A new rapid ISTAR assessment method

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Abstract

One of the most significant contributions to the Command and Control (C2) process is the input of high quality intelligence, surveillance, target acquisition and recognition (ISTAR) information, in a timely manner. In the past, the operational analysis (OA) to support this ISTAR capability has used detailed and explicit modelling, this was inflexible, lengthy, and costly to run. A novel and more abstract approach to the assessment of ISTAR capabilities and sensor mixes has been developed, which removes the need for detailed terrain data and explicit platform-level sensor and target deployments. This paper outlines the model, and presents some example output.

1. Introduction

The command and control (C2) process relies on high quality and timely intelligence input. The selection of the most appropriate and robust mix of intelligence, surveillance, target acquisition and reconnaissance (ISTAR) capabilities is thus an important component of the OA that supports both C2 and ISTAR procurement decisions, and increasingly, operational decisions. Addressing these questions currently uses methods and tools that are highly detailed, slow, costly to set-up and use, and not easily adaptable to novel capabilities, multiple scenarios or variations in the numbers of capabilities. However, a novel approach to this problem is presented in this paper that moves towards overcoming these difficulties.

Current military doctrine is placing more emphasis on flexibility, operational tempo and integrated communication and intelligence systems. The UK MoD has defined this set of concepts which underpin the theme of Network Enabled Capability (NEC): indicating that the success of future military operations will be driven more by the commander's ability to collect, assimilate, manage and distribute information necessary to overcome the complexities of the modern battlespace [1].

To support this emerging doctrine with OA requires similarly flexible and responsive tools. A Visual Basic (VB) Excel spreadsheet model has been developed that enables a rapid assessment of ISTAR mixes against an outline deployment, within the context of the commanders' critical information requirements (CCIRs). The model has been formulated by a combination of analytical tests, numerical routines and heuristic rules, in accordance with the NATO Code of Best Practice [2].

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2. Model requirements

This section outlines the requirements that were defined for the model, both operational, in order for it to meet study management aspirations, and technical, to ensure the required functionality.

Operational requirements

To achieve the operational goals identified above, it was determined that the model should:

- run on a PC, using Excel fronting Visual BASIC;
- represent spatial information (but without an explicit terrain database);
- represent a 'snapshot' period of time;
- run deterministically (but using probabilistic data);
- compute the results of a single run in less than one minute;
- output easy-to-understand metrics (e.g. 'traffic-light' confidence levels).

Technical requirements

The model was required to the following features of the ISTAR collection array at a simple level:

- the approximate spatial relationships between sensors and targets;
- the quality of physical information collected;
- the quality of information on unit intent;
- the interactions of sensor capabilities, target types and postures;
- the effects of terrain, weather and day/night on sensor performance.

Types of sensors

It was required to represent the following types of sensor:

- ground-based imaging sensors: optical and thermal;
- ground surveillance radars;
- unmanned acoustic and seismic sensors
- UAVs carrying a variety of sensors;
- weapon locating radars (WLRs) and sound ranging (SR) sensors;
- manned reconnaissance aircraft carrying imaging sensors and radars;
- electronic support measures (ESM).

Much of the burden of model fidelity is shifted onto the preparation of the input data. Factors such as the degree to which given weather conditions would degrade different types of imaging sensor are used to simulate the effects of environment and meteorology on performance scores. Dstl LSD has derived the data on these from other low-level performance models and studies.

3. Model description

The model represents the Blue force sensors, the Red target array including its deployment, posture and activity, and civilians, in a stylized manner, as homogeneous ‘blobs’. Although the model did not use explicit terrain, a simple map was needed to verify the spatial deployments, which enhances user confidence.

The model assesses the performance of sensor mixes against the target array over static ‘snapshots’. A ‘snapshot’ is defined as a period of time within a scenario, during which the target array can be assumed not to alter significantly in deployment and posture. (Snapshot length will depend on the command level being studied.) Although some aspects of time and movement are represented, no entities move during the run.

For each CCIR type, the model assesses those sensors that would be able to acquire sufficient information (in the simplest sense) about each target group to satisfy the constraints of that CCIR. This is assessed using a deterministic ‘logic engine’. This considers each sensor on each search group in turn, assessing its capability against each target group within the constraints of the CCIR in question. Six tests are conducted are as follows:

- spatial overlap between sensor footprint and target deployment: the proportion of a target’s area covered by a sensor;
- spectral compatibility between sensor and target signature in the broadest sense: a measure of the sensor/target spectral coupling dependent on meteorological, terrain and culture conditions (i.e. not just a electromagnetic assessment);
- activity (static/moving) compatibility between sensor and target postures: a flag to represent static, moving or dual sensor/target movement coupling – this allows the model to distinguish between moving and static target indicator (MTI and STI) radars;
- resolution (detection, recognition or identification) against CCIRs;
- target location errors (TLEs) against target density and CCIRs;
- timeliness of information delivery against target mobility and CCIRs.

Each of these tests produces a value on a scale between zero and one, representing the proportion of the target array that satisfies that particular test. The product of all these assessments for a given sensor-target pair will constitute their overall measure of performance in the context of the CCIR being considered. It is important to note that the multiplication operator implies statistical independence, which is thought valid, to a first order approximation, in this instance; it also implies an ‘AND’ logic, by which failing one of the six tests will fail the entire sensor/target assessment. Table 1 shows the interdependencies between the different factors and the six tests.

Factor \ Test	Spatial	Spectral	Activity	Resolution	TLE	Timeliness
Deployment	✔					
Relief	✔					
Terrain	✔	✔				
Meteorology	✔	✔				
CCIR				✔	✔	✔
Sensor capability	✔	✔	✔	✔	✔	
Blue platforms	✔	✔	✔	✔	✔	✔
Red targets	✔	✔	✔	✔	✔	✔

AND ⇒ MoP

Table 1: Interdependency between the different factors and the six tests

Target posture

An important property of a target is its posture. The posture of each target group is designated by a flag defining the proportion of target platforms are assumed to be doing what (exposed, moving, firing, static, hull-down or camouflaged, silent or emitting, etc.) in each given posture. Associated with the posture is a tear-down time in minutes. One of the CCIR categories (see below) is targeting. Targeting requires smaller TLEs and faster timeliness criteria. Thus, the tear-down time is the time within which targeting must occur if the target is likely to be there when the attack lands (because it will vary by platform type and posture, it cannot be a function of either of these alone.) Some example target posture data are set out in Table 2. For each posture there are ten properties, five of which (EO/IR is an example) are dependent on waveband. The full list of properties is as follows: moving, static, hull-down, camouflaged, EO/IR, direct fire, indirect fire and emitting.

