Ft. Detrick Defense Medical Logistics Center

Frederick, MD

Final Report

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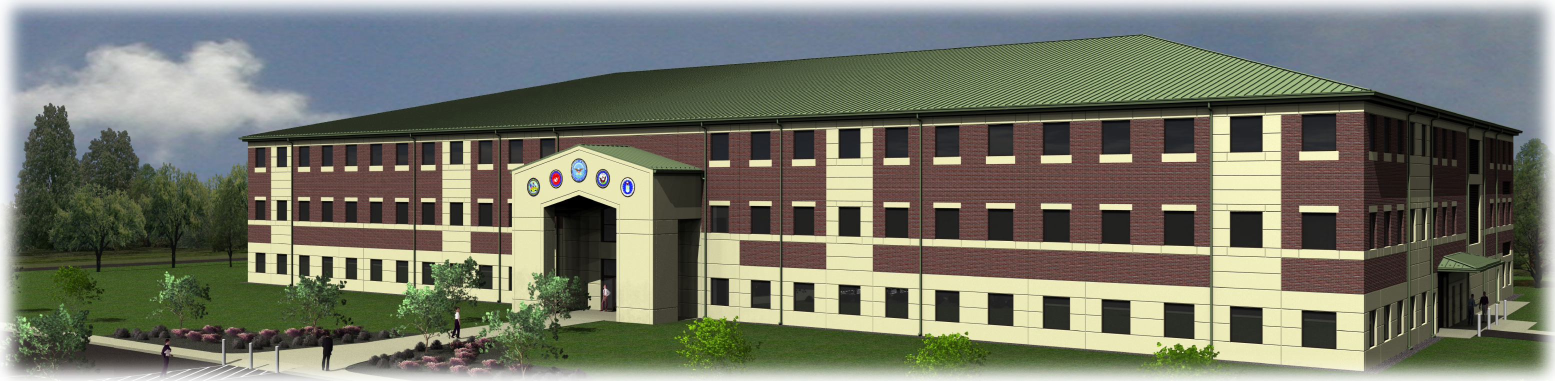

FT. DETRICK DMLC

Statistics

Function: Office building housing medical planning organizations within the Department of Defense
Size: 129,960 Square Feet, 3 stories
Construction Dates: September 2006 to April 2008
Delivery Method: Design-Build

Project Team

Owner: United States Government / Department of Defense
Owner Representative: U.S. Army Corps of Engineers – Baltimore District
General Contractor and Construction Manager: Mascaro Construction
Architects and Engineers: Baker and Associates

Architecture

Postmodern Design Influence
Double-Height Entry Vestibule
Brick Façade with Stone Accents at Windows and Lintels and Stone Base at First Floor
Gable-Style Metal Roof

Mechanical

Heating Hot Water System: 2 gas-fired boilers with primary/secondary pumping systems
Chilled Water System: 2 water-cooled chillers and 2 induced-draft cooling towers with primary/secondary pumping systems
Ventilation: 7 Air Handling Units each with return/relief fan to serve VAV terminal reheat units

Structural

Cast-in-place reinforced concrete foundation supported by reinforced concrete caissons with bells
Steel framed system with concrete floors
Walls formed by Tilt-Up Construction
Standing seam metal roof supported by metal roof deck

Electrical

4160V overhead distribution line delivers power to facility power transformer
480Y/277V system for lighting and HVAC, 208Y/120V system for receptacles and small loads
Linear fluorescent fixtures with T-8 lamps in ceiling grid
Down lights with compact fluorescent lamp used to accent or supplement other lighting
Automatic transfer switch and exterior power outlet provide means to connect to standby generator

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www.engr.psu.edu/ae/thesis/portfolios/2008/dnf113

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Executive summary

This report analyzes the existing mechanical systems of Ft. Detrick Defense Medical Logistics Center (DMLC) and proposes a redesign to improve the existing system. The existing systems were designed to meet typical ASHRAE guidelines as well as Anti-Terrorism/Force Protection guidelines mandatory for military structures. The building met most of the requirements for ASHRAE 62.1 and ASHRAE 90.1, as was studied in Technical Assignments 1 and 2. Because VAV systems are not the most energy efficient, a dedicated outdoor air system partnered with chilled beams and high induction diffusers was selected for the redesign. The building's electrical system was then resized to accommodate these changes. A constructed wetland was also added to the project as an architectural/site breadth topic to maintain sustainability. The goals of the redesign are:

- Decrease Lost Rentable Space
- Increase Energy Efficiency
- Maintain Affordability
- Maintain Occupant Safety and Indoor Air Quality
- Improve Sustainability

Since a DOAS system requires a smaller volume of air than a VAV system, only two DOAS units were needed to replace the six existing AHUs. Therefore, the lost rentable space decreased almost 2%. Because of the enthalpy wheel in the DOAS unit, the redesigned system saved 17.2% more energy than the existing system. Although the redesign is more expensive initially because of the higher cost of DOAS equipment and the added $38,700 for the constructed wetland, with the increased energy savings and savings to the electrical system, the design can payback in 5.2 years.

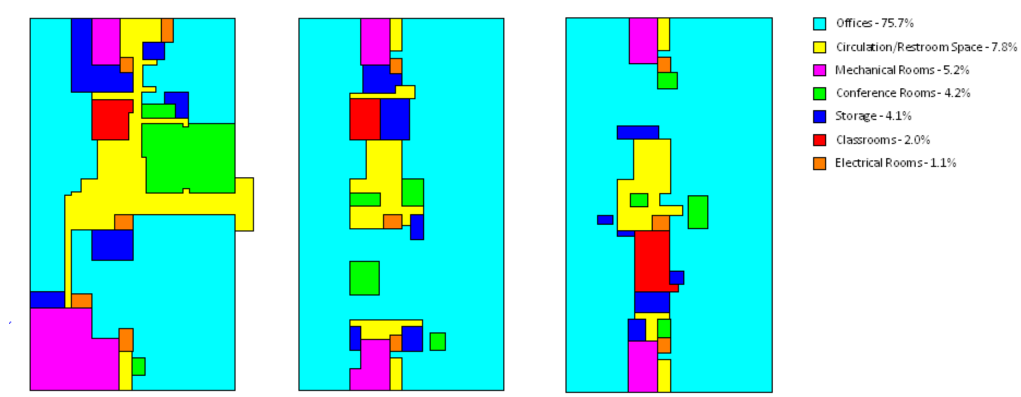
The contaminant removal analysis also showed that the DOAS was better for occupant safety. Although the DOAS takes two hours longer to flush out contaminants completely, it distributes the chemicals more evenly throughout the building at a concentration not harmful to the occupants. The design also made the building more sustainable, which was proven by the increase from SPiRiT (Sustainable Project Rating Tool) Silver to SPiRiT Gold. Six credits were obtained from the increase in energy efficiency, and one credit was obtained from the constructed wetland. In conclusion, all five of the project's objectives were met by the new system. Upon completion of the analysis, it was determined that if the owner was willing to pay the higher first cost, the redesigned system would be recommended.

Building Design Overview

Ft. Detrick Defense Medical Logistics Center (DMLC) is a three-story office building located on the Ft. Detrick military base in Frederick, MD. The building is 129,960 ft^2 and it houses the top medical planning organizations within the Department of Defense representing the Army, Navy, Air Force, and Marines. Figure 1 shows an area breakdown of the building and displays space relationships. As seen in this figure, the majority of the building consists of open office space. This minimizes the area needed strictly for circulation space. Mechanical rooms housing the building's air handling units (AHUs) are located at the north and south ends of the buildings. The central plant is located in the southwest corner of the first floor.

Figure 1

Space Relationship & Area Breakdown Diagram



First Floor Second Floor Third Floor

The mechanical engineer for Ft. Detrick, Baker and Associates, designed the building in accordance with the following specifications:

- ASHRAE 62.1-2004: Ventilation for Acceptable Indoor Air Quality
- ASHRAE 90.1-2004: Energy Efficient Design of New Buildings Except Low-Rise Residential Buildings
- Unified Facilities Criteria (UFC) 4-010-01: Anti-Terrorism/Force Protection (AT/FP) Standards
- UFC 3-410-01FA-Design: Heating, Ventilation, and Air Conditioning
- UFC 3-410-02A-Design: HVAC Control Systems
- Unified Facilities Guide Specifications (UFGS)

ASHRAE 62.1 and ASHRAE 90.1 are widely used in commercial building design. AT/FP, UFC, and UFGS are military-specific design standards. AT/FP guidelines were established for occupant safety in the incidence of a terrorist attack. Structural measures include blast-proof windows and requirements for preventing progressive collapse. Mechanical measures require that HVAC equipment is not roof-mounted. Exceptions include condensing units for DX systems and exhaust fans and hoods. The design also limits airborne contamination to reduce the potential for chemical, biological, and radiological agents being distributed throughout buildings. To ensure this, outdoor air intake louvers are placed on the second and third floor only. An emergency shutoff switch in the HVAC control system that can immediately shut down the air distribution system throughout the building in the event of contamination is also provided.

UFC and UFGS documents provide planning, design, and construction criteria and are applied to all Department of Defense structures. The basic principles of these documents are to design each system as simply as possible and to base system selections on life cycle cost effectiveness. They also require a specific amount of space for maintenance and commissioning of equipment. All designs must be sustainable according to the SPiRiT (Sustainable Project Rating Tool) rating system. This sustainability ranking system is used in lieu of LEED for all military buildings. Ft. Detrick will receive a Silver Rating when construction is complete.

The design outdoor conditions are taken from the mechanical scope of work for Ft. Detrick provided by Baker and Associates.

Table 1

Outdoor Design Conditions for Frederick, MD

Latitude	39°, 26 minutes
Longitude	77°, 26 minutes
Elevation	355 ft
Degree Days Heating (65°F Base)	5059
Degree Days Cooling (65°F Base)	948
Daily Range	26°F
Summer Winds	WNW 7.5 mph
Winter Winds	N 15 mph
Heating Design Dry Bulb Temperature	12°F
Cooling Design Dry Bulb Temperature	91°F
Cooling Design Wet Bulb Temperature	75°F

The design indoor conditions are also taken from the mechanical scope of work and are summarized in Table 2. Indoor design relative humidity is 50% in the summer with no humidity control in the winter unless noted otherwise. Night setback temperatures are 90°F in the summer and 55°F in the winter except in the IT/Comm Rooms.

Table 2
Indoor Design Criteria for Ft. Detrick

Space	Summer Indoor Temperature (°F)	Winter Indoor Temperature (°F)	Minimum Room Circulation (ACH/hr)	Outside Air (ACH/hr)	Maximum Noise Level (NC)	Notes
Offices	76	68	4	1	35	-
Conference Rooms	76	68	6	4	30	-
IT/Comm Rooms	72	72	6	2	40	-
Lobby	76	70	4	1	40	-
Classrooms	76	70	6	4	30	-
Corridors	76	68	6	2	30	-
Locker Rooms	78	68	10	2	35	-
Vestibule	-	50	-	-	40	-
Copy Rooms	76	70	10	2	40	-
Elevator Machine Room	90	50	-	-	45	-
File Storage Rooms	76	68	4	2	40	-
Storage	76	68	4	1	40	-
Cafeteria	76	68	5	1	40	-
Toilets/ Janitor Rooms	-	68	10	Exhaust	45	1
Arms Room	-	68	6	1	45	2
Mechanical/ Electrical Rooms	-	55	10	Exhaust	50	-
Receiving	76	55	4	1	40	-

1- Exhaust from adjacent areas
2- Dehumidifier to maintain 30% relative humidity

Mechanical Systems Description

A complete heating, ventilating, and air conditioning system is provided for Ft. Detrick. The systems are collectively controlled by a direct digital control (DDC) system, with the exception of the glycol system. The following sections describe each system in detail.

Hot Water System

The hot water distribution system for Ft. Detrick consists of two gas-fired boilers, two inline boiler circulation pumps, and two variable speed pumps. The boilers are each sized at 2160 MBH. Each boiler has an inline circulation pump to protect it from thermal shock. The building loop pumps are provided with variable frequency drives to adjust to the building flow requirements. The hot water piping is laid out in a reverse return loop. Supply water temperature is 180°F with a 20° design drop for the heating coils. The hot water serves HVAC heating loads only, which includes the AHU heating coils, VAV reheat coils, and unit heaters. Domestic water is heated by electric water heaters.

Chilled Water System

The chilled water distribution system for Ft. Detrick is a decoupled loop system consisting of two rotary screw water-cooled indoor chillers, two constant volume evaporator pumps serving the primary loop, and two variable volume pumps that provide chilled water to the building. The chillers are each sized at 220 tons. Chilled water leaving the evaporator is supplied at 42°F with a 12°F maximum rise designed for terminal unit air coils. Chilled water serves the cooling coils of AHU-1 through AHU-6.

Condenser Water System

The condenser water system consists of two induced-draft cooling towers and two constant volume condenser pumps that operate in a lead/lag fashion. These serve both chillers' condensing units, and are each sized for 630 gpm. The entering water temperature is 95°F and the leaving water temperature is 85°F. The entering air wet bulb temperature is 77°F.

Air Handling Systems

A variable air volume air handling system consists of VAV boxes and an air handling unit that supplies air to the boxes. Ft. Detrick contains six VAV systems (AHU-1 through AHU-6) that are on during regular operation and one emergency air handling unit that runs by generator power. AHUs 1 through 6 supply a mixture of outdoor and recirculated air to multiple zones. The emergency unit supplies only recirculated air. Each floor has two mechanical rooms, one on the north end and one on the south end, where an air handling unit is housed. The emergency unit is on the south end of the second floor and serves the Joint Operations Command office area if the power to AHU-4 goes out. All AHUs are controlled by variable frequency drives and distribute air through VAV hot-water reheat boxes. In this design, each zone is controlled individually by adjusting the airflow.

Glycol System

The building's glycol system serves air conditioning units in the communication rooms along with the emergency air handling unit. The units are served by a drycooler outside of the building. Control for the drycooler and its pumps is wired internally, so it is not connected to the DDC system. The glycol piping is run below grade and enters the building through the mechanical room on the first floor. Risers within the mechanical rooms distribute the glycol to the second and third floors.

ASHRAE 62.1 Analysis

For a building to comply with ASHRAE 62.1, the building must meet the guidelines of Sections 5 and 6 of the standard. Ft. Detrick met most of these guidelines. The building complies with Section 5 in that its louvers are not in the vicinity of any potential contaminants, including the parking lot, the main road, and the cooling towers. Louver controls are located in their corresponding mechanical room. However, according to the specifications, the louvers are designed for a maximum of 0.2 oz/(ft^2 free area), which does not meet ASHRAE's required maximum of 0.01 oz/(ft^2 free area). Also, the drawings do not show drain pans or any moisture removal devices. The louvers are designed with birdscreens, but no rain intrusion prevention or snow entrainment is specified.

