McCarran International Airport
Terminal 3
Las Vegas, NV

Thesis Proposal

Mechanical Systems Project Proposal

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Executive Summary

This proposal is for an alternative design to a portion of the mechanical system of Terminal 3 at McCarran International Airport located in Las Vegas, Nevada. The proposal outlines other alternative designs that were considered, as well as reasons why they were disregarded. In many cases, it was felt that these other alternative designs would not have a significant enough impact on the overall system to warrant further investigation. Many alternatives were also eliminated due to a lack of educational benefit.

The proposed thesis is a displacement ventilation strategy through the use of an underfloor air distribution (UFAD) system. It is proposed to utilize this design strategy in the airline gate hold rooms, as well as on the airside concourse of the terminal. Both of these areas are located on the southern portion of level 2. The existing system for the hold room areas is an overhead mixing system, which uses linear diffusers in the ceiling to achieve air distribution. The existing system for the airside concourse also uses a mixing system, but the air distribution comes from sidewall diffusers located high on the northern side of the concourse.

Preliminary research has indicated that the proposed thesis will likely achieve better indoor air quality and thermal comfort. Since these are two major concerns for these spaces, it is reasonable to believe that displacement ventilation is justified for these areas. Furthermore, the proposed thesis will also create the chance to learn about an emerging technology with many other potential applications.

The proposed thesis also covers two breadth topics in other engineering disciplines. The first of these breadth topics is an evaluation of the acoustical characteristics of the space. The existing design employs both sound attenuators and duct lining to reduce the acoustical impact of HVAC noise. Since the alternative mechanical design will result in lower air velocities, the possibility exists that these acoustical treatments will no longer be required in these spaces. The proposed acoustical analysis will also look at other noise factors within the space; including the operation of jet engines outside, as well as the noise from general activity inside the terminal.

The second proposed breadth topic will evaluate either construction management or architectural aspects of the same spaces. The addition of a raised floor will be required to accommodate the UFAD system. This has obvious cost and scheduling impacts that will have to be considered in the analysis. At the same time, this new floor system will also have architectural impacts on the space. Consideration will have to be given to accommodating this new floor system without significantly affecting ceiling heights in the spaces. Furthermore, the raised floor will have to make a smooth and level transition to areas that will not include a raised floor. This will likely require altering some floor elevations in other areas.

Most of the proposed work will be performed in accordance with various design guides that have been obtained on displacement ventilation and UFAD systems. These guidelines will serve as the major tool for completing the design process. Additionally, load simulations will be performed with Trane TRACE or similar software. The possibility also exists for some CFD modeling on airflows within the areas of proposed modification.

Architectural Background

Terminal 3 is a 1.8 million SF facility being developed on the northeast portion of the airport site. It will be a "unit" terminal at McCarran International Airport, as it will not be dependent on the existing terminals. The new terminal will provide 14 new gates serving both domestic and international flights. As a result, Terminal 3 will also include customs and border patrol services.

Terminal 3 consists of 5 levels. The below grade basement level includes mechanical and electrical rooms, storage, and Automated Transportation System (ATS) maintenance areas. Level 0 is below grade on the airside of the terminal, and at grade on the landside. It includes baggage claim, customs, an ATS station serving Satellite D, and back-of-house support facilities. This level also contains TSA passenger screening as Satellite D is a fully secure building. Level 1 is at grade on the airside of the terminal and above grade on the landside. It houses the baggage screening systems, airline support area, and other back-of-house facilities. This level is fully secure with the exception of a landing connecting Level 0 and Level 2. This landing will provide access from a new parking garage to be built with Terminal 3. Level 2 contains the new gates, concessions, gaming areas, concourses, ticketing counters, offices, and additional back-of-house facilities. Level 3 of the terminal consists only of mechanical penthouse spaces.

