AN ARCHITECTURAL THESIS

RICHMOND MUNICIPAL AIRPORT

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Ball State University
Muncie, Indiana
This book is dedicated to my family --
Dad, Mom, Tina, Tony, and David.
I would like to thank Bruce Meyer and Jack Wyman along with Bob Koester and Bruce Kieffer for their help with my design.

My deepest appreciation goes out to my friends for their help and support: Jeff Schroeder, Bruce Anderson, Marilee Lloyd, Larry Brenner, and Shawnda Brenner (for typing this). Thanks gang!
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During the summer while driving home from the graveyard shift at the factory, I contemplated my upcoming thesis project and what I might do. At the same time, I was thinking about aviation -- a hobby of mine. I have noticed numerous times that Richmond did not have any type of air travel service. There was a small airport for private planes, but nothing that would accommodate charter services for the public.

I then decided that an airport for Richmond would be a good project. While knowing a bit about airports to begin with, I chose to undertake this project in nine months that would normally take years to complete. Even though I would deal with everything as realistically as possible, I would not have to go through all of the bureaucratic red tape necessary to build an airport. This in itself cut down some on the time factor of design.

I knew that designing an airport would require that I be knowledgeable in all areas concerning the functions. There would be no if's, and's, or but's about it; the project would have to work efficiently. If it became clumsy, then it would not be successful in the end.

But there has to be more to an airport than just its function. Its function is to change a person's mode of transportation from traveling on the ground to through the air. Great technological achievements by Chanute, the Wright Brothers, and many others have made this possible. This transition zone should reflect that technology. And by using new technologies in construction, the spaces created can reflect the essence of an airport -- that transition zone from one mode of transportation to another. These ideas would become the basis for the design.

Just because Richmond is a small city didn't mean that it could not have a unique airport. So as the sun was beginning to peep over the horizon and shine through the morning dew on my windshield, I thought that the airport project could be very fascinating. Interesting images of the airport flashed through my mind, but little did I realize that my preconceptions were not even close...
Richmond, as a thriving community, has potential for a small to medium size airport. An assumption was made that the town and surrounding area could very well provide enough traffic to support the airport. A need for the airport to be able to expand was also written into the program.

After much research on runway restrictions, a cross runway pattern was found to be the most economical. This allows for the two longest runways that the site could offer. Now a Boeing 727 jet could easily land and take off at this airport. A substantial commercial airline would be able to locate in Richmond.

This runway layout presented four different areas to work with. But a decision had to be made first -- whether or not to keep the main terminal and the private pilot terminal adjacent to one another. After more research was completed, a decision was made to separate them mainly for security.

Now that the two areas were chosen, the project could be subdivided into four smaller areas: the main terminal, the control tower, the private pilot terminal, and the hangar areas. Since the public would be exposed to the main terminal more than the other areas, more design time was allotted to that. But the other parts would still receive the same considerations within the design process. All of these parts were then brought together as a whole into the final solution.
When I first began to design the main terminal, preconceptions ran through my mind that there was to be nothing like this before. It was to be aesthetically pleasing and interesting to look at. I also wanted something that functioned with efficiency.

The functional aspect of this project was all too critical. Many airport terminals required that the user make some sort of level change (whether it be by use of a ramp, stairs, or an escalator) to get from his car to the airplane or vice versa. Level changes cut down on the efficiency of the airport. So I wanted to keep the user on the same level while traveling from point A to point B. If the user was in a hurry, then there would not be any confusion to get where he needed to go. If he had time, then he could change levels to the restaurant or the bar.

Throughout all of this, the operations have to take place. Here I wanted to keep the airport operations tightly woven into the rest of the terminal. Keeping the operations area on the lowest level (the same level as planes) will allow the baggage area to be close to the ticket area and the baggage claim area. Other reasons for having the operations on a different level would be security and efficiency.

After everything has been worked out with the functional aspect of the project, I wanted to deal with the philosophical side of the airport. I soon realized that my preconceptions were just that. The main airports that I studied were the TWA Flight Center and Dulles Airport by Eero Saarinen; King Khaled International Airport by Hellmuth, Obata, & Kassabaum; the Walker Field Air Terminal by John Porter & Associates, the Kish Island Air Terminal by Rader Mileto Associates; and the 1982 NCARB designs.

Finding out the essence of the airport was the next step. I wanted to find out exactly what an airport was, what its functions were, and what kind of link it provided between the two different types of transportation: the plane and the car. Going from the car to the plane is a journey. A person changes from different modes of transportation through the use of the airport terminal. This metamorphosis should be apparent by the progression through the spaces within the terminal.

