**RECONSURVE Exploitation Plan Document**

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Table of Contents

[1 SCOPE 4](#_Toc419705240)

[1.1 Confidentiality 4](#_Toc419705241)

[2 TERMINOLOGY 5](#_Toc419705242)

[2.1 ABBREVIATIONS 5](#_Toc419705243)

[2.2 Definitions 5](#_Toc419705244)

[3 RECONSURVE Results 6](#_Toc419705245)

[**3.1** **ASELSAN** 6](#_Toc419705246)

[**3.1.1** Extended Command and Control System 6](#_Toc419705247)

[**3.2** **SRDC** 9](#_Toc419705248)

[**3.2.1** Situational Awareness 9](#_Toc419705249)

[**3.3** **Institut TELECOM/ATOL** 11](#_Toc419705250)

[**3.3.1** Expert System for the Detection of Ship Abnormal Behaviour (shared property with Ecole Navale) 11](#_Toc419705251)

[**3.3.2** Interactive System for the Management of Ship Abnormal Behaviour Detection Rules (Hyperion) 12](#_Toc419705252)

[**3.4** **EVITECH** 13](#_Toc419705253)

[**3.4.1** Topic Auto-tracking algorithm 13](#_Toc419705254)

[**3.4.2** Topic Boat detection algorithm from a mobile camera 14](#_Toc419705255)

[**3.4.3** Topic Image selection and improvement 14](#_Toc419705256)

[**3.5** **GMT** 15](#_Toc419705257)

[**3.5.1** AIS and Situational Awareness Web Services 15](#_Toc419705258)

[3.6 Ecole Navale 17](#_Toc419705259)

[**3.6.1** Expert System for the Detection of Ship Abnormal Behaviour 17](#_Toc419705260)

[3.7 THALES 17](#_Toc419705261)

[**3.7.1** Planification algorithms 17](#_Toc419705262)

[**3.7.2** Target classification 17](#_Toc419705263)

[**3.7.3** Risks situational awareness 18](#_Toc419705264)

[3.8 GREYC 20](#_Toc419705265)

[**3.8.1** Vessel Recognition 20](#_Toc419705266)

[3.9 CASSIDIAN 21](#_Toc419705267)

[ANNEXE I. Patents 22](#_Toc419705268)

#  SCOPE

The objectives of this document are to list the exploitation of the technologies/solutions developed within the framework of the RECONSURVE Project.

The document presents all exploitable knowledge and project results, which are classified as knowledge having a potential for industrial or commercial application in research activities or for developing, creating or marketing a product or process or for creating or providing a service.

Patents aspects are also listed in the document.

## Confidentiality

The overview tables and the exploitation plan are provided in the annexes to ITEA2 as exploitation results, the rest of the document is considered as CONFIDENTIAL, releasable only to RECONSURVE partners.

# TERMINOLOGY

## ABBREVIATIONS

C2 Command and Control

EO Electro Optic

GIS Geographical Information System

IR Infra Red

N/A Non Applicable

UAV Unmanned Air Vehicle

TBC To Be Completed

TRL Technology Readiness Level

VTS Vessel Trafic System

## Definitions

# RECONSURVE Results

RECONSURVE has developed and integrated a number of features as follows:

* UAV routing algorithms to make the surveillance operation cost-effective, autonomous UAV mission planning,
* Safe navigation management architecture principles for UAVs.
* Image enhancement algorithms
* Vessel detection, classification and tracking algorithms
* Integration of the whole chain of classification and processes from airborne video sources
* Decision level data fusion based on radar, EO/IR and GIS information
* Suspicious behaviour detection based on configurable and flexible rules created by Rule Editor.
* Maritime Situation Awareness Ontology as the reference information model for sea border surveillance
* Real-time unified situation picture through high level semantic reasoning and inference
* Decision Support tools with self learning capabilities for automatic decision making and risk assessment
* AIS-integrated chart system based on electronic charts
* Interoperability layer by using a Web service based architecture and a common situation awareness ontology.
* VATOZ Command and Control (C2) system development.

