Fast simulations of conflict with embedded Command and Control: An application of the use of Cellular Automata

Sean B Richardson and Lorraine Dodd

DRA Malvern, St Andrews Road, Malvern, WR14 3PS.

email: rista@taz.dra.hmg.gb
tele: (0)1684 896135
fax: (0)1684 894492

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ABSTRACT FOR 12 ISMOR

DRA Malvern is currently engaged in a programme of work aimed at MoD's need to be able to assess the effects of CIS and RISTA on the battlefield and in areas of low-level conflict, peace-making and peace-keeping.

To this end we have pursued a variety of avenues of research. One of these concerns simulation models of conflict, using the technique of Cellular Automata. Unlike large scripted simulations, cellular automata are frugal in resources, efficient in execution, versatile and flexible.

A specific model currently under design focuses on two distinct aspects: a Battlefield Domain, in which physical movements and the behaviour of military entities are represented; and a CIS Domain, within which the information war is modelled.

The Battlefield Domain comprises a hierarchy of simple automata representing combat units (at company level), headquarters and sensors. The automata manoeuvre across a two-dimensional battlefield and engage each other in response to simple rules based on the states of neighbouring automata. They are controlled by decisions made within the CIS Domain in response to simulated sensor reports fed to the CIS Domain from the Battlefield Domain.

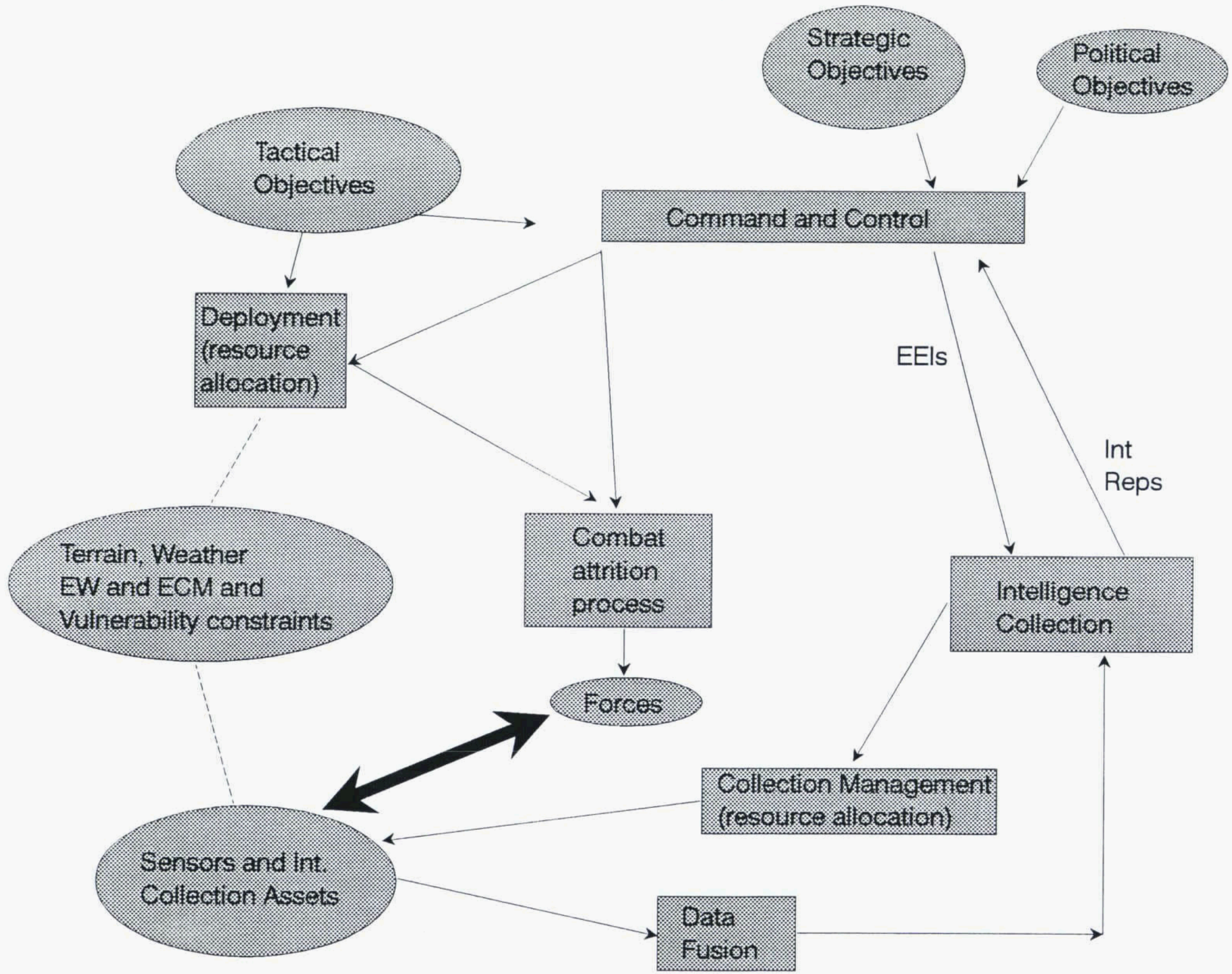
The CIS Domain consists of two parts: a hierarchy of situation assessment agents that builds up the patterns of force strength (*Threat Maps*) from sensor reports produced by the Battlefield Domain; and a hierarchy of command agents that determines from the Threat Maps simple decision rules to drive the behaviour of the automata within the Battlefield Domain.

