Pico Satellites

in Maritime Interdiction Operations

(PicoSat in MIO)

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Abstract

- Analyze capabilities and existing applications of Pico satellite technology to the maritime awareness tasks.

- Develop a set of Pico satellite integration experiments, enabling finding enhanced tagging, tracking, and global data sharing solutions for emerging network-controlled MIO scenarios.

Presentation Outline

1. Paper Abstract
2. Objectives
3. Conceptual Model
4. Technology Gap
5. Pico Mission Critical Parameters
6. Literature Review
7. WMD in MIO Scenarios
8. Conclusion and Future Work

Objectives

1. Pico Satellite Solutions in Maritime Interdiction Operations (MIO)
2. Tubesat solution in Maritime Situational Awareness
3. Pico Satellite in tracking and tagging WMD materials through SLOC's
4. Capability of transferring data from the scene of action to a central node ashore

Conceptual Model

1. Tubesat Integration in NPS MIO Testbed and Experiments
2. WMD tracking capability in MIO
3. Armor coastal waters from illegal WMD trafficking
4. Inevitable to cover 100 % sea environment
5. Realistic to cover major SLOC's

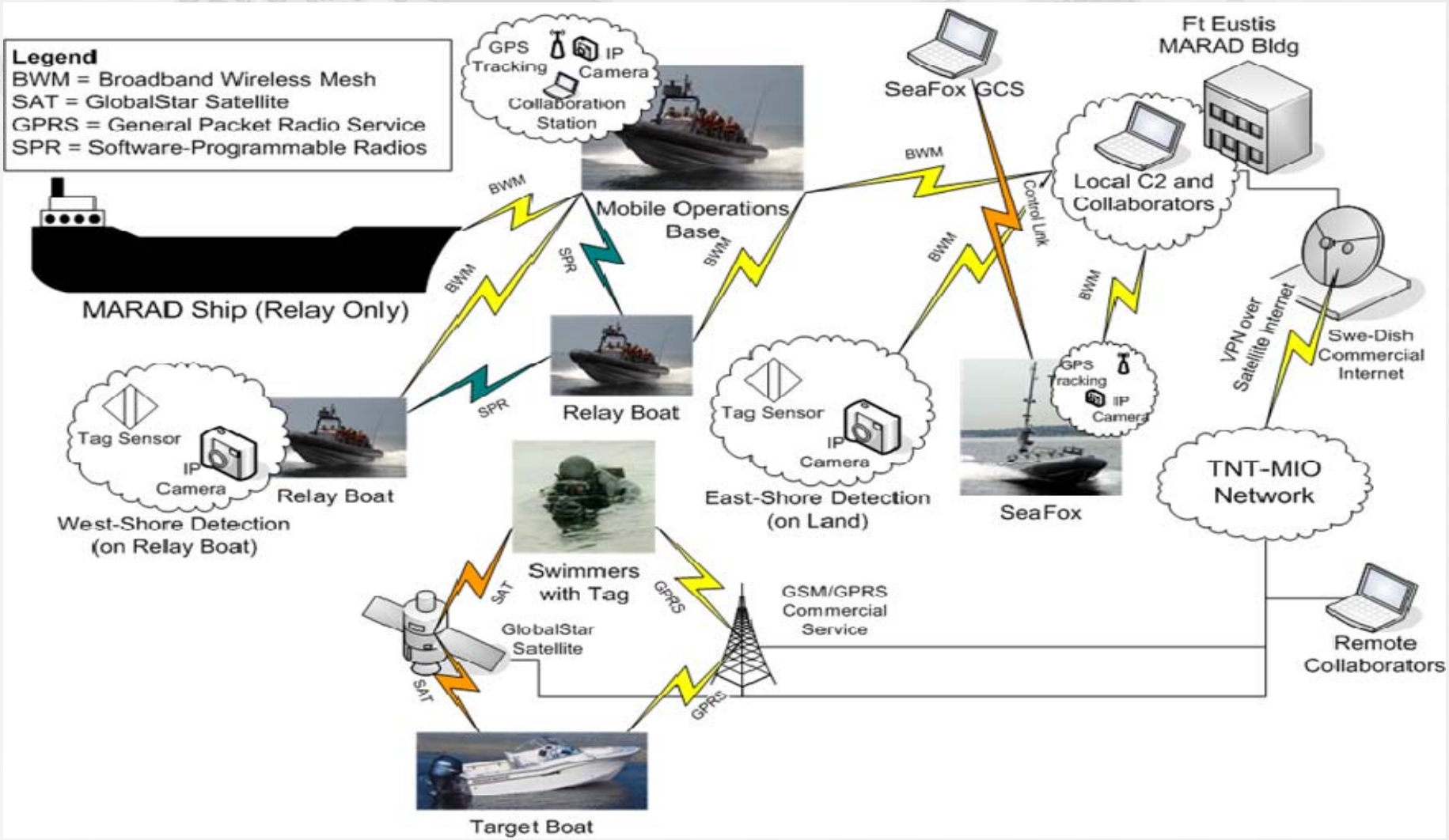
Conceptual Model

7. Creation of Check Points in the water
8. Pico Satellites in the global maritime arena
9. Uncover unknown areas of application ?

