VISIONICS DATA BASE GENERATION: AN INTEGRAL PART OF TRAINING, PLANNING AND MISSION REHEARSAL

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ABSTRACT

The 58th Special Operations Wing (SOW) of the Air Force Air Education and Training Command and Martin Marietta currently operate the largest data base generation facility in DoD tasked with producing high fidelity photo specific simulation data bases for DoD customers world wide. Started in August 1990, initial data base support was limited to five data base engineers producing basic training environments within western United States and the development of small mission rehearsal areas that were utilized by Air Force personnel only. Today, this facility has grown to twenty data base engineers and three full time intelligence personnel working around-the-clock seven days a week. Utilizing a dedicated state of the art Sun and Silicon Graphics network encompassing the latest technologically advanced applications, this team has produced nearly seven hundred thousand square nautical miles of visual data base supporting multiple customers in the Department of Defense.

This paper addresses the high fidelity simulation data base generation and the application of the standardization scheme developed at Kirtland to overcome the many challenges inherent in the construction of data bases. The joint contractor, government team at Kirtland has developed a standardization methodology that promotes efficiency, reduces cost, and improves quality. The technological barriers overcome involved integrating multiple disjointed data bases into a single contiguous landmass, converting data bases into multiple Image Generator formats, and scrutinizing the DMA specifications. The development of these standards and the substantial experience of the 58th SOW data base generation facility was instrumental in DoD's decision to co-locate the Project 2851 Simulator Data Base Facility (SDBF) at Kirtland. This facility will be networked with the 58 SOW data base facility for data base production and transformation synergy which will benefit all of DoD and industry.

About the Authors

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INTRODUCTION

Since August of 1990, a highly motivated team of government and contractor personnel has been efficiently developing large quantities of real world, photospecific data bases for combat oriented training and mission rehearsal . This government owned, contractor operated facility is now staffed with 20 data base engineers and three full time source data specialists supervised by a government intelligence and planning specialist. Experience ranges from helicopter, fixed wing, fighter, armor and sensor data base simulation programs. Much has been learned in "boldly going where no data base effort has gone before". This paper discusses the processes and standards developed as well as critical lessons learned. Now the largest government owned, contractor operated (GOCO) simulation data base generation system and library in the Department of Defense, this team has spent considerable time planning and implementing a unique approach to high quality, high accuracy rapid data base development which continues to evolve and improve to this day. Let's examines this process and learn from it's experiences, both good and bad.

LESSONS LEARNED

As the data base facility at Kirtland grew to accommodate additional tasking, the number and complexity of commonly encountered data base obstacles grew at an even quicker rate. Situations that might have normally occurred only once during the lifetime of a visual data base were now affecting the process in a multiplicative fashion. Small disjoint data bases needed combining, older data bases needed updating and moving models needed to look and act exactly the same way in every data base. Given normal production time lines, all of these issues are easily overcome using the traditional method of reformatting, retexturing and retuning. In a mission rehearsal environment it was, and still is, unacceptable as time becomes the critical factor. Compounding the situation were documentation and configuration management issues. Tracking and documenting the same files with singular differences soon accounted for nearly 30% of the man hours expended on the projects. Also, came the most difficult of lessons, that of data base conversions and source data. It was difficult to explain to a "customer" that indeed his area of interest had been constructed, however significant effort was necessary to "rebuild" the data base to fly on his visual system. To the customer, all the eloquent technical explanations boiled down to, "how long will it take". Source data became an issue early on when data base engineers began asking themselves questions such as "how tall does that fence look to you?", or "is that a wall or a hedge?". These questions brought up concerns that unqualified decisions might influence a crew to change their mission based on the virtual environment they were experiencing. The reality was painfully too obvious. After all, that's what combat oriented training and mission rehearsal is all about. Even today, data base engineers at most production sites are forced to make important decisions that are best suited for photo interpreters and image analysts. If accuracy is a critical *requirement, then it's critical* to have accurate source data information.

THE PROCESS

Addressing this last problem first, the acquisition of source data information to support the data base group was actually the easiest of all to solve. Consequently, a Tactical Analyst (photo interpreter), Electronic Warfare Analyst, and JARMS engineer (Jammers, Artillery, Radars, and Missile Systems) were added to the Kirtland site. It is their mission to support the data base process and enhance the simulation experience for all the users. Each member of this team has significant military experience in their associated fields. With this group of specialists formed, it was now time to address the other issues. The solution involved a two-fold approach. The first part involved the data base process itself, while the second dealt with a standardization scheme. The total solution had to accommodate rapid data base generation, conversions, connections, updates, and incorporate this newly created source data group, while the standards needed to affect every aspect of data base generation and remain flexible enough to accommodate the inherent uniqueness of each new environment.

