(2)

AD-A2[illegible] 624

R-6280

ASSESSMENT OF ULTRA-WIDEBAND (UWB) TECHNOLOGY

Prepared by

OSD/DARPA Ultra-Wideband Radar Review Panel

BATTELLE
Tactical Technology Center
505 King Avenue
Columbus, Ohio 43201-2693

Under

Contract No. DAAH01-88-C-0131
ARPA Order 6049

July 13, 1990

Approved for Public Release; Distribution Unlimited

Sponsored by

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
Arlington, Virginia 22209-2308

Monitored by

U.S. ARMY MISSILE COMMAND
Redstone Arsenal, Alabama 35898-5244

FOREWORD

The Defense Advanced Research Projects Agency (DARPA) and the Office of the Secretary of Defense (OSD) tasked Battelle to review ultra-wideband (UWB) technologies and applications. Battelle convened the Ultra-Wideband Radar Review Panel to examine the state of the art and the potential performance benefits and limitations of UWB technology, with particular emphasis on radar applications. The Panel was tasked with identifying and prioritizing UWB research to be pursued and exploited. This summary report presents the Panel's findings.

DISCLAIMER

The views and conclusions contained in this document are those of the OSD/DARPA Ultra-Wideband Review Panel and should not necessarily be interpreted as representing the official policies, either expressed or implied, of the Defense Advanced Research Projects Agency or the U.S. Government, or the views or policies of Battelle.

EXECUTIVE SUMMARY

Introduction

In view of the interest in ultra-wideband (UWB) technology, the Defense Advanced Research Projects Agency (DARPA) and the Office of the Secretary of Defense (OSD) contracted with Battelle to assess UWB technology and its potential military applications. Battelle convened a panel of experts drawn from the various technical areas concerned with UWB technology in order to perform this assessment. The Panel's assignment was to review the status of the work in the field, to examine the validity of a number of claims made by proponents, to determine potential performance benefits, and to recommend areas for Government R&D support. The Terms of Reference are given in the Appendix, along with a list of Panel members, Government advisors, and presenters, and the agendas of the Panel meetings.

The Panel reviewed available experimental data, analyses, literature, and various studies. It examined past and proposed research at DoD and DOE laboratories, as well as by industry and academia. It invited the proponents of UWB technology to disclose and explain their approaches, methods, and recommendations. It gave consideration to all views, and worked to identify and prioritize promising concepts for exploitation of UWB phenomena. This report presents the results of these efforts and recommends research which the Panel believes should be pursued and identifies areas which the Panel believes are not worthy of pursuit.

Scope

Interest in UWB technology has focused on three areas:

- Radar
- Communications
- Electronic warfare (EW) and RF weaponization.

The Panel concentrated on radar but invited the presentation of ideas on communications. No ideas or proposals for UWB communications systems

or techniques were presented, nor were any advantages for such systems apparent to the Panel. Examination of electronic warfare and RF weaponization applications was very limited. The restrictions imposed by the combination of security classification and the proprietary nature of many of the EW and weaponization concepts under development by the presenters made it difficult for the Panel to conduct an in-depth review of these areas. Further, the DoD has established a separate in-house committee to review a broader area that includes UWB applications to electronic warfare and weaponization. Thus, the Panel's efforts were almost entirely devoted to UWB radar issues.

Features o UWB Radar

UWB radars are characterized by very wide bandwidths and the commensurate fine range resolution. There are applications in which range resolutions on the order of one foot are desired, such as imaging typical tactical targets, and wideband techniques are routinely used for these. However, there are associated disadvantages as well, as evidenced by the preference to use the narrowest bandwidth consistent with need in order to minimize the processing burden. For example, a tenfold increase in bandwidth has significant impact on the cost of a system since, for a given surveillance volume, the number of resolution cells to be processed and the required processing for detection are both proportional to the bandwidth. In addition, the tenfold increase in number of cells, for all else constant, implies about a tenfold increase in the probability of false alarm or a small decrease in system sensitivity. For these reasons, wideband or ultra-wideband are used only when the increased percentage bandwidth presents a distinct advantage.

Essentially all of the interest in (and claims for) UWB radars have related to an impulse radar implementation which, in its simplest form, generates its radiated energy by applying a very short video pulse (hence "impulse") to an antenna. Other forms of UWB radars, "non-impulse" radars, are generally extrapolations and extensions of so-called conventional radars. Consequently, the Panel's efforts were concentrated on impulse radar technologies and capabilities.

