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## E-Copy Grant Transmittal

Date: 9/10/06  
Grant Number: 2002-RD-CX-K004  
Monitor: Joseph Heaps  
Title: Handheld Software Radio for Interoperability  
Authors: Andrew Beard  
Publication Date: 4/8/05  
Pages: 3  
Grantee: Vanu, Inc.  
One Porter Square, Suite 18  
Cambridge, MA 02140

### Notes:

OS&T Grant – NIJ would like this posted, but some of the report is very difficult to read and I would suggest abstracting only.

### Summary:

This project by Venu, Inc. concluded that future handheld software radio projects will need to address the challenges of developing a widely-tunable portable Radio Frequency (RF) transceiver, including the rising bandwidth of modern cell waveforms and moving data at higher sample rates between RF transceivers and standard consumer handheld devices. Attempts to address the difficulty and cost of manufacturing a widely-tunable handheld RF transceiver were largely unsuccessful due to the outsourcing of the RF hardware, which made it difficult to keep control of the development schedule and process.

**TRANSMITTAL FOR FINAL REPORTS AND OTHER AWARD PRODUCTS**  
**National Criminal Justice Reference Service**  
**National Institute of Justice**

<b>TO:</b> NCJRS/ORIC	<b>FROM:</b> Joseph Heaps
<b>DATE:</b> 5/18/05	<b>TELEPHONE:</b> 202-305-1554

**The following information will appear in the abstract:**

<b>AWARD#:</b> 2002-RD-CX-K004	<b>FUNDING SOURCE(S):</b> School Safety
<b>FINAL REPORT TITLE:</b> Handheld Software Radio for Interoperability	
<b>FINAL REPORT AUTHOR(S):</b> Andrew Beard	<b>FINAL REPORT DATE:</b> 4/8/05
<b>OTHER DOCUMENTS PRODUCED FROM AWARD:</b> N/A	
<b>GRANTEE NAME AND ADDRESS:</b>  <p align="center">Vanu, Inc          One Porter Square, Suite 18          Cambridge, MA 02140</p>	

**APPROVALS**

**Note: NIJ Assistant Director Approval is required to post the report on NCJRS**

Name	Initial	Date	Does not go to NCJRS <sup>1</sup>	To NCJRS: Abstract and Archive Only <sup>2</sup>	To NCJRS: Abstract, Archive and Post Online <sup>3</sup>
Joseph Heaps, Manager	J.H.	19 May	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Stan Ericson, Division Chief	SE	May 23	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
John S. Morgan, Ph.D. Assistant Director for S&T	JM	6/1/05	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

**Attached please find the final report for this grant in hardcopy and on CD-ROM.**

<sup>1</sup> While, the report will not go to NCJRS to be included in the archived, this form will become part of the grant file recording NIJ's decision.

<sup>2</sup> The report will go to NCJRS and be abstracted, included in the NCJRS Abstracts database, and a hardcopy will be available from the Reference Service

<sup>3</sup> In addition to steps in footnote 2, the report will be posted online in the NCJRS Virtual Library and a link to it will be created from the NCJRS Abstracts Database. Each report posted this way will include a title page with general information from the abstract and a standard disclaimer. The disclaimer is repeated at the foot of each page.

**U.S. DEPARTMENT OF JUSTICE**  
**Office of Justice Programs**  
**CATEGORICAL/DISCRETIONARY ASSISTANCE PROGRESS REPORT**

The information provided will be used by the grantor agency to monitor grantee cash flow to ensure proper use of Federal funds. No further monies or other benefits may be paid out under this program unless this report is completed and filed as required by existing law and regulations (Uniform Administrative Requirements for Grants and Cooperative Agreements—28 CFR, Part 66, Common Rule, and OMB Circular A-110).

1. GRANTEE Vahu, Inc.	2. AGENCY GRANT NUMBER 2002-RD-CX-K004	3. REPORT NO. 1
4. IMPLEMENTING SUBGRANTEES	5. REPORTING PERIOD (Week) FROM: 09/01/2002 TO: 08/30/2004	
6. SHORT TITLE OF PROJECT Handheld Software Defined Radio for Interoperability	7. GRANT AMOUNT \$144,282.00	8. TYPE OF REPORT REGULAR <input checked="" type="checkbox"/> SPECIAL <input type="checkbox"/> FINAL REPORT <input checked="" type="checkbox"/> REQUEST <input type="checkbox"/>
9. NAME AND TITLE OF PROJECT DIRECTOR Andrew Beard, Chief Operating Officer	10. SIGNATURE OF PROJECT DIRECTOR	11. DATE OF REPORT 4/8/05

12. COMMENCE REPORT HERE (Continue on plain paper)

**Intention of the project**

Vahu, Inc. received funds from the National Institute of Justice, pursuant to a cooperative agreement between Vahu, Inc. and the NIJ, for the purpose of developing an automated testing capability for the Radio Frequency (RF) components of a handheld Software Defined Radio. The manual testing of these RF components is currently a cost driver, which if not addressed will impede any meaningful deployment of these SDRs in the future.

