Raytheon
Customer Success Is Our Mission

AIR
LAND
SEA
SPACE
CYBER

'Make in India' Paradigm : Roadmap for a Future Ready Naval Force
Session 9: Coastal Surveillance, Response Systems and Platforms
Nik Khanna, President, India
April 19, 2016

Aligned with Customer Priorities

COMMAND, CONTROL & INTELLIGENCE
Raytheon integrates proven radars, sensors, navigation systems, and cyber technology to enable customers to collect, analyze and distribute information in real-time, giving them new ways to perceive and manage data.

ELECTRONIC WARFARE
Raytheon's advanced electronic warfare systems and capabilities give our warfighters the continued strategic advantage to effectively and safely execute their missions in the modern threat environment.

MISSILE DEFENSE
Raytheon's proven missile defense systems deliver protection against a broad range of current and emerging threats — ensuring peace of mind for the U.S. and its allies and making Raytheon the world's most trusted partner in missile defense.

PRECISION WEAPONS
Raytheon's reliable and cost-effective precision weapons hit the target, and only the target, while protecting warfighters, and helping to manage the cost of battle over the long term.

TRAINING & SERVICES
Raytheon's innovative approaches and proven tools help customers successfully train staff, sustain skills and maintain operations for a wide variety of high-consequence missions worldwide

CYBER
With decades of cyber and intelligence expertise, Raytheon offers unmatched end-to-end capabilities that help customers secure their space and confidently navigate the cyberdomain.

BROAD AND DEEP PORTFOLIO OF ADVANCED SOLUTIONS

INTEGRATED DEFENSE SYSTEMS	INTELLIGENCE, INFORMATION & SERVICES	MISSILE SYSTEMS	SPACE & AIRBORNE SYSTEMS	FORCEPOINT Powered By Raytheon
CSI	Cyber	AMRAAM®	Airborne Radars	Integrated Cybersecurity
Patriot™	Environmental Intelligence	Tomahawk	Electronic Warfare	Cybersecurity Analytics
Zumwalt	Training	SM-3®	Space Sensors	Insider Threat Protection
AN/TPY-2	Classified	Paveway™	Intelligence, Surveillance and Reconnaissance	Cybersecurity Forensics & Intelligence
AMDR	Modernization Through Sustainment	ESSM®	Special Mission Aircraft	Advanced Threat Protection

Raytheon has more than 15,000 contracts

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Requirement for Persistent Maritime Surveillance

7 Aug 2011, the MV Pavit Grounded on Juhu Beach, Mumbai

The Pavit, a 77 meter, 1000-ton vessel :

• Abandoned near Oman with machinery problems
• Drifted across the Arabian Sea and entered India's EEZ
• Remained undetected through tiers of security
• Eventually grounded at Juhu Beach

www.ndtv.com/article/india/mumbai-unguarded-nobody-saw-a-1000-ton-ship-coming-124334&cp