## **ASELSAN**

### Extended Command and Control System

In scope of RECONSURVE project ASELSAN improved and extended VATOZ C2 system. In this project, ASELSAN integrated Surveilleance Radar and AIS sensor to VATOZ Sensor Management System. After integration of new set of sensors, VATOZ C2 system accurately identifies ship types and tracks the vessels. Not only new set of sensors, but also Situational awareness component and Semantic Interoperability layer are also integrated to VATOZ C2 system. With the integration of these features, detecting and identfiying suspicious behavior and also covering the wide area see borders can be possible in maritime domain. Furthermore vessel recognition method and modulde developed in RECONURVE project is also integrated to C2 system. By this way VATOZ C2 system has additional information related with vessels even if AIS signal is not available.

#### Technical evaluation

Vessel classification for civilian ships on IR images recorded by UAV is challenging problem in maritime domain. Silhouettes, i.e. the bounding contours of planar shapes, provide fundamental information in representing object properties. Especially in imaging environments, where the level of detail and/or texture is low, silhouettes become the only source of information for object recognition purposes. By using automatic or semi-automatic segmentation methods, the bounding contours of an object can be segmented and the extracted silhouette can be used to classify the object. For this purpose, a scale (resolution) and rotation invariant representation of the silhouette is essentially required. Most studies on transform invariant representation of planar curves refer to the pioneering stuides of H. Asada and M. Brady [[[1]](#footnote-1)] and F. Mokhtarian and A. Mackworth [[[2]](#footnote-2)]. In H. Asada and M. Brady the concept of scale-space filtering is used to extract primitives over the curve and the primitives are parsed in a tree for a global representation of the silhouette. F. Mokhtarian and A. Mackworth define the curvature scale-space (CSS), in which absolute curvature zero crossings (or extrema) within the Gaussian scale space of the curve is sought and represented in a scale-space image. The CSS representation has been selected as a contour shape descriptor for MPEG-7 standardization as well F. Mokhtarian and M. Buber [[[3]](#footnote-3)]. As an attempt to fuse the two methods, behavior of corner models in CSS are examined and selected corners are transformed into a tree organization in A. Rattarangsi and R. T. Chin. [[[4]](#footnote-4)]. These methods provide means for globally representing the silhouette invariant of scale and resolution. However their matching algorithms become inefficient and cumbersome when starting point (over the silhouette) or rotation invariance is required. Instead of finding a general representation of the silhouette, the succeeding studies on scale-invariant curvature representation usually deal with detecting corners on curves. F. Mokhtarian and R. Suomela [[[5]](#footnote-5)] extract CSS corners from both gray level images and planar curves, by fusing canny edge detectors with the CSS method. In B. K. Ray and R. Pandyan [[[6]](#footnote-6)], although a scale-space search is avoided, an adaptive smoothing technique is proposed for detecting the scale of the corner. B. Zhong and W. Liao [[[7]](#footnote-7)] examine the behavior of Γ, END and STAIR corner models in their proposed direct curvature scalespace (DCSS), from which they extract DCSS corners and construct a global tree representation. This method is later corrected in B. Zhong, K.-K. Ma, andW. Liao [[[8]](#footnote-8)] by taking into account the effect non-uniform shrinkage of a planar curve along the scale axis. X. C. He and N. H. C. Yung [[[9]](#footnote-9)] define a mathematical measure for roundness of a corner and in an attempt to improve CSS corners, they fuse their corner detection method with canny edge detectors and find sharp corners on images and planar curves. Inspired by D. Lowe [[[10]](#footnote-10)], X. Zhang, H.Wang, M. Hong, L. Xu, D. Yang, and B. C. Lovell. [[[11]](#footnote-11)] detect corners based on the scale evolution difference of planar curves. All these methods focus on detecting corners, which is a reasonable approach since corners are repeatable, robust and efficient features. However forcing an algorithm to detect corners restricts us to find only the sharp changes over the curve. Silhouettes do not necessarily possess sharp corners. For instance, an object silhouette extracted from an infrared image by using activecontours based methods [[[12]](#footnote-12), [[13]](#footnote-13), [[14]](#footnote-14)], may possess merely round corners depending on the optimization technique used.

