Federal Aviation Administration

Memorandum

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To: All Regions, Manager, Airport Division

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Subject: Engineering Brief No. 78, Linear Equations for Evaluating the Separation of Airplane Design Groups on Parallel Taxiways and Taxiways to Fixed/Movable Objects

Engineering brief (EB) No. 78 provides industry and FAA Airports Regional Division Managers seven linear equations to evaluate proposed modification-to-standards (MOS) on the separation of parallel taxiway centerlines and the clearance of taxiways centerlines to fixed/movable objects.

The EB has several primary goals. First, the EB formalizes our systematic methodology for all Airplane Design Groups (ADG) to demonstrate when a proposed MOS provides an acceptable level of safety. Numeric values from a proposed MOS that cannot provide an acceptable level of safety always triggers an internal review with the other FAA Regional lines of business (LsOB). Second, the EB grants FAA Airports Regional Division Managers the authority to approve proposed MOSs using the linear equations to accommodate airplanes on existing taxi systems that provide acceptable level of safety. One exception to Regional approval authority is proposed MOS involving ADG VI airplanes, such as, the Airbus A380 and the Boeing 747-8. Lastly, the EB clarifies that because these linear equations formerly provided in AC 150/5300-13, Airport Design, were coordinated and approved by the other FAA LsOB, no further MOS coordination is normally necessary beyond the FAA Airports LsOB when a proposal provides an acceptable level of safety. However, coordination will be prudent whenever operational restrictions and/or standard operating procedures (SOP) and inter-LOB agreements are necessary.

Attachment

FAA
Airports

Engineering Brief No. 78

Linear Equations for Evaluating the Separation of Airplane Design Groups on Parallel Taxiways and Taxiways to Fixed/Movable Objects

Part 1: Background

This engineering brief provides industry with seven linear equations to evaluate proposed modification-to-standards (MOS) on the separation of parallel taxiway centerlines and the clearance of taxiways centerlines to fixed/movable objects. The primary goal of this engineering brief is to establish a systematic methodology for all Airplane Design Groups (ADG) to demonstrate when a proposed MOS provides an acceptable level of safety. A resulting numeric value provides an acceptable level of safety when it is smaller or equal to the existing parallel taxiway CL-to-CL separation or the existing taxiway CL to a fixed/movable object clearance.

A request for a MOS should be done only as a last resort by an airport operator after an exhaustive evaluation of all alternatives to meet design standard(s). In some cases where meeting the standard is not practicable a MOS can be reviewed. However, the airport operator should always keep the 20-year planning period in mind as to not restrict the growth of the airport to accommodate other larger airplane wingspans within the same ADG.

Because these linear equations were coordinated and approved by the other FAA lines-of business (LsOB), no further coordination is normally necessary beyond the FAA Airports LOB when a proposal provides an acceptable level of safety. However, their use does not exclude FAA Airports to determine if further internal coordination is necessary. For example, internal FAA coordination will be prudent whenever a submitted proposed MOS involves operational restrictions and/or standard operating procedures (SOP) and where inter-LOB agreements are necessary. Some other common areas needing resolution may include jet blast mitigation on curved sections of a taxi route and vehicle-object height restrictions for nearby service roads. Numeric values from a proposed MOS that cannot provide an acceptable level of safety always triggers an internal review with the other FAA Regional LsOB and AAS-100.

Although all seven linear equations use the parameter of airplane wingspan, a major difference exists. Four equations, referred to as Single ADG, require only one wingspan input while the remaining three equations, referred to as Dual ADG, require two wingspan inputs. Lastly, the latter three equations only apply to parallel taxiway CL-to-CL separations, not clearances for twy CL to fixed/movable objects.

Table 4-1 of Advisory Circular 150/5300-13A, *Airport Design*[1], provides the separation and clearance standards for parallel taxiway centerlines (CL), taxiway CLs to a fixed or movable

[1] Advisory circulars are available for free at the following web site: http://www.faa.gov/airports/resources/advisory_circulars/.

object, parallel taxilane CLs, and taxilane CLs to a fixed or movable object, according to Airplane Design Groups (ADG) I through VI.

Taxiways located in the airfield are designed for unrestricted taxiing operations where airplane speeds routinely exceed 20 mph. The previous edition of this advisory circular under Appendix 9, paragraph 2 read:

> *Since the taxiway system is the transitional facility which supports airport operational capacity, the capability to maintain an average taxiing speed of at least 20 mph (32 km per hour) needs to be built into the system.*

In comparison, taxilanes are associated with terminal aprons, gate areas, and cargo aprons because airplane taxiing speeds seldom go over 20 mph and more typically fall in the range of 5 to 15 mph.

