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THE STATE OF THE ART AND THE STATE OF THE PRACTICE
A Conceptual Model of Information Processing by a Land Commander
at Low Tactical Levels
Cognitive Domain Issues
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Abstract

The current modelling effort dedicated to sense-making is mainly directed at the whole information-processing / decision-making process and focused on high level issues. This article, based on an MSc thesis produced by Lionel Grillet-Aubert under the supervision of Jeremy Smith at Cranfield University (UK), presents a simple rule-based conceptual model of the information-processing part of the process as carried out by an individual commander at low tactical levels.
Schematically, the model operates in three stages, compiling a flow of pre-formatted messages into an aggregated tactical picture. The first stage represents the subjective appraisal to which every incoming piece of information is subjected and from which a confidence rating is produced. The main psychological factors behind this rating are investigated. The second stage represents the non-subjective interpretation of information, which turns it into intelligence. This process relies on an effort to correlate the received data with known enemy patterns and the current perception of the situation. The third stage brings together the results of the first two and produces the commander's tactical picture. For this stage, the possible manifestations of the influence of trust on information processing are investigated.

1 Introduction

In the field of network-enabled operations, a significant research effort has been and is being deployed to investigate the parameters which condition the translation of more real-time information into better military effects.

Considering that, on the one hand, current modelling efforts are particularly dedicated to the whole information-processing and decision-making process within headquarters, and on the other hand, significant operational responsibilities as regards political success are now granted to company-groups, the author felt that there existed a need to understand how commanders at these levels transform data into intelligence. Therefore, this paper focuses on one aspect of command and control in one particular environment, namely individual sense-making at low tactical levels.

The model which is presented thereafter represents a three-stage process. The first two stages are performed in parallel, i.e. independently of each other, and their outcomes are brought together by the third and last one. The first stage represents the subjective appraisal to which every incoming piece of information is subjected and from which a confidence rating is produced. The second stage represents the non-subjective interpretation of information, which turns it into intelligence.

2 Overview

Based on the author's observations, information processing by company commanders often shows the combination of two mechanisms:

- A (subjective) judgment which aims to determine the worth of a piece of information and the confidence it can be granted.
- An (objective) exploitation which utilizes data in order to draw a tactical picture.

The information-processing model described in this paper is represented in Figure 1, which is followed by a brief description of the mechanisms it uses.

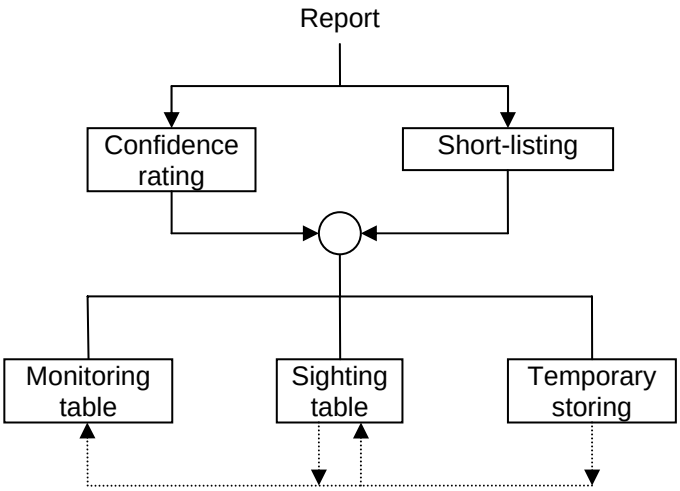

Figure 1: Model's Overview

A report is first subjected to a confidence rating which takes into consideration:

- Its source.
- Its aspect (formatting, sound of voice, choice of terms, etc.).

In parallel, an attempt is made to identify the reported entities with known enemy groupings, which are relevant at the company level (short-listing).

- If it succeeds, the identified groupings are carried forward in the process.
- If it fails, the information is left in raw form (i.e. entities).

The identified groupings (processed information) or reported entities (raw information) are matched with detections reported earlier.

