

July 2013

Aeronautical

GIS Best Practices

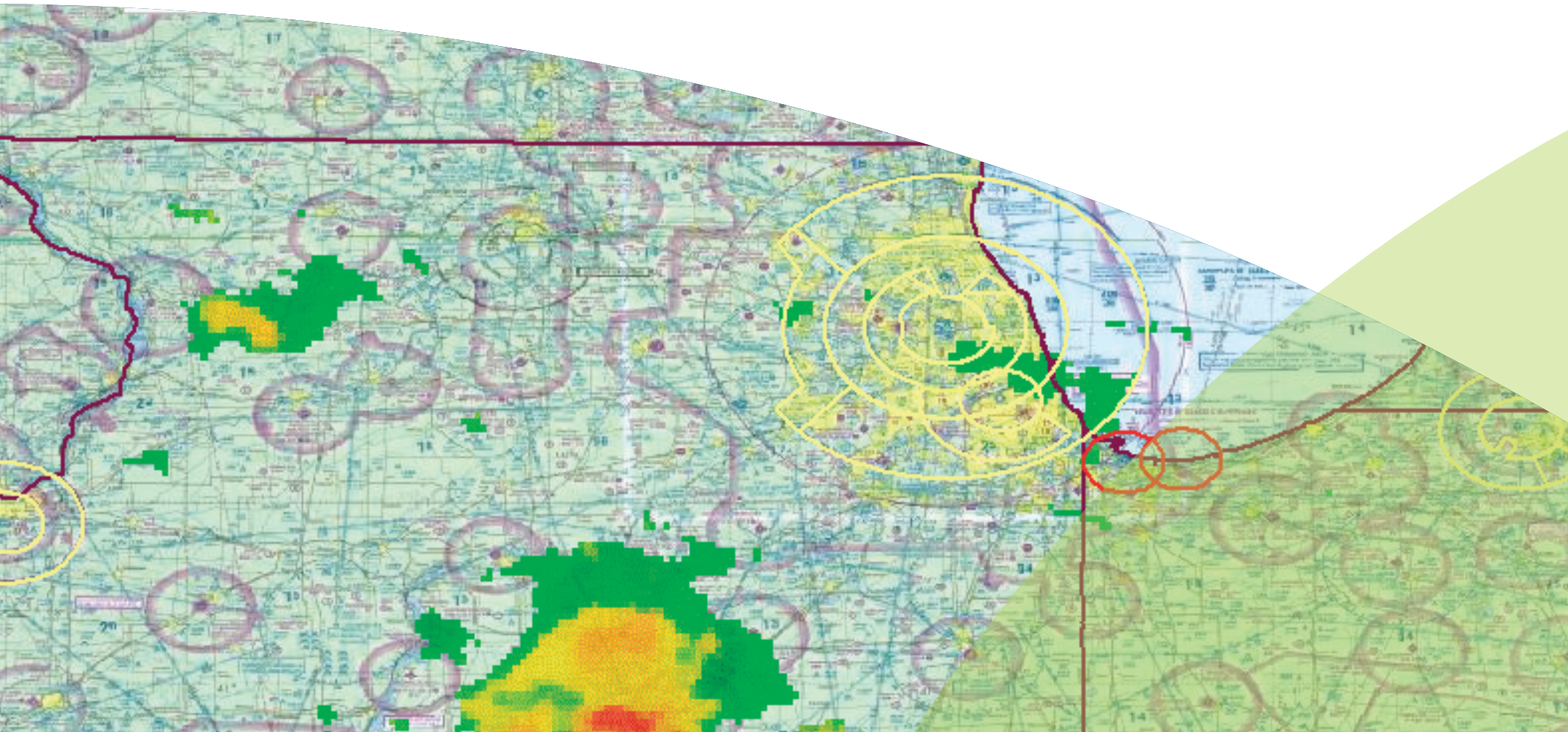


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What Is GIS?

Making decisions based on geography is basic to human thinking. Where shall we go, what will it be like, and what shall we do when we get there are applied to the simple event of going to the store or to the major event of launching a bathysphere into the ocean's depths. By understanding geography and people's relationship to location, we can make informed decisions about the way we live on our planet. A geographic information system (GIS) is a technological tool for comprehending geography and making intelligent decisions.

GIS organizes geographic data so that a person reading a map can select data necessary for a specific project or task. A thematic map has a table of contents that allows the reader to add layers of information to a basemap of real-world locations. For example, a social analyst might use the basemap of Eugene, Oregon, and select datasets from the U.S. Census Bureau to add data layers to a map that shows residents' education levels, ages, and employment status. With an ability to combine a variety of datasets in an infinite number of ways, GIS is a useful tool for nearly every field of knowledge from archaeology to zoology.

A good GIS program is able to process geographic data from a variety of sources and integrate it into a map project. Many

countries have an abundance of geographic data for analysis, and governments often make GIS datasets publicly available. Map file databases often come included with GIS packages; others can be obtained from both commercial vendors and government agencies. Some data is gathered in the field by global positioning units that attach a location coordinate (latitude and longitude) to a feature such as a pump station.

GIS maps are interactive. On the computer screen, map users can scan a GIS map in any direction, zoom in or out, and change the nature of the information contained in the map. They can choose whether to see the roads, how many roads to see, and how roads should be depicted. Then they can select what other items they wish to view alongside these roads such as storm drains, gas lines, rare plants, or hospitals. Some GIS programs are designed to perform sophisticated calculations for tracking storms or predicting erosion patterns. GIS applications can be embedded into common activities such as verifying an address.

From routinely performing work-related tasks to scientifically exploring the complexities of our world, GIS gives people the geographic advantage to become more productive, more aware, and more responsive citizens of planet Earth.

GIS for Aeronautical Organizations

Civil and military organizations must create and maintain digital aeronautical datasets and produce high-quality, database-driven charts that meet their unique specifications. GIS can help these agencies maintain, control, and disseminate data that meets their rigorous requirements.

With GIS, aeronautical organizations can

- Create, visualize, analyze, and disseminate critical data from Aeronautical Information Systems (AIS).
- Automatically update charts through the AIS to reduce data latency, redundancy, and errors.
- Produce a wide range of charting products, including International Civil Aviation Organization (ICAO)-compliant charts, from a central database.
- Share data using the Aeronautical Information Exchange Model (AIXM).
- Efficiently generate aeronautical charts for route planning, in-flight navigation, and takeoff and landing.

The International Civil Aviation Organization— Headquarters Montreal

Improves Air Navigation Planning Workflow and Data Management

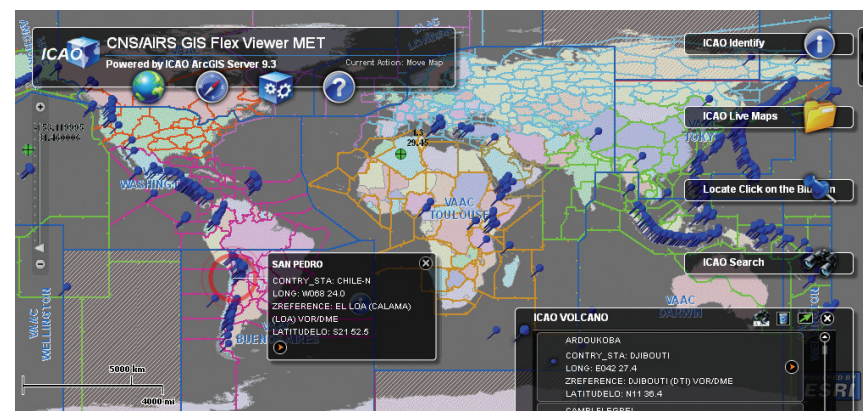
Challenge To ensure continued safety of airways, aviation authority needed to shift from static tabular data to an interactive GIS portal.

- Results**
- Implemented GIS portal hosting global data for local ICAO users
 - Developed processes to support coordination between state and international organizations
 - Increased frequency of data updates
 - Improved daily organization of work

“ArcGIS Server provides the platform for ICAO to develop more robust, user-friendly, and secure enterprise GIS applications.”

