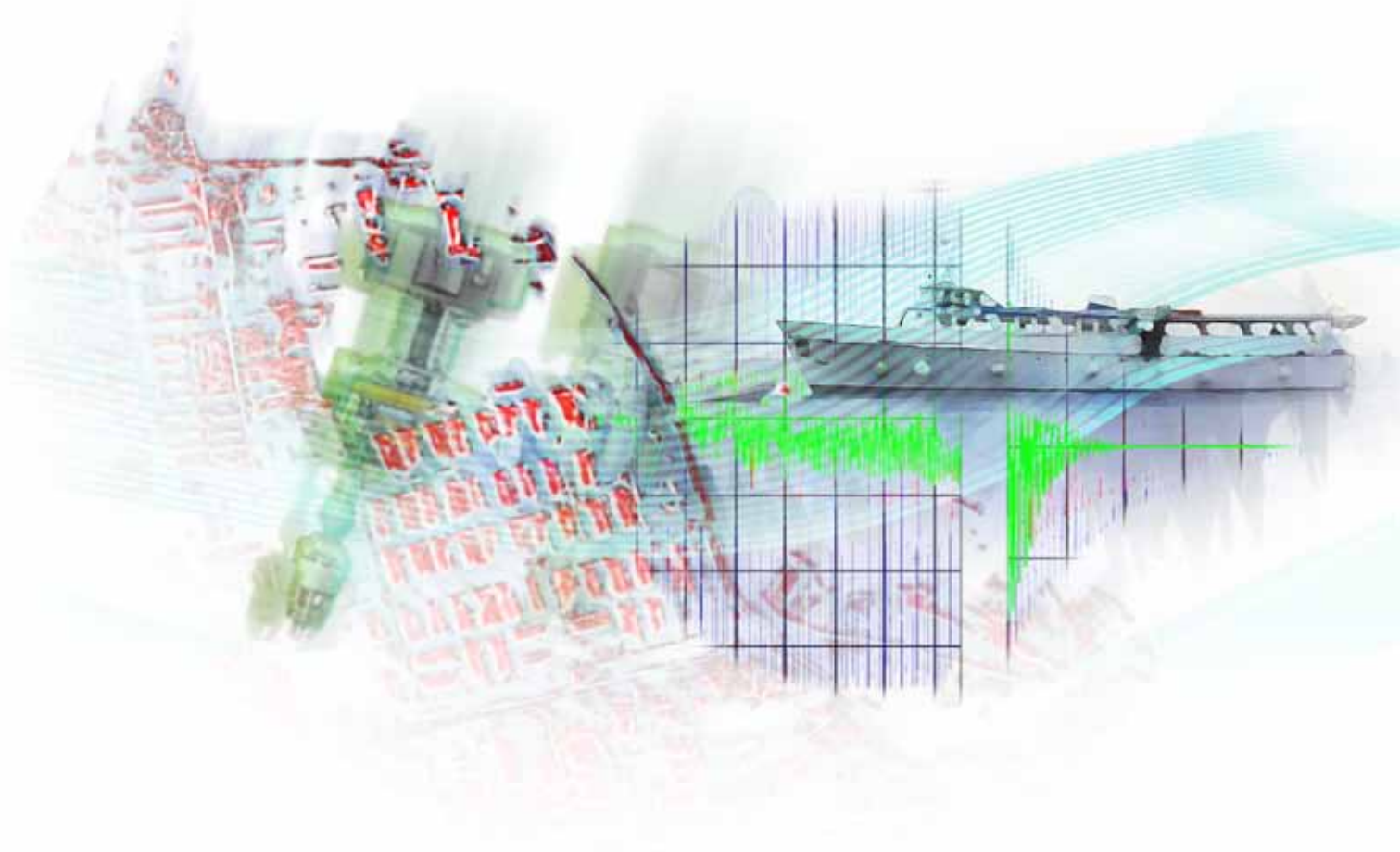
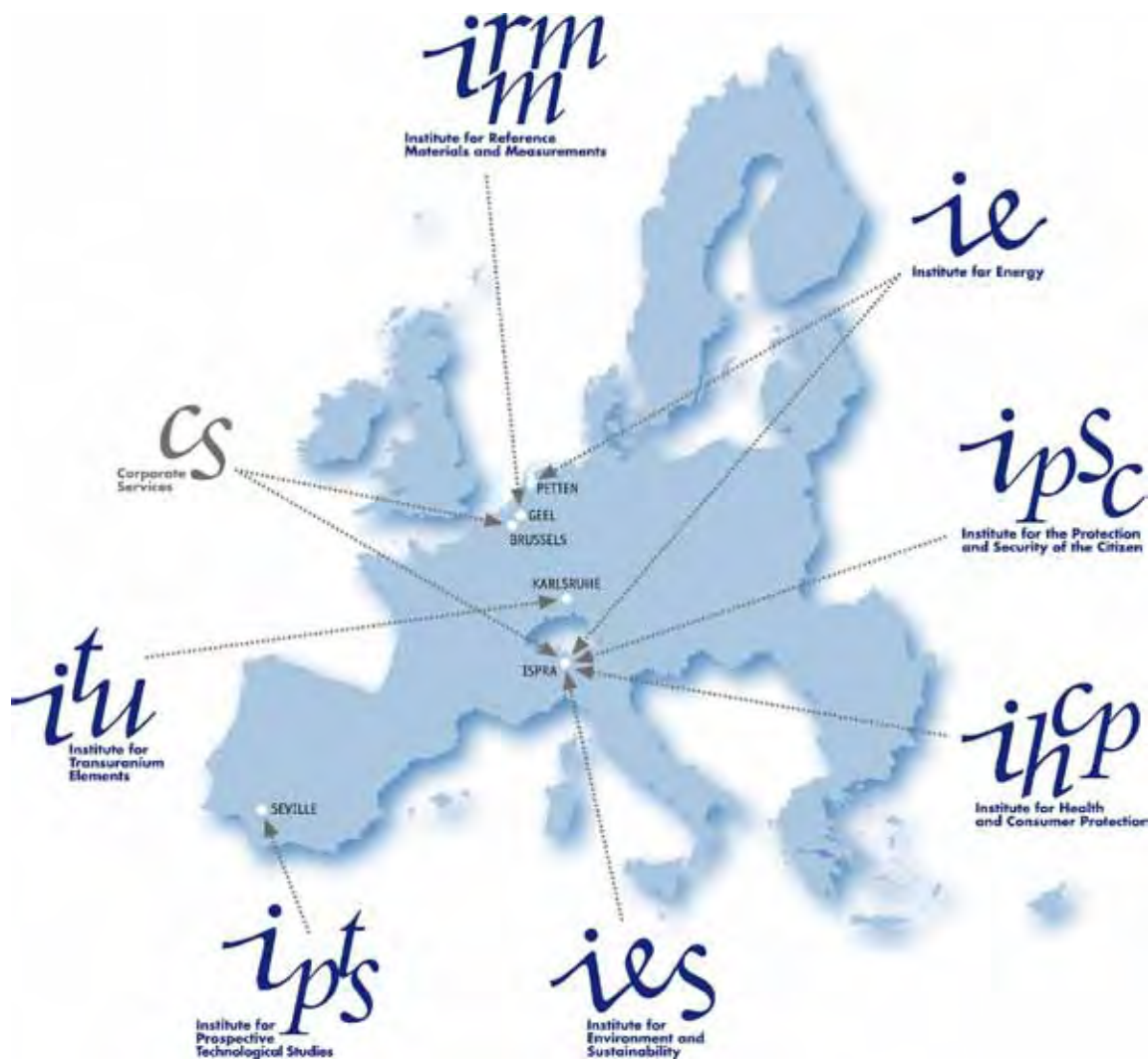


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Institute for the Protection
and Security of the Citizen



EXPLORATORY RESEARCH
PROJECTS 2 0 1 0



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IPSC Mission

The mission of the IPSC is to provide research results and to support EU policy-makers in their effort towards global security and towards protection of European citizens from accidents, deliberate attacks, fraud and illegal actions against EU policies.

EXPLORATORY RESEARCH
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Foreword

It is once again a pleasure to introduce the IPSC Exploratory Research Brochure.