In RECONSURVE project, a novel transform invariant silhouette representation and feature detection algorithm was developed. Transform invariant features are extracted from the difference of curvature scale-space (DoCSS). Inspired by both [[[15]](#footnote-15)] and [5], octaves of the curvature scale space are constructed and for each octave level, absolute curvature values are calculated. The extrema within DoCSS are located as features after a sub-pixel refinement on the curve and the scale axis, using a quadratic Laplacian approximation method similar to [15]. Orientations of the features are also calculated according to their positions and scales. As a result, features with position, scale and orientation information are extracted from the silhouette. Furthermore, using the extracted features, a silhouette feature histogram (SFH) representation, which encapsulates the positions, scales and orientations of all the features, is proposed. The representation is a depth image where feature positions and scales are transformed into bins (pixel positions), feature orientations are transformed into color and feature quantities are represented as depth. The proposed representation is scale and resolution invariant. Moreover, it is transformable under planar rotations, that is to say, rotation angle between the silhouettes of a rotated object can be computed by using the SFH images.

#### Gap between the development and a future commercial product

Ship recognition module depends on the algotihm and image database. There are massive numbers of civilian ships all over the world. For commercial ship recognition product, image database needs to be improved and includes different civilian ship types. By this way the classification success will be improved.

#### Exploitation plan

ASELSAN is the largest electronics integrator in Turkey and serves in the defence and homeland security market. ASELSAN also has extensive knowledge and experience in developing sensor, surveillance systems and platforms. ASELSAN is planning to use the results of this project to improve its current portfolio with new features and capabilities. RECONSURVE enhanced VATOZ®, which is sensor management product-line, with unmanned airborne system integration, situational awareness capability and new smart decision support functionality based on image processing and behavioural analysis. ASELSAN expects that these functionalities place the company to a leading position for future business opportunities in maritime surveillance, homeland security and wide area surveillance domain in Turkey.

ASELSAN is also well positioned to expand their business in the maritime surveillance market. There are also huge global opportunities, such as, the Brazilian SysGAAz program, which has $4 billion budget. ASELSAN is plannning to extend RECONSURVE Project to satisfy SysGAAz program requiremenets. An additional $1 billion opportunity exists for the maritime surveillance of the Arctic region, which is expected to be materialized in the coming decade.

#### Start-up & Spin-off

No start-up and spin-off company is planned as a result of RECONSURVE project in near future.

#### Patents

|  |  |  |
| --- | --- | --- |
| **Name** | **Date** | **Type of Application and****Number** |
| System and Method for Estimating Target Size | 12 December 2011 | InternationalPCT/IB2011/055618 |
| System and Method for Identifying Scale Invariant Features of Object Outlines on Images | 27 February 2012 | InternationalPCT/IB2012/050883 |
| System and Method Fof Describing Image Outlines | 01 April 2013 | InternationalPCT/IB2013/052598 |
| Method for Describing Planar Curves Using Morphological Scale Spaces  | 10 January 2014 | InternationalPCT/IB2014/058172 |

## **SRDC**

### Situational Awareness

In the scope of RECONSUVE project, the commercially viable product developed by SRDC is the Situational Awareness Component. This component decides whether a vessel is suspicious or not, by executing situational awareness rules based on DROOLS rule engine. To be more specific, the component receives track information from VATOZ command and control system (developed by ASELSAN) and then collects information about these tracks from both available Internet web sites such as Equasis.com, MarineTraffic.com, AISHub.com, VesselFinder.com and available national vessel databases (such as Port Management Information System of Maritime Affairs of Turkey and Turkish Coast Guard Database). After that executes the situational awareness rules on the collected data and if the vessel is identified as suspicious send alert information to the corresponding command and control systems including VATOZ.

#### Technical evaluation

The developed Situational Awareness Component communicates with Command and Control systems based on standards. And this allows the system to be able to talk with any command and control system. This ability of the component is also proved in the scope of RECONSURVE project. The Situational Awareness Component is able to talk both with VATOZ of ASELSAN and SecuriSyte of CASSIDIAN. Furthermore, the situational awareness rules used in the Situational Awareness Component is not hard coded. They are developed by DROOLS open source rule engine and necessary tools have been developed to configure these rules for cetain situations. It is also possible to add new rules to the Situtational Awareness Component. In this respect, the developed system is both generic and extensible.

