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Inverse Synthetic Aperture Radar Simulators as Software-defined Countermeasure Systems: Security by Obfuscation and Deception for Electronic & Computer Networks Warfare

Theodoros G. Kostis

Dept. of Information & Communication Systems Engineering,
University of the Aegean
HELLAS

1. Introduction

In the eighth episode of season five of the 1962 series of "Mission: Impossible" head operative Peter Graves inflates a life-sized plastic decoy detailing himself so to confuse in order to escape his opposing counterparts. It comes as no surprise that this episode is distinctively titled "Decoy". A decoy is a person, device or event of at least lesser and of preferable minimal value that serves purposes of security by distraction and obfuscation. This function is performed by introducing one or many replicas of a person, device or event in order to conceal the valuable original asset from the adversary interest groups that are actively seeking the friendly beneficiary with malevolent intent.

In our case the valuable asset is a military naval vessel or fleet that requires protection from airborne threats of enhanced electromagnetic nature or advanced radar surveillance and tracking sensor technologies. This work promotes the thesis that the current state of affairs in the field of modern air defence at sea demands distraction and obfuscation solutions based on software defined radar systems. Specifically the generation of the concept of coherent deception that is used to oppose high range resolution radar systems is argued to be more straightforward when performed by software-defined radar systems based on simulator sub-systems than by using dedicated to particular countermeasures hardware platforms of electronic protection for two main reasons. First with a simulator system it is easier to adjust the false target properties to the actual target properties so the adversary will not be able to distinguish the real target thus providing initial targeting hindrances. And then the convenience of adding reality enhancement effects, like the various noise and glint elements found in an actual returned high range resolution radar signal, thus increasing the confidence of the adversary regarding the validity of the contact. Therefore with a simulator system it is easier to adapt to sensor technology limitations and to incorporate the laws of physics in the countermeasure design always keeping in mind that the ultimate goal is to deceive the radar operator and radar system loop with emphasis on

the human element. The executive summary of this project is shown in Figure 1 in a visual form.
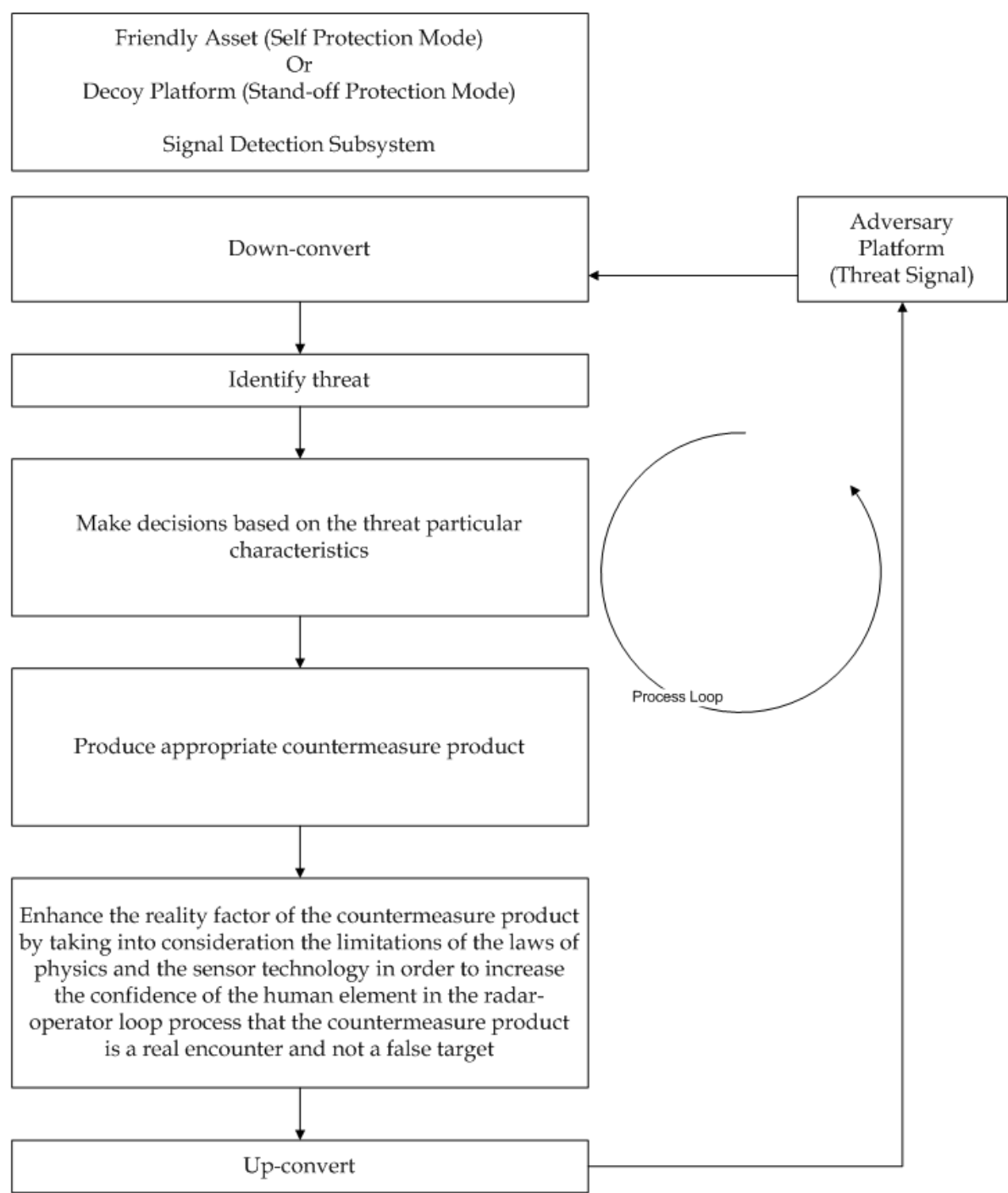

Fig. 1. Visual executive summary of the project.

In this chapter we will create a virtual environment that is considered to accept as inputs the just-in-time characteristics of a threat signal, pass them through a transfer function which is a simulator system and then produce false target images that are realistic because they abide by the current sensor technology limitations and the prevalent laws of physics.

In section 2 we argue that since coherent countermeasures are different from conventional naval countermeasures the concept of air defence at sea when high range resolution miniaturised sensors are involved needs to be reinvented. Here the literature review is presented for ISAR simulators and coherent countermeasures because our contribution is the amalgamation of these two fields. In section 3 we apply the concepts of conceptual modelling to the field of coherent countermeasures. In section 4 we present our implementation procedure, in the forms of the computing methodology, the algorithm design and the final simulator implementation. The results of this work can be found in section 5. Here the simulator is proven to be able to produce ISAR images affected by higher reflectivity on lower coordinates and angular glint effects which is a common case with extended military targets. Also we argue that the computing methodology can be reused in the domain of computer networks warfare by presenting the dual problem space decomposition for the case of a computer network jammer device. We also discuss the project success factor by ascertaining the ability of the current effort to be able to implement a simulator prototype of the initial conceptual model. Finally in section 6 concluding remarks are given and we also make a recommendation for future work by suggesting that the simulator should be recoded with the use of concepts from the field of parallel programming in order to increase its execution speed.

2. Coherent Countermeasures for Air Defence at Sea & ISAR Simulators

Distance is an integral factor in countermeasure activities. When the decoy signal is produced on-board the friendly asset it is called self-protection and when it is produced off-board it is called stand-off protection [Hill, 1988]. The large volume and weight of the countermeasure technology up to the 1990's demanded solutions of self-protection. Stand-off protection was usually performed either by friendly platforms that were far away from the threat signal or chaff systems, that is low value passive elements that would attract the threat away from its target because they exhibited greater radar cross section than the protected platform. For the above reasons conventional radar countermeasure techniques fell into two major categories: angle deception and range deception. In the first case an example is Inverse Gain Jamming. With this method the jamming function is performed by transmitting replicas of the adversary signal back to the hostile sensor. A strong replica when the illuminating signal is weak and vice versa either evens out the phases or over compensates the sensor producing either way the deception effect. With the second method an example is Range Gate Pull-Off (RGPO). The hostile radar concentrates on the target by placing a range gate of a few hundred meters around the target. Because it no longer looks for other signals it is termed that the radar has locked on the target. The RGPO method breaks the lock by making the hostile radar lose this gate thus producing the deception effect. Both methods work for conventional radar systems and will not deceive a high resolution sensor [Wiegand, 1991]. Both above countermeasure methods are applied to conventional radar tracking systems, like the monopulse method. But they are not efficient when the target is viewed by a high range resolution system in stand-off mode or when the

missile platform is equipped with a miniaturized high range resolution sensor (ISAR mode). Therefore the problem of air defence at sea needs to be re-invented for there is a need for direct ISAR countermeasures that would oppose a miniaturized high range resolution radar sensor.

2.1 Review of the State of the Art

We will perform a literature review on conventional ISAR simulators and then on coherent deception techniques in order to be able to draw comparisons and build the foundations of our work.

2.1.1 ISAR Simulators

Earlier studies by [Shillington et al, 1991] have described a technique used to simulate ISAR images of a ship model while under angular motions such as yaw, pitch and roll. [Porter et al 1994] have presented the theoretical analysis of SAR techniques as can be applied to ISAR imaging of ship targets. Emphasis is given in the exploitation of information resulting from the point spread function. Also foundations are laid towards the study of interference effects (glint). [Haywood et al, 1994] have introduced the ISARLAB software package which is a comprehensive set of functions that emulate the particular functions of an ISAR system. And [Emir et al, 1997] have developed a simulation program which can generate ISAR images of ships. The method is based on the localization of dominant scatterers and has applications in evaluating the performance of automatic ship classifiers.