The circulation path produced by this progression should be accentuated while the other functions (the ticket counter, baggage claim, restrooms, etc.) should play a side role in the airport terminal but be readily accessible in order to serve the public as efficiently as possible. The entry/exit points should read as distinctive features because they are the beginning and ending of the journey through the terminal. The central lobby (with the bar and restaurant) should read as a prominent feature because it is the focal point of the terminal building. There should be a continuous element of some sort (the structure, ceiling planes, mechanical systems, etc.) between these points so the metamorphic path will be apparent. Once the entry/exits are reached by the person, he should be aware that the building ends by a chunk of structure while beyond that is an opening up to the world outside.

Technology is another major thrust in this project. Many technological breakthroughs have been made to allow man to be transported in the air. Thus, the airport
terminal should reflect the complexity of these advancements by exposing structure and mechanical systems and by showing different technologies in the construction field.

A paradox of ideas arises here. Incorporating exposed systems into the building gives a person a feeling of complexity, harshness, and of being overwhelmed. At the same time, the spaces should reflect a human quality and scale about it. This idea of a space being scaled down, warm, and inviting allows for it to be more "human." These two ideas should be joined in a harmonious solution to allow for the human qualities to read while not losing the technological thrust of the project.

The other terminal for private pilots should not emphasize movement like the main terminal. Instead, the atmosphere should be one of an exclusive club where pilots can gather to tell their stories. The only criteria to attend would be an interest in aviation. A small plane sales division and a flying school would also be incorporated into this terminal area. While this terminal has separate issues behind its basic design, it can still relate to the site and the other terminal by use of structure, forms, etc. However, the private terminal should have its own features distinguishing it from other buildings.

The rest of the support buildings, the hangars, and the terminals should all come together in the end relating to each other and the site as a unified whole.
<table>
<thead>
<tr>
<th>Runway Length</th>
<th>Widths</th>
<th>Runway CL to Taxiway CL</th>
<th>CL of Taxiways to Aircraft Parking Area</th>
<th>CL of Taxiways to Obstacle</th>
<th>Runway CL to Building Line (Non-Instr.)</th>
<th>Runway CL to Building Line (Instr.)</th>
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</table>

CL CENTER LINE

- Terminal Building
- Aircraft Maintenance Area
- Taxiway
- Aircraft Parking Area
- Runway
- Runway Length

Elevation: 2000 ft.

334' min. to 5542' max.
<table>
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<tr>
<th>Aircraft</th>
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<th>Wing-span</th>
<th>Length</th>
<th>Maximum height</th>
<th>Minimum take-off weight (lb)</th>
<th>Maximum landing weight (lb)</th>
<th>Zero fuel weight (lb)</th>
<th>Engines</th>
<th>Runway length (ft)</th>
<th>Main gear, in.</th>
<th>Typical operating range</th>
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<td>New York-Paris</td>
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</table>

* Distance between main gear and nose gear.
* First number indicates first class configuration, second number coach configuration.
* Symbols: T = turbojet; TF = turbofan; TP = turboprop; P = piston.
* At maximum gross take-off weight—sea level, standard day, no wind, no runway slope.
* Dimensions are in inches. Where two figures are shown for lateral spacing, it means front and rear wheels have different spacings.

Tire contact pressures vary from 100 psi or less for the smaller aircraft to 160 psi for the large aircraft.

**Source:** Civil Transport Data Sheets prepared by Aviation Studies (International) Ltd., manufacturers, and airlines.
Recommended design criteria for secondary airports

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<tr>
<th>Design Feature</th>
<th>Criterion</th>
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<td>Length of landing strip</td>
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<td>Width of landing strip</td>
<td>250 feet</td>
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<tr>
<td>Length of paved runway</td>
<td>1,600 - 3,200 feet</td>
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<tr>
<td>Width of paved runway</td>
<td>75 feet</td>
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<tr>
<td>Width of taxiway</td>
<td>40 feet</td>
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<td>Distance between centerline of runway and centerline of parallel taxiway</td>
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<tr>
<td>Distance between centerline of taxiway and edge of aircraft</td>
<td>100 feet</td>
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<tr>
<td>Distance between centerline of taxiway and obstruction</td>
<td>75 feet</td>
</tr>
<tr>
<td>Centerline of landing strip or runway to building line</td>
<td>4% max</td>
</tr>
<tr>
<td>Effective gradient</td>
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<tr>
<td>Transverse taxiway of landing strip grade</td>
<td>1 1/2% max</td>
</tr>
<tr>
<td>Longitudinal runway of landing strip grade</td>
<td>2 1/2% max</td>
</tr>
<tr>
<td>Transverse taxiway grade</td>
<td>1/2% max</td>
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1-3. Comparative fuselage sections, door sill heights and relative terminal sizes of different aircrafts.

