DOCUMENTED BRIEFING

RAND

How Will the e-Explosion Affect How We Do Research?

Phase I: The E-DEL+I Proof-of-Concept Exercise

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Prepared for
The RAND Corporation

Arroyo Center

Approved for public release; distribution unlimited

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PREFACE

This documented briefing reports on the "How Will the e-Explosion Affect How We Do Research?" Project. In particular, it documents work performed during Phase I of the project, including descriptions of a research framework, examples of e-based capabilities associated with various components of the research framework, and a proof-of-concept exercise conducted to show feasibility and effectiveness of an e-based capability called "E-DEL+I." The work will interest those involved in research with participants in diverse locations.

This research results from RAND's continuing program of self-sponsored independent research. The author acknowledges the support for such research provided, in part, by the independent research and development provisions of RAND's contracts for the operation of its U.S. Department of Defense federally funded research and development centers.

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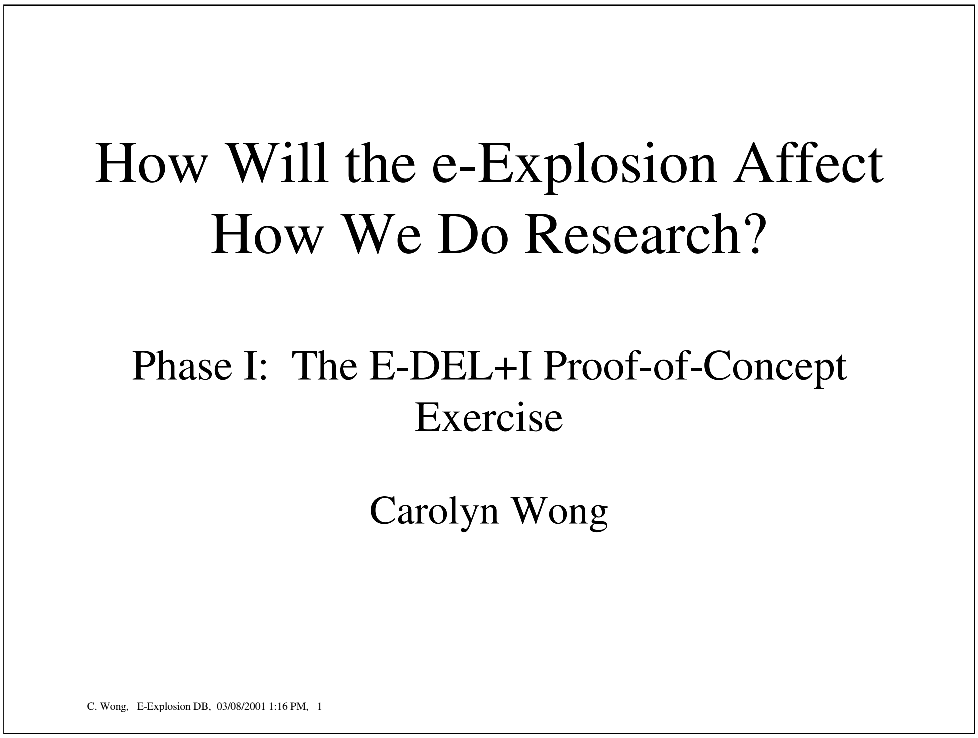
GLOSSARY

DoD	Department of Defense
E-DEL+I	Electronic Decision Enhancement Leverager plus Integrator
FCS	Future Combat System
IR&D	Independent Research and Development
Mac	Macintosh computer
NASA	National Aeronautics and Space Administration
PC	Windows based computer
R&D	Research and development
VTC	Videoteleconference



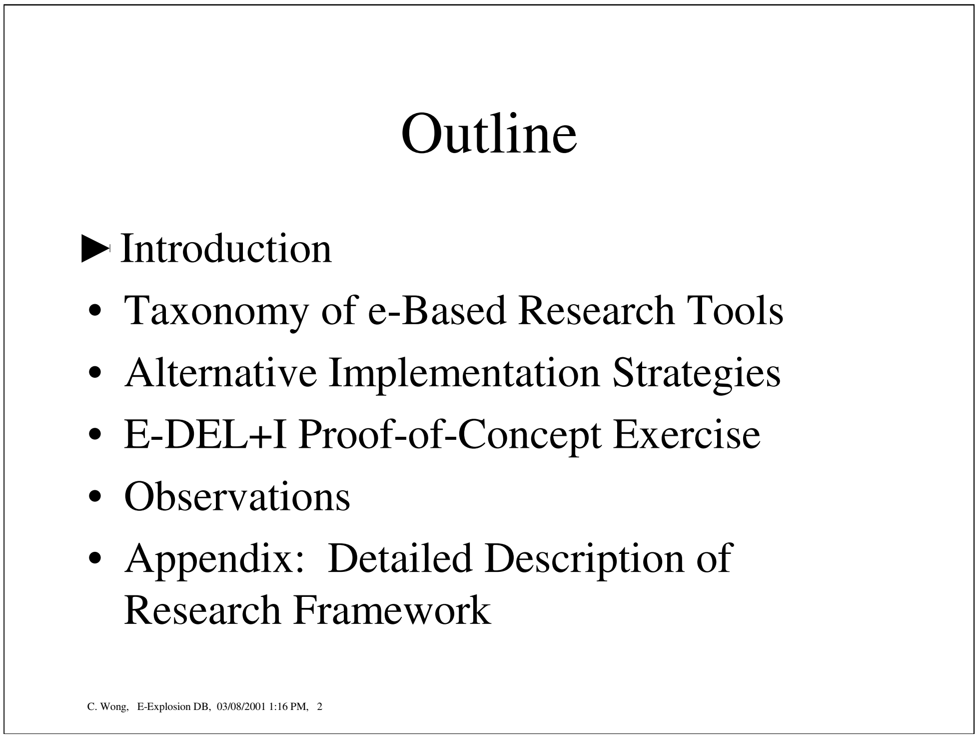
How Will the e-Explosion Affect How We Do Research?

Phase I: The E-DEL+I Proof-of-Concept Exercise

Carolyn Wong

This Independent Research and Development (IR&D) project is entitled “How Will the e-Explosion Affect How We Do Research?” For the purposes of this project, “e-explosion” means the proliferation and increased accessibility of computers and computer-based capabilities, such as the Internet and software packages, as well as the facilitation this type of automation has brought to many tasks.

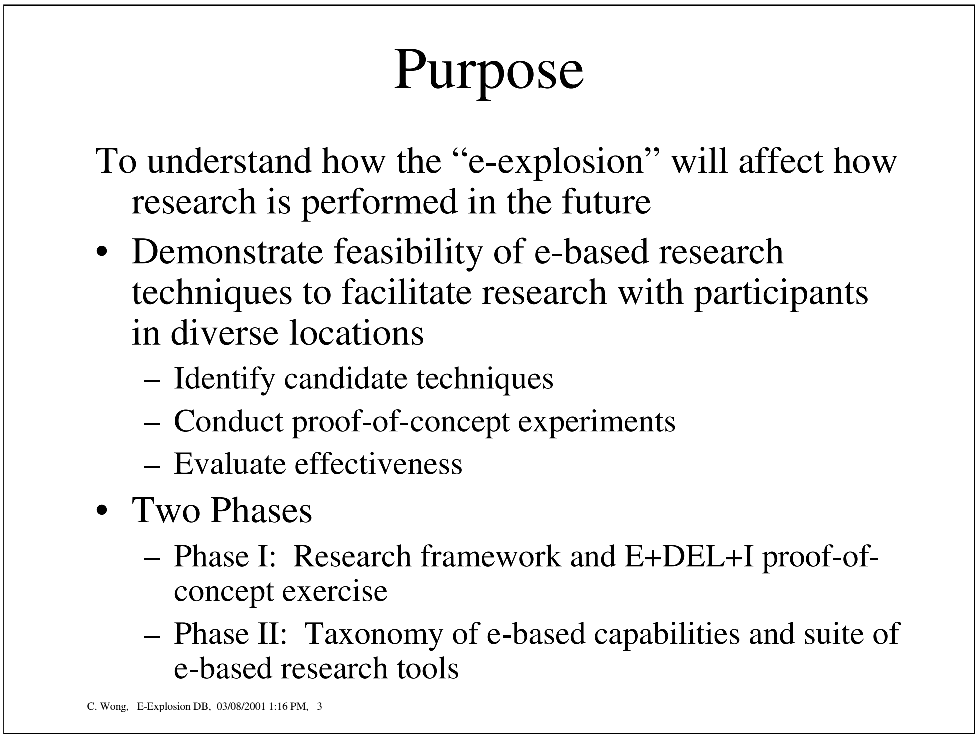
In the last decade, the “e-explosion” in the United States has changed nearly every aspect of how tasks and activities in the business, government, and personal worlds are conducted. For example, customers can place orders for everything from clothing to groceries on the Internet, the government accepts proposals electronically, and a large population uses e-mail regularly to communicate with friends and relatives. With the emergence of network communications, a new form of exchanging ideas, opinions, and results has also quietly emerged in the world of mathematical, technological, and scientific research. This project explores how research might be affected by the e-explosion.



Outline

► Introduction
- Taxonomy of e-Based Research Tools
- Alternative Implementation Strategies
- E-DEL+I Proof-of-Concept Exercise
- Observations
- Appendix: Detailed Description of Research Framework

In this documented briefing, we will first provide an introduction to the e-Explosion Project, including its two phases. That discussion will be followed by a description of the taxonomy work accomplished in the first phase of the project. Alternative strategies for conducting the proof-of-concept exercise, including a comparison of software packages, is presented next. It is followed by a description of the E-DEL+I (Electronic Decision Enhancement Leverager plus Integrator) proof-of-concept exercise. The briefing concludes with observations and insights drawn from the proof-of-concept exercise. The appendix contains a detailed description of the research framework.



Purpose

To understand how the “e-explosion” will affect how research is performed in the future

- Demonstrate feasibility of e-based research techniques to facilitate research with participants in diverse locations
  - Identify candidate techniques
  - Conduct proof-of-concept experiments
  - Evaluate effectiveness
- Two Phases
  - Phase I: Research framework and E+DEL+I proof-of-concept exercise
  - Phase II: Taxonomy of e-based capabilities and suite of e-based research tools

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The purpose of this project is to understand how the e-explosion will affect how research is performed in the future.

The participation of personnel in different locations can often enrich research and analysis activities. However, in science, technology, and other disciplines, research and analysis have largely been performed at single sites or divided into separate tasks if multiple sites are used. Findings of the multiple tasks are then integrated by one of the parties, and the result is considered collaborative research. With the instantaneous communication capability provided by the network, ideas, opinions, and results of ongoing research can now be transmitted instantly between numerous experts all over the world, with unlimited follow-up on ideas expressed in the exchanges. Real-time collaborative efforts can now more closely resemble scientists truly working side-by-side to accomplish a common goal. Thus, e-communication opens up opportunities to perform research in ways different from the traditional methods.

While research using e-based capabilities has some advantages, some problems might also make this approach inappropriate for some applications. For example, verification of information might be more difficult and work in progress might be disseminated prematurely. These issues should be considered before deciding to use an e-based capability. The appropriateness of using an e-based capability versus a more conventional approach should be decided on a case-by-case basis.

E-based approaches to research are not new to RAND. For example, in 1998 RAND researchers conducted a successful proof-of-concept demonstration of a Web-based science and technology planning technique called HyperForum. (See R. J. Lempert and J. Bonomo, *New Methods for Robust Science and Technology Planning,* Santa Monica, Calif.: RAND, DB-238-DARPA.)

To enhance our understanding of how the e-explosion will affect how we do research, this project will demonstrate the feasibility of e-based research techniques by showing how they can be used to facilitate research with participants in diverse locations. We will identify candidate techniques, conduct proof-of-concept experiments, and evaluate effectiveness.

The project has two phases. This first phase encompasses the development of a research framework and description of the E-DEL+I proof-of-concept exercise. The second phase will include a taxonomy of e-based research capabilities and description of a suite of e-based research tools.

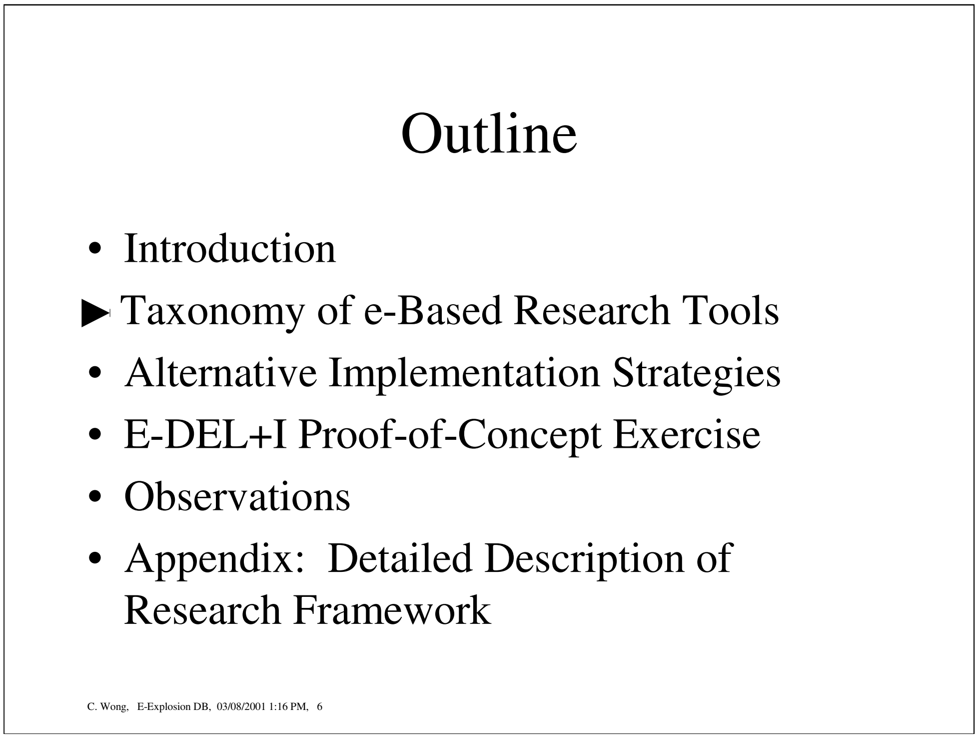
This documented briefing describes work accomplished in Phase I. It includes a description of the research framework. Examples of e-based capabilities that can be associated with some framework elements are also given to illustrate how a research taxonomy of e-based capabilities can be formed. The E-DEL+I capability is described in the report as a consensus-building technique. The documented briefing concludes with observations and insights from the proof-of-concept exercise.

Project Objectives

- Develop a research taxonomy
  - Based on research framework
  - Enables organized categorization of capabilities
    - Existing, evolving, conceptual
  - Enables strategic approach to enhancing research capabilities
- Investigate how research capabilities can be enhanced by exploiting the e-explosion
  - Collaboration from diverse locations
  - Improve, extend, or expand existing techniques
  - Identify new analytic capabilities
  - Proof-of-concept experiments

This project has two intertwined objectives that will be accomplished in the two phases of the project. This documented briefing documents work on both objectives accomplished during the first phase. The first objective is to develop a taxonomy of e-based research tools. The taxonomy will be based on a research framework. The framework is a representation of the interlocking steps of the generic research process. By understanding what happens at each step, we can focus attention on what e-based capabilities might enhance performance.

The second objective of the project is to investigate potentially beneficial e-capabilities. In particular, we are interested in tools that will allow for collaborative research among participants in diverse locations. We are also interested in established research techniques that might be improved, extended, or expanded through electronic implementation. Finally, we are interested in identifying new capabilities made possible by the e-explosion. When we identify a capability that meets one or more of these criteria and existing technology is sufficient to demonstrate the capability, we will design and carry out proof-of-concept experiments to confirm the usefulness of the e-capability.



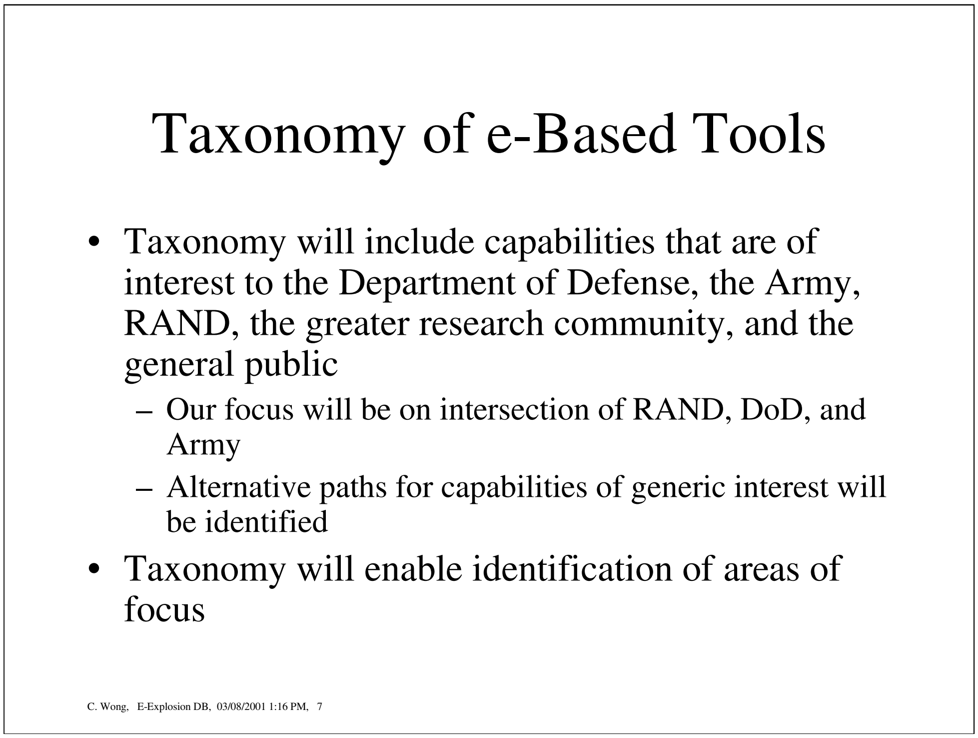
Outline

- Introduction

▶ Taxonomy of e-Based Research Tools

- Alternative Implementation Strategies
- E-DEL+I Proof-of-Concept Exercise
- Observations
- Appendix: Detailed Description of Research Framework

We will now discuss the Phase I work performed on the taxonomy of e-based research tools task.

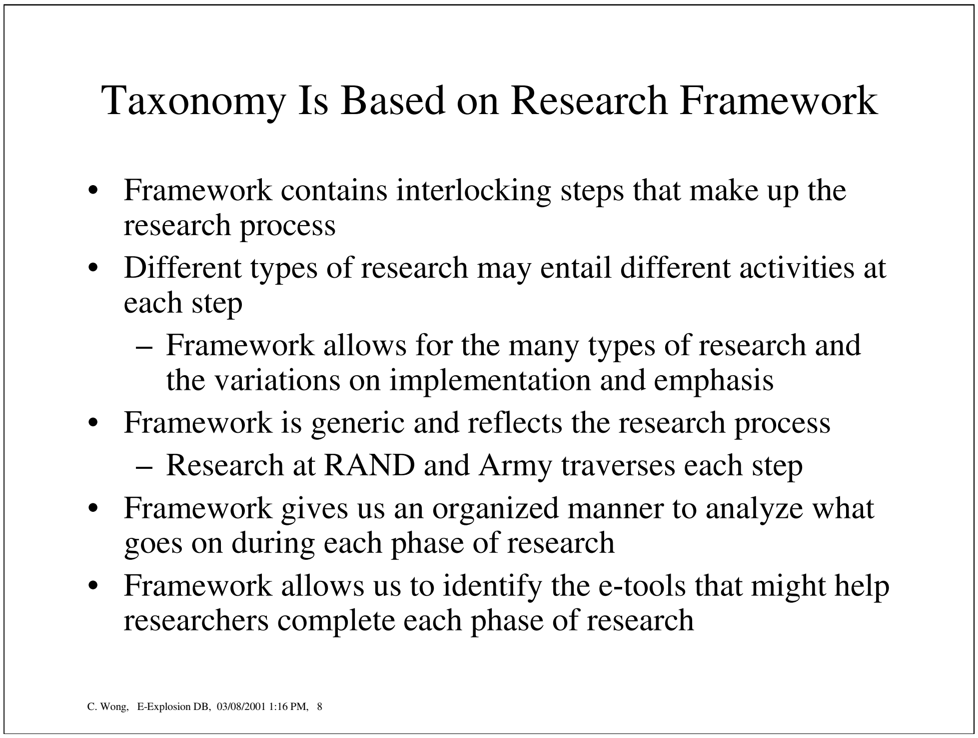


Taxonomy of e-Based Tools

- Taxonomy will include capabilities that are of interest to the Department of Defense, the Army, RAND, the greater research community, and the general public
  - Our focus will be on intersection of RAND, DoD, and Army
  - Alternative paths for capabilities of generic interest will be identified
- Taxonomy will enable identification of areas of focus

The research taxonomy includes capabilities that are of interest to the Department of Defense (DoD), the Army, RAND, the greater research community, and the general public. In the project, we will focus on those capabilities that are of interest to the DoD, the Army, and RAND. Hence, the types of research we will focus on include basic scientific research, applied technical research, and policy analysis. Those capabilities that fall outside this intersection will remain in the taxonomy, but no proof-of-concept experiments will be designed to demonstrate their usefulness.

In addition to identifying potentially useful capabilities, tools, and techniques, the taxonomy will allow for identifying areas of focus. For example, if our goal were to use e-techniques for hypotheses formulation, the taxonomy will show what capabilities are most likely to contribute to that goal. In this manner, the taxonomy can be used to develop strategies for exploiting the e-explosion.



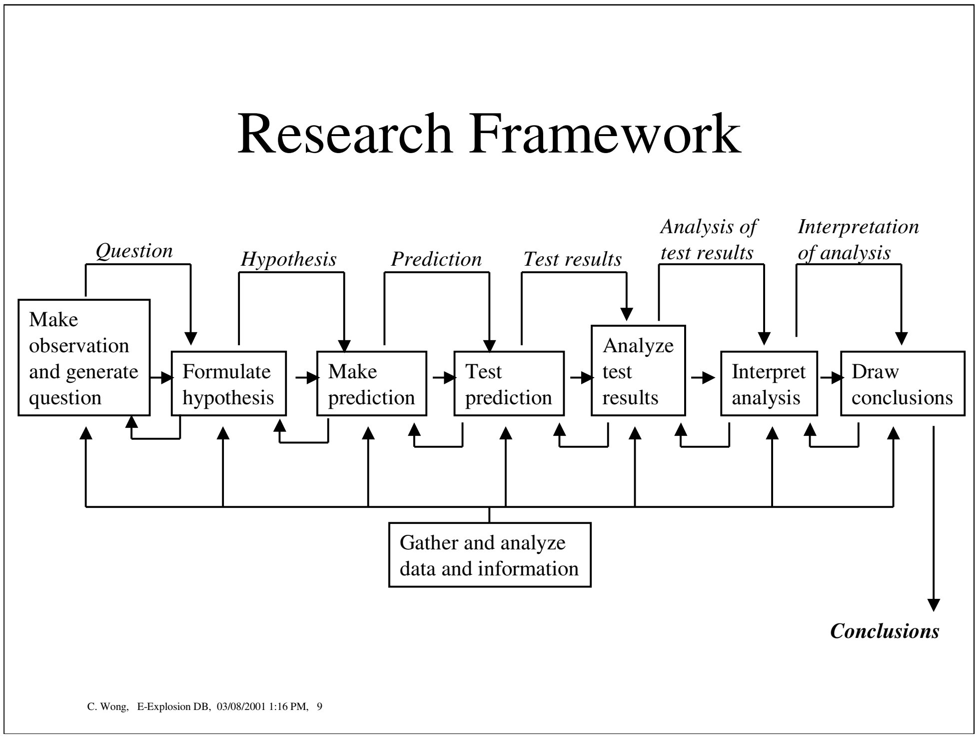
Taxonomy Is Based on Research Framework

- Framework contains interlocking steps that make up the research process
- Different types of research may entail different activities at each step
  - Framework allows for the many types of research and the variations on implementation and emphasis
- Framework is generic and reflects the research process
  - Research at RAND and Army traverses each step
- Framework gives us an organized manner to analyze what goes on during each phase of research
- Framework allows us to identify the e-tools that might help researchers complete each phase of research

The taxonomy of e-based research tools is based on a research framework. The research framework contains the interlocking steps that make up the research process. Different types of research may entail different activities at each step. The framework allows for the many types of research and the variations on implementation and emphasis.

The framework we have developed is generic and reflects a research process. In this representation, research traverses each interlocking step. In particular, research performed at RAND and research performed by the Army traverses each step, although different organizations or groups may perform each step. This research framework is consistent with various versions of the scientific method.

The framework allows us to analyze in an organized way events during each phase of the research process. By understanding what is to be accomplished at each step, we are then prepared to identify e-tools that might enhance the performance of each step.



Research Framework

Question

Hypothesis

Prediction

Test results

Analysis of test results

Interpretation of analysis

Make observation and generate question

Formulate hypothesis

Make prediction

Test prediction

Analyze test results

Interpret analysis

Draw conclusions

Gather and analyze data and information

Conclusions

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This figure depicts the research framework we developed for the taxonomy of e-based research tools. There are seven basic steps to the research process. These steps are shown above in the middle row of boxes. A research effort begins with an observation that generates a question to be investigated. This activity is followed by the formulation of a hypothesis. The researcher then makes a prediction about the hypothesis and proceeds to test the prediction. Analysis of the test results follows. That analysis is followed by an interpretation of the analysis and, finally, the researcher draws conclusions based on the entire research process. The research process ends with one or more conclusions regarding the question generated at the first step.