Discussion

Impulse radars have been around for a long time and there are a number of fielded systems that have been successfully used for terrain profiling and ground penetration to find buried objects.

The recent general interest, however, has centered on claims involving counter-stealth capabilities, Low Probability of Intercept (LPI), and detection of relocatable targets (in camouflage and foliage). In the technical community, there has been controversy over assertions that the "standard" analytical tools were either inappropriate or inadequate to deal with impulse radar issues.

An impulse radar can have substantial low frequency content and typically has high peak power and short pulse length. These properties are the basis for claims of unusual capabilities. In examining the subject, the Panel found it useful to separate such claimed capabilities into two categories: (1) those involving *pheromena which are unique* to impulse radars and (2) those in which impulse radar may offer one or more *advantages in implementation*.

Most of the claims for unique performance capabilities were based upon non-linear effects due to high power and/or short pulses. The Panel found no theoretical or experimental evidence of such effects at frequencies and operating ranges of interest.

The use of self-induced transparency (a truly non-linear phenomenon) has been suggested as a possible method for reducing atmospheric attenuation of millimeter waves. The Panel was able to look into this only briefly. It concluded that the likelihood of achieving a useful military capability taking advantage of potentially reduced atmospheric attenuation was slight but that it would be useful to have someone (e.g., the JASONS, the National Science Foundation, or a university) review and document the whole area of non-linear effects and any possible military applications.

Other claims for unique capabilities were examined and found to be in error. Specifically, "precursors", which have figured prominently in some discussions, are linear transients in distributed media and not unique to impulse systems. Further, the Panel saw no practical radar application of this phenomenon.

There are a number of applications where the combination of high resolution and low frequency is desirable. The most demonstrated are terrain profiling and earth penetration, but others such as foliage penetration or the possibility of simultaneous low-frequency surveillance with high resolution for target identification have been suggested and should be considered. Either conventional wideband (non-impulse) or impulse radars could accomplish these functions, but impulse radars might have a substantive advantage in implementation as measured by cost, size, or weight and deserve detailed examination. Shorter-range applications are most likely to manifest this advantage.

There have been three proposed capabilities for impulse radar that have received wide attention:

(A) Counter-Stealth. The Panel concluded that impulse radar is not "inherently anti-stealth." The primary technique used for achieving low radar cross section is shaping. Low frequencies (HF and VHF) can exploit target resonance effects which are independent of shaping and only a function of size. This phenomenon, however, holds for any radar operating in those bands and impulse radars have no unique advantages against shaping.

There are no effects in radar absorbing material (RAM) that are unique to impulse radar. Field strengths in practical applications are too low to excite material non-linearities. All observed effects are due to "out-of-band" operation (with respect to the RAM) and predictions to the contrary are due to a misunderstanding of electromagnetics. Standard measurement and diagnostic techniques routinely used by the stealth community deal with these issues completely.

(B) Detectability of the Radar (LPI). To make a radar's signal more difficult to intercept, radar designers resort to the use of complex waveforms and large processing gains. Even so, it is difficult to make a radar hard to detect even in the sidelobe region. The Panel concluded that the impulse radar, which typically has less processing gain, has no

special LPI characteristics and is readily detectable by an appropriately designed intercept receiver.

(C) Detection of Relocatable Targets. A capability of interest to both strategic and tactical forces is the detection of military targets when shielded or obscured by trees. Consequently, there has been interest in developing a foliage-penetration imaging radar with sufficient resolution to detect targets of interest with an acceptable false alarm rate. A radar with a resolution on the order of a few feet and operating at frequencies low enough to have tolerable attenuation through foliage might provide a useful capability. The Panel suggests that an impulse radar with a center frequency of a few hundred Megahertz may well be the best way to implement such a system. These design efforts and, if appropriate, experiments are needed to establish the military utility of such a system.

The Panel reviewed and analyzed all the other areas and issues pertinent to impulse radar. The Panel was favorably impressed by the designs of the existing systems for terrain profiling, etc.; by the possibilities of other short-range and possible medium range radar applications (See Recommendation A-1); and with the work on "sources" (i.e., generators of very high power pulses) and their possible application to conventional as well as impulse transmitters. Other than these issues, nothing startling or of unusual merit was found for impulse radar.

