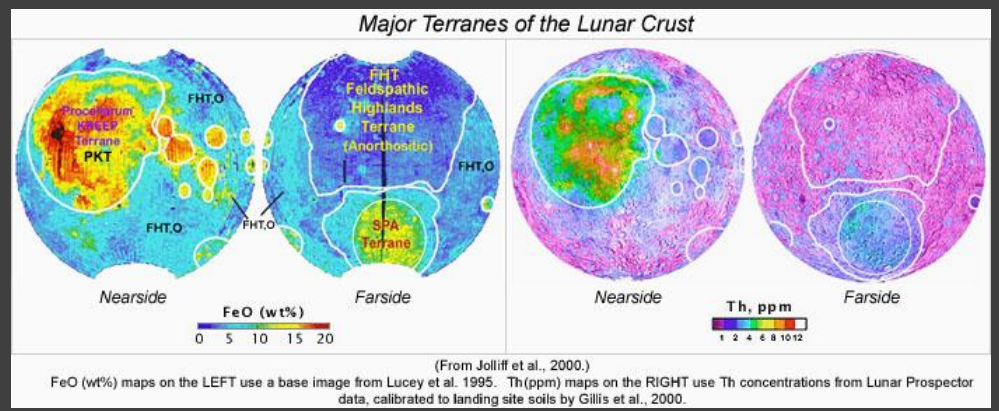
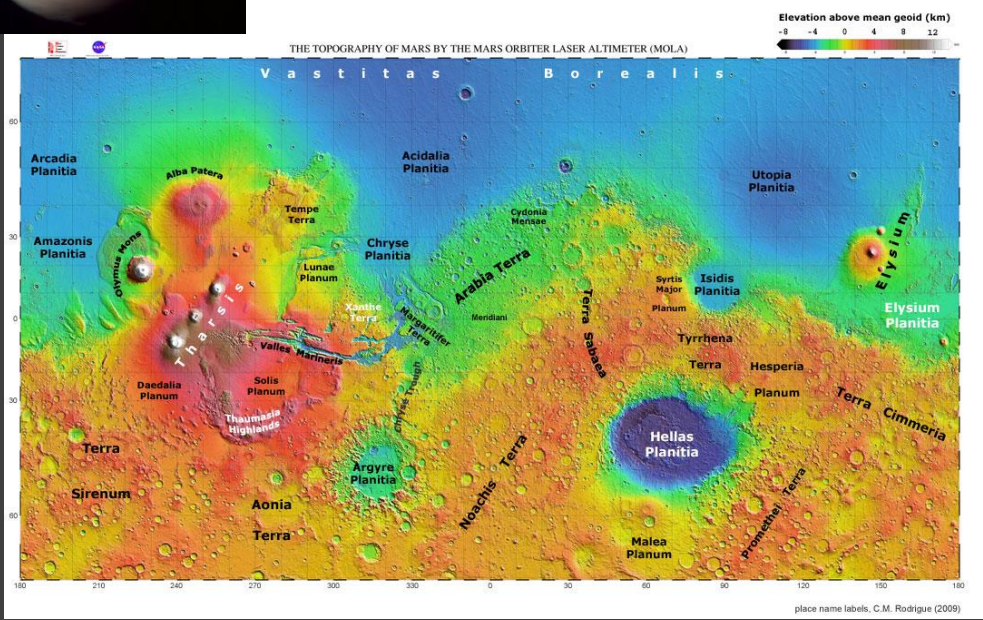