2010 was a particularly successful year for the programme. Two patent applications, three papers and a Framework Programme proposal have been produced, just in the first or second year of the projects, from less than 80 man months of staff time and less than 275k€ specific credits.

Five of the eight projects are applications of remote sensing and imaging and three are in civil, mechanical and communications engineering, reflecting the core technical skills of the Institute.

The projects are relevant to policy support in the areas of emergency and post-disaster recovery, public safety and law enforcement, including a new departure on labour-law enforcement in agriculture. In general, the policy applications are relevant both within the Union and in external aid and cooperation.

Exploratory Research is meant to be an instrument to pursue our longer term strategic focus, and to enable research activities aimed at building competence and preparing for future challenges which may not yet have materialized. I am confident that you will agree that the projects described in this brochure fulfil these aims very well.

Adam Lewis
Secretary of the
IPSC Scientific Committee

Message from the Director

Dear reader,

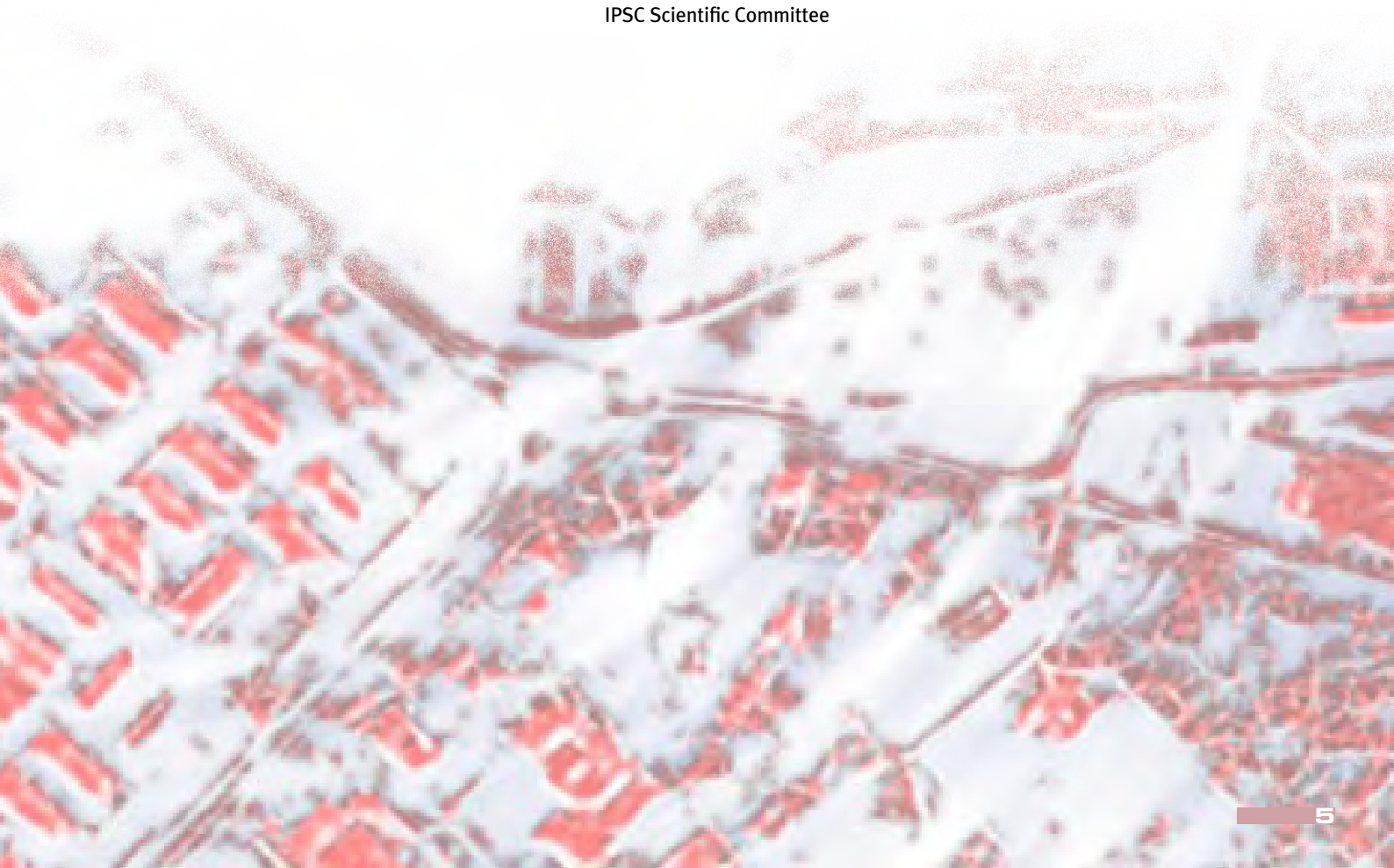
Most of the IPSC activities in the institutional work programme can be defined as applied research. In addition to that we have the exploratory research programme, which is conducted at a more fundamental level, to test new ideas and to address new areas of work.

Often the results of an exploratory research project are not directly of use by themselves, but they only provide some insight into a given new situation.

In previous years there were, however, some remarkable exceptions. At IPSC we have had exploratory research projects that have gone very far in producing significant results and eventually have developed into concrete applications. The area of *Fisheries Controls*, the *JRC Vessel Detection System* and the *SESAMONET system to guide the visually impaired*, are just a few examples of a direct transfer from exploratory research to application.

I wish that also the results presented in this document will successfully develop into tangible applications in the near future.

Stephan Lechner
IPSC Director
Chairman of the
IPSC Scientific Committee



Ultra-wide band radio channel characterization in body area networks

Objectives

The objective of this project is to complete and extend the research study on characteristics of an ultra-wide band (UWB) radio signal that propagate through and around the human body.

During the first year of the explorative project, the coexistence issue among wireless body area network (WBAN) arose as one of the major problems for the development and success of WBANs. In this second year, the objective of this exploratory project has been refocused on the development of an interference model that is useful to provide insights in the deployment of non-coordinated body area networks. In order to develop a realistic model for the interference generated by several devices simultaneously active, it is important to account for the geometry of the network where the interference is generated and for other environment dependent conditions.

WBAN can be considered for several applications in the fields of health care, safety and security. In the safety direction, WBANs can be used to increase the safety of people working in critical conditions. As an example, fire-fighters wearing WBANs can be monitored constantly in risk condition (fire, nuclear emergency, etc) in order to be able to recall them back if their physical condition deteriorate.

A major issue for WBANs is the spatial coexistence among uncoordinated networks active in a finite region and therefore exposed to the interference generated by multiple devices active simultaneously. In addition, state-of-the-art techniques are not amendable for analysis in realistic and specific environment where walls and obstacles are present. The goal is then to develop a methodology that can be directly used by operators or regulatory bodies to measure and plan the coexistence in specific environments.

Results

In order to develop a theoretical framework to address the coexistence issue among WBAN devices, we have used analytical tools drawn from stochastic geometry. Stochastic geometry provides a natural way of defining and computing macroscopic properties of wireless networks, by averaging over all potential geometrical patterns for the nodes. Modeling wireless communication networks in terms of stochastic geometry seems particularly relevant for large-scale networks. In particular, the locations of the network elements are seen as the realizations of some point processes. When the underlying random model is ergodic, the probabilistic analysis provides a way of estimating spatial averages, which often capture the key dependencies of the network performance characteristics as functions of a relatively small number of parameters. Typically, these are the densities of the underlying point processes and the parameters of the protocols involved. This is a very natural approach e.g. for ad-hoc networks, or more generally to describe user positions, when these are best described by random processes. But it can also be applied to represent both irregular and regular network architectures as observed in cellular wireless networks. In all these cases, such a space

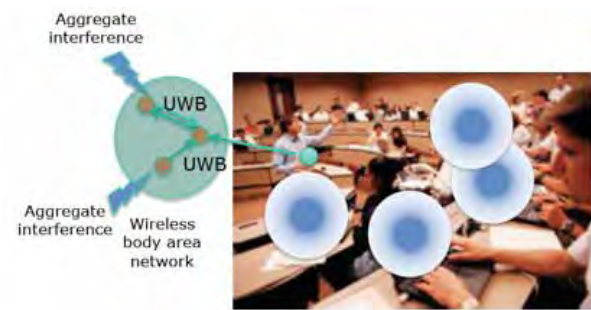


Fig. 1
Scenario with several WBANs active in the same environment.

average is performed on a large collection of nodes of the network executing some common protocol and is considered at some common time when one takes a snapshot of the network. Stochastic geometry, which is used as a tool for the evaluation of such spatial averages, is a rich branch of applied probability particularly adapted to the study of random phenomena on the plane or in higher dimension.