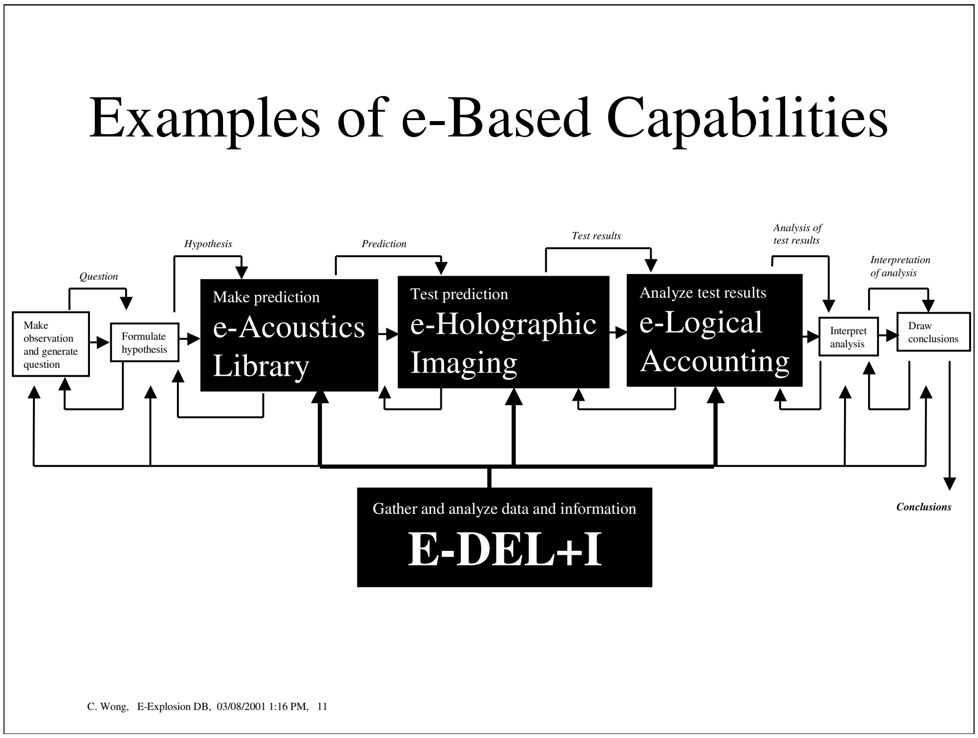
The backward arrows at the bottom of the boxes indicate the iterative nature of a typical research path. There may not be a one-time clean break between the steps. Rather, a set of formal or informal activities may help transition the research to the subsequent step.

The words in italics at the top of the figure show the products that result from the steps and that are input to the subsequent step. The “make observation and generate question” step results in a question that is input to the “formulate hypothesis” step. The “formulate hypothesis” step results in a hypothesis input to the “make prediction” step. The “make prediction” step results in a prediction input to the “test prediction” step. The “test prediction” step results in test results that are input to the “analyze test results” step. The “analyze test results” step results in an analysis of the test results input to the “interpret analysis" step. The "interpret analysis" step results in an interpretation of the analysis input to the "draw conclusions" step. The "draw conclusions" step results in one or more conclusions that address the question the research considered.

One of the most difficult activities to place was the "gather and analyze data and information" activity. As the figure shows, this activity is actually performed at every step. Different emphasis and methods might be used to perform this activity at the different steps.

E-capabilities can enhance or facilitate one or more steps of the research process. By associating e-capabilities with the steps they can influence, the research framework can serve as a structure for organizing a taxonomy of e-capabilites.

More detailed descriptions of each of the steps and the "gather and analyze data and information" activity are presented in the appendix: "Detailed Description of the Research Framework."



Examples of e-Based Capabilities

Question

Hypothesis

Prediction

Test results

Analysis of test results

Interpretation of analysis

Make observation and generate question

Formulate hypothesis

Make prediction
e-Acoustics Library

Test prediction
e-Holographic Imaging

Analyze test results
e-Logical Accounting

Interpret analysis

Draw conclusions

Conclusions

Gather and analyze data and information
E-DEL+I

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This figure shows examples of e-based tools currently in the taxonomy. For this initial phase of the project, we are concentrating on the “make prediction,” “test prediction,” “analyze test results,” and “gather and analyze data and information” steps of the research framework.

An e-Acoustics Library is an example of a tool that currently does not exist but is conceivably feasible and has a multitude of potential uses. Let us consider a civilian application first. Suppose a music writer/researcher wants to see if he can copyright a tune he has composed or a researcher wants to know the particulars of a specific piece of music but can only hum the tune. Currently, no way exists for either person to input a series of notes on a search engine and find the information he wants. An e-based acoustics library would be suited to inquiry by sound. Incorporated in such an e-tool would be a classification method to quickly identify and compare different sounds—a “Dewey decimal system” for sound. Acoustics experts may already have such a system, but it has not yet been adapted for Internet use.

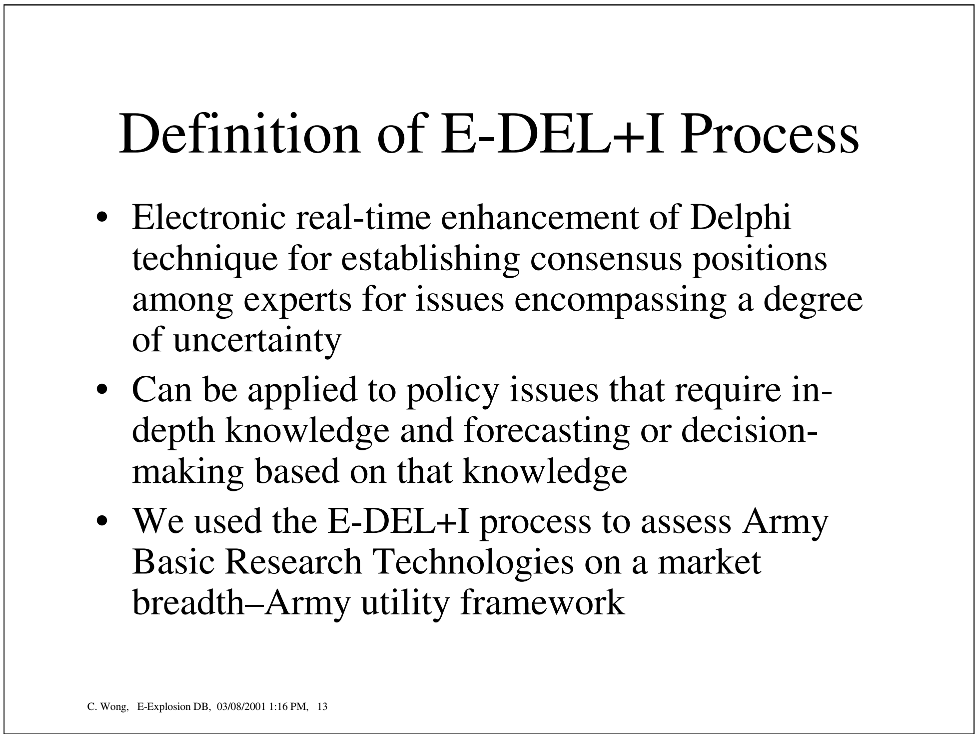
Such a capability would present a host of issues, such as how different a new set of sounds must be to be eligible for a new copyright or how much of a copyrighted piece can be used before a copyright is violated. The copyrighting or trademarking of sounds might expand.

This concept leads to a possible defense application. Could monitoring sound help identify what weapons or vehicles are being used by the enemy? Or perhaps, for example, if Ford Motor Company copyrighted the engine sound of its Bronco, it could then license the use of that sound to the Army for use in its tanks. The science of monitoring sound for intelligence purposes then becomes more complicated. The concept of countermeasures with respect to acoustics then becomes a field of study.

An e-Holographic Imaging tool could employ a (yet-to-be-developed) video camera to project a three-dimensional scene to another location. Applications would be numerous, with scientists in other locations able to view experiments virtually in person, concert-goers having virtual front-row center seats, etc.

A third e-technique is e-Logical Accounting in which experts in different specialties, using a structural approach, can contribute toward attaining a specific goal. For example, Fermat's Last Theorem was proved by a single mathematician who devoted seven years to the task. An oversight was discovered in his initial proof, but it was finally corrected with the assistance of another mathematician. If the mathematician had possessed an e-Logical Accounting capability whereby mathematicians could review his lines of reasoning as they were developed and offer their thoughts, would he have been able to address the oversight before his initial submission? Or could the proof have been accomplished in less time?

For this project, we focused on the "Gather and analyze data and information" portion of the research framework. In the "Gather and analyze data and information" activity, the researcher is selecting and acquiring or generating the data or information he needs to perform a step in the research process. Consensus-building among a panel of experts is one method for generating data. For this project, we focused on the "Gather and analyze data and information" portion of the research framework and developed a Delphi-inspired electronic consensus-building technique called the Electronic Decision Enhancement Leverager plus Integrator (E-DEL+I). E-DEL+I allows for four rounds of a Delphi exercise to be conducted in the course of a typical business meeting (two to three hours) while incorporating both written and oral media for input and maintaining the independence and anonymity of participants.



Definition of E-DEL+I Process

- Electronic real-time enhancement of Delphi technique for establishing consensus positions among experts for issues encompassing a degree of uncertainty
- Can be applied to policy issues that require in-depth knowledge and forecasting or decision-making based on that knowledge
- We used the E-DEL+I process to assess Army Basic Research Technologies on a market breadth–Army utility framework

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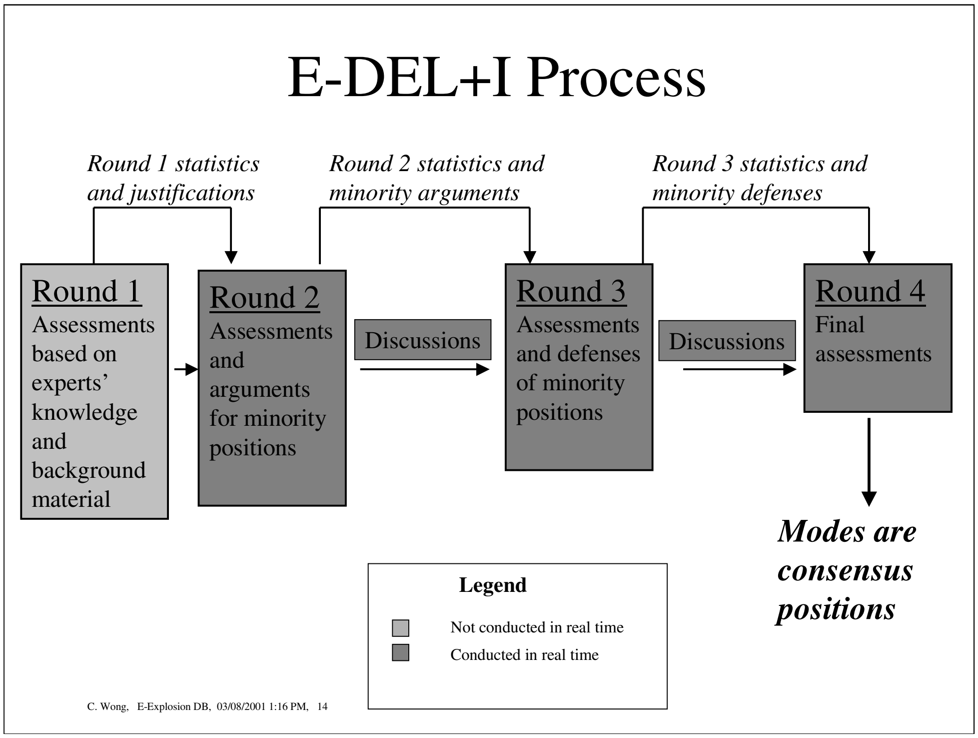
The E-DEL+I technique is an electronic real-time enhancement of the Delphi consensus-building methodology. This tool can be used for establishing consensus positions among experts for issues encompassing a degree of uncertainty. It can be applied to policy issues that require in-depth knowledge and forecasting or decisionmaking based on that knowledge. For example, economic and technology forecasts are often based on Delphi exercises.

In this project, we used the E-DEL+I technique to assess Army basic research technologies on a market breadth–Army utility framework. (A description of the market breadth–Army utility framework if given on p. 31 of this documented briefing. See Carolyn Wong, *An Analysis of Collaborative Research Opportunities for the Army*, Santa Monica, Calif.: RAND, MR-675-A, 1998, for a complete description of the market breadth–Army utility framework.)



E-DEL+I Process

Round 1 statistics and justifications

Round 2 statistics and minority arguments

Round 3 statistics and minority defenses

Round 1
Assessments based on experts' knowledge and background material

Round 2
Assessments and arguments for minority positions

Discussions

Round 3
Assessments and defenses of minority positions

Discussions

Round 4
Final assessments

Modes are consensus positions

Legend

▨ Not conducted in real time
■ Conducted in real time

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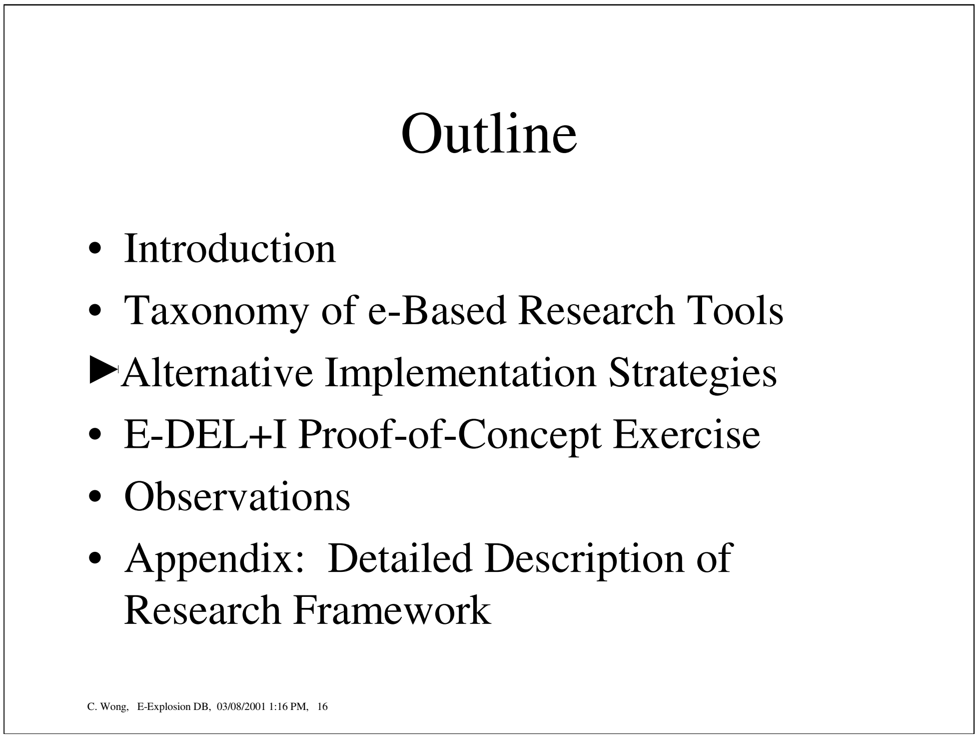
This chart shows the E-DEL+I process. The E-DEL+I process has four rounds. In the first round, experts complete questionnaires to supply assessments based on their specialized knowledge and background material provided. The exercise coordinator computes the statistical summary of the first-round inputs, and this summary—along with any justifications the experts provided with their assessments—is the feedback the exercise coordinator forwards to each participant along with a blank questionnaire. The experts review the feedback material and make a second assessment, this time supplying arguments for positions in the minority in the first round.

In the next step, however, the E-DEL+I process incorporates a real-time discussion period while the coordinator generates the feedback from the second round of inputs. At the end of the discussion period, a statistical summary and minority arguments from the second round are provided along with a third blank questionnaire for the third round. In the third round, participants again provide assessments and defenses for minority positions after reviewing the feedback material and considering what was presented in the discussion period. A second real-time discussion period occurs while the coordinator compiles the statistical summary and minority defenses from the third round. The summary and minority opinions along with a fourth questionnaire are sent to the participants at the end of the discussion period. In the fourth round, the experts provide their final assessments after reviewing and considering the feedback material and insights gained from the discussion periods. In our exercise, the statistical mode will be used as the consensus position. In other exercises, the mean or median may better reflect the consensus position.

In our exercise, the first round was not conducted in real time. This was a conscious decision to allow the participants an opportunity to review the background material adequately and familiarize themselves with the questionnaire format. It also allowed them to pose questions about the real-time sessions to follow. All subsequent steps were conducted in real time.



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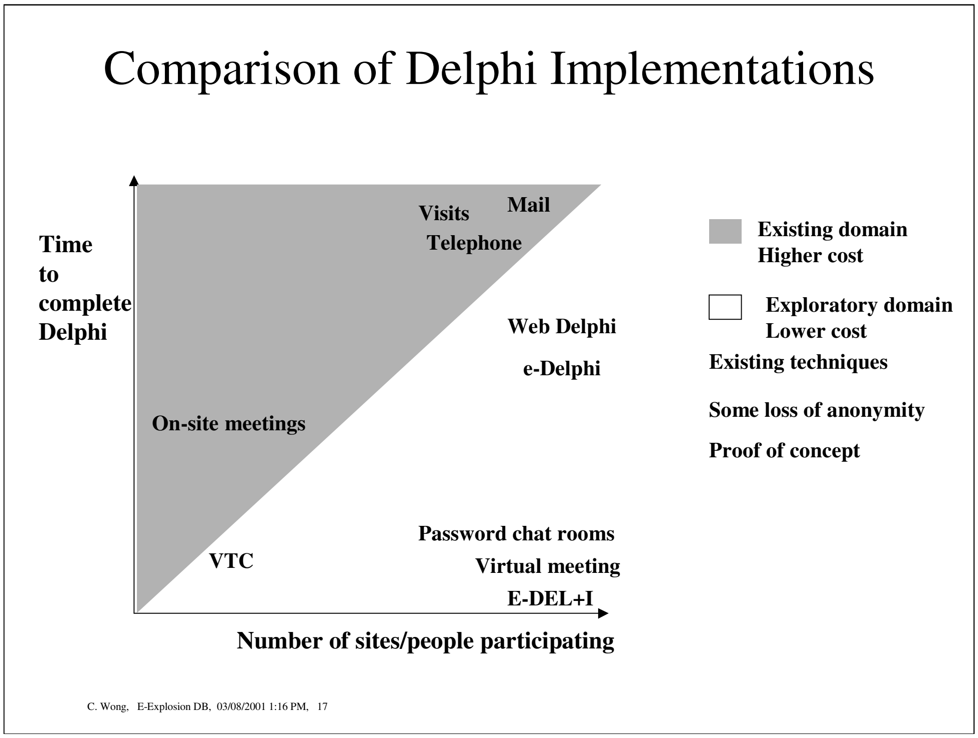
We will now discuss the alternative implementation strategies considered to conduct the proof-of-concept exercise.



Comparison of Delphi Implementations

▨ Existing domain
Higher cost

☐ Exploratory domain
Lower cost

Existing techniques

Some loss of anonymity

Proof of concept

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Before describing the experiment itself, it is useful to know how Delphi implementations have been carried out in the past—before the e-explosion. Delphi exercises have typically been conducted by mail, on-site meetings, in-person visits, or telephone. These implementations reside in the generally higher-cost existing domain shown in the shaded triangle.

In the mail implementation, participants are mailed questionnaires and asked to complete and return them for tabulation. Feedback material and a new questionnaire are forwarded to each participant for each subsequent round. This process can take months to accomplish and often entails reminder postcards and telephone calls. In addition, the focus of the experts is often fragmented by the prolonged exercise. Also, since these exercises are conducted with written input, those more gifted in written communications can have an advantage over those with stronger oral communications skills.

On-site meetings involve bringing all of the participants together to one site at the same time. In this setting, the exercise can be conducted in writing or orally. However, finding a time when all the participants can be brought together can be logistically challenging as well as expensive.

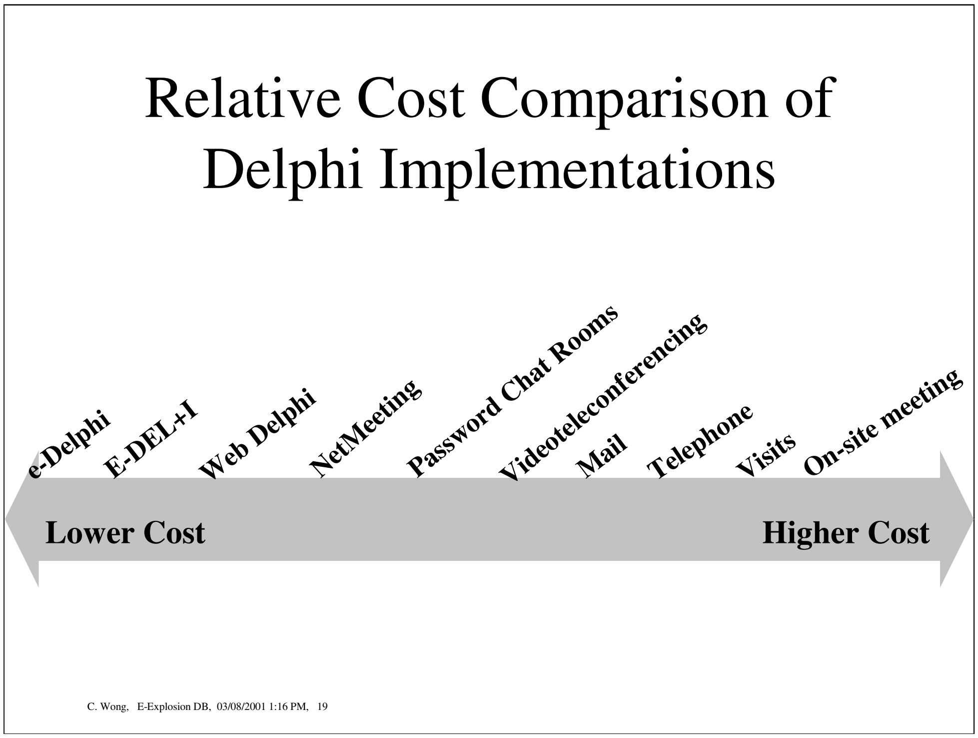
On-site visits and telephone interviews are less common. In these cases, one or more coordinators record the interview responses. The accuracy of the recording is paramount to the success of the exercise. Also, discussions cannot be incorporated. Because one or more coordinators are directly involved in contacting the participants, these implementations can be long in duration or restricted to smaller exercises.

In the exploratory domain are such implementations as video-teleconferencing (VTC), password chat rooms, and network communications packages, such as NetMeeting. With these techniques, some loss of anonymity is more likely because the participants are tagged with either a photo identifier in VTC or a written identifier in chat rooms and network communications packages. In these cases, steps should be taken, such as scrambling of identifiers after each round, to help ensure anonymity.

Web Delphi and e-Delphi techniques have been tried. In the Web technique, the Internet is used as the medium and the exercise and the material are generally posted on a Web site. Participants log onto the Web site during a specified period (e.g., a week) and provide inputs at times compatible with their individual schedules. Subsequent rounds are similarly conducted. This implementation cannot accommodate real-time discussions, and the exercise is conducted with written communications, possibly giving an advantage to those with strong writing skills. Instant Messaging and Internet Chat are other media that are growing rapidly, and these capabilities may also play roles in future Delphi-like exercises.

E-Delphi is a technique where e-mail is used to conduct the exercise. The participants receive exercise material via e-mail and return their responses using the same medium. Discussions are by e-mail, slightly delayed from real time, and the exercise is conducted with written communications possibly giving those with strong writing skills an advantage.

Finally, E-DEL+I is the subject of our proof-of-concept exercise, where we will incorporate both written and oral communications along with real-time conduct of the exercise.



Relative Cost Comparison of Delphi Implementations

e-Delphi
E-DEL+I
Web Delphi
NetMeeting
Password Chat Rooms
Videoteleconferencing
Mail
Telephone
Visits
On-site meeting

Lower Cost
Higher Cost

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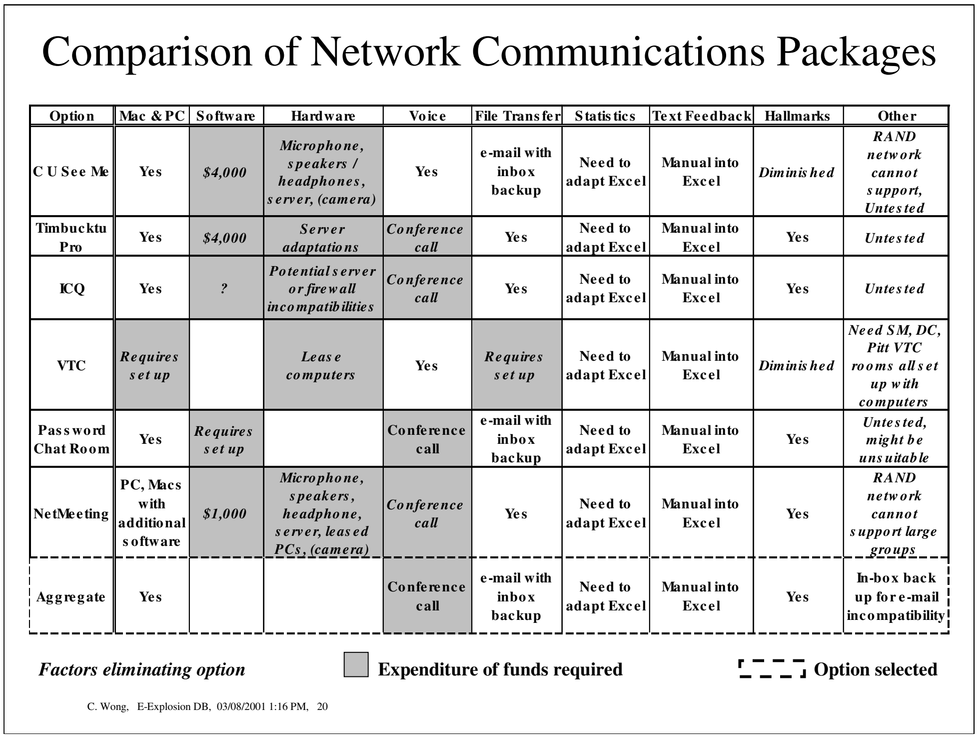
This figure shows the relative costs of conducting a Delphi exercise using various implementations. In general, the electronically based implementations such as e-Delphi, E-DEL+I, Web Delphi, NetMeeting, and Password Chat Rooms are less costly to conduct than the more traditional methods such as on-site meetings, visits, telephone, and mail. Videoteleconferencing (VTC) costs can vary greatly depending on access to facilities providing VTC services.