Pluto

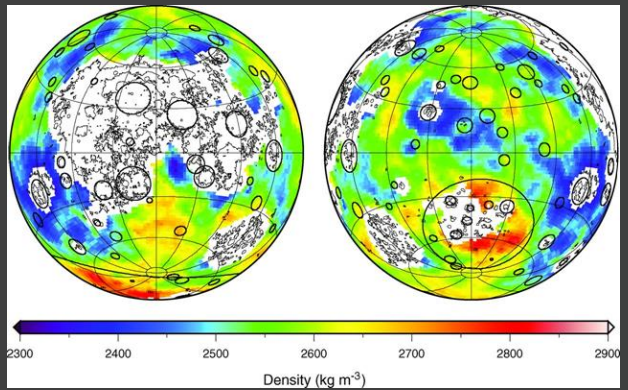
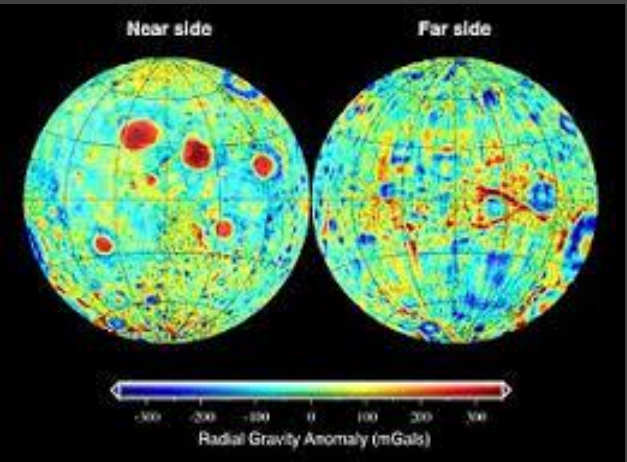


Io

MOON



(From Jolliff et al., 2000.)
 FeO (wt%) maps on the LEFT use a base image from Lucey et al. 1995. Th (ppm) maps on the RIGHT use Th concentrations from Lunar Prospector data, calibrated to landing site soils by Gillis et al., 2000.



Surface area of some planetary bodies

* Key: 1 sq mi ~ 2.59 sq km

- Surface area of
 - Earth: **509.9 million square kilometers**
 - Surface gravity: 9.8 m/s²
 - Approx distance to horizon: 4.6 km
 - Mars: **55.9 million square kilometers**
 - Surface gravity: 3.7 m/s²
 - Approx distance to horizon: 3.2 km
 - Deimos: 483.05 square kil
 - Surface gravity: 0.003 m/s²
 - Approx distance to horizon: 140.9 meters
 - Io: **41.9 million square kilometers**
 - Surface gravity: 1.8 m/s²
 - Approx distance to horizon: 2.48 km
 - Moon: **37.9 million square kilometers**
 - Surface gravity: 1.6 m/s²
 - Approx distance to horizon: 2.43 km
 - Pluto: **17.07 million square kilometers**
 - Surface gravity: 0.6 m/s²
 - Approx distance to horizon: 1.9 km

Equation of Motion for projectile:

$\theta = 45$ degrees

1 m/s = 2.24 ft/s

$$R = \frac{u^2 \sin 2\theta}{g}$$

Earth: $R = (1 \text{ m/s})^2 \sin 2(45 \text{ degrees}) / (9.8 \text{ m/s}^2) = 0.10 \text{ m}$

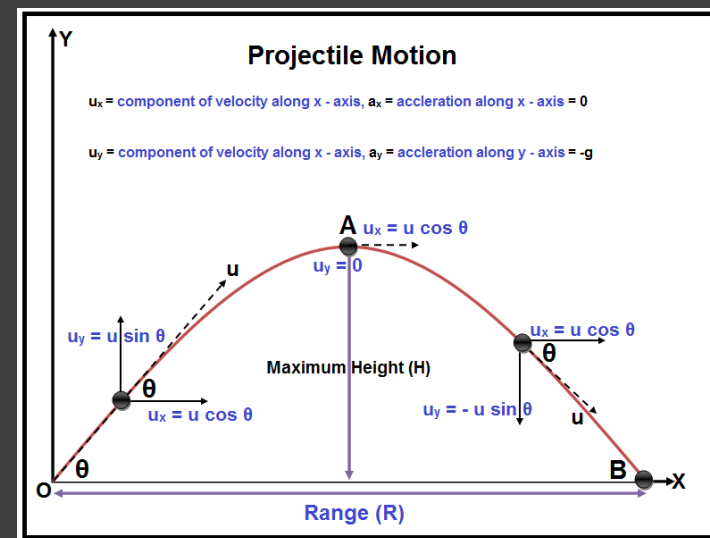
Mars: $R = (1 \text{ m/s})^2 \sin 2(45 \text{ degrees}) / (3.7 \text{ m/s}^2) = 0.27 \text{ m}$