The first task at hand was the re-evaluation of the data base process. Historically, detailed data base requirements were sketchy as air crews tried to describe in non technical terms what their mission might require from a visual data base. These discussions overlooked issues such as the source of provided latitude and longitude coordinates, the datums of these coordinates, lines of communication and obstruction data, threat information, and even the validation of the data. So who on the government side is qualified to provide this information? Thus began step one in modifying the data base process. Our local government simulator organization or OGU could ask these and other questions and if need be determine the answers *before* the data base work is ever started. The emphasis became "good source data from the start" and the adage "garbage in, garbage out" was adopted. Figure 1 illustrates how the new source data team was integrated into the data base generation process.

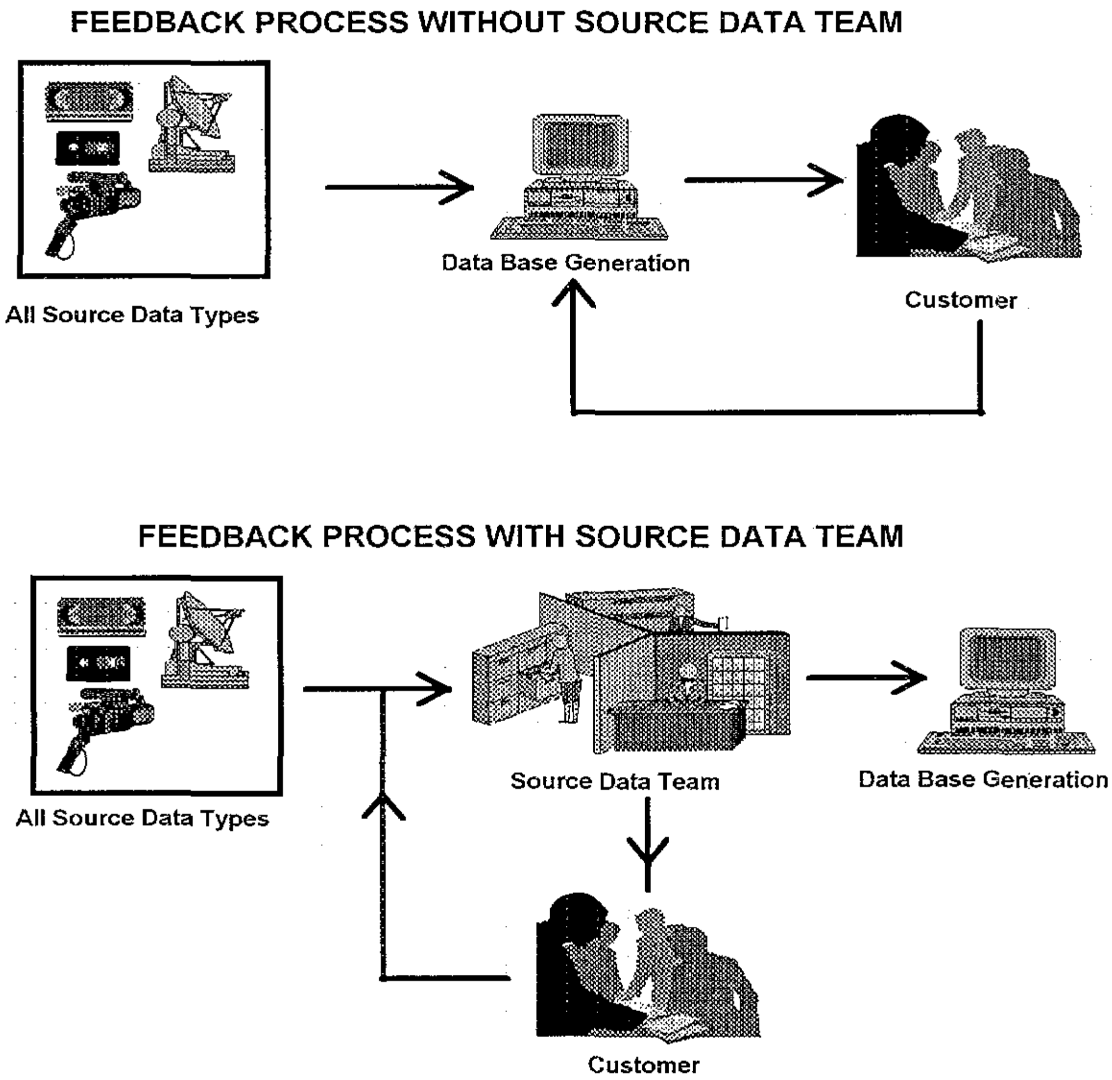


Figure 1

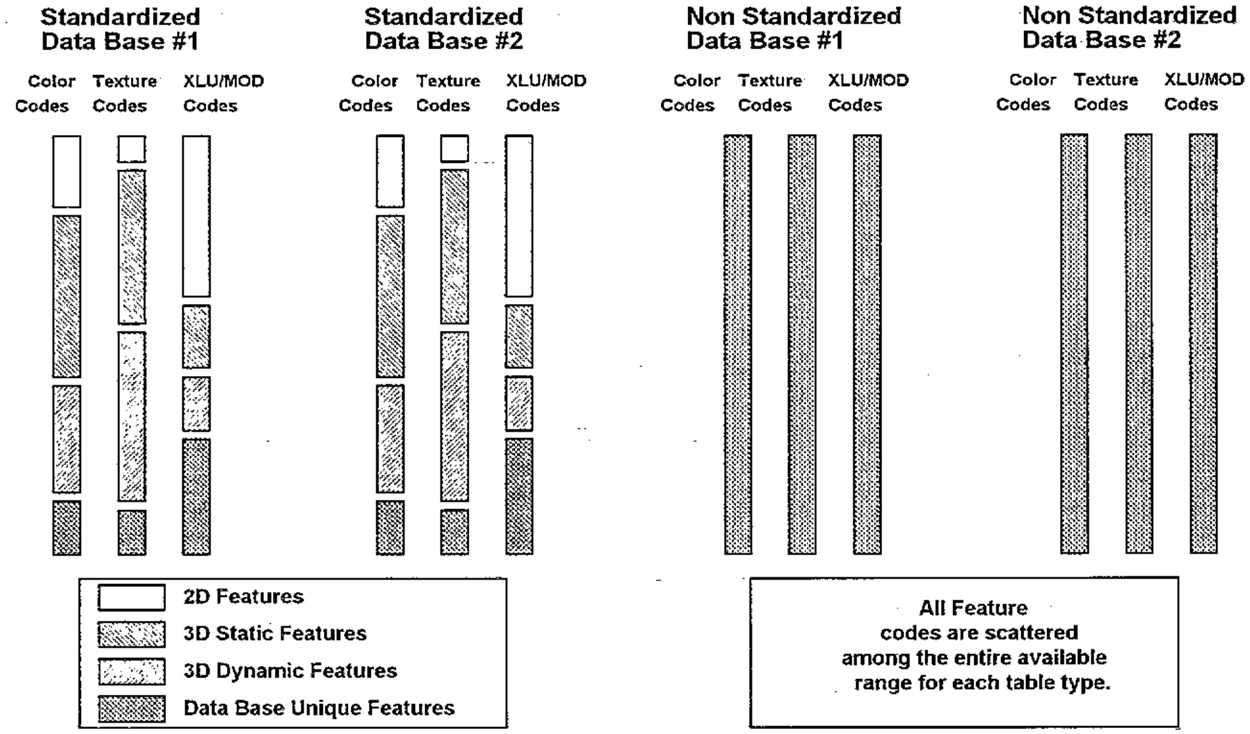
Now a procedure looked upon as ritual, our source data team is responsible for identifying coordinate datums, verifying the accuracy of these coordinates, identifying and prioritizing feature importance, and feature mensuration. They are also responsible for ordering, cataloging, and tracking every piece of source data received by the facility. Data base engineers now had a reliable, valuable, and best of all, local point of contact for source data and related information. To insure the government/contractor team has access to all types of source material of interest, the team is now equipped with state of the art mission planning workstations that allow receipt of media ranging from broadcast and VHS tape to 8mm tape, CD ROM and Laser Disk. Since it's inception in early 1991, the source data team at Kirtland has acquired, collated and processed the data needed to support both training and mission rehearsal activities. And, over the past several years, has amassed a documented data library now used by multiple "customers" in DoD for simulation support.

