THE NEO THREAT AND MITIGATION ISSUES: AN AIR FORCE PERSPECTIVE (BARELY)

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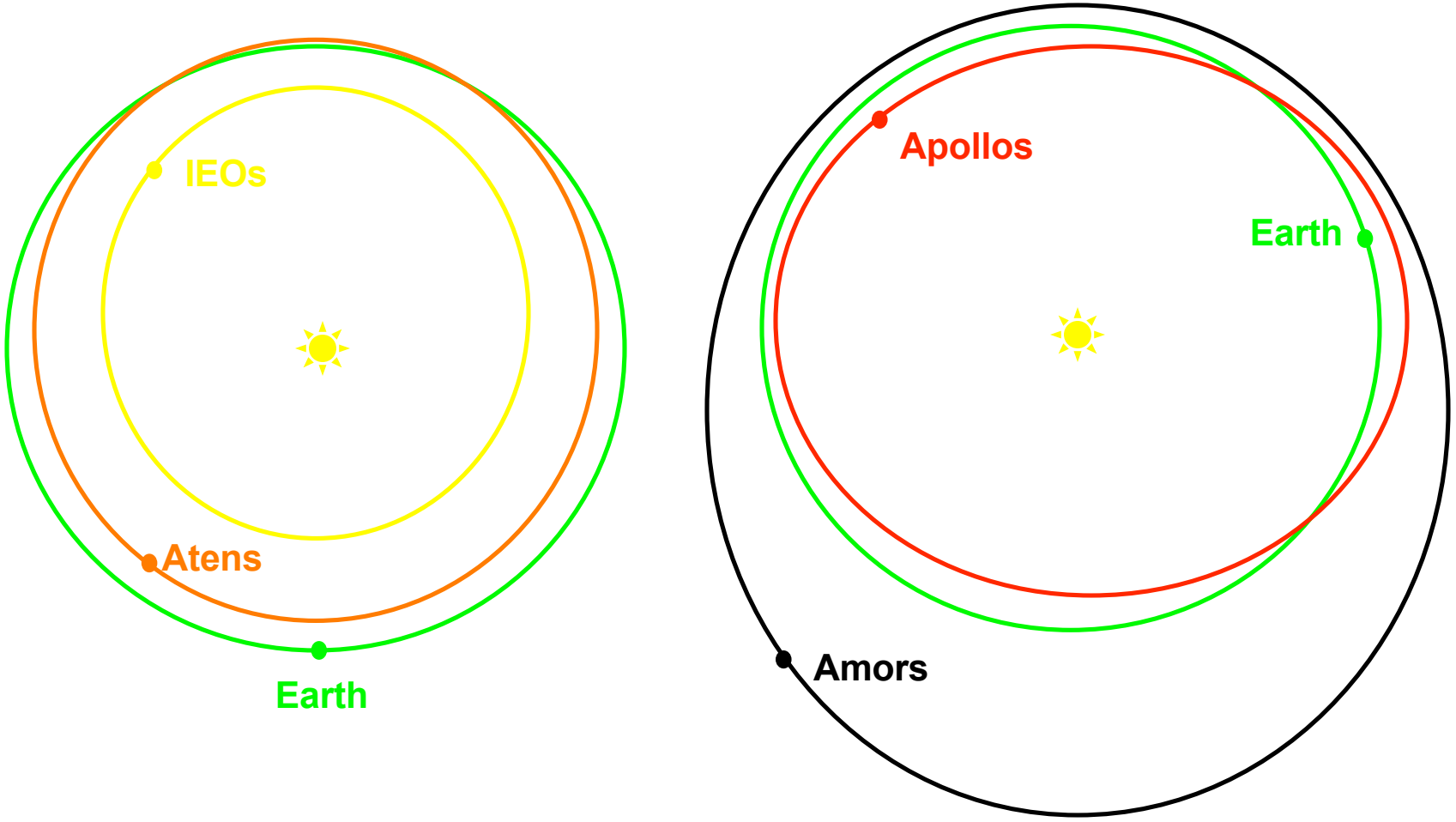
NEO THREAT MITIGATION

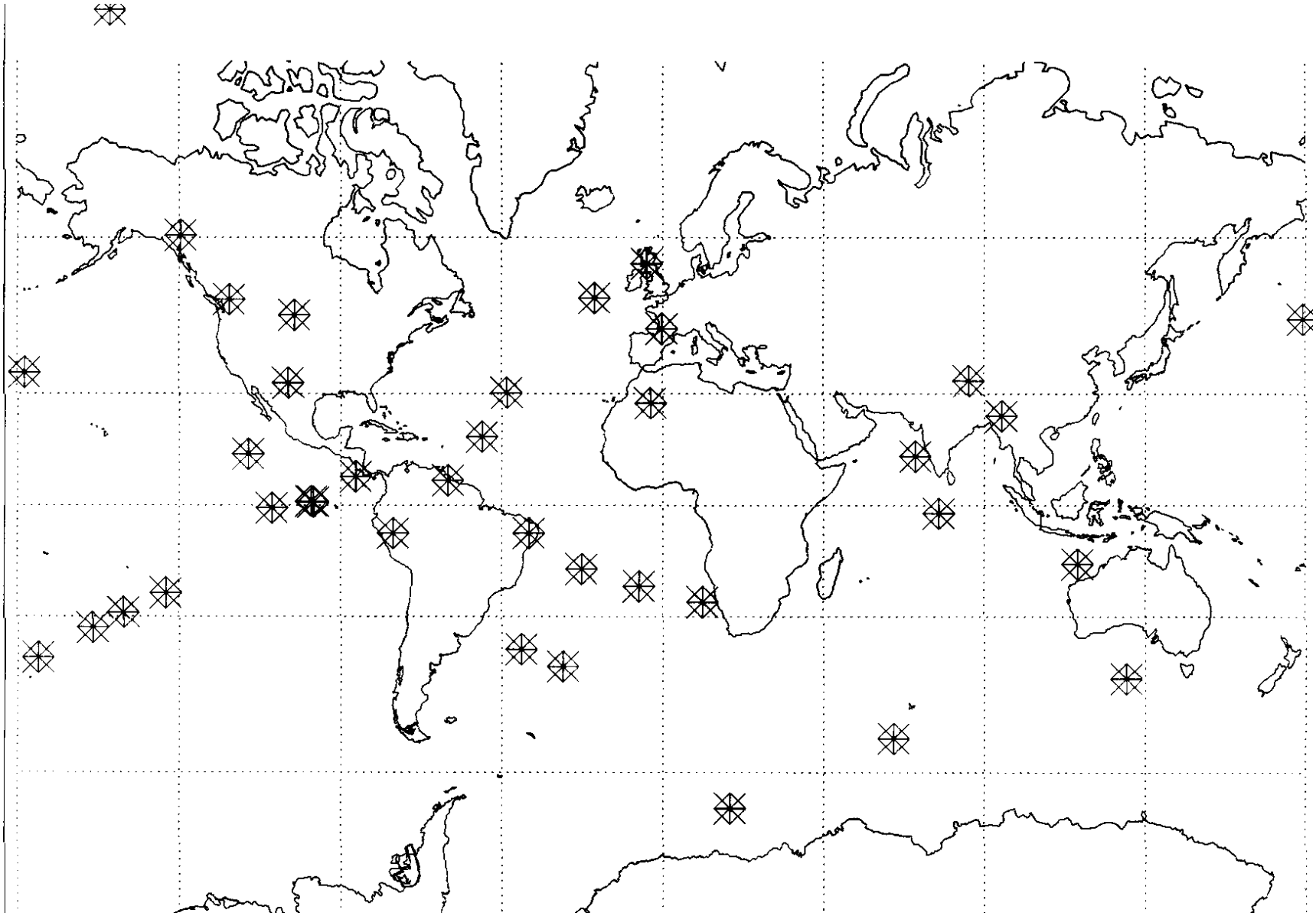
- **THE THREAT**
  - **•ATMOSPHERIC IMPACT**
  - **•METEOR STORMS**
  - **•SMALL (100 meter class) IMPACTS**
  - **•LARGE NEOS**
- **•SUGGESTED APPROACH**
  - **•NEO WARNING CENTER**
  - **•SYSTEMATIC NEO OBSERVATION (GROUND & SPACE-BASED)**
  - **•MICROSATELLITE IN-SITU MISSIONS – LOW COST LAUNCH (YES – THERE MAY BE SUCH A THING AS "CHEAP LAUNCH")**
  - **•COMMAND AND CONTROL**
- **•ISSUES -- NATIONAL AND INTERNATIONAL -- ROLE OF US MILITARY**

