# APPENDIX 1. ECONOMIC ANALYSIS

**1. BACKGROUND.** The information presented in this appendix was developed from research report DOT/FAA-RD-81/078. The cost data used are probably not current. However, the principles and procedures are applicable. An example is given for illustrative purposes.

**2. ANALYSIS METHOD.**

**a.** Present worth or present value economic analyses are considered the best methods for evaluating airport pavement design or rehabilitation alternatives. A discount rate of 4 percent is suggested together with an analysis period of 20 years. Residual salvage values should be calculated on the straight-line depreciated value of the alternative at the end of the analysis period. The initial cost and life expectancy of the various alternatives should be based on the engineer's experience with consideration given to local materials, environmental factors, and contractor capability.

**b.** The basic equation for determining present worth is shown below:

$$\mathrm{PW} = C + \sum_{i=1}^{m} M_i \left(\frac{1}{1+r}\right)^{n_i} - S\left(\frac{1}{1+r}\right)^{z}$$

**w**here:

PW = Present Worth
$C$ = Present Cost of initial design or rehabilitation activity
$m$ = Number of maintenance or rehabilitation activities
$M_i$ = Cost of the i$^{th}$ maintenance or rehabilitation alternative in terms of present costs, i.e., constant dollars
$r$ = Discount rate (four percent suggested)
$n_i$ = Number of years from the present of the i$^{th}$ maintenance or rehabilitation activity
$S$ = Salvage value at the end of the analysis period
$Z$ = Length of analysis period in years. The official FAA design period is 20 years. Design periods other than 20 years must be approved by the FAA.

The term

$$\left(\frac{1}{1+r}\right)^{n}$$

is commonly called the single payment present worth factor in most engineering economic textbooks. From a practical standpoint, if the difference in the present worth of costs between two design or rehabilitation alternatives is 10 percent or less, it is normally assumed to be insignificant and the present worth of the two alternatives can be assumed to be the same.

**3. STEP BY STEP PROCEDURE.** The information presented in this appendix is intended to demonstrate how to calculate cost comparisons for airport pavement alternatives using the present worth method. The following is a step by step procedure illustrating the analysis method.

**a.** Identify and record key project descriptions, such as—

**(1)** Project Number and Location
**(2)** Type of Facility
**(3)** Design Aircraft
**(4)** Annual Departure of Design Aircraft
**(5)** Subgrade Strength

**b.** If appropriate, determine the condition of existing pavement and record data, such as—

**(1)** Existing Pavement Layers (thicknesses, etc.)
**(2)** Condition of Pavement (description of distress, pavement condition index, PCI, see AC 150/5380-6, etc.)
**(3)** Skid Resistance
**(4)** Required Thickness of New Pavement

**c.** Identify what feasible alternatives are available.

**d.** Determine costs associated with each feasible alternative in terms of present day costs.

**(1)** Initial Cost
**(2)** Maintenance
**(3)** Future Rehabilitation

**e.** Calculate life-cycle cost for each alternative to be evaluated.

**f.** Summarize life-cycle costs, length of time required to perform and the chance for success for each alternative.

**g.** Evaluated the most promising alternatives based on costs, time required, operational constraints, chance for success, etc.

**h.** If the selection cannot be narrowed to one alternative in the evaluation process, the most promising alternatives should each be bid and the selection made on the basis of the lowest bid.

**4. EXAMPLE PROBLEM – LIGHT-LOAD GENERAL AVIATION AIRPORT**. An example problem is discussed below that illustrates the use of the present worth life-cycle costing techniques described above.

**a.** A general aviation airport runway is in need of rehabilitation. The existing pavement contains alligator, transverse: and longitudinal cracking. The design aircraft for the facility has a gross weight of 24,000 pounds (10 890 kg). Using the procedures in Chapter 5 of this circular, a 3 inch (76 mm) thick bituminous overlay is required to rehabilitate the pavement. Pertinent data are presented in the Project Summary.

**PROJECT SUMMARY**

| | | |
|---|---|---|
| Location | Muddville, TX | |
| Design Aircraft | 24,000 lbs. (10 890 kg) | |
| Number - A.I.P | 12-34-567 | |
| Annual Departures of Design Aircraft: | 3,000 | |
| Type of Facility | General Aviation | |
| Runway Subgrade Strength | CBR = 4 | |
| Runway length | 3,200 ft (75 m) | |
| Runway Width | 75 ft (23 m) | |
| **Existing Pavement:** | | |
| **Layer and Type** | **Thickness** | **Condition** |
| AC Surface | 4 in. (102 mm) | Poor |
| Untreated Base | 10 in (254 mm) | Good |
| Condition of Existing Pavement<br>Condition Survey | Alligator cracking, moderate 15% of area<br>Trans. cracking, moderate, 350'/station<br>Long. cracking, moderate, 400'/station<br>PCI = 35 | |
| Skid Resistance | Good | |
| **Required Thickness New Pavement** | | |
| Total Thickness Required | 18 in. (487 mm) | |
| Surface Layer | 2 in. (51 mm) | |
| Base Layer | 5 in. (127 mm) | |
| Subbase Layer | 11 in. (279 mm) | |

**b.** Seven rehabilitation alternatives, including surface, in-place, and hot-mix recycling, are considered feasible. The alternatives under consideration are—

**(1)** Asphalt-rubber chip seal to delay overlay
**(2)** Full width 3-inch (76 mm) direct overlay
**(3)** Surface recycle l-inch (25 mm) deep + 2-inch (5 1 mm) overlay
**(4)** Asphalt-rubber interlayer + 3-inch (76 mm) overlay
**(5)** Fabric interlayer + 3-inch (76 mm) overlay
**(6)** Cold recycle with asphalt emulsion 6-inch (152 mm) deep + 2-inch (51 mm) overlay
**(7)** Hot recycle and re-work base

**c.** The present day costs of various activities associated with these alternatives are estimated as shown in table 1.

### TABLE 1. COSTS OF REHABILITATION ACTIVITIES

| Rehabilitation Activity | Cost | |
|---|---|---|
| | $/yd | $/m$^2$ |
| Asphalt-Rubber Chip Seal | 1.25 | (1.50) |
| Asphalt-Rubber Interlayer | 1.25 | (1.50) |
| Fabric Interlayer | 1.20 | (1.44) |
| Surface Recycling | 0.90 | (1.08) |
| Asphaltic Concrete - 1 in. (25 mm) | 1.65 | (1.97) |
| Cold Recycle + 2 in. (5 1 mm) Overlay | 6.60 | (7.89) |
| Hot Recycle + Rework Base | 8.10 | (9.69) |

**d.** The life-cycle costs for each alternative are calculated. This example shows the calculations for only one alternative, the asphalt-rubber chip seal. The calculations are shown in table 2. Some of the important aspects of this analysis are discussed further below.

### TABLE 2. PRESENT WORTH LIFE-CYCLE COSTING

| EXAMPLE 1. ALTERNATIVE 1. ASPHALT-RUBBER CHIP SEAL | | | |
|---|---|---|---|
| Year | Cost $/yd$^2$ | Present Worth Factor 4% | Present Worth Dollars |
| 0 A-R Chip Seal | 1.25 | 1.0000 | 1.25 |
| 1 | | 0.9615 | |
| 2 | | 0.9246 | |
| 3 Maintenance | 0.25 | 0.8890 | 0.22 |
| 4 3” Overlay | 4.95 | 0.8548 | 4.23 |
| 5 | | 0.8219 | |
| 6 | | 0.7903 | |
| 7 | | 0.7599 | |
| 8 | | 0.7307 | |
| 9 | | 0.7026 | |
| 10 Maintenance | 0.10 | 0.6756 | 0.07 |
| 11 Maintenance | 0.10 | 0.6496 | 0.06 |
| 12 Maintenance | 0.10 | 0.6246 | 0.06 |
| 13 Maintenance | 0.10 | 0.6006 | 0.06 |
| 14 Maintenance | 0.25 | 0.5775 | 0.14 |
| 15 1-1/2″ Overlay | 2.48 | 0.5553 | 1.38 |
| 16 | | 0.5339 | |
| 17 | | 0.5134 | |
| 18 | | 0.4936 | |
| 19 Maintenance | 0.10 | 0.4746 | 0.05 |
| 20 Maintenance | 0.15 | 0.4564 | 0.07 |
| Sub Total | 9.83 | | |
| Salvage Value | -0.71 | 0.4564 | -0.32 |
| Total | 9.12 | | 7.3 |

Note: To convert from $/yd$^2$ to $/m$^2$, divide by 0.8361

**(1)** The asphalt-rubber chip seal is estimated to delay the need for an overlay for 4 years. In the third year, the asphalt-rubber chip seal will need maintenance costing $0.25/yd$^2$ ($0.29/m$^2$).

**(2)** In the fourth year, a 3-inch (76 mm) overlay will be required. This overlay will require maintenance starting in the 10th year and will require progressively more maintenance as time goes on. In the 14th year maintenance will reach $0.25/yd$^2$ ($0.29/m$^2$).

**(3)** In the 15th year, a l.5-inch (38mm) leveling course will be required. This leveling course will not require maintenance until the 19th year. Maintenance costs begin to escalate again as time goes on.

