

ASSESSMENT OF REALLOCATION OPTIONS

Another factor in the amount of spectrum required for ATM is the heavy workload at the test ranges. At some ranges it is necessary to simultaneously run from 12 to 13 to as many as 18 to 20 separate signals. The actual number being transmitted in the range area depends on the type of tests that are scheduled for that particular day. Since mutual interference typically limits the number of simultaneous ATM signals in the available bandwidth to only 12 or 13, it is only possible to exceed this number if receiver antenna discrimination or natural terrain shielding is available.

Aeronautical testing is now conducted on a very tight time schedule. Flight programs that suffer longer than normal delays will incur cost overruns. Test flight delays as a result of insufficient spectrum for simultaneous operations could add several months to larger test programs. The loss of the entire band could limit the ability to effectively schedule simultaneous test events on some ranges. Flight test and range personnel, as well as specialized hardware, will be idle during delays in testing. The Air Force stated that the anticipated delays in program test schedules resulting from the loss of the entire band would create an estimated 15 percent increase in time required for range operations. Using an estimate of \$1 million per day and 200 test days per range, a 15 percent increase in the test time translates to an additional \$180 million per year, assuming that the redesigned antennas fit within existing enclosures. Over a 5 year period, this is an increase of approximately \$900 million.¹²⁹

The primary ATM band for Government and commercial flight testing is the 1435-1525 MHz. This band is currently used very heavily and is extremely congested. The 2360-2390 MHz band is being used to support some current and future flight test operations and will be used to relieve the growing congestion in the 1435-1525 MHz band. All indications are that the use of ATM in the future is expected to increase. Figure 3-5 shows the increase in data requirements for ATM as a function of time. The number of parameters monitored during a test and data rates required is also expected to increase. Thus, the bandwidth required for each test is growing as well as the number of tests that are needed. Based on these factors, the congestion resulting from the loss of the 2310-2360 MHz portion of the band, and the excessive reallocation cost, reallocation of the entire 2360-2390 MHz band is not considered an option. However, reallocating a portion of the band is possible without complete disruption of the ATM operations in the band.

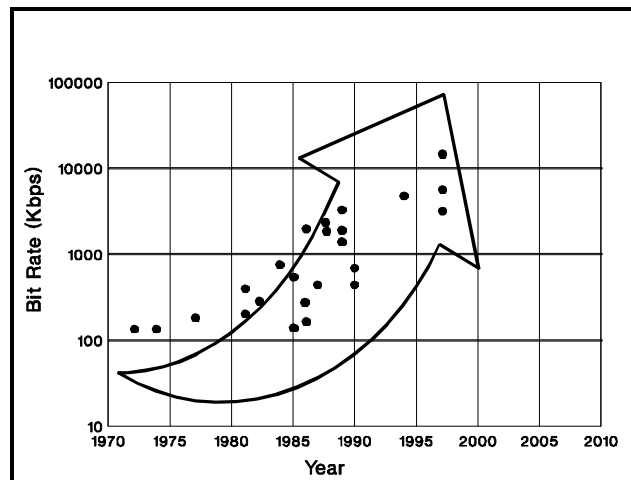


Figure 3-5. Data Requirements for ATM

ASSESSMENT OF REALLOCATION OPTIONS

Wideband ATM is becoming increasingly more important as a result of the high data rates and the corresponding high bandwidths anticipated for future flight test telemetry. Since there is only 30 MHz remaining in the 2360-2390 MHz band, reallocation of a large part of the band would all but eliminate the ability to perform wideband ATM functions.^o However, reallocating a 5 MHz segment would still leave 25 MHz of spectrum that could satisfy many of the anticipated wideband ATM spectrum requirements. Reallocating spectrum in the 2360-2390 MHz near the edges of the band versus the middle of the band will also minimize the impact on ATM operations.

The Air Force states that the reallocation of a portion of the band will have an impact on flight test programs. In Table 3-5 the Air Force provided examples of the impact that the loss of the 2360-2365 MHz band segment will have on flight test missions at the Air Force Flight Test Center (AFFTC) at Edwards AFB, CA.¹³⁰ The Air Force states that the reallocation of the 2360-2365 MHz band segment to the private sector would reduce the amount of spectrum available to the DoD for aeronautical telemetry by 17 percent. The Air Force estimates that the loss of this spectrum will result in \$1.5 billion in additional weapons system program costs over the next 10 years, caused by the cancellation of missions due to spectrum unavailability. The Air Force adds that multiple schedule slips with potential impacts with associated costs in delayed Milestone II and III decisions would also result, the cost of which is not included in the estimates provided in Table 3-5.¹³¹

The Air Force states that the loss of the 2360-2365 MHz band will also have an impact on the development of the nation's theater and national missile defense programs. The 2360-2390 MHz band or portions of the band are used for transfer of in-flight data during development and operational testing. Current Army systems, Theater High Altitude Air Defense (THAAD) and the National Missile Defense (NMD) programs require approximately 20 MHz of bandwidth in the 2360-2390 MHz band. The Navy Theater Ballistic Missile Defense (TBMD) program will require greater bandwidths extending to approximately 30 MHz. The Air Force states that while it may be possible to conduct some of the less complex test using some other frequencies, the loss of available bandwidth will make some data collection requirements impossible. The Air Force maintains that the current allocation is marginally sufficient to meet known and projected ballistic missile defense requirements. Any further reduction will require flight hardware redesign efforts, which are unfunded within these programs.¹³²

The DoD has stated that reallocation of the upper 5 MHz (2385-2390 MHz) instead of the lower 5 MHz (2360-2365 MHz) would minimize the impact on military flight test operations. The DoD maintains that reallocating the 2385-2390 MHz band segment will reduce costly modifications to the F-22 and other aircraft test programs. The DoD states that in order to minimize the impact on flight test operations the implementation date of the reallocation should be 2007. Furthermore, the DoD states that 10 military sites and additional civilian sites to be identified by AFTRCC must be protected from 2007 to 2010.¹³³

^o An issue identified in the Preliminary Agenda (Resolution GTPLEN1-4) for the World Radiocommunications Conference 2001 is to consider the spectrum requirements for wideband aeronautical telemetry in the bands between 3 and 30 GHz.

