Terminal 2, Pier E Dublin Airport

Fixed Link and Node Buildings

Building Information Modeling (BIM)

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Contents

1.0 INTRODUCTION

1.1.1 From the turn of the new millennium, Dublin Airport Authority (DAA) has sought to gain better control on its investment plans by commissioning specific studies to produce a Terminal and Pier Capacity Plan. This was an extraordinarily thorough assessment of the airport's potential options with regard to the provision of additional capacity. After in-depth analysis and investigation it was decided that Dublin Airport needed an extension to the present terminal, Pier D which needed also to be revamped and modernised the existing terminal. It was also decided to build a new terminal with a new pier (Pier E) and new runway to compensate for the growing capacity of the present terminal.

1.1.2 This report is intended to analyse the various considerations that a prospective ecology of the site and the local population and most importantly any undesirable effects of the development should be minimised.

1.1.3 DAA have great plans to create a more attractive airport for the public, all visitors and Irish residents alike. All work is scheduled for the new Terminal 2 to be open in 2010. The new Pier (E) which is part of the T2 project houses the new US Customs, Border and Protection (CBP) facility allowing transatlantic passengers to clear full US Customs and immigration at Dublin Airport. This new facility is one of two such facilities in Europe and should make a more attractive location for US-bound traffic.

1.1.4 Airports are extremely site specific and require a certain set of criteria in order to function adequately. This document is intended to show the criteria that a prospective developer should seek, and how the conditions of the site can be assessed.

1.1.5 The use of three-dimensional software applications to aid the design process has become a more common method within the modern construction industry. The advantage of such applications over existing drafting tools will be addressed later in this document. As an exercise, a three-dimensional model of a proposed terminal was constructed using Google Sketchup. This model was used to create visual interpretations of how the development of the New Terminal would impact on the natural landscape.

1.1.6 A three-dimensional model of The T2 Project was created using Building Information Modelling (BIM) also showing the new Pier E with the Fixed Links and Node Buildings (gates and tunnels off the Pier to the aircrafts), created using Google Sketchup software application was applied and tested to model the new Pier and co-ordinate the Fixed Links and Node Buildings together on Head of Stand Road. The report concludes as to how these applications can be utilised to aid decision making with regard to the design and layout of the Fixed Links and Node Buildings in relation to Pier E and Head of Stand Road; and finally, an examination of scope for further development.

1.1.7 The Aim of this report is to examine the design to the construction process of the new Terminal 2, Dublin Airport and test a suitable software platform to model Terminal 2 and Pier E with the Fixed Link and Node Buildings for public dissemination and also to co-ordinate contractors' drawings from each package.

1.1.8 The Objectives of the report is to…

a) Examine the background of the T2 project.
b) Carry out an analysis of considerations required when developing a new Terminal.
c) Develop a detailed graphic analysis of a three-dimensional model of the New Terminal and also the Fixed Link and Node Buildings and Pier E.
d) Create a three-dimensional model using the software application - Google Sketchup.
e) Examine how this application can be utilised to aid decision making with regard to the design and layout of the building.

1.1.9 Google Sketchup was the software used to create the 3-D model of T2, Pier E with Fixed Links and Node buildings. Google Sketchup is BIM. It is free to download from the Internet, allowing its users to create Three-Dimensional models in a simple and effective manner. Files created in Auto CAD are compatible with Google Sketchup, floor plans drawn in Auto CAD were imported into a Google Sketchup file at the appropriate scale, and then manipulated to create a three-dimensional model. Once the three-dimensional model has been completed, it can be exported back into Auto CAD if necessary and will appear as a wire frame model.

1.2.1 HISTORY OF DUBLIN AIRPORTS CAPACITY

Late 1930's

Planning and development began on the terminal building and grass runways. The terminal building was designed to cater for just 100,000 passengers a year.

January 19th 1940

At 9.00am Dublin Airport was officially opened and 14 Aer Lingus aircrafts departed Dublin (Collinstown) for Liverpool.

1940's

Europe was at war but Aer Lingus continued to operate flights to Liverpool twice a week.

1947

Flights departing from Dublin now ventured as far as Europe.

1948

The new concrete runways were completed.

1950

The airport had been used by 920,000 passengers.

1970's

The terminal building had far exceeded its capacity which was approximately six million passengers annually.

2009

Over 230 million passengers have travelled through Dublin Airport since the first flight took off in 1940. The airport has expanded and developed and now Dublin Airport is involved in a €2 billion capital development programme.

2010

The new terminal 2 is expected to be completed along with additional new piers and major improvements to the existing terminal.

2.0 BACKGROUND TO THE T2 PROJECT

2.1.1 The DAA set up a €2 billion 'Transforming Dublin Airport Programme' which is set to be completed in 2010. This includes the new gate facility, Pier D, an extension to the existing terminal, the construction of the new terminal T2 and also a new runway.

2.1.2 The DAA also drew up the 'Capacity Enhancement Report' in 2005 to ensure that the new airport plan would specifically consider the optimal location of the future passenger and baggage processing capacity.

2.1.3 The project has been granted five-year permission for the new terminal. This permission also includes a new pier (E), comprising of a 24,000sqm boarding gate facility with parking spaces for up to 19 long haul and short haul aircrafts. The new runway will be built 1.7km to the north of the existing main runway costing €150 million (at current prices). This will expand the potential airfield capacity to about 50 million passengers per year in the next four years. In December 2004 the planning application was lodged for the new runway and was granted in October 2005.

2.1.4 Nearly two years after the announcement of the Government's Aviation Action Plan in May 2005, planning permission for T2 was sought in August 2006 and granted in February 2007.

2.1.5 The new terminal and pier will facilitate the provision of considerable amount of additional long haul routes. These flights will link Dublin with North America, the Middle East and Asia. The New Terminal development will incorporate a new US Customers Border and Protection (CBP) facility. This will allow transatlantic passengers to clear full US customs and immigration at Dublin Airport.

Figure 1: Dublin Airport (Terminal 1)

3.0 ANALYSIS OF CONSIDERATIONS REQUIRED WHEN DEVELOPING A NEW TERMINAL

3.1.1 The DAA set up a €2 billion 'Transforming Dublin Airport Programme' which is set to be completed in 2010. This includes the new gate facility, Pier D, an extension to the existing terminal, the construction of the new terminal T2 and also a new runway.

3.1.2 The DAA also drew up the 'Capacity Enhancement Report' in 2005 to ensure that the new airport plan would specifically consider the optimal location of the future passenger and baggage processing capacity.

3.1.3 When developing a new Airport terminal, one must consider all the stakeholders involved. It must be intended that all the stakeholders identified are considered under the decision making process. It is also important to monitor the procedure performance and manage all works with regards to all considerations.

Figure 2: Historical Corbollis House being taken down.

3.1.4 The context of passenger flow and potential conflicts must be considered. This is due to the capacity constraints in road transportation. An Bord Pleanála set a condition that the combined capacity of Terminal 2 and Terminal 1 "*shall not exceed 32 million passengers per annum"* because of the capacity constraints in road transportation.

3.1.5 A new road network to manage the traffic generated by the airport's development must be determined. In the Dublin Airport development the go-ahead was granted for the demolition of the 18th Century Protected Structure Corballis House, in order to manage the traffic created by the development work. To improve the roads the DAA also paid levies to Fingal County Council. Including €21 million for the new runway and €12.5 million for the second terminal. This is only a fraction of the cost of road improvement; the remaining amount was generated from public funds.

3.1.6 Another consideration to be made in relation to local residents was the noise pollution from aircrafts. DAA had to submit a scheme for the voluntary noise insulation of local schools and houses that lie within the airports contour zone. This scheme had to be submitted to, and agreed in writing by Fingal County Council.

3.1.7 An Bord Pleanála set another condition that the average number of night-time aircraft movements should not exceed 65 flights "*so as to protect residential amenity"* of people living under the airports flight paths.

4.0 HEALTH AND SAFETY OF CONTRACTORS

4.1.1 DAA are extremely strict with regard to the employees and contractors who work within the Dublin Airport facility. All employees of all contractors working on site have to go through a very strict background security search including the last 10 years previous employment history, addresses and security history in order to get airport clearance. This enables an employee to have a Dublin Airport ***Work Permit*** and ***Site Access Pass*** (access pass depends on what area of work the employee will be involved on site) these are issued by the DAA at the access and Identification Centre. This process can take up to 3 months if employees have worked or lived abroad. For some contractors this causes significant delays to their programme because their employees cannot access any of the sites until this procedure is complete.

4.1.2 Although there are advantages to having these passes such as airport employees have their own security area to scan bags through when checking in for flights when going abroad with less queuing and discounts in airport shopping, cheaper bus services and cheap Airport hotel deals if the pass is displayed.

4.1.3 Also in order to work on site each employee must attend numerous compulsory health and safety seminars/inductions and training courses. The courses employees attend is decided depending on the area of the Airport the Contractor is required to work. In order to walk anywhere round site, each employee must have their work permit and work access pass on display at all times. The regular Safe Pass is not sufficient to work on site although each employee must have one to be on site, accompanied with the airport Access Passes. Also with health and safety requires everyone on site must wear a high visibility jacket and trousers, hard hat with induction stickers on display, safety boots, goggles and gloves.

4.2.1 PUTTING TOGETHER THE SUCESSFUL AND PROFESSIONAL 'T2 TEAM'

4.2.2. DAA we very selective in their appointment of lead design Contractors and Managers of the new Terminal. They undertook detailed research before selecting their new 'T2 Team'.

4.2.2 The first managing team member to be chosen were Pascal + Watson architects, who have over 150 years of experience in Rail transport and Air Transport. Over the years Pascal + Watson have built up a substantial portfolio of experience in these areas. In the UK, they have worked on the development of most major airports including Heathrow, Gatwick, Stansted, Manchester, Birmingham, Leeds and Bradford. Internationally they have developed designs for airport expansion at Naples, Pisa, Florence, Montenegro, Abu Dhabi Pafos and Larnaka Airports.

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(b) The second managing team member to be chosen were ARUP Consulting Engineers. ARUP manage and specialise in major infrastructure projects world wide and some of their most famous projects would include The Sydney Opera House, Australia, Pompidou in Paris and the Worlds first Eco-City in Dongtan, near Shanghai in China. They were chosen mainly because of their experience in Airport and rail link Infrastructure.

(c) The Third managing team member selected were MACE management consultants who have worked on such projects as The Venetian Macau, BA London Eye, British Museum Great Court, London's City Hall and Marina Bay Sands casino resort in Macau.

4.2.3 The T2 Team brought the New Terminal from Planning Stage to Tender Stage and then onto Construction Stage. At this point new contractors were added to the team for construction work, these included Laing O'Ruairc, SIAC, Buro Halpold, Mercury, Apollo, Alan Dale and Mc Namara's.

4.2.4 The construction work at Dublin Airport was very different to other large projects in Ireland. It was split into separate packages due to the sheer size of the development.

- Pier D (New Passenger Gates to Aircraft)
- Terminal 2.
- Pier E (New Passenger Gates to Aircraft)
- Fixed Links + Node Buildings (Stair cores & connection tunnels from gates to Aircraft)
- Apron Works (Aircraft Parking).
- New Runway

4.2.5 Each Package was planned out separately and went from Planning and Tender, to Construction as a separate job however each package had to also co-ordinate with the others. This made all contractors work more difficult as it placed extra burden on their communication skills with the requirement of many regular co-ordination meetings to take place to ensure the project would run smoothly and to schedule.

4.3.1 CO-ORDINATION OF PACKAGES AND CONSTRUCTION DRAWINGS

Fixed Linked and Node Buildings with Apron Works

4.3.2 Before Work could be co-ordinated between Pier E and the Fixed Links and Node Buildings Packages, they both had to be co-ordinated with the Apron Works Package. The original Survey of the Apron Works which all the drawings were based, did not correspond to the constructed area and so new levels and set out points had to be submitted to the contractors and the DAA so as to make all the drawings and site levels correspond with each other.

