SEARCH CAPABILITY OF THE TECNAM MRI SURVEILLANCE SYSTEM

October 2011

Indracompany.com

SEARCH CAPABILITY OF THE TECNAM MRI SYSTEM

SEARCH CAPABILITY OF THE TECNAM MRI SYSTEM

1. SCOPE

The scope of this report is to study the search capability of the TECNAM MRI system composed of the following subsystems:

Aircraft Tecnam P2006T, Certified FAA-FAR23 & EASA-CS23
Radar SEASPRAY 5000E
Electro-optical sensor FLIR ULTRAFORCE 275 HD
Transceiver AIS (Automatic Identification System)
Ground Station
Mission Computer
Ground station communications.

The report also contains sketches of a possible concept of operations, showing several typical search scenarios, tables and plots that could be used as a reference for planning.
The report is completed by the final conclusions and recommendations.

1.1. Disclaimer

The intention of this study is to achieve a first order approach for operative efficiency of the TECNAM MRI System. The results presented are to be used only for guidance and they do not take into account certain agents that impact the safety of the flight. In case of any disagreement with flight safety publications, the recommendations in the safety publications should prevail over those presented in this article.

2. VARIABLES AND ASSUMPTIONS

These are the following variables and considerations that have been taken into account:

2.1. Fuel consumption at different speeds and heights

The following tables provided by TECNAN, the aircraft manufacturer, have been assumed for performance:

ENDURANCE/RANGE CALCULATION at 1500-3000 ft

	Speed (Kts)	Total Fuel consumption (ltr/h)	Endurance (h)
Stall speed	47	24	6,58
	85	24	6,58
	100	26	6,08
	120	30	5,27
Cruise speed, 65%	135	32	4,94
Cruise speed, 75%	145	38	4,16
Max speed	155	44	3,59

ENDURANCE/RANGE CALCULATION at 6000-8000 ft

	Speed (Kts)	Total Fuel consumption (ltr/h)	Endurance (h)
Stall speed	47	24	6,58
	85	24	6,58
	100	28	5,64
	120	32	4,94
Cruise speed, 65%	135	34	4,65
Cruise speed, 75%	140	40	3,95
Max speed	155	46	3,43

2.2. Target size and Radar Cross Section (RCS)

The following values for target size and RCS have been used:

Target Type	Target Size (mts)	Target height (mts)	RCS (m2)
Small wooden boat	5	0,4	0,5
Zodiac	5-8	0,5	1,5
Speed boat	8-10	0,7	5
Pleasure Yacht	12-18	2	10
Fishing/Patrol Boat	20-25	2,5	100
Cargo Ship	100	10-15	10.000

2.3. Radar Range

These are the radar modes and values that have been used for radar range. They are provided by the radar manufacturer:

RCS (m^2)	Radar Height (ft)	Mode Used	SS5300E Uninstalled (Nmi)	SS5300E Installed (Nmi)
0,5	500	STM20Slow	10,9	10,3
1	500	STM20Slow	13,3	12,6
2	500	STM20Slow	15,8	15
5	500	LRS25	18	17
8	500	LRS50	20,1	19
40	500	LRS50	31,9	30,2
80	500	LRS50	37,5	35,5
300	500	LRS100	54,4	51,6

These ranges do not take into account the refractive effects of the low atmosphere that may increase or reduce dramatically the radar range.

2.4. Radar, VHF Horizon and AIS Range

Radar Horizon

The earth's atmosphere has a density that decreases exponentially with altitude. Because of this density gradient light and radar waves are refracted, thus targets can be tracked even beyond the geometrical horizon.

This effect is more pronounced at the lower frequencies than at higher frequencies.

The approximated geometrical horizon at low height, when height is small compared with the earth's radius, is given by the formula:

$d = \sqrt{2rh}$

Only valid for values h<<r, where d is the geometrical horizon, r is the radius of the earth at the equator and h is the height of the observer. To correct for refraction at the Radar SEASPRAY 5000E and light frequencies an analytical approximation called the "seven-sixths earth's radius assumption" p. 110[1] has been used:

$d = \sqrt{2rh}$

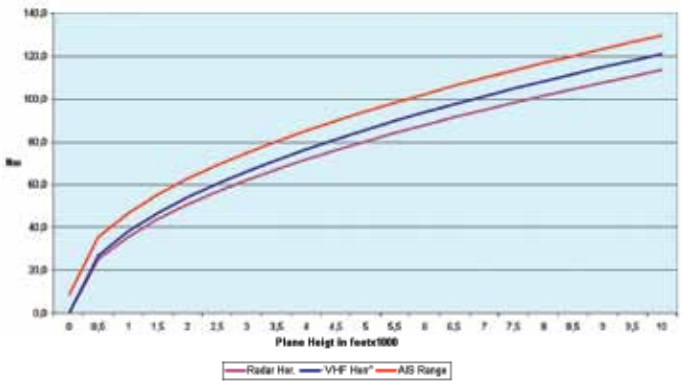
Only valid for values h<<r, where d is the radar horizon, r is the sevensixths of the radius of the earth at the equator and h is the height of the radar antenna.

VHF Horizon

To correct for refraction at lower frequencies, like the VHF frequencies, an analytical approximation called the "four-thirds earth approximation"p.109 [1] has been used, in which the radius of the earth is assumed to be one third larger.

AIS Range

To calculate the AIS range, it has been assumed that the antenna of the emitter ship is fitted at 50 feet height, therefore, the value of the AIS range is the sum of VHF horizon of the ship plus the VHF horizon of the aircraft.



[1] Daniel H. Wagner, W. Charles Mylander and Thomas J. Sander Naval Operations Analysis, third edition, U.S. Naval Institute, Annapolis, Maryland, 1999

The RADAR range is limited by its emitting power. The SEASPRAY 5000E which is used for this study operates at a power which makes its range smaller than the RADAR horizon which is limited by geometry. For this reason, the RADAR horizon is ignored throughout the rest of the report assuming it will never be a determining factor for the efficacy of the system.
Note that the following factors have been disregarded:

2.5. Refractive phenomena

In the naval environment, humid air near the sea may create a zone of lower density, called the inversion layer. This layer causes electromagnetic waves to follow the curvature of the earth, deviating from their targeted path.

The consequences of these phenomena have not been taken into account because they depend very particularly on the precise atmospheric conditions. However, systems that provide accurate predictions for the refraction effects on radar ranges have been developed. One of such systems is the Integrated Refractive Effects Prediction System (IREPS) which is described as[2]:

> "Electromagnetic radio propagation in the lower atmosphere often exhibits unexpected behaviour created by non-standard distributions of the radio refractivity of the atmosphere. The basic cause and effect have been understood since the 1940's and over the past decades numerous techniques have been developed in an attempt to assess such effects as they occur. The IREPS provides a method and means for acquiring, converting and interpreting refractivity data and will display their effects on specific sensor and weapons systems in near real time. Displays can be generated which show the refractivity structure, summarize their effects on wide classes of equipment, and indicate path loss versus range or actual detection range versus altitude for specific electromagnetic systems. A comprehensive world-wide climatology of refractive effects is available "on-line" to augment the on-scene refractivity data"

2.6. Sea state and wind

Sea state three has been assumed during the whole study. No wind has been assumed throughout the report. Note that wind will affect negatively the performances of the system in practically all situations.