The Panel also reviewed the claim that conventional analysis techniques were not applicable to impulse radar, and found that this claim was due to inadequate understanding of the issues or erroneous application of electromagnetic theory and is incorrect.

Principal Conclusions

(A) The Panel concluded that there is no credible evidence of unique phenomenological capabilities related to the claims made or proposals advocated to the Panel.

(B) The Panel concluded that impulse radar is not "inherently anti-stealth."

(C) The Panel concluded that impulse radar has no special LPI characteristics and is readily detectable by an appropriately designed intercept receiver.

(D) The Panel concluded that all applications presented could be implemented by alternative "non-impulse" techniques.

For every application of impulse radar which was presented, a corresponding example using a non-impulse radar was found. The Panel saw no applications for which only an impulse radar could work.

(E) The Panel found that impressive accomplishments have been achieved on impulse radars for terrain profiling, ground probing, and diagnostics--all short-range applications.

Terrain profiling can be done at higher frequencies, but terrain profiling through foliage requires low frequency and high resolution.

The Panel suggests that impulse radar probably represents the most cost-effective solution for the terrain profiling and ground probing applications.

(F) The Panel found that there may be other applications where impulse radars are preferable to non-impulse approaches due to potentially lower cost and lighter weight.

Impulse radars might have specific advantages for certain applications with regard to size, cost, weight, and ruggedness. Their applicability to other military requirements should be explored. (See Recommendation A-1)

(G) The Panel concluded that the available analysis tools are completely adequate and appropriate for dealing rigorously with impulse radar performance. However, the Panel cautions that care must be given to ensure their correct application and notes that this has not always been the case.

Excluding intensity-driven non-linearities and quantum phenomena, the Panel maintains that conventional classical, linear, time-invariant systems theory, statistical estimation and detection theory, and Maxwell's Equations fully describe all the phenomena presented that relate to impulse and non-sinusoidal radars.

(H) The Panel concluded that advances in sources for generating very high power short pulses are impressive and may be promising for conventional short pulse radar as well as impulse transmitters. These advances do not enable any unique capabilities but may impact the choice among possible implementations to achieve cost or weight advantages.

Key Recommendations

(A) The Panel makes three recommendations for DoD investments in UWB radar related studies and analyses:

(1) In order to examine in detail the implementation trade-off advantages, the Panel recommends that the DoD fund analyses of point designs using impulse and non-impulse approaches for four radar applications which appear to have important military applications:

- A short-range system for detecting moving targets behind walls or foliage
- A short-range airborne imaging radar for detecting military targets under canopy or in wooded terrain
- A medium-range (20 km) air defense radar for detection and non-cooperative identification of airborne targets, including but not limited to helicopters in the tree line
- A medium-range (20 km) radar for detection of sea skimming missiles in fleet defense applications

Suggested performance parameters for each system are given in the text of this report. The suggested level of effort for each of the point designs is one to two person-years.

(2) In order to support the point design studies in (A)(1) above, the Panel recommends that the DoD fund two other studies relevant to UWB (impulse or non-impulse) system designs:

- A review and analysis (based upon existing theory and measurement data) of clutter behavior for UWB radar systems
- An analysis that characterizes the range and angle pattern of UWB linear and planar antenna arrays.

The suggested level of effort of each study is one person-year.

(3) The Panel recommends that the DoD review the status of UWB source development in order to determine if additional R&D efforts are needed. It is suggested that this review be an in-house effort.

(B) The Panel makes three recommendations against DoD investments in UWB radar related efforts:

(1) The Panel recommends that no measurement programs of any kind on stealth materials or vehicles (e.g., to examine non-linear effects) be funded.

(2) The Panel recommends against funding of any system studies based upon unsubstantiated materials phenomena.

(3) The Panel recommends that no system development be undertaken until the results of recommendations (A)(1) and (A)(2) above are assessed and demonstrate the military value of such system(s).

This is not meant to exclude the investigations in progress at several Government laboratories which are aimed at understanding the technology and implementation implications of UWB radar systems.

(C) Finally, the Panel recommends the DoD sponsor a modest effort to document the characteristics of self induced transparency and any other non-linear effects relevant to their possible contributions to military systems. This

work could be accomplished as part of the JASONS' 1990 Summer Study, a National Science Foundation effort, or a funded University effort.

