Improving Data Collection Processes for F-16 Test Units at Nellis Air Force Base Nevada

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***Abstract* —** *Test units of the F-16 fighter jet collect significant amounts of data. It is important that this data gets processed, analyzed, and archived properly. This project focused in improving data collection processes with non-material solutions. There were three different processes analyzed. The baseline, a modification to the baseline, and the third process included a software that significantly expedited the data collection process. The software reduced data collection for more than 50% and is the optimal non-materiel solution that can be achieved.*

***Key Terms* —** *data collection, F-16, improving processes, testing.*

INTRODUCTION

Gathering data is different for every test unit in the Department of Defense. Test units, usually face problems gathering and analyzing data due to the big amounts of data transfer within a jet. Also, data collection can be difficult if proper maintenance is not performed on the regular basis. The amount of data collected in day can cost thousands of dollars and flying hours. Having a data process that secures the data collection can potentially save millions of dollars a year and allows to analyze the data efficiently.

The objective of these project is to optimize the data collection process and to reduce data collection time. The scope of the project was to find a series of solutions to archive data in a reliable way and that improves data collection storage.

Thus paper discusses more information about F-16s and its history, the data collected and methodology of this project, the results associated with every modification of the processes tested, and at the end gives a series of recommendations to optimize the process.

LITERATURE REVIEW

The F-16 known as Fighting Falcon or Viper was made by General Dynamics (now known as Lockheed Martin) in 1974 for the United States Air Force (USAF). This is a single engine, fly by wire fighter aircraft designed for an all-weather multirole scenario. Due to its maneuverability, this jet has proven its performance in air-to-air and air-to-ground missions. Compared to other fighter jets, the operation costs of an F-16 are lower by the hour and subsequently overall.

Since the introduction of the F-16 to the USAF in 1974, General Dynamics has produced over 4,600 aircrafts including the ones exported to other countries. In 1993, General Dynamics sold F-16's production to Lockheed Martin and nowadays production has been relocated from Texas to Greenville, South Carolina. In 2018, Lockheed Martin signed a contract for $14 billions to build 128 more jets to US allied partners. [1]

The F-16, shown in Figure 1, has a cropped-delta wing incorporating wing fuselage. These wings can carry multiple air to air missiles and air to ground weapons in different configurations.

Figure 1
General design of an F-16

The F-16 has a negative stability that allows it to be more maneuverable. This negative stability does not induce the jet to return straight level altitude. The bubble canopy allows the pilots to

have 360 visibility and a 40° look down visibility. The fire control radar (FCR) gives the F-16, 25 operating modes such as mapping, moving target indication, global position system, and many more [2].

Since the first F-16 has been produced it has been in constant upgrades. The first two models were the F-16 A/B. Model A is a single seat jet and Model B is two seat jet. The more modern models are F-16 C/D. Model C is a one-seater and Model D is a two-seater. These modern models have better radar, avionics, software upgrades and can carry different weapons than previous models. All F-16 jet belong to a block. Every block has unique characteristics such a type of engine or a slightly change in the hardware [3].

The F-16 has been exported all around the world to allied countries with United States. Some of the F-16 operators are Belgium, Iraq, Israel, Netherlands, Norway, Singapore, Jordan, Greece, Egypt, Denmark, South Korea, Thailand, Turkey, Taiwan among many others [4].

The F-16 C/D models are currently used for testing and fielding recommendations of new upgrades. These jets are upgraded with upcoming technologies and undergo rigorous tests to gather data and understand the systems. To gather data, test units have to removable cartridges. The Removable Memory Cartridge (RMC), Figure 2, gathers data in video form for the pilot's review. The Removable Memory Module (RMM), Figure 3 collects data in the form of "1" and "0". It can collect up to 256GB worth of data. The latter is used in this project to collect data and analyze data [5].

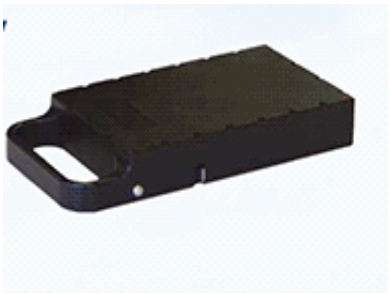

Figure 2
Removable Memory Catridge

Figure 3
Removable Memory Module

METHODOLOGY

This project is based on the change of the process to collect data. F-16 can collect hundreds of gigabytes worth of data per sortie. On ongoing data collection, the process will change for option the team thought it was best.

Process I (Baseline)

This baseline is how data has been collected for the past months. Is necessary to clarify that this process works with for our systems but is not optimal. It takes a significant amount of time to collect data, data is archived in multiple computers, and is cumbersome to retrieved data for future analysis. For this process, pilots take the RMM and RMC to collect data while flying. When the mission is completed, the pilots come back to office and archived data in a computer that's available for them. Downloading data can take up to 30 minutes per pilot. After downloading data, the pilots start debriefing. Debriefings can take up to a one hour depending on mission complexity. And after debriefing is when data can be transferred and analyzed.

Process II (Modification 1)

Process II is slightly modification of the baseline. For this process, pilots take the RMM and RMC to collect data while flying. When the mission is completed, the pilots come back to office and hand the RMM to the flight test engineer or the data transfer authority. They, download the data from the RMMs in the fastest computer. This

process will resolve the objective of archiving data and having an easy access for later review.

