Pavement Design and Construction of Taxilane “S” to Accommodate New Large Aircraft at LAX

Katie Chou, Ph.D., P.E.
Hatch Mott MacDonald, Los Angeles Office

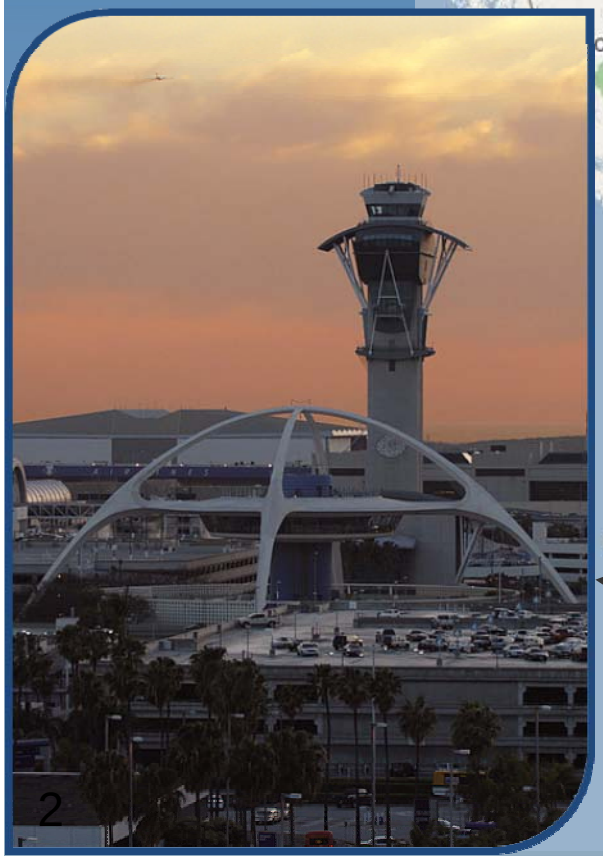
Presented to: 2011 SWIFT Conference, Montreal
Date: September 12, 2011

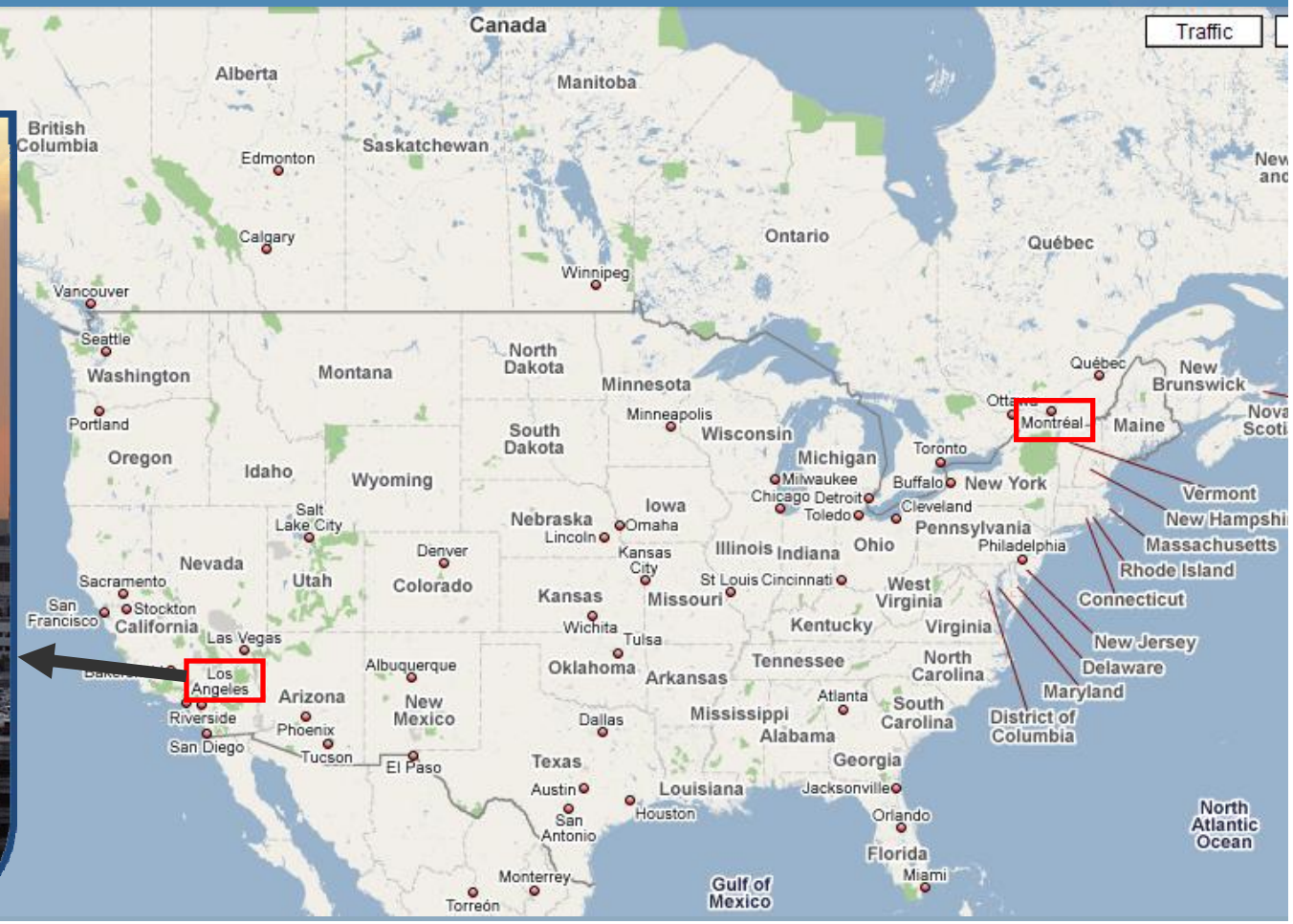
Presentation Outline

- Background and Program Overview
- Key Elements of Taxilane “S” Project
- Airfield Pavement Design
- Selective Results of Sensitivity Analyses
- Mix Design - FAA P-501 Concrete
- Mix Design - FAA P-306 Econocrete
- Site and Construction Photos

Background

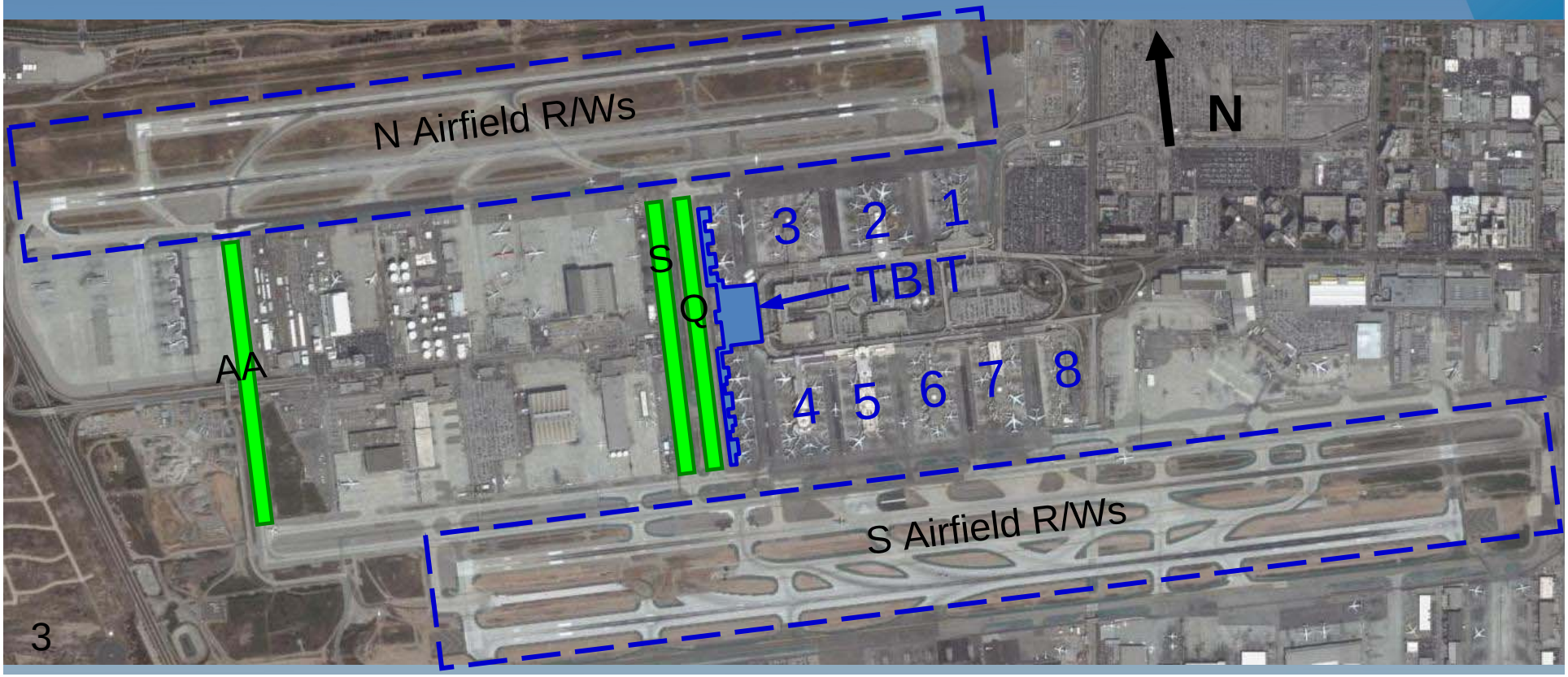
- 6th busiest A/P (world) w/ 58,915,100 passengers (10)
- 3rd busiest A/P (passenger traffic) in the US
- 2nd busiest A/P (**international** passenger) in the US





