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TECHNICAL REPORT

ARL-TR-98-1
9 January 1998

Copy Number 17

ONR Basic Research Program: Summary and Bibliographies

Final Report under Grant N00014-95-1-0317
1 January - 31 December 1995

Thomas G. Muir and Elaine C. Frazer

Prepared for: Office of Naval Research
Department of the Navy • Arlington, VA 22217-5660

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	9 Jan 98	1 Jan - 31 Dec 95

4. TITLE AND SUBTITLE

ONR Basic Research Program: Summary and Bibliographies, Final Report under Grant N00014-95-1-0317

5. FUNDING NUMBERS

N00014-95-1-0317

6. AUTHOR(S)

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7. PERFORMING ORGANIZATION NAMES(S) AND ADDRESS(ES)

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The University of Texas at Austin
P.O. Box 8029
Austin, Texas 78713-8029

8. PERFORMING ORGANIZATION REPORT NUMBER

ARL-TR-98-1

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Office of Naval Research
Department of the Navy
Arlington, Virginia 22217-5660

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

The Office of Naval Research (ONR) sponsored the Basic Research Program, a discretionary grant program for the purpose of giving university laboratory directors freedom to develop and apply their resources to basic research problems of naval relevance, which might not be known or appreciated by others in the community. Program guidelines included (1) involvement of students and faculty and (2) initiation of research in areas that could transition into either core or special research initiative (SRI) programs at ONR.

14. SUBJECT TERMS

15. NUMBER OF PAGES

22

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	SAR

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. 239-18
298-102

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1. INTRODUCTION

The subject grant was originally issued on 23 February 1995 in response to Applied Research Laboratories, The University of Texas at Austin (ARL:UT), proposal P-1649 dated 7 November 1994.[1] This grant was funded out of the Office of the Chief of Naval Research (ONR) discretionary block for support of this laboratory as well as the following laboratories: Applied Research Laboratory, Pennsylvania State University (ARL/PSU); Applied Physics Laboratory, University of Washington (APL:UW); and Marine Physics Laboratory, Scripps Institution of Oceanography, University of California at San Diego (MPL:SIO:UCSD). This block was originally administered by ONR Code 324OA, Dr. Mohsen Badiey. Dr. Jeffrey Simmen took over from Dr. Badiey in 1994. The purpose of the discretionary grant program is to give the laboratory directors freedom to develop and apply their resources to basic research problems of naval relevance, which may not be known or appreciated by others in the community. The guidelines of the program include (1) involvement of student and faculty and (2) initiation of research in areas that could transition into either core or special research initiative (SRI) programs at ONR.

Support for ARL:UT in FY95 was based on six research problems, funded as shown in Table 1.1.

Table 1.1

Research Project	Principal Investigator	Funding
Analysis and Modeling of Acoustic Propagation and Reverberation in Shallow Water Experiments	Dr. Evan Westwood	$80K
Combustive Sound Source	Mr. Preston Wilson	$75K
A Study of Sporadic E and Traveling Ionospheric Disturbances in a Mid-Latitude Ionosphere	Dr. Jeffrey Cook	$60K

Investigation of Shock/ Vortex Interactions	Dr. Janet Ellzey	$40K
Acoustic Agglomeration of Particulates for Pollution Abatement and Material Science Applications	Dr. O. A. Ezekoye	$62K
Empirical Investigation of Fault Induced Vibrations in Axial Flow Compressors	Dr. Joe Thornhill	$47K
High School Apprenticeship Program	Dr. Tom Muir, Ms. Elaine Hackert	$36K

Statistics on projects, students, faculty, etc., for the duration of this grant are shown in Table 1.2.

Table 1.2

ONR "ARL" PROGRAM

Purpose:

- Seed money - new 6.1 research
- Support UT professors and students on problems of naval relevance
- Support High School Apprenticeship Program

Administration:

- Dr. Jeffrey Simmen, ONR 321OA
- Individual ONR project officers
- ARL IR&D Coordinator

	FY89	FY90	FY91	FY92	FY93	FY94	FY95
$K	133	299	310	348	370	400	400
Active projects	11	5	6	7	8	7	7
Students	11	5	6	7	6	8	9
Faculty	9	4	5	6	4	6	4

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2. RESEARCH RESULTS

The following bibliographical information summarizes the scientific results produced under this grant. We included work that may have begun under the preceding ONR discretionary grant, but was either finished or reported during the subject grant.

