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Airborne Applications & Protecting Data-at-Rest

Military aircraft must constantly evolve to meet the growing demands of the aerial battlefield.

Legacy aircraft must be updated with the latest technology to meet modern mission requirements and counter ever-evolving threats. Data storage systems, also known as data-at-rest (DAR) solutions, are expected to provide the latest commercial capabilities to address the many requirements of military aircraft. Network attached storage (NAS) devices address these needs offering many benefits to military aircraft applications. This white paper introduces and explores these advantages.

Contents

Network attached storage

NAS devices are used in modern aircraft to provide data storage on Ethernet networks, and legacy aircraft are undergoing upgrades that typically include the addition of Ethernet networks. Aircraft NAS devices should be equipped with removable memory cartridges (RMCs), which can transport map and mission data to the aircraft. After the mission, the RMCs can transport sensor and maintenance data from the aircraft back to a ground station for analysis.

Since unmanned aircraft have no crew on board to protect the NAS from an adversary, the top-secret data must be protected with National Security Agency (NSA) approved encryption. That encryption can follow either of two options from the NSA –Type 1 encryption or Commercial Solutions for Classified (CSfC) encryption. Each type of encryption is NSA-approved, and each has distinct advantages. As a developer and manufacturer of NAS devices using both NSA CSfC and Type 1 encryption, we have compiled a list of factors to consider when deciding between these two NSA-approved programs view here. This list allows the user to adapt it to their program with its unique requirements and then make their own decision.

Common airborne pain points

Despite size differences, aircraft have several common issues or pain points.

Size, Weight, and Power

All aircraft face size, weight, and power (SWaP) constraints. For electronics like a NAS, size restriction is obvious, especially for the smaller aircraft. A large NAS device may just not fit. NAS size restrictions may also be applicable to the larger aircraft. If the NAS is smaller, then more electronics can be added to the aircraft. More sensors and computers make an ISR aircraft more flexible and valuable.

Weight and power are other restrictions. By reducing weight and power consumption, an aircraft can operate and remain on station longer.

Data Storage Capacity

All aircraft applications are concerned with data storage capacity. Operating independently, these vehicles must carry all the information necessary to perform the assigned tasks without intervention or continuous input. As mentioned, most aircraft collect sensor information during the mission (especially ISR aircraft), and the collection of more data is an ever-increasing pressure. Today and in the future, data storage capacity is a great concern.

Data Protection and NSA-approved Encryption

Whether manned or unmanned, aircraft are subject to loss and capture. The top-secret data on military aircraft must be protected so that an adversary cannot take advantage of the information if the vehicle is captured. Encryption of the data will protect it from being used. All the armed services require that DAR be protected with NSA-approved encryption.

Transportable, Secure Storage

Classified data must be transportable to and from the aircraft, with the most common method being via RMCs. For survivability from prolonged shock and vibration, the memory device inside the RMC is a solid-state drive (SSD). Before an aircraft mission, the map and mission plans are loaded onto the RMC, transported to the aircraft, and inserted into the aircraft's permanently mounted NAS. After the mission, the RMC is transported back to the ground station.

If the encryption is performed in the NAS and not in the RMC itself, then an adversary has less to work with if the RMC were captured or lost. This approach is documented in the whitepaper Choosing The Best DAR Encryption Location. It is preferred that the encryption mechanism is not transported outside the vehicle.

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Multiple Memory Cartridges

Smaller aircraft are especially SWaP constrained. Therefore, multiple cartridges in a NAS are not normal criteria or requirement. Larger aircraft may include multiple small NAS devices instead of one larger device. However, the concept of operations (CONOPS) for some aircraft requires the use of multiple RMCs in one NAS. An example of multiple memory cartridges is shown in Figure 4.

Network Connections of Computers

Any aircraft will have multiple computers on board. These computers perform a variety of functions including guidance, communications, and sensor management. To share data loaded prior to the mission and collected during the mission, Ethernet networks are generally used to connect these computers. Each computer is known as a network client.

As mentioned earlier, the central storage location for all these clients is the NAS. Multiple clients can store data on and retrieve data from the NAS.