#### Gap between the development and a future commercial product

The technical evaluation of the Situtational Awareness Component is performed in the scope of RECONSURVE Project and obtained good results. Detailed test results are presented in D7.6.1 and D7.6.2. Furthermore, the system is tested in real-life settings in the Turkish Coast Guard premises in Antalya, Turkey. Therefore, the current version of the system can be regarded as a commercial product. The following further actions should be performed thogh:

* Code analysis and optimization
* Code documentation
* Further tests

#### Exploitation plan

The main exploitation of the Situtational Awareness Component is planned to be performed in Turkish Coast Guards. Especially the integration of Situtational Awareness Component with the Port Management Information System of Maritime Affairs attracted their attentions. The explotation plan in this direction will be mainly carried out in 2015-2016.

In addition to this, this tool will be used for other projects in other domains such as EmergencyManagement and Sensor Management. What should be further done in these projects is to extend the rule set used. In this way, Situtational Awareness Component's customer base will increase. In this exploitation point, the timeline is 2015-2017.

#### Start-up & Spin-off

SRDC Ltd is already a spin-off of the Software Research and Development Center of Middle East Technical University.

#### Patents

During the course of RECONSURVE project, a patent application has not been realized. However, after the system becomes more mature, a patent application will be done.

## **Institut TELECOM/ATOL**

### Expert System for the Detection of Ship Abnormal Behaviour (shared property with Ecole Navale)

#### Technical evaluation

The expert system was developed jointly with Ecole Navale for the detection of ship abnormal behaviour based on RADAR, AIS and geographical data is in a prototype state. It has proven its capacity to provide efficient rule-based and both data-driven (statistical analysis) and human-driven abnormal behaviour detection on significant use-cases, yet not on a wide scale and in a totally realistic operational context. Therefore, one main activity still has to be conducted before it can be used as a component of an operational maritime surveillance system and proposed as a commercial product: the evaluation of its capacity to fulfill operational needs in a realistic context of use. This should be partially done before the end of the RECONSURVE project with the participation of operational end-users, but may also require additional evaluation that is out of the scope of a R&D project and might be performed after the end of the project with the help of the industrial partner of ATOL, namely Thales Airborne Systems.

#### Gap between the development and a future commercial product

The expert system being in a prototype state, its industrialization still has to be done before it can be integrated in a commercial solution. This industrialization is foreseen to be done by Thales Airborne Systems if the operational evaluation of the system proves that it is successful.

#### Exploitation plan

The plan for exploitation of the expert system is the following:

* Perform the operational evaluation with end-users in realistic context of use:
	+ Actor: Institut Telecom with the help of Thales Airborne Systems and the participation of end-users, the French Navy for exemple;
	+ Schedule: within 1 year maximum after the end of the project;
* Establish an exploitation agreement (licensing or else) between Ecole Navale, Institut Telecom and Thales Airborne Systems;
* Perform the insutrialisation of the expert system:
	+ Actor: Thales Airborne Systems;
	+ Schedule: from 1 to 4 years after the end of the project;
* Propose the expert system as a component of Thales Airborne System’s maritime surveillance systems product line:
	+ Actor: Thales Airborne Systems;
	+ Schedule: within 3 to 5 years after the end of the project.

An alternate exploitation plan would be to charge another company to industrialise the expert system under the appropriate exploitation agreement.

Additionally, the theoretical principles on which the expert system is based will be used by Ecole Navale mainly and possibly Institut Telecom for further research and teaching purposes. The appropriate agreements will be defined between Ecole Navale and Institut Telecom to make this possible.

#### Start-up & Spin-off

Not applicable as the expert system cannot be sold alone and needs to be integrated in a complete maritime surveillance solution.

#### Patents

Not foreseen.

### Interactive System for the Management of Ship Abnormal Behaviour Detection Rules (Hyperion)

#### Technical evaluation

The tabletop HMI for the management of ship abnormal behaviour detection rules (called Hyperion) is in a prototype state. Connected to a rule-based expert system for ship abnormal behaviour detection (see 3.3.1 above), it has proven to be appropriate and intuitive for the operational use of such a system, yet not in a totally realistic operational context. Therefore, one main activity still has to be conducted before it can be used as a component of an operational maritime surveillance system and proposed as a commercial product: the evaluation of its capacity to fulfill operational needs in a realistic context of use. This should be partially done before the end of the RECONSURVE project with the participation of operational end-users, but may also require additional evaluation that is out of the scope of a R&D project and might be performed after the end of the project with the help of the industrial partner of ATOL, namely Thales Airborne Systems.