—Gilbert Lasnier, GIS Services Manager, ICAO

The International Civil Aviation Organization (ICAO) is a specialized agency of the United Nations (UN). It serves as a global forum for member states to work together toward the safe, secure, and sustainable development of civil aviation.



The global aeronautical community can access ICAO GIS information via the Internet using ArcGIS.

ICAO works in close cooperation with other members of the UN, including the World Meteorological Organization, the International Telecommunications Union, the Universal Postal Union, the World Health Organization, and the International Maritime Organization. Nongovernmental organizations also participate with ICAO and include the International Air Transport Association, the Airports Council International, the International Federation of Air Line Pilots' Associations, and the International Council of Aircraft Owner and Pilot Associations.

The Challenge

Visualizing aviation data, such as major air traffic flows, regional air navigation plans, and other regional data is important to ICAO staff in order for them to ensure safe air travel. ICAO staff did not have an efficient way to see this data, relying on unsophisticated methods to organize their work and visualize data, which meant that information was not updated in a timely fashion. ICAO recognized the need for a better process that would allow data to be updated more frequently and efficiently, ensuring quality control of the data and ultimately safety of lives and property.

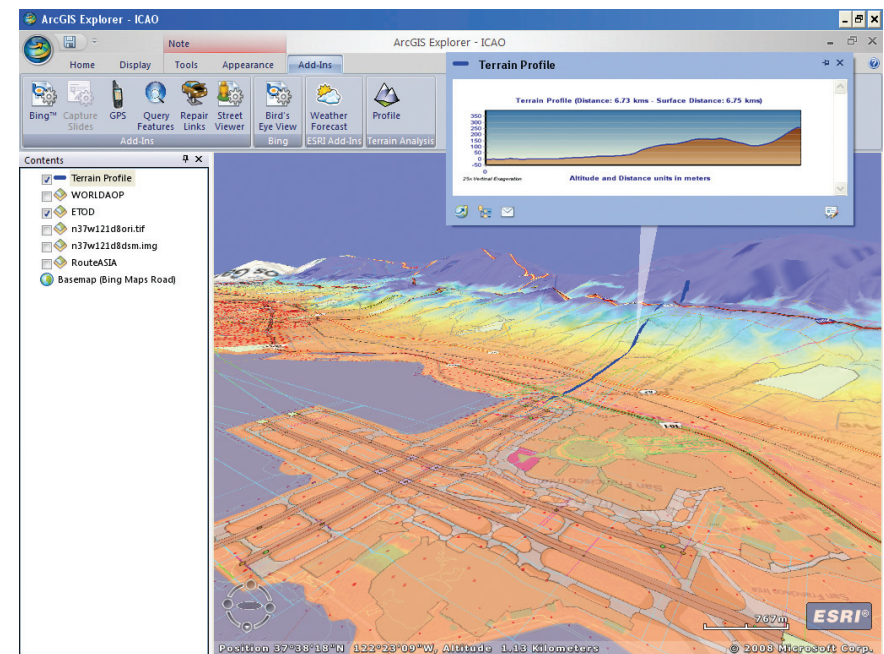
The Solution

In 2003, the Eleventh Air Navigation Conference (AN-Conf/11) recommended that ICAO develop a database containing all tabular material from ICAO regional air navigation plans together with major traffic flows and other regional data to achieve this goal. The database, along with all associated charts, would be made available through the Web. To meet these objectives, the organization had to make management of updates easier and allow more staff members within the ICAO community to access data. Esri's ArcGIS Server, a server-based geographic information system (GIS) solution with client access via the Web, was chosen to meet ICAO's needs.

The ICAO electronic Air Navigation Planning [eANP] GIS portal is a gateway combining a database and Internet-based GIS

technology allowing authorized users to submit, store, update, manipulate, analyze, and chart global air navigation planning data from a centralized ICAO server.

Phase one of eANP was deployed in fall 2008 and makes the ICAO Global Air Navigation Plan (GANP) database available to many users: states, the ICAO Council, ICAO staff at headquarters and in the field, regional planning and implementation groups, aviation partners, other UN agencies, civil aviation entities, and



eANP allows authorized users to submit, store, update, manipulate, analyze, and chart global air navigation planning data from a centralized ICAO server using ArcGIS.

the public. Users access the GIS portal via the Internet to browse data directly using a variety of clients depending on the use of the application, including Microsoft Internet Explorer, Esri ArcGIS Explorer, or ArcGIS desktop clients.

Essentially, eANP displays dynamic, interactive charts. Users are now able to perform many different functions besides viewing the data. They can create and view what-if scenarios of new routes, chart traffic flow information with other user-selected criteria, and update the data. Users can “fly” 3D electronic Terrain and Obstacle Databases (eTOD) in ArcGIS Explorer.

Global air navigation plans available in the GIS portal include Air Traffic Safety charts (ATSAnp), Flight Information Region charts (FIRAnp), Air Traffic Management charts (ATM), Aerodrome Operational Planning (AOP) satellite images, regional charts, and many other thematic maps. The GIS portal can be accessed online at <http://192.206.28.81/eganp/>.

Results

The GIS portal’s interactive maps are gradually replacing the air navigation plans that are now delivered on paper. This is beneficial to ICAO, as the data accessed via eANP is up-to-date and accurate, making it a more reliable means of navigation. Through eANP, air navigation systems are being implemented more efficiently at the national, regional, interregional, and global levels. EANP is beneficial for planning and analysis of planned

facilities status and services that need to be included in regional air navigation plans. Planning and implementation groups are able to take the information and expedite plans according to ICAO priorities “Having this information available online greatly facilitates updating and accessing the latest information for states, ICAO regional offices, and other users,” says Lasnier.

(Reprinted from the 2009 Esri case study)

Tiles on a Cloud

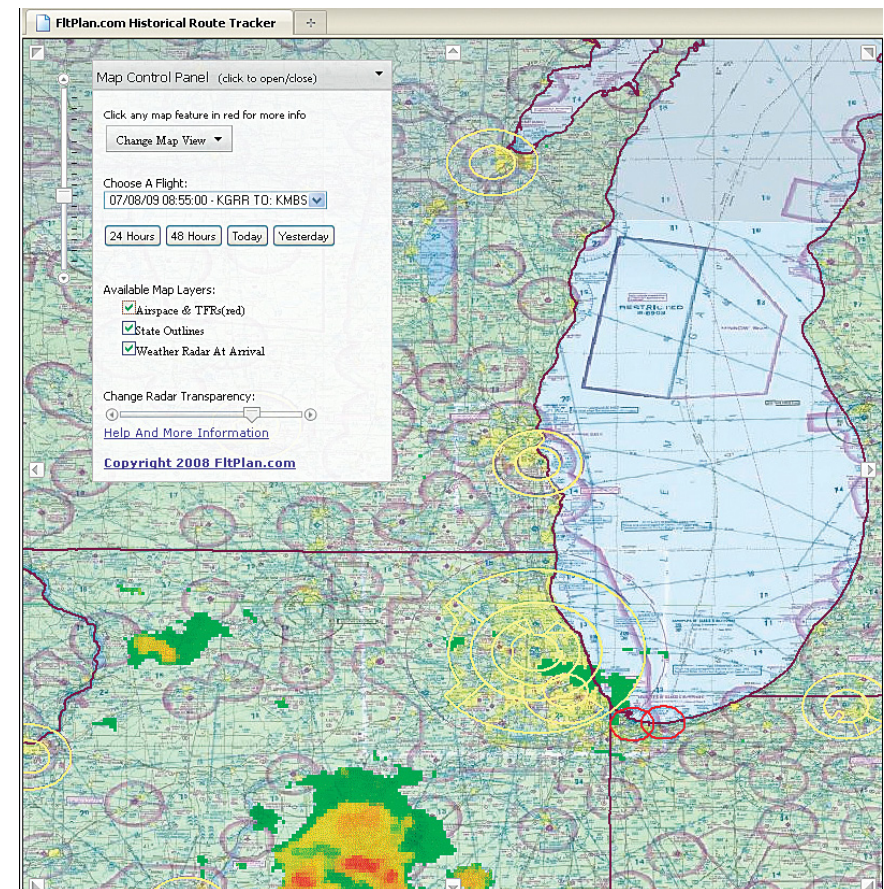
Cloud computing and ArcGIS Server deliver a thrifty solution

By Matthew DeMeritt, Esri Writer

In spring 2008, South Carolina GIS consulting firm and Esri business partner ROK Technologies (Roktech) saw great potential in Web services for assisting clients that needed to deliver cartographic imagery quickly.

