In general radiosonde receivers are very susceptible to co-channel interference, which makes sharing extremely difficult. Reallocation of any portion of this band on a mixed-use basis would have a detrimental effect on the ability of these Met Aids to perform their vital functions. Based on these factors reallocation of this band on a mixed-used basis is not seen as a viable option.

Public Benefit

The use of radiosondes in the 403-406 MHz band plays a critical role in delivery of accurate and timely weather information by the Federal Government to the public. The effect that accurate weather prediction has on the national economy, protection of lives and property, and general welfare of the public is very large but difficult to quantify. These frequencies are critical to providing these services with immeasurable benefits to the public.

Reallocation Options

In view of the importance of this band for weather prediction and the services already provided to the public by systems operating in the band, no public benefit would accrue by removing Federal Government access to this band. Reallocation for non-Federal use is therefore not considered to be a viable option.

932-935 AND 941-944 MHz BANDS

Band Usage

The 932-935 and 941-944 MHz bands are allocated to the Federal Government and non-Federal users for the fixed services on a co-equal shared basis. In addition, Government off-shore radiolocation operation is permitted on a non-interference basis limited to the military services. The 932-935 and 941-944 MHz bands are two of the few bands supporting fixed low-capacity communication links. The Federal agencies that use these bands include: FAA, Agriculture, DOE, DOI, Treasury, Navy, and USCG. Spectrum use for each agency is similar in both the 932-935 and 941-944 MHz bands. Usually, a transmit frequency in one band has a corresponding receive frequency in the other band or a paired channel.

The FAA uses these bands for low density communications links (voice and/or data). The majority of their assignments are authorized for the Low Density Radio Communication Link (LDRCL) system, which is deployed across the United States, in support of the NAS. Agriculture's assignments are concentrated on the West Coast and in the North-central States. These assignments are in support of their point-to-point, microwave backbone communications systems. The DOE operates fixed point-to-point microwave systems primarily in remote areas of the United States where their operations are not accessible by telephone. The DOI operates fixed point-to-point microwave systems that directly support law enforcement activities and dispatch systems for resource management and fire suppression.

The predominant non-Federal use of the 932-935 and 941-944 MHz bands is to support paging systems. Multiple Address Service (MAS) operations are also permitted to operate in these bands. Typical MAS users include numerous system control and data acquisition (SCADA) uses, point-of-sale applications (check and credit card verifications), security alarms, airport runway lighting control, and many miscellaneous applications.

Reallocation Considerations and Impact

The initial intent of creating the paired 932-935 and 941-944 MHz bands was to provide a point-to-point band for Federal Government point-to-point operations, especially those in the 406.1-420 MHz band. Later modifications to the policy included sharing the band between Federal Government, private, and public services, as well as allowing spectrum in each band to be used for MAS.

The 932-935 and 941-944 MHz bands are an important resource to satisfy low-capacity Federal Government fixed communications systems. The major Federal Government user of these bands is the FAA for interconnection of air traffic control facilities. As described in Section 2 of the NTIA Preliminary Report, the total Federal investment in these bands is approximately $200 million.[71] Most of the Federal Government applications that use these bands are located in areas where commercial communication service is either unavailable or is more expensive. Satisfying these low-capacity communication requirements in higher frequency bands will generally result in less efficient use of spectrum because of the unavailability of suitable low-capacity radio equipment.

The DOE uses this band in the western part of the United States for the SCADA system, and to control and protect the power transmission systems for the Bonneville Power Administration and the Western Area Power Administration. The DOE stated that this band has just recently been made available for low density, point-to-point applications by NTIA and the FCC. Any reallocation affecting DOE's use of the band would be met with strong opposition, because it demonstrates a lack of national spectrum planning by the licensing authorities. The DOE has an estimated investment in these bands that exceeds $5.6 million.[72]

Moreover, in compliance with OBRA 93, the 1710-1755 MHz portion of the 1710-1850 MHz band is scheduled for reallocation on January 1, 2004.[h] The NTIA Final Reallocation Report recommends the 932-935 and 941-944 MHz bands as a possible option to accommodate some of the displaced Federal fixed microwave stations in the 1710-1755 MHz band.[73] Several agencies have initiated the procurement process for microwave equipment in the 932-935 and 941-944 MHz bands for their low capacity stations. If these bands were to be reallocated, Federal Government users would be forced to relocate their microwave stations for a second time.

[h] An earlier availability date of January 1999 applies to the 25 largest U.S. cities and is further subject to timely reimbursement of Federal costs, including reimbursement directly from the private sector.

Public Benefit

The 932-935 and 941-944 MHz bands are coequally allocated for Federal Government and non-Federal use by the fixed service, serving important functions for both. Through the established frequency coordination procedure, no non-Federal request for a frequency assignment in these bands has ever been denied because of competing Federal Government use. It is anticipated that Federal Government needs for this spectrum can continue to be satisfied in this band with little or no impediment to continued non-Federal use. Therefore, little or no public benefit would appear to result from the withdrawal of Federal assignments under the requirements of Title III of the BBA 97.

Reallocation Options

Reallocation of the 932-935 and 941-944 MHz bands under the requirements of Title III would result in a significant cost and operational impact to the Federal Government while offering little or no benefit to the public. For this reason, reallocation of these bands is not considered to be a viable option.

1370-1378.55 AND 1383.55-1390 MHz BANDS

Band Usage

The 1370-1378.55 and 1383.55-1390 MHz band segments are part of the overall 1215-1400 MHz band. This region of the spectrum is excellent for radars used for long-range search, surveillance, and tracking, and it is used extensively by the Federal Government for these purposes. Long-range radars are operated in this part of the spectrum because the effects of rain and fog on radar target detection are very low and high-power transmitter tubes operate very efficiently. Both factors are important to achieve the long-range detection of targets necessary for air traffic control, national defense, and drug interdiction requirements. There is no other part of the allocated spectrum that offers such intrinsic advantages and is also available for such important functions. The large number of high-powered radars that require access to this band makes it very congested in some areas of the United States.

The newest long-range search radar in the Joint Surveillance System (JSS) that has recently been fielded is the Air Route Surveillance Radar Model 4 (ARSR-4) which provides air defense and air traffic control for the continental United States, Guam, and Hawaii. The ARSR-4 was fielded through a $1 billion Congressionally mandated joint FAA and Air Force program. The radar has an operational frequency range of 1215-1400 MHz and uses dual-channel frequency hopping technology for long-range and anti-jam search and tracking, and is capable of detecting small objects by minimizing clutter, weather, and multipath effects. Each channel pair requires 83 MHz of frequency separation to maintain its highest possible reliability. This radar system supports defense of the national airspace and provides initial coastal civil air traffic control.