LAX (2008)

- 2 Parallel Runway Systems
- 3 Crossfield Taxiways
- 9 Terminals; Tom Bradley International Terminal (TBIT)
- One A380 flight daily

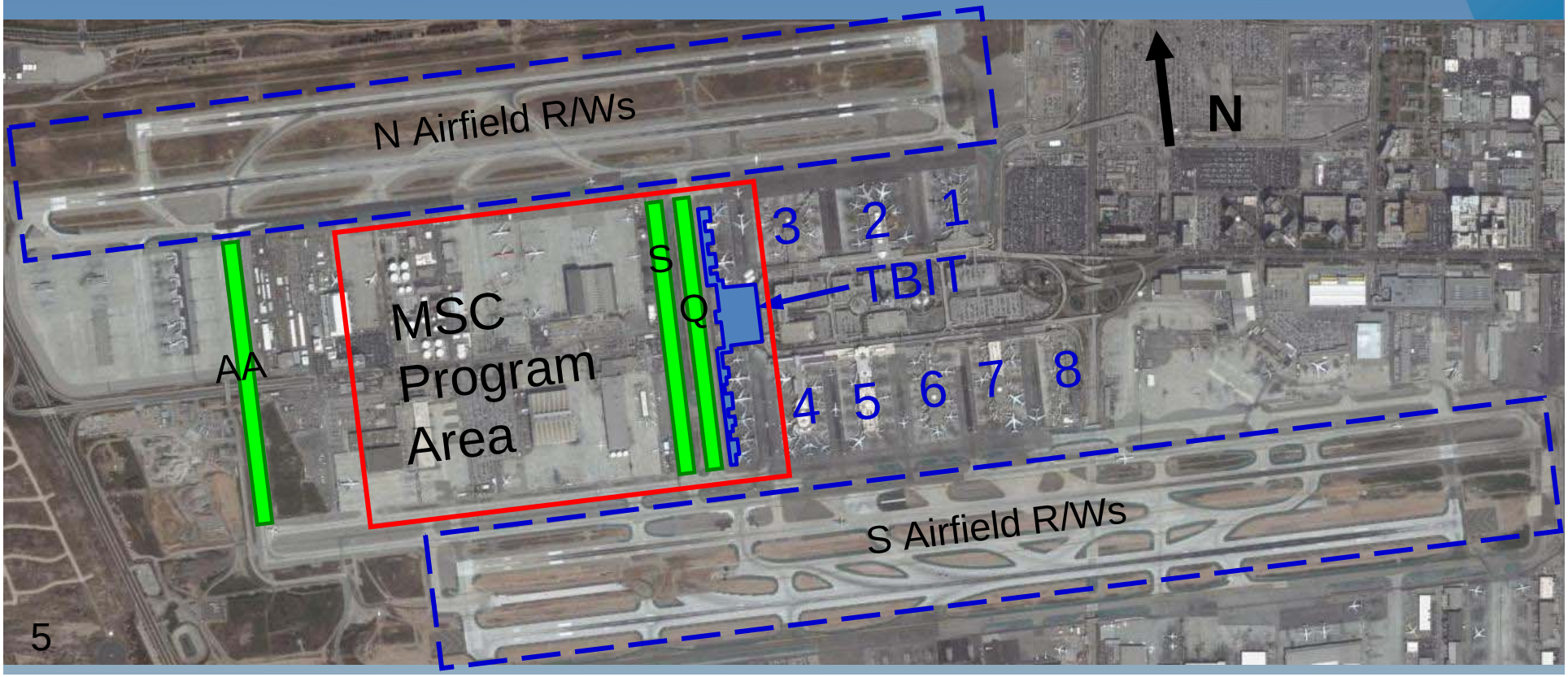


Challenges for LAX (2008)

- Aged infrastructure
- 14 A380 flights daily in 2013

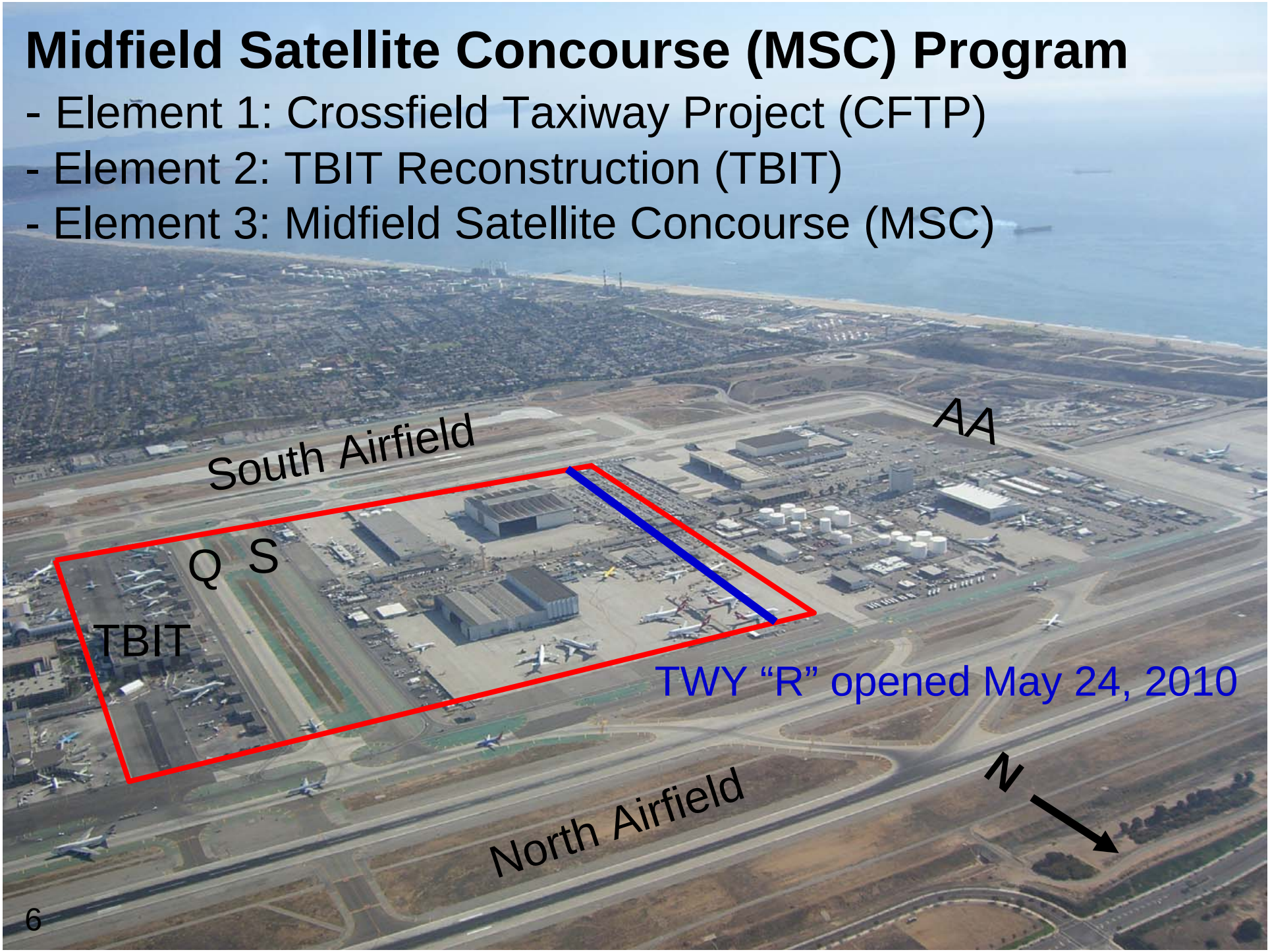
Challenges for LAX (Cont.)