Special attention is drawn to the requirement for full separation of secure and non-secure areas of the new terminal. The following terms are used throughout this report, and are defined here for clarification. The landside portion of the terminal refers to the unsecure portions of the terminal that do not require one to first pass through Transportation Security Administration (TSA) screening areas. The airside portion of the terminal refers to those areas that can only be accessed after having passed through TSA screening lanes.

A new central plant is being constructed to serve Terminal 3. This central plant will be located to the east of the terminal. As stated before, Terminal 3 also includes an ATS station with a tunnel connecting the terminal to the existing Satellite D facility.

Design Alternatives Considered

Throughout the completion of various technical assignments, many areas were noted as having potential for alternative designs. Some of these areas were within Terminal 3 itself, while others were noted for the new central plant that will serve Terminal 3. In general, considerations were given to both the airside and waterside components of the existing mechanical system.

Central Plant Chilled Water System

The first area considered for alternative designs was the central plant that will serve Terminal 3. This new central plant at McCarran International Airport will provide a peak cooling capacity of 11,000 tons by a variable primary flow chilled water system. This peak capacity is supplied by five 2,200 ton centrifugal chillers. An additional 2,200 ton centrifugal chiller will be provided as standby for a total of six chillers. Pumping requirements for this system are provided by three variable flow chilled water pumps serving the cooling load. An additional chilled water pump is provided as standby, resulting in a total of four chilled water pumps.

The condensing water system for the central plant will consist of field erected concrete cooling towers, with a total of six cells corresponding to the six chillers. Again, five of the cooling towers are provided to serve the cooling load, and one additional cell is provided as standby. The condenser water system is a constant flow system, with five condenser water pumps serving the condenser water load. An additional condenser water pump is provided as standby for a total of six condenser water pumps. Similar to the chilled water pumps and chillers, the condenser water pumps are decoupled from the cooling towers. This will allow for any one condenser water pump or group of condenser water pumps to operate with any one cooling tower or collection of cooling towers. Variable Frequency Drives (VFD's) will be included on the cooling tower fan motors to maintain appropriate condenser water temperatures. Finally, a total of two plate and frame heat exchanges are provided for chilled water return pre-cooling and waterside free cooling. Since the chilled water return pre-cooling mode will require the use of condenser water at two separate temperatures, the basin is divided by two sluice gates. When closed, these gates create two separate water basins served by different cooling towers.

Due to the large capacity of this chilled water plant, there are likely some modifications that could be made to the design to improve efficiency. Potential design alternatives include variation of condenser water temperatures, as well as chilled water temperatures. Potential changes to the chilled water temperatures could result in a reduced chilled water supply temperature. This reduced supply temperature could also be use to provide low temperature supply air that could result in significant changes to the airside systems. For example, reduced supply air temperatures could allow for smaller ductwork sizes, and also reduced fan energy.

While this design alternative could present some significant changes to both energy consumption rates and annual operating costs, it is not considered to be the ideal redesign. The redesign concept seems to be somewhat basic, and does not appear to provide enough educational value. Significant equipment changes are likely restricted by the large load, and minor configuration changes seem too small for a research period of one semester.

Thermal Energy Storage

The chilled water system at Terminal 3 is also a potential candidate for chilled water storage. This concept includes modifications to the existing central plant to accommodate a storage system, but is considered to be a separate set of ideas from those mentioned in the previous section. Depending on the type of storage system implemented, the idea of reduced supply air temperature mentioned in the previous section is also applicable to this design alternative. Despite this, the two are considered to be exclusive alternatives, and would not necessarily have to be done together.

While research in this topic would be of great educational value, the potential to implement it in the future seems quite limited. Unfortunately, thermal energy storage (TES) is not a widespread concept and the potential to apply it in my career may be fairly limited. As a result, the goal is to find a different topic of high educational value that can also be applied throughout my career. Concerns about redundancy on a TES design are also a factor. While redundancy can be implemented into a storage system, the feeling is that it would reduce the potential cost and energy savings of the overall system. As a result, such a storage system is not believed to be able to provide as great of a benefit to the chilled water system and the building.