2.1 ARCHIVAL PUBLICATIONS

Bibliographical data are presented here, as well as the abstract of each paper that appeared in refereed journals. Also included are publications that have been submitted but are still in the journal editing process.

1. Knobles, D. P., "Modal Time Series Structure in Range and Depth of a Shallow Water Area," J. Acoust. Soc. Am. **99** (4:2), 2553 (1966).

   A theoretical analysis of pressure time series generated by small explosive sources and recorded on both an HLA and a VLA deployed in the Hudson canyon region off the New Jersey coast near the AMCOR 6010 borehole is presented. The SVP in the water column has an isovelocity layer down to a depth of about 20 m followed by a strong negative gradient to about 45 m where the profile becomes approximately isovelocity to the seafloor at 73 m. This sound-speed structure creates a unique time series structure on the VLA as a function of source range. The data are simulated with a broadband normal-mode approach recently discussed in the literature [J. Acoust. Soc. Am. **98**, 1682-1698 (1995); IEEE J. Ocean. Eng. **21**(1) (1996)]. The representation of the spatial and temporal structure of the time series in terms of a modal structure reveals several unique aspects of the structure of the SVP in the water column and the geoacoustic structure of the bottom. The details of the modal structure of the sound field clearly define the propagation mechanisms in the water column and the interaction with the seafloor and sub-bottom sediment layers.

2. Knobles, D. P., E. K. Westwood, and J. Lemond, "Modal Time Series Structure in a Shallow Water Environment," submitted to IEEE J. Oceanic Engineering, August 1997.

   The broadband acoustic characterization of the Hudson Canyon region off the New Jersey Continental Shelf is studied with an analysis of pressure time series generated by small explosive sources and recorded on a vertical line array (VLA). The average water depth is about 72 m and the average sound speed profile (SSP) is downward-refracting over the mid-portions of the water column. The seabed is characterized by sediment layers possessing sand-like characteristics. The sound speed structure of the water column and the seabed structure create distinguishing modal features in the impulse response in the 250-500-Hz band. The details of the depth and range dependence of the time series on the VLA are sensitive to small perturbations of the structure of the upper layer of the SP, the water depth, and the seabed structure. This sensitivity of the acoustic field is investigated using a broadband range-dependent normal mode model called NAUTILUS. The representation of the spatial and temporal structure of the time series in terms of a modal structure reveals several unique effects of the SSP and the geoacoustic structure of the bottom on the group velocity of the modes over a large bandwidth. Individual modes can be identified in the measured data using direct data-simulation comparisons. Cross-correlation values between data and simulations in a 155 ms time window generally vary from 0.7 to 0.9 for sensors below the thermocline, but are much smaller for sensors above the thermocline.

3. Ellzey, Janet L., and Michael Henneke, "The Shock-Vortex Interaction: The Origins of the Acoustic Wave," Journal of Fluid Dynamics Research **21**, 171-184 (1997).

In this paper we discuss the mechanisms responsible for the formation of the acoustic wave when a shock interacts with a vortex. Experimental measurements have shown that this interaction produces a primarily quadrupolar acoustic wave with a strong compression attached to the shock front. We review earlier work which shows that this strong compression is due to the distortion of the shock. The origin of the quadrupolar component is examined by comparing two-dimensional computations of the shock-vortex interaction to those of an isolated elliptical vortex. The elliptical vortex is similar to the compressed vortex produced when a shock interacts with an initially circular vortex. We concentrate on interactions in which the shock transit time is short. The pressure field of the shock-vortex interaction is compared to that of an analogous isolated elliptical vortex for three cases: a weak shock interacting with a weak vortex, a strong shock interacting with a weak vortex, and a strong shock interacting with a strong vortex. Our results indicate that both shock distortion and vortex compression are important to the formation of the acoustic wave.

2.2 COMPLETED DISSERTATIONS AND THESES

Bibliographical information on these academic documents is presented here. It should be noted that each of the graduates is a U.S. citizen, and each is a potential candidate for a leadership role in the conduct of future naval research and development.

