



Joint
Advanced
Warfighting
Program

INSTITUTE FOR DEFENSE ANALYSES

FY2002 End of Year Report

Theodore S. Gold, Program Director
Joint Advanced Warfighting Program

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Preface

The *FY2002 End of Year Report* was prepared for the Board of Directors of the Joint Advanced Warfighting Program (JAWP). The Board comprises the Director, Joint Staff J7 (Chairman); Director, Joint Forces Command J9; Deputy Assistant Secretary of Defense, Advanced Systems and Concepts; and Deputy Assistant Secretary of Defense, Resources and Plans.

JAWP was established at the Institute for Defense Analyses (IDA) by the Office of the Secretary of Defense and the Joint Staff to serve as a catalyst for stimulating innovation and breakthrough change. The JAWP Team is composed of military personnel on joint assignments from each Service and civilian analysts from IDA. JAWP is located principally in Alexandria, Virginia, and includes an office in Norfolk, Virginia, that facilitates coordination with the United States Joint Forces Command.

This report does not necessarily reflect the views of IDA or the sponsors of JAWP. Our intent is to report on JAWP's work in FY2002, and to stimulate ideas, discussion, and, ultimately, the discovery and innovation that must fuel DoD's transformation.

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FY2002 End of Year Report

I. Introduction

This Fiscal Year (FY) 2002 End of Year report addresses the FY2001 Statement of Work of the Joint Advanced Warfighting Program (JAWP), summarizing the activities from October 2001 through September 2002. It highlights two activities: the Future Joint Force (FJF) I Experiment (Chapter II) and Joint Urban Operations (Chapter III), elaborations of which are provided in Appendices A and B.

Other FY2002 JAWP activities covered in this report are as follows:

- ▶ Metrics for transformation (Chapter IV)
- ▶ Continuous joint experimentation (Chapter V)
- ▶ Commercial-off-the-shelf (COTS) wargaming (Chapter VI)
- ▶ Industry and Allied collaboration (Chapter VII)
- ▶ Dominant Maneuver workshops (Chapter VIII)
- ▶ Advanced Mobility Concepts Study (Chapter IX)
- ▶ Redressing low density/high demand shortfalls (Chapter X)
- ▶ Technology Exploitation Workshop (Chapter XI)
- ▶ Millennium Challenge 02 (Chapter XII)
- ▶ Theater Effects-Based Operations Candidate Advanced Concept Technology Demonstration (ACTD) (Chapter XIII)
- ▶ A conference on regional stability in South Asia, co-sponsored by the Institute for Defense Analyses and the International Center for Religion and Diplomacy (Chapter XIV)
- ▶ Historical research on military innovation and transformation (Chapter XV). A paper (to be published in 2003) providing a his-

torical perspective on experimental military units is contained in Appendix C.

A list of recent publications of JAWP is provided in Chapter XVI. The appendices provide examples of the three types of JAWP activities: (1) designing and conducting experiments; (2) developing implementation Road Maps; and (3) performing studies and analyses, in this case, an historical study). A list of acronyms is provided in Appendix D.

II. Future Joint Forces I Experiment

Background

Because of its previous experience in developing the J9901 Attack Operations Against Critical Mobile Targets¹, JAWP was asked to conduct the Future Joint Force (FJF) I Experiment for US Joint Forces Command (JFCOM) and the Defense Advanced Research Projects Agency (DARPA). The experiment focused on the employment of a future joint force characterized by the following: horizontally integrated, high density ISR (intelligence, surveillance, and reconnaissance); extensive long-range precision strike; agile, distributed, ISR-rich ground elements; unmanned aerial and ground systems; and adaptive joint command and control.

In the next sections, and in greater detail in Appendix A, we offer thoughts on the implications of some of the results in the nearer term, exploiting existing capabilities, and in the longer-term, conducting follow-on experimentation.

¹ For more information about this earlier effort, see *Lessons Learned from the First Joint Experiment (J9901)*, Larry D. Budge and John Fricas, IDA Document D-2496, October 2000; and *The Joint Experiment J9901: Attack Operations Against Critical Mobile Targets*, Joint Advanced Warfighting Program, September 29, 2000, prepared for the USJFCOM.

Design and Conduct of the FJF Experiment

In a series of human-in-the-loop (HITL) simulation trials, the experiment pitted a notional future joint force against a numerically superior enemy in several scenarios designed to challenge the experimental force's capabilities. The experiment employed sensor-enabled, small ground units employing long-range fires from air, land, and sea in dispersed, high-tempo offensive and defensive operations. **Figure 1** depicts the FJF concept.

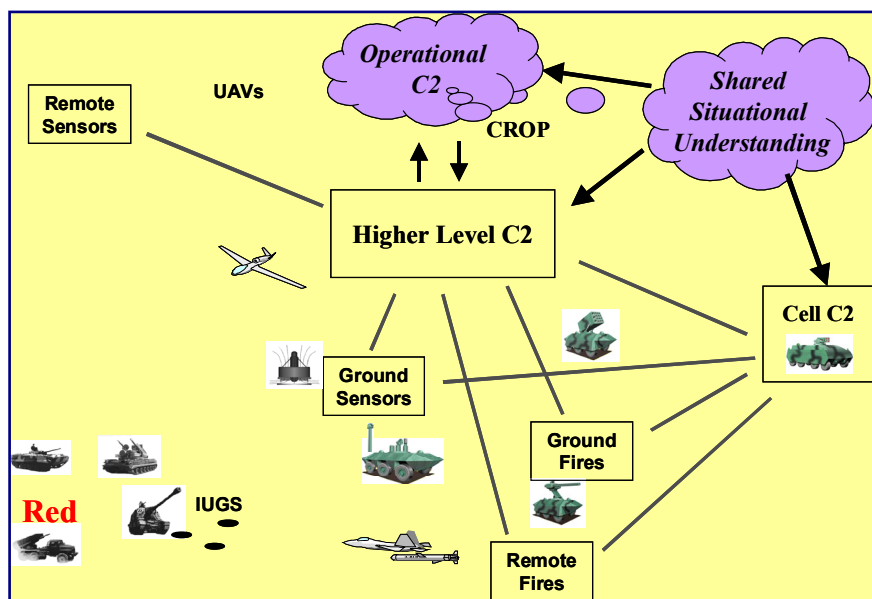


Figure 1. Experimental Concept

The heart of the experiment was four week-long trials conducted at the US Army's Mounted Maneuver Battle Lab (MMLB) at Ft Knox, Kentucky, and linked with the JFCOM Joint Training and Analysis Support Center in Suffolk, Virginia. In addition to members of JAWP and other research divisions from the Institute for Defense Analyses (IDA), participants in the HITL trials included personnel from the Army, JFCOM, Iowa and Kentucky Army National Guard, and one officer each from Canada and the United Kingdom.

The trials began in October 2001 and were extended through January 2002. Organization and analyses of the results followed, and numerous briefings

were presented during the spring and summer of 2002. An interim draft of this report was prepared and distributed to the sponsor in October 2002.²

The HITL simulations used in these trials were complemented by tabletop games and analysis using constructive models. Four different scenarios were used to stress varying aspects of Blue Force performance and were executed in a 180 x 220 kilometer battlespace with a wide range of foliage and terrain, but no urban terrain. The following findings emerged from the analysis of the experiment.

Command and Control

- ▶ The “Unit of Action,” the lowest level joint staff entity in this experiment, operated more in the role of “warfighter” than in the traditional staff supervisory role. This staff maneuvered sensors and weapons, managing uncertainty and shaping battlefield conditions for subordinate cells.
- ▶ Information displays used in the experiment need to be improved in order to support the attainment of Decision Superiority. Issues include information relevancy, accuracy, latency, and appropriate levels of analysis.
- ▶ Units exhibiting horizontal networking appeared to learn more and adapt faster than the units who communicated largely within a hierarchy.
- ▶ Intent-based orders and self-synchronization were observed and contributed to Blue Force effectiveness.

² *Future Joint Force I Experiment: Final Report (Interim Version)*, Larry D. Budge et al., IDA Paper P-3738, draft, October 2002.

Intelligence, Surveillance, and Reconnaissance

- ▶ The ability to achieve effective sensor coverage became the focal objective of Blue Force operations (facilitated by small staffs, few echelons and shared awareness).
- ▶ Sensors were operated in a complementary and synergistic manner. The combination of sensors, each with different capabilities and operated at different levels, proved effective in developing comprehensive coverage.
- ▶ The participants demonstrated increased proficiency over time in achieving accurate sensor coverage. The participants also demonstrated creativity in making use of all available systems to increase sensor coverage.
- ▶ While all sensors contributed, the workhorse throughout all the trials was the medium-altitude unmanned aerial vehicle (UAV).

Future Ground Force (Blue Force)

- ▶ The Blue Force achieved mission success in four of five trials against an opponent with significantly greater organic combat power.
- ▶ The Blue Force operated in a dispersed posture over a large area (approximately 180 x 220 kilometers). Dispersal, guided by shared situation awareness, was perhaps the primary contributor to Blue's survivability. However, real-world considerations of logistics, communications, and casualty evacuation were not represented in the experiment, and would decrease the Blue Force's ability to operate dispersed.
- ▶ Operations at lower echelons were very demanding on personnel. This implies that our future combatants will require a broader skill set, more experience, and specialized training.
- ▶ When Blue Forces were forced to accept casualties in close combat, they were able to take the majority of losses in unmanned

systems. Despite very high levels of situational awareness, fratricide still occurred among Blue forces, but friendly fire losses occurred mostly to unmanned systems.

Red Forces

- ▶ The Red Force challenged Blue concepts by continuously adapting to Blue capabilities. Red was ingenious in using civilians and battlefield clutter to complicate application of ROE (Rules of Engagement) and forcing Blue to greater sensor resolution.
- ▶ Red's operations were continuously impacted by the effectiveness of Blue's sensor systems. But ultimately Red's decision to avoid massing forces and moving in the open slowed its momentum and (eventually) led to its piecemeal destruction.
- ▶ Red Forces benefited significantly from UAVs (available to them in the late trials) to increase their situational awareness, and used their dismounted infantry as an effective sensor system throughout all the trials.

Integrating Unmanned Sensors into Manned Units

- ▶ The Blue ground force dramatically extended its range of influence and security through the employment of (1) substantial numbers of unmanned aerial and ground sensor platforms; (2) unattended sensor fields; and (3) external fires from distant air, land and sea platforms.
- ▶ Closer integration of sensors, long-range fires, and small ground units should be possible even with today's capabilities.
- ▶ Field and virtual experiments with units employing aerial and ground sensor platforms could evolve the concept and the maturity of robotic capabilities not only for RSTA but also for logistics, communication, and fires.

Pushing “Jointness” Lower

- ▶ Extension of joint command and control down to an echelon just above basic fighting formations enabled units at the lowest levels in the experiment to leverage and exploit sensor-generated information and long-range fires. These results correspond to operational experience in Afghanistan, which also suggests that combinations of joint manning at lower echelons could yield large pay-offs.
- ▶ More experiments, exercises, and analyses are needed to understand better the payoffs and costs of pushing jointness down to various echelons and to identify preferred ways of doing so.
- ▶ Joint experimentation by several brigade and wing combinations at training complexes could offer many benefits, among them (1) identifying communication needs; (2) learning how to make small force elements modular; and (3) learning how to maintain responsive sensor coverage and fires amid rapidly changing competition for priority.

Fighting for Information

- ▶ Overhead systems could not uncover the opponent’s most important capabilities by themselves. Ground units in this experiment had to fight for information, drawing opponents out of shielded terrain and capturing information about elements that had not been discovered. They often evoked enemy reaction by attacking known nodes deep in enemy-controlled territory and deploying by air to unimproved landing sites.
- ▶ Field experimentation (with combinations of tactical fixed-wing aircraft, tilt-rotor aircraft, and helicopters to deliver Army, Marine, and Special Operations units in similar missions) would help identify additional capabilities needed to carry out such missions.

Addressing Real-World Communications

- ▶ Robust communications, unconstrained by bandwidth, were assumed in order to explore the potential of extensive ISR, potentially enabling new ways to fight.
- ▶ As a first step towards understanding constrained communications, we analyzed the communications among the Blue Forces in the experiment to estimate bandwidth requirements.
- ▶ Follow-on experimentation should examine the robustness of the FJF concept against the following: (1) the opponents ability to exploit electronic and information warfare; (2) the effect of bandwidth constraints; and (3) how to enable units and commanders to cope with likely communications interruptions.
- ▶ Such experimentation, addressing the functions of command and control within plausible communication architectures, would guide the evolutionary fielding of new capabilities.

Overcoming Logistics Challenges

- ▶ While the experiment employed widely dispersed small units in enemy-controlled territory, it did not explore their logistical sustainment. The evacuation of casualties and replacement of disabled and destroyed vehicles and robotic platforms are among the real-world logistic challenges.
- ▶ Field experimentation with logistical support of the FJF concept can clarify its near-term viability and identify capabilities needed for its long-term viability.

The Importance of Leader Development

- ▶ The FJF I Experiment supports the notion that Decision Superiority is enabled by the ability to resource multiple subordinate decision cycles with adequate information, consequently empower-

ing leaders with the freedom to act faster than an opponent's ability to observe-orient-decide-act (OODA).³

- ▶ Units whose leaders exploited networking to foster horizontal communication had a steeper learning curve but became more effective than those with a more centralized command style characterized by vertical communication.
- ▶ Effective decentralized decision-making will depend on small-unit leaders able to operate in this highly empowered yet collaborative environment. Empowerment, along with understanding the commander's intent, should combine to mitigate units' potential loss of effectiveness when communications with senior commanders are interrupted or lost.
- ▶ A challenge will be training senior leaders to be comfortable with delegating decision-making to the appropriate level of command—particularly when all the conditions necessary for micro-management are available.

Finishing Decisively

- ▶ By its very nature, the RSTA-oriented Blue ground force in this experiment was not capable of bringing the fight to a decisive conclusion.
- ▶ Blue Forces were successful in achieving objectives such as disintegration of enemy command and control, air defense, and artillery systems and attrition of heavy combat systems.
- ▶ The Blue ground elements lacked the organic combat power to seize and hold terrain.
- ▶ Further experimentation (adding combinations of infantry and organic direct, beyond line-of-sight, and indirect fire delivery capabilities) is needed to determine appropriate capabilities for a fu-

³ The John Boyd Cycle, often called the OODA Loop.

ture ground force capable of achieving a full spectrum of military missions.

III. Joint Urban Operations

Roadmap for Joint Urban Operations

During 2002, JAWP completed the development of a *Department of Defense Roadmap for Improving Capabilities for Joint Urban Operations*⁴ to improve substantially the capabilities to conduct military operations in urban environments. This DoD Roadmap describes an overarching approach, based on new thinking and new technologies, to improving the capabilities of US forces to operate in urban environments. The new thinking is aimed at reducing the casualties and collateral damage traditionally associated with urban warfare by exploiting improved capabilities to *understand*, *shape*, and *engage* in an urban environment.

Such capabilities would enable the joint force commander to apply the principles of maneuver at the operational level, resulting in more focused engagements undertaken from more advantageous positions. The Roadmap identifies directions to pursue in all areas of DOTMLPF (Doctrine, Organization, Training, Materiel, Leadership, People, Facilities) that, if taken together, could realize the promise of the new approach.

Improving the Capabilities of Future Joint Force Commanders

JAWP's efforts were directed at improving the capabilities of future joint force commanders to conduct urban operations by (1) supporting the new organizational focus for joint urban operations; (2) developing the DoD Master Plan for Joint Urban Operations; and (3) conducting research and

⁴ *Department of Defense Roadmap for Improving Capabilities for Joint Urban Operations*, William J. Hurley et al., IDA Paper P-3643, two volumes, March 2002.

development. Each effort is discussed in more detail in the following sections.

1. Supporting the New Organizational Focus for Joint Urban Operations

On 17 September 2002, the Deputy Secretary of Defense designated the Combatant Commander, Joint Forces Command (CCJFCOM), as the DoD Executive Agent for Joint Urban Operations, starting on 1 January 2003. JAWP drafted an initial program and organizational structure for the Joint Urban Operations Office, which will be located at JFCOM and will support the CCJFCOM in his role as Executive Agent. JAWP also assisted the Joint Staff and the Office of the Secretary of Defense in drafting the charter that defines the responsibilities of the DoD Executive Agent.

2. Developing the DoD Master Plan for Joint Urban Operations

While JFCOM prepared to stand up the Joint Urban Operations Office, the Joint Urban Operations Special Study Group began developing the DoD Master Plan for Joint Urban Operations. The Special Study Group comprises 14 flag-level officers and is chaired by MG W. L. Sharp, US Army, Vice Director, J8. In January 2003, the Special Study Group will transition the Master Plan to CCJFCOM for execution and future development.

JAWP has supported development of the Master Plan by producing initial drafts for the Joint Urban Operations Working Group, which will submit a draft Master Plan to the Special Study Group in November 2002. JAWP will continue to support the revision process.

3. Experimentation Campaign Plan

JAWP contributed to the JFCOM J9⁵ Experimentation Campaign Plan by identifying options for experimentation on joint urban operations. Additionally, JAWP has begun planning for a series of Limited Objective Experiments that will explore the effectiveness of emerging operational concepts identi-

⁵ JFCOM's Joint Experimentation Directorate.

fied in the DoD Roadmap by using table-top map exercises and transparent wargames. The goal is to gain insights into emerging concepts while developing a *continuous experimentation capability*. This will initially employ broad experimentation tools and later evolve into a more detailed simulation environment (as the needed simulation capabilities become available). This effort will be carried out in collaboration with JFCOM in support of the activities of the Joint Urban Operations Executive Agent, with the objective of transitioning the process to JFCOM.

4. Conducting Research and Development

In collaboration with researchers at the George Washington University, JAWP's Col Mark Bean, USMC, drafted an Advanced Concept Technology Demonstration (ACTD) proposal aimed at constructing a prototype of an urban "Knowledge Management Center." This prototype would represent a broad, three-dimensional urban area dynamically overlaid with information regarding physical infrastructure, cultural aspects, positions, and the status of friendly and adversary forces, noncombatants, etc. Such a system could greatly enhance the ability of a joint force commander to cope with the complexity of an urban operation in his planning and decision processes.

JAWP also supported DARPA in formulating a major technology development program addressing the needs of urban operations.

- ▶ JAWP helped DARPA's Information Exploitation Office organize a workshop that reviewed the status of urban capabilities and identified promising technical directions for force improvements.
- ▶ JAWP is also supporting the Director's Office Review of Urban Operations, a special panel charged with recommending a DARPA-wide program to improve urban capabilities to the Director of DARPA.

At the same time we were involved with the organizational changes and developing the DoD Roadmap, we and our sponsors were also taking into consideration the increasing likelihood that urban operations could be conducted soon in the Middle East. JAWP invited the network of contributors to the DoD Roadmap to suggest actions that could be taken in 60 to 90 days that

could enhance urban capabilities. The responses were collected into an informal report.

JAWP also engaged in a number of supporting activities, including meeting with representatives of the Army's Topographical Engineering Center. This was in regard to the Center's work on three-dimensional representations of urban environments.

NATO Study on Urban Operations in Year 2020

JAWP has worked closely with a NATO Working Group that is developing recommendations to prepare for future NATO operations in urban environments. The NATO Research and Technology Organization (RTO) Study Group on Urban Operations in the Year 2020 held its seventh and final meeting in Rome, Italy, on May 13–17, 2002. The purpose was to complete the study report and prepare briefings that were given to the NATO RTO Committee on May 23 and 24 (also in Rome).

JAWP assisted in preparing the study report and final briefings. Delegates from seven nations (Canada, France, Germany, Italy, Netherlands, United Kingdom, United States) provided a consistent effort throughout the two-year study. Col Tom Sward, USMC, with JAWP, was the US Head of Delegation. Dr. Bill Hurley of JAWP and Mr. Duane Schattle (detailed to JAWP to work urban operations) were also members of the US delegation. The Study Director, Colonel Philip Baxter, UK Army, and representatives of the Dutch and Italian delegations presented the final briefings.

The basic approach taken by the study was similar to that developed by JAWP for the *Department of Defense Roadmap for Improving Capabilities for Joint Urban Operations*.⁶ The findings and recommendations of the two efforts are consistent, with some differences in detail. In general, the study group assessed NATO's current urban capabilities to be poor, and recommended a new "manoeuvrist" approach as having the potential for significant improvements. The study group identified desired capabilities and a number of

⁶ *Department of Defense Roadmap for Improving Capabilities for Joint Urban Operations*, William J. Hurley et al., IDA Paper P-3643, two volumes, March 2002.

promising directions for remedial actions in the areas of materiel, doctrine, organization, training, concept development, and experimentation.

To implement such changes, the study group recommended that NATO (1) establish a focal point within SHAPE (Supreme Headquarters Allied Powers Europe) dedicated to improving urban capabilities; (2) identify points of contact in all relevant elements of the NATO organization; and (3) establish a NATO working group to build a plan for, and coordinate, future urban-related initiatives. Further briefings are planned for the NATO Research and Technology Board, relevant branches of SHAPE, and other NATO offices.

IV. Metrics for Transformation

Background

JAWP led an IDA-wide study team on metrics to advance transformation. The study was sponsored by the Office of the Secretary of Defense, with Program Analysis and Evaluation leading and participation by Acquisition, Technology, and Logistics; Policy; and Office of Force Transformation. The study team was tasked to (1) develop a framework to think about transformation, Quadrennial Defense Review (QDR) goals, and metrics; (2) identify metrics for the QDR's six operational goals; and (3) apply them in exemplar cases, specifically:

- ▶ How the six QDR goals support an implied objective of getting and using decision superiority, a key element of Joint Vision 2020 and a major focus of the transformation objectives of the Chairman of the Joint Chiefs of Staff, General Richard B. Myers.
- ▶ The enablers appropriate to each goal, and the key metrics to use.
- ▶ How the enablers and metrics could be used to advance DoD's transformation, e.g., by analyzing an investment strategy, providing guidance on gaps, and/or measuring near-term progress. A portfolio of DoD's 97 ACTDs from 1995 to 2002 was used to test the use of these enablers and metrics.

- Examples of how the metrics could be used to provide top-level transformation guidance.

In the following sections, we present the final JAWP briefing on metrics for transformation.

Contribution of Goals to Transformed Force

The six operational goals in the QDR Report are the focus for DoD's immediate transformation efforts. These goals are individually desirable. But collectively, as depicted in **Figure 2** (below), three of the goals support an implied goal: Decision Superiority, all the time, everywhere. The other three goals exploit Decision Superiority to transform DoD's force effectiveness.