One of its clients, FltPlan.com, serves flight-tracking maps to the general aviation industry. FltPlan.com needed to accommodate sudden influxes of visitors to its site. Instead of making costly investments in hardware to expand the company's capacity, Roktech used a unique combination of ArcGIS Server tile processing and a relatively new type of cloud computing called Hardware as a Service (HaaS).

Because company budgets aren't always in step with the cost of advancing computer technology, the IT industry often creates workaround services that close the gap between what a user needs and what that user can afford. Software as a Service (SaaS) cloud computing is a more well-known example of this strategy. Software licenses are deployed to customers for on-demand use rather than deploying (and paying for) a multitude of individual installations on every device in an organization. In the same way, HaaS is cloud computing that allows organizations to purchase external computer processing power, storage, and data transfer



FltPlan.com serves flight-tracking maps to the general aviation industry.

services for a fraction of what it would cost to purchase new computers, servers, and T1 lines to furnish that same capacity. Typically, HaaS vendors charge clients for the services they use rather than a monthly fee.

Significance of the Map Cache

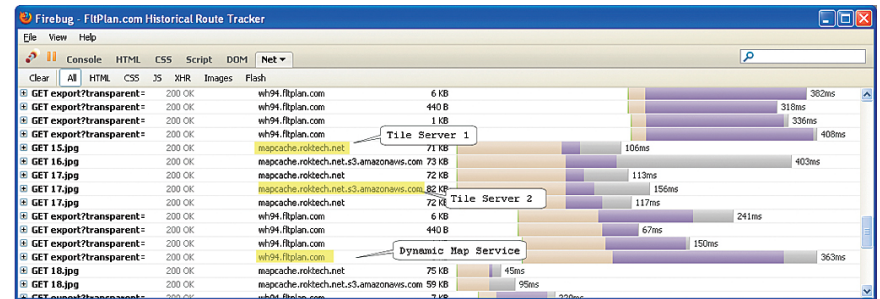
The introduction of the map cache in the latest version of ArcGIS Server greatly enhances the delivery of cartographic imagery. Maps are initially processed and cut into smaller tiles. Map caching increases the speed of GIS applications because it eliminates the need to request data from the database, process it, then send it to the browser on demand. In response to a request, preprocessed tiles fall seamlessly into place and users enjoy a pleasant Internet mapping experience. The strategy of using cached map layers that aren't frequently updated as base layers and dynamic map services for operational layers provides users with a much more responsive Web map.

Since the emergence of map-cached ArcGIS Server sites, user demand has noticeably increased. As a result, many smaller organizations that serve high-quality cartographic imagery are hitting a bandwidth limit fairly quickly as traffic to these sites grows. Since the cost of adding more T1 lines isn't realistic given limited budgets of many businesses and small governments, the result can be imagery that takes eons to render.

Cumulus Business

Roktech noticed many of its clients experiencing this bandwidth problem. "We asked ourselves—why not host our clients' map caches on our own servers and purchase data delivery services through Amazon S3 when we hit our own bandwidth ceiling?" explained Jason Harris, a GIS developer at Roktech. "Bandwidth logjams understandably make clients nervous, and this was a way to relieve their anxiety." Roktech called its new service tile cache hosting.

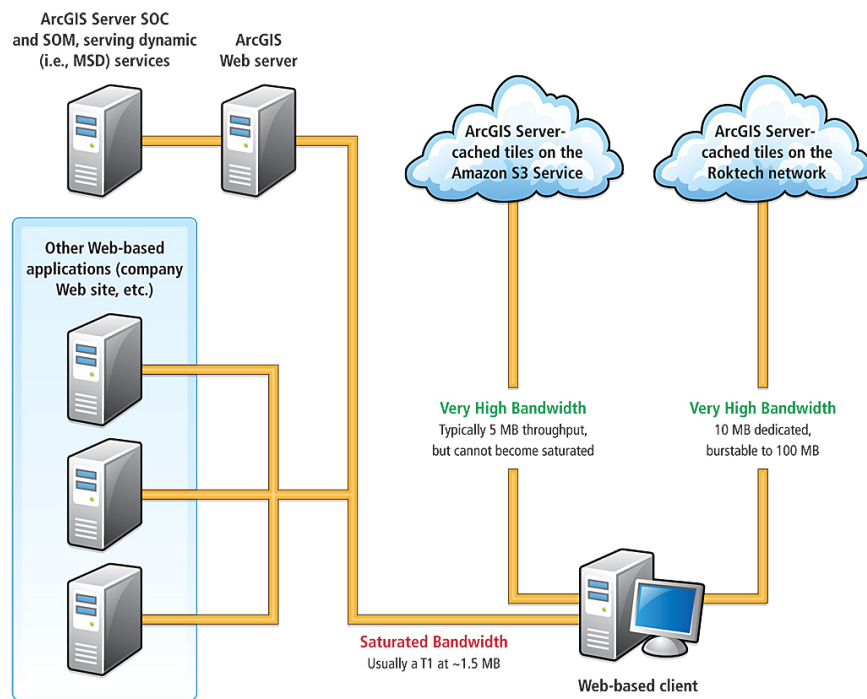
Tile cache hosting was successfully implemented for FltPlan.com, Roktech's client with the most pressing bandwidth issue. The flight-tracking Web site served a nationwide raster dataset via its new application created using the ArcGIS Server API for JavaScript. In addition to its main flight planning site, FltPlan.com ran sites that served ArcIMS maps and other ArcGIS-based dynamic layers. Even with its multiple T1 capacity, bandwidth



As the user base grows, Roktech simply increases the amount of data delivery services it requests from Amazon S3 and charges FltPlan.com accordingly.

for all FltPlan.com's sites became saturated within days of the new sites going live. Roktech moved FltPlan.com's map cache to its own facilities, offloaded the bandwidth draw to its own connection, and solved the problem.

"The issue arises when the ArcGIS Server host machine doesn't have the bandwidth to serve the tiles quickly enough," said Harris. "The site became so popular, and so quickly, that their available bandwidth bottlenecked practically overnight. With



Comparing the old and new architectures.

ArcGIS Server, we can now create these maps beforehand. When an Internet user requests a map, ArcGIS Server finds the correct tile and sends it. This was a time-saver compared to all the work that ArcIMS had to do before it could send the user a map."

The transfer of the map cache immediately made a huge difference in site performance. As FltPlan.com's site continues to become more popular with the general aviation industry, it scales nicely. As the user base grows, Roktech simply increases the amount of data delivery services it requests from Amazon S3 and charges FltPlan.com accordingly. This is a much cheaper alternative to adding more T1 lines and is just as useful for solving bandwidth problems experienced by other clients.

Configuring the Tiles

Both ArcGIS Server JavaScript and Flex APIs allow developers to tell applications to point to different tile servers. Essentially, tile servers are just places where map caches are stored. These tile servers (called "buckets" in Amazon S3 parlance) do not necessarily need to be on the same physical network as ArcGIS Server. Roktech specially processes the tiles and transfers the map cache tiles for storage on both its own fiber network and the Amazon S3 cloud service.

"That's the central concept," said Harris. "As developers, we have the ability to pull data in from multiple servers and locations and use it in the same map. Esri obviously gave these new APIs some

serious thought. The [ArcGIS] Server team made it incredibly simple to make engaging, dynamic mapping applications that attract so many users.”

Roktech decided to use Adobe ColdFusion to process the tiles and prepare them for the upload to the Amazon S3 service. Harris said ColdFusion was chosen because it’s tightly integrated with Adobe Flex and makes Internet application development and deployment quick and easy. It is also a natural fit for creating Web applications with ArcGIS Server.

