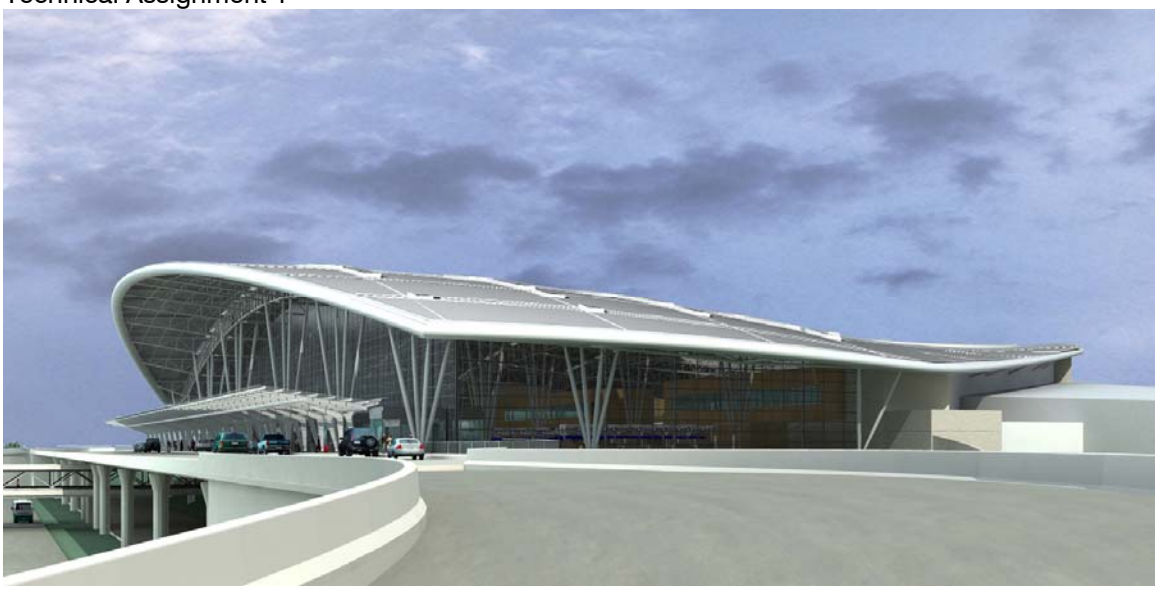
Ming Norman Tsui
October 5, 2005
Advisor: Dr. Moeck
Technical Assignment 1



Executive Summary:

The following technical report summarizes the current conditions of the lighting system Indianapolis International Airport- New Midfield Terminal. Four spaces will be analyzed: The exterior arrival/departure entrance, the civic plaza, the check-in/ticket hall and the passenger concourse.

Due to the lack of existing system performance data, educated assumptions were made for the evaluation portion of this report. Partial information for materials regarding their transmittance/reflectance was estimated in assumption. All recommended illuminance level and light loss factors were obtained from the IESNA Handbook 9th edition. ASHRAE 90.-1999 was used to determine all power allowance for each space. LEED-NC Version 2.1 Rating System is used for the assessment of LEED certification design criteria such as daylighting and light trespass.

The International Airport is going after a minimum of LEED Pilot certification. With the extensive use of daylight harvesting as well as energy savings generated by the daylight application, the INDY will set the standard for future airports that will be built in the United States.

Through the analysis and evaluation process, advantage and disadvantage of the existing system is praised and criticized. To truly enhance the existing condition, design criteria for each of the space are researched and considered. Moreover, to redesign each space following the design criteria enlisted from this report will further strengthen the final result, a better airport with a better lighting system performance.

Ming Norman Tsui
10/3/2005
Advisor: Dr. Moeck
Technical Assignment 1

Lighting Existing Conditions and Design Criteria Report

Material:

Reflectance(assumed):
Dry Wall – 40%
Hard Limestone Floor Panels – 20%
Aluminum Structural Elements – 50%
Stainless Steel Structural Elements – 60%
High Performance Paint Coating (Structural) – 50%
Carpet – 10%

Transmittance:
High Performance Curtainwall (Visionwall 3 Element Glazing System):

- Visible Light Transmission – 49%
- U Value – 0.21
- Shading Co-efficient – 0.19
- Solar Heat Gain Co-efficient – 0.18

Skylight Glazing – 66% (HOK Schematic Design Report)

Light loss factors (LLF):

a. Lamp Lumen Depreciation (LLD) – varies from fixtures to fixtures, however, the average should be assumed at 80%(0.8).
b. Luminaire Dirt Depreciation (LDD) – on a 6-month cleaning cycle under a very clean condition for indoor (98% or 0.98), and a dirty condition for outdoor (80% or 0.85).
c. Room Surface Dirt Depreciation (RSDD) - varies from fixtures to fixtures, however, the average should be assumed at 80%(0.8).
d. Ballast Factor (BF) – fluorescent (dimmable) ballasts are estimated to have an average value of 70% (0.7), while high intensity discharge (HID) are estimated to have an average value of 80% (0.8).
e. Total LLF = BF x LLD x LDD x RSDD

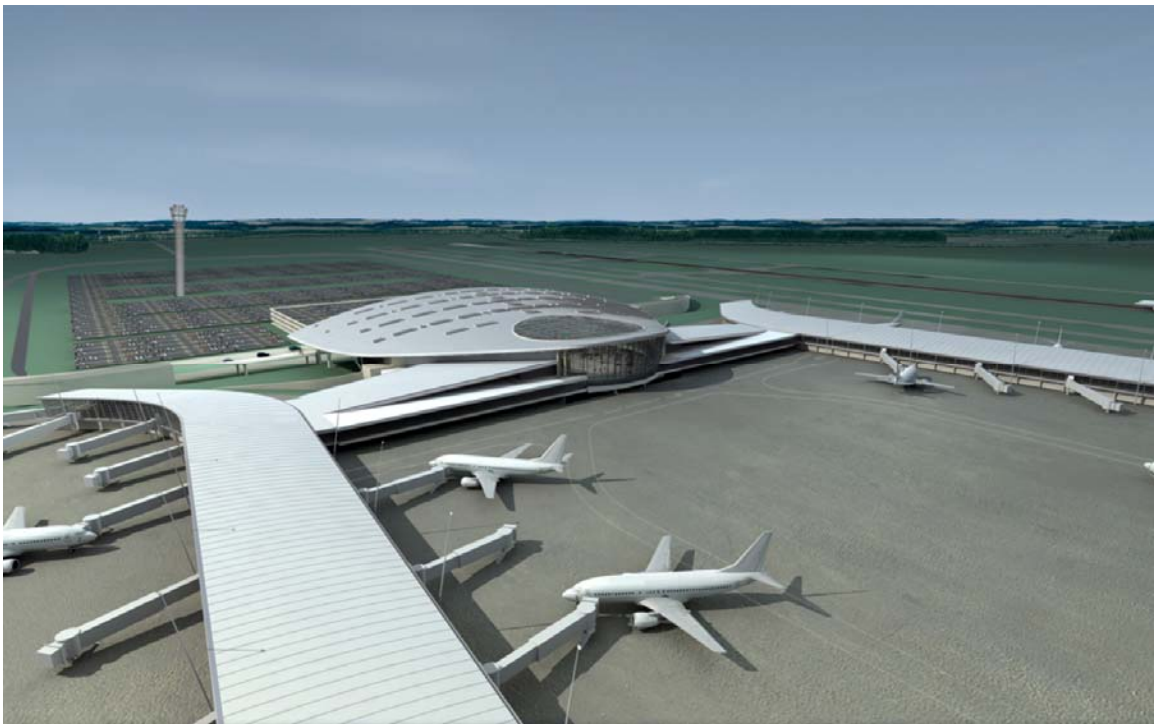
Exterior

- **Existing lighting systems**

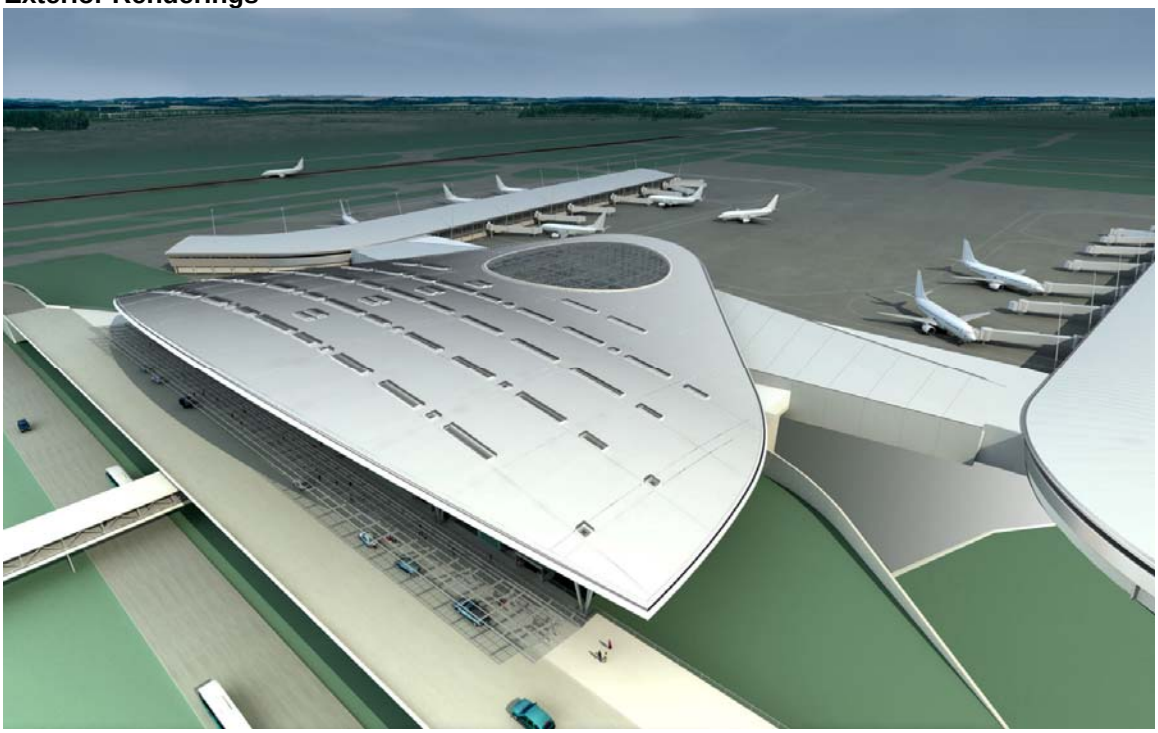
  - Site wall uplighting
    - Recessed in-grade uplight with 39W T6 metal halide.
  - East-West exterior uplighting
    - Semi-recessed exterior wall mounted asymmetric uplight with (2) T6 metal halide, wattage to be determined.
  - Arrival area
    - Recessed downlight with 32W triple tube compact fluorescent vertical lamp
  - Roadway at departure
    - 27.5 ft max height ornamental light pole with T6 metal halide, wattage to be determined.
  - Departure roadway canopy-pedestrian lighting
    - Surfaced mounted exterior wall asymmetric downlight with 70/150W T6 metal halide.
  - Departure roadway canopy- uplight to big roof above
    - Surface mounted exterior wall asymmetric uplight with (2) 70/150W T6 metal halide.

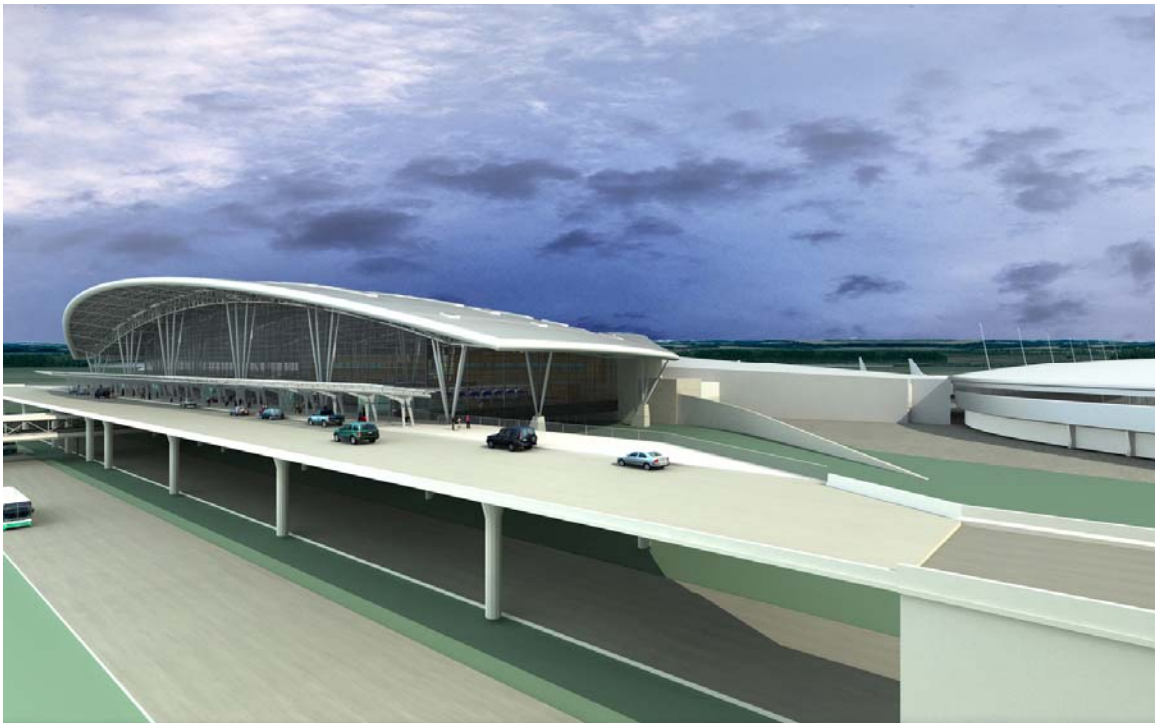
- Top portion of site wall
  - Wall mounted 36 in. length cantilever arm supporting asymmetric distribution wallwashing downlight with 70W T6 metal halide.

    - All 75/150W metal halide equipped with electronic ballast.
    - Photocell control on, Building Management System (BMS) time clock off (primarily used on the exterior lighting systems).