Classes of Near-Earth Asteroid Orbits

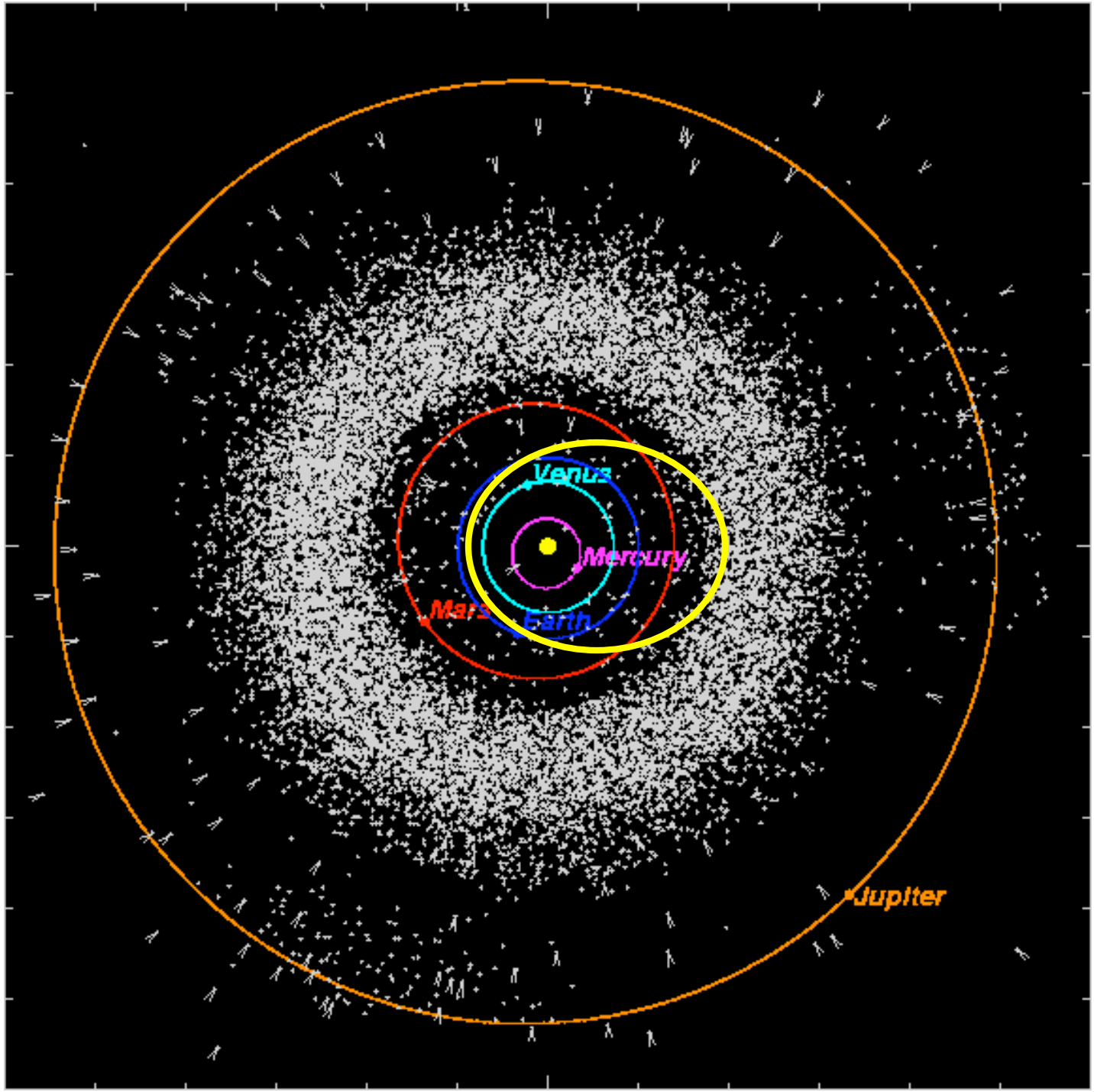


Dust cloud Photographs/Video Stills from Whitehorse

US AIR FORCE SATELLITE OBSERVATIONS OF LARGE METEORS -- JAN 1999-MARCH 2000




0
200 km
Inuvik
NORTHWEST
TERRITORIES
ARCTIC CIRCLE
ALASKA (U.S.A.)
Dawson
YUKON
Meteor path
WHITEHORSE
Carcross
BRITISH COLUMBIA
PACIFIC OCEAN