**(4)** The 20th year marks the end of the analysis period. The salvage value of the leveling course is: the ratio of the life remaining/to how long it will last; multiplied by its costs. The leveling course, constructed in the 15th year, is expected to have a life of 7 years. It was used for only 5 years during the analysis period. Thus, the leveling course had 2 years of life remaining at the end of the analysis period. The salvage value is 2/7 x $2.48 = $0.71. Discounting the salvage value to the 20th year yields a salvage value of $0.32. Since the salvage value is an asset rather than a cost, it is shown as a negative cost in table 2. All other activities are assumed to have no salvage value since their useful lives have been exhausted during the analysis period. In this example, a discount rate of 4 percent was assumed. The present worth calculations for the other six alternatives should be calculated in a similar fashion.

**e.** A final summary of all alternatives considered in this example is shown in table 3. This summary shows initial costs, life-cycle costs, construction times, and the probability for success in percent. This final summary is a convenient method of presenting all alternatives for evaluation. In this example a discount rate of 4 percent was used in all calculations. Maintenance and need for rehabilitation in future years are the engineer’s estimates.

**TABLE 3. SUMMARY OF ALTERNATIVES**

| Alternatives | First Cost $/yd$^2$ | Present Worth Life Cycle $/yd$^2$ | Time | Chance for Success % |
|---|---|---|---|---|
| #1 Asphalt-Rubber Chip Seal | 1.25 | 7.30 | 2 days | 90 |
| #2 Asphalt-Rubber Interlayer | 4.95 | 7.29 | 5 days | 95 |
| #3 Fabric Interlayer | 4.20 | 6.22 | 4 days | 97 |
| #4 Surface Recycling | 6.20 | 7.39 | 4 days | 97 |
| #5 Asphaltic Concrete - 1 in. (25 mm) | 6.15 | 7.74 | 4 days | 97 |
| #6 Cold Recycle + 2 in. (5 1 mm) Overlay | 6.60 | 7.41 | 6 days | 97 |
| #7 Hot Recycle + Rework Base | 8.10 | 8.46 | 6 days | 99 |

Note: To convert from $/yd$^2$ to $/m$^2$, divide by 0.8361

a. Comparing and ranking the various alternatives shown in table 3 yields the following results:

**TABLE 4. COMPARATIVE RANKING OF ALTERNATIVES**

| First Cost | Life-Cycle Cost | Time | Chance for Success |
|---|---|---|---|
| #1 | #3 | #1 | #7 |
| #3 | #2 | #3 | #3 |
| #2 | #1 | #4 | #4 |
| #5 | #4 | #5 | #5 |
| #4 | #6 | #2 | #6 |
| #6 | #5 | #6 | #2 |
| #7 | #7 | #7 | #1 |

The average life-cycle cost of all 7 alternatives is $7.40/yd$^2$ ($8.85/m$^2$). Adding and subtracting 10 percent to the average lifecycle cost yields a range of $6.66/yd$^2$ to $8.14/yd$^2$ ($7.97/m$^2$ to $9.74/m$^2$). Alternative #3, surface recycling with an overlay, is lowest in life-cycle costs. Life-cycle costs for alternatives #1, 3, 4, 5, and 6 are within the 10 percent range of the average cost. Alternative #7 is the most costly and exceeds 10 percent of the average cots. Alternative #3 appears to be the most promising as it ranks high in three of the four categories considered. The decision to select alternative #3 must consider the availability of contractors capable of performing surface recycling and the time required for completion.

**5. SUMMARY.** This appendix presents an economic procedure for evaluating a wide variety of airport pavement design strategies. While the design example addresses a rehabilitation project, the principles are applicable to designs of new pavements as well. Cost data used in the example are out of date and should be updated with more current local costs before individual evaluations leading to strategy selection are undertaken. Whenever possible, local costs should be used in all alternative analyses as local conditions sometimes vary considerably from broad overall averages.

# APPENDIX 2. ORDER 5300.7

**U.S. DEPARTMENT OF TRANSPORTATION**
FEDERAL AVIATION ADMINISTRATION

**ORDER**
**5300.7**

Effective Date:
October 6, 2005

**SUBJ:** Standard Naming Convention for Aircraft Landing Gear Configurations

**1. Purpose of This Order.** This Order establishes a standard convention for naming and characterizing aircraft landing gear configurations. Although this order is primarily directed at fixed wing airplanes, it is applicable to any aircraft using wheels for landing purposes.

**2. Who This Order Affects.** This Order impacts divisions in the Offices of Planning and Programming, Airport Safety and Standards, Air Traffic, Airway Facilities, and Flight Standards Services; the regional Airports, Air Traffic, Airway Facilities, and Flight Standards Divisions; and Airport District and Field Offices. It will also affect organizations and individuals external to the Federal Aviation Administration (FAA). A standardized naming convention will allow uniformity and consistency among Federal agencies and external entities when naming aircraft gear configurations. Pilots and airport operators will no longer need to learn multiple naming systems and will be able to use common aircraft landing gear names at all military and commercial facilities.

**3. Background of This Order.** Landing gear configuration and aircraft gross weight are an integral part of airfield pavement design and are often used to characterize pavement strength. Historically, most aircraft used relatively simple gear geometries such as a single wheel per strut or two wheels side by side on a landing strut. As aircraft became larger and heavier, they required additional wheels to prevent individual wheel loads from introducing excessively high stresses into the pavement structure. For economy and efficiency reasons, aircraft manufacturers added more wheels per landing strut whenever possible. This often led to groups of wheels placed side-by-side and in tandem configurations.

**a. Typical Gear Configurations.** Up until the late 1980s, the majority of civilian and military aircraft used three basic gear configurations: the “single wheel” (one wheel per strut), the “dual wheel” (two wheels side by side on a strut), and the “dual tandem” (two wheels side by side followed by two additional side-by-side wheels). As aircraft continued to increase in gross weight, manufacturers attempted to limit the damage imparted to pavements by increasing the total number of wheels. This was typically done by adding additional landing struts to the aircraft. For example, McDonnell Douglas originally manufactured the DC-10 with two landing struts using the dual tandem gear configuration. When the company produced the heavier DC-10-30 variation of the aircraft, it added an additional landing strut, using a dual wheel configuration, to the center of the aircraft. Another example is the Boeing 747 aircraft. To reduce the impact to airfield pavements, Boeing used four landing struts with dual tandem configurations on the B-747.

**b. Complex Gear Configurations.** The increasingly complex gear arrangements quickly outgrew the simple single, dual, and dual tandem descriptions. Additionally, other aircraft were developed with gear configurations that used numerous wheels in arrangements that could not be described by the three simple gear configurations. As the number and complexity of gear arrangements increased and with no coordinated effort to provide a uniform naming convention, the FAA, U.S. Air Force, and U.S. Navy developed different naming systems that were not easily cross-referenced.

**4. Definitions Used in This Order.**

**a. Main Gear.** “Main gear” means the primary landing gear that is symmetrical on either side of an aircraft. When multiple landing gears are present and are not in line with each other, the outer most gear pair is considered the main gear. Multiples of the main gear exist when a gear is in line with other gears along the longitudinal axis of the aircraft.

**b. Body/Belly Gear.** “Body/belly gear” refers to an additional landing gear or gears in the center portion of the aircraft between the main gears. Body/belly gears may be of a different type than the main gear and may be nonsymmetrical.

**5. Intended areas of use.** The naming convention shown in Figure 1 is intended for use in all civilian and military applications. All FAA pavement design guidance and FAA databases and database publications, e.g. 5010 Master Record, Airport/Facilities Directory, etc., will hereafter use the described aircraft gear naming convention. The Air Force and Navy will also adopt this system in their pavement guidance and facilities databases.

## 6. Aircraft Gear Geometry Naming Convention.

**a. Basic Name for Aircraft Gear Geometry.** Under the naming convention, abbreviated aircraft gear designations may include up to three variables: the main gear configuration, the body/belly gear configuration if body/belly gears are present, and an optional tire pressure code described below. Figure 1 illustrates the two primary variables.

**b. Basic Gear Type.** Gear type for an individual landing strut is determined by the number of wheels across a given axle (or axle line) and whether wheels are repeated in tandem. There may exist, however, instances in which multiple struts are in close proximity and are best treated as a single gear, e.g. Antonov AN-124 (see Figure 14). If body/belly gears are not present, the second portion of the name is omitted. For aircraft with multiple gears, such as the B-747 and the A380, the outer gear pair is treated as the main gear.

**c. Basic Gear Codes.** This naming convention uses the following codes for gear designation purposes (see Figure 2):

| | |
|---|---|
| S | Single |
| D | Dual |
| T | Triple |
| Q | Quadruple |

**d. Use of Historical Tandem Designation.** Although the verbal description continues to use the term “tandem” to describe tandem gear configurations, the tandem designation “T” no longer appears in the gear name. “T” now indicates triple wheels.