The final result of this second year project is the development of a statistical tool capable of measuring the coexistence of several WBANs in realistic environments where these networks can be used. The novelty of the proposed statistical tools, other than being able of capturing the spatial distribution of the concurrent devices simultaneously active, is the ability of including the characteristics of the environment where the devices are deployed. Specifically, in the model, radio propagation characteristics such as fading and shadowing due to the presence of obstacles that impair or modify the propagation of the radio signal are included. Moreover, the shape of the space where the devices are active can also be considered. All these characteristics make the statistical model for aggregate interference a very flexible tool to assess the issue of coexistence not only for the WBAN case but can provide an analysis of the coexistence issue in a generic multi-tier ad-hoc network where radio devices with different priorities to access the medium share the same radio spectrum allocation.

In figure 2, an example of how the aggregate interference model can be used is given for the case of a block of ten rooms. The WBAN's devices are located in 4 rooms (those ones with the highest aggregate interference value). As can be seen from the figure, we are able to calculate the aggregate interference mean power and its statistical distribution in each point of the environment under study providing very valuable information on the possibility of the networks to coexist. As expected, the presence of walls and the geometries of the environment have a strong impact on the characteristics of the interference. Knowing the statistical behaviour of the interference allows calculating several other parameters of the wireless networks and therefore allows also developing new strategies for improving the overall performance of the active WBANs.

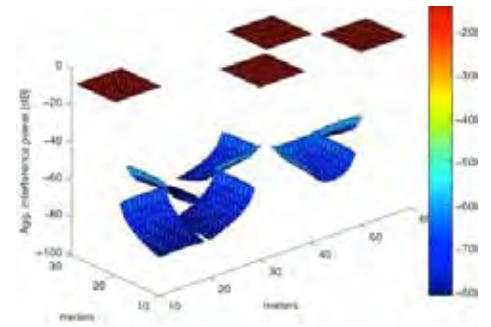


Fig. 2
Aggregate interference calculated in a scenario composed by two rows of 5 rooms. The interference is generated by several WBANs present in some of the rooms.

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Vibration mitigation of stay cables using a State Switched Inducer (SSI)

Objectives



Fig. 1
The cables of the Öresund bridge (Sweden) underwent large rain-ice-wind induced vibrations (galloping).

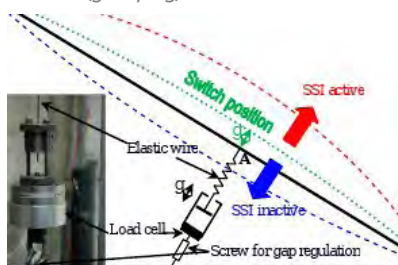


Fig. 2
The SSI device and its attachment on a stay cable.



Fig. 3
View of the JRC-ELSA facility for testing large stay cables.

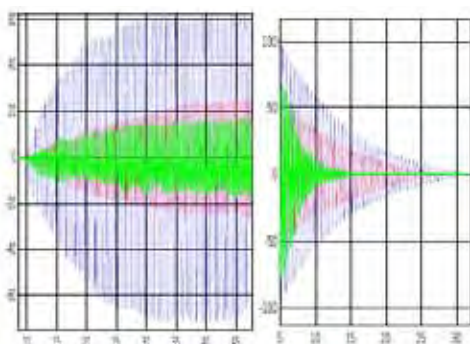


Fig. 4
Response of the cable C- (blue), C+ (red) and C± (green) under a resonant harmonic loading (left) and during free vibration decay (right).

Cable-stayed bridges have been widely constructed throughout the world, because they are recognised as the most efficient and cost-effective structural form in the 150m to 460m span range (fig. 1). However, the long and lightweight stay cables are extremely susceptible to low-amplitude wind, wind/rain, construction or traffic excitations because of their low inherent damping (less than 1%) and their numerous mode frequencies (fig. 6). Large amplitude vibrations of the cables (resonance) are therefore likely to occur frequently and may prematurely damage the anchorages thus reducing the service life of the bridge and possibly causing severe accidents.

In the past few decades, many approaches including structural, aerodynamic, and mechanical means, have been proposed to reduce or eliminate the stay cable vibrations. The most widespread devices are dampers attached to the cables close to their end, at the level of the bridge deck. Such dampers may be based on a frictional, viscous or hysteretic behaviour and may be passive, semi-active or active. However, they all work according to the same mechanical principle, by dissipating part of the (undesired) energy transmitted to the cables. Due to their position (near the anchorages), these dampers have a limited damping gain, with the exception of active dampers, which are more efficient but also very expensive, complex and energy dependent.

The objective of this project is to assess a State Switched Inducer (SSI), a new device aiming at reducing the stay cable vibrations. The SSI is an elastic wire having one end attached to the cable at a point A and the other end attached to the deck (fig. 2). This wire behaves as a unilateral spring: it works only when it is in tension that is, when the upward displacement of A becomes larger than a given value g which can be made positive, zero or negative by varying the initial length and tension of the wire. The position of A corresponding to the displacement g is called the switch position. Contrarily to the classical dampers mentioned earlier, the SSI does not dissipate energy since it is based on a purely elastic behaviour.

Results

Full scale tests have been performed on a 45m long cable of the European Laboratory for Structural Assessment (ELSA) (fig. 3) and have shown that the SSI is able to substantially reduce the cable vibrations. For comparison purposes, the same kind of tests (resonant harmonic loading and free vibration decay) have been performed in three configurations: unrestrained cable (C-), cable restrained by a bilateral elastic rod (C+) and cable restrained by a SSI (C±). On the experimental results displayed in fig. 4, the SSI appears to reduce the forced vibrations amplitude by a factor 1.5 (resp. 3.5) when compared to the C+ (resp. C-) configuration. It also greatly accelerates the decay of the free oscillations (apparent damping multiplied by 3 with respect to both C- and C+ configurations).

It is not yet clear why / how the SSI reduces the cable vibrations and, in order to find a rational explanation, the simplest idealisation of a

stay cable equipped with a SSI has been considered, namely the bilinear oscillator (BO). The BO is a single degree of freedom system characterised by a mass m , a damping coefficient c , a primary spring k and a secondary spring k' active only for displacement of the mass larger than a given gap value g (fig. 5). The parameters m , c and k can be set so as to reproduce the first fundamental vibration mode of the cable while k' and g represent the stiffness and switch position of the SSI. The BO has been extensively studied in the literature. Despite its apparent simplicity, it exhibits a complex (chaotic) behaviour. In fact, when subjected to harmonic loading, different kinds of motions, periodic or chaotic, stable or unstable, are possible and may coexist with bifurcations leading to them.

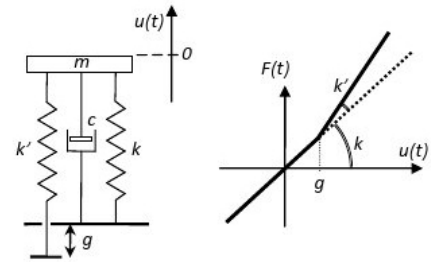


Fig. 5
The Bilinear Oscillator (BO).

The BO has been implemented in MATLAB in order to perform numerical simulations of the experimental tests (harmonic loading and free vibration decay), but the observed efficiency of the SSI could not be fully reproduced. It is however interesting to note that the harmonic response of the BO to forced vibrations has a frequency content very similar to the response spectrum of a cable (fig. 6). Therefore, the SSI might be able to trigger several modes of vibration of the cable so that the total kinetic energy would not concentrate on a particular mode but would be distributed among several modes, thus leading to a reduction of the amplitude of the cable response. However, in order to prove this theory, a bilinear oscillator with several degrees-of-freedom and thus several vibration modes should be considered and, eventually, a more realistic numerical model (finite element model of the cable + SSI system) will be required to accurately reproduce the experiments and, subsequently, to optimise the device characteristics of the SSI device (k' and g).

