UAS Payloads – Session 1

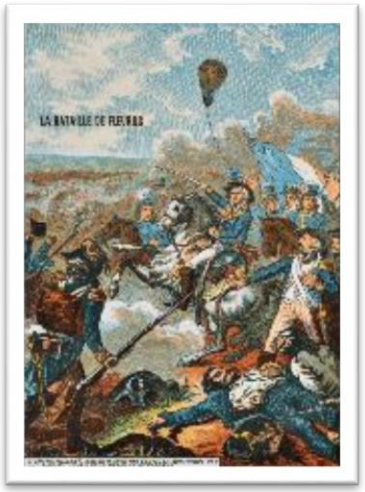
Robótica Aérea

Xin Chen/Manuel Barriopedro

➢ ISR Evolution

ISR		
Intelligence	**Surveillance**	**Reconnaissance**
The **product** after collection, processing, integration, analysis, evaluations and interpretation	**Systematic observation** of aerospace, surface, or subsurface areas, places, persons, or things by any means (video, aural, electronic,…). Sustained in time	**Information gathering** by any means about activities, resources of a potential enemy or to secure data concerning meteorological, hydrographic or geographic characteristics of a particular area. Transitory in time

Airborne ISR? The Historical Origin



French Revolution Wars (1794)

Platform Types: Balloon

Mission: Tactical Surveillance

Sensor: Visual (Telescope).
Range: 29 km

Datalink: written reports in a bag

WW I (1914-1918)

Platform Types: Manned FW Aircraft, Airships

Missions: Reconnaissance, ASW

Sensors: Plate Cameras (Vertical photography)

WW II(1939-1945)

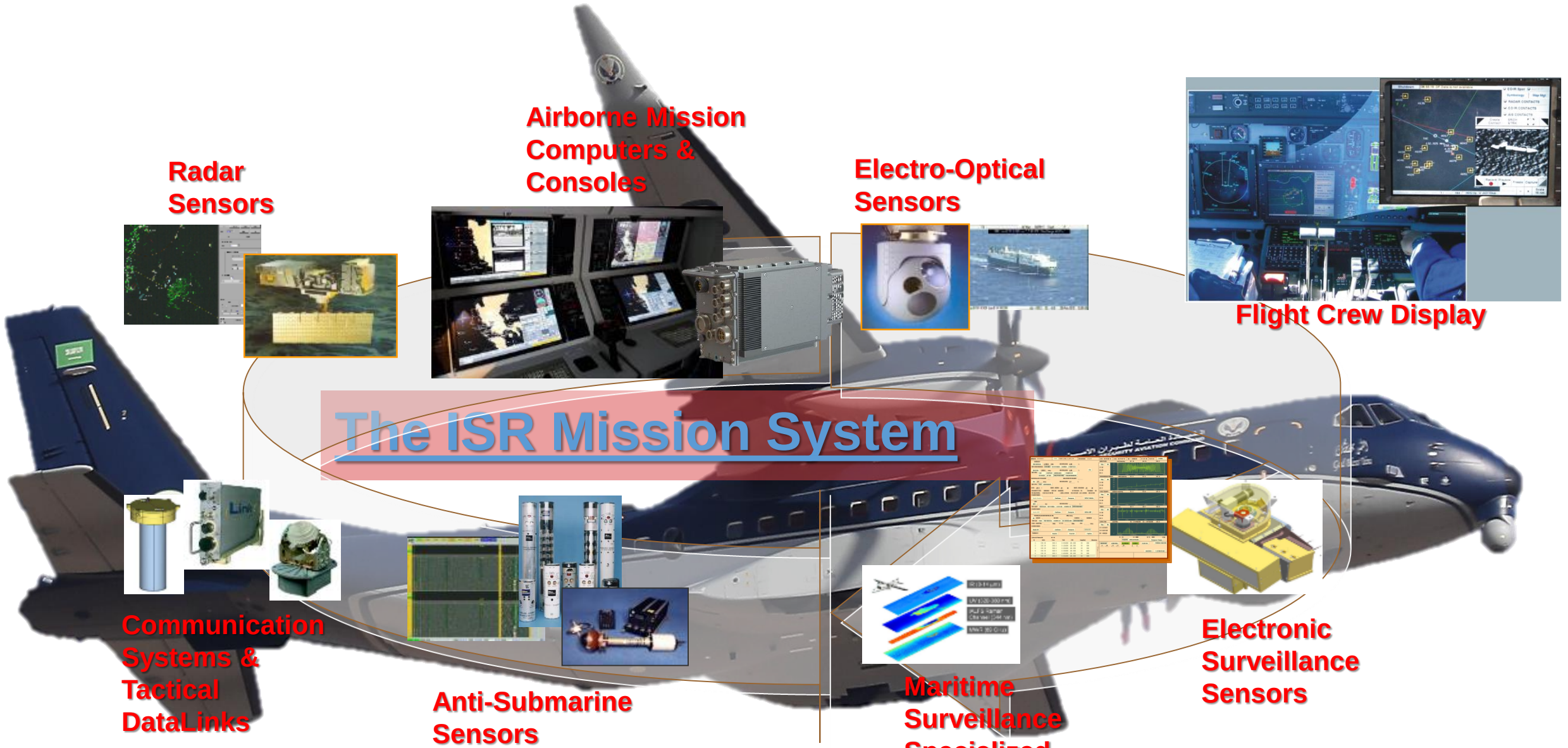
Platform Types: Manned FW Aircraft, Airships

Missions: Reconnaissance & Surveillance, ASW

Sensors: RADAR, Film Cameras, MAD

Airborne ISR – Current & Future assets

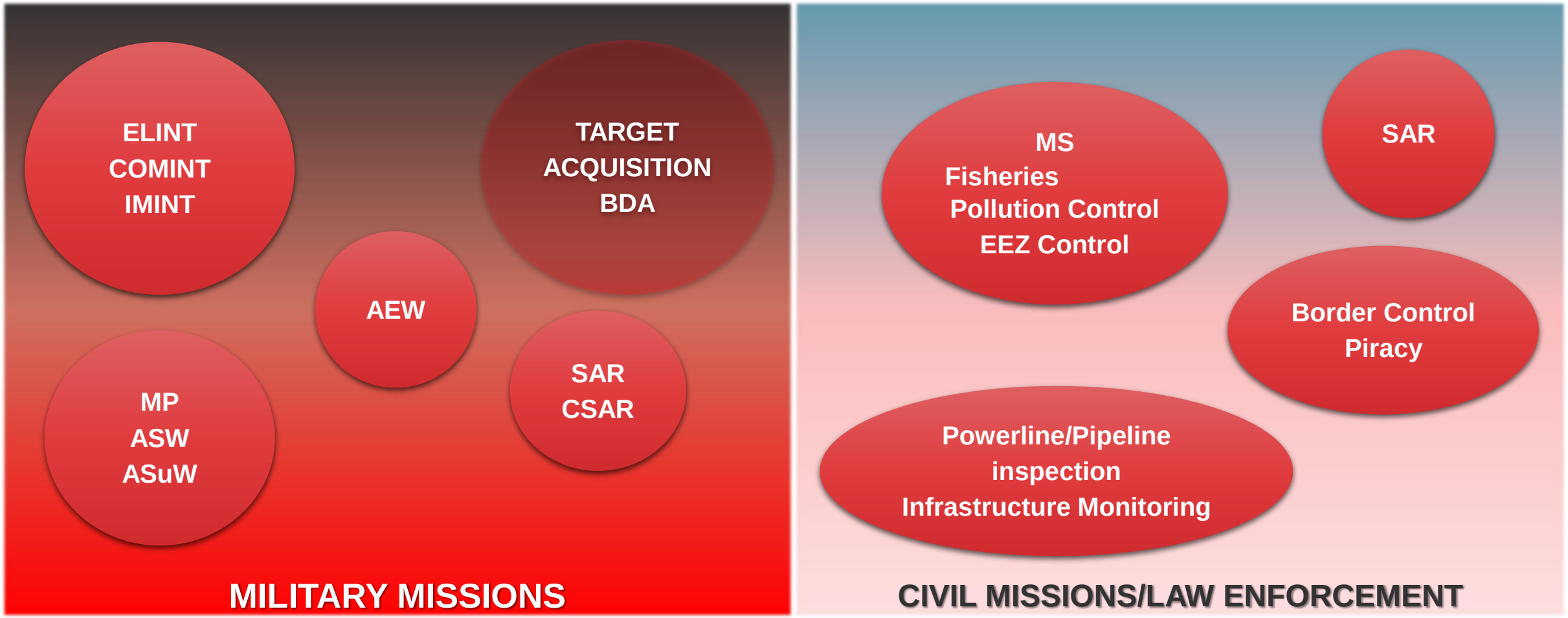
On board a manned ISR Aircraft



Module 9, Military Systems & Armament: Session 11, ISR

On board an UAV/RPA

Types of Missions encompassing ISR tasks



- # PAYLOADS & MISSIONS
- The set of sensors to be integrated in a Mission Sensor is highly dependent on the missions to be performed and the platform capacity to install them (i.e. weight, size and location)

SENSORS / MISSIONS	EO/IR	RADAR (Sea Modes)	RADAR (SAR/GMTI Modes)	SLAR	ESM /ELINT	COMINT	MAD	ACOUSTIC	IR/UV Scanner	PLS	AIS
Signal Intelligence	Optional	Optional	Optional		Required	Required					Optional
Anti-Sub. Warfare	Optional	Required			Optional	Optional	Required	Required			Optional
Imagery Intelligence	Required		Required								
Border Patrol	Required	Required	Required			Optional					Optional
Search & Rescue	Required	Required	Required								Required
Combat SAR	Required	Required	Required							Required	Optional
Pollution Fighting	Optional	Required		Required					Required		Optional

Required for the mission Optional for the mission

- # PAYLOADS & MISSIONS
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Signal Intelligence											
Anti-Sub. Warfare											
Imagery Intelligence											
Border Patrol											
Search & Rescue											
Combat SAR											
Pollution Fighting											

Very wide range of sensors and missions

Some sensors are multi-mission, generic sensors

Others are very mission specific

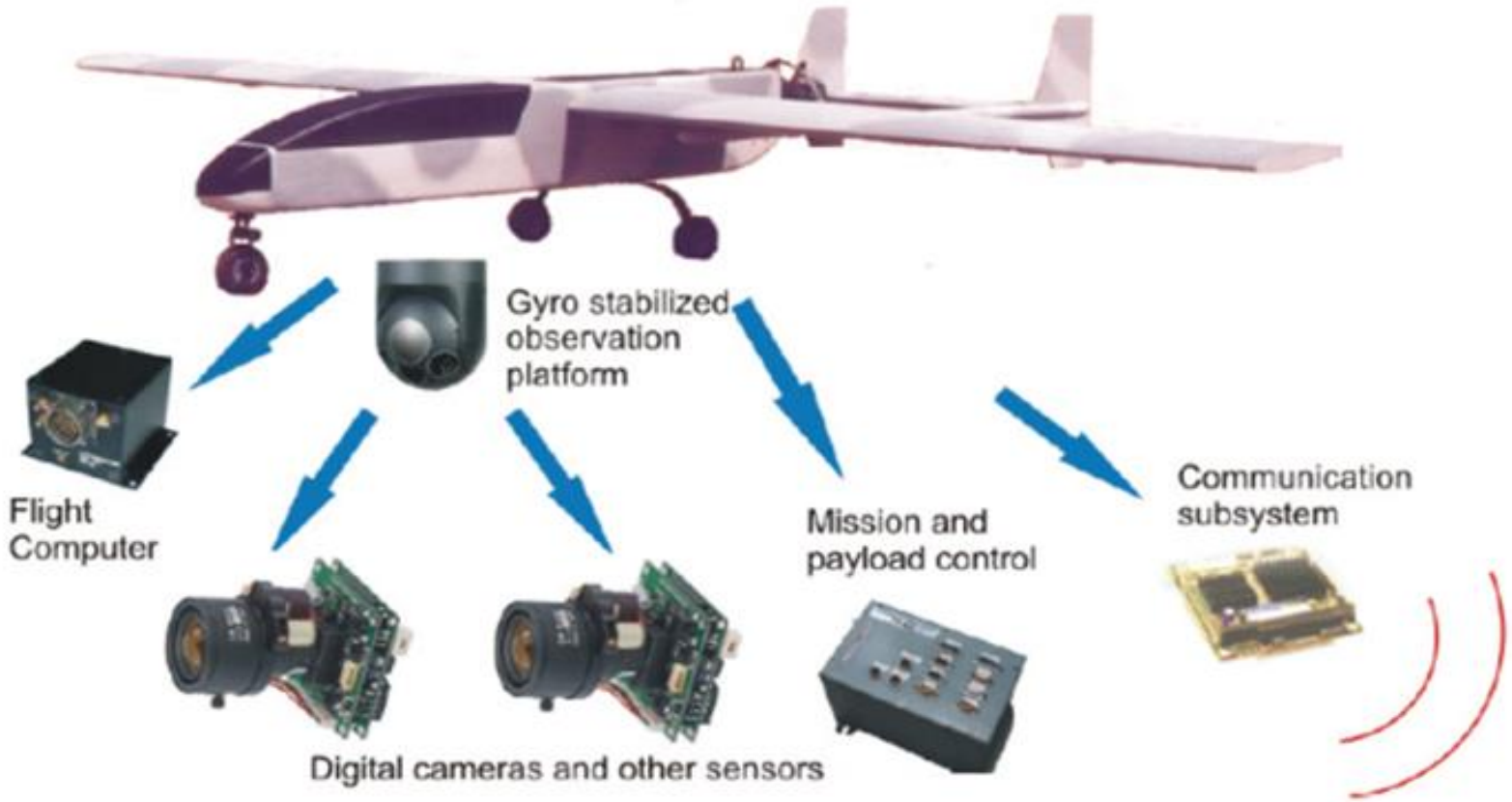
Need: Maintain common core while tailoring to specific missions/sensors/platforms

