Demonstrating the Operational Feasibility of New Technologies

The ARPI IFDs

Marie A. Bienkowski

SRI International
333 Ravenswood Avenue
Menlo Park, California 94025
415-859-5489
bienk@erg.sri.com

Gary Edwards

ISX Corporation
4301 North Fairfax Drive, Suite 301
Arlington, Virginia 22203
703-351-6420
gedwards@isx.com

Abstract

A critical part of successful technology transition is the demonstration of technology and research results in a context that is meaningful to users. Within such an operational context, application developers in the Advanced Research Projects Agency/Rome Laboratory (ARPA/RL) Planning Initiative (ARPI) integrate, apply, and demonstrate technology to produce Integrated Feasibility Demonstrations (IFDs). IFDs provide both a pull on research and development and a push of technology into operational settings. This paper[1] describes the three IFDs that have been conducted since the program began, as well as the current IFD, scheduled for presentation in May 1996. In addition to describing the operational problem and technical solution that each IFD addressed, we present the lessons learned from each and the overall methodology that is used in planning and conducting IFDs. Finally, we present other mechanisms of technology transfer besides IFDs, and give an example of a lateral technology transfer.

In ARPI, technology moves from researchers to users, and feedback is given by users to researchers. IFDs are a vital part of this user-centered approach to software engineering: they demonstrate to members of the operational community how maturing technologies can work together to address real problems.

Each annual IFD is ARPI's opportunity to demonstrate progress toward transitioning advanced technology into operational systems. The primary IFD objectives are as follows.

Advanced technology capabilities. IFDs highlight technologies that are (1) powerful enough to address complex problems, (2) sufficiently mature and scalable to address real world problems, and (3) applicable to a wide variety of domains.

Realistic operational application. IFDs showcase technologies engineered into applications that solve significant problems for real users in the context of their work practices, thereby winning user endorsement.

Readiness for transition. Technologies demonstrated in IFDs are scrutinized to determine their readiness to transition to other programs and projects that will advance them toward full operational use.

A pipeline for technology maturation. IFDs provide a venue for presenting ARPI as a "technology pipeline" that provides a stream of technologies that can significantly enhance operational systems.

ARPI has developed IFDs and an implementation plan for the fourth (see Table 1). These systems showcase realistic prototypes that could be integrated into a military command and control infrastructure, and have taught valuable lessons on ensuring success in technology insertion. (The IFDs were developed for and tested by various joint commands of the U.S. Armed Forces. A joint command is responsible for a specific geographical region—called a

[1] This article is based on material which was first published in IEEE Expert, Vol. 10, No. 1, pp. 27-33, February 1995 which is (c) Copyright 1995 IEEE. It is used with permission of IEEE.

theater of operations during an operation—and has elements from each of the military services.)

Table 1. Integrated Feasibility Demonstrations

	Primary Planning System	Focus
IFD-1	Dynamic Analysis and Replanning Tool (DART)	Constraint-directed search; planning and analysis for deployment
IFD-2	System for Operations Crisis Action Planning (SOCAP)	Operations and transportation planning for small-scale defensive military
IFD-3	Theater-level Analysis Replanning and Graphical Execution Toolbox (TARGET)	Multisite, case-based planning for civilian evacuation
IFD-4	Air Campaign Planning Tool (ACPT) Plan	Air campaign planning

IFD-1, DART, was developed just before and during Operation Desert Shield, thereby predating the start of ARPI and setting the baseline for the subsequent program. DART successfully supported transportation planning and analysis for the deployment portion of military planning. The U.S. Transportation Command participated in DART's development. The system has since been deployed to several operational sites.

IFD-2 demonstrated SOCAP, moving further toward the ARPI vision of component interoperability. SOCAP integrated advanced generative planning, temporal and case-based reasoning, and scheduling techniques to generate military operations plans. It demonstrated the first steps toward an explicit, reusable computer representation of a course of action, automated assistance for generating a course of action, and the first explicit reasoning thread from a course of action to the transportation data used by the U.S. Transportation Command. This thread enables immediate transportation analysis and feedback to the course-of-action generation process. The participating joint command was the U.S. Central Command.