Final Comment

Although, as noted herein, the Panel found interesting work under way and recommends additional efforts, it does not believe impulse radar offers a major new military capability nor correspondingly does it present the threat of a serious technological surprise.

APPENDIX

TERMS OF REFERENCE, PANEL MEMBERS, OBSERVERS, PRESENTERS, AND MEETING AGENDAS

ULTRA-WIDEBAND RADAR REVIEW PANEL

TERMS OF REFERENCE

1. Review what has been done in ultra-wideband radar development
   a. Available experimental data
   b. Literature, including Soviet unclassified, as available.
2. Review what is being done and what is proposed to be done
   a. Government laboratories, including DOE labs
   b. Industry and academe.
3. Determine potential performance benefits
   a. Radar technology for a variety of applications, including potential for low observable targets
   b. Countermeasures.
4. Identify technology issues and gaps in knowledge, and priority of importance.
5. Recommend research which should be pursued to resolve issues
   a Areas for further investigation
   b. Experimental tools/hardware needed.
6. Determine possible applications.

ULTRA-WIDEBAND REVIEW PANEL
PANEL MEMBERS

*Denotes Alternate

ELI BROOKNER
RAYTHEON
430 Boston Rd.
M/S B22
Wayland, MA 01778
W(508) 440-5636

JOHN CASHEN
NORTHROP
8900 Washington Blvd.
Pico Rivera, CA 90660-3783
W(213) 948-8985

GEORGE COOPER
CONSULTANT/GENERAL DYNAMICS-POMONA
4461 Glen Way
Claremont, CA 91711
W(714) 868-4891

JIM CORUM
BATTELLE
505 King Avenue
Room 4-133C
Columbus, OH 43201-0693
W(614) 424-3574

CURT DAVIS
LINCOLN LABS
P.O. Box 73, C490
244 Wood St.
Lexington, MA 02173
W(617) 981-7455

BERT FOWLER
CONSULTANT
15 Woodberry Rd.
Sudbury, MA 01776
W(508) 443-7509

ARCHIE GOLD
SAIC
1555 Wilson Blvd.
Suite 700
Arlington, VA 22209
W(703) 525-8585

EVAN IVERSON
LANL
P.O. Box 1663
M/S J580
Los Alamos, NM 87545
W(505) 667-0650

DAVE KRAMER
MITRE
Burlington Rd.
M/S A395
Bedford, MA 01730
W(617) 271-3672

IVAN LAHAIE *
ERIM
P.O. Box 8618
Ann Arbor, MI 48107
W(313) 994-1200, Ext 2217

JAY LOOMIS
MICOM
Cdr, US Army MICOM
ATTN: AMSMI-RD-AS-RA/Dr. Loomis
Redstone Arsenal, AL 35898-5253
W(205) 876-5017

LARRY LYNN
ATLANTIC AEROSPACE
ELECTRONICS CORP
6404 Ivy Ln.
Suite 300
Greenbelt, MD 20770
W(301) 982-5255

ROGER MANASSE
CONSULTANT
234 Canon Drive
Santa Barbara, CA 93105
W(818) 887-4299

ED MILLER
LANL
P.O. Box 1663
MEE-3, M/S J580
Los Alamos, NM 87545
W(505) 667-6249

DENNIS MURRAY
SAIC
3601 Aviation Blvd.
Suite 3600
Manhattan Beach, CA 90266
W(213) 536-0688

FRED NATHANSON
GTRI
11400 Dorchester Ln.
Rockville, MD 20852
W(301) 770-0752

DAVE NELSON
HARVARD/JASON
Lyman Laboratory of Physics
Harvard University
Cambridge, MA 02138
W(617) 495-4331

RICHARD NORTON *
R.J. Norton Company
21290 West Hillside Dr.
Topanga, CA 90290
W(213) 455-1138

ALAN PETERSON
STANFORD UNIVERSITY
227 Durand Bldg
Electrical Engineering
Stanford, CA 94305-4055
W(415) 723-3594

LEE POIRIER *
RADC/EEC
Rome Air Development Center
Electromagnetics Division
Hanscom AFB, MA 01731-5000
W(617) 377-2526