REUSE IS A MUST

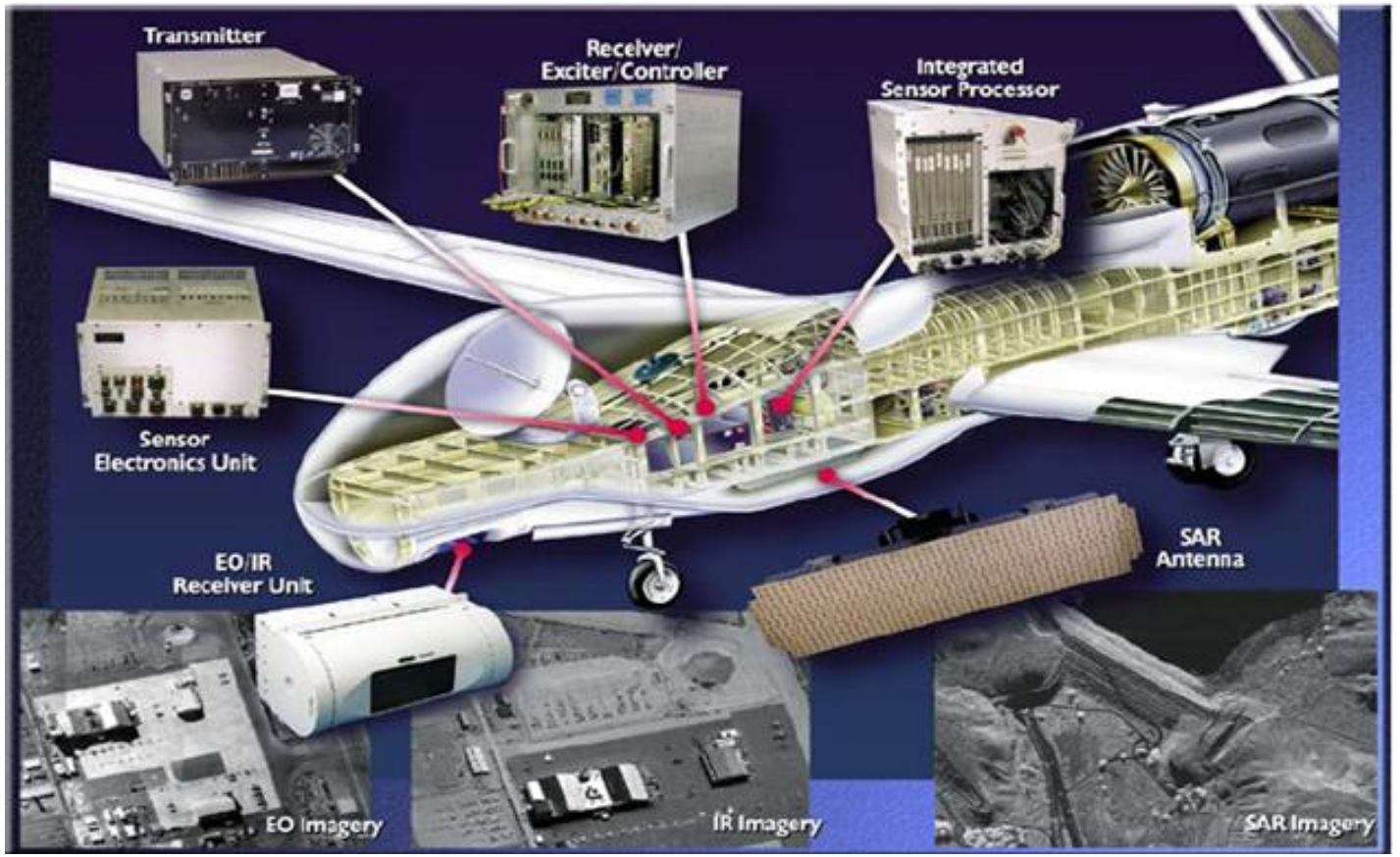
Required for the mission

Optional for the mission

➢ General Achitecturre



➢ General Achitecturre



➢ RADAR

Radars are everywhere

➢ RADAR

Radars are everywhere

➢ RADAR

Radars are everywhere

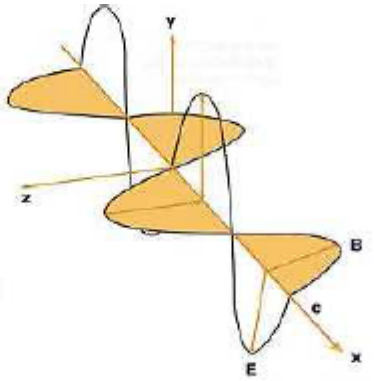
➢ RADAR

Radars are everywhere

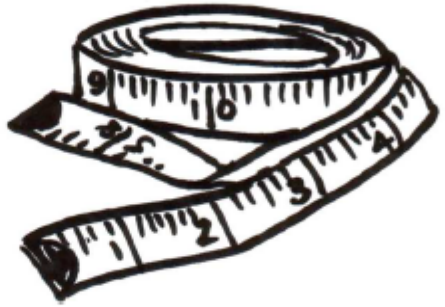
ISR&ASW SYSTEMS

- **RADAR**

RADAR
RAdio
Detection
And
Ranging



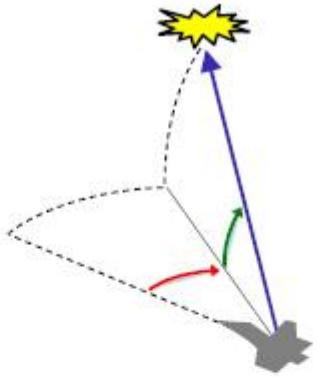
What does it do?



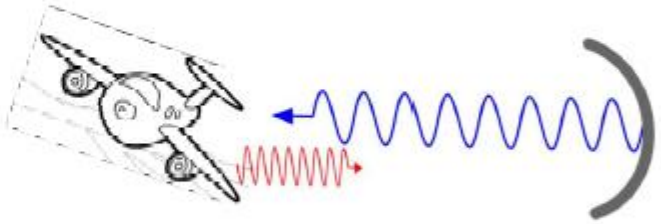
ISR&ASW SYSTEMS

➢ RADAR

What does it do?



- Detects Targets:
  - ✧ 2D: Range / Azimuth
  - ✧ 3D: Range / Azimuth / Elevation



- Calculates Speeds: range rate

- Creates Images

ISR&ASW SYSTEMS

➢ RADAR

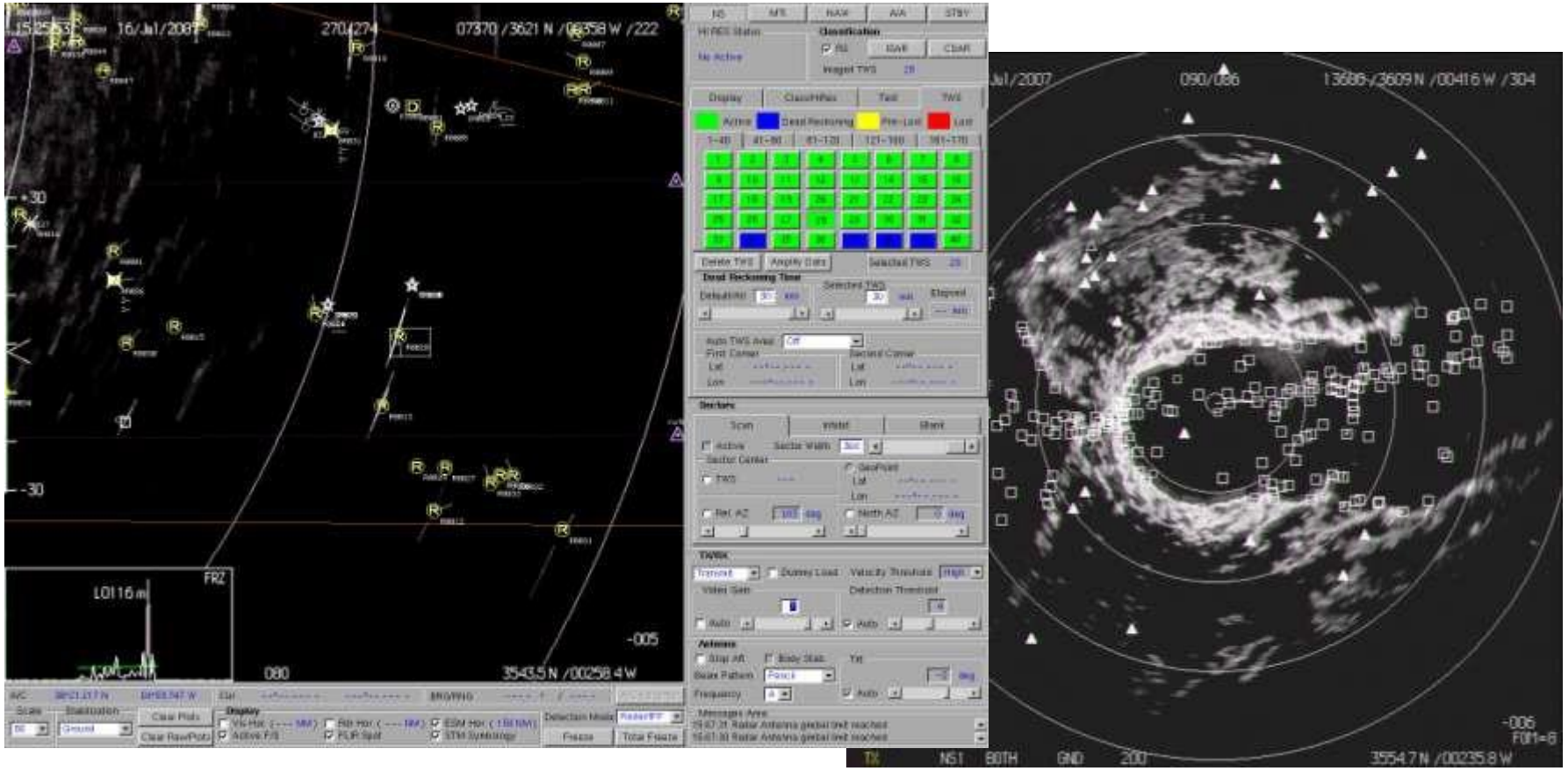
Modes

- Surface Search
  - Long Range Search (ASuW)
  - Short Range / Small targets detection (ASW)
- Air to Air
- MTI
- Imaging modes
  - Ground Mapping
  - Maritime targets classification: ISAR, Range Profile, CSAR
- Weather Avoidance
- DETECT AND AVOID (neither ISR nor ASW function, but extremely important)

ISR&ASW SYSTEMS

- **RADAR**

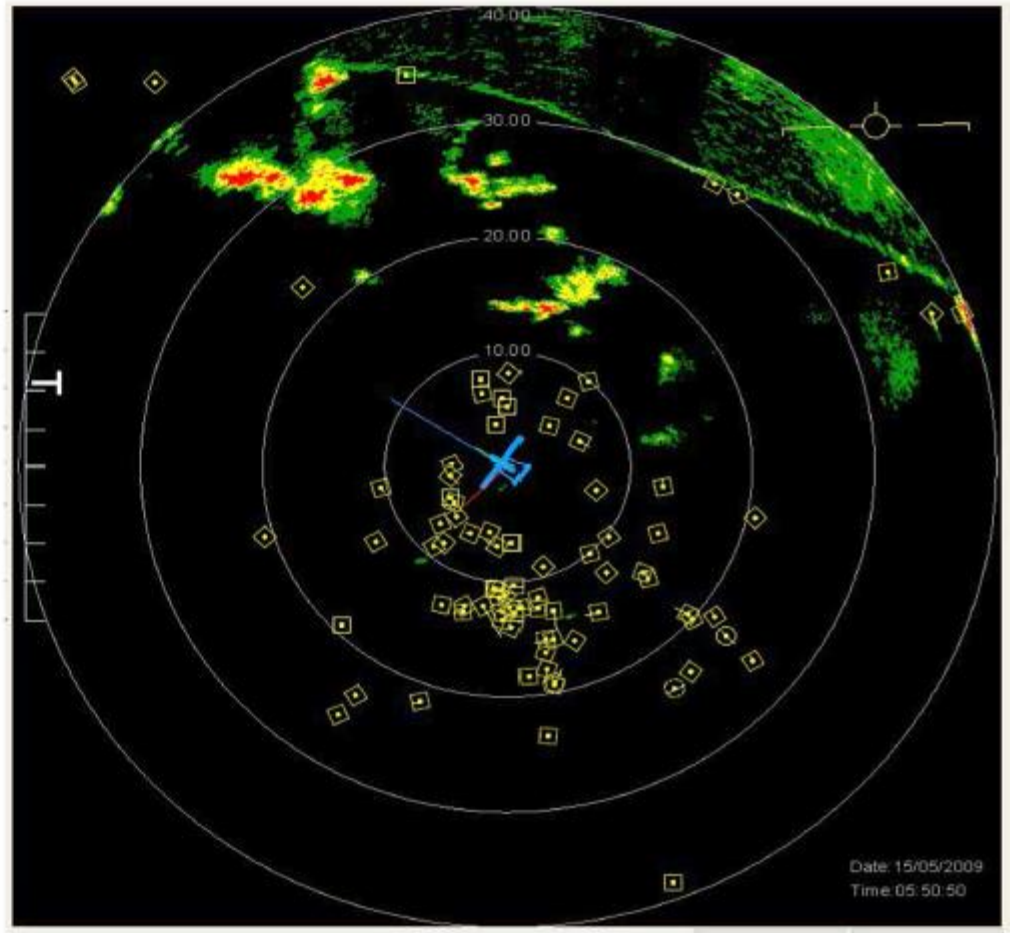
  Modes: Surface Search



ISR&ASW SYSTEMS

- **RADAR**

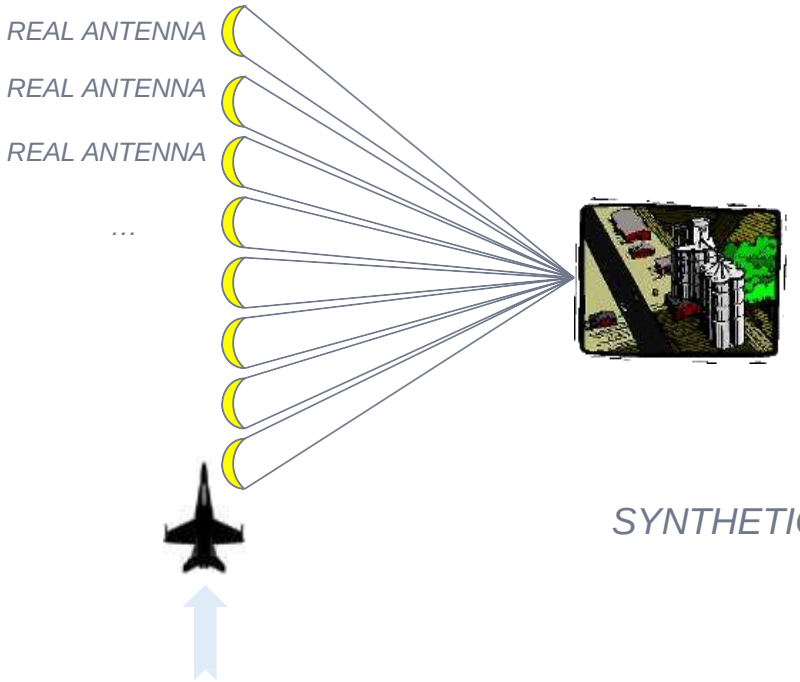
  Modes: Navigation & Weather

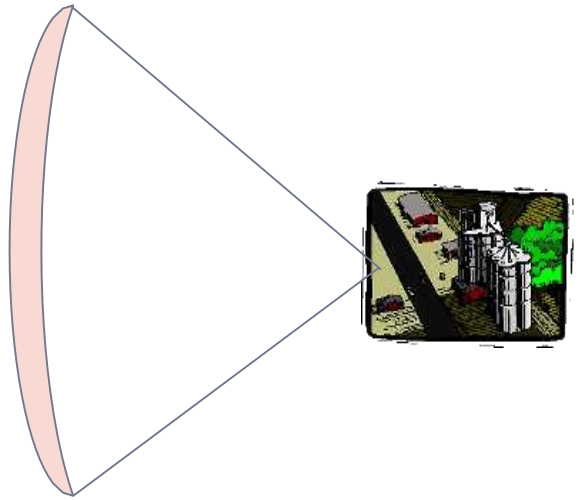


ISR&ASW SYSTEMS

- **RADAR**

  Modes: Synthetic Aperture Radar (SAR)