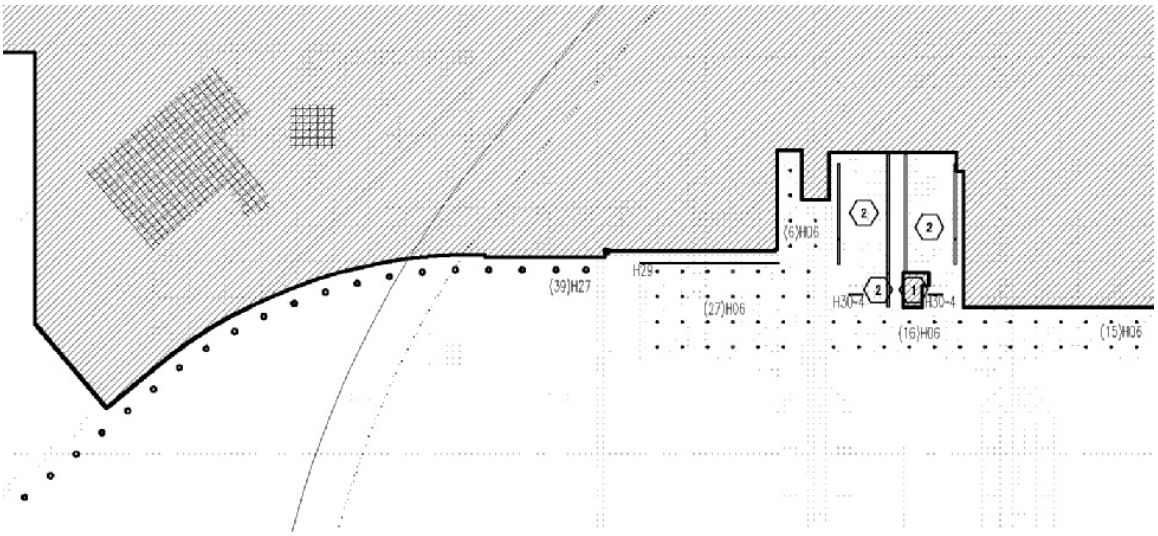
Exterior Renderings



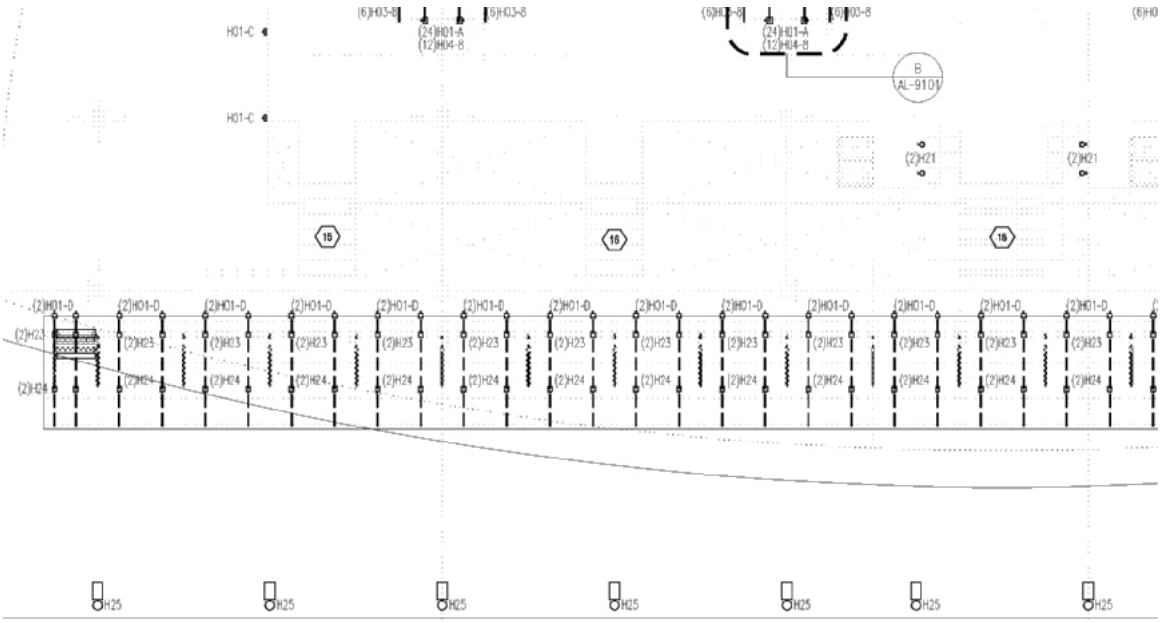


Daylight Perspective View

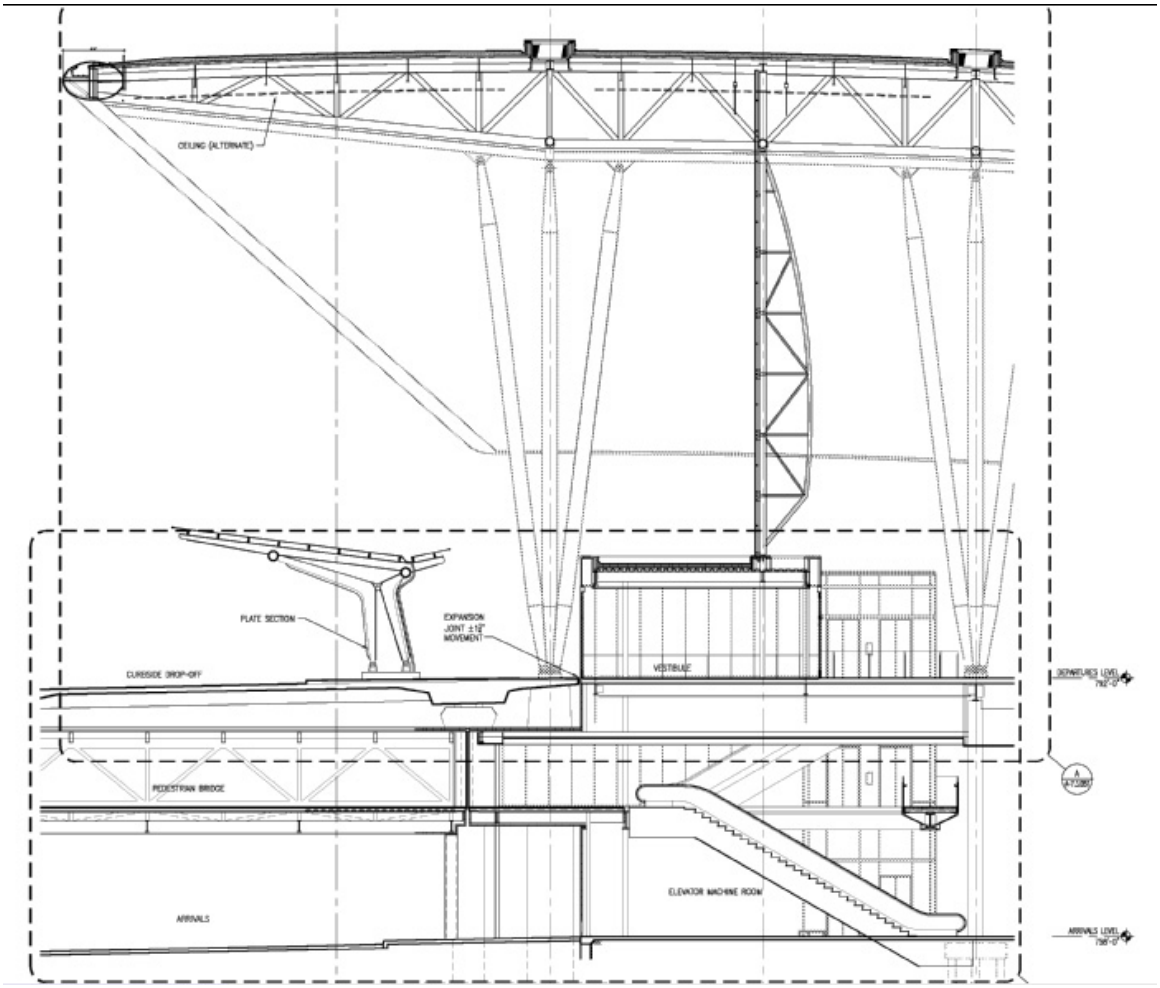
Electric Light-lit Night Perspective View



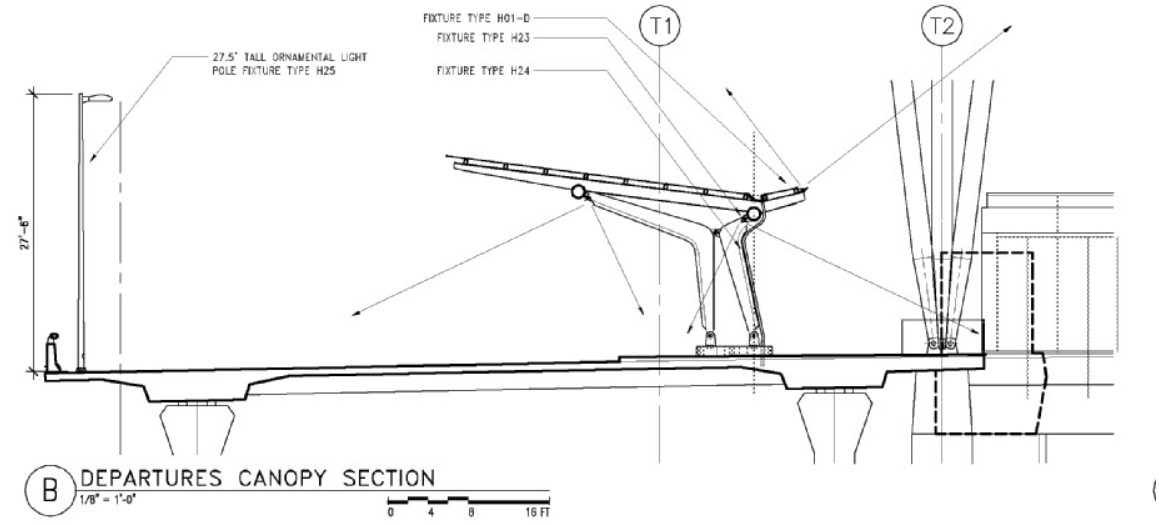
Exterior arrival roadway plus entry lighting, Plan



Exterior site uplight, departure roadway, canopy lighting plus west façade uplights, Plan



Terminal section



Departure canopy section

- **Design Criteria**

i. Appearance of this exterior space and luminaires is very important, since it is the first view contacting point from spectator's eye. Must announce a civic presence and lasting impression with great lighting.
ii. Color appearance and color contrast is very important because the lighting of this space must be well balanced for pleasing appearance as well as visibility to roadway drivers
iii. Direct glare must be avoided for oncoming traffic approaching from the road access since the glare might affect the drivers' visibility to signage at the departure/arrival area.
iv. Light distribution on surface is important because by ensuring an evenly distributed surface would enhance the overall appearance of the space as well as maintaining uniform illuminance for pedestrian conveyance.
v. Light pollution/trespass is important, since the departure canopy is made all out of glass, uplighting would project unwanted glare to sky and possibly affect pilot's flight visibility. Secondly, in accordance to the LEED guideline, all light trespass issue ought to be resolved in order to achieve the credit.
vi. Points of interest, with façade floodlighting, giving the structure a monumental appearance, can easily make the architecture itself a point of interest for tourist to visit.
vii. Reflected glare should also be avoided from the curtainwall façade and glass canopy due to the same reason as direct glare, to maintain visual comfort and visibility to signage at the departure/arrival area
viii. Source/task/eye geometry is very important to establish proportional and acceptable angular relationships between the viewer (driver) and the luminaire at the exterior of the building.
ix. Sparkle/desirable reflected highlights is somewhat important, and could be easily achieve with the glass canopy because it can add interest and dramatic-ness to the architecture itself.
x. Surface characteristic is very important and should be carefully consider when designing with a high glossy area façade, the inter-reflection would increase secularity on the surface and help reduce the undesirable contrast of luminaires against their background.
xi. Vertical illuminance is thus important because the vertical surfaces are the main visible elements to the drivers/pedestrians when approaching, hence, must reach an acceptable illuminance value for visibility.
xii. A minimum 1:3 uniformity illuminance ratio should be maintained for pedestrian and roadway.

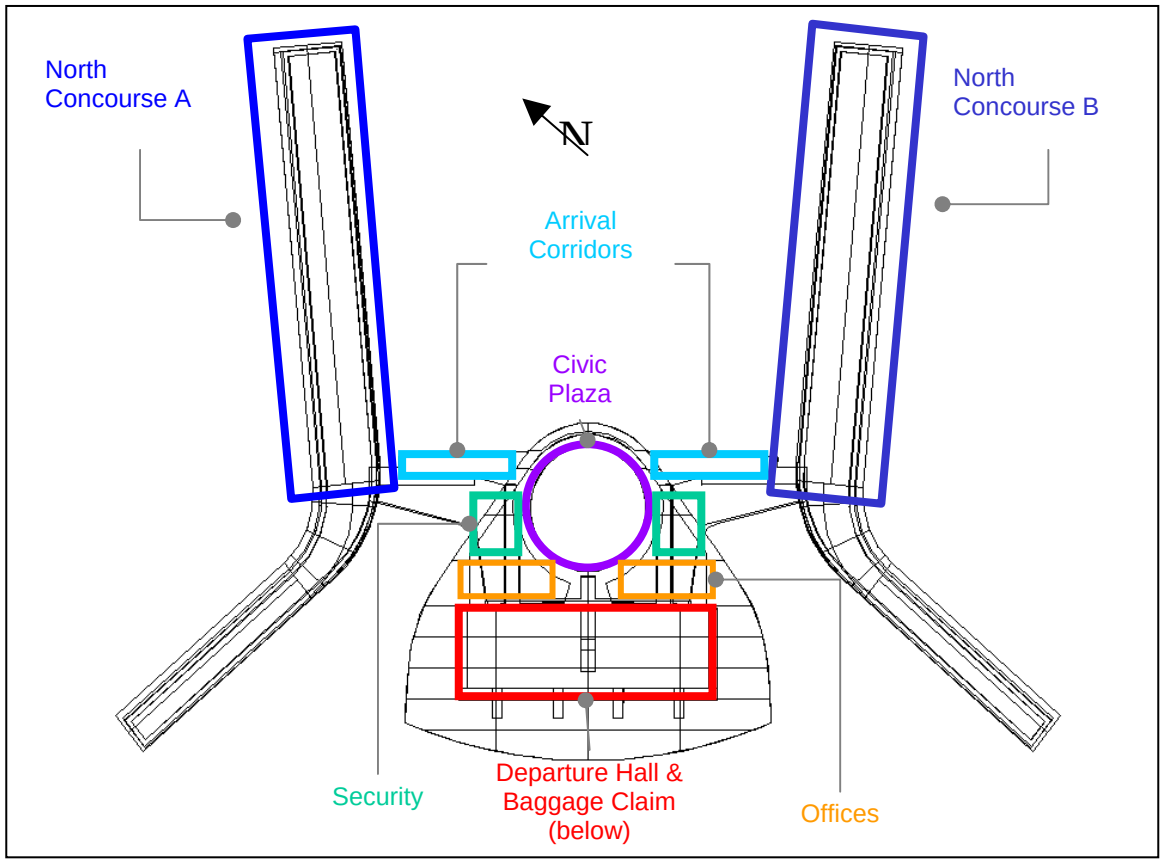
a. Exterior lighting power allowance is obtained from ASHRAE/IESNA Standard 90.1-1999, and they are set to be