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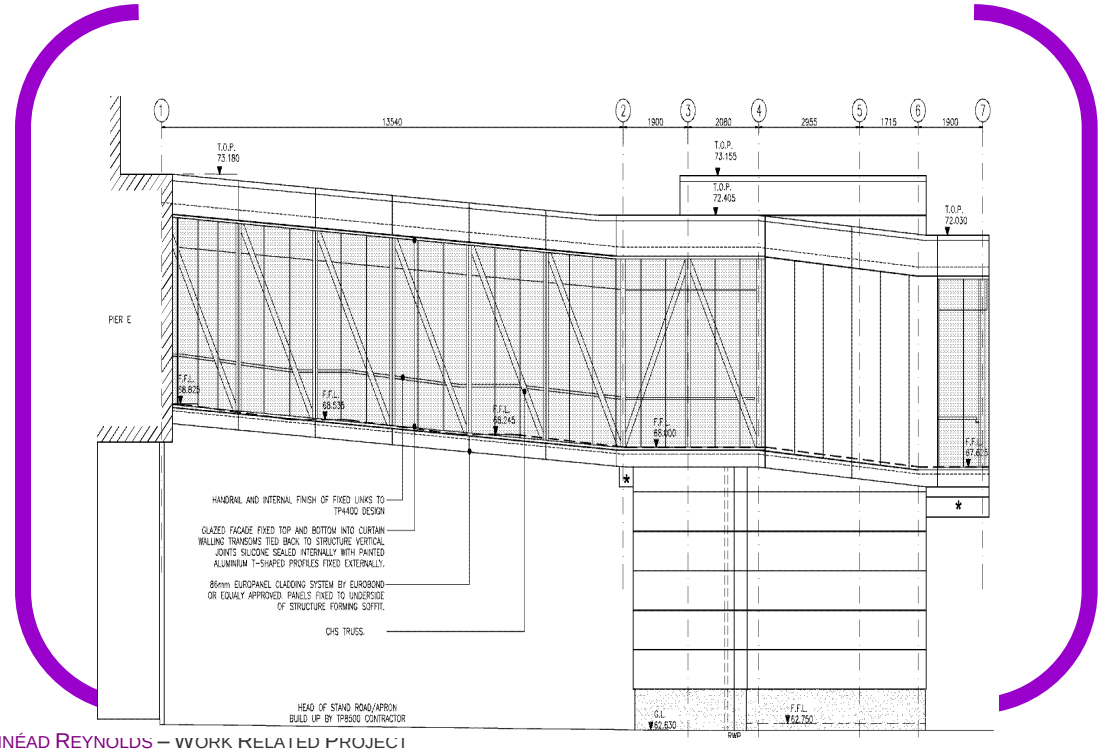
4.3.4 The Apron level was almost flat but was built at a very slight incline which affected the Pier E because it is an exceptionally long building being 4500m in length. This caused the level of the far end of the Pier to have a much higher drop than the top end which is the link to Terminal 2. In order to solve this issue a step in the foundations was created in the centre of Pier E. For the drawings to comply with current building regulations, in relation to the full capacity of people to be in the Pier at any given time. This step had to be made into a sloping floor for passengers to walk smoothly along with-out becoming a tripping hazard.

Figure 4: Pier E Construction Photos (November '08 to February '09)

4.3.5 This had a knock-on effect with the 11 new Fixed Links (Bridges to Node Building Stairs). The bridges had to be ramped to match the new Pier Levels at each gate. At the same time a minimum head height of 4.5m had to be achieved between Apron Level and the bottom of the bridges in order for airport vehicles to pass underneath. This required some bridges to ramp up to achieve the head height and then back down to match the level of the corresponding gate at Pier E. Another problem which arose was, the Node Buildings (Stair Cores) at each Fixed Link didn't comply to the current Fire Regulations and at the new levels, and 8 of these cores now required a second stair core which would enter the Apron level at a different level to the first due to the slight incline. After many co-ordination meetings between Contractors it was finally agreed that in order to save money on the project and due to the extra expense of the addition of 8 new stair cores, to change the cladding of the Node buildings from *Rain Screen* cladding (Used on the Main Terminal) to *Euro Clad*. This agreement was to even out the cost. The *Euro Clad* still had the same thermal efficiency and performance as the *Rain Screen* and also took up 50% of the space required for the *Rain Screen*. These problems were resolved between the co-ordination of Contractors drawings and the new design for the Pier E and the Fixed Links and Node Buildings. This necessitated a Planning re-submission to An Bord Pleanála after Tender stage in order for the scheme to be approved and to continue to construction stage. This approval was granted in December 2007 and construction then started early in 2008.

. *Figure 5: Typical Fixed Link and Node Building Elevation Construction Drawing*



4.3.6 The process between Tender Stage and Construction Stage was very swift and within a four week time scale all the appointed Contractors on the T2 team had to submit all their construction drawings in 3D format, as this was that every item which needed co-ordination could be completed swiftly and with ease. E.g.: Cladding and glazing could correspond to each other at exact site co-ordinates both vertically and horizontally. Also it is much easier to spot discrepancies between drawings if they are in 3D. In addition to this, the steel drawings were in 3D and this is easier to fix cladding at exact points along the steel frame and this made the drawings very clear for all the contractors involved.

4.4.1 THE GENERAL PUBLIC AND THE ENVIRONMENT

4.4.2 *The General Public and the Environment*

When developing a new Airport terminal one must consider the ordinary people as they are the ones mostly affected by the construction work. Dublin airport serves the community 24 hours a day, 7 days a week. Business must carry on as usual with out disruptions from contractors and construction work. This made the construction process very different to other projects developed in Ireland. Every phase of the construction process must be well planned out to make sure that every area of construction is securely sectioned off from public access but also well signposted so no one accidentally wonders in. It is very important that no one accept trained contractors enter the site at any given time. The NDP (National Development Plan) maps have set out 'Public Safety Zones' with regard to the safety of aircraft navigation. The purpose of Public Safety Zones is to protect the public on the ground from the possibility that an aircraft might crash in a populated area.

4.4.3 *Public Transport*

When extending Dublin Airport the public transport must be considered due to increases in the number of people travelling. The Metro North line is planned to run from St Stephen's Green via Dublin Airport to the north of Swords. The journey time from Stephens Green to Dublin Airport will be approximately 20 minutes. This is a important step in the creation of an incorporated public transport system for Dublin.

Figure 6: Proposed Metro Line to Dublin Airport

4.4.4 *Airport Road Upgrade*

As part of the T2 project, road works are now underway at the East Link Road at the main entrance road to Dublin Airport from the airport roundabout. This aims to improve road access at the airport and re-configure the roads to allow for the construction of new departures and arrivals roads for the new Terminal and is due to be completed by March 2010.

4.4.5 *Air Quality Environmental Issues at Dublin Airport*

Emissions from aircraft operations, airside vehicle traffic, Airport heating plant and landside vehicle traffic pollute the air at Airports. As part of the required devices under the planning permission of T2 and the air monitoring program at Dublin Airport, DAA have invested in a new Air Quality Monitoring Station in the Airfield halfway between the parallel runways. This measures the concentrations of different compounds in the air. The concentrations can then be compared with the limits set by the EU Directives.

Figure 7: Air Quality Monitoring Station, Dublin Airport

4.4.6 *Noise Management*

Noise can have a considerable effect on the environment and the quality of life enjoyed by individuals and the community. The airport has a need to minimize the undesirable impact of noise but this must be done so without placing unreasonable restrictions on the Airport Development. The Irish Aviation Authority has assisted in alleviating the impact of aircraft noise by the introduction of 'Departures Procedures' at Dublin Airport. This is to track aircraft away from major residential areas, and airlines have to follow designated flight paths to avoid causing noise over densely populated areas. Dublin airport does not currently impose noise charges which are applied at European Airports. As part of the commitment to minimizing noise impact at Dublin Airport, DAA have installed a noise and flight track monitoring system. This is to relate the intrusiveness of noise to individual aircraft landing and taking off.

5.0 THREE DIMENSIONAL MODELING

5.1.1 *Introduction*

5.1.2 The basic logic behind the proposal of creating a three-dimensional model is an image of the anticipated New Terminal would be more effective in assigning an image to those interested in how the development would impose on the natural landscape and its surrounding area.

5.1.3 Some times images can be more powerful than words, and consequently can then be used as a tool for developers/designers. If the observer can get a feel for the project, their opinion of the project will be more knowledgeable. It has become quite widespread that any substantial development is conveyed to the public at large through images, which are created using computer image altering software packages such as Adobe Photoshop, and BIM software applications such as ArchiCAD, and, as used for this model, Google Sketchup.

5.1.4 The use of BIM software applications during the design practice has become quite common in architectural and engineering practices throughout Ireland. The process of bringing a project from the outset idea to completion had changed very little over the centuries proceeding in the introduction of CAD applications. This is where an architect or an engineer provides working drawings and written specifications as instructions for the construction stage of a development.

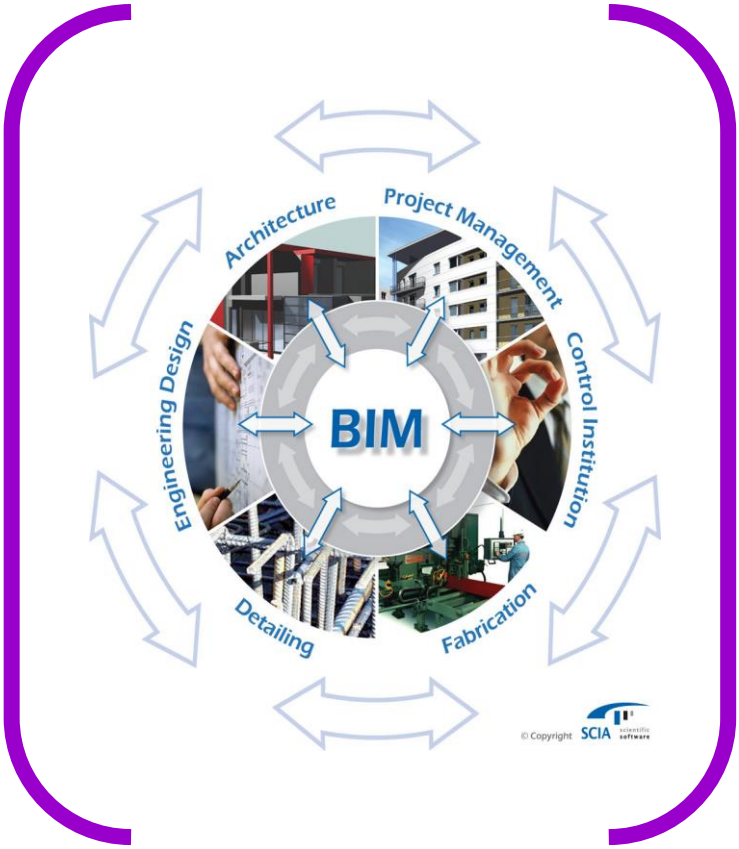


Figure 8: BIM Diagram Illustrating each area of construction which benefit its use

5.2.1 THE DEVELOPMENT OF CAD APPLICATIONS

5.2.2 The introduction of CAD applications has revolutionised the drafting process of Architectural and Engineering process, as drawings can be produced at a far greater rate, to a superior standard of accuracy and quality.

5.2.3 The basic fundamental elements of CAD applications have acted as a baseline for the development of the more advanced BIM software applications such as ArchiCAD, and Google Sketchup. Whereas the earlier versions of CAD applications such as AutoCAD rely solely on the digitalising of the basic elements of drafting such as the line and the arc, which are then used to represent objects in a building, the more advanced applications use these basic elements to create three-dimensional objects which can then be used to create the desired building. The objects that are created and used within the BIM software applications allow the designer to produce a full set of working drawings (Plans, Elevations & Sections) from just one drawing.

5.2.4 When using basic Auto CAD applications, the designer produces separate drawings to represent floor plans, sections, elevations and detailed drawings. Any presentation drawings such as perspective, isometric or axonometric views will require the designer to create another separate drawing of the building to illustrate this. There is the option within basic CAD applications to create three-dimensional models; however, this is quite a laborious procedure that can take a considerate amount of time.

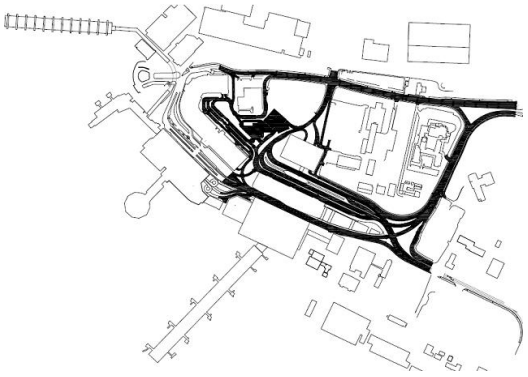


Figure 9: CAD Drawing Plan of T1 & T2

5.3.1 BUILDING INFORMATION MODELING (BIM)

5.3.2 BIM is a ground-breaking development now used in the building industry in Ireland, and it will effect delivery of models, contractual relationships, and the very way in which firms are hired and engaged in projects. (Sive, T., 2007).

5.3.2 BIM software applications such as ArchiCAD allow the designer to create a model of a proposed building, while being able to extract from this model all of the drawings required; floor plans, elevations, sections, detailed drawings and presentation drawings. As all the information is put into a central database, the programme then creates a bill of materials as the model is being constructed. This also means that any changes that are made to the building in a particular view, they are automatically updated in all other views.

