# A New Navy Component Command Headquarters Building:
Balancing the Design Challenges of Security, Sustainability and Energy Efficiency

Reid Perry
May 2013

*Submitted towards the fulfillment of the requirements for the Doctor of Architecture Degree*

School of Architecture
University of Hawaiʻi at Mānoa

**Doctorate Project Committee**
Steve Meder, Chairperson
Don Goo
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*We certify that we have read this Doctorate Project and that, in our opinion, it is satisfactory in scope and quality in fulfillment as a Doctorate Project for the degree of Doctor of Architecture in the School of Architecture, University of Hawai'i at Mānoa.*

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# Abstract

Strong scientific evidence shows that carbon emissions as a result of human activities are the primary contributor to global warming and the resulting climate change. Carbon emissions are a byproduct of energy generation from fossil fuels, and the building industry accounts for roughly half of the energy consumption, through its processes and operations, across economic sectors. There has been a serious effort recently, to stem this adverse contribution. The organization, Architecture 2030, was created in response to this and has issued their “Challenge 2030”. It calls for the building industry to become carbon neutral by the year 2030.

The federal government has accepted the reality of climate change and has identified it as a national security issue. As a result, the Department of Defense has embarked on an aggressive plan to reduce its contribution to greenhouse gas emissions. A major part of that effort is building and retrofitting buildings in their inventory to be sustainable. However, the department’s facility investment strategy focuses on meeting mission needs and with increasingly limited resources, those mission needs can trump sustainable design goals. One solution to this issue would be to show that meeting security design requirements that meet the mission needs can be balanced with sustainable design. This design project is aimed at addressing the design aspect of possible solution to balancing the two by analyzing the two requirements, finding conflicts and tradeoffs and developing synergies

The research consisted of three phases: Establishing an understanding of the nature of the U. S. Pacific Fleet Command which provided the mission needs, operational activities and personnel organization that would inform the project requirements, Attaining an understanding of security and sustainable design standards and processes followed by an analysis of potential conflicts, tradeoffs and synergies between the two, and lastly reviewing case studies of similar building types that have both security and sustainable attributes that would possibly substantiate some of the analysis in the previous stage. This was then applied to the initial stages of the architectural design process with the goal of a conceptual design that reflects the results of the analysis.

In the DoD design and construction process an integrated planning and design team would be convened in the earliest stage to conduct a design charrette to identify conflicts, tradeoffs and synergies that might be encountered. This process is critical to accomplish early so as to ensure all concerns and issues are addressed to mitigate future problems. Ideally, this document and its analysis will be a product that entities in the DoD building sector can use in the early stages of the design process regardless of the participation of dedicated security design consultants. This could ultimately be in the form of a ready reference for early stage planning and conceptual design development.

The analysis provided in this project document can be used by designers, architects, building owners and other disciplines to evaluate and balance security, sustainability and energy efficiency measures that will allow them to be part of the solution to the problems of climate change. With further exploration into energy and life cycle cost analysis this project document could be used as a basis for follow-on efforts to craft a Unified Facilities Criteria document that codifies these processes and conclusions.

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## List of Abbreviations and Acronyms

| | |
|---|---|
| AHU | Air Handling Unit |
| AMP | Ampere |
| AOR | Area of Responsibility |
| ASHRAE | American Society of Heating, Refrigerating and Air-Conditioning Engineers |
| BAS | Building Automation System |
| BIM | Building Information Modeling |
| BIPV | Building Integrated PhotoVoltaic |
| Btu | British Thermal Unit |
| CBECS | Commercial Building Energy Consumption Survey |
| CBR | Chemical, Biological and Radiation |
| CDD | Cooling Degree Days |
| CHP | Combined Heat and Power |
| COP | Coefficient of Performance |
| COLPRO | Collective Protection Area |
| CPF | Commander, Pacific Fleet |
| CPTED | Crime Prevention Through Environmental Design |
| CRAH | Computer Room Air Handler |
| C – Factor | Thermal Conductance |
| CY | Calendar Year |
| DBT | Design Basis Threat |
| DOAS | Dedicated Outdoor Air System |
| DOD | Department of Defense |
| DOE | Department of Energy |
| DX | Direct Expansion (Direct Refrigerant) |

| | |
|---|---|
| EEM | Energy Efficiency Measure |
| EER | Energy Efficiency Rating |
| ECM | Energy Conservation Measure |
| EDPM | Ethylene Propylene Diene Monomer |
| EISA | Energy Independence and Security Act of 2007 |
| EO | Executive Order |
| EPAct | Energy Performance Act |
| ERV | Energy Recovery Ventilation |
| EUI | Energy Use Intensity |
| FCU | Fan Coil Unit |
| FEMP | Federal Energy Management Program |
| FY | Fiscal Year |
| GHG | Greenhouse Gas |
| HDD | Heating Degree Days |
| HVAC | Heating Ventilation and Air Conditioning |
| IAQ | Indoor Air Quality |
| IEQ | Indoor Environmental Quality |
| IESNA | Illuminating Engineering Society of North America |
| IPD | Integrated Project Delivery |
| JCS | Joint Chiefs of Staff |
| LBL | Lawrence Berkeley National Laboratory |
| LED | Light Emitting Diode |
| LEED | Leadership in Energy and Environmental Design |
| LOP | Level of Protection |
| LowE | Low Emissivity |

| | |
|---|---|
| LPD | Lighting Power Density |
| LRV | Light Reflectance Value |
| LSG | Light to Solar Gain Ration |
| MRT | Mean Radiant Temperature |
| NAVFAC | Naval Facilities Engineering Command |
| NCA | National Command Authority |
| NDS | National Defense Strategy |
| NMS | National Military Strategy |
| NREL | National Renewable Energy Laboratory |
| NSS | National Security Strategy |
| N1 | Administration Department |
| N2 | Intelligence Department |
| N3 | Operations Department |
| N4 | Logistics and Fleet Maintenance Department |
| N5 | Plans and Policy Department |
| N6 | Command Communications, Computers and Information |
| N7 | Training and Readiness Directorate |
| N8 | Requirements directorate |
| OPTEMPO | Operational Tempo |
| PC | Personal Computer |
| PLD | Plug Load Density |
| PNNL | Pacific Northwest National Laboratory |
| POTUS | President of the United States |
| PUE | Power Usage Effectiveness |
| PV | Photovoltaic |

| | |
|---|---|
| RFP | Request for Proposal |
| RFQ | Request for Qualifications |
| RSL | Research Support Facility |
| R – Value | Thermal Resistance |
| SAD | Seasonal Affective Disorder |
| SCIF | Special Compartmented Information Facility |
| SECDEF | Secretary of Defense |
| SEER | Seasonal Energy Efficiency Ratio |
| SHGC | Solar Heat Gain Coefficient |
| SIP | Structural Insulated Panels |
| SRI | Solar Reflectivity Index |
| UCP | Unified Command Plan |
| UFC | Unified Facilities Criteria |
| UPS | Uninterruptible Power Source |
| USACE | U.S. Army Corps of Engineers |
| USGBC | U.S. Green Building Council |
| USPACOM | U.S. Pacific Command |
| U – Factor | Thermal Transmittance |
| VAV | Variable Air Volume |
| VCP | Visual Comfort Probability |
| VLT | Visible Light Transmittance |
| WBDG | Whole Building Design Guide |
| w.c. | Water Column (measure of pressure) |
| WWR | Window to Wall Ratio |

# PART I: RESEARCH

# Chapter 1. Introduction and Problem

## 1.1 Background

Executive Order (EO) 13514 *Federal Leadership in Environmental, Energy and Economic Performance* directs all federal departments and agencies to develop and update an annual Strategic Sustainability Performance Plan (SSPP). As part of that effort the agencies shall manage the short and long term effect of climate change on the agencies mission and operations by evaluating climate change risks and vulnerabilities. In response, the Department of Defense (DoD) developed a Climate Change Adaptation Roadmap (CCAR) planning document as an appendix to their SSPP. The DoD strategic policy on climate change adaptation originated from the 2010 Quadrennial Defense Review (QDR) by the Secretary of Defense (SECDEF). The QDR is the mechanism by which the canons of the National Defense Strategy (NDS) are adapted into policies and initiatives. The QDR identified that climate change has national security implications. The QDR also projected that climate change will affect the DoD in two ways; first that climate change will shape the operating environment, roles and missions that the department will face, and second the department will need to address the resulting impacts of climate change on its facilities, infrastructure and military capabilities. This determination that climate change is a national security issue worthy of the level of commitment to preparing for it and countering it is a major shift in policy for the DoD. A major part of the DoD sustainability Plan is attaining energy efficiency and security.

*"Buildings consume roughly 37% of the primary energy and 67% of the total electricity used each year in the United States. They also produce 35% of U.S. and 9% of global carbon dioxide ($CO_2$) emissions. Preliminary figures indicate that in FY 1997, Federal government facilities used nearly 350.3 trillion British Thermal Units (Btus) of energy in approximately 500,000 buildings at a total cost of $3.6 billion."*

This particular quote is the opening paragraph to the "Low-Energy Building Design Guidelines: Energy efficient design for new Federal facilities," published as a part of the Federal Energy Management Program by the Department of Energy, and it was a clarion call to all Federal agencies with regard to energy efficiency.

The current economic crisis that began in 2008, has hit the DoD budget as well as other US government agencies at a difficult time. It is a time in which we are engaged in numerous costly contingencies around the world which have amplified and exacerbated the effects of the economic crisis. Cutbacks in DoD spending as a result of the CY 2013 sequestration for both the active force and DoD contracts have resulted in an increased emphasis on cost savings. Although it is true that over the last several decades the military has taken great strides in their contribution to sustainability; it is this galvanizing moment in time in which economic, political, global and environmental factors may help to actually facilitate the establishment of more meaningful and lasting measures. Climate responsive design can be an impactful way of furthering this cause.

The US Pacific Fleet Headquarters is in charge of all Naval Operations in the Pacific Ocean and nearby regions. The Commander, U.S. Pacific Fleet (COMPACFLT) reports directly to the Commander, U.S. Pacific Command, (CDR USPACOM) who is in charge of all military operations in the Pacific Theater of Operations, ground, air and sea. The specific mission, vision and guiding principles of COMPACFLT taken directly from their website are:

*"Mission. U.S. Pacific Fleet protects and defends the collective maritime interests of the United States and its allies and partners in the Asia-Pacific region. In support of U.S. Pacific Command and with allies and partners, U.S. Pacific Fleet enhances stability, promotes maritime security and freedom of the seas, deters aggression and when necessary, fights to win.*

*Vision. A combat-ready and surge-capable fleet that is ready to respond rapidly to any contingency, that cooperates with allies and partners to promote maritime security and freedom of the seas, that deters and when necessary defeats threats to national security through decisive naval, joint and combined operations.*

*Guiding Principles. The six principles below guide everything that we do every day—our plans, policies, operations, activities, engagement — with the aim of promoting peace and preventing conflict, while setting the conditions for a successful response to any contingency.*

*Warfighting mission will be our focus. We will maintain credible, combat-ready, and forward-deployed forces that can execute missions across the full range of military operations. To do so, we must have:*

- *Credible leadership, proficient Sailors*
- *Capable platforms, superior technology*
- *Innovative operational concepts*
- *Adaptive plans and Command & Control*

*We will shape a strong, resilient Fleet posture so that our forces and support structure can sustain readiness for any contingency, now and in the future. To do so, we must:*

- *Make ourselves efficient and effective*
- *Balance operations, training and maintenance for sustainable readiness*
- *Rigorously assess and understand risk*

*We will strengthen and deepen alliances and partnerships to promote collective security. Trust and cooperation are fundamental to our ability to promote peace and also to respond to crises. We will seek to build true partnerships based on mutual understanding and respect.*

*We will be prepared to operate in naval, joint, and combined environments.*

***We will be good stewards of our Nation's resources - fiscal, material and environmental.***

*We value our people and their families. Their contribution is central to mission accomplishment. Our policies and culture must consider the well-being of our people in order to ensure a combat-ready force."*[1]

The passage in **Bold** is a relatively new entry in the Commander's mission statement and highlights the heightened emphasis on energy efficiency and environmental stewardship in the Navy specifically and generally across the military. It illustrates the need for an appropriately designed headquarters and is a good lead-in to the project's focus.

In the larger context, various organizations have raised the red flag on global warming and environmental impacts we humans inflict upon our planet. At all levels, humans have taken

[1] Commander, U.S. Pacific Fleet, " Mission, Vision and Guiding Principles,", http://www.cpf.navy.mil/about/ , (Accessed March 20, 2013).

our earth and its resources for granted, from governments poorly managing their country's natural resources to the individual absentmindedly tossing a plastic water bottle on the side of the road, eventually to end up in a waterway or ocean.  According to the U.S. Energy Information Administration, coal is responsible for 81% of the $CO_2$ emissions produced by electricity generation (over a third of total U.S. $CO_2$ emissions), natural gas 16.9% and petroleum 1.6%. Of the electricity we consume, over three-quarters (75.7%) goes just to operate the buildings we live and work in every day. By comparison, industry uses 23% and transportation, less than 1%[2].  As you can see the building industry's contribution to global warming is significant. Alternatively, our gluttony for fossil fuels and other energy sources is severely affecting our ground, air and water.  Natural Gas, highly touted as an alternative to petroleum, apparently has some concerning issues with its extraction.  There are numerous reports of ground/tap water in homes near natural gas extraction sites that are tainted with the gas, with some so bad that the occupants could light their tap water with a match[3].

This environment, paradoxically, should be good for consideration of alternative energy sources, to which Hawaii has much potential.  Locally, Hawaii has been dealing with issues of sustainability at a slow pace, as evidence by their heavy reliance on fossil fuels. (Fig. 1)

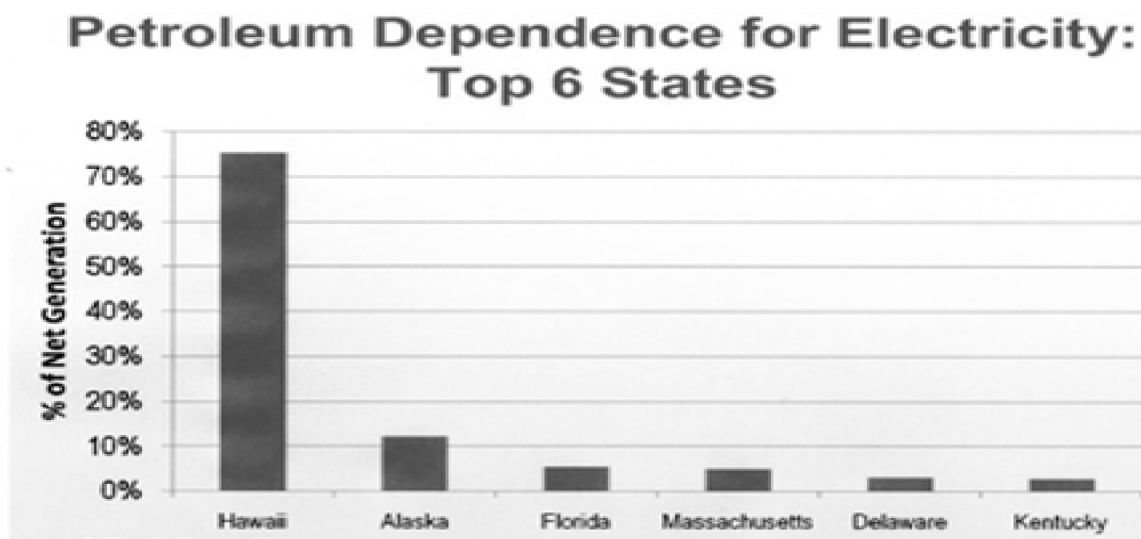


**Figure 1.  Bar chart depicting top 6 states dependent on petroleum to generate electricity and as a percentage of net generation.  *Source*: Hawaii Clean Energy Initiative Roadmap**

[2] Architecture2030. "Why?" http://architecture2030.org/the_problem/buildings_problem_why. (Accessed March 20, 2013).

[3] You tube video depicting resident living in close proximity to a Natural Gas extraction site lighting his tap water with a match. WATERUNDERATTACK.COM.  http://www.youtube.com/watch?v=U01EK76Sy4A (accessed Mar 20, 2013)

Oddly, this is in contrast to Hawaii's potential in sustainability and alternate energy sources.[4] sources.

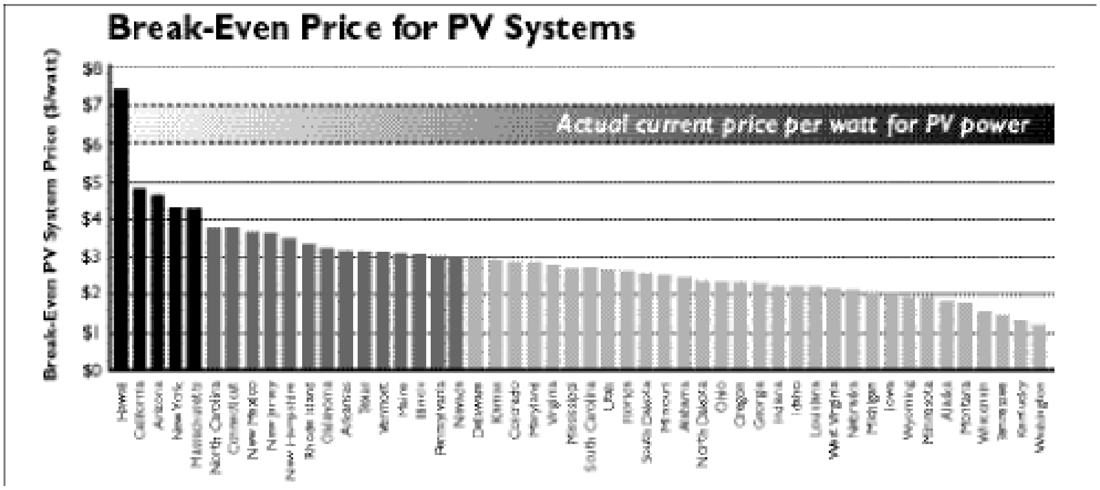


**Figure 2. Bar Chart depicting state by state break-even price for PV systems which illustrates Hawaii's solar potential in terms of cost recoupment. *Source*: homeenergy.org**

Military units and facilities on Hawaii are directly affected by these same issues. The military is subject to similar cost constraints, as they do not ship commodities and materials via military transport. Rather they ship via commercial contract as well. They are also subject to the same energy cost constraints, and in some cases more so, in this present environment. The Secretary of Defense (SECDEF) has mandated that the DoD will implement austerity measures like the rest of the US government. In the past, fuel and energy consumption was not emphasized in the office or in base housing. This is no longer the case, and in fact is now highly emphasized, whereas before residents did not pay utilities, they now do. They are issued monthly limits and when they exceed them they pay the difference.[5] Military higher echelons now put their commanders on notice that they are responsible for their unit's energy consumption and it will reflect on their fitness report or evaluation.

The political, social and economic environment should be ripe for change, but it will take additional effort on behalf of individuals and sympathetic and sensitive organizations to make

[4] Hawaii State Depart of Business, Economic Development and Tourism. http://hawaii.gov/dbedt/. (Accessed Mar 20, 2013)
[5] http://usmilitary.about.com/od/benefits/a/utilities.htm. Article reports on military plans to "privatize" housing and efforts to establish baseline energy consumption which if exceeded will require the occupant to pay the difference. Thus incentivizing energy efficiency.

the sacrifices and cultural shifts it will require. Our part as Architects is no small one. Architecture 2030, an organization started by Architect, Ed Mazria in 2003 has identified the building sector as the largest energy consumer in the U.S. They have reported that the built environment accounts for nearly half (49%) of all energy consumed in the United States and 75.7% of the total electricity produced (to operate buildings). The industry is also responsible for nearly half of all Carbon Dioxide emissions (49%). In comparison, the Transportation and Industrial sectors are responsible for 35 and 19 Percent respectively. The Architecture 2030 challenge is to transform the U.S. and global Building Sector from the major contributor of greenhouse gas emissions to a central part of the solution to the climate change, energy consumption, and economic crises. They have outlined a path to carbon neutrality by 2030 in the following way:

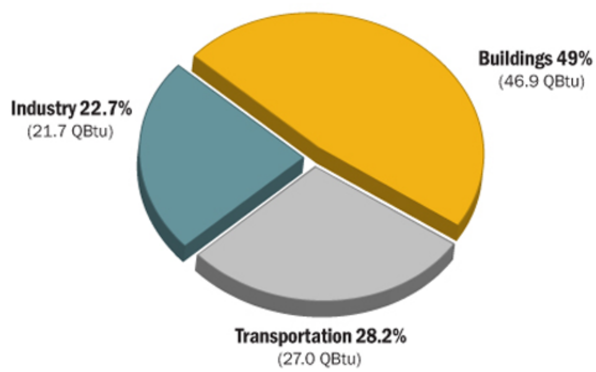


**Figure 3. Pie Chart illustrating energy consumption by sector in the U.S. *Source*: Architecture2030.org**

- All new buildings, developments and major renovations are designed to meet a fossil fuel, greenhouse gas (GHG) emitting, energy consumption performance standard of 50% of the regional (or country) average for that building type.
- At a minimum, an amount of existing building area equal to that of new construction be renovated annually to meet a fossil fuel, GHG emitting, energy consumption performance standard of 50% of the regional (or country) average for that building type.
- The fossil fuel reduction standard for all new buildings be increased to:

60% in 2010

70% in 2015

80% in 2020

90% in 2025

Carbon-neutral by 2030 (zero fossil-fuel, GHG emitting energy to operate).

This may be accomplished through innovative design strategies, application of renewable technologies and/or the purchase (maximum 20%) of renewable energy[6].

This project will focus on a whole building design process that is sensitive to the need to do our part as architects and to take on the challenge. The process should carefully balance security and sustainable design requirements, specifically focusing on design related measures that architects have the most influence on. Identifying those measures that are synergistic and address specific security and sustainable requirements simultaneously will provide a valuable tool in ensuring all minimum and building specific standards are met.

## 1.2 Problem Statement

The DoD has set aggressive sustainability and energy efficiency goals and although committed to attaining them over time, will not hit intermediate goals. This issue is due, in part to the sheer magnitude of the effort and the limited funds available. Additionally there is a common perception that sustainable design objectives conflict with security design requirements. Just by the nature of the DoD, security design is the higher priority in order to meet mission needs. This lack of sufficient funds, long prioritized list of existing and new construction projects needing both security and energy efficient design and a perception that it is too costly to accomplish both sufficiently, likely contributes to decision makers culling projects. What can be done to help decision makers decide that it is practical and possible to effectively plan, design and construct secure and energy efficient buildings?

## 1.3 Hypothesis

A high performance military component commander's headquarters building can be actualized through responsive design strategies tailored to Hawaii's climate through thoughtful balancing of competing security and energy efficient design criteria by leveraging sets of synergistic approaches.

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[6] Architecture2030.org (accessed 11 April 2013)

# Chapter 2. Research and Exploration

## 2.1 Scope of Research

The research was focused primarily on the design aspects and considerations of a building of this typology. The unique elements of a command and control facility of this type required gaining knowledge and understanding of the nature of the headquarters itself and the historical and modern context. Additionally, and in support of the main focus, research was aimed at identifying the DOD design processes and criteria, the nature of Navy component commands, tropical design and security design considerations. An understanding of both sustainable and security design criteria of the DOD facilitated balancing them while at the same time maximizing energy efficiency. Although present day DOD sustainable design requirements include attaining the USGBC LEED gold rating, the research emphasis in this study was not completely on LEED, but on ways and methods of increasing energy efficiency that facilitated maximizing LEED credit while not compromising necessary security. The research efforts center on studying energy efficiency design in tropical climates, precedent studies on similar type buildings, study of human comfort and performance and understanding how DOD security design requirements impact achieving sustainable objectives and vice versa.

## 2.2 Research Objectives

The following objectives were used to facilitate the design of a high performance and secure headquarters facility

- Understand the DoD design and construction process
- Understand the various DoD, Navy and Installation design criteria
- Understand the nature of a component commander's headquarters
- Understand Hawaii's climate and environment
- Determine design strategies that respond to Hawaii's climate

- Determine design strategies that address security requirements of Department of Defense buildings
- Propose and justify these strategies from an energy standpoint with a regional perspective
- Survey historical and modern precedent for parallels and applications
- Determine design strategies that overcome the constraints resulting from unique military and governmental building construction requirements.
- Determine Design Strategies that balance Sustainable and Security Design Criteria.

## 2.3 Research Methodology

In the first phase of the Doctorate project, the main research focus was gathering information and data that facilitated the secure and energy efficient design of a high level command center in a tropical climate. This research helped to identify challenges, tradeoffs and opportunities in applying both security and sustainable design criteria in the unique DoD design and construction environment. These required developing an applicable understanding of; DoD design and construction standards and sustainable goals, the inherent conflict of synthesizing goals, and documented opportunities and tradeoffs when goals are synthesized. Additionally, it was important to develop an understanding of sustainable design approaches for Hawaii's climate. Lastly, the study of relevant examples of transferrable design approaches to a DoD Headquarters facility in the tropics and elsewhere provided precedent security and sustainable design approaches.

The second phase of the project expanded on the research phase, and resulted in a process and design synthesis of the investigated information and data. Utilizing the information gathered from these processes, program, site and conceptual iterations were developed that conformed to program requirements. The emphasis was on balancing security and sustainable design criteria, but more importantly attaining high level energy efficiency.

## 2.4 U.S. Pacific Fleet Command

### 2.4.1 U. S. Pacific Fleet History

The Pacific Fleet headquarters has a storied past in our Nation's history. The headquarters in Pearl Harbor was established just months before the Japanese surprise attack of Dec 7, 1941 that started the United States' "War in the Pacific". Therefore, it became the central headquarters in the war with the axis powers in the Pacific, before there was a unified regional commander. Names like Admiral Nimitz and Admiral Spruance commanded the fleet, and Admirals Halsey, Fletcher and Kinkaid's pictures adorn the walls of the commander's office. The original building still stands in the headquarters complex and is on the National Historic Register.

### 2.4.2 Pacific Region Command Overview

A quick overview of the Pacific command structure and governing documents starts at the White House.

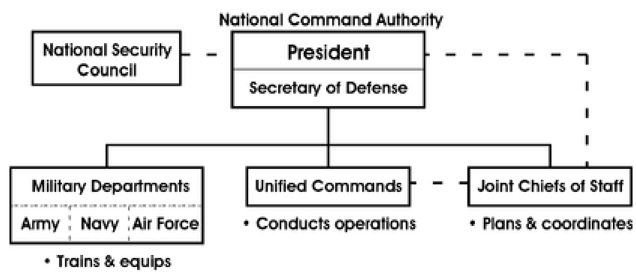


**Figure 4. National Command Authority organizational chart. Source: GlobalSecurity.org**

The Secretary of Defense (SECDEF), as a cabinet member and representative of the President of the United States (POTUS) leads three distinct branches under the National Command Authority (NCA). The Military Departments; Army, Navy and Air Force are responsible for training and equipping their respective Forces. The Unified (Joint) Commands are responsible for conducting operations in their region or functional area. The Joint Chiefs of Staff (JCS) then plan and coordinate amongst services and Unified Commands; they also have a place at the NCA table as direct advisors for their service components and the military in general.

Based on the POTUS' vision, the Executive branch produces the National Security Strategy (NSS) which outlines primary national security focus areas/concerns and how the administration plans

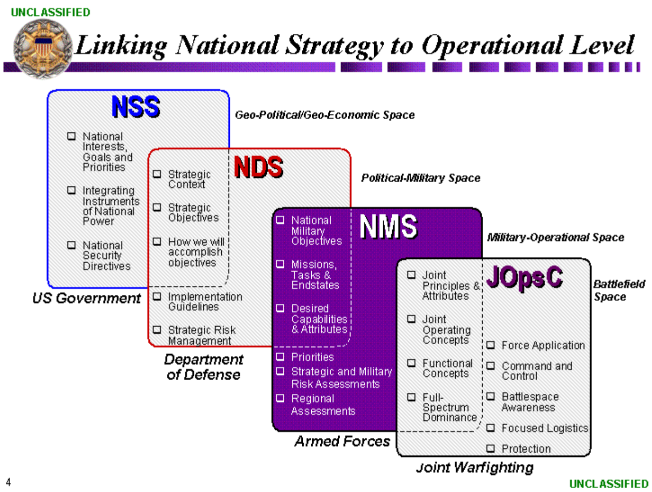


**Figure 5. Hierarchy of national strategy governing documents. *Source*: JP-1**

to deal with them.[7] The Goldwater-Nichols Act of 1986 is the legal foundation of the development of the document and provides guidance and direction in the reformation of the Department of Defense (DoD). The NSS is generated at the beginning of each successive presidential administration and is general in content then supported by more elaborating documents from each executive department. The 2010 NSS for the first time specifically identified climate change as a problem and priority. The National Defense Strategy (NDS) flows from the NSS and is the "capstone" document of the Department of Defense. It also provides a framework for other DoD strategic guidance, specifically on campaign and contingency planning, force development, and intelligence.

The DoD, by way of the Chairman of the Joint Chiefs of Staff with input from the Regional Combatant Commanders, then drafts the National Military Strategy (NMS), which provides a brief but more detailed military strategy in support of the NSS objectives. Additionally, a yearly NMS report is developed that;

> *"provide(s) a description of the strategic environment and the opportunities and challenges that affect United States national interests and United States national security."*[8]

The Unified Command Plan (UCP) is updated annually and delineates areas of responsibility or combatant command alignments or assignments of the Unified Combatant Commands.[9] These commands consist of 6 regional commands and 4 functional commands, of which the USPACOM is a regional command. Each command consists of at least two service or

[7] National Security Strategy 2010
[8] National Military Strategy 2010
[9] http://www.defense.gov/home/features/2009/0109_unifiedcommand/ (accessed 11 April 2013)

functional areas that make up the overall command structure and is commanded by a 4 star Admiral or General. USPACOM has all services, or components, represented along with supporting organizations and agencies. The US Pacific Fleet is the Navy component of USPACOM and is commanded by a 4 star Admiral. COMPACFLT is then responsible for:

*"… support of U.S. Pacific Command and with allies and partners, U.S. Pacific Fleet enhances stability, promotes maritime security and freedom of the seas, deters aggression and when necessary, fights to win."* [10]

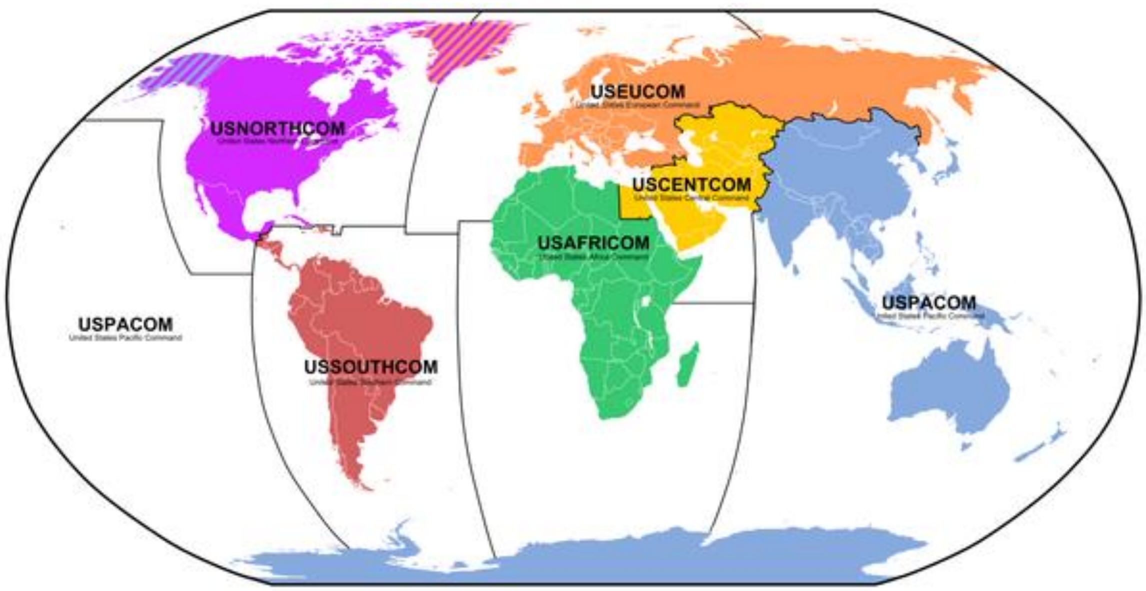


**Figure 6. Unified Command Plan Areas of Responsibility.** ***Source*****: Unified Command Plan 2008.**

The headquarters and its staff are then charged with carrying out the Commander's intent and vision in support of CDR USPACOM. The commander has a full range of tools and technology, at his disposal to complete the mission. His headquarters then needs a modern, responsive, fully mission capable facility to accomplish the mission. The headquarters will house 8-10 departments and 5-6 supporting agencies as well as numerous interagency offices co-located for coordination. The full range of administrative, planning, coordination and operational activities; political, diplomatic and military, will be executed in this facility.

[10] www.cpf.navy.mil (accessed 11 April 2013)

### 2.4.3 The People

The PACFLT headquarters staff will consist of approximately 450-500 military and civilian personnel. It will also house liaisons from other agencies and service components, both DoD and Federal as well as foreign military liaisons. Although each member's duties vary, their primary mission is to support the commander's intent and vision as outlined above. Military personnel rotation policies generally result in an "Operational" tour, followed by an "Administrative" or "Staff" tour and so on, in a career progression. A standard Navy rotation is three years on "Sea" or operational duty and three years on "Shore" duty. Sea duty would include assignment to a ship, submarine, squadron or other operational or field unit. With few exceptions a "staff" tour is a shore duty tour. From a personnel management perspective it affords the Navy member a "rest" from the rigors, dangers and Operational Tempo (OPTEMPO) of Sea duty before they continue the rotation cycle. The going in premise or motivation of this design project was the creation of a high performance building that meets the modern warfighting requirements of the commander and is responsive to the climate and the occupant. Human comfort, performance and productivity go hand in hand and while energy conservation is the primary focus this project requires that we consider how it can enhance the working environment of a demographic that has one of the most arduous and dangerous jobs in the world.

## 2.5 Sustainable Design Considerations

During the initial phase of the doctorate project it is important to understand the fundamental energy and environmental design conditions of Hawai'i. An understanding of Climate, Site, and Building type and how the building is affected in that location based on mass and configuration are critical to the building's design. Climate is one of the most important variables in the design of an energy efficient building. The following external forces and opportunities must be understood in order to then apply measures that facilitate that energy efficient goal.

### 2.5.1 Human Biology

#### 2.5.1.1 Human Comfort

Six Factors affect human comfort. Air movement, humidity, air temperature and mean radiant temperature (temp of surrounding objects and surface) are environmental and physical exertion and clothing are chosen by the person. In Hot and humid climates, air movement is essential to comfort if not mechanically conditioning the space. Because we will endeavor to maximize passive and natural methods to enhance comfort, capturing the naturally occurring trade and Kona winds will be important. Air movement does not lower the temperature; it does cool the human body by giving it a cool sensation as a result of heat loss by convection and by evaporation of the body. The body cools itself naturally in hot conditions by sweating, with the resulting evaporation of the sweat transferring heat, cooling the body. Velocity of this air movement is important in that if it increases, the upper human comfort limit increases. As you approach 100-200 feet per minute of air velocity, you begin to reach a point in which the air movement is noticeable and risks becoming annoying. Therefore, an air movement velocity in the range of 50-200 is the goal, depending upon the temperature you are trying to make more comfortable.

Humidity is the amount of water vapor in the air. It regulates air temperature by absorbing thermal radiation both from the Sun and the Earth. When relative humidity exceeds 80% an increase in air movement per increase in relative humidity should offset the increase. Temperature decreases caused by evaporation increase comfort levels.

Air temperature in the mid 60s to lower 80s is generally in the Human comfort zone. It varies according to the person and also the climate to which the person is accustomed to.

Mean Radiant Temperature (MRT) affects the body's ability to lose heat by radiation. The higher the MRT the more difficult it is for the body to cool itself.

The Bioclimatic chart illustrates the human comfort zone in a moderate climate, with the shaded region in the middle the ideal. Around it are climatic elements that affect comfort and indicate corrective measures to improve comfort if out of the zone. If after plotting your dry bulb temperature (vertical axis) and your relative humidity (horizontal axis) you are just above the zone you will need to apply wind at the indicated wind speed to make the person comfortable.  For example at a temp of $83^{0}$F and a relative humidity of 60%, you would need to provide wind at approximately 200 ft./min.  In some cases you would need to add moisture to the air.  Another example would be at a temp of $83^{0}$F and a relative humidity of 15% you would need to add 5 grains of moisture per pound of air.

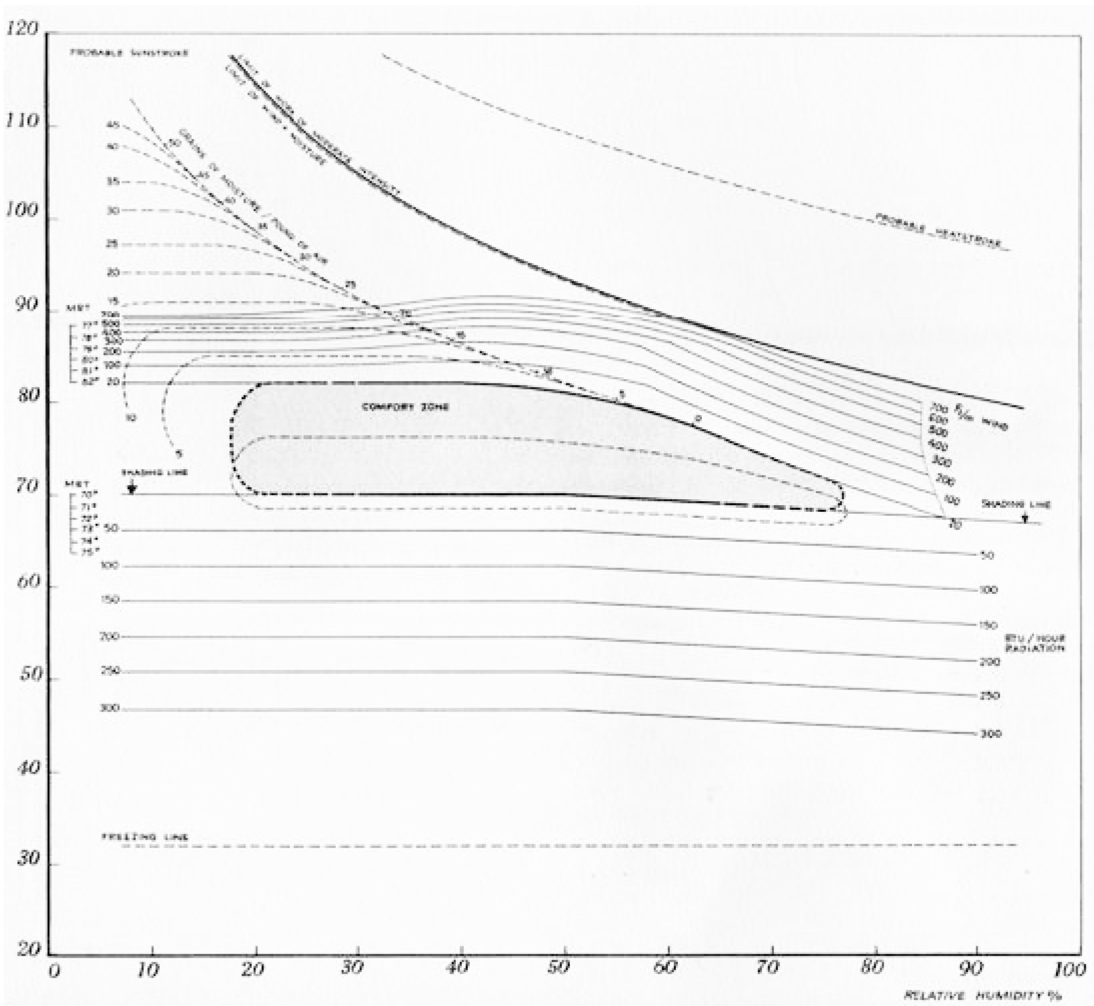


**Figure 7. Bioclimatic chart illustrating the human comfort zone and when outside the zone, types of measures that can be implemented to improve comfort levels. *Source*: Victor Olgyay, "Design for Climate".**

### 2.5.1.2 Human Performance

According to Huntington,

> "*These observations suggest that man's physical strength and mental activity are at their best within a given range of climatic conditions, and that outside this range efficiency lessens, while stresses and the possibility of disease increase*."

His observations included studying different levels of productivity output at different geographic locations as well as output during different times of the day and different seasons. His findings essentially stated that in extreme environments human productivity did not compare favorably to more moderate climates or seasons. He also found that during the extreme parts of the day in hot or cold climates of less extreme locations productivity decreased.

This leads to the observation that controlling a working environment adequately and appropriately for the climate will increase health, wellbeing and performance. Responsive strategies to Hawaii's generally mild climate are still important to counter the extremes of the day and seasons. Although the humidity is moderate in Hawaii there are periods of high humidity, and due to the many microclimates, some locations are more humid than others.

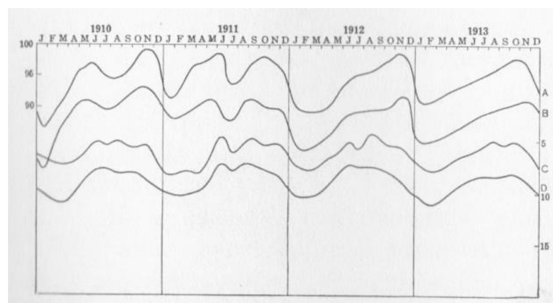

**Figure 8. Seasonal variations in productivity.** ***Source*: Ellsworth Huntington, "Principles of Human Geography".**

## 2.5.2 Design for Energy Efficiency and Human Comfort

Because so much of the energy use in buildings is devoted to human comfort by producing an artificial indoor environment, providing climate sensitive design will be an important step in cutting energy demand and enhancing human comfort. Some estimates show that appropriate design could cut heating and cooling energy consumption by at 60% and lighting energy draw by at least 50% in buildings in the U.S. With that, the emphasis for energy efficient design will be to address the following considerations:

- Building orientation and massing to leverage solar access and to provide shading and natural lighting.
- Access to daylight
- Effects of micro-climate on building
- Thermal efficiency of building envelope and fenestration
- Properly sized and efficient Heating, Ventilating and Air Conditioning (HVAC) equipment
- Adequate fresh air supply
- Minimization of electric loads from lighting, appliances and miscellaneous equipment
- Leverage alternative energy sources

### 2.5.3 Solar Control and Heat Gain

When it comes to our abundant amount of sunshine in Hawai'i, two things are important; harnessing the sun for its renewable energy and light and mitigating the heat gain. Controlling the amount of the sun's radiant energy penetrating the building envelope is important. Therefore, understanding the characteristics of sunlight will aid in leveraging and addressing it.

#### 2.5.3.1 Solar Geometry

A basic understanding of solar geometry will help in applying appropriate strategies to mitigate heat gain through the envelope, enhance daylighting opportunities and to design shading devices.

The amount and makeup of solar radiation reaching the atmosphere's outer edge is called the Solar Constant and does not vary. The amount reaching the surface of the earth varies widely with sun angles, elevation and atmospheric composition. The tilt of the earth's axis and its orbit around the sun is the cause of the seasons. On Jun 21, the northern hemisphere is tilted toward the sun and receives the highest amount of radiation. Conversely, on Dec 21 the southern hemisphere is tilted toward the sun at which time the northern hemisphere receives its minimum radiation from the sun. The farther north or south from the equator you go the more extreme the radiation differentials are.  In Honolulu, at the 21st parallel, we are just below the Tropic of Cancer, which is at 23.5°N which means that Hawaii's sun can be quite intense over the summer months with the summer solstice on 21 Jun and the sun at its most northerly position on the longest day of the year. The vertical angle where the sun's rays hit the earth is the Altitude Angle[11].  The Altitude angle determines how much of the solar radiation will be absorbed by the atmosphere. Lower angles pass through more of the atmosphere and absorb more of the radiation making it weaker and more modified in composition.

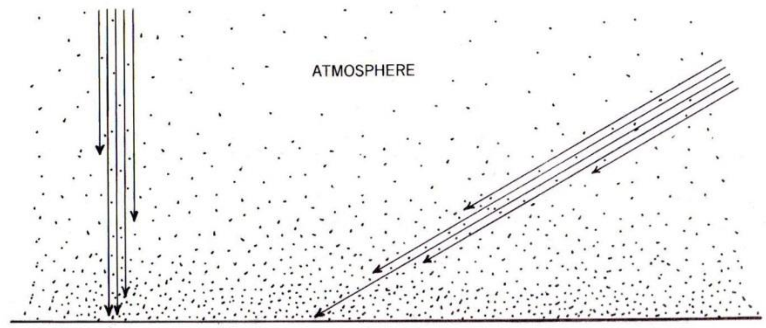


**Figure 9. Altitude angle. *Source*: Norbert Lechner: Heating , Cooling, Lighting**

Another element of the altitude angle, relates to the Cosine Law[12] in which the lower the angle of the sun, or the lower in the sky the sun is, the more the sunbeams are spread over

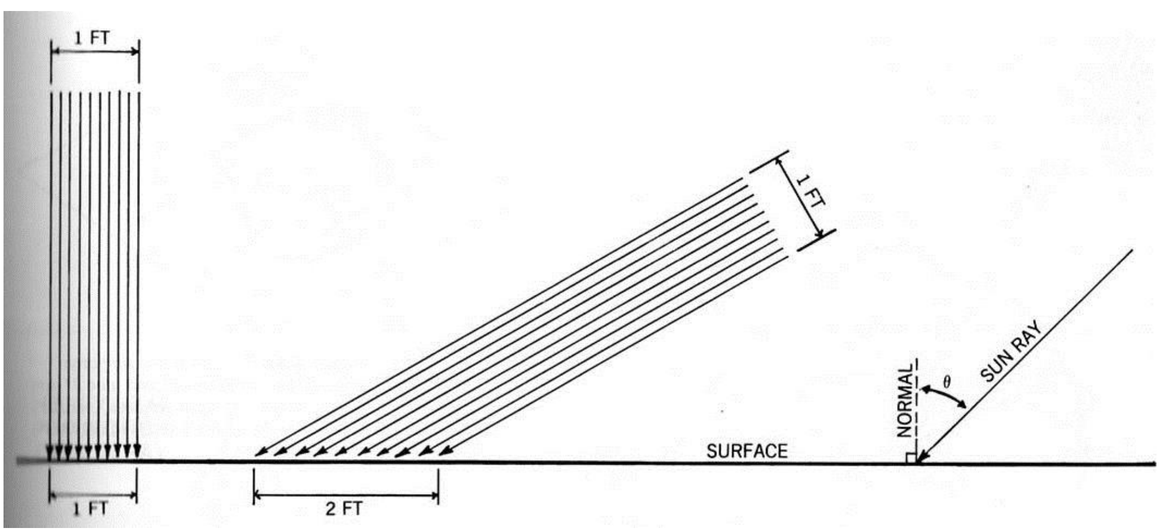


**Figure 10. Chart illustrating how lower sun angle spreads sunbeams over larger area thus weakening the energy striking per unit of land. *Source*: Norbert Lechner; Heating , Cooling, Lighting.**

[11] Norbert Lechner, *Heating Cooling, Lighting: Sustainable Design Methods for Architects* (Hoboken: Wiley and Sons, 2009) 213
[12] Lechner, 134.

the land, thus weakening the sunlight per unit of land it strikes. This explains, in part, why Hawaii's climate is hot; the sun's rays strike at a steeper altitude angle focusing the suns energy at its strongest. This illustrates what we are up against with respect to heat gain and mitigating it is one of our biggest goals.

We have many options available to address undesirable heat gain; orientation, ventilation, radiant barriers, insulation, shading, landscaping, material choices and color, for example. Temperature control utilizing several of these options while minimizing the need for mechanical conditioning will be a main design goal.

#### 2.5.3.2 Shading

To the extent security design restrictions allow, shading from trees and manmade shading devices will be a key strategy for year round solar control, particularly shading of windows. Because, horizontal glazing such as skylights receive the most solar radiation, as much as 4 times[13] that of a south facing window, we will avoid their use for the most part. East and west facing windows receive as much as 2 times that of a south facing window. Therefore, we will emphasize shading on the east and west facing windows, to a lesser extent on the south facing windows and even less so on the north. Conversely, we will consider minimizing glazing where more shading is needed and maximizing it where we intend to take better advantage of daylighting strategies. Several types of shading can be considered with each addressing the different components of the total solar load; direct, diffuse and reflected radiation.

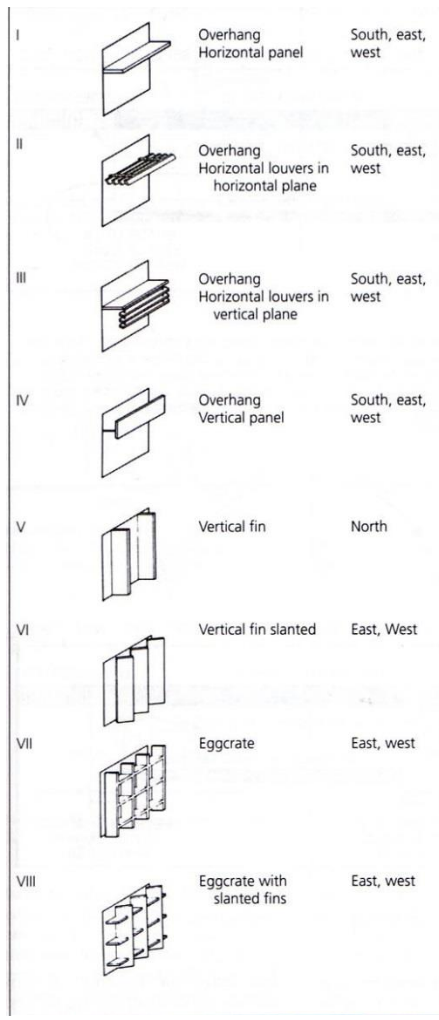


**Figure 11. Exterior shading devices.**
***Source*: Norbert Lechner.**

[13] Lechner, 214

- Exterior.

Exterior shading devices can include overhangs, horizontal louvers and mini louver screens either fixed or movable as well as vertical elements. Because of Hawaii's location, year round hot weather and steep sun angles, fixed shading devices tend to make more sense. Movable devices are used more in Hold/cold climates to gain heat in winter and mitigate heat in summer as a result of the lower sun angles at those latitudes. When you wish to gain heat you move the device to allow sun in and when you wish to block it you move it back to shade the area/window.

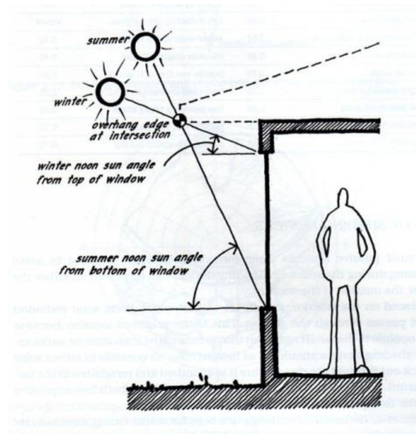


**Figure 12. Winter and summer sun angles help to determine optimum shading device dimensions. *Source*: Lechner**

Exterior shading is the most effective and desirable. Additional considerations in combination with shading include; well-considered window placement, light colored walls, shading patios and walls in addition to windows and use of natural vegetation and foliage as shading elements.

- Interior

Best case, you stop the sunlight on the outside of the building, however, if you are unable to use exterior devices or you need to augment the exterior systems, interior shading is advised. These might include blinds, screens and shutters. Because heat still enters and is trapped between the glazing and device, eventually it escapes into the room. Ideally, it is coupled with LowE glazing that minimizes heat transfer through the opening.

#### 2.5.3.3 Orientation

Carefully considering building orientation is important. Orientation to optimize exterior and interior (where possible) ventilation, mitigate air infiltration and heat gain and maximize solar potential will be critical in the whole building design. Providing ample outdoor spaces that are shaded and cool, capturing the natural breezes will be an alternative to interior spaces for social gathering and informal meetings, as well as rest and relaxation from the rigors of the job.

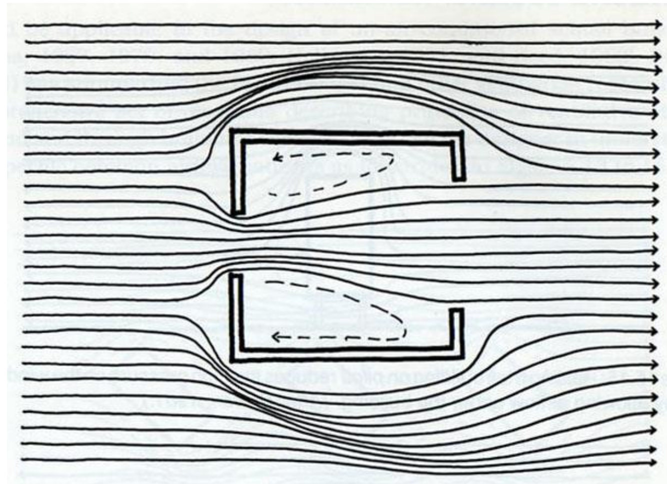

**Figure 13. "People cooling" inlet smaller than the outlet increases velocity. *Source*: Lechner**

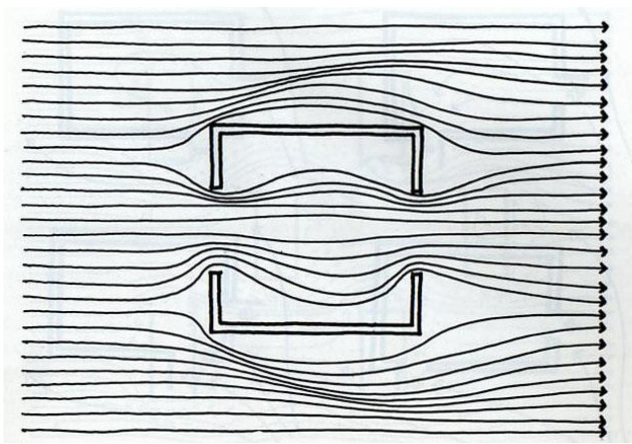

**Figure 14. "Building cooling" inlet and outlet same size maximizing air exchange in the space. *Source*: Lechner**

In order to capture adequate ventilation in our outdoor spaces and to facilitate any possible stack effect system incorporated, we need to carefully consider angle, size of openings and location of obstructions. Because of our trade winds, placing openings on the east side and or providing corridors between buildings running east/west will take better advantage of the prevailing breezes. We can attempt to serve several purposes: Because we are intending to place exterior spaces between buildings, by creating courtyards and corridors as well as open air atriums, "people cooling" will be the goal. We'd do this by making the inlet smaller than the outlet which maximizes airspeed through the space. If cooling the building were the priority, making the inlet and outlet the same size would maximize air exchange. However, because we intend to use atriums and enclosed spaces as well and because of our force protection restrictions of opening up the spaces to the outside, we need to use the stack effect as much as possible. We will have anywhere from 2-4 floors which will require stairwells. Some stairwells will be fire escapes, but some will be in the open atriums. Coupled with the stairwells and exhaust vents above them, we can do one of three things. We can use a stack

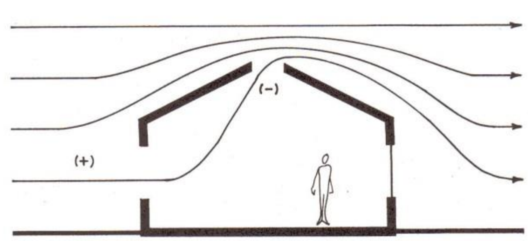


**Figure 15. The Venturi effect causes air to be exhausted at roof opening or near apex. *Source:* Lechner**

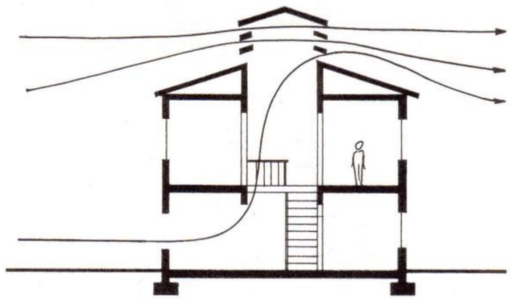

Figure 16. The stair well coupled with the ventilation path and use of both the Venturi and Bernoulli Effect make for effective vertical ventilation. *Source*: Lechner

effect system which relies on natural convection, or we can take advantage of the Venturi or Bernoulli Effect or both. The stack effect doesn't necessarily rely on wind, but it can be improved by it. By coupling a path that goes through several floors and either the Venturi or Bernoulli effect with an exhaust at the apex that is one way we can increase our air exchange even in an enclosed space. By identifying areas that do not require application of security criteria and that can have natural ventilation we can take advantage of these strategies. Examples would include atria leading to an access control point, open air food courts on north side of complex or outdoor circulation between buildings or building wings.

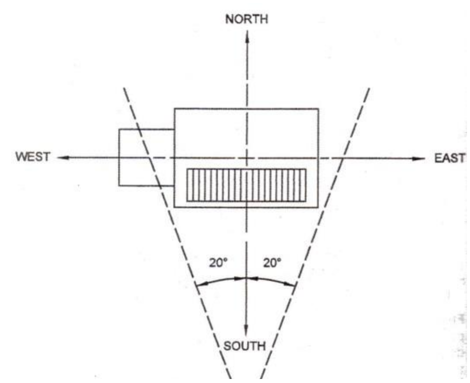


**Figure 17. Optimum orientation 15-20° either side of N/S is optimal. *Source*: Lechner**

The buildings orientation will also determine the amount of solar radiation striking the walls, windows and roof. Because daylighting will also be an important strategy to minimize the energy load, correct orientation will be a big determinate in its success.

East and West facing walls should have minimal surface area exposed to the sun. It would be optimum for the long sides of the building to face North and South, with the majority of glazing on these sides. This is because it minimizes the heat gain on those sides as compared to the east and west sides that get strong morning and evening sun exposure. An orientation in which the building is angled anywhere from 15-20°either side of true north or south is optimal. Of the several viable sites in the Makalapa complex, one is heavily shaded with mature trees, one is shaded by the Makalapa crater rim and the other is exposed on a knoll. The exposed site affords the most solar potential but also solar heat gain and is a tradeoff that must be considered. Use of this site would require the most creative use of solar heat gain mitigation strategies on all sides, but it would provide an opportunity to utilize a robust Building Integrated Photovoltaic system. The shaded site still provides ample sun exposure for solar potential with an orientation of east to west.

### 2.5.3.4 Envelope

Use of insulation, radiant barriers, cool roofs, green screens and roofs, LowE and/or spectrally selective glazing and light colored walls will all facilitate minimizing heat gain. Additionally this will be an opportunity to incorporate Building Integrated PV into the envelope. Insulation will be an effective barrier to conduction and some radiant heat transfer. It will also effect convective heat movement. The more insulation the better. All walls and roofs will be insulated, with the insulation at an appropriate R-value of 40 for ceilings and 14 for walls at a minimum.[14] By using this it will effectively buffer thermal heat transfer by reducing the amount of heat passing to the interior. Insulation comes in several different forms; batts, rigid foam, spray-in and loose fill are the most prevalent.

Radiant Barriers as a complement to insulation can be very effective as well. If one were just to have an empty air space in the wall cavity with no insulation or radiant barrier the R-value would always be less than 1.[15] By providing the thermal resistance of insulation and the reflective properties of a radiant barrier, you improve your insulating properties. All radiant barriers act as either reflectors or non-emitters, depending on the direction of heat flow. A radiant barrier will reduce heat transfer either by reflecting 95 percent of the heat radiation or by emitting only 5 percent of that emitted by materials that do not act as radiant barriers. They are usually made of a highly polished meal foil that is oriented facing an air space of at least ½" thick. They can be applied to both sides of the airspace which would then reflect more effectively, 95 percent on one side and 4.8 percent on the other for a total of 99.8 percent reflected radiation.[16] The best location for a radiant barrier in Hawaii is in the roof, where studies have shown that heat gain can be reduced by 40 percent.[17]

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[14] Lechner, 471
[15] Ibid
[16] Benjamin Stein and John S. Reynolds, *Mechanical and Electrical Equipment for Buildings* (Hoboken: Wiley and Sons, 2006) 183
[17] Lechner, 474

Cool roofs, particularly at Hawaii's latitude, with its steeper sun angles provide excellent heat gain mitigation. Two important factors to consider when designing and selecting cool roof materials are reflectance and emissivity. Depending on your source and standard, different combinations of levels of reflectance and emissivity are ideal.[18] Basically the higher the reflectance and lower the emissivity the better. A Solar Reflective Index (SRI) uses both in its calculation of a roofs thermal properties which produces a number between 1 and 100, with the higher the number the better. The LEED standard uses this index and calls for an index of at least 78 over 75 percent of the roofs surface area to attain one point toward a rating.[19] Lighter colored (low SRI) roofs generally are more thermally sound but modern technologies have allowed some darker colored materials to attain relatively low SRIs thus facilitating a broader range of roof material choices that are thermally effective and energy efficient.[20]

Another effective system through the envelope is glazing that minimizes heat gain such as LowE and spectrally selective glazing.

Because windows also affect the amount of light entering the building you must be careful not to shade too much or use counterproductive window treatments. In some cases windows with tinting or films actually get hotter due to the absorption of the solar heat. By using LowE windows you increase reflectivity and decrease emissivity. Spectrally selective windows perform similarly, but rather allow the visible but not the infrared part of solar radiation to pass through the glazing.[21]

**Figure 18. Extensive Green roof with low water requirement and thin layer.**
**Source: greenroofs.com**

[18] http://www.facilitiesnet.com/energyefficiency/article/Energy-Gains-The-Envelope-Please--4091. Article discusses envelope energy efficiencies and identifies differing standards on ideal cool roof reflectance and emissivity.
[19] LEED Sustainable Sites credit 7.2 applies to roof with 2:12 pitch.
[20] http://www.kingspanpanels.us/sustainability/cool-roofs.aspx. Kingspan cool roof color palette reveals darker colors with relatively low SRIs.
[21] Olgyay, pg. 69

Green screens, although generally not incorporated into the envelope, help to augment the other wall systems incorporating color, insulation and radiant barriers. The Green screen is natural and aesthetically pleasing way to provide shade and a barrier to solar radiation. Green roofs on the other hand are incorporated into the envelope, but must be carefully designed and constructed. Because the possibility of leakage is a great danger to critical systems, use and placement will be restricted. That said, a well designed and constructed green roof with native dry land vegetation, relying on rain water can be quite safe to use even over critical areas given an adequate buffer between the green roof and critical space.

This coupled with light exterior colors, a radiant barrier, shading from natural vegetation in the form of green screens; green roofs and/or trees will effectively minimize the cooling requirement. A green roof is a viable option and based on two of the available sites in the complex, can be incorporated into an outdoor gathering area.

### 2.5.4 Humidity control

Controlling humidity is a big challenge in tropical and sub-tropical climates. It can be challenging for even the most efficient environmental control system to adequately dehumidify a space to the degree needed to avoid the perils of humidity; mold and mildew. This coupled with security design requirements for the type of occupancy we are designing for which require air tight spaces to address potential airborne threats will make humidity control an important measure to get right.

