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Clinical Engineering Department Strategic Graphical Dashboard to Enhance Maintenance Planning and Asset Management

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***Abstract*—The Clinical Engineering (a.k.a. Biomedical Engineering) Department has heretofore lagged in adoption of some of the leading-edge information system tools used in other industries. This present application is part of a DOD-funded SBIR grant to improve the overall management of medical technology, and describes the capabilities that Strategic Graphical Dashboards (SGDs) can afford. This SGD is built on top of an Oracle database, and uses custom-written graphic objects like gauges, fuel tanks, and Geographic Information System (GIS) maps to improve and accelerate decision making.**

I. Introduction

THIS paper discusses the ongoing application of Strategic Graphical Dashboard (SGD) technologies to a growing number of important medical applications. Not only have the sheer number of medical data warehouses and repositories in military and civilian healthcare applications have proved challenging for useful application due to the sheer size and complexity of the knowledge-base (HighTechMaui 2002, Stratton and Dick 2002). Advances in graphical software development tools like LabView and others allowed development of soft-configurable display systems that simplify human interpretation in several ways. First, such systems allow the developer to create graphical and audible display metaphors, like speedometers, bar displays, color- and brightness encoded symbols, and unique sound libraries, to focus user attention on the most important information (Rosow and Adam, 2003).

This paper is closely associated with two prior papers on the Joint Medical Asset Repository (JMAR) by Sloane, Rosow, and Adam (2004). In those papers, the full details of the JMAR design and application is explained more fully. This present paper discusses a novel Clinical Engineering enhancement being developed during the Phase 2 SBIR-funded grant for the JMAR system.

II. SYSTEM DESCRIPTION

This latest evolution of a medical technology SGD is through a military-funded, Phase 2 SBIR project (Stratton and Dick, 2002) to enhance the military's ongoing medical informatics and business reengineering research project known as the Joint Medical Asset Repository (JMAR). JMAR is a relational database system created to integrate very diverse medical supply information from the US military services existing information systems. JMAR was originally envisioned to correct medical supply and drug distribution problems that occurred during Operation Desert Storm, and it received additional strong impetus and urgency from the September 11th terrorist attacks (HighTechMaui, 2002).

The basic logistics and supply chain management issues are not dissimilar to published efforts in other industries (Clark and Crosson, 1997) simply stated, the Surgeon Generals of all three military branches would like to ensure access to any required drug, supply, or medical device regardless of which branch owns or inventories it. For example, an early JMAR module is one that integrates the information on available blood supplies from the three services existing information systems. By updating the JMAR knowledge base daily, the military's medical supply teams can locate needed plasma and blood types, deploy it where and when necessary, and coordinate replenishment activities to minimize overall waste.

JMAR is based on a centralized Oracle engine, with a growing interface library to allow integrating information from the hundreds of heterogeneous systems in use by the medical services. This not only facilitates medical care to saves lives, but it also eliminates the hours and hours of staff time to make phone calls around the world that such searches required. Most drugs, supplies, and eventually most medical devices information will be integrated into the JMAR system, allowing it to serve as a global metadatabase for the military's medical leaders. Realization of the full scope of JMAR will take many more years, as it must eventually integrate complex information models like those used for medical equipment maintenance, updates, recalls, and repairs.

SGD's may have applications in the battle to manage alarm "overload," too. The large number of medical and information technologies deployed in healthcare settings have created a huge cognitive overload for clinicians. The JCAHO regulatory body has created a new set of alarm management goals for 2003 (JCAHO 2003) to begin the process of applying systemic thinking to resolving these problems. SGD's may show promise in this regard, because the convergence of information and medical technologies (Sloane 2001) will make it feasible to integrate the data, including alarms, from many, if not most clinically- and managerially-relevant systems. A properly-designed SGD

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should make it easier for a nurse or doctor to focus on critical, life-threatening alarms instead of delaying care by attending to less pressing alarms. Improvements in this area may make home health care safer and more effective, too, as lay users have great difficulty interpreting the significance, and selecting actions, when faced with multiple simultaneous alarms.

