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## ADDENDUM Results

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# Microwave Landing System (MLS) Channel Plans and Traffic Loading

FEDERAL AVIATION ADMINISTRATION

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Final Report

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## ADDENDUM

### Results

#### Revised Pulse Loading Determination (August 1982)

The magnitude of the maximum pulse loading situation within the STLM was reinvestigated based on the following change of inputs.

a) It was assumed that the victim transponder (previously defined as El Monte) in the STLM is replying at its maximum rate of 5000 pp/s. This required a redefinition of the aircraft within this service volume as follows:

| Location     | Number of A/C | Altitude (feet) | Interrogation Rate (pp/s) | Number of Interrogators |
|--------------|---------------|-----------------|---------------------------|-------------------------|
| Ground       | 50            | 0               | 40                        | 1                       |
| Final        | 6             | below 2000      | 40                        | 2                       |
| Intermediate | 26            | 2000-4000       | 16                        | 2                       |
| Stack        | 55            | above 4000      | 16                        | 2                       |
| Initial      | 55            | above 4000      | 16                        | 2                       |

b) The uplink interrogator loading was calculated at distances of 22, and 7 nmi. The interrogator at 22 nmi was in the narrow band mode. At 7 nmi the interrogator was wide band. Beacon transponder squitter rates of 700 and 1350 will be used.

c) The following minimum uplink and downlink power density requirements was used:

| <u>Uplink</u>          | <u>Downlink</u>        | <u>Distance</u>      |
|------------------------|------------------------|----------------------|
| -80 dBw/m <sup>2</sup> | -83 dBw/m <sup>2</sup> | 7 nmi (wide band)    |
| -87 dBw/m <sup>2</sup> | -93 dBw/m <sup>2</sup> | 22 nmi (narrow band) |

d) Receiver thresholds of -20, -14, -9, -6, 0, and +6 dB will be examined in both the uplink and downlink cases.

e) Two blocks of channels from the Amsterdam channel plan was tested in the STLM. First, channels within 5 MHz of channel 24X; second, channels within 5 MHz of channel 90Y.

The results reflect two types of pulse loading interactions:

1. Undesired interrogations at a transponder from aircraft operating in a different service volume but transmitting on a frequency within the victim transponder's receiver bandwidth (air-to-ground loading).

2. Undesired replies and squitter received at an interrogator from a transponder servicing a different service volume but transmitting on a frequency within the victim interrogator's receiver bandwidth (ground-to-air loading).

The interrogation loading on a transponder at El Monte, California, with the desired signal interrogator (aircraft) at 22 and 7 nmi for channels 24X and 90Y, respectively is provided in TABLES 5A, 5B, 6A, and 6B. The loading as noted in the tables is separated vertically into that which comes from cofrequency or adjacent-frequency undesired sources and whether the interfering interrogators are operating in the enroute or precision mode.<sup>a</sup> The horizontal separation of the data in the tables reflects the relative power level between the desired and undesired interrogations at the transponder receiver input terminals. Note that with the exception of the one row marked "total individual pulses," the numbers in the tables represent interrogations not individual pulses.

If one considers an enroute/precision system, a transponder receiver with a relatively wide bandwidth ( $\pm 3.5$  MHz) and with a -20 dB threshold level, the maximum number of individual air-to-ground pulses to be considered in a pulse loading analysis is 72,832 (see TABLE 5A). If the threshold level is higher

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<sup>a</sup>Precision mode was assumed for aircraft in final approach within 7 nmi of the runway and those in takeoff.

than -20 dB (i.e., -18 dB), this maximum number would be a bit smaller, perhaps 71,592 as an estimate by interpolation.

The reply loading on an aircraft operating in the service volume of a DME/P transponder at El Monte, California, for various conditions of "demand loading" is provided in TABLES 10A through 13B. Demand loading refers to the potential for the idle reply rate of a transponder to be set at some value below 2700 replies/second (e.g., 1350 or 700), and that this reply rate would increase above that idle rate only when required in order to service additional aircraft in the service volume. The advantage of demand loading is that it could remove a significant amount of unnecessary squitter from the electromagnetic environment.

TABLES 10A through 13B are organized in a similar manner to TABLES 5A through 6B with the loading separated by that which comes from cofrequency or adjacent-frequency sources and also separated by relative desired- and undesired-signal power level at the interrogator input terminals. Note that in TABLES 10A through 13B, the loading numbers represent replies and squitter, not individual pulses, with the exception of the last row marked "total individual pulses."

The data reflected in TABLES 10A through 13B indicates that for an enroute/precision system, an interrogator with a relatively wide bandwidth while operating in the precision mode ( $\pm 3.5$  MHz) and with a -20 dB threshold level while in final approach or takeoff, the maximum number of individual ground-to-air pulses to be considered in a pulse loading analysis is 107,100 pulses per second (see TABLE 10A) when demand loading is not considered. If a demand loaded DME/P system is introduced throughout the STLM, with an idle reply rate of 700 replies/second, the pulse-loading situation reduces to 79,800 pulses per second (see TABLE 12A). This situation is somewhat less severe for an aircraft operating in the same service volume but in the enroute mode (i.e., narrower bandwidth, higher threshold).