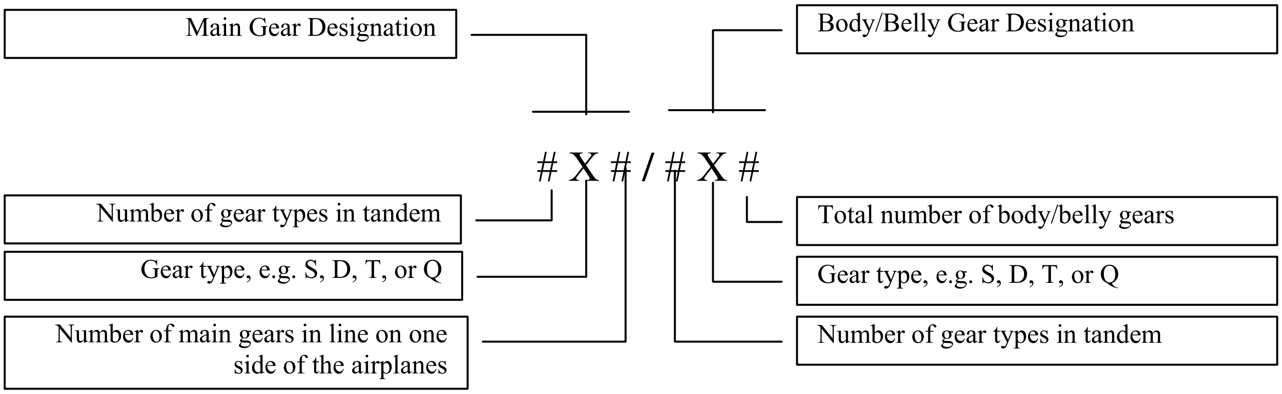

Figure 1. Aircraft Gear Naming Convention

**e. Main Gear Portion of Gear Designation.** The first portion of the aircraft gear name comprises the main gear designation. This portion may consist of up to three characters. The first character indicates the number of tandem sets or wheels in tandem, e.g. 3D = three dual gears in tandem. (If a tandem configuration is not present, the leading value of “1” is omitted.) Typical names are S = Single, 2D = two dual wheels in Tandem, 5D = five dual wheels in tandem, and 2T = two triple wheels in tandem.

**(1)** The second character of the gear designation indicates the gear code, e.g. S, D, T, or Q.

**(2)** The third character of the gear designation is a numeric value that indicates multiples of gears. For the main gear, the gear designation assumes that the gear is present on both sides (symmetrical) of the aircraft and that the reported value indicates the number of gears on one side of the aircraft. A value of 1 is used for aircraft with one gear on each side of the airplane. For simplicity, a value of 1 is assumed and is omitted from the main gear designation. Aircraft with more than one main gear on each side of the aircraft and where the gears are in line will use a value indicating the number of gears in line. For example, the Ilyushin IL-76 has two gears containing quadruple wheels on each side of the aircraft and is designated as a Q2 (see Figure 20).

**f. Body/Belly Gear Portion of Gear Designation.** The second portion of the aircraft gear name is used when body/belly gears are present. If body/belly gears are present, the main gear designation is followed by a forward slash (/), then the body/belly gear designation. For example, the B-747 aircraft has a two dual wheels in tandem main gear and two dual wheels in tandem body/belly gears. The full gear designation for this aircraft is 2D/2D2. The body/belly gear designation is similar to the main gear designation except that the trailing numeric value denotes the total number of body/belly gears present, e.g. 2D1 = one dual tandem body/belly gear; 2D2 = two dual tandem body/belly gears. Because body/belly gear arrangement may not be symmetrical, the gear code must identify the total number of gears present, and a value of 1 is not omitted if only one gear exists.

**g. Extension of Naming Convention.** Future aircraft might require additional body/belly gears that are nonsymmetrical and/or nonuniform. In these instances, the body/belly gear designation will contain a hyphen to indicate the nonuniform gear geometry. For demonstration purposes, consider adding one dual wheel body/belly gear to the existing 2D/2D2 gear configuration. The resulting gear name would be 2D/2D2-D.

**h. Unique Gear Configurations.** The Lockheed C-5 Galaxy has a unique gear type and is difficult to name using the proposed method. This aircraft will not be classified using the new naming convention and will continue to be referred to directly as the C5. Gear configurations such as those on the Boeing C-17, Antonov AN-124, and Ilusyin IL-76 might also cause some confusion; see Figures 8, 14, and 20, respectively. In these cases, it is important to observe the number of landing struts and the proximity of the struts. In the case of the AN-124, it is more advantageous to address the multiple landing struts as one gear, i.e. 5D or five duals in tandem, rather than use D5 or dual wheel gears with five sets per side of the aircraft. Due to wheel proximity, the C-17 gear is more appropriately called a 2T as it appears to have triple wheels in tandem. In contrast, the IL-76 has considerable spacing between the struts and should be designated as a Q2.

**i. Examples of Gear Geometry Naming Convention.** Figure 2 provides examples of generic gear types in individual and multiple tandem configurations. Figures 3 through 20 provide examples of known gear configurations.

**j. Comparison of Naming Convention to Historical Procedures.** Table 3 demonstrates the proposed naming convention and references the historic FAA, U.S. Air Force, and U.S. Navy methods. The historic Air Force methodology also addresses the configuration of the aircraft nose gear. Due to the insignificance of the pavement load imposed by the nose gear, the proposed method does not address nose gear configuration.

**k. Inclusion of Tire Pressure Information.** In addition to specifying gear geometry, the aircraft gear designation can also indicate the tire pressures at which the aircraft operates. Although tire pressure effects on airfield pavements are secondary to aircraft load and wheel spacing, they can have a significant impact on the ability of the pavement to accommodate a specific aircraft.

**(1)** The Aircraft Classification Number (ACN) and the Pavement Classification Number (PCN) system created by the International Civil Aviation Organization (ICAO) has defined and categorized aircraft tire pressures into four groups for reporting purposes. Table 1 lists these groups and their assigned codes.

Table 1. Standard Tire Pressure Categories

| Category | Range | | Code Designation |
|---|---|---|---|
| | psi | MPa | |
| High | No limit | No Limit | W |
| Medium | 146 - 217 | 1.01 - 1.5 | X |
| Low | 74 - 145 | 0.51 - 1.0 | Y |
| Very Low | 0 - 73 | 0.0 - 0.5 | Z |

**(2)** To allow for the reporting of tire pressure, the gear naming convention includes a third variable. Using the codes identified by the International Civil Aviation Organization (ICAO), the tire pressure can be included in parentheses after the standard gear nomenclature. Table 2 provides sample gear names with and without the additional tire pressure code.

Table 2. Sample Gear Names With and Without Tire Pressure Codes

| Gear Name Without Tire Pressure | Gear Name With Tire Pressure |
|---|---|
| S | S(W) |
| 2S | 2S(X) |
| 2D/2D1 | 2D/2D1(Z) |
| Q2 | Q2(Y) |
| 2D/3D2 | 2D/3D2(Z) |

Table 3. Proposed Naming Convention with Historical FAA, U.S. Air Force, and U.S. Navy Nomenclatures

| | | Historic FAA Designations | | | | | US Air Force Designations | | | | US NAVY Designations | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Proposed Nomeclature** | **Reference Figure** | **FAA Name** | **Main Gear** | **Belly gear** | **# belly gear** | **Total # wheels - excluding nose** | **Air Force Designation** | **Air Force types** | **Air Force Name** | **NOSE GEAR** | **Navy Name** | **Navy Designation** | **DOD Flight Information** | **Typical Aircraft** |
| **S** | 3 | Single Wheel | SW | | | 2 | S | A | Single, Tricycle | Single Wheel | Single Tricycle | ST | S | F-14, F15 |
| **S** | 4 | Single Wheel | SW | | | 2 | S | B | Single, Tricycle | Dual wheel | | | | |
| **D** | 5 | Dual wheel | DW | | | 4 | T | C | Twin, Tricycle | Single Wheel | | | | Beech 1900 |
| **D** | 6 | Dual wheel | DW | | | 4 | T | D | Twin, Tricycle | Dual wheel | Dual Tricycle | DT | T | B-737, P3 (C-9) |
| **2S** | 7 | Single Tandem | | | | 4 | S-TA | E | Single, Tandem Tricycle | Dual wheel | Single Tandem Tricycle | STT | ST | C-130 |
| **2T** | 8 | | | | | 12 | TR-TA | L | Twin-Tandem, Tricycle | Dual wheel | Triple Tandem | TRT | TRT | C-17 |
| **2D** | 9 | Dual Tandem | DT | | | 8 | T-TA | F | Twin-Tandem, Tricycle | Dual wheel | Dual Tandem Tricycle | DTT | TT | B757, KC135, C141 |
| **2D/D1** | 10 | Dual tandem | DT | DW | 1 | 10 | T-TA | H | Twin-Tandem, Tricycle | Dual wheel | Single Belly Twin Tandem | SBTT | SBTT | L1011, DC-10 |
| **2D/2D1** | 11 | Dual Tandem | DT | DT | 1 | 12 | | | | Dual wheel | | | | A340-600 |
| **2D/2D2** | 12 | Double Dual Tandem | DT | DT | 2 | 16 | T-TA | J | Twin-Tandem, Tricycle | Dual wheel | Double Dual Tandem | DDT | DDT | B-747, (E-4) |
| **3D** | 13 | Triple dual Tandem | TDT | | | 12 | | | | Dual wheel | | | | B-777 |
| **5D** | 14 | | | | | 20 | | | | 4 across | | | | An-124 |
| **7D** | 15 | | | | | 28 | | | | 4 across | | | | An-225 |
| **2D/3D2** | 16 | | DT | TDT | 2 | 20 | | | | Dual wheel | | | | A380 |
| **C5** | 17 | | | | | 24 | T-D-TA | K | Twin-Delta-Tandem, Tricycle | 4 across | Twin Delta Tandem | TDT | TDT | C-5 |
| **D2** | 18 | | | | | 8 | T-T | G | Twin-Twin, Bicycle | No Nose Gear - single outrigger | Twin Twin Tricycle | TT | TT | B-52 |
| **Q** | 19 | | | | | 8 | | | | | | | | HS-121 Trident |
| **Q2** | 20 | | | | | 16 | | | | | | | | IL-76 |