Io: $R = (1 \text{ m/s})^2 \sin 2(45 \text{ degrees}) / (1.8 \text{ m/s}^2) = 0.55 \text{ m}$

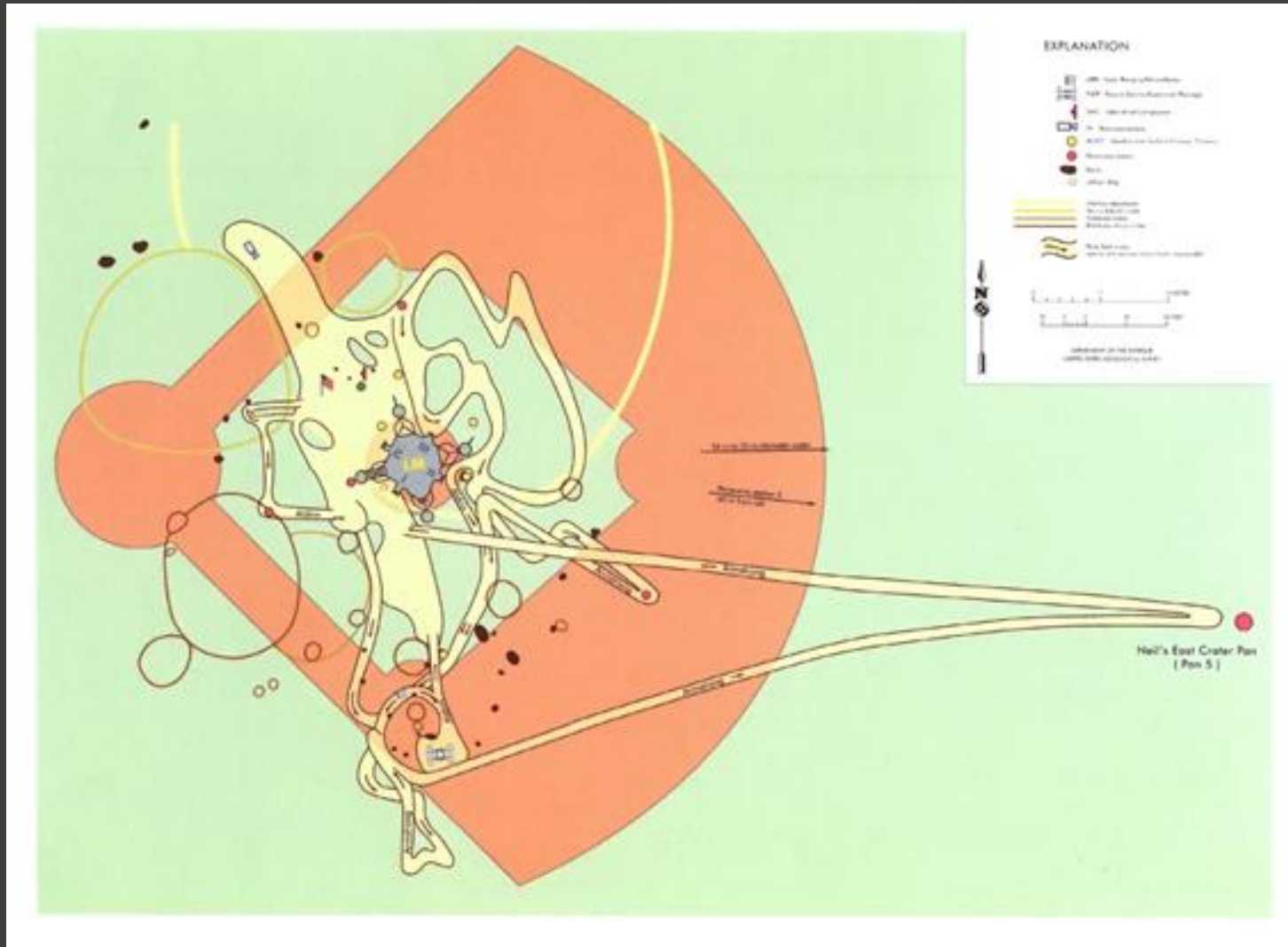
Moon: $R = (1 \text{ m/s})^2 \sin 2(45 \text{ degrees}) / (1.6 \text{ m/s}^2) = 0.63 \text{ m}$

