

MachineTalker[®] - NASA-UAV Board

**Final Report UAV Sensor Flight Test
Including Reference Documents**

MTI Document Number: MTI-2005-007

By MachineTalker, Inc.
513 De La Vina Street, Santa Barbara, CA 93101
Attention: Gerald A. Nadler, Chief Scientist
Phone: 978-897-2865

SAIC Contract: SAIC Subcontract # 4400094795

Science Applications International Corporation
One Enterprise Parkway, Suite 300, Hampton, Virginia
Attention: Walter Miller, Contract Technical Administrator
Phone: 757-827-4851

30 September 2005

MachineTalker - NASA-UAV Board Final Report UAV Sensor Flight Test

1.0	Preface	1
2.0	Test Configuration and Protocol.....	1
2.1	Terminology.....	1
	Table - Sensor Reference.....	1
2.2	Wireless On-Board UAV Configuration and Flight Test	2
	Figure 1 - Wireless Means of Data Collection From On-Board Sensors.....	2
3.0	Flight Testing Wireless MachineTalkers® and NASA Sensors.....	3
4.0	Flight Test Results and Conclusions.....	3
	Charts of Raw Data After Storage in Excel	3
	Photographs of Flight Preparation and Flight Test	4

ADENDA TO FINAL REPORT

EXHIBIT A

NASA - UAV Sensor Board Protocol

INCLUDED REFERENCES - PROJECT DOCUMENTS

Project To Instrument a NASA UAV with a MachineTalker® Wireless Sensor Network
Configuration Guide and Evaluation Report

CD CONTAINING ALL DOCUMENTS, PHOTOGRAPHS AND FLIGHT TEST MOVIE

MachineTalker® - NASA-UAV Board Final Report UAV Sensor Flight Test

1.0 Preface

This Final Report covers the installation and testing in flight of MachineTalker® units used as wireless Sensor Data Loggers. The key is to distribute devices within an airframe that can gather sensor data by wireless means, thereby eliminating cabling within an aircraft. Tests were done using an Unmanned Aerial Vehicle (UAV) as the airframe, mounted with avionics sensors. Data was gathered by MachineTalkers® and forwarded by wireless connection to a collection point and then, in a "fly-by", transferred to a ground station for display.

2.0 Test Configuration and Overview (Refer to Figure 1)

2.1 - Terminology

Logger: The Logger is a MachineTalker® unit that receives data from internal or external sensors and stores that data in memory. It is capable of uploading this information to a *Collector* unit. Logger 1 is labeled as the NASA Talker® (See Configuration Guide).

Collector: The Collector is a MachineTalker® unit that has all of the functionality of a Logger unit. Beyond that, it can download or "collect" sensor data from multiple Loggers that are co-located or located in nearby aircraft while in flight. The Collector transfers collected sensor data to a ground station (referred to as the *Base Station*), when passing in proximity.

Base Station: The Base Station consists of a MachineTalker® unit is interfaced to a PC with a GUI application program for display. The Base Station receives sensor data (logs) from the airborne Collector and provides a command line type of user interface to the PC.

NASA Sensor Board: From the software view, the NASA Sensor Board is a "black box" that contains an array of sensors. Communication to its associated Logger is via an RS-232 connection.

Log Transfer Protocol: This is a lightweight, application level protocol to transfer logs between Loggers, Collector, and Base station.

NASA Sensor Board Hardware: The avionics sensor board contains 8 sensors. NASA references are in the Table (below) and in Exhibit A - "UAV Sensor Board Terminology":

Sensor #1	Sensor	Sensor #	Sensor
0	Gyroscope 1 (U18)	4	1-Axis Accelerometer - Z (U30)
1	Gyroscope 2 (U17)	5	2-Axis Accelerometer - X (U31)
2	Gyroscope 3 (U16)	6	2-Axis Accelerometer - Y (U31)
3	Pressure 1 - Differential (U23)	7	Pressure 2 - Absolute (U14)

2.2 - Wireless On-Board UAV Configuration and Flight Test

To demonstrate wireless data collection from on-board sensors the UAV was outfitted with the NASA-UAV Sensor Board and 2 MachineTalkers®; as shown in Figure 1. One Talker®, the "Logger", was connected by RS-232 cable to the NASA Sensor Board and programmed to absorb the NASA output stream containing data from 8 different sensors.

Another on-board Talker®, the "Collector", was programmed to gather and store data from 1 or more Loggers over wireless connection. Those Loggers can be located in the same UAV or on-board other UAVs that are flying nearby.

Once the sensor data is gathered, the Collector unit forwards all such data to the ground station (Base Station) as the UAV flies by. Data can be collected from a number of sensors serviced by the Loggers, sent on to the Collector and then "forwarded" to the Base Station.