Recent studies by [Wong et al, 2006] have clearly presented the mathematical basis of the Inverse Synthetic Aperture process. [Ling et al, 2006] have investigated the acquisition of top or side view ISAR images with the proper cross range scaling. The technique is based on the measurement of slopes of the two main feature lines of the ship, which are the center line and the stern line. This process has the advantage of using only the acquired image to complete its tasks. [Lord et al, 2006] have investigated methods to obtain three dimensional radar cross section (RCS) images using the ISAR concept. Results are provided towards the degradations effect of specular multipath effects on the final image. [Rice et al, 2006] have described a method of ISAR image classification based on a comparison of Range-Doppler imagery to existing three dimensional ship reference models. This technique uses a sequence of ISAR images in order to estimate the dominant ship motion. In all above indicative work there is no mention of the computing force that provides the motion of the radar and target platforms.

Our work makes an attempt to fill in the details of an ISAR simulation analysis in a virtual reality environment which is supported by a software defined radar system.

2.1.2 Coherent Deception Techniques

Using a simulator in the context of a software defined radar system falls under the coherent deception electronic attack technique. In this manner multiple targets can be generated which must have features nearly identical to the real ship target. And in order to ensure correct geometry and realistic false target velocities there is a need to take into account an estimation of the range, velocity and heading of the threat signal, as stated in [Baldwinson, 2008]. From [Yuan] it is concluded that is is beneficial to implement the false target signal entirely algorithmically. The purpose of the research is to obscure the real target into a cloud

of other plausible yet false targets as stated by [Rui]. The analysis in [Xiaohan] states that the fake target mask, which are mainly coordinates and backscatter intensities, are stored in advance and that the Doppler's slope is important in the deception imaging process because it helps the threat signal to focus on the false target. We address this point in our simulations. Further false target geometry explanations can be found in example in [Rongbing, 2007] where a geometry and signal model is presented. For an ASIC (application specific integrated circuit) approach [Fouts et al 2005] have implemented the first documented hardware-based complete false target generator system. Nevertheless the exact contents of the look-up table that synthesizes the target are not fully discussed.

3. Conceptual Modelling for Coherent Countermeasures

We need to establish the fact that an ISAR simulator can be used as a software-defined radar system in order to perform coherent countermeasure activities. For that reason we have implemented an ISAR simulator which addresses the reflectivity solution of an extended naval target as seen by an airborne high range resolution sensor [Kostis et al, 2005; Kostis et al, 2006; Kostis et al, 2007; Kostis, 2008]. We found that the design could easily be extended to accommodate an added value which is a glint effects generator [Kostis EUSAR, 2008; Kostis et al, PCI2007]. For ISAR countermeasures purposes we argue that by injecting glint effects in the digital signal processing process the simulator can now produce more realistic results [Kostis, 2008]. This added value is necessary in order to add realistic effects to the false target as stated by [Neri, 2007]. For this value added process there are two methods of creating angular glint, Poynting vector and phase gradient. The first method is discussed in [Chen] where glint is calculated by the deviation of the Poynting vector and the heading vector. The second method is discussed in [Ming] where and RCS (radar cross section) based compensation method is presented. For our purposes we have used the approaches found in [Schleher] and [Shirman] where they base the glint estimation on the transversal component of the interconnecting vector between the two interfering sources.

From our work stems the research question of how useful, economic and straightforward it would be for this ISAR simulator to support a software defined radar system in order to perform electronic warfare functions. In this section we present the conceptual modelling steps of the simulator. And in the next section we present the results that bear the proof that this software defined system is capable to produce functions of security by obfuscation.

We are considering the case that the threats are equipped with high resolution microwave (radar) sensors that are capable of resolving the ship target in slant, cross and even height ranges while always tracking their most prominent points. Relevant effective soft-kill methods, which means deceive rather than destroy, is the capture of the threat signal in digital radio frequency memory, its down-conversion, its injection with false target reflectivity data by digital signal processing means, its up-conversion and final re-transmission to the threat sensor [Neri, 2007].

Our major contribution is at the provision of an Interferometric Inverse Synthetic Aperture Radar simulator which can generate realistic false target effects by adding glint noise to the false target reflectivity solution. The threat signal always tries to compensate for this noise as it is an inherent characteristic of an extended target.

3.1 Application Domain Definition

The task of Application Domain Definition is given to the SMEs that have authoritative information about the actual situational context. Usually at this point in time the SMEs will hold several meetings with the SEs and discuss the theoretical and practical milestones that have to be observed during the course of the project. Usually at this stage the SEs will have only superficial knowledge about the subject matter. On the other hand SEs that can perform the task of SMEs are valuable for any particular situation. We now explain the operational abilities of High Range Resolution radar systems by presenting a short relevant theoretical background. The main theoretical aspects for ISAR imaging are in order of logical progression: SAR imaging, spotlight mode of SAR imaging leading to ISAR imaging.

A SAR system has an antenna aperture which is synthesised by the combination of relatable parts rather than the real dimensions of its physical antenna. The SAR imaging principle is based on two foundations:

- Coherence.

- Sampling. The digitisation of continuous processes. The synthetic array is made up in a radar digital signal processor.

The major advantage of SAR systems is much better slant and cross range resolutions. A numerical example will be utilised to illustrate all the above in mathematical terms. Starting with a conventional 10GHz radar with an antenna aperture of 3 meters looking down to a target 10 Km away, the cross range resolution is :

$$\Delta x = \frac{\lambda}{d} R = \frac{0.03}{3} 10000 = 100m \tag{1}$$

This azimuth resolution is very low because a single resolution cell is illuminated at any one time. For example two ships less than 100 meters apart at the same range would appear as only one echo. Thus they cannot be resolved by the radar of Figure 2.
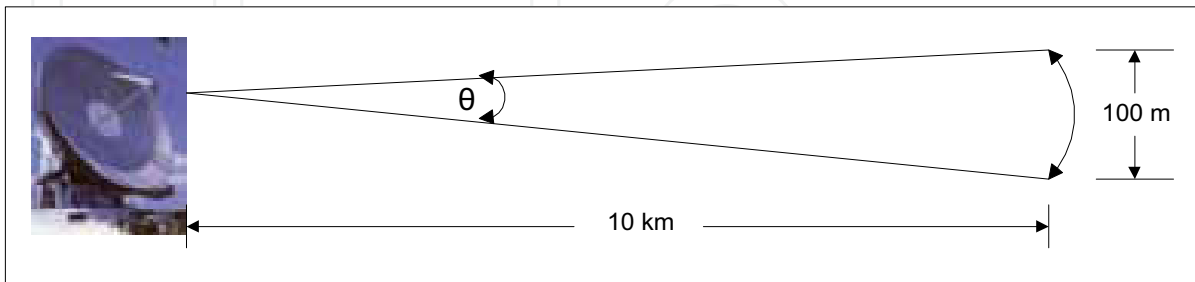

Fig. 2. Conventional Radar Angular Resolution or Real Aperture Radar (RAR).

Now assuming stationary targets and employing an airborne SAR system at the same frequency and range the azimuth resolution $\Delta\chi$ can be brought from 100 meters down to 3 meters, as shown in Figure 3.
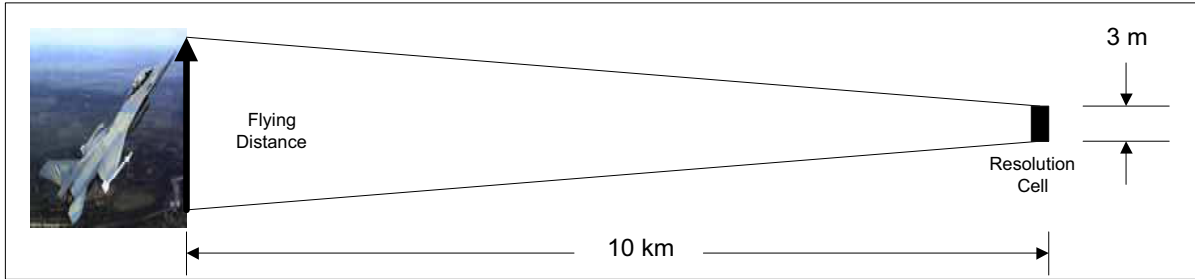
Fig. 3. Synthetic Aperture Radar (SAR).

The fly time should equal the distance of :

$$\Delta x = 3m = \frac{\lambda}{d} R \Rightarrow R = \frac{3d}{\lambda} = \frac{3*3}{0.03} = 300m \tag{2}$$

Therefore when the airborne synthetic aperture system flies for 300 meters around or across the target the azimuth resolution becomes much finer at only 3 meters long.