Key: 1 B-727, 2 B-707, 3 DC-10/L-1011, 4 B-747.

(Source: American Airlines Inc.)
### MAIN TERMINAL

1. **Drop-off/Pickup**  
   - Baggage drop-off 1568 sq. ft.
2. **Lobby**  
   - Lounge 9252 sq. ft.
   - Lockers
   - Telephones
   - Information
3. **Car rental** 400 sq. ft.
4. **Ticket Counter** 1750 sq. ft.
5. **Operations Area** 1900 sq. ft.
6. **Baggage Claim** 1800 sq. ft.
7. **Security** 900 sq. ft.
8. **Gift Shop** 2500 sq. ft.
9. **Restrooms** 2260 sq. ft.
10. **Janitor** 200 sq. ft.
11. **Passenger Check-in** 800 sq. ft.
12. **Secured Waiting** 5160 sq. ft.
13. **Restaurant** 5400 sq. ft.
14. **Kitchen** 1200 sq. ft.
15. **Bar** 2400 sq. ft.
16. **Cargo Area** 2400 sq. ft.
17. **Employee Area** 2600 sq. ft.
18. **Luggage carrier area** 3840 sq. ft.
19. **Mechanical** 1200 sq. ft.
20. **Storage** 3900 sq. ft.
21. **Snowplow garage** 3100 sq. ft.
22. **Circulation & walls** 14538 sq. ft.

**TOTAL** 67500 sq. ft.

### MAINTENANCE HANGAR

1. **Aircraft Area** 6000 sq. ft.
2. **Rescue & Fire truck parking** 750 sq. ft.
3. **Maintenance Garages** 750 sq. ft.
4. **Offices** 500 sq. ft.
   - Fueling area

**TOTAL** 8000 sq. ft.

### PRIVATE PILOT TERMINAL

1. **Lobby** 1950 sq. ft.
2. **Pilot Check-in** 340 sq. ft.
3. **Data Room** 300 sq. ft.
4. **Snack Bar w/Kitchen** 2000 sq. ft.
5. **Restrooms** 350 sq. ft.
6. **Reception** 340 sq. ft.
7. **Offices** 1240 sq. ft.
8. **Locker room** 340 sq. ft.
9. **Classroom** 340 sq. ft.
10. **Circulation** 900 sq. ft.

**TOTAL** 8100 sq. ft.
When I first began to look at the surrounding Richmond area, a fairly flat site was needed that could accommodate the tremendous length of the runways. The area around the site also had to be of a low residential nature. But at the same time I also wanted to keep it close to town.

The site that was chosen has easy access to it. It is located at the northwest corner just outside of city limits near the industrial part of town. This provides for easy transporting of cargo that is to be shipped by air. The downtown business area is not more than a fifteen minute drive away.

The location of the site also provides quick access for those from outside of Richmond by being near three major highways: U.S. 40 to the south and I-70 and 35 to the north.
SITE DRAINAGE: The site slopes south and southwest with a creek that runs through the west side of the site.

VEGETATION: There is a wooded area that is on the southwest portion of the site. The woods also follow along the creek. The rest of the site is made up of corn and bean fields.

SOIL CONDITIONS: The soil is mostly clay with gravel areas.

WILDLIFE: There are farm animals, a variety of birds, and the usual ground life: rabbits, ground hogs, field mice, and snakes.

EXISTING STRUCTURES: There are a few scattered farmhouses that will be bought and removed.

EDGE CONDITIONS: All edges of the site are rigid (roads to the east, west, and south, and a railroad to the north).

WIND CONDITIONS: The winds are predominantly from the west, southwest with the strongest winds from the northwest. Refer to the wind rose.

SUN ANGLES: The sun path diagrams at the 40°N latitude give the needed information (Graphic Standards).

SIZE OF SITE: 680 acres.

