

DERA

International Workshop on Knowledge-Based Planning for Coalition Forces

Edinburgh, Scotland, 10th and 11th May 1999

Supported by The Technical Cooperation Program,
European Office of Aerospace Research and Development,
Air Force Office of Scientific Research,
United State Air Force Research Laboratory/Information Directorate at Rome,
Defense Advance Research Projects Agency,
and the UK Defence Evaluation Research Agency.

Organised as part of the contribution of the
DARPA/Air Force Research Laboratory (Rome) Planning Initiative (ARPI)
by the Artificial Intelligence Applications Institute, University of Edinburgh

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DTIC QUALITY INSPECTED 4

19991209 073

AQF00-03-0686

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE 14 May 1999		3. REPORT TYPE AND DATES COVERED Conference Proceedings	
4. TITLE AND SUBTITLE Workshop on Knowledge Based Planning for Coalition Forces				5. FUNDING NUMBERS F61775-99-WF001	
6. AUTHOR(S) Conference Committee					
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) University of Edinburgh 80 South Bridge Edinburgh EH1 1HN United Kingdom				8. PERFORMING ORGANIZATION REPORT NUMBER N/A	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) EOARD PSC 802 BOX 14 FPO 09499-0200				10. SPONSORING/MONITORING AGENCY REPORT NUMBER CSP 99-5001	
11. SUPPLEMENTARY NOTES					
12a. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution is unlimited.				12b. DISTRIBUTION CODE A	
13. ABSTRACT (Maximum 200 words) The Final Proceedings for Workshop on Knowledge Based Planning for Coalition Forces, 10 May 1999 - 11 May 1999 This is an interdisciplinary conference. Topics include 1. Competing doctrine, decision making, rules of engagement, 2. Different technology skills and equipment levels, 3. Questionable compatibility of respective national information systems, 4. Limited models for coalition force operations, and 5. Command authorities - agreement and transfers.					
14. SUBJECT TERMS EOARD, C3I, Artificial Intelligence, Coalition Forces Planning				15. NUMBER OF PAGES 200	
				16. PRICE CODE N/A	
17. SECURITY CLASSIFICATION OF REPORT UNCLASSIFIED	18. SECURITY CLASSIFICATION OF THIS PAGE UNCLASSIFIED	19. SECURITY CLASSIFICATION OF ABSTRACT UNCLASSIFIED	20. LIMITATION OF ABSTRACT UL		

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102

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Part 2 – Plenary Session Papers

McCrabb, Mr Maris “Buster”, Logicon Advanced Technology, Inc.

- *Is George Bernard Shaw Still Right? Lessons from Coalition Operation*

Desimone, Dr Robert, DERA

- *Coalition/Joint Planning Aids The Latest Developments*

Wentz, Mr Larry K, VP Advanced Communications Systems

- *Coalition Information Operations*

Rathmell, Dr Tony, DERA

- *A UK TTCP – C3I – TP9 Perspective of Command and Control Planning Issues for Future Coalition “War Avoidance” Operations*

Jensen, Mr Jens, PACOM J3

- *Chican Scenario (as of 4 Sep 98) “Peer Competitor Campaign”*

Cohen, Prof Paul, University of Massachusetts

- *Understanding Courses of Action*

Tate, Prof Austin et al, AIAI, University of Edinburgh

- *Using Shared Models of Activity to Underpin Coalition Planning*

Schlichter, Commander William, US Navy

- *Common Operational Modelling, Planning and Simulation Strategy (COMPASS)*

Martin, Dr Peter, Logica UK Ltd

- *Co-operative intelligent agents for coalition planning – the EUCLID Project and the CABLE Architecture*

Part 3 – Participation Position Papers

Berger, Mr Jean, Defence Research Establishment Valcartier

- *Defence Research Establishment Valcartier (DREV, DND, Canada) – based Planning Systems/Activities*
- *A Summary*

David, Dr Richard, Head Command and Control Australian Theatre Group

- *Australian Coalition Planning Issues and Requirements*

Garvey, Dr Thomas D, Artificial Intelligence Center, SRI International

- *Technical Challenges for Knowledge –Based Planning for Coalition Forces*

Illingworth, Mr Mark, Defence Evaluation and Research Agency

- *Joint Logistic Planning (J4)*

Jensen, Mr Jens, Assistant Deputy for Crisis Operations, PACOM J3

- *Holding Chaos at Bay - Thoughts on Coalition Operations*

Jensen, Mr Jens et al, Assistant Deputy for Crisis Operations

- *What is in a Plan? – A Common Operational Environment for Planning for Coalition Military Operations*

Kendal, Mr Rocky & Kettler, Dr Brian, ISX Corporation

- *A Coalition Based Collective Representation*

Kingston, Mr John, AIAI, University of Edinburgh

- *Models of Planning*

Lambert, Dr Dale Austin, Defence Science and Technology Organisation

- *Knowledge Level Interoperability*

Picard, Mr Gaetan & Berger, Mr Jean, Defence Research Establishment Valcartier

- *Toward Collaborative Planning Support – A Summary of Selected Activities at Defence Research Establishment Valcartier (Canada)*

Smille, Dr Robert J, SPAWAR Systems Center – San Diego

- *Information Support Systems for Coalition Operations (ISSCO)*

Swartout, Mr Bill, USC/Information Sciences Institute

- *Position Statement for the Workshop on Knowledge-Based Planning for Coalition Forces*

Wind, Lt Col Robert, USAF, Chief Plans Branch

- *AC2ISRC*

1.0 Workshop Aims and Description

1.1 Workshop Goal

The goal of this workshop is to identify several near and long term technical challenges in the application of knowledge-based planning to the coalition command and control environment. These technical challenges will become the foundation for a future collaborative coalition planning research programme.

1.2 Workshop Description and Agenda

A workshop to bring together the community of international researchers, developers, government representatives and military personnel to discuss emerging advanced planning technology and how it might be further developed to support military coalition planning and execution. While other technical challenges such as security, and release of information exist, this workshop will focus solely on the use of Knowledge-based systems during the planning process of coalition operations to transcend cultural, language, and Rules of Engagement (ROE) barriers among coalition partners.

Many current and an increasing number of future military missions will involve multinational coalition forces which must be rapidly drawn together, flexibly led, responsively deployed and agile to address a wide variety of dynamically evolving tasks. Modern military operations involve defensive, policing and humanitarian missions both locally or in far-flung regions of the world. Many missions are conducted as part of a joint force with other nations to achieve objectives set by the international community. In these missions there is a need for agility, responsiveness and effectiveness in the use of limited resources to achieve complex and multiple objectives. There are frequent changes of requirements and the situation is often fluid. Effective means to clearly define and relay the mission objectives through to planning and logistics support staff and then on to the coalition partners and personnel in the field are essential.

Planning is a core competence and a core task for any organisation - including the military. But, planning should not be seen as detached from execution, monitoring and control. It is a critical process that allows one to create and manipulate the context for execution (hopefully to one's own advantage) and a process that must be intimately involved with execution.

1.3 Coalition C3I Key Issues

- ¹Different doctrine, decision making, rules of engagement and, in general, mission "agendas"
- Different technology skill and equipment levels
- Questionable compatibility of respective national information systems
- Limited models for coalition force operations
- Command authorities - agreement and transfers
- Information systems resource sharing agreements & capacity
- Different interpretation of situational information
- Lack of compatible security architectures

¹ Notes provided by LeRoy Pearce, Canadian MOD.

2.0 Agenda

Day 1 - 10 May 1999

0900 – 0920 Introduction

- Welcome, Introductions, Admin. Comments
Prof. Austin Tate, AIAI (Workshop Organiser)
- Workshop Objective
Dr. Scott Fouse, ISX (Workshop Facilitator & Chairman)

0920 – 1000 Coalition Issues

- Information Concepts for Coalition
Dr. Nort Fowler - AFRL & TTCP-US
- George Bernard Shaw was Right: Lessons from Coalition Operations
Maris "Buster" McCrabb, Logicon

1000 – 1030 Coalition Planning Challenges

- ARPI Coalition Planning Program
Mr. Rick Metzger, AFRL/IF
- Coalition/Joint Planning Aids
Dr. Roberto Desimone, DERA Malvern

1030 – 1100 BREAK

1100 – 1200 Coalition Planning Problem

- Lessons from Bosnia: The IFOR Experience
Dr. Larry Wentz, Advanced Communications Systems Inc.
- OOTW Coalition Forces Operations and Logistics Support TP9
Coalition Scenario
Dr. Tony Rathmell, DERA
- Coalition Logistics
Major Richard Devonshire, MOD (UK)
- Command and Control Scenario – the ACOA Program
Mr. Jens Jensen, PACOM J3

1200 – 1230 Working Groups Introduction

Dr. Scott Fouse, ISX

1230 – 1400 LUNCH

1400 – 1600 Working Group Breakouts

1. Knowledge-Based Planning for Coalition Operations Other Than War

Lead: Mr. Ed Walker;
scenario expert (TTCP/TP9 scenario): Dr. Tony Rathmell;
ambassadors: Dr. Paul Cohen -> C2, Dr. Steve Milligan -> Logistics
local support: Dr. John Levine, AIAI

2. Knowledge-Based Planning for Coalition Command & Control

Lead: Dr. Tom Garvey;
scenario expert (ACOA scenario): Mr. Jens Jensen;
ambassadors: Dr. Steve Smith -> Logistics, Dr. Bill Swartout -> OOTW
local support: Dr. Peter Jarvis, AIAI

3. Knowledge-Based Planning for Coalition Logistics

Lead: Dr. Roberto Desimone;
scenario expert (DERA scenario): Major Richard Devonshire;
ambassadors: Dr. Jitu Patel -> C2, Mr. Rocky Kendall -> OOTW
local support: Mr. John Kingston, AIAI

1600 – 1630 BREAK

1630 – 1700 Working Group Issues

1800 – 2000 SOCIAL EVENT:

Scottish Whisky Appreciation Society, Tour and Tutored Tasting,
Royal Mile, Edinburgh

* Informal Groups for Dinner in the City

Day 2 - 11 May 1999

0900 – 0915 Admin. Comments

Prof. Austin Tate, AIAI & Dr. Scott Fouse, ISX

0915 – 1030 Technical Contributions

- **Deep Understanding of Operations for Automated C3 Systems**
Prof. Paul Cohen, University of Massachusetts
- **Shared Models of Activity to Underpin Coalition Planning**
Prof. Austin Tate, AIAI, University of Edinburgh
- **Distributed Collaborative Environment - the COMPASS Project**
Cdr. William Schlichter, SPAWAR Systems Center
- **Co-operative intelligent agents for coalition planning - the EUCLID Project and the CABLE Architecture**
Dr. Peter Martin, Logica

1030 – 1100 BREAK

1100 – 1230 Working Group Breakouts

1230 – 1330 LUNCH

1330 – 1500 Working Group Breakouts

1500 – 1530 BREAK

1530 – 1630 Working Group Outbriefs and Issues

1630 – 1700 Planning for the Future

Dr. Scott Fouse, ISX

1930 for 1945

WORKSHOP DINNER:

The Dome, 14 George Street,

3.0 Working Group Issues

3.1 Workshop Issues – Scott Fouse

The goal of this workshop is to identify several near and long term technical challenges in the application of knowledge-based planning to the coalition command and control environment. These technical challenges will become the foundation for a future collaborative coalition planning research program. To insure that these technical challenges we develop over the course of the workshop are relevant, we will start with discussions of the operational issues. Over the course of the two days, we will be breaking up into three working groups (to allow us to get into small enough groups to enable real work to be accomplished). Each of these working groups will look at different operational aspects of coalition operations, ranging from command and control aspects, logistics aspects, and Operations other than War. Each of these groups will let their discussions on the operational issues lead them to the technical issues, using scenarios to guide the discussion.

To help frame the discussions, the organizers have created an initial list of technical issues that we expect to be touched on in the various working groups. While we hope that this list contains many of the important technical issues, we also expect that the discussions at the workshop will add to and reshape this list.

The base set of operational issues that we are starting from, as stated by LeRoy Pearce, are:

- Different doctrine, decision making, rules of engagement and, in general, mission "agendas"
- Different technology skill and equipment levels
- Questionable compatibility of respective national information systems
- Limited models for coalition force operations
- Command authorities - agreement and transfers
- Information systems resource sharing agreements & capacity
- Different interpretation of situational information
- Lack of compatible security architectures

Workshop Technical Issues - Scott Fouse

After discussion with the workshop organizers, I have captured an initial list of technical issues that can be used stimulate discussion, both in the plenary sessions and in the three working groups. Each of these issues could have one or more pages written about them, but for the purposes of this workshop, we will leave the descriptions at the "bumper sticker" level. Also, to provide some organization to the list, I have put them into 5 groups, listed below.

Representation Issues

How do we represent the capabilities, resource requirements, and operational constraints offered by coalition partners so that they can be factored into a comprehensive operational plan?

How do we represent operations in an "open" fashion so that we can quickly respond to highly dynamic situations, with a variety of response options? How do we integrate with legacy systems?

Interoperability Issues

The central importance of sharable objective, activity, process and capability terminology, models, knowledge and information. Note the term "sharable" rather than "common" or "shared" as we must not assume any sort of commonality for flexible international force composition will be a characteristic of coalition operations.

What issues are presented by differing constraints on the releasability of information to coalition partners. How can technology aid in dealing with the problem that different coalition partners will in fact have different situation descriptions, due to intelligence assets that will not be shared?

How do we integrate resource models from the various coalition partners?

How do we deal with the different logistical needs of the coalition partners?

Communication Issues

What technology can we look to support communication between coalition partners. Language translation, Simulation, Visualization, Storytelling?

How do we bridge the experience gap. Effective communication relies on finding common experience base. For coalition operations, can technology help to bridge that gap?

Agile, Adaptive Environment Issues

The need to have the facility to be given an agile and effective response to joining in any grouping of nations which cannot assume that shared C2 systems and shared data models pre-exist. The need to be able to accept command authority from another nation under these circumstances.

As we are addressing the various issues already cited we must be aware that they must be dynamic which emphasises the reduced time we are all trying to achieve for planning and executing decisions. We cannot let the technology slow down the process.

Rapid acquisition of knowledge in a coalition environment - can technology support incorporating lessons learned on day 1 into the plan for day 2?

Process Management/General Automation Issues

What new requirements must be considered for mixed initiative management?

What roles should we focus on for initial support by knowledge-based planning and management methods?

Each of the working group leads created an issue list for their group, and these are provided below.

3.2 Command and Control (C2) Working Group – Tom Garvey

In the Command and Control (C2) working group, we will address a number of challenging technical questions, including the following (further information may be found in Tom Garvey's position paper, reproduced in these proceedings).

1. How do we represent the capabilities, resource requirements, and operational constraints offered by coalition partners so that they can be factored into a comprehensive operational plan?
2. How do we represent operations in an "open" fashion so that we can quickly respond to highly dynamic situations, with a variety of response options? How do we integrate with legacy systems?
3. What issues are presented by differing constraints on the releaseability of information to coalition partners? What about different logistical needs?
4. What new requirements must be considered for mixed-initiative management?
5. What roles should we focus on for initial support by knowledge-based planning and management methods?

At the end of the workshop, we aim to be able to identify key technical capabilities and attendant R&D directions that will develop the technology necessary to enable knowledge-based C2--planning, process-and-workflow management, and control-to provide significant operational advantages in future coalition operations.

3.3 Operations Other Than War (OOTW) Working Group – Ed Walker

Coalition planning for relief and war avoidance missions is complicated by the need to consider simultaneous, interacting - and potentially conflicting - diplomatic, political/civil and military objectives and plans. Analysis of previous coalition operations has identified a wide range of problems from basic interoperability and operational doctrine to implicit cultural issues that impede planning or create differences of understanding, commitment and control. In addition to these, the issues particular to OOTW operations are:

1. extraordinarily broad spectrum of potential plans
2. exceptionally dynamic planning and execution environments
3. multiplicity of contributing and subsidiary plans by each coalition member
4. adversarial exploitation of the plan itself
5. unconventional means for which neither norms nor countermeasures are well developed
6. ad hoc experience, cross-organizational resource conflicts, unfamiliar risks

A central issue for the panel will be to identify and focus on any OOTW issues that are different in kind, or in extreme degree, from Coalition Planning issues in general. A key technical issue that will be discussed is simulation as a communications medium. Rather than just rely on language translation technology to deal with communication among the coalition partners, look to some richer communication technology.

3.4 Logistics (Log) Working Group – Roberto Desimone

- Shared representation of coalition logistics capabilities and resources
 - TPFDDs vs DOAST vs NATO standards
 - Common Logistics Picture
 - Coalition partner and Host Nation Support capabilities
 - Airlift/Sealift/ Land Transportation – reusable resources
 - Types of logistics (Type I,II,III,IV,V, etc) - consumable resources
 - Measures of sustainment
- Coping with multiple cultures, languages, doctrine, ROEs, complicated by significant host nation support.
- Interoperability of comms and information systems (CIS)
 - ADAMS (NATO Logistics system)
 - US/UK/Can Logistics CISs
- Explicit coalition logistics planning process to avoid ambiguity, duplication and information gaps in coalition logistics plans.
- Validation of coalition plans using coalition simulation models (HLA compliance) complicated by potential inconsistencies between multiple models.
- Security restrictions complicated by links to commercial carriers for air/sealift.

4.0 Attendees

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5.0 Acknowledgements

The Edinburgh Workshop on Knowledge-Based Planning for Coalition Operations was generously supported by:

- The Technical Cooperation Program;
- European Office of Aerospace Research and Development, Air Force Office of Scientific Research;
- United State Air Force Research Laboratory/Information Directorate, Rome Research Site;
- Defense Advance Research Projects Agency; and
- UK Defence Evaluation Research Agency.

It was organised as part of the contribution of the DARPA/Air Force Research Laboratory (Rome) Planning Initiative (ARPI) by the Artificial Intelligence Applications Institute, University of Edinburgh.

Thanks are due to the organising team:

- Roberto Desimone (DERA, Malvern)
- Jerry Dussault (AFRL, TTCP Representative)
- Dan Fayette (AFRL/IFT)
- Scott Fouse (ISX Corporation)
- Barry McKinney (EOARD)
- Rick Metzger (AFRL/IFTB)
- Austin Tate (AIAI, University of Edinburgh)

Scott Fouse also acted as overall facilitator for the workshop, and was supported by three Working Group Chairmen:

- Roberto Desimone
- Tom Garvey
- Ed Walker

Local arrangements support was provided by AIAI, University of Edinburgh staff before, during and after the event:

- Ken Baird
- Deirdre Burke
- Bridget Clyde
- John Kingston
- John Levine
- Peter Jarvis
- Jane Rankin
- Austin Tate

Thanks to all who helped and to those who participated in the workshop.

Is George Bernard Shaw Still Right? Lessons from Coalition Operations

Maris "Buster" McCrabb

Logicon Advanced Technology, Inc.

Introduction

In the movie *Patton*, the flamboyant American General is shown giving a speech where he uses the George Bernard Shaw quip that the "Americans and the British are two peoples separated by a common language." In many ways, that aphorism can be used to characterize coalition military operations.

These operations have been the norm throughout history and there is no reason to believe this will be any different in the future. However, some fundamental changes have taken place in the planning and execution of these highly intricate operations, especially in the 20th century and particularly given the military revolution wrought by the advent of airpower. During World War II operations can best be characterized as coordinated--better than merely cooperative--but not integrated. During DESERT STORM in 1990-1991 and Bosnia in 1994-1996, operations were better integrated but perhaps best described as still only synchronized. To become fully integrated, not only must the technical means military personnel use, but also the processes and most importantly, the context of operations must become truly shared. In other words, what is required at a minimum is a shared perspective.

As used here, *cooperation* is the loosest bonding between military forces of two (or more) nation-states in the planning, execution and assessment of operations. It may or may not involve efforts towards a similar end or use of similar means. *Coordination*, on the other hand, does require some conscious desire towards a common end or use of a common means. But it does not require any formal support/supporting arrangement. *Synchronization* is the next step towards combining efforts and does require specification of which military force will be supported by another in particular circumstances. However, military forces retain their individual identity. To be *integrated* at some level¹ forces must be mixed and matched towards not only a common goal, but use common means and lose their individual identity. Supported and supporting arrangements are not required because these forces are essentially employed as one force, regardless of their national origin.

This essay is a short romp through three of the most significant coalition operations the United States (US), the United Kingdom (UK), and other major powers in Europe

¹ Obviously "at some level" is wide open to interpretation. For example, does the fact that forces retain their own squadron identification and fly in their own leader-follower formations mean air forces are not integrated despite having those formations form an integral part of a larger force package? This essay would maintain the forces are, in this example, integrated at the mission and engagement level, but not at the force element level. There they are synchronized. Since the focus in this essay is the operational level of conflict, whether an operation is cooperative, coordinated, synchronized or integrated is from the point of view of that level.

engaged in during the 20th century. The goal is to gain some insight into the problems that military personnel faced in coalition operations under conditions of great uncertainty and stress. Specifically, the interest here is how these problems affected the knowledge needs of military planners, both before operations commenced and during execution.

At best these are highlights, not history. It is anecdotal, not analytical. And the stories are not "who shot who" or "there I was" war stories. Space limitation is one consideration but the larger reason is the purpose. This is not meant to be a full-blown, comprehensive history, but insight. History teaches no lessons but people can profitably use the past to gain appreciation of the problems similar operations, now and in the future, might face. The case can be made, at least this essay so contends, that coalition operations place unique demands on the people, processes, technical means, and organizations charged with conducting these campaigns. Lacking a shared perspective worsens these demands.

Therefore, the first relevancy of this essay is to coalition operations in general. As Prussian General Von Moltke the Elder is credited with pointing out, a plan is nothing but planning is everything. This is because of the ad hoc nature of warfare. Coalition operations make warfare all that more challenging. Besides an intelligent adversary that reacts, military personnel engaged in coalition operations face a multitude of challenges in such areas as language, equipment, and perspective differences (Rice 1997). But somehow these must be overcome and melded into a single, coherent plan of action in order to get any mission done whether a humanitarian mission in the midst of the genocidal civil war in Rwanda or peacemaking operations in the Balkans. Furthermore some argue these missions are becoming more the norm since the end of the Cold War when the uneasy balance of terror between the nuclear superpowers tended to place limits on regional flare-ups. Events sparking response appear almost randomly. Near instantaneous worldwide communications fuel calls for an international response. Forces are mobilized and deployed quickly, often to areas in which they have had little to no experience or training. Partners are gained or cajoled. And somehow, in this increasingly information technology-driven world, the computers and communication devices these various forces use must all work together. The data, information, and one-day knowledge these machines voraciously consume must be available almost instantaneously. There is scant time to build or maintain data/knowledge bases. So the second major area of relevancy is for those who design and develop those technologies that support coalition operations.

While pure "knowledge" may be objective (that is, an outside party using the same methodology and data will arrive at the same conclusion), the type of knowledge the military people required in these operations was very contextually dependent. Furthermore, the most critical element in each context was how the various coalition partners viewed the mechanism for achieving specific military (or perhaps quasi-military) objectives. From these various perspectives, different targeting strategies were pursued. That, in turn, drove quite different information requirements.

Thus perhaps the most fundamental lesson one can take away from this brief survey is that any technology that purports to provide a knowledge base from which disparate coalition partners can draw from, must find away to wrap the data elements and information with context.

The next important lesson is related to how various planning organizations interfaced within themselves and between themselves. If one views these as formal (for example, specified supported/supporting arrangements) and informal organizational structural inter-faces/intra-faces, one is struck by the very ad hoc and fluid nature of these arrangements. Secondly, they are very personality dependent. Finally, they consist of a rather few number of key individuals. The lesson here is that technology must conform to these structures, not the other way around, to be efficient. Otherwise, much effort will be expended by the actors in seeking ways to work around the perceived "technology roadblock."

This essay looks at some key parts of the Combined Bomber Offensive waged by the US Army Air Forces (USAAF) and the UK's Royal Air Force (RAF) against the Axis powers during World War II (WWII). The second case is the air campaign conducted against Iraq during DESERT STORM and the third is military operations in Bosnia-Herzegovina during 1994-1996.

The closing looks at some significant trends these examples highlight and examines their implications. Finally, the author, with much trepidation, offers some largely unformed ideas on where knowledge base development might move. The first development task, though, is a working definition of "knowledge."

Non-technical authors should be loath to hazard technical definitions, but since this essay seeks to shed some insight on these issues for those whose job it is to build technical items, this task seems essential. First of all, it must be stressed the use here of "knowledge" (and therefore "knowledge bases") does not conform to the varied on-going research efforts within the computer science fields. To do so would be counter-productive in that one would then be in a position of viewing past activities through the lens of current technologies instead of the other way round.

The framework used here is the "cognitive hierarchy" used in Naval Doctrine Publication (NDP) 6, *Naval Command and Control*. The first step is *data*, the bits and bytes gathered mainly by sensors in the form of raw signals and passed by telephone, radio, computer, etc. Data becomes *information* once it is collected and processed into usable form. "*Knowledge* results from analyzing, correlating, and fusing data that have been processed [i.e., is information] and evaluated as to their reliability, relevance, and importance." (NDP 6, 22; emphasis added) From knowledge, humans begin to see patterns and most importantly recognize what is not there—"the things that will forever remain unknown—and thus to identify the uncertainty we must deal with." (Ibid.) *Understanding* comes from applying judgment to that knowledge. "Judgment is a purely human skill, based on experience, expertise, and intuition." (Ibid, 23)

This framework is used in reverse by this essay. Based on the commander's "experience, expertise, and intuition" what knowledge (information, data) requirements can derived? Just as with any asset, knowledge is a finite (hence scarce) resource that comes at a cost. Assuming, therefore, an excess of data elements over knowledge required, what elements will be "processed"? Which analyzed, correlated and fused?

A final key element in this cognitive hierarchy—that becomes evident through the cases—is where the lines get drawn between technical and human involvement. Machines automatically do currently most data collection with little human involvement and increasingly that is true of the process of turning data into information. Knowledge processes on the other hand, are a mixed bag. Much fusion and correlation is done

automatically but humans do most analysis. This, then, brings in context to the equation. The implications, then, are that knowledge bases must include the human context, "wrapped" around the information, to be useful. Next, since analysis contains a subjective element, other users of the knowledge base must be made aware of "what is verified information, what is opinion." Tied to this, of course, is the whole minefield of maintaining knowledge bases: finding and eliminating false "knowledge," purging "old" knowledge, and the like. Tough challenges.²

It is this essay's hope that the short cases presented here will give some insight into those knowledge requirements commanders and their staffs have faced in the past. The first, and to some still the "Big One" of course was the Second World War.

RAF/USAAF Bombing of German Industry in WWII

Even before the shooting part of WWII started on 1 Sep 39 with the German invasion of Poland, airpower had already played a significant role. A significant reason British Prime Minister Neville Chamberlain acceded to German Chancellor Adolph Hitler's demands in the "Munich crisis" of fall 1938 was the fear of the German Air Force and the pitiful state of UK (and French) air forces. In the US this lesson did not go unheeded. In the largest defense budget ever submitted while the US was ostensibly at peace and isolationism ran strong, President Franklin Roosevelt devoted the bulk of his 1938 and 1939 submission to building the US Army Air Corps. (Overy 1980)

During World War I (WWI), airpower was at most a footnote to the trench warfare, and resulting carnage, of the Western Front. During WWII, however, airpower played a decisive role (some argue *the* decisive role) at strategic, operational, and tactical levels. Yet little in the two decades between those great wars could lead anyone to predict with any certainty what airpower could, or should, accomplish.

First of all, strategists of all stripes had more theory than experience to deal with. What was good about this state of affairs is many different ideas on the employment of airpower could be thought over, argued, written about, and touted as the answer to the overwhelming desire to avoid another costly, bloody war like the last. What was bad about this state, though, was the little opportunity to evaluate these various ideas that were at odds with each other in either real wars or controlled, honest, experimentation. The Spanish Civil War, for example, became the source of "data" used to support the claims of all sides of the airpower debate. Other "proofs" were mere showmanship, like the US Air Service's³ "bombing" of German warships that were of known location, dead in the water, and undefended.

² This does not, for course, exhaust all the theoretical (let alone technical) challenges. Differentiating meaning, intention, and understanding is crucial. This can be called the "vertical dimension" of knowledge with the data-to-understanding being the horizontal dimension. Briefly, meaning refers to the literal (e.g., lexicographical) language and comes mainly through usage. It is the "physical" message of language. Intention refers to that purpose the user wishes to achieve. It is the "message sent." It arises *a priori* of usage. Understanding comes from the receiver, not the sender, and therefore also arises from usage.

³ In a desire to be accurate but not confusing, the US air arm was part of the US Army from its founding in 1907 until 1947 when it became the US Air Force (USAF). From basically the end of World War I it was the US Army Air Service until 1926 when it became the US Army Air Corps (USAAC). It remained so until 1942 when it became the US Army Air Force (USAAF).

Secondly, during those twenty years, airpower underwent rapid technological change. From the flimsy, vulnerable, short-range craft of WWI, the next war saw the advent of aircraft that could carry immense (for those days) payloads over great distances and deliver them with (again, for those days) startling accuracy. Airpower enthusiasts seized on these emerging capabilities (many while they were still on drawing boards) to argue that airpower would allow fleets of bombers to cross relatively harmlessly over enemy ground forces and strike directly at the heart of an enemy's war-making capability. Unfortunately, the pace of change was such that one, theorists could hardly keep up, and two, many theories were built in complete ignorance of technologies being developed that would severely hamper air operations. But perhaps most importantly, these various theories were based on different notions of how airpower would effect change in the enemy's behavior.

These different philosophies of mechanism between the USAAF and RAF resulted in vastly different targeting strategies that in turn required different knowledge needs. The focus here is on the strategic bombing campaign. There were also significant disagreements over what would now be regarded as the operational campaign, especially in the months immediately leading up to OVERLORD, the Allied invasion of Northwest France on 6 June 1944.⁴ Further, there were some significant differences between air and land planners over the most effective and efficient mechanism for achieving victory over Germany.⁵ What is "mechanism" and why is it important, especially for airpower

Mechanism, along with objectives, resources, center-of-gravity, and strategy, comprises one of the key elements in the conceptual plan for the employing a force. It answers why and how the strategy chosen will achieve the objective assigned using the resources available? It is vitally important when the cause and effect is indirect. Since many hold airpower is best employed in such an indirect mode, mechanism assumes great importance for airpower strategists. It is absolutely necessary to understand the relationship between objectives (or desired end state); the strategy developed to accomplish that end state; the resources required to make the strategy work; and mechanism. The other equally significant element, center-of-gravity analysis, will not be directly addressed in this essay nor will resources be given much attention.

For example, suppose a strategist after analyzing the enemy and their own strengths and weaknesses, and given a set of resources, determines the best approach for the use of airpower is to attack the enemy's re-supply network so that the ground offensive airpower is supporting will be successful. The mechanism here is: without adequate re-supply, enemy frontline forces will be weaker thus tilting the combat power ratio between our forces and theirs in our favor thus increasing the likelihood we will be successful. As will be shown, the different view of mechanism had significant on the planning and

⁴ This became known as the "transportation plan" advocated by RAF Air Chief Marshall Sir Arthur Tedder and the "oil plan" pushed by USAAF Lt Gen Carl A. "Tooe" Spaatz. This debate is just as illuminating for knowledge base requirements as the strategic bombing case, though somewhat narrower. Supreme Allied Commander US Army General Dwight D. Eisenhower decided in favor of the Tedder plan in March 1944 though allowing Spaatz to pursue his plan as circumstances allowed. Which, of course, they did.

⁵ This dates to the desire for independence by US airmen who admired the RAF's co-equal status (at least that is how it appeared) with the Royal Navy and British Army. Basically the airmen believed airpower alone could bring Germany to its knees. Ground soldiers believed the only way to defeat any enemy is to defeat its armies in battle. The mechanism, apparently true for centuries, is that a defeated army leads to an undefended nation. Faced with this prospect, a rational leader would sue for peace.

conduct of the campaign. They also, by extension, had significant impacts on the two air forces knowledge needs.

The British believed there was no one specific strategic target set more important than any other was. Therefore the best use for airpower was to cause as high a general level of destruction as possible. This, they believed, would demoralize the German people, workers specifically, leading to a general decline in productivity, leading to a reduced level of armament output, that would limit the German forces' capability and ability to wage war.

Most of this belief came from how the RAF viewed their experiences in WWI. First, that war's air commander viewed the "moral effect" (more precisely, psychological) as much more important than the "material effect." Second, since the RAF lacked the resources to disrupt or destroy any significant part of the German war economy, and those target sets were generally well-defended, and bombing accuracy was dismal, attacking widely versus deeply preserved resources. Third, much 19th century military theory emphasized the importance of psychology in military operations. Fourth, their own national experience of German attacks against London which sparked the formation of the RAF led them to appreciate the disruptive effects of air attack on civilians in particular. Finally, airpower offered the means to spread effects broadly through and enemy state. Air Officer Commander-in-Chief of RAF Bomber Command, Sir Arthur "Bomber" Harris said his primary mission was to "make life intolerable for Germans in Germany" and his aim was "the destruction of German cities, the killing of German workers, and the disruption of civilized community life throughout Germany." (Biddle 1995, 124)

The Americans did not engage in strategic air attacks in WWI. In their studies after that war, they found the RAF attacks had no discernable affect on either the civilian population of Germany or its military forces. They also faulted the RAF for failing to systematically study the German war-making firms to see how one industry might depend on another. The second factor in the American theoretical evolution was the air arm's fight for independence from the US Army. They thus sought an independent mission to justify their call for independent command.⁶ They discovered this in strategic attack.

Like the RAF, the US Army Air Corps sought a strategy that was acceptable to the public and civilian politicians (Conrad 1993). The carnage of WWI led to calls for disarmament and outlawing war that meshed with the natural American desire for isolation from outside involvement. Strategic attack against German war industries offered a way to reduce what today is called collateral damage.

These different mechanism philosophies led naturally to different targeting objectives even though there was some intent and effort made to coordinate these two approaches. In 1940 as the RAF started bombing Germany in earnest, it initially started with daylight raids against industrial targets; especially those located in the Ruhr valley. Unfortunately due to inadequate bombers and the lack of fighter escort, those missions proved intolerably costly. In February 1942, just as the US Army Air Force (USAAF) was gearing up for its own unescorted, precision-bombing daylight operations from the UK, the RAF switched almost exclusively to attacks against urban areas of cities. The explicit

⁶ This was also the reason USAAF forces were just not combined with RAF forces in the UK like Commonwealth forces were integrated, though generally above squadron or wing level.

object was to undermine morale by rendering "the German industrial population homeless, spiritless, and in so far as possible, dead" (Biddle 1995, 117)

Thus by the end of 1942, there were two different strategic bombing operations taking place over Germany largely from organizations based in the UK. The RAF targeted enemy will directly by attacking the population, at least the urban population, directly. The USAAF, on the other hand, targeted enemy capability directly by aiming at their ability to produce war material. Was one mechanism better? At the pivotal Casablanca Conference held in January 1943, both sides argued their case.

At stake was much more than airpower targeting strategies. Fundamentally the US and UK disagreed on the basic strategy for ending the war in Europe (Overy 1980). The Americans sought a more direct route by invading the continent as early as possible. This strategy, they believed, had the added benefit of cementing the Soviets to the alliance and prevent a replay of WWI when they signed a separate peace with the Germans. The British favored a more indirect strategy of attacking Sicily and Italy first (the "soft underbelly of Europe" in Churchill's phrase) while continuing the blockade and strategic bombing of Germany. As so typical of coalition operations, the agreement was a compromise where each got what they sought. The US could continue daylight bombing operations and planning for a cross-channel invasion. The UK got a commitment to the Mediterranean strategy once North Africa was secured (which occurred in May 1943).

For the strategic bombing planners of RAF Bomber Command and USSAF Eighth Air Force, the outcome was the Combined Bomber Offensive Plan of May 1943. Six systems consisting of 76 targets were listed (Watts 1984, Appendix). Further, RAF-USSAF "combined efforts" were addressed but with this caveat: "This plan does not attempt to prescribe the *major effort* of the RAF Bomber Command. It simply recognizes the fact that when precision targets are bombed by the Eighth Air Force in daylight, the effort *should* be complemented and completed by RAF bombing attacks against the surrounding industrial area at night." (Ibid., emphasis added)

What was the actual outcome from either of these approaches is, still now, more than fifty years after the fact, very much in dispute. The one area the US Strategic Bombing Survey and British Bombing Survey Unit agreed on was the futility of "targeting civilian morale per se." (Biddle 1995, 126) On the other hand, the RAF attacks against German cities were undoubtedly destructive (Richards 1994). Furthermore, strategic bombing did cause Germany to divert substantial assets to protect their industrial sites and it did place an absolute maximum on how much war material they could produce (Overy 1995).

The most important lesson for those interested in knowledge base development is that drawing from past experiences is a potential minefield. "The wartime experience [WWI] had revealed the very steep, early portion of a marginal returns curve, so that those studying it tended to extrapolate linearly." (Biddle 1995, 98) Furthermore, as the post-WWI and post-WWII studies on the effect of airpower showed, analysts looking at the same data can arrive at fundamentally different conclusions. Closely related is the error the British made when they expected the German population to react against the bombing of cities in WWII liked their own population had done during WWI. This despite their experience with the German *Blitz* against London starting in September 1941 and continuing sporadically throughout most the war. They discounted any notion that populations might become used to air attack. Theorists of the 1920s and 1930s postulated that since air attacks ranging across the homeland meant there was no place to hide, and

since civilians were “softer” than military forces, such attacks would at best cause populations to rise up against government and demand a stop or at worst, cause the population to become lethargic.

Finally, the convergence on the desire to attack as precisely as possible led to the need for precise information on not only location, but also composition and dependencies of one target to a whole host of other entities. This requirement would be magnified many fold in another great coalition operation⁷ involving the Americans and the British—the Persian Gulf War.

Desert STORM

When Iraq invaded Kuwait in early August 1990 and annexed it as the “19th Province,” perhaps the last thing Saddam Hussein and US President George Bush imagined was that less than eight months later a coalition that included almost every country in the United Nations—including Arab—would hold together long enough to militarily expel Iraqi forces and liberate Kuwait. And while many countries did “contribute” to Iraq’s defeat, the major players militarily were a few western and Arab nations. For the airpower forces, they were almost all members of the North Atlantic Treaty Organization (NATO) with the US and UK providing the bulk of forces.⁸ A first glance, one would suspect NATO would have eliminated the issues of divergence between the USAF and RAF over the best use airpower exhibited in WWII.

It is significant that DESERT STORM was a coalition operation and not an alliance one. The main difference is that coalitions tend to be short-lived and exist only for a given situation. Alliances are formalized through international treaties and exist over long periods of time, even when the original conditions that led to the formation of the alliance no longer exist. The most significant aspect of this difference for this essay is alliances how the means and time to develop shared perspectives between its members whereas coalitions do not. For example, NATO had at least developed rudimentary common procedures over a generation of cooperation, but since this was not a NATO operation most of those procedures did not apply. Other considerations also played an important role. First, while some partners were not completely former foes, at least they were not old buddies (e.g., Egypt, Syria). Second, there were significant differences in equipment levels, capabilities and the skills between many of the partners (Atkinson 1993, 152-155).

Airpower matured immensely since WWII, but not all parts matured to the same degree. Platforms undoubtedly matured the most. British and American planners of the early 1940’s could not dream of the capabilities today’s planners take for granted. Stealth, sensors, range, accuracy (in both navigation and weapons delivery) and electronic warfare (EW) have shifted the balance between the offensive and defensive

⁷ This is not to denigrate the UK-US operations that started almost while the embers from WWII were still hot. The Berlin Airlift, Korean War and other less well known operations faced many if not all of the problems recounted here. This subject obviously is worth book-length treatment, a space luxury not affordable here.

⁸ Unlike operations in the Balkans, examined in the next section, DESERT STORM was not a NATO operation. The closest NATO came to participating was the deployment of the Allied Command Europe (ACE) Mobile Force-Air to Turkey. Some conflict arose, however, with that force and the air strikes flown by the US-only JTF PROVEN FORCE out of Turkey against northern and central Iraq. This essay’s author was the campaign planner for PROVEN FORCE.

capabilities of airpower. While Stanley Baldwin could tell the House of Commons in 1930 that the "bombers will always get through" even though there was little empirical evidence of that, today it is a truism, at least for the western air forces. Furthermore it is the combination of these capabilities that is truly impressive. F-117 *Nighthawk* aircraft could fly undetected hundreds of miles to a precise building in a major metropolitan area surrounded by an advanced air defense system, then use on-board infrared sensors to precisely guide a weapon via a laser beam down an airshaft. Could that happen every time? No. Did it happen more often than not? Yes.⁹

Weapons probably matured the second most. In DESERT STORM, precision guided munitions (PGMs) were the star of the show even though they constituted only a fraction (<5%) of all the weapons employed. While laser-guided bombs (LGBs) were the bulk of PGMs employed, AGM-65 Maverick air-to-surface anti-tank missiles, GBU-15 glide bombs, and HARMs (High Speed Anti-Radiation Missiles) were also prominently, and effectively, used. The significance of these weapons is based on the concept of "economy of force." This principle of war states that only the minimum required force should be used so as to preserve combat power for other operations. While not as efficient as "one target-one bomb," PGMs did allow a wider range of targets to be struck simultaneously with the same degree of assured damage as would otherwise be the case. This also enhances the survivability of the delivering aircraft.

Command and control (C2) probably matured the least since WWII. The technology generally kept pace though there were some key exceptions such as digital communications and computer assistance for planners. However, the operational art skills did not. Generally this is blamed on the Cold War where the almost exclusive focus on Europe and Korea had two dilatory effects. First, since operations there had been determined for so long, there was no need to plan afresh. Surely changes to plans were made over time, but they were largely incremental, not a *de novo* start as was required by the Iraqi invasion. Second, both anticipated contingencies—most especially in Europe—were tied up with the use of nuclear weapons and the superpower confrontation between the US and the Soviet Union. If one truly believed a Warsaw Pact invasion of Central Europe would become a general nuclear exchange within a few days of weeks, planners concentrated mainly on preventing that occurrence rather than winning a conventional war, though there were some dissenters (e.g., Mearsheimer 1982). Of course the major causality of the lost operational art was the failure to grow a new generation of operational-level planners who understood strategy and who could think through the mechanisms various strategy options offered.

The major difference over what mechanism would most likely achieve DESERT STORM's objectives was between the air and land component planners rather than between the various air forces. This, of course, was not new. There was a significant difference of opinion between air and land planners during WWII.¹⁰ When Iraq invaded, Commander-in-Chief US Central Command (CINCUSCENTCOM or "CINCCENT" for short) US Army General H. Norman Schwarzkopf knew he had a problem. There was no

⁹ No better proof of this, of course, is the loss of a F-117 near Belgrade during air attacks there in March 1999.