When the radar beam is focused on one point in space the concept is call Spotlight Synthetic Aperture Radar, as shown in Figure 4.
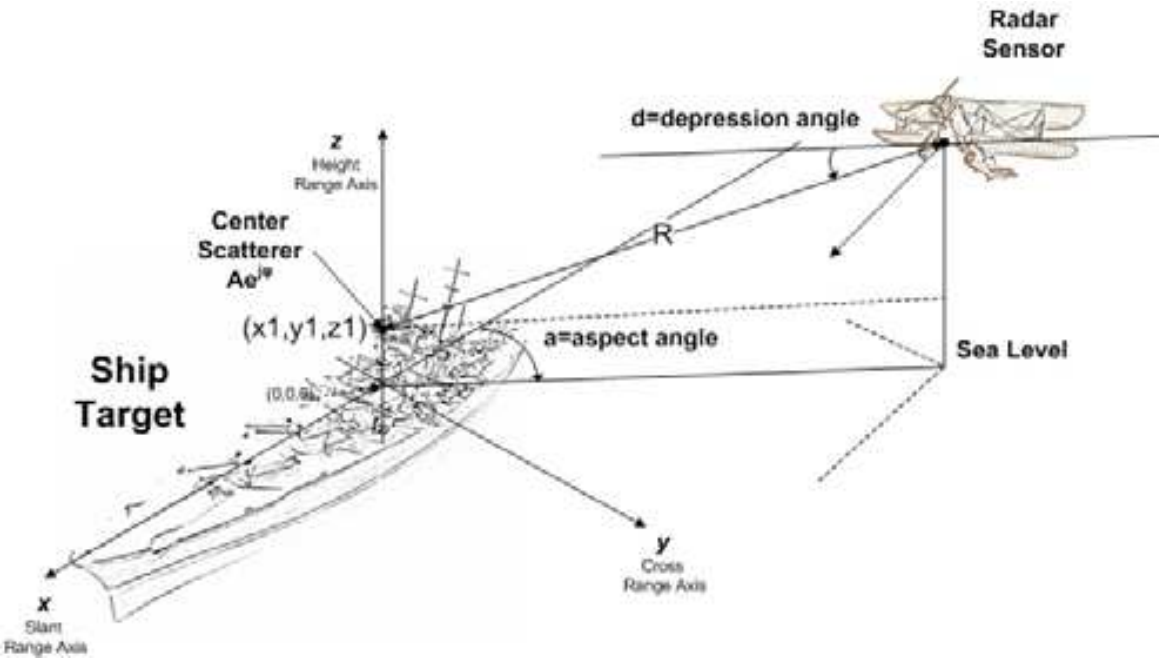

Fig. 4. Spotlight Synthetic Aperture Radar.

Spotlight SAR is the dual of the Inverse Synthetic Aperture Radar concept that will be used to image the naval target. The duality is that in Spotlight SAR the radar is moving where the target remains still. In ISAR imaging the radar is still where the target provides the motion that synthesizes the extended antenna aperture that leads to the higher resolution image.

In order to create false targets an introductory procedure is shown in Figure 5 [Kostis et al, IOP MST 2009].
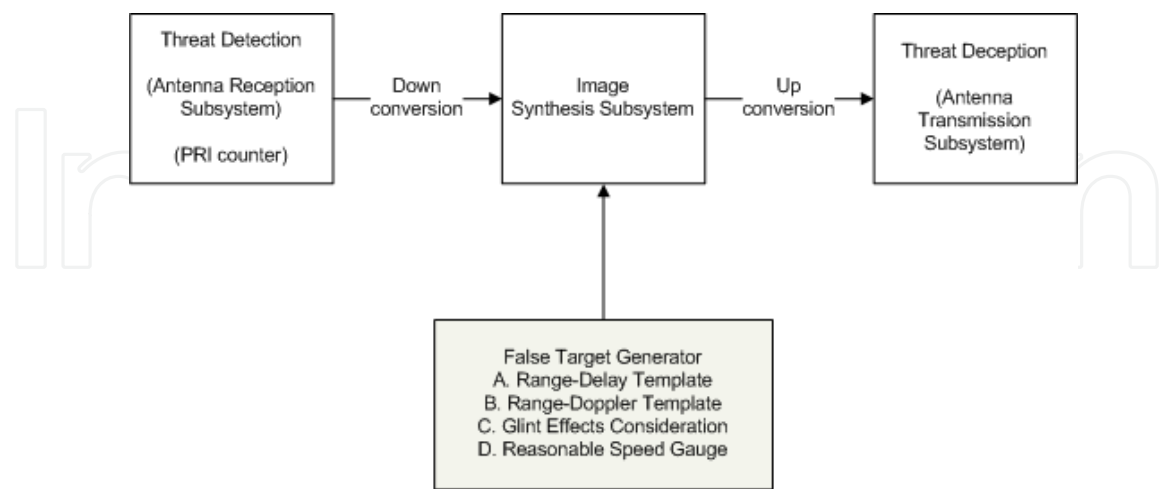

Fig. 5. The position of the False Target Generator Subsystem

Care must be given to the False Target Generator subsystem. Its outcome must resemble a signal that has all the necessary characteristics of an inverse scattering coming from a true target. For example the signal must contain mild or severe elements of angular glint noise. In other words the reality factor is decided by the ability of the false target generator subsystem.

3.2 Problem Space Decomposition

The entities and processes that must be represented for the successful accomplishment of the simulation are defined. For this project the list of entities as shown in Table 1.

	Simulation	Reality
1	Target cartesian coordinates plus inherent amplitude & phase	Target physical properties & electromagnetic signature
2	Radar slant range and cross range cartesian coordinates with respect to the center of the target	Most prominent appears to be the middle of the ship for this project. But it could be in the stern or the bow of the ship.
3	Sea-level distance from radar to target	FM height finder radar (altimeter) on airborne platform
4	Radar operational parameters	ISAR system particulars
5	Aspect angle from radar to target	Change of aspect angle from radar to target provides the resolution acquisition process

6	Glint Effects	Physical Phenomenon
7	Pace Engine	Target movement due to forces of nature
8	ISAR processor details	Range-Doppler processing
9	ISAR system output	Slant Range Profile and ISAR Image of target

Table 1. Entities

Now we can draw the necessary associations between the entities and come up with the corresponding processes, as shown in Table 2. Again as above the comparison between the reality and the simulation is strongly taken into account.

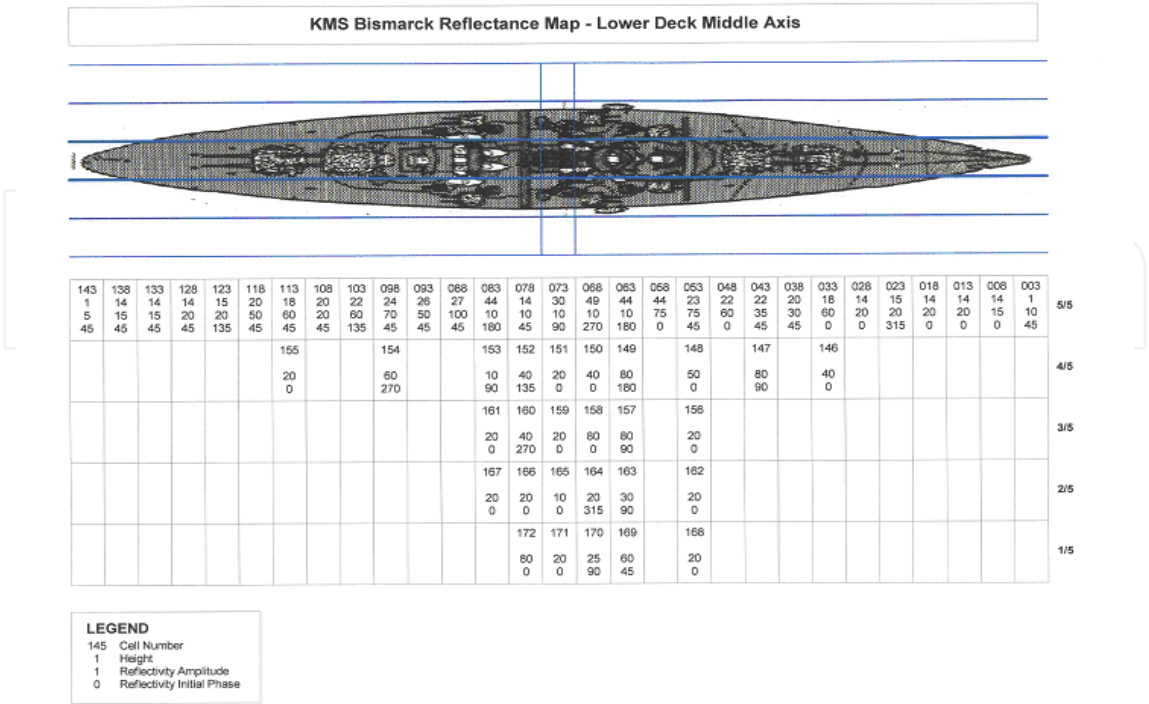|	Simulation	Reality
A	Provide information to the Pace Engine of target Cartesian coordinates to the pace engine	Physical presence and movement of target
B	Provide information to the Pace Engine of radar two-dimensional (slant ranger and cross range) coordinates	Physical presence and movement of radar
C	Provide information to the Pace Engine of radar's third (height range) dimensional coordinates	Measurement - captures reality with a sensor
D	Provide information to the ISAR Processor about the radar's operational parameters	Instrumentation – operational information
E	Aspect angle variation	Caused by changes in target/radar location
F	Glint Effects Injection	Digital Signal processing Conditioning (Masking)
G	From Pace Engine to rotated points database	Caused by changes in time
H	From Pace Engine Database to ISAR Processor	Recording Process – processes history of target in computer memory
I	From points database to ISAR processor	Computer process – Range-Doppler Processing - translates reality to computer memory

Table 2. Processes

3.3 Entity Abstraction Degree

The representational abstraction of the involved entities is finalized in this step. The level of accuracy, precision, resolution and fidelity of the entities and processes is determined. The main element that can have various levels of detail is the target's initial reflectivity solution at an aspect angle of forty-five degrees. First the extended naval target is modelled as an isotropic or directive point scatterers model, as shown in Figure 6 [Kostis et al, IJSSST 2009].

Fig. 6. Single Layer Model

Then the false target is synthesised by taking the reflectivity grouping of multiple layers across the ship superstructure. An example is shown in Figure 7, where another layer is included in the calculations.