Target posture \ Property	Moving	Hull-down	EO/IR
Advance	20%	0%	100%
Camouflage	0%	100%	30%
Convoy	70%	0%	100%
Emit and Skit	10%	60%	100%
Indirect fire	5%	100%	100%
Hasty	2%	100%	60%
Hide	0%	100%	0%
Moving	100%	0%	100%
Open	10%	30%	100%
Hide	10%	70%	20%

Table 2: Example sub-set of target posture options and properties

Terrain

The effects of both terrain and weather (see following section) impinge on the performance of various sensor types; such effects have been well-documented [3]. Terrain effects are divided into two aspects: relief and culture. For each terrain category the percentage cover for 'trees', 'buildings' and 'open', respectively, is multiplied by a 'reduction factor' associated with that terrain type for each waveband; this results in an overall culture modifier that reduces the range of a sensor. This reduction of range is both culture and spectrally dependent. In addition to this, the sensor belongs to a searcher class, for example: ground, unmanned air vehicle (UAV), electronic waveband (EW) or sound-ranging (SR). Each searcher class has an associated 'reduction factor' dependent upon relief type.

Table 3 indicates that terrain features affect the spectral test and spatial tests only. The terrain options are user-driven and are listed as follows:

Terrain \ Property	Culture		Searcher type			
	Trees	Bldgs	Ground	UAV	EW	SR
Featureless, flat	0%	0%	1.0	1.0	1.0	1.0
Desert, flat	0%	1%	0.9	1.0	1.0	1.0
Desert, rolling	0%	1%	0.8	0.9	1.0	1.0
Europe, flat	27%	3%	1.0	1.0	1.0	1.0
Europe, rolling	17%	3%	0.8	0.9	1.0	1.0
Hilly	27%	3%	0.6	0.8	0.9	1.0
Mountain	60%	1%	0.4	0.6	0.8	0.9

Table 3: Example terrain feature options and properties

The inclusion of the 'Featureless, flat' option is included since it represents an option without any terrain, which provides a method of measuring terrain effects, culture effects and meteorological effects, respectively. Reducing the effective range for line and circle sensors modifies the spatial test; such a terrain 'effectiveness factor' is dependent on both the terrain type and the searcher type (i.e. ground, UAV, EW or SR). Multiplying the spatial test score reduces the effectiveness of the area sensors by the corresponding terrain 'effectiveness' factor for the specific searcher type. (Note that for the 'Featureless, flat' this factor is set to one).

Meteorology

The 'modifying' factor for meteorology is sensor waveband dependent. Each weather type is assigned a factor for each of the wavebands. This factor multiplies the overall coupling score thereby modifying the degree of sensor/target coupling appropriately.

Meteorological influences are highly dependent on waveband. Table 4 shows the range scaling factors for each weather/waveband pair. This effect is simulated using a similar technique to that used for terrain effects. Each meteorology option has associated eight 'effectiveness' factors, relating to the spectrum of wavebands. Essentially, these multiplying factors reduce the coupling by modifying the effective range of the sensors (according to waveband), in a manner similar to the searcher type dependent 'effectiveness' factor discussed in the Terrain effects section.

Met. \ Waveband	Optical	SWIR	MWIR	LWIR	MMW	CMW	VHF	HF	WLR	SW
Clear day	1.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Cloudy day	0.6	0.0	0.8	0.8	1.0	1.0	1.0	1.0	1.0	1.0
Rain day	0.3	0.0	0.4	0.4	0.6	0.7	0.8	0.9	0.9	0.8
Windy day	0.6	0.0	0.8	0.8	1.0	1.0	1.0	1.0	1.0	0.6
Clear night	0.2	0.5	0.7	0.7	1.0	1.0	1.0	1.0	1.0	1.0
Cloudy night	0.0	0.15	0.7	0.7	1.0	1.0	1.0	1.0	1.0	1.0
Rain night	0.0	0.05	0.4	0.4	0.6	0.7	0.8	0.9	0.9	0.9
Windy night	0.0	0.15	0.7	0.7	1.0	1.0	1.0	1.0	1.0	0.6

Table 4: Example of weather options and properties by sensor waveband

CCIR

This is the fundamental driver for the ISTAR C2 process. These requirements are influenced by resolution, timeliness and TLE, and are outlined in Table 5. Each CCIR option can be mapped onto a level of acquisition, i.e. Planning (recognition), Targeting (identification), Terrain (detection) and Techint (technical exploitation). The acquisition levels are used to determine the resolution test: the acquisition levels D/R/I/T are assigned index 1/2/3/4, respectively.

CCIR \ Property	Resolution (D/R/I/T)	TLE (m)	Timeliness (minutes)
Planning	R	500	60
Targeting	I	20	5
Terrain	D	100	120
Techint	T	500	600

Table 5: Example CCIR options and properties

4. Example Results

Deployment: the map

Figure 1 shows the representation of deployments that serves as a visual aid. The map is entirely input data driven and is able to represent: point sensors (blue circles); area sensors (blue rectangles); line sensors (blue lines with the reach extent indicated by the green arrows); point targets (small red circles); radial targets (red circles); area targets (red rectangles) and formation targets (red lines). The resolution of the map is derived automatically, based upon the extent of deployments. The reduction in ranges due to terrain and meteorological effects is indicated by the ‘bar’ crossing the reach arrow for line search groups and the concentric perimeter for the radial search groups.

