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Current Impacts to Digital Map Processing for the AN/ASQ-196 Digital Map System

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The Honeywell model AN/ASQ-196 is an aging digital map system employed as part of the integrated avionics on the AV-8B and F/A-18C/D aircraft to support display of digital moving maps. The Tactical Aircraft Moving Map Capability (TAMMAC) program at the Naval Air Systems Command (NAVAIR PMA 209) is developing and testing the next-generation digital map system scheduled to replace the An/ASQ-196 over the next few years (Boeing 1996; Lohrenz et al. 1997a,b). However, it may be many years before all current digital map systems have been retrofitted for TAMMAC.

This report briefly describes the impacts and obsolescence issues related to the AN/ASQ-196 digital map system. The impacts described in this report focus on digital map processing issues, media limitations, and operational usage rates.

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CURRENT IMPACTS TO DIGITAL MAP PROCESSING FOR THE AN/ASQ-196 DIGITAL MAP SYSTEM

OVERVIEW

The Honeywell model AN/ASQ-196 is an aging digital map system used as part of the integrated avionics on the AV-8B and F/A-18 C/D aircraft to support display of digital moving maps. The Tactical Aircraft Moving Map Capability (TAMMAC) program at the Naval Air Systems Command (NAVAIR PMA 209) is developing and testing the next-generation digital map system scheduled to replace the AN/ASQ-196 over the next few years (Boeing 1996; Lohrenz et al., 1997a, b). However, it may be many years before all current digital map systems have been retrofitted for TAMMAC.

This report briefly describes the impacts and obsolescence issues related to the AN/ASQ-196 digital map system. The impacts described in this report focus on digital map processing issues, media limitations, and current operational usage rates.

AIRCRAFT OPTICAL DISKS

The AN/ASQ-196 digital map system uses a digital memory unit (DMU), which functions like a floppy drive, connected to a digital map computer (DMC). The removable disk in the DMU is known as an Aircraft Optical Disk (AOD): a militarized Write Once, Read Many (WORM), two-sided optical disk (Ronish 1988). Each AOD is programmed with a map theater (on each side) comprised of multiple scales of scanned map data for an area of interest (Trenchard et al. 1998b). Existing data on an AOD cannot be overwritten, but new data can be appended to an AOD if disk space and format restrictions permit. An AOD is limited to 260 megabytes (MB) per side, which severely limits the amount of map coverage that can be stored on a disk. Only one side of an AOD can be accessed while in flight (the disk can only be turned over when the aircraft has landed). Thus, many map theaters are logically divided into north/south or east/west sections (e.g., East and West Coast CONUS).

The Japanese company that manufactured the specially coated glass used to produce AODs discontinued their production in 1993. As a result, NRL negotiated a “last-time buy” contract with the U.S. AOD supplier (Honeywell) to procure enough AODs to support the F/A-18 and AV-8B programs until all AN/ASQ-196 systems have been retrofitted to TAMMAC. This contract has expired, and Honeywell no longer produces AODs. However, several procurement options on the NRL contract were never exercised, and Honeywell retains slightly more than 900 blank AODs still available for purchase (Table 1). AODs are proprietary (i.e., not producible by other companies) and out of production. Therefore, care must be taken to ensure that enough media is available to support aircraft operations for the life of the AN/ASQ-196.

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Table 1 — AODs Purchased under NRL "Last-Time Buy" Contract with Honeywell

Description		**#AODs**	
Last-time-buy allotment			5465
AODs purchased, to date:			
	U.S. F/A-18	3473	
	U.S. AV-8B	200	
	Finn F/A-18	384	
	Swiss F/A-18	200	
	Kuwait F/A-18	200	
	Malaysia F/A-18	64	
	Thailand F/A-18	25	
	Italian AV-8B	5	
Total purchased		4551	
Still available to purchase			***914***

DMU WRITERS

The DMU in an aircraft cannot write data to an AOD; an aircraft DMU can only read AODs. Specially prepared DMUs integrated with ground support systems write map theaters to AODs. These "DMU writers" are not nearly as reliable as their DMU reader counterparts. In 1994, the Naval Air Warfare Center (NAWC) in Indianapolis reported that DMU writers have a mean time between failures of less than 100 hours. While this failure rate appears to have improved somewhat over the past few years, a DMU writer failure can bring AOD production to a halt.