- If a match is established then information goes into a monitoring table.
- If no match is established then:
  - If the report's confidence rating is high enough, information is accepted (sighting table).
  - If the rating is low, information is kept aside until it can be confirmed or discarded (temporary storing).

3 Confidence Rating

3.1 Information Quality

In its Network-Centric Operations conceptual framework, the DoD Command and Control Research Program defines the following attributes of information quality:

- Correctness: extent to which information is consistent with ground truth.
- Completeness: extent to which information relevant to ground truth is collected.
- Currency: age of information.
- Timeliness: extent to which currency of information is suitable to its use.
- Consistency: extent to which information is consistent with prior information.
- Precision: level of measurement detail of information item.
- Accuracy: appropriateness of precision of information for a particular use.
- Relevance: proportion of information collected that is related to task at hand.

Of all these attributes, a commander has only access to currency / timeliness, consistency and precision / accuracy.

Currency, however, is not always directly accessible. It is often estimated as a function of the report's originator. For instance, a report from a platoon leader follows almost immediately the occurrence of an event, whereas a report from brigade assets via the battlegroup HQ has gone a longer way and is likely to be delayed. From this heuristic estimate of the age of information and depending on the object of the report, an evaluation of timeliness is carried out. For instance, a report sent half an hour ago about a moving militia column is definitely out of date, whereas one sent an hour ago about a division HQ may still be valid. The estimate of timeliness definitely influences the exploitation of a report's content. However, and although it is based on rules-of-thumb, it is very much an objective evaluation and as such can be dissociated from the parameters of subjective rating.

A poor precision, on the other hand, can lead the commander to either one of the following three assumptions about the source:

1. It gave as good a report as it could and information, though it shows a low level of detail, remains valuable and ought to be exploited as it is.
2. It gave a poor level of detail because of too much haste in the assessment of the situation or in the preparation of the message. In practice, it is followed by a request to reformulate the report. The second report then leads to one of the other two assumptions.
3. It provided a low level of precision because of a lack of understanding and thus information is judged dubious. This assumption is generally imputable to the commander's being in doubt about the source's abilities.

Whatever the opinion formed by the commander is, we will presume that the influence of the level of detail is actually determined by the commander's confidence in the source.

Similarly, the lack of consistency can be interpreted either as an unexpected development in the situation or a mistake from the source of the report. Therefore, and like the level of detail, it will be taken as an offshoot of the commander's confidence in the source rather than a subjective parameter on its own.

3.2 Report's Aspect

In addition to considerations about the source, confidence in a message relies also on how it appears and how it sounds, i.e. correct formatting, concise and precise phrasing, confident expression, etc. All these external aspects of a report are significant at low tactical levels because they often provide a measure of the originator's confidence in his own assessment and, in the long-term, a measure of his professionalism.

Indeed, whereas a report's lack of precision or consistency may result from the environment (e.g. skilled opponent), the report's structure and expression depends only on the informant's ability to express clearly his understanding of the situation. Therefore, it contributes directly to:

- An immediate rating of the report's worth.
- The progressive building of confidence in the source's professionalism.

3.3 Trust in a Source

Before tackling the building of trust in a source, we can describe its main foundations. They usually combine the commander's perception of:

- The suitability and reliability of its set of sensors (technical characteristics).
- The competence of its operators (human characteristics).

The respective importance of each aspect is conditioned by the extent to which the source relies on each to collect data.

This perception may be based purely on preconceptions or built over time on more objective ground, e.g. in the course of day-to-day activities, exercises or deployment. The closer and the longer a commander works alongside a particular source, the more accurately the

commander's trust level will reflect the source's actual competence. This underlines the importance of common training or – at the very least – common, realistic and trustworthy training standards.

Preconceptions are significantly more dependent on the commander's personality and experience than on the source's actual quality and can hardly be generalized. We can however set forth a few hypotheses about the mechanisms that contribute to their generation:

- Decomposition: the commander combines his opinion about the source's main characteristics (e.g. type of unit, equipment, nationality, etc.)
- Similarity: the commander uses an opinion he formed about sources with similar features in the past.
- Reputation: the commander relies on what he heard, read or saw about the source.