Necessary Precautions
As previously stated taxilanes as compared to taxiways are associated with non-movement areas of the airport that are uncontrolled by the airport tower control tower (ATCT). Hence, prior to approving a Conditional Approved MOS involving a taxilane application located in a movement area, the FAA Airports must inform ATCT that a taxilane will exist outside the non-movement area. Additionally, taxilane applications in both movement and non-movement areas need to include a speed restriction as a condition for MOS approval. These necessary precautions are established so ATCT and Local Control will not expedite taxiing airplanes in a speed-restricted taxi route.

Part 2: Single Airplane Design Group Linear Equations for Taxiway and Taxilane Separation and Clearance Design Standards

All taxi design separation and clearance standards promulgated by table 4-1 historically were derived by the four linear equations shown in table 1 below in conjunction with the upper wingspan value for each ADG. For example, all numeric values found under the ADG V column applied the upper wingspan of 214 feet in equations # 1 – 4. Substituting a wingspan value smaller than the upper wingspan value will result in a nonstandard taxi design.

Equation Number	Design Element	Separation per Airplane Design Group (ADG = wingspan under review)
1	Taxiway CL to Parallel Taxiway CL	$S_1 = 1.2 \times Wingspan_{ADG^*} + 10$ feet
2	Taxiway CL to fixed/movable object	$S_2 = 0.7 \times Wingspan_{ADG^*} + 10$ feet
3	Taxilane CL to Parallel Taxilane CL	$S_3 = 1.1 \times Wingspan_{ADG^*} + 10$ feet
4	Taxilane CL to fixed/movable object	$S_4 = 0.6 \times Wingspan_{ADG^*} + 10$ feet

Table 1

Part 3: Modification-to-Standards (MOS) Applications for Single Wingspan

Although new construction or reconstruction of an existing taxi system is built to the design standards, site conditions that are not practicable to improve could limit the available separation and clearance. In response to such difficulties, AC 150/5300-13A refers to the use of these four linear equations in conjunction with a lower wingspan value to determine if an *acceptable level of safety* can be achieved for the site condition(s). In dealing with such circumstances, airport operators should use the linear equations to support their proposed modification-to-standard (MOS). Such usage results in short narrative proposed MOSs that show the linear equation computation(s) with no further supplementary, in-depth supportive documentation. However, their use does not exclude additional review by FAA Airports to determine if further coordination is necessary with other FAA lines of business. For example, a submitted proposed MOS may involve an internal FAA evaluation of various operational impacts needing resolution, such as jet blast mitigation, vehicle height restrictions for nearby service roads, etc.

Procedurally, users of table 1 should initially apply taxiway equations #1 and #2 rather than taxilane equations #3 and #4 since the former equations may avoid the introduction of FAA-approved operational limitations, while the latter equations will include limiting measures. Part 4 provides an actual case study to illustrate the process and the possibility to avoid limitations.

Part 4: Case Study: MOS Application for the Boeing 747-8 – Airplane Design Group VI

The Boeing 747-8, an ADG VI airplane that began operations in late summer 2011, is serving airports designed for ADG V B747-100/200/400 service. Table 4-1 illustrates the immediate impacts by an ADG VI airplane on the existing ADG V taxiway system. That is, the standard taxi CL separation for parallel taxiways for the ADG V Boeing 747-400 measures 267 feet; for the ADG VI B747-8, it measures 324 feet—an increased CL-to-CL separation of 57 feet. Consequently, airport operators that receive this ADG VI airplane, but not expecting to accommodate a larger ADG VI airplane within the 20-year planning period, may need to submit a proposed MOS for designated B747-8 taxi routes. Fortunately the impact to the parallel taxiway CL-to-CL separation is less because the B747-8 wingspan measures 224.5 feet, which places it toward the bottom of the ADG VI wingspan range (214 feet but not over 262 feet). The design objective for the B747-8 or for any airplane is to find a solution that allows taxiing operations without any operational limitations.

(1) Airports Built to Former FAA Taxi Separation Standards. Prior to the 1980s, airports serving air carrier traffic were built with greater parallel taxiway CL-to-CL separations[2], e.g., 300 feet. This raises the question whether a MOS is necessary for simultaneous B747-8s operating on such parallel taxiways.