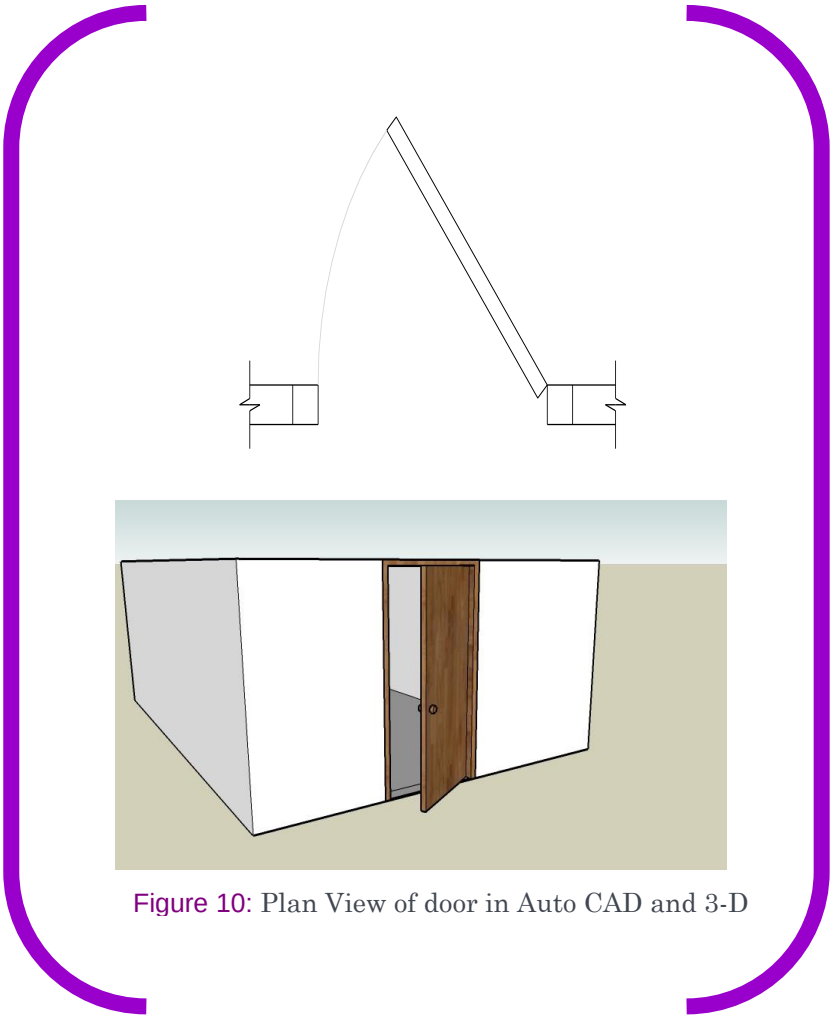


Figure 10: Plan View of door in Auto CAD and 3-D

5.3.3 **Figure 10** illustrates the benefit of using BIM. The basic CAD programmes prior to BIM relied on objects such as lines and arcs to create an illustration of well-understood drawings that were highly symbolic. For example, a door in a basic CAD application is conveyed in plan as a rectangle, representing the door, coming off a wall at an angle and an arc representing the door swing joining it back to the wall. When using the same objects within the BIM software applications, they are shown as true representations of themselves. For example, a wall drawn in BIM represents a wall in the physical world, and a door represents an actual door, and can include comprehensive information such as the material to be used, the colour, method of fixing, fire rating, cost, manufacturer, etc. (Sive, T. 2007).

5.3.4 These objects within BIM are intelligent, can understand and interact with the surrounding environment. For example, if an object such as a window or a door is inserted into a cavity wall in plan view, the programme will automatically edit the wall around the object, inserting cavity closers, DPC and a lintel. The designer can then use the other views to establish whether the location and dimensioning of the object are acceptable. If the object is moved or resized, the programme will perform the changes in all views automatically.

5.3.5 Since the objects within BIM are intelligent by character, they also contain information on thermal conductivity. It is therefore possible to use as an item to analyse the Building Energy Rating (BER) of the proposed design. This is a topic growing in importance in the industry today due to the need for BER Certificates to be obtained for any new builds now constructed in Ireland.

5.3.6 Clients may find it difficult to understand working drawings, so they may decide that they want to see graphical representations of how the design will look when the development is completed. BIM offers the user an option of creating very detailed graphical representations of the proposed structure, which can appeal to different learning types and help to build an understanding of the project as a whole.

5.4.1 GOOGLE SKETCHUP

5.4.2 The BIM software which was selected to create the three-dimensional model of the New Terminal 2 at Dublin Airport was Google Sketchup. Google Sketchup is a simple form of BIM, it is a vector based software application which was introduced to the World Wide Web in 2000. It is free for anyone to download from the internet, allowing its users to create three-dimensional models in a simple and effective manner anywhere in the world.

5.4.3 Files created in AutoCAD are compatible with Google Sketchup, whereby floor plans drawn in AutoCAD can be imported into a Google Sketchup file at the appropriate scale, and can then be manipulated to create it into a three-dimensional model. Once the three-dimensional model has been completed, if desired it can then be exported back into AutoCAD and will appear as a wire frame model. Since these software applications work in tandem with one another, it is quite common that Google Sketchup be used in design offices as a basic form of BIM to aid design processes and produce presentation drawings for the client and the public alike.

5.4.4 Recently in Ireland, there was a significant development in the use of Google Sketchup, showing how the Christ Church Cathedral in Dublin was captured in the form of a three-dimensional model by digital computer modelling company 'Inshore Surveys'. The model is currently in use by Google Earth so that prospective visitors may take a virtual tour of Dublin City Centre from the comfort of their own home.

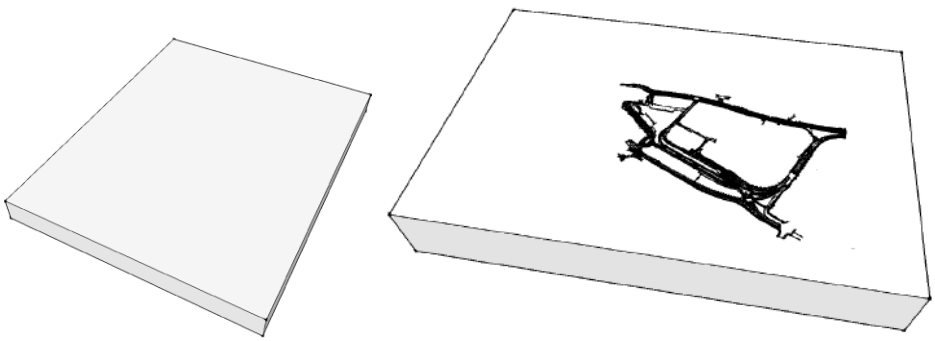
5.4.5 Figure 11 below illustrates how the image of Christ Church Cathedral has been captured through the use of Google Earth and Google Sketchup combined.

Figure 11: Image of Christ Church Cathedral, as it appears in Google Earth

5.5.1 CONSTRUCTION OF THE 3-D MODEL

5.5.2 The process of constructing the three-dimensional model of the New Terminal is underlined in this section. A function within Google Sketchup allows the user to create a landscape that will maintain a desired view; this landscape is referred to as a "*scene*", upon the push of a button. This option also allows the user to create images of that scene in the form of "*jpegs*". This function was utilised to create images of the construction of the three-dimensional model of Terminal 2 so that a step by step process could be produced for this project.

Figure 12: 2-D layout of the Road on the landscape

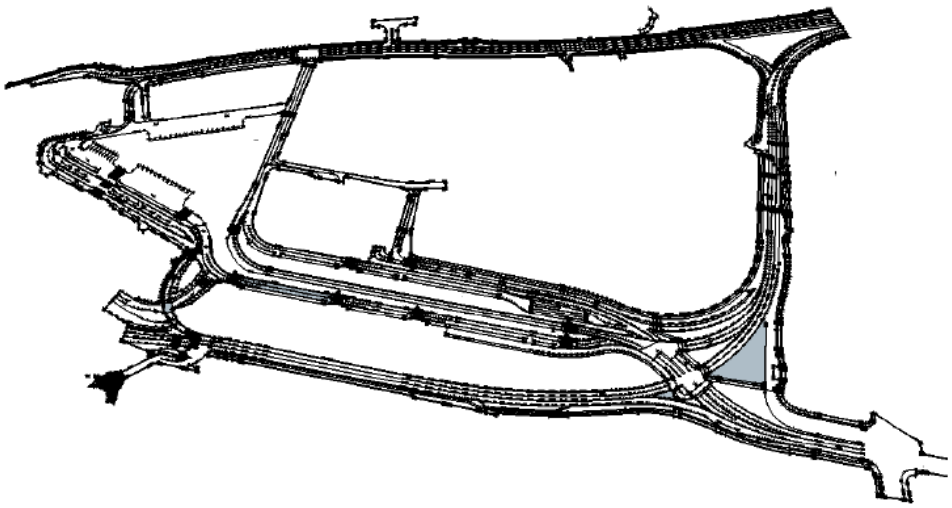


5.5.3 Firstly a landscape area was drawn in Google Sketchup, the size of the T1 and T2, and the road layout was then imported in from the Auto CAD drawings. The road layout is the first item to be imported into Google Sketchup. Each area of the road must be made a solid entity to as to extrude the contours.

5.6.1 EXTRUDING THE ROAD CONTOURS TO FORM A 3-DIMENSIONAL BASE

5.5.2 Initially, the base of the model was drawn out in Google Sketchup and extruded to form a rigid base for the model. The contours of the road on the site were

Figure 13: *2-D layout of the Road*



then laid out on the surface as is shown in **Figure 13.**

5.5.3 It was decided to have the new road network running through the model in order to introduce a sense of scale, and to convey how the development would interact with the urban landscape. This also shows how the new road will pass through the new Terminal 2 to get to the current Terminal 1. This means that Terminal 2 will be seen by everyone traveling to Dublin Airport. This was a simple process as the Engineers drawings of the roads were drawn using the basic two-dimensional commands in Auto CAD such as the drawing of an arc or a line. The Road Network could by inserted directly into the model from the Auto CAD file.

5.7.1 LAYOUT OF THE ROADS ON THE BASE

5.7.2 Once the road had been laid out on the base, they each became separate entities within the model. These separate entities could then be extruded through the vertical axis to any particular displacement by use of the "*push/pull*" 

5.7.3 Once It was decided that the road would by extruded to one even displacement, and that each of the contours would be extruded in intervals of 200mm, in order to achieve a somewhat realistic level of grading. The process of extruding the roads of the model is shown below in **Figure 14**.

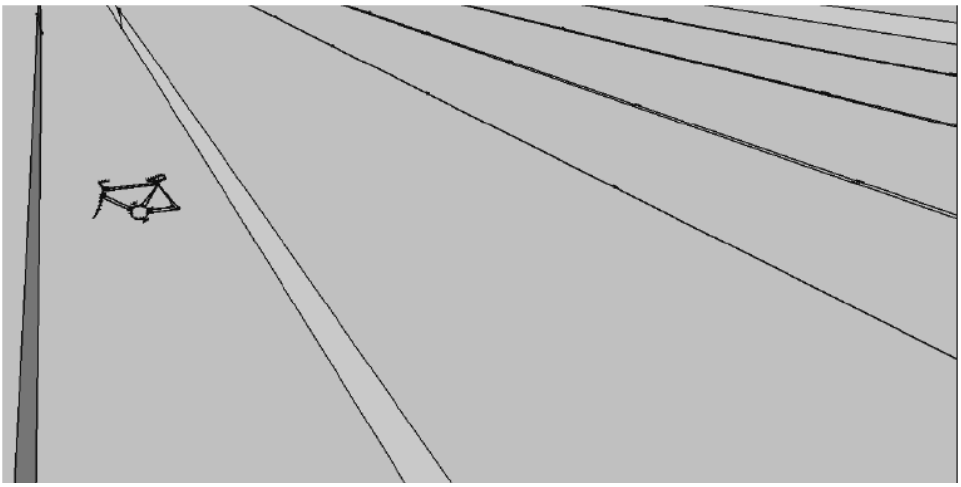


Figure 14: *Extrusion of the road contours to form the site*

5.8.1 APPLYING TEXTURES TO THE MODEL

5.8.2 Once the roads of the model had been sufficiently extruded, the area of the model could then be shaded in order to provide a more realistic interpretation of the landscape. This is represented in ***Figure 15***. Google Sketchup provides various textures that represent vegetation as well as man-made surface textures such as tarmac. A texture can be applied to a surface simply, by use of the "*bucket*" function.