Once the cache is converted, it is simply uploaded to the Amazon S3 service. Roktech uses Bucket Explorer (www.bucketexplorer.com), an interface for Amazon S3, for uploading the cache because it is extremely easy to use and does the job quickly. According to Harris, uploading the cache takes time and requires patience but is well worth the effort because the payoff is huge.

Sustainable Growth

“Because of the time-sensitive nature of flight planning, we wanted to provide the smooth-scrolling map service for users—like the kind you’d see on the big sites like Google Maps,” said Ken Wilson, president of FltPlan.com. “Esri and Roktech found a way to do that for us, giving our sites the speed of the larger sites. We could not have sustained the popularity of our sites with slow-rendering maps.”

Until the price of adding multiple T1s becomes ridiculously cheap, HaaS cloud computing is an inexpensive solution for the bandwidth bottleneck experienced by smaller organizations. “I don’t know the nuts and bolts of it,” Wilson confessed. “I do know that Esri and Roktech helped us meet our goals of immediate mapping at a fraction of the price of expanding our fiber network. In the end, that’s all that matters.”

(Reprinted from the Fall 2009 issue of *ArcUser* magazine)

Romanian Civil Aeronautical Authority Creates and Edits High-Quality Data

Enhancing Safety, Security, and Efficiency with GIS

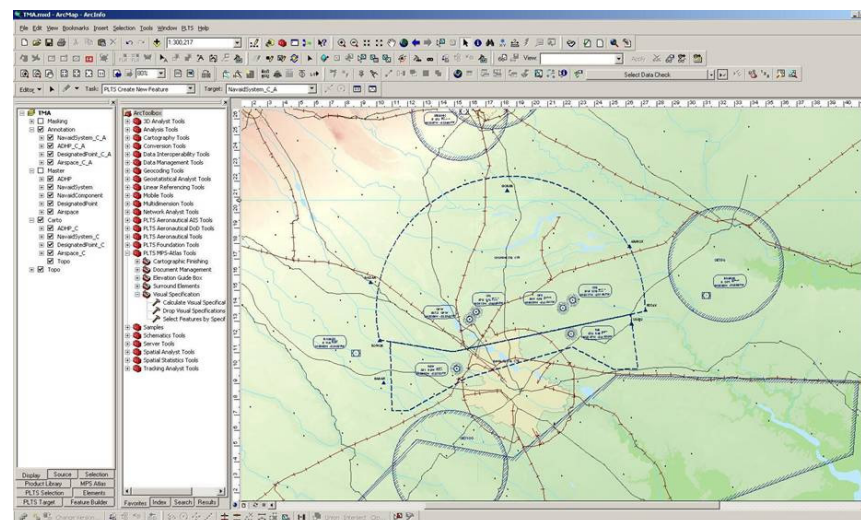
Highlights

- RCAA chose ArcGIS because the software provides a standards-based platform.
- RCAA efficiently manages its aeronautical information and produces high-quality charts.
- ArcGIS 3D Analyst allows RCAA to visualize and analyze surface data from many viewpoints.

In 1910, Romanian scientist Henri Coanda built the world's first jet engine, and the country has been on the forefront of aviation ever since. Today, Romania has a well-developed airport infrastructure, including 17 commercial airports, with most open for international traffic. To ensure aviation operations are safe, secure, and efficient, the Romanian Civil Aeronautical Authority (RCAA) was created. RCAA regulates all civil aviation activities in the country, including licensing pilots, registering aircraft, and certifying that aircraft and engine designs are safe for use. RCAA is coordinated with all other civil aviation authorities around the world by the United Nations' International Civil Aviation Organization (ICAO).

As with other aviation authorities, RCAA is faced with doing more with less and with the limited funds of a public organization.

Historically, it used computer-aided design and drafting software for creating maps and charts. Three years ago, RCAA looked for a solution that would allow it to efficiently create the products required to do its job, as well as share data with ICAO in the best way possible. After looking at many solutions, RCAA chose ArcGIS because the software provides a standards-based platform for the spatial analysis, data management, and mapping the organization was required to perform.



The Romanian Civil Aeronautical Authority uses GIS for data management, creating and editing cartographic products, and viewing spatial data.

“RCAA now has the ability to efficiently create and edit cartographic products that support our aviation operations,” says Mihai Necula, head of the Air Navigation and Aeronautical Information System (AIS) Department, RCAA.

RCAA uses ArcGIS for data management and mapping and viewing spatial data. “We saw the benefits of centrally managing our aeronautical data with GIS once we started using the software,” says Necula. “Upgrading our implementation means we will be further integrated into our AIS and capable of doing more spatial data viewing and analysis, including creating 3D representations, which is very important when managing airspace.”

RCAA upgraded its current ArcGIS solution to include the specialized extensions ArcGIS Data Interoperability, Esri Aeronautical Solution, and ArcGIS 3D Analyst. The ArcGIS Data Interoperability software extension makes data importing easier for RCAA by eliminating barriers to data sharing through state-of-the-art direct data access, complex data transformation, and import/export capabilities. The RCAA production lines also utilized FME 2008 from ESRI Canada Limited Business Partner (Surrey, British Columbia) Safe Software Inc. FME 2008 extends ArcGIS software’s data translation and integration.

Once data is imported, Esri Aeronautical Solution allows RCAA to efficiently manage its aeronautical information and produce high-quality charts. “We now have a robust editing environment

in a map-based visual editing workspace,” says Luliana Radu, aeronautical inspector, RCAA. “This gives me precise control of feature parameters, one-touch data maintenance, and the ability to make a change to a feature once in the database that is reflected on all related products automatically. The software is very efficient and allows me to produce data and chart products faster with better quality.”

ArcGIS 3D Analyst allows RCAA to effectively visualize and analyze surface data from many viewpoints, query a surface, and determine what is visible from various locations.

(Reprinted from the Summer 2009 issue of ArcNews Online)

The National Geospatial-Intelligence Agency

Providing On-Time Geospatial Information

Challenge Provide aeronautical, nautical, and topographic maps, charts, and data to customers with immediate, on-demand access to relevant geospatial intelligence where and when they need it.

- Results**
- Maritime charts are available the day after being cleared for release instead of the traditional six to eight weeks.
 - Production time has dropped from hundreds of hours to less than one for some maps and charts.
 - Production time is determined based on the intended use of the product—saving person-hours and reducing expenses.

“Esri’s ArcGIS Server allowed us to create ePODS, a solution that meets our customers’ needs for rapid, automated dissemination of relevant data and hard-copy products.”

—Susan Marchant, ePODS Program Manager and Contracting Officers Representative, NGA

The National Geospatial-Intelligence Agency (NGA) is a U.S. Department of Defense combat support agency and a member of the national intelligence community. Its primary mission is to provide geospatial intelligence (GEOINT) to U.S. armed forces and government agencies in support of national security.

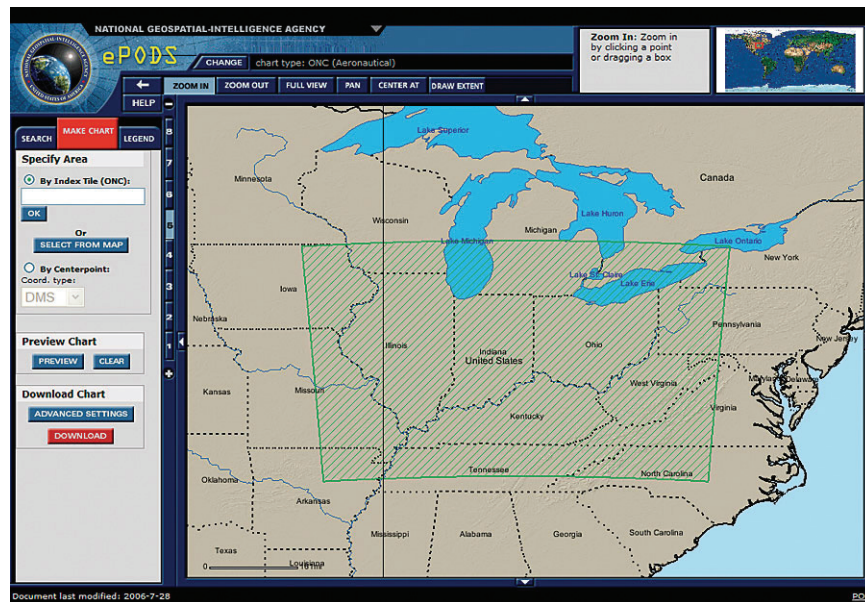
The geospatial intelligence that NGA provides is important on the home front as well. Navigation safety is a critical function of the agency and would be virtually impossible without knowing the geographic features that affect aeronautical and nautical navigation.