Building entrance with canopy or free standing canopy (Departure)	3 W/sq.ft. of canopied area
Building entrance without canopy (Arrival)	33 W/linear foot of door width
Building facades	0.25 W/sq.ft. of illuminated façade area

b. Required illuminance level is obtained from the IES Lighting Handbook, 9th edition, and they are set to be

Illuminance category B- Simple orientation for short visits (Entrance)		50 lx (5 fc)
Surface (façade)	**Surroundings**	
Medium-to-Light	Dark	30 lx (3 fc)

- **Evaluation of Existing Lighting Condition:**
  - The existing exterior spaces including the departure canopy/entrance, arrival entrance and west façade. To announce a civic presence on the appearance of the terminal, the existing façade flood lighting has utilized metal halide uplights mounted atop of departure canopies. To also conform to the LEED NC requirement on minimum light trespass credit, appropriate aiming angles should be calculated to avoid façade uplights that contributes any light pollution toward the sky. Airport terminals and landing areas are very sensitive toward unwanted light sources coming from the ground up. Judging from the spacing of the roadway light poles, uniformity should be achieved, however, reflected glare can be caused by the nearby canopies glasses when viewing from roadways when approaching the terminal. The surface characteristic (canopy glass with the metal frame) has certainly created sparkling, desirable highlights in front of the façade. Exaggerating the point of interest appearance for the terminal, best view by tourists' approaching from the roadway.
  - During daytime, no lighting are utilized besides daylight, here is the overview of the daylight strategy and the daylit areas:



- Possible LLF incurred: 0.8x0.8x0.85x0.8 = 0.4352

Civic Plaza

- **Existing lighting systems**

i. General ambient area lighting and accent floodlighting
   - 28 ft. tall interior floor mounted tapered steel light pole with T6 metal halide.
     - 150W for ambient indirect luminaries
     - 70W for low mount accents
     - 150W for high mount accents

ii. Sign band at civic plaza perimeter
   - 4-12 ft. length continuous recessed linear fluorescent wallwash luminaire with 4 in. ceiling aperture width and without louver using (1) T5HO lamp.

iii. Circulation lighting at civic plaza perimeter
   - 4-12 ft. length continuous recessed linear fluorescent downlight luminaire with 6 in. ceiling aperture width and blade louver using (1) T5HO lamp.

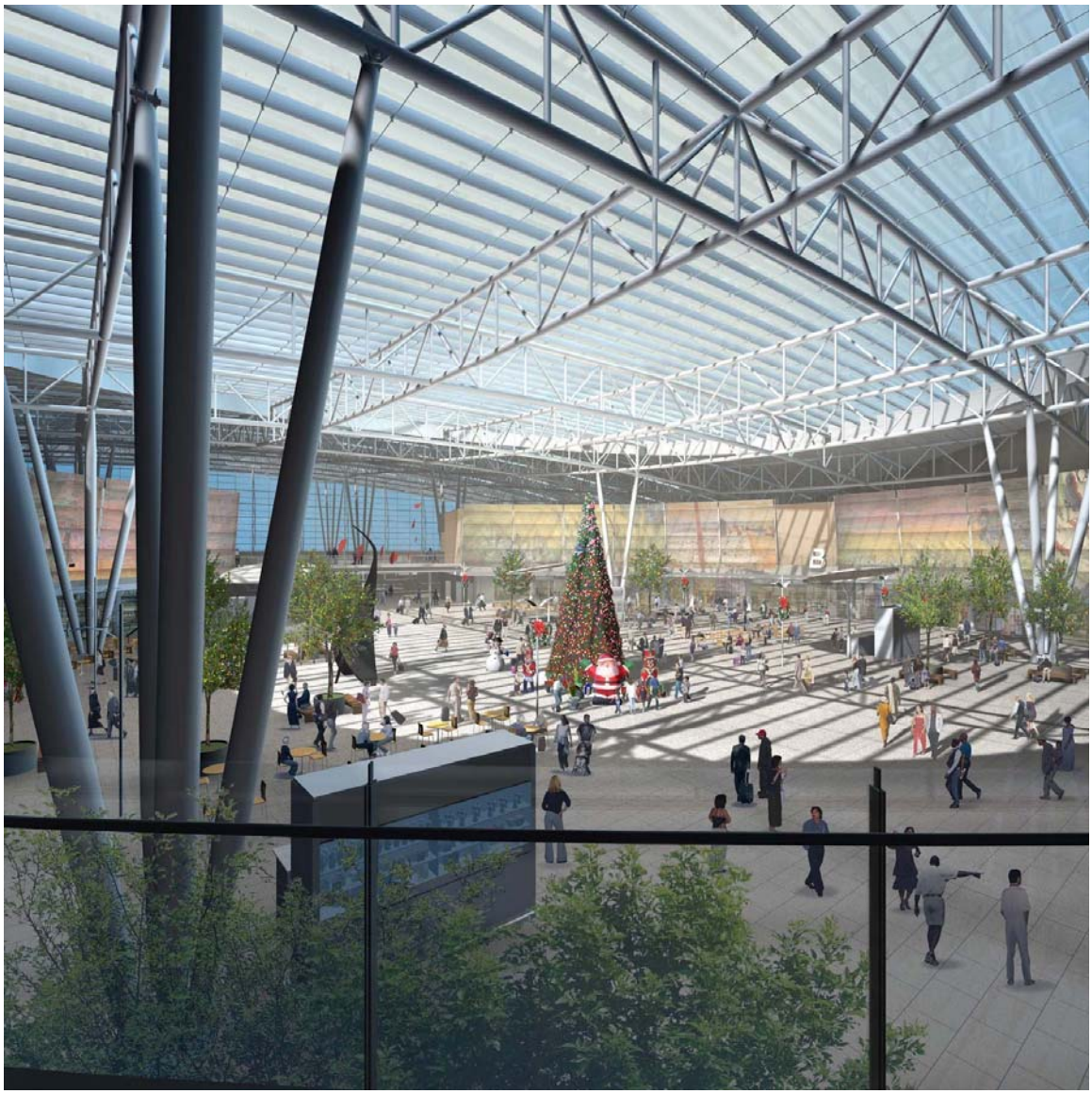
iv. Underside of bridge at civic plaza
   - Decorative surface mounted glass glowy dome with RGB color changing LED lamps.

v. Depressed transfer corridor air to air at civic plaza airside overlock
   - Fully recessed in-wall step light with 32W triple tube compact fluorescent with integral ballast

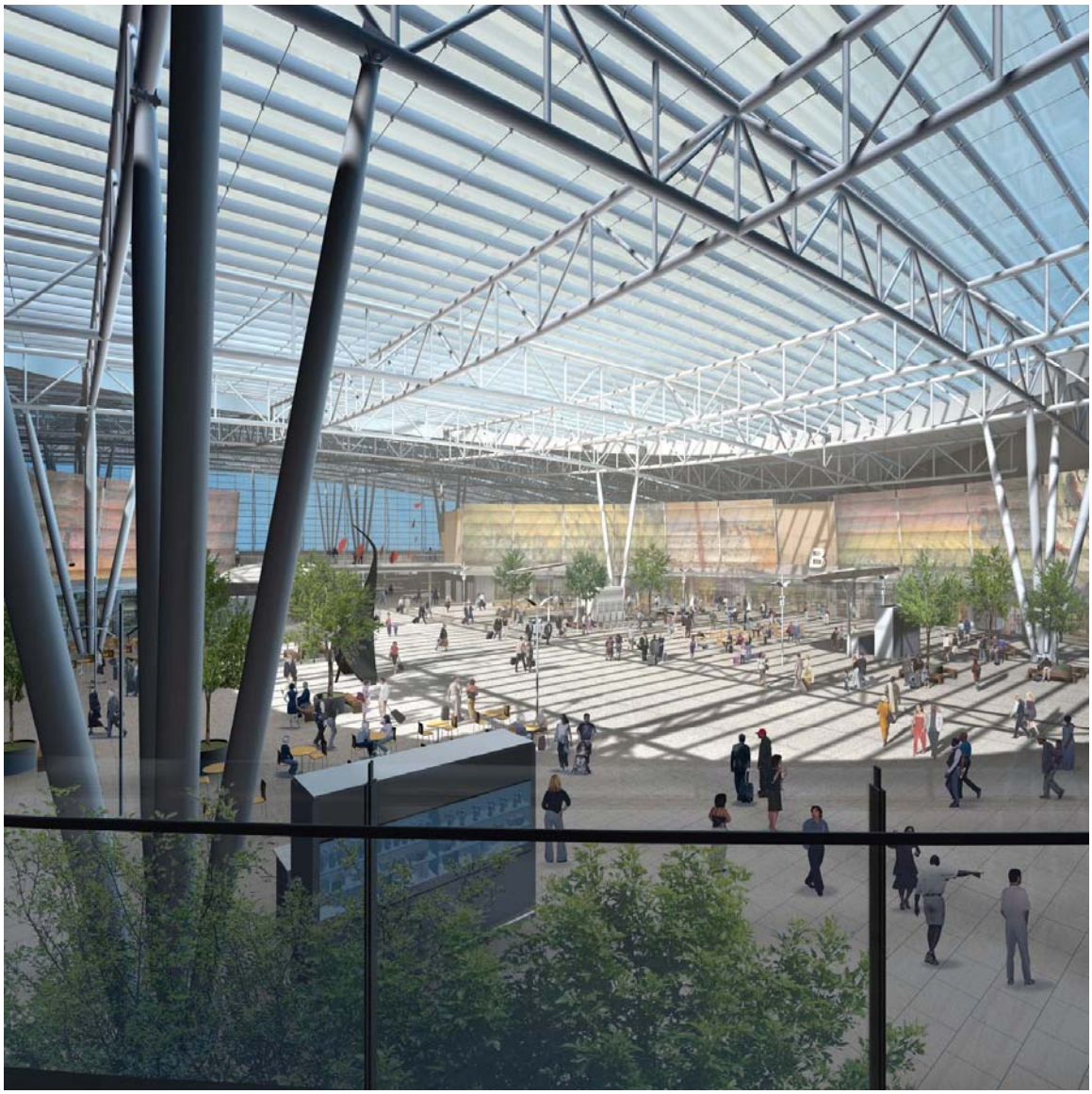
vi. Elliptical tree structure at civic plaza
   - Surface mounted decorative glowy uplight with 40W Biax compact fluorescent lamp.

   - All interior metal halide lighting within 28' of curtainwall/glazing/glass shall be photocell controlled to turn "OFF" in dedicated zones of 50% on/off. Entire areas where metal halide lamping utilized are not intended to be completely extinguished at one time due to start-up/restrike times
   - All interior fluorescent lighting within 32' of curtainwall/glazing/glass are photocell controlled to dim automatically from 100% to 10%
   - All fluorescent lighting in these zones are provided with dimmable ballasts and wall box dimmer control
   - Occupancy sensor with no local override such as public restroom
   - Photocell control of dimmable electronic ballasts within the fixtures used primarily for daylight contribution, the lights will be turned on/off by the BMS then dim up/down during the day via the local phocells and dimmable electronic ballasts.
   - Programmable, present relay panel with local low-voltage present scene stations.
   - All public space lighting are connected to a BMS system to permit dedicated preset looks/scenes to the public areas.
   - LED lamp technology with integral “Driver/Transformer” mounted on a 4” J-box.

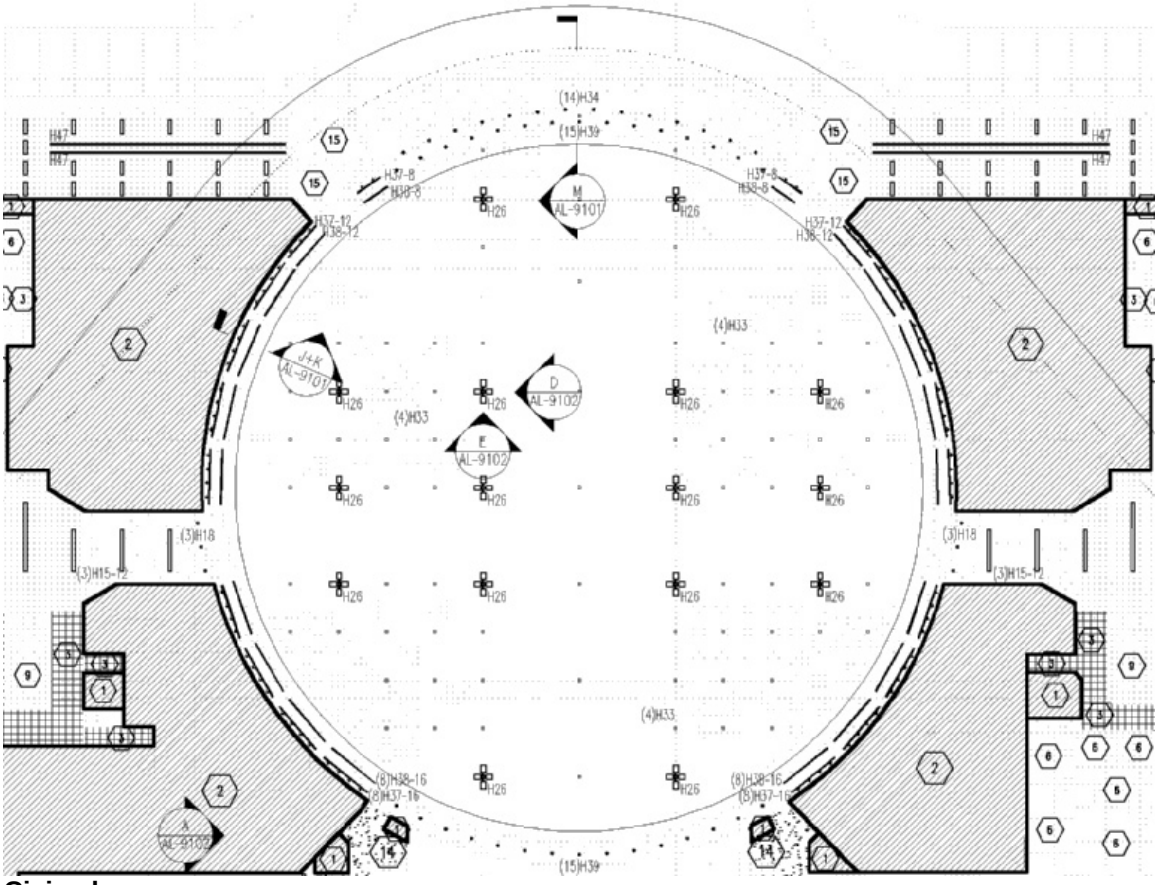
- Daylight elements
   - High performance curtain wall with single insulating glazing, transmittance is estimated at 40%.
   - Civic Plaza Skylight with transitional grid shell and single glazing are estimated to have a transmittance of 66%.
   - All public area floors are hard limestone panels, estimated reflectance at 20%.
   - All steel tube structural supports are coated with high performance paint, estimated reflectance at 50%. Other stainless steel structural elements are estimated to have reflectance at 60%.