Ventilation air from the AHU is ducted directly to VAV boxes and can be balanced by a thermostat in each zone. Once construction is completed, testing and balancing of the airflow will be performed in accordance with AABC MN-1, NEBB TABES, or SMACNA HVACTAB.

Rooms in the building that require an exhaust system are the restrooms, locker rooms, and janitor closets. These rooms are clustered together at the same location on every floor. A main vertical exhaust duct serves these spaces and is negatively pressurized. The branch on each floor converges into the vertical exhaust main which connects to an exhaust fan in the attic. After passing through the fan, the exhaust air is ducted up through a rooftop relief ventilator.

The building is designed to be resistant to mold growth and erosion per UL 181. The AHUs contain MERV 7 pre-filters and MERV 13 primary filters to ensure particulate matter removal. Both factors are in compliance with ASHRAE 62.1-2007.

Compliance with Section 6 is determined using the Ventilation Rate Calculation Procedure. Only zones served by AHU-1 through AHU-7 (emergency unit) were analyzed. For a system that recirculates air to comply with ASHRAE 62.1, the total design outdoor air intake (V_{ot}) must be less than or equal to the actual outdoor air intake. The actual outdoor air intake was taken from the air handling unit schedule in the design documents. The following table summarizes Ft. Detrick's compliance with ASHRAE 62.1.

Table 3
Section 6 Compliance Summary

AHU	Maximum Z_p	Nominal OA ($\sum V_{oz}$)	Total Design OA Intake (V_{ot})	OA Supplied	Comply
1	0.58	2843	4566	4460	NO
2	0.53	1733	2951	4210	YES
3	0.52	2235	3589	4975	YES
4	0.36	2092	2704	4550	YES
5	0.33	2120	2686	4670	YES
6	0.56	2584	4438	4985	YES
7	0.18	376	394	450	YES

The minimum outdoor air required for AHU-1 per ASHRAE 62.1 exceeds the actual outdoor air supplied by 106 cfm, so it is not in compliance with the standard. Note that the critical zone for this air handler is a storage room. The critical zone is where maximum Z_p and minimum E_v occur. Since a storage facility likely will not be occupied 100% of the time, the designer may have assumed that supplying that space with 58% outdoor air was not critical. Since ASHRAE 62.1 permits reduction in outdoor air relative to the full occupancy value if occupancy is intermittent, Ft. Detrick is assumed to be in compliance with Section 6.

ASHRAE 90.1 Analysis

Building Envelope Compliance

There are two compliance paths in ASHRAE 90.1 that can be used to evaluate the building envelope. Ft. Detrick meets the requirements of the Prescriptive Building Envelope Option. This option can be used when a building's vertical fenestration is less than 50% of the gross wall area and the skylight fenestration is less than 5% of the gross roof area. Ft. Detrick has no skylights, so the second requirement was met automatically. Table 4 summarizes the total glass area versus the total wall area, and shows that the first requirement is also met.

Table 4
Vertical Fenestration Summary

Window Quantity	Area Per Window	Total Glass Area	Total Wall Area	Percent Vertical Fenestration
213	24.89 ft^2	5302 ft^2	33,182 ft^2	15.98%

The Prescriptive Building Envelope Option is described in Section 5.5 of ASHRAE 90.1. Frederick, MD is classified as climate zone 4A, so Table 5.5-4 is used to determine the building envelope requirements. Ft. Detrick is categorized as 'nonresidential' in this chart. Tables 5 and 6 compare actual material characteristics with ASHRAE values. The actual insulation R-values and fenestration values are taken from the specifications for Ft. Detrick provided by Baker and Associates.

Table 5
Building Envelope Compliance - Opaque Elements

Building Component		Insulation Minimum R-Value	Actual Insulation R-value	Comply
Roofs				
	Insulation Entirely Above Deck	R-15	R-20	YES
Walls, Above Grade				
	Mass	R-5.7	R-13	YES
Floors				
	Mass	R-6.3	R-5	NO
Opaque Doors				
	Swinging	R-2 (U-0.7)	R-10	YES

Table 6
Building Envelope Compliance - Fenestration

Vertical Glazing 15.98% of Wall	Maximum per ASHRAE	Actual per Design Documents	Comply
U-Value Fixed	0.57	0.29	YES
U-Value Operable	0.57	0.29	YES
SHGC All Orientations	0.39	0.38	YES
SHGC North-Oriented	0.49	0.38	YES

HVAC Systems Compliance

Since Ft. Detrick is a new construction and not an addition or renovation, HVAC systems compliance is determined by Section 6.2 of ASHRAE 90.1. It is greater than two stories, so sections 6.4 and 6.5 are the compliance path. Table 7 summarizes the building's compliance with the minimum equipment efficiencies listed in Section 6.4.

Table 7
Minimum Equipment Efficiency Compliance

Equipment	Quantity	Minimum Efficiency (ASHRAE)	ASHRAE 90.1-2004 Table Reference	Actual Efficiency	Comply
Rotary Screw Water Cooled Chiller	2	COP = 4.90	6.8.1 C	COP = 5.39	YES
Gas-Fired Boilers	2	E_T = 75%	6.8.1 F	E_T = 80%	YES
Centrifugal Fan Cooling Towers	2	gpm/hp = 20.0	6.8.1 G	gpm/hp = 42	YES

Unit heaters and air conditioning units are not listed in the table above, but are designed to comply with ASHRAE 90.1. It is called out in specification section 15700A-14 of the design documents that "Units shall have an efficiency meeting or exceeding ASHRAE 90.1 requirements". However, the SEER value for the air conditioning units (manufactured by Liebert) and the efficiency of the unit heaters (manufactured by Trane) are not included in the manufacturer's cut sheets in the engineer's design analysis.

Ft. Detrick is also in compliance with the standards for insulation. Its ductwork is insulated with 1" thick rigid mineral fiber per the design documents. An R-value was not specified for this material in the design documents, but ROXUL, a manufacturer of rigid mineral fiber, list the R-value as 4.2. For an unvented attic with roof insulation, the minimum R-value listed in ASHRAE 90.1 is 3.5. Therefore, the ductwork insulation complies. The piping insulation is also in compliance with ASHRAE 90.1, as seen in Table 8.

Table 8
Minimum Pipe Insulation Thickness Compliance

	Heating Hot Water			Domestic Hot Water			Chilled Water		
Nominal Pipe Size (in)	Min. Thick.	Actual Thick.	Comply	Min. Thick.	Actual Thick.	Comply	Min. Thick.	Actual Thick.	Comply
<1	1	1	YES	0.5	1	YES	0.5	1	YES
1 to <1 1/2	1	1		0.5	1		0.5	1	
1 1/2 to <4	1	1.5		1	1		1	1	
4 to <8	1.5	1.5		1	1		1	1	
Operating Temperature Range (°F)	141-200			105+			40-60		

The service water heating is also in compliance with ASHRAE 90.1. The required performance for an electric hot water heater is determined by the energy factor (EF). For all four electric hot water heaters, the EF is above the minimum requirement, as is illustrated in Table 9.

Table 9
Minimum Service Water Heater Efficiency Compliance

Heater Location	Volume (gal)	Minimum EF	Actual EF	Comply
Janitor Closets	40	0.877	0.897	YES
Under Sinks	6	0.922	0.942	YES

EF=0.93-(0.00132*gal)

Power, Lighting, & Motor Compliance

The power compliance requirements are outlined in Section 8 of ASHRAE 90.1. It states that the feeder conductors must be sized for a maximum 2% voltage drop, and the branch circuit conductors must be sized for a maximum 3% voltage drop, both at design load conditions. The power distribution system for Ft. Detrick is designed to comply with these criteria.

The lighting compliance requirements are outlined in Section 9. The goal of this section is to establish a maximum interior lighting power allowance. The Space-By-Space Method Compliance Path was chosen for analysis. Table 10 summarizes the compliance of different area types within Ft. Detrick.

Table 10
Maximum Interior Lighting Power Allowance

Building Area Type	Area (ft^2)	W/ft^2 (Table 9.5.1)	Required Watts	Actual Watts	Comply
Cafeteria	801	0.9	721	592	YES
Classroom	2646	1.2	3175	3564	NO
Conference	5406	1.3	7028	7284	NO
Corridor	1558	0.5	779	3788	NO
Electrical/Mechanical Room	8148	1.5	12,222	6048	YES
Lobby	3246	1.3	4220	3264	YES
Office - Enclosed/Open	98,377	1.1	108,215	138,885	NO
Restrooms	2655	0.9	2390	3240	NO
Stairs	1823	0.6	1094	1632	NO
Storage	5300	0.9	4770	5288	NO
Total	**129,960**	**-**	**144,613**	**173,585**	**NO**

Motor efficiency compliance is determined by the standards in Section 10. Efficiency is calculated by dividing the brake horsepower by the input horsepower. These values are from the mechanical schedules and manufacturer's cut sheets, and are summarized in Table 11. Return fan data is from the manufacturer's (Loren Cook) cut sheets. Motors not listed in the chart are smaller than 1 hp, and thus are not required to comply with the standard.

Table 11
Minimum Motor Efficiency Compliance

Equipment	Input HP	BHP	Actual Efficiency	Required Efficiency per Table 10.8	Comply
Return Fan 1	5	3.29	65.8%	87.5%	NO
Return Fan 2	5	3.29	65.8%	87.5%	NO
Return Fan 3	5	3.45	69.0%	87.5%	NO
Return Fan 4	5	3.17	63.4%	87.5%	NO
Return Fan 5	5	4.12	82.4%	87.5%	NO
Return Fan 6	5	4.12	82.4%	87.5%	NO
Supply Fan 1	25	21.88	87.5%	91.7%	NO
Supply Fan 2	25	22.04	88.1%	91.7%	NO
Supply Fan 3	30	26.40	88.0%	93.0%	NO
Supply Fan 4	30	25.11	83.7%	93.0%	NO
Supply Fan 5	30	29.03	96.8%	93.0%	YES
Supply Fan 6	30	29.78	99.3%	93.0%	YES
Supply Fan 7	2	1.23	61.5%	86.5%	NO
Pumps 1, 2	3	2.30	76.7%	87.5%	NO
Pumps 3, 4	10	9.34	93.4%	89.5%	YES
Pumps 5, 6	10	8.17	81.7%	89.5%	NO
Pumps 7, 8	15	11.83	78.9%	91.0%	NO
Pumps 9, 10	10	8.75	87.5%	89.5%	NO

Depth Topic - Mechanical Redesign

Problem Statement

The mechanical systems in Ft. Detrick were designed to meet standards for energy efficiency and occupant safety and comfort, as discussed in the Building Design Overview. The building was also designed to receive a Silver SPiRiT Rating, which demonstrates the designer's interest in sustainability. Although the building meets these design standards, improvements can be made to the existing design to increase energy efficiency, occupant safety, and sustainability.

The air handling units serve VAV reheat boxes in each zone. This is a good option for Ft. Detrick because it has many different types of spaces. Each zone contains a thermostat so occupants can adjust to the desired temperature. This is important because zones next to exterior walls, for example, may need more heat in the winter than interior zones. A drawback of VAV reheat systems, however, is that at part load conditions, air enters the VAV boxes at low temperatures. The box then reheats the cool air to the desired temperature of the occupants, which is inefficient and can get expensive. Also, because of the reheat coils, boilers and boiler pumps have to run all year round, which can also get expensive. By replacing the VAV reheat system with a more efficient system, the owner can save money and energy.

Redesign Objectives

Because of the potential for improving the existing mechanical system, it will be redesigned in this study. The VAV AHUs and reheat boxes will be replaced with a more efficient system that has a lower life cycle cost while still keeping in mind the safety of the occupants. The objectives for the redesign are as follows:

- Decrease Lost Rentable Space
- Increase Energy Efficiency
- Maintain Affordability
- Maintain Occupant Safety and Indoor Air Quality
- Improve Sustainability

In addition to redesigning the HVAC system, an architectural/site breadth topic and an electrical breadth topic will be studied keeping the same goals in mind.

Proposed Redesign

As mentioned in the Problem Statement, the current air handling system consists of six air handling units that serve VAV reheat boxes. These systems use excess energy in the reheat process. In the redesign, dedicated outdoor air systems (DOAS) will replace the building's air handling units. These systems will decrease the amount of energy used and the amount of equipment required for operation. Decreasing the total amount of equipment decreases the number of mechanical rooms needed, which would decrease the percent of lost rentable space and save the owner first cost.

Being a military building, protection against terrorism is a requirement for design. Because a dedicated outdoor air system does not use recirculated air, any biological or chemical agents released inside the building will not be recirculated, which could reduce the amount of time it takes to purge the building of contaminants. However, since a dedicated outdoor air system supplies a smaller quantity of air than a VAV system, the amount of time it takes to purge the building of contaminants may actually increase. Also, there is essentially no carryover with proper enthalpy wheel selection and operation.

Because of the relatively low distribution temperature of dedicated outdoor air systems, high-induction diffusers will be used in lieu of regular diffusers to supply air to the conditioned spaces without reheating. These diffusers are specially designed to encourage the mixing of air.

Chilled beams will be included in the redesign as a passive cooling system. They will be incorporated into the ceiling grid in the open office. The cool air will fall to the occupied zones while warm air from the space rises and is drawn into the void created by the descending cooled air. The chilled beams will be most effective along the building's perimeter where they will counteract heat gained from the exterior. Chilled beams will not be placed directly above a high heat load, such as a copy machine, because the rising warm air counteracts the falling current of cool air attempting to develop from the beam.

Cooling loads found in the energy analysis of the existing system (Technical Assignment 2) were similar to those taken from the design documents. However, a passive cooling system would be beneficial to the system as a whole. There would be no additional energy needed to power these systems because they cool through convection and radiation. However, these systems would increase the demand for chilled water. Therefore, the energy used by the chilled water pumps would increase.

Dedicated outdoor air units will be selected as a basis for design in order to obtain exact measurements to check the lost rentable space. An energy study of the redesigned system and a life cycle cost calculation will be performed in Trace. A contaminant removal analysis will examine how well the building flushes out contaminates released inside and outside of the building. The analysis will compare the existing system's effectiveness to the effectiveness of the redesigned system. In addition, the building's SPiRiT credits will be recalculated to measure sustainability of the redesign.