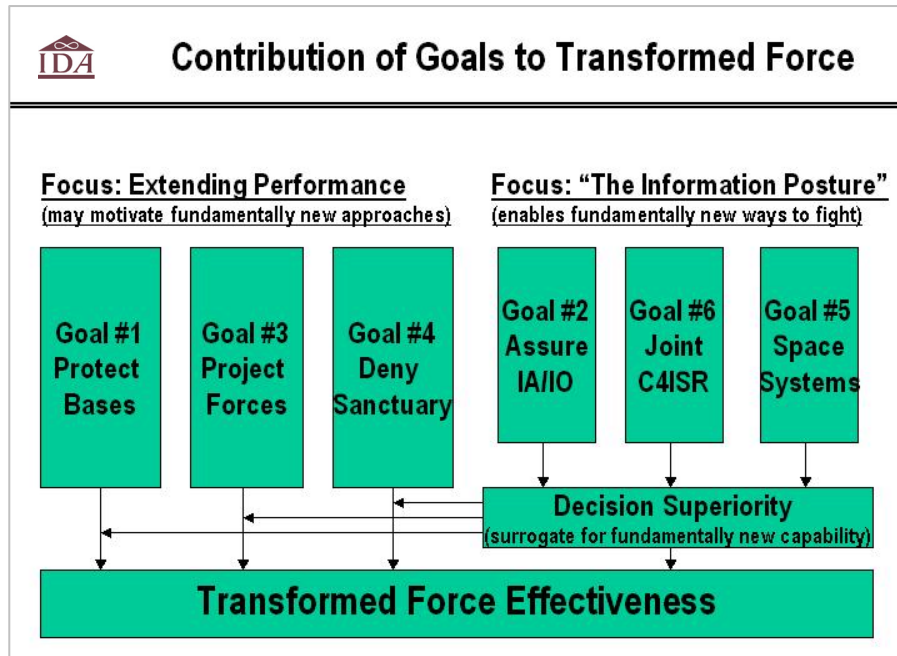


Figure 2. Contributions of Goals to Transformed Force

Contributions of Goals to Decision Superiority

Goals 2, 5, and 6 lead to gaining and maintaining Decision Superiority. As depicted in **Figure 3** (next page), the basis for superior decisions is capabili-

ties meeting Goal 6, Interoperable Joint C4ISR (command, control, communications, computers, intelligence surveillance, and reconnaissance).

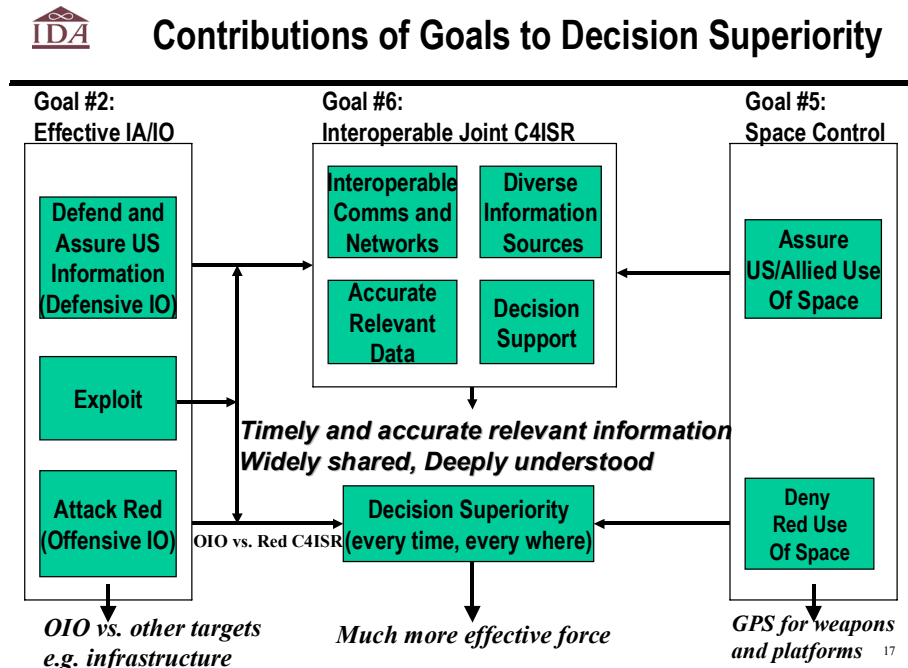


Figure 3. Contribution of Goals to Decision Superiority

The capabilities for Goals 2 and 5 contribute by protecting our networks, sensors, and data from Red challenges. This is accomplished by assuring US–Allied use of space (Goal 5) and by Information Operations that defend and assure US information (Goal 2). Goal 5 capabilities also contribute by denying Red access to, and use of, space, sensors, communications, navigation, etc. Similarly, Goal 2 capabilities contribute through Information Operations that target Red C4ISR—denying Red the ability to get relevant information, to share it, or to understand it. *The objective is a truly transformational capability: Decision Superiority—all the time, against any adversary, everywhere.*

Three Performance Attributes Provide a Basis for Decision Superiority Metrics

Performance attributes for interoperable joint C4ISR and the implied Decision Superiority goals, and the metrics for them, are shown in **Figure 4** (next page). The *timeliness* of relevant information is measured by the *latency of in-*

formation and the *speed of decision-making*, while the *accuracy* can be measured by its *completeness* and *correctness*.

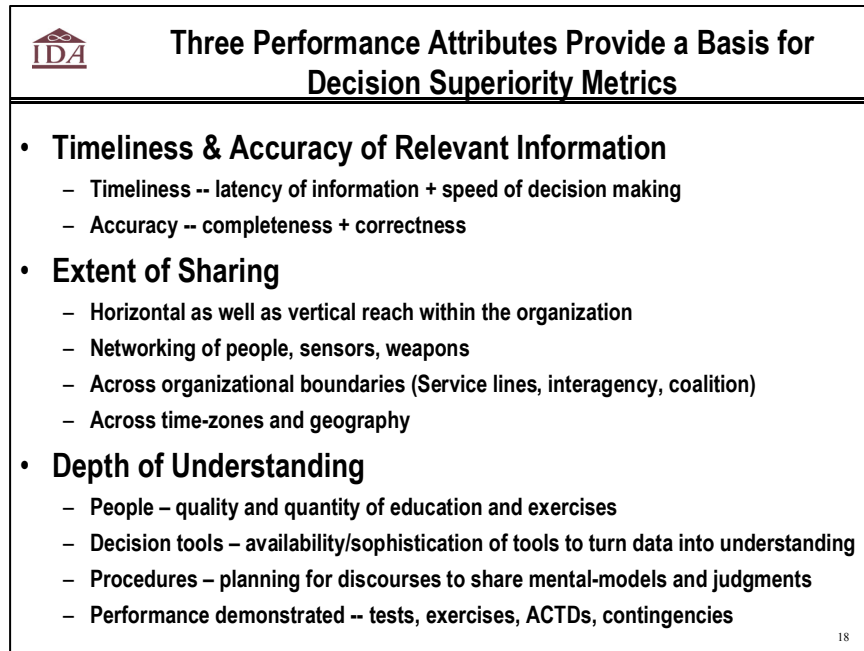


Figure 4. Three Performance Attributes Provide a Basis for Decision Superiority Metrics

The extent of sharing involves horizontal and vertical reach within the organization, across organizational and national boundaries, and among sensors, users, and shooters. The depth of understanding involves people *and* the decision tools and procedures that support them. These attributes and metrics would be applied to both US and Red capabilities to assess the extent of Decision Superiority.

Why Decision Superiority As a Goal

Goals 1, 3, and 4 can be advanced by using Decision Superiority, which can enable much more effective force use, as highlighted in **Figure 5** (next page). It could enable new operational concepts relevant to a specific QDR goal.



Why Decision Superiority As a Goal

- **Enable operational concepts relevant to specific QDR goals**
 - Urban ops with less casualties/collateral, by emphasizing Understand and Shape
 - Attack of mobile targets emphasizing rapid sense-and-attack ops
 - Rapid decisive joint operations using decision superiority as “armor”
- **Enable new ways to fight in a range of future joint operations**
 - Self-synchronized operations
 - Operational-level effects based operations
 - focused on adaptation to effects of actions, rather than target attrition
 - Operations with much less idle force:
 - more target information in a target poor environment
 - faster decision making vs. time-sensitive targets
 - reduced operational uncertainty, to reduce need for uncommitted reserves

Figure 5. Why Decision Superiority As a Goal

More broadly, Decision Superiority could also enable new ways to fight in a range of joint operations, e.g., enabling self-synchronization, enabling Effects-Based Operations, and/or enabling operations with much less idle force.

V. Concept-Based Continuous Joint Experimentation

Transformation to truly new capabilities will involve new operational concepts and associated changes in doctrine and organization—not merely the introduction of new technologies. There is widespread agreement within DoD that experimentation is necessary for such transformation. However, there is less concurrence about what an experiment is and how it should be conducted. Indeed, experiments assume different guises in different fields.

Ten Attributes of a Joint Experimentation Campaign

Based on JAWP’s experiences in conducting joint experiments, and its experiences in other current and historical efforts, we have developed and promul-

gated a vision of joint experimentation campaign that encompasses the following ten attributes:

1. Continuous concept-based campaign of “small” experiments versus large episodic schedule-based events to support pursuit of new joint concepts and capabilities.
2. World-class simulation team, tools, and venue (quality people are most important...to rapidly tailor the simulation environment to different conditions and new capabilities as experiments progress) capable of human-in-the-loop (HITL) simulation as an especially powerful tool.
3. Dedicated experimental unit (does not need to be large—a headquarters core could suffice).
4. A greater role for “exploratory” experimentation and an environment supportive of discovery and learning. (This has to be fostered by senior DoD leadership. It is also very difficult to obtain this environment with large and expensive field activities.)
5. New concepts challenged by formidable adaptive Red Team (too often so-called experiments have no Red Team at all or else rely on scripted red play).
6. Robust and creative data collection (the challenge is to capture the human dimensions and measures relevant to command and control).
7. Processes to collect, interpret, and disseminate findings.
8. Linkage to Service and geographic and functional combatant command efforts (including ACTDs).
9. Linkage to real-world operations.
10. Processes to both “pull and push” promising results toward implementation (without this we have circular—not spiral—development).

Exploratory Experiments

In this section, we elaborate on three aspects of joint experimentation. Exploratory experiments are intended to learn about the fundamental features of a concept, to discover its vulnerabilities, and to seek ways to make it more robust. They generally do not validate hypotheses or demonstrate propositions. Exploratory experiments are particularly apt when the subject is military operations, where the human dimension is so central to the behavior of extremely complex systems.

Exploratory experiments also play an important role in the physical sciences as a complement to the more widely recognized theory-oriented experiments. (A thoughtful discussion of the differences is presented in Ribe and Steinle's article on exploratory experimentation.⁷)

Concept-Based Continuous Experimentation

Concept-based continuous experimentation would provide an environment where (1) concepts could be pushed to failure, (2) players could learn from failure and adapt, (3) concepts could be modified, and (4) follow-on experiments tailored to build on what was learned.

Concept-based continuous experimentation would offer the flexibility to "connect" with real-world operations as they occur by tailoring experiments to support the operations, incorporating lessons learned from the real operations, and leveraging the experience and motivation of those engaged in such operations.

JAWP has worked with JFCOM to establish a robust capability for continuous experimentation and make it a major element in the joint experimentation campaign. *Continuous experimentation would provide an engine to spur spiral development of joint command and control systems and joint force headquarters.*

The effort we propose would involve concurrent enhancement of a set of experimental tools, including the transition of the Joint Semi-Automated

⁷ Neil Ribe and Friedrich Steinle, "Exploratory Experimentation: Goethe, Land, and Color Theory," *Physics Today* July 2002, pp. 43–49.

Forces (JSAF) simulation onto a network of DoD supercomputers using scalable-parallel processing. This would substantially increase the scale and complexity of operations that could be investigated.

HITL Simulation

HITL simulation is a powerful experimentation tool that complements learning from real-world operations, field experiments, tabletop gaming, constructive simulations, and other sources. Putting humans in a synthetic environment allows flexibility in examining a range of scenarios, conditions, and postulated future capabilities. The direct human participation allows the pitting of Red and Blue Forces against each other to learn what complex adaptive adversaries might do to defeat the concepts.

HITL simulation is also an especially appropriate tool for joint command and control, exploring how to exploit the power of shared situation understanding while reducing the vulnerabilities of networks.

VI. COTS Gaming Paradigm for Joint Experimentation

JAWP began exploring the potential of commercial off-the-shelf (COTS) online computer games to contribute to transformation in general and joint experimentation in particular. A major attraction is the potential to increase the number of people and organizations that interact in the experimentation process. The paradigm allows experiments with very large numbers of participants, as well as large numbers of simultaneous experiments involving a more limited number of participants. Thus, it could offer an important complement to the more standard experimentation venues in use within DoD (these generally support only a few experiments at a time).

Opening up experimentation and involving many more in the innovation and discovery process can accelerate transformation to new capabilities.⁸ There

⁸ The Defense Science Board 2001 Summer Study on Defense Science and Technology noted that “massive multiplayer games...follow the trend toward network-based col-

are, however, limitations with current COTS online computer games that will have to be addressed.

Currently, COTS-style tools offer some very appealing attributes for *meta-experimentation*, such as:

- ▶ large numbers of games (i.e., experiments) can be conducted simultaneously and continuously;
- ▶ the games are easily modified and so the experimentation cycle is short;
- ▶ different groups in different locations can develop their own versions of the games;
- ▶ the games tend to be modular in construction so new components can be easily added; and
- ▶ the games spontaneously develop online communities of interested parties.

The power of COTS game technology has been demonstrated by the new Army recruiting game, *America's Army*, released 4 July 2002. This game was developed by the Modeling, Virtual Environment and Simulation Institute at the Naval Post Graduate School in Monterey, California, in conjunction with several commercial companies and game developers, including Dolby Digital Sound. The game is based on the Unreal Engine code developed by the Epic Games Company, which is used in several commercial games such as *Unreal Tournament* (released in 1999). *America's Army* was of great interest to us because of its substantial success in the public arena, and because it was developed from within DoD. The lessons learned from its development has considerable value if DoD is to use and/or develop COTS-style games in the future.

Using commercial games for experimentation is different than using them for training, recruiting, or entertainment. Experimentation places a heavy

laboration by providing ways for players to create and contribute new technologies, virtual new spaces and new tactics for use by the entire community of players.”

premium on data collection. Many computer games are only interested in variations on how many of the opponents are killed. More sophisticated and subtle data collection would be necessary for experimentation. For example, it may be more important to know the time it takes to detect a target and how the target was detected than to know if the target was actually destroyed. Further, most computer games provide more attention to weapon capabilities than to sensor capabilities. With the importance of ISR in modern warfare, more capable sensor modeling will be required than is currently used in COTS games.

In our search of the commercial market for games with the necessary fidelity for use in experimentation, we looked for game features that would be useful for joint experimentation. Many of these desired features are related to establishing the open culture common in the commercial gaming world. The desired features include the following:

- ▶ a personal computer based interface
- ▶ a capability to network geographically dispersed players into a common game;
- ▶ jointness
- ▶ at least one human player per side
- ▶ basic database editing toolset
- ▶ a military “feel” (no aliens or death rays) and appropriate rules of engagement
- ▶ some accounting for imperfect knowledge
- ▶ automated data collection
- ▶ an online community of players

Although most of the games we have examined allow the players to be given incomplete information, only one provided false information. In addition, the presence of non-combatants such as refugees and civilians is usually ignored. For DoD’s experimentation purposes, the “fog of war” will have to be significantly expanded from that usually found in the commercial games.

Furthermore, to use these games to explore Effects-Based Operations and other operational-level issues will most certainly involve enhancement, perhaps using techniques already found in COTS games such as SimCity, a game that portrays the development of the inhabitants and infrastructure of a city over time. *A major challenge would be transferring the entity-based simulation of detail in tactically oriented games to experiments examining the operational level of war, where human interaction on the conceptual level is important.*

In our survey of COTS games, we looked for games that could be used in a proof-of-concept or a demonstration experiment. To date the best candidate identified for an internal JAWP demonstration experiment is “Brigade Combat Team (BCT) Commander.” BCT Commander was written by an Army captain outside his official capacity and is played on a three-dimensional map. It uses standard military map icons, and so has the appropriate “feel” similar to DoD simulations such as JANUS. We have discussed with the developer of BCT Commander minor alterations to the game to better suit the needs of a demonstration experiment. An interesting limited demonstration would involve using BCT Commander to play a scenario replicated from one of the four trials of the Future Joint Force I Experiment played in 2002.

While BCT Commander is the best tool we have found so far, we are continuing to watch for new game releases and have contacted several developers with potentially useful games that are still early in the development process. In doing this we have discovered low-cost opportunities to influence the design of these games to make them more useful for the DoD experimentation process.

VII. Industry and Allied Collaboration

Industry

Joint experimentation to date has been largely done in-house by and with DoD or DoD-chartered organizations. We are exploring a greater role for defense industry. The intent is to leverage its expertise, modeling and simulation capabilities, and facilities—and do it in a way that would help it shape its own discretionary activities to support DoD transformation objectives.

JAWP has conducted two meetings with representatives of industry, both sponsored by the Deputy Under Secretary of Defense (Advanced Systems and Concepts). Participants in the first meeting included representatives from Boeing, Lockheed-Martin, Northrup-Grumman/TRW, and Raytheon. At the second meeting, a senior representative from General Dynamics joined; since then we have had a request from British Aerospace to join although it is unclear whether that will be feasible due to foreign ownership of the company.

Industry representatives expressed confidence that they could work together under memoranda of understanding that would protect intellectual property rights. However, they stressed that the experiments should be classified to permit the introduction of technologies that have not yet been made public. Future meetings will identify specific industry capabilities and the roles they might play in FY2003–2004 experimentation.

Allies

Allies have participated in all of our experiments. We exchange ideas with allied counterpart organizations. Building on those relationships, we have had four visits during the year by senior allies interested in their organizations participating in future experimentation.

- ▶ A Singaporean delegation, led by RADM Richard Lim Cherng Yih, visited in June 2002, resulting in an agreement to hold a follow-on detailed exploration of options for Singaporean participation in joint experimentation and for exchanges of conceptual work on new operational thinking.
- ▶ A UK delegation led by Commodore Nance, the UK Director of Joint Combat Developments, visited in June 2002. We plan to reciprocate in the Spring of 2003.
- ▶ MG Jonathan Bailey, Director General of Doctrine and Development, provided the British Army's perspectives on operations in Afghanistan in September 2002.
- ▶ Air Vice Marshall John Blackburn, Australia's Director of Policy Guidance and Analysis, and Commodore James Goldrick, Australia's Director of Military Strategy, visited in September 2002.

JAWP sent a team to Israel in November 2002 to participate in an Urban Operations Wargame in which Singapore and the United Kingdom also participated.

- ▶ Israeli representatives exposed some of the lessons its operational commanders learned during urban combat in the West Bank to US, UK, and Singaporean representatives.
- ▶ The wargame exposed Israeli and Singaporean participants to US and UK experience in long-distance deployments and coalition operations.

This joint effort led to an agreement for the United States to host a follow-on game in FY2003, and for Singapore to host an FY2004 follow-on. Each will be focused on urban operations and out-of-area contingency operations.

Related Activities

As a follow-up to the Future Joint Force I Experiment, COL Bob Cone, USA, and Lt Col Jeff Cohen, USAF, visited the United Kingdom in January 2002. They met with Commodore Adrian Nance, UK Director of Joint Combat Developments, and his staff. The discussion included the role of experimentation in transformation, preliminary insights from the experiment (in which a British officer participated), and possibilities for future cooperation in concept development and experimentation.

During this trip to the United Kingdom, COL Cone also gave presentations at the Royal Armored Corps and the Command and Control Center at Warminster on command and control, based on his own experiences commanding the US Army's first embedded digital brigade.

In December 2001, Col Tom Sward, USMC, and Dr. Ted Gold visited with Air Commodore John Blackburn, Director, General Military Strategy, Australian Defence Force in Canberra. This was an invited follow-on to JFCOM's Multinational Concept Development and Experimentation Symposium held in Oslo, Norway, in September 2001. At Canberra, Col Sward and Dr. Gold met with members of Australia's Strategy Group, Defence Science and Technology Office, and each of their three Military Services. Topics of discussion included transformation, concept development and experimentation,

and an exchange of ideas on Effects-Based Operations. We agreed to exchange papers and look for possibilities for cooperation on future experiments.

VIII. Dominant Maneuver Workshops

The JAWP organized and hosted three workshops related to the use of Dominant Maneuver by the future joint force. These workshops looked at specific operational aspects and issues in three areas, and identified emerging technologies that could significantly improve operational capabilities in each.

- ▶ Workshop No. 1: Move and Sustain the Force, July 17–20 July 2001.
- ▶ Workshop No. 2: Command and Control the Force, 20–22 February 2002.
- ▶ Workshop No. 3: Intelligence, Surveillance, and Reconnaissance, 9–11 April 2002.

Workshop No. 1: Move and Sustain the Force

The first workshop brought industry, the military research and development community, and military operators together to address the exploitation of new mobility technologies. These technologies would enable the seamless movement of forces and their sustainment from peacetime operating areas through intermediate staging bases outside enemy reach and directly into combat. The main issue was overcoming the risks of being denied “benign” regional access in a crisis. Among the participants explored were the following:

1. the use of intermediate staging bases that were more difficult for the enemy to attack;
2. reducing the need for extensive Reception Onward Movement, Staging, and Integration; and
3. streamlining logistic support.

One approach described was a combination of sea bases of varied functions from which to project fires, ISR, special operations forces, ground maneuver forces, and logistics directly onto enemy controlled territory. A complementary suite of VSTOL (Vertical/Short Takeoff and Landing) and rotary-wing aircraft were matched to the functions described.

Workshop No. 2: Command and Control the Force

The second workshop focused on joint command and control at the joint task force level. Participants included representatives from Joint Forces, Space, Central, European and Pacific Commands.

Two broad themes were addressed: (1) Organizing standing joint command and control capabilities; and (2) providing command and control services and materiel capabilities to combatant commanders. Included in the exploration were US Pacific Command's designated Joint Task Force Augmentation Cells, JFCOM's Standing Joint Force Headquarters, and complementary information technologies.

Workshop No. 3: Intelligence, Surveillance, and Reconnaissance

The purpose of this workshop was to deepen our understanding of the relationships between Decision Superiority and Dominant Maneuver by identifying the requisite underlying joint ISR capabilities as integrated into joint command and control. General Richard B. Myers, the Chairman, Joint Chiefs of Staff, was the keynote speaker. Five panels (composed of representatives from Services, the Joint Chiefs of Staff, OSD, JFCOM, private industry, and JAWP) addressed the following topics:

- ▶ Future sensor requirements for joint concepts
- ▶ Sensor management/data fusion and correlation
- ▶ ISR/sensor requirements for COP/CROP [common operational picture/ common relevant operational picture]

- ▶ Mid-term organizational fixes for the Chairman's Strategic Plan
- ▶ Joint and Service C4ISR relationships and Standing JTF HQ [Joint Task Force Headquarters] organizations

The results of all the workshop efforts were submitted to the Joint Staff J8 sponsor.