Simulations employing the technique of cellular automata appear to be superior to other forms of simulation if only on grounds of computational complexity. They are faster in execution, more frugal with resources and easier to modify in response to changing requirements. There are several related reasons for this superiority. Principally, the size of the code is much smaller than that required by scripted simulations. The automata are *empowered* to implement a local policy rather than a global schedule. They are free to take decisions and the rules of engagement that they follow are relatively simple and few. By contrast, a scripted simulation in which every combination of outcomes must be specified is unwieldy.

RISTA studies project group

- ***AIM***
  - to establish the military value of RISTA systems
- ***METHOD***
  - by exploring the management, collection, analysis, collation and utility of sensor-derived information

C3I processes



HIGH LEVEL OPERATIONS MODEL

Purpose: To investigate the impact of the RISTA process and product quality on operation outcome

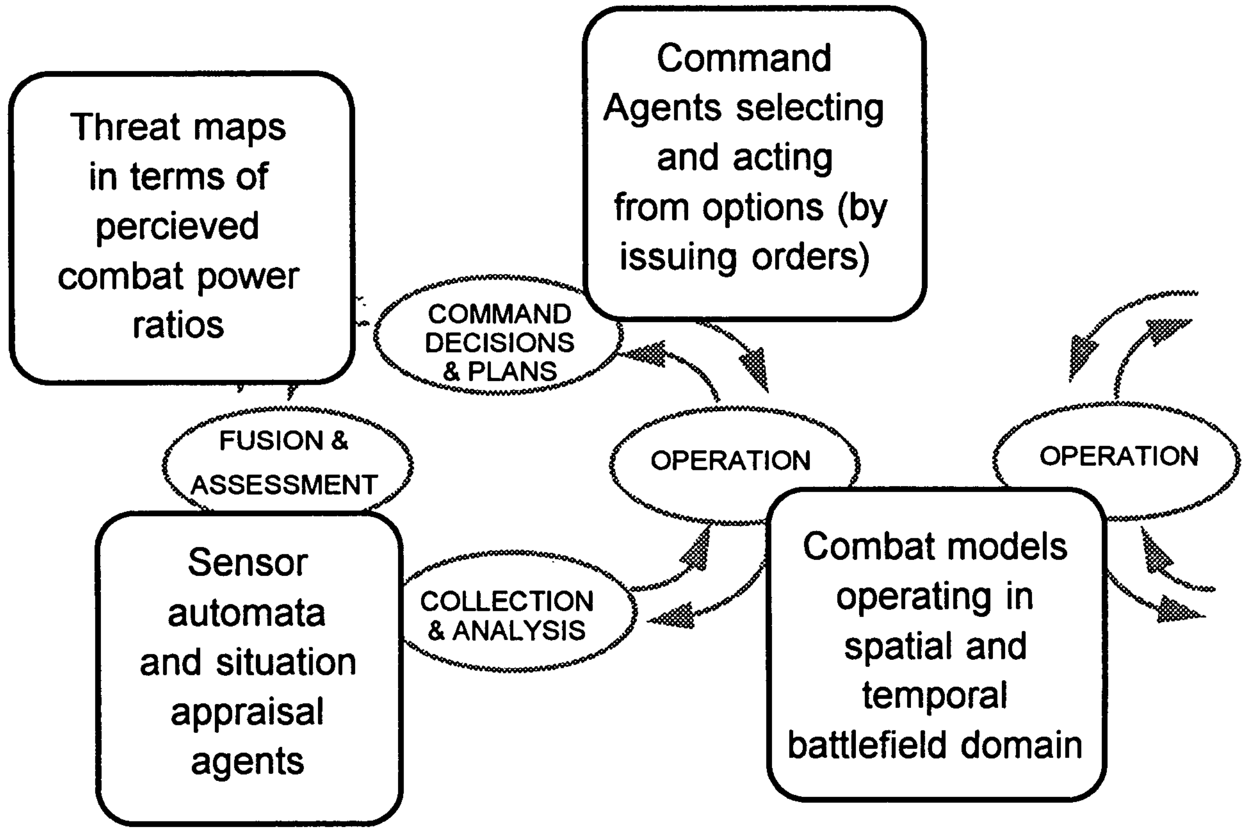
Need: There is currently no viable model which is capable of fast modelling the four key components, (collection, perception, command decision and force behaviour) in both combat and non-combat operations