Note that these behaviours can occur in combination.

A problem when dealing with information sources and studying the foundations of the confidence they are granted in a military environment lies in the fact that most act as information centres, i.e. receiving, processing and then distributing intelligence. It may be that the provided intelligence is straightforwardly relayed from another source whose identity is disclosed, in which case the commander is likely to submit the report to a rating that takes the original source into account. However, in most cases information is the result of multiple reports, whose sources are not disclosed. In these usual circumstances, as far as trust is concerned, the hub (e.g. battlegroup HQ, platoon leader, etc.) represents a proxy for all unidentified information sources because, in the receiver's mind, it ought to have analyzed the worth of information before sending it (or posting it on the network). Therefore, the commander's confidence rating of the report is likely to reflect his confidence on the people who carried out the evaluation and who directly transmitted it to him.

In order to summarize the observations which were presented in this section, we can write that two features contribute to the production of a subjective appraisal of a piece of information:

- Its aspect (i.e. structure, wording and expression).
- Its source (actual or by proxy).

For each feature, an experimental effort must be dedicated to the determination of:

- The factors that make them up.
- Their evolution with time.
- Their contribution to the confidence rating.

Some hypotheses were formulated about the first two points. However, there is a need for a comprehensive study which, considering the significant subjectivity of the problem, requires an extensive survey of company commanders.

An interesting point to investigate would be the impact on sense-making of disclosing or not disclosing the identity of an information source within a network-enabled environment.

3.4 Confidence Scale

Finally, two questions need to be addressed in order to characterize the subjective evaluation of information performed by a commander:

1. What scale does he use to express the confidence rating of a piece of information?
2. Depending on the level of trust it is conferred, how is processed a piece of information?

The scale may be as simple as trust/distrust, trust/dubious/distrust, or a percentage. Considering the need for simplicity at low tactical levels, it is likely that, however extended and detailed a scale a company commander says he uses, it can certainly be reduced to a much simpler one. For instance, imagine a commander who presumably uses a percentage. If asked to rate a stream of reports over time, the rates awarded would probably be located around a few discrete percentages and his scale reduced to a simpler categorical one.

As for the second point, considering that making marks on a map is the most likely method of information storage that a commander utilizes, his alternatives regarding the manipulation of a specific piece of information are limited. As a non-exhaustive list of examples, he can draw the reported elements, draw them with an uncertainty mark (e.g. question tag), keep them in mind and wait for confirmation (but memory capacity is limited), ignore them altogether, etc.

4 Short-Listing / Short-List Building

Before his subjective judgment determines what he will do with a particular piece of information, a commander generally inserts, even though temporarily, the reports he receives in his mental picture of the situation in order to check its plausibility. The influence of the subjective assessment is brought to bear when this mental picture is transcribed from the mind onto the map.

In their effort to draw a meaningful picture of their tactical situation, commanders at low tactical levels generally found their sense-making on two assumptions about enemy activities.

The first assumption derives from what we could refer to as a behavioural consistency from the part of the enemy. At one end of the military spectrum, i.e. structured forces, consistency is prompted by the existence of established doctrine and procedures. At the other end, where lay insurgent cells or armed bands, patterns do not always exist initially. However, some may emerge over time for reasons including, but not limited to, growth in number (integrated in more structured organizations, grouped into 'copycat' cells, etc.), limited equipment and supply (reducing the scope of operations), previous military training (setting habits), limited planning capability (inclining to repeat patterns), ideological, political, racial affiliation (influencing objectives, organization, recruitment, means, training, etc.).

Clues about behavioural consistency during operations are usually gathered through the creation and continuous updating of a log, in which enemy activities are reported and from which patterns may come into view.