¹⁰ There are startling similarities between the USAAC planners who put together AWPD-1 against Germany, in the summer of 1941 and those who put together the INSTANT THUNDER plan in August 1990 against Iraq. Similarities the latter proudly acknowledged.

in-theater US forces. With the huge distances involved, the quickest capability he could bring to bear was airpower. Therefore, within 48 hours of the invasion, Schwarzkopf and his air commander, US Air Force Lieutenant General Charles A. Horner briefed President Bush on a rough air campaign. The strategy was classic: gain air superiority over the battlefield then attack Iraqi resupply efforts. The mechanism: by denying supply, Iraqi ground forces will be unable to sustain combat operations and will be forced to retreat or, if they do not, be vulnerable to a counter-offensive. In essence, this became the genesis of what was known as the "TAC plan."¹¹

Within 96 hours of the invasion, another plan, radically different from the TAC plan, began taking shape in the basement of the Pentagon under the direction of US Air Force Colonel John A. Warden, III. The essence of this plan was to attack the Iraqi centers-of-gravity (COGs)¹² that would have the most immediate impact on Iraqi leadership. His mechanism was as straightforward as Horner's was: with his COGs destroyed, an enemy would be forced to give up—or lose power—because they would no longer have the capacity to continue (Reynolds 1995). Much of the confusion, and mythology, over "Warden's plan versus the TAC plan" arises from the misunderstanding of the original purposes of those two competing plans. The TAC plan was to stop Iraqi forces if they continued into Saudi Arabia.¹³ The Warden plan, known subsequently as INSTANT THUNDER was a retaliation plan in Schwarzkopf's mind, at least initially (Gordon and Trainor 1995, 76; Schwarzkopf 1992, 313).

No clearer image arises of this essay's thesis on the importance of shared perspective, particularly in coalition operations, than the different perspectives over the land campaign both between the US Army and US Marine Corps, and between the US and its Arab coalition partners. The commander of US Marine forces in theater sought a frontal attack into Kuwait than even the Marine Commandant found ill advised. US Army planners, on the other hand, eventually settled for the famous "Left Hook" that sought to avoid direct battle until all odds were in the coalition favor. Finally, Syria became reluctant to commit its army to the land offensive forcing CENTCOM planners to place them in a reserve role. This in turn led to some backsliding on the part of the Egyptian forces again forcing planners to alter the concept so the Egyptians could attack 24 hours after the initial wave (Schwarzkopf 1992).¹⁴

¹¹ TAC was the US Air Force's Tactical Air Command. The term "TAC plan" is often used derisively by those who felt it was too subservient to land power and failed to exploit the full range of airpower's ability.

¹² Defined by the US DOD Dictionary as "those characteristics, capabilities, or localities from which a military force derives its freedom of action, physical strength or will to fight." Note the term "military force." The great Prussian theorist, Carl von Clausewitz used a more expansive phrase to include all of the enemy state, not just its military forces. Again this highlights the different perspectives: does one wage war against the enemy nation-state or only against its military forces? The Warden plan was premised on the former; the TAC plan on the latter.

¹³ Another continuing source of confusion between the "TAC plan" and "Warden plan" is timing. The first "TAC plan" as used in this essay comes from General Horner within hours of Iraq's invasion. The others start, at TAC headquarters located at Langley AFB, VA then eventually in Saudi Arabia, as alternatives to some perceived shortcomings in Warden's plan as originally proposed 9 Aug 90.

¹⁴ In another case, the US Marines were forced to change their attack plan to accommodate Saudi commanders. When asked why he vetoed the Marine's plan, Saudi Prince Khalid responded simply "Pride." (Gordon and Trainor 1995, 170-172)

These differing perspectives, especially over mechanism, played out specifically when it came to targeting. The first disagreement occurred when Warden briefed Schwarzkopf on the INSTANT THUNDER plan on 17 Aug 90 though it had been presaged when Warden briefed the Chairman of the US Joint Chiefs of Staff, US Army General Colin Powell, on 11 August. The first question, which also was raised by TAC planners, was if Iraqi ground forces moved against Saudi Arabia from their positions in Kuwait? Warden's initial plan dealt only with strategic targets and operationally, only with Iraqi air defenses. The second question, and the one raised specifically by Powell, was whether even if Hussein acceded to demands due to the Warden's plan (in other words, accepting as given the unstated mechanism of INSTANT THUNDER), would not leaving his (assumed quite powerful) ground forces intact just leave a further mess it deal with sometime later?

At root, this was the fault line. And there were several dimensions to the debate. The one detailed here deals with how the context of the situation shaped the perspectives of the various sides and how, in turn, this precluded the emergence of a shared perspective despite commonality of language and concept. Not too simply put, the Warden plan from concept to targeting was concerned with the best application of airpower while the TAC plan from concept to targeting was concerned with the best manner of accomplishing their mission. In the later light it seems clear that despite two one-to-one presentations of the Warden plan between himself and Schwarzkopf within an eight day period, both men saw INSTANT THUNDER from completely different points-of-view (Gordon and Trainor 1995, 90). For Warden, it was an integrated war-winning plan. For the CINC, it was a "Chinese menu" of retaliatory strike options.¹⁵

This divergence of perspective increases as the planning shifted from the Pentagon and USCENTCOM's Florida headquarters to Saudi Arabia. As the Warden plan and TAC plan get merged, the major source of divergence occurs between the land component planners and the air component planners. Again the basic first principle disagreement lies with mechanism. Reflecting traditional ground forces' perspective, land component planners viewed the destruction of Iraqi ground forces as the means to victory: a defeated army meant an undefended nation that would cause Iraqi leadership to accede to the coalition demands. This belief, then, led those planners to seek the best use of airpower to support ground power in their quest of defeating the Iraqi forces. Air planners, on the other hand, believed that by attacking a broad set of Iraqi COGs, that the Iraqi leadership would be paralyzed (Hallion 1992, 151).

Like every other military operation, DESERT STORM offers up no clear, crisp evidence upon which one can base any conclusive argument over which position was right. However, on balance post-war official reports lend more credence to the air planner's view than the ground planner's view (US Department of Defense 1992; US Air Force 1993). Not that "airpower could win all by itself" but rather that a successful air

¹⁵ Compare, for instance, the account in Reynolds (1995, 103-110) with that in Schwarzkopf (1992, 318-321) of the 17 Aug 90 Warden brief to CINCCENT and his staff. Even more telling is this in Reynolds describing Warden's presentation of INSTANT THUNDER to General Horner in Riyadh, Saudi Arabia: "It was curious that these two men [Warden and Horner] were so far apart intellectually and emotionally. Both wore flight suits, both were fighter pilots, and both had done combat tours in Vietnam.... Yet, they seemed to have no common lineage—nothing upon which to build mutual trust or confidence." (1995, 122)

campaign is a necessary condition for any successful land (or naval) campaign.¹⁶ Of course this lesson is a repeat of ones learned as long ago as World War II and validated in every major military conflict since. What the Gulf War did not resolve, however, is what *type* of air campaign is most effective. Since neither the Warden plan nor the TAC plan was executed in their pure form, it is an unanswerable question. And given the axiom that "every war is unique," any purported answer would be meaningless anyway. What are of some use, however, are the lessons one might take away on the processes, especially in planning.

Clearly the singular achievement of planning in DESERT STORM was the attempt to centralize all planning into a few responsible organizations. The JFACC (US Air Force Lieutenant General Chuck Horner) generally gets the most attention but early on the CINC (US Army General H. Norman Schwarzkopf) attempted the same trick for the ground campaign. The second achievement was planning that came "top down" in that attacks were planned against targets because of the effect the commander desired, not simply because it was "there." One wishes to exercise caution here. This is not to say that previous campaigns did not attempt this linkage. Rather it was due to the integration of the campaign—both organizationally and intellectually—that facilitated the linkage. Finally, notwithstanding the following remarks, coalition issues were in the forefront of strategic and operational level planners from the very beginning. Furthermore, the JFACC concept proved adept at incorporating coalition considerations. Despite their focus on Joint operations, Winnefeld and Johnson (1993) acknowledged that in DESERT STORM allied forces "represented one more layer of complexity; JFACC tried to broker national and service interests and develop [an air campaign] that fulfilled both his responsibilities and those external requirements." (122)

Examples of bad planning, unfortunately, are numerous and easy to find. Fortunately, they generally occurred before 17 Jan 91, and not after. The most significant was the plethora of small, independent, and unconnected "special planning groups." The US Secretary of Defense had one (the "Western Excursion"). The Chairman of the US Joint Chiefs of Staff had one. The CINC had one, possible two. The JFACC had one (the "Black Hole") until December 1990. While all were well intentioned, one can easily see the potential for mass confusion had Iraqi forces attacked during the November-December "second deployment." None worked together and most did not include coalition members to any great extent (e.g., Atkinson 1993, 108). In fact, General Horner explicitly decided that until the plan was fairly robust, no coalition planners would be involved (Reynolds 1995, 127). This was important. When coalition partners were brought onto the planning teams, it was clear they had meaningful differences with the Americans, especially over Iraqi intentions (Gordon and Trainor 1995, 74).

In the last case examined here, coalition operations in Bosnia, this problem of multiple, non-connected planning efforts was absent. Why this was so, however, is not clear. For one thing, the time from the Iraqi invasion to the time the overall theater

¹⁶ This largely sterile debate, played again during the air campaign against Serbia that commenced in March 1999, largely reflects more bureaucratic in-fighting than reality. No instrument of military power, nor any national instrument of power for that matter, can be so finely parsed as to say it is operating "by itself." As if "infantry" could be the decisive element of ground power absent artillery or (in modern armies) armor or attack helicopters. This even without considering the criticality of combat service support elements like engineers, supply and transportation forces, and the like.

campaign plan was done to almost executable detail was very short, less than three months. In Bosnia, planners worked up an evolutionary set of plans over three years.

Bosnia

In July 1992, NATO deployed naval forces to the Adriatic to monitor shipping to the former Yugoslavian republics.¹⁷ The United Nations had imposed an embargo the fall before and placed peacekeepers in Croatia the previous spring. Those "Blue Berets" moved into Bosnia-Herzegovina that September and NATO air patrols, sent to enforce a UN resolution banning all flights not approved by the UN peacekeeping forces, started on 16 October 1992. This operation, DENY FLIGHT, started the sequence of events that led in August 1995 to DELIBERATE FORCE, the direct military action against Bosnian Serb forces designed to force them to the negotiation table. In this it was successful.¹⁸ This series of operations resulted in many "firsts" for NATO. It was the first real military campaign it ever waged in its 40+ years of existence. It was the first "out-of-area" operation. This means military operations conducted against an adversary that did not directly threaten a member. It should be recalled that during the Gulf War, NATO took no offensive action, and defensive preparations of questionable value, even though the enemy state was right on the border of a member state (Turkey). Finally, the Balkans operations were considered "operations-other-than-war" (OOTW). These missions include operations such as humanitarian relief, peacekeeping, peace enforcement and peace making. They were never part of NATO's original intent.

The key point of this section is to examine the difficulty of assessing context in these areas. Since context is such a critical part of constructing a knowledge base, understanding where these pitfalls lie becomes of utmost importance.

These OOTW missions cover a wide range of activities that previously went by such names as guerilla warfare, foreign internal defense, counter-insurgency, nation-building and so forth.¹⁹ Modern usage can be misleading. Generally these missions are listed as humanitarian relief, peacekeeping, peace enforcement, and peace making. Only the last three concern us here.²⁰ The first point to be made is they are not along some "continuum." Second, peacekeeping requires strict neutrality between the peacekeeping force and the various sides to the conflict. Third, ostensibly there is no fighting for a peacekeeping force whereas peacemakers or enforcers at least must anticipate fighting if not, as in Bosnia, actually starting military operations.

¹⁷ This account draws heavily from the Balkans Air Campaign Study conducted and published (Owen forthcoming) under the auspices of the US Air Force's Air University. This essay's author was part of that research team. While conducted under the principles of academic freedom, it should in no way be considered the definitive work on the subject. On the other hand, one awaits eagerly for the "definitive" work on the US Civil War.

¹⁸ One danger of writing history is the intrusion of current events. As this was being written (March 1999), NATO launched airstrikes against Serbia in response to atrocities they are perpetrating in Kosovo. Supporters of these strikes routinely use the success of the Bosnia air campaign to bolster their claim that similar attacks will work in Kosovo.

¹⁹ Two worthwhile sources on OOTW and its political and military ramifications in the context of the post-Cold War era are Snow (1993a and 1993b).

²⁰ These are illustrative, not definitive categories. See Boutros-Ghali (1992) and the US Joint Warfighting Center (1995) sources for definitive organizational perspectives.

Historically, militaries viewed these quasi-constabulary missions with some disdain. While there is a whole host of differences, four major considerations shape the armed forces' view of these missions. First, these missions are not so clear-cut as "normal" military missions. Nowhere is that most evident than in the lack of a clearly discernable "end state": that state, or set of conditions, the military commander seeks to achieve so that other instruments of national power (normally political-diplomatic) can take over. Second, given the "glue" of the Cold War that seemed to keep many regional conflicts in check (or at least the major power's response to those conflicts), these missions can occur almost anywhere: humanitarian relief in the Caucasus and central Africa, peace-enforcement and peace-making in the Balkans, show-of-force in the Taiwanese Strait. Tied closely with this, the third major change is the uncertainty of partners in any given operation. Further, these partners include significant numbers of "non-military" organizations such as the International Red Cross, religious relief agencies, and others. Finally, due to the political sensitivities of these missions, the rules-of-engagement (ROE) tend to be extensive and quite restrictive. This, in turn, leads to a shift in the traditional balance of "centralized command-decentralized execution" to more centralization of both.

This inversion of traditional military norms is mirrored in the changes between the national instruments of power as to their application and perceived effectiveness. In conventional conflicts, military force is normally seen as a blunt instrument whereas the political instrument is seen as the more discriminating. However, with the advent of precision weapons and delivery systems, military forces are seen as highly discriminatory. A good example of this was the planned use of airpower to protect individual "safe areas" around towns and villages in Bosnia. On the other hand, two examples highlight the use (or threat) of military operations by diplomats as blunt means to force Bosnian Serb compliance.

Before DELIBERATE FORCE commenced, US Assistant Secretary of State Richard Holbrooke, also the lead negotiator, went on a US news program and "threatened a six-to-twelve month campaign of air strikes against the Bosnian Serbs to level the playing field" and force the Serbs to the negotiation table (Mueller 1998, sec. 1-13). Unfortunately, Holbrooke's objective was never one that NATO had agreed to. In fact, protecting the safe areas remained the overt goal of DELIBERATE FORCE. Further, unstated but essential political objectives is not unique to OOTW. Yet, the presence of these, when held by only some members of a coalition, greatly complicates military operations. As will be shown below, this became an important matter during execution of the air campaign.

The second instance occurred during the air operation itself. During planning, a deliberate pause was built in so that the Bosnian Serbs could assess for themselves the damage to their forces and supporting infrastructure. Yugoslavian President Slobodan Milosevic hoped the pause would make it more difficult politically for NATO to resume bombing. However, when the attacks resumed on 5 September, at the insistence of the diplomats, Milosevic's last hopes were dashed and soon after he agreed to terms. "Mr. [Christopher] Hill [Holbrooke's assistant in the negotiations] did not need up-to-the-minute bomb damage assessments to tell him the effectiveness of the air campaign; he could see the impact on President Milosevic's face." (McLaughlin 1998, sec. 7-2) However, just as important as the air strikes were the Croatian land offensive (Operation

STORM) that started on 3 August 1995—weeks before the air campaign—perhaps was just as decisive. What this points up is the blurred strategic-operational-tactical environment so typical of OOTW.

Other examples of this blurring is determining who is the “good guy” and who is the “bad guy”; and who is in charge (and when). Too often the issue was starkly put as “the Serbs are the bad guys and the Muslims are the good guys” but the reality was more muddled. For example, the proximate cause of the fighting in Bosnia can be traced to the March 1992 vote by Bosnian Muslims (44% of the 1991 population in Bosnia) and Bosnian Croats (18%) to succeed from Yugoslavia. This struck fear in the Bosnian Serbs (31% of the population) who feared they would be persecuted as their brethren had been in Croatia when it left the federation (along with Slovenia) in the summer of 1991.

The issue of “who’s in charge” though is of more immediate import to this essay since that will have great influence on what objectives will be pursued in what manner and when, which drives knowledge requirements of targeting and the like. For most of the DENY FLIGHT/DELIBERATE FORCE operation the answer was two: the UN and NATO. This was formalized in the “dual key” arrangement. Basically this meant that both organizations had to approve the use of force. Practically, it meant force could hardly be used in a reactive manner since approval times could stretch for hours, hardly useful when friendly forces requested immediate assistance. Fundamental to this arrangement was the different perspective and philosophies exhibited by the UN and NATO.

The first point to emphasize is this disagreement did not arise due to the differing outlook of diplomats versus military commanders. On the contrary, French Lieutenant General Bernard Janvier, the UN Protection Force (UNPROFOR) commander had led French ground forces in DESERT STORM. His deputy, British Lieutenant General Rupert Smith had also been a division commander in that war. Interestingly enough, it was on the NATO side where one finds little recent experience in major military operations from the Supreme Allied Commander Europe US Army General George Joulwan down until one reaches US Air Force Major General Hal Hornburg, the Director of the Combined Air Operations Center (CAOC) at Vicenza, Italy. Secondly, as has already been alluded to, there was a significant difference between the military commanders and the diplomats. This prompted Ambassador Holbrooke to remark, “the same people who had doubts about it [the bombing campaign] ran it so brilliantly.” (McLaughlin 1998, sec. 7-2)

Janvier agreed Bosnian Serb forces needed to be attacked but he wanted a close reign so they would feel “pain but not death.” As the person in charge of the peacekeeping forces on the ground in Bosnia, and who faced the humiliating task of freeing those of his forces who had been taken hostage by the Bosnian Serbs, one can see his perspective. (Conversino 1998, sec. 5-2) US Navy Admiral Leighton W. “Snuffy” Smith, Commander-in-Chief of Allied Forces Southern Europe (CINCAFSOUTH) wanted to attack logistics and command and control (C2) facilities. As pointed out, the NATO objective was protection of the safe areas. Admiral Smith believed the heavy weapons posed the greatest threat to those areas but were exceedingly difficult to find let alone attack. Hence he felt attacking the supply and C2 nets offered the best strategy. There is a key point here. Janvier’s mission was one of peacekeeping whereas Admiral Smith’s was one of peace enforcement. NATO air planners, though, encouraged senior leadership, and

especially in the UN, to take a more expansive view of the air campaign. They believed a more 'strategic' orientation would more quickly cause all levels of Serbian leadership (both within Bosnia and in Belgrade) to acquiesce to UN and NATO demands. In other words, they argued for a broader peace-making role. Finally, air planners insisted on a comprehensive suppression of air defense (SEAD) operation in order to minimize threats to allied aircraft and expand the area for freedom of air maneuver.

Thus four sets of mechanisms can be identified, not all complementary. First was UNPROFOR. Janvier wanted to protect the safe areas and his forces on the ground in the same way: minimal force applied under maximum control. CINCAFSOUTH too wanted to protect the safe areas but also to reduce the combat power of the Bosnian Serb Army (BSA) so they would be less a threat in the future. Hence his mechanism followed that of classic interdiction: reduce the effectiveness of military forces indirectly by reducing their supplies and the ability of commanders to orchestrate their forces over large areas. The wider view of the campaign (reflected in so-called "zones of action"; ZOA) essentially viewed all of Bosnia as two "safe areas," one in the southeast and one in the northeast. According to Chris Campbell (1998), the acceptance of this by the UN in July 1995 was "a significant step in the direction of a strategic air campaign" because the "UN finally understood that activities occurring outside the safe areas ... had a significant impact on more than one safe area..." (sec. 4-9) Finally, the SEAD options sought two complementary mechanisms. One, the increased freedom of operations would make follow-on air strikes not only less dangerous but also more unpredictable. Two, the belief was the BSA air defense structure formed a significant part of their combat power. In summary, the Janvier mechanism could complement the CINCAFSOUTH mechanism but was at odds with the ZOA and SEAD mechanisms. Either the ZOA or SEAD ones could complement Admiral Smith's mechanism while air planners believed those two highly complementary. How successful was DENY FLIGHT or DELIBERATE FORCE?

The air policing operation was doomed from the start by three constraints. First, the decision was made quite early to exclude helicopter flights from the ban. One reason was they are terribly unpredictable as to origin and destination. Another was the short duration of most of those flights. Third was the detection difficulty, especially in such mountainous terrain. But perhaps most damaging was the fear if NATO shot one down, "its owners would rapidly fabricate evidence that it had been on a humanitarian mission loaded with noncombatants, potentially causing a public relations disaster for NATO." (Mueller 1998, sec. 1-9) The next constraint was the severe limitation placed on the use of NATO force. "Denying" aircraft flights is a negative aim that does little to prevent BSA forces from over running safe areas with ground forces. NATO recognized this very early, authorizing planning for the offensive use of airpower as early as August 1993. But events in May 1995 showed how difficult these operations were. In response to BSA shelling of Sarajevo, the UN requested retaliatory air strikes that were duly carried out. These proved counterproductive when, as they had in similar occasions before, the BSA took 370 UN peacekeepers hostage and used them as "human shields" around suspected NATO targets (and on TV screens worldwide). NATO and the UN had no choice but to cease those attacks. The final constraint was the "dual key" arrangement outlined earlier. As a practical matter it gave the UN an absolute veto over NATO operations. That proved crucial in DELIBERATE FORCE.

The offensive air operations that commenced in the early hours of 30 Aug 95 are seen by many as an overwhelming success. And in broad outline they were. The goals were to get the Bosnian Serbs and their Yugoslavian allies to the negotiation table, to secure the safe areas from further BSA incursions, and to further reduce BSA combat power so as to "level the playing field" vis a vis the Bosnian Muslims. It is in some of the nuances that assessment gets more problematic. First, the UN directed what was to be a 24-hour pause in operations.²¹ This was contentious among the key players. Ambassador Holbrooke, Admiral Smith, and General Janvier all initially supported the pause. NATO Secretary General Willy Claes, General Joulwan and air planners who saw the pause as a throwback to the "on-again, off-again bad old days" of Vietnam, opposed giving up any initiative.

The other issue always under the immediate surface was the "Americanization" of the Bosnia operation. As Owen (1998b) points out, arguably this underlay the "dual key" arrangement. If this arrangement was needed so as to prevent an "irresponsible or ill-advised" attack, who would mount such a thing? The UN? No, their forces were lightly armed peacekeepers. NATO? Not if all (then) sixteen nations had to agree. No, the fear was the American "cowboys" would use the cloak of NATO to pursue their own aims and who, to European eyes at least, seemed too willing to draw blood. This became a greater concern when the NATO uniformed command structure was seen as "pure US" from SACEUR General Joulwan down to the wing commander at Aviano Air Base, Italy and the USS Theodore Roosevelt aircraft carrier in the Adriatic. The bulk of air attacks would be launched from these two locations. By contrast, the UN side was all "non-US" from the Secretary General down to the UNPROFOR commander and his deputy. From this starting point, three lessons seem clear.

The first lesson deals with the Bosnian air operation as a coalition event. Here the record is mixed. At the theater and above level, it was clearly a coalition operation. Claes, Joulwan, both Smiths, Janvier and others worked closely and constantly together and, despite their differing organizational perspectives, forged an effective and workable shared perspective. Unfortunately, at the operational planning level, things were seen differently. US Air Force Colonel Douglas Richardson, Hornburg's deputy for current operations, believed the operation resulted in closer NATO ties between the eight NATO countries that flew. The CAOC was nominally under the command of Italian Air Force General Andrea Fornasiero but he apparently recognized the dominant role played by the Americans. Further, other non-US NATO officers saw DELIBERATE FORCE as a US-run operation with just a veneer of participation by others so it could be portrayed as a NATO operation (Conversino 1998).

The second lesson is that technology dictated the role countries could play at both the operational and tactical levels. At the tactical level two considerations drove the choice of weapons and platforms: the desire to limit collateral damage and national restrictions. The first consideration mandated the use of precision-guided munitions (PGMs) to a maximum amount possible. However, neither the Dutch nor the Italian aircraft that participated possessed PGM capability. The second consideration also limited the planner's use of certain platforms. Both the German and Turkish governments proscribed

²¹ Due to weather and other unforeseen events, the pause actually lasted 1-5 Sep 95. There was an additional pause that started on 14 Sep. Soon after, the Bosnian Serbs agreed to terms.

what missions their aircraft could participate in regardless of the capabilities of either their aircraft or their aircrews. The upshot of all this is the Americans ended up flying two-thirds of all the sorties and dropped over 85% of all PGMs. At the operational level, interoperability was the main consideration. NATO command centers were never known as state-of-the-art facilities and this was even truer of the CAOC in Vicenza. Hence as operations heated up, almost all the command, control, communications, computer, intelligence, surveillance, and reconnaissance (C4ISR) capability came from the US. Further, NATO planners, schooled in ways of countering a massive Warsaw Pact invasion of NATO's Central Front, were ill-prepared to plan, conduct and assess OOTW mission conducted out-of-area in the Southern Region. Thus many US individuals and organizations such as the 32nd Air Operations Group, Checkmate, and even Colonel Dave Deptula of DESERT STORM "Black Hole" fame were sent to assist. That these were "US only" efforts only added to the perception that Bosnia was mainly an American operation. Furthermore, since these individuals and teams came and went, plus the fact that most of the US folks in the CAOC were there for short tours of duty, mitigated much sense of unit cohesion.

Major Mark C. McLaughlin wrote: "Although the CAOC BDA [battle damage assessment] team knew the location of each DMPI [desired mean point of impact; where the bomb's supposed to hit], or aim point, and could determine the physical damage to the targets, it was difficult to link the apparent physical damage to functional damage and to the theater objective of compelling the Bosnian Serbs to withdraw equipment from the TEZ [total exclusion zone]." (McLaughlin 1998b, sec. 6-4) This third lesson gets re-learned time and again: there is scarce any way to connect what damage has (or has not) been done to a physical entity and whether or not the theater commander's objective has been accomplished. This, in the past and evident here in both the strategic bombing of Germany in WWII and DESERT STORM, has caused planners to apply overwhelming force against lots of targets in the belief that something will ultimately give. However as Bosnia shows, in OOTW that "massive force" mechanism is seldom an option. Bosnia also showed that NATO BDA doctrine, like US BDA doctrine and NATO campaign planning doctrine, was non-existent. Absent any such concepts, it is little wonder at the lack of technology available to assist in any of these endeavors whether in a US-only let alone a coalition environment.

What Have We Learned

There seem some discernable trends through these case studies in terms of coalition coupling, partner hierarchy, and doctrinal interoperability. The first area looks at coupling of organizational infrastructure interfaces along a spectrum from cooperation, through coordination, then synchronization, and finally integration (Kirin 1996). The UK-US experience in WWII was largely cooperative and with some effort (and much lip service) to coordination. They did not even have a common command center. In DESERT STORM, largely due to the shared NATO experience of the major players, air efforts were fully synchronized and arguably integrated *in the execution stage only*. The few "outliers" were the difference of opinion between the US Air Force and US Marines, the political limitations faced by the Royal Canadian Air Force, and the presence of many (albeit small) coalition forces which were, if not former enemies, and least former adversaries. DENY FLIGHT/DELIBERATE FORCE, on the other hand, were fully

integrated operations with some caveat on what is meant by integration. The main cause of this was that these operations were specific NATO operations (the first, it must be recalled, to be real “shooting” events plus the first ever voyage into so-called “out-of-area” operations). The caveat is the political restrictions on operations. For some outside observers, this might have seemed intrusive and an undue interference with “military” operations. On the contrary, the very history of the alliance pointed the way for such reservations. It was just that Bosnia proved the first real test that made the ever-present reality more visible.

Partner hierarchy and doctrine interoperability is closely tied. In 1942, the UK was clearly the senior partner in the alliance initially. Just as clearly, before WWII there were very limited cases where air forces actually trained or coordinated doctrine. Worsening this of course was the fact that the RAF had been flying combat missions for over two years; had initially pursued then abandoned daylight attacks against German industry; before the Americans arrived. In the Gulf War and again in the Balkans, the shared NATO experience, even as weak as it was, gave the partners what Sir Michael Howard calls “a standard to deviate from.” Likewise, while there is little doubt the US dominated the planning (and provided the bulk of the air forces) for DESERT STORM and DENY FLIGHT/DELIBERATE FORCE, the nature of the operations, especially Bosnia, mitigated the American’s ability to have things totally their way.

These trends so briefly noted have several implications for knowledge bases (KB). Most obvious is that integrated operations require integrated KB. The challenge here is the fundamental challenge of coalition operations: How can one build a KB *prompter hoc* without knowing who the playing partners are, where (and when) the missions might take place, and what sort of missions might be required (and why)? Second, the senior partner will tend to be the “owner” of the KB especially if they have been engaged in operations before the other partners come on board. This was not just true in WWII, it was also true when JOINT ENDEAVOR, a peacekeeping endeavor, replaced earlier operations in Bosnia. The Russians, and others, joined an on-going operation. Unless one envisions a “one-world” KB, this might prove the most difficult problem. Finally, the doctrinal interoperability is most likely among formally aligned partners and, if the NATO experience is any guide, even then it is a thin veneer. As pointed out, context is crucial and is a major discriminator between what this author’s image of a KB is versus a “souped up” (e.g., faster, smarter retrieval means, etc.) relational database. Lest this sound too pessimistic, let the essay close with some thoughts on what might be accomplished that would add real value to military operations.

Where Do We Need to Go?

There are some key facts one must keep in the forefront when contemplating building or using knowledge bases for military operations within a coalition environment:

- Warfare is more art than science.
- Art is more intra-cultural than inter-culture, even more so than language.
- Culture is context-specific.
- History is the entire context we have about the past. In individual terms, history means experience, the source of expertise.
- Context is more science than art but human perspective of context is more art than science.

- Finally, airpower is more science than art especially compared to land power.

Therefore, any KB problem must seek to answer how context can be included along with the data-turned-information that marks the current state-of-the-art of relational database systems. However, that is not the only problem a KB developer faces. Two others are multi-level security (MLS) concerns and interoperability. Of course, these are development problems not necessarily research ones but some appreciation of these is necessary in order to tackle the real problem of KB: capturing different perspectives of the same context.

In one sense MLS is the easiest problem to solve. Basically it is a policy issue. Unfortunately, once the policy issued is one requiring discrimination of access to certain knowledge or certain knowledge at specified times, it becomes a technology issue. The first barrier to overcome with interoperability is understanding that it need not mean "same" or "Buy American." Otherwise, the commonplace wisdom is that commercial markets will sort out the standards issue so that machines can interoperate together. From one sense this is quite right. Electronic commerce, to become the "wave of the future" so many predict, does require disparate machines to work together. Furthermore, e-commerce also requires levels of encryption some believe more than exceeds military forces' requirements for MLS. Undoubtedly that is true for almost all applications (nuclear, chemical and biological weapons come to mind as exceptions) which only highlights the basic policy nature of the MLS issue.

Which brings us to the tough question for knowledge developers: can the different perspectives which shape knowledge for various groupings be captured in such a way that a shared, though not common, perspective can be shown? For sure efforts to code primitive terms into machine-readable language and grammar are important first steps. But as this brief run through past operations seems to demonstrate, that necessary condition is not nearly sufficient to be called a shared representation.

The classic story over how different context lead to different perspectives despite common language is when three people from different military services are told to "secure that building." The marine implants mines and machine gun nests with interlocking fields of fire and sternly reports "Sir, the building is secured." The soldier checks every door to make sure its locked and turns on the alarm systems and dutifully reports "Sir, the building is secured." The airmen takes out a 30 year lease at favorable terms with an option to buy and proudly reports "Sir, the building is secured." George Bernard Shaw would understand.

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COALITION/JOINT PLANNING AIDS

The Latest Developments



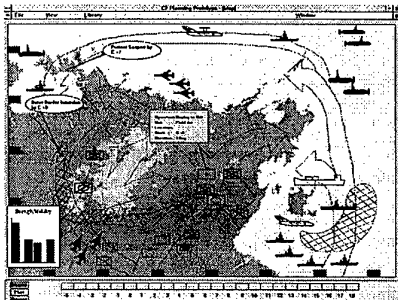
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DERA

Coalition/Joint Planning Aids: Vision

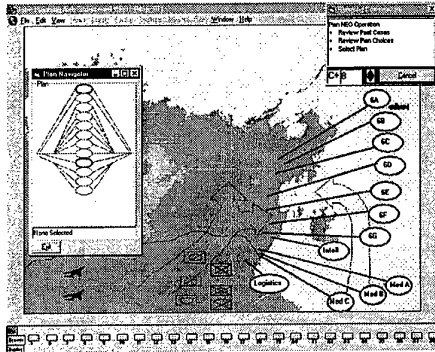
- Examine how planning aids can support J5 cell in coordinating and integrating coalition/joint operations planning tasks
- Capitalise on planning languages for capturing coalition/joint military doctrine and for recording planning decisions and lessons learned
- Explore the integration of planning aids with operational C2 systems & develop insertion strategy into future UK/Coalition C2 systems



... above all, support coalition operations planners in developing more accurate, consistent, timely, robust COAs, plan guidance & command directives for lower echelons

DERA

Key Issues: Coalition Planning



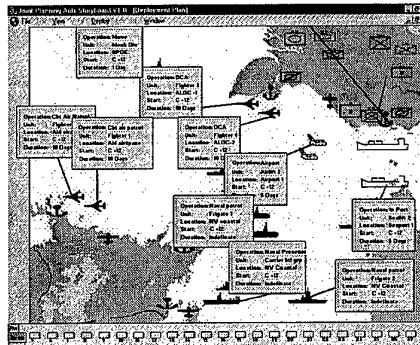
- Shared representations of coalition capabilities/resources
- Coping with multiple cultures, languages, doctrine, ROEs
- Interoperability of comms and information systems (CIS)
- Co-ordination of coalition planning process
- Validation of coalition plans
- Security restrictions

Generate and validate coalition plans reflecting roles, tasks, resources of coalition partners in achieving overall mission/campaign objectives

DERA

Key Capabilities: Planning Aids

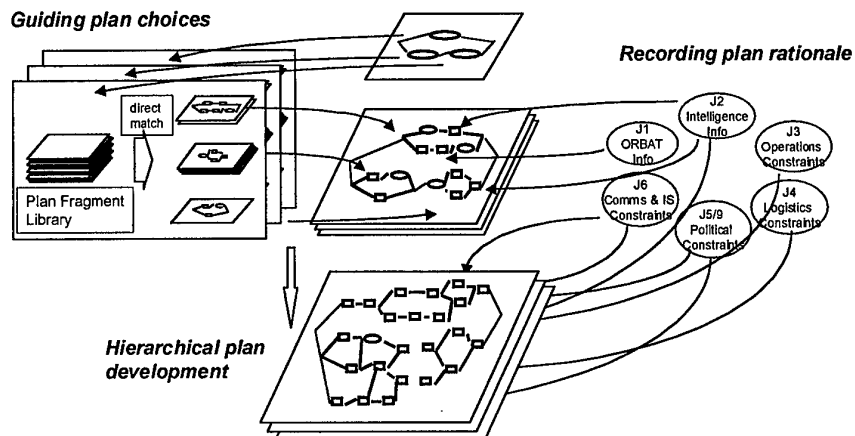
- Recording coalition planning decisions & intentions
- Determining feasible COAs, coalition and support forces
- Resolving resource conflicts & plan inconsistencies
- Browsing current & past COAs in multiple contexts
- Highlighting uncertainty & plan robustness measures



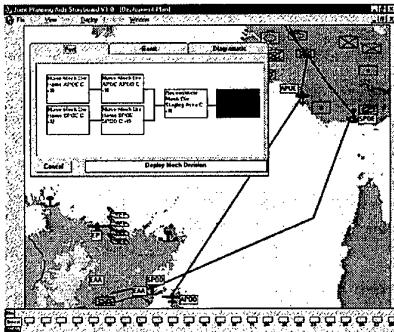
Provide collaborative and dynamic replanning capability

DERA

Supporting COA generation



Status of Planning Aids Research



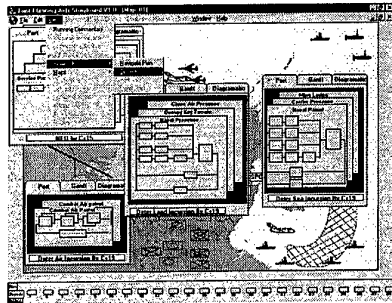
- Partial implementation of underlying planning technology
- Partial knowledge-base of joint planning doctrine & procedures
- Reassessing where aids can best support planning process
- Exploring integration of planning technology within C2 systems
- Planning for tests and trials on operational scenarios

.... validating the operational benefits derived from incorporating planning aids technology into the coalition/joint planning process

DERA

Conclusions

- Promising results in using the planning technology to record decisions, correlate them with situation data & check overall plan consistency
- Explicit planning languages provide excellent foundation for more distributed & collaborative planning process with complete audit trail
- Planning technology would provide a value-added information layer on top of operational C2 systems, not a replacement for them



... Military planners need more computational support to help coordinate and integrate joint planning tasks, especially for more diverse, high tempo and rapidly changing situations

DERA

Coalition Information Operations

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Introduction

The information environment of today is becoming increasingly complex and developments in information technology are revolutionizing how nations and their militaries, organizations, and people interact. The merging of civilian and military information networks, databases, and technologies put vast amounts of information at the user's fingertips. The advanced information systems and capabilities may enable the military to achieve an operational advantage while denying those capabilities to the adversary—referred to by the military as information dominance. Achieving a knowledge advantage requires a highly developed sense of information requirements and an ability to manage the collection, processing, use, and dissemination of that information to the right place, at the right time, for the right purpose. The military information environment consists of both friendly and adversarial military and non-military elements. It also includes organizations that support, enable, or significantly influence a military operation.

Taking advantage of the power of information and information technology and integrating all aspects of information to achieve the full potential for enhancing military operations is referred to as *Information Operations* (IO). The employment of IO in peace operations is different than war. Peace operations need to accommodate a different (and more restrictive) set of constraints than those that apply to wartime operations. There are operational, legal, and political constraints that control, shape, and influence how the military, civil, political and faction actors behave and employ the tools of IO to achieve their (often competing) objectives. The political will of the UN, NATO, the United States, and other nations to win the hearts and minds of potential adversaries is also a critical factor. The will of NATO and the nations has been challenged by the Bosnia crisis. Adapting the go-to-war capabilities of the military to accommodate the needs of a coalition peacekeeping information operation is a challenge as well. These were significant challenges for NATO and the nations that participated in *Operation Joint Endeavor* and now *Joint Guard*.

Coalition planning is difficult under the best of circumstances but for real-world operations where forces will be put in harms way and nationally driven political agendas influence national objectives in support of the coalition, it becomes even more complicated. The political "will" to share information is a significant issue and the personalities of the key players can make or break the effectiveness of a coalition operation. There are also doctrinal, cultural, and language factors that come into play. Knowledge of and shared understanding of the situation become factors as well. Finally, not all players come to the table with a common set of experiences and capabilities. A challenge for the future is to create a non-threatening environment where sharing can be achieved as part of the planning process. Education and training programs can also be employed to better prepare the leadership and staff to operate in a multi-national environment, especially in situations where one's parent nation may not be in charge of the coalition force.

An attempt has been made herein to pull together the story of *coalition information operations* in Bosnia with particular emphasis on the Implementation Force (IFOR) experience. Establishment of the IFOR Information Campaign is used to illustrate some of

the problems associated with coalition planning where the players had limited experience and there was no agreed doctrine. The story is based on the insights derived from the author's visits to Bosnia, interviews with those who have been there and those who have supported them, and lessons learned reports emerging from the IFOR and early phases of the Stabilization Force (SFOR) operations.

Background

Complex emergencies incorporate aspects of war and OOTW. Conditions of combat indeed occur during most peace operations. But when they occur, they take place in a political and operational environment quite different from that of most operations of the past. There is no "enemy," except starvation, waves of refugees, economic degradation, or the conflict itself that peacekeepers have come to stop. The "belligerents" are hard to identify. Victory (or in military parlance, "end state") is less clear and even less emotionally satisfying than in combat. Numerous civilian, military, and other international actors crowd the "battlefield." The public, while supportive at the outset, may be sensitive about casualties. The media and society's attention may wander. Most important, peace operations take place in a fishbowl of journalistic and public scrutiny. The effects of TV and global communications on the management of such complex contingency operations in the 21st century will extend far beyond the relationships of TV news and the military. The "CNN effect" provides the clearest signs of the implications of global TV for national policy making and military operations.

Military involvement in complex contingency operations by itself cannot, however, resolve the underlying causes of complex emergencies. It can help reduce the symptoms (such as hunger and chaos) and it can buy time for other policy tools (such as diplomacy and economic support) to help resolve these issues. Bosnia is a case in point. IFOR was a military success but politically the Dayton Agreement was a failure in this same time period. The reason for this was largely because the political and civil efforts and the military deployment were carefully separated on the ground.

Recent experience also suggests that too often the focus of the military intervention has been on short-term objectives rather than long-term political goals of conflict resolution and return to normalcy. The participants (adversaries as well as political, military, civil, non-governmental, and international organizations) must view the crisis as a problem to be solved and not as a contest to be won.¹ Military planners need to be able to better understand the interactions between their activities, humanitarian assistance, civil reconstruction, economic recovery, and future requirements in order to improve their chances of "getting it right" when they must intervene. In other words, if the military wants to help win the peace, they must prepare for peace.² This was a situation faced by PSYOP forces in Bosnia. The IFOR Multinational Division Information Campaign interests were focused on short-term objectives and they wanted tactical PSYOP support to help address these objectives. The IFOR Information Campaign was, however, centrally controlled out of the IFOR headquarters in Sarajevo and led by the Combined Joint IFOR Information Campaign Task Force (CJIICTF). The CJIICTF had to worry about the long-term goals and Bosnia wide strategic objectives that often conflicted with the Division's tactically oriented short-term objectives.

¹ DSD Research Report 97-1, Doing Windows: Non-traditional Military Responses to Complex Emergencies, Center for Naval Warfare Studies, Naval War College.

² Ibid.

Information operations involve actions taken to affect adversary information and information systems while defending one's own capabilities.³ IO applies across all phases of an operation and the range of military operations, and at every level of war. Information Warfare is IO conducted during time of crisis or conflict to achieve or promote specific objectives over a specific adversary or adversaries. Defensive IO activities are conducted on a continuous basis and are an inherent part of force employment across the range of military operations. IO may involve complex legal and policy issues requiring careful review and national-level coordination and approval. As an integrating strategy, IO focuses on the vulnerabilities and opportunities presented by the increasing dependence of the U.S. and its adversaries on information and information systems. IO also comprises a strategy that integrates the U.S. military element of national power with all elements of national power to achieve objectives. IO can, therefore, support the overall USG strategic engagement policy throughout the range of military options.⁴ Successful IO provides the commanders with an information advantage over the adversaries that allows them to make more timely decisions and effect appropriate actions to influence a favorable outcome.