[2] United States Patent 4.125.893 Hitney et al. Nov. 14, 1978

3. SEARCH MODES

The sole search mode used is the Random Search. Alternative Systematic Searches have not been considered because the natural process of target detection and classification is closer to a random search than to a systematic one.

3.1. Random Search

A random search takes place under the following conditions:

The target distribution position is assumed to be uniform in a search area. All points in the search area are equally likely to be the point of placement of the target.

The behaviour of the searcher is sufficiently random that at each instant all points in the area are equally likely to be the point of placement of the searcher.

In a short interval of time of length Δt the sensor covers an incremental region of area $wv\Delta t$, so the probability of detection in that interval is:
$wv\Delta t/A$, where w is the sweep width, v is the speed of the exploring plane and A is the searched area.

The sweep width is defined as "the lateral range beyond which as many targets are detected as are missed at lesser ranges". Although it is a different statistical concept, the value assumed throughout this study for w is the range at which there is a 50 percent chance of detection. This approximation is valid for independent continuous looking searches pp 143 and 167[1]

This is an idealization, but it leads to an approximation to the cumulative detection probability when sensor movement has speed v and is unsystematic. Thus wv/A may be reasonably assumed a constant detection rate, in this case, the probability of detection in a random search is given by:

Prob. of Detection(t) =1-exp(-wvt/A) P145[1]

The ratio wvt/A is known as the coverage factor and equal to the number of times the area has been swept.

3.2. Random Search of an Expanding Region

The formula employed in a random search can be generalized for the case where the area of the region changes over time. A case which is of particular interest is the case when the region of uncertainty expands circularly and the target position remains uniformly distributed within the expanding region. An example of this is the case of a sighted target and a searcher tasked to the sighting point to perform a random search. The target's position is assumed initially to be uniformly distributed within a circular disc of radius r and thereafter the target could be evading in any direction at a maximum speed u.

The probability of detection in a random search of an expanding region (evading target) is pp181-182[1]

Prob. of Detection(t) =1-exp (-wvt/ πr(r+ut))

In this case, the coverage factor is a function of the search time:

Coverage factor(t)= wvt/πr(r+ut)

The two formulae above for the probability of detection have been used for the calculations showed on tables and curves.

4. EFFICENCY OF THE VISUAL SYSTEM

4.1. National Image Interpretability Rating Scales NIIRS

NIIRS is a task-based scale used for rating imagery acquired from various imaging systems. The NIIRS originated in the Intelligence Community and is the standard used by imagery analysts, collection managers, imagery scientists, and sensor designers. The imagery analysis tasks that comprise the NIIRS have, in the past, focused mainly on military equipment.

The concept underlying the NIIRS is that imagery analysts should be able to perform more demanding interpretation tasks as the quality or interpretability of the imagery increases. The NIIRS consists of 10 graduated levels (0 to 9), with several interpretation tasks or criteria forming each level. These criteria indicate the amount of information that can be extracted from an image at a given interpretability level. With a NIIRS 2 image, for example, analysts should lust be able to detect large buildings, while on NIIRS 6 imagery they should just be able to identify automobiles as sedans or station wagons.

The NIIRS concept provides a means to directly relate the quality of an image to the interpretation tasks for which it may be used. Although the NIIRS has been primarily applied in the evaluation of aerial imagery, it provides a systematic approach to measuring the quality of photographic or digital imagery, the performance of image capture devices, and the effects of image processing algorithms.

The terms **detect**, **distinguish between**, and **identify** are used extensively in the NIIRS criteria. The definitions are:

- **Detect:**
Detect is the capability to find or discover the presence or existence of an installation, object, activity, or item of interest, based on its general shape (configuration) and on other contextual information in the scene. Some level of identification is implied in detection, so that the feature detected can be properly named.

- **Distinguish Between:**
The distinguish between level is the capability to determine that two detected objects are of different types or classes based on one or more distinguishing features.

- **Identify:**
Identify is the capability to name an object by type or class, based primarily on its configuration and detailed components. Identification depends on observation of detail in the image and not through information from non-imagery sources.

4.2 NIIRS criteria for the Naval Scenario

The following table defines NIIRS concepts used:

NIIRS	Ground Resolved Distace mts.	Visible NIIRS	Radar NIIRS	Infrared NIIRS
0		Interpretability of the imagery is precluded by obscuration, degradation, or very poor resolution.	Interpretability of the imagery is precluded by obscuration, degradation, or very poor resolution.	Interpretability of the imagery is precluded by obscuration, degradation, or very poor resolution.
1	Over 9.0	Detect a medium-sized port facility and/or distinguish between taxi-ways and runways at a large airfield.	Detect, based on presence of piers and warehouses, a port facility.	Detect large ocean-going vessels (e.g., aircraft carrier, super-tanker) in open water.
2	4.5 - 9.0	Detect large buildings at a naval facility (e.g., warehouses, construction hall).	Detect large ships (e.g., freighters or tankers) at a known port facility.	Distinguish between naval and commercial port facilities based on type and configuration of large functional areas.
3	2.5 - 4.5	Identify a large surface ship in port by type (cruiser, auxiliary ship, merchant).	Determine the location of the superstructure (e.g., fore, amidships, aft) on a medium-sized freighter.	Distinguish between large (e.g, greater than 200 meter) freighters and tankers.
4	1.2 - 2.5	Determine the shape of the bow (pointed or blunt/ rounded) on a medium-sized submarine.	Identify square bow shape of Landing Ship Tank (LST).	Identify individual closed cargo hold hatches on large merchant ships.
5	0.75 - 1.2	Identify air surveillance radar on combat vessels.	Distinguish bow shape and length/width differences of big submarines.	Identify the stack shape (e.g., square, round, oval) on large (e.g., greater than 200 meter) merchant ships.
6	0.40 - 0.75	Identify individual launcher covers (8) of vertically launched missiles on combat vessels.	Distinguish between a raised helicopter deck) and a helicopter deck with main deck on a cruiser.	Identify missile tube hatches on submarines.
7	0.20 - 0.40	Identify the individual tubes of the antisubmarine weapons of escorts.	Distinguish between bow mounted missile system and bow mounted gun turret.	Detect mooring cleats or bollards on piers.
8	0.10 - 0.20	Detect winch cables on deck-mounted cranes.	Distinguish limber hole shape and configuration differences between SSBNs.	Identify individual horizontal and vertical ribs on a radar antenna.
9	Less than 0.10	Identify braid of ropes (I to 3 inches in diameter).	Identify individual hatch covers of vertically launched surface-to-air system	Identify individual command guidance strip antennas on a missile.