The second assumption, which we can term localized consistency, relies on common-sense that translates into a number of rules such as:

- If an element is detected in some place at some time, then it should still be located in the area after a short time.
- If two elements are detected close in space and at the same time, then they may belong to the same grouping.
- If two elements are detected close in time and space and show similarities, then they may belong to the same group and may even be the same one.

Since a commander, especially at the company level, uses a map to represent contact reports, this set of rules simply reflects the acknowledged ability of the human mind to go beyond sensory information. It means that while a commander draws tactical symbols on his map, he will at the same time draw inferences between them, based on similarities and proximity in time and space.

In order to explain the short-listing mechanisms, we will first consider an example in which the commander has knowledge about the enemy's order of battle and initial information about what he is going to face. The expected opposing force (OPFOR) amounts to an armoured infantry company structured along the doctrinal lines of NATO's generic enemy.

Knowing the enemy's structure, we assume that the commander strives to identify enemy 'platoon-level' elements, which are relevant to him, from the raw information his subordinates send to him. The so-called 'platoon-level' elements typically include in the case of a 'carmine' armoured infantry company group:

- 1 command vehicle(s).
- 1 or 2 reconnaissance patrol(s).
- 1 tank troop(s).
- 3 or 4 infantry platoon(s).
- 1 Artillery/mortar observation vehicle(s).
- 1 to 3 engineer vehicle(s) / section(s).

We use a two-step process to model the objective exploitation of subordinates' reports by the company commander. These two steps reflect respectively the ideas of behavioural and localized consistency:

- Attempt to determine which known enemy element a report is referring to.
- Attempt to link the content of successive reports over time.

4.1 First Step

The nature of a detected element can be described with various levels of precision:

- Activity detection: smoke, noise, lights, etc.
- Element detection: personnel, vehicle or installation.
- Recognition: personnel, truck, tank, APC, IFV etc.
- Identification: dismounted infantry, engineers, T 72, BRDM 2, etc.

From now on, the observation of an enemy element, whatever its level of precision is, will be generically referred to as a DRI (Detection, Recognition, Identification).

A special case can be made with what could be referred to as a positive identification by a subordinate. It is the result of a report, in which not only personnel and materiel are identified but also the grouping to which they belong (e.g. squad of an infantry platoon, tank from a reconnaissance patrol, command BMP, etc.). This kind of report enables the commander to skip the first step of his interpretation process.

Back to reports short of positive identification, the following table gives an example of information that may be transmitted depending on the report's level of precision and the observed element.

Enemy elements	**Known equipment**	**Activity detection**	**Element detection**	**Recognition**	**Identification**
Command vehicle	BMP	Smoke Noise Movement	Vehicles	IFV	BMP
Recon patrol	BRDM T tanks			APC Tanks	BRDM T tanks
Tank troop	T tanks			Tanks	T tanks
Armoured infantry	Personnel BMP		Personnel Vehicles	Personnel IFV	Infantrymen BMP
Engineers	Personnel BTR			Personnel APC	Engineers BTR
FOO	BMP		Vehicle	IFV	BMP

Table 1: Reported Enemy Elements with Various Levels of Detail

Taking into account the 'volume' in addition to the 'nature' of the reported elements, we can represent the commander's mental evaluation of the likely and unlikely types of observed elements with the following template.

Keys: X: possible on its own.
O: possible but not alone.
Void: discarded.

