SPACE UTILIZATION OPTIMIZATION

OVERVIEW

This narrative addresses use of Space Utilization Optimization as part of an integrated Geographic Information System (GIS) based spatial data management and decision support system as implemented at the National Aeronautics and Space Administration's (NASA) Langley Research Center (LaRC).

This information is based on the GIS Team's experience at NASA LaRC as well as experience gained working with partners that have similar goals. The space utilization optimization and supporting tools were developed to address the need for optimizing facility usage in order to minimize operational costs while maximizing synergy between employees and organizations. As these tools were developed for relatively complex Government facilities, they should be readily adaptable for use in others environments.

The GIS Team's long-term goal is to enhance and develop this technology, in order to provide objective tools for organizations to control cost while accomplishing their primary mission with increased efficiency and effectiveness.

BACKGROUND

LaRC, the oldest of ten major NASA Centers, is located in Hampton, Virginia, adjacent to the Langley Air Force Base. Historically, the general scope of LaRC has been 800 acres and 300+ buildings comprising 6,000+ rooms totaling 3+ million square feet, with assets valued at approximately $3 billion. The facilities were designed to house over 4,000 Civil Service and contract employees. LaRC has been identified with Aeronautical or Wind Tunnel research for over 50 years, but also supports many other disciplines, including Structures and Materials, Flight Electronics, and Atmospheric Sciences. Such diverse capabilities require a massive and complex infrastructure as well as specially designed buildings. More recently LaRC has experienced significant reductions in operational, maintenance, and staffing funding while simultaneously adapting to major mission changes, including development of the next generation of space vehicle. All of the aforementioned contribute to LaRC's need to make optimal use of its current and projected facilities and resources. The only way to properly address the changing mission profile of LaRC is through dynamic and structured allocation of resources, including the assignment of space within each facility and across the Center.

GIS for LaRC was born more than two decades ago out of an anticipated need to address facility planning more efficiently and effectively by capturing corporate knowledge into configuration management and decision support systems. Integration of data sets was seen as a key method to ensure sustainable data maintenance. Integration efforts include support to functions such as Master Plan, Real Property, Utility Systems, Environmental, Facility Full Cost, Maintenance, Personnel, and Space Utilization. A primary goal was to cultivate and manage the most stringent data that was available, reducing the number of data sets and encouraging data use in order to simplify maintenance by multiple users.

GIS has been fostered at LaRC by a Team consisting of a few Civil Servants, with contract support making up the majority of personnel. The team has grown in recent years to approximately a dozen, plus a year-round group of about 10 interns. The GIS Team has strived to be associated with the Center's Facility Engineering group so that the philosophy of "most stringent data" was supported. The GIS Team not only addresses the needs of LaRC, but also outside organizations through partnerships. These partnerships were formed when outside organizations such as other NASA Centers or Government entities such as the Air Force were interested in a capability that LaRC's GIS Team was pursuing. These partnerships allowed distributed funding for development efforts, which allowed more aggressive pursuit of many capabilities over the years.

BUILDING INTERIOR DATA

LaRC's GIS Team manages plant level spatial data for the facility, as well as having managed building interior details in GIS for over a decade. The LaRC GIS Team has chosen to maintain room level data in a non-georeferenced fashion. The data looks much like an architect's plan for a building that depicts multiple floors of a building orthographically laid out on a large drawing. The large drawings for all the buildings are then maintained in a grid that is independent of details for other buildings and infrastructure such as roads. Subsequently, the data is translated, scaled, and rotated to allow the room level data to overlay the plant level data when needed. To accomplish the translation of data diagonals are used to match the data maintained in the grid to the georefenced data.

A valuable application of this technique allows users to demonstrate outdoor/indoor utility alignment. This approach maintains legacy views of building interior space as well as deal with known distortions between building and plant data. Additionally, the process has been extended to a hybrid CAD – GIS environment for some partners such as Johnson Space Center (JSC). This process allows the owners of the building interior data to receive the benefits of spatial data analysis available through previously developed LaRC processes. The CAD – GIS hybrid approach can either be used as a measure to allow a gradual transition to GIS maintenance or integrated into a long-term data maintenance process.

