Fleet Numerical Meteorology and Oceanography Center

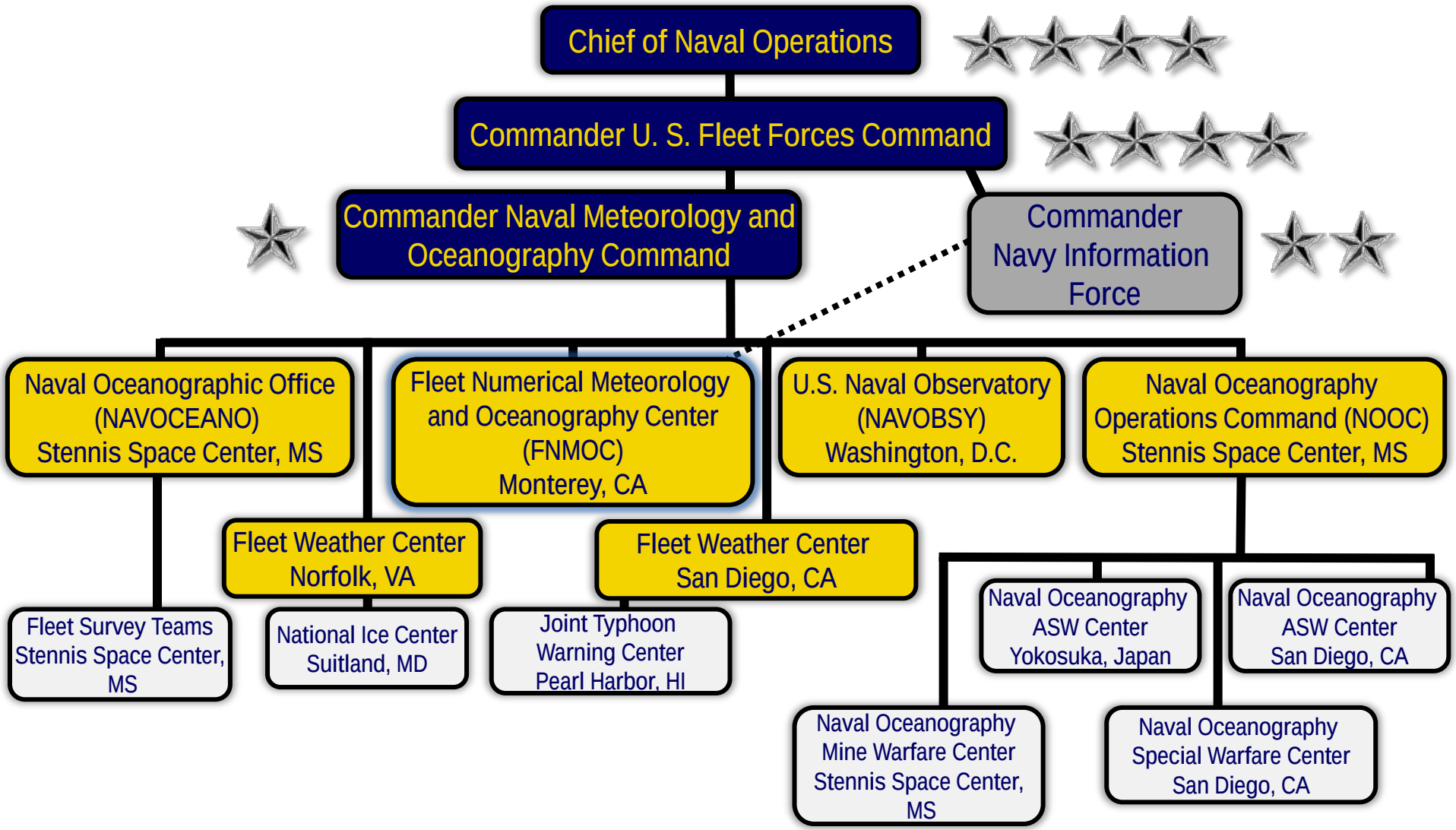
CAPT Russ Smith
Commanding Officer

Mr. Bill Kerr
Technical Director

CDR Sean Robinson
Executive Officer

James Vermeulen
Data Ingest Team Supervisor,
OFCM/COPC Inter-agency Coordination

METOC Enterprise



Mission-Functions-Tasks

Mission

FNMOC drives warfighting effectiveness and fleet safety of Naval, Joint and Coalition forces by operating and disseminating assured global and regional numerical environmental prediction and applied decision-making services

Vision

DoD's Premier Numerical Modeling Center - Lead for Physical Battlespace Awareness and Operational Advantage

Functions

- FNMOC employs Assured C2 to deliver Physical Battlespace Awareness and directly support Integrated Fires. Products include: operational climatology support, custom high resolution weather prediction areas, weapon system inputs proven to improve performance and accuracy, specific ocean state data, go/no-go decision tools, tactical decision aids (TDAs), optimum path flight plans, and a variety of other mission-critical METOC data, products, and services.
- Serve as DISA Node for 12 DoD organizations on central California coast
- Strategic deterrence support

Tasks

- Operate a High Performance Computing Center (HPCC) with capabilities at every classification level
- Collaborate with NAVO, NRL, NCEP, NESDIS, and 557th Weather Wing (WW)
- Primary host of Navy Enterprise Portal-Oceanography (NEP-Oc) and alternate host of Flight Weather Briefer (FWB) servers

Team FNMOC

- Diverse team of highly-educated, technically proficient and warfighting-experienced Sailors, Civilians and Contractors.
  - 17 Officers
    - METOC, IP, SWO, Intel
    - 33% MS Degree
    - 90% Warfare qualified
  - 123 Civilian & 30 Contractors:
    - Predominantly Physical Science and Computer Science
    - 7% PhD, 23% MS Degree, 34% BS Degree
    - 42% eligible to retire within 5 years
      - Broad and deep experience in the mission and the science
      - Succession challenges

Core Capabilities

- Operationally Reliable: Assured and Resilient Global and Regional Numerical Atmospheric and Oceanographic Prediction at all classification levels
- Climatology support to Naval, Intelligence Community, and DoD Operations and Exercises at all classification levels
- Produce and disseminate METOC products tailored to mission requirements
- Safety of flight and navigation AND operational advantage

FNMOC delivers Physical Battlespace Awareness (PBA) and directly supports Integrated Fires (IF)

Cybersecurity-compliant systems and communications paths directly support Assured Command and Control (AC2)

Global and Tailored Regional Atmospheric & Oceanographic Prediction…

Numerical Weather Prediction
Basic Equations

Vertical coordinate

$$\eta = \eta(p, p_s, p_{top})$$

$$p = A(\eta) + B(\eta)\pi$$

$$\pi = p_s - p_{top}$$

Continuity Eqn

$$\frac{\partial}{\partial t}\left(\frac{\partial p}{\partial \eta}\right) + \vec{\nabla}\bullet\left(\vec{V}\frac{\partial p}{\partial \eta}\right) + \frac{\partial}{\partial \eta}\left(\dot{\eta}\frac{\partial p}{\partial \eta}\right) = 0$$

Surface Pressure Eqn

$$\frac{\partial \pi}{\partial t} + \int_{\eta_t}^{\eta_b} \vec{\nabla}\bullet\left(\vec{V}\frac{\partial p}{\partial \eta}\right) d\eta = 0$$