KMS Bismarck Reflectance Map - Lower Deck Middle Axis

143	138	133	128	123	118	113	108	103	098	093	088	083	078	073	068	063	058	053	048	043	038	033	028	023	018	013	008	003	
1	14	14	14	15	20	18	20	22	24	26	27	44	14	30	49	44	44	23	22	22	20	18	14	15	14	14	14	1	5/5
5	15	15	20	20	50	60	20	60	70	50	100	10	10	10	10	10	75	75	60	35	30	60	20	20	20	20	15	10	
45	45	45	45	135	45	45	45	135	45	45	45	180	45	90	270	180	0	45	0	45	45	0	0	315	0	0	0	45	
						155			154			153	152	151	150	149		148		147		146							4/5
						20			60			10	40	20	40	80		50		80		40							
						0			270			90	135	0	0	180		0		90		0							
												161	160	159	158	157		156											3/5
												20	40	20	80	80		20											
												0	270	0	0	90		0											
												167	166	165	164	163		162											2/5
												20	20	10	20	30		20											
												0	0	0	315	90		0											
												172	171	170	169	168													1/5
												80	20	25	60	20													
												0	0	90	45	0													

LEGEND
145 Cell Number
1   Height
1   Reflectivity Amplitude
0   Reflectivity Initial Phase

Fig. 7. Middle layer reflectivity generation.

Now the inverse scattering modelling is affected by the pace engine. The Pace engine is the computing moving force that proceeds the points on the ship in time to new locations from their initial values depending on the motion of the ship. The movement is performed by an affine transformations module that provides roll, yaw, pitch and translations functions. All time processions actions are placed into the context of a three-dimensional environment, which is depicted in Figure 8.
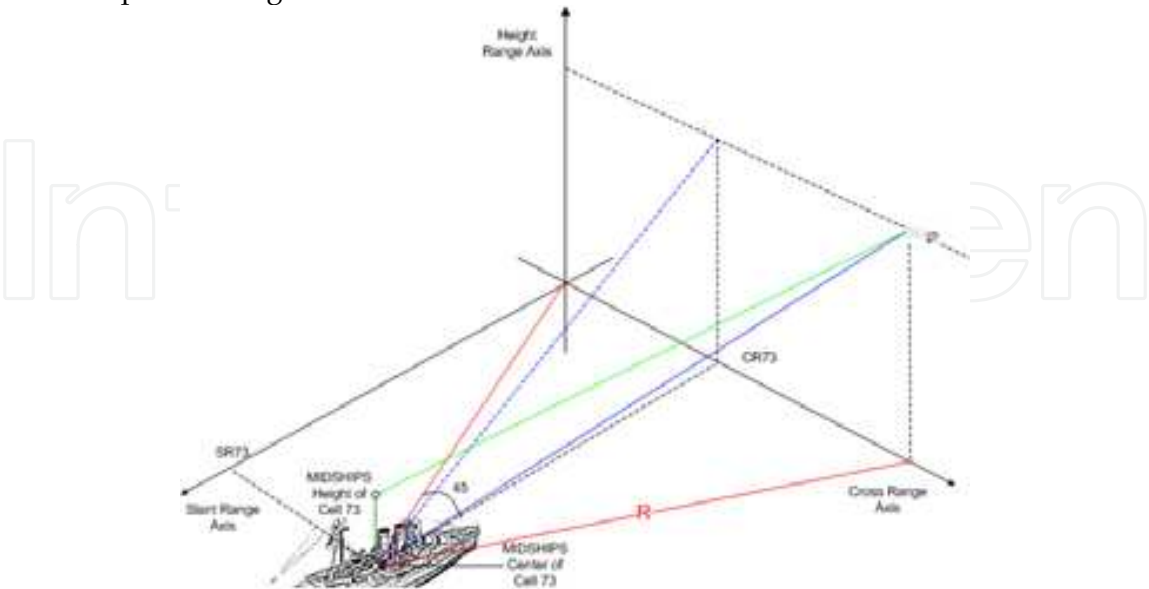
Fig. 8. Synthetic Environment Modelling

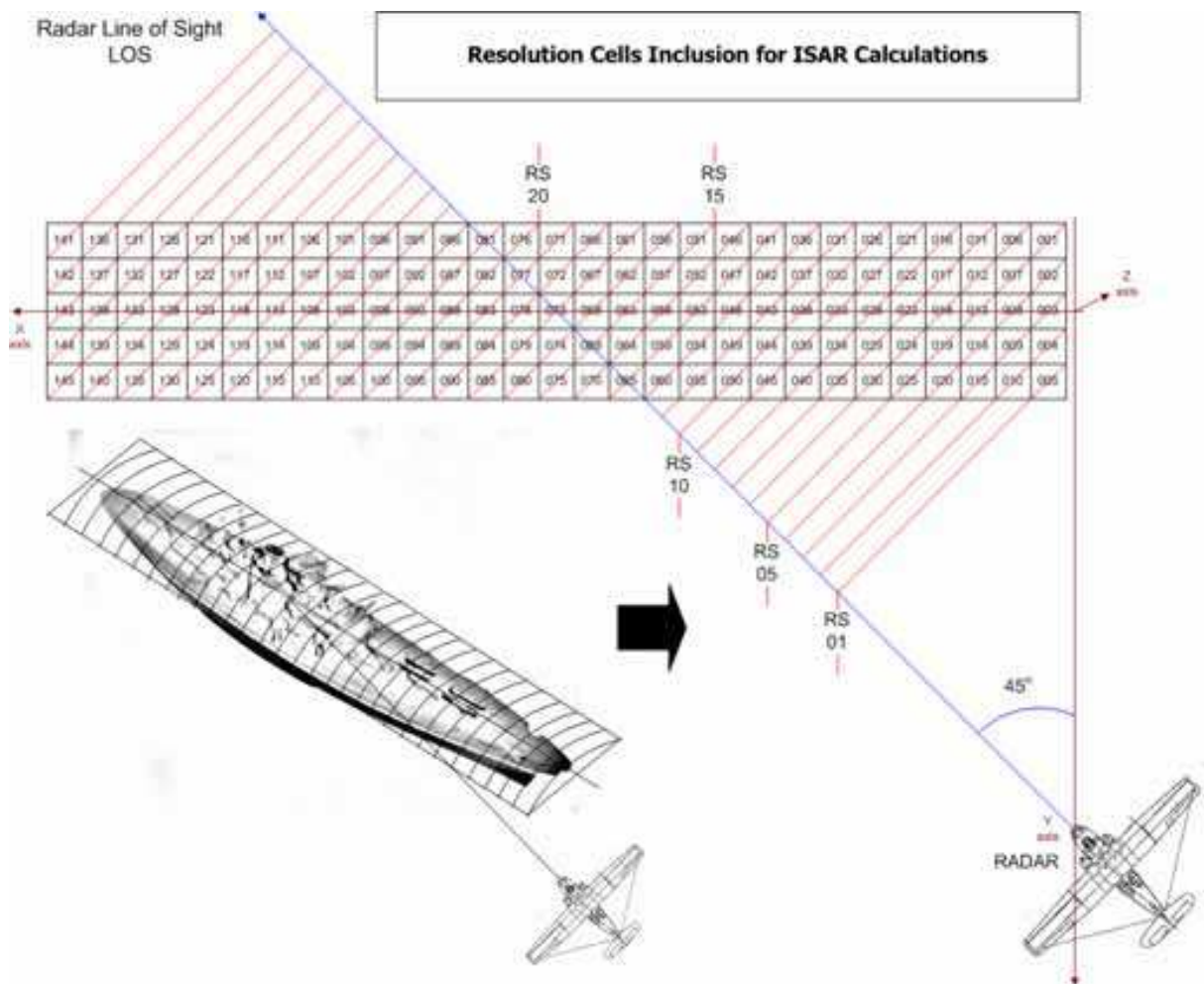And the graphical representation of the inverse scattering is shown in Figure 9.

Fig. 9. Theoretical implementation (Polar Format Approximation)

3.4 Entity Relationship Identification

The relationships among the entities are identified in this design phase. It is ensured that all constraints and boundary conditions are properly imposed by the simulation context. All operational and functional requirements are taken into consideration, as shown in Figure 10.
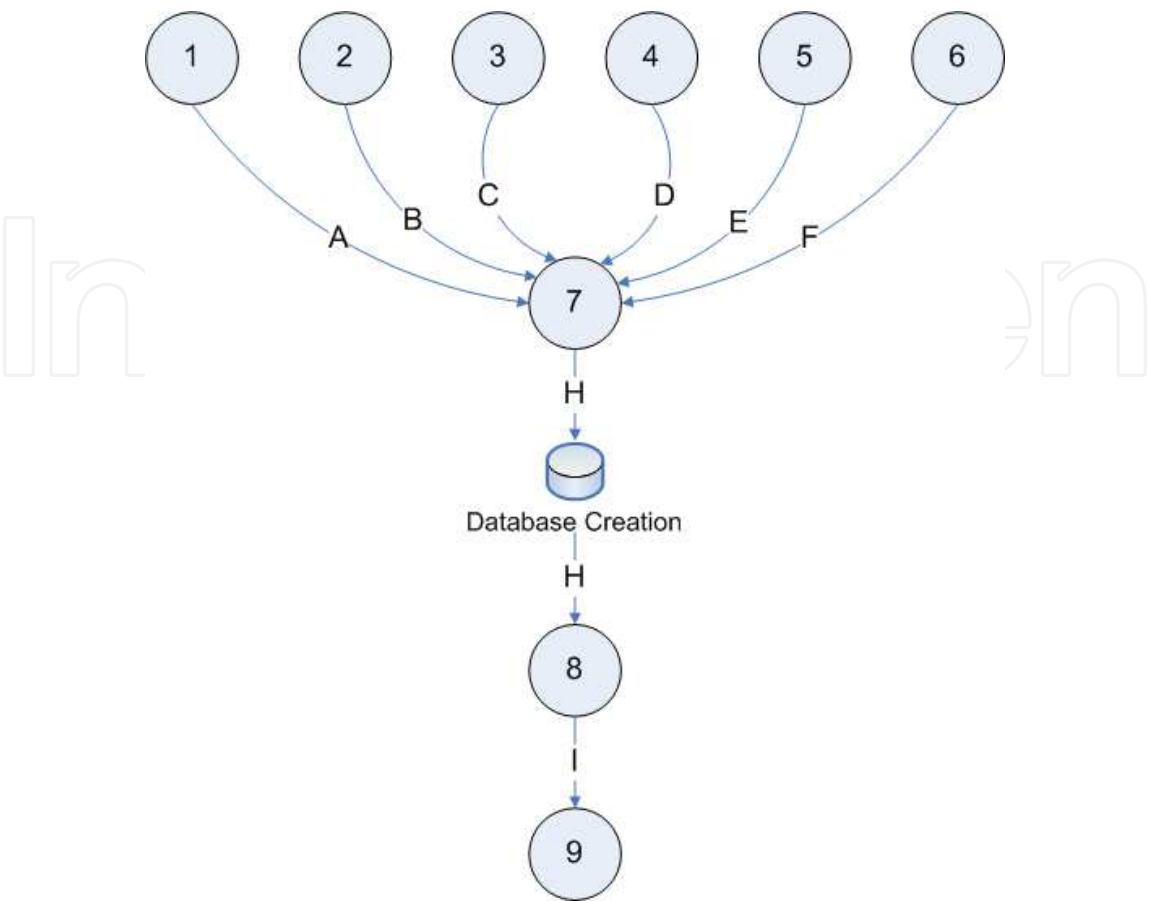
Fig. 10. Entity Relationship (E-R) identification