LaRC GIS Team's experience indicates that geometry that accurately describes the interior of facilities is extremely beneficial for a multitude of functions. A variety of functions can be addressed by starting with a baseline data set describing a facility's perimeter polygon, interior polygons, and each room or addressable space (such as stairways, elevators, etc.). Subsequent efforts with the application of additional spatial data may include other systems such as electrical panels, fire equipment, communication jacks, handicap accessible features, or egress routes. Similarly, experience indicates that as additional information is layered on the basic floor plan, it is more likely that changes to the floor plan and its associated data will be reported. Encouraging critique from numerous perspectives enhances accuracy and sustainability of the data.

Additionally, tying the graphical data to other processes including Relational Database Management Systems outside of SDE such as tabular Space Utilization, Real Property, and Maintenance Management tools, and implementing periodic gap analyses reinforce sustainability of the data. Some examples of this are; comparison of building footprints with the facility's Real Property data, and base mapping with floor plans for gross square feet analysis for the buildings. Links to relational database management systems such as maintenance management or communications requiring equipment to have a valid building/room location and active links with Personnel data would reinforce the data accuracy, currency, and sustainability.

EXAMPLE OF NEED FOR SPACE UTILIZATION OPTIMIZATION

Langley Research Center, along with the rest of the Agency and other Federal and State organizations, as with much of the corporate world, continues to experience pressure to undergo major downsizing and reorganization. The stimulus for these includes alterations in mission requirements, the introduction of full-cost accounting methods, funding cuts, and the excessive operational and maintenance costs associated with aging infrastructure. LaRC felt even further pressure from the change in NASA's mission emphasis from aeronautics to space exploration. As a reaction to external stimulus, LaRC established an initial goal to continue to support projected missions with reductions of 25% in land, buildings, and personnel at LaRC.

The extreme complexity of LaRC's facilities (partially due to their age of 50+ years—heavy walls from Cold War era construction) was a major motivation for LaRC to pursue automated optimization for space utilization. Additionally, there is a need for a mechanism to overturn the heavily entrenched legacy processes of perceived "ownership," whereby an organization or function that had existed in a building for decades essentially determined how the building would be used forever. As with other GIS process, we strive to provide objective decision support tools to dislodge the legacy ownership environment, and to have reorganization efforts driven more from potential synergy benefits and cost avoidance. The current approach reports the value in dollars of any scenario under consideration in an effort to reduce impact of subjective decision-making.

The need existed for a Center-wide strategic capability to support more effective and efficient facility management through the use of Geographic Information System (GIS) and optimization technologies. In addition to the usual requirements for office space, NASA Centers and other Federal facilities must satisfy a wide range of special space requirements (e.g. laboratories, wind tunnels and launch facilities) to support a diverse and evolving mission. Efficiently managing the changing mission and projects with limited resources is a challenging task. Space and facilities managers needed a decision support system that can track changing workforce and project requirements and map those against available facility resources. Such a system will significantly enhance decision-making in determining optimal space allocation and scheduling by considering project lifetimes and changes in resource needs while balancing immediate needs with forecasted requirements. Additionally, the system would provide objective analysis to achieve an optimal combination of adaptive reuse and "repair by replacement" projects to address deteriorating conditions and increasing maintenance backlog for the Center's facilities.

In late 2004 LaRC was preparing for a major reorganization, and bracing for four or more months of turmoil. During this period, the Center expected to relocate up to 3000 people, reduce average office space per person from the current 190+ square feet to a target 125 and free up approximately 100 facilities for closure and demolition. This situation was the mother of invention for automated space optimization at LaRC.