Dedicated Outdoor Air System

A dedicated outdoor air system (DOAS) was also considered for some public areas of Terminal 3. The intent of this alternative design would be to provide a different strategy for the supply of outdoor air to various spaces. The existing system utilizes carbon dioxide monitoring, but DOAS has the potential to provide for more accurate control of ventilation requirements.

The main concern with this design strategy is the likelihood of major fluctuations in occupant densities throughout the terminal. These population changes would require the use of VAV DOAS system. Such a system would likely not reduce the complexity of the existing system, and may actually make the system more complicated. DOAS is probably best reserved for buildings with more constant occupant loads, and therefore is not considered to be an ideal application for Terminal 3.

Proposed Redesign

Background Information

As mentioned earlier, Terminal 3 includes 14 new airline gates to better serve passengers through McCarran International Airport. Each of these gates has an adjacent hold room providing seating to those waiting to board a plane, as well as a loading area for use when the plane is being boarded. These spaces are located on the south side of the second floor, which is a secure area. In other words, this area can only be accessed by those who have passed through the TSA screening area. Since many of these gates serve reasonably large aircraft, there can be a significant amount of people in a hold room at a given time. This tends to result in fairly crowded hold rooms, and a high occupant density per square foot. These gate areas are all connected through the airside concourse, which is also a secure area. This concourse area is provided mostly for public circulation, but includes some fixed seating for concessions and gaming areas.

The existing mechanical system in this area is a traditional overhead mixing air distribution system. The gate loading areas and hold rooms are all served by linear ceiling diffusers, whereas the concourse area is served by high sidewall nozzle diffusers. Figure 1 shows an interior rendering of the space. On the left, a typical airline gate is shown. This includes the seating for the hold rooms, as well as the actual loading area. In the center of the rendering, the airside concourse is shown. Finally, the various concessions and other tenant spaces are shown to the right. The wall to the right also shows the location of the current sidewall diffusers. The ceiling slope is also an important aspect of this space. The low side of the ceiling, located in the hold room space is approximately 12'-6" above finished floor. From here, the ceiling slopes up to a height of 30'-6" above the floor.

Figure 1: Interior rendering for airside portion of Terminal 3.

Problems to be Addressed in Design

The main concerns in the hold room spaces are thermal comfort and indoor air quality. In order to meet these requirements, fairly large quantities of conditioned air are supplied to the spaces. However, these high quantities of air also result in higher energy consumption and annual costs. This is especially true when the amount of outdoor air required is taken into account. In an effort to help minimize the energy consumption of the existing system, the spaces include carbon dioxide sensors that allow for the reduction of outside air quantities.

Similar concerns exist in the concourse area as well, but the ceiling height now becomes a major consideration as well. A traditional mixing system would require entrainment of a significant amount of air due to the increased volume of the space. The current use of sidewall diffusers here likely provides for efficient mixing of the space, and maintains acceptable thermal comfort levels.

The main goal of any system in these spaces should be the ability to create a healthy indoor environment, with attention given to both air quality and thermal comfort. Furthermore, this system should be energy efficient and flexible to the frequent changes in occupant density. In fact, the true problem of the level 2 airside portion is a balance of these two goals. Oftentimes increasing one of these variables causes a corresponding sacrifice in other aspects.

Proposed Solution to Design Problems

The proposed design alternative for these spaces is a displacement ventilation strategy achieved through the use of an underfloor air distribution (UFAD) system. Displacement ventilation could also be performed through the use of diffusers located low in the walls. The problem with the latter strategy is the open architecture of the space. The only major wall area in this space is the exterior wall, which contains expansive amounts of glass. This and other considerations would make it quite undesirable to include any air distribution in this wall. As Figure 1 shows, the only other vertical surfaces in these spaces are column enclosures, and other short segments of walls along the airside concourse. Since the area and spacing of these surfaces would also be difficult to work with, the air distribution is best located in the floor as opposed to near the floor.