Comparison of Network Communications Packages

Option	Mac & PC	Software	Hardware	Voice	File Transfer	Statistics	Text Feedback	Hallmarks	Other
C U See Me	Yes	*$4,000*	*Microphone, speakers / headphones, server, (camera)*	Yes	e-mail with inbox backup	Need to adapt Excel	Manual into Excel	*Diminished*	*RAND network cannot support, Untested*
Timbucktu Pro	Yes	*$4,000*	*Server adaptations*	*Conference call*	Yes	Need to adapt Excel	Manual into Excel	Yes	*Untested*
ICQ	Yes	*?*	*Potential server or firewall incompatibilities*	*Conference call*	Yes	Need to adapt Excel	Manual into Excel	Yes	*Untested*
VTC	*Requires set up*		*Lease computers*	Yes	*Requires set up*	Need to adapt Excel	Manual into Excel	*Diminished*	*Need SM, DC, Pitt VTC rooms all set up with computers*
Password Chat Room	Yes	*Requires set up*		Conference call	e-mail with inbox backup	Need to adapt Excel	Manual into Excel	Yes	*Untested, might be unsuitable*
NetMeeting	PC, Macs with additional software	*$1,000*	*Microphone, speakers, headphone, server, leased PCs, (camera)*	*Conference call*	Yes	Need to adapt Excel	Manual into Excel	Yes	*RAND network cannot support large groups*
Aggregate	Yes			Conference call	e-mail with inbox backup	Need to adapt Excel	Manual into Excel	Yes	In-box back up for e-mail incompatibility

Factors eliminating option ▨ **Expenditure of funds required** ⬚ **Option selected**

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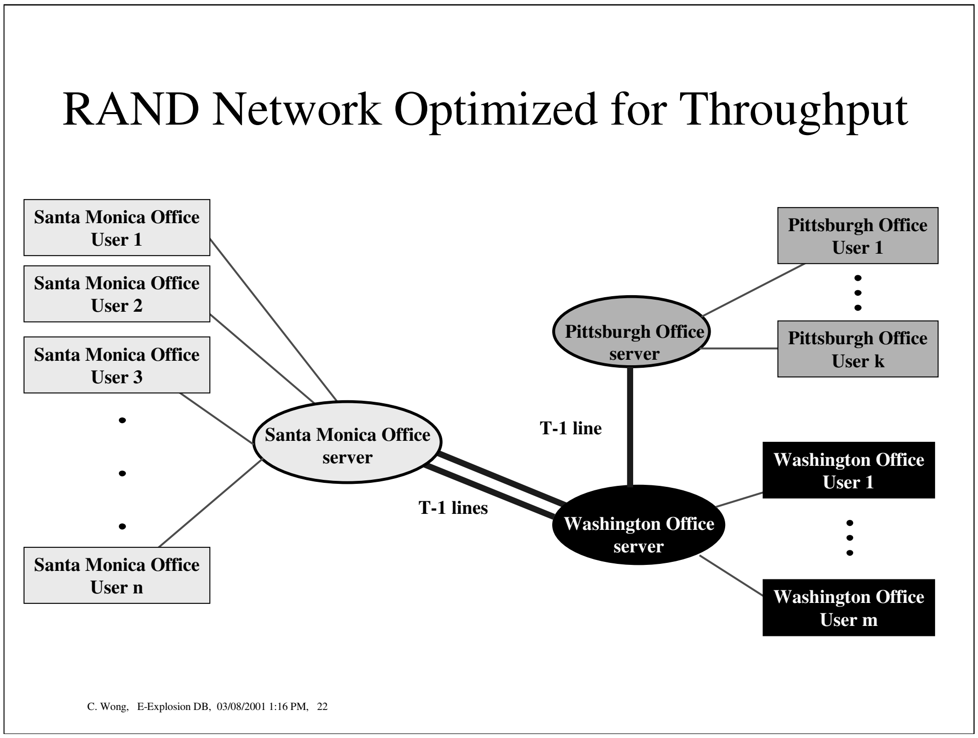
We examined several ways to conduct the proof-of-concept exercise. This figure shows a comparison of the various alternatives along a number of dimensions. Each row in the matrix shows a different alternative. The shaded boxes are elements that would require additional costs in either purchasing or leasing software or hardware or manpower costs that would be in addition to participant and exercise coordinator costs. Elements in italic type show the factors that together eliminated the option. The Aggregate option in the last row was selected for the proof-of-concept exercise.

In the Aggregate alternative, Macs and PCs could be accommodated. Hence, participants could use the computer equipment they already had in their offices. No additional hardware or software would be required. All-way voice communications would be established through a conference call with a third-party provider. (For this exercise, Genesys Conferencing provided the conference call services at a rate of $20 per hour per participant.) Participants would use e-mail as the primary method for sending their completed questionnaires to the exercise coordinator. The existing inbox capability established by the RAND computing department was designated as a backup file transfer mechanism should e-mail become unavailable at any time during the real-time exercise. We exploited the statistical computation capability of Excel to compute the statistical feedback. Text feedback would also be provided via Excel because this would allow the participant to use a single software package to complete the questionnaire as well as write his minority arguments and defenses. Compilation of the participants’ questionnaires would be a manual procedure performed by the exercise coordinator. (In a second exercise, some Excel software macros were written by team participant David Owen to allow for semiautomated compilation of questionnaire responses.) Finally, the Aggregate method could accommodate the hallmarks of Delphi exercises—anonymity and independence of the participants.



RAND Network Optimized for Throughput

Santa Monica Office User 1

Santa Monica Office User 2

Santa Monica Office User 3

Santa Monica Office User n

Santa Monica Office server

T-1 lines

T-1 line

Pittsburgh Office server

Pittsburgh Office User 1

Pittsburgh Office User k

Washington Office server

Washington Office User 1

Washington Office User m

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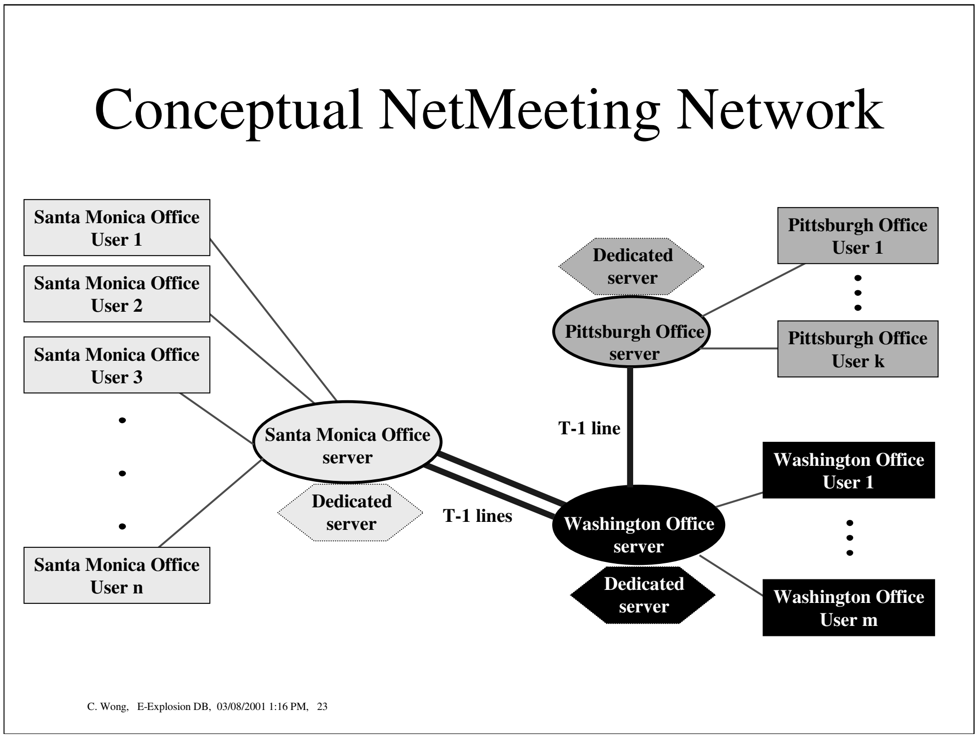
This figure provides an overview of the RAND network. One of the reasons for choosing the Aggregate method was that most of the expert participants would be RAND employees or consultants and the Aggregate method exploits the capabilities of the RAND intranet. The RAND intranet is optimized to provide maximum throughput between points regardless of the protocol. It is essentially one or two T-1 lines, each of which provides 1.5 megabits per second network throughput. Our preexercise tests showed that forwarding questionnaires as Excel e-mail attachments met the real-time constraints of the proof-of-concept exercise.



Conceptual NetMeeting Network

Santa Monica Office User 1

Santa Monica Office User 2

Santa Monica Office User 3

•

•

•

Santa Monica Office User n

Santa Monica Office server

Dedicated server

T-1 lines

Dedicated server

Pittsburgh Office server

Pittsburgh Office User 1

•
•
•

Pittsburgh Office User k

T-1 line

Washington Office server

Dedicated server

Washington Office User 1

•
•
•

Washington Office User m

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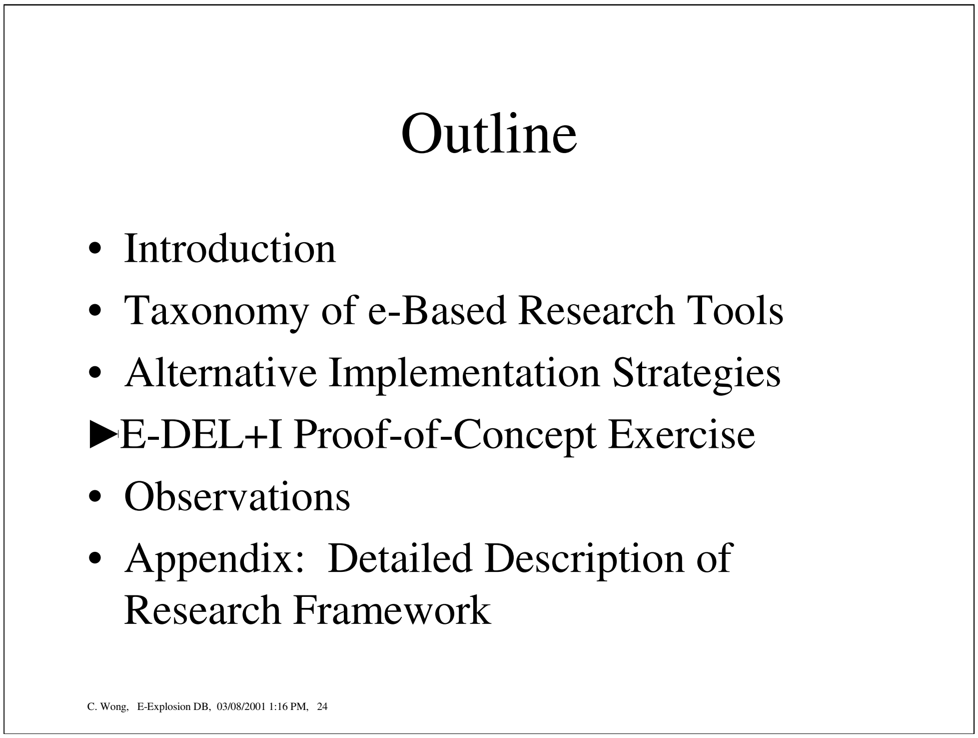
By comparison, for the complementary Microsoft NetMeeting package to work efficiently, a setup similar to the one shown on this figure would have been needed to meet the constraints of the proof-of-concept exercise. Likewise, the other existing commercial software packages could not be efficiently accommodated on the existing RAND network without incurring substantial expenses to adapt the software.



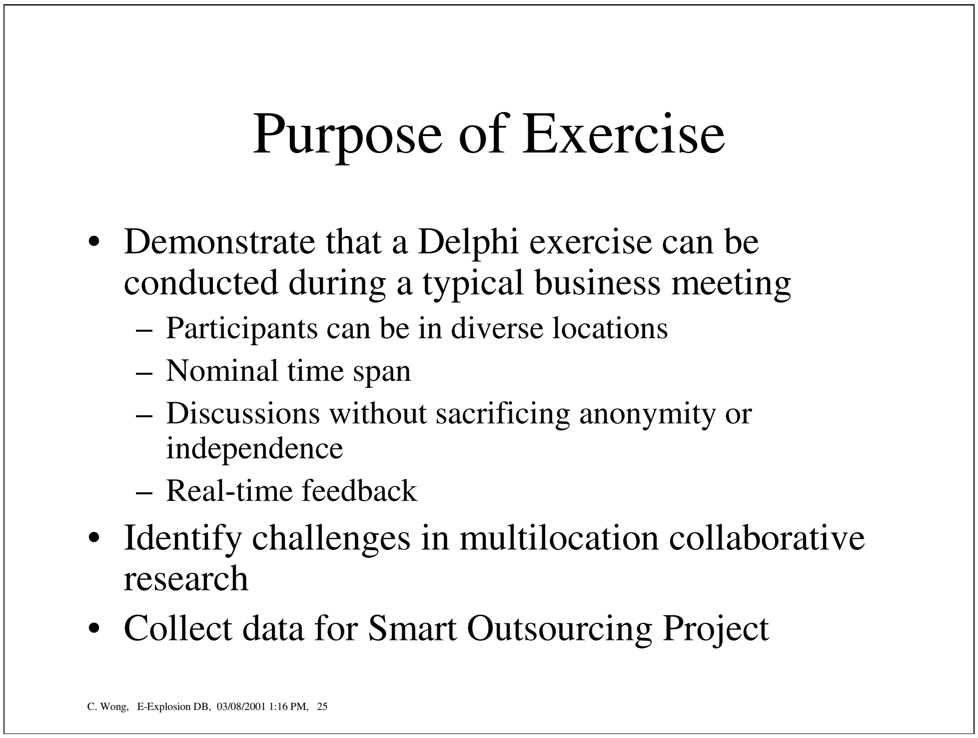
Outline

- Introduction
- Taxonomy of e-Based Research Tools
- Alternative Implementation Strategies

►E-DEL+I Proof-of-Concept Exercise

- Observations
- Appendix: Detailed Description of Research Framework

We will now discuss the E-DEL+I proof-of-concept exercise.



Purpose of Exercise

- Demonstrate that a Delphi exercise can be conducted during a typical business meeting
  - Participants can be in diverse locations
  - Nominal time span
  - Discussions without sacrificing anonymity or independence
  - Real-time feedback
- Identify challenges in multilocation collaborative research
- Collect data for Smart Outsourcing Project

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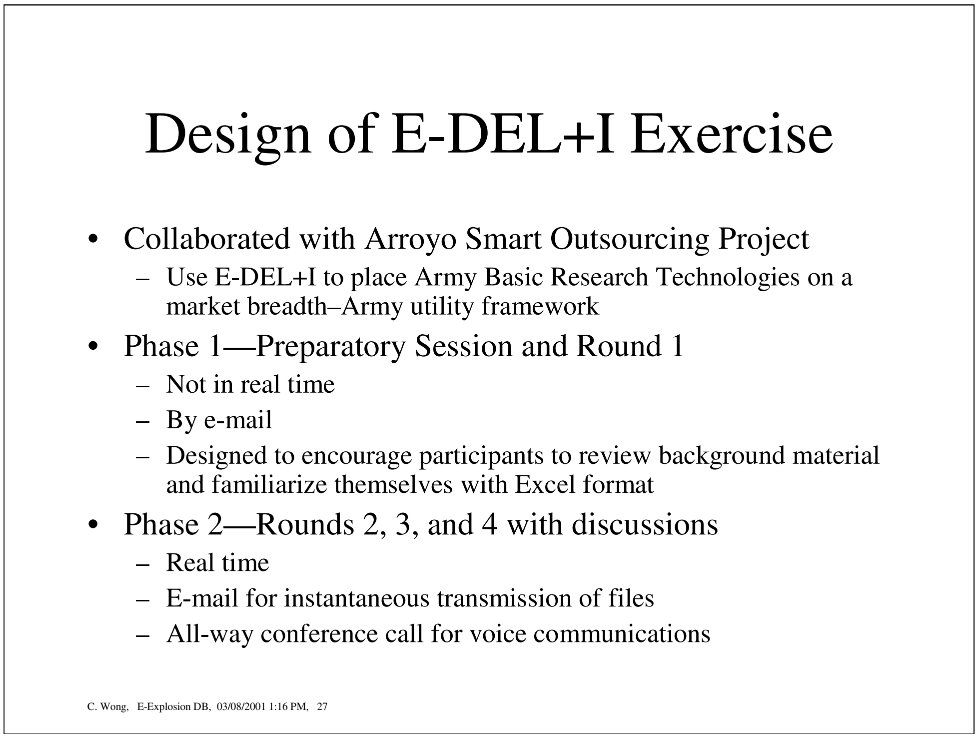
Our E-DEL+I proof-of-concept exercise had several purposes. One was to demonstrate that a Delphi-like exercise can be conducted during a typical business meeting. If this could be demonstrated, then a phase of research could be accomplished in significantly less time than other implementations allow. For our exercise, participants would be in diverse locations. In fact, each participant took part in the exercise from his or her own office. Offices were in Santa Monica, Arlington, and Pittsburgh. (Computer connections were actually made through the RAND Santa Monica, Washington, and Pittsburgh offices as well as from the University of Southern California in Los Angeles. In a second exercise using this implementation, computer connections were made through the three RAND offices as well as from the University of Southern California and from Army Materiel Command Headquarters in Arlington, Virginia.) We sought to demonstrate that a phase of research could be completed in a nominal time span—two to three hours. In addition, we sought to show that real-time discussion sessions could be incorporated without sacrificing the anonymity or independence of the participants—the hallmarks of a Delphi exercise. Furthermore, we wanted to show that it is possible to provide real-time feedback to the participants to enhance their assessment abilities.

Since the proof-of-concept exercise would be the first of its kind, we also wanted to identify any challenges that this type of collaborative research effort might have.

Finally, we collaborated with the Arroyo Center Smart Outsourcing Project and generated data needed for it, completing a phase of research for that project.

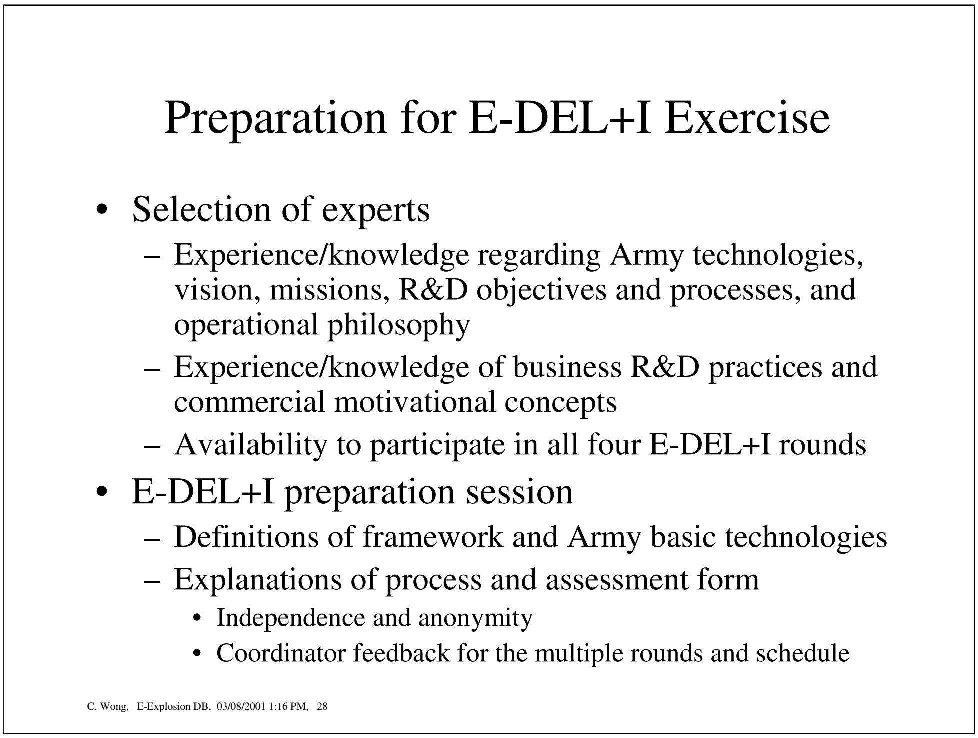


Design of E-DEL+I Exercise

- Collaborated with Arroyo Smart Outsourcing Project
  - Use E-DEL+I to place Army Basic Research Technologies on a market breadth–Army utility framework
- Phase 1—Preparatory Session and Round 1
  - Not in real time
  - By e-mail
  - Designed to encourage participants to review background material and familiarize themselves with Excel format
- Phase 2—Rounds 2, 3, and 4 with discussions
  - Real time
  - E-mail for instantaneous transmission of files
  - All-way conference call for voice communications

The purpose of the Arroyo Center Smart Outsourcing Project was to identify technologies that were good candidates for the Army to use for various outsourcing approaches to accomplish research goals. It included a task to place the Army Basic Research Technologies on a market breadth–Army utility framework. One method for accomplishing this task is through a Delphi exercise. We collaborated with the Smart Outsourcing Project and used the E-DEL+I method to accomplish the task. Hence, the collaboration would allow the Smart Outsourcing Project to complete a phase of research at the same time it allowed the e-Explosion Project to accomplish its proof-of-concept exercise for the E-DEL+I technique.

We divided the exercise into two parts. The first phase consisted of a preparatory session and the first round of the exercise. This phase was deliberately not conducted in real time, but rather by e-mail so that the participants had a chance to ask questions about the E-DEL+I process and familiarize themselves with the questionnaire format and e-mail attachment file transfer process. The second phase consisted of Rounds 2, 3, and 4 with discussion periods. The second phase was conducted in real time using e-mail for file transmissions and an all-way conference call for the discussion sessions.

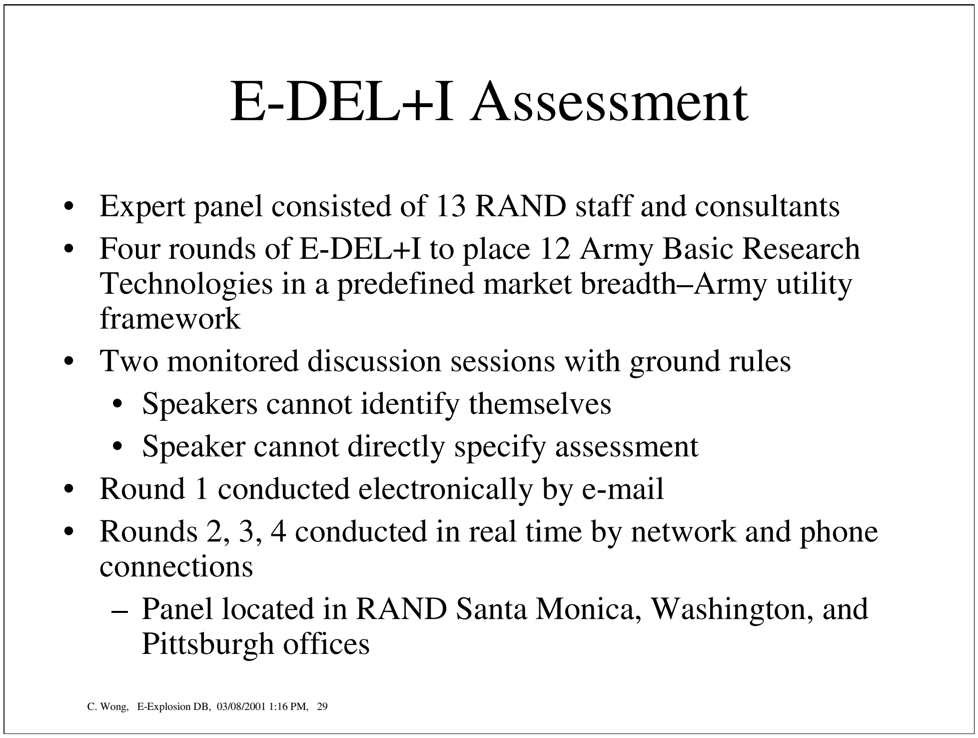


Preparation for E-DEL+I Exercise

- Selection of experts
  - Experience/knowledge regarding Army technologies, vision, missions, R&D objectives and processes, and operational philosophy
  - Experience/knowledge of business R&D practices and commercial motivational concepts
  - Availability to participate in all four E-DEL+I rounds
- E-DEL+I preparation session
  - Definitions of framework and Army basic technologies
  - Explanations of process and assessment form
    - Independence and anonymity
    - Coordinator feedback for the multiple rounds and schedule

One of our first tasks was to select the experts who would participate in the proof-of-concept exercise. We worked with the Smart Outsourcing Project team to identify suitable participants. The criteria for selection included experience and knowledge of Army technologies, vision, missions, research and development objectives and processes, and Army operational philosophy. In addition, the participants were required to have some degree of experience or knowledge of business research and development practices and commercial motivational concepts. Finally, the participant had to be available to participate in both phases of the exercise.