JIM RALSTON
IDA
1801 N. Beauregard Street
Alexandria, VA 22311
W(703) 578-2823

STAN ROBINSON
ERIM
P.O. BOx 8618
Ann Arbor, MI 48107
W(313) 994-1200, Ext 2505

JAY SCHINDLER
RADC/EE
Rome Air Development Center
Electromagnetics Division
Hanscom AFB, MA 01731-5000
W(617) 377-3700

MERRILL SKOLNIK
NAVAL RESEARCH
LABORATORY
455 Overlook Ave. S.W.
Code 5300
Washington, DC 20375-5000
W(202) 767-2936

NICK TOMLJANOVICH *
MITRE
Burlington Rd.
M/S A395
Bedford, MA 01730
W(617) 271-5564

ULTRA-WIDEBAND REVIEW PANEL
OBSERVERS

GREGORY V. CIRINCIONE
SAIC
1555 Wilson Blvd.
Suite 700
Arlington, VA 22209
W(703) 525-8585

COL BARRY CRANE
ODDRE (R&AT/ET)
ATTN: COL Crane
Room 3D1089
The Pentagon
Washington, DC 20301-3080
W(202) 695-0005

JOHN DAVID
HARRY DIAMOND
LABORATORIES
Department of the Army
Harry Diamond Laboratories
ATTN: SLCHD-ST-R/John David
2800 Powder Mill Road
Adelphi, MD 20783
W(202) 394-2530

JOHN N. ENTZMINGER
DARPA/TTO
1400 Wilson Blvd.
Arlington, VA 22209
(703) 694-2440

DOMINICK GIGLIO
DARPA/TTO
1400 Wilson Blvd.
Arlington, VA 22209
W(703) 694-8232

BRENDON GODFREY
(505) 844-9856

PETE HOAG
JCLO Office
1215 Jefferson Davis Highway
Room 1208
Arlington, VA 22202
W(202) 692-5675

JIM HOGARTY
JCLO Office
1215 Jefferson Davis Highway
Room 1208
Arlington, VA 22202
W(202) 692-5675

BERT HUI
DARPA/DSO
1400 Wilson Blvd.
Arlington, VA 22209
W(703) 694-2440

JOHN MCCORKLE
HARRY DIAMOND LABORATORIES
Department of the Army
ATTN: John McCorkle
2800 Powder Mill Road
Adelphi, MD 20783
W(202) 394-2530

RICHARD MUIR
NAVSEA
Commander
Naval Sea Systems Command
Department of the Navy
Washington, DC 20362-5101
W(703) 437-7516

ART PAVEL
DARPA/AVSTO
1400 Wilson Blvd.
Arlington, VA 22209
W(202) 694-1893

VINCENT PUGLIELLI
BATTELLE
505 King Avenue
Room 4-1-33E
Columbus, OH 43201-2693
W(614) 424-7319

GEORGE T. RUCK
BATTELLE
505 King Avenue
Room 4-1-33B
Columbus, OH 43201-2693
W(614) 424-5685

RAY SIEWART
ODDRE (R&AT/ET)
ATTN: Mr. Siewart
Room 3D1089
The Pentagon
Washington, DC 20301-3080
W(703) 697-7922

PHILIP L. SOUCY
SAF/AQ
Department of the Air Force
ATTN: SAF/AQ
Washington, DC 20330-1000

FRANK E. WELKER
USAF/RADC
Griffiss Air Force Base, NY 13441-5700
W(315) 330-4437

MIKE WICKS
RADC/OCT
Griffiss Air Force Base, NY 13441-5700
W(315) 330-4437

ROBERT WILLIAMS
DARPA/DIRO
1400 Wilson Blvd.
Arlington, VA 22309
W(703) 694-2564

ELI ZIMET
OFFICE OF NAVAL TECHNOLOGY
800 N. Quincy St.
Arlington, VA 22217-5000
W(202) 696-4771