UFAD can also be implemented as part of a turbulent flow design. In this type of application, the intent is to mix the air within the space. However, this strategy varies significantly from traditional overhead mixing systems in that only the room air within the first six feet above the floor is mixed. In doing this, the air located closer to the ceiling is considered a portion of the unoccupied zone and does not need to be conditioned. This upper layer of warmer air also helps to carry contaminants away from the occupied zone, and is returned to the air handling unit through return grilles located in the ceiling.

It is believed that either UFAD strategy could be successful in this space, but that a displacement ventilation strategy could provide better stratification of the space. As a result, indoor air quality and thermal comfort may be better enhanced with the underfloor displacement ventilation system as opposed to the underfloor turbulent distribution system. Further research in this matter will be done early to determine the system that is best for the indicated spaces.

Justification of Redesign

The alternative design combination of displacement ventilation and UFAD is believed to be justified for several reasons. Some of these include better thermal comfort and indoor air quality, increased energy efficiency, high feasibility, and also educational value.

As preliminary research for this proposal, several case studies and basic design guides have been read. Most, if not all of these sources, have indicated that the way in which displacement systems operate allows for the creation of a better indoor environment. Instead of simply mixing the air and diluting contaminants, displacement ventilation seeks to stratify the air and carry these contaminants away from the occupied zone. This is achieved by supplying cooler air at the floor level. From here, this air is heated by people and equipment within the space. Due to buoyancy forces, this warmer air is moved upwards toward the ceiling. In turn, the contaminants in the air are also removed with the warmer air. Furthermore, the supply of conditioned air directly to the occupied zone ensures that cooling loads are met directly within the space.

The same research efforts indicated above have also shown that displacement ventilation and UFAD can result in reduced energy consumption. Since air is being supplied directly to the occupied zone, it is supplied at higher temperatures than overhead mixing systems. As a result, less energy is used to condition the supply air. Furthermore, ASHRAE Standard 62.1 indicates that ventilation effectiveness values of UFAD systems are higher than those for overhead mixing systems. This will allow for a reduction in design outdoor airflow required at the outdoor air intake of each air handler, which will allow for further energy savings.

The final justifications for this redesign are a combination of feasibility and educational value. As mentioned in the design alternatives section, there were several other topics considered for this thesis proposal. However, many of them failed to have significant educational value. For example, some chiller optimization efforts could have been performed, but they wouldn't have granted me the chance to thoroughly learn any new topics. Other topics potentially have a higher educational value, but are not commonly implemented as real world designs. As a result, the minimal chances to apply such a strategy reduce its educational value. It is believed that both displacement ventilation and UFAD strategies are considered more common place than other alternative design strategies. The research performed for this redesign will allow me to develop a significant amount of knowledge on these types of systems, and also a chance to realistically apply it throughout my career.

Proposed Acoustical Design Breadth

Background Information

Due to concerns about mechanical noise within Terminal 3, sound attenuators are being included in duct mains for both supply air and return air ductwork. Additionally, duct lining is being provided for a limited extent of these duct mains. It is also important to note that these attenuation efforts are included both in private office spaces, and various public areas throughout the terminal.

Problems to be Addressed in Design

The obvious problem with these spaces is the potential for noise disturbances. The existing acoustical design efforts have addressed the issue of HVAC noise, but other noise sources exist within the space and must be considered. A large source of noise at McCarran International Airport results from the operation of jet engines outside. In fact, this is probably considered to be the most significant noise source at Terminal 3.

Other smaller noise sources include general conversation between occupants of the spaces, noise from smaller equipment within the space (e.g. machines in gaming areas), and announcements made through the paging system within the building. The ideal design solution to the space should consider all of these noise sources, and not only HVAC noise. There is the possibility that the existing acoustical design does not account for these other noise sources, and may not function as desired. The existing design may also be a wasted first cost in that other noise sources not taken into account may be the controlling factors within the space.