Because properly ventilated space is also critical to a secure facility, potential moisture further adds to the challenge by increasing cooling loads[22]. Moisture can enter the building envelope in one of 4 ways, liquid water through cracks, holes or gaps, liquid water through capillary action through porous materials or tiny holes, water vapor via air leakage through cracks and holes in the envelope, Water vapor intrusion as a result of difference in vapor pressures.

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[22] Lechner, p 149.

Clearly mitigating these sources is critical not just for moisture control but for conditions where air filtration or the need to make the building airtight in extremis is necessary. One of the more problematic is air leakage and using a wind barrier that reduces humid outdoor air from entering, is an effective practice. Another method is using exhaust fans in areas prone to moisture such as the bathrooms and kitchen areas. Venting roofs and walls if able is advised as well as designing and incorporating appropriate drainage. Lastly, using insulation that does not promote condensation such as non-porous or foam insulation is effective.

Ensuring state of the art control systems are routinely monitored and ensuring routine occupant education coupled with occupancy sensors should also go a long way toward mitigated the problems arising from humidity.

### 2.5.5 Lighting

Lighting, for commercial buildings, is the single largest operating cost in the U.S., accounting for approximately one third of total electrical energy costs.[23] Lighting affects both human comfort and performance as well as energy efficiency. Well designed and integrated lighting will be important to achieve both. Understanding the basic properties of light is an important part of lighting design.

Visible light is only a small part of the electromagnetic spectrum but is not the only aspect of it we are concerned with, as there are some non-visible portions that still affect us. Ultraviolet (UV) and infrared (IR) areas of the spectrum are areas that should be considered in design. UV light can damage human tissue, organic matter, furniture and art. IR radiation is felt as heat, or thermal radiation. Light sources can produce IR, UV and visible radiation. This thermal radiation in a hot humid climate is one source of heat gain to be mitigated.

There are several sources of light that are generated. The three are point, line and area sources. Each source can behave similarly, depending on distance to/from the object illuminated. Point sources, such as incandescent light bulb, originate from a single point.

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[23]Farrar-Nagy, Sarah and Sheila J. Hayter. *Los Alamos National Laboratory Sustainable Design Guide*. (LANL Site Planning and Construction Committee, 2002) 82

However it can behave as an area source when close up.  A Line source is created when a point source is extended along an axis.  An example would be a line of fluorescent lights.  An area source is a light source extended along two axes.  Examples include light from overcast skies, ceiling luminosity and indirect light sources.

Several measurements of light characteristics are important to understand when designing for light. The rate at which light is emitted from its source is called lumens and the power with which it comes out is called luminous flux.  Thus the measurement of luminous flux is lumens.  Another important measurement of light is the ratio of light output to energy input and it is call efficacy.  A fluorescent lamp has a higher efficacy than an incandescent light. Incandescent lamps emit approximately a quarter as mush light as a fluorescent lamp for a given amount of electricity.[24]  Understanding distribution of light is also important; candlepower, or candelas, describes the intensity of the beam of light in any direction. Differing types of lamps with the same measure of lumens can have differing candlepower.  For instance, a spot light versus a flood light would differ because the spot light focuses the beam increasing the intensity, while the flood light spreads the beam diffusing the intensity.  When a light source illuminates a surface, the number of lumens striking on each square foot of a surface is called illuminance and is measure in footcandles.  To determine footcandles, you determine the number of lumens emitted from a light source, divide that by the area of the surface (assume the light falls uniformly on the surface) in square feet and the resulting figure is the number of footcandles.  For example if a light source emits 100 lumens, uniformly, on a 5 square foot surface, the number of lumens per square foot is 20, or 20 footcandles. The final significant measure of a light's characteristics is brightness or luminance.  Brightness is based on the perception of the brightness of an object by the human eye while luminance refers to the measurement of that brightness by a light meter.  Luminance is the amount of that light actually reflected and measurable, while brightness can be affected by other factors that would affect the human eye, such as brightness of surrounding objects and the eye's ability to adjust under varying light conditions and levels. Light can come from directional and non-directional or omnidirectional sources.  Directional light is easier to control when illuminating a specific target, while omnidirectional light affords diffuse light.

[24] Lechner, 346.

Light can be controlled several ways. When light meets a material, it can behave differently based on the property of the material. Properties of the material that might affect light reflection from it include whether it is polished, rough or matte. Types of reflectance include specular, spread and diffuse. Specular reflectance is associated with polished surfaces such as mirrors and means that the outgoing reflection angle is equal to the angle of the incoming light. With a steeper angle you get a steeper outgoing reflection and vice versa. Reflection from a mirrored surface with slight irregularities or one that is rough results in spread reflection which is primarily from the angle of the mirror with a slightly wider and softened cone pattern. The third type is diffuse and results from light reflecting off of matte surfaces equally in all directions. The first two types are considered directional, while the last is consider non directional or omnidirectional. Diffuse light is good for attaining a wide distribution of light.

**Figure 19. Daylighting strategies taking advantage of natural light by bouncing light into interior and using light colors. *Source*: NREL**

2.5.5.1 Daylighting

Effectively incorporating natural light is integral to both reducing the lighting load and increasing human comfort and performance. By maximizing natural light in the space you reduce the need for electric lighting, thus reducing energy demand and the corresponding internal thermal load. . Usable light without heat gain is the goal of daylighting and this diffused light can be four times as efficient as fluorescent fixtures.[25] Increasing it also has been shown to increase human comfort and performance through connection to the outside and by the physiologically and psychologically beneficial aspects of natural light. Daylighting is the term used to describe this strategy in which we “bounce or diffuse light deep into a space.”[26] The location of the opening allowing light in determines the

[25] Ibid
[26] Hawaii Design Strategies for Energy Efficient Architecture

type of daylighting. Sidelighting refers to openings in the walls. Toplighting refers to light coming from above such as skylights or clerestories. Equally as important as where the light comes in from is what happens to the light once it enters. To be effective in daylighting, light reflection and receiving surfaces must be carefully considered. The ceiling is considered the best surface to take advantage of reflected light.[27].Considerations when choosing these strategies include; amount of glazing, window head height and ceiling height, Window to Wall (WWR) ratio, wall and ceiling colors, furniture height and orientation. Window head height considerations for determining an effective daylight zone indicates that a standard window size provides an effective daylight zone 1.5 times the window head height. This varies based on overall window size and the visible transmittance of the window. An increase in the head height coupled with a light shelf to bounce the light further can provide an effective daylight zone of approximately 1.5 to 2 times the window head height. Also important is ceiling height, but this is basically a factor because it prevents a higher window head height. Sloping the ceiling up towards the outer wall provides a workaround by allowing a higher head height. Because several factors may affect daylight availability, being aware of the options provides alternative strategies when constrained by site or building conditions and restrictions. A good example is, based on Hawaii's location and the desire to minimize solar heat gain while still leveraging daylight, a strategy that couples a shading device with a light shelf for bouncing deeper into the space allows for smaller glazing that might otherwise cause excessive heat gain. One particularly effective system is the light louver system, which provides continual shade and projects daylight into the space with an innovative design that turns the shade slats upside down. By coupling a lower shaded view window and an upper daylight window with a fixed light louver shade, you preclude the necessity for an interior light shelf that could be a falling hazard in extremis. However, optimizing the amount of glazing on the North and South sides of the building and minimizing it on the East and West sides can accomplish several of the design energy efficiency goals. This requires careful consideration due to the solar heat gain issues that arise, potentially excessive glare and the security design restrictions that are in place for this type of structure. We can maximize energy savings from daylighting by taking advantage of when ambient sun levels, solar heat gain and electric power consumption are all at their peaks.

[27] Egan, M. David and Victor Olgyay, Architectural Lighting, (Boston: McGraw Hill) 108.

Our process for effectively leveraging daylighting, will be to insure we consider design strategies early in the process, when we develop massing and orientation options. We'll develop those options with an eye toward planning interior spaces for access to daylight. Assessing where critical tasks will be performed allows us to minimize sunlight and glare in those locations. Based on initial configurations we will then be able to determine where our effective daylight will fall and allow us to zone for electric lighting integration which will include determining control strategies.

**Figure 20. North and South walls with high windows and glazing as well as light colored walls, ceiling and floors to bounce light. *Source*: energydesignresources.com**

By placing circulation corridors along the South walls and between the open office bay zone and the enclosed office zone, coupled with high interior windows along office space walls, light can be captured and projected into interior spaces without compromising security requirements and can minimize heat gain in the occupied zones. However, again, care must be taken to avoid direct light as this can result in excessive glare and unwanted heat.

2.5.5.2 Electric lighting

Integrating daylighting with electric lighting will be a key energy efficiency strategy. Additional measures include using fluorescent or Light Emitting Diode (LED) lamps, Efficient ballasts, appropriate lighting types and wattages for specific space uses, controllers and sensors (light level, occupancy, no-occupancy and motion), occupant education and an in house commissioning process that augments the process required during design/construction and post occupancy.

Determining the visual needs of each space will be an important first step in the lighting design which will facilitate identifying the types of lighting needed. Four types of lighting will be used; ambient, task, accent and emergency or egress lighting. Ideally, ambient lighting is addressed first and is used for general or circulation lighting. Task lighting is used when clearly defined lighting levels are needed to complete detailed tasks. Ambient and task lighting will generally be used in areas of high occupancy such as the open and closed office spaces and break areas. Accent lighting will be used for more architectural applications such as highlighting images or art in circulation and break areas. And lastly emergency or egress lighting will serve to facilitate wayfinding in an emergency and illuminate important signage or areas of safety and egress. Linear fluorescent lamps will be the best type of lighting for all of the types of lighting to be used. The benefits are high efficacy and controllability.

For ambient lighting, integrating with day lit spaces entails identifying illumination levels in daylighting zones, defining the occupancy zones then determining minimum ambient lighting levels based on space use.[28] Select lighting fixture types to most efficiently provide the ambient light called for in specific spaces. Fixtures that provide directional, non-directional or a combination of the two should be considered. Ideally, as the levels decrease the deeper into the space, light level sensors placed at points covering zones of likely differing light levels will adjust electric lighting to accommodate the differences, keeping even light levels across the space. Where natural light levels allow, electric lighting will be turned off or set to a low level.

Task lighting will augment the ambient lighting where important visual tasks are to be performed, such as at a desk, or for a tabletop exercise or planning meeting. To be most efficient, determine where task lighting is needed then balance the ambient light levels available with the task light levels needed using lighting controls, both automatic and manual.

Accent lighting will be used to a far lesser extent because the useful light it provides is

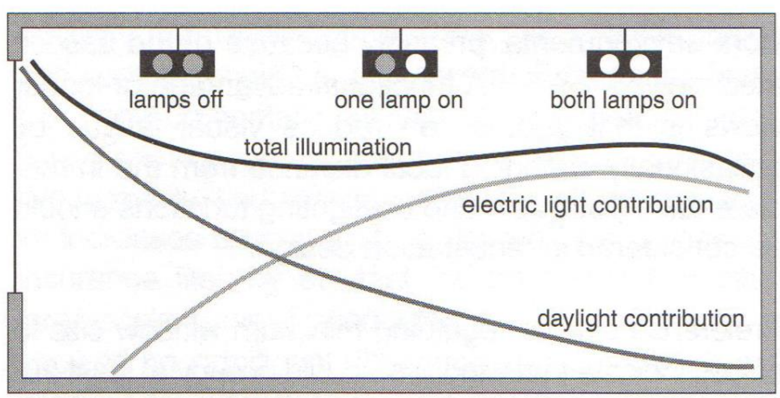


**Figure 21. Integrated lighting adjusts electric lighting according to available daylight levels. *Source*: IESNA Daylighting Design Guide.**

[28] IESNA guidelines recommend light levels for space types and can be found in IESNA lighting handbook.

outweighed by the energy it will likely consume. However, highlighting certain architectural features for aesthetic reasons, such as images, art or structure which will have an emphasis in this design and will be an important consideration. Key to efficient design will be to minimize the need but also to balance ambient and accent lighting, where ambient lighting is reduced where accent lighting is used. This will serve to improve contrast between the two and facilitate accenting the objects. Additional measures include using occupancy sensors to ensure the lights are only on when someone is there to view what is being accented and use the lowest wattage fixture possible to achieve the desired effect.

Lastly emergency, egress or safety lighting is governed by building codes and sufficient lighting is important to satisfy those requirements and to ensure safe entrance, occupancy and egress of the building. The lighting shall illuminate potential hazards, circulation areas, entrances, exits and safe havens. As with other lighting types, selecting low energy fixtures is important, but not without sacrificing the illumination levels required. Operate the lighting only when needed using occupancy or photo sensors or lighting tied alarms. Utilization of separate circuits allows for shutoff when not needed.

Well design lighting controls will complete the lighting design by matching lighting output to occupancy schedules and illumination requirements. The two main types of controls are manual or automatic controls. When occupants are generally in the space for short periods of time or sudden shifts in light levels will be disturbing to occupants, use of manual on-off or stepped controls are good options. When integrating daylighting with electric lighting, dimming controls associated with light level sensors can automatically adjust electric lighting to balance available daylight and attain designed illumination levels. Dimming controls can also be manually controlled to occupant preference and generally are used where daylight is unavailable such as closed office or interior spaces. In these cases occupancy sensors can be coupled with the dimmers to ensure lights are not used when occupants are not present, but can be adjusted when they are.

### 2.5.6 HVAC

HVAC systems can account for approximately 40-60% of overall energy consumption in a building.[29] HVAC also is a major contributor to occupant health and comfort and contributes significantly to indoor air quality. Many factors have contributed to increases in HVAC loads in modern buildings including; an increase in the use of glazing, larger buildings, sealed buildings, and increased use of energy demanding and heat emitting equipment. A problem with the advent of modern HVAC was over sizing, under insulating and inefficiency. Over the subsequent years, architectural designers became less concerned with passive cooling and heating strategies with the ability to condition spaces mechanically. It allowed designers to design buildings that didn't possess the telltale passive design characteristics and allowed them to increase glazing and accept massing and orientations that might not have been optimal to passively reduce heating and cooling loads.

Getting back to basics, with respect to designing an efficient HVAC system, starts with an understanding of the climate and solar and environmental conditions of the site location. With this information you can design to reduce the thermal loads that come from lighting, equipment and solar heat gain. This is why when designing for energy efficiency, passive design is the first step, optimizing daylight and mitigating heat gain through the envelope, and followed by energy efficient lighting design. Reducing these thermal loads then provides a start point for determining a right sized, efficient system that achieves the design comfort level. In a hot humid environment efficient cooling systems must also successfully and efficiently dehumidify the incoming conditioned air. In Hawaii's climate the primary system will be a cooling system that provides adequate dehumidification.

Because the natural tendency is for heat to "flow" from warm/hot to cool/cold, during the warm summer months a building inevitably gains heat to some extent, both internally and externally. A basic mechanical cooling system transfers heat from a room to what is broadly termed a refrigeration machine, and then from there it is pumped to a "heat sink". The heat sink

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[29] Abraham, Loren E, and Sal Agnello. *The Sustainable Building Technical Manual. (* U.S. Green Building Council, 1996) IV 43

is usually outdoor air, but can be water or the ground. It is important to point out that the only way you are removing the heat is when you are pumping heat from a cooler temperature to a higher temperature.

Refrigeration systems to consider include vapor compression or absorption and they come in two main types; central plant systems, or unitary or packaged systems, each with their own unique space and system requirements. The larger system requiring more space is the central system. These systems, depending on building size and load can require a considerable amount of space. The primary system for the central plant is a core chiller and the secondary is the distribution system consisting of pipes, ducts, air handlers and terminal units. These components generally reside in different parts of the building along the generation and distribution path.

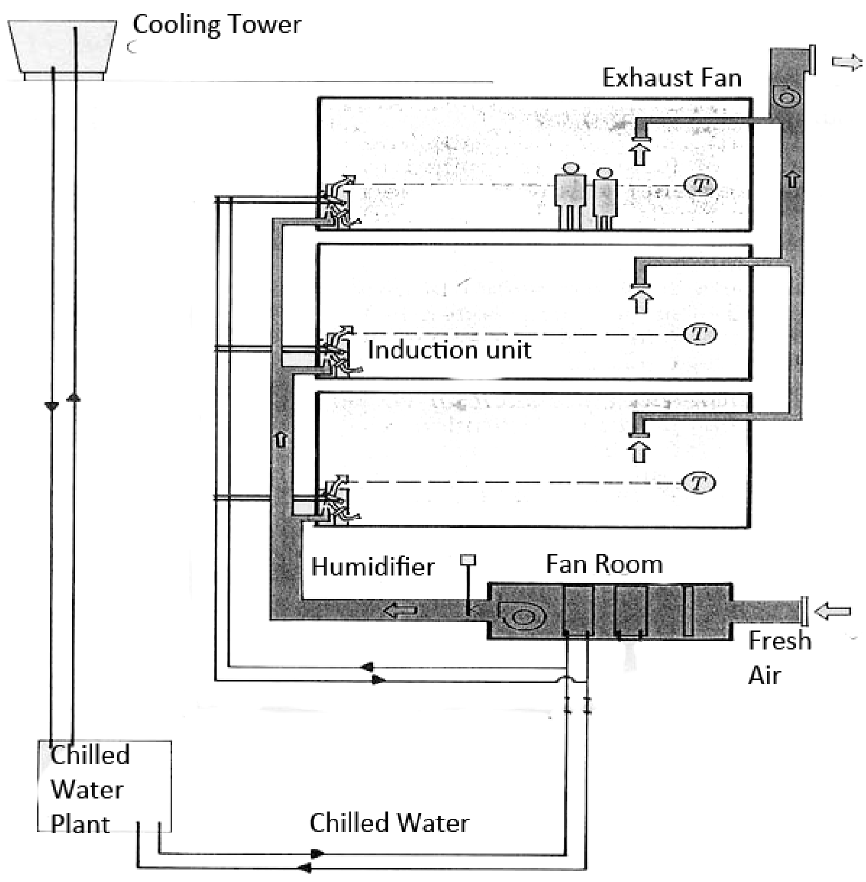


**Figure 22. Air Water Induction System. *Source*: Norbert Lechner**

The unitary or packaged system is a smaller system in which the main cooling components are combined into a “packaged” unit that can be more versatile in placement, generally on the rooftop. These smaller sizes also allow for ganging and locations closer to the space to be conditioned.

Vapor compression cooling systems consist of a refrigeration cycle that includes an electric motor, compressor, condenser, evaporator, expansion device and controls. The system can cool either air or water as the cooling medium. The cycle process is a loop in which the refrigerant varies in state between liquid and gas (vapor). Using the diagram in Fig. 23, you see a refrigerant cycle using water as the cooling

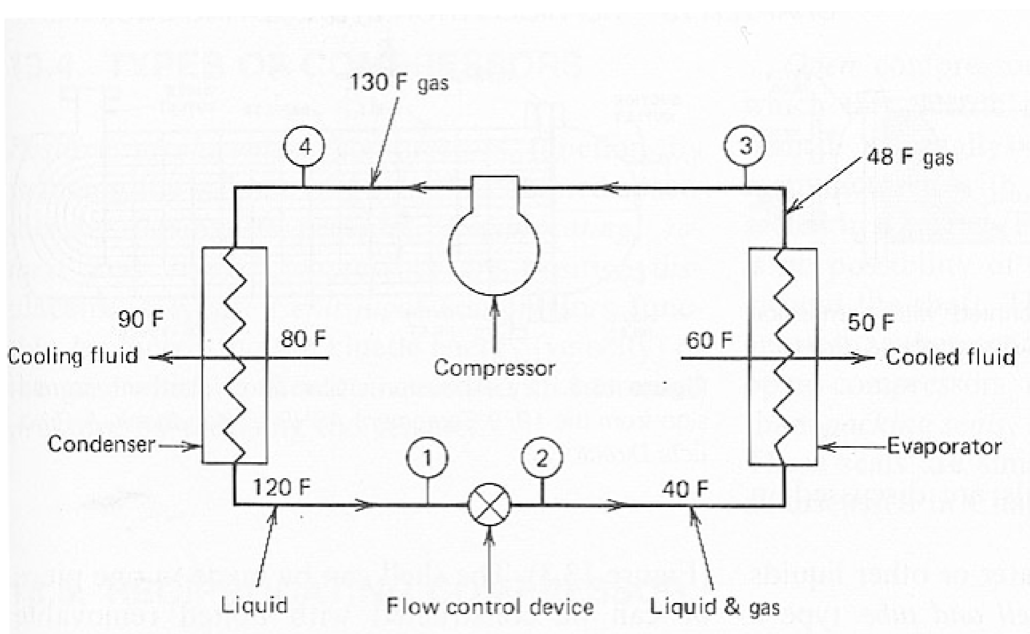


**Figure 23. Refrigeration cycle. *Source*: Norbert Lechner**

medium. At point 1 the refrigerant is in a liquid state and under high pressure and temperature. As it is allowed to pass through the flow control device it loses pressure which results in vaporization and a reduction in temperature at point 2. As it proceeds through the heat exchanging evaporator to point 3, it picks up the heat of the warmer cooling water. At point 3 it is now a gas at a low pressure and temperature. In order to get it back to its original liquid state at high temperature and pressure to start the process again, it goes through a compressor which increases the pressure of the refrigerant so that at point 4 it is still a gas but at a higher pressure and slightly higher temperature.  It now goes through another heat exchanger called a condenser to complete the process of transforming it back to a liquid.  In the condenser, more heat is extracted by transferring heat to the now cooler cooling fluid, but this time as waste heat and the refrigerant now arrives at point 1 again as a high pressure high temperature liquid.

Absorption cooling systems don't require pumps or moving parts and are based on liquid absorption of certain vapors.  Although no pumps or moving parts are required, a source of heat is needed and can be supplied with a gas flame or possibly waste heat from another process.  In the system, as the water evaporates and is drawn to the liquid that absorbs it, it passes a coil containing the water that has its heat drawn by the water vapor, thus creating chilled water for cooling .  As the process continues and the liquid reaches a point where it no longer has the capacity to absorb the vapor, it is heated to boil off the absorbed water as vapor again, and then is transferred to a condenser where it is transformed back to liquid water and back to the original water reservoir.  This process is inefficient but becomes efficient when the source of heat is cheap, such as solar hot water.

Comparing these two systems, the vapor compression system is more efficient but requires mechanical power that needs electricity to run.  This mechanical power drives pumps that circulate the refrigerant.

Again, in order for the system to cool the building heat must be transferred out.  The initial transfer is from the room to the refrigeration machine and includes several methods.  These heat transfer methods include direct refrigerant or DX (direct expansion) systems, all air, all water or a combination of air and water.  The best example of a DX system is the residential window or through the wall unit, where the indoor air to be cooled flows directly over the evaporator cooling coils and returns to the room as cooler air.  This system just consists of two fans and the refrigeration machine.  The all air system is similar in that air is blown over the evaporator coils but then is distributed by a system of ductwork to the rooms.  This requires larger fans and in some cases a lot of ductwork and terminals.  In the all water system, water is cooled by the coils then pumped to fan coil units in each space that then cool and distribute the air.  Pumps pumping the water generally require less energy than the fans pumping the air.  The all water system then needs a separate ventilation system for outside air, such as operable windows thus rendering it unsuitable for interior rooms.  The combination system allows for compromise between the two systems, it allows for a smaller air system to then ventilate, dehumidify and filter the air while the water system still performs most of the cooling allowing for use in interior spaces. Heat now needs to be transferred to the outside heat sink into the air, water or ground. Smaller buildings will have outdoor air blown over the condenser coils then discharged. Larger buildings may use either evaporative condensers or cooling towers which are usually separate from the refrigeration machine. Both use evaporating water to dump the heat, which requires a small amount of water to be continuously provided as it evaporates.

Distribution of the conditioned air is accomplished by ducting, which can come in several shapes and sizes each with their own costs and benefits. Shape and size are important in large applications and appropriately sized ducting will have a big impact on efficiency. Additionally, properly insulating and sealing the ducting to prevent cooling transmission loss is critical.

Other important functions of HVAC include exhaust of unwanted interior elements and filtration of outside and inside air. Indoor environmental quality, in addition to comfort is essential for human performance.

A survey of HVAC system elements provides a look at where efficiencies can be gained. Much is available on efficient options for respective climates. As this project is not about designing an HVAC system in detail, identifying precedent setting systems and/or research on specific system efficacies will provide the design systems that will be analyzed against security criteria.

Not oversizing HVAC systems is an important first step. Right sizing systems can include providing two smaller redundant systems, where one system operates when the load is smaller and the other is energized when the load increases beyond the capacity of the single system. This is more efficient than operating a large system at part load capacity.[30] Various components including; fans, pumps and chillers now come in increasingly higher efficiency units. These coupled with thoughtfully designed systems that shorten duct lengths, appropriately insulate and seal ducting will improve efficiency significantly. With the other efficiency methods

[30] Hootman, Tom. *Net Zero Energy Design: A Guide for Commercial Architecture.* (Hoboken: Wiley and Sons, 2013) 240

properly applied, you can now adjust your temperature setbacks to provide slightly higher indoor temperatures during cooling periods for when air conditioning is needed as a final efficiency measure.

Two systems stand out as appropriate responses with respect to addressing security design issues; all-air Variable Air Volume (VAV) systems and, Dedicated Outdoor Air Systems (DOAS). Each has various configurations that are more efficient depending on climate zone and building type. Both provide some of the best control and filtration of outside air for a medium sized office building in climate zone 1A.[31] The DOAS, however, provides the best humidity control, filtration and control of air of the two and is the better system for critical DoD facilities and most of its main spaces, in warm humid climates with strict security design requirements.[32] Coupled with a parallel radiant cooling system, a second dehumidifying wheel in addition to the Enthalpy wheel, the various higher efficiency motors, fans and pumps, the DOAS will be an excellent system for this application.

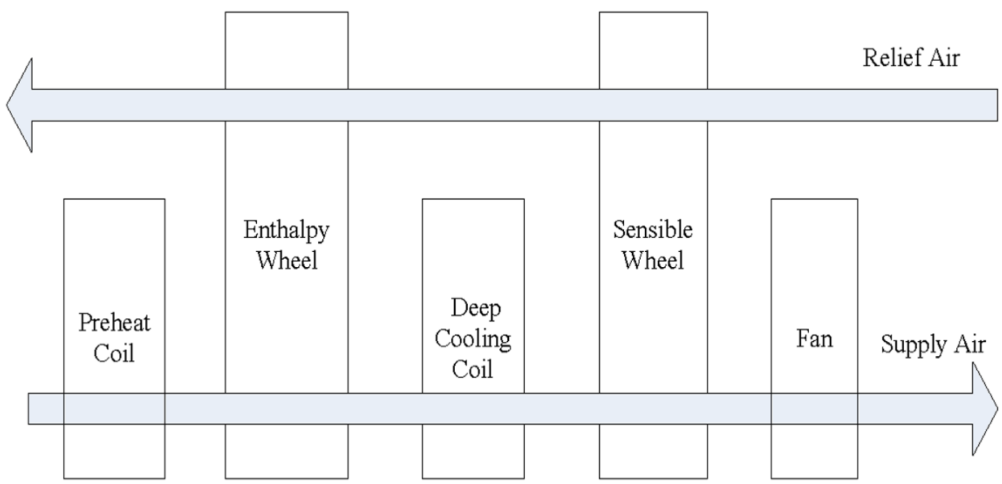


**Figure 24.. Dedicated Outdoor Air System schematic with deep cooling coil. *Source*: Emmerich**

Additionally, adding motorized outdoor air dampers and demand controlled-ventilation further provide the systems that address many of the issues related to Chemical, Biological and

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[31] Stanley Mumma, "Designing Dedicated Outdoor Air Systems." *ASHRAE Journal.* (May 2001): 28.

[32] IBID

Radiation (CBR) agent protection and other security design criteria. The additional VAV system provides the capability of more rapidly adjusting temperatures in a large space that has highly fluctuating schedules such as an auditorium or large conference room. These types of spaces can sit vacant for a long time and then become full for a period of time. The VAV air based system can more effectively ramp up air exchanges and fix rapid heat gain increases as a result of relatively large numbers of personnel occupying a room.

### 2.5.7 Plug Loads

Although a relatively small contributor to energy demand in commercial office buildings, equipment plug loads can be an easy target in energy savings. Modern electrical equipment and machines now mostly have energy consumption ratings that facilitate selection of the most cost effective and energy efficient solutions. Additionally, right sizing equipment can have a big impact, as well as adjusting usage habits. A good example is the use of personal computers or workstations. An ongoing survey of laptop and desktop power usage is posted on University of Pennsylvania's website and shows that laptops used at moderate activity levels required considerably less watts than desktops with LCD monitors under the same usage conditions.[33] Also tests conducted by CNET labs[34] indicated that, on average laptops use only 25 watts when idle and about 60 watts when being used while desktops use approximately 100 watts when idle and 145 watts when being used. Usage habits also affect energy demand. Graphics and animation intensive programs have higher energy demands than word processing programs and setting your monitors brightness on the highest level will also draw the most power.

In many electrical appliances, the piece of equipment continues to draw a small amount of power even when not in use or in standby, this has several names including "vampire power",

[33] University of Pennsylvania: Information Systems and Computing. "Approximate Desktop, Notebook, & Netbook Power Usage." http://www.upenn.edu/computing/provider/docs/hardware/powerusage.html. (Accessed March 24, 2013)

[34]National Geographic: Green Living. "Do Laptops Save on Electricity Bills?" by Mike Williams. http://greenliving.nationalgeographic.com/laptops-save-electricity-bills-2998.html. (Accessed on 24 March 2013)

vampire draw" and "phantom load". This can be addressed in computers by using the computer's power management functions to adjust power based on expected use and occupancy. Additionally, establishing occupant training and policies that emphasize power management and encourage user habits should be used. Power strips that allow de-energizing multiple pieces of equipment at the same time when not in use for longer periods make it easier for occupants to establish good power management habits. Lastly, selecting equipment that has been rated as energy efficient such as Energy Star, should be pursued to the greatest extent allowable under project and budget constraints.

### 2.5.8 Renewable Energy Sources

#### 2.5.8.1 Photovoltaics

As illustrated above, Hawaii has great potential in the sun's energy. Capturing that will go a long ways toward energy independence at the regional level. Our design will go to great lengths to maximize harnessing of this limitless resource. Systems can include PV film on windows and exterior surfaces, integrated solar shields (shade/energy). Every horizontal or near horizontal space with be examined as a location for solar potential. This, coupled with appropriate orientation to maximize the sun's rays should allow for a standalone system. The main issue with many of these alternative energy sources in Hawaii is cost. To justify a system, life cycle costs must be considered and sold to the client. Again, the commissioning process has led to advances in the efficiency of buildings at a nominal fee as compared to the overall cost savings.[35]

To determine optimal solar orientation, we consider when energy demand is highest and calculate the appropriate PV array tilt. Because Hawaii is in a hot humid climate, high energy demand for cooling is basically year round. However, demand is at its peak in the summer months when the noon sun is almost directly overhead. Ideal solar tilt is then calculated for summer cooling by subtracting $15^{o}$ from Honolulu's latitude of $21.5^{o}$ N which works out to be $6.5^{o}$. When determining which method of using Photovoltaics, either flat on a sloped roof or tilted on a flat roof, the optimum orientation will be near east to west .

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[35] Lechner 192

One useful strategy is to combine a green roof with PV panels. Because the PV panels operate more efficiently when the surrounding temperature is regulated, elevating them off the roof surface allows for cooling from ventilation to counter the Sol Air effect and increased heat that comes from it. The green roof addresses this also, cools the roof and facilitates cooling the PV panels above. Then anywhere the PV is not covering the roof, the green roof is still providing an insulate effect for the envelope.

#### 2.5.8.2 Solar thermal

Heating of water should not have to come from an energy source other than the sun. Because heating water is quite expensive as a percentage of total energy costs it is rather important to reduce the requirement. Granted, commercial buildings have less of a heated water requirement, it is still worth addressing. Options include hot water on demand and solar water heating systems. With the hot water on demand, there is still an energy requirement to heat the water, but savings are gained by not having to maintain the heat in a reservoir. The water is heated “on demand” as it passed through the system, requiring the heating elements to only be on for a short period of time the hot water is required. Kitchens, bathrooms, utility rooms and locker rooms will be the biggest users. As with PV, the most efficient orientation and tilt is a function of latitude.

### 2.5.9 Integrated controllers

Another critical element of this whole building design is the use of a building control system. Utilizing occupancy, heat and light sensors, rheostats, temperature controls and cut-off switches as well as monitoring of the systems. Many spaces will require near constant cold temperatures and others, regulated consistent temperatures. Because maximizing ease of use and minimizing the amount of time the occupants have to worry about these systems (which maximizes the accomplishment of the mission) is the goal, integrated controllers will be vital to achieve our overall objectives.

2.5.10 Climate Analysis and Design Tools

Modern design tools are very effective at rapidly and comprehensively analyzing climate and site conditions. Several useful outputs include Bioclimatic and Psychrometric charts which graphically

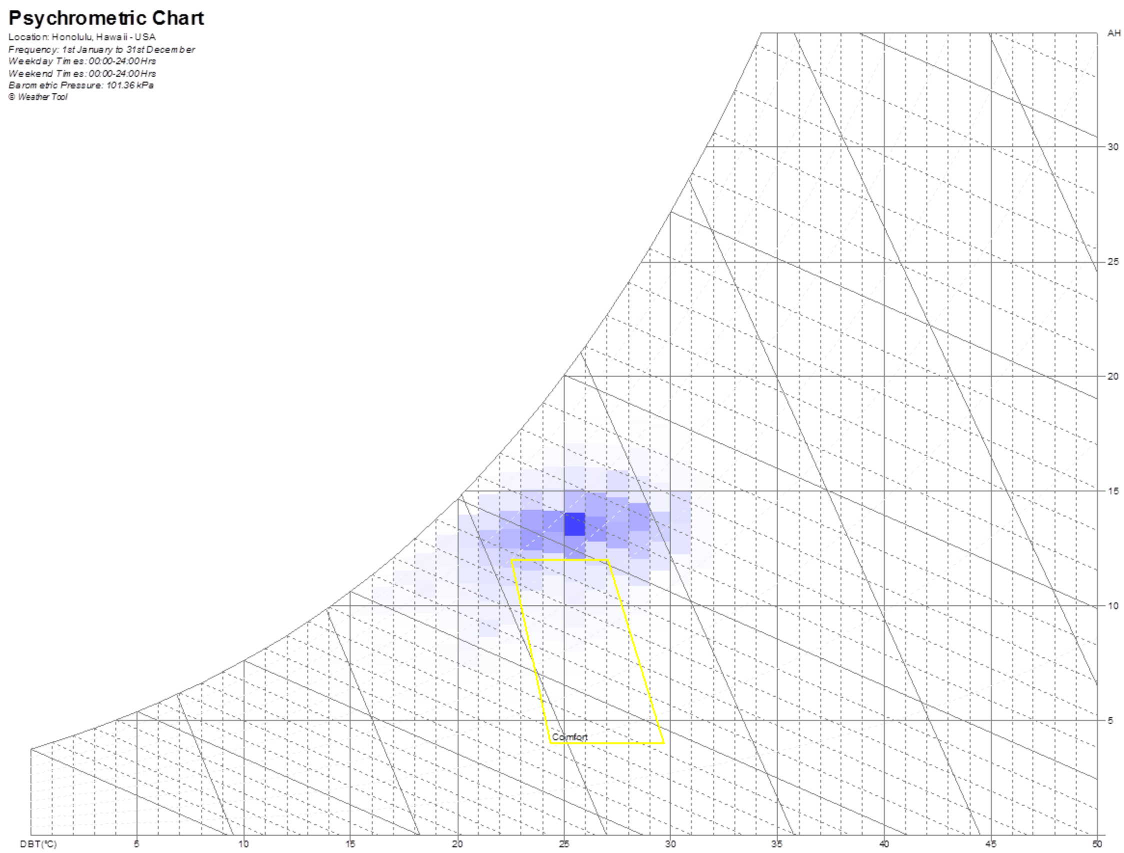


**Figure 25. Psychrometric chart provides visual illustration of comfort zone for specific geographic locations. *Source*: Ecotect Weather tool.**

illustrate human comfort levels based on temperature and humidity. They can be used to chart and identify passive design strategies to address temperatures and humidity levels outside the comfort zone. The chart is generated for different climate zones thus providing different comfort zone parameters.

The Sunpath diagram provides a 2D or 3D graphic illustration of the sun's path over the earth at varying times of the day, month and year and is useful in determining both the sun's angle/altitude and azimuth at any given time of day throughout the year.  This diagram can also be used to plot site and adjacent obstructions that can be advantageous in identifying shade opportunities.

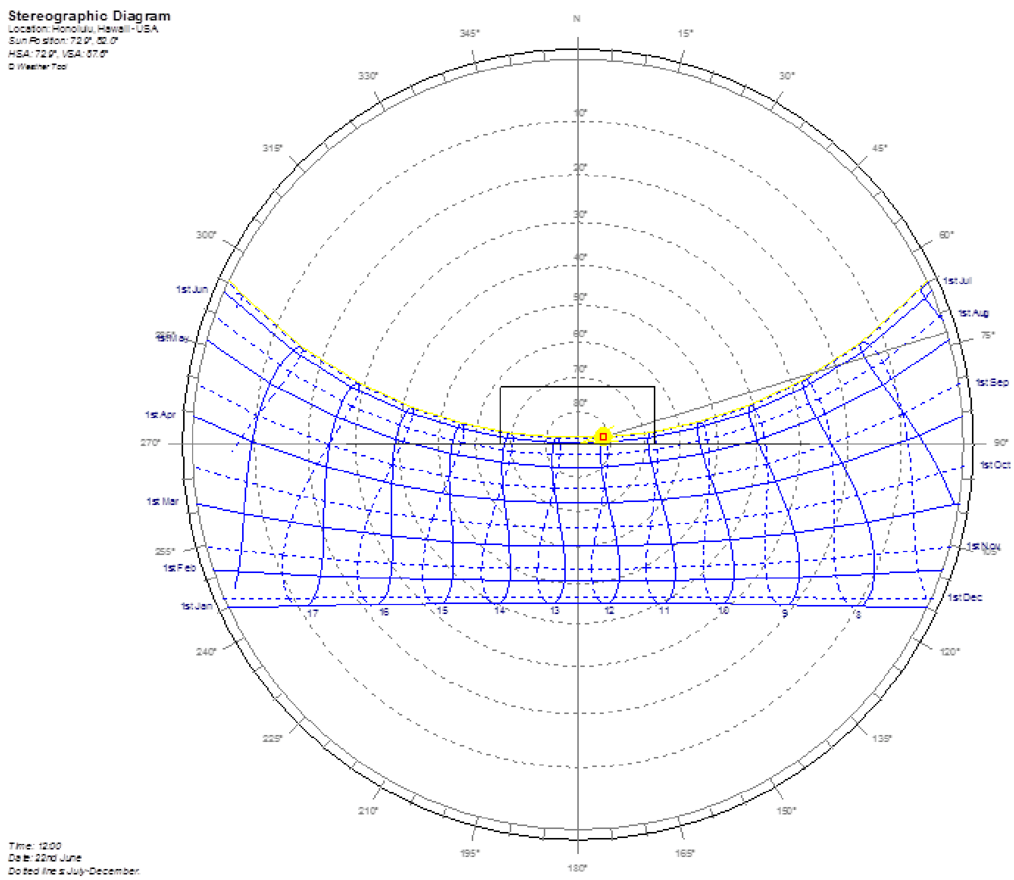


**Figure 26. Sample Sunpath diagram for Honolulu.** ***Source*****: Ecotect weather tool.**

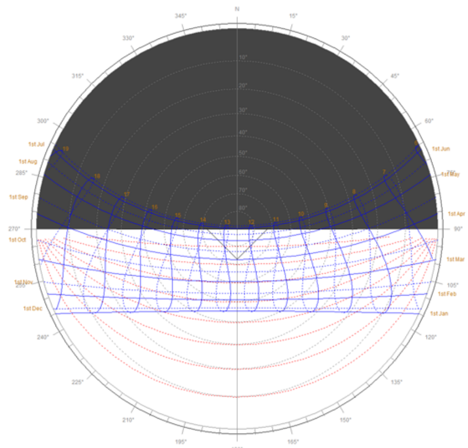

**Figure 27. Shading mask showing no shading device. *Source*: Ecotect.**

A shading mask diagram coupled with a sunpath diagram can provide a visual verification of sunshade device design efficiency. A shading mask diagram can be generated for any window exposure and with the sunpath diagram overlaid illustrates at what times during the year that the window is shaded with the designed shaded device. Figure 27 shows a shading mask for a window on a south wall with no shading device. The dark area represents the shelf shaded building and area below this shows the time and days of the year when the window gets direct sunlight exposure. Figure 28 shows a shading mask for a window with an 18” horizontal shading shelf at the top of a 4 ft. by 4ft window on the same wall. It shows that during the middle of the day, with the exception of the winter time, the window is 100 percent shaded. By adding vertical sunshades to the window, creating an enclosing sunshade system, you further extend the shaded period. Figure 29 shows the same south window with both vertical and horizontal sunshades. The vertical shades now provide shading for early morning and late afternoon low angle sun. The shading mask diagram is therefore quite useful to test early stage window shading options.

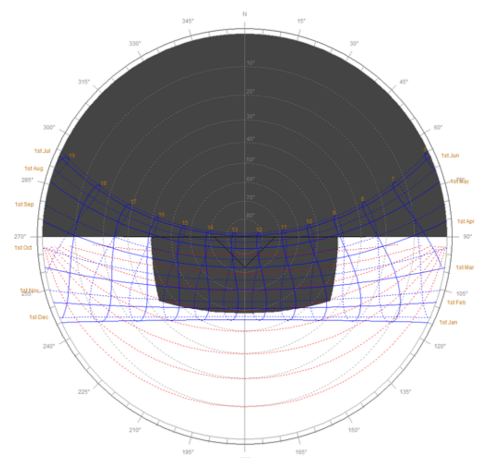

**Figure 28. Shading mask with horizontal shading device. *Source*: Ecotect.**

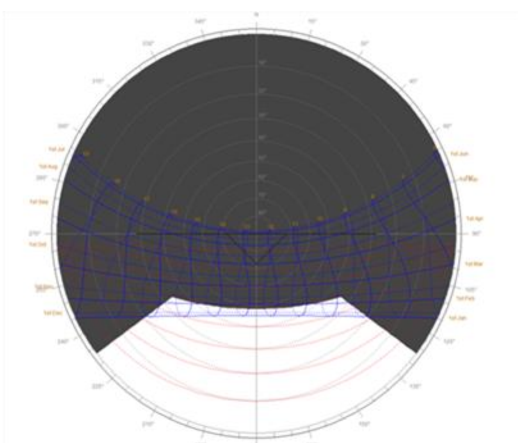

**Figure 29. Shading mask with horizontal and vertical shading device. *Source*: Ecotect.**

Wind Rose charts can provide historical data in graphic form on prevailing winds. This can be useful in determining ventilation strategies and building orientation.

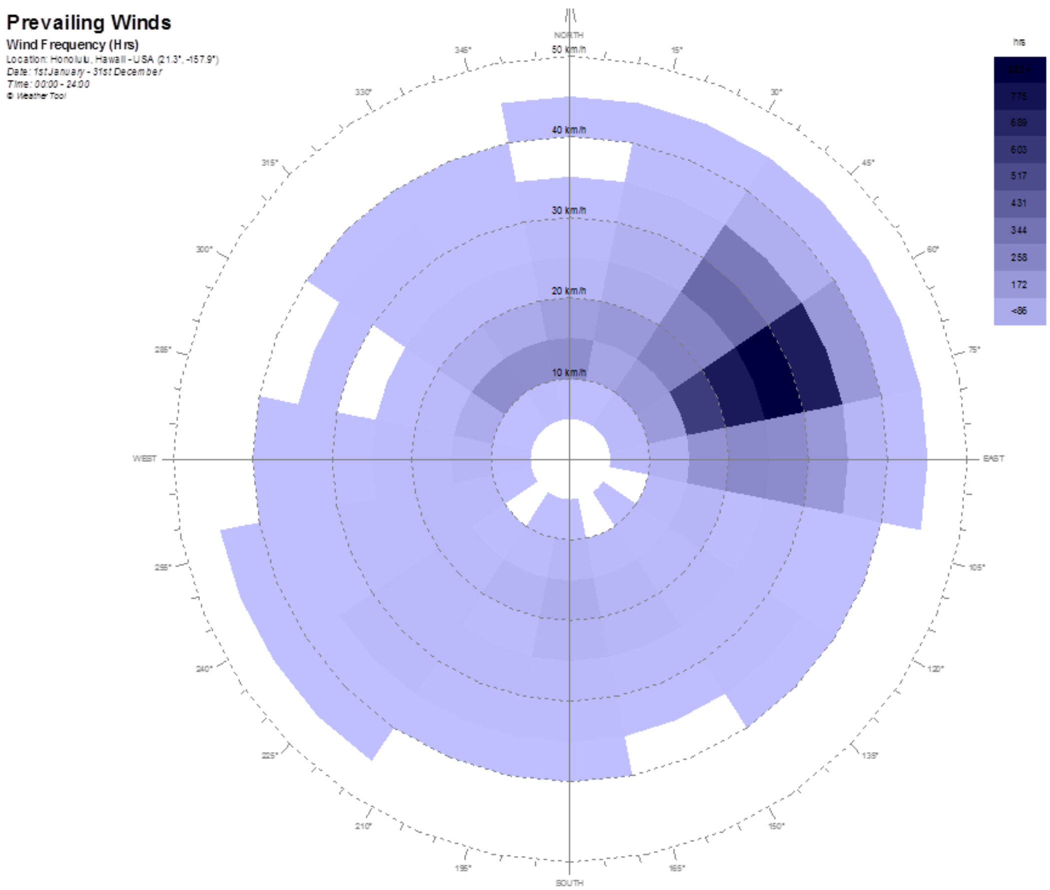


**Figure 30. Sample Wind rose of Honolulu annual prevailing winds using Ecotect Weather tool. *Source*: Ecotect weather tool.**

Climate charts can also be very useful in analyzing historical temperature, humidity, solar and weather conditions and relationships. The below set of graphs show varying interrelated information.  The upper graph represents monthly diurnal averages of temperature and solar radiation.  The green band along the middle of the fluctuating high and low daily temperature is the associated comfort zone.  Note how it basically mirrors the path of the average daily temperature.

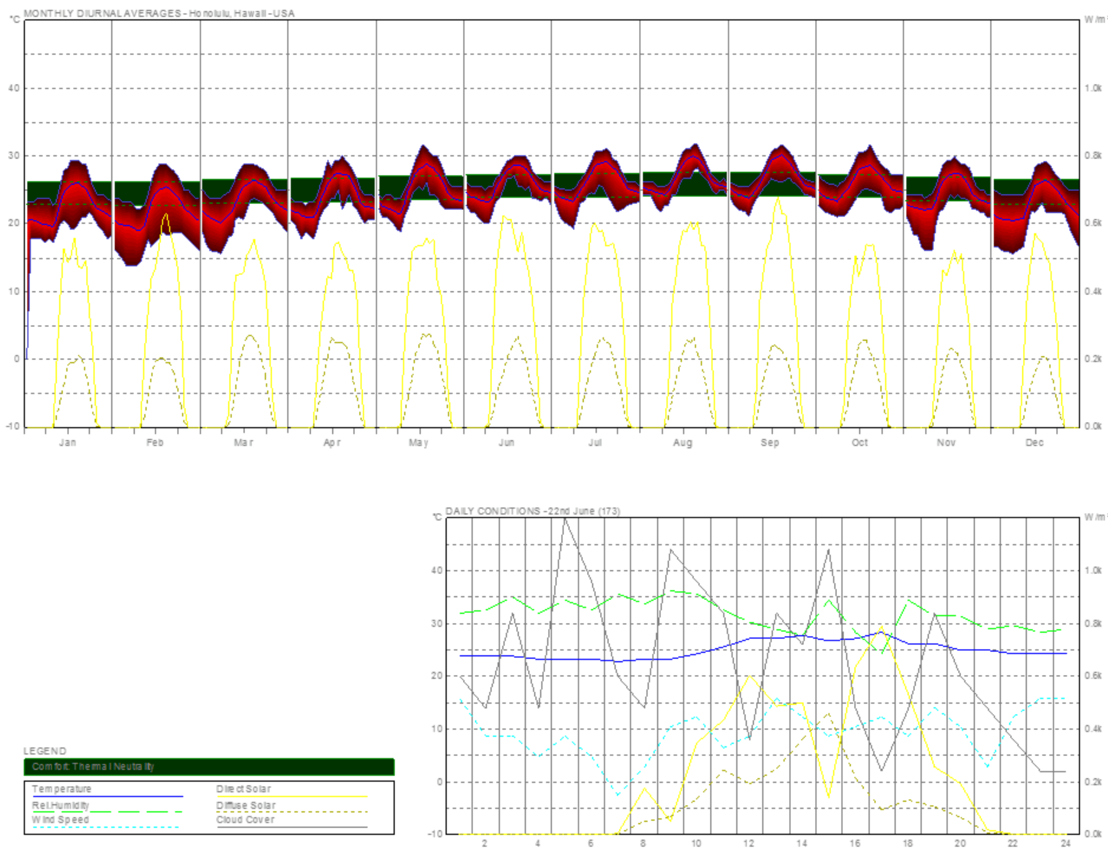


**Figure 31. Monthly diurnal averages for Honolulu. *Source*: Ecotect weather tool.**

Although you can manually enter data to utilize some of the tools, now if you have access to a computer and the internet you can utilize one of many available tools.  They can either be web-based or software that you can download.  Some more well-known programs include Ecotect (and its standalone Weather tool). The advantage of some of these programs is that they are comprehensive and can provide initial climate analysis tools and graphic output.

### 2.5.11 Hawaii's Climate

An understanding of climatic conditions at the site is an important variable in the design of an energy efficient building. The local climatic conditions affect external thermal loads, inform passive design opportunities and provide potential sources of renewable energy. The island of Oahu is located at approximately 21˚26; N and 157˚58'W and is just below the Tropic of Cancer and is considered a subtropical region. Using the U.S. Department of Energy's climate zone classification, Hawaii is in zone 1A, Very Hot-Humid. It is characterized by year- long warm to hot humid weather with moderate rainfall. Figure 32 shows that there is little seasonal variation in temperature and only a slight variation in precipitation. Design priorities from an energy efficiency standpoint are to reduce the cooling load by minimizing solar radiation, reducing thermal conduction through the envelope, lowering internal heat gain through lighting and equipment load reductions, and using light colors on the exterior surfaces to reflect rather than absorb solar radiation. The Psychrometric chart for Honolulu in Figure 33 illustrates a buildings comfort zone (in yellow) and plots hourly temp readings. This pretty clearly shows that the hourly temperatures are mostly outside the comfort zone and cooling loads predominate. This necessitates a vigorous pursuit of efficient and successful methods of lowering potential heat gains. The Psychrometric chart in Figure 34 illustrates active cooling measures that may be used to address heat gain. The suggested cooling strategies include natural ventilation however; most of the spaces in the proposed design will not have operable windows due to proposed CBR protection strategies. Some spaces though do provide operable windows and natural ventilation.

The Honolulu wind rose diagram in Figure 35 illustrates predominate trade winds out of the ENE for much of the year. Again, as natural ventilation will be used minimally, the main consideration with respect to winds is its effect on air infiltration. The buildings' orientation in relation to the surrounding terrain will need to be carefully considered and the predominate direction of the winds will be a factor in that orientation in concert with the solar characteristics.

Figure 36 illustrates optimum building orientation for solar efficiency with a long axis approximately on an east west axis.

Figures 37 and 38 further show sunpath diagrams for Honolulu with sun positions on June 1st and Dec 1st at 9:00 AM respectively. It is important to note that the sun's angle and altitude in the winter months never exceeds 90$^{o}$ for more than a short period, which indicates the opportunity for larger fenestration apertures and no real requirement for shading on the north façade. Conversely, in the summer months the sun's angle is relatively low in the south sky and adequate shading will and smaller apertures should be strongly considered. These sunpath diagrams inform daylighting design and heat gain mitigation strategies in that large open day lit spaces are best configured on the south wall but glare and heat gain must be addressed. Also reducing wall area on the east and west facades reduces heat gain. This would imply a long narrow building oriented along an east west axis with few or heavily shaded or screened fenestration on the east and west walls, larger unshaded windows on the north wall and carefully designed daylighting windows on the south wall.

Tables 1 through 4 show climate data in tabular form.

**Table 1 Honolulu annual average temperatures**

| | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** | **Annual** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Avg. Temperature | 72.9 | 73 | 74.4 | 75.8 | 77.5 | 79.4 | 81 | 81.4 | 81 | 79.6 | 77.2 | 74.1 | 77.2 |
| Avg. Max Temperature | 80.1 | 80.5 | 81.6 | 82.8 | 84.7 | 86.5 | 88 | 88.7 | 88.5 | 86.9 | 84.1 | 81.2 | 84.4 |
| Avg. Min Temperature | 65.6 | 65.4 | 67.2 | 68.7 | 70.3 | 72.2 | 74 | 74.2 | 73.5 | 72.3 | 70.3 | 67 | 70 |
| Days with Max Temp of 90 F or Higher | 0 | 0 | 0 | 0 | < 0.5 | 2 | 6 | 12 | 11 | 5 | 0 | 0 | 37 |
| Days with Min Temp Below Freezing | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Source: City-Data.com**

**Table 1 Honolulu heating and cooling degree days**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Heating Degree Days | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cooling Degree Days | 245 | 224 | 291 | 324 | 388 | 432 | 481 | 508 | 480 | 453 | 366 | 282 | 4474 |

***Source*: City-data.com**

**Table 2 Honolulu annual precipitation**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Precipitation (inches) | 3.5 | 2.2 | 2.2 | 1.5 | 1.1 | 0.5 | 0.6 | 0.4 | 0.8 | 2.3 | 3 | 3.8 | 22 |
| Days with Precipitation 0.01 inch or More | 9 | 9 | 9 | 9 | 7 | 6 | 7 | 6 | 7 | 9 | 9 | 10 | 97 |

***Source*: City-Data.com**

**Table 3 Honolulu climate data**

| **Climate Data** | |
|---|---|
| Climate classification (Koppen) | A, Tropical |
| Climate Zone | 1A, Hot, Humid |
| Heating degree days base 65 | 0 |
| Cooling Degree days base 65 | 4474 |

**Source: City-Data.com**

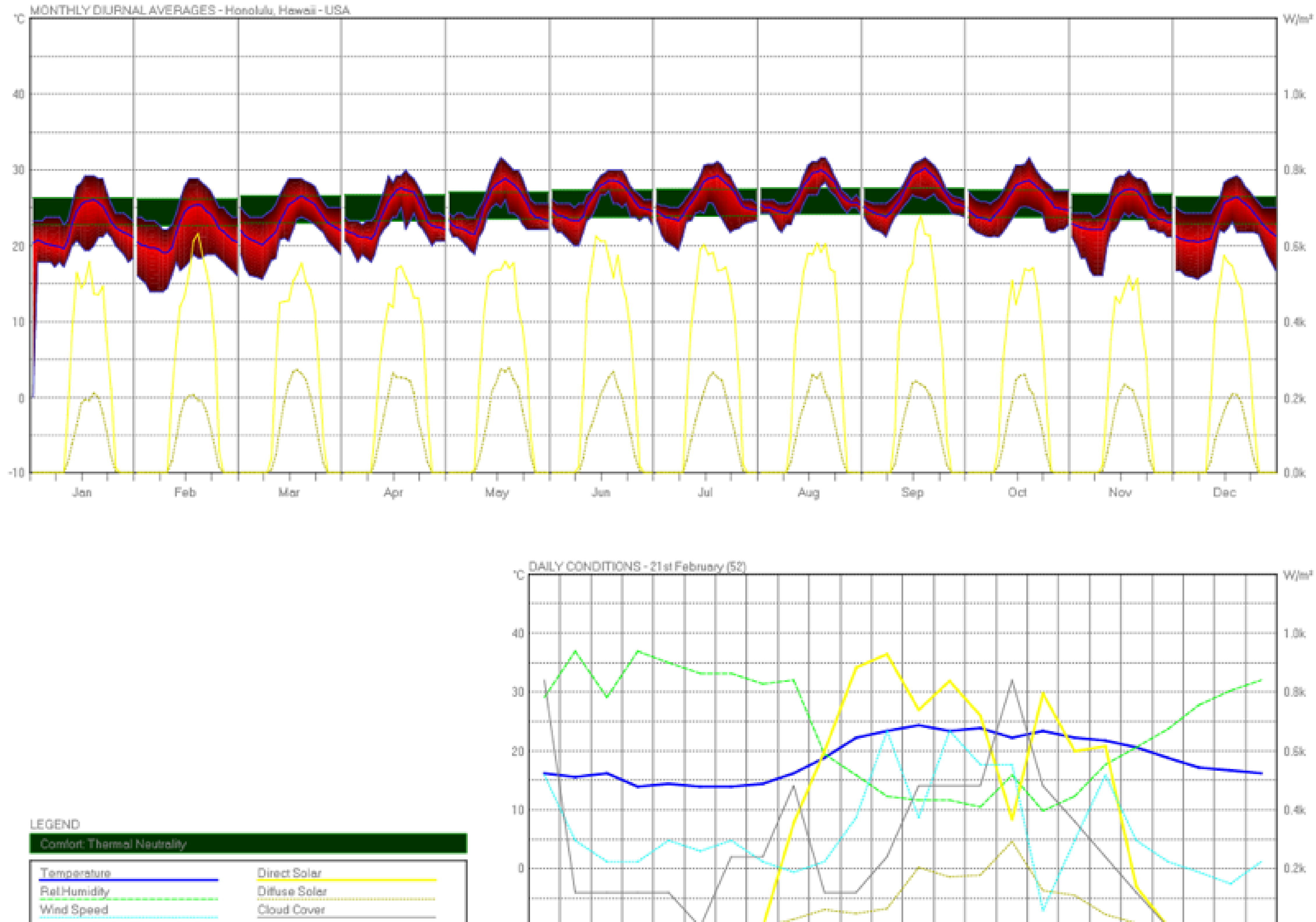


**Figure 32. Monthly diurnal averages. Source: Ecotect Weather tool.**

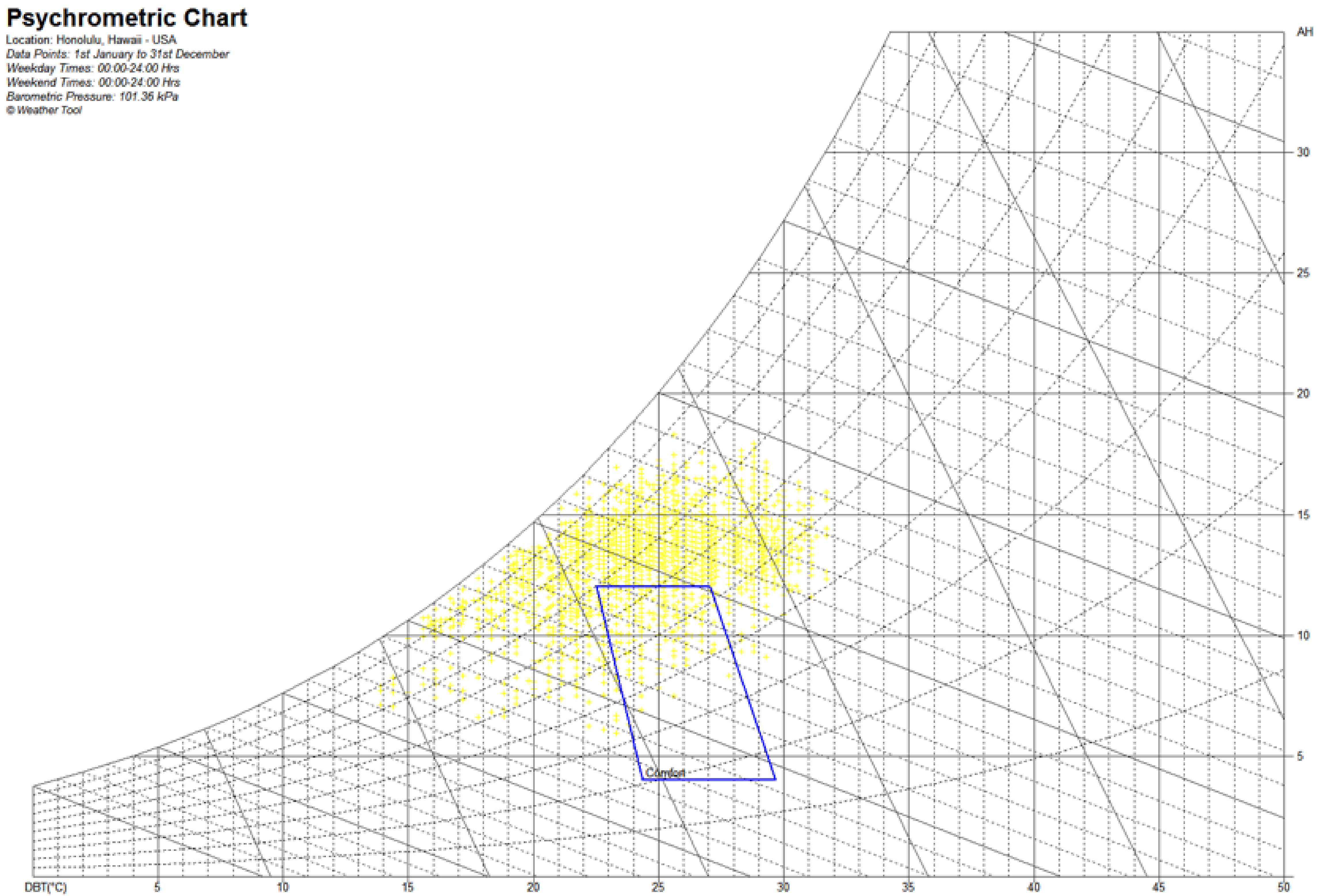


**Figure 33. Psychrometric chart illustrating comfort zone for Honolulu. Source: Ecotect Weather tool.**

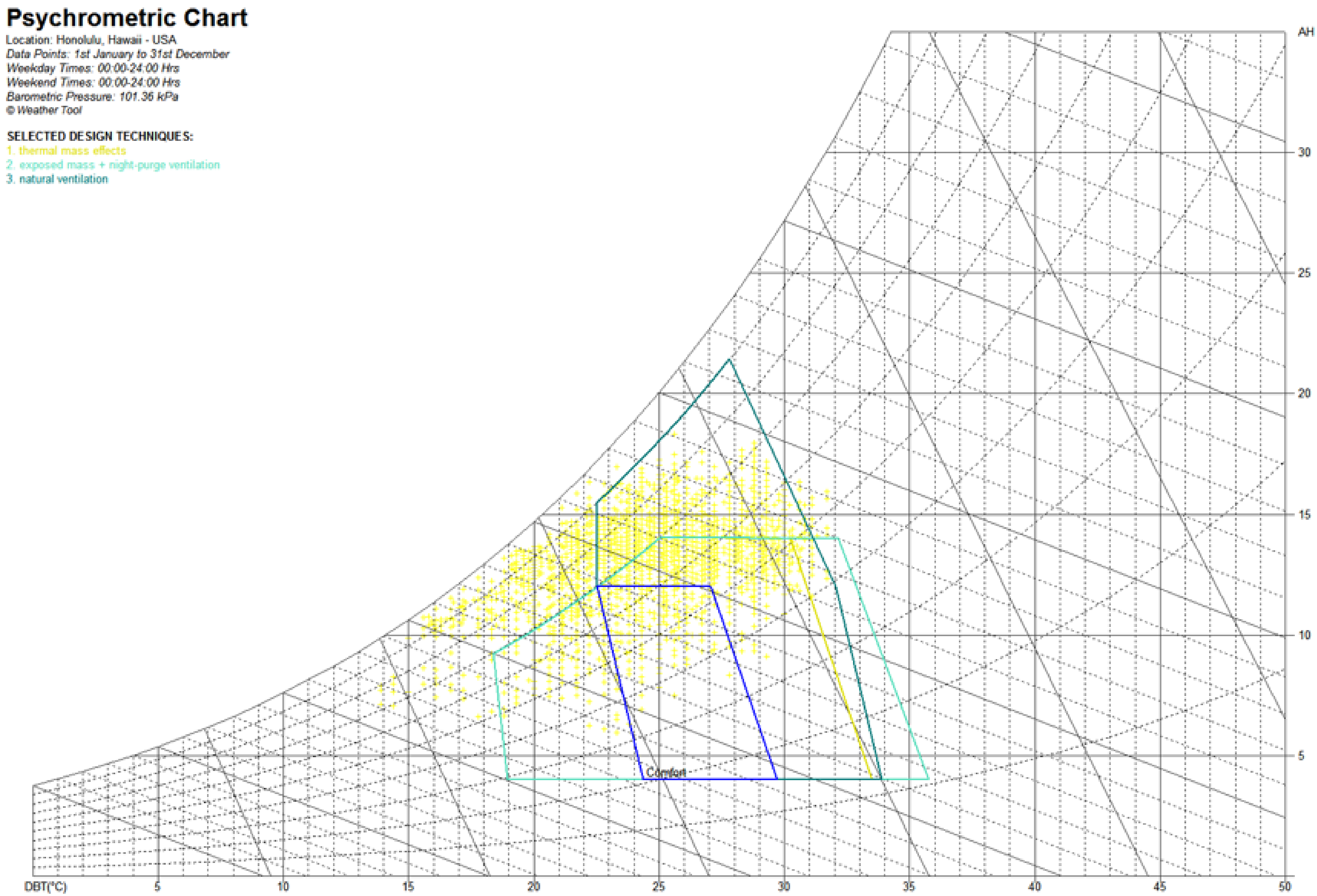


**Figure 34. Psychrometric chart for Honolulu with suggested cooling strategies. Source: Ecotect Weather tool.**

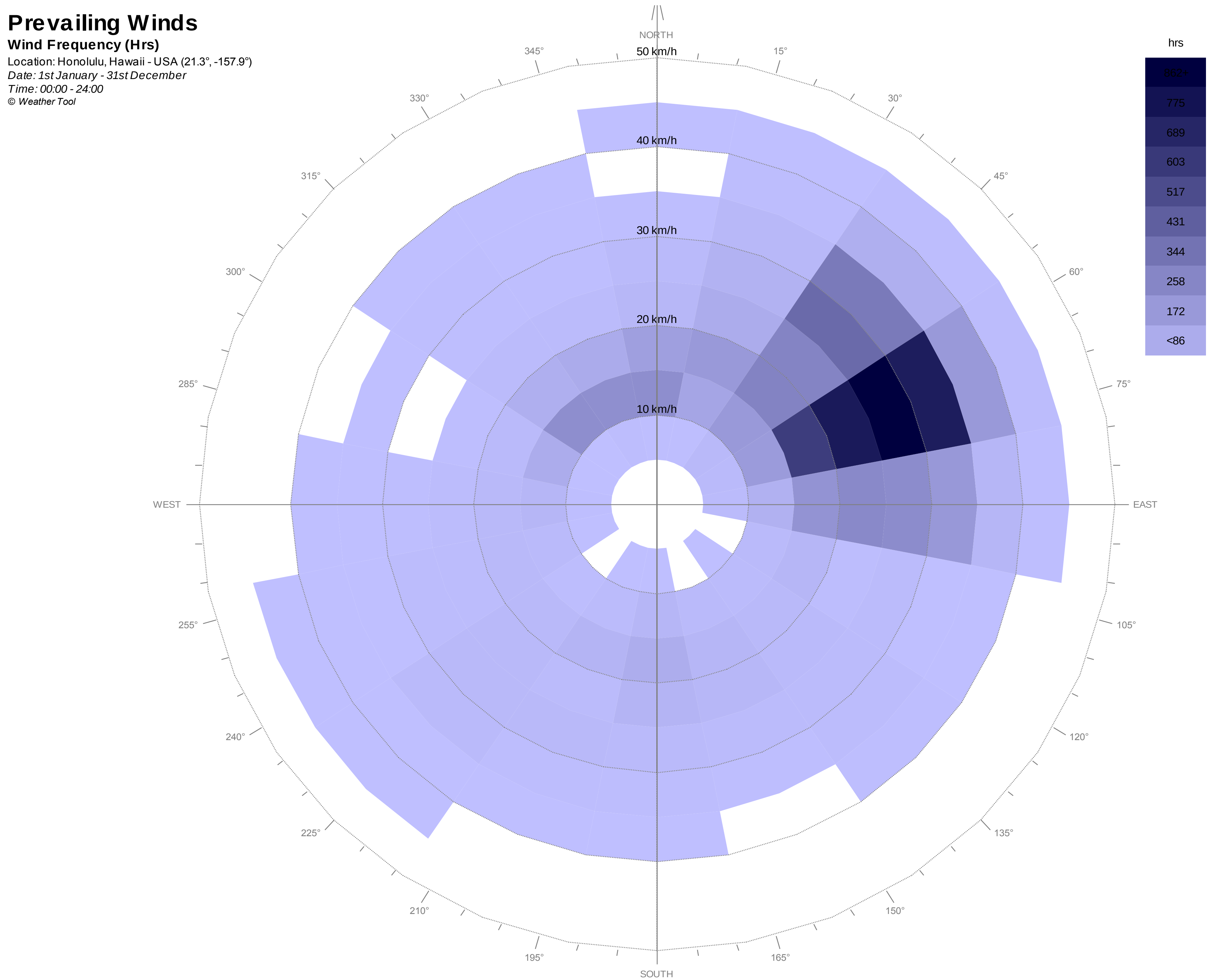


**Figure 35. Honolulu prevailing winds. Provides graphic of wind frequency and illustrates predominant tradewinds out of the ENE. Source: Ecotect Weather tool.**