With the challenge looming, LaRC's GIS Team began the development of a series of automated tools based on Geographic Information System (GIS) and Relational Database Management System (RDBMS) technology to support managers in this complex reorganization effort. These tools support the development of multiple scenarios using both objective and subjective decision criteria to visualize and analyze various possible space allocation solutions.

LaRC GIS Team has learned much from the initial endeavor and is pursuing a project to refine the previously developed prototype capabilities, which will result in an integrated and sustainable space utilization decision support environment for LaRC and other large and complex facilities.

INITIAL CAPABILITIES

The capabilities outlined in this section represent deliverables under the earliest phase of the evolutionary development strategy. During this early phase, visualization of current personnel location, organizational distribution, and space utilization was made readily available to Center personnel with standard web browsers. This tool allowed infrastructure managers to readily assess current organizational space allocation and to determine overcrowded and/or underutilized facilities.

To help meet the challenge of reducing operational costs by more efficiently utilizing available space, the NASA LaRC GIS Team tested and continued the development of optimization algorithms. Originally developed in conjunction with NASA design optimization engineers, the initial algorithm was designed to help redistribute organizational slots based on a variety of user-defined criteria (i.e., lab/technical space constraints, organizational synergy constraints, move minimizations). A web-based tool was originally developed and is expected to be reengineered to assist space utilization planners in analysis of information concerning laboratory and technical space. Data collected from this tool was made available to the optimization algorithm to further refine constraint definition and cost metrics. Additional improvements in efficient space utilization were explored through the development and implementation of more advanced optimization algorithms such as genetic or simulated annealing algorithms for space optimization as a part of the proposed Space Planning Framework.

Using the power of the ArcGIS software coupled with custom Visual Basic code, the NASA LaRC GIS Team developed an early GIS application that allowed space utilization managers to construct and evaluate various “what-if” move-planning scenarios. The application allowed the interactive manipulation of organizational slots both within buildings and between buildings while displaying space utilization parameters (i.e. over/under capacity) in real time. Coupled with the optimization algorithm, this tool enabled space utilization managers to rapidly evaluate proposed scenarios. The tool retains the legacy capability for managers to add constraints such as room or personnel “lock down,” after which the remaining space can be optimized.

SPACE UTILIZATION OPTIMIZATION PROCESS AND TOOLS

Space allocation planning is a complex problem involving the allocation of limited resources to meet business goals, reduce operating costs, and promote an effective and productive workplace. The optimization process has many facets and is very complex. So that some benefit could be realized from incremental accomplishments during the development phase, the effort was broken down into modules. These modules include visualization, optimization algorithm, data maintenance, web interface, technical space, etc. The following narrative roughly parallels the development process.

VISUALIZATION: One of the difficulties with talking about space planning in the context of a large organization like NASA Langley Research Center is the problem of getting the big picture without losing the necessary details. The following outlines our next generation of user interface: This interface will employ a dashboard concept which will allow the user to access any or all data representations such as the unit square diagram, the Plant level map, the building interior layout, and any supporting tabular data. The capability will allow consumers of solutions to readily see relative size and proximity of buildings, rooms, and personnel for an entire base. Additionally, the tool uses any symbolization and labeling available through GIS. For more detailed analysis, additional conventional map views and building layouts with room details are available. The user will be able to visualize current conditions and various proposed optimization solutions and manually adjust conditions through tools such as drag and drop.

Thus far GIS-based visualization tools that address both Plant level and individual building level have been developed. To address Plant level visualization a tool that we refer to as “Unit Square” or “spatial subdivision diagram” has been developed. This diagramming technique uses an abstract representation of all buildings at the Center compressed into a rectangle. Since the focus is on space utilization, features such as roads, parking lots, grass, etc., are not addressed in the data-viewing tool. The diagram capability maximizes any view window for the data under consideration. The tool effectively eliminates white space (distance between buildings) on a drawing by compression and proportioning the data.