Report			Command vehicle	Recon patrol	Tank troop	Infantry platoon	Engineer section	FOO vehicle
Level of precision	Reported nature	Reported volume						
Activity detection	Smoke, noise, movement, etc.		X	X	X	X	X	X
Element detection	Vehicles	1	X	X	X	X	X	X
		< *ptn*	O	X	X	X	O	O
		> *ptn*	O	O	O	O	O	O
	Personnel	< *sqd*	X	X	X	X	X	X
		> *sqd*	O	O	O	X	O	O
		> *ptn*	O	O	O	O	O	O
Recognition	Tank	1		X	X			
		< *ptn*		O	X			
		> *ptn*		O	O			
	IFV	1	X			X		X
		< *ptn*	O			X		O
		> *ptn*	O			O		O
	APC	1		X			X	
		< *pat*		X			O	
		< *ptn*		O			O	
		> *ptn*		O			O	
Identification	T tank	1		X	X			
		< *ptn*		O	X			
		> *ptn*		O	O			
	BMP	1	X			X	X	X
		< *ptn*	O			X	X	O
		> *ptn*	O			O	O	O
	BTR	1					X	
		< *ptn*					X	
		> *ptn*					O	
	BRDM	< *pat*		X				
		> *pat*		X				
	Personnel with AP weapons	< *sqd*	X	X	X	X	X	X
		> *sqd*	O	O	O	X	X	O
	Personnel with AT weapons	< *sqd*		X		X	X	
		> *sqd*		O		X	X	

Table 2: Mental Template

The values assigned to *pat, sqd* and *ptn* are subjective limits below which a commander can consider that he is facing a patrol, a squad or a platoon. Examples of such limits are shown in the following table.

Elements	Expected nature	Expected volume
Command vehicle	BMP	1
Reconnaissance combat patrol	BRDM T tanks	2 1
Tank troop	T tanks	4
Infantry platoon	Personnel BMP	~ 30 4
Combat engineers section	Personnel BTR	~10 1
Forward Observing Parties	BMP	1

Table 3: Expected Volume of Enemy Elements

The result of the first step is to establish a short-list, as shown in table 4, of the types of enemy platoon-level elements which may have been detected, based on the knowledge the commander possesses about the enemy order of battle.

Platoon-level elements	Command vehicle	Recon patrol	Tank troop	Infantry platoon	Engineer section	Observation vehicle
Potential presence						

Table 4: Short-List

4.1.1 Single-Type Detection

For any single-type detection, in which there is only one type of element reported, the second row of table 4 contains a variable number of X's (i.e. the element can account for the whole DRI) and O's (i.e. the element can only account for part of the DRI). Table 5 shows a few examples of short-lists.

Reports	Short-lists	Command vehicle	Recon patrol	Tank troop	Infantry platoon	Engineer section	Observation vehicle
3 Tanks	Initial		O	X			
3 APC	Initial		O			O	
6 IFV	Initial	O			O		O

Table 5: Examples of short-lists

This first mental evaluation is then refined by the following mechanism:

- If there is at least an X in the row, which means that some groupings can account for the whole DRI, all O's are removed from the short-list because those elements are less likely.
- If there is no X, which means that the commander receives a large DRI that likely involves several 'platoon-level' elements, several short-lists are generated. The process is explained below.

Among all short-listed elements of a large DRI, the most likely one (i.e. the largest one) is singled out and placed in a first short-list alone and with an X. The number of entities it counts

is then removed from the initial DRI. This new (and reduced) DRI is subjected to a new short-listing. If there is still no X but only O's, the process is repeated on the reduced short-list. If at least an X appears, then all O's are removed and two short-lists are attached to the total DRI.

To illustrate each one of these points, let us use the previous three examples:

Reports	Short-lists	Command vehicle	Recon patrol	Tank troop	Infantry platoon	Engineer section	Observation vehicle
3 Tanks	Initial		O	X			
	Final			X			
3 APC	Initial		O			O	
	Final		X				
			X			X	
6 IFV	Initial	O			O		O
	Intermed.				X		
		O			X		O
	Final				X		
					X		

Table 6: Examples of refined short-lists

4.1.2 Multiple-Type Detections

In the case of multiple-type DRI (e.g. tanks and APC), single-type short-lists are generated from the report, refined and then combined through a set of rules summarized in Table 7. For instance, if we were to process the following report, "2 wheeled armoured vehicles and 1 tank at grid 123456 heading south", then we would first consider 2 wheeled armoured vehicles and 1 tank separately.

The first column of the table indicates the number of X's attached to a single 'platoon-level' element across all individual short-lists generated by the report. The second column shows what will be attached to this element in the compounded short-list.