4.3 NIIRS for the P2006T MRI

Ultraforce 275 HD main characteristics are the following:

IR CAMERA	HFOV	VFOV
Pixels	640	512
Detector size (µm)	15	15
Focal Distance (mm)	300	300
Detector total size (mm):	9,6	7,68
FOV (°):	1,83	1,47

CCD CAMERA	HFOV	VFOV
Pixels	1280	720
Detector SIze (µm)	15	15
FOV (°):	2,00	1,45
Detector total size (mm):	19,2	10,8
Focal Distance (mm)	550,0	426,7

4.3 NIIRS for the P2006T MRI

Considering those characteristics the following performances may be expected:

FLIR ULTRAFORCE 275 HD

DISTANCE (m)	RESOLUTION IR (m)	NIIRS IR	RESOLUTION CCD (m)	NIIRS CCD
100	0,01	NIIRS 9	0,01	NIIRS 9
200	0,02	NIIRS 9	0,01	NIIRS 9
500	0,05	NIIRS 9	0,03	NIIRS 9
1.000	0,10	NIIRS 8	0,05	NIIRS 9
2.000	0,20	NIIRS 7	0,11	NIIRS 8
5.000	0,50	NIIRS 6	0,27	NIIRS 6
10.000	1,00	NIIRS 5	0,55	NIIRS 5
20.000	2,00	NIIRS 4	1,09	NIIRS 4
50.000	5,00	NIIRS 2	2,73	NIIRS 2
100.000	10,00	NIIRS 1	5,46	NIIRS 1

With regards to radar imaging the following performance may be espected for the different SAR modes:

SELEX SEASPRAY 5000E		NIIRS RADAR
SPOT SAR MEDIUM RESOLUTION		NIIRS 5
Resolution	1,00 m	
Area	1km x 1km	
SPOT SAR HIGH RESOLUTION		NIIRS 6
Resolution	0,50 m	
Area	500m x 500m	
STRIP SAR RESOLUTION		NIIRS 1
Resolution	10,00 m	
Swath width	20,00 Nm	
STRIP SAR RESOLUTION		NIIRS 1
Resolution	20,00 m	
Swath width	40,00 Nm	

5. DRAFT OF THE CONCEPT OF OPERATIONS (CONOPS)

The operation will be carried on in three stages: Planning, Mission Development and Operation Analysis.

5.1. Planning

The participating entities will be the flight crew and the ground station operators. During this first stage a number of data will be gathered:

Aeronautical information.

Meteo info, including the IREPS info to determine the optimal flight height.

Intelligence information extracted from the Intelligence database.

Lesson Learnt information extracted from the Lesson Learnt Database.
For the management of all of this information it is convenient to have distributed automatic mission planning system.

The information required for the flight will be stored in a format that allows it to be loaded in the mission computer of the plane.

The mission planning system will collect the information for the pre-flight briefing.

5.2. Mission Development

During the Mission Development stage, the planning proposed during the previous stage will be followed as accurately as possible. It is basically described by the following actions:

Detection
The AIS will perform the long range detection. For shorter distances, the radar and the optical camera will be used.

Classification
When there is lack of correlation between a target detected by the radar and the AIS, it should be classified, firstly by using the SAR and ISAR capability of the radar and eventually by the camera or visual sighting.

As much information as possible will be gathered. If the plane is inside the communication range of the ground station, the operators will be able to alleviate significant effort of the flight crew.

5.3. Operation Analysis

Once the flight has terminated a hot wash up will be performed followed by a detailed analysis to draw conclusions and adjust parameters of the databases used.

With the analysis stage, the operation cycle is closed.

6. TECNAM MRI VS. EC-135

The goal of this section is to compare the efficiency of the searches performed by a Tecnam MRI and a Helo EC-135.

These are the specifications of the hypothetical scenarios and the detection parameters for both platforms:

Target, Fishing Boat 100 Sqm of RCS
Patrol Area, 3600 SqNm
Sweep Width Plane Radar, 69Nm
Sweep Width Helo Camera, 20 N
Max. Range Plane, 500Nm
Max. Range Helo, 342Nm[3]
Sea State, 3

The search results for different distances to the operation zone are shown on the table below.

RANGE to OPZONE (Nm)	30	40	50	60	70	80
Swiped Area Plane SqNm	25345	24158	22971	21784	20597	19411
Swiped Area Helo SqNm	5640	5240	4840	4440	3640	3240
Coverage Factor Plane	2,53	2,42	2,30	2,18	2,06	1,94
Coverage Factor Helo	0,56	0,52	0,48	0,44	0,36	0,32
Advantage Factor	4,49	4,61	4,75	4,91	5,66	5,99

It can be seen that the plane coverage factor is significantly larger than that of the helo. This is due to its larger sweep width and the time spent over the patrol area. The advantage factor in this table represents the number of helos that would be required to achieve the same efficiency as one plane.

[3] Eurocopter Comercial Information

7. CONCLUSIONS AND RECOMMENDATIONS

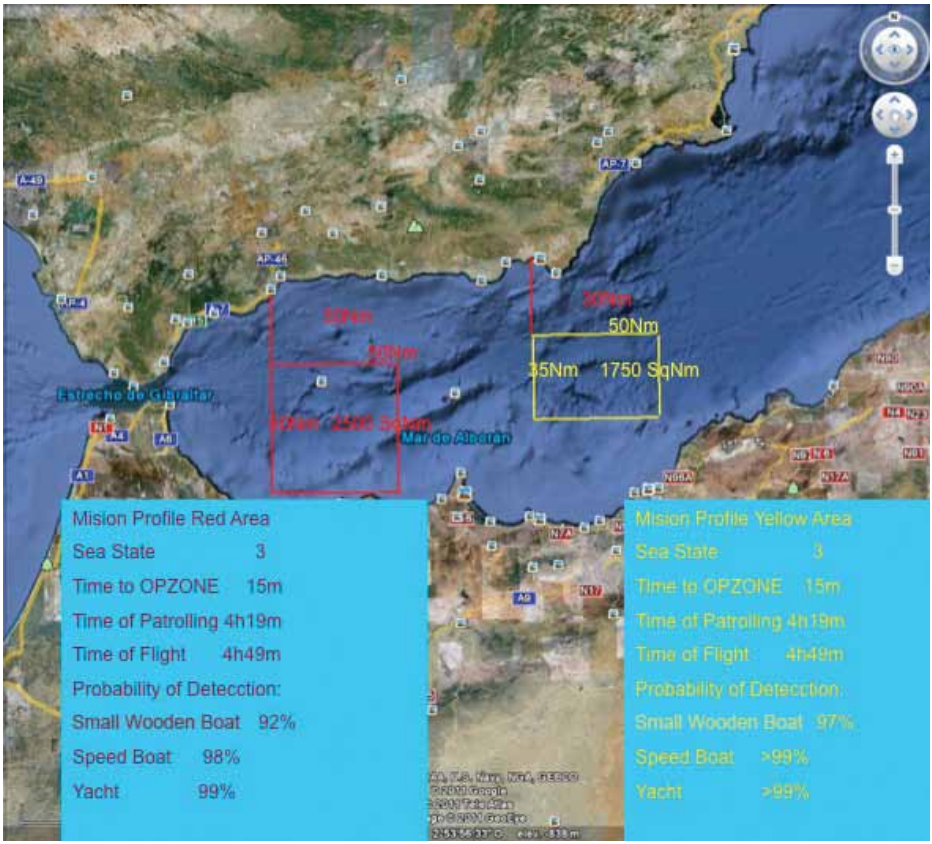
This report shows that the performance of the TECNAN MRI system for detection of targets at sea in a littoral scenario is highly satisfactory and exceeds the searches by helo with a much higher probability of detection.

