

Beyond Identification – High Memory RFID in Aviation

Bob Hamlin
Tego, Inc.

Copyright © 2009 SAE International

ABSTRACT

The RFID on Parts Project Team has recently completed and approved Spec 2000 Chapter 9, "RFID on Parts". Once approved by the ATA e-Business Steering Group, this standard will allow for archiving and sharing part history information directly on RFID tags using the User Memory Bank. Using a structure similar to a File Storage System, this standard organizes tag data in a structured and indexed system so that information can be shared among all members of the supply chain.

Now that high memory, passive tags are becoming available, when used in conjunction with the "RFID on Parts" standard, they make it possible to tag parts not just with an identification number, but with birth records, a full history of maintenance activities and user archives. Since end users and maintenance organizations will no longer need to rely solely on information retrieved from a centralized database, new processes and efficiencies can be realized.

This paper describes how the Spec 2000 standard allows tag data to be shared among all members of the supply chain and describes the uses and benefits of high memory tags in aviation.

INTRODUCTION

Successful use of RFID on aircraft parts has required the development of technology and standards for fully passive UHF tags. This technology has matured in recent years and the addition of high memory will allow the use of passive tags for purposes that go beyond

identification into a media for information exchange. Passive tags can now store part information and maintenance records without the environmental waste, limited life and weight of battery-powered active tags.

Instrumental to this progress was the FAA approval of passive RFID use on aircraft parts in June 2005 [1]. This ruling allows for RFID tags to be attached to aircraft parts provided that the following criteria are met:

- The tags must operate in the "passive-only" mode.
- The tags must not reflect back ambient RF energy of greater than 35 dBm. (This is to make sure that the tags don't pick up energy emitted by the engines or other devices, reflect it back and possibly interfere with aircraft systems.)
- The frequency used by the tags needs to be outside the published aviation frequency bands to prevent interference with aircraft systems. (The most common RFID frequencies—2.45 MHz, 915 MHz and 13.56 MHz—do not overlap with any frequencies used in aviation and are acceptable for tagging parts.)
- Passive tags must be interrogated, or read only on the ground when the airplane is not in operation.
- The tags must function properly when installed and be designed "to operate in an aircraft operational environment with robust radio frequency stability."

With tags approved for use on aircraft, there has been continued interest in adopting the technology for

identification and traceability purposes between trading partners.

The Air Transport Association (ATA) oversees Spec 2000. Its primary goal is to provide cost-effective, state-of-the-art methods for information exchange across the airline industry's supply chain. The Spec 2000 e-business system was specifically designed for the airline industry's procurement and repair transactions relevant to aircraft maintenance. The system was created by the airline industry to revolutionize the multi-billion dollar aviation parts business. It is comprised of a comprehensive set of e-business specifications, products and services.

Spec 2000 Chapter 9, Automated Identification and Data Capture (AIDC), is the commercial aviation industry's standard for the permanent identification of parts, shipping/receiving information, and traceability. The permanent parts marking standards include bar-coding, data matrix and RFID. [2]

Spec 2000 Chapter 9-5 is "RFID on Parts". Originally focused on identification methods, it has recently been expanded to standardize the use of high memory tags [3]. Although RFID tags have been in mainstream use for many years, only recently has technology allowed for passive UHF tags with more than the typical 96 bits found on supply chain tags. For example, the recently introduced TegoTag has 32 KiloBytes of non-volatile memory and works with unmodified commercially available interrogators [4].

As the FAA approval, the standards and available technology come together, the aerospace industry will be able to use passive tags for logging, cataloging and tracking many thousands of parts to support airline maintenance and repair. A passive tag attached to specific parts can hold copies of the entire maintenance history of the parts, providing valuable information to personnel responsible for the upkeep of an aircraft. Technicians can make repairs in an efficient and economical manner never before possible with the older identification tags and centralized databases.

This paper provides an overview of the memory organization found on UHF RFID tags along with a description of the "RFID on Parts" standard and the container structure it presents for storing data in User memory. For perspective, a comparison of this container structure is made to common file storage systems such as File Allocation Table (FAT) or New Technology File System (NTFS). With the memory structure in hand, aviation-specific record formats are described. Finally, some examples of the motivations and benefits of storing large amounts of data on high memory tags is provided.

RFID FOR IDENTIFICATION

TAG COMMUNICATION AND MEMORY

RFID tags in use today are used primarily for identification. Items are tagged with devices that contain just enough memory to store a reference number which is used to uniquely identify the item and often times as an index into a database that contains more information about the item. There are some high memory tags available, but they are mainly battery-assisted tags.

Communication with these tags happens over an air interface that is specified in [5] and [6]. These standards identify 11 over-the-air commands that tags must respond to plus four optional commands. Some of these commands are used to isolate a single tag out of a large population through a process known as singulation. Once singulated, a tag responds with a uniquely identifying number known as the Electronic Product Code (EPC) number. Subsequently, the EPC number can be used to address the tag, and its memory can be accessed using Read and Write commands. In order to retrieve data out of tag memory, something must be known of the memory organization.

ACCESSING DATA IN TAG MEMORY

As seen in Figure 1, tag memory is divided into 4 banks. The EPC bank contains the EPC number, and it is stored at a fixed address. Both the tag and the interrogator know that the EPC number is always stored in the EPC bank starting at address 20 hex. There are some commands that require the tag to return its EPC number, and the tag knows where to access that information without any address being provided or performing any indirect lookups. Similarly, an interrogator Read to Bank 1 and address 20 will always return the EPC number.

