IN THESE TIMES OF GLOBAL CHANGE, many facility emphases are competing for limited resources. With antiterrorism we have federal mandates and employee demands for safer and more secure workplaces. These same employees, backed by federal and state environmental guidelines, are also demanding “greener,” more environmentally friendly and sustainable facilities. Other examples of competing factors are aesthetics, handicap accessibility, and in some cases, historical preservation. Yet, unlimited resources to fulfill all the needs and wishes are seldom, if ever, available in private or public construction. Although it is currently popular to profess a bias to life cycle costs, first costs are still the main factor for appropriations in public construction and the driving decision for most private construction projects. Making the right balancing decisions is primary, but documenting these decisions and the rationale behind them are equally important both for appropriation committees and for documenting sustainability certification. The Georgia Institute of Technology used guidance from the Pentagon Renovation and Construction Program Office (PENREN/C); the U.S. Green Building Council, Leadership in Energy and Environmental Design (LEED™) rating system; and the multi-agency draft “Whole Building Design Guide (WBDG), LEED™-DoD Minimum Antiterrorism Standards for Buildings: Issues and Strategies.” Although this research was based on input from federal agencies, it has applicability to any organization balancing competing factors. The names of decision-makers may change, such as lending institute versus appropriation committee, or force protection versus employee safety; but the decisions are essentially the same for public and private construction planners and decision makers. With minor effort and creativity, this model can be tailored to any organization.

Pentagon Renovation and Construction Program Office (PENREN/C)

The Pentagon Renovation and Construction Program Office (PENREN/C), has a subteam in the Integrated Sustainable Design and Construction Team (ISDT) that is tasked with identifying, implementing, and tracking ways to make the 60-year old Pentagon a healthy, safe, and secure facility. (Renovator, 2003) This ISDC team is an integrated project team that includes members from Pentagon Renovation (PENREN/C) project teams, the Washington Headquarters Services Federal Facilities Division, their contractors, and university research teams. As stated by their team leader, the ISDT “The Pentagon Renovation Program incorporates sustainable design and construction initiatives into its projects to create facilities that are flexible, environmentally-friendly and healthier for Pentagon personnel.” (Renovator, 2003)

PENREN/C is using the U. S. Green Building Council’s (USGBC), Leadership in Energy and
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Environmental Design (LEED™) rating system to track building performance and to report progress toward achieving sustainable goals. PENREN/C’s short-term goal is meeting or exceeding environmental building standards and achieving LEED™ Certification on all PENREN/C projects. The ISDT leader, states “The LEED™ Rating System is an effective tool to track our progress towards building a more sustainable Pentagon.” (Renovator, 2003)

However, in the wake of the terrorist attacks of September 11, PENREN/C and its ISDC Team shouldered the additional responsibility of integrating and balancing sustainable design issues with force protection measures necessary for Pentagon protection. PENREN/C’s goal is to become a recognized government leader in implementing sustainable design and construction initiatives, while balancing budget constraints and force protection issues. (DBIA, 2004)

LEED™

According to the USGBC, “The Leadership in Energy and Environmental Design (LEED™) Green Building Rating System is a voluntary, consensus-based national standard for developing high-performance, sustainable buildings.” Composed of representatives from all facets of the building industry, the USGBC is charged with developing LEED™ standards to encourage highly efficient sustainable design and construction performance. Currently, the USGBC has developed LEED™ standards for “New Construction and Major Renovation Projects” (LEED™ 2.1), “Existing Building Operations” (LEED-EB™, Pilot version) and “Commercial interiors projects” (LEED-CI™, Pilot version). Numerous USGBC committees work collaboratively with one another to develop new standards for the LEED™ Rating Systems.

