**Issues:**—

- Understanding the true Nature of Command and Control
- Modelling Command and Control Systems
- Capturing requirements and turning them into Command and Control Systems
Rubbishing Conventional Wisdom

• “To gain the most from information systems, one has to radically reorganize overall processes so that the power of the machinery can be brought to bear. Cost-benefits can only really be achieved this way”

• Real conflict and warfare is unpredictable. Prescriptive approaches have continually failed in the past, resulting in grandiose, expensive monuments to messianic faith in technology

• Command and control is essentially of and by people, exhibiting human dimensions of leadership, charisma, *sang froid*, courage, and-particularly-adaptability to situation

• The eventual processes are not really predictable—they emerge in response to the unpredictable environment, witness DICS, where preconceived message formats were rarely used.
What really happens!

- In the real world, new conflicts generate new situations.
- C^2 organizations are thrown together into alien situations, and teams form under pressure.
- Far from depending on technology, each new situation is the subject of intense interpersonal debate, using even communications only occasionally.
- Once human decisions are reached and strategy/tactics formulated, then technology may be used to inform, to elaborate and support the plan.
- Engineers and technologists might like to think that technology rules C^2, but it does not.
Modelling and Simulation Shortfalls?

“Orchestrated? You start conducting and then some son-of-a-bitch climbs out of the orchestra stalls and comes after you with a bayonet!”

*General Norman Schwarzkopf*

- Is Command and Control, *in extremis*, controlled aggression through fear, while excess testosterone and adrenalin make the legs tremble and the palms sweat?

- If so, then the types of model and (to a lesser extent) simulation above—which neglect the whiff of grapeshot, the clatter of battle—are unlikely to describe reality
C2 and SE, VR

- If Command and Control is about teams, planning, briefings and group decisions, then **HCI / MMI must enable comprehensive person-to-person interchange.**
- If Command and Control is about *team-management of aggression*, should *understanding behaviour* be to the fore?
- If Command and Control is about maintaining force *morale, esprit-de-corps, coherence*, should *group psychology* be evident?
- **Solo-immersion VR ≠ command and control**
- Networked-immersion VR may, for the first time, enable:—
  - expert C² personnel to develop interpersonal team performance
  - expert teams to evolve their own C³I requirements, in SE, without writing
  - eliminate the paper chase from user ‘specifier’ systems engineer ‘information engineer’ commissioning engineer ‘customer’ user
  - eventually, eliminate specific, prescriptive C³I

*Following discussion explores these ideas*
Understanding the Complexity of $\mathbb{C}^2$
Fractal C²

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<td>Enemy ORBATS, intentions</td>
<td>Intelligence</td>
<td>Enemy ORBATS, intentions</td>
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<td>Constraints</td>
<td>Constraints</td>
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N.B. N² chart appears at each and every C² location
Behaviour Management

Cognition

- Tacit knowledge

Nature

- Evolution
  - Emotion
  - Energy
  - Character
  - Instinct

- Constraint

Stimulus

- Drive

Belief System

- World models

Selection

- Motivation
  - Beliefs
  - Roles
  - Stereotypes,
  - Categories
  - Values
  - Ethics
  - Morals
  - Self-perception

Experience

Drift

Environment

Nurture
Mission and Behaviour Models—Interactions

Belief is the end, not the beginning, of understanding
after Johann Wolfgang von Goethe

Note: double helices
Psychology of Operations Rooms Layouts

"It's all there on Star trek"

- External Sensors, Comms Consoles
- Swivel Chairs
- Large-Screen Display
  — Outward-Looking
- Bridge
- Science & Comms
  — Reactive
  — Outward Looking
- Captain Swivel Chair
- Engineering
  — Sidelined
- Operators
  — Controlled
  — Outward-Looking
  - Weapons
  - Navigation
  - Attitude & Speed
- Height Differential
Startrek—the Next Generation—a new Psychology?

Bridge Engineering Position

Security, communications, defence and weapons

Tactical Officer

First Officer → Captain → Ship’s Counsellor

Helm

Sensor management and interpretation

Internal controls

Science Officer

Personnel management, captain’s conscience, negotiating aide

Captain’s Ready Room

Large Screen Display
Belief system

Interpretation of everyday events, situations

Reducing psychological uncertainty

Straightforward believer's World Model

Reinforcement

Rôle models of "good" and "bad" behaviour

Reward/punishment concepts

Co-operative social behaviour

Social cohesion

Power structures

Icon establishment

Training

Indoctrination/education in belief system

Decision-making in Command and Control

Fear reduction

Reducing psychological uncertainty

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Note: double helices

Leadership & discipline

Maintaining/reinforcing the belief system
New Belief System attracts believers if it is:

- self-re-inforcing
- supported by education and regulation

Failing Belief System is v. difficult to sustain once a downward trend is established.