Daylight Civic Plaza View - Winter



Daylight Civic Plaza View - Summer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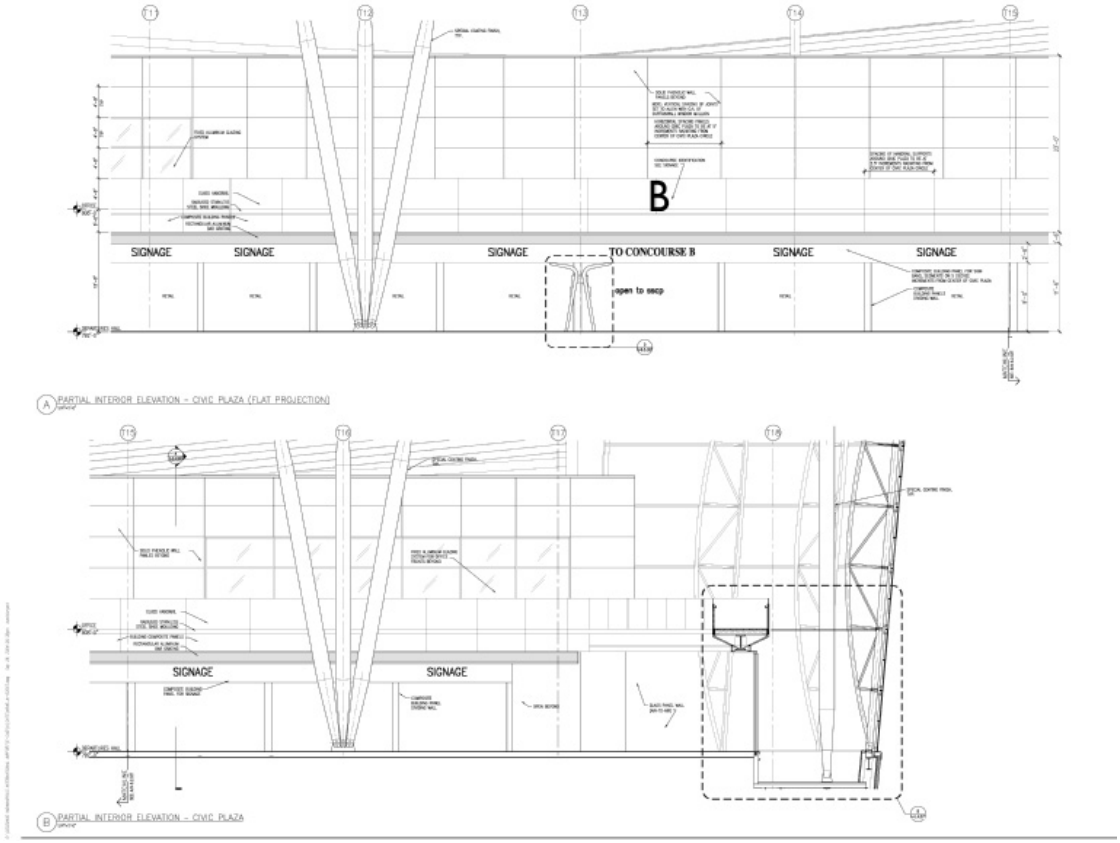
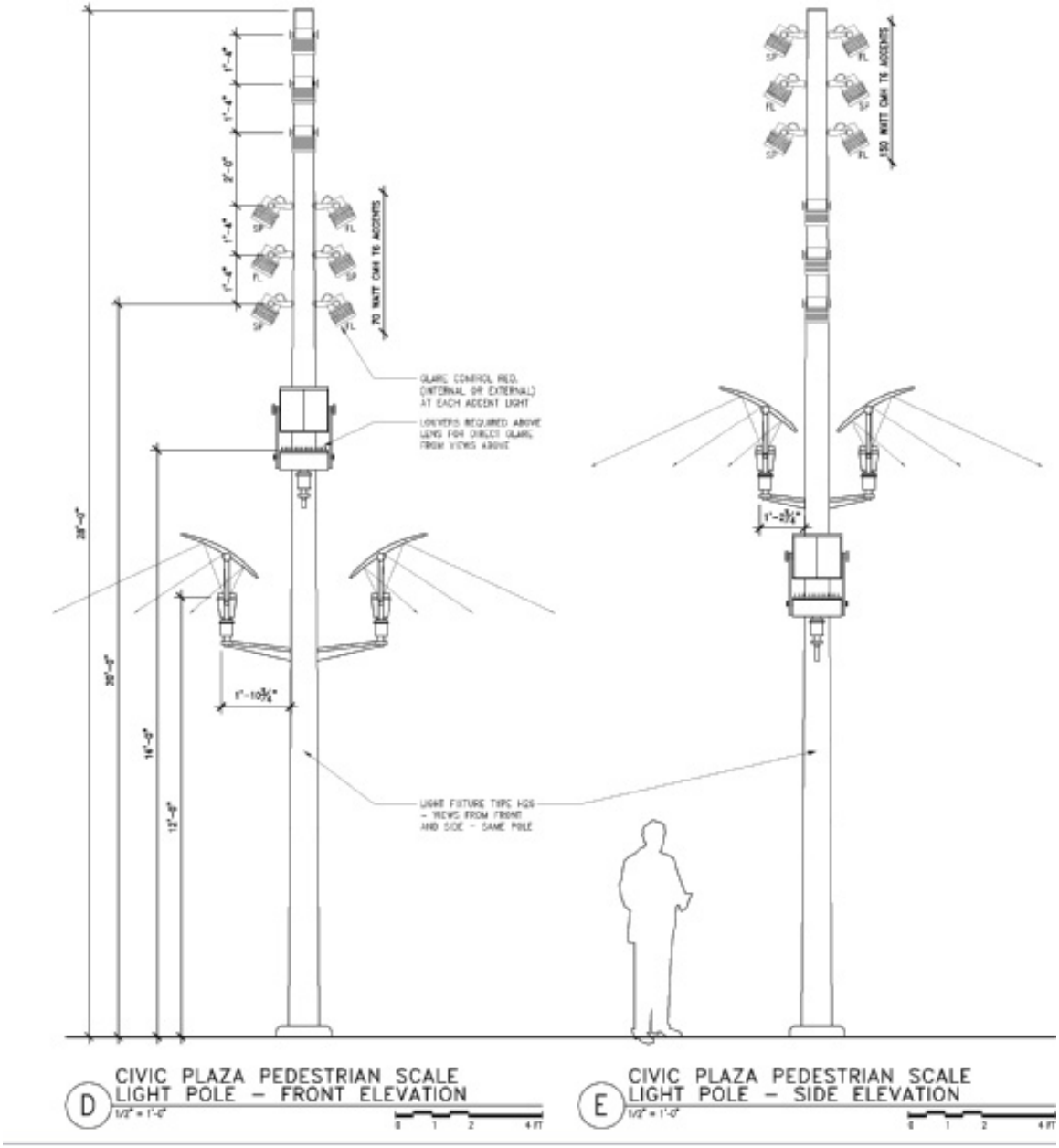
Civic plaza



Civic plaza interior elevation



- **Design Criteria**
  - The existing civic plaza has an extensive daylight system that utilizes both a high performance curtain wall as well as a skylight dome. During daytime, even under an overcast sky, hardly any electric lighting is required. Therefore, minimum amount of lighting equipment is installed in the center of the space for the purposes of night illumination. Decorative/aesthetical light pole are placed in for both flood and accent lighting the civic plaza. This setup certainly has draw the whole surround into this point of interest by focusing/project daylight onto the surface. The intensity of the daylight formed an extremely bright and warm center

while the sunlight scattered to the surround, balancing a well defined color contrast on the perimeter of the civic plaza versus the center. However, potential direct/reflected glare problem could occur for passengers/end users if the location of where they stand has direct view toward skylight/curtainwall glass under certain time of the day. Possible reflected glare can also occur due to the high reflectance paint of the surround architectural/structural elements.

- Possible LLF incurred: 0.8x0.8x0.98x0.8 = 0.5

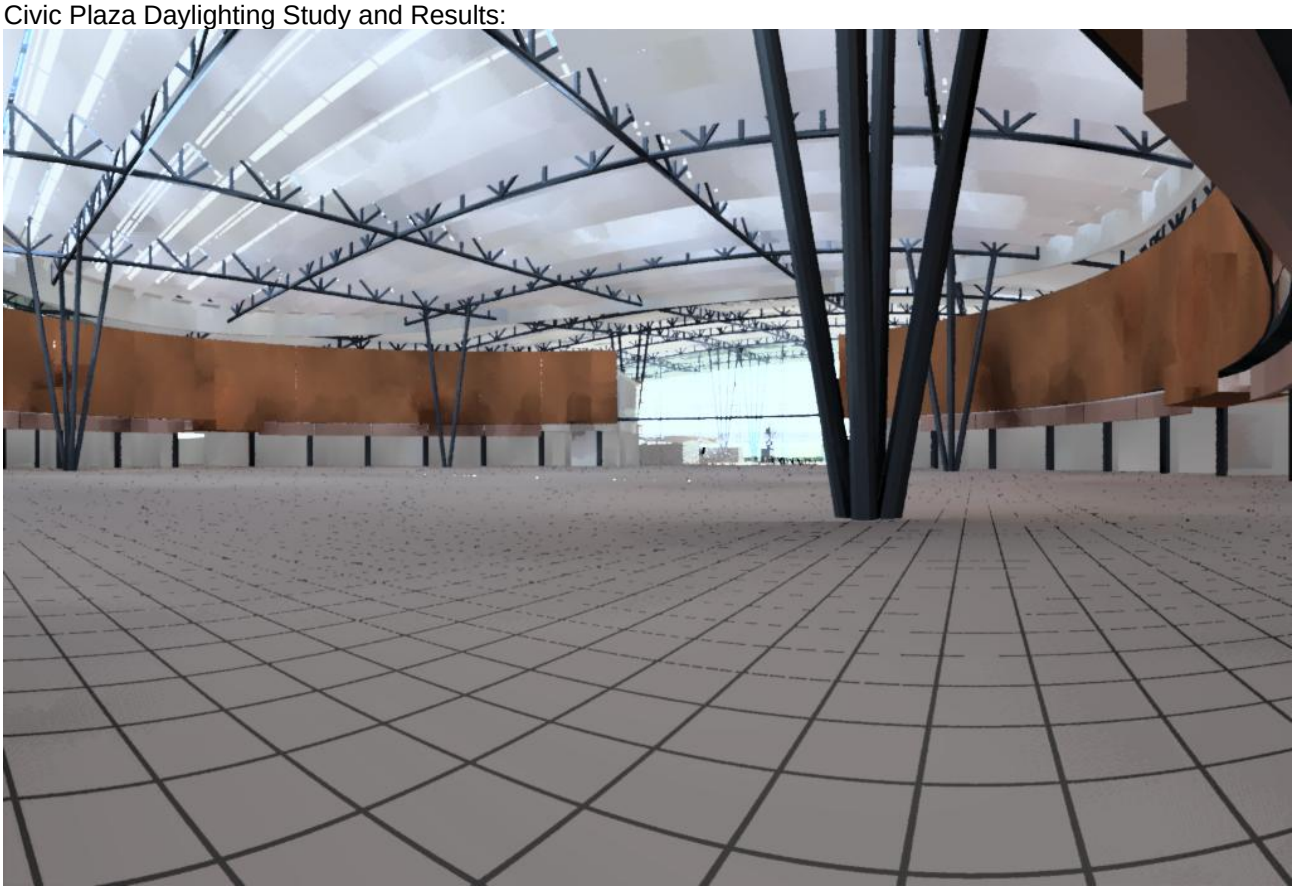
- **Daylighting Design Criteria**

  - Quantity - Provide all ambient lighting needs
  - Quality - Provide a visually comfortable, glare free and uniform space for workers and travelers
  - Quality - Maintain views out for departing occupants through the glazing system to provide a connection to the outdoors
  - Integration - Minimize unwanted summertime heat gains

- **Evaluation of Existing Lighting Condition**

  - The existing civic plaza has an extensive daylight system that utilizes both a high performance curtain wall as well as a skylight dome. During daytime, even under an overcast sky, hardly any electric lighting is required. Therefore, minimum amount of lighting equipment is installed in the center of the space for the purposes of night illumination. Decorative/aesthetical light pole are placed in for both flood and accent lighting the civic plaza. This setup certainly has draw the whole surround into this point of interest by focusing/project daylight onto the surface. The intensity of the daylight formed an extremely bright and warm center while the sunlight scattered to the surround, balancing a well defined color contrast on the perimeter of the civic plaza versus the center. However, potential direct/reflected glare problem could occur for passengers/end users if the location of where they stand has direct view toward skylight/curtainwall glass under certain time of the day. Possible reflected glare can also occur due to the high reflectance paint of the surround architectural/structural elements.
  - Possible LLF incurred: 0.8x0.8x0.98x0.8 = 0.5

Civic Plaza Daylighting Study and Results:



		Clear Sky			Cloudy Sky		
		Avg	Max	Min	Avg	Max	Min
Winter							
	8:00AM	40	56	16	2	3	1
	10:00AM	179	1459	54	136	178	39
	12:00PM	409	1674	86	205	266	56
	2:00PM	282	1461	78	192	253	55
	4:00PM	132	408	43	99	131	28
	Average	**208**	**1012**	**55**	**127**	**166**	**36**
Equinox							
	8:00AM	275	932	45	107	141	31
	10:00AM	901	3912	104	259	343	68
	12:00PM	1570	3021	125	344	465	87
	2:00PM	1385	3630	127	336	447	88
	4:00PM	588	2170	99	241	320	61
	Average	**944**	**2733**	**100**	**257**	**343**	**67**
Summer							
	8:00AM	774	3263	111	222	290	59
	10:00AM	1691	3177	166	361	481	93
	12:00PM	2928	3924	185	435	589	119
	2:00PM	2683	3802	187	424	556	108
	4:00PM	1424	2859	151	332	434	84
	Average	**1900**	**3405**	**160**	**355**	**470**	**92**
Annual Average		**999**	**2471**	**104**	**249**	**331**	**66**

Civic Plaza Electric Light AGI Cals:

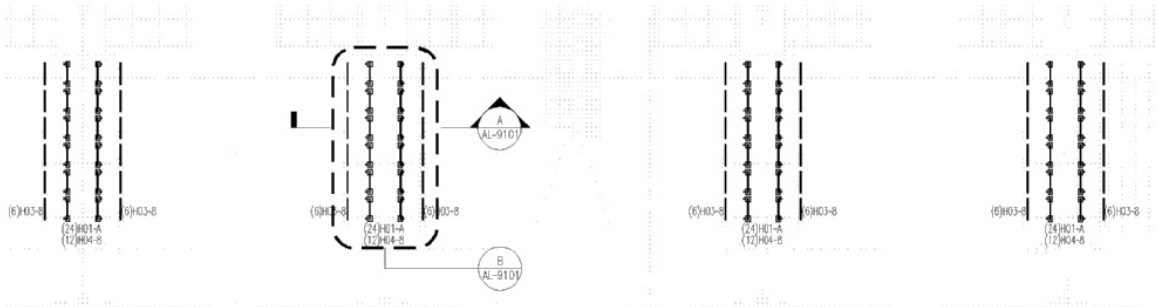
See attached document

Ticket Hall/ Passenger Check-in Counter Hall

- **Existing lighting systems**

  - Ticket canopy uplight
    - Structure surface mounted asymmetric uplight with (2) T6 metal halide, wattage to be announced.
  - Ticket counter
    - 8’ length pendant mounted direct/indirect linear fluorescent luminaire with (2) T8 lamp, lensed uplight and baffled downlight
  - Ticket counter, baggage line
    - 8’ length pendant mounted (integrated within signature) direct linear fluorescent luminaire with (1) T5 standard lamp, louvered downlight with very narrow 2” width

      - All fluorescent lighting in these zones are provided with dimmable ballasts and wall box dimmer control
      - All metal halide lamp equipped with electronic ballast.
      - All metal halides in this zone are not photocell controlled to turn OFF or dimmed at anytime.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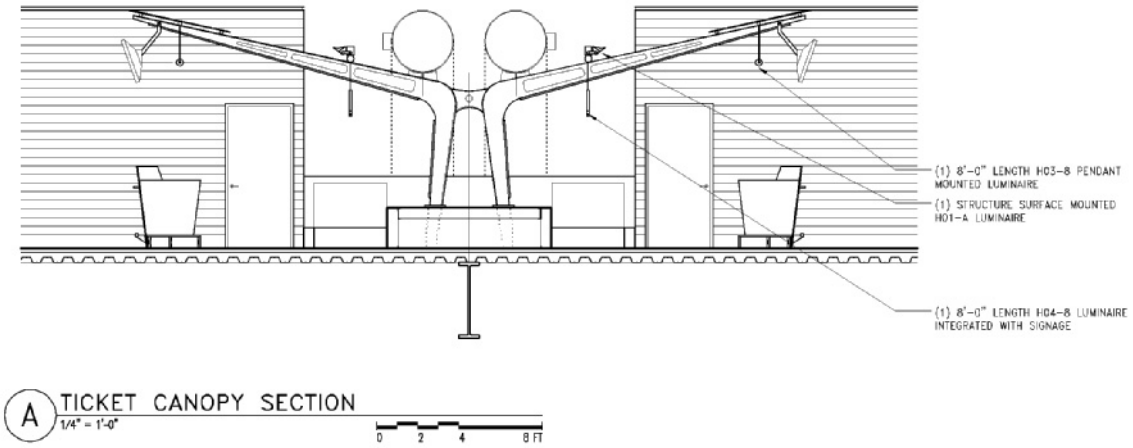
Ticket hall



Ticket canopy section

- **Design Criteria**

  - Appearance of space and luminaires is important that must ensure luminaires are properly integrated into signage and not interfere with VDT displays, as well as keeping a pleasing, non-clustered appearance.
  - Color appearance and color contrast is very important considering that an appropriate level of illuminance ratio should be established for the application of task lighting.
  - Direct glare is very important and must be avoided in order to provide maximum end user visual comfort.
  - Light distribution(uniformity) on surface is very important for this space because of the extensive task application is involved.
  - Points of interest is somewhat important, intuitively, the lighting function itself should be able to direct passenger to this location for check-in activities.
  - Reflected glare is very important, and should avoid it from occurring on VDT displays at check in counters as well as flight info screen areas.
  - Shadow issues is very important in this space since large amount of tasklighting are in place for its purposes, must avoid harsh/sharp obstructing shadows that interferes with task visibility.
  - Source/task/eye geometry is important that an appropriate angular relationship between the viewer, task(VDT displays) and the luminaire(signage luminaire) should be established.
  - Surface characteristic is very important and should be carefully consider when designing with structural elements that has coated a rather high reflectance paint that would increase specularity on the surface and help reduce the undesirable contrast of luminaires against their background.
  - A maximum of 1:10 illuminance ratio should be maintained for optimal task performance.

a. Check-in/ticket hall lighting power allowance is obtained from ASHRAE/IESNA Standard 90.1-1999, and they are assumed to be in the case of transportation category, with additional power allowance allowed.

Terminal - Ticket Counter	1.8 w/ft^2

b. Required illuminance level is obtained from the IES Lighting Handbook, 9th edition, and they are set to be

Illuminance category E- Performance of visual tasks of high contrast and small size	500 lx (50 fc)

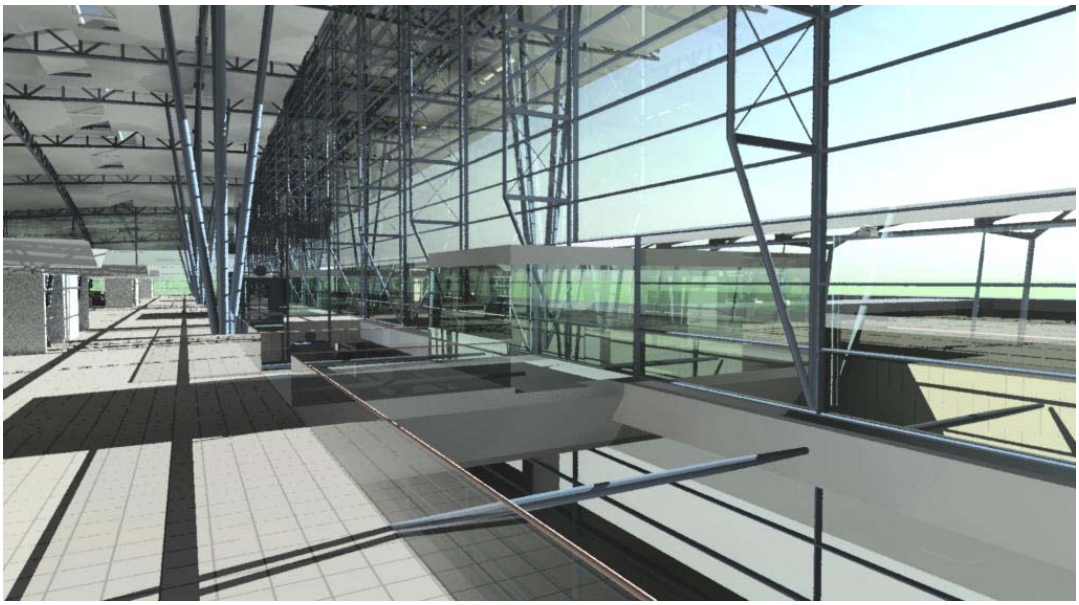
- **Daylighting Design Criteria**

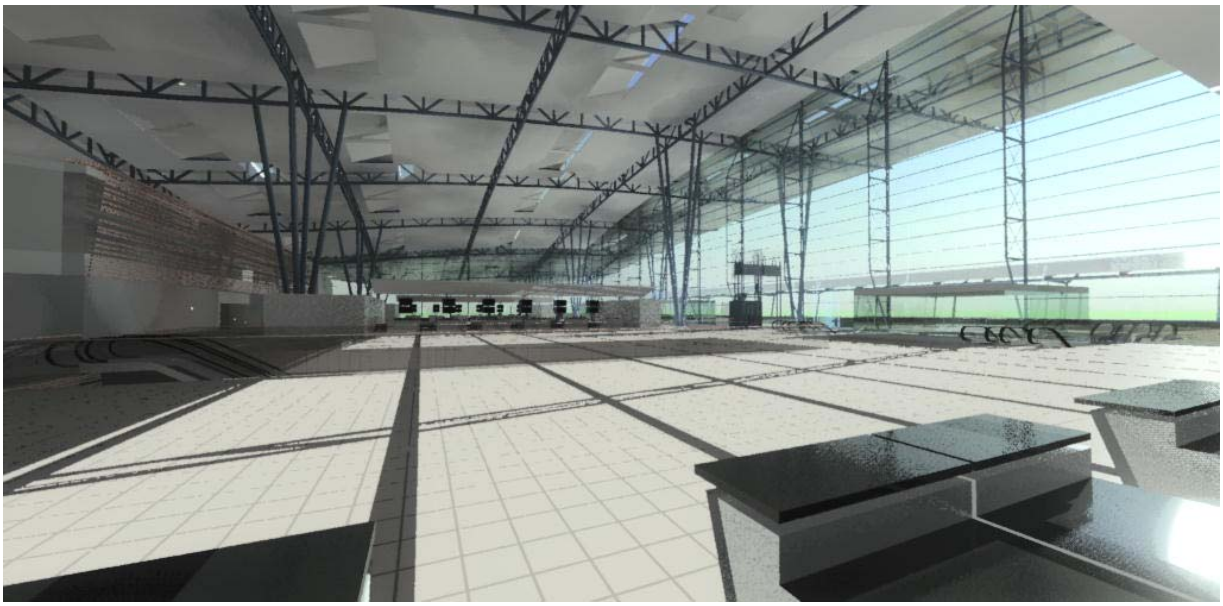
  - Quantity - Provide ambient lighting of at least 30fc over the entire workplane for the majority of the year under both clear and overcast skies
  - Quality - Use contrast ratios to add visual interest and to visually define the shape of the roof
  - Quality - Brighten dark areas of the ceiling to improve uniformity while maintaining acceptable contrast ratios on the ceiling
  - Quality - Create sparkle with instances of direct sunlight in selected areas on the ticketing floor, perhaps on the rear limestone wall or floor openings
  - Quality - Manage the contrast ratio created by the adjacency to Indy Place
  - Quality/Useability - Minimize glare and discomfort from direct light through south-west glazing
  - Useability/Integration - Minimize summertime solar heat gains / maximize wintertime solar heat gains to the occupied zones and appropriately with mechanical systems
  - Integration - Integrate skylights with structural system
  - Integration/Cost - Minimize cost and complexity of the daylighting design

- **Evaluation of Existing Lighting Condition**

  - The check-in/ticket hall consists of 96 check-in counters with extensive VDT displays' presence just about everywhere you turn within this space. The ticket canopy overhangs a VDT displays as well as a signage with a luminaire integrated into it. This design has greatly reduced the chance of having direct/reflected glare cast to/from the glass canopy as well as glares that could interfere the views toward the VDT displays. Linear fluorescent luminaries are utilized to ensure soft shadowing as well as uniformity of light distribution over the work plane. However, ticket canopy structure mounted uplight near the east side of the ticket hall can potentially cause light trespass and contribute light pollution toward the skylight, causing light leakage. Once again, possible reflected glare can also occur due to the high reflectance paint of the surround architectural/structural elements.
  - Possible LLF incurred: 0.8x0.8x0.98x0.8 = 0.5

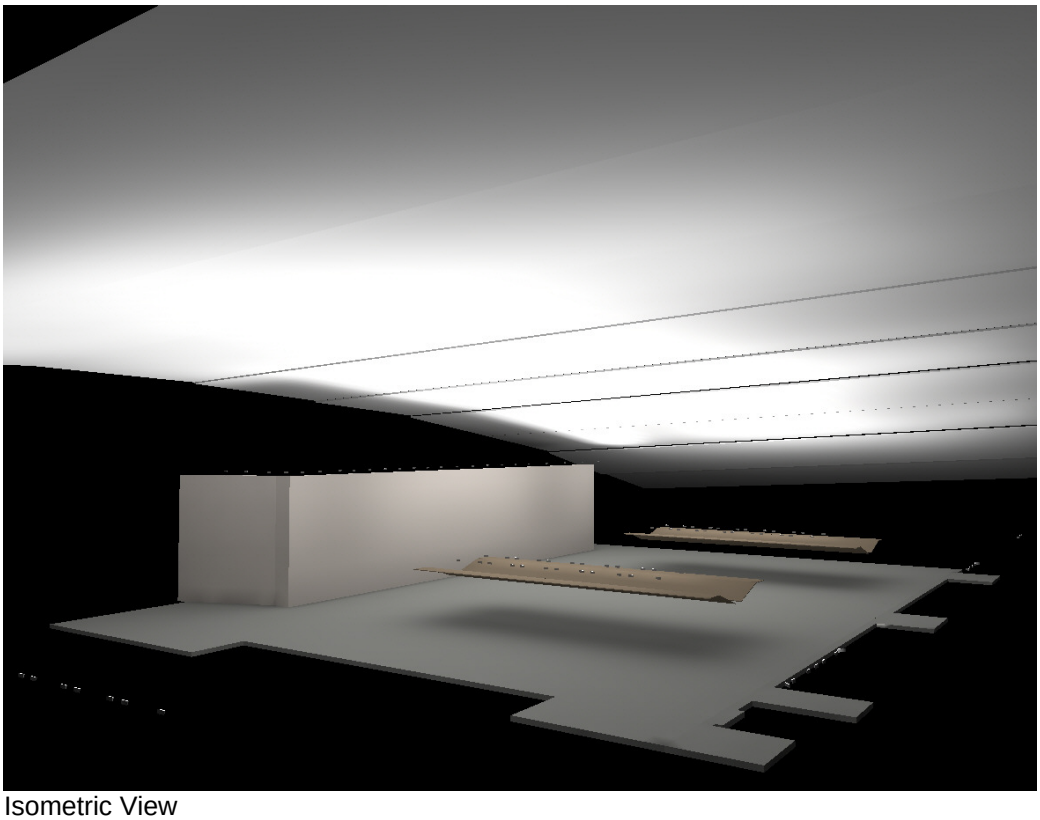
Ticket Hall Daylighting Study and Results