The C4ISR community emphasis on advanced military information technology and its use in warfare tends to leave many with the impression that IO is Information Warfare (IW) and in particular, Computer Network Attack (CNA). IW and CNA are elements but IO is really much broader than this and in fact, its use is broader than DOD in general. The principles of IO have non-military government applications as well as political, civil, law enforcement, industry, and other uses. There is a major human component that is often overlooked. The revolution in information technology serves as an IO enabler and facilitates the use of IO in a much more effective way than was achievable before. It supports breaking down "stove-piped" operations through improved collaboration, coordination, and sharing of information. Improved horizontal and vertical integration serves to leverage the independent (but inter-related) activities to achieve a whole that is greater than the sum of the individual parts, i.e., achieve synergy.

The Information Age has introduced significant information and information systems vulnerabilities. Protection of our ability to conduct information operations will be one of the biggest challenges ahead for the military and the U.S. Government in general. The national security posture of the United States has become increasingly dependent on its information infrastructure and these infrastructures are vulnerable to tampering, exploitation, and catastrophic failures. In regard to the latter, the failure of the Galaxy 4 satellite once again served as a wake-up call that clearly illustrates the impact a major communications and information system failure can have on information services and operations that depend on this connectivity. Although back up capabilities could be employed to eventually restore service, it was a matter of days to restore service--not nearly instantaneous restoration. As a result, pager, radio and TV services and other information connectivity dependent services were interrupted including essential medical services. The "information revolution" presents new operational and technological challenges to achieve victory through information dominance and to ensure the future security of not only the infrastructure (both at home and deployed) but the nation as well. Protecting the information environment requires a sound approach to managing risk, including the change in the value of information from one phase of a military operation to the next.

Information—A Force Multiplier

³ DOD Directive S-3600.1, Information Operations.

⁴ JP 3-13, Joint Doctrine for Information Operations, 2nd draft, July 1997.

In today's high-technology environment, information activities can determine the success or failure of the military operation. The "CNN effect" (unsubstantiated media reports), coupled with the "information revolution," created formidable challenges for the IFOR military. In Bosnia there was media presence throughout the country when IFOR arrived. The information networks serving the media, IFOR and its coalition member nations, and the rest of the free world provided an ability to share information at a speed and efficiency never before experienced. Frequently media reports of incidents would reach the home country and/or higher headquarters before the commander on the ground was aware of the situation and able to react. Adapting to the Bosnia media environment created a challenge for the IFOR Public Information activities that had to establish credibility with local, ethnic, national, and international media while competing with an already established and trusted (coerced to accept) local and national media. The IFOR Information Campaign also had a difficult set of problems to deal with which included the media; active Serb, Croat, and Muslim propaganda campaigns; and the local population's media consumption habits that were miss-read initially by IFOR.

The media's influence on policy and military operations is not a new issue and was a factor in the Bosnia operation. It is interesting to note, however, that the traditional military view that the media represents a necessary evil for commanders to deal with rather than an opportunity to gain military advantage is changing. The degree of this change became quite evident in IFOR's positive approach to public information, which became a leading element of the operation. There was a proactive IFOR public information campaign that maintained credible relations with the press and had the IFOR commander's support from the outset. On the other hand, the globalization of information and television created some difficult challenges for the military. The military processing of information was often too slow to keep up with the speed of media reporting. The power of television and global information networks, such as the Internet, were not fully exploited by the IFOR information campaign at the outset, although over time they did become key elements of the operation.

It is clear that the media can exert influence on policy (although it is still within government officials' power to control) regarding peace operations and related military support activities. The lesson to be learned by the policymakers and military is that they must communicate the policy goals and objectives of the operation clearly and simply. The motives for the operation need to be equally clear and simple, but also compelling, so that citizens and allies will want to be part of the operation while adversaries will feel powerless to escape the inevitable outcome if they oppose our goals. If this is done, then the why and how we do what we must do will be known and observed in the actions that follow and the media will tell the story—a way to leverage the power and influence of the media.⁵

The pervasive use of commercial off-the-shelf (COTS) information products and services propelled NATO and IFOR into the Information Age and into a new way of doing business. There was extensive use of e-mail and a reduced reliance on formal messaging. Video teleconferencing (VTC) was used daily by command elements for collaboration and coordination and became the C2 system of choice. PowerPoint vu-graph briefings were used as the medium of choice for presentations and sharing of information and were readily distributed over the IFOR data networks. A cottage industry of "PowerPoint Rangers" emerged, as the presentations became very sophisticated. The data networks were used for collaborative planning and distribution of wide-band information such as images.

The Internet became a major player in the Bosnia operation. Internet home pages (e.g., DOD's BOSNIALINK and NATO, SHAPE, AFSOUTH, IFOR, and Task Force Eagle home pages) were used by the Public Affairs organizations to inform and update the general

⁵ Frank Stech, *Winning CNN Wars*, Parameters, 1994.

public. The Public Information offices used the Internet for media interactions and translations of foreign news articles. The Information Campaign staff "surfed" the Internet for information on the situation in Bosnia (e.g., news reports, adversary propaganda, biographic data on key leaders, and cultural and demographic information). The intelligence community used it for open-source assessments. Even the factions used the Internet to inform (and in some cases misinform) and present their case to the world audience. International and humanitarian organizations had home pages on the Internet (e.g., the UN and RELIEFWEB, respectively) that provided information related to their activities in Bosnia. The Internet also had value as part of the MWR support, e.g., educational material, travel information, and e-mails to home from the troops in the field.

The "Night Owl," which was produced by the United States at Camp Lukavac in MND (N), provided a daily summary of news and media commentary—a Bosnia version of the Pentagon's "Early Bird." Through its publication and use, commanders and staff were able to gain a better appreciation for the political, economic, and cultural environment. The IIC staff also used this as a key source of information.

The ease with which information could be shared fostered active and sometimes lengthy reporting (such as daily situation reports). The problem soon became one of finding the useful details among the wealth of information available. Managing all of the information available to the commander and his staff was a serious problem. Users did not have adequate automated tools to search for available information. Likewise, there were inadequate tools for managing information collection, storage, and distribution.

Information Operations—Some Realities

Conducting IO requires the close, continuous integration of offensive and defensive capabilities and activities, as well as effective design, integration, and interaction of C2 with intelligence support. Major offensive IO capabilities include, but are not limited to, C2 warfare (C2W) elements, such as operations security (OPSEC), PSYOP, military deception, electronic warfare (EW), physical destruction, and computer network attack (CNA). Defensive IO capabilities include physical security, counter-deception, counter-PSYOP (also called counter-propaganda), counterintelligence, and electronic protection. IO-related activities include information assurance (IA), public affairs (PA), and civil affairs (CA). IA protects and defends information and information systems by ensuring their availability, integrity, identification and authentication, confidentiality, and non-repudiation. It also includes restoration of information systems by incorporating protection, detection, reconstitution, and reaction capabilities. PA communicates accurate, balanced, and credible information to critical leaders and the public. CA establishes relations among military forces, the public, and civil authorities to exchange information, build understanding, and gain information.

IO is an emerging doctrine within the U.S. military community. It does not offer any panaceas. Perfect knowledge is not the objective. The military objective is still to enter an operational theater capable of achieving relative superior combat power against an enemy, or to establish situational dominance in OOTW. IO doctrine is virtually non-existent for the UN and NATO, especially for military support to peace operations. In the international environment there are important IO-related sovereignty implications that still need to be understood under the ground rules for coalition peace operations. These raises a fundamental question of whether the UN and NATO would even have the political will to employ such a strategy in a real-world peace operation. Actions such as deception and misinformation are not a part of their rules of engagement and many nations have a strong negative reaction to PSYOP, especially for peace operations. Peace operations and war are under the influence of

different operational and political constraints. Applying IO in a coalition peace operation means adapting a go-to-war strategy for a peace operation. Integration of IO functions in the multinational environment will be a real challenge—it's a tough enough job nationally across service boundaries and functional domains.

IO has not yet been practiced to its fullest extent as described above and set forth in the Joint Staff publication JP 3-13, *Joint Doctrine for Information Operations*, 2nd draft (dated July 1997) or the Army manual FM 100-6, *Information Operations* (dated August 1996). Most operational staff elements performing IO functions act autonomously. IO is difficult to do and in the final analysis, we may not be smart enough yet to employ IO as a fully integrated strategy. The Bosnia experience provides an opportunity to gain some insights into the types of adaptations that might have to be considered to support multinational coalition peace operations and some insights into U.S. progress in implementing IO as a strategy for multinational peace operations.

Some U.S. national experience with IO has been acquired through recent real-world peace operations, the most recent being *Operation Joint Endeavor* and *Operation Joint Guard* and the experiences of the 1AD and 1ID, respectively, in Multinational Division (North) (MND (N)). The U.S. Bosnia experience, although limited, has been a step in the direction of achieving integrated operations through improved coordination and synchronization of activities related to PA, CA, PSYOP, POLAD, and G2/G3. Force protection and dealing with the former warring factions (FWF) activities were also incorporated. The improved coordination and synchronization of activities evolved over the Implementation Force (IFOR) phase of the operation and became more of an integral part of the operation in MND (N) with the deployment of the 1ID in support of the Stabilization Force (SFOR) phase of the operation.

MG Meigs, USA, the commander 1ID and MND (N) under SFOR, employed the Land Information Warfare Activity (LIWA) to assist him and his staff in the development (based on FM 100-6 doctrine) and execution of an information operation and information campaign. This activity supported MND (N), not SFOR per se, and was the first information campaign supporting a multinational peacekeeping force since the publication of the new Army doctrine. The 1ID and LIWA applied the new doctrine and process that enabled the commander MND (N) to execute a synchronized information operation and campaign, something that had not been accomplished for IFOR.

The IFOR experience was essentially an ad hoc, learn-as-you-go strategy. Coalition IO doctrine was essentially non-existent for the UN, NATO, and the other IFOR member nations. Some of the IFOR national units understood IO principles and concepts while others did not. It is difficult enough to orchestrate information operations as an U.S. national strategy; orchestrating a coalition information operation in a multinational environment is an even more difficult challenge.

The score card for the IFOR de facto implementation of IO-like activities in Bosnia has both pluses and minuses. IFOR staff was doing many of the functions and activities that comprise IO but not as a fully integrated strategy. A number of factors made it difficult to put an integrated, top-down driven process in place—some driven by the lack of doctrine and NATO political sensitivities (especially the association with psychological operations) and others by national doctrinal differences associated with IO-related functional areas such as PSYOP, CA, and PA. There were no enemies declared and this was a NATO first-ever so there was little NATO doctrine and experience to guide activities.

In the absence of doctrine, IO for IFOR mainly evolved around the IFOR Information Campaign (IIC). There was an exception in MND (N) where force protection (clear U.S. guidance—take no casualties) was also a key element of the integrated operations plan. IIC actions were aimed at force protection, the military annex to the Dayton Accords, and

detering the local population from engaging in hostile actions against IFOR troops. The Public Information Campaign was designed to inform and build a trusting relationship with the local and international media. Civil Affairs aimed its efforts at informing the local population about civil affairs activities and their impact on the population's daily life.

The coordination of the various information activities was a difficult task because the Dayton Accords did not designate a single authority to synchronize military and civil activities. There were growing pains associated with the establishment of the IFOR C2 structure and its relationship with national military elements as well as the establishment of the international organizations' structures, including their relationships with the military.

Physical protection measures for IFOR commanders and their staff and command centers and communications facilities varied across the theater. Information assurance and protection measures for the federated system of systems that comprised the IFOR C3I network also varied across the NATO, national, and commercial systems that were used to create the network. Problems with computer viruses were experienced not only with the IFOR and ARRC data networks but also with most computers brought into the theater. Virus detection and correction measures were put in place as well as a user information awareness campaign. Other network protection tools and capabilities such as configuration management and intrusion detection and protection for the data networks were slow in implementation. Sharing and release of sensitive information to the coalition partners required special NATO classification categories and release procedures. Extensive use of liaison operations was employed to bridge language, cultural, and operational gaps.

The IFOR Information Operations Experience

Bosnia is, of course, an operation other than war (OOTW) with all of the associated ambiguities, complexities and challenges. As experienced in other OOTWs, these operations tend to be frustrating because the structure militaries take for granted such as a unified chain of command and clear, simple rules of engagement, are lacking. For many reasons, OOTWs are usually messy and almost always involve ad hoc coalitions of the willing with politically driven command arrangements. More often than not, they will involve, at least in practice, a consultative environment in which key parties will need to develop and maintain a common understanding of the mission, issues and progress towards meeting the end state. Planning and executing such operations are also complicated by factors such as short time lines, a highly dynamic environment and uneven capabilities and experience among coalition members.

Coalition peacekeeping operations are accompanied by other doctrine, culture and language differences that challenge the overall coordination of the mission and ability to achieve unity of effort. Traditions, concepts, customs, and attitudes were sometimes not compatible and needed to be coordinated. Although a common language (such as English or French) was desired to participate, many of the players were not able to speak or understand the language used, placing an added burden on the coordination activities.

The threats in Bosnia were real. There were multiple belligerent factions and a "front line" that was 360 degrees. The three former warring factions not only possessed combat power but also a robust intelligence collection capability. In the case of the Serbs, there was an active information campaign targeted against NATO, member NATO nations, and IFOR. The Karadzic regime was extremely well organized and had a seamless military-political-media continuum. They were the home team, spoke the home language to the home culture, and had an internal security system that could apply thuggery to keep people in line if all else failed. The Croats and Muslims also had active and effective propaganda campaigns in place.

There were land mines everywhere, snipers, and the possibilities of civil disturbances. Terrorists, organized crime, and petty criminals were also considered in the threat picture. Some of the toughest terrain in the world and formidable weather conditions posed a significant challenge to mobility and everyday survival of the operation. Local civilians were hired as linguists, cooks, maids, handymen, electricians, and carpenters and their activities needed to be monitored.

The local, national, and ethnic media were well established and generally trusted. The population of Bosnia was literate and well educated and comfortable with all forms of media that characterizes an "information society." There were exceptions such as Gorazde (an isolated Muslim-dominated enclave), which had little access to the news media and the outside world. The international, national, and local television, radio, and print journalists were everywhere questioning soldiers and reporting on events as they occurred.

The intelligence setting for *Operation Joint Endeavor* was Bosnia-Herzegovina, Hungary, Croatia, Serbia, and parts of the Central European Region. IFOR and the nations had one eye on the military activity of the FWF and the other on potential disruptions to civil order. Intelligence had to cast a wide net, far beyond the theater of operation, to grasp the influences in the area. This was an operation of worldwide proportion and implications.

Initial Conditions

The Dayton Accord failed to designate a single authority to synchronize the military, political, economic, and humanitarian aspects of the mission. This lack of unified political direction was a risk to the success of IFOR. The General Framework Agreement established three structures for implementation: an Implementation Force for the military aspects, a High Representative to coordinate civil tasks, and Donors Conferences to stimulate reconstruction. The High Representative was not a UN Special Representative with UN authority. His political guidance came from a Steering Board of the Peace Implementation Council, which was not an internationally recognized organization. Given the UN's reluctance to take the lead, there was no internationally recognized political organization providing overall direction. Consequently, the three structures remained virtually autonomous, operating within a loose framework of cooperation and without a formal structure for developing unified policy.

The absence of a standing political organization exacerbated the inherent difficulties of synchronizing the civil-military implementation of the peace process. Ad hoc arrangements were initially employed to facilitate the civil-military collaboration and cooperation and more formal arrangements were employed later through participation in the Office of the High Representative-established Joint Civil Commission (JCC). At the outset of the operation, IFOR established a Joint Military Commission (JMC) as the central body for commanders of the military factions and IFOR to coordinate and resolve problems.

IFOR troops faced serious public information challenges. IFOR succeeded a discredited UN mission and needed to distance itself from the poor image the UN garnered during the four years of UNPROFOR. In addition to IFOR, there were seven other organizations tasked with implementing the Dayton agreement. Hence, cooperation and sharing was essential to enhance the credibility of IFOR and the international community with the international and local press. The IFOR public information activities achieved a generally high standard of information exchange with the media. It had the commander's support from the outset and active cooperation with the media was promoted, including early attempts to build trusting relationships with the media by being open and truthful. International and national media coverage of IFOR was generally positive or neutral.

Reporters in theater expressed satisfaction with the IFOR policies and procedures and the military spokespeople achieved a high level of credibility.

As noted earlier, the doctrine for IO for peacekeeping was non-existent for NATO and SHAPE and many of the participating nations. Furthermore, the doctrines for PA, CA, PSYOP, and related IO functional areas were either non-existent, under development, or recently revised. National doctrines differed for many of the functional areas that comprise IO. The command and control of national PSYOP contingents remained with the participating nations (mainly the United States with participation from the UK, France, and Germany) and was not placed under NATO C2 during the IFOR operation. CA was new to NATO and there were national doctrine differences. OPLAN 40105 called for Public Information (PI) offices and coalition press and information centers (CPIC) with each of the major IFOR headquarters. In Sarajevo, IFOR and the ARRC shared a press center and staff in the Holiday Inn but this caused confusion in the chain of command. There was a dual command relationship and at times the ARRC and IFOR gave conflicting guidance to the PI office. The multinational divisions commanders preferred to bring their own national PI assets to run the PI program, introducing confusion into the IFOR PI operation: conflicting IFOR and national doctrine, procedures, and guidance on the nature and amount of information to be released to the media. The PA, CA, and PSYOP aspects of the IFOR campaign required special attention to ensure coordination and synchronization of related activities. Ad hoc committees were established at the IFOR, ARRC, and multinational division levels to facilitate coordination. There was no mechanism for the coordination of IO-like activities across the broader set of military, civil, humanitarian, and economic players. This was largely a military action at the outset. Ad hoc coordination groups were established over time to facilitate coordination of the IIC over a broader set of military and international organization participants.

Protection of U.S. forces was a significant issue and took on a higher degree of importance than had been seen in other U.S. military peace support operations. It was a formal part of the OPLAN mission statement and permeated all aspects of mission execution. Many non-U.S. IFOR participants believed that U.S. force protection measures were politically motivated and not based on a realistic threat assessment. MGEN William Nash, USA and Commander MND (N), defended the tough self-protection standard as important for both safety and discipline reasons.

Enforcement of force protection was inconsistent between U.S. service members serving under U.S. command and those serving under NATO control. Civil agencies were concerned that this inconsistency was sending mixed signals to the warring factions. The stringent U.S. force protection measures directly hampered civil-military cooperation, PSYOP, and counterintelligence/human-intelligence (CI/HUMINT) activities in the MND (N) area of operation and the ability of U.S. soldiers to move away from the "peace-enforcement-only" mindset. The second- and third-order effects of the stringent force protection measures were underestimated. There was some easing of the rules over time as the operation evolved and more civil affairs work was performed off post.

OPSEC was particularly challenging. The operational environment was reasonably stable for Bosnia. The lack of an obvious threat encouraged or invited complacency. Other types of OPSEC risks had to be managed as well. There were numerous television and print journalists questioning soldiers. On a daily basis, hundreds of local national workers entered IFOR areas of operation. It was a challenge to keep a close eye on these daily visitors. OPSEC is an operations function, not a security function per se. Therefore, there must be a proponent for OPSEC functions and the functions must be integrated into the planning and execution of the operation.

Civil-military activities in support of peace operations were new for NATO. There was no common understanding by commanders and staff at all levels of IFOR of the capabilities, roles, and mission of CA units (referred to by NATO as Civil-Military Cooperation (CIMIC)) and personnel. This lack of understanding led to misperceptions that the CIMIC activities were contributing to mission creep and resulted in some unanticipated constraints being placed on their operation until their value became more apparent to the commanders. The civil-military aspects also did not receive sufficient attention during the military planning and initial execution phase of the operation due to the heavy emphasis on the enforcement of the Dayton Accords (military annex) and emphasis on force protection. Civil-military activities prior to IFOR were very narrowly conceived by NATO and were generally regarded as "rear area" activities associated with host-nation logistic support and reducing or minimizing refugee interference. This combat-oriented doctrine had little relevance in the Bosnia context. The essence of the IFOR mission was to maintain a safe and secure environment so that reconciliation and reconstruction could take place. Since mission accomplishment depended upon effective civil-military cooperation, such cooperation and the CIMIC organizational element, in particular, became a vital "front line" asset. In this regard, Admiral Leighton Smith, USN and COMIFOR, made the following comment upon his departure from IFOR, "In November we never heard of CIMIC. We had no idea what you did. Now we can't live without you."

Intelligence requirements in Bosnia varied depending upon the phase of the operation but consistently required expertise in military, political, cultural, and economic issue areas. The operation had to monitor a wide spectrum of threats including the FWF, criminal activities, extremists, civil disturbances, and terrorism. It also had to monitor FWF equipment storage sites and barracks, the Zone of Separation, mass gravesites, and potential "hot spots" caused by freedom of movement, resettlement, and inter-ethnic conflict. The operation muddled any clear division among strategic, theater, and tactical levels and had to adapt to differences in NATO and national doctrines and procedures. Force protection measures and the constant threat of land mines forced an adaptation of normal operating procedures. Analytical efforts were challenged. It was difficult to collect and exploit the full range of information, identify indicators, and provide predictive analysis. The analysts were trained for hard targeting-based analysis supporting military courses of action; they were not as well prepared for "softer" analysis of political issues, treaty compliance, civil unrest, vigilante activities, election support, refugee movements, and faction and population intentions. Since "soft analysis" was more challenging and difficult, there was a tendency to be more reactive and to analyze what happened rather than predict what might happen. In retrospect, indicators of events were often there—the challenge was developing the expertise to recognize and use these insights to influence outcomes. This placed high demands on intellectual and analytical flexibility.

There were communications and information system security issues as well. Although the NATO and national military systems operated Secret system-high, there were others that were not secure. The UN VSAT network, INMARSAT, cellular, and the commercial PTT telephone systems were not protected and they were used frequently for command and control purposes. The Internet was used frequently. NATO information network virus and intrusion protection measures were slow in implementation. Diskettes were shared between classified and unclassified systems and there was a lack of discipline and standard operating procedures. During IFOR, an enormous amount of classified and unclassified material was produced; extra care had to be taken when dealing with mixed classifications of information. There was a lack of security devices such as secure telephones, safes, and shredders. Security was an ongoing responsibility for which improvements were continuously made over the duration of the IFOR phase of the operation.

The NATO IO-related rules of engagement (the de facto IO doctrine) for IFOR were fairly restrictive. The information campaign was to be based on truth and factual information and IFOR was to always identify itself as the source. IFOR was forbidden to use misinformation and deception and the campaign could not take actions that would undermine the factions, take sides, or directly refute FWF misinformation activities. It became clear early on in the operation that the FWF needed the ability to command and control their forces in order to be able to comply with the Dayton Accords. Therefore, actions such as jamming, electronic deception, and physical destruction were not used by IFOR against the FWF C2 and information systems. NATO and U.S. doctrine stipulated that a separation between Public Affairs (Information) and PSYOP functions must be preserved to maintain the credibility of Public Affairs spokespeople and products. There was also a NATO reluctance to tackle difficult or controversial issues such as war criminals or the fact that the parties were failing to live up to the agreement they had signed.

Upon arrival in country, IFOR made it very clear to the FWF that they were different from UNPROFOR and were there to enforce compliance with the Dayton Accords, including the use of force if necessary. Checkpoints and bunkers were bulldozed, roadblocks were shut down, and the FWF were separated and their equipment and forces placed in cantonment areas and barracks. On 19 February 1996, COMIFOR held a meeting of the Joint Military Commission onboard the carrier *USS George Washington*. COMIFOR stated that the reason for having the meeting onboard the "Spirit of Freedom" was to give the leaders of the FWF a display of the firepower the United States was prepared to use in the enforcement of the Dayton Peace Accords.

IFOR's tremendous military firepower was a major deterrent but the military also put a lot of faith in the deterrent power of "information dominance." IFOR, through its intelligence operation (supported by significant national contributions, especially from the United States) and information campaign, was able to make it clear to the FWF that they could monitor them any time of the day or night under all weather conditions. Violations were experienced from time to time: weapons discovered in unauthorized locations, soldiers and tanks in the Zone of Separation, and unauthorized police checkpoints. IFOR commanders did not tolerate violations, and swift actions were taken when the FWF tested IFOR's resolve. The ability to see, understand the situation, and strike with precision had its effect in deterring aggressive actions on the part of the FWF and in maintaining the peace. In the words of MGEN Nash, "We don't have arguments. We hand them pictures, and they move their tanks."

Information Campaign—Some Challenges

Although PSYOP is an official NATO term, some North Atlantic Council members did not want to be associated with a PSYOP campaign. PSYOP has a public relations problem. There are misperceptions about the relationship between PSYOP and intelligence. An even larger misperception surrounds the relationship between PSYOP and Public Affairs. Public Affairs try to keep its distance from PSYOP. Many organizations and individuals—from the UN to non-governmental organizations (NGOs) to journalists unfamiliar with the military—hear the term and the image of "The Manchurian Candidate" comes to mind. In addition, some of the major partners in the coalition (among them the French forces) showed reluctance at first toward the use of U.S. PSYOP forces. The French reluctance was due to political and historical reasons associated with their experience in the Algerian conflict in 1961. The IFOR planners renamed the psychological operations campaign the "IFOR Information Campaign" and this seemed to ease most fears.

PSYOP is an operational tool (under the G/J-3) designed to shape target audiences' perceptions so that they create the least possible interference with friendly forces. The IIC was designed to influence attitudes and shape behavior of groups within the area of operation using multimedia communications and planned activities designed to facilitate the peace enforcement. More specifically, it was designed to "seize and maintain the initiative by imparting timely and effective information within the commander's intent."

The term "information campaign" referred to the coordinated and synchronized use of different information activities within the IFOR command. The campaign had three components:

- A PA campaign designed to establish NATO's credibility with the international media to gain support from the contributing nations for the mission. Public Information Officers executed this mission.
- A PSYOP campaign designed to influence the local population and its leaders in favor of IFOR troops and operations. PSYOP units (mainly U.S.) undertook this aspect of the campaign.
- A CA/CIMIC information campaign designed to inform audiences about civil-military cooperation and to release information to aid the local populations. CA/CIMIC elements (mainly U.S. Army) undertook this mission.

At the outset, the IIC was conceived as a force protection tool and was used to deter the FWF and local populations from engaging in hostile actions against IFOR troops and from interfering with IFOR operations. The campaign targeted the three sub-groups: Bosniacs, Bosnian Croats, and Bosnian Serbs. Products were designed according to each target and impact expectations differed. The products were intended to send clear signals to faction leaders on NATO's resolve, mandate, and capabilities. They were also used to convince the local population that a brighter future would await them if the Dayton agreement were fully complied with. As it became more apparent that the local population and factions were neither acting hostile nor interfering with IFOR operations and that the FWF were generally in compliance with the Dayton Accords, the focus of the campaign shifted to national elections, refugee returns, and reconstruction.

The CJIICTF was established to take over the PSYOP aspects, orchestrate the IIC, and coordinate the IIC-related activities of the Public Affairs, Civil Affairs, and PSYOP. It also attempted to coordinate IIC activities with the international organizations such as the UNHCR, OSCE, OHR, UN-IPTF, and others. The CJIICTF consisted mainly of U.S. PSYOP personnel and assets with supporting elements from the United Kingdom, Germany, and France. There were also some limited Spanish and Italian PSYOP activities in the MND (SE) area. U.S. tactical PSYOP teams were deployed and attached to the subordinate command elements. The mission was to disseminate pre-approved PSYOP products; broadcast loudspeaker messages, and disseminate command information. The teams also conducted assessments of the area of operation and made contact with the local media sources to gain information for the CJIICTF. Although the CJIICTF operated as a component command of IFOR with staff supervision from the IFOR CJ3, none of the national PSYOP units were placed under NATO C2. This situation created problems such as dual NATO and national chains for product approval and IIC execution direction. For the United States, Title X issues (no JTF commander equivalent for the U.S. forces) affected administrative and logistics support to deployed U.S. PSYOP personnel.

The CJIICTF headquarters developed products and COMIFOR (later the COMARRC) approved all products. It was felt that since all three FWFs were in each of the MND sectors that a top-down approach facilitated product coherence (unity of effort) and

ensured that a single authority would review products before release. The centralized PSYOP product approval, production, and distribution process was at times cumbersome and slow. Approval- and distribution-related delays sometimes resulted in time-sensitive information getting to the local population too late to have the desired effect, especially in MND (N) where, because of force protection rules, four-vehicle convoys were required to deliver the printed material to lower command levels.

Products did not always fully meet the needs of the tactical PSYOP mission. Those that had a high degree of receptivity at the strategic level and were targeted for the broader Bosnia-Herzegovina population were not always well received at the tactical level or by the local population. Furthermore, a number of the products were felt to be too "American" for the provincial regions of Bosnia and did not reflect the European advertising traditions prevalent in the Bosnia region of this part of the world. The MND commanders and the tactical PSYOP teams felt they needed more freedom and flexibility to tailor and produce products for use with their local population. In this regard, there was some freedom but it was limited to within the scope of the COMIFOR-approved activities.

In some cases, the CJIICTF mission statement and "commander's intent" did not get distributed to appropriate levels of the command structure. The command and control relationships also needed to be more clearly articulated, disseminated to the elements involved, and consistently implemented. Additionally, changes, caveats, or exceptions also needed to be made clear to all organizations affected. PSYOP teams were less effective in situations where they were subordinated to the G-5 at the tactical level and/or did not participate as part of the commander's battle staff. Working for the G-5 essentially turned PSYOP into a Civil Affairs support activity. A combination of these factors, compounded by the MND (N) mode of operation, hampered the ability of some tactical PSYOP teams to effectively accomplish their mission—particularly in the MND (N) area of operation.

Differences in PSYOP doctrine, particularly between the United States and the United Kingdom, were an issue. The top-down product development approach of the United States, who ran the CJIICTF, was in direct conflict with the UK approach that favored a decentralized, grassroots product development. The British also thought the approval process was too cumbersome. They favored delegating product approval authority to the lowest level practical. The French, who were reluctant to use PSYOP forces, only allowed a limited U.S. PSYOP presence in MND (SE)—a liaison officer and FM radio section. Occasionally, the French allowed the CJIICTF to pass out the COMIFOR *Herald of Peace* (a weekly newspaper published by the U.S. forces) and voter education products. Other contingents such as the Spanish and Italians did not cooperate closely with the CJIICTF but did use "information policies" in support of their G-5 activities.

The organic communications support at the tactical level was limited and in some cases inadequate to support the mission. The U.S. tactical PSYOP teams relied almost solely on the units they supported for their communications. Relying on "borrowing" phones and computers often proved problematic due to the heavy usage of this equipment by all elements. At times, it took several hours for the tactical PSYOP teams to reach headquarters elements and the deployed teams. The urban nature of the mission often required the tactical teams to split up and conduct operations indoors as well as outdoors and in areas such as crowded markets. The lack of adequate communications for the dismounted operations became a force protection issue.

In some areas of Bosnia, such as those occupied by the Serbs, an information campaign targeted against NATO was already in full operation when the IFOR troops arrived. Hence, the IIC was at a disadvantage at the outset because it had to compete immediately with an already-established and effective campaign that could get inside of the IFOR decision loop and outmaneuver some of the initial IIC efforts.

IFOR also had some problems adapting to the local population's media consumption habits. While IFOR relied primarily on printed material (*Herald of Peace* and *MICKO* (a monthly youth magazine produced by the German forces), posters, and handbills) and radio to start with, the Bosnia's preferred medium was television. Also, IFOR radio initially transmitted on AM and the Bosnia's listened mostly to FM radios.

The media used by IFOR at the outset was largely driven by capabilities available from the deployed PSYOP resources (mainly from the United States that relied heavily on radio, printed material, and loud speaker systems). There was also limited NATO funding for acquiring airtime on the local and national radio and television stations. NATO funding to acquire FM radio and television stations for sole use by the IIC was not available. Some local radio stations provided free airtime for IFOR use. In return, IFOR provided the radio stations with pop music tapes. Over time, adjustments were made to accommodate other media forms such as FM radio and buying airtime on local and national radio and television stations. Once IFOR money became available to pay for airtime, the free use of local stations was withdrawn.

The U.S. PSYOP platform, Commando Solo, was not deployed during the IFOR phase of the operation. This platform has a wide range of radio and television broadcast capabilities. It did see some limited test usage in support of the September 1997 election activities during the SFOR phase of the operation. Deployment of Commando Solo is expensive; hence, the reluctance to use it in a funding-constrained operation.

Information Battle Damage Assessment

It was difficult to measure the real impact of the IIC. Establishing a direct link between a message and a specific attitude and response was difficult. Research shows that communication's impact is almost never direct. Furthermore, the CJIICTF did not have adequate staff (both numbers and qualifications) to conduct an effective assessment of their impact. Pre- and post-testing of products was conducted to assess impact on local populations. Pre-testing (for adequacy and language) relied heavily on local workers within the headquarters before production. Sometimes tactical teams in the field were employed. IFOR and the multinational divisions employed Civil Affairs, PSYOP, Special Operations, and intelligence teams as well as other elements for post-testing to survey perceptions and attitudes and to collect information that could be used to assess the effectiveness of the IIC and to identify adjustments to improve its effectiveness. Feedback from other sources such as local newspapers, radio and television broadcasts and the Internet were used as well. As the U.S. Army FM 100-6 points out, "The challenge of Information Battle Damage Assessment (BDA) is to be able to assess the effects of our efforts without the benefit of physical damage. The effects may well be trends, activities, and patterns in future adversary actions."

Impact indicators such as level of effort (number of products developed and disseminated by the CJIICTF), acceptance rate (people's reaction when presented with the product), and behavioral change (population behavior before and after a specific campaign) were employed for each product developed. Unfortunately, these measures were imperfect because they did not document the full impact of the mission. Hence, it was difficult to effectively adapt the IIC to the local environment.

There were both successes and failures in the products prepared and distributed by the IIC. The *Herald of Peace*, *MIRKO*, and Superman mine awareness comic books (produced by U.S. forces) were major successes. There were other products that were not as successful because they failed to adequately consider the cultural implications or fell prey to the FWF propaganda campaigns. For example, there was a poster with a chess game that implied that

the next move was Bosnia's. This was translated by the FWF propaganda campaigns to mean that the international community viewed Bosnia as a game. There was also a poster showing a girl running through a field of tall grass to illustrate freedom of movement. Unfortunately, in Bosnia a field of uncut tall grass means mines. Even the Superman comic books over time fell prey to criticism—the implication emerging was that Superman would save you if you played in the minefields.

The reluctance of IFOR to take on controversial issues such as war criminals had its downside as well. For example, the reluctance to deal with indicted war criminals went as far as modifying a poster printed on the behalf of the ICTY (International Criminal Tribunal for former-Yugoslavia). The original poster identified all publicly indicted war criminals with their last known addresses. After journalists challenged the U.S. military's claim that it had insufficient intelligence to arrest the war criminals by pointing to the addresses on the poster (reporters had been able to locate 12 of the indicted war criminals just using this information), IFOR reprinted the poster without the addresses. This decision outraged the ICTY, who asked that its logo be removed from the poster. At the end of this controversy, IFOR decided not to distribute the posters with the addresses omitted. The conciliatory tone of the IIC dismayed many in the international community working in Bosnia. For example, OHR officials commented that they had little use for a campaign that was too weak to have substantial impact.

The IIC proved to be a difficult task and the jury is still out on its overall success for the IFOR operation (i.e., military, civil, political, economic, and humanitarian aspects). It was certainly a success during the first 9 months of the operation in support of force protection and military compliance activities. LTG Mike Walker, UKA, Commander ARRC, said, "the IIC was an unqualified success during military compliance activities (D+3 through D+120) and in support of the September 1996 National elections." There were also some successes against the Serbs, e.g., war criminal awareness posters and the destruction of 250 tons of Bosnian Serb munitions, *Operation Volcano*. Over time, speeches by Karadzic became reactive and he complained about IIC messages and actions. A top-down driven campaign plan with top-down driven products was viewed as an important contributor to the military successes.

Thoughts for the Future

Bosnia is a living prototype of a post-Cold War contingency operation. If we learn the correct lessons from the operation and act upon them, the payoff could be considerable. One should not forget that potential adversaries of the NATO alliance and the United States, in particular, will not be so foolish as to neglect glaring weakness in the doctrine and tactics and information systems and services implemented in support of the IFOR operation. Active countermeasures against coalition information and information systems may be the case in future operations. Doctrine and tactics based upon an assumed freedom to communicate and ability to achieve information dominance may not be sufficient the next time around, even for peace operations.

The IFOR experience has contributed to shaping the emerging coalition information operations doctrine and capabilities. Some thoughts for future consideration:

- Information operations require a comprehensive and integrated strategy from the inception of the operation. It requires the military commander's personal involvement and leadership and it must be a key element of his operations plan and staff.
- PSYOP needs to exploit the capabilities of the global information environment including dissemination of its information campaign products. The capabilities of the global

Internet and television need to be exploited by the information campaign both as a source of information and a medium for informing.

- Information assurance and protection requires that careful attention be given to the globalization of information and information systems. Computer viruses, data network intrusion detection and protection, and exploitation of the Internet need to be carefully addressed.
- Information operations needs improved education and training programs such as the NDU and DIA IO education programs and the LIWA IO training program for Field Support Teams.
- Information operations require better tools and trained staff to perform information battle damage assessment.
- Intelligence support to peacekeeping information operations requires improved predictive intelligence capabilities with qualified staff in the areas of political, cultural, and economic disciplines and "soft analysis" capabilities and experience. Also need improved intellectual and analytical flexibility.
- Peacekeeping information operations are broader than just the military piece. It needs to include the integration and exploitation of the civil, political and economic pieces as well.

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A UK TTCP – C3I – TP9 Perspective of Command and Control Planning Issues for Future Coalition 'War Avoidance' Operations. – R A Rathmell DERA Malvern.

It is some 160 years since Clausewitz treatise on the strategy of war that has influenced the doctrine and tactics of military forces through two World Wars during this Century. Following the failure of diplomatic means for the resolution of disputes, the primary objectives of war may be summarised as; crush the enemy into defeat, deny him the logistic support to enable him to recover, and, convince him of the justness of the victors cause. It is in winning the subsequent 'hearts and minds' campaign that the real difficulties lie for the lasting settlement of disputes and it is, so often, the atrocities of war that spawn and feed the deeply held animosities between neighbours which threaten civilised behaviour. As Liddell Hart wrote: "The more I reflect on the experience of history, the more I come to see the instability of solutions achieved by force alone."

The collapse of the Warsaw Pact and the resulting reduction in the threat of Global War has served to reveal and stimulate the underlying local ethnic and cultural conflicts in a variety of differing locations which if left to propagate, could seriously impact World stability. Conflicts which result in violence that impacts basic human rights and/or transcends national boundaries is a matter for United Nations attention where resolution can be debated and action taken under internationally agreed procedures. Where the maintenance of resulting agreements becomes an issue, the UN may impose sanctions and seek to enforce these by deploying a 'coalition force' comprising military and civilian personnel from a number of nations under a single command empowered to act on its behalf in preserving the agreed settlement. The creation of a multi-national coalition force is desirable in order to give credence to the international nature of the agreement to the operation and to amortise the commitment of resources. The coalition force commander is directly responsible to the Secretary General of the United Nations and acts within a formally agreed UN Directive.

The nature of such operations will span a broad range of missions from war through operations other than war (OOTW). The OOTW cover a range of missions where the UN Forces are not in direct conflict with Nation State(s) but are required to perform a 'neutral third party' operation. This is usually the result of a situation that is beyond the capability of the individual Nations(s) to resolve because it is an internecine issue or is beyond their individual resources. These may be further subdivided into war avoidance and humanitarian aid missions. The war avoidance operations cover the spectrum of 'policing' activities that are required to restore 'peaceful normality' in hostile situations between two or more population elements or State(s) in conflict. In these circumstances the UN Forces must act as an independent arbiter in discharging the associated UN Resolution and is therefore acting in the role of 'referee'. These operations are characterised by Rules of Engagement, which restrain the use of weapons in order to preserve the neutrality of the operation. Countering terrorism and international crime may also be considered to lie within such missions because they can also be a significantly destabilising influence and may require the co-operation of international agencies in order to limit their insidious effects.

Thus, war avoidance operations are primarily characterised by the resolution of conflicts by lawful means. Their key objectives are markedly different from those of war and, for the

purpose of contrast with Clausewitz, may be summarised as, to promote the agreed UN solution to the dispute, assure the basic human freedoms and the rule of law, and, restore democratic processes and stability. Achievement of these objectives requires a balance of diplomatic, political/civil and military persuasion.

Planning is rightly deemed to be a key function in military operations and it is an established process. However, for war avoidance missions, this is further complicated by the need to consider the diplomatic, political/civil and military issues in deriving the plan and conducting the operation. The need to agree and co-ordinate multi-national military and civilian resources with widely disparate experience, objectives and tasks and the attendant security implications and logistic requirements thus compounds the actual process. Analysis of previous coalition operations has identified a wide range of problems from basic interoperability and doctrine through cultural issues resulting in differences of understanding, commitment and control. Furthermore, the spectrum of potential solutions and the dynamics of the solution environment mean that there will be multiple plans of scope and interaction that is complex and time variant. These issues will compound problems with the subsequent decision and execution processes. As if this is not a sufficient challenge to planning research, in the case of war avoidance missions, and perhaps unlike the planning for natural disasters, the 'protagonist' will constantly seek to exploit continuity of intent in a plan. This is exacerbated when the new dimensions of conflict transcend conventional warfare by seeking to introduce progressively greater degrees of barbaric behaviour in order to achieve goals, embarrass the coalition force and frustrate a negotiated settlement. Thus the application of conventional war planning in such situations may be less than adequate and there is no norm for unconventional means. The challenge is therefore to develop planning strategies and techniques that enable past experience, resource conflict resolution and risk prognosis, to be conducted in a timely manner within a complex war avoidance mission environment.

TTCP - C3I - TP9 has a remit to examine the issues of command and control for future coalition force operations. Central to this is the technology for the future strategic/tactical command post environment and collaborative planning is one of the principal enabling technologies. To this end, experiments are being proposed which draw on the supporting resources of the C3I Group and other groups within TTCP to focus on the issues and identify technology capability gaps in such operations. The first of these experiments is scheduled for June/July 1999 and will be based on a coalition planning exercise for which it is hoped that suitable techniques and initial tools will result from this Workshop. This and subsequent exercises will be based on a functional operational scenario supported by a series of vignettes which will be designed to test the strengths and weaknesses of the various technologies under differing war avoidance situations from, establishing a cessation of hostilities, to restoration of normality.