NPS fill in the Technology Gap

Space Application	Satellite System (Micro / Pico)	Technology Gap
Maritime Tracking	AISat, M3MSat (Micro)	NO
Imaging	Ikonos, Spot, GeoEye (Micro)	NO
Radar	SARSat	NO
E/O – I/R	L band SARSat (Micro)	NO
Maritime Communications	Inmarsat (Micro)	NO
Maritime Positioning	GPS, Galileo (Micro)	NO
Global Maritime Awareness	C Sigma Int' collaboration (Micro)	NO
WMD MIO Sensing	**NPS Tubesat Picosatellite**	**YES**

Tubesat and NPS MIO Testbed



Pico – Mission Critical Parameters

- Satellite Operational Lifetime.
- Real or Near Real time Tracking Capabilities.
- Accuracy of Tracking.
- Available Data Transmission Techniques.
- Available Data Channels.
- Operating Principles of small satellites.
- Tactical Implications in MIO
- Video Capability.
- Reach Back Capability.
- Serve humanitarian missions

Pico – Operational Characteristics

- Types of orbits (equatorial – polar for small sats)
- Footprints.
- Segments that use and provide.
- Lifetime consideration.
- Time of Revisit.
- Services that is able to provide such as SMS / FAX / Teleconference – Video.
- Security that is being enabled.
- Available data rate.
- Probability to establish a call.
- Probability of maintaining a call for LEO – Small satellites.
- Back up satellites for service if needed.
- Ability for crosslink with Pico sats to transfer data if needed.
- Ability of global coverage.

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Pico – Operational Characteristics

- Available power throughput
- Ability of the signal to penetrate through materials (walls or inside a ship).
- How the signal is transmitted through oceans and distant sea regions
- Meteorological situation for pico sat operation.
- Blue force (allies) or Red force (enemies) tracking?
- Vertical / Horizontal accuracy, e.g. cargo vessels between searching decks.
- What are the available clock accuracy?
- On board processing in Pico sats ?
- Micro propulsion available in Pico sats ? – Stabilized orbit
- Possibility of reorbiting a pico sat in order to tag and track the maritime asset.
- If there are no terrestrial networks what are the implications in MIO scenario?

Literature Review

Small Satellites: Tactical Ad Hoc Networking Nodes in the Low Orbit

- Small-satellite systems may provide a low-cost and readily deployable solution for disaster detection and monitoring
- Classification of Small Satellites (<500kg):

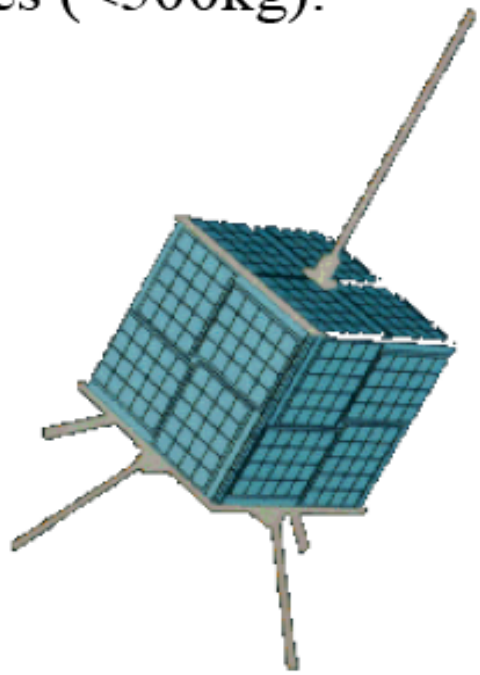
Mini satellite **100-500kg**

Micro satellite **10-100kg** (TacSats)

Nano satellite **1-10kg**

Pico satellite **0.1-1kg**

Femto satellite **<100g**



Literature Review

Small Satellites: Low Cost Private Platforms

- CubeSat-class platforms are becoming most common:
  - -University of Surrey
  - -Stanford University SSDL
  - -Hawaii Space Flight Lab
  - -University of Toronto Space Flight Lab
  - -Aerospace Corporation
  - -Angstrom Aerospace, Sweden
  - -Naval Postgraduate School

- SFL University of Toronto: AISS CubeSat for maritime tracking
- Rubin-9 (Angstrom Aerospace, Sweden) with UWB radios (<10kg, Uo Bremen Ground Station)

Literature Review

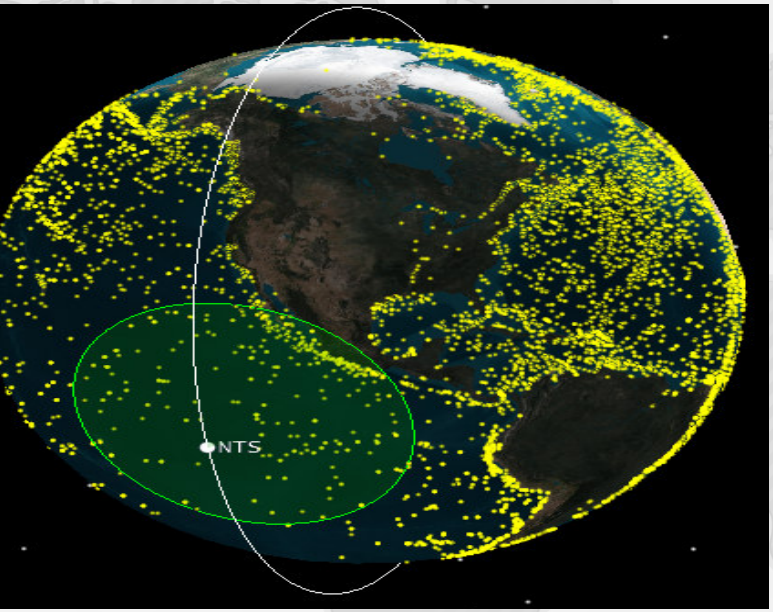
Small Satellites in Maritime Situational Awareness