- Stay competitive/ retain airlines
- Midfield Satellite Concourse (MSC) Program Group VI (Code F) infrastructure



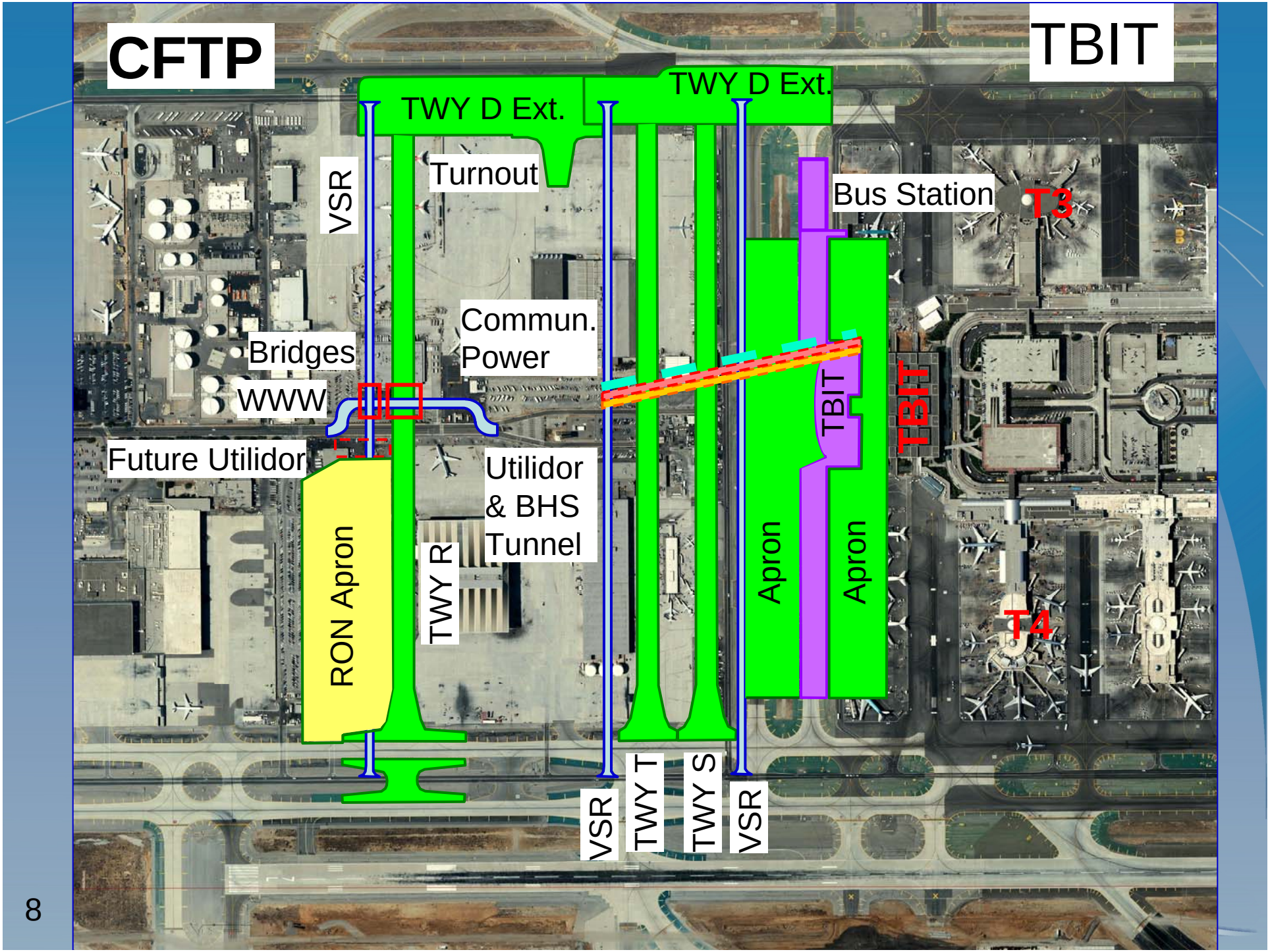
Midfield Satellite Concourse (MSC) Program

- Element 1: Crossfield Taxiway Project (CFTP)
- Element 2: TBIT Reconstruction (TBIT)
- Element 3: Midfield Satellite Concourse (MSC)

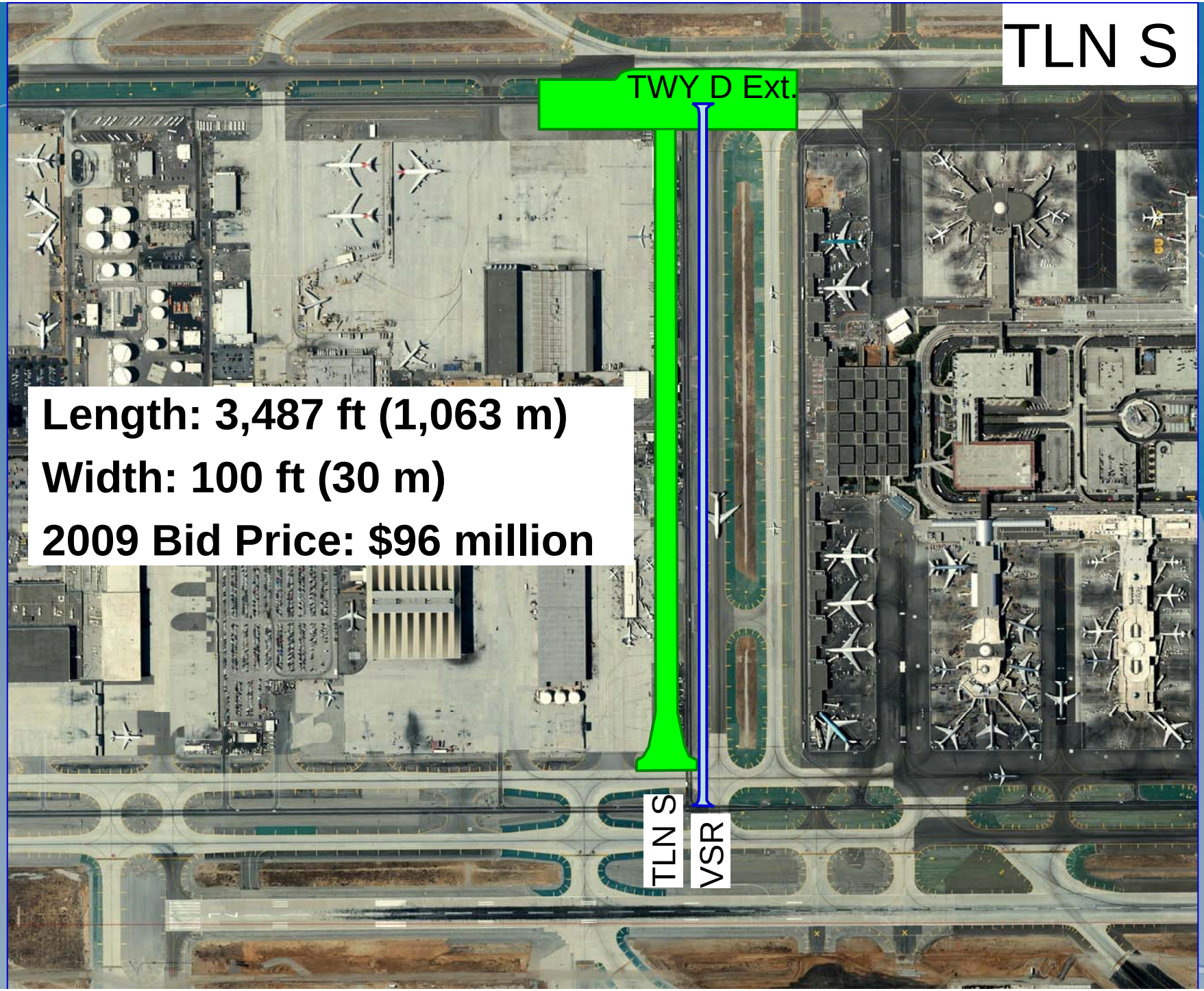


Presentation Outline

- Background and Program Overview
- √ Key Elements of Taxilane “S” Project
- Airfield Pavement Design
- Selective Results of Sensitivity Analyses
- Mix Design - FAA P-501 Concrete
- Mix Design - FAA P-306 Econocrete
- Site and Construction Photos


CFTP
TBIT
TWY D Ext.
TWY D Ext.
Turnout
VSR
Bus Station
T3
Commun.
Power
Bridges
WWW
TBIT
TBIT
Future Utilidor
Utilidor
& BHS
Tunnel
RON Apron
TWY R
Apron
Apron
T4
VSR
TWY T
TWY S
VSR