This SBIR-funded SGD project is intended to make the vast JMAR information resource more accessible to the military users at all levels, including inventory managers, financial planners, logisticians, and senior medical officers like the Surgeon Generals. JMAR's centralized information system will allow regression analysis, seasonal forecasting, wartime and catastrophic modeling, Pareto charting and other statistical tools to be mined. The SGD, in turn, will turn that information into usable symbols for rapid and accurate decisions instead of relying on complex, voluminous reports.

III. Clinical Engineering SGDs

Several Clinical Engineering examples can help to illustrate the power that SGDs can add. For example many parameters are shown in Figure 1. This management dashboard is designed to help make decisions about the age and value of biomedical equipment. The Total Value and Average Remaining Life of the at the selected medical center has been transformed from simple figures to graphic symbols. The "gauges" on the left side show that the Total Value and Average Life values with respect to at full-scale as well as the number of devices in the sample. On the right hand side, the stacked-bar graphs indicates the value of assets within each condition grouping. The graph line is a Pareto tool, allowing rapid assessment of the 80/20 point that many decisions can be made.

It is important to realize that every part of the dashboard is dynamic. The user can select any military base, any type of equipment, any one or more condition codes, etc, and the gauges and charts will immediately be updated with the relevant information. This process is often referred to as "data mining," with the added graphical display enhancements directly and immediately tracking the selected data.

In addition, the user can "drill down" into any part of the graph shown on the right. For example, if the user clicked on the top part of the first stacked bars, they would see the