IFD-3 moved still further toward the vision of distributed planning by demonstrating new technology to help resolve resource conflicts in a multiple-deployment scenario and to further assist course-of-action generation. The demonstrated system, called TARGET, was designed to support the U.S. Commander-in-Chief, Pacific Command Joint Task Force concept of operations. As a result of its performance, TARGET has been selected as a component of the Global Command and Control System.

The forerunner to IFD-4 is ACPT, which helps capture and analyze at the strategic level the information needed to generate a prioritized candidate target list for a variety of scenarios. A legacy software system then can analyze this list for effectiveness and resource use. ACPT is being transitioned for support as an operational tool by the U.S. Air Force (USAF). A testbed version of ACPT will support IFD-4 by integrating advanced ARPI technologies: developers have already linked SOCAP to ACPT to turn air objectives into air tasks.

DART

In operations that require massive deployments, the movement of troops and materiel is limited not only by the availability of transportation resources, but also by the ability to command and control these assets. As a result, a crucial component of crisis action planning is the development and feasibility analysis of deployment plans.

Unfortunately, human planners are hindered by the volume and complexity of the time-phased force deployment data (TPFDD) that describes the movement requirements for troops and materiel. A typical TPFDD contains a few thousand entries, each describing which combat unit is being deployed, where and when it arrives at its destination, and how it is transported. These TPFDDs are input to simulators to estimate a plan's gross transportation feasibility, followed by paper-and-pencil analysis of the model's results. The result is difficult to change when a commander decides on a different course of action or when events force changes.

The developers who examined this deployment planning scenario as a potential area for technology insertion identified the need to help planners visualize and modify movement requirements, develop and display the transportation plans that generate the movement requirements, and enable the rapid analysis of changes required by deployment force resequencing.

The resulting IFD-1 prototype—DART—enabled a shift from existing practices by supporting several tasks associated with creating and refining TPFDDs: evaluating multiple options and refining a plan; graphically examining a TPFDD; performing complex queries; asking "what if?" questions; and finding errors, making changes, and producing a complete flow plan in substantially less time than was previously possible. With DART, planners can set up and run strategic transportation models in minutes rather than hours or days, so they can consider more alternatives and produce a more feasible course of action in less time.

As developed by Bolt Beranek and Newman Inc. (BBN), Ascent Technologies, and SRA, DART's open-systems architecture centers on an off-the-shelf relational database (Oracle) that is used as a blackboard for communication among several system modules (see Figure 1). This database stores the TPFDD as well as associated deployment and situation data that is downloaded from and uploaded to the World Wide Military Command and Control System. DART is also coupled with an automated version of the existing RapidSim feasibility simulator (letting a user quickly obtain graphical results), and with the Prototype Feasibility Estimator that was developed as part of ARPI's Common Prototyping Environment.

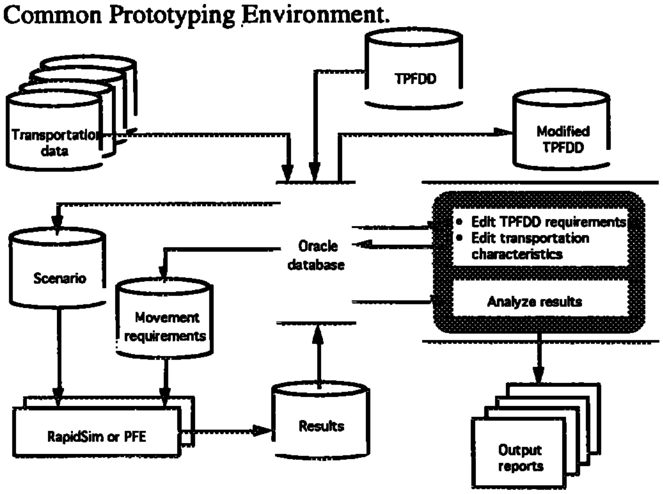

Figure 1. DART System Architecture

DART was designed to be easily understood by new users and easily tailored to meet an individual commander's needs. The interface has several components:

- A spreadsheet-style representation of the TPFDD to show each transportation leg
- A movement-requirements interface for modifying timelines and units involved in the deployment and for querying the database
- A map interface that displays the points of origin, air and sea ports, destinations, and routes
- A model setup and analysis interface that allows planners to flexibly choose parameters for model inputs and detailed visualization of the results of a model run.

