Goals:

- *Promote Corps of Engineers as an exciting place to work for those in the field of Geomatics*
- *Promote Geomatics as an exciting field of study.*
- *Share lessons from professional experience.*

The Map-of-Everything: The Challenges of Supporting a Large Engineering Organization with GIS

Title Slide

Good afternoon everyone. Would you say if I told you they could give your customers everything they ask for and yet still fail them? As I'm here today, I thought I'd share with you some of my experiences from my time working at the Corps of Engineers in their Geospatial Engineering Section, including one of the most important lessons I've learned in my professional career. Over 15 years ago, we created a web-based product called the Enterprise GIS Intramap. It was intended to be the last map you'll ever need, making cartography virtually obsolete. I thought of it as the Map-of-Everything, a true wonder of its time. As it turns out (I'm giving away the ending here) it was anything but, despite the effort invested in it.

Act 1: Corps of Engineers Missions

Slide: navigation, levees, emergency operations, regulations

But I'm getting ahead of myself here. To understand the role of GIS at the Corps of Engineers, it's worth exploring the Corps of Engineers itself and its Civil Works mission. The Corps of Engineers is the federal agency responsible for applying Engineering to solve the many challenges of managing the nation's water resources. Specifically, this includes maintaining the nation's navigable waterways such as the Mississippi River through dredging, partnering with local communities to design and build flood defenses such as levees and flood walls, preserving wetlands by enforcing regulations that require companies that impact wetlands with their construction to mitigate, that is to build an equivalent amount of wetland elsewhere. During emergencies such as high river stages or hurricanes, the Corps of Engineers activates an Emergency Operations Office to provide technical support to local communities. After emergencies, the Corps works under the authority of FEMA to execute missions to provide power, water, blue-roof tarp, and debris removal to the affected population.

Slide: Districts

The Corps of Engineers is divided into districts, each with their own geographical jurisdiction. I work at the headquarters of the New Orleans District, which covers the southern half of Louisiana. Even though we are small geographically, we are a veritable hub of activity and circumstance. For instance, southern Louisiana is home to the Port of New Orleans and the Port of South Louisiana, the latter of which is regularly the nation's top ranking port in annual total tonnage of cargo handled. In addition to the ports, there are a number of refineries and other business that depend on the Mississippi River for their livelihoods. South Louisiana includes 900+ miles of levees and flood walls defending communities along the Mississippi and Atchafalaya Rivers, which would otherwise flood those areas on a near-annual basis. An additional 425+ miles of levee and flood walls defend The New Orleans metropolitan area,

Plaquemines Parish, and Lower Lafourche and Terrebonne Parishes from hurricanes. Finally, south Louisiana is facing the constant threat of landloss and subsidence from various factors including pipeline canal excavations and levees blocking sediments from spreading outside of the river.

With so many disparate challenges and areas of responsibilities, it's easy to imagine how valuable a GIS program would be to such an organization. Without data collection, analysis, and visualization, one could easily miss important details needed to plan and review project work or operations. Fortunately, with the support of our Engineering Survey section who specialized in field data collection and remote sensing, we have just the office to handle our organization's GIS needs.

Act 2: Systems and Programming

Slide: Geospatial Engineering

The Geospatial Engineering Office is responsible for software development, data management, cartography, and print production in support of projects and operations at Corps of Engineers. When I first started, I was fortunate to be mentored by Jay Ratcliff, now Dr. Jay Ratcliff, who arguably invented GIS before it was really called GIS. I was impressed by level of talent and professional skill I saw; it was not unlike the folks I worked with at MIT. Even now, over a third of our office has master degrees in computer science / geography or professional Engineering certification. Aside from the talent, I always enjoyed that every assignment and project I worked on seemed to be a unique challenge. Rarely, did I feel I was doing the same thing over and over again. We were solving problems and it was very rewarding. Let me briefly show you some examples of our team's projects:

1) Structure Value Data Collection – (*Slide SVGIS)*To determine whether a project such as levee construction should happen or not, the Corps weighs the estimated cost of constructing the project against the value of the properties that would be protected by the project. To get these values, our team developed a field data collection application for our Economists to evaluate properties in the project area. We were able to compile data collected into databases and combine it with hydraulic modeling output to give our Project Managers certainty in their cost-benefit calculations.
2) Donaldsonville to the Gulf – (*Slide DTOG)* This was another project that we worked on. We needed to create an elevation surface for hydraulic modeling. Our sources for the model included publically available FEMA LIDAR data and a series of cross sections and profiles with elevation data collected by our Engineering Survey Section for the various bayous near Lac Des Allemands. Due to budget constraints, we only had one cross-section for approximately every mile of bayou. We were able to use interpolation of the cross sections along the profile to densify the points to match the LIDAR to create a viable surface model for our Hydraulic Engineers.
3) Wrecks database – *(Slide: Wrecks)* I wasn't personally involved in this one, but I could definitely appreciate the work and found the results fascinating. Using high resolution multi-beam SONAR data, we were able to identify location of shipwrecks and other obstructions in the Mississippi River and help our Operations folks communicate this information to river navigation interests.
4) Roughness Coefficient Calculations – *(Slide Roughness)* Here was a case where we were assisting our Hydraulics office with the development of a hurricane storm surge model. We needed to