Drawing on the vast experience of the data base engineers, the entire team scrutinized the remaining areas of the data base process down to the smallest details involving file structures and tools used. Focusing on the tasks that required the most effort, combining data bases became the first target. The first manifestation was the realization that the construction of a data base is not a linear process. Several different tasks can be performed simultaneously and merged at some point later in the process. The key is to insure that when the merge takes place all the pieces match precisely so that no rework or duplication of work needs to take place. This merging process may be as simple as combining two files together or as complicated as combining two data bases together. Based on our experience, independently designed data bases will have to be combined into a single contiguous landmass. With additional growth planned in the future, it was originally postulated that if there were some way to insure that like features in every data base were identically attributed, combining data bases would be greatly simplified. The only time required would then be that needed to integrate the geospecific features inherent to each separate data base into the combined total. The solution was obvious. We needed to create a standardized set of global attributes and a library of three dimensional features. The global attribute set that resulted was designed to be as rich in data as the data base generation software would allow. Beginning from Defense Mapping Agency's (DMA) level 2 Digital Feature Analysis Data specification guide, it also includes all those attributes unique to visual and sensor data bases. Colors, texture references, modulation, translucency, and lod curves to name a few were all accounted for. The impetus was that regardless of what application the data base is designed for, over attribution could never be a draw back. An example of the value added can best be demonstrated using a program whose requirement may only be to produce a sensor data base. By utilizing the over attribution methodology, the customer would not only receive a data base that was correctly attributed for his sensor displays, but the out-the-window representation would also be correct. If this program were now planning to upgrade their training system to include visual displays, no time or money would be expended reworking the data base to accommodate the new requirement.

The second area of focus was data base conversions. To this end, the engineers evaluated conversions to other CompuScene image generators, back transformations to DMA format, the Standard Interchange Format (SIF) developed under project 2851, and even into formats of other image generator (IG) vendors. Because it is difficult, if not impossible, to foresee all the formats a data base might end up in, the global attribution set also includes fields that seem useless to our internal data base generation structure. Again, the more attribution the more valuable the data. Since this global attribute set has been in place, not a single man hour has been expended reworking data due to the lack of attribution. Clearly however, conversions to other image generator formats may require limited types of rework due to the intrinsic differences in IG architectures and their associated capabilities.

The standardized library of 3D features also began with DMA's level 2 DFAD specification. It was then enhanced to include vegetation models, generic buildings, animals, and several other additions. Intended to be attributed as richly as the 2D features, this library would serve as the baseline for all new data bases. During its development however, it became apparent that DMA does not support the diversity of features that might be used in a visual data base. For instance, if the desired model is a helicopter or an airplane, what FID (Feature Identification Code) do you assign? How about features such as animals, and most other transportation or military models? To solve this problem we drew upon the sensor data base experience of the group. Because sensor data bases need to support the breakout of significant "hot spots" of a target, there existed a method of assigning FID codes and then calculating the corresponding sensor colors. This method involved extending the normal set of DMA supplied FID codes that end at 999 into the 1000s range. By adopting the extended FID list and the associated Infra Red Math Model that assigns sensor color into the data base process, the three dimensional models could now be attributed equally as well as the generic DMA features. With this standardized library of 2D and 3D features, combining and converting generic data bases no longer requires the reshuffling of feature attributes or the modification of color, texture, modulation, translucency, or other tunable visual attributes. The appearance of the ocean in one data base was exactly the same as in another. This improved process meant that a data base engineer would no longer need to utilize valuable Image Generation time to validate any of the features in the standardized library. They were guaranteed to be correct. A savings of both time and money.

The next task was to migrate the standardization methodology down to the file structure level. Every reference file and look up table used during the production of a data base was evaluated for possibilities of standardization. Some files, such as lighting tables, were partitioned into aircraft, rotor wing, friendly and foe sections while others were partitioned to segregate 2D, 3D, moving models and geospecific features. The goal was to try and produce a file structure that segregated static and dynamic features as well as differentiating two dimensional from three dimensional features. It also had to be flexible enough to accommodate expansion and the unavoidable subjective tuning that all photo specific and geospecific features go through. Using a color table as an example, if a color needed modification, such as the blue of a river, we wanted to localize the change to rivers only. Hence a 3D feature that may use that same color blue on a wall or a portion of a fuselage remains unaffected. While implementing these file changes, look up tables and reference files began to appear repetitious within themselves.



Combination of these two data bases requires the merging of the data base unique ranges only.

Combination of these two data base requires significant work to separate duplicate usage of codes from each different data base.