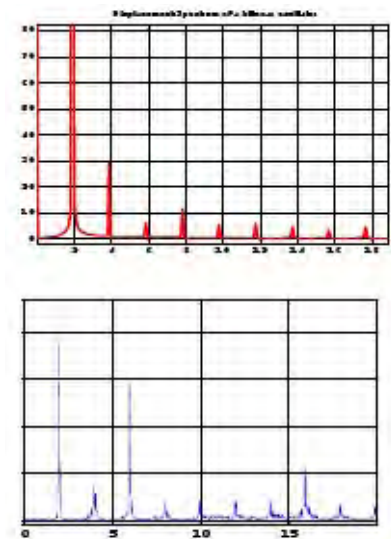


Fig. 6
Remarkable resemblance between the response spectrum of the BO (red) and the response spectrum of a cable (blue).

An optimised SSI device is expected to outperform the existing passive solutions of vibration mitigation. Furthermore, SSI devices are very cheap and do not require maintenance. Their practical installation on existing bridges does not present aesthetic prescription. Further research, experimental as well as numerical, is however needed to fully understand their mechanical principle and to provide rules for optimising them.

Patent Application

A State Switch Inducer of NITINOL* for the mitigation of cable vibrations.
Proposal n. 2850

* NITINOL is a Shape Memory Alloy made of Nickel and Titanium

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Passive automatic identification system for maritime surveillance

Objectives

Suitable situational awareness over the seas can be achieved through maritime surveillance in order to deal with issues related to illegal immigration, smuggling, piracy and blue borders control. Widely used technologies in maritime surveillance are active (e.g. coastal radar, space based Synthetic Aperture Radar - SAR), passive (e.g. Electro-Optical sensors) or cooperative reporting systems (e.g. Automatic Identification System - AIS). Despite the all-weather and 24/7 capability, currently operational radar systems cannot be easily installed due to the relatively large physical size, cost and licensing regulations. On the other hand, although being passive, Electro-Optical sensors suffer visibility and coverage limitations. Recently introduced as self reporting technique for maritime surveillance, AIS enables vessels to broadcast messages encoding their position, velocity and identity. Such messages can be received by nominally 20 Nautical Miles from the coast. Nevertheless, similarly to other broadcasting systems, the AIS cooperative nature makes it vulnerable to false or missing declarations. Moreover, AIS is not mandatory for all vessels, yielding a partial picture of the vessel traffic.

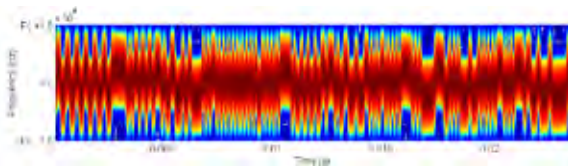


Fig. 1 Spectrogram of a real AIS class-B message recorded at the JRC. The signal after being frequency demodulated is typically decoded and the state vector information of the transmitter is retrieved. Nevertheless, in this study, the modulated waveform properties are investigated to infer the non-cooperative traffic picture. The waveform information content is subsequently used to form the cooperative traffic picture.

Passive-AIS (P-AIS) is a novel exploitation of AIS, representing a low cost solution to augment the information that can be derived from the existing AIS infrastructure. This is achieved by analysing indirect reflections of the broadcast AIS signals over targets of interest. The objective of the project, carried out as in collaboration between the Action “Vessel Surveillance and Port Security” and the Action “Communications and Radar Sensors Networks for Security Applications”, is to provide a first insight into the feasibility of P-AIS.

Results

Passive radar systems make use of the radiation of other transmitters (also known as illuminators of opportunity) to detect targets by means of their reflected energy. The P-AIS concept is represented by the combination of a self-reporting (AIS) and a non-cooperative approach (passive radar), based on the use of the widespread AIS emissions as illuminators of opportunity. Differently from typical passive radar applications that are characterised by a 3D scenario, P-AIS is related to the approximately 2D sea surface environment, which facilitates the unambiguous localisation of the target. Like other Very High Frequency (VHF) passive radar applications, P-AIS is characterised by (i) the low frequency and low complexity of the receiver design and (ii) the large Radar Cross-Section (RCS) of the targets compared to those in, for instance, C- and X-band. The latter point is due to resonance scattering as the typical complex scatterers present a size comparable to the transmitted wavelength (around 1.85 m). The specific added value of AIS as an illuminator of opportunity resides in the possibility of implementing a time-separated multistatic network, where only one transmitter at a time is illuminating omnidirectionally in azimuth, preventing the time overlap of signals within the transmission channel.

Figure 1 shows a real AIS message recorded at a centre frequency $F_c = 162.025$ MHz. The frequency modulated signal, instead of being demodulated and decoded, has been analysed in order to describe the waveform properties for radar applications. This is done by investigating the relevant ambiguity function, a series of matched filtering output computed for different Doppler shifts, in other words a function of the two parameters delay τ (range) and velocity v (Doppler).

Figure 2 shows the un-weighted ambiguity function $|\chi(\tau, v)|^2$ of a real AIS message. The autocovariance function shows the relatively good range ambiguity properties and the range resolution limitations of AIS waveforms. The exact numbers will be related to the specific message, although the variations are expected to be small. This is a consequence of the duration and the modulation spectrum of the AIS signals as regulated by international standards. The monostatic resolution performance can be seen as the best case of the P-AIS system when considering a single bistatic pair. The range resolution limitations can be mitigated using multiple illuminators, by processing multiple scattered AIS signals from distributed illuminators and implementing multilateration techniques. The intersection of the isorange ellipsoids defined by each bistatic pair leads to cells of different size, in principle significantly smaller than the monostatic resolution.

P-AIS can be used in forward scattering mode, sensing targets crossing the illuminator-observer baseline. The detection is performed on the power of the received signal and no range resolution is achieved. Such limitation can be overcome again by processing the information broadcast by a network of AIS transmitters. The expected scattering behavior in the VHF Mie region is currently under investigation with field measurements.

The exploratory P-AIS concept shows the potential of AIS reporting vessels to form a synchronised network of illuminators of opportunity for maritime traffic monitoring applications. The use of the signal information content and the time separated multistatic configuration are novel aspects compared to conventional bistatic passive radar, and are expected to significantly improve the bandwidth and power limitations of the transmitted AIS waveform. The results obtained shall be the basis to further investigate the performance and limitations of P-AIS technology within the relevant institutionalised activities in 2011.

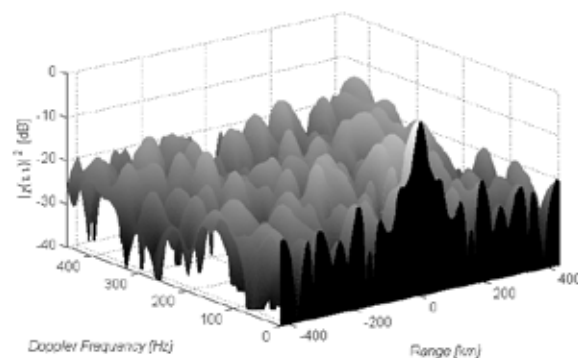


Fig. 2
Ambiguity function computed for the real AIS message in figure 1. The bandwidth constraints show reduced range resolution performance compensated by relatively low ambiguities both in the range and Doppler dimensions.

Publication

Vespe, M. Sciotti, M. Greidanus, H. Fortuny-Guasch, J., "Potential of passive AIS technology", *Electronics Letters*, September 30 2010, volume 46, issue 20, pp. 1397-1399, ISSN: 0013-5194.

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Computational steering of post-disaster damage assessment workflow

Objectives

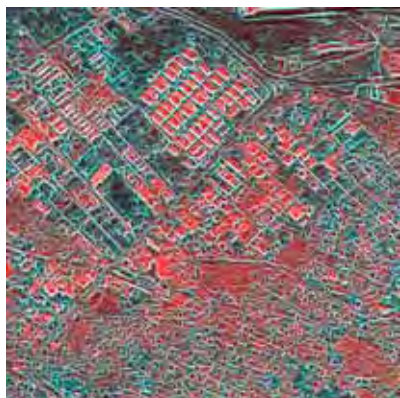


Fig. 1
Output of Correlation Computation. The above figure was computed using the fast GPU implementation developed within the context of our exploratory research. The result is based on a sample taken from the image and rotated in eleven directions. Note the delineation of linear features including roads and buildings.