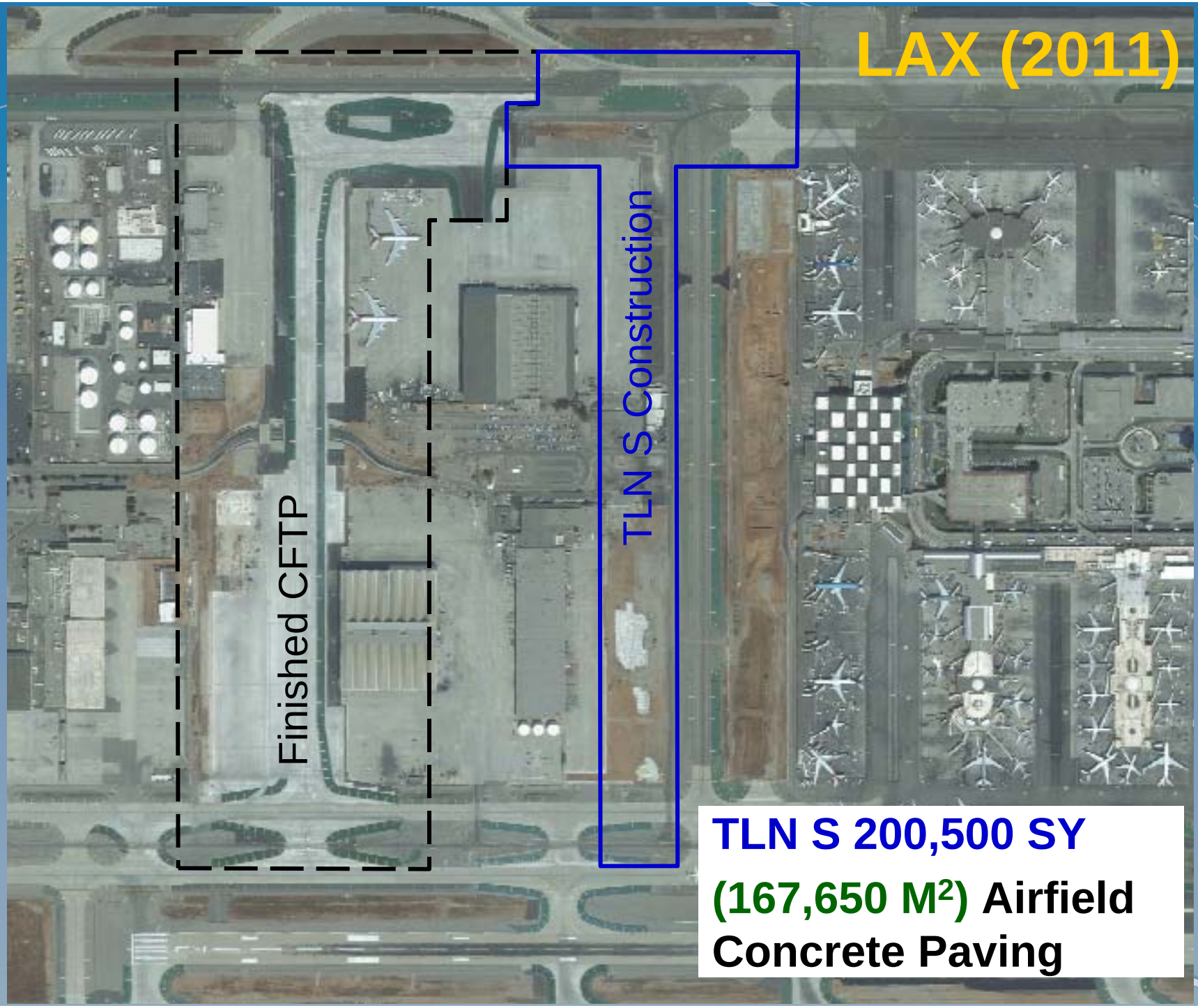
TLN S



Length: 3,487 ft (1,063 m)

Width: 100 ft (30 m)

2009 Bid Price: $96 million


LAX (2011)
Finished CFTP
TLN S Construction
TLN S 200,500 SY
(167,650 M²) Airfield
Concrete Paving

Presentation Outline

- Background and Program Overview
- Key Elements of Taxilane “S” Project
- Airfield Pavement Design
- Selective Results of Sensitivity Analyses
- Mix Design - FAA P-501 Concrete
- Mix Design - FAA P-306 Econocrete
- Site and Construction Photos

Design Traffic

% of Runway Traffic / Aircraft Mix		Average Annual Departures					
		20-year Design (2010 ~ 2030)			40-year Design (2010 ~ 2050)		
		100%	75%	50%	100%	75%	50%
Heavy Jets	A380	1,798	1,348	899	2,316	1,737	1,158
	B747-400	20,402	15,301	10,201	26,284	19,713	13,142
	MD-10 etc	5,432	4,074	2,716	6,999	5,249	3,499
	A340 Series	1,456	1,092	728	1,876	1,407	938
	B777-200ER	5,407	4,055	2,704	6,966	5,225	3,483
	B767 Series	32,721	24,540	16,360	42,155	31,616	21,077
Light Jets	B757-200	31,344	23,508	15,672	40,381	30,286	20,191
	B737 Series	16,912	12,684	8,456	21,789	16,341	10,894
	MD-80 Series	12,494	9,371	6,247	16,096	12,072	8,048
	MD-90	801	601	401	1,032	774	516
	A320	16,778	12,583	8,389	21,616	16,212	10,808
	DC-9 Series	854	641	427	1,100	825	550
	Bombardier	16,025	12,018	8,012	20,645	15,483	10,323
	Gulfstream G-4	636	477	318	819	614	410
	Embraer 145XR	1,039	779	519	1,338	1,004	669

TLN S Pavement Design - Subgrade Soils

- 32 borings drilled
- Logs indicate:

  subgrade soils

  are SM, SP or SP-SM

TLN S Pavement Design – Design K Value

- California Bearing Ratio (CBR)
- Correlation Eq.:

$$k = \left[\frac{1500 \times CBR}{26}\right]^{0.7788}$$

	CBR (90% RC)	CBR (95% RC)	CBR (100% RC)
Mean	8	28.6	58.67
Standard Deviation, STD	1	7.57	25.21
CBR (85% Reliability)	6.96	20.75	32.54
Estimated k	106 pci (28.8 MPa/m)	249 pci (67.6 MPa/m)	354 pci (96.1 MPa/m)

Design K (baseline) = 200 pci (54.3 MPa/m)

TLN S Pavement Design – Other Design Inputs

Los Angeles World Airports: 40-year Design Life

Parametric Study Table

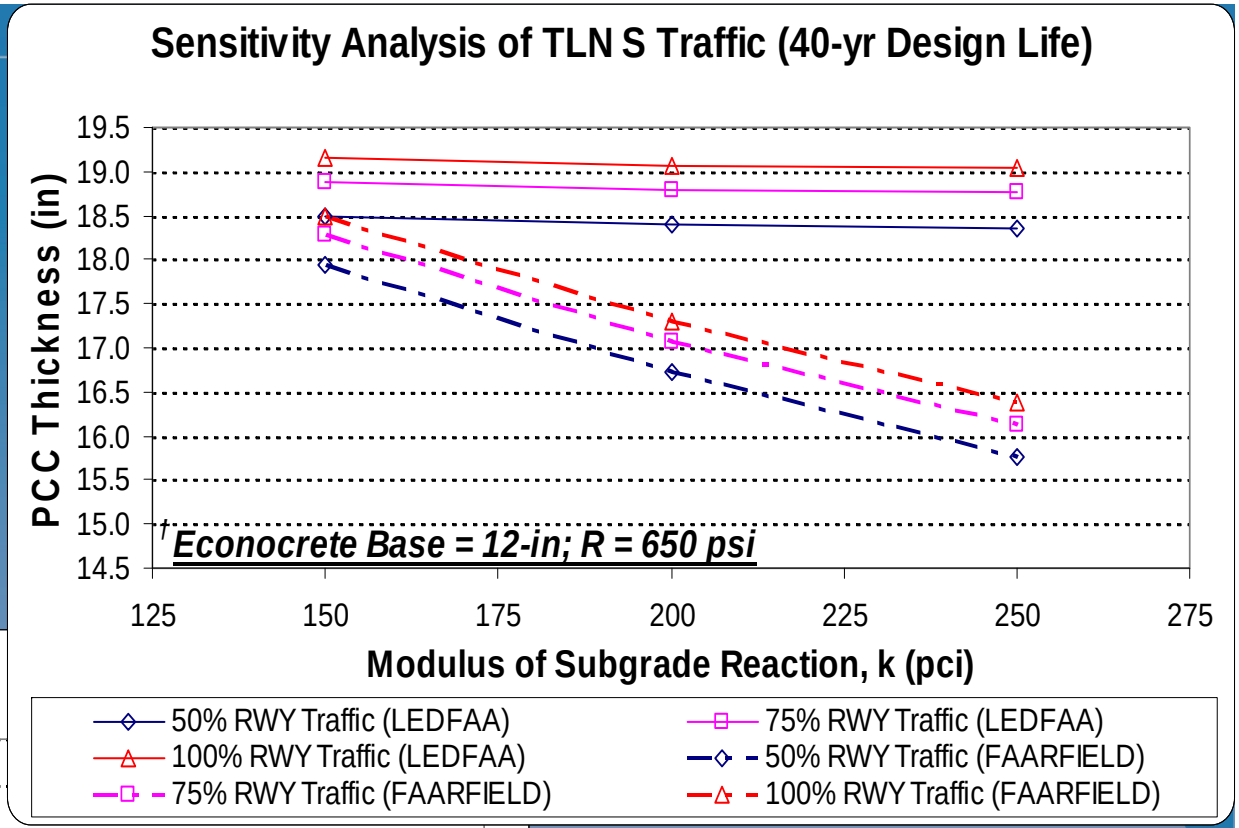
Design Program	LEDFAA 1.3; FAARFIELD v1.302
Design Life, years	20, 40
Design Traffic, % of Runway Traffic	100% (baseline), 75%, 50%
Modulus of Subgrade Reaction, k, pci (MPa/m)	150, 200 (baseline), 250 28.8, 67.6 (baseline), 96.1
Concrete Flexural Strength, R, psi (MPa)	650 (baseline), 675, 700 4.485 (baseline), 4.658, 4.83
Base Course Material	Econocrete (baseline), CTB
Base Course Thickness, inch (mm)	4, 6, 8, 10, 12 (baseline) 100, 150, 200, 250, 300 (baseline)