ASSESSMENT OF REALLOCATION OPTIONS

Table 3-5.
Examples of AFFTC Projects Impacted by the Loss of the
2360-2365 MHz Band Segment¹³⁴

AFFTC PROJECT	IMPACT ON AFFTC PROJECT
F-22	The F-22 Engineering Manufacturing and Development (EMD) program is scheduled to fly through FY02. The program is estimated to support about 3,000 sorties in the EMD phase. The loss of the 2360-2365 MHz band segment would delay about 500 sorties past the estimated completion date. Based on a cost of \$3 million per aircraft per month, it is estimated a \$125 million program cost increase $((500/12) \times \$3 \text{ million})$. This does not address additional contract costs, or additional cost due to a 8 month slippage (17 percent of 48 months total flying program length) to Milestone III decision.
Joint Strike Fighter	The Joint Strike Fighter is currently in phase II (Dem/Val). The program estimate is for a \$2.2 billion dollar effort with 24 flights per month over 6 months (144 sorties). A loss of the 2360-2365 MHz band segment would extend the program another month to accomplish 24 delayed flights. This would result in an estimated 1 month slip in the Milestone II decision. The additional month slip would cost the program an additional \$42 million $(2.2 \text{ billion} / 52 \text{ months program length})$. The EMD phase of the program is scheduled to fly 3,000 sorties in 36 months. A loss of the 2360-2365 MHz band segment would delay about 500 sorties past the estimated completion date. Based on a cost of \$3 million per aircraft per month and an effective sortie rate per aircraft around 12 sorties per month. It is estimated a that there will be a \$125 million program cost increase $((500/12) \times \$3 \text{ million})$ in flight costs. The EMD program is a \$16 billion $(\$16 \text{ billion over } 78 \text{ months results in } \$205 \text{ million per month})$. Based on 10 functional aircraft flying 12 sorties each per month, a slip of 5 months is estimated to make up the 500 sorties. This would require a contract extension costing almost \$1 billion. This does not address additional costs due to a 5 month slippage to the milestone III decision.
Airborne Laser Lab	The Dem/Val of the Airborne Laser Lab will be impacted by the loss of the 2360-2365 MHz band segment. This 73 month program is estimated to cost \$210,000 per month. Based on 270 flight hours with 17 percent delayed due to spectrum non-availability (46 hours). The 17 percent delay would cause a 6 month slip (based on 36 flying months) with a \$1.2 million additional program cost.
F-16	\$75 million resulting from numerous 1 to 3 month program slips.
F-15	\$50 million resulting from numerous 1 to 3 month program slips.
B-1	\$15 million resulting from numerous 1 to 3 month program slips.
B-2	\$15 million resulting from numerous 1 to 3 month program slips.
V-22	\$30 million resulting from numerous 3 to 6 month program slips.

ASSESSMENT OF REALLOCATION OPTIONS

The DoD states that reallocation of 2385-2390 MHz rather than 2360-2365 MHz would mitigate the impact to all other programs in this band. The DoD states that the test and evaluation community continues to operate as a secondary user in the 2110-2360 MHz band, even though this portion of the spectrum was previously allocated. The DoD maintains that the retention of the 2360-2365 MHz band would allow test ranges to continue operating across a contiguous band of 2310-2385 MHz until new users below 2360 MHz became operational. The DoD further states that a contiguous band also permits more efficient use of the spectrum. The DoD adds that the strategy of using contiguous bandwidth would reduce the impact in program test schedules from approximately \$350 million per year to roughly \$205 million per year. This will result in a savings of \$145 million per year until the lower adjacent band becomes unavailable for telemetry use.¹³⁵

The Air Force states that the loss of any portion of this heavily used band will impact Government and commercial flight testing of manned aircraft. The Air Force states that reallocation of the 2385-2390 MHz band will cost an estimated \$100 million for each of the three major test ranges.¹³⁶ This estimate assumes that suitable spectrum will be available for relocation such that current equipment can be retuned and that extensive system modifications will not be required to operate on new frequencies or to avoid interfering with new commercial users. If replacement of major systems is required, relocation costs could be significantly higher.¹³⁷

The Navy states that the loss of the 2385-2390 MHz band will result in program slippages that will impact their ability to test and field aircraft weapon systems. The Navy maintains that losing this additional spectrum will delay the F-18 E/F test and evaluation program as well as other projects at major test ranges. The Navy estimates that the total reallocation cost could exceed \$160 million.¹³⁸ This estimate assumes that suitable spectrum will be available for relocation such that current equipment can be retuned and that extensive system modifications will not be required to operate on new frequencies or to avoid interfering with new commercial users. If replacement of major systems is required, relocation costs could be significantly higher.¹³⁹