Bold rectangular areas represent all of the facilities buildings. They are roughly oriented based on proximity to buildings around them. The size of the polygon represents usable space within the facility. The rectangle that represents a building can be further subdivided to address all rooms. The blocks within the building represent the space of each room. Again, size is proportional and relative position to the real world location is maintained, with multiple floors of buildings delineated with shadow lines. There are many areas in a building such as circulation areas, stairwells, bathrooms, mechanical equipment rooms, etc. which may not be germane to a space allocation problem and thus need not be included for analysis via the visualization tool.

Symbolization can then be applied to the unit squares for buildings and rooms to show those spaces that are appropriate for general office use and technical areas symbolized based on the owning organization. The closeness in color is indicative of the closeness of the organizations in the organizational hierarchy. A similar scheme is used to color point features indicating all the personnel at the center. The aforementioned technique can visualize not only area but also any commodity or value such as maintenance cost where size could represent cost.

The goal for optimum synergy would be to have similar colors in close proximity. The unit square diagram provides a dense and concise visualization allowing user interaction with the massive and diverse data associated with managing a complex facilities space. The unit square approach can be extended to illustrate each person’s space at the Center. Thus from one interface or data view, the user can interact with data for the entire center that represents either building level, room level, or personnel level data.

METRICS AND CONSTRAINTS: Due to the complexity of the space utilization-planning task, it is useful to have a model so that one scenario can be compared to others as we estimate progress toward some goal. That model must address critical variables and effects but be simple enough to make analysis feasible.

Infrastructure-related costs are obvious components to be addressed in the model; less obvious components of a cost model are those that capture the more nebulous effects on performance of a group such as organization communications. These communications or organizational interaction translates to a synergy component in the overall equation.

In order to make the model as flexible as possible, it needs to be as general as possible. The first generalization is to refer to any person or function that consumes space as a consumer. This could be a laboratory, a conference area, etc. Similarly, both office and technical areas are simply referred to as space. These spaces provide certain resources that the consumers need. The most common resource is of course area, but additional resources can be modeled like communications jacks, bandwidth, power, environmental impact, etc.

Once we have our basic components we need to be able to evaluate and compare particular allocation plans. We need to be able to ask, “Does this allocation meet our rules?” and “In comparing two valid allocations, which one is objectively better?” Processing of the optimum placement of consumers in the Center’s facilities will be governed by “constraints.” These “Go - No Go” parameters include considerations such as adequate space for the function (minimum area for varying types of employee), compatibility with adjacent functions (supervisors/employees not placed in the same room), and compatibility with features that the space readily provides (floor loads, high bay, etc.). Further evaluation of the quality of the proposed use of space is driven by “metrics.” These softer controls address issues such as organizational synergy (the closer personnel are positioned within an organization, the better the metric), move costs, and symmetrical distribution of space.

The result is a proposed scenario that meets all constraints and is rated by metrics. The quality of the solution is expressed in dollars, allowing space utilization personnel to present various solutions to management for consideration. The different scenarios will inevitably include manual adjustments to address an organization’s political issues; the cost of the potential changes provides a discriminator for more objective analysis. Management may then decide if the manually induced change is worth the expenditure to the organization to address the political issue.

DATA MANAGEMENT: As with any system, collecting and maintaining accurate and current data represent challenges for the organization. One problem is that the aforementioned process requires pulling data from many different sources including personnel, GIS, space utilization, with these sources of data constantly changing. The process we use is to snapshot the data, resolve any consistency issues, and as needed, reconcile any resulting plan with a current snapshot. Resolving and mapping the source data to our general model is very time intensive and involves both data and scenario-specific considerations.

An XML schema was developed to provide a language for the model. This language is tightly bound to the source code implementation and is reflective of the very general nature of the model. Since virtually every data source has some sort of mapping to an XML schema, the XQuery language was used to leverage data transformation. The result is a “recipe” that addresses the heavy lifting required to arrange or systematize the corporate knowledge.