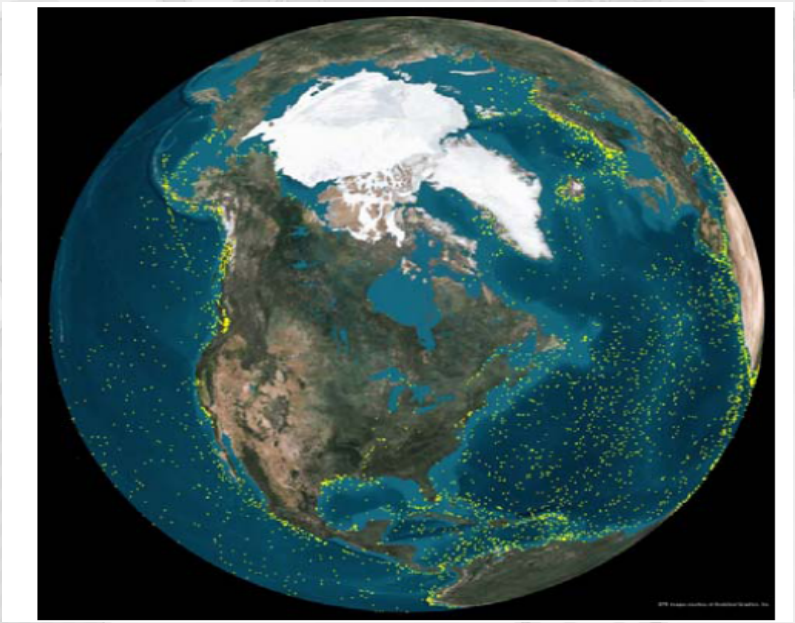
Satellites with **Space Maritime Tracking** capability for **M/V** and

WMD materials (if any) ?

Literature Review

Nanosatellite Tracking Ships (NTS),
Canadian Nanospace eXperiment 6 (CanX-6)
(University of Toronto – UTIAS - Space Flight Laboratory)



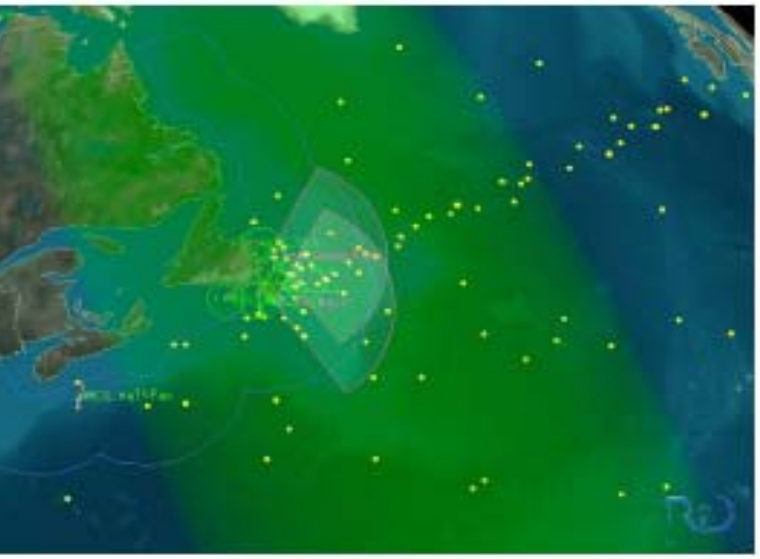


Launched 28 April 2008

Detect AIS signal from space for global ship tracking and monitoring

Literature Review

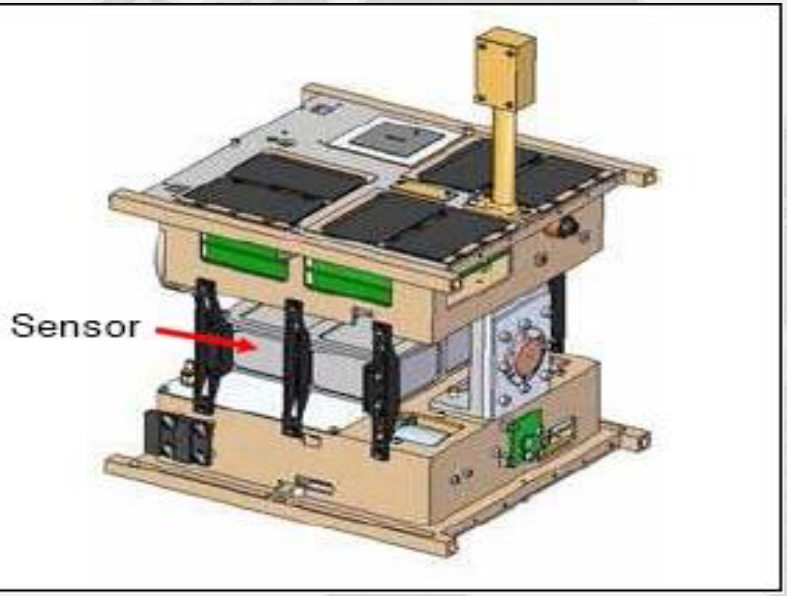
aritime Monitoring and Messaging Satellite (M3MSat)