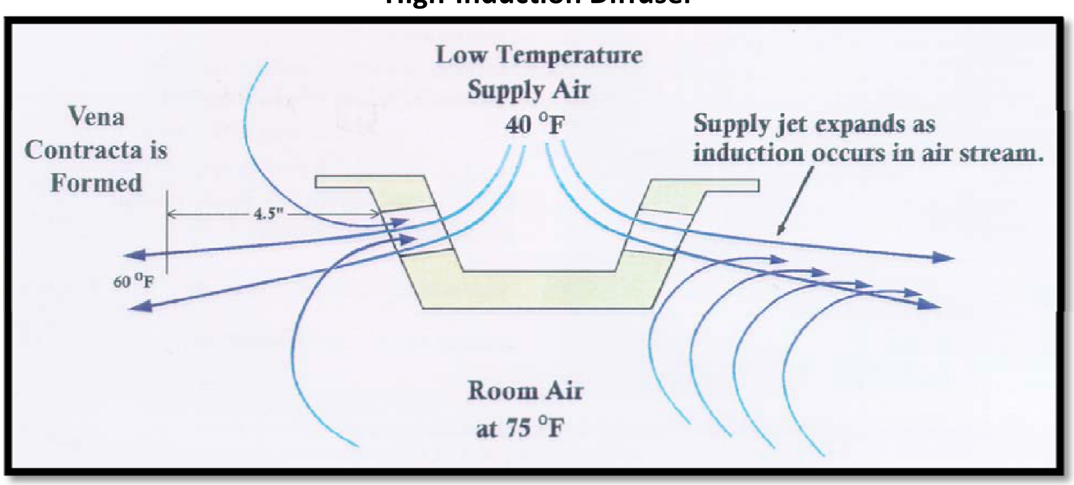
DOAS/Chilled Beam Design

To begin designing the DOAS/chilled beam system, the design outdoor air conditions must be determined. The cooling and dehumidification design conditions differ from that of a more conventional VAV system. Ft. Detrick's design loads were computed based on the peak dry bulb temperature (91°F) and mean coincident wet bulb temperature (75°F). In a dedicated outdoor air system, the outdoor air enthalpy is reduced by the enthalpy wheels during the summer months. The wheel transfers excess moisture and sensible heat from the outdoor air to the relatively dry and cool exhaust air. Since the cooling coil follows the enthalpy wheel, it is sized based on the enthalpy of the outdoor air after it passes through the wheel. Therefore, the design temperatures will instead be the peak wet bulb (78°F) and mean coincident dry bulb (88°F) temperatures, because they have a higher enthalpy.

With the addition of radiant cooling through the chilled beams, the space temperature is reduced by about 2°F. Consequently, the room thermostat can be set about 2°F higher without any change in supply temperature. Therefore, the cooling dry bulb thermostat temperature was raised from 75°F to 77°F.

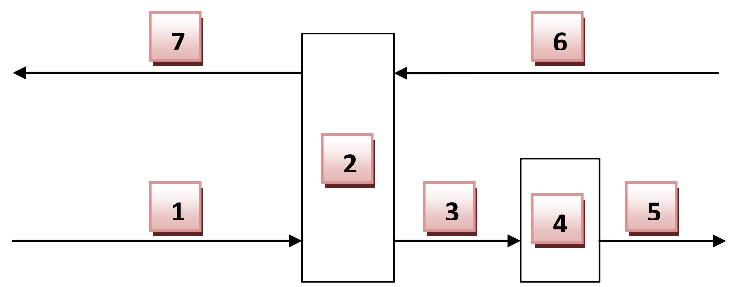
In a DOAS/chilled beam system, the supply air must be dehumidified enough to maintain the target space humidity level in each space. The cooling coil cools and dehumidifies the supply air preconditioned by the enthalpy wheel to meet this dryness. This analysis will assume a supply air dry bulb temperature of 48°F at saturated conditions. This is 7°F lower than the current design (55°F). This low-temperature air can be supplied directly to the conditioned spaces without reheating by using high-induction diffusers. High-induction diffusers are manufactured to encourage the mixing of air to prevent stagnation. This is important in a dedicated outdoor air system because the supply air temperature can be set low while still maintaining adequate throw out of the diffusers. Figure 2 shows a diagram of how this is accomplished.

Figure 2
High-Induction Diffuser



Vena Contracta occurs when room air is pulled back into the jet nozzle and is mixed with the primary supply air stream. Induction continues throughout its throw due to the high mass and velocity of the individual circular jets. Room air adjacent to the supply jets is entrained into the stream, expanding and transferring heat to the jet. Within a few inches from the diffuser, the temperature of the supply air has increased to the extent that "dumping" of cold air into the space and onto the occupants does not occur. Figure 3 shows a flow diagram of the cooling design conditions at each stage of the DOAS.

Figure 3
DOAS Design Cooling Conditions



1. Outdoor Air: 88°F db/78°F wb
2. Enthalpy Wheel
3. Preconditioned Air: 82°F db/0.0134 lb_{H20}/lb_{dry}
4. Cooling Coil
5. Supply Air: 48°F db/19.5 BTU/lb
6. Return Air: 77°F db/50% RH
7. Exhaust Air

The amount of air supplied to the spaces will also decrease with a dedicated outdoor air system. According to ASHRAE 62.1, the total design outdoor air intake for 100% outdoor air systems is equal to the sum of the zone uncorrected outdoor air flows. System ventilation efficiency is not factored in because the outdoor air fraction is always 1. Tables 12 and 13 illustrate the outdoor air savings with the redesign.

Table 12
Outdoor Air Savings from DOAS-1

	Vot (current design)	Vot 100% OA (∑Voz)	Difference
AHU-1	4460	2843	
AHU-3	4975	2235	
AHU-5	4670	2120	
Total	14,105	**7198**	6907

Table 13
Outdoor Air Savings from DOAS-2

	Vot (current design)	Vot 100% OA (∑Voz)	Difference
AHU-2	4210	1773	
AHU-4	4550	2092	
AHU-6	4985	2584	
Total	13,745	**6449**	7296

These charts show that the outdoor air supplied can decrease by about half by switching to a dedicated outdoor air system. The basis of design for the DOAS units in this analysis is the Innovent PS-2074, pictured in Figure 4. Two 8000 cfm units will be necessary for this project, one to replace AHUs 1, 3, and 5, and one to replace AHUs 2, 4, and 6. The wheel effectiveness is 70%. The zoning plans for the existing and redesigned systems are displayed in Figure 5.

Figure 4
Innovent PS-2074 Dedicated Outdoor Air Unit

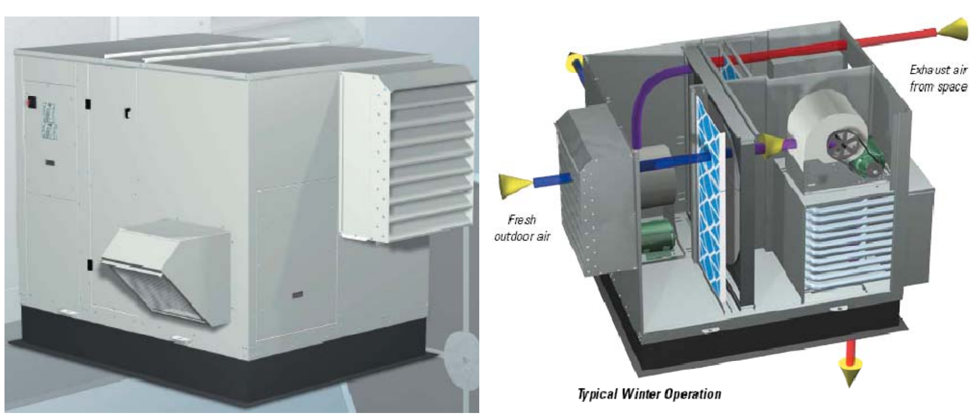
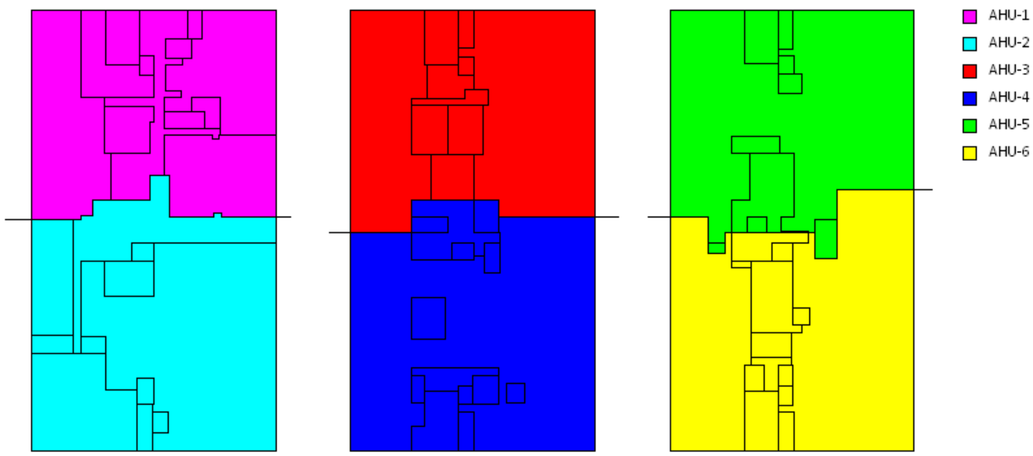
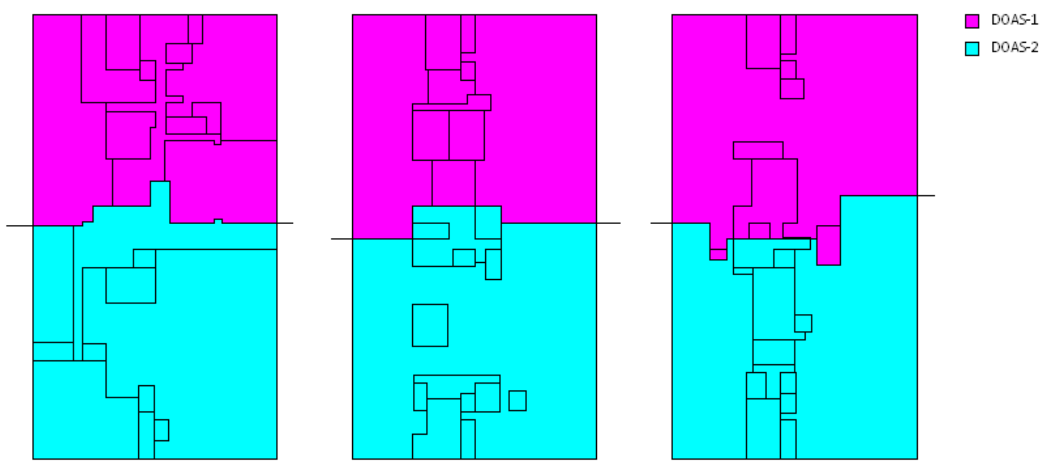


Figure 5

Zoning Plans for Existing System and Redesigned System



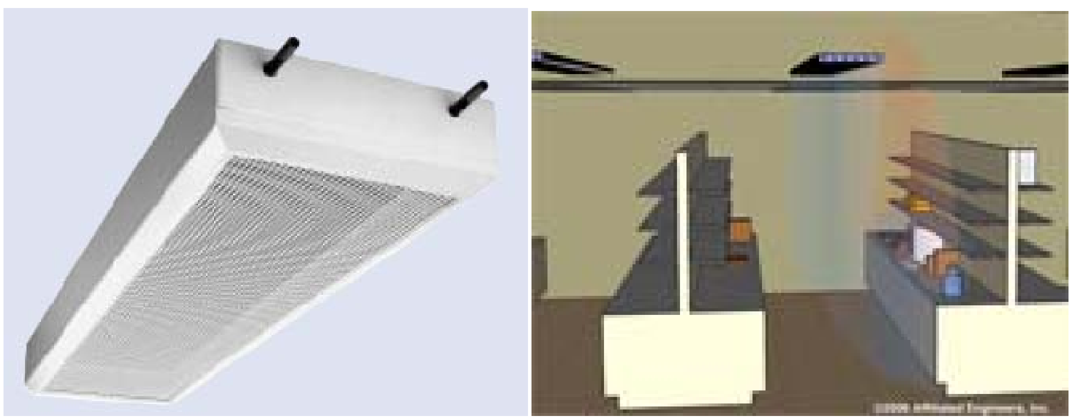
First Floor Second Floor Third Floor



First Floor Second Floor Third Floor

The basis of design for the chilled beams is the TROX PKV passive chilled beam. The capacity of each unit is 180 BTU/hr, which will lessen the cooling load on the DOAS. The TROX unit and a diagram of the flow of air are illustrated in Figure 6.

Figure 6
TROX PKV Passive Chilled Beam

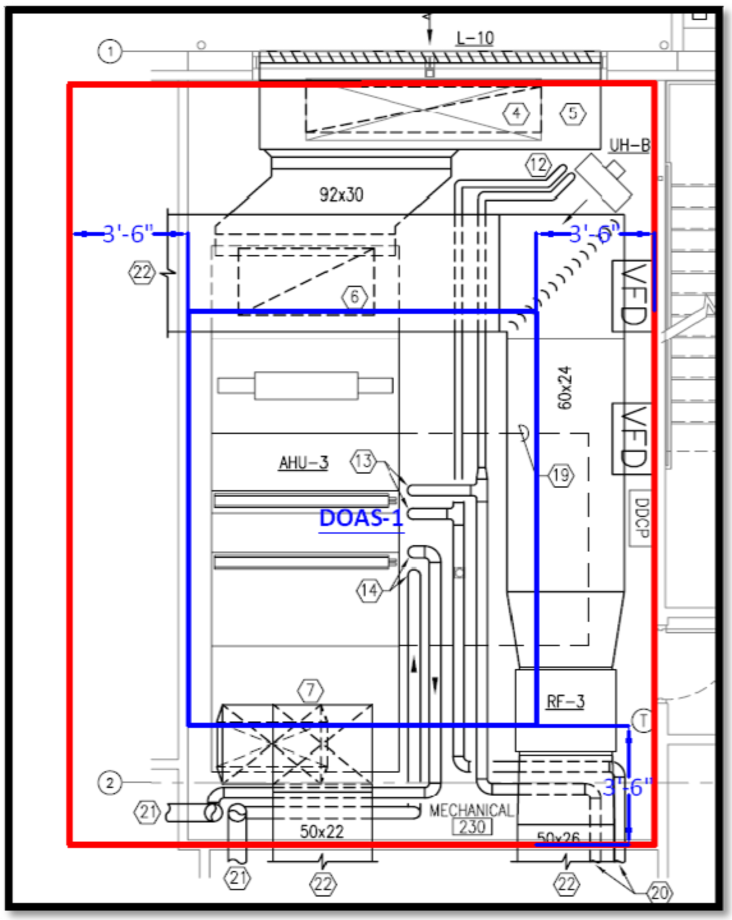


Lost Rentable Space Analysis

Ft. Detrick is a three-story building with a 43,320 ft^2 footprint. The total square footage is 129,960 ft^2. Six mechanical rooms house the air handling units, and there is one boiler room and one mechanical chase. Each mechanical room is 655 square feet, and the boiler room is 2790 square feet. The mechanical chase contains the boiler flues and is located within the mechanical rooms. Therefore, it adds no additional square footage. Since air handling units only serve the floor that they are located on, no vertical duct shafts are required. Additionally, all hot water, chilled water, and glycol piping is run vertically within the mechanical rooms. The total square footage taken up by mechanical space for the existing system is 6720 square feet. This is 5.2% of the total area, so 5.2% of the building's rentable space is lost.