The Air Force also operates an extensive network of radars that have the capability to tune in the 1215-1400 MHz frequency range. The AN/FPS-117 and AN/FPS-124 form an array of radars stretching across North America from Alaska via Canada to Greenland, and are designed to provide long-range detection and coverage for drug interdiction support and tactical command and control. Due to extreme northern locations of these radars, the physics of radiowave propagation in the 1215-1400 MHz frequency range is even more critical for target detection requirements.

The Navy operates long-range shipborne radars for missile detection and the Mark 23 (MK 23) Target Acquisition System (TAS) in the 1215-1400 MHz band. The MK 23 provides target information to the NATO SEASPARROW Surface Missile System (NSSMS).

In addition to the long-range radar systems the military also operates the GPS Range Applications Joint Program Office (RAJPO) Data Link System (DLS) in the 1350-1400 MHz band. The RAJPO DLS rebroadcasts real time position information of high velocity manned and unmanned airborne platforms during test and training system operations. This system is critical to ensuring the safety of personnel during training or test operations on military ranges. A total procurement of 719 units has been authorized at 25 sites throughout the United States. Each airborne participant rebroadcasts satellite derived time and location information via a pair of frequencies in the 1350-1400 and 1427-1435 MHz bands.[i] This dual frequency operation is required to ensure data availability in rugged terrain and to overcome the problems encountered with multipath fading during training exercises.

The Next Generation Target Control System (NGTCS) is being developed in part of the 1380-1390 MHz frequency band. The NGTCS is a development program whose immediate goal is to provide a common control system for unmanned target vehicles at three DoD test ranges, and whose ultimate goal is to extend that system to all DoD test ranges. To date the program has spent about $40 million of an anticipated development cost of over $100 million for the initial three ranges. Of the $40 million, approximately $20 million has been spent on the RF data link. It is anticipated that another $20 million will be spent to complete the link in the near future.[74]

The Army uses the bands in the 1350-1850 MHz frequency range for tactical transportable radio relay systems linking various headquarters and functional nodes into an area-wide integrated network for systems such as the Mobile Subscriber Equipment (MSE) and the Tri-Service Tactical Communications. To maintain interoperability with U.S. military allies, this frequency range is standardized within the NATO alliance. However, only a portion of these bands is available for peacetime training exercises. The Army also uses this band for the video links associated with unmanned air vehicle (UAV) and unmanned ground vehicles (UGV).

The FAA also operates several versions of Air Route Surveillance Radars (ARSRs) for air traffic control in the adjacent 1215-1350 MHz band. These radars include the ARSR-1, ARSR-2, and ARSR-3.

[i] The 1390-1400 and 1427-1432 MHz band segments have already been identified for reallocation under OBRA 93.

The 1350-1400 MHz band is important for radio astronomy observation of red-shifted hydrogen spectral lines. Most of the galaxies detected using the hydrogen spectral lines and the associated red-shift frequency occur in the 1350-1400 MHz region of the spectrum. Although radio astronomy observations using the 1350-1400 MHz band are on an unprotected basis, the band is nevertheless extremely important to the success of many domestic and international scientific studies.[75]

The total estimated investment cost of Federal systems that are capable of operating in the 1370-1378.55 and 1383.55-1390 MHz band segments exceeds $2 billion.[76] A detailed description of the other systems that are capable of operating in the 1215-1400 MHz band is provided in the Spectrum Requirements Report,[77] the Preliminary Report,[78] and the Final Report.[79]

Reallocation Considerations and Impact

The functions discussed in the previous section that are performed in the 1370-1378.55 and 1383.55-1390 MHz band segments are important for meeting Federal agency mission requirements. Alternatives such as using commercial vendors, non-radiating systems, or different frequencies are not practical. While estimating the cost and mission impact to the Federal Government is difficult, it is clear that reallocation of both band segments is not possible without causing excessive impact to the Federal Government. Reallocation of one of the band segments is possible, however it must be done in such a way as to minimize the impact on Federal operations.

As discussed in Section 2, there is a satellite downlink that operates in the 1378.55-1383.55 MHz frequency range. This downlink is on each of the satellites in the GPS constellation and it is used to transmit an alerting signal that is part of the Nuclear Detonation System (NDS). In the event of a nuclear explosion the NDS will broadcast nuclear detection data to a variety of fixed and mobile stations allowing the National Command Authority and battlefield commanders to meet operational requirements for managing U.S. nuclear forces. The Air Force states that the 1380-1385 MHz band cannot be reallocated under any circumstances since it is used to receive satellite-based nuclear detonation signals and must be protected.[80]

Under OBRA 93 the 1390-1400 MHz band segment is to be reallocated for non-Federal use in January 1999. As a result of this scheduled reallocation many of the systems that have the capability to operate in the 1350-1400 MHz band will have to be modified to some extent. In some cases it will be necessary to install filters to prevent interference to non-Federal users, while in other cases it will be necessary to make modifications to the software that controls the frequency hopping algorithms to lock out those frequencies that are in the reallocated portion of the spectrum. Since the 1390-1400 MHz band segment is scheduled for reallocation in 1999 the modifications to the affected systems have not been implemented. From the standpoint of system modification, it would be desirable to reallocate spectrum that is adjacent to the spectrum already identified for reallocation. This would simplify any filter designs or software modifications that would be required. Reallocating spectrum in the 1370-1378.55 MHz band segment would require bandpass and notch filters in addition to the filters required for the 1390-1400 MHz portion. Each time a filter is added there is an associated insertion loss. The ARSR-4 for example, has a distributed array transmit/receive module. Therefore, filtering on this radar requires individual filters on each module. The insertion loss that results from adding additional filters will decrease the probability of detection and degrade the overall performance of the radar. Based on cost and operational performance it is better to reallocate the 1385-1390 MHz band segment than the 1370-1378.55 MHz band segment.