ULTRA-WIDEBAND REVIEW PANEL
PRESENTERS

M. SKOLNIK
NRL

M. WICKS
RADC

C. DAVIS
LINCOLN LABS

D. KRAMER
MITRE

E. THOMPSON
DIA

J. COLEMAN
DIA

B. CRANE
U.S. ARMY

V. PUSATARI
NOSC

L. FULLERTON
TIME DOMAIN SYSTEMS

J. MCCORKLE
HDL

J. CORUM
BATTELLE

H. HARMUTH
CU

T. JOHNSON
BOEING

T BARRETT
BOEING

S. DAVIS
POWER SPECTRA

W. HAPPER
JASON

C. PHILLIPS
THERMO-ELECTRON

D. SULLIVAN
MRC

L. FRAZIER
GENERAL DYNAMICS

R. VICKERS
SRI

G. ROSS
ANRO

F. ZUCKER
RADC

A. SCHUTZ
GSSI

R. MOREY
GSSI

J. P. HANSEN
NRL

J. YOUNG
OHIO STATE U.

R. HUTCHINS
BDM

W. PEARSON
MCDONNELL DOUGLAS

G. COOPER
GENERAL DYNAMICS

S. PENG
TELEDYNE RYAN ELECTRONICS

D. MILLER
U. OF ROCHESTER

K. OUGSTON
U. OF VERMONT

M. FRIEDMAN
NORTHEASTERN U.

B. WILLIAMS
DARPA

M. VAN BLARICUM
TOYON

T. SARKAR
SYRACUSE U.

AGENDA

ULTRA-WIDEBAND STUDY - SESSION I

February 22, 1990

0830-0840	Welcome & Introduction	B. Tullington
0840-0900	Study Objective & General Discussion	C.A. Fowler
0900-1000	NRL Activities	M. Skolnik
1000-1015	Break	
1015-1115	RADC/OCT Program Review	M. Wicks
1115-1215	Lincoln Lab/RADC/MITRE Study	L. Pourier/ C. Davis
1215-1315	Working Lunch/Panel Discussion	
1315-1445	DIA	Ed Thompson/ J. Coleman
1445-1500	Break	
1500-1700	Panel Discussion	C.A. Fowler/ Jim Corum
1700	Meeting Adjourned	

ULTRA-WIDEBAND STUDY

AGENDA

March 20, 1990

SPC Conference Room
1500 Wilson Boulevard
Arlington, VA 22209

Times	Subject	Presenter
0830 - 0840	Welcome	B. Tullington, Battelle
0840 - 0915	Chairman's Remarks	C. Fowler
0915 - 1015	Current UWB Projects	B. Crane, USA
1015 - 1030	Break	
1030 - 1130	NOSC UWB Programs	V. Pusatari, NOSC
1130 - 1230	Working Lunch	
1230 - 1330	UWB Experimental Results	L. Fullerton, Time Domain Systems
1330 - 1430	Foliage Penetration UWB SAR	J. McCorkle, HDL
1430 - 1450	Break	
1450 - 1550	Review of Los Alamos UWB Conference	J. Corum, Battelle
1530 - 1700	Panel Discussion	C. Fowler/ J. Corum, Battelle
1700	Chairman's Remarks & Adjournment	C. Fowler

ULTRA-WIDEBAND STUDY

AGENDA

March 28,1990

SAIC Conference Room
1555 Wilson Boulevard
Suite 700
Arlington, VA 22209

Times	Subject	Presenter
0830 - 0840	Welcome	B. Tullington, Battelle
0840 - 0900	Chairman's Remarks	C. Fowler
0900 - 1000	General Principles of UWB	H. Harmuth, CU
1000 - 1020	Boeing Company Programs, Introduction	T. Johnson, Boeing
1020 - 1040	Break	
1040 - 1140	Theoretical Approach to UWB Radar	T. Barrett, Boeing
1140 - 1210	Working Lunch	
1210 - 1310	Near-term UWB Applications	S. Davis, Power Spectra
1310 - 1510	UWB Applications	H. Harmuth, CU
1510 - 1530	Break	
1530 - 1630	Analysis of Impulse Radar and Materials Effects	W. Happer, JASONS
1630 - 1700	Panel Discussion	C. Fowler, J. Corum Battelle
1700	Chairman's Remarks & Adjournment	C. Fowler

ULTRA-WIDEBAND STUDY

AGENDA

March 29, 1990

SAIC Conference Room
1555 Wilson Boulevard
Suite 700
Arlington, VA 22209

Times	Subject	Presenter
0830 - 0840	Welcome	B. Tullington, Battelle
0840 - 0900	Chairman's Remarks	C. Fowler
0900 - 1000	Panel Discussion	C.Fowler/ J. Corum, Battelle
1000 - 1020	Break	
1020 - 1120	Application of UWB for Radar	C. Phillips, Thermo-Electron
1120 - 1200	Working Lunch	
1200 - 1300	UWB Weapon Applications	D. Sullivan, MRC
1300 - 1400	UWB Weapon Applications	L. Frazier, GD
1400 - 1420	Break	
1420 - 1520	UWB Aircraft Signatures	R. Vickers, SRI
1530 - 1700	Panel Discussion	C. Fowler/ J. Corum Battelle
1700	Chairman's Remarks & Adjournment	C. Fowler