TABLE 5A  
 AIR-TO-GROUND (INTERROGATION) LOADING AT A TRANSPONDER  
 FOR A DESIRED-SIGNAL INTERROGATOR AT 22 nmi ( $\pm 4$  MHz ABOUT 24X)

| Relative Frequency                   | Interrogator Type-Mode <sup>a</sup> | Number of Interrogations <sup>b</sup> Per Second |                |               |               |               |               |
|--------------------------------------|-------------------------------------|--|----------------|---------------|---------------|---------------|---------------|
|                                      |                                     | U/D $\geq -20$                                   | U/D $\geq -14$ | U/D $\geq -9$ | U/D $\geq -6$ | U/D $\geq +0$ | U/D $\geq +6$ |
| Cofrequency                          | DME/N-En route                      | 0  | 0              | 0             | 0             | 0             | 0             |
|                                      | DME/P-En route                      | 8384   | 7968           | 7616          | 7280          | 6528          | 6016          |
|                                      | DME/P-Precision                     | 4160   | 4080           | 3840          | 3840          | 3600          | 2640          |
| $\pm 1$ MHz                          | DME/N-En route                      | 1350   | 1290           | 1200          | 1050          | 810           | 660           |
|                                      | DME/P-En route                      | 4448   | 3744           | 2784          | 1952          | 928           | 448           |
|                                      | DME/P-Precision                     | 800  | 640            | 560           | 560           | 480           | 320           |
| $\pm 2$ MHz                          | DME/N-En route                      | 0  | 0              | 0             | 0             | 0             | 0             |
|                                      | DME/P-En route                      | 6016   | 5680           | 4656          | 3936          | 2192          | 1088          |
|                                      | DME/P-Precision                     | 960  | 880            | 480           | 480           | 240           | 0             |
| $\pm 3$ MHz                          | DME/N-En route                      | 2220   | 2070           | 1830          | 1710          | 1500          | 1200          |
|                                      | DME/P-En route                      | 864  | 864            | 816           | 816           | 512           | 320           |
|                                      | DME/P-Precision                     | 240  | 240            | 160           | 160           | 80            | 0             |
| $\pm 4$ MHz                          | DME/N-En route                      | 0  | 0              | 0             | 0             | 0             | 0             |
|                                      | DME/P-En route                      | 4896   | 4640           | 4224          | 3808          | 3232          | 2624          |
|                                      | DME/P-Precision                     | 2080   | 1840           | 1760          | 1760          | 1680          | 720           |
| Total Interrogation                  | DME/N-En route                      | 3570   | 3360           | 3030          | 2760          | 2310          | 1860          |
|                                      | DME/P-En route                      | 24606  | 22896          | 20096         | 17792         | 13392         | 10496         |
|                                      | DME/P-Precision                     | 8240   | 7680           | 6800          | 6800          | 6080          | 3680          |
| Total Individual Pulses <sup>c</sup> |                                     | 72832  | 67872          | 59852         | 54704         | 43564         | 32072         |

<sup>a</sup>Interfering interrogator type and mode: conventional DME/N; MLS DME/P.

<sup>b</sup>Numbers of interrogations greater than or equal to an undesired-to-desired signal power ratio (U/D) of -20, -9, -6 dB, etc., are represented in each column.

<sup>c</sup>Assuming all aircraft in final approach or takeoff are operating in the precision mode and transmitting 3 pulses per interrogation.

TABLE 5B  
 AIR-TO-GROUND (INTERROGATION) LOADING AT A TRANSPONDER  
 FOR A DESIRED-SIGNAL INTERROGATOR AT 22 nmi ( $\pm 4$  MHz ABOUT 90Y)

| Relative Frequency                   | Interrogator Type-Mode <sup>a</sup> | Number of Interrogations <sup>b</sup> Per Second |           |          |          |          |          |
|--------------------------------------|-------------------------------------|--|-----------|----------|----------|----------|----------|
|                                      |                                     | U/D > -20  | U/D > -14 | U/D > -9 | U/D > -6 | U/D > +0 | U/D > +6 |
| Cofrequency                          | DME/N-En route                      | 840  | 660       | 390      | 270      | 90       | 0        |
|                                      | DME/P-En route                      | 6080   | 5952      | 5952     | 5952     | 5824     | 5440     |
|                                      | DME/P-Precision                     | 3440   | 3440      | 3280     | 3280     | 3120     | 2480     |
| $\pm 1$ MHz                          | DME/N-En route                      | 2790   | 2700      | 2460     | 2130     | 1650     | 1320     |
|                                      | DME/P-En route                      | 1648   | 1280      | 912      | 736      | 512      | 320      |
|                                      | DME/P-Precision                     | 240  | 240       | 160      | 160      | 80       | 0        |
| $\pm 2$ MHz                          | DME/N-En route                      | 1320   | 1260      | 780      | 630      | 240      | 180      |
|                                      | DME/P-En route                      | 2560   | 2304      | 1664     | 1024     | 288      | 128      |
|                                      | DME/P-Precision                     | 560  | 400       | 400      | 400      | 400      | 160      |
| $\pm 3$ MHz                          | DME/N-En route                      | 2520   | 2370      | 2250     | 1950     | 1650     | 1320     |
|                                      | DME/P-En route                      | 2368   | 2304      | 2176     | 1984     | 1248     | 704      |
|                                      | DME/P-Precision                     | 640  | 560       | 320      | 320      | 160      | 0        |
| $\pm 4$ MHz                          | DME/N-En route                      | 1590   | 1320      | 810      | 480      | 150      | 60       |
|                                      | DME/P-En route                      | 4688   | 4544      | 4336     | 4032     | 3184     | 2432     |
|                                      | DME/P-En route                      | 1840   | 1680      | 1440     | 1440     | 1280     | 480      |
| Total                                | DME/N-En route                      | 9060   | 8310      | 6690     | 5460     | 3780     | 2880     |
|                                      | DME/P-En route                      | 17344  | 16384     | 15040    | 13728    | 11056    | 9024     |
| Interrogation                        | DME/P-Precision                     | 6720   | 6320      | 5600     | 5600     | 5040     | 3120     |
| Total Individual Pulses <sup>c</sup> |                                     | 66248  | 62028     | 54660    | 49576    | 39752    | 30048    |

<sup>a</sup>Interfering interrogator type and mode: conventional DME/N; MLS DME/P.

