NGA CASE NO. 04-204

AERONAUTICAL TRANSFORMATION: PAPER TO DIGITS CHANGING THE WAY THE NATIONAL GEOSPATIAL-INTELLIGENCE AGENCY CREATES AERONAUTICAL PRODUCTS

Charles L. (Chuck) McGaugh Jr.

June 25, 2004

NATIONAL GEOSPATIAL-INTELLIGENCE AGENCY

AERONAUTICAL TRANSFORMATION: PAPER TO DIGITS

CHANGING THE WAY THE NATIONAL GEOSPATIAL-INTELLIGENCE AGENCY CREATES AERONAUTICAL PRODUCTS

By: Charles L. (Chuck) McGaugh, Jr.
National Geospatial Intelligence Officer for Aeronautical Services
National Geospatial-Intelligence Agency (NGA)

ABSTRACT

Transformation of the Aeronautical Flight Information Publications (FLIP) and Navigation/Planning (Nav/Plan) Chart production process at the National Geospatial-Intelligence Agency (NGA) has been underway for the past two years. These efforts have culminated in the successful transition of the methodology to produce and maintain FLIP. The process by which the PLTS was modified to support the creation and maintenance of digital charts from NGA's aeronautical data holdings will be discussed. Additionally, the ongoing follow-on efforts to modify the PLTS to support the production and maintenance of NGA's FLIP Terminal procedures products and Nav/Plan charts are being worked as the 'next' and 'after next'. The resulting improvements in product quality and accuracy, labor efficiencies, and future applications of the new digital aeronautical data/products will be presented and demonstrated.

INTRODUCTION

Transformation involves “a major change in form, nature, or function,” as defined by Merriam Webster’s Collegiate Dictionary (tenth edition). Since early 2002, NGA has been undertaking a “makeover” in the way the Agency does business and supports customers in the near future. NGA is transforming from a “product centric” to a “data-centric” organization. In the words of NGA Director retired Air Force Lt. Gen. James R. Clapper Jr., the transformed NGA—as a data centric organization—will “provide customers instant access to specific geospatial intelligence.” One piece of this transformation is the way Flight Information Publications (FLIP) are produced and disseminated to customers. The development of capabilities such as ESRI’s Production Line Tool Set – Aero (PLTS – Aero) is an example of a piece of the successful transformation efforts underway at NGA.

In order to understand the transformation that PLTS – Aero has brought to NGA, a familiarity with the history of Flight Information Publications and aeronautical data is of the essence. Powered flight began a short 100 years ago. Computers have only been around for the past fifty years and desktop computing has been in existence about half of that. The methods whereby aeronautical information is compiled and transmitted to the users have just recently begun to evolve. With the advent of extremely fast, relatively inexpensive, personal computers and large amounts of local storage, the methods to create, publish and distribute of Flight Information Publications is on the verge of being revolutionized.

THE HISTORY OF AERONAUTICAL CHARTING

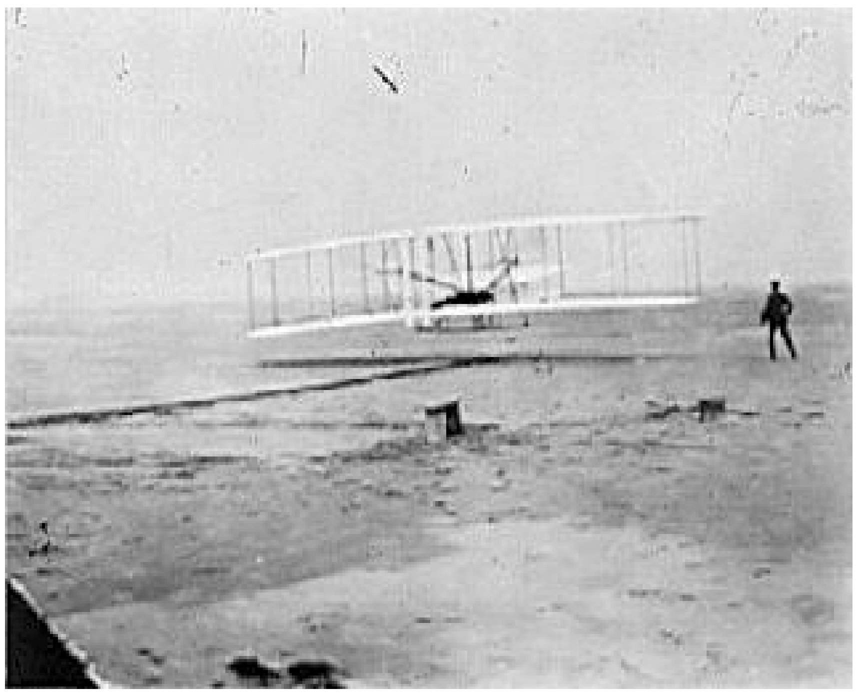

Figure 1: The Wright Brothers First Flight. (Picture courtesy of Library of Congress, Prints & Photographs Division, LC-USZ62-6166-A)