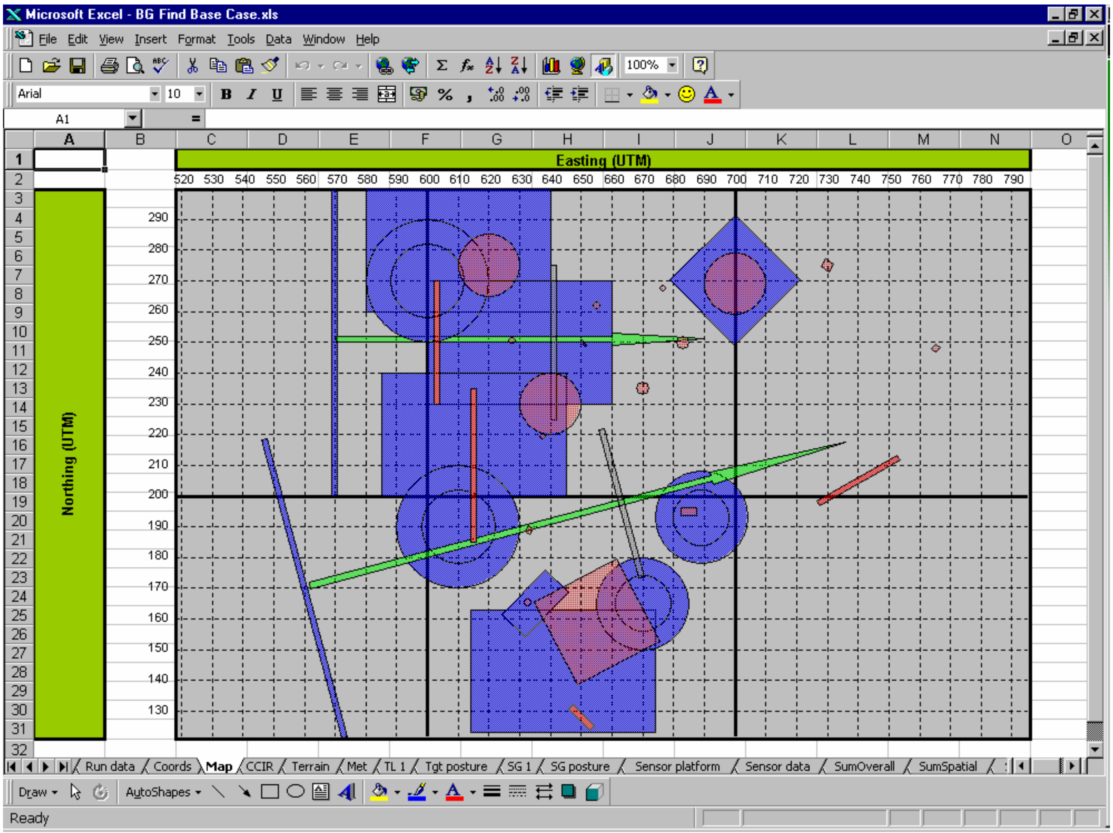


Figure 1: Example screen showing simplified map of search and target groups

Summary table

Figure 2 shows an example of a summary table of the base case (i.e. ‘Planning’ CCIR, ‘Europe, hilly’ terrain ‘Clear day’ meteorology) as illustrated by the scenario shown in Figure 1. Each sensor is listed across the rows and each target is listed across the columns: this is data driven (i.e. this table is created every time the program is executed – the lists are generated from the data input spreadsheets). The score in each cell is the product of the scores from the individual tests for the corresponding sensor/target pair. The colour coding of the sensor/target cells is as follows: ‘red’ indicates a failure (or close failure: notice some red cells have non-zero scores); ‘yellow’ signifies an intermediate pass (which implies some tests have been fully passed and some partially); ‘green’ indicates full (or close to full) compliance. The purpose of the colour scheme is to act as a visual aid, the score levels for the three colours can be varied independently for each individual test until a plausible set of criteria is achieved. The number of ‘yellow’ and ‘green’ sensors and targets, respectively, is indicated (horizontally, for the sensor performance, and vertically, for the target susceptibility) to give a measure of the ISTAR MoP.

The scoring system was deliberately designed to produce a broad intermediate category between ‘green’ (a good sensor/target coupling) and ‘red’ (no coupling) for two reasons. Firstly, to reflect the reality that incomplete information on a target is better than no information. Secondly, uncertainties and simplification in the data and method would have led to dangerous instabilities in a 'yes/no' binary output.

Overall summary. Parameters: TL 1; SG 1; Europe, hilly; Planning; Clear day

	Name/Type	Sensors													
		1. Scout-1	2. Scout-2	3. Scout-3	4. Engr-R	5. MUAV-1	6. LEWT	7. FOO-1	8. FOO-2	9. MFC-1	10. MFC-2	11. A Sqn	12. SRT		
Targets	1. TkRegtHQ	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	1
	2. Dump	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
	3. Relay	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
	4. Ech	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
	5. AD1	0.00	0.50	0.00	0.54	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	2	1
	6. AD2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
	7. Mtr Ptn	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1	0
	8. TkCoy1	0.30	0.05	0.00	0.00	0.00	0.04	0.00	0.21	0.00	0.00	0.00	0.00	0	2
	9. TkCoy2	0.00	0.18	0.00	0.26	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.30	0	3
	10. TkCoy3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
	11. Recce	0.08	0.30	0.00	0.09	0.00	0.04	0.00	0.24	0.00	0.00	0.00	0.03	0	2
	12. ATk Ptn	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	1
	13. EW Ptn	0.00	0.09	0.00	0.39	0.00	0.17	0.39	0.00	0.00	0.00	0.00	0.00	0	3
	14. RAG	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0	1
	15. WLR1	0.30	0.30	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0	2
	16. WLR2	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.30	0	3
	17. DivEngr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0	1
	18. MR Bn1	0.00	0.00	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.28	0.01	0.15	0	3
	19. MR logs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
	20. Civilians	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	1
		0	2	0	1	0	0	0	0	0	0	0	0		
		2	4	3	2	1	2	1	2	1	1	1	4		

Figure 2: Overall results summary table for the base case

Figure 3 is the overall summary table for the base case scenario with the substitution of the 'Targeting' CCIR feature option. It is clear that increasing the C2 demands (i.e., timeliness and TLE) significantly reduces the performance of the sensors. This has the effect of deteriorating the performance of most sensors.