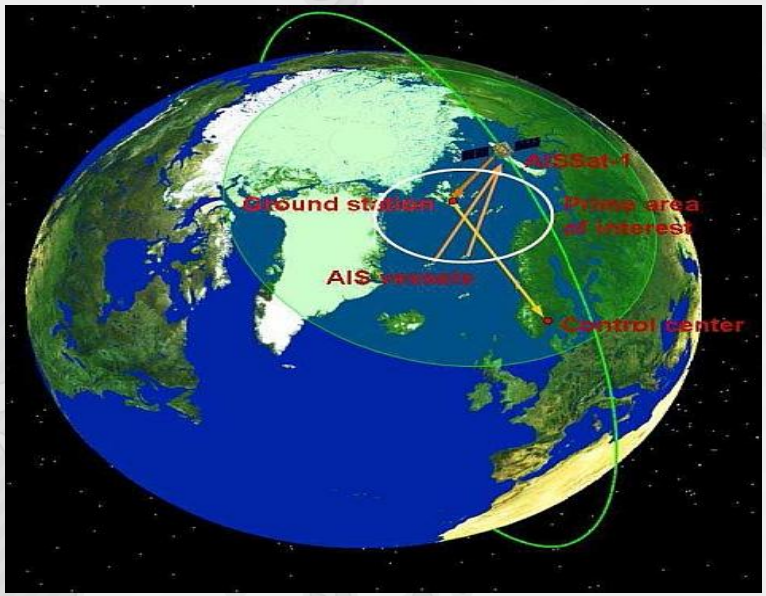


Canadian Space Agency
Maritime Surveillance
In orbit by the end of 2010
Surveillance in Canadian TTW
Cover zone 50-1000 nm outside TTW

Literature Review

AISSat -1 Automatic Identification System Satellite

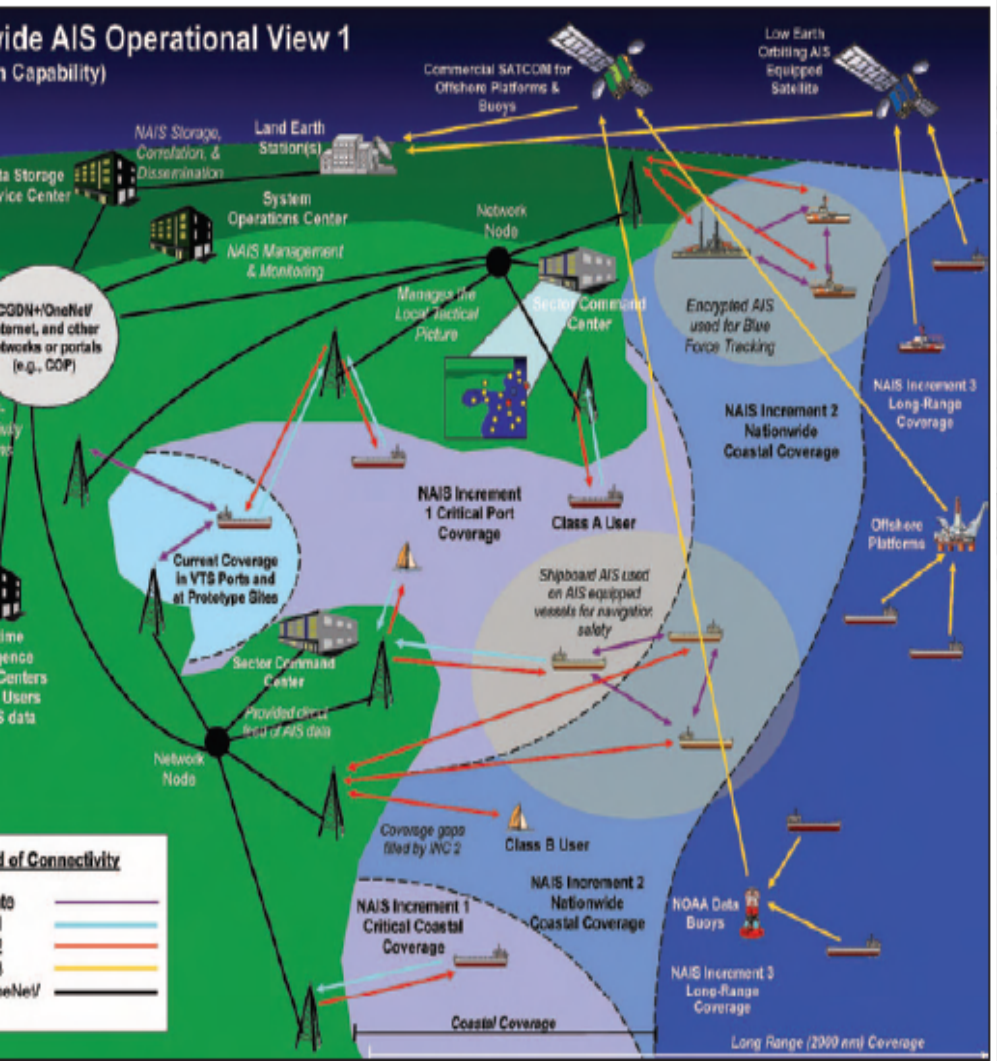




Mission: Monitoring Norwegian fjords and shorelines
Wide Area observation
VHF Receiver
5 daily passes over Norwegian TTW

Literature Review

TACSAT-2: Maritime Surveillance Satellite for U.S. Coast Guard

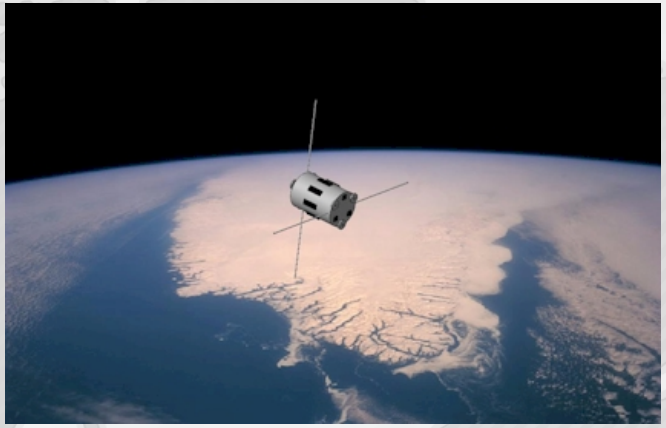


- Nation wide Identification System
- Track ships in 55 critical ports
- Identify ships as far as 2000 nm
- Operational by 2014