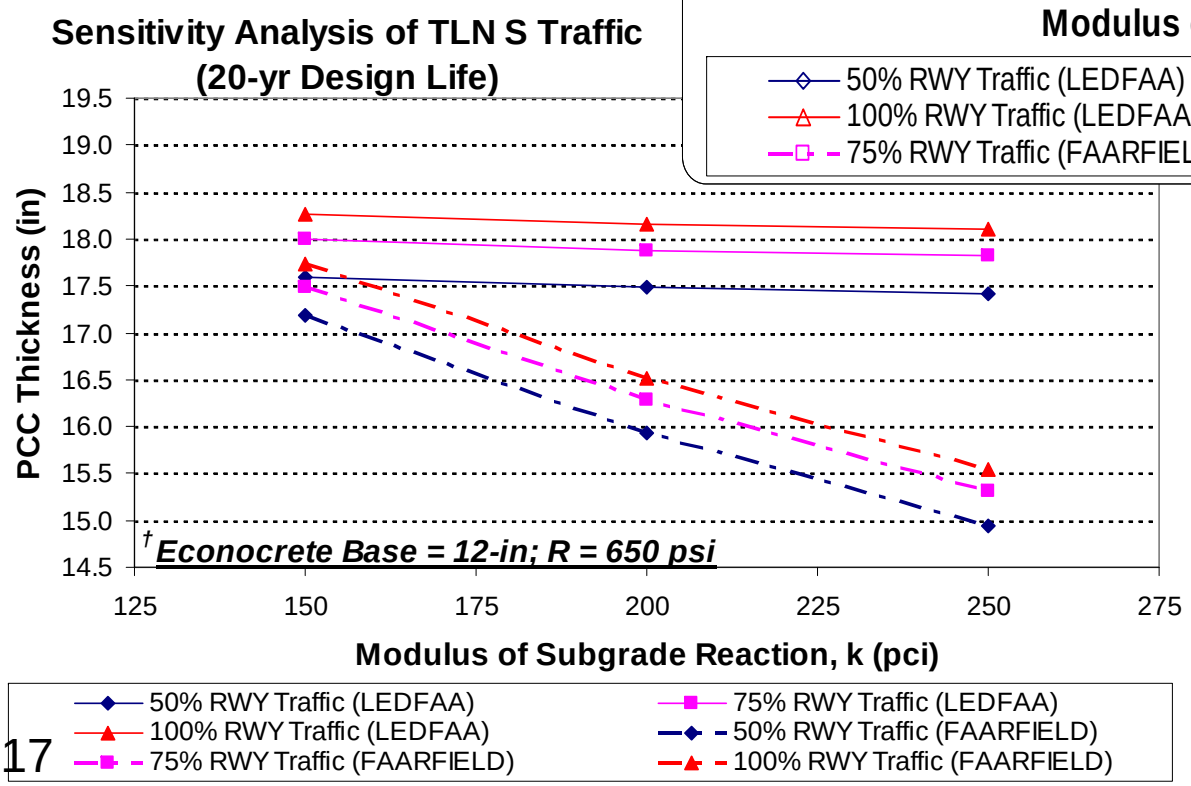
Presentation Outline

- Background and Program Overview
- Key Elements of Taxilane “S” Project
- Airfield Pavement Design
- Selective Results of Sensitivity Analyses
- Mix Design - FAA P-501 Concrete
- Mix Design - FAA P-306 Econocrete
- Site and Construction Photos

Design Traffic v.s. Modulus of Subgrade Reaction (k)