4. Implementation Procedure

The implementation procedure follows the rules of a complex system. In other words many individual components or transfer functions of the simulator when combined give a unique property or emergence to the output. Also the current implementation is process oriented. Every point on the target is passed through all transfer functions of the simulator in order to produce its corresponding output. The emergence of the system becomes obvious when all the points are put together in a graph. Each individual point cannot tell its tale. All of the points produce top view images or side view images of the target. This decision depends on the building blocks of the simulator.

4.1 Computing Methodology
The set of methods that define the processes and the order of this project is to be achieved is shown in Figure 11.
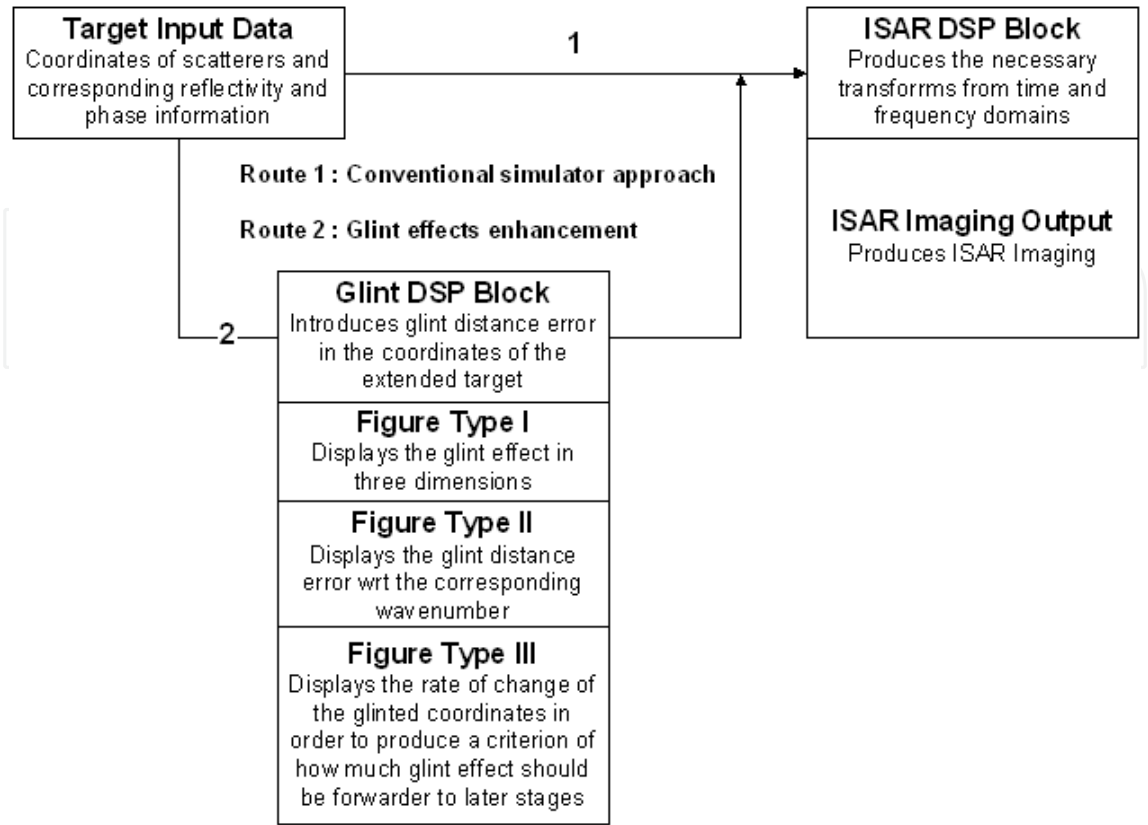
Fig. 11. Computing Methodology

4.2 Simulator Implementation

The simulator software implementation followed the process oriented technique as shown in Figure 12.

Get target point's x,y and z coordinates

Introduce Glint Effects

Pace Engine : Affine Transformations

Each point creates
32 movement points

Get radar antenna point's x,y and z
coordinates

A

Distance Calculator (32 distances)

Get target point's reflectivity and phase
information

B

Slant Range Profiles
(Time Domain)

ISAR Image
(Frequency Domain)
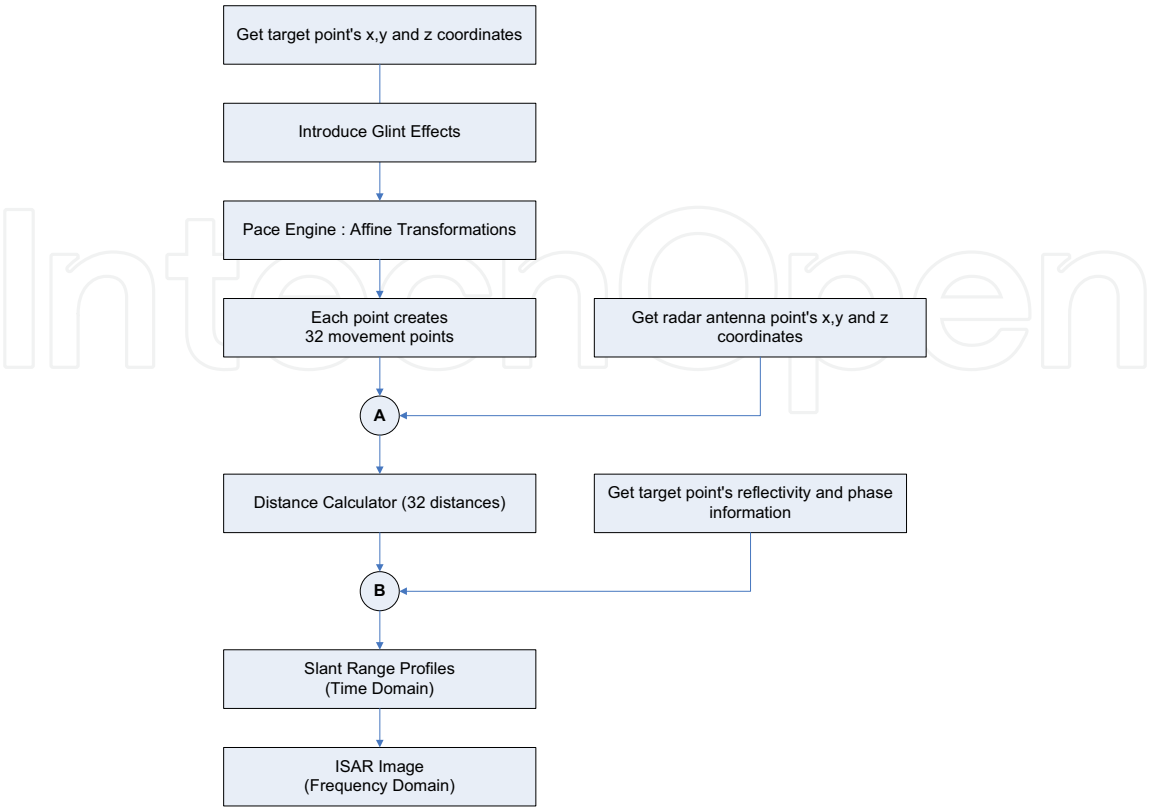
Fig. 12. Simulator Implementation of the FB-14 modular software system

The conceptual design and software implementation steps are now complete. The process resulted in the creation of the FB-14 software defined radar system. The system design is highly modular. That means that the context of the software defined radar system can be easily verified, validated, reused and extended. We then move on to assess the results obtained from our efforts.

5. Simulation Results

The results correspond to ISAR images expected to be obtained by the range Doppler method. These results were formally presented at the International Journal of Systems, Science & Technology. There is a value added function that adds glint effects to the output in order to increase the validity of the output which was presented at the Measurement, Science & Technology Journal of the Institute of Physics.. The third stage of this project was presented at NATO SET-136 Specialist's Meeting on Software Defined Radar.