Assembling First Tube Sats for MIO experiments

CENTER FOR NETWORK CENETIX INNOVATION AND EXPERIMENTATION

Tubesat – Interorbital Company



Tube Sat Characteristics

as: Owners can build their own uplink and downlink installation. There is no need for a radio operator license.

ions:

t Tube:

.70 cm (3.42 in)

6 cm (3.37 in)

= 12.2 cm (4.8125 in)

t Retainer to Retainer Length: 13.5 cm (5.3125 in)

ment Cylinder:

0.20 cm (4.00 in)

98 cm (3.93 in)

between the outside of the TubeSat and the inside of the Deployment Unit is 0.64 cm (0.25 in). This gap be utilized for solar cells, antennas, or other hardware.

ment or Function Space:

.56 cm (3.37 in)

= 5.08 cm (2 in)

eiver Options:

r Radio Band at Frequency 433 MHz

: 4.5–5.0 VDC

500 mW

Free:

Small Satellite WMD Sensing Gap

ace stem	Category	Lifetime	Orbit	Mission
TS	Cube	2-3 years	LEO	**AIS** Maritime Tracking
MSat	Cube	2-3 years	LEO	**AIS** Maritime Tracking
Sat-1	Micro	2-3 years	LEO	**AIS** Maritime Tracking
CSAT	Micro	2-3 years	LEO	**AIS** Maritime Tracking
pesat	**Pico**	**3 months**	**LEO with *Orbital Decay***	**WMD in Maritime Interdiction Operations**

TUBESAT

onfiguration for NPS MIO experiment

- Three Tubesat Pico satellites
- Launch Dec 2010 from Tonga
- Suborbital Test launches in Mojave Dessert
- STK demonstration of the orbital path / scenario
- Winter Launch when the Sun activity is less so to diminish the orbital decay parameter and increase the actual active time of having the satellites in orbit (3-4 months)
- In the future apply micro propulsion elements on Tubesat Pico satellites in order to make them stable in orbit.