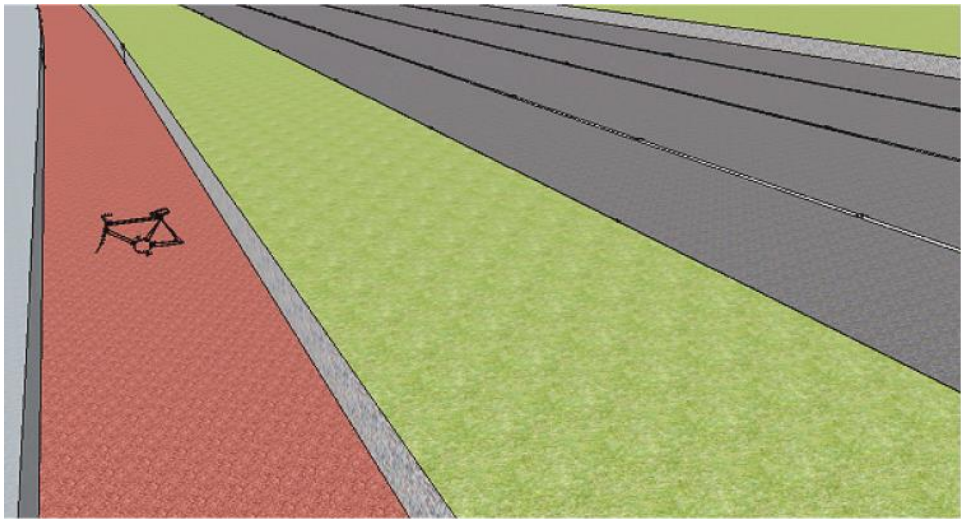
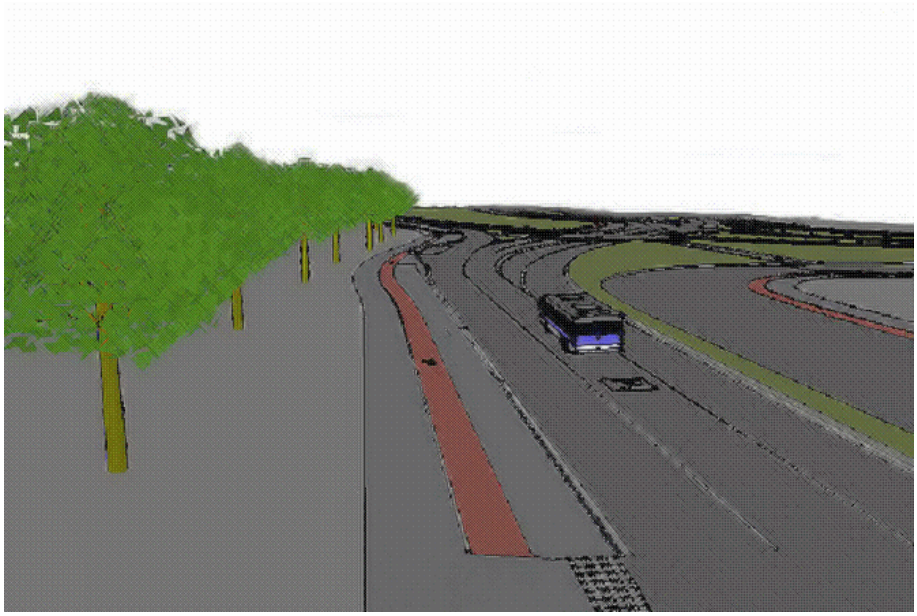


Figure 15: *Texturing of the road layout to provide a realistic appearance*

5.9.1 ADDING DETAIL TO THE MODEL

5.8.2 The next stage of the process was to insert details into the model, in order to make it more realistic. This was achieved through the inclusion of a number of buildings around the airport grounds of the model, as well as some vegetation. The buildings were created using the same techniques as used for the base model. The vegetation that was used in the model includes the various trees that are available in the Google Sketchup "*landscape components*" library. The insertion of the details is illustrated in ***Figure 16*** below.

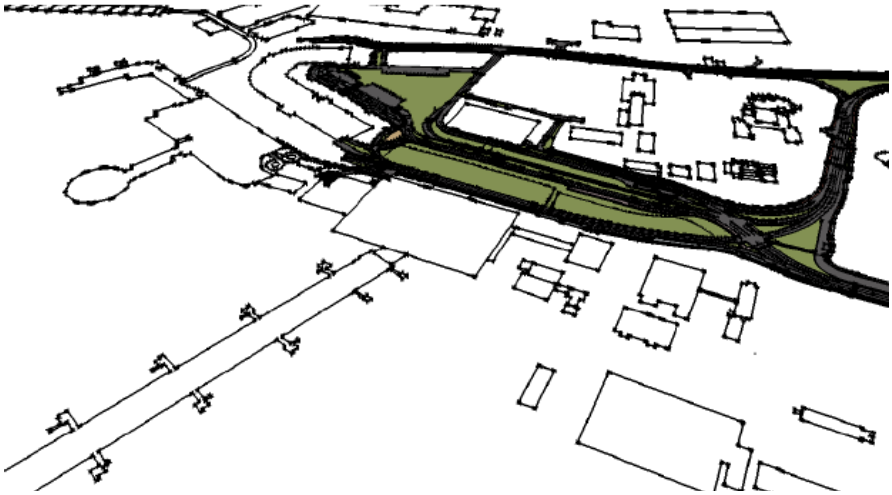
Figure 16: *Adding the details*

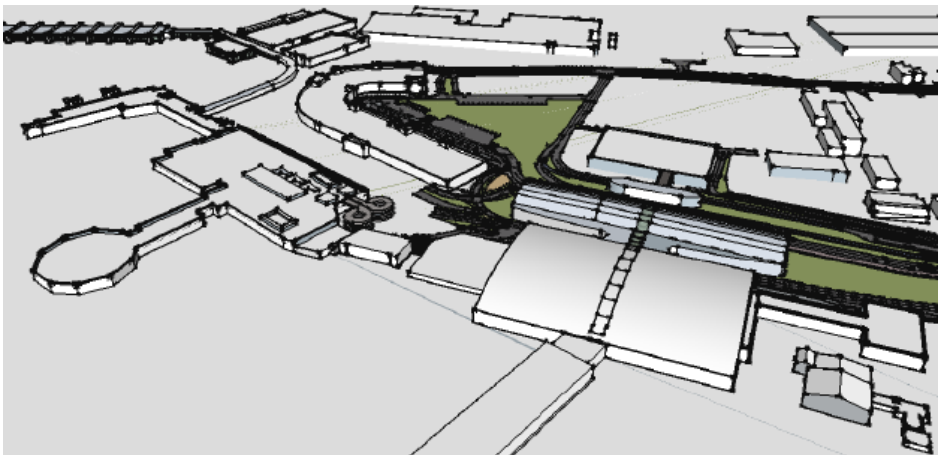


5.10.1 INSERTING BUILDINGS INTO THE MODEL

5.10.2 The work carried out on the model to this point indicates how the site would appear prior to the construction of the Airport. Using this model as a reference, three-dimensional representations of the new Terminal 2 and Pier E were inserted. The images of the model displayed in this section are but a few of many that illustrate how the model was constructed. A CD has been submitted along with this report containing a full set of step by step construction images, along with a copy of the finished three-dimensional model. This model was then used to create the presentation drawings.

Figure 17: *Adding the Buildings to the Model*

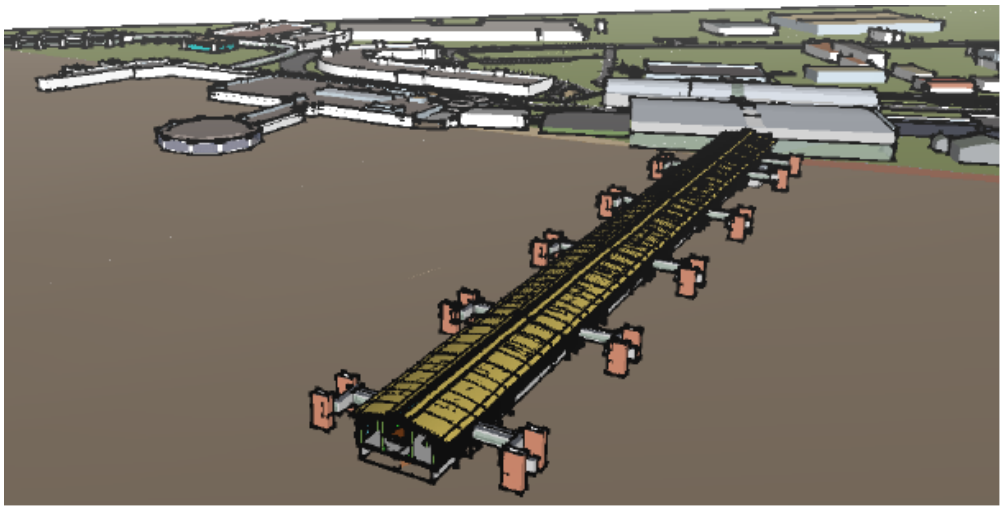




6.0 UTILISING THE THREE-DIMENSIONAL MODEL FOR PRESENTATION IMAGES

6.1.1 Both of the three-dimensional models, pre-construction and post construction were then used to create views that could be shown to the local community, the local authority and the client as a representation of how the development of the new airport would interact with the natural landscape. This would offer a more detailed understanding of the project. In order to make these representations as realistic as possible, an image of the surrounding landscape was inserted into the model to act as the background setting for the development. This gives a graphical representation of the visual impact of development on the natural landscape.

Figure 18: *View of the sight prior to background insertion*



6.1.2 ***Figures 18 & 19*** above indicate how the proposed development would appear looking from Pier E towards the New Terminal 2 and also showing the current Terminal 1. This image, along with other similar "*before and after*" images would be used to illustrate to the local authority and the local community how the development would impact on the natural landscape and what buildings are presently built and located on the site. Any feedback given on the images, either positive or negative, would be of benefit to the designer, as the layout, location, size, and colour of the finishes could then be adjusted to produce a more acceptable and ecstatically pleasing design.

6.1.2 If a prospective developer utilises the benefits of three-dimensional modelling as outlined in this section, and addresses the considerations provided in this report with regard to the location and analysis of the site, there would be a greater balance between what the developer would like to build, what would be acceptable to the public and all of those affected by the development.

6.1.3 If a prospective Overall, the development of Terminal 2 will benefit the country through rural investment and expanded employment in the future.

Figure 19: *View of the sight with background insertion*

7.0 LIMITATIONS OF RESEARCH AND CONCLUSION

7.1.1 *Limitations of Research*

7.1.2 The Airport discussed in this report is developing and growing in importance constantly, and as a result, this is a report based on the current situation of the development. There is scope for further research at Dublin Airport, including further insight into more developments which are likely to become increasingly important in the coming years such as the DAA's plans for the new Airport City (Commercial & Shopping District) which is planned to be completed by 2030.

7.2.1 *Conclusion*

7.2.2 This document has analysed the various considerations that a prospective developer must take into account when proposing the development of a new Airport Terminal. As has been explained in this document, it is much easier to successfully develop an Airport if all of the effected parties are involved and considered during the entire process. Consideration must be given to the effect that the development would have in the natural landscape of the site, the ecology of the site, and the local population. Undesirable effects of the development must be minimised. This is not applicable to Airport developments alone, but is true of all other major developments in Ireland and/or worldwide.

7.2.3 DAA have great plans to create a better airport for the public some of which is presently under construction. These plans not only prove promising for Irish residents but will also attract and benefit all visitors to and from Ireland. If all work goes as scheduled, the new terminal will open up new opportunities in 2010. The new Pier (E) which is part of the T2 project will have the new US Customs, Border and Protection (CBP) facility allowing transatlantic passengers to clear full US Customs and immigration at Dublin Airport. This new facility is one of only two such facilities in all of Europe (the other facility is in Shannon Airport). This will make a more attractive location for US-bound traffic to and from the City.

7.2.4 The new development had to take all stakeholders into consideration in order for the project to run smoothly with little disturbances to residents and traffic. The passenger flow, capacity in road transportation, the new road network to manage the traffic generated with the construction process and also the noise pollution to local schools and residents all need to be analysed and put into action to make the massive project go ahead without interfering with the general public and normal day to day airport work and also scheduled flights to run as normal with no disruptions.

7.2.5 Airports are extremely site specific, and require a certain set of criteria in order to function adequately. This document has addressed the criteria that a prospective developer should seek, and how the conditions of the site can be assessed.

7.2.6 This report shows the use of three-dimensional software applications which aid the design process. This has become more common throughout the modern construction industry. The advantages of such applications over existing drafting tools have been addressed in this document. As an exercise, a three-dimensional model of a proposed Terminal was constructed using Google Sketchup. This model was used to create visual interpretations of how the development of the whole project would impact on the natural landscape.

7.2.7 The report was used to examine the from Design Stage to the construction process of the new Terminal 2 and test a suitable software platform to model the development for public dissemination and also to co-ordinate contractors drawings from each package.

7.2.8 Google Sketchup was used to create the three-dimensional model. Files were created in Auto CAD and imported into Google Sketchup. The floor plans were drawn in Auto CAD first, and then imported into a Google Sketchup to create the three-dimensional model. Once the model was completed, it can now be exported back into Auto CAD at a later date and will appear as a wire frame model in 3D.

7.2.9 A three-dimensional model of The T2 Project created using BIM showing The Terminal, Pier E with the Fixed Links and Node Buildings (gates and tunnels off the Pier to the Planes) and surrounding buildings, created using Google Sketchup software application was applied and tested to model the new Pier and co-ordinate the Fixed Links and Node Buildings together on Head of Stand Road. The report concludes on how these applications can be utilised to aid decision making with regard to the design and layout of the Fixed Links and Node Buildings in relation to Pier E and Head of Stand Road; and finally, an examination of scope for further development.

7.2.10.1 Overall, this document can be utilised to assist the development of Terminal 2 in a manner that is productive, efficient, and above all, sympathetic to the beauty of the natural landscape.