The reallocation of the 1390-1400 MHz band segment under OBRA 93 will reduce the 39 frequency pairs (channels) available to the ARSR-4 by four. The reallocation of the 1385-1390 MHz band segment will further reduce the number of available ARSR-4 channels by four. This leaves 31 channels for current and future ARSR-4 operations. In addition to the channels lost through reallocation there are also ARSR-4 channels that can not be used because of operational restrictions (e.g., same frequencies as the NDS). A review of the GMF indicates that all of the frequency assignments for the ARSR-4 radars are located below 1370 MHz for normal operations. Therefore, the reallocation of the 1385-1390 MHz band segment will not impact the currently fielded ARSR-4 radars. However, in order to protect future commercial users from receiving interference, additional filters will be required at an estimated cost of $10 million.[81] Even with the channels lost through reallocation, the restricted channels, and the channels used by the currently fielded ARSR-4 radars, five channels will remain for future ARSR-4 radars. The FAA and Air Force are also concerned that continuing to reallocate spectrum used by the ARSR-4 will further impact the dual-frequency hopping capability that is key to its design. The Air Force states that the need to have frequency-hopping, anti-jam capabilities and the use of Air Traffic Control and other radars will make retuning and/or restricted use difficult in some areas. The Air Force maintains that the reallocation of the 1385-1390 MHz band segment will degrade the radar's frequency hopping capability that is key to its design for antijamming defense.[82] The FAA and Air Force state that reallocation at a minimum could require software modifications estimated to cost $35 million. Spectrum congestion already exists in this band and if the remaining available frequencies cannot support future dual-frequency requirements, hardware modifications estimated at $588 million and taking 5 years to complete will be required.[83]

In an attempt to avoid unnecessary and costly disruption of Federal operations in remote locations, the Final Report allowed Federal radars located in Alaska to continue operating on a secondary basis in the 1390-1400 MHz band segment that was identified for reallocation.[84] The same approach can be used for the reallocation of the 1385-1390 MHz band segment. The AN/FPS-117 and AN/FPS-124 radars located in Alaska will continue to operate in the 1385-1390 MHz band segment on a secondary basis. In response to the reallocation of the 1390-1400 MHz band segment, the Air Force stated that operation on a secondary basis was an acceptable option only if interference does not occur. In the event that interference does occur the Air Force stated that modifications or replacement of the radar would be necessary.[85] The Air Force also stated that the loss of spectrum in the 1350-1400 MHz band may make interference resolution with similar radars in Canada and Iceland more difficult.[86] These same comments would also apply to the reallocation of the 1385-1390 MHz band segment.

The Air Force and the FAA also operate a limited number of AN/FPS-117 radars within the continental United States. The AN/FPS-117 radar is capable of randomly hopping among 18 channels in the 1215-1400 MHz band.[87] The Air Force states that the reallocation of the 1390-1400 MHz band segment under OBRA 93 and the loss of the 1385-1390 MHz band segment under BBA 97 will result in a loss of an aggregate of 25 percent of its available channels. Similar losses will occur for the AN/FPS-124 and the ARSR-4. The Air Force maintains that the loss of additional spectrum will severely impair the radar's survivability in a hostile environment, reducing its capability to detect threats to national security, and may result in the need to redesign some of the radars.[88]

The Air Force further states that the radars operating is this band have already lost access to the 1390-1400 MHz band segment under OBRA 93 and would need to be further modified in order to prevent interference to commercial users. The Air Force and FAA estimate that the minimum cost for the modifications would be $100 million for the AN/FPS-117; $49 million for the ARSR-4; and $20 million for the AN/FPS-124. The modification costs include the need to install additional filtering and modify software. If hardware redesign/replacement is necessary the Air Force and FAA estimate it will cost $350 million to replace the AN/FPS-117, $588 million to replace the ARSR-4, and $150 million to replace the AN/FPS-124.[89]

The DoD has raised the issue of radar operations during wartime and has requested that for the 1385-1390 MHz band, the following footnote should be included in the National Table of Frequency Allocations:

> ***"During a national defense situation, as determined by CINCNORAD, these radars are authorized to use their full wartime hopset that includes this spectrum."***

While NTIA understands the defense concerns, adopting a footnote such as this can be a very complex issue. Although this proposal may be well defined in military terms, it is still vague from a national spectrum management standpoint. The impact that this proposed footnote would have on the "exclusive" reallocation status of this band to the private sector is unknown at this time. NTIA and the DoD will work with the FCC during the reallocation process in the 1385-1390 MHz band to insure that wartime emergency considerations will be addressed to maintain national security.

Because of the required dual frequency operation, the Federal investment in the RAJPO DLS may be jeopardized if continued access to the 1350-1400 MHz band is not available. After reallocation the 1390-1400 MHz band segment under OBRA 93 and the proposed reallocation of the 1385-1390 MHz band segment, 35 MHz will remain for RAJPO DLS operations. Each RAJPO DLS requires 8 MHz of bandwidth for operations, including guard bands. The loss of the proposed bandwidth will all but eliminate the ability to conduct simultaneous independent operations at some test ranges. The continued loss of spectrum in the 1350-1390 MHz band may serve to increase the spectrum congestion that already exists for test ranges that are using the RAJPO DLS. In response to the reallocation of the 1390-1400 MHz band segment, the Air Force stated that the Southwestern United States presents the most critical RAJPO DLS operation area.[90] There are six test and training facilities in close proximity to each other, which requires six unique frequency pairs for interference free simultaneous operations. If the ranges are unable to perform simultaneous operations it could limit their ability to effectively schedule test events. The Air Force estimated that the costs due to delays in aircraft testing can exceed $1 million per occurrence.[91] To reduce the impact on the Federal Government, the Final Report permitted RAJPO DLS operations at specified test ranges to continue for 10 years. The same approach could be used for the reallocation of the 1385-1390 MHz band segment. The Air Force states that the loss of 1380-1390 MHz band will likely cause the RAJPO DLS to be completely redesigned at a cost of $50 to 70 million to replace its functionality. Moreover, the Air Force states that loss of several more RAJPO DLS channels will cause costly delays in the flight test programs of major multibillion dollar aircraft.[92]

The Air Force states that the data link for the NGTCS has been designed to operate on two frequencies within the 1350-1390 MHz band. The Air Force states that this is a multi-user band, and frequencies used for transmission are chosen to reduce interference both between the two NGTCS frequencies and between those frequencies used by the RAJPO DLS and the ARSR-4 radars. The Air Force maintains that with the loss of one fourth of the band, there would be no clear frequencies available for the NGTCS, at some test ranges, without shutting down other systems. The Air Force states that a new frequency band for the NGTCS will be required for operation without interference. The Air Force adds that the since the NGTCS data link was optimized for operation in the current band, a new band would require extensive redesign, potentially wasting all of the $20 to 40 million investment costs, and incurring additional costs in program delays.[93]