ISR&ASW SYSTEMS

- **RADAR – SAR Image**

ISR&ASW SYSTEMS

- **RADAR – SAR Image**

ISR&ASW SYSTEMS

- **RADAR – SAR Image**

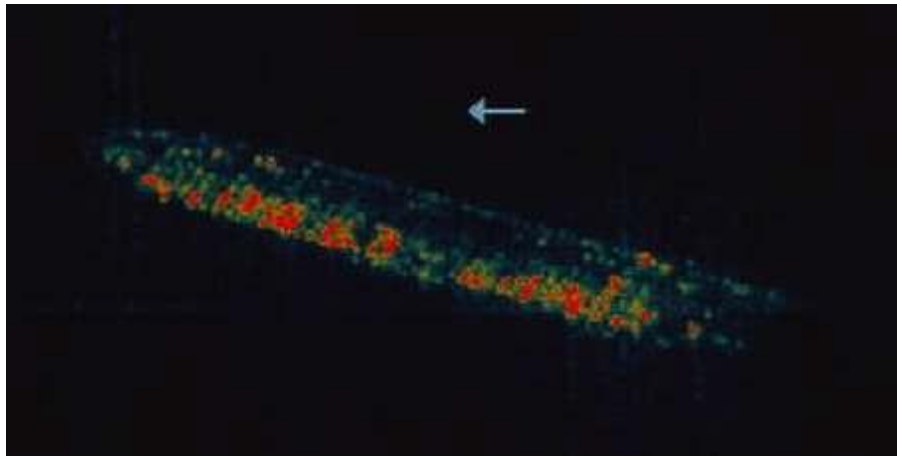
ISR&ASW SYSTEMS

- **RADAR – SAR Image**

ISR&ASW SYSTEMS

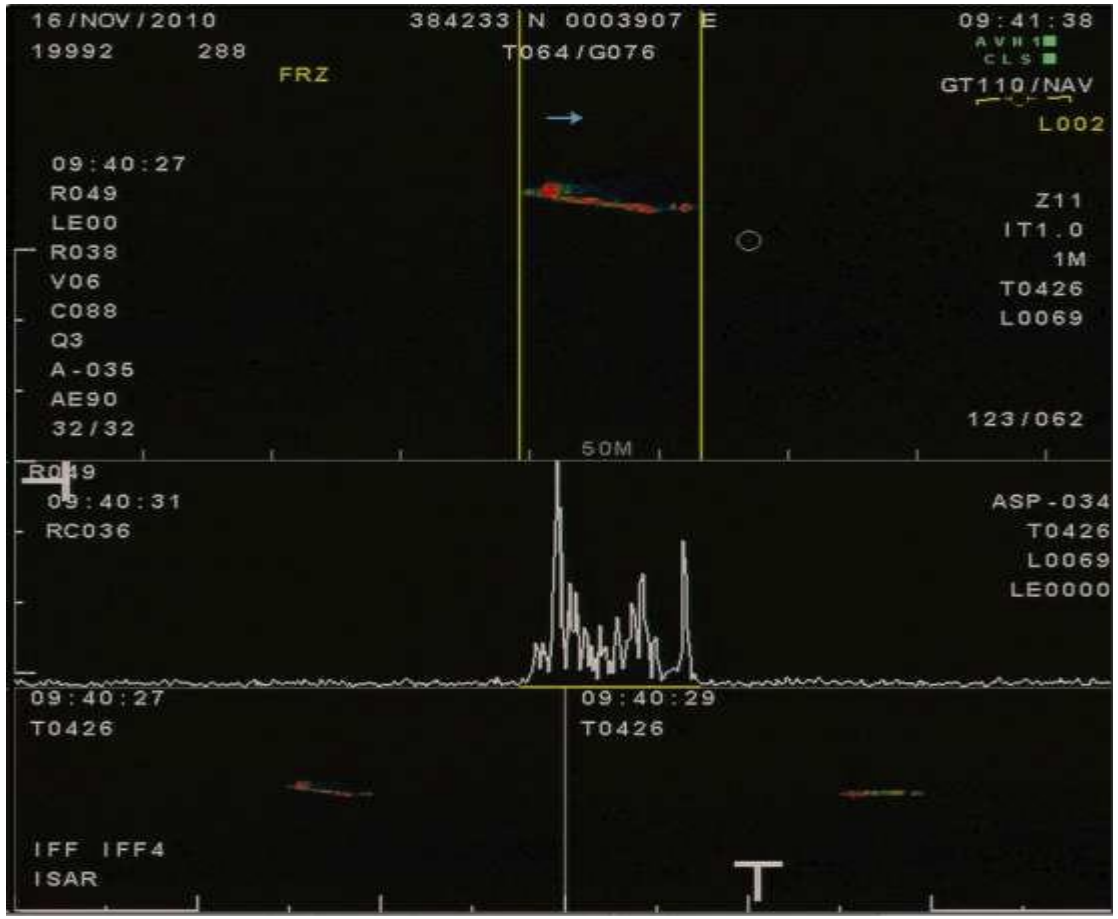
➢ RADAR – Isar Mode

- Ships / Surface targets classification
- Inverse SAR: Automatic plots extraction
  - Uses ships movement to obtain shape
  - High Sea States / small targets: optimum
  - only one dimension



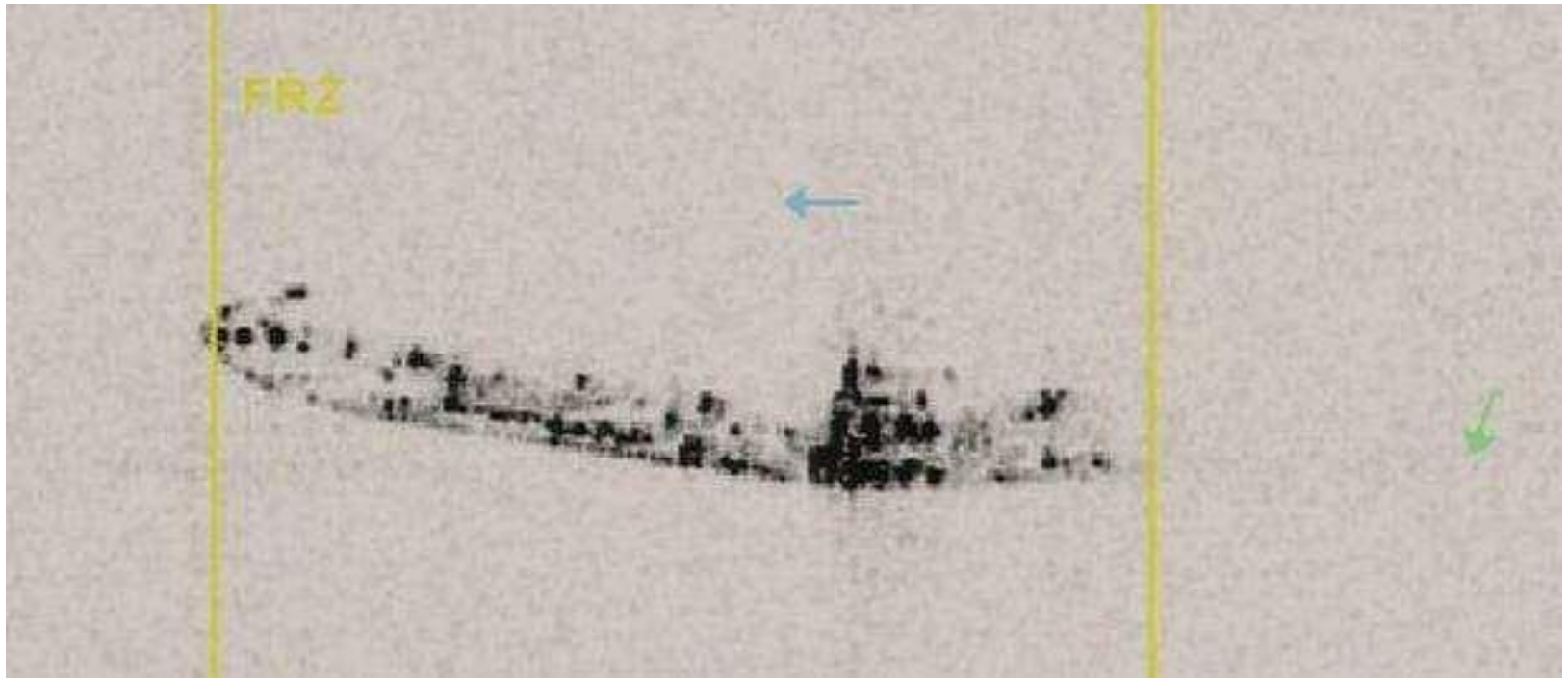
ISR&ASW SYSTEMS

- **RADAR – Isar Image**



ISR&ASW SYSTEMS

- **RADAR – Isar Image**

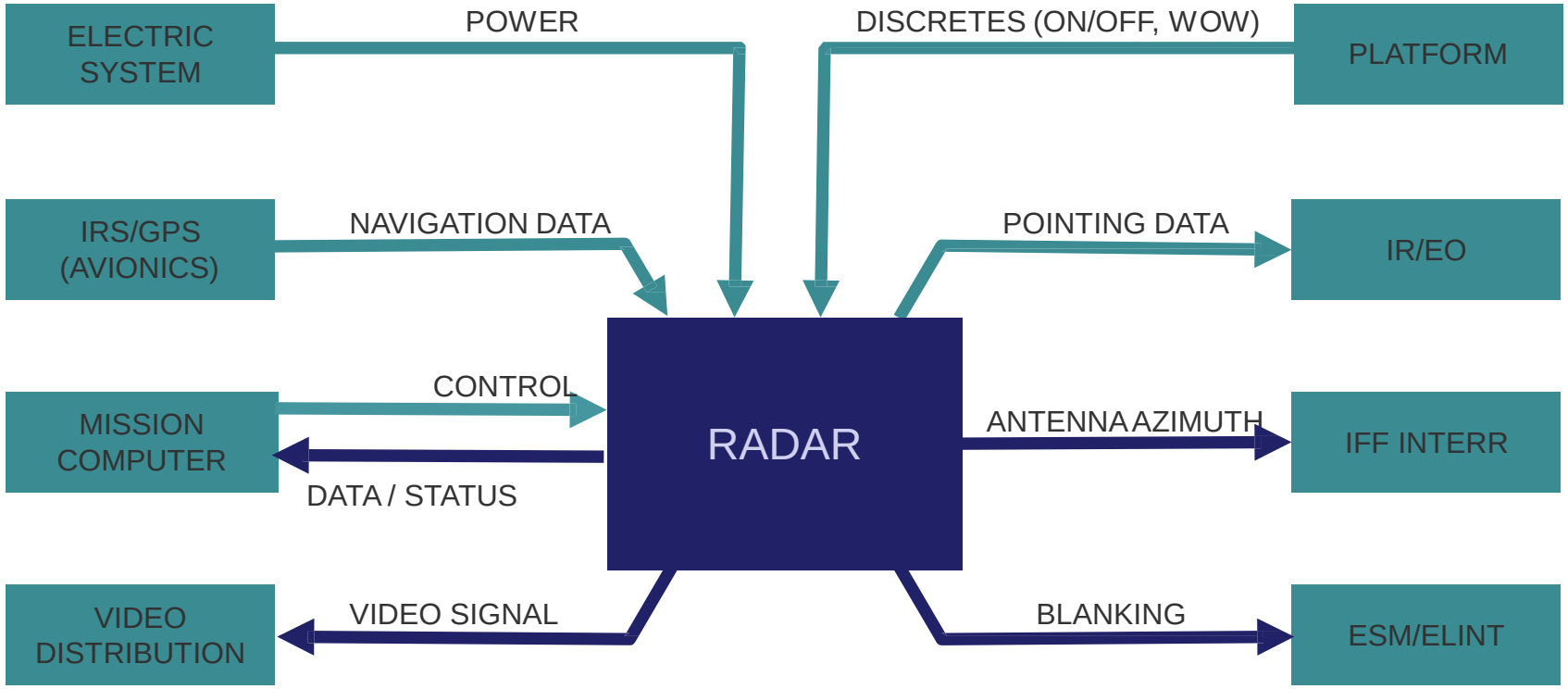


ISR&ASW SYSTEMS

- **RADAR – GMTI over SAR**

ISR&ASW SYSTEMS

➢ RADAR – External Interfaces



ISR&ASW SYSTEMS

- **RADAR**

Components / Equipment

- –Transmitter
- –Antenna
- –Receiver
- –Signal / Data Processor
- –RF Auxiliary

NOTE sometimes packing is different:

- Receiver + Transmitter = R/T

Or

- Signal Processor + Data Processor + Receiver = Radar Processor

ISR&ASW SYSTEMS

➢ RADAR

Transmitter

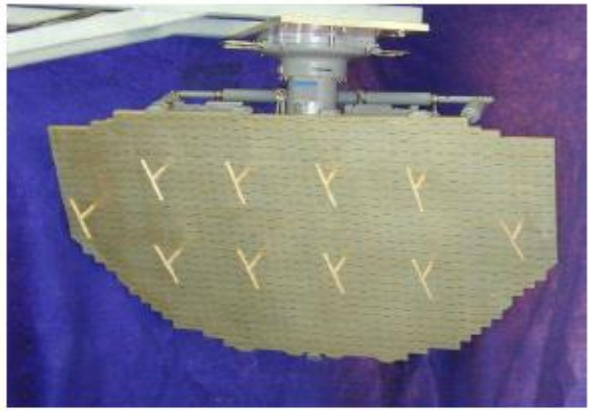
- RF pulse amplifier
- Based in Travelling Wave Tube (TWT)
- Highly coherent
- Big Power Consumer
- Most heat dissipating Radar unit: cooling!

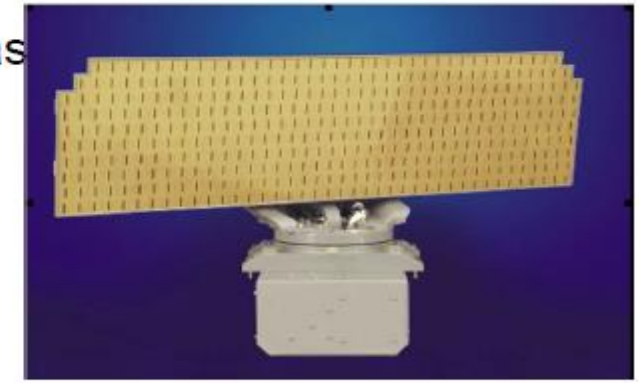
ISR&ASW SYSTEMS

➢ RADAR

Antenna

- Radiates energy into the air
- Elements:
  - Radiating element
  - Pedestal
  - Motors
  - Rotary joint
- Monopulse: AZ and / or EL channels to increas angular resolution





ISR&ASW SYSTEMS

➢ RADAR

Signal Processor

- Processes receiver output (A/D)
- Targets detection (CFAR)
- Image generation algorithms
- Sends target information / images to Data processor

ISR&ASW SYSTEMS

- **RADAR**

Mechanical Installation /LRU location

ISR&ASW SYSTEMS

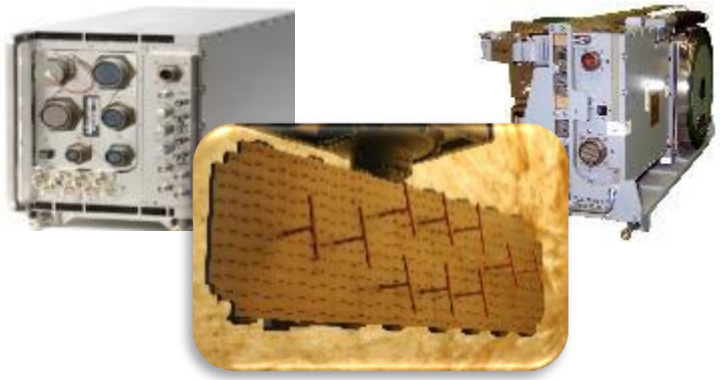
- **RADAR**

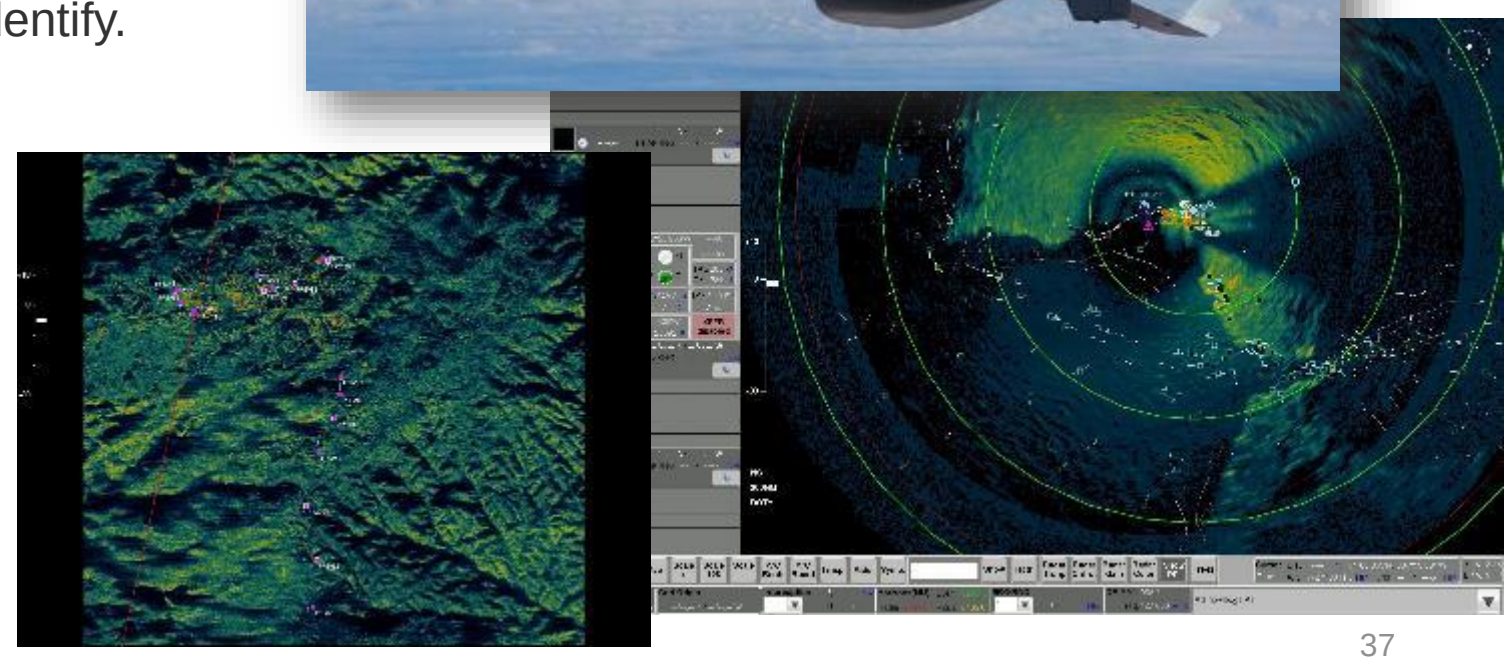
ISR&ASW SYSTEMS

Multimode RADAR

- Description
- Primary sensors for many missions.
- Ground and Sea Surface as well as Air-to-Air long range surveillance and detection capability.
- Imaging modes – Synthetic Aperture Radar (SAR) techniques.
- Allows the operator to detect, classify, identify.