IX. Advanced Mobility Concepts Study

At the request of JFCOM J9, JAWP led the Joint Integration Work Group (JIWG) segment of the Defense Planning Guidance-directed Advanced Mobility Concept Study. The study's purpose was to identify joint operational concepts and objectives for inter- and intra-theater airlift, sealift, ground transportation, infrastructure, and pre-positioning. This capabilities-based study examined the mobility needs associated with joint and Service warfighting concepts.

Using scenarios and opposing force lists developed for the Army Transformation Wargame, JAWP examined the application of Service force modules under a joint task force employing JFCOM's Rapid Decisive Operations (RDO) concept. Using a two-sided tabletop wargaming format, the JAWP identified force capabilities required to support the RDO concept, and developed operational force sequencing needed by a follow-on effort to generate joint Time Phased Force Deployment Data.

X. Redressing Low Density/High Demand Shortfalls

In 1996, the Secretary of Defense approved Global Military Force Policy to assist senior-level decision-makers in allocating and employing certain scarce and widely used assets, referred to as low density/high demand (LD/HD) assets. In recognition of the critical shortage of LD/HD assets, the FY 2004–2009 Defense Planning Guidance (DPG), directed the Under Secretaries for Personnel and Readiness (P&R) and Acquisition, Technology, and Lo-

gistics (AT&L) to lead studies to mitigate and eventually eliminate LD/HD shortfalls.

IDA assisted USD (AT&L) in creating a department-wide plan for remedying LD/HD shortfalls over the next decade. This quick response effort, which involved five IDA research divisions, was co-led by JAWP and IDA's Systems Evaluation Division. The focus was on resolving shortfalls in intelligence, surveillance, and target acquisition capabilities, the largest block of assets currently identified as LD/HD.

JAWP developed the study's outbrief and final report for the Secretary of Defense. The report highlighted LD/HD problems that will not be resolved by current Service transformation plans. It also suggested a follow-on effort that explores ways of integrating stove-piped ISR capabilities and developing a more coherent replacement process for systems expected to pass out of the inventory over the next decade. The classified report was briefed to the Secretary in October 2002.

XI. Technology Exploitation Workshop

On 4–6 September 2002, JAWP and IDA's Science and Technology Division collaborated to conduct a Technology Exploitation Workshop in support of JFCOM. The workshop explored the use of six technologies in future military operations in which there has been substantial and promising development:

- ▶ sensors
- ▶ nanotechnology
- ▶ information technology
- ▶ robotics
- ▶ biotechnology
- ▶ new materials

Active duty military and technologists from government, academia, and industry were among the more than 50 participants attending the workshop. Using a wargame to relate technology to real-world operational problems, the participants grappled with how these technologies might enable new military capabilities in two times frames: *the next 5 years* and *the next 10 to 15 years*. Four scenarios—involving time-urgent operations in demanding environments—were provided to the participants to stimulate thinking.

XII. Millennium Challenge 02

Members of the JAWP staff observed portions of Millennium Challenge 02 (MC02) to learn from them and translate the lessons into follow-on experimentation. JAWP observed events at the MC02 Command Post and at other experimentation sites.

Members of JAWP's Norfolk, Virginia, office attended major events in the Tidewater area while two other JAWP teams traveled west to observe MC02 field experimentation. One visited the Joint Expeditionary Force Experiment (JEFX) at Nellis Air Force Base, Nevada. The JEFX series was designed to explore employment of the Air Force in Twenty-First Century Expeditionary Aerospace Force Operations. Another team visited the urban training area (formerly George Air Force Base) near Victorville, California. This site was the scene of the third phase of USMC Millennium Dragon 02, the urban combined-arms exercise.

XIII. Theater Effects-Based Operations Candidate ACTD

At the request of OSD, JAWP is helping to formulate a candidate FY2004 Effects-Based Operations-related ACTD. The intent of this ACTD is to develop and deliver tools to the Commander, Combined Forces Command Korea, that would improve his ability to (1) plan and execute actions and (2) anticipate and assess the effects of such actions (i.e., gain decision superiority).

The Army's Joint Precision Strike Demonstration Project Office is working with Korea, the Pacific Command, JFCOM, the Air Force Research Lab, the Joint Warfare Analysis Center, and other organizations in putting this ACTD together. If approved, initial work would start in FY2004. The tools developed in this ACTD are intended to be used in other regional commands.

XIV. IDA–ICRD Conference on Regional Stability in South Asia

In March 2002, IDA and the International Center for Religion and Diplomacy (ICRD) co-hosted a two-day seminar with Pakistani and Afghani representatives to discuss regional stability and the road ahead for rebuilding Afghanistan. The seminar, conducted as an IDA Central Research Project, consisted of facilitated working group and plenary sessions on diplomatic, security, economic, cultural, and informational aspects of rebuilding Afghanistan. Two dozen representatives from the US State Department, US Agency of International Development, DoD, and the World Bank met with a dozen South Asian representatives from the Institute for Policy Studies in Islamabad, Pakistan, and academic and businessmen from the Afghan *diaspora*. A report on the conference has been finalized and distributed: *Conference on Regional Stability in South Asia: Establishing a Dialogue on the Future of Afghanistan, March 6–7, 2002*, IDA Paper P-3715, September 2002.

XV. Historical Perspectives on Military Innovation and Transformation

Throughout the year, under the leadership of Dr. Williamson Murray, JAWP has conducted historical research to illuminate past efforts to deal with issues that DoD currently faces. Appendix C contains a summary of his *Experimental Units: The Historical Record*.⁹ Two other historical studies were developed during FY2002:

- ▶ *Experimentation in the Period Between the Two World Wars: Lessons for the Twenty-First Century*, Williamson Murray, IDA Document D-2502, November 2002.
- ▶ *War and Urban Terrain in the Twenty-First Century*, Williamson Murray, IDA Paper P-3568, November 2000.

⁹ *Experimental Units: The Historical Record*, Williamson Murray, IDA Paper P-3684, May 2002.

XVI. Publications of JAWP

Experimentation

Experimental Units: The Historical Record, Williamson Murray, IDA Paper P-3684, May 2002.

Lessons Learned: Commanding a Digital Brigade Combat Team, Rick Lynch, IDA Paper P-3616, June 2001.

US Army and US Marine Corps Interoperability: A Bottom-up Series of Experiments, Rick Lynch, Tom O'Leary, Tom Clemons, and Doug Henderson, IDA Paper P-3537, November 2000.

Experimentation in the Period Between the Two World Wars: Lessons for the Twenty-First Century, Williamson Murray, IDA Document D-2502, November 2002.

Lessons Learned from the First Joint Experiment (J9901), Larry D. Budge and John Fricas, IDA Document D-2496, October 2000.

The Joint Experiment J9901: Attack Operations Against Critical Mobile Targets, Joint Advanced Warfighting Program, September 29, 2000. Prepared for the US Joint Forces Command.

Joint Warfighting Experimentation: Ingredients for Success, James H. Kurtz, IDA Document D-2437, September 2000.

Framework for Joint Experimentation—Transformation's Enabler, Karl Lowe, IDA Document D-2280, January 1999.

Joint Concept Development

Applying Rapid Decisive Operations: Possibilities for 2010, Karl H. Lowe, IDA Paper P-3602, December 2001.

Department of Defense Roadmap for Improving Capabilities for Joint Urban Operations, two volumes, William J. Hurley, Alec Wahlman; COL Thomas Sward, USMC; Duane Schattle; and Joel B. Resnick, IDA Paper P-3643. For Official Use Only.

Future Joint Force Headquarters, Scott Schisser, IDA Paper P-3601, December 2001.

An Historical Perspective on Effects-Based Operations, Williamson Murray, with Thomas O'Leary, Joel Resnick, Dennis Gleeson, and Gwen Linde, IDA Paper P-3606, October 2001.

Taking the Revolution in Military Affairs Downtown: New Approaches to Urban Operations, William J. Hurley, IDA Paper P-3593, August 2001. For Official Use Only.

Joint Strike Force Operational Concept, Rick Lynch, David Bolanos, Thomas Clemons, Kathleen Echiverri, Dennis J. Gleeson, Jr., Doug Henderson, Aleksandra Rohde, Scott Schisser, IDA Paper P-3578, July 2001. For Official Use Only.

New Perspectives on Effects-Based Operations: Annotated Briefing, Dennis J. Gleeson, Gwen Linde, Kathleen McGrath, Adrienne Murphy, Williamson Murray, Tom O'Leary, Joel B. Resnick, IDA Document D-2583, June 2001.

War and Urban Terrain in the Twenty-First Century, Williamson Murray, IDA Paper P-3568, November 2000.

Military Operations in Urban Terrain: A Survey of Journal Articles, D. Robert Worley, Alec Wahlman, and Dennis Gleeson, Jr., IDA Document D-2521, October 2000.

Transformation Process

The Unified Command Structure: Issues for the Next Review, Karl H. Lowe, Adrienne Janetti, Drew Lewis, Charles Pasquale, IDA Paper P-3736, December 2002. For Official Use Only.

Military Transformation and Legacy Forces, Williamson Murray and Thomas O'Leary, IDA Paper P-3633, April 2002.

Red Teaming: Shaping the Transformation Process. Annotated Briefing, John Sandoz, IDA Document D-2590, June 2001.

Thinking About Innovation, Williamson Murray, IDA Paper P-3576, June 2001.

Red Teaming: A Means for Transformation, John F. Sandoz, IDA Paper P-3580, January 2001.

Developing Metrics for DoD's Transformation, Joel B. Resnick, IDA Document D-2528, October 2000.

Seminars and Workshops

Workshop on Advanced Technologies for Urban Operations, November 14-15, 2000: Summary of Proceedings, William J. Hurley, IDA Document D-2574, June 2001. For Official Use Only.

Joint Advanced Warfare Seminar, James H. Kurtz, Daniel E. Moore, and Joel B. Resnick, IDA Document D-2346, July 1999.

Workshop on Advanced Technologies and Future Joint Warfighting, April 8-10, 1999: Summary of Proceedings, William J. Hurley, Phillip Gould, and Nancy P. Licato, IDA Document D-2343, May 1999.

General

FY2002 End of Year Report, Theodore S. Gold et al., multi-volume set, February 2003, forthcoming.

FY2001 End of Year Report, Theodore S. Gold et al., multi-volume set, January 2002, forthcoming.

FY2000 End of Year Report: Volumes I, II, and III, Theodore S. Gold et al., IDA Paper P-3571, November 2000.

Appendix A. Future Joint Force I Experiment

Introduction

Transformation to new, breakthrough military capabilities requires more than the introduction of new hardware, new software, or new technologies. The most important component of transformation will likely be the development and introduction of new concepts, for example, the new ways of organizing and employing both legacy and new systems and technologies. *Concept-based continuous joint experimentation* has the potential to assist the Department of Defense in this exploration of new concepts.

As part of this exploration, the Joint Advanced Warfighting Program (JAWP), under the sponsorship of the Deputy Under Secretary of Defense (Advanced Systems & Concepts), developed and conducted the Future Joint Force (FJF) I Experiment for the US Joint Forces Command (JFCOM) and the Defense Advanced Research Projects Agency (DARPA).

The experiment had several objectives, but none turned out to be more relevant than understanding the value—and challenge—of pushing *jointness* to the lowest possible levels. The FJF I Experiment, which was largely conducted in a virtual environment, explored the functions and performance of a postulated Future Joint Force against an adaptable adversary in several tactical scenarios.

The FJF was robustly networked with a multi-tier sensor architecture, a small but ISR-rich¹ ground element, a diverse suite of precision weapons, numerous unmanned aerial and ground systems, and a lean command and control (C2) arrangement. The ground element of the Blue Force could be characterized as a battalion-size motorized light reconnaissance unit—rich in sensors and remote fires but poor in armor protection, infantry fighting vehicles, and infantry. In contrast, the Red Force was an armor-heavy, brigade-like force that was initially enhanced with unmanned aerial vehicles (UAVs). In the latter trials, Red had other capabilities increasingly available to potential adversaries, such as an active protection system, decoys, and radar countermeasures.

The organizing theme of the FJF concept was creating and exploiting shared situational understanding, developed through a network of diverse sensors and a collaborative environment (horizontally and vertically).

- ▶ The sensor network contributed to shared situational awareness through a common relevant operating picture (CROP).

¹ Intelligence, surveillance, and reconnaissance.

- The collaborative environment fostered the value-added judgment and context that raised *awareness* to *understanding* and enabled *decision superiority*.

A distinguishing feature of the sensor network was the inclusion of an extensive sensor suite organic to the FJF's ground elements. As an indication of the richness of the ISR assets, this battalion-size unit possessed more than 90 UAVs—a vast increase when compared with the number possessed by today's organizations.

Four Levels of Decision-Making

Within this experiment, four levels of decision-making were considered by the JAWP Team. (These are depicted in [Figure A-1](#) below.)

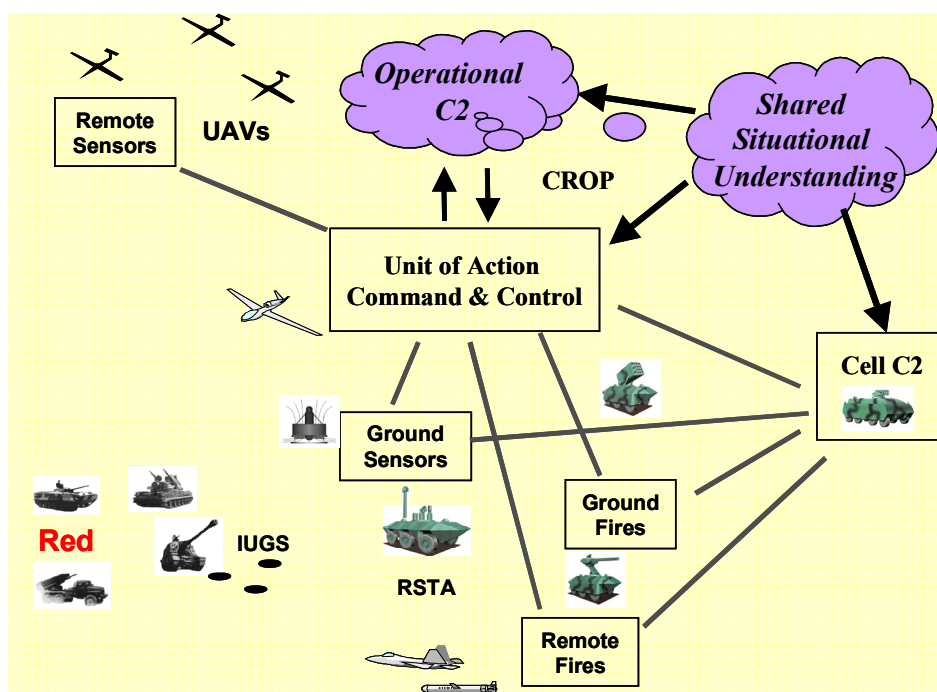


Figure A-1. FJF I Experiment Concept

The Joint Force Commander. The JFC's perspective was not played explicitly but several operational functions were performed by the experiment's Control Team.

The joint Unit of Action. Functions performed by the single Unit of Action C2 node included integrating sensors and weapons, maneuvering sensors, engaging Red Forces with remote and organic ground weapons, and providing command and control to subordinate ground units (called *cells* in this experiment). This joint Unit of Action C2 node

can be considered either as an aggregation of several levels of tactical and operational command or representative of a much flatter future C2 arrangement.

The Cell. The Cell C2 node was the tactical headquarters for each of six cells that constituted the ground elements of the joint force in this experiment. The Cell C2 node maneuvered its reconnaissance, surveillance, and target acquisition (RSTA) assets—manned and unmanned, ground and aerial—to develop situational understanding and provide targeting information. The Cell C2 node and its subordinate elements engaged Red forces with organic ground and remote weapons.

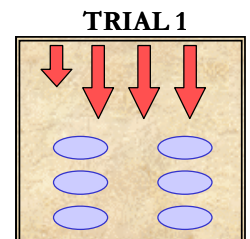
The individual RSTA vehicles. There were six of these two-person vehicles in each Cell, each vehicle controlling three robotic ground RSTA vehicles and two small UAVs.

The Trials

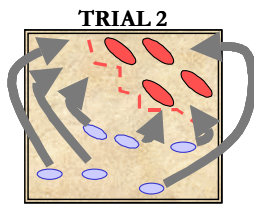
The heart of the experiment were four week-long trials conducted at the US Army's Mounted Maneuver Battle Lab at Ft Knox, Kentucky, linked with the JFCOM Joint Training and Analysis Support Center in Suffolk, Virginia. In addition to using human-in-the-loop (HITL) simulations, these HITL trials were also complemented by table-top games and analysis using constructive models.

Four different scenarios were used during the five experimental trials. These scenarios were developed to stress varying aspects of Blue Force performance and were executed in a 180 x 330 kilometer battlespace with a wide range of foliage and terrain (but no urban terrain).

Defend and Delay Mission. This mission provided the Red Force with the initiative in attacking to link up with a partisan element to achieve success. Red launched a series of highly dispersed, coordinated attacks to avoid detection, penetrate Blue defenses, and link up with partisan elements. Blue sought to prevent this link-up by forcing Red to stop short of its objectives. Blue was successful in achieving its mission by occupying virtually the entire available battlespace with its sensor coverage, finding and destroying components of key enemy systems, and destroying most of the enemy's combat vehicles. However, significant Red dismounted infantry remained at the end of the trial.



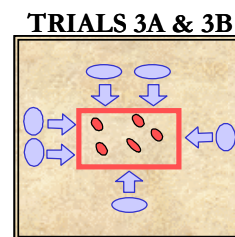
*Red Force attacking.
Blue Force defending and
delaying.*



*Blue Force attacking.
Red (larger ovals) defending.*

Deliberate Attack Mission. This mission provided the attacking Blue Force with the initiative and time to attack and destroy defending the Red Force. Red established a well-prepared defense and was prepared to reinforce with mobile reserves. Blue systematically identified and destroyed Red's command and control, air defenses, and artillery (shaping operations)—to the extent possible—with remote sensors and fires. Blue then began a series of sequenced ground maneuvers to evoke additional Red forces and achieve more complete sensor coverage. Blue was successful in this mission by disintegrating key enemy systems and destroying enemy combat vehicles. Significant Red dismounted infantry remained at the end of the trial.

Strike Mission. This mission required the Blue Force to fight for intelligence in a time-constrained environment to prevent the Red Force from launching theater ballistic missiles (TBMs) at strategic targets. The Red Force consisted of several armored and mechanized battalions defending a single battalion of mobile TBM launchers. The Red Force possessed enhanced capabilities including improved UAV sensors, longer-range artillery, vehicle camouflage, decoys, and special operations forces.

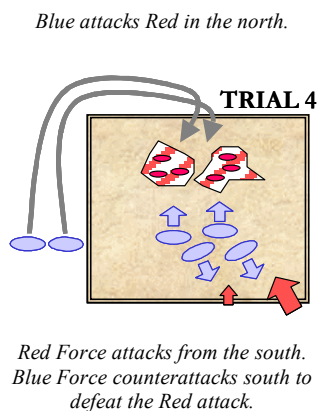


*Blue Force attacking.
Red Force defending & launching mobile TBMs.*

Two trials were conducted with increasing time criticality. In Trial 3A, Blue was given about six hours to conduct shaping operations prior to the Red Force achieving a capability to launch TBMs. Blue was successful in this trial. By accepting heavy losses in unmanned sensor systems in order to gain information, Blue was able to target Red launch vehicles prior to launch.

In Trial 3B, Red began launching mobile TBMs immediately without any opportunity for Blue to conduct shaping operations. While Blue was successful at killing all but one Red mobile TBM launchers in about four hours, Red successfully launched nearly all its mobile TBMs against strategic targets. And while Blue aggressively committed both manned and unmanned reconnaissance assets, they were unable to target and destroy Red's mobile TBMs fast enough to prevent launches.

Hasty Attack Mission. This mission caused the Blue Force to react to a number of unexpected enemy actions, thereby testing Blue's ability to maintain synoptic sensor coverage of the entire battlespace and to rapidly refocus sensor and weapons assets to defeat the enemy force.



Red began with two enhanced armor and mechanized battalions defending along an international boundary. Blue conducted vertical envelopments to prevent the enemy's withdrawal across the international boundary, and then began systematic destruction of defending enemy forces. As soon as all Blue assets were committed to this fight, an additional heavy Red brigade launched an attack from the south aimed at the rear of the Blue Force. Blue quickly detected this movement at long range, and counterattacked with sufficient sensor and weapons coverage (shaping operations) to destroy the attacking force while continuing to prosecute the fight against the defending force.

What Happened

- ▶ The Blue Force accomplished its mission in four of the experiment's five trials despite grossly inferior organic combat power when compared to the Red Force. The Blue Force took heavy losses, but those losses were predominately in unmanned systems.
- ▶ The Blue Force was capable of operating over long distances and influencing a much larger area of operations than had been traditionally covered by a force of equivalent size. However, real-world considerations of logistics, communication, and casualty evacuation were not represented in the experiment and would decrease the Blue Force's ability to operate in a dispersed manner.
- ▶ While Blue achieved success in RSTA missions, it experienced significant difficulty in dealing with Red's dismounted infantry.

Why It Happened

Long-range sensors and remote fires let the Blue Force "see" and engage the Red Force early and at distances beyond line-of-sight (BLOS). The availability and creative application of large quantities of diverse and agile ground-based sensors contributed significantly to the Blue Force's ability to achieve situational awareness and develop actionable target information.

To accomplish all of this, achieving effective sensor coverage became the focal objective of Blue Force operations (facilitated by small staffs, few echelons, and shared aware-

ness). Even with the extensive network of sensors, Blue did not lift the “fog of war” but instead had to continually “maneuver” its sensors in order to gain conditions supporting decision superiority.

- ▶ Blue and Red participants demonstrated substantial growth and increased proficiency over time in achieving accurate sensor coverage. The participants also demonstrated creativity in making use of all available systems to increase sensor coverage. This effect was more pronounced in the Blue Force than the Red Force because of Blue’s more extensive training time and resultant experience.
- ▶ Blue sensors acquired approximately 50% of the Red Force during any given trial hour and about 80% of the Red Force over time.
- ▶ Sensors were operated in a complementary and synergistic manner. The combination of sensors, each with different capabilities and operated at different altitudes, proved effective in developing comprehensive coverage.

Information displays and standards of information relevancy, accuracy, and latency that were available to Blue players did not fully support the attainment of decision superiority. In the after action data collection, Blue players indicated that situational awareness was their most time-consuming task, taking up about a third of their time. This figure, while low with respect to analog environments (where much of the communication is focused on “where are you?”), is still higher than where we want it to be in shared situational awareness environments.

Despite significant improvement and learning by Blue participants, operations at lower echelons continued to be very demanding on personnel. This implies that our future combatants will require a broader skill set, more experience, and specialized training.

Inter-cell communications during the trials reflected different command styles: *hierarchical* (mostly vertical communications), or *networking* (considerable horizontal communications). Based on subjective judgments by the evaluators, it appeared that the networking cell was less effective in the early trials, but improved more rapidly as a result of learning on the job, and seemed more adaptive by the last trial.