This summary has introduced a number of issues associated with the planning of coalition operations for war avoidance missions and these, together with the scenario and first vignette will be presented and further detailed as the needs of the Workshop require. If they can be effectively addressed, it is likely that the planning of future missions for humanitarian aid, war avoidance and war situations will be facilitated.

CHICAN SCENARIO

CHICAN SCENARIO (as of 4 Sep 98) "Peer Competitor Campaign"

Appendix C

Intelligence Estimate

UNCLASSIFIED

USSPACECOM J2
Peterson AFB, CO
1 October 1998/1200 MST

INTELLIGENCE ESTIMATE NUMBER—JWID 002

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1. Mission. Keep ASEAN nations independent and sovereign.

2. Adversary Situation.

The extraordinary rates of economic growth and the high degree of economic interdependence are changing both the structure of security relations and the tendencies for creating conflict or peace in the region. The fast pace of economic growth in the ASEAN region has made foreign investment very popular. Economic vitality for the region is dependent upon relatively long and vulnerable Sea Lines of Communication (SLOCs). The security environment of this region is essentially maritime. In terms of shipping movements, it is one of the busiest in the world. non-state adversaries (pirates) are starting to become a focus of concern to nations dependent on trade through the SLOCs. In addition, the Information Age is redefining the role of nations in an international arena. In the Pacific region, the leading powers are becoming more aware of the information media and its potential. Military power projections are still primarily accomplished through ground, naval and air operations. However, the space medium with its linkages to Information Operations (IO) is creating new standards for power projection. All nations in this region are participatory to the Global Information Infrastructure (GII). Acquisition and deployment of more advanced weapon systems as well as a major effort to realign forces and strategy to evolving IO principals and doctrine are underway.

CHICAN's national objectives include comprehensive modernization of the country, particularly with the armed forces. CHICAN is a peer competitor with the US in terms of military power projection for this region. CHICAN considers nuclear weapons primarily within the larger context of maintaining deterrence vis-à-vis the United States and Russia and as enhancing its status as an international power. They have established a space

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infrastructure for mission payload launch via Pegasus-equivalent launches from Juneau and Point Barrow. Indigenous technological development and the marketplace have enabled CHICAN to conduct effective power projection in the region. CHICAN has both acquired technology from leading telecommunications and weapons firms as well as from indigenous development. This modernization encompasses major improvements to CHICAN's technological base, economy, and military establishment, as well as rapid economic growth, domestic stability, regional economic hegemony and eventual control of claimed territories, to include the SPICEY ISLANDS.

As the predominant power in the region, CHICAN has commenced an aggressive program to establish economic hegemony over the region and reduce the influence and military presence of other powers (US, India). Their existing markets had been shifting to other Asian and Western producers of software and information systems. Most notably the ASEAN family of nations (ASEAN-T (Maui), ASEAN-V (Hawaii), ASEAN-M (Molokai), ASEAN-P (Kauai)) 700 nm to the south of Anchorage have established an economic block with strong ties to CHICAN adversaries (US, India).

Additionally, a dispute between CHICAN and the ASEAN commonwealth nations over the SPICEY ISLANDS (Lanai, Kahoolawe) has escalated. The proximity to nearby oil and gas-producing sedimentary basins suggests the potential for significant oil and gas deposits, but the region is largely unexplored, and there are no reliable estimates of potential reserves; commercial exploitation has yet to be determined. Additionally, they are key to controlling the sea routes from which 20 percent of the world's shipping passes.

a. Characteristics of the Area of Operations.

(1) Military Geography

(a) Topography

1. Existing Situation. The waterways through the region are strategically important for both merchant and naval vessels. Coastal and offshore resources provide a principal means of livelihood in many of the countries in the region.

The SPICEY ISLANDS comprise 2 major islands, Lanai and Kahoolawe with several islets, coral reefs, and sea mounts in the area. The terrain is flat and tropical. The SPICEY ISLANDS are located about two-thirds of the way between ASEAN-V and ASEAN-P. Total land area is about 150 sq km. ASEAN nation total coastline is 750nm.

The coastline of CHICAN sweeps in a great arc some 5000 km in extent. It contains many low mountains and hills. Its jagged outline exhibits a monotonous succession of bays separated by peninsulas and islands with precipitous slopes. The CHICAN forces are much farther from the disputed islands than the ASEAN

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forces. CHICAN surface forces facing serious opposition in the waters surrounding the SPICEY ISLANDS requires effective air cover in order to survive.

2. **Effect on Adversary Capabilities.** Regional topography impacts CHICAN military forces in several ways: Nuclear/Chemical/Biological operations are focused around mountainous terrain to mask mobile missile operations and establish hard to detect missile silos. The rough terrain affects communication equipment and systems by increasing Chican reliance upon space based systems.
3. **Effect on Friendly Courses of Action.** ASEAN member nations defensive options are influenced by topography by increasing dependancy on air defense and maritime operations. Army forces are limited in size. Surveillance are employed from the mountain tops of each island.

(b) Hydrography

1. **Existing Situation.** SPICEY ISLANDS cover 926 km of coastline.
2. **Effect on Adversary Capabilities.** SPICEY ISLANDS pose a serious maritime hazard due to numerous reefs and shoals.
3. **Effect on Friendly Courses of Action.** SPICEY ISLANDS pose a serious maritime hazard due to numerous reefs and shoals.

(c) Climate and Weather

1. **Existing Situation.** CHICAN's southern region and the entire ASEAN region reside in the equatorial region. The tropical conditions provide substantial cloud cover and limited visibility. Mudslides are frequent, causing complications for logistic operations in the southern region. Typhoons are frequent in the March-April timeframe.
2. **Effect on Adversary Capabilities:** CHICAN troops are familiar with the terrain and vegetation. Maritime operations are frequently hampered by typhoons.
3. **Effect on Friendly Courses of Action.** ASEAN military forces are accustomed to operations under tropical conditions. Maritime operations are limited during periods of typhoons.

(2) Transportation

CHICAN SCENARIO

(a) **Existing Situation.** The prevailing mode of transportation is primarily maritime with an evolving civil air industry. SPICEY ISLANDS has no infrastructure.

(b) **Effect on Adversary Capabilities.**

CHICAN's civil air fleet covers the entire country on a daily basis. Chican possesses over 100 airfields. CHICAN possesses a substantial logistic infrastructure to support operations in the southern region, to include: 55,180 km 1.435-standard gauge railroads; 500,000 km of highways of which 70,000 km are paved and 30,000 km of inland waterways which are navigable by maritime traffic. CHICAN has several excellent ports, the most prominent being Anchorage, Valdez, and Juneau.

(c) **Effect on Friendly Courses of Action.**

The ASEAN nations possess a small but effective civil air fleet to serve the island nations. However, they possess limited resources to conduct airlift support to the member nations. ASEAN members possess a limited infrastructure to support the member nations. The combined rail network covers 654 km. ASEAN members have 904km (495nm) if inland waterways. There are 4,689km of roads, of which 2,600nm are paved surfaces and 1500nm are gravel and crushed stone and 589nm are rural road.

(3) **Telecommunications**

(a) **Existing Situation.**

CHICAN's public telecommunications system is controlled and operated by the government. HF/UHF/SHF is also integrated into military planning. The agency manages a modern and efficient system with an average of 16 fixed telephones, 48 radios, and 51 television receivers per 100 persons. Cellular devices are used by almost the entire business community and much of the middle class.

ASEAN members share a state-of-the-art telecommunications network between the island nations. International communications are offered over satellite ground stations, a microwave network between the neighboring countries, and via HF. The satellite earth station at Paumalu, Oahu, is operated by INTELSAT. The HF radio-communications facilities are quite old and handle only a fraction of the international traffic. In most cases they are used only as backup systems to the satellite and radio-relay routes. The VHF system using repeater stations enable direct and continual contact to most military departments and districts.

(b) **Effect on Adversary Capabilities.**

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The CHICAN government relies on the telecommunications infrastructure to support military operations in the southern region. Satellites are employed extensively. CHICAN communication network consists of coaxial cables, microwave links, 20,000,000 telephones, broadcast stations (274 AM/FM, 202 TV), satellite earth stations (4 Pacific Ocean INTELSAT, 1 Indian Ocean INTELSAT)

CHICAN C3 is further supported by redundant and survivable communications. The CHICAN communications facility oversees a high-capacity national cable network serving the capital. Three army subordinate communication centers support the respective military sector. The communication centers are estimated to provide an interface between the military and civilian communications. Connectivity is achieved through landline (buried trunklines, coaxial networks, fiber optics), troposcatter (maximum separation at 108nm), microwave line of sight (point to point range from 16 to 32nm), omnidirectional radios (range capability in excess of 300nm) and satellite communications (INTELSAT , INMARSAT).

(c) Effect on Friendly Courses of Action.

Inter-island telecommunications form the critical link to defensive operations. Each nation subscribes to the INTELSAT network and has committed extensively to the future IRIDIUM network.

(4) Politics

(a) Existing Situation

CHICAN is an authoritarian government which constantly faces a leadership succession problem and a strong desire to preserve the political system. The political leadership is jointly shared by the party and military. The organizational framework of the regime is rapidly decaying. Corruption is endemic at levels of bureaucracy. The government has sought to mobilize nationalism to justify its authoritarian rule, resulting in a more assertive and aggressive foreign policy.

(b) Effect on Adversary Capabilities. The CHICAN leadership sees itself as a irredentist power and is determined to maintain regional hegemony over the ASEAN region, particularly the SPICEY ISLANDS.

(c) Effect on Friendly Courses of Action

ASEAN is a security community. No member would consider the use of force to settle disputes. The ASEAN members comprise a mix of governments, from totalitarian to democratic institutions. However, the ASEAN nations continue to move in the direction of increased military cooperation focused against a CHICAN hegemony.

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The UN has frequently conferred over CHICAN efforts to establish hegemony over the SPICEY ISLANDS.

(5) Economics

(a) Existing Situation.

CHICAN is a rapidly evolving economic program, despite the totalitarian form of government. The country enjoys strong fundamentals that provide a good basis for economic growth. It is a continental economy with a rich natural resource base and a large domestic market. Its labor force is relatively diligent and well-educated. It has enjoyed a high national savings rate generating substantial capital for domestic investment. However, it is increasing demand for imported petroleum has focused increased attention towards the ASEAN region and the SPICEY ISLANDS petroleum reserves.

(b) Effect on Adversary Capabilities

CHICAN's GDP is estimated at \$1 trillion, per capita GDP is 2,000 and the real growth rate is -5 %. Annual exports are \$15 billion and annual imports are \$20 billion. The defense allocation is a healthy 10 percent of the GDP. Interest in information systems is growing. To further finance this effort, CHICAN is conducting an aggressive arms sales program and offering the services of its space launch program to wealthy client states such as KORONA.

(c) Effect on Friendly Courses of Action

The shift to information technologies over the past four years has been lucrative for the ASEAN nations. The ASEAN members combined GDP is now \$500 billion.

(6) Sociology

(a) Existing Situation.

CHICAN society is struggling to maintain control in an era of the Information Age. State controlled work units still prevail but are not as dominant as a result of increasing channels of outside influence such as global internet and the ASEAN media. Conflict in the region would serve as an opportunity to divert the CHICAN population from internal problems.

Religion is an important influence in the region. Buddhist, Taoist, Christian and Islamic societies are predominant in this region. The CHICAN population is comprised of 50 percent Buddhist, 45 percent Taoist. Birth rate is 17.78/1,000 population. Death rate is 7.63 deaths/1,000 population. Life expectancy is 68 years for males, 69 years for females.

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ASEAN members comprise 30 percent Buddhist, 20 percent Taoist, 25 percent Christian and 25 percent Muslim. Birth rates average is 15.3 births/1,000 population. Death rate is 5.7 deaths/population. Life expectancy is 72 years for males and 78 years for females.

(b) Effect on Adversary Capabilities.

CHICAN will look at the effect of outside influences such as Internet and media as a direct threat to their regime. Cultural integrity is maintained through repressive measures.

(c) Effect on Friendly Courses of Action.

ASEAN linkages are rapidly growing, providing a common bond on several indigenous cultural opportunities. The Information Age is welcomed for it provides a means to increase the social bonds between the islands. Outside influences such as the US or India are also looked upon favorably for the ASEAN leaders see them as a means to catapult them into the leading levels of economic development.

(7) Science and Technology

- (a) **Existing Situation.** With the collapse of the Soviet Union, CHICAN has afforded new opportunities to enhance its military and military-industrial base. Huge amounts of hardware and technology in the areas of aerospace and nuclear fields are being acquired from foreign nationals working in CHICAN defense industries. CHICAN is pursuing a strategy of close political and economic ties to nations that can pay the right price for goods and services offered. CHICAN has invested heavily in the space arena. They have established two space ports (Juneau, Point Barrow) to provide commercial launch for worldwide clients, especially those opposed to US interests.
- (b) **Effect on Adversary Capabilities.** Although a powerful nation in the region, CHICAN's military technology is 8 years behind the west. However, through lucrative financial arrangements with allies such as KORONA, CHICAN has been able to access more sophisticated weapons technology. Additionally, CHICAN's nuclear weapons capability provides a degree of security and national identity against any perceived aggression in the region.
- (c) **Effect on Friendly Courses of Action.** ASEAN members technology is shifting towards information infrastructures. They have developed a lucrative software construction capability based on extensive relations with India over the past 10 years. The US has recently been contracted to provide a source of technology to support ASEAN information architectures.

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b. Adversary Military Situation (Ground, Naval, Air, Other Service)

(1) Strength.

CHICAN is able to project forces in combined operations at some distance from its borders either through maritime or air forces. This is of great concern for the ASEAN nations. CHICAN maintains a significant portion of its army along the southern border. CHICAN air operations continue maritime partrols and combat air patrols adjacent to the SPICEY ISLANDS. The CHICAN navy maintains a substantial rapid reaction force that is amphibious capable. Attack submarine patrols remain at increased operations.

(2) Composition.

Air Force: 50 FLANKER; 200 J-6; 150 J-7; 100 B-7; 50 Q-7; 10 Be-6; 8 EY-8; 5 Boeing 707 In-Flight Refueling A/C

Army: 15 Infantry Divisions; 10 Mechanized Infantry Divisions; 10 Armor Divisions; 6 Rapid Reaction Battalions

Navy: 18 DDGs; 36 FFs; 400 Patrol and Coastal Combatants; 10 SSNs; 50 SS's; 25 Amphibious Assault Ships; 50 Landing Craft; 4 Rapid Reaction Brigades

(3) Location and Disposition.

CHICAN command and control against ASEAN member nations is accomplished at the National Command Headquarters at Anchorage. This provided redundant C3 capability in support of senior civilian governmental leadership. CHICAN Defense Headquarters at Valdez provided the highest echelon military command for the operations in the southern region. The CHICAN joint command centers exercise operational control over all services within their area of responsibility.

(4) Availability of Reinforcements. CHICAN possesses a very dynamic maritime logistics infrastructure to move personnel and equipment to areas around the region. Rapid reaction forces can be called upon to support this effort.

(5) Movements and Activities. CHICAN has established a rapid reaction force and amphibious rapid deployment force based at the Juneau peninsula.

(6) Logistics

Rail and road networks are in place to reinforce the CHICAN front. CHICAN has several excellent ports, the most prominent being Anchorage. CHICAN maintains a large merchant fleet consisting primarily of break bulk cargo, container, and POL

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tankers, none of which exceed 12,000 tons. CHICAN's southern region has over 50 airfields, most of which are all weather.

(7) Operational Capability to Launch Missiles.

CHICAN has over 100 nuclear warheads deployed operationally on ballistic missiles. Additional warheads are in storage. CHICAN is committed to a no first use policy. They possess a significant inventory of mobile missiles. ICBMs are used as strategic weapons and are believed to be totally nuclear-capable. A limited inventory (50 missiles) of IRBMs are capable of ranging targets in the ASEAN region.

(8) Serviceability and Operational Rates of Aircraft

CHICAN Air Force missions are air defense, air support to the army, and anti-submarine warfare. They possess advanced multi-role fighter aircraft capable of maritime attack as well as air defense capabilities. CHICAN air defense is accomplished by SU-30/FLANKER, J-6, J-7 and J-8. FLANKER has been observed uploaded with AA-10 AAM's. FLANKER fighters play a secondary role in the CHICAN Air Defense system; as long as radar-guided SAMs are operational, fighters are normally used along the threat axis, but behind the SAM envelopes. Fighters may be employed for point defense of high value targets. Fighters rely heavily upon accurate and timely GCI information for effective employment of their weapon system. Fighter forces are heavily dependent upon Command and Control. The principal battle management node in the air defense system is the Sector Operations Center (SOC), which is responsible for mission coordination of SAMs and fighters.

Primary anti-shipping operations are conducted by the B-7 fighter/bomber. Anti-submarine warfare (ASUW) is accomplished by Be-6 (MADGE).

CHICAN air support to the army is accomplished by Q-5 fighter/bomber. Most of CHICAN wartime tactical air operations focus on close air support. The aircraft conduct attacks from very low to medium altitudes using various tactics and ordnance. Basic formation is two sections in trail. Prior to entering target area sections, aircraft separate for weapons release in the mission area. Mission success is marginal due to pilot training deficiencies, inadequate pilot involvement in mission planning and inappropriate tactics.

(9) Operational Capabilities of Combatant Vessels

CHICAN Naval units are assigned to CHICAN's two naval bases (Adak, Juneau). CHICAN also maintains two naval relocation/resupply bases designed to provide CHICAN Naval forces with an alternative, survivable support infrastructure in the event of hostilities. These facilities provide refueling, rearmament and limited maintenance/repair support to CHICAN Naval forces.

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(10) Technical Characteristics of Equipment

The majority of CHICAN equipment is indigenously produced. Some US weapons and electronics have been acquired through the marketplace. The marketplace has become the determining factor towards CHICAN military abilities to wage war in the region. CHICAN has established several commercial fronts to acquire technology from leading weapons technology firms. Additional sources of technology came from CHICAN reverse-engineering several weapons technologies. The technicians employed for reverse engineering were hired from industries in Europe and other parts of Asia.

(11) Electronic Intelligence

The CHICAN possesses a dynamic electronic intelligence capability. SIGINT/Radio Electronic Combat (REC) have been upgraded through commercial purchase. SIGINT operations are conducted from Anchorage. Communication intelligence focuses on UHF/VHF/HF command and control, naval and aircraft communications. Many SIGINT acquisitions are designed to collect maritime surveillance information. SIGINT stations are found throughout the southern CHICAN coast. They also possess a small fleet of advanced airborne SIGINT aircraft. The EY-8 aircraft are equipped with the BM/KZ-8608 electronic intelligence (ELINT) system designed to monitor shipborne radar emissions.

(12) Space

CHICAN is developing a space warfare headquarters. Their command center is to be designed to control a system of space stations and bases. They are striving to maintain a warfighting capability consisting of satellites and weapons systems for fighting, command, reconnaissance, and early warning. Presently warning is accomplished by eight phased-array radars along the coast.

CHICAN strategists are seriously concerned about the need to incorporate space satellites and weapons into their operational doctrines. Space is now considered one of CHICAN's strategic frontiers along with land boundaries, territorial waters and airspace. CHICAN possesses a limited number of co-orbital ASAT capability to put at risk low orbiting satellites. They have commenced research on developing a space-based and air-launched ASAT capability. Military satellites are legitimate targets in war and ASAT is a legitimate means to a target.

(13) Nuclear/Chemical/Biological Weapons.

CHICAN has over 100 nuclear warheads deployed operationally on ballistic missiles.

CHICAN has an advanced chemical warfare program, including research and development, production and weaponization capabilities. CHICAN's current

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inventory of chemical agents includes the full range of traditional agents, and is conducting research into more advanced agents. It has a wide variety of delivery systems for chemical agents, including tube artillery, rockets, mortars, landmines, aerial bombs, sprayers, and SRBMs.

CHICAN possesses an advanced biotechnology infrastructure and the biocontainment facilities necessary to perform research and development on lethal pathogens.

(14) **Significant Strengths and Weaknesses.**

CHICAN possesses the strongest military in the region. It covers all dimensions of conflict.

CHICAN's access to state-of-the-art technology is limited to tenuous relationships with nations such as KORONA.

c. **Adversary Unconventional and Psychological Warfare Situation**

- (1) **Guerrilla.** CHICAN possesses a dynamic network of guerrilla cells in place throughout Asia.
- (2) **Psychological.** CHICAN assets continue to mount aggressive collection and disinformation operations against ASEAN.
- (3) **Subversion:** CHICAN can demonstrate a capability.
- (4) **Sabotage.** CHICAN can demonstrate a capability.

d. **Adversary Information Operations (IO)**

(1) **Psychological Operations (PSYOP)**

Global communications are creating a market for providing a twist to the broadcast medium, effecting both allies and adversaries.

(2) **Operations Security (OPSEC)**

CHICAN military security has traditionally been very effective. CHICAN military has been sensitive to the vulnerabilities that exist from global satellite networks and communication access.

CHICAN conducts intelligence collection through several means, to include recruitment of target country nationals, support to dissident groups, assassination and other violent means. CHICAN focuses on acquisition of military and technological information, in addition to counterintelligence operations. This includes criminal, counterintelligence and counter-espionage investigations; collection of military

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intelligence abroad, including technical, political and economic intelligence relevant to foreign military capabilities and intentions; and monitoring activities of foreign military attaches in CHICAN. CHICAN elements continue to mount aggressive collection and disinformation operations against ASEAN and provide intelligence support for radical elements. CHICAN agents abroad are reportedly have four primary techniques for obtaining raw reporting; elicitation, monitoring of overt media, visual observation and human sources. CHICAN conducts telephone intercepts, microphone plants and radio intercepts.

(3) Military Deception

An elite corps of military personnel are trained according to traditional Soviet *maskirovka* (deception) operations.

(4) Physical Destruction

CHICAN's traditional means to put an adversary at risk. The marketplace is providing limited numbers of precision guided munitions.

(5) Electronic Warfare

CHICAN has acquired state-of-the-art equipment from commercial-off-the-shelf purchases as well as through the global weapons industry black market.

(6) Computer Network Attack (CNA)

CHICAN does not have an indigenous network of computer network attack personnel. However, through the market place CHICAN has contracted a viable threat against global information infrastructures (GII). CHICAN has funded an extensive infrastructure of computer hackers from sources through out the globe over the past four years. CHICAN leadership placed a high priority on establishing a global network of computer hackers. Their efforts have been covert, developing strategies to penetrate established national information infrastructures (NII) and defense information infrastructures (DII).

3. Adversary Capabilities.

- a. **Ground Capabilities.** CHICAN ground operations will be primarily amphibious against an ASEAN adversary.
- b. **Air Capabilities**
 - (1) Based on an estimated strength of 300 fighters and medium bomber aircraft, the adversary can attack in the area of operations with 500 sorties per day for the first 2

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days, followed by a sustained rate of 200 sorties per day, and 100 bomber sorties per day, for 1 day followed by a sustained rate of 75 sorties.

- (2) Using airfields in the vicinity of Anchorage, the adversary has sufficient transport sorties to lift one regiment in a single lift to airfields in the vicinity of ASEAN-V, ASEAN-T and ASEAN-P with 2 hours flying time.
- c. **Naval Capabilities.** The growing CHICAN navy is upgrading existing inventories and procuring a new class of missile frigates as well as a new class of various small assault and supporting ships for sustaining operations further from shore and for longer periods. CHICAN can conduct sustained sea and air operations in the ASEAN area.
- d. **Nuclear Capabilities.** CHICAN frequently has stated that it will never be the first to use nuclear weapons against another nuclear power and that it never will use them against a nonnuclear power.
- e. **Chemical Biological.** The adversary can employ CB agents sarin, VX, and mustard in the area of operations at any time delivered by air, cannon, and rocket artillery and by SRBM.
- f. **Unconventional Warfare (UW).** The adversary can conduct UW operations in the area within 3 days after starting the operation using dissident ethnic elements and the political adversaries of the current government.
- g. **Joint Capabilities.** The adversary can continue to defend in its present position with 5 divisions, supported by 3 artillery battalions, and reinforced by 3 mechanized divisions with 48 hours of the starting movement.
Adversary defense also can be supported by 150 fighter sorties daily for a sustained period and by continuous naval surface and air operations employing 8 DGs, 16 DDs, and 20 SSNs.

4. Analysis of Adversary Capabilities.

In a limited war, the premium will be on speed and overwhelming military superiority in order to defeat enemy forces early and decisively. It will require an ability to concentrate firepower on the enemy's own local air, naval, and missile forces. In the early stages of the war, all types of effective methods of attack to destroy the enemy's superiority in high technology weapons and air power before these come into play. Everything from computer viruses to disrupt command to missiles, aircraft, submarines, and elite special forces.

Missile attacks with conventional warheads will be used to attack coalition aircraft carriers, air bases, naval bases and command headquarters.

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5. Conclusions.

CHICAN views their country as an emerging great power and measures their capabilities against the US, not those of lesser powers like ASEAN.

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Understanding Courses of Action

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Command and control assumes shared understanding, and while the fog of war might make communication difficult, incomplete, even ambiguous; and while coalition forces may have different conventions, iconography, and even doctrine; one generally communicates with well-trained people, and people are very good at understanding. Computers are not. For programs to be useful assistants to commanders and staffs, they must understand military operations much better than they do now. I will survey efforts to give computers deep understanding of military operations, particularly planning courses of action and controlling operations, illustrating my brief talk with projects from the DARPA/AFRL High Performance Knowledge Bases project, including my own Capture the Flag war gaming system.

The premise of this paper is that intelligent computer systems will have many important roles in military decision making, command and control. Not everyone agrees with this premise. Recently I visited Marines at Camp Pendleton who told me, "A map with a hole in it is still a map, but a computer with a hole in it is worthless junk." So strong is the reliance on physical media in this culture that maps are copied onto acetates and transported by hand from one command post to another. Most communications are by telephone or radio, not email. Databases are not shared, planning and scheduling are not automated, sensitive data are not redundantly distributed, and situation awareness is maintained with great difficulty in the ephemeral, limited memories of commanders' staffs. At Camp Pendleton I also saw preliminary forays into integrated electronic situation awareness and wearable computers for individual Marines, so I am hopeful that the power of computing will eventually be felt on the battlefield.

The most promising technologies include mobile computing, which allows tasks to migrate in a web of processors, so if one computer is destroyed another picks up where the first left off; visualization of battlespace data, particularly visualizations of the *dynamics* of campaigns; wearable computers to give all soldiers information about their buddies and their tasks, and to provide automated situation awareness; human computer interaction tools, to give soldiers hands-free access to their computers in very difficult circumstances; and a range of techniques that we call planning and decision aids, ranging from logistics scheduling to course of action evaluation.

Some of these applications require information systems to *understand* military operations. My subject in this paper is information systems for course of action analysis. I will describe work on this problem undertaken in the DARPA-sponsored High Performance Knowledge Bases initiative, focusing on our own wargaming system, Capture the Flag. My goal is to show that knowledge-based systems have much to contribute to course of action analysis, particularly when their military knowledge is supported by a foundation of common physical knowledge.

The DARPA High Performance Knowledge Bases Initiative

Early in the summer of 1999, a handful of computer programs will be shown scenarios for courses of action and will offer a wide range of critiques, including these:

The COA may not be suitable because an element of the commander's intent is not accomplished

The COA may not be suitable because one or more of the tasks will not accomplish its purpose

The COA may not be feasible because a unit has inadequate forces for an assigned task

The COA may not be feasible because a unit appears to be excessively constrained (for example, by a control measure), preventing it from accomplishing the mission

The COA assumes some risk or may not be acceptable because a unit is responsible for a disproportionately large area of operations

The COA assumes some risk or may not be acceptable because the COA keeps few or no forces in reserve

The COA assumes some risk or may not be acceptable because a feasible enemy action can cause the mission to fail

The COA sketch provides insufficient control of fires and/or movement

The COA sketch is ambiguous with respect to responsibility for enemy forces

The COA is not effectively applying the principle of mass because the main effort is not weighted for success

This COA is not effectively applying the principle of maneuver because the terrain does not appear to support the form of maneuver indicated

This COA is not effectively applying the principle of surprise because the most suitable terrain available has invariably been chosen for tactical operations

What does a computer program need to know to offer critiques like these? It needs to be able to interpret courses of action, both the textual part and the sketch; it needs to understand phrases like "commander's intent" and "risk" and "principle of surprise"; it needs to understand the role of terrain; it should be able to draw inferences about how forces interact, in particular, it should anticipate success and failure of tasks and subtasks.

The DARPA High Performance Knowledge Bases initiative is building course of action analysis systems with these capabilities (it also is building systems for intelligence analysis in the chemical/biological warfare arena). The systems are provided a scenario with a course of action sketch and a textual description, and these are automatically translated into a formal language (Cycl, a kind of formal logic). The sketch and part of the description of a scenario are shown in Figures 1 and 2.

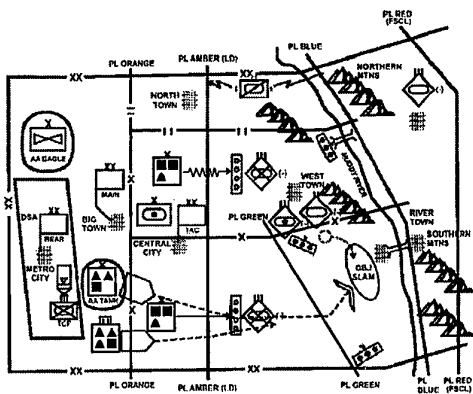


Figure 1. Scenario sketch for HPKB COA analysis problem.

COA Scenario 1

Products of Mission Analysis

Enemy Combat Power

Red unit is a tank division (REDMECHDIVISION 1), consisting of [[2 of mechanized infantry regiment (REDMECHREGIMENT1, REDMECHREGIMENT2) equipped with BTR-60, consisting of [2 of mechanized infantry battalions, equipped with BTR-60 1 of tank battalion, equipped with T-64 1 of artillery battalion equipped with 122mm SP (in direct support)]] ...

Current combat power

Blue unit is a mechanized infantry division (BLUEDIVISION1) consisting of [[2 of mechanized infantry brigade consisting of [2 of mechanized infantry battalions equipped with M2 1 of tank battalion equipped with M1A2 1 of artillery battalion equipped with 155 SP (in direct support)]] ...

Mission of Adjacent Units

Mission and intent one up:

Mission: 10th (US) Corps attacks to destroy Belligerian Guard forces in vicinity South Town 13 0600 Aug XX in order to defeat enemy ability to sustain combat operations in AO GOLD. Intent: The intent is to disrupt enemy ability to sustain combat operations in AO GOLD. First destroy Belligerian Guard in vicinity South Town east of Muddy River. ...

Specified or implied tasks

Seize OBJ SLAM in order to protect boundary between BLUEDIVISION1 and BLUEDIVISION2 (Corps Main Effort) and then retain OBJ SLAM. Prevent enemy forces from penetrate our boundary to the south. ...

Figure 2. Excerpted Scenario Description

Given the sketch and description of a scenario, as in Figures 1 and 2, the next step in automated COA analysis is to generate a formal description of the scenario. This process is largely automated and will eventually be entirely automated. One thing that makes this automation possible is a COA sketching tool developed by Ken Forbus at Northwestern

University. It parses sketches of COAs made by humans and generates formal descriptions of from the sketches. Figure 3 shows a very small fragment of the formal translation of the sketch and text in Figures 1 and 2. You can see statements about battle positions and locations, units and their missions.

```
Constant: BP5.
in Mt: COAExMt.
F: (isa BP5 GeographicalRegion).
F: (hasAttributes BP5 BattlePositionProposed).
F: (nameString BP5 "BP5").
F: (shape BP5 Polygon).

Constant: P265.
in Mt: COAExMt.
F: (isa P265 GeographicalThing).
F: (latitude P265 (Degree-UnitOfAngularMeasure 47.68)).
F: (longitude P265 (Degree-UnitOfAngularMeasure 27.8186)).

Constant: RedArtilleryRegt1.
in Mt: COAExMt.
F: (isa RedArtilleryRegt1 SelfPropelledFieldArtilleryUnit-
MilitarySpecialty).
F: (echelonOfUnit RedArtilleryRegt1 Regiment-
UnitDesignation).
F: (sovereignAllegianceOfOrg RedArtilleryRegt1 Red-Side).
F: (troopStrengthOfUnit RedArtilleryRegt1 ReducedStatus).
F: (structureOfUnitUnspecified RedArtilleryRegt1).
F: (nameString RedArtilleryRegt1 "REDARTILLERYREGT1").

Constant: FollowAndAssume_1.
in Mt: COAExMt.
F: (isa FollowAndAssume_1 MilitaryOffensiveTask).
F: (isa FollowAndAssume_1 Movement-TranslationEvent).
F: (isa FollowAndAssume_1 Translation-SingleTrajectory).
F: (unitAssignedToTask FollowAndAssume_1 BlueTankBgd1).
F: (objectActedOn FollowAndAssume_1 OBJ_Slam).
F: (isa FollowAndAssume_1 FollowAndAssume-MilitaryTask).
F: (mainTaskOfOperation BlueDivisionCOAOp
FollowAndAssume_1).
```

Figure 3. Part of the formal translation of the sketch and text in Figures 1 and 2.

The formal statement of the scenario and the COA supports reasoning, specifically reasoning to answer questions about the strengths and weaknesses of the COA. Reasoning is mediated by a huge number of axioms about courses of action. Axioms are rules that the systems can use to infer conclusions, given premises. For example, the following axioms define what it means to breach a blocked path and a minefield.

```
F : (implies
  (and
    (isa ?PATH Path-Customary)
    (pathState ?PATH PathBlocked))
  (sitResultsInProp
```

```

(thereExists ?BREACH
  (isa ?BLOCK Breach-MilitaryTask))
(pathState ?PATH PathOpen)
Breach-MilitaryTask
pathState)) .

```

```

F : (implies
  (and
    (isa ?BREACH Breach-MilitaryTask)
    (isa ?MF MineField)
    (objectActedOn ?BREACH ?MF))
  (isa ?BREACH (RemovalFn Mine-Weapon)))

```

In the full paper, I will give examples of how axioms like these are used to answer questions. For now, note that answers to questions are generally derived by reasoning with axioms, not by war gaming, yet humans answer questions about courses of action by simulating them. For this reason, among others, my group's contribution to the HPKB COA analysis problem is a war gaming system, called Capture the Flag. Generally, humans play against the system, controlling the units on one side, while an intelligent adversary plans its own COAs and plays the other side. In the HPKB project, however, we run the COAs specified in the scenarios against the intelligent adversary. Although Capture the Flag isn't fully integrated with the other HPKB systems, yet, we anticipate that it will support question-answering as shown in the following illustration (due to Adam Pease, who is responsible for integrating the HPKB systems, including the Cyc knowledge base):

"Blue 11, a mechanized brigade unit (Supporting Effort 1) attacks in the north to fix EF"

- AFS provides the fact that Blue 11 fails in its task
- AFS provides the fact that Blue takes 1 hour to fail

"Blue 12, a mechanized brigade unit (Supporting Effort 2) attacks in the south to penetrate EF vicinity of PL_AMBER in order to enable the conduct of forward passage of lines, and the seizure of OBJ_SLAM by Main Effort"

- AFS provides the fact that Blue 12 takes at least 3 hours to penetrate EF
- Northwestern University's geographic reasoner determines it would take 1 hour for the Red unit that isn't fixed to travel to the red unit at PL_AMBER
- Cyc determines therefore that Blue does not have sufficient time to accomplish the mission because Blue 11 can't fix red for long enough

Although it is exciting to see Capture the Flag integrated as a component of a course of action critiquing system, this is not why we built Capture the Flag. We built it to test the theory that all human knowledge is grounded in a relatively small number of physical schemas. If true, this suggests that knowledge about military campaigns can be constructed readily from a small set of primitives, and this set will constitute an interlingua for translation among different languages and representational conventions in coalition information systems.

The Capture the Flag Project

At the University of Massachusetts we have developed a simulation of war games and a planner, called Capture the Flag, which beats human adversaries in more than half the games it plays. Red forces are controlled by the planner, Blue by a human adversary. Some features of the game are roughly realistic: mobility is influenced by terrain, attrition is modeled by Lanchester equations, and Red forces are coordinated by tactics. Most importantly, tempo strongly influences outcomes. When Blue loses the tempo, Red presses its advantage. A tactical disadvantage quickly spreads to a scenario-wide loss of initiative, Blue becomes reactive, and eventually loses the game.

Although the planner currently plays autonomously, it is intended as a mixed-initiative assistant to human planners. A fielded planner would support course of action development, helping commanders to evaluate alternatives and to "think outside the box." In war games the planner can play autonomously as an intelligent adversary, or as an assistant. Capture the Flag is intended to have the same pedagogical roles as strong chess algorithms: providing a fast, unflagging, powerful opponent for students of tactics and strategy.

The planner wins because it considers a huge number of tactical combinations, it continuously re-evaluates its commitments, it has a better sense of timing than human adversaries, and it doesn't lose track of its assets in complex situations, as humans do. These advantages are interrelated; in particular, timing and tactics are inextricable.

Physical Schema Planning

Capture the Flag is based on the idea that many physical processes are built from a small set of *physical schemas* such as *push*, *move*, *apply force*, *block*, *contain*, *follow*, and so on. Furthermore, these schemas are *primitive* in the sense that every child learns them very early in life, and uses them to plan his or her activities and interpret the activities of others. There is even some evidence that non-physical processes may be grounded in these simple, primitive physical schemas: Lakoff and Johnson, for example, make a strong case that much metaphor involves representing nonphysical things and processes as physical. For example, we speak of grasping an idea, containing information, pressing an advantage, facing an uphill battle, turning up the heat, and so on. I believe that physical schemas really are the foundation of much of what we know, that they explain how sensorimotor agents like infants make the transition to cognitive agents like us. I believe that planning a military campaign involves very similar reasoning as planning an offense in football, or a continuation in chess, or a path through heavy traffic. When my daughter pushes blocks around on her table and calls them cars, she is telling me that cars and her blocks have much in common – mass, velocity, rigid construction – and that the interactions between cars can be simulated by pushing blocks past each other, into each other, lining them up, and so on.

The language of military tactics is essentially physical, and has been at least since Clausewitz introduced physics into the study of warfare. Here are a few excerpts from Clausewitz, selected pretty much at random:

“The conduct of war resembles the workings of an intricate machine with tremendous friction, so that combinations which are easily planned on paper can be executed only with great effort. Consequently the commander's free will and intelligence find themselves hampered at every turn, and remarkable strength of mind and spirit are needed to overcome this resistance.”

“... there is no higher and simpler law of strategy than that of *keeping one's forces concentrated*.”

“... the stronger force not only destroys the weaker, but ... its impetus carries the weaker force along with it. ... In practice this is true, but only when war resembles a mechanical thrust.”

Clausewitz relies on physical metaphors for his characterizations both of units on the battlefield and also for command and control. He views command as a kind of force, sufficient to overcome the friction encountered as a plan is executed.

Because we view tactical warfare as comprising physical processes such as movement, applying force, blocking, supporting, and so on, our Capture the Flag system has three parts:

The Abstract Force Simulator (AFS). Processes in AFS are modeled as interactions of masses, called *blobs*. Blobs have a small set of physical features, including mass, velocity, friction, radius, attack strength, and so on. A blob is an abstract unit; it could be an army, a soldier, or a political entity. Every blob has a small set of primitive actions it can perform, primarily move and apply-force. All other physical schemas are built from these primitives. Simply by changing the physics of the simulator, that is, how mass is affected by collisions, the friction for a blobs moving over types of surfaces, the resilience of units to collisions, and so on., we can transform AFS from a simulator of military units into a simulator of billiard balls.

AFS is a tick-based simulator, but the ticks are small enough to accurately model the physical interactions between blobs. Although blobs themselves move continuously in 2D space, for reasons of efficiency, the properties of this space, such as terrain attributes, are represented as a discrete grid of rectangular cells. Such a grid of cells is also used internally to bin spatially proximal blobs, making the time complexity of collision detection and blob sensor modeling no greater than linear in terms of the number of blobs in the simulator. AFS was designed from the outset to be able to simulate large numbers (on the order of hundreds or thousands) of blobs. The physics of the simulation are presently defined by the following parameters:

Blob-specific attributes:

- maximum acceleration and deceleration
- friction of the blob on different surfaces
- viscosity and elasticity: do blobs pass through one another or bounce off?

Global parameters:

- the effect of terrain on blobs
- the different types of blobs present in the simulation (such as blobs that need sustenance)
- the damage model: how blobs affect each others' masses by moving through each other or applying force.
- sustenance model: do blobs have to be resupplied in order to prevent them from losing mass?

AFS allows us to express a blob's internal structure by composing it from smaller blobs, much like an army is composed of smaller organizational units and ultimately individual soldiers. But we don't have to take the internal structure into account when simulating, since at any level of abstraction, every blob is completely characterized by the physical attributes associated with it. Armies can move and apply force just like individual soldiers do. The physics of armies is different than the physics of soldiers, and the time and space scales are different, but the main idea behind AFS is that we can simulate at the "army" level if we so desire – if we believe it is unnecessary or inefficient to simulate in more detail.

Since AFS is basically just simulating physics, the top-level control loop of the simulator is quite straightforward: On each tick, loop over all blobs in the simulator and update each one based on the forces acting on it. If blobs interact, the physics of the world will specify what form their interaction will take. Then update the blob's low-level sensors, if it has any. Each blob is assumed to have a state reflector, a data structure that expresses the current state of the blob's sensory experience. It is the simulator's job to update this data structure.

Hierarchical Agent Control

The blob control architecture is hierarchical. We use the physical primitives *move* and *apply-force* to construct schematic plans for domain-specific actions like convoy and sneak-attack. Higher levels of control provide goals and context for the lower levels, and lower levels provide sensory reports, messages, and errors to the higher levels. A higher level cannot overrule the sensory information provided by a lower level, nor can a lower level interfere with the control of a higher level.

The AFS control architecture provides facilities for sensor management, action scheduling, message passing, and resource arbitration. Since all of AFS's actions are physically grounded, we can even control real-life robots.

The GRASP Planner

Capture the Flag has many agents and flags on each side. Any generative planning solution would face an enormous branching factor since many possible action combinations can be executed at any given time. To cope with this problem, we rely on a partial hierarchical planner, which retrieves plans from a set of pre-compiled skeletal plans, and uses heuristics to allocate resources in a reasonable way (for example, an *attack* plan will rarely attack a target with a smaller force than the force defending it).

When several plans apply, military planners will play out a plan and determine how the opponent might react to it. A wargame is a qualitative simulation. The Capture the Flag planner does the same: it simulates potential plans at some abstract level, then applies a static evaluation function to select the best plan. The static evaluation function incorporates such factors as relative strength and number of captured and threatened flags of both teams, to describe how desirable this future world state is.