Figure 2

Again using the color table as an example, there might be a range of shades of blue reserved for 2D features the same range repeated for 3D features and yet again for moving models. Were we actually sacrificing image generator capability for data base standardization? Well, not entirely. When an Image Generator is designed, experience dictates that little forethought is put into the analysis of actually how many colors or curves a visual data base might actually use. In reality, the numbers are usually based solely on the power of two theory, and even then are usually made as large as possible. Image Generators that tout 256 translucency curves for example normally have data bases built that use only 20-30% of those curves! Also, keep in mind that the partitions within any particular file do not need to be of equal size. A crude example might be to set aside only 5 different shades of green for two dimensional features while the three dimensional features might allocate 20 different shades. Figure 2 is a graphical representation of how a pair of standardized and non standardized data bases might have their color codes, texture codes, and translucency and modulation codes arranged. The combination of the two standardized data bases simply requires the merging of the data base unique feature ranges, while the combining of the two non standardized data bases will require significant rework to reorganize the attribution codes to make a single contiguous data base.

We now had in place a standardization scheme that encompassed all the generic and shared features that might somehow be affected during the combining of two independent data bases, or the conversion to other formats. It was now time to approach those features of a data base that made it truly unique. The geospecific features and imagery files. Because these are the features of a data base that an air crew is most interested in, the *process* by which these areas were developed became suspect for improvement. The standardization scheme already adopted up to now would only insure that the features are built technically correct. The difficult part was insuring spatial and dimensional accuracy. Oddly enough, the first step in improving the process for the development of areas of interest was education. It is difficult for a data base engineer to tell a crew member how accurate an area might be if they are unaware of the inherent inaccuracies of the sources used to create it. Thus began a rigorous education program. Gathering all the educational materials possible and again working closely with the source data team, the data base engineers learned about charts, maps, datums, imagery, and more. They became concerned about the accuracy of each and every piece of source they were using and even investigated the accuracy of the tools they were using. A more educated engineer will always result in a better end product. The results represented a significant improvement in quality and accuracy. Not only did the engineers get a tremendous education, but they were now able to help educate the multiple government customers now requesting data base products from the facility. If you want an *accurate data base you must have accurate source.* Crew members were sensitized to these issues and fully briefed before they entered the simulators. In some cases features in the data base were purposely discolored to indicate that unreliable data was used to create that particular area. Extending the standard methodology into this type of development resulted in standardized naming conventions for geospecific features, and the advent of new tools. When all was said and done, the development time for photo textured, geospecific areas was decreased by approximately 40%.

The last area that endured scrutiny was documentation and configuration management. Although often overlooked and their value underestimated, both of these areas were of great concern. They were taking a considerable amount of time to complete, and were at the mercy of the project leads who double as documentation authors. Some of the configuration management issues were overcome simply due to the adoption of the new standard processes. Once the "standard" data base files have been captured, only the imagery and geospecific or unique features remain. Not only did the hours to perform these tasks drop but so did the amount of removable data storage used to archive a data base. Historically, configuration management has been viewed as a cumbersome bureaucratic aristocracy, where only the chosen few were allowed to breach the security of a configuration managed library. At Kirtland we have made some marked changes to that philosophy. All the data captured by the configuration management team is available to every engineer at any time of day or night. It is stored on removable optical disks inside the data base lab itself. Maintained copacetic via standard computer security techniques, the attitude adopted was one where configuration management was viewed as necessary, but should not be seen as inaccessible. Documentation was another relatively easy area to implement a standard philosophy. Document templates for each required document were created. This method requires engineers to merely cut and paste relative information while keeping the standard verbiage intact. This approach also proves handy for the customer as they have become accustomed to the standard documentation format for each data base. Still a time consuming chore, efforts are under way to automate the documentation process to further reduce what *will* always be viewed by an engineer as drudgery. This standard of configuration management will allow easier interchange of data bases between DoD customers using the Mil-Standards established by the joint service Project 2851

IMPLEMENTATION

At last the process had been streamlined and a comprehensive standard agreed upon. But how were we going to ensure it was used? Accessibility and consistency were now the focus. Just as people are disappointed by a restaurant whose meals taste *different every time, if our standards were not* consistent and accessible they would inevitably fail in reaching their ultimate goal. The standard data base, as is it commonly referred to, is configured on the data base network just as every other data base is. It is also captured on removable media by configuration management. To keep the standard process evolving, weekly unit meetings are used as a forum for engineers to present ideas or modifications. The files on the system are left unprotected to allow engineers to use this data as a testing ground before any formal presentations are made. When additions or modifications to the standard need to be formalized, all the engineers are queried for their evaluation of the change. The final approval rests on the core group of lead engineers. To insure that new engineers were able to learn these standards and apply them correctly, a complete set of documentation was maintained throughout the entire development cycle of the processes and procedures. Now referred to as the "standard document" it serves as a bible to help guide engineers through visual data base development. In addition, the government produced a five hour course on data base generation and a text on source data for simulation data bases.