Pluto: $R = (1 \text{ m/s})^2 \sin 2(45 \text{ degrees}) / (0.6 \text{ m/s}^2) = 1.67 \text{ m}$

Deimos: $R = (1 \text{ m/s})^2 \sin 2(45 \text{ degrees}) / (0.003 \text{ m/s}^2) = 333.33 \text{ m}$



Compare: Apollo 11 landing site



Distance from home plate to
Pitcher's mound in MLB: 18.5 m

MLB fastball ave: 90 mph \sim 40 m/s

Compare:

Moon: $R = (40 \text{ m/s})^2 \sin^2(45 \text{ degrees}) / (1.6 \text{ m/s}^2) = 1,000 \text{ m}$

Earth: $R = (40 \text{ m/s})^2 \sin^2(45 \text{ degrees}) / (9.8 \text{ m/s}^2) = 163.2 \text{ m}$

FAA Regulations for Launch Range Corridors/Spaceports

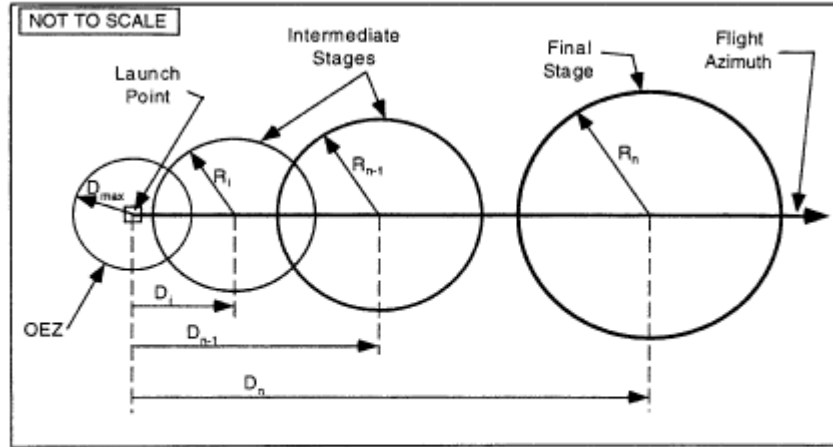


Figure D-1

Unguided Suborbital Launch Vehicle Overflight Exclusion Zone and Impact Dispersion Areas