1. Neal, Debra Leigh, (M.S., Aerospace Engineering, May 1995). "Experimental Identification of Rotating Stall in an Axial Flow Compressor."

2. Manoucheri, Michael P. (M.S., Engineering, August 1995). "Investigation of Acoustic Agglomeration in a Three Dimensional Standing Wave Field."

2.3 PAPERS PRESENTED AT MEETINGS

Titles, authors, and meeting data for papers presented at meetings are listed below. This listing does not include papers presented at meetings which have subsequently been issued as archival papers. Most, if not all, of the papers listed below will also be issued as archival papers. The presentation of scientific papers at meetings is a give-and-take process that enables the authors to receive criticism, comments, and an exchange of information that sharpens the work perspective and its ultimate relevance, prior to submission as an archival contribution.

1. Manoucheri, M., and O. A. Ezekoye, "Polystyrene Soot Agglomeration Enhancement in an Ultrasonic Acoustic Field," The Fourth International Congress on Toxic Combustion Byproducts, Berkeley, CA, June 1995.

2.4 ARL:UT REPORTS

In addition to the archival papers, dissertations, theses, and other highly valued scientific documents cited above, there is a very real and important need for the publication of a variety of reports that are useful in the conduct of work.

1. Thornhill, R. Joe, "Predictive Maintenance for Roller Bearings," Applied Research Laboratories Group Report No. 97-13 (GR-SP-97-13), Applied Research Laboratories, The University of Texas at Austin, 9 December 1997.

2. Knobles, D. P., E. K. Westwood, and J. Lemond, "Modal Time Series Structure in a Downward-Refractive Shallow Water Environment," Applied Research Laboratories Technical Paper No. 97-13 (ARL-TP-97-13), Applied Research Laboratories, The University of Texas at Austin, 14 August 1997.

3. Muir, Thomas G., and Elaine C. Hackert, Eds., "The Department of Defense Science and Engineering Apprenticeship Program for High School Students, Summer Program 1995," Applied Research Laboratories Technical Report No. 95-33 (ARL-TR-95-33), Applied Research Laboratories, The University of Texas at Austin.

2.5 DoD SCIENCE AND ENGINEERING APPRENTICESHIP PROGRAM

The purpose of the apprenticeship program is to provide outstanding recent high school graduates with hands-on experience in the stimulating research environment and encourage them to pursue careers in the science and engineering disciplines, particularly in those areas related to the needs of the Department of Defense. Students were selected for this program on the basis of their academic records, scholastic aptitude test results, and applications. Each student was assigned to a research project to be performed under the supervision of a research staff member at ARL:UT. At the end of the apprenticeship in mid-August, students gave oral presentations, using visual aids, for the Laboratories' directors, and prepared short technical papers summarizing their project results. The annual report included technical papers by the following student authors, whose abstracts appear below. Editing of the abstracts was minimal to preserve their originality of expression.

<u>1995 Participants</u>

Julia Cervantes	A Comparison of Electromagnetic Wave Propagation Software

Christopher Chilek	A Study of Sea Floor Sediment through Reflection Loss
Katherine Doerr	The Web of the Future: An Interactive World Wide Web Using the Virtual Reality Modeling Language
Russell Henrichs	Sound Propagation through Wind Turbulence
Jacob Hodges	Weaving the Web of the Future: A Discourse on Internet Page Design as It Relates to Project Tracking and Oversight Using the World Wide Web
Ari Molofsky	The Influence of Dissolved Gasses on the Dielectric Breakdown of Water
Denise Moraw	Applying New Technology to Criminal Investigations
Jennifer Pope	Analysis of Ambient Noise in the Surf Zone
Tommy Rhyne	Hands-On Help with HTML
Yuhki Tajima	Signal Processing for Silicon Vertex Tracking Detectors
Ryan Tamblin	GSRSS Positioning Software Integration
Scott White	Transit Orbit Prediction on the World Wide Web

Abstracts of Apprenticeship Reports

1. Julia Cervantes. A Comparison of Electromagnetic Wave Propagation Software.

Differences for software programs and techniques of modeling diffraction were studied, and also various parameters of modeling techniques and programs are varied and are compared. The propagation of diffracted waves is calculated in different ways using different techniques. Certain techniques prove to be more precise than others in certain circumstances. The three techniques of diffraction considered in this study are the knife edge diffraction technique, the geometrical theory of diffraction, and the parabolic equation technique.