Overall summary. Parameters: TL 1; SG 1; Europe, hilly; Targeting; Clear day

	Name/Type	Sensors													
		1. Scout-1	2. Scout-2	3. Scout-3	4. Engr-R	5. MUAV-1	6. LEWT	7. FOO-1	8. FOO-2	9. MFC-1	10. MFC-2	11. A Sqn	12. SRT		
Targets	1. TkRegtHQ	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
	2. Dump	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
	3. Relay	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
	4. Ech	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
	5. AD1	0.00	0.20	0.00	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	2
	6. AD2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
	7. Mtr Ptn	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1	0
	8. TkCoy1	0.30	0.05	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0	2
	9. TkCoy2	0.00	0.18	0.00	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0	3
	10. TkCoy3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
	11. Recce	0.02	0.06	0.00	0.04	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0	1
	12. ATk Ptn	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	1
	13. EW Ptn	0.00	0.04	0.00	0.31	0.00	0.00	0.31	0.00	0.00	0.00	0.00	0.00	0	2
	14. RAG	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0	1
	15. WLR1	0.12	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	2
	16. WLR2	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.02	0	1
	17. DivEngr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0	1
	18. MR Bn1	0.00	0.00	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.28	0.01	0.08	0	2
	19. MR logs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
	20. Civilians	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	1
		0	1	0	0	0	0	0	0	0	0	0	0		
		2	3	3	3	1	0	1	2	1	1	0	2		

Figure 3: Overall summary for same scenario with 'Targeting' CCIR

Figure 4 is the overall summary table for base case scenario with the substitution of the 'Rain night' meteorology feature option. It is clear that the substituting poorer weather conditions the overall degree of spectral coupling is decreased, indicated by the appearance of more yellow and red cells and the corresponding lower score values. The performance of search groups, such as Scout, relying on the optical waveband experience most deterioration.

Overall summary. Parameters: TL 1; SG 1; Europe, hilly; Planning; Rain night

Name/Type	1. Scout-1	2. Scout-2	3. Scout-3	4. Engr-R	5. MUAV-1	6. LEWT	7. FOO-1	8. FOO-2	9. MFC-1	10. MFC-2	11. A Sqn	12. SRT		
	Sensors													
Targets: 1. TkRegtHQ	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
2. Dump	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
3. Relay	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
4. Ech	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
5. AD1	0.00	0.20	0.00	0.37	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0	3
6. AD2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
7. Mtr Ptn	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	1
8. TkCoy1	0.12	0.02	0.00	0.00	0.00	0.03	0.00	0.13	0.00	0.00	0.00	0.00	0	2
9. TkCoy2	0.00	0.07	0.00	0.18	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.24	0	2
10. TkCoy3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
11. Recce	0.03	0.12	0.00	0.06	0.00	0.03	0.00	0.14	0.00	0.00	0.00	0.02	0	2
12. ATk Ptn	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	1
13. EW Ptn	0.00	0.04	0.00	0.27	0.00	0.15	0.24	0.00	0.00	0.00	0.00	0.00	0	3
14. RAG	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0	1
15. WLR1	0.12	0.12	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0	2
16. WLR2	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.24	0	3
17. DivEngr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0	1
18. MR Bn1	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.12	0	3
19. MR logs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
20. Civilians	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
	0	0	0	0	0	0	0	0	0	0	0	0		
	2	4	3	3	0	2	1	2	1	1	1	4		

Figure 4: Overall summary for same scenario with 'Rain night' weather option

The effect of CCIR is illustrated by comparing Figure 4 with Figure 2. By changing only the CCIR criteria from 'Planning' to 'Techint', there is a clear reduction in the strength of sensor/target coupling. Furthermore, those sensors, such as the LEWT, become 'uncoupled' when the CCIR criterion is more demanding.

5. Planned developments

After the first studies are complete, Dstl LSD plans to develop this into a more general ISTAR assessment tool. This enhancement will be in four areas: improved C3I, improved terrain, enhanced resolution of STA capabilities, and allowance for sensor vulnerability. It is imperative that both are achieved without sacrificing the simplified nature of the deployments that lie at the centre of its usability.

The C3I enhancements will include a more explicit representation of the intelligence process than is currently possible with simple time delays, including a model of the rate at which information can be interpreted. The model will require options that represent information flow under the UK's planned Network Enabled Capability (NEC). There will also be explicit constraints in space and bandwidth on the downlinks and back-links from the sensors to the intelligence cells, influenced by the operational context (including enemy deception measures), the environment, and by enemy electronic countermeasures (ECM).

It is planned to enhance the terrain to include simple areas of differentiated terrain, while keeping in the same spirit as the simplified unit deployments. This would enable a significant town or mountain range to be differentiated from surrounding plains by the effect that it has at the top level on sensor deployment and performance.

Eventually, the STA model will be enhanced to include some of the factors that are currently part of data preparation. This will enable sensor numbers issues to be assessed more accurately, and target signatures to be modelled dynamically. These features will also be linked to the enhanced terrain model. There is also an aspiration that the technique could be extended to include satellite surveillance and human intelligence (HUMINT).

Finally, it is planned to include an abstract sensor loss rate model that draws on the results of explicit ISTAR modelling studies, and that allows for the sensors' deployments (e.g. the altitudes of aircraft, and the stand-off achievable from the enemy), threat levels, and environmental conditions. For speed of assessment, the model will avoid any explicit attrition modelling.

6. Summary and discussion

This paper presents a new high level, automated ISTAR sensor assessment tool. The model is data-driven and quick to use; the model is designed to avoid all the drawbacks associated with existing detailed engineering models and explicit terrain and deployments. However, like all high level models, the burden of fidelity is shifted onto the low-level tools that are used to prepare the input data.

The likely performance of each search group against each target group is assessed, dependent upon sensor capabilities, deployments, meteorological conditions, terrain type and CCIRs, which reflect the C2 environment and rules of engagement prevailing in that scenario. The method can also handle a very wide range of sensor and platform types, including imaging and EW sensors.

The environmental influences are accounted for by using a combination of a reduced 'effective' range and modifying the strength of coupling (analogous to reducing the rate of coverage for area sensors). The inclusion of properties such as target posture enhances the fidelity of the model to reflect realistic battlefield scenarios. A modular design allows any combination of the six tests can be carried out independently, thus enabling user-verification and checking of each of the chosen tests.