We offered a preparation session to all participants. During this session, we reviewed the definitions of the market breadth–Army utility framework and the Army Basic Research Technologies. In addition, we provided oral explanations of the E-DEL+I process and reviewed the assessment form (i.e., the questionnaire). We emphasized the importance of the participants' maintenance of independence and anonymity in providing their assessments and explained the role of the coordinator. In addition, we informed the participants that an assistant would be available should anyone have e-mail problems or problems with conference call procedures. (Janie Young of RAND served as the assistant during the exercise.) All of this information was provided in writing by e-mail prior to the preparation session. Hence, attending the preparation session was optional.

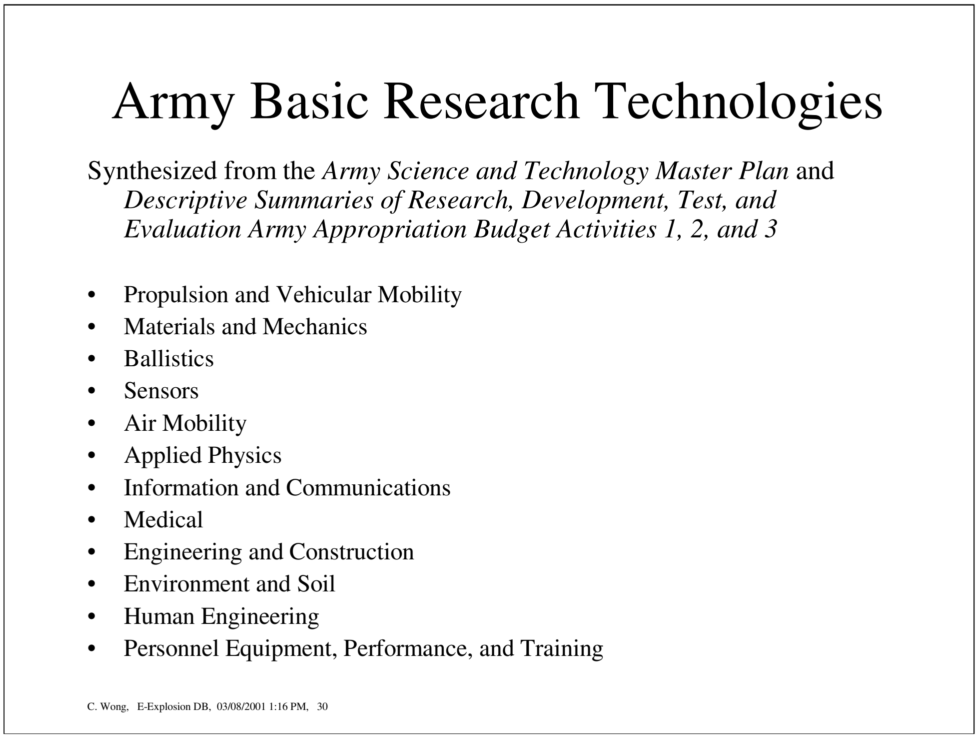


E-DEL+I Assessment

- Expert panel consisted of 13 RAND staff and consultants
- Four rounds of E-DEL+I to place 12 Army Basic Research Technologies in a predefined market breadth–Army utility framework
- Two monitored discussion sessions with ground rules
  - Speakers cannot identify themselves
  - Speaker cannot directly specify assessment
- Round 1 conducted electronically by e-mail
- Rounds 2, 3, 4 conducted in real time by network and phone connections
  - Panel located in RAND Santa Monica, Washington, and Pittsburgh offices

The E-DEL+I assessment consisted of four rounds of expert assessments to place twelve Army Basic Research Technologies on a predefined market breadth–Army utility framework. The expert panel of participants consisted of 13 RAND staff and consultants. Round 1 was conducted electronically, where participants returned their completed first-round questionnaires to the exercise coordinator by e-mail. Rounds 2, 3, and 4 were conducted in real time on January 19, 2001. Expert panel members participated from their Santa Monica, Washington, and Pittsburgh RAND offices. (One consultant established computer connections through the University of Southern California.)

Two discussion sessions were included as part of the exercise. The first discussion session occurred between the second and third rounds. The second discussion session occurred between the third and fourth rounds. We specified two ground rules for the monitored discussion sessions. The first rule was that the speaker could not identify himself either by name or by job title. The second rule was that the speaker could not directly specify his assessment. We imposed these rules to ensure the anonymity and independence aspects of the exercise. (Bruce Held of RAND served as the discussion monitor.) No violations of the ground rules occurred.

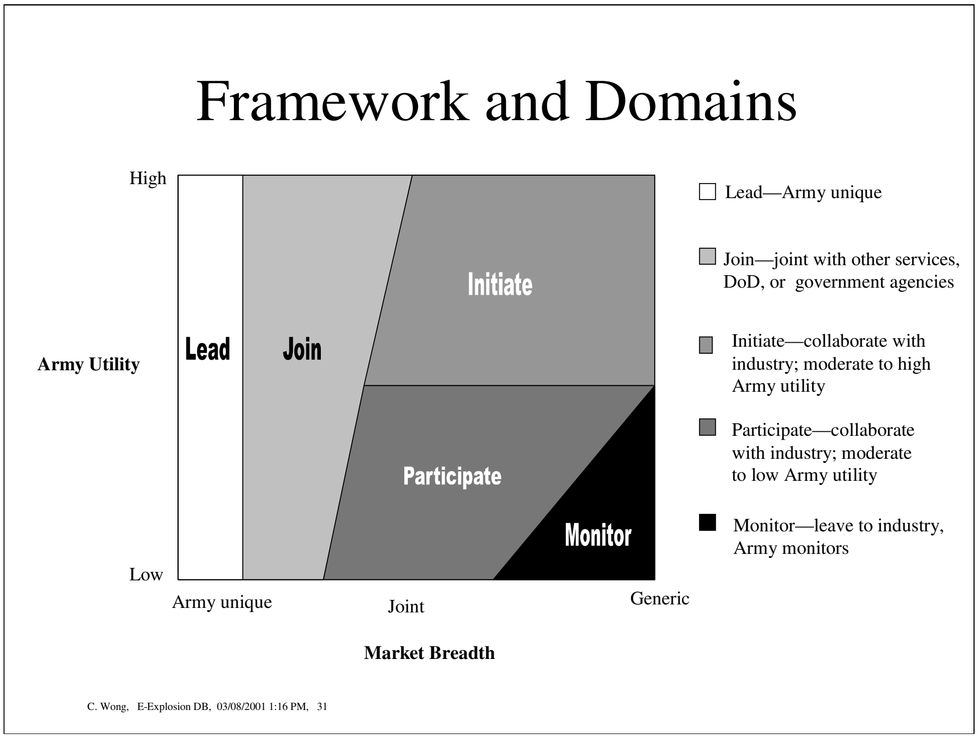


Army Basic Research Technologies

Synthesized from the *Army Science and Technology Master Plan* and *Descriptive Summaries of Research, Development, Test, and Evaluation Army Appropriation Budget Activities 1, 2, and 3*

- Propulsion and Vehicular Mobility
- Materials and Mechanics
- Ballistics
- Sensors
- Air Mobility
- Applied Physics
- Information and Communications
- Medical
- Engineering and Construction
- Environment and Soil
- Human Engineering
- Personnel Equipment, Performance, and Training

The Army Basic Research Technologies that the expert panel placed on the market breadth–Army utility framework are shown on this figure.



Framework and Domains

☐ Lead—Army unique

▨ Join—joint with other services, DoD, or government agencies

▨ Initiate—collaborate with industry; moderate to high Army utility

▨ Participate—collaborate with industry; moderate to low Army utility

■ Monitor—leave to industry, Army monitors

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This figure shows the market breadth–Army utility framework. Market breadth means the amount of appeal the technology has to the commercial sector and hence how interested other sectors might be in performing basic research in the technology. Army utility is the amount of potential contribution the technology has in helping the Army accomplish its military mission.

The framework is composed of five domains: Lead, Join, Initiate, Participate, and Monitor. The E-DEL+I exercise asked each member of the expert panel to independently and anonymously place each of the twelve Army Basic Research Technologies in the domain that, in that expert's judgment, best reflects the technology's market breadth and Army utility.

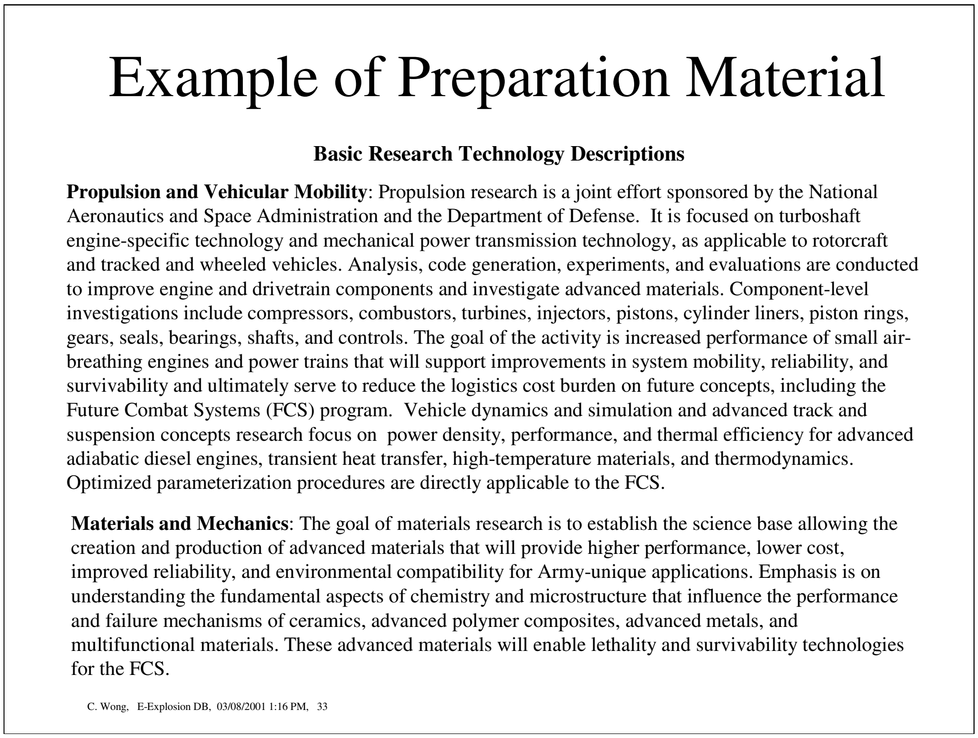
A "Lead" placement indicates that the technology has limited appeal outside of the Army and hence the Army must perform most of the basic research in-house.

A "Join" placement indicates that the technology is of interest to other military or government agencies and an effective approach is for the Army to perform basic research in the technology as joint projects with one or more of the other interested government entities.

An "Initiate" placement indicates that the technology has moderate to high Army utility and also appeals to industry. The Army should collaborate with industry but might want to initiate the effort to help ensure that its military-specific needs are met.

A “Participate” placement indicates that the technology has of moderate to low Army utility and also appeals to industry. The Army should collaborate with industry to accomplish basic research goals in these technologies.

A “Monitor” placement indicates that the technology has moderate to low Army utility and has high industry appeal. The Army can rely on industry to perform basic research in these technologies, supplying little or no Army resources.



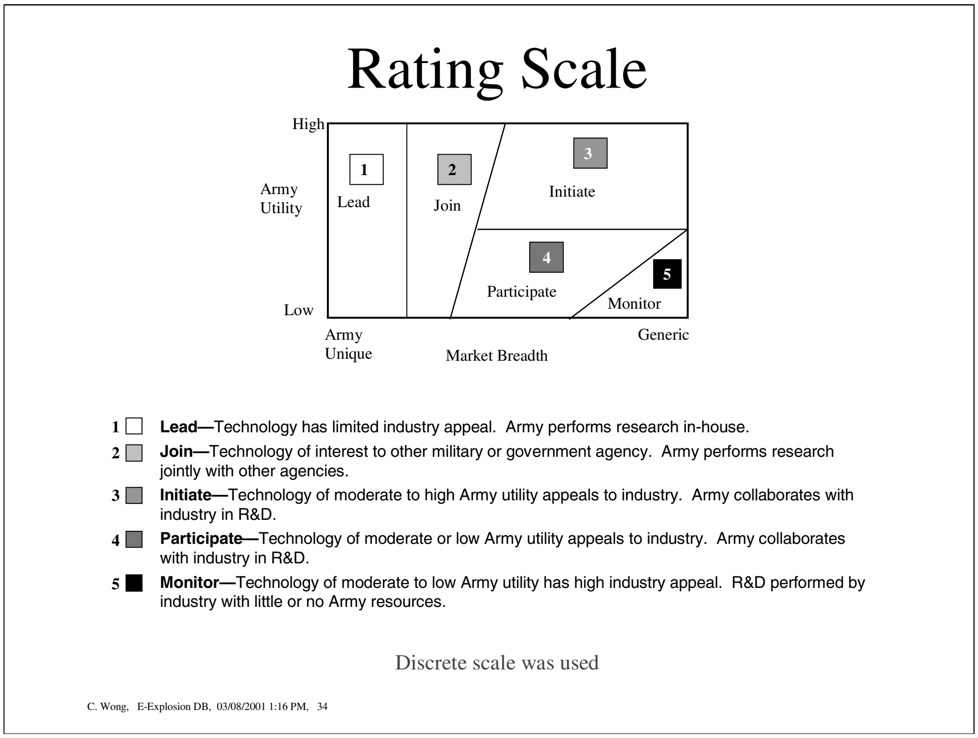
Example of Preparation Material

Basic Research Technology Descriptions

Propulsion and Vehicular Mobility: Propulsion research is a joint effort sponsored by the National Aeronautics and Space Administration and the Department of Defense. It is focused on turboshaft engine-specific technology and mechanical power transmission technology, as applicable to rotorcraft and tracked and wheeled vehicles. Analysis, code generation, experiments, and evaluations are conducted to improve engine and drivetrain components and investigate advanced materials. Component-level investigations include compressors, combustors, turbines, injectors, pistons, cylinder liners, piston rings, gears, seals, bearings, shafts, and controls. The goal of the activity is increased performance of small air-breathing engines and power trains that will support improvements in system mobility, reliability, and survivability and ultimately serve to reduce the logistics cost burden on future concepts, including the Future Combat Systems (FCS) program. Vehicle dynamics and simulation and advanced track and suspension concepts research focus on power density, performance, and thermal efficiency for advanced adiabatic diesel engines, transient heat transfer, high-temperature materials, and thermodynamics. Optimized parameterization procedures are directly applicable to the FCS.

Materials and Mechanics: The goal of materials research is to establish the science base allowing the creation and production of advanced materials that will provide higher performance, lower cost, improved reliability, and environmental compatibility for Army-unique applications. Emphasis is on understanding the fundamental aspects of chemistry and microstructure that influence the performance and failure mechanisms of ceramics, advanced polymer composites, advanced metals, and multifunctional materials. These advanced materials will enable lethality and survivability technologies for the FCS.

This figure shows an example of the background material that was provided to all participants. Participants received the material as e-mail attachments. In addition, the material was orally reviewed during the optional preparation session.



Rating Scale

1 ☐ **Lead—**Technology has limited industry appeal. Army performs research in-house.

2 ▨ **Join—**Technology of interest to other military or government agency. Army performs research jointly with other agencies.

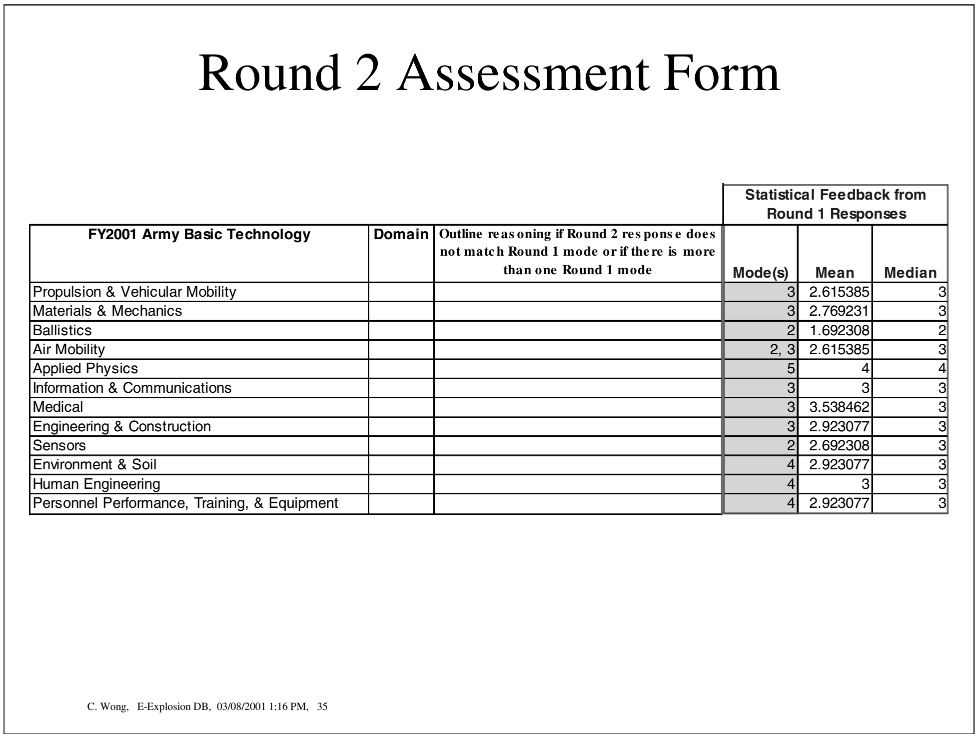
3 ▨ **Initiate—**Technology of moderate to high Army utility appeals to industry. Army collaborates with industry in R&D.

4 ▨ **Participate—**Technology of moderate or low Army utility appeals to industry. Army collaborates with industry in R&D.

5 ■ **Monitor—**Technology of moderate to low Army utility has high industry appeal. R&D performed by industry with little or no Army resources.

Discrete scale was used

This figure shows the predetermined rating scale the participants used to assess placement of the technologies. For each Army Basic Research Technology, the participant would designate the integer from one to five that he felt best reflects that technology's market breadth and Army utility.



Round 2 Assessment Form

			Statistical Feedback from Round 1 Responses		
FY2001 Army Basic Technology	**Domain**	**Outline reasoning if Round 2 response does not match Round 1 mode or if there is more than one Round 1 mode**	**Mode(s)**	**Mean**	**Median**
Propulsion & Vehicular Mobility			3	2.615385	3
Materials & Mechanics			3	2.769231	3
Ballistics			2	1.692308	2
Air Mobility			2, 3	2.615385	3
Applied Physics			5	4	4
Information & Communications			3	3	3
Medical			3	3.538462	3
Engineering & Construction			3	2.923077	3
Sensors			2	2.692308	3
Environment & Soil			4	2.923077	3
Human Engineering			4	3	3
Personnel Performance, Training, & Equipment			4	2.923077	3

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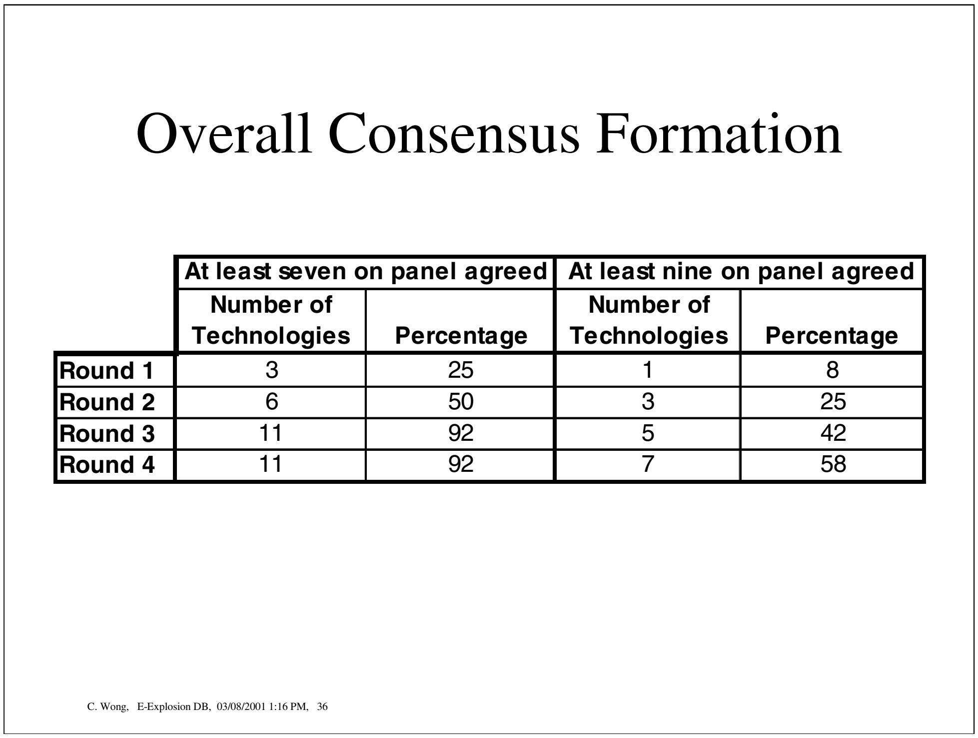
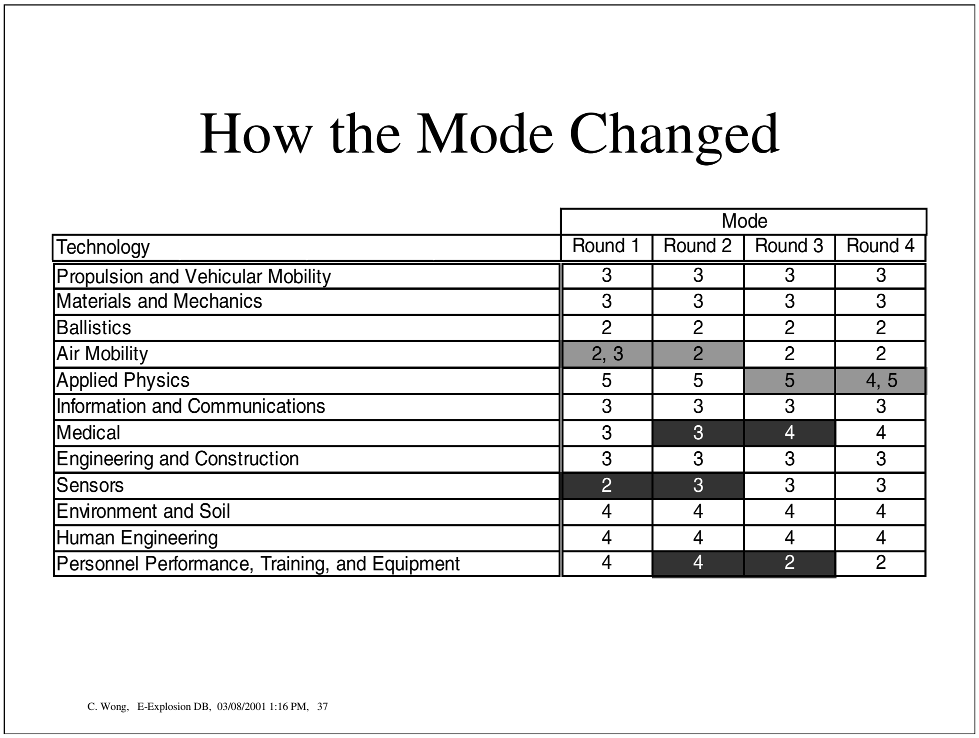
This figure shows the Round 2 Assessment form. The E-DEL+I exercise assessment forms were developed in Excel. Excel was chosen because all participants already had this software package installed on their computers; Excel has a well-known interface; Excel is very easy to use as a prototyping tool; and Excel could accommodate the needs of the proof-of-concept exercise with minimal software development costs. In addition, computation of statistical feedback would be facilitated by Excel's built-in statistical functions.