The Air Force states that the increased use of this frequency band, coupled with the fact that the 1390-1400 MHz band has already been scheduled for reallocation to the private sector, could make any further reallocation costly and further constrain DoD operations. The Air Force contends that no part of this frequency band should be reallocated under any circumstances as it will severely constrain their operations and may be very costly. The Air Force believes that there are no other frequency bands appropriate for some of these missions and the remaining spectrum may not be adequate to meet all their requirements.[94] The Air Force estimates that the cost to reallocate the 1385-1390 MHz band segment could exceed $200 million.[95] 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.[96]

The loss of the 1390-1400 MHz band segment under OBRA 93 and the proposed reallocation of the 1385-1390 MHz band segment will result in an 8 percent reduction of the frequencies available for the Navy's shipborne radars and the MK 23 TAS. As stated in the Final Report, the reallocation approach that could be taken is to retune the radars and the MK 23 TAS within the remaining 1215-1385 MHz frequency range.[97] In response to the loss of the 1390-1400 MHz band segment, the Navy stated that reducing the available bandwidth will reduce the anti-jamming and interference margins of the radars making them more susceptible to interference from new and existing systems operating in the remaining portion of the band.[98] Reallocation of the 1385-1390 MHz band segment will further reduce the number of available unique channels for the MK 23 TAS. The Navy stated that the impact of losing more spectrum in the 1350-1400 MHz band is particularly severe if two or more ships are operating within 200 nautical miles (nmi) of each other. The Navy also stated that EM energy from one MK 23 TAS can couple into the receiver of another MK 23 TAS causing interference that can be so severe as to render the MK 23 TAS incapable of detecting targets and performing its mission.[99] The reallocation of the 1385-1400 MHz portion of the band will require software modifications for the frequency hopping algorithms and hardware modifications to design and install filters. Engineering studies will also be necessary to analyze the specific impact and provide guidance on measures to avoid electromagnetic interference.

The Navy states that the Marine Corps also operates the AN/TPS-59 long-range air surveillance radar and point-to-point digital wide band communication systems in the 1215-1400 MHz band. The Navy estimates that the total reallocation cost for the 1385-1390 MHz band segment could exceed $3.8 million.[100] 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.[101]

The tactical radio relay systems used by the Army are tunable over the entire 1350-1850 MHz frequency range. Although the reallocation of the 1390-1400 MHz under OBRA 93 and the 1385-1390 MHz currently proposed represents only a small portion of the operational bandwidth of these systems, the availability of authorized frequencies has continued to dwindle. The Army states that within the tuning range of the MSE and the AN/GRC-103 Band IV tactical radios, 60 MHz of spectrum was reallocated to the private sector under OBRA 93. The Army further states that the loss of the 1385-1390 MHz band segment will result in reaccommodation of communication nets associated with the MSE and the AN/GRC-103 and the video links associated with UAV and UGV systems. The Army maintains that some of these video links may have to be redesigned to operate in alternate spectrum. The Army estimates that the reallocation of the 1385-1390 MHz band segment could exceed $200 million.[102] 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.[103]

The loss of the 1385-1400 MHz band segment will increase the spectrum congestion in the entire 1215-1400 MHz band. This congestion is, in part, a result of the power output tubes used in the radar design and the post-tube filtering. The spurious emissions of all of the existing FAA radar systems in the adjacent 1215-1350 MHz band are high and will require that these radars be retrofitted with filters to protect non-Federal applications in the 1385-1400 MHz band segment. The FAA estimates that the cost to install filters on all of their radars could be as much as $10 million, depending on the non-Federal applications in the adjacent band.[104]

Radio astronomy observations using the 1350-1400 MHz band are on an unprotected basis. The band is nevertheless extremely important to the success of many domestic and international scientific studies. In order to reduce the impact on important Federal and university radio astronomy operations the National Science Foundation states that reallocation the 1385-1390 MHz band segment for non-Federal use must include restrictions on space-to-Earth and airborne transmissions.

Public Benefit

From a public benefit standpoint, spectrum in the 1385-1390 MHz band segment offers both positive and negative attributes. This band is in a region of the radio frequency spectrum with propagation characteristics that can support a wide variety of commercial fixed and mobile applications. The conversion of existing technologies for use in this band will make it possible to market rapidly new equipment for commercial use. This band is adjacent to the 1390-1400 MHz band already identified for reallocation under OBRA 93. Combining the two band segments will create a 15 MHz block of spectrum allowing greater flexibility in the development of commercial products and services. The 15 MHz can be used as one contiguous block and employ Time Division Duplex (TDD) technology, or it could be divided into two 5 MHz segments that can be paired with a 5 MHz transmit and receive separation to support mobile applications that typically will employ Frequency Division Duplex (FDD) technology. The 1385-1400 MHz band can also be paired with spectrum in the 1427-1435 MHz band (also scheduled for reallocation) which will substantially enhance its utility for emerging wireless technologies. In order to realize the full public benefit of this band the reallocation availability date should be consistent with that of the 1390-1400 MHz and 1427-1435 MHz bands.

This band segment has flexible frequency allocations in Europe and Africa for fixed and mobile services. This will support flexibility in the services that could be implemented and could foster U.S. export opportunities.

A concern in reallocating this band segment for non-Federal use is that it is adjacent to high-powered, megawatt, radar systems. Numerous case histories exist of interference from adjacent band high-power radar systems due to inadequate receiver selectivity. The FCC generally declines to establish receiver standards allowing industry to reach a consensus on receiver design. Even though the Federal Government has established one of the most restrictive radar transmitter standards in the world, poorly designed commercial receivers in the adjacent band will likely receive serious interference in many geographic areas.

Reallocation Options

The 1370-1378.55 and 1383.55-1390 MHz band segments are part of the 1215-1400 MHz band that is used by the Federal Government for long range search, surveillance, and tracking radars, aeronautical telemetry and telecommand systems, and tactical radio relay for the military. The 1390-1400 MHz band segment is scheduled for reallocation under OBRA 93 creating congestion in the remaining portions of the band. There is a high estimated investment by the Federal Government in systems capable of operating in the 1215-1400 MHz band making reallocation of both band segments for non-Federal use very costly. The loss of both band segments would also result in excessive impact to the missions performed by the Federal agencies which include: air traffic control, national defense, and drug interdiction.