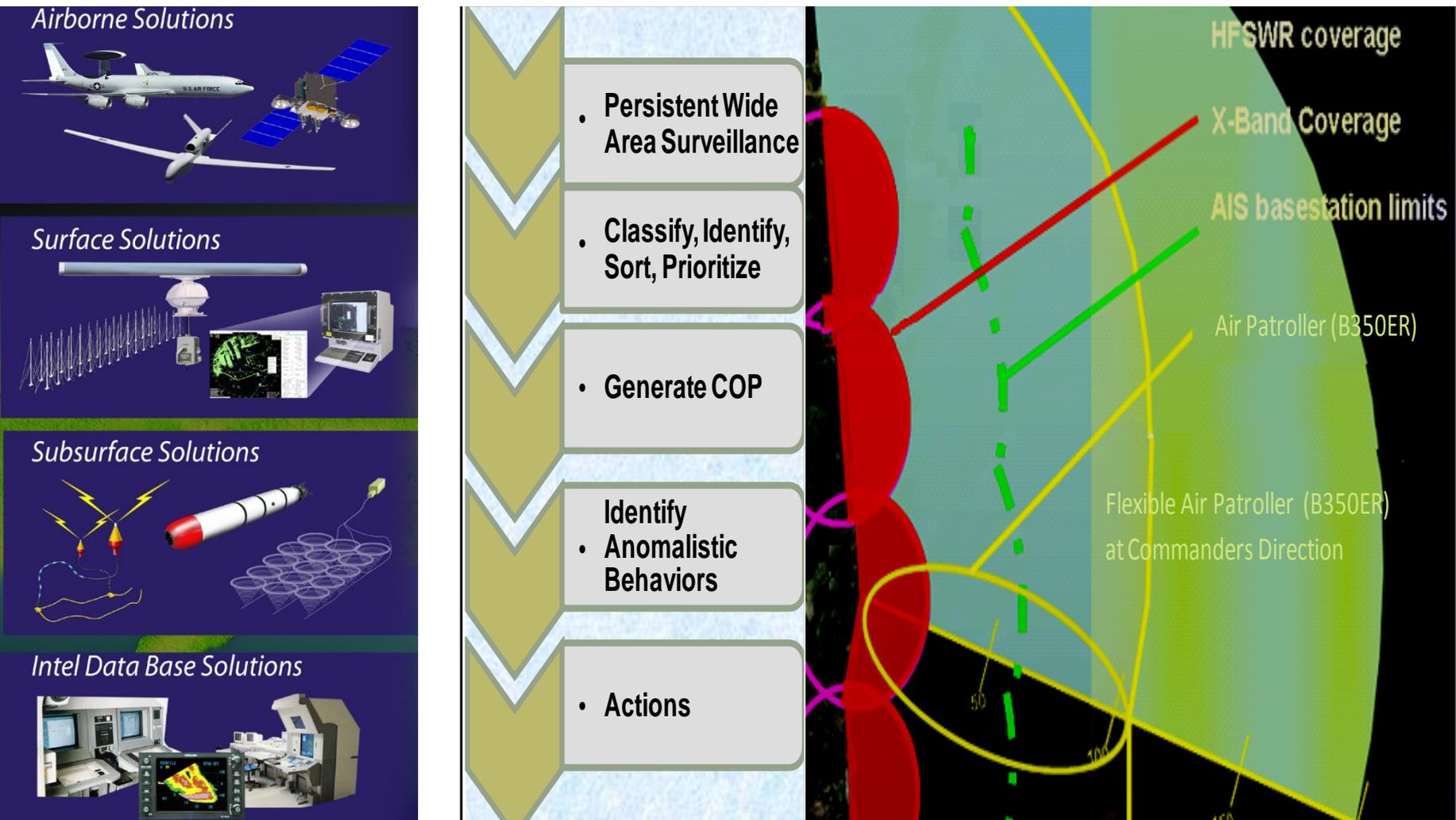# Requirement for Persistent Maritime Domain Awareness

To protect maritime sovereignty and economic resources, enforcement agencies require persistent real-time information concerning the location, identification and activity of ships operating within their 200 nautical mile Exclusive Economic Zone (EEZ).

Areas of Concern:
- National/Border Security
- Resource Protection (fisheries, oil and gas etc.)
- Piracy
- Illegal Immigration
- Narcotic Trafficking
- Environmental Monitoring and Protection
- Search and Rescue
- Safe Navigation

INTEGRATED MARITIME DOMAIN AWARENESS FOR BORDER SECURITY

Airborne Solutions

Surface Solutions

Subsurface Solutions

Intel Data Base Solutions

- Persistent Wide Area Surveillance
- Classify, Identify, Sort, Prioritize
- Generate COP
- Identify Anomalistic Behaviors
- Actions

HFSWR coverage

X-Band Coverage

AIS basestation limits

Air Patroller (B350ER)

Flexible Air Patroller (B350ER) at Commanders Direction

Coastal & Over-the-Horizon Surveillance

Raytheon Canada has developed two key sensors to provide persistent surveillance of both cooperative and non-cooperative vessels

- High Frequency Surface Wave Radar – HFSWR
- Marine Small Target Tracker - MSTT

▪ **HFSWR monitors vessel traffic throughout the 200 nm Exclusive Economic Zone**

▪ **MSTT provides small vessel detection in territorial waters**

▪ **Together, HFSWR & MSTT in conjunction with microwave radar provide a complete maritime picture**

▪ **MSTT and HFSWR provide high confidence tracks in standard message formats and integrate easily with all Command & Control and Decision Support Systems**.