7. References

[1] 'Urban Operations in the Year 2020', RTO Technical Report, RTO/NATO (2003)
[2] 'NATO: Code of Best Practice for C2 Assessment', CCRP, (2002)
[3] 'Military Operations Research Analyst's Handbook. Volume I: Terrain, Unit Movement and Environment', Ed. Warren K. Olsen, (1994)

A new rapid ISTAR assessment method

P.R. Syms and N.S. Walmsley

Dstl Land Systems Dept., Fort Halstead, UK

CCRTS June 2004, Track 1 Paper 082

Dstl/CP10855

Outline

- Introduction
  - background, need and development
- Model requirements
- Model description
- Example results
- Planned developments
- Summary
  - references and questions

Introduction

Introduction

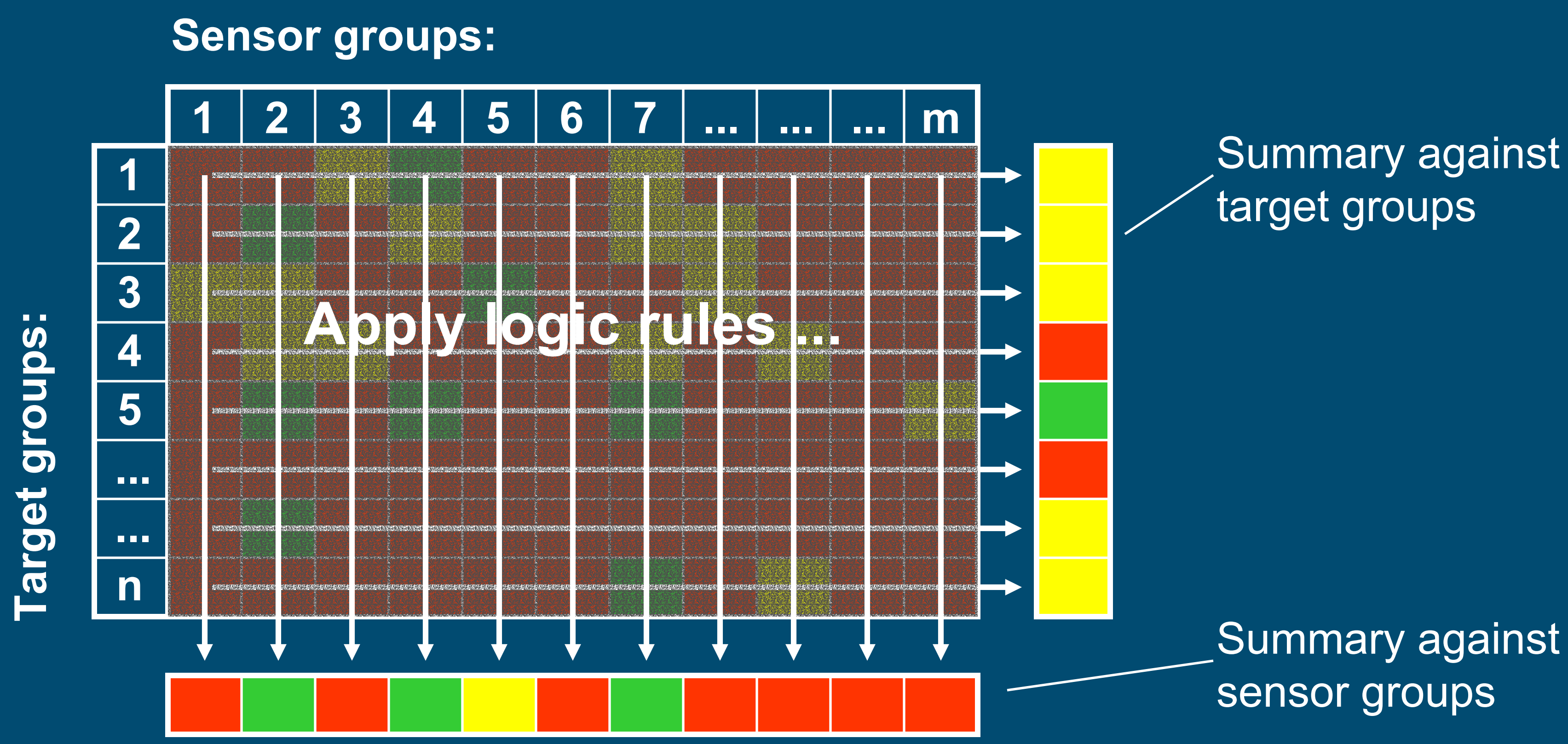
- C2 is driven by the receipt of timely ISTAR information
- Previous OA support used explicit, detailed data
  - proved inflexible and costly to run
- Dstl LSD developed a new and abstract approach …
  - no need for detailed terrain data
  - no requirement for explicit platform-level deployments
- To assess quality and timeliness from an ISTAR mix supporting the main decisions in a scenario
  - used at unit (i.e. BG) level in this preliminary study

Background

- Gap identified in C4ISTAR assessment capabilities
  - between detailed platform-level explicit modelling …
  - and judgemental techniques, e.g. military assessment panels (MAPs) and BOGSAT
- Also request from NATO support to ARRC HQ OA
- Deep fires TA study in 2002 laid conceptual framework
  - but populated judgementally – subjective and time-consuming
  - and open to ‘criterion drift’ between evaluating cases
- Allowed a framework for capability gap analysis ...

Principal of assessment

- Based on a contingency table of sensors against targets:



Model description

Model requirements

- **Operational:** VB for Excel, spatial information, represent a ‘snapshot’ in time, run deterministically using probabilistic data, output easy metrics
- **Technical:** approximate spatial overlap, interaction of sensor capabilities with target types and postures, effects of terrain/met/night/day on sensor performance
- **Types of sensor:** ground-based imaging (optical and thermal), GSRs, unmanned acoustic and seismic, UAV-borne, WLRs, SRs, manned recce airborne, ESM