Status: A prototype PC based solution is to be demonstrated in November 1995

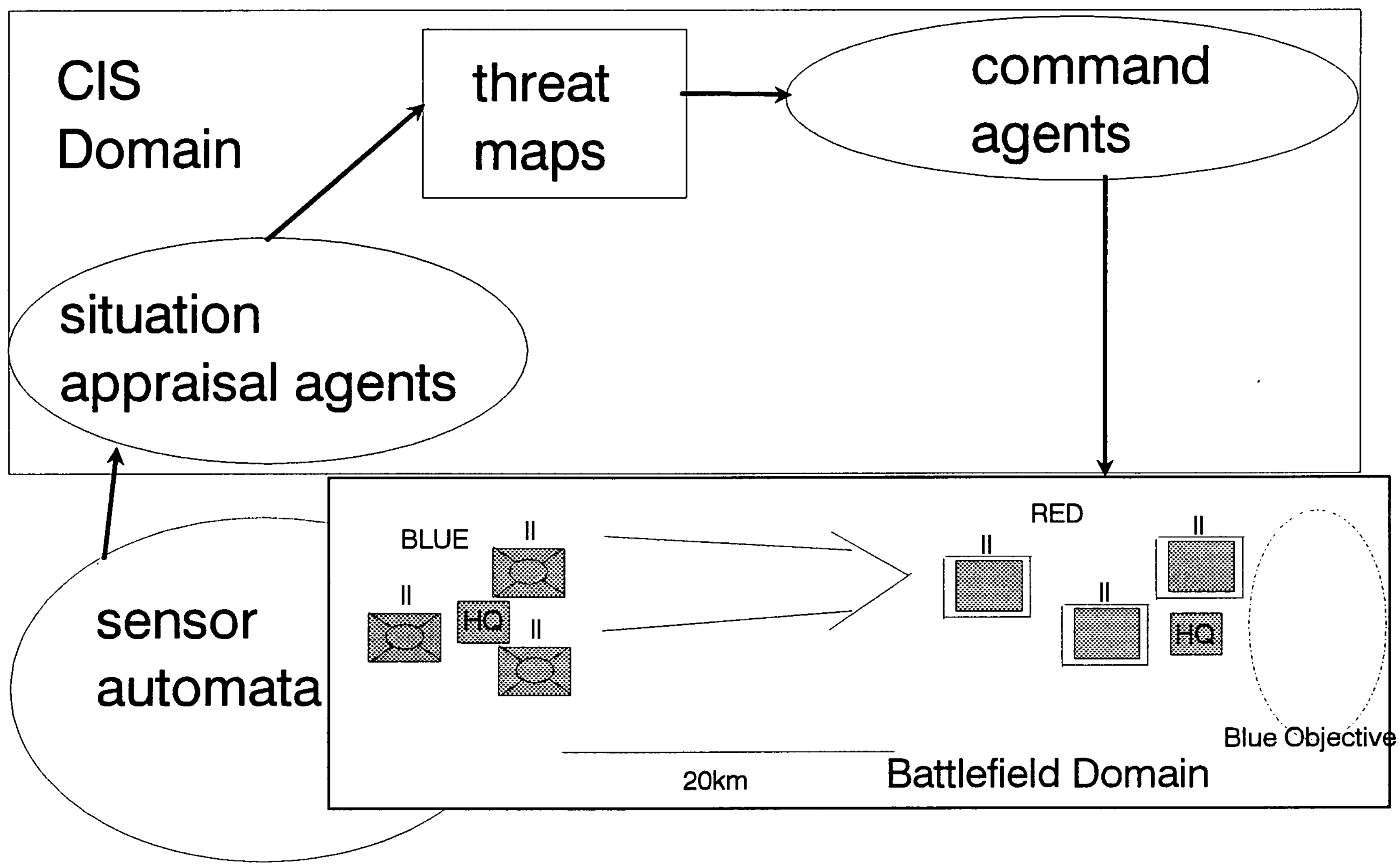
Spin-offs ?: Rapid scenario generation and wargaming.
Operational what-ifs (decision support)
Training
Information warfare