Venus
Mercury
Earth
Jupiter

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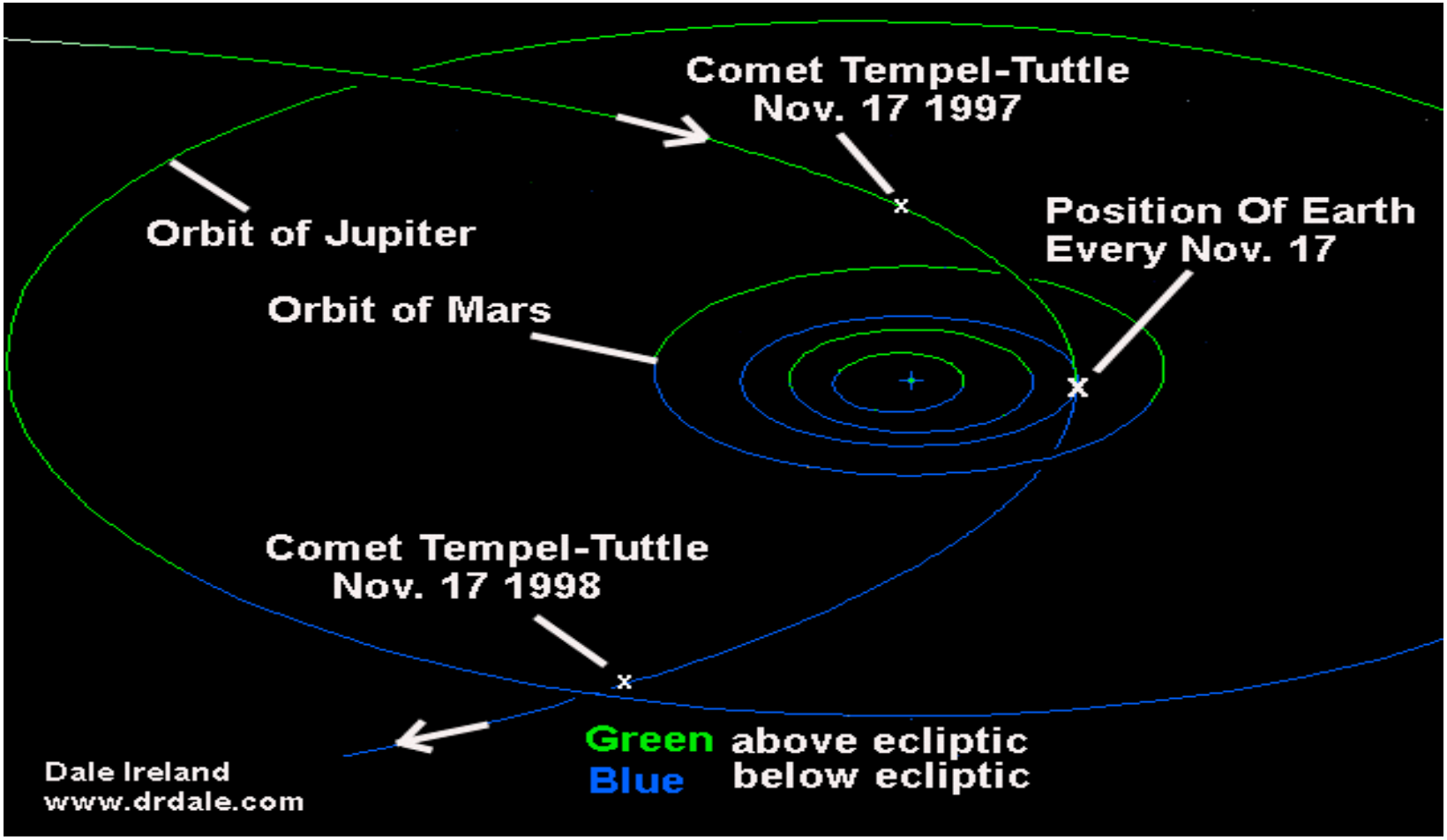
- SMALL NEO IMPACT OVER MED.
- CRISIS SITUATION IN SOUTH ASIA
- NO ORGANIZED GLOBAL CLEARING HOUSE
  - Could establish an NEO Warning Center in Cheyenne Mountain -- need to have assigned mission!

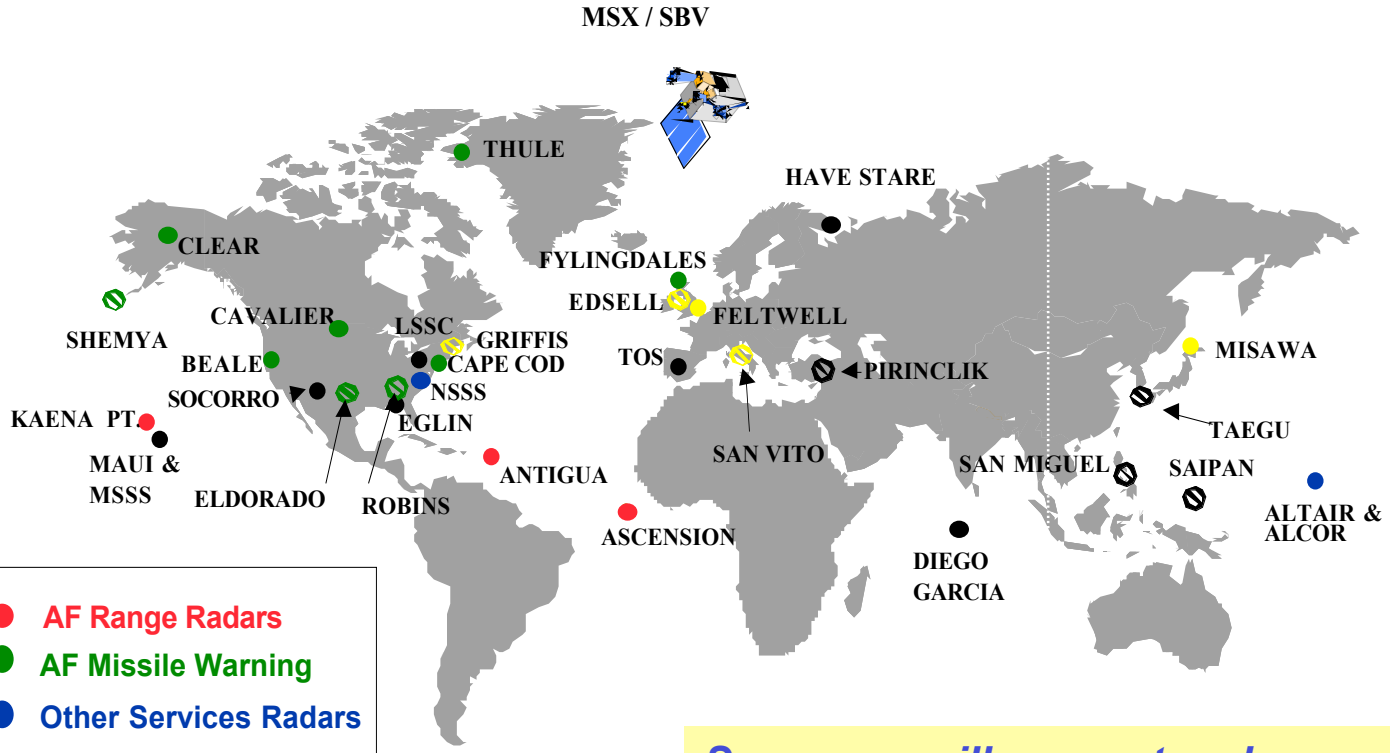
Orbital Mechanics of Leonid Generating Comet Tempel-Tuttle