Software Updates

Another pain point for aircraft developers and users is software maintenance of the network clients. To upgrade a client, it must be removed from the aircraft and transported back to a maintenance depot which has the software upgrade facilities.

Unless spare clients are inserted, the removal of a client computer from the aircraft shuts down that aircraft until the client is updated and reinstalled.

applications in new Ethernet based networks.

Downtime is highly undesirable for valuable aircraft. This removal and re-insertion also put strain and wear on the cables and connectors.

Environment

Temperature - Any aircraft will experience temperature extremes. Aircraft are deployed in the desert, tropics, and arctic. Even in the hot desert, an aircraft will undergo drastic changes from takeoff to high altitude.

Shock and Vibration - All aircraft and their electronic payloads are exposed to varying and often high levels of shock and vibration. Helicopters may produce more vibration than shock. A Navy fighter may experience more landing and takeoff shock than vibration. A NAS device must be able to endure the required levels of shock and vibration for each application.

Altitude - Altitude is another issue with most aircraft. While helicopters rarely get above 10,000 feet, a fighter may reach 40,000 feet and a high altitude long endurance (HALE) unmanned aerial vehicles (UAVs) may reach 70,000 feet or more. Cooling of a NAS device will be more difficult at higher altitudes due to reduced air density.

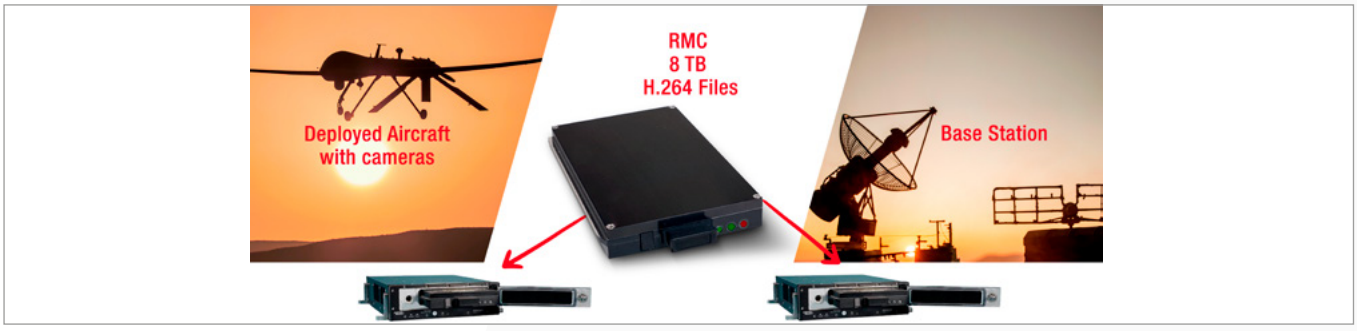

Figure 1 - Data transport to and from an aircraft

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	Fighter	Bomber & Transport	Refueling	ISR	Helicopter
SWaP Performance	●●●	●●	●	●	●●●
Data Storage Capacity	●●	●●	●●	●●●	●●
Data Protection and Encryption	●●●	●●●	●●●	●●●	●●●
Transportable, Secure Storage	●●●	●●●	●●●	●●●	●●●
Multiple Memory Cartridges	●	●●	●	●●●	●●
Network Connection of Computers	●	●●	●●	●●●	●
Software Updates	●●●	●●	●●	●●	●●●
Temperature Excursions	●●	●●●	●●●	●●●	●
Humidity Protection	●●	●●	●●	●●	●●
Shock Protection	●●●	●●●	●●●	●●●	●●
Vibration Protection	●●	●●	●●	●●	●●●

Table 2 - Key storage characteristics typical of various aircraft and defense missions

NAS examples

Aircraft developers use small, secure NAS devices from Curtiss-Wright, shown in Figure 2 and Figure 4 as their storage solution. Let us see why.

DTS1 NAS

The DTS1 is the industry's first commercial off-the-shelf (COTS) NAS solution that supports two layers of full disk encryption in a single NAS device. The DTS1 is a small form factor file server that weighs just three

pounds, occupies less than 50 cubic inches, and provides scalable storage of up to 8 TB on a single removable memory cartridge (RMC) which can be easily transported. The RMC is small enough to fit into a shirt pocket.