1 pci = 0.2717 MPa/m
1 in = 25 mm

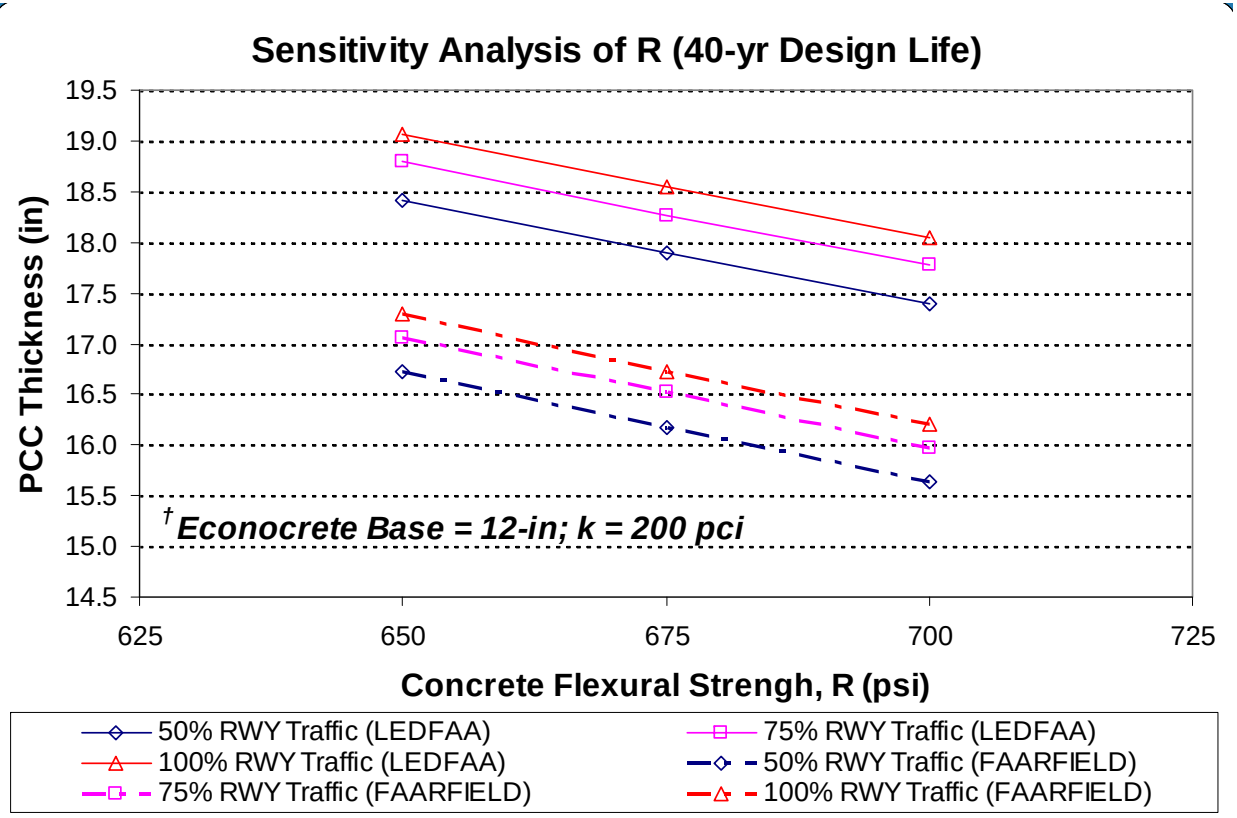


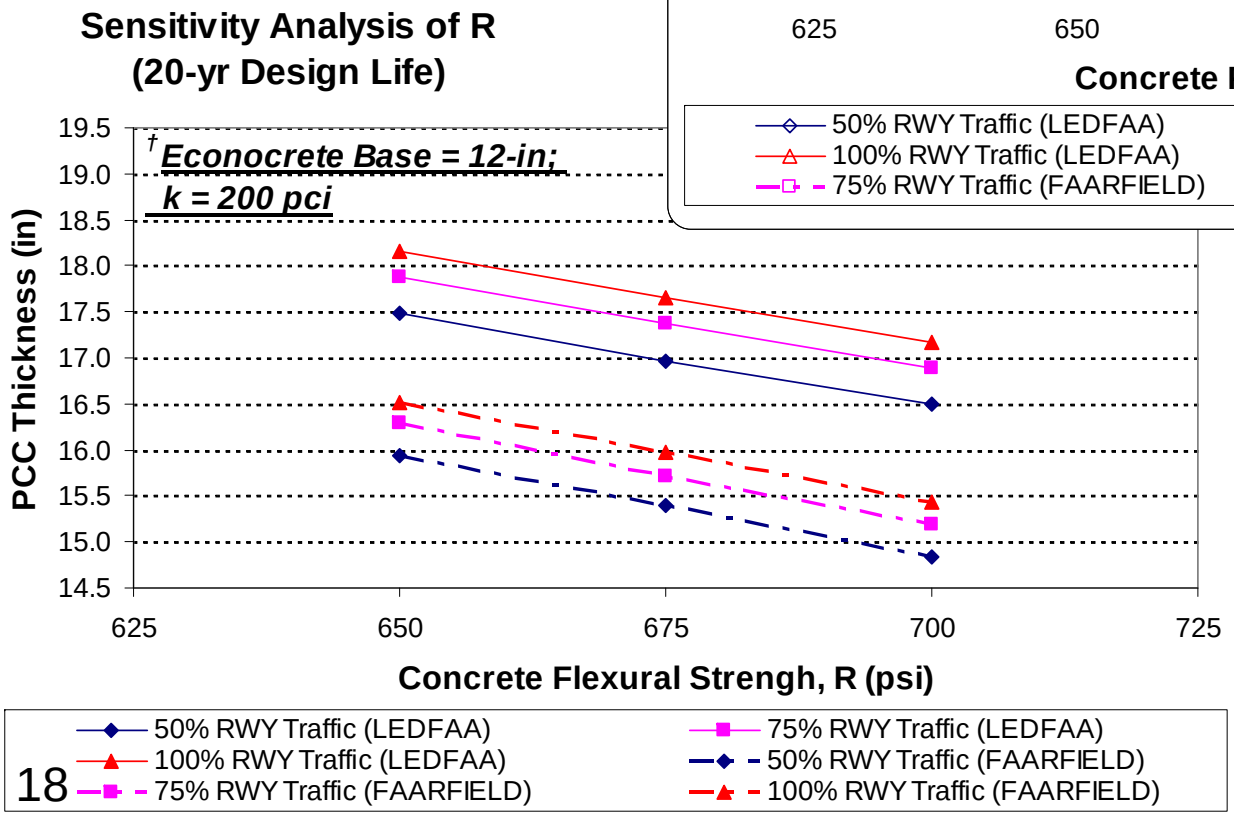


- LEDFAA:
  PCC h reduction is minimal as the k increases
- FAARFIELD:
  PCC h is reduced by 1”, when k increases from 200 to 250 pci

Design Traffic v.s. Concrete Flexural Strength (R)

1 pci = 0.2717 MPa/m
1 in = 25 mm

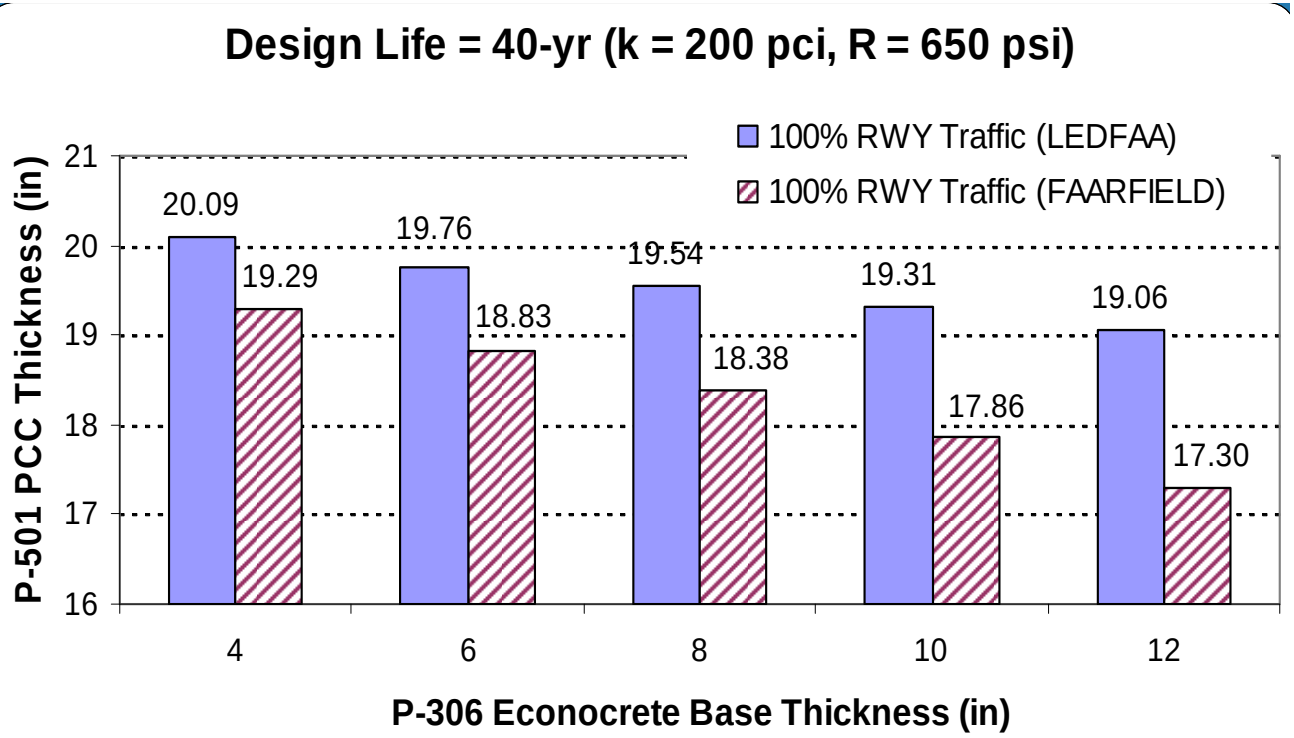


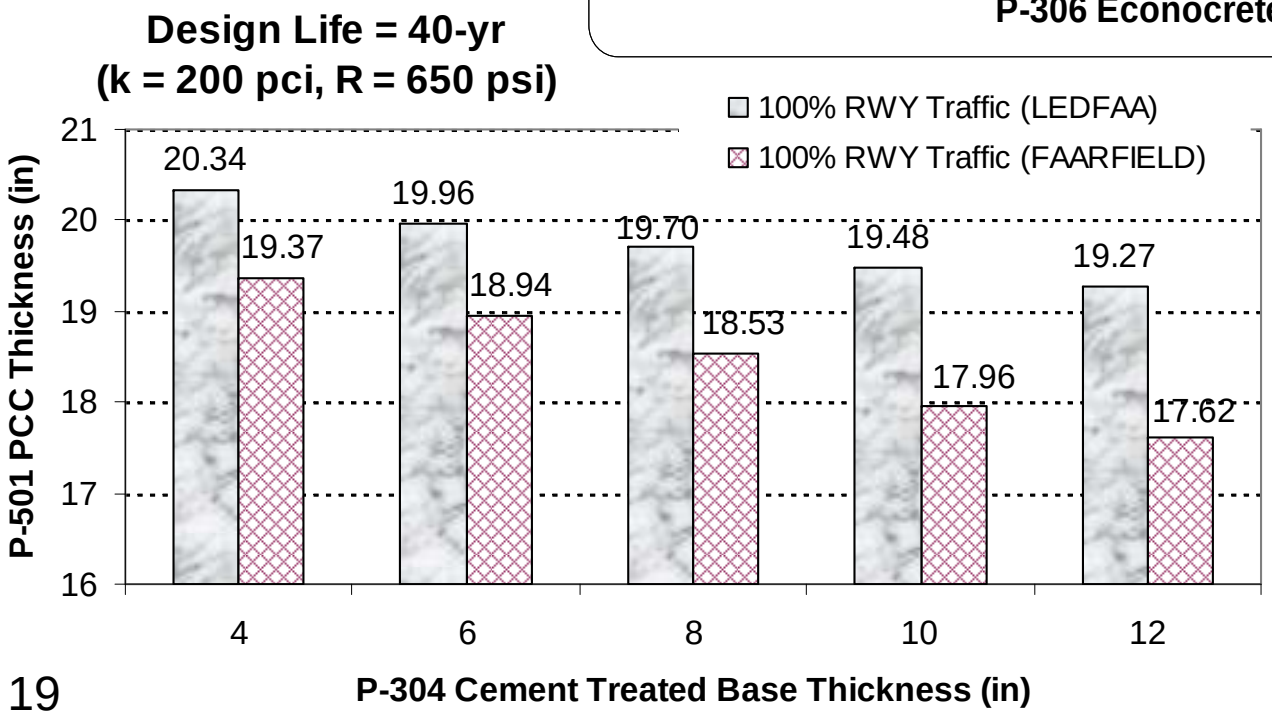


- With a 25-psi increase of R, PCC h is reduced by 0.5”