<sup>b</sup>Numbers of interrogations greater than or equal to an undesired-to-desired signal power ratio (U/D) of -20, -9, -6 dB, etc., are represented in each column.

<sup>c</sup>Assuming all aircraft in final approach or takeoff are operating in the precision mode and transmitting 3 pulses per interrogation.

TABLE 6A  
 AIR-TO-GROUND (INTERROGATION) LOADING AT A TRANSPONDER  
 FOR A DESIRED-SIGNAL INTERROGATOR AT 7 nmi ( $\pm 4$  MHz ABOUT 24X)

| Relative Frequency                   | Interrogator Type-Mode <sup>a</sup> | Number of Interrogations <sup>b</sup> Per Second |           |          |          |          |          |
|--------------------------------------|-------------------------------------|--|-----------|----------|----------|----------|----------|
|                                      |                                     | U/D > -20  | U/D > -14 | U/D > -9 | U/D > -6 | U/D > +0 | U/D > +6 |
| Cofrequency                          | DME/N-En route                      | 0  | 0         | 0        | 0        | 0        | 0        |
|                                      | DME/P-En route                      | 8512   | 7280      | 6624     | 6016     | 4048     | 1232     |
|                                      | DME/P-Precision                     | 3840   | 3840      | 3600     | 2640     | 2640     | 2160     |
| $\pm 1$ MHz                          | DME/N-En route                      | 900  | 870       | 690      | 600      | 390      | 180      |
|                                      | DME/P-En route                      | 2912   | 2048      | 800      | 288      | 128      | 16       |
|                                      | DME/P-Precision                     | 480  | 480       | 400      | 160      | 160      | 0        |
| $\pm 2$ MHz                          | DME/N-En route                      | 0  | 0         | 0        | 0        | 0        | 0        |
|                                      | DME/P-En route                      | 4656   | 3936      | 2192     | 1088     | 416      | 32       |
|                                      | DME/P-Precision                     | 480  | 480       | 240      | 0        | 0        | 0        |
| $\pm 3$ MHz                          | DME/N-En route                      | 1800   | 1710      | 1500     | 1200     | 900      | 570      |
|                                      | DME/P-En route                      | 816  | 752       | 512      | 320      | 96       | 0        |
|                                      | DME/P-Precision                     | 160  | 160       | 80       | 0        | 0        | 0        |
| $\pm 4$ MHz                          | DME/N-En route                      | 0  | 0         | 0        | 0        | 0        | 0        |
|                                      | DME/P-En route                      | 4256   | 3808      | 3232     | 2624     | 2320     | 1088     |
|                                      | DME/P-En route                      | 1760   | 1760      | 1680     | 720      | 720      | 240      |
| Total Interrogation                  | DME/N-En route                      | 2700   | 2580      | 2190     | 1800     | 1290     | 750      |
|                                      | DME/P-En route                      | 2452   | 17824     | 13360    | 10336    | 7008     | 2368     |
|                                      | DME/P-Precision                     | 6720   | 6720      | 6000     | 3520     | 3520     | 2400     |
| Total Individual Pulses <sup>c</sup> |                                     | 61144  | 54248     | 43100    | 31312    | 23636    | 11036    |

<sup>a</sup>Interfering interrogator type and mode: conventional DME/N; MLS DME/P.

<sup>b</sup>Numbers of interrogations greater than or equal to an undesired-to-desired signal power ratio (U/D) of -20, -9, -6 dB, etc., are represented in each column.

<sup>c</sup>Assuming all aircraft in final approach or takeoff are operating in the precision mode and transmitting 3 pulses per interrogation.

TABLE 6B  
 AIR-TO-GROUND (INTERROGATION) LOADING AT A TRANSPONDER  
 FOR A DESIRED-SIGNAL INTERROGATOR AT 7 nmi ( $\pm 4$  MHz ABOUT 90Y)

| Relative Frequency                   | Interrogator Type-Mode <sup>a</sup> | Number of Interrogations <sup>b</sup> Per Second |                |               |               |               |               |
|--------------------------------------|-------------------------------------|--|----------------|---------------|---------------|---------------|---------------|
|                                      |                                     | U/D $\geq$ -20                                   | U/D $\geq$ -14 | U/D $\geq$ -9 | U/D $\geq$ -6 | U/D $\geq$ +0 | U/D $\geq$ +6 |
| Cofrequency                          | DME/N-En route                      | 360  | 270            | 90            | 0             | 0             | 0             |
|                                      | DME/P-En route                      | 5952   | 5952           | 5824          | 5440          | 3680          | 1152          |
|                                      | DME/P-Precision                     | 3280   | 3280           | 3120          | 2480          | 2480          | 2160          |
| $\pm 1$ MHz                          | DME/N-En route                      | 2280   | 2070           | 1650          | 1320          | 870           | 420           |
|                                      | DME/P-En route                      | 1184   | 896            | 448           | 160           | 32            | 0             |
|                                      | DME/P-Precision                     | 80   | 80             | 0             | 0             | 0             | 0             |
| $\pm 2$ MHz                          | DME/N-En route                      | 780  | 630            | 360           | 180           | 60            | 0             |
|                                      | DME/P-En route                      | 1216   | 768            | 224           | 128           | 96            | 48            |
|                                      | DME/P-Precision                     | 400  | 400            | 400           | 160           | 160           | 0             |
| $\pm 3$ MHz                          | DME/N-En route                      | 1200   | 1200           | 1140          | 840           | 690           | 480           |
|                                      | DME/P-En route                      | 2176   | 1984           | 1248          | 704           | 320           | 32            |
|                                      | DME/P-Precision                     | 320  | 320            | 160           | 0             | 0             | 0             |
| $\pm 4$ MHz                          | DME/N-En route                      | 540  | 330            | 120           | 30            | 0             | 0             |
|                                      | DME/P-En route                      | 4336   | 4032           | 3184          | 2432          | 1888          | 768           |
|                                      | DME/P-En route                      | 1440   | 1440           | 1280          | 480           | 480           | 160           |
| Total Interrogation                  | DME/N-En route                      | 5160   | 4500           | 3360          | 2370          | 1620          | 900           |
|                                      | DME/P-En route                      | 14864  | 13632          | 10480         | 8704          | 6016          | 2000          |
|                                      | DME/P-Precision                     | 5520   | 5520           | 4960          | 3120          | 3120          | 2320          |
| Total Individual Pulses <sup>c</sup> |                                     | 51088  | 47304          | 37600         | 28388         | 21512         | 10440         |