5.1 Single Layer & Multi-Layer Model Results
Invoking the single layer model which involves only the top points of the superstructure, the output of Figure 13 is created.
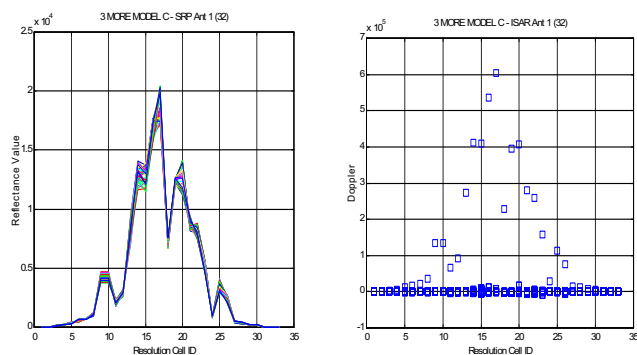
Fig. 13. Single Layer Slant Range Profile and corresponding ISAR image

Next by invoking the multiple layer model which involves the top and middle points of the superstructure, the output of Figure 14 is created.
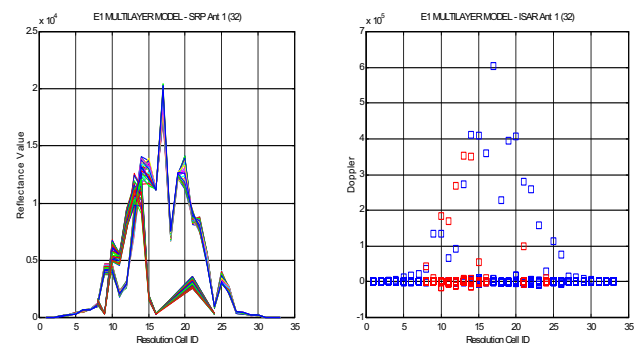
Fig. 14. Multiple Layer Slant Range Profile and corresponding ISAR image

5.2 ISAR Reflectivity Results & Issues for Military Targets

Military targets are different from civilian targets in the fact that there are many high reflectivity centers of reflectivity on lower coordinates. These high reflectivity values distort the ISAR image accordingly and killed ISAR operators look for these distortions in order to classify or even identify a radar contact. Our simulator can produce such effects as shown in Figure 15. Outputs of two antennas situated on a baseline of one meter away from each other are shown in order to demonstrate how different the image can be even when the antennas are very close to each other.
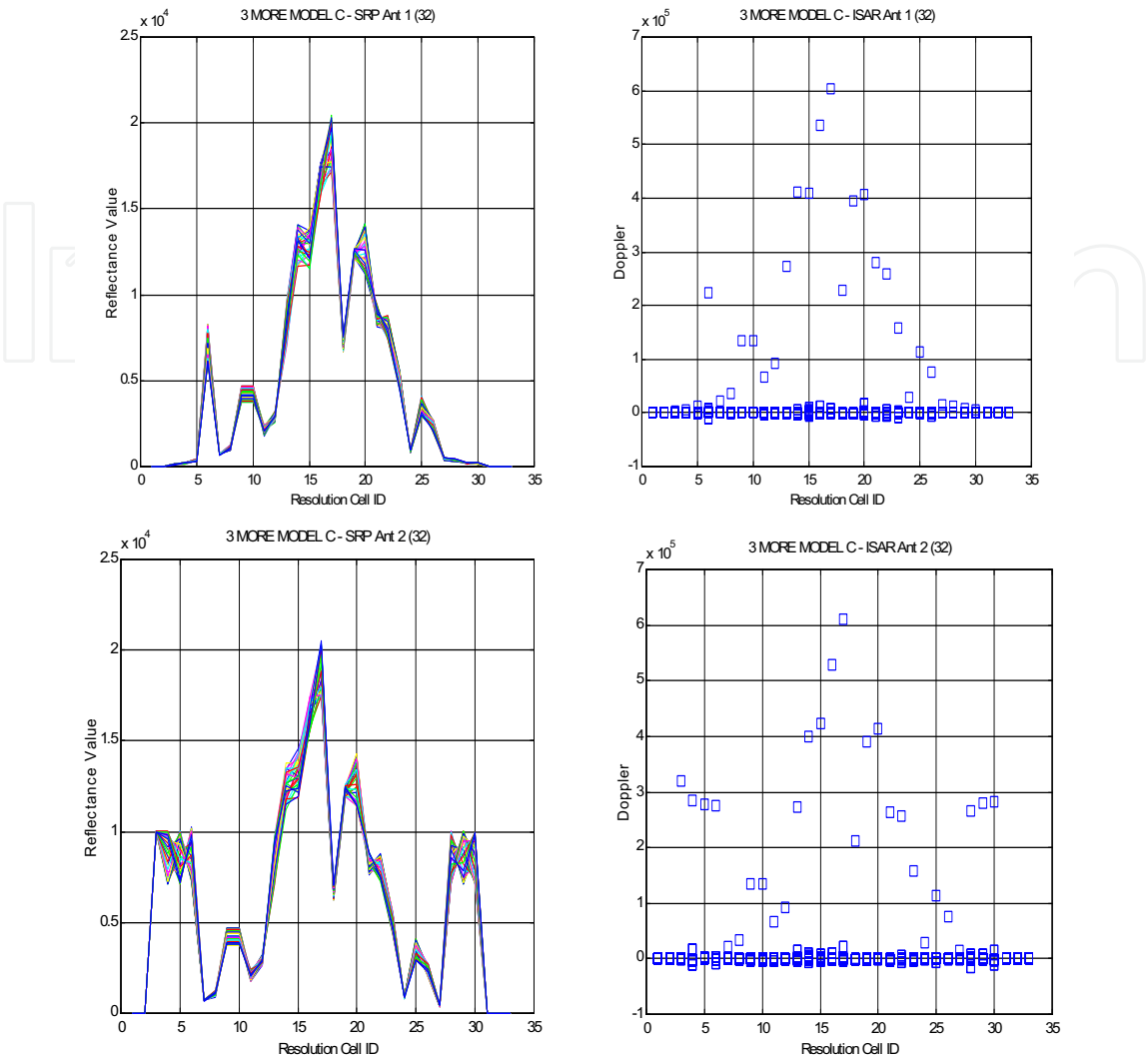
Fig. 15. ISAR Shortcomings Effect using the Single Layer Model.

5.3 Angular Glint Results & Issues for Military Targets

In order to increase the validity of the simulator output to the adversary radar-operator system the phenomenon of angular glint is introduced.

The first result is inspired by [Skolnik, 2001] and demonstrates the glint effect in a three dimensional synthetic environment with respect to the real target points. We call this component Glint Effect in 3D at the target and is shown in Figure 15(a).
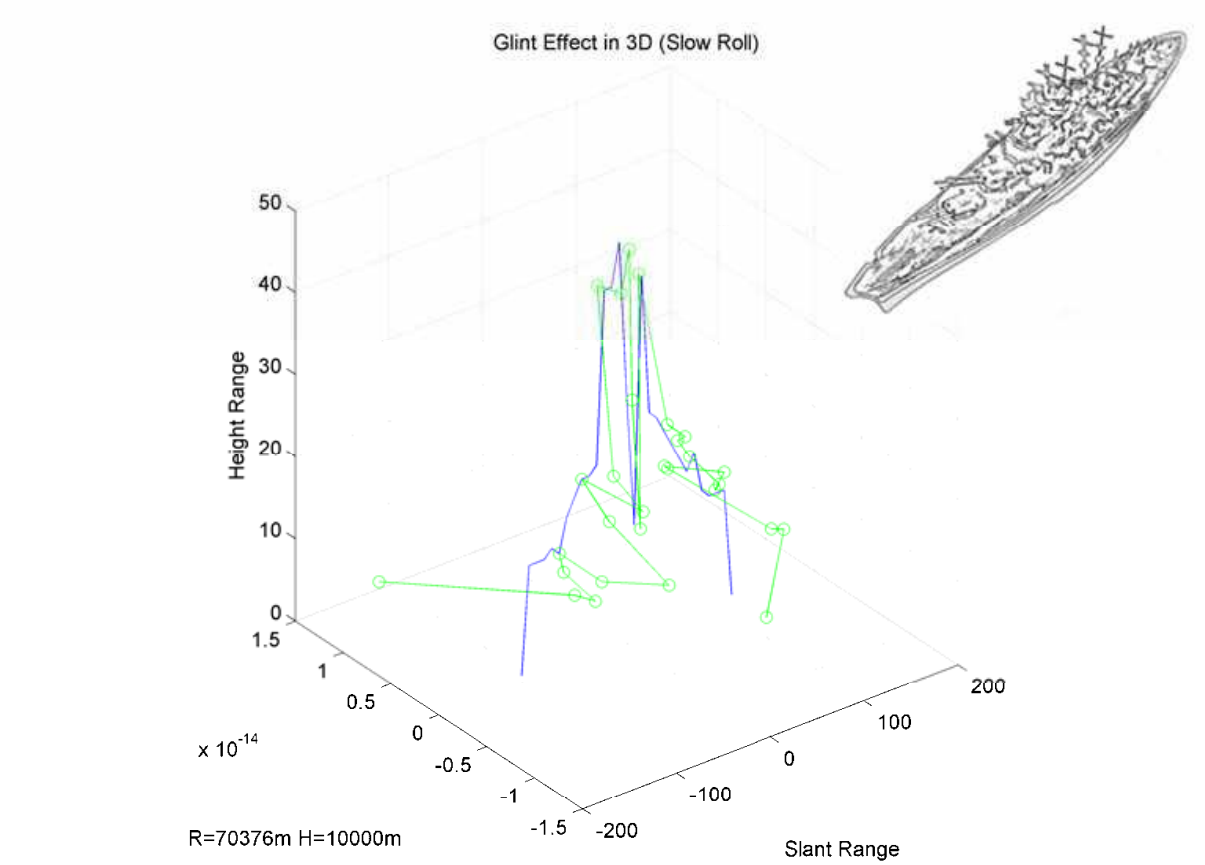
Fig. 16.