Shortly after the Wright brothers made their historic first flights, the skies began to fill with aircraft. At first, these aircraft were limited to short flights in clear weather due to the hazards to navigation. Aircraft used transportation routes to navigate by, even flying low to the railroads during reduced visibility, coining the phrase "hugging the UP" in reference to the Union Pacific lines. Early pilots began making personal notes to help them navigate to and land at increasingly distant airports. In fact, selling these notes to other pilots was the beginning of what would become an aeronautical information corporation for Elrey Jeppesen. But even with the best information and charts, air travel was still limited by visibility. In the 1930's, radio technology got a foothold in aeronautical navigation, providing pilots with the ability to navigate farther distances through unfamiliar surroundings, even in reduced visibility. In 1941, the first instrument approach and landing charts were developed, serving pilots with the need to land in low visibility.

By this time, aviation was already a matter of interest outside the United States as well. Aviation navigation was a subject at the Paris Peace Conference of 1919 and it was led by a special aeronautical commission, which had its origin in the Inter-Allied Aviation Committee created in 1917. At the same time, civil air transport enterprises were created in many European States and in North America, some of which were already engaged in international operations (Paris-London, Paris-Brussels). Many organizations, in groups and individually began drafting standards for aviation related maps, charts, and information.

During World War II, the demand for charts increased dramatically. By 1943, production had increased from around 500,000 per year to over 11 million. The Army and Navy Air Forces each built their own custom charts to fit their wartime needs. By the end of the war, it was clear that standardized products and symbology were needed to support international air travel. It was for this reason that, in 1943, the US initiated studies of post-war civil aviation problems, which, once more, confirmed the belief that they were to be tackled on an international scale. As President Roosevelt put it, economic development of the world and "healing the wounds of war" depended on this international solution.

The following years saw the establishment and maturity of many of the aeronautical and aviation related agencies and associations that we see today. The Federal Aviation Administration (FAA), which began supporting civil aviation in the US in 1926, became a global voice. The International Civil Aviation Organization (ICAO), a specialized agency of the United Nations, was mandated to ensure the safe, efficient, and orderly evolution of international civil aviation. Today, these organizations and others drive the look and feel of aviation products worldwide. In addition to the physical characteristics, these organizations have mandated an update cycle, ensuring that all aircraft are flying on the same data. Depending on the region of the world, this cycle is effective every 28 days or multiples of 28 days.

It is easy to see how a map of the world's airports and airways, updated every 28 days, and limited by international standards can become a huge challenge. This challenge is the mission of NGA's Aeronautical Division. The products generated by this division are the Flight Information Publications (FLIP). The process of producing these FLIP global charts required a large staff of aeronautical analysts, quality assurance specialists, and contractor (negative maintenance) personnel. Significant effort and expertise was required for chart maintenance. The United States Department of Defense relies solely on NGA's

Aeronautical Division for the provision of these products. Without delivery of them every 28 days, the U.S. Military could not execute their flying missions.

Figure 2: An Example Of An Enroute Chart

In the manual "negative maintenance" process, the geographic area analysts used drafting tools to create chart overlay lithographs to meet precise standards. For less complex chart changes, the analyst crafted textually descriptive directions called Data Abstracts using detailed format standards. Due to the complexity of the work and technical writing involved, all information received a second level review by quality assurance specialists to insure the information going to the contractor met standards and was similar across all overlapping charts. The contractor used the Data Abstract information and/or the hand drawn lithographs to create sticky-backed strip waxing film overlays for text and/or graphic symbols. Each change was applied manually by scraping off old annotations and graphics and replacing with the modification for the master versions of each chart. With over 1000 changes per month, this tedious process required great skill. Each of the four colors used on charts required a separate master layer and screened colors required additional layers. The stick-up master charts were then used as the positive in a photo process to create negatives for each layer for every chart. In the busiest cycle, the negative maintenance contractor produced over 145 charts with an average of six layers each. Accuracy was imperative to ensure the layers merged to form the completed Enroute Chart when printed.

With so many changes and the possibility of human error at many stages of production, consistent quality required great effort. Review and rework prior to publication expended many work hours, and required substantial lead-time to ensure the charts were finished before the next cycle began.

The next most logical chapter in this story would be how technology has changed this unbelievably difficult process over the past decades. Surprisingly though, this methodology, discussed above, describes the work of NGA in this business area until a little over a year ago.

STICK-UP: THE ELEMENT OF CHANGE

Strip waxing film, better known as stick-up, was the weak link in the chain that finally started the transformation need. While the GIS/Mapping community might have been ready to support this process long before, it took a stick-up crisis in 2002 to force a change. The world's only manufacturer stopped producing the stick-up material, and a new supplier could not be found. All remaining stock was purchased, but the clock started ticking. There were no suitable substitutes for the strip waxing film. A new method for correcting the charts had to be found, before all the stick-up was gone.