MQ-9B Sea Guardian. *Picture General Atomics*





ISR&ASW SYSTEMS

➢ **EO/IR**

EO/IR Remote Sensing

EO: Electro Optical Sensors, are devices that sense light or light changes and ...
... convert them into imagery representation or
... extract information from them that is converted into data

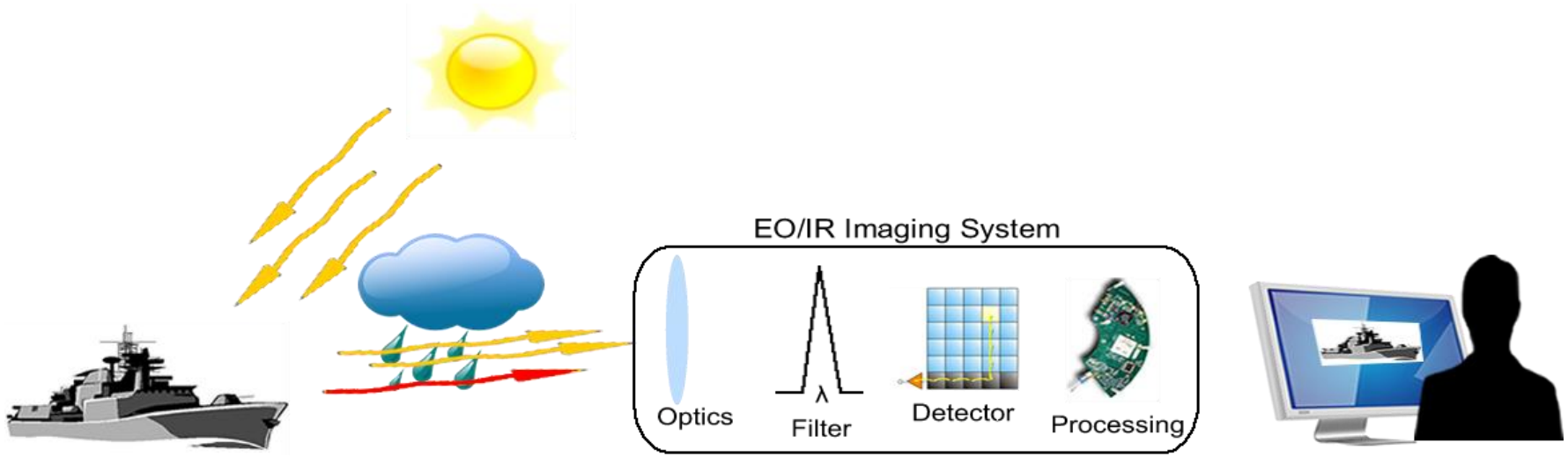
Light: Photons or electromagnetic radiation in the visible spectrum, expanded by the Infrared and Ultraviolet spectrum

Information: E.g. colour (wavelength(s)) and intensity (amplitude) at a direction (angular coordinates). Further data processing may filter clusters/patterns and conclude on their kinematics and identity

ISR&ASW SYSTEMS

➢ **EO/IR**

EO/IR Remote Sensing

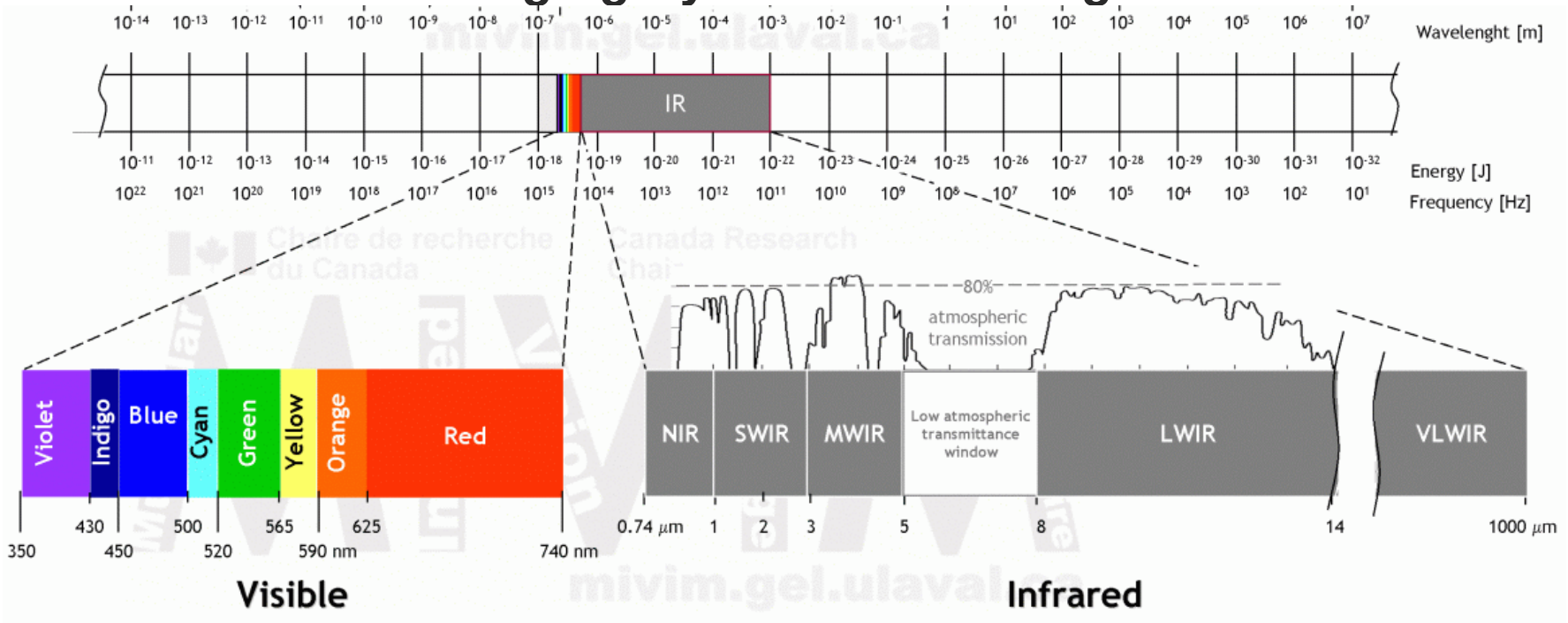


Target in background & clutter → Atmospherics → EO/IR Imaging System → Display System → Observer

ISR&ASW SYSTEMS

- **EO/IR**

EO/IR Imaging Systems Wavelength



1. **Reflection of incident radiation (Visible, NIR, SWIR (Short Wavelenght IR)**
2. **Emission by the own target because of its temperature(MWIR, LWIR)**

ISR&ASW SYSTEMS

➢ EO/IR

EO/IR Remote Sensing

- **NIR:** near infrared, de 0,74 a 1 μm, muy pegado al visible (se suele utilizer para tener mejor visibilidad en el ocaso)
- **SWIR**: longitud de onda de 0,9 a 1,7 μm principalmente, auqnue puede abarcar de 1 a 3. Se utilizan para capturar imágenes a través de humo, niebla y neblina (única longitude de onda capaz de penetrarla)
- **MWIR**: longitud de onda de 3 a 5 μm. Se utilizan para detector ciertos gases (metano, propano, etanol, etc), por lo que son de gran utilidad en drones para vigilar determinadas maquinarias o infraestructuras
- **LWIR**: longitud de onda de 8 a 14 μm. Se utilizan cuando se quiere hacer inspección de temperatura

ISR&ASW SYSTEMS

➢ **EO/IR - Equipment**

- **Turret**
- **Control Processor/Electronics Unit**
- **Operator Input Devices**

ISR&ASW SYSTEMS

➢ EO/IR - Equipment

Turret

- ❑Houses EO/IR optical sensors
- ❑IMU may mounted onto optical bench
- ❑Functions:
  - ▪Shields sensors from environment (hermetically sealed)
  - •Provides pointing in azimuth and elevation
  - ▪Provides stabilization to preserve sensor fidelity

ISR&ASW SYSTEMS

➢ EO/IR - Equipment

Control Processor/Electronics Units

- Central connection point for all system LRUs and interface to external equipment.
- Power input for the whole system (28VDC)
- Contains:
  - Main processor
  - Video processing cards
  - Interface Cards
  - AVT Card (autotracker)
  - GPS Receiver

ISR&ASW SYSTEMS

➢ EO/IR - Equipment

Control Processor/Electronics Units

- Integration advances makes possible to include this components into the turret

Control Processor

AVT

GPS Rx

IR Video Processor

ISR&ASW SYSTEMS

➢ EO/IR - Equipment

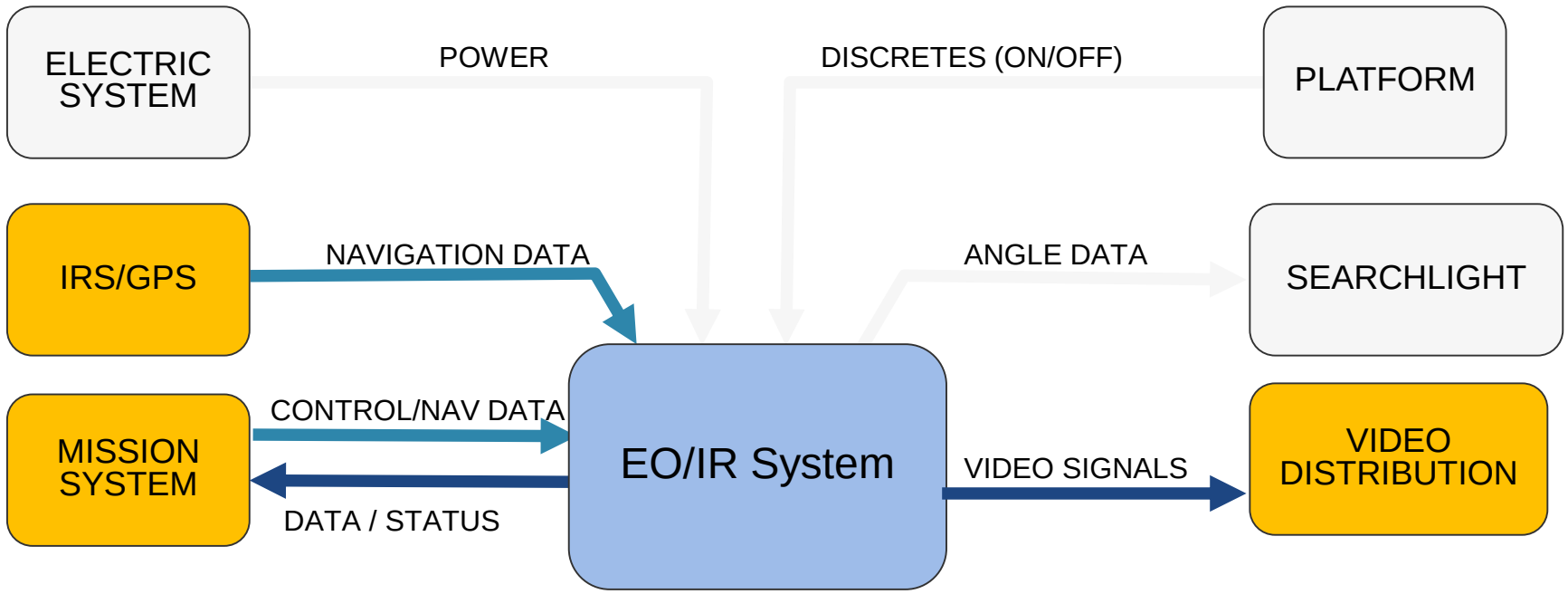
Operator Control Device

- Slew transducer to allow gimbal steering
- Field of View, mode of operation, sensor selection,...