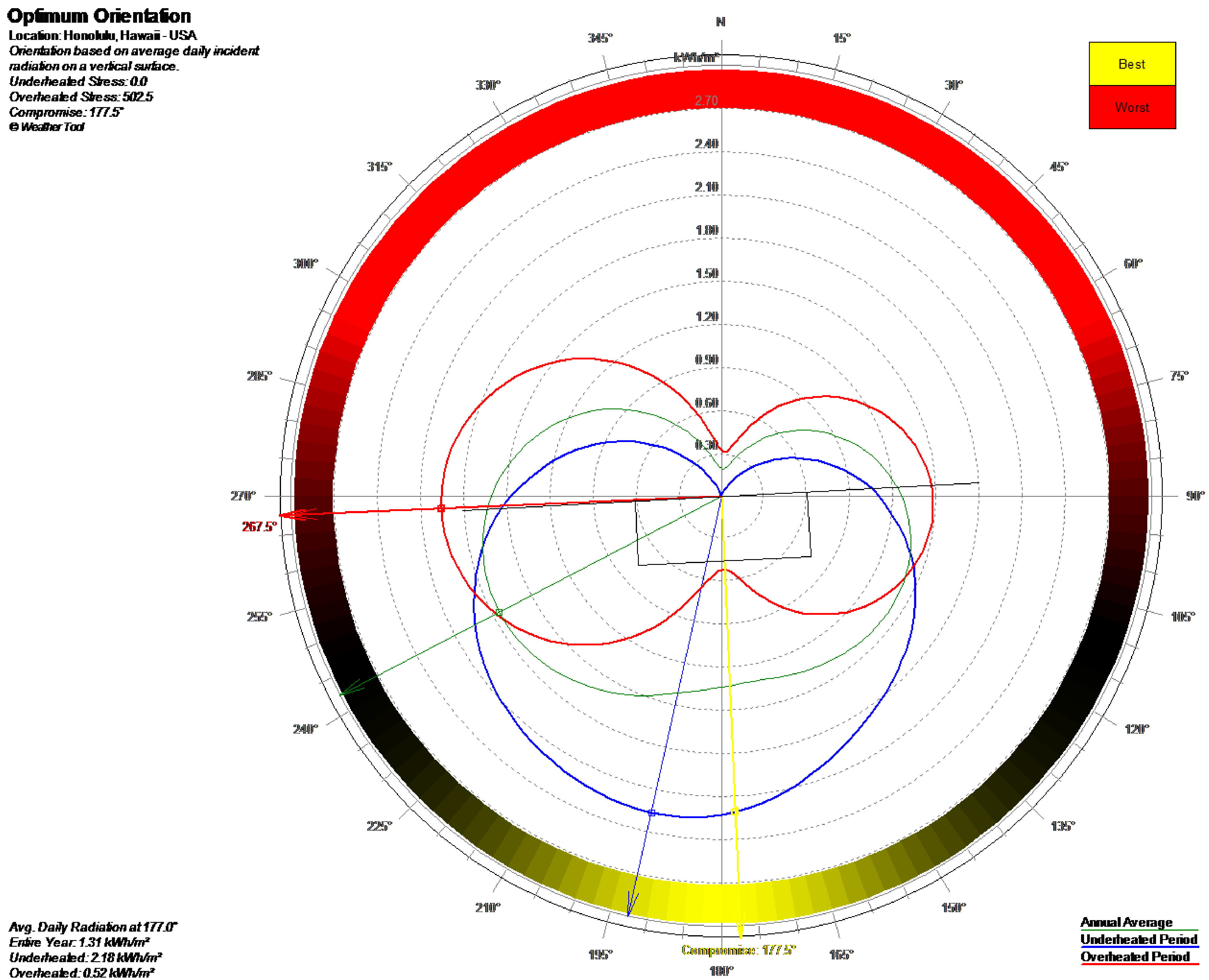


Figure 36. Optimum orientation for solar efficiency at Honolulu latitude. Source: Ecotect Weather tool.

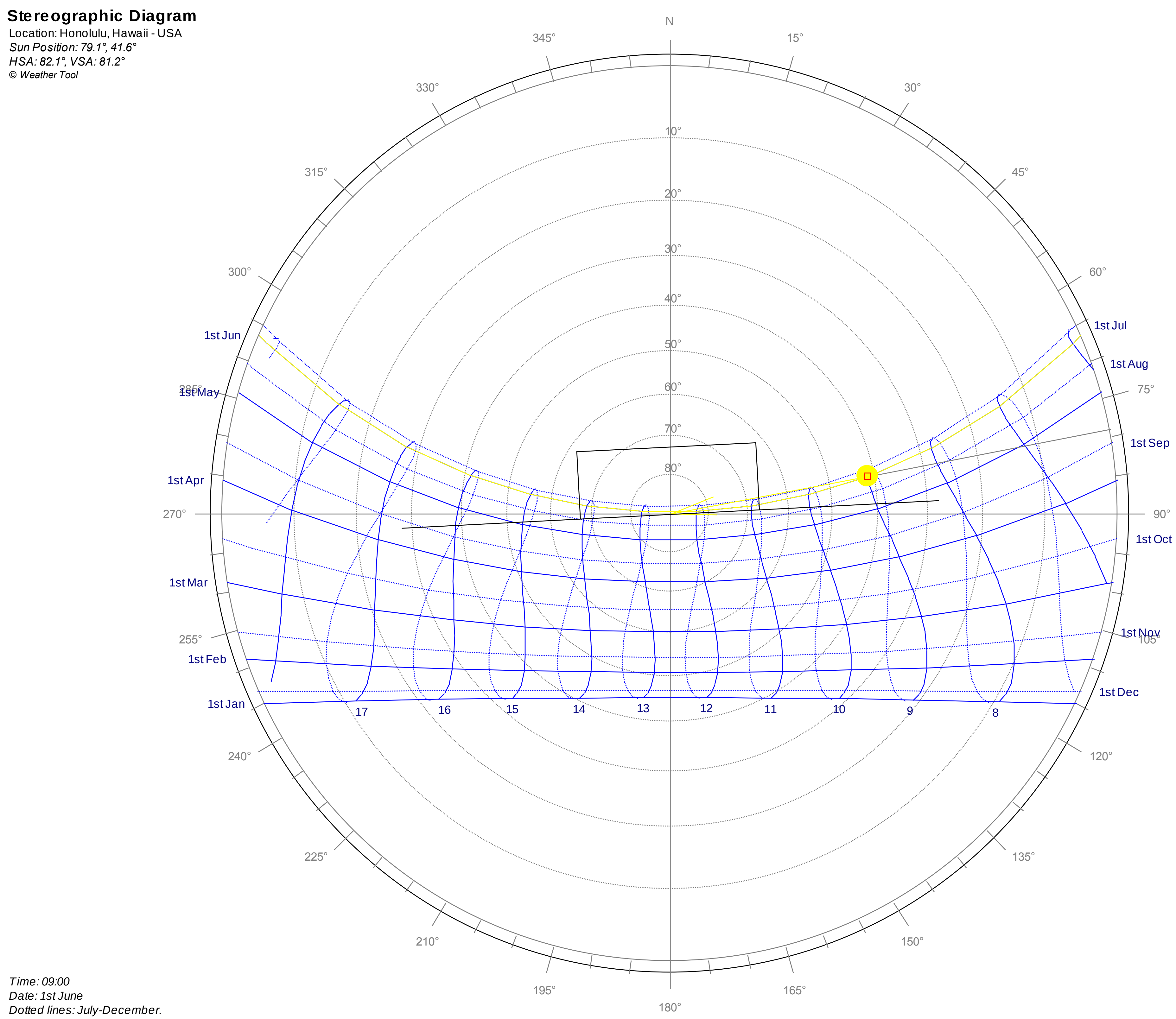


**Figure 37. Sun path diagram for Honolulu showing sun position on June 1st at 9:00 AM. Source: Ecotect Weather tool.**

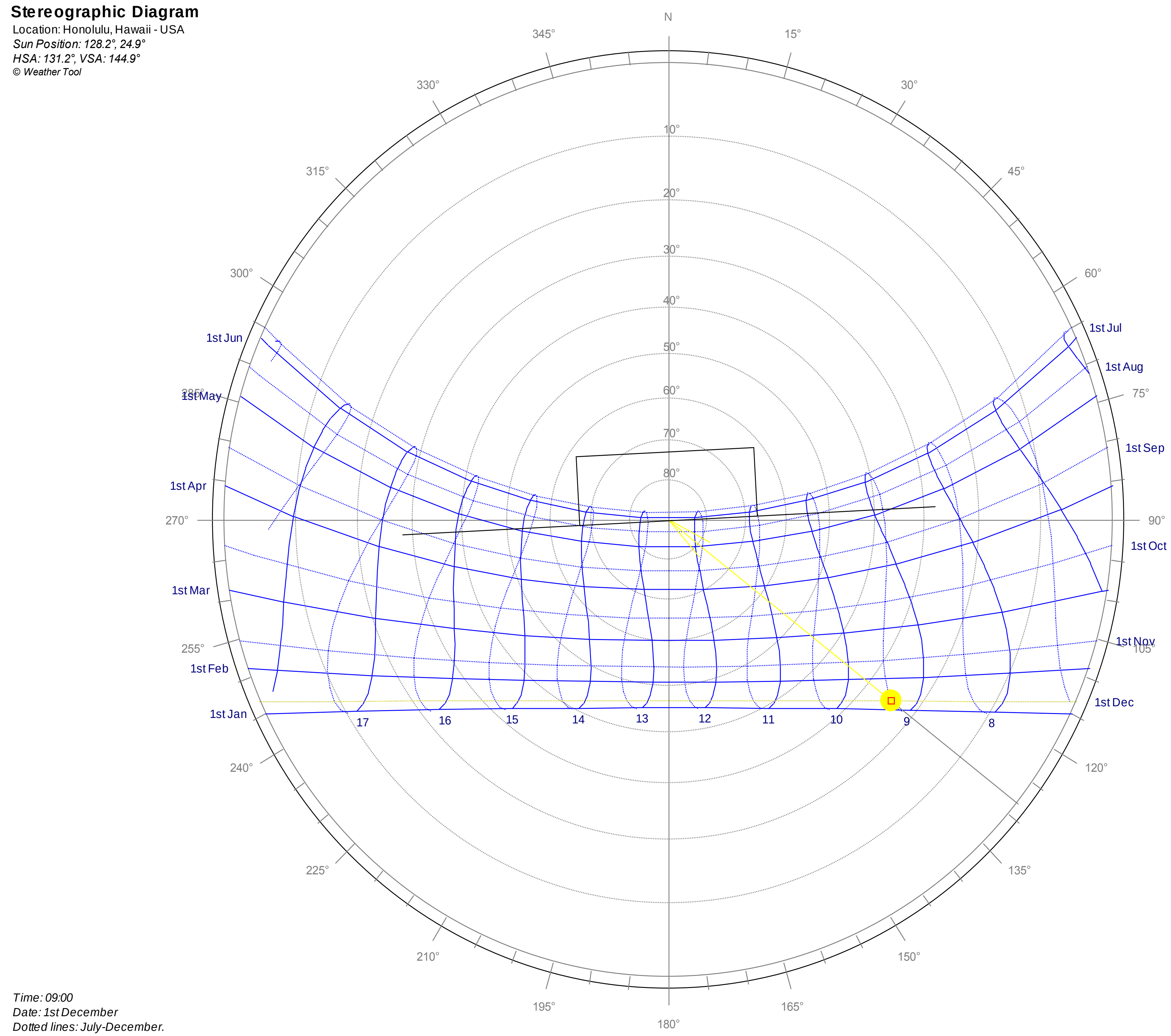


**Figure 38. Sunpath diagram for Honolulu on Dec 1st at 9:00 AM. Source: Ecotect Weather tool.**

### 2.5.12 Sustainable Design Standards

Certain Unified Facilities Criteria provide the sustainable policies of the Military Departments to satisfy the Office of Management and Budget Energy Management requirement to demonstrate comprehensive implementation of a sustainability program for green buildings that at a minimum requires sustainability design principles on all new construction and major renovations and is consistent with Energy Policy Act of 2005 (EPAct 2005) and Executive Order 13123 ( EO 13123), and/or is implementing the Memorandum of Understanding on Federal Leadership in High Performance and Sustainable Buildings.

In the military, these policies need to be couched in a way that addresses a national security interest and a means to an end in mission accomplishment. Developing sustainable facilities can enhance national security by increasing the DoD's energy reliability and security, and improve the image and reputation of DoD as a steward of environmental resources. For example, strategically located storm water retention ponds can serve as barrier between roadways and key DoD facilities. Incorporating renewable energy technologies and distributed energy generation into projects can provide highly reliable on-site power while limiting peak demand charges. Therefore, "from a military perspective, sustainability is the capacity to continue the mission without compromise. It is the ability to operate into the future without decline – either in the mission or the natural and man-made systems that support it."[36] Sustainable Development in the built environment includes six fundamental principles per the USGBC:

- Optimize Site Potential
- Optimize Energy Use
- Protect and Conserve Water
- Use Environmentally Preferable Products and Practices
- Enhance Indoor Environmental Quality (IEQ)
- Optimize Operational and Maintenance Practices

[36] UFC 4-030-01 Sustainable Development. Provides planning, design, construction, sustainment, restoration, and modernization criteria, and applies to the Military Departments, the Defense Agencies, and the DoD Field Activities.

### 2.5.12.1 Department of Defense Energy Conservation Standards

UFC 3-440-1 Energy Conservation states:

> "Specifically, new buildings shall be designed to comply with ASHRAE Standard 90.1. In addition, to complying with the standard, 'new' buildings shall also achieve an energy consumption level that is at least 30 percent below the level achieved under ASHRAE Standard 90.1."

and,

> "All energy consuming products shall be either ENERGY STAR-qualified or 'FEMP-recommended'. These products are in the upper 25 percent of energy efficiency in their class."

These standards apply to all new buildings and include guidance on usage of renewable energy sources "to the maximum extent possible" and goes on to require that a minimum of 30% of hot water be generated by a solar hot water source.

### 2.5.12.2 Design Process for Energy Efficiency

Processes and activities in energy efficient design include performing site analysis and resulting building massing and configuration analysis. These then inform Passive Solar Design strategies that address envelope, shading and daylighting. A program test fit exercise will then take the previous information and allow determination of the best location for unoccupied and occupied spaces, with consideration of heat gain and outdoor connection. Lastly, the data gathered then helps to determine what type, size, location and distribution of Mechanical and Electrical systems are needed.

A very important element was also to begin to take a closer look at energy efficiency strategies for the site and building together, as well as potential for use of renewable energies. The overall effort shouldn't be to come up with the most strategies or measures, but instead to determine the most effective from a cost standpoint and to an only slightly lesser extent, their holistic effectiveness. Even though this project doesn't emphasize cost considerations, they are still a very important part of decision making, and it should be emphasized that in an integrated team environment it would be one of the most important considerations to the client

#### 2.5.12.3 Baseline Energy Model (Medium Office Building)

In order to leverage the information and data readily available from several sources including the Department of Energy's Energy Efficiency and Renewable Energy website, and because there is no accessible prototype for a DOD headquarters building, a basic medium commercial office building will be used as a prototype. The benchmark building and data below was directly derived from the Department of Energy's "Technical Support Document: 50% Energy Savings Design Technology Packages for Medium Office Buildings", which created a Baseline Building Energy Model from the ASHRAE Standard 90.1-2004[37]. In association with the Pacific Northwest National Laboratory (PNNL) the benchmark energy data was generated using EnergyPlus Software.

The baseline energy model would be a simple rectangular building roughly the same size filling the site with as low a profile as possible. It will be a minimally code compliant medium sized office building. The energy use of this building typically represents the high-end of allowable energy use and sets the standard against which you can compare your design's projected energy efficiency. This benchmark would then be used to measure success as strategies are tested.

The overall energy use metric is defined as the Energy Use Intensity (EUI).[38] It is a measure of total annual building energy use divided by the gross building floor area. For the purposes of this design project, the benchmark will be expressed in terms of Site EUI vs. source EUI[39] as Site EUI is a measure of energy that can be read at the meter. The derived Baseline Energy Model will then provide the starting EUI from which the end use intensities, or power

[37] Where ever the 2004 standard is referenced, it has been compared to the 2007 standard and modifications have been made to reflect the updated standard
[38] Net Zero Energy design pg. 102
[39] Site EUI is energy use measured at the meter inside of the site while Source EUI is a measure of energy used at the site plus energy lost due to transmission variables.

densities, will be derived for all loads.  These will then be compared to the energy efficiency results of the proposed Energy Conservation Measures (ECM).

### 2.5.12.3.1 Baseline Building Operating Characteristics

The building is assumed to follow typical office occupancy patterns with peak occupancy occurring from 8 AM to 5 PM weekdays with limited occupancy beginning at 6 AM and extending until midnight for janitorial functions. For the medium office, Saturday occupancy is modeled at 10-30% of peak and limited Sunday and holiday occupancy (approximately 5%) is assumed. Schedules for lighting and miscellaneous equipment were matched to occupancy schedules with additional limited usage during unoccupied times. HVAC system schedules were matched to the occupancy schedules, and allow for earlier startup times to bring the space to the desired temperature at the beginning of normal occupancy. Chart illustrates the typical weekday schedules for occupancy, lighting equipment and HVAC fans for the medium office, as simulated in EnergyPlus.

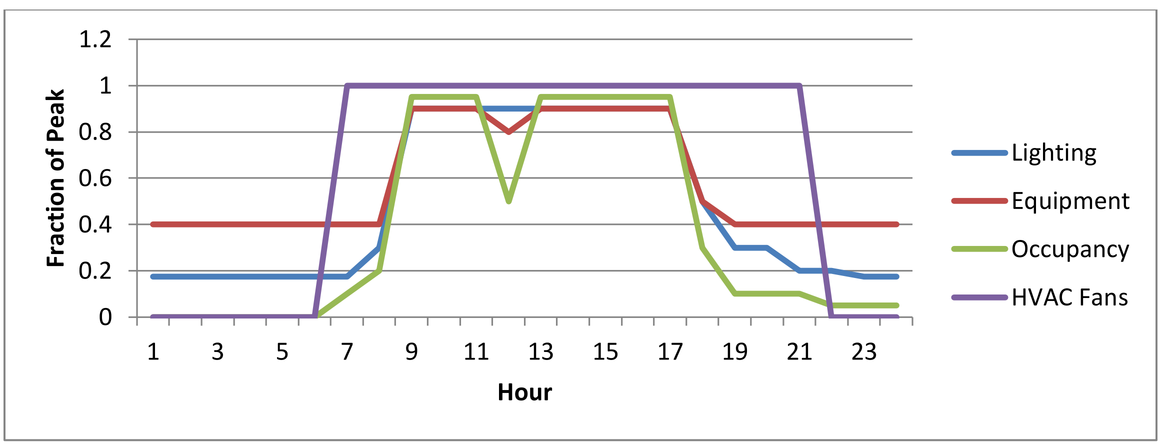


Figure 39. Baseline Medium office building occupancy schedule. *Source*: U.S. Dept. of Energy. *Advanced Energy Design Guide for Small to Medium Office Buildings: Achieving 50% Energy Savings Towards a Net Zero Energy Building.*

### 2.5.13 Sustainable Strategies

The following strategies have been established for design of DoD buildings and follow the LEED categories as most federal new construction projects are required to attain higher and higher LEED certifications.

Site selection is the initial important step, developing the site appropriately follows and then taking advantage of natural site features, and optimizing potential for passive solar heating and cooling, daylighting, and natural ventilation. Strategies for selecting, planning, and developing sites follow the USGBC LEED checklist and include:

- Select Appropriate Sites
- Control Erosion, Sedimentation, and Water Quality
- Provide Alternative Transportation
- Minimize Site and Habitat Disturbance
- Manage Storm Water Runoff
- Reduce Heat Islands

The Federal Government uses an estimated 244-256 billion gallons of water annually, which translates into about $0.5 billion to $1 billion for potable water and sewer runs, not including the significant amount spent on maintenance, repair and system upgrades.[40] Consumption of water in many areas of the country exceeds the ability of the supplying aquifer to replenish itself. Because potable water sources are becoming increasingly scarce, previously, both Executive Order 13123 and the Energy Policy Act of 1992 required Federal agencies to install cost-effective water conservation measures in their facilities but did not include water conservation goals. Executive Order 13423 requires agencies to reduce water consumption intensity by 2 percent annually through 2015. Each service should develop and implement facility water management plans for their new and existing facilities based on the Federal Energy Management Program's (FEMP) Facility Water Management Planning Guidelines and ten Best Management Practices for Water Conservation. Among these, strategies for reducing

[40] http://www1.eere.energy.gov/femp/pdfs/waterefficiency_fedoffices.pdf (accessed 11 April 2013)

potable water consumption and minimizing the impacts of wastewater systems include using potable water efficiently and reusing and recycling water on-site.

Energy security is a top priority for the US Government. For the DOD, it is important to develop ways to reduce energy loads, increase efficiency, and find and leverage alternative energy sources in facilities. Two directives require federal agencies to install cost-effective energy conservation measures in their facilities; Executive Order 13423 and the Energy Policy Act of 2005. Strategies for conserving energy, encouraging the use of non-grid source energy and protecting the atmosphere include; use HVAC, and refrigerating equipment containing non-CFC-based refrigerants, HCFCs and Halons, energy-efficient building envelope and lighting systems and efficient, properly-sized HVAC equipment. New DoD buildings should meet or exceed the current version of ASHRAE 90.1.[41] In addition, the Energy Policy Act of 2005 requires new Federal buildings to use 30% less energy than ASHRAE 90.1-2004

Federal agencies are directed to perform several environmentally friendly activities including using environmentally sound products, recycled content, and reducing the quantity and use of toxic and hazardous chemicals and materials.[42] Other key strategies for reducing the use of new raw materials, limiting waste materials, and reducing environmental impacts of transportation as well as supporting regional economies include; renovating existing facilities, limit construction debris, reuse materials, products, and equipment, give preference to locally produced materials with low embodied energy content, use rapidly renewable materials and certified wood products

Invariably, healthy and comfortable environments will enable occupants to better perform assignments to meet their service's mission. Strategies for creating and maintaining a healthy and productive indoor environment include; adequate ventilation, avoid the use of materials high in pollutants, ensure thermal comfort and occupant environmental controls, optimize daylighting and views, provide acoustical comfort.

[41] UFC 4-030-01 Sustainable Development

[42] Executive Order 13423, "Strengthening Federal Environmental, Energy, and Transportation Management"

## 2.6 Security Design Considerations and Strategies

As the other important element of this design project, an understating of security design in the federal and DoD realm is critical. The following is a survey of requirements, processes and strategies that have been promulgated in various federal and DoD documents and will serve to better understand where conflicts and synergies might be. The DoD requires a minimum antiterrorism standard across building types, but also requires an assessment of overall security requirements for each project. This additional assessment process may or may not result in enhanced or upgraded security measures beyond the minimum standards.

### 2.6.1 Department of Defense Minimum Antiterrorism Standards

UFC 4-010-1 *DoD Minimum Antiterrorism Standards for Buildings* provide a minimum level of protection for all DoD facilities and a starting point for design. The criteria are placed in four categories; Site Planning, Structural Design, Architectural Design and Electrical and Mechanical Design.

**Table 4 DoD Minimum Antiterrorism Standards for Buildings.**

| **DoD Minimum Antiterrorism Standards for buildings** | |
|---|---|
| Design Phase | Standard |
| Site planning | Standoff distances |
| | Unobstructed space |
| | Drive-up/drop-off area |
| | Access roads |
| | Parking beneath bldgs. And on rooftops |
| | |
| Structural Design | Progressives collapse resistance |
| | Structural isolation |
| | Building overhangs and breezeways |
| | Exterior masonry walls |
| | |
| Architectural design | Windows and skylights |
| | Building entrance layout |
| | Exterior doors |
| | Mail rooms |
| | Roof access |
| | Overhead mounted architectural features |

| | |
|---|---|
| Electrical and Mechanical design | Air intakes |
| | Mail room ventilation |
| | Emergency air distribution shutoff |
| | Equipment bracing |
| | Mass notification |

***Source*: UFC 4-010-01 DoD Minimum Antiterrorism Standards for Buildings.**

outlines the standards. This framework provides for a process that follows the design stages. Major design strategies that are the most effective and economical in protecting DoD personnel include; maximizing standoff distance, preventing building collapse, minimizing hazardous flying debris, providing effective building layout, limiting airborne contamination and providing mass notification. These major design strategies provide a glimpse of the potential synergies with sustainable design: Maximizing standoff infers open space, preventing building collapse likely calls for reinforced mass walls in many cases, minimizing flying debris might require minimizing glazing, providing effective building layout could mean optimizing daylighting potential or thermal zoning, limiting airborne contamination equates to improving indoor environmental quality and providing mass notification implies an integrated control system.

### 2.6.2 Security Criteria Development

The design criteria development process is a procedure for developing criteria for a facility. It is designed to capture and apply the inputs of the integrated planning and design teams. The procedure includes the development of preliminary design criteria based on consideration of the assets associated with a facility in terms of their value to their users and the likelihoods that different aggressors will target them. The preliminary design criteria are then evaluated using a preliminary risk analysis. The design teams may then adjust the preliminary design criteria to reflect the risk analysis or the cost necessary to implement the design criteria. They may also adjust the criteria as necessary according to the professional judgments of the team members based on local and regional considerations. The resulting design criteria will be the basis for security planning and preliminary design.

It is essential to the effectiveness of security design criteria development to have an interdisciplinary team involved in the process. All the members of that team have unique perspectives that need to be reflected in the effort. The team should be convened at the inception of project planning and should provide review and oversight at all stages of project development.

The first important step once the design team is convened is to identify assets to be protected; they include elements beyond just the building construction, general people, to information, equipment and processes. Next is to determine the asset value. The process provides criteria to determine asset value based on several factors including location, purpose of asset, strategic importance, and mission criticality. Once the asset values have been determined, the priority assets are pared down based on reaching certain thresholds. The next step is to determine types of aggressors and their likely tactics. These are developed based on several factors including; current geo-political environment, location (domestic or international, rural or urban), infrastructure, and others. Certain types of aggressors will exhibit certain propensities or likely tactics and the likelihood will be based on intelligence and other factors. Threat levels are derived from these and consolidated into an initial design basis threat (DBT) and initial levels of protection (LOP) required. Very important at this stage is to assess planning level risk and acceptability of those risk levels. In all likelihood there will be constraints to implementation of all of the measures required. They could be imposed by land constraints, government constraints (foreign and domestic), resource constraints and time constraints. The resulting criteria along with the minimum standards required will be the security basis of design.

#### 2.6.2.1 Considerations/Threats and Tactics

Historical patterns and trends in aggressor activity indicate general categories of aggressors and their objectives and the common tactics that they can be predicted to use against DoD assets. These aggressor tactics and their associated tools, weapons, explosives, and agents are the basis for the threat to assets. Understanding the basis for the threat and the aggressors' objectives is essential to effective security design. For the purposes of designing a protective system, the perpetrators of terrorist or criminal acts or acts of espionage are not important. The important issue is how an aggressor attacks the asset and with what. The aggressors will not be carried into the design criteria. The purpose of this is to provide a common basis for defining threat for the purposes of facility design. Additional threat parameters may be added as necessary.

#### 2.6.2.1.1 Aggressors and Objectives

Aggressors are people who perform hostile acts against assets such as equipment, personnel, and operations. Aggressor objectives include; Inflicting injury or death on people, Destroying or damaging facilities, property, equipment, or resources, Stealing equipment, materiel, or information, Creating adverse publicity. Aggressors may use the first three objectives to accomplish the fourth.

There are four broad categories of aggressors and include criminals, protesters, terrorists, and subversives. Hostile acts performed by these aggressors range from crimes such as burglary to low-intensity conflict such as unconventional warfare. Each of these aggressor categories describes predictable aggressors that pose threats to DoD assets and who share common objectives and tactics.

Criminals are divided into one of three possible groups based on their degree of sophistication. These three groups are defined as unsophisticated criminals, sophisticated criminals, and organized criminal groups. The common objective for all three criminal groups is assumed to be theft of assets.

Only violent protesters are considered to be a threat. Protesters include the two general groups of vandals/activists and extremist protesters. Both groups are politically or issues oriented and act out of frustration, discontent, or anger against the actions of other social or political groups. The primary objectives of both groups commonly include destruction and publicity.

Vandals/activists are commonly unsophisticated and superficially destructive. They generally do not intend to injure people or cause extensive damage to their targets. Their actions may be covert or overt. Typically, they choose symbolic targets that pose little risk to them. For the purposes of risk analysis in this document, vandals/activists are grouped with criminals.

Extremist protest groups are moderately sophisticated and are usually more destructive than vandals. Their actions are frequently overt and may involve the additional objective or consequence of injuring people. They attack symbolic targets, including authority figures such as high-ranking officials and police, weapon systems, and things they consider to be environmentally unsound. For the purposes of risk analysis in this document, extremist protest groups are grouped with terrorists.

Terrorists are ideologically, politically, or issue oriented. They commonly work in small, well-organized groups or cells. They are sophisticated, skilled with tools and weapons, and possess an efficient planning capability. Terrorist objectives usually include death, destruction, theft, and publicity. Three types of terrorist groups are identified based on their areas of operation and their sophistication. The three types are domestic terrorists, international terrorists, and state sponsored terrorists.

Subversives include aggressors from foreign governments or from groups trying to overthrow the government by force. They include saboteurs and foreign intelligence agents. Saboteurs include guerrillas and unconventional warfare forces. They are paramilitary or actual military personnel who are very sophisticated, highly skilled, and employ meticulous planning. They commonly act in small groups, have an unlimited arsenal of weapons, and are well-trained in the use of those weapons. The objectives of saboteurs usually include destruction of property and death and their targets include mission-critical personnel, equipment, and operations. Foreign intelligence agents are highly skilled and very sophisticated. They are generally foreign agents, but they frequently employ insiders for assistance. These agents commonly operate covertly to avoid detection before, during, or after an action. Their objective is usually assumed to be theft of sensitive information.

#### 2.6.2.1.2 Aggressor Tactics

Aggressors have historically employed a wide range of offensive strategies reflecting their capabilities and objectives. Table 6 lists and describes the specific tactics.

**Table 6. Aggressor tactics and descriptions.**

| Aggressor Tactic | Description |
|---|---|
| Moving Vehicle Bomb | Aggressors drive an explosives-laden car or truck into a facility and detonate the explosives. The aggressors' goals are to damage or destroy the facility and/or to kill people. This is a suicide attack. |
| Stationary Vehicle Bomb | Aggressors covertly park an explosives-laden car or truck near a facility. It is assumed that the aggressors park the vehicle in a legal location to avoid being noticed. The aggressors then detonate the explosives either by time delay or remote control. The aggressors' goals in this tactic are the same as for the moving vehicle bomb tactic with the additional goal of destroying assets within the blast area. |
| Hand Delivered Device | Aggressors attempt to enter a facility or get close to the exterior of a facility or to assets not located within a facility with either placed or thrown explosives or incendiary devices. This tactic also includes explosive or incendiary devices delivered through the mail or to supply and materiel handling points such as loading docks. The aggressors' goals are to damage the facility, to injure or kill its occupants, or to damage or destroy assets. |
| Indirect Fire Weapons | Military or improvised indirect fire weapons are fired at a facility from a significant distance. Indirect fire weapons (commonly mortars or rockets) do not require a clear line of sight to the target. They can be fired over obstacles. The aggressors' goals are to damage the facility, to injure or kill its occupants, or to damage or destroy assets. |
| Direct Fire Weapons | Aggressors fire weapons that require direct lines of sight to targets. These attacks may be from a significant distance or may be close-up as in a drive-by shooting. Direct fire weapons include antitank weapons and various small arms, such as pistols, submachine guns, shotguns, and rifles. The aggressors' goals are to injure or kill facility occupants or to damage or destroy assets. |
| Forced Entry | Aggressors forcibly enter a facility using forced entry tools, explosives, and small arms. The aggressor uses the tools and explosives to create a man-passable opening or to operate an operable assembly in the facility's walls, doors, roof, windows, or utility openings. The aggressor may also use explosives or small arms to overpower guards as part of this tactic. The aggressor's goals are to steal or destroy assets, compromise information, injure or kill facility occupants, or disrupt operations. |
| Covert Entry | Aggressors attempt to enter a facility or portion of a facility to which they do not have authorized access by using false credentials, by stealth, and by surreptitious entry. Covert entry can either be by people not associated with a facility or insiders who try to access areas in which they are not authorized. The aggressors' goals are to steal assets, to compromise information, to disrupt operations, or to injure or kill building occupants. |
| Visual Surveillance | Aggressors employ ocular and photographic devices such as binoculars and cameras with telephoto lenses to monitor facility or installation operations or to see assets. The aggressors' goal is to compromise information. Aggressors may also use this tactic as a precursor to other tactics to determine information about an asset of interest or about security measures. |
| Acoustic Eavesdropping | Aggressors employ listening devices from outside a facility or restricted area of a facility to monitor voice communication or other audibly transmitted information. The aggressors' goal in this tactic is to compromise information. |
| Electronic Emanations Eavesdropping | Aggressors employ electronic emanation surveillance equipment from outside a facility or restricted area of a facility to intercept electronic emanations from computers, communications, and related equipment. The aggressors' goal in this tactic is to compromise information. |
| Airborne Contamination | Aggressors contaminate the air supply of a facility by introducing chemical, biological, or radiological agents into it. These agents can be delivered to facilities either by external or internal release. External release can be from directed plumes spread from a standoff distance, from a point or line source, from general aerial release, or by directly inserting them into outside air intakes. Internal release can be through the mail, by supplies delivery, direct release within the building area, or insertion into the building ventilation system. The aggressors' goal is to kill or injure people. |
| Waterborne Contamination | Aggressors contaminate the water supply to a facility by introducing chemical, biological, or radiological agents into it. These agents can be introduced into the system at any location with varying effectiveness depending on the quantity of water and the contaminant involved. The aggressors' goal is to kill or injure people. |
| Waterfront Attacks | Aggressors attack people or other waterfront assets from the water either by swimming or on watercraft. Attacks on waterfront assets from the land are covered by other tactics. The aggressors' goal is to kill or injure people or to damage or destroy equipment or other assets. |

**Source: Unified Facilities Criteria 4-020-01 DoD Security Engineering Facilities Planning Manual.**

### 2.6.3 Levels of Protection

Levels of protection reflect the degree to which an asset is protected against the threat based on its value to its user. A level of protection of "very high" corresponds to a low possibility that an asset will be compromised if attacked. For some tactics, level of protection refers to the amount of damage a facility or asset would be allowed to sustain in the event of an attack. A low amount of allowed damage equates to a high level of protection. For other tactics, level of protection refers to the probability that an aggressor will be defeated before the asset is compromised. A high probability of defeat equates to a high level of protection. There can be one or more levels of protection; very high, high, medium, low, or very low, for each of the 12 tactics. Levels of protection apply to all threat severity levels for each tactic. The initial level of protection may be changed after further analysis.

### 2.6.4 Design Basis Threat

The Design Basis Threat is determined in order to provide an appropriate preliminary protective system to counter each applicable aggressor tactic. It represents the worst-case of the respective threat severity levels for each tactic by an aggressor against a given asset.

### 2.6.5 Security Design Strategies

The design strategies in table 7 then address the respective aggressor tactic considering various required levels of protection.

**Table 7. Security Strategies and descriptions.**

| <u>**Aggressor tactic**</u><br><br><u>**Security measure**</u> | <u>**Description**</u> |
|---|---|
| **Vehicle Bombs** (Mobile/Stationary) | |
| -Standoff | The pressures resulting from explosive blasts can be very high, but they decrease rapidly with distance. That suggests that where land is available the least expensive way to provide protection against explosives is to maximize the standoff distance. The design strategy, therefore, is to provide as much standoff distance between protected facilities and potential locations for vehicles, such as parking areas, roadways, and other locations that could be accessible by vehicles. The only difference in the application of this strategy for moving vehicle bombs versus stationary vehicle bombs with respect to standoff distance is that the locations to be considered for the stationary vehicle bomb can be limited to those where parking or other vehicle access is common. The reason for that is the assumption that the aggressors who would employ the stationary vehicle bomb seek to be covert as described in the baseline threat. In the case of the moving vehicle bomb, that assumption is invalid because the aggressors are assumed to be suicidal. Detection is assumed not to be a deterrent to them. |
| -Building Hardening | Where the standoff distance from a vehicle bomb to a protected facility is sufficient, the facility can be of conventional construction, which means that it can be built without any hardening of building elements. One major exception to that are windows, which would have to be constructed to minimize fragmentation as reflected in the windows required by the DoD Minimum Antiterrorism Standards for Buildings (UFC 4-010-01). Where the sufficient standoff distances cannot be provided, building elements such as walls, doors, windows, roofs, and, potentially, building superstructures may have to be hardened to resist the explosive effects to the applicable level of protection. |
| -Vehicle Barriers | The strategies for both of these tactics include the application of some form of vehicle barriers to establish and maintain the standoff distance between vehicles and facilities. Those barriers will commonly include passive perimeter barriers that define the standoff distance and active barriers that allow entry through the perimeter. For the stationary vehicle bomb tactic, both the passive perimeter and active barriers only need to define the perimeter and provide an obstacle whose breaching would draw attention. For the moving vehicle bomb tactic those barriers must actually stop the kinetic energy of the moving vehicle because the driver is assumed to be suicidal. |
| **Hand Delivered Devices** | |
| -Detection | Detect the device and to ensure that assets inside buildings are protected in accordance with the applicable level of protection in the event a device detonates. For devices assumed to be placed on the exterior of the building, that generally requires an unobstructed space within which placed explosives or incendiary devices can be visually detected and building elements that are designed to resist the explosive effects of a detonation outside the distance associated with that unobstructed space. For devices at entry and delivery points into buildings, the general design strategy includes providing for detection of the device at those points and designing those areas to minimize damage to assets inside the building from a detonation inside those entry or delivery points. |
| **Indirect Fire Weapons** | |
| -Building Hardening | Design a targeted building to protect assets inside it from the detonation of the threat weapon at locations that vary by level of protection. That design will generally require building hardening, which will vary with threat severity because the weapons range from simple incendiary devices to large improvised high explosive warheads. Specific design strategies vary based on the distance from the impact of the threat weapon to the target building, the response of the building elements to the detonation of the weapon, and the fragment penetration through the building elements. |
| **Direct Fire Weapons** | |
| -Shielding/Hardening | Because there are generally no opportunities to detect and prevent direct fire weapons attacks, the design strategies for this tactic are based on shielding and hardening. The strategy involves identifying vantage points from which direct fire weapons can be launched and, depending on the level of protection, either blocking sightlines to assets and building occupants or hardening the building elements to resist the direct fire weapons effects. |

| | |
|---|---|
| **Airborne Contamination** | |
| -Access Control/Screening | The general design strategy is to provide access control and screening to ensure that agents are not introduced into buildings and to design the building elements and building support systems to ensure that agents introduced from outside the buildings or at entry and delivery points are kept out of the buildings. |
| -Collective Protection | Building envelopes will be designed to minimize air infiltration and exfiltration and that at other than the very low level of protection the buildings will be pressurized to keep airborne agents out. That pressurization requires filtration to retain the purity of the makeup air necessary to retain over pressurization. In addition, ventilation systems for entry and delivery points will be isolated from the remainder of the buildings. |
| Detection/Intel | Automatic detectors can be used to initiate protective actions such as shutdown of ventilation systems, closing outside air intakes, or turning on filtration systems. Detection of radiological agents can be performed quickly with off-the-shelf equipment. However, current biological detection technology requires a minimum delay of approximately 15 minutes to detect the presence of biological agents, although there is high-end research and development equipment capable of detecting within a few minutes. Practical application of chemical detection is limited by several factors. Therefore, the design strategy will be dependent on intelligence or operational detection of events rather than automated detection. |
| **Waterborne Contamination** | |
| -Detection/Filtration | The strategy for this tactic is to protect treated potable water supply and distribution system components from the introduction of large quantities of contaminants at likely access points and from small quantities introduction into the system closer to or inside buildings through physical security. It also includes providing alternate drinking water sources in the event that the water gets contaminated. It involves both contamination avoidance and treatment. The locations to which this design strategy is should be applied include the following; water sources, treatment plants, treated water storage, water distribution system, building water supply plumbing. |
| **Forced Entry** | |
| -Detection/Barrier | The design strategy for this tactic is to detect aggressors either prior to their reaching barriers or as they attempt to breach them and then to provide sufficient delay to forced entry in the construction of those barriers to allow responding forces to arrive and defeat the aggressors before they can compromise the asset. Inherent in this strategy, therefore, is that there is an intrusion detection system that provides an alarm to a monitoring station in response to intrusion and that there is a response force that can respond to an alarm and reach its location before aggressors are able to breach the barriers between that point and the assets being protected. |
| **Covert Entry** | |
| -Access Control | The general design strategy is limited to providing construction that presents a barrier between potential aggressors and assets and then providing access control through those barriers. Where only outsiders are a concern, that approach can be applied to entire buildings or large areas of buildings. Where insiders are a concern, there may have to be compartmentalization within the building. |
| **Visual Surveillance** | |
| -Shielding | The design strategy for mitigating this tactic involves preventing unauthorized people from seeing assets that users do not want to be seen. The strategy for this tactic is simply to prevent aggressors from seeing assets. |
| Acoustic Eavesdropping | |
| -Sound Attenuation | The strategy for this tactic is to<br><br>design building exteriors or rooms within buildings that have construction that attenuates sound transmission so that secure conversations can be held in the building. |

***Source*: Unified Facilities Criteria 4-020-01 DoD Security Engineering Facilities Planning Manual.**

# Chapter 3. Analysis and Synthesis

As might be suspected, there are potential conflicts between sustainable and security design criteria, but there are also synergies and compatible strategies that provide mutual solutions to design challenges  Balancing these requirements is important to both, reach the minimum objectives of security design and attain the desired LEED credits and energy efficiency goals. Additionally, sustainable and security criteria must be considered within a total project framework including impacts on human comfort and the environment, regardless of the level of appropriate protection. Modern security design is based on dealing with multiple potential hazards. . Because both are of such importance to the government recently , there is not a lot of literature or research on balancing energy efficient and security requirements. However, tools and processes to accomplish this are in early stages of development. A good example of the synthesis of the two design considerations is the LEED DoD Anti-Terrorism Standards Tool that can be found on the Whole Building Design Guide (WBDG) website. It is important to understand the interaction between security and green design objectives by emphasizing the 'whole building' or integrated design process, identifying potential conflicts between green and security approaches, and highlighting green design opportunities within specific security strategies and areas of synergy. Knowing this information can help to define and understand the interrelationships between the project's needs and achieve balanced design solutions that will minimize environmental impacts as well as ensure the security, health, safety, and comfort of building occupants.

There are 21 minimum security standards across four main design areas; site, structure, architectural design and electrical and mechanical systems.  There are 5 main LEED categories and associated prerequisites; sustainable sites (SS), water efficiency (WE), energy and atmosphere (EA), materials and resources (MR), and indoor environmental quality (IEQ). Of the associated category prerequisites only 3 would appear to be areas where architects would have influence and are design related;  WE prerequisite 1, water use reduction, EA prerequisite 2, minimum energy performance and IEQ prerequisite 1, minimum indoor air quality.  Of the remaining optional LEED credits the focus is on design related credits that the architect would have influence on.  The methodology in identifying synergies and conflicts would then be to start with each security standard minimum and associate it with a planning and design stage then associate it with a relevant LEED prerequisite or credit and EEM. For instance, when considering structural design security standards, the probable relevant design stages would be massing and orientation, structure and passive design. In each of those, EEMs that might be considered could include proper solar orientation that syncs with standoff requirements, insulated precast concrete sandwich panels, air barriers and daylighting and design related LEED credits that would be considered might include; SS credit 7.2 heat island effect-roof, or MR credit 1 building reuse-maintain existing walls, floors and roof. Another method could be to approach it by using the main LEED categories and then identifying relevant security measures and ECMs. Either way, the results are sets of measures that then need to be categorized into universal synergies, or synergies that can be used across building types and site types and restraints, non-universal synergies, conflicting measures (requiring tradeoffs and/or compromises), and individual measures that are neither synergistic nor conflicting. This last category of measures would likely be those that have little to no cost to implement. These sets of measures would then be utilized during the design planning process when identifying project requirements.

## 3.1 Department of Defense planning and design process

Project planning and programming is the first stage of the DoD facility development and design process. Decisions made during this stage provide the DoD planners and designers direction for the rest of the process. Establishing project development goals, defining the process to achieve them, and developing a clear understanding of the expected results outline this process.

Step 1: Define Responsibilities and Procedures.

Within the development and design process, assign responsibilities for managing the project and the program. Use formal or informal partnering within the team to ensure early buy-in, commitment, and understanding of project security and sustainability goals. At the initial meeting, the team should create a mechanism for shared exchange of information throughout the duration of the project to ensure all design decisions mesh with the different discipline areas..

Step 2: Design Charrette.

A planning/programming charrette is conducted in the earliest stages of the project. The purpose is to identify and resolve issues of standardization, functionality, location, scope, and cost which might potentially affect the project. Security and sustainable criteria will be some of the issues addressed during this stage. Critical to balancing the criteria is the ability to identify potential conflicts and synergies at this point. This provides a framework and starting point for subsequent stages in which to leverage. These are captured in the project requirements and goals.

Step 3: Project requirements/goals.

Identify and describe the project's goals as part of the project requirements. The project requirements will dictate how aggressively each development principle can be pursued. In particular, the environmental needs of each space (e.g. the desirability of daylighting, specific temperature/humidity conditions, acoustical requirements, etc.) as well as security requirements must be considered. This is the step in which sets of pre-established measures are presented. The measures would include sustainable, security and synergistic measures. Having identified universally applicable synergistic measures you would then need to assess the potential viability of the remaining synergies. Sets identified as conflicting would also then need to be reviewed for tradeoffs and compromises.

Sustainable goals might include the following:[43]

- Environmental impacts
- Energy and water conservation
- Use of renewable energy sources
- Use of environmentally preferable materials
- Use of recycled materials
- Life-cycle costs
- Indoor environmental quality
- Employee safety and security

[43] UFC 4-030-01 Sustainable Development.

- Operations and maintenance considerations including availability, ease of maintenance, access, and safety
- Commissioning
- Construction and demolition waste management
- Deconstruction and disposal.

Security goals might include:

- Use of existing security infrastructure
- Impact on surrounding neighborhoods
- Protected space at perimeter of compound
- Circulation vs. standoff
- Threat surveillance mitigation
- Blast protection, CBR protection vs. visual connection to outdoors

Sustainable and security design conflicts and synergy goals might include:

- Combine standoff and unobstructed space areas with water management areas or green space for heat Island effect mitigation
- Review blast protection requirements reducing possibility of falling objects in occupancy zones with possible light shelve strategies
- Review CBR protection restrictions to the use of light tubes for daylighting
- Ensure air tight envelope and pressurized building for humidity control, heat gain mitigation and CBR protection.

Step 4: Identify Certification Goals.

Specify the LEED rating level desired, and identify if the project will be registered with USGBC and the LEED documentation submitted for certification. The Navy presently requires all new construction to obtain a LEED Gold standard.

Step 5: Evaluate siting alternatives.

Identify and evaluate possible siting alternatives, considering the following sustainable aspects: building reuse; storm water and erosion; building footprint, orientation, massing, form, and height; existing landscape; access to public transportation; natural habitat; solar gain; local and/or renewable resources; and security aspects: standoff, CBR protection, Blast protection, and threat surveillance . The impact on the existing and surrounding community should also be considered when siting a project.

Step 6: Develop passive design strategies

Based on climate and site, develop conceptual massings and identify optimal orientation. Include shading and daylighting studies with the aim of reducing cooling loads resulting from internal and external heat gains and electric lighting loads.

Step 7: Conduct a Preliminary Energy Analysis.

The conceptual design should be energy modeled and cost modeled and then revised to ensure the optimum design and cost solution. Cost models can help balance project costs by identifying potential trade-offs where necessary to bring overall project cost in line with DoD cost criteria and project funding.

With the exception of step 7 above, the design planning process described will be the workflow for developing the conceptual design. The process should identify potential conflicts, tradeoffs and synergies more effectively then if it were accomplished later in the design process.

## 3.2 Conflicts, Tradeoffs and Synergies

Capturing the potential tradeoffs and opportunities early is important as it establishes a thought process that leads to the development of solutions at a point where costs won't necessarily be a big factor. However, not considering them at this early stage could be costly when it is determined later that a design solution is incompatible with an important standard or criteria and a fix requires reordering material or redesigning a major part of the project at great cost of funds and time. For example, increasing glazing area to provide daylighting can be incompatible with the desire to decrease glazing to minimize a flying glass hazard in an explosive detonation. Not identifying this point early would likely require a redesign of window sizes, if not caught early enough, or addition of a ballistic film that may or may not be sufficient based on window size and type. Similarly, designating surface parking away from a building to provide appropriate stand-off distance can limit the extent to which a project can meet its site disturbance reduction goals. These inherent conflicts challenge the project team to find creative solutions for the issues at hand early.

The items below follow the LEED template and are also areas of interaction between security and sustainable goals and measures. The benefits and disadvantages of pursuing these strategies are decisions to be made early, weighing them against the project's identified requirements and desired outcome in order to achieve a balanced design.

Security and sustainable site planning strategies can significantly affect each other. For example, a facility's risk can be increased and security can be compromised by siting it in an urban area to protect and preserve habitat and natural resources; locating carpool parking and bike racks nearby to promote alternative transportation, and installing covered walkways and landscaping to reduce heat islands and control erosion. On the other hand, security measures such as building setbacks, or standoff distances, to create protective building perimeters and to restrict access; installing barriers to withstand assaults by moving vehicles; and locating parking areas in remote areas and/or eliminating under-building parking areas to minimize blast effects from potential vehicle bombs, usually result in increased development of open space, habitat disturbance, and possibly erosion.

The erosion of soil caused by precipitation or wind can lead to destruction of vegetation, degradation of property, and sedimentation of local water bodies as well as unstable building foundations and potential loss of structural integrity. Erosion control measures can be implemented to stabilize the soil and/or to retain sediment after erosion had occurred. These help to reduce the negative impacts on water and air quality as well as mitigate potential damage to a building's foundation and structural system due to floods, mudslides, torrential rainstorms, and other natural hazards.

Keeping sustainability and safety goals in mind, designers can create landscaping schemes that can at once reduce environmental impacts and deter threats. For example, landscaping elements such as retention ponds and berms can be used to control erosion, manage storm water, and reduce heat islands while also serving as physical barriers to control access to a building and to deflect the effects of a blast. Native or climate tolerant trees can help to improve the quality of the site as well as provide protection by obscuring assets and people. Note, however, that trees can also screen perpetrators from view. Crime Prevention through Environmental Design (CPTED) is a strategy that uses natural access control, natural surveillance, and territoriality and boundary definition to reduce the threat opportunities and improve piece of mind for personnel.[44] Early coordination of sustainable site design with CPTED is critical to avoid conflicts between the two strategies.

Typically, rain collection systems consist of stand- alone, exterior rain collection tanks located near the building. These tanks can create concealment opportunities and vulnerable areas, especially when they are located within the unobstructed space and/or minimum standoff distance. Consider integrating rainwater collection and storage systems into the architecture of the facility, such as the building facade.

One of the synergistic technologies for achieving water conservation and fire safety is a dry fire hydrant. Dry hydrants are non-pressurized suction pipe systems that are permanently installed in ponds or lakes and use the untreated water, instead of municipal water, to fight fires. Utilized in areas that lack conventional fire protection, areas that cannot handle the large volumes of water due to antiquated systems, or during peak use seasons when there is low water pressure, dry hydrants allow fire departments to be much more efficient by providing close water sources to fire risks. Since dry hydrants are installed below frost line and do not require electricity, they are capable of supplying water in the case of natural disasters such as hurricanes and tornadoes when electricity lines are knocked down, or during extreme cold or hot weather where conventional hydrant pipes can freeze or break. Also, dry fire hydrants help to save precious drinking water and conserve energy by using rainwater that does not need to be processed to be used for fighting fires.

Constructed wetlands, used for wastewater treatment, can be incorporated into perimeter protection strategies to control vehicular and pedestrian access

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[44] http://cptedsecurity.com/cpted_design_guidelines.htm. (accessed 11 April 2013)

Because the opportunity to reduce load and employ energy efficiency measures is dependent on the chosen project site and site design, a site planned for security may not be optimal for energy performance. The installation of onsite power generation and fuel supply for back-up power for increased power reliability may increase noise and development of open space as well as cause habitat disturbance. Also, additional equipment and systems needed to mitigate natural hazards, protect against fires, and defend against terrorist attacks will increase the building's energy load and may affect its energy performance. The roof of covered parking shelters could be used to mount photovoltaic modules to provide quiet onsite power while eliminating the need to use additional open space for power generation.

Commissioning, although not necessarily part of the initial stages of the design process, is important to consider for its contribution to the potential overall energy efficiency of the project. Commissioning is the systematic process of ensuring and documenting that all building systems perform according to specification and design intent, consistent with the owner's operational needs. The goals of commissioning are to improve the building delivery process; to provide a safe and healthy facility; to improve energy performance; to reduce operating costs; to provide operations and maintenance staff orientation and training; and to improve systems documentation. According to the US Department of Energy[45], commissioning can improve new building energy performance by 8% to 30%. The more complex the building type and the more integrated the building systems, the more likely that a building commissioning process will prove valuable. Use commissioning to verify that the project's security, safety and sustainability goals have been achieved.

Integrated Building Automation and Control Systems (BAS) integrate and automate traditionally stand-alone building automation and control systems such as HVAC, fire, lighting, and security systems into one comprehensive system. This enables electronic monitoring and control of air flow, space temperature, system performance, energy conservation, fire alarms, security functions, etc. from a single, centralized location for optimized building operations, energy efficiency, indoor comfort, safety and security. For example, a BAS can be programmed such that a duct sensor can monitor the efficiency of the air flow, but can also detect a

[45] http://www1.eere.energy.gov/femp/pdfs/OM_7.pdf, pg1. (accessed 11 April 2013) Chapter excerpt from O&M bet practices guide, version 3.0. discusses benefits of commissioning of buildings.

contaminant in the ductwork and alarm the facility manager who can then reconfigure the HVAC system in that part of the building, notify the proper officials, and evacuate occupants safely.

The use of renewable energy technologies reduces environmental impacts associated with utility energy production and use such as natural resources destruction, air pollution, and water pollution. They also offer the potential for lower cost, higher service reliability, high power quality, increased energy efficiency, and energy security.

Dangerous glass shards caused by natural hazards, accidents, or explosions can harm building occupants and visitors. Certain window films are designed to help hold shattered glass together, and make the glass stronger, and more resistant to breakage for improved safety and security. In addition, these films can reduce solar heat gain, glare, and fading for energy conservation and occupant comfort.

Identify the security level of the proposed building and prevent unneeded security upgrades that might use more resources and materials than needed. A comprehensive threat assessment, vulnerability assessment, and risk analysis is required to identify the appropriate level of security for the building.

There are some security and safety products that are made of materials with recycled content or other environmentally preferable characteristics. Examples include reinforced concrete site furniture made with slag and recycled content metal fencing. These will require a dedicated effort to track down and can be time and resource consuming, however there has been an effort to develop databases available to the industry and public that identify approved materials. Manufactures are increasingly providing literature on the sustainability and content of their products.

Daylighting can also contribute to the security of a building by shedding light on otherwise dark corners, it does increase the potential for glass hazard caused by natural disasters, accidents, or blast events. Size and locate windows with detonation points in mind. Understanding that extensive damage to conventional glazing can still result since blast pressures will wrap around buildings.[46] Where appropriate, specify blast resistant glazing or window film that can also reject heat and glare. Avoid poor quality and “slap on” exterior

[46] Thomas Telford, *Blast Effects on Buildings* 2nd ed. TT limited: London, 2009. Pg 39

ornamentation, including certain sun control and shading devices that can break away easily. Make every effort to integrate shading and daylighting strategies into the structural design to preclude having to add extra devices. Also, note that the placement of windows and doors to allow for good visibility and surveillance may interfere with daylighting schemes.