Number of X's across N short-lists	Result in the compounded list
N	X
At least 1	O
0	Void

Table 7: Rules for short-lists combination

Table 8 and 9 shows examples of multiple-type DRI and the resulting single-type short-lists to be compounded.

Reports	Short-lists	Command vehicle	Recon patrol	Tank troop	Infantry platoon	Engineer section	Observation vehicle
1 APC 3 tanks	APC		X			X	
	Tanks		O	X			
1 APC 1 tank	APC		X			X	
	Tanks		X	X			
2 APC 5 tanks	APC		X			O	
	Tanks			O			

Table 8: Decomposition of multiple-type detections in single-type short-lists

If one of the single-type short-list is a large one, i.e. it contains no X, as is the case in the third example, the decomposition used earlier for single-type short-list will be applied. Table 9 shows the result of this decomposition for the third example.

Reports	Stage	Short-lists	Comm vehicle	Recon patrol	Tank troop	Infantry platoon	Engineer section	Obs. vehicle
2 APC 5 tanks	Initial	APC (2)		X			O	
		Tanks (5)			O			
	Decomposed	APC (2)		X				
		Tanks (4)			X			
		Tanks (1)		X	X			

Table 9: Examples of Decomposition

As in the previous section, if there is an X in a short-list, then all O's are removed. This is illustrated by the APC's short-list in the previous example. This works also for the compounded short-lists as will be illustrated in the next table.

To illustrate the complete procedure (using table 7), let us use the previous examples:

Reports	Short-lists	Command vehicle	Recon patrol	Tank troop	Infantry platoon	Engineer section	Observation vehicle
1 APC 3 tanks	APC		X			X	
	Tanks		O	X			
	Combined		O	O		O	
1 APC 1 tank	APC		X			X	
	Tank		X	X			
	Combined		X	O		O	
	Final		X				
2 APC 5 tanks	APC		X			O	
	Tanks			O			
	Tanks (4)			X			
	Tanks (1)		X	X			
	Combined			X			
			X				

Table 10: Examples of Multiple Detections

In the third example, 5 tanks give rise to two short-lists: one with a tank troop and one with the remaining tank. Only the latter will be combined to the 2 APC to produce a short-list with a reconnaissance patrol, since the former is already assumed to represent a tank troop.

4.2 Short-List Building

Thus far, in order to illustrate the model's mechanisms simply, we assumed that the reported elements could be found in the enemy's known structure. However, two more possibilities must be considered:

1. There is no initial intelligence about the reported elements, i.e. they are neither explicitly included in nor excluded from the commander's mental template.
2. Initial intelligence indicates that the reported elements are not part of enemy forces.

In the first case, the first step of the objective information exploitation is not directly applicable since it relies explicitly on knowledge about the opponents' order of battle. As for the second step, it remains valid. Basically, all such reports from subordinates, neighbours and higher levels, are received, matched and logged directly in raw form, i.e. they do not go through the first step. Matching and logging mechanisms – the second step – are explained below.

Even though the first step is not directly applicable, it does not mean that it must be altogether discarded. As mentioned earlier, even though the opponents do not exhibit a clear order of battle, they might show over time a certain number of recognizable and consistent patterns, which can be used as the basis for the implementation of a first step.

The idea consists therefore in building a log of all reported activities over time, in order to outline typical task organizations, pieces of equipment, areas of operation, modus operandi and even specific groups.

The handling of the second case is less obvious because reliant on three subjective parameters:

- Confidence in initial intelligence.
- Trust in the unexpected report.
- Personal estimate of enemy resources.

The manipulation of such information must be examined experimentally, but basically two reactions can be anticipated:

- Information is discarded (greater confidence in initial intelligence).
- Information is treated as though there were no initial intelligence (greater trust in the report), in which case the manipulation is similar to that performed with an unknown opponent.

4.3 Information from outside the Company

The demonstration of the first-step mechanisms of the objective information exploitation used information reported by subordinates. The following sections extend the model to the processing of neighbours' and higher-level information.