When a natural disaster strikes in a populated region anywhere in the world, both people and property are affected. To help the citizens of the devastated area recover, the amount of damage must be assessed in order to plan emergency response and reconstruction efforts. Post-disaster damage assessments are supported by digital maps produced by the interpretation of satellite and airborne remotely sensed imagery. A team of experts at the Joint Research Centre of the European Commission's (JRC) Institute for the Protection and Security of the Citizen (IPSC) produce such assessments quickly using the most current geo-spatial information available and regularly update that information as new imagery is acquired over the affected area and new data made available. In order to provide such assessments promptly and reliably the damage assessment workflow requires computational resources that apply in-house developed algorithms to automate information extraction from the imagery and direct the experts attention to heavily affected areas. Automating the assessment procedure is the key to ensure timely, objective and repeatable damage assessments.

The project objective is based on the positive results of research initiated last year on the use of Graphics Processing Unit (GPU) computing for High Performance Computing (HPC) solutions. Now, the GPU computing based image processing algorithms that are being developed by the Action "Geo-Spatial Information Analysis for Global Security and Stability" (ISFEREA) must be accessible to the damage assessment analyst by integrating the processing capabilities into the post-disaster damage assessment workflow. This objective is being achieved in two stages. The first stage involves connecting the GPU computing workstations into a cluster and integrating it with the currently available CPU based computing cluster. In the second stage, tools for the visualisation of image processing results in real-time and an interface allowing the analyst to guide and change the damage assessment image processing workflow on the fly via a user interface are developed.

Results

The biggest natural disaster of 2010 was the Haiti earthquake which occurred on January 12th devastating the capital of Port-au-Prince and nearby towns. For the international community involved in the rescue, recovery and rebuilding efforts, this was both an eye opening experience and chance to test new technologies. From the image processing standpoint, the number and the quality of the remotely sensed imagery acquired to help support the ongoing relief operations that were released to the public was a first in such a situation. Furthermore, the outpouring of both expert and non-expert collaborative image analysis was unprecedented.

The JRC and ISFEREA in particular played an important role in providing the EC with vital information to support decision makers with the Haiti crisis. The in-house automated image processing damage as-

assessment workflows were put to the test and analysts examining the results prepared almost daily map updates as new imagery was provided and algorithms were adjusted. This was also a time when new ideas were put forth to improve automatic image analysis and one of the ideas was to compare a set of sample images that include objects of interest to a remotely sensed scene with a much larger extent.

The idea of comparing small image samples called image chips to a larger image to find matches is not new and is usually based on image correlation. The problem is that such processing is demanding and requires a lot of computing power and can take days even using today's workstations. Since tens or hundreds of image chips should be compared, this exacerbates the processing issue even more. Consequently, we used the parallel processing capabilities of GPU computing to reduce the time it takes to run the analysis. We have been testing the new algorithm on the Haiti imagery and producing favourable results (figure 1). However, when processing very large image data sets with powerful algorithms, the issue that arises is that the output can be just as difficult to handle because of the amount of information that is generated. The second objective of our research tries to deal with this issue.

Visualisation and the manageable manipulation of the results by the analyst is paramount to extract the vital information in a timely manner during a time of crisis (figure 2). The same GPU computing hardware can be applied to re-arrange and drive the displays that present the results. This technology will be tested and demonstrated in the context of a crisis room where stake holders can collaborate on analysis and information sharing to provide the necessary knowledge to decision makers in their roles. The idea of computational steering whereby users can influence the image processing workflow during processing is extremely valuable in this context and part of the work will be carried out jointly with the Critech action.

Our continued involvement with the GPU computing research community has promoted our research team which has culminated in an FP7 proposal with six partners ranging from academia, public research organisations and the private sector. The proposal focused on providing the European community with HPC GPU computing solutions through the development of optimised libraries for a variety of image processing domains. We also fostered GPU computing within the JRC by organising a successful specialised GPU computing course for image processing using CUDA.



Fig. 2
Visualising the geo-spatial information during a crisis is paramount to coordinate a response. In this picture, an automated image processing output is presented on the video screen with a picture from the field shown inset. The coordinator uses an input device (an Apple iPad is shown here) from which they can control what is shown on the video screen.

FP7 proposal

“Optimisation, Scalability and Porting of Computer Vision & Machine Learning Algorithms to the GPU-EU (OptiMaLCV-EU)”
Submitted under the call: ICT EU-Russia Co-ordinated Call - FP7-2011-ICT-EU-Russia
Small or medium-scale focused research project (STREP) proposal - Collaborative projects.

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Guido Lemoine and Jacek Syrczynski

Geo-Information and Visual Perception (GI&VP)

Objectives

JRC is exploring the improvement of the human assessment of building damage by applying image enhancement processing before photo-interpretation phase. The JRC is designing a series of experiments to assess the effect of such processing on recognition mechanisms.

In the frame of the Geo-Information and Visual Perception (GI&VP) project, we apply a cognitive approach to the remotely sensed imagery photo-interpretation process, exploring the possibility to improve the assessment of building damage, traditionally carried out by the time consuming and error prone human interpretation. This task is often performed following disasters to support the information needs of emergency rescue for humanitarian relief intervention. Therefore, while on the one hand there is a high pressure to deliver a result as quickly as possible, on the other hand it is of the highest importance to ensure the quality of the assessment.

The Action “Geo-Spatial Information Analysis for Global Security and Stability” (ISFEREA) has developed several algorithms aimed at promoting the salience of targets in complex backgrounds, with the purpose of improving semi and fully automatic image information extraction. As a rich plethora of different processing methods could be at the photo-interpreter’s disposal, it becomes increasingly useful to test if different processing methods have an effect on the subjective task performance (quality and speed) of identifying building damage.

The images below (figure 1) show examples of JRC image processing chains under test in the current experiment. a) “unprocessed” sub-sample of input image used during post-earthquake damage assessment in Haiti (2010) in the operational image interpretation tasks, b) “unsharpened” the same image after conditional local convolution enhancing small details, c) “cc64” the same image after a simplification based on alpha-omega constraint connectivity on connected components and d) “rubble” the same image with injected knowledge-driven image information extracted by multi-scale differential morphological profiles (DMP).

In these experiments the JRC is examining the human photo-interpreters while performing a target detection task on a given set of differently processed images in order to achieve a measure of the efficiency of the single enhancement processing method. During these experiments we record and analyse thinking aloud – semi-structured interview, mouse click responses and eye movements. Figure 2 shows some examples of the output obtained during the eye tracking sessions: (left) “heat map” representing density of duration and localization of the fixations during the image analysis and (right) “gaze plot” representing the fixations order.

Results

Experiment #1 is articulated into three steps: thinking aloud – semi-structured interview, pilot experiment, full experiment.



Fig. 1
Example of image used for damage assessment in Haiti (2010) and some processing under test in the current experiment.

- a) “unprocessed” raw image data
- b) “unsharpened”
- c) “cc64”
- d) “rubble” processing

The **thinking aloud – semi-structured interview** is composed of 4 different image processing methods developed by the JRC. The aim of this preliminary semi-structured interview was to collect individual opinions that are deemed to fine-tuning the pilot experiment.

Participants: 3 groups composed of three participants, each one representative of a particular skillfulness level: none, basic, good experience. The total number of the participants was 9. Apparatus: 4 Dell monitors 1280 x 1024 resolution.

Stimuli: 1 image tile (1024 x 1024 pixels, 15 cm resolution) in 4 different processing methods: “unprocessed”; “cc64”; “rubble”; “unsharpened”.

Procedure: the participants were shown simultaneously the same image tile produced by 4 different processing methods in order to detect destroyed buildings; no time constraint was given; the participants were asked to think aloud while performing the task and, at the end, to answer some specific questions about the perception of the images.

Results: the interviews were audio-recorded and the results of the verbal data were assessed to identify processing methods to put under test in the pilot experiment: after having ranked the processing methods, according to the verbal data analysis, the “unprocessed” tiles were never ranked the worst; the “cc64” were ranked the worst for 82% of the cases, while the “rubble” were ranked the best for 40% of cases. Consequently, the “unprocessed” and the “rubble” processing chains are selected as material of the pilot experiment phase.