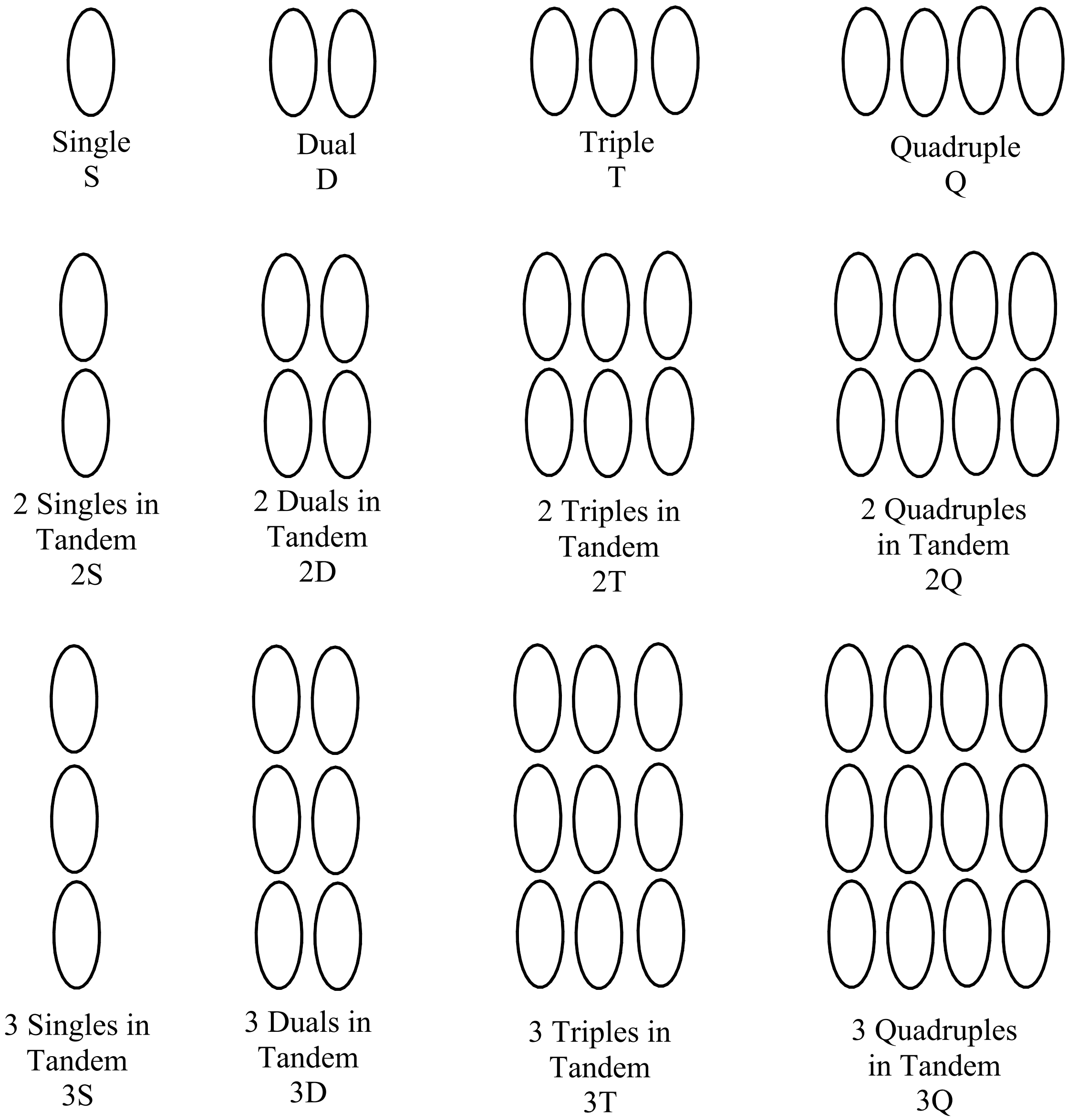

Figure 2. Generic Gear Configurations. Increase numeric value for additional tandem axles.

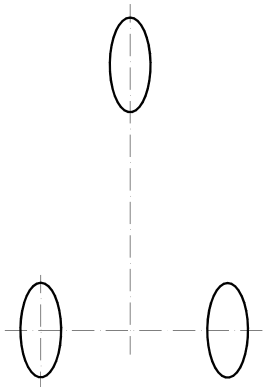

Figure 3. S - Single Wheel Main Gear with Single Wheel Nose Gear

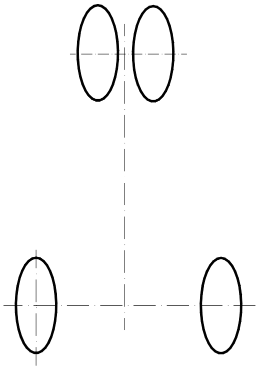

Figure 4. S - Single Wheel Main Gear with Dual Wheel Nose Gear

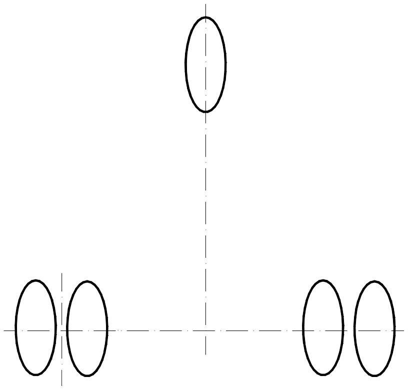

Figure 5. D - Dual Wheel Main Gear with Single Wheel Nose Gear

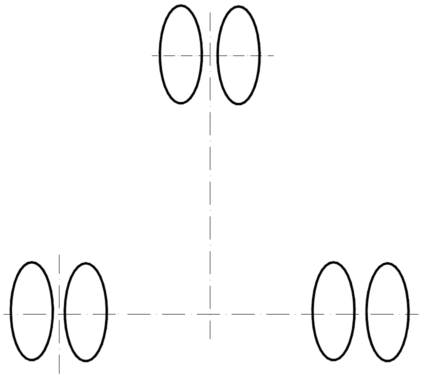

Figure 6. D - Dual Wheel Main Gear with Dual Wheel Nose Gear

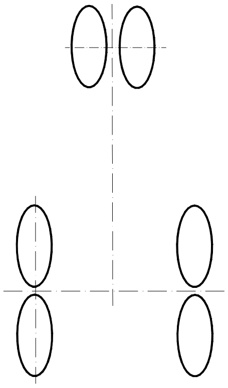

Figure 7. 2S - Two Single Wheels in Tandem Main Gear with Dual Wheel Nose Gear, Lockheed C-130

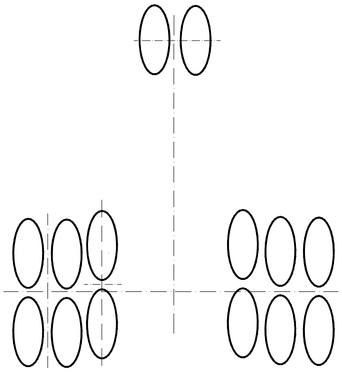

Figure 8. 2T - Two Triple wheels in Tandem Main Gear with Dual Wheel Nose Gear, Boeing C-17

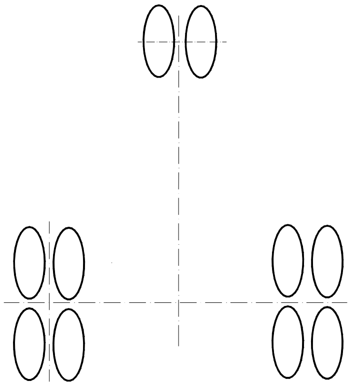

Figure 9. 2D - Two Dual Wheels in Tandem Main Gear with Dual Wheel Nose Gear

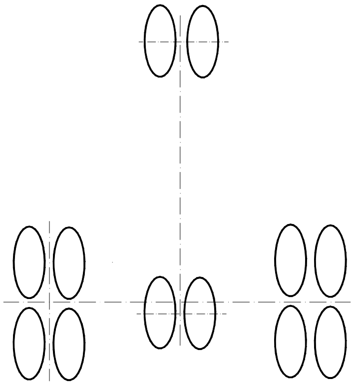

Figure 10. 2D/D1 - Two Dual Wheels in Tandem Main Gear/Dual Wheel Body Gear with Dual Wheel Nose Gear, McDonnell Douglas DC-10, Lockheed L-1011

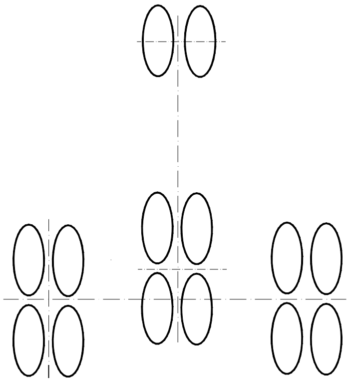

Figure 11. 2D/2D1 Two Dual Wheels in Tandem Main Gear/Two Dual Wheels in Tandem Body Gear with Dual Wheel Nose Gear, Airbus A340-600