To help insure the implementation of the new processes, several new tools were designed and built by the engineers at Kirtland. The concept was to *eliminate as much user induced error from the* process as possible. Through painful experience something as insignificant as a typographical error can wreak havoc during the generation of a data base costing hours or even days of progress. The first step in reducing error was to reduce that actual work load required to complete a specific task. Take building a model for instance. The implementation of all the new standards and processes meant that the creation of something as simple as a three dimensional box became a complex task. Paging through documentation searching for the correct ranges in attribute files, look up tables, lighting files and numerous other files just meant more opportunity for error to creep in. To address model building in particular, a task that takes up about 50% of data base development, our engineers generated their own primitive model tool. Customized for our specific requirements, it incorporates all of the a-fore-mentioned standards and combines them into an easy to use graphical user interface, while maintaining all of the interdependencies encountered in feature attribution. The selection of a FID code for instance automatically reduces to the modeler's options for surface material codes and other parameters to only those values identified as valid per the adopted standard. Originally targeted for inexperienced data base engineers, we found that sometimes too much flexibility was a hindrance. None-the-less this home brewed modeler has enjoyed tremendous success and is now used by everyone in the group to create nearly 80-90% of the generic structures in a data base.

THE RESULTS

To validate the end result, detailed metrics for nearly every individual task were tracked both before and after the implementation of these the new processes and standards. Trends and bottlenecks were identified and corrective action taken if needed. The group had reduced the original data base production time by more than 50%, with continuing reductions in the new future! The accumulation and tracking of all the data even lead to the development of a data base estimating tool that has proven to be incredibly accurate. *Even as this paper is written, new* standards are being developed to accommodate the new generation of image generators. In the words of our own data base engineers, a standard is not only a way of doing things it's an attitude. Things get done right the first time. As another engineer put it, if you're not going to take the time to do it right the first time when will you take the time to correct it? Of course the final and most important tests are performed everyday; by our customer. Since the implementation of these standard processes the data base group at Kirtland has had one data base pass through a fully integrated ATP without a single test discrepancy, and most other data bases have discrepancy numbers down in the 10s. Our confidence in this process has been further confirmed by spatial integrity tests verified against real world known information and conducted by an independent government agency. Their evaluation proved the old adage of "garbage in, garbage out" and validated our accuracies when provided quality source data.

The other key aspect of the finished product is correlation. If a training system has an environment that includes out the window, radar, FLIR, NVG, navigational aids, and Electronic Warfare data bases, it is essential that they are 100% correlated. The easiest way to insure correlation is to build all of these data bases from a single source file. A source file so rich in attribution, so consistent, that it carries within its file structure all the data required to genesis these other data bases. At Kirtland that is exactly what we do. As a member of the joint government/contractor team at Kirtland , we believe we maintain some the highest standards in the industry, and have four years of training and mission rehearsal data base experience to prove it. We hope sharing our experiences will benefit other DoD customers and contractors now and in the future.

THE FUTURE

The future is bright for the continued expansion of simulation data base efforts at Kirtland. In 1994, the Air Force established the Simulator Data Base Facility or SDBF at Kirtland. The SDBF is the operational implementation of the joint service Project 2851 and the culmination of twelve years of research and development which have resulted in the two key military standards for the economic development and interchange of simulator data bases. These Mil-Stds, 1820 and 1821 will greatly increase data base productivity and availability. The SDBF will library and enhance data bases and models in these standards as well as contractor formatted run time data bases and fully prepared geo-referenced imagery. DoD customers can order standard or enhanced data bases for a small fee for service. The SDBF is expected to save millions of dollars in its first two years of operation by eliminating the current duplication of efforts in data base and model development. The SDBF further establishes Kirtland as a center of excellence for DoD simulation data base development and modification. We encourage all DoD customers to take advantage of the SDBF to allow concentration of program dollars to customize already developed data bases instead of recreating them.