The U.S. Transportation Command used initial prototypes of DART to make deployment decisions early in Desert Shield. In November 1990, DART was demonstrated to the U.S. Transportation Command, and was immediately fielded to Europe to help the U.S. European Command deploy tanks and personnel to Saudi Arabia. DART was clearly faster than the only other functional system for creating and tracking TPFDDs, and DART's graphics enhanced the ability to visualize plans.

Three key elements of DART's development led to its success:

1. Direct, early, and frequent user involvement through rapid prototyping and short development cycles, including a series of increasingly robust prototypes, well-matched to user needs, with an evolution time scale of weeks and months
2. Flexible software management that aggressively exploited information technology (for example, integrating AI scheduling technology with relational database, networking, and user interface techniques)
3. A "megaprogramming" approach, which exploited existing system components and off-the-shelf technology to get technical innovations into the hands of users.

Transportation planners readily accepted DART because they had helped define the initial prototype's capabilities, refine the prototype into the operational system, and analyze elapsed planning and analysis times to quantitatively identify the major sources of improvement.

The ARPI community subsequently used some of DART's components and unclassified data to provide both data for testing and a component for the standard environment for demonstrations and evaluations. The scheduling researchers used the TPFDD data structures, and IFD-2 developers used the entire DART system. Programmatically, DART served as the prototype for the IFD process.

SOCAP

Planning major operations involves tracking multiple plans generated at multiple, distributed planning sites and maintaining the dependencies among the actions in these plans. Although both activities are indispensable for providing plan justifications and replanning, they are difficult for human planners.

The need to create robust plans also requires that a planner explore qualitatively different plans. The planner must choose operations (including location and time) at many levels of detail, select the proper military units and resources, observe rules of engagement, satisfy operational constraints (such as troop limits), and make key assumptions explicit. The resulting plans, for a small-scale operation, can easily contain hundreds of actions describing the employment and deployment of forces, and these plans must be evaluated for feasibility from various perspectives (for example, logistics).

The developers who examined this problem identified the need to

- Help planners select the correct operations to form a set of qualitatively different plans
- Maintain dependencies (including temporal ones) and check consistency among the operations in a plan
- Set up input for different feasibility estimators like DART
- Support changes to the plan.

SRI International designed SOCAP to provide these capabilities, and IFD-2's main operational focus was to help an operations planner determine (using DART) that a course of action (interactively generated using SOCAP) is transportationally feasible. The goal was to improve the accuracy and flexibility of crisis response plans developed for joint operations, and to reduce plan development time.

SOCAP comprises SIPE-2, a domain-independent, knowledge-based planning system; a user interface that guides a planner through the decisions needed to generate a military operations plan; a situation map display system; and modules that connect SOCAP to existing feasibility estimators.

Figure 2 shows the inputs, outputs, and user interaction during plan generation. The input (plan specification) comprises the description of the mission and its purpose, the plan guidance, and the apportioned forces. SOCAP generates plans by addressing these with the known military employment and deployment actions, and then generates a plan representation that can be displayed or excerpted in different ways for different purposes: as network and map displays, as time-phased actions for transportation analysis, or possibly as natural language.