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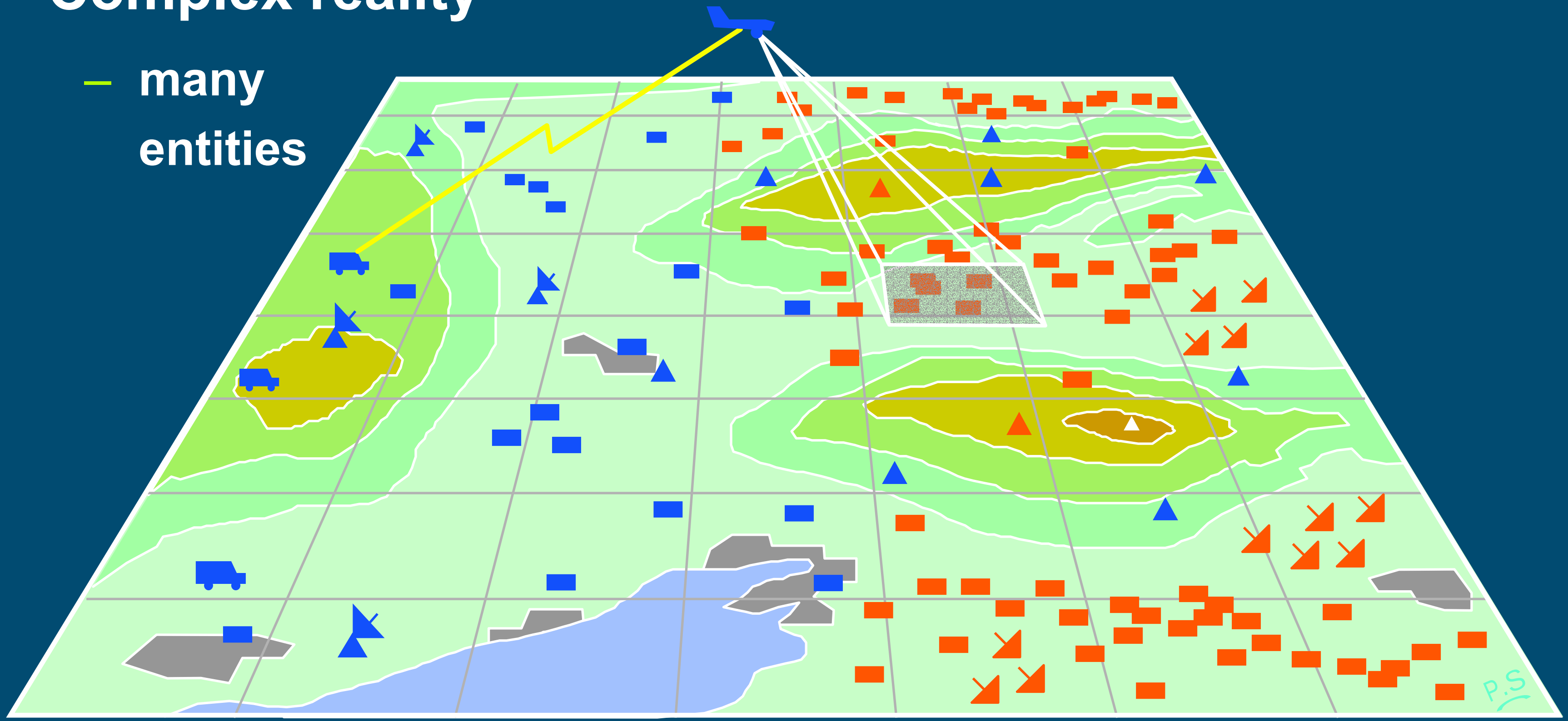
Model overview … 1

- Complex reality
  - many entities



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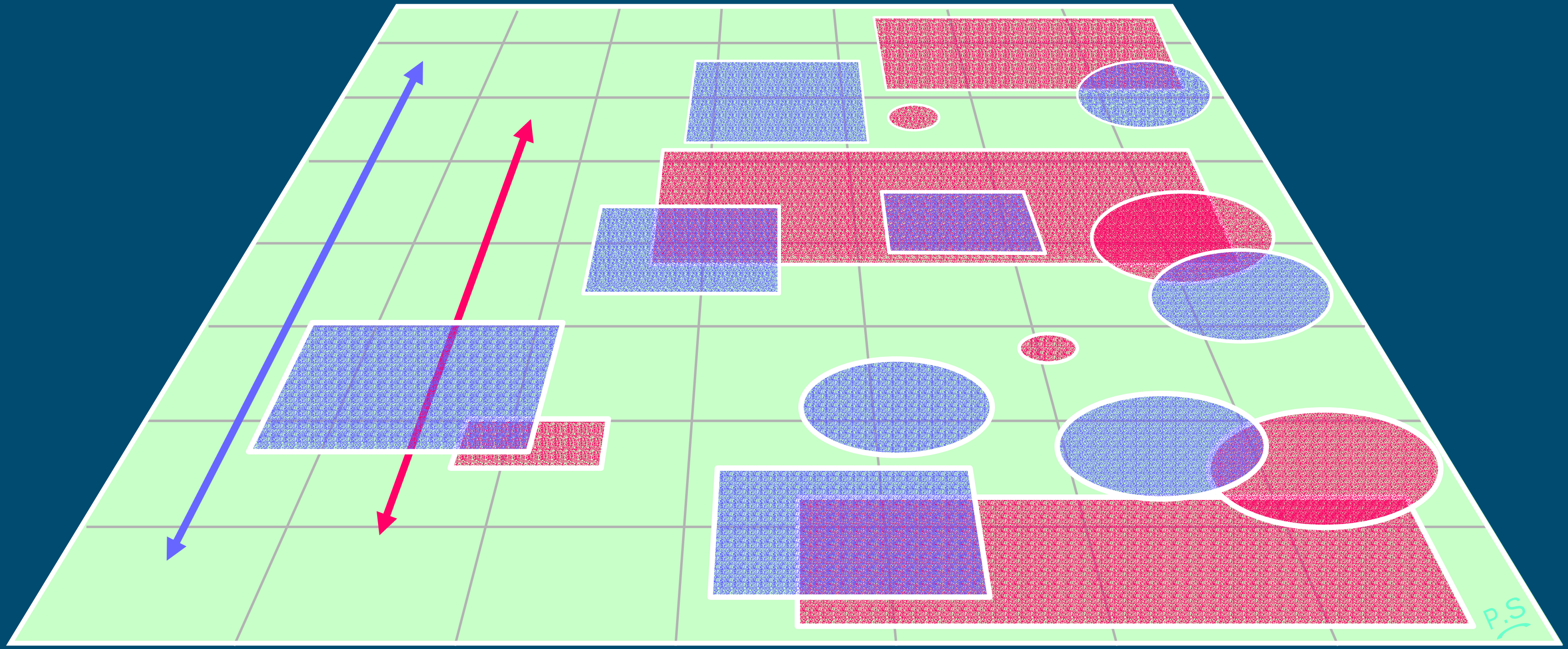
Model overview … 2

- Simplified view



Model description

- Blue sensors and Red targets are represented spatially as homogeneous ‘blobs’
- Sensor performance is measure over ‘snapshots’
  - assuming quasi-static deployments
  - target postures reflect unit movement and other activities
  - e.g. advancing, open, hide, ‘shoot and scoot’, etc.
- Terrain (including culture) assumed homogeneous
- Meteorological effects on some sensors
- Levels of CCIR represented
  - influencing timeliness, TLE and resolution

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‘Logic engine’

