REPORT DOCUMENTATION PAGE

AFRL-SR-BL-TR-99-

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1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	5 August 1998	Final Report, covers 1 August 1997 -- 1 August 1998

4. TITLE AND SUBTITLE
A passive radar for atmospheric remote sensing using commercial FM broadcasts

5. FUNDING NUMBERS
AFOSR Grant
F49620-96-1-0138

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9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
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Bolling AFB, DC 20332

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
This is the final report for this grant

12a. DISTRIBUTION / AVAILABILITY STATEMENT
Distribution unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 Words)*

We are developing a completely passive bistatic radar using commercial FM broadcasts near 100 MHz. By correlating a clean copy of the broadcasts with the weak, delayed scatter at a remote site, we will generate the full range-Doppler profile of ion acoustic turbulence near the auroral electrojets. More precisely we will be calculating the cross ambiguity function of data from two receivers separated by approximately 100 km, intending to detect targets at slant ranges as large as 1000 km.

The AFOSR funded portion of this project is now complete. We have completed construction of a fully functional bistatic radar, synchronized in time and frequency using Global Positioning System (GPS) technology. We have successfully detected aircraft at ranges as great as 240 km with 1.5 m/s velocity resolution. Detection of aircraft is an important step in detecting auroral turbulence, which has similar scattered power and Doppler shift.

An overview of this work has been presented at two international conferences and resulted in two refereed publications and three MS theses.

14. SUBJECT TERMS
Passive bistatic radar, ionosphere, radar signal processing

15. NUMBER OF PAGES
3

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	ul

1 Objectives

This research project is devoted to the development of a completely passive bistatic radar for studies of turbulence in the lower ionosphere. In particular we propose to take advantage of commercial FM broadcasts near 100 MHz which have high average power and excellent ambiguity function, corresponding to superb sensitivity and full Doppler spectrum recovery with fine range resolution.

Although our effort is aimed at upper atmospheric studies, this radar system should be quite effective at detecting meteor trails, aircraft, and possibly even satellites.

2 Status of Effort

In the last year we have completed full proof-of-concept experiments and successfully detected two classes of targets with a completely passive system. Both aircraft and geologic features (Mt. Rainier) are regularly detected. Significant improvements in the basic signal processing enable us to process data at approximately one percent of real time. We can continuously record data until the recording media fill, which is approximately one hour.

As this AFOSR grant closes four graduate students are working on the project, as well as eight undergraduate students. The students currently are working to improve the signal processing algorithms for greater efficiency and resolution, accomodating various systematic errors in the receivers.

We maintain a World Wide Web page for recent results:

`http://rcs.ee.washington.edu/spp/Projects/Manastash/status/mrr.html`

We are seeking funding from both the National Science Foundation and AFOSR to continue activity on this project. Our total request from both agencies is $200,000 per year.

3 Accomplishments

Mr Frank Lind has successfully completed development of a working bistatic receiver pair. These receivers are synchronized using the Global Positioning System to about 100 ns sampling jitter, and about 0.001 Hz in center frequency. The receivers have very simple direct conversion topology, and are inexpensively constructed from modern surface mount components largely intended for cellular telephone service. Each receiver is controlled by a conventional personal computer running the `linux` operating system, and include multichannel synchronous analog to digital converters (12 bits, 8 channels). The entire receiver system can be duplicated for about $10,000 per receiver station.

The receivers have been in nearly continuous operation since November 1997; some power outages created problems at the remote site which have been mitigated by the addition of uninterruptible power supplies. Currently the system is quite robust and we are very pleased with its performance ... although we also have several enhancements in mind for new students to develop.

Ms Dawn Gidner has built an excellent log-periodic antenna to provide useful azimuthal control of the remote site, and we intend to increase the gain to about 20 dB in the next year.

This project has attracted considerable attention in the international geophysics community. We have been invited to speak at the URSI General Assembly (Lille, France, 1996), and the Western Pacific meeting of the AGU (Taipei, Taiwan, 1998) to describe this completely passive radar system.

Last summer Mr Chad Lindstrom completed his MS thesis using the radar system to detect aircraft. Mr Lindstrom is now serving at the USAF Phillips Lab at Kirtland Air Force Base, New Mexico.

4 Personnel Supported

1. Dr John D. Sahr, PI
2. Mr Frank Lind, second year graduate student (Geophysics Department)
3. Mr Chad Lindstrom, beginning graduate student (Electrical Enginering)

5 Technical Publications

5.1 Journal Publications

1. Sahr and Lind, "The Manastash Ridge Radar: A Passive Bistatic Radar for Upper Atmospheric Radio Science," Radio Science, v32, p2345-58, 1997.

2. Sahr and Lind, "Passive Radio Remote Sensing of the Atmosphere using Transmitters of Opportunity," Radio Science Bulletin, v284, p4-7, 1998

5.2 other

It is expected that Mr Frank Lind will complete his PhD in August 1999. His dissertation will contain substantial documentation describing this radar. Currently we have undertaken and standard documentation methodology for our hardware and software, and there are approximately 200 pages of such documentation that we have produced ourselves (as opposed to having assembled from vendors, etc.). Some of this documentation may be found on the World Wide Web:

`http://rcs.ee.washington.edu/spp/Manuals/mrr_hwman.pdf`

6 Interactions/Transitions

6.1 Conference Presentations

1. Sahr, Passive Correlative Radar Methods, URSI General Assembly, Lille France, August 1996.

2. Lind and Sahr, The Manastash Ridge Radar, Western Pacific Meeting of the AGU, Taipei Taiwan, July 1998

6.2 Transitions

Dr Richard Lodwig of Lockheed Martin Federal Systems visited us last December. We investigated the possibility of receiving support from Lockheed, which has a significant development in a related passive radar method. Unfortunately the University and Lockheed could not resolve differences of opinion in the ownership of intellectual property, and so that source of support did not blossom.

Mr Chad Lindstrom completed his MS thesis in July 1997, and subsequently took a position in the Air Force at Phillips Lab, Kirtland Air Force Base. Mr Lindstrom's thesis dealt with the engineering issues relevant to a monostatic passive radar system, as opposed to the bistatic system which is our main focus.

7 Patent Disclosures

(none)

8 Honors

- John D. Sahr: Henry Booker Fellowship, URSI-US National Committee, presented at URSI General Assembly, Lille, France, August 1996.

- Frank Lind: First Prize, Student Poster Contest, UW Department of Electrical Engineering, "Passive Bistatic Radar for Remote Sensing of Ionospheric Turbulence," April 1996.

- For publications and research related to this effort, John Sahr was promoted to Associate Professor in Autumn 1997.