Vertical Motion Eqn

$$\left(\dot{\eta}\frac{\partial p}{\partial \eta}\right)_{\eta_t} = \left(\dot{\eta}\frac{\partial p}{\partial \eta}\right)_{\eta_b} = 0$$

$$\dot{\eta}\frac{\partial p}{\partial \eta} = -\int_{\eta_t}^{\eta}\left[\frac{\partial}{\partial t}\left(\frac{\partial p}{\partial \eta}\right) + \vec{\nabla}\bullet\left(\vec{V}\frac{\partial p}{\partial \eta}\right)\right] d\eta$$

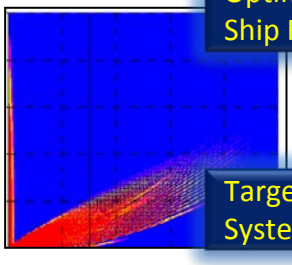
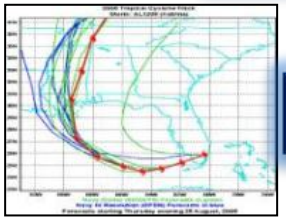
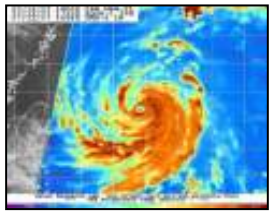
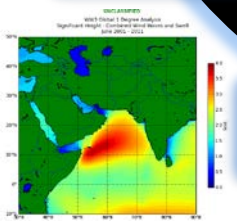
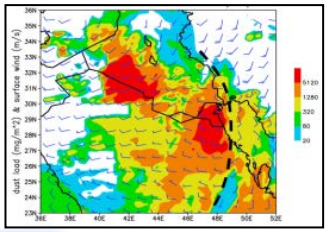
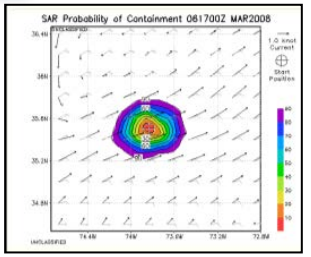
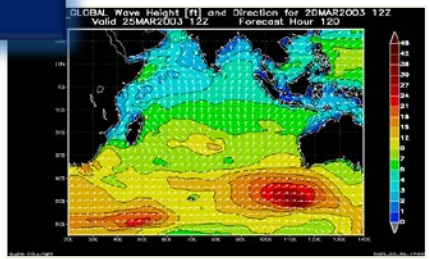
Constituent Eqn

$$\frac{\partial q}{\partial t} + \vec{V}\bullet\vec{\nabla}q + \dot{\eta}\frac{\partial q}{\partial \eta} = F_q$$

... and a few more...

processing ~12 million observations...
running ~5 million grid points, 12 times per day...
requiring a total of ~11 million lines of code...

FNMOC Operational Capabilities

Ocean Acoustic Forecasting

Aircraft Routing OPARS

Automated High Seas / Wind Warnings

Visibility/Dust Forecasts

Optimum Track Ship Route - WEAX

Electro-Optical Forecasts

Target Weapon Systems

Search and Rescue

Ice Forecasts

CEEMS

Tropical Cyclone Forecasts

Long-Range Planning

Operational Climatology

Ballistic Wind Computations

TCPED

Dissemination

Tasking

Collection

Processing

Exploitation & Analysis

NAVGEM Global Modeling

COAMPS Regional Modeling

NIPRNET – JWICS – SIPRNET

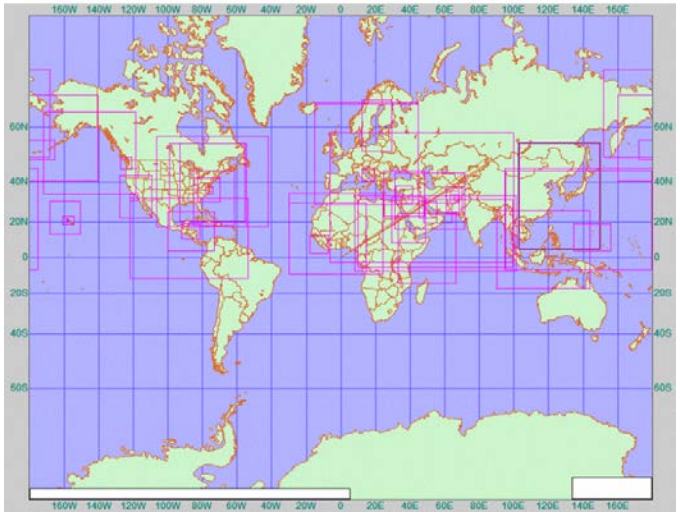
UNCLASSIFIED / FOUO

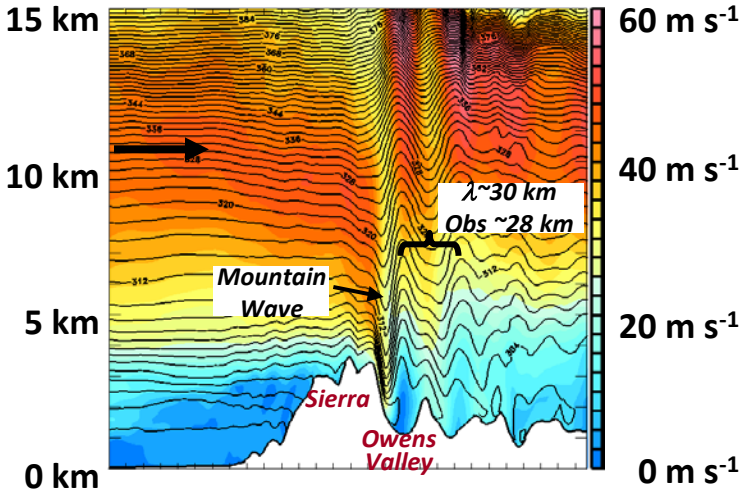
Models Overview

- **NAVGEM 1.4**– NAVal Global Environment Model; (T425L60) ~ 31 km, 60 vertical levels; Semi-Lagrangian dynamic core model. ***At the center of FNMOC production***.
- **COAMPS v5.2** – Coupled Ocean/Atmosphere Mesoscale Prediction System; high resolution model for quick response to warfighter support requests(< 1 day); multi-nested to less than 1 km; 60 vertical levels. Special support for tropical cyclones, dust, EM and acoustic propagation. Driven by NAVGEM. Run at all classification levels ***At the center of FNMOC production. 65/45/18***
- **WW3 v4.18** – WaveWatch III; ocean wave model; global (~35KM) and regional (5KM) implementations. Driven by NAVGEM and COAMPS. Model bias can be "tuned".
- **COAMPS - TC** – COAMPS centered on JTWC official forecast.
- **WW3 TC-OFCL** – WW3 forced by JTWC official forecast (as inserted into NAVGEM)
- **NAVGEM Ensemble 1.4.31**– Global 21-member, 16-day forecast, to T359 (33km)L60; supports 20-member global WW3 ensemble. Uses customized ensemble transform method to match member perturbations to model error. With the NCEP and CMC global ensembles, forms the National Unified Operational Prediction Capability (NUOPC) 60 member multi-model ensemble.
- **NAAPS** – Navy Atmospheric Aerosol Prediction System; the only operational global aerosol model. Atmospheric optical properties output feeds Target Acquisition Weapons Software (TAWS). Driven by NAVGEM.
- **AAP** – Atmospheric Acoustic Propagation; is a system for predicting the probability that a human ear will detect a helicopter in theater. System is a part of COAMPS-OS, atmospheric forecast from COAMPS.