#### Gap between the development and a future commercial product

The tabletop HMI being in a prototype state, its industrialization still has to be done before it can be integrated in a commercial solution. This industrialization is foreseen to be done by Thales Airborne Systems if the operational evaluation of the HMI proves successful.

#### Exploitation plan

The plan for exploitation of the tabletop HMI is the following:

* Perform the operational evaluation with end-users in realistic context of use:
	+ Actor: Institut Telecom with the help of Thales Airborne Systems and the participation of end-users, the French Navy for exemple;
	+ Schedule: within 1 year maximum after the end of the project;
* Establish an exploitation agreement (licensing or else) between Institut Telecom and Thales Airborne Systems;
* Perform the insutrialisation of the HMI:
	+ Actor: Thales Airborne Systems;
	+ Schedule: from 1 to 3 years after the end of the project;
* Propose the HMI together with a ship abnormal behaviour detection system as a component of Thales Airborne System’s maritime surveillance systems product line:
	+ Actor: Thales Airborne Systems;
	+ Schedule: within 3 to 5 years after the end of the project.

Additionally, the theoretical principles on which the HMI is based will be used by Institut Telecom for further research and teaching purposes.

#### Start-up & Spin-off

Not applicable as the HMI cannot be sold alone and needs to be coupled with a ship abnormal behaviour detection solution.

#### Patents

Not foreseen.

## **EVITECH**

In the RECONSURVE project framework, inside the integration corpus software, used to integrate our works with other partners, we have developed several video analytics software innovative functions:

* an auto-tracking algorithm for boat tracking,
* a boat detection algorithm, from a mobile camera, for detectin of a boat from the UAV camera images,
* image selection and improvement techniques, in order to provide the best information for the classification algorithms.

The exploitation evaluation has been made by the company which has developed each component / topic.

### Topic Auto-tracking algorithm

The auto-tracking algorithm was developed at the beginning of the project. It is completely new software. It was deployed by THALES on the Croatia/Bosnia maritime border for boat moves surveillance, in the framework of European Community supported contract.

#### Technical evaluation

The software was evaluated positively since it succeeded in being validated by THALES and by the final customer. It starts from a detection initialization from a third party mean (e. g. a radar, in Coratia, or the boat detection algorithm, in the Reconsurve project), and then starts the drive of the dome PTZ engines in order to maintain the boat in the middle of the image, as long as it is possible.

#### Gap between the development and a future commercial product

The development is already used for a commercial use.

#### Exploitation plan

We intend to propose this algorithm inside our Jaguar product. However, maritime surveillance contracts are really difficult to address for a SME, and thus we will work with large integrators or camera builders in order to propose it.

#### Start-up & Spin-off

Not applicable.

#### Patents

Software : not applicable.

### Topic Boat detection algorithm from a mobile camera

The auto-tracking algorithm was developed in the second year of the project. It is completely new software. It was tested by AIRBUS on videos taken from a UAV, for a few hours of tests, for early boat detection over the sea (when the UAV begins to have visibility on the boat, while it is still small), in the framework of the RECONSURVE project.

#### Technical evaluation

The software was tested positively over these videos. It operates in real time, and detects all the incoming boats after a few seconds. If the coast is visible with structured buildings, it raises a few false alarms, but this case is not difficult to eliminate, using the absolute coordinates of the detection and matching it with the maps to eliminate all water emerged objects: coast, islands, and even rocks.

#### Gap between the development and a future commercial product

Real time version of this algorithm was developed and validated over several detections. It now requires more extensive tests to establish performance more largely. We can also port it on our ready-to-embed card (5 Watts, 75 grammes) in order to provide an UAV embedabble function.

However, this will only be done with UAV operators (small market).

#### Exploitation plan

We intend to propose this algorithm as a stand alone product. Maritime surveillance contracts are really difficult to address for a SME, and thus we will work with large integrators or camera builders in order to propose it.

#### Start-up & Spin-off

Not applicable.