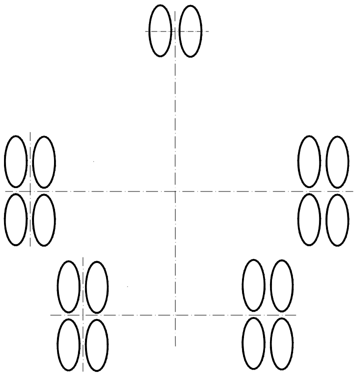

Figure 12. 2D/2D2 - Two Dual Wheels in Tandem Main Gear/Two Dual Wheels in Tandem Body Gear with Dual Wheel Nose Gear, Boeing B-747

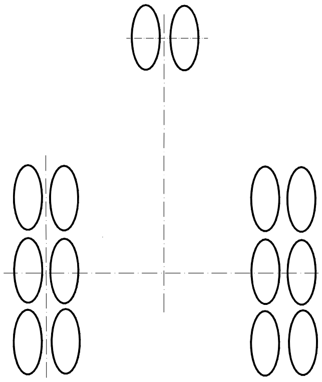

Figure 13. 3D - Three Dual Wheels in Tandem Main Gear with Dual Wheel Nose Gear, Boeing B-777

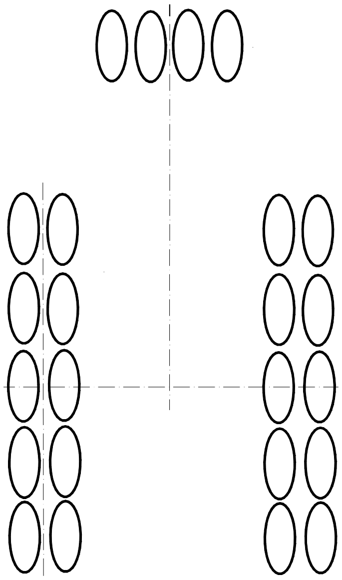

Figure 14. 5D - Five Dual Wheels in Tandem Main Gear with Quadruple Nose Gear, Antonov AN-124

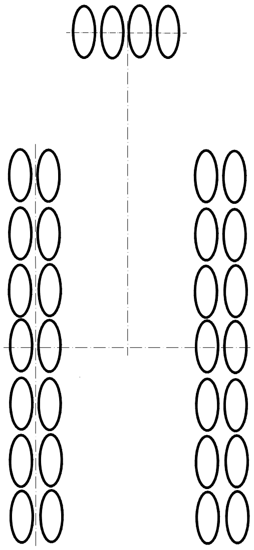

Figure 15. 7D - Seven Dual Wheels in Tandem Main Gear with Quadruple Nose Gear, Antonov AN-225

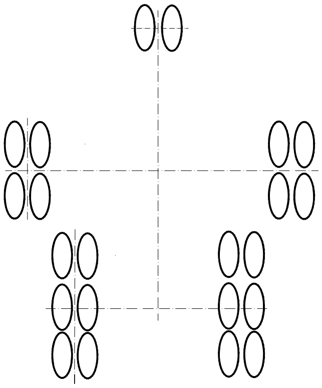

Figure 16. 2D/3D2 - Two Dual Wheels in Tandem Main Gear/Three Dual Wheels in Tandem Body Gear with Dual wheel Nose Gear, Airbus A380

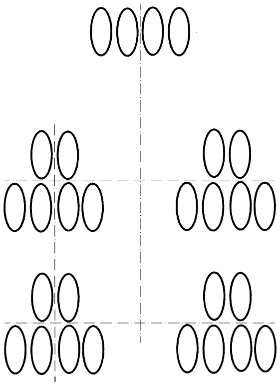

Figure 17. C5 - Complex Gear Comprised of Dual Wheel and Quadruple Wheel Combination with Quadruple Wheel Nose Gear, Lockheed C5 Galaxy

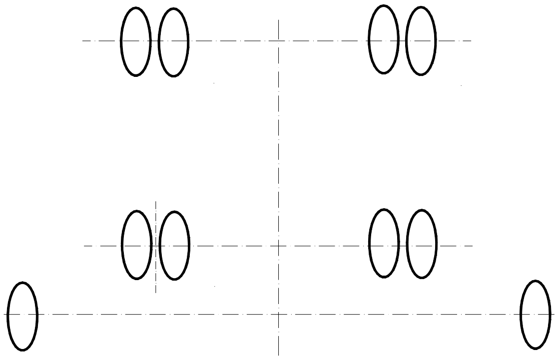

Figure 18. D2 - Dual Wheel Gear Two Struts per Side Main Gear with No Separate Nose Gear (note that single wheel outriggers are ignored), Boeing B-52 Bomber

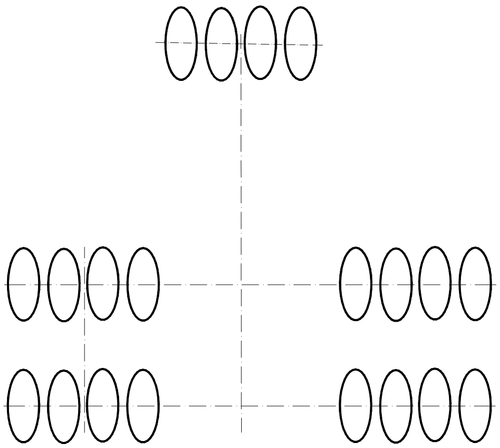

Figure 20. Q2 - Quadruple Wheels Two Struts per Side with Quadruple Nose Gear, Ilyushin IL-76

David L. Bennett
Director of Airport Safety and Standards

# APPENDIX 3. DESIGN OF STRUCTURES FOR HEAVY AIRPLANES

**1. BACKGROUND.** Airport structures such as culverts and bridges are usually designed to last for the foreseeable future of the airport. Information concerning the landing gear arrangement of future heavy airplanes is speculative. It may be assumed with sufficient confidence that strengthening of pavements to accommodate future airplanes can be performed without undue problems. Strengthening of structures, however, may prove to be extremely difficult, costly, and time-consuming. Point loadings on some structures may be increased; while on overpasses, the entire airplanes weight may be imposed on a deck span, pier, or footing.

**2. RECOMMENDED DESIGN PARAMETERS.**

**a. Structural Considerations.** For many structures the design is highly dependent upon the airplane landing gear configuration. Our assessment indicates that three basic configurations, shown in figure 1, will, if all are considered in the design of the bridge components, provide sufficient support for any airplane which may be forthcoming. These consist of two areas enclosing eight wheels each, or 16 wheels per airplane comprising the main gear. Nose gears, as such, are not considered, except as they occur in the static load. The “area” dimensions are 6 to 8 feet by 20 feet (2-3 m by 6 m) each supporting half of the airplane gross weight. Wheel prints are uniformly spaced within their respective areas.

**b. Foundation Design.** Foundation design will vary with soil type and depth. No departure from accepted methodology is anticipated; except that for shallow structures, such as inlets and culverts, the concentrated loads may require heavier and wider spread footings than those presently provided by the structural standards in current use. For buried structures, such as culverts, the following guidance from AASHTO is recommended.

**(1)** When the depth of fill is less than 2 feet, the wheel loads will be treated as concentrate loads.

**(2)** When the depth of fill is 2 feet or more, wheel loads will be considered as uniformly distributed over a square with sides equal to l-3/4 times the depth of the fill. When such areas from several concentrations overlap, the total load will be uniformly distributed over the area defined by the outside limits of the individual areas, but the total width of distribution will not exceed the total width of the supporting slab.

**c. Loads.** It should be noted that all loads discussed herein are to be considered as dead load plus live loads. The design of structures subject to direct wheel loads should also anticipate braking loads as high as 0.7 G (for no-slip brakes).

**d. Direct Loading.** Decks and covers subject to direct heavy airplane loadings such as manhole covers, inlet grates, utility tunnel roofs, bridges, etc., should be designed for the following loadings:

**(1)** Manhole covers for 100,000 lb. (45 000 kg) wheel loads with 250 psi (1.72 MPa) tire pressure.

**(2)** For spans of 2 feet (0.6 m) or less in the least direction, a uniform live load of 250 psi (1.72 MPa).

**(3)** For spans of 2 feet (0.6 m) or greater in the least direction, the design will be based on the number of wheels which will fit the span. Wheel loads of 50,000 to 75,000 pounds (22 700 to 34 000 kg) should be considered.

**(4)** Special consideration will be given to structures that will be required to support both in-line and diagonal traffic lanes, such as diagonal taxiways or apron taxi routes. If structures require expansion joints, load transfer may not be possible.