COAMPS: Regional to Tactical Scale Rapid Response Support

- Coupled Ocean / Atmosphere Mesoscale Prediction System (COAMPS)
  - Re-locatable in ***minutes*** for on-demand operations support
  - Optimized for coastal prediction through close coupling with ocean models
  - Nested grid, resolution up to **1.67km**
  - Run for many areas at all classification levels, multiple times per day
  - Forecasts typically to 72 hours
  - Developed and supported by NRL
  - Rapid Environmental Assessment (REA) run on an hourly basis with radar ingest





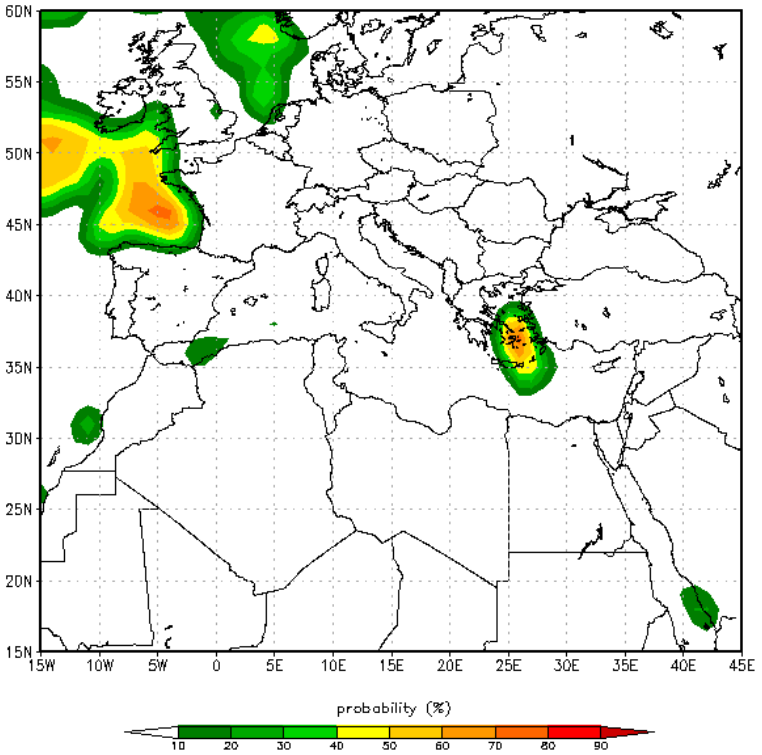
Cross section of temperature and wind speeds from COAMPS showing mountain waves over the Sierras

Ensembles: Long Prediction

Ensembles: Value Added Forecasting

- Model skill out to 5-10 days
- Probabilistic forecasts
- Tailored thresholding

- Forecast reliability (or divergence in model determinations) can be estimated from the “spread” shown in individual model members (on the “spaghetti” plots)

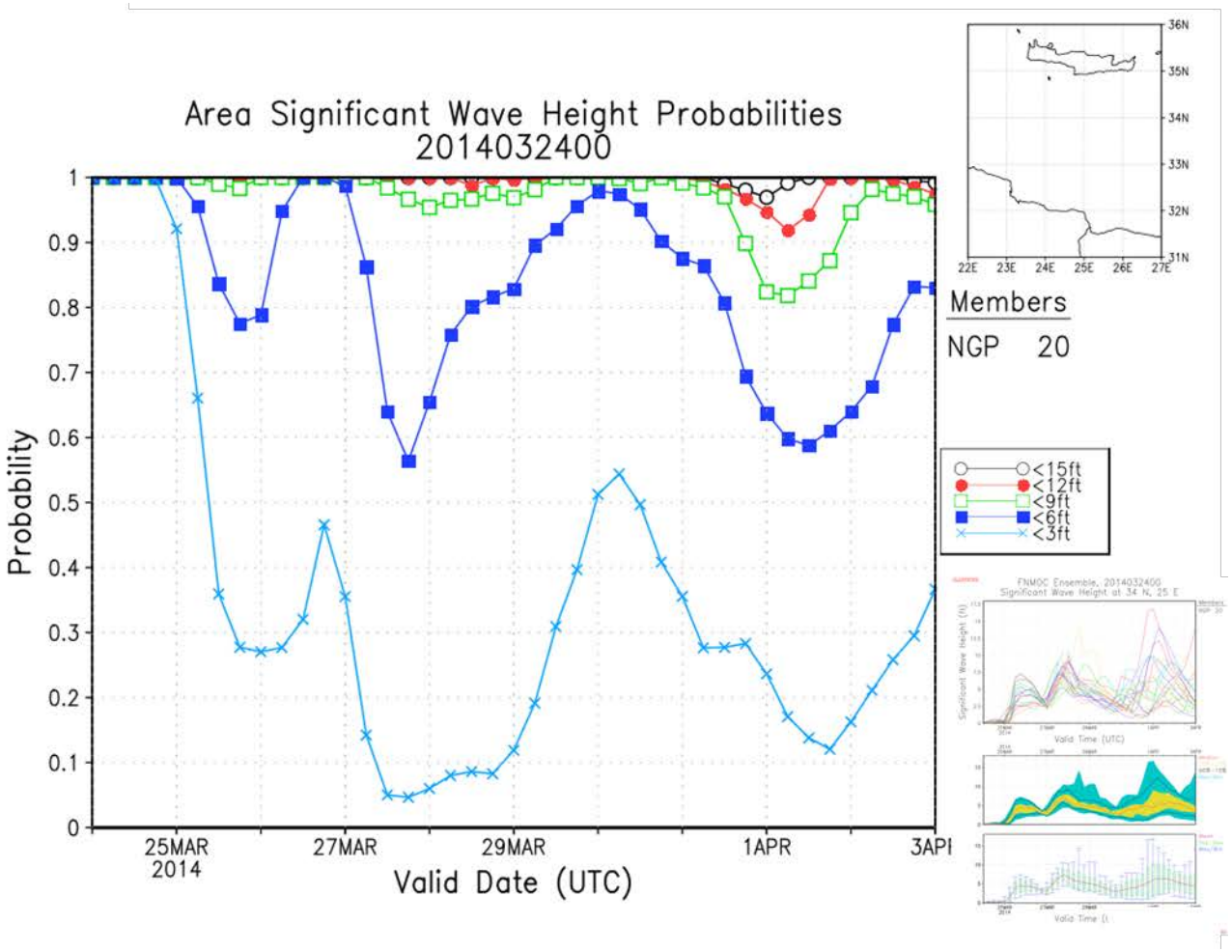


NUOPC = Multi-model Ensemble (USN, NCEP, Canadian Met)

Warfighting Support Division

- A COCOM-focused operational reach back center for Joint Physical Battlespace Awareness and Mission Effectiveness
- Proactive coordination of tailored HPC/NWP production and Climate Support (ACAF and Climate Portal) to COCOM operations, exercises and contingency operations
- Engage COCOM and Fleet METOC officers, IC METOC, FWCs, RBCs (NOMWC and NOAC), and other traditional METOC partners
- Lead cross-functional teams with ONR / NRL and NPS to integrate/OPTEST leading edge technology and potential transition programs (ie NEXRAD/HWDDC REA, AAP, etc)
- Bridging advances in science to warfighter operational advantage
  - Executive Summaries for upgrades/changes in capability
  - Expanding T&T and V&V capability
  - Proactive Customer Engagement early exercise/operations cycle
  - Coordination to advance the request and capability delivered