Design Traffic v.s. Base Thickness

1 pci = 0.2717 MPa/m
1 in = 25 mm





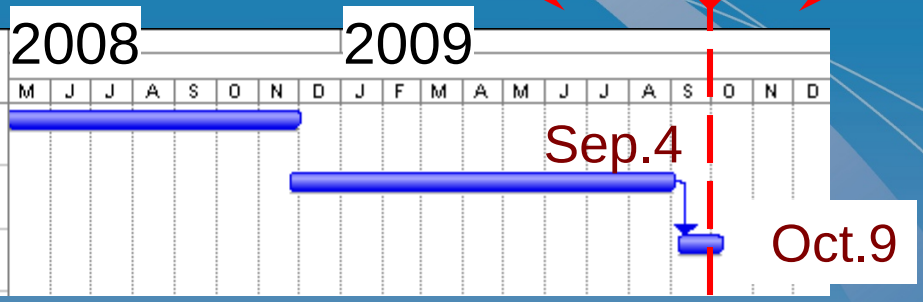
- With a CTB, PCC h is increased approximately by 0.25” (40-yr design)

Recommended TLN S Pavement Section

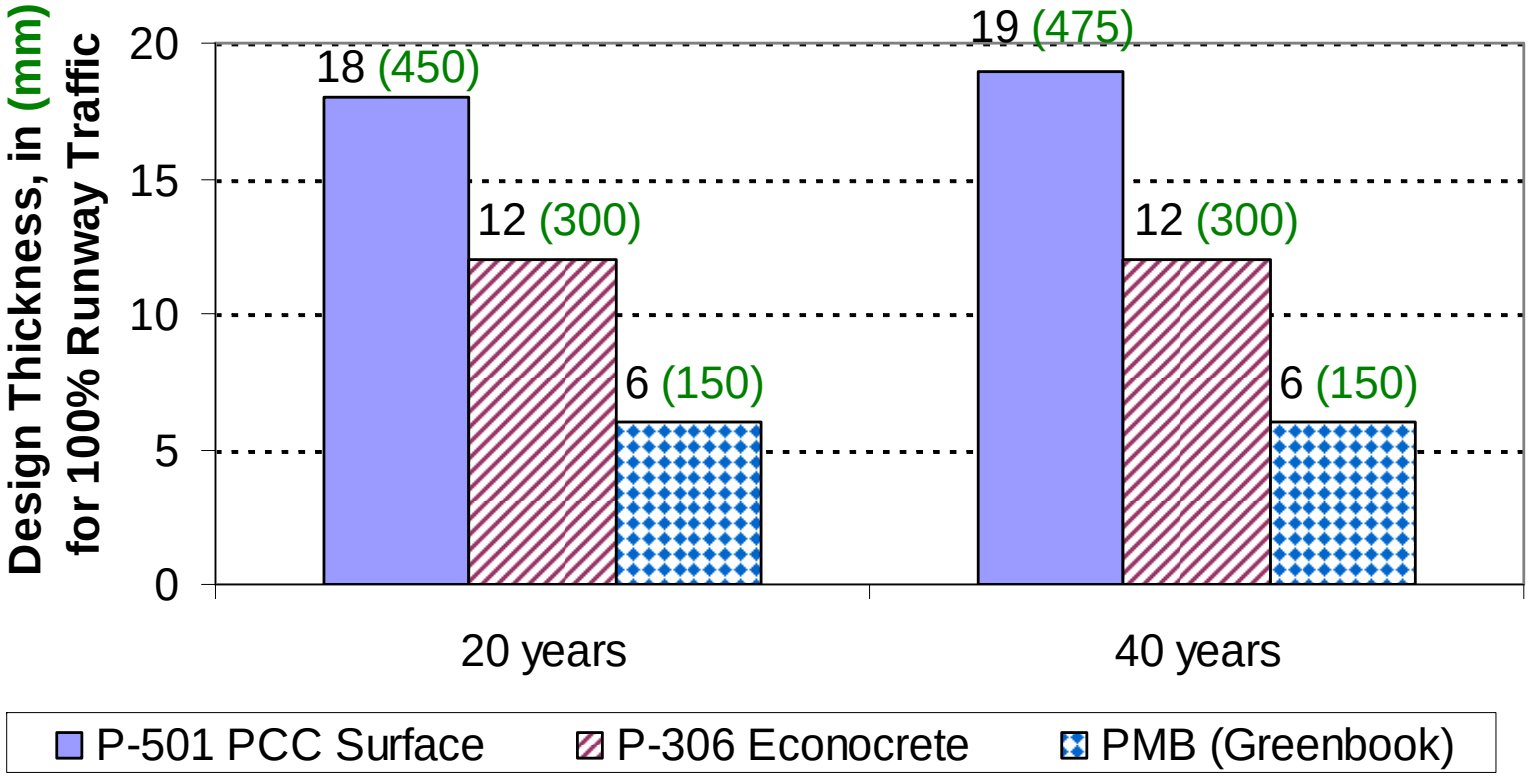
9/30/2009

LEDFAA FAARFIELD

ID	Task Name
1	Crossfield Taxiway Project
2	Taxilane S (Pkg 1)
3	Taxilane S (Pkg 2)



Modulus of Subgrade Reaction, k = 200 pci (67.6 MPa/m)
Concrete Flexural Strength, R = 650 psi (4.485 MPa)



Presentation Outline

- Background and Program Overview
- Key Elements of Taxilane “S” Project
- Airfield Pavement Design
- Selective Results of Sensitivity Analyses
- Mix Design - FAA P-501 Concrete
- Mix Design - FAA P-306 Econocrete
- Site and Construction Photos

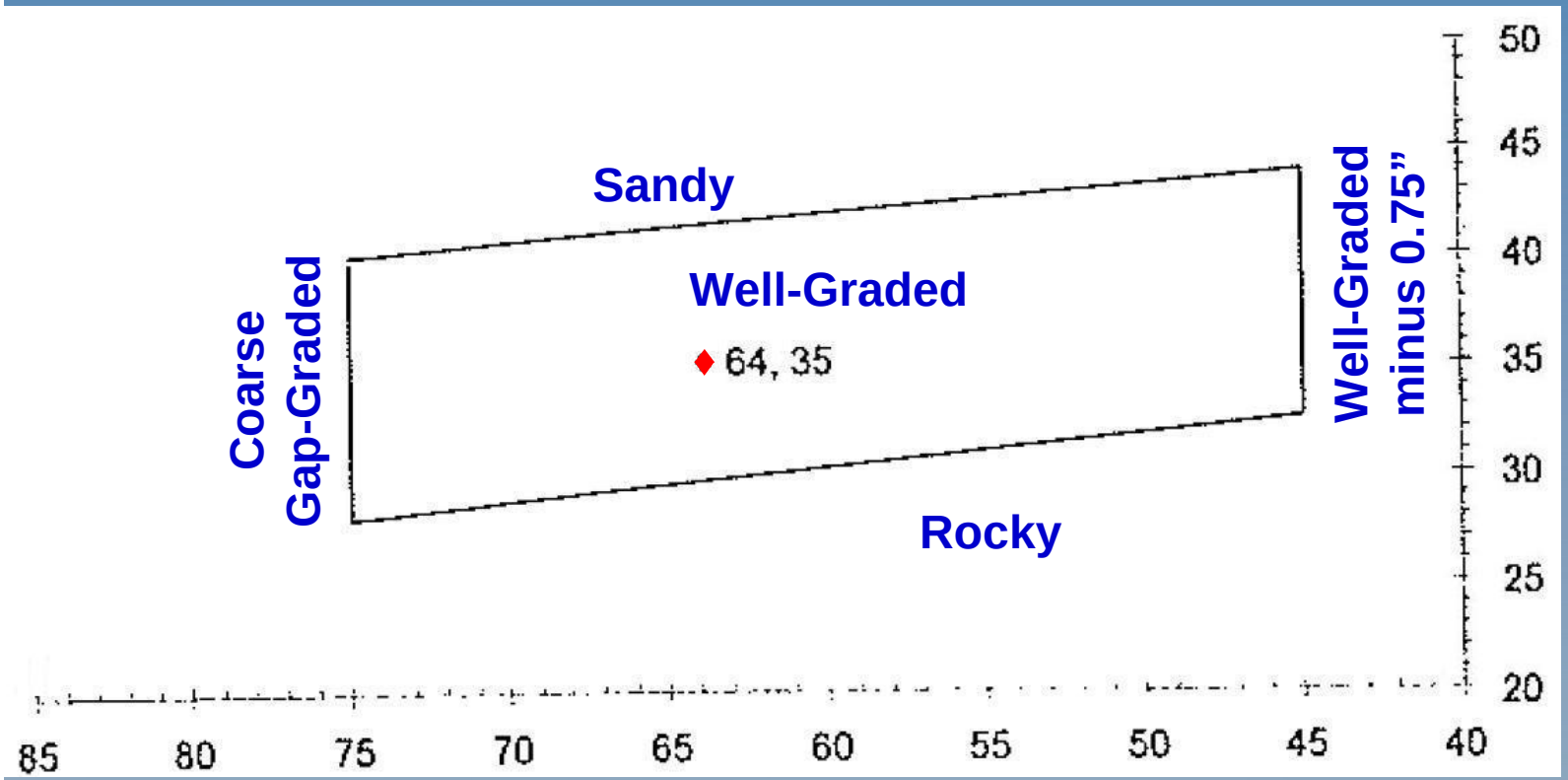
Concrete (FAA P-501) Mix Design (Slip-form)