The Army also uses this band for a variety of in-flight telemetry and other telemetry uses. The Army states that their use could be accommodated in the remaining telemetry spectrum, but programs would be more expensive due to more testing time required to gather data. The Army estimates that the reallocation cost for the 2385-2390 MHz band segment could exceed \$20 million.¹⁴⁰ This estimate assumes that suitable spectrum will be available for relocation such that current equipment can be retuned and that extensive system modifications will not be required to operate on new frequencies or to avoid interfering with new commercial users. If replacement of major systems is required, relocation costs could be significantly higher.¹⁴¹

The NSF states that reallocation of the 2385-2390 MHz band will affect the NAIC radar that operates at 2380 MHz with a 20 MHz bandwidth. The NSF states that this radar has just been refurbished with joint NSF and NASA funding. The estimated cost of relocating the radar is approximately \$5 million. The NSF believes that relocating this 1 Megawatt radar will be extremely

ASSESSMENT OF REALLOCATION OPTIONS

difficult, and that the preferred option is to provide protection to it indefinitely, particularly from airborne and satellite downlink transmissions.¹⁴² The area affected is Puerto Rico and the U.S. Virgin Islands.

NASA states that the loss of any portion of the 2360-2390 MHz band would impact the Scientific Balloon Program, which is a joint program with the Canadians.^p NASA states that the new transmitters purchased for the Scientific Balloon Program are multi-band and tunable over the entire 2300-2399.5 MHz band.¹⁴³ However, NASA believes that the congestion that currently exists in the band will make it impossible to relocate this activity and that other spectrum would have to be found.¹⁴⁴ NASA states that unavailability of spectrum will mean the loss of three flights per year from resulting from inadequate ground support or not having options to avoid frequency conflicts. NASA states that the direct impact could be expected during the heaviest flight schedule periods of March thru October each year. NASA maintains that because of the time sensitive nature of many of these experiments, delays resulting from the loss of spectrum will probably have the impact of tarnishing the reliability of the Scientific Balloon support capabilities. believes that they may well lose their ability to meet some of the program flight support capabilities.¹⁴⁵

NASA states that their Aeronautical Telemetry Program would also suffer as a result of losing more spectrum in the 2360-2390 MHz band. NASA maintains that losing more spectrum without identifying spectrum to replace it is only delaying the problem to a time when it will become more serious because projects are going to higher data rates and higher resolution video. NASA states that studies on data compression have shown only minimal gains in bandwidth resolution which will not come close to keeping up with the increases in bandwidth requirements for ATM. NASA states that the transmitters used in their Aeronautical Telemetry Program are tunable, and if they are able to retune within the same band the estimated reallocation cost will be minimal.

The DOE states that their airborne ranging system has an 11 MHz bandwidth, with the ground uplink operating at 2315.48 MHz and the airborne downlink operating at 2379.8 MHz. The DOE states that the reallocation of the 2385-2390 MHz band will not cause a substantial impact to the airborne downlink if: 1) the authorized bandwidth can be reduced slightly from 11 MHz to 10.4 MHz and 2) the new private sector service has equipment that is not susceptible to relatively low-level emissions from the adjacent band. The DOE believes that since small frequency adjustments can be made to their system there should be no substantial impact.¹⁴⁶

Footnote US 276 identifies six frequencies in the 2310-2390 MHz band that can be used for commercial ELVs. The six frequencies are: 2312.5 MHz, 2332.5 MHz, 2352.5 MHz, 2364.5 MHz, 2370.5 MHz, and 2382.5 MHz. The allocation of the 2305-2360 MHz band for satellite DARS and

^p This program was forced to move from its original assignments in the 1400 MHz band to the current assignments between 2365.5 to 2386.5 MHz to avoid interference with the introduction of Canadian Terrestrial-Digital Audio Radio.

ASSESSMENT OF REALLOCATION OPTIONS

WCS leaves only the upper three frequencies available on a primary basis for commercial launch telemetry. The lower three frequencies are still available on a secondary basis and are not protected from interference. These frequencies will support both the ground telemetry for testing and the telemetry for the launch. NASA and the Air Force launch government payloads, including military satellites, weather satellites, data relay satellites, and scientific payloads, among others. NASA and the Air Force have launch sites at several locations in the United States. The Federal Government uses the 2200-2300 MHz band for the launch telemetry. Currently all of the commercial launch telemetry spectrum requirements are being satisfied in the 2200-2300 MHz band. There have been no requests made for the commercial launch telemetry frequencies in the 2360-2390 MHz band.

Public Benefit

The 2385-2390 MHz band is in a region of the radio frequency spectrum where the current state-of-the-art technologies can lead to the early development and implementation of new commercial products and services. The worldwide allocation to fixed, mobile, and radiolocation services provides the flexibility to support a wide variety of new technologies both domestically and potentially for export. While this segment of spectrum is somewhat narrow, the proximity to frequencies already assigned for commercial use; the availability of equipment; and the flexible regulatory structure will enhance its utility for emerging technologies.

A concern in reallocating this band for non-Federal use is that it is immediately adjacent to airborne telemetry systems. Reallocation of the 2385-2390 MHz band must be accompanied by mandatory commercial receiver and transmitter standards to reduce the potential for mutual adjacent band interference.

