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14. ABSTRACT
Report describes work performed by Ohio University in the research of a software radio architecture applied to satellite-based navigation receivers.

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15. SUBJECT TERMS
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Realtime Implementation of L1-Band Software Radios

AFOSR Grant F49620-96-1-0368

Final Report for 1996-2000

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1. Objectives

This research project seeks to exploit the advantages of the software radio concept when applied to the Navstar Global Positioning System (GPS). The software radio concept involves the use of minimal front-end hardware, followed by analog-to-digital conversion with the resulting samples being processed exclusively by a programmable microprocessor. The result is a flexible platform which reduces the errors and degradation found with conventional RF front-ends. The availability of raw samples allows for optimal processing.

Before the software radio benefits can be achieved, however, a realtime testbed is required. Given the limited computational power available in current PC's, a prudent first step is to assemble a platform which can collect data later for post-processing. This was the result of the initial efforts in the program. The next step is to optimize the processing algorithms and prepare them for realtime implementation. This has been the focus of the most recent efforts.

2. Status of Effort

Work early in the program focused on the realtime acquisition of A/D data. The ICS-650 data acquisition board (from Interactive Circuits & Systems Ltd) was successfully interfaced to a PC. It is now possible to stream data continuously to a PC harddrive, at a rate of 5 MHz, until the disk is full. This allows for significant data sets (i.e., on the order of minutes worth of data) to be collected for later processing.

Over the past several years, considerable effort has been focused on development and optimization of GPS satellite signal acquisition algorithms. Towards the end of the program, however, the focus shifted to tracking algorithms. The first step in the evaluation of GPS tracking loops is the assessment of noise performance. For the pseudorange, this may be done most effectively by examining the difference between pseudorange and carrier-phase measurements. Thus the most recent work focused on the algorithms which produce these two types of measurements.

Under the follow-on grant for this ongoing work, efforts will be directed towards optimization of block-processing tracking algorithms, design and development of novel interference

identification and mitigation algorithms, and consideration of optimal software integration with inertial measurement units.

3. Accomplishments

Algorithms to form both the pseudorange and carrier-phase measurements have been successfully produced. Extensive testing of these algorithms, however, showed inconsistency between the pseudorange and carrier-phase. An investigation was conducted and the problem was traced to the use of multiple independent oscillators in the experimental receiver front-end. Specifically, the problem involves the use of one clock for signal downconversion and a separate clock to drive the A/D converter. The result is a pseudo-clock rate apparent in the carrier-phase but not the pseudorange data. Current efforts are being directed towards the development of a new front-end with a single clock. This is a key issue in software receiver architectural design.

It should also be pointed out that the work being funded by this grant is having a broader impact. In summer 2000, IBM announced a new GPS receiver design which utilizes direct downconversion and simultaneous digitization (a.k.a., bandpass sampling) of the RF signal. The benefits include reduced hardware and improved life-cycle performance through the elimination of analog components which exhibit performance degradation with age. The research supported by this grant demonstrated the first-ever simultaneous direct digitization and software acquisition of GPS and Glonass (Russian satellite navigation system). This fundamental research was reported several years ago and now is being marketed commercially.

4. Personnel Supported

Dr. Michael S. Braasch, Principal Investigator
Mr. Joe Kelly, Graduate Student

5. Technical Publications

Journal Publications - None
Theses/Dissertations - None
Conference Proceedings - None

6. Interactions/Transitions

6.1 Conference Presentations - None

6.2 Transitions

We continue to work with Dr. James Tsui at Wright Labs in this effort. Dr. Tsui and his colleagues are also working on GPS software receiver acquisition and tracking algorithms.

7. Patent Disclosures - None

8. Honors - None