To achieve higher detection prediction accuracy and an optimal height of patrolling using the Radar systems it is recommended the addition of an IREPS type system.

To perform a quick and precise mission planning and manage all of the operational information it is recommended the development of a distributed mission planning automatic tool.

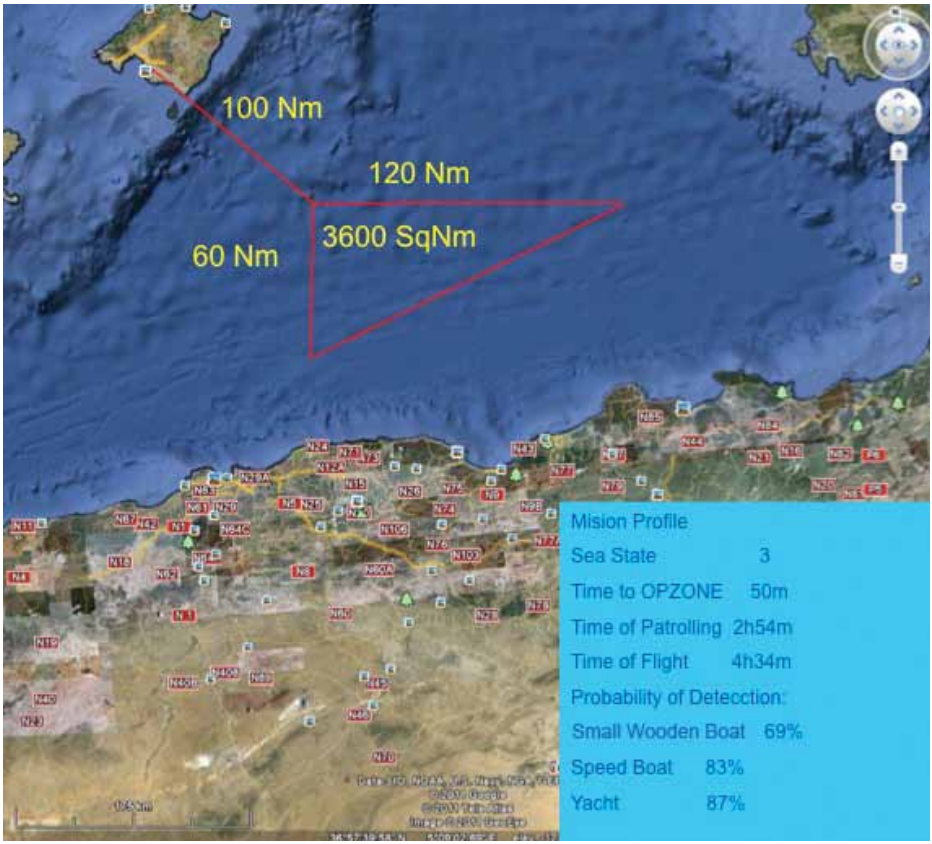
Scenario 1

Probability of detection for different targets in a random search.
Surface Area 2500 and 1750 SqNm.
Distance 30 Nm.



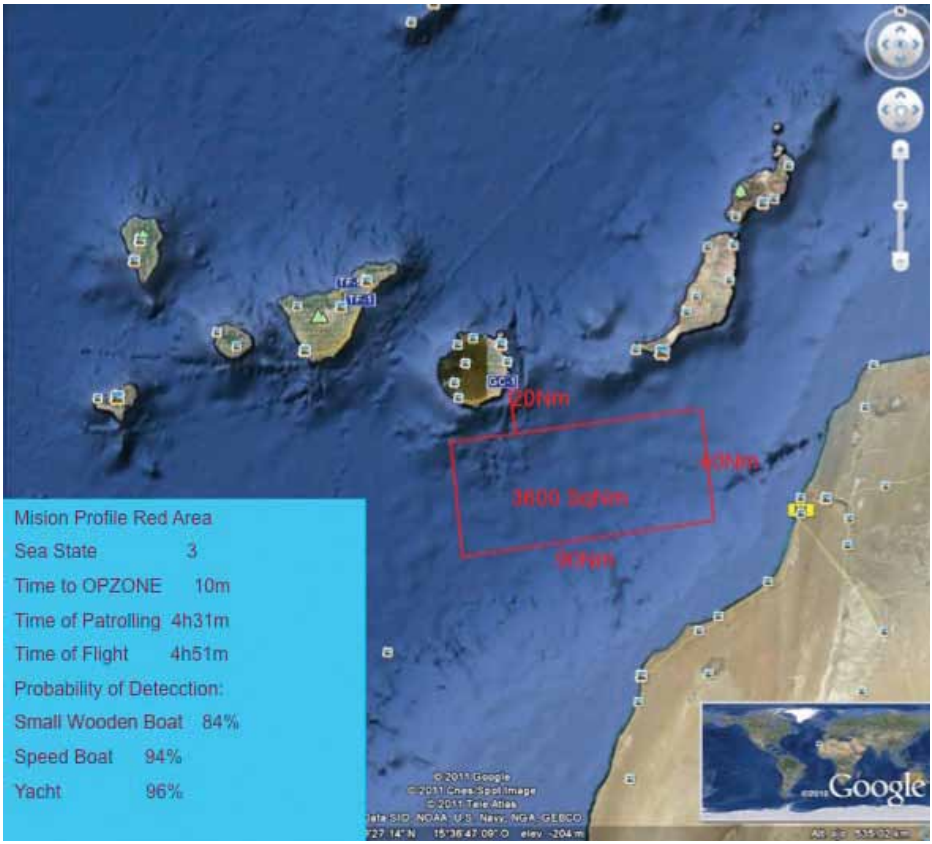
Scenario 2

Probability of detection for different targets in a random search.
Surface Area 3600 SqNm.
Distance 100 Nm.



