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The National Oceanic and Atmospheric Administration's Air Resources Laboratory / Atmospheric Turbulence and Diffusion Division (NOAA/ARL/ATDD) conducted a network traffic study of its DJI S-1000 small unmanned aircraft system (sUAS) on October 3, 2016 to better understand if any data collected by the aircraft could be transmitted to the Internet during flight or during the subsequent transfer of the data to computers for post-processing. This study was conducted in response to a concern that the aircraft manufacturer DJI might be covertly collecting data from the aircraft while in flight.

The DJI S-1000 is an eight-rotor helicopter capable of carrying up to 4.5 kg payload for 10-12 minutes. NOAA/ARL/ATDD uses the DJI S-1000 to perform measurements of atmospheric temperature, relative humidity, and pressure, as well as to measure the Earth's surface characteristics in the visible and infrared portion of the electromagnetic spectrum.

Figure 1 - The DJI S-1000 flying at Knox County Radio Control (KCRC) model flying field near Knoxville, TN.

The S-1000 carries instruments to make scientific measurements of the Earth's surface and the atmosphere in which it flies. The table below describes the instruments onboard the S-1000:

Instrument	Data collected	Stored onboard?	Transmitted in real-time?
DJI A2 Autopilot	Inertial Data	N/A	Yes
DJI iOSD Mk II	A2+GoPro Hero 3	Yes	Yes
GoPro Hero 3	Visible video	Yes	Yes
FLIR IR Camera	Infrared images	Yes	No
iMet-XQ	T/RH/P	Yes	No

NOAA/ARL/ATDD's DJI S-1000 uses a Futaba T14SG transmitter with a DJI A2 autopilot to control the aircraft. The A2 autopilot interprets commands from the Futaba transmitter held by the pilot and manipulates the rotational speed of each motor and propeller to accomplish flight maneuvers. The A2 autopilot also sends inertial data such as the aircraft's position (e.g. latitude longitude, altitude), its velocity, and its acceleration to a DJI iOSD Mk II device on board the aircraft.

The iOSD Mk II interfaces with a GoPro Hero 3 video camera and the A2 autopilot to combine inertial data and video that is then transmitted in real-time to a portable display that is held by an observer on the ground via an AVL58 5.8 GHz video link. The data transmitted by the iOSD Mk II is used only for real-time information to assist the pilot with control of the vehicle.

The maximum range of the AVL58 5.8 GHz video link has been shown experimentally to be approximately 550 meters. It should be noted that there is no provision on NOAA/ARL/ATDD's DJI S-1000 for any other method of real-time data transmission from the vehicle other than the aforementioned AVL58 5.8 GHz video link. Neither is there any sort of Wi-Fi or cellular-based transceiver aboard this aircraft. Therefore, there is no possible way the inertial or video data from the flight could be transmitted beyond 550 meters while the aircraft is in flight.

The iOSD Mk II also records the inertial data collected by the autopilot during flight and stores it on a solid-state disk drive onboard the aircraft. After flight, the iOSD Mk II files are transferred from the aircraft to a computer using DJI iOSD Assistant 4.0 software. These native DJI flight files are used to document the location of the aircraft during flight and are stored in a compressed binary format. They contain approximately 114 KB of data per second of flight time, which corresponds to a data storage rate of approximately 192 samples per second.

It should be noted that the DJI Go App is not used by this aircraft or any of its associated systems.

The scientific instruments, which include the FLIR IR camera and iMet-XQ temperature and relative humidity sensor, are completely independent of the DJI systems. All data from these instruments are stored onboard each respective device and downloaded to a data processing computer using non-DJI software after each flight.

The goal of this test was to determine the quantity and type of network traffic that occurs when the native DJI flight file was transferred from the S-1000 aircraft to a Windows computer that was connected to the Internet. In particular, we looked for any evidence that files containing inertial flight data from the aircraft were being transferred via the Internet during the file transfer.

Preparation for the test included installing Wireshark software on the Windows computer. This software was used to capture all packets moving to and from the computer on any port and provide diagnostic information for those packets. Care was taken to setup the computer to minimize extraneous network traffic prior to initiating the test.

The test began by running the Wireshark program to initiate packet capture, powering the Futaba transmitter, powering the DJI S-1000, and connecting a USB cable between the DJI -1000's iOSD Mk II

USB port and the Windows computer's USB port. Next, the DJI iOSD Assistant software 4.0 was run on the Windows computer.

The iOSD Mk II Assistant software 4.0 contains a link to a program called DataViewer, which was started. Next, the solid-state disk drive on the iOSD Mk II was attached to the computer by following software prompts. The inertial files were then transferred to the local machine using ZTree file management software, which was equivalent to copying the file from the remote drive to the local computer hard drive using Windows Explorer.

Additional testing was performed by allowing the DataViewer program to open one of the inertial data files and display its contents. During all steps of the process all network traffic to and from the machine was collected and stored. Finally, the A2 Assistant 1.3 autopilot software was run and its function verified. The control sticks and switches on the Futaba transmitter were exercised and their values confirmed on the software display and both programs terminated.

The packet analysis showed a total of 192 TCP/IP packets transferred while running the DJI iOSD Assistant 4.1 software and the DJI A2 Assistant 1.3 autopilot software. The total amount of data transferred by TCP/IP during the test was 30835 bytes in 192 transactions. The size of each inertial file transferred for this test was 19693568 bytes, 12943360 bytes, 3923968 bytes, and 3862528 bytes, respectively, for a total of 40423424 bytes. It should be noted that the ratio of the total amount of TCP/IP data transferred to and from DJI servers during the test to the size of the inertial files transferred from the aircraft to the computer was 0.0007628, or 0.076%.

The majority of transactions to the DJI servers were to login to DJI servers hosted at both Amazon Web Services and Linode to check for software updates. These transactions are quite common for software of this type, and nothing unusual was detected during the experiment. There was no evidence that the software used in this test – which is the same software used during the S-1000 field studies – covertly transferred aircraft flight data to any remote computer on the Internet.