4.3.1 Neighbours' Reports

Neighbours' reports can carry raw or pre-processed information. Raw information on the battlegroup's network is equivalent to information transmitted by troop/platoon leaders on company groups networks and can therefore be treated as such. Pre-processed, on the other hand, has been submitted to another company commander's sense-making process. Therefore, the first step is complete and cannot be duplicated since raw information has been fused and is thus unavailable.

Note that the delay between a DRI and the reception of the report cannot be considered negligible in the case of neighbours' reports, since information has been analysed by another commander before it was broadcasted on the battlegroup network. The problem of delayed report will be dealt with later on.

4.3.2 Higher-Level Information

Higher-level information from the battlegroup or from the chain of command of reinforcements attached to the company (e.g. artillery, engineers, etc.) may be raw, delivered after company-level decomposition or left in higher-level pre-processed state.

Raw and company-level information is exploited following the procedure explained for neighbours' reports. As for information left in a higher-level pre-processed state, it must be decomposed by the company commander along the organisational lines of the known order of battle of the enemy. After decomposition, however, elements ought to be incorporated in the sighting table rather than in the monitoring table because of a lack of definite precision. The difference between these two tables and the associated mechanism is explained below.

As was the case with neighbours' reports, the delay between DRI and reception of report cannot be ignored.

4.4 Second Step

All short-list generated by the first step are individually submitted to the second step.

One of the following actions is performed on each short-list:

- If it contains only one element (i.e. one X):
  - If it is successfully matched with an element already detected, then information is updated.
  - If it cannot be matched, it is logged as a new element.
- If it contains more than one element (i.e. several X's):
  - If one of them is successfully matched with an element already detected, then:
    1. Information is updated.
    2. The entities represented by this element are removed from the DRI which is sent back to the first step of objective exploitation for re-processing (and the resulting short-list will be submitted to the second step again).
  - If none of them can be matched, then the DRI is logged in raw form.

Before explaining the matching procedure, we will present the tables which will be used throughout the second step.

4.4.1 Templates

Note that while the first step was essentially a mental process, the second step usually develops into a map representation, which shows at the reported position:

- Element's description or estimate (standard icons, ellipses and crosses, etc.).
- Element's attitude (arrows for moving, dotted green circle for digging, etc.).
- Other relevant information in limited quantity (e.g. DRI's time tag).

The design of each template attempts to reflect this graphic representation.

If only one element is short-listed or if it can be matched with an already detected element, the following table is used, which we will refer to as the monitoring template.

		Last position	Last attitude	Sighting time	*Validity time limit*	*Tactical mobility*
Command vehicles	1					
	+					
Recon patrols	1					
	2					
	+					
Tank troops	1					
	+					
Infantry platoons	1					
	2					
	3					
	+					
Engineer sections	1					
	2					
	3					
	+					
Observing parties	1					
	+					

Table 11: Monitoring template

If several element are short-listed and none of them can be matched, the following table is used, which we will refer to as the sighting template.

		Instance	Volume	Position	Attitude	Time tag	*Validity time limit*
Activity detection	Smoke	1	N/A		N/A		N/A
		2	N/A		N/A		N/A
			N/A		N/A		N/A
	Noise	1	N/A		N/A		N/A
		2	N/A		N/A		N/A
			N/A		N/A		N/A
	Etc.		N/A		N/A		N/A
Element detection	Vehicles	1					
		2					
	Personnel	1					
		2					
Recognition	Tanks	1					
		2					
	Tracked armoured vehicles	1					
		2					
	Wheeled armoured vehicles	1					
		2					

Table 12: Sighting Template

Validity time limit as well as *tactical mobility and constraints* represent an evaluation conducted by the commander on the basis of the type of unit considered, the battlefield environment, the action conducted, the enemy doctrine, etc. When the time elapsed since the last report has reached the validity time limit, then the last position reported is removed from the chart (i.e. erased from the map).

