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13. ABSTRACT (Maximum 200 words) Efforts over the last two years have been directed towards characterization of quantization error effects in software radio interference mitigation algorithms. A high fidelity GPS software signal simulator was constructed during the 2001-2002 time frame. This simulator emulated the GPS signal-in-space and the receiver front-end-processing including the analog-to-digital (A/D) conversion process. The simulator allowed one to control precisely the scenario under investigation. Efforts over the past year have been directed towards validation of the simulation against actual collected data with interference present.			
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**Realtime Implementation of L1-Band Software Radios**  
**AFOSR Grant F49620-01-1-0284**  
**Final Report**  
**Principal Investigator: Michael S. Braasch**

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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. The software radio concept allows for the processing of data in blocks rather than in the sequential nature of traditional GPS receivers. This enables frequency-domain processing via the FFT along with the possibility of other transform-based techniques. It is envisioned that this approach will allow for the development of receivers with higher levels of robustness than is possible using current technology. Specifically, software-radio processing will allow for faster acquisition times, operation through higher levels of jammer-to-signal ratios, lower noise performance achieved simultaneously with high dynamics and deeper integration of the GPS with inertial navigation systems.

### 2. Status of Effort

Efforts over the last two years have been directed towards characterization of quantization error effects in software radio interference mitigation algorithms. A high fidelity GPS software signal simulator was constructed during the 2001-2002 time frame. This simulator emulated the GPS signal-in-space and the receiver front-end processing including the analog-to-digital (A/D) conversion process. The simulator allowed one to control precisely the scenario under investigation. Efforts over the past year have been directed toward validation of the simulation against actual collected data with interference present.

### 3. Accomplishments

Narrow-band interference has been addressed so far. The mitigation technique involves the use of an FFT to convert the raw digitized samples from the time domain to the frequency domain. Since the GPS signal is approximately 20 dB below the noise floor, the spectrum should be flat. However, in the presence of significant interference (i.e., above the noise floor), traditional spectrum estimation techniques can be applied to identify the interference present. For this research, a simple FFT-based estimator is utilized. The frequency bins containing the interference are nulled and the resulting spectrum is inverse-FFT'd back to the time domain.

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The signal is then passed on to the usual GPS software radio acquisition and tracking algorithms.

The key question being considered is the performance of the tracking versus the number bits used in the analog-to-digital conversion. Commercial off-the-shelf receivers use from 1 to 3 bits of quantization. Furthermore, most GPS software radio research has assumed the use of 12 to 16 bits of quantization. However, this research has demonstrated a non-linear relationship between tracking accuracy and quantization error when using this software notch-filter approach to narrow-band interference mitigation. Tracking accuracy improves dramatically from 3 bits up to 7 bits. However, performance is essentially unchanged from 7 bits up to 12 bits. This is an important result since it indicates the final hardware architecture may be able to use one-byte words for the samples rather than two-byte words. This would have a significant impact on the final hardware design.

#### 4. Personnel Supported

Dr. Michael S. Braasch, Principal Investigator  
Mr. Curt Cutright, Research Engineer

#### 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