In weighing the cost and operational impact to the Federal Government with the potential benefits to the public, reallocation for exclusive non-Federal use of the 1385-1390 MHz band segment is feasible. Reallocating the lower 1370-1378.55 MHz band segment will result in greater cost and mission impact to the Federal Government. Limiting the reallocation to the 1385-1390 MHz band segment is a reasonable balance between providing additional spectrum resources for non-Federal use and reducing the cost and operational impact to the allocated Federal services.

High-powered FAA and DoD radars will continue to operate in the lower adjacent band. Reallocating the 1385-1390 MHz band segment for non-Federal use will require modifications to the Federal radar systems, which will include modifications to the frequency hopping software and installing filters on the radar transmitters to reduce interference. In addition, adopting adequate industry receiver standards in this band is essential to reduce the potential for interference. Reallocation of the 1385-1390 MHz band must also be accompanied by mandatory transmitter standards to reduce the potential for interference to the Nuclear Detonation System. To avoid unnecessary disruption of Federal operations in isolated remote locations, the Federal radars operating in Alaska will continue on a secondary basis. To provide for the continued operation of certain high-valued DoD systems, continued Federal Government use of the 1385-1390 MHz band at the selected sites in Table 3-3 will continue for 9 years after the scheduled reallocation date.[105] The geographical representation of the site locations is shown in Figure 3-3. To minimize the impact on the radio astronomy service, reallocation for space-to-Earth links or airborne applications must not be permitted.

Table 3-3.[j]

Sites at Which Federal Systems in the 1385-1390 MHz Band
Will Continue to Operate for 9 Years After the Scheduled Reallocation Date

Location	Coordinates	Protection Radius
China Lake/Edwards AFB, CA	35°29'N 117°16'W	100 km
White Sands Missile Range/Holloman AFB, NM	32°11'N 106°20'W	160 km
Utah Test and Training Range/Dugway Proving Ground, Hill AFB, UT	40°57'N 113°05'W	160 km
Point Mugu, CA	34°07'N 119°09'W	80 km
Patuxent River, MD	38°17'N 076°24'W	70 km
Nellis AFB, NV	37°29'N 114°14'W	130 km
Fort Huachuca, AZ	31°33'N 110°18'W	80 km
Eglin AFB, FL/Gulfport ANG Range, MS/ Fort Rucker, AL	30°28'N 086°31'W	100 km
Wright-Patterson AFB, OH	39°50'N 084°03'W	80 km
Aberdeen Proving Ground, MD	39°29'N 076°08'W	80 km
Yuma Proving Ground, AZ	32°29'N 114°20'W	80 km
Fort Greely, AK	63°47'N 145°52'W	80 km
Redstone Arsenal, AL	34°35'N 086°35'W	80 km
Alpene Range, MI	44°23'N 083°20'W	80 km
Camp Shelby, MS	31°20'N 089°18'W	80 km
AUTEC[k]	24°30'N 078°00'W	80 km

[j] The DoD has raised the issue of radar operations during wartime. NTIA and DoD will work with the FCC during the reallocation process in the 1385-1390 MHz band to insure that wartime emergency considerations will be addressed to maintain national security.

[k] This site is located outside of the Continental United States.

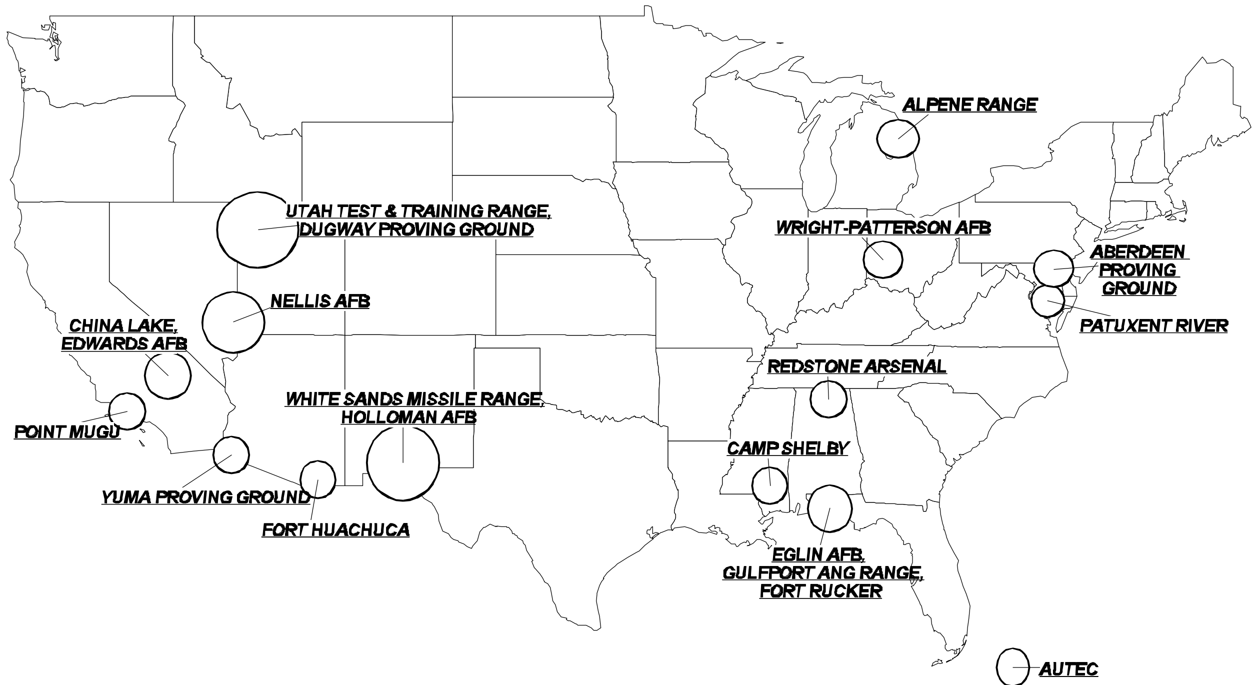

Figure 3-3.
Sites at Which Federal Systems in the 1385-1390 MHz Band Will Continue to Operate for 9 Years After the Scheduled Reallocation Date

1432-1435 MHz BAND

Band Usage

This band is allocated for Federal Government fixed and mobile services, and limited primarily to the military. The fixed service is used in support of proficiency training using tactical radio relay systems at specific Army bases. These tactical radio relay systems have broad tuning ranges, which include the 200-400, 600-1000, and 1350-1850 MHz ranges.