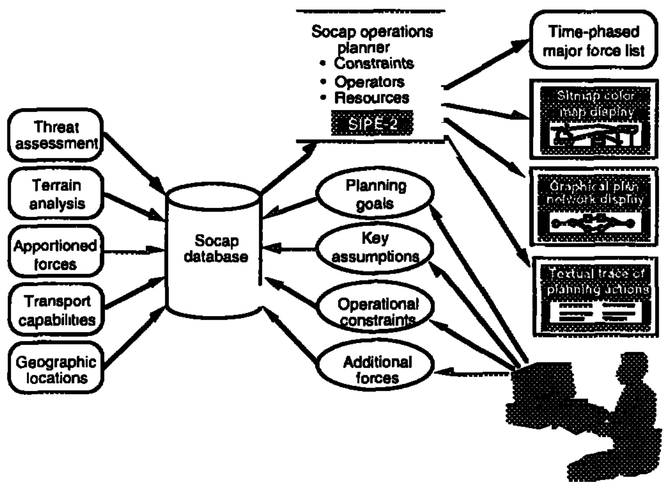

Figure 2. SOCAP Functional Overview

Although the plan generated by SOCAP has both employment and deployment actions, SOCAP does not generate TPFDDs. In IFD-2, the gap between the plan generated by SOCAP and the TPFDD input expected by DART was bridged by a module that elaborates the transportation requirements produced by SOCAP (it expands the combat unit movements, and adds supporting units and their transportation requirements). BBN and the ISX Corporation (ISX) developed this module and participated in the IFD-2 integration tasks.

Unlike DART, IFD-2 was designed to demonstrate the applicability of a specific piece of AI technology to this domain. To do this, the developers isolated a small chunk of the larger problem, scaled back the requirements for interaction with legacy systems, and developed a scenario that would demonstrate the technology in a realistic way yet be feasible in less than 1 year. However, the lack of integration with legacy systems meant that the audience for IFD-2 focused on the side issue of getting up-to-date data, instead of seeing the possibilities for quicker and better plan generation. Also, the lack of a well-defined champion for the technology at the U.S. Central Command (and the lack of interest in transportation analysis) meant that SOCAP's support for more automated feasibility estimation went unnoticed.

For practitioners of applied AI, the most interesting aspect of IFD-2 was the identification of technology gaps in SOCAP that were closed in ARPI's Technology Integration Experiments (TIEs). As a result of user feedback, SIPE-2 was also extended, for example, to let users specify the order in which goals are pursued.

An integration experiment was recently completed between SOCAP and ACPT to generate air tasks from air objectives, thus forming the basis for feasibility estimations of air campaign plans. This has led to the nomination of SOCAP as a component of IFD-4.

TARGET

Whether conducting large or small military operations, planners at multiple locations must coordinate and collaborate. They need to share data and information in real time and to work jointly on shared processes. They collaborate best by communicating written and verbal information instantly, but the existing support technology (such as telephones and fax machines) forces a sequential planning method, instead of letting planners operate as if they were in the same room.

Sequential planning and slow information exchange hinder planners who must develop and maintain multiple plans simultaneously; this becomes necessary when many conflicts are in parallel, such as in military deterrence, civilian evacuation, or humanitarian relief operations. In this collaborative planning context, planners need support for rapidly selecting, tailoring, and evaluating force structure at various levels of detail. All these requirements and limitations together suggest the need for

- Seamless and distributed plan generation and assessment (for both operations plans and deployment schedules)
- A common representation of the plan and its justification that traces initial guidance and goals, through choices for specific actions, to a complete and time-phased force list
- Collaboration and information-sharing tools that can be applied to military planning.

Providing these capabilities led to the development of IFD-3, which focused on helping joint-task-force planners to handle humanitarian and military operations simultaneously. TARGET, the primary component of IFD-3, was developed by BBN to provide a common repository of planning information and a means of data exchange. It supports collaborative planning in a distributed environment, and allows groups at a single site to access its capabilities in a decision-support toolbox. The planning activities are integrated via a common plan representation and an underlying object-oriented knowledge base. The representation models the structure and rationale for plans, enables combat and transportation analysis of operational alternatives, and provides the entry point for rapidly incorporating and tracking changes to the plans as a result of these analyses.