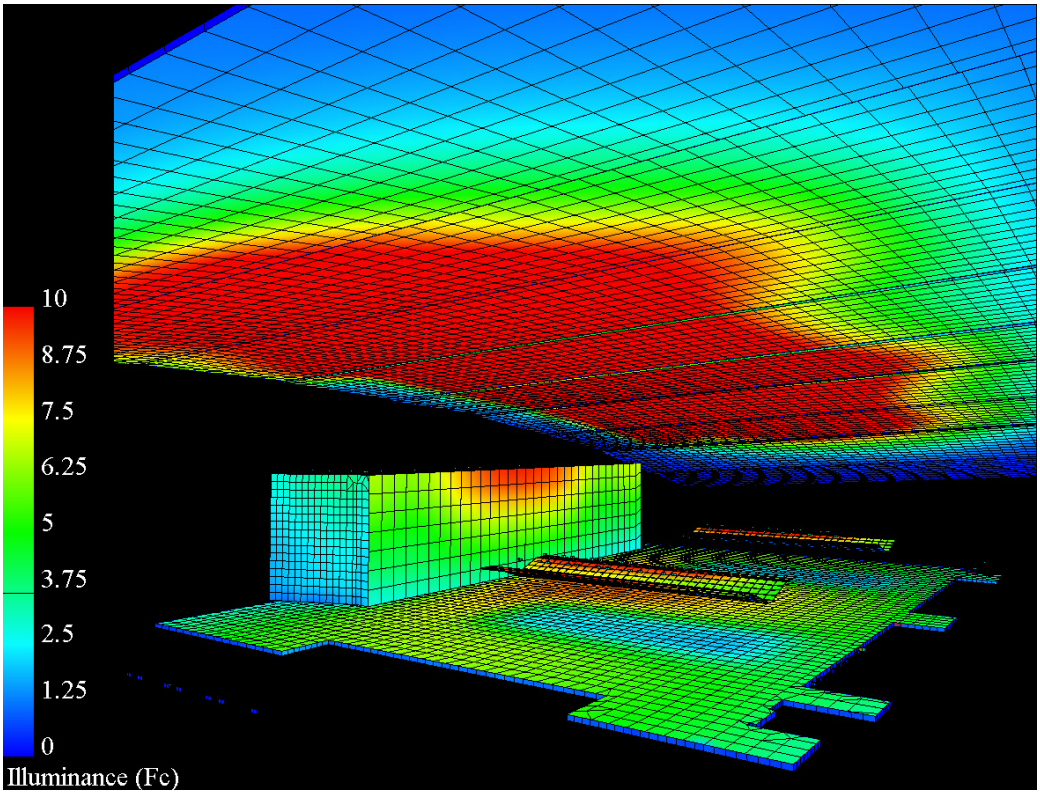


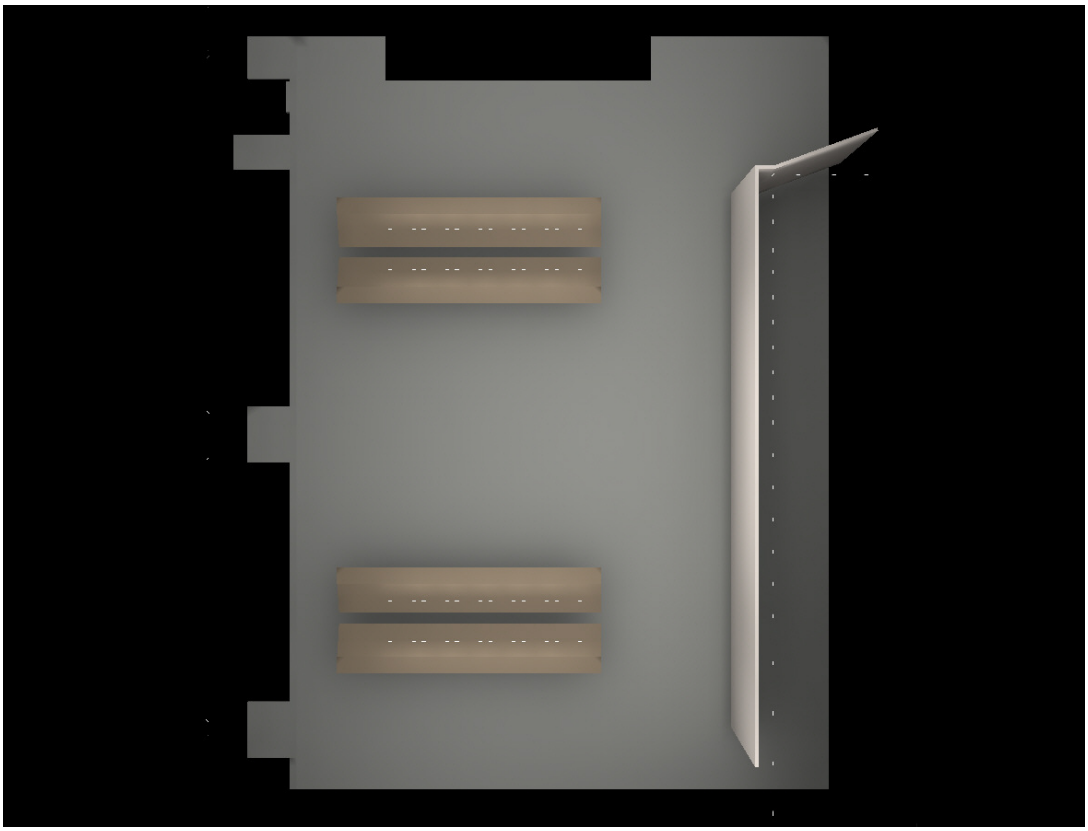
		Clear Sky				Cloudy Sky			
		Perimeter Average	Central Average	Total Avg	Max	Perimeter Average	Central Average	Total Avg	Max
Winter									
	8:00AM	12	9	10	21	3	4	4	5
	10:00AM	59	31	45	726	15	13	14	29
	12:00PM	95	61	78	1707	21	18	19	44
	2:00PM	401	88	245	2128	20	17	18	41
	4:00PM	304	293	298	846	12	11	11	22
	Average	**174**	**96**	**135**	**1086**	**14**	**12**	**13**	**28**
Equinox									
	8:00AM	57	25	41	445	12	11	12	26
	10:00AM	84	62	73	2452	25	22	24	56
	12:00PM	98	88	93	3591	32	27	30	68
	2:00PM	182	126	154	3504	32	27	29	69
	4:00PM	131	96	113	2127	24	20	22	54
	Average	**110**	**79**	**95**	**2424**	**25**	**21**	**23**	**55**
Summer									
	8:00AM	51	86	69	2010	22	19	20	44
	10:00AM	70	121	95	4536	34	28	31	72
	12:00PM	153	108	130	4822	40	33	37	93
	2:00PM	130	148	139	6671	39	33	36	88
	4:00PM	142	110	126	3458	31	26	29	70
	Average	**109**	**115**	**112**	**4299**	**33**	**28**	**31**	**73**
Annual Average		**126**	**92**	**109**	**2558**	**24**	**21**	**23**	**53**

Electric Lighting AGI Calculations and Results:

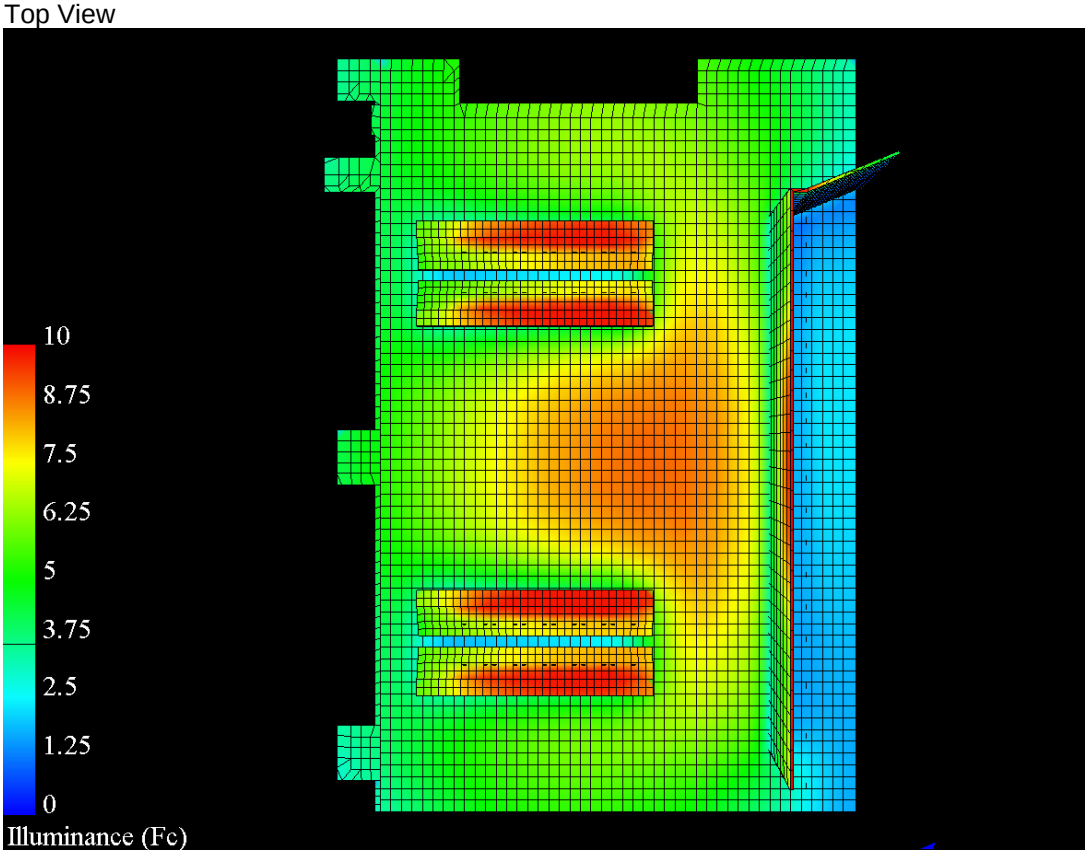


Isometric View





Top View

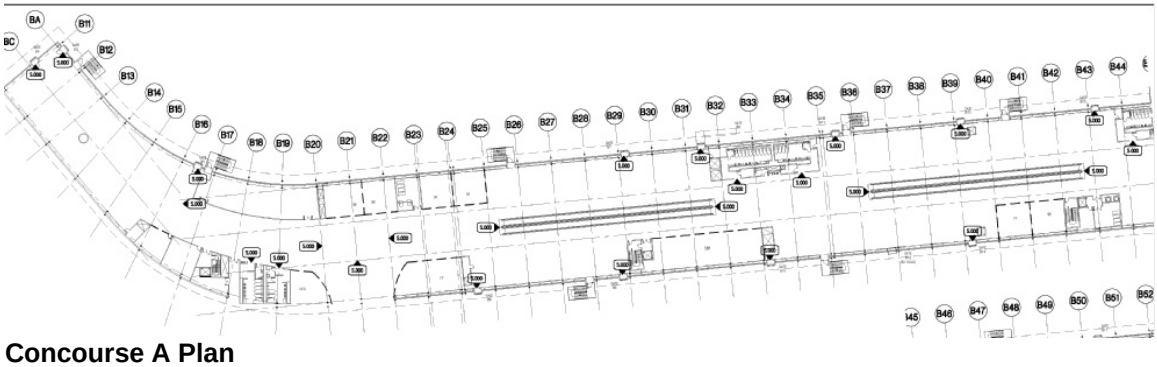


Passenger Concourse A/B

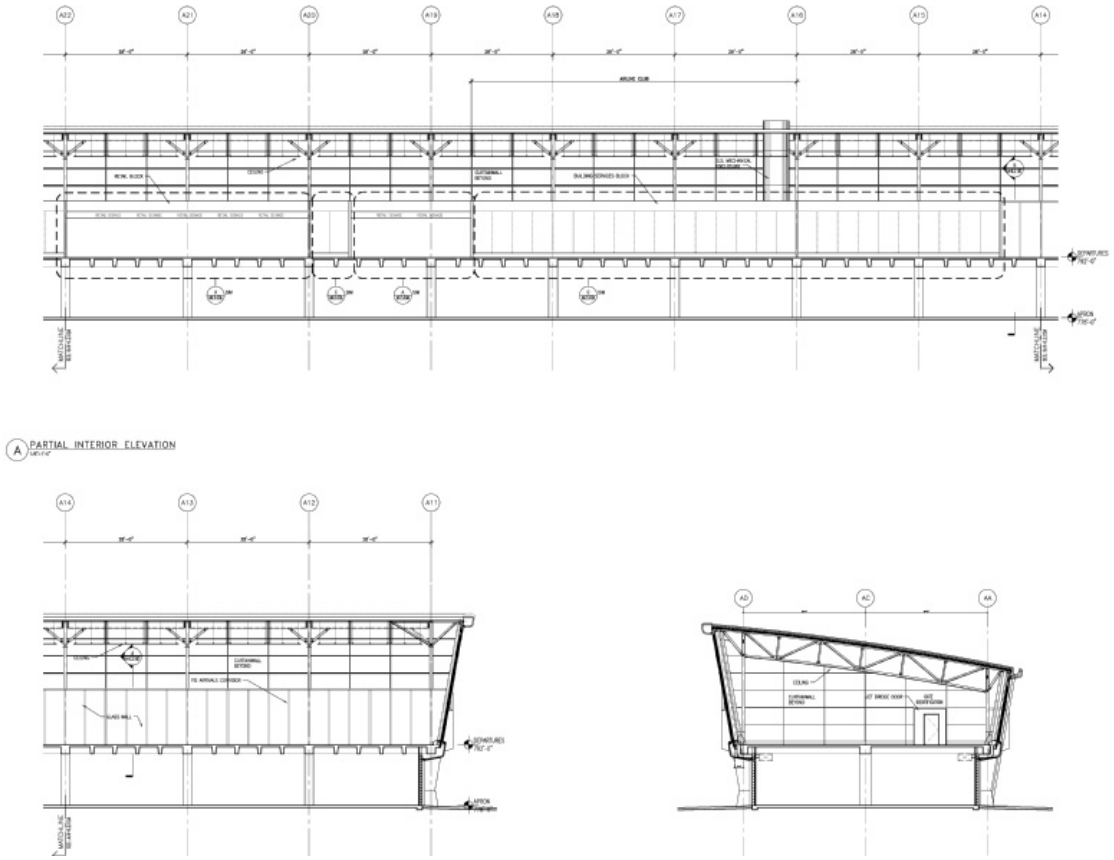
- **Existing lighting systems**

  - Concourse/Circulation
    - X' length recessed linear fluorescent louvered direct luminaire with 12" nominal width fixture housing (2) T8 lamps.
  - Concourse – perimeter(near curtain wall)
    - X' length pendant mounted linear fluorescent louvered direct luminaire with 12" nominal width fixture housing (2) T8 lamps.
  - Concourse ceiling – center circulation
    - Recessed adjustable metal halide downlight with (1) T6 lamp, wattage to be determined.
  - Concourse ceiling – perimeter circulation
    - Recessed adjustable metal halide downlight with (1) T6 lamp, wattage to be determined.