8.0 REFERENCES

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8.1.3 http://www.dublinairport.com/about-us/media-centre/press-releases/092007.html (accessed 08/11/08)

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8.1.8 http://www.fingalcoco.ie/Planning/LocalAreaPlans/AirportLocalAreaPlan/SEAReportl.pdf (accessed 08/11/08)

8.1.9 http://www.dublinairport.com/about-us/community-affairs/YA07.pdf (accessed 08/11/08)

8.1.10 Richard Fellows and Anita Liu,(1997) *Research Methods for Construction* 2nd Edition

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8.1.13 http://www.arup.com/arup/historyandculture.cfm (accessed 31-01-09)

8.1.14 http://www.macegroup.com/projects (accessed 31-01-09)

8.1.15 http://www.ndp.ie/viewdoc.asp?fn=%2Fdocuments%2FNDP20072013%2Foverview.htm (accessed 31-01-2009)

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8.1.25 *Building Information Model,* USA: Illinois University of Technology

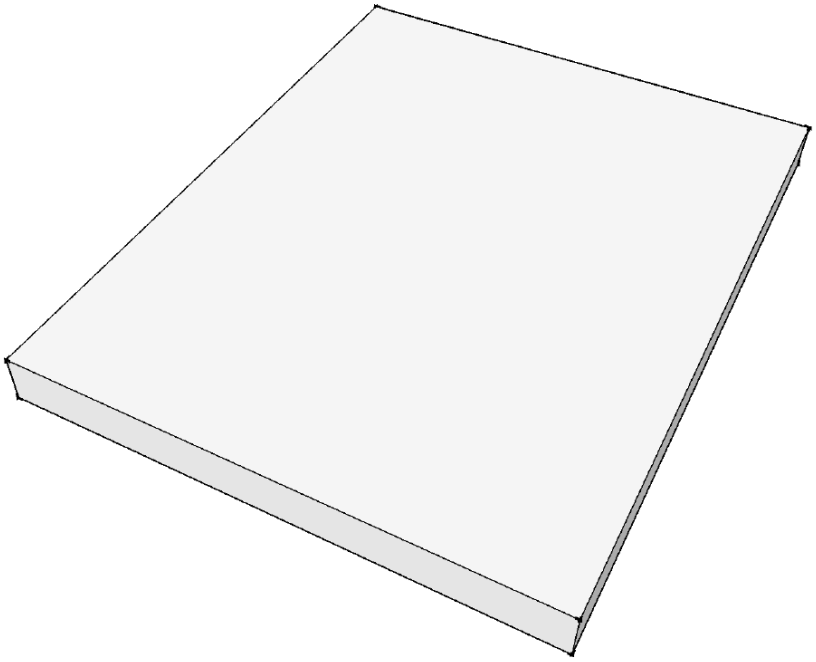
8.1.26 SIVE, T.(2007) *BIM (Building Information Modelling): A marketing Primer and call to Action,* USA: Society for Marketing Professional Services Foundation.

9.0 APPENDICES

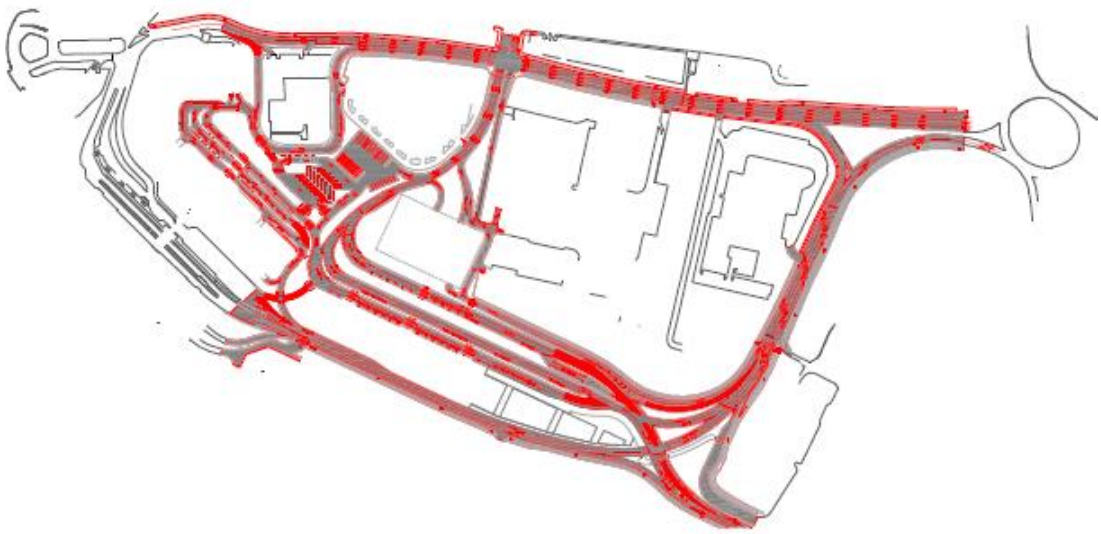
9.1.1 *List of Figures*

9.2.1 STEP BY STEP PROCESS OF MAKING THE MODEL

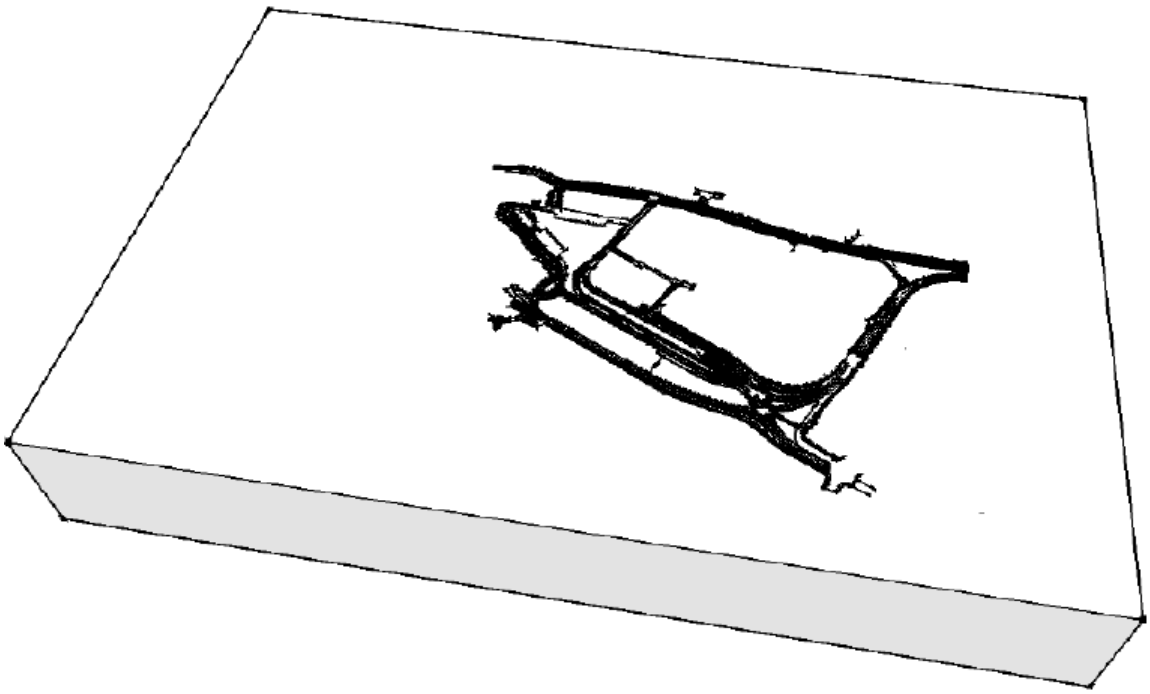
9.2.2 *Step 1: Setting out the Base of the Model*