With the redesign, each DOAS unit is comprised of three AHUs, as described in Tables 12 and 13. Because there are only two DOAS units in the redesign as compared to six AHUs in the existing design, four mechanical rooms can be eliminated. However, since the DOAS units are larger, the two mechanical rooms need to be enlarged in order to meet the equipment clearances. Figure 7 shows the new mechanical room layout. The red line represents the new boundary of the mechanical room.

Figure 7
New Mechanical Room Layout



The width of the room needs to increase by 42" in order to meet equipment clearances. This increases the area of each mechanical room by 114 ft^2, for a total lost rentable space of 4328 ft^2. This is 3.3% of the total area, which is a decrease of almost 2% from the existing system. From a layout standpoint, it is clear that the DOAS is a better option because it conserves space.

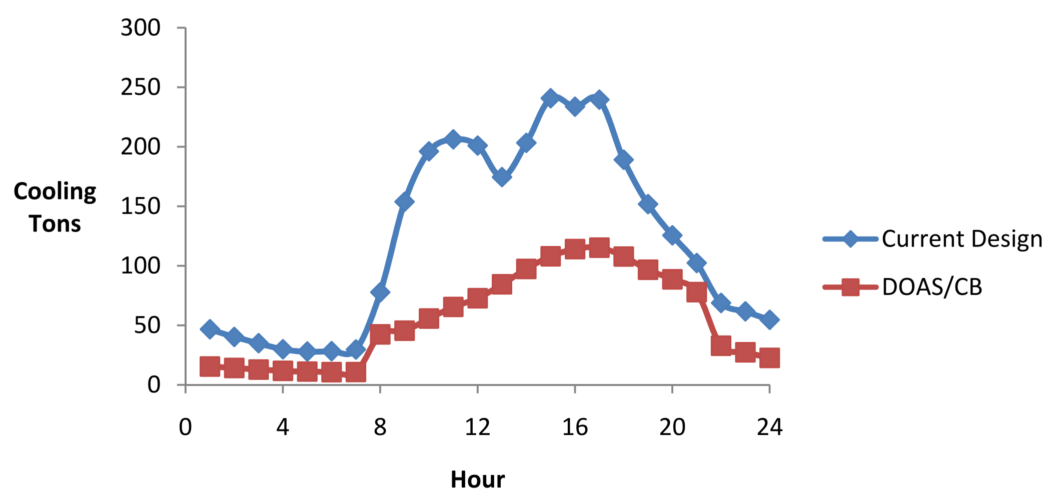
Energy Analysis

The design loads for the redesign are estimated using Trane's Trace 700. These loads are compared to the loads from the original design, which are also calculated using Trace. The outdoor air ventilation rates, electrical loads, and design occupancies are taken from the design documents provided by Baker and Associates. The lighting W/ft^2 is taken from Table 10. The occupancy, lighting, and equipment schedules are not stated in the design documents, so Trace's default office schedules are used. Infiltration is neglected in this calculation since it is also neglected in the design documents. Appendix A shows the Trace inputs for design load estimation in further detail. An annual energy consumption analysis was performed for the redesign using the same internal generations and envelope characteristics as in the design load estimation. The results are summarized in Table 14 and Figures 8 and 9.

Table 14
Energy Consumption Comparison

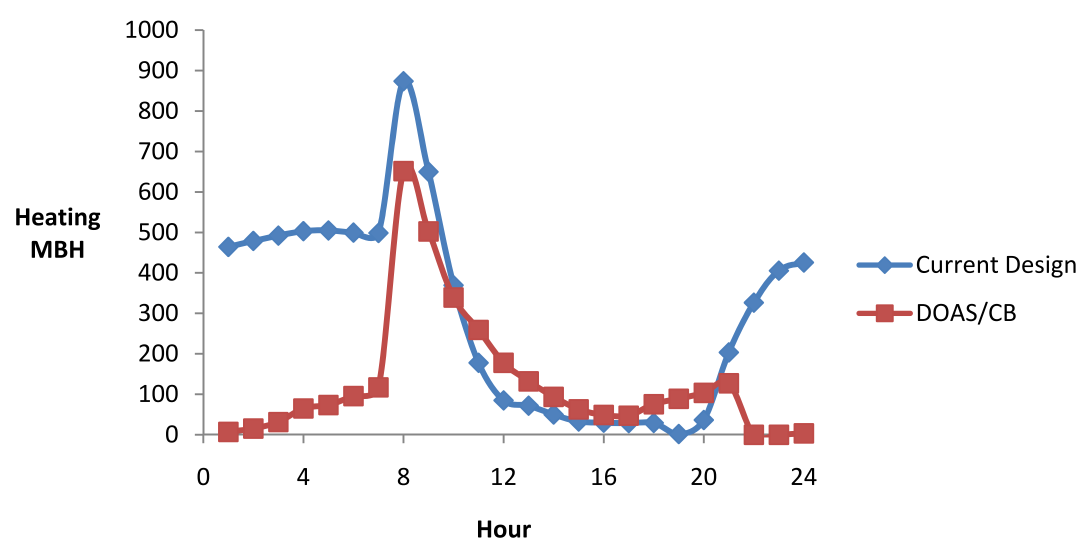
	Annual Electric Consumption (kWh)	Annual Gas Consumption (Therms)
Current Design	1,535,794	16,460
DOAS/Chilled Beam	1,519,313	5,441
Difference	16,481	11,019

Figure 8
Weekday Cooling Load - June



The peak cooling demand occurs during the building's hours of operation: from 6 am to 6 pm. As the figure displays, the cooling load decreases for the DOAS/chilled beam system. Even with the addition of cooling equipment with the chilled beams, the cooling load is less with the redesign because the 100% outdoor air units supply a smaller volume of outdoor air to be cooled.

Figure 9
Weekday Heating Load - January



The results for the weekday heating load are as anticipated. The building's heating demand is low from 6 am to 6 pm because the building is occupied. The spike in the graph occurs because the units have to heat the building to room temperature (75°F for existing and 77°F for redesign). Because the building is unoccupied from 6 pm to 6 am, there is no heat load generated inside the building by occupants or office equipment. The existing system runs more at night than the redesigned system to keep the nighttime setpoint at 55°F. The DOAS/chilled beam system takes less energy because it recovers energy through the enthalpy wheel.

Cost Analysis

Since the amount of energy usage decreased with the DOAS/chilled beam system, the cost of energy decreased as well. Boilers on the project are powered by natural gas, and all other HVAC equipment is electric. The utility company for Ft. Detrick is Baltimore Gas and Electric, and their rates are outlined in Table 15.

Table 15
Utility Rates - Baltimore Gas and Electric

Utility Type	Rate Type	Summer Charge	Winter Charge
Electric Consumption	On Peak	$0.07/kWh	$0.055/kWh
Electric Consumption	Off Peak	$0.044/kWh	$0.04/kWh
Electric Demand	On Peak	$10.22/kW	$4.94/kW
Electric Demand	Off Peak	$4.94/kW	$4.94/kW
Gas Consumption	-	$0.4165/therm	

Note that yearly energy utilization data could not be obtained since the building is currently under construction. These rates are estimates used by Baker and Associates in their energy analysis. A summer charge is applied from the start of June until the end of September. A winter charge is applied to utilities for all other months. These rates were applied to the existing system as well as the redesigned system using Trace. The total annual utility costs for the existing system and the redesigned system are $164,529 and $136,252. By switching to a DOAS/chilled beam system, the building owner would save $28,277 per year in energy bills, which is a 17.2% decrease in energy. Much of the savings occurs on the heating side, which may be because VAV reheat was eliminated. Although the DOAS units are cooling less air than the AHUs, the addition of the chilled beams "cancels out" the cooling savings. A second factor that must be considered in the cost analysis is initial cost, which is summarized in Table 16.

Table 16
Initial Cost Comparison

Equipment	Existing System	Redesign DOAS/CB	Difference
Diffusers (493)	$20,460	$21,300	-$840
VAV Boxes (164)	$87,740	$ -	$87,740
Chilled Beams (1460)	$ -	$276,750	-$276,750
VAV AHUs (6)	$187,800	$ -	$87,800
DOAS Units (2)	$ -	$86,000	-$86,000
Total	$296,000	$384,050	-$88,050

The cost of the redesign is $88,050 more than the existing system, which is a 23% increase. All costs listed are the installed costs of the equipment. This does not include downsizing ducts or the central plant due to the decreased amount of air required for the dedicated outdoor air system. Those reductions may reduce the cost of the DOAS/chilled beam option. Regardless, the increase in first cost of the DOAS/chilled beam system pays back in 3.9 years. Table 17 outlines the life cycle cost of the DOAS/chilled beam system and compares it to the current design.

Table 17
Life Cycle Cost Comparison, Redesign vs. Existing Design

Year	Cash Flow Difference	Cumulative Cash Flow Difference	Present Value of Flow Difference	Life Cycle Cost Difference
0	-88,050	-88,050	-88,050	-88,050
1	28,277	-59,772	25,706	-62,343
2	28,277	-31,495	23,369	-38,973
3	28,277	-3,217	21,245	-17,728
4	28,277	25,059	19,313	1,585
5	28,277	53,337	17,558	19,143
6	28,277	81,614	15,961	35,105
7	28,277	109,892	14,510	49,616
8	28,277	138,169	13,191	62,808
9	28,277	166,447	11,992	74,800
10	28,277	194,724	10,902	85,702
11	28,277	223,002	9,911	95,614
12	28,277	251,279	9,010	104,624
13	28,277	279,557	8,190	112,815
14	28,277	307,834	7,446	120,261
15	28,277	336,112	6,769	127,030
16	28,277	364,389	6,154	133,184
17	28,277	392,667	5,594	138,779
18	28,277	420,944	5,085	143,865
19	28,277	449,222	4,632	148,488
20	28,277	477,499	4,203	152,692

The 20-year life cycle cost of the existing system is $1,696,733 and the life cycle cost of the redesign is $1,544,041. This significant cost savings and relatively short payback period proves that the redesign is feasible. The interest rate assumed is 10%. Maintenance costs were assumed to be about the same for the two systems and therefore were neglected in the calculation.

Contaminant Removal Analysis

Indoor air quality is especially important for Ft. Detrick since it is a military structure. The building design criteria include measures for occupant safety in the event of a terrorist attack. An attack by releasing contaminants into the building can be done in a number of ways. This study will analyze how quickly the existing system and the redesigned system can purge the building of contaminants released through two instances. The first study analyzes the effects when contaminants are released into the outdoor air intake of an air handling unit, and the second study analyzes the effects of contaminants released inside of the building.

The NIST program CONTAMW2 was used to generate these results. The building was analyzed six times using six different sizes of contaminants in the 0.1-5 µm range. To determine the effectiveness of the air handling systems' removal of contaminants released outside of the building, an initial concentration of 1 x 10^9 particles/meter was assigned to the air intake of an air handler. Figures 10 and 11 illustrate the spread of contaminants in the existing system versus in the redesigned DOAS system. The darker shades of red indicate higher concentrations of contaminants in the zone. The blue star indicates the location of the AHU or DOAS that has a contaminated intake. Particle removal by deposition on surfaces is not included in the analysis.

Figure 10 – Existing System Contaminant Removal
Contaminant Released in AHU-2 Intake