Overall Consensus Formation

	At least seven on panel agreed		At least nine on panel agreed	
	Number of Technologies	Percentage	Number of Technologies	Percentage
Round 1	3	25	1	8
Round 2	6	50	3	25
Round 3	11	92	5	42
Round 4	11	92	7	58

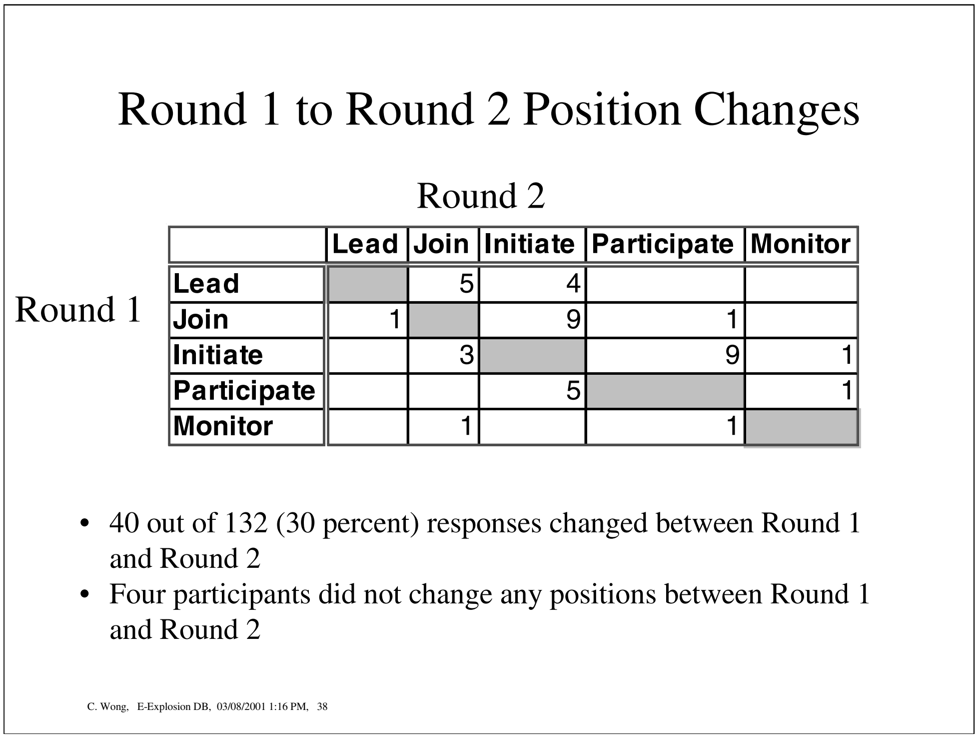
This figure shows the results of each round of the exercise. The second column shows the number of technologies where at least seven expert panel members agreed on placement in the framework for each round. The associated percentages are shown in the third column. The fourth column shows the number of technologies where at least nine expert panel members agreed on placement in the framework for each round. The associated percentages are shown in the fifth column. Using the results shown in either the second column or the fourth column, this figure shows that the feedback and discussion sessions helped establish consensus positions for more technologies in each subsequent round. Using the results shown in the second column, consensus was reached on 11 of the 12 technologies in Round 4. Using the results shown in the fourth column, consensus was reached on 7 of the 12 technologies in the final round.



How the Mode Changed

	Mode			
Technology	Round 1	Round 2	Round 3	Round 4
Propulsion and Vehicular Mobility	3	3	3	3
Materials and Mechanics	3	3	3	3
Ballistics	2	2	2	2
Air Mobility	2, 3	2	2	2
Applied Physics	5	5	5	4, 5
Information and Communications	3	3	3	3
Medical	3	3	4	4
Engineering and Construction	3	3	3	3
Sensors	2	3	3	3
Environment and Soil	4	4	4	4
Human Engineering	4	4	4	4
Personnel Performance, Training, and Equipment	4	4	2	2

For this exercise, the mode was used as the consensus position statistic. Since we are placing technologies on a framework, where most experts placed the technology (i.e., in the Lead, Join, Initiate, Participate, or Monitor domains) is the best indication of a consensus position among them. Because the statistical mode of each round is mathematically defined as the category with the greatest number of placements by the experts, this statistic is the most appropriate measure of consensus for this exercise. This figure shows how the mode changed for each technology for each round. The lighter-shaded boxes show how either dual modes changed to single modes or single modes changed to dual modes in the subsequent round. The darker-shaded boxes show single modes changing to other single modes in the subsequent round. The unshaded boxes show constant modes from one round to the subsequent round.



Round 1 to Round 2 Position Changes

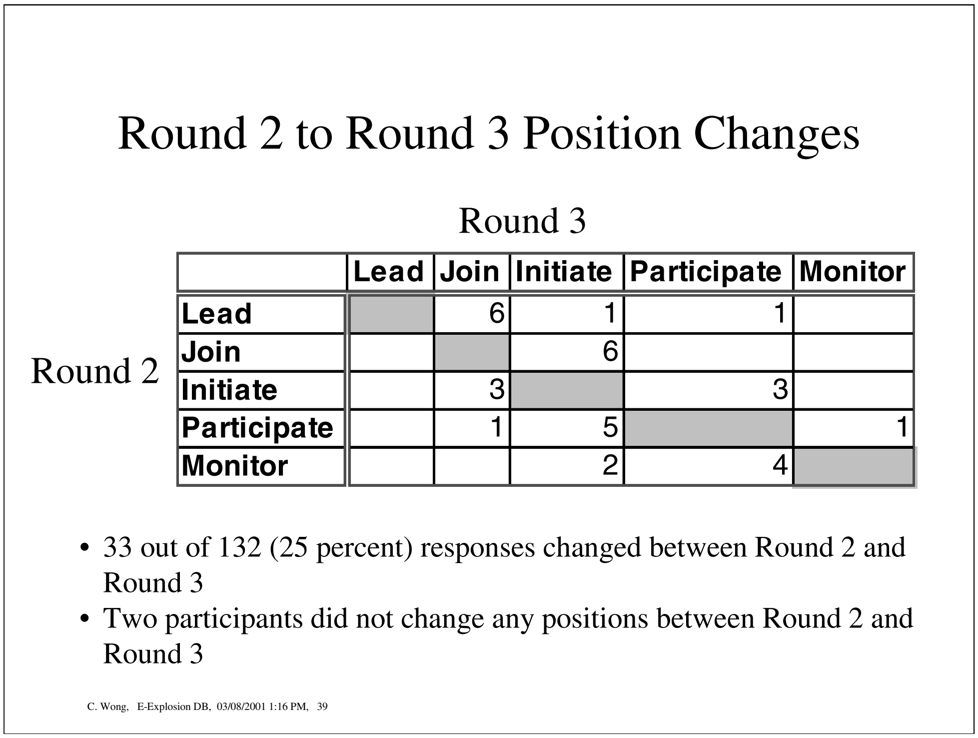
Round 2

Round 1

	Lead	Join	Initiate	Participate	Monitor
Lead		5	4		
Join	1		9	1	
Initiate		3		9	1
Participate			5		1
Monitor		1		1	

- 40 out of 132 (30 percent) responses changed between Round 1 and Round 2
- Four participants did not change any positions between Round 1 and Round 2

This figure shows how the participants changed their positions between Round 1 and Round 2. For example, one expert changed his placement of one technology from Join to Lead from Round 1 to Round 2. Likewise, three Round 1 Initiate votes were changed to Join in Round 2. In total, 40 out of 132 (30 percent) of the assessments were changed between the first two rounds. Four participants did not change any of their assessments for any technology between the first and second round.



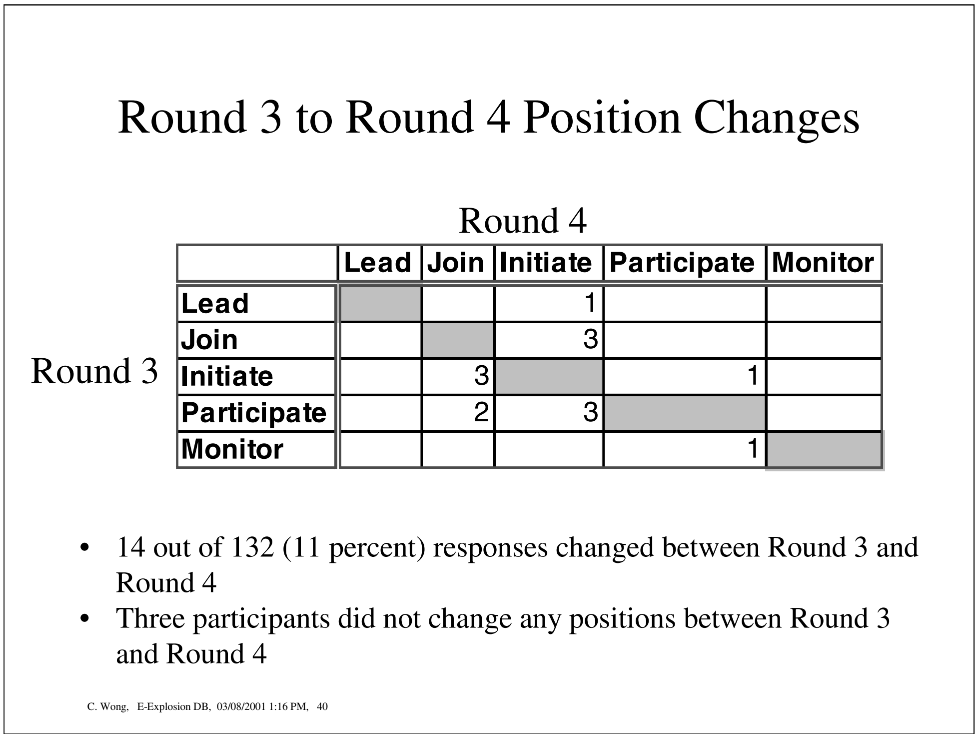
Round 2 to Round 3 Position Changes

Round 3

		Lead	**Join**	**Initiate**	**Participate**	**Monitor**
Round 2	**Lead**		6	1	1	
	Join			6		
	Initiate		3		3	
	Participate		1	5		1
	Monitor			2	4	

- 33 out of 132 (25 percent) responses changed between Round 2 and Round 3
- Two participants did not change any positions between Round 2 and Round 3

Thirty-three out of 132 assessments (25 percent) were changed between Round 2 and Round 3. Two participants did not change any assessments between the second and third round.



Round 3 to Round 4 Position Changes

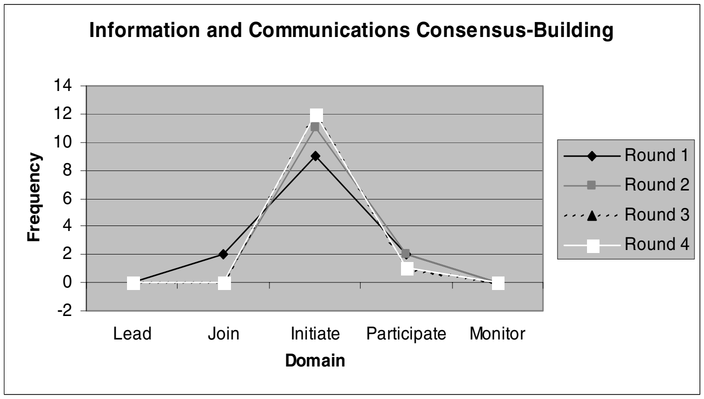
Round 4

Round 3		Lead	Join	Initiate	Participate	Monitor
	Lead			1		
	Join			3		
	Initiate		3		1	
	Participate		2	3		
	Monitor				1	

- 14 out of 132 (11 percent) responses changed between Round 3 and Round 4
- Three participants did not change any positions between Round 3 and Round 4

Fourteen out of 132 assessments (11 percent) were changed between Round 3 and Round 4. Three participants did not change any positions between Round 3 and Round 4.

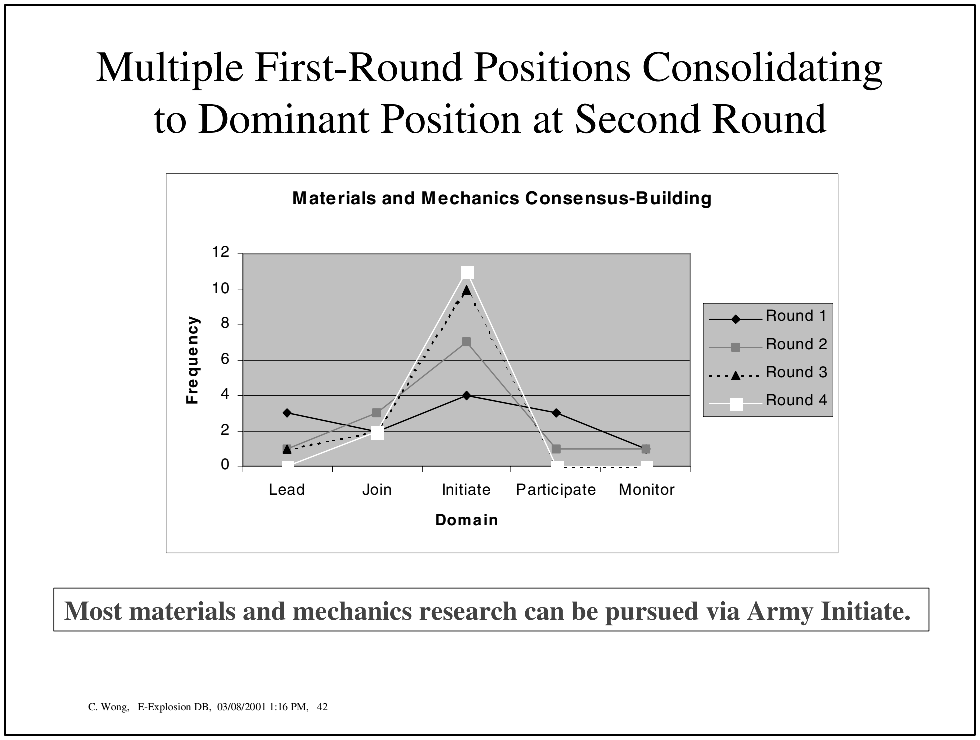
Strong First-Round Consensus with Further Buildup



Most information and communications basic research can be pursued via Army Initiate.

Seven different patterns of consensus-building were detected in this exercise. For this analysis, we used the criterion that a consensus is achieved for a technology when at least seven members of the expert panel placed the technology in the same domain in the framework. We use the term “strong consensus” to mean that more than seven members of the expert panel placed the technology in the same domain in the framework. In addition, the term “no consensus” means that less than seven members of the expert panel placed the technology in the same domain in the framework. The patterns range from a strong consensus in the first round and holding or building for the remaining rounds to no consensus in the early rounds and a strong consensus by the final round. This figure and the next six figures describe the consensus-building patterns.

This figure shows the consensus-building process for the Information and Communications technology. In this case, the panel members indicated that most information and communications research can be pursued via an “Army Initiate” approach. That is, the Army initiates basic research efforts in this technology. (See Carolyn Wong, *An Analysis of Collaborative Research Opportunities for the Army*, Santa Monica, Calif.: RAND, MR-675-A, for more details on the Lead, Join, Initiate, Participate, and Monitor aspects of the market breadth–Army utility framework.) In this case, most panel members agreed on the Initiate placement in the first round. Subsequent rounds only increased this initial consensus.



Multiple First-Round Positions Consolidating to Dominant Position at Second Round

Most materials and mechanics research can be pursued via Army Initiate.

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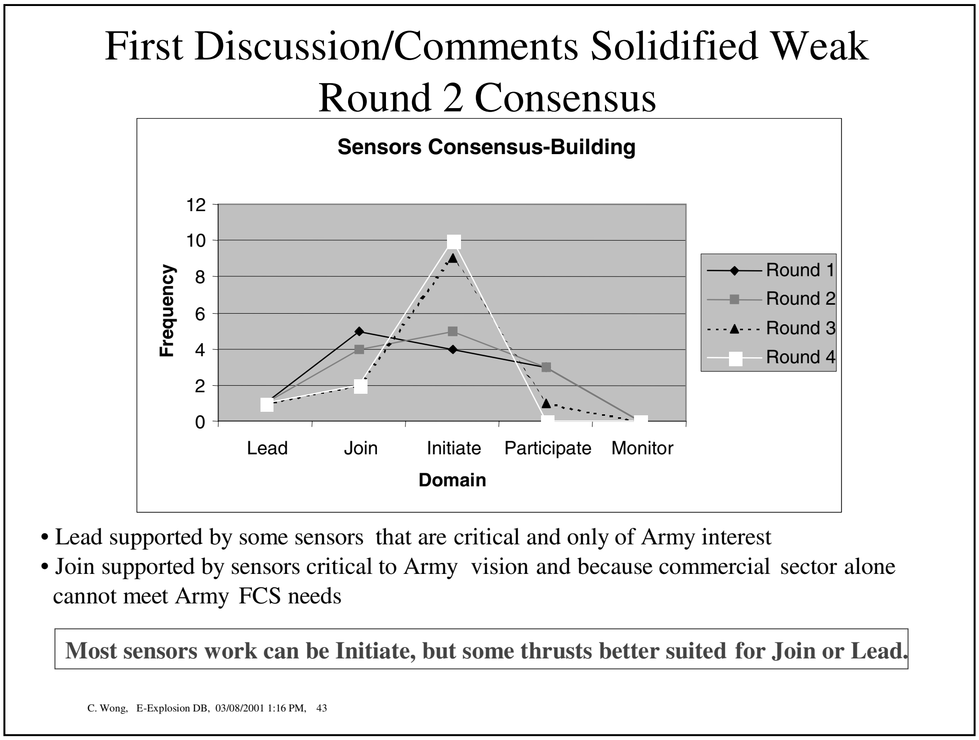
For the Materials and Mechanics technology, the first-round assessments were spread among all of the placement categories. The feedback material provided between the first two rounds helped achieve a consensus in the second round. The Round 2 feedback and first discussion session raised the consensus level in the third round, and the consensus position topped out without changing again in the fourth round. In this case, the consensus position was not established until the second round and it remained consistent, building up to the fourth round near-unanimous assessment. At the end of the exercise, all but one expert agreed that most Materials and Mechanics research can be pursued with an Army Initiate approach.



First Discussion/Comments Solidified Weak Round 2 Consensus

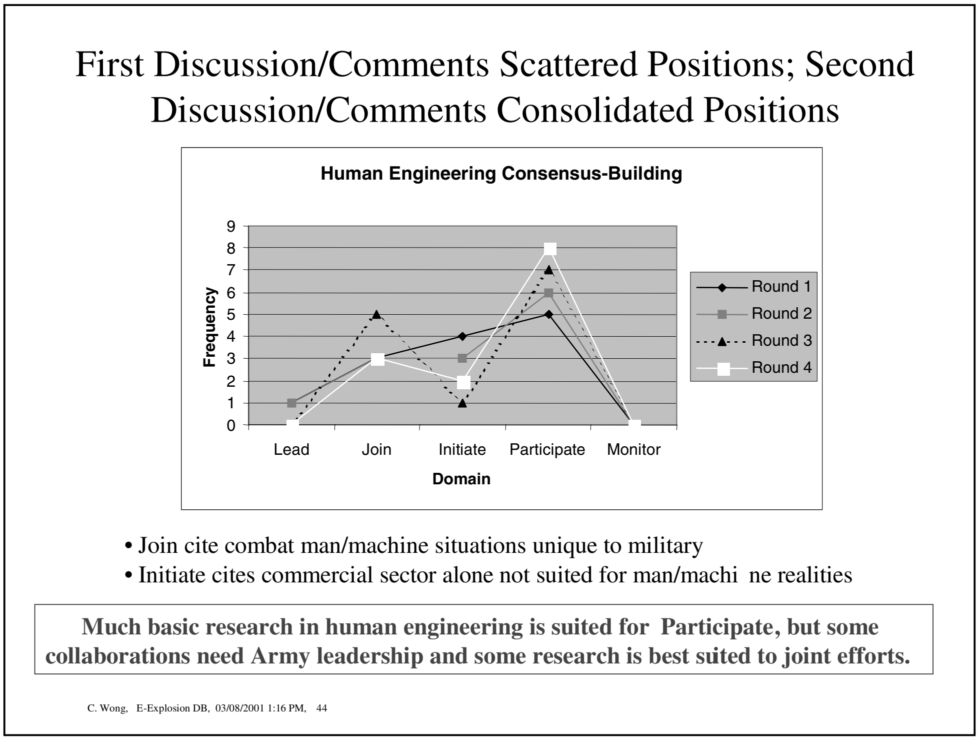
- Lead supported by some sensors that are critical and only of Army interest
- Join supported by sensors critical to Army vision and because commercial sector alone cannot meet Army FCS needs

Most sensors work can be Initiate, but some thrusts better suited for Join or Lead.

C. Wong, E-Explosion DB, 03/08/2001 1:16 PM, 43

In the Sensors technology, the expert assessments were scattered among the Lead, Join, Initiate, and Participate positions for the first two rounds. This indicates that the feedback material provided between Rounds 1 and 2 did not convince many to change their initial assessments. A significant change occurred between the second and third rounds. The third-round assessments show a clear “Initiate” consensus position. We can infer that the written feedback as well as the first discussion session imparted convincing arguments that spurred nearly a quarter of the expert panel to change their assessment to the Initiate position. In this case, no consensus was established until the third round, and the fourth round brought only a minor one-vote increase to the consensus position. The feedback and initial discussion session were key to establishing a consensus position for the Sensors technology. (Note that this pattern shows the dangers of conducting truncated two-round Delphi exercises as mail implementations often do to decrease the duration of the exercise.)

In this case, the justifications, minority arguments, and defenses contained material useful to the Smart Outsourcing Project. The experts supporting the Lead position consistently argued that some sensors are critical and are only of interest to the Army. The Join position supporters cited that sensors are critical to the Army vision and that the commercial sector alone cannot meet Army Future Combat System (FCS) needs. They advocate a position that the most effective Army approach to accomplish basic research in sensors are joint efforts by the Army and other military services.



First Discussion/Comments Scattered Positions; Second Discussion/Comments Consolidated Positions

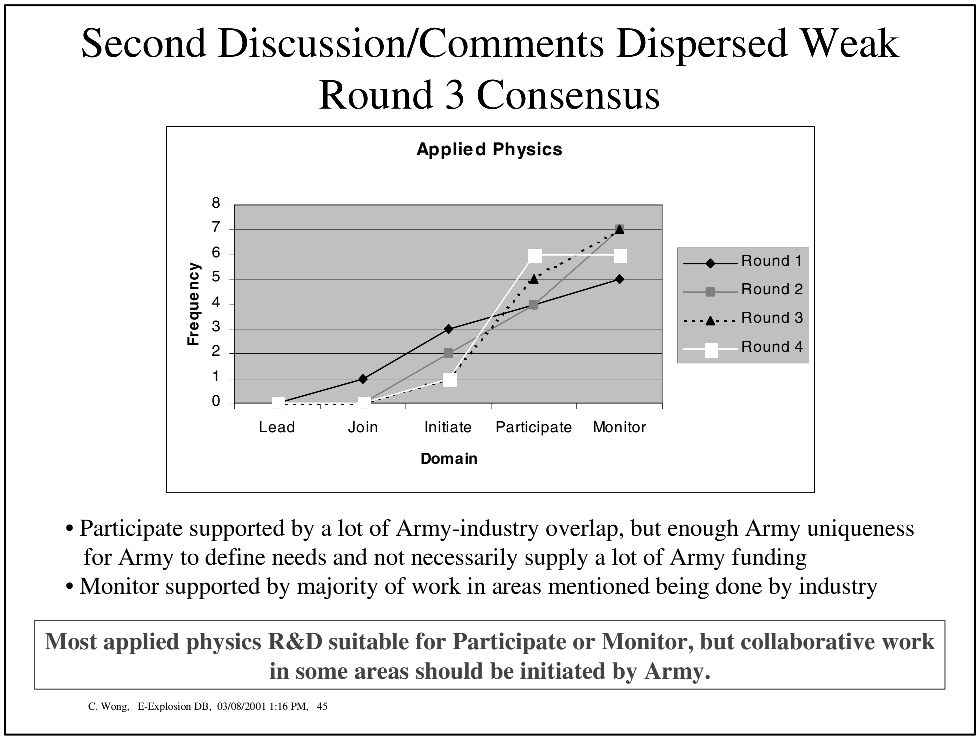
- Join cite combat man/machine situations unique to military
- Initiate cites commercial sector alone not suited for man/machine realities

Much basic research in human engineering is suited for Participate, but some collaborations need Army leadership and some research is best suited to joint efforts.

C. Wong, E-Explosion DB, 03/08/2001 1:16 PM, 44

The exercise results show yet a different consensus-building pattern for the Human Engineering technology. In this case, the first two rounds did not produce consensus positions. The material in the feedback to Round 3 and first discussion session between the second and third round split the panel into two camps—one favoring the Join position and the other favoring the Participate position. Feedback from the third round and the second discussion session convinced eight participants to vote for the Participate position. Hence, in this case, the strong consensus was not reached until the fourth round.

Once again, the justifications, minority arguments, and defenses provided information useful to the Smart Outsourcing Project. Those supporting the Join position stated that combat man/machine situations are unique to the military and hence that joint efforts with other military services constitute the best approach for the Army to accomplish basic research goals in human engineering. The Initiate proponent presented a similar argument stating that the commercial sector alone is not suited to basic research for man/machine realities. This expert's Initiate position indicates that he believes the commercial sector can, however, play a significant role.



Second Discussion/Comments Dispersed Weak Round 3 Consensus

- Participate supported by a lot of Army-industry overlap, but enough Army uniqueness for Army to define needs and not necessarily supply a lot of Army funding
- Monitor supported by majority of work in areas mentioned being done by industry

Most applied physics R&D suitable for Participate or Monitor, but collaborative work in some areas should be initiated by Army.