A GIS solution was an obvious choice, but there were many obstacles. The biggest obstacle, as it is in any GIS project, was the lack of data. An aeronautical database did exist, it was kept current, and the attribution was robust. The data quality was exceptional but there was one big problem. The data was not geospatial.

ENTER ESRI

NGA's Aeronautical Division turned to ESRI for help in solving this critical problem. NGA aeronautical analysts shared their knowledge of navigation and the ESRI engineers shared their knowledge of GIS solutions. The two groups didn't always speak the same language, but with a singular goal in mind, soon became partners in the mission.

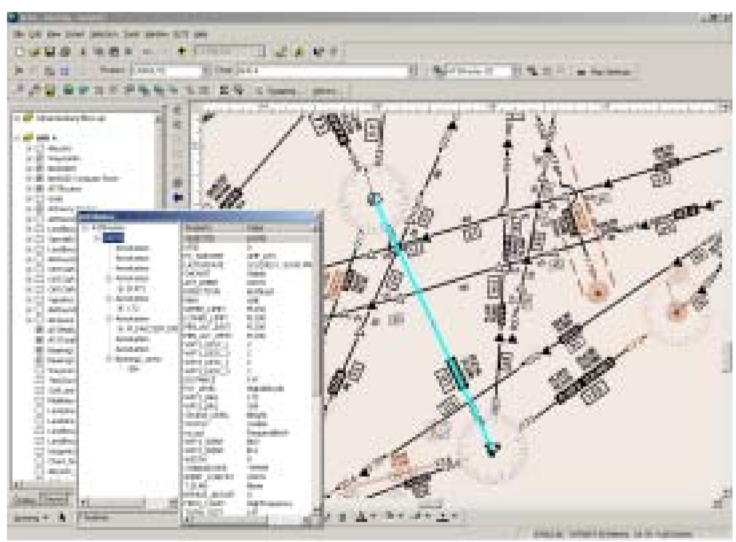

Figure 3: An Enroute Chart Being Created From NGA's Aeronautical Data By ESRI's PLTS-Aero Application

For the past two years, NGA and ESRI have worked on an ambitious program to overcome technology hurdles and create a completely GIS-based aeronautical charting process to produce the NGA standard aeronautical charting products. The foundation of the approach is the geodatabase. With the collaborative effort of NGA and ESRI teams, additional fields were identified to support digital chart production. The NGA aeronautical database was imported into an ESRI ArcSDE geodatabase and data was pre-formatted for charts during the data ingest. On a weekly basis, NGA provides database updates and these transactions are loaded into the geodatabase that has been optimized for cartographic output. The process to load the geodatabase and provide updates is simple and quick. NGA runs a SYBASE compare function to identify adds, changes, and deletes and forwards them to ESRI's server via FTP. Quality is ensured through several steps: incoming data is assessed against rule sets, an automated quality control (QC) is provided via batch checks for attribution and spatial checks, and an actual visual inspection of data is performed to validate cartographic placement, symbol density, and assure proper symbol/data orientation. ESRI has even employed PSTracker, a web based scheduling tool that allows for monitoring of job progress, to track every chart in every phase of production and NGA has an on-line link to monitor the contractor's progress. Government and Contractor collaboration has been a key element to the success of this effort.

A web based Problem and Resolution (PAR) database serves as the medium to document discussions between NGA and ESRI and facilitates decision-making. The PAR database is retained as a knowledge base for guidance. Several hundred items,

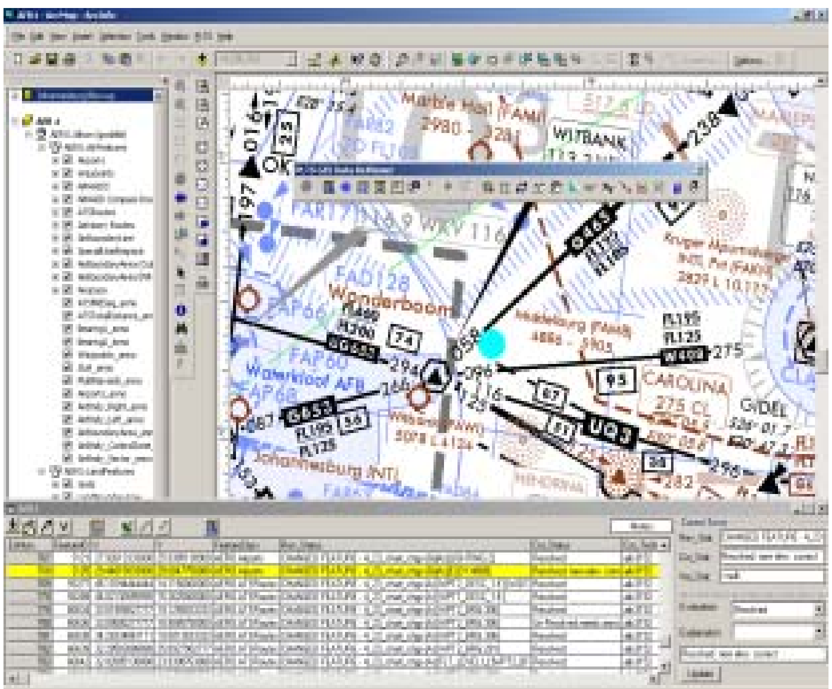

Figure 4: ESRI's PLTS Reviewer Drives Aeronautical GIS Analysts To Recent Data Changes

which were not covered by Enroute chart specifications, have been documented during initial production period utilizing this concept.