9.2.3 *Step 2: Import the Auto CAD Layout onto the Model*

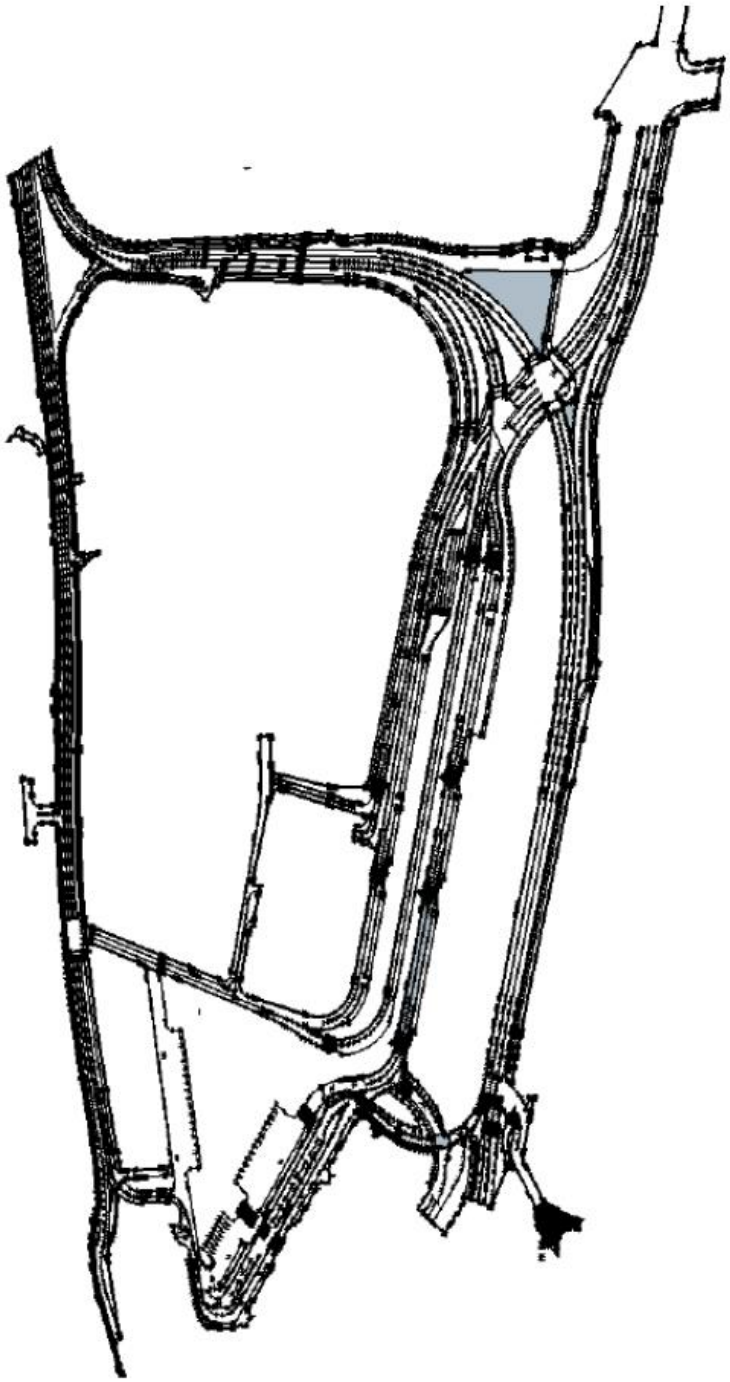


Auto CAD Drawing



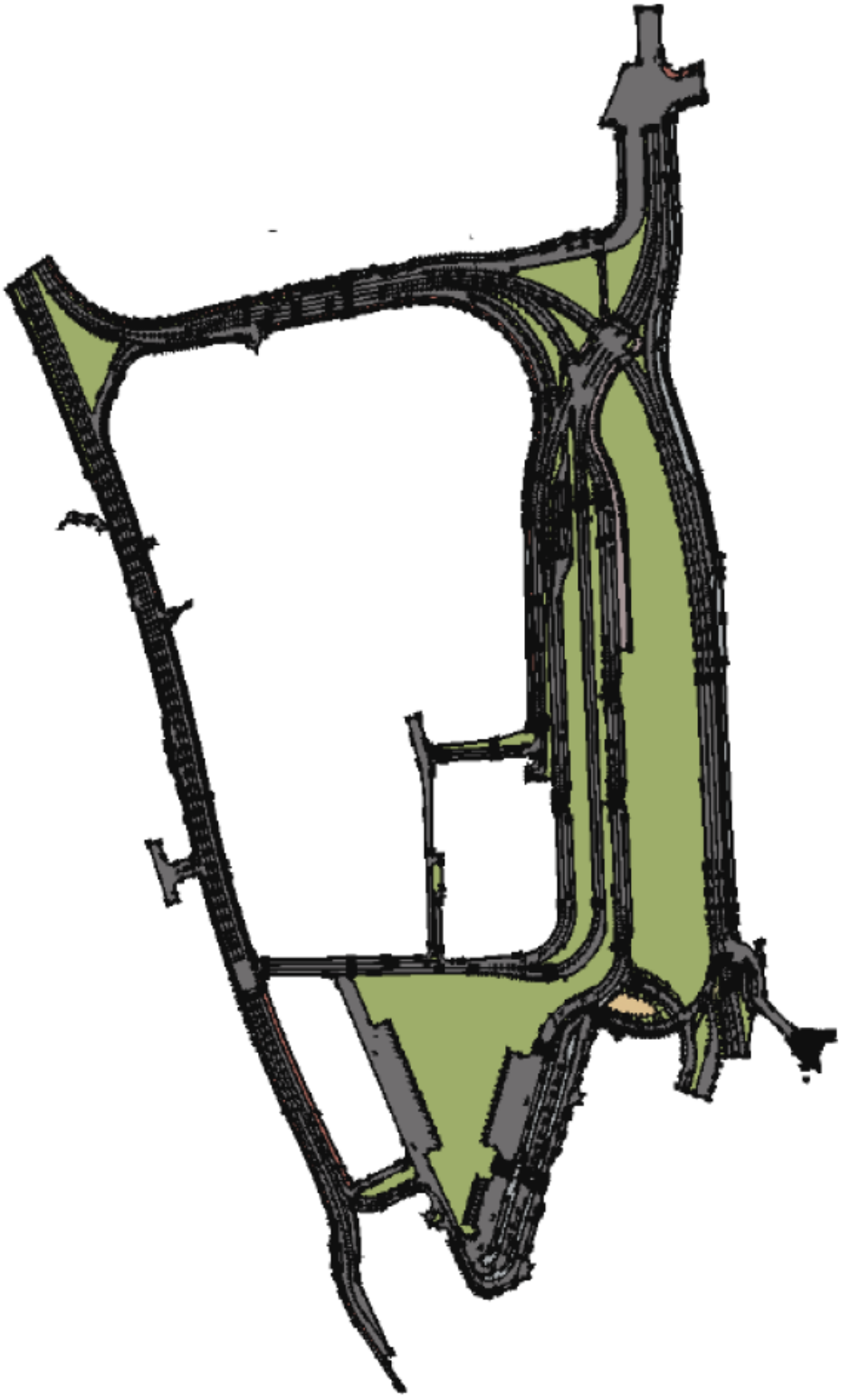
Auto CAD Drawing imported onto Base

9.2.4 *Step 3: Each area of the Road made into separate Solid Entities*



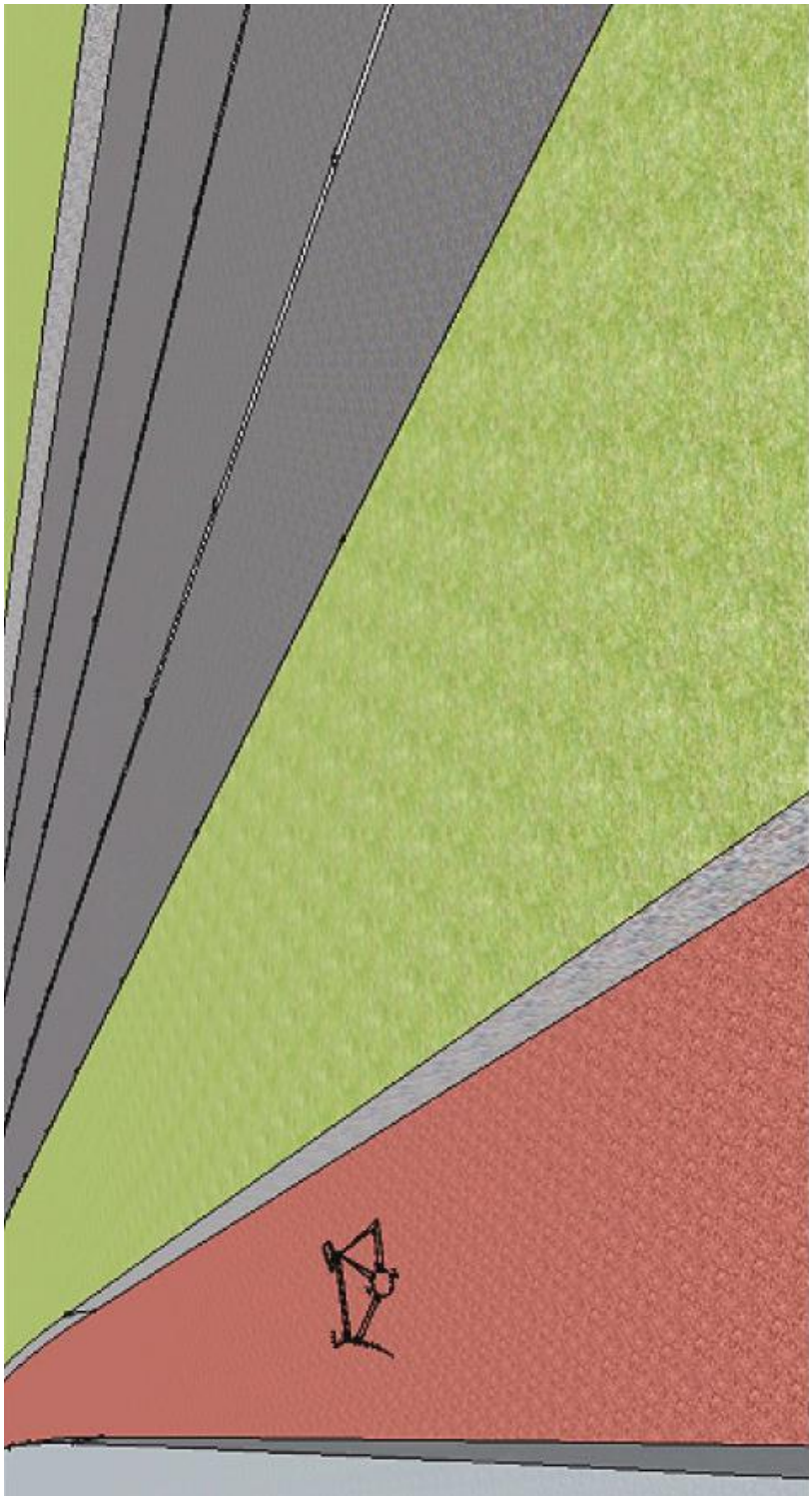
Each area made solid

9.2.5 *Step 4: Adding Textures to the Model*



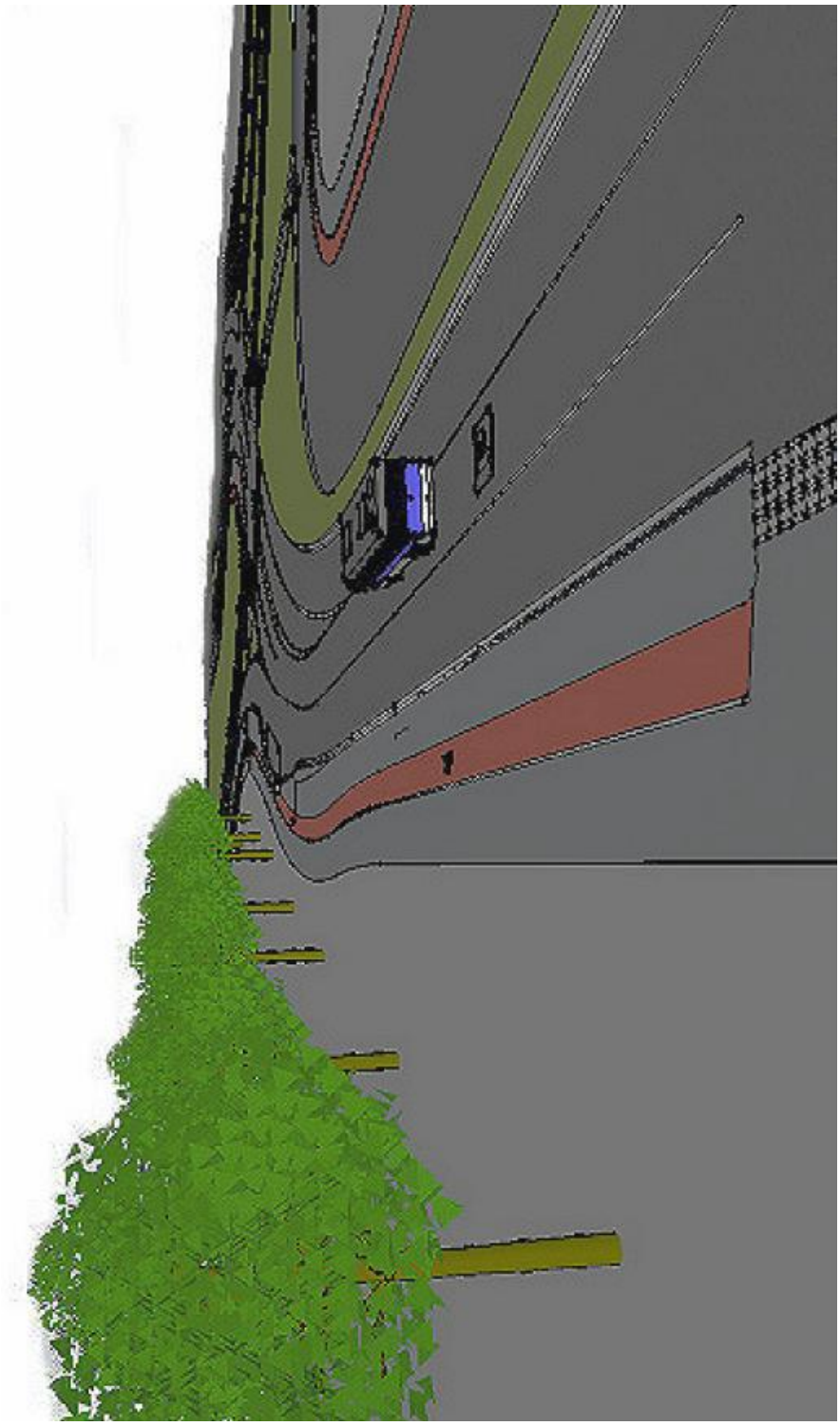
Textures added to give a realistic appearance to the road

9.2.6 *Step 5: Contours of the Road pushed to give depth to the Road in the Model*



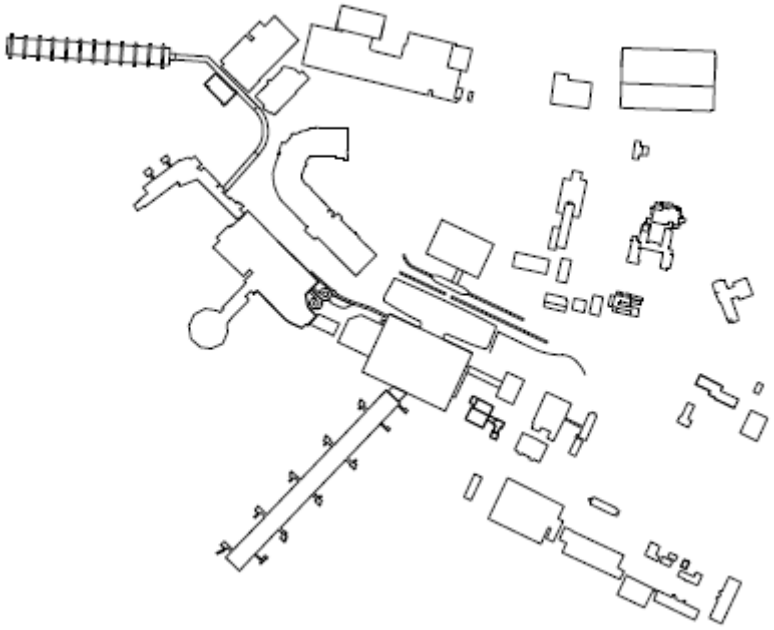
Road pushed down by 200mm

9.2.7 *Step 6: Details added into the Model, Trees etc, Exported from Google Skethcup Library*