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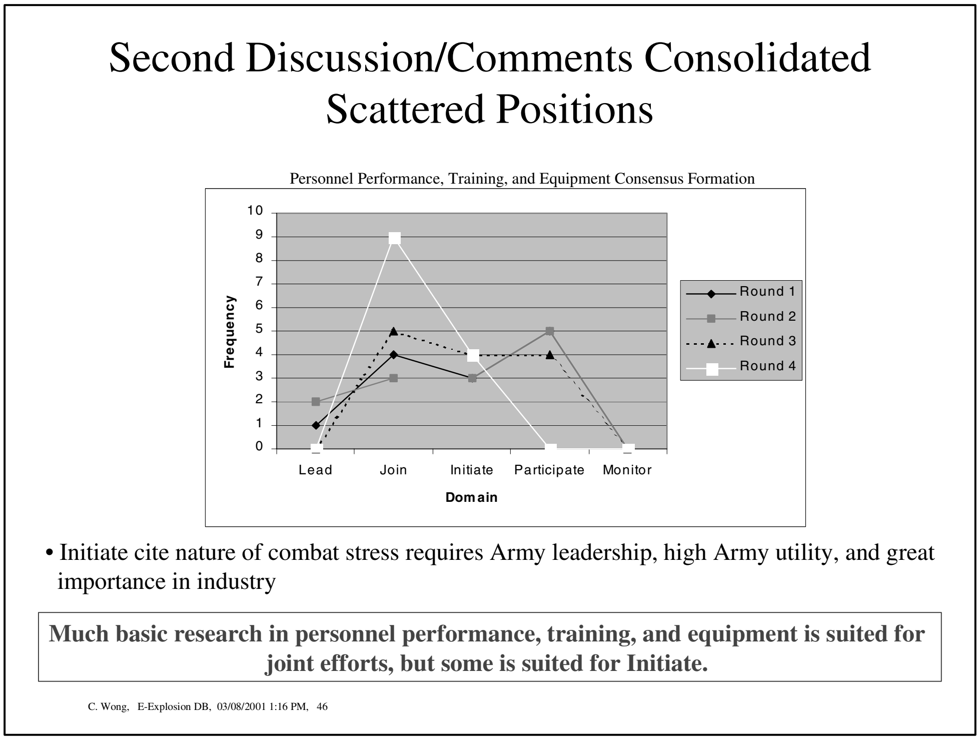
The Applied Physics technology area shows an exercise pattern in which the consensus actually became weaker in the final round. A predominance for the Monitor position was indicated, but no consensus position was established in the first round. However, the second and third rounds are marked by nearly identical results and a Monitor consensus position. Hence the feedback from the first round convinced some experts to change their position to Monitor. The feedback from the third round and the initial discussion period did not change the consensus strength. However, the feedback from the third round and the second discussion session broke the consensus, and the fourth round resulted in no final consensus position—only a split between the Participate and Monitor positions. Supporters of the Participate position stated that much overlap can be found between Army and industry in this area, but uniqueness in Army basic research goals in applied physics warrants the Army to define its needs and not necessarily supply a lot of funding for basic research toward those needs. The Monitor group cited that the majority of work going on in the applied physics area is already being done by industry and, hence, that the Army can rely on the Monitor approach.



Second Discussion/Comments Consolidated Scattered Positions

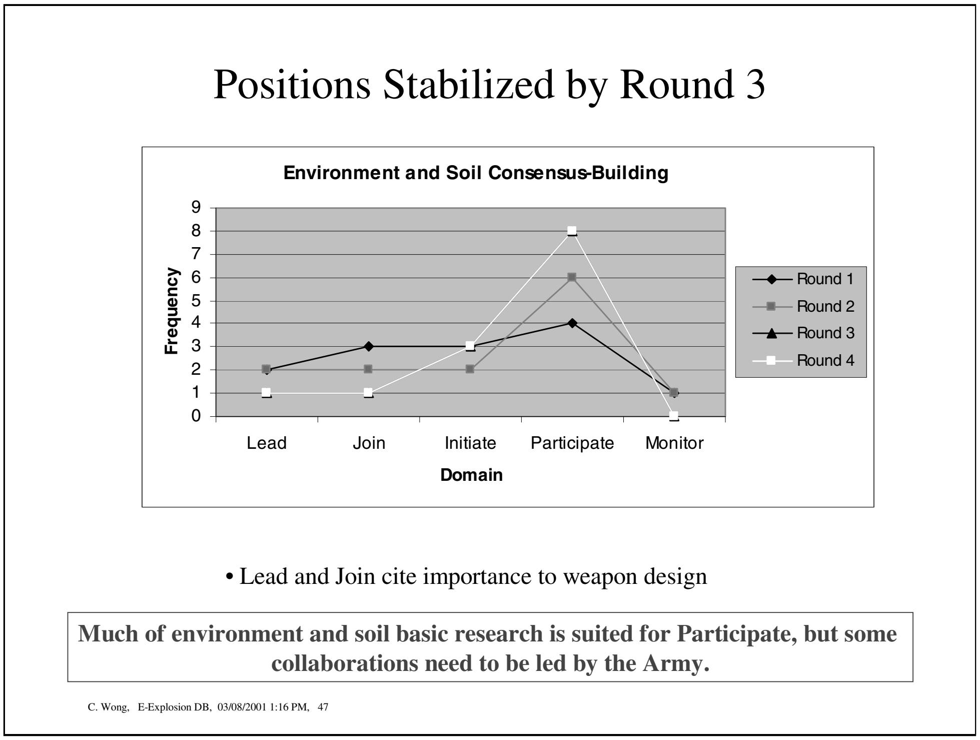
Personnel Performance, Training, and Equipment Consensus Formation

- Initiate cite nature of combat stress requires Army leadership, high Army utility, and great importance in industry

Much basic research in personnel performance, training, and equipment is suited for joint efforts, but some is suited for Initiate.

C. Wong, E-Explosion DB, 03/08/2001 1:16 PM, 46

For the Personnel Performance, Training, and Equipment technology area, the exercise results were scattered for the first three rounds. The Join consensus position was reached after the participants received feedback from Round 3 and took part in the second discussion session. In the fourth round, all experts supported either the Join or Initiate positions. The Initiate supporters pointed out that the nature of combat stress requires Army leadership. In addition, there is high Army utility, but this area is also of great importance to industry. From these comments and the exercise results, the Smart Outsourcing team was able to conclude that much basic research in Personnel Performance, Training, and Equipment technology is suited for joint efforts with other military services, but some is suited for the Initiate approach with industry.



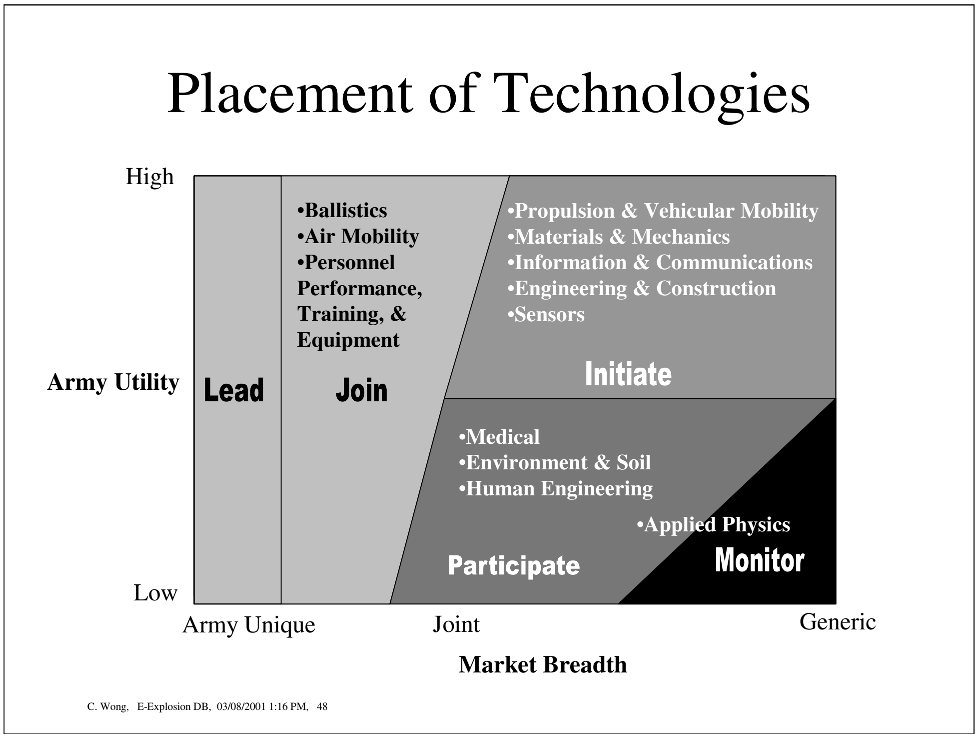
Positions Stabilized by Round 3

- Lead and Join cite importance to weapon design

Much of environment and soil basic research is suited for Participate, but some collaborations need to be led by the Army.

This figure shows the consensus-building pattern for the Environment and Soil technology area. In this case, a Participate consensus position was established in the third round. Hence, feedback from the second round and the initial discussion period consolidated the expert panel viewpoints. The fourth-round returns were identical to the third-round returns, indicating that the feedback from the third round and the second discussion session did not change anyone's assessment in this technology area.

The Lead and Join dissenters consistently cited the importance of this area to weapon design as their argument for the Lead or Join positions.



Placement of Technologies

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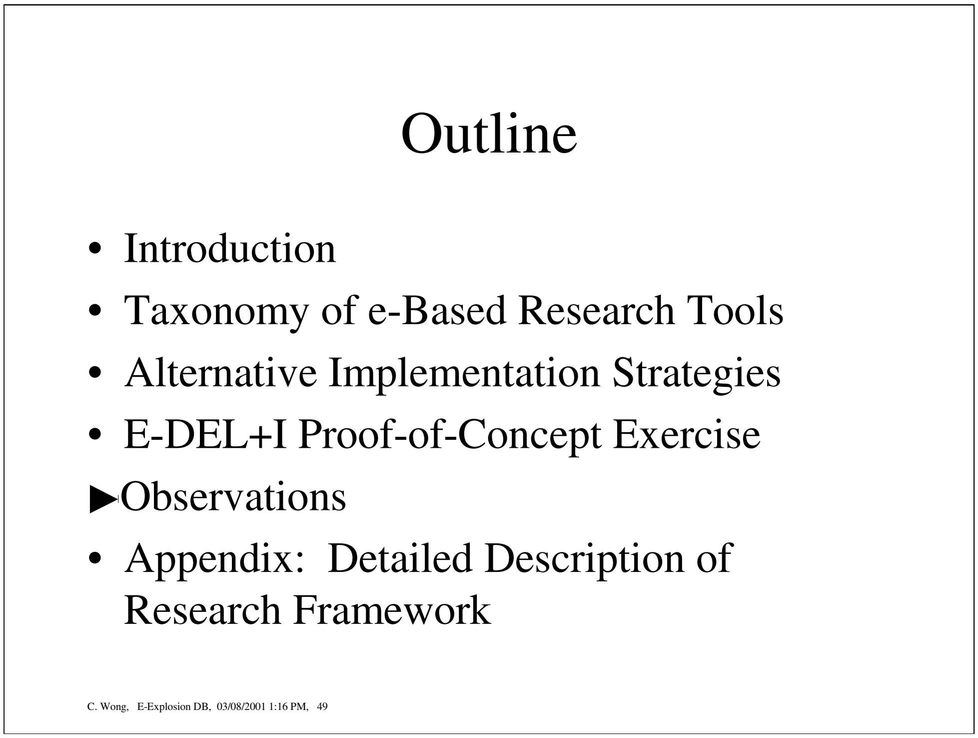
The previous seven figures showed the consensus-building patterns for selected technologies. This figure shows the final framework placements for all the technologies using the criterion that a consensus was achieved if at least seven members of the expert panel placed the technology in the same domain in the framework. Note that the Applied Physics technology is shown in both the Participate and Monitor domains, indicating the lack of consensus and bimodal predominances of the final results for this technology area.

As an indication of sensitivity to the criterion used for concluding that a consensus was reached, only seven of the technologies would be shown on this figure as having achieved consensus positions if we had used the criterion that consensus requires at least nine experts placing the technology in a particular domain. At the extreme, no consensus positions would be shown if for each technology we required all 13 panel members to agree before declaring a consensus.



Outline

- Introduction
- Taxonomy of e-Based Research Tools
- Alternative Implementation Strategies
- E-DEL+I Proof-of-Concept Exercise

▶Observations

- Appendix: Detailed Description of Research Framework

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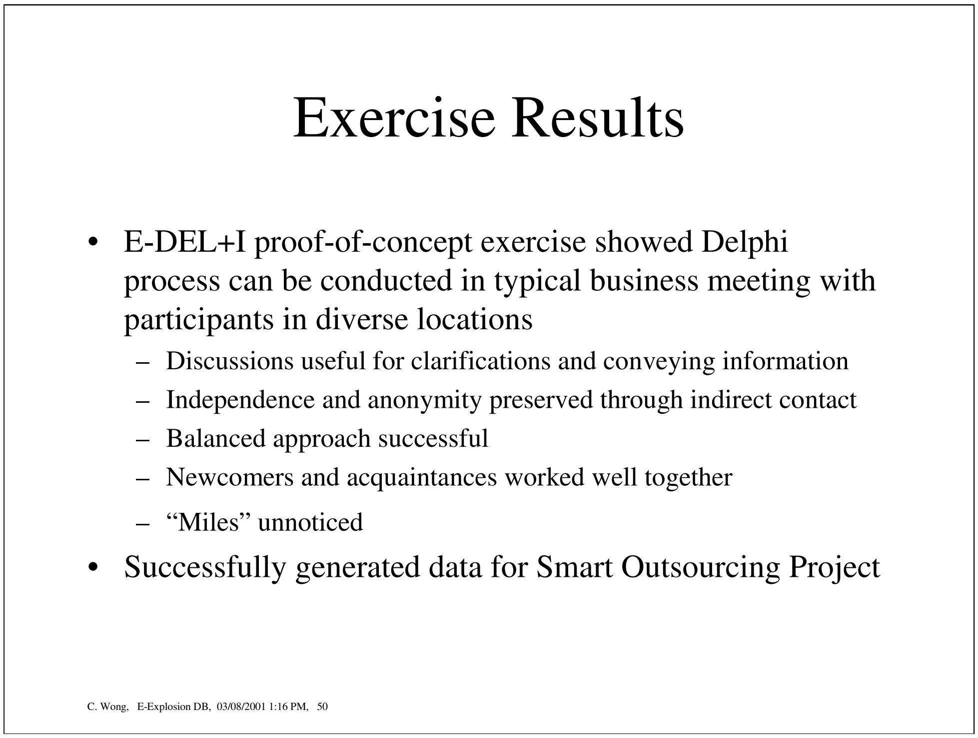
We will now discuss observations and insights gained from the E-DEL+I proof-of-concept exercise.



Exercise Results

- E-DEL+I proof-of-concept exercise showed Delphi process can be conducted in typical business meeting with participants in diverse locations
  - Discussions useful for clarifications and conveying information
  - Independence and anonymity preserved through indirect contact
  - Balanced approach successful
  - Newcomers and acquaintances worked well together
  - “Miles” unnoticed
- Successfully generated data for Smart Outsourcing Project

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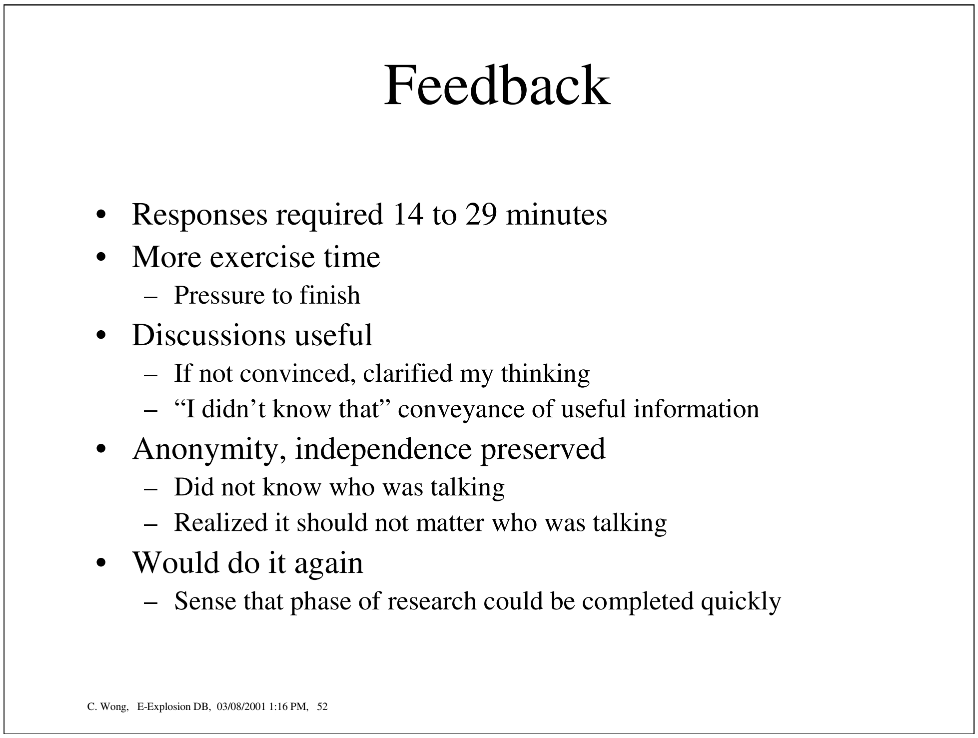
The E-DEL+I proof-of-concept exercise took two hours and 45 minutes to complete, illustrating that this approach can complete a phase of research during a typical business meeting with participants in diverse locations. Furthermore, the discussion sessions were useful both for clarifications and for conveying information. Some positions were changed as a result of the discussion sessions. With our two basic ground rules, we were able to preserve the independence and anonymity hallmarks throughout the exercise because the participants only had indirect contact via the conference telephone call. The balanced approach in which participants with strong writing skills could use a written medium to explain their positions and those with strong speaking skills could use the real-time oral discussion sessions to explain their positions worked well. Informal postexercise interviews with the participants indicated that all felt they had adequate opportunities and comfortable means to convey their thoughts, although some did express a preference for writing, whereas others said they just jotted notes in their written responses, preferring to address the group during the discussion sessions.

The expert panel consisted of colleagues who had worked closely together as well as newcomers unacquainted with any other participant. However, the newcomers felt that their input was welcome and did not detect any bias against their participation. That we appeared to achieve a level playing field for all participants is evidenced by postexercise comments, such as “I didn’t know who was talking, so I had to assume that he knew what he was talking about.”

In addition, the “miles” between the physical locations appeared to go unnoticed during the exercise, demonstrating that with the appropriate tools, research can be effectively and successfully accomplished with participants in diverse locations.

Finally, the exercise successfully completed a research task for the Smart Outsourcing Project, generating the information that project was seeking.

We did not conduct a parallel exercise to see how the consensus-building patterns or results of the proof-of-concept exercise might compare with a conventionally conducted Delphi. We believe, however, that the balanced approach and discussion sessions, elements not available in conventional exercises, helped the experts make well-informed judgments. In addition, the only expense we incurred that would not have been incurred in a conventional exercise was the cost of the all-way conference call (less than $900), while a conventionally conducted exercise would have incurred many higher expenditures that the E-DEL+I exercise did not incur. For example, the costs of bringing the 13 researchers to a single physical location for a conventional on-site exercise would have been at least $6,000 for travel expenses alone.



Feedback

- Responses required 14 to 29 minutes
- More exercise time
  - Pressure to finish
- Discussions useful
  - If not convinced, clarified my thinking
  - "I didn't know that" conveyance of useful information
- Anonymity, independence preserved
  - Did not know who was talking
  - Realized it should not matter who was talking
- Would do it again
  - Sense that phase of research could be completed quickly

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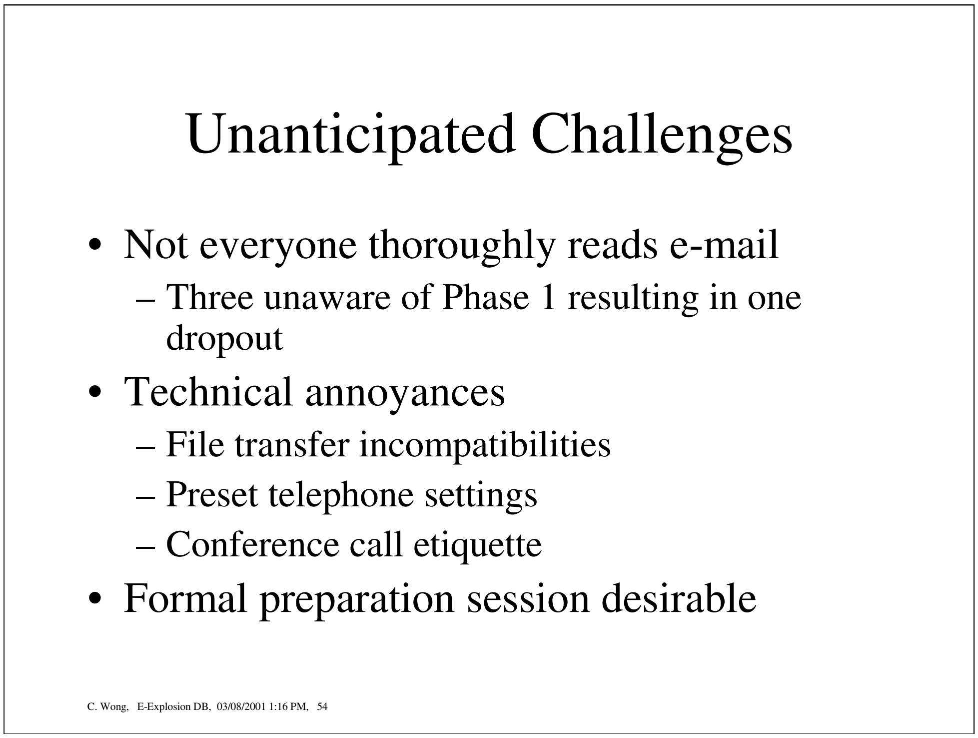
The exercise participants were informed of the agenda but were not given specific durations to complete each round or discussion session. Participants took between 14 and 29 minutes to complete each assessment questionnaire (rating the technologies plus supplying any supporting arguments). Even though the participants did not receive any time limits and were told to take as much time as they needed, postexercise interviews indicated that several participants felt that they were under pressure to complete the questionnaires quickly. In retrospect, some of this feeling might have been generated because the discussion sessions were scheduled to begin as soon as a quorum of participants had completed the questionnaires and had something to say (determined by the discussion monitor). The participants completed the questionnaires with the conference call on hold, so they were not aware when the discussions would start but would simply join in after completing their responses. Nevertheless, a few participants felt that if they did not complete the questionnaire quickly, they would miss out on the discussion session. This shows that some participants viewed the discussion sessions as valuable.

Further indications that the participants valued the discussion sessions are postexercise interview comments stating that the discussions helped clarify thinking even if the participants were not persuaded to change their positions. Conveying information appeared to be a major role of the discussion sessions because in postexercise interviews some participants said they were exposed to different views of technology areas that they themselves knew something about.

Anonymity and independence appeared to have been preserved. Postexercise interviews showed that the participants were not always sure who was talking, and some indicated that they finally realized that it should not matter who was talking.

The final question in the postexercise interview was whether the participant would participate in another such exercise. All participants indicated that they would.



Unanticipated Challenges

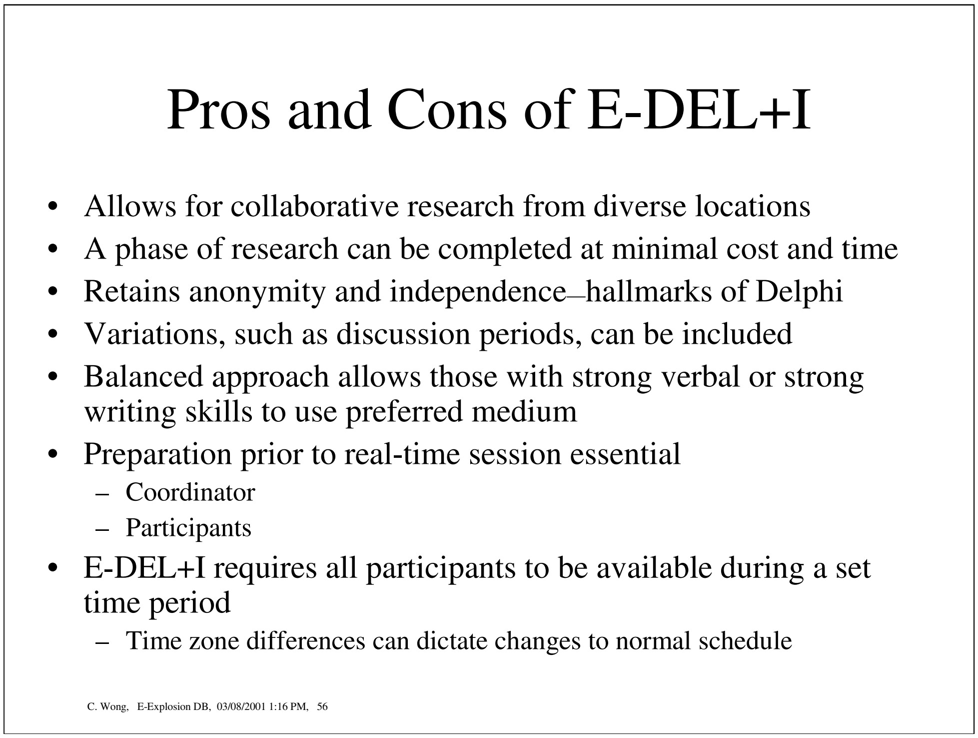
- Not everyone thoroughly reads e-mail
  - Three unaware of Phase 1 resulting in one dropout
- Technical annoyances
  - File transfer incompatibilities
  - Preset telephone settings
  - Conference call etiquette
- Formal preparation session desirable

Although the feedback from the exercise participants was generally positive and the exercise did accomplish its purposes, not everything happened as expected.