MARITIME BORDERS SURVEILLANCE OPTIONS
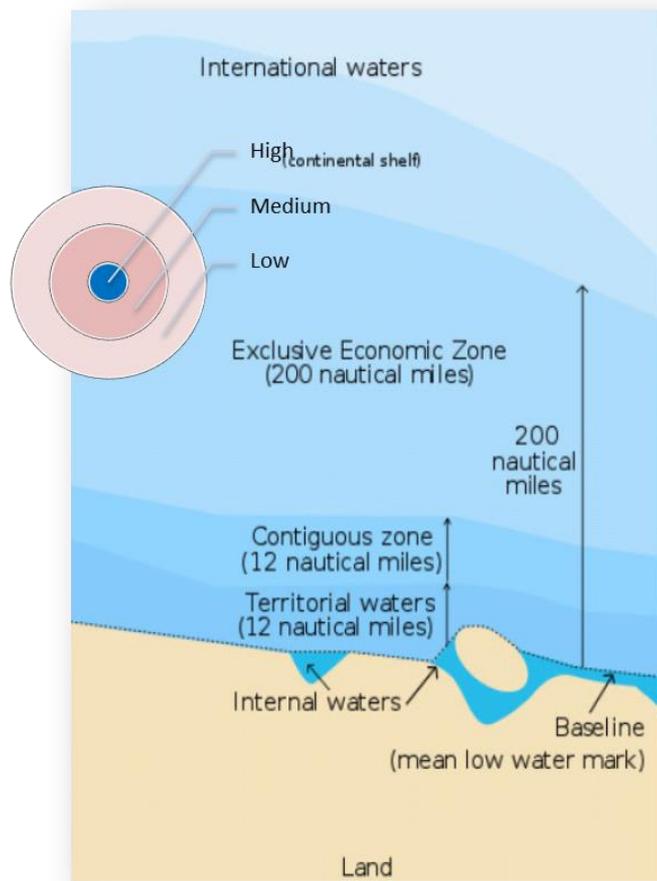
Traffic Density	Threat Level	Economic Value	Revisit time	Sensor
Low	Low	Low	Low	Space-based radar, S-AIS & LRIT
Medium	Medium	High	Medium	Patrollers HFSWR
High	High	High	High	AIS VTS Type radars

Objective is to identify vessels of interest at a range where appropriate action can be taken

Radars for Maritime Domain Awareness

Surveillance

Land-based VTS radars
- 20m vessel 60 km
- Persistent Tracking

Land-based HFSWR
- 20m vessel, 280 km
- Persistent Tracking
- Day/night dependency

Land-based OTH radars (HF)
- 20m vessel, 3000 km
- Persistent Tracking

U.S. Navy ROTHR
2.6-km Receiving Array

Reconnaissance

Space-based C-Band radars
- Minimum detectable vessel 25m
- Approx. 500km swath
- Vessel Position Update ~ every 2-days