<sup>a</sup>Interfering interrogator type and mode: conventional DME/N; MLS DME/P.

<sup>b</sup>Numbers of interrogations greater than or equal to an undesired-to-desired signal power ratio (U/D) of -20, -9, -6 dB, etc., are represented in each column.

<sup>c</sup>Assuming all aircraft in final approach or takeoff are operating in the precision mode and transmitting 3 pulses per interrogation.

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TABLE 10A  
GROUND-TO-AIR (REPLY) LOADING OF AN AIRCRAFT AT 22 nmi ( $\pm 4$  MHz ABOUT 24X)  
(Assuming an Unloaded DME/N Transponder Reply Rate of  
3600 Replies/Second for TACAN and 2700 Replies for  
VOR-DME and an Unloaded DME/P Transponder Reply Rate  
of 1350 Replies/Second)

| Relative Frequency                   | Interrogator Type-Mode <sup>a</sup> | Number of Interrogations <sup>b</sup> Per Second |           |          |          |          |          |
|--------------------------------------|-------------------------------------|--|-----------|----------|----------|----------|----------|
|                                      |                                     | U/D > -20  | U/D > -14 | U/D > -9 | U/D > -6 | U/D > +0 | U/D > +6 |
| Cofrequency                          | DME/N-En route                      | 0  | 0         | 0        | 0        | 0        | 0        |
|                                      | DME/P-En route                      | 4860   | 2916      | 2916     | 1944     | 1944     | 1944     |
|                                      | DME/P-Precision                     | 1890   | 1134      | 1134     | 756      | 756      | 756      |
| $\pm 1$ MHz                          | DME/N-En route                      | 10800  | 10800     | 10800    | 10800    | 10800    | 10800    |
|                                      | DME/P-En route                      | 0  | 0         | 0        | 0        | 0        | 0        |
|                                      | DME/P-Precision                     | 0  | 0         | 0        | 0        | 0        | 0        |
| $\pm 2$ MHz                          | DME/N-En route                      | 0  | 0         | 0        | 0        | 0        | 0        |
|                                      | DME/P-En route                      | 9720   | 9720      | 6804     | 2976     | 2916     | 7944     |
|                                      | DME/P-Precision                     | 3780   | 3780      | 2646     | 1134     | 1134     | 756      |
| $\pm 3$ MHz                          | DME/N-En route                      | 14400  | 14400     | 14400    | 14400    | 14400    | 10800    |
|                                      | DME/P-En route                      | 0  | 0         | 0        | 0        | 0        | 0        |
|                                      | DME/P-Precision                     | 0  | 0         | 0        | 0        | 0        | 0        |
| $\pm 4$ MHz                          | DME/N-En route                      | 0  | 0         | 0        | 0        | 0        | 0        |
|                                      | DME/P-En route                      | 5832   | 5832      | 4860     | 4860     | 2916     | 2916     |
|                                      | DME/P-Precision                     | 2268   | 2268      | 1890     | 1890     | 1134     | 1134     |
| Total Interrogation                  | DME/N-En route                      | 25200  | 25200     | 25200    | 25200    | 25200    | 21600    |
|                                      | DME/P-En route                      | 20412  | 18468     | 14580    | 9720     | 7776     | 6804     |
|                                      | DME/P-Precision                     | 7938   | 7182      | 5670     | 3780     | 3024     | 2646     |
| Total Individual Pulses <sup>c</sup> |                                     | 107100   | 101700    | 90900    | 77400    | 72000    | 62100    |

<sup>a</sup>Interfering transponder type and mode.

<sup>b</sup>Numbers of replies greater than or equal to an undesired-to-desired signal power ratio (U/D) of -20, -9, -6 dB, etc., are represented in each column.

<sup>c</sup>Assuming that DME/P transponders reply with 3 pulses (precision mode) whenever they are interrogated with 3 pulses (aircraft in final approach or takeoff).

TABLE 10B  
GROUND-TO-AIR (REPLY) LOADING OF AN AIRCRAFT AT 22 nmi ( $\pm 4$  MHz ABOUT 90Y)  
(Assuming an Unloaded DME/N Transponder Reply Rate of  
3600 Replies/Second for TACAN and 2700 Replies for  
VOR-DME and an Unloaded DME/P Transponder Reply Rate  
of 1350 Replies/Second)