The Challenge

Geospatial intelligence is a critical tool for U.S. armed forces and the intelligence community, aiding the front line by providing accurate depictions of the geographic features relevant to the mission at hand. For NGA’s GEOINT operations to function successfully, the data must be timely, relevant, and correct. NGA needed to supply updated, accurate data in support of their users’ missions in a timely manner.

The Solution

Beginning in 2001, NGA began transforming its processes and system to better support its mission. The agency looked for new and innovative ways to improve its labor-intensive and time-consuming mapping, charting, and data management processes. Through a collaborative effort with Esri Professional Services in 2002, NGA's Aeronautical Division created an automated, geographic information system (GIS)-based charting process that significantly reduced the time required to update, produce, and



With ePODS, a user can preview the extent of an existing Operational Navigation Chart (ONC). (International copyright 2007, NGA, U.S. government)

disseminate Flight Information Publications (FLIPs). The success of this project served as an impetus for NGA to modernize nautical and topographic mapping and charting as well.

In 2004, NGA contracted again with Esri Professional Services for a new initiative, Enterprise Product on Demand Services (ePODS). Using the aeronautical project as a model, NGA wanted to automate map and chart creation to gain efficiency and reduce errors. Allowing customers timely access to the most current NGA data in all domains was very important. The ability to design and print custom maps was also high on the list of desired functionality.

The ePODS project is a Web portal allowing users the on-demand access to the data they require. Via a Web interface, users select the data they need, configure it into a map, apply specific cartographic rules, preview the end product, and print it or download a source package (data, instructions, and media) to work locally on the maps for further refinement.

The first iteration of the ePODS system went into production in September 2007. The ePODS system was built on service-oriented architecture (SOA) using Esri's ArcGIS family of products. ArcGIS Server and ArcIMS provide GIS Web services and portal functionality, respectively. Esri's mapping and charting solutions provide robust final touch-up and finishing environments for aeronautical, nautical, and topographic maps and charts that NGA chooses to edit prior to publication.

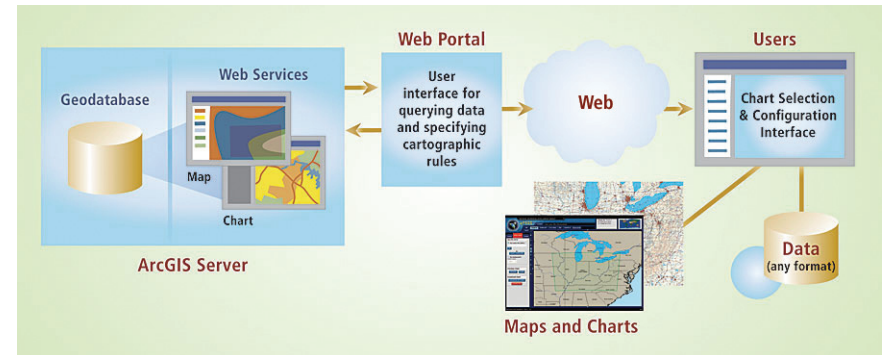
The Results

With ePODS, NGA customers can access the most current NGA data holdings to build on-demand nautical maps and charts. For example, digital ePODS-Maritime (ePODS-M) charts are usually available for use the day after NGA clears a new edition nautical chart for release. By contrast, traditional paper nautical charts are available six to eight weeks later. For some maps and charts, production time has dropped from hundreds of hours to less than one.

NGA further increased its efficiency by using ePODS to determine on a case-by-case basis how much production time to spend on a product based on the intended use of the product—there's no need to spend hundreds of hours finishing a one-off product that will only be used for quick analysis.

Using the ePODS system, navigation safety has been significantly improved for both military personnel and civilians with the improvements in accuracy and timeliness of aeronautical and nautical charts.

(Reprinted from the 2008 Esri case study)



The ePODS architecture is based on a service-oriented architecture (SOA) with a SOAP Web service exposed that allows the POD server to be called from multiple applications.

Esri Helps ICAO Improve Data Management and Workflow for Air Navigation Planning

Aviation Authority Shifts from Static Data to an Interactive Platform for Viewing, Planning, and Reporting Using ArcGIS

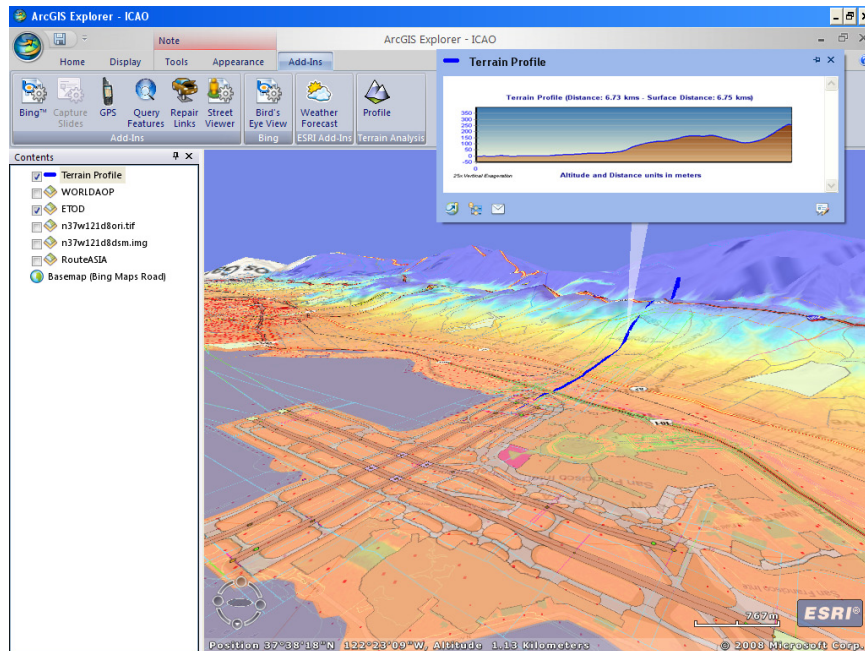
Redlands, California—The International Civil Aviation Organization (ICAO) is making air navigation safer through more timely access to accurate data. Using ArcGIS Server, a server-based geographic information system (GIS) from Esri, ICAO is creating a Web-based portal containing various global air navigation charts that can be viewed and accessed over the Internet.

Providing access to the data is particularly beneficial for the planning, monitoring, and analysis of newly planned facilities and services in regional air navigation plans (ANP). Having this information makes it easier for planning and implementation groups to expedite projects in accordance with ICAO priorities.

“Providing this information online greatly facilitates updating and accessing the latest information for ICAO regional offices and other users,” says Gilbert Lasnier, GIS services manager, ICAO.

The system is called the ICAO electronic Air Navigation Plan (eANP) GIS portal and provides access to the ICAO Global Air Navigation Plan database. Global air navigation plans that are available include air traffic safety charts, flight information region charts, air traffic management charts, aerodrome operations planning, satellite images, regional charts, and many other thematic maps.

A variety of clients can be used to view and manipulate the data including Microsoft Internet Explorer, Esri ArcGIS Explorer, or any other ArcGIS Desktop client. To begin, a user opens a Web service; selects a region; then views, edits, or analyzes the data. What-if scenarios of new routes and chart traffic information can be created and applied to the data. Users can also fly 3D



electronic Terrain and Obstacle Databases (eTOD) in ArcGIS Explorer.