Blue players adapted quickly to the much larger Red ground force and learned to use unmanned systems to accomplish the mission and to protect the manned systems.

- ▶ When the Blue Force was forced to accept casualties in close combat, it was able to take the majority of losses in unmanned systems.
- ▶ Despite very high levels of situational awareness, fratricide still occurred among the Blue Force, but friendly fire losses occurred mostly to unmanned systems.

The Red Force challenged the FJF concept by continuously adapting to Blue capabilities.

- ▶ Red used civilians and battlefield clutter to complicate application of rules of engagement, forcing Blue to gain greater sensor resolution.
- ▶ Red also used the enhanced-sensor UAVs provided in Trials 3A, 3B, and 4 to increase its situational awareness. At the same time, it used its dismounted infantry as an effective sensor system throughout all the trial scenarios.
- ▶ Red tried a variety of movement techniques ranging from dispersed operations using camouflage and concealment to rapid movement by massed forces.

Caveats and Limitations

Any warfighting experiment—except perhaps the one that is done during actual combat—is an abstraction of reality that involves simplifying assumptions. We simplified the HITL phase of this experiment in several respects:

- ▶ We assumed that the FJF was already in its starting positions, and thus did not simulate the strategic deployment or entry operations into the theater.
- ▶ Likewise, assured logistics and sustainment were assumed, so we did not simulate either function.
- ▶ We also assumed robust communications for both sides.

The rationale for these assumptions was that if a concept did not show promise under these favorable conditions, it would be even less promising with degraded communications and logistics demands. However, the JAWP Team did capture and analyze the communications flow. Still, realistic communication and deployment logistics must be addressed in further experimentation on the FJF concept.

We did not simulate competing demands for joint sensor and weapons assets by other elements of the Joint Task Force (JTF). Although we used the highest fidelity synthetic terrain (DTED² Level II) that was available, its relatively smooth surface enabled the ground robots to have greater mobility and agility than they would on real terrain.

Implications

The experiment employed sensor-enabled, small ground units employing long-range fires from air, land, and sea in dispersed, high-tempo offensive and defensive operations. While one experiment cannot offer a proof of concept, it does suggest promising areas for further exploration with existing capabilities.

Integration of unmanned sensor platforms into manned units. Unconstrained by communication and bandwidth limitations, the Blue ground force employed in this experiment was able to dramatically extend its range of influence and its security through:

- ▶ the employment of substantial numbers of unmanned aerial and ground sensor platforms, and
- ▶ the employment of unattended sensor fields.

The integration of sensors, long-range fires, and small ground units should be possible with today's capabilities. Providing several existing units with roughly comparable numbers of aerial and ground sensor platforms for experimentation could more quickly evolve the concept and the maturity of robotic capabilities not only for RSTA but for logistics, communication, and fire functions as well.

Pushing "jointness" lower. Extension of joint command and control to an echelon just above basic fighting formations enabled units at the lowest levels to leverage and exploit sensor-generated information and long-range fires. While that is possible today, the echelon to which it is necessary and practical requires further exploration.

Operations in Afghanistan suggest small combinations of joint manning could reap large pay-offs. Joint experimentation with the concept by several brigade and wing combinations at major training complexes could:

- ▶ identify associated communication and bandwidth requirements,

² Digital Terrain Elevation Data.

- ▶ explore how deep joint manning of headquarters and units is necessary or practical,
- ▶ identify core requisites of modularity, and
- ▶ explore how to maintain responsiveness of sensor coverage and fires amid rapidly changing competition for priority.

Fighting for information. Because overhead systems alone could not uncover the most important capabilities of the opponent, ground units in this experiment had to fight for information, drawing opponents out of shielded terrain and capturing information about elements that had not been discovered. They often did so by evoking enemy reaction by attacking known nodes deep in enemy-controlled territory, and deploying by air to unimproved landing sites.

Field experimentation with alternatives that employ today's array of tactical fixed-wing aircraft, tilt-rotor aircraft, and helicopters to deliver Army, Marine, and special operations units in similar missions would improve understanding of what additional capabilities light and middleweight forces need to carry out such missions, and what can be done to improve the survivability of their tactical air mobility.

Logistics. While the experiment employed widely dispersed small units in enemy-controlled territory, it did not explore their logistical sustainment. Of particular concern is the evacuation of casualties and replacement of disabled or destroyed vehicles and robotic platforms. Field experimentation with logistical support of the concept is needed to clarify its near-term viability and the capabilities needed for its long-term viability.

Finishing decisively. By its very nature, the ground force used in this experiment was oriented on RSTA missions and was not capable of bringing the fight to a decisive conclusion. In fact, while successful in achieving specified objectives such as disintegration of enemy command and control, air defense, and artillery systems and attrition of heavy combat systems, Blue Forces were unable to destroy more than 30% of enemy dismounted infantry, allowing the enemy to control key and decisive terrain.

The Blue RSTA Forces playing in this experiment lacked adequate organic combat power to achieve the basic conditions required of military success in many missions—the ability to hold and secure terrain. Further experimentation adding combinations of infantry and organic direct, BLOS, and indirect fire delivery capabilities is needed to de-

termine appropriate capabilities for a future ground force capable of achieving a full spectrum of military missions.

Leader development. The experiment suggests that decision superiority is enabled by the ability to resource multiple subordinate decision cycles with adequate information, and empower the leaders with the freedom of action to act faster than an opponent's ability to observe-orient-decide-act.

Effective decentralized decision-making will depend on small-unit leaders trained to operate in this highly autonomous and yet collaborative environment. Units whose leaders exploited networking to share information and to cue each other regarding enemy location and intent appeared to be more effective than those relying on centralized direction in the experiment.

The skill also enabled units to continue the mission when communications with senior leaders were interrupted or lost. Equally important was the training of senior leaders who were comfortable with delegating decision-making to the appropriate level of command even when all the conditions necessary to enable micromanagement were available, and micromanaging may have seemed appropriate.

Concept-Based Continuous Joint Experimentation Process

Concept-based continuous joint experimentation provides an environment in which new concepts—that is, new ways of organizing and employing both legacy and new systems and technologies—can be pushed to failure; modified; and then pushed to failure again in a series of series of HITL trials. This process explores new concepts through an iterative series of workshops, seminars, constructive simulations, HITL virtual simulations, and field activities (as depicted in **Figure A–2** on the next page).

At each step in the process, the concept may be modified or even rejected, based on what has been learned in that step. The joint experimentation process should also be “connected” to real-world operations by tailoring experiments to support ongoing operations, rapidly incorporating lessons learned from these operations, and leveraging the experience of those engaged in such operations.

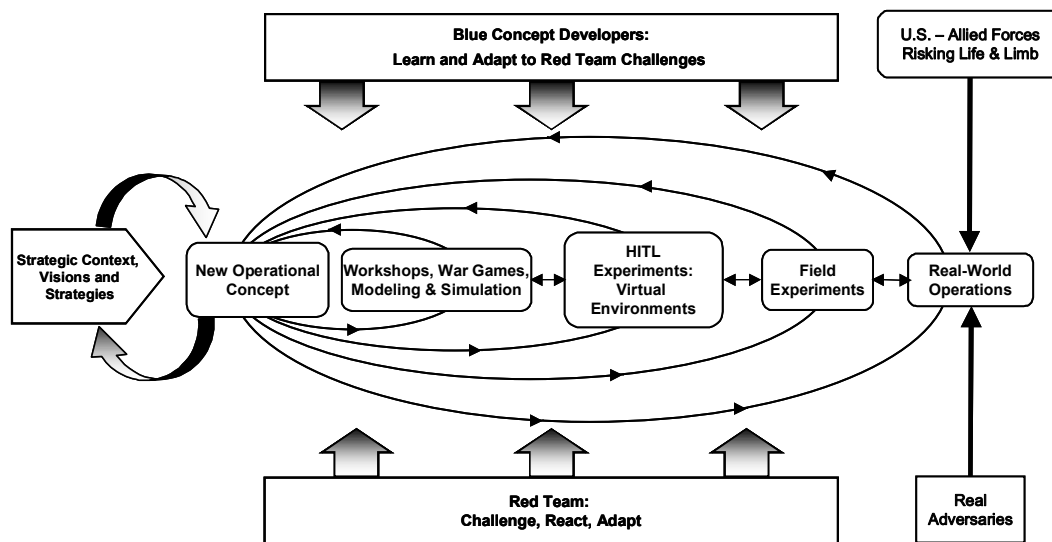


Figure A-2. The Continuous Joint Experimentation Process

At each step in the process, the concept may be modified or even rejected, based on what has been learned in that step. The joint experimentation process should also be “connected” to real-world operations by tailoring experiments to support ongoing operations, rapidly incorporating lessons learned from these operations, and leveraging the experience of those engaged in such operations.

The operational concept and organization for the FJF was derived from several sources, including work by JFCOM, DARPA, the Army’s Training and Doctrine Command (TRADOC), and the Defense Science Board.

The Blue concept developers—civilian and military members of the JAWP with assistance from outside sources—were responsible for the development of the FJF concept throughout the experiment. The Red Team was responsible for challenging the FJF concept at every step in the process. It was led by a military member of the JAWP with assistance from a wide range of subject matter experts. These experts included staff members of the Institute for Defense Analyses, TRADOC, and the Defense Adaptive Red Team (DART), which was sponsored by the Deputy Under Secretary of Defense (Advanced Systems & Concepts) in the Department of Defense.

The JAWP Team began exploring the FJF concept through a series of seminars and war games. The team also brought in sensor and weapon experts to help determine the ca-

pabilities that the FJF could possess in the mid-term timeframe. As a result of these war games, the team made changes, among them:

- ▶ increasing the number of ground and low-altitude air robotic sensors to provide a higher level of situational awareness at the ground level,
- ▶ adding reconnaissance squads to each cell to provide the flexibility of dismounted scouts, and
- ▶ adding robotic guns to each cell to enhance the close-in defense capability.

Following the seminars and war games, the National Defense Research Institute (NDRI) at the RAND Corporation conducted a series of constructive simulation runs to explore the capability of the FJF concept against a large Red armor force in offensive and defensive scenarios. The NDRI analyses were used to further refine capabilities that would be explored in the HITL phase, and substantiated the need (identified in the war games) for additional ground robotic sensors, including unattended ground sensors.

The HITL phase of the experiment (see [Figure A-3](#) below) provided a richness not available in the earlier phases of the experiment process. In this phase, Blue commanders and staffs engaged their Red adversaries in a virtual battlespace that challenged the FJF concept over a series of trials using entity-level, real-time simulation.

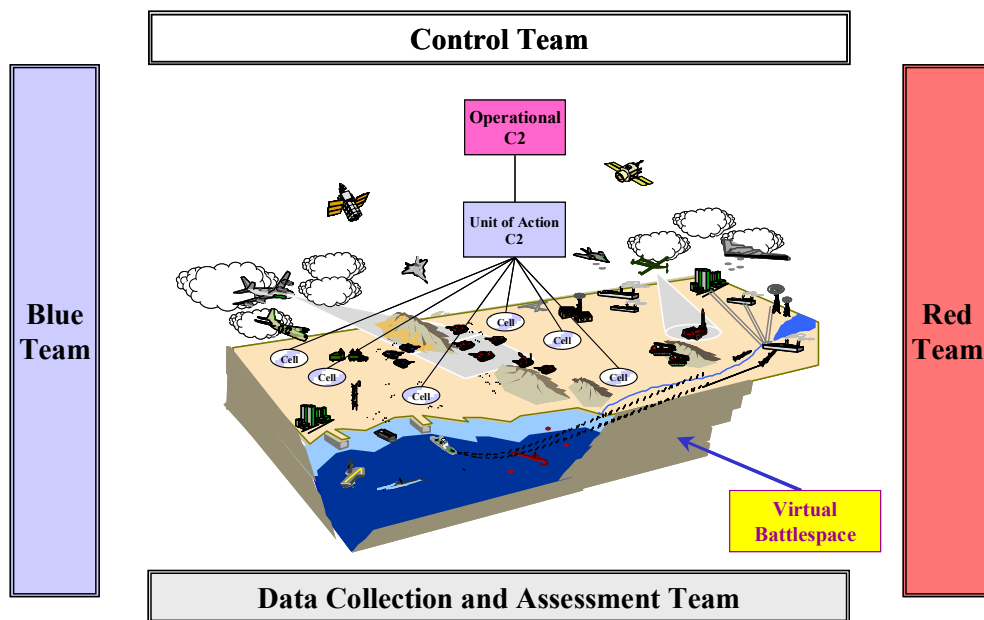


Figure A-3. FJF I Experiment HITL Simulation Architecture

Each trial was constructed to explore specific capabilities of the FJF concept. The Red Force was given the freedom, within its capabilities, to adopt tactics to defeat the Blue Force. Red capabilities were increased over the course of the trials to determine if Red could break the FJF concept.

Using JFCOM's Joint Semi-Automated Force (JSAF) simulation as a base, the JSAF Team linked with the Mounted Maneuver Battle Lab at Ft Knox to provide a richer simulation of the future ground force component than was in the JSAF simulation. This included 2 manned simulators for the Unit of Action C2 node and 18 manned simulators for 2 of the 6 cells.

For the four one-week HITL simulation trials, military members of the JAWP, augmented by a Canadian officer and a British officer, staffed the Unit of Action C2 node while the cells were manned by 40 officers and men from the Iowa and Kentucky Army National Guard. The use of Reserve Component personnel in the HITL phase of continuous joint experiments may provide a substitute for a dedicated active duty experimental unit.

The Control Team represented the JTF Commander and his staff who interacted with the Unit of Action to provide operational orders and guidance, and to provide the larger theater context to the players. In addition, the Control Team provided overall experiment supervision and control.

Robust data collection was essential, particularly in regard to capturing the human dimensions of command and control. Members of the Data Collection and Assessment Team assessed command and control throughout the Blue force and observed the performance of the individual players to assess their ability to execute the concept. This effort was complemented by surveys and questionnaires administered to the players on a daily basis, with the results entered into a database. Outside agencies, e.g., Army Research Laboratory, were also contracted to provide additional surveys and analysis. We believe much remains to be learned about effective experimentation data collection.

Concluding Comments

The experiment explored and identified promising paths to accelerate new joint force capabilities, some evidenced already to varying degree in OPERATION ENDURING FREEDOM, the Afghanistan campaign. These capabilities included horizontally integrated ISR; effective long-range strike; distributed and agile ground forces directing fires

from a global arsenal; unmanned systems integrated into the force; and adaptive joint command and control

The experiment pointed to an approach that would provide a powerful new element in an experimentation campaign. This approach envisions continuous use of a distributed HITL capability that connects JFCOM intellectually as well as electronically with Service, Command, and other key players. The experiment described in this report made effective use of the HITL tool (so important when command and control is the focus) but did not rise to this standard.

Only one Army center (the Mounted Maneuver Battlespace Laboratory at Fort Knox) was linked with JFCOM. Furthermore, the experiment certainly was not continuous—considerable energy was expended in setting up and tearing down the experimental environment, leaving less time for experimentation and learning. Finally, the short time available for experimentation precluded further examination of issues raised during the trials.

This experiment provided only a glimpse of the power continuous experimentation holds in examining the evolving interaction of operational concepts, emerging technologies, and changing organizational structures. Through this and other efforts, the Department of Defense is improving its ability to conduct joint experiments. However, in order for these activities to be enablers of transformation, it also must improve its processes to assess and act on the results of experiments.

Appendix B.
Department of Defense Roadmap
for Improving Capabilities for
Joint Urban Operations

I. Introduction

Over the coming decades the US military will almost certainly be called upon to conduct operations in areas characterized by man-made structures, noncombatants and infrastructures, i.e., urban areas. Urban areas are political, cultural, and financial centers; and they act as hubs for transportation, information, and manufacturing. Most scenarios at the lower levels of conflict, including counter-terrorism, focus on civilians, and therefore on urban areas.

The urban environment constrains many of the advantages that US forces currently enjoy in open environments. Operations in urban environments involve risks of high casualties to friendly forces and noncombatants, as well as extensive collateral damage. In many scenarios, such unintended consequences may, in themselves, defeat the goals of US involvement.

The challenge for the Department of Defense (DoD) is twofold:

- ▶ to improve the urban capabilities of current legacy forces, which have been primarily designed for operations in open environments; and
- ▶ to develop new approaches that address the unique demands of urban operations and that hold the promise of dramatic improvement.

Almost all recent DoD activities aimed at improving urban capabilities have focused on the first of the above, that is, on single-Service near-term improvements to current methods of tactical operations. Examples include the US Marine Corps' Urban Warrior and Project Metropolis programs; the Army's Combined Arms Military Operations on Urbanized Terrain (MOUT) Task Force; and the Army/Marine Corps/Office of the Secretary of Defense (OSD) MOUT Advanced Concept Technology Demonstration (ACTD). These programs, though vitally needed, have not sought the types of dramatic improvements that may be possible with new approaches that take an operational, vice tactical, perspective. Indeed, the exploration of such approaches will require changing how the Department thinks, organizes, and invests regarding urban operations.

Despite a growing unease that the urban environment is a known vulnerability of US forces, DoD has *not* made a major commitment to dramatically improve urban capabilities. Concerns about this situation have been expressed from both within and outside

DoD.¹ However, recent efforts within DoD have begun to explore new approaches to improving current capabilities. Examples at the Joint Force Commander level in particular include the following:

- ▶ The Chairman, Joint Chiefs of Staff (CJCS) J8 Dominant Maneuver Assessment Division has served as the focal point for operational-level military assessments regarding joint urban issues for the past five years.
- ▶ During that same period of time, the informal Joint Urban Working Group (JUWG) collaborated on, participated in, supervised, and led joint urban assessments and wargames in the areas of joint urban doctrine; urban modeling and simulation (M&S); joint urban capabilities; urban intelligence, surveillance, and reconnaissance (ISR); urban command, control, and communications (C3); and joint urban training and facilities. These assessments identified shortcomings and gaps regarding current, joint, operational-level urban capabilities, and served as the starting point for the development of this Roadmap.

Complementing the Joint Staff efforts have been a number of endeavors, including the following:

- ▶ OSD (Policy) has chaired an informal urban working group to share information of interest throughout DoD.
- ▶ The Assistant Secretary of Defense (ASD) for Command, Control, Communications, and Intelligence (C3I) has established a Defense Intelligence Urban Working Group to address urban ISR issues.
- ▶ In support of a commitment made by the Deputy Secretary of Defense to the US Congress,² the Joint Staff (J8) is chairing a flag-level Special Study Group to advise the Secretary regarding the creation of a DoD Executive Agent and the development of a *DoD Master Plan* to address joint urban capabilities.

¹ Defense Planning Guidance, FY-2001; US General Accounting Office, “Focused Attention Needed to Prepare US Forces for Combat in Urban Areas,” February 2000; U. S. House of Representatives, Floyd D. Spence National Defense Authorization Act for FY 2001, Committee on Armed Services, Report 106–616, p. 342.

² Letter from Deputy Secretary of Defense to Chairman, Subcommittee on Defense, Committee on Appropriations, May 2001.

- ▶ A *Handbook for Joint Urban Operations*, drafted by the Air Force, has been approved and distributed by the Joint Staff.³
- ▶ And, for the first time, joint doctrine for urban operations is being developed.⁴

These DoD efforts are pursuing promising paths, but until a focal point is established with authority and resources to coordinate and advance them, improvements will continue to be evolutionary. And there is hope that significant improvement can be achieved. New approaches—leveraging joint capabilities at the operational level—hold the promise of achieving urban objectives while significantly reducing (but not eliminating) casualties and collateral damage. These approaches are based on new capabilities for understanding and shaping at the operational level *before* engaging, and by engaging with precision effects from less vulnerable positions. These approaches are sparked by emerging technologies but can only be realized through changes in all elements of DOTMLPF (doctrine, organization, training, materiel, leadership, people, facilities).

To help advance these new approaches, the Joint Advanced Warfighting Program (JAWP) at the Institute for Defense Analyses (IDA) was tasked to develop this report, *Department of Defense Roadmap for Improving Capabilities for Joint Urban Operations*. The Roadmap identifies directions to pursue in order to improve dramatically the capabilities of future Joint Force Commanders to conduct military operations involving urban environments.

II. Outline

The following sections summarize the results of the Roadmap. (Readers interested in a specific topic can skip ahead to that section in the Summary.) Details are given in the main report.

Section III, “New Thinking: the Overarching Concept,” describes the overarching operational-level approach in terms of the components Understand, Shape, Engage, Consolidate, and Transition (USECT). Page B–6.

³ US Department of Defense, *Handbook for Joint Urban Operations*, US Government Printing Office, Washington, DC, 2000.

⁴ US Department of Defense, Joint Staff, *Doctrine for Joint Urban Operations*, Joint Publication 3-06, 2nd draft, October 2000.

Section IV, “The Roadmap Process,” describes the range of urban missions, types of operational concepts, required operational capabilities, capability assessments, current DoD programs and activities, and the “landscape” of needed programs and activities. Page B–7.

Section V, “Key Directions for Initiatives: Operational Capabilities,” summarizes the initiatives needed to improve the capabilities in each of the USECT categories. Page B–13.

Section VI, “Key Directions for Initiatives: Supporting Activities,” summarizes the programs and activities needed to support the achievement of the above capabilities. These are given in terms of the DOTMLPF categories and categories addressing Policy and Legality, Coalition and Interagency, Concept Development and Experimentation, and Modeling and Simulation. Page B–20.

Section VII, “Summary of the Strawman Program,” presents a Strawman Program of initiatives addressing the key directions identified in Sections V and VI, and gives (rough) cost estimates. Page B–27.

Section VIII, “Implementation,” discusses DoD actions that are needed in order to realize the Strawman Program. Page B–28.

Section IX, “Conclusion,” presents a brief summary and identifies the most critical organizational needs facing DoD. Page B–29.

III. New Thinking: The Overarching Concept

Traditional approaches to urban operations result from the difficulty in acquiring information in an urban environment. Without information regarding the nature, positions, and movements of the enemy force, the friendly force commander must rely on approaches that are static (*siege*), indiscriminate (*rubble-ization*), or which trade casualties for information by sending ground forces blindly forward to establish close contact with the enemy (*frontal assault*).

The draft *Doctrine for Joint Urban Operations* describes an urban operation in terms of five components: Understand, Shape, Engage, Consolidate, and Transition (USECT).⁵ Tradi-

⁵ US Department of Defense, Joint Staff, *Doctrine for Joint Urban Operations*, Joint Publication 3-06, 2nd draft, October 2000.

tional urban operations have emphasized the “Engage” component (usEct) because of the difficulty in gaining information. This is sometimes referred to as an “attritionist” approach to urban operations, and entails high casualties and extensive collateral damage.