The **pilot experiment** is composed of 2 different processing methods which have been selected according to the results of the thinking aloud – semi-structured interview step.

Participants: 1 skilled photo-interpreter, 1 basic-knowledge photo-interpreter

Apparatus: Remote eye tracker Tobii T120.

Stimuli: 50 image tiles (25 “unprocessed” and 25 “rubble”) containing from 0 to 3 targets.

Procedure: The image tiles were randomly presented and displayed for 5 seconds each. The subject was asked to identify the targets by clicking on them.

Results: clicking responses and eye movements were recorded and analysed. Provisional results showed in both cases (skilled photo-interpreter, basic-knowledge photo-interpreter) strong positive influence of the “rubble” processing on the task performance. In order to measure the effectiveness of the image processing and representation, we can use as metric the time spent by the interpreters on the right targets (AOIs) with respect to the total inspection time available in the specific task. We consider this as an empirical estimation of the target saliency as the measured capacity to attract the attention of the image analyst. The proportion of time spent by the interpreter inspecting the right targets in the image is 30.27% and 12.73% in the case of the “rubble” and “unprocessed” processing, respectively. Preliminary results show a clear effect of the performance of image processing on the image information recognition (see fig. 3).

We expect to carry out the **full experiment** with the following structure:

Participants: Participants are divided into 2 groups: the first composed of experienced photo-interpreters and the second composed of people who have only basic knowledge of photo-interpretation. As the participants will be only ISFEREA team members, the first group will be composed of 4 subjects and the second of 8 to 10 subjects.

Apparatus: Remote eye tracker Tobii T120

Stimuli: A set of 150 image tiles (1024 x 1024 pixels, 15 cm resolution), 30 for different processing methods, “unprocessed”; “cc64”; “rubble”; “unsharpened”.

Procedure: The image tiles are randomly presented and displayed for 5 seconds each. The subject is asked to identify the targets by clicking on them.

Results: clicking responses and eye movements are recorded and analysed in order to identify the most efficient enhancement processing amongst the ones developed by the JRC; correlate enhancement processing - task performance - target saliency.



Fig. 2
Example of eye tracking analysis output: (left) “heat map” (right) “gaze plot”.

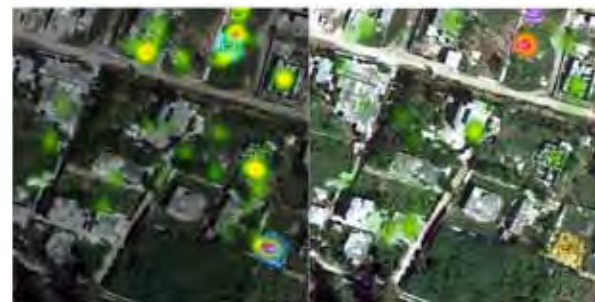


Fig. 3
Example of eye tracking analysis output: (left) “heat map” and clicking responses on AOI in “rubble” image tile; (right) “heat map” and clicking responses on AOI in “unprocessed” image tile.

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Maritime Targets in High-Resolution Satellite-SAR Imagery

Objectives

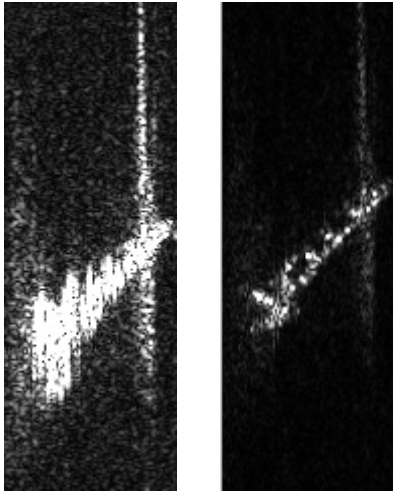


Fig. 1
Original (left) and processed (right) satellite SAR image of a large cargo vessel. The autofocus algorithm manages to correct the phase errors, disclosing the details of the vessel's structure.

(Original SAR data TerraSAR-X © DLR 2010)

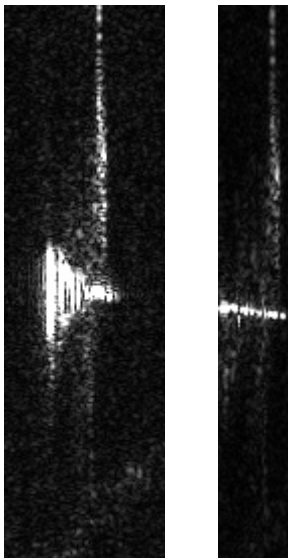


Fig. 2
Original (left) and processed (right) satellite SAR image of a medium-sized vessel. The algorithm is able to focus the image and to obtain a more accurate estimation of the vessel's length and width.

(Original SAR data Radarsat-2 © MDA 2010)

The “secret” of making high-resolution Synthetic Aperture Radar (SAR) images from space is based on the use of sophisticated processing techniques. Different approaches are needed for the image's range direction (away from the radar) and for the cross-range direction. While in the former dimension this process is straightforward, in the cross-range dimension it relies on the modelling of the positions of the elementary point reflectors in the scene during the entire time that the synthetic aperture is constructed. In addition, the long time during which the target is illuminated by the radar – needed to achieve high resolution – makes the system prone to phase errors due to unknown variations in the radar-to-target distance.

In the case of a SAR image of a vessel, most of the cross-range phase errors of the signal are produced by target movements due to sea waves. The consequence of that on the final image is that vessels are relocated in cross-range due to their velocity in the range direction, and defocused due to their cross-range velocity and range acceleration.

Aiming at improving the focusing of satellite SAR images of ships, the present research project's objectives were:

- 1 Evaluation of auto-focus techniques applied to SAR high-resolution imaging of vessels.
- 2 Investigation of the possibilities to apply ISAR processing, a technique developed for airborne SAR, and hybrid SAR/ISAR processing to high-resolution satellite SAR data in order to obtain well-focused, high resolution images of ships.

Results

For the execution of the project, a field campaign was organised in which seven very-high-resolution SAR images (of the Radarsat-2 and TerraSAR-X satellites) were acquired. The campaign took place in the Bay of Koper (Slovenia) between May, 17th and June, 4th, 2010. For the experiment, a total of seven different boats were imaged several times in order to analyse their movements during image acquisition. The boats had sizes ranging from small (5.8 m) to medium (37 m). The campaign was co-organised by the Faculty of Maritime Studies and Transport of the University of Ljubljana at Portoroz, who also joined in the analysis and interpretation of the measurements. Theoretical support to the algorithm development was given by the department of Signal Theory and Communications at the Technical University of Catalonia (UPC) in Barcelona.

After carrying out the project, the following conclusions and recommendations can be derived:

- 1 Although it was not the main target of the project, all the vessels could be detected on the images, proving the capability of the spotlight mode for detecting very small vessels by radar from space in the presence of low to moderate sea swell.

- 2 Although the degree of success obviously depends on the structure of the radar scatterers and their stability during the integration time, autofocus algorithms are capable of improving detectability and image quality of vessels, despite the fact that they were originally designed to deal with static targets whereas vessels are dynamic.
- 3 Improvement has been found in all size categories of vessels. Greater and more stable targets are easier to focus, but the developed algorithms are also able to improve the size estimates of the smaller targets.
- 4 This work shows how the imaging of targets can be remarkably improved by further advances in SAR processing. Such processing needs to be applied, however, not on the usually delivered final image product, but on the intermediate so-called Single-Look Complex (SLC) product. More widespread use of SLC imagery of high-resolution SAR modes in the framework of Vessel Detection Systems (VDS) in connection with the results presented here promises real improvements in vessel parameter determination (e.g. length) and target recognition & classification. It is also expected that these techniques will reduce the number of false alarms.



Fig. 3
During one of the experiments at sea, with
boats deployed by the University of Ljubljana
at Portoroz

PROJECT LEADER

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TEAM MEMBER

Franc Dimc

Fighting slavery in agriculture

Objectives

In some EU agricultural areas, workers are exploited and their rights violated. This is possible due to their clandestine status and/or their extreme poverty. Press reports explicitly talk about 'slaves', referring to conditions such as:

- non-existent or very low payments,
- extended working hours,
- in-human living conditions,
- no available health assistance often jeopardizing workers lives.