Before the XML/XQuery capability was available, preparation for an optimization run took two weeks of intensive effort. Using the “recipe” capability, preparation for a run takes about thirty minutes.

OPTIMIZATION ALGORITHM: Once we had a model instance, we could manually manipulate allocations and get feedback on the constraints and metrics; but what we would like is to have the computer automatically find an allocation that is in some sense “optimal.” To get a grasp of how big a possible solution set for a complex facility is, we will start with a small model. A small example that might be considered would be a proposed move involving four people and five rooms. In this example there are many possible mappings of the consumers to the space. In fact, for this simple problem, there are about a thousand distinct allocations. We could easily calculate each of these, throw out the ones that don't meet our constraints, and pick the remaining one that has the lowest composite cost metric.

When the problem LaRC faces, with roughly 4000 people and 4000 spaces, is addressed, the resulting number of permutations is enormous. This equates to 10 to the 14,400th power. To get a handle on how large this number is, an estimate of the number of grains of sand in all the world's beaches is 10 to the 18th power and the number of atoms in the observable universe is 10 to the 80th power. Obviously, no amount of computational power could ever force an answer via an exhaustive process. What is needed is a method that gives a very good result in a reasonable amount of computational time.

The current optimization approach divides the search into two parts. The first part is a constraint solver that takes an allocation, which has violated one or more constraints and finds a solution in the same neighborhood that satisfies all the constraints. The design is interesting because we needed a framework that is extensible, so the process needs to work for constraints we haven't yet imagined. The second part of the search is a greedy heuristic that takes the most direct route from a given constrained solution to a constrained local optimum. It does this by iterating over a priority queue of consumers and using an efficient local first search. The solution that we get is a local, not a global, optimum.

Optimization is conducted not only from the current condition but also from a random allocation. The results from these processes typically are good synergy within the smallest organizational units, but a lot of issues are noted where large scale changes might improve the higher-level synergy and collocation with technical space. What we would like to do is take the good ideas from each and make them fit together. By evaluating the metrics per consumer in each solution, we can create a new solution that tries to combine the best of both. Doing this inevitably results in a solution that doesn't meet the constraints and may not initially look better, but through constraint solving and re-applying the greedy heuristic we have a viable alternative. Combine this with a progressive filtering algorithm, and we can often find improvements to any local optimum. Feeding the process a stream of random solutions enables it to integrate progressively smaller ideas into an improving final solution.

The following illustrates the benefits of large-scale optimization at a complex facility such as LaRC. The combined metrics for the Center's current space allocation produces a value around 25 million dollars. If we apply the greedy heuristic alone, requiring just a couple of minutes, the resulting allocation has a combined metric of 15 million dollars; and, if we run that through the meta-heuristic over about 24 hours, the resulting solution is approximately 11 million dollars and the rate of improvement is generally very low after that.

Much of the previously described effort has been documented through videos that are available from LaRC GIS's outside website at the following URL under optimization. http://gis.larc.nasa.gov/

FUTURE EFFORTS

WEB INTERFACE: Recent work is focusing on the development of a dashboard-style web interface that affords an information-dense visual analysis experience. The capability gives context-sensitive and immediate graphical feedback showing progress in meeting constraints and reducing costs, thereby offering space planners a powerful decision support system. The current focus is on providing drag and drop style planning for fine-tuning of optimization solutions.

ADMINISTRATIVE SPACE: In one example, the optimization separated staff functions from their respective senior managers, based on the lack of definition of synergy between the functions. Subsequent analysis of this problem may lead to a new way to describe affinity between managers and their immediate support staff and the type of space they need. Under this new model, office suites (areas compatible for senior manager, deputy, and administrative assistant) and potential occupants may be assigned exclusivity values that will allow the optimization algorithm to better manage the unique resources (both real property and human).

OPTIMIZATION ALGORITHM: The first is alternative search methods including population based and hierarchical meta-heuristics. Specifically we are working with Operations Research faculty at William and Mary on extending the greedy heuristic with tabu search.