ULTRA-WIDEBAND STUDY

AGENDA

April 4, 1990

SPC Conference Room
1500 Wilson Boulevard
Arlington, VA 22209

Times	Subject	Presenter
0830 - 0840	Welcome	B. Tullington, Battelle
0840 - 0900	Chairman's Remarks	C. Fowler
0900 - 1000	UWB Applications	G. Ross, ANRO
1000 - 1020	Break	
1020 - 1120	Fundamental Issues	F. Zucker, RADC
1120 - 1200	Working Lunch	
1200 - 1300	Impulse Radar	A. Schutz, GSSI
1300 - 1400	UWB Technologies	R. Morey, GSSI
1400 - 1420	Break	
1420 - 1520	Absorber Measuring Contrasting UWB Instantaneous Swept Frequency Techniques	J.P. Hansen, NRL
1520 - 1620	UWB Diagnostic Target Imaging	J. Young, OSU
1620 - 1700	Panel Discussion	C. Fowler/J. Corum
1700	Chairman's Remarks & Adjournment	C. Fowler

ULTRA-WIDEBAND STUDY

AGENDA

April 5, 1990

SPC Conference Room
1500 Wilson Boulevard
Arlington, VA 22209

Times	Subject	Presenter
0830 - 0900	Welcome/Chairman's Remarks	B. Tullington, Battelle/C. Fowler
0900 - 1000	Impulse Radar Clutter Models	J. Copeland, BDM
1000 - 1015	Break	
1015 - 1115	Low Observables	W. Pearson, McDonnell Douglas
1115 - 1215	Noise Radar & Working Lunch	G. Cooper
1215 - 1700	Panel Discussion	C. Fowler/J. Corum
1700	Adjournment	C. Fowler

DoD/DARPA BTI Committee Review of Boeing Aerospace Electronics
Energy Crafting for Optimum Propagation (ECOP) Concept
(Energy Propagation Technology)

April 24, 1990

The Boeing Company
Rosslyn Center, 20th & 21st Floors
1700 North Moore Street
Rosslyn, VA 22209
(703) 558-9600

8:30-8:35	Introduction & Overview (J. B. Walsh, Boeing A&E, VP R&E)
8:35-9:00	Summary of Energy Crafting for Optimum Propagation (ECOP) Concept (Terence Barrett, Boeing A&B)
9:00-10:00	First Proposition of ECOP, addressing 70% of effort (Terence Barrett): The optimum emitted signal is that which is matched, filtered, (in both frequency and time), to the medium, target shape and material, and the desired results (Matched Filtering Adaptive Reconfigurable Array)
10:00-10:30	Discussion & Questions
10:30-10:45	Break
10:45-11:15	Teledyne Ryan Electronics (Sheng Peng): Adaptive Reconfigurable Timed Array
11:15-12:15	General Dynamics (Larry Frazier): Side-Looking Imaging Radar
12:15-12:30	Lunch (Catered Working Lunch)
12:30-13:30	Power Spectra Inc. (Steve Davis): Bulk Avalanche Semiconductor Switch
13:30-13:45	Testing of Interceptor Hardware (Don Simms or Ed Trou, Boeing A&E)
13:45-14:00	Break
14:00-15:00	Second Proposition of ECOP, addressing 30% of effort (Terence Barrett): The Dielectric response of media to transient signals of sufficiently short duration is distinctly different from the dielectric response to steady state signals. (Radiation Matter Interactions).
15:00-15:15	Discussion & Questions
15:15-15:30	Break
15:30-16:00	University of Rochester (Dwayne Miller): Dielectric effects with transient signals
16:00-16:30	University of Vermont (Kurt Oughstun): Precursor effects of radar frequencies
16:30-17:00	Northeastern University (Marvin Friedman): Advanced electromagnetic theory
17:00-17:15	Potential Applications Spectrum of UWB
17:15-17:30	Summary of ECOP COncept: Propositions #1 & #2
17:30-17:45	Recommendations for BTI/Other Government Support of UWB Activities
17:45-18:00	Discussion & Questions
18:00-18:30	Committee Deliberations
18:30	END