Our first surprise was that not everyone thoroughly reads e-mail. Fourteen experts initially agreed to participate in the exercise. After the deadline for returning the first-round responses, three responses were missing. We contacted the participants who had not responded. All three acknowledged receiving the e-mail announcing the start of the exercise. However, they had not read it thoroughly enough to realize that they were supposed to complete the first-round questionnaire. Two of these individuals then furnished their missing responses, and one decided not to participate (resulting in 13 participants).

There were also some technical difficulties. The first was that we found file transfer incompatibilities among the different platforms being used by the participants. Fortunately, dropping the file into the exercise coordinator's inbox worked successfully for the e-mail attachments that could not be read. (A variant of this solution, such as anonymous drop boxes, might be required if participants unable to return responses by e-mail did not have access to RAND internal drop boxes.) Second, we found that the telephones at RAND have preset settings that had to be changed for the conference call to take place. Fortunately, this problem was discovered prior to the exercise, and we were able to send telephone instructions to all the participants in advance. Finally, none of the participants had very much experience with 13-way conference calls and conference call etiquette involving such issues as background noise (e.g., tapping with a pencil, putting down a coffee cup) had to be relayed to ensure that the telephones did not cut speakers off in attempts to pick up the background noise.

Although all participants were sent background material and exercise participation instructions, most preferred a formal preparation session in which the exercise coordinator explained each item rather than going through the material on their own.



Pros and Cons of E-DEL+I

- Allows for collaborative research from diverse locations
- A phase of research can be completed at minimal cost and time
- Retains anonymity and independence—hallmarks of Delphi
- Variations, such as discussion periods, can be included
- Balanced approach allows those with strong verbal or strong writing skills to use preferred medium
- Preparation prior to real-time session essential
  - Coordinator
  - Participants
- E-DEL+I requires all participants to be available during a set time period
  - Time zone differences can dictate changes to normal schedule

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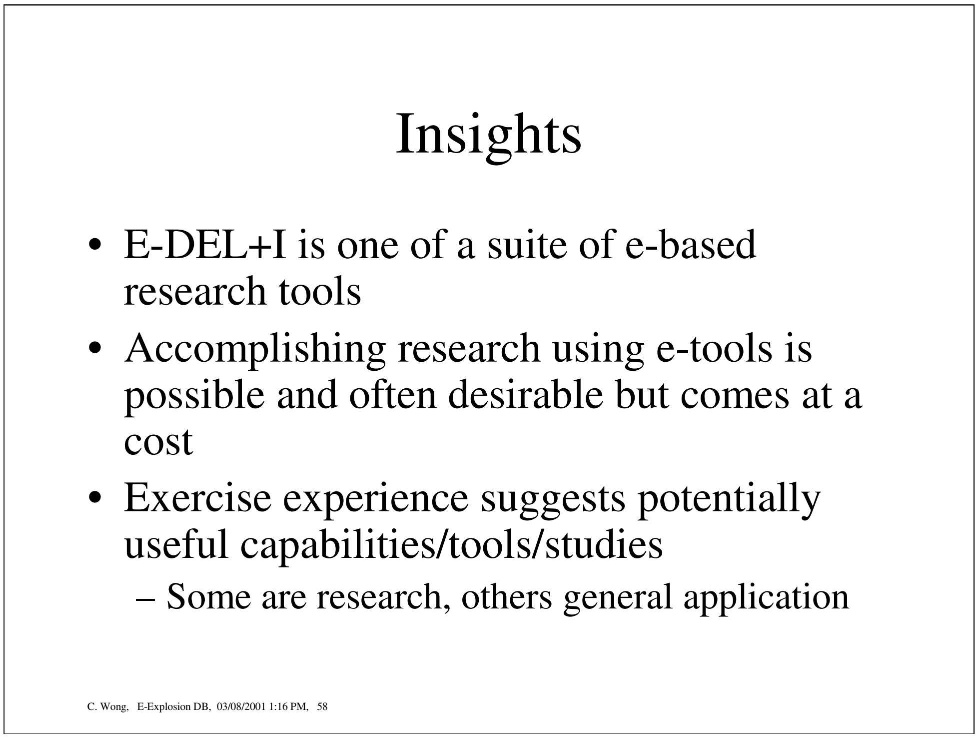
The E-DEL+I proof-of-concept exercise shows that it can be used for collaborative research with participants in diverse locations. Using this technique, a phase of research can be completed at minimal cost and in a minimal amount of time. Our implementation of the technique allows for retention of the anonymity and independence hallmarks of Delphi exercises. We demonstrated that discussion sessions can be valuable input mechanisms. Finally, the balanced approach uniquely incorporated into the technique allows participants with strong verbal or writing skills to participate using their preferred medium.

On the negative side, preparation prior to the real-time session is essential. The coordinator must design and send out the questionnaires and background material well before the real-time session. In addition, the participants must review the material prior to the real-time session. While such preparations are no different from those that participants in any type of business meeting might be expected to make, the coordinator had no opportunity to refine or revise questionnaire processing procedure because of the real-time nature of the exercise. In a conventional exercise, the coordinator could revise processing procedures after receiving all of the questionnaires or could even reprocess them. The participants must also be available during a specific period on a specific date. Time differences can cause inconveniences. For example, by majority preference, the participants in our proof-of-concept exercise who were physically located on the East Coast voluntarily shifted their noon lunch hour to participate. (The proof-of-concept exercise took place from noon to 2:45 p.m., Eastern Standard Time.)



Insights

- E-DEL+I is one of a suite of e-based research tools
- Accomplishing research using e-tools is possible and often desirable but comes at a cost
- Exercise experience suggests potentially useful capabilities/tools/studies
  - Some are research, others general application

Our experience with E-DEL+I yielded some insights. The first is that E-DEL+I can be viewed as one of a suite of e-based research tools, much as Word is one of the tools in the Microsoft Office Suite. Second, distributed data generation for research is possible and has some distinct advantages, but a cost is also involved. Finally, the proof-of-concept exercise suggests some potentially useful capabilities, tools, and studies, some of them research-oriented and others with a more general application. The following figures will elaborate on each of these insights.

E-DEL+I Is One of a Suite of Research Tools

- Similar to Microsoft Office Suite
- Alternative paths toward reality
  - Develop within RAND for RAND and Army or client use only
  - Develop within RAND available with or without fee to public
  - License implementation, outside developer, share benefits
- RAND experience enables us to specify requirements, desirable features, options
  - For example, statistics generation, prose formatting, directed tutorial versus questionnaire
  - Might be some intersection with survey requirements

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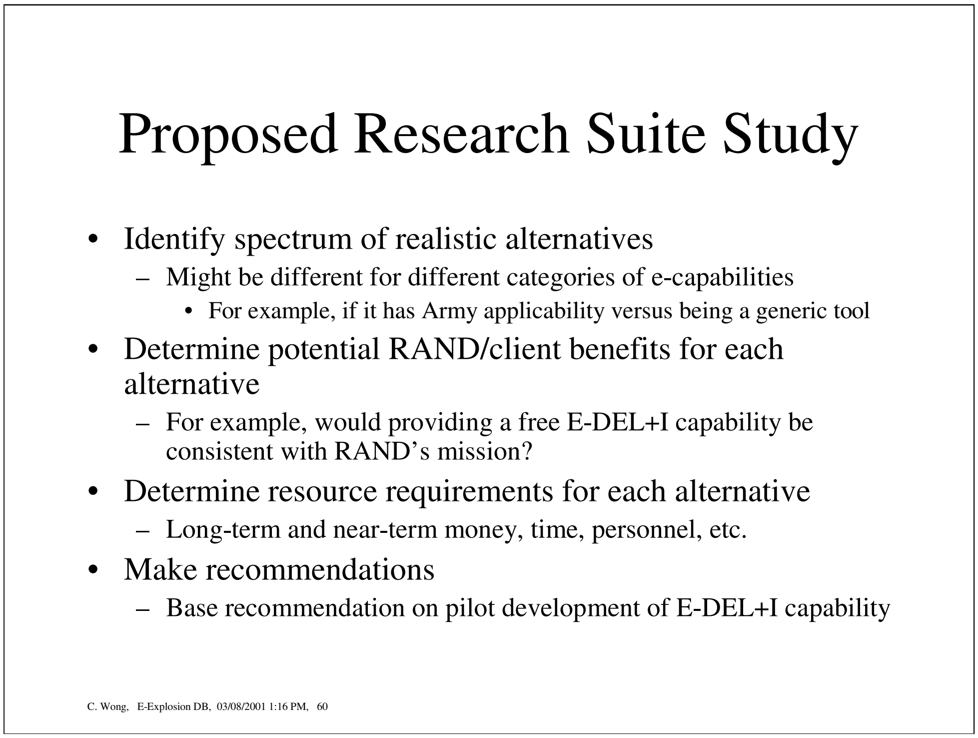
E-DEL+I can be viewed as one capability in a suite of research tools much as Word or Excel is a capability in the Microsoft Office Suite. The taxonomy of e-based capabilities can be used to identify other candidate capabilities to include in such a suite.

Should this path be followed, several alternatives are available to make such a suite a reality. One is to develop the suite of tools within RAND for RAND and Army or client use only. Alternatively, the suite can be developed within RAND but made available to the public with or without user fees. Third, the suite can be licensed for outside development, where RAND would share the benefits with the developer.

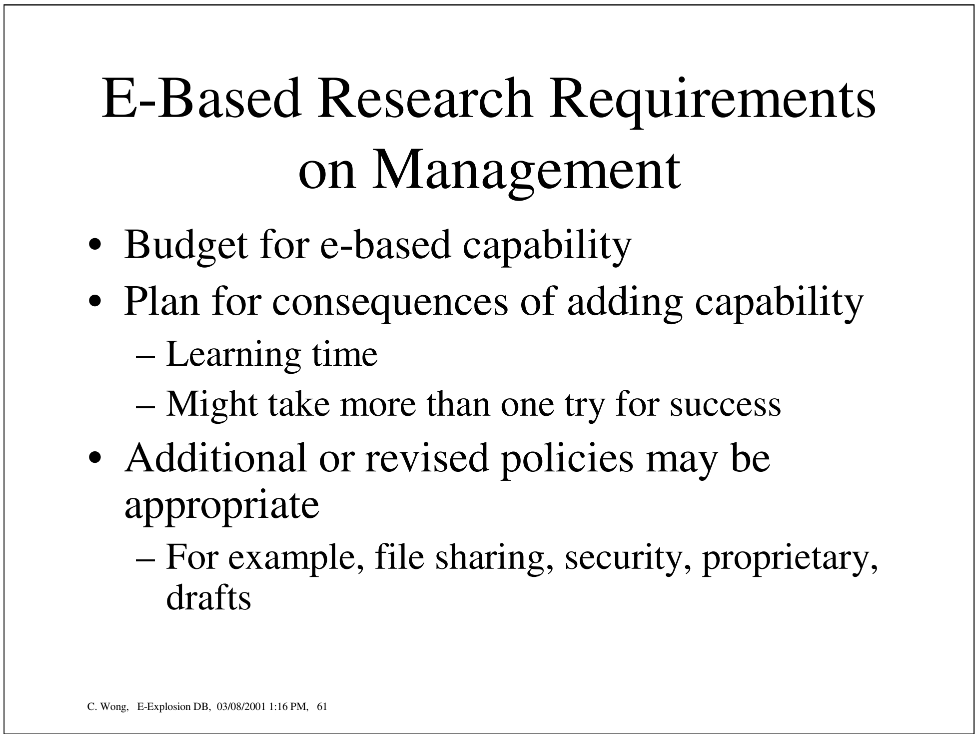
Whatever path is chosen, RAND should remain a participant because its unique collective experience in research and analysis enables RAND to specify requirements, desirable features, and options that should be included in a suite of e-capabilities for research. For example, statistics generation, prose formatting, directed tutorials, or survey requirements might be desirable attributes for research tools.



Proposed Research Suite Study

- Identify spectrum of realistic alternatives
  - Might be different for different categories of e-capabilities
    - For example, if it has Army applicability versus being a generic tool
- Determine potential RAND/client benefits for each alternative
  - For example, would providing a free E-DEL+I capability be consistent with RAND’s mission?
- Determine resource requirements for each alternative
  - Long-term and near-term money, time, personnel, etc.
- Make recommendations
  - Base recommendation on pilot development of E-DEL+I capability

A recommended follow-on study should include such tasks as identifying the spectrum of realistic alternatives. There might be different categories of e-based capabilities. For example, some may be applicable only to the military, whereas others have more generic applications. Once the alternatives are identified, a determination should be made of the potential for each alternative in terms of benefits to RAND or its clients. For example, would providing a free E-DEL+I capability be consistent with RAND’s mission? Once the potential benefits are known, resource requirements for the most promising alternatives need to be determined. For example, what are the long-term and near-term, time, resource, and dollar requirements? Finally, the study should make recommendations on how to pursue a pilot development of the E-DEL+I capability.



E-Based Research Requirements on Management

- Budget for e-based capability
- Plan for consequences of adding capability
  - Learning time
  - Might take more than one try for success
- Additional or revised policies may be appropriate
  - For example, file sharing, security, proprietary, drafts

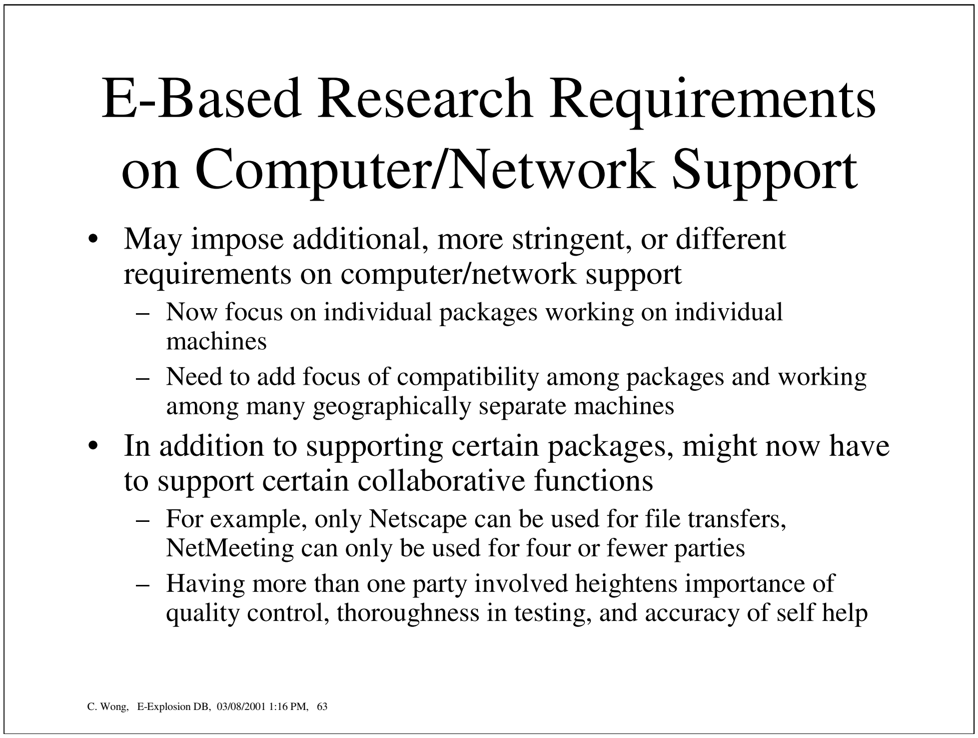
Some management moves are required to use e-tools successfully to conduct research with participants in diverse locations. First, such collaboration must be included in the effort’s budget. Second, because using e-tools to conduct research with participants in diverse locations is a new way of completing research, management should plan for possible consequences of adding such a capability. For example, researchers might need a learning period to get used to working in this manner. As such, more than one try might be required for success. Finally, additional or revised corporate policies may be required. For example, policies on file sharing, computer security, and sharing of draft documents may have to be modified.

Of course, collaborative research has occurred between RAND researchers in the Santa Monica and Washington offices for years. Most of the past collaborative efforts have involved different tasks performed at each site with the results of the multiple tasks integrated at one of the sites. E-based research capabilities is an alternative approach to perform research from diverse locations, and, in some cases, use of these techniques might be more cost-effective and enable more researchers to participate. In addition, a research task might be accomplished in less time than with other methods.

E-Based Research Requirements on Researchers

- Determine which functions are required
  - For example, instantaneous file transfers, multiway voice communications, file sharing, video, secure chat
- Prioritize functions
  - Not everything can be supported
- Be adaptive
  - Learn new programs, procedures, equipment

Researchers must also be adaptive. In providing e-based collaborative research capabilities, management cannot be expected to provide every option at the start. Hence, researchers must prioritize and determine which functions are most important. For example, among instantaneous file transfers, multiway voice communications, file sharing, video capability, or secure chat, which are more valuable for conducting collaborative research with colleagues in different locations? In addition, to gain new e-based research capabilities, researchers may be required to learn new programs or procedures and familiarize themselves with new equipment.



E-Based Research Requirements on Computer/Network Support

- May impose additional, more stringent, or different requirements on computer/network support
  - Now focus on individual packages working on individual machines
  - Need to add focus of compatibility among packages and working among many geographically separate machines
- In addition to supporting certain packages, might now have to support certain collaborative functions
  - For example, only Netscape can be used for file transfers, NetMeeting can only be used for four or fewer parties
  - Having more than one party involved heightens importance of quality control, thoroughness in testing, and accuracy of self help

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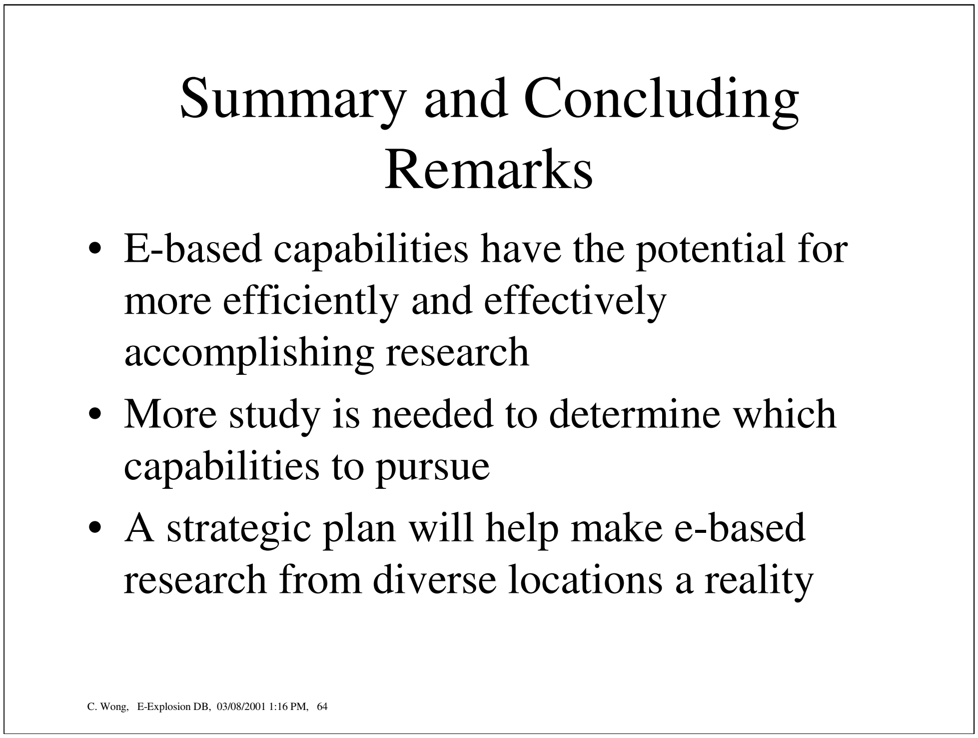
Achieving e-based collaborative research capabilities might also place requirements on computer and network support staffs. One current focus of computer support is individual packages working on individual machines. Another focus is compatibility among packages. Achieving e-based collaborative research capabilities might heighten the visibility of compatibility among packages as well as heighten concern about compatibility of subsets of computers in many locations. In addition to supporting individual packages, collaborative functions might have to be supported. For example, NetMeeting might have to be supported for a certain number of researchers. Since e-based collaborative research tools involve more than one party, there might be some heightened importance or priority in quality control, thoroughness of testing, and accuracy of self-help.

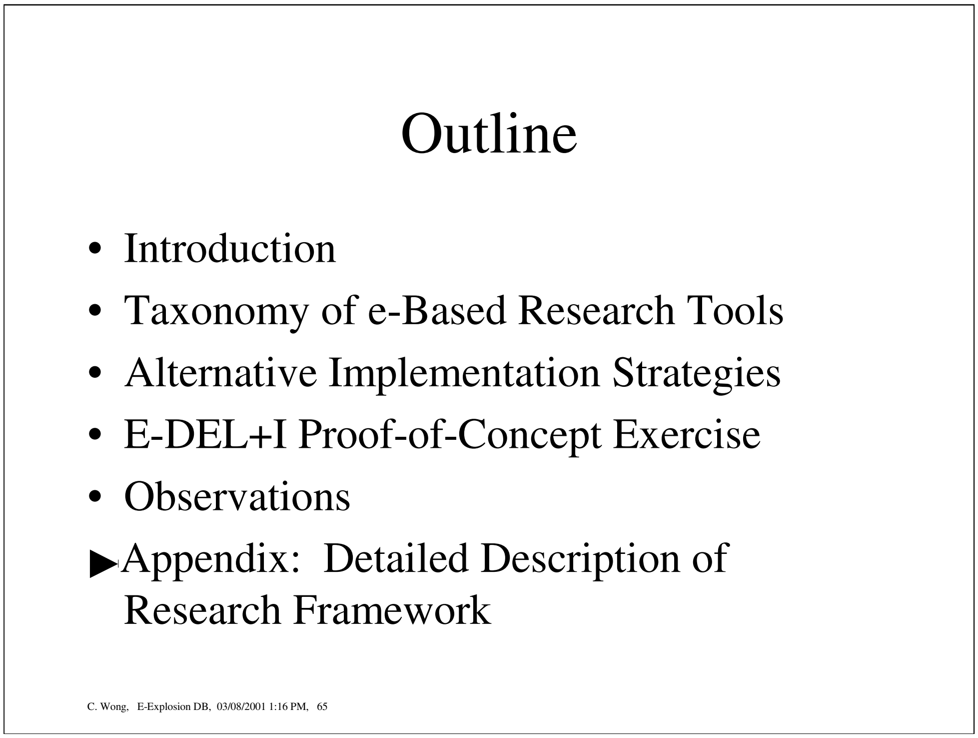


Summary and Concluding Remarks

- E-based capabilities have the potential for more efficiently and effectively accomplishing research
- More study is needed to determine which capabilities to pursue
- A strategic plan will help make e-based research from diverse locations a reality

E-based research capabilities have the potential to allow researchers to more effectively and more efficiently accomplish their research tasks. In particular, e-capabilities can ease accomplishment of research tasks at less cost and time. Such e-tools can also allow more researchers to participate in a research task. More study is required to determine which e-capabilities will provide the greatest return. A strategic plan will help make e-based research from diverse locations a reality.

Postscript: A second E-DEL+I exercise was conducted on March 19, 2001 to place the Army's Applied Research Technologies on the same market breadth–Army utility framework. Fourteen experts participated, some of whom also participated in the proof-of-concept exercise described in this documented briefing. The second exercise also generated data that was used in the Arroyo Center Smart Outsourcing Project. A representative from the Army Materiel Command, representing the sponsor of the Smart Outsourcing Project, participated in the second exercise, showing that participants without access to the RAND intranet could also successfully participate. The second exercise tested some improvements designed to mitigate the challenges identified in the first E-DEL+I exercise. Phase I of the "How Will the e-Explosion Affect How We Do Research?" Project culminated with two provisional patents for the processes developed.

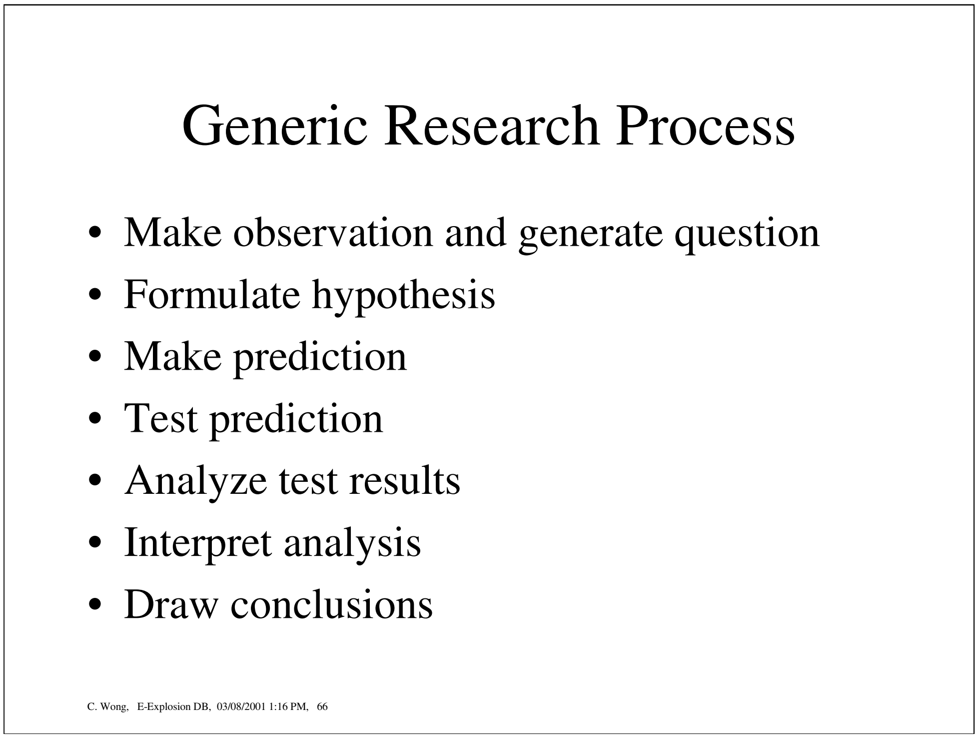


Outline

- Introduction
- Taxonomy of e-Based Research Tools
- Alternative Implementation Strategies
- E-DEL+I Proof-of-Concept Exercise
- Observations

▶ Appendix: Detailed Description of Research Framework

The next nine figures constitute the appendix to this documented briefing. This appendix contains detailed descriptions of the seven steps of the research framework (make an observation and generate a question, formulate a hypothesis, make a prediction, test the prediction, analyze the test results, interpret the analysis of the test results, and draw conclusions), as well as the “gather and analyze data and information” activity, which takes place in each step.