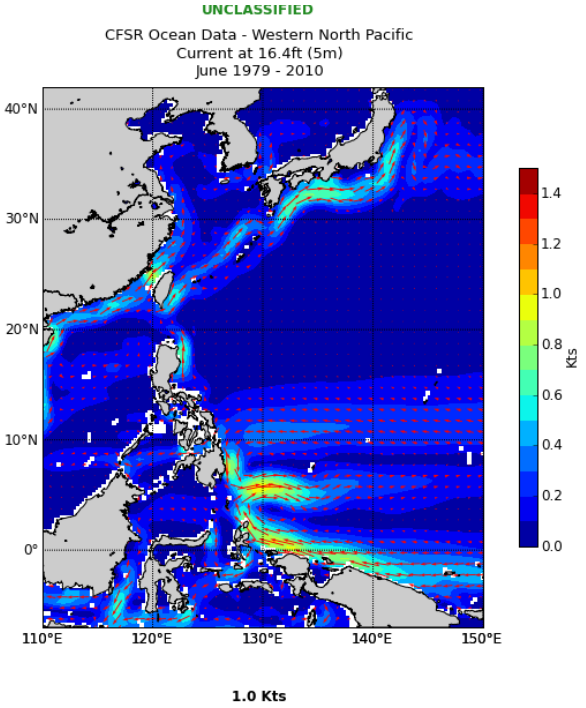
WW3 Ensemble Support for CAPE RAY

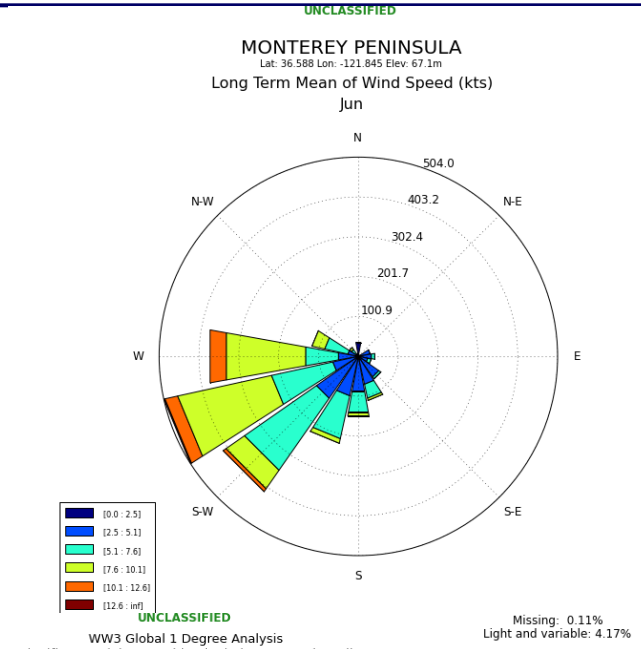


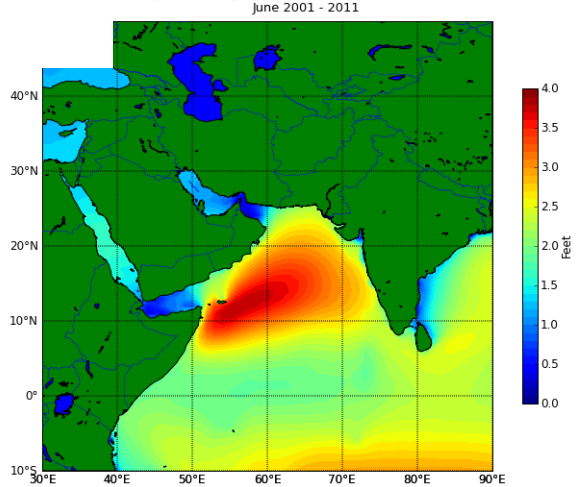
Supporting safe and successful destruction of Syrian WMDs

Operational Climatology

- Archives/Updates ocean surface (i.e. wind and swell waves) and atmospheric numerical model fields
- Maintains the Advanced Climate Analysis and Forecasting (ACAF) system
- All classification levels
- Arctic / El Nino outlooks
- Fastest-growing area of mission support
- New Trend and Tendencies (TnT) support

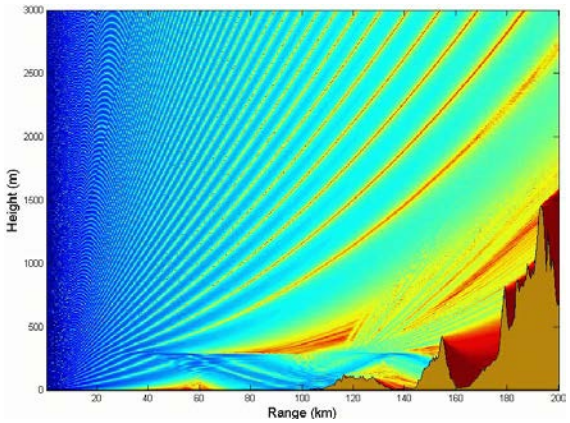






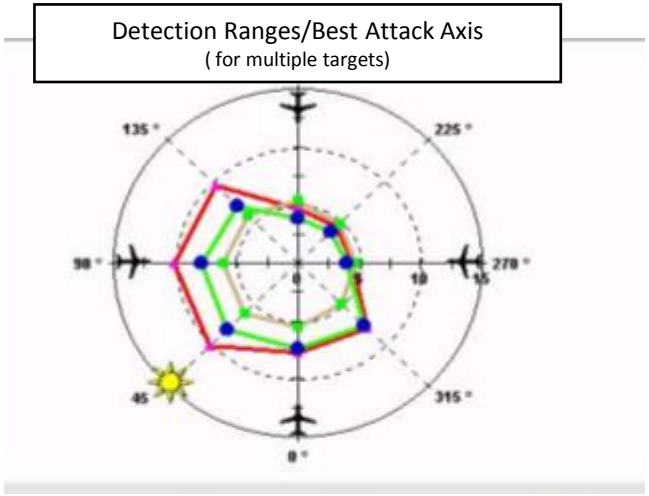
Tactical Decision Aids

Advanced Refractive Effects Prediction System (AREPS)



- FWC's provide RBC

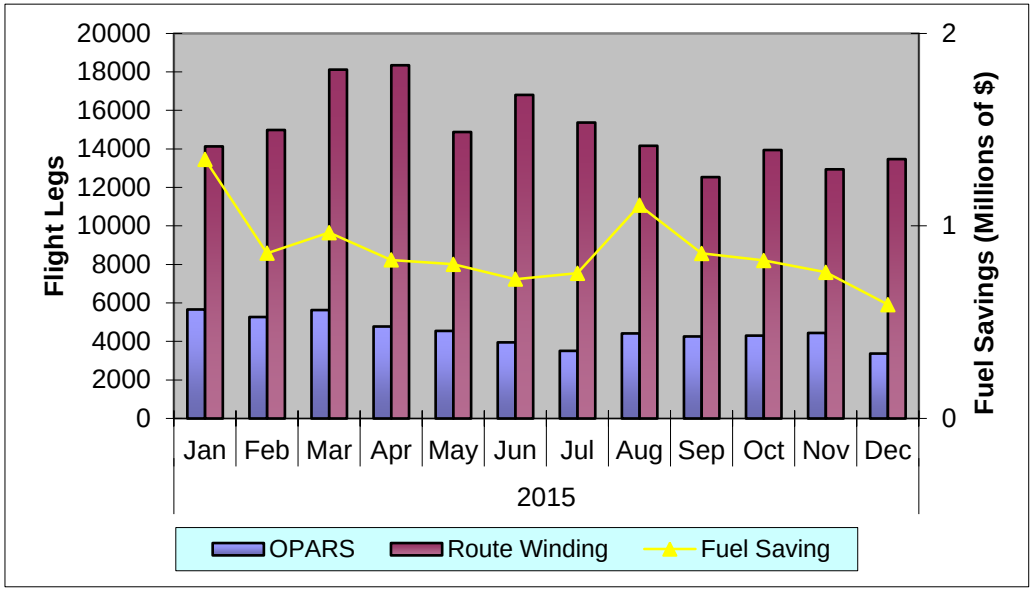
Target Acquisition Weapons Software (TAWS)