The target of our initial testing was an RF transceiver designed by Hand Radio, funded through a separate contract. It was specified to cover spectrum from 20 MHz to 2.5 GHz, with selectable bandwidths and sample rates. It was specified to support both full- and half-duplex signals to allow AMPS support as well as more modern cell waveforms.

**Accomplishments**

We started by developing the necessary interface software for our handheld system based around the IPAQ. We created a software test suite to verify the correct behavior of the RF component in order to lay the groundwork for the automated testing. Our tests cover the data transfer, the control mechanisms, and a subset of the RF characteristics that the component could provide. We intended to extend the RF characteristic testing after we had completed the preliminary testing.

Much of this preliminary work was focused around the hardware interface to the IPAQ itself, and the FPGA support and Linux driver work necessary for the interface.

While we were waiting for a more powerful handheld RF frontend to be assembled by our third party contractor, Hand Radio, we worked to develop a demo unit with an RF component from General Dynamics Decision Systems. The RF component was a reworked RF component out of their PRC-112 military radio, and we were optimistic that it should be fairly straightforward to modify the circuitry to provide the flexible tuning that makes software radio so powerful. We worked with General Dynamics to produce a radio with transceiving capabilities in the UHF and VHF spectrum.

There was a good amount of FPGA rework to do in order to interface with the GD prototype RF component. In addition, we improved the user interface and the realtime performance, having never had a good realtime data source to test with before.

We also presented a paper and demonstrated the prototype to the NIJ at a conference in May. We demonstrated a handheld running both FM two-way radio and APCO 25 on different UHF and VHF bands. (continued)

13. CERTIFICATION BY GRANTEE (Official Signature)	14. DATE 4/8/05
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We continued refining our prototype with the GDDS RF component, but did not come to a development agreement beyond prototyping. We also wrote two papers ["A handheld software radio based on the ipaq PDA: Software (Jessica Forbess, Andrew Chiu)" and "A handheld software radio based on the ipaq PDA: Hardware (Jessica Forbess, Mark Wormley)"] discussing our work on the hardware and software aspects of the handheld radio for the SDR Forum 2003, which were presented by Jessica Forbess, which were well received. The one discussing our software techniques won Best Paper of the Forum.

We also were able to work to interface the handheld with our original RF component, the Zeta, provided by Hand Radio. We scheduled one day to debug the interface, and made progress, but Hand Radio could not make time in their schedule beyond that day. We worked through the debugging process separately afterwards until we needed their knowledge of the RF component to continue debugging.

We continued trying to work with Alan Hand in the future. His handheld radio should have provided great flexibility for more software radio, but he failed to make room in his schedule to work with us.

#### Failures

Months after the deadline to deliver a working prototype, Alan Hand could not schedule any working meetings or even provide us with another firmware download for more debugging. We gave up on him supplying us with an RF component.

To keep the door open for future work, we have ported our software to the newest version of the iPAQ, which also required porting it to the newest version of our open source compiler, gcc.

We pursued two different RF components from two separate vendors. After significant development work had been done, neither of the vendors was able to supply us with a functional component. One vendor backed out after deciding to pursue the handheld SDR market on its own. The other vendor was unable to provide us with a functional component far after the deadline we had set.

Once we had determined there were no suitable RF transceiver devices left to pursue in the short term, we targeted a receive-only system, similar to our current luggable monitoring system, but much smaller. The system is based around a rugged handheld made by Antelope Technologies. The A/D conversion is performed by a Red River Pocketwatch CardBus card, and the RF component is the DRS Nanoceptor. After installing Linux, it was a fairly straightforward process to compile our previously existing code for the device, and run it. Our entire monitoring system including the graphical interface worked out of the box, except for CDMA, which required slightly more processing speed.

Our future work will be focused on improving the graphical interface to make it more convenient for a smaller display and no keyboard. We also intend to examine CDMA to identify and implement enough optimization to allow it to run on the 1 GHz Transmeta processor.

We have made good progress in identifying partners to develop RF front ends for infrastructure projects. We will continue look for partners for handheld RF development.

### Conclusions

Future handheld projects will need to address the problem of a widely-tunable portable RF transceiver. They should also pay attention to the rising bandwidth of modern cell waveforms, and not overlook the problem of moving data at higher sample rates between the RF transceiver and a standard consumer handheld with limited data rate interfaces.

Our attempt to address some of the difficulty and cost of manufacturing a widely-tunable handheld RF transceiver was primarily unsuccessful due to the outsourcing of the RF hardware, which made it difficult to keep control of the development schedule and process.