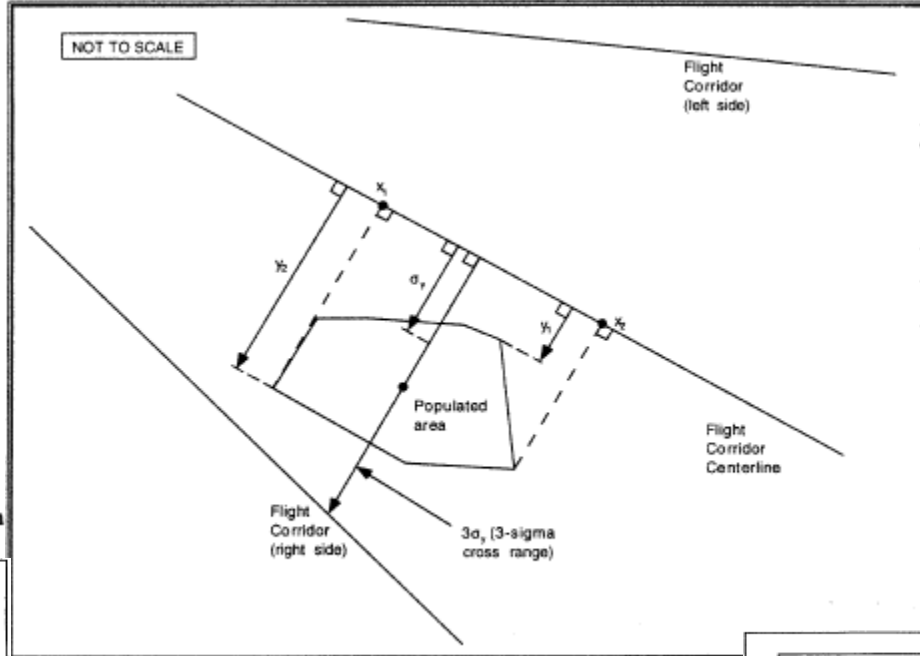


Figure C-1: Analysis of an Appendix A Flight Corridor

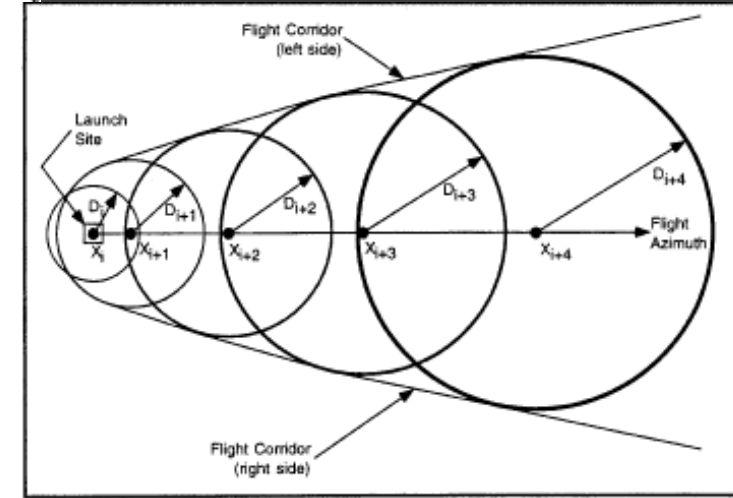


Figure B-1: Launch Area of a Flight Corridor

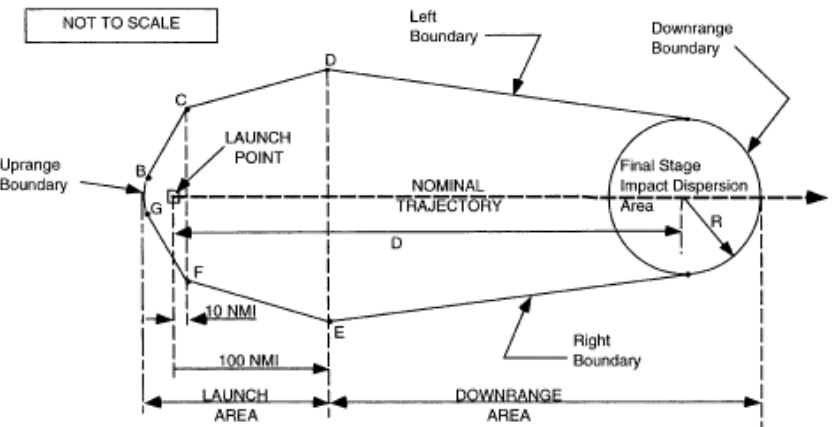


Figure A-4

Flight Corridor for Guided Sub-Orbital Launch Vehicles

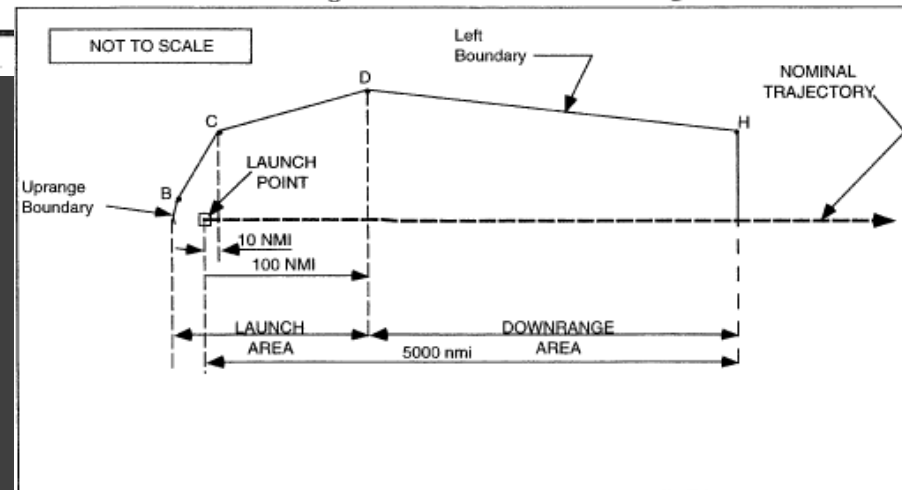


Figure A-3

Construction of Left Boundary of Flight Corridor

*For illustration purposes

FAA Regulations for Launch Range Corridors/Spaceports

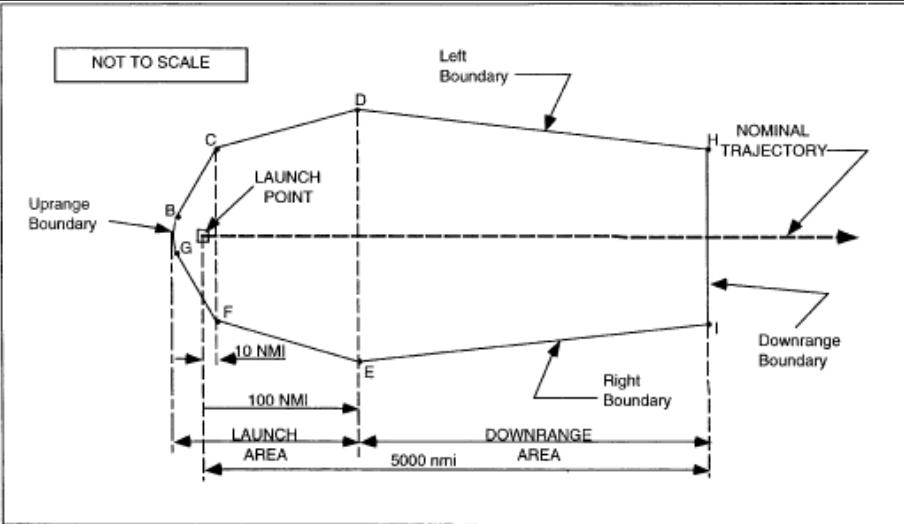


Figure A-2
Flight Corridor

Table A-3: Flight Corridor Line Segment Lengths

D_{max} (in)		Line Segment Lengths ($\times 10^6$ inches)		
Orbital Launch Vehicles		\overline{CF}	\overline{DE}	\overline{HI}
Small	87600 (1.20 nm)	2.87620 (39.45 nm)	8.59452 (117.87 nm)	128.566 (1763.27 nm)
Medium	111,600 (1.53 nm)	2.97220 (40.76 nm)	8.64252 (118.53 nm)	128.566 (1763.27 nm)
Med-Large	127,200 (1.74 nm)	3.03460 (41.62 nm)	8.67372 (118.96 nm)	128.566 (1763.27 nm)
Large	156,000 (2.14 nm)	3.14979 (43.20 nm)	8.73131 (119.75 nm)	128.566 (1763.27 nm)
Suborbital Launch Vehicles		\overline{CF}	\overline{DE}	\overline{HI}
Guided	96,000 (1.32 nm)	2.90980 (39.91 nm)	8.61132 (118.10 nm)	N/A