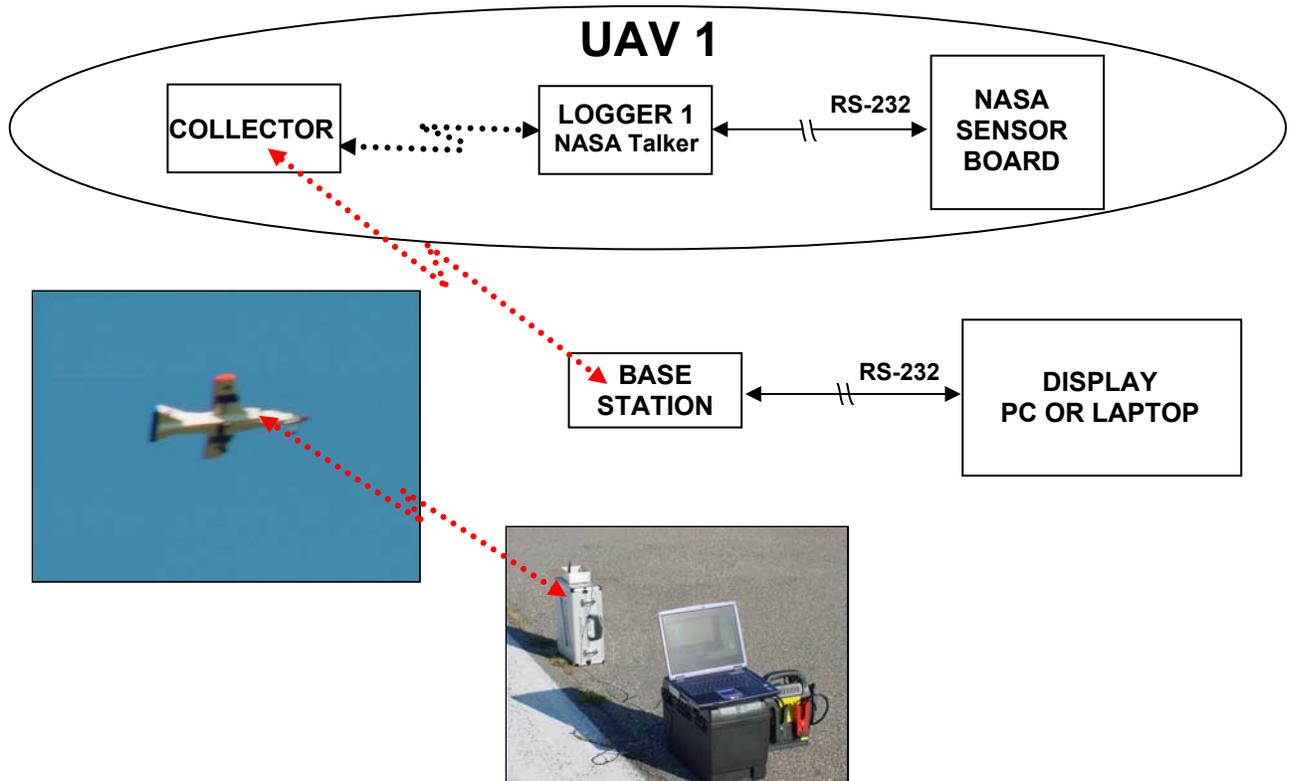


Figure 1 - Wireless Means of Data Collection From On-Board Sensors.

3.0 Flight Testing Wireless MachineTalkers® and NASA Sensors

The series of photographs, below, depict the UAV and the mounted circuit boards of the MachineTalkers® and the NASA Sensor Board. Graphical results are displayed on the Ground Station laptop computer after being gathered from a selected NASA Sensor.

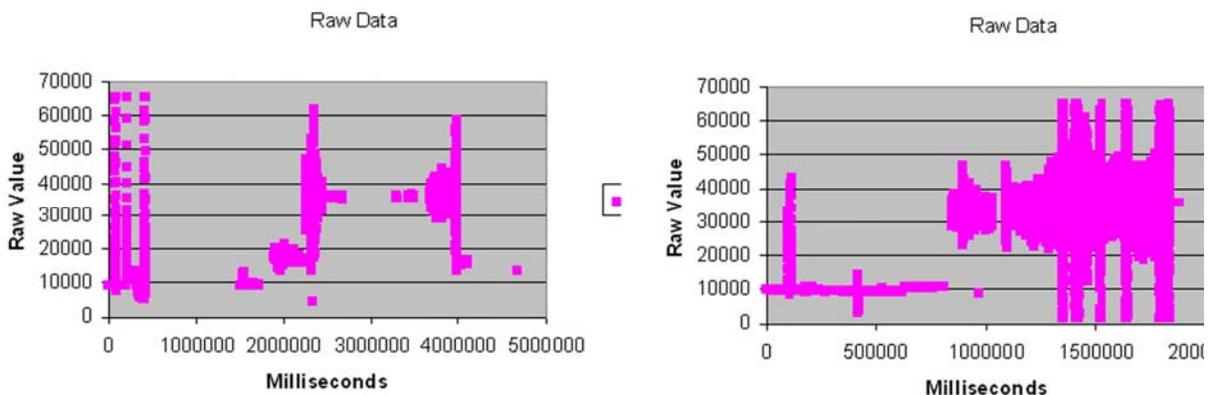
Sensor selection is made by the User at the laptop. The command is sent up to the Collector and passed to the Logger that strips the requested data out of the data stream coming from the NASA Sensor Board.. Any one of the 8 channels can be selected as the data source to be displayed.