Courtesy of Peter Brown, University of Western Ontario

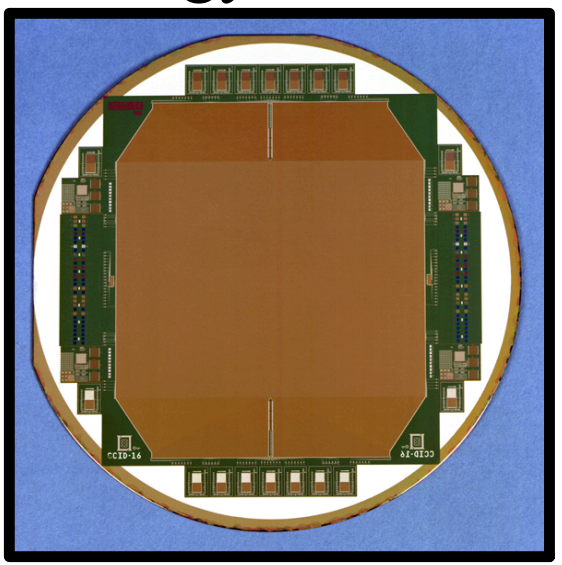
Space Surveillance Network (SSN)

SSN Sensors



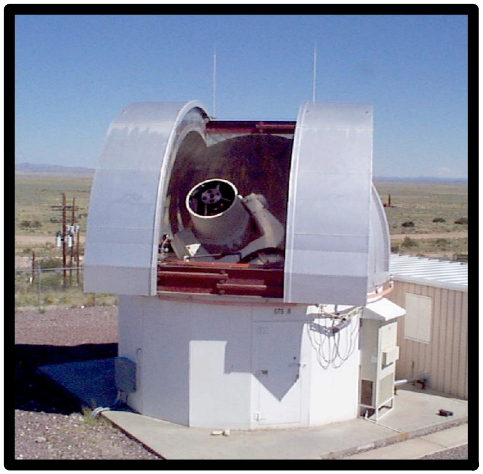
Space surveillance network - currently maintains a catalog of approximately 2500 deep space and 7000 near earth objects ranging from baseball size to the size of a greyhound bus

Applying Space Surveillance Technology to Asteroid Detection



Asteroid and comet impact warning for Earth identified as a potential USAF mission

- **USAF Science Advisory Board (SAB) report on Space Surveillance, Debris, Asteroids and Comets (1996)**



GTS-2 (GEODSS) Telescope

Lincoln Laboratory developed CCD

- **2560 x 1960 pixels, 2.25 arcsec per pixel**
- **Very low readout noise (few electrons per pixel)**
- **Back illuminated**
- **Peak quantum efficiency > 95%**
- **Solar weighted quantum efficiency = 65%**
- **Frame transfer to frame buffer in milliseconds**

2003 NASA SMALL NEO STUDY

- POTENTIALLY HAZARDOUS OBJECTS (PHOS) SHOULD BE OBSERVED DOWN TO D=140M
- COMETS SMALL PART OF THREAT (1%)
- RECOMMEND 90% COMPLETE SURVEY DOWN TO 140M – 7-20YEARS, CONSIDER SPACE/GROUND OBSERVING SYSTEMS ($31M - $417M)

HAZARD SUMMARY (2003 NASA REPORT)