IFD-3 exploited and integrated several existing AI and conventional technologies (see Figure 3), including

- Case-based reasoning (for force selection)
- Decision-theoretic techniques (for plan trade-off analysis)
- Constraint-based scheduling (for force scheduling)
- Knowledge/data representation techniques (for the common plan representation).

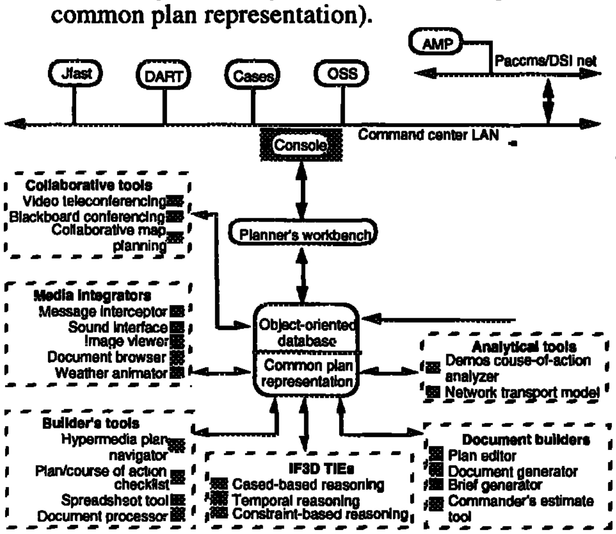

Figure 3. TARGET System Architecture

TARGET also includes Loggen (developed by the MITRE Corporation [MITRE]), which generates nonunit cargo records for TPFDDs in DART, and the Course of Action Selection Tool (developed by NRAD), which uses fuzzy logic to help compare plans. IFD-3 allowed users to communicate through such techniques as shared maps and video conferencing, thereby effectively exploiting existing technology to support distributed, collaborative planning.

Case-based reasoners. General Electric Corporate Research Division (GE-CRD) provided a Case-Based Force Selector (CAFS) for civilian evacuations. CAFS receives information on a military task, its location, and the expected threat at that location, and retrieves the most suitable forces from its library, using such features as the type of task, the terrain at the location, and the type of threat. CAFS then develops a set of force suggestions by finding available forces of the same type as the retrieved forces, or by adapting similar forces.

Format, developed by MITRE, was used to acquire force module information from each service component at the U.S. Pacific Command, primarily to support the crisis team that manages deployment. (A force module consists of combat units and their support units.) Format uses case-based reasoning to store and index force modules; a deployment planner can then create, retrieve, view, and modify the modules for new situations, and build hierarchical relationships among them.

Decision-theoretic plan-evaluation system. Rockwell (with support from ISX) provided decision-theoretic capabilities for estimating the feasibility, costs, casualties, and times for various plans, and for capturing the assumptions and the rationale behind the evaluation process. This is done by producing a set of estimates and entries that can support the development of a plan-selection matrix. The user instantiates a generic plan with specific locations, forces, and destinations, along with the (possible) uncertainties associated with this information (represented by probability distributions), and then performs trade-off analyses for different courses of action. Once the necessary information is specified, the model performs a dynamic simulation of the plan, producing such outputs as the time to complete the plan, and the plan's risk factors.

Constraint-based scheduler. Carnegie Mellon University integrated Distributed Transportation Scheduling in OPIS (DITOPS), a tool for generating, analyzing, and revising logistics schedules, with TARGET. DITOPS uses advanced constraint-directed scheduling (including constraint analysis and a control architecture that flexibly applies different scheduling and rescheduling methods) to handle transportation scheduling. In IFD-3, DITOPS checked constraints and analyzed resource use during high-level employment planning, thus supporting force selection and subsequent deployment scheduling.

TARGET's success. TARGET was received favorably by joint-task-force planners, and is undergoing continued development and deployment. Many of its products, however, did not get fed back into ARPI for use by researchers in testing and evaluating their tools. This is due, in part, to the demands placed on the developers by the success of TARGET.