TECHNICAL SPACE: While the code fully supports technical space, there are a lot of very specific requirements that need to be mapped. Parallel development efforts are underway to extend automated optimization to address this diverse space. Currently, this process is focused on LaRC data, with an attempt to align with General Services Administration (GSA) categories, and then describe unique features associated with each category of tech space. Subsequently, average costs for demolition and creation of unique features will be used to calculate feasibility of converting one type of technical space to another.

SCHEDULING: The goal is to provide a scheduling capability that optimizes support to mission and projects and replaces the legacy model where a particular organization owns specific buildings. The Optimization tool will provide space utilization and facility managers an immediate as well as a long-term overview of localized and broader options and impacts associated with current and proposed use of the facilities space. Staging and decisions regarding which project should be supported at the facility are planned to be addressed. The goal is to objectively support Agency level decisions regarding placement of future projects. The Optimization tool will facilitate analysis to support facility closures, and on/off-center leases. We feel this concept may be extrapolated to other organizations regarding functions such as mission changes for the facility or possibly functions such as Base Realignment and Closure (BRAC).

AUTOMATIC ROUTING: The current distance model is Euclidean between the room and building centroids with a fixed inter-floor distance. We would like to be able to model using more accurate distances derived from automatic routing within the facility to improve the solutions.

HUMAN FACTORS: A very interesting area is social networks where we see many similar types of networks appear to follow a power law or scale free structure. In these networks we see that most nodes have few connections, but some nodes have many. In our case, this would imply that some people within the organization are critical pathways for communication.

SPIN-OFFS: In the process of implementing the space allocation planning tools, extensive knowledge and experience was gained with many new software technologies including XQuery, Rest and Ajax Web Architectures, the Dojo Toolkit, and ESRI's ArcGIS Server and Javascript/Rest API. This will yield many beneficial products such as more intuitive and powerful web interfaces for many GIS and RDMS tools.

RETURN ON INVESTMENT

In terms of tactical investment strategy, the proposed system promotes the public good at any facility by modeling and objectively analyzing impacts on issues such as safety and security, historic preservation, natural resources conservation, workforce productivity, environmental quality, and energy and materials efficiency. Enabling sound stewardship of public assets is a fundamental goal of such a strategic planning effort. The space utilization optimization system, its underlying technology, or spin-offs from development of the technology, may benefit other Federal facilities such as DOD, GSA, and the GIS industry in general through technology transfer activities.

Use of optimization algorithms in concert with GIS promises extensive benefits for government facilities. The benefits associated with the system under development can be illustrated with a concrete example: The goal of a 2005 office consolidation project at LaRC was to reduce office space utilization from 192 to 125 sq. ft./person. A manual decision process was used due to time constraints and lack of funding for GIS support. The resulting subjective solution moved 2500 personnel and achieved 149 sq. ft./person with an average cost per move of $354/person. Subsequently, a prototype automated optimization model similar to the one proposed here gave an objective solution whereby the goal of 125 sq. ft./person could have been achieved by relocating only 1200 personnel. The optimization approach would have saved the Center about $460K, minimized disruption of normal operations, and achieved greater organizational synergy. This example addresses only move-related costs for a single effort focused on office space. Annual cost savings associated with additional facility closures accrued over multiple years and across multiple Centers would result in millions of dollars of benefit to the Agency.

LaRC has many times more technical facilities space as it has in office facilities, with the current replacement value (CRV) of the technical facilities dwarfing the CRV of the office facilities (approx. 30x). Additionally, the cost for operating the technical facilities is nine times as much as for the office facilities. In the LaRC example, operations-and-maintenance-cost avoidance for facilities that have been recently closed is approximately $2.9M. Annual operations and maintenance cost savings resulting from use of a GIS-based optimization capability associated with facility closures accrued over multiple years and across multiple Centers would result in hundreds of millions of dollars of benefit to the Government.