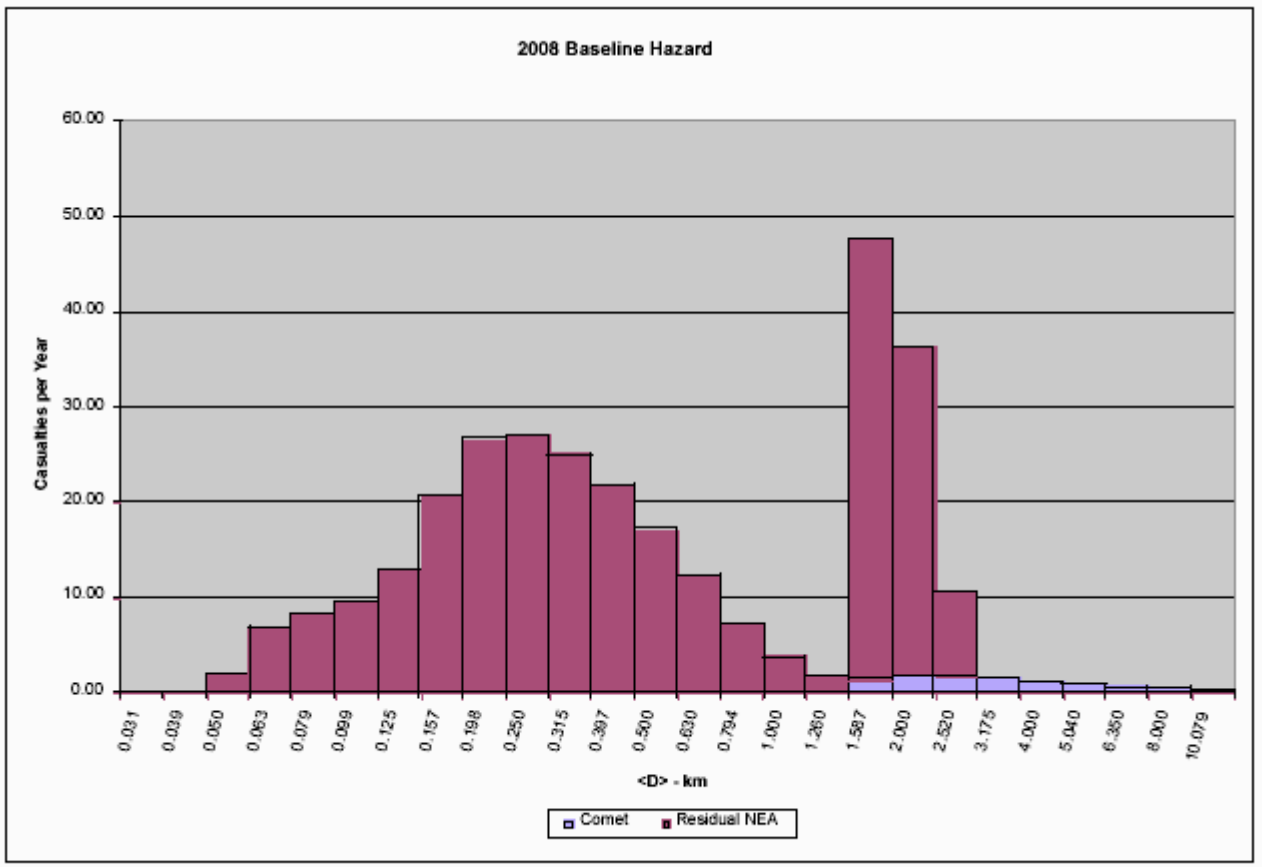


Figure 3-9: Residual impact hazard from all sources, including LP comets.

COST vs PERFORMANCE SURVEILLANCE SYSTEMS

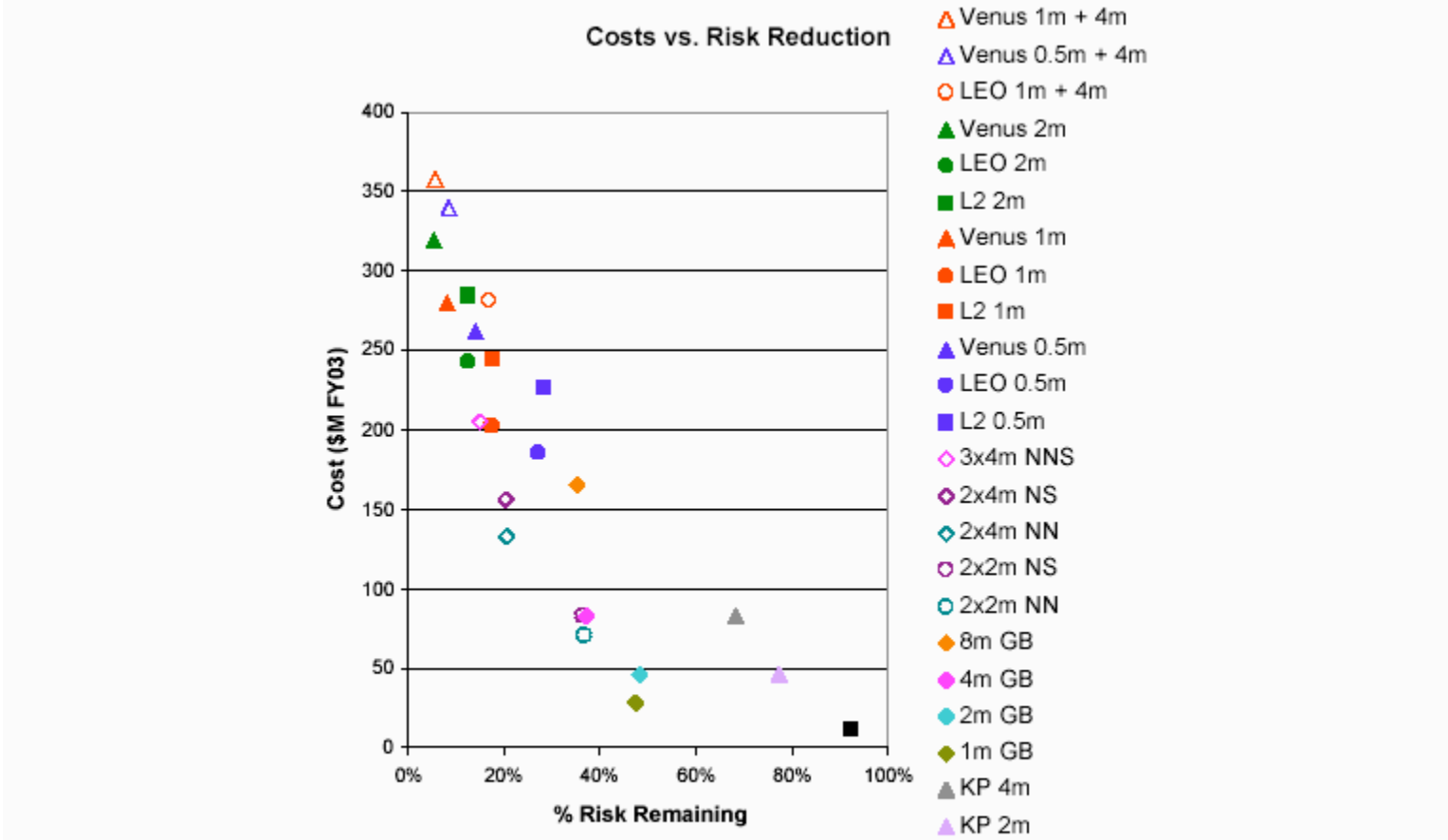


Figure 9-3: For various ground-based, space-based, and combined search systems, the system cost is plotted versus the % of the sub-global risk remaining after a 10-year survey

FUTURE SPACE SURVEILLANCE

- THE KEY NEED IS TO CATALOG MOST NEOS THAT ARE POTENTIALLY THREATENING
- FOCUS FOR “PLANETARY DEFENSE” SHOULD BE ON “SMALL OBJECTS” 10-500 METERS
- MICROSATELLITE TECHNOLOGY PROVIDES US THE MEANS TO FIND SMALL NEOS, STUDY THEM “IN-SITU” AND DIVERT THEM IF NECESSARY