Simulation is a costly operation, and in order to do it efficiently, Capture the Flag must be able to jump ahead to times when interesting events take place in the world. This is difficult because Capture the Flag takes place in continuous space and essentially continuous time. Naïve forward search is intractable because the search space is essentially infinite. Naïve decomposition of the state space into states, for instance, by laying a grid over the physical space or advancing time by pre-established large units, introduces a variety of pathologies. Our solution is to dynamically find state boundaries called *critical points*. Instead of advancing the world tick by tick, which is time-consuming, we jump right to the next critical point.

A critical point is a time during the execution of an action where a decision might be made, or the time at which it might change its behavior. If this decision can be made at any time during an interval, it is the *latest* such time.

Critical point search is illustrated in Figure 4, in which a white blob is considering attacking a black flag. The search is complicated by a black blob in the vicinity. It might defend its flag or attack the white flag. The white planner wishes to assess the outcome of its plan in both conditions. It could do this by advancing time forward in very small increments, expanding the entire state space of the interaction between the forces, but fortunately, it doesn't have to. The points marked CP in Figure 4 are critical points for white's plan. The first (the one closest to the white blob's current location) occurs at the last instant at which the black blob could move back to its flag and defend it successfully. The second occurs at the last instant at which the white blob could abandon its attack and scurry back to defend its flag if black attacks it. It is not necessary, to evaluate white's plan, to simulate the state of the game *except* at these points and the points at which black and white reach their own or opponent flags. Critical point search is very efficient and allows the planner to evaluate plans by straightforward minimax search.

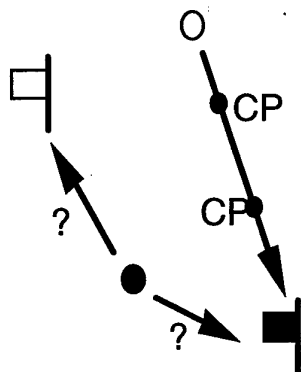


Figure 4. An illustration of critical points for search.

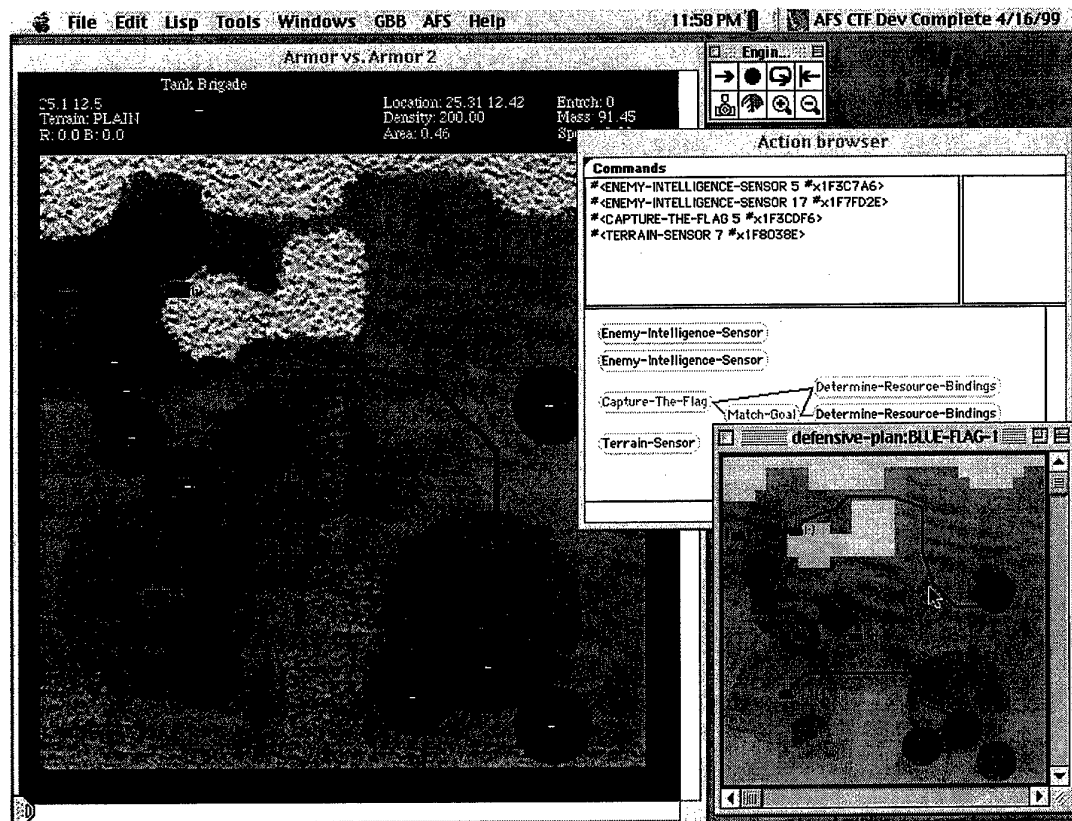


Figure 5. A screen capture of the Capture the Flag system

A screen image of the Capture the Flag system is shown in Figure 5. The leftmost panel shows the state of the game with forces arrayed on terrain. One can make out military symbols for these forces. The circles around each show the radius of direct fire – the region within which one blob can apply force to another. The arrows in the leftmost panel represent part of the Red planner's plan. A similar image in the lower right of the screen represents the Red planner's assessment of Blue's best actions. The other panel shows part of the plan hierarchy for the Red planner.

Conclusion

The premise of this paper is that computer systems can understand courses of action and other aspects of military command and control, but to do so requires vast amounts of knowledge. I have illustrated this point with the HPKB course of action analysis problem, and with the Capture the Flag wargaming system. The latter system is particularly interesting from the standpoint of coalition forces because it is grounded in a small number of physical schemas, which could form an interlingua for translating between assertions in formal systems used by different coalition partners.

Using Shared Models of Activity to Underpin Coalition Planning

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Abstract

A shared understanding, based on a shared underlying conceptual model, for objectives, the world state, activities, plans, the planning process, and inter-agent responsibilities and authorities can provide a framework for systems to support Coalition Operations. Such a shared model can have value in supporting separate organisational entities with their own internal or legacy systems, but coming together into "virtual organisations" for specific missions and to achieve specific objectives.

This paper describes research which it is proposed is conducted within the US DARPA Control of Agent-Based Systems (CoABS) Program.

Introduction

We intend to address the issue of how to make productive use of human and computer-based agents who are cooperating to carry out one or more tasks where multiple options for a solution are being considered. We will explore mixed initiative interaction between autonomous human and software agents in an environment where the agents may play a variety of roles, have varying capabilities and availability (time and resource limitations), and are constrained by the authorities they have been given. Crucially, many of these aspects will be dynamically determined via agent interactions within the agent organization.

We will contribute towards the development of agent interoperability standards, develop prototype tools, and ensure that the concepts are effectively taken up by providing readily available demonstrations of the concepts in a simple framework. The work plan will seek to ensure that the project team is able to engage with those organizations and individuals capable of transferring the concepts and technology into productive military use.

Our proposal is focussed on Team Coordination. To address the creation of agents that can play roles as team members, we will investigate both the agents that

can fit into teams and the organizational structure of the teams themselves. It is possible for such a "team player" agent to act as a controller, maintaining coordination with further computational resources, agents or humans. Team coordination will play a central role in agent-based organizations, including cases that involve specialized human agents. Moreover, team structures will continue to be useful for software agents, just as they have continued to be useful for humans, even when there are large numbers of self-organizing adaptive agents.

Our work on "Team Player Agents" will begin by using a particular team structure which we believe is well-suited to cooperative planning and control and to the envisaged demonstrations of the team coordination approach in a suitable challenge problem domain. However, we believe that general principles will emerge from this structure.

Our approach allows agents to take initiative within the authorities or autonomy they have been allowed. This can be dynamically and precisely defined. We will employ a set of related models shared by agents to underpin purposeful coordination. The models provide:

- **Shared Task Model** – a mixed initiative model of the cooperative planning and control tasks as "mutually constraining the space of behavior".
- **Shared Plan Model** – a rich plan representation using a common constraint model of activity.
- **Shared Space of Options** – explicit inter-agent option management.
- **Shared Model of Agent Processing Capabilities** – as handlers of outstanding issues.
- **Shared Understanding of Authority** – management of the authority to do work (to handle issues).

In particular, the work will explore authority management between agents, and the content of such communication. This central aspect makes use of the other

models shared by the agents. A workflow management approach will be the basis for each agent's understanding of its tasking environment. Each agent will have a set of agendas reflecting its links to other agents, and a set of outstanding issues within its problem solving state for the range of options it is working on.

Explicit management of inter-agent process coordination will be used as a basis for the creation of prototype configurable process state visualization and management control tools – which we refer to as “Intelligent Process Panels” – I-P². Hierarchical abstraction will be employed to ensure communication at an appropriate level to the agents and humans involved. The panels will be used for experiments with a variety of team coordination aids. Earlier work on a “COA Evaluation Matrix” interface to a web-accessible O-Plan Planner Agent, and on an Air Campaign Planning “Process Panel” (ACP³) within ARPT's TIE 97-1, will be used as a basis for this work.

The project's deliverables will include agent control concepts, re-usable shared models of agent organizations suited to cooperative planning and control, re-usable prototype tools and packaged web-accessible demonstrations on chosen challenge problems.

The research could demonstrate the following benefits for future military systems involving teams of human and software agents:

- Utility as a unifying principle for inter-agent and tool coordination and for user interface design.
- Management of “to do” lists for software agents and humans.
- Allowance for configuration or re-configuration of process flow to suit user needs and to respond to circumstances.
- Integration basis for future inter-agent mixed initiative planning framework for co-operative problem solving, intelligent workflow, distributed event handling and process management.
- Looking towards future active Intelligent Task and Option Management rather than simple workflow step enactment.

The need for aids to support team coordination becomes more important as the scenario environment gets more ambitious. It becomes vital when multiple options are being concurrently developed by teams in which the members are changing over time (such as in hand overs and shift working).

Our approach is compatible with the “Model-Viewer-Controller” style of systems integration architecture being promoted by the JTF ATD Reference

Architecture and its successors leading up to the AITS Reference Architecture. We are promoting the use of explicit management of intelligent authorizable agents within a task-driven environment as a basis for mixed initiative interaction supportable by the controller in the AITS architecture and related systems in use in JFACC and a range of DARPA-sponsored programs. The research proposed will allow us to engage with the communities developing standards for the architecture, for the representations used within it, and for the component technologies that it will integrate.

We intend to develop links with other CoABS program participants to develop a suitable challenge problem or scenario. This would form a concrete example to refine our own concepts and ensure that they are usable in a variety of agent integration architectures.

It has been suggested by the DARPA CoABS Program management that a scenario relating to Coalition Operations could form a suitable basis for our work.

Innovative Claims

We will explore a number of interrelated ways to maintain effective control of agent systems and to enable agents in a team to cooperate purposefully to solve problems requiring multiple skills and needing multiple solution options. We will investigate both the agents that can fit into teams and the organizational structure of the teams themselves, bringing together work in AI Planning with recent advances in process management, workflow and organizational modeling.

We will address a problem typical of that found in many realistic military planning environments. A mixture of human specialists and computational agents will work together to explore multiple plan options to deal with a dynamically evolving situation.

To address this scenario we will create novel ways to represent and use authority among agents, and we will explore the contents of such authority descriptions. The capabilities and roles of the agents involved and their relationships to one another will be modeled. AI planning technology will be used to assist agents in planning their own or a team's cooperative processes, in seeking sub-processes to respond to dynamically assigned tasks, and to adapt to changing circumstances, or to problems that emerge with a previously selected process plan.

Our approach to effective inter-agent cooperation can be outlined as follows:

- Inter-related, shared models provide a sound basis for agent cooperation.
- Authority management among the agents in a team is an effective way to control behavior and prevent

conflicts.

- Clear definition of the roles and capabilities of humans and systems assists in agent communication and task-driven cooperation.
- Team activity monitoring and visualization via configurable "Planning Process Panels" helps human users to control and understand agent system behavior.
- Team activity and individual agent workflow planning and re-planning allow agents and teams to better manage their own activities.
- Agent agendas support inter-agent tasking, keeping track of agent activity, and can support explanation of what's happening.

A possible extension would be to record and make use of process design decision rationale, alongside the complementary dependency and causal rationale which is traditionally found in process and activity models. Communication of this knowledge would be used to support decision-making by promoting a shared understanding of each agent's objectives and the outstanding issues along with the options being considered to address them. It would connect agents to their specific roles and responsibilities in the planning and control processes.

Vision

Agent Organization

Our proposal addresses the coordination of work between members of a team of specialist human and software agents to realize the benefits of an agent approach to defining an overall system which can act purposefully. Our approach sets in place an *organization* of agents much as is found in normal enterprises. Clear tasking, an understanding of authority management, and shared models of how agents perform their functions and interact are the basic building blocks to be explored in the proposed research.

An organization contains a set of agents. These agents may be individual humans or system tools, or they may act as a representative, or a coordinator, of a team of other agents¹. Each plays one or more roles which in some cases may be dynamically determined. Depending on their role in the organization, some are

able to accept tasking from other agents or from outside the organization. Each agent has a set of capabilities which determine the functions it can perform² and the quality and responsiveness it can achieve in the performance of those functions. The availability of agents in time and space, and the cost of using those agents, will be variable (for both human and software agents).

Cooperative Planning and Execution Tasks

We will show (i) the selection of suitable processes for performing planning and control tasks that involve dynamic configuration of an agent team, (ii) team cooperation on the task, and (iii) the responsive reorganization of the processes and team as circumstances vary. We will demonstrate that the inter-agent models enable robust and purposeful cooperative exploration of multiple options for behavior in the domain for which the plans are being created.

Each agent will maintain its own unique perspective on the shared tasks being undertaken by the organization. We will create "Planning Process Panels" to act as a human agent's window on the status of the organization or agent team's work. Such panels will also support an agent in calling up sub-processes suited to the particular tasks in hand, and the resources that can be used to perform these tasks at any time – using an intelligent workflow planning aid [Drabble *et al.*, 1997a]. Dynamic reconfigurability to repair processes "on-the-fly" [Drabble *et al.*, 1997b; Reece *et al.*, 1993] will be incorporated. For agents with suitable roles and authority, this same panel will act as a "Process Control Panel". Each panel will be customizable to reflect the level of abstraction which the agent or user wishes to see, the role they play, the permissions they have to task other agents, the capabilities they have available, and so on.

Inter-Agent Task Driven Cooperation

We have elected to work with just two human agents in order to simplify the research infrastructure and tools needed to demonstrate the concepts to be explored during the research³. We will use a scenario of two human agents and a collection of software agents (some of which may have direct user interfaces involving the two "agent" humans or others interacting in this limited

²These could also be dynamically determined, but in the proposed research they will be considered fixed to make the areas to be explored tractable.

³This is a limitation for the demonstrations and evaluation experiments only. The team coordination framework to be explored will allow for multiple human or software agents.

¹An example of such a coordinator might be a "room representative" in Mitre's Collaborative Virtual Workspace.

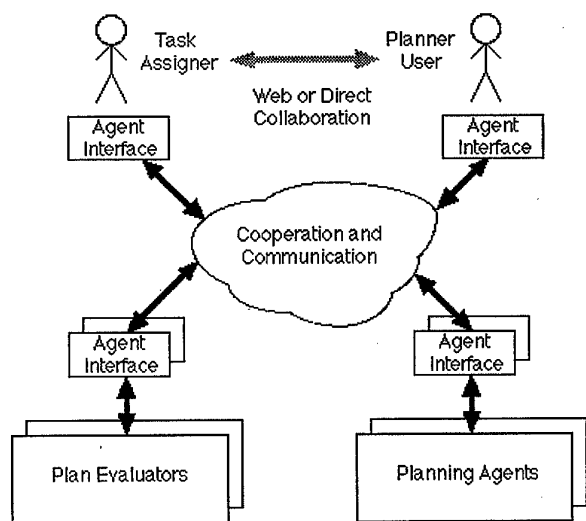


Figure 1: User Collaboration and Agent Cooperation

way). This is shown in Figure 1. The human and system agents will have a range of different roles and have differing responsibility (authority) and technical capabilities to perform their joint tasks. The two humans would play roles equivalent to a commander and a military staff member. The system tools and agents would provide automated or semi-automated planning, plan evaluation and execution support. We envisage that between 5 and 10 such automated agents will be used, dependent on the scenarios chosen. The human and software agents within the environment would interface via a suitable agent "wrapper" through the communications network (local or wide area). However, the project will take as an assumption that direct human-to-human communication is possible via other routes (via collaboration software or directly), and that some tools may be used directly by users outside of the scope of the communicated agent-to-agent interactions. This is a realistic situation in many organizations. We will also assume that some of the software agents "wrap" legacy applications and cannot therefore be assumed to be able to provide processing state feedback unless the agents themselves communicate such information⁴.

While only a small number of agents are involved, the rich possible interactions between groups of such agents will be represented in the work. The two humans will communicate using readily available (and

⁴These are assumptions used in an approach the project team has taken before in realistic enterprise process support for a number of practical applications [Fraser and Tate, 1995]

low cost) collaboration tools (initially conferencing tools within Netscape 4 or Internet Explorer 4). However, we believe that the concepts we will explore will be relevant to more than two humans, and will be compatible with more sophisticated collaboration tools such as MCC's Collaboration Management Infrastructure or Mitre's Collaborative Virtual Workspace. On TIEs within and beyond the ABS program, we hope to work with these groups to achieve a synergy of approaches to add task-driven cooperation based on shared models into the emerging collaboration tools.

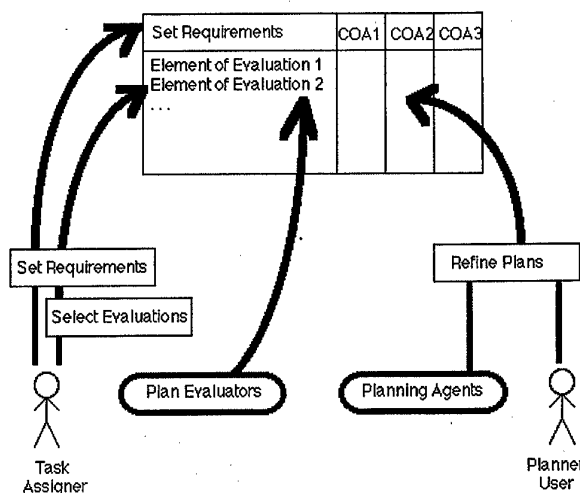


Figure 2: Roles of the Human and Software Agents

The human agents and some of the software agents would be truly mixed initiative, and able to take the initiative within their (dynamically assigned) authorities and capabilities in the collaboration. Figure 2 illustrates the individual roles that could be assigned to the agents for a shared model of the task of providing a set of alternative Courses Of Action (COAs) for some task and providing comparative evaluations of those COAs. In this scenario, there is a "Task Assigning" commander, a human planning staff member, and a set of cooperating computer-based planning and plan evaluation agents. The human and software agents can cooperate by having a shared understanding of their roles and authorities in the development of the "COA Matrix".

Technical Rationale

This proposal addresses the control of agents that can be members of a team and can coordinate their efforts with other human and software agents. A shared view of the cooperation and authority relationships between agents and the roles of those agents is used to guide or

constrain agent activity and to ensure that it is productively channeled towards task achievement. The approach involves work in a number of related areas which are described in the following sections:

Shared Models and Standards

We will investigate the use of shared models for task-directed communication between human and software agents who are jointly exploring a range of alternative options for activity (COAs). Activity planning is chosen as a demonstration area for the proposed research in order to make maximum use of previous research assets of the project team. However, the approach is intended to apply across a range of other types of co-operative tasks.

Five concepts are being used as the basis for exploring multi-agent and mixed initiative work involving humans and software systems. Together these provide for a *shared* model of what each agent can and is authorized to do and what those agents can act upon. The concepts are:

1. **Shared Task Model** – a mixed initiative model of the cooperative planning task as “mutually constraining the space of behavior” [Tate, 1994].
2. **Shared Plan Model** – a rich plan representation using a common constraint model of activity (<I-N-CA>) - based on our earlier work on <I-N-OVA> [Tate, 1996].
3. **Shared Space of Options** – explicit option management [Tate et. al., 1998].
4. **Shared Model of Agent Processing Capabilities** – handlers for issues, agent functional capabilities and constraint managers [Tate et. al., 1996].
5. **Shared Understanding of Authority** – management of the authority to do work (to handle issues) which may take into account options, phases and levels of abstraction of the work processes [Tate, 1993; Jarvis et. al., 1999].

The proposed research will develop all aspects of these important and related shared models, but will particularly seek to make significant progress on the authority management aspect. This central aspect in turn involves communication about all the other shared models.

Using these shared views of the roles and function of various users and systems involved in a command, planning and control environment, we will demonstrate a number of planning agents being used to support mixed initiative task specification and plan refinement over the world wide web.

I-X - I-Technology

Previous work on O-Plan (Open Planning Architecture [Currie and Tate, 1991; Tate et. al., 1994]) has explored mixed initiative planning methods and their application to realistic problems in logistics, air campaign planning and crisis action response [Tate et. al., 1996] and Non-Combatant Evacuation Operations (NEOs) [Drabble et. al., 1995; Tate, 1994]. A number of “user roles” were identified to help clarify some of the types of interaction involved and to assist in the provision of suitable support to the various roles [Tate, 1994]. A demonstration environment has been created which uses the World Wide Web to allow users access from any web browser to an O-Plan planning agent (see Figure 3 [Tate et. al., 1998]).

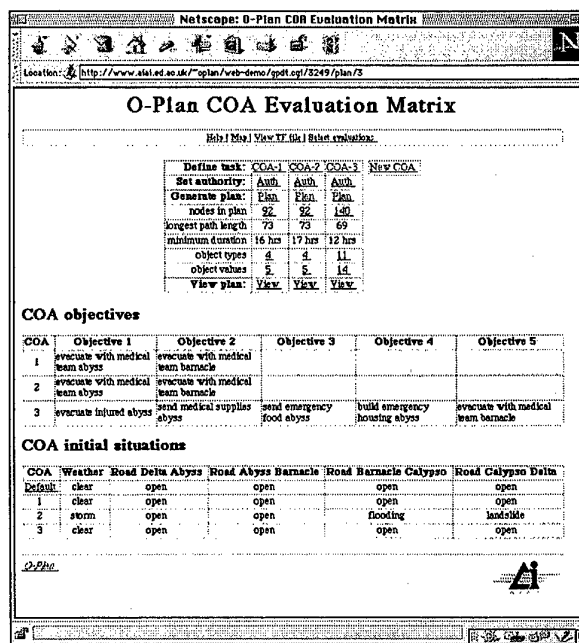


Figure 3: O-Plan Pacifica “COA Matrix” Demonstration

A number of aspects of the O-Plan Technology base have become more important to our work in explicit process management and workflow support for communities of agents. These include a process editor and its library, process and workflow control panels, and user interface technology for displaying the status of cooperation in a mixed initiative environment. We are proposing to draw on the existing O-Plan technology and systems to further develop some of these aspects, to make the underlying concepts clearer, and to better package them for use by others. We also plan to implement much of the

new systems in Java. We call the systems collectively *I-X - I-Technology* - the "I" standing for "Intelligent" amongst other things. See the web page at <http://www.aiai.ed.ac.uk/project/ix> [Tate, 1999] for more details.

We propose to conduct the I-Technology work of the project in such a way that the system and its demonstrations will be available via web delivery either running on Edinburgh servers for demonstration and occasional use, or available for freely accessible download for use by others in an embedded or packaged way in their own systems. *Lightweight* Java-based tools are to be created to support the work⁵. Java-based process/task management control panels will be used to act as a focus for the investigation of suitable views onto the shared models and controls that are helpful to the different roles of the users involved.

While the I-Technology package prototyping environment includes modules for each necessary part of the system, it is not proposed that each be developed to the same level of detail. The eventual aim is that the concepts and modules simply act as a framework to show how shared protocols and models can be interchanged between tools that perform the specific roles of each module included. Importantly, it is also not anticipated that the tools to be developed act as an alternative to system integration frameworks (such as the JTF ATD Reference Architecture or its successors, the GCCS LES Framework and the AITS Reference Architecture). Rather, the research proposed and the individual modules will act as guides to next-generation possibilities for parts of these environments. It is anticipated that this will allow convergence with next generation COTS and GOTS tools and protocols - which by then may have been influenced by the proposed research.

There will be 6 parts in the I-Technology Package:

1. I-PE - a process editor that can be used to create and maintain the process models used for inter-agent activity. Import and export to and from other formats will be supported. The eventual aim is for the development of the Process Editor to be taken much further by incorporating research in process rationale capture and explicit design process issue recording in such a way that it can be used in all other aspects of this research.
2. I-PL - an interface to a process librarian for storing and retrieving process models for use elsewhere in

⁵In a similar way to AIAI's earlier C++ based HARDY Meta-CASE and Model-to-Web publishing tools released freely and in widespread use - e.g. for ACP Process Modeling under ARPI - see <http://arpi.isx.com/community/doma.html>.

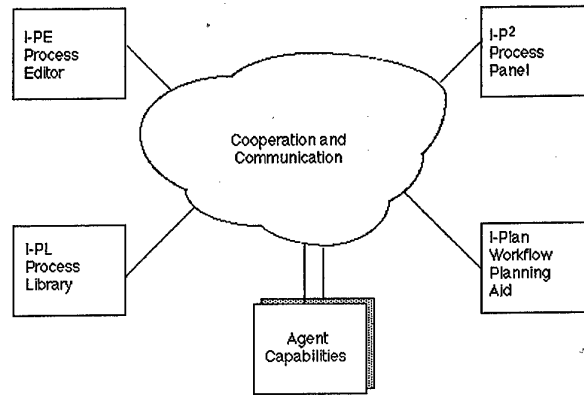


Figure 4: Components of the I-Technology Package

the agent environment. It is anticipated that this will be quite simple in its implementation. The research on this aspect will rather concentrate on the interfaces to such a library as it is anticipated that object-oriented standard librarians will be created by others in the DARPA and military program community.

3. I-P² - an intelligent workflow controller technology base that will allow process status visualization or process control panels to be created for individual human agents. The technology will support alternative views of the status of the process, the agents involved and the process products that are being created or modified. Our emerging model of inter-agent authority management in a mixed initiative environment will be supported. The technology will be designed to be incorporated alongside COTS or GOTS workflow technologies, or to be an experimental base for novel explorations of new workflow control principles.
4. I-Plan as a workflow planning aid - as a demonstration of a specialist process an agent management aid, an O-Plan agent (using existing O-Plan technology), will be incorporated. This will be based on earlier work on using O-Plan as an ACP Process Workflow Planning Aid, performed in a "qualifier" for an earlier proposed demonstrator (IFD-5) under ARPI [Drabble *et. al.*, 1997].
5. I-Plan as a system component or agent capability - as a demonstration of an automated authorizable mixed initiative planning agent within the framework. It is anticipated that cooperation with others under the CoABS program will lead to the characterization of their technologies in such a way that

these can be defined as such capabilities. Our work to define a Process Panel for TIE 97-1 under ARPI has allowed us to perform some initial work on such a task involving 7 DARPA-sponsored research tools.

6. A set of demonstration and briefing materials to make use of the above Technology Package. This will allow for the incorporation of the domain demonstration materials if they are not considered sensitive.

As mentioned earlier, each part of this framework will not be developed to the same level of detail. Some (such as the Process Librarian) will be simple versions that act as stubs for more comprehensive and standardized services (such as CORBA-compliant object systems) that will perform these roles in future military systems. We will use standard basic protocols at a transport layer that are already widely adopted (KQML is likely, though this would be easily reconfigured).

We will particularly concentrate on the creation of the configurable Intelligent Process Panel Technology (I-P²), and a Process Editor that can support configurable and adaptable process models which can record process causal and dependency rationale (and with an optional work package – process design rationale [Polyak and Tate, 1998]).

I-P² – Process Panel User Interface Technology

Process status visualization tools have already been explored by us as part of ARPI's TIE 97-1. This used user interface and process display concepts that have emerged from O-Plan research on mixed initiative workflow to support crisis management planning and control [Tate et. al., 1998]. An example Air Campaign Planning Process Panel (ACP³) proposed for monitoring agent interactions (human and 7 different systems communicating both manually and via KQML) is shown in Figure 5. Such tools have been crafted specifically for the demonstration needs to date and have used a mixture of CGI scripting, a Lisp-based HTTP server, and hand crafted Java code. The experience gained will now enable us to package the concepts for more flexible re-use and configurability – using a wider range of process status displays, e.g.,

- process perspective
- process product or results perspective
- task/objective status perspective
- option under exploration perspective

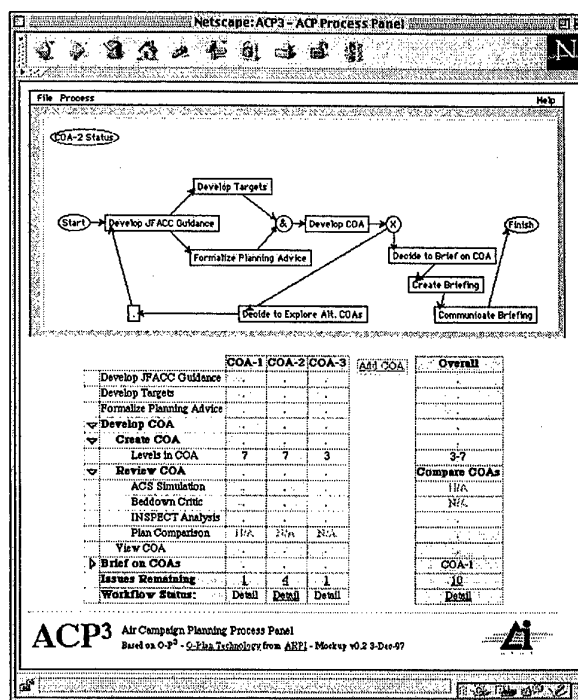


Figure 5: ACP³ – Air Campaign Planning Process Panel from ARPI TIE 97-1 and EFX-98

- agent or system tool perspective

The design incorporates facilities to enable such a panel to act as an *Process Control Panel* for an agent to interact in a mixed initiative way with others. The model of Mixed Initiative Interaction for a Planning and Control environment that can be supported by the approach is the *mutual constraining of behavior by refining a set of alternative partial plans*. Humans and software systems can work in harmony through employing a shared view of their roles as being to constrain the space of admitted behavior. Workflow ordering and priorities can be applied to impose specific styles of authority to plan within the system. Two extremes are possible: user driven plan expansion followed by system “filling-in” of details; or fully automatic system-driven planning (with perhaps occasional appeals to an user to take predefined decisions). In more practical use, we envisage a mixed initiative form of interaction in which humans and software systems proceed by mutually constraining the plan using their own areas of strength.

I-PE – Multi-Perspective and Issue-Based Process Editor

A process editor will be created (as a Java-based web accessible facility) to support the initial creation, and subsequent maintenance of, the shared models of the domain which are required.

Issue-based reasoning will be used to capture the state of modeling especially when multiple domain experts and modelers are involved and there are inconsistencies in the information available. We call this approach *Multi-Perspective Modeling*. An initial methodology for planning domain modeling (the *O-Plan TF Method*) will be developed further. We will extend this process/plan domain modeling methodology to allow for the design of structures for teams of agents, involving such things as establishing roles and authorities. Simple tools currently being used to validate a domain model when loaded into a planner (as in the *O-Plan TF Compiler*) will be elaborated to provide greater support during domain construction and maintenance. Import and export facilities from and to emerging standard representations such as IDEF0, PIF, NIST PSL, HPKB's PSM Language and SPAR will be provided in a robust way.

As shown in Figure 6, AIAI has been moving towards an approach to support modeling where we use a range of methods, and create a single shared model based on one or more small generic ontologies or conceptual models. The terminology in the model is anchored in a lexicon, which itself can be developed during modeling. Modeling support is provided by the creation of an *agenda* of outstanding modeling *issues*. These will eventually be handled by seeking *issue handlers* which will select appropriate methods or tools to help the modeler address the outstanding issues.

AIAI has done practical modeling work using this technique (e.g. on the ARPI ISAT Project Air Campaign Planning Process and with the UK Search and Rescue Coordination Center). We have also used Multi-Perspective Approaches to reasoning about plans in the O-Plan work under ARPI.

Typical multiple perspective modeling approaches used by us have created a single ontologically underpinned model using our work on ontologies for processes and for enterprises and utilizing several modeling methods from Europe (such as CommonKADS - itself combining a number of perspectives), the UK (such as Role/Activity Diagrams), and the USA (such as IDEF-3). Multiple-view or multiple perspective modeling is viewed in the software engineering and requirements capture communities as a valuable technique.

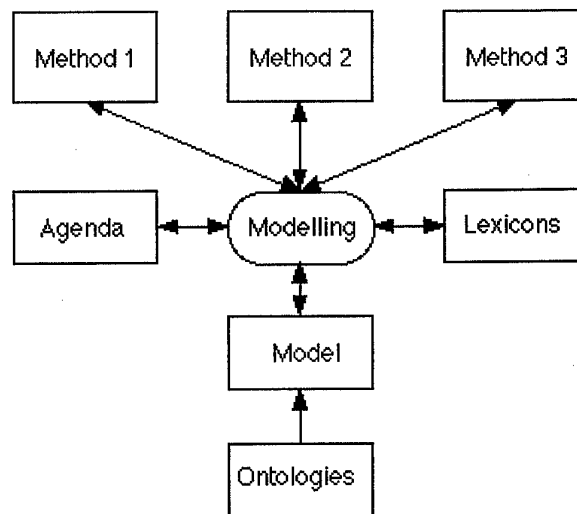


Figure 6: Multi-Perspective Modeling Approach

Inter-Agent Rationale Communication

In the proposed optional work package (WP7), we wish to renew work (which has languished since the mid 1980s) on the capture of design and decision rationale in plans and process descriptions [Daniel, 1983]. In this earlier work, decisions were captured during planning via decision graphs. These graphs were used to maintain the dependencies between a planning agent's decisions and the resultant structure of the plan. This facilitated intelligent re-planning since failures in plan execution could be traced back to the original decision. Only plan elements that depended on this decision were removed from the plan. This provided value to automated planning, but applies to human cooperation aspects as well.

This type of knowledge can be used to build a bridge between work on design rationale capture and the use of such information in process management and planning. One planning perspective considers a plan to be a specialized type of design [Tate, 1996a]. Given this viewpoint, we can incorporate design rationale research by managing a plan or plan fragment as a designed artifact. A rich corpus of methods, representations, notations, etc. from the design research community [Moran and Carroll, 1996] can be drawn upon to effectively and efficiently utilize this knowledge.

This decision rationale is complementary to the dependencies and causal rationale that is maintained in most AI planners today. We recently completed a review of these aspects of planning rationale [Polyak and Tate, 1998]. In this review, we point out the fact that

decision rationale in AI planning is still in its infancy and we report on some of our initial work in incorporating a design rationale approach. The design rationale will be utilized across the proposal framework, and its utility will be evaluated.

Evaluation Plan

The overall aim of this work is to have human and software agents working together to construct shared plans and to explore a range of alternative plan options. Our proposal is that the coordination of the effort will be facilitated by the twin notions of authority and user roles. This is analogous to the authority models and user roles adopted by human teams to ensure that members work together efficiently while cooperating and negotiating on areas of mutual interest.

We propose four related strands of evaluation work: experimentation with authority models, tackling the ABS program challenge problems that are appropriate to our work, qualitative comparison of each of our demonstration deliverables [D1, D2 and D3] against our proposed vision; and extension of our existing software instrumentation and testing to deal with plans requiring the cooperation of more than one planning agent. Each of these strands is described in the sections which follow.

Authority Models and User Roles

Our team coordination approach allows multiple planning agents, plan evaluation agents and human users to work together to explore a range of courses of action to be used in response to a developing situation.

We will experiment with different authority models to see which features produce the best results for various problems, including challenge problems selected from the set proposed for the ABS program. A hypothesis for this has been provided through task analyses in a range of realistic problems (see [Tate, 1994]). We will experiment with different styles of interaction between the computer and human agents, based on the explicit and shared notion of an authority to perform some action (such as the authority to plan) and with the human agents being assigned user roles (such as task assignment agent), with appropriate interfaces being provided to the human agents.

There are a number of trade-offs to be explored in this area. A strict model of authority would result in no conflict between agents, but might also result in a low quality solution (due to not allowing agents to do things that might improve the plan), under-use of agents capabilities, or tedious and trivial user interaction. The opposite model, of allowing all agents to do everything they are capable of with no agent hav-

ing authority over another, could result in an unnecessary amount of conflict, including deadlocked situations. Any model of authority proposed needs to be tested for the quality of the solution, the time taken to reach that solution, the amount of time spent in unproductive conflict, perceived support to some types of user, and so on.

Coalition Challenge Problems

Well-designed challenge problems are an important part of our evaluation strategy. It is our wish to select a challenge problem that requires support to Coalition military operations in areas such as Operations Other Than War (OOTW). We are already familiar with operations such as Non-combatant Evacuation Operations (NEOs), so these might be one areas to explore with potential collaborators.

In tackling these challenge problems, we hope to demonstrate two important aspects of the proposed work. The first is the basic technical capability of the software planning and plan evaluation agents to work together to construct and criticize a plan in these complex domains. The second is the ability of the system of agents as a whole, including the human agents, to effectively and efficiently explore a space of possible plan options to respond to an emerging situation. This will involve experimentation using simulated user trials at AIAI, with the human agents being appropriately briefed and then given a scenario to respond to. The subjects for these trials would be members of AIAI staff and students from the Division of Infomatics. These trials would not only give a measure of the success in tackling the challenge problems, but would also give valuable feedback for the system developers on (for example) the style of graphical interaction with the system (i.e. the interfaces provided for the human agents to interact with the other agents present).

Comparison with Proposed Vision

Each of our demonstration deliverables represents a step towards our proposed vision. It is therefore essential to compare each one against our final goal to see both what we have achieved so far and which aspects of the vision are easier or harder than we expected. In doing this, we will also try to determine which technological features, such as the use of clear and explicit user roles or the specific types of authority description, are crucial in supporting the various features of the vision, such as agent organization and inter-agent task driven cooperation.

Software Instrumentation and Testing

The current O-Plan system accommodates a number of facilities to allow for development testing, evalua-

tion experimentation, and software instrumentation. An auto-testing capability allows a package of domain descriptions and tasks to be provided to the planner, one or more plans to be generated for each task in the selected domains, and the results to be compared to previously generated plans. A "sanity checker" for plans automates much of the inspection that would otherwise be needed to check that the plans generated are valid against a set of criteria. These facilities allow for repeatable testing of an O-Plan Planning Agent against test suites and provide "hooks" for extending the types of automatic testing that can be done on the plans generated by O-Plan.

For our I-X and I-Plan systems, we propose to use this test suite on our individual planning agents and construct an additional test suite of plans to be constructed by a number of planning agents working together. Since a multi-agent system is, in essence, a complex piece of software, it is even more important to apply these testing techniques to the system of software agents as a whole.

The compiler for the O-Plan Task Formalism (TF) domain description language already provides good levels of diagnostic support to domain writers and will be extended during the proposed project to provide feedback through I-PE (Process Editor) to domain experts who are describing processes and plans. The Task Formalism Compiler can be run in a "checking mode" separately to the O-Plan planner to provide such information for use in the Process Editor.

Acknowledgements

The O-Plan project is sponsored by the Defence Advanced Research Projects Agency (DARPA) and the U.S. Air Force Research Laboratory (AFRL) under grant number F30602-99-1-0024. Mr. Wayne Bosco at AFRL (Rome) monitors the O-Plan project. Dr. Doug Dyer, Dr. Mark McHenry and Dr. Jim Hendler at DARPA, and Mr. Ken Sharpe of SAIC also guide the project. The U.S. Government and the University of Edinburgh are authorized to reproduce and distribute reprints for their purposes notwithstanding any copyright annotation hereon. The views and conclusions contained herein are those of the authors and should not be interpreted as necessarily representing official policies or endorsements, either express or implied, of DARPA, AFRL, the US Government or the University of Edinburgh.

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COMMON OPERATIONAL MODELING, PLANNING AND SIMULATION STRATEGY (COMPASS)

Project Overview

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PURPOSE

This document addresses, in abbreviated form, the progress of the Common Operational Modeling, Planning and Simulation Strategy (COMPASS) Project, from prototype development to operational fielding in DoD Command, Control, Communications, Computers and Intelligence (C4I), Mission Planning (MP) and Modeling and Simulation (M&S) systems. There have been a total of twenty-two C4I, MP and M&S systems (and associated system prototypes) integrated with COMPASS DCP and M&S services to date.

BACKGROUND

In July 1994, the Defense Modeling and Simulation Office (DMSO) sponsored a C4I-to-SIM Initiative in support of the DoD's *Modeling and Simulation Master Plan* (DMSO, 1995). Goals of this initiative were to: (1) take M&S to war and (2) train as you fight. Achieving such goals would provide a valuable force multiplier for operational planners. It would give them a much greater capability to review and refine plans based on insight and analysis derived from M&S capabilities, including mission preview and rehearsal. If achieved, these goals would afford warfighters the opportunity to collaborate first during the planning process, and then collaborate with M&S agencies, gaining more effective combat power from improved, cohesive, collaboratively developed -- and analyzed -- plans.

COMPASS PROJECT

In August 1994, DMSO began their sponsorship of the COMPASS project and selected the Naval Command, Control, and Ocean Surveillance Center's Research, Development, Test & Evaluation Division (NCCOSC RDT&E DIV, now known as SPAWAR Systems Center San

Diego) as the lead laboratory for technical project management. The goals of the COMPASS project were to:

- prototype the use of a common messaging environment to allow M&S services to better support C4I process;
- demonstrate the operational benefits to joint warfighters of DCP tools to support M&S services for C4I/MP systems;
- facilitate interoperability of M&S with C4I systems.