Using this world aeronautical geodatabase foundation, ESRI Aeronautical GIS Analysts are able to produce charts of any scale, orientation, and projection in addition to the standard NGA series of aeronautical charts. Charts are produced using a combination of ESRI Arc Map 8.3, Production Line Tool Sets (PLTS), and Maplex Label Extensions. The PLTS Map Production System manages the chart series design and incorporates intelligent elements that are automatically updated based on the content with the geodatabase.

Because the software is based on a geodatabase, update management is many times more efficient than in traditional manual chart production. One-time data entry allows for greater accuracy by eliminating the possibility of errors in the production chain. When a feature update is transferred from the NGA database to the ESRI geodatabase, the change is automatically and immediately reflected on all associated charts. Text associated with modified features is automatically updated as well, using feature-linked annotation capability.

As a direct result, quality has improved. The automatic update workflow translates into less manual effort and removes the possibility of error propagation as the data is never re-typed after it is entered into the NGA Aero database. With feature-linked annotation in place, Aeronautical GIS Analysts only need to visit changes to confirm the automated software solution for placement of the change. The workflow process has built-in quality provisions and includes the use of the PLTS ReViewer components to drive to change locations for quick QC and verification / tracking.

Nearly two years after beginning this journey, all 147 NGA FLIP Enroute Charts will have been converted via this process by the end of 2004. Countless numbers of errors have been eliminated and product quality has been elevated. NGA continues to deliver millions of Enroute Charts to aviators every 28 days without delay and the output product is so similar to the manually prepared DoD charts that customers never noticed. But most importantly, the digital Enroute Chart process supports the direct-to-plate printing, completely eliminating the need for stick-up.

SUCCESS SPAWNS IDEAS FOR THE FUTURE

While FLIP Enroute Charts were a problem that had to be solved quickly, the process of transformation opened eyes to evaluate other products. The Aeronautical Division has an entire family of products, each critical to flight safety and each unique. The success of the Enroute Charts program has led the division to examine each of the other products. The FLIP Terminal products, a line of large-scale books that provide information about the terminal (or landing) phase of flight will be the next to be transformed. Based upon the successful work with the Enroute Charts, the Navigation/Planning Charts seem to be a candidate as well. Already, prototypes are being developed that appear to be quite promising. Because aeronautical products have this long history of global standardization and regulations, each has its own unique issues. But the collaboration of GIS professionals, ESRI tools, and the aeronautical expertise of NGA analysts have made this transformation a certain success. The next two sections will discuss some of the results from these two prototype initiatives.

TERMINALS

The act of flight can be divided into three phases: Planning, Enroute, and Terminal. Planning covers determining where the flight will occur and the necessary provisions that must be accounted for before committing to the flight. Specific products used in planning are the Navigation/Planning Charts. The technology associated with these charts will be discussed in a later section of this paper. The enroute phase covers the period or travel from one airport to another. The products used in the enroute phase were discussed previously in this paper. The Terminal phase covers the takeoff or landing aspects of flight, considered to be most critical phase of flight operations. The above figure shows a standard terminal procedure. The diagram on the right side of the figure was generated by hand based upon data that is read by an analyst from the NGA aeronautical database. The diagram on the left side of the figure was a prototype

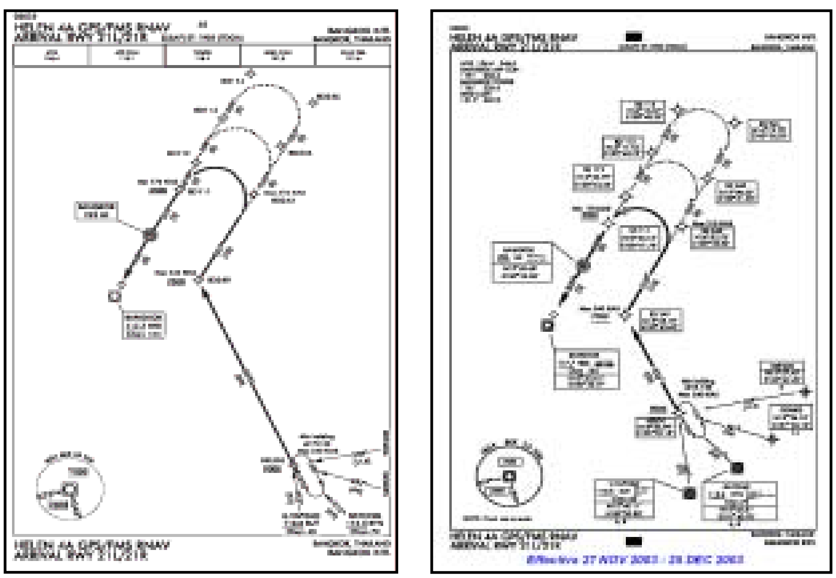

Figure 5: Examples Of Terminal Procedures: The Diagram On The Left Is A Procedure Generated Automatically, Right Is A Procedure Generated By Hand.