Mobile use is primarily air-to-ground telemetry and ground-to-air telecommand links to support various operational and testing programs mainly at military electronic test ranges. One major system that operates in this band is the RAJPO DLS. The RAJPO DLS, with a Federal investment cost of $70 million, is being operated in the vicinity of 22 DoD test and training ranges, and in the broad areas covered by their associated airspace to relay precise aircraft location to ground control locations. The RAJPO DLS is crucial to the flight testing of many high value aircraft. To achieve the required communications reliability this system operates in both the 1350-1400 and 1427-1435 MHz bands.

The Air Force also uses this band for drone control, remote control of ordnance handling robots and the data link for the Tethered Aerostat Radar System (TARS)) at Cudjoe Key, FL (about 20 miles west of Key West and over 120 miles from populated areas in mainland Florida).

The 1427-1435 MHz band is used for proficiency training using various guided weapon systems by the Navy. The weapon systems and supporting data links that operate in this band include: the AWW-13 Advanced Data Link, Walleye, and SLAM. The Navy inventory currently includes approximately 200 AWW-13's, 800 SLAM, and 7800 planned JSOW Unitary weapons.[106]

Compounding the problem are weapons in development that are planning to use the AWW-13, including the Joint Standoff Weapon Unitary variant (JSOW Unitary), and Expanded Response. The AWW-13 requires spectrum for both command and video functions.[107] The Navy estimates that they have an investment cost of $567 million in equipment capable of operating in the 1432-1435 MHz band.[108]

The Army uses this band for radio relay systems and for unmanned airborne vehicle video and telemetry downlinks. The Army estimates their investment in this band to be approximately $70 million.[109]

The DOE also uses this band for warehouse materials management and range airborne telemetry at the Nevada Test Site.

Reallocation Considerations and Impact

The RAJPO DLS was designed so that frequencies may be chosen within the authorized bands of 1350-1400 and 1427-1435 MHz, under software control. As a result of OBRA 93, after the year 2008, the 1390-1400 and 1427-1432 MHz band segments are no longer available for Federal use. To achieve the designed communications reliability under low-level flight conditions, simultaneous dual frequency operation is required, with adequate frequency separation to assure reliable communications. Since adequate frequency separation is not available solely within the 1350-1390 MHz band the RAJPO DLS requires at a minimum 3 MHz in the 1427-1435 MHz band. Therefore, continued access to the remaining 1432-1435 MHz band is crucial to maintain low altitude communications reliability requirements. Loss of access to the 1432-1435 MHz band segment would require a major redesign of the RAJPO DLS to operate with the required reliability in alternative frequency bands.[110] However, the continued loss of spectrum below 3 GHz makes finding alternative bands that are allocated to the Federal Government at an acceptably low frequency difficult.

The Navy states that the complete loss of the 1432-1435 MHz band segment would also affect the operations of missile command and guidance telemetry systems. The lower portion of the band will be completely lost for military use within the United States and territories in 2008, ultimately affecting weapon system testing and training.[111] The Navy maintains that the only other channels available for test and training use are in the 1432-1435 MHz portion of the band, which has not been used for training to date to minimize the probability of compromising the full capabilities of the weapon systems.[112] The Navy states that the missiles in their inventory have factory-fixed frequencies of operation within the 1432-1435 MHz band segment and their expected service life runs well into the next century.[113]

For the weapon and data link systems the Navy identified three options for dealing with the loss of the 1432-1435 MHz band: 1) change the frequency band of operation for the AWW-13 and associated weapons; 2) develop a new digital video link with frequency agility or spread spectrum techniques and apply advanced compression techniques; 3) modify an existing radio or data link system to meet weapon data link requirements.[114] The Navy indicates that all of these options would require significant financial and technical investments for development and retrofit of both weapon and pod subsystems. The Navy estimates that development time could conceivably take 2 to 5 years depending on the alternatives considered with retrofit taking several additional years. The Navy believes that these options would also result in a negative impact on weapons acquisition and maintenance budgets and weapon inventory readiness.[115] The Navy estimates that if it is necessary to relocate or retune all of their systems in the 1432-1435 MHz band it would cost $2.3 billion.[116]

The Navy states that the complete reallocation of this band will make the required dual frequency operation of the RAJPO DLS impossible. The Navy also indicates that the loss of this band for missile command operations will render their systems more susceptible to jamming effects and will impair their terminal guidance. The Navy estimates that the costs associated with the reallocation of this spectrum to accommodate missile control systems and precision strike operations will be $67 million. 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.[117]

The Air Force states that if using the RAJPO DLS under the mixed-use reallocation status is found to be feasible, no reallocation cost is anticipated. However, the Air Force states that the close proximity of test ranges in the Southwest of the United States requires using all the available spectrum to prevent interference. If at some point, sharing is determined to be unfeasible, the Air Force estimates that it would cost the DoD between $50 million to $70 million to replace the lost functionality. The Air Force adds that since the RAJPO DLS aircraft are used at altitudes as high as 30,000 feet, devices used by the public beyond the bounds of test ranges could experience interference.[118]

The mixed-use reallocation of this band would permit the Air Force drone control and remote control ordnance handling robot systems operating at Eglin Air Force Base to continue. If operations are not allowed to continue the Air Force estimates that replacing the robot control link should be on the order of $150,000. The Air Force did not have a cost estimate to replace the drone control link.[119] The Air Force estimates that it will cost an estimated $100,000 to replace the data link to control the TARS. However, due to the low power (0.2 Watts), directional antenna, and remote location, the Air Force believes that there is a minimal possibility to cause interference or to constrain any future commercial services if the band is reallocated on a mixed-use basis.[120]

The Army states that if the mixed-use reallocation status proves feasible, no costs are expected. However, if at some point, sharing is determined to be unfeasible, then a major development of new equipment to operate in other bands may have to be undertaken. The Army estimates that the reallocation cost could exceed $150,000 if continued use of the band is not possible.[121]

DOE estimates that the cost to re-accommodate the warehouse materials management and range telemetry systems would be $300,000.[122] The DOE is requesting that the operations within warehouse buildings at their Savannah River Plant be permitted to continue under the mixed-use reallocation status. The low-powered equipment operates within a large metal building complex within the controlled access area of the Savannah River site and is the heart of a warehouse management system. A radius of 3 km would be required to protect the DOE operations at this location.[123]