| Relative Frequency                   | Interrogator Type-Mode <sup>a</sup> | Number of Interrogations <sup>b</sup> Per Second |           |          |          |          |          |
|--------------------------------------|-------------------------------------|--|-----------|----------|----------|----------|----------|
|                                      |                                     | U/D > -20  | U/D > -14 | U/D > -9 | U/D > -6 | U/D > +0 | U/D > +6 |
| Cofrequency                          | DME/N-En route                      | 0  | 0         | 0        | 0        | 0        | 0        |
|                                      | DME/P-En route                      | 3888   | 2916      | 2916     | 972      | 972      | 972      |
|                                      | DME/P-Precision                     | 1512   | 1134      | 1134     | 378      | 378      | 378      |
| $\pm 1$ MHz                          | DME/N-En route                      | 0  | 0         | 0        | 0        | 0        | 0        |
|                                      | DME/P-En route                      | 9720   | 8748      | 6804     | 5832     | 4860     | 4860     |
|                                      | DME/P-Precision                     | 3780   | 3402      | 2646     | 2268     | 1890     | 1890     |
| $\pm 2$ MHz                          | DME/N-En route                      | 0  | 0         | 0        | 0        | 0        | 0        |
|                                      | DME/P-En route                      | 9720   | 9720      | 8748     | 3888     | 2916     | 1944     |
|                                      | DME/P-Precision                     | 3780   | 3780      | 3402     | 1512     | 1134     | 756      |
| $\pm 3$ MHz                          | DME/N-En route                      | 0  | 0         | 0        | 0        | 0        | 0        |
|                                      | DME/P-En route                      | 6804   | 6804      | 4860     | 3888     | 3888     | 3888     |
|                                      | DME/P-Precision                     | 2646   | 2646      | 1890     | 1512     | 1512     | 1512     |
| $\pm 4$ MHz                          | DME/N-En route                      | 0  | 0         | 0        | 0        | 0        | 0        |
|                                      | DME/P-En route                      | 5832   | 5832      | 5832     | 4860     | 3888     | 3888     |
|                                      | DME/P-En route                      | 2268   | 2268      | 2268     | 1890     | 1512     | 1512     |
| Total Interrogation                  | DME/N-En route                      | 0  | 0         | 0        | 0        | 0        | 0        |
|                                      | DME/P-En route                      | 35964  | 34020     | 29160    | 19440    | 16524    | 15552    |
|                                      | DME/P-Precision                     | 13986  | 13230     | 11340    | 7560     | 6426     | 6048     |
| Total Individual Pulses <sup>c</sup> |                                     | 99900  | 94500     | 81000    | 54000    | 45900    | 43200    |

<sup>a</sup>Interfering transponder type and mode.

<sup>b</sup>Numbers of replies greater than or equal to an undesired-to-desired signal power ratio (U/D) of -20, -9, -6 dB, etc., are represented in each column.

<sup>c</sup>Assuming that DME/P transponders reply with 3 pulses (precision mode) whenever they are interrogated with 3 pulses (aircraft in final approach or takeoff).

TABLE 11A

GROUND-TO-AIR (REPLY) LOADING OF AN AIRCRAFT AT 7 nmi ( $\pm 4$  MHz ABOUT 24X)  
 (Assuming an Unloaded DME/N Transponder Reply Rate of  
 3600 Replies/Second for TACAN and 2700 Replies for  
 VOR-DME and an Unloaded DME/P Transponder Reply Rate  
 of 1350 Replies/Second)

| Relative Frequency                   | Interrogator Type-Mode <sup>a</sup> | Number of Interrogations <sup>b</sup> Per Second |           |          |          |          |          |
|--------------------------------------|-------------------------------------|--|-----------|----------|----------|----------|----------|
|                                      |                                     | U/D > -20  | U/D > -14 | U/D > -9 | U/D > -6 | U/D > +0 | U/D > +6 |
| Cofrequency                          | DME/N-En route                      | 0  | 0         | 0        | 0        | 0        | 0        |
|                                      | DME/P-En route                      | 4860   | 3888      | 3888     | 2916     | 972      | 972      |
|                                      | DME/P-Precision                     | 1890   | 1512      | 1512     | 1134     | 378      | 378      |
| $\pm 1$ MHz                          | DME/N-En route                      | 10800  | 10800     | 10800    | 10800    | 7200     | 7200     |
|                                      | DME/P-En route                      | 0  | 0         | 0        | 0        | 0        | 0        |
|                                      | DME/P-Precision                     | 0  | 0         | 0        | 0        | 0        | 0        |
| $\pm 2$ MHz                          | DME/N-En route                      | 0  | 0         | 0        | 0        | 0        | 0        |
|                                      | DME/P-En route                      | 5832   | 2916      | 972      | 972      | 0        | 0        |
|                                      | DME/P-Precision                     | 2268   | 1134      | 378      | 378      | 0        | 0        |
| $\pm 3$ MHz                          | DME/N-En route                      | 7200   | 7200      | 7200     | 7200     | 7200     | 7200     |
|                                      | DME/P-En route                      | 0  | 0         | 0        | 0        | 0        | 0        |
|                                      | DME/P-Precision                     | 0  | 0         | 0        | 0        | 0        | 0        |
| $\pm 4$ MHz                          | DME/N-En route                      | 0  | 0         | 0        | 0        | 0        | 0        |
|                                      | DME/P-En route                      | 3888   | 2916      | 1944     | 1944     | 1944     | 1944     |
|                                      | DME/P-En route                      | 1512   | 1134      | 756      | 756      | 756      | 756      |
| Total Interrogation                  | DME/N-En route                      | 18000  | 18000     | 18000    | 18000    | 14400    | 14400    |
|                                      | DME/P-En route                      | 14580  | 9720      | 6804     | 5832     | 2916     | 2916     |
|                                      | DME/P-Precision                     | 5670   | 3780      | 2646     | 2268     | 1134     | 1134     |
| Total Individual Pulses <sup>c</sup> |                                     | 76500  | 63000     | 45450    | 261000   | 316900   | 36900    |

<sup>a</sup>Interfering transponder type and mode.

<sup>b</sup>Numbers of replies greater than or equal to an undesired-to-desired signal power ratio (U/D) of -20, -9, -6 dB, etc., are represented in each column.

<sup>c</sup>Assuming that DME/P transponders reply with 3 pulses (precision mode) whenever they are interrogated with 3 pulses (aircraft in final approach or takeoff).