that was created directly from the database using the PLTS-Aero. Modifications have been made to the basic PLTS-Aero application to provide capability for the creation on the FLIP Terminal products. This application of software to a database was a logical extension of the technology used to generate the Enroute Charts as described previously. A second phase of this project is required to formalize and optimize the changes to the PLTS-Aero before is can be used for production, however the initial results look very promising. The movement by NGA from creating the Terminal Products by hand or by digitization to a process that creates the products automatically from the database moves the aeronautical capabilities one step closer to the Agency Director's vision of a data-centric organization versus a product centric organization.

NAVIGATION/PLANNING CHARTS

Navigation Planning Charts are a series of maps produced by NGA to provide geospatial information to military aircrews. The NAV/PLAN series of charts consist of the following types and scales:

Series	Name	Scale
GNC	Global Navigation Chart	1: 5,000,000
JNC	Jet Navigation Chart	1: 2,000,000
ONC	Operational Navigation Chart	1:1,000,000
TPC	Tactical Pilotage Chart	1:500,000
JOG	Joint Operations Graphic	1:250,000

Figure 6: An example of an Operational Navigation Chart (ONC). Note the Caution, Air Information Currency

DoD aircrews utilize Navigation/Planning Charts, commonly referred to as NAV/PLAN Charts, to accomplish assigned missions. The DoD mission planners also utilize the charts during the planning phase of flight operations. In the 1990's the National Geospatial-Intelligence Agency (NGA) developed a raster digital format of these charts called Compressed Arc Digitized raster Graphics (CADRG). This digital, geographically referenced format allows for the NAV/PLAN charts to be used in numerous applications requiring digital data. Current uses consist of digital flight planning systems, situational awareness for unmanned vehicles, on-board flight tracking systems and Electronic Kneeboard, for real time situational awareness in the cockpit.

When conceived in the 1950's and 1960's, the intention was to keep NAV/PLAN charts current with an aggressive production program. As time progressed, more and more of the charts became increasingly labor intensive to maintain due to the number of revisions generated by increasing amounts of geospatial sources. Changes to these charts result largely from the aeronautical

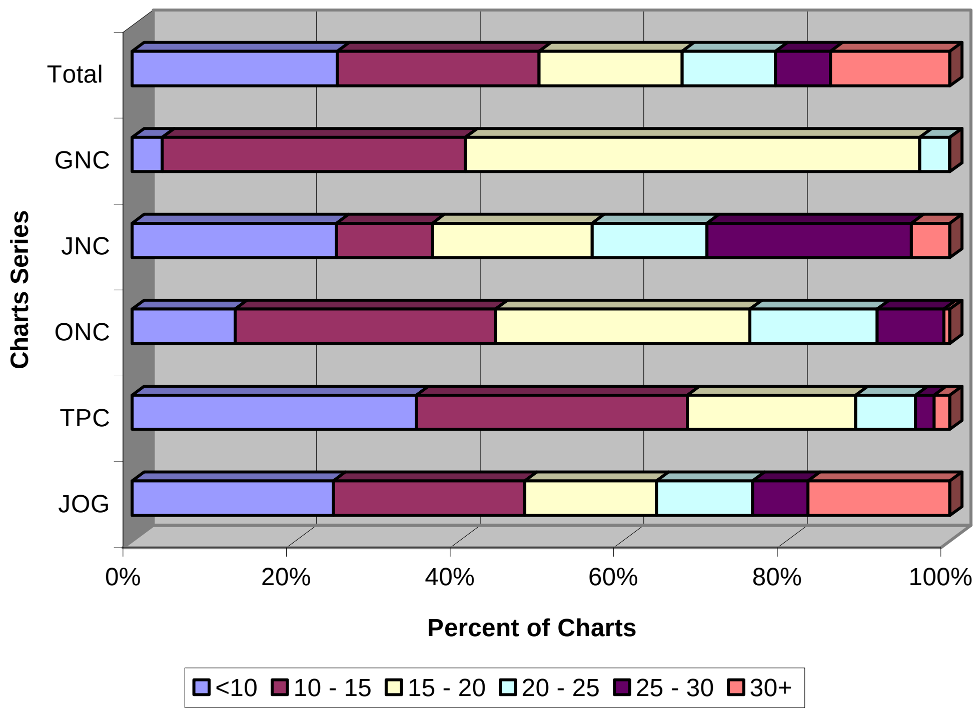

Figure 7: Current Age of NGA's Navigation Planning Charts as of March 2004. Age represents Air Date of Chart. Base information date is either the same or (usually) much older.