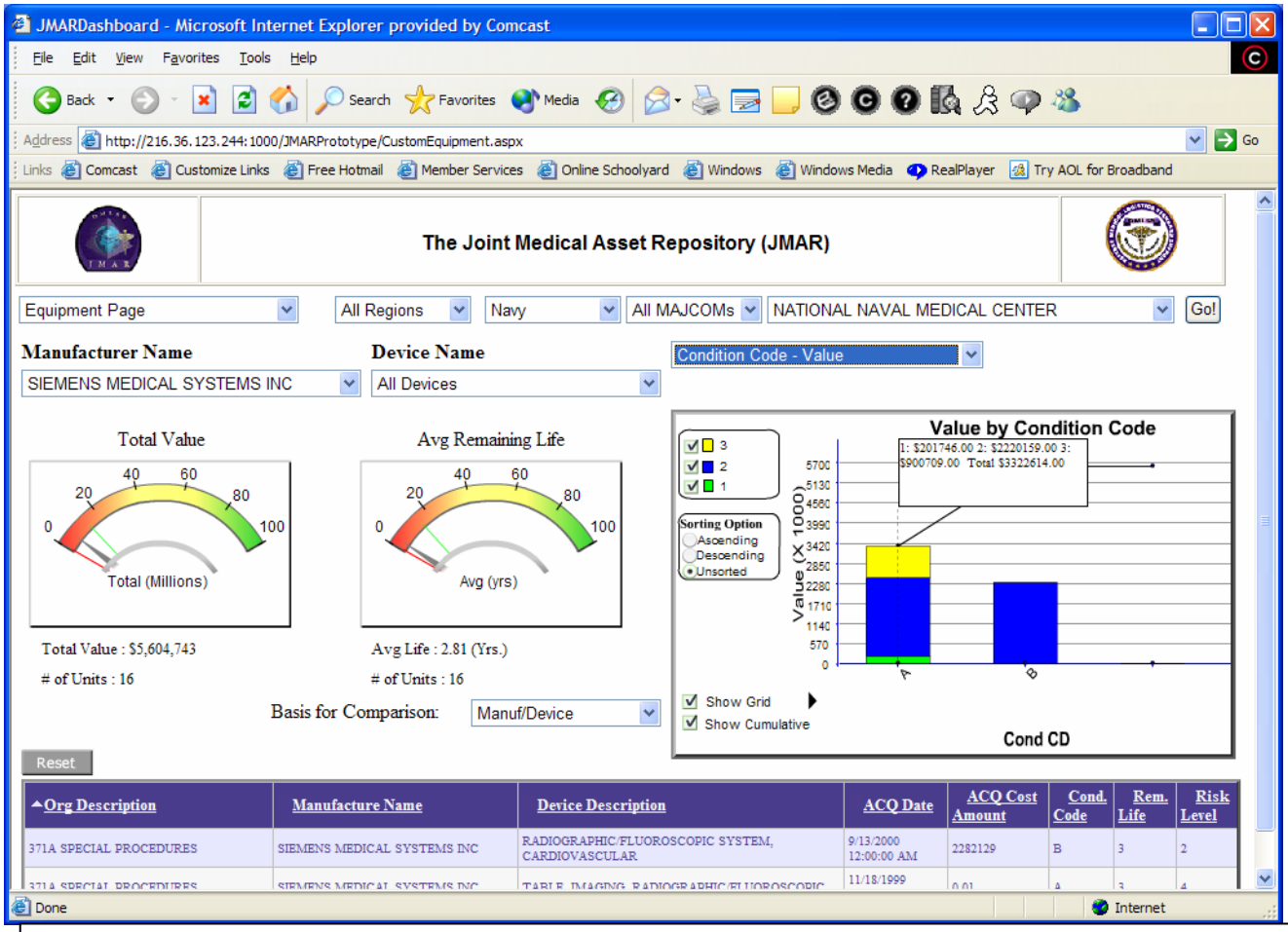

Figure 1 SGD showing medical device asset values by condition codes (A-Excellent; B-Average; C-Fair/Poor)

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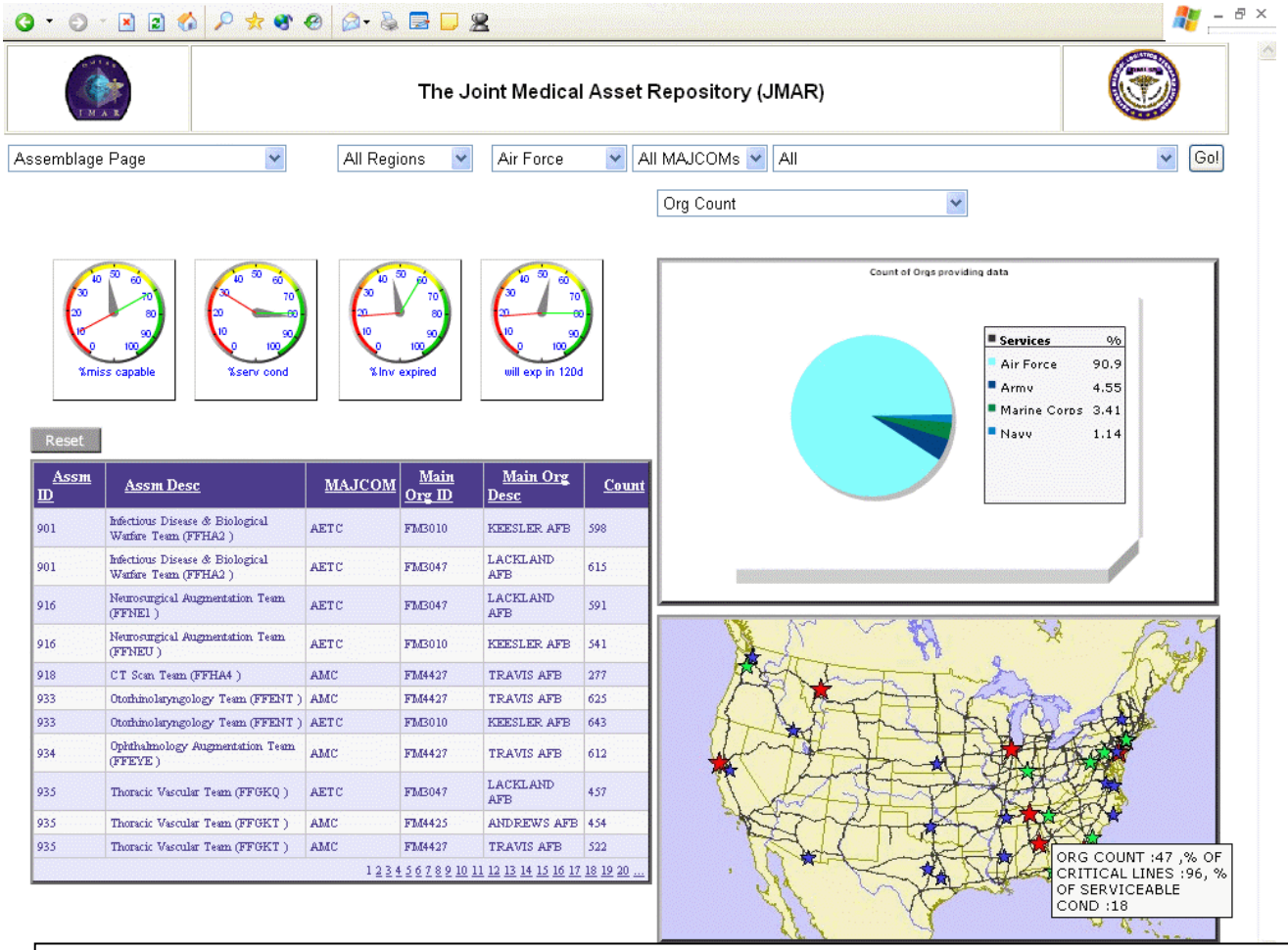