Proposed Approach -- In Situ Experiments

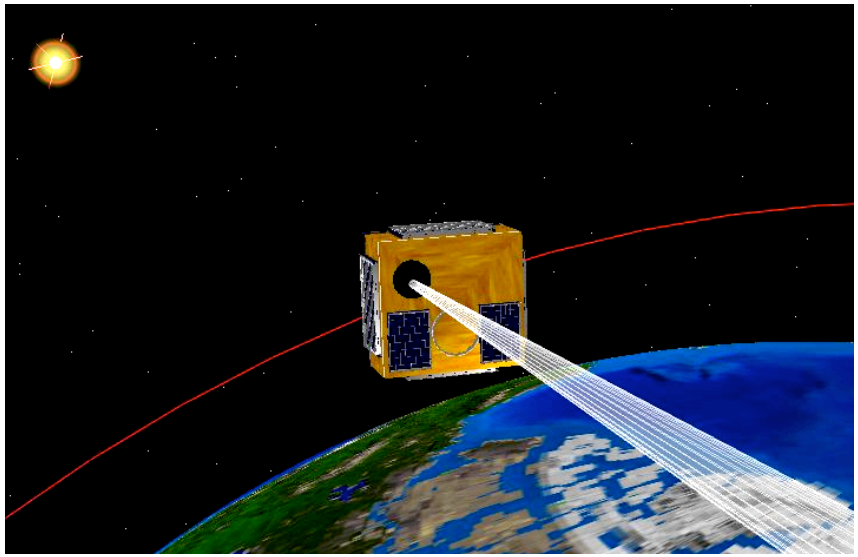
- CONDUCT EXTENSIVE SURVEY FROM LOW-COST SPACE SURVEILLANCE MICROSATELLITES
- IDENTIFY A SUITABLE COLLECTION OF “SMALL” ASTEROIDS
- PLACE A “FLEET” OF MICROSATELLITES INTO LUNAR TRANSFER OR “WEAK STABILITY” BOUNDARY ORBITS
- PERFORM “IN-SITU” SAMPLING OF DIFFERENT ASTEROID CLASSES
- SELECT SEVERAL SMALL ASTEROIDS OF DIFFERENT CLASSES FOR “KINETIC” DIVERT EXPERIMENTS

USAF “MSX” SATELLITE

What is a MicroSat?

- Micro-Satellites fall into the 10-200kg category and are capable of many missions:
  - Imaging
  - Surveillance
  - Communications
  - Weather
  - Environmental Monitoring
  - Space Exploration

MOST: "Microvariability and Oscillations of STars"



- First CSA microsatellite.
- Space astronomy mission.
- Dynacon is Prime Contractor

- ***Status:***
  - In Phase D; pre-ship review by end of 2001
  - Launch scheduled for early 2003 (on Delta-2, with Radarsat 2).
- ***Innovative Elements:***
  - Highly-accurate (~ 10 arc-seconds) attitude control.
  - Science-grade imaging telescope.

EELV Secondary Payload Adaptor (ESPA)

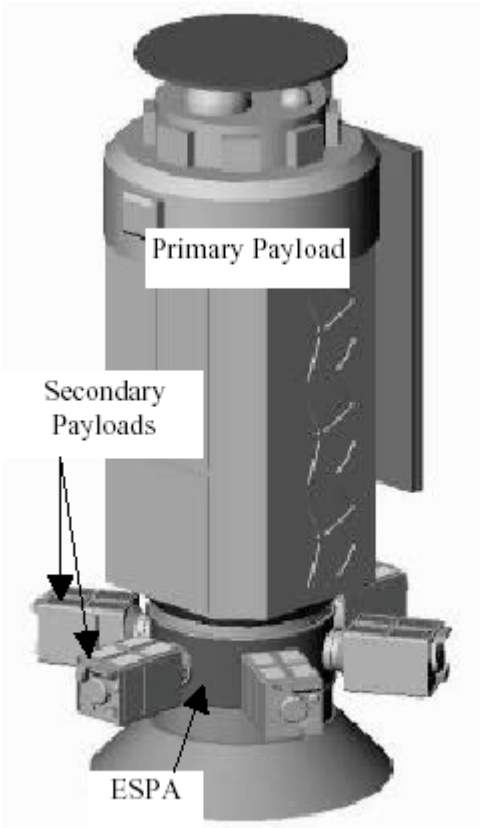
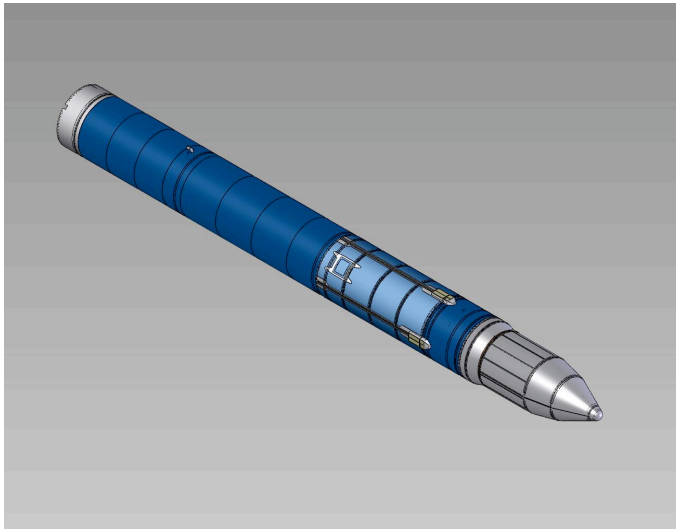


Figure 1. ESPA on the Launch Vehicle Stack.

Falcon Summary (SpaceX)

- Payload capability: Approx 1100 lbs to LEO (28.5 deg)
- Launch from both Eastern and Western Ranges
- Multiple manifest, secondary, and piggyback capabilities
- Benign payload environment
- $6M per vehicle through 2004
- First launch possible by late 2003