VIEWS: There are views into the site from all of the roads that allow the whole site to be viewed since it will be fairly unobstructed. Views to the north from the site are the worst because a junkyard is located there.
MAJOR HIGHWAYS:
- U.S. HIGHWAY 40
  - East-West
  - approximately 1½ miles south of site
- INTERSTATE HIGHWAY 70
  - East-West
  - approximately 3 miles north to interchange
- U.S. HIGHWAY 35
  - North-South
  - approximately 2 miles north

MAJOR ROADS TRAVELED TO REACH AIRPORT TERMINAL:
- SALISBURY ROAD
  - two lanes
  - east (adjacent)
  - heavy traffic during hours when factories let out from industrial zone to the east
  - heavy traffic during fair time and when other functions are taking place at the fairgrounds across the street to the east
- CROWE ROAD
  - two lanes
  - south (adjacent)
  - heavy traffic during fair time
- ROUND BARN ROAD
  - two lanes
  - west (adjacent)
  - heavy traffic during quitting time from factory to the south
- JACKSON ROAD
  - runs through site
  - Remove!
- NW "L" STREET
  - two lanes
  - east
  - heavy traffic from industrial zone to the east

TRAFFIC TO AND FROM SURROUNDING ZONES AND AREAS:
- INDUSTRIAL ZONE
  - east
  - takes 5 to 10 minutes to reach
  - major factories and plants of Richmond
- BUSINESS AREA
  - downtown
  - east
  - takes 10 to 15 minutes to reach
  - major businesses of Richmond
- SHOPPING AREAS
  - major area on east side
  - 20 minutes enroute
  - downtown area
  - west side along U.S. 40 south of site
- HOSPITALS
  - Reid Memorial
  - east 10 to 15 minutes
  - in case of emergency
  - state hospital
  - east
Before the runways could be laid out, a number of issues had to be checked into first: wind patterns, lengths of runways needed for certain sizes of planes, airspace obstructions, clear zones, and setbacks.

Wind patterns are very important to laying out a runway. Taking off or landing into the wind is preferred. That doesn't happen most of the time, but by laying the runway the same direction as the wind most frequently blows, landing into the wind can happen a good percentage of the time. By studying a wind rose chart, percentages of the time that the wind blows from the 16 compass points can be found. The nearest one to the site was located in Indianapolis. The wind blows from the southwest the greatest percentage of the time.

Also, a chart showing the fastest mile and direction of wind was consulted. This chart showed that the greatest wind came from the northwest at 111 mph.

The wind patterns corresponded with the runway configuration needed on the site to get the maximum lengths: the northwest-southeast axis and the southwest-northeast axis.

These runway lengths (6300' NW-SE & 4400' SW-NW) now enabled planes of a substantial size to fly in and out of Richmond. The largest one to the used is a Boeing 727 jet.

While all of this worked out, obstructions into the airspace around the site had to be checked. There were a number of items to check: a high-power tension line to the west, a water tower to the southwest, and radio towers to the east-southeast. Also surrounding the site are power lines and telephone lines which can be buried. The tension line and the water tower were found to be below the airspace. The two towers were outside of the airspace. Thus, for the runway configuration proposed, none of these obstacles would present any serious problems.

The final runway lengths mentioned earlier were set after calculating the clear zones from the end of each runway to the nearest obstacle (be it trees, railroads, roads, etc.).

After all of the regulations for laying out runways were sifted through and added with the previous research, the runway configurations were finalized. Then setbacks for the taxiways were calculated. The taxiways were located adjacent to the future sites of the terminals. After that, the buildable area was figured from more setbacks.

Now the site was ready for the buildings.
The two terminals, the tower, and other support buildings are laid out in the south and the east areas. These areas are the most accessible from the highways and from town. The issues that were dealt with were the environment, the functional aspect, and three separate axes.

When dealing with environmental factors, the buildings had some things in common. Everything is laid to provide protection, in some ways from the harsh northwest winter winds. The entrance on the main terminal is to the northeast and to the south on the private terminal. The hangars are set up to provide a sheltered paved lot.

Functionally, the two terminals are set in as close to the runways as possible. Thus, the planes have easy access from the terminals to the runways and vice versa. Also, the terminals are in the middle of everything and define a core of activity.

The tower is laid out on the same axis as the two terminals. While the two wings of the main terminal are very prominent features, the tower is set in closer to the terminal so it does not compete with the wings by being on the same line.