assign roughness coefficients to a grid used in an AdCirc storm surge model. These coefficient reflected how much friction the terrain at the location would have against the wind using 1992 LAGAP data as our source terrain classification. (Forest land would have a high roughness, while open water would have virtually no roughness). For each grid point, we calculated a distance-weighted roughness value for each directional wedge. At the time, I was very proud of myself for realizing the many terrain cells were the same as adjacent cells and creating a heuristic to reduce the calculation time by using a lower resolution aggregated version of the GAP data in those cases.

Act 3: The Eponymous Map-of-Everything

(Slide: Intramap)

In addition to solving problem for others offices at the Corps, our charge also included "making GIS available" to all computer users in our district. Our plan was to unify our datasets and publish them through a central web-based mapping application, using a product from ESRI called ArcIMS. Here are some examples:

1) Surveys – *(Slide : Surveys)*I mentioned our Engineering Survey Section already. One of their primary functions is collection location and elevation data for project areas prior to performing studies or construction work. Oftentimes, the Corps of Engineers winds up working in the same areas. Sometimes, depending on factors such as "currentness" and accuracy, surveys from previous projects can be reused. However, without knowing exactly where the survey was or what was surveyed, there is no way to make such a determination. By building a central dataset of surveys and traverse, we were able to help our Survey folks maximize the value of their assets and reduce the number of redundant surveys.
2) Boring Logs -- *(Slide: Borings)* Boring logs are used to determine the properties of soil at various depths, including classification, strength, grain size, and moisture content. The properties are essential to planning construction. For instance, in the case of borrow pits, certain classifications of soil such as sand or peat can't be used to build levees. Another example is riverbanks. A weak soil stratum under a river bank could lead to a bank collapse. In those cases, we need to know and understand this issue in case we need to armor the bank with riprap. In addition to the map layer and a tool to "find" boring logs, we included a link to a generated page in the Boring Log Database application, a software system our office created several years earlier.
3) RAMS -- *(Slide: RAMS).* At the time, our regulatory office tracked locations of permit requests in an external system called RAMS. This was one of the first examples of our office using our webmap to provide data from an external database.
4) Wrecks – *(Slide Wrecks)* Here are the wrecks I previously mentioned.
5) Real Estate. Here is the Real Estate Track we own created from Platt maps and legal descriptions. This is good to know for Project Planning: construction is much cheaper and occurs much more quickly if we do not have to have our local partners acquire new real estate servitudes.

Those were just a few examples. We worked with a number of other offices and became familiar with their roles and data interests. The experience was much like making a stone soup. *(Explain ex tempore)* As we worked with people, we continued to add layers, tools, and options to our web map and, after

every round of improvements, we would work on preparing and presenting demonstrations to our prospective users and our district's leadership. Even looking back at it today, it was an impressive system, well ahead of its time. So here it was, the eponymous Map-of-Everything. Unfortunately for us back then, the reception was underwhelming. The notes from that time period also revealed that funding was hard to come by. What exactly happened? Well, I've always considered myself a modern-day Epimetheus, bestowed with the gift of exquisite hindsight. Here's what I would opine:

(Slide: What went wrong)