and obstruction information. The base information (roads, contours, elevations, etc.), cause changes as well, but to a lesser degree. Eventually the charts began to be produced with updated aeronautical information over the older base information. The current charts have one date for the base information and one date for the Aeronautical Information, commonly referred to as the Aeronautical Currency Date of the chart. The aeronautical currency dates of most charts are significantly later that the base information dates. Due to a prioritization of resources these updates to the NAV/PLAN charts became less frequent thus resulting in the aging problem with the charts. The graph depicts the age of the NAV/PLAN charts. The average age of the 6166 charts is over fifteen years old.

To mitigate the problem of the charts becoming outdated, NGA created the Chart Update Manual (CHUM). CHUM provided the capability for NGA to publish changes to the charts on a periodic basis without reprinting the charts. CHUM is a list of additions, modifications and deletions required to make an existing version of a chart current. Every month a CHUM publication is released defining the changes to the entire set of charts in the NAV/PLAN series. Every month chart users are required to "pencil in" the changes listed in the CHUM product to their copy of the NAV/PLAN charts in order to maintain their currency. The digitized version of the charts (CADRG) is a scanned version of the latest version of the hardcopy charts. Changes since the chart was scanned could not be made via the "pencil in" method so a digital version of the CHUM called Digital CHUM or DCHUM was created. The DCHUM resolves the issue of keeping the CADRG products up to date. The method used to apply the DCHUM changes to the digital map file causes a symbol (either obstruction or airfield or other change) to be overlaid on the digital map. In the case of a modification or deletion, crosshatches are utilized to remove items that are in the original map print. As the focus of efforts within NGA has been shifted over the years, the reliance upon CHUM and DCHUM has increased and the revisions to

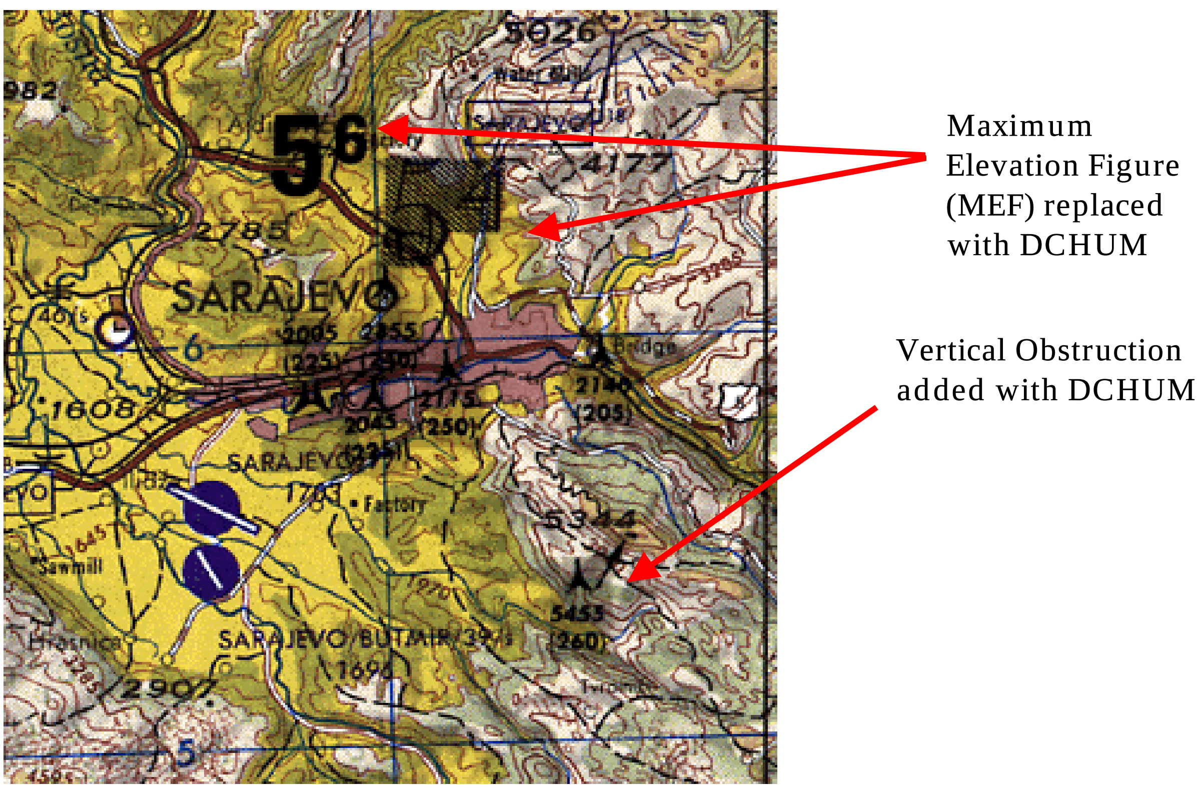

Figure 8: An example of CADRG with DCHUM applied. Notice the smudged areas near the Vertical Obstructions that were added. Also note the Maximum Elevation Figure (MEF) that has been replaced with DCHUM as well.