Applying equation #1 from table 1 for the B747-8 with a wingspan of 224.5 feet yields:

Result #1 $S_{1\text{-B747-8 Taxiway}} = 1.2 \times 224.5 \text{ feet} + 10 \text{ feet} = 279.4 \text{ feet}.$

Since the resulting value is less than the available 300-foot CL-to-CL separation, no MOS is required.

[2] Cancelled AC 150/5335-1A, Airport Design Standards – Airports Served By Air Carriers – Taxiways.

(2) Airports Built to Current FAA Taxi Separation Standards. In 1989 AC 150/5300-13 was introduced. It promulgated lower taxiway and taxilane separation and clearance design standards that continue today under AC 150/5300-13A. It reduced the parallel taxiway CL-to-CL separation for ADG V from 300 feet to 267 feet. Was there an impact? It depends on the airplane wing span under evaluation.

Result #1 from above already confirms that this operation requires at least 279.4 feet, greater separation than the current 267-foot design standard. Hence, the airport operator should apply taxilane criterion, equation #3 to find out whether the operation can continue with an FAA-conditionally approved MOS with limitation(s).

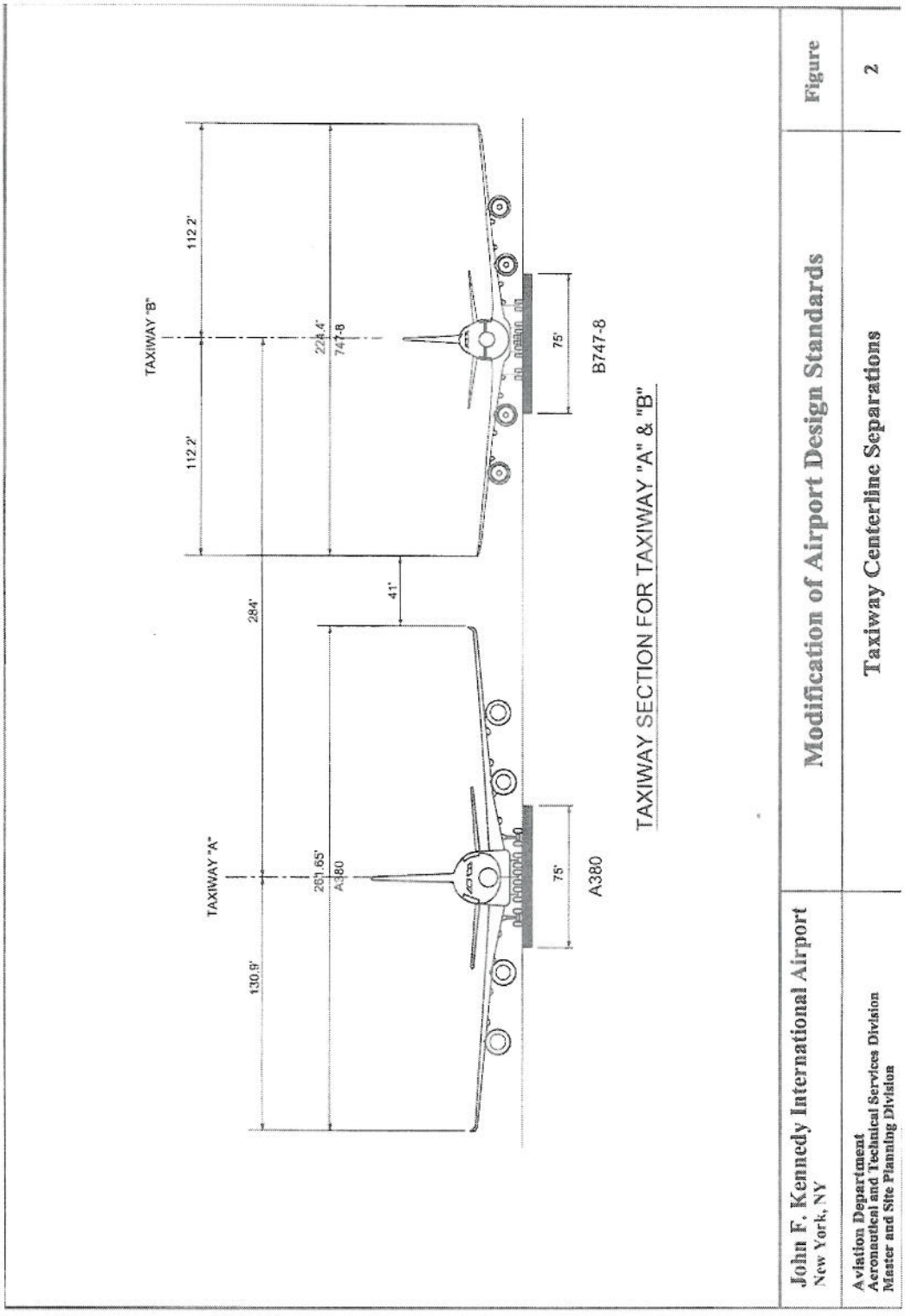
Result #2 $S_{3\text{-B747-8 Taxilane}}$ = 1.1 x 224.5 feet + 10 feet = 256.95 feet.