- Runs six ‘coupling tests’ on each sensor/target pair:
  - spatial overlap
  - spectral compatibility
  - activity compatibility (for STI/MTI sensors)
  - resolution (DRI)
  - target location error (TLE)
  - timeliness
- All compared against target and CCIR parameters
- Sensor must pass all six to acquire target group

Influences on logic engine

Factor: / Test:	Spatial	Spectral	Activity	Resolution	TLE	Timeliness
Deployments	🗐					
Relief	🗐					
Terrain features	🗐	🗐				
Meteorology	🗐	🗐				
CCIR				🗐	🗐	🗐
Sensor performance	🗐	🗐	🗐	🗐	🗐	
Searcher platform/group	🗐		🗐			🗐
Target group postures		🗐	🗐	🗐	🗐	🗐

‘AND’ logic $\Longrightarrow$ MoP

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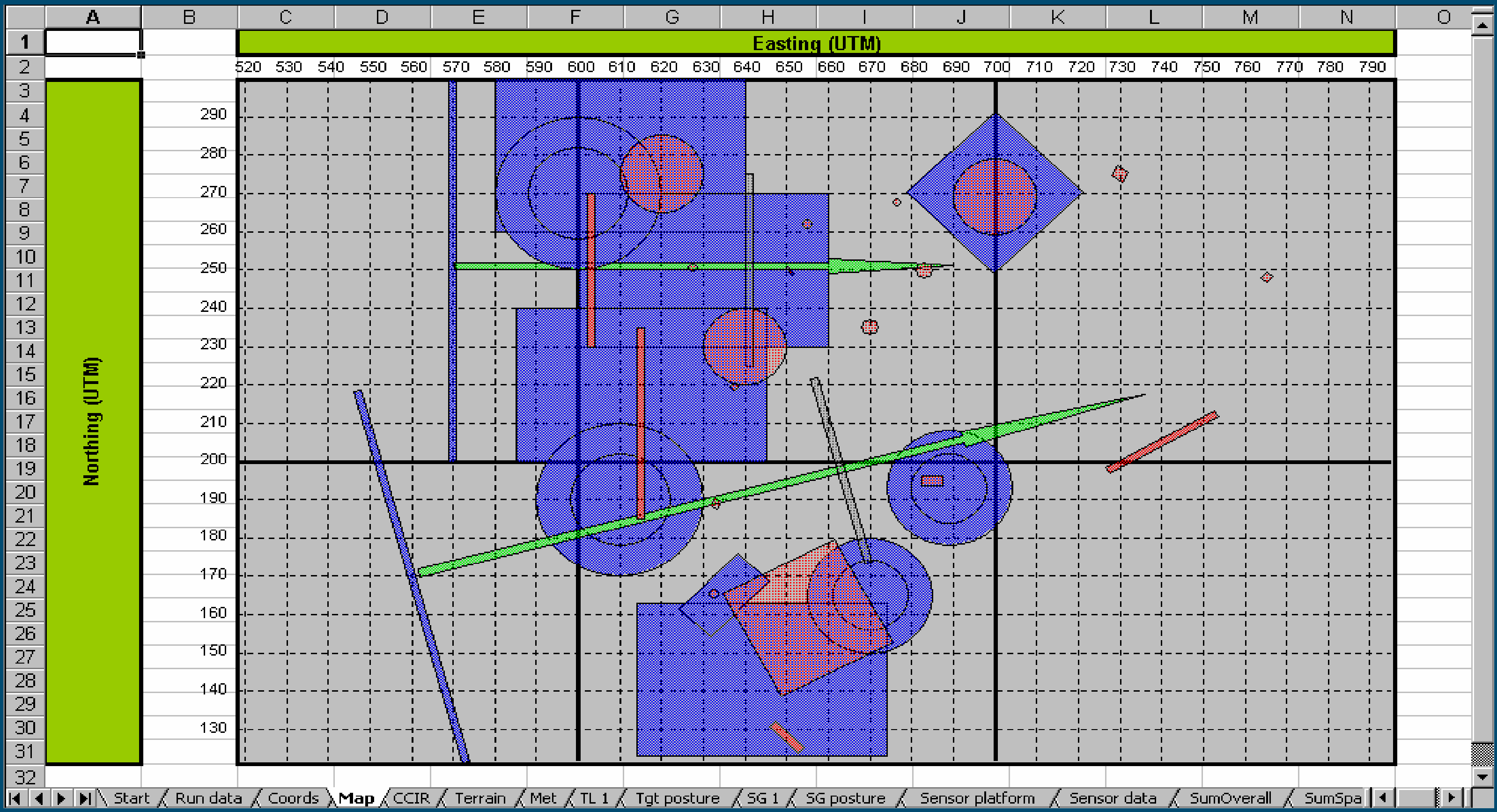
Example results

Example results



Base case summary

Overall summary. Parameters: TL 1; SG 1; Europe, hilly; Planning; Clear day

Name/Type	Sensors													
	1. Scout-1	2. Scout-2	3. Scout-3	4. Engr-R	5. MUAV-1	6. LEWT	7. FOO-1	8. FOO-2	9. MFC-1	10. MFC-2	11. A Sqn	12. SRT		
1. TkRegtHQ	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	1
2. Dump	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
3. Relay	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
4. Ech	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
5. AD1	0.00	0.50	0.00	0.54	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	2	1
6. AD2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
7. Mtr Ptn	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1	0
8. TkCoy1	0.30	0.05	0.00	0.00	0.00	0.04	0.00	0.21	0.00	0.00	0.00	0.00	0	2
9. TkCoy2	0.00	0.18	0.00	0.26	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.30	0	3
10. TkCoy3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
11. Recce	0.08	0.30	0.00	0.09	0.00	0.04	0.00	0.24	0.00	0.00	0.00	0.03	0	2
12. ATk Ptn	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	1
13. EW Ptn	0.00	0.09	0.00	0.39	0.00	0.17	0.39	0.00	0.00	0.00	0.00	0.00	0	3
14. RAG	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0	1
15. WLR1	0.30	0.30	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0	2
16. WLR2	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.30	0	3
17. DivEngr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0	1
18. MR Bn1	0.00	0.00	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.28	0.01	0.15	0	3
19. MR logs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
20. Civilians	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	1