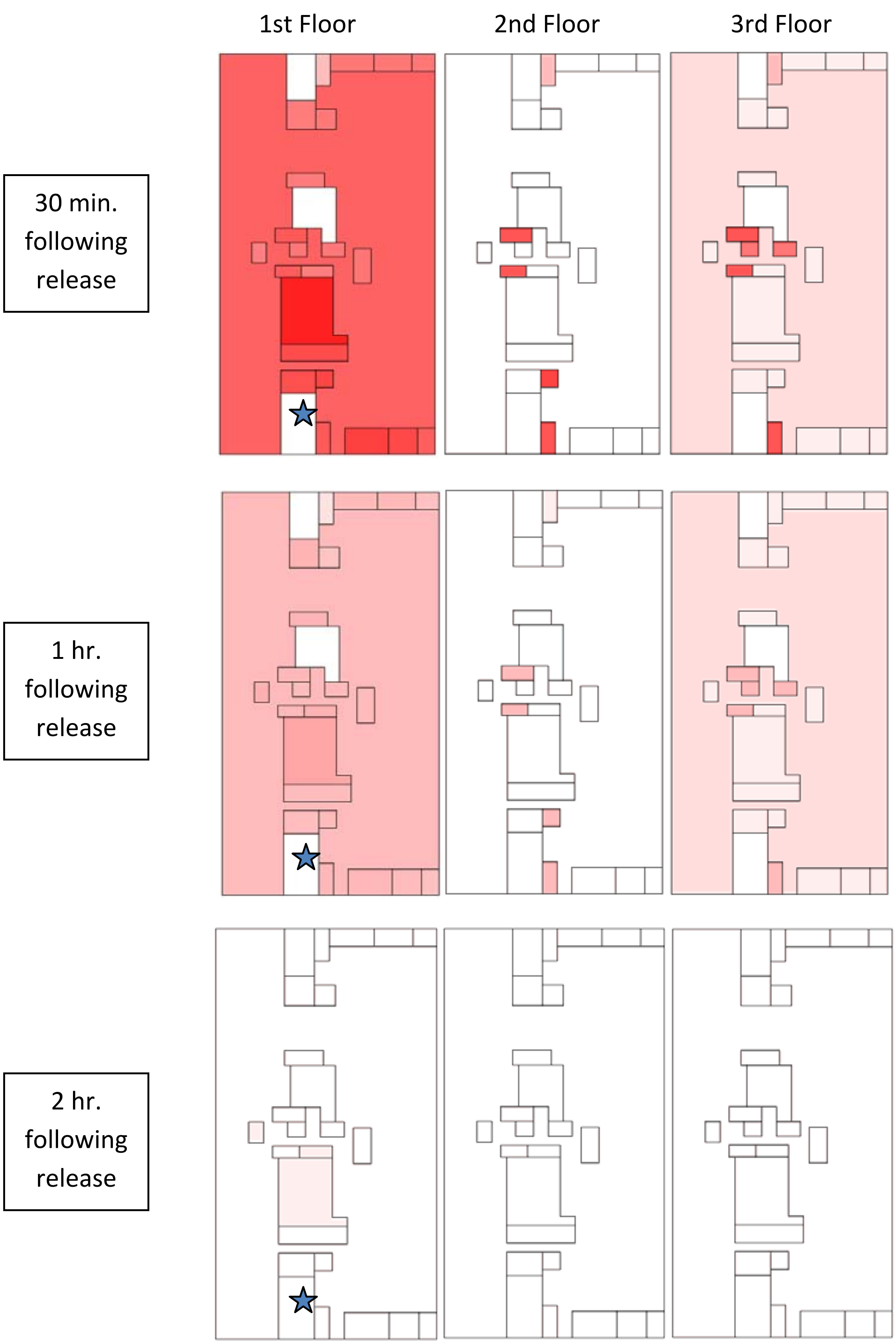
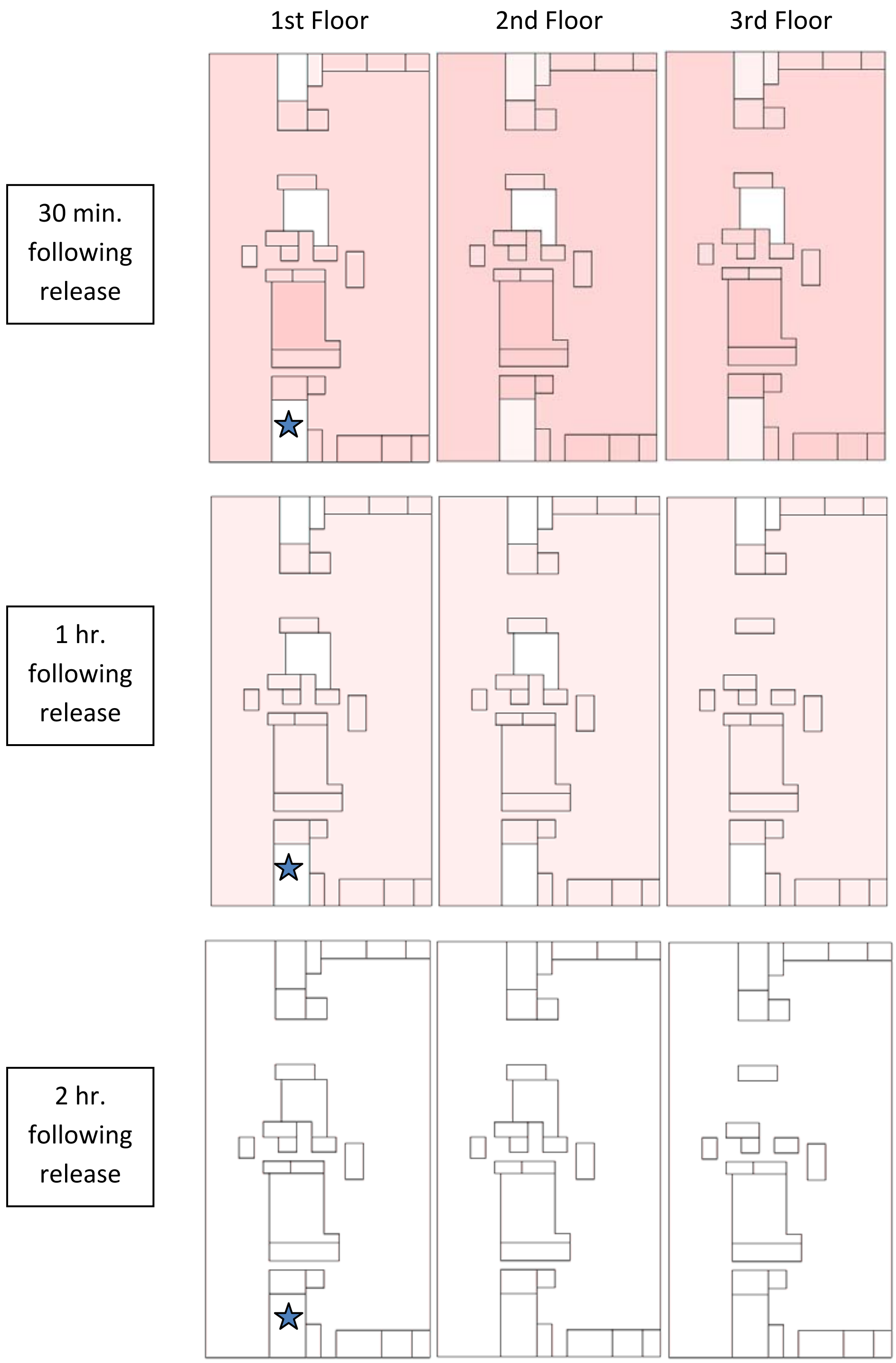
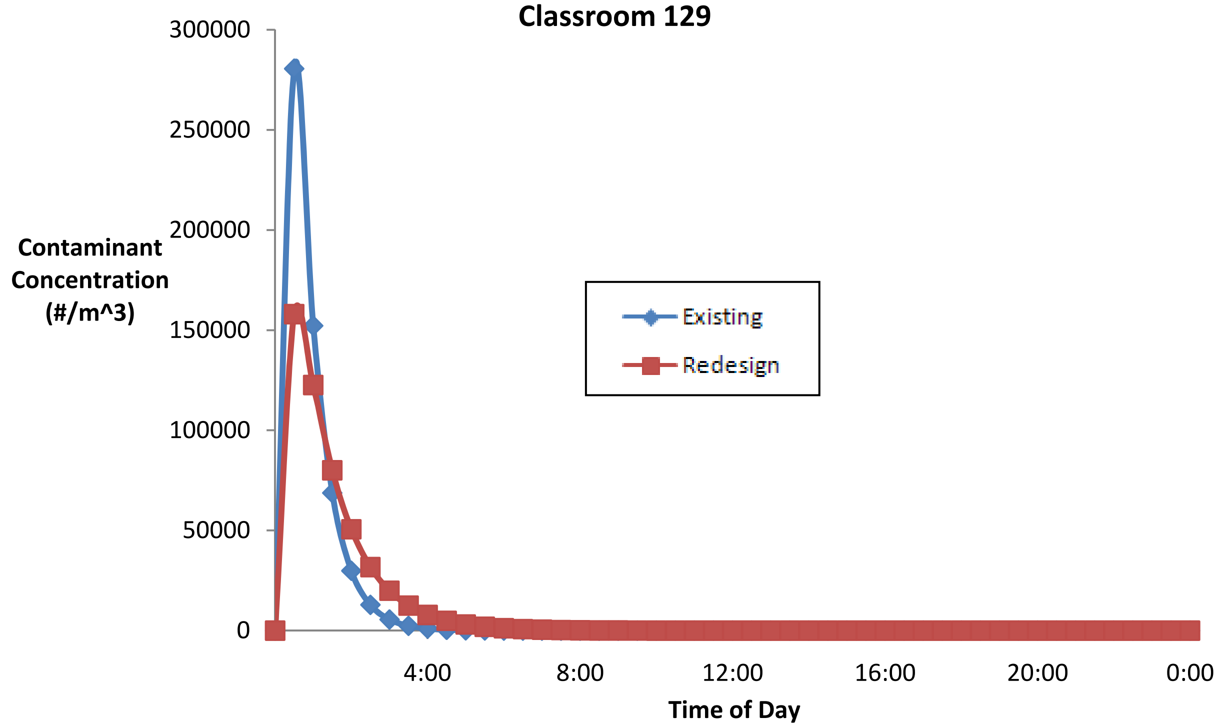


Figure 11 – Redesigned System Contaminant Removal
Contaminant Released in DOAS-2 Intake



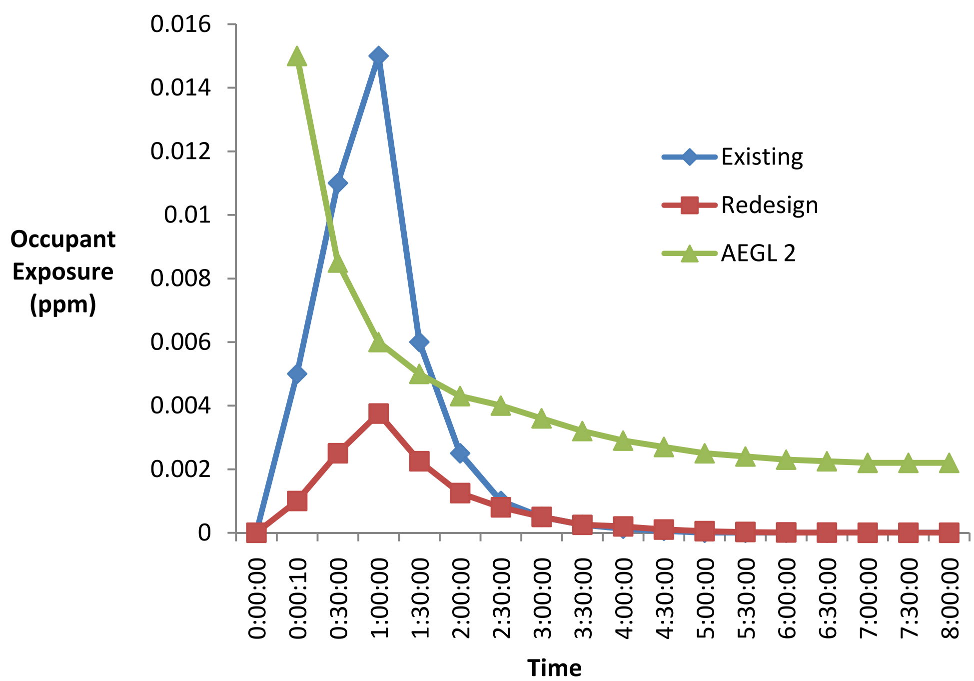
These figures are from the 0.1 µm analysis, but the 1-5 µm analyses produced similar results for both the existing design and the redesign. The dark red color of the first floor clearly shows that the existing system has a higher initial concentration of contaminants than the redesigned system. This could be because the existing system has 6 air handling units and the redesigned system has 2 dedicated outdoor air units. Therefore, AHU-2 distributes air to the south end of the first floor only, and any other contaminant concentrations in the building are due to leakage. DOAS-2 supplies air to the south end of all three floors, which results in a lower contaminant concentration, but not in a lower amount of contaminants. From the figures, it is evident that the DOAS distributes a reduced concentration of contaminants, but it takes longer for the DOAS to flush out the building completely. Because it can be difficult to see the differences in the shades of light red in the later hours of the simulation, the first floor classroom zone is displayed graphically in Figure 12 to compare the flush-out times of the existing system vs. the redesign.

Figure 12
Concentration vs. Time
Classroom 129



As seen in this graph, the existing system can flush out the contaminants completely by 4:00, whereas the DOAS does not flush out the system until about 6:00. This may be due to the DOAS supplying a smaller quantity of air than the existing system. To get a better idea of how this two hour difference affects occupant safety, Figure 13 shows the amount of contaminants an occupant in the classroom is exposed to in the existing system and the redesigned system and measures it against the acute exposure guideline levels (AEGLs) for a particular contaminant. The AEGL are intended to describe the risk to humans from a once-in-a-lifetime exposure to airborne chemicals. AEGL data for this study was selected arbitrarily from the EPA website. The initial concentration (1 ppm) was chosen to yield indoor concentrations in a reasonable range of interest. The simulation results are intended to display the relative concentration or exposure between the two cases rather than the absolute concentration and exposure values themselves.

Figure 13
Concentration vs. Time - Classroom 129
Acute Exposure



This data reveals that the two hour flush-out time between 4:00 and 6:00 is not critical. The existing system is at a dangerous level from 30 minutes to 90 minutes after the contaminant has been released, while the redesigned system never reaches a dangerous level. From this, it can be determined that the DOAS system is in fact the better choice for occupant safety in the event of a contaminant release.

To determine the effectiveness of the air handling systems' removal of contaminants released *inside* the building, the open office space on the first floor was assigned an initial concentration of 1×10^9 particles/meter. Figures 14 and 15 illustrate the spread of contaminants in the existing system versus in the redesigned DOAS system. These results are similar to the results of the contaminated outdoor air analysis except that for the indoor analysis, the building was flushed more quickly for both systems.

Figure 14 – Existing System Contaminant Removal
Contaminant Released in Open Office