HIGH LEVEL OPERATIONS MODEL

Model Components



Schematic description of the prototype model



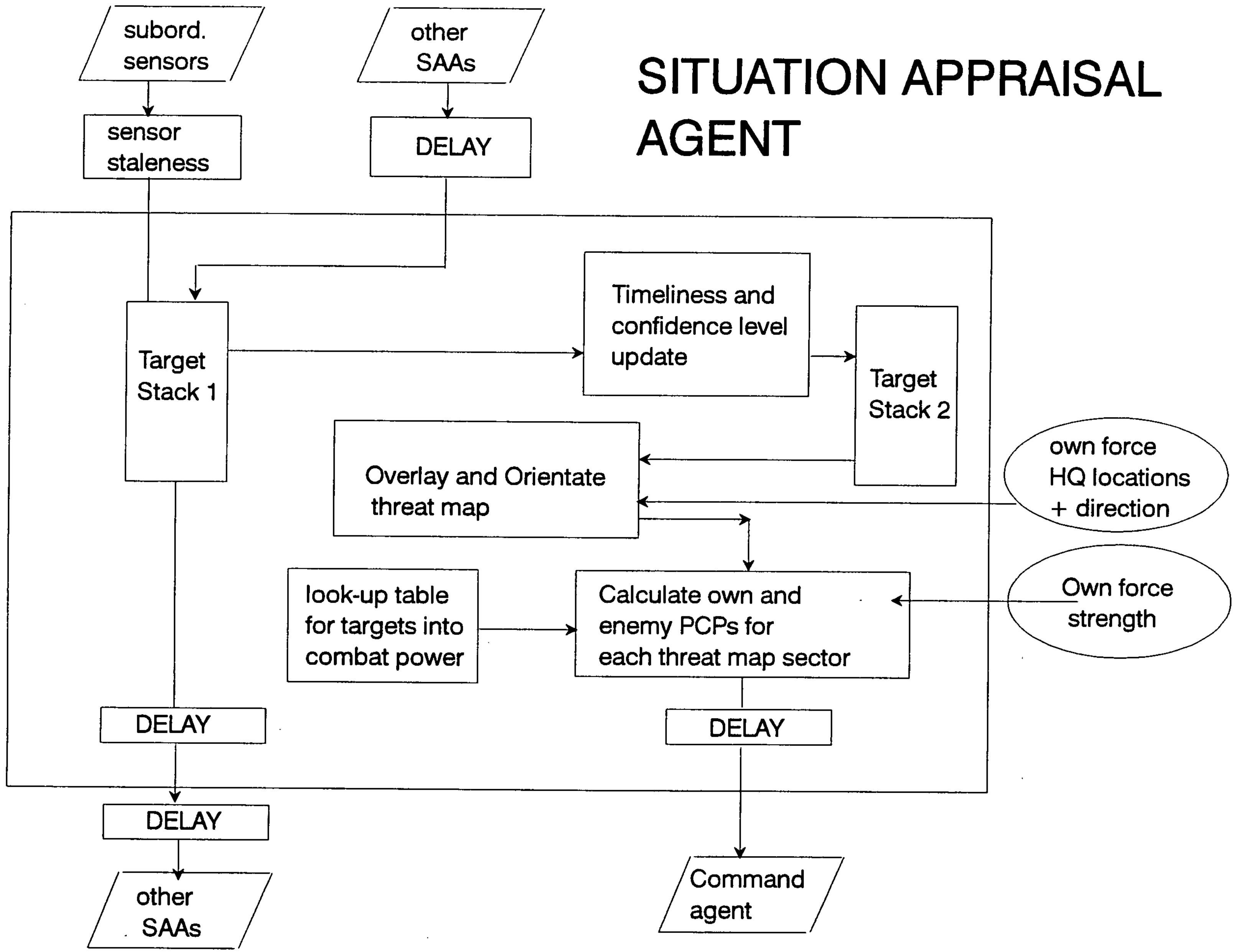
What are Cellular Automata?