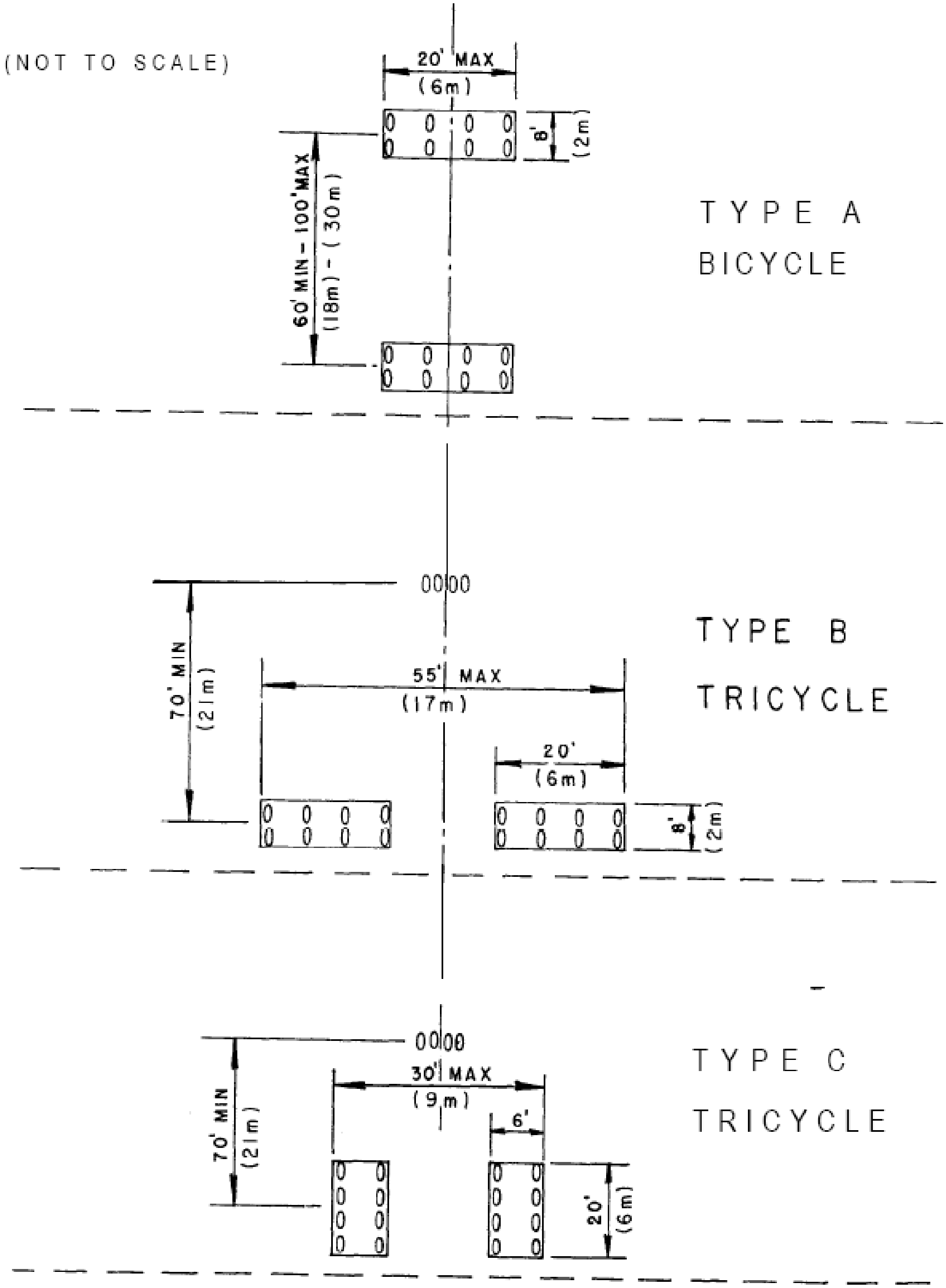

FIGURE 1. TYPICAL GEAR CONFIGURATION FOR DESIGN OF STRUCTURES

# APPENDIX 4. RELATED READING MATERIAL

Electronic copies of the latest versions of the following FAA publications are available on the FAA website. Printed copies can be requested from the Department of Transportation, Subsequent Distribution Office, Ardmore East Business Center, 3341 Q 75th Ave, Landover, MD 20785. The Department of Transportation, however, will charge a fee for some of these documents.

The following advisory circulars and orders are available for download on the FAA website (http://www.faa.gov):

1. AC 150/5300-9, Predesign, Prebid, and Preconstruction Conferences for Airport Grant Projects.
2. AC 150/5300-13, Airport Design.
3. AC 150/5320-5, Surface Drainage Design.
4. AC 150/5320-12, Measurement, Construction and Maintenance of Skid Resistance Airport Pavement Surfaces.
5. AC 150/5320-17, Airfield Pavement Surface Evaluation and Rating Manual.
6. AC 150/5335-5, Standardized Method of Reporting Airport Pavement Strength-PCN.
7. AC 150/5340-30, Design and Installation Details for Airport Visual Aids.
8. AC 150/5370-10, Standard for Specifying Construction of Airports.
9. AC 150/5370-11, Use of Nondestructive Testing Devices in the Evaluation of Airport Pavement.
10. AC 150/5370-14, Hot Mix Asphalt Paving Handbook.
11. AC 150/5380-6, Guidelines and Procedures for Maintenance of Airport Pavements.
12. Order 5300.7, Standard Naming Convention for Aircraft Landing Gear Configurations.

Copies of the following technical reports may be obtained from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161 (http://www.ntis.gov):

13. DOT/FAA/AR-04/46, Operational Life of Airport Pavements, by Garg, Guo, and McQueen, December 2004.
14. FAA-RD-73-169, Review of Soil Classification Systems Applicable to Airport Pavement Design, by Yoder, May 1974; AD-783-190.
15. FAA-RD-73-198, Vol. 1, Comparative Performance of Structural Layers in Pavement Systems. Volume I. Design, Construction, and Behavior under Traffic of Pavement Test Sections, by Burns, Rone, Brabston , and Ulery, June 1974; AD-0785-024.
16. FAA-RD-73-198, Vol. 3, Comparative Performance of Structural Layers in Pavement Systems, Volume III: Design and Construction of MESL, by Hammitt, December 1974; ADA-005-893.
17. FAA-RD-74-030, Design of Civil Airfield Pavement for Seasonal Frost and Permafrost Conditions, by Berg, October 1974; ADA-006-284.
18. FAA-RD-74-033, Vol. 3, Continuously Reinforced Concrete Airfield Pavement. Volume III. Design Manual for Continuously Reinforced Concrete Pavement, by Treybig, McCullough, and Hudson, May 1974; AD-0780-512.
19. FAA-RD-74-036, Field Survey and Analysis of Aircraft Distribution on Airport Pavements, by Ho Sang, February 1975; ADA-011-488.
20. FAA-RD-74-039, Pavement Response to Aircraft Dynamic Loads. Volume II. Presentation and Analysis of Data, by Ledbetter, September 1975, ADA-022-806.
21. FAA-RD-74-199, Development of a Structural Design Procedure for Flexible Airport Pavements, by Barker, and Brabston, September 1975; ADA-019-205.

22. FAA-RD-75-110, Vol. 2, Methodology for Determining, Isolating, and Correcting Runway Roughness, by Seeman, and Nielsen, June 1977; ADA-044-328.
23. FAA-RD-76-066, Design and Construction of Airport Pavements on Expansive Soils, by McKeen, June 1976; ADA-028-094.
24. FAA-RD-76-179, Structural Design of Pavements for Light Aircraft, by Ladd, Parker, and Pereira, December 1976; ADA-041-300.
25. FAA-RD-77-81, Development of a Structural Design Procedure for Rigid Airport Pavements, by Parker, Barker, Gunkel, and Odom, April 1979; ADA-069-548.
26. FAA-RD-81-078, Economic Analysis of Airport Pavement Rehabilitation Alternatives – An Engineering Manual, by Epps, and Wootan, October 1981; ADA-112-550.
27. FAA-PM-84/14, Performance of airport pavements under high traffic intensities.
28. DOT/FAA/PM-85115, Validation of Procedures for Pavement Design on Expansive Soils, by McKeen, July 1985; ADA-160-739.
29. FAA-PM-87/19, Design of Overlays for Rigid Airport Pavements, by Rollings, April 1988, ADA-194-331.

Copies of ASTM standards may be obtained from the American Society for Testing and Materials, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, Pennsylvania, 19428-2959 (http://www.astm.org/):

30. ASTM D420, Standard Guide to Site Characterization for Engineering Design Construction Purposes.
31. ASTM D421,Standard Practice for Dry Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants.
32. ASTM D422, Standard Test Method for Particle-Size Analysis of Soils.
33. ASTM D427, Test Method for Shrinkage Factors of Soils by the Mercury Method.
34. ASTM D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft$^3$ (600 kN-m/m$^3$)).
35. ASTM D1557, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft$^3$ (2,700 kN-m/m$^3$)).
36. ASTM D1587, Thin-Walled Tube Sampling of Soils for Geotechnical Purposes.
37. ASTM D1883, Standard Test Method for CBR (California Bearing Ratio) of Laboratory-Compacted Soils.
38. ASTM D2434, Standard Test Method for Permeability of Granular Soils (Constant Head).
39. ASTM D2487, Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).
40. ASTM D2488, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure).
41. ASTM D2573, Standard Test Method for Field Vane Shear Test in Cohesive Soil
42. ASTM D3080, Standard Test Method for Direct Shear Test of Soils Under Consolidated Drained Conditions.
43. ASTM D4318, Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
44. ASTM D4429, Standard Test Method for CBR (California Bearing Ratio) of Soils in Place.
45. ASTM D4632, Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
46. ASTM D5340, Standard Test Method for Airport Pavement Condition Index Surveys.
47. ASTM C39/C39M, Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
48. ASTM C78, Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading).