Natural ventilation has become an increasingly energy-efficient and attractive method for providing acceptable indoor air quality and maintaining a healthy, comfortable, and productive indoor climate rather than the more prevailing approach of using energy-intensive mechanical ventilation. Power sources are not needed to operate natural ventilation systems, so building occupants can maintain their level of comfort in the event of power shortages or blackouts. On the other hand, natural ventilation systems could bring outside contaminants inside. For critical and high-risk buildings, mechanical ventilation with special filters is recommended to protect against possible CBR agents from entering interior spaces. Although more energy will be used, mechanical ventilation does allow for precise control of humidity, preventing the growth of mold and mildew that could spill onto the floor and contaminate the under-floor air.

Exposure of building occupants to potentially hazardous CBR agents negatively impacts the indoor environment and can pose serious health threats. To help maintain superior indoor air quality and protect people's health, DOAS and dedicated exhaust systems can be installed. DOAS use separate air handlers to condition and deliver the minimum required constant volume of outdoor air. Be sure to protect all outdoor air intakes and locate discharge points away from them.

Air infiltration is an issue in which steps to mitigate are mutually beneficial to both achieving security and sustainable design criteria. In traditional construction, infiltration occurs through gaps and cracks in the building envelope. Excess infiltration of hot humid air can create uncomfortable indoor environments, increase cooling costs and hasten the deterioration of important equipment. Such unintentional infiltration is also a concern for an exterior CBR release at some distance from a building, such as a large-scale attack. Decreasing infiltration improves comfort, saves energy, controls moisture, reduces indoor pollution, and promotes ventilation. Also, tight building construction in combination with building pressurization can be an effective CBR-protection strategy.

### 3.3 Decision Support Matrix

One of the most important focus areas of this project is to develop an integrated design process that takes into consideration all of the required criteria and standards. One of the ways to accomplish this or a product that can be used in the future planning, programming and design phases is a decision support matrix. Refer to Appendix D for a draft of the matrix.

# Part II: DESIGN

# Chapter 4. Process and Implementation

The design phase of this doctorate was a synthesis of the research to produce a conceptual design of a regional component headquarters facility. The design process incorporated the criteria development and design analysis that identified the tradeoffs necessary when considering security and sustainable design requirements. It started with programming and predesign, proceeded to conceptual design development and will end with representations of conceptual design solutions and energy conservation measures that informed the design.

The design intent was to create a building that is responsive to Hawaii's climate and provides a headquarters that is commensurate with the importance and stature of a regional component commander's command and control facility. It showcases a building that epitomizes the Department of Defense and Navy's emphasis on moving away from fossil fuel dependency and all of the political military consequences that have come with it over the decades. The foundation of the energy efficient design aspects of the design was the identification of a diverse and integrated selection of passive strategies. The passive strategies facilitated using low energy active systems and together provided a whole building energy efficient solution that allowed for onsite renewable energy generation that nearly offset overall building energy consumption. Understanding how energy is typically used in buildings and ensuring energy efficiency measures were applied was a keystone to integrating the other design requirements. These passive strategies may or may not be in conflict with the additional security design criteria necessary for this building type. This design project is then a survey of that necessary balance.

The location of the site and influence of existing infrastructure guided much of the security design requirements and minimized substantial additions or alterations to the site. Few site related conflicts existed when balancing security and sustainable design requirements. For example the need to reduce a buildings footprint and reduce open space development, conflicted directly with the security requirement to provide a backup energy source away from the primary energy source. Because of the Makalapa installation site zoning designation and the lack of zoning restrictions, the standoff requirement afforded the ability to provide a backup location inside the perimeter of the security fence and outside of the standoff and unobstructed space limit.  This then facilitated one of the synergies of coupling standoff and unobstructed space requirements with the sustainable objectives to provide undeveloped space and water runoff management areas.

## 4.1 Project Requirements

For this doctoral study, successful project design will balance security and sustainable design and will be 30% more efficient than the ASHRAE 90.1 - 2007 Standard. Several main priorities represent a holistic approach to design.  Optimizing environmental, economic and social concerns is sometimes described as the "triple bottom line" and works to create buildings that eliminate negative impacts on the environment.[47] Additionally, the unique security requirements of a component headquarter facility identifies requirements both to a minimum anti-terrorism standard and to the requirements of the building and command type.  The following list details those requirements that then will be addressed in the design:

- Highly mission capable
- Expandable and flexible
- LEED Gold rating
- Appropriate departmental adjacencies
- Harnessing the suns energy.  Maximizing the amount of energy from solar sources, ideally providing all of the required power for the required mechanical cooling of vital systems, lighting and other active systems.
- Minimizing solar heat gain
- Reducing the cooling load
- Maximizing passive and natural cooling.

[47] Triple bottom line refers to people, planet and profit. First coined in 1994 by John Elkington, the founder of a British consultancy called SustainAbility

- Control humidity.
- Minimizing energy load of electrical lighting.
- Maximizing natural lighting.
- Maximizing HVAC energy efficiency
- Minimizing HVAC size
- Maximizing the feel of a natural surrounding with landscaping and captured views
- Providing interior public open spaces
- Provide service, retail and recreation areas
- Clustering heavy energy users to maximize efficiency of mechanical systems.
- Appropriate zoning use plan and respective control systems
- Provide minimum AT security design standards
- Express structure and systems in progressive collapse and blast resistant design
- Maximize use and visibility of high end cutting edge energy efficiency technologies.
- Biophilic elements in enclosed areas devoid of views and natural light
- Target Energy Use Intensity (EUI) of 50 kBtu/ft$^2$/yr

### 4.1.1 COMPACFLT HQ Security Design Criteria

The COMPACFLT headquarter security design criteria were developed using the DoD's security criteria development process.[48] To summarize; COMPACFLT staff and the Makalapa Critical Infrastructure were identified as the two PACFLT Asset Categories that were the most likely targets of an aggressor action. The PACFLT staff is further broken down into mission

[48] Refer to Appendix C for more detailed information on the process and results.

essential personnel and the general population, with mission essential personnel at the highest risk. Next Terrorists, both international and domestic, as well as Saboteurs were identified as the most likely aggressors. The most likely aggressor tactics were identified as Hand Delivered Devices, Forced Entry and Visual Surveillance, with a Design Basis Threat of Medium or greater. Visual Surveillance had the highest Design Basis Threat at High. The Criteria analysis determined that based on the fact that the COMPACFLT HQ Complex is in the United States, on an existing well protected and established military installation with numerous other military facilities nearby, that it is not a high threat environment. Due to the complex's proximity and natural defenses, reasonable standoffs are already in place with the exception of the northern perimeter fence line which allows some visual access. With several siting options with similar defensible characteristics and all having access to the same established infrastructure; access control, drive up areas, surveillance, security personnel, the security design requirements for the most part allow us to follow the DoD's Minimum Antiterrorism Design Standards. There is however, a requirement to provide enhanced security design based on the function and importance as a command and control center in the pacific area of responsibility. Because of the level of classification of that requirement and the lack of access to it, we will assume for this project that we are bound by the criteria developed above and minimum standards everywhere else.

### 4.1.2 U.S. Navy LEED Criteria

The US Navy has promulgated that all new construction be built to LEED Gold standard whenever possible, replacing the previous requirement to attain LEED Silver.[49] Based on previous experience with LEED, in order to attain LEED Gold at a minimum, it will be critical to address energy conservation and usage as that category has the greatest potential to maximize LEED credits. Additionally, opportunities exist to attain credits under the Innovation in Design and Regional Priorities categories. By satisfying the standards of Regional Priorities, you in effect, double the credits in the original categories. Cost is an important element of attaining LEED credits based on project budgetary constraints but will not be considered in this project in

[49] http://www.wbdg.org/ccb/NAVFAC/ECB/ecb_2011_01.pdf. NAVFAC Energy Construction bulletin, 2011, 01. (accessed 11 April 2013)

order to place the focus on the strategies to attain the credits, and addressing, deconflicting and finding synergies with security design requirements.

## 4.2 Program

### 4.2.1 Occupancy Category

This headquarters building falls under Occupancy Category IV[50], Buildings and other structures designed as essential facilities. The COMPACFLT Headquarters can be described as "Buildings and other structures not included in Category V, having DoD mission-essential command, control, primary communications, data handling, and intelligence functions that are not duplicated at geographically separate locations as designated by the using agency", where category V buildings are considered National Strategic Assets with distinct criteria that the COMPACFLT headquarters does not meet.

### 4.2.2 Organization

A typical Navy component command will have 8-10 departments. Those include:

- N00 The Commander
- N0 Special staff (in support of the commander)
- N1 Manpower and Personnel
- N2 Intelligence
- N3 Operations
- N4 Logistics
- N5 Plans
- N6 Command, Control, Communications, Computers and Intelligence (C4I)
- N7 Training and Readiness

[50] UFC 3-301-01 Structural Engineering, pg 5, table 2-2.

- N8 Requirements

The Pacific Fleet Commander has chosen to organize his staff in the following way:

- N00 The Commander
- N0 Special Staff
- N1 Total Fleet Force Manpower and Personnel
- N2/N39 Intelligence/Information Operations
- N3/N7 Operations, Training and Readiness
- N4 Logistics, Fleet Supply and Ordnance
- N43 Fleet Maintenance
- N5/N8 Plans, Policies and Requirements
- N6 C4I

Table 8 below summarizes floor areas and is rounded up to accommodate circulation and various other spatial and service elements. The net floor area is the area needed for the functional spaces, whereas the gross floor area of the building is measures from the exterior wall edges. Circulation area is the area required to support the functional areas. Refer to Appendix A for more detailed descriptions of each department.

**Table 8. Directorate projected floor areas.**

| **Departments and Directorates** | **Estimated Floor area 218 $ft^2$/person** | **Floor area (rounded up)** |
|---|---|---|
| N00/Executive | 3992 | 5,000 |
| N0/Special Staff | 4668 | 5,000 |
| N1 | 2724 | 5,000 |
| N2/39 | 13,760 | 15,000 |
| N3/7 | 8308 | 10,000 |
| N4 | 4532 | 5,000 |
| N5/8 | 6420 | 10,000 |
| N6 | 4180 | 5,000 |
| Auxiliary/Miscellaneous | 70,100 | 75,000 |
| | | **Total: 125,000 $ft^2$** |

***Source*: COMPACFLT website.**

### 4.2.3 Space Types

**Table 9. Space types**

| Space | Space Type | Schedule/occupancy | Description |
|---|---|---|---|
| Atrium | public space | Frequent transient occupancy during normal working hours, less outside of working hours | Entry atrium, high ceilings, natural ventilation with stack effect. Transit to lobby. |
| Auditorium | conference | Low occupancy | 2 story height, stage, presentations, large screen projector |
| Data Center | building support | Medium transient occupancy. 24/7. | High cooling demand, med occupancy, dedicated HVAC and ventilation, hardened |
| Command center | Office - Enclosed | 24/7<br>High during normal working hours, medium all other times | Dedicated HVAC, ventilation and power source. Must be standalone operation. Hardened and close to CDR suite. Centrally located. |
| Conference rooms | Conference | various | Various sizes and occupancy durations, enclosed spaces some with soundproofed glass walls |
| Food Service | Building support | Normal working hours only. No weekends | Refrigeration, kitchens, cooking |
| General storage | Building support | Low | Shell space |
| Retail | Building support | Normal working hours. High-staff, med- patrons. No weekends | Retail type varies |
| Library | Building support | Normal working hours, high –staff, low-patrons. No weekends | |
| Loading dock/receiving | Building support | Normal working hours, low on weekends | Various loading requirements and equipment sizes |
| Lobby | Public space | Frequent transient occupancy during normal working hours and weekends | Visitor waiting |
| Mail center | Building support | 10-3 for patrons, staffed during normal working hours. Partial staffing on Saturday. | |
| Office – enclosed | Office enclosed | Normal working hours full staffing and partial outside of working hours | Mostly located on north wall and in core |
| Office – open bay | Office open bay | Normal working hours full staffing and partial outside of normal working hours | Mostly located on south wall to facilitate daylighting |
| Parking structure | Building support/outside | Normal working hours full and partial outside of normal working hours | Detached from main building, safety, security lighting requirements. Covered with PV canopies and charging stations. Two + decks |
| Physical fitness center | Building support | Staffed during normal working hours only. | Small staff and includes locker rooms and separate fitness classrooms |
| Plaza | Outside | Normal working hours | Safety and security lighting |
| Private toilets | Building support | Normal working hours and partial outside of normal working hours | Individual toilets for executives access only from office |
| Public toilet | Building support | Same as office space | Occupancy sensors, low flow fixtures, sensors. |
| Mechanical/electrical | Building support | Low occupancy, | little to no HVAC requirement |
| Circulation/corridors | Public space | High | Safety and security lighting, wayfinding |

4.2.4 Occupancy Schedules

COMPACFLT occupancy patterns slightly differ from standard civilian occupancy schedules due to the military culture of getting up early to workout and exercise and depart later due to time differences across the area of responsibility, and the necessity to collaborate with units as distant as Mideast and Washington, DC. The command center is manned around the clock by a full “battlestaff” and is augmented slightly during the day and during contingencies. Normal weekday work hours for military personnel are usually from 7:30 AM to 5:30 PM with a 1 hour lunch break from between 11:00 AM to 1:00 PM. Normal weekday work hours for civilian personnel vary according to the Federal or Contractor policy to which the individual is associated, but it is generally between 8-9:00 AM to 4-5:00 PM. Military personnel quite frequently work on weekends, usually on Saturday or Sunday morning or afternoon. This again, is mainly due to the need to collaborate with units in other time zones.

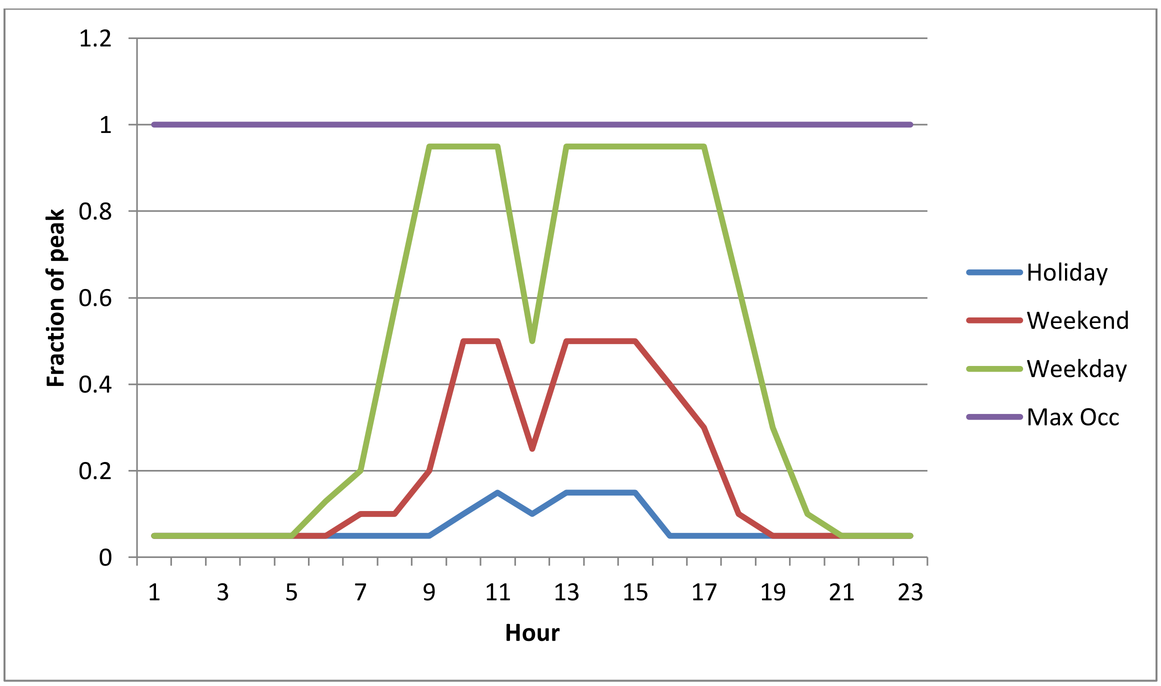



**Figure 40. Predicted occupancy schedule for COMPACFLT HQ.**

### 4.2.5 Program Data

**Table 10. Program data**

| Program Data | |
|---|---|
| Occupants | 600 |
| Occupied hours per week (main buildings) | 65 |
| Visitors per week | 150 |
| Occupied hours per week (command center) | 168 |
| Main program space types<br>• Open office<br>• Private office<br>• Conference<br>• Common areas<br>• Data/IT space<br>• Command center<br>• Building support<br>• Retail/Restaurant | |

## 4.3 Site

In the initial phases of the design and after establishment of initial project requirements a search for site opportunities and risk was engaged. This was an important research and assessment activity, which would supply the design process with relevant design data and lay the foundation for achieving high performance and secure design. For energy design, conditions include an understanding of program and occupancy, climate, site resources and constraints and massing and orientation.


**Figure 41. Circulation and parking on site. *Source*: Google Earth**

4.3.1 Site Analysis and Assessment

Although the complex is near the harbor it is located in an extinct volcanic crater which makes the topography hilly and varied with several amphitheater like spaces and knolls. The complex is framed by the H1 Freeway to the east, Kamehameha Highway to the west, Halawa Stream to the north and Radford Drive to the south.

The base can be accessed one of three ways; the main gate off of the Kamehameha Highway ( open 24 hrs.), the back gate off of Salt Lake Blvd (morning and afternoon hours only) and the Radford drive entrance (special access only). Several roads service the complex and all are in good condition with no alterations required. A large amount of parking is available and all are open to elements.

The complex is approx. 160 acres. Several identified sites are of ample size (approx. 3-5 acres).It has a panoramic view of the Koolau mountains to the east and two sites have potential vies of The Waianae Range and the Pearl Harbor Navy piers.

The Honolulu land Use Ordinance identifies the Makalapa site as zoned F-1 and P-1. This

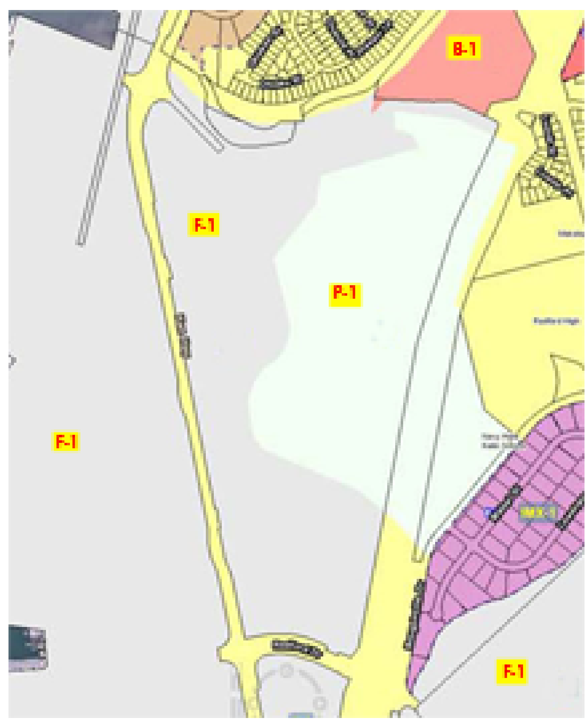



**Figure 42. Makalapa zoning. *Source*: Honolulu DPP**

designation basically allows the Navy to do whatever it deems necessary on the site for its mission accomplishment.

*"The purpose of creating the F-1 military and federal preservation district is to identify areas in military or federal government use and to permit the full range of military or federal government activities."*

*"Within the P-1 restricted preservation district, all uses, structures and development standards shall be governed by the appropriate state agencies."*

*"Within an F-1 military and federal preservation district, all military and federal uses and structures shall be permitted."*[51]

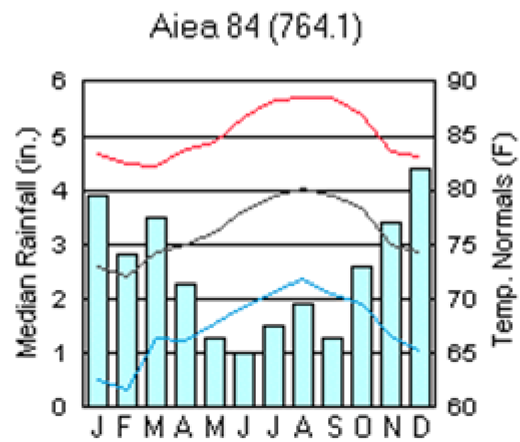



**Figure 43. Aiea weather station data. *Source*: City-data.com**

The complex has many large mature trees including Monkey pod, Ficus, and Kukui that provide much shade for several of the existing buildings. The central part of the complex is where most of the parking is and little vegetation occurs there. It would be advantageous to take advantage of the mature trees to possibly put one or several at the heart of a courtyard design or along the west/south perimeter of the design.

Because consolidation is one of the aims of the design project, all current structures are fair game with the exception of those that are on Historical Register or are otherwise off limits. This includes the original HQ building.

The Makalapa complex is in the lower leeward mountain slopes sub region and has more rainfall than the leeward lowlands, but less than the windward side at the same level.

The Aiea weather station is the closest, about 1 mile away. . Because the site has varied topography the winds can be affected by the steep slope to the NE and north of the complex as well as along the outer basin of the crater. The winds tend to lessen and stagnate in the interior

[51] City and County of Honolulu Land Use Ordinance (LUO)

of the crater. Generally, the winds are stronger at about noontime and die down toward the evening.

### 4.3.2 Site Selection

Based on the analysis of the overall Makalapa complex and with due consideration to security and sustainable design opportunities and constraints, three viable sites were chosen for further analysis. Each has unique characteristics in relation to the others and the complex as a whole. In addition to the security and sustainable design criteria used to analyze and select the appropriate site, the level of prominence of the site and opportunities for a grand approach shall also be considered.


**Figure 44. Site options. *Source*: Google Earth**

Site A is located adjacent to the main gate of the Makalapa Complex in the northwest corner and currently has one structure on it that houses both Joint Intelligence Center Pacific and the majority of the Operations Department. This site's main attributes are; that it sits in a prominent location along the northwest perimeter of the complex, it lies in a depression outside of the rim of the Makalapa crater providing shade in the mornings and a natural rear barrier to line of sight. Because it is close to the main gate, it also has the best access to public transportation and the fence line provides an immediate barrier and intermediate defense zone and standoff. The drawbacks to the site are similar to the attributes, because of its proximity to the perimeter and fence line it is easy to observe activities around the headquarters. Additionally, even though a standoff well within standards is afforded, because it is in direct line of sight of the roadway it is at risk to Direct Fire Weapons. Although parking is available in other parts of the complex, the current parking will need to be relocated. This is the smallest of the three site options, which also limits open space and water management systems opportunities and any alternative energy systems will need to be solely BIPV and roof mounted or otherwise located at a distance to the site. Lastly, because of the site's small size, it limits building options to a small to medium footprint. This site is rated third of the three options.

**Figure 45. Site A.** ***Source*****: Google Earth**

Site B is located in the north central area of the Makalapa complex. It is situated below the west rim of the crater. On the rim are the senior officer living quarters and to the north, east and south are existing parking areas for the complex. This site has little shade, and although late in the day it gets some shade, it is a local hot spot most of the day with little wind inside of the crater. Because it is the most central site, it is the most protected and out of view which is an attribute. It is also adjacent to a large swath of open area that will facilitate standoff and opportunities for a PV array field. It is the largest site of the three assuming your willingness to trade parking for building footprint. There is ample room for an adjacent parking structure to make up for the lost parking. One of the main drawbacks is its lack of prominence in relation to the overall site. It would also front the Bachelors Officers Quarters and affect its access to parking and create some additional noise. Overall this site is ranked two of the three options.

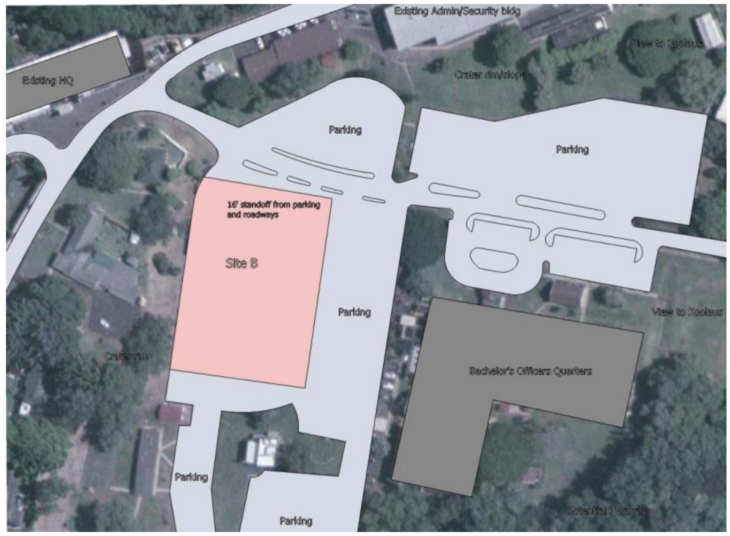


**Figure 46. Site B. *Source*: Google Earth**

Site C is situated prominently on the second highest point in Makalapa, in the northeast corner. It borders the northern perimeter fence line that sits high above the Halawa Stream beyond providing a natural and inaccessible barrier. Despite it sitting up on the north rim of the crater it does not afford ready vantage points for any potential aggressors. The site is almost as large as the second site and is also surrounded by parking and has several existing buildings, however, each houses a PACFLT component and they will relocate to the new building if displaced. The location has the most favorable wind conditions, getting the full trades coming down from the Koolaus. With even a single story building, the views are the best of the three and the site provides the best opportunity for an impressive approach and entrance to the HQ compound. With three to four floors the views are vastly improved and allow for the higher floors to see the two mountain ranges, the ocean or both. The

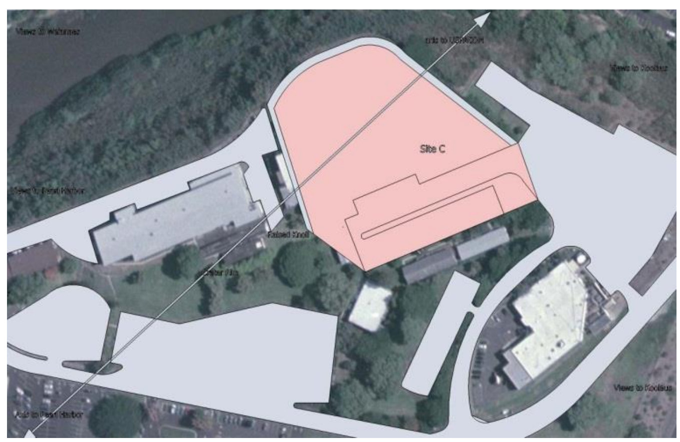


**Figure 47. Site C. *Source*: Google Earth**

commander's suite has the potential for spectacular views. This site based on achieving good ratings in all of the criteria is considered the best of the three.

### 4.3.3 Selected Site Criteria Assessment

The selected site provided the best opportunities to address all minimum security criteria and provided the most optimum location to apply the most impactful sustainable measures. Figure 48 provides important standoff security criteria determinants for the selected site. The site provides ample space for the calculated program area with several massing and orientation options available. The red area represents the extent of the required standoff and unobstructed space distances required which provide a maximum footprint available. The footprint assumes the buildings that already occupy the area are demolished as these house command departments that can be consolidated into the new building. Existing buildings that house non-affiliated tenant units will remain. Two existing parking areas are identified as potential parking structures that will serve to consolidate parking and in the case of the northeast parking area, will provide a buffer to the visual and defensive buffer to the perimeter.

The perimeter fence immediately north of the primary controlled access route has a steeply sloped and heavily vegetated zone just beyond it that runs down to the Halawa stream which provides a natural terrain barrier and complicates both visual surveillance and potential targeting, two aggressor tactics that are determined to be most likely.

The existing circulation infrastructure will provide three separate access routes and may require slight improvement and enhancement. Associated with the access routes, are drive up drop off areas. These areas are permitted for certain facilities and allow for a closer standoff distance. In the case of the headquarters, because of the nature of the command and the frequency and necessity to drive senior officers and foreign officials up to the entry requires these possible areas. Depending on the ultimate configuration there are several potential locations but those illustrated are the most likely.

The selected site facilitates attainment of both minimum security standards and required LEED criteria. The Makalapa complex has a large amount of open green space that can be leveraged for addressing heat island effects, water management and renewable energy generation.

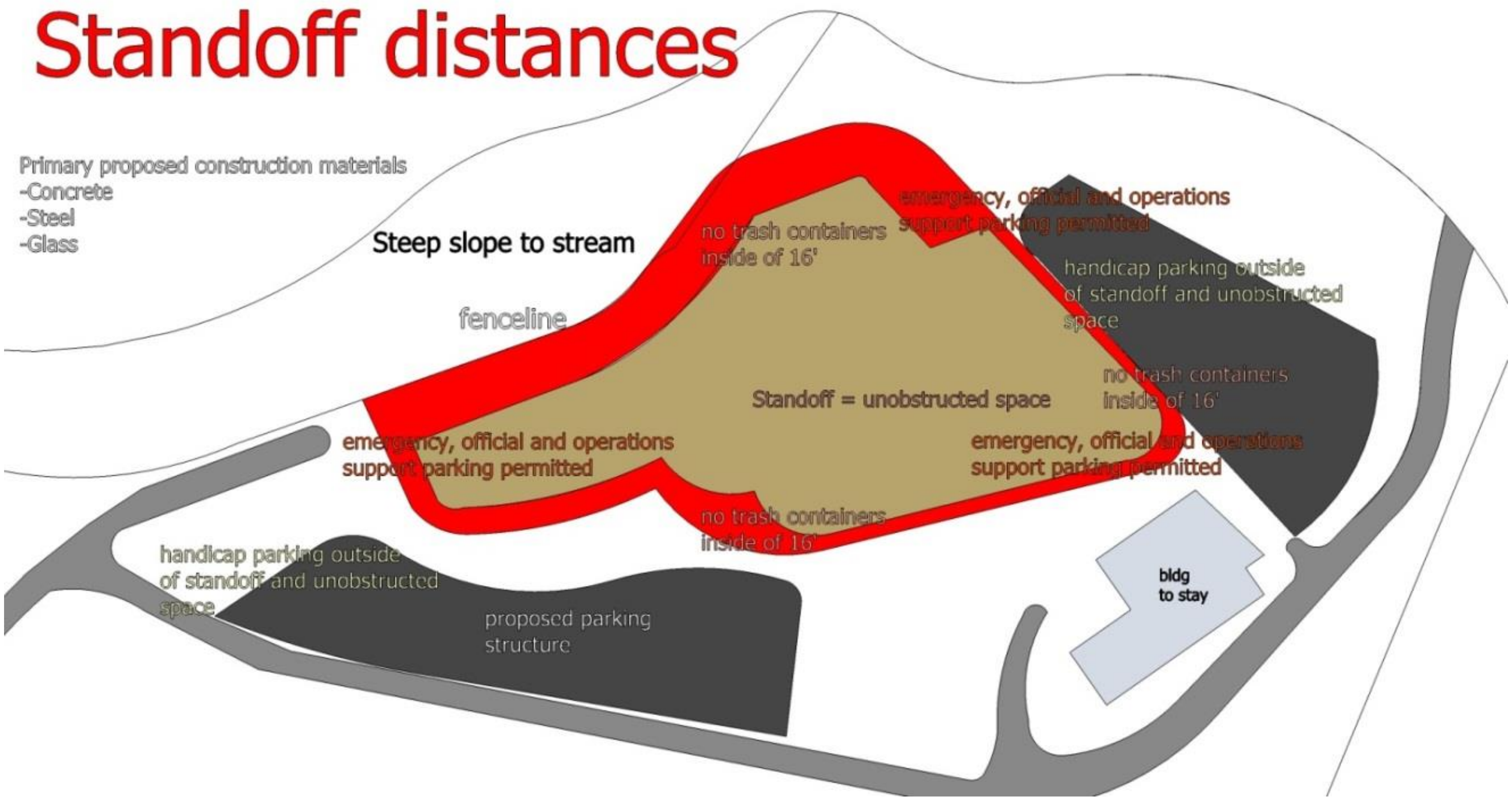



**Figure 48. Area provides potential access to the site and illustrates a primary controlled access route, a secondary interior access route that also serves a tenant unit and a third service access route that could also serve any possible parking structure in that area**

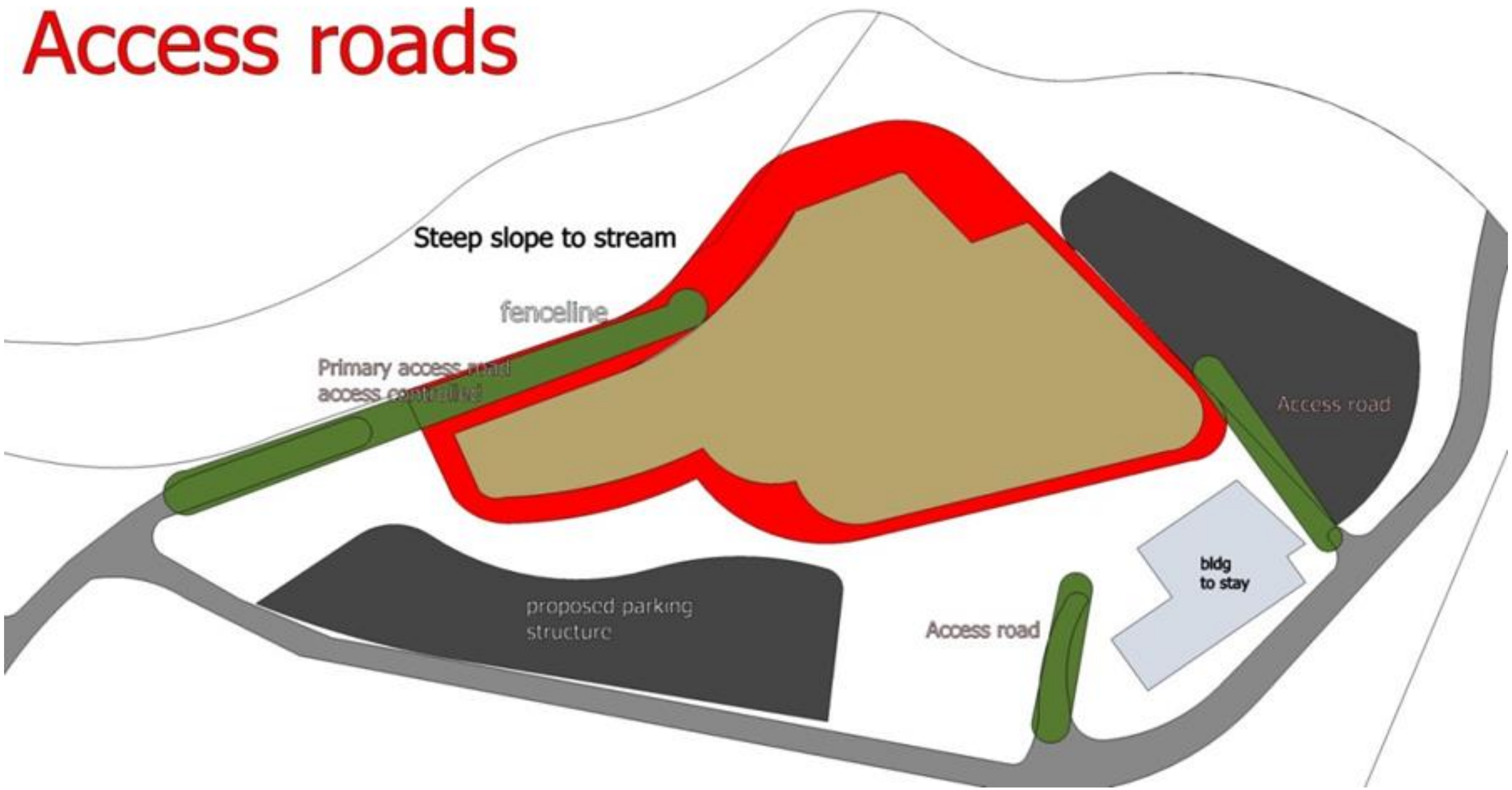


Figure 49. Access road locations and surrounding circulation.

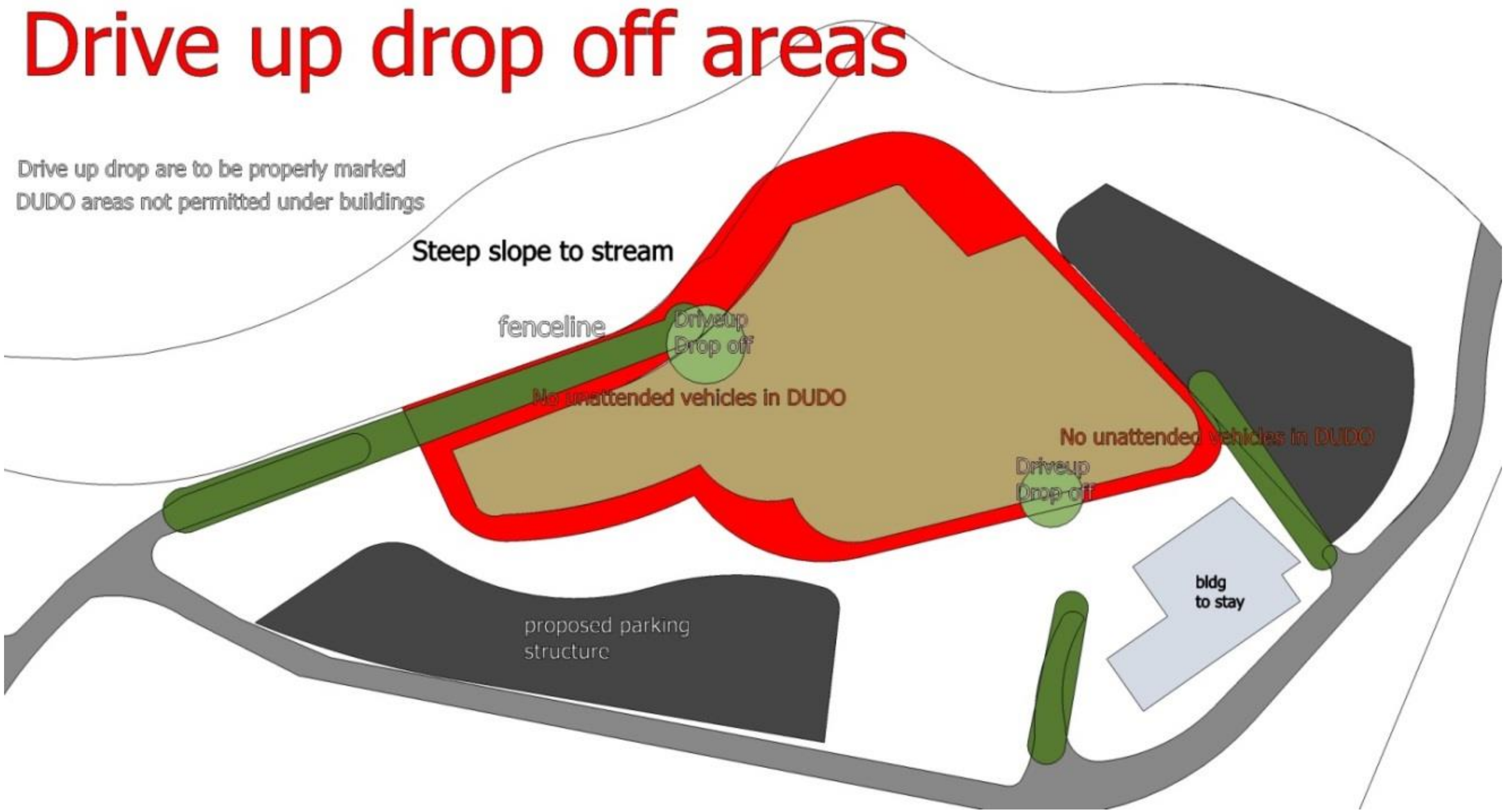



**Figure 50. Area provides an idea of potential areas for drive up and drop.**

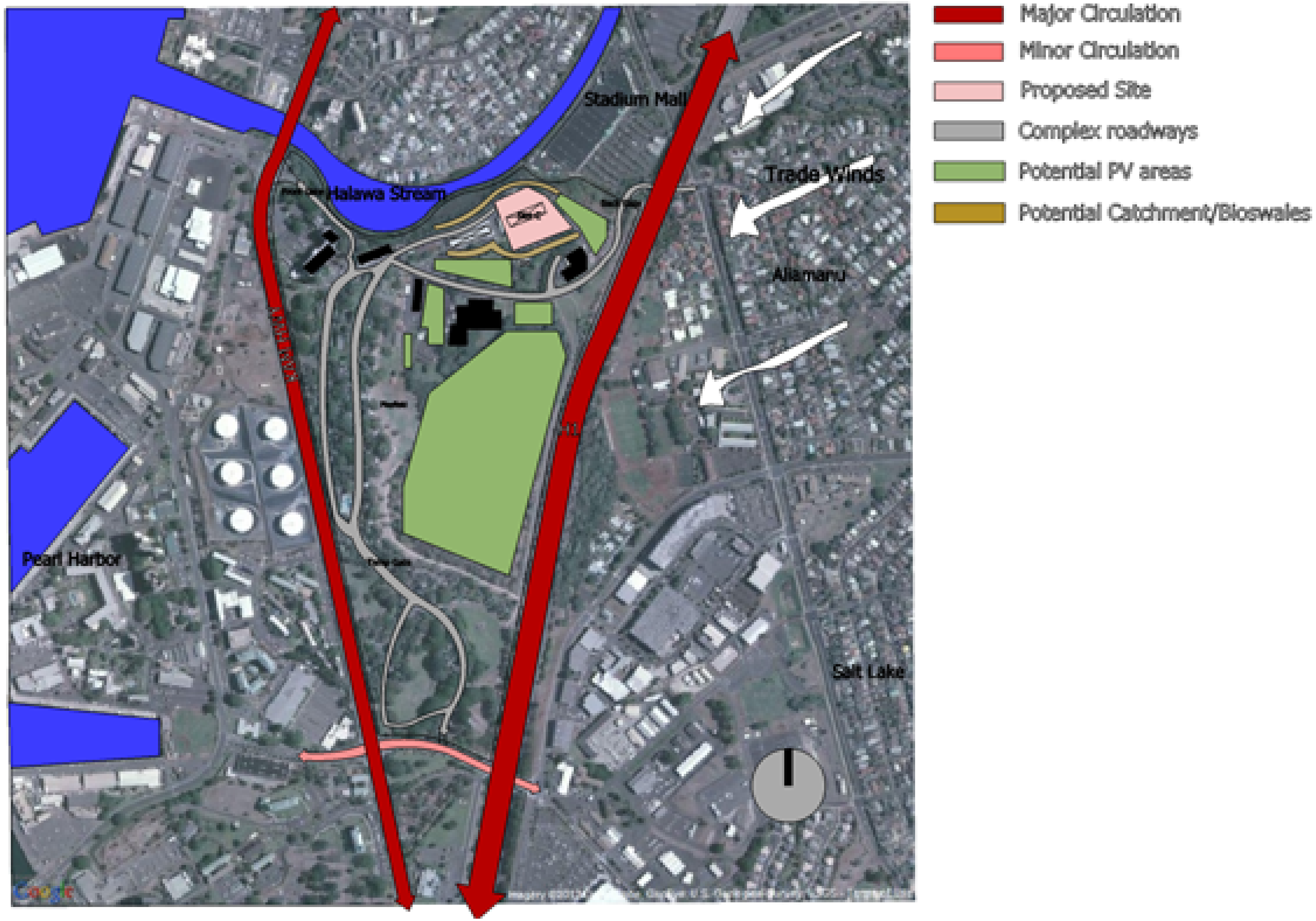



Figure 51. Selected site location and adjacencies.

**Table 11. SIte selection criteria.**

| Security Minimum Standards – Site | LEED Standards – Site Selection |
|---|---|
| Standard 1: Standoff distance<br>Site located at perimeter of complex<br>Sits on rim of makalapa crater<br>Halawa Stream and steep embankment to north as natural barrier<br>Ample room to move footprint around site as needed | SS Cr 1 Site selection – previously developed<br>SS Cr 2 Demo existing bldg.<br>SS Cr 3 unknown level of contamination |
| Standard 2: Unobstructed space<br>Same as standoff or 33' whichever is longer<br>No parking in space | SS Cr 4.1 Alt Transportation public bus within ¼ mile<br>SS Cr 4.2 Alt Trans. Ample room for bike parking. Cannot be in building in unobstructed space<br>SS Cr 4.3 low emit parking in lot to be incorporated<br>SS Cr 4.4 now new parking area created, use existing and build parking structure |
| Standard 3: Drive up Drop off<br>3 existing access roads and ample room and standoff to accommodate | SS Cr 5.1 Site Development surrounding preservation area can be enhanced with wetlands water management system<br>SS Cr 5.2 ample space to counter footprint with natural habitat |
| Standard 4: Access roads<br>3 access roads and two access controlled gates<br>Adjacent to rear manned gate | SS Cr 6.1 Storm water Quantity control bioswales downslope and water catchment in interior courtyard basins<br>SS Cr 6.2 Storm water Quality Control |
| Standard 5: Parking beneath buildings or on rooftops<br>Several adjacent areas outside of standoff away from building that can accommodate parking or parking structure | SS Cr 7.1 Heat Island Effect non-roof can landscape with low plantings close to building perimeter and walkways can be pervious paving<br>SS Cr 7.2Heat Island roof - light colored cool roofing |
| | SS Cr 8 Light Pollution reduction – downlights vs. uplights<br>Campus lighting can make these points a challenge |
| **Analysis/Assessment Criteria:**<br>Prominent raised location<br>Allows more impressive views for commander<br>Largest available area without displacing agencies slated to occupy new building<br>At North Perimeter fence increasing risk, however terrain at rear is inaccessible with steep slope and stream<br>Adds additional aggressor tactic with less reaction time – waterborne assault – but terrain mitigates<br>Existing access roads can be leveraged<br>Best location to include parking structure adjacent to it<br>Parking structure location can provide both visual screen and intermediate explosive impact screen outside of standoff and unobstructed space<br>Site has full LEED potential assuming funding and permission<br>Basically same tradeoffs and synergies available as other two site options | |

***Source*: UFC 4-010-01 DoD Minimum AntiTerrorism Stanards for Buildings and LEED NC.**

4.4 Structure

Decisions on the buildings structural alternatives were centered on providing as open an interior space as possible to maximize passive design strategies, while still providing the progressive collapse, blast resistance and CBR protection required.   The alternatives included an all concrete system and a combination of precast exterior panels and a concrete and steel interior system of concrete columns and steel trusses. The all concrete structural system was deemed the best based on the ability to provide the openness and the structural system that supported the security design criteria.  The system consisted of site cast reinforced and post tensioned concrete columns and one way concrete slab with slab bands. The skin would be primarily insulated concrete precast sandwich panels. This system would be based on 32’ bays, with columns spanned by the slab beams, spaced 32’ on center along the long axis of the building.

**Figure 52. Building section showing open bay and enclosed office area created by structural elements. *Source*: SketchUp**

The north wing would be a two floor wing and the south, three floors, with a building support connector space connecting the two.  The Command Center,  would be a double floor height space of the south wing and would have walls of reinforced site cast concrete for blast protection and would aid in minimizing the need to seal the space for CBR hazard protection. Progressive collapse, seismic and direct fire mitigation design criteria call for Tie Forces to mechanically tie the building together. Three horizontal tie systems must be provided; Longitudinal, Transverse, and Peripheral. We can use the floor and roof systems to provide the longitudinal, transverse and peripheral tie forces and as an alternate, use structural members.

Vertical ties are provided by the columns and any load bearing walls used and will be tied continuously from the foundation to the roof level.

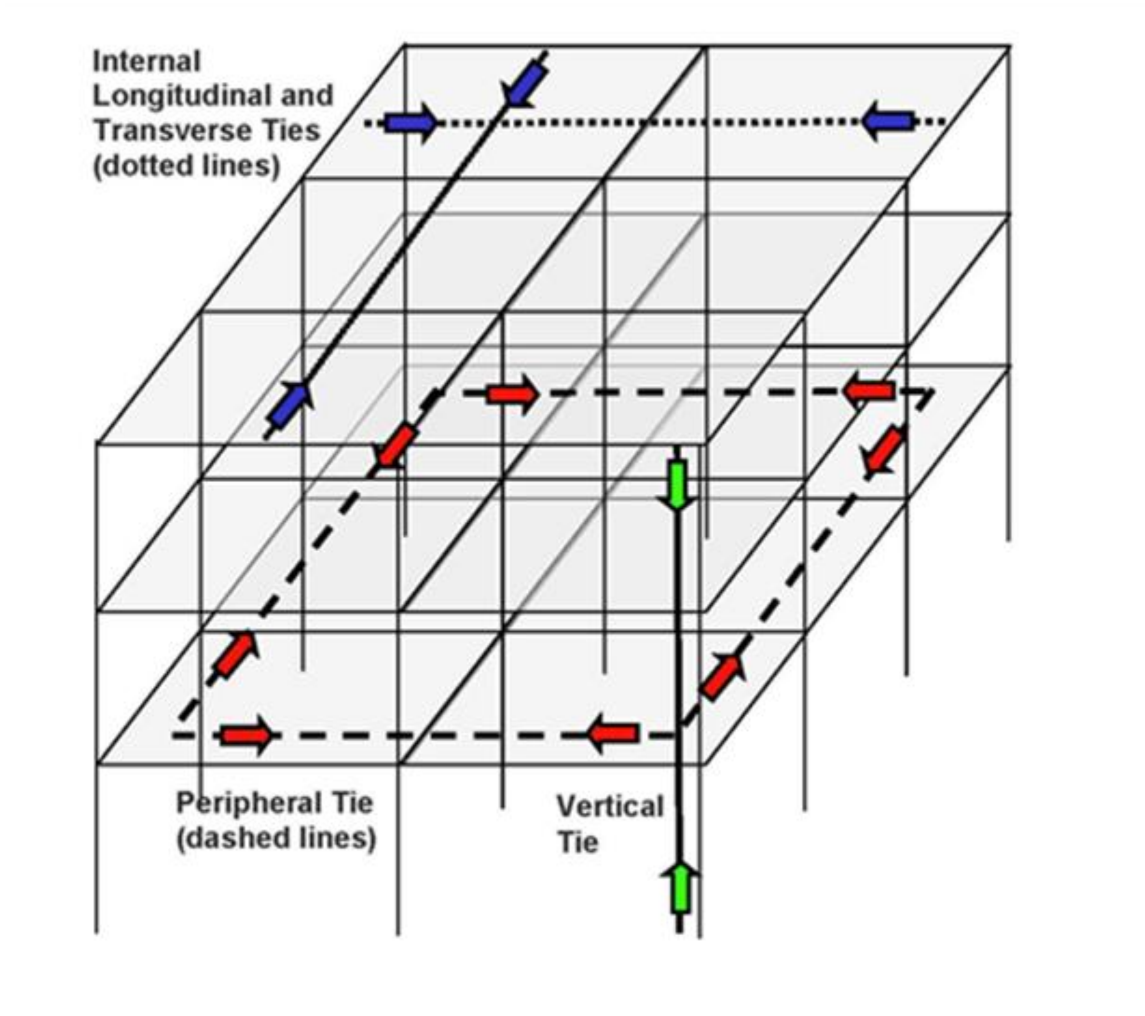



**Figure 53. Progressive collapse design. Required tie forces include Longitudinal and transverse ties (blue arrows), peripheral ties (red arrows), and vertical ties (green arrows). *Source*: UFC 4-023-03 *Design to Resist Progressive Collapse.***

This structural system layout more than met the daylighting goals. The slab bands provided the support without the need for longitudinal girder spanning beams that would have adversely affected daylight reflection and penetration off the ceiling.

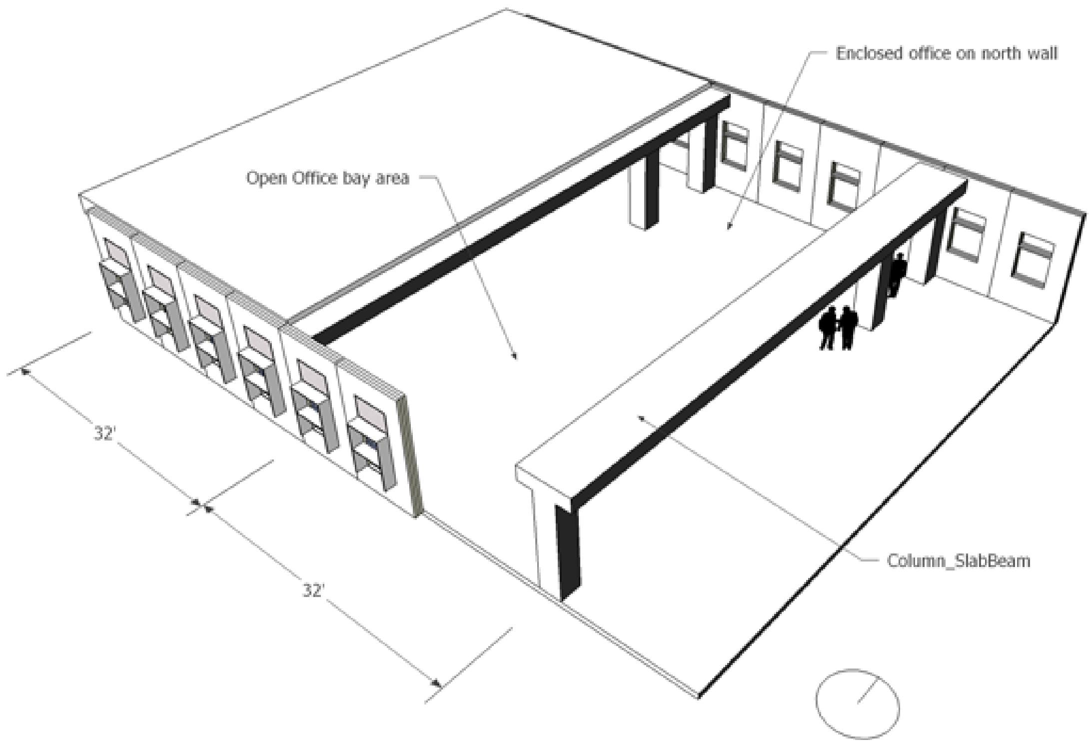



**Figure 54. Structural system includes concrete columns and slab bands, with insulated, reinforced precast sandwich panels on exterior walls. *Source*: SketchUp**

The smooth one way slab ceiling can now either be painted a light color or a light colored acoustical panel can be attached. This system also allows for a deeper plenum space for mechanical, electrical and fire safety systems. Lastly with an exposed underside of the slab, a core cooling system can now be an option when selecting an HVAC system later in the design process. A poured concrete roof will complete the structural system, allowing for either an insulation layer and light colored surface to be installed or a green roof with the option of attaching a photovoltaic array.

## 4.5 Passive Design

Critical to providing a highly energy efficient design, is to leverage passive design strategies that significantly lower building loads. During this early stage, we will identify optimum massing and configuration. Decisions on massing and orientation have largely been considered when looking at the site and what attributes and constraints were presented. The relative footprint that was considered must now be more refined in order to optimize the leveraging of sun, wind and site terrain for both sustainable and security considerations. Specifically, optimizing green space, minimizing heat gain, whether direct or radiated from heat islands, maximizing solar renewable energy potential and considering standoff, approaches, surveillance areas and security vulnerabilities that might inadvertently result. Another important element of the intent is for the design to reflect seasonal variations in solar intensity

#### 4.5.1 Massing, Orientation and Site layout

Because the chosen site is on an exposed rim above the Makalapa crater and due to security requirements, little to no shade trees or shading elements exist in the immediate area. The site area is large enough to accommodate any building orientation. Use of the Sun Path Diagram and Optimum Orientation diagram indicate that an approximately east /west building long axis is optimal. Building massing on the site called for either a long narrow building or one that resembled letters of the alphabet[52] which would facilitate daylighting potential and reduce heat gain on self-shaded walls.

The selected site has the advantage of being relatively flat and in a prominent location. It also has established infrastructure that will need little augmentation. The existing main building will be razed and two adjacent buildings housing tenant commands will be retained. Because this site is at the northeastern point of the Makalapa complex and backs up to the rear perimeter, standoff, as a result will be greater than on the east, south and west sides of the site. The initial conceptual footprint provided ample open space to accommodate this standoff requirement as well as the unobscured area requirement. Because of the Level of Protection required, addressing lines of sight directly into the building was a high priority. Due to its location along the perimeter, limited vantage points existed on the northeast quadrant outside the fence line but from a distance. This could be addressed with screening, either natural or manmade. Because there was a need to augment parking due to the loss of some parking area and there exists a requirement to either not add parking or reduce it, adding a parking structure

[52]The Department of Energy's Advanced Energy Design Guide for Small/Medium sized buildings., describes the ideal bldg. shape as resembling the letters, H, L or U, which optimizes daylighting potential by reducing floor plate depth and contributes to self-shading, thus potentially reducing heat gain.


**Figure 55. Site massing and configuration studies.** ***Source*****: Google Earth**

over existing open parking area was a good solution. The amount of parking ideally would also free up open space below the downslope, south and east of the building. An integral parking cover/PV system would augment the planned PV array field, roof mounted and possible BIPV systems. Additionally open parking areas will either be repaved if needed due to age with pervious paving or light colored asphalt concrete or incorporate a median consisting of bioswales in the large swaths of asphalt paved parking. The main synergy attained is also the most obvious and that is leveraging the sustainable requirements of capturing open space, reducing heat island causing elements and managing storm water by providing natural filtering habitat with the security requirement of open space to provide standoff, unobstructed space and electronic surveillance in the areas immediately surrounding the building and the interstitial spaces between the building cluster. Other synergies attained were reducing the necessary parking footprint with a parking structure that serves as a visual and defensive screen, adding naturally landscaped berms/barriers at previously developed (pavement or bldg.) areas and key points around the building cluster for vehicle barriers and delaying mechanisms.

Several options were available for circulation around the site which also provided four main entry options. It was determined that the best entry point culminated from the shortest distance from the main gate, but allowed for a flag corridor and roundabout on the northwest side of the structure. A drive up and drop off area was provided in two main locations and access control was attained through visual and physical barriers along the approach corridor.

Three distinctly different preliminary massings and configurations were analyzed based on site attributes, climate and program requirements. A 64' building depth would provide 100% daylighting, a three wing and two wing arrangement with a connecting service corridor and single building with a double loaded configuration with service/closed office core and open bay office areas at the perimeter were considered. (figs X-X) Orientation of all three configurations was along the same axis. (E/W)

**Figure 56. Three massing and configuration options: *a*. single building double width; *b*. 2 wings with connector space; *c*. 3 wings with connector space. *Source*: Google Earth**

The arrangement of the building complex accommodated several criteria, placing the main tenants of each building in proximity to departments that they deal with most. For instance the Operations, Training and Readiness division, which operates the Command Center works most closely with the intelligence division and the Commander. Therefore the operations division and Command Center was located in the largest building in the interior of the cluster. The Administration and Personnel division is located at the perimeter and is the first building you enter as this is where access control and the security functions exist. The Logistics division works closely with all of the other functions, but is located at the other side of the cluster. The three main organizational functions, operations, plans and intelligence are arrayed close in proximity to the command center.

A south facing orientation optimizes daylighting based on the proposed building depth. Breaking out the basic important operating functions of the building further facilitated placement of occupancies and attainment of the following program requirements:

- Location and Orientation of building cluster to maximize solar access for renewables, take advantage of trade winds for outdoor spaces, mitigate solar heat gain, enhance daylighting potential and mitigate glare
- High Vantage point (high ground more defensible)
- High ground creates oblique angle for direct fire weapons
- Shade provided by adjacent buildings, large shade trees outside of unobstructed space (33')
- Complicate Visual Surveillance with perimeter fence, berms and parking garage
- Direct Fire Protection by having buildings oriented inward with mass walls at perimeter of building walls, while walls facing into center of building cluster has more glazing for daylighting and visual comfort
- Space inside cluster/between bldgs. provides usable green space and potential for bioswales/water catchment areas.
- Green roofs or high ground soil at lower perimeter walls provides insulation and protective barrier
- Address heat island with green space, lighter colored concrete, bldgs. shading bldgs.
- Larger site affords more standoff and unobstructed space and surveillance of grounds

A slight adjustment of the orientation of the south wing of the selected configuration produced the final massing and orientation of the headquarters in fig. 57 This took better advantage of the overall site dimensions and provided and interior open space and natural views for those on lower floors facing inward. Shading studies later in this chapter support this slight adjustment and show little adverse effect.

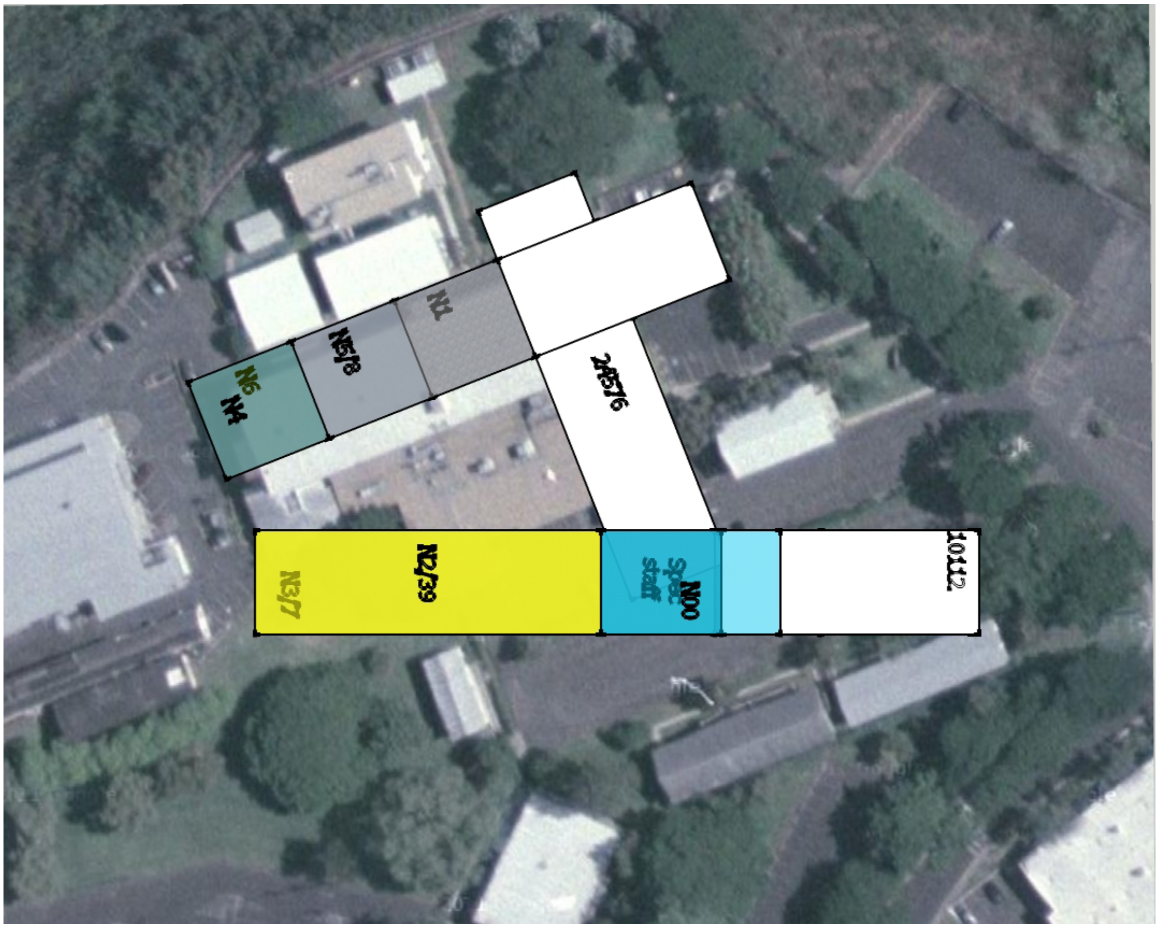



**Figure 57. Final conceptual massing and configuration.** ***Source*** **Google Earth**

### 4.5.2 Thermal Zoning

Zoning of the building program required identifying separate zones based on building operating function. The five basic functions include; open office bays, enclosed office areas, conference areas, building support, and public space. These categories are based on occupancy such that open and enclosed office spaces and some public space would have near 100 percent occupancy during normal working hours, while the others would have either periodic (conference, some public space, some building support) or near zero occupancy (some building support). Placement of the occupancies was a balance of human comfort and performance considerations, security considerations and operational adjacencies. In general, the core or building support spaces were placed to the northern perimeter and at building wing intersections. These acted as both a security buffer and placed the spaces that didn't require any daylight or high daylight penetration. The conference and enclosed office spaces also were placed on the north side because the depth of these spaces would be less and required less daylighting penetration for effective daylighting. The open office bays requiring the most optimum daylighting penetration were placed on the south walls. Pushing the workstations away from the south wall and providing circulation immediately along those walls put the normally occupied spaces at a distance from the inevitable heat gain from the windows and still provided the level of designed daylighting. Lastly, the east and west facing walls would be recessed to self-shade and because of their smaller size would have less surface area to address solar heat gain through the envelope and glazing.

