Montgomery County Equipment Maintenance and Operations Center

Mechanical Thesis Proposal Revision 1

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Mechanical Option
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Executive Summary:

The Montgomery County Equipment Maintenance and Operations Center, Building 1 (EMOC 1) is a 75,000 square foot building in Rockville, Maryland designed to be the new hub for Montgomery County's ground transportation services. EMOC 1 is a multi-purpose building consisting of both garage space for maintenance and office space for operations. The building is still under construction and is scheduled to be finished in February of 2013. The design strives for LEED silver or better.

The current mechanical system consists of two major divisions - the garage space and the office space. The garage space is serviced by two Energy Recovery Units (ERU) and one Heating and Ventilating (HV) unit, both to provide only heating to the space. Cooling is done by natural ventilation aided by large Circulating Fans (CF) and rooftop gravity ventilators placed evenly throughout the garage spaces.

The office spaces are serviced by three Rooftop Air Handling Units (RTU). These are VAV systems with a central heating and cooling plant. These systems are balanced so that they are of relatively equal size and service separate areas of the building with minimal ductwork.

Two alternatives will be considered in this thesis. Each alternative addresses a change for both the garage space and the office space since they can be considered independent divisions of the building. In the garage spaces, the effect number of Energy Recovery Units will be analyzed. The offices spaces will be analyzed on a change to two large Rooftop Units in one alternative, and a change to Chilled Beams in the other. The comparisons between the alternatives and the existing system will support conclusions about the methodology in designing systems with these energy efficient components.

Along with the study of the mechanical system of the building, the breadth topics of Architecture and Acoustics will be addressed. Details of all aspects of the study can be found later in this document.

Review of Existing Mechanical System:

EMOC 1 is serviced by six main systems, all stemming from a central heating and cooling plant. Those six systems include two energy recovery units and one heating and ventilating unit servicing the garage spaces, and three rooftop air handling units servicing the offices spaces.

The garage spaces are quite unique in their design as there is no cooling done by the mechanical system. Cooling is provided by the use of natural ventilation aided by large circulating fans and gravity rooftop units. The fans and the gravity units use very little energy when compared to what would be required for air conditioning of the space. The circulating fans and the gravity rooftop units expel heat from the higher ceiling areas of the garage and help it to either leave through the roof or be pushed out through the garage bay doors. The criteria that allowed this to be a viable solution was the simple fact that the garage bay doors will be opened quite often so vehicles can enter the maintenance areas. Rather than fighting nature and trying to condition the space, the building works with the natural infiltration to provide a comfortable working environment.

The office spaces in the building are serviced simply by three rooftop air handling units. They are VAV systems all stemming from the same heating and cooling plants. These units only service the office spaces and not the garage spaces due to the design objectives specified above.

The energy use of the systems adds up to a total cost of approximately $26,464 per year. The details of the energy usage and annual operating cost are show below:

Table 1 - Energy Use by System

Plant	System	Main Coil (MBh or tons)
Heating	RTU-1	79
	RTU-2	158
	RTU-3	77
	ERU-1	611
	ERU-2	714
	HV-1	75
	Heating Total:	**1,714 MBh**
Cooling	RTU-1	28.6
	RTU-2	55.0
	RTU-3	22.0
	Cooling Total:	**105.6 tons**

Table 2 - Annual Costs

Utility	Cost ($/Yr)
Electric	26,061
Gas	363
Total	26,464

Thesis Design Objectives:

After thoroughly analyzing the existing system, my objectives in this thesis are to look into the methodology of designing systems with energy recovery units, rooftop units, and natural ventilation. The main objective will be to make conclusions about what methods of design will reduce energy use the most by changing the mechanical systems to the alternatives discussed later in this proposal.

Some of the major design objectives that will remain consistent with the original design throughout the study will include the natural cooling of the garage spaces aided by circulating fans and gravity rooftop ventilators, the use of a green roof (although more green roof space will be available with the proposed alternatives), and the division of the office space from the garage space.

The objectives for the breadth topics are relatively simple yet necessary for a comfortable and productive work space. The acoustical objective is to minimize the amount of garage noise infiltrating the office space. This infiltration leads to distractions and therefore reduced productivity.

The architectural objectives will be coordinated with the mechanical system design in order to make the office spaces a more pleasant and aesthetically pleasing workspace. This will also be linked to the acoustic breadth in terms of certain wall placements and construction techniques to provide acoustical barriers.

Alternative Designs to be Considered:

Alternative 1 - 1 Energy Recovery Unit and 2 Rooftop Units

This alternative will employ the use of only one large energy recovery unit for the garage spaces and two large rooftop units for the office spaces. The objective for this alternative will be to make conclusions as to whether it is better to use less rooftop units in place of dispersed smaller units for energy efficiency. The energy recovery units will be the same type of unit that exists in the designs now, however it will be much larger to accommodate the increased load. The rooftop units will also be the same type of system, just a different size, as the existing three are now. The reason for two rooftop units as opposed to one very large unit is to address the owner's need for different operating schedules.

Potential issues with employing these larger systems will mostly be in terms of the duct space required in the building. The larger air supply coming from the units will require larger ducts, and that means more space within the building for mechanical equipment.