“In conjunction with PENREN/C’s existing sustainable design and construction practices, the U.S. Green Building Council’s LEED™ Rating System provides PENREN/C with a rigorous set of criteria for Existing Buildings (LEED EB™) that was developed on the basis of LEED™ 2.0 for New Construction and major renovations. The objective of the LEED EB™ Rating System Pilot version is to ensure the system “is practical and workable for application in real buildings,” according to the USGBC web site. (Renovator, 2003)

As a pilot program member, the PENREN/C design-build team has integrated the guidelines of LEED™ for Existing Buildings (LEED EB™), LEED EB™ addresses whole-building cleaning and maintenance issues including chemicals, ongoing Indoor Air Quality (IAQ), energy efficiency performance, water efficiency performance, recycling initiatives and systems upgrades to enhance building performance. Based on performance of the guidelines set forth in the LEED EB™ Rating System, successful projects can be certified by the USGBC. LEED EB™ requires the support of the design team as well as the building owner and facilities staff. The PENREN/C keeps regular metrics on various projects to track the Program’s overall LEED™ performance.

Whole Building Design Guide

The model discussed in this paper was designed as a pilot model to demonstrate the concepts and the capabilities of the decision matrix to balance sustainability and antiterrorism issues in construction or renovation. Many other factors, such as first costs, life cycle costs, functionality, etc., must also be balanced with sustainability and antiterrorism. The model should be tailored for each user’s priorities and can be tailored for individual projects. For example, PENREN has specific goals for sustainability and antiterrorism, but these may vary slightly for each project. The renovation for the Office of the Secretary of Defense will place higher weights on hardening and protection (antiterrorism factors) than sustainability, but construction of the Pentagon gym, also known as the POAC—Pentagon Officers Athletic Center, will place higher weights on air flow and mold prevention (sustainability features) than window glazing (an antiterrorism factor.) The pilot model was based on the analyses found in the multi-agency Whole Building Design Guide (WBDG) (LEED-ATFP-07 Apr 2004), (www.wbdg.org) quoted in the following paragraphs.

“In 1999, Executive Order 13123 required federal agencies to incorporate sustainable design principles into their projects. A few years ago, because of the September 11, 2001 attacks, building security also became a top priority. Responding to these two issues, a number of agencies adopted the USGBC Leadership in Energy and Environmental Design (LEED™) Green Building Rating System to help them measure the sustainability of their projects; the Department of Defense (DoD) issued its Unified
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Facilities Criteria (UFC) 4-010-01, DoD Minimum Antiterrorism Standards for Buildings to minimize the likelihood of mass casualties from terrorist attacks; and the Interagency Security Committee (ISC) issued the ISC Security Design Criteria for new federal office buildings and major modernizations to protect from smaller explosive threats and reduce collateral effects from larger threats.”

Sustainability and security often may be seen as competing for limited resources. In this time of enhanced security risk and awareness, facility owners and occupants demand that security be an important consideration in facility design and construction. At the same time, as a society, we desire to have functional, efficient and environmentally friendly buildings, and our agencies or companies want to provide the most productive environment for workers health and well being. Hence, the challenge: how do we meet the right balance? This resource page addresses sustainability and anti-terrorism objectives concurrently, from the DoD perspective. Specifically, related DoD antiterrorism standards are identified for each LEED credit. The security implications of strategies used to achieve each LEED credit are discussed with regard to their inter-relationship.

With this information in hand, the project team can work together more effectively throughout a project’s life cycle, using a “whole building” approach, to develop successful, efficient solutions for a high performance and secure building. Note that this approach does not
consider the potential synergies and conflicts with other building design objectives. Refer to other sections of the WBDG for discussions of the following: Aesthetics, Accessible, Cost-Effective, Functional, Historic Preservation, and Productive. Standards other than those of the DoD are also not considered explicitly herein. However, the reader may use the basic premises as many may apply to non-DoD applications.

It is important to understand that while security is required, the specific level of required security varies from project to project. In order to facilitate the appropriate level of protection and countermeasures to meet the security challenges, a comprehensive threat assessment, vulnerability assessment, and risk analysis should be conducted to identify the appropriate level of security for the building. This will help ensure that project funds are directed at real needs in a focused manner, thus allowing other project aspects such as architectural expression and other amenities to be developed.