In the late 1990's a major change occurred to the method that vertical obstructions are collected, analyzed and processed. The systems utilized for the processing of obstructions were migrated from a mainframe UNISYS computer that required analysts to input features and attributes by hand in a command line fashion. The entries were typed in an "IBM punch card format", eighty characters per line, three lines per feature. The quantity of vertical obstructions in the "UNISYS" database at the time the migration took place (circa 1999) was around 250,000 points. The new system referred to as the Aeronautical Obstacle Environment, provided the obstruction analyst the ability to graphically display and attribute added, modified and deleted points and was expanded to accommodate lines and areas as well. Another important capability that the new system provided was the ability to utilize a database rule set and processes to automatically ingest points, lines and areas with little or no interaction by an analyst as long as the incoming data satisfies strict quality and format standards defined by database rule sets. With these capabilities the VO data holdings at NGA have grown to over 5 million points and lines as of May 2004. As a result, the CHUM product has grown to three 500-page volumes and the DCHUM has become so intense on some charts that little base information can be recognized due to overlapping features. The drastic increase in the number of obstructions plus the infrequent update to the NAV/PLAN charts has created a critical issue with the utility of these products.

Because of the success of the Enroute Chart production efforts as discussed previously in this paper, the NGA and ESRI teams collaborated to develop a concept and prototype

Figure 9: Maps On Demand User Interface Prototype

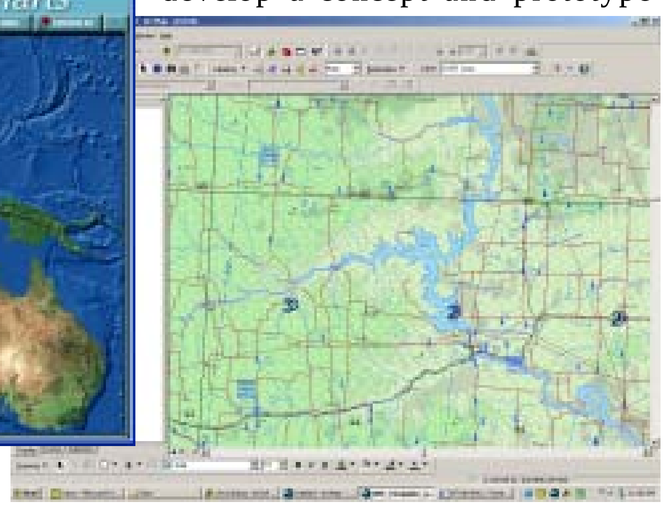

Figure 10: Creation Of A Chart Using Maps On Demand

to produce NAV/PLAN charts from traditional NGA database and data sources. These sources consisted of base map information (from VMAP level 0 and 1), Aeronautical data (from DAFIF™), Vertical Obstruction information (from the DVOF) and terrain information (from DTED®). Also included were scale specific rule sets that governed the amount of information to be displayed at the specific scales required to be displayed. These datasets were fused together with new features within the PLTS-Aero application and a web interface was added for user interaction. The prototype of this functionality demonstrated two different NAV/PLAN chart scales. The Operational Navigation Chart (ONC) at 1:1M and the Tactical Pilotage Chart (TPC) at 1:500K were representative examples that would prove the technology. The web interface allowed user interaction for the creation and download of a map situated at any location a user desires. The map is created from the latest published information, thus it is as CURRENT as the data holdings that NGA has to offer.

A second phase of the concept is currently being defined. The extension of these efforts will include the production of all NAV PLAN scales and chart types as well as extracting the data from geospatial databases within NGA as opposed to geospatial products. Eventually this concept, referred to as “Maps on Demand”, will be connected to the NGA’s Geospatial-Intelligence Knowledgebase (GKB) containing the latest and greatest NGA geospatial information. The user will be able to create and order every standard NAV/PLAN chart product or create custom charts centered at the users coordinate. This function alone can solve an age-old issue; “Why is every war fought at the four corners where the chart meets?” The user is also envisioned to be able to select the specific format for the chart output (e.g. PDF, CADRG, GEOTIFF, etc.). The requirement for CHUM and DCHUM becomes unnecessary once the Maps on Demand concept is implemented.

The Maps on Demand concept is another example of NGA moving from a product centric enterprise to a data centric enterprise. NGA acknowledges that its customers will require the existing products for the foreseeable future; however resources within NGA will be able to spend more of their valuable time on the evaluation, collection and analysis of data while applications like the PLTS-Aero and Maps on Demand provide the product generation capability.