Figure 2 Assemblage management dashboard using map capabilities for all four military services.

individual pieces of equipment and all relevant data such as purchase date, purchase price, vendor, etc. This type of interactive dashboard system works like many web browsers, in that one can move forward and backwards when drilling into information, or one can select a menu option to go directly to a different piece of information or function.

Figure 2 shows another powerful application, this time with what are referred to as "assemblages," which represent pre-configured combinations of devices and supplies (e.g., portable x-ray equipment, film, and developers, or surgical tables, lamps, drapes, scalpels, sutures, etc.) Assemblages are created to allow rapid deployment without risk of missing items. However, locating specific, complete, and non-expired assemblages can be a tremendous challenge. In the map shown on the right side of Figure 2 are different colored stars (green, red, and blue), indicating the number of serviceable or unserviceable assemblages and their locations. In addition, the system indicates the proportion of the assemblages that are located at Army, Air Force, Navy, or Marine bases, which helps ensure that no opportunities are overlooked. If desired, plane flights, train transit and departure times, driving times, or postal service alternatives can all be overlaid on the map to aid decision making.

IV. CONCLUSIONS

Although many aspects of the JMAR system design must necessarily remain secret, the overall JMAR metadatabase design and dashboard implementation represents a valuable opportunity to explore the challenges and constraints of integrating a large amount of disparate information from any number of heterogonous databases. In addition, the use of dashboard display techniques to reformat complex data into easily-interpreted, graphically-enhanced symbols will make enhance the users' ability to mine this data for statistically valid and important knowledge. The Strategic Digital Dashboards display critical information it in a form that will allow rapid decisions, reduced costs, and better confidence. SGD development in the JMAR project will be another step in the evolution of complex medical information systems that can improve military and civilian medical supply logistics at a time when healthcare's economic losses and clinical errors continue to be headline news.

Clinical Engineering departments may be well advised to look for similar tools in their future information systems. They are widely used in other industries, and can clearly be adapted to our field.

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