4.4.2 Initialization of templates

After having received his operations order (OpO) and studied his terrain, a commander starts his Intelligence Preparation of the Battlefield (IPB), which will produce an initial idea of which enemy elements are likely to be observed, where and when.

Because of their inherent lack of precision, estimates resulting from the IPB are bound to be logged in the sighting template. Then, at the end of this time limit, information would be updated or discarded.

4.4.3 Matching Procedure

Matching consists in linking the last report with a previous one, thus relying on what was labelled earlier localized consistency.

The elements short-listed at the end of the first step are, in the second step, compared to elements in the monitoring or sighting tables whose description is similar. A match will be established if, in addition to nature and volume, successive positions and attitudes are consistent.

Using the various parameters we mentioned, a match between two reports can be established if some conditions are fulfilled, the most significant ones being:

1. Matching natures of reported elements and consistent volume.
2. Distance between reported positions divided by time elapsed between reports below a reasonable limit on tactical mobility.
3. New attitude consistent with previous one.

Note that if a report, due to end up in the sighting table, is matched with a previous report in the monitoring table, then information is upgraded and the new report can be placed in the monitoring table.

4.5 Delayed Reports

So far, except for the fact that we asserted it did not contribute to the subjective evaluation of a report, we have not yet properly dealt with the timeliness of information. The reason lies in the fact that, having explained the matching procedure, it will be easier to outline the possible behaviour induced by untimely data.

An untimely report delivers valuable information only if:

1. Though late, it represents the most recent reference to a particular series of events.
2. It confirms a more recent but distrusted report.

The first condition is normally enough to consider that any untimely report ought to be treated like a timely report because this condition can only be checked if the report goes through the whole process. If so is the case, three situations may arise during the matching process:

- The delayed report can be matched to a more recent report in the monitoring table and thus nothing is changed.
- The delayed report can be matched with a more recent but less detailed report in the sighting table. Then, the more recent report is upgraded.
- The delayed report cannot be matched with any more recent report and therefore is logged in either one of the tables.

However, the reactions of commanders in the face of delayed reports are variable and ought to be investigated. As for trust and consistency, there are several related questions to address:

1. What parameters contribute to the evaluation of timeliness and to what extent?
2. What scale is used to express the timeliness of a piece of information?
3. Depending on the timeliness rating on this scale, how is processed a piece of information?

5 Monitoring / Sighting / Storing

The previous sections described distinctly the objective exploitation and subjective appraisal of reports. This third stage brings the results of these mechanisms together.

The complete model works as follows:

1. A confidence rating is attributed to incoming reports, based on the knowledge of the source and the general form of the report.
2. Reports are interpreted without any consideration for their confidence rating.
3. Two cases arise depending on the report's consistency:
   - If information is consistent with previously logged (i.e. trusted) information, then the report is logged.
   - If information is not supported by previous information, then, depending upon the commander' trust behaviour and the confidence rating he attributed to the report, information is:
     - Logged.
     - Discarded.
     - Held up in a temporary table until it can be confirmed, contradicted, or until it is out-of-date.

The temporary table is simply a second sighting table. Reported elements or entities contained in it are submitted to the same matching process explained earlier. And in case they can be matched with the content of a trusted report, then they are transferred to either the monitoring or the sighting table.

6 Conclusion

This conceptual model, based on the author's observations, primarily intends to transcribe the main features of the sense-making process which can be found in individual commanders at low tactical levels and to provide a foundation for further investigation.

The next step of development ought to be carried out through a series of experiments which should:

- Formally validate the model's mechanisms (validation was restricted to a limited number of reviews by company commanders)
- Characterize the various parameters which were outlined by lists of hypotheses

Once validated and populated, owing to its simplicity, the model can be implemented using rule-based applications or environments. From there, since it has been built without reliance on specific command structure, means of communication (face to face, over the radio, through a mail-like system, etc.) or means of visual display (map, computer screen, etc.), it could be used to compare alternative configurations.