TABLE 11B  
GROUND-TO-AIR (REPLY) LOADING OF AN AIRCRAFT AT 7 nmi ( $\pm 4$  MHz ABOUT 90Y)  
(Assuming an Unloaded DME/N Transponder Reply Rate of  
3600 Replies/Second for TACAN and 2700 Replies for  
VOR-DME and an Unloaded DME/P Transponder Reply Rate  
of 1350 Replies/Second)

| Relative Frequency                   | Interrogator Type-Mode <sup>a</sup> | Number of Interrogations <sup>b</sup> Per Second |           |          |          |          |          |
|--------------------------------------|-------------------------------------|--|-----------|----------|----------|----------|----------|
|                                      |                                     | U/D > -20  | U/D > -14 | U/D > -9 | U/D > -6 | U/D > +0 | U/D > +6 |
| Cofrequency                          | DME/N-En route                      | 0  | 0         | 0        | 0        | 0        | 0        |
|                                      | DME/P-En route                      | 2916   | 972       | 972      | 972      | 0        | 0        |
|                                      | DME/P-Precision                     | 1134   | 378       | 378      | 378      | 0        | 0        |
| $\pm 1$ MHz                          | DME/N-En route                      | 0  | 0         | 0        | 0        | 0        | 0        |
|                                      | DME/P-En route                      | 5832   | 3888      | 2916     | 1944     | 0        | 0        |
|                                      | DME/P-Precision                     | 2268   | 1512      | 1134     | 756      | 0        | 0        |
| $\pm 2$ MHz                          | DME/N-En route                      | 0  | 0         | 0        | 0        | 0        | 0        |
|                                      | DME/P-En route                      | 8748   | 2916      | 0        | 0        | 0        | 0        |
|                                      | DME/P-Precision                     | 3402   | 1134      | 0        | 0        | 0        | 0        |
| $\pm 3$ MHz                          | DME/N-En route                      | 0  | 0         | 0        | 0        | 0        | 0        |
|                                      | DME/P-En route                      | 4860   | 3888      | 3888     | 3888     | 3888     | 388      |
|                                      | DME/P-Precision                     | 1890   | 1512      | 1512     | 1512     | 1512     | 1512     |
| $\pm 4$ MHz                          | DME/N-En route                      | 0  | 0         | 0        | 0        | 0        | 0        |
|                                      | DME/P-En route                      | 5832   | 3888      | 1944     | 972      | 972      | 972      |
|                                      | DME/P-En route                      | 2268   | 1512      | 756      | 378      | 378      | 378      |
| Total Interrogation                  | DME/N-En route                      | 0  | 0         | 0        | 0        | 0        | 0        |
|                                      | DME/P-En route                      | 28188  | 15552     | 9720     | 7776     | 4860     | 4860     |
|                                      | DME/P-Precision                     | 10962  | 6048      | 3780     | 3024     | 1890     | 1890     |
| Total Individual Pulses <sup>c</sup> |                                     | 78300  | 43200     | 27000    | 21600    | 13500    | 13500    |

<sup>a</sup>Interfering transponder type and mode.

<sup>b</sup>Numbers of replies greater than or equal to an undesired-to-desired signal power ratio (U/D) of -20, -9, -6 dB, etc., are represented in each column.

<sup>c</sup>Assuming that DME/P transponders reply with 3 pulses (precision mode) whenever they are interrogated with 3 pulses (aircraft in final approach or takeoff).

TABLE 12A  
GROUND-TO-AIR (REPLY) LOADING OF AN AIRCRAFT AT 22 nmi ( $\pm 4$  MHz ABOUT 24X)  
(Assuming an Unloaded DME/N Transponder Reply Rate of  
3600 Replies/Second for TACAN and 2700 Replies for  
VOR-DME and an Unloaded DME/P Transponder Reply Rate  
of 700 Replies/Second)

| Relative Frequency                   | Interrogator Type-Mode <sup>a</sup> | Number of Interrogations <sup>b</sup> Per Second |           |          |          |          |          |
|--------------------------------------|-------------------------------------|--|-----------|----------|----------|----------|----------|
|                                      |                                     | U/D > -20  | U/D > -14 | U/D > -9 | U/D > -6 | U/D > +0 | U/D > +6 |
| Cofrequency                          | DME/N-En route                      | 0  | 0         | 0        | 0        | 0        | 0        |
|                                      | DME/P-En route                      | 2205   | 1323      | 1323     | 882      | 882      | 882      |
|                                      | DME/P-Precision                     | 1295   | 777       | 777      | 518      | 518      | 518      |
| $\pm 1$ MHz                          | DME/N-En route                      | 10800  | 10800     | 10800    | 10800    | 10800    | 10800    |
|                                      | DME/P-En route                      | 0  | 0         | 0        | 0        | 0        | 0        |
|                                      | DME/P-Precision                     | 0  | 0         | 0        | 0        | 0        | 0        |
| $\pm 2$ MHz                          | DME/N-En route                      | 0  | 0         | 0        | 0        | 0        | 0        |
|                                      | DME/P-En route                      | 4410   | 4410      | 3087     | 1323     | 1323     | 882      |
|                                      | DME/P-Precision                     | 2590   | 2590      | 1813     | 777      | 777      | 518      |
| $\pm 3$ MHz                          | DME/N-En route                      | 14400  | 14400     | 14400    | 14400    | 14400    | 10800    |
|                                      | DME/P-En route                      | 0  | 0         | 0        | 0        | 0        | 0        |
|                                      | DME/P-Precision                     | 0  | 0         | 0        | 0        | 0        | 0        |
| $\pm 4$ MHz                          | DME/N-En route                      | 0  | 0         | 0        | 0        | 0        | 0        |
|                                      | DME/P-En route                      | 2646   | 2646      | 2205     | 2205     | 1323     | 1323     |
|                                      | DME/P-En route                      | 1554   | 1554      | 1295     | 1295     | 777      | 777      |
| Total                                | DME/N-En route                      | 25200  | 25200     | 25200    | 25200    | 25200    | 21600    |
|                                      | DME/P-En route                      | 9261   | 8379      | 6615     | 4410     | 3528     | 3087     |
| Interrogation                        | DME/P-Precision                     | 5439   | 4921      | 3885     | 2590     | 2072     | 1813     |
| Total Individual Pulses <sup>c</sup> |                                     | 79800  | 77000     | 71400    | 64400    | 61600    | 53000    |

<sup>a</sup>Interfering transponder type and mode.