*For illustration purposes

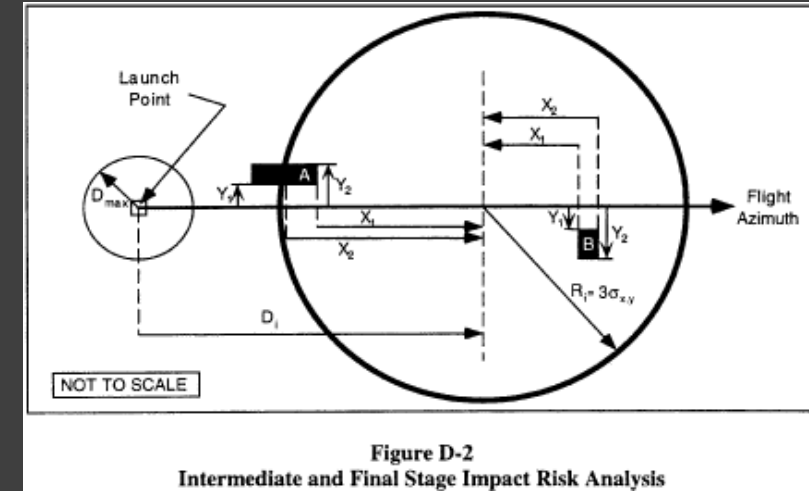


Figure D-2
Intermediate and Final Stage Impact Risk Analysis

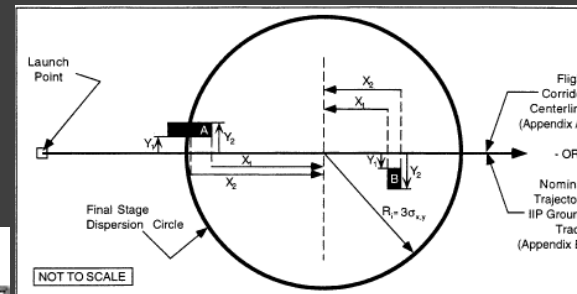


Figure C-3: Appendix A and B Final Stage Impact Risk Analysis

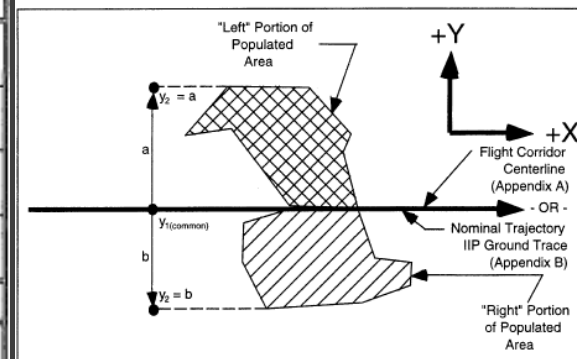


Figure C-4: Flight Azimuth Intersecting a Populated Area

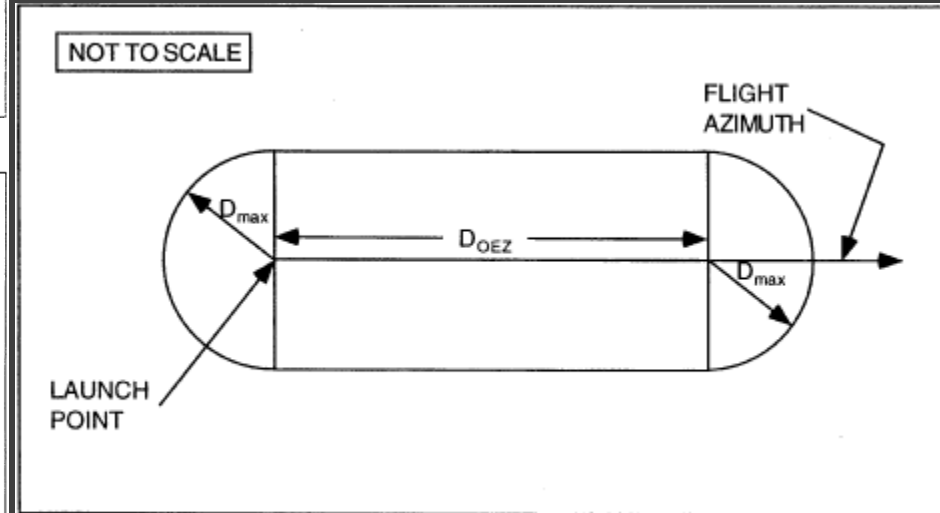


Figure A-1
Overflight Exclusion Zone

What do non-interference zones implicate for the future?

- Mathematics and physics behind non interference zones impact policy and law making
- Risk regime is under debate
 - Fundamental to safety and efficient operations
 - Space technology safety standardization
 - Protect human life and investments
- Authorization and continuing supervision
- Standardization of operations
- Rules of the road
- Duties of care
- Due regard to the corresponding interests of others and notification
- Overflight rights
- Exploration and use vs prohibition on national appropriation ~ temporal prohibition on perfecting title (inchoate title)

Questions?

Thank you