#### Patents

Software : not applicable.

### Topic Image selection and improvement

Several image selection and improvement techniques have been proposed and prototyped in the framework of the project, based on image size selection, image contrast improvements, and super-resolution techniques.

The principles consisted into providing the best images to the classification algorithm, and to check how were the results in order to see if the improvements brought better information for classification as random images.

#### Technical evaluation

If the selection of higher resolution images from initial boat detection was somehow self-evident because of the classification techniques, which require an information level as rich as possible in order to classify image, the image contrast improvement demonstrated almost no result on the classification algorithms. However, images looked more readable from a human eye, but this was no use on the classification process.

With naked eyes, looking at the x2 super-resolution images, we could hardly observe improvements. Super-resolution of very small targets, for example, does not go to a resolution level where the boat inscriptions could be readable over super-resolved images while ti would not be readable on the source images (the boat is too small). Even if the resolution is better, it is difficult to describe the improvements. However, the super-resolution algorithms demonstrated a slight improvement, with better classification, and improvement of the classification rates in a large majority of cases. The software was evaluated positively by GREYC, since it succeeded in classifying better and sometimes correctly boats that unless should not have been classified as correctly.

#### Gap between the development and a future commercial product

The development is still a prototype. The super-resolution algorithm requires a number of matrix inversion steps that was set manually and would require more extensive tests and automation. It is a long process requiring sometimes several minutes (especially when the image is big). However, we expect to develop it in the framework of future UAV programs in coordination with large companies such as AIRBUS.

#### Exploitation plan

We intend to propose this algorithm to large UAV builders and operators.

#### Start-up & Spin-off

Not applicable.

#### Patents

Software : not applicable.

## **GMT**

### AIS and Situational Awareness Web Services

In scope of RECONSURVE project GMT developed AIS system and Situational Awareness web services such as Smuggling, Area Analysis, Collision Detection, Sailing Patern Analysis.

#### Technical evaluation

The developed prototype’s system functionality and performance is planned to be validated the at the user test bed.

#### Gap between the development and a future commercial product

| **No** | **Requrements** | **Current** | **Future** |
| --- | --- | --- | --- |
| 1 | S-57 ENC overlay | Applied | Planned |
| 2 | AIS integration | Applied | Planned |
| 3 | land + satellite map overlay | Applied | Planned |
| 4 | collision prediction analysis | Applied | Planned |
| 5 | dangerous area analysis  | Applied | Planned |
| 6 | traffic zone / route analysis | Applied | Planned |
| 7 | sailing pattern analysis | Applied | Planned |
| 8 | mobile application service | Applied | Planned |
| 9 | alerting function | Applied | Planned |
| 10 | radar overlay | Not applied | Planned |
| 11 | VHF-DSC function | Not applied | Planned |
| 12 | weather sensor integration | Not applied | Planned |
| 13 | CCTV integration | Not applied | Planned |
| 14 | port in/out management | Not applied | Planned |
| 15 | S-100, 101 overlay | Not applied | Planned |
| 16 | 3G/LTE, UHF communication integration | Not applied | Planned |

#### Exploitation plan

Korea Coast Guard has upgraded vessel monitoring system to intelligent surveillance system starting from 2011 and some of technology regarding situational awareness has been applied. KCG will invest in the development of analyzing big data based on ship position information.

Ministry of Oceans and Fisheries aimed to build e-Navigation implementation roadmap in 2014 and will build related systems until 2018. Thus, they focuse on the work for funding and we expect a lot of project regarding intelligent surveillance.

V-PASS project is ongoing to develop and install navigational equipment for small vessels. This system can be integrated with other sensors such as AIS, Radar etc and we expect additional project for preventing ship accidents at sea.

#### Start-up & Spin-off

Economical and environmental damage can be reduced through preventing ship accidents at sea. There is big demand to upgrade most of VTS systems in Korea, which is supplied by Foreigne Company. Thus, GMT expects more than 10 million dollars for export substitution effect through commercialization.

#### Patents

A patent regarding situational awareness system will be applied.

## **Ecole Navale**

### Expert System for the Detection of Ship Abnormal Behaviour

Reference to **Section 3.3.1** Ecole Navale and Institut TELECOM/ATOL collaborated for this topic.