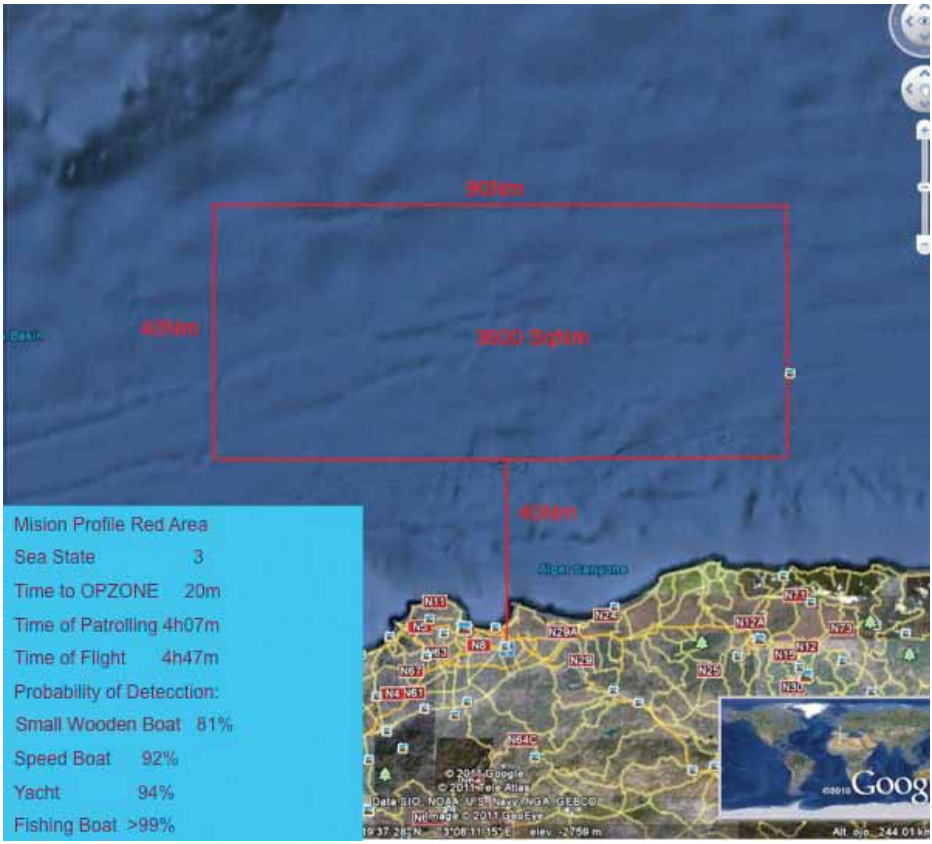
Scenario 3

Probability of detection for different targets in a random search.
Surface Area 3600 SqNm.
Distance 20 Nm.



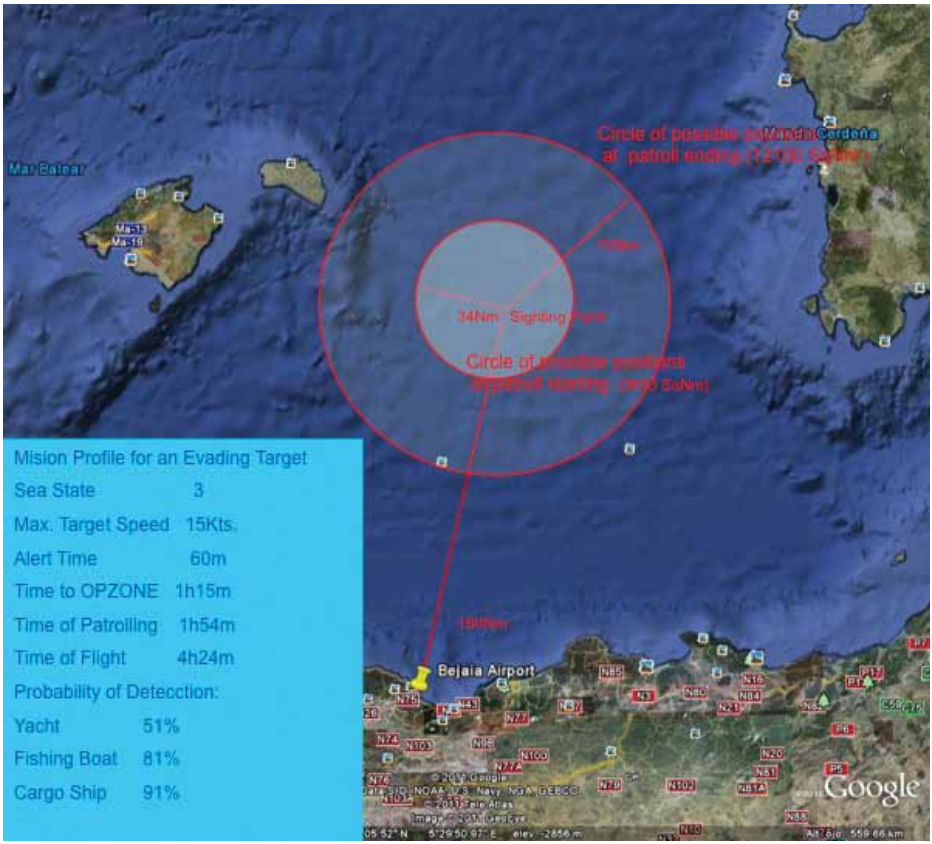
Scenario 4

Probability of detection for different targets in a random search.
Surface Area 3600 SqNm.
Distance 40 Nm.



Scenario 5

Probability of detection for different evading targets in a random search.
Distance to sighting point 150 Nm
Alert time 60 m



Scenario 6

Probability of detection for different evading targets in a random search.
Distance to sighting point 100 Nm
Alert time 60 m