Sudden, major increase in policing, punishment and education
Belief System Battle

Assyrians besieging a city

—from the Assyrian Marbles, British Museum
Conclusion from Models

- Command and Control is about *two* distinct Struggles
  1. The Struggle within **Blue/Red Force** to maintain its own **Belief System**
  2. The struggle between **Blue Force**’s Belief System and **Red Force**’s Belief System
1. If Command and Control is about decision-making, then…
2. …models of technology or decision-making do not explain C²…possibly because…
3. Shared/unshared Belief Systems colour individual’s and group’s decision-making…showing that, at its heart…
4. C² is a struggle within and between Belief Systems…explaining, perhaps, why…
5. Traditional models and simulations fall short.
6. In time, and with caution, VR could let:—
   – engineers provide ever-improving environments
   – commanders propagate beliefs, values and leadership through those environments
   – users design, train and operate in self-determined environments
A Human-Centred View of $C^2$ Organization
Adaptability in Systems

Adaptable, Social Human Sub-system

Rigid, Social Machine Sub-system
Information System Paradigms

Users communicate via rigid, limited database, using only one of five senses—slow, ineffective, non-adaptive, humans as machine-minders

"Deus ex Machina"

Users communicate directly and via machine; humans adapt, machines do not. Machine quickly obsolescent.

"Users Good—Machines Better"
Human-Centred Paradigm

Rule 1: "Command is of, and by, people"
Rule 2: —
Evolve team-based, human-centred systems
The Potential Rôle for SEVR
An Alternative Procurement Philosophy

- Who knows what they want to do? — The User
- Who has all the experience at doing it? — the User
- Who should be developing C2 and Management Systems?
- — the Expert User
Robust Command Systems

- There is no job so mundane that it lacks a 'wrinkle'. Humans are past masters at finding easier / better ways to do anything.
- Experienced Command system operators have already learned many wrinkles as individuals, *but also as teams*.
- Requirements capture is therefore virtually impossible by our present methods—e.g. talking to individuals, building fast prototypes.
- Rule 1. Use expert Command system operators to capture their *own* requirements.
Accelerated Evolution Approach—AEA(1)

- **Step 1.** Eliminate as much technology as possible — create a *human* Command System Team of current experts which uses manual methods.
- **Step 2.** Give the Team *time* to build its repertoire of individual and group skills, interpersonal relationships, group effectiveness. Use extra manpower to achieve performance.
- **Step 3.** *Stress* the Team—simulated Command, cooperation with other force elements, real drudgery, simultaneous representative variety. External DS to be experts, too. Continue until manual team is highly proficient.
Accelerated Evolution Approach—AEA(2)

- **Step 4.** *Team* identifies Sub-Teams, bottlenecks, areas for improvement—i.e. the Team proposes its own productivity enhancement, individual-by-individual, sub-team-by-sub-team, absolute minimal technology integration

- **Step 5.** Provide the Team with its proposed support

- **Step 6.** Repeat steps 2 to 4

- **Step 7.** Resist the temptation to integrate all the technological support features—that's the path to software overruns, project delays and inflexible technological 'solutions'
The AEA System

- Conceived and evolved by current experts for experts
- User-effort directed at System Performance, not at overcoming technology limitations
- Guaranteed outcome:
  - evolves from a manual system (=working system)
  - degree of evolution controllable (= time/cost controlled)
- Self validating design—user-specified, situation-evolved
- Emergent-property directed—performance, interoperable, flexible, adaptable, damage tolerant (non-nodal)
- Inherent team training
- Avoids "integrate / automate" trap = reduced complement, but:
  - increases maintenance • increases cost • reduces adaptability • causes near-term obsolescence.
Division’s Virtual Representation of HMS Marlborough Combat Centre
Getting the Picture Straight

- Division’s VR Picture of HMS Marlborough Combat Room is missing the essential ingredient…
- …so, put experienced users into virtual environments
- Allow experienced users to adapt mutual behaviour to deal with variety of (simulated) threats
- review, update, evolve supporting virtual technology
- Set virtual teams against virtual teams, not just to train, but to evolve mutual technology requirements
Understanding—the Bottom Line

• 1. Understand our own *superb human capabilities*
  » —communication, cooperation, correlation, commitment, courage, intellect, ingenuity (C5I2?)
  » —adaptability
  » —mental-modelling
  » —fast individual decision-taking/satisficing

• 2. Understand our *human frailties*
  » —decision-information overload
  » —slower group dynamics

• 3. Use technology to *compensate* for our *weaknesses*

• 4. *Avoid* technology which *impairs* our individual and group *strengths*