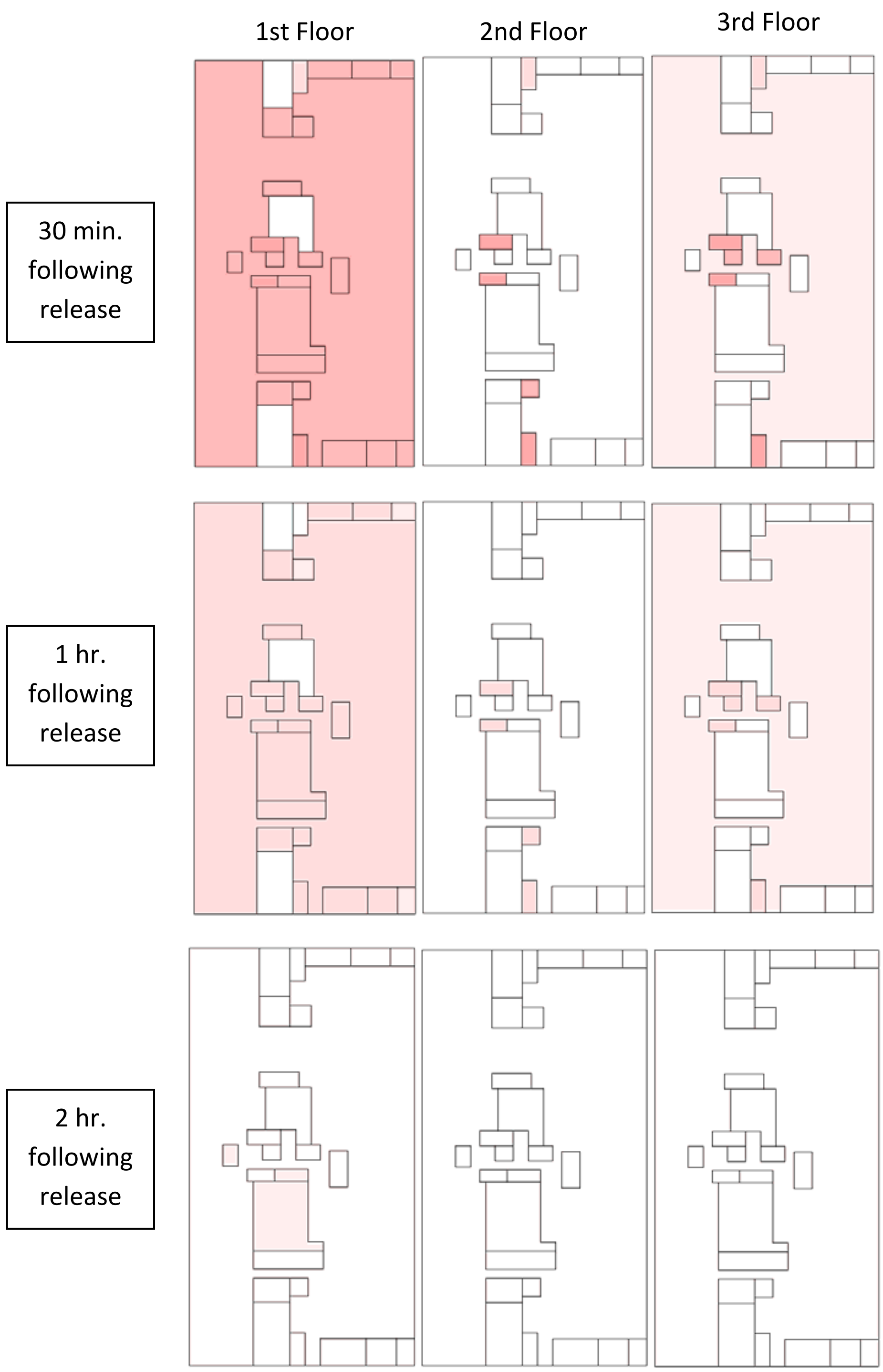
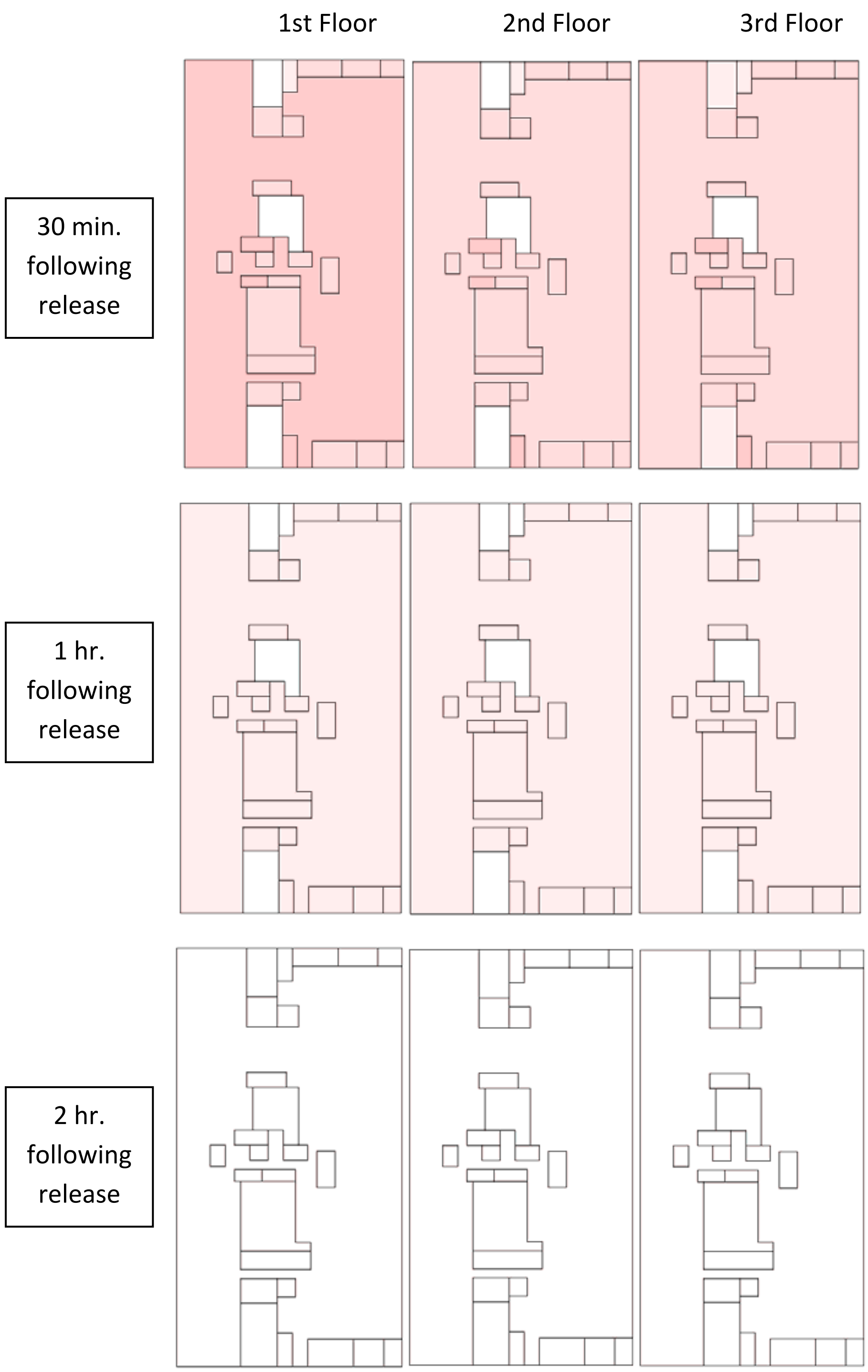


Figure 15 – Redesigned System Contaminant Removal
Contaminant Released in Open Office



SPiRiT Analysis

Since Ft. Detrick is a military building, the SPiRiT rating system is used to rank sustainability in lieu of LEED. SPiRiT stands for Sustainable Project Rating Tool. The format is similar to LEED in that it gives a rating based on a certain amount of credits obtained. SPiRiT however is out of 100 credits where as LEED is out of 69. Ft. Detrick cannot receive LEED certification because it only meets the criteria for 19 credits, but it can receive 40 credits according to the SPiRiT rating system, which is a Silver rating. The extra credits were obtained because there are three additional categories in the SPiRiT system: Facility Delivery Process, Current Mission, and Future Missions.

The credits under the Facility Delivery Process category are achieved by a holistic delivery of the facility. On Ft. Detrick, this is met by including the entire project team in the delivery process. The project team includes the future occupants of the building, contracting staff, owner representatives, project manager, architects, and engineers. Project goals were identified early, and charrettes were executed at different stages of delivery to get everyone involved in the design. This increased communication relates to sustainability because the project is completed efficiently. The design process for Ft. Detrick actually finished ahead of the original schedule, which saves time and energy for everyone involved.

The credits in the Current Mission category break into two parts. The first is to develop an Operations and Maintenance program. Frequent maintenance is important to sustainability because a building may be heating and cooling sufficiently for occupant comfort, but the equipment may be using more energy than is required to do so. The second part of this category is Soldier and Workplace Productivity and Retention. The theory behind this credit is that a high quality indoor environment is directly related to the productivity of the workers in that environment.

The third category, Future Missions, awards credits based on the functional life of the building and the ability of the building to adapt to future usages. Ft. Detrick is mostly open office space, so it can accommodate a wide range of future occupancies. With a rectangular footprint, it is efficient in shape, so there is a possibility for expansion. The facility is also designed for recycling of materials and systems.

As stated in the Proposed Redesign, the redesign will meet or exceed the current SPiRiT rating. For Ft. Detrick to receive SPiRiT Gold, designers need to obtain seven more points. Six of these have been obtained from the redesigned mechanical system. According to ASHRAE 90.1, a

VAV-reheat system with chillers, like the existing system, is considered a baseline system and receives no credits for optimizing energy performance. Since the redesign contains energy recovery, the energy consumption decreased by 17.2%. The SPiRiT system awards one point for every 2.5% reduction in design energy, and thus the redesign earns 6 additional SPiRiT points. An additional point was obtained from the constructed wetland, which will be described in the next section. A summary of the SPiRiT credits for the existing design versus the redesign can be found in Appendix B.

Breadth Topics

The mechanical redesign solutions discussed in the previous sections would affect other building systems if implemented. This section of the report discusses in detail the changes that will need to be made to the electrical system and the costs associated with these changes. It will also discuss the feasibility of implementing an on-site wastewater treatment system to obtain the extra SPiRiT point for SPiRiT Gold. Increase in cost and changes to the site are factors that will be considered in this breadth area.

Electrical Breadth

Implementing the DOAS/chilled beam system changes the overall amount of power required for the building. Because of this, the distribution panels and wiring need resized as part of the electrical breadth. A cost analysis will be done on the new panels and wiring to more fully analyze the cost impact of the changes to the mechanical system.

Since the chilled beams have no moving parts, the only electrical power that they require is for the low-voltage connection to the actuator for the control valve. This will be omitted in this analysis because it is small compared to the rest of the system. The fan motors for the AHU supply fans and the return fans are high efficiency, T-frame, squirrel-cage motors. Motor factors were obtained from NEC Tables 430.250 and Table 430.52. The DOAS units are 10 hp each, and they will both be placed on panel DP4. The air handling units and their corresponding return fans can be eliminated; therefore panelboard DP5 can also be eliminated. The following tables show the existing panelboards and how they were modified for the redesign. The wires are copper on the project and were sized according to NEC standards and the project specifications.

Table 18
Existing Panelboard DP4

Location: Mechanical Room 230 Size: 400A					Service: 480/277V, 3PH, 3W Feed: MAIN SWBD			
	Description	Load (VA)	BKR		BKR	Load (VA)	Description	
1		9422	70	A	15	2106		2
3	AHU-1	9422	70	B	15	2106	RF-1	4
5		9422	70	C	15	2106		6
7		11085	80	A	15	2106		8
9	AHU-3	11085	80	B	15	2106	RF-3	10
11		11085	80	C	15	2106		12
13		11085	80	A	15	2106		14
15	AHU-5	11085	80	B	15	2106	RF-5	16
17		11085	80	C	15	2106		18
19				A				20
21				B				22

Table 19
Existing Panelboard DP5

Location: Mechanical Room 252 Size: 400A					Service: 480/277V, 3PH, 3W Feed: MAIN SWBD			
	Description	Load (VA)	BKR		BKR	Load (VA)	Description	
1		9422	70	A	15	2106		2
3	AHU-2	9422	70	B	15	2106	RF-2	4
5		9422	70	C	15	2106		6
7		11085	80	A	15	2106		8
9	AHU-4	11085	80	B	15	2106	RF-4	10
11		11085	80	C	15	2106		12
13		11085	80	A	15	2106		14
15	AHU-6	11085	80	B	15	2106	RF-6	16
17		11085	80	C	15	2106		18
19				A				20
21				B				22

Table 20
Existing Main Switchboard

Panel Designation: MAIN SWBD
Location: Electrical Room 121 | Service: 480/277V, 3PH, 4W
Size: 1600A | Feed: MAIN TRANSFORMER

	Description	Load (VA)	BKR		BKR	Load (VA)	Description	
1				A				2
3	DP-1 & LP-1		400	B	400		DP-4	4
5				C				6
7				A				8
9	DP-2 & LP-2		400	B	400		DP-5	10
11				C				12
13				A				14
15	DP-3 & LP-3		400	B	400		DP-6	16
17				C				18
19				A				20
21	ELEVATOR 1		90	B	400		CH-1	22
23				C				24
25				A				26
27	ELEVATOR 2		90	B	250		CH-2	28
29				C				30
31				A				32
33	MANUAL TRANS SW		400	B				34
35				C				36
37	PKG LOT LIGHTS		20	A	20		SITE LIGHTS	38
39	PKG LOT LIGHTS		20	B	20		PKG LOT LIGHTS	40
41	CT LIGHTS		20	C	20		PKG LOT LIGHTS	42

Table 21
Redesigned Main Switchboard

Panel Designation: MAIN SWBD								
Location: Electrical Room 121					Service: 480/277V, 3PH, 4W			
Size: 1600A					Feed: MAIN TRANSFORMER			
	Description	Load (VA)	BKR		BKR	Load (VA)	Description	
1				A				2
3	DP-1 & LP-1		400	B	80		DP-4	4
5				C				6
7				A				8
9	DP-2 & LP-2		400	B	-		-	10
11				C				12
13				A				14
15	DP-3 & LP-3		400	B	400		DP-6	16
17				C				18
19				A				20
21	ELEVATOR 1		90	B	400		CH-1	22
23				C				24
25				A				26
27	ELEVATOR 2		90	B	250		CH-2	28
29				C				30
31				A				32
33	MANUAL TRANS SW		400	B				34
35				C				36
37	PKG LOT LIGHTS		20	A	20		SITE LIGHTS	38
39	PKG LOT LIGHTS		20	B	20		PKG LOT LIGHTS	40
41	CT LIGHTS		20	C	20		PKG LOT LIGHTS	42

The cost of adding the wires and breakers are summarized in Table 22, and the costs of the wires no longer necessary are summarized in Table 23. The result is a cost savings of $17,066.

Table 22
Cost of Electrical Additions

Added	Qty.	Cost per 100 LF	LF	Total Cost
#10 Wire	6	59.50	36	$129
25 A Breaker	6	-	-	$4,074
			Total	**$4,203**

Table 23
Cost of Electrical Subtractions

Subtracted	Qty.	Cost per 100 LF	LF	Total Cost
#3 Wire	6	196.00	100	$1,176
#4 Wire	12	166.50	64	$1,279
#12 Wire	18	47.90	128	$1,104
70 A Breaker	6	-	-	$4,818
80 A Breaker	12	-	-	$4,818
15 A Breaker	18	-	-	$4,074
Panel DP5	1	-	-	$4,000
			Total	**$21,268**

Architectural/Site Breadth

The goal of the architectural/site breadth is to obtain SPiRiT credit 2.C2, which requires innovative use of wastewater technology. This can be done by reusing storm water or grey water for sewage conveyance or implementing an on-site wastewater treatment system. The wastewater treatment system that will be used for this purpose will be in the form of a constructed wetland that is architecturally appealing and works well on the site.

Wastewater treatment plants traditionally dewater sludge by pouring it onto sand beds to let the water drain out or by putting it through filter presses to squeeze out the water. Constructed wetlands, however, use planting beds of wetland vegetation to treat or dewater various types of noxious effluents, including sewage sludge. According to New England Waste Systems, this method is far more economical than sand beds or filter presses, yet it reduces the amount of solid residue to a fraction of what a press leaves. The company says that sand beds and filter presses can extract only about 80 gallons of water from 100 gallons of sludge, whereas reed beds can extract as much as 97 gallons of water from the same amount of sludge. Furthermore, the reeds convey oxygen to their roots, making it possible for aerobic bacteria to live below the surface and metabolize volatile solids in the waste. Because it is environmentally friendly and more efficient, it is easy to see why a constructed wetland is deserving of a SPiRiT credit. The credit says that the wetland must treat at least 50% of wastewater on-site to tertiary standards. Because this system can treat such a large quantity of water with such a high efficiency, this design should exceed the requirements of the credit.

Two main types of constructed wetlands are free water surface systems and subsurface flow systems. A free water surface (FWS) wetland will be used because of its affordability. An FWS system consists of a shallow basin with a constructed subsurface barrier made of impervious material to prevent seepage. Soil supports the vegetation, and water flows over the soil. The shallow water depth, low flow velocity, and presence of plant stalks regulate water flow and prevent back flow.

FWS systems are sized based on the gallons of water the building's occupants use per day. Ft. Detrick uses approximately 24,300 gallons per day. Since the building is under construction, this value was obtained by assuming that each occupant uses 20 gallons per day and the building is at maximum occupancy. Using the design guidelines from the Design Manual for Constructed Wetlands and Aquatic Plant Systems for Municipal Water Treatment, the area of the wetland was determined to be 4300 ft^2, and 3 ft deep. Construction costs are summarized in Table 24.

Table 24

Construction Cost Summary - FWS Constructed Wetland

Excavation/Compaction	$8,668.80
Soil/Gravel	$2,786.40
Liner	$12,267.90
Plants	$5,495.40
Plumbing	$9,481.50
Total	**$38,700.00**

Construction and operation of wetlands is typically about one-fourth or less of the cost of conventional systems. Conventional treatment systems can be energy and resource intensive. Not only does electricity add cost, but also lubricants, disinfectants, and other chemicals may be needed for these treatment methods. For example, it is customary to add chemical polymers to wastewater before it is sent through a filter press. Maintenance requirements for a FWS system are far lower than with other types of treatment because the filtration treatment occurs naturally and there are no moving parts. Therefore, a maintenance cost was neglected in the cost analysis.