Emerging approaches to urban operations are based on gaining a significantly improved understanding of the enemy, the urban area and its inhabitants, and then using this understanding to shape the battlespace, provide key advantages, and enable the projection of precision effects from less vulnerable positions. In this approach the Joint Force Commander (JFC) understands and shapes *before* engaging (usSect), and then engages from less vulnerable positions with precision effects and not overwhelming lethal force. Such an approach is becoming feasible because of emerging technologies in sensors, information, unmanned systems, precision guidance, and non-lethal weapons. However, systems based on such technologies must be developed and tested, new operational concepts employing them must be explored through experimentation, and packages of associated DOTMPLF changes must be effected before the promise can become reality. The Roadmap describes directions for this exploration and development.

Efforts to improve urban capabilities must take a two-pronged approach. Since the need for traditional, close-up engagements cannot be eliminated in the foreseeable future, improved capabilities must continue to be sought at that level. On the other hand, improvements in operational-level situation awareness could significantly reduce the number of close-up engagements needed to achieve objectives in urban areas. Improvements could also create dramatically more favorable conditions when such engagements are necessary.

IV. The Roadmap Process

A. Definition and Focus

The Roadmap identifies directions to pursue in order to improve significantly the capabilities of future JFCs to conduct military operations involving urban terrain. The focus of the Roadmap is on a “toolkit” of capabilities that supports a range of operational concepts so that a future JFC can tailor an approach for any specific situation.

By taking the perspective of a future JFC, the Roadmap focuses on the joint operational level. However, strategic and tactical levels are also considered. The strategic level determines the context and initial conditions, the resources and methods available to the JFC, and the nature of the desired end state. Likewise, tactical capabilities are the build-

ing blocks of operational capabilities, and dramatic improvements at the operational level can depend on advances at the tactical level.

The process of developing a Roadmap starts with the overarching concept as described in the previous section, and the output of the process is a program of initiatives that can provide the JFC with capabilities that realize the overarching concept. This process is outlined in **Table B-1** below.

Table B-1. Roadmap Process

1. Articulate the overarching concept	5. Determine the capabilities required to enable the operational concepts
2. Describe the range of urban missions	6. Assess the status of those capabilities
3. Describe the range of conditions that may prevail for a given mission	7. Review current programs aimed at improving the status
4. Identify alternative operational concepts for executing the missions	8. Identify gaps and directions for program initiatives

B. Missions

Table B-2 lists the types of urban missions that may be assigned to a JFC. These are characterized in terms of the objectives of the missions, which may range from capturing an urban area through peace operations.

Table B-2. Types of Urban Missions

Objective is the urban area itself: ▶ Capture ▶ Defend ▶ Isolate/neutralize Objective is within an urban area: ▶ Neutralize an enemy force ▶ Conduct focused offense (e.g., against a facility; includes generation of “effects” against utilities, information, mobility) ▶ Conduct focused defense (e.g., create a sanctuary or conduct a rescue operation) Objective is to protect or assist people in an urban area: ▶ Neutralize combatants (e.g., peace operation) ▶ Provide humanitarian assistance ▶ Provide civil support in the United States

C. Conditions

The severity of the conditions under which a mission can be accomplished is a measure of a JFC's capabilities. The range of such conditions is illustrated in **Figure B-1** below, using as an example the Mogadishu operations of 1992 and 1993. This figure shows 12 axes corresponding to different types of conditions. The distance from the origin on each axis represents the degree of difficulty associated with a given condition. A scenario is represented by a polygon that intersects each axis. The “scale” used may be quantitative (e.g., size) but more often will be qualitative (e.g., “attitude of civilians” ranging from “very friendly” to “very hostile”). In the Mogadishu example, the increasingly hostile attitude of civilians, the increasing level of conflict, and the resultant increase in Blue political hesitancy were critical conditions that changed between the 1992 and 1993 phases.

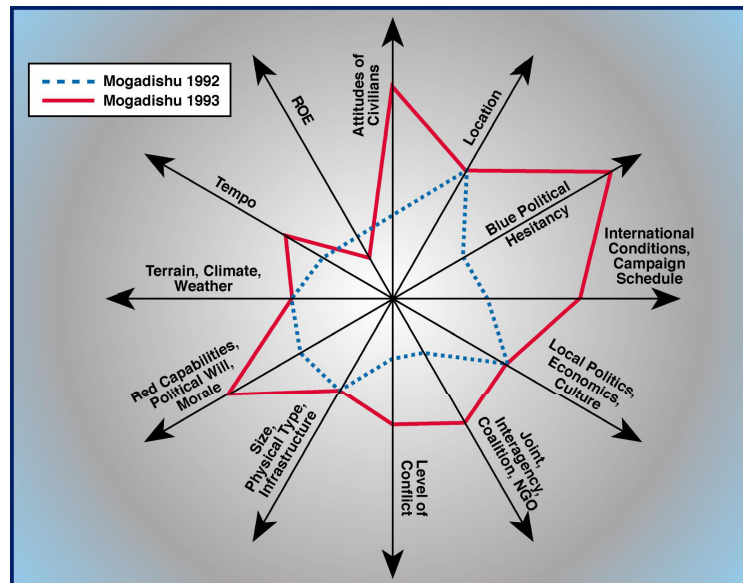


Figure B-1. Types of Urban Missions

In general, the challenge is to develop capabilities that will enable a future JFC to handle those missions and conditions that correspond to likely, realistic scenarios.

D. Operational Concepts

There are three general approaches that a JFC might take regarding the use of ground forces in an urban operation: Standoff Engagement (e.g., siege or remote strike); Temporary Ground-Force Presence (e.g., a raid or Noncombatant Evacuation Operation

(NEO)); and Sustained Ground-Force Presence (e.g., capture an area or peacekeeping). These approaches may be used singly or in combination.

Each of these approaches applies to a different set of the missions and conditions listed in **Table B-2** and **Figure B-1**, and each requires different sets of capabilities for its success. As the extent of ground-force presence in an urban area increases, so does the range of missions that can be performed and the number of capabilities that are required. In general, the required capabilities are “nested”: those that support Standoff Engagement also support Temporary Ground-Force Presence and those that support Temporary Ground-Force Presence also support Sustained Ground-Force Presence. This “nesting” can be used to help prioritize development efforts. The Roadmap addresses all three approaches.

To identify required capabilities, the Roadmap process begins with a particularly challenging mission (CAPTURE AN URBAN AREA), and identifies a range of notional operational concepts (both traditional and emerging) that a JFC might employ. These concepts are listed in **Figure B-2** below.

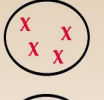
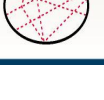
Concepts	Traditional	Emerging
Isolation	Siege 	Nodal Isolation 
Remote Strike	Rubble-ize 	Precision Strike 
Ground Assault	Frontal 	Nodal Capture and Expansion 
		Blitz: Soft-point Capture & Expansion 
		Segment and Capture/Isolate 

Figure B-2. Types of Operational Concepts (CAPTURE AN URBAN AREA)

Three of the concepts correspond to traditional approaches to capturing a city: *Siege*, *Rubble-ize*, and *Frontal Assault*. Such approaches are driven by an inability to gain understanding in an urban environment. These approaches either (1) avoid entering the city (*Rubble-ize* or *Siege*) or (2) enter the city with ground forces and gain understanding of

enemy positions and capabilities by establishing close contact (and then respond with overwhelming lethal force). Under most conditions all three approaches will result in high levels of civilian casualties. *Rubble-ize* and *Frontal Assault* will also result in extensive collateral damage, and *Frontal Assault* generally results in high friendly casualties as well.

The five emerging operational concepts are more surgical and offer the prospect of significantly reducing both friendly and civilian casualties, and collateral damage. They may also take less time and involve a more economical use of Blue forces than the traditional alternatives. However, they also require greatly improved capabilities for achieving situation awareness *before* engaging. A central focus of the Roadmap is to determine whether the needed levels of understanding can be achieved.

E. Capabilities

Next, the urban-specific capabilities that enable the operational concepts for the CAPTURE AN URBAN AREA mission are identified. Thirty-one basic capabilities emerge from this process (detailed in Volume II of the Roadmap), and are grouped into categories according to the “USECT” scheme shown in **Table B-3** (below).⁶

Table B-3. Urban Capabilities Within USECT Categories

► Understand Component ❑ Strategic Setting ❑ Physical Environment ❑ Population ❑ Red Forces ❑ Blue Forces ► Shape Component ❑ Strategic Setting ❑ Physical Environment ❑ Population ❑ Red Forces ❑ Blue Forces	► Engage Component ❑ Weapon Delivery ❑ Weapon Effects ❑ Information Ops, Psyops ► Consolidate Component ❑ Security ❑ Support of Civilians ❑ Infrastructure Repair ► Transition Component ❑ Civilian authority
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The remaining missions are then considered, and it turns out that the capabilities required for the CAPTURE AN URBAN AREA mission are also sufficient for the other, less demanding, missions. (See Volume II, Appendix D of the Roadmap for details.)

⁶ See Chapter III of this volume.

This process of identifying needed capabilities is summarized and illustrated in **Figure B-3** (below).

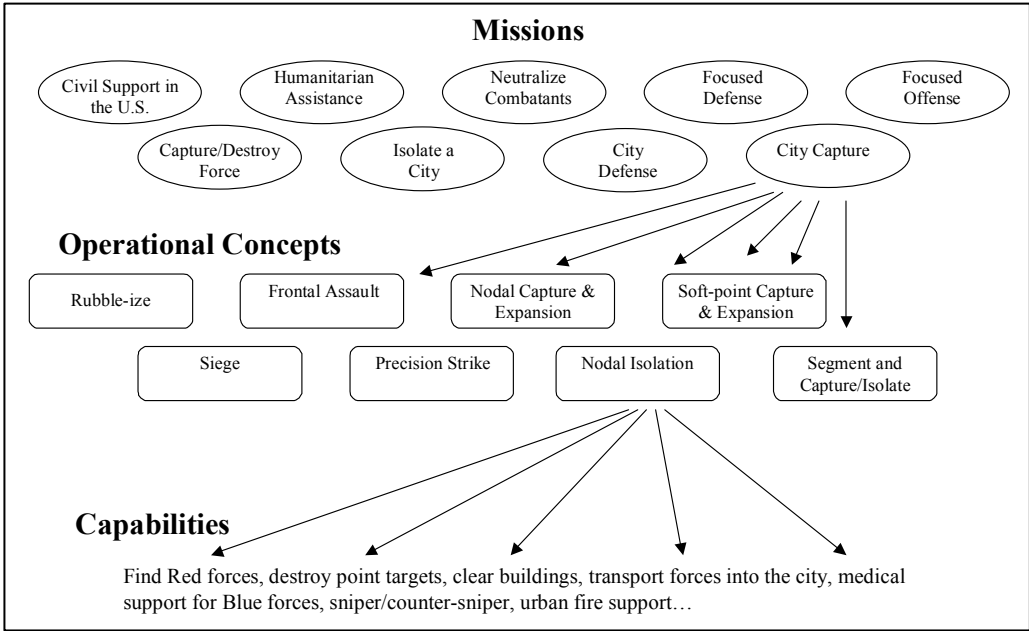


Figure B-3. Mission – Operational Concept – Capability Relationship

F. Status

In general, for *all* of these categories, current capabilities are assessed as being either *poor* or *fair* with significant shortfalls. These assessments are based on recent DoD studies, meetings, workshops, a review of the recent open literature, and comments of reviewers. See Volume II for details about these assessments.

G. Current Programs and Activities

Next, current DoD programs and activities addressing urban capabilities are reviewed. See Chapter IV and Appendix A for timelines of activities in each USECT category and brief program descriptions, respectively. In general, recent and current programs and activities emphasize single-Service capabilities at the tactical level with near- to mid-term goals for force introduction.

H. Directions

The “landscape” of new programs and activities is illustrated in **Table B-4** (on the next page). The USECT categories of capabilities in the first column are taken from **Table B-3** (page B-11), and initiatives that can produce the desired capabilities are character-

ized according to DOTMLPF categories plus categories addressing Policy and Legality, Coalition and Interagency, Concept Development and Experimentation, and Modeling and Simulation. This scheme enables proposals to be related to the capabilities they support, and for gaps to be identified. Key directions for initiatives in each of these categories are described in Sections V and VI that follow.

Table B-4. Landscape of Initiatives for Improving Urban Capabilities

Operational Capabilities	Doctrine	Organization	Training	Material	Leadership	People	Facilities	Policy & Legality	Coalition & Inter-agency	Concept Dev. & Exp.	M&S
► Understand											
☐ Strategic Setting											
☐ Physical Environment											
☐ Population											
☐ Red Forces											
☐ Blue Forces											
► Shape											
☐ Strategic Setting											
☐ Physical Environment											
☐ Population											
☐ Red Forces											
☐ Blue Forces											
► Engage											
☐ Weapon Delivery											
☐ Weapon Effects											
☐ Information Ops, Psyops											
► Consolidate											
☐ Security											
☐ Support of Civilians											
☐ Infrastructure Repair											
► Transition											
☐ Civilian authority											

V. Key Directions for Initiatives: Operational Capabilities

Using the process described in Section IV, the Roadmap identifies directions for initiatives. Highlights of these are summarized in this section in terms of operational capabilities (using the USECT scheme), and in Section VI (starting on page B-20) in terms of supporting activities (using the DOTMLPF scheme).

The program described here is intended as a strawman to stimulate and focus subsequent discussion. It emphasizes high-payoff directions. It is *not* based on detailed proposals, and therefore gives only ball-park cost estimates based on rough comparisons to analogous programs.

Since the approaches and systems identified have not been proven, the Strawman Program focuses on development, not acquisition. The total cost indicates the level of effort required if the Department decides to make a major commitment to dramatically improve urban capabilities.

A. Understand

Physical Environment. Understanding the physical environment provides the backdrop for understanding the positions and movements of Red forces and developing plans for shaping and engaging.

Challenges

- ▶ Three-dimensional maps of urban areas, including subterranean structures, interiors of key buildings, infrastructure systems, and activity levels.
- ▶ Timely gathering, processing, tailoring, and distribution of results to all levels.

Directions

- ▶ Rapid techniques for mining existing data sources.
- ▶ Rapid, focusable data-gathering systems and processes, including sensors, platforms, processing, and distribution.

Program

- ▶ Explore existing activities and commit additional urban-specific development funds (~\$20 million/year).

Red Forces

Challenges

- ▶ The central challenges faced by the new approaches to urban operations are determining Red locations, critical points, movements, and status, and distinguishing Red from friends and neutrals.

Directions

- ▶ Sensors that can function in an urban environment, such as networked short-range sensors, staring sensors, through-wall sensors, and sensors that employ tagging techniques.
- ▶ Platforms to position or carry sensors.
- ▶ Data fusion techniques to create an integrated picture of Red forces from independent, possibly disparate, sources of information.

- ▶ Systems for leveraging the noncombatant population, especially when the population is friendly, such as secure wireless communications for providing a “neighborhood watch on steroids.”

Program

- ▶ Explore existing activities and commit additional urban-specific development funds (~\$50 million/year, based on four sensor programs, four platform programs, one data fusion program, and one program aimed at leveraging civilians, and an estimate of \$5 million/year per program).

Blue Forces. The complexity of the urban environment and the pace of conflict there create a high demand for detailed, timely information. In addition, structures create “dead zones” in communications coverage.

Challenge

- ▶ Reliable, secure, high-bandwidth command, control, and communications (C3) in the urban environment.

Directions

- ▶ Establishment of local, wide-bandwidth, wireless C3 networks linked to higher levels, e.g., using land or air-based transceivers.

Program

- ▶ Explore existing defense and commercial programs and commit additional development funds (~\$5 million/year).

Strategic Background, Motivation, and Thinking of Red, Allies, and Noncombatants

Challenge

- ▶ The urban environment places high demands on the “operational art” of the JFC, particularly in less-than-full-scale-war operations where tensions among strategic objectives, operational constraints, and coalition-building tend to be high.

Directions

- ▶ Leader development to enable future JFCs to be comfortable in complex multinational roles.
- ▶ Organizational structures and procedures for effective reach-back capabilities that would allow the JFC to efficiently access expertise from DoD, interagency, multinational, and non-governmental organization (NGO) sources.

Program

- ▶ Leader development is addressed in Section VI on page B–24.
- ▶ Develop JFC reach-back capabilities (~\$5 million/year).

B. Shape

Shaping capabilities enable the JFC to act upon the understanding developed above to enhance his position and degrade Red's.

Restrict Red Options

Challenges

- ▶ Control or destruction of Red's critical assets.
- ▶ Isolation or segmentation of the Red force by restricting the mobility of Red vehicles and personnel (especially *before* Blue engages with substantial ground forces).
- ▶ Control of Red information and psychological environment.

Directions

- ▶ Shaping actions that restrict Red options are based on the *coordination* of capabilities to first understand and then engage with the appropriate effects. Those capabilities are addressed above in the Understand section (page B–14) and below in the Engage section (page B–18). The ability to combine these capabilities to produce effective shaping actions depends ultimately on the operational art of the commander, and therefore on developments in the non-materiel aspects of DOTMLPF.

Program

- ▶ Initiate concept development and experimentation programs that address new approaches to shaping actions in an urban environment at the operational level. These would exploit emerging technical capabilities for understanding, C3, engaging with precision effects, information operations, and psychological operations (\$5 million/year).

Expand Blue Options. Blue's information environment was addressed previously in the Understand section (page B–14). Here the focus is on the protection, mobility, and support of forces in an urban environment.

Challenges

- ▶ Providing force protection in an environment where Blue may have to operate within Red's sensor and attack ranges, and Red may have the advantage of protected positions.
- ▶ Aircraft, ground vehicles and personnel all face mobility challenges in urban terrain, where structures and obstacles are compounded by close-up threats.
- ▶ Regarding support functions, challenges to force protection and mobility are compounded by the high consumption and casualty rates typical of urban operations.

Directions: Protection

- ▶ Development of unmanned systems for detection, targeting, engaging, and support functions. Such systems may be air or ground based, stationary or mobile. They may span a range of sizes from the nanoscale to large vehicles, and may be tailored for the urban environment (e.g., stealth, ability to penetrate urban features such as pipes, or perch on structures.)
- ▶ Development of systems for the protection of personnel including lightweight ballistic protection, systems that detect and neutralize mines and booby traps, counter-sniper systems, and nuclear-biological-chemical (NBC) detection and protection systems.

Directions: Mobility

- ▶ Improvement of the urban survivability of ground vehicles and rotary wing aircraft.
- ▶ Improvement of the urban mobility of individual personnel (e.g., exoskeletons).

Directions: Support

- ▶ Development of unmanned support systems; precision delivery.
- ▶ Development of systems for monitoring medical status, providing remote care, or evacuating casualties within the urban environment.

Program

- ▶ Develop programs in each of the above three areas (each about the size of the MOUT ACTD program; see Appendix A for details) (~\$50 million/year).

Influencing and Controlling the Strategic Background and the Noncombatant Population

Challenge

- ▶ To influence the strategic environment to Blue's advantage.

Directions

- ▶ Information systems that control and exploit existing infrastructure such as local television or radio stations; secure cellular communications; automatic translation devices; rapidly assembled shelter and care facilities; and means of planning and conducting psychological operations to empower and support friendly civilians while diminishing Red's effectiveness.
- ▶ Organizational structures that enable Blue commanders to better integrate with US agencies, multinational partners, and NGOs.

Program

- ▶ Directions addressed by programs under the Understand, Engage, and Consolidate sections.

C. Engage

Weapon Delivery

Challenges

- ▶ Rapid response to time-critical targets; precision attack where structures may interfere with trajectories or approaches; three-dimensional targeting; moving targets; underground targets.

Directions

- ▶ Target tracking/tagging; rapid C3 and quick-response weapons with autonomous redetection capabilities (such as loitering weapons) for time-critical targets; variable-trajectories for difficult-to-reach aim points; penetrating warheads for underground targets.

Program

- ▶ Explore ongoing activities and commit urban-specific development funds (~\$20 million/year).

Weapon Effects

Challenges

- ▶ Generating the desired effects while reducing noncombatant casualties and collateral damage.
- ▶ Determining post-attack effectiveness.

Directions

- ▶ Warheads with reduced kinetic effects; thermo-baric weapons.

- ▶ Non-lethal effects including directed-energy weapons (both electro-magnetic and acoustic) to control personnel or disable vehicles and other electronic systems; chemical agents (such as calmatives) to clear buildings or to engage an enemy who is among noncombatants; soft projectiles; obstacles; sticky or slippery foams; anti-vehicular traps.

Program

- ▶ Initiate an urban-specific kinetic effects program (~\$10 million/year).
- ▶ Initiate an urban-specific non-lethal effects program that leverages current Joint Non-lethal Weapons Directorate efforts (~\$20 million/year).

Information Operations, Psychological Operations. The urban environment is information- and people-intensive, and therefore heightens the importance of information and psychological operations.

Challenges

- ▶ Conducting effective information operations and determining post-attack effectiveness.
- ▶ Conducting effective psychological operations.

Directions

- ▶ Developing technical tools of information operations.
- ▶ Achieving knowledge of Red's information-based systems.
- ▶ Developing technical capabilities and cultural understanding for psychological operations.

Program

- ▶ Explore ongoing activities and commit urban-specific development funds (~\$10 million/year).

D. Consolidate and Transition

Challenges

- ▶ Number of forces required to maintain security of an urban area.
- ▶ Restoration of basic services to the population.
- ▶ Restore rule of law and transition to stable government.

Directions. Many areas relevant to Consolidate and Transition have already been addressed, such as non-lethal systems for security and crowd control, autonomous sen-

sors and weapons for sentries or patrols, and reach-back capabilities for access to expertise. Other relevant areas include

- ▶ Systems that support the restoration of infrastructure (such as water, power, and transportation) and that provide for the basic needs of the population (food, shelter, and medical).
- ▶ Organizational approaches that enable combat forces to hand off the Consolidate and Transition phases to specialized units. Such units may also be employed for peacekeeping and humanitarian assistance missions in lesser contingencies.

Program

- ▶ Explore current activities addressing restoration of infrastructure and services, and commit development funds (~\$10 million/year).
- ▶ Assess alternatives for forming “consolidation” forces and civil affairs units (including Active/Reserve mix). (The cost of this program is included under “Organization” on page B–21.)

VI. Key Directions for Initiatives: Supporting Activities

The above capabilities can only be realized through coordinated “packages” of changes in DOTMLPF and categories addressing Policy and Legality, Coalition and Interagency, Concept Development and Experimentation, and Modeling and Simulation. This section summarizes some of the key challenges and directions in each of these supporting areas.

A. Doctrine

Doctrine forms the basis from which urban operations are planned and executed: it is the glue that links current military capabilities to methods of employment.

Challenges

- ▶ There is no joint, operational-level doctrine addressing urban operations.
- ▶ There is currently no effective, adaptive process for the maintenance and revision of joint urban doctrine based on exercises and real-world experience.
- ▶ There is no interagency doctrine for urban operations.
- ▶ There is no multinational doctrine for urban operations.

Program

- ▶ Expand current Service and Joint Staff efforts to enhance organizational support and increase resources for the development and maintenance of joint, inter-agency, and multi-national urban doctrine.
- ▶ Complete the publication of Joint Publication 3-06, *Doctrine for Joint Urban Operations*.
- ▶ Create an active joint center for urban “lessons learned.”
- ▶ Develop doctrine for interagency and multinational urban operations.