## **THALES**

### Planification algorithms

The chosen model is the one of the shortest-path in a free space but with additional constraints and the addition of a coverage problem with a embedded sensor. The drone has to go from the first area to the last one and cover all the mission areas in sequence with the sensor. This path has to avoid restricted areas. The transit between the missions’ areas has to be the shortest and the coverage of one areas has to reduce the number of “turns” of the drone. The chaining of the missions areas has to minimize the late for the mission’s start. To solve these problems, Thales has develop a combination of Dijkstra and cellular Boustrophédon algorithms.

#### Technical evaluation

First tests of the planification algorithm have been conducted showing that the time to compute the routes needed for French scenarios are lower than one second. We are confident in the fact that such algorithm can work in real Thales’ cases

#### Gap between the development and a future commercial product

The current version of the planification algorithm is TRL 5. That means that we need some more work to test it, and improve if needed, on real data sets in real environment. Moreover, after this phase, an industrialization phase will be needed to raise the TRL. We can expect integrate this algorithm in Thales products in 2-3 years.

#### Exploitation plan

Reference to **Section 3.7.3.3**

#### Start-up & Spin-off

No Start-up nor Spin-off

#### Patents

No patents

### Target classification

Thales has started new task on target classification by getting the video corpus from Cassidian and extracting images for analyzing the data. This first study reveals that the quality of the images and the number of images per class was too reduced to be able to expect good results on target classification. Thales then exchanged findings with the GREYC in order to work on the same data corpus, consisting in five classes of boats with several subclasses each. This dataset was gathered in RECONSURVE by the GREYC and shared with Thales.

#### Technical evaluation

First tests on our internal algorithm based on spiking neural networks shows very poor results on the image data base provided by the GREYC.

For this task, Thales is currently testing spiking neural networks algorithms for unsupervised (non-labelled) classification of maritime targets. The unsupervised learning method is based on Spike-Timing Dependent Plasticity which considers the relative timing of spikes in order to strengthen or weaken synaptic connections between neurons in the network and thus provide a form of clustering leading to class-specialized output neurons. At the moment spikes are generated based on luminance in the original images. Initial tests indicate however that even though the database provided by GREYC is much larger than the acquired CASSIDIAN database in terms of number of learning examples, still intra-class and inter-class variability represent the main hurdle for this kind of unsupervised algorithms. Such algorithms usually rely on a large number of similar learning examples in order to automatically extract patterns. Our tests show that one neural layer is not enough in order to classify such a database with acceptable performance in the absence of extensive image pre-processing such as contours or interest points detection, segmentation, etc. Therefore, the current estimated TRL of this algorithm is TRL 2.

#### Gap between the development and a future commercial product

The neural networks algorithm will need more research efforts before reaching TRL 3 or 4 for this kind of application. The gap until a future commercial product is estimated to about 5-7 years.

#### Exploitation plan

Reference to **Section 3.7.3.3**

#### Start-up & Spin-off

No Start-up nor Spin-off

#### Patents

No patents

### Risks situational awareness

Thales has continued the work on algorithms developments and tests for risk evaluation, forecasting and alerting. The risk model developed previously has been tested over simulated maritime traffic and field-acquired traffic to test its efficiency and calibrate its parameters to ensure robustness to various maritime situations. The set of criteria and measures that has been defined before to describe the behaviour and detect specific events have been checked regarding the scenario designed for French demonstration. The algorithms have been under implementation and will be tested on the defined scenario for the RECONSURVE demonstration.

In a second time, Thales has worked on first version of algorithms to detect a threat but with a view centered on the sheep rather than looking at the global situation. This second approach can complement the first one by providing a threat level specific for the ship commander in order to help “decide and react” regarding the threat. On the reaction side, Thales is also working on optimization algorithms to better design the answer to be proposed in front on a threat.

#### Technical evaluation

The risk model developed in previous periods has been tested over simulated traffic and field-acquired traffic to test its efficiency and calibrate its parameters to ensure robustness to various maritime situations. These tests did allow a preliminary validation for situations identified as of interest, and tests need to be repeated with real data to ensure that this algorithm can provide good results and that the models are generic enough to be reused in a close context without too much configuration work.