Optimum Path Aircraft Routing System (OPARS)

Estimated Fuel Cost Avoidance for 2015: **$10,405,825**

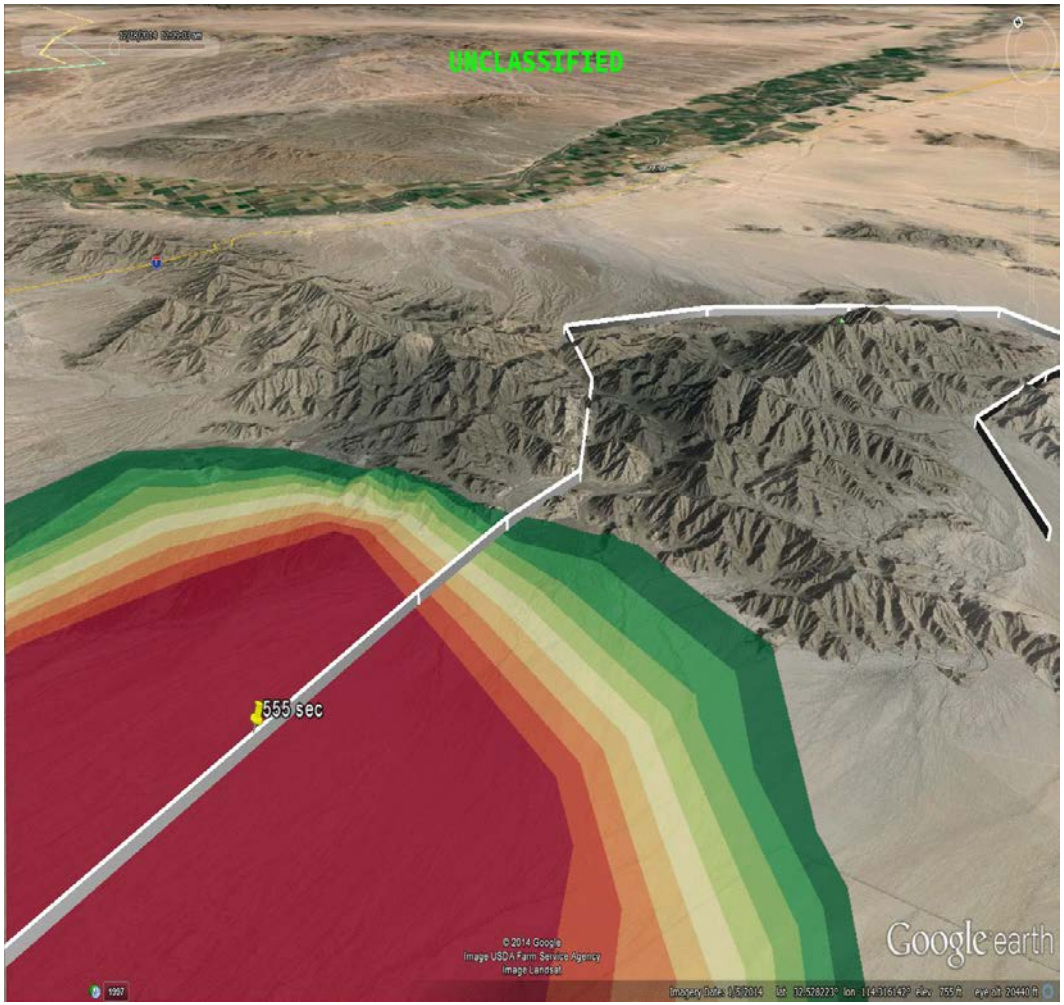
(Based on customer supplied cost avoidance percentage and Navy contract price of fuel per gallon)



Warfighters supported	6,160
** By Command/Unit/Squadron/Individual*	
Number of aircraft types supported	91
** Top 5 aircraft types: UC35, C12, P3C, KC130J, C130*	
Total OPARS flight legs requested	54,183
Total PFPS flight requests	179,727

Atmospheric Acoustic Propagation

- NASA code adapted to Navy requirements by NRL MMD
- Combines weather & terrain
- Web GIS interface
- Multiple output formats: KML, Shapefile, PNG
- Initial OPTEST and OPEVAL completed
- Future:
  - Additional airframes
  - Multi-platform capability
  - Optimum path routing
  - Threat avoidance routing