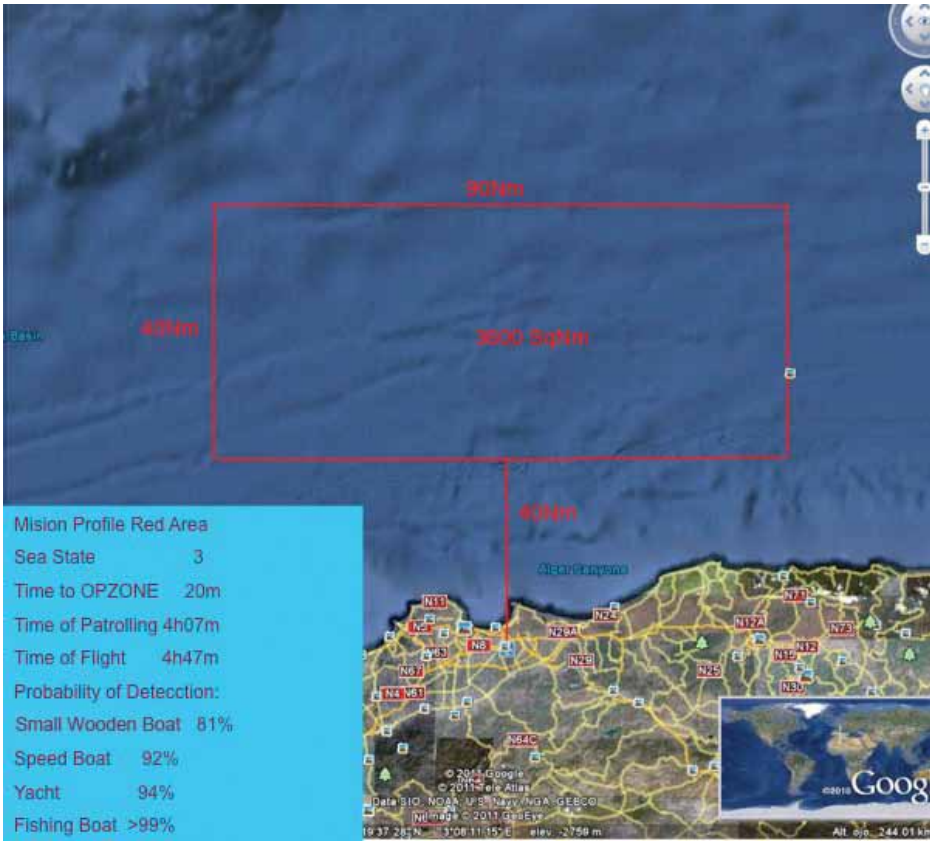


TABLE AND CURVES SMALL WOODEN BOAT

Small wooden boat

EXPECTED TARGET RCS m2	OPZONE AREA Sqnm	OPZONE AREA Sqnm	OPZONE AREA Sqnm	OPZONE AREA Sqnm	OPZONE AREA Sqnm
0,50	1600	2500	3600	6400	10000
RANGE to OPZONE (Nm)	Prob. of Detection %	Prob. of Detection %	Prob. of Detection %	Prob. of Detection %	Prob. of Detection %
30	98,07	92,01	82,71	62,74	46,84
40	97,68	91,01	81,23	60,97	45,24
50	97,21	89,88	79,62	59,13	43,60
60	96,64	88,61	77,87	57,19	41,90
70	95,96	87,17	75,98	55,17	40,16
80	95,14	85,56	73,92	53,05	38,36
90	94,15	83,75	71,69	50,83	36,51
100	92,96	81,71	69,26	48,50	34,60
110	91,54	79,41	66,63	46,06	32,64
120	89,82	76,82	63,77	43,51	30,62
130	87,75	73,91	60,67	40,84	28,53
140	85,26	70,63	57,30	38,04	26,39
150	82,26	66,94	53,64	35,10	24,17
160	78,66	62,79	49,67	32,03	21,90
170	74,33	58,11	45,36	28,82	19,55
180	69,11	52,85	40,68	25,45	17,14
190	62,84	46,93	35,59	21,92	14,65
200	55,29	40,26	30,08	18,23	12,08

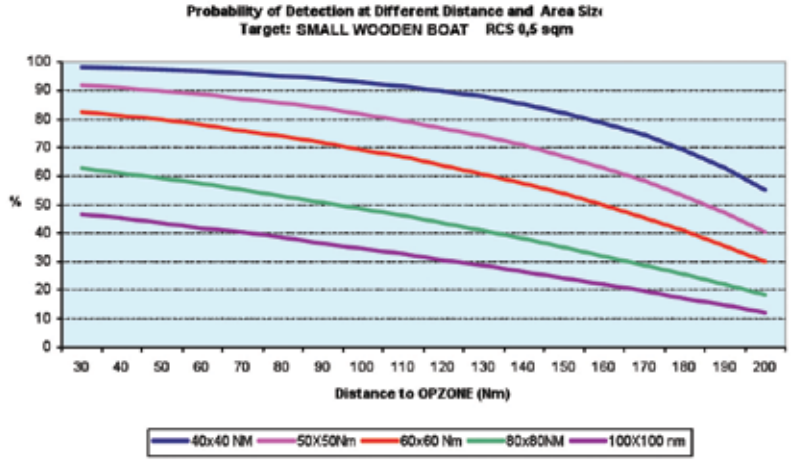


TABLE AND CURVES ZODIAC

Zodiac

EXPECTED TARGET RCS m2	OPZONE AREA Sqnm	OPZONE AREA Sqnm	OPZONE AREA Sqnm	OPZONE AREA Sqnm	OPZONE AREA Sqnm
0,50	1600	2500	3600	6400	10000
RANGE to OPZONE (Nm)	Prob. of Detection %	Prob. of Detection %	Prob. of Detection %	Prob. of Detection %	Prob. of Detection %
30	98,32	92,69	83,74	64,00	48,00
40	97,97	91,73	82,29	62,23	46,38
50	97,54	90,66	80,72	60,38	44,71
60	97,02	89,44	79,01	58,44	42,99
70	96,39	88,06	77,14	56,41	41,22
80	95,63	86,51	75,12	54,27	39,39
90	94,70	84,75	72,91	52,03	37,51
100	93,59	82,76	70,50	49,68	35,56
110	92,23	80,51	67,88	47,21	33,56
120	90,60	77,98	65,03	44,62	31,49
130	88,61	75,11	61,93	41,91	29,36
140	86,21	71,86	58,55	39,06	27,17
150	83,30	68,20	54,87	36,08	24,90
160	79,78	64,05	50,86	32,94	22,57
170	75,52	59,37	46,50	29,66	20,16
180	70,35	54,07	41,75	26,21	17,68
190	64,10	48,09	36,57	22,59	15,12
200	56,53	41,32	30,94	18,80	12,48

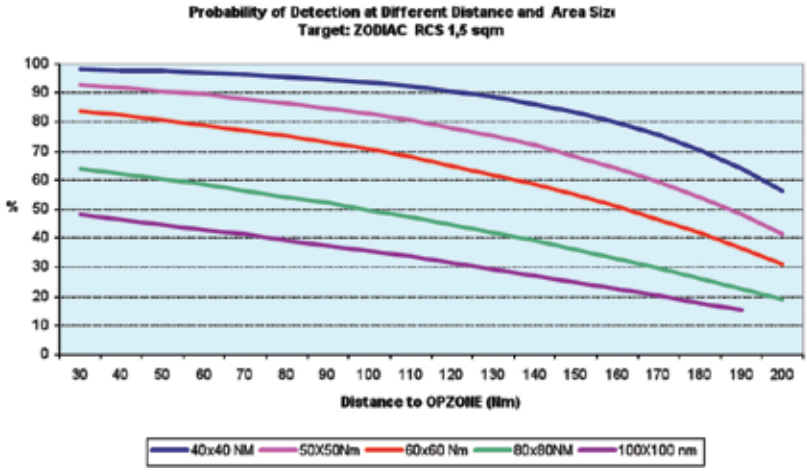


TABLE AND CURVES SPEED BOAT

Speed Boat

EXPECTED TARGET RCS m2	OPZONE AREA Sqnm	OPZONE AREA Sqnm	OPZONE AREA Sqnm	OPZONE AREA Sqnm	OPZONE AREA Sqnm
5,00	1600	2500	3600	6400	10000
RANGE to OPZONE (Nm)	Prob. of Detection %	Prob. of Detection %	Prob. of Detection %	Prob. of Detection %	Prob. of Detection %
30	99,73	97,74	92,81	77,25	61,24
40	99,65	97,30	91,87	75,62	59,48
50	99,53	96,78	90,80	73,87	57,64
60	99,38	96,15	89,59	71,99	55,72
70	99,19	95,41	88,23	69,98	53,71
80	98,93	94,51	86,68	67,83	51,61
90	98,59	93,45	84,93	65,52	49,41
100	98,13	92,18	82,96	63,04	47,11
110	97,54	90,66	80,72	60,39	44,71
120	96,75	88,84	78,19	57,54	42,20
130	95,71	86,67	75,33	54,49	39,58
140	94,34	84,09	72,09	51,22	36,84
150	92,53	80,99	68,43	47,72	33,97
160	90,14	77,30	64,29	43,97	30,98
170	86,99	72,89	59,61	39,94	27,84
180	82,83	67,63	54,31	35,63	24,57
190	77,35	61,34	48,31	31,01	21,15
200	70,10	53,83	41,53	26,06	17,57