ISR&ASW SYSTEMS

➢ EO/IR - Architecture

Basic EO/IR Architecture – External interfaces



ISR&ASW SYSTEMS

➢ EO/IR - Equipment

ISR&ASW SYSTEMS

➢ EO/IR - Equipment

ISR&ASW SYSTEMS

- **EO/IR - Equipment**

ISR&ASW SYSTEMS

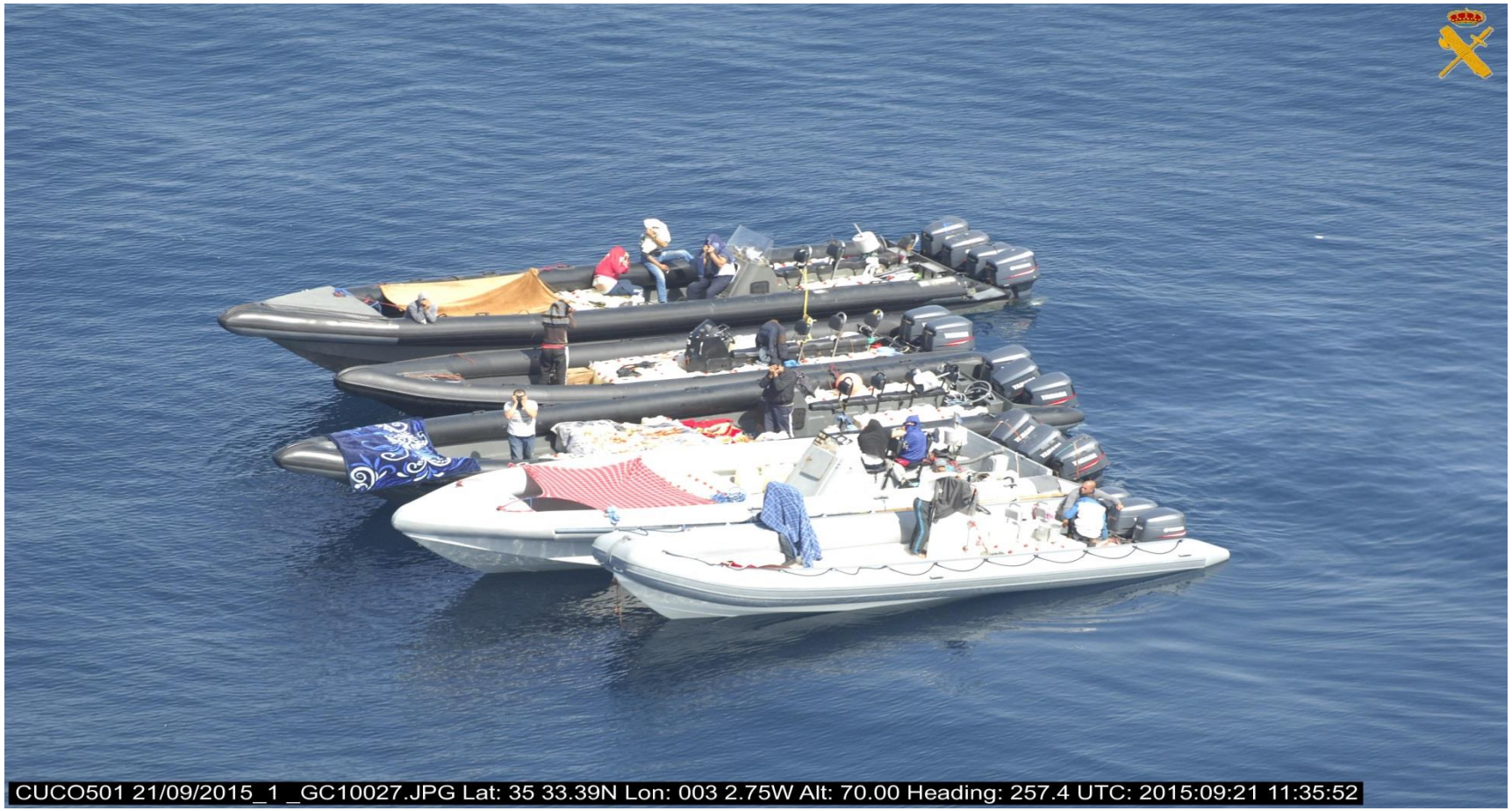
- **EO/IR - Equipment**

ISR&ASW SYSTEMS

- **EO/IR - Equipment**

ISR&ASW SYSTEMS

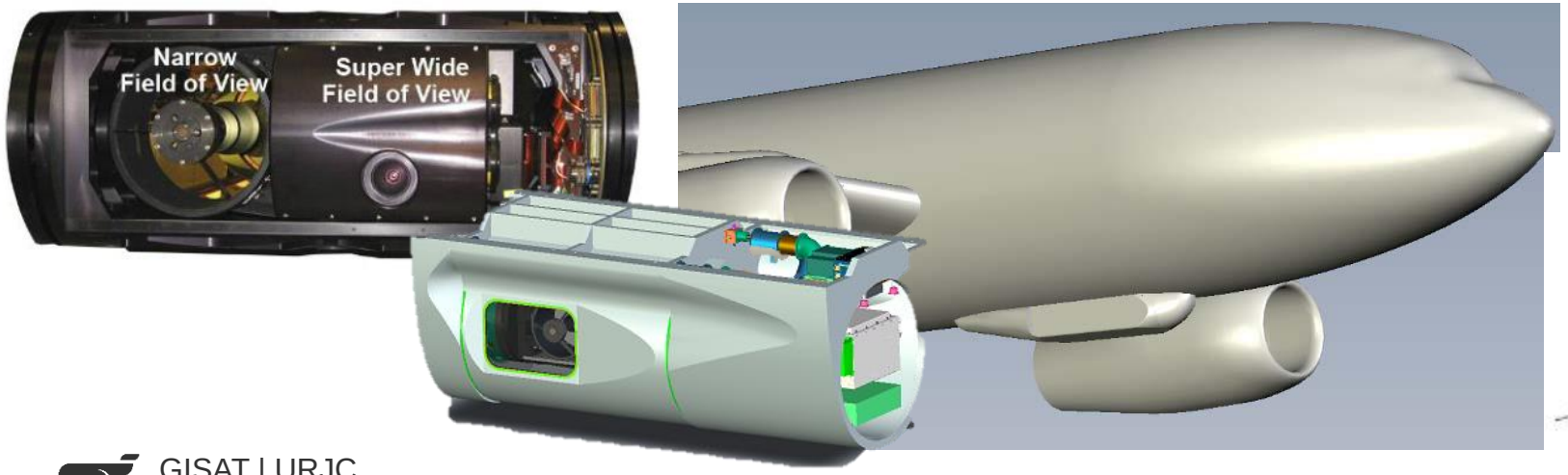
- **EO/IR - Equipment**

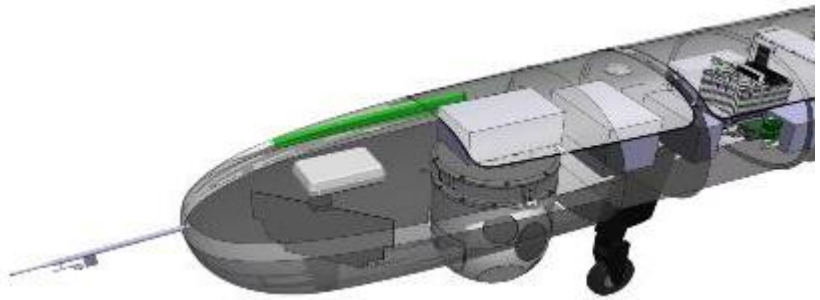


ISR&ASW SYSTEMS

EO/IR Imaging Systems

- Description
- Provides multi-spectral video or imagery (LWIR or MWIR, SWIR, NIR and Visible).
- Allows the operator to detect, classify, identify and track a target.
- Basic ISR general sensor, applies to multiple missions





ISR&ASW SYSTEMS

ESM/ELINT

- Description
- Provides capability to detect and analyse RADAR emitters in an specific frequency band. (Typically 2 GHz to 18 GHz, optional 0,5 GHz to 2 GHz and 18GHz to 40 GHz)
- Capability to intercept, track, analyse, geolocate and identify RF emissions.
- Capability to record track information, pulse and audio at operator's request during the mission to be deeper analysed on ground after the flight.

- Capability of real time on-board intrapulse analysis.
- Capacity of audio alarm (upon threat detection) and audio track.
- Self-protection of the platform through Radar Warning function and integration with the countermeasure systems (Chaff & Flares, MAWS).

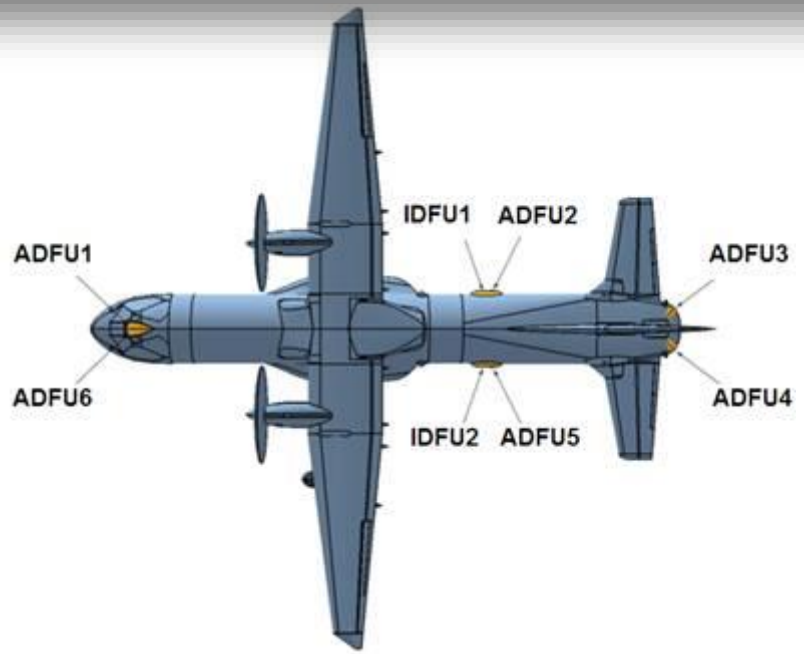
Heron RPAS with ELINT antenna suite. *Photo IAI's website*

ISR&ASW SYSTEMS

ESM/ELINT

Installation

- ESM systems deal with specific installation constrains due to the nature of the high frequency signals processed. These constraints affect the installation of the equipment in the aircraft: antennae/radome installation, distance and RF signal wiring (length, routing/bending).
- Antenna installation:
  - ✓ Line of sight free of obstacles in elevation (Typically +/- 60º or +/- 90º)
  - ✓ Line of sight free of obstacles in azimuth (Typically 150º, but 180º desirable)
  - ✓ Antennae spaced each 60º



ISR&ASW SYSTEMS

ESM/ELINT

Hot Topics

- Other systems on the aircraft (own systems) operating in the ESM band will cause false detections and saturation (even damage) on the aircraft ESM.
  - ✓ Blanking signals: Radar Altimeter; IFF; CIT; Search Radar…/
  - ✓ Antenna relocation
  - ✓ Filters
- Need for Calibration procedures:
  - ✓ GROUND: Installation on the aircraft → Dedicated ground test (adjustments if necessary)
  - ✓ FLIGHT: Specific flight test. Data gathering and analysis. Known emmitters

ISR&ASW SYSTEMS

ESM/ELINT

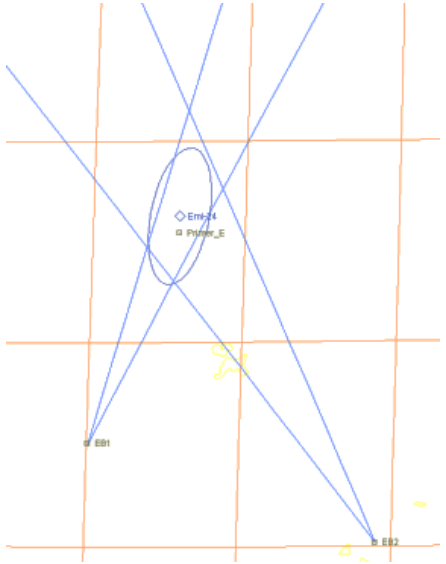
Hot Topics

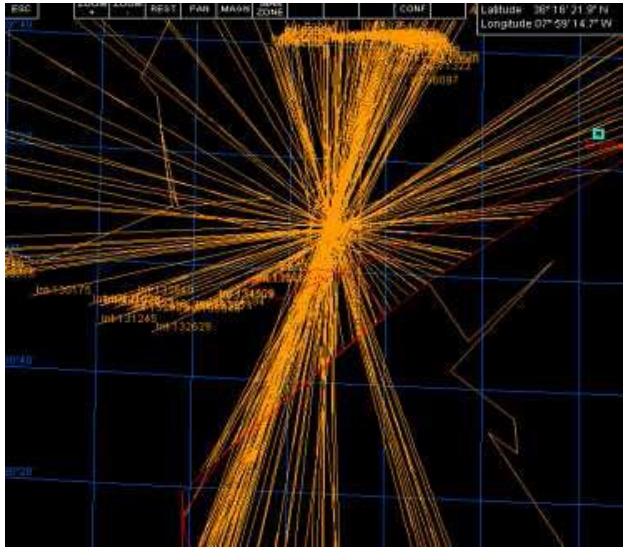
System's performance qualification

– Geolocation Accuracy:

- To have a good geolocalization it is required a rectilinear and levelled flight.
- It is necessary as well to have Known position Radars
- The more quantity of information the better geolocalization

For a Radar at 80NM, the ellipse mayor radius could have around 10 Km

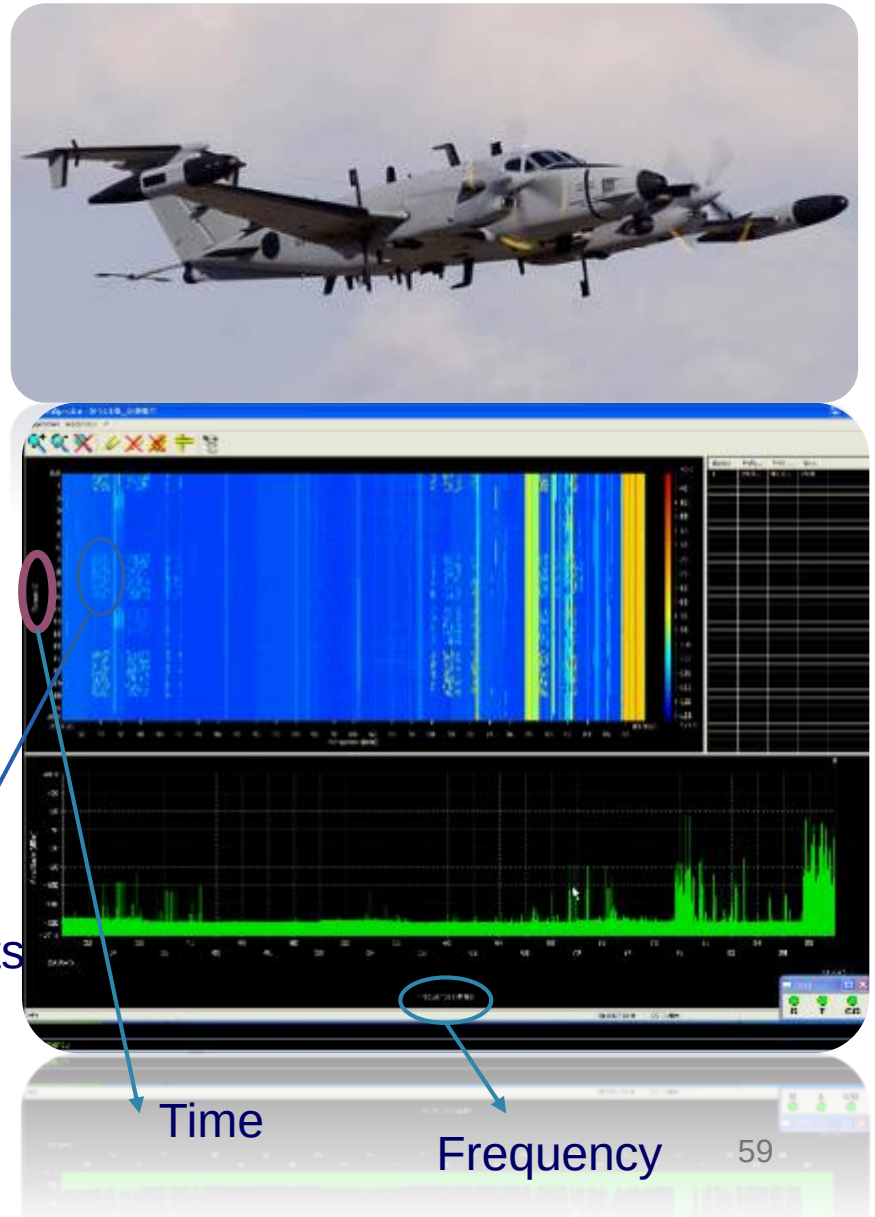




ISR&ASW SYSTEMS

COMINT

- Description
- COMINT stands for Communication Intelligence
- The system main task is the intelligence-gathering of communications by interception of radiofrequency signals
- The primary functions of COMINT Systems are:
  - ✓ Search and Interception of the communications
  - ✓ Direction Finding (DF) and geolocalization of the emitter
  - ✓ Building EOB-including all nets and emitters
  - ✓ Signal Analysis
  - ✓ Monitoring of the communications
  - ✓ Recording of the signals detected to perform on ground analysis
- Performance linked to installation complexity and flight profile



ISR&ASW SYSTEMS

COMINT

Installation

- COMINT processors and servers are installed in avionics racks
- COMINT antennae are the critical element to achieve good DF performances in signal detection, installed at the same horizontal plane
- The covered RF band and the accuracy of the Angle of Arrival (AoA) determine the shape and size of the interferometric array
- Typical communication frequency signals detected by COMINT systems are included in the band from 20 MHz to 3 GHz (opt. 2 MHz to 20 MHz), that is approximately signals with wavelength from 150 cm to 10 cm. Wavelength values are relevant as the AoA accuracy is directly related to the aperture of the COMINT antenna array. The array aperture has to cover 1 or several times the wavelength of the interesting signals
- Covering different frequency bands implies different arrays, each one with the appropriate aperture
- The antennae of the array are placed at different relatives positions in order to cover the different wavelengths included in the frequency band

Complex system – High Perf

Simple system – Lower Pe

ISR&ASW SYSTEMS

COMINT

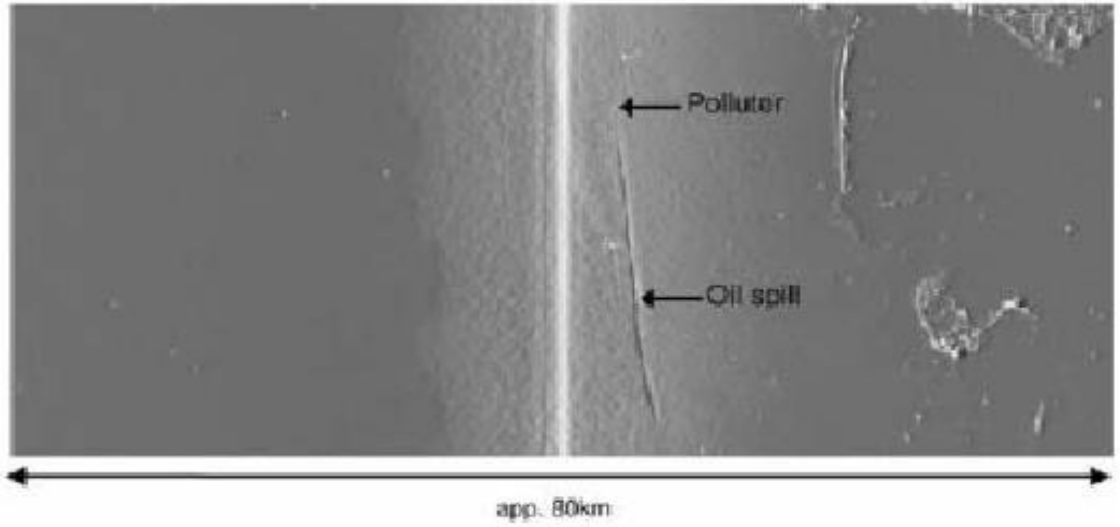
Hot Topics

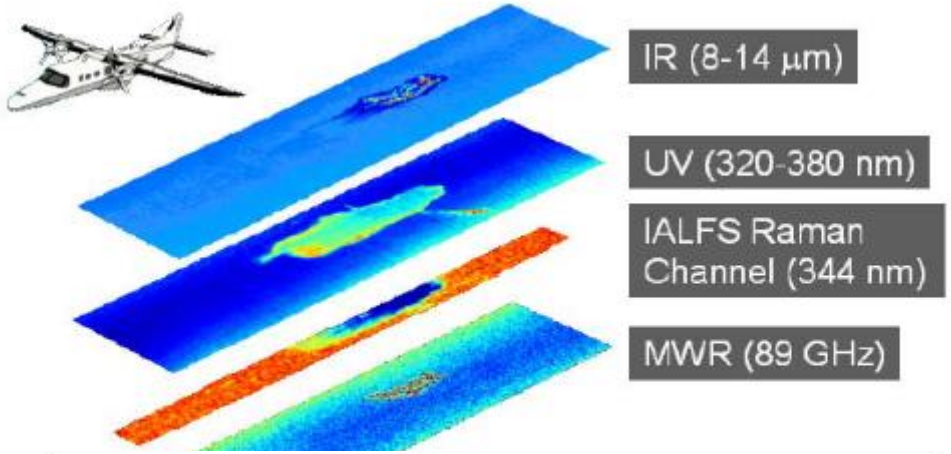
- Antennae location
- Other systems on the aircraft (own systems) operating in the COMINT band will cause false detections and saturation on the aircraft COMINT: Search Radar, IFF interrogator, VUHF radios, DME, WBDL, TCAS, LINK16…
- System's performance qualification:
  - Suppliers only commits the performances demonstrated at lab level
  - Customer requires the performances to be demonstrated at aircraft level and in operational conditions
  - It is difficult to achieve a controlled environment for performance evaluation
  - Needs collaborative emitter stations (i.e. from national armies/air forces)
  - Calibration Flights might be needed if calibration on ground not enough. Require specific support equipment and administrative authorization (use of spectrum)

ISR&ASW SYSTEMS

Sea Pollution Sensors

- Description
- A Sea Pollution Detection System consists on a combination of short and long range sensors intended for the detection, recording and analysis of maritime pollution data.
- These systems, together with a tactical system monitoring the maritime traffic, enables the offensing vessel identification, and therefore, reports generation to be used in a legal way against it.