Honeywell is the original manufacturer of the proprietary DMUs and the sole supplier of DMU parts. Honeywell will repair a faulty DMU writer for approximately $12,000, with an estimated repair time of at least 90 days. In reality, it often takes many months for a DMU writer to be fixed, verified, and returned, due to the growing obsolescence of various DMU parts and the fact that Honeywell must cycle its DMU writers through both its Phoenix repair depot and Albuquerque to perform quality assurance. The longest reported repair time for a single DMU is nearly a year: NRL shipped a failed DMU to Honeywell in October 1998, and the repaired DMU was returned to NRL in June 1999. This repair schedule is not expected to improve as the DMUs continue to age and fail.

F/A-18 AOD USAGE/FAILURE RATES

The following AOD usage and failure rates are provided only for the U.S. F/A-18 program, because the usage statistics for the F/A-18 are considered to be the most reliable in the NRL AOD tracking database. This is because NRL is the sole provider of programmed F/A-18 AODs and the depot for all failed and destroyed F/A-18 AODs. Other platforms (e.g., the U.S. AV-8B and foreign aircraft platforms) program and distribute AODs at locations other than NRL. Therefore, those AODs are not tracked in the NRL database, other than their original purchase from Honeywell and initial distribution by NRL to the Fleet (Trenchard et al. 1998a).

Since early 1991, NRL has programmed 1512 F/A-18 AODs out of a total of 3672 listed in the NRL database. Of these 1512 AODs, 186 are considered unusable for various reasons: 123 were originally programmed, but failed in the field for some reason, 40 were broken or destroyed in the field, and 23 are a combination of AODs that were lost and those that are considered prototype or "scratch" disks. Given these figures, the AOD failure rate and average annual usage for all F/A-18 AODs over the past 9 years (1991 to 1999, inclusive) can be calculated as follows:

#AODs failed, lost, destroyed, etc.	= 186		
AOD failure rate* as % of all used AODs	= 186/1512	=	12.3 % failure*
Average annual usage (all expended AODs)	= 1512/ 9	=	168 disks used/year

** This failure rate includes destroyed and lost AODs, as well as AODs that failed in the field.*

These average usage and failure rates can be used to determine whether there will be sufficient AOD resources available to support the F/A-18 digital moving map systems until the transition from the AN/ASQ-196 to TAMMAC is complete (currently projected for the year 2010). Assuming these usage and failure rates remain relatively stable, and assuming F/A-18 does not purchase additional AODs, there will be an estimated 312 blank (unused) disks remaining in the F/A-18 stock by 2010:

Total F/A-18 AODs logged in database (assuming no new purchases)		=	3672
Est. #AODs expended from 1991 – 2010 (20 years)	= 20 * 168	=	3360
Est. remaining blank AODs by the end of 2010	= 3672 – 3360	=	312

Numerous factors can contribute to AOD failures, including degraded DMU writers, Fleet-use mishaps, and age/environmental degradation. Failures may occur at NRL (while writing to an AOD) or many months (or even years) later in the Fleet. Failed AODs that have been returned from the Fleet are typically older disks. In the past few years, NRL has successfully repaired and recycled 34 previously failed F/A-18 AODs. (These repaired and recycled AODs are not included in the failure rate shown above, since they are now considered useable.) Overall, however, a 12% failure rate can be expected to continue over the life of this project.

CAC PRODUCTION AND CURRENCY ISSUES

The Compressed Aeronautical Chart (CAC) is the source data for the AN/ASQ-196 (Ronish 1988; Lohrenz et al. 1998). The Map Data Formatting Facility (MDFF) at the Naval Research Laboratory (NRL Code 7440.1) developed the CAC database and processing system from 1989 to 1995 (Lohrenz and Ryan 1990; Myrick et al. 1998). In 1995, the NRL MDFF transitioned the CAC processing system to the National Imagery and Mapping Agency (NIMA).