The location of the wetland will be on the north east side of the building. When entering the building, the wetland will be to the right, providing a pleasing landscape. Figure 16 provides a diagram of where the wetland fits on the site, and Figure 17 shows a 3D rendering of what the wetland might look like.

Figure 16
View of Wetland on Site

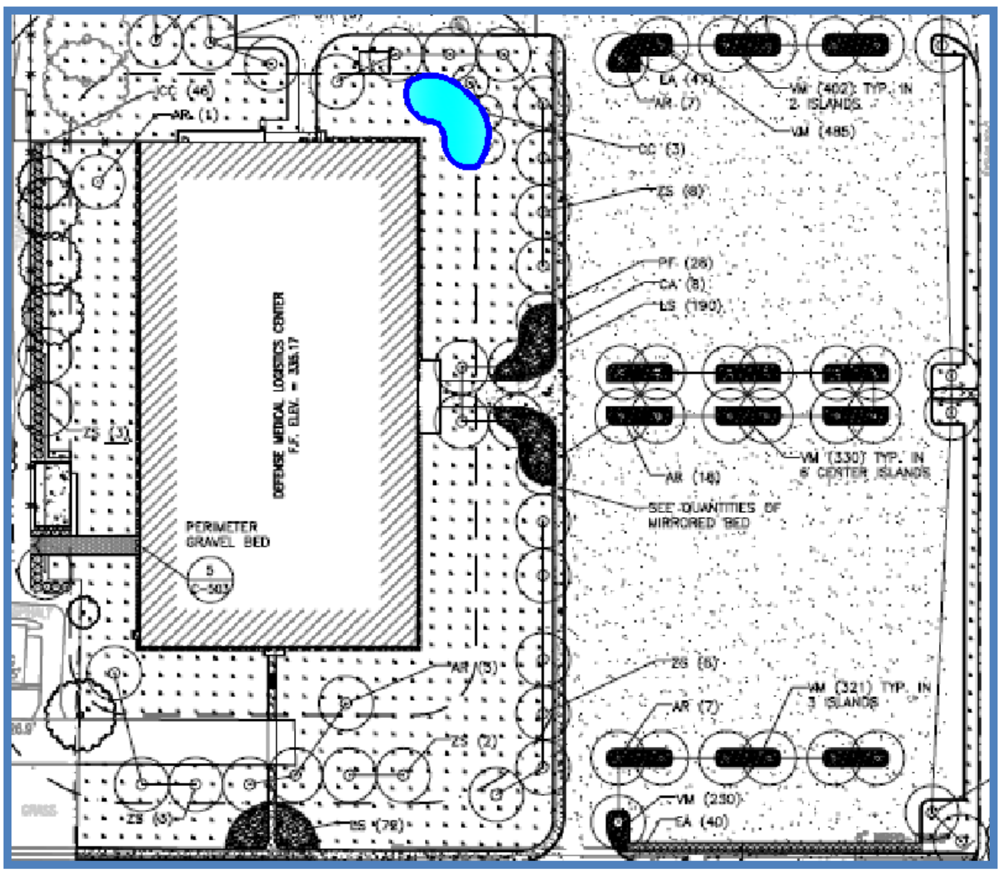


Figure 17
3D Rendering of Wetland

Breadth Life Cycle Cost

When the electrical savings ($17,066) is subtracted from the cost of the constructed wetland ($38,700), the total cost of the breadth changes comes to $21,634. This additional cost is added to the redesigned mechanical system cost ($384,050) for a total of $405,684. Because of this, the life cycle cost decreases and the payback period increases. This is illustrated in Table 25.

Table 25
Life Cycle Cost Comparison, Redesign + Breadth vs. Existing Design

Year	Cash Flow Difference	Cumulative Cash Flow Difference	Present Value of Flow Difference	Life Cycle Cost Difference
0	-109,684	-109,684	-109,684	-109,684
1	28,277	-81,406	25,706	-83,977
2	28,277	-53,129	23,369	-60,607
3	28,277	-24,851	21,245	-39,362
4	28,277	3,425	19,313	-20,048
5	28,277	31,703	17,558	-2,490
6	28,277	59,980	15,961	13,417
7	28,277	88,258	14,510	27,982
8	28,277	116,535	13,191	41,174
9	28,277	144,813	11,992	53,166
10	28,277	173,090	10,902	64,068
11	28,277	201,368	9,911	73,980
12	28,277	229,645	9,010	82,990
13	28,277	257,923	8,190	91,181
14	28,277	286,200	7,446	98,627
15	28,277	314,478	6,769	105,396
16	28,277	342,755	6,154	111,550
17	28,277	371,033	5,594	117,145
18	28,277	399,310	5,085	122,231
19	28,277	427,588	4,623	126,854
20	28,277	455,865	4,203	131,058

The new life cycle cost analysis shows that if the mechanical and electrical systems are redesigned and the wetland is implemented, the owner would save $131,058 after 20 years. The payback time would increase from 3.9 years to 5.2 years; an increase of 1.3 years. This is still a reasonable amount of time, and in the end the owner will still save money.

Conclusions and Recommendations

The DOAS/chilled beam system was indeed an improvement over the existing VAV AHU system. The redesign objectives set at the beginning of the project were:

- Decrease Lost Rentable Space
- Increase Energy Efficiency
- Maintain Affordability
- Maintain Occupant Safety and Indoor Air Quality
- Improve Sustainability

The DOAS decreased space by almost 2%, fulfilling the first goal. Energy efficiency improved by 17.2%, which satisfied the second goal and also earned 6 SPiRiT credits. Although the DOAS/chilled beam system had a higher initial cost and the constructed wetland added cost, the energy savings over a 20 year period saved the owner $131,058 with a payback period of only 5.2 years. Since the period is relatively short, the redesigned system is still a viable option.

The contaminant removal analysis also produced good results for the redesigned system. Although it takes the DOAS longer to flush out the building completely, the building occupants are never exposed to contaminants at a dangerous level. Sustainability was also improved upon, which is exemplified in the increase from SPiRiT Silver to SPiRiT Gold.

The only drawback to the DOAS/chilled beam system is initial cost. If the owner would be willing to pay the extra $109,684 upfront, the system would certainly be recommend for its long-term benefits.

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Appendix A – Trace Inputs for Design Load Estimation

Internal Generation Inputs:

Heat Generation from People

Occupancy Type	Sensible Load (BTUh)	Latent Load (BTUh)
Cafeteria/Alcove	275	275
Classroom	250	200
Conference Room	245	155
General Office Space	250	200
Lobby/Corridor	250	200
Storage, Equipment Rooms	275	275

Heat Generation from Electrical Equipment

Room Type	Heat Generation
Cafeteria/Alcove	7800 BTUh
Classroom	150 W
Conference Room	150 W
Open Office	1.5 W/SF
Enclosed Office	150 W
Equipment Rooms	2 W/SF

Construction Material Inputs:

Construction U-values

Surface	U-value
Floor	0.21261
Roof	0.04301
Exterior Wall	0.05000
Interior Partition	0.38795
Window	0.32000

Occupancy Schedule:

Vent - Office — Simulation type: Reduced year

		Start time	End time	Percentage	
January - December	Cooling design to Weekday	Start time	End time	Percentage	Utilization
		Midnight	7 a.m.	0.0	
		7 a.m.	6 p.m.	100.0	
		6 p.m.	Midnight	0.0	
Heating Design		Start time	End time	Percentage	Utilization
		Midnight	Midnight	100.0	
January - December	Saturday to Sunday	Start time	End time	Percentage	Utilization
		Midnight	Midnight	0.0	

Lighting Schedule:

Lights - Office — Simulation type: Reduced year

January - December	Cooling design to Weekday	Start time	End time	Percentage	Utilization
		Midnight	6 a.m.	0.0	
		6 a.m.	7 a.m.	10.0	
		7 a.m.	8 a.m.	50.0	
		8 a.m.	5 p.m.	100.0	
		5 p.m.	6 p.m.	50.0	
		6 p.m.	7 p.m.	10.0	
		7 p.m.	Midnight	0.0	
Heating Design		Start time	End time	Percentage	Utilization
		Midnight	Midnight	0.0	
January - December	Saturday to Sunday	Start time	End time	Percentage	Utilization
		Midnight	Midnight	0.0	

Equipment Schedule:

Misc - Low rise office — Simulation type: Reduced year

		Start time	End time	Percentage	Utilization
January - December	Cooling design to Weekday				
		Midnight	7 a.m.	5.0	
		7 a.m.	8 a.m.	80.0	
		8 a.m.	10 a.m.	90.0	
		10 a.m.	noon	95.0	
		noon	2 p.m.	80.0	
		2 p.m.	4 p.m.	90.0	
		4 p.m.	5 p.m.	95.0	
		5 p.m.	6 p.m.	80.0	
		6 p.m.	7 p.m.	70.0	
		7 p.m.	8 p.m.	60.0	
		8 p.m.	9 p.m.	40.0	
		9 p.m.	10 p.m.	30.0	
		10 p.m.	Midnight	20.0	
Heating Design		Start time	End time	Percentage	Utilization
		Midnight	Midnight	0.0	
January - December	Saturday to Sunday	Start time	End time	Percentage	Utilization
		Midnight	Midnight	5.0	

Appendix B – SPiRiT Checklists

Existing Design:

	SPiRiT PREREQUISITES/ CREDITS	POINTS AVAIL.	YES	PROBABLE	MAYBE	NO	SUSTAINABLE REVIEW COMMENTS/ ACTION ITEMS
1.0	**SUSTAINABLE SITES**						
1.R1	Site Prerequisite: Erosion and Sedimentation Control	REQ'D.					To be performed
1.C1	Site Credit 1: Site Selection	1	**1**				Site Selected by Client - within developed Military Base
	Site Credit 1: Site Selection	1	**1**				Project located on previously developed portion of site, close to existing facilities.
1.C2	Site Credit 2: Installation/Base Redevelopment	1	**1**				Proposed building is located within existing Fort Detrick installation.
	Site Credit 2: Installation/Base Redevelopment	1	**1**				
1.C3	Site Credit 3: Brownfield Redevelopment	1				**1**	Site not a brownfield
1.C4	Site Credit 4: Alternative Transportation	1			**1**		
	Site Credit 4: Alternative Transportation	1				**1**	Showers not available conveniently.
	Site Credit 4: Alternative Transportation	1				**1**	Fueling station proximity unknown.

	Site Credit 4: Alternative Transportation	1				**1**	Parking exceeds base requirements.
1.C5	Site Credit 5: Reduced Site Disturbance	1	**1**				Design likely to conform - impervious surfaces being reduced, trees and lawn area being added
	Site Credit 5: Reduced Site Disturbance	1	**1**				Design likely to conform
1.C6	Site Credit 6: Stormwater Management	1	**1**				Stormwater management plan should meets intent
	Site Credit 6: Stormwater Management	1	**1**				
1.C7	Site Credit 7: Landscape and Exterior Design to Reduce Heat Islands	1				**1**	Trees have been removed from parking program - design will not achieve 30% shading
	Site Credit 7: Landscape and Exterior Design to Reduce Heat Islands	1				**1**	Ft Detrick standard roof color (green) will not qualify.
1.C8	Site Credit 8: Light Pollution Reduction	1	**1**				Normal illumination practice with cut-off fixtures will meet this requirement.
1.C9	Site Credit 9: Optimize Site Features	1	**1**				Cut and fill limited. Daylighting incorporated as possible with extensive exterior surfaces and windows, some operable.
1.C10	Site Credit 10: Facility Impact	1	**1**				Detrick JMLC is new facility on existing developed site, clustering existing dispersed groups.
	Site Credit 10: Facility Impact	1	**1**				Meetings with local and state code officials.

1.C11	Site Credit 11: Site Ecology	1	**1**				Design team and occupants to develop plan, in conjunction with mitigation of existing facilities.
	Sustainable Sites	**19**	**13**	**0**	**1**	**6**	
2.0	**WATER EFFICIENCY**						
2.C1	Water Credit 1: Water Efficient Landscaping	1	**1**				
	Water Credit 1: Water Efficient Landscaping	1	**1**				No permanent irrigation is planned for this facility
2.C2	Water Credit 2: Innovative Wastewater Technologies	1				**1**	Cost - prohibitive
2.C3	Water Credit 3: Water Use Reduction	1				**1**	Not practical without waterless urinals / ultra low flow fixtures which are not desired.
	Water Credit 3: Water Use Reduction	1				**1**	Not practical without waterless urinals / ultra low flow fixtures which are not desired.
	Water Efficiency	**5**	**2**	**0**	**0**	**3**	
3.0	**ENERGY and ATMOSPHERE**						
3.R1	Prerequisite 1: Fundamental Building Systems Commissioning	REQ'D.					Commissioning must occur
3.R2	Prerequisite 2: Minimum Energy Performance	REQ'D.					Design components meet ASHRAE minimum performance requirements (envelope, mechanical systems, lighting systems)
3.R3	Prerequisite 3: CFC Reduction in HVAC&R Equipment	REQ'D.					