      - All metal halide downlight equipped with integral electronic ballast.
      - All interior metal halide lighting within 28' of curtainwall/glazing/glass shall be photocell controlled to turn "OFF" in dedicated zones of 50% on/off. Entire areas where metal halide lamping utilized are not intended to be completely extinguished at one time due to start-up/restrike times
      - All interior fluorescent lighting within 32' of curtainwall/glazing/glass are photocell controlled to dim automatically from 100% to 10%
      - All fluorescent lighting in these zones are provided with dimmable ballasts and wall box dimmer control
      - Occupancy sensor with no local override such as public restroom
      - Photocell control of dimmable electronic ballasts within the fixtures used primarily for daylight contribution, the lights will be turned on/off by the BMS then dim up/down during the day via the local phocells and dimmable electronic ballasts.



Concourse A Plan



Concourse elevation

- **Design Criteria**

  - Appearance of space and luminaires is important that must ensure luminaires are properly integrated into signage and not interfere with VDT displays, as well as keeping a pleasing, non-clustered appearance. Airport concourses is a highly stressful space to be dwell in, whether it is resulting from traveling fatigueness or flight delay frustration, it is important to create a highly comfortable and visually pleasing ambience.
  - Color appearance and color contrast is very important considering that an appropriate level of illuminance ratio should be established for the application of task lighting while maintaining an acceptable contrast ratio for resting/sleeping.
  - Direct glare is very important and must be avoided in order to provide maximum end user visual comfort; curtainwall must be properly shielded from direct sun glare.
  - Light distribution (uniformity) on surface is very important for this space because of the extensive task application is involved.
  - Reflected glare is very important, and should avoid it from occurring on VDT displays at check in counters as well as flight info screen areas.
  - Shadow issues is very important in this space since large amount of tasklighting are in place for its purposes, must avoid harsh/sharp obstructing shadows that interferes with task visibility.
  - Surface characteristic is very important and should be carefully consider when designing with structural elements that has coated a rather high reflectance paint that would increase specularity on the surface and help reduce the undesirable contrast of luminaires against their background.

- Vertical illuminance
- System control flexibility is highly important, due to the need to constantly adjust the light level with the outside weather or to switch between preset appearance of the space for passenger comfort.
- A maximum of 1:10 illuminance ratio should be maintained for optimal task performance.

a. Concourse lighting power allowance is obtained from ASHRAE/IESNA Standard 90.1-1999, and they are assumed to be in the case of transportation category, with additional power allowance allowed.

Airport - Concourse	0.7 w/ft^2

b. Required illuminance level is obtained from the IES Lighting Handbook, 9th edition, and they are set to be

Illuminance category D- Performance of visual tasks of high contrast and large size	300 lx (30 fc)

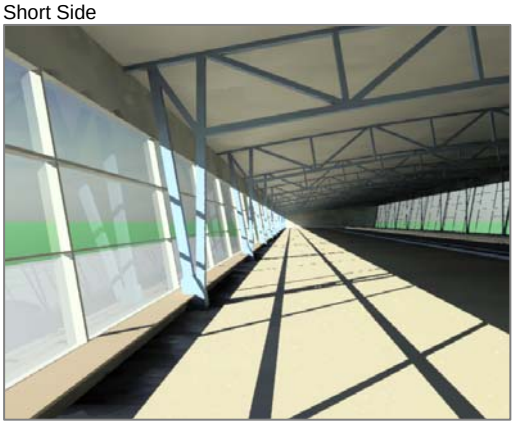
- **Daylighting Design Criteria**

  - Minimize heat gains throughout the year.
  - Provide ambient lighting requirements of 30 fc for the perimeter zones of the concourses. This is a 45' deep zone on the high side of the concourses and a 25' deep zone on the low side of the concourses.
  - Minimize glare and large contrast ratios throughout the year.
  - Provide a uniform daylight distribution, balancing with electric lighting if necessary to create a uniform luminous environment.
  - Minimize cost and complexity of the daylighting design while maintaining quality.

- **Evaluation of Existing Lighting Condition**
  - Airport concourses is a highly stressful space for occupants to be dwelling in, whether it is resulting from traveling fatigueness or flight delay frustration, it is important to create a highly comfortable and visually pleasing ambience. With this in mind, the flexibility of control is very essential, since accommodating passengers' comfort can change drastically from one hour to another. The design of the control system has met the requirement for flexibility and adaptability considering that all lighting equipments are to a central BMS that has different lighting condition under preset scenarios. Recessed linear fluorescent luminaries are also in used to achieve an indirect, soothing ambient for the main concourse circulatory area. Visual comfort also means direct/reflected glare should be avoided at all time; this means the proper shielding of the curtain wall would do the job. Wherever there're task areas, linear fluorescent luminaries are utilized to ensure soft shadowing as well as uniformity of light distribution over the task work plane.
  - Possible LLF incurred: 0.8x0.8x0.98x0.8 = 0.5

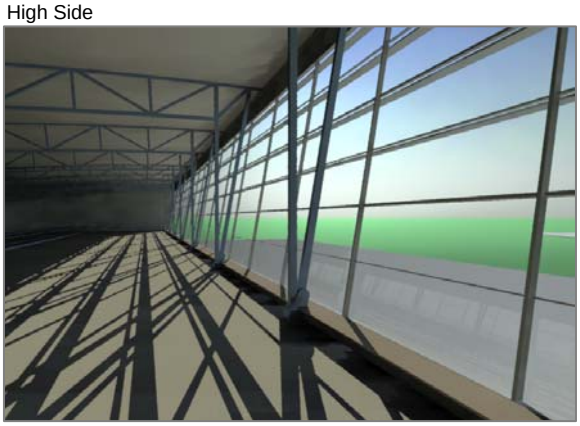
Daylighting Study and Results (Concourse B only):