Total: ~\$1 million/year.

B. Organization

Challenges. The design of forces for urban operations raises key organizational issues, among them:

- ▶ Alternative organizational structures for distributed joint urban combat operations.
- ▶ Specialized units for urban combat operations.
- ▶ Specialized units and organizational arrangements with non-military agencies (including NGOs) for the Consolidate and Transition components of an urban operation, and more generally, for urban humanitarian assistance and peacekeeping missions.
- ▶ The appropriate Active/Reserve mix for non-combat units.

Program

- ▶ Initiate concept development and experimentation program for new combat organizations.
- ▶ Conduct studies and analyses of different organizational approaches to post-combat or non-combat roles.

Total: ~\$1 million/year.

C. Training, People, and Facilities

Training for urban operations encompasses Service core training, interoperability training, and joint task force training.

Challenges

- ▶ There are no interoperability or joint urban training requirements.

- ▶ There are no urban-related recruiting, selection, or training standards.
- ▶ Training facilities cannot effectively handle large units (battalion and above), combined arms, joint forces, multinational forces, or operational-level considerations. They are generally not networked to other facilities; they lack likely modern features such as infrastructure; they are not populated; they do not include diverse features such as high-rises or subterranean structures; and they are not adequately instrumented.

Program

- ▶ Define urban skills; establish training standards for individual personnel.
- ▶ Establish joint training requirements; plan joint/interoperable training development.
- ▶ Develop a plan for joint training facilities.

Total: ~\$5 million/year.

D. Materiel

Materiel developments can spark changes in DOTMLPF leading to major improvements in capabilities. Progress can be made at three levels: science and technology (S&T), systems development, and systems acquisition. Approaches that offer the potential for major improvements in urban capabilities are, in general, unproven and therefore not ready for materiel acquisition. We therefore focus here on system development and S&T.

System Development. Directions for system development were described previously in Section V with regard to achieving specific USECT capabilities. Here we summarize some of the important directions identified.

Directions: Understand

- ▶ Automated search/mining of existing databases; 3D mapping.
- ▶ Sensors that are effective in an urban environment: networked; staring; activity sensors (e.g., movement, utilities usage); through-wall; tagging.
- ▶ Platforms for carrying/deploying sensors and communications assets: air or ground, manned or unmanned.
- ▶ Information fusion, processing, display and decision aids.
- ▶ Urban C3; position location; reach-back.

Directions: Shape

- ▶ Improved systems for information operations.
- ▶ Anti-personnel and anti-vehicle barriers.
- ▶ Unattended sensor/weapons (lethal and non-lethal).
- ▶ Reliable, secure information environment.
- ▶ Survivable ground vehicles; survivable rotary wing aircraft.
- ▶ Ballistic protection for personnel (and vehicles).
- ▶ Chemical/Biological/Radiological protection.
- ▶ Counter-sniper systems.
- ▶ Mine/Booby trap detection and neutralization.
- ▶ Ground force support systems (including medical).
- ▶ Unmanned systems (e.g., RSTA (Reconnaissance, Surveillance, and Target Acquisition); engagement; support).

Direction: Engage

- ▶ Standoff precision engagement.
- ▶ Rapid sensor/ shooter links.
- ▶ Variable-trajectory weapons.
- ▶ Engaging moving targets and buried targets.
- ▶ Reduced-effects kinetic munitions.
- ▶ Non-lethal effects (e.g., directed energy, chemical).
- ▶ BDA (battle damage assessment) for non-lethal effects.

Directions: Consolidate and Transition

- ▶ Sentry systems; barriers.
- ▶ Systems enabling the restoration of infrastructure, and civilian support.

Science and Technology. Although generally applicable across all environments, some areas of S&T may address problems that are of special importance to urban environments, such as technologies that enable robots to negotiate stairs or sensors to penetrate walls.

Directions

- ▶ Information technologies: rapid mapping, visualization, networks, wide-band wireless communications, decision-support.

- ▶ Robotics.
- ▶ Sensor technologies.
- ▶ Air and ground vehicle technologies.
- ▶ Non-lethal effects.
- ▶ Miniaturization.
- ▶ Materials (e.g., for ballistic protection).
- ▶ Exoskeletons.
- ▶ Power sources, propulsion.
- ▶ Chemical/Biological/Radiological detection and protection.

Program

- ▶ Initiate urban-specific S&T development programs (~\$20 million).

E. Leadership

Urban conflict presents unique challenges to the JFC due to the complexity of its physical environment, its human dimension, and the likely involvement of interagency, multi-national, and NGO interests. The Roadmap focuses on providing a toolkit of capabilities to the JFC, but how effectively those tools are used depends on the JFC's "operational art." Therefore leader development becomes critical.

Challenges

- ▶ There are currently no formal programs of instruction to prepare prospective JFCs for urban conflict.

Program

- ▶ Create formal urban-specific programs of instruction at the joint, Service, and interagency senior schools.
- ▶ Create centers of expertise in Service and joint organizations that could enable an incoming JFC to quickly "get up to speed" regarding the unique demands of urban operations.

Total: ~\$1 million/year.

F. Policy and Legality

Current policy and legal agreements were created to deal with conflict by traditional means. Such issues now require reconsideration in light of new approaches to urban conflict.

Challenges

- ▶ Several existing policy and legal agreements constrain or prohibit the use of promising approaches to urban operations. These approaches include the use of non-lethal chemical agents, robotic weapons, and certain types of information operations.

Program

- ▶ Identify constraining policies or legal agreements, and explore options for either creating operating guidelines that assure compliance, or modifying the policies or legal agreements (~\$1 million/year).

G. Coalition, Interagency, and Non-Governmental Organizations

All components of a modern urban operation are likely to require that the JFC interact closely with interagency, multinational, and NGOs.

Challenges

- ▶ Communication and coordination between military and interagency, multinational, and NGOs are limited by a lack of established lines of communication, organizational cross-representation, contingency planning, exercise participation, and education.

Program

- ▶ Promote communication and coordination between future JFCs and interagency, multinational, and NGOs by implementing organizational changes, means of communication, educational activities, cooperative programs, and combined exercises (~\$1 million/year).

H. Concept Development and Experimentation

There are technical risks, operational risks, and cost risks in the proposed new approaches to joint urban operations. Therefore, concept development and experimentation are essential next steps.

Challenges

- ▶ Many underlying technologies have to be developed into systems, and these systems need to be demonstrated.
- ▶ New operational concepts have to be defined in detail and explored in realistic environments against determined and resourceful opponents.
- ▶ Costs of the new approaches have to be determined.

Program

- ▶ Coordinated developmental activities addressing these challenges can proceed in parallel. The two key components are (1) system development and demonstration and (2) concept development and experimentation.

All of the tools of concept development and experimentation are relevant:

- ▣ Studies, analyses, and constructive simulations.
- ▣ Seminars and wargames.
- ▣ Human-in-the-loop (HITL) virtual simulations.
- ▣ Field exercises.

Initial efforts can be small scale and emphasize the tools at the top of the list. In addition, concept developers can focus Limited-Objective Experiments on key elements of a concept, or dedicate “slices” of larger experimental events to specific urban issues. Later, more extensive HITL simulations and field experiments would be appropriate.

Total: ~\$20 million.

I. Modeling and Simulation

Modeling and simulation are essential tools of training, system development, concept development, and experimentation. They also support operational capabilities.

Challenges

- ▶ Few models have any MOUT representational capability, particularly at the operational level, and the new, large DoD-sponsored models—such as JSIMS (Joint Simulation and Integrated Modeling System) and JWARS (Joint Warfare Simulation)—have *no* MOUT capability at all.

Program

- ▶ Plan and fund improved models for MOUT. Enhance existing models, such as JCATS (Joint Conflict and Tactical Simulation), and incorporate MOUT capabilities in emerging future models. Define and adapt more realistic approaches to the verification, validation, and accreditation of these models.
- ▶ Plan and develop digitized databases for urban terrain, interiors, and infrastructure. Represent the dynamic linkages between military operations and the state of the environment (including infrastructure).
- ▶ Instrument MOUT sites in order to collect data and develop models for individual human response and small-unit behavior.

- Familiarize managers, trainers, and analysts with the development requirements, proper use, and limitations of models and simulations.

Total: ~\$10 million/year.

VII. Summary of the Strawman Program

Table B-5 below summarizes the Strawman Program and Organizational Activities, with Oversight estimated at \$5 million/year and a Center of Excellence/Battle Lab at \$5 million/year. The total cost of a major DoD commitment to improving capabilities is roughly \$300 million/year.

Table B-5. Program Summary (Costs in \$M/year)

► Understand	~80
❑ Physical Environment (data mining, mapping)	~20
❑ Red (sensors, platforms, processing, human intelligence)	~50
❑ Blue (C3, position location)	~5
❑ Strategic Background (reach-back)	~5
► Shape	~55
❑ Red, Noncombatant (control information, mobility, infrastructure)	~5
❑ Blue (protection, mobility, support)	~50
► Engage	~60
❑ Delivery (3D precision, speed, variable trajectory, penetrating)	~20
❑ Effects (non-lethal, reduced yield,)	~30
❑ Information Ops, Psychological Ops	~10
► Consolidate & Transition	~10
❑ Restoration of infrastructure & services, special units	~10
► Supporting Activities	~90
❑ Doctrine (joint, multinational)	~1
❑ Organization (studies, experimentation)	~1
❑ Training, People, Facilities (joint standards & facilities)	~5
❑ Materiel (S&T) (sensor tech, robotics, non-lethals, information tech.)	~20
❑ Policy and Legality (studies)	~1
❑ Coalition and Interagency (studies)	~1
❑ Concept Development and Experimentation	~50
❑ Leadership (Professional Military Education, centers)	~1
❑ Modeling & Simulation	~10
► Organizational Activities	~10
❑ Oversight	~5
❑ Center of Excellence and Battle Lab	~5
Total:	~300 \$M/year

VIII. Implementation

Of course it is one thing to identify promising directions for changes to DOTMLPF, and quite another to actually implement such changes—it has been historically difficult to get support for improving urban capabilities. The following describes four elements of an effective implementation program.

1. Increase the level of DoD oversight and attention.

- ▶ Establish a DoD focal point (i.e., an Executive Agent) for urban operations. The Special Study Group for Urban Operations has recommended that Commander, US Joint Forces Command, be the Executive Agent for Joint Urban Operations, starting in January 2003. Once appointed, the Executive Agent will be responsible for maintaining and executing a *DoD Master Plan* for improving capabilities for urban operations.
- ▶ Establish a joint office focusing on urban requirements.
- ▶ Establish points of contact throughout DoD for urban operations (OSD, Joint Staff, Combatant Commanders, Services, Agencies).

2. Increase the priority and sense of urgency within existing organizations for exploring urban issues.

- ▶ The intelligence community, defense agencies, the US Joint Forces Command, research and development centers, and other organizations are able to give a higher priority to urban issues within existing funding.

3. Create a new organization for funding urban initiatives.

- ▶ For example, the Executive Agent could be funded to develop the Master Plan *and* be given funds to begin execution. Later on, when systems are ready for acquisition, a joint program office may be considered.

4. Develop non-DoD relationships.

- ▶ There is considerable overlap in capabilities needed for foreign military operations and for homeland defense. Strong interagency relationships that are focused on urban issues must be created and sustained with non-DoD agencies (e.g., Homeland Defense, Justice, State, Energy, the Central Intelligence Agency).

- ▶ Likewise, multinational contacts that are focused on urban issues must be developed, e.g., with NATO and its members.

IX. Conclusion

This document identifies new directions for significantly improving a future JFC's capabilities for conducting urban operations. These directions are based on new thinking and new technologies. The new thinking emerging from the DoD communities looks beyond the single-Service tactical level, and seeks major improvements by leveraging joint capabilities at the operational level. The new technologies hold the promise of enabling the new capabilities if they are accompanied by coordinated packages of changes across all elements of DOTMLPF and other supporting activities.

However, if the pursuit of these new directions is to be effective, DoD will have to change the way it thinks, organizes, and invests regarding urban operations. The most critical organizational needs are to create an Executive Agent for urban operations within DoD, and to bring the urban environment into the mainstream of DoD processes, including requirements, budgeting, system development, concept development, and experimentation.

Appendix C. Experimental Units: The Historical Record

Executive Summary

Introduction

In the past *Experimental units* have played a major role in extending combat capabilities and developing new concepts and doctrine for military organizations confronting seemingly insoluble challenges. Consequently, experimental units have become an essential part of the processes of successful and often revolutionary transformation and innovation.

This paper focuses on experimental units in the first half of the twentieth century: the experimental units of the First World War (German Stormtroopers and the British tank corps) and the experimental units in the interwar years (the German panzer force, the British Experimental Tank Force, and the US Navy's carrier experiments). All faced the same types of problems, and any success in the field was based, in part, on their leaders' ability to challenge the traditions and culture of their services.

Experimental Units in World War I (1914–1918)

The German Army's Stormtroop Experiment. The Germans created feedback loops to build an accurate picture of the battlefield, and used this to empower experimental units whose culture, tactical concept, and doctrine, and even weaponry were quite different than the regular line infantry units.

In 1916, the new Quartermaster General of the German Army, General Erich Ludendorff, initiated a wide-ranging re-assessment of German doctrine and battlefield concepts in reaction to the overwhelming materiel superiority of the British Army in the battle of the Somme. As a result, a substantial portion of German defenders were moved towards the rear and out of the range of enemy artillery which had emerged in 1916 as the war's great killer. To hold defensive positions, the Germans now relied on a thin screen of machine gunners, a number of fortified positions with interlocking fields of fire, and counterattacks launched from positions out of the range of enemy artillery. The key component in the new German scheme of defensive warfare would be the counterattack.

Leading the counterattack were Stormtroopers, a recent innovation that emerged from the raiding units organized originally to handle the exigencies of trench warfare. The

Stormtroopers were equipped with new and more effective weapons, but more importantly their training, doctrine, and leadership differed substantially from regular line infantry units. The Stormtroop units brought new concepts of combined-arms fire and maneuver to a battlefield once characterized by tactical futility. In addition, they eventually served as instructors to the regular infantry formations with which they served.

The British Army's Experimental Tank Corps. The British creation of a tank force was the other interesting employment of experimental units during World War I. The tank did not exist as a weapon or even as a concept—at least in the minds of military men—before the outbreak of World War I. The first tanks were developed by desperate innovation in the United Kingdom.

Among the difficulties the British confronted was the reality that no organization existed either to employ or to maintain such vehicles. Tactical conceptions did not yet exist for their employment in combat, nor did the means exist for these new weapons to cooperate with the infantry, much less the artillery.

Initial setbacks were not sufficient to end the British Expeditionary Force's support for continued development of the weapons system. The experimental Tank Corps attracted and then nurtured a number of imaginative and innovative advocates for the further development and employment of the tank. By November 1917, the crews of the Royal Tank Corps had learned how to work with the infantry and the artillery.

After much experimenting, the tank forces eventually played a major role in the Allied victory in the late summer and fall of 1918. In the long term, the experimental tank unit was responsible for creating an entirely new weapons system and opening up one of the avenues through which modern combined-arms mechanized warfare would emerge in the 1940s.

Experiment Units and the Interwar Years (1919–1939)

The years between 1919 and 1939 showed imaginative use of experimental units to expand and develop new concepts and technologies. Experimental units were essential to the development of mechanized combined-arms warfare, carrier warfare, airborne assault, amphibious warfare, and strategic bombing. Experimental units also proved to be crucial in translating concepts emerging from World War I into a form usable by the larger force structure. In the two cases recounted here, the development of mechanized combined-arms warfare and the development of carrier warfare, the combat forces that

evolved from the experimental units of World War I came to dominate the conduct of war by the armies and navies of World War II.

The Creation of the German Panzer Force and the Failure of the British Experimental Tank Force. The German Army took a number of important steps to improve its performance in the next conflict. It established experimental mechanized and motorized units to explore:

- ▶ *independent tank battalions*, largely aimed at supporting the infantry;
- ▶ *independent tank regiments*, with an emphasis on all-armored formations;
- ▶ *motorized infantry divisions*, to explore increasing the maneuverability of the infantry;
- ▶ *light divisions*, to explore the use of cavalry and armor working together as a reconnaissance force; and
- ▶ *armored divisions*.

All received provisional status within the framework of the regular army buildup, but clearly the intention was to discover, through experiments and exercises, what worked and what did not.

By the late 1930s, the work with the *Wehrmacht's* experimental units had begun to pay off, as the winners and losers became clear. The clearest winner was the panzer division, with three divisions established in 1935.

The British emerged from World War I with the most experienced armored force. But the drastic downsizing in the war's aftermath shrank the Tank Corps to a few insignificant units. Despite considerable restraints, Lord Milne, the Chief of the Imperial General Staff, established an experimental armored force out of the hodgepodge of motorized and tank units for the 1927 maneuvers.

This experiment exposed some of the difficulties in waging operations with mobile forces. But at the same time, the light tank force executed a stunning twenty-five-mile march that entirely dislocated the opposing force and brought the maneuvers to a halt. Succeeding maneuvers with experimental forces over the course of the next two years, and then again in 1934, suggested the operational parameters within which mechanized warfare might operate. These British experiments were the most imaginative and

innovative of the interwar period. *Unfortunately, it was the Germans who learned the most from these efforts.*

The US Navy's Carrier Experiment. The late entry of the United States into the First World War robbed its navy of opportunities to participate in significant naval action outside of anti-submarine warfare. Moreover, the Royal Navy, its only real rival in the 1920s, emerged from the war with the first flush deck carrier and considerable experience in launching aircraft off ships. Yet twenty years later, at the outbreak of the Second World War, the carriers of the US Navy would possess capabilities significantly superior to those of the Royal Navy.

Concluding Comments

Confronted with a dynamic environment involving technological and tactical change, military institutions have used experimental units not only to point the way to the future but as a means to further the doctrinal and conceptual possibilities. Among the implications for today:

- ▶ Radically new weapons systems demand the creation of experimental units.
- ▶ The military should address the past honestly and carefully, and not use lessons-learned analyses to justify current concepts and beliefs or to make their officers look good.
- ▶ Feedback loops should be used to empower and build on experimental units, and help build a more accurate picture of the battlefield.
- ▶ Experimental units should remain connected to an intelligent basic doctrine capable of expansion and flexibility.
- ▶ Concepts and tactical framework for the experimental forces should be tested to their limits. When the results show that the experimental units are not working out, they should be changed.
- ▶ To challenge the traditions and culture of a military service still requires the services of mavericks, usually seen as the outsiders.

Introduction

Military institutions invariably believe their organizational structures, doctrine, training, and tactics are second to none. Consequently, any significant change represents a threat to hard-earned truisms, beliefs, and capabilities. There is some basis to such attitudes. Radical change not only has the potential to bring about significant advances in military performance, it also has the potential to destroy significant military capabilities inherited from the past as well as military capabilities that rest on realistic appraisals of the harsh, fundamental nature of war. Understandably, there is a sense among some in the Services that the current structures of U.S. forces represent the final stage in the processes of military evolution stretching back four hundred years.

Unfortunately, the biological sciences suggest there is no such thing as *stasis* in living, dynamic organisms.¹ In a complex adaptive environment, organizations either adapt to changing circumstances or they die. Military institutions that have refused to adapt to new paradigms of war were inevitably those that lost wars and placed the survival of their nations in jeopardy. And it is clear that we are presently living in an era of revolutionary technological change not only for society but for military institutions as well.

Over the past four hundred years, armies and navies (and eventually air forces) have been involved in ever faster processes of change and adaptation. In periods of great social and technological changes, those processes have resulted in military revolutions or revolutions in military affairs.² One of the crucial enablers in those processes has

¹ I am indebted to LtGen Paul Van Riper, USMC (ret.), for this point and for a wider understanding of the relationship between history and the new sciences that depend on nonlinearity.

² For a recent view of what has actually been involved in so-called “Revolutions in Military Affairs,” see MacGregor Knox and Williamson Murray, *The Dynamics of Military Revolution, 1300–2050* (Cambridge, UK: Cambridge University Press, 2001), especially chapter 1. In the case of military revolutions, massive changes in the political landscape, such as the creation of the concept of the modern state, the French Revolution, and the Industrial Revolution, have created changes so vast and fundamental that military institutions themselves have been altered in fundamental ways, and the entire social, political, and economic basis of war altered as well. Such military revolutions are so vast and all encompassing that military institutions have had little ability to control their own fates. Revolutions in Military Affairs, on the other hand, have been more discreet in their forms and outcomes. While there are considerable uncertainties in their evolution, military institutions, given the right circumstances and leadership, can exercise considerable control over their own transformation. For the processes involved in the latter case, see Williamson Murray and Allan R. Millett, *Military Innovation in the Interwar Period* (Cambridge, UK: Cambridge University Press, 1996).

been the use of experimental units to explore the possibilities and provide a guide to difficult and uncertain tactical and operational problems. This has been the case in times of both war and peace, where the establishment and success of experimental units have played a major role in the emergence of new concepts and approaches raised by either technological change or changes in the nature of war.

This paper focuses on the creation and utility of experimental units in the military history of the first half of the twentieth century. Among the examples studied by the author were:

- ▶ Experimental units in World War I: (1) The German Army's Stormtroop experiment. (2) The British Army's experimental tank corps.
- ▶ Experimental units in the interwar years: (1) The creation of the German panzer force. (2) The failure of the British experimental tank force. (3) The US Navy's carriers experiment.

This paper explores the dynamics by which military institutions have used experimental units to examine the potential of new technologies, tactics, and operational concepts. Confronted with a dynamic environment in which technological and tactical change was the order of the day, some military institutions have used experimental units not only to point the way to the future but as a means to further the doctrinal and conceptual possibilities. But even in war, with its direct feedback, the ability to learn and adapt by using such experimental units has proven difficult. Nevertheless, experimental units have proven to be an essential part of the processes of successful transformation and innovation in the twentieth century.

Experimental Units in World War I

If experimental units were of considerable use in the early periods of Western military history to extend and develop combat capabilities, they have played a crucial role in developing concepts and doctrine throughout the course of the twentieth century.³ Technological change had an enormous impact on the conduct of World War I, as military organizations grappled with seemingly insoluble problems. In peacetime, military institutions confront the fact that technological change might well require very different solutions to the tactical and doctrinal problems they confront. In war and

³ For a discussion of the role of experimental units before 1900, see the appendix to this document.

peace, experimental units proved have extended combat capabilities, and, in some cases, created the basis for revolutionary transformation.⁴

The German Army's Stormtroop Experiment

World War I presented the most difficult set of tactical and technological problems that military organizations have ever confronted.⁵ The Battle of the Somme in 1916 best represents the tactical futility of that war, where masses of men slaughtered each other in battles marked by a lack of imagination on the part of military leaders and their staffs. Towards the end of that battle the new Quartermaster General of the German Army, General Erich Ludendorff, initiated a wide-ranging reassessment of German doctrine and battlefield concepts in reaction to the British Army's overwhelming materiel superiority.⁶

After an exhaustive examination of the deficiencies that had appeared in the German Army's conduct of the Somme, Ludendorff had the General Staff issue a new doctrinal concept, "The Principles of Command in the Defensive Battle in Position Warfare."⁷ The new doctrine moved a substantial portion of the defenders rearward out of the range of enemy artillery, since by 1916 artillery had emerged as the war's great killer. To hold a defensive position, the Germans now relied on thin screen of machine gunners, a number of fortified positions with interlocking fields of fire, and counterattacks

⁴ Or what in current terminology is called a "Revolution in Military Affairs."