Reallocation Options

The 2360-2390 MHz band is allocated to the Federal Government for aeronautical flight test telemetry, radars used for scientific observations, and telemetry for commercial launch vehicles. The primary aeronautical telemetry band is the 1435-1525 MHz band which is currently used very heavily by both the Federal Government and the commercial aviation industry. With the extreme congestion in the 1435-1525 MHz band both Federal and commercial users are beginning to move some of their ATM operations to the 2360-2390 MHz band. Previous reductions in the 2310-2390 MHz band have reduced the allocation to only 30 MHz. At the same time, demands for increased bandwidth driven by new information-intensive technologies are being incorporated in U.S. systems. Based on these factors as well as the excessive cost impact to the Federal Government, reallocation of the entire 2360-2390 MHz band is not possible.

In balancing the public benefits and the impact to the Federal Government, a feasible option is to reallocate the 2385-2390 MHz portion of this band for exclusive non-Federal use. The Federal Government will retain the rest of the band to satisfy current and future ATM flight test spectrum requirements. A large majority of the equipment that operates in the 2360-2390 MHz band is tunable

ASSESSMENT OF REALLOCATION OPTIONS

providing a great deal of flexibility within the band. Loss of this spectrum could however have an impact on simultaneous ATM flight test operations at some test ranges. Retaining the 25 MHz of contiguous spectrum will also permit some wide band ATM operations that are envisioned in the future to continue. Reallocation of the upper portion of the band eliminates the concerns expressed by the DoD with regards to the impact of flight test operations. The loss of the 2385-2390 MHz band segment does impact one of the frequencies planned for use by commercial launch telemetry. Currently there are no commercial launch facilities using the frequencies in the 2360-2390 MHz band. There are also other existing Federal Government communications facilities and frequency bands that are being used to support the commercial launches. Since airborne systems will continue to operate in the adjacent band commercial receiver and transmitter standards must be adopted to minimize potential adjacent band interference. To provide protection to the Arecibo Planetary Radar, airborne transmissions and space-to-Earth transmissions will be prohibited in Puerto Rico.

In order to provide adequate time for engineering studies on spectrum efficient modulation techniques, budgeting, and modification of equipment it will require a minimum of seven years (2005) to reallocate this band for non-Federal use. To minimize the operational impact on flight test programs that are ongoing or planned to begin in the near future continued Federal and commercial use of the 2385-2390 MHz band at the selected sites in Table 3-6 will continue for 2 years after the scheduled reallocation date. The geographical representation of the site locations is shown in Figure 3-6.

ASSESSMENT OF REALLOCATION OPTIONS

Table 3-6.^q

Sites at Which Federal and Commercial Systems in the 2385-2390 MHz Band Will Continue to Operate for 2 Years After the Scheduled Reallocation Date

Location	Coordinates	Protection Radius
Yuma Proving Ground, AZ	32°54'N 114°20'W	160 km
Nellis AFB, NV	37°48'N 116°28'W	160 km
White Sands Missile Range, NM	32°58'N 106°23'W	160 km
Utah Test Range, UT	40°12'N 112°54'W	160 km
China Lake, CA	35°40'N 117°41'W	160 km
Eglin AFB, FL	30°30'N 086°30'W	160 km
Cape Canaveral, FL	28°33'N 080°34'W	160 km
Seattle, WA	47°32'N 122°18'W	160 km
St. Louis, MO	38°45'N 090°22'W	160 km
Palm Beach County, FL	26°54'N 080°19'W	160 km
Barking Sands, HI ^r	22°07'N 159°40'W	160 km
Roosevelt Roads, PR ^r	18°14'N 065°38'W	160 km
Glasgow, MT	48°25'N 106°32'W	160 km
Edwards AFB, CA	34°54'N 117°53'W	100 km
Patuxent River, MD	38°17'N 076°25'W	100 km
Wichita, KS	37°40'N 097°26'W	160 km
Roswell, NM	33°18'N 104°32'W	160 km

^q The DoD has raised concerns about the need to include additional military sites in this band. NTIA and DoD will assess the need to include additional sites and work with the FCC during the reallocation process to insure that disruption to critical military operations is minimized.

^r This site is located outside of the Continental United States.