For instance, in 2006, the media covered the situation of workers during the tomato harvest season in Puglia, in Foggia province, defining them as the 'contemporary' slaves, for the above reasons. Local authorities were criticized for not performing efficient controls on farmers and traders. Afterwards, Regione Puglia allocated a special budget to strengthen controls, increasing the frequency and involvement of police authorities.

In addition to the question of human rights, law infringement occurs when pension contributions are unpaid: therefore. The law stipulates it is necessary to declare the employment of temporary workers in advance. Therefore, the absence of 'a priori' declaration can be, in our opinion, the unconvertible evidence of law infringement.

The objective of the study was to propose a control methodology able to increase the control capacity (and efficiency) of local and national administrations to discourage farmers from using illegal practices. Therefore a methodology was outlined: to collect satellite imagery (1m resolution) to detect harvesting activity and possibly to count workers; then, using field coordinates, to identify the land owner and check his or her official declaration of workers employed for that specific day to spot discrepancies.

Results

The Area of Interest (AOI) was in the countryside between Foggia and S. Severo. These are the most intensive tomato-growing municipalities of the Foggia province lowland (Apulia, Southern Italy). In that area, the harvesting period is from late June until early October. A VHR GeoEye-1 product was ordered over an area of 205 km². GeoEye-1 was chosen because, at the moment, it is the commercial satellite sensor with the best resolution. The Italian Paying Agency for agricultural subsidies offered the provision of aerial imagery (0.25 m resolution) free of charge for the same purpose, covering almost twice the AOI. The satellite imagery was collected on 20 August and the aerial imagery on 31 August.

An on-the-spot (OTS) visit was carried out on 15-16 September, to interview controllers and collect information about the workers and machinery deployment during the harvesting operations.

Public bodies involved in the control activity in Foggia province are the Work Inspectorate (Ministry of Welfare) and the Provincia di Foggia (NUTS-3 local administration). Work Inspectorate is in charge of



Fig. 1
GeoEye-1 image on the Area of Interest. As the image orthorectification has been achieved in late December, the second part of the project - targeting the land owners' identification and the declaration checks, is ongoing.
(GeoEye-1 © GeoEye Inc; 2010 distributed by e-GEOS)

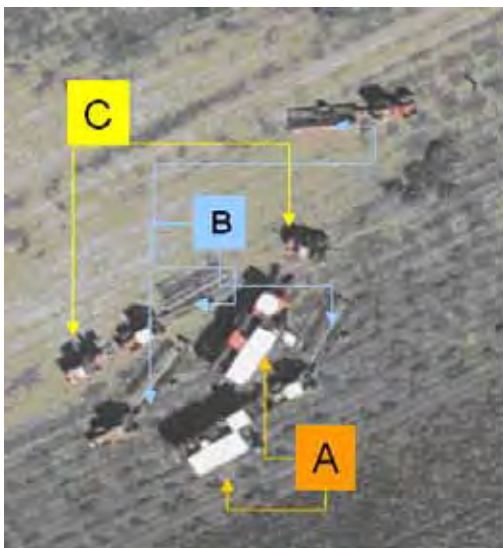


Fig. 2
Extract from satellite datum: 2 harvesting machines (A) + 4 tractors pulling lorries (B) + 2 forklift trucks (C)

OTS controls: in 2009, 1500 controls performed, 5000 workers identified (10% extra-EU workers), 2M € sanctions. Work Inspectorate control (variable) costs are (approximately) € 75.000 + € 500.000 (the special budget from Regione Puglia, to support Police help).

Provincia di Foggia manages the database in which farmers declare the workers they are going to employ (on-line, at the latest the day before). Late declarations have to be duly justified (unexpected events i.e. fire, flood, etc.) to skip sanctions. There is also another procedure (via fax) if the Internet connection doesn't work.

The first feedback comment is that since 2006 the situation has changed because controls have increased; in addition, to employ fewer workers, mechanical harvesting has increased. This can be considered also as a result of the above-mentioned press campaign. The effect is that there are less workers employed the harvest (actually working on the ground) while the majority is employed on board the harvesting machinery to perform the fruit selection or to drive tractors and/or forklift trucks to lift and lower the bins from trucks.

The analysis of the imagery (both aerial and satellite) revealed (for both days) around 25 harvests on-going, of which 1 fully manual (fig.1): images resolution does not allow the distinguishing of human beings from the background (and therefore precise counting of workers is impossible) but allows us to detect trucks, tractors, harvesting machines and forklift trucks. We can, therefore, perform an indirect counting of workers. From the information collected during the field visits, we learned that the presence of such a set-up would indicate the presence of at least 7 workers: 1 harvesting machine driver, 1 fruit selector on board, 2 tractor drivers, 2 on the pulled lorry, 1 driving the fork-lift manual harvesting teams (15-20 workers) are deployed only when wet conditions prevent machines entering the plot.

Once in possession of the field coordinates where the workers were counted (directly or indirectly) through the image analysis, we trace the name of the owner (through the database managed by AGEA): then, in the database managed by Provincia di Foggia, controllers will be able to check the number of persons declared via the fiscal code.

The other feedback from interviewed controllers is that to prosecute and sanction farmers hiring people without following the official procedure, you need to identify the worker, so the remote counting won't be effective.

From our side, we comment that while the inspection campaign costs around 575.000 €, a single satellite image costs 3500 €: this seems quite cost-effective!

In conclusion, it is feasible to establish a cost-effective, - control procedure based on satellite imagery if a new legislation about control procedure is issued; not based upon on-site workers identification but by means of a later control of on-line declarations. Until such a procedure is in place, imagery can be used at least to achieve statistics on workers employment and risk analysis; to draft a 'black' list of farmers to target the controls for the following season. A new technology to strengthen controls would be a strong deterrent against infringements.



Fig. 3
Extract from airborne datum: 2 harvesting machines (low side of the picture), 5 trucks + 1 tractor pulling a lorry + 2 forklift trucks & many bins (full and empty)
(© Telaer - AGEA, 2010, distributed by SIN)

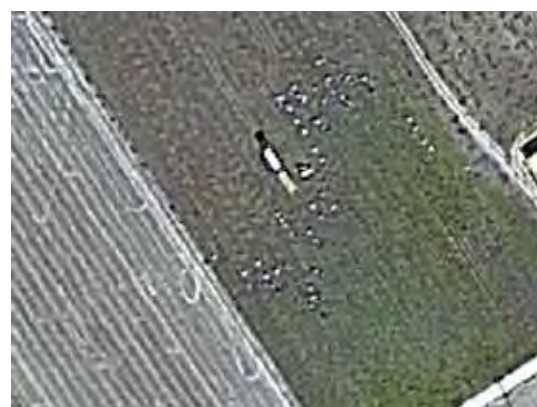


Fig. 4
Satellite datum: field entirely harvested manually, with many bins scattered on it.

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Agnieszka Walczynska (image orthorectification)

1. 50€ x 6 controllers x 250 days.

In-cell tool for remote operation on spent nuclear material

Objectives

During the last years the JRC has been involved in several international projects whose aim was the remediation of a former warehouse facility with Spent Nuclear Fuels (SNFs) stored in so-called Dry Storage Units (DSUs). The facility presents a general state of degradation due to poor maintenance causing serious environmental and safety concerns. The role of the JRC has been to provide expertise on remote handling and contribute with its labs for experimental validation. Several studies were conducted in order to identify the main particularities of this type of facilities and to provide a suitable solution.

Based on this previous knowledge, the objective of this Exploratory Research Project is the study, design and development of a new teleoperated system for carrying out inspection and manipulation tasks of SNFs inside DSU cells. Instead of a rigid kinematic chain, the system is based on the idea of a capsule that can be deployed inside a DSU cell with the appropriate tool by means of a convention crane and ropes. This characteristic increases the flexibility of the system and makes it especially suitable for working on areas with poor maintenance and general degradation, since in this case flexibility is an essential requirement in order to accomplish the tasks with a good performance despite of the uncertainties of the environment.