Likewise, the transponder ID (TID) bank is used to hold the TID number, a read-only number written to the tag's microchip by the chip manufacturer, and typically nothing else. The TID number contains information specific to the tag manufacturer, and often times a serial number of the tag (as opposed to a serial number of the item to which it is attached), and it is always stored at address zero.

The only other bank in use by an identification tag is the Reserved bank, which holds the Access password and the Kill password if those features are in use. Again, these passwords are always stored at specific fixed addresses in the Reserved bank.

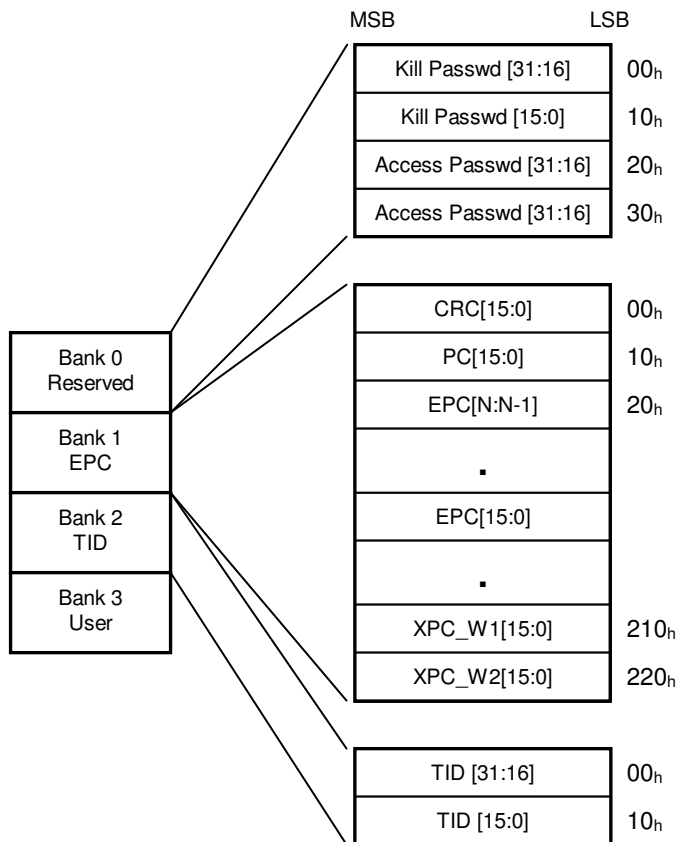


Figure 1. EPC Global Memory Structure and Contents

With only a few data items being stored and retrieved, a fixed address scheme is both practical and efficient. But fixed addresses do not scale to larger amounts of storage and can never account for all information that might be stored.

RFID FOR INFORMATION EXCHANGE

The standards also allow for a fourth bank known as the User bank. This is simply an empty memory bank that can be used to hold user-specific data. Few tags today are available with User memory, but those that are available can store from 64 Bytes of data up to a maximum of 32 or 64K Bytes.

Only the Read and Write commands can be used to access the User bank, and no structure is specified for the contents of this bank. The absolute addressing scheme used for the other banks is not applicable to space this large, or to free form user data. While it could be possible to say “always store the manufacturer’s CAGE code at address 100” or “always store the condition code at address 240”, but such a method is very restrictive, does not allow for unforeseen applications, and does not scale with memory size or technology.

What is needed is a general purpose data organization system, like a file management system, that allows for

user-specific data to be stored in an efficient manner yet also allows for the rapid retrieval of that information.

COMPARISON TO FILE MANAGEMENT SYSTEMS

Especially since memory on passive tags is by necessity non-volatile, the requirements around User memory can be compared to the storage needs of a disk operating system, or any managed system that includes removable storage media. Systems such as the File Allocation Table (FAT) system or the New Technology File System (NTFS) used by the Windows operating system, do not allow access to individual storage locations. Instead, all data must be stored in files, which are then stored in folders and subfolders.

In addition to the content stored in the files, some amount of structural information is also stored to make the media more usable. Certain utility information is stored at fixed addresses. The operating system needs to rely on those locations for certain basic information about the disk or storage media; things like how large the space is, what version of the formatting is in use, and how the memory is structured into sectors and clusters. Once that structure is discovered, a directory table provides an overview of the contents – what files and folders are currently stored, how big they are and of what type. An operating system can discover and display that information without parsing the entire storage contents. Finally, the directory table is used to efficiently locate the files and the unused space.

The end result is that when storage media is written by one computing system, it can be removed to another computing system and the contents accessed efficiently.

THE RFID CONTAINER SYSTEM

The recent update to Spec 2000 Chapter 9-5 describes a data organization structure that is appropriate for RFID User memory.

An overview of the container structure is shown in Figure 2. As with the disk management systems described above, direct access to individual memory locations is not allowed. Instead, all content is stored in records which is described and pointed to by a Table of Contents. Further overhead allows for error detection and correction.

The Table of Contents

The start of the container structure is the Table of Contents (ToC) header, which is stored at an absolute address. This is critical since application software running on an interrogator needs some point of reference to know how to access the structure. No provisions for such a container exist in the other standards, and no pointer to the container is stored in the other memory banks, so the ToC header must start at a known address.