<sup>b</sup>Numbers of replies greater than or equal to an undesired-to-desired signal power ratio (U/D) of -20, -9, -6 dB, etc., are represented in each column.

<sup>c</sup>Assuming that DME/P transponders reply with 3 pulses (precision mode) whenever they are interrogated with 3 pulses (aircraft in final approach or takeoff).

TABLE 12B  
GROUND-TO-AIR (REPLY) LOADING OF AN AIRCRAFT AT 22 nmi ( $\pm 4$  MHz ABOUT 90Y)  
(Assuming an Unloaded DME/N Transponder Reply Rate of  
3600 Replies/Second for TACAN and 2700 Replies for  
VOR-DME and an Unloaded DME/P Transponder Reply Rate  
of 700 Replies/Second)

| Relative Frequency                   | Interrogator Type-Mode <sup>a</sup> | Number of Interrogations <sup>b</sup> Per Second |                |               |               |               |               |
|--------------------------------------|-------------------------------------|--|----------------|---------------|---------------|---------------|---------------|
|                                      |                                     | U/D $\geq$ -20                                   | U/D $\geq$ -14 | U/D $\geq$ -9 | U/D $\geq$ -6 | U/D $\geq$ +0 | U/D $\geq$ +6 |
| Cofrequency                          | DME/N-En route                      | 0  | 0              | 0             | 0             | 0             | 0             |
|                                      | DME/P-En route                      | 1764   | 1323           | 1323          | 441           | 441           | 441           |
|                                      | DME/P-Precision                     | 1036   | 777            | 777           | 259           | 259           | 259           |
| $\pm 1$ MHz                          | DME/N-En route                      | 0  | 0              | 0             | 0             | 0             | 0             |
|                                      | DME/P-En route                      | 4410   | 3969           | 3087          | 2646          | 2205          | 2205          |
|                                      | DME/P-Precision                     | 2590   | 2331           | 1813          | 1554          | 1295          | 1295          |
| $\pm 2$ MHz                          | DME/N-En route                      | 0  | 0              | 0             | 0             | 0             | 0             |
|                                      | DME/P-En route                      | 4410   | 4410           | 3969          | 1764          | 1323          | 882           |
|                                      | DME/P-Precision                     | 2590   | 2590           | 2331          | 1036          | 777           | 518           |
| $\pm 3$ MHz                          | DME/N-En route                      | 0  | 0              | 0             | 0             | 0             | 0             |
|                                      | DME/P-En route                      | 3087   | 3087           | 2205          | 1764          | 1764          | 1764          |
|                                      | DME/P-Precision                     | 1813   | 1813           | 1295          | 1036          | 1036          | 1036          |
| $\pm 4$ MHz                          | DME/N-En route                      | 0  | 0              | 0             | 0             | 0             | 0             |
|                                      | DME/P-En route                      | 2646   | 2646           | 2646          | 2205          | 1764          | 1764          |
|                                      | DME/P-En route                      | 1554   | 1554           | 1554          | 1295          | 1036          | 1036          |
| Total Interrogation                  | DME/N-En route                      | 0  | 0              | 0             | 0             | 0             | 0             |
|                                      | DME/P-En route                      | 16317  | 15435          | 13230         | 8820          | 7497          | 7056          |
|                                      | DME/P-Precision                     | 9583   | 9065           | 7770          | 5180          | 4403          | 4144          |
| Total Individual Pulses <sup>c</sup> |                                     | 51800  | 49000          | 42000         | 28000         | 23800         | 22400         |

<sup>a</sup>Interfering transponder type and mode.

<sup>b</sup>Numbers of replies greater than or equal to an undesired-to-desired signal power ratio (U/D) of -20, -9, -6 dB, etc., are represented in each column.

<sup>c</sup>Assuming that DME/P transponders reply with 3 pulses (precision mode) whenever they are interrogated with 3 pulses (aircraft in final approach or takeoff).

TABLE 13A  
GROUND-TO-AIR (REPLY) LOADING OF AN AIRCRAFT AT 7 nmi ( $\pm 4$  MHz ABOUT 24X)  
(Assuming an Unloaded DME/N Transponder Reply Rate of  
3600 Replies/Second for TACAN and 2700 Replies for  
VOR-DME and an Unloaded DME/P Transponder Reply Rate  
of 700 Replies/Second)