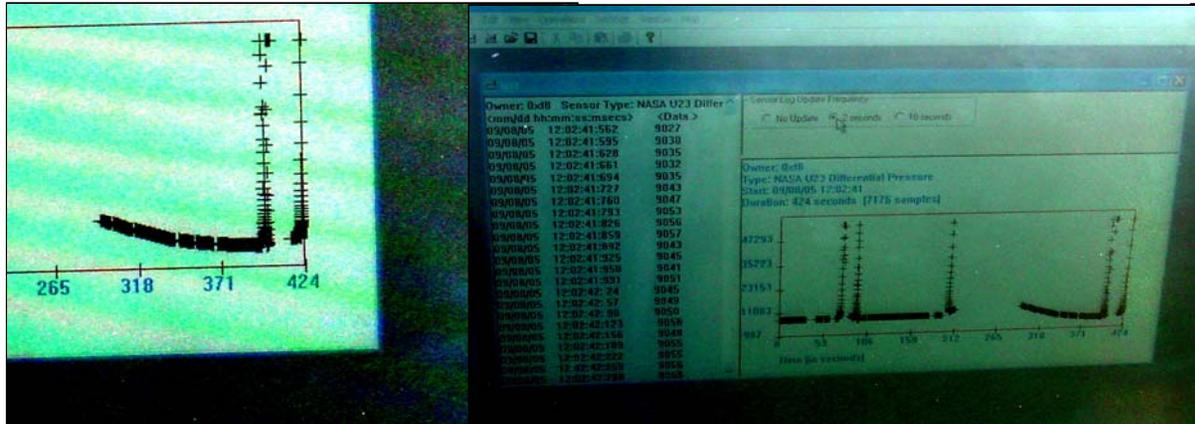
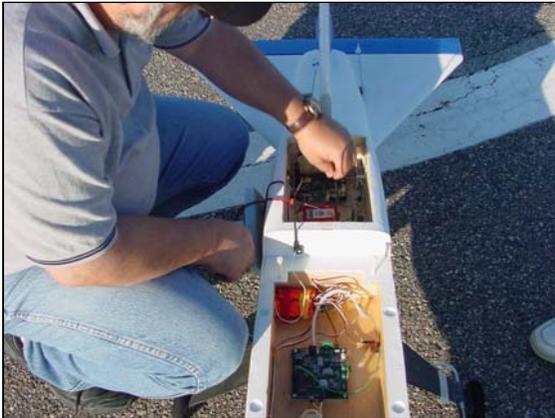
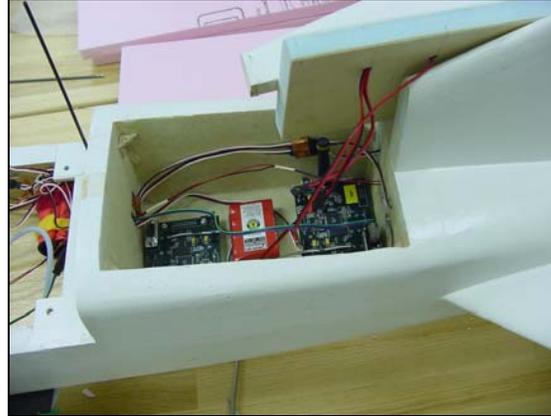
4.0 Flight Test Results and Conclusions

The result of this development project has shown that sensors can be serviced in flight, by wireless means, and when coupled with on-board intelligent devices (MachineTalkers®), that non-critical control services can be initiated and decisions made. When programmed to do so, the MachineTalker® can be made to both gather the sensor data and process in real-time while in flight. Further, Talkers® automatically form mesh networks with other Talkers® that are in radio-range, therefore a Collector in one UAV may also gather and process data from Loggers in companion UAVs while in flight.

The accumulation of photographs on the next page illustrate the preparation of a UAV to take part in the testing and the flight test itself. Base Station graphic data is shown in the lower-left photos, sourced from recorded listings of time-stamped sensor values.

A software program to convert the listings from flight data to actual parametric information has been provided to NASA, along with processed listings and graphs in Excel spreadsheet form. The two graphs below have been drawn from 2 different channel of recorded flight data and passed through the conversion process to be displayed off of the spreadsheet data..





ADENDA TO FINAL REPORT

EXHIBIT A

UAV Sensor Board Protocol

INCLUDED REFERENCES - PROJECT DOCUMENTS

Project To Instrument a NASA UAV with a MachineTalker® Wireless Sensor Network
Configuration Guide and Evaluation Report

CD CONTAINING ALL DOCUMENTS, PHOTOGRAPHS AND FLIGHT TEST MOVIE