ISR&ASW SYSTEMS

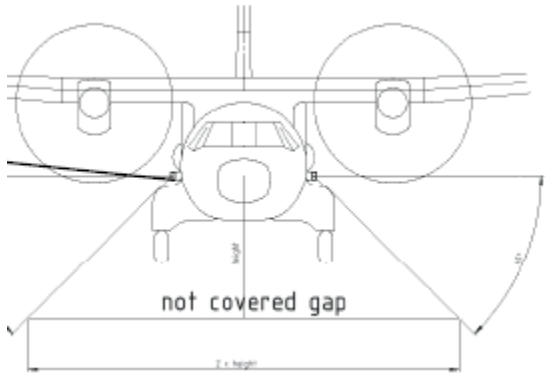
Sea Pollution Detection Systems

- **For pollution agents Detection and Identification Long Range Sensors**:
  - ✓ SLAR: Side Looking Airborne Radar
  - ✓ SAR (Synthetic Aperture Radar) Imaging modes
  - ✓ SAR images from satellite
- **For Sizing (area, thickness, volume) and pollution agents Classification Short Range Sensors**:
  - ✓ IR/UV Line Scanner
  - ✓ VIS: Visual Scanner
  - ✓ MWR: Microwaves Scanner
  - ✓ IALFS: Imaging Laser FluoroSensor
  - ✓ LFSL: Laser FluoroSensor Light
- **For data Processing, Analysis, Presentation and Storage**:
  - ✓ Operation Central Unit
  - ✓ Ground Station

	SLAR	IR	UV	MWR	IALFS	LFS
Alcance	20NM a cada lado	2 x altura de vuelo			0.5 x altura de vuelo.	N/A
Clasificación de contaminantes	NO				SI	
Sensible a los espesores	N/A	>2µm	>0,1µm	50µm to 2.5mm	0,1µm to 20µm	
Resolución espacial	37.7m en alcance y 75m en rumbo	3.5m		>5m	10m píxel a píxel	N/A
Detección de contaminate bajo el agua	NO				SI	
Operable por la noche	SI	SI	NO	SI		
Medida de espesores	NO			50µm to 2.5mm	0,1µm to 20µm	
Inhabilitado por meteorología		Nubes			Nubes	

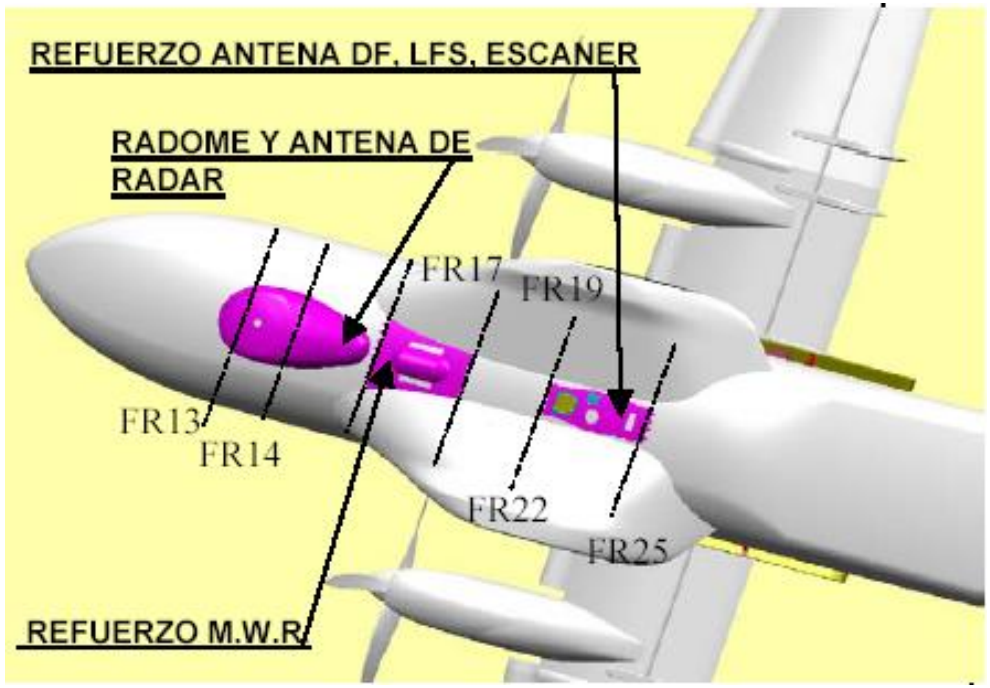
ISR&ASW SYSTEMS

Sea Pollution Detection Systems



Installation of the Main Sensors

- SLAR
  - ✓ Transponder is installed in avionics racks
  - ✓ Antennae: one at each side of fuselage, simetrically o just one in the simetry axis of the aircraft; upper side os the antenna during horizontal flight must be as horizontal as possible
- Scanners
  - ✓ Control unit is installed in avionics racks or under floor
  - ✓ Scan Head: allocated in the bottom side of the fuselage where a window shall be opened (protected by a door to prevent the glass from damages during take off and landing) which shall allow the vision field required by the sensor (90º) perpendicular to flight direction, centered with simetry aircraft axis



ISR&ASW SYSTEMS

Sea Pollution Detection Systems

Hot Topics

- May need to spill vegetable oil in the sea to demonstrate system performance
- Difficult test to accomplish, vegetable oil disappears very quickly
- Collaboration with local agencies fighting sea pollution.
- Can be verified to some extent using targets of opportunity

ISR&ASW SYSTEMS

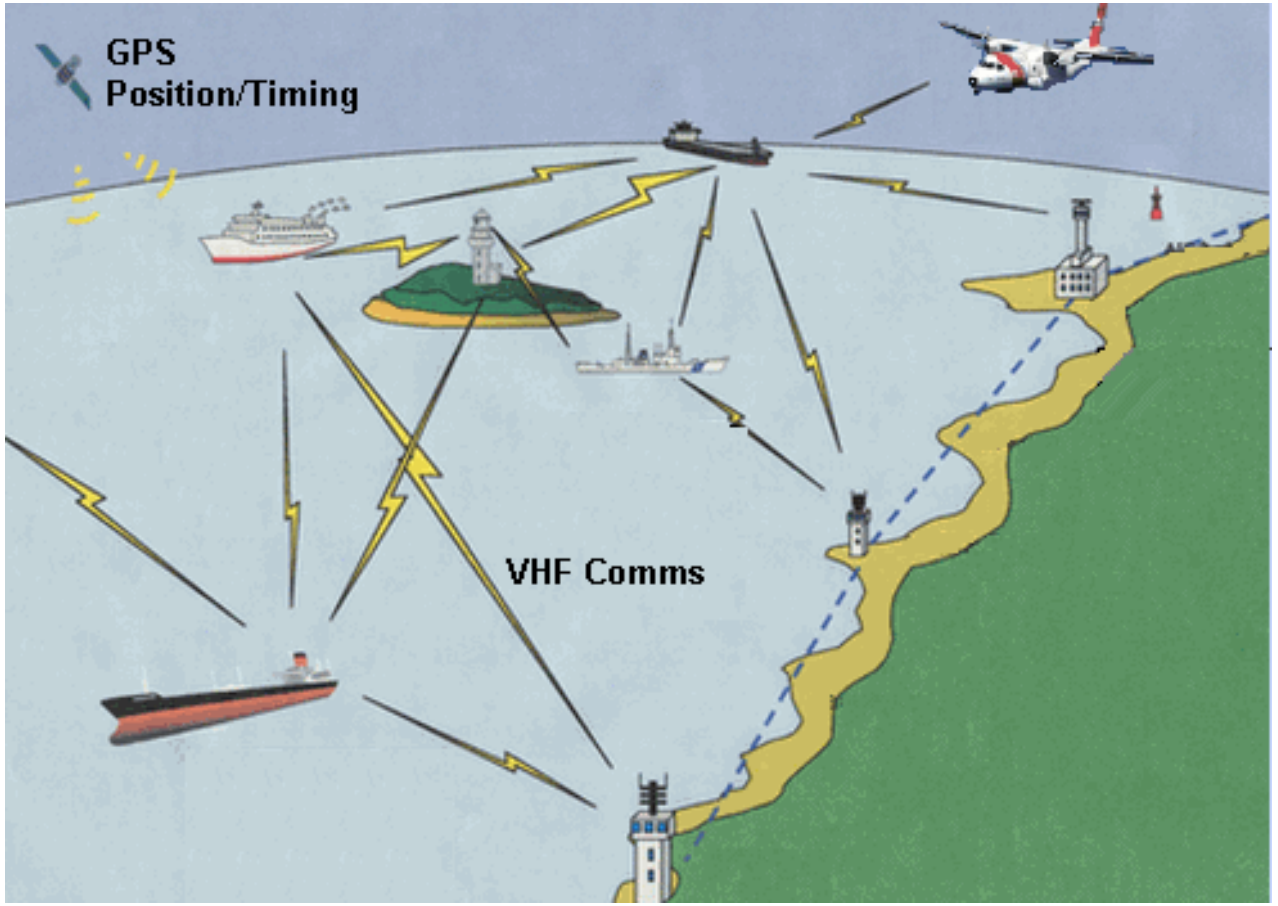
➢ AIS - Definition

What is the Automatic Identification System (AIS)?

- An AIS transponder determines its own position, speed and course using a built in GPS receiver.
- This information is combined with other important navigation information and automatically communicated between AIS equipped targets without any user interaction.
- AIS data exchange is over VHF radio frequencies.
- AIS transponder can be installed on ships, airborne and shore stations.
- AIS transponder supplied by SAAB.

ISR&ASW SYSTEMS

- **AIS - Conops**



ISR&ASW SYSTEMS

➢ AIS - Conops

AIS identifies AIS fitted targets…

…and what happens if not all ships have AIS or some that have AIS have it turned off?

The International Maritime Organization's International Convention for *the Safety of Life at Sea* (SOLAS) requires AIS to be fitted aboard:

- All ships with gross tonnage (GT) of 300 or more tons enganged in international voyages
- All ships with gross tonnage (GT) of 500 or more tons not engaged in international voyages.
- Passenger ships regardless of size.

Additionally, a number of other countries have started AIS mandate programs which require large numbers of vessels to fit an AIS device for safety and national security purposes, including its use on boats.

ISR&ASW SYSTEMS

➢ AIS - Conops

What is the AIS used for?

- AIS was developed to identify and locate targets providing extra precise information that can be used in **collision avoidance**.

- **Traffic Services**: In busy waters, AIS provides additional traffic awareness and information about the configuration and movements of targets.

- **Maritime Security**: AIS data fused with radar systems allows the authorities to differentiate between targets more easily.

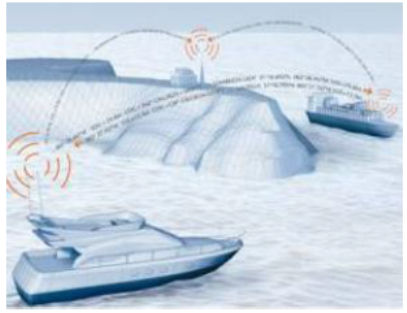
- **Search and Rescue:** AIS can provide data on the position and navigation status of other targets in the vicinity. AIS can enhance awareness of available resources.

- **Accident investigation:** AIS provides accurate data on time, identity, GPS-based position, heading, COG, speed, etc. rather than the less accurate information provided by radar.

ISR&ASW SYSTEMS

➢ AIS - Conops

AIS information **supplements RADAR,** enhancing a RADAR picture when used together:



- ➢ AIS detects equipped targets in situations where the RADAR detection is limited (poor weather conditions).
- ➢ RADAR does not depend on signal transmissions from targets.
- ➢ VHF radio signals 'see around the corner' giving better coverage than RADAR.
- ➢ AIS not only locates but identifies targets, providing extra information.
- ➢ Discrimination of targets: AIS targets not mistaken for waves, rocks…
- ➢ AIS low power consumption

RADAR LRU	115 V 400Hz	28VDC (W)
	Consumption (VA)	Consumption (W)
AP	200	280
RT	1725	28
SP	517.5	N/A

AIS LRU		28VDC (W)
		Consumption (W)
AIS Transponder	TX-On	70
	TX-Off	17
GPS Antenna		From AIS Transponder
VHF Antenna		N/A

ISR&ASW SYSTEMS

➢ AIS - Conops

AIS Report data:

- MMSI
- Navigational Status
- Rate of Turn
- Speed over Ground (SOG)
- Position
- Course over Ground (COG)
- True Heading
- IMO Number
- Category

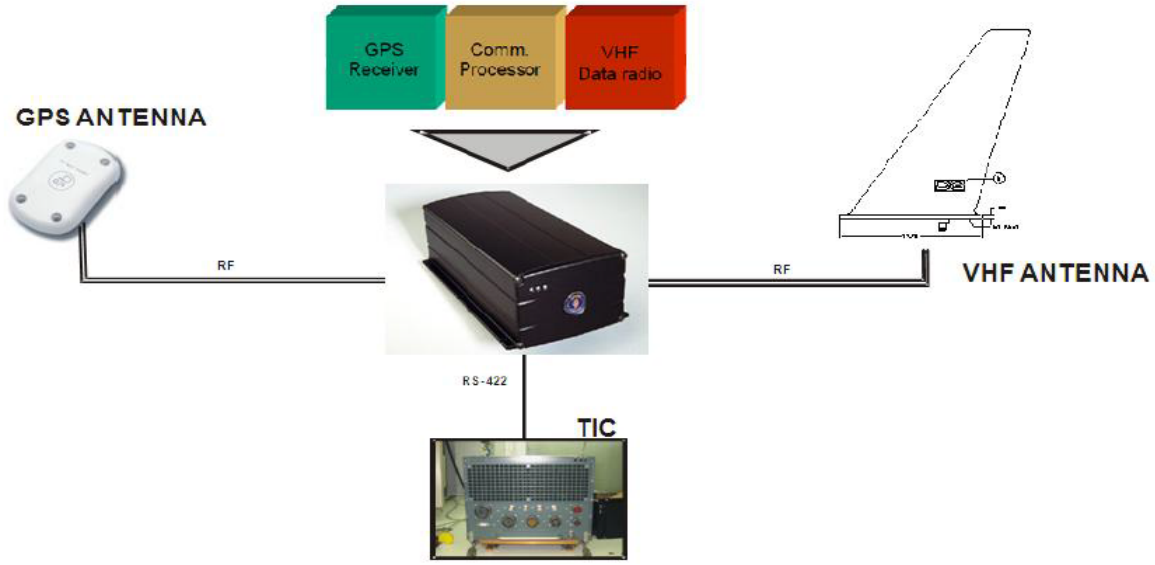
- Ship's Name
- Type of Ship
- Dimensions
- Type of position fixing device
- Draught of ship
- Destination
- Call Sign
- Estimated Time of Arrival
- Nationality

ISR&ASW SYSTEMS

➢ AIS - Architecture

Airborne AIS System Composition

- AIS System is composed by 3 LRUs:
  - R4A Transponder (SAAB TransponderTech)
  - VHF Antenna (DAYTON GRANGER, INC)
  - GPS Antenna (AEROANTENNA)