2. Christopher Chilek. A Study of Sea Floor Sediment through Reflection Loss.

The purpose of this project was to use sonar to determine sea floor composition. Identification of sediment was to be accomplished through the comparison of reflection coefficients calculated from sonar waves above known sediment types. Possible applications include finding buried underwater mines.

3. Katherine Doerr. The Web of the Future: An Interactive World Wide Web Using the Virtual Reality Modeling Language.

The Internet and World Wide Web (WWW) have lately emerged as powerful and simple means of accessing immense amounts of information made available via interconnected computer networks throughout the world. Browser's user-friendly interface allows for trails of intuition-based research to be created, and the simplicity of the HyperText Markup Language (HTML) allows users to manipulate the WWW from both a client and a server standpoint. What is the potential for even further development of interactivity on the WWW?

4. Russell Henrichs. Sound Propagation through Wind Turbulence.

Applied Research Laboratories recently acquired a used wind tunnel. While the laboratory has done much research on sound propagation in the water, very little has been researched at ARL:UT about sound propagation through the air. The tunnel provided the opportunity to investigate the effects of wind turbulence on sound propagation. Research on sound propagation in the turbulence has many practical applications, including development of improved methods for detecting low flying aircraft.

5. Jacob Hodges. Weaving the Web of the Future: A Discourse on Internet Page Design as It Relates to Project Tracking and Oversight Using the World Wide Web.

The Systems Integration, Test, and Documentation (SIG) Project is responsible for the support and development of the software engineering process for the Information Warfare Division. The main project SIG was involved with is the Radio Frequency Mission Planner or RFMP, although our work did cross over to other projects. To support the software processes, the sponsors, management, and project staff needed an easily accessible repository of project information. This information includes action items, internal test reports, and project documents that need to be tracked and controlled. The World Wide Web was chosen to provide access to the data contained in the project database.

6. Ari Molofsky. The Influence of Dissolved Gasses on the Dielectric Breakdown of Water.

Spark discharges in water can be used as a source of low frequency acoustic waves for sonar. The process leading to the formation of an underwater electric arc requires further research, and this experiment focused on the influence of dissolved gasses on the breakdown of water. In particular, the dependence of the time to breakdown on dissolved gas content is systematically investigated.

7. Denise Moraw. Applying New Technology to Criminal Investigations.

Because of the high costs involved with the legal disposal of hazardous wastes, many people and companies have begun to illegally dump toxic wastes. One method of disposal is to dump the wastes in old, depleted oil

drilling sites. Illegally dumping toxic wastes allows those involved to avoid the high costs associated with the proper disposal and remediation of toxic waste. Also the illegal dumping of toxic wastes causes great concern because the illegally dumped waste can contaminate the underground water supply. Through the use of new technological advances, ARL:UT proposed to help the government covertly monitor sites where toxic wastes are frequently dumped. One way that this can be accomplished is through video taping the actual crime with the help of hidden low light and infrared video cameras using new charge coupled device (CCD) technology. ARL:UT can also help the government reduce the cost of catching those who are illegally dumping toxic wastes by applying previously existing ARL:UT technology.

8. Jennifer Pope. Analysis of Ambient Noise in the Surf Zone.

Ambient noise was measured along the coast of Duck, North Carolina, at ranges up to 7.5 km from the shore. Water depths ranged from 6 m to 23 m. Data collection took place on October 6-9, 1994. Three DIFAR sensors were used: an omni-directional sensor and two directionals oriented along magnetic cardinal coordinates (north/south and east/west). Excluding those measured by a pier-side buoy, noise levels were found to decrease with range from shore, and between 100 and 1000 Hz they peaked at about 450 Hz. The pier buoy picked up most noise coming from the seaward direction, buoys at 2 and 4 km showed directionality toward the shore for most frequencies, and a buoy at 7.5 km showed peaks coming from different directions for different frequencies. The results showed general agreement with previous work done by Wilson, Wolf, and Ingenito, indicating that breaking surf contributes significantly to ambient noise in the surf zone.