Figure 11: An Example Of A Chart Created By The Maps On Demand Process

CONCLUSION

The NGA Aeronautical Division has survived for decades, operating in an environment that utilized traditional cartographic skills, analysis, and a tremendous depth of aeronautical knowledge. Our processes included redundant operations, multiple instances of the same feature data and massive inefficiencies. As a result, data integrity and quality control were compromised, often without our realization. It was only through the dedication and hard work of NGA employees that we did not compromise the safety of our customers.

A large percentage of energy was focused on the format and appearance of products, rather than the depth of knowledge behind the data. Through this collaborative effort our eyes were opened to a new way of doing business, and our processes were transformed. Today, analysts devote their energy to creating and maintaining quality aeronautical information. Technology then transforms that quality data into a representation that the customer can utilize. Everyone does what he or she does best, and the customer receives a product so much like the original, they never notice the difference.

But the story doesn't end there. Not only did this solution provide the legacy products, it has provided the solution to an entire new world of products never available before. Because the old methodology was so cumbersome, requests to change a legacy product were very costly and required considerable time to implement. Today, customers have a variety of options, from various digital formats, to various printing options. When digital heads-up displays and electronic kneeboards are ready for the cockpit, the data will be ready to support it. And now that the data has been transformed into geospatially-referenced digits, the data can be fused with other information for additional analysis, portrayals and applications that have yet to be conceived. Utilizing the geospatial knowledge of our contracted experts, the aeronautical expertise of our NGA analysts, and the power of GIS, even the sky is no longer the limit.

REFERENCES

NIMA Public Affairs Office. "What's The Transformation All About?" NIMA Pathfinder Jan/Feb 2003: Pages 8-9

History of Civil Aviation. International Civil Aviation Organization. 4 June 2004 <http://www.icao.int>

The History of Jeppesen. Jeppesen Sanderson Inc. 4 June 2004 <http://www.jeppesen.com>

AUTHOR INFORMATION

Charles L. (Chuck) McGaugh, Jr.
National Geospatial Intelligence Officer for Aeronautical Services
National Geospatial-Intelligence Agency (NGA)
Analysis and Production Directorate
Office of Global Navigation (PV)

Office of Corporate Relations
Public Affairs
4600 Sangamore Road
Bethesda, MD 20816-5003

CHARLES "Chuck" L. MCGAUGH JR.

Mr. McGaugh initiated his federal career as a U.S. Marine Corp navigator aboard KC-130/P-3 aircraft. His USMC tour of duty lasted from 1975 through 1979 and took him around the world supporting aerial refueling operations for USMC and USN aircraft. This navigation experience provided the aviation skills necessary to become an Aeronautical Analyst for the Defense Mapping Agency (DMA) in 1980. Mr. McGaugh performed in a variety of production roles to include compilation of Navigation and Planning Charts and aeronautical analysis in support of digital aeronautical intelligence products. He also served in a variety of staff and supervisory positions throughout the aeronautical production process. Mr. McGaugh led the transition from legacy aeronautical production to a softcopy environment within the DMA Digital Production Systems (DPS).

In 1995, Mr. McGaugh moved to the Acquisition and Technology business unit. There he led a re-engineering effort focused on the migration of the aeronautical systems and processes to a primarily Commercial Off-the-Shelf (COTS) production platform. Mr. McGaugh also performed as the Contract Officer Representative (COR) for the Aeronautical Migration Systems (AMS) development. In 1998, Mr. McGaugh was reassigned as an acquisition Program Manager (PM) and led a team of CORs responsible for a variety of exploitation production systems. His responsibilities included the Front End Processing Environment (FPE), SEG 18, AMS, and the Target Management System (TMS). He was also responsible for the imagery and geospatial exploitation tools that included RULER, MET, JTW, and JMTK.

In 2000, Mr. McGaugh transitioned back to geospatial activities as the Branch Chief responsible for the geospatial production contracts in the Commercial Partnerships Division. He was responsible for financing, contract management execution, and the commercial industry that supports the out-sourced production of geospatial data and products. In December 2002, Mr. McGaugh became the National Geospatial Intelligence Officer for Aeronautical Services as a Defense Intelligence Senior Leader (DISL). His mission is to further the technology of the Agency in meeting emerging aeronautical requirements from the military and intelligence communities. He is also influential in tradecraft development for the Aeronautical Analysis workforce.

Mr. McGaugh completed the USAF Air Command and Staff College at Maxwell AFB, Montgomery, AL in 1988. His acquisition education includes Defense Acquisition Workforce Improvement Act (DAWIA), Level II certification in the disciplines of *Program Management* and *Manufacturing, Production, and Quality Assurance*. He is a certified acquisition professional and a member of the DOD Acquisition Corp. Mr. McGaugh is currently working towards his Masters in Business Administration (MBA) from St. Louis University.

(current as of April 2004)