Proposed Solution to Design Problems

In order to better focus the design efforts in this area, acoustical analysis will be performed in detail only for the areas considered in the main redesign. That is, the focus will be on acoustical noise within the gate hold rooms and airside concourse. Since the HVAC system in this area is being significantly modified by the alternate design, acoustical characteristics of the system are subject to dramatic changes. The initial feeling is that the UFAD system will allow for lower airflow velocities, and will substantially reduce the amount of sound attenuation required. Therefore, the new system will be evaluated from an acoustical standpoint, and appropriate modifications will be made.

This redesign will also focus on the alternative noise sources mentioned above. Efforts will be made to gather typical noise data for these other sources, and they will be taken into account. This will ensure that any sound attenuation efforts made on the mechanical system will in fact be successful. This will also allow for discussion of other acoustical considerations within the space, and any potential design solutions to eliminate them.

Proposed Construction Management or Architectural Design Breadth

Background Information

This design breadth also focuses on the portions of the building covered in the other redesign areas. The existing floor design is a concrete slab on metal deck assembly. This is similar to the spaces adjacent to this area, as well as other spaces within Terminal 3. Such a floor system is not compatible with the requirements for a UFAD system and would require modification.

Problems to be Addressed in Design

Implementation of a UFAD system in this space would require a raised floor assembly. Since the redesigned space does not have such a floor system, one will have to be included. Addition of such a floor system will affect the construction cost, and also the total construction time. The use of this floor system can also have an impact on the floor to ceiling height within the space, as well as transitions to floor heights of neighboring spaces. In order to keep a consistent floor level throughout level 2, the existing floor will have to be lowered in the area being redesigned. The other alternative is to raise the floor elevation of the other spaces on level 2.

Proposed Solution to Design Problems

As mentioned earlier, a raised floor assembly will be required to accommodate the UFAD system. The analysis performed for this section will take into account the affect that such an addition will have on the overall construction process. Obviously the floor system will require an additional amount of money as it will be installed in addition to the already existing floor system. Furthermore, there will also be impacts on the construction schedule due to the added time required to install such a floor system. My analysis will take into account both of these factors to determine if the raised floor system is feasible. There are likely several downsides to adding such a floor system, but it will be required to implement the desired HVAC system. That being said, these negative impacts will be compared to the overall benefits that can be achieved with the UFAD system.

The possibility also exists to perform an architectural breadth on the impact of the floor system. This analysis will discuss the impact of a reduced ceiling height, as well as the affect of altering floor elevations. It is also important to evaluate the need to maintain a consistent floor elevation throughout level 2. Such a study will include an evaluation of the effects of raising or lowering various portions of the second level to determine the best solution.

There will also be some discussion of general structural impacts of the raised floor system. Some floor height modifications will likely be required in order to create a level surface between the areas with a raised floor and the adjacent areas without a raised floor. Structural feasibility of such a modification will be addressed, but not analyzed in great detail due to some limitations. A detailed analysis would likely require extensive modeling that I am not familiar with, and that would require a great deal of time for a building of this size. Furthermore, the building is located in a seismic zone which I have not dealt with in previous experiences. While these create potential learning experiences, they are likely far too complicated for a breadth topic and would distract from my mechanical systems emphasis.

Preliminary Research Efforts

Substantial efforts have already been made to prepare for the incorporation of the alternative HVAC design. Most of these efforts began with some research into existing displacement ventilation systems, and the potential benefits. The use of UFAD systems has also been looked at during this research. Most of this research was performed by searching for articles recently published in ASHRAE Journal on these topics. This research helped to prove that displacement ventilation through UFAD could be a reasonable application to the airside portion of level 2.