- **Boolean Automata in a 2-dimensional lattice**
  - each has a binary on-off state
  - an automaton turns on or off under certain rules
  - these rules are usually local to the automaton
- **Complex patterns of behaviour emerge**
  - even using simple deterministic rules

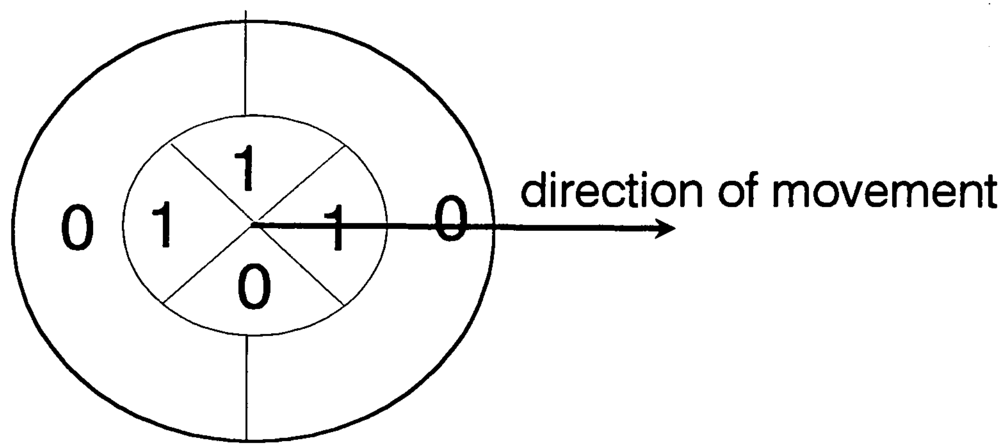
Cellular Automata in combat models

- **Combat Automata on a 2-d battlefield lattice**
  - each cell contains a state vector comprising terrain details, number and type of force unit, etc.
  - attrition rules within the fight radius of the automaton
  - movement rules depend on local Command Agent output or overall objective.
- **Extensions using other types of lattice**
  - tree-structures to represent the command hierarchy
  - threat map abstraction to give decision-maker's view