ASSESSMENT OF REALLOCATION OPTIONS

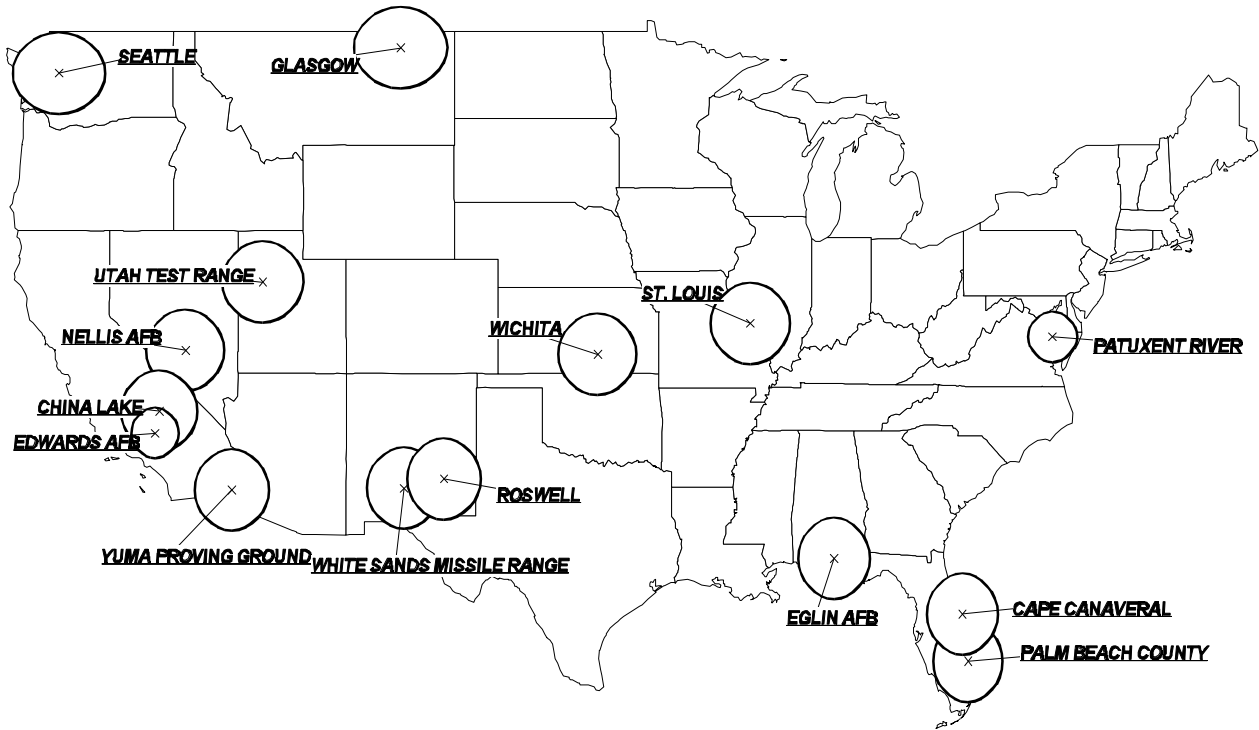


Figure 3-6.
Sites at Which Federal and Commercial Systems in the 2385-2390 MHz Band
Will Continue to Operate for 2 Years After the Scheduled Reallocation Date

ASSESSMENT OF REALLOCATION OPTIONS

ENDNOTES

Requests for copies of references from Federal departments and agencies should be referred to the originating organization. Parts of the reference material may be exempt from public release.

1. Memorandum from the AFFMA/SCA, to Chairman, IRAC, Subject: Pre-decisional AF BBA 97 Reallocation Cost Information, (Nov. 1997) [hereinafter AFFMA/SCA Letter], at 2.
2. Letter from Lawrence A. Wasson, IRAC Representative, Department of Energy IRAC Representative, to Gerald Hurt, Office of Spectrum Management, U.S. Department of Commerce (Oct. 1997) [hereinafter DOE Letter], at 4.
3. Letter from Rick Murphy, Interior IRAC Representative, to Edwin E. Dinkle, Executive Secretary, IRAC, National Telecommunications and Information Administration (Oct.17, 1997) [hereinafter DOI Investment Cost Letter], at 1.
4. National Telecommunications and Information Administration, U.S. Department of Commerce, NTIA Report 89-241, *Meteor Burst System Communications Compatibility* (Mar. 1989), at 4.
5. AFFMA/SCA Letter, *supra* note 1, at 2.
6. DOE Letter, *supra* note 2, at 4.
7. *Id.*
8. *Id.* at 5.
9. *Id.*
10. DOI Investment Cost Letter, *supra* note 3, at 1.
11. Letter from Julio “Rick” Murphy, Interior IRAC Representative, to Edwin E. Dinkle, Executive Secretary, IRAC, National Telecommunications and Information Administration (Oct. 28, 1997) [hereinafter DOI Reallocation Cost Letter], at 1.
12. National Telecommunications and Information Administration, U.S. Department of Commerce, Public Safety Wireless Advisory Committee, Final Report, Vol. 2, Appendices (Sept.1996), at 637.
13. *Id.* at 638.
14. National Telecommunications and Information Administration, U.S. Department of Commerce, Public Safety Wireless Advisory Committee, Final Report, Vol. 1, (Sept.1996), at 58.
15. Balanced Budget Act of 1997, Pub. L. No. 105-33, 111 Stat. 251, § 113(c)(3)(a).

ASSESSMENT OF REALLOCATION OPTIONS

16. MCEB-M 149-71, U.S. Military Frequency Allocation Plan for 132.0-150.8 MHz band, (Confidential) Military Communications-Electronics Board, Washington, D.C., (April 1971).
17. Telecommunications Authorization Act of 1992, Pub. L. No. 102-538, 106 Stat. 3533 (1992).
18. National Telecommunications and Information Administration, U.S. Department of Commerce, NTIA Report 93-300, *Land Mobile Spectrum Efficiency*, (Oct. 1993) [hereinafter NTIA Land Mobile Spectrum Efficiency Report], at 1.
19. *Id.* at 8.
20. *Id.* at 53.
21. Memorandum from William J. Donahue, Lt. General, USAF, Director, Communications and Information, for Assistant Secretary of Defense, ASD/C3I, Subject: Impacts of the Balanced Budget Act of 1997 to the Air Force (Dec. 8, 1997) [hereinafter Air Force Impact Letter], at 4.
22. Memorandum from Nelson Pollack, Air Force IRAC Member, AFFMA/SCA, for NTIA BBA 97 Team, Subject: AF Comments on Second Draft of NTIA Balanced Budget Act of 1997 (BBA 97) Report (Dec. 30, 1997) [hereinafter Air Force Comments on the Second Draft], at 5.
23. Memorandum from Frank Holderness, Army Spectrum Manager, Army IRAC Member, for National Telecommunications and Information Administration Balanced Budget Act of 1997 Team, Subject: Army Comments on Spectrum Reallocation Study as Required by the Balanced Budget Act of 1997, Second Draft, NTIA Special Publication 98-36, 18 Dec. 97 (Dec. 30, 1997) [hereinafter Army Comments on Second Draft], at 6.
24. Memorandum from B. L. Swearingen, Navy IRAC Member, for National Telecommunications and Information Administration SEAD BBA-97 Project Team, Subject: Navy Comments on Second Draft of the NTIA Spectrum Reallocation Study Required by Title III of the Balanced Budget Act of 1997 (Dec. 24, 1997) [hereinafter Navy Comments on Second Draft], at 4.
25. *Id.*
26. Letter from (James Turk for), Paul K. Reid, Jr., Federal Emergency Management Agency, to Gerald Hurt, Office of Spectrum Management, U.S. Department of Commerce (Dec. 15, 1997) [hereinafter FEMA Letter], at 1.
27. Air Force Impact Letter, *supra* note 21, at 5; Army Comments on Second Draft, *supra* note 23, at 7.