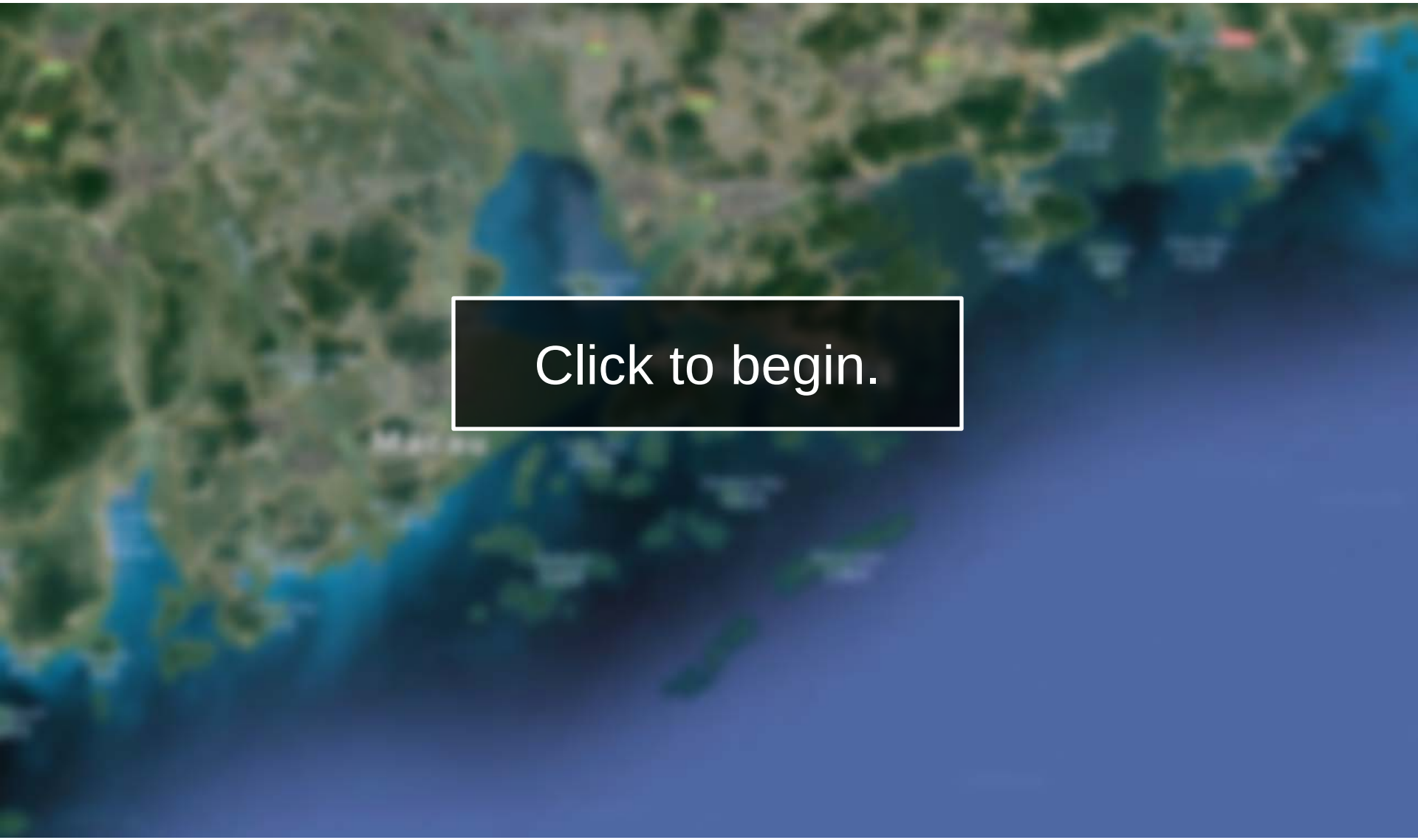


Green = 10-40% detection, Red = 90-100%

Special Projects

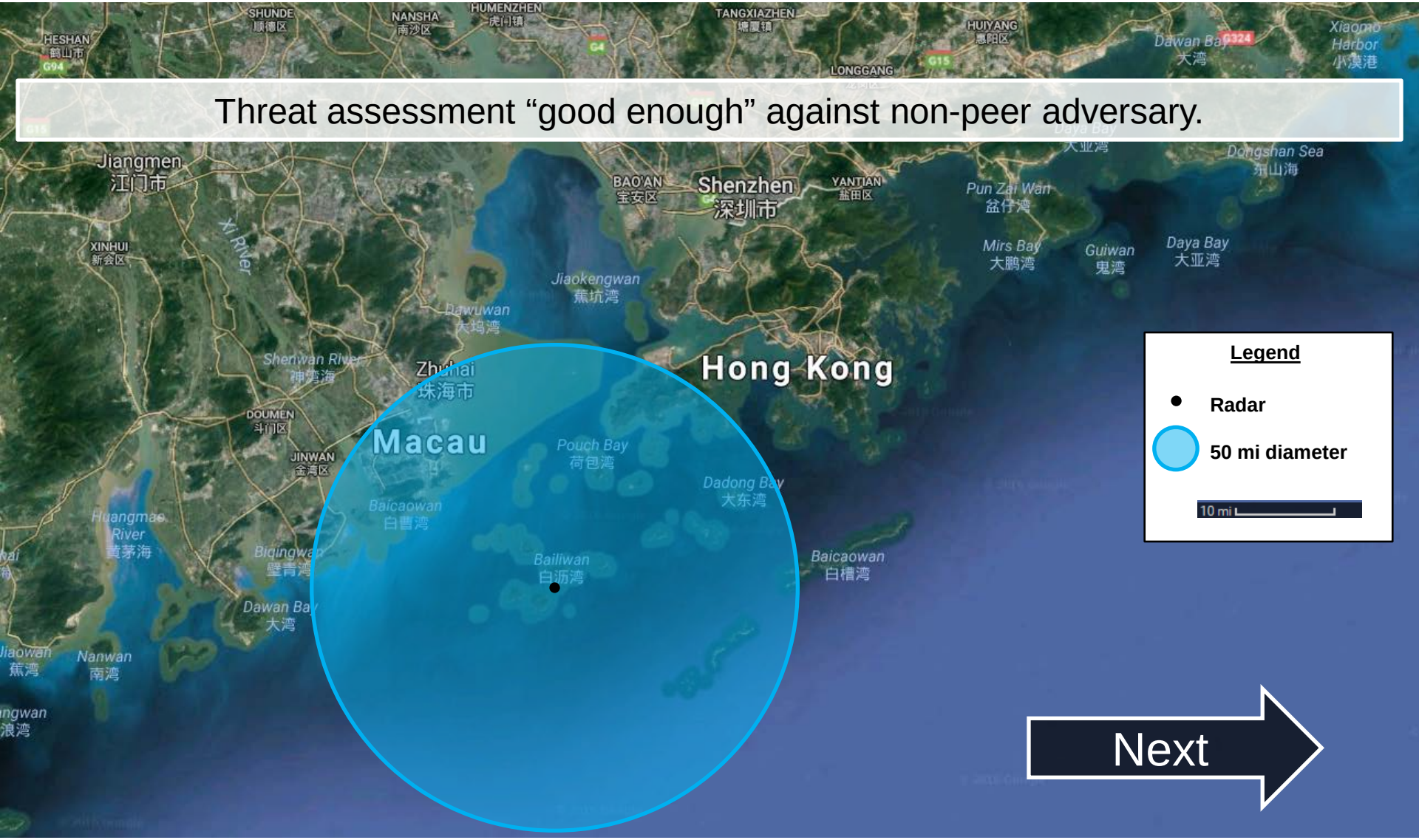
- Executive Agent for Information Warfare / Intelligence Community integration
- Cloud Computing
- JWICS Efforts
  - Peer modeling capability
  - Global environmental modeling in SCIF
- Electromagnetic Warfare gap
  - Ionospheric parameters (GAIM-FP when will it become available?)
  - Roadshows and warfighter requirements
- GBS and Comms Denied Environments
- Continuous Integration Environment
  - Collaboration with NPS, SPAWAR and others
- Unified Modeling with NAVO NP31