WMD in MIO Scenarios

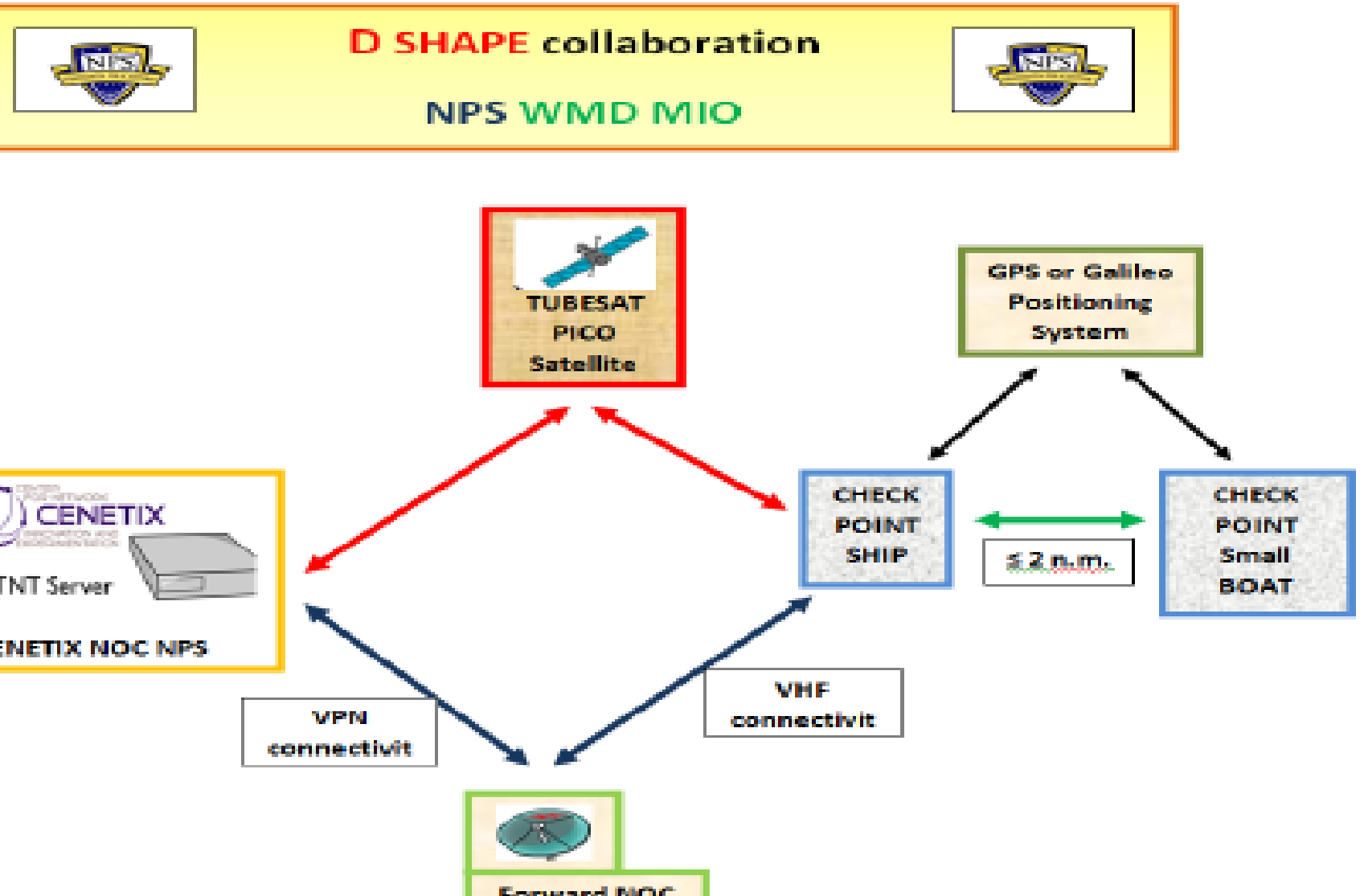
Coastal – Territorial Waters

Harbor Entrance

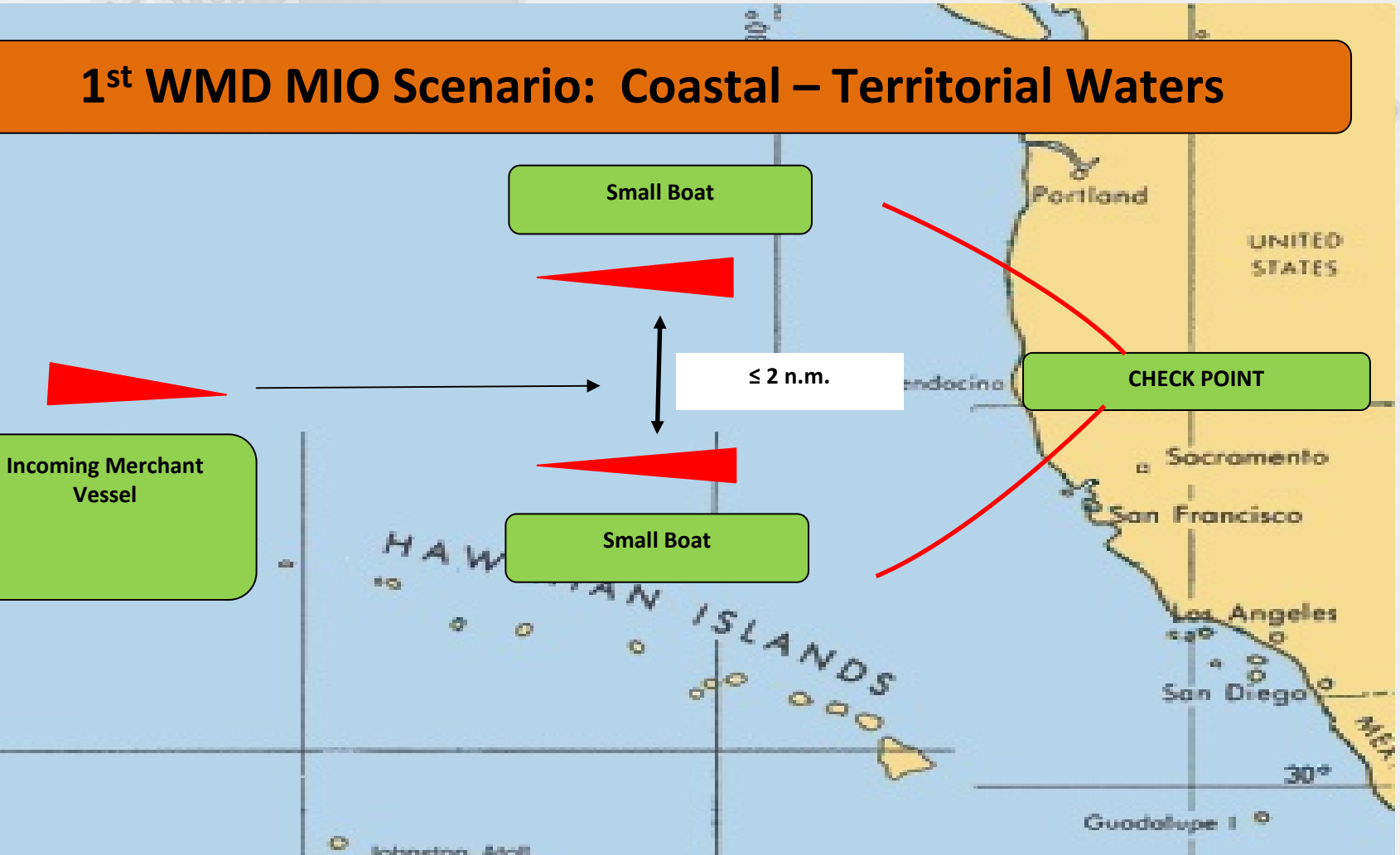
Riverine – Bay Area Traffic