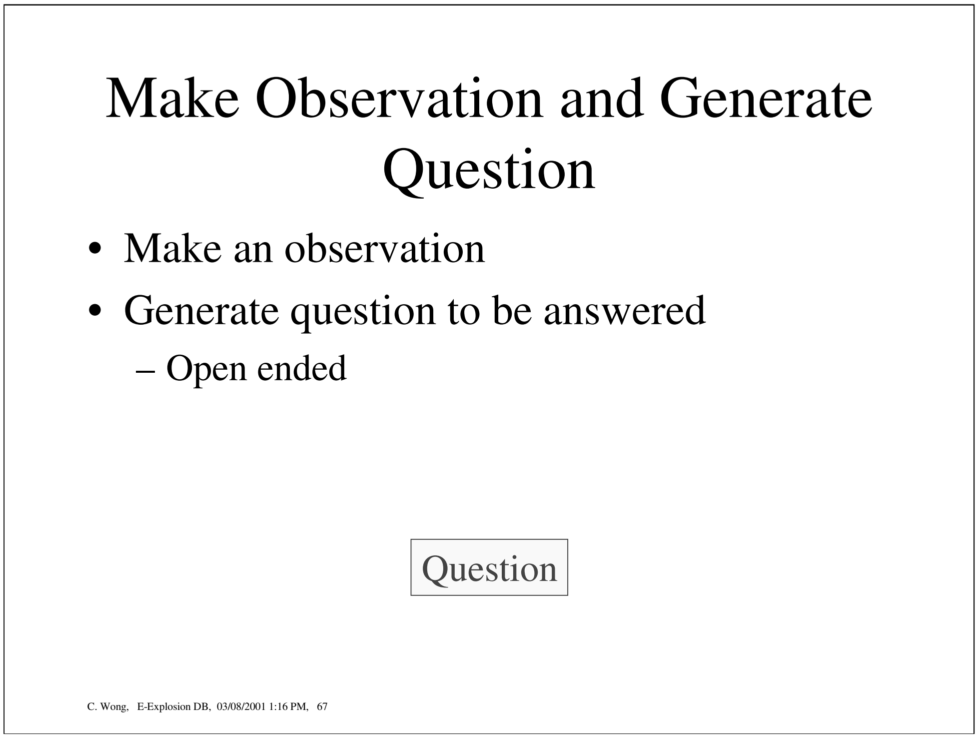


Generic Research Process

- Make observation and generate question
- Formulate hypothesis
- Make prediction
- Test prediction
- Analyze test results
- Interpret analysis
- Draw conclusions

We examine the steps of the generic research process more closely. As the research framework showed, the seven steps of the generic research process are to make an observation and generate a question, formulate a hypothesis, make a prediction, test the prediction, analyze the test results, interpret the analysis of the test results, and draw conclusions.

In the following figures, we will examine each of these steps.



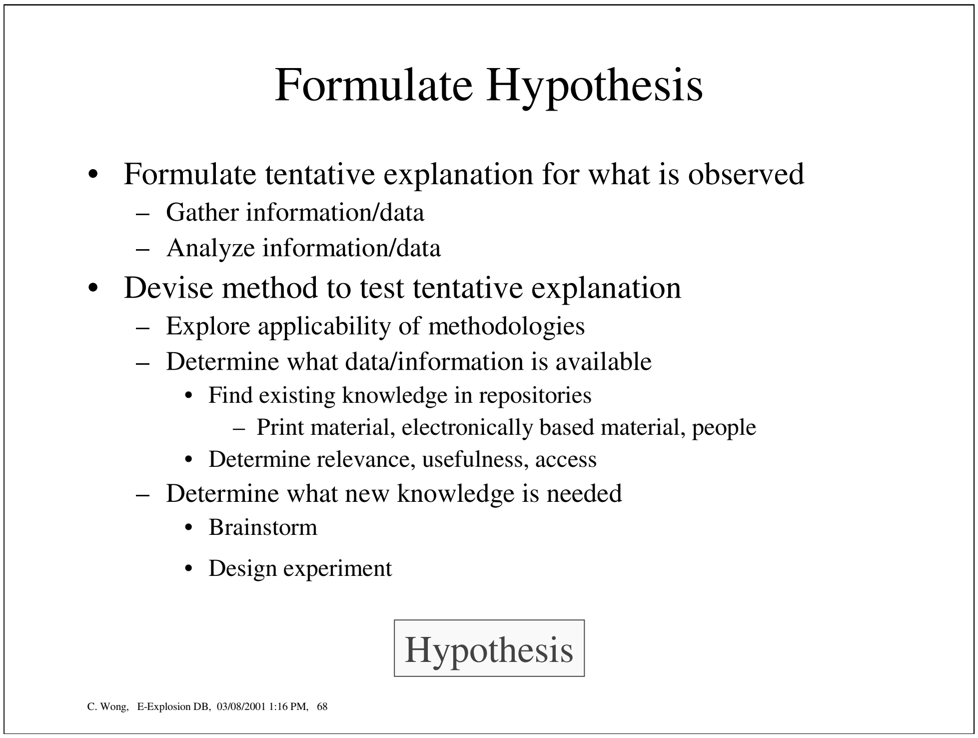
Make Observation and Generate Question

- Make an observation
- Generate question to be answered
  - Open ended

Question

Observations can be made under any circumstances. The generation of a question based on an observation is a thought process augmented by generally brief data/information analysis. Often the data/information considered is what is already known to the observer. That is, at this stage, little time might be spent gathering data/information to generate a research questions. Research questions usually evolve into open-ended questions.

The product of this step is a research question that is carried into the next step, hypothesis formulation.



Formulate Hypothesis

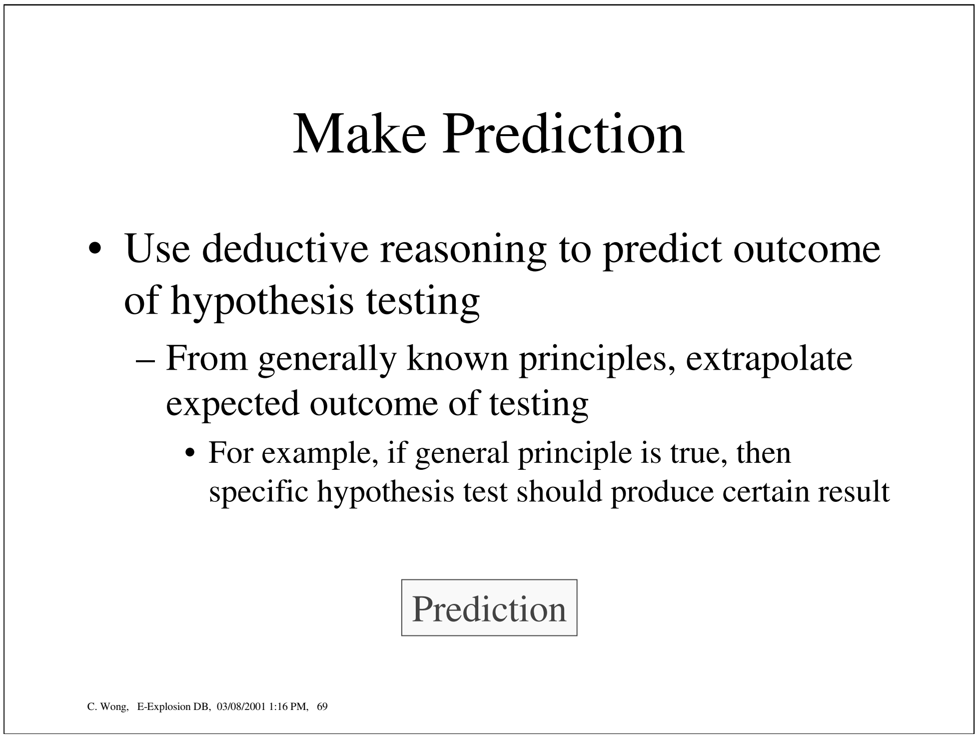
- Formulate tentative explanation for what is observed
  - Gather information/data
  - Analyze information/data
- Devise method to test tentative explanation
  - Explore applicability of methodologies
  - Determine what data/information is available
    - Find existing knowledge in repositories
      - Print material, electronically based material, people
    - Determine relevance, usefulness, access
  - Determine what new knowledge is needed
    - Brainstorm
    - Design experiment

Hypothesis

Once a research question is generated, the research moves on to the “formulate hypothesis” step. A hypothesis is a tentative explanation for what is observed. To formulate a hypothesis, a researcher might gather and analyze information. This activity can be extensive or minor in nature.

The task of hypothesis formulation also involves consideration of how the hypothesis might be tested. Part of the task is to devise candidate methods to test the hypothesis. This activity would involve exploring applicability of established methodologies or deriving variants.

The product of this step is a hypothesis that is carried into the next step, making a prediction.



Make Prediction

- Use deductive reasoning to predict outcome of hypothesis testing
  - From generally known principles, extrapolate expected outcome of testing
    - For example, if general principle is true, then specific hypothesis test should produce certain result

Prediction

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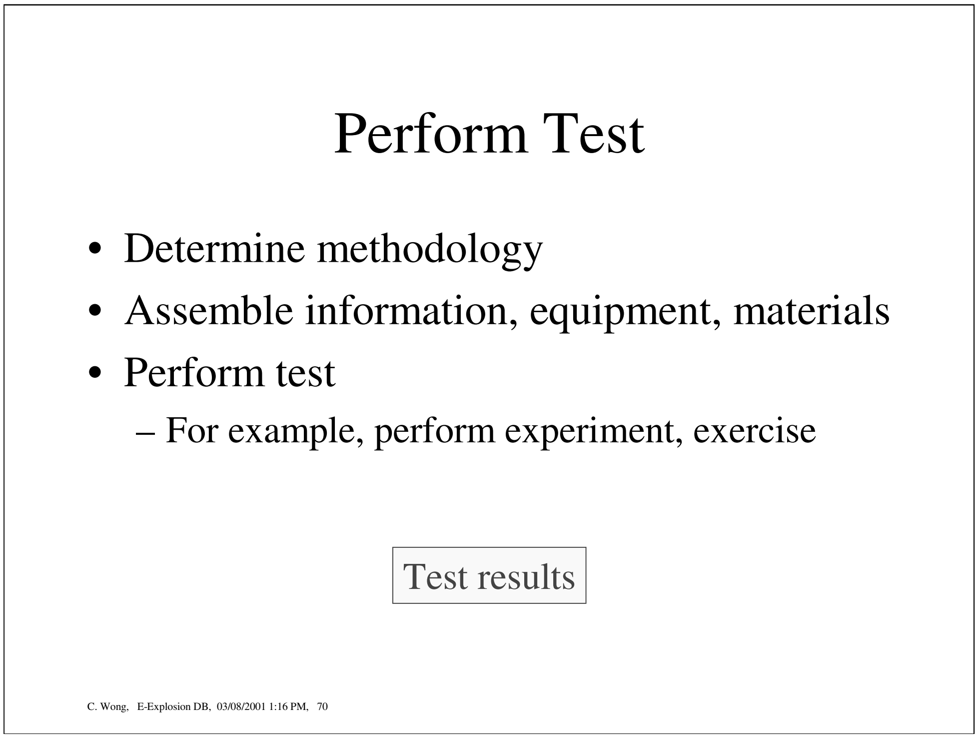
Once the researcher has formulated a hypothesis and established how the hypothesis might be tested, he must make a prediction about the outcome of the hypothesis testing. Generally, the researcher will use deductive reasoning to determine the prediction. That is, the researcher will apply generally known principles and extrapolate an expected outcome of the hypothesis testing. For example, if a general principle is true, then specific hypothesis testing should produce a certain result.

The product of this step is a prediction that is carried into the next step, performing the hypothesis testing.



Perform Test

- Determine methodology
- Assemble information, equipment, materials
- Perform test
  - For example, perform experiment, exercise

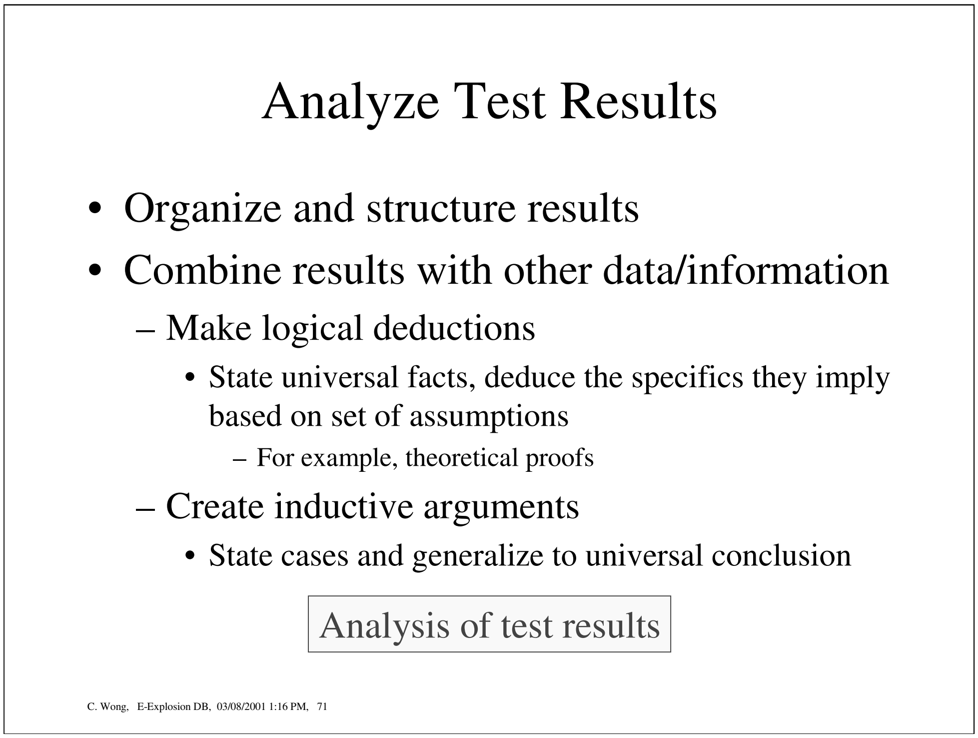
Test results

The initial task in the “perform test” step is to decide on a methodology. Normally, the methodology selected will be one of the candidate techniques identified in the hypothesis formulation step. Minor modifications may be required for practicality, cost, schedule, or other resource considerations. Researchers must be attentive that the modifications do not affect the applicability of the methodology.

Sometimes, the test is performed by the researchers themselves, and other times it may be performed by a group designated and monitored by the researchers. In either case, the required information, data, equipment, materials, and supplies must be assembled and the participants must be identified and available.

Finally, the test is performed.

The product of this step is the raw test results that are carried into the next step, “analyze test results.”



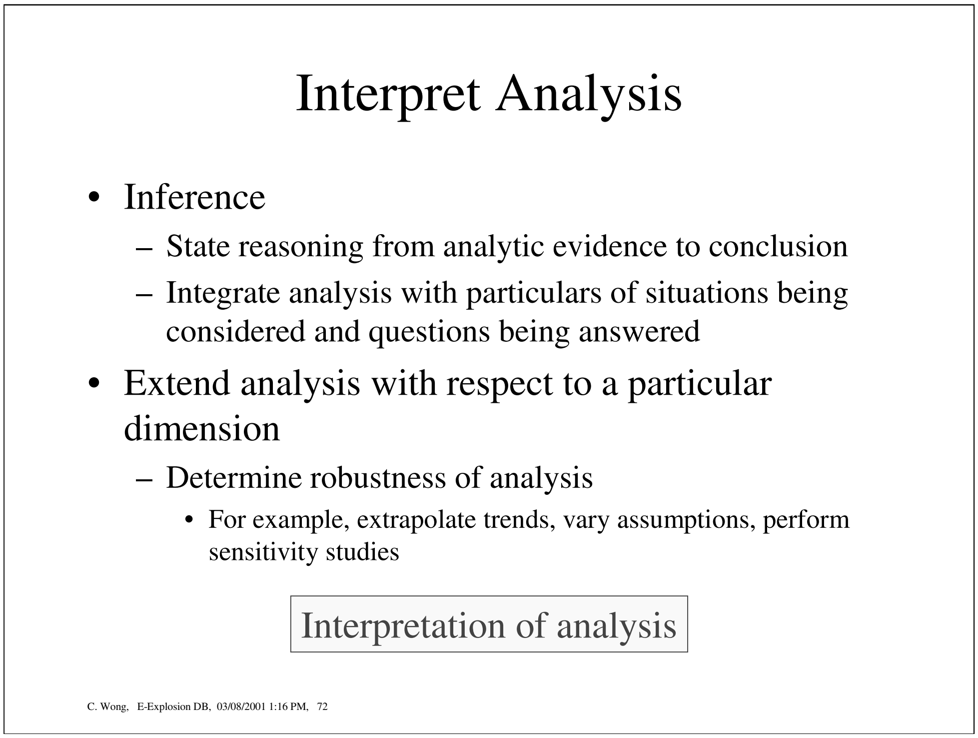
Analyze Test Results

- Organize and structure results
- Combine results with other data/information
  - Make logical deductions
    - State universal facts, deduce the specifics they imply based on set of assumptions
      - For example, theoretical proofs
  - Create inductive arguments
    - State cases and generalize to universal conclusion

Analysis of test results

The raw test results need to be organized and structured. Analysis methods applicable to this step include statistics generation, sorting methods, and classification techniques. The test results might be combined with other data or information to make logical deductions. For example, the researcher might consider universal facts and deduce the specifics they imply based on a set of assumptions. Inductive arguments, in which the researcher states specific cases and generalizes them to universal conclusions, may also be employed.

The product of this step is an analysis of the test results, which is input to the "interpret analysis" step.



Interpret Analysis

- Inference
  - State reasoning from analytic evidence to conclusion
  - Integrate analysis with particulars of situations being considered and questions being answered
- Extend analysis with respect to a particular dimension
  - Determine robustness of analysis
    - For example, extrapolate trends, vary assumptions, perform sensitivity studies

Interpretation of analysis

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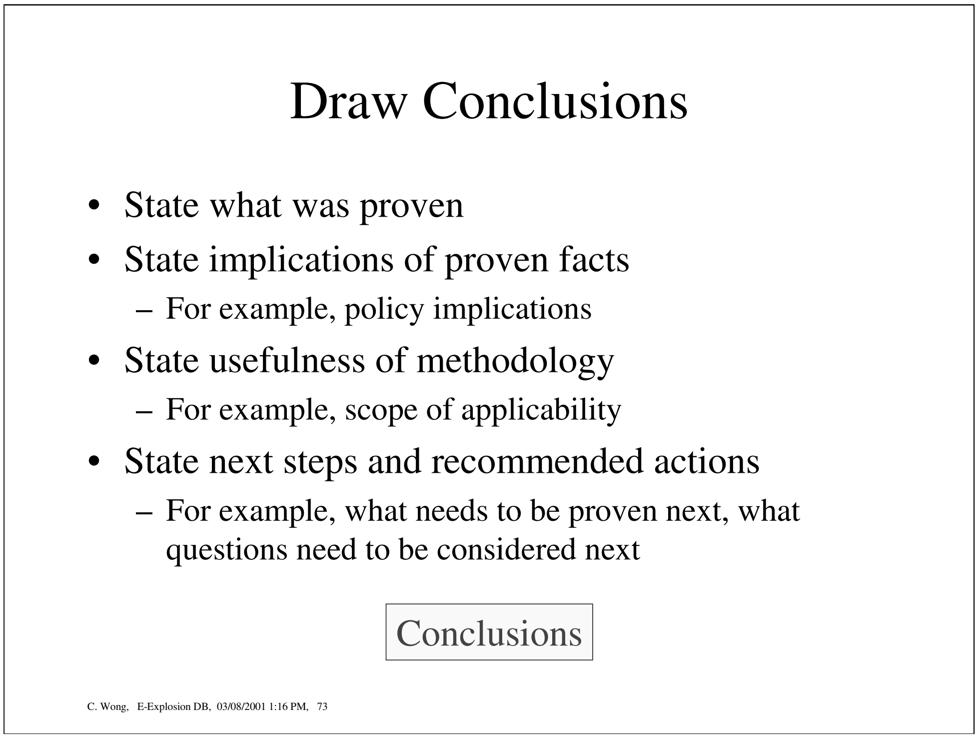
When interpreting the analysis of the test results, the researcher establishes a chain of reasoning from the analytic evidence to possible conclusions. The researcher might integrate the analysis with particulars of the situations considered and the question being addressed. To help with the interpretation, the researcher might attempt to extend the analysis with respect to particular dimensions. The researcher might attempt to determine the robustness of the analysis by extrapolating trends, varying the assumptions, and performing sensitivity analysis. These techniques will help the researcher establish the extent of the validity of the analysis.

The product of this step is an interpretation of the analysis that is carried onto the final step of the research process, “drawing conclusions.”



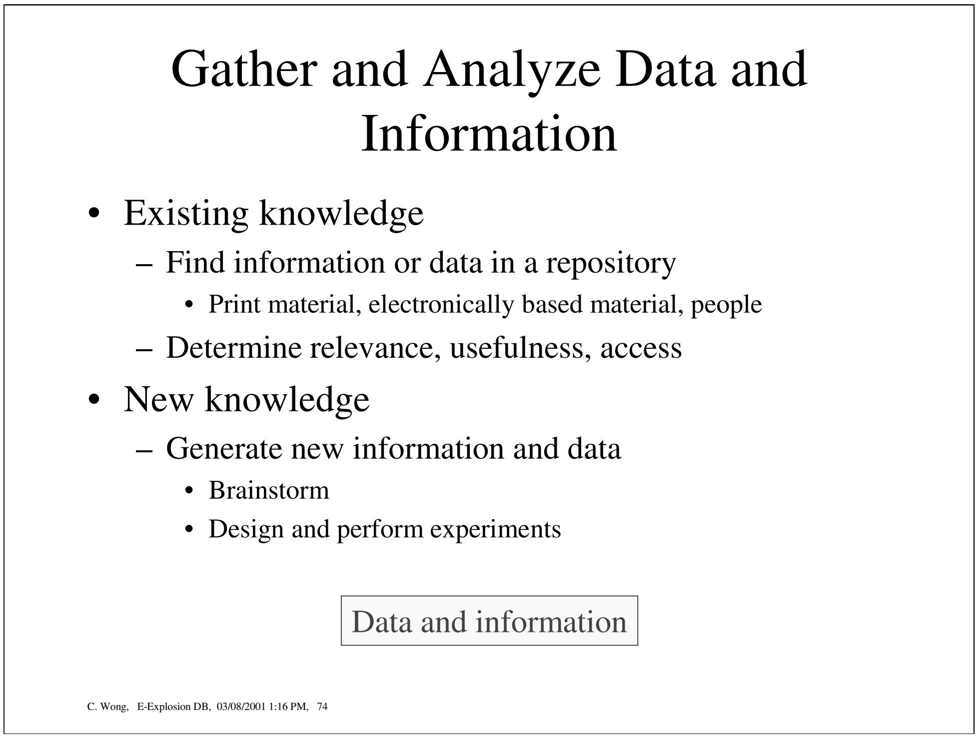
Draw Conclusions

- State what was proven
- State implications of proven facts
  - For example, policy implications
- State usefulness of methodology
  - For example, scope of applicability
- State next steps and recommended actions
  - For example, what needs to be proven next, what questions need to be considered next

Conclusions

At this step, the researcher states what has been proven. The researcher's underlying assumptions must be made clear to effect an unambiguous understanding of the proven facts. The researcher may also state the implications of what has been proven. For example, policy implications might be discussed. The usefulness of the test methodology employed and the scope of its applicability may also be part of the researcher's conclusions. Finally, the researcher may state the next steps or recommend actions about what needs to be proven next or what questions should be considered in the future.

The product of this step is the researcher's set of conclusions.



Gather and Analyze Data and Information

- Existing knowledge
  - Find information or data in a repository
    - Print material, electronically based material, people
  - Determine relevance, usefulness, access
- New knowledge
  - Generate new information and data
    - Brainstorm
    - Design and perform experiments

Data and information

Throughout the research process, the researcher is gathering and analyzing data and information. The research must consider what information or data is available for each step of the research process and how much time and effort will be afforded to evaluate that information. Some of this information might exist in repositories such as print libraries, or, electronically, in databases. People can also furnish information, and more involved data collection might be required to gather information from a human source.

The relevance, usefulness, accuracy, and access to the information must also be established.

Finally, new knowledge might be required to perform a step adequately. New knowledge might stem from brainstorming activities or from experiments.

The product of this activity is data and information that will be used to perform each step of the research process.