Exploiting the Operational Advantage

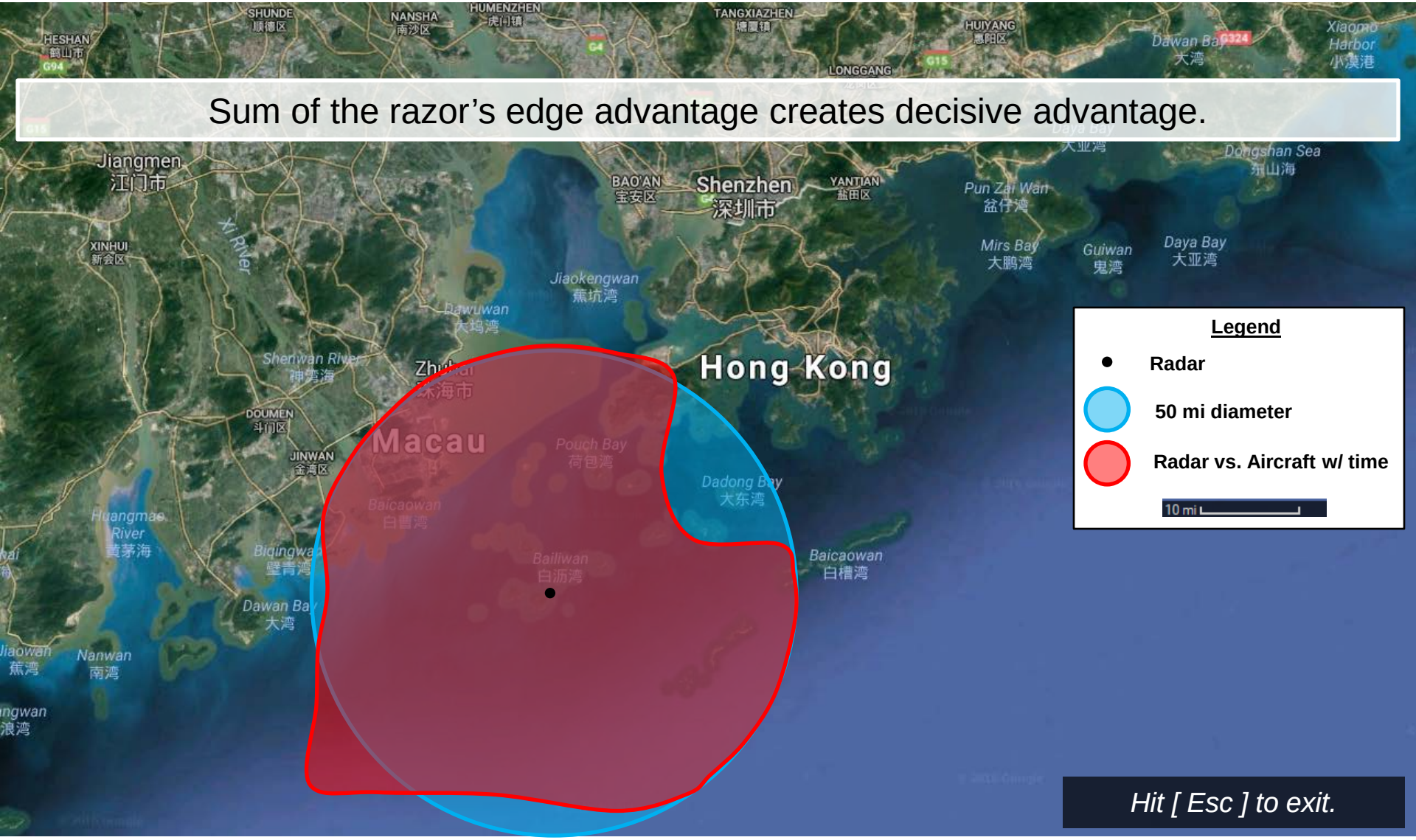


Exploiting the Operational Advantage

Threat assessment “good enough” against non-peer adversary.



Sum of the razor's edge advantage creates decisive advantage.



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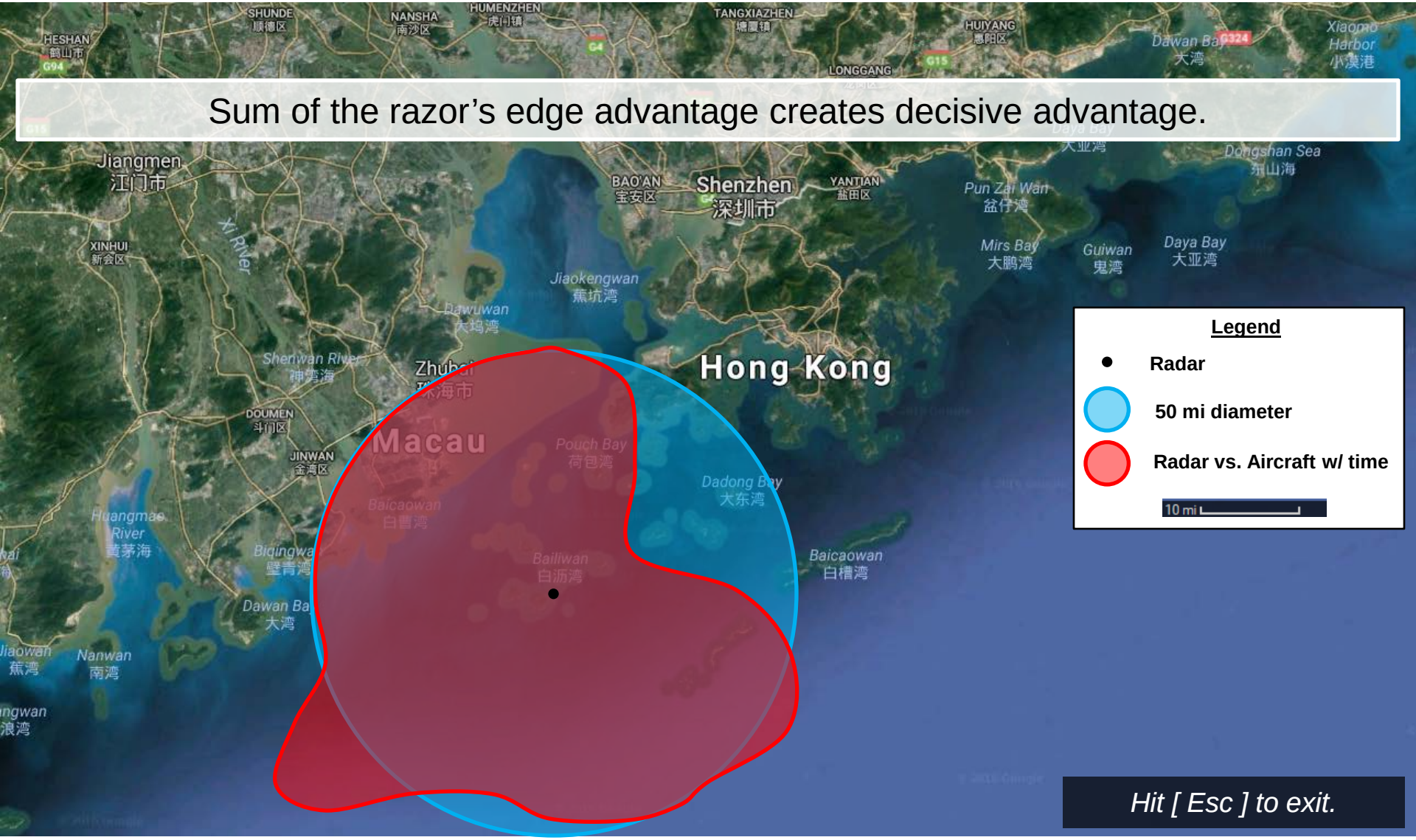