In the same vein, some LEED credits are not applicable or feasible for some projects. As such, a sustainable design/LEED charrette or workshop should be conducted during the planning and/or concept design phase. The workshop entails a credit by credit discussion of all the LEED credits. At the same time, goals and initial strategies for each applicable credit are developed. Conclusions and recommendations from the threat and vulnerability assessments and risk analysis should be taken into consideration during the charrette so potential conflicting or synergistic approaches can be identified and addressed early.

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The Model

Whole buildings design not only looks at how materials, systems and products of within a building connect and overlap, but also looks at how the building and its systems can be integrated with supporting systems on its site and within its community. A successful whole buildings design is a solution that is greater than the sum of its parts. The fundamental challenge of whole buildings design is to understand that all building systems are interdependent.

The following gives some examples of interdependencies (excerpts from the Whole Building Design Guide).

The choice of a mechanical system, might, for example, impact the quality of the air in the building, the ease of maintenance, Global Climate Change, operating costs, fuel choice, and whether the windows of a building are operable. In turn, the size of the mechanical system will depend on factors such as the type of lighting used, how much natural daylight is brought in, how the space is organized, the facility’s operating hours, and the local microclimate.

Other interdependencies highlighted in the Whole Building Design Guide consider that it can be difficult to produce a truly integrated design when highly specialized disciplines prepare separate pieces of the design. Current design practice fosters an environment where designers focus on specific areas of expertise, rather than the whole building. There is a tremendous volume of project documentation needed to support claimed LEED™ points, and it is difficult to keep up with the many products and materials available in the burgeoning “green” market.

Acknowledging this interdependence, the decision maker eases the allocation process and the documentation of the decision process by considering the issues independently. In some cases, the funding dollars are from different appropriations or must be reported separately, thus requiring analysis of the interdependent factors independently. The methodology used in the model development assumes the components are independent and can be weighted against each other. Through a systematic analysis, even analyzed separately, of these interdependent issues, a much more efficient and cost-effective building can be produced.

The model can be considered a sustainability scoring tool. It is a helpful decision making tool. It is a simple, Excel-based program that allows for side-by-side
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C. Energy & Atmosphere [EA]:
- **Prerequisite 1**: Fundamental Building Systems Commissioning
- **Prerequisite 2**: Minimum Energy Performance
- **Prerequisite 3**: CFC Reduction in HVAC&R Equipment

<table>
<thead>
<tr>
<th>EA Credit 1</th>
<th>Optimize Energy Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>EA Credit 2.1</td>
<td>Renewable Energy, 5%</td>
</tr>
<tr>
<td>EA Credit 2.2</td>
<td>Renewable Energy, 10%</td>
</tr>
<tr>
<td>EA Credit 2.3</td>
<td>Renewable Energy, 20%</td>
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<tr>
<td>EA Credit 3</td>
<td>Additional Commissioning</td>
</tr>
<tr>
<td>EA Credit 4</td>
<td>Ozone Protection</td>
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<tr>
<td>EA Credit 5</td>
<td>Measurement &amp; Verification</td>
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<tr>
<td>EA Credit 6</td>
<td>Green Power</td>
</tr>
</tbody>
</table>