| Relative<br>Frequency                | Interrogator<br>Type-Mode <sup>a</sup> | Number of Interrogations <sup>b</sup> Per Second |                |               |               |               |               |
|--------------------------------------|--|--|----------------|---------------|---------------|---------------|---------------|
|                                      |  | U/D $\geq$ -20                                   | U/D $\geq$ -14 | U/D $\geq$ -9 | U/D $\geq$ -6 | U/D $\geq$ +0 | U/D $\geq$ +6 |
| Cofrequency                          | DME/N-En route                         | 0  | 0              | 0             | 0             | 0             | 0             |
|                                      | DME/P-En route                         | 2205   | 1036           | 1036          | 1323          | 441           | 441           |
|                                      | DME/P-Precision                        | 1295   | 1764           | 1764          | 777           | 259           | 259           |
| $\pm 1$ MHz                          | DME/N-En route                         | 10800  | 10800          | 10800         | 10800         | 7200          | 7200          |
|                                      | DME/P-En route                         | 0  | 0              | 0             | 0             | 0             | 0             |
|                                      | DME/P-Precision                        | 0  | 0              | 0             | 0             | 0             | 0             |
| $\pm 2$ MHz                          | DME/N-En route                         | 0  | 0              | 0             | 0             | 0             | 0             |
|                                      | DME/P-En route                         | 2646   | 1323           | 441           | 441           | 0             | 0             |
|                                      | DME/P-Precision                        | 1554   | 777            | 259           | 259           | 0             | 0             |
| $\pm 3$ MHz                          | DME/N-En route                         | 7200   | 7200           | 7200          | 7200          | 7200          | 7200          |
|                                      | DME/P-En route                         | 0  | 0              | 0             | 0             | 0             | 0             |
|                                      | DME/P-Precision                        | 0  | 0              | 0             | 0             | 0             | 0             |
| $\pm 4$ MHz                          | DME/N-En route                         | 0  | 0              | 0             | 0             | 0             | 0             |
|                                      | DME/P-En route                         | 1764   | 1323           | 882           | 882           | 882           | 882           |
|                                      | DME/P-En route                         | 1036   | 777            | 518           | 518           | 518           | 518           |
| Total<br>Interrogation               | DME/N-En route                         | 18000  | 18000          | 18000         | 18000         | 14400         | 14400         |
|                                      | DME/P-En route                         | 6615   | 3682           | 2359          | 2646          | 1323          | 1323          |
|                                      | DME/P-Precision                        | 3885   | 3318           | 2541          | 1554          | 777           | 777           |
| Total Individual Pulses <sup>c</sup> |  | 57000  | 50000          | 45800         | 44400         | 33000         | 33000         |

<sup>a</sup>Interfering transponder type and mode.

<sup>b</sup>Numbers of replies greater than or equal to an undesired-to-desired signal power ratio (U/D) of -20, -9, -6 dB, etc., are represented in each column.

<sup>c</sup>Assuming that DME/P transponders reply with 3 pulses (precision mode) whenever they are interrogated with 3 pulses (aircraft in final approach or takeoff).

TABLE 13B  
GROUND-TO-AIR (REPLY) LOADING OF AN AIRCRAFT AT 7 nmi ( $\pm 4$  MHz ABOUT 90Y)  
(Assuming an Unloaded DME/N Transponder Reply Rate of  
3600 Replies/Second for TACAN and 2700 Replies for  
VOR-DME and an Unloaded DME/P Transponder Reply Rate  
of 700 Replies/Second)

| Relative Frequency                   | Interrogator Type-Mode <sup>a</sup> | Number of Interrogations <sup>b</sup> Per Second |                |               |               |               |               |
|--------------------------------------|-------------------------------------|--|----------------|---------------|---------------|---------------|---------------|
|                                      |                                     | U/D $\geq$ -20                                   | U/D $\geq$ -14 | U/D $\geq$ -9 | U/D $\geq$ -6 | U/D $\geq$ +0 | U/D $\geq$ +6 |
| Cofrequency                          | DME/N-En route                      | 0  | 0              | 0             | 0             | 0             | 0             |
|                                      | DME/P-En route                      | 1323   | 441            | 441           | 441           | 0             | 0             |
|                                      | DME/P-Precision                     | 777  | 259            | 259           | 259           | 0             | 0             |
| $\pm 1$ MHz                          | DME/N-En route                      | 0  | 0              | 0             | 0             | 0             | 0             |
|                                      | DME/P-En route                      | 2646   | 1764           | 1323          | 882           | 0             | 0             |
|                                      | DME/P-Precision                     | 1554   | 1036           | 777           | 518           | 0             | 0             |
| $\pm 2$ MHz                          | DME/N-En route                      | 0  | 0              | 0             | 0             | 0             | 0             |
|                                      | DME/P-En route                      | 3969   | 1323           | 0             | 0             | 0             | 0             |
|                                      | DME/P-Precision                     | 2331   | 777            | 0             | 0             | 0             | 0             |
| $\pm 3$ MHz                          | DME/N-En route                      | 0  | 0              | 0             | 0             | 0             | 0             |
|                                      | DME/P-En route                      | 2205   | 1764           | 1764          | 1764          | 1764          | 1764          |
|                                      | DME/P-Precision                     | 1295   | 1036           | 1036          | 1036          | 1036          | 1036          |
| $\pm 4$ MHz                          | DME/N-En route                      | 0  | 0              | 0             | 0             | 0             | 0             |
|                                      | DME/P-En route                      | 2646   | 1764           | 882           | 441           | 441           | 441           |
|                                      | DME/P-Precision                     | 1554   | 1036           | 518           | 259           | 259           | 259           |
| Total Interrogation                  | DME/N-En route                      | 0  | 0              | 0             | 0             | 0             | 0             |
|                                      | DME/P-En route                      | 12789  | 7056           | 4410          | 3528          | 2205          | 2205          |
|                                      | DME/P-Precision                     | 7511   | 4144           | 2590          | 2092          | 1295          | 1295          |
| Total Individual Pulses <sup>c</sup> |                                     | 40600  | 22400          | 74000         | 11200         | 7000          | 7000          |

<sup>a</sup>Interfering transponder type and mode.

<sup>b</sup>Numbers of replies greater than or equal to an undesired-to-desired signal power ratio (U/D) of -20, -9, -6 dB, etc., are represented in each column.

<sup>c</sup>Assuming that DME/P transponders reply with 3 pulses (precision mode) whenever they are interrogated with 3 pulses (aircraft in final approach or takeoff).