ASSESSMENT OF REALLOCATION OPTIONS

28. National Telecommunications and Information Administration, U.S. Department of Commerce, *Manual of Regulations and Procedures for Federal Radio Frequency Management*, (Sept. 1995) (Revised Sept. 1996, Jan., and May 1997) [hereinafter NTIA Manual], at 4-96.
29. Letter from Julio “Rick” Murphy, Interior IRAC Representative, to Gerald F. Hurt, Chief, Spectrum Engineering and Analysis Division, Subject: Requested Comments on the Proposed Spectrum Reallocation Plan dated December 16, 1997 (Dec. 18, 1997) [hereinafter DOI Comments on Spectrum Reallocation Plan], at 1.
30. Letter from Elwood Lewis, USPS IRAC Representative, to BBA 97 Project Team, Subject: Removal of Footnote G5 from 406.1-420 MHz Band (Dec. 19, 1997), at 1.
31. Memorandum from Richard Allen, Alternate IRAC Representative, DOJ, to BBA 97 Project Team, Subject: Spectrum Reallocation Plan Required by Title III of the BBA 97 (Dec. 23, 1997) [hereinafter DOJ Comments on Spectrum Reallocation Plan], at 1.
32. Letter from D. A. Koppie, Treasury IRAC Representative, to BBA 97 Project Team, Subject: Spectrum Reallocation Plan Required by Title III of the BBA 97 (Dec. 24, 1997) [hereinafter Treasury Letter], at 1.
33. NTIA Land Mobile Spectrum Efficiency Report, *supra* note 18, at 53.
34. Air Force Comments on the Second Draft, *supra* note 22, at 6.
35. *Id.* at 6 and 7.
36. Air Force Impact Letter, *supra* note 21, at 5.
37. Letter from Anthony M. Valletta, Acting Assistant Secretary of Defense, to Larry Irving, Assistant Secretary of Commerce for Communications and Information, Department of Commerce (Jan. 21, 1998) [hereinafter Valletta Letter], at 1.
38. *Id.*
39. Army Comments on Second Draft, *supra* note 23, at 7.
40. Memorandum from R. M. Nutwell, Rear Admiral, U.S. Navy, Deputy Director, Space, Information, Warfare, Command and Control, for the Assistant Secretary of Defense (C3I), Subject: Reallocation of Spectrum in Accordance with the Balanced Budget Act of 1997 (Dec. 9, 1997) [hereinafter Navy Impact Letter], at 3.
41. Memorandum from B. L. Swearingen, Navy IRAC Member, to NTIA SEAD BBA-97 Project Team, Subject: Navy Comments on the NTIA Spectrum Reallocation Study as required by the

ASSESSMENT OF REALLOCATION OPTIONS

Balanced Budget Act of 1997 (First Draft NTIA Special Publication 98-36) (Dec. 16, 1997) [hereinafter Navy Comments on First Draft], at 3.

42. *Id.* at 2.

43. Memorandum from B. Swearingen, Navy IRAC Member, to NTIA SEAD BBA-97 Project Team, Subject: Navy Operational Sites Requiring Protection (Dec. 16, 1997) [hereinafter Navy Site Protection Letter], at 2.

44. Navy Comments on Second Draft, *supra* note 24, at 5.

45. Memorandum from B. L. Swearingen, Navy IRAC Member, for the National Telecommunications and Information Administration SEAD BBA-97 Project Team, Subject: DON Cost Impact Matrix (Jan. 16, 1998) [hereinafter Navy Cost Matrix Memo] at 3.

46. Valletta Letter, *supra* note 36, at 1.

47. DOE Letter, *supra* note 2, at 1.

48. FEMA Letter, *supra* note 26, at 1.

49. Electronic-mail from Jim Hollansworth, NASA, to Ed Drocella, NTIA, Subject: NASA Reallocation Impact Data (Oct. 15, 1997), at 2.

50. Memorandum from Richard N. Allen, Alternate IRAC Representative, Department of Justice, to BBA 97 Project Team, Subject: Spectrum Reallocation Plan Required by Title III of the BBA 97 (Dec. 17, 1997), at 1; Treasury Letter, *supra* note 32, at 1.

51. Navy Impact Letter, *supra* note 40, at 3.

52. Letter from Julio “Rick” Murphy, Interior IRAC Representative, to Edwin E. Dinkle, Executive Secretary, IRAC, National Telecommunications and Information Administration (Dec. 4, 1997) [hereinafter DOI Comments on BBA97 Draft Report], at 1.