Since the resulting value is less than the available 267-foot CL-to-CL separation, the airport operator's MOS has merit if it includes some appropriate FAA-approved operational limitation(s). A common mitigation measure used by airport operators is to restrict the taxiing speed of the larger, less taxied airplane. Field research conducted by the FAA on the taxi CL wander behavior of larger airplanes indicated that 15 mph was a defining speed threshold between taxilane operations and taxiway operations. Another commonly used mitigation option is to restrict the maximum wingspan for the other airplanes operating on the adjacent parallel taxiway. In either case see the Necessary Precautions Box in Part 1 when dealing with taxilanes.

Part 5: Industry Inquiry - Procedure for Parallel Taxiways Serving Different Airplane Wingspans

A common inquiry by industry is how to accommodate two different airplanes within the same ADG or from within different ADGs on an existing parallel taxiway system. Industry inquired because linear equations #1 - #4 are limited to a single airplane wingspan (variable). For example, figure 1 shows one inquiry by Port Authority of New York and New Jersey for JFK International Airport that received an FAA-approved conditional MOS for parallel Taxiways A and B to handle simultaneous Airbus A380 and the Boeing 747-8 taxiing operations. The submitted MOS showed only a 41-foot wingtip-to-wingtip separation between the A380 and the B747-8 for the existing parallel taxiway CL-to-CL separation of 284 feet. Table 4-3, from the previous edition of AC 150/5300-13 whose values remain in effect today, is reprinted below to illustrate the standard wingtip clearance standards among the ADGs for taxiways and taxilane applications.

Figure 1


TAXIWAY "B"
112.2'
112.2'
228.4'
747-8
75'
B747-8
284'
41'
TAXIWAY "A"
261.65'
A380
75'
A380
130.5'
TAXIWAY SECTION FOR TAXIWAY "A" & "B"
John F. Kennedy International Airport
New York, NY
Modification of Airport Design Standards
Figure
2
Aviation Department
Aeronautical and Technical Services Division
Master and Site Planning Division
Taxiway Centerline Separations

ITEM	Airplane Design Group					
	I	II	III	IV	V	VI
Taxiway Wingtip Clearance	20 ft	26 ft	34 ft	44 ft	53 ft	62 ft
	6 m	8 m	10.5 m	13.5 m	16 m	19 m
Taxilane Wingtip Clearance	15 ft	18 ft	22 ft	27 ft	31 ft	36 ft
	4.5 m	5.5 m	6.5 m	8 m	9.5 m	11 m

Table 4-3. Wingtip clearance standards (Former AC 150/5300-13)

Part 6: Dual Airplane Design Groups Linear equations for Parallel Taxiway Centerline Separations

To expedite future MOS proposals involving only parallel taxi designs, the Airport Engineering Division (AAS-100) developed three new linear equations shown in table 2 for change 17 for the previous edition of AC 150/5300-13. Table 2 is applicable to all ADGs for evaluating two airplane wingspans within the same ADG or different ADGs on existing parallel taxi designs.

New Parallel Taxiway Centerline Linear Equations for Dual Airplane Design Group Evaluations (All Airplane Design Groups)
Equation #5 for Dual Parallel Taxiway Application **$1.2 \times [(WS_1 + WS_2) / 2] + 10$ feet = CL-to-CL Separation**
Equation #6 for Dual Parallel Taxilane Application **$1.1 \times [(WS_1 + WS_2) / 2] + 10$ feet = CL-to-CL Separation**
Equations #7 for Mixed Parallel Taxiway and Taxilane Application **$[(1.2 \times WS_1 + 1.1 \times WS_2) / 2] + 10$ feet = CL-to-CL Separation**
NOTE: The red-coded 1.1 coefficient multiplier implies that a taxiing speed limitation is required on the corresponding wingspan(s).