ACPT

Advances in weapon systems now enable USAF planners to focus campaigns on selected key targets, thereby maximizing success while minimizing costs and risks. However, to take advantage of this capability, air campaign planners must rapidly acquire, aggregate, and analyze a huge amount of data. To implement the resulting plans, the planners must identify target and asset allocations, and then assess the overall plan to insure that it is feasible in terms of predictable effectiveness and attrition, logistical work-ability (such as aircraft, munitions, fuel, and support), asset use, and so on.

ISX developed ACPT to capture the experience of air campaign planners in Desert Storm, codify that experience as a reusable planning process, and develop a tool to support it in the future. ACPT lets air campaign planners analyze areas of potential trouble around the world and readily access maps, imagery, country studies of the enemy's economic and political infrastructure, target analyses, and order-of-battle information.

ACPT consists of a graphical form- and map-based environment for

- Inputing and analyzing the scenario
- Analyzing the strengths and weaknesses of the key players of the region (relying on the intelligence database)
- Expanding and linking objectives from the national level down to the selection of air tasks
- Developing, sequencing, and prioritizing targets
- Applying simulation tools to assess campaign feasibility and effectiveness.

As a by-product of the analysis required for the final output, the planner will have manually defined the linked set of objectives; this leaves an audit trail that the planning staff can trace to understand the significance of a target selection made by another planner.

ACPT is implemented in an agent-oriented architecture (see Figure 4). Specialized agents address classes of functions for data communications and management, agent creation and registration, transparent access to databases and models ("wrapper" agents), planning, managing user information and presentations, and supporting user command interfaces. This architecture lets ACPT directly interface with other planners, simulation models, and databases, including a force deployment model that generates deployment data from a force structure, a force application model that determines the optimal combination of forces and weapons for accomplishing a mission, a classified intelligence database, and the SOCAP planning system applied to generating air tasks from air objectives.

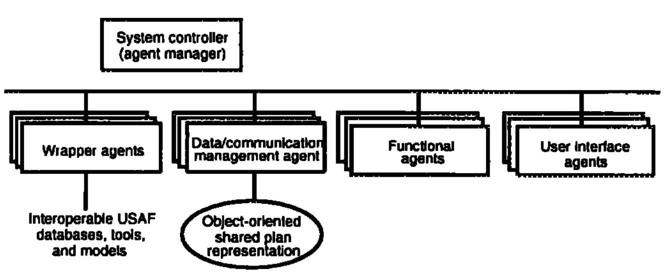

Figure 4. Air Campaign Planning Tool Architecture

Early on, ACPT was used to support a team of 14 intelligence and planning officers in a realistic crisis-planning exercise. ACPT enabled the planning staff to develop a workable plan, which previously would have consumed months of manual effort, in just 36 hours.

ACPT is the cornerstone of IFD-4 (scheduled for May 1996), which will contain two types of demonstrations. The core demonstration will be the centerpiece of the IFD, and will be built around plan generation, critiquing, and modification capabilities added to ACPT through the integration of advanced AI technologies: generative planning, knowledge acquisition consistency checking, and temporal reasoning. In constructing this core demonstration, SRI, ISX, the Information Sciences Institute (ISI), and GE-CRD are engaging, along with Checkmate staff, in a user-centered application development project. We are building the demonstration around a complex real-world problem, and are building the applications in a manner that allows the planning process to be open and inspectible. The resulting IFD-4 application represents a major product of the initiative, ready to transition to programs for operational insertion.

The second tier of the IFD demonstrations will present a small set of critical capabilities TIEs. These TIEs include technology components that appear to be very close to supporting the core demonstration, but that need to be demonstrated as technically capable of supporting it. They serve as the first application of these technology components in a real user's work process. While these demonstrations will be similar in nature to the core, the level of investment will be less than a full scale application, and the demonstrations correspondingly smaller in scope The current set of these TIEs is under deliberation. Interestingly, the first set included Tachyon and ISI's EXPECT system, which eventually became part of the core demonstration.