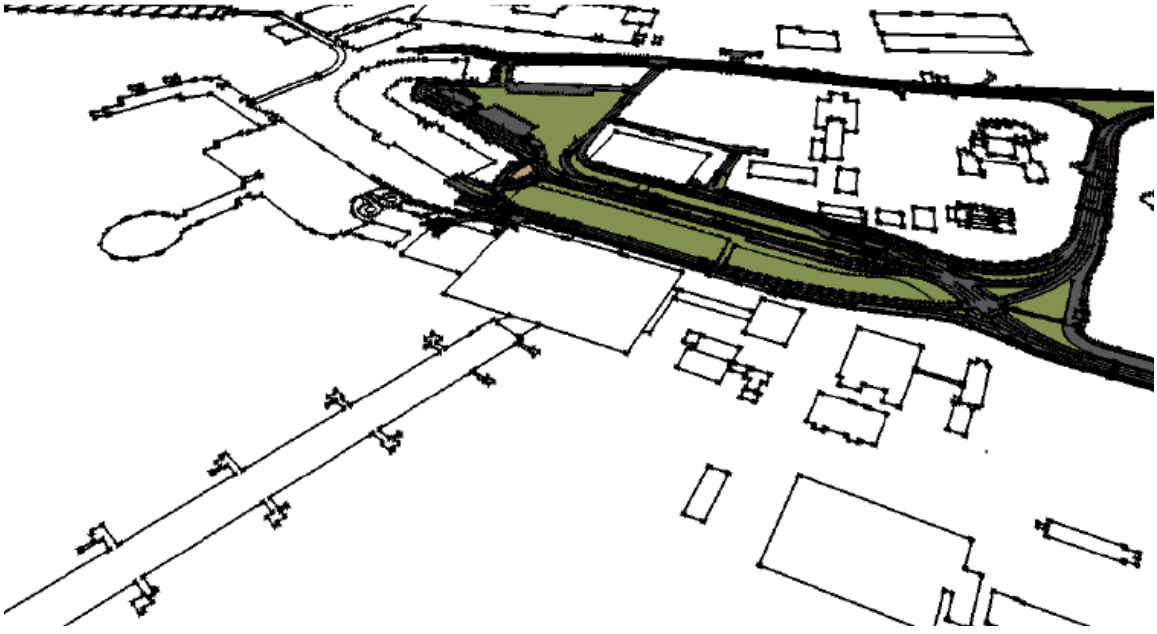


Trees and Bus added to model

9.2.8 *Step 7: Import the Auto CAD Buildings Layout into the Model*

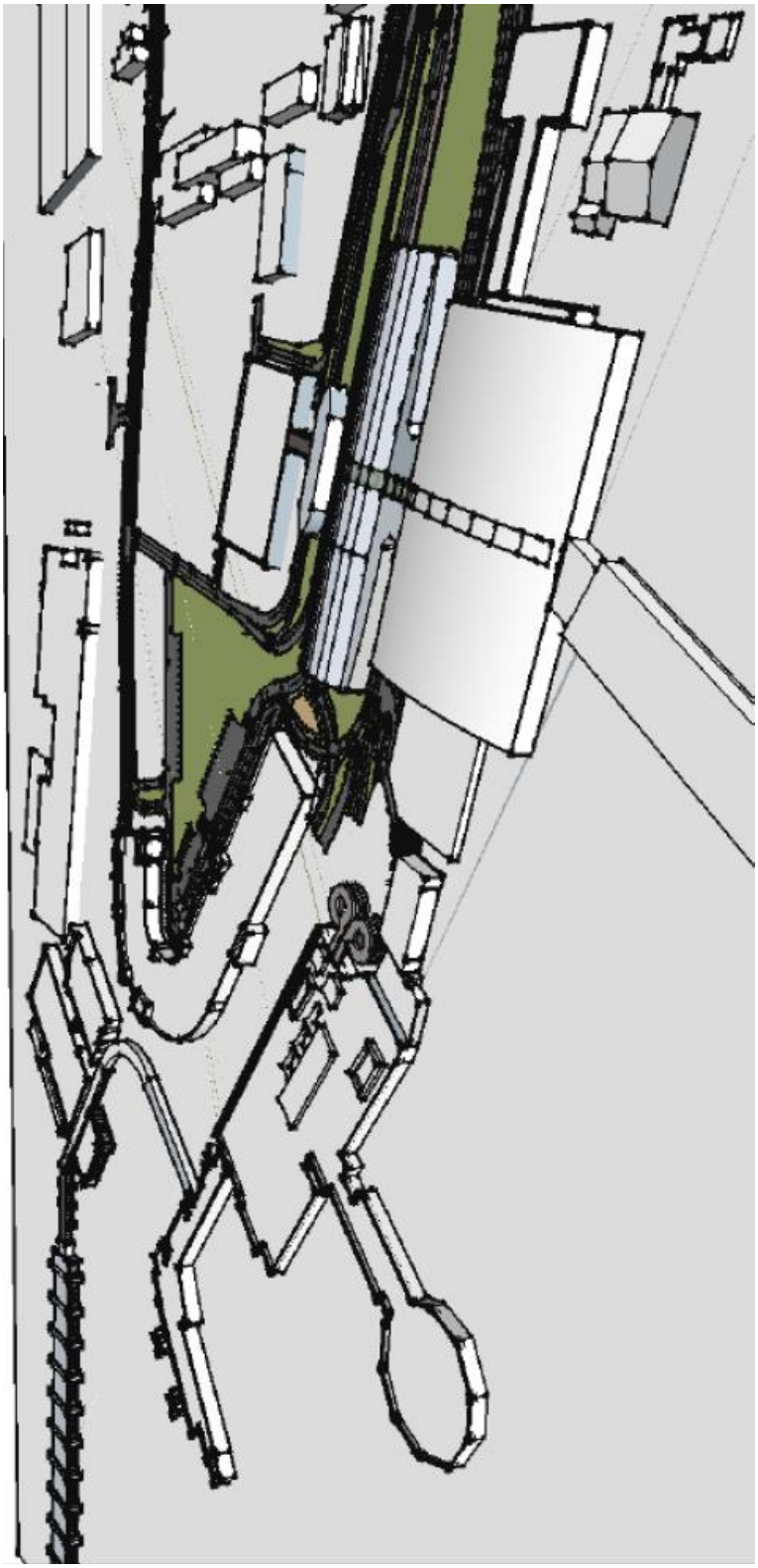


Auto CAD Drawing



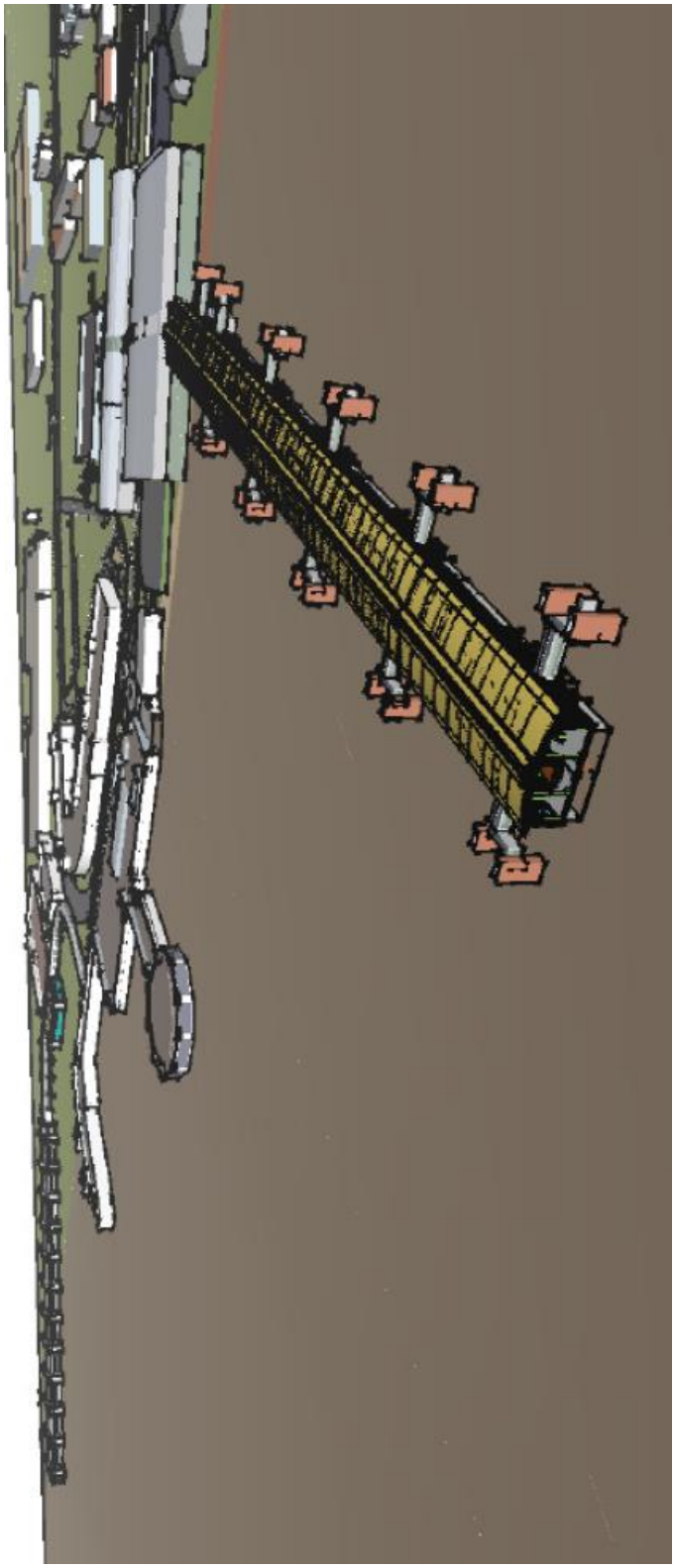
Auto CAD Drawing imported into Model

9.2.9 *Step 8: Extruding the Buildings into 3D*



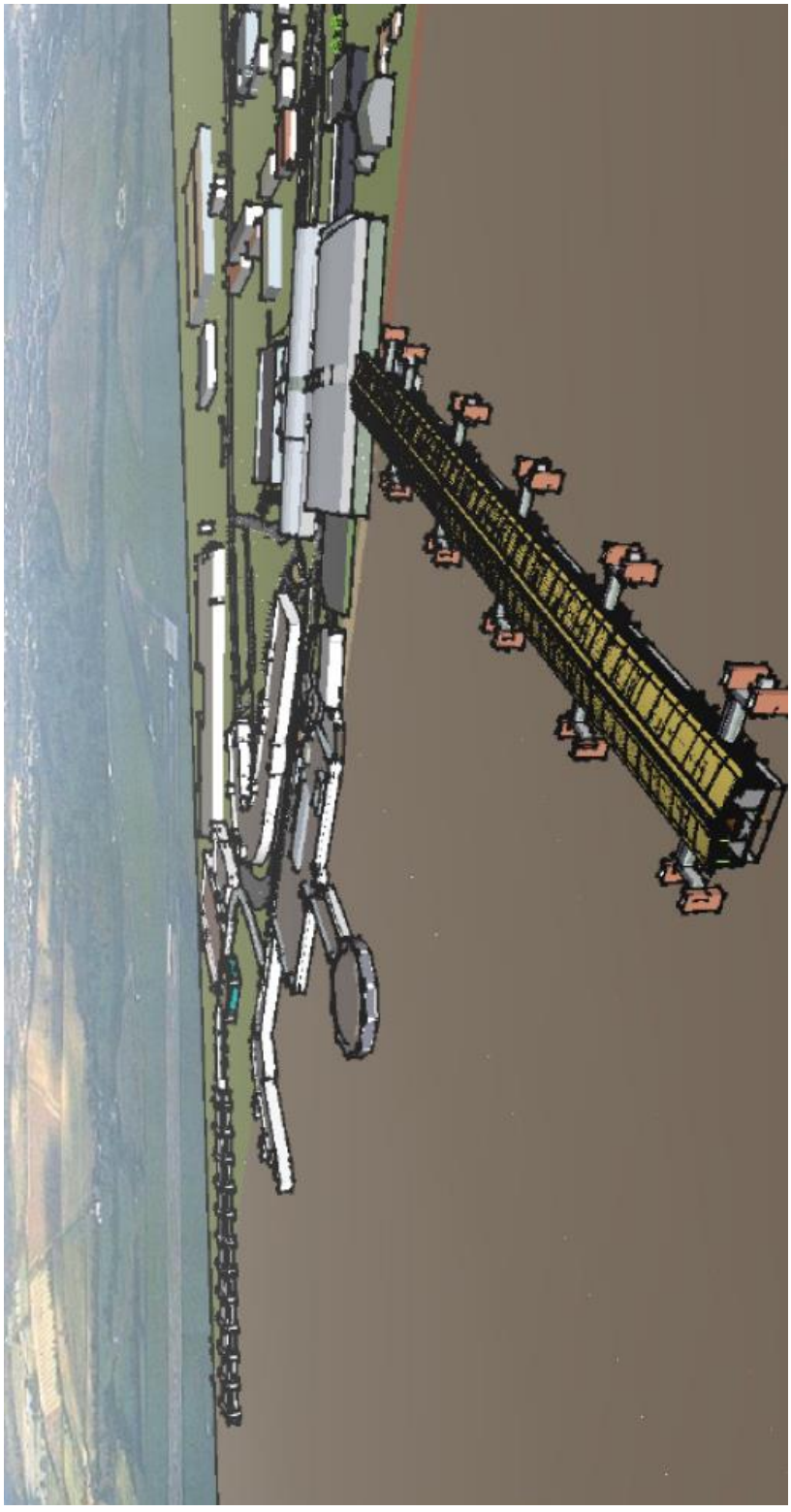
Model looking towards Terminal 1 & Terminal 2 from Pier E