53. Air Force Impact Letter, *supra* note 21, at 6.

54. Navy Impact Letter, *supra* note 40, at 3; Letter from Bruce Swearingen, Navy IRAC Member, to Gerry Hurt, SEAD/NTIA, Subject: Relocation Costs Affected by BBA-97 (Secret) (Oct. 28, 1997) [hereinafter Navy Cost Letter], at 1.

55. Army Comments on Second Draft, *supra* note 23, at 8.

ASSESSMENT OF REALLOCATION OPTIONS

56. *Amendment of Parts 0, 1, 2, and 95 of the Commission's Rules to Provide Interactive Video and Data Services*, Report and Order, GEN Docket No. 91-2, 7 FCC Rcd 1630 (1992).
57. *Implementation of Section 309(j) of the Communications Act -- Competitive Bidding*, Fourth Report and Order, PP Docket No. 93-253, 9 FCC Rcd 2330 (1994) (adopting IVDS competitive bidding design).
58. *Allocation of the 219-220 MHz Band for Use by the Amateur Radio Service*, Report and Order, ET Docket No. 93-40, 10 FCC Rcd 4446 (1995).
59. *Id.*
60. DOE Letter, *supra* note 2, at 6.
61. DOI Investment Cost Letter, *supra* note 3, at 1.
62. DOI Comments on BBA97 Draft Report, *supra* note 52, at 1.
63. NTIA Manual, *supra* note 28, at §8.2.42.
64. Letter from Richard Allen, Alternate IRAC Representative for the Department of Justice, to Mr. Ed Drocella, National Telecommunications and Information Administration, Subject: DOJ Comments on Proposed NTIA Spectrum Reallocation Plan (Oct. 17, 1997), at 1; Memorandum from D. A. Koppie, Treasury IRAC Representative, for Ed Drocella, SEAD BBA 97 Project Team, National Telecommunications and Information Administration, Subject: Reallocation Costs (Oct. 30, 1997), at 1.
65. Air Force Impact Letter, *supra* note 21, at 6.
66. Air Force Comments on the Second Draft, *supra* note 22, at 2.
67. Army Comments on Second Draft, *supra* note 23, at 8.
68. *Id.* at 3.
69. Navy Impact Letter, *supra* note 40, at 4.
70. International Telecommunication Union Working Party 7C, Document United States Working Party (USWP)-7C/57 (Rev. 4).
71. National Telecommunications and Information Administration, U.S. Department of Commerce, NTIA Special Publication 94-27, *Preliminary Spectrum Reallocation Report* (Feb. 1994) [hereinafter NTIA Preliminary Report], at 2-33.

ASSESSMENT OF REALLOCATION OPTIONS

72. DOE Letter, *supra* note 2, at 2.
73. National Telecommunications and Information Administration, U.S. Department of Commerce, NTIA Special Publication 95-32, Spectrum Reallocation Final Report (Feb. 1995) [hereinafter NTIA Final Report], at A-8.
74. Memorandum from MILDEP IRAC Members, for NTIA BBA 97 Team, Subject: AF Comments on NTIA Draft balanced Budget Act of 1997 (BBA 97) Plan: 1385-1390 MHz and 2360-2365 MHz Frequency Bands (Dec. 19, 1997) [hereinafter Air Force Letter on the Impact to 1385-1390 MHz and 2360-2365 MHz Bands], at 8.
75. NTIA Preliminary Report, *supra* note 71, at 4-12.
76. *Id.* at 2-16 and 2-33.
77. National Telecommunications and Information Administration, U.S. Department of Commerce, NTIA Special Publication 94-31, U.S. National Spectrum Requirements: Projections and Trends (Mar. 1995), at 128.
78. NTIA Preliminary Report, *supra* note 71, at 4-9.
79. NTIA Final Report, *supra* note 73, at 3-4.
80. Air Force Impact Letter, *supra* note 21, at 11.
81. Letter from Gerald Markey, Program Director for Spectrum Policy and Management, Federal Aviation Administration, to Edwin Dinkle, Executive Secretary, IRAC, National Telecommunications and Information Administration, Subject: Second Draft of the NTIA Spectrum Reallocation Study Required by Title III of the BBA 97 (Dec. 29, 1997) [hereinafter FAA Comments on Second Draft], at 2.
82. Air Force Comments on the Second Draft, *supra* note 22, at 3.
83. NTIA Final Report, *supra* note 73, at 3-8; FAA Comments on Second Draft, *supra* note 81, at 2.
84. NTIA Final Report, *supra* note 73, at 4-4.
85. *Id.* at 3-7.
86. *Id.*