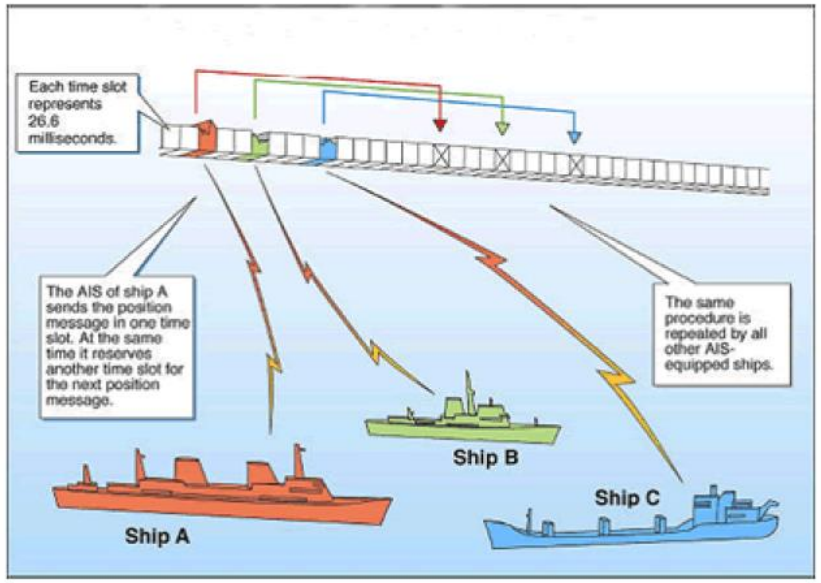


ISR&ASW SYSTEMS

➢ AIS - Architecture

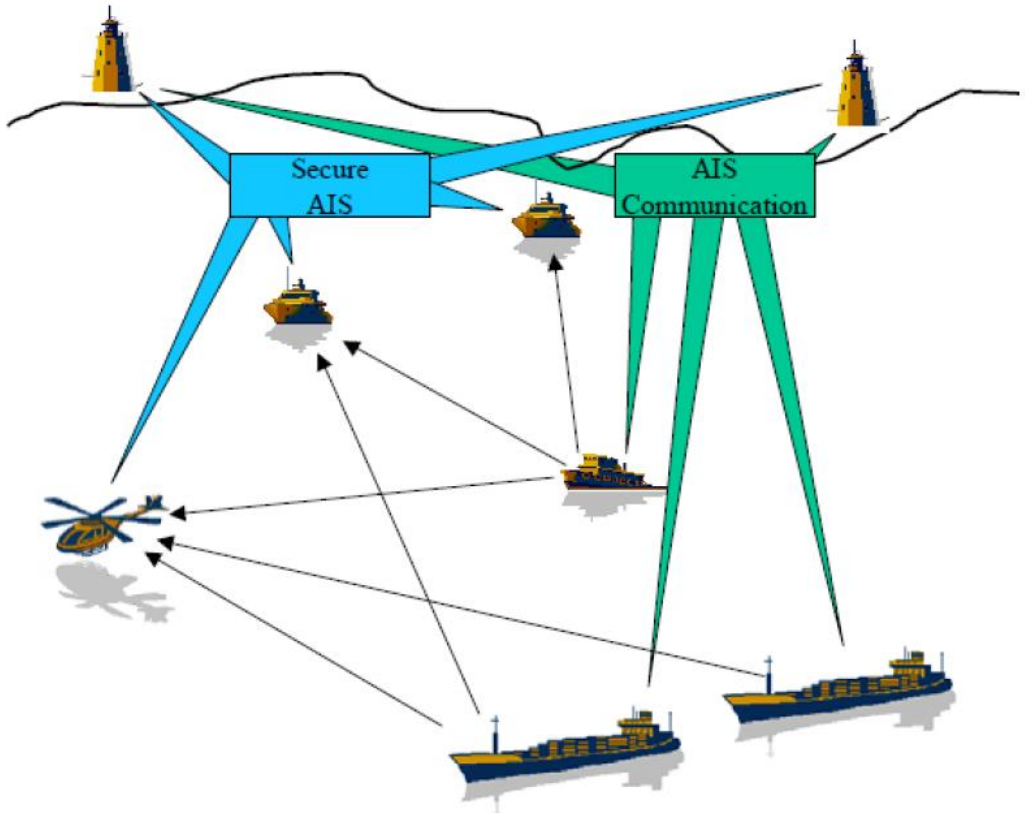
- Global Positioning System (GPS) receiver: This subsystem handles the navigation and timing accuracy of the system.

- Communication Processor: This subsystem handles all protocols and external interfaces used. It controls the slot allocation for the transponder transmissions.



ISR&ASW SYSTEMS

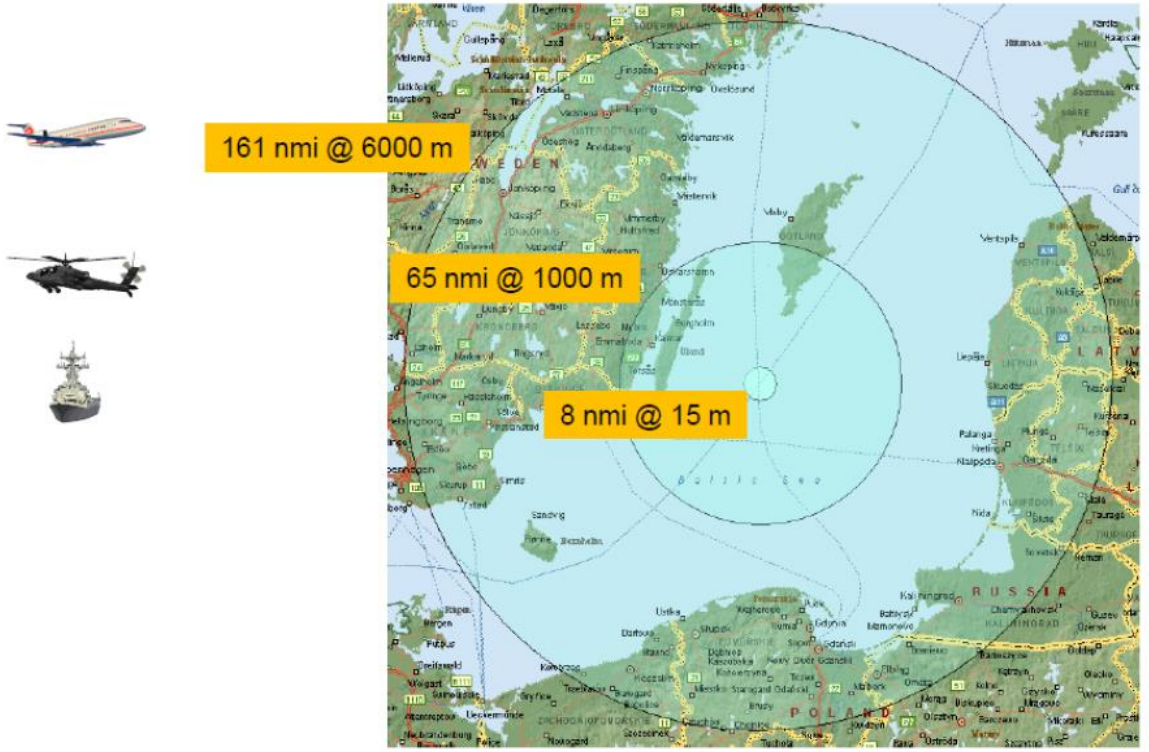
- **AIS – Secure AIS**



ISR&ASW SYSTEMS

➢ AIS – Range of Use

Range Extension (Line of sight)



isr&ASW SYSTEMS

- **Acoustic System**

*Una aeronave se considera **ASW** cuando tiene como principal misión detectar, localizar, seguir, clasificar* y en su caso dañar o destruir submarinos enemigos.

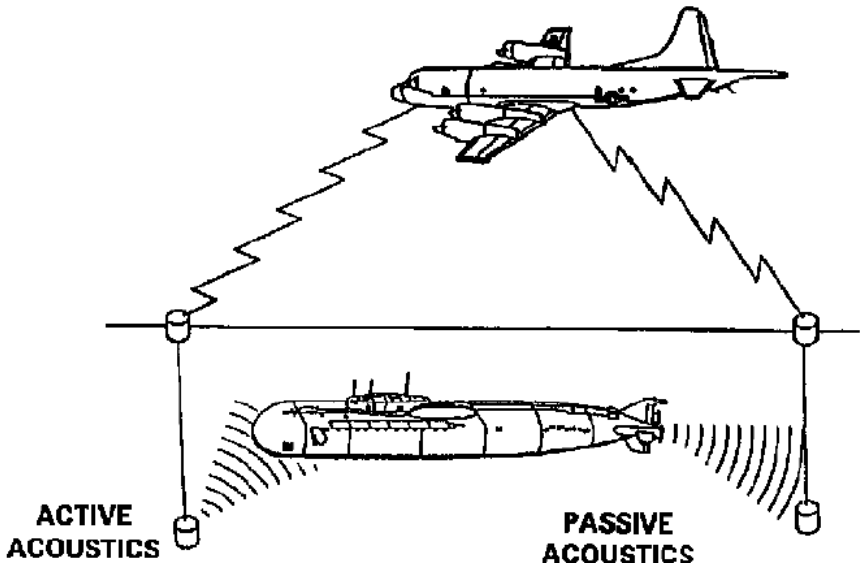
Los sistemas acústicos embarcados se encargan de las cuatro primeras tareas,… dejando las dos últimas a “otros” sistemas.

isr&ASW SYSTEMS

➢ Acoustic System

El sistema acústico es un sistema que utiliza la señal recibida por unos elementos desplegados en el agua y encargados de enviar al avión el audio detectado (dentro del agua) .

Dichos elementos se conocen como “Sonoboyas”.



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➢ Acoustic System

Conocimientos Fundamentales

1. Sonoboyas

2. Comportamiento del medio

3. Tecnología Embarcada.

4. Características de los objetos de interés.

isr&ASW SYSTEMS

➢ Acoustic System

La tecnología embarcada en un Sistema ACUSTICO se compone de los siguientes elementos

- Antenas de recepción.
- Receptor de sonoboyas.
- Sistema Procesador de Señal.
- Sistema de almacenamiento de Datos acústicos.
- Transceptor de emisión de pulsos para sonoboyas activas.
- Antena de emisión de comandos (DICASS/CFS).

isr&ASW SYSTEMS

➢ Acoustic System

- Un sistema acústico tiene que realizar las siguientes funciones para poder realizar su misión.
  - Recibir la señal desplegada por las sonoboyas –Conjunto Receptor
  - Procesar dicha señal- Conjunto Procesador
  - Comandar las sonoboyas desplegadas
  - Grabar señales acústicas.

isr&ASW SYSTEMS

- **Acoustic System**

isr&ASW SYSTEMS

- **Acoustic System**

The MQ-9A flying with the pneumatic sonobuoy dispenser system during the demonstration. (Photo: GA-ASI)

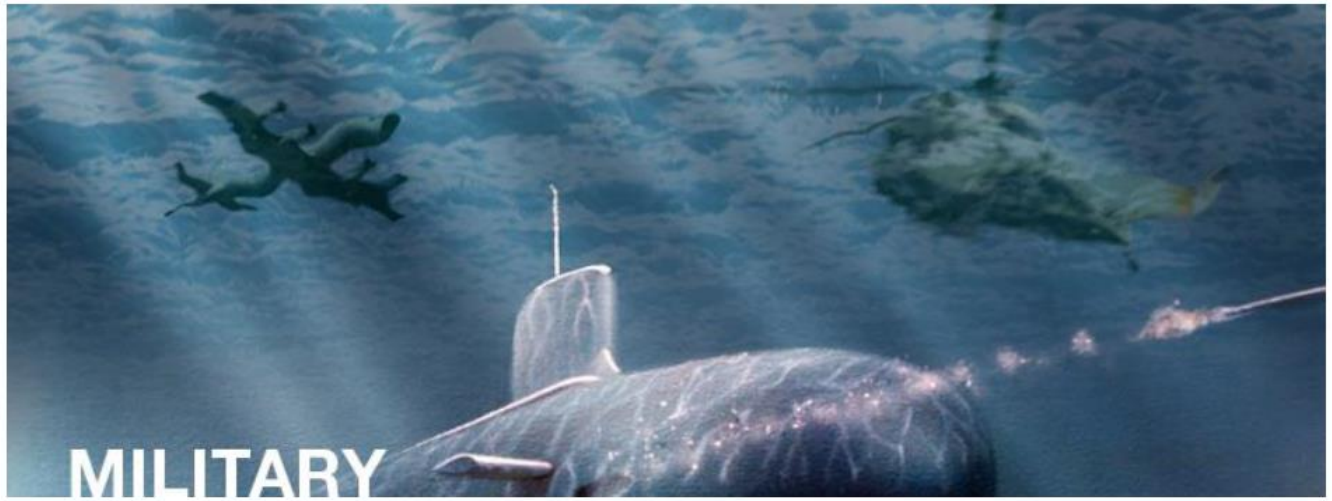
isr&ASW SYSTEMS

➢ MAD

- **MAD: Magnetic Anomaly Detector**

  La masa metálica del submarino produce una variación magnética o anomalía en el campo magnético terrestre que es detectada por el Sistema MAD.

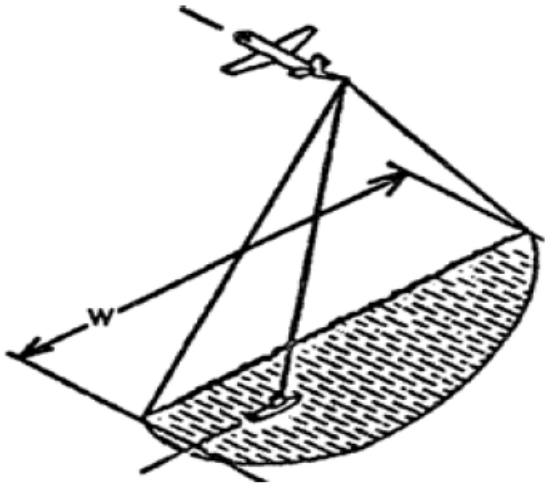
  El MAD se usa en aviones de guerra antisubmarina (ASW) y **no es un sensor de búsqueda**.



isr&ASW SYSTEMS

➢ MAD

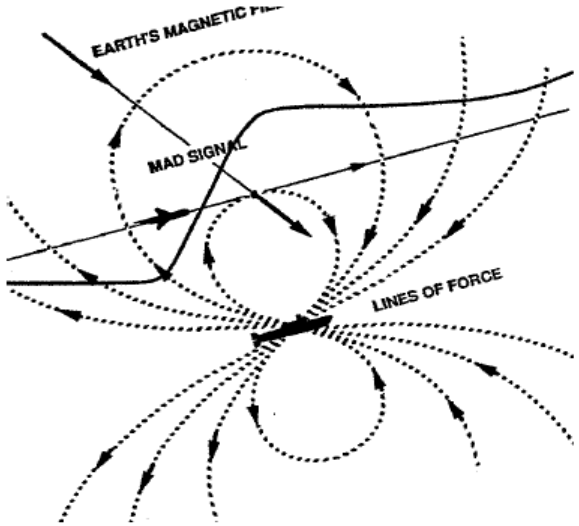
- Mide anomalías en el campo magnético terrestre para detectar submarinos.
- Realiza las detecciones de forma automática, alertando al operador con una alarma de audio cuando se producen.
- La capacidad de detección del MAD depende de ciertos parámetros, como son:
  - Tamaño del submarino.
  - Profundidad y rumbo del submarino.
  - Características del ruido presente durante la detección.
  - Latitud magnética
  - Etc