Global or partial coverage of the CAC library currently exists for seven chart series and geographic scales (Table 2). Gaps in CAC coverage at the TPC and JOG-A (see the Acronym column in Table 2) series exist in some areas of the world, where source map information is scarce. In addition, there is sparse source map information (and, therefore, sparse CAC coverage) for both of the TLM series.

Table 2 — Chart Series and Scales in the CAC Database

Chart Series Name	**Acronym**	**Chart Scale:** M = million k = thousand
* Global Navigation Charts	GNC	1:5 M
Jet Navigation Charts	JNC	1:2 M
* Operational Navigational Charts	ONC	1:1 M
Tactical Pilotage Charts	TPC	1:500 k
Joint Operational Graphics (Air)	JOG-A	1:250 k
Tactical Line Maps	TLM-100	1:100 k
* Tactical Line Maps	TLM-50	1:50 k

* These series are not displayable in the current AN/ASQ-196 system.

From 1995 until 1998, NIMA produced and distributed new CAC editions on compact disk (CD) and updated previous CAC CDs. However, NIMA has not produced any new or updated CAC CDs in over a year. NIMA plans to outsource CAC processing back to NRL before the end of CY99, at which time NRL will once again be responsible for both CAC and AOD processing (for the F/A-18 program). The geographic areas of priority for updating CAC have not yet been determined.

Determining the need for up-to-date CAC information from an AOD perspective is difficult. Once an AOD is written, it cannot be overwritten. Therefore, it is impossible to update a *full* AOD with new or revised CAC coverage. Only partially written AODs can be appended with new CAC coverage. The processing steps involved in building a new map theater are as follows:

1. Define a map theater (i.e., geographic bounds and scales) on a map processing system.
2. Construct the map theater from the most current CAC sources available.
3. Archive the map theater to CD for building future AODs.

Once a map theater is archived to CD, the data comprising the theater is static. AODs are typically built directly from an archived map theater on CD, to ensure consistency among AODs in the Fleet. If new or updated CAC data later becomes available, a map theater must be reconstructed to incorporate the new data, although this is seldom done. While a map theater *definition* may be several years old, the currency of the map theater's data is determined by the date of the map theater's most recent archive to CD (assuming updated CAC data have been maintained on the map processing system). Therefore, CAC currency for a given AOD is determined by comparing the date on which the AOD was written with the most recent archival date (at the time of the AOD build) of its map theater.

Since AODs can only be appended (not overwritten), there is no way to update an existing AOD with newly updated map segments. If the currency of map data on AODs is or will become an issue, the only method to support this is by writing updated map theaters to new, replacement AODs. Since AODs are no longer in production, replacing all programmed AODs with AODs containing updated map data would not only be very costly, but could create a premature shortage of AODs. A more realistic approach would be to selectively update AODs as needed.

One possible method of quantifying the currency of CAC data on an AOD is to track how many times a Chart Update Manual (CHUM) has been released for the CAC data since the map theater was archived for the AOD in question. NIMA releases CHUM information in digital form (DCHUM) if the updated map information might impact flight safety. Therefore, the number of DCHUM releases for a given geographic area of interest would be a good indication of how out-of-date an AOD is, from a safety-of-flight perspective. This indicator, along with the military criticality of a given location, should be used to define appropriate and realistic CAC and AOD update schedules for the F/A-18 program. Similar measures could be taken to define CAC and AOD update schedules for the AV-8B program, as well as FMS programs, all of which have significantly fewer AOD resources than F/A-18.

SUMMARY

F/A-18 and AV-8B naval aircraft in the U.S. and abroad use an aging digital moving-map system that will be replaced by the TAMMAC system over the next 10 years. Until this transition is complete, care must be taken to balance two important goals:

(1) Guarantee the continued availability of media (i.e., AODs) to support the legacy map systems.
(2) Ensure flight safety by maintaining an up-to-date map (i.e., CAC) database.

In order to meet these goals, NRL recommends performing a detailed analysis of existing AODs (including the currency of the CAC data contained therein), future AOD requirements (as outlined in this report), currently available CAC data, and DCHUM releases to define a realistic and appropriate update schedule for the AODs and supporting CAC database.

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