ASSESSMENT OF REALLOCATION OPTIONS

87. Electromagnetic Compatibility Analysis Center, ECAC-CR-85-025, *An EMC Analysis for the Proposed Operation of the AN/FPS-117 Radar at Gibbsboro AFS, NJ* (June 1985), at 2-3.
88. Air Force Impact Letter, *supra* note 21, at 11.
89. *Id.*; FAA Comments on Second Draft, *supra* note 81, at 2.
90. NTIA Final Report, *supra* note 73, at 3-8.
91. *Id.*
92. Air Force Impact Letter, *supra* note 21, at 12.
93. Air Force Letter on the Impact to 1385-1390 MHz and 2360-2365 MHz Bands, *supra* note 74, at 8.
94. Air Force Impact Letter, *supra* note 21, at 12.
95. *Id.* at 3.
96. Valletta Letter, *supra* note 37, at 1.
97. NTIA Final Report, *supra* note 73, at 3-4.
98. *Id.*
99. *Id.*
100. Navy Cost Matrix Memo, *supra* note 45, at 5.
101. Valletta Letter, *supra* note 37, at 1.
102. Army Comments on Second Draft, *supra* note 23, at 5.
103. Valletta Letter, *supra* note 37, at 1.
104. FAA Comments on Second Draft, *supra* note 81, at 2; NTIA Final Report, *supra* note 73, at 3-9.
105. Memorandum from Nelson V. Pollack - GM-15, AF IRAC Member, U.S. Department of the Air Force, for Chairman of IRAC, Subject: RAJPO Data Link System Description (Aug. 13, 1996), at 1; Memorandum from Nelson V. Pollack, AF IRAC Member, U.S. Department of the Air Force, for NTIA OSM, Subject: AF Comments on NTIA Draft Balanced Budget Act of 1997 (BBA 97) Report, Table 3-5 (Dec. 8, 1996) [hereinafter Air Force RAJPO Memos], at 2.

ASSESSMENT OF REALLOCATION OPTIONS

106. Fax from Bruce Swearingen, Naval Electromagnetic Spectrum Center, to Gerald Hurt, NTIA Spectrum Engineering and Analysis Division, Subject: Spectrum Reallocation Impact on Navy Data Link Weapon Systems (Oct. 7, 1997) [hereinafter Weapon Systems Letter], at 6.
107. *Id.* at 4.
108. Navy Cost Letter, *supra* note 54, at 2.
109. Army Comments on Second Draft, *supra* note 23, at 11.
110. NTIA Preliminary Report, *supra* note 71, at 4-27.
111. Weapon Systems Letter, *supra* note 106, at 1 and 4.
112. *Id.* at 4.
113. Letter from M. J. Langston, Deputy Assistant Secretary of the Navy (Command, Control, Communications, Computers and Intelligence/Electronic Warfare/Space) to Richard Parlow, Associate Administrator, Office of Spectrum Management, U.S. Department of Commerce (Sept. 26, 1997), at 5.
114. Weapon Systems Letter, *supra* note 106, at 4.
115. *Id.* at 5.
116. Navy Cost Letter, *supra* note 54, at 5.
117. Valletta Letter, *supra* note 37, at 1.
118. Air Force Impact Letter, *supra* note 21, at 10.
119. *Id.*
120. *Id.*
121. Army Comments on Second Draft, *supra* note 23, at 5 and 11.
122. DOE Letter, *supra* note 2, at 2.
123. Letter from William L. Hollingsworth, IRAC Representative Department of Energy, to Gerald Hurt, Office of Spectrum Management, U.S. Department of Commerce (Dec. 8, 1997), at 2.
124. Air Force RAJPO Memos, *supra* note 105, at 1.

ASSESSMENT OF REALLOCATION OPTIONS

125. *Establishment of Rules and Policies for the Digital Audio Radio Satellite Service in the 2310-2360 MHz Frequency Band*, Report and Order, IB Docket No. 95-91 12 FCC Rcd 5754 (1997).
126. *Amendment of the Commission's Rules to Establish Part 27, the Wireless Communication Service*, Report and Order, GN Docket No. 96-228 (Feb. 1997).
127. E-Mail from William L. Hollingsworth, IRAC Representative Department of Energy, to Edward Drocella, NTIA, Subject: Comments to 2385-2390 MHz Band Reallocation (Jan. 12, 1998) [hereinafter DOE Comments on 2385-2390 MHz], at 1.
128. Air Force Letter on the Impact to 1385-1390 MHz and 2360-2365 MHz Bands, *supra* note 74, at 2.
129. *Id.*
130. *Id.* at 3.
131. *Id.*
132. *Id.* at 4.
133. Letter from (James E. Soos for) Anthony M. Valletta, Acting Assistant Secretary of Defense, to Larry Irving, Assistant Secretary of Commerce for Communications and Information (Dec. 30, 1997), at 1.
134. *Id.*
135. Memorandum for NTIA BBA Team from Nelson Pollack, Air Force IRAC Member, Subject: Relative S-Band Cost and Mission Impacts (Jan. 26, 1998), at 2.
136. Letter from Anthony M. Valletta [Unsigned], Acting Assistant Secretary of Defense, to Larry Irving, Assistant Secretary of Commerce for Communications and Information, U.S. Department of Commerce (Jan. 16, 1998) [hereinafter DoD Cost and Mission Impact Letter], at 7.
137. Valletta Letter, *supra* note 37, at 1.
138. Navy Cost Matrix Memo, *supra* note 45, at 7.
139. Valletta Letter, *supra* note 37, at 1.
140. Army Comments on Second Draft, *supra* note 23, at 5.

ASSESSMENT OF REALLOCATION OPTIONS

141. Valletta Letter, *supra* note 37, at 1.

142. Letter from Tomas Gergely, NSF IRAC Representative, to E. Drocella, NTIA, U.S. Department of Commerce (Jan. 15, 1998), at 2.

143. Letter from David Struba, Acting Director, Program Integration Division, Office of Space Flight, National Aeronautics and Space Administration, to Mr. William Hatch, Chairman, Interdepartment Radio Advisory Committee, NTIA/Department of Commerce (Dec. 23, 1997), at 2.

144. *Id.*

145. *Id.* at 3.

146. DOE Comments on 2385-2390 MHz, *supra* note 127, at 1.