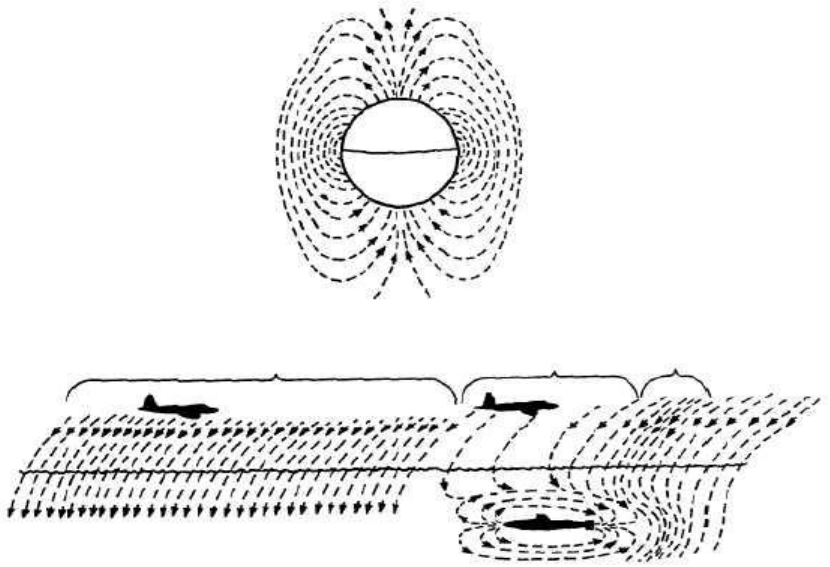


isr&ASW SYSTEMS

➢ MAD

- Cómo se obtienen las detecciones MAD:
  - El “Detecting Head” se orienta mecánicamente a un ángulo fijo (45º) respecto al campo magnético terrestre, independientemente de la actitud de la aeronave. De esta manera “ve” dicho campo magnético terrestre como una constante, permitiéndole detectar cambios en la misma (detecta componentes alineadas con el campo magnético terrestre del campo magnético creado por el submarino)

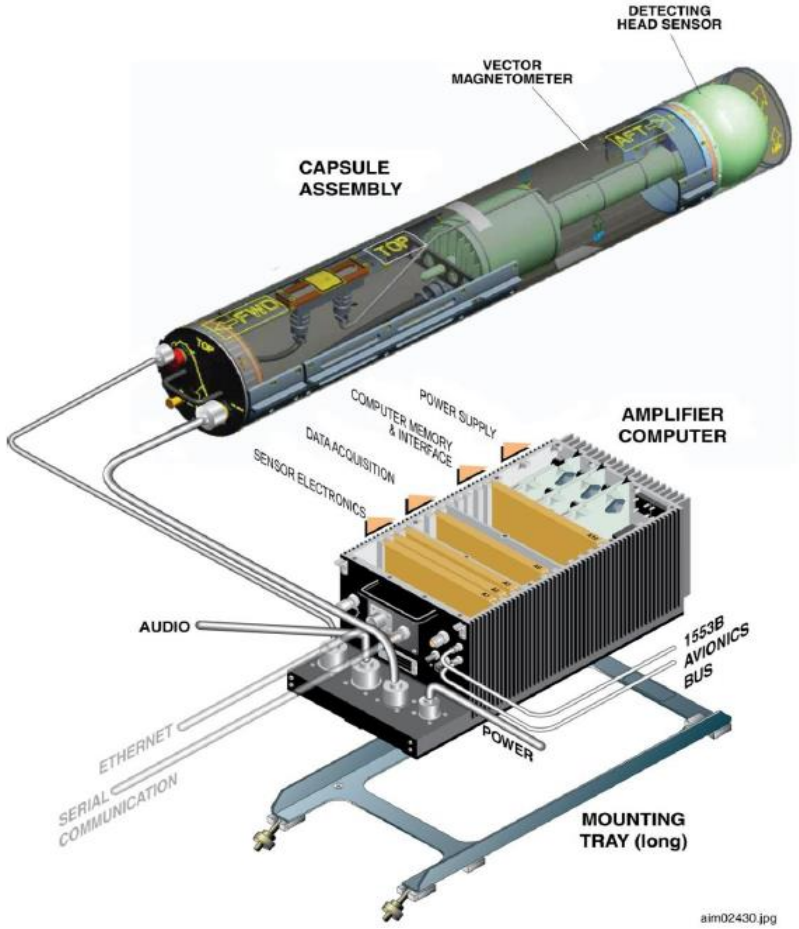




isr&ASW SYSTEMS

➢ MAD

- El Sistema MAD consiste básicamente en:
  - Un sensor (detecting head), que detecta los cambios en el campo magnético terrestre
  - Un magnetómetro (vector magnetometer), para compensar las interferencias producidas por las maniobras del avión
  - Un procesador de la señal (amplifier computer) para maximizar ésta frente al ruido y poder así detectar la anomalía generada por la presencia de un submarino



isr&ASW SYSTEMS

➢ MAD

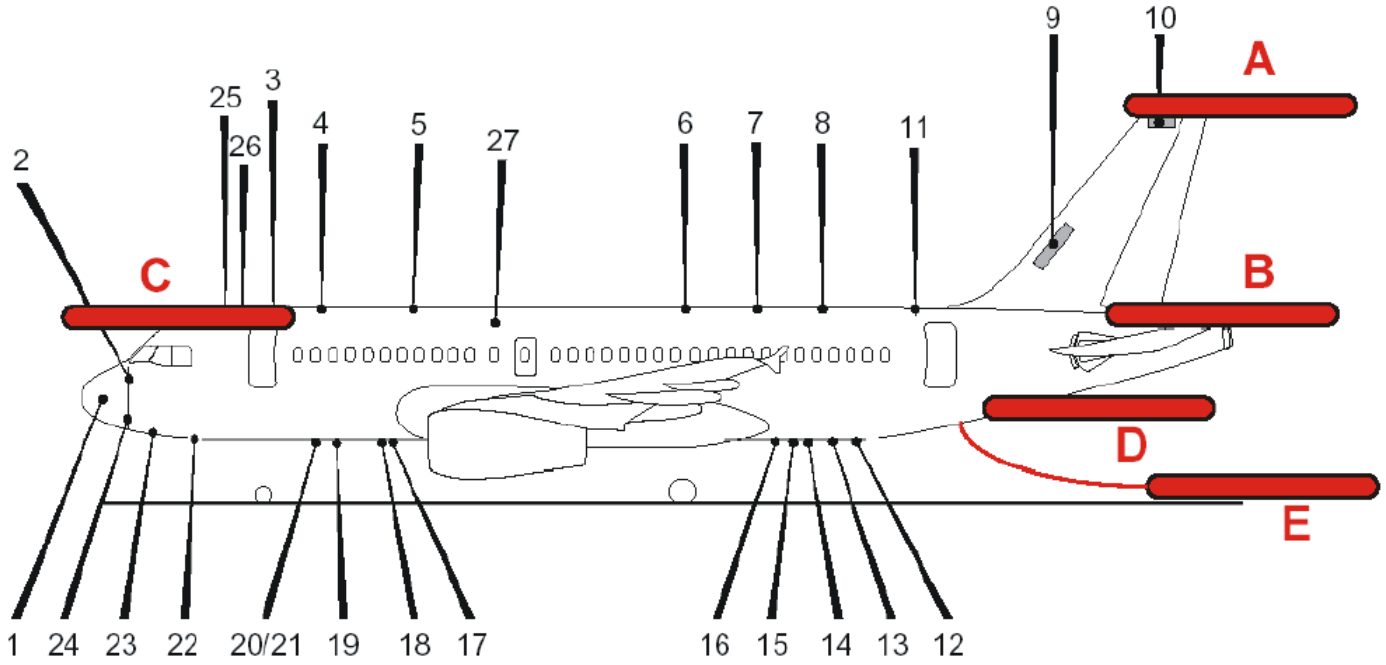
- **Instalación de la Cápsula:** la cápsula se instala en el interior de un elemento denominado Boom. Dado que este Boom contiene los sensores que realizan la medición del campo magnético, sus requisitos de diseño e instalación, así como los de fijación de la cápsula en su interior, son exigentes para minimizar el ruido magnético en su proximidad y que no decrezca la capacidad de detección:
  - El boom debe ser rígido y lo más largo posible para alejarlo de los ruidos del avión.
  - Se debe encontrar lo más alejado posible de superficies metálicas del avión. La mínima distancia recomendada por CAE son 20ft (unos 6m).
  - Se debe encontrar lo más alejado posible de superficies móviles y unidades de potencia del avión.
  - Se debe evitar el uso de metales para su construcción.
  - La cápsula debe estar fija dentro del boom.

isr&ASW SYSTEMS

➢ MAD

Teniendo en cuenta los requisitos antes mencionados, para cada avión:

- Se localizan, mediante estudio conjunto con el Suministrador del MAD, distintas zonas donde sería posible la instalación del Boom.
- En general, el Boom se instala en el área de la cola del avión para minimizar la interferencia magnética del avión.



isr&ASW SYSTEMS

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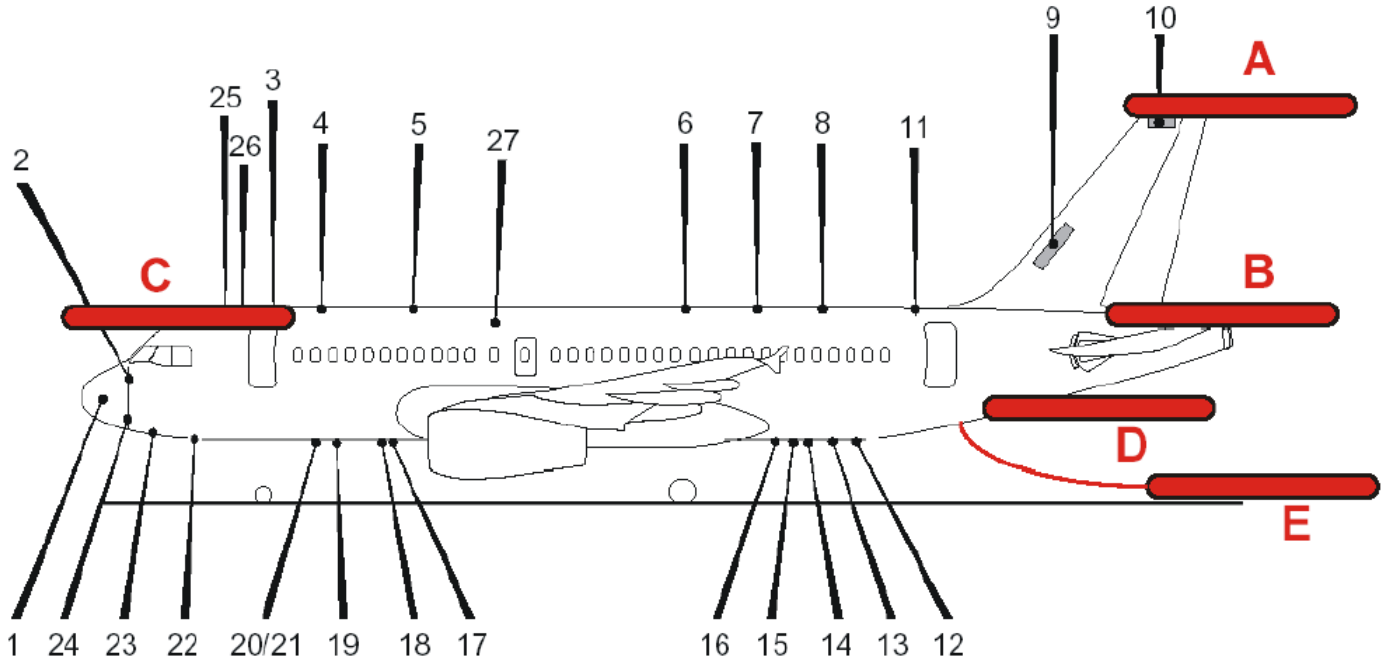
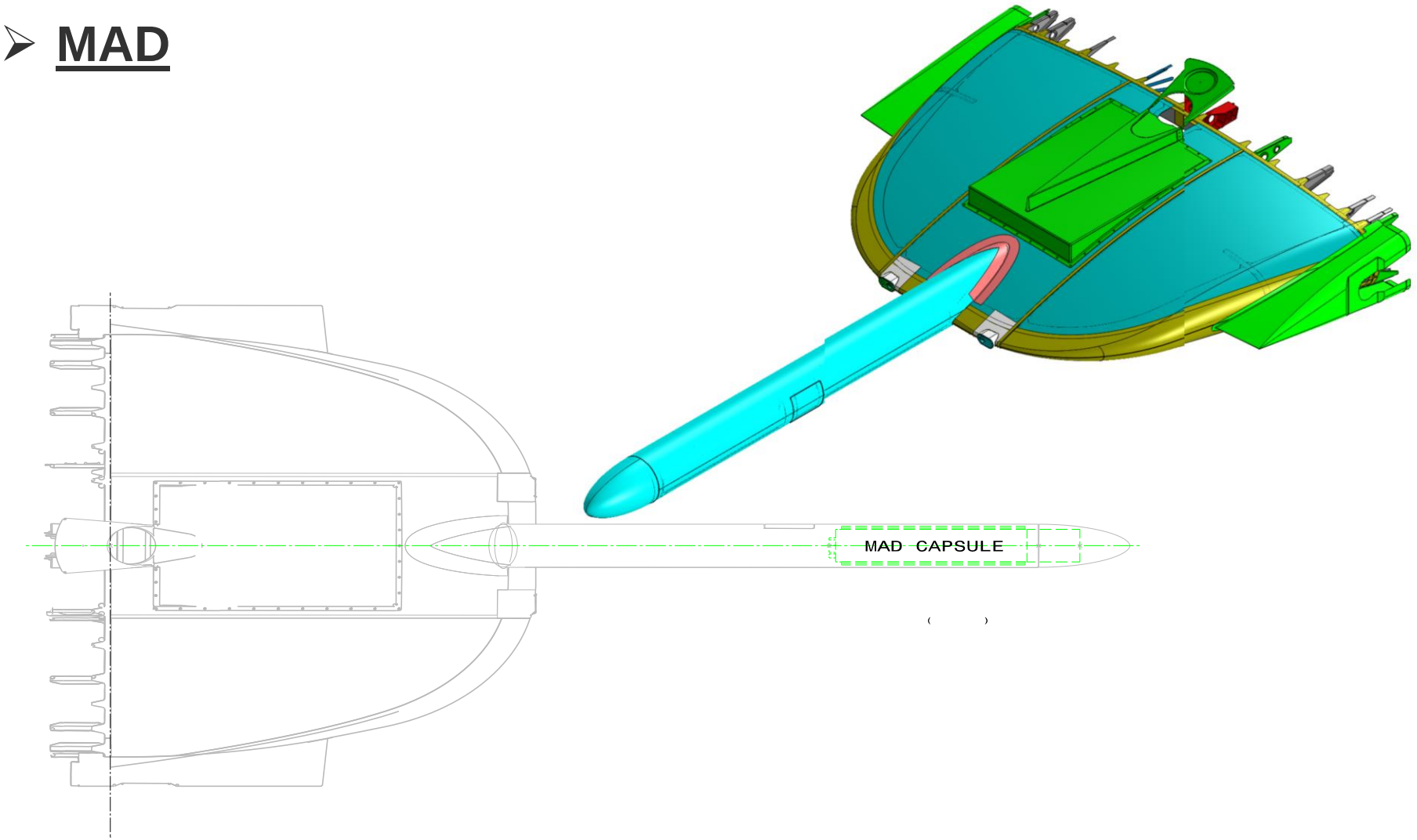


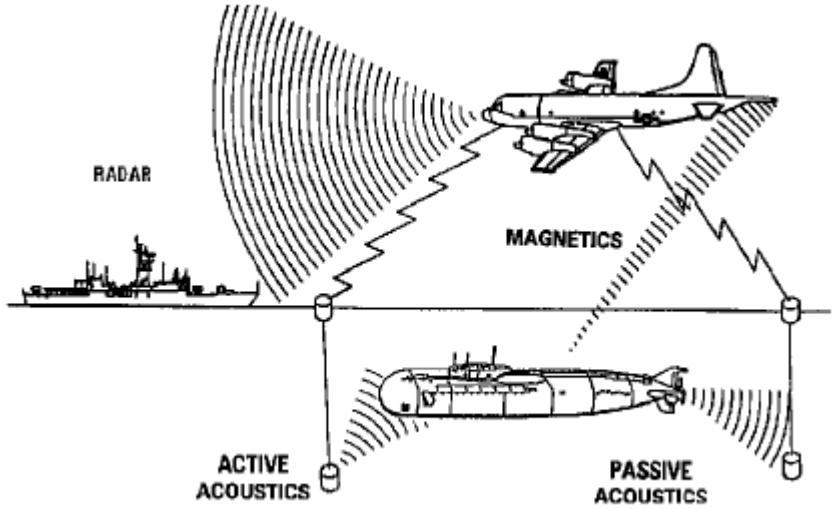
isr&ASW SYSTEMS

- **MAD**



isr&ASW SYSTEMS

- **MAD**



El MAD se emplea para confirmar la suelta del torpedo, realizando de nuevo la detección del submarino durante el ataque.

isr&ASW SYSTEMS

- **MAD**

isr&ASW SYSTEMS

- **MAD**

Future Trends