9. Tommy Rhyne. Hands-On Help with HTML.

As the Synthetic Theater of War (STOW) project was reassigned to various positions, ARL:UT was assigned the configuration management and software configuration management responsibilities. Therefore the Configuration Management (CM) Subdivision was put in place to monitor changes in Modular Semi-Automated Forces (ModSAF) builds, improvements, and hardware. Their basic responsibility was to ensure that Synthetic Forces (SF) are interoperable and to provide performance optimizations and enhancements to existing SF software to all SF developers. In turn, Version and Integration Control System (VICS) was created. VICS was developed to provide access to all major systems to all parties involved in ModSAF. It is sponsored by the Advanced Research Projects Agency (ARPA) and is being created at ARL:UT to support the STOW software development effort. The development effort consists of various geographically dislocated development organizations separately funded by ARPA. VICS will be used to maintain a centralized code repository, which includes version control across a wide-area Internet, and to integrate the software changes provided by the disparate organizations. VICS will also provide reports and statistics to support the management and integration of this wide-area software development effort. This code repository will be accessible to anyone with an Internet connection, a World Wide Web browser (Netscape 1.1N is the only supported browser at present), and an authorized VICS user account. At first this was attempted strictly via a Web page, but this method encountered problems impossible to overcome.

10. Yuhki Tajima. Signal Processing for Silicon Vertex Tracking Detectors.

At the Brookhaven National Laboratory, a new accelerator facility known as the Relativistic Heavy Ion Collider (RHIC) is being developed. Each part of

the collider is important to the project, and every component must be tested and perfected until scientists can be sure that it will work. In a collider, two beams of particles (nuclei of some heavy atoms) are accelerated toward each other so that they collide and release many sub-atomic particles. This is useful to physicists because they may study these particles to better theorize about the origin and the properties of the universe. However, in order to detect these particles, extremely sensitive detectors and powerful computers must be used. In July 1994, the prototype STAR-1 silicon drift detectors were tested. During these tests, three prototype silicon drift detectors (SDD, which will make up the silicon vertex trackers [SVT] in the Solenoidal Tracker at RHIC [STAR]) were tested for signal and noise levels, detector efficiency, position resolution, and the readout electronics and data acquisition system. These were tested using a beam of particles, a relatively well-known composition, so that it would be easier to evaluate the detectors' performance. The problem I was confronted with was to evaluate various approaches for discriminating signals created when charged particles pass through the SDDs from the excess noise created by the electronics and to determine the efficiency of the detectors.

11. Ryan Tamblin. GSRSS Positioning Software Integration.

ARL:UT was given the task of designing a GPS-based sled track survey system (GSTSS) at the Holloman High Speed Sled Track (HSST) in New Mexico to solve the shifting difficulties at Holloman. The GSTSS was required to provide sub-centimeter level positioning accuracy of the HSST, which would push current GPS technology to its limit. In addition a network needed to be designed consisting of 20 low cost GPS receivers with power supplies, which would utilize differential GPS processing techniques to monitor the track at the required accuracy level. This complex, spread-out network also was required to be in near realtime. The responsibilities of ARL:UT included the mitigation of multipath, which would call for experimentation with antenna placement due to

the highly reflective nature of the Holloman site. Data transfer methods would have to be considered; near realtime processing would be difficult to accomplish with a slow transfer system. The GSTSS system would need to be tested at the Holloman site and then, after its completion, would need to be installed by ARL:UT. Holloman personnel then had to be trained in the implementation of the system.

12. Scott White. Transit Orbit Prediction on the World Wide Web.

Control of the Transit Satellite System will soon pass to the Applied Research Laboratories at the University of Texas (ARL:UT). To support the use of these satellites, an easy-to-use computer tool has been developed to provide information about this satellite system. The tool is accessible via a World Wide Web (WWW) browser, such as Mosaic or Netscape, at *http://sgdsah.arlut.utexas.edu*. Developed in HTML, the interactive web site has a fill-in form which allows the client to query the server for orbital predictions of the satellites for ground stations around the world. The Transit Orbital Prediction Page integrates the best features of the WWW and SatTrack.

REFERENCES

1. ARL:UT proposal Ser P-1649, dated 7 November 1994, from Dr. F. Michael Pestorius, ARL:UT Director, to Dr. Mohsen Badiey, ONR Code 324OA, for $400,000 for the performance period 1 January 1995 through 12 months.

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