The energy recovery unit will need ducts reaching from some central point on the building's roof to the garage spaces on the wings of the building. These are long duct runs and will need to be placed carefully. The rooftop unit will not necessarily have longer duct runs, but will rather need ducts of much larger cross-sectional area. It will need to be determined in this study as to whether the space required will impede any normal operations in the building.

Alternative 2 - 4 Energy Recovery Units and Chilled Beams

Alternative 2 will address the possibility that using more smaller energy recovery units will conserve more energy in the overall system. This is the antithesis of the situation presented in Alternative 1. Also, the use of chilled beams in the office spaces will be studied in place of a conventional air conditioning system. Heating will still be done by a rooftop unit.

Chilled beams are especially temperamental when it comes to relative humidity. According to psychrometrics, condensation will occur on a surface if that surface is below the dew point of the space. The pipes in the chilled beam will produce condensation if this case is true. This introduces a short-circuit hazard if the chilled beam is coupled with a light fixture. In most cases, and air conditioner assist is used to make the air more suitable for using chilled beams. The air conditioner is not meant to handle the full load of the space, but rather just the dehumidification of the space.

The use of 4 energy recovery units will greatly reduce ductwork, however, it will introduce new structural elements around the roof of the garage space. The units will also reduce the amount of green roof available. All of these issues will be taken into account as the energy consumption is calculated.

Justification of Alternatives:

The justification for selecting these alternatives is that this thesis will examine which option is best in terms of energy consumption. In the garage spaces, the number of energy recovery units will be addressed as the variable. It will answer the question of whether using one large system or using multiple smaller systems is more energy efficient for the same space.

The alternatives presented for the office spaces will examine two different possibilities in terms of energy efficiency. The existing design calls for three rooftop VAV units. This compared with Alternative 1 will answer the same question presented for the garage spaces - are large systems or multiple smaller systems better for energy consumption? Alternative 2 will examine a completely different option of using chilled beams. Chilled beams are already in use in some buildings in the vicinity of EMOC 1 which proves that the climate of the area makes it possible to use them.

The air quality and comfort of the spaces in question will be constants throughout this study. Operating cost and construction cost will be determined along with the energy consumption and energy use costs. The systems will also be assessed for their maintainability. The existing systems are relatively simple to maintain so care will need to be taken in designing the new alternative systems.

Breadth Topics:

Architecture:

The current architecture of the building is mainly for functionality. There are small measures taken to provide a comfortable and pleasant work environment, however certain aspects could be improved or modified in conjunction with the proposed alternative mechanical systems. One item of particular interest is the current air handler placed in the same area as the rooftop courtyard connected to the office spaces. This issue will be addressed in order to provide places, like the courtyard, that are enjoyable for the occupants of the building. The option of enclosing this courtyard with a glass atrium will be addressed as well. This will change the aesthetic value of the courtyard to a year-round place for office workers to relax and take their breaks. An atrium here would also link to the mechanical system by providing a small chimney effect in the building, providing natural ventilation.

Other issues that will be addressed are the construction materials, methods, and overall placement of interior walls and ceilings in conjunction with the Acoustics breadth topic.

Acoustics:

Acoustics are a major factor in how productive an office space can be. This building presents very specific challenges as it is both an office space and a garage space. Garage noise would certainly be distracting and frustrating if heard throughout the office spaces. With the architectural breadth in mind, an acoustic study will be done based on the existing conditions will done as well as with the alternative conditions. Suggestions will be made on wall placement and construction to minimize the transmission of noise and to make the space as comfortable as possible for work.

Integration and Coordination:

The most prominent coordination need will be with the structural design team. Mechanical components cut through and work around structural components in almost all cases. Also, the weight of the new alternative systems and their placement must be carefully coordinated so that the structure is able to support them. The existing design for structure will be considered during the study of the alternatives, but some changes will be suggested as placement is determined.

Coordination with the electrical design team will also be necessary. The new systems will require different electrical loads, which means different wire sizes and potentially even different switchgear.

Finally, coordination with the construction team will be necessary to ensure that all components of the new systems are installed correctly. This coordination will be mainly for quality control.