Courtesy Radarsat International

Airborne radars
- 20m vessel to ~ 100km

Ship-based Navigation radars
- 20 m vessel to ~40 km in calm conditions

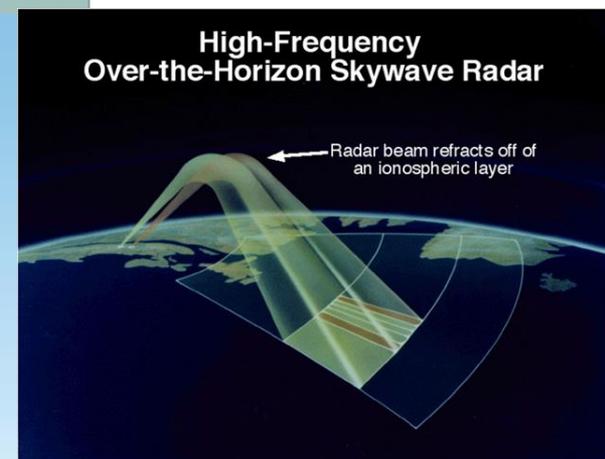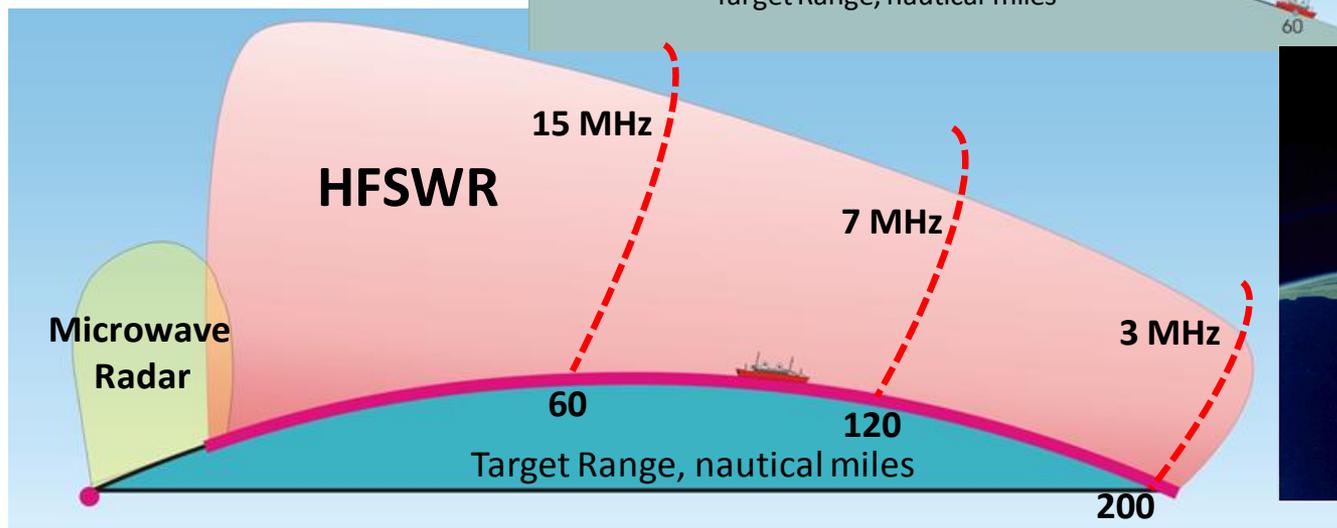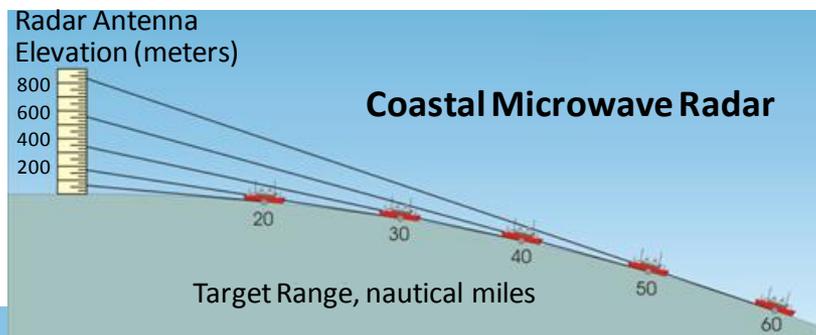## Fixed Radars Required for Persistent Surveillance Platform Mounted Radars for Reconnaissance.

Land based Radar for Persistency

Coastal Microwave Radar
Only operates in a Line-of-Sight mode
Generally limited to first 20 or 30 nautical miles (nm).

HF Surface Wave Radar
Lower the frequency the greater the range. Typical minimum range 20 nm

Radar Antenna Elevation (meters)

Coastal Microwave Radar

800
600
400
200

Target Range, nautical miles

20
30
40
50
60

15 MHz

HFSWR

7 MHz

Microwave Radar

3 MHz

60

120

Target Range, nautical miles

200

High-Frequency Over-the-Horizon Skywave Radar

← Radar beam refracts off of an ionospheric layer

HFSWR
surface wave radar

HFSWR: the Foundation of a Maritime Domain Awareness System

provides continuous, persistent surveillance of surface vessels throughout a nation's 200 nautical mile Exclusive Economic Zone (EEZ)

100%Canadian

Raytheon's HFSWR is protected by the following patents US6717545, CN1643398A, DE60301564D1, DE60301564T2, EP1485730A1, EP1485730B1, US20030174088, WO2003079046A1, WO2003079046A9, CA2478816A1, CN1653354A, DE60304692D1, DE60304692T2, DE60309748D1, DE60309748T2, EP1485731A2, EP1485731B1, US20040178951, WO2003079045A2, WO2003079045A3, CA2478940A1, CA2478940C, CN1653353A, DE60309006D1, DE60309006T2, EP1485728A2, EP1485728B1, US6867731, WO2003079037A2, WO2003079037A3, CA2567572A1, CA2567572C, S20050242985, WO2005111655A2, WO2005111655A3, US7626535, US7791413, Additional patents are pending.