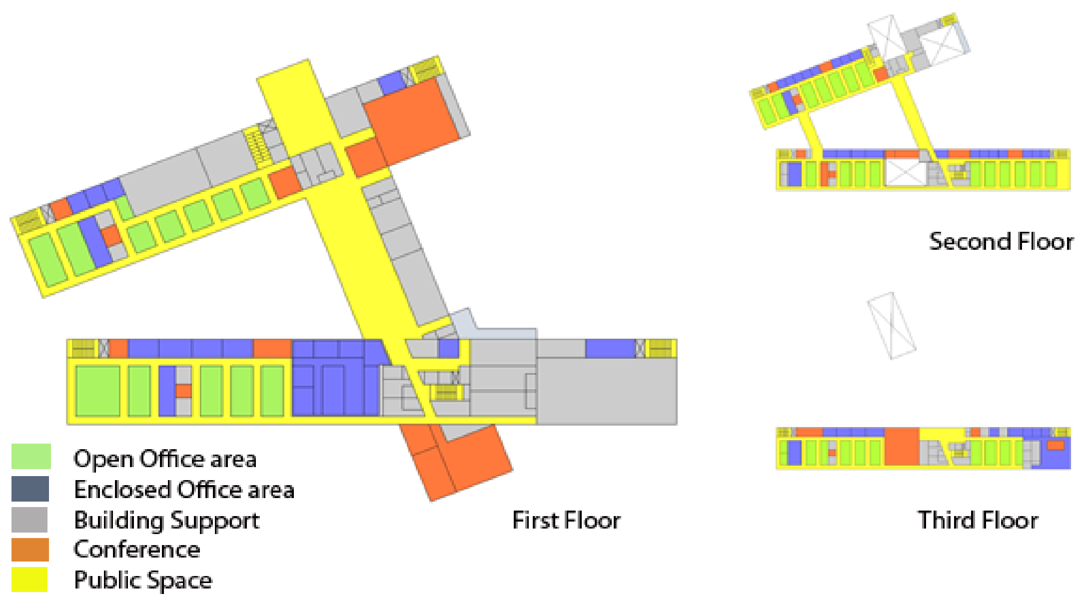



**Figure 58. Main space uses and thermal considerations.** ***Source*****: SketchUp**

4.5.3 Envelope

Decisions on the buildings envelope options will be partially tied to those of the selected structural system to augment structural integrity for the reasons previously stated but also to provide the neutralized envelope that will contribute to the buildings energy efficiency and the air tight and pressurization requirements of CBR protection. Additionally, consideration must be given to balancing the need for daylighting and views to the outside to protection from aggressor surveillance and targeting. The minimum anti-terrorism security standards coupled with its location do not require hardening of the structure, however the facility type likely adds a necessary level of protection that can be assumed to require some hardening for direct fire weapons. The minimum standards only require obscuration of the building to complicate targeting, but the use of a thermally massive insulated wall also provides characteristics that serve our energy efficient goals, as well as any acoustic requirements.

Main considerations for reducing cooling loads with regards to the envelope are skin heat flow, solar heat gain, and infiltration. Additionally we desire to take advantage of daylighting opportunities which further reduce cooling loads by minimizing electric lighting requirements and the internal heat gain that comes with it.

#### 4.5.3.1 Baseline Envelope

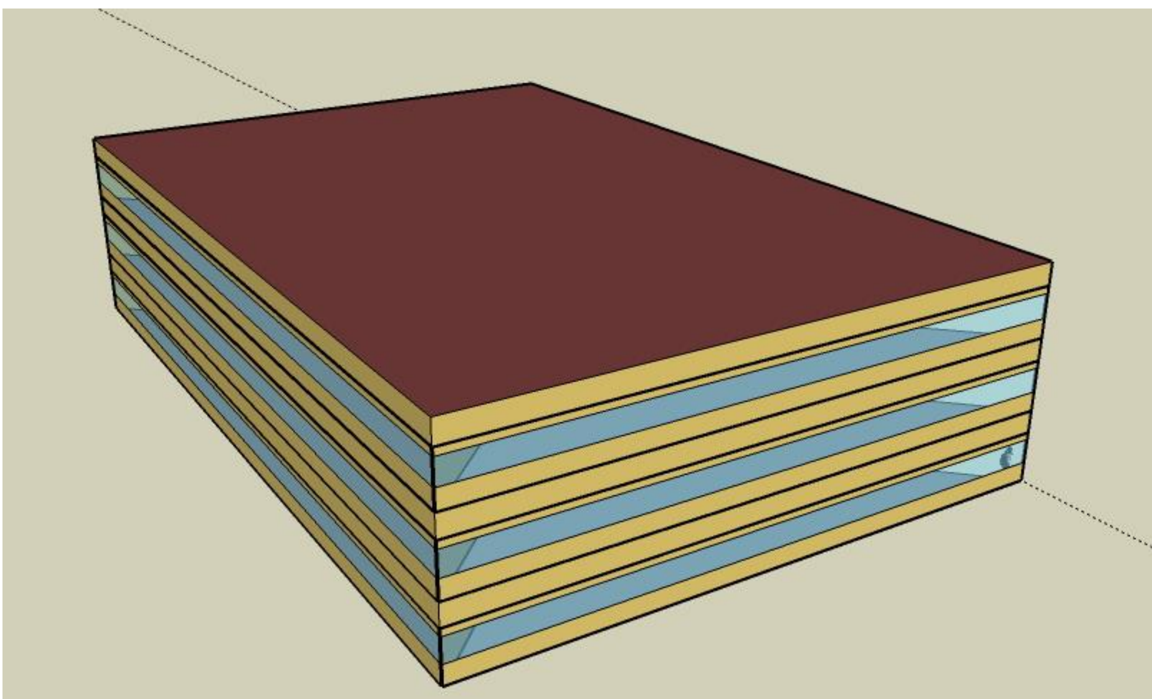


**Figure 59. Axonometric view of benchmark medium office building. *Source*: Department of Energy Advanced Energy Design Guide for Small and Medium Office Buildings: Achieving 50% Energy Savings Towards a Net Zero Energy Building.**

The following medium office building baseline was pulled directly from the 50% energy efficiency design guides available on the Department of Energy website. It provides the baseline model characteristics which represent minimally code compliant design of typical medium sized office buildings. The model output was then used to test energy efficiency measures across climate zones.

Building opaque constructions include steel-framed walls, flat roof with insulation above the deck and slab–on-grade floors. These envelope structures represent common construction practice for medium office buildings in the U.S. based on information from the Commercial Building Energy Consumption Survey (CBECS) data. The baseline building envelope characteristics were developed to meet the prescriptive design option requirements of the Standard Section 5.3 Prescriptive Building Envelope Option. The following paragraphs describe the assumptions used for modeling the baseline building envelope components, including the exterior walls, roofs, slab-on-grade floors, fenestration, and infiltration.

The exterior walls of the medium office baseline building are steel framed with stucco exterior cladding. There is fiberglass batt insulation within the stud cavity and additional rigid insulation when needed to meet climate zone specific requirements. The exterior wall includes the following layers:

• Exterior air film, R=0.17 ft2·F·h/Btu

• 0.75-in. thick stucco, R=0.08 ft2·F·h/Btu

• 0.625-in. thick gypsum board, R=0.56 ft2·F·h/Btu

• 2-in x 4-in steel studs @ 16-in on center with R=13 ft2·F·h/Btu fiberglass batt insulation in stud cavity

• Additional board insulation (varies by climate)

• 0.625-in. thick gypsum board, R=0.56 ft2·F·h/Btu

• Interior air film, R=0.68 ft2·F·h/Btu

R-values for most of the above layers were derived from Appendix A (Rated R-Value of Insulation and Assembly U-Factor, C-Factor, And F-Factor Determination) of the Standard. Insulation R-values were selected to create a wall assembly that just meets the maximum U-value required in Tables 5.5.1 through 5.5.8 of the Standard for different climate zones.

The baseline uses a flat roof that consists of a roof membrane over rigid insulation, uninterrupted by framing, over a structural metal deck. Roof insulation R-values were also set to match the maximum roof U-value requirements in Tables 5.5.1 through 5.5.8 of the Standard for different climate zones. The roof construction is defined with the following layers:

- Exterior air film, R=0.17 ft2·F·h/Btu
- Continuous rigid insulation (thickness and R-value vary by climate)
- Metal deck, R=0
- Interior air film heat flow up, R=0.61 ft2·F·h/Btu

The Standard does not specify either roof reflectivity or emittance. In the baseline prototypes, the roof exterior finish was chosen as a single-ply roof membrane of grey EPDM (ethylene propylene diene terpolymer membrane). From a cool roofing materials database by the Lawrence Berkeley National Laboratory, the solar reflectance and the thermal emittance of the EPDM was defined respectively as 0.23 and 0.87.

The ground floor is carpet over 6 in. concrete slab floor poured directly on to the earth (slab-on-grade). Modeled below the slab is 12 in. soil, with soil conductivity of 0.75 Btu/ ft2·F·h. In contrast to the U-factor for other envelope assemblies, the F-factor is set to match the minimum requirements for unheated slab-on-grade floors in Tables 5.5.1 through 5.5.8 of Standard 90.1, based on climate. F-factor is expressed as the conductance of the surface per unit length of building perimeter.

The medium-sized office buildings generally have moderate window-to-wall (WWR) ratios, usually in the 20% to 30% range according to the CBECS data. The overall WWR of the baseline building was chosen as 33% for the medium office. The windows have a height of 4 ft. and are distributed evenly in continuous ribbons around the perimeter of the building.

Chapter 5 of the Standard lists U-factor and solar heat gain coefficient (SHGC) requirements based on climate zone, window-to-wall ratio, and window operator type (fixed or operable). Based on an estimated weighting of 4.6% operable and 95.4% fixed windows[53]

[53] ASHRAE SSPC 90.1 Envelope Subcommittee provided the estimated weighting factor based on the Ducker Fenestration Market Data.

Based on CBECS, the primary fenestration type in medium office buildings is curtain wall and storefront. Buildings with fixed frame windows can achieve lower U-factors because of lower frame conductance.

The U-Factor for climate zone 1 was 1.08 Btu/h ft$^2$ F and the SHGC was .28.

There is no requirement for maximum air infiltration rate. Building air infiltration is addressed only indirectly in the Standard through the requirements for building envelope sealing, fenestration and door air leakage, etc. For the baseline, the infiltration rate was assumed to be 1.8 cfm/ft$^2$ of above-grade envelope surface area at 0.3 in. w.c. based on the study by the National Institute of Standards and Technologies.[54]

The input design infiltration was calculated as 0.2016 cfm/ft$^2$ of above-grade exterior wall surface area, equivalent to the base infiltration rate of 1.8 cfm/ft$^2$ of above-grade envelope surface area at 0.3 in. w.c.

#### 4.5.3.2 Design efficiency measures

The approach then will be to address reducing heat flow, mitigating heat gain and stopping air infiltration. Because of Oahu's location and the relatively high solar altitude, the roof will be a major source of solar heat gain and can be mitigated with light colors and enhanced insulation. The structural and security requirements call for a mass wall. The proposal is reinforced concrete precast sandwich panels. The sandwich panels will consist of two reinforced concrete panels on the interior and exterior sandwiching a rigid insulation panel. This serves two purposes, it provides the insulate qualities but also the added blast protection. The insulation will be continuous rigid board insulation to improve thermal performance. Table 12 shows the wall assembly U-factors and the respective insulation R-values for the baseline model and the design solution ECM. The table reflects an almost **50%** reduction in thermal conductance over the baseline.

[54] Emmerich, Steven J. and Timothy McDowell, "Analysis of Dedicated Outdoor Air Systems for Different Climates." (Ninth International IBPSA Conference, Montreal, CA, August 2005).

#### 4.5.3.2.1Exterior Walls

The exterior insulated precast wall panels will consist of a 4in insulation layer sandwiched by a reinforced 4in outside concrete panel and a 5in reinforced inside concrete panel. The panels and panel connections will be air and water tight. At the horizontal panel joints, an inner and outer seal will consist of an outboard sealant and inboard backer rod. The outer sealant and backer rod will be drained at vertical joints and the inner sealant and backer rod will be continuous for water and air control.

**Table 12 Insulation requirement comparison for above grade mass wall**

| Climate zone | Baseline | | Design | |
|---|---|---|---|---|
| | Assembly U-factor Btu/h·ft$^2$·F | Rated Insulation R-value ft$^2$·F·h/Btu | Assembly U-factor Btu/h·ft$^2$·F | Rated insulation R-value ft$^2$·F·h/Btu |
| 1 | **0.313** | NR | **0.068** | R-3.2 + R-7.5 c.i.+R-1.0 +R-3.2 |
| c.i.=continuous insulation NR = not required in zone 1 U=1/ΣR | | | | |

***Source*: DOE Energy Design guide parameters.**

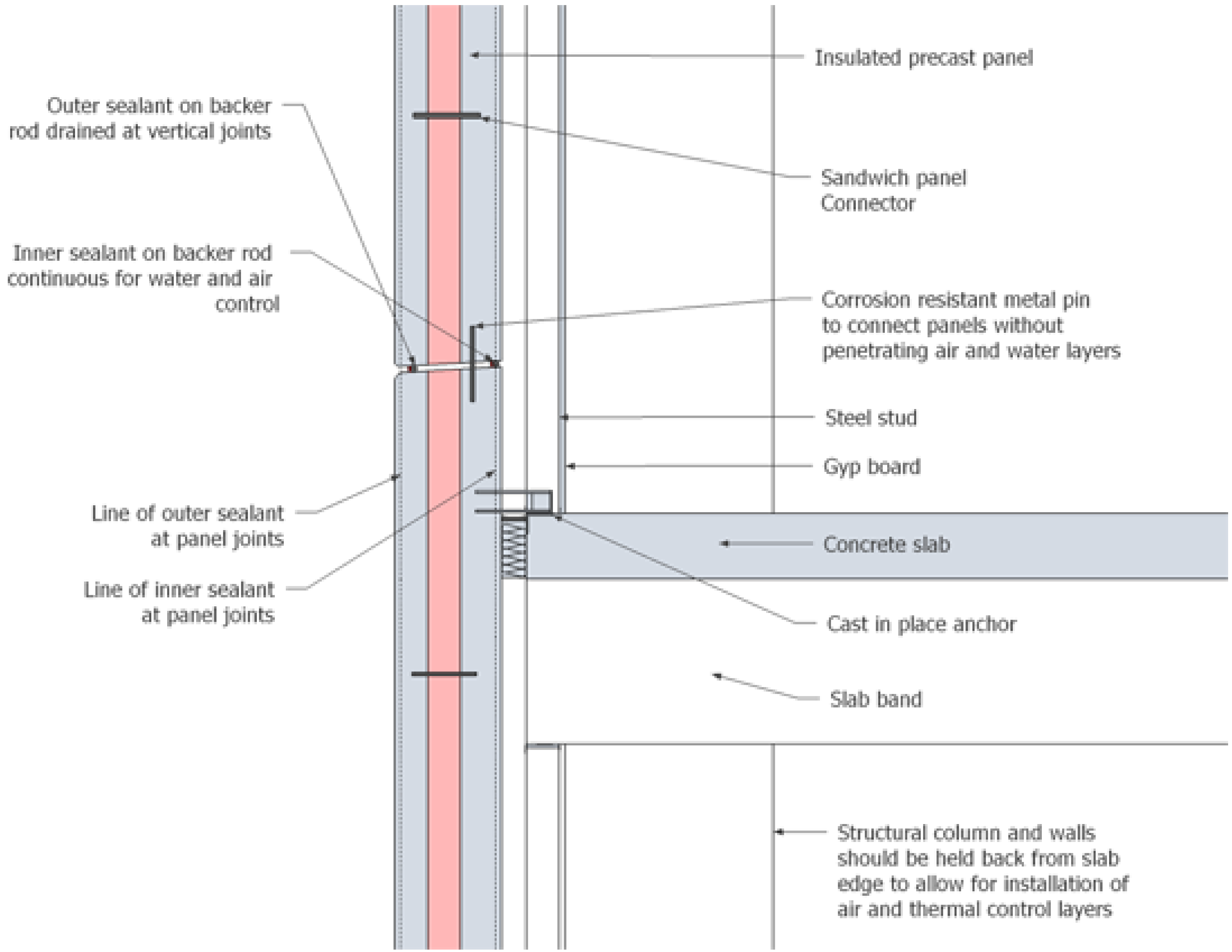



**Figure 60. Wall Section of proposed precast exterior wall panel.** ***Source*****: Sketchup.**

#### 4.5.3.2.2 Roof

Another effective measure is the use of cool roofs, particularly in hot climates. This approach reduces the Sol-air temperature which contributes to heat transfer through the envelope. Remembering that higher Solar Reflectivity Index (SRI) values are more desirable, the measure of a roof's ability to reject solar heat, applying an exterior layer of a white ethylene propylene diene monomer( EDPM) coating to the concrete roof deck will provide a solar reflectance of 0.69, infrared emittance of 0.87 resulting in an SRI of approximately 88 as compared to a bare sealed concrete roof slab with a solar reflectance of 0.25, infrared emittance of 0.9 and an SRI of 31.[55] The SRI margin of 57 equates to a temperature increase differential of 45˚ F at the roof surface.

**Table 13. Insulation requirement comparison for the roof with continuous insulation above deck**

| Climate Zone | Baseline | | Design | |
|---|---|---|---|---|
| | Assembly U-Factor | Rated Insulation R-value | Assembly U-factor | Rated Insulation R-value |
| 1 | 0.063 | R-15 c.i. | 0.093 | R-20 c.i. |
| c.i.=continuous insulation | | NR=not required in zone 1 | | U=1/R |

***Source:*** **DOE Energy Design Guide parameters.**

#### 4.5.3.2.3 Fenestration

The openings in the envelope, or fenestration, are critical points to address as they are usually thermally weak points. Window-to-wall (WWR) ratios will be carefully balanced with daylighting strategies. With the desire to provide effective daylight well into the open bay office spaces, the use of a combination of view windows with shading and daylighting windows with light louver devices will allow low WWR to 30% on the south walls, 21 percent on the north walls, 32 percent on the east walls and 31 percent on the West walls. Normally a higher WWR on the north wall would be desirable to provide the needed daylight, but the design proposal calls for several spaces with no windows, including the command center and data center. The overall objective is to reduce the WWR while balancing the desire to provide views to the

[55] G.Z. Brown and Mark Dekay, Sun, Wind and Light: Arch Design Start, 221

outside. In the baseline model, fenestration consisted of ribbon windows encircling the building without regard to solar and thermal issues that result. In this design, careful consideration is given to the orientation and exposure of the walls and windows with regard to adjacent occupancies and daylighting and view goals. The desirable views of the mountain ranges are to the north and east and less desirable views of the urban/suburban areas are to the west and south. The winter sun angles at this latitude will be the most extreme on the south exposure, requiring shading devices, while the late afternoon sun exposure on the west wall will need to be addressed year round. Balancing these requirements called for larger view/daylighting windows on the north wall to capture the views without risk of excessive heat gain, larger but shaded glazing on the east wall, smaller combination, shaded view and daylighting windows on the south wall, and smaller shaded and tinted glazing on the west side. The exterior shading cavities on the west and east sides provide shading of the glazing well into the afternoon. A filtering scrim is also added to the west side perimeter that provided access to views but added a pleasant light filtering affect.

Because there is a somewhat delicate balance between window size and construction and obtaining the benefits of daylighting, we looked at a couple of different window sizes for each exposure and came up with approximate sizes and configurations for each. In general it was determined that the south wall would have smaller windows for heat mitigation and glare reduction due to the amount of direct sun and the north wall would have larger windows higher up the wall because the north light provides much less direct sun. On the south wall, determining the height of the lower view window hinged around the acceptable size of the shading device that would be needed. The head height of the overall window combination was determined by the depth of the daylight penetration we were seeking. The light louvers provide 14’ of daylight penetration per 1 foot of window height[56]. Therefore a 3 foot upper window height coupled with the lower view window height of 3-4 ft. would theoretically project useful daylight approximately 42 feet into the space. Additionally by using other daylighting strategies in the interior spaces we were able to narrow the window widths to further decrease the WWR.

[56] http://lightlouver.com/lightlouver-description, (accessed 11 April 2013) describes light louver characteristics

The design will propose south windows that provide a lower triple pane lowE view window with a low .23 SHGC, a low thermal transmittance; with a U-factor of .17 and a VLT of 43 percent to help reduce glare. The view window will incorporate the 3 sided shading device that is roughly estimated to be 18-24 inches deep. The upper daylighting window will be double paned lowE with a higher VLT of 70 percent to facilitate daylight penetration and a higher SHGC of .38 because the heat gain is abated by the lightlouver system which doubles as a shading device while still bouncing light deep into the space. This lightlouver system needs no adjustment or shading, in fact shading would adversely affect its performance.

Security requirements for fenestration consist of preventing flying debris as a result of blast fragmentation. Methods to address this can be to use a ballistic window film, both tinted and non-tinted, that serve both glass debris issues and heat gain/glare issues and wall integrated window assemblies that both help to seal the opening and strengthen the connection. The proposal for the films on the west wall and lower view window on the south wall to be tinted, while the window films on the east and north wall to have clear ballistic films.

**Table 14. Window U-factor and Solar Heat Gain Coefficient**

| Climate Zone | Baseline | | Design | |
|---|---|---|---|---|
| | U-factor | SHGC | U-factor | SHGC |
| 1 | **1.22**[1] | 0.25 | **0.65** | 0.25 |
| [1]U-factor values for window assemblies are for both window and framing systems | | | | |

***Source*: DOE Energy Design Guide parameters.**

#### 4.5.3.2.4Air infiltration

Lastly, to address air infiltration the best approach is to ensure a sealed envelope is achieved. Tightly sealing all joints and seams across precast panels as well as doors and windows should ensure an airtight envelope. This additionally serves to facilitate security measures requiring air tightness for CBR protection.

**Table 15. Envelope ECMs**

| Envelope Energy Conservation Measures | |
|---|---|
| In Design | Other possible ECMs |
| Additional insulation (enhanced) | Daylight enhancing shades |
| Cool roof | Shading from adjacent buildings |
| High Performance windows | Thermal mass |
| Window overhangs/Light shelves | |

### 4.5.4 Shading

The design goal in this location is to not allow any sunlight penetration directly into the interior due to the associated heat gain. At Honolulu's latitude of $21.5^0$ North, the seasonal variation in sun angles range from 45.2 $^0$F above the southern horizon at solar noon on Dec 22$^{nd}$ to 87.7 $^0$F above that northern horizon, almost directly overhead, on June 21$^{st}$ at solar noon.

The determination of appropriate orientation and massing of the building footprint addressed some shading considerations. Creating a long axis along an east west orientation, provided the least sun exposed surface area and therefore the least direct heat gains to mitigate. Additionally on those facades, the walls were set back to provide self-shading exterior cavities/spaces. A cavity or exterior space is created by pushing in the interior to exterior envelope and creating a perforated screen or scrim and shading overhang that still allows fenestration and filtered daylight to pass. Security design requirements do not prevent this strategy and actually prevent direct line of sight surveillance or targeting.

#### 4.5.4.1 Vegetation

Standoff and unobstructed space security requirements are relatively strict in that placing vegetation in these zones is prevented if they significantly obstruct the ability of a passersby or occupants form observing possible threats placed out of sight, ,such as behind low shrubs, behind small structures or large tree trunks  However, if the vegetation is placed such that the overhang penetrates these zones and does not provide a significantly obstruction, then is it permissible  This requires a rather large tree with a broad overhang, but there are a couple of species that could work.  Two site locations would include the centered on the entry circle and outside of the west facade.  Two monkeypod trees at each wings' west façade placed just outside of the standoff of 60 feet would eventually provide some shade at the lower sun angle later in the day.  The tree at the center of the entry circle would eventually shade the entry circle pavement reducing heat island effects of the asphalt pavement.

#### 4.5.4.2 Shading devices/Light shelves

Shading devices are used on the south facing windows to help address the winter sun exposure.

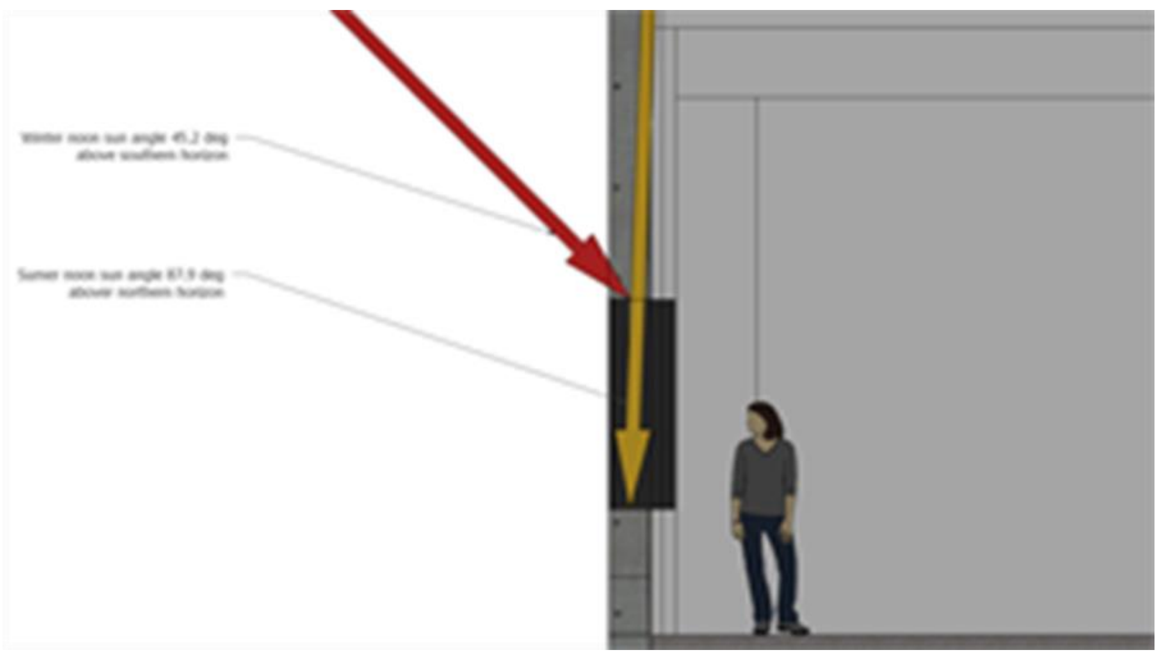


**Figure 61. Winter and Summer sun angle studies. *Source*: SketchUp**

The depth of the devices was balanced with automatic shades.  The devices were limited to the lower view windows while the upper daylight windows used the lightlouver system, described earlier, to shade.   Because of the shading device necessitated shading the lower portion of the view window, shades that lift rather than lower could be used and still provide some views or the surrounding area and skies.  Shading device design was based on optimizing daylight and minimizing heat gain by shading the glazing.

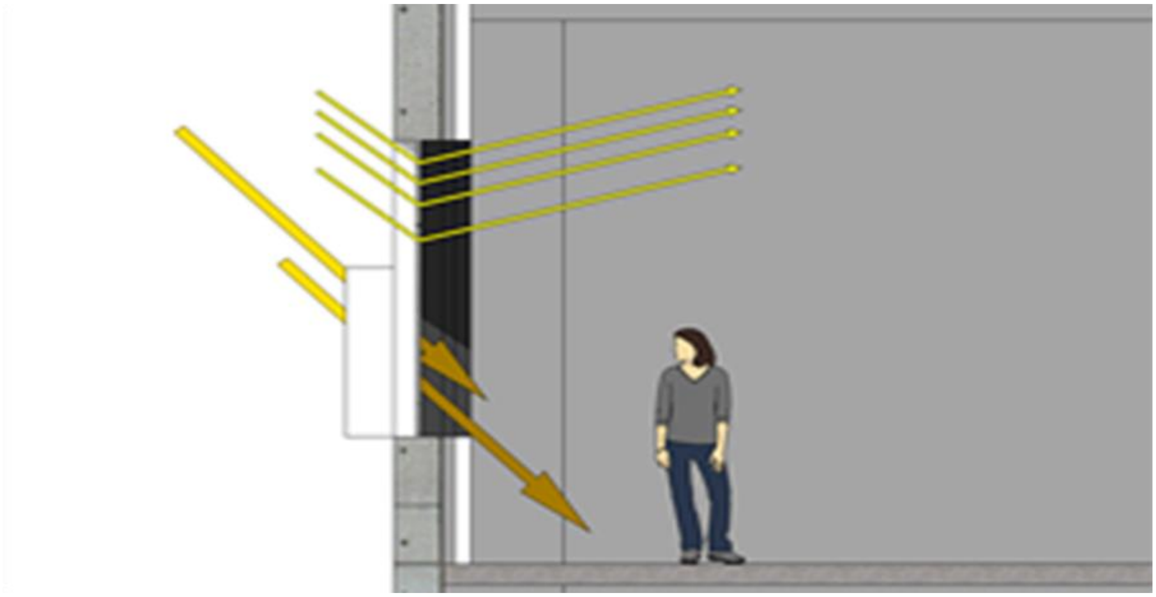


**Figure 62. Daylight and view split window system. *Source*: SketchUp.**

Consideration was given to the security requirement that called for minimizing flying debris from an explosive event.  For this project a less detailed daylighting and shading analysis still provides reliable information at this stage of the design.

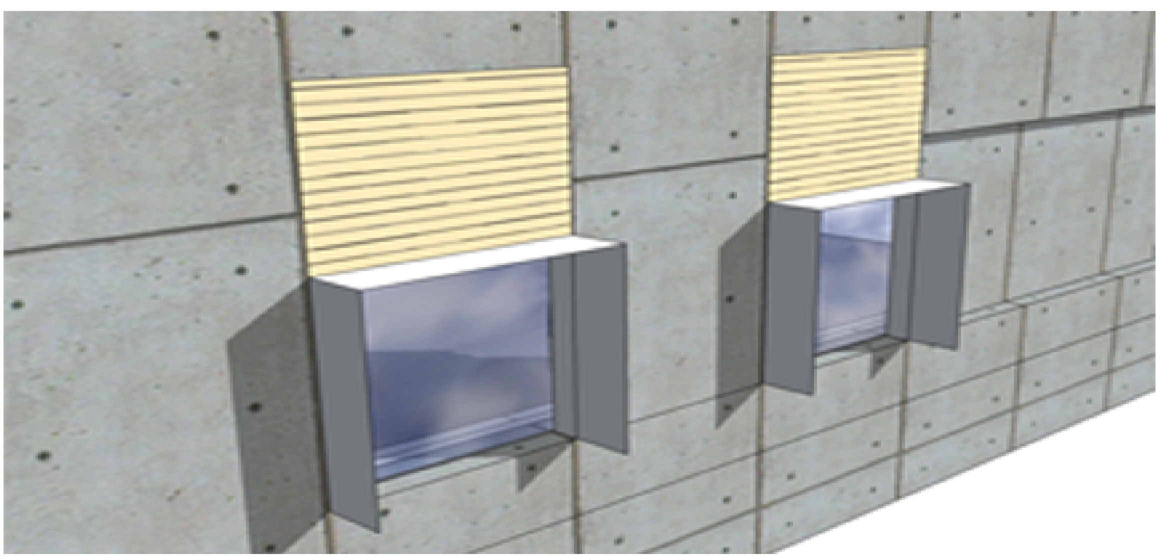


**Figure 63. Example of window system. Daylighting window above with lightlouvers and view window below with horizontal and vertical shading. *Source*: SketchUp.**

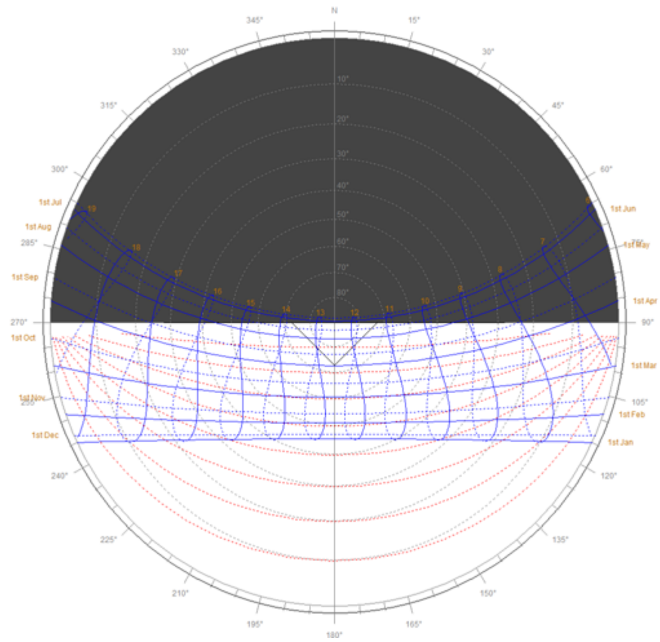


**Figure 64. No shading device.: *Source*: Ecotect.**

A shading mask is used to illustrate the proposed shading device design efficiency. The sun path diagram overlaid on the shading mask illustrates when the designed window is shaded during the day and year. In the following set of diagrams a window with a south exposure is used for calculations. In figure 64 no shading device is used and the shade provided by the building itself is represented by the dark area. In the figure 65 a horizontal sunshade the width of the window and 18" deep is used and provides the illustrated shading periods. Here you see that the shading device provides 100% shading during the periods of roughly mid spring to mid fall from 0930 to 1630. It also illustrates that the sunshade does not completely shade the window during the winter months. Figure 66 illustrates a sunshade, or in this case a sunshelf, that is continuous along the entire width of the south wall. It shows that the shading period is extended earlier in the morning and later in the day during those same months. Figure 67 now shows a sunshade that has three sides

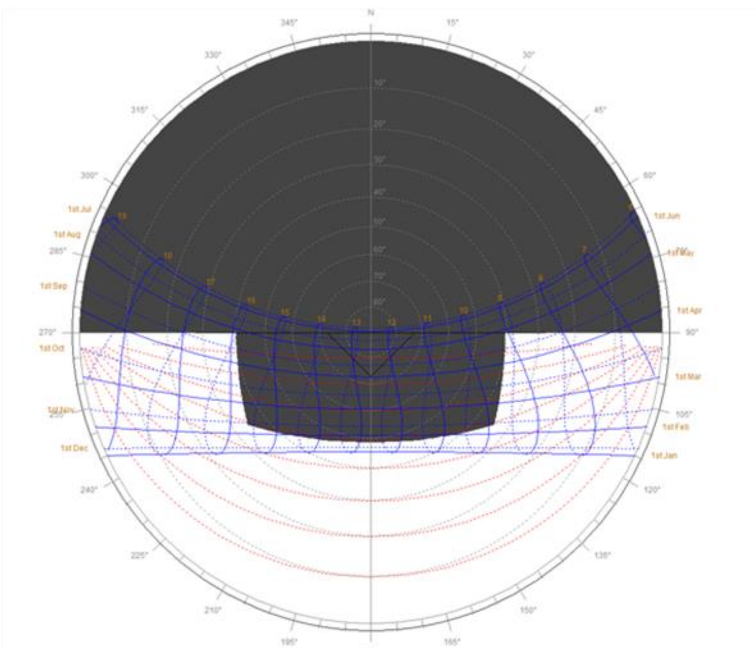


**Figure 65. Horizontal shading device only. *Source*: Ecotect.**

surrounding the view window, which now provides shade from the low angle morning and late afternoon sun during that same period. It is a good illustration of the efficiency of a three sided sunshade. Keep in mind that increasing the depth of the sunshade, or moving the window frame deeper into the wall panel, will increase the shaded area of the window, but this must be balanced mainly with the security design criteria addressing flying debris and falling objects in the occupied zones. The proposed shading device design successfully provided shade to the south facing windows for most of the year as illustrated in figure 67. For the remaining part of the year an interior operable shade can be used or the heat gain can be mitigated with the performance of the selected window.

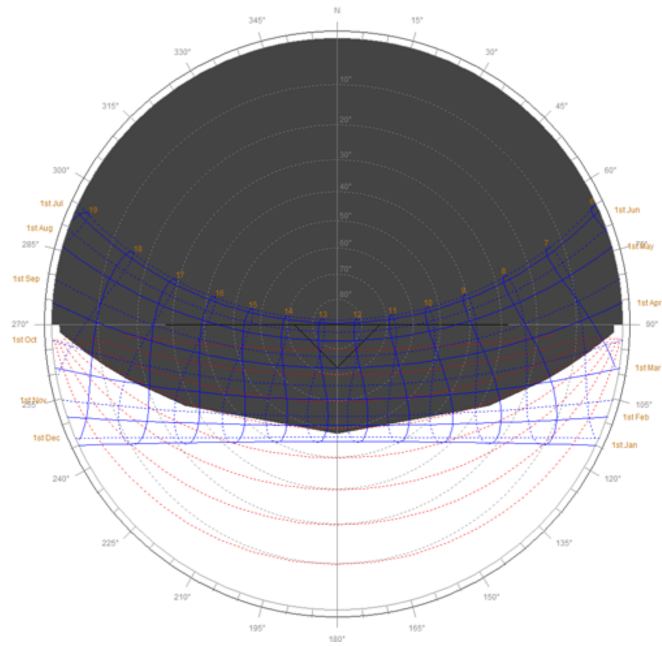


**Figure 66. Horizontal sunshelf, extending along entire width of wall. *Source*: Ecotect.**

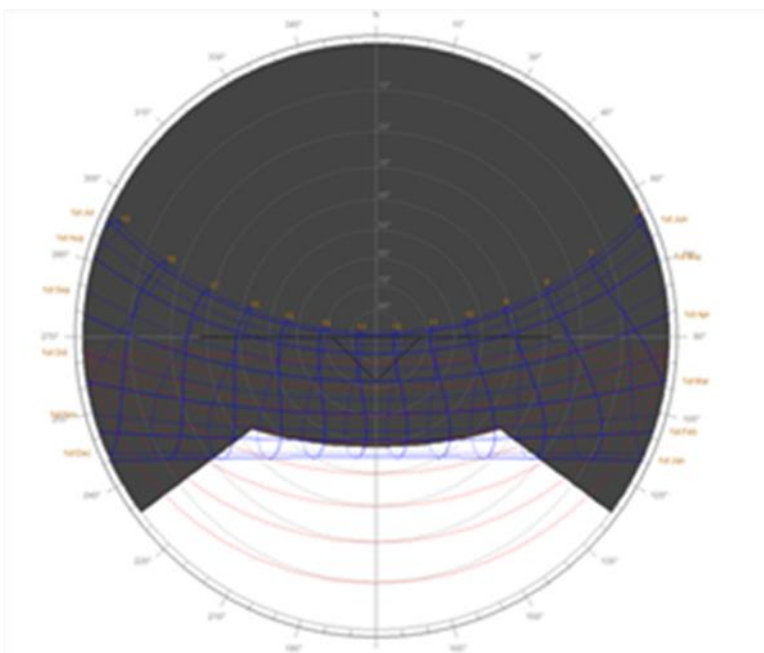


**Figure 67. Horizontal and vertical shading devices. *Source*: Ecotect.**

4.5.5 Daylighting

The buildings massing, orientation and ceiling height contributed greatly to realizing the daylighting potential as well as appropriately innovatively designed fenestration solutions including, size and solar control devices, that aided in bouncing light deeper into the space on the south exposure. The sidelighting method predominated in all of the work areas and some toplighting was used in the entry atrium and public connector space/retail area. In the process of the daylighting design and space planning, I answered four key questions relating to each space; first, the importance of daylight, second, the importance of views, third, frequency of use, and finally, time of day and year it will be occupied.

**Table 56. Daylight program criteria for each major space type.**

| Daylight program criteria | |
|---|---|
| Open Office | Daylight and view desired, occupants have control, occupied full staff during normal working hours, part staffing outside of normal working hours |
| Enclosed office | Daylight and view desired, occupants have control, full staffing normal working hours, part staffing outside of normal working hours |
| Building support | Minimal daylight or view needed, some full occupancy some part occupancy |
| Building core | No daylight or views needed, transient occupancy, occupancy sensors |
| Public space | Daylight and view desired for main areas. Daylight and view not required for circulation. Transient occupancy. |
| Conference | Minimal daylight and view required |

The necessity to leverage daylight occurred at the perimeter zones where most of the offices and some occupied building support space were located. The need for light was less where some of the less occupied or core spaces were located in the interior zones. With the daylighting emphasis on the south side where the open bay office space was, the north exposure required less depth of penetration due to the size of the rooms along the north wall. The buildings main program categories were arrayed in relation to lighting objectives, requirements and the necessity of access to the exterior. A building shading study gives a quick idea of shadow casting and is preliminary indicator of sunlight patterns for daylighting potential. This understanding then helps to identify distribution of diffuse illumination and direct sunlight as well as recognizing direct sunlight patterns and the time of day they occur. Views worth capturing are confined to the Koolau mountain range to the east and the Waianae mountains to the Northwest.

#### 4.5.5.1 Space planning

Utilizing the rule of thumb that the practical depth of the daylight zone is 1.5 to 2 times the window height, which results in an initial design depth of 18'-20', we expanded that by providing the light shelves and daylighting shade louvers. The open office areas then had a depth of approximately 42 feet. This depth didn't provide practical daylight all the way to 42 feet but coupled with other measures and integration with electric lighting provided the ambient lighting offset we desired to achieve. The enclosed office spaces were mostly arrayed along the north wall and had depths of 14 feet, which provide ample light levels. Ordinarily, because the enclosed offices have a lower occupancy than the open office bays which are for the most part continually occupied during normal working hours, they could be used as buffer spaces on the east and west walls. In our design, we chose to use the exterior cavity spaces described earlier as the buffer, allowing us to place the enclosed office areas in a location that didn't require additional measures to mitigate heat gain or direct sunlight when the sun angles were lower in the morning and later afternoon. Less occupied building support and core spaces needing little to no daylight were arrayed in zones that didn't provide as much daylight if any.

Security design criteria did not inhibit the daylighting design with regard to space planning. The building support spaces with special design criteria were still placed where daylight was least available based on their size and function, but also in relation to relevant departments in the program.

#### 4.5.5.2 Glare and thermal control

The massing and the shape of the building really drove the necessity for glare and thermal control, with the north exposure needing little to no measures and the east and west creating the biggest challenge. The challenge was addressed with the recessed screened exterior cavity spaces. The south wall provided the best daylight access but also required measures to control glare and thermal control, particularly during the winter months, with the sun lower in the southern sky. The solar control devices described earlier will should provide appropriate control.

#### 4.5.5.3 Workstations

Workstation design supported daylighting mainly by not inhibiting light penetration.

**Figure 68. Proposed workstation layout provides low separators parallel to exterior wall and slightly taller separators perpendicular to exterior wall. *Source*: SketchUp.**

Workstation separation panels perpendicular to the exterior wall will be no higher than 65” to provide a sense of enclosure and panels parallel to the wall will be kept low, at or below 42” which will minimize affecting the distribution of light. Workstations will also be designed so that occupants face parallel to window openings, avoiding visual discomfort and excessive contrast that results when facing the source of light and the resulting brightness. The better light for tasks is that which reaches the task indirectly, reflected or bounced of a white wall or ceiling.

#### 4.5.5.4 Interior surface finishes

Light reflectance values (LRV) were important considerations and the rules of thumb for ceiling , walls and floors have been shown to be too dark to achieve maximum energy efficiency.[57] Therefore the recommended LRVs were; ceiling 80 %, walls 85%, Work Surfaces 85% and Floor 10%. This represented an increase of 35% for walls, a decrease of 10% for floors, while the ceiling remained unchanged. The 85% LRV of the back wall opposite the perimeter wall will help to balance the brightness of the view through the perimeter windows. The importance of getting this right is that by balancing the perceived brightness of the entire space, it will seem bright. Lastly, by providing a structural system that has few interior columns that might obstruct light and that would need to be addressed we minimize surfaces needed appropriate finishes. A possible option for this project is to use light colored acoustic panels attached to the concrete ceiling that double as light

**Figure 69. Light colored ceiling panels. Photograph by Travis Watson.**

[57] Daylighting Guide for the Commercial Office, Advanced Energy Office, 7.

reflective surfaces. It eliminates the need to paint or color the concrete a light color, provides a smooth reflective surface and provides acoustic sound dampening.

#### 4.5.5.5 Zones

At this point we begin to consider lighting integration measures. The open office space, because of its depth will need to be zoned according to daylight availability. On the south wall, based on the rules of thumb and the designed window head height of 10’, the daylight zone will be up to 20’ away from the exterior wall into the open office area and will serve as the first daylight zone, the second daylight zone will extend another 20’ to 40’ from the exterior wall. On the north wall where enclosed office areas predominate, effective daylight penetration only needs to extend 14’ to the opposite wall, so the window head height of 7 feet without the need for any light bouncing devices or shading will provide a single daylight zone extending to the wall. Figure 70 below is a partial plan view of the west end of the south wing. It illustrates daylight penetration (daylight factor) of an overcast sky at 1200 noon on any given day of the year in Honolulu. Along the north wall are enclosed office spaces. Along the south wall are open office bays, with the exception of an enclosed conference room and an exterior buffer shading space on the west end. The design approach resulted in a 2% daylight factor at 17 ft. from the south wall with a window head heights of 10 ft. and approximately 20 fc at 20 ft. from the south wall. We were able to attain a daylight factor of 2 percent and 20 fc on the north enclosed offices to 10ft from the north wall. The east and west exposures have been used mainly for building support spaces, but also have the exterior shading cavity space, so a daylight requirement was deemed less important in the design. Photo cells then control groups of fixtures based on available light in the respective zone. When ample daylight is available, sensors reduce light output. Electric lighting integration will be discussed more detail in the following chapter.

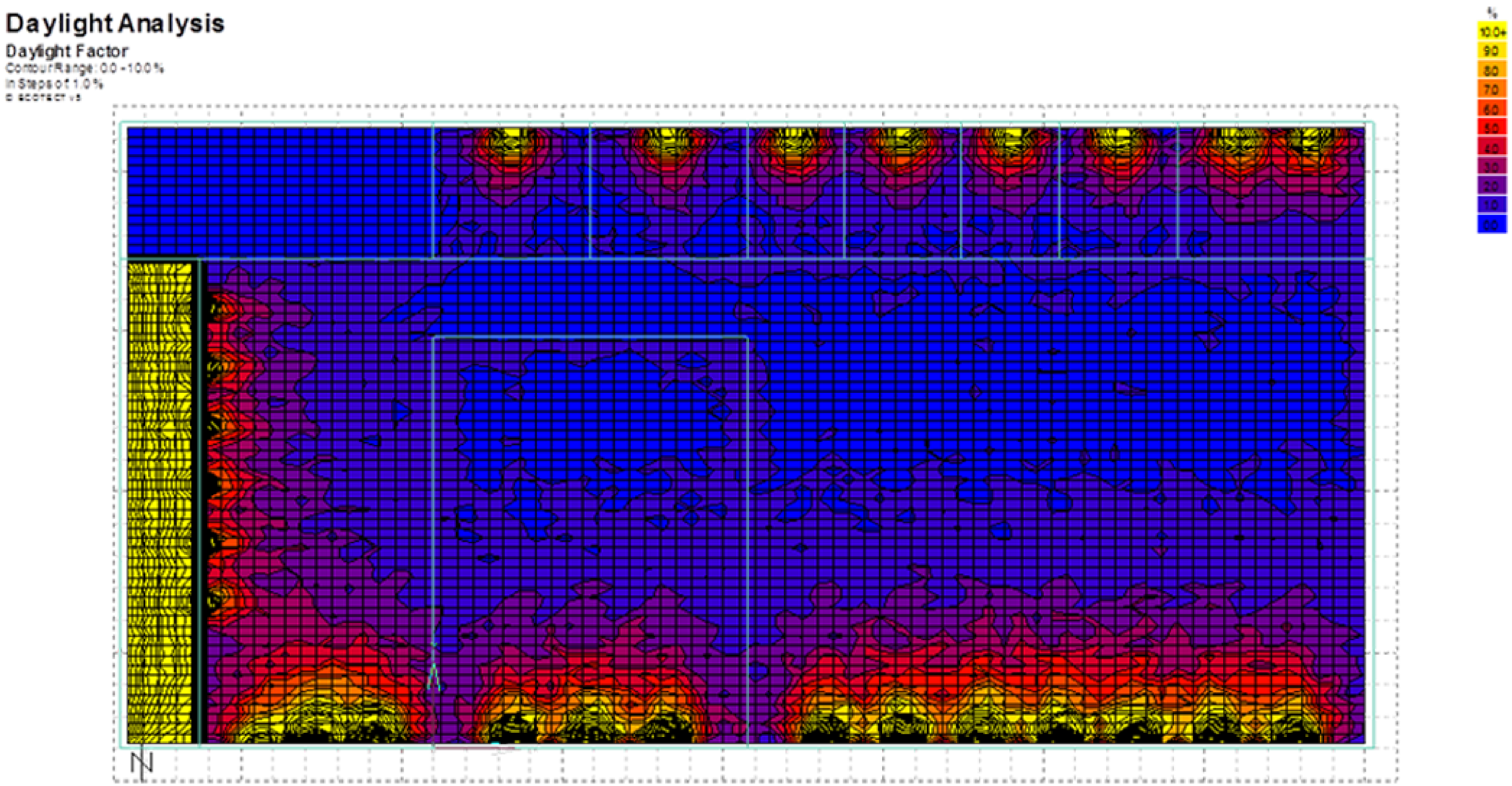



**Figure 70. Daylight Factors for selected spaces in proposed design.** ***Source*****: Ecotect.**

## 4.6 Lighting Systems

An energy efficient electric lighting design will be the result of careful daylighting integration. Security lighting adds an extra layer, but can be designed so that it accomplishes safety and landscape lighting requirements. The overall architectural goal is to create a consistent impression for the visitor and optimize performance and visual comfort for the personnel working there.

### 4.6.1 Baseline Lighting

The baseline lighting system is assumed to just meet the lighting power density requirements of Table 9.5.1 of the ASHRAE Standard 90.1- 2007. Ambient lighting power density for the entire building is input at an average of 1.0 $W/ft^2$ for all areas. The Standard also includes various mandatory interior lighting control requirements including building-wide automatic shutoff and occupancy sensor control in some locations likely to be found in office buildings including conference rooms, meeting rooms, and break rooms. Mandatory controls were not explicitly simulated in the baseline because the lighting diversity schedule is assumed to have considered these mandatory controls.

### 4.6.2 Occupancy and Space Visual and Lighting Requirements

Determining space lighting requirements for visual comfort and task needs begin to inform lighting design types and arrangements. A thorough analysis of what types of tasks and activities will be performed, design goals, spatial qualities, design development issues and potential or proposed systems will be a critical design step in achieving energy efficiency. Table 17 provides a complete analysis for each space type and area.

**Table 17. Lighting Program Table**

| **Lighting Program Chart** | | | | | |
|---|---|---|---|---|---|
| **Space** | **Design Goals**<br>Subjective visual impressions | **Spatial quality**<br>Biological needs<br>Psych. needs | **Activities**<br>Activity needs<br>Visual tasks | **Design development issues** | **Systems**<br>Illuminance<br>Fixtures |
| Entry Atrium, visitor access control | Spacious, soaring, formal, organized, enveloping | Daylight<br>Clarity and reference for orientation | view murals and views, check in activities, reading, writing, listening | Tall soaring mostly glazed space, highlight murals, reinforce command image, bright walls, use fluorescent and LED lamps, vertical and horizontal illum. Photo sensors dimmable | 30 fc<br>Ambient, task, Accent, Safety/egress,Security |
| Public and connector spaces | Bright directional | Daylight, clarity and reference for orientation, relaxation | Moving, walking, seeing floor, stairs, activities of short and long duration | Long narrow spaces and open day lit space, bright finishes, horizontal and vertical illumination, photo sensors dimmable | 10-20 fc<br>Ambient, Accent, Safety/egress, Security |
| Circulation | Bright directional | Physical orientation for wayfinding, physical security | Moving walking, seeing floor, stairs, activities of short duration | Long narrow spaces, spaces along open office areas, bright finishes, horizontal and vertical illumination, photo sensors dimmable | 10 fc<br>Ambient, Accent, Safety/egress, Security |
| Open office bay | Spacious, bright, pleasant | Daylight, contact with outdoors personal territory | Paperwork, LCD monitor viewing, reading, writing, activities of long duration | Daylight, open bay, needs integrated lighting, wide and long, Horizontal illum., auto dimming, photo sensors | 20-30 fc<br>Ambient, Task, Accent, Safety/egress |
| Enclosed office | Bright, welcoming, | Daylight, contact with outdoors personal territory | Paperwork, reading, writing, LCD monitor viewing, activities of short and long duration | Small space, daylight, integrated lighting, auto dimming, horizontal illum. | 25 fc<br>Ambient, Task, Safety/egress |
| Retail | Bright, welcoming | Relaxing, daylight | Viewing retail items, transactions | Small to medium spaces, bright walls, use fluorescent lamps, LED | 30 fc<br>Ambient, Accent, Safety/egress, security |
| Food court | Bright, welcoming | Relaxing, daylight | | | 30 fc<br>Ambient, task, Accent, Safety/ egress, security |
| Gym | Spacious, views to outside | Daylight<br>Sidelighting and toplighting | exercising | Large open space, use fluorescent lamps horizontal illumination | 20 fc<br>Ambient, Safety/egress |
| Auditorium | Clean, bright, focused | Enclosed, clarity for viewing screen or presentation | Viewing presentations and speakers, sitting for long duration | Large enclosed space, sloping, horizontal and vertical illumination, dimmable, reinforce command image | 50 fc<br>Ambient, Accent, Safety/egress |
| Conference | Bright, open and intimate, productive | Clarity, privacy | Viewing presentations and speakers, sitting for long duration | Enclosed space, some with glass walls, and some with daylight, horizontal and vertical illum. | 35 fc<br>Ambient, Accent, Safety/egress |
| Core spaces | Utilitarian, bright | Clarity, focus on activities | Activities of short duration, standing or sitting, work on equipment, toplighting possible | Enclosed, no windows, need switchable bright and directional light for work on equipment | 35 fc<br>ambient |
| Building support | Bright, productive | Personal territory, daylight | Paperwork, reading, writing, activities of long duration | Small to medium spaces, bright walls, horizontal illumination | 50 fc<br>Ambient, Task, Safety/egress |

| | | | | | |
|---|---|---|---|---|---|
| Command center | Bright, organized, productive | Focus on activities, physical security | Paperwork, viewing LCD screens and wall monitors, reading writing, activities of long duration | Enclosed space, horizontal and vertical illumination | 50 fc<br>Ambient Task, accent, Safety/egress |
| Data center | Bright, directional | Focus on activities, physical security | Activities of short and long duration, work on data servers | Enclosed space, horizontal and vertical illum. Rectilinear space, bright lighting, use fluorescent lighting. | 35 fc<br>Ambient, Safety/egress |
| Bathrooms | Bright | Relaxation, personal territory | Short duration, standing , sitting | Enclosed space, horizontal and vertical illum. | 5 fc, 20 fc (mirror)<br>Ambient, Task |
| CDR's suite | Bright, formal | Daylight, Physical security, focus on activities, contact with outdoors, relaxation | Activities of varying duration, reading, writing, viewing LCD monitors, paperwork | Day lit, open and enclosed spaces, reinforce command image, horizontal and vertical illum. Bright and intimate areas. | 50 fc<br>Ambient, Task, Accent, Safety/egress |
| Outdoor entry plaza | Well lit directional | Clarity and reference, physical security | Walking, moving, activities of short duration | Well lit, reinforce U.S. and command image, flag illum uplights , or sidelights, glare control highlight approaching vehicles and people, avoid shadowing | 3 fc<br>Ambient, Accent, Safety/egress, Security |
| Interior plaza | Less bright, Intimate, islands | Relaxation, physical security, personal territory | Walking sitting, activities of short to medium duration | Landscape lighting for small intimate areas and uplighting for central monkeypod, ext. wall washers | .2-.5 fc<br>Ambient, Accent, Safety/egress, Security |
| East plaza | Well lit, directional | Relaxation, physical security | Walking, sitting, activities of short to medium duration | Sitting area for food court | .2-.5 fc<br>Ambient, Accent, Safety/egress, Security |
| Outdoor perimeter area | Framing, directional | Physical security, physical orientation for wayfinding, clarity and reference | Walking, seeing stairs | Illuminate fenceline and approach to entry, pole mounted spacing 4-5 times mounting hgt | .2 fc<br>Ambient, Accent, Safety/egress, Security |
| Parking garage | Bright, directional | Physical security/ wayfinding, | Walking, wayfinding, driving, low brightness | Wall washing to improve brightness and contrast | 5 fc<br>Ambient, Accent, Safety/egress, Security |

4.6.3 Lighting Types

An important strategy we took was to separate the illumination requirements for ambient and task lighting in many of the spaces. By accepting lower ambient light levels in the overall space than the light levels needed at the desks, we can use task lighting at the desk to bring the light levels up to that required. The primary daylighting zone was established at 20 ft. from the south exterior wall and 14 ft. from the north wall. Fig. 71 below illustrates four representative occupancy zones; open office bay along the south wall, enclosed office and building support along the north wall, a core space and stairwell at the northwest corner and a conference space at the southwest corner

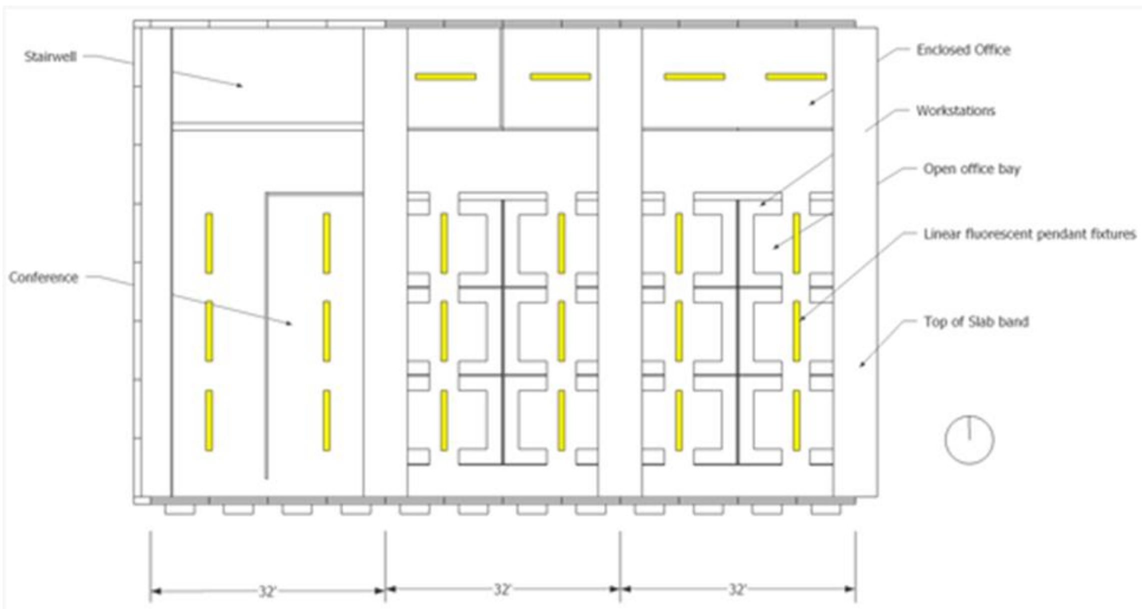



**Figure 71. Proposed ambient lighting plan for four representative spaces. *Source*: SketchUp.**

. In the open office bays, we set up our ambient lighting system by placing 3 high performance T8 liner fluorescent direct/indirect luminaires running perpendicular to the south wall. The office workstations were set up in 12' x 36' modules, with 24 workstations in each module. One linear luminaire serves a 4 desk unit providing lensed direct lighting and indirect uplighting for a total of 6 luminaires per module. Each luminaire has two 25 watt lamps that are dimmable separately. Photo sensors are used to adjust lighting based on available daylight levels and penetration and are placed on the ceiling approximately one window head height width from the wall. The dimming function will allow for gradual and imperceptible dimming so as not to disturb occupants.  In the enclosed offices around the perimeter walls with daylighting windows we will provide luminaires with a single 25 watt lamp and are controlled with a manual switch and an occupancy sensor. The enclosed offices will be provided with lower ambient light levels where occupants rely on task lights to complete work.  The conference room lights are also controlled by occupancy sensors, and the number of luminaires is dependent on room size.