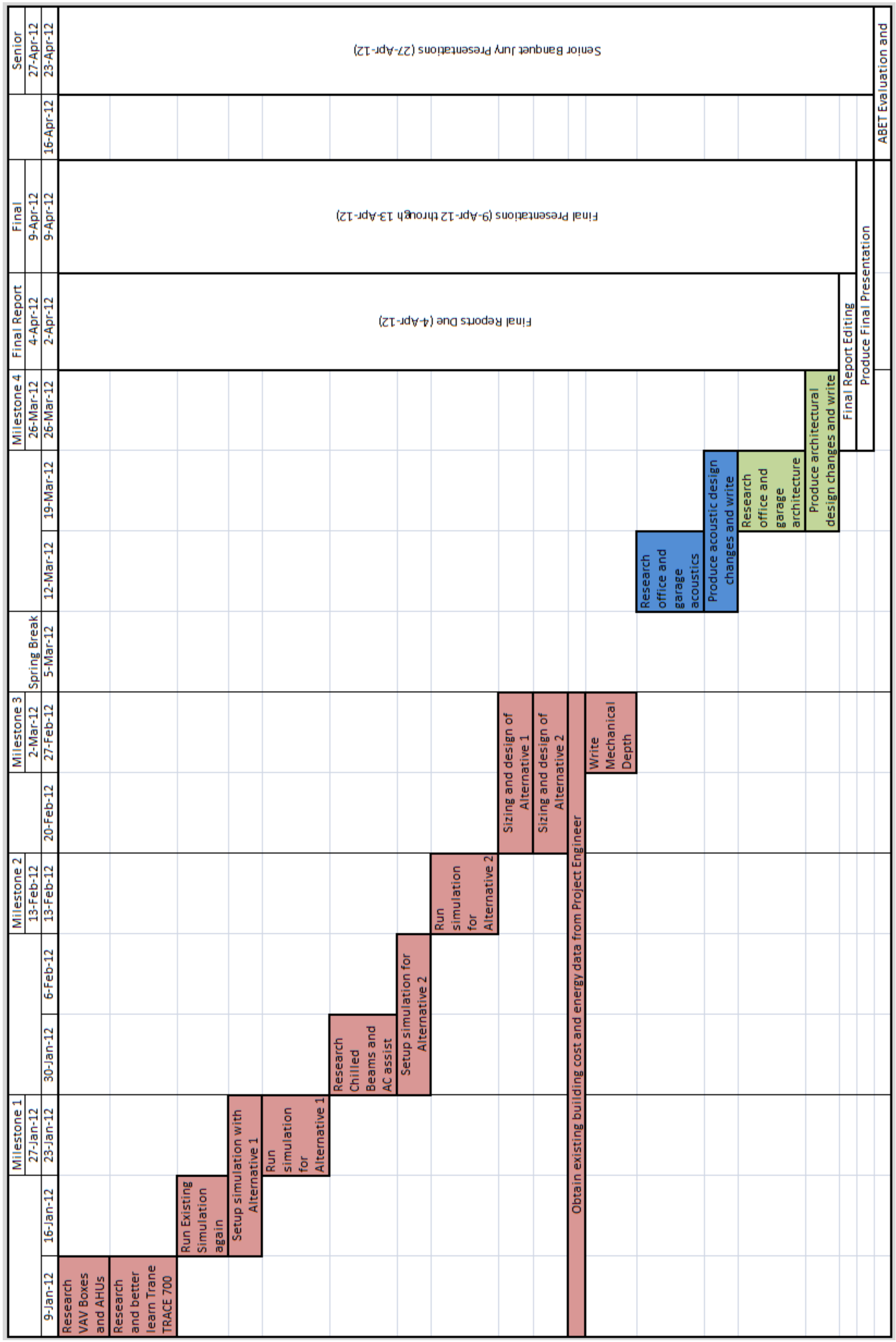
Research Tools and Methods:

The main computer resource that will be used is Trane TRACE 700. This will be used for all energy consumption and operating cost estimation. Microsoft Excel and Matlab will also be used for other calculations, data processing, and reporting.

For the architectural breadth, research will be done in the library and on the internet to find what aspects of a building make office spaces productive, comfortable, and pleasant. These aspects will then be considered for their practicality and potential use in EMOC 1.

For the acoustics study, hand calculations, Excel, and Matlab will be used based on transmission loss values, reflections, and line of sight to make suggestions for each alternative. Wall placement and construction will be taken into account as well as ceiling and floor construction.

Work Plan:


Milestone 1
27-Jan-12
Milestone 2
13-Feb-12
Milestone 3
2-Mar-12
Spring Break
Milestone 4
26-Mar-12
Final Report
4-Apr-12
Final
9-Apr-12
Senior
27-Apr-12
9-Jan-12
16-Jan-12
23-Jan-12
30-Jan-12
6-Feb-12
13-Feb-12
20-Feb-12
27-Feb-12
5-Mar-12
12-Mar-12
19-Mar-12
26-Mar-12
2-Apr-12
9-Apr-12
16-Apr-12
23-Apr-12
Research VAV Boxes and AHUs
Research and better learn Trane TRACE 700
Run Existing Simulation again
Setup simulation with Alternative 1
Run simulation for Alternative 1
Research Chilled Beams and AC assist
Setup simulation for Alternative 2
Run simulation for Alternative 2
Sizing and design of Alternative 1
Sizing and design of Alternative 2
Obtain existing building cost and energy data from Project Engineer
Write Mechanical Depth
Research office and garage acoustics
Produce acoustic design changes and write
Research office and garage architecture
Produce architectural design changes and write
Final Report Editing
Produce Final Presentation
ABET Evaluation and
Final Reports Due (4-Apr-12)
Final Presentations (9-Apr-12 through 13-Apr-12)
Senior Banquet Jury Presentations (27-Apr-12)

Depth Study	
Architectural Breadth	
Acoustics Breadth	

Milestones:	
1	Simulation for Alternative 1 Complete
2	Simulation for Alternative 2 Complete
3	Mechanical Depth Complete
4	Breadth Topics Complete