Short Side

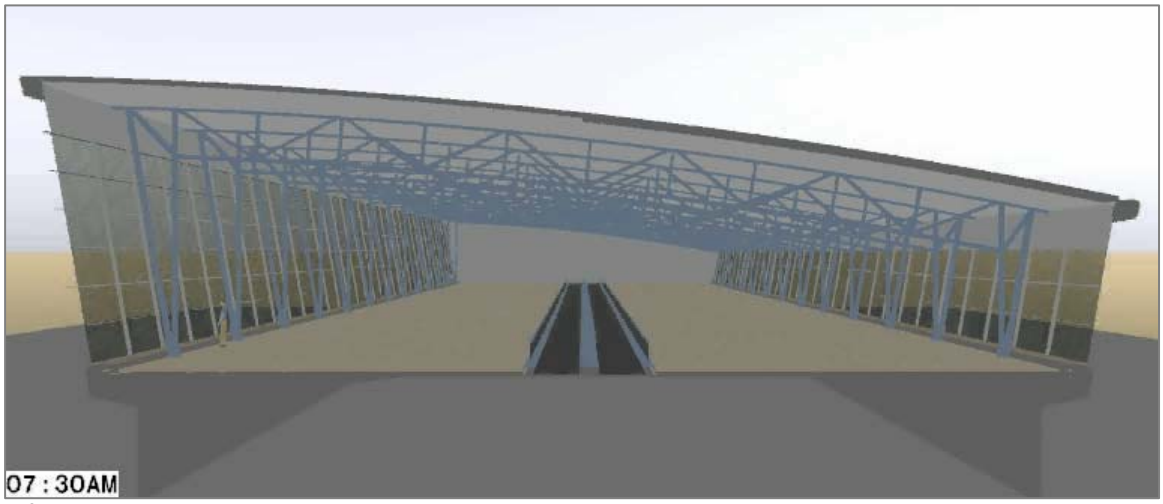


Summer, 6:00 PM

High Side



Summer, 7:00 AM



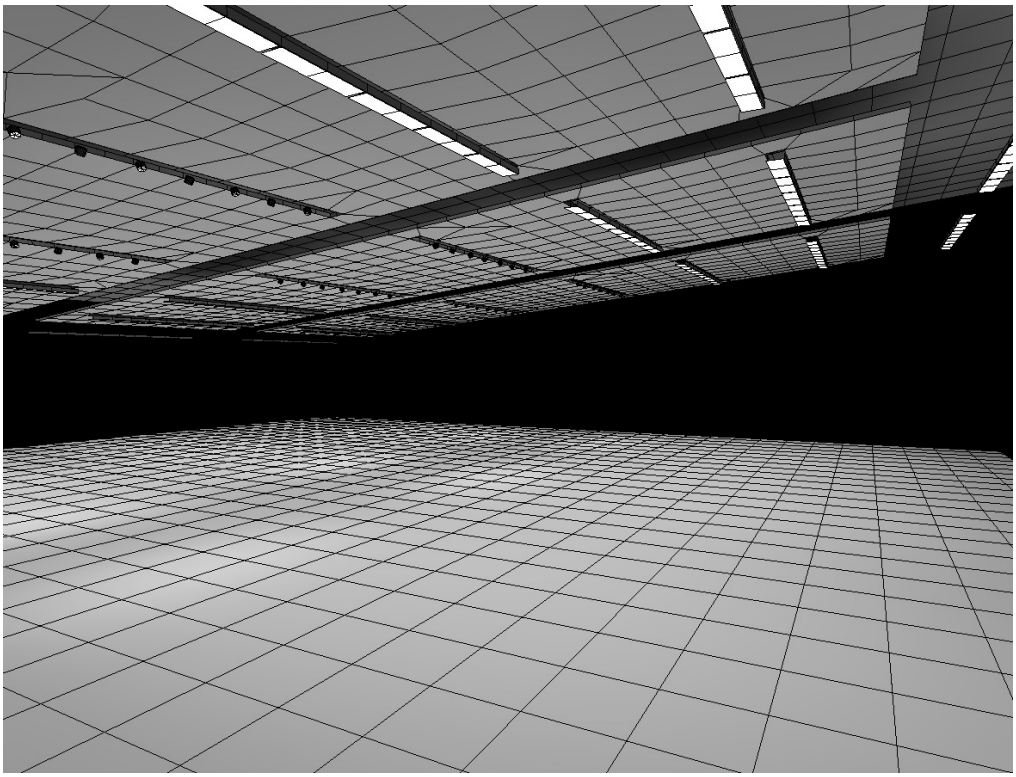
Winter

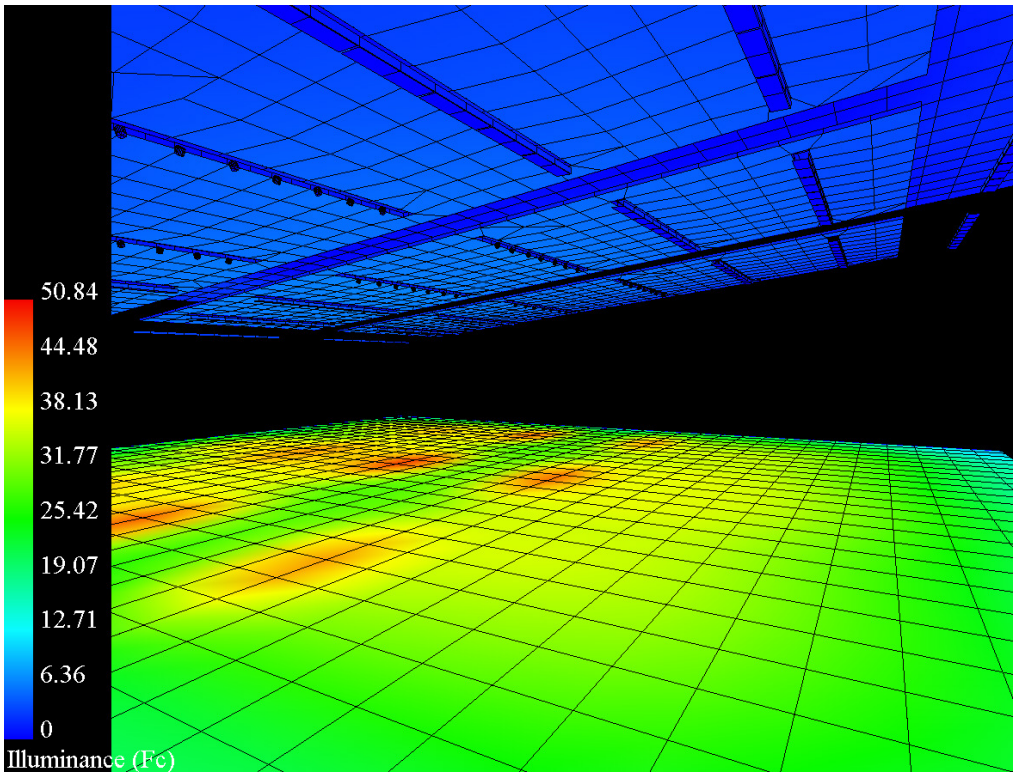
Summer

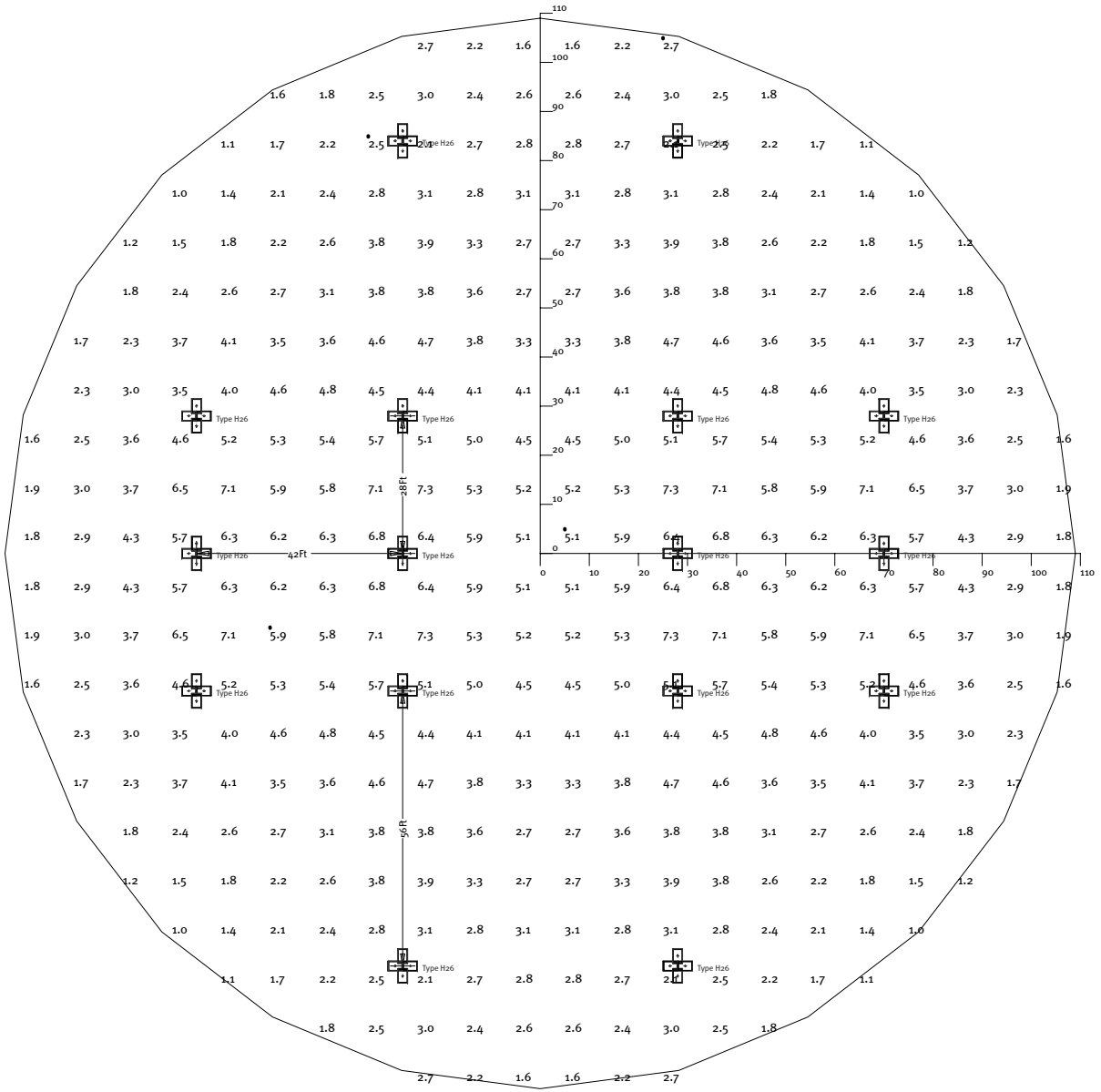
	Clear Sky			Cloudy Sky		
	High Perimeter Average	Center Average	Low Perimeter Average	High Perimeter Average	Center Average	Low Perimeter Average
Winter						
8:00 AM	24	15	16	0	0	0
10:00 AM	556	451	274	23	11	18
12:00 PM	807	213	89	35	18	28
2:00 PM	377	75	53	33	16	25
4:00 PM	37	22	28	17	8	13
6:00 PM	4	3	5	0	0	0
Average	301	130	77	18	9	14
Equinox						
8:00 AM	334	246	150	18	9	14
10:00 AM	903	163	93	43	22	34
12:00 PM	431	119	81	57	30	46
2:00 PM	145	80	77	57	28	45
4:00 PM	71	50	67	40	20	33
6:00 PM	26	26	117	14	7	11
Average	318	114	98	38	19	30
Summer						
8:00 AM	349	80	58	38	19	29
10:00 AM	451	97	75	61	31	48
12:00 PM	182	103	95	74	37	57
2:00 PM	137	90	109	72	35	55
4:00 PM	78	65	106	57	28	44
6:00 PM	49	64	437	31	16	24
Average	208	83	147	55	28	43
Annual Average	276	109	107	37	19	29

Electric Lighting AGI Calculations:

See attached document at last page for Results




50.84
44.48
38.13
31.77
25.42
19.07
12.71
6.36
0
Illuminance (Fc)



Luminaire Location Summary						
Project: Indianapolis Airport - Civic Plaza						
SeqNo	Label	X	Y	Z	Orient	Tilt
7	Type H26	-70	-28	17.1	0	0
8	Type H26	-70	0	17.1	0	0
9	Type H26	-70	28	17.1	0	0
10	Type H26	-28	-28	17.1	0	0
11	Type H26	-28	0	17.1	0	0
12	Type H26	-28	28	17.1	0	0
13	Type H26	28	-28	17.1	0	0
14	Type H26	28	0	17.1	0	0
15	Type H26	28	28	17.1	0	0
16	Type H26	70	-28	17.1	0	0
17	Type H26	70	0	17.1	0	0
18	Type H26	70	28	17.1	0	0
19	Type H26	-28	-84	17.1	0	0
20	Type H26	-28	84	17.1	0	0
21	Type H26	28	-84	17.1	0	0
22	Type H26	28	84	17.1	0	0

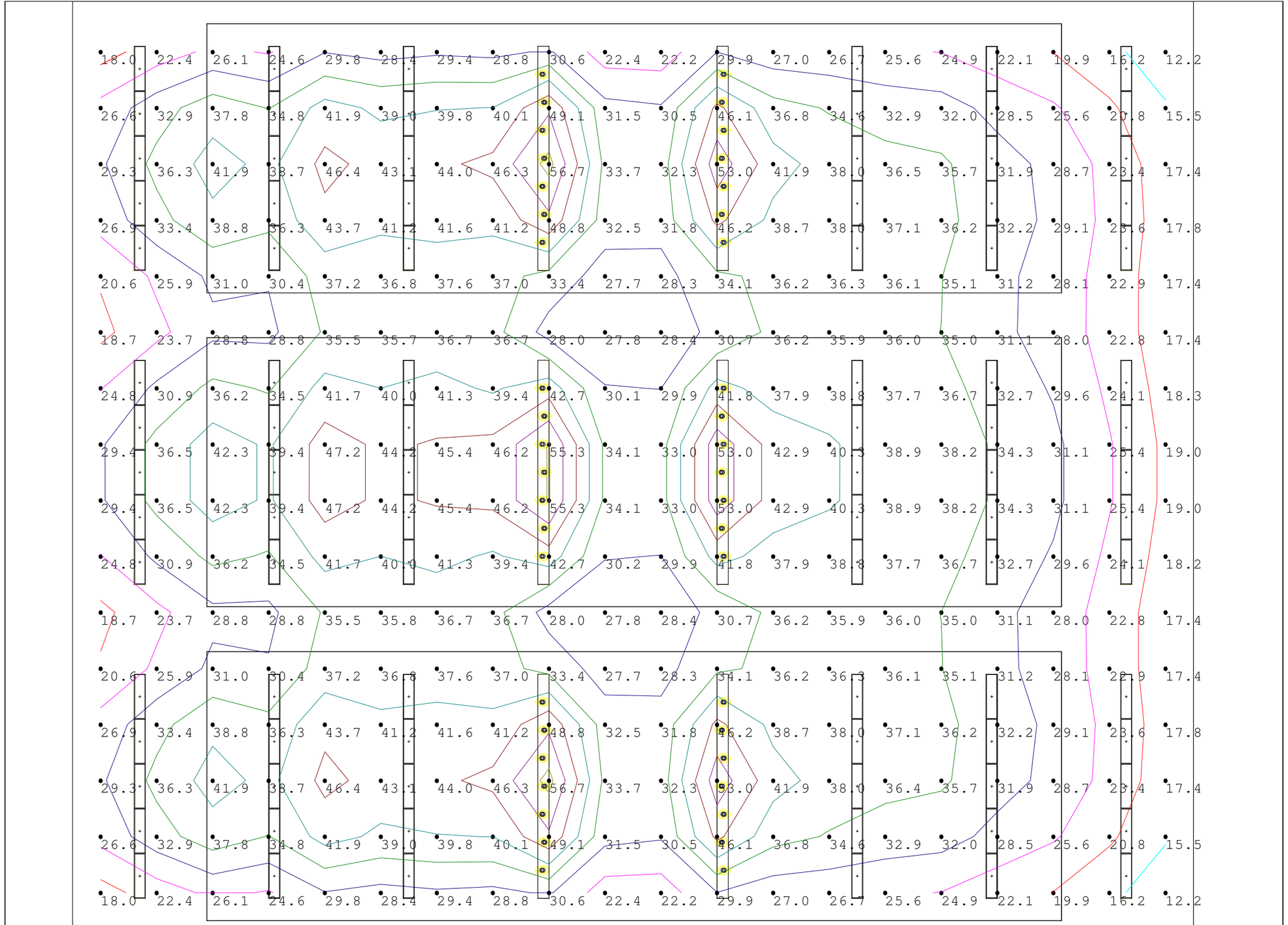
Expanded Luminaire Location Summary						
Project: Indianapolis Airport - Civic Plaza						
SeqNo	Label	X	Y	Z	Orient	Tilt
7	Campo 450-L	-70	-26	13.1	90	0
7	Campo 450-L	-70	-30	13.1	270	0
7	Campo 450-H	-68.5	-28	17.1	0	0
7	Campo 450-H	-71.5	-28	17.1	180	0
8	Campo 450-L	-70	2	13.1	90	0
8	Campo 450-L	-70	-2	13.1	270	0
8	Campo 450-H	-68.5	0	17.1	0	0
8	Campo 450-H	-71.5	0	17.1	180	0
9	Campo 450-L	-70	30	13.1	90	0
9	Campo 450-L	-70	26	13.1	270	0
9	Campo 450-H	-68.5	28	17.1	0	0
9	Campo 450-H	-71.5	28	17.1	180	0
10	Campo 450-L	-28	-26	13.1	90	0
10	Campo 450-L	-28	-30	13.1	270	0
10	Campo 450-H	-26.5	-28	17.1	0	0
10	Campo 450-H	-29.5	-28	17.1	180	0
11	Campo 450-L	-28	2	13.1	90	0
11	Campo 450-L	-28	-2	13.1	270	0
11	Campo 450-H	-26.5	0	17.1	0	0
11	Campo 450-H	-29.5	0	17.1	180	0
12	Campo 450-L	-28	30	13.1	90	0
12	Campo 450-L	-28	26	13.1	270	0
12	Campo 450-H	-26.5	28	17.1	0	0
12	Campo 450-H	-29.5	28	17.1	180	0
13	Campo 450-L	28	-26	13.1	90	0
13	Campo 450-L	28	-30	13.1	270	0
13	Campo 450-H	29.5	-28	17.1	0	0
13	Campo 450-H	26.5	-28	17.1	180	0
14	Campo 450-L	28	2	13.1	90	0
14	Campo 450-L	28	-2	13.1	270	0
14	Campo 450-H	29.5	0	17.1	0	0
14	Campo 450-H	26.5	0	17.1	180	0
15	Campo 450-L	28	30	13.1	90	0
15	Campo 450-L	28	26	13.1	270	0
15	Campo 450-H	29.5	28	17.1	0	0
15	Campo 450-H	26.5	28	17.1	180	0
16	Campo 450-L	70	-26	13.1	90	0
16	Campo 450-L	70	-30	13.1	270	0
16	Campo 450-H	71.5	-28	17.1	0	0
16	Campo 450-H	68.5	-28	17.1	180	0
17	Campo 450-L	70	2	13.1	90	0
17	Campo 450-L	70	-2	13.1	270	0
17	Campo 450-H	71.5	0	17.1	0	0
17	Campo 450-H	68.5	0	17.1	180	0
18	Campo 450-L	70	30	13.1	90	0
18	Campo 450-L	70	26	13.1	270	0
18	Campo 450-H	71.5	28	17.1	0	0
18	Campo 450-H	68.5	28	17.1	180	0
19	Campo 450-L	-28	-82	13.1	90	0
19	Campo 450-L	-28	-86	13.1	270	0
19	Campo 450-H	-26.5	-84	17.1	0	0
19	Campo 450-H	-29.5	-84	17.1	180	0
20	Campo 450-L	-28	86	13.1	90	0
20	Campo 450-L	-28	82	13.1	270	0
20	Campo 450-H	-26.5	84	17.1	0	0
20	Campo 450-H	-29.5	84	17.1	180	0
21	Campo 450-L	28	-82	13.1	90	0
21	Campo 450-L	28	-86	13.1	270	0
21	Campo 450-H	29.5	-84	17.1	0	0
21	Campo 450-H	26.5	-84	17.1	180	0
22	Campo 450-L	28	86	13.1	90	0
22	Campo 450-L	28	82	13.1	270	0
22	Campo 450-H	29.5	84	17.1	0	0
22	Campo 450-H	26.5	84	17.1	180	0

Numeric Summary							
Project: Indianapolis Airport - Civic Plaza							
Label	CalcType	Units	Avg	Max	Min	Avg/Min	Max/Min
Civic Plaza	Illuminance	Fc	3.63	7.3	1.0	3.63	7.30

Civic Plaza Calculation

Actual results may vary due to line voltage variances, site conditions, obstructions, and manufacturing tolerances of lamps and ballasts.

Luminaire Schedule						
Project: Indianapolis Airport - Civic Plaza						
Symbol	Qty	Label	Arrangement	Lumens	LLF	Description
	16	Type H26	GROUP	N.A.	0.723	Campo 450 - 150w CMH - TD7 lamp, RX7s double-ended lamp; Sail aimed @ 30°



Luminaire Schedule						
Project: All Projects						
Symbol	Qty	Label	Arrangement	Lumens	LLF	Description
	90	H52+53	SINGLE	5900	0.729	P82-1T8-04-SPL
	42	H58+59	SINGLE	6200	0.729	M4T6-4950LI

Concourse Calculation

Numeric Summary							
Project: All Projects							
Label	CalcType	Units	Avg	Max	Min	Avg/Min	Max/Min
CalcPts	Illuminance	Fc	33.28	56.7	12.2	2.73	4.65