⁵ As Paul Kennedy has suggested about World War I, "[B]ecause soldiers simply could not break through a trench system, their generals' plans for campaign successes were stalemated on each side; these operational failures in turn impacted upon the strategic debate at the highest level, and thus upon the strategic options being considered by national policy makers; and these *pari passu* [at an equal pace; side by side] affected the consideration of ends versus means at the political level, the changing nature of civil-military relations, and the allocation of natural resources." Paul Kennedy, "Military Effectiveness in the First World War," in *Military Effectiveness*, vol. 1, *The First World War*, edited by Allan R. Millett and Williamson Murray (London: Allen & Unwin, 1988), p. 330.

⁶ Ludendorff was in fact not a logistician at all but rather the equivalent to the chief of staff to the new leader of the German army, Field Marshal Paul von Hindenburg. Moreover, Ludendorff under the German system possessed far greater powers (to include those of dual command) than any chief of staff in the British or American systems.

⁷ For a brilliant short discussion of the processes through which the Germans went in developing a new way of fighting the defensive battle, see Timothy Lupfer, *The Dynamics of Doctrine: The Changes in German Tactical Doctrine During the First World War*, Combat Studies Institute, Leavenworth Papers, July 1981. In his memoirs Ludendorff made clear that his expectation from his interviews of front-line commanders and soldiers was to hear "their real views and have a clear idea of the true situation, not a favorable report made to order." Erich von [sic] Ludendorff, *Ludendorff's Own Story, August 1914–November 1918*, vol. 1 (New York: Harper & Brothers, 1919), p. 24.

launched from positions out of the range of enemy artillery fire. The key component in the new German scheme of defensive warfare would be the *counterattack*.

Here Ludendorff and the proponents of the new doctrine found the development of “Stormtroop” experimental units during 1915 and 1916 of enormous utility. The Stormtroop units had emerged from raiding units organized to handle the exigencies of trench warfare in 1915. On April 1, 1916, on the basis of successes gained by the assault companies in the initial assault on Verdun, the high command on the Western Front had ordered the concentration of specialized units into a special experimental battalion, Assault Battalion “Rohr,” named for its innovator and commander, Captain Willy Martin Rohr. Along with Rohr’s new battalion, the Germans also converted four *Jäger* battalions to the same pattern.⁸

During his visit to the Western front in September 1916, Ludendorff came across these experimental units and was immediately convinced of their value.⁹ As he indicates in his memoirs:

On the Eastern Front we had for the most part adhered to the old tactical methods and the old training which we had learned in days of peace. Here [in the west] we met with new conditions, and it was my duty to adapt myself to them.¹⁰

Ludendorff ordered Rohr to conduct schools in stormtroop tactics and concepts so that the German armies on the Western Front could begin training Stormtroop companies for their divisions, and eventually for the regiments within each division.¹¹

The recasting of German defensive doctrine also resulted in efforts to expand the experimental Stormtroop force. With Ludendorff’s energy and support behind the

⁸ Bruce I. Gudmundsson, *Stormtroop Tactics, Innovation in the German Army, 1914–1918* (New York: Praeger, 1989), p. 77.

⁹ D. J. Goodspeed, *Ludendorff, Genius of World War I* (Boston: Houghton Mifflin, 1966), p. 194.

¹⁰ Ludendorff, *Ludendorff’s Own Story*, vol. 1, p. 324. As for the Stormtroop formations, Ludendorff writes that “the formation of storm troops from the infantry, which had begun during the war, had not only to be regularized, but to be adapted to the common good. The instruction formations and the storm battalions had proved their high value both intrinsically and for the improvement of the infantry generally. They were examples to be imitated by the other men. But for this it was necessary to have a training-manual prepared, and this had not yet been done.” Ludendorff, *Ludendorff’s Own Story*, p. 323.

¹¹ Gudmundsson, *Stormtroop Tactics*, pp. 80–81.

program, by February 1917 German forces on the Western Front possessed fifteen assault battalions and two independent assault companies, all trained in the new concepts of combined-arms fire and maneuver, which had been developed by the Stormtroop units.¹²

The battles of 1917 tested these new formations, and the German Army, to the breaking point. Hitherto, whether in company or battalion form, the Stormtroop units had been regarded largely as raiding parties. Now, their essential role was to serve as the lead units of the counterattack forces—in other words they were no longer the initiators of action but responders to the enemy's actions. The demand placed on them to develop new tactics, techniques, and procedures was that much greater; and they held the key role of serving as instructors to the regular infantry formations with which they served.

The continued experimental nature of the Stormtroop units in the organizational framework of the German Army was underlined by the fact that they remained provisional units “with no home barracks, no district from which to draw recruits, no connection to a particular locality, no genealogy like those which linked many other units in the German Army to eighteenth and even seventeenth century regiments, and no colors.”¹³ But this did not mean that they did not continue to draw the elite of the officer corps, non-commissioned officers (NCOs), and enlisted ranks. Moreover, the insignia of some Stormtroop units was the same as the Prussian Guards, the most prestigious unit in the German Army.

By the end of 1917, the Germans had developed enough expertise and effectiveness in the Stormtroop units to be able to launch corps-sized counterattacks. In November 1917, the British gained a major victory at Cambrai through the use of tanks; their attack ruptured defensive positions held by second-rate German infantry units. Ten days later the German Second Army launched its counterattack with thirteen divisions against the newly dug British defenses. Using its one Stormtroop battalion along with the assault companies of the attacking divisions, the Germans were able to win back all the territory they had lost and then some. The assault by the Stormtroopers heralded the wider adaptation of infiltration, exploitation, and decentralized tactics that would reintroduce maneuver to the battlefield. The Second Army's counterattack represented

¹² Gudmundsson, *Stormtroop Tactics*, p. 84.

¹³ Gudmundsson, *Stormtroop Tactics*, p. 86.

a stunning victory for the Germans, coming so shortly after the success of British tanks at Cambrai.¹⁴

Aiming to achieve victory in spring 1918, before the Americans could arrive on the Western Front in substantial numbers, Ludendorff now took the lessons learned by the experimental Stormtroop units and applied them to retraining and reorganizing a substantial portion of the units on the Western Front.¹⁵ What is particularly interesting in this effort was the ability of the German General Staff system to produce a new doctrinal manual based on the actual experiences of the experimental Stormtroop units (and others), establish schools for training officers (from generals down to lieutenants) and NCOs in the new concepts, and then train the attack divisions with carefully selected personnel from the company to the division level.¹⁶ On January 1, 1918, the German High Command issued its new doctrine of the attack, *The Attack in Position Warfare*.¹⁷ Less than three months later, on March 21, 1918, the German Army launched its massive offensive against the British armies in Flanders and northern France.¹⁸

The Germans were to achieve an enormous tactical success in that offensive, entirely breaking through the British defenses along a wide front and for a short time threatening to drive the French and British armies apart. Ironically, those tactical victories of March 1918 did not lead to impressive operational gains, and instead placed the Germans in an even more difficult strategic situation than they had been before their offensive in the west.¹⁹ What is important here is the fact that the Germans succeeded

¹⁴ Gudmundsson, *Stormtroop Tactics*, pp. 139–141.

¹⁵ Until relatively recently, historians attributed the German successes in spring 1918 to reinforcements received from the Eastern Front, divisions released by the collapse of Tsarist Russia and the seizure of power in that country by the Bolsheviks. In fact, Ludendorff kept most of the forces in the east for much of the year for two reasons: first, because he continued to pursue his megalomaniacal territorial goals; and second because a substantial number of the troops had already become infected by Bolshevik propaganda and were deserting in droves from the troop trains that moved them across Germany from the Eastern Front to the Western Front.

¹⁶ For the processes, see in particular *Reichsarchiv, Der Weltkrieg, 1914 bis 1918*, vol. 14, *Die Kriegführung an der Westfront im Jahre 1918* (Bonn: Bundesarchiv, 1956), pp. 41–42; see also Ludendorff, *Ludendorff's Own Story*, vol. 2, pp. 200–211.

¹⁷ For a concise, clear explanation of the new doctrine, see Lupfer, *The Dynamics of Doctrine*, pp. 41–49.

¹⁸ For more about that, see Martin Middlebrook, *The Kaiser's Battle, 21 March 1918: The First Day of the German Spring Offensive* (London: Penguin Books, 1978).

¹⁹ That failure reflected a number of peculiar factors in the German way of war, including the understandably narrow focus in 1918 by all the armies engaged in the fighting on the Western Front on solving the tactical problems raised by trench warfare. On the peculiarities of the German “way of

over the course of World War I in inventing the tactics, techniques, and procedures of combined-arms maneuver warfare—least at the tactical level—largely due to the experiences gained by the experimental Stormtroop units.

To all intents and purposes, the Germans succeeded in inventing modern war through the use of the Stormtroop experimental units. The key enabler to that process began with the establishment of experimental raiding units in 1915 at the platoon and company level, and then in 1916 the concentration of experimental Stormtroop and assault units at the battalion level. The ability of the Germans to use feedback loops to build an accurate picture of the battlefield was indeed admirable.²⁰ But equally important was their willingness to empower and then build on experimental units, whose culture, tactical concepts and doctrine, and even weaponry were quite different than the regular line infantry units.

The British Army's Experimental Tank Corps

Another interesting employment of experimental units to develop new approaches to war during the conduct of campaigns in World War I was the British Army's creation of a tank force, which was to play a major role in the Allied victory in late summer and fall 1918. The tank did not exist as a weapon or even as a concept—at least in the minds of military men—before the outbreak of the conflict. It received its initial impetus for development from Winston Churchill in 1914, when Churchill was still First Lord of the Admiralty.²¹

The first tanks were developed by desperate innovation in the United Kingdom. The greatest difficulties the British confronted in employing were the harsh realities that

- ▶ no organization existed to employ or maintain such vehicles,
- ▶ no tactical conceptions yet existed for their employment in combat, and

war,” see Williamson Murray, *German Military Effectiveness* (Baltimore, MD: Nautical and Aviation Publishing, 1992).

²⁰ Feedback loops create the ability of an organization to pass accurate information up the chain of command so that commanders at higher levels and their staffs can gain an accurate picture of what is actually happening on the battlefield.

²¹ The most thorough and careful reconstruction of the development of the tank in the British Army is J. P. Harris, *Men, Ideas, and Tanks: British Military Thought and Armoured Forces, 1903–1939* (Manchester, UK: Manchester University Press, 1995).

- no means yet existed for tanks to cooperate with infantry, much less artillery.

Given the lack of reliability of a new technology and weapons system, just getting tanks to the battlefield in France from the factories and training facilities in the United Kingdom represented a considerable challenge.

Recent research has shown that the postwar view propagated by British armored war advocates J. F. C. Fuller and B. H. Liddell Hart—namely that Field Marshall Sir Douglas Haig and the British High Command displayed little interest in tanks—was not true. In fact, Haig, the commander of the British Expeditionary Force in France, was quite supportive of the development of the tank, along with a number of other weapons systems.²² As Fuller grudgingly admitted after the war, Haig’s use of the first experimental tank unit at the Somme in September 1916 was an absolute necessity in order to examine the tactical utility of the armored fighting vehicle as well as its mechanical limitations.²³

Discovering the best way to employ such a radically new weapons system demanded the creation of an experimental unit. The establishment of the experimental tank unit in Britain received the initial title of “the Heavy Branch Machine Gun Corps”—the title undoubtedly an effort to provide security about the development of a new weapon. In July 1917, with the tank now having received considerable publicity in the British press, and undoubtedly known to the Germans by its use in battle, the experimental unit received a Royal Warrant constituting it as the “Tank Corps.”²⁴ The new title came at a time when the fortunes of the tank hardly appeared bright. Armored fighting vehicles had proven of some use on the Somme, but in the Messines attack of June 7, 1917, out of sixty-nine tanks used, only nineteen proved of any use to the attacking infantry,

²² In February of 1917, Haig placed tanks as his number three priority after the Royal Air Service—soon to become the Royal Air Force—and 188 locomotives to support the light railways behind British lines. With those exceptions Haig noted, “the prompt and continuous delivery of Tanks at the greatest rate at which they can be turned out and shipped to France should be ensured.” Harris, *Men, Ideas, and Tanks*, p. 73.

²³ After the war Fuller commented on the first use of the tanks on the Somme to Liddell Hart in the following terms: “The use of the tanks on 15 September [1916] was not a mistake. Serious mechanical defects [were] manifested. No peace test can equal a war test.” Quoted in Harris, *Men, Ideas, and Tanks*, p. 74.

²⁴ Harris, *Men, Ideas, and Tanks*, p. 101.

while forty-eight of the tanks ditched (i.e., stuck in trenches) and seventeen broke down entirely.²⁵

A number of factors contributed to the initial difficulties the British encountered in utilizing the new weapon:

- ▶ First, there was little commonality of experience between the tank crews and the front-line infantry, as there had been between the Stormtroops and the front-line German infantry.
- ▶ Equally important, the initial commitment involved the tanks in terrain that had been thoroughly chewed up by artillery bombardments, straining vehicles that were already mechanically unreliable.

Nevertheless, initial setbacks were not sufficient to end the British Expeditionary Force's support for continued development of the weapons system.²⁶ Moreover, the experimental Tank Corps attracted and then nurtured a number of imaginative and innovative advocates for the further development and employment of the tank. Foremost among these was J. F. C. Fuller.

In November 1917, Haig supported a major blow by the Tank Corps against German positions at Cambrai. Here there was no long preliminary bombardment to alert the Germans and wreck the landscape. Rather after a short, sharp bombardment, over three hundred tanks struck out across no-man's land, with fifty-four held in reserve. The attack succeeded in entirely rupturing the German front lines. The success must be seen as a sign of the emergence of combined-arms warfare rather than a singular success for the Tank Corps.²⁷ By now the crews in the Royal Tank Corps were learning how to work with the infantry, while the artillery bombardment, predicated on new techniques of indirect fire and off-the-map shooting, was able to make major contributions. Finally, the Royal Air Force rolled in with the first true use of massed close air support in the war.

²⁵ Harris, *Men, Ideas, and Tanks*, p. 99.

²⁶ And that support, which placed tanks lower in priority than other weapons systems such as aircraft, must be seen in the light of the tank's performance to that point in the war rather than in the light of what tanks proved able to do decades in the future.

²⁷ Which is how Fuller and Liddell Hart would see it throughout the interwar period.

The Cambrai success was such that the Tank Corps would have an even more important role in 1918. But it still remained very much an experimental unit. Above all, it still was not a regiment, the key mark of permanence in the British Army's scheme of organization. Moreover, in the defensive fighting that marked the first half of 1918 on the Allied side, it remained of limited utility because of its lack of speed and mechanical reliability. Nevertheless, by 1918 the experimental force had reached quite respectable proportions. Reorganized after the Battle of Cambrai, the Tank Corps was to have two heavy groups and one light group, each heavy with two brigades, each with 288 tanks. The light group was to consist of 410 of a new, more mobile armored fighting vehicle.

In the first major British offensive of 1918, the Amiens attack beginning on August 8, 1918, the Tank Corps was able to make a substantial—if not decisive—contribution to a victory that Ludendorff later described as the “blackest” day of the German Army in the war. A sudden, massive artillery barrage, the skillful use of gas, and 430 tanks, working with infantry with whom they had carefully trained, destroyed six German divisions in a day.²⁸

Succeeding British attacks over the course of the next three months were not able to utilize the tanks quite so effectively, due in part to losses suffered in the Amiens attack and in part to the speed with which conventional attacks now moved against a collapsing and defeated German Army. Nevertheless, the experimental Tank Corps made a substantial contribution to the successive British victories. It paid for its success in blood: of the 7,200 fully trained officers and men on the rolls of the Tank Corps on August 8, with a further 500 men in training, 561 officers and 2,627 Other Corps Ranks became casualties in three months of fighting.²⁹

In the long term, the experimental tank unit was responsible for creating an entirely new weapons system and opening one of the avenues through which modern combined-arms, mechanized warfare would emerge in the 1940s. From the beginning, British innovators confronted enormous difficulties:

- ▶ They first had to develop a new weapons system on a weak technological base;

²⁸ Harris, *Men, Ideas, and Tanks*, pp. 169–179.

²⁹ Harris, *Men, Ideas, and Tanks*, p. 186.

- ▶ they had to figure out how to integrate that weapons system into an emerging and complex system of war; and
- ▶ they had to build up a support and training and logistics base to support the continued employment of a weapons system, the technology of which was also undergoing rapid change.

As one tank officer suggested with some pride shortly after the war:

Taking it all in all, I doubt if there can be anything, even in the exceptional records of the war, to equal in extent and variety the growth of the technical, instructional, and supply branches of the Tank Corps during the last two years [of the war].³⁰

Experimental Units in the Interwar Years

The period between the two world wars (1919–1939) is rich with the use of experimental units to expand and develop new concepts and technologies. Experimental units were used in creating mechanized, combined-arms warfare; carrier warfare; airborne assault; amphibious warfare; and strategic bombing. For brevity's sake, this paper will concentrate on the first two: the development of mechanized, combined-arms warfare and of carrier warfare. Experimental, or provisional, units proved to be crucial in taking concepts emerging from World War I and translating those concepts into a form usable by the larger force structure.³¹ In the two cases recounted here, the combat forces that evolved from those initial experimental units came to dominate the conduct of war by the armies and navies of World War II.

The Creation of the German Panzer Force

As the German Army emerged from its defeat in World War I, it took a number of important steps to prepare for the next conflict.³² Its new commander-in-chief after the

³⁰ Harris, *Men, Ideas, and Tanks*, p. 188

³¹ Historians have often argued that military institutions tend to study the last war and that is why they do badly in the next. Nothing could be further from the truth: military institutions rarely study the past war honestly or carefully. Rather they look to past wars to justify their current concepts and beliefs, which all too often have little to do with the harsh world of battlefield experience.

³² For a more extensive examination of the development of mechanized, combined-arms warfare, see Williamson Murray, "Armored Warfare," in *Military Innovation in the Interwar Period*, ed. by Williamson Murray and Allan R. Millett (Cambridge, UK: Cambridge University Press, 1996).

Kapp Putsch in 1920, General Hans von Seeckt, set about changing the culture of the officer corps during the downsizing demanded by the victorious Allies. At the same time he set in motion a major lessons-learned analysis of the army's combat experiences in World War I, spearheaded by fifty-seven different committees. This latter effort resulted in the promulgation of a new basic doctrine, codified in 1932 into *Die Truppenführung*, perhaps the most realistic and influential doctrinal manual ever written. Even though the German Army possessed no tanks in 1932 and had had only the most limited experience with armored fighting vehicles during World War I, *Die Truppenführung* makes explicit reference to the contribution that tanks could make not only in the breakthrough phase of major operations but in the exploitation phase as well.³³

However brilliant the Germans' theoretical musings on the possibilities of mechanized warfare when rearmament began in January 1933, the Germans still had virtually no experience with tanks.³⁴ German industry still grappled with the problems of producing a brand new weapons system (the first modern tanks would not reach the *Wehrmacht* until late 1938). Moreover, the German Army also confronted a host of problems from the tactical to the operational and logistic.

Ever the careful professionals, the Germans established a number of experimental mechanized and motorized units to explore the possibilities. These experimental units included independent tank battalions (largely aimed at supporting the infantry), independent tank regiments (with an emphasis on all-armored formations), motorized infantry divisions (to explore increasing the maneuverability of the infantry), light divisions (to explore the use of cavalry and armor working together as a reconnaissance force), and armored divisions. All received provisional status within the framework of the regular army buildup, but clearly the intention was to discover through experiments and exercises, what worked and what did not.

While these units were establishing themselves, the Chief of the General Staff, General Ludwig Beck, had his staff explore their use at operational levels. In 1935 Beck conducted a General Staff ride on how the army might make use of a panzer corps; the

³³ *Die Truppenführung* explicitly stated that "when closely tied to the infantry, the tanks are deprived of their inherent speed"—a very different outlook from that which the French possessed throughout this period. Chef der Heeresleitung, *Die Truppenführung* (Berlin, 1933).

³⁴ In his memoirs the German tank pioneer Heinz Guderian claims that he had never seen the inside of a tank when tasked to teach tank tactics; the General Staff rectified this weakness by packing him off to Sweden for four weeks' service with a Swedish tank unit. Heinz Guderian, *Panzer Leader* (New York: Da Capo Press, 1996), p. 23.

next year the General Staff ride examined the operational possibilities of a hypothetical panzer army. By the end of 1935, Beck was recommending that panzer divisions—established only a few months earlier—be used for attacks against long-range objectives, acting as an independent force “in association with other motorized weapons.”³⁵

By the late 1930s the work with the experimental units had begun to pay off, as the winners and losers became clear. The clearest winner was the panzer division, the first three of which had been established in 1935.³⁶ In late summer 1938 the army leadership established three additional panzer divisions, folding into them the previously independent experimental tank regiments and battalions. A year later, the campaign against Poland revealed that the four light divisions did not possess sufficient punch. In the aftermath of the German victory, these divisions were immediately converted into panzer divisions, one of which, the 7th, Erwin Rommel led with such success during the ensuing French campaign. The senior army leadership decided to keep a limited number of the motorized infantry divisions because they could perform a useful bridge between the rapidly moving panzer formations and the slower infantry divisions that made up the bulk of the German Army.

Several points about the way the Germans worked up and evaluated these experimental units deserve emphasis:

- ▶ First, the experimental units remained connected to an expansive and intelligent basic doctrine—*Die Truppenführung*—that emphasized maneuver, exploitation, and decentralized leadership.
- ▶ Second, in their experiments and exercises the Germans tested the concepts and tactical framework of the experimental force to the maximum. The lessons-learned analysis aimed at discovering what actually would happen on the battlefields of the future, not at “validating” the current doctrine (or, in the case of the French Army, dogma).
- ▶ Third, the Germans were even more rigorous and demanding in their examination of what had actually happened in combat. Their lessons-learned

³⁵ Wilhelm Deist, *The Wehrmacht and German Rearmament* (London: MacMillan, 1981), pp. 42–43.

³⁶ On the initial decision to establish the panzer divisions, see Robert O’Neil, “Doctrine and Training in the German Army,” in *The Theory and Practice of War*, ed. by Michael Howard (New York: Fredrick A. Praeger, 1966), p. 157.

processes were not exercises aimed at making generals look good.³⁷

- ▶ Finally, when the results of experiments and exercises indicated that experimental units were not working out, the Germans did not hesitate to disband them. Two such instances were the independent panzer regiments and the light divisions, both of which the Germans decided to fold into the proven experimental unit—the panzer division.