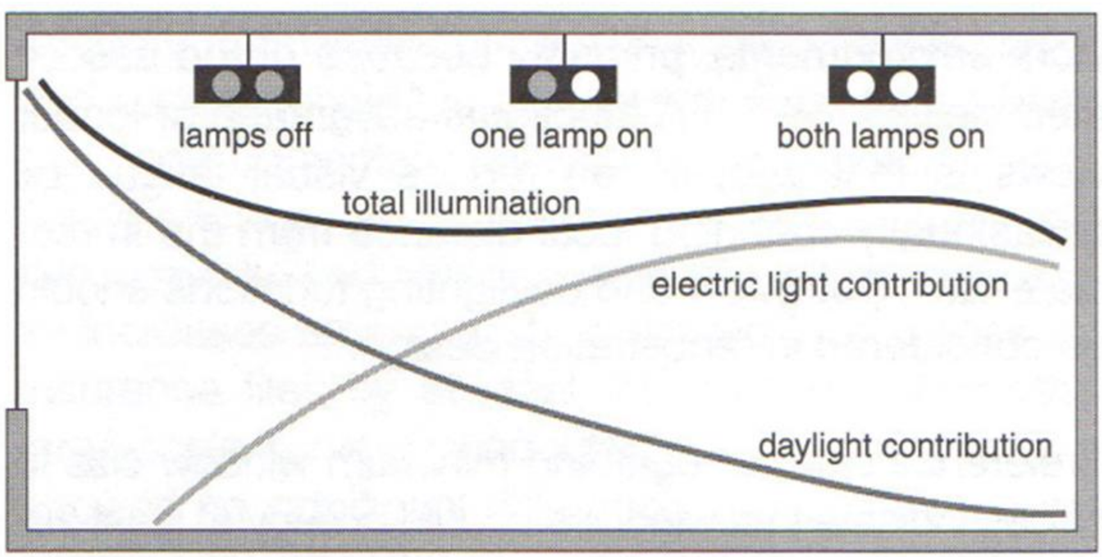



**Figure 71. Daylight integration matrix.** ***Source*****: IESNA Daylighting manual.**

The fixture of choice for almost all of the ambient lighting needs is a variant of the direct indirect linear luminaire because it provides the efficiency of the direct light without the associated poor lighting quality and the uniformity of the indirect uplight, but tempers the increased energy use of the indirect component by combining with a lensed downlight.  The fixtures will be set at 18 inches below the ceiling to ensure uniform illuminance and to facilitate ventilation to keep the fixtures cool.  Each workstation and office will be outfitted with a 6 watt LED task lamp.  For visual comfort, the task illumination will not be more than three times that of the ambient illumination.  The task lamps will be operated by the occupants with manual controls but augmented with occupancy sensors.  The light will turn off automatically if unoccupied or switched off manually.

Accent lighting will be kept to a minimum and will be used to highlight the aesthetic features of the building and also art and memorabilia.  Accent lighting will also be used to complement safety/egress lighting along the corridors where artwork, portraits and the memorabilia are placed and to accent structure which will facilitate wayfinding and provide visual interest. The main entry atrium will have large images that will be highlighted. The accent lighting will have the lowest wattage fixtures possible and rely on LED systems. Occupancy sensors ensure the accent lights are on only when people are present in the space. . Lastly, ambient light levels will be reduced near accent lighting to improve contrast.[58]

Security and safety lighting will also be the lowest wattage possible to provide the required light levels. Again occupancy sensors will be used to ensure safety lighting is only on when people are present in the respective space. An important aspect of safety and security lighting is that they need to be on their own dedicated circuits and in the case of the security lighting, powered by a backup power system. This adds an extra layer of lighting demand that the ordinary office building does not normally have, but ensuring we use the lowest wattage necessary, high efficiency fixtures and light levels no higher than required we will achieve the same efficiencies in our security lighting component of the overall lighting load.

### 4.6.4 Lighting Controls

The two main lighting control strategies used are to ensure they the lights not on when people are not present and there is no other lighting requirement, and daylighting controls. The first is accomplished with vacancy sensors, which are different from occupancy sensors in that you must manually turn on the lights and then they can either be manually turned off or after a set period when vacancy is detected the lights are turned off automatically. The daylighting controls have been described earlier, they work with photo sensors, but can work with the vacancy sensors to ensure the lights are turned off when no one is present. These control strategies, minimize reliance on human beings to turn off the lights when they vacate, but it requires they turn them on when they are needed vs. turning them on regardless of light levels and need.

[58] Sarah Farrar-Nagy, and Sheila J. Hayter. *Los Alamos National Laboratory Sustainable Design Guide*. (LANL Site Planning and Construction Committee, 2002) 87

#### 4.6.5 Designed Lighting Power Densities

A reduction in lighting power density can be achieved by the use of energy efficient lighting systems, daylighting and integration and layout of ambient and task lighting with daylighting, use of controllers and occupancy sensors and LED/CFL lamps. The Lighting power density for the whole building is 1.0 W/ft$^2$ in the baseline. The baseline assumes a basic lighting layout with manual switches and minimal daylighting assistance. By utilizing the ECMs above we could achieve an LPD of .75 W/ft$^2$ which represents a **25%** reduction in lighting density. Use of occupancy sensors in selected spaces has shown to reduce peak LPD by 16.8% over the baseline.

Daylight harvesting allows us to minimize the load by lighting perimeter spaces with natural light and allowing us to use less electric lighting. An integrated system also allows us to use less light closer to the exterior wall and to adjust the light levels to make up for reduced light levels due to sky cover or changing lighting conditions.

**Table 68. Lighting ECMs**

| **Lighting Energy Conservation Measures** | |
|---|---|
| In Design | Other ECMs |
| Improved Lighting Power Density | LED Lamps |
| Integrated controllers/Occupancy sensors | |
| Daylight Harvesting | |

### 4.7 Miscellaneous Plug Loads

Miscellaneous electrical equipment is considered a large energy end user. In office buildings, plug loads can be 25% of total building energy consumption.[59] In the proposed approach we will ensure we have right-sized equipment. For example, selecting laptops instead of desktop PCs for certain workstations reduces the energy use as laptops require less energy. Secondly, we will ensure we maximize use of highly energy efficient equipment when able. Energy Star rated equipment are prescreened and provide initial estimates of energy use per

[59] Chad Lobato, Shanti Press and Micheal Sheppy. Reducing Plug and Process Loads for a Large Scale. Low Energy Building. (Lecture: ASHRAE Winter Conference Las Vegas, NV. Feb 2011) 5

year. The below table illustrates plug load calculations for the baseline and proposed design for the building's south wing with an occupancy of 250 staff. Note that both rightsizing and energy efficiency are reflected in the laptop and desktop categories. In the baseline there are roughly the same amounts of laptops and desktops and both indicate lower efficiencies than the proposed approach. When moving to the improved conservation measure you have the same number of PCs but fewer desktops than laptops, more efficient systems and a combined plug load reduction of 3407 W. The chart illustrates a **27%** reduction in plug load density from .74 W/ft$^2$ to .55 W/ft$^2$

**Table 79. Office equipment plug loads and overall plug load density efficiency**

| **Office Equipment** | Typical office bldg. | | | Notional design proposal | | |
|---|---|---|---|---|---|---|
| Plug Load | Qty | Plug load per (W) | PL Total (W) | Qty | Plug load per (W) | Plug load (W) |
| Computers- servers | 8 | 65 | 520 | 8 | 54 | 432 |
| Computers – desktop | 134 | 65 | 8710 | 89 | 54 | 4806 |
| Computers - laptop | 134 | 19 | 2546 | 179 | 17 | 3043 |
| Monitors –server - LCD | 8 | 35 | 280 | 8 | 24 | 192 |
| Monitors – desktop - LCD | 268 | 35 | 9380 | 268 | 24 | 6432 |
| Laser printer | 8 | 215 | 1720 | 8 | 180 | 1440 |
| Copy Machine | 4 | 1100 | 4400 | 4 | 500 | 2000 |
| Fax machine | 8 | 35 | 280 | 8 | 17 | 136 |
| Water Cooler | 8 | 350 | 2800 | 8 | 193 | 1544 |
| Refrigerator | 8 | 76 | 608 | 8 | 65 | 520 |
| Vending machine | 4 | 770 | 3080 | 4 | 770 | 3080 |
| Coffee maker | 4 | 1050 | 4200 | 4 | 1050 | 4200 |
| Misc. equip | 30 | 30 | 900 | 30 | 30 | 900 |
| Other small appliances | 250 | 4 | 1000 | 250 | 4 | 1000 |
| TOTAL Plug load | | | 40,424 | | | 29,725 |
| **Plug load density, W/ft$^2$** | | | **0.75** | | | **0.55** |
| | | | | | | |

***Source:*** **DOE Energy Design Guide parameters.**

Another efficiency measure is to use auto power management of some equipment. This includes occupancy sensors controlling equipment, and power controllers on equipment such as vending machines and coffee makers.

**Table 20. Plug load ECMs**

| **Plug load Energy Conservation Measures** | |
|---|---|
| In Design | Other ECMs |
| Right-sized equipment | |
| Energy efficient/Energy Star equipment | |
| Power management of computers and equip | |

## 4.8 HVAC

Having reduced the cooling load in earlier design stages by neutralizing the envelope, minimizing heat gain from inside (equipment) and out (solar/thermal gains) and reducing lighting density and the resulting heat, we can now propose a right sized efficient HVAC system to address the remaining cooling load. Several alternatives were assessed and two potential systems with the best prospects were selected, the all air VAV system and a combination DOAS and hydronic radiant cooling system. These two were further considered and one was selected for the main system based on projected ability to address the most challenging issue in climate zone 1A, humidity and similarly to provide a ventilation system that was rapidly controllable for CBR protection and the other for specific requirements relating to large assembly spaces. Several studies have shown that Dedicated Outdoor Air Systems' (DOAS) ability to dehumidify air in hot humid climates exceeds the Variable Air Volume (VAV) systems.[60] This is due to the inability of the VAV to adequately handle and condition the volume of air to the extent needed to….[61] Therefore, the DOAS system with a parallel radiant cooling system will be used in addition to other energy efficiency measures that will make the proposed system even more efficient.

[60] Mumma, 28
[61] Mumma, 28

4.8.1 Baseline HVAC

Based on an analysis of CBECS data, it was determined that office buildings with the size of the medium office prototype primarily use packaged rooftop variable air volume (VAV) heating and air conditioning equipment.

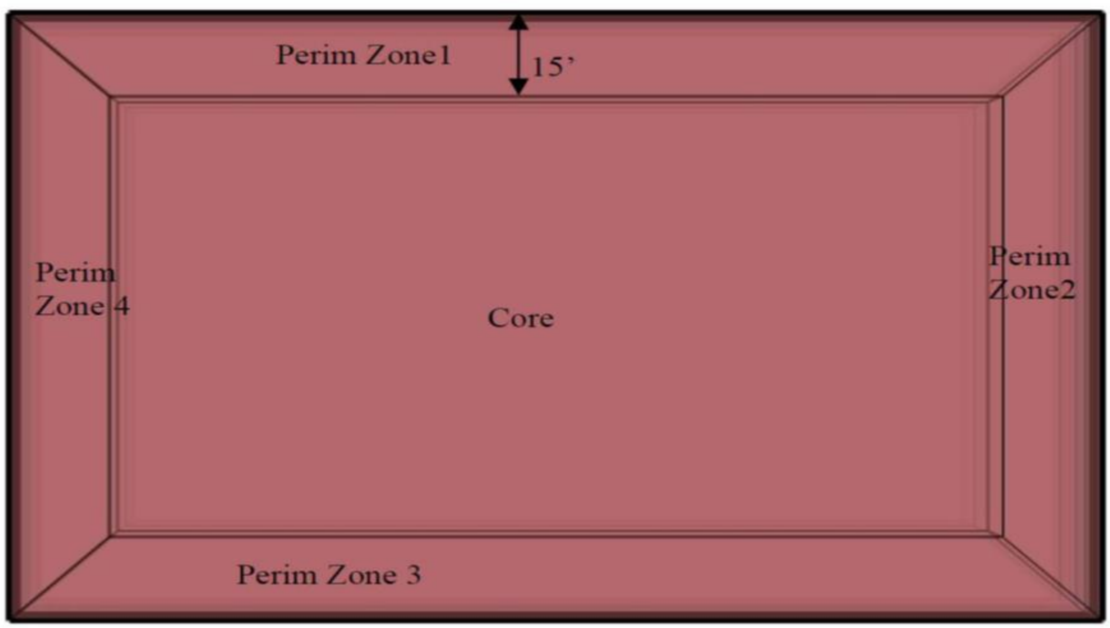



**Figure 73. HVAC Zoning Map for Medium Office Building.** ***Source*****: DOE Energy Design Guide parameters.**

The operating schedule is based on the building occupancy. The system is scheduled "on" 1 hour prior to occupancy to pre-condition the space, and the system is scheduled "off" 1 hour after most occupants leave (Figure X). When the system is "on", the fan runs continuously to supply the required ventilation air, while the compressor and furnace cycle on and off to meet the building's cooling and heating loads. During off hours, the system will shut off and only cycle "on" when the setback thermostat control calls for heating or cooling to maintain the setback temperature. A single HVAC system schedule is used for all the packaged units in the building.

The building is also divided into five thermal zones on each of the three floors. The zones are established using a "four and core" approach with each orientation defining a perimeter zone that extends from the exterior wall inward for 15 ft. Each floor is served by an individual HVAC system. Figure 73 shows a zoning map of the medium office building.

The systems maintain a 70°F heating set point and 75°F cooling set point during occupied hours. During off hours, thermostat setback control strategy is also applied in the baseline prototypes, assuming a 5°F temperature setback to 65°F for heating and 5°F temperature setup to 80°F for cooling.

Equipment sizing refers to the method used to determine the capacity of the DX cooling coil, furnace and supply fan airflow in the packaged rooftop unit. The baseline model uses a "design day" method for sizing equipment.

The Standard specifies HVAC equipment efficiency based on heating and cooling capacities. For single packaged equipment with cooling capacities less than 65,000 Btu/hr. (19 kW), efficiency is rated by seasonal energy efficiency ratio (SEER), which represents an average efficiency throughout the year. SEER is defined as the total cooling output of an air conditioner during its normal annual usage period for cooling (in Btu) divided by the total electric energy during the same period (in Wh). Larger cooling equipment with cooling capacities greater than 65,000 Btu/hr. (19 kW) is rated by energy efficiency ratio (EER), which represents efficiency at a particular design condition, and is defined as the ratio of net cooling capacity in Btu/hr. to total rate of electric input in Watts at rated conditions.

The Standard specifies maximum fan power allowances for fans with motors exceeding 5 hp (3.73 kW). Based on system sizing runs, all of the fan systems in the medium office baseline had motors in excess of 5 hp (3.73 kW). In the Standard, the maximum fan power allowance is expressed as a total fan system horsepower per supply fan airflow in cfm. Fan system power is based on the total of supply fans, return fans, and exhaust fans. Because the medium office building includes only supply fans, this requirement is a maximum allowance for the supply fan motor. According to the Standard, the maximum allowance is 0.0017 hp /cfm for systems with supply air volume less than 20,000 cfm and 0.0015 hp / cfm for systems with supply air volume greater than 20,000 cfm. In the Medium Office baseline, there are supply fans both below and above the 20,000 cfm threshold depending on served thermal zones and climate locations.

Outdoor air ventilation requirements used in the baseline were as required by ASHRAE Ventilation Standard 62.1-2004. Standard 62.1-200 provides a methodology for calculating the ventilation requirements for offices with HVAC systems that include multiple zones. Initially, airflow is calculated based on 0.06 cfm/ft2 of floor area plus 5 cfm per person. Assuming typical office occupancy rates of 5 people per 1,000 square feet (gross), the ventilation rate for the baseline medium office building is 0.085 cfm/ft2 of gross area. This is adjusted for critical zones and ventilation effectiveness resulting in a ventilation rate of 0.1115 cfm/ft2. In climate zones 1, 2, and 3, where gravity dampers are allowed by the Standard, the dampers were simulated as being open to minimum position whenever the HVAC system is running, even when the building is unoccupied.

### 4.8.2 System Design

#### 4.8.2.1 Program Space Requirements

**Table21. HVAC program for space types and areas.**

| **HVAC Program chart** | | |
|---|---|---|
| Space | No. Occ | Space comment |
| Entry Atrium, visitor access control | 10 | Vestibule or other access control device, tall space, large amount of glazing, transient occupancy |
| Public and connector spaces | 10 | Glazing in connector space, transient occupancy |
| General circulation | 10 | interior circulation along south wall is projected to be used much, main circulation is along north side of open office bay, stairwells no AC just vent, transient occupancy |
| Open office bay | 250 | Not occupied at all times, higher loads during normal working hours, human comfort important, no individual control over systems |
| Enclosed office | 65 | Not occupied at all times, individual temp adjustment, SCIFs enclosed, others no intermediate ceiling for radiant systems and air circulation |
| Retail | 10 | Open to outside elements, transient occupancy except small staff |
| Food court | 25 | Outdoor/indoor with vestibule, |
| Gym | 30 | Operable windows, no AC ceiling fans, maximize daylight |

| | | |
|---|---|---|
| Auditorium | 100 | Enclosed, rapid buildup of personnel, high internal cooling load |
| Conference | 35 | Both enclosed and daylit. Adjacent to enclosed and open office |
| Core spaces | 2 | Windowless, no AC, insulated ducting, vert/horizontal |
| Building support | 10 | Various types |
| Command center | 35 | Enclosed, redundant HVAC and UPS |
| Data center | 2 | Hot aisle, under floor distro, ceiling vent, north wall, windowless |
| Bathrooms | 2 | Core, no HVAC, vented |
| CDR's suite | 12 | Daylight, extra glazing, kitchen, conference, open and closed office |

#### 4.8.2.2 Zoning

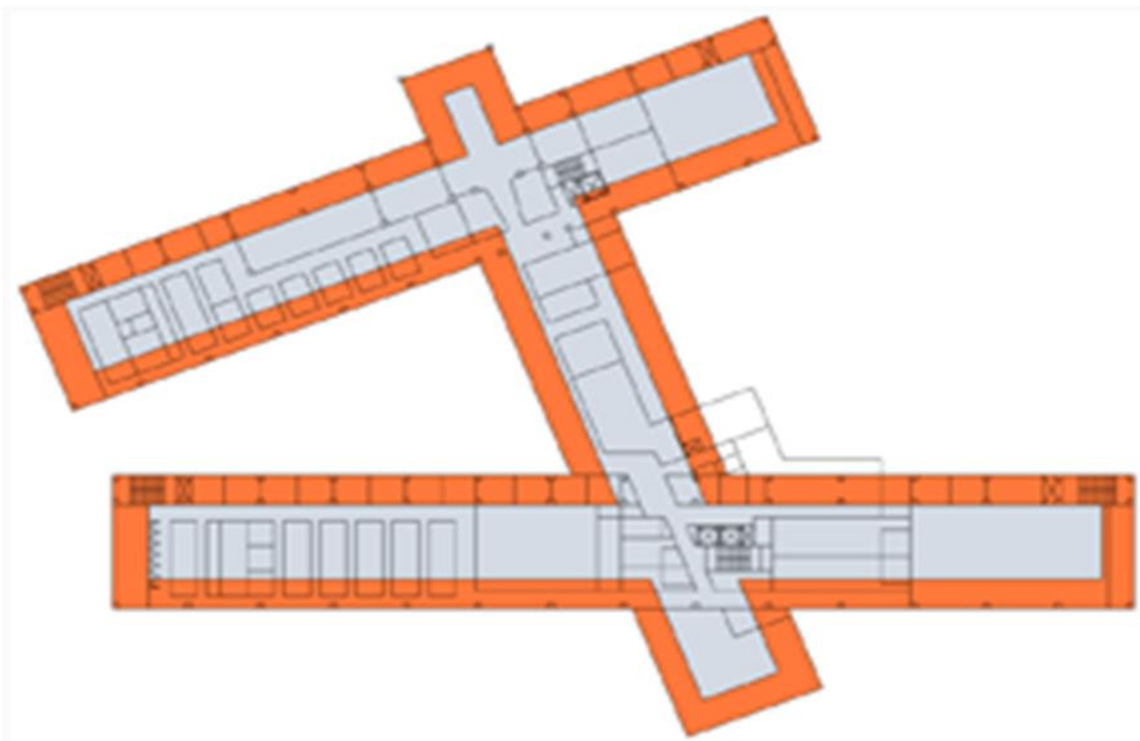


**Figure 74. Perimeter and interior thermal zoning. *Source*: SketchUp.**

The program space requirements provided minimum conditions of temperature and humidity. We then grouped spaces with similar space conditioning requirements into single zones to the greatest extent possible. HVAC systems were then assigned to the zones. Most of the headquarters building was enclosed with inoperable windows due to design requirements.

Some of the building support spaces were naturally ventilated with HVAC conditioning and some had no conditioning requirement. Normally, we would calculate space loads based on these zones with simulation tools, but for this project we will use rules of thumb in order to derive "ball park" data to determine the necessary capacity of the HVAC equipment. A big consideration was how the grouped zones were affected by internal and external loads. To get a good idea of these effects, a perimeter zone and interior zone was over laid on the floor plan to see the relationship of the grouped zones to these loads. The perimeter zone extended 14' in from the exterior walls and the interior zone consisted of the remaining floor area inside of that. We have shown that our envelope design and daylighting plan has reduced the associated loads through the envelope and from solar heat gain associated with direct sunlight. However, a relatively higher external gain should be expected from the perimeter zones. In the interior zone it was expected that internal loads would predominate, but with the increased efficiency lighting, efficient equipment and use habits with much lower heat output and an overall more efficient envelope affecting the entire building, we set ourselves up for requiring lower capacity HAVC systems.

#### 4.8.2.3 Systems and Security

The hydronic cooling system will consist of water cooled chillers and a cooling tower with a high Coefficient of Performance (COP). As discussed earlier, there are several options for the radiant cooling, the preferred method is core cooling in which the hydronic tubing is embedded in the concrete floor, which requires a clear area and few obstructions below the ceiling to facilitate the radiant cooling. The DOAS will consist of packaged fresh air units which will be placed on the roof tops of the north and south wing as well as the connector space closest to their respective zones. The packaged VAV unit servicing the auditorium will be placed over the north end of the auditorium where the structure permits. The system design provides for both highly energy efficient systems that also satisfy the security requirements of CBR protection, command center isolation, Special Compartmented Information Facility (SCIF) ventilation control , Collective Protection (COLPRO) requirements. For the most part no conflicts exist between sustainable and security criteria because the proposed systems provide excellent solutions to both.

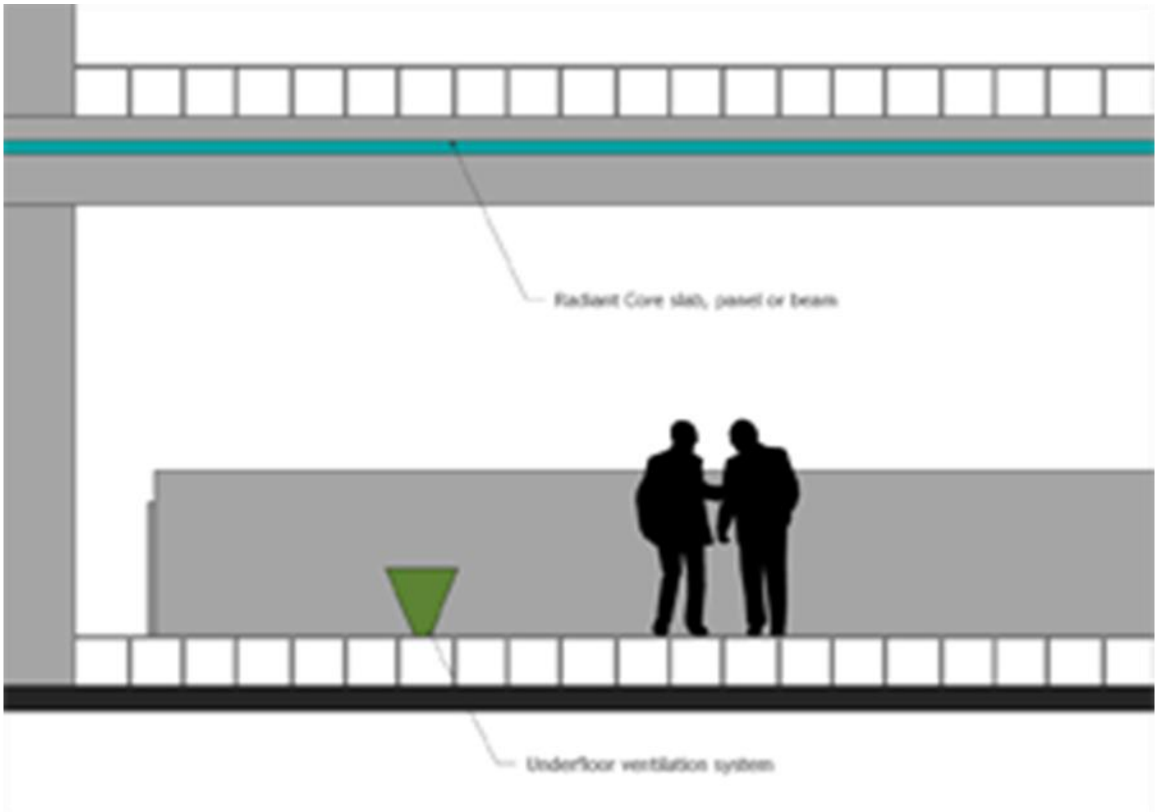


**Figure 75. Raised floor air distribution section and radiant slab illustration.** ***Source:*** **SketchUp.**

4.8.2.4 Sizing and Distribution

The core spaces are placed to provide efficient and unobtrusive horizontal and vertical distribution conduits. Because it is a core cooling system and a DOAS underfloor distribution, suspended ducting is reduced greatly. The core cooling distribution starts at the vertical core space intersections of each floor and is distributed through tubing embedded in the concrete screed or core. The underfloor DOAS distribution is highly flexible and unimpeded by structure and minimizes its adverse effects on daylighting and air flow in the space if suspended.

For the proposed VAV and DOAS systems, single packaged units are available and for the size of this headquarters, are ideal for their flexibility. Two VAV, five DOAS and one Computer Room Air Handling (CRAH) packaged units are proposed. The two VAV units will be used in zones that require rapidly increased air volumes with highly varying occupancies, the auditorium and Commander's briefing space. For unit sizing efficiency, immediately adjacent spaces with similar characteristics will also be serviced by these units, to include the access control area and wargaming and exercise center.  The 5 DOAS zones primarily consist of the office spaces, both open and closed offices and some building support areas.  The command center occupies one of the DOAS zones and also consists of a redundant backup unit.


**Figure 76. Building core spaces layout. *Source*: SketchUp.**

The data center size is based on a rough estimate of computer room requirements that may still exist based on the DoD national data center consolidation program.[62] The HVAC requirements in a hot humid climate are addressed by providing a high performance CRAH system and appropriate configuration and is discussed in more detail in the data center design section. Table 22 lists zones, space types and areas, and unit sizes and capacities.

[62] DoD Data Center consolidation initiative, http://www.doncio.navy.mil/TagResults.aspx?ID=118, (accessed 10 April 2013) reduce DoD data centers for cost savings and cyber security.

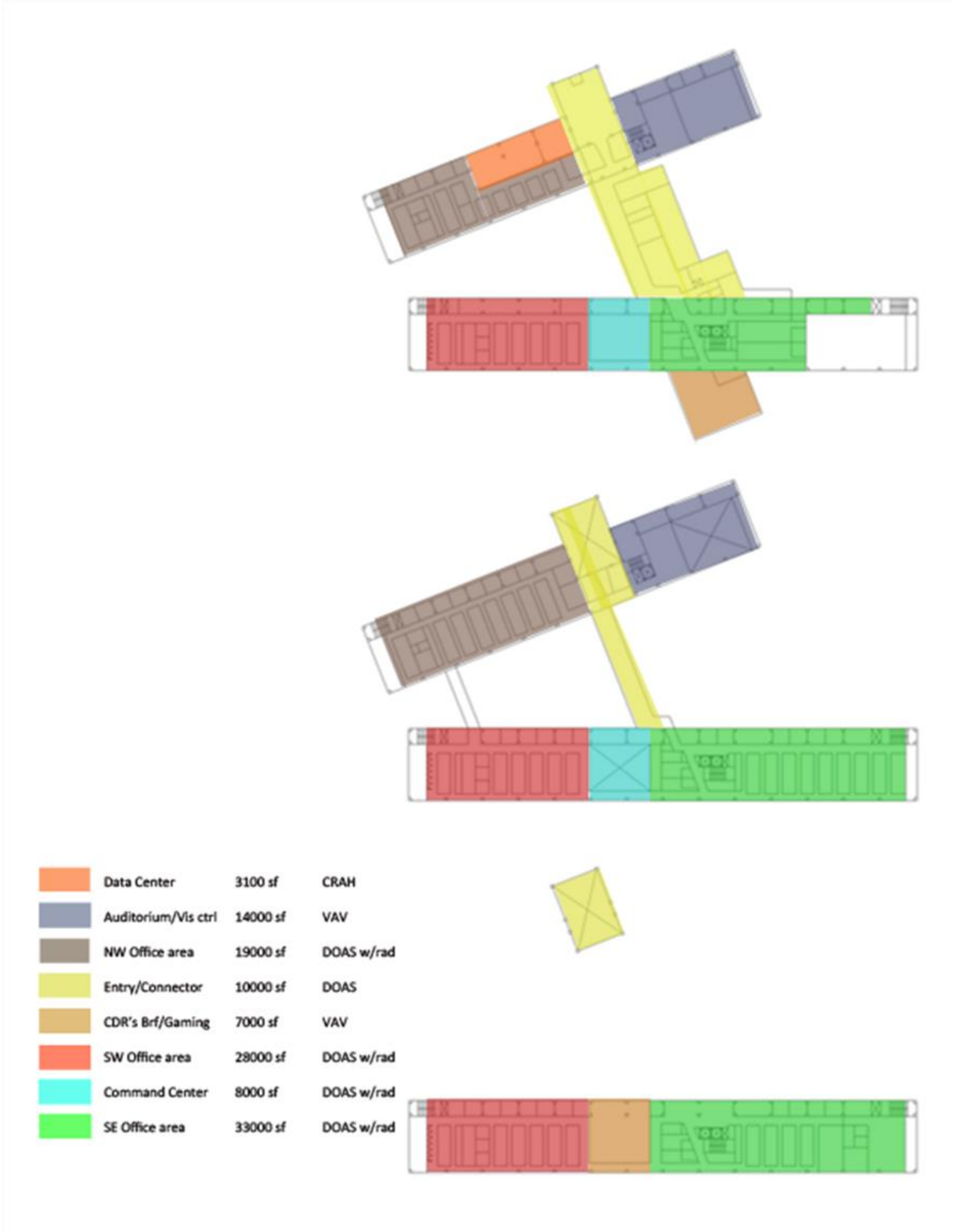



**Figure 77. HVAC zones and proposed systems.**

**Table 22. HVAC zones and proposed systems.**

| Zone(s) | Area ($ft^2$) | System/Packaged Unit size (L/W/H) | Capacity (tons) | Sys.cooling air Vol. (CFM) | Chill water plant area total[1] ($ft^2$) | Cool twrs area total[1] ($ft^2$) |
|---|---|---|---|---|---|---|
| 1. Auditorium/ Access Control (2 flrs) | 14000 | VAV (25'/7'/5') | 48 | 25000 | 350 | 60 |
| 2. Data Center | 3100 | CRAH (10'/7'/5') | <10 | <1000 | 70 | <10 |
| 3. Entry/Connector (2 flrs) | 10000 | DOAS (20'/7'/5') | 38 | 15000 | 280 | 48 |
| 4. Command Center (2 flrs) | 8000 | DOAS w/radiant core cooling (x2) (17'/7'/5') | 22 (22) | 10000 | 150 (150) | 28 (28) |
| 5. CDR's briefing/Gaming Center (2 flrs) | 7000 | VAV (11'/7'/5') | 20 | 12000 | 140 | 25 |
| 6. NW Office area (2 flrs) | 19000 | DOAS w/ radiant core coiling (25'/7'/5') | 48 | 20000 | 350 | 60 |
| 7. SW Office area (3 flrs) | 28000 | DOAS w/radiant core cooling (36'/8'/8') | 71 | 35000 | 500 | 90 |
| 8. SE Office area | 33000 | DOAS w/radiant core cooling (40'/8'/8') | 90 | 40000 | 690 | 102 |
| Totals: | 125000 | | CRAH: 10<br>VAV: 68<br>DOAS:291 | CRAH:<1000<br>VAV: 37000<br>DOAS:120000 | 2530 | 423 |

1. Chilled water plants and cooling tower areas can be combined to determine number of plants and towers needed

### 4.8.3 Design Efficiency Measures

Some specific efficiency measures for Hawaii's climate include a DX cooling coil that provides deep cooling in the system, which is important in the DOAS in hot humid climates. As moisture control is so important in this environment, the DX cooling coil provides the cooling necessary without the condensation problems.[63] Energy Recovery Ventilation (ERV) can also be employed and is a component that reclaims energy from exhaust airflows to precondition the outdoor ventilation airflows. This allows heat and moisture transfer between the exhaust air and the outdoor air. Despite increases in fan energy required the overall energy efficiency gains are sufficient enough to warrant ERV use in climate zone 1A.[64] Motorized outdoor air dampers served two purposes, first it provided an additional efficiency measure but also provided the outdoor air control required of CBR protection requirements. The motorized dampers allow outdoor air intake to be shutoff during unoccupied periods. In addition to this measure Demand Controlled Ventilation (DCV) is proposed which modulates the amount of outdoor ventilation air in response to actual occupancy in the zones as it varies during the day. $CO_2$ sensors can be used to measure changes in occupancy

**Table 23. HVAC ECMs**

| **HVAC Energy Conservation Measures** | |
|---|---|
| <u>In Design</u> | <u>Other ECMs</u> |
| Dedicated Outdoor Air System | Radiant cooling/Thermal mass |
| DX cooling coil[1] | |
| Energy Recovery Ventilation (ERV)[1] | |
| Motorized outdoor damper[1] | |
| [1]Augments design solution HVAC system | |

[63] U.S. Dept. of Energy. *Advanced Energy Design Guide for Small to Medium Office Buildings: Achieving 50% Energy Savings Towards a Net Zero Energy Building.* (Atlanta: ASHRAE, 2011) 170

[64] Pulsifer, J. E., A. R. Raffray, and M. S. Tillack. "Improved Performance of Energy Recovery Ventilators Using Advanced Porous Heat Transfer Media." UCSD-ENG-089. December 2001

## 4.9 Service Hot Water System

### 4.9.1 Baseline Service Hot Water

The baseline service hot water system for the medium office building is defined as a gas-fired storage water heater with a hot water recirculation loop. The equipment meets the minimum equipment efficiency requirements under the Standard. The hot water supply temperature is assumed to be 120°F.

The typical hot water use for office buildings is 1 gallon (3.8 L) per person per day, as shown in Table 7 of Chapter 49 Service Water Heating in ASHRAE Applications Handbook. This results in a daily hot water consumption of 268 gallons for the prototype medium office building. From the amount and the profile of daily hot water consumption, the peak hot water flow rate was calculated as 0.832 gpm.

The water heater storage tank volume was sized based on the methodology described in the 2007 ASHRAE Applications Handbook. According to Table 7 of Chapter 49, the maximum hourly hot water demand is about 0.4 gallons per person. This leads to a peak demand of 107 gallon for the modeled prototype office building. Assuming 70% of the hot water in a storage tank is usable[65] , the storage tank capacity is sized as 153 gallons. The simulation includes two tanks of 100 gallons each.

The water heater thermal efficiency was set as 0.80 to match the minimum performance requirement under the Standard for gas storage water heater with rated input ≥ 75,000 Btu/hr.

### 4.9.2 Design Efficiency Measures

For this design the focus was a simple one due the low level of contribution to the overall onsite energy use contribution of service hot water to office building load. Improving thermal efficiency by using high efficiency condensing water heaters and by reducing pipe runs, minimizing circulation losses. Additionally, consideration should be given to using on demand water heaters for needs that are farther away from central core requirements.

[65] ASHRAE Standard 90.1-2007

## 4.10 Energy Sources

### 4.10.1 Renewable Energy

In addition to standard energy sources from the public utility and secondary and emergency local sources, a PV or PV and wind hybrid system can augment the system. Opportunities exist with BIPV, roof mounted and an Array field. The intent is to use all three. Starting with horizontal areas with PV potential; the parking structure, parking areas, roofs and usable open space amount to approximately 400,000 $ft^2$. The parking structure alone accounts for roughly 55,000 $ft^2$ which, if using single-crystal silicon cell panels as shading devices will provide approximately 660,000 W using an average of 6 sun hours for Oahu.

# Chapter 5. Conceptual Design

The conceptual design provides a visual representation of the applied synergistic sustainable, energy efficient and security measures and design responses to Hawaii's climate. The design is prominent in that it is sited in a location on the Makalapa crater rim that affords views of the Koolau mountains and sits above the crater below. Only the Commander's living quarters on base sits higher on an adjacent side of the crater rim. The site plan focuses on leveraging the existing security infrastructure and the size of the site to provide the necessary standoff and green space. With Hawaii's frequent trade winds, shaded outdoor areas in an around the headquarters are used for quiet areas of respite and relaxation. The approach to the formal and ceremonial entrance to the facility is along an access road lined with international flags of the countries in the pacific area of responsibility. The access road punctuates at a flag circle with a central flag staff that carries the state flag and American flag. The road around the perimeter of the flag circle is bordered by a protective berm and bioswale. A large pond or "moat" at the entry atrium that must be crossed echoes the crossing of the ocean to far off ports. It also serves as a water catchment and a fountain in it serves double duty as a visual element and a replacement for a cooling tower. The entry atrium is the only mainly glass enclosed space and is also one of the few spaces that can be naturally ventilated. The actual entry to the space is through a vestibule that serves both to control access and air infiltration. The atrium is a soaring space with murals that depict elements of naval warfare capabilities and historic events. The floor also has a map of the pacific. After passing through visitor control you enter a "hatch" that directs you to the rest of the building. The building consists of two main wings joined by a "connector" space that houses support areas. The north wing is two floors in which the N01, N1, N6 and N4 are located. The south wing is four floors with a commander's suite (Eagles Nest) on the fourth floor. The south wing has the N2, N3, N5 and N00 located in it. Each of the wings is mainly an open bay office space on the south wall and enclosed offices on the north walls separated by the connector space and core spaces in the middle and conference rooms further to the perimeter of the east and west sides. The mainly concrete construction provides tall ceilings and with little ducting due to under floor distribution of air and radiant core cooling, daylighting is optimized. As the buildings are generally oriented on an east west axis and one wing is canted slightly an interior courtyard is created. This courtyard can be accessed from the south parking lot through a reclaimed habitat area and from several exits in each wing and connector space. A food court and retail area is located on the other side of the connector space from the courtyard. It faces North East and takes advantage of the trade winds to the maximum extent possible. A rear staff entry from the parking structure passes by the food and retail area. A rear service access road ends at the receiving area where several support spaces are located including the mail room, which has unique security requirements necessitating placement in protected area. The Eagle's Nest looks out over the Makalapa compound and the extensive green roofs on each of the spaces as well as out toward the ocean and the mountain ranges.

5.1 Site Plan

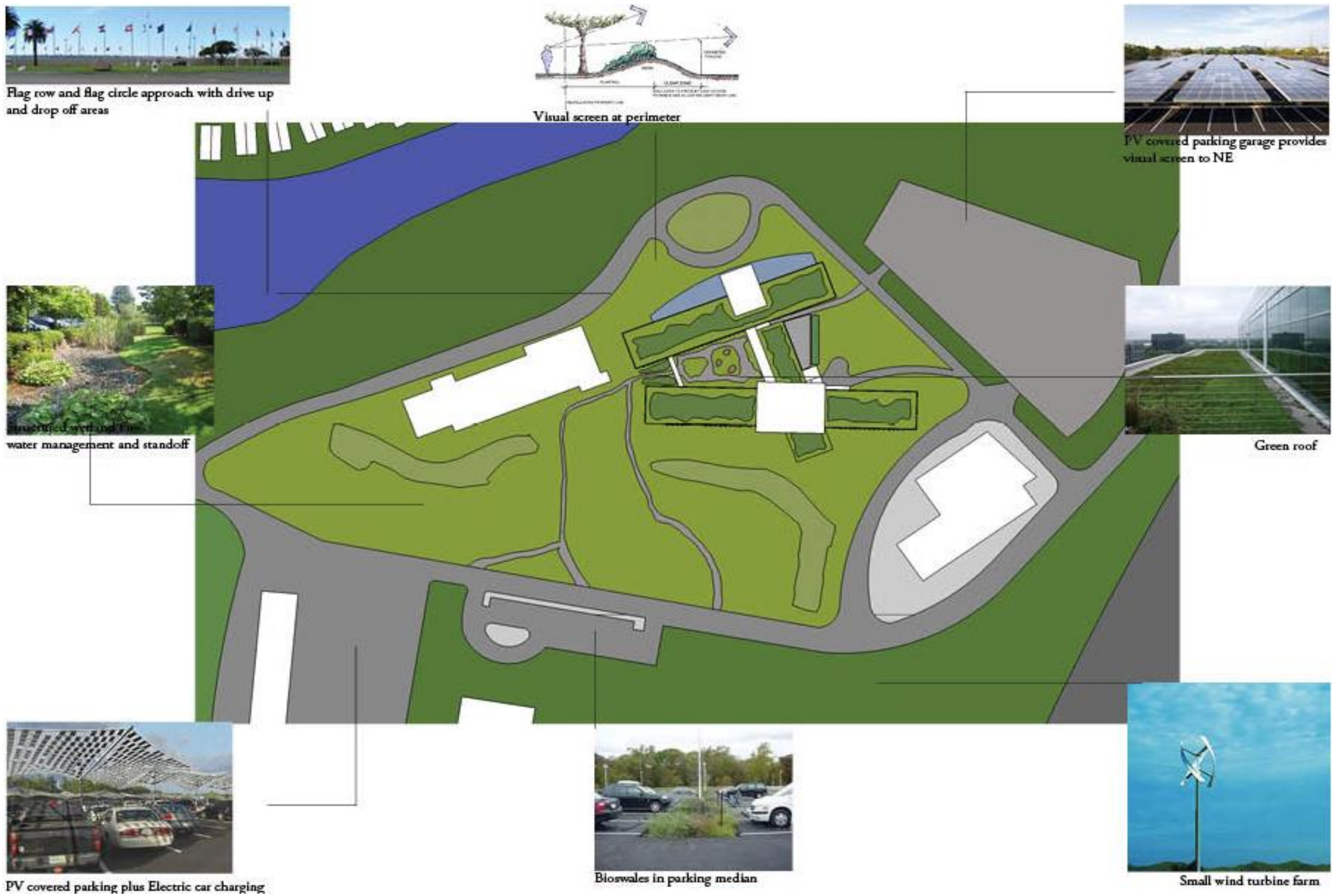



**Figure 78. Proposed site plan and security and sustainable measures.** ***Source*****: SketchUp.**

5.2 Floor Plans

5.2.1 First Floor

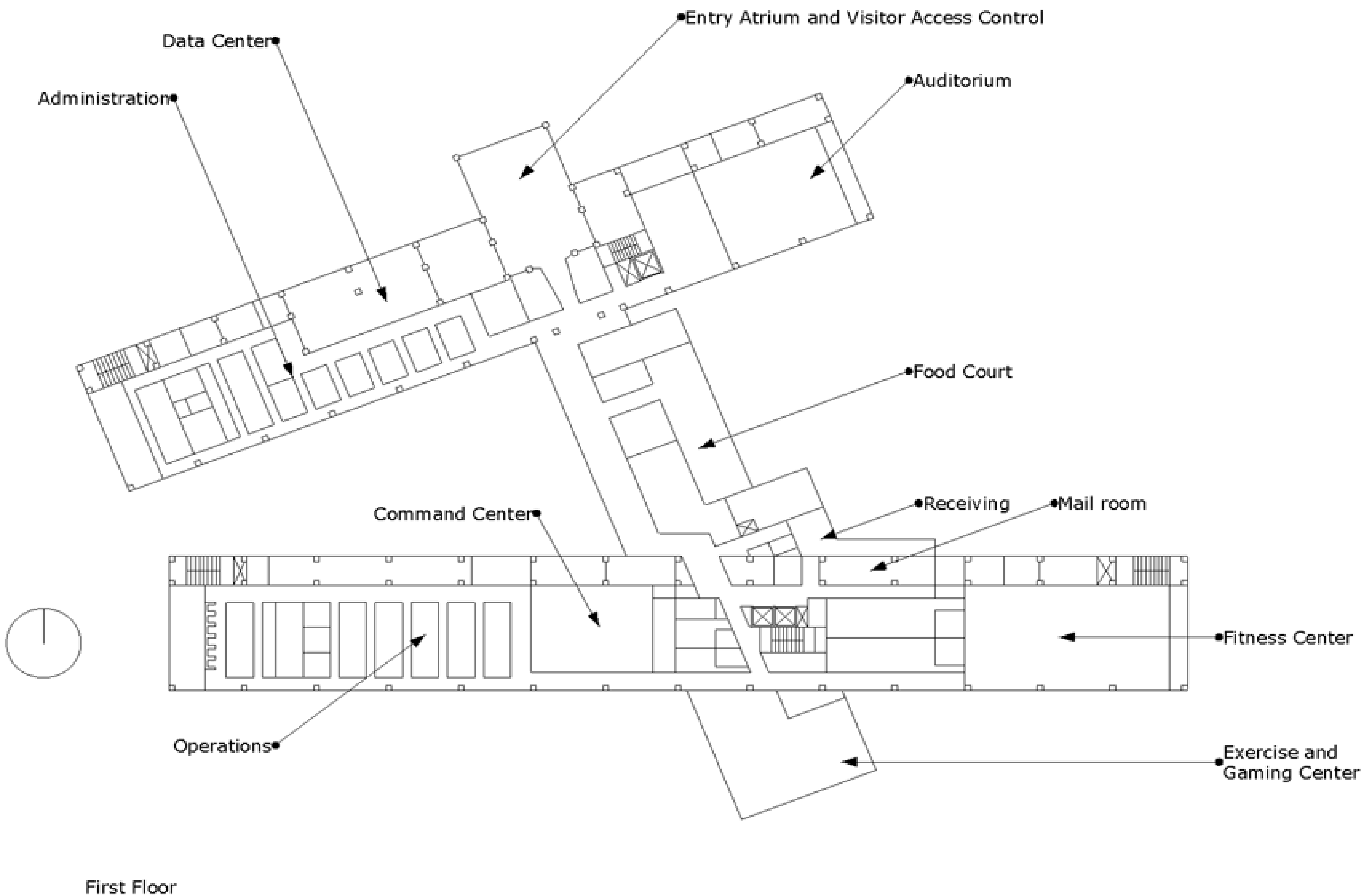



**Figure 79. First floor layout**

5.2.2 Second Floor

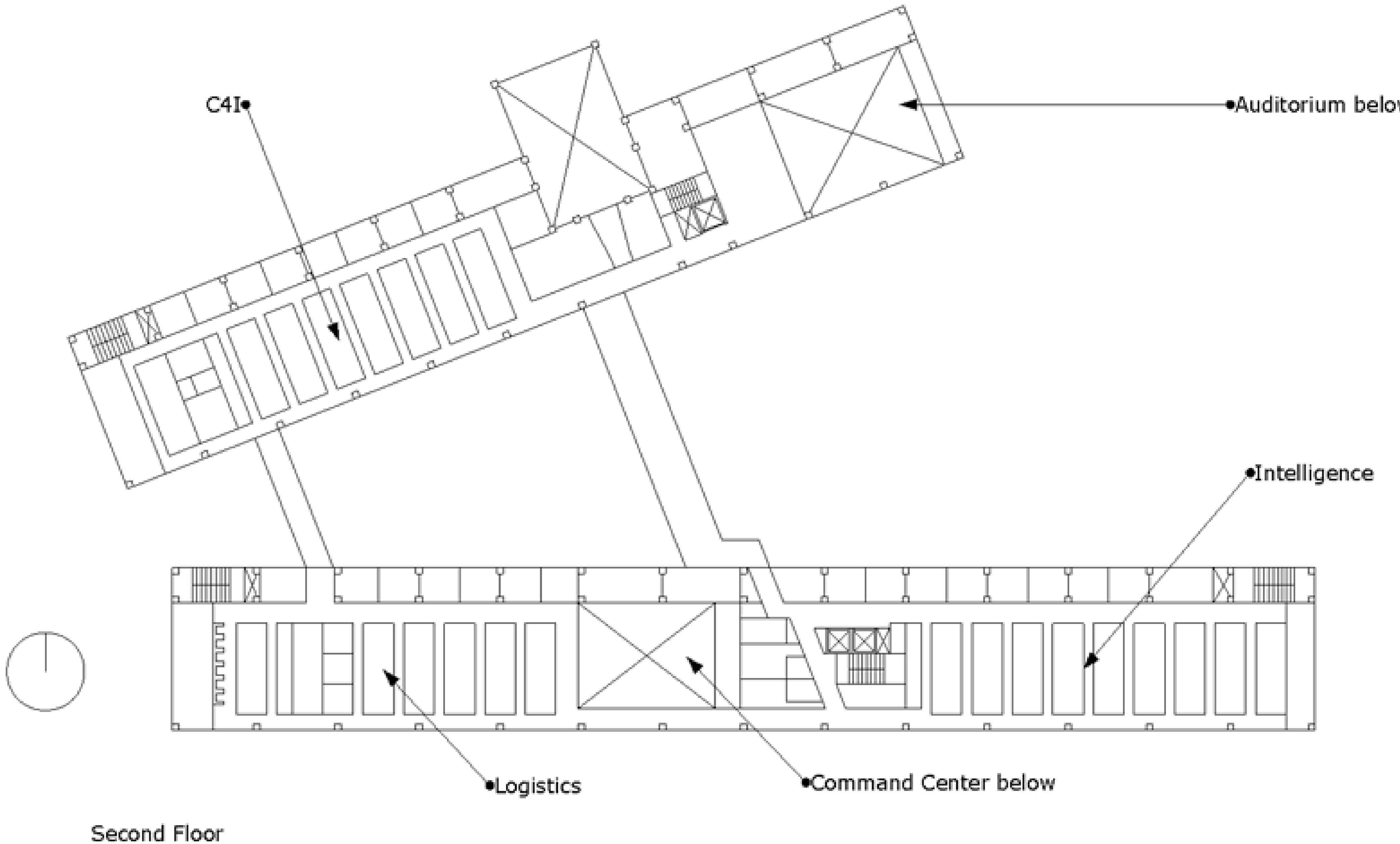



**Figure 80. Second floor layout**

5.2.3 Third Floor

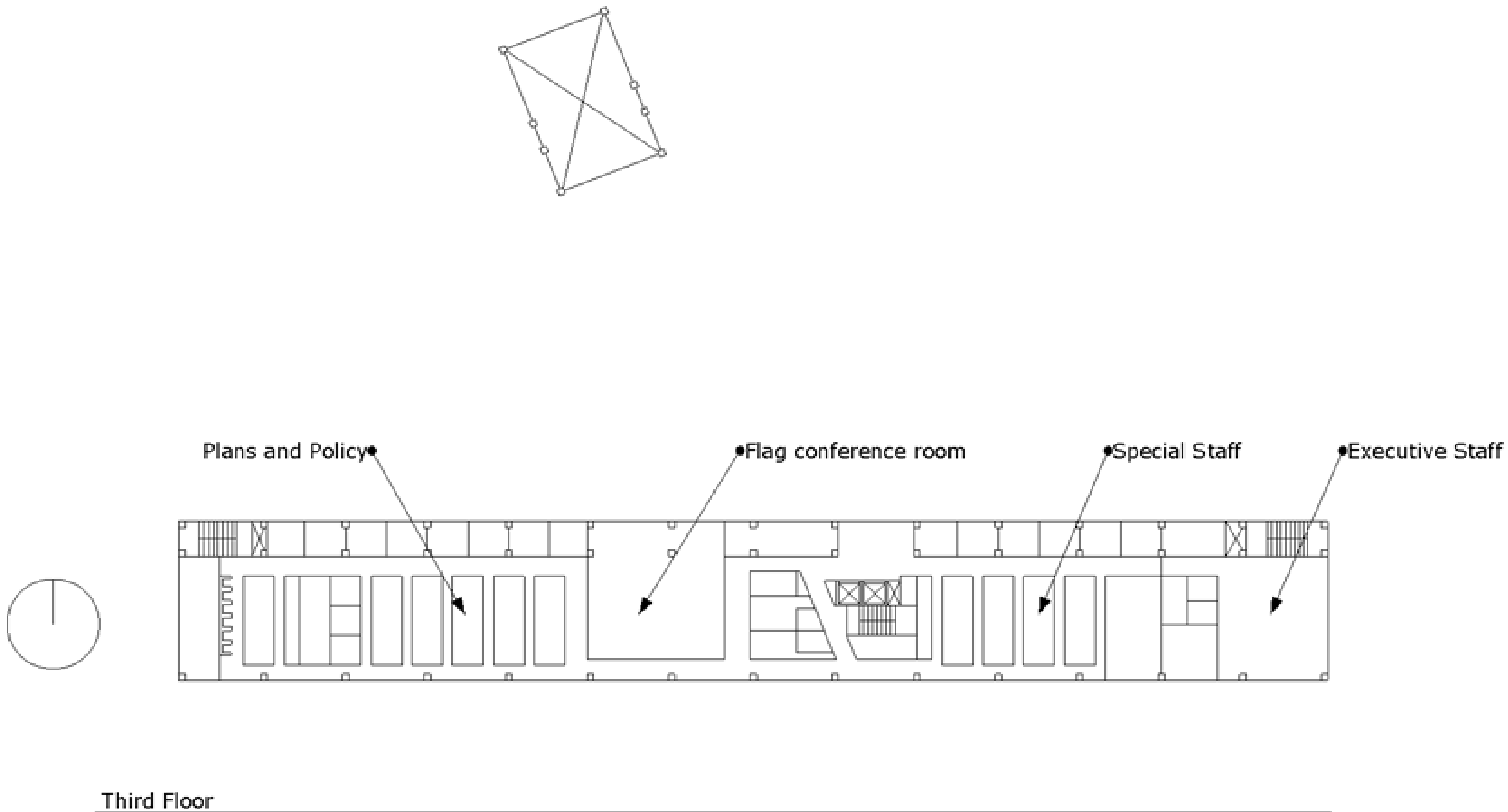
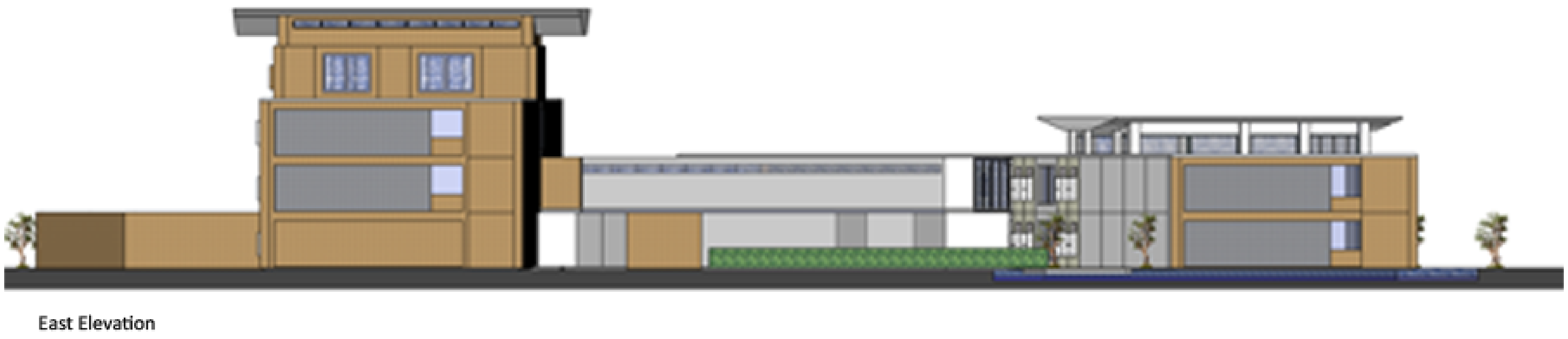



**Figure 81. Third Floor layout**

5.3 Elevations

5.3.1 North and East Elevations

a.




b.


**Figure 82. Elevations: a, East; b, North**

5.3.2 South and West Elevations

a.

South Elevation

b.

West Elevation

**Figure 83. Elevations: a, South; b, West**

## 5.4 Perspectives

Three selected spaces in the design have been chosen because they embody the goals and objectives of this project, which was to create an inspirational, secure, energy efficient and sustainable headquarters building. The entry atrium was chosen because that is the face of the building. The visitor's first impression and also the immediately accessible and generally targeted location. The next location is the command center, the heart and soul of the headquarters. Occupied 24 hours a day and a mission critical space, it also is one of the biggest energy loads due to the number of hours in continuous operation and the IT and data load. The third and an important area because of its prominence and importance is the Commander's Suite. In addition to housing the boss, it is located in the most prominent location in the building; it will host numerous high ranking military leaders, both foreign and U.S., and many diplomats and government officials. Because of its location on the top floor and its vantage point the extensive glazing will create an energy and security challenge.

### 5.4.1 Site

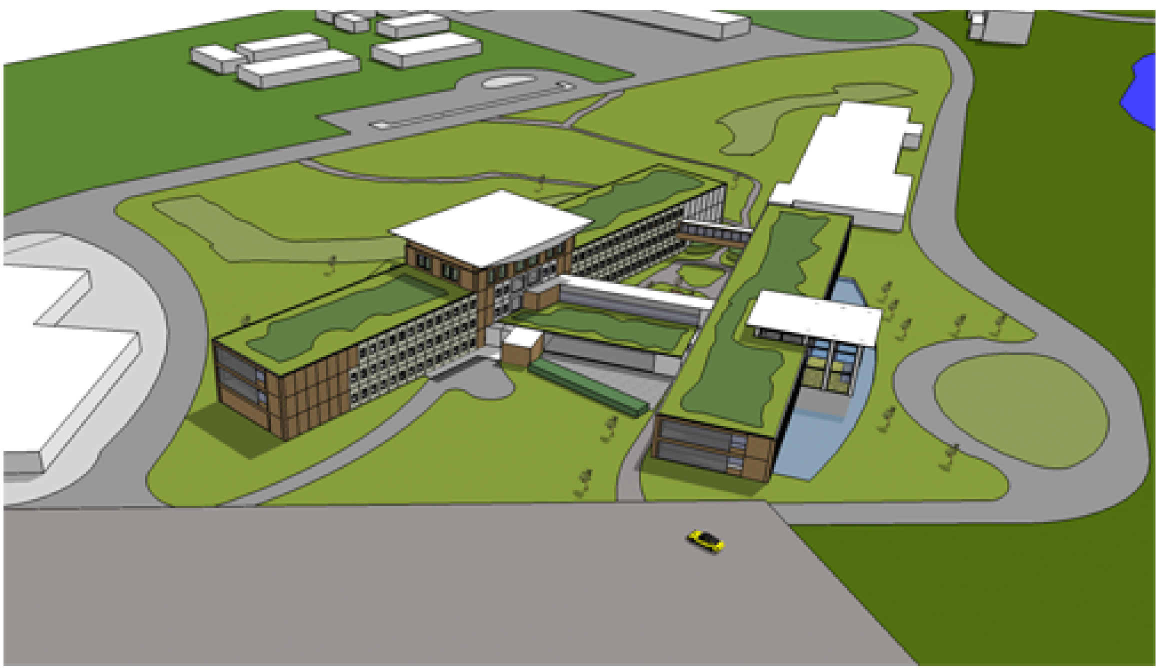


**Figure 84. COMPACFLT Site Plan perspective. *Source*: SketchUp.**

5.4.2 Entry Atrium

The entry atrium area serves as the visitor's welcome to a high level command and control center. The design intent is to have a soaring daylit space that evokes the Navy but with contrasting elements such as; exposed/expressed structural and mechanical elements. This contrasts with the narrow, dark Navy ship passageways ("P-ways") all sailors are used to. The exposed structure and mechanical would echo the same P-ways, but with a modern more high tech look. Additionally, we'll include historical artifacts and murals on the walls depicting common and inspirational scenes from the Navy's history and of modern weapon systems. The

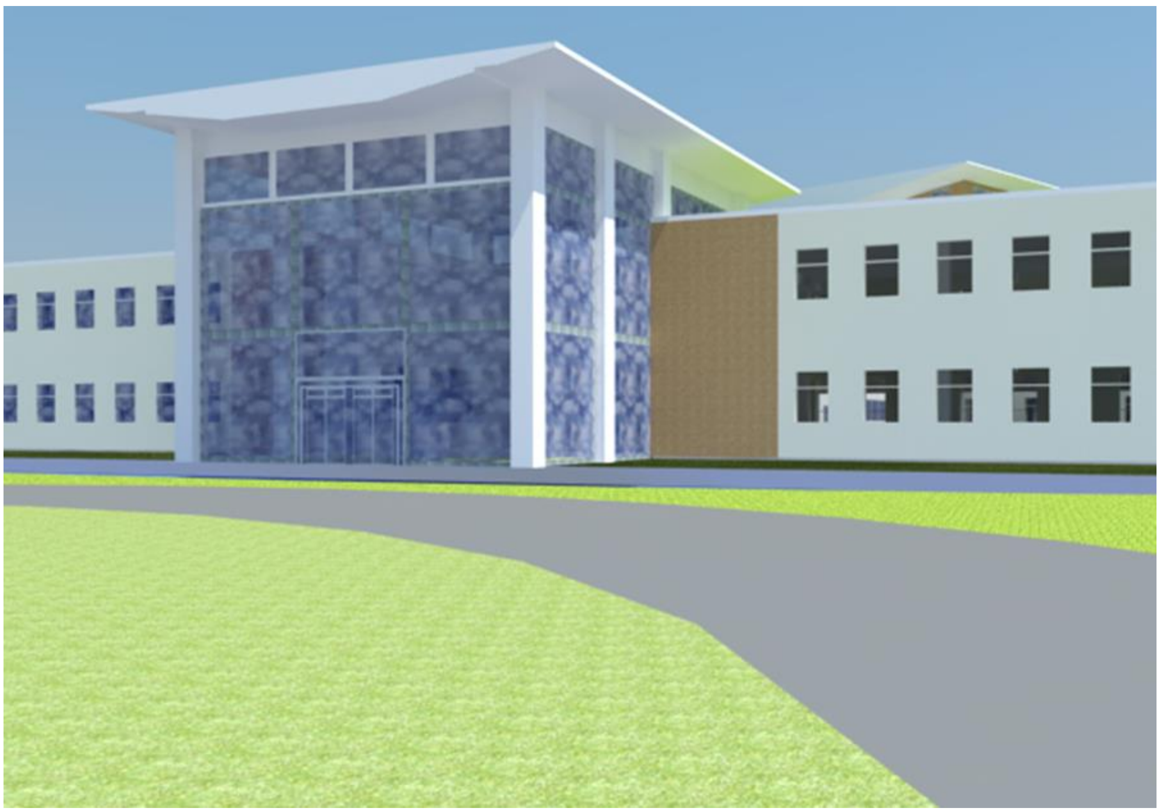


**Figure 85. COMPACFLT Entry Atrium. *Source*: SketchUp.**

character should serve to inspire and motivate occupants and visitors. The security design challenges with such a space are mainly with the glazing, in that it increases the risk of hazardous flying debris in the event of an explosive event and, because the entry faces the perimeter fence, it creates a visual vulnerability or direct line of sight. The sustainable design challenges are mainly the solar heat gain of so much glazing. These two challenges provide an opportunity to attain a design synergy by specifying glazing that is dual paned with lowE glass on the outer pane and laminated[66], tinted glass on the inner pane. Structurally, the frames should be aluminum or steel and primary mullions that span between points of structural support shall be considered supporting frame members. The exterior glass doors shall be designed to the same framing standards as the window wall. To mitigate the direct line of sight vulnerability, the tinting complicates the threat slightly but the perimeter condition in that area will need to be addresses with some screening outside of the standoff area and the unobstructed space. This can be accomplished with a berm or landscape trees/hedge to the inside of the fence line and/or screening material in the fence.