3.C1	Energy Credit 1: Optimize Energy Performance.	20				**20**	No systems are BEYOND ASHRAE 90.1 requirements (i.e., heat recovery, additional insulation beyond 90.1, footcandles required do not permit reduction in W/ft^2 for lighting).
3.C2	Energy Credit 2: Renewable Energy	4				**4**	No solar, etc.
3.C3	Energy Credit 3: Additional Commissioning	1				**1**	Significant first-cost
3.C5	Energy Credit 5: Measurement and Verification	1				**1**	Significant first-cost
3.C6	Energy Credit 6: Green Power	1				**1**	Additional cost to owner.
3.C7	Energy Credit 7: Distributed Generation	1				**1**	Economies of scale do not permit co-gen to be considered for this facility.
	Energy and Atmosphere	**28**	**0**	**0**	**0**	**28**	
4.0	**MATERIALS and RESOURCES**						
4.R1	Materials Prerequisite: Storage & Collection of Recyclables	REQ'D.	**x**				Space to be provided as part of mechanical or other service room.
4.C1	Materials Credit 1: Building Reuse	1				**1**	new building - project will not achieve
	Materials Credit 1: Building Reuse	1				**1**	see above
	Materials Credit 1: Building Reuse	1				**1**	see above
4.C2	Materials Credit 2: Construction Waste Management	1				**1**	Available - cost shifts to contractor - market return may yield no net cost increase. Extra material due to building demolition
	Materials Credit 2: Construction Waste Management	1				**1**	see above

4.C3	Materials Credit 3: Resource Reuse	1				**1**	Reuse of building components not currently anticipated
	Materials Credit 3: Resource Reuse	1				**1**	Reuse of building components not currently anticipated
4.C4	Materials Credit 4: Recycled Content	1	**1**				Generally available in recycled structural steel and steel studs.
	Materials Credit 4: Recycled Content	1				**1**	More difficult to achieve
4.C5	Materials Credit 5: Local/Regional Materials	1	**1**				Readily available in numerous building materials
	Materials Credit 5: Local/Regional Materials	1	**1**				Readily available in numerous building materials
4.C6	Material Credit 6: Rapidly Renewable Materials	1				**1**	Not available for high-durability non-combustible commercial construction
4.C7	Material Credit 7: Certified Wood	1				**1**	Use of wood products is limited in this design. Specifications may be developed to require Contractor to achieve and track
	Materials and Resources	**13**	**3**	**0**	**0**	**10**	
5.0	**INDOOR ENVIRONMENTAL QUALITY**						
5.R1	IEQ Prerequisite 1: Minimum IAQ Performance	REQ'D.					
5.R2	IEQ Prerequisite 2: Environmental Tobacco Smoke (ETS) Control	REQ'D.					
5.C1	IEQ Credit 1: IAQ Monitoring	1	**1**				
5.C2	IEQ Credit 2: Increase Ventilation Effectiveness	1				**1**	
5.C3	IEQ Credit 3: Construction IAQ Management Plan	1		**1**			Added moderate cost shifted to Contractor

	IEQ Credit 3: Construction IAQ Management Plan	1		**1**			Added moderate cost shifted to Contractor
5.C4	IEQ Credit 4: Low-Emitting Materials	1	**1**				Readily available products
	IEQ Credit 4: Low-Emitting Materials	1	**1**				Readily available products
	IEQ Credit 4: Low-Emitting Materials	1	**1**				Readily available products
	IEQ Credit 4: Low-Emitting Materials	1				**1**	Specifications will include requirements for wood products including casework
5.C5	IEQ Credit 5: Indoor Chemical and Pollutant Source Control	1			**1**		Areas must include exhaust for copiers - normal exhaust at toilets and janitors - readily achievable
5.C6	IEQ Credit 6: Controllability of Systems	1				**1**	Cost Prohibitive
	IEQ Credit 6: Controllability of Systems	1				**1**	Cost Prohibitive
5.C7	IEQ Credit 7: Thermal Comfort	1	**1**				included in design
	IEQ Credit 7: Thermal Comfort	1				**1**	unlikely due to high added first cost and maintenance
5.C8	IEQ Credit 8: Daylight and Views	1	**1**				Most occupied spaces have direct access to extensive windows
	IEQ Credit 8: Daylight and Views	1				**1**	Direct sightlines do not exist for 90% of spaces
5.C9	IEQ Credit 9: Acoustic Environment/ Noise Control	1	**1**				Readily achievable
5.C10	IEQ Credit 10: IAQ Management Plan	1	**1**				Readily achievable
	Indoor Environmental Quality	**17**	**8**	**2**	**1**	**6**	

6.0	**FACILITY DELIVERY PROCESS**						
	Facility Delivery Credit 1: Holistic Delivery of Facility	1	**1**				Readily achievable as part of process
	Facility Delivery Credit 1: Holistic Delivery of Facility	1	**1**				Readily achievable as part of process
	Facility Delivery Credit 1: Holistic Delivery of Facility	1	**1**				Readily achievable as part of process
	Facility Delivery Credit 1: Holistic Delivery of Facility	1	**1**				Readily achievable as part of process
	Facility Delivery Credit 1: Holistic Delivery of Facility	2	**2**				Readily achievable as part of process
	Facility Delivery Credit 1: Holistic Delivery of Facility	1	**1**				Readily achievable as part of process
	Facility Delivery Process	**7**	**7**	**0**	**0**	**0**	
7.0	**CURRENT MISSION**						
7.C1	Current Mission Credit 1: Operation and Maintenance	2	**2**				Readily achievable as part of process
		1	**1**				Readily achievable as part of process
7.C2	Current Mission Credit 2: Soldier and Workplace Productivity and Retention	1	**1**				Readily achievable as part of process
		1	**1**				Readily achievable as part of process
		1	**1**				Readily achievable as part of process
	Current Mission	**6**	**6**	**0**	**0**	**0**	

8.0	FUTURE MISSIONS						
8.C1	Future Missions Credit 1: Functional Life of Facility and Supporting Systems	1	1				Readily achievable as part of process
		1	1				Readily achievable as part of process
8.C2	Future Missions Credit 2: Adaptation, Renewal and Future Use	1	1				Readily achievable as part of process
		1	1				Readily achievable as part of process
	Future Mission	**4**	**4**	**0**	**0**	**0**	
	CREDIT TOTALS	**100**	**43**	**2**	**2**	**53**	
	Yes		**43**		**Silver**		

SPiRiT CERTIFICATIONS: Bronze: 25-34 Points
Silver: 35-49 Points
Gold: 50-74 Points
Platinum: 75-100 Points

Redesign:

	SPiRiT PREREQUISITES/ CREDITS	POINTS AVAIL.	YES	PROBABLE	MAYBE	NO	SUSTAINABLE REVIEW COMMENTS/ ACTION ITEMS
1.0	**SUSTAINABLE SITES**						
1.R1	Site Prerequisite: Erosion and Sedimentation Control	REQ'D.					To be performed
1.C1	Site Credit 1: Site Selection	1	**1**				Site Selected by Client - within developed Military Base
	Site Credit 1: Site Selection	1	**1**				Project located on previously developed portion of site, close to existing facilities.
1.C2	Site Credit 2: Installation/Base Redevelopment	1	**1**				Proposed building is located within existing Fort Detrick installation.
	Site Credit 2: Installation/Base Redevelopment	1	**1**				
1.C3	Site Credit 3: Brownfield Redevelopment	1				**1**	Site not a brownfield
1.C4	Site Credit 4: Alternative Transportation	1			**1**		
	Site Credit 4: Alternative Transportation	1				**1**	Showers not available conveniently.
	Site Credit 4: Alternative Transportation	1				**1**	Fueling station proximity unknown.
	Site Credit 4: Alternative Transportation	1				**1**	Parking exceeds base requirements.

1.C5	Site Credit 5: Reduced Site Disturbance	1	**1**				Design likely to conform - impervious surfaces being reduced, trees and lawn area being added
	Site Credit 5: Reduced Site Disturbance	1	**1**				Design likely to conform
1.C6	Site Credit 6: Stormwater Management	1	**1**				Stormwater management plan should meets intent
	Site Credit 6: Stormwater Management	1	**1**				
1.C7	Site Credit 7: Landscape and Exterior Design to Reduce Heat Islands	1				**1**	Trees have been removed from parking program - design will not achieve 30% shading
	Site Credit 7: Landscape and Exterior Design to Reduce Heat Islands	1				**1**	Ft Detrick standard roof color (green) will not qualify.
1.C8	Site Credit 8: Light Pollution Reduction	1	**1**				Normal illumination practice with cut-off fixtures will meet this requirement.
1.C9	Site Credit 9: Optimize Site Features	1	**1**				Cut and fill limited. Daylighting incorporated as possible with extensive exterior surfaces and windows, some operable.
1.C10	Site Credit 10: Facility Impact	1	**1**				Detrick JMLC is new facility on existing developed site, clustering existing dispersed groups.
	Site Credit 10: Facility Impact	1	**1**				Meetings with local and state code officials.

1.C11	Site Credit 11: Site Ecology	1	**1**				Design team and occupants to develop plan, in conjunction with mitigation of existing facilities.
	Sustainable Sites	**19**	**13**	**0**	**1**	**6**	
2.0	**WATER EFFICIENCY**						
2.C1	Water Credit 1: Water Efficient Landscaping	1	**1**				
	Water Credit 1: Water Efficient Landscaping	1	**1**				No permanent irrigation is planned for this facility
2.C2	Water Credit 2: Innovative Wastewater Technologies	1	**1**				Cost - prohibitive
2.C3	Water Credit 3: Water Use Reduction	1				**1**	Not practical without waterless urinals / ultra low flow fixtures which are not desired.
	Water Credit 3: Water Use Reduction	1				**1**	Not practical without waterless urinals / ultra low flow fixtures which are not desired.
	Water Efficiency	**5**	**3**	**0**	**0**	**2**	
3.0	**ENERGY and ATMOSPHERE**						
3.R1	Prerequisite 1: Fundamental Building Systems Commissioning	REQ'D.					Commissioning must occur
3.R2	Prerequisite 2: Minimum Energy Performance	REQ'D.					Design components meet ASHRAE minimum performance requirements (envelope, mechanical systems, lighting systems)
3.R3	Prerequisite 3: CFC Reduction in HVAC&R Equipment	REQ'D.					

3.C1	Energy Credit 1: Optimize Energy Performance.	20	**6**			**14**	No systems are BEYOND ASHRAE 90.1 requirements (i.e., heat recovery, additional insulation beyond 90.1, Footcandles required do not permit reduction in W/ft^2 for lighting).
3.C2	Energy Credit 2: Renewable Energy	4				**4**	No solar, etc.
3.C3	Energy Credit 3: Additional Commissioning	1				**1**	Significant first-cost
3.C5	Energy Credit 5: Measurement and Verification	1				**1**	Significant first-cost
3.C6	Energy Credit 6: Green Power	1				**1**	Additional cost to owner.
3.C7	Energy Credit 7: Distributed Generation	1				**1**	Economies of scale do not permit co-gen to be considered for this facility.
	Energy and Atmosphere	**28**	**6**	**0**	**0**	**22**	
4.0	**MATERIALS and RESOURCES**						
4.R1	Materials Prerequisite: Storage & Collection of Recyclables	REQ'D.	**x**				Space to be provided as part of mechanical or other service room.
4.C1	Materials Credit 1: Building Reuse	1				**1**	new building - project will not achieve
	Materials Credit 1: Building Reuse	1				**1**	see above
	Materials Credit 1: Building Reuse	1				**1**	see above
4.C2	Materials Credit 2: Construction Waste Management	1				**1**	Available - cost shifts to contractor - market return may yield no net cost increase. Extra material due to building demolition
	Materials Credit 2: Construction Waste Management	1				**1**	see above

4.C3	Materials Credit 3: Resource Reuse	1				**1**	Reuse of building components not currently anticipated
	Materials Credit 3: Resource Reuse	1				**1**	Reuse of building components not currently anticipated
4.C4	Materials Credit 4: Recycled Content	1	**1**				Generally available in recycled structural steel and steel studs.
	Materials Credit 4: Recycled Content	1				**1**	More difficult to achieve
4.C5	Materials Credit 5: Local/Regional Materials	1	**1**				Readily available in numerous building materials
	Materials Credit 5: Local/Regional Materials	1	**1**				Readily available in numerous building materials
4.C6	Material Credit 6: Rapidly Renewable Materials	1				**1**	Not available for high-durability non-combustible commercial construction
4.C7	Material Credit 7: Certified Wood	1				**1**	Use of wood products is limited in this design. Specifications may be developed to require Contractor to achieve and track
	Materials and Resources	**13**	**3**	**0**	**0**	**10**	
5.0	**INDOOR ENVIRONMENTAL QUALITY**						
5.R1	IEQ Prerequisite 1: Minimum IAQ Performance	REQ'D.					
5.R2	IEQ Prerequisite 2: Environmental Tobacco Smoke (ETS) Control	REQ'D.					
5.C1	IEQ Credit 1: IAQ Monitoring	1	**1**				
5.C2	IEQ Credit 2: Increase Ventilation Effectiveness	1				**1**	
5.C3	IEQ Credit 3: Construction IAQ Management Plan	1		**1**			Added moderate cost shifted to Contractor

	IEQ Credit 3: Construction IAQ Management Plan	1		**1**			Added moderate cost shifted to Contractor
5.C4	IEQ Credit 4: Low-Emitting Materials	1	**1**				Readily available products
	IEQ Credit 4: Low-Emitting Materials	1	**1**				Readily available products
	IEQ Credit 4: Low-Emitting Materials	1	**1**				Readily available products
	IEQ Credit 4: Low-Emitting Materials	1				**1**	Specifications will include requirements for wood products including casework
5.C5	IEQ Credit 5: Indoor Chemical and Pollutant Source Control	1			**1**		Areas must include exhaust for copiers - normal exhaust at toilets and janitors - readily achievable
5.C6	IEQ Credit 6: Controllability of Systems	1				**1**	Cost Prohibitive
	IEQ Credit 6: Controllability of Systems	1				**1**	Cost Prohibitive
5.C7	IEQ Credit 7: Thermal Comfort	1	**1**				included in design
	IEQ Credit 7: Thermal Comfort	1				**1**	unlikely due to high added first cost and maintenance
5.C8	IEQ Credit 8: Daylight and Views	1	**1**				Most occupied spaces have direct access to extensive windows
	IEQ Credit 8: Daylight and Views	1				**1**	Direct sightlines do not exist for 90% of spaces
5.C9	IEQ Credit 9: Acoustic Environment/ Noise Control	1	**1**				Readily achievable
5.C10	IEQ Credit 10: IAQ Management Plan	1	**1**				Readily achievable
	Indoor Environmental Quality	**17**	**8**	**2**	**1**	**6**	

6.0	**FACILITY DELIVERY PROCESS**						
	Facility Delivery Credit 1: Holistic Delivery of Facility	1	**1**				Readily achievable as part of process
	Facility Delivery Credit 1: Holistic Delivery of Facility	1	**1**				Readily achievable as part of process
	Facility Delivery Credit 1: Holistic Delivery of Facility	1	**1**				Readily achievable as part of process
	Facility Delivery Credit 1: Holistic Delivery of Facility	1	**1**				Readily achievable as part of process
	Facility Delivery Credit 1: Holistic Delivery of Facility	2	**2**				Readily achievable as part of process
	Facility Delivery Credit 1: Holistic Delivery of Facility	1	**1**				Readily achievable as part of process
	Facility Delivery Process	**7**	**7**	**0**	**0**	**0**	
7.0	**CURRENT MISSION**						
7.C1	Current Mission Credit 1: Operation and Maintenance	2	**2**				Readily achievable as part of process
		1	**1**				Readily achievable as part of process
7.C2	Current Mission Credit 2: Soldier and Workplace Productivity and Retention	1	**1**				Readily achievable as part of process
		1	**1**				Readily achievable as part of process
		1	**1**				Readily achievable as part of process
	Current Mission	**6**	**6**	**0**	**0**	**0**	
8.0	**FUTURE MISSIONS**						
8.C1	Future Missions Credit 1: Functional Life of Facility and Supporting Systems	1	**1**				Readily achievable as part of process
		1	**1**				Readily achievable as part of process

8.C2	Future Missions Credit 2: Adaptation, Renewal and Future Use	1	**1**				Readily achievable as part of process
		1	**1**				Readily achievable as part of process
	Future Mission	**4**	**4**	**0**	**0**	**0**	
	CREDIT TOTALS	**100**	**50**	**2**	**2**	**46**	
	Yes		**50**		**Gold**		

SPiRiT CERTIFICATIONS: Bronze: 25-34 Points
Silver: 35-49 Points
Gold: 50-74 Points
Platinum: 75-100 Points