Since April 1995, COMPASS has shown the operational benefits of DCP/M&S services to members of U.S. Air Force, Army, Navy, Marine, Special Operations and Coalition Forces in Joint and Service sponsored demonstrations and Joint Task Force training exercises:

1. Special Operations Forces Demonstration (USSOCOM, 12-13 Apr 1995)
2. Joint Warrior Interoperability Demonstration 1995 (Joint Staff, 18-29 Sep 1995)
3. Joint Task Force Exercise 96-1 (USACOM, 29 Nov - 16 Dec 1995)
4. Joint Task Force Exercise 96-1 (PACOM, 8-18 Mar 1996)
5. Combined Joint Task Force Exercise 96-2 (USACOM, 25 Apr - 19 May 1996)
6. Joint Task Force Exercise 96-2 (PACOM, 5-15 Aug 1996)
7. Joint Warrior Interoperability Demonstration 1996 (Joint Staff, 5-29 Aug 1996)
8. Joint Task Force Exercise 97-1 (USACOM, 7-23 Oct 1996)
9. Joint Task Force Exercise 97-1 (PACOM, 10-21 Feb 1997)
10. Fleet Battle Experiment Alfa/ Hunter Warrior 97 Demonstration (PACOM, 3-12 Mar 1997)
11. Roving Sands 97 Training Exercise (USSOCOM, 14-25 Apr 1997)
12. Kernel Blitz 97 Training Exercise (PACOM, 20 Jun-3 Jul 1997)
13. Joint Warrior Interoperability Demonstration 1997 (Joint Staff, 7-31 Jul 1997)
14. Joint Task Force Exercise 97-2 (PACOM, 14-25 Jul 1997)
15. Unified Endeavor 98 (USACOM, 26 Oct - 4 Nov 1997)
16. Joint Task Force Exercise 98-1 (PACOM/BMDO, 12-25 Apr 1998)
17. Fleet Battle Experiment Charlie (COMSECONDFLT/Maritime Battle Center, 1-5 May 1998)
18. Joint Project Optic Windmill (EUCOM, 11-19 May 1998)
19. Joint Warrior Interoperability Demonstration 1998 (JCS Assessment, 8-31 Jul 1998)
20. Fleet Battle Experiment Delta (COMSEVENTHFLT/Maritime Battle Center, 24 Sept - 1 Nov 1998)

In summary, COMPASS has participated in seven major Joint exercises/experiments, ten major Fleet exercises, and four separate JWIDS (selected as a Golden Nugget twice). Without exception, the COMPASS concept and COMPASS middleware distinguished itself as key elements contributing to the success of each event. Warfighter comments such as: "...easy to use, extremely effective and provided an added dimension [to joint planning]..." attest to the simple effectiveness of the COMPASS strategy.

COMPASS CONCEPT

The COMPASS operational concept is to provide DCP services via non-intrusive software "middleware" to C4I, MP and M&S systems so that live, virtual, and constructive simulations could be accessed during C4I and mission planning processes. This access would enable planners to gain insights based on results -- and feedback -- from M&S services. The ultimate implementation of this concept would eventually be to use the same "virtual battlefield" to plan, rehearse, re-plan, execute, monitor plans, simulate, or train -- using M&S to satisfy warfighter requirements.

COMPASS DCP/M&S SERVICES

COMPASS middleware consists of five Government-Off-The-Shelf (GOTS) core services, complemented by four Commercial-Off-The-Shelf (COTS) services. These services facilitate and enhance distributed collaborative exchanges between various C4I and MP systems, as well as between C4I / MP systems collectively with M&S systems.

(Note: the term middleware indicates that COMPASS must be integrated with a host C4I, MP or M&S system to function properly. Systems that incorporate COMPASS middleware are often referred to as "COMPASS enabled")

COMPASS GOTS CORE SERVICES

- **Session Management**

Allows for creating, joining, monitoring, leaving or rejoining a collaborative session and specifying roles, either public or private.

- **Shared Overlay Management**

Enables the exchange of geo-registered annotations, routes, weapons effects, and other overlays selected by users for viewing or receipt during sessions.

- **Composite Mission Preview**

Supports viewing animated, synchronized display (moving icons) of multiple element plans, comprising a complete mission plan for preview by session participants.

- **Simulated Mission Rehearsal**

Empowers users to view animated display of multiple element plans, as executed by Distributed Interactive Simulation (DIS)-capable models and simulations that are session participants.

- **Track Data Base Management Server (Track Server)**

Using the same functionality as DIS-based mission rehearsal, selected tracks from the Global Command and Control System (GCCS) Track Data Base Manager can be shared and updated periodically with all other COMPASS-capable workstations. These tracks can also be shared

with non-GCCS COMPASS workstations regardless of their ability to access the Common Operational Picture (COP) or their DII COE compliance level.

COMPASS COTS SERVICES

- **Whiteboard (WB)**

The shared whiteboard (currently Rendezvous) permits session participants to exchange pixel-based text and graphics. Relevant information can be "cut and pasted" into the whiteboard for discussion during collaborative sessions. In addition, WB tools permit drawing, typing, and image sharing.

- **Chat**

Chat is a versatile capability that allows text-to-text exchange of typed information between multiple stations during periods of low or degraded bandwidth availability. Because of this factor, it is typically both the primary and default means of collaborating.

- **Visual Audio Teleconferencing (VAT) and Video Interactive Conferencing (VIC)**

Provides the ability to teleconference among DCP players using video/audio teleconferencing applications installed on C⁴I, mission planning, and M&S systems. Mission planners can employ VAT and VIC to conduct face-to-face discussions during collaborative planning sessions. Additionally, VIC can be used to "share" video-based M&S products (such as fly-through simulation systems).

- **Collaborative Virtual Workspace (CVW)**

A collection of electronic virtual rooms; each room incorporates the planners, information, and tools appropriate to a task, operation, or service. CVW allows the warfighter to intuitively join, participate, and depart from collaborative planning sessions as required. It helps eliminate confusion as to what session to join, simplifies communications and connectivity issues, and provides common access to basic COMPASS services through a virtual DCP Conference center metaphor.

COMPASS SOFTWARE ARCHITECTURE

COMPASS middleware is a non-intrusive application that uses client-server software architecture – any workstation can be a client; any workstation can be a server. This feature permits uninterrupted operations in the event of a server casualty. COMPASS servers are available to "COMPASS enabled" host systems through the use of an Application Program Interface (API).

COMPASS ENABLED M&S SYSTEMS

Since 1994, twelve M&S systems have been integrated with COMPASS services:

1. Air Courses of Action Assessment Model (ACAAM)

2. Nuclear Chemical, Biological, Radiological/ Planner (NCBR/P)
3. Coordinated Adaptive Planning System (CAPS)
4. Extended Air Defense Simulation (EADSIM)
5. Force Level Analysis and Mission Effectiveness System (FLAMES)
6. Interactive Tactical Environment Management System (ITEMS)
7. Modular Semi-Automated Forces (ModSAF)
8. Operational Multiscale Environment Model with Grid Adaptivity (OMEGA)
9. PowerScene
10. Virtual Interactive Target (VIT)
11. Hazard Prediction and Analysis Capability (HPAC)
12. BMDO's Commander's Analysis and Planning System (BMDO CAPS)

COMPASS ENABLED C4I SYSTEMS

Since 1994, eight C4I or MP systems been integrated with COMPASS services (this list does not include additional systems which were prototype R&D precursors to some of the now more mature systems listed below):

1. Advanced Command & Control Enroute System (AC2ES)
2. Air Force Mission Support System (AFMSS)
3. Contingency Theater Automated Planning System (CTAPS)
4. Global Command and Control System (GCCS)
5. Joint Force Air Component Commander (JFACC) Planning Tool (JPT, formerly ACPT)
6. Maneuver Control System (MCS)
7. Special Operations Forces Planning and Rehearsal System (SOFPARS)
8. Tactical Automated Mission Planning System (TAMPS)

HP AND PC VERSIONS OF COMPASS

The first COMPASS capable Personal Computer (PC) version (using Microsoft Windows NT operating system) was fielded in the Defense Threat Reduction Agency (DTRA) Hazard Prediction and Analysis Capability (HPAC) in 1998. This version is fully compliant with the PC version of the DII COE (version 3.2). Additionally, COMPASS server/client capability is under development for GCCS (WIN NT) and for HP UNIX environments.

GOVERNMENT SOFTWARE IV&V TESTING

Beginning in 1995, the COMPASS team has performed government software tests, appropriate to an Independent Verification & Validation (IV&V) role for NCCOSC RDT& E DIV as the COMPASS Project Office. Also, the COMPASS project team has worked with DISA Joint Interoperability Test Center (JITC) in completion of applicable functional certification tests of COMPASS middleware. In addition to performing IV&V tests, a COMPASS Software Support Activity (SSA) team was established to resolve software trouble reports, and to coordinate

resolution of these reports with SAIC, the developer of COMPASS, and other parties (including host system program offices).

COMPASS SSA efforts have focused on the use of current configuration management processes and up-to-date methods for cost-effective control of software engineering related products, including documentation: *COMPASS Project Software Configuration Management Plan* (NCCOSC RDT&E DIV, 1997). The Defense Information Systems Agency (DISA) Joint Interoperability Test Command (JITC) has recommended full certification for COMPASS server and client software/middleware (JITC, 1997).

WARRIOR FAMILIARIZATION AND EVALUATION

In 1996, the COMPASS project began the Warrior Familiarization and Evaluation (WF&E) Initiative that provided COMPASS services (now incorporated in 22 COMPASS enabled C4I and M&S systems) at selected military sites. This R&D program was terminated at the end of 1997, having achieved the desired results of generating operational feedback to improve and enhance the COMPASS development effort.

SUMMARY

The successful employment of COMPASS in numerous operational events has proven -- without doubt -- the concept of distributed collaborative planning and support for the warfighter. The use of COMPASS tools and services repeatedly added immeasurable direct value to Combined, Coalition and Joint planning process regardless of warfare area, echelon of command, or operational theater. Integrating C4I, Mission Planning and Modeling and Simulation systems into a synergistic, distributed collaborative environment, provided operational planners with increased flexibility, better response times, better understanding of plans, and the increased accuracy necessary to conduct warfare in today's modern battlespace. COMPASS permits C4I and MP system operators to "reach-back" and "join" the virtual battlespace -- using M&S in full partnership with planning and execution processes -- wherever and whenever required. Finally, COMPASS is DII COE compliant, has been selected as the Joint DCP tool for GCCS, and will be both a GCCS (client) and DII COE (server) segment in the future.

Co-operative intelligent agents for coalition planning - the EUCLID Project and the CABLE Architecture

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Abstract

Under the EUCLID RTP 6.1 project, the GRACE consortium of 17 European companies, led by Logica, developed some 14 AI tools to support situation awareness and military planning, and integrated them in a multi-agent distributed architecture. This paper summarises the work and identifies key issues for future work on knowledge-based planning for coalition forces.

Contents

This paper has the following structure:

- Introduction
- Objectives
- Technology Overview
- Overview of Facilities and Subsystems
- Achievements of the Project
- Recommendations
 - Background to recommendations
 - General recommendations
 - Specific recommendations
- Key Issues for Future Work on Knowledge-based Planning for Coalition Forces
 - Continuous dynamic re-planning
 - Time-critical planning
 - User interface for distributed, multi-agent, group-working systems
 - Co-operative planning
 - Software and knowledge engineering bottleneck
- References
- Acknowledgements
- Acronyms and Project-specific Terms

Introduction

EUCLID (European Co-operation for the Long term In Defence) is a collaborative military research programme initiated by the Western European Armaments Group. It is divided into a number of CEPA's (Common European Priority Areas) representing areas of shared research interest. CEPA 6 is concerned with Advanced Information

Processing and Communications. Work on CEPA 6 is further divided into a number of Research and Technology Projects (RTP's). EUCLID RTP 6.1 was an applied research contract led by Logica UK Limited and undertaken by the GRACE Consortium (Grouping for Research into Advanced C³I for Europe).

The objective of RTP 6.1 was to accelerate the application of Artificial Intelligence (AI) techniques and also advanced software engineering and HCI techniques to Command, Control, Communications and Intelligence (C³I) systems.

The clients for the work were seven Ministries of Defence (MoD's) represented by a Management Group (MG), chaired by the UK's Defence Evaluation and Research Agency (DERA).

The seven nations represented were: Denmark, France, Italy, Norway, the Netherlands, Spain and the UK. The GRACE consortium undertaking the work comprised 9 companies together with 7 subcontractors across 7 nations, as shown in Figure 1.

Logica in the UK was the lead company. The working language for the project and all its deliverables was English. (Note: acronyms and project-specific terms are defined at the end of the paper)

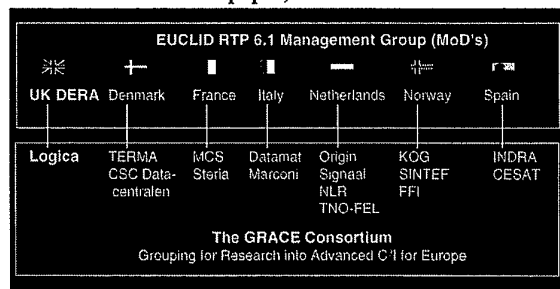


Figure 1: EUCLID RTP 6.1 participants

The project was carried out between Autumn 1993 and Autumn 1998 and had a total value of about £17M, of which the GRACE companies contributed 24%. About 125

man years of effort was expended on the project, resulting in an integrated software demonstrator comprising about 800,000 lines of C++ code and 167 deliverable documents and working papers. The results and software from the project are available for exploitation by the participating MoDs and GRACE organisations, subject to the Intellectual Property Right requirements of the Contract and GRACE Collaboration Agreement. The demonstrator shows the military benefits achieved using artificial intelligence in a multi-agent architecture, and remains available for demonstrations at Logica until June 2000.

Objectives

The main objective of the project was:

To accelerate the application of AI techniques, including advanced software engineering and HCI (Human-Computer Interface) techniques, in command, control, communications and intelligence (C³I) systems.

To achieve this objective, the project was to:

- develop intelligent tools for:
 - automated report analysis
 - time-critical decision support, planning and tasking (DSPT) in the army and naval domains
- define and implement a workstation architecture able to accommodate existing and emerging methods and tools, and to forge new standards
- form domain simulations drawn from land tactical and naval systems to aid the development and testing of the architecture and its methods
- encourage European collaboration in C³I research and development.

An output of the work, completed in Autumn 1998, was a demonstrator system incorporating three C³I workstations which incorporate AI technologies functioning as a complete system, able to perform designated tasks in the army and naval domains.

It is emphasised that the purpose of this research project was to demonstrate how AI, HCI and software engineering techniques can be applied to C³I functions, not to develop new AI techniques for their own sake, nor to develop a complete and integrated operational C³I workstation. However, it was necessary to implement sufficient non-intelligent functionality to effectively demonstrate and integrate the intelligent tools.

In order to ensure that the work had clear military objectives, workshops were held between the GRACE researchers and military experts to agree the users and tasks to be supported, the scenarios in which the facilities would be developed and the military benefits to be demonstrated. The term 'facility' was used specifically to mean a software tool that:

- used AI

- supported the user in specific tasks, to give a clear military benefit to him, in the agreed scenario
- had a user interface, and could thus be demonstrated.

Each participating company took responsibility for one or more facilities, giving a clear partitioning of the work. However a further objective of the project was to integrate the facilities together, at three main levels, as shown in Figure 2:

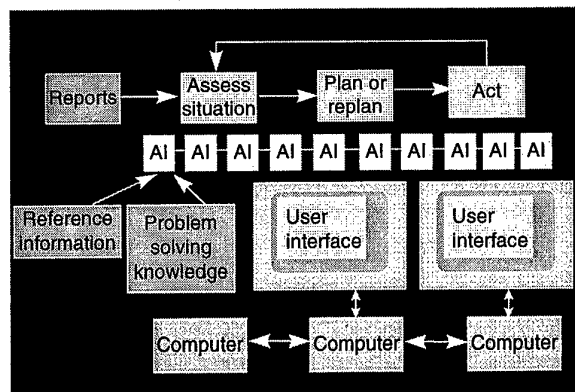


Figure 2: System integration requirements

- Facilities, which incorporate a wide range of different AI techniques, have to communicate with each other to request and provide services or information.
- Facilities should be able to run on any of a set of networked computers, which may be of different types running different operating systems.
- Multiple users need to be able to use an appropriate subset of facilities, on their own workstation, and to group-work with other users.

The objective of encouraging European collaboration was reflected in the fact that the software for the integrated demonstrator was developed on 17 different sites, calling for a high degree of European collaboration and co-ordination.

The project represented a major investment by the participating MoDs and GRACE companies. There is thus an implicit objective that exploitation and re-use of the results and software from the project be achieved, initially in support of further research and ultimately in operational systems.

Technology Overview

One of the first activities on the project, when it started in 1993, was to review available COTS (Commercial Off The Shelf) hardware and software, open systems standards and AI techniques. The objective was to select those that were leading edge, yet were robust, well supported and appeared likely to be in a strong market position to the

year 2000 and beyond. In most areas we succeeded in this, by choosing the standards and COTS software shown in Figure 3.

The main development platform was Sun workstations running Solaris. Some applications (including the System Architecture) were subsequently ported to PCs running Windows-NT, and we were able to demonstrate applications running over mixed networks of Suns and PCs. We used the CORBA (Common Object Request Broker Architecture) standard for inter-operation of distributed object-oriented software, as implemented in the Orbix Object Request Broker from Iona. The RTP 6.1 architecture comprising CABLE (distributed agents) and FIONA (user interfaces) forms a layer on top of ORBIX. The user interface complies with the X-Windows and OSF/MOTIF standards and builds on the ILOG Views product. FIONA enables the development of uniform and consistent user interfaces for distributed applications, and supports plug-and-play of components.

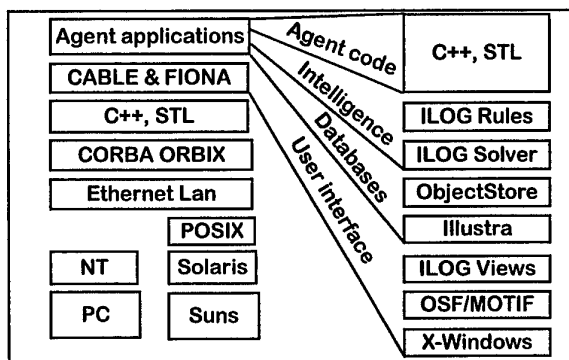


Figure 3: Standards and COTS hardware and software

There was no difficulty in arriving at a consensus that we should take a fully object-oriented (OO) approach to the work, implementing software in C++ (Java not having emerged at the time the decision was made). We extended the OO paradigm by adopting an architecture based on multiple co-operating intelligent agents.

We expected that most of our AI applications would take a rule-based approach. However we left developers free to use the AI techniques that would give most military benefit in their facility. It turned out that a very wide range of AI techniques were used, with some predominance of constraint-based techniques. The multi-agent architecture gave us a uniform architecture for plugging together agents using very different AI techniques.

As show in Figure 3, within each intelligent agent either custom C++ code (incorporating the STL libraries if necessary) or a range of COTS software can be used. For rule-based AI we used ILOG's Rules C++ library and for constraint-based AI their Solver library. Other AI software (not shown in the figure) was used in specific areas including VBS (Valuation Based System) from Sintef for probabilistic reasoning and Leda for spatial reasoning. We

developed our own software in C++ for other AI, including FKM (Fuzzy Knowledge Manager) for fuzzy knowledge, TIM for reasoning about time and RACAS (Resource Allocator) which uses simulated annealing.

The main database product used was Objectstore, which is an Object-Oriented Database Management System. This was used to hold the Wide Area Picture, which is a central component of the demonstrator, and ObjectStore was also used in the Tactical Threat Analyser. Illustra is a Relational Database Management System extended to deal efficiently with spatial data types. We used this minimally, for holding vector map data. We did not make use of relational databases, as such.

We selected the COTS by consensus because all partners had to use the same COTS and the choice had technical and financial implications for the participants. We took care to ensure that the different COTS were compatible with each other. In some cases this meant staying with older versions of COTS rather than updating to the latest version.

For object-oriented analysis and design we adopted Rumbaugh's OMT (Object Modelling Technique) approach, supported by the CADRE's Object Team OMT tool. The OMT approach proved satisfactory, although it has since been superseded by UML (Unified Modelling Language). Object Team was, in practice, used as little more than a drawing tool. For designing multi-agent systems we used the FUN (Functional UNit approach) which was developed by Logica on a previous project called CADDIE. This has been used throughout EUCLID RTP 6.1 and in some spin-off projects in the UK, and has proved useful for analysing and structuring multi-agent applications.

The COTS and standards selected have proved to be a sound basis for the work. If we were making the selection now, with the experience we have gained and the progress made in the marketplace since 1993, we might make adjustments in the following areas:

- CORBA is an open standard, not specific to any one vendor, but Microsoft's COM (Component Object Model) and DCOM (Distributed COM) provide an alternative with wide take-up, including in current or imminent C³I systems. We now see CORBA and COM as complementary. The use of PC's for affordable workstations implies the use of COM on the desktop, integrated with CORBA for enterprise-wide integration taking in legacy systems and servers on other platforms (e.g. UNIX). In addition Web access is increasingly being provided to provide a lightweight and portable interface for information access and update.
- Today Java is a serious alternative to C++. It would have provided more elegant solutions and extra capabilities in some areas, more platform independence and better support for developing nomadic agents. Concern remains that Java code can run significantly slower than equivalent C++ code, unless compiled.
- In seeking to exploit the results of the project, we have found that there is more acceptance of the PC Windows

NT platform than Sun Solaris, particularly in moving from research to operational systems, and for cost-effective user workstations.

- The use of COTS software has saved us from re-inventing the wheel. However it does lead to quite an expensive development environment, particularly in respect of the ILOG libraries which we have used heavily, and set against developer expectations of cost on the PC platform. Run-time licences are significantly cheaper than developer licences, but the total cost of run-time licences and maintenance can be still be significant if software is deployed widely, and upgrading different COTS at different times can be problematic.
- We did not use a COTS map display and storage package and in retrospect it would have been worth doing so, although it is important to use software that is open to extension rather than a closed GIS (Geographic Information System).
- It might have been worth incorporating Oracle as the leading RDBMS (Relational Database Management System) and this would have been compatible with DCADM (a UK army data model) and many operational C³I systems. While we have fully embraced an object-oriented approach and not needed to make use of an RDBMS, it is likely that in scaling up to an operational systems an RDBMS would be needed. Illustra, which we used for geographic data, was taken over by Informix during the course of the project and their products merged.

At the beginning of the project we investigated the possibility of re-using some software, techniques, data and digital maps from other completed or ongoing military projects. This proved difficult to do because we had to be able to release any item used to every participating MoD and organisation, preferably at unclassified level. In most areas we therefore took the approach of either using COTS or custom-developed software. We made use of informal company contacts into other relevant international programmes (e.g. NATO Data Fusion Demonstrator) and national classified projects to try to avoid overlapping with their areas of work.

In seeking to exploit the technologies developed on the project into other programmes, we have been most successful in two areas:

- using the multi-agent architecture, CABLE (with FIONA where appropriate) to rapidly develop intelligent, distributed applications for applied research programmes
- providing particular decision support tools into applied research programmes or new operational systems for which the military benefit is evident; in these applications the underlying AI techniques are seen as merely a means to an end and the tools may be adopted without the underlying multi-agent architecture.

It was always the intention that the project would feed into applied research programmes and technology

demonstrators, then subsequently into operational systems likely to be in service in about 2015. Where we have, nevertheless, sought to exploit the outputs of the project in operational systems currently under development, the technologies chosen have made this more difficult in the following areas:

- most such systems use Microsoft dominated architectures on PC Windows NT platforms and do not embrace the CORBA standard
- they have their own user interface solution, which has a significant impact on the architecture
- they use an ORACLE relational database and have their own data structures, data models and object models
- they use commercially available GIS and mapping software
- the COTS software used in EUCLID RTP 6.1 adds quite a lot of cost, if these COTS are not already in use by the project.

We recommend that in future research of this sort, the participating MoDs should identify which forthcoming national operational systems should be the focus for exploiting the outputs of the project. This would have influenced our choice of technologies, or at least our emphasis, in some areas.

Overview of Facilities and Subsystems

The main workstreams in EUCLID RTP 6.1, as shown in Figure 4, are:

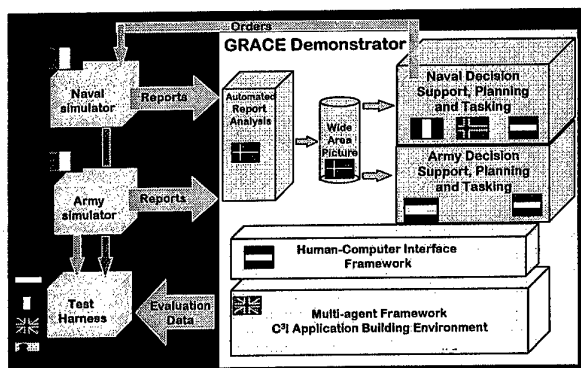


Figure 4: Overview of the EUCLID RTP 6.1 software

Automated Report Analysis (ARA): led by Denmark, this work analyses incoming reports and constructs a Wide Area Picture as input to Decision Support Planning and Tasking (DSPT). Although simple data fusion is provided, there was a conscious wish not to major on this, as it was the main topic for the NATO DFD project which was in progress over a similar time period. The work on ARA is illustrated in overview in Figure 5.

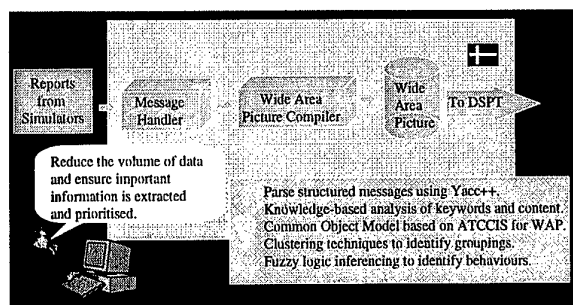


Figure 5: Automated Report Analysis overview

Army DSPT: carried out by Spain and the Netherlands; developed aids to Terrain Analysis, Course of Action Construction, Manoeuvre Planning and Fire Support Planning. The work on Army DSPT is illustrated in overview in Figure 6.

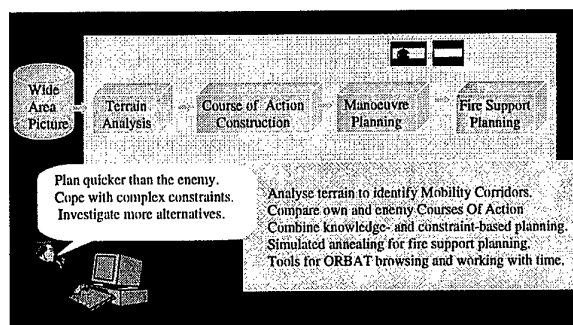


Figure 6: Army Decision Support, Planning & Tasking overview

Naval Decision Support, Planning and Tasking (DSPT): led by France, supported by Norway and the Netherlands; developed aids to ASuW (Anti-Surface Warfare) planning, Engagement Co-ordination and Tactical Threat Analysis. The work on naval DSPT is illustrated in Figure 7.

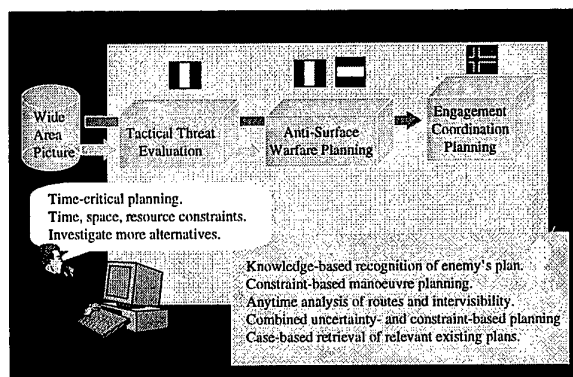


Figure 7: Naval Decision Support, Planning & Tasking overview

The above workstreams directly provide military support to the command process. The following provide the infrastructure of the demonstrator:

- CABLE (Co-operative Agent Building Environment): this supports the development and running of C³I applications as multiple, interacting intelligent agents; this work was led by the UK
- HCI Framework (known as FIONA - Framework for the Integration Of Networked Applications): this work, led by the Netherlands includes the DOHP (Digital Overhead Projector), a map display with overlays controlled by individual, distributed C³I components.

Figure 8 illustrates how CABLE and FIONA fit together to enable agents to interact with each other and with the user.

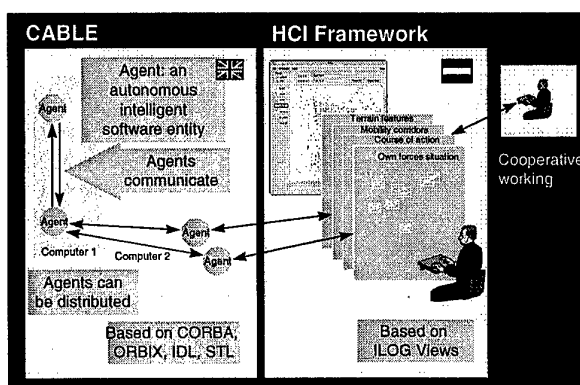


Figure 8: Multi-agent, multi-user architecture

The following support testing of the demonstrator:

- Simulator: separate land and naval simulators provide a report stream as input to the GRACE demonstrator. This work was led by Italy.
- Test Harness: provides mechanisms for logging and analysing performance, and comparing results with ground truth data from the simulator.

Achievements of the Project

EUCLID RTP 6.1 has produced an integrated demonstrator featuring two key innovations:

- an agent-based information/software architecture to integrate diverse artificial intelligence based applications, and
- an integrated suite of command decision support tools applying AI technologies.

The integration architecture comprises:

- CABLE for developing and running software structured as multiple co-operating intelligent agents. For time-critical applications, Real-Time CABLE

Extensions enable agents to be developed that provide their services within a guaranteed response time.

- FIONA to provides the user interface between one or more users and multiple agents, including a map-and-overlay display called the DOHP (Digital Overhead Projector).

A significant achievement of the project was the integration of some 800,000 lines of code developed by developers in 17 different locations across Europe without an integration team. The main integration activity was completed in one week. This was possible because the architecture and development approach provided a clear definition of the service interfaces between agents, underpinned by an agreed object model of the domain, and an integration mechanism for the user interface.

Both CABLE and FIONA embrace the CORBA standard as implemented in Orbix, enabling multi-agent software to be distributed at run-time across a mixed network of Sun Solaris and PC Windows-NT workstations. CABLE, FIONA and the FUN Methodology for specifying and designing multi-agent systems have been used effectively across the GRACE consortium and are applicable to any problem domain characterised by distributed software, multiple users and an element of artificial intelligence. They are particularly well suited to intelligent decision support and modelling and simulation applications, whether military or not. At the time of writing 10 new projects, most in the UK, have exploited this architecture, with a total value of 2 MECU (£1.4M).

Some 14 tools are provided to support different aspects of army and naval situation assessment and planning, using a wide range of AI techniques, each suited to the problem at hand:

- report analysis and situation assessment
 - AMP - Automatic Message Processing, using object-oriented parsing techniques to extract message content
 - WAP & WAPC - Wide Area Picture & Compilation, using fuzzy logic and clustering algorithms to identify significant enemy behaviours and groupings, and a publish-and-subscribe mechanism to notify other tools of changes to the WAP
 - GCM - GRACE Common Model; an object model used to represent the Wide Area Picture and encyclopaedic data, so that all agents can exchange information in an agreed form
 - ADVERTISER - enabling the user to define rules to trigger alerts on significant changes in the situation
 - TTA - Tactical Threat Analysis, using rule-based techniques to represent possible enemy plans and what would be observed at each stage of those plans, to provide analysis of enemy activity
- army decision support, planning and tasking
 - MADRID - Map Display; to store, display and manipulate vector feature data

- TEA - Terrain analysis & mobility corridor construction; using a geometric algorithm to identify mobility corridors suitable for units needing a particular doctrinal frontage
- COAC - Course of Action comparison, for comparing own versus enemy courses of action using Weapon Effectiveness Indices and Weighted Unit Values
- MFSP - Manoeuvre Planner; this integrates a number of planning tools including scheduling using TIM, a synchronisation matrix display and simulation of the possible evolution of own and enemy activities, taking account of doctrine and the terrain.
- TIM - Time manager; a software tool for representing and reasoning with time constraints.
- FORCE - ORBAT Browser, for multiple users to view and change an ORBAT or Task Organisation.
- RACAS - Resource Allocator; uses simulated annealing in an anytime formulation to allocate own aircraft and weapons to attack enemy targets.
- naval decision support, planning and tasking
 - EC - Engagement Co-ordination; uses spatial reasoning, probabilistic reasoning and constraint-based techniques to plan a naval engagement
 - TeART - Terrain analysis; anytime analysis of: routes, missile range areas and intervisibility, in which solution quality is traded against timeliness.
 - TED - Terrain Exploitation and Display; a tool for automating the production of colour maps based on terrain elevation data.
 - MPB/SP - Manoeuvre Plan Browser and Situation Predictor; uses user-defined hypotheses to predict future positions of friend or foe units
 - MCFP - Manoeuvre co-ordinator and formation planner, using constraint-based techniques for reasoning about co-ordinated manoeuvres.

Each of these tools represents up to 5 years work by one of the participating companies, and it is not possible to describe them adequately in the space available here. For more information please see the EUCLID RTP 6.1 Web site, referenced at the end of this paper.

The tools were generally intended to support the human command team, by automating only those aspects of a task that are better suited to the machine. Each of the tools was evaluated and demonstrated using simulated data from a naval landing force scenario or an army peace enforcement scenario. The benefits typically found from using AI techniques compared with manual planning were:

- automatic alerting to significant events or changes in the situation
- quicker planning
- consideration of more alternative plans
- improved consistency and accuracy of plans, e.g. through plan critiquing
- more constraints (time, space, terrain, resources) were taken into account.

Recommendations

Background to recommendations

The project has developed about 800,000 lines of new C++ code, 14 different C³I tools and a powerful integration architecture. These have been developed over 5 years using 125 man years of effort at a cost overall of around 16 MECU to the participating MoDs and 5 MECU to the participating companies. It is therefore important that all participating MoDs and companies achieve a high level of exploitation of the software and techniques developed. A programme re-using just 10% of the RTP 6.1 software - 1 or 2 tools and 80,000 lines of code - will potentially save 10 man years effort.

There are two main elements of the work that can be exploited - the architecture (CABLE/FIONA) and the tools. Taking individual tools is relatively easy, since in most cases the novel techniques are embodied in C++ code that is independent of the RTP 6.1 architecture. Exploiting the multi-agent architecture is a bigger commitment, which may be difficult in existing operational systems, but which provides major advantages in terms of ease of integration and of distribution over a heterogeneous architecture supporting multiple users, which are pre-requisites for next generation systems.

It is expected that the main route for exploitation will be into applied research programmes and technology demonstrators within national or coalition military research programmes. These need to adapt the RTP 6.1 work to particular military applications, systems and architectures.

In particular the tools developed by RTP 6.1 need to be extended by using more military input to develop deeper classified knowledge and constraint bases, and to be evaluated using a wider range of scenarios addressing particular national or coalition interests. It should be noted that RTP 6.1's tools are example applications of AI techniques and in many cases the same techniques could be generalised to different scenarios and domains (army, navy, air, joint, coalition, non-military).

To assist exploitation of the results of the project:

- the RTP 6.1 demonstrator will be available for demonstrations at Logica's Cambridge, UK office to June 2000
- a CD of project documents and software is available to participating companies and MoDs from Logica
- a World Wide Web site (<http://public.logica.com/~grace>) is available with unrestricted access to many areas
- an FTP site (with password protection) is available to participating companies and MoDs for downloading software and documents.

General recommendations

RTP 6.1 has demonstrated what can be achieved today by integrating COTS software, and applying existing and

adapted AI techniques to C³I. Two general recommendations emerge:

- for each problem tackled, a suitable AI technique must be selected, even though this means the final system may have to use a spectrum of different techniques and knowledge representations working together
- architectures and standards adopted, even for research demonstrators, need to enable software to:
 - be distributed over a heterogeneous network of computers
 - support multiple co-operating users
 - incorporate a range of COTS software
 - use a wide range of AI or algorithmic techniques
 - integrate software from a number of different developers and legacy systems
 - be robust to new hardware and software innovations (e.g. a change of operating system and hardware platform), and
 - provide scalability so there can be a continuous transition from research demonstrators to operational systems.

Specific recommendations

Turning to specific recommendations for research and development building on RTP 6.1:

- For CABLE, the architecture needs to embrace DCOM and COM in order to be adopted more readily in operational systems running on PC NT. Questions about the security of CORBA and the performance overhead of CABLE and CORBA need to be answered. CABLE agents need to incorporate more innate intelligence (e.g. the Beliefs, Desires and Intentions model) in order to better support inter-agent negotiation. Java needs to be further assessed as an option for agent implementation.
- For FIONA, the user interface needs to better reflect the multi-agent nature of the underlying software, for example by enabling the user to see and start available agents, to monitor their activities and to more flexibly invoke agent services. The proliferation of dialogue boxes for agents needs to be controlled, for example by supplying a set of tabbed dialogue boxes for agents, analogous to the DOHP mechanism for geographic information. All aspects of the user interface (specific tools as well as the generic mechanisms) would benefit from greater military input.
- The potential of the CABLE/FIONA architecture for non-military applications should be explored. Some of the situation awareness and planning tools developed for military applications by the project could be generalised to non-military applications. For example this is already happening with TIM, which is a general time-constrained reasoning tool and is being applied to scheduling the flow of aircraft around Spanish airports.
- Regarding map facilities, rather than adding new functionality to the RTP 6.1 map and GIS facilities (MADRID, TED), it is recommended that commercially available libraries be incorporated into

the architecture, coupled with the FIONA DOHP. It is noted that while Digital Terrain Elevation maps and scanned maps are relatively easily available, vector map data is only available for a few locations, and some is of poor quality. It is recommended that scanned maps be provided for user backdrop, terrain elevation maps for automated tools but that effort on tools that are reliant on good vector map data should be in proportion to the quality of available data. Roads then water are the highest priority vector features to make available to automated tools.

- For databases, data models and object models, it is clear that available standards and data are not keeping pace with the needs of research projects or operational systems. The GRACE Common Model (loosely based on the NATO ATCCIS model) has met the needs of RTP 6.1 in both the army and naval domain. It is recommended that appropriate emerging standards be adopted and extended in new work (e.g. for the British Army, DCADM which provides both a data model and a populated encyclopaedic database). However it should be noted that it is possible to translate between different data or object models provided a consistent underlying ontology has been used, so establishing the ontology is the key task.
- It is clear that ORACLE is the relational database of choice in operational systems and should be incorporated in future work, alongside an Object-Oriented Database such as ObjectStore. The RTP 6.1 architecture may need to be extended to take account of data distribution by database replication, rather than just through agent-to-agent service provision.
- A significant proportion of C³I tools are time-critical in the sense that the user needs the result within a particular time and is prepared to trade off solution quality against timeliness. Providing this is particularly difficult in a multi-process and/or distributed environment, when the amount of CPU time available to any one process is not predictable, and the workload can vary depending on the scenario. RTP 6.1 has developed different solutions to this problem:
 - RTCE (Real-Time CABLE Enhancements) provide Solaris-specific mechanisms to guaranteeing and optimising CPU resources given to an agent so that it can commit to providing a solution in a fixed time.
 - Some of the AI techniques (for example in TeART and RACAS) have been implemented in a form that lets them be interrupted at any time to provide the best solutions available up to that time.

These techniques should be consolidated and carried forward into future work.

- The combination of AMP, WAP, FIONA's DOHP, the publish and subscribe notification mechanism and the query mechanism, underpinned by the GRACE Common Model and CABLE, provides a powerful architecture for maintaining, viewing and disseminating dynamic situation and static encyclopaedic information.

This should be further developed, generalised and optimised.

- For situation assessment, the concepts used in TTA (Tactical Threat Analyser) for representing a current situation in terms meaningful to the military should be combined with those used in WAPC (Wide Area Picture Compiler), ADVERTISER (user-defined alerts) and SSA (Situation Similarity Assessor) to give an integrated set of tools for representing the current situation, assessing the threat, and alerting the user.
- As well as being further developed for their specific target applications, the plan-related agents developed on the project should be generalised and more closely integrated, so that they can tackle a wider range of planning problems and scenarios, and make more use of each others services. They can be seen as falling into functional groups which should each provide their services in a more consistent form:
 - terrain analysis: e.g. TeART, MC constructor
 - route and manoeuvre planning: e.g. TeART, MCFP
 - resource allocation: e.g. RACAS, EC
 - scheduling: e.g. TIM, PV, aspects of MCFP.
- The RTP 6.1 Plan Viewer display represents a key display format for military plans. Future work on this and other aspects of the user interface would benefit from more military evaluation. It would be beneficial to use a consistent internal representation of the plan (and its various elements), including constraints, throughout the tools developed and across the different domains (army, navy,...), for example in the form of a plan description language, consistent with those developed in other research programmes.
- Multi-agent architectures provide the potential for harnessing 'emergent behaviour' to give desirable properties like robustness, resilience to information overload and optimal use of processing and bandwidth resources. Further research should study how small groups of agents working together can realise these attributes and form building blocks (or 'design patterns') for distributed system architectures.
- The work has demonstrated the close relationship between military planning and simulation. Future work should further exploit the commonality between the tools used for each, and the possibility to use simulation tools both for what-if simulation and to project future expectations as a basis for alerting the user to unexpected events. The Global Planner (GP, which is part of MFSP), can provide a starting point for such work.

It is clear that the trend is to greater international co-operation, in military operations, in procurement and in research. The hard-won experience of how to co-operate effectively on a large scale research project such as this, should be noted.

Key Issues for Future Work on Knowledge-based Planning for Coalition Forces

This section discusses key issues for future work on knowledge-based planning for coalition forces, based on experience from EUCLID RTP 6.1 and other AI planning applications developed by Logica UK Limited and Logica Carnegie Group in the US.

Continuous dynamic re-planning

Just as maintaining the situation picture is a continuous process, so maintaining the plan should be a continuous and dynamic process. While the initial plan may be based on a monolithic analysis of the situation (if the situation is not changing too rapidly), as soon as the plan begins to be executed, or the situation planned for changes, the plan needs to change. Small changes in the situation (e.g. in the positions of participating own or enemy units) may be addressed by small changes to the plan, without disrupting major assumptions, but at some point it may be necessary to make a more wide-ranging change to the plan. Constraints or situation similarity measures can be used to identify such situations. Similarly a change in the planning objectives (whether triggered by the change in the situation or by command) may trigger production of a new plan.

With improved computer support and communications it is no longer necessary to prepare a new or modified plan as a single discrete activity, then communicate this 'complete' plan to others in the command hierarchy. Instead we envisage a sliding scale of commitment, in which the planner only commits to and communicates those elements of the plan that have implications for the actions of his own unit or others. In re-planning to address the changing situation, we seek a balance between the cost of change (minimising disruption) and how optimal the plan is.

In situations that change rapidly, to an extent that could invalidate a plan before it is complete, it is necessary to use the results of situation awareness to rapidly arrive at a rough plan, which will then be refined to the extent that time and the changing situation permit.

The military user is not looking for an optimal solution. The real world is measured too imprecisely and the responses of the enemy cannot be predicted with a high level of confidence. A good enough solution derived within the deadline, and robust to changes in the situation is of greater military benefit.

Dynamic re-planning and a sliding scale of commitment, if fully embraced, imply a change in planning doctrine, tolerating greater uncertainty, by postponing commitment for as long as possible and by actively trading off plan quality against timeliness.

Time-critical planning

A military planning or re-planning activity usually has associated with it an explicit or implicit deadline by which the results must be provided. When using knowledge-based planning techniques it can be difficult to meet such a deadline because:

- the complexity of the military situation to be planned for may be difficult to anticipate
- some AI techniques have unpredictable computational costs
- in a distributed multi-agent (or similar) system, each agent may not know in advance what share of the processing time it will get.