The DTS1 provides two layers of Commercial Solutions for Classified (CSfC) encryption, one hardware and one software layer. As noted earlier, CSfC is an NSA-approved approach for protecting classified National Security Systems (NSS) information. To become NSA approved, the two DTS1 encryption layers have each been certified by National Information Assurance Partnership (NIAP) under the Common Criteria (CC) program and are also listed as approved NSA CSfC components. Because the DTS1 layers are already NSA CSfC approved, aircraft developers can securely store top-secret data on-board the aircraft and then safely transport the data on the RMC. The RMC is considered unclassified when removed and unpowered.

Figure 2 - DTS1 from Curtiss-Wright

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Figure 3 - Multiple Memory Cartridges

The DTS1's unique, award-winning approach was the first COTS NAS device to include two layers of full disk encryption into a single device reducing risk, schedule, and cost.

With many Ethernet-connected computer systems (or network clients), several aircraft developers use the DTS1 to not only store and protect the classified data, but also to host the operating systems (OS) and applications (APPs) for dozens of network clients. Instead of having a hard disk on each network client, the DTS1 distributes the OS and APPs to each client. These disk-less network clients would be considered 'thin clients' without a typical local hard drive (known as direct attached storage). At first glance, this elimination of the local drives is an effort to reduce size, weight, and power (SWaP) on an aircraft. While SWaP performance is indeed increased, the real reason for this approach is to reduce maintenance efforts and risk.

While being used as a file server, the DTS1 can also accept streams of MPEG video from cameras or other similar Ethernet based sensors that produce video. These video files are encrypted prior to storage, just like the standard files received via network file system (NFS).

The DTS1 reduces technical risk since it is a COTS product that has already been developed, tested, and deployed. The current technology readiness level (TRL) rating is 9 (the highest).

Since both layers of encryption have been tested and approved, the program schedule risk is reduced.

There is no waiting for NSA approval. Many of the aircraft programs had compressed schedules that required low risk, existing products.

In most programs, budgets were limited. So, the low cost DTS1 provided an excellent option. And no engineering development was required for the product or the encryption approval.

DTS3 NAS

As shown in Figure 4, the DTS3 has been deployed on aircraft for several years. The DTS3 is a NAS with four Gigabit Ethernet (1GbE) ports and 3 RMCs.

The network clients can store data selectively on

any one of the three RMCs. For instance, maintenance data can be stored on RMC#3 during the deployment. Then that RMC could be returned to a specific base station computer for maintenance data analysis.

Map data could be pre-loaded onto RMC#1 and made available to any of the network clients.

Mission plans and data could be stored on RMC#2 and made available to any network clients. Each RMC comes from a particular ground station computer and goes back to that computer for off-load. See also Figure 3 - Multiple Memory Cartridges.

Figure 4 - DTS3 NAS from Curtiss-Wright

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Each RMC in the DTS3 can hold 2TB of data (6TB total). This allows for the quick off-load and transport of lots of data. This data is available for post-mission analysis.

HSR10 - 10 gigabit Ethernet NAS

The sensors on today's modern deployed applications produce data at higher rates than in past years. New and upgraded aircraft are being equipped with more of these high-speed sensors. So, the demand for data handling and data storage is ever-increasing.

These demands for faster networks and more storage have driven system developers to require 10 gigabit Ethernet (10GbE) connectivity. Video-based sensors stream MPEG4 video across 10GbE connections. Various radar systems are being deployed from traditional radar to side aperture radar (SAR), and these radar systems are streaming incredible amounts of data for processing and storage. Radar systems are being upgraded constantly and again, producing more data. With multiple such 10GbE sensors, the airborne NAS device is required to absorb all this data requiring several special properties.

Figure 5 – HSR10 NAS from Curtiss-Wright

One thing about sensors, especially high-speed ones, is that they do not wait. The NAS cannot cry 'Uncle' and try to slow down the sensors. There is no stopping in such an architecture.

First, such a high-speed NAS must have one or more 10GbE interfaces on the front end. The 10GbE interfaces must be specially configured to reduce overhead and increase total data throughput.