Recently when Johnson Space Center was evaluating Optimization technology for possible investment, they conducted their own ROI analysis. They concluded that investment to extend their Space Utilization with Optimization would pay for itself with efficiency benefits if their use of space was compressed enough for one organization not to have to rent outside space during their upcoming mission change. They also recognized that effectiveness and less quantifiable benefits would be realized by achieving better synergy within and between their organizations.

Investments in optimization and GIS technology for facilities management in general will propagate to other Centers, Federal, and possibly non-government facilities. This technology will be especially beneficial to facilities experiencing major organizational changes, consolidation, growth, or downsizing. Modern spatial data management and planning support will enable the facilities embracing the technology to respond more rapidly and efficiently to changing mission goals, budgets, Federal requirements (environmental, security), and disaster planning/recovery.

CONCLUSION

NASA’s human resources and facilities are its greatest strategic assets. The proposed system will optimize the mapping of these assets to achieve Center and Agency objectives. The system will enable prioritized resource alignment with NASA’s strategic objectives. More efficient use of existing and proposed infrastructure will reduce facility-related costs, and more efficient scheduling of resources will minimize delays, thus promoting successful realization of mission goals.

LaRC GIS has produced several major components of an operational software package for space allocation optimization. This provides NASA LaRC and partners with tools for improved decision-making, which will result in improvements to center/base operations and cost savings. LaRC GIS is currently planning development and integration of many other capabilities. Currently available foundational components include a robust Oracle-based Space Utilization database with extensive web interface, GIS-based data management techniques for building interior features that allow overlay of interior details with georeferenced mapping, optimization algorithm for administrative space, and visualization tools such as spatial subdivision and building/personnel layout diagram.

The aforementioned contribute to a discrete optimization toolkit which produces solutions that minimize the combined costs associated with lack of organizational synergy, functional synergy, inefficient space utilization, and move costs. XML schema was developed for the space allocation optimization model. The XQuery language was leveraged to produce a concise and manageable mapping from the disparate source data into the XML model schema, which dramatically reduce data preparation time. The spatial subdivision diagram visualization tools have also been significantly enhanced, providing decision-makers with a comprehensive view of spatially sparse datasets and allowing them to make well-informed choices much more quickly. Work is currently underway to provide a web interface that will not only display proposed solutions, but also allow manual adjustment of the scenario.

Development and deployment of this strategic decision support system was estimated three years ago to cost $1+M/year over a 5-year period. Due to priority conflicts and budget limitations, funding was not obtained. Subsequent development efforts have included partners that required focus on specific user needs with less than optimal funding levels. However, we have been able to keep the proposed technology alive and maintain a significant portion of the original vision and have been far more successful than envisioned.

A large portion of the risk associated with the development of an optimization capability has been mitigated by applying optimization algorithms to space utilization. Work is underway currently to generalize the implementation so that the application will be more applicable to organizations beyond LaRC. The previously described optimization algorithm has been implemented and tested for several proposed administrative space changes at LaRC, as well as with partners such as Air Combat Command, and will soon to be applied at Johnson Space Center. These tests will yield additional rules that will be addressed as the optimization code evolves.

The LaRC GIS Team has made much progress and is planning future development, refinement, and integration of spatial analysis tools for move planning and space utilization. Some of the capabilities LaRC GIS is considering include long-term scheduling (cradle-to-grave project planning), automatic route generation (better distance calculations for synergy analysis with many other potential benefits), technical space optimization (compatibility and cost feasibility analysis to convert various types of space to address new missions based on creation and deletion of unique features), management of versions of scenarios (integrate best features from different scenarios, efficiently extending analysis capabilities to environments where data exists only in CAD and Spreadsheets).

If your organization has interests that align with the goals of the LaRC GIS Team in the area of Space Utilization and Optimization, please feel free to contact us regarding possible partnering to continue or accelerate the previously outlined capabilities.

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