We have overcome these difficulties in some of the agents developed on the EUCLID RTP 6.1 project by providing:

- planning agents that can be interrupted at any time and provide the best solutions found up to that time
- planning agents that use domain knowledge to develop the plan most likely to be optimal, first
- agents that calculate their results at progressively higher resolutions, so that a rough, but 'safe' solution is available quickly, and better solutions are then provided subsequently
- an agent associated with each processor, and closely coupled with the operating system, that provides guaranteed processing resources to other agents to enable them to schedule their activities to meet their deadlines (or to know in advance that they cannot meet them)
- a load-balancing capability in the multi-agent architecture, so that new agents can be started up on the least loaded processors in a network.

Such techniques are essential in knowledge-based planning systems to ensure that solution quality is traded off against timeliness in an optimal way, and available processing resource is used to best effect. Similar techniques can be used to optimise the use of network bandwidth and operator workload.

User interface for distributed, multi-agent, group-working systems

Our vision for knowledge-based planning systems is of a group of human planners and a set of intelligent agents working as a single co-operative organisation over a networked computer system. The human planners will be firmly in control, making use of their experience, judgement and creativity and initiating, reviewing and editing plans.

We see agents as mainly dealing with aspects relating to maintaining and disseminating the situation picture, and dealing with constraints and options related to time, space, terrain, resources and activities. They must support knowledge-based structures that correspond to the expert's

conceptualisation of the problem and represent them on the user interface in a way that supports human decision making.

The user interface needs to enable the user to understand what the agents have done and can do, rather than blindly accepting their advice.

Such an organisation of humans and agents requires that each user's interface enables him to group-work with other users and to freely access the services of all other agents, even if they are running on remote machines. The architecture needs to support the results of all relevant agents (even if running on other computers) being combined into a single display for the user. The EUCLID RTP 6.1 Digital Overhead Projector display is an example of this, for a geographic view. The user interface also needs to give the user ways of conceptualising and visualising the information sources, services and other users participating in planning in a highly distributed, multi-user system. The EUCLID RTP 6.1 approach of using analogies between distributed software and human organisations provides some insights here.

Co-operative planning

To enable shared situation awareness and co-operative planning, whether between agents within a single architecture, or between different coalition systems, it is necessary to exchange information and service requests and to know that they will be correctly interpreted. The key element is an agreed ontology for the information that needs to be exchanged. Most ontologies are related back to the real world problem domain through free text definitions of their basic concepts. This means that it remains the responsibility of the programmer or knowledge engineer to interpret the real-world meaning of the concepts in the same way at both ends of the dialogue. For agents or systems developed by different developers to tackle different problems, even with a common ontology there is a risk of different interpretations. There is a need for research in this area to try to capture more of the real world meaning of concepts in software. This leads us ultimately towards natural language understanding, common sense reasoning and machine learning, which are immensely difficult and inter-related problems requiring a paradigm shift, but which should be our long term goal.

We note that the use of knowledge-based techniques for situation awareness or planning typically introduces new concepts which are complex, high level and imprecise. Examples are descriptions of the nature of an enemy threat (c.f. the concepts in the EUCLID RTP 6.1 Tactical Threat Analysis tool) and descriptions of the qualities of alternative plans. These are often defined by the developer in a non-standard way. Such higher level concepts are not commonly represented in a uniform way in current ontologies, but will need to be communicated within and between future co-operative planning systems.

Additional to the ontology, a common entity-relationship or object model is highly desirable, but not essential because conversion between different

representations is possible. It is by no means essential that the same representation of information is used internally to agents or other software entities. Indeed, our experience from EUCLID RTP 6.1 is that so many different AI techniques and knowledge representations are used in different agents, that using a common representation internally may be an unnecessary burden.

As part of the ontology, we believe that more emphasis needs to be given to defining the services and service protocols for agents (or systems of agents), to enable them to co-operate. We have taken some steps in this direction with the FUN methodology and the CABLE architecture, but only within a single architecture, not yet for inter-operation between different architectures.

Software and knowledge engineering bottleneck

Once knowledge-based situation awareness and planning tools are scaled up to operational military systems, which must be able to cope with many different geographical locations and military situations, they may comprise millions of lines of code, thousands of rules (or equivalent) and large databases. Implementing such a system takes teams of 10's or 100's of developers some years and there is a risk that the knowledge it embodies is out of date before it becomes operational. Furthermore the pace of technological change and the evolution of military and commercial standards and systems can lead to difficulties in making the transition from research into an operational system. To help alleviate these problems we recommend that:

- existing experience, conceptual models, design concepts and useful architectural elements should be re-used from existing work, rather than starting from scratch in new research and development; more detailed re-use of software and knowledge bases is more problematic, with the work to adapt them often being more burdensome than implementing anew
- research software be designed to be compatible with current or imminent operational systems, including using the same COTS software, military and IT standards, maps and databases, to enable a quick transition into operational use if the research is successful
- the use of AI and knowledge-based approaches should be highly pragmatic, using the minimum amount of knowledge necessary to achieve a military advantage, and encapsulating the use of these techniques so they can be readily integrated with non-AI software. Relatively simple techniques, which might be overlooked by academic AI researchers, can provide a strong advantage to the military planner and, since they are easy to understand, gain greater acceptance and take-up. Nevertheless there is usually a need for a knowledge-based system to include a critical mass of knowledge, without which the system will not be of significant benefit.
- an underlying information and software integration architecture should be used which provides consistency

at the information level even if different COTS software and standards are used for implementation

- that cross-national sharing of information and software be used to leverage faster progress, with clear responsibilities for each participant, so they can progress without detailed inter-working.

In summary, interesting challenges remain in developing knowledge-based planning systems for coalition forces, and the EUCLID RTP 6.1 project is one source of insights into possible solutions.

References

More detailed information about the project can be found on the project Web site:

<http://public.logica.com/~grace>

Some detailed information on the Web site and the project FTP server is accessible to the participating companies and the MoD's of UK, Denmark, France, Italy, the Netherlands, Norway and Spain under password protection. For access, please contact the author.

Acknowledgements

The work reported here was carried out under contract MAL1a/0262 between DERA Malvern, UK, acting on behalf of the EUCLID RTP 6.1 Management Group and Logica UK Limited acting on behalf on the GRACE Consortium under the terms of the GRACE Consortium Collaboration Agreement. The work was jointly funded by the participating MoD's (UK, Denmark, France, Italy, the Netherlands, Norway and Spain) and the organisations making up the GRACE Consortium.

Acronyms and Project-specific Terms

ADVERTISER	Rule-based alerts and alarms tool
AI	Artificial Intelligence
AMP	Automated Message Processor
ARA	Automated Report Analyser
ASuW	Anti-Surface Warfare
C++	A programming language
C ³ I	Command, Control, Communications and Intelligence
CABLE	Co-operative Agent Building Environment
CADDIE	A multi-agent research project
CADRE	A software tool supplier
CD	Compact Disk
CEPA	Common European Priority Area
COAC	Course of Action Construction tool
COM	Microsoft's Common Object Model
CORBA	Common Object Request Broker Architecture: a standard
COTS	Commercial Off The Shelf

DCADM	A common data model for the British army
DCOM	Microsoft's Distributed Common Object Model
DERA	UK's Defence Evaluation and Research Agency
DFD	NATO Data Fusion Demonstrator
DOHP	Digital Overhead Projector tool
DSPT	Decision Support, Planning and Tasking
ECU	European Currency Unit
EUCLID	European Co-operation for the Long term In Defence
FIONA	User interface architecture for the project
FKM	Fuzzy Knowledge Manager
FORCE	ORBAT browser tool
FTP	File Transfer Protocol
FUN	Functional Unit: an organisation of agents
GCM	GRACE Common (object) Model
GIS	Geographic Information System
GP	Global Planner tool for what-if simulation
GRACE	Grouping for Research into Advanced C3I for Europe
HCI	Human-Computer Interface
ILOG	A software tool supplier
Leda	Spatial reasoning software
MADRID	Map display tool
MCFP	Manoeuvre Co-ordinator and Formation Planner tool
MECU	Million ECU's
MFSP	Manoeuvre and Fire Support Planner tool
MG	Management Group (of MoD's)
MoD	Ministry of Defence
MPB/SP	Manoeuvre Plan Browser and Situation Predictor tool
NATO	North Atlantic Treaty Organisation
OMT	Object Modelling Technique
ORACLE	A relational database
ORB	Object Request Broker
ORBAT	Order of Battle
Orbix	An ORB supplied by Iona
PC	Personal Computer
PV	Private Venture funding
RACAS	Resource Allocator tool
RDBMS	Relational Database Management System
RTCE	Real-Time CABLE Enhancements
RTP	Research and Technology Project
SSA	Situation Similarity Assessor tool
STL	Standard Template Library
TEA	Terrain Analysis tool
TeART	Real-time Terrain Analysis tool
TED	Terrain Elevation Display tool
TIM	Time Manager tool
TTA	Tactical Threat Assessor tool
UK	United Kingdom
UML	Unified Modelling Language
VBS	Valuation Based System
WAP	Wide Area Picture
WAPC	WAP Compiler

Defence Research Establishment Valcartier (DREV, DND, Canada) **-based Planning Systems/Activities - A Summary**

The following is a short description of Defence Research Establishment Valcartier (DREV, DND, Canada) - based tools or activities relevant to collaborative planning.

Adaptive Intelligent System (AIS)
Group Decision Support System (GDSS)
Business Objects and Working Flows
Wing and Squadron Planning (WASP)
Electronic Battle Box (EBB)

Adaptive Intelligent System (AIS):

Current tactical mission planning systems operating in a highly dynamic and uncertain environment work in real-time but cannot guarantee efficient solutions. Potential constraints and conditions associated with mission criticality impose the development of adaptive reasoning capabilities to support resource planning, monitoring and control. A blackboard-based approach for an adaptive intelligent system targeted to air vehicle tactical mission planning has been developed. An adaptive intelligent system is a system designed to modify its behavior in response to a dynamic and uncertain environment in order to successfully reach its goals. The proposed approach consists in evolving the opportunistic nature of the basic blackboard paradigm to support real-time dynamic planning and execution control in a time-varying and uncertain environment. The blackboard-based system mainly involves four major components, namely the blackboard (data storage), the knowledge sources, the control unit and the communication manager. The baseline architecture allows for the concurrent execution of multiple knowledge sources and provides explicit mechanisms to support event-driven and goal-directed (planning-based) problem-solving. As part of planning-based control, resource-bounded reasoning can be achieved through a meta-level control of computation responsible for deliberation scheduling and run-time monitoring of anytime knowledge sources. Based upon an object-oriented approach, a prototype of the baseline architecture has been partly implemented. It provides a suitable platform to initiate the investigation of real-time artificial intelligence concepts related to cognitive tasks such as planning and monitoring. This initiative is a significant contribution toward the development of an automated real-time advisory decision support system for resource management. The blackboard paradigm turns out to be a natural approach to support collaborative planning.

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Group Decision Support System (GDSS):

Integration of Information Technologies (TI) and Multiple Criteria Decision Aid to Implement a Distributed & Unsynchronised Group Decision Support System (DUGDSS). The appearance of group decision support systems predates to the 1971, when a system called EMISARI was implemented at the US Office of Emergency Preparedness to support the decision making process [Holsapple and Whinston, 1996]¹. Huber (1984)² defines the term GDSS as "*a set of software, hardware, language components, and procedures that support a group of people engaged in a decision-related meeting*". The aim of a GDSS is to reduce the losses that can result from working as a group, while keeping (or enhancing) the gains that group work can yield. The rapid growth of the Intranets and the Internet and the development of supportive software are

¹ Holsapple, C. W. and Whinston, A. B. (1996), *Decision Support Systems: A Knowledge-Based Approach*. Course Technology, Massachusetts.

² Huber, G. P. (1984), "Issues in the Design of Group Decision Support Systems". *MIS Quarterly*, 8 (3).

likely to accelerate the trend of people working in dispersed groups [Pervan, 1998]³. Deciding in groups whose members are in different locations needs an increasing use of Information Technologies to communicate, to access to relevant information/knowledge and to progress in the decision making process. Geographic distribution and divergent agendas of the group members raises the difficulty of the synchronisation. Therefore, it is imperative to develop new GDSS allowing the members of the group to intervene in the decision making process at different moments of time. These considerations lead to a Distributed and Unsynchronised Group Decision Support System.

According to Bouyssou (1993)⁴, decision-making situation is commonly multidimensional. Then, it is realistic to take into account many conflicting viewpoints (conflicting criteria) to support the decision. Multicriteria Decision Aid (MCDA) approaches and procedures appear to be appropriate to this kind of decision making situations. Within the MCDA area, many Approaches/Procedures were developed to help a group of decision-makers reaching a decision (sorting, choice, negotiation, ranking, structuring, etc.) when considering simultaneously a set of conflicting and incommensurable criteria/attributes.

The aim of this research project is to integrate/develop Multicriteria Group Decision Aid Approaches/Procedures and Information Technologies in order to implement a new DUGDSS in the context of the C². We intend to apply such DUGDSS to the coalition planning &/or to joint operations within the CF.

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Business Objects and Working Flows

Towards an Interoperable Environment for CCISs Based on Business Objects and WorkFlows:

A *Command & Control Information System* (CCIS) plays a crucial role in the military field. In a battlefield, for example, a commander takes *decisions* concerning his troops' operations using the several information that are provided by the CCIS. While using only one CCIS seems obvious, the task becomes very *complex* when several CCISs are involved, in the same time. This situation occurs when, for example, different countries decide to set up a *coalition* environment for a disaster relief. Indeed, each CCIS has its own functional and structural characteristics. Moreover, CCISs may be spread across networks and may use low-bandwidth channels for communications. In order to help military users, we aim at developing an interoperable environment for CCISs in the BOWFIC2 project (BOWFIC2 stands for *Business Objects and WorkFlows for Interoperable Command & Control*).

The main motivation behind the development of an interoperable environment for CCISs is to facilitate the exchange of information and services. However, there exist only few design approaches that orient designers in the development of such an environment. Furthermore, it becomes urgent to assist users in satisfying their needs. Currently, a user has to locate adequate CCISs, adapt his behavior to their interfaces, and finally, understand their characteristics and requirements. As a possible solution, we suggest to involve several specialized components, called *Business Objects* (BOs), that will perform these operations on users' behalf. Moreover, given the complexity of managing distributed and heterogeneous CCISs, we suggest to specify the operation mode of these BOs, using *WorkFlows* (WFs).

To elaborate the BOWFIC2 architecture, several elements have been considered. For instance, *maintain* the autonomy and independence of the CCISs; *reduce* the informational disparities of the interconnected CCISs; *help* users satisfy their needs without worrying about the characteristics of the CCISs; *evaluate* the communication channels performance; and *protect* the CCISs from the unauthorized accesses. At the basis of the BOWFIC2 architecture, three types of BOs are required: a *BO-CCIS* to identify a CCIS, a *BO-User* to identify a user, and a *BO-Supervisor* to monitor the interactions that occur between BO-CCISs and BO-Users. Moreover, three module constitute the BOWFIC2 architecture. The first module, called *services provider*, contains CCISs with their corresponding BO-CCISs. The second module, called *services*

³ Pervan, G. P. (1998), "A Review of Research in Group Support Systems: Leaders, Approaches and Directions". *Decision Support Systems*, 23, 149-159.

⁴ Bouyssou (1993), "Decision Multicritère ou Aide Multicritère?". Newsletter of the European Working Group "Multicriterial Aid for Decisions", 2 (2), 1-2.

consumer, contains users with their corresponding BO-Users. Finally, the third module, called meeting infrastructure, allows BO-Users and BO-CCISs to meet and collaborate in a common workplace. The BO-Supervisor manages the meeting infrastructure and sets up a *security policy* to monitor the access of the BO-CCISs and BO-Users to this infrastructure. Five stages describe the operating mode of the BOWFIC2 architecture environment: *initialization, meeting, post-meeting, operating, and maintenance*.

One of the main issues we are addressing in the design of the BOWFIC2 environment, is the *ontology* issue. An ontology is a *means* to represent and exchange information that are understood by all the participants of the interoperable environment. By establishing an ontology, we offer a common terminological basis for the various interconnected CCISs, hence reducing for users the risks of getting inconsistent information. For the CCISs, ontological disparities exist at different levels. First, being generally developed in an independent way, CCISs present disparities in the vocabulary used to describe their information (different ontologies), which makes it difficult for users to use several CCISs simultaneously. Moreover, a user has to express his needs according to his own vocabulary and to his own comprehension.

In this paper, we briefly described the major characteristics of the BOWFIC2 environment that aims at applying BOs and WFs to the design of an interoperable environment for CCISs. A CCIS is a military system that provides a commander with actions to be taken. In the BOWFIC2 environment, BOs are able to fulfill services offered to users and specified by WFs.

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Wing and Squadron Planning (WASP)

This system is mainly an authoring tool supporting the creation and dissemination of Air Tasking Orders at the Wing and Squadron level for the Canadian Air Force.

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Electronic Battle Box (EBB):

The planning flavor shows a collection of authoring tools to support land operations and deployments at different unit levels (ORBAT construction and refinements). It supports an army corps structure for coalition forces, logistic planning, movement and transportation planning. EBB has also some interesting features to exploit a rich database useful to build coalition plans based on doctrines. A more detailed description and a demonstration might be made available on demand (CD).

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AUSTRALIAN COALITION PLANNING ISSUES AND REQUIREMENTS

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1 Priority for planning

The HQ Australian Theatre is a recently established level of command in Australia, to enhance Australia's ability to plan and conduct a major campaign. The development of a campaign planning capability is a top priority of the current Commander Australian Theatre (COMAST). Given that any major Australian campaign will almost certainly be conducted in a coalition context, there is considerable interest in ways of enhancing coalition planning, at the Theatre level of command.

2 Current problems

Some of the current basic problems faced in coalition planning are:

- Lack of basic secure connectivity with relevant agencies in coalition nations.
- Lack of interoperability of systems to allow meaningful information exchange and collaborative working.
- National versus coalition security constraints, which limits the connectivity other nations can have to Australian systems and vice versa.
- Lack of agreed process and doctrine, and lack of suitably trained staff across the coalition.

In other words, there are some clear current problems which will need to be addressed in the short to medium term before any Knowledge Based planning tools could have a positive impact in the medium to long term.

3 Areas of specific research interest

3.1 *Generic planning process issues*

- **Knowledge working.** How can we enhance the use of our existing knowledge for the planning and conduct of military operations? That is, recognising that knowledge working is a human intensive activity which our computer systems have been slow to support.

3.2 *Specific planning process issues*

- **Problem framing.** How can we help decision makers frame problems in the most helpful way?
- **Mission analysis/information synthesis.** How can we help decision makers gather and synthesise the information which will be needed? (Information Management, visualisation issues)
- **Course of Action analysis.** How can we help decision makers evaluate various options, spot flaws and develop better COAs? (Modelling and Simulation, Campaign analysis tools)
- **Execution.** How can we speed the development of orders once courses of action have been agreed (force deployment assistants)
- **Situation Assessment/Dynamic re-evaluation.** How can we help decision makers evaluate the impact of new information on current plans?

Technical Challenges for Knowledge-Based Planning for Coalition Forces

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Issues

For a decade, joint operations have driven US military doctrine and technology development. For much longer, however, coalition operations have been the norm and while current doctrine embraces coalition operations, technology development must extend well beyond where it is today. Command and control (C^2) of coalition operations introduces complexities that extend far beyond those already faced in controlling forces from a single nation.

Coalitions represent an unpredictable melange of capabilities, structures, policies, languages, cultures and military doctrines and rules of engagement. Integrating these disparate elements into an effective, coherent military force requires the ability to overcome the barriers imposed by these differences.

Knowledge-based planning (KBP) techniques could offer significant advantages in managing this new level of complexity. However, successful application of KBP methods will require new capabilities and emphases, particularly focusing on interoperability and sharing, distributed operations and negotiation, management of constraints, and highly templated activities.

Technology Challenges

Effective control of a single nation's forces requires the ability to use distributed assets to build plans, to execute those plans, and to monitor their effects, and to adjust the plans in the face of failure, success, enemy actions, and environmental effects. To address these issues, current technical work is focused on developing methods for **distributed, collaborative planning** using shared representations of a plan, **mixed-initiative planning** where humans and automated systems work in teams, and **open-ended** (or "rolling horizon") **activities**, where planning, execution, monitoring, and adaptation are smoothly integrated. Other work is elevating the state-of-the-art of **agent technology**, which will provide more flexible, real time methods for continuously adapting plans and activities. Capabilities in these areas still lag far behind

those needed to support unilateral military activities and further work is needed.

Technical developments that become even more critical for coalition operations lie in the following areas:

• Representations

- **Use of operational templates.** In order to manage the complexity and to limit search combinatorics as many activities as possible must be described by adaptive templates that can be selected, configured, instantiated, and adapted on the basis of the specific situation where they are to be employed.
- **Multiple abstraction levels.** Managing the development of activities at multiple, coherent abstraction levels will help reduce some of the complexity of C^2 problems and will bound options and excursions for lower level activities.
- **Uncertainty.** Misunderstandings, communication difficulties, latencies in information systems and other factors will magnify uncertainties that are already a part of military operations. These must be represented and handled explicitly. Close monitoring of activities, objectives-driven information gathering, and contingency planning will be essential.

• Interoperability

- **Shared representations and structures.** There must be ontological support for linking capabilities, resources, and requirements into a commonly understood framework.
- **Open systems.** Today's monolithic C^2 systems will not be flexible enough to adapt to coalition operations. It is essential that information sources describing key attributes such as logistics requirements and sources, intelligence resources, movement data, communication abilities and tables of organization be able to be linked quickly and correctly into the system. Ontologies must be developed that facilitate the rapid creation of wrappers and mediators for coalition partners' systems.
- **Agent architectures.** Modularity and plug-and-play components will be essential to enable systems to be tailored quickly to specific tasks. Agent architectures could provide an effective framework

to enable systems to be created "on the fly" and rapidly adapted to changing situations.

- **Process Management**

- **Meta-control of C² processes.** Management of the entire C² process, including logistics, intelligence, communications, personnel, medical, and humanitarian relief must be explicitly controlled in order to ensure that all activities are fully supported and integrated and are carried out efficiently. These workflow or process management operations must be able to handle real time, deadline-driven requirements. Decision-making will require explicit consideration of time-value-based utility functions.
- **Process visibility and controllability.** It will be essential for human operators to quickly understand the status of operations and to interact in a natural and meaningful fashion with their systems. Tailored interfaces and the advice metaphor will be particularly relevant. Interfaces to the systems will need to be multilingual.
- **Sophisticated constraint handling.** Coalition partners will differ in a number of areas that will create constraints on operations. Rules of engagement will vary among nations. Cultural and religious differences will impose additional constraints. Security and restrictions on the release of information will impose additional constraints. Methods must allow for greater flexibility in specifying constraints and preferences, for smoothly adjusting constraints, and for managing priorities.
- **Negotiation methods.** A key approach for handling inconsistencies and reaching agreement with coalition partners will be to use negotiation. New methods for interacting with human and software agents will be required along with methods for assigning values to requirements and positions.
- **Continuous evaluation of plans and activities** Methods for assigning values to plans and partial plans will be needed to enable informed selections among competing options and to focus plan development. Plan quality metrics must be defined that take into account military principles such as simplicity, speed, security, and unity of purpose.
- **Information management.** Explicit closed-loop control of information creation processes will be necessary. In particular, the process of recognizing information needs, planning for their satisfaction, managing collection assets, exploiting and interpreting raw data, developing information products, and disseminating the products to the right recipients, within the time required will require close control if C² processes are to be able to operate at maximum efficiency.

each technical area will be to develop these capabilities in an integrated and coherent fashion.

Progress and application of each of the technical areas outlined here offer the potential to greatly assist in the management of the complexity inherent in a coalition operation. The challenge over and above those posed by

Joint Logistic Planning (J4)

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Biographical

Mark Illingworth is a project manager in the Systems Infrastructure & Integration and Joint Applications Group in the Land Battle Management Department of DERA. After graduating in Mathematics, he served in 16th/5th The Queen's Royal Lancers, part of the British Army's Royal Armoured Corps. He commanded the logistic support squadron of the Regiment on operations. After obtaining an in-service master's degree in Design of Information Systems, he went on to specialise in Command and Information Systems. He helped to design the UK Land Forces Command Support System and taught at the Defence IT Management Training Centre. He joined DERA after leaving the Army and is now in his fourth year at Malvern.

Current Research

Mark is the leader of the newly authorised Joint Logistics Planning (J4) task within the UK Ministry of Defence Applied Research Package Departmental, Strategic & Joint Information Communications Systems. This three-year task will examine how AI planning technology can be applied to support logistic planning at the joint-service operational level. It is well recognised that for most operations this will involve working as part of a coalition.

Mark has also taken over as the manager of a project, within the Corporate Research Programme Computing, Information and Signal Processing Technology Group, entitled integration of effectiveness and uncertainty into planning languages to support military operations. This project will examine the use of simulation to support planning. The field of logistics planning provides a possible example application.

Holding Chaos at Bay

Thoughts on Coalition Operations

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Abstract

The purpose of this paper is to provide background and discussion points on the operational requirements for a responsive, agile, coalition command and control environment. Technology can support this environment but its vision is driven by operational imperatives.

Introduction

Coalition operations of any kind are chaotic by their very nature. Bringing disparate organizations together in an ad hoc organization is challenging enough but when you add the element of war, urgency, culture, language and other differences the blending can be disordered. Technologies can be used to significantly improve the chances for success of military operations. The thesis of this paper, then, Holding Chaos at Bay is really about significantly improving the ability of coalition partners to rapidly meld together, often in trying circumstances. The most significant enabling technology in the past thirty years has been the development of TCP/IP networks which are becoming ubiquitous. Applications that take advantage of these networks enable the rapid exchange of information in many languages. To take advantage of this technology it is essential that the command and control structure be digital. Everything being done in a digital environment then allows rapid exchange of information and collaboration that will significantly improve situation awareness.

There are a number of rules that should be applied to take advantage of the necessary digital environment:

- **All communication must be digital.** Email is becoming the common means for collaboration. Ensuring communications is by email enables other technologies to be employed in plan building or in translation from one language to another. Email encourages interaction between

people. It also flattens the structure of organizations. Other technologies (e.g., newsgroups and interactive CHAT) are useful in some cases but aren't as interesting as email.

- **Study data online to gain and share insights easily.** You need to gather data at every step in the military decision-making process (MDMP). Making data digital from the start can trigger a whole range of positive improvements.
- **Shift military planners and decision-makers into high-level thinking.** All levels of the chain of command need to see data. Planners and decision-makers need to turn passive data into active information. We need to start thinking of information-as-a-verb. It is essential that the data seek time be significantly reduced. When data is readily available it significantly reduces search-time and increases think-time.
- **Use digital tools to create virtual teams.** A collaborative culture has to be developed where people come together with a common goal and quickly bring closure to an issue. Active agents can be built to help monitor and coordinate the efforts of the group. Collective knowledge is enabled with a digital environment. Digital tools are the best way to open the door and add flexibility. If the right people can be working on the issues within minutes or hours instead of days, an organization obtains a huge advantage.
- **Convert every paper process to a digital process.** Any process which requires printing out a piece of paper is suspect.
- **Use digital tools to eliminate single-task jobs.** Every single task job is a candidate for automation.

- **Create a digital feedback loop.**
- **Take a look at process and simplify it wherever possible.** Solve the right problem don't beat it to death.
- **Keep an eye on the grand picture.** The commander's intent is essential if personnel are to understand and carryout orders. This is also important so subordinates can respond rapidly to the changing situation. Digital command and control enables rapid dissemination of commander's intent.
- **Too many hand-offs create too many likely points of failure.** This supports the concept of simplifying process. Take a look at the U.S. military deployment process. It must be made less complex.
- **Creating a new process is a major project.** You should have a specific definition of success, a specific beginning and end in terms of time, tasks, and intermediate milestones.
- **Use digital systems to route problems immediately.** Its always nice to receive good news, however, bad news must also be passed and shared quickly.
- **Use digital communication to redefine the boundaries.** Develop a web work style, in which each contributor or organization organizes itself optimally.
- **Transform every process into just in time delivery.** Products and information need to arrive when they are needed. No sooner, certainly no later.
- **Use digital delivery to eliminate the middleman.** If a middleman is required then he must add value to the process.
- **Use digital tools to help people solve problems for themselves.** This is a key point. Data and information must be readily available. Rather than send off a request for information, the information should be available in a short time from the user's workstation.

Definitions

This paper begins with definitions, which are necessary for a clear understanding of what we are trying to accomplish in improving the types of military operations under study here. The Adaptive Course of Action Advanced Concept Technology Demonstration (ACOA) will assist in the discussion as one example of what the Crisis Action Planning and Execution Community needs to support it.

ACOA—Adaptive Course of Action Advanced Concept Technology Demonstration. This will be discussed later in the paper.

Alliance—An alliance is the result of formal agreements (e.g., treaties) between two or more nations for broad, long-term objectives, which further the common interests of the members.

Coalition—An ad hoc arrangement between two or more nations for common action.

Coalition action—Multinational action outside the bounds of established alliances, usually for single occasions or longer cooperation in a narrow sector of common interest.

Collaboration—Two or more people get together, whether virtually or real, with a common goal or problem, work together, and when they leave a product is left behind.

Combined—Between two or more forces or agencies of two or more allies. (When all allies or services are not involved, the participating nations and services shall be identified, e.g., Combined Navies.)

Combined doctrine—Fundamental principles that guide the employment of forces of two or more nations in coordinated action toward a common objective. It is ratified by participating nations.

Combined operation—An operation conducted by forces of two or more allied nations acting together for the accomplishment of a single mission.

Command—The authority that a commander in the Armed Forces lawfully exercises over subordinates by virtue of rank or assignment. Command includes the authority and responsibility for effectively using available resources and for planning the employment of, organizing, directing, coordinating, and controlling military forces for the accomplishment of assigned missions. It also includes responsibility for health, welfare, morale, protection, and discipline of assigned personnel.

Command and Control—The exercise of authority and direction by a properly designated commander over as-

signed and attached forces in the accomplishment of the mission. Command and control functions are performed through an arrangement of personnel, equipment, communications, facilities, and procedures employed by a commander in planning, directing, coordinating, and controlling forces and operations in the accomplishment of the mission. Also called C².

Command and control system—The facilities, equipment, communications, procedures, and personnel essential to a commander for planning, directing, and controlling operations of assigned forces pursuant to the missions assigned.

Joint—Connotes activities, operations, organizations, etc., in which elements of two or more Military Departments participate.

Multination—Between two or more forces or agencies of two or more nations or coalition partners.

Interesting

In the Starwars series of novels there is an intergalactic creature described called the Taurill. The Taurill are a hive minded animal each linked telepathically making each individuals mind a part of the collective intelligence. Each individual gathers data through its senses and is able to take action with the group as a whole. By providing a digital environment, we are enabling the rapid exchange of data and information, which is available across the network, nears real-time. This capability enables collective observation, orientation, decision and action.

Requirements

Military operators often cannot articulate in technical terms what they would like a system to do. Often, they don't really know what they want until they see it. When technical people then deliver a tool that does what the operator wanted but it really didn't solve the real problem. The next few paragraphs will try to establish some of the requirements required in a Coalition Planning and Execution System. Application developers must recognize that the planning process whether at the coalition, national, theater, operational, or tactical level is nearly the same. It should also be apparent that the automation of this process must make a real difference in the ability of the planning community to plan and ultimately execute a military campaign or operation.

It is time to step back from the fray and take a look at the existing process and determine what needs to be changed to improve the process as a whole. When the existing processes were created we used mimeograph

machines, typewriters, message traffic, and snail mail. We now have Computers, TCP/IP networks, faxes, message traffic, email, World Wide Web, and other capabilities. Our processes, however, remain much the same, they need to change.

The following deal with our ability to handle documents:

- **Shared data/information Files/Documents**--the most fundamental requirement. Generalized file sharing is to be available across the entire global domain in which any on-line collaborative working relationship is established (e.g., worldwide). Having documents resident on servers rather than workstations simplifies a lot of collaborative requirements (e.g., security). This is another way to say a digital environment is essential.
- **Mixed-Object Data/Documents**--to provide for an arbitrary mix of text, diagrams, equations, tables, raster-scan images (single frames or live video), spread sheets, recorded sound, etc. -- all bundled within a common "envelope" to be stored, transmitted, read (played) and print as a coherent entity called a "document".
- **Explicitly Structured Data/Documents**--where the objects comprising a document are arranged in an explicit hierarchical structure, and compound-object substructures may be explicitly addressed for access or to manipulate the structural relationships.
- **Global, Human-Understandable, Object Addresses**--in principle, every object that someone might validly want/need to cite should have an unambiguous address, capable of being portrayed in a manner as to be human readable and interpretable. Our application must be usable by the computer novice. Remember that you may be in a 24-hour operation where actions may span several action officers. Data must remain accessible throughout the action process.
- **View Control of Objects' Form, Sequence and Content**--where a structured, mixed-object document may be displayed in a window according to a flexible choice of viewing options--especially by selective level clipping (outline for viewing), but also by filtering on content, by truncation or some algorithmic view that provides a more useful portrayal of structure and/or object content (including new sequences or groupings of objects that actually reside in other documents). Editing on structure or object content directly

from such special views would be allowed whenever appropriate.

- **The Basic "Hyper" Characteristics**--where embedded objects called links can point to any arbitrary object within the document, or within another document in a specified domain of documents--and the link can be actuated by a user or an automatic process to "go see what is at the other end," or "bring the other-end object to this location," or "execute the process identified at the other end." (These executable processes may control peripheral devices such as CD-ROM, videodisk players, etc.)
- **Hyperdocument "Back-Link" Capability**--when reading a hyperdocument on-line, a user can utilize information about links from other objects within this or other hyperdocuments that point to this hyperdocument--or to designated objects or passages of interest in this hyperdocument.
- **Link Addresses That Are Readable and Interpretable by Humans**--one of the "viewing options" for displaying/printing a link object should provide a human-readable description of the "address path" leading to the cited object; AND, the human must be able to read the path description, interpret it, and follow it (find the destination "by hand" so to speak). The system must be understandable by computer novices.
- **Personal Signature Encryption**--where a user can affix his personal signature to a document, or a specified segment within the document, using a private signature key. Users can verify that the signature is authentic and that no bit of the signed document or document segment has been altered since it was signed. Signed document segments can be copied or moved in full without interfering with later signature verification. When plans become approved, this feature is essential to maintain the integrity of the document.
- **Hard-Copy Print Options to Show Addresses of Objects and Address Specification of Links**--so that, besides on-line workers being able to follow a link-citation path (manually, or via an automatic link jump), people working with associated hard copy can read and interpret the link-citation, and follow the indicated path to the cited object in the designated hard-copy document. Also, suppose that a hard-copy worker wants to have a link to a given object established in the on-line file. By visual inspection of the hard copy, he should be able to determine a valid address path

to that object and for instance hand-write an appropriate link specification for later on-line entry, or dictate it over a phone to a colleague.

- **Hyperdocument Mail**--where an integrated, general-purpose mail service enables a hyperdocument of any size to be mailed. Any embedded links are also faithfully transmitted--and any recipient can then follow those links to their designated targets that may be in other mail items, in common-access files, or in "library" items.
- **The Hyperdocument "Journal System"**--an integrated library-like system where a hyperdocument message or document can be submitted using a submittal form (technically an email message form), and an automated "clerk" assigns a catalog number, stores the item, notifies recipients with a link for easy retrieval, notifies of suppressions, catalogs it for future searching, and manages document collections. Access is guaranteed when referenced by its catalog number, or "jumped to" with an appropriate link. Links within newly submitted hyperdocuments can cite any passages within any of the prior documents, and the back-link service lets the on-line reader of a document detect and "go examine" any passage of a subsequent document that has a link citing that passage.
- **Access Control**--Hyperdocuments in personal, group, and library files can have access restrictions down to the object level.
- **External Document Control (XDoc)**--(Not exactly a "hyperdocument" issue, but an important system issue here.) Documents not integrated into the above on-line and interactive environment (e.g., hard-copy documents and other records otherwise external to the Open Hyperdocument System (OHS)) can very effectively be managed by employing the same "catalog system" as for hyperdocument libraries--with back-link service to indicate citations to these "off-line" records from hyperdocument (and other) data bases. OHS users can find out what is being said about these "Xdoc" records in the hyperdocument world.

Features that should be part of this system:

- **Intercom**--control or observe another computer and speak to its user at the same time. Whether you are connected via network cable or through modems, no additional voice link is required. In addition to collaboration, this feature supports remote application assistance and training. Ulti-

mately, the computer should translate the conversation to the users native language.

- **File transfer**--Send and Exchange--send files or folders electronically to other computers. Recipients are automatically notified of incoming files. File transfer is carried out in the background while you continue to work at your computer. To quickly send files, you can drag files and folders to a desktop icon. The exchange service lets you copy information to and from the folders and drives on another computer just as if they were attached to your own computer. If an addressee is not on line, the transfer is held for future delivery.
- **Customizable destinations**--Drop Senders--Send services includes a Save Drop Sender command. You can choose this command after entering a destination address; the application creates a Drop Sender desktop icon that remembers the destination and the files and folders you have selected. Once created, all you need to do to send the same files or folders to that destination is double-click the destination's Drop Sender icon. You can also drag other items onto the Drop Sender icon, and they will be immediately sent to the remembered destination.
- **Flashnotes pop-up messaging**--The Send service provides the option of creating a Flashnote message that can be displayed automatically on the recipients' screens.
- **File recovery**--Suppose your session uploading or downloading a file is interrupted. When the transfer is resumed it should start at the point at which it was interrupted rather than having to start over from the beginning.
- **Exchange menu**--When connected to another computer an Exchange menu appears with appropriate mouse gestures (e.g., Desktop, New Folder, Open, and Remove functions). Others might include Go To, Rename, Get Info, and Find.
- **Screen sharing**--You can use your computer to control another computer. This will help with user support, training, and collaboration.
- **Netscape plug-in**--A Netscape plug-in which enhances your web browser with these services.
- **Chat**--Let your fingers do the talking--A quick access chat window for a quick, small exchange

using your typing skills. Ultimately, voice recognition should let you dictate the text.

- **Notify me**--The Notify me service can alert you when another user has begun using his or her computer so you can call that user or begin an attended access session.
- **On-line help**--similar to the Apple Guide concept. Real help.
- **Drag and Drop**--all services and applications support drag and drop.
- **Comprehensive, multi-level security**--You can define any number of registered users. These are users who have accounts and passwords to access your computer or a server. Each registered user can be assigned any combination of services: Send, Copy To (Exchange), Copy From (Exchange), Remove, Chat, Intercom, Control, Observe, Notify Me, If you want incoming connections only when you are at your computer, you can use the Admit Temporary Guests command or its counterpart, the Ask for Permission feature.
- **Address books**--You can create address books by adding addresses from the New Connection window or by importing an address list from a text file. You can drag an address directly from a transport tab to an address book window or from one address book to another.
- **411 Service**--Every user on the network must have a personal record on file with the system. If not present, at first log-in the system will require appropriate information to be filled in. For example: Name, grade, command, and email address, phone number..... Personnel who do not hit the system over an extended period of time will be deleted from the database. If they attempt to use the system at a later date they will be required to complete the data form again. The key here is that everyone active on the system will have an active file so that they can be searched for.
- **Activity Log**--All connections made to your computer showing users' names, network addresses, telephone numbers, then they connected or attempted to connect, and which privileges they used.
- **Virtual meeting space**--effective tools to manage a distributed, collaborative, planning network.

- **Artificial Intelligence**--agents, wizards, sentinels that automate the process of building and executing a plan.
- **Automated workflow**--more than fill in the blank or box. As decisions (choices) are made the workflow manager guides the planner through the process, notifies other planners of progress, identifies potential pitfalls, etc.
- **Newscast**--a browser which gathers information from the web and displays it. This would require the Intel community to assemble and publish "news" (intelligence). Users could configure their browser for items of interest.
- **Drag and Drop TPFDD**--ability to build TPFDDs in the back ground by dragging and dropping. (Time Phased Force and Deployment Data).
- **Automatic document formatting**--automatically generate formatted documents from data input and from information resident in the knowledge base. XML may provide an interesting solution here.
- **Desktop Video-conferencing (DTV)**-- capability to transmit audio and video of participants and documents across a TCP/IP network. Bandwidth use controls and the capability to use audio and video separately or together.
- **Interactive, shared Whiteboard**--capability to connect two or more systems so that participants can share documents (text documents, spread sheets, presentations, graphics, maps, etc) and interactively create, review, edit, and revise plans, presentations, and other documents. Drag and drop a document on the whiteboard to display it locally and transmit it.
- **Interactive shared map**--A tool to view maps and provides the means to actively collaborate on it in a distributed manner. Document, graphic, URL icons can be placed on the map to provide additional data.
- **Newsgroup**--Capability to provide near real time transfer of information to a wide variety of planners. The supporting server provides the platform for access to a wide variety of data files (text, spreadsheets, presentations, maps, photographs, etc.) for a wider range of information sharing in a broadcast environment.
- **Email**--The capability to send and receive electronic mail with attachments across a network. Need a return receipt capability. Also need sophisticated sets of automatic actions that will file messages, highlight their presence, alert, etc.
- **Chat Tool**--Capabilities allow users in multiple locations to communicate simultaneously by typing messages. Tool will record dialogue for later use. This is useful for minor coordination but not long-discussions and is most useful for minor coordination. Voice recognition technology may make this more useful.
- **World Wide Web Services**--The ability to use web browsers to search for and retrieve information.
- **Facsimile**--The capability to send unclassified and classified faxes to other locations who may not be on the net. Once committed to send, the system delivers the fax (secure or unsecure).
- **Netminder services**--When designated web page changes, notification is made to interested parties.
- **Office Suite**--almost by default the standard within the planning community is MS Office. Our efforts should be built around MS Office 2000.
- **Servers**--Capability for users to publish, store, and search documents (OPLANS, CONPLANS, maps, past operations, lessons learned, etc.) online. Possible servers include situation, plan, map, web, comms, The whole enterprise must be digital.
- **Information Transfer Services**--Seamless communications and information transfer (drag and drop).
- **Groupware**--group enablers that assist in virtual and real meeting management.

It cannot be emphasized enough, the planning process is a continuous flow from the time that planning starts through to successful completion of the mission. At first, there may only be a perception that something is wrong and the event that starts a plan may be small or large. We have been planning contingency operations for the Korean Peninsula for a number of years now and the process has become cyclic in its updates. On-the-other-hand, an event to mission completion may last only hours or days. The responsibility for planning falls mainly on the war-

fighting CINCs. Others provide supporting roles. Even if a CINC chooses to designate a CJTF, it is the CINC who remains responsible to the NCA for the military plan.