Process III (New Software)

This process was not foreseen by the test team. Counterparts from another test units use a software called DACS Akers to download RMM data. For this process, pilots take the RMM and RMC to collect data while flying. When the mission is completed, the pilots come back to the office and hand the RMM to the flight test engineer or the data transfer authority. They, download the data from the RMMs in the fastest computer with the new software installed.

ANALYSIS

The analysis for this project was very simple. The average time per computer and the average time per RMM were calculated. This baseline process is how the team is gathered data from the past few years. Table 1 contains the raw data for time collecting data and the averages per computer. Across all three computers downloading data can take up 23 minutes and 45 seconds while other computers can download data faster with a minimum of 15 minutes and 45 seconds. Thus, average for computer number 1 is 17 minutes and 01 seconds, for computer number 2 is 20 minutes and 04 seconds, and for computer 3, 21 minutes and 47 seconds.

Table 1
Time for data transfer for each computer for baseline

Computers				
Day	1	2	3	Avg time
Day 1	18:34	20:32	21:33	20:13
Day 2	16:12	20:14	19:33	18:39
Day 3	16:43	19:23	21:22	19:09
Day 4	17:43	20:20	21:37	19:53
Day 5	15:45	20:14	22:54	19:37
Day 6	16:54	19:34	--	18:14
Day 7	17:19	20:12	23:45	20:25
Average	17:01	20:04	21:47	19:37

Since computer number 1 was the fastest computer archiving data, Table 1, the team used this to solve archiving problems. Every RMM was downloaded, and data was saved in computer number 1. Although it was faster, it this process does not give a solution to the problem of expediting the process, but just provides a solution for retrieval data. Table 2 summarizes the data points collected when downloading data in computer number 1.

Table 2
Time for data transfer for computer 1

Day	RMM 1	RMM 2	RMM 3
Day 1	17:05	15:01	16:37
Day 2	17:28	17:10	17:15
Day 3	16:42	15:43	17:23
Day 4	17:22	17:31	17:40
Average	17:09	16:21	17:13

Process number three involves a software called DACS Akers. This process expedited data download and data transferred. It decreased downloading time by more than 50 percent when compared to other processes. Table 3 summarizes the data collection point and time for computer with the software installed.

Table 3
Time for data transfer with new software

Day	RMM 1	RMM 2	RMM3
Day 1	7:02	8:32	6:45
Day 2	6:55	7:33	7:17
Day 3	5:59	8:13	7:27
Day 4	7:34	7:08	7:56
Average	6:52	7:51	7:21

DISCUSSION

Baseline

Some of the constraints of this process is that is not streamline. It takes too much time to process data and archive it. When retrieving data, it can be cumbersome since data is downloaded in three

different computers. If a specific mission needs to be review, all three computers must be search until finding that specific mission. Some pros are that more people can download data at the same time. If a computer brakes, not all the data is lost. Only data to the specific computer gets corrupted.

Process II (Modification 1)

Some disadvantages are that all data is archived in one computer. This data can get lost if the computer brakes or have a malfunction. Since all data is downloaded by two team members, this can cause problems if none of them is available to download data. Process is faster than the baseline but is not optimal solution. Some advantages are that since two people are assigned to collect data, data can be archived in an organize format. Data is easier to find for future reviews. If a hard drive reaches full capacity, is easy to exchange the internal hard drive to a new empty drive.

Process III (New Software)

For this process some disadvantages are that data is archived in one computer. This data can get lost if the computer brakes or have `malfunctions like in Process II. Since all data is downloaded by two people, this can cause problems if none of the is available to download data. Minimal personnel are authorized to use this software. License key for the software needs renewal every year. Some advantages are that downloading data is faster with this software. It reduces the time of collecting data by 67%. It provides thousands of data points and easier method to understand and analyze data. It resolves the issue of reducing time and retrieving data.

CONCLUSION AND RECOMMENDATIONS

After comparing all three process and analyzing the data, the third process significantly improves the data collection process time better than the others. Although, this process is not optimal, since there are some risks involve with it, it can be an alternate solution until new equipment can be purchased to optimize the process. Is clearly to the team that if the process needs to be fully optimized, equipment such as new computers, external hard drives, internal hard drives must be purchase. Other recommendations to improve this process, is that computers should be network within each other, for everyone to see the same data from different computers and not a specific one.

REFERENCES

[1] Air Force Life Cycle Management (2021 May 18). Air Force opens new F-16 production line for foreign military sales. Available https://www.af.mil/News/ Article-Display/Article/2619834/air-force-opens-new -f-16-production-line-for-foreign-military-sales/

[2] Sherman, R. (2008 May). F-16 Fighting Falcon overview. Available https://man.fas.org/dod-101/sys/ac/f-16.htm

[3] Air Combat Command Public Affairs. (2021 Sept). F-16 Fighting Falcon. Available https://www.af.mil/ About-Us/Fact-Sheets/Display/Article/104505/f-16-fighting-falcon/

[4] The F-16 Ultimate Site. (2022). F-16 Users. Available https://www.f-16.net/f-16_users.html

[5] Air Force Technology. (2022). Calculex Rugged Solid-State Recorders. Available https://www.airforce-technology.com/contractors/flight-data-recording/calculex/