This is the glint mask that is applied to the false target. In order to better visualise this stage which corresponds to the input of the project a three dimensional type of graph is selected because the distortion of the original points can be better seen in this configuration.

The second module is inspired by [Barton, pp. 101-103] and depicts the glint effect in as seen from above the target by the radar. The Glint Effect in 2D is shown in Figure 15(b).
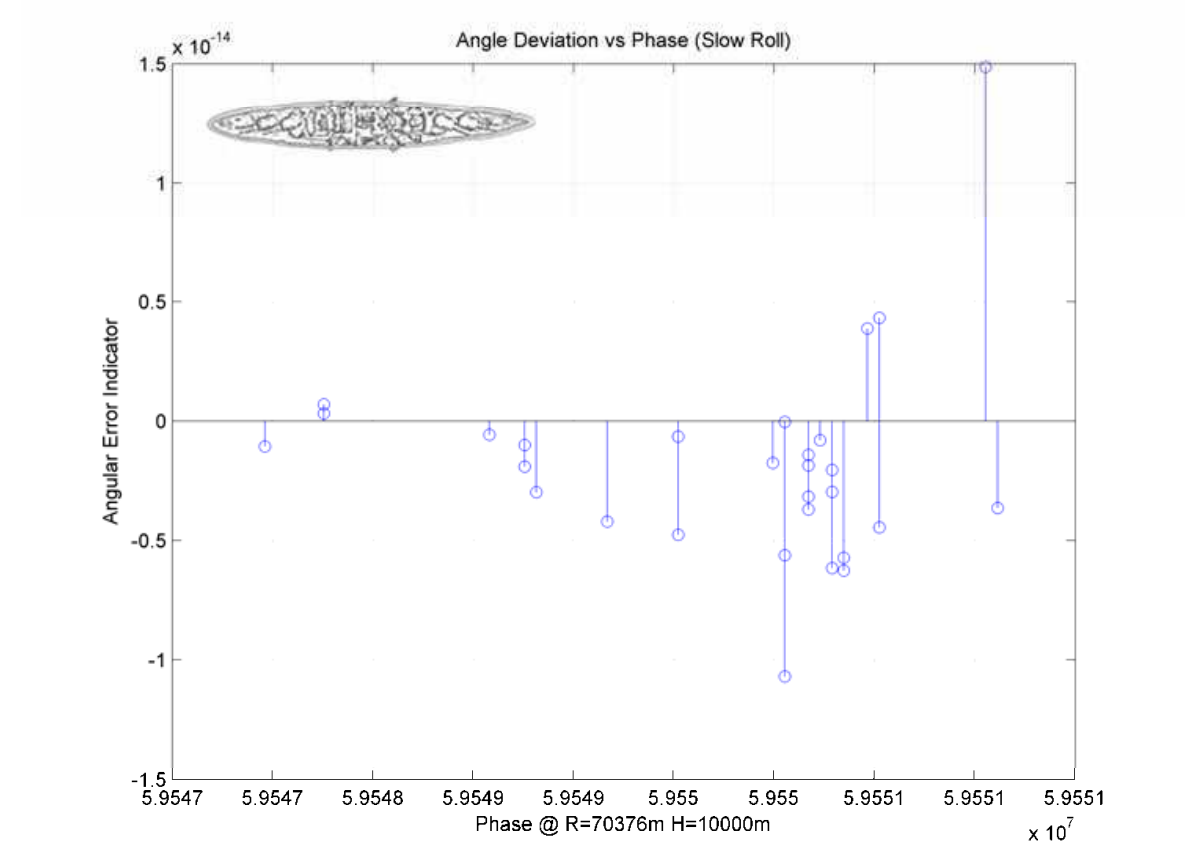
Fig. 17.

This is the glint results as it is received by the threat signal. In order to better visualise this stage which corresponds to the output of the project a two dimensional type of graph is selected, because the wavenumber distortion can be better seen in this configuration.

We use the final module to investigate the effect that the angular error has on the velocity vector back at the received threat signal. Using this method we try to measure the factor of realism of our glint formula. This result is shown in Figure 18.
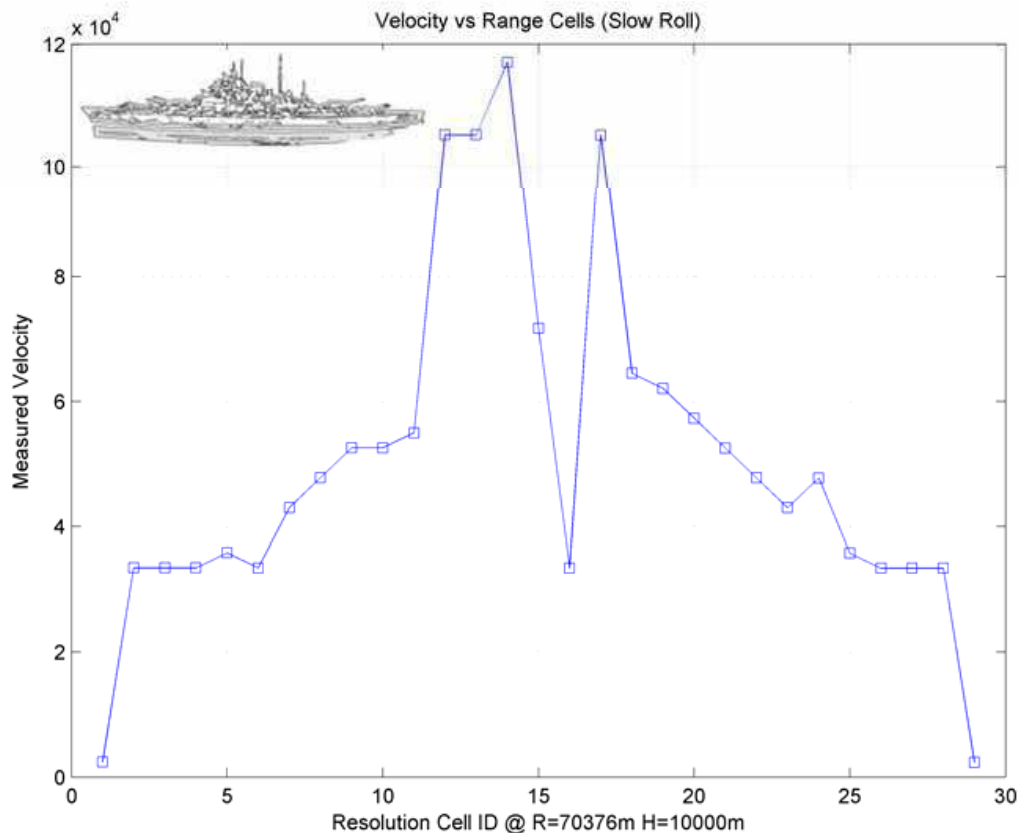
Fig. 18. Starting Point - Range @ 38nmi (70.376 Km) / Height @ 32808ft (10000m)

This is a graph that can be created because the target performs a pure roll motion which in high resolution imaging results in a side-view of the target. The threat system can perform such tests after storing the history of the received signal in order to ascertain its validity either as a side-view or as a top view image. According to this data mining process the threat system could output a decision of how the target is oriented. In this case the verdict would be that the target is mostly performing a roll and is a naval target of great proportions.

5.4 Domain Reusability: Computer Networks Security
Up to now we have devised a computing methodology in order to create false target entities. Also an effort is made so that these entities possess qualities that resemble the real situation as close as possible. By looking at the steps of the application domain definition and problem space decomposition for the electronic warfare case we found that the same computing methodology can be used for the computer networks warfare case. Generally the community of interest (COI) for this project is military training and network-centric operations and warfare [Balci et al, 2007, p.176]. For example the application domain definition for the computer networks case is shown in Figure 19, which is identical in principle to the previous study for the electronic warfare case.
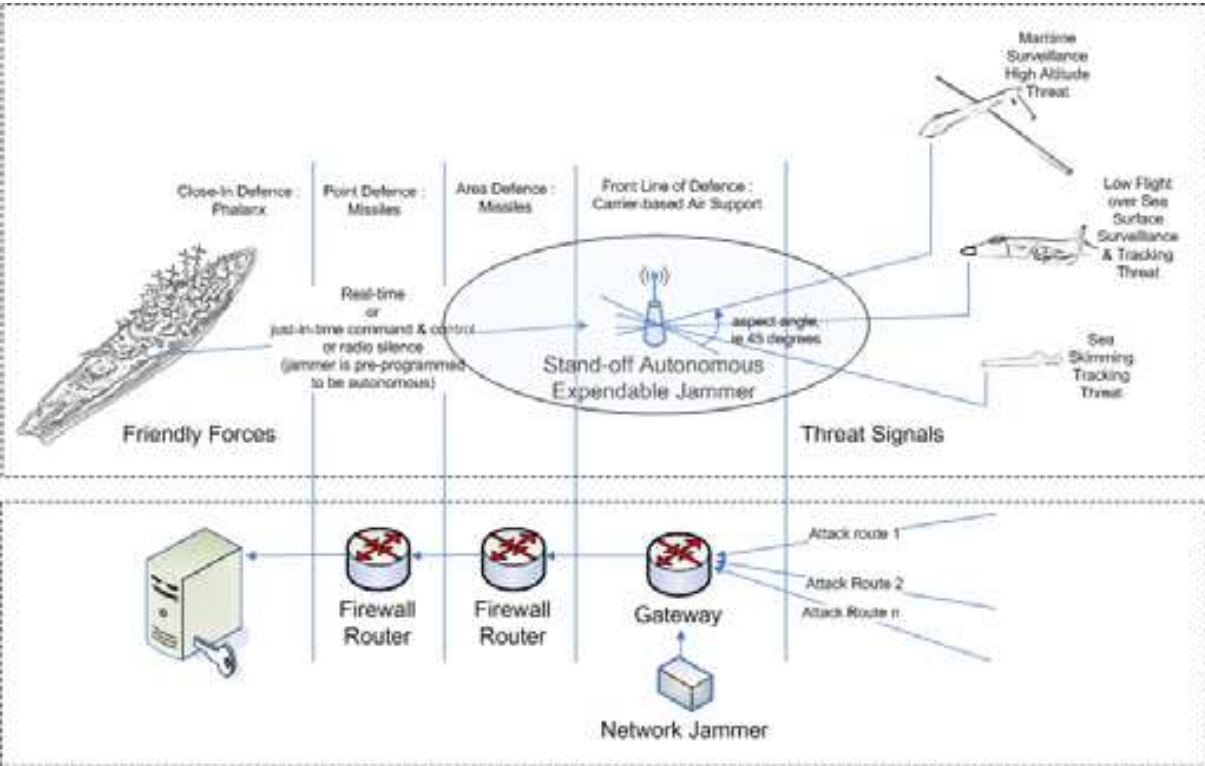
Fig. 19. ADD for the Computer Networks Warfare case.