Public Benefit

While the 1432-1435 MHz band segment is somewhat narrow (3 MHz), it nevertheless must be viewed as having a high public benefit if reallocated for commercial use. The lower portion 1427-1432 MHz (5 MHz) is already scheduled to be transferred for commercial use as a result of OBRA 93. Reallocation of the 1432-1435 MHz would result in a block of spectrum that is 8 MHz wide. It is located in a region of the spectrum that has very desirable radio wave propagation characteristics, able to effectively support a variety of commercial applications. Its worldwide frequency allocation for both fixed and mobile services further support the flexibility in services that could be implemented and could possibly foster U.S. export opportunities. Being located in the region of the spectrum that has radio propagation characteristics suitable for fixed and mobile applications, it is expected that existing technology could be adapted rapidly to this new band and marketed at an early stage. The ability to pair this band with spectrum that is also being reallocated in the 1390-1400 MHz band for duplex voice and/or data link applications could also substantially enhance its utility for emerging wireless technologies.[1]

[1] As a result of OBRA 93, the 1390-1400 MHz band segment is being reallocated for exclusive non-Federal use on January 1, 1999.

Reallocation Options

The 1427-1435 MHz band is used by the Federal Government for military tactical radio relay communications and military test range aeronautical telecommand and telemetering applications. The lower band segment (1427-1432 MHz) is already scheduled for reallocation for exclusive non-Federal use. There is a high estimated investment by the military in equipment capable of operating in this band making reallocation of the entire band for non-Federal use very costly.

Reallocation of the 1432-1435 MHz band segment for exclusive non-Federal use would result in a complete loss of the Federal investment in the RAJPO DLS and the missile command and guidance systems. There is an estimated high investment by the military in equipment capable of operating in this band making reallocation of the remaining 1432-1435 MHz band segment for exclusive non-Federal use very costly. However, reallocation of the 1432-1435 MHz band segment on a mixed-use basis with continued operations at a limited number of Federal Government electronic and missile test ranges would preserve the investment that the DoD has made in this band, while making additional spectrum available for new commercial applications.

In balancing the public benefit and impact (mission and cost) to the Federal Government, a feasible option is to reallocate the remaining 1432-1435 MHz band segment for non-Federal use on a mixed-use basis. This would preserve the investment made by the Federal Government and permit essential military operations to continue, while making additional spectrum available for the development of commercial wireless applications. In addition, essential military airborne operations at the sites listed in Table 3-4 and their associated airspace will be protected indefinitely.[124] The geographical representation of the site locations is shown in Figure 3-4.

2360-2390 MHz BAND

Band Usage

The 2360-2390 MHz band is the remaining part of the 2310-2390 MHz band that is used in conjunction with the 1435-1525 MHz band for ATM functions. The 1992 World Administrative Radio Conference (WARC-92) allocated spectrum to satellite audio broadcasting. The United States obtained 2310-2360 MHz for domestic satellite audio broadcasting. The FCC has since allocated the spectrum 2320-2345 MHz on a primary basis to the Digital Audio Radio Satellite Service (satellite DARS)[125] and the 2305-2320 and 2345-2360 MHz to the Wireless Communication Service (WCS).[126] This reallocation of spectrum reduced the available spectrum for ATM from 80 MHz to 30 MHz.

The remaining 2360-2390 MHz band is allocated on a primary basis to the Federal Government for the mobile and radiolocation services. The military uses this band to support telemetry in the flight testing of aircraft, spacecraft, and missiles at nine major military test ranges and numerous test facilities. The use of flight test telemetry is the only way to insure that the DoD accepts a fully tested quality product. This band is used to support such programs as the F-22, the Joint Strike Fighter, B-1, B-2, F-18 E/F, and the Ballistic Missile Defense Program.

Table 3-4.[m]
Sites at Which Federal Systems in the 1432-1435 MHz Band
Will Be Protected Indefinitely

Location	Coordinates	Protection Radius
China Lake/Edwards AFB, CA	35°29'N 117°16'W	100 km
White Sands Missile Range/Holloman AFB, NM	32°11'N 106°20'W	160 km
Utah Test and Training Range/Dugway Proving Ground/Hill AFB, UT	40°57'N 113°05'W	160 km
Patuxent River, MD	38°17'N 076°24'W	70 km
Nellis AFB, NV	37°29'N 114°14'W	130 km
Fort Huachuca, AZ	31°33'N 110°18'W	80 km
Eglin AFB, Tyndall AFB, FL/Gulfport ANG Range, MS/Fort Rucker, AL	30°28'N 086°31'W	140 km
Yuma Proving Ground, AZ	32°29'N 114°20'W	160 km
Fort Greely, AK	63°47'N 145°52'W	80 km
Redstone Arsenal, AL	34°35'N 086°35'W	80 km
Alpene Range, MI	44°23'N 083°20'W	80 km
Camp Shelby, MS	31°20'N 089°18'W	80 km
AUTEC[n]	24°30'N 078°00'W	80 km
MCAS Beaufort, SC	32°26'N 080°40'W	160 km
MCAS Cherry Point, NC	34°54'N 076°53'W	100 km
NAS Cecil Field, FL	30°13'N 081°53'W	160 km
NAS Fallon, NV	39°30'N 118°46'W	100 km
NAS Oceana, VA	36°49'N 076°01'W	100 km
NAS Whidbey Island, WA	48°21'N 122°39'W	70 km
NCTAMS, GUM[n]	13°35'N 144°51'E	80 km
Lemoore, CA	36°20'N 119°57'W	120 km
Naval Space Operations Center, ME	44°24'N 068°01'W	80 km
Savannah River, SC	33°15'N 081°39'W	3 km

[m] 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 the disruption to critical military operations is minimized.

[n] This site is located outside of the Continental United States.