	0	2	0	1	0	0	0	0	0	0	0	0
	2	4	3	2	1	2	1	2	1	1	1	4

CCIR variation: Targeting

Overall summary. Parameters: TL 1; SG 1; Europe, hilly; Targeting; Clear day

Name/Type	Sensors													
	1. Scout-1	2. Scout-2	3. Scout-3	4. Engr-R	5. MUAV-1	6. LEWT	7. FOO-1	8. FOO-2	9. MFC-1	10. MFC-2	11. A Sqn	12. SRT		
1. TkRegtHQ	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
2. Dump	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
3. Relay	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
4. Ech	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
5. AD1	0.00	0.20	0.00	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	2
6. AD2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
7. Mtr Ptn	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1	0
8. TkCoy1	0.30	0.05	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0	2
9. TkCoy2	0.00	0.18	0.00	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0	3
10. TkCoy3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
11. Recce	0.02	0.06	0.00	0.04	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0	1
12. ATk Ptn	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	1
13. EW Ptn	0.00	0.04	0.00	0.31	0.00	0.00	0.31	0.00	0.00	0.00	0.00	0.00	0	2
14. RAG	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0	1
15. WLR1	0.12	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	2
16. WLR2	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.02	0	1
17. DivEngr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0	1
18. MR Bn1	0.00	0.00	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.28	0.01	0.08	0	2
19. MR logs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
20. Civilians	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	1
	0	1	0	0	0	0	0	0	0	0	0	0		
	2	3	3	3	1	0	1	2	1	1	0	2		

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Meteorological variation: Rain, night

Overall summary. Parameters: TL 1; SG 1; Europe, hilly; Planning; Rain night

Name/Type	Sensors													
	1. Scout-1	2. Scout-2	3. Scout-3	4. Engr-R	5. MUAV-1	6. LEWT	7. FOO-1	8. FOO-2	9. MFC-1	10. MFC-2	11. A Sqn	12. SRT		
1. TkRegtHQ	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
2. Dump	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
3. Relay	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
4. Ech	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
5. AD1	0.00	0.20	0.00	0.37	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0	3
6. AD2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
7. Mtr Ptn	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	1
8. TkCoy1	0.12	0.02	0.00	0.00	0.00	0.03	0.00	0.13	0.00	0.00	0.00	0.00	0	2
9. TkCoy2	0.00	0.07	0.00	0.18	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.24	0	2
10. TkCoy3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
11. Recce	0.03	0.12	0.00	0.06	0.00	0.03	0.00	0.14	0.00	0.00	0.00	0.02	0	2
12. ATk Ptn	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	1
13. EW Ptn	0.00	0.04	0.00	0.27	0.00	0.15	0.24	0.00	0.00	0.00	0.00	0.00	0	3
14. RAG	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0	1
15. WLR1	0.12	0.12	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0	2
16. WLR2	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.24	0	3
17. DivEngr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0	1
18. MR Bn1	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.12	0	3
19. MR logs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
20. Civilians	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0

	0	0	0	0	0	0	0	0	0	0	0	0
	2	4	3	3	0	2	1	2	1	1	1	4

Terrain variation: Desert, flat

Overall summary. Parameters: TL 1; SG 1; Desert, flat; Planning; Clear day

Name/Type	Sensors													
	1. Scout-1	2. Scout-2	3. Scout-3	4. Engr-R	5. MUAV-1	6. LEWT	7. FOO-1	8. FOO-2	9. MFC-1	10. MFC-2	11. A Sqn	12. SRT		
1. TkRegtHQ	0.00	0.27	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0	1
2. Dump	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0	0
3. Relay	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
4. Ech	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
5. AD1	0.00	0.89	0.00	0.89	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	2	1
6. AD2	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0	1
7. Mtr Ptn	0.00	0.89	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	1	1
8. TkCoy1	0.54	0.09	0.00	0.00	0.00	0.04	0.00	0.24	0.00	0.00	0.00	0.00	1	1
9. TkCoy2	0.00	0.32	0.00	0.43	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.30	0	3
10. TkCoy3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
11. Recce	0.15	0.54	0.00	0.15	0.00	0.04	0.00	0.27	0.00	0.00	0.00	0.03	1	3
12. ATk Ptn	0.00	0.00	0.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1	0
13. EW Ptn	0.00	0.16	0.00	0.65	0.00	0.17	0.45	0.00	0.00	0.00	0.00	0.00	1	3
14. RAG	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0	1
15. WLR1	0.54	0.54	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	2	0
16. WLR2	0.00	0.00	0.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.54	0.30	2	1
17. DivEngr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0	1
18. MR Bn1	0.00	0.00	0.57	0.00	0.00	0.00	0.00	0.00	0.00	0.34	0.02	0.15	1	2
19. MR logs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
20. Civilians	0.00	0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	1

	2	4	3	2	0	0	0	0	0	0	1	0
	1	3	0	2	1	4	1	2	1	1	0	4

15–17 June 2004

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Strengths and weaknesses

- Comparative strengths of new model ...
  - flexibility to model ISTAR from unit to theatre levels
  - represents a wide variety of collectors on an equal basis
  - rapid preparation and runs: pilot study ran 80 cases in one day
- Comparative weaknesses …
  - simple models shift burden of modelling onto data …GIGO!
  - uniform terrain assumption
  - poor representation of time
  - poor modelling of the intelligence process

Conclusions

- New technique developed to meet changing needs
  - speed, flexibility and responsiveness
  - for equipment procurement and operational support
- Used successfully on an ISTAR capability study
  - into equipments at the unit (battalion) level
- Strengths and weaknesses common to simple models ...

Planned developments

- C3I enhancements to include the intelligence process
  - improving representation of NEC
- Better terrain representation
  - simple terrain areas, similar to deployment method
- Enhanced resolution of sensor capabilities
  - search rates and range-related performance
- Allowance for sensor vulnerability
  - using mean time between loss (MTBL) curves
- Aim to encompass HUMINT on comparable basis

15–17 June 2004

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Summary, references and questions

Summary

- A new rapid, high-level, automated ISTAR assessment tool
  - avoids drawbacks of detailed, engineering-type models
  - runs deterministically with probabilistic data
  - suited to quick capability gap analysis
- Modular design allows the six tests to be run independently
  - flexible, user-friendly, and easily verified
- Wide range of sensors and platform types
  - all assessed on an equitable basis
  - target posture included to reflect realistic battlefield scenarios
- CCIRs, terrain and meteorology reflect C2 environment and RoEs
- Potentially suitable for front-line OA use

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Questions?

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