Results

The development of this exploratory research project entailed the building and validation of a first prototype of the remote operated device, which has been done in three stages:

Conceptual design of the system

The device was designed taking into account the characteristics of the DSU cells and the possible uncertainties, the tasks to be done inside them and the deployment methodology. Based on these requirements, the system was divided in two main parts (fig. 1):

- A *fixing mechanism* which its functions are to provide a common interface with the deployment equipment (i.e. the crane) and a stable platform for the tools that operate inside the cell
- A *set of tools*, specifically designed for each task and stored in a rack easily accessible for the fixing mechanism. The tools can be attached and unattached to the fixing mechanism by means of an industrial tool changer capable to supply the required services (power, pneumatic air, electronic connections, etc.)

Due to the diversity of tasks to be done inside the DSU cells and the time frame, the designs focused on the fixing mechanism and the tool for retrieving the Spent Nuclear Fuels, which is considered one of the most critical tasks.

Development of simulation tools

A software simulator was developed in collaboration with the University of Verona, for validating the initial designs of the system and for analyzing its performance in the working scenario (fig. 3). With the use

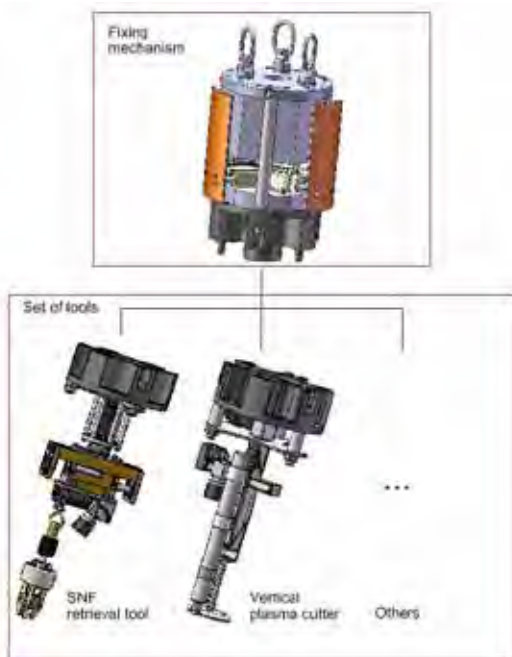


Fig. 1
Conceptual design of the system based on a fixing mechanism and a set tools specific for each task.



Fig. 2
Fixing mechanism prototype.

of a simulator it is also possible to test unexpected situations which could be difficult to setup in a real environment.

Due to the fact that the device is remotely operated, its response to the movements commanded by the operator and the interaction with the working environment are important aspects to be considered in the simulations and they should be as realistic as possible. For this reason, the simulator integrates a dynamic engine which allows to define the physical properties of the objects and the interaction between them accordingly. The user can interact with the virtual environment through a GUI panel and the keyboard, which allow to command the same movements than in the real system and to modify the position of the camera in order to identify the best views for carrying out the tasks.

The use of teleoperated systems requires some training for non-experts users. Then, ultimately, the simulator could be used as a tool to train operators in order that they become familiar with the teleoperated system before carrying out tests with real mock-ups.

Building of the prototype and experimental validation

A first prototype of the fixing mechanism was built based on the results obtained in the previous stages (fig.2). The mechanism is composed of three pneumatic actuators whose movements are commanded by three electrovalves, position and pressure sensors that give the position of each actuator and an estimation of the contact forces, respectively, and the fix part of a tool changer. The control system is based on Generis, the software development platform for robotics developed at JRC under the real-time operating system VxWorks.

The RIALTO lab was set up with real size mock-ups of the DSU cells, canisters and SNFs in order to test the performance of the prototype. The lab was already equipped with a Cartesian gantry robot that was used for the insertion and retrieval of the device inside the DSU cell mock-up. The test consisted in three phases: first, the insertion of the device inside a cell changing its inclination within a range from 0 to 5.7 degrees with respect to the vertical axes (fig. 4); then, the device was blocked inside the cell and its rigidity checked trying to move it from its position; finally, the device was retrieved from the cell. All the tests were conducted successfully and the device performed as it was expected.

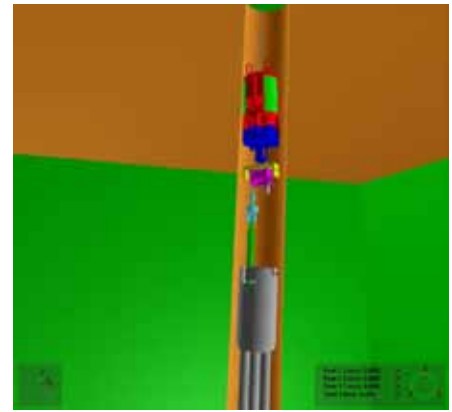


Fig. 3
Internal view of the simulator with the proposed device retrieving a Spent Nuclear Fuel from the canister.



Fig. 4
Insertion of the fixing mechanism in an inclined DSU cell mock-up.

Patent Application

“Remotely controlled handling device for operating in storage cells”
European Patent Office Submission n.1042784
Application n. EP10195756.

Publications

Cornella J., Puig D. and Sequeira V., “Remotely Controlled Device for Operating inside Storage Cells: Conceptual Design and Early Results”, submitted.

Cornella J., Zerbato D., Giona L., Fiorini P. and Sequeira V., “Dynamic Simulator for the Remote Retrieval of Spent Nuclear Fuel”, submitted.

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JRC and the IPSC

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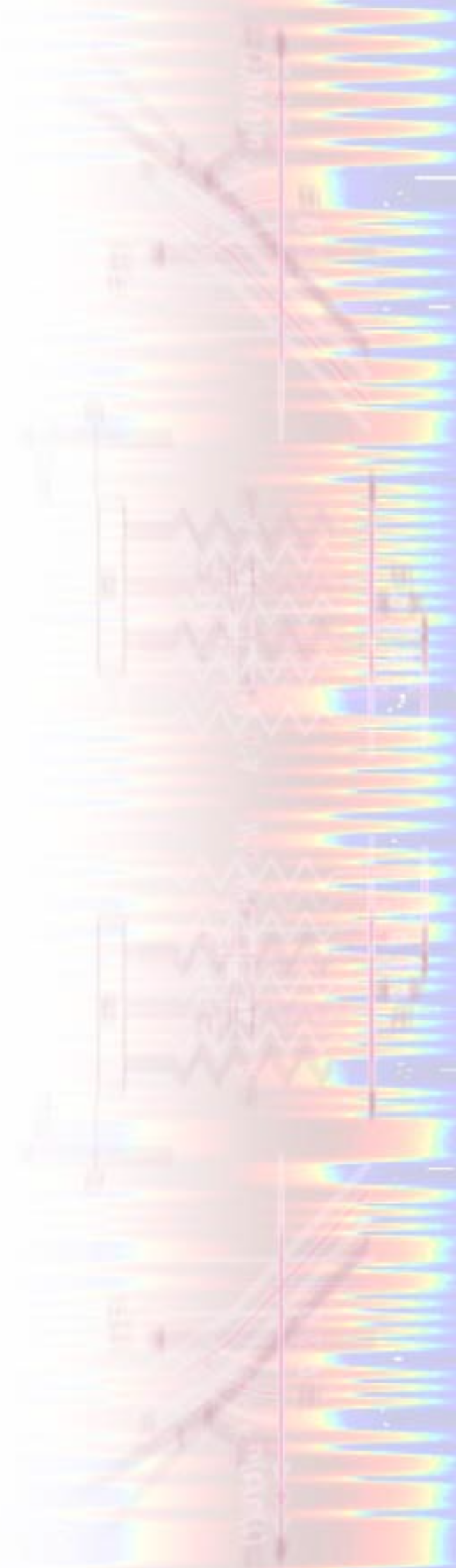
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Abstract

The report describes the main objectives and results of the eight exploratory research projects carried out at IPSC during 2010.



The mission of the Joint Research Centre is to provide customer-driven scientific and technical support for the conception, development, implementation and monitoring of European Union policies. As a service of the European Commission, the Joint Research Centre functions as a reference centre of science and technology for the Union. Close to the policy-making process, it serves the common interest of the Member States, while being independent of special interests, whether private or national.