ICAO members, including regional planning and implementation groups, aviation partners, United Nations agencies, civil aviation entities, and ICAO staff, can browse and interact with the data. The public can access the GIS portal through the ICAO Web site.

By implementing Esri technology in a GIS portal, ICAO will be satisfying both the global and regional demand to replace paper air navigation plans, utilize ANP online viewers, view meteorology reporting, and provide easy access to data. For more information on how Esri GIS is used for aeronautical charts and maps, visit esri.com/aeronautical.

(Reprinted from the October 15, 2009, Esri press release)

Aeronautical Transformation

From Paper to Digits at the National Geospatial-Intelligence Agency

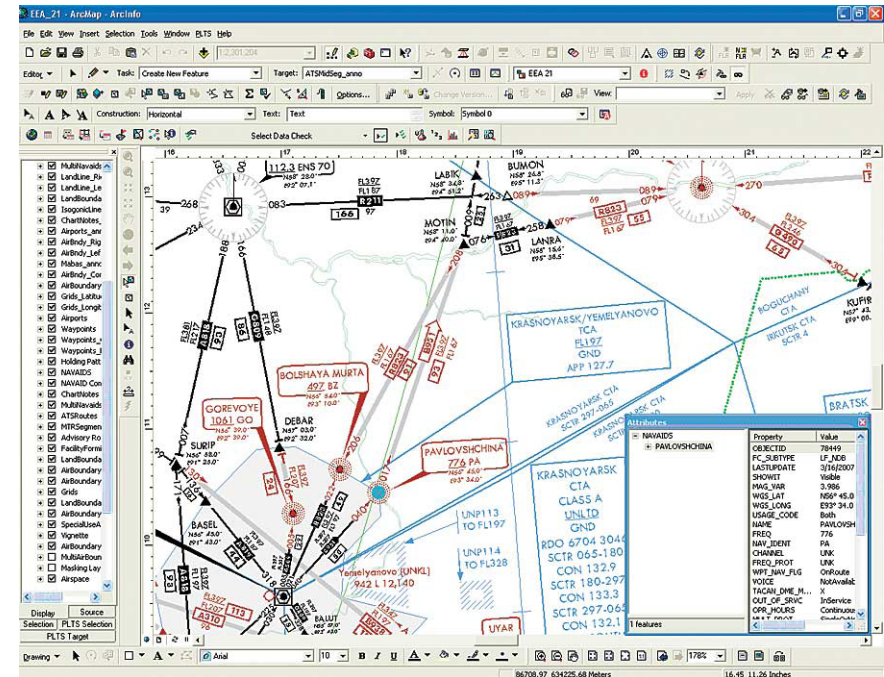
By Charles L. (Chuck) McGaugh, Jr., Director, Office of Global Navigation, National Geospatial-Intelligence Agency

Highlights

- NGA moved from a productcentric to a datacentric organization.
- GIS changed the way flight information publications are produced and distributed.
- Geospatially enabled data enables fusion with other data for additional analysis.

Transformation involves “a major change in form, nature, or function,” as defined by *Merriam-Webster’s Collegiate Dictionary*, Tenth Edition. Starting in early 2002, the National Geospatial-Intelligence Agency (NGA) undertook a transformation in the way the agency does business and supports customers by moving from a productcentric to a datacentric organization. The goal, in the words of former NGA director and retired Air Force Lt. Gen. James R. Clapper, Jr., was to provide customers “instant access to specific geospatial intelligence.”

Headquartered in Bethesda, Maryland, NGA is a U.S. Department of Defense combat support agency and a member of the national intelligence community. The agency’s mission is to provide timely,



NGA has replaced its manual process for creating aeronautical charting products with a completely GIS-based process. Shown is an Enroute Chart being created using GIS.

relevant, and accurate geospatial intelligence in support of U.S. national security.

The agency's mission includes providing accurate aeronautical charts that are updated on a nationally and internationally mandated schedule. The transformation began with the implementation of GIS to change the way NGA Flight Information Publications (FLIPs) are produced and disseminated to customers.

Outdated Processes

Until 2002, the process of producing NGA FLIP global charts required a large staff of aeronautical analysts, quality assurance specialists, and contractor personnel. Significant effort and expertise were required for chart maintenance. 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 of review by quality assurance specialists to ensure that it met NGA standards and was similar across all overlapping charts.

The contractor used the data abstracts and/or the hand-drawn lithographs to create sticky-backed strip waxing ("stick-up") film overlays for text and/or graphic symbols. Each change was applied manually by scraping off old annotations and graphics and replacing them with the modification for the master versions of each chart.

With more than 1,000 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 overlays were then used as the positive in a photo process to create negatives for each layer for every chart. In the busiest cycle, contractors produced more than 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.

Sticky Crisis

While the GIS and mapping community might have been ready to support digital aeronautical charting long before, it took a stick-up crisis to force a change. The world's only manufacturer of stick-up stopped producing the material in 2001, 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, most notably the lack of data. An aeronautical database did exist, it was kept current, and the attribution was robust. The data quality was exceptional, but it was not geospatial.

The Solution: Digital Enroute Charts

NGA's Aeronautical Division turned to Esri for help in solving this critical problem. Together they worked on an ambitious program to create a completely GIS-based process to produce NGA aeronautical charting products. The foundation of the approach was Production Line Tool Set (PLTS) for ArcGIS—Aeronautical Solution, which allowed NGA to develop a database-driven system to support digital aeronautical chart production. The NGA aeronautical database is imported into a geodatabase, and data is preformatted for charts during the data ingest. On a weekly basis, NGA provides database updates, and these transactions are loaded into the geodatabase, which has been optimized for cartographic output. Quality is ensured through several steps, and a Web-based scheduling tool monitors job progress, tracking every chart in every phase of production.

Using this foundation, NGA is able to produce charts of any scale, orientation, and projection, in addition to the standard NGA series of aeronautical charts. Esri Aeronautical Solution manages the chart series design and incorporates intelligent elements

that are automatically updated based on the content in the geodatabase.

The database-driven system makes update management many times more efficient than in traditional manual chart production. One-time data entry allows greater accuracy by eliminating the possibility of errors in the production chain. When a feature update is transferred from the NGA database to the 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 of the automation, digital data is synchronized with the paper product, and product quality has dramatically improved.

NGA continues to deliver hundreds of thousands of Enroute Charts to aviators every 28 days without delay, and the output product is so similar to the manually prepared charts that customers never noticed. The digital Enroute Chart process supports direct-to-plate printing, completely eliminating the need for film overlays and stick-up.

Success Transforms NGA to Datacentric Organization

With NGA's traditional methods, a large percentage of energy was focused on the format and appearance of products, rather than on the depth of knowledge behind the data. Through this

effort, its 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.

The database-driven system also enables NGA to give customers a variety of new product options, from various digital formats to various printing options. 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. Using the geospatial knowledge of NGA's contracted experts, the aeronautical expertise of NGA analysts, and the power of GIS, even the sky is no longer the limit.

More Information

Excerpted from "Aeronautical Transformation: Paper to Digits—Changing the Way the National Geospatial-Intelligence Agency Creates Aeronautical Products," presented by Charles L. (Chuck) McGaugh, Jr., at the 2004 Esri International User Conference. For more information, contact the NGA Office of Corporate Affairs, Public Affairs Office (Web: nga.mil).