9.2.10 *Step 9: Textures added to the finished Buildings*



Model looking towards Terminal 1 & Terminal 2 from Pier E

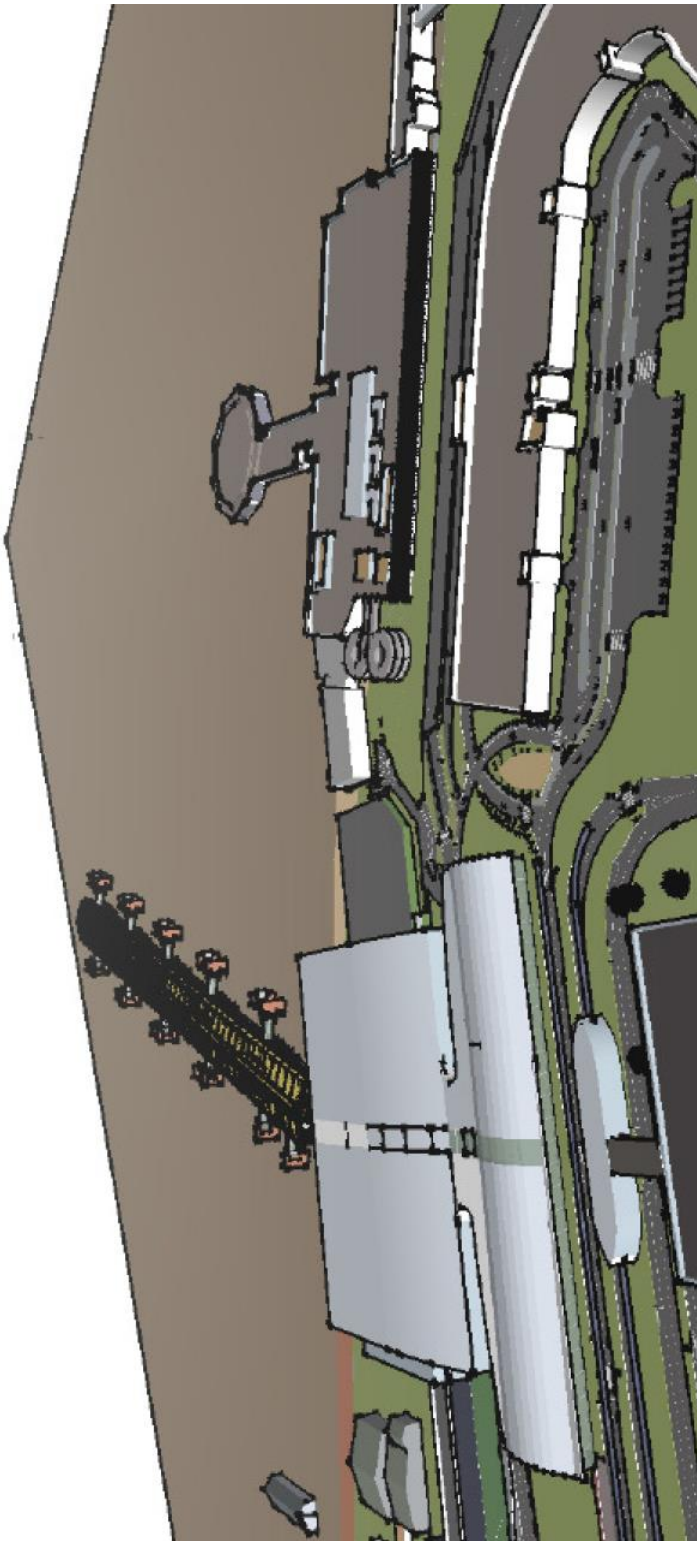
9.2.11 *Step 10: Scene added to give a realistic effect*



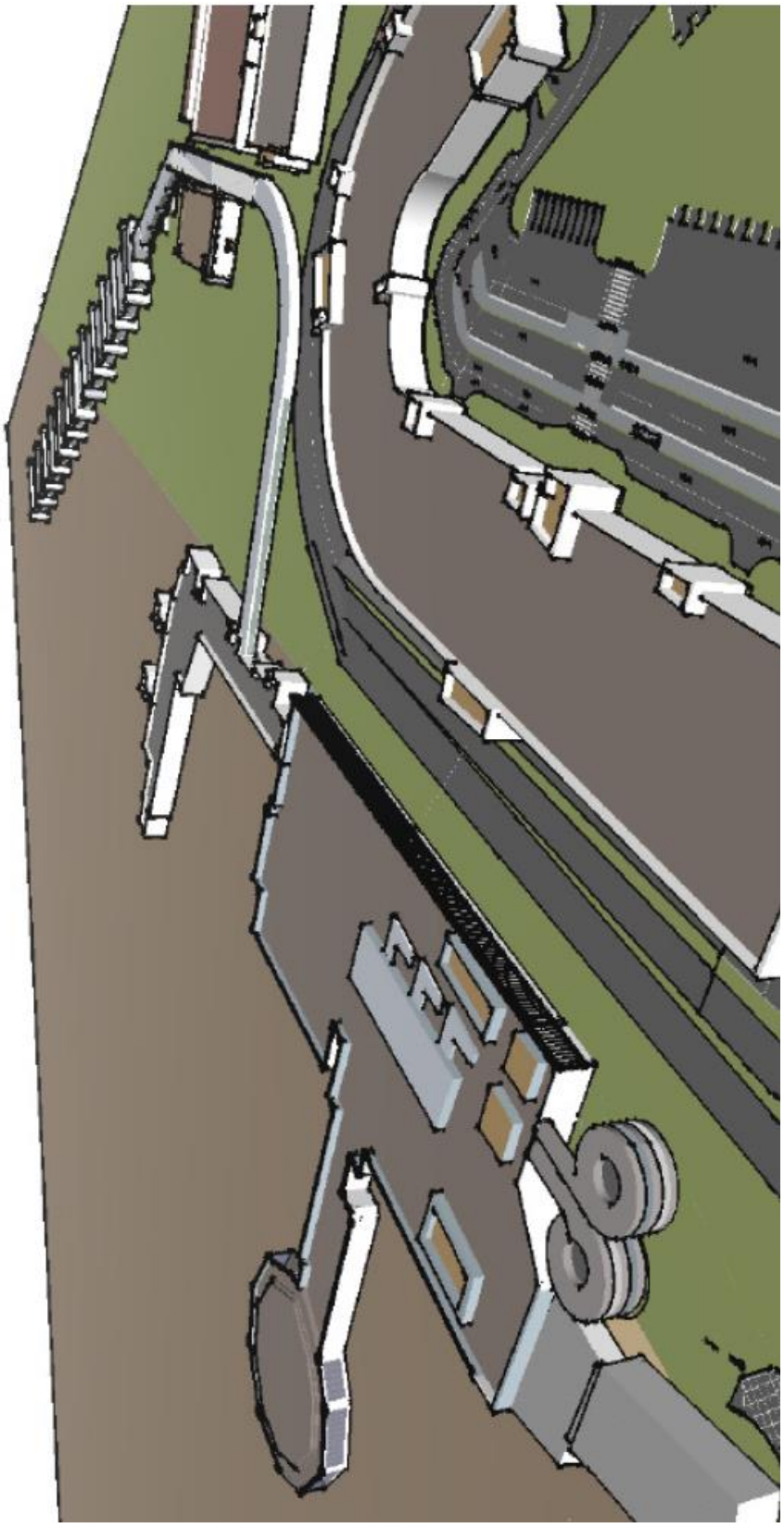
Scene added Terminal 1 & Terminal 2 from Pier E

9.3.1 IMAGES OF COMPLETED MODEL

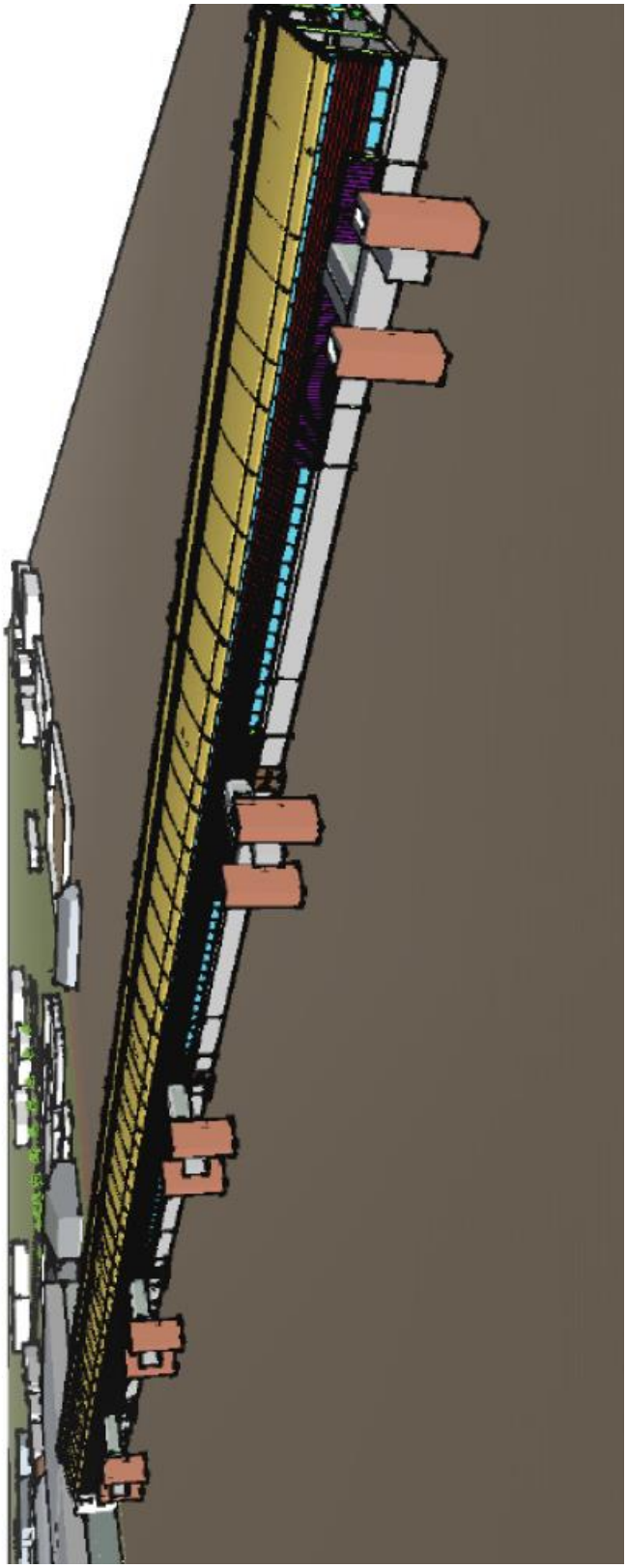
9.3.2 *Front View if Terminal 1 & Terminal 2*



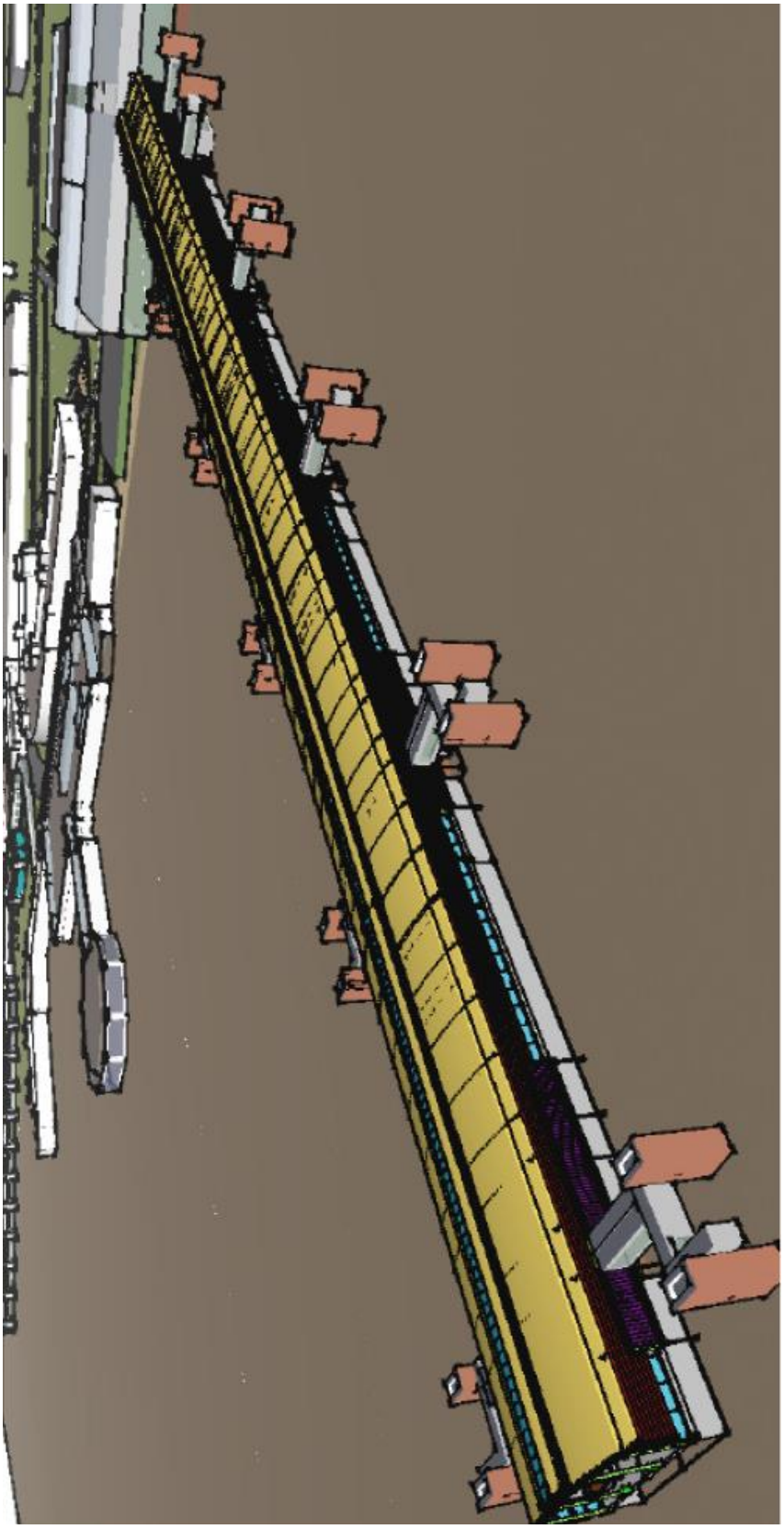
9.3.3 *Terminal 1 & Pier D*



9.3.4 *Pier E, North View*



9.3.5 *Pier E, South View*



9.3.6 *Pier E, Internal View*