The Failure of the British Experimental Tank Force

The British emerged from World War I with the most experienced armored force, one that as we have seen played a major role in the British victories of 1918. But with the drastic downsizing in the war's aftermath, the Tank Corps shrank to a few insignificant units. From the first, the politicians made clear to the British Army's leadership that it would receive only minimal funding in order to defend the empire's distant outposts. The army would certainly *not* receive the resources required for a role on the continent, fighting at the side of Britain's World War I allies.³⁸ Despite the considerable constraints both in mission and in resources, Lord Milne, the Chief of the Imperial General Staff (commander-in-chief of the army), established an experimental armored force for the 1927 maneuvers out of the hodgepodge of motorized and tank units present in the army.³⁹ Milne gave the experimental force the broadest directive and was willing to appoint the army's leading tank advocate and expert, Lieutenant Colonel J. F. C. Fuller, to command the force. Astonishingly, Fuller turned the assignment down—the worst decision of his career.

Nevertheless, the 1927 experiment with the provisional tank force proceeded. Its course did indicate some of the difficulties in waging operations with mobile forces. But at the same time, the light tank force executed a stunning twenty-five-mile march that entirely dislocated the opposing force and brought the maneuvers to a halt. Succeeding

³⁷ For how the German lessons-learned analysis process worked with chilling efficiency, see Williamson Murray, "The German Response to Victory in Poland: A Case Study in Professionalism," *Armed Forces and Society*, Winter 1981.

³⁸ This would remain the situation until March 1939, in the aftermath of the German occupation of the Czech Republic. For its impact on the army, see Williamson Murray, *The Change in the European Balance of Power, 1938–1939, The Path to Ruin* (Princeton, NJ: Princeton University Press, 1984), particularly chapter 2.

³⁹ For an insightful report on the implications of the initial British experiments with mechanized war, see in particular Reichswehrministerium, Berlin, 10.11.26, "Darstellung neuzeitlicher Kampfwagen," National Archives, T-79/62/000789.

maneuvers with experimental forces over the course of the next two years, and then again in 1934, suggested the operational parameters within which mechanized warfare might operate. These British experiments were the most imaginative and innovative of the interwar period. Unfortunately, it was the Germans who learned the most from these efforts. They watched the British experiments carefully and used them as the jumping-off point for developing their concepts of large-scale mechanized operations.⁴⁰

The cause of this failure of the experimental force to contribute to British preparations for war lay in three areas:

- ▶ First, as already mentioned, the army focused on serving as a colonial force, with little thought or effort made to prepare for war on the European continent.
- ▶ Second, the experimental force was not closely connected to the army as a whole, in either a cultural or an organizational sense. The tankers remained outsiders, innovators who appeared to aim at disturbing the army's traditions and culture.
- ▶ Third, the officer corps was intellectually lazy, preferring polo and tennis to studying seriously the profession of arms.⁴¹

With no coherent vision or concept of war into which the efforts of the experimental tank force could fit, the experiments were quickly forgotten, making barely a dent in the army's overall culture. (Interestingly, the British Army only constituted *a single committee* to study the lessons of World War I, and that in 1932—14 years after the war's end. Thus, the British had to begin anew in 1939 to build a mechanized force that could

⁴⁰ A contributing factor was the fact that German officers had been brought up in a common doctrine—*Die Truppenführung*—that emphasized maneuver, exploitation, speed, and decentralized operations within a combined-arms framework.

⁴¹ On the culture of the British Army, see Brian Bond's brilliant study, *British Military Policy Between the Two World Wars* (Oxford: Oxford University Press, 1980). In 1939, British tank pioneer Percy Hobart commented in a letter to his wife on his difficulties in getting his officers up to snuff in the newly formed armored division in Egypt: "I had the cavalry CO's in and laid my cards on the table. They are such nice chaps, socially. That's what makes it so difficult. But they're...so easily satisfied with an excuse if things aren't right, so prone to blame the machine or machinery, and unless someone upsets all their polo, ...it's so hard to get anything more into them or any more work out of them." Quoted in Murray, "Armored Warfare," *Military Innovation in the Interwar Period*, p. 23.

meet the Germans on equal terms in northwest Europe—a task they failed to accomplish even by war’s end.

The Carrier Experiments of the US Navy

The US Navy emerged from World War I as one of the two great naval powers in the world (Britain being the other). Nevertheless, the late entry of the United States into the war robbed its navy of opportunities to participate in significant naval action outside of anti-submarine warfare. Moreover, the Royal Navy, its rival in the 1920s, emerged from the war with the first flush deck carrier and considerable experience in launching aircraft off ships. Yet twenty years later, at the outbreak of the Second World War, the US Navy would possess capabilities in its carriers significantly superior to those of the Royal Navy, and these capabilities would provide the essential element for victory in the Pacific.⁴²

The first U.S. carrier was the USS *Langley*, converted from the collier *Jupiter* in the early 1920s. The *Langley* was clearly seen as an experimental ship. The *Lexington* and the *Saratoga*, both converted from the hulls of battle cruisers made excess by the 1922 Washington Naval Treaties, were experimental units at first. Their experimental nature is suggested by the fact that both ships were initially equipped with 8-inch guns in the belief that they might well participate directly in surface fleet actions. The 8-inch guns would not be removed until the early 1940s, shortly before the war.

The rapid development of American carrier capabilities began with analytic war games conducted at the Naval War College in Newport, Rhode, Island, in the early 1920s under the guidance of Admiral William Sims. The results indicated that air power launched from carriers should come in “pulses” of combat power rather than “streams,” as was the case with naval gunfire.⁴³ This insight, gained at a time when the US Navy did not possess a single carrier, had implications of enormous importance. It indicated that in a battle between carrier forces, the side with the ability to get the largest number of aircraft into the air would enjoy an important advantage. As the

⁴² For an outstanding examination of the factors that drove carrier innovations in the US Navy and the Royal Navy, see Thomas C. Hone, Norman Friedman, and Mark Mandel, *American and British Aircraft Carrier Development, 1919–1941* (Annapolis, MD: Naval Institute Press, 1999). See also Barry Watts and Williamson Murray, “Military Innovation in Peacetime,” in *Military Innovation in the Interwar Period*, chapter 10.

⁴³ Hone, Friedman, and Mandel, *American and British Aircraft Carrier Development*, p. 34.

Second World War would prove, this was as true in the ability to defeat attacking enemy formations as well as it was in the hitting power of the attacking forces.⁴⁴

Thus, when the *Langley* joined the fleet, even before completion of the larger *Saratoga* and *Lexington*, Captain Joseph Reeves pushed his new command to develop more rapid launch and recovery procedures. Reeves's efforts were further intensified by the pressures placed on naval aviation by the Morrow Board, which was examining the role of naval aviation within the context of overall air power policy in the United States, and the court martial of General "Billy" Mitchell. Within a six-month period, Reeves demonstrated a significant improvement in the *Langley*'s ability to launch and recover aircraft.⁴⁵ The result of his intensive experimentation on the *Langley* was the innovative use of arresting wires and crash barriers, and the creation of deck parks.

A comparison of the *Langley*'s complements of aircraft in 1926 and 1927 reveals how much Reeves was able to achieve in a relatively short period. In 1926, the *Langley* had carried only fourteen aircraft; one year later it could operate forty-eight.⁴⁶ But Reeves' achievement went well beyond increasing the number of aircraft a carrier could carry and use. It provided the Navy with the evidence to convince the Morrow Board that carriers and naval aviation had a significant future, and that Mitchell was wrong about making *all* U.S. air power part of an independent air force.

The status of carriers as experimental vessels, however, continued well beyond Reeves's initial successes. When the *Saratoga* and the *Lexington* joined the fleet in late 1927, Reeves was already advocating that they be used as a fast striking force. Still, it took nearly two years to work the bugs out of the two ships to deal with the complex problems raised by the addition of these two very different ships to a Navy still largely focused on the battleship. Fire-fighting arrangements, how to refuel safely on both the hanger and flight decks, and how to store and load ordnance were only a few among many challenges. Finally, over the course of the 1930s, the increasing power, improved flight characteristics, and lengthening range of new generations of aircraft began to make the carrier a formidable weapon of war.

By 1929 the Navy had worked out many of the technical problems of employing a carrier, but as the authors of the foremost work on carrier aviation in the interwar

⁴⁴ In 1923, only the hitting power was obvious.

⁴⁵ Hone, Friedman, Mandeles, *American and British Aircraft Carrier Development*, pp. 38–43.

⁴⁶ Hone, Friedman, Mandeles, *American and British Aircraft Carrier Development*, p. 45.

period note: “The leaders of U.S. Navy aviation, such as Rear Admiral Reeves, realized by 1929 that the proper model for carrier warfare was not the same as for surface ship engagements, but they could not anticipate, from the evidence, what the new world of carrier warfare would be like.”⁴⁷ It would take a further twelve years of peacetime innovation and development of concepts and doctrine, and then the harsh test of two years of war in the Pacific, before the carrier emerged from its status as an experimental unit, and became the dominant weapon of naval warfare.

Concluding Comments

Confronted with a dynamic environment in which technological and tactical change was the order of the day, some military institutions have used experimental units not only to point the way to the future but as a means to further the doctrinal and conceptual possibilities. In preparing for warfighting in this century, America’s military leaders must remember what history has demonstrated in the pursuit of new weapons systems and revolutionary new ways to fight:

- ▶ The capabilities and limitations of radically new weapons systems can best be discovered through the creation of experimental units.
- ▶ The military should use lessons-learned analyses to challenge current concepts and beliefs, and not to justify them or to make their officers look good.
- ▶ Feedback loops should be used to empower and build on experimental units, and help build a more accurate picture of the battlefield.
- ▶ Experimental units should remain connected to an intelligent basic doctrine capable of expansion and flexibility.
- ▶ Concepts and tactical framework of the experimental forces should be tested to their limits. When the results show that the experimental units are not working out, they should be changed.
- ▶ To challenge the traditions and culture of a military service still requires the services of mavericks, usually seen as the outsiders.

⁴⁷ Hone, Friedman, Mandel, *American and British Aircraft Carrier Development*, p. 51.

Appendix.

Experimental Units Before the Twentieth Century

As early as the end of the sixteenth century, the Dutch, under Prince Maurice of Orange, created special units, disciplined and trained to use the Roman orders of command drill to facilitate both movement and performance on the battlefield.⁴⁸ (The Dutch were the first European military organization to use such commands since the fifth century. By the end of the seventeenth century, Europeans following the example of the Dutch had developed a modern day equivalent of the Roman legion—disciplined, obedient battle formations that could and did remain in battle for sustained periods of time. Moreover, these “new model” armies were fully responsive to the civil authorities of the modern state.

What made these new formations so devastating in combat with the world outside of Europe was that their disciplined organization allowed the maximum use of the new technologies of firepower. However, for the next century, from approximately 1700 through to the end of the Napoleonic Wars (1815), a technological *stasis* set in, resulting in few changes to the weaponry with which European armies confronted each other on the battlefield.⁴⁹

⁴⁸ The great German military historian, Hans Delbrück, indicates that Maurice of Orange and his commanders “drew from the ancient authors the realization of the value for a unit of a cohesiveness attained through continuous practice, and on the base of the ancient source they created the new drill techniques. If one can ever do so, it is precisely here that we can speak of the renaissance of a lost art” (referring to the ability of the Romans to maneuver complex tactical formations on the battlefield in a disciplined and effective fashion). These experimental units had to work out such basic realities as to what a two-phased command actually involved (as in “Right...Face” as opposed to “right face”). From these experimental units flowed the eventual development of disciplined and responsive military formations on which the creation of the modern state depended, the basic building block in the rise of the West. For further elaboration on this point see Hans Delbrück, *History of the Art of War*, vol. 4, *The Dawn of Modern Warfare*, translated by Walter J. Renfro, Jr. (Lincoln, NB: University of Nebraska Press, 1985), pp. 156–160.

⁴⁹ One example of technological *stasis*: The “Brown Bess” musket that equipped Marlborough’s English Army at the beginning of the eighteenth century also equipped the Duke of Wellington’s soldiers in their battles against Napoleon’s troops in the first decades of the nineteenth century in the Peninsula Campaign and at Waterloo.

The French Revolution

In contrast to the stagnation of weaponry, there was considerable change in the form of units at both the tactical and operational levels, particularly during the French Revolution. In 1792 the politicians in charge of the Revolution in Paris unleashed a war against the *ancien regimes* (the European monarchies). Given the flight of most senior officers of the French Army in the face of a revolution that targeted the French nobility, with a resulting collapse of discipline, the French revolutionaries soon confronted a catastrophic military situation, one which threatened not only the very survival of the Revolution but their own lives and welfare as well. The leaders of the revolution responded in two fashions. In the first case they ripped up the European rule book on how war should be conducted and embarked on a radical rethinking and recasting of the European “way of war.” As Clausewitz suggests in his monumental study *On War*, the French made war a matter of mobilizing the entire resources of the nation as well as its manpower:

Suddenly war again became the business of the people—a people of thirty millions, all of whom considered themselves to be citizens...The people became participants in war; instead of governments and armies as hitherto, the full weight of the nation was thrown into the balance. The resources and efforts now available for use surpassed all conventional limits; nothing now impeded the vigor with which war could be waged, and consequently the opponents of France faced the utmost peril.⁵⁰

Confronted with the mobilization of their population, French military leaders had to figure out how best to use the abundant manpower that the *levée en masse* (the mass conscription ordered in August 1793) had provided.⁵¹ From the first the new volunteers

⁵⁰ Carl von Clausewitz, *On War*, translated and edited by Michael Howard and Peter Paret (Princeton, NJ: Princeton University Press, 1975), p. 592. Clausewitz also makes clear that the major factor in the eruption of French Revolutionaries and Napoleonic legions on the European scene was largely the result of the failure of the *ancien regimes* to adapt to the changes in war. “Not until statesmen had at last perceived the nature of the forces that had emerged in France, could they foresee the broad effect all this would have on war; and only in that way could they appreciate the scale of the means that would have to be employed, and how best to apply them [in order to affect the forces of Revolutionary and Napoleonic France].” Clausewitz, *On War*, p. 609.

⁵¹ The law for the *levée en masse*, as passed by the Assembly in Paris stated that “From this moment, until our enemies have been driven from the territory of the Republic, the entire French nation is permanently called to the colors. The young men will go into battle; married men will forge weapons and transport supplies; women will make tents and uniforms, and serve in the hospitals; children will make old cloth into bandages; old men will have themselves carried to the public squares to rouse the courage of the warriors and preach hatred of kings, and the unity of the Republic.” Quoted in Stanley

and conscripts ran into considerable suspicion from those members of the *ancien régime's* military forces who had transferred their loyalty to the Republic. Not surprisingly, the raw formations of the *levée en masse* possessed little of the discipline or training of the regular army. The Marquis de Lafayette, in his brief tenure in command of the Army of the North, experimented with combining regular and volunteer/conscript battalions in brigades, the former to provide discipline and organization, the latter the enthusiasm of the citizen.⁵² These experimental units soon evolved into the *demi brigades* on which the new French Army was to be built.

The general lack of eighteenth-century discipline and training in the new units created by the *levée en masse* led to the creation of new experimental tactical units, which were to have a profound effect on the European battlefields of the next two decades. The ill-disciplined but ideologically committed troops of Revolutionary armies formed the basis of experimental units of skirmishers. These units suffered considerably from desertion, but they proved capable of putting out clouds of skirmishers to harry the disciplined mass formations of their opponents. Such soldiers, called *tirailleurs*, thoroughly disconcerted the enemy armies and were soon a major factor in French successes.

The second manner with which the French responded to the challenges posed by the new mass armies was to make changes at the operational level. Here, with the ruthless pressure of their revolutionary masters, who demanded nothing but success on the battlefield, French generals rapidly adapted the proposals of prewar theorists to reorganize the army into all-arms divisions (various combinations of cavalry, artillery, and infantry). As with tactical units such as the *tirailleurs*, the process involved considerable experimentation in actual campaigns as well as on the field of battle. The new experimental units allowed the French greater latitude and speed of movement. Moreover, the new units had the ability to defend themselves while under attack from stronger enemy forces.

A decade later Napoleon took the divisional system and formed experimental units called *corps*, which provided even greater operational latitude for himself and his

Chodorow and MacGregor Knox, *The Mainstream of Western Civilization*, fifth edition (New York: Harcourt, Brace, Jovanovich Publishers, 1989), p. 658.

⁵² For a general discussion of the evolution of French tactics and experimental units, see John Lynn, *The Bayonets of the Republic, Motivation and Tactics in the Army of Revolutionary France, 1791–1794* (Urbana, IL: University of Illinois Press, 1984).

subordinate commanders.⁵³ The Napoleonic system built on the tactical and organizational successes of the Revolution to create an even more effective military system. Between 1793 and 1815, the French created the organizational framework within which armies have operated at the operational level over the past two hundred years.

1815–1914: Experimental Units and the Revolution in War

The period between 1815 and 1914 saw enormous technological changes that revolutionized the conduct of war. The great powers and their armies and navies were largely at peace.⁵⁴ The exceptions were a few short periods:

1854–1855, the Crimean War	1866, the Seven Weeks War
1859, the Austrian-French War in Italy	1870–71, Franco-Prussian War
1864, the war over Schleswig-Holstein	

However, navies when at sea are always at war with nature. The vast changes in technology, particularly at the end of the nineteenth century, meant that virtually every ship type the admiralities constructed represented an experimental unit.

The development of the battleship underlines this fact. John Arbuthnot “Jackie” Fischer’s first ship, on which he served as a midshipman, was the *Warrior*, the premier battleship in the Royal Navy in 1863. The *Warrior* cost £265,000, displaced 9,180 tons, and possessed a top speed of 14 knots. Fifty-one years later, when Fisher was First Sea Lord, the Royal Navy was bringing into service the first of its *Queen Elizabeth* class battleships, ships that cost £2,600,000, displaced 27,500 tons, and possessed a top speed of 24 knots. The main armament of the *Queen Elizabeths* were eight 15-inch guns, the broadsides of which weighed nearly 3,200 pounds, that could reach out twenty-five kilometers, as opposed to the forty 68-pounders with which that the *Warrior* had been equipped.⁵⁵

⁵³ This greater flexibility played a major role in the French victory at Auerstadt, when a French corps, under the command of Marshal Davout destroyed the bulk of the Prussian Army. For the Napoleonic system of war, see David Chandler, *The Campaigns of Napoleon* (New York: MacMillan, 1966), particularly Part III.

⁵⁴ America was not yet a great power and its Civil War was the one exception to the pattern of relatively short, decisive wars. Surprisingly, the American armies on both sides displayed relatively little interest in creating experimental units. Perhaps the very scale of the conflict as well as the enormous problems associated in fighting such a war by politics and military organizations that had no experience in fighting wars minimized the very American instinct to innovate and experiment in new directions.

⁵⁵ Holger Herwig, “The Battlefleet Revolution, 1885–1914,” in Knox and Murray, *The Dynamics of Military Revolution*, p. 114.

This revolution in battleship design forced navies to stake enormous resources on experimental units and design—some of which proved their feasibility and some of which failed. Fisher’s decision to build the HMS *Dreadnought* in 1904 represented a considerable gamble, which eventually proved advantageous to the Royal Navy in the run up to World War I. That design gave the British the lead in the construction of modern battleships and undermined the German strategy for achieving naval dominance in a sustained naval arms race.

But not all of Fisher’s experimental units were so successful. His battle cruiser class, which sacrificed armor for speed, possessed so little protection that its ships were simply not survivable when confronting fully armored battleships in combat. The loss of the British battle cruisers *Indefatigable*, *Queen Mary*, and *Invincible*—each at a cost of more than a thousand sailors and officers—at the Battle of Jutland in 1916 underlines the price to be paid when experimental units fail to live up to expectations.⁵⁶

⁵⁶ For a first class examination of the cultural and technological factors that resulted in the Royal Navy’s failures at Jutland, see Andrew Gordon, *The Rules of the Game, Jutland and British Naval Command* (London: John Murray, 1996).

Appendix D.

Acronyms and Abbreviations

ACTD	Advanced Concept Technology Demonstration
ADF	Australian Defense Force
ASD	Assistant Secretary of Defense
AT&L	Acquisition, Technology, and Logistics
BCT	Brigade Combat Team
BDA	Battle damage assessment
BLOS	Beyond line-of-sight
C2	Command and control
C3	Command, control, and communications
C31	Command, control, communications, and intelligence
C4ISR	Command, control, communications, computers, intelligence, surveillance, and reconnaissance
CCJFCOM	Combatant Commander, Joint Forces Command
CDE	Concept Development and Experimentation
CJCS	Chairman, Joint Chiefs of Staff
COP/CROP	Common Operational Picture/Common Operational Relevant Picture
COTS	Commercial-off-the-Shelf
DARPA	Defense Advanced Research Projects Agency
DART	Defense Adaptive Red Team
DoD	Department of Defense
DOTMLPF	Doctrine, Organization, Training, Materiel, Leadership, People, and Facilities
DPG	Defense Planning Guidance
DSTO	Defense Science and Technology Office
DTED	Digital Terrain Elevation Data
EBO	Effects-based operations
FJF	Future Joint Force
FY	Fiscal Year
HITL	human-in-the-loop
IA	Information assurance

ICRD	International Center for Religion and Diplomacy
IDA	Institute for Defense Analyses
IO	Information Assurance
ISR	Intelligence, surveillance, and reconnaissance
J8	Joint Staff
JAWP	Joint Advanced Warfighting Program
JCATS	Joint Conflict and Tactical Simulation
JEFX	Joint Expeditionary Aerospace Force operations
JFCOM	Joint Forces Command
JFCs	Joint Force Commanders
JIWG	Joint Integration Work Group
JSAF	Joint Semi-Automated Forces
JSIMS	Joint Simulation and Integrated Modeling System
JTF HQ	Joint Task Force Headquarters
JUWG	Joint Urban Working Group
JWARS	Joint Warfare Simulation
LD/HD	Low density/high density
M&S	modeling and simulation
MMLB	Mounted Maneuver Battle Lab
MOUT	Military Operations on Urbanized Terrain
NBC	Nuclear-biological-chemical
NCOs	Non-commissioned officers
NDRI	National Defense Research Institute
NGO	Non-governmental organization
OFT	Office of Force Transformation
OODA	Observe-orient-decide-act
OSD	Office of the Secretary of Defense
P&R	Personnel and Readiness
QDR	Quadrennial Defense Review
RDO	Rapid Decisive Operations
ROE	Rules of engagement

RSTA	Reconnaissance, surveillance, and target acquisition
RTO	Research and Technology Organization
S&T	Science and technology
SHAPE	Supreme Headquarters Allied Powers Europe
TBMs	Theater ballistic missiles
TRADOC	Training and Doctrine Command
UAV	Unmanned aerial vehicle
USECT	Understand, Shape, Engage, Consolidate, and Transition
VSTOL	Vertical/Short Takeoff & Landing

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