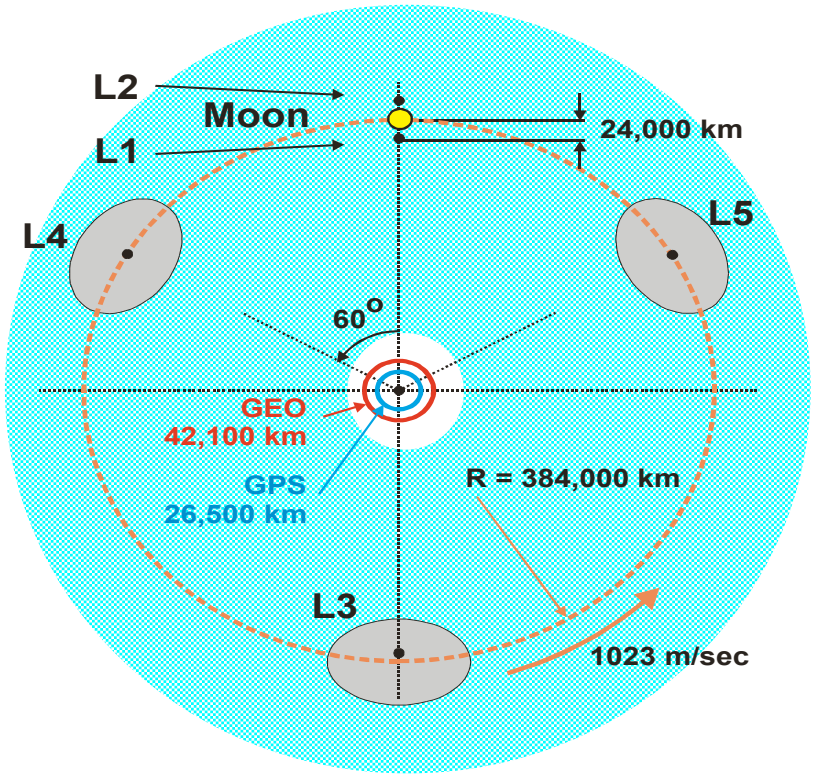
- Diameter 5.5’ tapering to 5’
- Length 68’
- 1st Stage Parachute/Water Recovery
- 1st Stage Lox/RP1
- 2nd Stage Lox/RP1

DARPA RASCAL LV

The Responsive Access, Small Cargo, Affordable Launch (RASCAL) program will design and develop a low cost orbital insertion capability for dedicated micro-size satellite payloads. The concept is to develop a responsive, routine, small payload delivery system capable of providing flexible access to space using a combination of reusable and low cost expendable vehicle elements. Specifically, the RASCAL system will be comprised of a reusable airplane-like first stage vehicle called the reusable launch vehicle and a second stage expendable rocket vehicle. The RASCAL demonstration objectives are to place satellites and commodity payloads, between 50 and 130 kilograms in weight, into low earth orbit at any time, any inclination with launch efficiency of $20,000 per kilogram or less.

Cis-Lunar Space (Near Earth Deep Space)

- Earth-Moon system
- Lagrangian (Libration) points
  - L1, L2, L3 – unstable
  - L4, L5 – stable
- Minimal propellant requirements for station-keeping
- 200 kg microsat can operate within entire region as well as translunar region



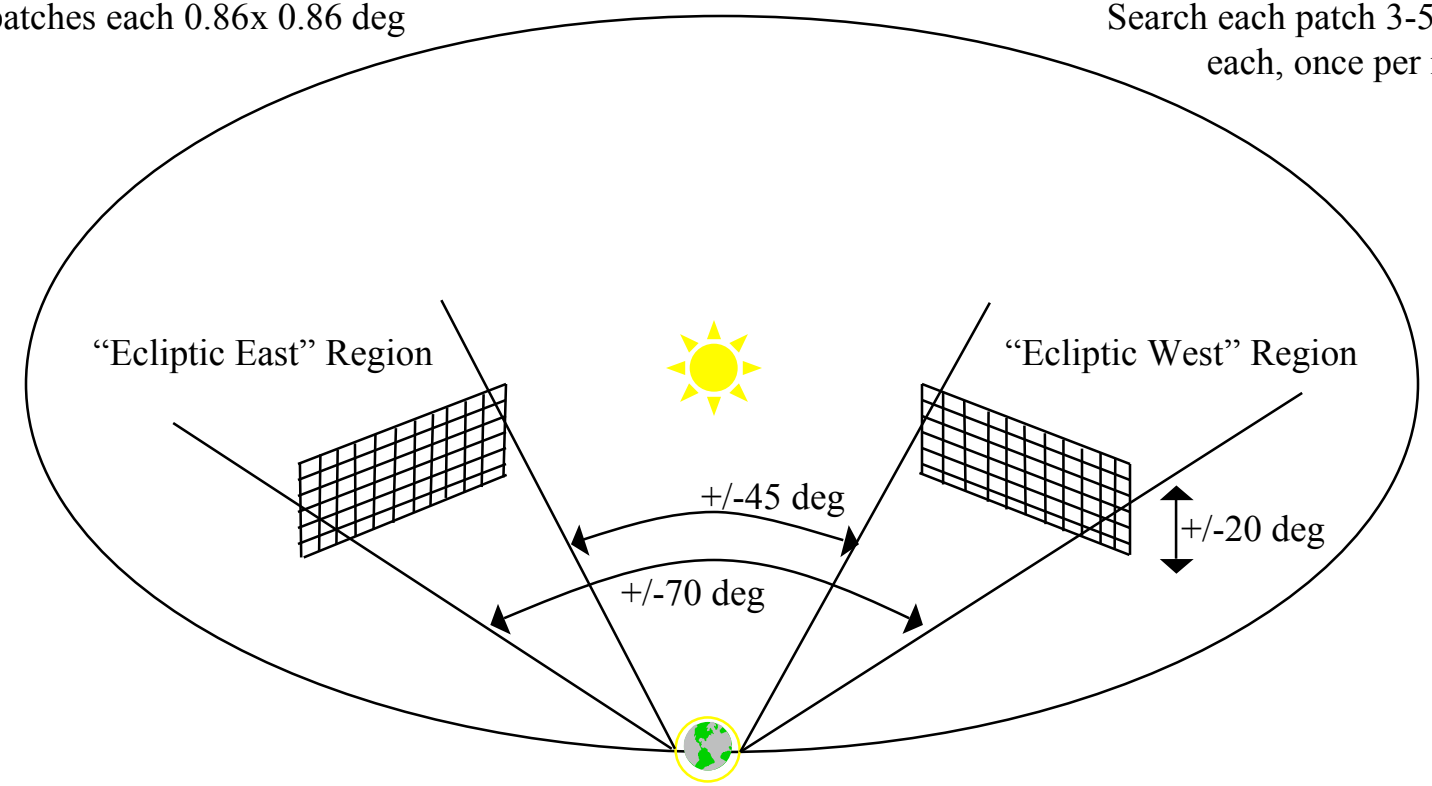
The Canadian "Near Earth Space Surveillance" (NESS) mission

- ***A Dual-Use Mission:***
  - ***Satellite Tracking R&D***
  - ***Asteroid Search/Tracking***
- ***Synergy:***
  - Both applications need the same type of instrument and support platform.
- ***Status:***
  - Concept studies underway, supported by Canadian Space Agency (CSA--space science) and Canadian Department of National Defence (DND-Space Surveillance)