ULTRA-WIDEBAND
SUB-PANEL ATTENDANCE LIST

April 24, 1990
(GOVERNMENT ONLY)

NAME	AFFILIATION
CORUM, JAMES F.	BATTELLE
ENTZMINGER, JOHN	DARPA
HOAG, PETER	JCLO
HOGARTY, JIM	JCLO
IVERSON, EVAN	LANL
LOOMIS, JAY	MICOM
MUIR, RICHARD	NAVSEA
POIRIER, LEE	RADC
PUGLIELLI, VINCENT G.	BATTELLE
RALSTON, JAMES	IDA
RUCK, GEORGE T.	BATTELLE
SCHINDLER, JAY	RADC
SKOLNIK, MERRILL	NRL
SOUCY, PHILIP	SAF/AQ
TULLINGTON, BERNIE	BATTELLE
WILLIAMS, ROBERT	DARPA
OLIVER, MARION	JHU/APL
HUI, BERTRAM	DARPA
MCCORKLE, JOHN	HDL

ULTRA-WIDEBAND STUDY

AGENDA

April 25, 26, 1990

BATTELLE CONFERENCE ROOM
1300 N. 17th Street, Suite 1520
Arlington, VA 22209
Telephone, (703) 875-3340

Times	Subject	Presenter
	APRIL 25, 1990 - SUB PANEL MEETING	
1000 - 1005	Welcome, Sub-Panel	B. Tullington, Battelle
1005 - 1015	Remarks	J. Entzminger, DARPA
1015 - 1200	Sub Panel Discussions & Conclusions from Boeing Session	J. Entzminger/J. Corum
1200 - 1345	Lunch Break	
	APRIL 25, 1990 - FULL PANEL MEETING	
1345 - 1400	Opening Remarks, Full Panel	C. Fowler
1400 - 1450	Systems Aspects of Resonance-Based Target Identification	M. VanBlaricum, Toyon
1450 - 1500	Break	
1500 - 1550	Conventional LaPlace Transient EM Issues	T. Sarkar, Syracuse
1550 - 1630	Sub Panel Report on Boeing Session	J. Entzminger/J. Corum
1630 - 1700	Panel Discussions	C. Fowler/J. Corum
1700	Chairman's Remarks & Adjournment	C. Fowler

APRIL 26, 1990 - FULL PANEL MEETING

0830 - 0845	Opening Remarks	C. Fowler
0845 - 1700	Panel Discussions & Reports	C. Fowler
1200 - 1245	Working Lunch	
1700	Chairman's Remarks & Adjournment	C. Fowler

ULTRA-WIDEBAND STUDY

AGENDA

June 14, 1990

BATTELLE CONFERENCE ROOM
1300 N. 17th Street, Suite 1520
Arlington, VA 22209
Telephone, (703) 875-3340

Times	Subject	Presenter
0830 - 0845	Welcome/Chairman's Remarks	C. Fowler
0845 - 0900	Draft Report Organization and General Comments	J. Corum, Battelle
0900 - 1700	Final Report Discussion	C. Fowler
1200 - 1245	Working Lunch	
1700	Closing Remarks	C. Fowler

250 East River Road
Rochester, New York 14623

Laboratory for Laser Energetics

TEL 716 275 5101

Agenda

Ultrawide Band Radar Panel Site Visit

Friday, 11 May 1990

11:30	Tour of Facilities at the Laboratory for Laser Energetics	Dwayne Miller Sam Letzring William Donaldson
12:30	Lunch on Site	
13:00	Short Pulse Effects in the Optical Regime	Joseph Eberly
14:00	Experimental Observation of Short Pulse Effects.Outline of Experimental Program	Dwayne Miller
15:00	High Power Photoconductive Switching for Microwave Pulse Generation	William Donaldson
16:00	Summary Meeting Adjourned	

ULTRA-WIDEBAND SUB-PANEL
ATTENDANCE LIST

May 11, 1990

University of Rochester

NAME	AFFILIATION
JAMES RALSTON	IDA
MERRILL SKOLNIK	NRL
GEORGE RUCK	BATTELLE
VINCE PUGLIELLI	BATTELLE
JAMES CORUM	BATTELLE