Open Sea Traffic

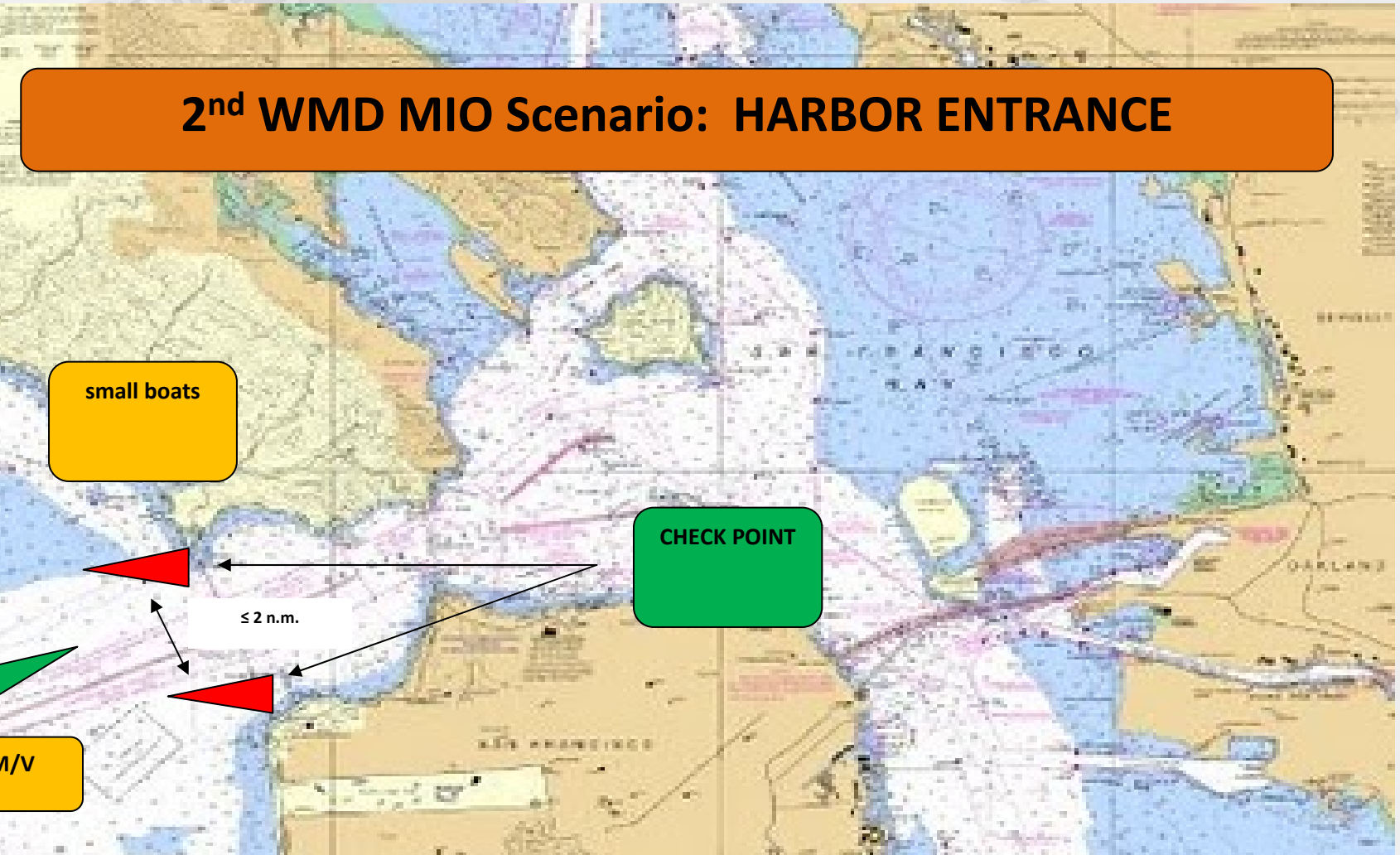
Basic Connectivity Scheme
Showing PICO satellite introduction
in the regular MIO data sharing channels