Both the core demonstration and critical capabilities TIEs have some specific entry criteria for the IFD. These include

- A specific concept of operations, endorsed by real users, that identifies how and where the technology-based application fits into the user's work process in a way that has significant impact
- Identification of specific requirements for knowledge sources and data sources
- A user-endorsed Final Exam that specifies success criteria
- An integration plan.

It is important that each TIE demonstration includes a clear example of the technology's application to a real-world problem (even if the example is futuristic), and a clear roadmap describing when the technology is expected to provide useful products.

ACPT and the ACP process will be the focus for two other IFDs beyond IFD-4. IFD-5 will have a strong scheduling focus, to support the Joint Force Air Component Command (JFACC) program's desire for a continuous planning/scheduling mode, where users work strategy to task to execution in a process other than a waterfall process.

Oil-Spill Contingency Evaluation

In an example of lateral technology transition, SOCAP has been applied to another domain with both military and commercial significance: oil-spill contingency response planning. The response problem is a race against time; to be cost-effective, cleanup actions must be successful before the time predicted for the oil's landfall. SRI is developing the Spill Response Configuration System (SRCS) to help U.S. Coast Guard (USCG) planners determine the best types, quantities, and prepositioning of equipment and personnel to respond to oil spills in U.S. coastal and harbor waters. It will also highlight shortfalls in cleanup resources and help the USCG explore the trade-offs and costs associated with remediating these shortfalls. Planning and drill exercises (at national and local levels) could use this system to develop and evaluate plans to respond to spill scenarios anywhere on the U.S. coastline.

In SRCS, SOCAP has been integrated with other software tools to support equipment and logistics plan development and evaluation, spill-trajectory simulation, and map display of planning results. To explore a configuration-planning problem, the user first provides relevant information about the spill scenarios to be examined and the equipment available for responding to the spill. This information, together with evolving situation facts, provides the main inputs for the planner.

As planning proceeds, the simulation part of the system determines the resulting disposition of the oil, and its eventual effects and damage. Spill simulations are developed either from historic spill records or from a trajectory-projection model of oil spreading on the sea. The USCG has done extensive studies of the risk of oil spills along the U.S. coast; from these studies a representative set of spill scenarios can be selected for equipment-configuration planning.

The planning and simulation steps generate alternative response plans, which are then evaluated. To estimate the effectiveness of the cleanup operations, the evaluation combines the predictions of the oil's movement with the planned use of equipment. The best equipment configurations are determined by comparing the effectiveness of the alternative plans, starting with assumptions about the equipment level and location. After the optimal response plan is chosen, the user can modify the scenario, the locations of spill response resources, or the choices of operations to see how well the plan fares under changes.

SRCS uses SOCAP to plan the deployment and employment of each major piece of equipment during a simulated spill. The planning methodology in SOCAP (SIPE-2) breaks down the top-level problem successively into a set of subgoals; at the lowest level are equipment deployment and employment procedures. Using SOCAP, SRCS can keep track of the constraints of time precedence, concurrent resource use, and deployment time, to determine the feasible choices at each planning point, based on the situation, equipment capabilities, and prior actions.

SRCS has been demonstrated successfully to USCG personnel from the National Strike Force, the Marine Environmental Pollution Division, and the Groton R&D Center. The next step is to train USCG personnel to use the system to obtain further feedback about what is needed to make the system operational. SRI is improving the ability of SRCS to generate plans that accomplish better cleanup with less environmental impact. This work includes integrating innovations from SOCAP into SRCS, such as a better way for users to modify plans and to replan.

Other Mechanisms for Technology Transfer

In addition to the IFDs, ARPI technology has been integrated, demonstrated, and evaluated for user exercises and user-sponsored demonstrations. For the exercises, personnel typically received some minimal training (about one week) to enable them to operate the tools. Developers were on hand during the exercise, primarily to observe how the tools were used, to record user reactions, to evaluate tool effectiveness, and to document recommended changes or enhancements.