Shifting Gears

The Pacific Command is the sponsor for the Adaptive Course of Action Advanced Concept Technology Demonstration (ACOA). The ACOA keystone is the common database (Campaign Object) that is its foundation. The applications that are being developed allow the operator to interact with the database.

Mission

ACOA serves the Joint Operations Planning and Execution Community by adding value with a commitment to continuous improvement, innovation, and mutual satisfaction.

Principles:

- Continuous Improvement and Innovation are central to our pursuit of excellence.
- Crisis Action Organization Focus aligns our organization, resources, and strategies to exceed total partner satisfaction.
- Partner involvement is essential to create an environment in which each partner is will and able to contribute his or her efforts, knowledge, and ideas to achieve our mission and strategy.
- Partnerships are a foundation of our strategy as we continuously seek new ways to value, develop, maintain, and enhance mutually beneficial relationships.

Values

Quality. User focus. Subject matter leadership. Pursuit of excellence. Integrity. Timeliness. Resource management. Safety. Innovation. Bureaucratic avoidance. Entrepreneurialism. User/Developer Teamwork.

Technology

Technology can transform the military. More importantly it can revolutionize coalition operations. Technology is the engine that will drive our organizations forward, and it must constantly evolve to support as well as help shape our strategies. Technology is the responsibility of everyone not just technical experts. Using technology to speed up a flawed process is like trying to help a drunk get home by giving him the keys to a Porsche: he'll still crash; he'll just be going faster when he hits the wall.

We need to determine what technology will add value and then look for the tools needed to deliver it. What is interesting and exciting to a technology expert may not have the same charm for the end user. Smart weapons make military operations more efficient. However, the real Revolution in Military Affairs is our ability to more effectively command and control by having greater situation awareness. Deploying and employing the right force at the right time needs to be our goal.

The new ideal is for information to flow freely and instantly to anyone, anywhere, anytime. Value is added by serving that standard, not by slowing it down. That certainly is new, and it presents problems for most conventionally structured organizations. How can you embrace an open-architecture model if there are parts of your operation that you can't let people see?

In our new paradigm we aren't dealing with organizations we are dealing with individuals, sitting before a screen, exploring for ideas. It's more about connections, the free flow of information, and bringing people together. Technology properly applied provides the power to monitor everything everyone does from the moment they join to the moment they detach.

The big mystery after many groupware installations is how to use all the collaborative juice for more than just glorified e-mail. Often this seems a heavy-duty task, and it can be if you immediately attempt it on a global scale. Better to take small steps, one at a time. A great place to start this integration would be a small-scale test, like the ~~Joint~~ Combined Warrior Interoperability Demonstrations. Care in introducing collaboration tools is required. More than any other kind of application technology, it must be accompanied with a concept of operations.

Group collaboration occurs when a collection of people sharing ideas, information and similar objectives participate in a collective knowledge transfer experience. It is essential that their work be captured for later use. If a product is not produced then the participants had a conversation. Most researchers conclude the technology procedures and guidelines must be optimized for each specific collaborative task or project.

Applications must be convenient to the user, efficient, and easy to use, and lack technological difficulties. The user must have a sense of engagement. Visually oriented face-to-face communication is socially oriented and rich, supporting informal communication because it highlights participants' interaction and interpersonal relations. Written language in electronic form lacks two key features found in face-to-face dialog: (a) the necessity to respond to and coordinate with another person, on-line in real-time and (b) the use and integration of precise non-verbal as well as verbal elements.

Sharing of information. Informal contacts that result from frequent opportunities for communication often leads to collaboration. There is a logarithmic decline in

communication frequency with distance between potential communicators.

Individual gratification. Subjects who participate more in group discussion and collaboration are more satisfied with the results. Any evaluation should include perceptions of benefits, information overload, fairness and equality, quality of collaboration outcome, satisfaction with working relationships

Philosophers have debated what "knowledge" is since before Plato. Humans, being social animals often share data, information and knowledge. Today, technology not only supports the efficient and continuous sharing of knowledge for greater productivity and competitive advantage, but it also allows us to share data and information. Knowledge is something that occurs in and between people. 60-80% of all the knowledge and information in the world is held in people's minds and the remainder resides in libraries and databases. Our goal should be to cultivate environments that permit collaboration to flourish. The technology is like a good plow, however, even the best plow is only as good as the farmer using it. Knowledge will always emerge from a well-tended field.

Knowledge-Based Collaboration Webs are a representation for linking together all of the information necessary to support a collaborative Problem Solving Effort. We assume that collaborations occur when people have shared goals and form shared plans to achieve those goals. The plans (and the goals, for that matter) are always open to revision.

Information Dominance: The Key to Success: Capture, Recover, Preserve, and Effectively use organizational knowledge systems that understand decisions, plans, interpretations. Ubiquitous environments, which communicate naturally, infrastructures that, bring people together by understanding context and content

In 1996, Americans sent over 100 million e-mails a day; within the next five years, that number is expected to exceed 5 billion. Three years ago, who know the meaning of www.anything? Note that over half the people in the world have never made a telephone call, let alone used a computer. We need to be able to translate our data to multiple languages on the fly.

Change

No one likes change, except, perhaps, a wet baby. Change isn't linear anymore. It's a time bomb, acceleratWorld class has no meaning. The same with best or number one. You can't measure it.

Conclusion

Holding chaos at bay. Through this paper an attempt has been made to identify the problems faced by coalition partners in planning and executing military operations. I

have covered a few definitions to get us on the same page for the discussion. Then, I identified, as generally as possible, the requirements that must be addressed in a coalition planning and execution system. There are few original thoughts in this paper but a melding of many ideas and concepts accumulated over many years of experience at the end user level of this problem. I've addressed the ACOA ACTD and followed that with a few remarks about technology. I am hopeful that this paper will contribute to the discussions on the topic that brings us together. Technologists continue to search of the "killer app". There isn't one, because as soon as you publish one there is someone who'll do it better. Just like the concept of "world class" or "number 1" it is often not measurable. It's time to build a baseline system with the technology available to day, incrementally improve from that base.

What is in a Plan? -- A Common Operational Environment for Planning for Coalition Military Operations

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Distributed Collaborative Planning (DCP) allows geographically dispersed commands to electronically interact to share common perceptions about crisis assessment, Course of Action (COA) development, with adaptive Joint force generation for support of combat forces in crisis situations.

The Defense Advanced Research Projects Agency (DARPA) and the Air Force Research Lab (AFRL) have co-sponsored several initiatives aimed at developing tools to support tomorrow's technological needs in support of military operational planning and scheduling. Many of these technologies have been successfully demonstrated in a series of military exercises and demonstrations. Through these exercises and demonstrations we have gained significant experience in identifying and developing tools to meet requirements of operational users in both deliberate and crisis planning.

The authors have been involved in developing technologies and spinoffs to support planning operations for the past several years to include exercises using coalition forces. For example, TARGET (a course of action development tool) and ForMAT (a force deployment tool) as well as their spinoffs (JTF Planner and FMedit) have been used to support several Joint Warrior Interoperability Demonstrations (JWID). Specifically, in JWID 95, where JWID focused on the area of distributed collaborative planning and the continuing evolution towards seamless

battlespace management for combat and relief operations across missions, Services, non-DOD agencies, and Allies; DCP sessions were supported through the JTF Planner, TARGET and ForMAT/FMedit using VTC, whiteboards, e-mail, graphics, and image transfer among the CJTF, the Allies at Camp Pendleton, and staff in Australia. JWID 96 followed up with similar interactions with the CJTF located at Fort Bragg and components dispersed at other locations to include a ship afloat.

Common Representation

The nature of future military operations demands that they be Joint and most probably combined or coalition. The DARPA supported Adaptive Course of Action (ACOA) ACTD provides the means to employ new technologies in the Joint Operations Planning and Execution environment. ACOA enables the concurrent, joint, distributed, collaborative environment to conduct both operations planning and execution. Throughout each of the phases of crisis planning and execution, ACOA tools provide the joint military planner with the capability to become situationally aware, assess the environment, conduct execution planning, execute the military decision-making process, and successfully execute the joint plan. The ACOA tool suite is also a key enabler in achieving Joint Vision 2010.

Coordinated theater-level operations involving widely dispersed CINCs and support Agencies are a reality. Commanders need an increased capability to react quickly and effectively to address combat and operations other than war scenarios on a global basis. A common representation with a suite of common distributive collaborative tools are also needed to support Coalition Planning. We envision a suite of tools, similar to those already in the ACOA program that would provide step-by-step guidance for planners involved in coalition planning. These tools would generate products at various stages of planning and provide analysis capabilities to enable the planners to test alternative planning strategies. Most important, a common representation for an emerging plan would be provided. In this environment, each coalition planner would be able to use tools that are crafted for their specific needs and yet products developed by a specialized tool could be merged into a common representation that is available for use by any of the other (coalition) planners.

In JWID 95 and JWID 96, one of the most promising DCP demonstrations was the JTF Planner. The JTF Planner connected the decision maker to a variety of information services. The JTF Planner provided a simplified "shell" interface that reduced the complexity involved in accessing those services. We believe that the computer interface that each planner interacts with is equally important to the underlying representation of the plan. Furthermore, our experience with TARGET and the JTF Planner indicates that users benefit from a stable environment that allows

them to concentrate on the task at hand and to focus more on the job of creating a comprehensive plan without worrying about all of the procedural and product generation issues. Adaptability of the system to various planning situations from Deliberate to Crisis and from combat to operations other than war is also critical. This adaptability and reduction of complexity in the planning and execution process are fertile areas for the use of knowledge based systems.

Two ACOA tools particularly oriented toward supporting coalition planning are the WebPlanner and JADE. The WebPlanner evolved from the TARGET system. It is implemented in JAVA, and leverages off object-oriented storage and CORBA-based distribution. The WebPlanner extends the ability of joint planning tools and information to all members of the joint planning team. It accelerates multi-staff collaboration during situation assessment, execution planning, and execution. It provides for the generation of planning products through it's tight integration with Microsoft Word and Powerpoint. Finally, the WebPlanner provides an automated assistant that guides novice users through the critical steps of plan development.

The WebPlanner is linked to JADE (Joint Assistant for Deployment and Execution). JADE provides a specialized suite of knowledge-based tools that support the generation of a first-cut force deployment plan using pre-defined force packages and a map-oriented "drag-and-drop" technology. JADE evolved from the ForMAT and FMEdit systems that were used in JWID 94, JWID 95 and JWID 96, as well as in several Tempo Brave exercises where coalition forces were involved. JADE also supports drill down access to underlying information and it's automated "assistant" provides users with advice and suggestions on how to construct and modify an evolving deployment plan.

Based on years of experience dealing with joint coalition force operations and developing tools to support these operations, the authors believe that knowledge-based technology can contribute significantly to enhancing coalition force operations. It is envisioned that knowledge-based systems can assist in maintaining a common representation of the plan as well as a common understanding of the policies and procedures to be employed for coalition force operations. Knowledge-based systems can also contribute to the desire for adaptability and simplification of the process, freeing the users to concentrate on the job and removing some of the complexity and intimidation of inexperienced users working in a coalition environment.

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A COALITION BASED COLLECTIVE REPRESENTATION

This dissertation assumes that most anywhere on the global grid (location), if something happens (event), there will be a decision made (most likely through a coalition-standing or ad hoc), that produces some type of response (action), to solve the problem caused by the event. In this day and age of digitization, there is a great opportunity to automate a lot of this decision process and possibly even design a proactive capability vice the reactive one in place today. One of the major stumbling blocks is the way in which the real-time situation (location, event and follow-on actions) is represented to the decision-makers such that they can enact the appropriate response and attain the desired results.

From this short fall comes a requirement for the development and maintenance of a real-time "Collective Representation" (CR) designed to cover the coalition area of interest. The reason we call this a Collective Representation, vice a Common Representation, is that each member of a coalition relies on their own intelligence sources to produce raw sensor data (e.g. Predator video, etc.), additional data (pilot mission reports, etc.), and fused information (e.g. situation updates from national intelligence, etc.). Since they do not always share all of this information there is the strong possibility that each nation has a different situation representation. It is also assumed that each nation will never give up accessing their national systems. As HRH General Khaled bin Sultan said in his book Desert Warrior, "however close two allies might be, there is always a certain jockeying for advantage and always, in my experience, a measure of information which each side keeps to itself". As a result, the development of a Common Representation is really not feasible and the coalition decision process becomes paralyzed. The idea of a Collective Representation is based on the development of agents that use domain specific content to derive the common objects required that in-turn provide the services capable of building the CR. From the CR the coalition can then make rapid decisions and proactively take actions to stop negative events from occurring.

These software agents would basically comprise three classes: (see depiction on page 2)

Agents using domain specific and coalition approved definitions to develop the domain content (Content View Agents)

- Shared Ontology
- Common C2 Schema
- Common Data Objects

Agents using this domain content to search coalition and non-coalition sources and construct the CR. (Content Building Agents)

- Logistics agent that construct friendly database representation

- Weather agent that constructs weather picture

- Target agent that constructs enemy COGs, target sets, targets, DMPs

- Neutral agent to construct neutral database

- Etc.

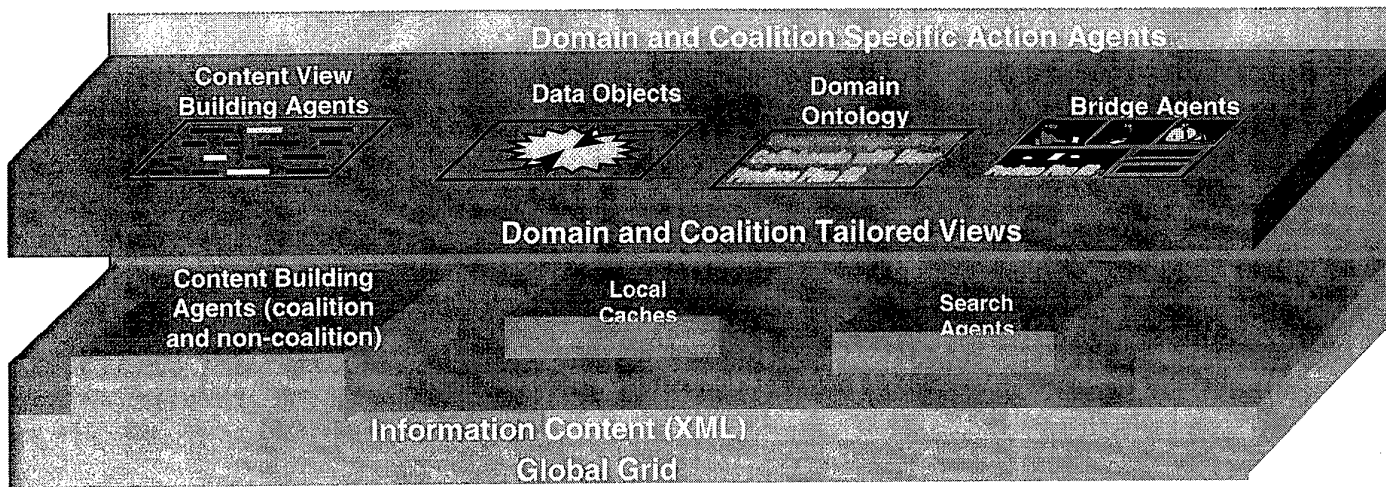
Agents, using the CR to make domain specific action recommendations. (Domain Action Agents)

- Logistic agents that provide resource management recommendations

- Employment agents that provide concepts for the use of military forces

- Etc.

This type of structure can be used not only for the employment of military forces to drop bombs, fly air defense, etc., but also provides the same support to humanitarian activities. Thus the system is scalable to the situation as it evolves.



Position Paper: Models of Planning

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John Kingston is a Research Fellow at the Artificial Intelligence Applications Institute, currently part of the Division of Informatics at the University of Edinburgh. After obtaining an Honours degree in Psychology, he obtained a Master's degree in Knowledge Based Systems at the University of Edinburgh.

In my 12 years at AIAI, I have been involved in AI work with various companies and organizations, ranging from the UK Health and Safety Executive to the US Air Force and from Unilever to the University of Edinburgh. The key to the success of my work has been my use and application of the CommonKADS methodology for knowledge analysis and KBS design. Understanding and adapting the multi-perspective approach inherent in the CommonKADS methodology has enabled me to analyse captured knowledge, present it to clients and experts for verification, and use it as a sound basis for system development.

Recently, my interests have moved to applying the same multi-perspective modelling approach to knowledge management, via the capture and effective representation of corporate knowledge assets. My research interests include techniques for capturing knowledge and modelling knowledge, methods for distributing knowledge (particularly intelligent Internet-based software), and the development of real-world applications which verify and exemplify all the aforementioned techniques.

My interest in planning stems from my applied research work in the capture of knowledge and the development of knowledge based systems. From this basis, I have conducted work in the following areas:

- Developing a model of knowledge based planning suitable for the CommonKADS library of generic inference structures. This model was based on the approach to planning taken by O-Plan. The model was applied to planning of missions for Search and Rescue helicopters.
- Linking planning with the pioneering Cyc system [see e.g. <http://www.cyc.com/halslegacy.html>], as part of the DARPA-sponsored High Performance Knowledge Bases initiative. Our work on this project has included the development of a fully declarative planner within Cyc for solving obstacle workaround problems, and we are currently assisting in a joint project to develop critiquers for military course of action mission plans.
- Developing capability models of problem solving methods, with the aim of describing problem solving methods (including planners, or methods for planning) sufficiently richly to enable informed choices between methods to be made.
- Considering new techniques for acquiring knowledge of constraints, which are critical to any planner.

Knowledge Level Interoperability

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Abstract

This paper briefly outlines attitude programming and the ATTITUDE development before exploiting it to advocate coalition pursuit of interoperability at the knowledge level.

Attitude Programming

The nature of programming has changed considerably over the past half a century. The earliest computers suffered from two major impediments:

- Performance Problem: electronic computers were unreliable and high cost items; and
- Communication Problem: machine interaction was difficult, requiring specialisations held by a privileged few.

The Communication Problem wrought a communicative gulf between user and computer, with the user flush with human conceptualisations at one extremity, and the computer as a complex switching device at the other.

The extent of the divide between human and user has steadily diminished over time, largely under the auspices of the Automation Principle (adapted from MacLennan, 1983). It states that *if any of the tasks that are undertaken by a user in communicating with a computer are mechanical, tedious, error prone or prevalent, then they should be automated within the computer, and interfaced to as if primitive thereafter*. The introduction of machine languages, assembly languages, higher level languages, graphical user interfaces *et cetera* exemplify the transition. The effect has been to drag the computer closer to the communicative practices of the user by embedding those practices within the machine.

Interaction with the machine would closely resemble interactions with a human if the Automation Principle could be applied to its limit. An analysis of our language shows that we interact with humans by ascribing mental attitudes to them, such as beliefs, desires, hopes *et cetera*. Syntactically we do this through propositional attitude expressions having the syntactical form

<subject> <attitude> that <proposition>.

To illustrate,

Fred believes that the sky is blue

is a propositional attitude expression. The subject (e.g. Fred) expresses which individual has the propositional attitude; the proposition (e.g. the sky is blue) expresses some assertion about the world; and the attitude (e.g.

believes) expresses the kind of response the subject has toward the proposition.

The author contends that if we conceptualise our interaction with humans through propositional attitude expressions, and we want interactions with our machines to resemble interactions with one another, then we ought to interact with our machines through propositional attitudes. With subtle modification, propositional attitude observations such as

Fred believes that the sky is blue

can be transformed into propositional attitude instructions issued to software agent Fred like

Fred believe that the sky is blue.

The author calls this attitude programming.

ATTITUDE

ATTITUDE is a system that is being developed to service attitude programming. ATTITUDE allows the user to define multi-agent systems in which each individual agent has beliefs, desires, expectations and anticipations about the world. These attitudes can also be appropriated to dynamically formed groups of individual agents in certain ways.

Interaction with ATTITUDE occurs both procedurally and declaratively. Procedural interaction occurs through reactive plans formed by linking propositional attitude instructions via regular expression operators. Preliminary case-based reasoning work has additionally been undertaken based upon the back propagation of weakest precondition semantics across plans (Rutten, 1998). Declarative interaction occurs through the belief of Horn clauses, or Horn clauses with conditional probability tables, as ATTITUDE also supports first order Bayesian inference, including conditional probability queries (Fabian and Lambert, 1998).

ATTITUDE's propositional expressions accommodate different types of expression elements. Two of the more exotic are: (a) schedules, so that agents can perform scheduling operations and include references to those schedules within assertions; and (a) situations, so that agents can partition their beliefs; assemble those partitions selectively to perform "what if" reasoning; and include references to those partitions within assertions (Lambert, 1999).

The Knowledge Level

In 1979, Allen Newell proposed the "the knowledge level" (Newell, 1982). Newell's contention was: (a) that computational systems could be viewed at different levels of abstraction, including the computer program (symbol) level, the logic unit level, the circuit level and the device level; and (b) that there is a knowledge level above the program level. At the program level the computational system is understood in terms of representations, data structures and processes. At the knowledge level, the computational system is understood as having beliefs and desires (goals), such that the agent's actions are designed to satisfy its desires, given its beliefs. The program level description shows *how* the knowledge level behaviour is attained, but the behaviour of the computational system can be predicted and explained from knowledge level descriptions alone.

When engaged in practice, the propositional assertions within propositional attitude instructions are used to express claims about the world. The underlying presumption is that the world can be understood and represented by sets of propositional assertions, or facts. The idea of a world of facts is historically a relatively recent one. It culminated when Wittgenstein (1922) supplanted Aristotle's world of objects with a world of facts, in which the facts are expressible through a formal language.

The classical AI paradigm generally accepts that formally represented facts can serve as knowledge level descriptions. Beliefs about the world are then conceived as beliefs about a world of facts, and those facts can be represented through formal languages. So when understood at the knowledge level, the behaviour of the computational system can be expressed in terms of the relationships between formal language beliefs and desires that are ascribed to the computational system. The active representations operating at the underlying program level of abstraction might be quite different, or as with ATTITUDE, they might correlate closely.

Knowledge Level Interoperability

In contemplating combined operations involving coalition partners, the issue of interoperability looms large. As we migrate more toward knowledge-based situation assessment and decision-making systems, knowledge-based connectivity across coalition forces, in particular, must be managed.

Interoperability is often viewed as a technological problem and, as a consequence, proposed solutions often involve the use of identical software and/or hardware. But a variety of legal, political, economic, social and technological drivers will at times prohibit coalition partners from deploying the same technological solutions. For the same task, some will use a relational database on machine type X, while others might perhaps employ a

classical planner on machine brand Y. The establishment of coalition interoperability through a reliance on identical products at the program level of abstraction is, in general, a false hope.

A more feasible approach is to acquire interoperability through identity at the knowledge level. Under this approach interoperability derives from a common framework for viewing the world - a common understanding of the kinds of facts that are admissible. This would require the development of coalition standards for the formal conceptualisation of such things as space and time, tactical manoeuvres, political models, *et cetera*. In a logicist setting, addressing each of these issues would require the selection of appropriate formal language terms and predicates to represent the objects and relationships of interest, together with a set of axioms to constrain their meaning (Chang and Keisler, 1977). The resulting axiomatic theories then effectively deliver a knowledge level design specification for coalition knowledge-based systems, without dictating *how* that conceptual framework is implemented at the program level.

By designing future technological systems in accordance with knowledge level standards, humans will be better able to operate between disparate implementations, and automated interoperability can be designed around conversions between the different implementations of the same knowledge level features.

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Toward Collaborative Planning Support – A Summary of Selected Activities at Defence Research Establishment Valcartier (Canada)

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Abstract

A brief description of selected command and control activities currently ongoing at Defence Research Establishment Valcartier (DREV, Canada) is given. It includes material and references to some key activities and related tools relevant to collaborative planning, namely, Adaptive Intelligent System (AIS), Group Decision Support System (GDSS), An Advisor System for Situation Assessment and Information Gathering (ASISA), Business Objects and Working Flows, Wing and Squadron Prototype (WASP) system, and Electronic Battle Box (EBB) system.

Adaptive Intelligent System (AIS)

Current operational and tactical mission planning systems operating in a highly dynamic and uncertain environment work in real-time but cannot guarantee efficient solutions. Potential constraints and conditions associated with mission criticality impose the development of adaptive reasoning capabilities to support resource planning, monitoring and control. A blackboard-based approach for an adaptive intelligent system targeted to air vehicle tactical mission planning has been developed¹. An adaptive intelligent system is a system designed to modify its behavior in response to a dynamic and uncertain environment in order to successfully reach its goals. The proposed approach consists in evolving the opportunistic nature of the basic blackboard paradigm to support real-time dynamic planning and execution control in a time-varying and uncertain environment. The blackboard-based system mainly involves four major components, namely the blackboard (data storage), the knowledge sources, the control unit and the communication manager. The baseline architecture allows for the concurrent execution of multiple knowledge sources and provides explicit mechanisms to support event-driven and goal-directed (planning-based) problem-solving. As part of planning-based control, resource-bounded reasoning can be achieved through a

meta-level control of computation responsible for deliberation scheduling and run-time monitoring of anytime knowledge sources. Based upon an object-oriented approach, a prototype of the baseline architecture has been partly implemented. It provides a suitable platform to initiate the investigation of real-time artificial intelligence concepts related to cognitive tasks such as planning and monitoring. This initiative is a significant contribution toward the development of an automated real-time advisory decision support system for resource management. The blackboard paradigm appears to be a natural approach to support or extend some form of collaborative planning.

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Group Decision Support System (GDSS)

Integration of Information Technologies (IT) and Multiple Criteria Decision Aid to Implement a Distributed & Unsynchronised Group Decision Support System (DUGDSS). The appearance of group decision support systems predates to the 1971, when a system called EMISARI was implemented at the US Office of Emergency Preparedness to support the decision making process [Holsapple and Whinston, 1996]². Huber (1984)³ defines the term GDSS as "a set of software, hardware, language components, and procedures that support a group of people engaged in a decision-related meeting". The aim of a GDSS is to reduce the losses that can result from working as a group, while keeping (or enhancing) the gains that group work can yield. The rapid growth of the Intranets and the Internet and the development of supportive software are likely to accelerate the trend of people working in dispersed groups [Pervan, 1998]⁴.

² Holsapple, C. W. and Whinston, A. B. (1996), *Decision Support Systems: A Knowledge-Based Approach*. Course Technology, Massachusetts.

³ Huber, G. P. (1984), "Issues in the Design of Group Decision Support Systems". *MIS Quarterly*, 8 (3).

⁴ Pervan, G. P. (1998), "A Review of Research in Group Support Systems: Leaders, Approaches

¹ Berger J. et al. (1997), "Toward an Adaptive Intelligent System for Tactical Mission Planning", 1997 Symposium on Command and Control Research and Technology, National Defense University, June 1997, Washington, DC.

Deciding in groups whose members are in different locations needs an increasing use of Information Technologies to communicate, to access to relevant information/knowledge and to progress in the decision making process. Geographic distribution and divergent agendas of the group members raises the difficulty of the synchronisation. Therefore, it is imperative to develop new GDSS allowing the members of the group to intervene in the decision making process at different moments of time. These considerations lead to a Distributed and Unsynchronised Group Decision Support System.

According to Bouyssou (1993)⁵, decision-making situation is commonly multidimensional. Then, it is realistic to take into account many conflicting viewpoints (conflicting criteria) to support the decision. Multicriteria Decision Aid (MCDA) approaches and procedures appear to be appropriate to this kind of decision making situations. Within the MCDA area, many Approaches/Procedures were developed to help a group of decision-makers reaching a decision (sorting, choice, negotiation, ranking, structuring, etc.) when considering simultaneously a set of conflicting and incommensurable criteria/attributes.

The aim of this research project is to integrate/develop Multicriteria Group Decision Aid Approaches/Procedures and Information Technologies in order to implement a new DUGDSS in the context of the C². We intend to apply such DUGDSS to the coalition planning &/or to joint operations within the Canadian Forces.

Investigators: Adel Guitouni, M. Bélanger (adel.guitouni@drev.dnd.ca)

ASISA: An Advisor System for Situation Assessment and Information Gathering

DREV is conducting activities to build an advisor system for situation assessment and information gathering. The system is based on a combination of Case-Based Reasoning (CBR) and Hierarchical Task Network (HTN) Planning techniques. CBR is advantageous in approximate reasoning from the current situations in real time, and is good in dealing with loosely structured descriptions of domain knowledge. HTN based planning, on the other hand, provides a formalism for organizing tasks and their relations in a hierarchical and temporal framework. The combination of these two techniques provides an underlying model for solving situation assessment problems.

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Business Objects and Working Flows

This effort revolves around the following theme: Towards an Interoperable Environment for CCISs Based on Business Objects and WorkFlows.

and Directions". *Decision Support Systems*, 23, 149-159.

⁵ Bouyssou (1993), "Decision Multicritère ou Aide Multicritère?". Newsletter of the European Working Group "Multicriteria Aid for Decisions", 2 (2), 1-2.

A *Command & Control Information System* (CCIS) plays a crucial role in the military field. In a battlefield, for example, a commander takes *decisions* concerning his troops' operations using the several information that are provided by the CCIS. While using only one CCIS seems obvious, the task becomes very *complex* when several CCISs are involved, in the same time. This situation occurs when, for example, different countries decide to set up a *coalition* environment for a disaster relief. Indeed, each CCIS has its own functional and structural characteristics. Moreover, CCISs may be spread across networks and may use low-bandwidth channels for communications. In order to help military users, we aim at developing an interoperable environment for CCISs in the BOWFIC2 project (BOWFIC2 stands for *Business Objects and WorkFlows for Interoperable Command & Control*).

The main motivation behind the development of an interoperable environment for CCISs is to facilitate the exchange of information and services. However, there exist only few design approaches that orient designers in the development of such an environment. Furthermore, it becomes urgent to assist users in satisfying their needs. Currently, a user has to locate adequate CCISs, adapt his behavior to their interfaces, and finally, understand their characteristics and requirements. As a possible solution, we suggest to involve several specialized components, called *Business Objects* (BOs), that will perform these operations on users' behalf. Moreover, given the complexity of managing distributed and heterogeneous CCISs, we suggest to specify the operation mode of these BOs, using *WorkFlows* (WFs).

To elaborate the BOWFIC2 architecture, several elements have been considered. For instance, *maintain* the autonomy and independence of the CCISs; *reduce* the informational disparities of the interconnected CCISs; *help* users satisfy their needs without worrying about the characteristics of the CCISs; *evaluate* the communication channels performance; and *protect* the CCISs from the unauthorized accesses. At the basis of the BOWFIC2 architecture, three types of BOs are required: a *BO-CCIS* to identify a CCIS, a *BO-User* to identify a user, and a *BO-Supervisor* to monitor the interactions that occur between BO-CCISs and BO-Users. Moreover, three module constitute the BOWFIC2 architecture. The first module, called *services provider*, contains CCISs with their corresponding BO-CCISs. The second module, called *services consumer*, contains users with their corresponding BO-Users. Finally, the third module, called meeting infrastructure, allows BO-Users and BO-CCISs to meet and collaborate in a common workplace. The BO-Supervisor manages the meeting infrastructure and sets up a *security policy* to monitor the access of the BO-CCISs and BO-Users to this infrastructure. Five stages describe the operating mode of the BOWFIC2 architecture environment: *initialization*, *meeting*, *post-meeting*, *operating*, and *maintenance*.

One of the main issues we are addressing in the design of the BOWFIC2 environment, is the *ontology* issue. An

ontology is a *means* to represent and exchange information that are understood by all the participants of the interoperable environment. By establishing an ontology, we offer a common terminological basis for the various interconnected CCISs, hence reducing for users the risks of getting inconsistent information. For the CCISs, ontological disparities exist at different levels. First, being generally developed in an independent way, CCISs present disparities in the vocabulary used to describe their information (different ontologies), which makes it difficult for users to use several CCISs simultaneously. Moreover, a user has to express his needs according to his own vocabulary and to his own comprehension.

In this paper, we briefly described the major characteristics of the BOWFIC2 environment that aims at applying BOs and WFs to the design of an interoperable environment for CCISs. A CCIS is a military system that provides a commander with actions to be taken. In the BOWFIC2 environment, BOs are able to fulfill services offered to users and specified by WFs.

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Wing and Squadron Prototype (WASP)

The aim of the project is to develop a functional prototype to meet and validate Air Force requirements for mission support primarily at the Wing and Squadron levels but also at 1 CAD/CANR HQ. WASP proposes an event-driven, seamless approach for treating mission requests from 1 CAD down to the assignment of crew and aircraft at the wing and squadron levels. USMTF ATOs may be received and parsed from external systems, or be generated and disseminated to appropriate operations centres. WASP also integrates a weather sub-system to provide information on weather factors that may affect current or near-term operations. The WASP prototype will be evolved to include internet/intranet technologies in a distributed worksharing environment, with investigations in the use of CORBA, DCOM, and implementation in JAVA.

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Electronic Battle Box (EBB)

The planning flavor shows a collection of authoring tools to support land operations and deployments at different unit levels (ORBAT construction and refinements). It supports an army corps structure for coalition forces, from database and doctrinal documents browsing, to logistic planning, lift, movement and, transportation planning. EBB has also some interesting features to exploit a rich database useful to build coalition plans based on doctrines. The EBB Suite has been developed using Delphi in a Windows environment. A more detailed description and a demonstration are available on demand (CD).

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INFORMATION SUPPORT SYSTEMS FOR COALITION OPERATIONS (ISSCO)

Objective:

Improve the ability of military personnel to:

- plan for,
- understand, and
- predict

decision making behavior of foreign nationals in coalition operations other than war (C/OOTW).

Problem: In 40 years (1950-89) there were ten military operations involving US forces. In the next seven years (1990-96), that number was 25. The majority of those were operations other than war (OOTW), many of which involved coalition partners. Coalition operations and operations other than war (C/OOTW) require U.S. military personnel to work with foreign nationals (both military and civilian) of differing cultures. Mission success depends upon the ability of US military personnel to understand, predict and anticipate the decision making behavior of people from these diverse cultures. In addition, there are C/OOTW situations such as humanitarian assistance/disaster relief (HA/DR), in which the military have only a support role.

As C/OOTW increase in number, there is an increase in the interaction between our military and foreign civilian groups including civilian governmental organizations (CGOs), non-governmental organizations (NGOs), private volunteer organizations (PVOs) and various special interest groups. In C/OOTW the U.S. military needs to understand and appreciate the effect that culture may play in how the coalition partners, both military and civilian, interpret and implement their role in the operation.

Goals:

The near-term goals for the ISSCO project include:

1. Identify the characteristics of military and civilian organizations that would likely be involved in C/OOTW. Emphasize the organizational structure, roles and responsibilities, and available resources.
2. Review past C/OOTW involving both foreign military and civilian groups. Analyze structural factors surrounding these incidents as they contribute to the success or failure of the operation.
3. Establish and maintain liaison with experts in C/OOTW, including military staff, representatives of civilian organizations, and researchers. Collect information about C/OOTW tasks and situations in which operational users would need to predict how task, organizational, and cultural factors influence decision making. Determine user decision requirements, information flow sequences, and potential operational usage scenarios for ISSCO system design.
4. Review research studies and analyses relevant to C/OOTW to identify cognitive, organizational, and cultural factors that are important for effective collaboration in coalition operations. Examine relevant findings from applied areas, such as field tests, military exercises, international business experiences, historical incidents, and similar events. Compile this information into a knowledge base for use with the ISSCO system.
5. Develop display designs that support the decision tasks, information requirements, and collaborative processes in C/OOTW.

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Issue Points for Knowledge-Based Planning Workshop:

1. In Coalition Operations how does the workflow differ from non-Coalition Operations? Who is involved? What do they do? How does the CINC plan for Coalition Operations? How is the Joint Task Force established, particularly in determining which Coalition partners will be participants, and, what elements of the Coalition forces will be part of the JTF? Is the Universal Joint Task List used? How?
2. How are civilian-military operations defined in a Coalition Force? What is the process for establishing and maintaining a Civilian-Military Operations Center (CMOC)? What are the factors that contribute to effective Civilian-Military cooperation and mission success? What variables make a difference in task performance?
3. How is effectiveness measured in Coalition Operations (Process measures, Outcome measures)? Are measures taken throughout the operation? How are lessons learned used?
4. For the CMOC, how does the task sequence, command links, protocol, and procedures differ? How is inter-organizational coordination facilitated? What is the process for inclusion/exclusion of civilian governmental organizations (CGOs), non-governmental organizations (NGOs), and private volunteer organizations (PVOs)?
5. What are the weaknesses/strengths of Coalition Operations in communication, planning, training, and cooperation?
6. What are the intercultural conflicts among groups in Coalition Operations? What are the best ways to deal with political and organizational differences in objectives, mistrust, etc...? Being that understanding culture plays some role in inter-group effectiveness, how can improvements be made in this area? How can a Coalition Force more thoroughly integrate an understanding of the host nation's culture?
7. What are the information needs of a Coalition Force as it relates to possible collaborative tools or organizational data bases highlighting: organizational differences, ways to work with, and or pathways to optimize inter-group cooperation? What tools are currently employed to help in Coalition Operations?

Position Statement for the Workshop on Knowledge-Based Planning for Coalition Forces

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For the foreseeable future, it will not be possible to completely automate complex military planning operations. Instead, what is required is a collaboration between man and machine, where the strengths of each offset the weaknesses of the other. In such a collaboration, a computer will be able to carry out operations methodically and avoid making the careless errors that a fatigued person might, while people will use their superior ability to evaluate situations and apply extensive knowledge to guide the overall process. Thus, we need to develop tools that allow people and machines to work together to create successful plans.

For collaboration forces, additional impediments hinder coordinated planning. Datasets will almost inevitably be heterogeneous — developed using different schema and encoded in different database tools. Yet for a successful coalition, that data must be shared, and it must be possible to connect dissimilar systems quickly. Additionally, members of the coalition will speak different languages, making it more difficult to work together. Below, I briefly describe some of the work that we have done in the Intelligent Systems Division at ISI that addresses some of these concerns.

Mastermind Objectives Editor

As part of the DARPA/RL ARPI and JFACC programs, we created an editor for military objectives (such as “delay red forces in southern Cyberland”). This editor uses a case grammar based representation to capture the underlying structure behind the objectives. This grammar is linked to an extensive ontology for air campaign planning. The grammar allows us to constrain the entries a person might make based on what has already been entered. For example, if a user enters the verb “destroy” the editor automatically restricts the objects that could be entered to just those that make sense for that verb. Because the objects that are created with the editor are linked back to an extensive domain ontology, the user creates a formal representation of the objective as he enters it, thus allowing other systems to reason with the objective. Additional information about Mastermind may be found at <http://www.isi.edu/~mm-proj/>

Strategy Development Assistant (SDA)

The SDA helps a user decompose high level objectives and keeps track of underlying assumptions that are made during the process. The SDA works together with the Objectives Editor described above so that users always retain the option of manually customizing any plan. The SDA has a library of plan templates that express how a variety of objectives may be decomposed. Each subobjective specified by a template

may have applicability conditions associated with it that specify when that step is relevant. The SDA uses its knowledge base to evaluate the conditions to determine whether a given step is relevant or not. For example, "defending sea LOCs" will probably not be relevant if an operation is totally land-based. Since the user may have knowledge that the system lacks it is always possible for the user to override. Any decisions about what steps are relevant or irrelevant are remembered by the SDA so that if conditions change the decisions may be reconsidered. The SDA helps speed the development of plans while capturing the assumptions that underlie them. For more information see <http://www.isi.edu/isd/JFACC/SDA/SDA-interface.html>

INSPECT Plan Critiquer

When people are fatigued, they may easily make disastrous mistakes. The size and complexity of a military campaign plan exacerbates the problem, making it harder to find errors. INSPECT is a tool that checks a plan to catch such mistakes. INSPECT checks plans against a library of common errors. When it finds an error it explains it to the user and suggests possible ways the error might be resolved. The main benefit of INSPECT is that it can "raise the floor" on plan quality. Additionally, by finding errors early in the planning process, INSPECT can help reduce wasted effort. INSPECT checks for errors in plan structure, problems in resources to support the plan, and coherency. We have recently extended INSPECT to check for problems that arise from cross-functional dependencies, such as between force support and force application. Since these planning operations are often performed by different (human) teams they can be a rich source of errors. More information about INSPECT may be found at: <http://www.isi.edu/expect/inspect.html>

Integration of heterogeneous data sources

Since coalition forces are often assembled in an "ad hoc" fashion, it is likely that the datasets they bring with them will not be aligned or accessible in an integrated fashion. The SIMS project has been developing a framework to support the integration of heterogeneous data sources. SIMS uses a model, expressed in Loom, of the terms relevant to a user in some domain. Mappings are then created between these terms and the available data resources. When a query comes in, SIMS uses the model to select the appropriate databases for answering the query and then constructs a plan for obtaining the answer. This plan is iteratively optimized taking into account such factors as network delay in transporting the data. For more information on SIMS see: <http://www.isi.edu/sims/sims-homepage.html>

Machine translation

Coalition forces speak different languages. Machine translation (MT) can help bridge the gap, particularly given the highly structured nature of many military messages. The Natural Language group at ISI has created Gazelle, a framework for MT that combines statistical and symbolic techniques to translate texts in a variety of languages including Spanish, Japanese and Arabic. The framework has been used by others to create translators for additional languages. More information on our MT work may be found at: <http://www.isi.edu/natural-language/nlp-at-isi.html>

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AC2ISRC

Mission Serves as the lead organization to integrate and influence C2&ISR for the Air Force

Primary Tasks

- Integrate air & space C2&ISR operational & delegated system architectures, roadmaps, requirements and standards.
- Build aerospace C2&ISR modernization strategies, integrated mission area plans, investment plans and divestment strategies and C4I Support Plans.
- Ensure roadmaps, requirements, and architectures link to the AF Modernization Planning Process, Strategic Plan and future evolutions.
- Help AF Major Commands (MAJCOM) and Agencies develop and field training programs for current, emerging and future C2&ISR systems and concepts.
- Serve as AF interface establishing all C2&ISR Joint Tactics, Techniques and Procedures.
- Act as AF experimentation implementing agent for Air Combat Command (ACC)

Centers and Process Integration Division

Mission Lead Battle Management C2 Center, system, training and process modernization for national agencies, warfighting Commander-in-Chiefs (CINC) and component commands.

Primary Tasks

- Develop and fiscally plan force and unit C2 center requirements, modeling and force structure
- Develop and deliver suitable warfighter hardware, software and processes to form an integrated C2 weapon system
- Integrate Information Operations and C2 centers
- Develop Operational Architecture and Concept of Operations (CONOP) supporting the future aerospace C2 vision

Plans Branch

Mission Conduct operations research and C2 system analysis to formulate, plan and guide C2 center procedural and operational architecture evolution and modernization.

Primary Tasks

Plan, build and maintain C2 Enterprise Operational Architecture
C2 Evolutionary Acquisition and Spiral Development methodology
Plan C2 center divestment

Quest

How can USAF and coalition partner architectures best complement and federate to support military coalition planning and execution?