Security requirements at the entry include; access control measures, electronic surveillance systems, Chemical, Biological and Radiation protection by sealing joints and creating air tight envelope. Access control usually takes the form of several security doors accessible with a personal identification card with electronic chip. An entry vestibule will serve as a synergistic measure by proving access control, control air infiltration. Surveillance systems will be both on the interior and exterior of the entry.

Sustainable approaches to be used at the entry can include mitigating the heat gain, which addresses human comfort and energy demand. Materials used are renewable, low VOC and non-toxic.

5.4.3 Command Center

The Command Center will be located in the Operations building and is double story height Because of its importance; the command center needs to be provided dedicated and redundant systems. It will be a large special compartmented information facility with peripheral rooms housing a variety of warfare specialties and will have a large floor to ceiling set of screens for monitoring the pacific area events, assets and current operations and contingencies. It will also have several banks of computer terminals for current operations personnel and watch standers. Access will be controlled and extra structural support will be applied. It will also need to be structured to provide longer spans for the 64’x64’ space. Because it causes a break in the required progressive collapse longitudinal tie system of the overall building it will need to be

[66] Interlayer thickness specified in UFC 4-010-01 DOD minimum Anti-Terrorism Standards for Buildings sect. B-3.1.3.1. pg. 68.

peripherally tied to provide longitudinal tie continuity.  Security challenges for this space include energy security, progressive collapse risk with the increased span requirement of the larger open space, and ventilation and emergency air distribution in extremis.

An obvious and simple synergy is the complimentary requirements of energy security and providing alternative energy sources such as PV.  The PV systems that will be incorporated into the design (BIPV) and the roof top and PV array field will provide up to 60 % of the total estimated building demand. The progressive collapse risk is mitigated with proper ties, an alternative load path and sizing. Sustainable challenges include countering the energy load of the space, addressing the indoor environmental quality of a windowless and sealed space. Utilizing some Biophilic principles, to bring in outdoor scenes is one solution, but also ensuring that as many minor disturbances (odors, background noises/sounds, lighting) as possible are either minimized or eradicated is another.  The main effort should be to ensure non-toxic materials, low VOC paints, soothing colors, adequate filtration; good acoustics are provided and specified.

**Figure 86. Pacific Air Forces Command Center. *Source*: Broadatacom.com**

5.4.4 Commander's Suite, The Eagles Nest

The Commander's Suite should be an extension of the character of the rest of the building, to include the imposing as well as inspirational, it will overlook the command center and provide areas for relaxation, two conference rooms with different characters and functions; one a highly secure briefing space and one an informal meeting room for diplomatic, political, command and social functions. A galley will be adjacent as well as sleeping quarters. It will be prominently placed at the top of the Bldg. 4 and overlook the courtyard with views to the ocean and both mountain ranges. Similar to the entry challenges, the amount of glazing issue is compounded with the fact that now the space is in a prominent location that is more vulnerable. Also, similar to the sustainable challenges the glazing increases the heat gain if not properly addressed.

**Figure 87. South facade of conceptual design show fourth floor Commander's Suite, "The Eagles Nest".** ***Source*****: SketchUp.**

# Chapter 6. Summary and Conclusion

## 6.1 Summary

Security design is basically unique to a narrow element of the building sector. The federal government and specifically the Department of Defense, and have established minimum security design standards that all of their capital inventory shall adhere to. Within the last decade, the Department has also accepted the LEED standard and has established a set of guiding principles that will steer their efforts in attaining their sustainability goals. Current DOD energy efficiency standards call for attaining a minimum energy efficiency reduction of 30% below the ASHRAE 90.1-2007 standard. The military services in some cases have established more stringent sustainable standards. This trend is based on the realization that energy efficiency is a national security issue.

For this project, the emphasis was on architectural design related approaches to balancing security and sustainable design. That emphasis goes even further to primarily energy efficiency aspects of sustainable design; those aspects that architects have the most influence and input on. There are numerous energy efficiency measures that can be leveraged by design professionals to improve the energy efficiency of buildings. In the Defense Department realm, it is also important for these measures to mesh well with required security design requirements. This search for synergistic approaches to the unique requirements of security design and the increasingly universally accepted sustainable standards can be aided by having a set of approaches that can be applied regardless of site restraints and climatic conditions. Additionally, sets can be created that identify obvious synergies, not so obvious synergies and conflicts with suggested compromises and/or tradeoffs.

The research methodology for developing these products was in five phases. First, develop an understanding of the nature of a regional Navy component command including the hierarchy, mission, regional responsibilities and people. Second, develop an understanding of security and sustainable design including minimum standards and strategies. Third, study available case studies and precedents to provide insight into measures and strategies that have or may have been used to balance security and sustainable design. Fourth, conduct an analysis and assessment of those strategies that can be identified as universally applicable, applicable under certain conditions, and those that are in conflict and decisions need to be made on tradeoffs and compromises. Lastly, engage in a design exercise that provides an indication of the efficacy of the design strategies identified in the fourth phase.

The design process was used to test the approaches and was restricted to planning and the early design stages where decisions carry major importance to attaining the project requirements. The design decisions are then represented in a conceptual model that serves as a visual reference of one set of approaches, but not the only set of approaches.

All early predesign activities would be engaged in a planning and design charette. The stages consisted of establishing the clients project requirements, which included identifying security and sustainable design criteria, programming, site inventory and analysis, site selection, massing and configuration studies, surveying passive design approaches, which would look at envelope, fenestration, daylighting, shading, that would serve to reduce cooling and lighting loads and identify efficient electrical and mechanical systems. With the appropriate interdisciplinary design team a variety of analytics can be applied beyond the scope of this design project. These would include Life Cycle Cost Analysis and Energy Analysis which would serve to substantiate approaches with concrete data pertaining directly to the specific project design proposals. Short of this enhanced data, case studies and precedents can provide points of reference and that was what was used in this project.

The project requirements were created as a notional and “best guess” set of requirements with the exception of the minimum security criteria, additional criteria generated through the security criteria development process, sustainable and energy conservation minimum requirements and building codes. The security criteria development process was an involved evolution that provided the likely aggressors and likely threats from those particular aggressors. These project requirements then framed the following stages.

The program was developed based on experience and available information on the command website. Emphasis was placed on attaining a high performance and technologically advanced building to support the command’s mission and personnel into the future. It was determined that it was important establish appropriate department adjacencies according to routine relationships and operating procedures. Several important functions needed to be located carefully and included access control, the command center (a SCIF), the COLPRO area, and the commanders suite. There were other important functions that existed but these were emphasized for this project. A preliminary overall building area was calculated and informed the site analysis.

The site and climate analysis focused on finding appropriate site alternatives inside the Pearl Harbor Makalapa campus. The analysis aimed to identify a location that best balanced the established security and sustainable criteria as well as other applicable project requirements. These include the location that best provided requisite area that could accommodate standoff, unobstructed space, access control, drive up and drop off areas and open space for solar and wind access, heat island mitigation, water management, and shading. With the site selected based on a rating system that included the above criteria and an analysis of several different test building configuration footprints and heights, a more detailed massing,, orientation and configuration exercise was performed. The main synergy with respect to site was combining open space and water management areas into the standoff, unobstructed space and access control strategies. Conversely a major conflict involved the same requirements but under different site circumstances. If the site needed to be in an urban area and open space was at a premium, a decision would need to be made with regard to priority and as has been stated before, security will take precedent.

The primary goal of the massing and orientation stage was to ensure that the building program area and notional configuration would in fact work at that site location, but also that the site accommodated potential passive design strategies. With the preliminary program adjacencies established, issues of optimum orientation for wind and sun, thermal zoning, potential structural system, blast protection, and surveillance mitigation, and programmatic flexibility. The site offered many options, but the main considerations were solar orientation to minimize heat gain and optimize daylighting potential. With two of the most important goals of reducing the lighting and cooling load, the main synergy was programmatic but not universally applicable. One of the considerations in determining the appropriate massing and configuration was thermal zoning, placing spaces with similar thermal characteristics in the same zones. The main spaces were separated into enclosed office, open office, building support, circulation, conference, and core.

Passive design strategies for the envelope included several universal synergies that can be used across project types. Use of a reinforced and insulated concrete sandwich panels provides thermal mass, aides in providing an airtight envelope, can be properly tied for progressive collapse resistance and blast protection, and can, if designed appropriately be used for shading. By using the innovative view/daylighting window combination, you reduce window to wall ratios, thus reducing glazing, reducing cooling load, improving daylighting and yet still providing the exterior views that enhance occupant comfort and well-being. Vestibules round out the synergistic envelope measures, they too can be used in most if not all project types and serve to both control access, restrict surveillance and reduce unconditioned and potential contaminated air infiltration from the frequent entries and exits of the occupants.

Two important synergies emerged in the lighting design. The first related to the previous passive design effort in daylighting in that with improved daylight access interior spaces have improved visibility in daytime extremis situations regardless of electric lighting condition. Also, integrated security lighting with high performance lamps, motion and occupancy sensors and lighting controls can serve the same purpose and be energy efficient.

Utilizing high performance systems, occupancy sensors, right sizing equipment, energy star rated electrical equipment are complimentary goals in both security and energy efficient approaches.

The mechanical system selected, the Dedicated Outdoor Air System, is the ideal system for sub- tropical Hawaii, but also for many other locales as the research literature has shown. By itself it could conceivably condition the spaces adequately, but coupled with a radiant core cooling system in the concrete slab it provides a highly energy efficient system as well as a system that provides the air control and filtration required for CBR protection. Additionally use of Variable Speed drives allows for energy efficient and rapid adjustment and venting in extremis. VFDs also allow quick braking to stop fans faster in a threat event.

The final universal synergistic approach to consider is an integrated control system that can tie many of the systems together. This Integrated Building Automation and Control System integrates and automates HVAC, Fire, lighting, window shading and tinting, and security systems into one comprehensive systems. The system will enable electronic monitoring and control of air flow, space temperature, system performance, energy conservation, fire alarms and security functions from a single, centralized location. This will optimize building operations, energy efficiency, indoor comfort, security and safety.

Couple the listed synergistic approaches with renewable energy technologies such as Photovoltaics and wind turbines provides energy that is less susceptible to local or campus grid disturbances and Net Zero Energy is a possibility for the project.

The overall analysis of the security and sustainable approaches and measures produced sets of measures that could be categorized as; synergistic and universally applicable, synergistic, conflicting requiring tradeoffs and/or compromises, and neither synergistic nor conflicting (standalone security or energy efficient). Finding synergistic strategies that are universally applicable provides a planning template across building types and site conditions. This template can be used at the earliest stages of design when either the interdisciplinary team is convened or when planners are meeting to discuss project requirements. The universal strategies represent the “big muscle movements” that need not be discussed at length. Generally, the planning charettes are time constrained and any efficiencies that can be leveraged are highly useful. More importantly though, if security experts are not present these strategies are going to be the first ones they would have provided. The set is not long but is augmented with other strategies that are not universally applicable but may be for their project type and site characteristics. This step will require some analysis to determine the appropriate measures from the set. Another set consists of strategies that conflict and require a tradeoff and/or compromise. These are the most important to carefully analyze through energy analysis and LCCA. The set is then a start point for further more detailed analysis. Lastly, there is a set of strategies that are neither synergistic nor conflicting. In this case, they are generally recommended strategies that also have to have some level of energy analysis or LCCA.

## 6.2 Conclusion

This project originally began as a desire to design a high performance building as a replacement for the Commander Pacific Fleet Headquarters. The decision to choose this project type was based on experience working at the facility and working at the new Pacific

Command headquarters. The existing headquarter building, although recently renovated, high tech and fully mission capable, because of its age, does not appear to be as energy efficient as it could be. It also is too small to house the all of the command departments. The original design applied regionally responsive design strategies that have been rendered less effective with new security design requirements and the reliance energy generated from fossil fuels to power the building. As the research phase progressed, it was determined that security design of DoD facilities took precedent with respect to other requirements. Also, although there were many sources of guidance for both sustainable and security design of DoD facilities there was little written about balancing the two. With the added emphasis on sustainable design and with climate change deemed a national security issue , The DoD has developed a short and long term sustainability plan. The plan's progress is assessed on a yearly basis and the most recent assessment, although positive in the long term is less so for the short term goals. One reason is that the priorities established in their sustainable guiding principles don't mesh with their LEED standards. While successfully building or retrofitting buildings to the LEED Gold or Silver standard, many still do not rise to the standards of some of the established guiding principles. This, coupled with limited resources, results in ignoring buildings that meet mission needs that have not met sustainable standards and focusing on buildings that do not meet mission needs ***and*** do not meet sustainable standards. This opens up an opportunity to show that these synergistic measures can overcome some of these sticking points

A high performance headquarters building that is responsive to Hawaii's climate, the needs of its occupants and addresses the security and energy efficient requirements can be attainable. By applying these synergistic strategies early in the planning and design process you assure some of the most important security and sustainable design requirements are addressed without confliction. One cannot minimize the importance of human comfort and performance in attaining it. It would be easy to focus solely on energy efficiency and assume that by providing a design with low energy demands and high tech systems you would be delivering a satisfactory product. While it is true that you would be providing cost savings to the DoD, you could be at risk of reducing the overall comfort and performance of your occupants and does not necessarily address deeper sustainability principles, applications or the larger issues impacting climate change. You could be providing impressive new technologies, but not in an integrated and intelligent way as to improve the human performance of the service men and women who would be executing their critical functions. No less important is the notion that these men and women deserve a high performance workplace that serves to enhance their jobs and their lives and that national security has been deemed inextricably linked to fuel and energy self-reliance.

The concluded research and conceptual design analysis can now be a spring board to an appropriately designed structure. The results should be thought of "as something to consider" when proceeding. A structure that is in fact responsive to Hawaii's climate, to the needs of a modern command and control center and to the well-deserved needs of the men and women that work within. It should provide the commander with the tools to accomplish the mission he has so importantly articulated.

## 6.3 Further research

This project was an intensive process of research, comprehension, understanding, analysis, synthesis and ultimately design. As many a dissertation concludes with additional unanswered questions, this doctorate project has been no different in that regard. With more time and expertise, a full energy analysis of proposed energy efficiency measures and access to post occupancy and commissioning information for some of the DoD building case studies would have provided a better indication of whether design and project goals were met. Analysis of envelope thermal properties, more detailed daylighting analysis, and generation of proposed end use intensities would have provided additional justification for proposed strategies. Many of the precedents that were studied and used as evidence of the success of the proposed strategies were adequate for the purposes of this project.

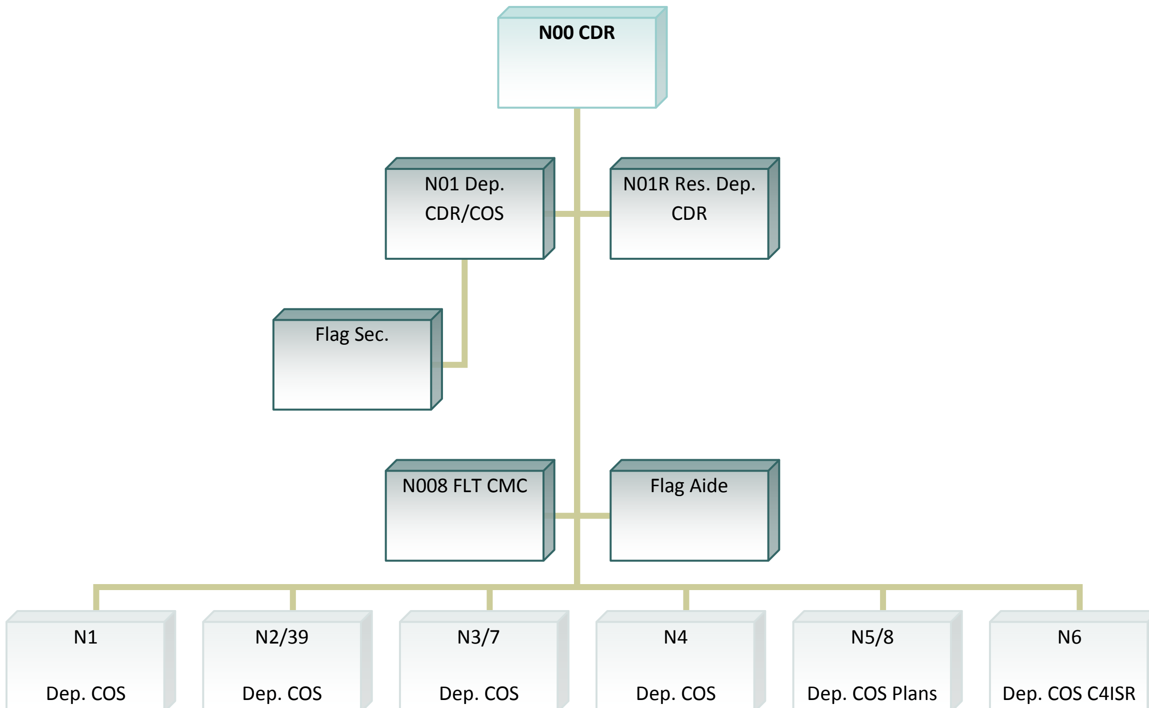
Very important to clients is cost and although alluded to at several points in the project document, ideally in any follow on research Life Cycle Cost Analysis will be critical in determining whether the analysis and proposed synergies are truly cost effective.

Lastly, a more detailed analysis and study of various site types with a broad array of restraints would truly round out this research topic. It would provide a better idea of how all of the strategies other than the universally synergistic strategies relate and work under more restrictive constraints in many cases. The Makalapa site was mature, on an established base and with a lot of open area.  Another building type in a more constrained site in an urban area or foreign land might have many more conflicts.

# Part III: APPENDICES

# Appendix A   COMPACFLT Program

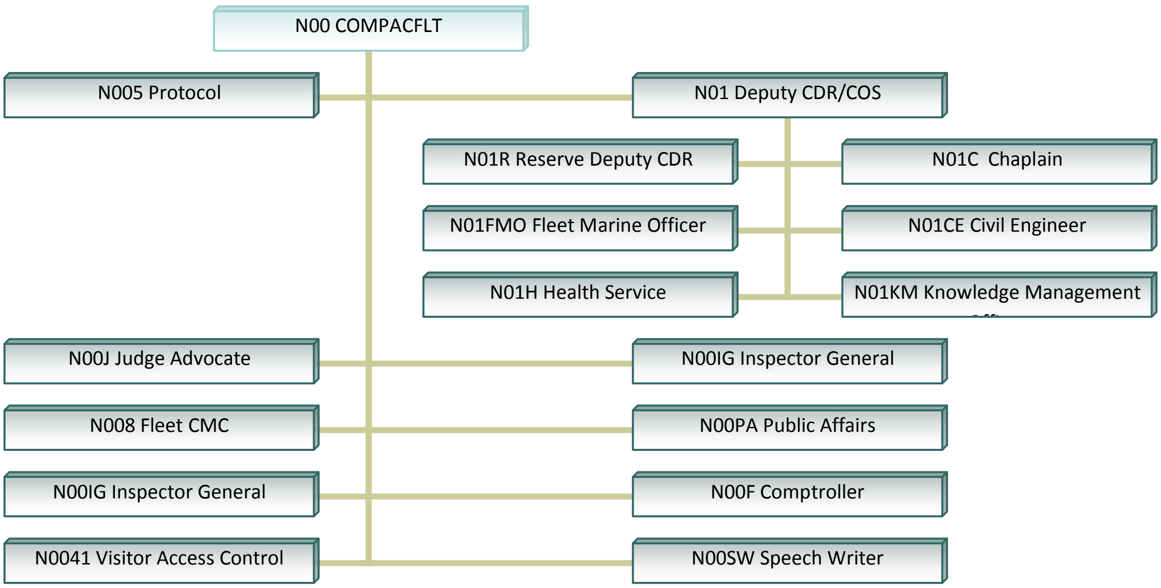
## A-1. Organization Chart




## A-2. Program

The COMPACFLT program is an estimate of space sizes, needs and loads based on number of personnel, visitors and equipment. When determining space needs, consideration must be given to providing spaces that permit occupants to; think and plan, meet and communicate, host visitors and store equipment and records. By assessing space needs we can derive floor plan area estimates, layout and HVAC, Lighting and Equipment loads. Thermal zoning of the floorplate helps to place occupied and unoccupied spaces appropriately by identifying comfort zones for occupied spaces and buffer zones for unoccupied spaces. The below program tables provide data that will help in this pursuit and aid in estimating energy efficiency and whether targets have been met.

## N00 Commander/Flag Staff




The Commander, Deputy Commander/Chief of Staff, Reserve Deputy Commander, Fleet Command Master Chief and several other executive officers, aides and advisor will reside in the Commander's area which will consist of 5 individual offices and a small open bay area surrounded by the executive spaces. A large and small briefing room for the commander will serve as SCIFs with an attached kitchen (mess).

22 staff members including commander and 10 additional assigned to mess for 36 total staff.

| | |
|---|---|
| 1 – 20'x40' CDR's suite w/bath | 800 |
| 1 – 20'x30' adjoining meeting room (SCIF) | 600 |
| 1 – 20'x30' Visitor Meeting room (Ceremonial) | 600 |
| 1 – 20'x50' adjoining galley (kitchen) | 1200 |
| 1 – 14'x20' Dep. CDR Suite w/ bathroom | 600 |
| 1 - 14'x20' Reserve CDR Suite w/bathroom | 280 |
| 1 – 14'x14' FCMC office | 196 |
| 1 – 14' x 14' Flag Secretary | 196 |

| | |
|---|---|
| 1 – 14’x14’ Flag aide | 196 |
| 2 – 14’x14’ staff bathrooms | 392 |
| 1 - 40’x50’ Exec admin open bay | 2000 |

a. Admin CPO desk
b. 2 - Flag writer desks
c. 3 - Flag admin desks

| | |
|---|---|
| 1 – 40’ x 40’ Visitor Access Control | 1600 |

**N00 Executive Staff** **7848 $ft^2$**

## N00/N01 Special Staff

Beginning with the special staff, the commander has several aides and advisors that represent the Navy's Staff Corps, such as Fleet Civil Engineer, Comptroller (Financial), Judge Advocate General (JAG- Legal), Public Affairs (PAO), Health Services (Medical), Chaplain (Religious), Fleet Marine Officer (FMF - USMCPAC liaison and advisor), Fleet Maintenance (N43) and each consist of a small staff. They currently, in most cases, reside in outbuildings in the PACFLT complex. Several ideally would be collocated in the main HQ building if space allowed. Numbers of personnel assigned to each staff code are in parentheses following the department/office title for 22 staff total.

| Comptroller (4) | sq. ft. |
|---|---|
| 1- 30'x30' open bay office | 900 |
| 1- 16'x16' office | 256 |

| JAG (4) | |
|---|---|
| 1- 30'x30' open bay office | 900 |
| 1 - 16'x16' office | 256 |

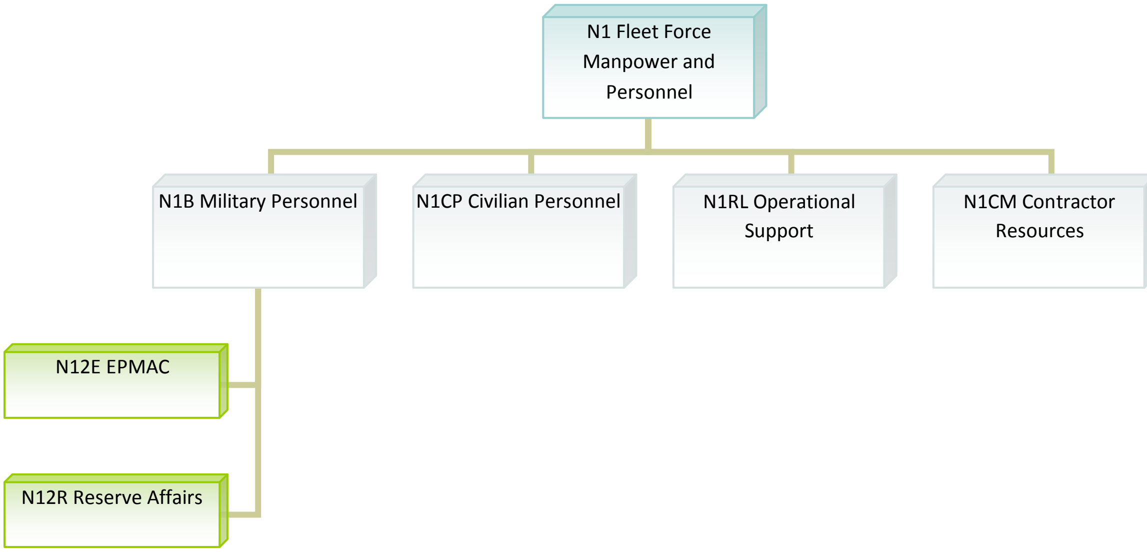
| PAO/Chaplain (4) | |
|---|---|
| 1- 30'x30' open bay office | 900 |
| 1- 14'x14' office | 196 |
| 1-14'x14' office | 196 |

| FMF (2) | |
|---|---|
| 1 – 16x16' office | 256 |

| | |
|---|---|
| Fleet CEC (2) | |
| 1 – 16’x16’ office | 256 |
| Fleet Maintenance (2) | |
| 1 -16’x16’ office | 256 |
| Health Services (4) | |
| 1 – 16’ x16’ office | 256 |

**Special Staff** **4796 $ft^2$**

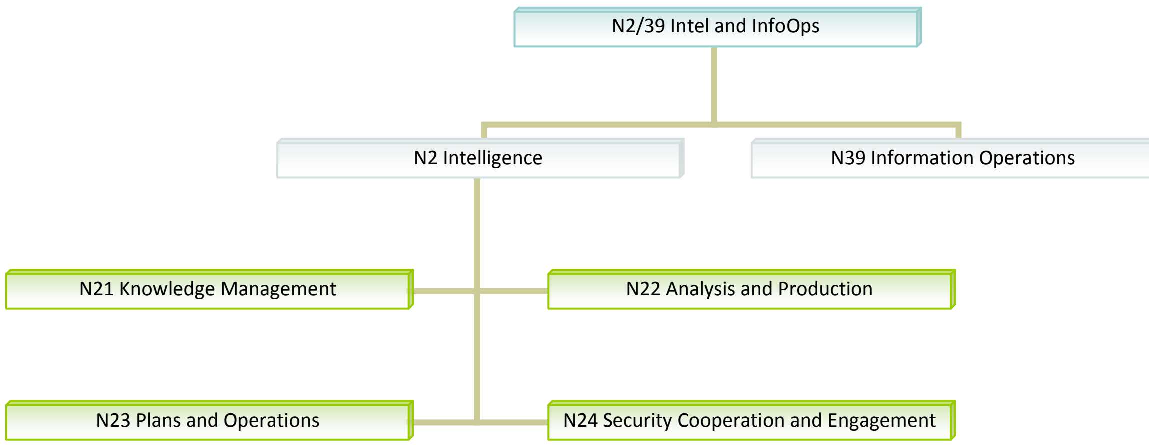
# N1 Total Fleet Force Manpower and Personnel




The Deputy Chief of Staff for Total Fleet Force Manpower and Personnel, N1, staff will work out of an open bay layout with several individual offices for Branch heads and the Director. The director of the N1 is a senior executive civilian, Flag equivalent. The nature of their job requires much storage space and one small meeting room and one large meeting room as well as a SCIF space. Staff totals 34 personnel.

| | |
|---|---|
| 1 – 20’x30’ office suite w/ bath | 600 |
| 5 - 14’x14’ Office | 980 |
| 1 – 14’x20’ VTC conference room | 280 |
| 1 – 20’x20’ VTC conference room | 400 |
| 2 – 40’x40’ open bay office | 3200 |
| 1 – 14’x30’ men’s bath/locker | 420 |
| 1 – 14’x30’ women’s bath/locker | 420 |
| 1 - 20’x20’ SCIF/Closed office | 400 |
| **N1 Staff** | **7412 ft$^2$** |

## N2/39 intelligence and Information Operations



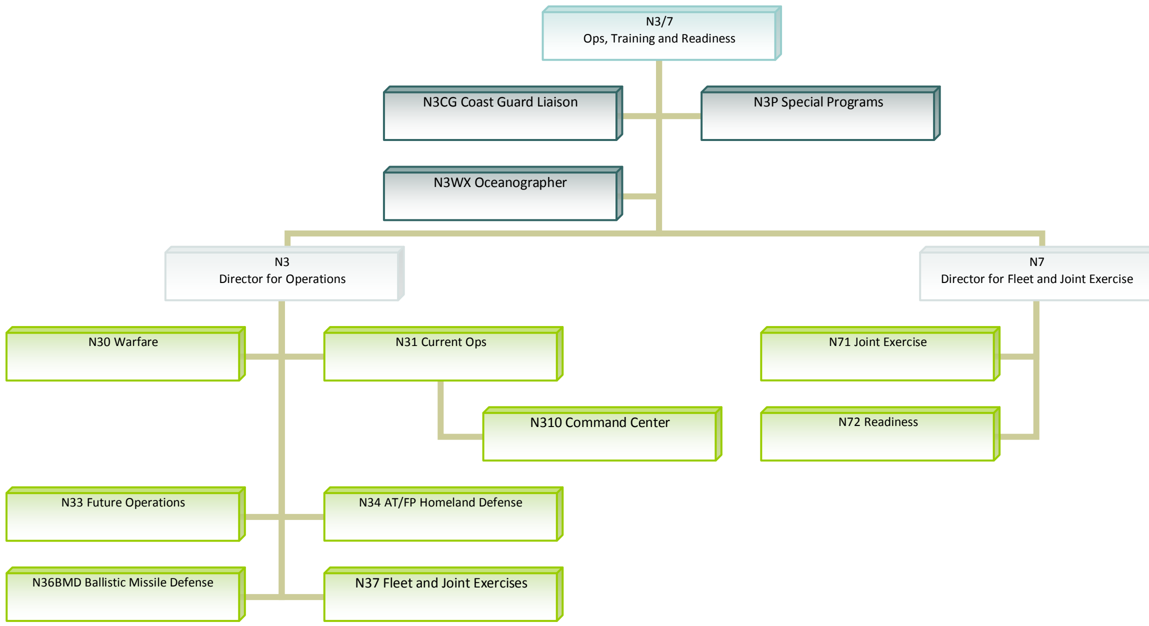

The Deputy Chief of Staff for Intelligence and Information Operations, N2/39, a one star admiral and their staff are a complicated mix of specialties with high security classifications. They will require several SCIF spaces, an Intelligence Operations Center (NIOC), several clustered secure bays with requisite storage, several meeting rooms and several individual offices for Branch heads and the Director. The N39 Staff will also require a SCIF space which can be collocated with one of the N2 SCIFs as well a couple of clustered bays with storage. Total staff is 62 personnel.

N2 (46)

| | |
|---|---|
| 2 - 20'x40' SCIF | 1600 |
| 1 – 40'x40' NIOC (SCIF) | 1600 |
| 4 – 40'x40' office bays | 6400 |
| 7 – 15'x15' offices | 1575 |
| 1 – 20'x30' VTC/ large meeting room | 600 |
| 1 – 14'x20' VTC/small meeting room | 280 |
| 1 – 14'x40' men's bath/locker | 560 |

| | | |
|---|---|---|
| 1 – 14’x30’ women’s bath/locker | 420 | |
| | | |
| N39 (16) | | |
| 1 – 20’x30’ N2/N39 SCIF | 600 | |
| 2 – 40’x40’ office bays | 3200 | |
| 1 – 15’x15’ office | 225 | |
| **N2/39 Staff** | | **13516 $ft^2$** |

## N3/7 Operations, Training and Readiness

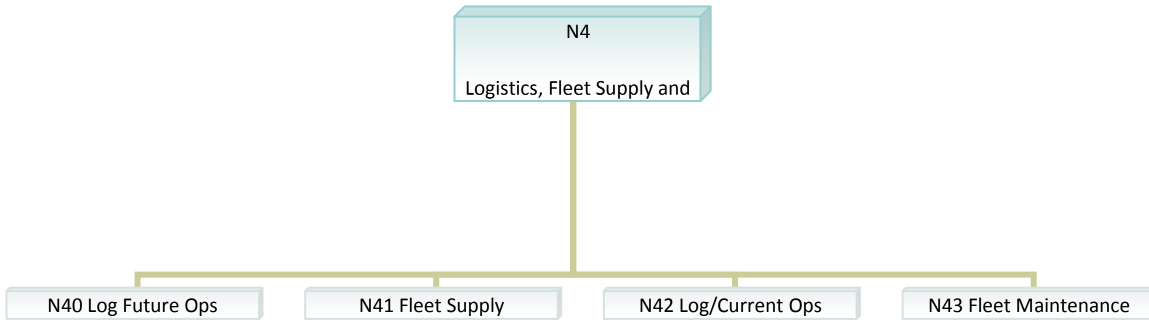



The Deputy Chief of Staff for Operations, Training and Readiness, N3/N7, has two Directorates which will have small admin staffs consisting of a CPO, an LPO and 2-3 admin personnel. There will be a total of 10 branches, with Warfare (10), Current Ops (12) and Future Ops (8) Ballistic Missile defense (8) and AT/FP (8) as the largest, while Special Programs (6), Oceanographer (3), Fleet and Joint Exercises (6) and Coast Guard Liaison (1) will require less space. Additionally, an Operations or Command Center will be required as well as a SCIF space and large and small briefing rooms. The N3/N7, a one star Flag Officer, the N3 Director and the N7 Director, both O-6 Captains, will have their own offices and both will have staff spread out in several clustered spaces with each branch head rating an individual office. Total staff includes 83 personnel.

| | |
|---|---|
| 1 – 20’x30 N3/7 suite w/Bath | 600 |
| 1 – 16’x16’ N3 Director office | 196 |

| | |
|---|---|
| 1 – 16’x16’ N7 Director office | 196 |
| 9 – 12’x12’ branch head offices | 1296 |
| 1 – 60’x60’ command center | 3600 |
| 2 – 20’x20’ SCIFs | 800 |
| 8– 40’x40’ ops staff open bay offices | 12800 |
| 2 – 20’x20’ VTC/meeting rooms | 800 |
| 1 – 12’x20’ VTC/meeting room | 240 |
| 1 – 14’x40’ men’s bath/locker | 560 |
| 1 – 14’x40’ women’s bath/locker | 560 |
| **N3/7** | **18094 ft$^2$** |

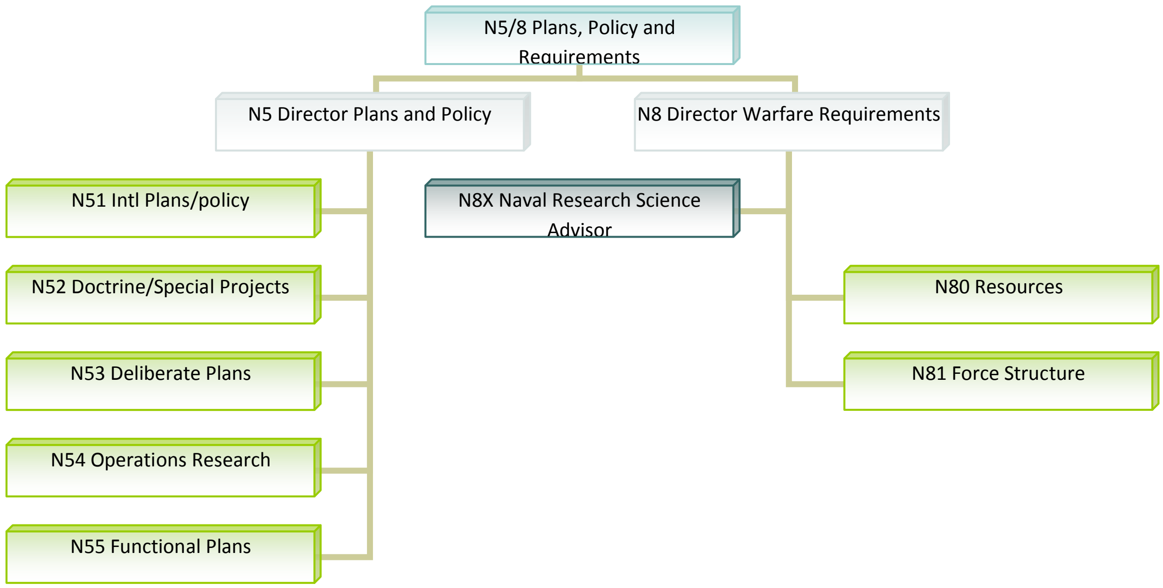
## N4 Logistics, Fleet Supply and Ordnance




The Deputy Chief of Staff for Logistics, Fleet Supply and Ordnance, N4, also a one star Flag Officer, has 3 branches, two O-6 Captains and one one star Flag Officer requiring an office for each and two open bay office spaces with one SCIF and a briefing room. The bulk of the N43 is off site located at JB Pearl Harbor-Hickam. On site staff consists of 30 personnel.

| | |
|---|---|
| 1 – 20'x30' N4 suite w/bath | 600 |
| 1 - 20'x20' N4 admin office | 400 |
| 3 – 12'x12' branch head offices | 432 |
| 2 – 40'x40' open bay office | 3200 |
| 1 – 20'x20' SCIF | 400 |
| 1 – 14'x30' men's bath/locker | 420 |
| 1 – 14'x30' women's bath/locker | 420 |
| 1 – 20'x20' VTC/meeting room | 400 |
| **N4/43** | **4360 $ft^2$** |

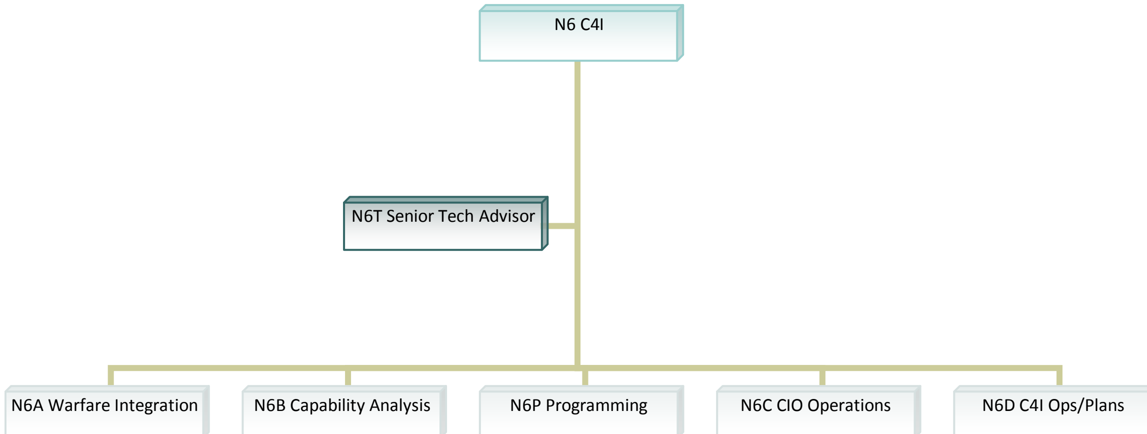
## N5/8 Plans, Policies and Requirements




The Deputy Chief of Staff for Plans, Policy and Requirements, N5/N8, a one start Flag Officer is responsible for two directorates, 5 branches and will require 3 individual offices, two open bay spaces, a SCIF and Briefing room. One of the Directorates, the N5, Plans and Policy is led by a Senior Executive and has his/her own office. Total staff consists of 40 personnel.

| | | |
|---|---|---|
| 1 – 20’x30’ N3/8 suite with bath | | 600 |
| 2 – 16’x20’ Directorate head offices | w/bath | 640 |
| 1 – 20’x20’ admin space | | 400 |
| 2 – 30’x40’ open bay office | | 2400 |
| 1 – 20’x20’ SCIF | | 400 |
| 1 – 20’x30’ meeting room | | 600 |
| 1 – 20’x20’ meeting room SCIF | | 400 |
| 1 – 14’x40’ men’s’ bath/locker | | 560 |
| 1 – 14’x30’ women’s bath/locker | | 420 |
| **N5/8** | | **8720 ft$^2$** |

## N6 Command, Control, Communications, Computers and Intelligence (C4I)




The Deputy Chief of Staff for C4I N6, is a civilian Senior Executive Service, Federal employee and is responsible for 5 branches; Programming, Capability Analysis, CIO Operations, C4I Ops/plans and Warfare Integration. Department will require 6 individual offices, two open bay spaces, a SCIF and a briefing room. Staff consists of 40 personnel.

| | |
|---|---|
| 1 – 20’x30’ N6 Suite | 600 |
| 5 – 16’x20’ Directors offices | 960 |
| 1 – 20’x20’ admin space | 400 |
| 1 – 20’x20’ SCIF | 400 |
| 2 – 40’x40’ open bay offices | 3200 |
| 1 - Data Center | 2000 |
| 1 – 20’x30’ VTC/meeting room | 600 |
| 2 – 14’x30’ men’s and women’s bath/locker | 840 |
| **N6** | **8720 $ft^2$** |

## Auxiliary Spaces

Auxiliary spaces include 3 large conference rooms clustered together, a modeling and simulation room, an exercise room and a library, a common mess and eating area, a retail space (shoppette), food court, gym, men's and women's locker rooms, barber shop, and post office

- 1 – 64'x80' Main conference room 5120
- 2 – 64'x52' break out conference rooms 6656
- 1 – 64'x64' modeling and simulation room 4096
- 1 – 64'x128' gym/workout/Lockers/showers 8192
- 1 – 16'x32' library 512
- 1 – 40' x 40' Post Office 1600
- 1 – 64'x200' NEX/Food Court/vendors 12800
- 1 – 64'x200' maintenance/auxiliary/receiving 12800

**Aux/Misc spaces 47616 ft2**

Total estimated square footage required **125,000 ft$^2$**

# Appendix B Case Studies in Sustainable and Security Design

## *B-1. Naval Base Ventura County (NBVC) Port Hueneme Energy and Sustainability Showcase Building – Ventura, CA*

This case study building was chosen because it was intended as a showcase building for NAVFAC energy efficiency efforts "to demonstrate applications of the latest concepts in energy-efficient and sustainable facility design, construction and operation." It houses the NBVC Public works department. It is approximately 17000 SF and consists of a 10000 SF remodel and 7000 SF addition. It is a single building in an urban setting completed in June 0f 2001. It is being used as a test bed for new sustainable technologies and received a LEED rating of "gold". The building was intended to be completely day lit using clerestory windows, light colors and reflective light shelves to project light into the spaces. It is an open bay layout, foregoing floor to ceiling walls that would inhibit light travel. The electric lighting consists of high efficiency fluorescent lighting with occupancy and light level sensors that have override switches. At completion, the building's energy performance was approximately 55% more efficient than California's 1995 Title 24 Energy Efficiency Standards.

Figure B-1. NBVC Port Hueneme Public Works Bldg. computer model.

Green Specs:

Energy and Carbon Emissions

- LEED Gold
- Retrofit
- Mature trees preserved
- Pervious surfaces, impervious minimized
- High Performance windows
- Orientation for passive solar cooling
- Duct insulation exceeds 1995 CA Title 24
- Programmable thermostat
- Paints light colored or reflective
- Cool roof
- Shaded high-efficiency air
- On-demand hot water circulation pump
- Occupancy sensors
- Solar water heating system
- Clerestories and light shelves for daylighting
- Fluorescent lighting
- Solar PV (278 kW)
- Energy Star appliances

Water

- Water efficient landscape
- Porous pavers
- Bioswale for storm water runoff

Figure B-2. NBVC Port Hueneme daylighting image.

## *B-2. Hawaii Gateway Energy Center – Hawaii*

The Hawaii Gateway Energy Center is located in Kailua-Kona, Hawaii and is 3600SF consisting of 2 buildings completed in October, 2004. Its most prominent feature is the sloped truss system that both serves as a support for the PV system and provides shade. It is a 20kW grid-tied system providing 10 percent more energy than the building demands. The design firm, Ferraro Choi Associates, intended the structure to be a visual draw to visitors. In fact, a visitor survey indicated 70% of visitors came in because they were driving by (it is on the way to/from the airport) and were drawn by the unique structure.

Figure B-3. Hawaii Gateway Center.

Interestingly, despite the center's location in a hot, humid and dry part of Hawaii it is described as "pleasant and almost cool for some people." This is a result of the unique integrated system employed; thermal heat

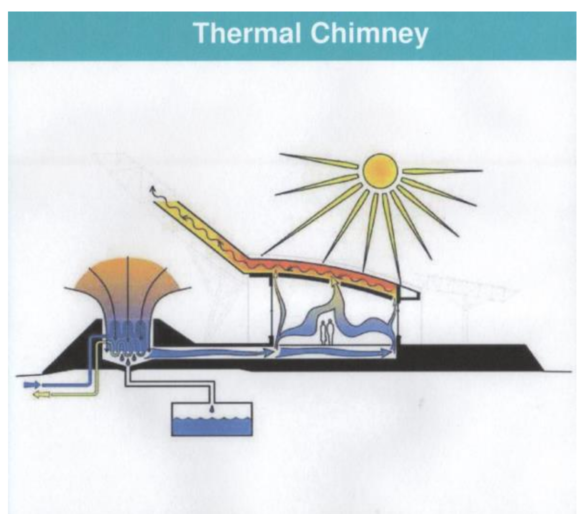



Figure B-4. Theraml chimney design diagram. Source: Ferraro Choi presentation illustration of Thermal Heat Stack System.

stacks and a Sea Water Cooling System. The roof is actually designed to collect heat using a plenum which draws air up utilizing the stack effect. As the air is drawn up it siphons fresh air into the building. This fresh air is passed through coils filled with 45 deg deep sea water. The coils act to cool the air and to dehumidify the air as it condenses on the cold coils. This condensation is captured and used for flushing toilets and irrigating the plantings.

Figure B-5. Gateway Center meeting room.

Solar gain in this hot dry area is minimized by orientation on an east/west axis. Daylighting strategies provide all of the light during the day's working hours. Occupancy sensors were also employed. Overhangs help to minimize glare and direct sunlight.

Green Specs:

Energy and Carbon Emissions

- LEED NC v2 Platinum
- Pervious surfaces, impervious minimized
- High Performance windows
- Orientation for passive solar cooling
- Programmable thermostat
- Paints light colored or reflective
- Thermal Chimney
- Sea Water Cooling
- Occupancy and Daylight sensors
- Solar water heating system
- Daylighting
- Fluorescent lighting
- Solar PV (20kW grid-tied)
- Energy Star appliances

Water

- Water efficient Native landscape
- Porous pavers
- Waterless urinals
- Faucet aerators

Materials and furnishings

- Zero VOC interior paint
- No VOC adhesives
- Steel framing
- 50% recycled content carpet
- Formaldehyde-free insulation

Community

- Occupant and community training on energy efficiency
- Signage and tours of facility

**Figure B-6. Hawaii Gateway Center view from oceanside**

## *B-3. Pacific Air Force Headquarters (Historical Precedent) - Hawaii*

The Pacific Air Force Headquarters building is being considered as an historic design precedent for Hawaii's climate. Originally an enlisted barracks completed before WWII in Oct 1940. It was the largest military barracks ever built at the time. Housing 3,300 enlisted

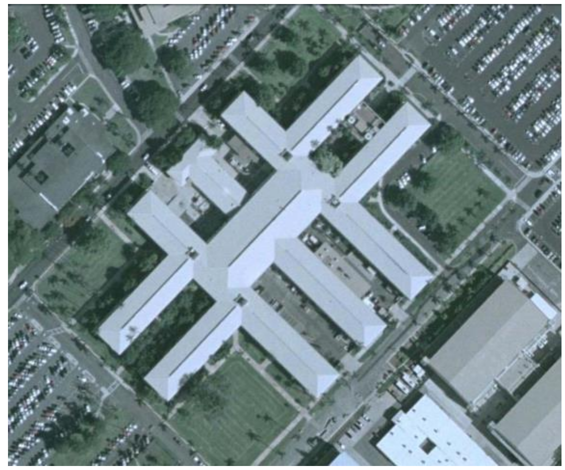


Figure B-7. Overhead view of Pacific Air Forces Headquarter bldg.

Figure B-8. PACAF HQ windows and shading "eyebrow".

airmen it consisted of a central mess hall surrounded by 10 wings. In 1957 upon establishment of the Pacific Air Forces Command it transitioned to a headquarters building. The mess hall was a large open bay about 100 ft. wide while the barracks wings were approximately 60 ft. wide. It is a three story, reinforced concrete structure with a typical Hawaiian hip roof. Design features responsive to Hawaii's climate include an orientation that takes advantage of the predominate trade winds. External window


Figure B-9. PACAF HQ rear entry showing vegetation.

shelves that serve as a shading devices. Long building wings that facilitate daylighting, natural ventilation and provide shaded outdoor areas.  Landscaping that includes large specimen trees for shading and plantings along perimeter to mitigate the heat island effect.

Figure B-10.  PACAF HQ “Hall of Heroes”.

## *B-4. Defense Intelligence Analysis Center (DIAC), Bolling Air Force Base, Washington, DC*

The approximately $100 million project is a first-class, six story 450,000 sf office building designed to consolidate uniquely skilled intelligence personnel currently working in lease spaces throughout the region. Connected to an existing building via a corridor, the project successfully integrates security and sustainability features within the design, creating an energy-efficient, comfortable, yet very secure facility. For example, the design of the facility takes advantage of the earth berm behind so it would be able to withstand impact by a truck traveling at 40 MPH.

Figure B-11 Defense Intelligence Analysis Center aerial view

Figures B-12 Defense Intelligence Analysis Center, Bolling AFB, Washington, DC

# Appendix C DoD Security Design Criteria Development

## *C-1. Security Planning Assessment Process Synopsis*

The assessment process included the following steps, calculations and results and summarize the attached worksheets:

Step 1: Convene the Planning Team

Step 2: Identify assets

Determine facility type – Headquarters/Operational Facility

Determine default assets –

**Table C-1. Default assets**

| Asset category | Asset | Asset value rating |
|---|---|---|
| A | People : Mission critical<br>People: General Pop. | .76<br>.67 |
| F | Arms, ammunition and explosives (AA&E) | .24 |
| H | Communications/Electronics test, measurement, & diagnostic equipment and tool kits and night vision devices | .16 |
| M | Audiovisual equipment, training devices, & sub caliber devices | .16 |
| N | Miscellaneous pilferable assets and currency or negotiable instruments | .16 |
| O | Critical Infrastructure & industrial equipment | .85 |
| P | Controlled cryptographic equipment | .48 |
| Q | Sensitive information | 1 |
| R | Activities and operations | .8 |

Step 3: Determine asset value (for each asset)

Assess Value rating factors – then sum ratings factors – then Determine Asset Value rating

**Table C-2. Asset value rating factors**

| Asset category | Asset | value | Action |
|---|---|---|---|
| A | People: Msn critical | .76 ≤ .5/NO | Go to Step 4/aggressor likelihoods |
| A | People: Gen Pop. | .67 ≤ .5/NO | Go to step 4 |
| F | AA&E | .24 ≤ .5/YES | Apply min standards |
| H/M/N | Comms/Elec test/ AV/Misc | .16 ≤ .5/YES | Apply min standards |
| O | Critical Infrastructure | .85 ≤ .5/NO | Go to Step 4 |
| P | Controlled Crypto | .48 ≤ .5/Yes | Apply min standards |
| Q | Sensitive Information | 1 ≤ .5/NO | Go to Step 4 |
| R | Activities and Ops | .8 ≤ .5/NO | Got to Step 4 |

Step 4: Determine Aggressor Likelihoods for A, O, Q, and R.

(See Asset Value/Aggressor Likelihood Worksheet)

A. Select Applicable Aggressors on worksheet using table 3-9
B. Assess Aggressor Likelihood Factors on worksheet using Tables 3-10 to 3-23
C. Sum Likelihood Rating Factors on worksheet
D. Determine Aggressor Likelihood Rating ($T_L$)
E. Make decision on decision tree

| Asset Category/Asset | Ignore all aggressors except: |
|---|---|
| A/People/Mission Critical and Gen. Pop. | International terrorists |
| | State sponsored Terrorists |
| O/Critical Infrastructure | International Terrorists |
| | State sponsored terrorists |
| | Saboteurs |

| | |
|---|---|
| Q/Sensitive Information | ignore all |
| R/Activities and Operations | ignore all |

Step 5: Identify Likely Tactics and Threat Severity Levels

(See  Tactic, Threat Severity, and Level of Protection Worksheet)

A. Select Potential Tactics based on Asset using table 3-24
B. Select Applicable Tactics based of Aggressor using table 3-25
C. Select Applicable tactic threat severity levels using table 3-26

Step 6: Consolidate into Initial Design Basis Threat

(See Tactic, Threat Severity, and Level of Protection Worksheet)

At bottom of worksheet

Step 7: Determine Initial Level of Protection

(See Tactic, Threat Severity, and Level of Protection Worksheet)

At bottom of worksheet

Step 8: Determine Planning Risk Levels

(See Risk Level Calculation Worksheet)

A. Determine Threat Effectiveness rating ($T_e$) using table 3-29
B. Select Initial Protection Factors for Target LOP ($P_1$) using table 3-30
C. Average $P_1$ within target groups ($P_{1a}$vg)
D. Adjust Initial Protection Factors based on equation 3-1
E. Calculate Risk Levels using equation 3-2 (Risk=R= Asset Value Rating Av x Highest TL x (1-Pe))

Step 9:  Assess Acceptability of Risk Levels

A. Evaluate Cost of Protective System (Chapter 6)

Risk and Cost are acceptable

Step 10: Identify User Constraints (to be used in narrative of security planning assessment)

A. Political considerations
B. Appearance/Public perception
C. Regulations
D. Procedural or Operational: Deliveries
E. Procedural or Operational: Restricted areas
F. Procedural or Operational: Access control
G. Procedural or Operational: Functional requirements (relationships, types of ops, special requirements for layout)
H. Facility and Site constraints: Occupancy requirements
I. Facility and Site constraints: Parking lots and Roads
J. Fac. And Site constraints: fences and lighting
K. Fac. And Site constraints: Electronic security systems
L. Fac. And site constraints: Architectural Theme
M. Fac. And Site constraints: Existing facilities – which will consolidate and which remain, or move
N. Fac. And Site constraints: Misc wildlife habitat, floodplain etc.
O. Response force: Armed force
P. Response force: EOD
Q. Response force: Fire dept.
R. Response time
S. Manpower allocation

## *C-2. Security Planning Worksheets*

The following worksheets were utilized to develop appropriate security design criteria that will be in addition to the minimum AT standards for DOD buildings.