#### Gap between the development and a future commercial product

The current version of the risks algorithms is typically TRL 4. That means that we need some more work to test it, and improve if needed, on real data sets in real environment. Moreover, after this phase, an industrialization phase will be needed to raise the TRL. First on-site tests have been scheduled, and we expect that this algorithm can be implemented in a Thales product in 3-4 years.

#### Exploitation plan

Thales is a world leader for mission critical information systems, with activities in three core businesses: aerospace, defense, and security. It employs 68000 people worldwide (50 countries). It provides its customers with all the key functions in the critical information loop, from detection and processing to transmission and distribution. Thales develops its strategic capabilities in component, software and system engineering and architectures through its R&T organization.

Focusing on the RECONSURVE project, Thales is a major player in surveillance & C2 systems, and the emergence of UAV market will significantly impact manned air vehicle, with the emergence of new players providing UAV based avionics for manned air vehicle. Mastering UAV avionics in order to consolidate current position in manned air vehicle in their exploitation in surveillance system is of utmost importance for Thales. The results of the project will in particular pave the way for Thales to new Navigation Management System for UAVs guaranteeing certification and safety as required for mission in general air traffic, and to the integration of robust and novel algorithms in Thales decision support systems.

Research done in RECONSURVE will follow an internal de-risking process in collaboration with production units, with the goal of embedding the algorithms in future software products. Targeted products especially include maritime surveillance solutions, aircraft routing services.

The current plan for planification algorithms and for risk situational awareness is to transfer these activites and knowledge to a collaboration between the research center TRT and one or multiple Thales Business Units in order that they evaluate if these algorithms and model can go higher in the TRL, until 6. If this phase is successful, the next one will be a full transfer to one or more Thales Business Lines to industrialize the results inside a Thales product for proposing to our clients.

#### Start-up & Spin-off

No Start-up nor Spin-off

#### Patents

No patents

## **GREYC**

### Vessel Recognition

In RECONSURVE, GREYC have been developping an automatic tool that is able to recognize boat categories in images. The project partners have defined a list of 5 main boat categories and 12 boat sub-categories, and the goal is to predict if any boat of one of these 17 categories is present in the image. A second task consists of assessing whether a given attribute is present or absent in a given boat, by analyzing the image, given as probability of presence/absence of the attribute. In this context, we defined a list of 19 attributes that have been identified.

In order to quantify our recognition performances, classification/detection errors must be computed from an annotated database. Thus, the first work we constructed image database for each of the defined categories. The database contains 5303 images. Annotators identified the boat categories and they localized each boat with a bounding box. In addition, they localized the attributes with bounding boxes and they filtered the images (redundancy, formatting, etc).

#### Technical evaluation

Regarding the boat category recognition, the developed approach consists of extracting local dense features, encoding the images, and finally uses a classifier to compute a category probability. Classification performances are given in terms of confusion matrices. The main result that must be emphasized is that in the best scenario we are able to distinguish the 5 boat categories with 7% mean error.

Regarding attribute detection, the proposed method is based on both encoding and classifying random windows in the region of interest. The probability of a given attribute is directly related to the random window classification. We decided to measure the detection performance in terms of ROC curves.

#### Gap between the development and a future commercial product

The developped technology cannot be a product in itself (it can be a component of a commercial product), and for this reason it is difficult to characterize the gap between the development and a future commercial product. One way to improve the performance and hence to get closer to a product would be to take several images of the target and combine the different images (different viewpoints).

#### Exploitation plan

We intend to continue the develpment of the developped technology during new projects involving industrial partners (e.g. EVITECH).

#### Start-up & Spin-off

Not foreseen.

#### Patents

Not foreseen.

## CASSIDIAN

Cassidian has not provided any input fort his document.

1. Patents

|  |  |  |
| --- | --- | --- |
| **Patents PENDING (first issue)** | **Patents GRANTED (first issue)** | **Do you want give details of these patents ?** |
| System and Method for Estimating Target Size |  |  |
| System and Method for Identifying Scale Invariant Features of Object Outlines on Images |  |  |
| System and Method Fof Describing Image Outlines |  |  |
| Method for Describing Planar Curves Using Morphological Scale Spaces  |  |  |

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