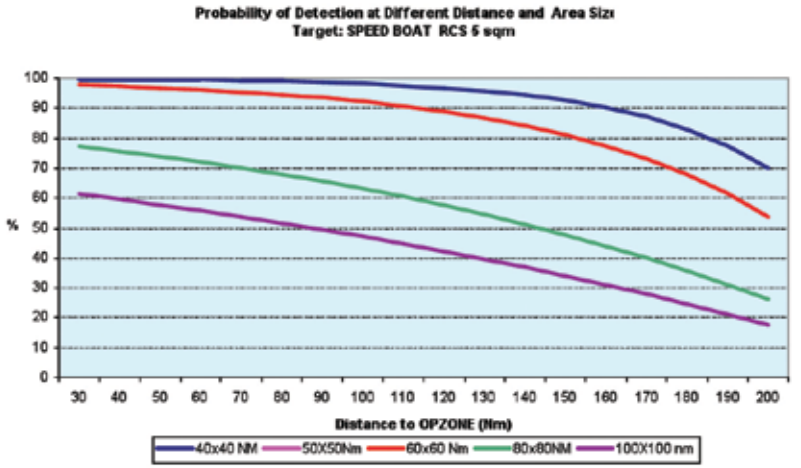


TABLE AND CURVES YACHT

Pleasure Yacht

EXPECTED TARGET RCS m2	OPZONE AREA Sqnm	OPZONE AREA Sqnm	OPZONE AREA Sqnm	OPZONE AREA Sqnm	OPZONE AREA Sqnm
10,00	1600	2500	3600	6400	10000
RANGE to OPZONE (Nm)	Prob. of Detection %	Prob. of Detection %	Prob. of Detection %	Prob. of Detection %	Prob. of Detection %
30	99,88	98,67	95,02	81,50	66,04
40	99,84	98,37	94,27	79,98	64,28
50	99,78	98,01	93,40	78,33	62,42
60	99,70	97,56	92,41	76,55	60,47
70	99,59	97,01	91,27	74,62	58,42
80	99,43	96,34	89,95	72,54	56,27
90	99,22	95,52	88,43	70,28	54,00
100	98,93	94,52	86,69	67,83	51,61
110	98,53	93,29	84,68	65,19	49,10
120	97,99	91,78	82,37	62,32	46,46
130	97,24	89,94	79,71	59,23	43,68
140	96,21	87,69	76,65	55,87	40,76
150	94,80	84,92	73,12	52,25	37,69
160	92,87	81,54	69,07	48,32	34,46
170	90,21	77,41	64,41	44,07	31,06
180	86,58	72,34	59,04	39,47	27,48
190	81,59	66,14	52,86	34,49	23,72
200	74,74	58,55	45,75	29,11	19,76

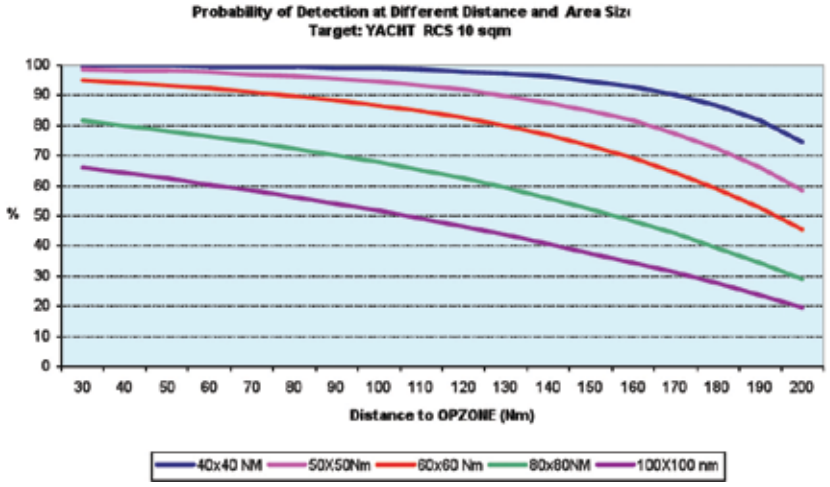


TABLE AND CURVES FISHING/PATROL BOAT

Fishing/Patrol Boat

EXPECTED TARGET RCS m2	OPZONE AREA Sqnm	OPZONE AREA Sqnm	OPZONE AREA Sqnm	OPZONE AREA Sqnm	OPZONE AREA Sqnm
100,00	1600	2500	3600	6400	10000
RANGE to OPZONE (Nm)	Prob. of Detection %	Prob. of Detection %	Prob. of Detection %	Prob. of Detection %	Prob. of Detection %
30	100,00	100,00	99,91	98,09	92,07
40	100,00	99,99	99,88	97,71	91,07
50	100,00	99,99	99,83	97,24	89,95
60	100,00	99,98	99,76	96,68	88,68
70	100,00	99,97	99,67	96,00	87,25
80	100,00	99,96	99,54	95,18	85,64
90	100,00	99,93	99,37	94,20	83,84
100	100,00	99,89	99,12	93,02	81,80
110	100,00	99,82	98,78	91,60	79,50
120	99,99	99,72	98,30	89,88	76,92
130	99,98	99,54	97,63	87,82	74,01
140	99,95	99,27	96,71	85,34	70,74
150	99,90	98,82	95,42	82,35	67,05
160	99,80	98,10	93,63	78,76	62,90
170	99,57	96,95	91,15	74,43	58,22
180	99,10	95,10	87,69	69,22	52,96
190	98,11	92,13	82,88	62,95	47,03
200	96,04	87,34	76,19	55,39	40,35