(Reprinted from the Summer 2007 issue of ArcNews Online)

Manchester Airport in the United Kingdom Manages Significant Growth

Flexible GIS Ensures Business Sustainability

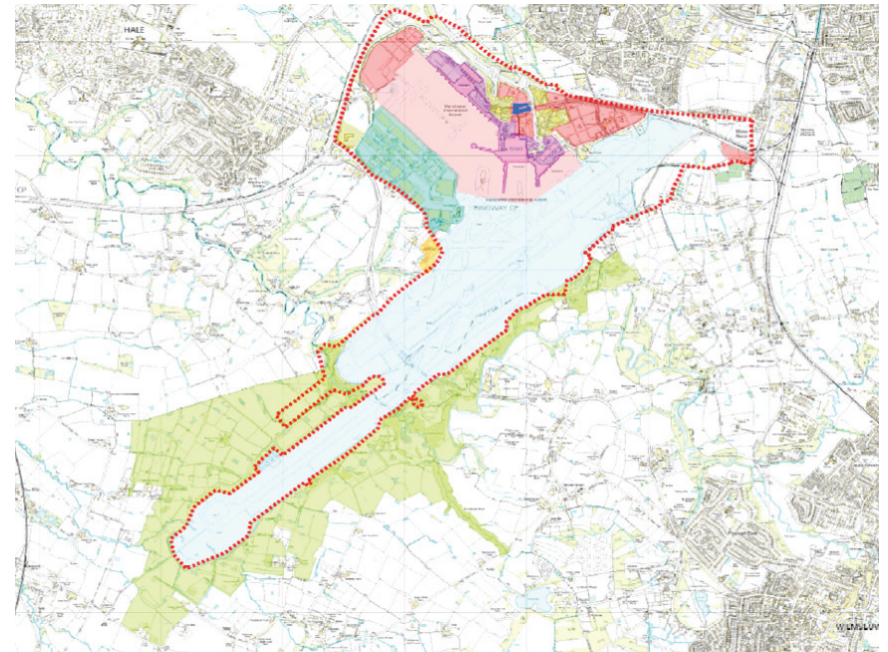
Highlights

- ArcGIS saves the airport US\$220,000 and 1,200 person-hours per year.
- GIS now touches on all aspects of running the airport.
- ArcGIS integrates seamlessly into business models and evolves with the airport's needs.

Situated on 1,544 acres, Manchester Airport in the United Kingdom operates as a small city, serving 22.7 million passengers and handling 151,000 tons of freight each year. As a sustainable business, the airport itself employs 19,700 people working at 310 different companies at the facility. The airport is positioned to grow to serve 50 million passengers within 30 years with the support of government initiatives in the country.

Managing the space used at the airport is no small feat. From car parks and retail shops to runways and habitat areas, Manchester Airport must be effective when running its business. To add to the challenge, the airport never sleeps; it must remain operational 24/7. For the innovative organization, the airport's management created a planning team tasked with finding the best way to tackle challenges faced by different business units

through the use of technology. Given the mission to become better than all other airports by making the customer's journey a positive experience, Manchester Airport knew it needed a solution that could manage all aspects of the airport's business: economic, social, and environmental.



The Manchester Airport used GIS to help plan sustained growth until 2030.

Begin with Noise Contours

“Our question at the time was how many parcels are inside the noise contour,” explains Vickie Withnell, chief technology officer at Manchester Airport. “If noise contours are areas, or polygons, then we could overlay that onto our surrounding properties map and count how many were inside. We easily saw how many homeowners might qualify for specific programs to help mitigate noise, such as installation of soundproof window glazing. The CAD-based system we were using at the time just couldn’t do that.”

Airport authorities began evaluating alternative technologies and decided that the value of ESRI technology was immediately clear. Thus, Manchester Airport began using GIS in the late 1990s specifically to map noise contours. With approximately 26,000 properties affected by moderate to high noise levels, GIS was invaluable in managing where the properties were located and which services were utilized by individual owners and keeping check on complaints.

Now the Whole Airport Finds Value in GIS

From this project, the use of GIS spread organically through the airport and now touches on all aspects of its operation: retail, planning, marketing, development, and airfield operations; community relations; ground transportation; environmental planning; and utilities. The Planning Department is now primarily

focused on GIS, specifically employing ArcGIS Server, since “everything we could do in PowerPoint or with pictures, we can do better with GIS,” says Withnell. “In the end, GIS has proven to be a flexible solution, allowing us to manage data, model new scenarios, and create easy-to-understand presentations for growth and management at our facility.”

Managing the retail side, with its 130 shops and restaurants and retail sales in excess of US\$447 million a year, GIS has proved its usefulness once more. From initial planning for a retail outlet to ensuring proper licensing and store expansion, ArcGIS assists in visualizing the impact of each store on airport operations. “The airport has a waiting list for available space, so GIS is necessary for us to manage our space effectively,” says Withnell.

Part of the challenge in making the airport an enjoyable place to visit is ensuring its accessibility. To that end, Manchester Airport expects to reduce the overall number of passengers who drive to the airport by 40 percent and staff who drive by 50 percent. GIS has been invaluable for managing Manchester rail hub improvements, a US\$74-million investment for the airport. Using the software, the Planning Department analyzed where best to place car parks and plan 24-hour bus, rail, and coach times and routes based on mapped demographics, the existing transportation network, and travel times.

“GIS assisted us in every aspect, even planning for and averting standard social dangers when traveling late at nonpeak hours,” emphasizes Withnell. By providing skylink travel to airport buildings late at night and staff with safety advice, train travel is an effective means to get to and from the airport.

Being a good corporate citizen is important to the airport, as well. This translates into proactively assisting in education and ecology in surrounding areas. On the education front, the airport has developed literacy programs for use by schoolchildren online and



The airport has three terminals and two runways serving nearly 23 million passengers per year.

at the airport and as an outreach to schools. GIS is used to create school address lists for mailing educational packs to surrounding schools. Ecology means managing habitat areas effectively and in compliance with environmental controls. The airport is flanked by British countryside, and GIS helps ensure that creatures like the Great Crested Newt, bats, and badgers continue to live in comfort.

“Managing the land and understanding the habitat area sometimes means changing the landscape,” says Withnell. “GIS helps us manage the land, from creating new ponds in the correct locations to ensuring that new development doesn’t encroach on our wildlife areas.”

The Results

For more than 10 years, GIS has helped Manchester Airport transform itself from a transportation hub to a sustainable business. ArcGIS Server has assisted in mapping, analyzing, and mitigating the business, social, and environmental aspects of the airport, ensuring that it remains a profitable business sensitive to its impact on the community. Having data managed centrally allows it to be kept up-to-date easily and shared effectively with contractors and other agencies. This saves time and ensures that the data is accurate, consistent, and timely.

Using ArcGIS Server, Withnell estimates the airport is saving upwards of US\$220,000 and 1,200 person-hours a year just in operational costs of map production and data collection.

“GIS is an efficient way to manage time, effort, and budgets,” explains Withnell. “It integrates seamlessly into our business and evolves with our needs, helping us fulfill our stated aims of being a responsible neighbor, investing in our community, and spending money on the things that really matter.”

(Reprinted from the Spring 2009 issue of *ArcNews* Online)

Enterprise GIS Takes Off at Phoenix Sky Harbor International

Highlights

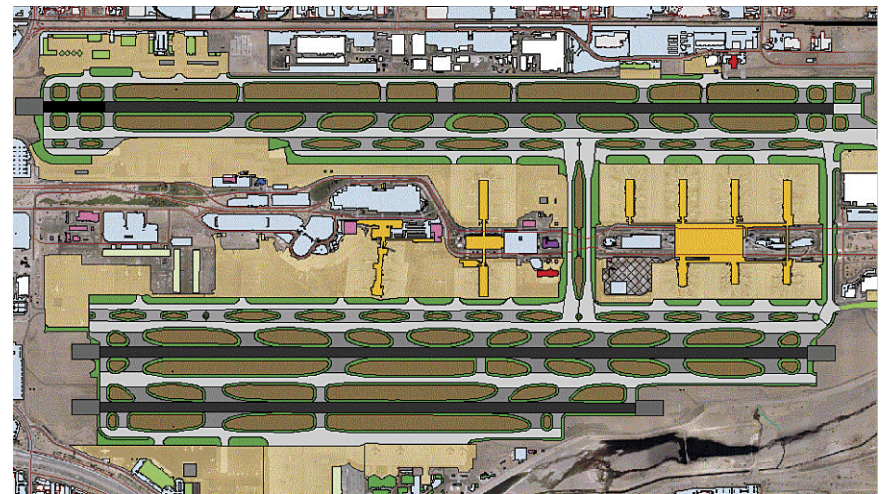
- The enterprise GIS is stored in Oracle Spatial and accessed through ArcGIS.
- The GIS includes business tools for managing the airport's operations and growing number of assets.
- About 85 staff members, who are neither GIS specialists nor technicians, access the GIS weekly.