Another strong effort has also been made to begin learning more about the fundamentals of displacement ventilation and UFAD. In order to assist in this process, a design guide was obtained from Price, a manufacturer of products used in these systems. This design guide also includes a products catalog that will allow for selection of components required by the system, as well as software that includes a training module on the design of both displacement ventilation and UFAD systems. I've already started my review of this design guide, and plan to continue it through the start of the spring semester.

Finally, a recent meeting with the lead mechanical engineer for Terminal 3 has allowed me to obtain a professional opinion of my proposed redesign. This has allowed me to sort through some various system configurations, as well as the pros and cons of each. This meeting also made me fully aware of the impacts my proposed design could have on other disciplines. This is a resource that will continue to be consulted throughout the redesign process, as it has proven a successful strategy so far.

References

The following list is the current selection of materials that will be used throughout the redesign process. Additional resources will likely be required, and will be determined as the research process continues.

1. American Society of Heating Refrigerating and Air Conditioning Engineers, Inc. 2007. ANSI / ASHRAE Standard 62.1-2007, *Ventilation for Acceptable Indoor Air Quality*.
2. E.H. Price Limited. 2005. *Underfloor & Displacement Ventilation Systems.*
3. Bauman, F. et al. 2007. "Cooling Airflow Design Calculations for UFAD". *ASHRAE Journal 49 (10).*
4. Sczomak, D.P. and Barry, T. 2006. "Underfloor for Technology Firm". *ASHRAE Journal 48 (4).*
5. Bauman, F. and Daly A. 2004. *Underfloor Air Distribution Design Guide.* ASHRAE.
6. Chen Q. and Glicksman, L. 2003. *System Performance Evaluation and Design Guidelines for Displacement Ventilation.* ASHRAE.

Tools and Methods to be Implemented During Design

The use of several tools will be required to complete the proposed work. The first of these will be software capable of modeling the building loads. The current intent is to use Trane TRACE to calculate the cooling loads of the space, and also perform energy analysis on the system. The potential exists to use alternative software programs for this modeling as well. The final decision on which program to use will be determined by ease of use and appropriateness for the proposed work.

Other software that may be used for the proposed thesis work includes computational fluid dynamics (CFD) modeling. If considered necessary, CFD analysis will be performed to determine the resulting airflows within the space. This modeling will provide data on air stratification within the space, thereby indicating the efficiency of the system in displacing contaminants and heat from the occupied zone. Since software like this may be complicated to use, existing generic models may be used in place of a model that is specific to the area of the proposed work. This conclusion will be made after some experimentation with the software itself.

Most of the remaining design work will be performed in accordance with various design guides. ASHRAE currently has two publications that will likely be used to perform the proposed work. The first of these is a guideline on displacement ventilation systems, and the second is a guideline on UFAD systems. The use of ASHRAE Standard 62.1-2007 will also be used to calculate ventilation requirements for the space. Finally, manufacturer's catalogs will be used for the remaining design decisions. These catalogs will provide necessary product information that will indicate the components required to create a working system.

Intended Work Schedule

The following monthly calendars indicate the preliminary schedule for progress in the proposed work. It is considered to be tentative, and will be adjusted as necessary to reflect major changes to the original schedule. This tentative schedule is designed to take into account delays in the schedule. Typically, Saturday is reserved as a day off. In the event that the proposed thesis work falls behind, this extra day can be used to account for work that is not yet completed.

January 2008						
Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**
	1	2	3	4	5	6
7 Continue Research on System Design	8 Continue Research on System Design	9 Continue Research on System Design	10 Continue Research on System Design	11	12	13
14 Spring Semester Begins	15 Start New Load Simulation	16 Continue Load Simulation	17 Continue Load Simulation	18 Finish Load Simulation, Organize Output	19	20 ASHRAE Winter Meeting
21 ASHRAE Winter Meeting	22 ASHRAE Winter Meeting	23 ASHRAE Winter Meeting	24 Calculate Ventilation Requirements	25 Calculate Ventilation Requirements	26	27 Calculate Ventilation Requirements
28 Select & Layout Components for System, Further Research	29 Select & Layout Components for System, Further Research	30 Select & Layout Components for System, Further Research	31 Select & Layout Components for System, Further Research			

Figure 2: Proposed schedule.