1) User Proficiency: Early 2000's Corps of Engineers staff had limited exposure to GIS with the exception of the type of people who would work in our office. At the time, there were not as many geomatics programs, such as the one here at Nicholls State, offered by universities to get people familiar with the field. When I first started working for the Corps of Engineers I had never even of heard of GIS. At least I came from a computer science background, so I was able to pick it up. Many of our Engineers were barely computer literate outside of using CAD.
2) User Interface Scaling Issues. As we built the Intramap application over time, we kept adding new layers. Unfortunately while the number of datasets grow, the amount of screen space remains constant. Eventually, the user interface gets to a point where, even if you have the functionality your users need, you instead intimidate the user by exposing them to an ever-greater level of complexity. Compounding the problem was that most of our data layers required specialized tools, which further ratcheted up user interface complexity. A study on internet usage (Nielson 2011) revealed that if a user leaves a web page, it is likely to happen within the first 10 seconds. If you recall the web map interfaces that caught on with the general public back then, it was Google maps where there were no layers from which to choose and the only tools available were map navigation and text search.
3) Performance Scaling Issues: Another internet study (?) revealed that 3 seconds after a web page interaction, a user notices a clear lag in the responsiveness in the application. ArcIMS would render each dataset dynamically, so each additional rendered layers adds to the total latency experienced by the end user. Using a map application that takes noticeable time to render leads to the user regarding the application as "slow", a sure death sentence for the future of any application.
4) Tobin's Library Metaphor: There were a number of folks we ran into who disparaged the Intramap because it was missing a data record or layer in which they were specifically interested. Former college Tom Tobin would describe building the GIS like a library. You can construct a magnificent building and gather books from around the world , but if a patron comes in and you don't have the book they want, the whole is useful, at least to them.
5) Commoditization – We only started to run into this with Intramap. As we were investing heavily in ArcIMS as our platform. Other mapping software was just starting to become popular with the layman computer user, notably Google Map and Google Earth. Eventually, ESRI would event kill off their own ArcIMS software in favor of ArcGIS server. We had already made a huge investment in ArcIMS and planned to continue. Our sponsors were hesitant to continue in this direction; they may have been more inclined to support a new product. New is usually perceived as better when it comes to software and most of the time, I would agree that is the case.
6) Tragedy of the Commons. In the 2000s, when funding became scare, overhead activities, even the ones that benefited the Corps as a whole, had their funding eroded. The various offices looked to

each other to fill the gap. Even so, since there wasn't a direct benefit in the Intramap they could perceive, there was no real commitment on their part.

Eventually, our program got to a point where we were spending more time trying to get support for it through demos, effectively trying to justify our existence, rather than actually making improvements. In 2005, under budgetary pressures, our district began the process of unwinding our GIS program. We lost some good talent right as we were coming to the realization of what we were doing wrong. I remember coming to these conclusions speaking with a friend and co-worker of mine from time, Mr. Greg Gagliano, just before he left.

(Slide Lessons)

1) Lesson 1: Target the needs of workers over leadership. It's a fair assumption (and I'm pretty sure it still holds up today) that people like colonels and senior project managers are not going to be using our GIS software on a daily basis. Generally, they are likely to need to use GIS to answer one-off questions *(Provide Example?).* In contrast, the subordinates: engineers, technicians, and specialists are much more likely to have consistent needs and are much more likely to be technically proficient with GIS. That leads me to…
2) Lesson 2: Focus on the user's workflow and automate frequently used workflows. GIS shows its worth the most when it's used to solve problems. In a sense we were already doing this as I demonstrated earlier. Every time we would work on a project and deliver a product such as a map or dataset, we enjoy our share of praise and accolades. Project work was more rewarding and more value to our organization than creating a central web map. But we were limited by number. We are just one office of a dozen people or so serving an organization of about 1000 workers. The best way to serve our co-workers is to remove ourselves from the process and automate certain workflows where we can get the most value (*example*). This would get us most of the way to what would be in my mind a successful GIS program, but there would need to be one more piece…
3) Lesson 3: Educate and empower users (especially for simple infrequent use cases) instead of building software systems. The Roman Empire was built not only through conquest, but also through empowerment and delegation. After defeating a population, the Romans would give them some measure of autonomy and let them do things for themselves. Not only did such a strategy reduce the administrative burden of Rome, allowing it to scale to the size it did, but it also gave the new subjects a sense of ownership in the empire, at least to some extent. In that sense, if we could have more folks across the district do some of things we do with the data we have, they would have more buy-in and would support us more, while reduce our office's burden.

Act 4: The Return

We have nice insights and goods ideas, but it seems a bit too late. We had already lost most of our GIS staff, including Mr. Gagliano and Dr. Ratcliff. As for myself, I was also being nudged out the door, having been given a 30 day notice at one point.

However, through a stroke of fortune or misfortune, 2005 was also the year of hurricane Katrina. It was not too long after that, we would have a chance to prove the value of GIS to the Corps of Engineers. The Corps of Engineers was no longer an esoteric federal agency, whose work was taken for granted. Instead the Corps would be a household name, at the forefront of a major campaign to restore and improve the flood defenses of New Orleans, amongst other missions. One of my proudest accomplishments since I

worked at work was plundering the underappreciated and underutilized GIS talent of the Minerals Management Service, appealing to their sense of patriotism. So, we built a new team to support the massive influx of work related to Post-Katrina Hurricane Reconstruction and restored our GIS office. Restore may not be right word. We took a quite different approach based on our realizations from our experience with the Intramap. The approach we took:

1) Centralize Data we own and manage in a Database. One of the first things when we were trying to bring back GIS was to concentrate our datasets into a single central Oracle database. This was quite the contrast to the before time, where we were centralizing everything through an application. (Keep in mind commoditization means that eventually any application will become obsolete. That is much harder to say with respect to databases.) This would make datasets easier find and make them more authoritative. We built mosaics of our raster datasets. Instead of having to sort through individual photos, with a bit of processing on my end, users could just look a single large image in real time at a scale-appropriate resolution. Despite its simplicity and obviousness, this was by far the most valuable feat I've personally accomplished at the Corps. Even if a colleague knows nothing of the software systems I've been a part, they have loaded and used imagery, lidar, or multibeam without having to filter and piece it together themselves. Untold thousands of aggregate man-hours have been saved this way.
2) Deploy ArcMap to as many end users as possible. We trained end users on ArcMap and exposed them to the myriad datasets we manage. (No single, central webmap like Intramap before). Gradually, more and more new employee are already familiar with the ArcMap software.
3) EGIS Gateway: A very simple concept promoted by our former GIS Lead, Ralph Scheid, the EGIS Gateway is simply a catalog of layers and maps managed by our office served out to our users through an ArcGIS Addin that appears when they start up the software. The layers include a thumbnail preview and FDGC standard metadata to help users find resouces and decide if they are appropriate for the need at hand. This application dovetails nicely into our strategy of promoting proficiency in ArcMap usage.
4) Build tools as distinct extensions to ArcMap instead of web tools. Not only did this make sense, considering we are pushing the client software, but we found Addins are cheaper to build and maintain. Specifically, we didn't have to build as many tools, since we were encouraging users to use built-in tools.
5) Improve Data Acquisition. At the same time as we were getting our house in order, our Engineering Survey Section was also working on advancing their own capabilities. In addition to traditional surveys, our Survey Section got into terrestrial lidar, unmanned aerial vehicles, and marine drones. They've also hired on additional talent, including two lodestars from the Nicholls state geomatics program: Kent Hebert and Cody Parks, whom by the way are presenting on UAV Infrastructure Monitoring tomorrow morning. Go see it.
6) Build web applications with GIS in them, instead of GIS web maps. In cases where we need a centralized software system, we build the application around the data. GIS is part of the application where appropriate, but it is not the entire application. Typically I find other folks make GIS application where there is a single map and all interactions occur through that map. Not that I have some empathy for these folks. I say there are many cases where that structure can be alienating to the users. In addition to the problems of latency I pointed out earlier, the map interface tends to break down if the data structure is more complicated than single unrelated tables or feature classes. I'm proud of the fact that many of our web applications have gone on to

be used at the national level, including PETS to manage permits and FREEBOARD to manage inspections and materials for emergency response.

Act 5: Conclusion

So there you have it: the story of the map of everything. I want to think we were the first of the many districts, labs, and other Corps office to try something like. I can say with confidence that we were not the last. Corpsmap, SimSuite, REDI, MODA: these are some names of GIS viewer systems developed by other groups within the Corps. They each met with some degree of success initially, then fell out of favor when they reached a critical mass of data layers and / or another shiny new solution came along. The Corps is trying again with another national centralized system. This time it is based off of ArcGIS Portal and Storymaps. I've seen it and it looks very slick and impressive. I don't think it will succeed though. However, I would love to be proven wrong. We'll see if they can overcome the same forces that brought down Intramap. For our part, we'll keep providing content and data through the power of web services to these other systems as they come and go, letting them handle the aggregation. And when they get replaced, we will provide data to whatever comes next through whatever protocols come next. I consider that a happy ending, at least for now.

You'll notice in the example of projects I mentioned, it was clear and obvious who we were helping and how we were helping them. In the case of the general-purpose map-of-everything, we were giving our customers everything they were asking for, helping everybody, which I now realize is really helping nobody. The question we should have asked is not "Can we do it?", but rather "Should we be doing it?" or "What should be doing instead?" That was my takeaway. So ultimately this is what I hope to leave you with: In the course of your professional endeavors, always remember who you are working for and always understand how your work will benefit them. The moment you don't, that's when you should recognize you're in trouble. Thank you and I bid you all adieu.

Our survey oriented Geomati-sists [sic] have advanced the District and the Corps of Engineers with UAS utilization and standardization of UAS processes and equipment. Our need for survey-oriented graduates is critical in order to support the myriad of datums, epochs, subsidence and tying it all together.

New Orleans (semi-regrettably…) is a hotbed of these issues – providing a great training ground for future geomati-sists. Mark Huber had leveraged his talents and expertises to move up to the Amry Geospatial center. Many have moved on to impactive positions in government and private industry.