In September 1993, the U.S. Pacific Command used the IFD-3 tool suite in an exercise. The users suggested several enhancements during the exercise, primarily regarding the user interface and additional functionality. After the exercise, the command endorsed not only the tool suite, but also ARPI's process of user-focused research and development. The command also requested

- Extensions to TARGET's "anchor desk" concept, including the addition of weather and logistics systems
- Support for force generation, using case-based reasoning
- In-theater transportation scheduling and routing
- Support for the decomposition of higher level objectives into more detailed objectives, tasks, and schedules, and supporting the monitoring and tracing of each during plan execution
- Changes to the user interface.

These requests led to further development of the tool suite (some of these were present in later user-sponsored demonstrations, as discussed below).

ARPI also obtains feedback and evaluation through annual Joint Warrior Interoperability Demonstrations (JWIDs) led by the U.S. Armed Forces. The JWIDs' events demonstrate the integration and interoperability of command and control systems and subsystems with communications networks, thus providing an opportunity to evaluate a prototype in a quasirealistic system environment, and to examine "concept of operations" issues with participating users. Unlike an IFD, which is targeted to a specific user who has participated in the development of the demonstration. JWIDs showcase technology to a broader audience, and allow developers to see a range of insertion points for technology.

In JWID '93, the IFD-3 tool suite was installed on a U.S. Navy ship and at Camp Smith, Hawaii, to demonstrate how it could help collaboratively plan an operation. As a result, TARGET was identified as a tool to be implemented in a future release of the Global Command and Control System, and a copy of the system was installed at the USACOM for evaluation in a spring 1994 exercise.

For JWID '94, ARPI collaborated with several other agencies to demonstrate distributed collaborative planning for combat and disaster relief operations seamlessly across missions, services, non-Department of Defense (DoD) agencies, and echelons. For a combat-based scenario, the demonstration supported planning and execution at all levels of command. A secondary scenario for disaster relief demonstrated the use of ARPI technology for collaboration between the DoD and the Federal Emergency Management Agency. Organizations at nine sites, ranging from Hawaii to Virginia, were connected by a special communications network for the demonstration.

The JWIDs encourage enhancements and additions to existing tool suites. For example, for JWID '94, TARGET featured

- An enhanced user interface
- Case-based storage and retrieval of adaptive joint force packages in Format
- Tachyon, a temporal reasoning tool developed by GE-CRD, to support force sequencing
- An interactive scheduler for in-theater airlift, based on the ARPI-supported KTS scheduler developed by Kestrel
- Task and objective passing between TARGET and ACPT.

In addition, ACPT was integrated with existing tools to support the development and execution of "air tasking."

Conclusion

Overall, the IFDs taught us valuable lessons about technology insertion. DART showed the value of early delivery of an authoring tool, and demonstrated how advanced technology can augment such tools. However, we also learned that details—such as the delivery form—are critical to success. In SOCAP, we learned that state-of-the-art AI tools can address operational scenarios, but that insufficient attention to the existing user processes can lead to a technology-rich solution that has little user buy-in. In TARGET, we swung in the opposite direction: we focused the development primarily on an authoring tool set that had considerable user buy-in; the resulting tool didn't showcase the impact of advanced AI technology to the users.

We are now applying these insights to the development of ACPT. We attribute ACPT's early acceptance to developing an authoring tool "up front," to obtaining user buy-in to a process reengineering for their existing planning processes, and to basing the authoring tool on an architecture that will support technology insertion. This enables technology insertion into an accepted user process, with a real operational constituency that can provide ongoing support and endorsement for technology-rich IFDs.

The IFDs and user-sponsored demonstrations such as the JWIDs not only give the ARPI research community feedback on the technology's utility, but also provide them with insight on how the technology should be "packaged" and how it must interoperate with other systems in the user environment. This transition strategy provides face-to-face interactions between researchers and users that enable requirements to flow back to the research community with a clarity that printed material rarely, if ever, achieves. This shortens the cycle from laboratory to the field, and insures that when the technology gets to the field it is what the user wants and needs.

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