The worksheets include:



[1] Remaining worksheets deal with the asset most likely to be targeted as determined in the first set of worksheets

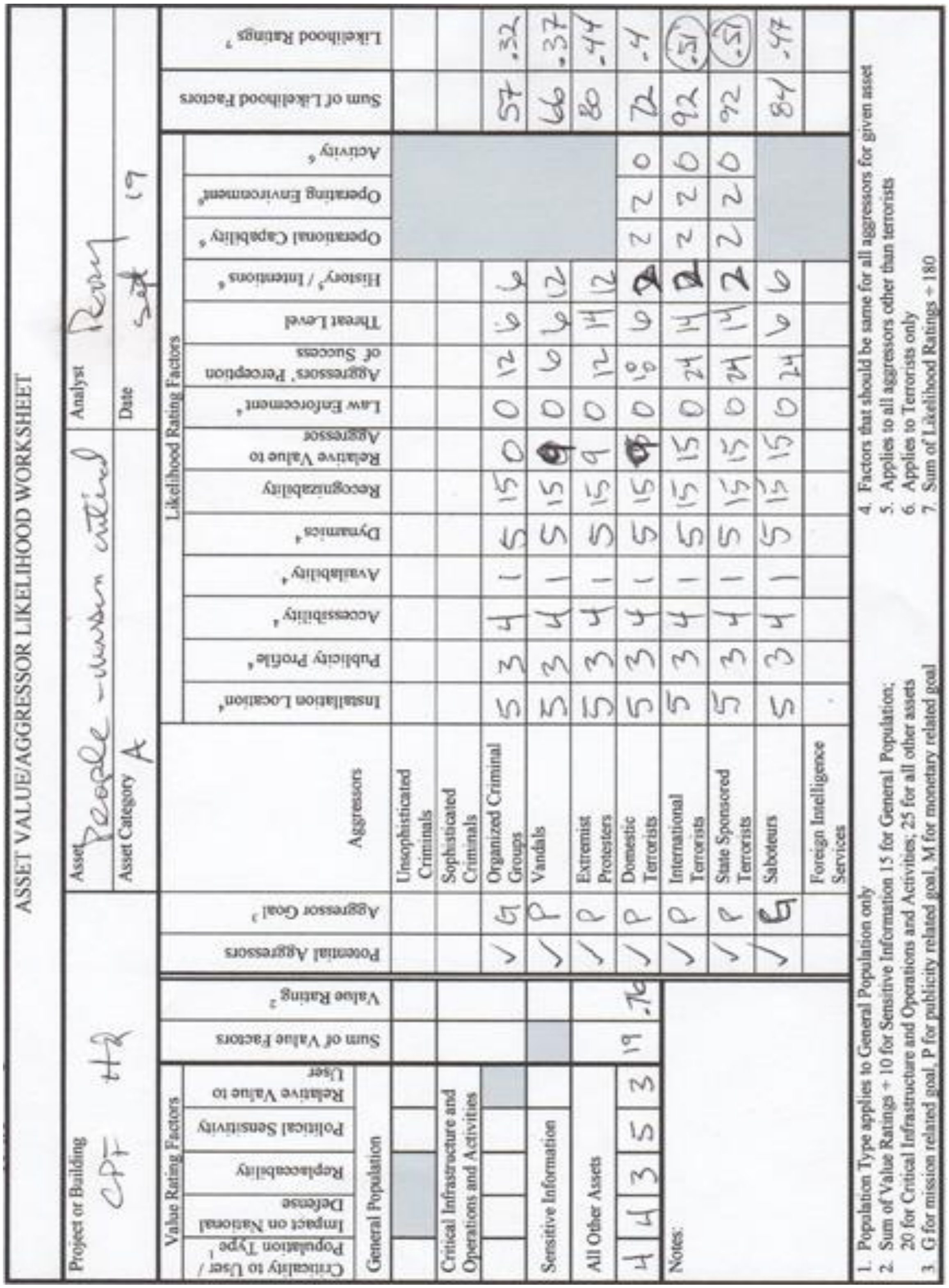
# DESIGN CRITERIA SUMMARY WORKSHEET

| Project or Building | Analyst | Date |
|---|---|---|
| CPF HQ | | |

| Assets | Asset Category | Asset Value Rating | Tactics: Explosive and Incendiary Devices — Moving Vehicle Devices DBT | Moving Vehicle Devices LOP | Stationary Vehicle Devices DBT | Stationary Vehicle Devices LOP | Hand Delivered Devices DBT | Hand Delivered Devices LOP | Standoff Weapons — Indirect Fire Weapons DBT | Indirect Fire Weapons LOP | Direct fire weapons DBT | Direct fire weapons LOP | Entry Tactics — Forced Entry DBT | Forced Entry LOP | Covert Entry DBT | Covert Entry LOP | Surveillance and Eavesdropping — Visual Surveillance DBT | Visual Surveillance LOP | Acoustic Eavesdropping DBT | Acoustic Eavesdropping LOP | Electronic Emanations Eavesdropping DBT | Electronic Emanations Eavesdropping LOP | Contamination Tactics — Airborne Contamination DBT | Airborne Contamination LOP | Waterborne Contamination DBT | Waterborne Contamination LOP | Waterfront Attack DBT | Waterfront Attack LOP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| People GOV POP / MSN CRIT | A | .67 / .76 | L | M | L | M | M | M | L | M | L | L | M | M | L | M | H | H | | | | | L | M | L | M | L | M |
| AA & E | F | .24 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| COMMS/ELEC | H | .16 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| AV | M | .16 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| MISC PILFERABLE | N | .16 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CRITICAL INFRASTRUCTURE | O | .85 | L | M | L | M | M | M | L | M | L | M | M | M | L | M | H | H | | | | | L | M | L | M | L | M |
| CONTROLLED CRYPTO | P | .48 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| SENSITIVE INFO | Q | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ACTIVITIES & OPS | R | .8 | | | | | | | | | | | | | | | | | | | | | | | | | | |

DBT = Design Basis Threat severity level LOP = Level of Protection

**Figure C-1. Design criteria summary worksheet**



ASSET VALUE/AGGRESSOR LIKELIHOOD WORKSHEET

| Project or Building | Asset | Analyst |
|---|---|---|
| CPF HQ | People - mission critical | Rory |
| | Asset Category A | Date Sept 19 |

**Value Rating Factors**

| | Criticality to User / Population Type[1] | Impact on National Defense | Replaceability | Political Sensitivity | Relative Value to User | Sum of Value Factors | Value Rating[2] |
|---|---|---|---|---|---|---|---|
| General Population | | | | | | | |
| Critical Infrastructure and Operations and Activities | | | | | | | |
| Sensitive Information | | | | | | | |
| All Other Assets | 4 | 4 | 3 | 5 | 3 | 19 | .76 |

Notes:

**Likelihood Rating Factors**

| Potential Aggressors | Aggressor Goal[3] | Aggressors | Installation Location[4] | Publicity Profile[4] | Accessibility[4] | Availability[4] | Dynamics[4] | Recognizability | Relative Value to Aggressor | Law Enforcement[4] | Aggressors' Perception of Success | Threat Level | History[5] / Intentions[5] | Operational Capability[6] | Operating Environment[6] | Activity[6] | Sum of Likelihood Factors | Likelihood Ratings[7] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Unsophisticated Criminals | | | | | | | | | | | | | | | | |
| | | Sophisticated Criminals | | | | | | | | | | | | | | | | |
| ✓ | G | Organized Criminal Groups | 5 | 3 | 4 | 1 | 5 | 15 | 0 | 0 | 12 | 6 | 6 | | | | 57 | .32 |
| ✓ | P | Vandals | 5 | 3 | 4 | 1 | 5 | 15 | 9 | 0 | 6 | 6 | 12 | | | | 66 | .37 |
| ✓ | P | Extremist Protesters | 5 | 3 | 4 | 1 | 5 | 15 | 9 | 0 | 12 | 14 | 12 | | | | 80 | .44 |
| ✓ | P | Domestic Terrorists | 5 | 3 | 4 | 1 | 5 | 15 | 9 | 0 | 18 | 6 | 2 | 2 | 2 | 0 | 72 | .4 |
| ✓ | P | International Terrorists | 5 | 3 | 4 | 1 | 5 | 15 | 15 | 0 | 24 | 14 | 2 | 2 | 2 | 0 | 92 | .51 |
| ✓ | P | State Sponsored Terrorists | 5 | 3 | 4 | 1 | 5 | 15 | 15 | 0 | 24 | 14 | 2 | 2 | 2 | 0 | 92 | .51 |
| ✓ | G | Saboteurs | 5 | 3 | 4 | 1 | 5 | 15 | 15 | 0 | 24 | 6 | 6 | | | | 84 | .47 |
| | | Foreign Intelligence Services | | | | | | | | | | | | | | | | |

1. Population Type applies to General Population only
2. Sum of Value Ratings ÷ 10 for Sensitive Information 15 for General Population; 20 for Critical Infrastructure and Operations and Activities; 25 for all other assets
3. G for mission related goal, P for publicity related goal, M for monetary related goal
4. Factors that should be same for all aggressors for given asset
5. Applies to all aggressors other than terrorists
6. Applies to Terrorists only
7. Sum of Likelihood Ratings ÷ 180

**Figure C-2. Asset Value/Aggressor likelihood worksheet**

# ASSET VALUE/AGGRESSOR LIKELIHOOD WORKSHEET

| Project or Building | Asset | Analyst |
|---|---|---|
| CPF HQ | People general Pop. | |
| | Asset Category A | Date |

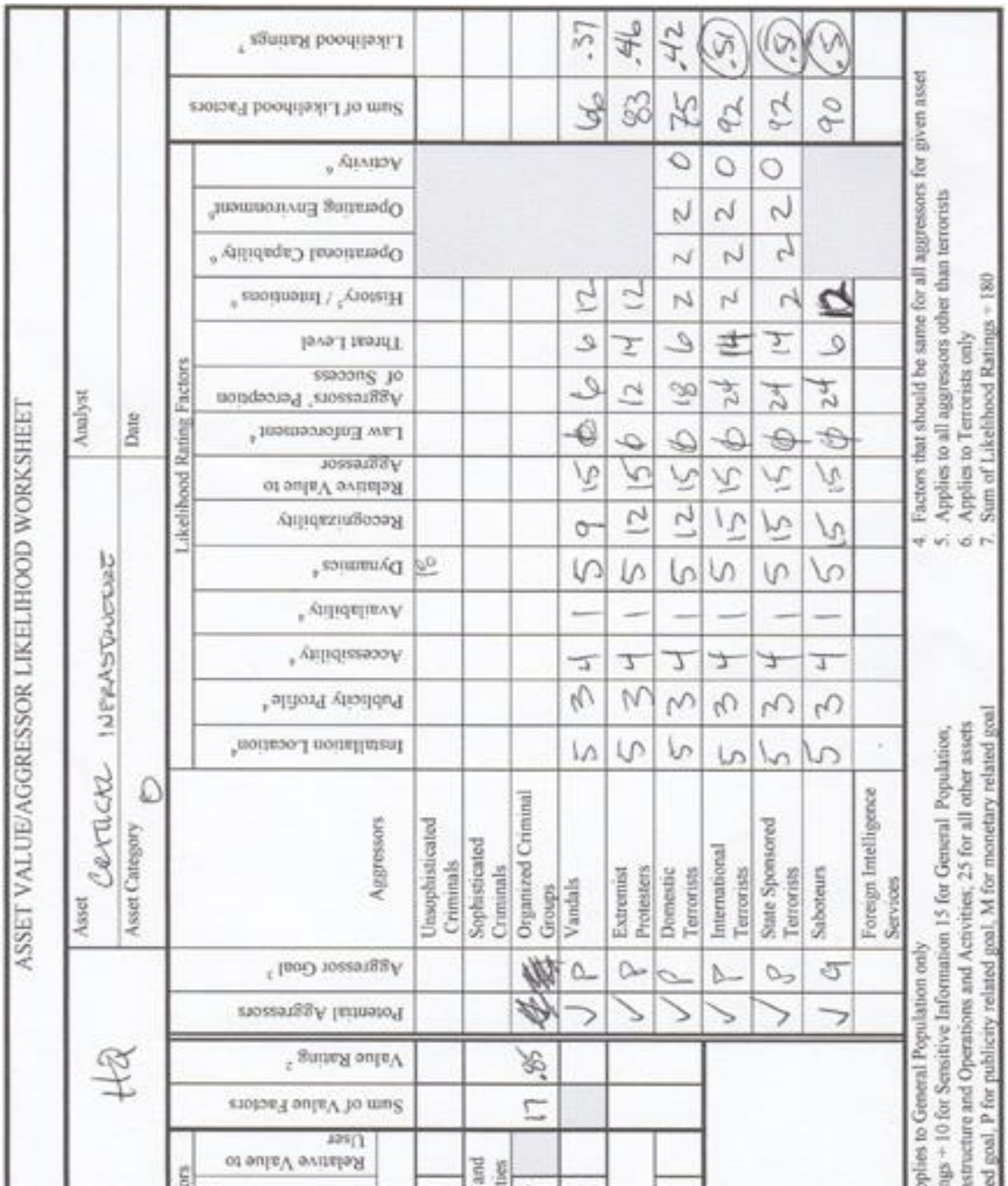
| Value Rating Factors: Criticality to User / Population Type[1] | Impact on National Defense | Replaceability | Political Sensitivity | Relative Value to User | Sum of Value Factors | Value Rating[2] |
|---|---|---|---|---|---|---|
| General Population | | | | | | |
| 1 | | | 5 | 4 | 10 | .67 |
| Critical Infrastructure and Operations and Activities | | | | | | |
| | | | | | | |
| Sensitive Information | | | | | | |
| All Other Assets | | | | | | |
| | | | | | | |

Notes:

| Potential Aggressors | Aggressor Goal[3] | Aggressors | Installation Location[4] | Publicity Profile[4] | Accessibility[4] | Availability[4] | Dynamics[4] | Recognizability | Relative Value to Aggressor | Law Enforcement[4] | Aggressors' Perception of Success | Threat Level | History[5] / Intentions[6] | Operational Capability[6] | Operating Environment[6] | Activity[6] | Sum of Likelihood Factors | Likelihood Ratings[7] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Unsophisticated Criminals | | | | | | | | | | | | | | | | |
| | | Sophisticated Criminals | | | | | | | | | | | | | | | | |
| ✓ | G | Organized Criminal Groups | 5 | 3 | 4 | 1 | 5 | 15 | Ø | Ø | 12 | 6 | 6 | | | | 57 | .32 |
| ✓ | P | Vandals | 5 | 3 | 4 | 1 | 5 | 15 | 9 | Ø | 6 | 6 | 12 | | | | 66 | .37 |
| ✓ | P | Extremist Protesters | 5 | 3 | 4 | 1 | 5 | 15 | 9 | Ø | 12 | 14 | 12 | | | | 80 | .44 |
| ✓ | P | Domestic Terrorists | 5 | 3 | 4 | 1 | 5 | 15 | 9 | Ø | 18 | 6 | 2 | 2 | 2 | 0 | 72 | .4 |
| ✓ | P | International Terrorists | 5 | 3 | 4 | 1 | 5 | 15 | 15 | Ø | 24 | 14 | 2 | 2 | 2 | 0 | 92 | .51 |
| ✓ | P | State Sponsored Terrorists | 5 | 3 | 4 | 1 | 5 | 15 | 15 | Ø | 24 | 14 | 2 | 2 | 2 | 0 | 92 | .51 |
| ✓ | G | Saboteurs | 5 | 3 | 4 | 1 | 5 | 15 | 15 | Ø | 24 | 6 | 6 | | | | 84 | .47 |
| | | Foreign Intelligence Services | | | | | | | | | | | | | | | | |

1. Population Type applies to General Population only
2. Sum of Value Ratings ÷ 10 for Sensitive Information 15 for General Population; 20 for Critical Infrastructure and Operations and Activities; 25 for all other assets
3. G for mission related goal, P for publicity related goal, M for monetary related goal
4. Factors that should be same for all aggressors for given asset
5. Applies to all aggressors other than terrorists
6. Applies to Terrorists only
7. Sum of Likelihood Ratings ÷ 180

Figure C-3. Asset value/aggressor likelihood worksheet - People general population



ASSET VALUE/AGGRESSOR LIKELIHOOD WORKSHEET

Project or Building: CPF HQ

Asset: CRITICAL INFRASTRUCTURE

Asset Category: D

Analyst:

Date:

| Value Rating Factors | Criticality to User / Population Type[1] | Impact on National Defense | Replaceability | Political Sensitivity | Relative Value to User | Sum of Value Factors | Value Rating[2] |
|---|---|---|---|---|---|---|---|
| General Population | | | | | | | |
| Critical Infrastructure and Operations and Activities | 5 | 4 | 3 | 5 | | 17 | .85 |
| Sensitive Information | | | | | | | |
| All Other Assets | | | | | | | |

Notes:

| Potential Aggressors | Aggressor Goal[3] | Aggressors | Installation Location[4] | Publicity Profile[4] | Accessibility[4] | Availability[4] | Dynamics[4] | Recognizability | Relative Value to Aggressor | Law Enforcement[4] | Aggressors' Perception of Success | Threat Level | History[5] / Intentions[6] | Operational Capability[6] | Operating Environment[6] | Activity[6] | Sum of Likelihood Factors | Likelihood Ratings[7] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Unsophisticated Criminals | | | | | 18 | | | | | | | | | | | |
| | | Sophisticated Criminals | | | | | | | | | | | | | | | | |
| | | Organized Criminal Groups | | | | | | | | | | | | | | | | |
| ✓ | P | Vandals | 5 | 3 | 4 | 1 | 5 | 9 | 15 | 0 | 6 | 6 | 12 | | | | 66 | .37 |
| ✓ | P | Extremist Protesters | 5 | 3 | 4 | 1 | 5 | 12 | 15 | 6 | 12 | 14 | 12 | | | | 83 | .46 |
| ✓ | P | Domestic Terrorists | 5 | 3 | 4 | 1 | 5 | 12 | 15 | 6 | 18 | 6 | 2 | 2 | 2 | 0 | 75 | .42 |
| ✓ | P | International Terrorists | 5 | 3 | 4 | 1 | 5 | 15 | 15 | 0 | 24 | 14 | 2 | 2 | 2 | 0 | 92 | .51 |
| ✓ | P | State Sponsored Terrorists | 5 | 3 | 4 | 1 | 5 | 15 | 15 | 0 | 24 | 14 | 2 | 2 | 2 | 0 | 92 | .51 |
| ✓ | G | Saboteurs | 5 | 3 | 4 | 1 | 5 | 15 | 15 | 0 | 24 | 6 | 12 | | | | 90 | .5 |
| | | Foreign Intelligence Services | | | | | | | | | | | | | | | | |

1. Population Type applies to General Population only
2. Sum of Value Ratings ÷ 10 for Sensitive Information 15 for General Population; 20 for Critical Infrastructure and Operations and Activities; 25 for all other assets
3. G for mission related goal, P for publicity related goal, M for monetary related goal
4. Factors that should be same for all aggressors for given asset
5. Applies to all aggressors other than terrorists
6. Applies to Terrorists only
7. Sum of Likelihood Ratings ÷ 180

Figure C-4. Asset value/aggressor likelihood worksheet - critical infrastructure

## ASSET VALUE/AGGRESSOR LIKELIHOOD WORKSHEET

| | | |
|---|---|---|
| Project or Building: CPF HQ | Asset: Sensitive information | Analyst: |
| | Asset Category: Q | Date: |

| Value Rating Factors | Criticality to User / Population Type[1] | Impact on National Defense | Replaceability | Political Sensitivity | Relative Value to User | Sum of Value Factors | Value Rating[2] |
|---|---|---|---|---|---|---|---|
| General Population | | | | | | | |
| Critical Infrastructure and Operations and Activities | | | | | | | |
| Sensitive Information | | | | | 10 | | 1 |
| All Other Assets | | | | | | | |

Notes:

| Potential Aggressors | Aggressor Goal[3] | Aggressors | Installation Location[4] | Publicity Profile[4] | Accessibility[4] | Availability[4] | Dynamics[4] | Recognizability | Relative Value to Aggressor | Law Enforcement[4] | Aggressors' Perception of Success | Threat Level | History[5] / Intentions[6] | Operational Capability[6] | Operating Environment[6] | Activity[6] | Sum of Likelihood Factors | Likelihood Ratings[7] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Unsophisticated Criminals | | | | | | | | | | | | | | | | |
| | | Sophisticated Criminals | | | | | | | | | | | | | | | | |
| ✓ | G | Organized Criminal Groups | 5 | 3 | 4 | 3 | 3 | 6 | 15 | 0 | 6 | 6 | 6 | | | | 57 | .32 |
| | | Vandals | | | | | | | | | | | | | | | | |
| | | Extremist Protesters | | | | | | | | | | | | | | | | |
| | | Domestic Terrorists | | | | | | | | | | | | | | | | |
| | | International Terrorists | | | | | | | | | | | | | | | | |
| | | State Sponsored Terrorists | | | | | | | | | | | | | | | | |
| ✓ | G | Saboteurs | 5 | 3 | 4 | 3 | 3 | 9 | 15 | 0 | 12 | 6 | 24 | | | | 84 | .47 |
| ✓ | G | Foreign Intelligence Services | 5 | 3 | 4 | 3 | 3 | 9 | 15 | 0 | 12 | 6 | 30 | | | | 78 | .43 |

1. Population Type applies to General Population only
2. Sum of Value Ratings ÷ 10 for Sensitive Information 15 for General Population, 20 for Critical Infrastructure and Operations and Activities; 25 for all other assets
3. G for mission related goal, P for publicity related goal, M for monetary related goal
4. Factors that should be same for all aggressors for given asset
5. Applies to all aggressors other than terrorists
6. Applies to Terrorists only
7. Sum of Likelihood Ratings ÷ 180

**Figure C-5. Asset value/aggressor likelihood worksheet - sensitive information**

## ASSET VALUE/AGGRESSOR LIKELIHOOD WORKSHEET

| Project or Building | Asset | Analyst |
|---|---|---|
| CPF HQ | ACTIVITES and OPS | |
| | Asset Category: R | Date: |

| Value Rating Factors | Criticality to User / Population Type[1] | Impact on National Defense | Replaceability | Political Sensitivity | Relative Value to User | Sum of Value Factors | Value Rating[2] |
|---|---|---|---|---|---|---|---|
| General Population | | | | | | | |
| Critical Infrastructure and Operations and Activities | 5 | 5 | 1 | 5 | | 16 | .8 |
| Sensitive Information | | | | | | | |
| All Other Assets | | | | | | | |

Notes:

| Potential Aggressors | Aggressor Goal[3] | Aggressors | Installation Location[4] | Publicity Profile[4] | Accessibility[4] | Availability[4] | Dynamics[4] | Recognizability | Relative Value to Aggressor | Law Enforcement[4] | Aggressors' Perception of Success | Threat Level | History[5] / Intentions[6] | Operational Capability[6] | Operating Environment[6] | Activity[6] | Sum of Likelihood Factors | Likelihood Ratings[7] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Unsophisticated Criminals | | | | | | | | | | | | | | | | |
| | | Sophisticated Criminals | | | | | | | | | | | | | | | | |
| ✓ | G | Organized Criminal Groups | 5 | 3 | 4 | 1 | 3 | 12 | 8 | 0 | 12 | 6 | 6 | | | | 57 | .33 |
| | | Vandals | | | | | | | | | | | | | | | | |
| ✓ | G | Extremist Protesters | 5 | 3 | 4 | 1 | 3 | 12 | 15 | 0 | 12 | 6 | 12 | | | | 73 | .41 |
| ✓ | P | Domestic Terrorists | 5 | 3 | 4 | 1 | 3 | 12 | 15 | 0 | 12 | 5 | 2 | 2 | 2 | Ø | 66 | .37 |
| ✓ | P | International Terrorists | 5 | 3 | 4 | 1 | 3 | 15 | 15 | 0 | 12 | 5 | 2 | 2 | 2 | Ø | 69 | .38 |
| ✓ | P | State Sponsored Terrorists | 5 | 3 | 4 | 1 | 3 | 15 | 15 | 0 | 12 | 5 | 2 | 2 | 2 | Ø | 69 | .38 |
| ✓ | G | Saboteurs | 5 | 3 | 4 | 1 | 3 | 15 | 8 | 0 | 12 | 6 | 12 | | | | 69 | .38 |
| ✓ | G | Foreign Intelligence Services | 5 | 3 | 4 | 1 | 3 | 15 | 8 | 0 | 12 | 6 | 24 | | | | 81 | .45 |

1. Population Type applies to General Population only
2. Sum of Value Ratings ÷ 10 for Sensitive Information 15 for General Population, 20 for Critical Infrastructure and Operations and Activities; 25 for all other assets
3. G for mission related goal, P for publicity related goal, M for monetary related goal
4. Factors that should be same for all aggressors for given asset
5. Applies to all aggressors other than terrorists
6. Applies to Terrorists only
7. Sum of Likelihood Ratings ÷ 180

**Figure C-6. Asset value/aggressor likelihood worksheet - activities and operations**

# ASSET VALUE/AGGRESSOR LIKELIHOOD WORKSHEET

| | |
|---|---|
| Project or Building: CPF HQ | Asset: CONTROLLED CRYPTO |
| Analyst: | Asset Category: P |
| Date: | |

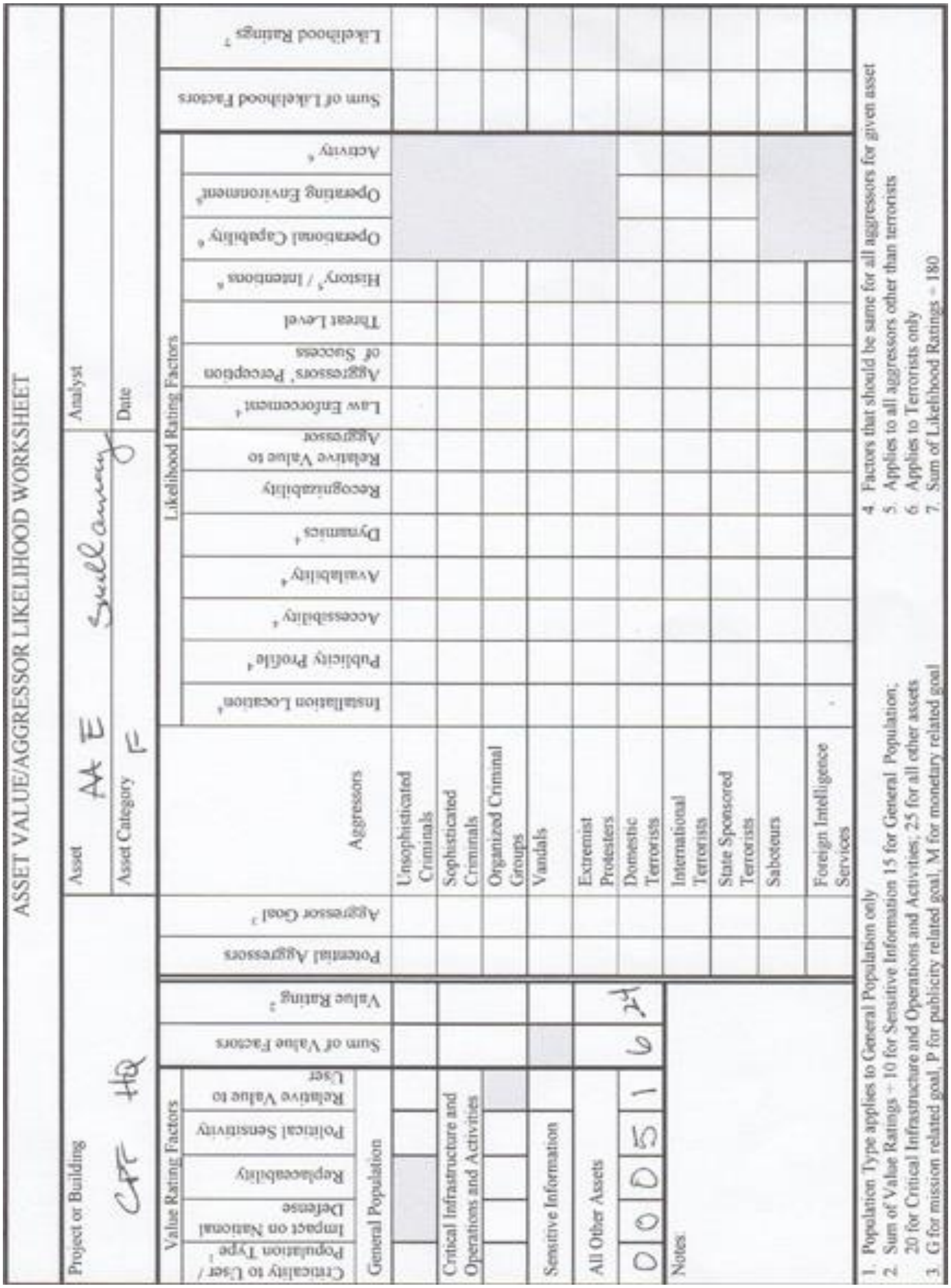
| Value Rating Factors: Criticality to User / Population Type[1] | Impact on National Defense | Replaceability | Political Sensitivity | Relative Value to User | Sum of Value Factors | Value Rating[2] |
|---|---|---|---|---|---|---|
| General Population | | | | | | |
| | | | | | | |
| Critical Infrastructure and Operations and Activities | | | | | | |
| | | | | | | |
| Sensitive Information | | | | | | |
| All Other Assets | | | | | | |
| 4 | 3 | 0 | ɸ | 5 | 12 | .48 |

Notes:

| Potential Aggressors | Aggressor Goal[3] | Aggressors | Installation Location[4] | Publicity Profile[4] | Accessibility[4] | Availability[4] | Dynamics[4] | Recognizability | Relative Value to Aggressor | Law Enforcement[4] | Aggressors' Perception of Success | Threat Level | History[5] / Intentions[6] | Operational Capability[6] | Operating Environment[6] | Activity[6] | Sum of Likelihood Factors | Likelihood Ratings[7] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Unsophisticated Criminals | | | | | | | | | | | | | | | | |
| | | Sophisticated Criminals | | | | | | | | | | | | | | | | |
| | | Organized Criminal Groups | | | | | | | | | | | | | | | | |
| | | Vandals | | | | | | | | | | | | | | | | |
| | | Extremist Protesters | | | | | | | | | | | | | | | | |
| | | Domestic Terrorists | | | | | | | | | | | | | | | | |
| | | International Terrorists | | | | | | | | | | | | | | | | |
| | | State Sponsored Terrorists | | | | | | | | | | | | | | | | |
| | | Saboteurs | | | | | | | | | | | | | | | | |
| | | Foreign Intelligence Services | | | | | | | | | | | | | | | | |

1. Population Type applies to General Population only
2. Sum of Value Ratings ÷ 10 for Sensitive Information 15 for General Population; 20 for Critical Infrastructure and Operations and Activities; 25 for all other assets
3. G for mission related goal, P for publicity related goal, M for monetary related goal
4. Factors that should be same for all aggressors for given asset
5. Applies to all aggressors other than terrorists
6. Applies to Terrorists only
7. Sum of Likelihood Ratings ÷ 180

**Figure C-7. Asset value/aggressor likelihood worksheet - controlled cryptologic equipment**


ASSET VALUE/AGGRESSOR LIKELIHOOD WORKSHEET

| Project or Building | Asset | Analyst |
|---|---|---|
| CPF HQ | AA E | Sullaway |
| | Asset Category F | Date |

| Value Rating Factors: Criticality to User / Population Type[1] | Impact on National Defense | Replaceability | Political Sensitivity | Relative Value to User | Sum of Value Factors | Value Rating[2] |
|---|---|---|---|---|---|---|
| General Population | | | | | | |
| | | | | | | |
| Critical Infrastructure and Operations and Activities | | | | | | |
| | | | | | | |
| Sensitive Information | | | | | | |
| All Other Assets | | | | | | |
| 0 | 0 | 0 | 5 | 1 | 6 | 24 |

Notes:

| Potential Aggressors | Aggressor Goal[3] | Aggressors | Installation Location[4] | Publicity Profile[4] | Accessibility[4] | Availability[4] | Dynamics[4] | Recognizability | Relative Value to Aggressor | Law Enforcement[4] | Aggressors' Perception of Success | Threat Level | History[5] / Intentions[6] | Operational Capability[6] | Operating Environment[6] | Activity[6] | Sum of Likelihood Factors | Likelihood Ratings[7] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Unsophisticated Criminals | | | | | | | | | | | | | | | | |
| | | Sophisticated Criminals | | | | | | | | | | | | | | | | |
| | | Organized Criminal Groups | | | | | | | | | | | | | | | | |
| | | Vandals | | | | | | | | | | | | | | | | |
| | | Extremist Protesters | | | | | | | | | | | | | | | | |
| | | Domestic Terrorists | | | | | | | | | | | | | | | | |
| | | International Terrorists | | | | | | | | | | | | | | | | |
| | | State Sponsored Terrorists | | | | | | | | | | | | | | | | |
| | | Saboteurs | | | | | | | | | | | | | | | | |
| | | Foreign Intelligence Services | | | | | | | | | | | | | | | | |

1. Population Type applies to General Population only
2. Sum of Value Ratings ÷ 10 for Sensitive Information 15 for General Population; 20 for Critical Infrastructure and Operations and Activities; 25 for all other assets
3. G for mission related goal, P for publicity related goal, M for monetary related goal
4. Factors that should be same for all aggressors for given asset
5. Applies to all aggressors other than terrorists
6. Applies to Terrorists only
7. Sum of Likelihood Ratings ÷ 180

**Figure C-8. Asset value/aggressor likelihood worksheet –A, A & E**

# ASSET VALUE/AGGRESSOR LIKELIHOOD WORKSHEET

| Project or Building | Asset | Analyst |
|---|---|---|
| CPF HQ | COMMS/ELEC / AV / MISC PLFB | |
| | Asset Category H / M / N | Date |

| Value Rating Factors | | | | | | |
|---|---|---|---|---|---|---|
| Criticality to User / Population Type [1] | Impact on National Defense | Replaceability | Political Sensitivity | Relative Value to User | Sum of Value Factors | Value Rating [2] |
| General Population | | | | | | |
| | | | | | | |
| Critical Infrastructure and Operations and Activities | | | | | | |
| | | | | | | |
| Sensitive Information | | | | | | |
| All Other Assets | | | | | | |
| 0 | 0 | 0 | 3 | 1 | 4 | .16 |

Notes:

| Potential Aggressors | Aggressor Goal [3] | Aggressors | Installation Location [4] | Publicity Profile [4] | Accessibility [4] | Availability [4] | Dynamics [4] | Recognizability | Relative Value to Aggressor | Law Enforcement [4] | Aggressors' Perception of Success | Threat Level | History [5] / Intentions [6] | Operational Capability [6] | Operating Environment [6] | Activity [6] | Sum of Likelihood Factors | Likelihood Ratings [7] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Unsophisticated Criminals | | | | | | | | | | | | | | | | |
| | | Sophisticated Criminals | | | | | | | | | | | | | | | | |
| | | Organized Criminal Groups | | | | | | | | | | | | | | | | |
| | | Vandals | | | | | | | | | | | | | | | | |
| | | Extremist Protesters | | | | | | | | | | | | | | | | |
| | | Domestic Terrorists | | | | | | | | | | | | | | | | |
| | | International Terrorists | | | | | | | | | | | | | | | | |
| | | State Sponsored Terrorists | | | | | | | | | | | | | | | | |
| | | Saboteurs | | | | | | | | | | | | | | | | |
| | | Foreign Intelligence Services | | | | | | | | | | | | | | | | |

1. Population Type applies to General Population only
2. Sum of Value Ratings ÷ 10 for Sensitive Information 15 for General Population; 20 for Critical Infrastructure and Operations and Activities; 25 for all other assets
3. G for mission related goal, P for publicity related goal, M for monetary related goal
4. Factors that should be same for all aggressors for given asset
5. Applies to all aggressors other than terrorists
6. Applies to Terrorists only
7. Sum of Likelihood Ratings ÷ 180

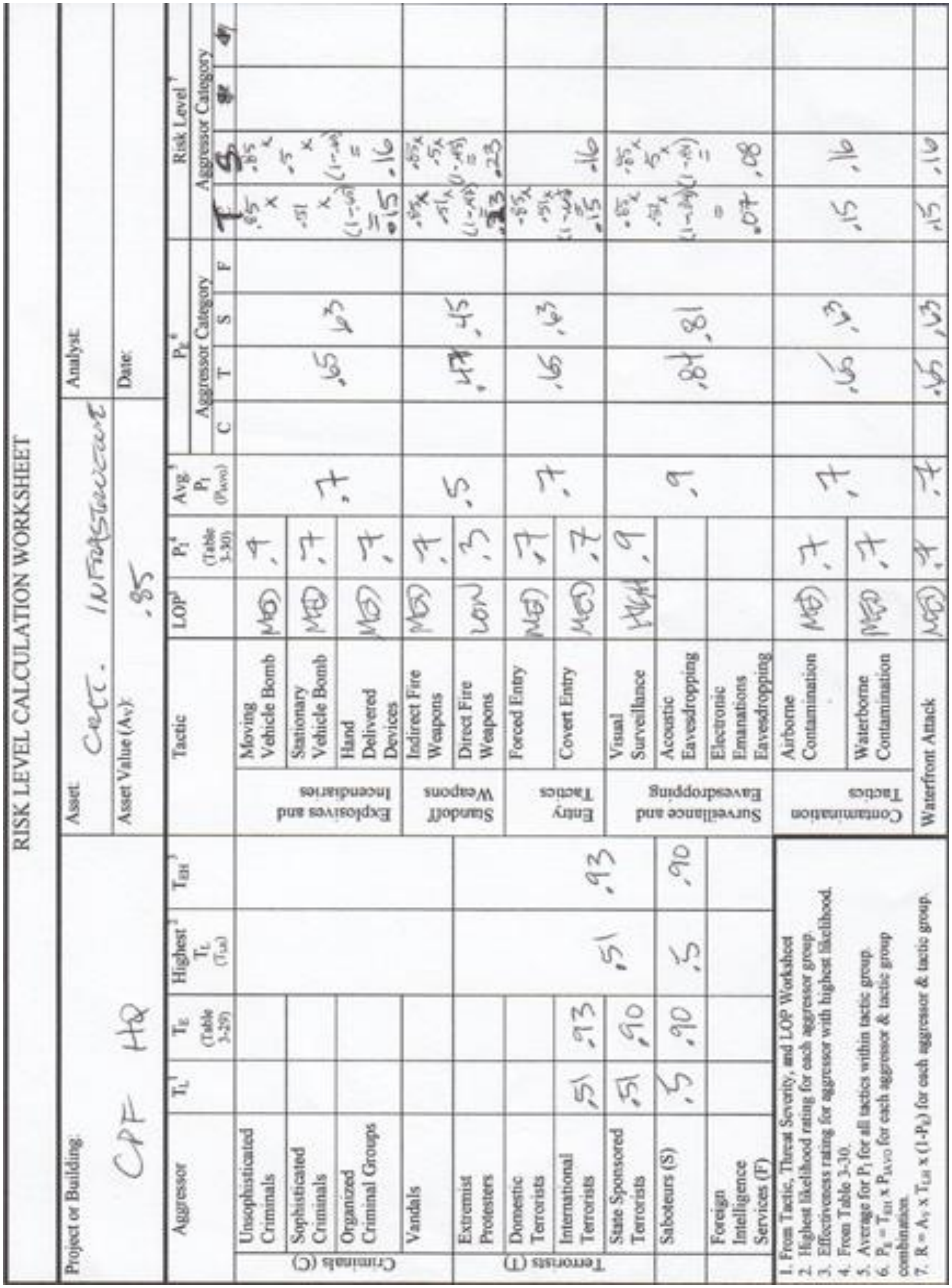
**Figure C-9. Asset value/aggressor likelihood worksheet - comm/elec/AV/misc**

TACTIC, THREAT SEVERITY, AND LEVEL OF PROTECTION WORKSHEET

| Project or Building | Asset | Asset Category | Asset Value | Analyst | Date |
|---|---|---|---|---|---|
| CPF HQ | CRITICAL INFRASTRUCTURE | C | .85 | | |

| Aggressors \ Tactics | Aggressor Likelihood | Explosives and Incendiary Devices: Moving Vehicle Devices | Explosives and Incendiary Devices: Stationary Vehicle Devices | Explosives and Incendiary Devices: Hand Delivered Devices | Standoff Weapons: Indirect Fire Weapons | Standoff Weapons: Direct fire weapons | Entry: Forced Entry | Entry: Covert Entry | Surveillance and Eavesdropping: Visual Surveillance | Surveillance and Eavesdropping: Acoustic Eavesdropping | Surveillance and Eavesdropping: Electronic Emanations Eavesdropping | Contamination: Airborne Contamination | Contamination: Waterborne Contamination | Waterfront Attack |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Applicable Tactics | | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | | ✓ |
| Unsophisticated Criminals | | | | | | | | | | | | | | |
| Sophisticated Criminals | | | | | | | | | | | | | | |
| Organized Criminal Groups | | | | | | | | | | | | | | |
| Vandals | | | | | | | | | | | | | | |
| Extremist Protesters | | | | | | | | | | | | | | |
| Domestic Terrorists | | | | | | | | | | | | | | |
| International Terrorists | .51 | L M H | L M H | M H | L M H | L M H | L M H | L M H | H | | | L M | L M | L M |
| State Sponsored Terrorists | .51 | L M H VH | L M H VH | M H | L M H VH | L M H VH | L M H VH | L M H VH | H | | | L M H | L M H | L M H |
| Saboteurs | .5 | | | M H | L M H VH | L M H VH | L M VH | L M H VH | H | | | L M H | L M H | L M H |
| Foreign Intelligence Services | | | | | | | L M H | L M H | L M H | L M H | L M H | | | |
| Initial Design Basis Threat (highest Threat Severity Level for each tactic) | | L | L | M | L | L | M | L | H | | | L | L | L |
| Initial Level of Protection for Applicable Tactic (Table 3-28) | | MED | MED | MED | MED | LOW | MED | MED | HIGH | | | MED | MED | MED |

**Figure C-10. Tactic, threat severity, and level of protection worksheet**



RISK LEVEL CALCULATION WORKSHEET

| Project or Building: | Asset: | Analyst: |
|---|---|---|
| CPF HQ | CRIT. INFRASTRUCTURE | |
| | Asset Value ($A_V$): .85 | Date: |

| Aggressor group | Aggressor | $T_L$ [1] | $T_E$ (Table 3-29) | Highest $T_L$ ($T_{LH}$) [2] | $T_{EH}$ [3] |
|---|---|---|---|---|---|
| Criminals (C) | Unsophisticated Criminals | | | | |
| Criminals (C) | Sophisticated Criminals | | | | |
| Criminals (C) | Organized Criminal Groups | | | | |
| Criminals (C) | Vandals | | | | |
| Terrorists (T) | Extremist Protesters | | | .51 | .93 |
| Terrorists (T) | Domestic Terrorists | | | | |
| Terrorists (T) | International Terrorists | .51 | .93 | | |
| Terrorists (T) | State Sponsored Terrorists | .51 | .90 | | |
| | Saboteurs (S) | .5 | .90 | .5 | .90 |
| | Foreign Intelligence Services (F) | | | | |

| Tactic group | Tactic | LOP [1] | $P_I$ [4] (Table 3-30) | Avg. $P_I$ ($P_{IAVG}$) [5] | $P_E$ [6] C | $P_E$ T | $P_E$ S | $P_E$ F | Risk Level [7] T | Risk Level S | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Explosives and Incendiaries | Moving Vehicle Bomb | MED | .7 | .7 | | .65 | .63 | | .85 x .51 x (1-.65) = .15 | .85 x .5 x (1-.63) = .16 | | |
| Explosives and Incendiaries | Stationary Vehicle Bomb | MED | .7 | | | | | | | | | |
| Explosives and Incendiaries | Hand Delivered Devices | MED | .7 | | | | | | | | | |
| Standoff Weapons | Indirect Fire Weapons | MED | .7 | .5 | | .47 | .45 | | .85 x .51 x (1-.47) = .23 | .85 x .5 x (1-.45) = .23 | | |
| Standoff Weapons | Direct Fire Weapons | LOW | .3 | | | | | | | | | |
| Entry Tactics | Forced Entry | MED | .7 | .7 | | .65 | .63 | | .85 x .51 x (1-.65) = .15 | .16 | | |
| Entry Tactics | Covert Entry | MED | .7 | | | | | | | | | |
| Surveillance and Eavesdropping | Visual Surveillance | HIGH | .9 | .9 | | .84 | .81 | | .85 x .51 x (1-.84) = .07 | .85 x .5 x (1-.81) = .08 | | |
| Surveillance and Eavesdropping | Acoustic Eavesdropping | | | | | | | | | | | |
| Surveillance and Eavesdropping | Electronic Emanations Eavesdropping | | | | | | | | | | | |
| Contamination Tactics | Airborne Contamination | MED | .7 | .7 | | .65 | .63 | | .15 | .16 | | |
| Contamination Tactics | Waterborne Contamination | MED | .7 | | | | | | | | | |
| | Waterfront Attack | MED | .7 | .7 | | .65 | .63 | | .15 | .16 | | |

1. From Tactic, Threat Severity, and LOP Worksheet
2. Highest likelihood rating for each aggressor group.
3. Effectiveness rating for aggressor with highest likelihood.
4. From Table 3-30.
5. Average for $P_I$ for all tactics within tactic group.
6. $P_E = T_{EH} \times P_{IAVG}$ for each aggressor & tactic group combination.
7. $R = A_V \times T_{LH} \times (1-P_E)$ for each aggressor & tactic group.

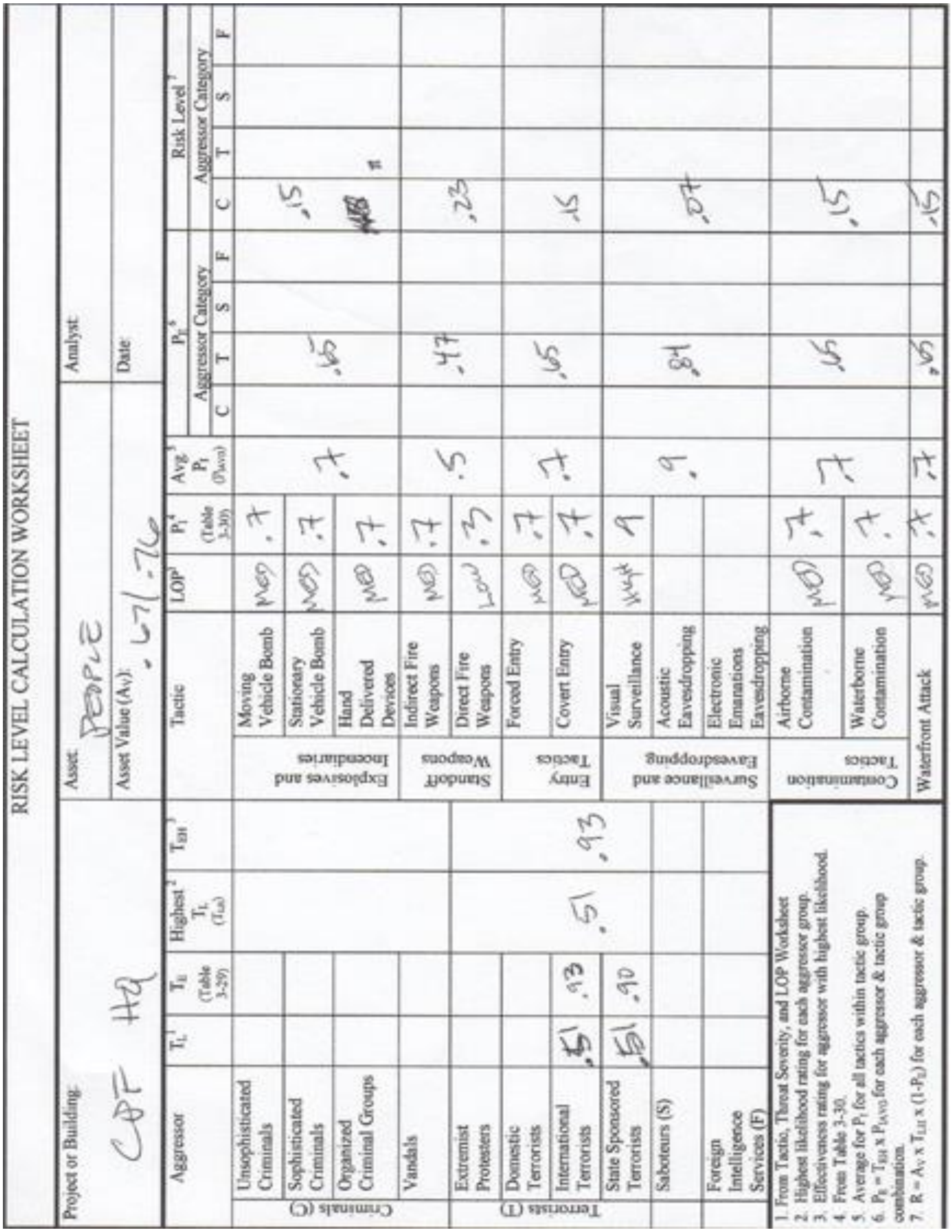
**Figure C-11. Risk level calculation worksheet**

TACTIC, THREAT SEVERITY, AND LEVEL OF PROTECTION WORKSHEET

| Project or Building | Asset | Asset Category | Asset Value | Analyst | Date |
|---|---|---|---|---|---|
| CPF HQ | PEOPLE | A | .67 / .76 | | |

| Aggressors \ Tactics | Aggressor Likelihood | Explosives and Incendiary Devices: Moving Vehicle Devices | Explosives and Incendiary Devices: Stationary Vehicle Devices | Explosives and Incendiary Devices: Hand Delivered Devices | Standoff Weapons: Indirect Fire Weapons | Standoff Weapons: Direct fire weapons | Entry: Forced Entry | Entry: Covert Entry | Surveillance and Eavesdropping: Visual Surveillance | Surveillance and Eavesdropping: Acoustic Eavesdropping | Surveillance and Eavesdropping: Electronic Emanations Eavesdropping | Contamination: Airborne Contamination | Contamination: Waterborne Contamination | Waterfront Attack |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Applicable Tactics | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | ✓ | ✓ | ✓ |
| Unsophisticated Criminals | | | | | | | | | | | | | | |
| Sophisticated Criminals | | | | | | | | | | | | | | |
| Organized Criminal Groups | | | | | | | | | | | | | | |
| Vandals | | | | | | | | | | | | | | |
| Extremist Protesters | | | | | | | | | | | | | | |
| Domestic Terrorists | | | | | | | | | | | | | | |
| International Terrorists | .51 | L M H | L M H | M H | L M H | L M H | L M H | L M H | H | | | L M | L M | L M |
| State Sponsored Terrorists | .51 | L M H VH | L M H VH | M H | L M H VH | L M H VH | M H VH | L M H VH | H | | | L M H | L M H | L M H |
| Saboteurs | | | | | | | | | | | | | | |
| Foreign Intelligence Services | | | | | | | | | | | | | | |
| Initial Design Basis Threat (highest Threat Severity Level for each tactic) | | L | L | M | L | L | M | L | H | | | L | L | L |
| Initial Level of Protection for Applicable Tactic (Table 3-28) @ .76 value | | MOD | MOD | MOD | MOD | LOW | MOD | MOD | HIGH | | | MOD | MOD | MOD |

**Figure C-12. Tactic, threat level, and level of protection - people**



RISK LEVEL CALCULATION WORKSHEET

Project or Building: CPF HQ

Asset: PEOPLE

Asset Value ($A_V$): .67/.76

Analyst:

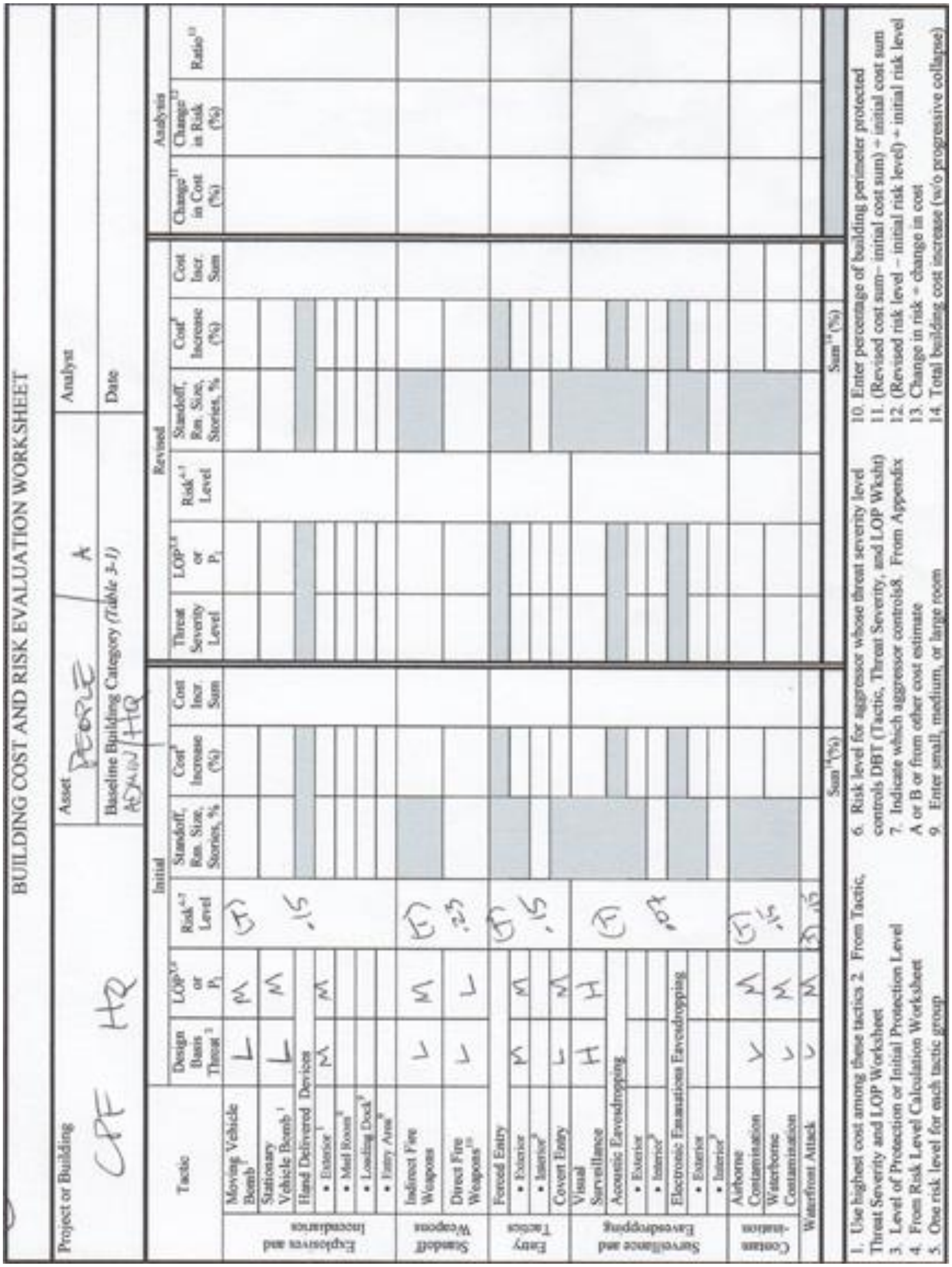
Date:

| | Aggressor | $T_L$ [1] | $T_E$ (Table 3-29) | Highest [2] $T_L$ ($T_{LH}$) | $T_{EH}$ [3] |
|---|---|---|---|---|---|
| Criminals (C) | Unsophisticated Criminals | | | | |
| | Sophisticated Criminals | | | | |
| | Organized Criminal Groups | | | | |
| | Vandals | | | | |
| Terrorists (T) | Extremist Protesters | | | | |
| | Domestic Terrorists | | | | |
| | International Terrorists | .51 | .93 | .51 | .93 |
| | State Sponsored Terrorists | .51 | .90 | | |
| | Saboteurs (S) | | | | |
| | Foreign Intelligence Services (F) | | | | |

| | Tactic | LOP [1] | $P_I$ [4] (Table 3-30) | Avg [5] $P_I$ ($P_{IAVG}$) | $P_E$ [6] C | $P_E$ T | $P_E$ S | $P_E$ F | Risk Level [7] C | Risk Level T | Risk Level S | Risk Level F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Explosives and Incendiaries | Moving Vehicle Bomb | MED | .7 | .7 | | .65 | | | .15 | | | |
| | Stationary Vehicle Bomb | MED | .7 | | | | | | | | | |
| | Hand Delivered Devices | MED | .7 | | | | | | | | | |
| Standoff Weapons | Indirect Fire Weapons | MED | .7 | .5 | | .47 | | | .23 | | | |
| | Direct Fire Weapons | LOW | .3 | | | | | | | | | |
| Entry Tactics | Forced Entry | MED | .7 | .7 | | .65 | | | .15 | | | |
| | Covert Entry | MED | .7 | | | | | | | | | |
| Surveillance and Eavesdropping | Visual Surveillance | HIGH | .9 | .9 | | .84 | | | .07 | | | |
| | Acoustic Eavesdropping | | | | | | | | | | | |
| | Electronic Emanations Eavesdropping | | | | | | | | | | | |
| Contamination Tactics | Airborne Contamination | MED | .7 | .7 | | .65 | | | .15 | | | |
| | Waterborne Contamination | MED | .7 | | | | | | | | | |
| Waterfront Attack | | MED | .7 | .7 | | .65 | | | .15 | | | |

1. From Tactic, Threat Severity, and LOP Worksheet
2. Highest likelihood rating for each aggressor group.
3. Effectiveness rating for aggressor with highest likelihood.
4. From Table 3-30.
5. Average for $P_I$ for all tactics within tactic group.
6. $P_E = T_{EH} \times P_{IAVG}$ for each aggressor & tactic group combination.
7. $R = A_V \times T_{LH} \times (1-P_E)$ for each aggressor & tactic group.

**Figure C-13. Risk level calculation worksheet - people**



BUILDING COST AND RISK EVALUATION WORKSHEET

| Project or Building | Asset | Analyst |
|---|---|---|
| CPF HQ | PEOPLE / A | |
| | Baseline Building Category (Table 3-1) ADMIN/HQ | Date |

| Group | Tactic | Initial: Design Basis Threat[3] | Initial: LOP[2,8] or $P_1$ | Initial: Risk[4-7] Level | Initial: Standoff, Rm. Size, Stories, % | Initial: Cost[8] Increase (%) | Initial: Cost Incr. Sum | Revised: Threat Severity Level | Revised: LOP[2,8] or $P_1$ | Revised: Risk[4-7] Level | Revised: Standoff, Rm. Size, Stories, % | Revised: Cost[8] Increase (%) | Revised: Cost Incr. Sum | Analysis: Change[11] in Cost (%) | Analysis: Change[12] in Risk (%) | Analysis: Ratio[13] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Explosives and Incendiaries | Moving Vehicle Bomb[1] | L | M | (T) | | | | | | | | | | | | |
| | Stationary Vehicle Bomb[1] | L | M | .15 | | | | | | | | | | | | |
| | Hand Delivered Devices | | | | | | | | | | | | | | | |
| | • Exterior[1] | M | M | | | | | | | | | | | | | |
| | • Mail Room[9] | | | | | | | | | | | | | | | |
| | • Loading Dock[9] | | | | | | | | | | | | | | | |
| | • Entry Area[9] | | | | | | | | | | | | | | | |
| Standoff Weapons | Indirect Fire Weapons | L | M | (T) | | | | | | | | | | | | |
| | Direct Fire Weapons[10] | L | L | .23 | | | | | | | | | | | | |
| Entry Tactics | Forced Entry | | | (T) | | | | | | | | | | | | |
| | • Exterior | M | M | .15 | | | | | | | | | | | | |
| | • Interior[9] | | | | | | | | | | | | | | | |
| | Covert Entry | L | M | | | | | | | | | | | | | |
| Surveillance and Eavesdropping | Visual Surveillance | H | H | (T) | | | | | | | | | | | | |
| | Acoustic Eavesdropping | | | | | | | | | | | | | | | |
| | • Exterior | | | | | | | | | | | | | | | |
| | • Interior[9] | | | .07 | | | | | | | | | | | | |
| | Electronic Emanations Eavesdropping | | | | | | | | | | | | | | | |
| | • Exterior | | | | | | | | | | | | | | | |
| | • Interior[9] | | | | | | | | | | | | | | | |
| Contamination | Airborne Contamination | L | M | (T) | | | | | | | | | | | | |
| | Waterborne Contamination | L | M | .15 | | | | | | | | | | | | |
| Waterfront Attack | | L | M | (T) .15 | | | | | | | | | | | | |
| | | | | | | Sum[14] (%) | | | | | | Sum[14] (%) | | | | |

1. Use highest cost among these tactics 2. From Tactic, Threat Severity and LOP Worksheet
3. Level of Protection or Initial Protection Level
4. From Risk Level Calculation Worksheet
5. One risk level for each tactic group
6. Risk level for aggressor whose threat severity level controls DBT (Tactic, Threat Severity, and LOP Wksht)
7. Indicate which aggressor controls8. From Appendix A or B or from other cost estimate
9. Enter small, medium, or large room
10. Enter percentage of building perimeter protected
11. (Revised cost sum– initial cost sum) ÷ initial cost sum
12. (Revised risk level – initial risk level) ÷ initial risk level
13. Change in risk ÷ change in cost
14. Total building cost increase (w/o progressive collapse)

**Figure C-14. Building cost and risk evaluation worksheet - people**

**BUILDING COST AND RISK EVALUATION WORKSHEET**

| | | | |
|---|---|---|---|
| Project or Building: CPF HQ | Asset: ~~[illegible]~~ Critical infrastructure | Analyst: | |
| | Baseline Building Category (*Table 3-1*): ADMIN / HQ | Date: | |

| | Tactic | Initial: Design Basis Threat[2] | Initial: LOP[3,4] or $P_1$ | Initial: Risk[4-7] Level | Initial: Standoff, Rm. Size, Stories, % | Initial: Cost[8] Increase (%) | Initial: Cost Incr. Sum | Revised: Threat Severity Level | Revised: LOP[3,4] or $P_1$ | Revised: Risk[4-7] Level | Revised: Standoff, Rm. Size, Stories, % | Revised: Cost[8] Increase (%) | Revised: Cost Incr. Sum | Analysis: Change[11] in Cost (%) | Analysis: Change[12] in Risk (%) | Analysis: Ratio[13] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Explosives and Incendiaries | Moving Vehicle Bomb[1] | L | M | (S) | | | | | | | | | | | | |
| | Stationary Vehicle Bomb[1] | L | M | | | | | | | | | | | | | |
| | Hand Delivered Devices | | | .16 | | | | | | | | | | | | |
| | • Exterior[1] | M | M | | | | | | | | | | | | | |
| | • Mail Room[9] | * | | | | | | | | | | | | | | |
| | • Loading Dock[9] | | | | | | | | | | | | | | | |
| | • Entry Area[9] | | | | | | | | | | | | | | | |
| Standoff Weapons | Indirect Fire Weapons | L | M | (T) | | | | | | | | | | | | |
| | Direct Fire Weapons[10] | L | M | .23 | | | | | | | | | | | | |
| Entry Tactics | Forced Entry | | | (S) | | | | | | | | | | | | |
| | • Exterior | M | M | | | | | | | | | | | | | |
| | • Interior[9] | | | .16 | | | | | | | | | | | | |
| | Covert Entry | L | M | | | | | | | | | | | | | |
| Surveillance and Eavesdropping | Visual Surveillance | H | H | (S) | | | | | | | | | | | | |
| | Acoustic Eavesdropping | | | | | | | | | | | | | | | |
| | • Exterior | | | | | | | | | | | | | | | |
| | • Interior[9] | | | .08 | | | | | | | | | | | | |
| | Electronic Emanations Eavesdropping | | | | | | | | | | | | | | | |
| | • Exterior | | | | | | | | | | | | | | | |
| | • Interior[9] | | | | | | | | | | | | | | | |
| Contamination | Airborne Contamination | L | M | (S) .16 | | | | | | | | | | | | |
| | Waterborne Contamination | L | M | | | | | | | | | | | | | |
| | Waterfront Attack | L | M | (S) .16 | | | | | | | | | | | | |
| | | | | | | Sum[14] (%) | | | | | | Sum[14] (%) | | | | |

1. Use highest cost among these tactics 2. From Tactic, Threat Severity and LOP Worksheet
3. Level of Protection or Initial Protection Level
4. From Risk Level Calculation Worksheet
5. One risk level for each tactic group
6. Risk level for aggressor whose threat severity level controls DBT (Tactic, Threat Severity, and LOP Wksht)
7. Indicate which aggressor controls8. From Appendix A or B or from other cost estimate
9. Enter small, medium, or large room
10. Enter percentage of building perimeter protected
11. (Revised cost sum – initial cost sum) ÷ initial cost sum
12. (Revised risk level – initial risk level) ÷ initial risk level
13. Change in risk ÷ change in cost
14. Total building cost increase (w/o progressive collapse)

**Figure C-15. Building cost and risk evaluation worksheet - critical infrastructure**

# Appendix D Decision Support Matrix

This matrix is meant to be cross referenced. In it are both security and sustainable design criteria to be met. It provides methods, synergies and opportunities in each category to facilitate meeting both criteria or at least help identify which are in conflict and supports the decision making process in determining tradeoffs and compromises.

| Develop a Sustainable Site/Site Planning | |
|---|---|
| Sustainable Design Strategies | Security Design Considerations and Opportunities |
| Standoff and unobstructed space requirements provide opportunities for green space, water catchment, natural habitat, wetlands and better solar access. Judicious use of trees and plantings provide shade | |
| Large combined campus provides security efficiencies with common fence lines, standoffs, access control etc. vs. separate buildings, as well as energy efficiencies with common use of water catchment; load matching, energy generation and distribution, HVAC central systems and distribution. | |
| Select appropriate site. Avoid certain types of land. | May be in conflict. Due to DoD needs. Use wetlands and habitat for standoff, defense zones |
| Alt transportation measure | |
| Protect surrounding habitat | |
| Provide open space | Incorporate standoff into bio swales, berms, pervious paving. Syncs with surveillance and unobstructed space requirement |
| Manage stormwater runoff | Standoff |
| Reduce Heat island | Landscape standoff and unobstructed space |
| Eliminate light pollution | Conflict with surveillance requirement. Syncs with reducing visibility of assets from vantage points at night. |

| Efficient Use of Water | |
|---|---|
| Sustainable Design Strategies | Security Design Considerations and Opportunities |
| Reduce indoor potable water consumption | Integrate water management in standoff strategies |
| Replace cooling tower with pond fountain | |
| Install water efficient landscaping | |
| | |
| | |
| | |

| Energy Conservation | |
|---|---|
| Sustainable Design Strategies | Security Design Considerations and Opportunities |
| Conserve energy | |
| Track building energy performance | Incorporate into greater electronic surveillance and monitoring system |
| Use Renewable energy | |
| | Energy security can be attained by onsite energy generation such as wind, geo thermal, solar |

| Choose Materials wisely | |
|---|---|
| Sustainable Design Strategies | Security Design Considerations and Opportunities |
| Choose eco preferable materials | Glazing requires blast resistant film in some cases to reduce flying debris hazard |

| Preserve and Protect Indoor Environmental Quality | |
|---|---|
| Sustainable Design Strategies | Security Design Considerations and Opportunities |
| Improve ventilation | Air tight envelope for CBR protection |
| Manage air contaminants | Window specifications couple blast resistance with daylighting features and heat gain mitigation |
| Spec less toxic materials | Balance views with anti –surveillance measures |
| Incorporate Occupant controls | |
| Provide daylight and views | |
| Reduce noise and ensure good acoustics | |

| Access Control | |
|---|---|
| Safety and Security Strategies | Sustainable Design Considerations/Opportunities |
| Use barriers to prevent passage of vehicles | Use natural and/or environmentally friendly barriers (e.g., trees, retention ponds, etc.). Use reinforced site furniture, planters, etc. as vehicle barriers. |
| Minimize public entrances into the building | Integrate with daylighting scheme |
| Secure vulnerable openings (e.g. doors, first floor windows) | Integrate with daylighting scheme |
| Install electronic access systems (e.g., parking, elevators) | Use energy-efficient systems. Consider renewable and/or distributed energy resources |
| Secure critical functions (e.g., IT, mechanical systems) | Consider dedicated ventilation and/or exhaust systems |

| Surveillance | |
|---|---|
| Safety and Security Strategies | Sustainable Design Considerations/Opportunities |
| Avoid spaces that permit concealment | Integrate with daylighting scheme |
| Define public versus private interior zones | Use signage and other directional devices manufactured from recycled material. Use barriers with low-VOC or no VOC finishes. |
| Avoid blocking lines of sight with fencing and landscaping | Integrate with landscaping and daylighting schemes. |
| Locate public areas (e.g., restrooms) where they can be easily observed | |
| Design lighting to reinforce natural surveillance | Integrate with building automation and control systems. Use energy-efficient systems. Consider renewable and/or distributed energy sources, such as solar power night lighting. |
| Install intrusion devices and video systems | Integrate with building automation and control systems. Use energy-efficient lighting and controls. Use low-light or no-light cameras for scene observation that minimize/eliminate the need for electrical lighting. Consider renewable and/or distributed energy sources |
| Use screen and tracking systems | Integrate with building automation and control systems. Use energy-efficient lighting. Consider renewable and/or distributed energy sources |

| Blast Protection | |
|---|---|
| Safety and Security Strategies | Sustainable Design Considerations/Opportunities |
| Design structural systems to prevent or delay building collapse | Integrate with passive solar design and solar shading. Use sustainable materials (e.g., fly-ash concrete, slag concrete, steel columns, etc.) |
| Use building configurations to better resist blast shock waves | Integrate with passive solar design and daylighting scheme |
| Maximize distances between parking and buildings | Integrate with alternative transportation plans |
| Size and locate windows with detonation points in mind | Integrate with daylighting scheme. Specify glazing or window films that reduce heat gain and glare and provide blast protection. |
| Use blast or ballistic resistant glazing | Use blast or ballistic resistant window films that are also energy-efficient (reduce heat gain and glare) |

| | |
|---|---|
| Increase strength of exterior cladding and nonstructural elements | Use sustainable materials. Consider thermal benefits of strengthened cladding options |
| Avoid exterior ornamentation that can break away | Integrate with sun control and shading devices |

| Chemical, Biological, Radiological Protection | |
|---|---|
| Safety and Security Strategies | Sustainable Design Considerations/Opportunities |
| Elevate fresh air intakes | Integrate with energy-efficient HVAC system |
| Prevent unauthorized access to fresh-air intakes | Specify bars and grates to be manufactured with recycled steel |
| Reduce need for utilities. | Consider renewable such as daylighting, passive solar heating, photovoltaics, and geothermal; and/or distributed energy resources |
| Apply external air filtration and over pressurization techniques | Integrate with building automation and control systems |
| Use internal air filtration technologies | Integrate with building automation and control systems |
| Secure vulnerable areas (e.g., mail rooms, loading docks, mechanical rooms, storage) | Consider dedicated ventilation and/or exhaust systems |
| | |
| | |

| Energy Security | |
|---|---|
| Safety and Security Strategies | Sustainable Design Considerations/Opportunities |
| Create redundant systems | Reduce need for energy. Use energy-efficient systems. Consider renewable and/or distributed energy resources |
| Reduce need for utilities. | Consider renewable such as daylighting, passive solar heating, photovoltaics, and geothermal; and/or distributed energy resources |

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