- Coarse aggregate:
  60% 1” aggregate (1,835 lbs/cy)
- Fine aggregate:
  40% WCS (1,223 lbs/cy)
- ASTM C1567: no potential for Alkali-Silica Reactivity
  - Ave. expansion @ 28-day
    = 0.07% (< 0.1%)
- Type II cement (625 lbs/cy)
  used with 20% replaced by class F fly ash
- Water-reducing admixture used (meets ASTM C494)
- Air-entraining admixture used (meets ASTM C260)

Combined Aggregate Blend		40.0%	60.0%	100%
Aggregate Type		Vulcan Irwindale Washed Concrete Sand	Vulcan Corona BLENDED 1" x # 4 Rock	Combined Aggregate Grading - Cumulative % Passing
	DATA Through	5/5/10	5/5/10	
Sieve Size	Absorption	1.00%	0.40%	
	Specific Gravity	2.68	2.68	
Sieve Size	Sieve Size			
50 mm	2"	100	100	100
37.5 mm	1-1/2"	100	100	100
25 mm	1"	100	96	98
19 mm	3/4"	100	82	89
12.5 mm	1/2"	100	44	66
9.5 mm	3/8"	100	28	57
4.75 mm	No. 4	98	6	43
2.36 mm	No. 8	81	1	33
1.18 mm	No. 16	62		25
.600 mm	No. 30	42		17
.300 mm	No. 50	21		8
.150 mm	No. 100	9		4
.075 mm	No. 200	3.7	0	1

Concrete (FAA P-501) Mix Design (Slip-form) – Continue

- Design water-cement ratio = 0.44 < 0.45; Design Air Content = 3%
- Design slump (slip-form) = 1.25” < 1.5”
- Coarseness factor (45 ~ 75) = 64, Acceptable
- Workability factor (28 ~ 41) = 35, Acceptable
- Flexural strength @ 28-day = 715 psi > 650 psi



Presentation Outline

- Background and Program Overview
- Key Elements of Taxilane “S” Project
- Airfield Pavement Design
- Selective Results of Sensitivity Analyses
- Mix Design - FAA P-501 Concrete
- Mix Design - FAA P-306 Econocrete
- Site and Construction Photos

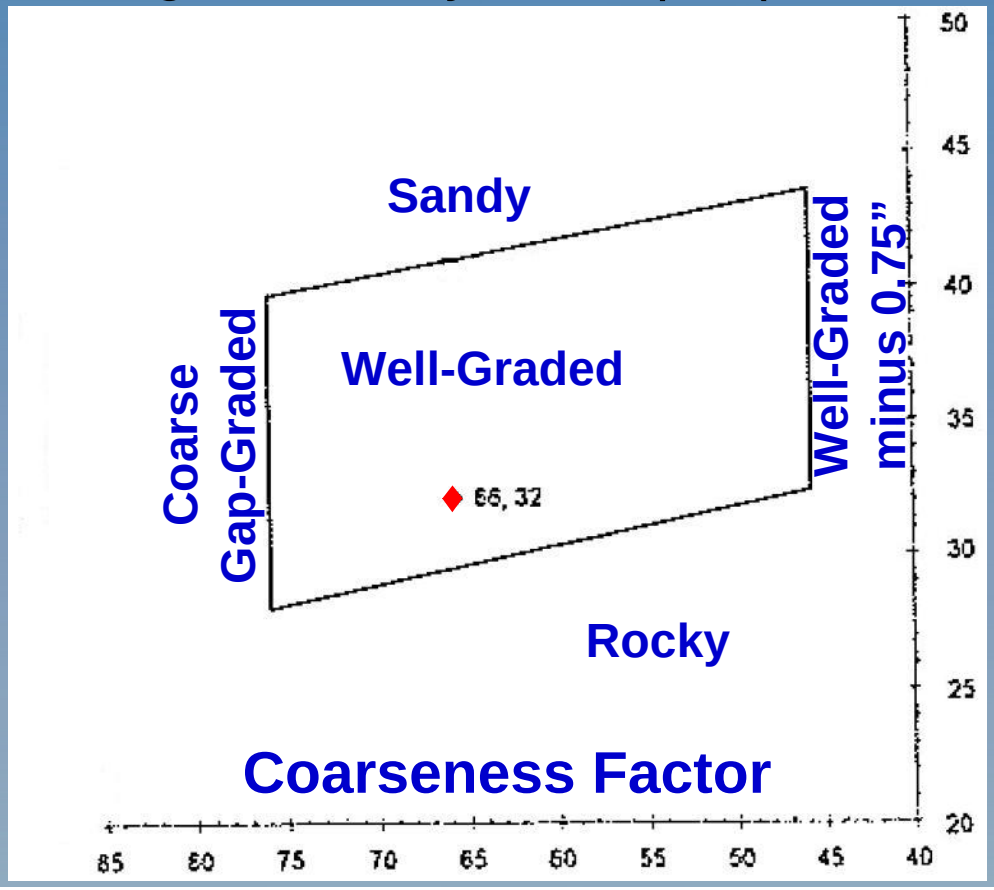
Econocrete (FAA P-306) Mix Design (Slip-form)

- Coarse aggregate:
  84% 1” recycled aggregate (2,432 lbs/cy)
- Fine aggregate:
  16% native sand (499 lbs/cy)
- ASTM C1260: no potential for Alkali-Silica Reactivity of recycled aggregates
  - Ave. expansion @ 16-day = 0.06% (< 0.1%)
- Type II cement used (240 lbs/cy)
- Water = 317 lbs/cy
- Water-reducing admixture used (meets ASTM C494)
- Air-entraining admixture used (meets ASTM C260)

Combined Aggregate Blend		16.0%	84.0%	100%
		Agg #1	Agg #2	
Type		LAX - Native Sand	Recycled Aggregate - LAX Crusher	Combined Aggregate Grading - Cumulative % Passing
	Average Through	5/1/10	5/1/2010	
	Absorption	1.00%	3.6%	
	Specific Gravity	2.62	2.43	
Sieve Size	Sieve Size			
50 mm	2"	100	100	100
37.5 mm	1-1/2"	100	100	100
25 mm	1"	100	96	97
19 mm	3/4"	100	83	86
12.5 mm	1/2"	99	53	69
9.5 mm	3/8"	98	54	61
4.75 mm	No. 4	97	39	48
2.36 mm	No. 8	97	30	41
1.18 mm	No. 16	96	23	35
.600 mm	No. 30	90	18	30
.300 mm	No. 50	34	11	15
.150 mm	No. 100	8	6	6
.075 mm	No. 200	5	4	4

Econocrete (FAA P-306) Mix Design (Slip-form) - Continue

- Average slump (slip-form) = 2”; Average Air Content = 6.4 %
- Coarseness factor (45 ~ 75) = 66, Acceptable
- Workability factor (28 ~ 41) = 32, Acceptable
- Compressive Strength @ 3-day = 505 psi > 500 psi
- Compressive Strength @ 7-day = 720 psi (500 – 800 psi)



Presentation Outline

- Background and Program Overview
- Key Elements of Taxilane “S” Project
- Airfield Pavement Design
- Selective Results of Sensitivity Analyses
- Mix Design - FAA P-501 Concrete
- Mix Design - FAA P-306 Econocrete
- Site and Construction Photos

Existing Taxiway “S” before Demolition

Site and String Line Setup for Econocrete Paving

Crew Check Econocrete Thickness

P-306 Econocrete Paving (Hand-form)

Curing Compound for Econocrete (Hand Spray)

Econocrete Paving (Slip-form)

More Fresh Econocrete

Fresh Econocrete with Curing Compound

P-501 Concrete Paving (Slip-form)

P-501 Concrete Paving (Slip-form)

Concrete Trucks Waiting on Site

Dowel Basket

Dowel Basket

Beam Specimens, Slump & Air Content Tests

Protective Pads for Crawler Tracks

Edge Slump

Surface Texture

P-501 Concrete with Curing Compound (Cont.)

P-501 Concrete – High Spot Removal

Dust Control

Cured Econocrete

Cured Concrete

Drilled Holes for Dowels

Mark Joint Location for Sawcutting

Newly Sawed PCC Joint

Joint Sawcutting

Joint Preparation

Joint Seal

Thicken Edge

Steel Reinforcements

Acknowledgements

- Los Angeles World Airports (LAWA)
- Hatch Mott MacDonald
  - Mr. Curtis Wright
  - Mr. Paul Nolan
  - Mr. Christopher Solecki
- Prime Contractor: Flatiron West, Inc.
- Construction Support Services: Ch2m Hill
- Overall Capital Improvement Program Management: AECOM & partners including Parsons Brinckerhoff

Thank You

Photo taken from http://en.wikipedia.org/wiki/Los_Angeles_Airport