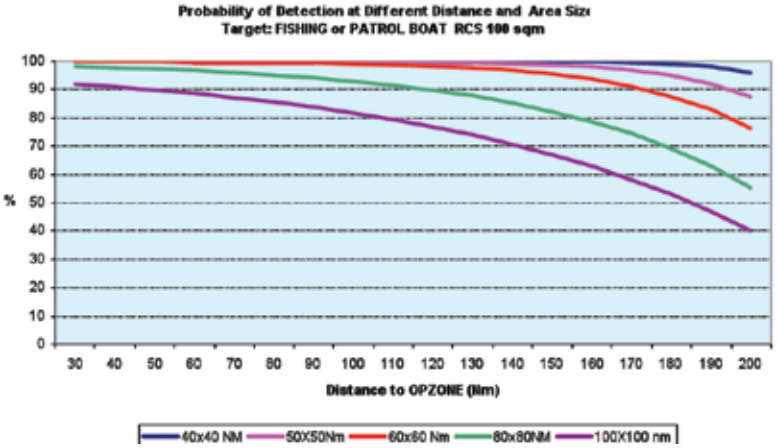


TABLE AND CURVES CARGO SHIP

Cargo Ship

EXPECTED TARGET RCS m2	OPZONE AREA Sqnm	OPZONE AREA Sqnm	OPZONE AREA Sqnm	OPZONE AREA Sqnm	OPZONE AREA Sqnm
10000,00	1600	2500	3600	6400	10000
RANGE to OPZONE (Nm)	Prob. of Detection %	Prob. of Detection %	Prob. of Detection %	Prob. of Detection %	Prob. of Detection %
30	100,00	100,00	100,00	99,73	97,74
40	100,00	100,00	100,00	99,65	97,30
50	100,00	100,00	99,99	99,53	96,78
60	100,00	100,00	99,99	99,38	96,15
70	100,00	100,00	99,98	99,19	95,41
80	100,00	100,00	99,97	98,93	94,51
90	100,00	100,00	99,95	98,59	93,45
100	100,00	100,00	99,92	98,13	92,18
110	100,00	99,99	99,86	97,54	90,66
120	100,00	99,98	99,77	96,75	88,84
130	100,00	99,97	99,63	95,71	86,67
140	100,00	99,94	99,39	94,34	84,09
150	100,00	99,87	99,01	92,53	80,99
160	99,99	99,73	98,37	90,14	77,30
170	99,97	99,46	97,34	86,99	72,89
180	99,91	98,90	95,64	82,83	67,63
190	99,74	97,77	92,86	77,35	61,34
200	99,20	95,45	88,31	70,10	53,83

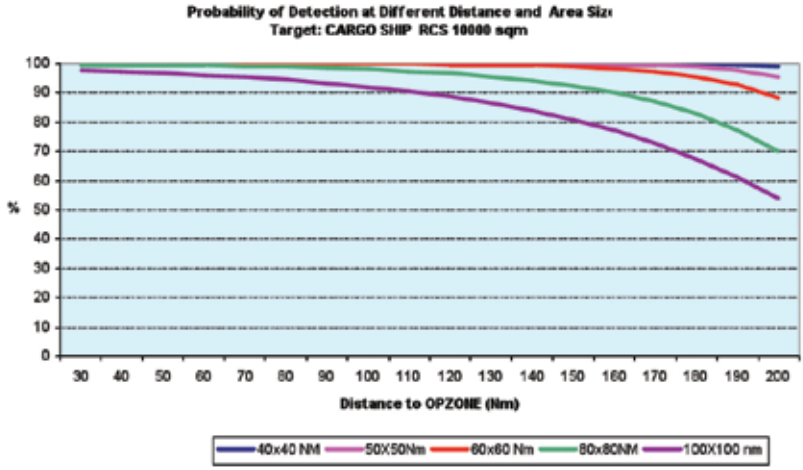
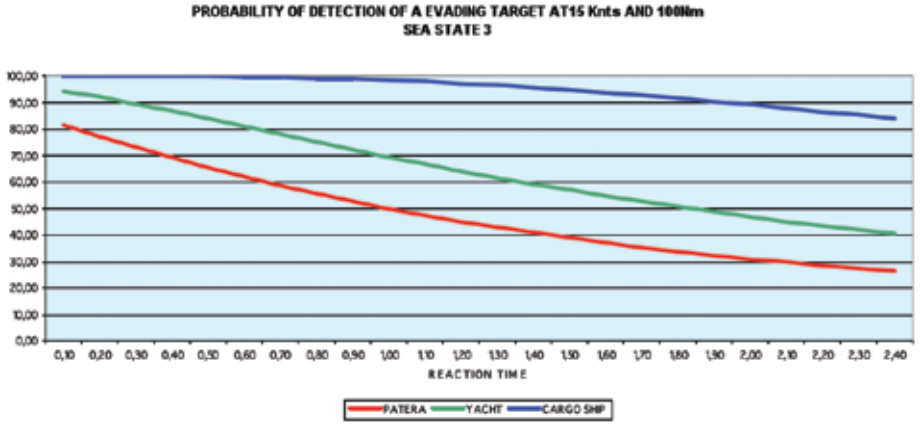


TABLE AND CURVES DIFFERENT EVADING TARGETS

Probability of detection of different evading targets and reaction times

DISTANCE to DATUM 100 NM		MAX. TARGET SPEED 15 KTS.			SEA STATE 3	
REACTION TIME Hrs	SMALL WOODEN BOAT	ZODIAC	SPEED BOAT	YACHT	FISHING BOAT	CARGO SHIP
0,10	81,31	82,37	91,92	94,31	99,88	100,00
0,20	77,15	78,30	89,08	91,98	99,73	99,99
0,30	73,09	74,30	86,04	89,40	99,48	99,96
0,40	69,19	70,43	82,89	86,63	99,11	99,91
0,50	65,47	66,72	79,71	83,75	98,60	99,83
0,60	61,95	63,21	76,53	80,83	97,93	99,70
0,70	58,64	59,89	73,40	77,89	97,10	99,50
0,80	55,54	56,78	70,35	74,98	96,13	99,23
0,90	52,64	53,86	67,40	72,12	95,01	98,87
1,00	49,92	51,12	64,56	69,34	93,76	98,42
1,10	47,39	48,56	61,84	66,64	92,40	97,88
1,20	45,03	46,16	59,24	64,04	90,93	97,24
1,30	42,82	43,93	56,76	61,54	89,38	96,51
1,40	40,76	41,83	54,40	59,14	87,76	95,68
1,50	38,83	39,87	52,16	56,84	86,08	94,76
1,60	37,03	38,04	50,03	54,64	84,36	93,77
1,70	35,34	36,32	48,01	52,55	82,61	92,69
1,80	33,77	34,71	46,09	50,55	80,85	91,56
1,90	32,28	33,20	44,28	48,64	79,07	90,36
2,00	30,89	31,78	42,55	46,83	77,29	89,11
2,10	29,59	30,45	40,92	45,10	75,52	87,81
2,20	28,36	29,19	39,37	43,46	73,76	86,48
2,30	27,21	28,01	37,89	41,89	72,03	85,12
2,40	26,12	26,90	36,50	40,40	70,31	83,74



TECNAM AVIATION

AIRBORNE TECHNOLOGIES

SELEX GALILEO

FLIR

Indra and Tecnam reserves the right to modify these specifications without prior notice.

Avenida de Bruselas, 35
28108 Alcobendas
Madrid (Spain)
P: + 34 914 805 000
F: + 34 914 805 057
indracompany.com

Henri Dunant, 21, 2º H
28036 Madrid (Spain)
P: + 34 913 458 506
F: + 34 913 458 506
tecnam@tecnamaviation.es
www.tecnammri.com