HF Surface Wave Radar — Raytheon HFSWR — Repertio parvula potestas magna

![Raytheon]

HFSWR Program Timelines

1988-2002: Canadian R&D
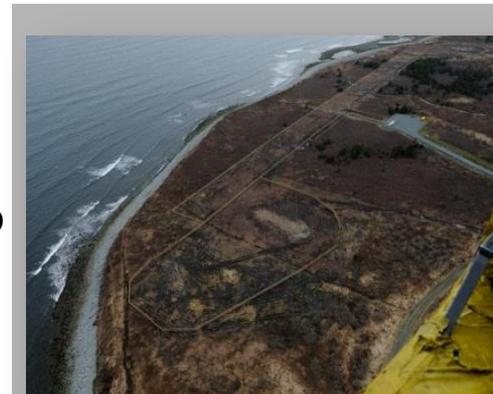**2003-2007:** SWR503 System Operational with Canadian Navy
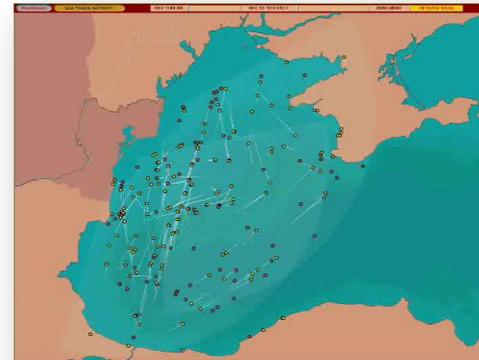
Movie Black Sea

2009: Second International Sale. Two Systems for coverage of the Black Sea.

Movie Asia

2008: First international sale to Asian Navy.

2011-15: Raytheon Canada receives PASE TDP contract to develop 3rd Generation HFSWR system for Canadian Government.

Halifax HFSWR Site

Transmit Antenna #1

Equipment Shelter

Receive Array

3rd Generation HFSWR Design Highlights

- **Direct Conversion Receiver-Exciter technology**
  - ✓ A software based radar approach
- **Extensive use of COTS products**
- **Computer Operating System**
  - ✓ All S/W functions hosted on a common processing system with industry standard Linux OS.
- **Custom Transmitter**
  - ✓ excellent gain and phase linearity
  - ✓ Resulting in low and constrained side-lobes
- **Intelligent Spectrum Monitoring**
  - ✓ Automated Pro-active Option Available
  - ✓ Cognitive Operation Enabled: Sense and Adapt
  - ✓ Enables operation in the congested HF spectrum without causing interference to other users

RX SYSTEM

TX SYSTEM

3rd Gen HFSWR Performance Specifications

VESSEL TYPE	MAXIMUM DETECTION RANGE (km)		
	Sea States 0-4* 0-15 knot wind day/night	Sea States 5-6 15-25 knot wind day/night	Sea State 7 25-35 knot wind day/night
Small Vessel *65 ft trawler*	230/210	75/75	
Medium Vessel *~1000 ton displacement*	300/220	300/220†	180/180†
Large Vessel *>3000 ton displacement*	370/260	370/260	370/260

DAY/NIGHT TRACK RANGES FOR MEDIUM VESSEL IN SS5 ARE APPROX DOUBLE THOSE ACHIEVED WITH FIRST/SECOND GENERATION TECHNOLOGY

Summary: Over-the-Horizon Surveillance

- **HFSWR was designed to be affordable system to provide surveillance 200+ nautical miles EEZ**

  – Allows naval assets to be deployed very efficiently and effectively to interdict real problems

  – Very low maintenance and completely unmanned operation from remote locations

  – Easily integrated with other systems (AIS, cameras, etc)

A Proven Naval force multiplier

HFSWR – Seeing Beyond

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