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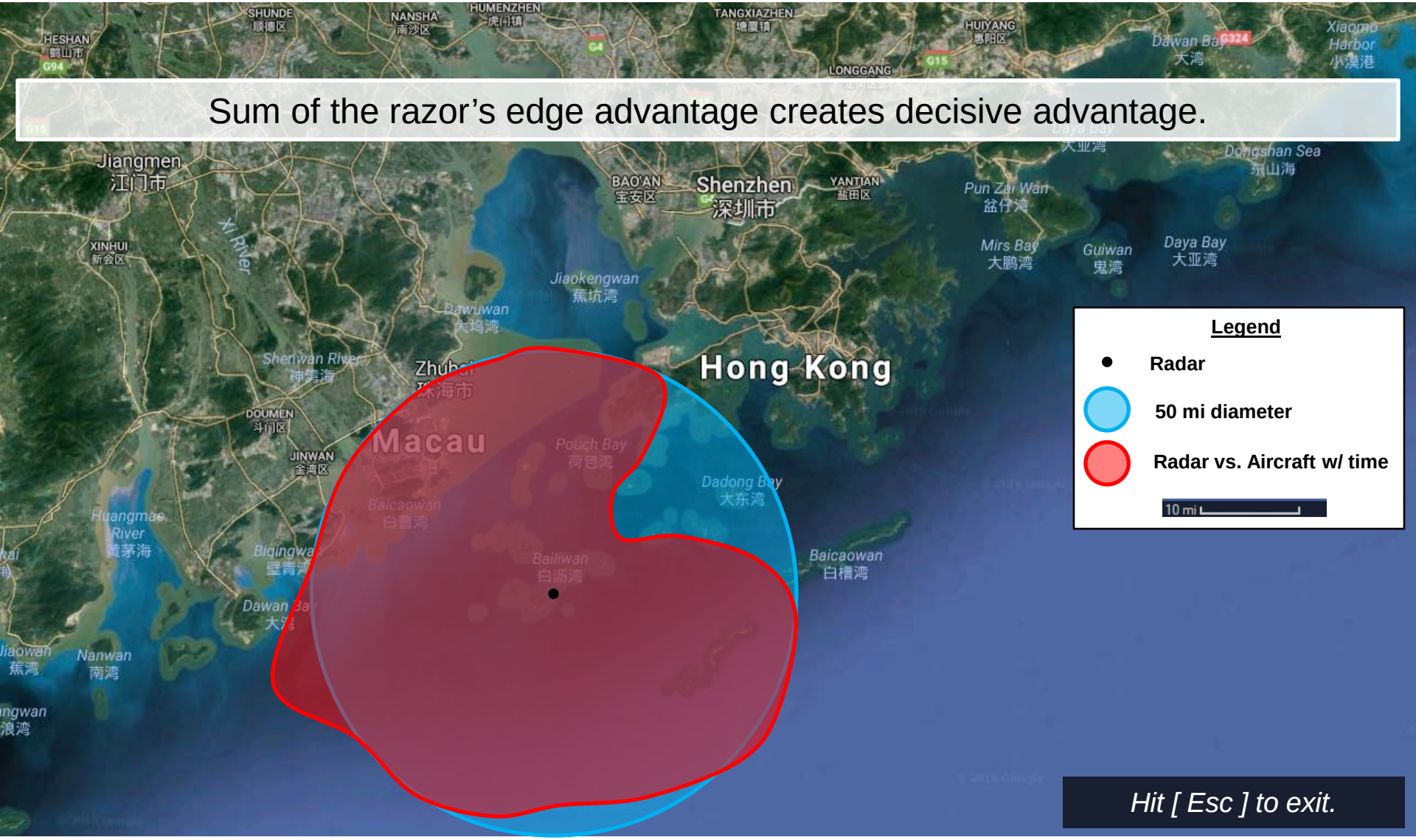

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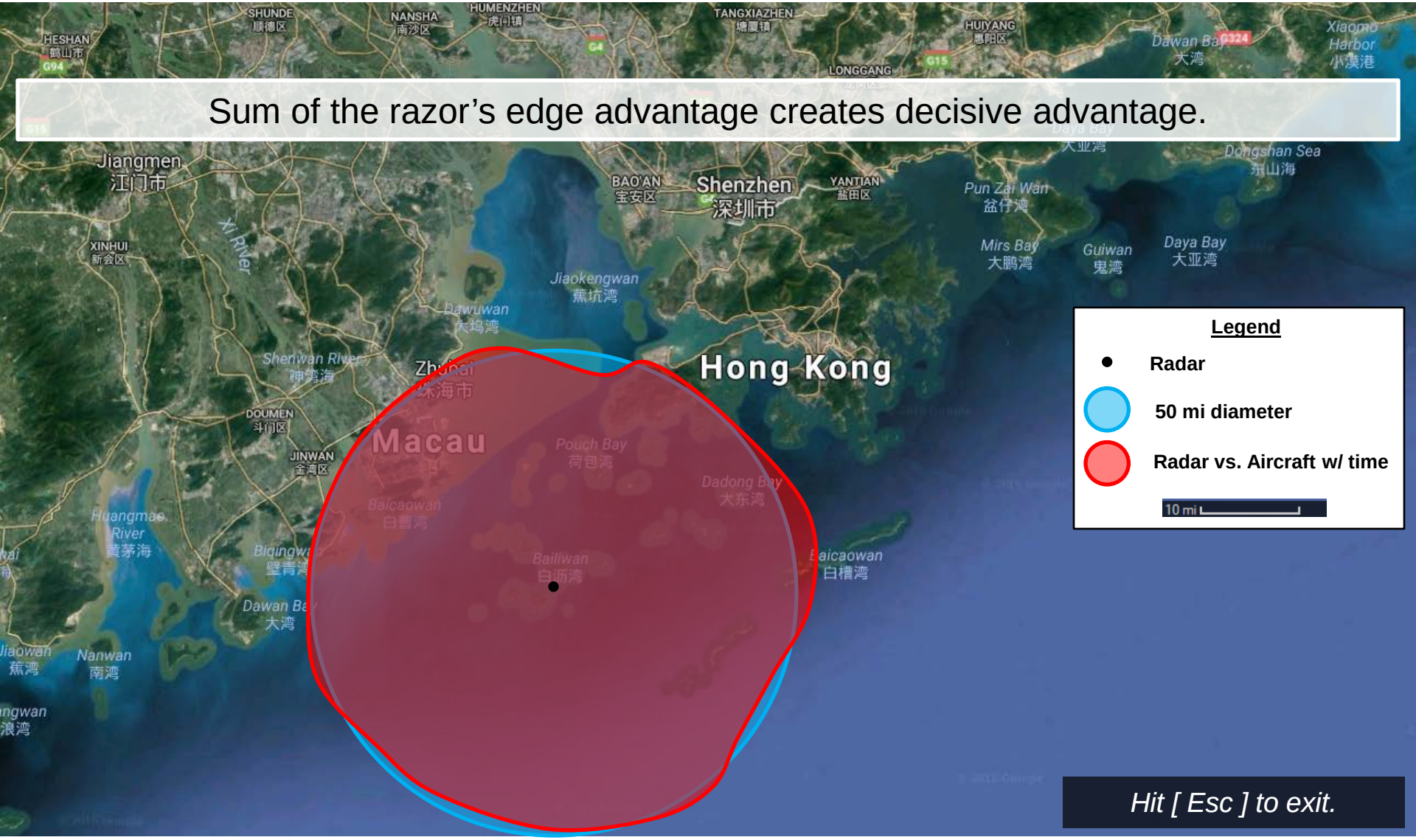

Vision & Takeaways

Vision

DoD's Premier Numerical Modeling Center - Lead for Physical Battlespace Awareness and Operational Advantage

Takeaways

FNMOC is the foundation for fleet safety

Every ‘forecast’ for ships, submarines, aircraft and special forces start with FNMOC environmental prediction & production services

FNMOC provides the foundation for Physical Battlespace Awareness and provides direct support to Integrated Fires

Cybersecure assimilation, production and delivery enabling assured C2

Only center that models the Global and Regional Atmosphere to DoD CS Standards

Provides climatological support to Joint and Naval Operations

Questions


FLEET NUMERICAL METEOROLOGY AND OCEANOGRAPHY CENTER
MONTEREY, CA