The last part of the planning criteria are the three axes: one from the center of where the runways intersect to the main terminal, one from the main terminal to the private pilot terminal, and one from the private pilot terminal back to the center of the runways. This layout is the basis for many other design decisions about the terminals.
For the main terminal, the spatial sequence is very important. The journey through the airport terminal reflects the metamorphosis that takes place from the car to the plane:

DROP-OFF·TRANSITION·LOBBY·TRANSITION·WAITING

The approach to the terminal also has quite a bit of meaning in the design. Once a person drives onto the site, the entrance comes directly into view between the walls of trees. Then the road turns to the right, and the runways are seen. As the road begins to circle around, the terminal comes into view again. When the person stops at the drop-off zone, the metamorphic trip begins.

The drop-off area is semi-open with the overhead plane transparent but higher. The triangular mass on the outer edge of the building acts as a beginning to the terminal. The combination of the mass and the higher roof plane indicates that something happens within this space.

The transition area has a lower ceiling plane, but it is still transparent. The entry acts as a funnel to get people through a certain point. The walls to the funnel are opaque with a glass curtain wall designating the entrance. Once a person travels through the entry, the overhead glass plane begins to slope up again with the impression that there is another important space to come. The ticket counter and the baggage claim areas are to the sides with lower, opaque ceiling planes.

The glass ceiling plane sloping up or down defines the logical path to follow from the car to the airplane.

The lobby area has the highest ceiling because this is where the major thrust of the metamorphosis idea takes place. The cylindrical elevator acts as another mass signifying the importance of this space. Many activities take place throughout the area: resting, viewing, browsing through the gift shop, and dining and drinking on the levels above.

The path then splits in two while still using the format of the sloping glass ceiling. The terminal is set up so that just one of the waiting area wings can be built, but the concept deals with the assumption that Richmond will have a large enough population to constitute building both wings.

Once again the ceiling begins to slope down to indicate a transition. This zone is
defined by a bridge from the main body of the terminal to the waiting areas. This gets the people out to the airplanes. The bridge is completely enclosed with glass except for the floor.

When the glass ceiling begins to slope up again, another part of the terminal is coming up. There is a mass signifying that the end of the terminal is near. As the bridge is left behind, a person sees the separate entries to the two airplanes. If there is time before the person needs to board, then a waiting area is provided that allows a directional opening of the space with glass walls.

The sequence can also be experienced the other way from the plane to the car. Either way, with the absence of level changes and the spaces set up at the right places along the journey, a person can enjoy nice views, chatting with some friends, browsing in the gift shop, dining in a nice restaurant, having a nice, cool drink ...
The structure used in the airport terminals stems from the technological thrust of the project. The columns are steel tubes; some are filled with concrete for structural purposes. The ground floor has dark brown concrete blocks and is set in from the edge of the rest of the building so there is the expression of a reverse base.

The rest of the terminal is made up of poured concrete and steel beams except for the glass areas. The glass is a dark bronze tint to cut down on heat gain and glare. The sloped glass area is made up of steel columns, mullions, and open web joists that will add to the complexity of the interior with more expressions of the technological thrust. The glass bridges are made up of two large trusses spanning from the main part of the terminal to the waiting areas.

Since there is a large amount of glass area, there will still be quite a bit of heat gain. The mechanical systems are set up to handle this. During the summer, vents by the top of the elevator cylinder will open up to exhaust the excess by natural heat convection (see building section). During the winter, the heated air accumulating at the top can be pumped back down to the bottom.
Process is an important consideration for the user of the airport. Supporting functions surround the lobby.

Function Relationship Schematic
Tower
As the time began to run out on the project, the studies and the research were starting to pay off. I went through numerous concepts which all just seemed to touch the tip of the problem. After I had looked these over, I attempted to redefine the problem.

After this had been done, the design began to come together and to do what I had intended it to do: reflect the idea of the airport terminal as a place of transition. This idea is that a person goes through a metamorphosis as he travels from the car to the airplane using the airport terminal as a catalyst.

I also was striving for a unified project with a number of buildings relating but acting as their own separate entities. The functions of the airport were to work to the letter. A person can move through the airport as fast as he/she wants to without being confused or lost. The baggage carriers drive into the south door, send up the luggage, pick up more baggage, and head back out again without driving around passengers.

The project has turned out to be very interesting and simple in the way it works. But the terminal is complex in the ideas behind it and the way it is put together. When filled with furniture, people, and plants, the spaces will become even more alive with noise from everywhere (including the architecture itself). But it is not haphazardly thrown together. There is order and meaning to this madness.

As I look back upon it all, I believe that I successfully solved this problem that was put before me. I have also learned that there was more to it than just solving the problem -- it could be fun, too.