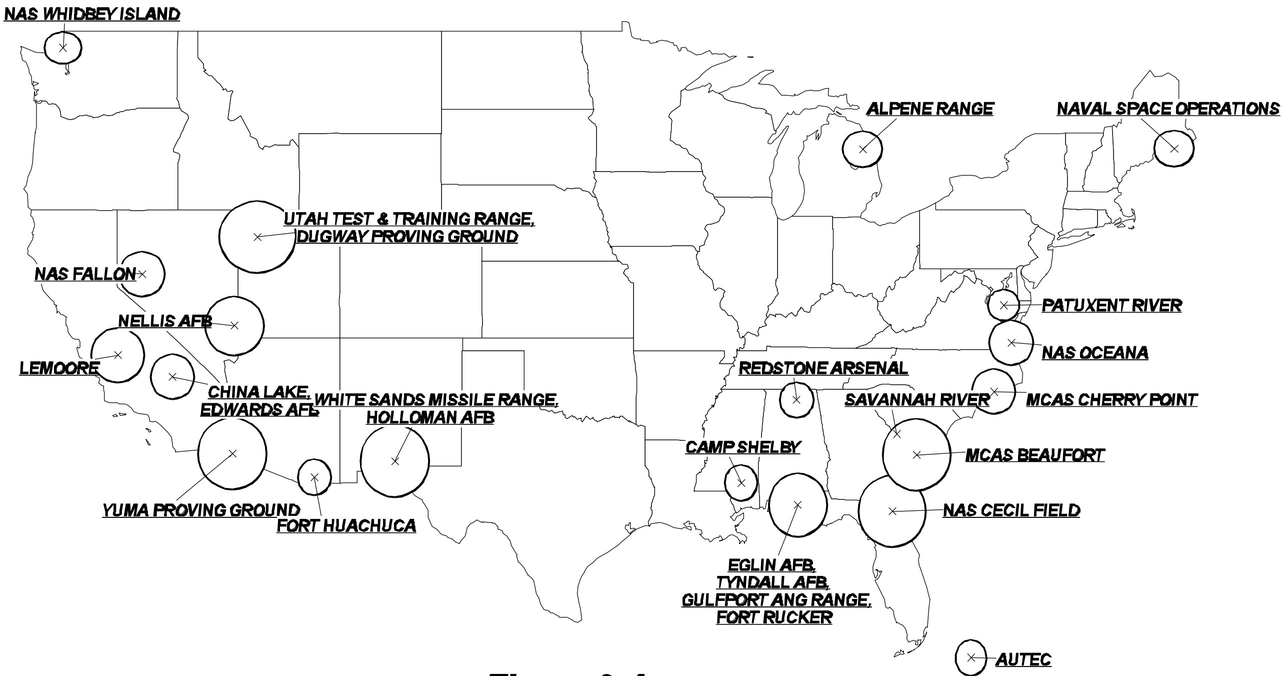

Figure 3-4.
Sites at Which Federal Systems in the 1432-1435 MHz Band Will Be Protected Indefinitely

NASA has two test centers that use the 2360-2390 MHz band in conjunction with the Scientific Balloon Program and the Aeronautical Telemetry Program for UAVs. The Scientific Balloon Program currently conducts 12 to 16 flights per year. NASA's use of the band for aeronautical telemetry averages 2 to 4 hours per day, however, it is anticipated that the total usage will increase.

The DOE uses this band for an airborne ranging system that supports Sandia National Laboratory research and development at Edwards AFB, CA and in New Mexico.[127]

The commercial aviation industry is also using this band for aeronautical flight testing. The 1435-1525 MHz band is vital for aeronautical flight test telemetry and is used heavily by the commercial aviation industry. In order to relieve the congestion in the 1435-1525 MHz band and to satisfy the growing need for wideband ATM the 2360-2390 MHz band is being used. AFTRCC coordinates the use of this band by the private sector.

Cornell University operates the National Astronomy and Ionospheric Center (NAIC) under a cooperative agreement with NSF. NAIC in turn, operates a megawatt planetary research radar occupying 20 MHz of bandwidth centered at 2380 MHz as part of the $100 million Arecibo Observatory in Puerto Rico. It is the world's largest radio telescope and radar station. Radar echoes from objects such as comets, planets, and the Moon contain information about surface properties, orbit and object size. This enables controllers, for example, to guide spacecraft accurately to specific positions on other planets. The Arecibo planetary radar is also used to keep track of space debris, and to detect minor objects in the solar system. It is one of the only two such facilities, the other being part of NASA's Deep Space Network, at Goldstone, CA. Some bistatic radar applications require simultaneous operations at both facilities.

In addition to the ATM functions, satellite launch facilities (Cape Canaveral, FL and Vandenberg, CA) have equipped their ranges with 2360-2390 MHz band systems to support expendable launch vehicles (ELV). This ELV allocation is primarily to support commercial ELVs at Federal Government launch facilities. The allocation was made to allow these ranges to meet the Presidential directive to provide Federal Government launch support to the commercial space program. The Department of Transportation's Office of Commercial Space Transportation (OCST) promotes and licenses commercial launch vehicles. To accommodate the telemetry requirements of commercial launch vehicles, the FCC and NTIA allocated six frequencies in the 2310-2390 MHz band. Since the FCC allocated the 2310-2360 MHz band for satellite DARS and WCS, the use of the three lower ELV telemetry channels may be difficult to utilize. To date no use has been made of this band for ELV operations.

Reallocation Considerations and Impact

Relocating the aeronautical telemetry operations from the 2360-2390 MHz band to an entirely new band is not seen as being a technically feasible alternative. The Air Force provided a first-level assessment of range impacts and has identified required infrastructure costs for telemetry equipment redesign and replacement of transmitters, filters, antennas, additional tracking stations and integration into the range data collection and display system. Based upon the cost in similar developmental efforts, the Air Force estimates that these costs could exceed $80 to $100 million per test range. For the six key test ranges, the Air Force states that reallocation of all aeronautical telemetry operations in the 2360-2390 MHz band could result in a total cost that could be as high as $600 million.[128]

A key determinant of the spectrum required for ATM is the number of separate RF signals being simultaneously transmitted. Each transmitter/transmitted signal is composed of multiplexed data streams from many sensors, normally several hundred. The number of sensors inputting data into each ATM transmitter is a minimum of 40 or 50, and data from approximately 8,000 are continuously sent in the case of the B-2. It is anticipated that the number of sensors required for flight testing will continue to grow. The other main determinant of ATM spectrum use is the bandwidth of the individual transmitted signal, this principally results from the number of sensors employed during the test. The increasing number of sensors required during flight testing results in higher data rates and higher resolution video requirements. Studies on data compression and spectral efficient modulation techniques are being performed to satisfy the bandwidth requirements of the current and future aeronautical telemetry systems.