Table 2

Part 7: Rationale for Table 2

Table 2 incorporates the rationale behind table 4-3 which uses the concept of creating a "safety wingtip box [SWB]" between the wingtips of two identical airplane wingspans and between the wingtip of an airplane to a fixed/movable object. For example, 62 feet is the $SWB_{ADGVI\text{-}Taxiway}$ for ADG VI parallel taxiways (obtained by subtracting the table entry from the corresponding maximum wingspan of the ADG). For reference,

Result #3 $SWB_{ADG\ VI\text{-}Taxiway} = 324 - 262 = 62$ feet
Result #4 $SWB_{ADG\ V\text{-}Taxiway} = 267 - 214 = 53$ feet

For airplane wingspans within a given ADG, such as the B747-8 with wingspan of 224.5 feet, use equation #1 with 1.2 x 224.5 + 10 = 279.5 feet, then subtract 224.5 to obtain $SWB_{B747\text{-}8\text{-}Taxiway}$.

Result #5 $SWB_{B747\text{-}8\text{-}Taxiway} = 279.5 - 224.5 = 55$ feet

The same process, but using equation #3, determines taxilane SWBs.

Result #6 $SWB_{ADG\ VI\text{-}Taxilane} = 298 - 262 = 36$ feet
Result #7 $SWB_{ADG\ V\text{-}Taxilane} = 245 - 214 = 31$ feet
Result #8 $SWB_{B747\text{-}8\text{-}Taxilane} = 257 - 224.5 = 32.5$ feet

Table 2 uses the same SWB concept but takes the average of two SWBs associated with the two airplane wingspans being evaluated. Take note that the green color-coded coefficient 1.2 implies no operational limitation. In contrast, the red coefficient 1.1 requires some operational limitation.

Part 8: Design Process for Table 2 and JFK Proposed MOS from Part 5

JFK MOS Proposal – Allow Simultaneous Airbus A380 and Boeing 747-8 Operations on Parallel Taxiways A and B.

Figure 1 illustrated that the available parallel taxiway CL-to CL separation is 284 feet with a 41-foot SWB wingtip-to-wingtip separation. Procedurally start with Case 1 equation #5, then equation #7, followed by equation #6 shown below.

Case 1 Equation #5 – Evaluate Dual Taxiway Criterion to avoid any operational restrictions

Use **1.2** x [(WS_1 + WS_2) / 2] + 10 feet = average CL-to-CL separation
1.2 x [(261.7 + 224.5) / 2] + 10 feet = 301.7 feet

Result: There is insufficient separation because the average CL-to-CL separation of 301.7 feet exceeds the available 284-foot CL-to-CL separation.

Case 2 Equation #7 – Evaluate A380 Taxilane Criterion and B747-8 Taxiway Criterion to avoid operational restrictions on one airplane

Use [(**1.2** x WS_1 + **1.1** x WS_2) / 2] + 10 feet = CL-to-CL Separation
[(**1.2** x 224.5 + **1.1** x 261.7) / 2] + 10 feet = [(269.4 + 287.9) /2] + 10 = 288.6 feet

Result: There is insufficient separation because the average CL-to-CL of 288.6 feet exceeds the available 284-foot CL-to-CL separation.

Case 3 Equation #6 – Evaluate Dual Taxilane Criteria to permit the operation but with both airplanes having restrictions

Use **1.1** x [(WS_1 + WS_2) / 2] + 10 feet = average CL-to-CL separation
1.1 x [(261.7 + 224.5) / 2] + 10 feet = 277.41 feet

Result: There is sufficient separation because the average CL-to-CL of 277.41 feet is less than the available 284-foot CL-to-CL separation. The airport operator needs to include proposed operational limitations with the submitted MOS. Because this proposed MOS involved taxilanes the FAA issued a conditionally approved MOS (one condition being the taxi speed restriction of 15 mph) and ATCT was informed that taxilanes exist in the movement area.

Part 9: Purpose

This engineering brief grants FAA Airports Regional Division Managers the authority to approve proposed MOSs using the linear equations from tables 1 and 2 to accommodate airplanes on existing taxi systems. One exception to Regional approval authority is proposed MOSs involving ADG VI airplanes, such as, the Airbus A380 and the Boeing 747-8. New construction needs to meet the full separation and clearance standards per AC 150/5300-13A. In some cases, further coordination with other regional lines of business may be necessary. When completed, the Regional Division must send a copy of the issued Approved Conditional MOS to the Airport Engineering Division, AAS-100. New taxiway construction or reconstruction that receives Federal funding under the Airport Improvement Program (AIP) or is approved for the use of Passenger Facility Charges (PFC) must be built in accordance with AC 150/5300-13A.

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