49. ASTM C496/C496M, Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens.
50. ASTM A185/A185M-06e1 Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete
51. ASTM A615/A615M-07, Standard Specification for Deformed and Plain Carbon Steel Bars for Concrete Reinforcement-AASHTO No. M 31
52. ASTM A996/A996M-06a Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement
53. ASTM A497/A497M-06e1 Standard Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete

Copies of AASHTO standards may be obtained from the American Association of State Highway & Transportation Officials, 444 North Capitol Street N.W., Suite 249, Washington, DC 20001 (http://www.transportation.org/):

54. AASHTO T 194, Standard Method of Test for Determination of Organic Matter in Soils by Wet Combustion.
55. AASHTO T 222, Standard Method of Test for Nonrepetitive Static Plate Load Test of Soils and Flexible Pavement Components for Use in Evaluation and Design of Airport and Highway Pavements.

Copies of Unified Facility Criteria (UFC) may be obtained from the US Department of Defense website (http://65.204.17.188//report/doc_ufc.html):

56. UFC 3-260-02, Pavement Design for Airfields, Unified Facility Criteria (UFC), June 2001 (Superseding U.S. Army and Air Force, Pavement design for seasonal frost conditions, U.S. Army and Air Force, TM 5-818-2, AFM 88-6 Chapter 4, U.S. Army, Air Force and NAVFAC TM 5-825-2/AFM 88-6 Chapter 2/DM 21.3, Flexible Pavement Design for Airfields, U.S. Army and Air Force, Technical Manual TM 5-824-3/AFM 88-6 Chapter 3, Rigid Pavements for Airfields Other than Army.

Copies of the following publications are available from Asphalt Institute, 2696 Research Park Drive, Lexington, KY 40511-8480 (http://www.asphaltinstitute.org/):

57. MS-11, Thickness Design – Airports.
58. MS-10, Soils Manual.
59. MS-19, Basic Asphalt Emulsion Manual.
60. IS-154, Thickness Design-Asphalt Pavements for General Aviation.
61. SW-1 Asphalt Pavement Thickness Design Software.

Miscellaneous

62. Soil Cement Construction Handbook, Portland Cement Association, 5420 Old Orchard Road, Skokie, Illinois 60077, 1995.
63. NIKE3D - A Nonlinear, Implicit, Three-Dimensional Finite Element Code for Solid and Structural Mechanics – User's Manual, by Maker, B., Ferencz, R.M., and Hallquist, J.O., Lawrence Livermore National Laboratory, Livermore, California, Report No. UCRL-MA-105268 Rev.1, April 1995.
64. FHWA-HI-95-038, Geosynthetic Design and Construction Guidelines, 1995.
65. Berggren, W.P., Prediction of temperature distribution in frozen soils, *Transactions of the American Geophysical Union*, *24* (3), 71-77, 1943.
66. Development of Guidelines for Rubblization, Airfield Asphalt Pavement Technology Program (AAPTP) Report 04-01, by Buncher, M. (Principal Investigator), Fitts, G., Scullion, T., and McQueen, R., Draft Report, November 2007.
67. Best Practices for Airport Portland Cement Concrete Pavement Construction (Rigid Airport Pavement), Innovative Pavement Research Foundation (IPRF), Report IPRF-01-G-002-1, by Kohn, S. and Tayabji, S. (Principal Investigators), April 2003.

# APPENDIX 5. AIRFIELD PAVEMENT DESIGN SOFTWARE

**1. BACKGROUND**. This appendix announces software to aid in the design of airfield pavements in accordance with the new design procedure presented in Chapters 3, 4 and 5 of this AC. The software is called FAARFIELD and incorporates two subprograms LEAF, implemented as a Microsoft Windows$^{TM}$ dynamic link library written in Visual Basic$^{TM}$ 2005, which performs Layered Elastic Analysis (LEA) computations and NIKE3D_FAA, a three-dimensional finite element computational program implemented as a dynamic link library written in FORTRAN. NIKE3D_FAA is a modification of the NIKE3D software program originally developed by the US Department of Energy, Lawrence Livermore National Laboratory (LLNL), Livermore, California. NIKE3D and INGRID (3D mesh generation software for NIKE3D) are distributed in compiled form under the terms of a software sharing agreement between the FAA and LLNL.

The remainder of the FAARFIELD program is written in Visual Basic$^{TM}$ 2005 and operates under Microsoft Windows$^{TM}$. Software for the previous design method as described in AC 150/5320-6D is also presented in this appendix and uses Microsoft Excel $^{TM}$ as a platform with Visual Basic $^{TM}$ for Applications (VBA) Macros to facilitate the design process.

**2. AVAILABLE SOFTWARE AND SUPPORT MATERIAL**.

FAARFIELD implements both layered elastic-based and three-dimensional finite element-based design procedures for new and overlay designs of flexible and rigid pavements, respectively. For flexible pavement design, FAARFIELD uses the maximum vertical strain at the top of the subgrade, and the maximum horizontal strain at the bottom of the asphalt surface layer, as the predictors of pavement structural life. For rigid pavement design, FAARFIELD uses the maximum horizontal stress at the bottom edge of the PCC slab as the predictor of pavement structural life.

The design method to determine pavement thickness as described in AC 150/5320-6D uses two programs (spreadsheets). Program F805FAA.XLS determines pavement thickness requirements for flexible pavement sections and bituminous overlays on existing flexible pavement sections. Program R805FAA.XLS determines pavement thickness requirements for rigid pavement sections and bituminous or Portland cement concrete overlays on existing rigid or flexible pavement sections. Reference manuals, which guide users through each step, are available for both programs. Pavement designs developed using the Frost Design feature of the spreadsheets are consistent with the Reduced Subgrade Strength method described in Chapter 3. The spreadsheets will produce thickness designs consistent with the nomographs used in AC 150/5320-6D.

**3. ACCESS TO SOFTWARE**. Design software and user manuals may be downloaded directly from the FAA Office of Airport Safety and Standards website (http://www.faa.gov/airports/engineering/design_software/). Updates or additions to the design software and manuals will be posted online, as well.

**4. USE OF SOFTWARE**. Numerical results from the programs may be used to complete FAA Form 5100-1, Airport Pavement Design. When used to develop the pavement design, the printed results of the software should be attached to Form 5100-1. Results from the program design summary and the airplane mixture data provide sufficient information to reproduce and review the pavement thickness design. Additional design information is required to complete Form 5100-1.

# APPENDIX 6. FAARFIELD INTERNAL AIRPLANE LIBRARY

## AIRPLANE LISTING BY GROUP

### TABLE 1. GENERIC AIRPLANE GROUP

| | Airplane Name | Gross Taxi Weight (lbs) | Gear Designation |
|---|---|---|---|
| 1 | SWL-50 | 50,000 | S |
| 2 | Sngl Whl-3 | 3,000 | S |
| 3 | Sngl Whl-5 | 5,000 | S |
| 4 | Sngl Whl-10 | 10,000 | S |
| 5 | Sngl Whl-12.5 | 12,500 | S |
| 6 | Sngl Whl-15 | 15,000 | S |
| 7 | Sngl Whl-20 | 20,000 | S |
| 8 | Sngl Whl-30 | 30,000 | S |
| 9 | Sngl Whl-45 | 45,000 | S |
| 10 | Sngl Whl-60 | 60,000 | S |
| 11 | Sngl Whl-75 | 75,000 | S |
| 12 | Dual Whl-10 | 10,000 | D |
| 13 | Dual Whl-20 | 20,000 | D |
| 14 | Dual Whl-30 | 30,000 | D |
| 15 | Dual Whl-45 | 45,000 | D |
| 16 | Dual Whl-50 | 50,000 | D |
| 17 | Dual Whl-60 | 60,000 | D |
| 18 | Dual Whl-75 | 75,000 | D |
| 19 | Dual Whl-100 | 100,000 | D |
| 20 | Dual Whl-150 | 150,000 | D |
| 21 | Dual Whl-200 | 200,000 | D |
| 22 | Dual Tan-100 | 100,000 | 2D |
| 23 | Dual Tan-150 | 150,000 | 2D |
| 24 | Dual Tan-200 | 200,000 | 2D |
| 25 | Dual Tan-300 | 300,000 | 2D |
| 26 | Dual Tan-400 | 400,000 | 2D |