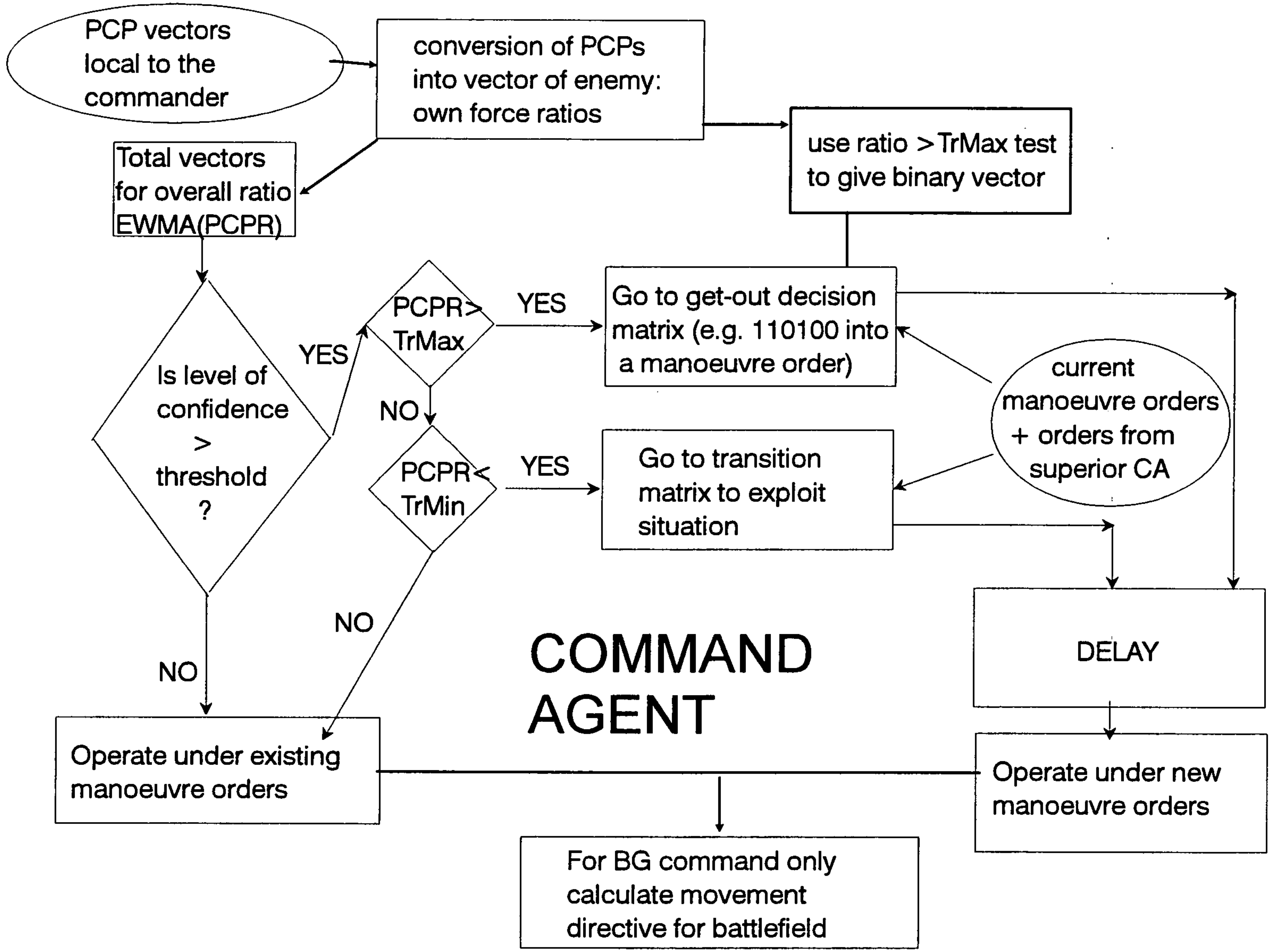
SITUATION APPRAISAL AGENT



The six sector threat map represents areas of high and low enemy strengths relative to own strength.



It is represented as a vector 110100 which is translated into a manoeuvre order for the command agent.


PCP vectors local to the commander
conversion of PCPs into vector of enemy: own force ratios
Total vectors for overall ratio EWMA(PCPR)
use ratio > TrMax test to give binary vector
Is level of confidence > threshold ?
YES
NO
PCPR> TrMax
YES
NO
PCPR< TrMin
YES
NO
Go to get-out decision matrix (e.g. 110100 into a manoeuvre order)
Go to transition matrix to exploit situation
current manoeuvre orders + orders from superior CA
DELAY
COMMAND AGENT
Operate under existing manoeuvre orders
Operate under new manoeuvre orders
For BG command only calculate movement directive for battlefield

Manoeuvre orders

- **Eight types of manoeuvre are used :**
  - Advance to contact
  - Deliberate attack
  - Hasty attack
  - Pursuit
  - Counter attack
  - Deliberate Defence
  - Hasty Defence
  - Withdrawal

Cellular Automata modelling

- **Simple local rules**
  - battlefield automata are driven by movement rules with associated rules for attrition.
  - sensor automata use the intervisibility mask and their own local exploitation rules.
  - command agents use their local threat map lattice to make manoeuvre decision.
- **Interaction creates complex emergent behaviour**
- **Easy implementation of different operational settings**
  - no if-then rules which are specific to the scenario
  - easy to change manoeuvre types, get-out matrices, etc.

If you require copies of recently published papers please contact either Sean or Lorraine

- *High Level Cellular Automata Model: a functional description* by **Lorraine Dodd**
  - DRA/LSS/LSC1/10/95 July 1995
- *Modelling of adaptable C3I systems: Final report* by **Sean B Richardson**
  - DRA/CIS(CSS1B)/TR94022/1.0 December 1994