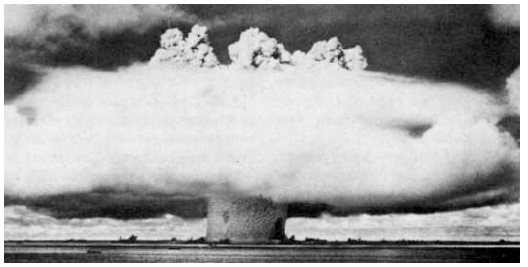
Asteroid Search Regions

Search patches each 0.86x 0.86 deg

Search each patch 3-5 times each, once per month



MITIGATION



MITIGATION

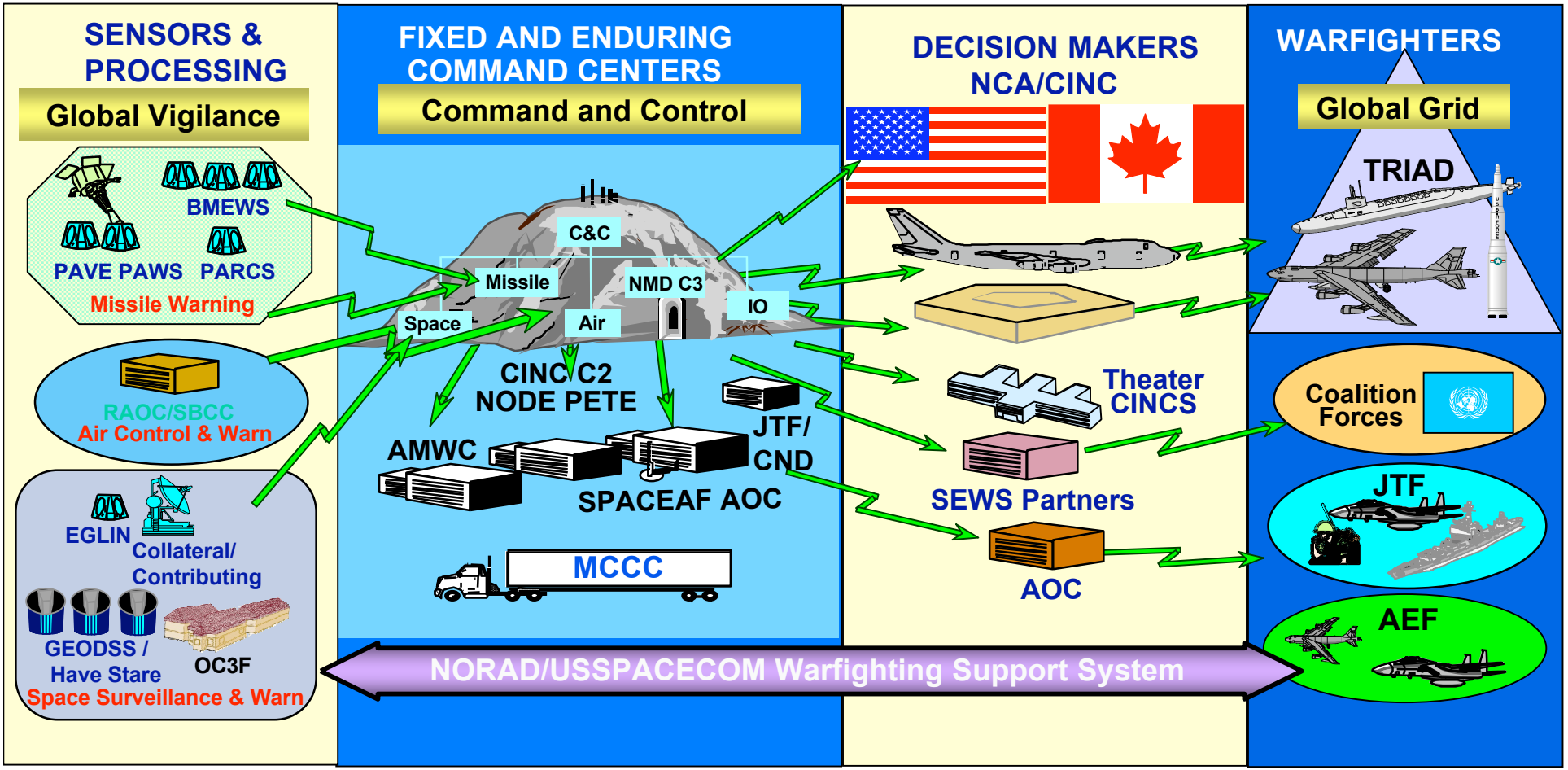
- BEST-IDENTIFY OBJECTS DECADES OR CENTURIES OUT
  - EXPLORE OBJECT
  - DIVERT USING “CONVENTIONAL” MEANS
    - CHEMICAL OR ELECTRIC PROPULSION
    - “IMPACT” MOVEMENT
    - “YARKOVSKY” EFFECT -- USE SOLAR RADIATION PRESSURE
- SURPRISE OBJECT -- ESPECIALLY A “COMET”
  - DIVERSION “HARD”
  - DISRUPTION “DANGEROUS” - “RUBBLE PILE” PROBLEM
- “GIGGLE FACTOR”!!!

MITIGATION - COMMAND AND CONTROL

•THE REAL ISSUE ON PLANETARY DEFENSE IS NOT "WEAPONS" -- ITS "COMMAND AND CONTROL" -- C-2

- •WHO IDENTIFIES THE THREAT?
- •WHO BELIEVES THAT ITS REAL AND WHY?
- •WHO TELLS WHOM ABOUT THE THREAT?
- •WHO DECIDES WHAT TO DO?
- •WHO BUILDS AND EXECUTES THE OPERATION?
- •WHO PAYS?
- •WHO COORDINATES WITH ALL THE EFFECTED PARTIES?
- •WHO TESTS THE MITIGATION METHOD?
- •WHO GETS BLAMED WHEN IT GOES WRONG?

C2 Environment for Today's Missile Warning



Align With Global Warfighter/C2 Goals

CONCLUSIONS

- **DOD "MAY" BE INTERESTED IN "GENERAL" PROBLEM**
- **FOCUS ON DUAL USE AND PROBLEMS RELATING TO NATIONAL SECURITY – SPACE SITUATION AWARENESS AND TECHNOLOGY**
- **WORK "COMMAND AND CONTROL FIRST**
- **MICROSATELLITES AND "CHEAP" ACCESS TO SPACE ARE "REVOLUTIONARY"**
- **OPPORTUNITY WITH NEW PRESIDENTIAL SPACE EXPLORATION VISION!**