### TABLE 2. AIRBUS GROUP

| | **Airplane Name** | **Gross Taxi Weight (lbs)** | **Gear Designation** |
|---|---|---|---|
| 1 | A300-B2 SB | 315,041 | 2D |
| 2 | A300-B2 std | 315,041 | 2D |
| 3 | A300-B4 std | 365,747 | 2D |
| 4 | A300-B4 LB | 365,747 | 2D |
| 5 | A300-600 std | 380,518 | 2D |
| 6 | A300-600 LB | 380,518 | 2D |
| 7 | A310-200 | 315,041 | 2D |
| 8 | A310-300 | 315,041 | 2D |
| 9 | A318-100 std | 124,341 | D |
| 10 | A318-100 opt | 150,796 | D |
| 11 | A319-100 std | 141,978 | D |
| 12 | A319-100 opt | 150,796 | D |
| 13 | A320-100 | 150,796 | D |
| 14 | A320-200 Twin std | 162,922 | D |
| 15 | A320-200 Twin opt | 172,842 | D |
| 16 | A320 Bogie | 162,922 | 2D |
| 17 | A321-100 std | 183,866 | D |
| 18 | A321-100 opt | 188,275 | D |
| 19 | A321-200 std | 197,093 | D |
| 20 | A321-200 opt | 207,014 | D |
| 21 | A330-200 std | 509,047 | 2D |
| 22 | A330-200 opt | 515,661 | 2D |
| 23 | A330-300 std | 509,047 | 2D |
| 24 | A330-300 opt | 515,661 | 2D |
| 25 | A340-200 std | 568,563 | 2D/D1 |
| 26 | A340-200 opt | 575,176 | 2D/D1 |
| 27 | A340-300 std | 608,245 | 2D/D1 |
| 28 | A340-300 opt | 611,552 | 2D/D1 |
| 29 | A340-500 std | 813,947 | 2D/2D1 |
| 30 | A340-500 opt | 840,402 | 2D/2D1 |
| 31 | A340-600 std | 805,128 | 2D/2D1 |
| 32 | A340-600 opt | 840,402 | 2D/2D1 |
| 33 | A380-800 | 1,239,000 | 2D/3D2 |
| 34 | A380-800F | 1,305,125 | 2D/3D2 |

### TABLE 3. BOEING GROUP

| | Airplane Name | Gross Taxi Weight (lbs) | Gear Designation |
|---|---|---|---|
| 1 | B707-320C | 336,000 | 2D |
| 2 | B720B | 235,000 | 2D |
| 3 | B717-200 HGW | 122,000 | D |
| 4 | B727-100C Alternate | 170,000 | D |
| 5 | Adv. B727-200C Basic | 185,200 | D |
| 6 | Adv. B727-200 Option | 210,000 | D |
| 7 | B737-100 | 111,000 | D |
| 8 | Adv. B737-200 | 128,600 | D |
| 9 | Adv. B737-200 LP | 117,500 | D |
| 10 | B737-300 | 140,000 | D |
| 11 | B737-400 | 150,500 | D |
| 12 | B737-500 | 134,000 | D |
| 13 | B737-600 | 145,000 | D |
| 14 | B737-700 | 155,000 | D |
| 15 | B737-800 | 174,700 | D |
| 16 | B737-900 ER | 188,200 | D |
| 17 | B737 BBJ2 | 174,700 | D |
| 18 | B747-100 SF | 738,000 | 2D/2D2 |
| 19 | B747-200B Combi Mixd | 836,000 | 2D/2D2 |
| 20 | B747-300 Combi Mixed | 836,000 | 2D/2D2 |
| 21 | B747-400 | 877,000 | 2D/2D2 |
| 22 | B747-400ER | 913,000 | 2D/2D2 |
| 23 | B747-SP | 703,000 | 2D/2D2 |
| 24 | B757-200 | 256,000 | 2D |
| 25 | B757-300 | 271,000 | 2D |
| 26 | B767-200 | 317,000 | 2D |
| 27 | B767-200 ER | 396,000 | 2D |
| 28 | B767-300 ER | 413,000 | 2D |
| 29 | B767-400 ER | 451,000 | 2D |
| 30 | B777-200 Baseline | 537,000 | 3D |
| 31 | B777-200 ER | 657,000 | 3D |
| 32 | B777-200LR | 768,800 | 3D |
| 33 | B777-300 Baseline | 662,000 | 3D |
| 34 | B777-300 ER | 777,000 | 3D |
| 35 | B787-8 | 478,000 | 2D |
| 36 | B787-9 | 542,000 | 2D |

## TABLE 4. OTHER COMMERCIAL AIRPLANES GROUP

| | Airplane Name | Gross Taxi Weight (lbs) | Gear Designation |
|---|---|---|---|
| 1 | An-124 | 877,430 | 5D |
| 2 | An-225 | 1,322,750 | 7D |
| 3 | BAe 146 | 95,000 | D |
| 4 | Concorde | 410,000 | 2D |
| 5 | DC3 | 25,199 | S |
| 6 | DC4 | 73,002 | D |
| 7 | DC8-43 | 318,000 | 2D |
| 8 | DC8-63/73 | 358,000 | 2D |
| 9 | DC9-32 | 109,000 | D |
| 10 | DC9-51 | 122,000 | D |
| 11 | DC10-10 | 458,000 | 2D |
| 12 | DC10-30/40 | 583,000 | 2D/D1 |
| 13 | Fokker F100 | 101,000 | D |
| 14 | IL62 | 358,472 | 2D |
| 15 | IL76T | 376,990 | 3Q |
| 16 | IL86 | 466,278 | 2D/2D1 |
| 17 | L-1011 | 498,000 | 2D |
| 18 | MD11ER | 633,000 | 2D/D1 |
| 19 | MD83 | 161,000 | D |
| 20 | MD90-30 ER | 168,500 | D |
| 21 | TU134A | 108,027 | 2D |
| 22 | TU154B | 216,053 | 3D |

## TABLE 5. GENERAL AVIATION GROUP

| | Airplane Name | Gross Taxi Weight (lbs) | Gear Designation |
|---|---|---|---|
| 1 | Aztec-D | 5,200 | S |
| 2 | Baron-E-55 | 5,424 | S |
| 3 | BeechJet-400 | 15,500 | S |
| 4 | BeechJet-400A | 16,300 | S |
| 5 | Bonanza-F-33A | 3,412 | S |
| 6 | Canadair-CL-215 | 33,000 | S |
| 7 | Centurion-210 | 4,100 | S |
| 8 | Challenger-CL-604 | 48,200 | D |
| 9 | Chancellor-414 | 6,200 | S |
| 10 | Chk.Arrow-PA-28-200 | 2,500 | S |
| 11 | Chk.Six-PA-32 | 3,400 | S |
| 12 | Citation-525 | 10,500 | S |
| 13 | Citation-550B | 15,000 | S |
| 14 | Citation-V | 16,500 | S |
| 15 | Citation-VI/VII | 23,200 | D |
| 16 | Citation-X | 36,000 | D |
| 17 | Conquest-441 | 9,925 | S |

## TABLE 5. GENERAL AVIATION GROUP (cont.)

| | Airplane Name | Gross Taxi Weight (lbs) | Gear Designation |
|---|---|---|---|
| 17 | Conquest-441 | 9,925 | S |
| 18 | DC-3 | 26,900 | S |
| 19 | Falcon-50 | 38,800 | D |
| 20 | Falcon-900 | 45,500 | D |
| 21 | Falcon-2000 | 35,000 | D |
| 22 | Fokker-F-28-1000 | 66,500 | D |
| 23 | Fokker-F-28-2000 | 65,000 | D |
| 24 | Fokker-F-28-4000 | 73,000 | D |
| 25 | GrnCaravan-CE-208B | 8,750 | S |
| 26 | Gulfstream-G-II | 66,000 | D |
| 27 | Gulfstream-G-III | 70,200 | D |
| 28 | Gulfstream-G-IV | 75,000 | D |
| 29 | Gulfstream-G-V | 90,900 | D |
| 30 | Hawker-800 | 27,520 | D |
| 31 | Hawker-800XP | 28,120 | D |
| 32 | KingAir-B-100 | 11,500 | D |
| 33 | KingAir-C-90 | 9,710 | S |
| 34 | Learjet-35A/65A | 18,000 | D |
| 35 | Learjet-55 | 21,500 | D |
| 36 | Malibu-PA-46-350P | 4,118 | S |
| 37 | Navajo-C | 6,536 | S |
| 38 | RegionalJet-200 | 47,450 | D |
| 39 | RegionalJet-700 | 72,500 | D |
| 40 | Sabreliner-40 | 19,035 | S |
| 41 | Sabreliner-60 | 20,372 | S |
| 42 | Sabreliner-65 | 24,000 | S |
| 43 | Sabreliner-80 | 23,500 | D |
| 44 | Sarat.PA-32R-301 | 3,616 | S |
| 45 | Seneca-II | 4,570 | S |
| 46 | Shorts-330-200 | 22,900 | S |
| 47 | Shorts-360 | 27,200 | S |
| 48 | Skyhawk-172 | 2,558 | S |
| 49 | Skylane-1-82 | 3,110 | S |
| 50 | Stationair-206 | 3,612 | S |
| 51 | SuperKingAir-300 | 14,100 | D |
| 52 | SuperKingAir-350 | 15,100 | D |
| 53 | SuperKingAir-B200 | 12,590 | D |

## TABLE 6. MILITARY GROUP

| | Airplane Name | Gross Taxi Weight (lbs) | Gear Designation |
|---|---|---|---|
| 1 | C-5 | 769,000 | Complex |
| 2 | C-17A | 585,000 | 2T |
| 3 | C-123 | 60,000 | S |
| 4 | C-130 | 155,000 | 2S |
| 5 | C-141 | 345,000 | 2D |
| 6 | F-15C | 68,000 | S |
| 7 | F-16C | 42,300 | S |
| 8 | F/A-18C | 56,000 | S |
| 9 | KC-10 | 583,000 | 2D/D1 |
| 10 | P-3 | 142,000 | D |