February 2008						
Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**
				1	2	3 Select & Layout Components for System, Further Research
4 Select & Layout Components for System, Further Research	5 Select & Layout Components for System, Further Research	6 Select & Layout Components for System, Further Research	7 Select & Layout Components for System, Further Research	8 Select Air Handling Units	9	10 Select Air Handling Units
11 Gather Data for CM / Arch Breadth	12 Gather Data for CM / Arch Breadth	13 Begin Cost / Schedule Analysis for Raised Floor	14 Continue Cost / Schedule Analysis for Raised Floor	15 Continue Cost / Schedule Analysis for Raised Floor	16	17 Finish Cost / Schedule Analysis for Raised Floor
18 Evaluate Architectural Impacts of Raised Floor	19 Evaluate Architectural Impacts of Raised Floor	20 Evaluate Architectural Impacts of Raised Floor	21 Finish CM /Arch Breadth Work	22 Gather Data for Acoustical Breadth	23	24 Gather Data for Acoustical Breadth
25 Begin Design Modifications for Acoustical Breadth	26 Continue Acoustical Breadth Work	27 Continue Acoustical Breadth Work	28 Continue Acoustical Breadth Work	29 Finish Acoustical Breadth Work		

Figure 2 Continued: Proposed schedule.

March 2008

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
					1	2
3 Refine Calculation Work for All Areas	4 Refine Calculation Work for All Areas	5 Refine Calculation Work for All Areas	6 Refine Calculation Work for All Areas	7 Refine Calculation Work for All Areas	8 Depart State College for Spring Break	9 Spring Break
10 Spring Break	11 Spring Break	12 Spring Break	13 Spring Break	14 Spring Break	15 Return to State College from Spring Break	16
17 Begin Work on Final Report	18 Continue Work on Final Report	19 Continue Work on Final Report	20 Continue Work on Final Report	21 Continue Work on Final Report	22	23
24 Continue Work on Final Report	25 Continue Work on Final Report	26 Continue Work on Final Report	27 Continue Work on Final Report	28 Continue Work on Final Report	29	30
31 Start Work On Presentation						

Figure 2 Continued: Proposed schedule.

April 2008						
Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**
	1 Continue Work On Presentation	2 Continue Work On Presentation	3 Continue Work On Presentation	4 Finish Work On Presentation	5	6 Start Revisions to Final Report and Presentation
7 Continue Revisions to Final Report and Presentation	8 Continue Revisions to Final Report and Presentation	9 ASHRAE Central PA Chapter Student Night	10 Continue Revisions to Final Report and Presentation	11 Submit Final Report (Anticipated Date)	12 Rehearse Presentation	13 Rehearse Presentation
14 Faculty Jury Presentations	15 Faculty Jury Presentations	16 Faculty Jury Presentations	17 Faculty Jury Presentations	18 Faculty Jury Presentations	19	20
21	22	23	24	25	26	27
28	29	30	May 2nd: Awards Jury / Senior Banquet			

Figure 2 Continued: Proposed schedule.

References

American Society of Heating Refrigerating and Air Conditioning Engineers, Inc. 2007. ANSI / ASHRAE Standard 62.1-2007, *Ventilation for Acceptable Indoor Air Quality*.

E.H. Price Limited. 2005. *Underfloor & Displacement Ventilation Systems.*

JBA Consulting Engineers. 2007. *Construction Drawings for McCarran International Airport – Terminal 3 and Related Projects, Volume 9 of 14, Mechanical.*

PGAL, LLC; et al. 2007. *Construction Drawings for McCarran International Airport – Terminal 3 and Related Projects, Central Utility Plant.*