Second, the internal NAS architecture in the middle must be able to move massive amounts of data continuously. Very high-speed, multi-core processors, high-speed busses, and direct memory access (DMA) are used to streamline the flow of data from the front end to the back end.

Third, the actual storage devices on the back end must be able to absorb all the data on a continuous basis. SATA (serial ATA) storage has been used for years. However, NVMe (non-volatile memory express) memory is much faster and more scalable.

So, NVMe is the right choice for the back end of a very high- speed NAS system. NVMe is being used on newer laptops and other computers today, and rugged versions are now available for deployed applications.

An example of such a very high-speed NAS is shown in Figure 5. The HSR10 has multiple 10Gbe ports, streamlined internal architecture, and NVMe memory in removable cartridges. The HSR10 is a small NAS system, but not as small as the DTS1 shown in Figure 2 or the DTS3 shown in Figure 4.

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Conclusion & Summary

Network attached storage is used in today's modern and upgraded defense aircraft. The new NAS devices are designed with great functionality and built into small yet capable packages.

Aircraft requirements are met with the NAS examples – HSR10, DTS1, and DTS3. The DTS1 is especially small, occupying only fifty cubic inches and weighing just three pounds with a removable memory cartridge included.

It consumes only 15 watts of power at 28VDC. The DTS3 is a bit larger, weighs more, and consumes more power than the DTS1. Both are 1GbE-based NAS devices, and both have removable cartridges. The HSR10 is larger than either DTS1 or DTS3. It supports network speeds of 10 gigabit per sec (10GbE) and provides fast storage modules.

ISR applications seek maximum storage capacity, even in the smallest aircraft. With the ever- increasing demands for sensor storage, the DTS1 and DTS3 support the current needs and we are planning to expand their density as solid-state drive capacities increase. The HSR10 example collects data faster and can be scaled to much larger storage.

The RMC, which is the same device used in both the DTS1 and DTS3, is protected while in transport. The data is encrypted by special mechanisms in the DTS1 and DTS3 NAS devices prior to storage on the RMC. The RMC is considered unclassified when removed from the NAS chassis, unpowered, and transported. An adversary will find no advantage if an RMC were to be obtained somehow.

The DTS3 satisfies the unique requirement for multiple cartridges. With the three RMCs, one can be loaded with mission data, while a second one can be loaded with map data. With two RMCs, each can source from a different ground station computer. The third RMC can store maintenance data and be returned to a different ground station computer. With the DTS3's unique software, each RMC can be individually addressed by any client in the network. Data can be stored on the exact RMC desired.

The HSR10, DTS1, and DTS3 are NAS devices that appear to the client as local hard drives. They all support industry standard storage protocols – NFS, CIFS, FTP, iSCSI, and HTTP and come with PXE protocol which allows them to host the operating system and applications for each client. This network booting (or NetBoot) approach can save a great deal of time during client software upgrades and can reduce cost and risk. For more information regarding network booting reducing maintenance, refer to the white paper: Using NetBoot to Reduce Maintenance and SWaP-C in Embedded Systems.

The DTS1, DTS3, and HSR10 offer developers a low risk, low-cost approach to network attached storage. These small devices provide many terabytes of storage and protects the classified data with modern hardware and software encryption methods. These rugged NAS devices can support airborne applications in new Ethernet based networks.

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The case studies below offer further insights as to how effective and efficient storage solutions can be deployed to various aircraft used for defense missions

Case Study	Aircraft Type
Aircraft looks to Modernize Storage of Sensitive Data Case Study	Fixed-wing, manned ISR
Protecting Data-at-Rest with NSA CSfC Approved Encryption Case Study	Fixed-wing, unmanned ISR
Airplane Developer Looks to Protect ISR Data with Encryption	Fixed-wing, manned ISR
Mission Recorder With Secure Data Storage for Utility Helicopter	Manned helicopter
SWaP-optimized Data Storage, Recording, and Networking Reduces Helicopter Program Risk and Costs	Manned helicopter
Rugged Recording and Mission Computing	Fixed-wing, manned fighter
Degraded Visual Environment: Uncovering the Invisible	Manned helicopter
High Speed NAS for a Wide-Area Persistent Surveillance Pod	Fixed-wing, unmanned ISR

Table 2 - Airborne Case Studies

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