A brief comparison with the electronic warfare case brings the contents of Table 3 for the entities and Table 4 for the processes for the computer networks warfare case.

	CNW Simulation Entity	CNW Entity Attributes	EW Simulation Entity	EW Entity Attributes
A	Open ports emulation	Server hardware and software characteristics and functionalities	Target Cartesian coordinates plus inherent amplitude & phase as point scatterers input to a simulator system	Target physical properties & electromagnetic signature
B	Computer entity emulation - Operating System attribute	Ping times from black hat to white hat computer – main point of existence	Radar slant range and cross range cartesian coordinates with respect to the center of the target	Most prominent appears to be the middle of the ship for this project. But it could be in the stern or the bow of the ship.
			Sea-level distance from radar to target	FM height finder radar (altimeter) on airborne platform

C	Physical routes of computer attack via a variety of networks and platforms	B. Extra net/server characteristics that helps the hacker to recognize target.	Type of vessel	Superstructure characteristics Geometry of worldspace
D	Port scanning & mapping abilities Information gathering Open ports OS Version Service Packs	Probing target computer Hacker's pre-attack actions Information gathering for the specific target Possible vulnerabilities	Radar operational parameters	ISAR systems particulars
E	Reality factors that affect the black hat professional's opinion about the validity of the target	Hacker: ANALYSIS of the information gathering results Decision about the validity of a probe	Glint representation details	Physical phenomenon impossible to disregard
F	Data properties through time	Packet and traffic inspection	Pace Engine	Target movement due to forces of nature Change of aspect angle from radar to target provides the resolution acquisition process
G	Specialized Applications - Database Server Processing	SQL Input - SQL Injection	ISAR processor details	Range-Doppler processing
H	Special Network Node Properties	Data Traffic	ISAR system output	Slant Range Profile and ISAR Image of the target

Table 3. Entities for the Computer Networks Warfare Case

	Simulation	Reality		
1	Close environment – server hidden	Net/Server properties	Provide information to the Pace Engine of target Cartesian coordinates to the pace engine	Physical presence and movement of target
2	Motivation profit and/or spy/destroy	Hacker's motivation	Provide information to the Pace Engine of radar two-dimensional (slant ranger and cross range) coordinates	Physical presence and movement of radar
3	pro-Hacker public/private tools	Hacker's knowledge/Tools	Provide information to the Pace Engine of radar's third (height range) dimensional coordinates	Measurement - captures reality with a sensor
4	Complex network environment	Possible Net/Server architecture/characteristics	Provide information to the ISAR Processor about the radar's operational parameters	Instrumentation – operational information
5	Many servers (fussiness)	Possible Net/Server architecture/characteristics including normal the net's/server's fussiness and attitudes.	Aspect angle variation	Caused by changes in target/radar location

6	Time Alterations of target characteristics	Target may alter characteristics due (service packs, admin observations, service requirements, new machines (for network)	Glint Effects Injection	Digital Signal processing Conditioning (Masking)
7	What the black hat professional sees – the output of the multiple false host generator	Information gathering concluded for the specific target	From Pace Engine to rotated points database	Caused by changes in time
8	Time Alterations of target characteristics	Target may alter characteristics due (service packs, admin observations, service requirements, new machines (for network)	From Pace Engine Database to ISAR Processor	Recording Process – processes history of target in computer memory

Table 4. Processes for the Computer Networks Warfare Case

5.5 Current Deficiencies: Computational Complexity Issues & Future Work

This research approach formulated a prototype in order to establish the credibility of the effort. Actual implementations call for parallel processing elements in order to speed up the processing of the false target generation. The complete computing methodology is very easy to translate to a parallel algorithm version and this will be shown in future works. It is noteworthy to mention that the Fast Fourier Transform algorithm that this project is using in order to create the final stage (frequency domain representation) can use the advantages of parallel processing.

For future research we propose improvements in the software engineering side with the introduction of the concepts of parallel processing and additions to the reality output of the project like sea clutter effects. The main issue in the synthesis of coherent countermeasures is the high speed that is required in order to complete all the numerical transactions. Therefore the domain of parallel programming fits nicely in this situation. We can propose an embedded system with many processors that help the synthesis process to be completed in the shortest time possible. Also added-value aspects of this world can be incorporated in the future like sea clutter effects. Sea is a rich environment that needs to be convincingly replicated in open seas and litortal environments.

6. Discussion

[Salt, 2008] has published a very interesting paper detailing pitfalls in the realisation, usage and expectations of simulation system implementations in general. Let us discuss how this implementation stands to the test of the seven habits of highly defective simulation projects.

- Trifle Worship. The overall design of the model has a satisfactory amount of detail. The balance between precision and accuracy yields an output that is satisfactory.

- Belief in Answers. The main aim of the simulation is to prove that ISAR images can be generated. Other secondary answers from this work, like signal-to-noise ration studies are possible but not relevant to the primary purpose. Therefore the modellers have understood the purpose of the system under investigation.

- Connectionism. There are no different models connected to each other. There is only one model that is constructed in a highly modular manner.

- The Black Box Mistake. Substantial work has been done in order to conduct white box testing. Verification and validation tests have been widely published in conferences and research journals. These tests are conducted in part and in whole of the simulation model.

- Methodolatry. Methods and processes are observed in all aspects of the implementation of the simulator. We don't claim that it is a fixed drill for conducting the domain reusability entities and processes section. Nevertheless following an established method provides a solid head start towards venturing into the implementation of similar, parallel and yet interestingly diverse fields of electronic warfare.

- The Dead Fish Fallacy. The design of the simulator is highly modular. This attribute provides the implemented model with great potential for reusability and extendibility options. Therefore the dynamic complexity of the project has received the attention required. For example the diagramming method depicts in different instances the entity-relationship class diagrams and the executable representations of the code.

- The Jehovah Problem. The differences between the model and the reality it represents have been duly noted. The functional decomposition of the simulator implementation is available. Nevertheless the valuable part of this work is the behaviour of the system to different inputs and not its inner functions. The model provides behaviour, not an answer. It tries to simulate the inverse scattering of a high range resolution radar system in order to infect the adversary radar operator with its behaviour. The degree of this infection is important because over a threshold it makes the adversary human element to want to investigate the area of the incoming signal. Because its behavioural aspects appear worthwhile and tempting to be investigated.

7. Conclusions

Software-defined radar concepts and techniques can be used in an effective and adaptable manner in order to provide deception countermeasures against coherent radar systems by utilizing a simulator base. The main contribution of this work is the derivation of a computing methodology which can be applied for both electronic warfare and computer networks warfare fields. And the main purpose of this work is to provide security functions through obfuscation of the real asset in an environment of other false entities thus further proving deception services by luring the hostile parties to engage false entities or in any way avoid the real asset. It is worthwhile to point out that the design tools of coherent countermeasures, being dynamically pictorial in nature, are no different than a painting or a movie feature. As is art forgery, the more the resemblance to the real prototype the higher the chances a buyer will be persuaded to invest in the false copy. Because the buyer will be infected, as Tolstoy so vividly explained, with the artistic persuasion of the false masterpiece. In a final note, the act of implementing coherent countermeasures using a simulator base is an integral part of the amazing field of Art.

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Modelling Simulation and Optimization

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Computer-Aided Design and system analysis aim to find mathematical models that allow emulating the behaviour of components and facilities. The high competitiveness in industry, the little time available for product development and the high cost in terms of time and money of producing the initial prototypes means that the computer-aided design and analysis of products are taking on major importance. On the other hand, in most areas of engineering the components of a system are interconnected and belong to different domains of physics (mechanics, electrics, hydraulics, thermal...). When developing a complete multidisciplinary system, it needs to integrate a design procedure to ensure that it will be successfully achieved. Engineering systems require an analysis of their dynamic behaviour (evolution over time or path of their different variables). The purpose of modelling and simulating dynamic systems is to generate a set of algebraic and differential equations or a mathematical model. In order to perform rapid product optimisation iterations, the models must be formulated and evaluated in the most efficient way. Automated environments contribute to this. One of the pioneers of simulation technology in medicine defines simulation as a technique, not a technology, that replaces real experiences with guided experiences reproducing important aspects of the real world in a fully interactive fashion [iii]. In the following chapters the reader will be introduced to the world of simulation in topics of current interest such as medicine, military purposes and their use in industry for diverse applications that range from the use of networks to combining thermal, chemical or electrical aspects, among others. We hope that after reading the different sections of this book we will have succeeded in bringing across what the scientific community is doing in the field of simulation and that it will be to your interest and liking. Lastly, we would like to thank all the authors for their excellent contributions in the different areas of simulation.

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