**TOTAL ENERGY & ATMOSPHERE SCORE:**

D. Materials & Resources [MR]:
- **Prerequisite**: Storage & Collection of Recyclables

| MR Credit 1.1 | Building Reuse, Maintain 75% of Existing Shell |
| MR Credit 1.3 | Building Reuse, Maintain 100% Shell/Structure and 50% Non-Shell/Non-Structure |
| MR Credit 2.1 | Construction Waste Management, Divert 50% From Landfill |
| MR Credit 2.2 | Construction Waste Management, Divert 75% |
| MR Credit 3.1 | Resource Reuse, Specify 5% |
| MR Credit 3.2 | Resource Reuse, Specify 10% |
| MR Credit 4.1 | Recycled Content, Specify 5% [post-consumer +1/2 post industrial] |
| MR Credit 4.2 | Recycled Content, Specify 10% [post-consumer +1/2 post industrial] |
| MR Credit 5.1 | Regional Materials, 20% Manufactured regionally |
| MR Credit 5.2 | Regional Materials, 50% extracted regionally |
| MR Credit 6 | Rapidly Renewable Materials [MR Credit 6] |
| MR Credit 7 | Certified Wood [MR Credit 7] |

**TOTAL MATERIALS & RESOURCES:**

Comparison of multiple products. The model roots are derived from the Whole Building Design Guide and the LEED™ rating system. The user is free to define relevant weighting factors to match the requirements of each project. In searching a material/product database, the user defines relevant search factors.

The first three figures display a sample of the Credit factors, the Y axis in the total matrix, used in the pilot decision matrix. These credit factors were taken directly from the draft Whole Building Design Guide. Figure 1 shows Credit Factors for Sustainable Sites and Water Efficiency. Figure 2 shows Credit Factors for Energy and Atmosphere and Materials and Resources. Figure 3 shows Credit Factors for Indoor Environmental Quality and Innovation and Design Processes. Figure 4, the X axis of the total matrix, displays each product being evaluated with their weights for sustainability and security. In this sample Figure 4, the weights are equal at 50/50, but can be changed by the user. Under each product, the comparison variables and their weighting factors are presented. In this pilot model, only sustainability and security are used as comparison variables. First costs and life cycle costs are other factors recommended for comparisons. A third column is for the total of the comparative variables. Each total should add to 100 percent.

Under each element of Credit Factors, such as Figure 1 A: Sustainable Sites [SS] or B. Water Efficiency [WE], any required prerequisite is documented. The total of the contribution for that sub credit factor is summed at the bottom of that credit, such as Total Sustainable Sites score or Total Water Efficiency Score, as shown on Figure 1. A Grand Total Score is computed at the bottom of the entire matrix for each product being evaluated. Given this design, all elements of the decision are documented and are visible for scrutiny or for challenge by other contributors to the decision. The most important aspect is that every contribution to the decision is visible.

Figure 4 displays the weighting factors and the individual contribution of each component. Again the most important aspect is the every contribution to the decision is visible. If a contributor to the decision process disagrees with a particular outcome, that contributor can re-evaluated each component of the decision, conduct sensitivity analyses of each compo-
The total weighting scheme is demonstrated in Figure 5, shoeing sustainability and security. These may be expanded to include other variables such as first cost, or life cycle costs, or others important to the decision maker. Figure 6 summarizes the Credit Factors and associated importance weights.

Figure 7 and Figure 8 provide a sample of a future development if the user chooses to develop utility curves and an application of multiattribute utility theory. For many factors, a utility curve may be a more appropriate scoring technique than a raw score for competing products. Utility curves document the owner/decision values associated with each contribution for a product. For example, in sustainability factor water efficiency, there may be a threshold required by the Clean Water Act or the Environmental Protection Agency (EPA). Threshold values will be documented as a step function in utility curves. Any value less that the required threshold value has zero utility to the decision maker. Similarly, many of the security or protection elements have a minimum acceptable value, represented by a step function in utility curves. Utility curves vary widely by the situation, the human values contributing to the utility curve, and application of the utility. A separate science in decision theory is needed to cover the design application of utility curves. Utility curves are included in this discussion only to acknowledge that many elements of sustainability and security have threshold values that can not be ignored in the decision process.