Already one of the 10 busiest airports in the world, with approximately 1,500 flights, 100,000 passengers, and 700 tons of cargo daily, Phoenix Sky Harbor International Airport generates an economic impact of more than \$90 million a day for Arizona's largest metropolitan area.

With a growing pool of travelers and cargo relying on the airport for safe passage to a final destination, the City of Phoenix recognized that its Aviation Department needed an enterprise-wide GIS that would combine data locked in existing information systems into a single user interface and could serve more than 200 airport personnel simultaneously. Such a system would not only improve customer service and safety, but it would also allow

users to effectively manage their work activities by providing accurate and current information.

"We recognized the need for an enterprise-class information system to support changes from planned development," says City of Phoenix assistant aviation director Carl Newman. "We were confident that with these increased efficiencies, GIS would pay for itself over time."



GIS portal users can access this overview map of Phoenix Sky Harbor International Airport.

A major requirement was that a significant number of staff, who are neither GIS specialists nor technicians, would need to access the GIS weekly to review or plan maintenance work orders, check interior space measurements and calculate rates for airport tenants, create area maps with aerial images showing existing conditions and planned improvements, insert maps into slide presentations for management, and output maps and data for internal and external reporting.

In 2007, the city and its Aviation Department made the decision to move forward with GIS technology and selected Esri Business Partner Woolpert, Inc., a design, engineering, and geospatial firm located in Dayton, Ohio, with experience in the airport industry, to assist with the implementation.

All the data for the GIS is stored in Oracle Spatial and accessed through ArcGIS. Aviation Department personnel—about 85 unique users from the Aviation Department’s 10 divisions—use the resultant system via a Web portal built on the ArcGIS Server platform. The enterprise GIS also includes business tools for managing the airport’s operations and growing number of assets.

“Before 2007, data on interior and exterior assets was maintained in several systems, which weren’t always compatible,” explains Michael Youngs, Phoenix Aviation Department GIS program manager. “If someone asked a basic question like, ‘How many fire extinguishers do we service?’ there was no easy way to answer.”

Information on the Fly

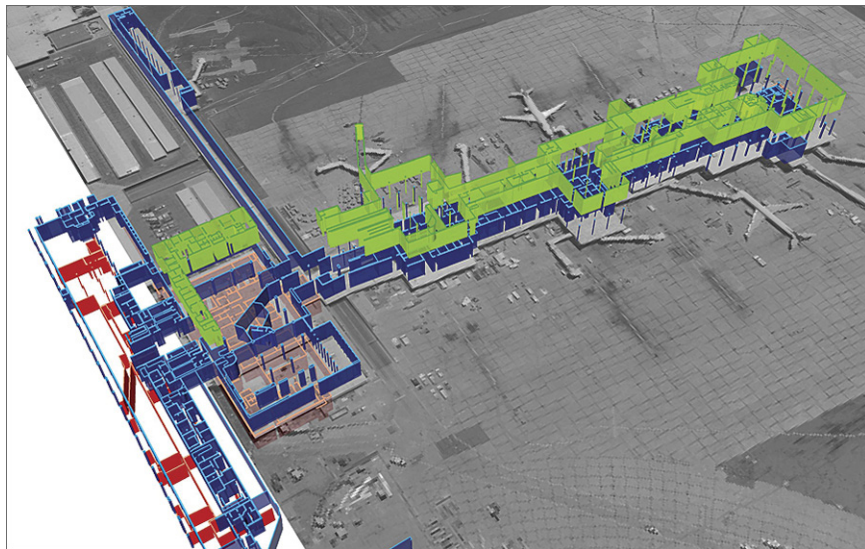
The airport’s enterprise GIS features an abundance of data, sophisticated technology, and reengineered business processes. The enterprise system gives airport employees access to

- Aerial photography and digital orthophotos of areas surrounding the airport operations area
- Aboveground features and underground utility data
- A geodatabase design with 300 feature classes, from smoke detectors and passenger assistance monitors to noise contours and 3D roof prints
- Interior floor plan data and attribution for buildings in and around the airport, collected via floor plan surveys and CAD drawing conversions
- An intranet viewing portal based on ArcGIS Server technology
- Information that was integrated from the previously existing systems
- Ten servers in multiple clustered environments, which provide performance, reliability, and availability, including a redundant failover system at a remote location in case of system outages

What users cannot get in self-serve mode from the portal, they get by submitting requests to the GIS group. User requests, about 16 per month, typically involve oversized, data-rich maps;

custom reports; or complex queries. “We’re getting repeat requests now because users understand what we can do for them,” says Jamie Ritchie, the department’s GIS coordinator.

For example, to assist the Operations Department, the GIS group created new emergency evacuation maps, which had been difficult to update and reproduce. These maps, complete with exits, assembly areas, and varying “you are here” orientations, were saved as PDF files on DVDs so tenants could print and post maps and share them with employees. Explains Youngs, “We could produce these because we have very accurate interior building data, which is atypical for airport GIS programs.”



The airport stacked floor plans are available in the GIS.

To assist the Fiscal Management Department, the GIS group completed a space accounting and reconciliation project. “In one day, we generated maps and reports identifying discrepancies in actual versus leased square footage,” Youngs adds. “Without the GIS, this would have been labor intensive using a wheel and tape measure and taken a month or longer.”

Phoenix Sky Harbor International Airport is currently developing the PHX Sky Train, which by 2013 will begin transporting passengers to and from the airport, reducing the number of vehicles, easing traffic and curb congestion, and providing a seamless connection with the regional light rail system.

“We saved on startup costs for the train project because we provided engineers with digital terrain models, contour data, and orthophoto imagery from the GIS,” Youngs explains. “So they didn’t have to collect that data again.”

Custom Tools Streamline Daily Business

A critical application for portal users is the GIS interface with Phoenix Aviation Department’s work order management system. When a maintenance worker must replace air conditioning equipment, for example, the worker accesses the portal to find the exact location and other equipment nearby due for maintenance. This exercise maximizes productivity, as it combines activities.

“Uniting the GIS with the work order management system allows us to plan efficiently, and it’s just one way the GIS is saving money,” says Youngs.

Another custom application helps users manage airfield signage. Employees can access signage locations and images through the portal, plan and track maintenance, and generate reports to show compliance with Federal Aviation Administration (FAA) standards.

The ArcGIS Server interface with the computer-aided dispatch system allows dispatchers to access geographic data when addressing calls. “We’re now considered the official source of data for airport police and fire dispatch,” says Newman.

One of the newest features to the airport’s GIS is a project planning tool that allows users to add a proposed project location to the GIS, query the system, and run reports to detect potential conflicts, such as affected utilities and other projects planned in that area. More business tools are planned. According to aviation director Danny Murphy, “Our goal is to produce a tool for every business function at the airport that relies on location information.”

Naturally, some operating practices needed to be revamped before GIS was implemented. For example, Aviation Department workflows were redesigned so that changes in the field, such as new construction, retrofits, maintenance, and tenant improvements, could be intercepted, captured, and recorded in the system by the airport’s GIS technicians. Described as

the heart and soul of the data maintenance operation, the GIS enables the technicians to update the system constantly, with most changes being completed within days.

The same group conducts random field checks using GPS and surveying equipment and audits interior spaces to verify data on converted CAD drawings. Employees who observe an update, such as an airfield light not captured in the GIS, can use the system’s redline tool to identify the change so it can be validated in the field and included in the GIS.

Youngs and Ritchie train employees on portal navigation and procedures for requesting custom maps and reports. Youngs routinely gives project updates to management at all levels. “We continue to show everyone what the capabilities are and keep our customers engaged and excited,” says Youngs.

(Reprinted from the Spring 2010 issue of ArcNews Online)

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