1st Scenario Territorial Waters

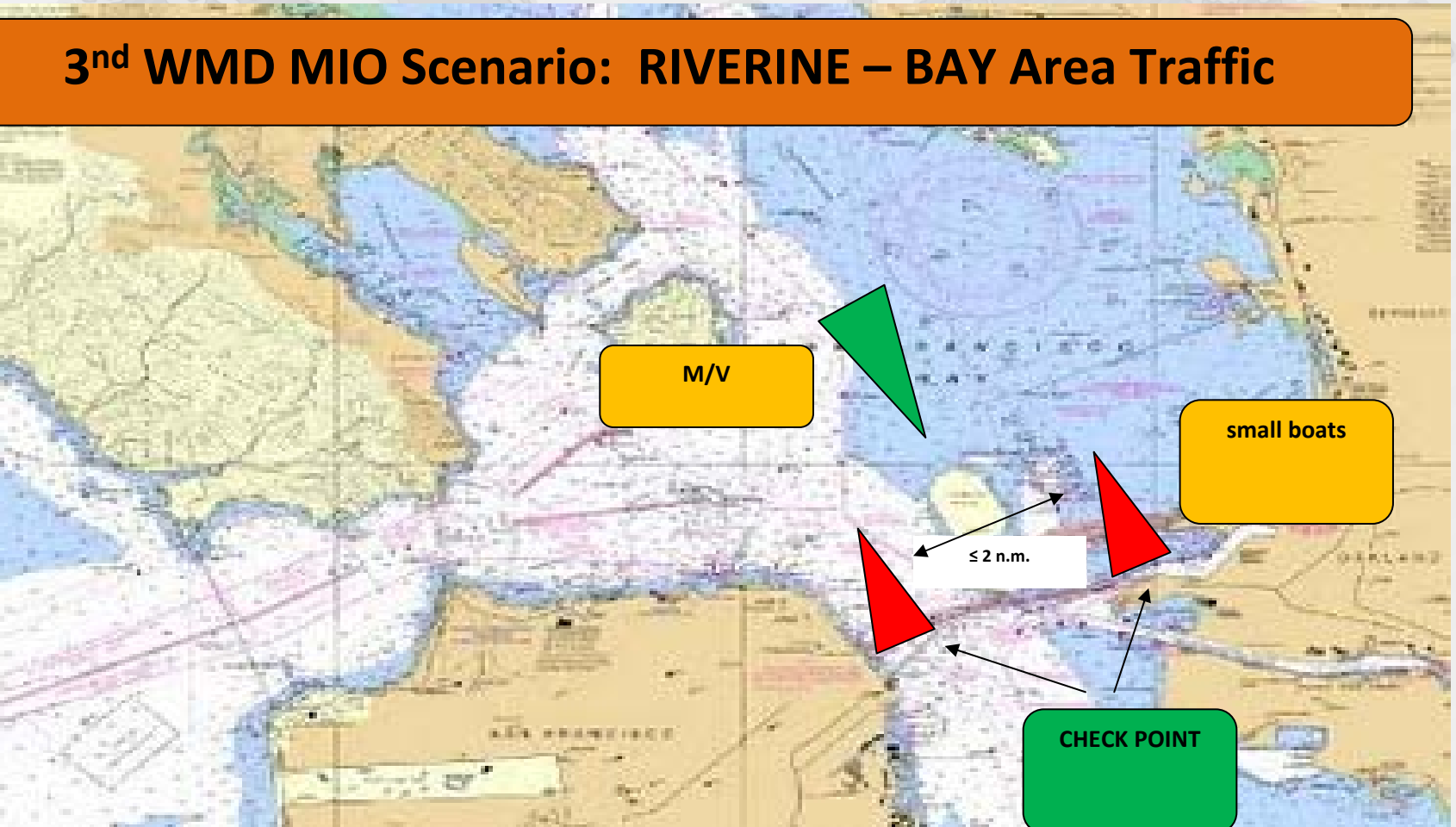


2nd Scenario
Harbor Entrance

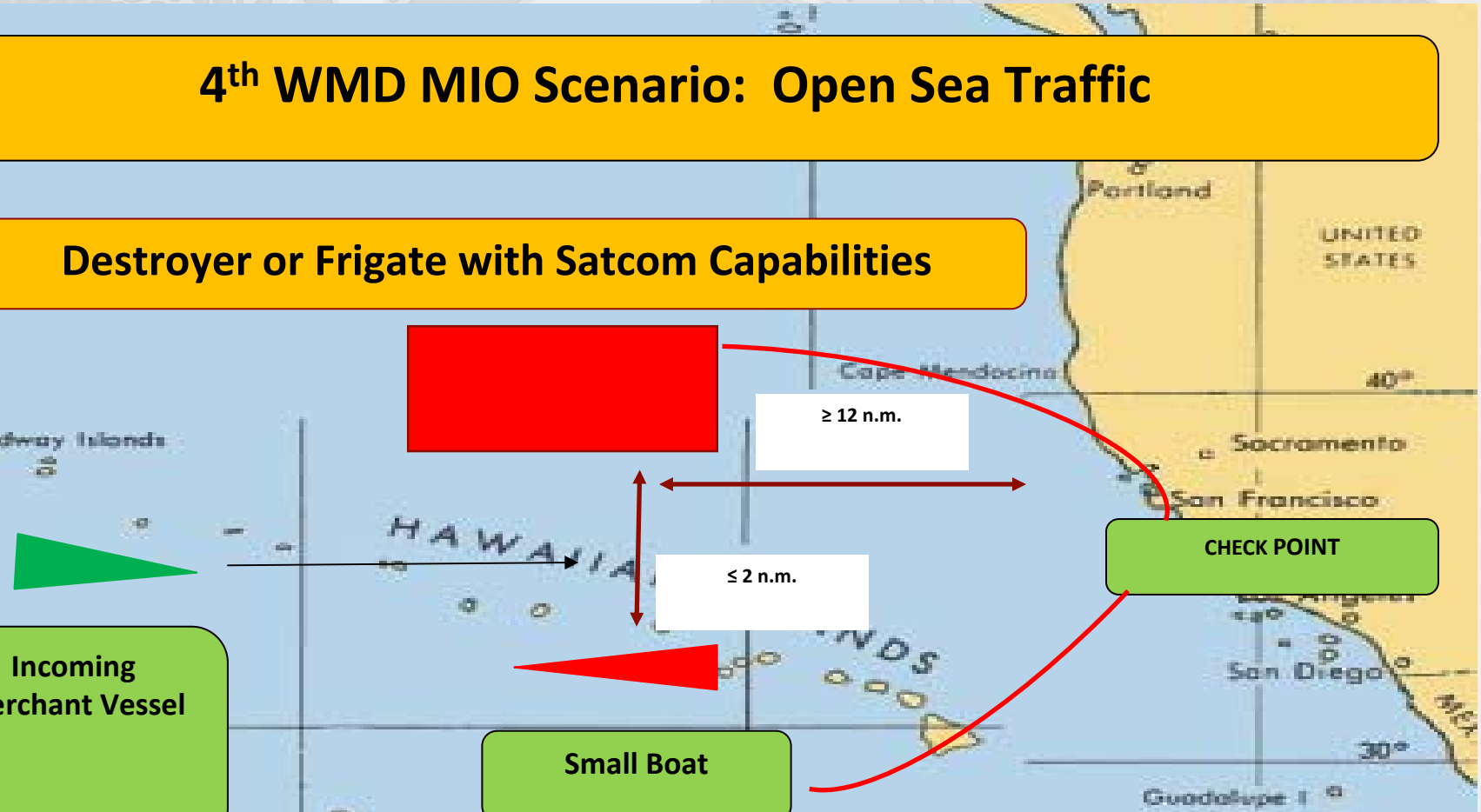


3rd Scenario
Bay Area Traffic

3nd WMD MIO Scenario: RIVERINE – BAY Area Traffic



4th Scenario
Open Sea Traffic



Conclusions
Future Work

- Above Scenarios to be tested in 3 month timeframe
- Proliferation of WMD in MIO is an innovative and pioneering approach
- NPS is trying to fill in the technology Gap
- Apply Pico satellites technology with micro propulsion elements in order to make Tubesat stable in orbit
- Make WMD in MIO procedures fast and easy through Pico satellites and ensure that SLOC's are safeguarded from the "Red Team"

Questions ?