An example of a single product analysis in this model could be demonstrated with the use of interior paint. In Figure 1, any credit that could apply to paint would be completed with a rating. Obviously, interior paint would not apply to all categories such as Sustainable Sites, but where it applies, in Indoor Environmental Quality, each applicable line would be rated for both the interior paints Sustainability Score and Security Score. For instance, credit 3.1 & 3.2, Optimize Use of IAQ Complaint Products, the interior paint cannot exceed the U.S. Green Seal’s standard GS-11 for volatile organic compound (VOC) and chemical component limits for emissions. If our selected paint meets this standard, we get a full score on Sustainability. If this is generic paint, there may be a zero score for Security. However, there are paints (Line-X Paxcon for example) that now contain chemical strengtheners to enable the coating to protect against shattering and massive collapse. The paint essentially holds the wall together under specific circumstances. This paint can therefore receive a score for security based on its use and location within the building and your judgment of the impact this paint could produce. This paint also is reported to have zero VOC’s.

Interior paint could also have scores in Sustainability for Optimizing Energy Performance (Energy & Atmosphere Credit 1) if it includes insulating properties that help to conserve energy. Interior paint may also provide Sustainability scores for improvements in Building Operations and Maintenance (Energy & Atmosphere Credit...
3.2) through ease of use and maintenance, saving costs and prolonging the useful life of the finishes. These two scores may have counterbalancing Security impacts; however, most interior paint would have no impact to security involving energy performance or maintenance issues.

A separate process to support the decision model is the development of a building product manufacturers’ data base, under design by Tectonic Network, Inc., (www.techtonicnetwork.com) Countless products should be readily searched to find those that best meet project requirements specified by the decision maker. Manufacturers would input the sustainable properties of products and materials. The database can be quickly populated, easily maintained, and kept current by the manufacturers. The responsibility of documenting the sustainability contributions, on which a user can filter products, will be on the manufacturer, who also must provide LEED required documentation and the appropriate letters of verification. Without a known clearinghouse to scrutinize manufacturer provided information, users will have to verify product claims. Smaller or fledgling manufacturers may need external support to determine the sustainable properties of their products or the capability to input the information on to the database. Both process and products need to be approved by the USGBC to attain LEED project certification. Information on listed products will be built from manufacturers providing information to have their products included in the database. Availability of comparative construction materials is based on the weighting criteria provided by the decision maker, not

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<thead>
<tr>
<th>Enter Name of Product #1=</th>
<th>Enter Name of Product #2=</th>
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<tbody>
<tr>
<td>Sustainability</td>
<td>Security</td>
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<td>50%</td>
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### Weight Factors for Sustainability and Security

(enter weight factors between 1 & 100 in the following light green areas)

**Sustainability:**

<table>
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<tr>
<th>Sustainability is for the Products (1-100)</th>
<th>100</th>
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**Security:**

<table>
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<tr>
<th>How Important Security is for the Products (1-100)</th>
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<th>Figure 4</th>
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<th>Weight Factors for Sustainability and Security</th>
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<tbody>
<tr>
<td>(enter weight factors between 1 &amp; 100 in the following light green areas)</td>
</tr>
<tr>
<td><strong>Sustainability:</strong> On scale of 1-100 How Important Sustainability is for the Products (1-100)</td>
</tr>
<tr>
<td><strong>Security:</strong> On scale of 1-100 How Important Security is for the Products (1-100)</td>
</tr>
</tbody>
</table>
any form of restricted competition, thus the
government and private owners should have
no concerns using the database.

Conclusions

There are several advantages of adapting
this pilot model to specific projects and
adding additional user defined criteria. The
model helps keep all designers aware of the
bigger picture the relation of their design
choices to values provided by the owner/
decision maker. Once these tools are fully
implemented, the user can expect to realize
the following benefits:

☑ Better design integration
☑ Paperless LEED point tracking system that…
  ✔ Documents rationale behind building
  material selections
  ✔ Provides a systematic approach that
  can be audited if needed
☑ Ability to accumulate sustainability
  statistics for consideration on future
  projects.

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