

# NASA Response to NTIA re 1755-1850 MHz Comparable Bands

*Version 3c  
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## Question 1 -- Draft Response

1. *1755-1850 MHz Bands Characteristics --For each type of 1755-1850 MHz operation as provided in the NTIA chart, each affected agency, will provide the following:*
  - 1.1. *Identify, by type, the systems they have in this band and the numbers of each system*
  - 1.2. *Identify the number of assignments by system type.*
  - 1.3. *Identify the type of assignment by system (i.e., Local, regional, US/USA/US&P, etc)*
  - 1.4. *Provide a brief description of the type of operation.*
  - 1.5. *Provide geographical area location of assignments, gross assessment of time of operation.*

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NASA uses the 1755-1850 MHz band for support in two categories of service identified by NTIA -- "Air to Ground Telemetry" and "UAS, UAV, RPV". NASA use of this RF spectrum is for reception of data, including video, from airborne vehicles and for telecommand of those vehicles.

Vehicles include experimental aircraft, remotely piloted aircraft, and high altitude balloons. Commercial services are not readily available for NASA operations, and, given the experimental and research nature of NASA projects, would likely not be appropriate in any case.

One of NASA's initiatives is to pioneer the identification, development, and verification of high-payoff aeronautics technologies. It is focused on developing technology solutions that will eliminate barriers to growth for the civil aviation system and provide a safe, efficient national aviation system. NASA conducts testing in the areas of aviation, flight research, airframes, and aeropropulsion. It operates one-of-a-kind aircraft to support a wide variety of research missions. These testbeds provide platforms for sensor validation, and for aerodynamic, system, and propulsion research and testing.

NASA requires access to aeronautical telemetry frequency allocations for links between in-flight experimental aerospace vehicles and ground systems. RF spectrum is used to provide real time data information from test vehicles to the ground, real time video of cockpit or project information, and real time command and control of the vehicle, including flight termination. Telemetry is used for the real time monitoring of flight research/test parameters that are necessary in order to minimize the risk to the pilot and aircraft during the performance of maneuvers intended to push the flight envelope of test vehicles.

In addition to flight test and research operations for experimental vehicles, NASA also operates unmanned aeronautical vehicles (UAV) for the purpose of conducting airborne remote sensing and science observations. These operations might involve development and calibration of sensors, or collection of data to support NASA Earth science programs concerned with the measurement of environmental parameters. NASA's Langley Research Center has used scale

model aircraft to augment wind tunnel research for many years. Both powered and un-powered models have been used for airframe research, noise studies, control system development, low-speed handling. One of its major endeavors has been in stall/spin and low-speed stability testing. Powered or un-powered models are flown in low speed flight while the reactions to control inputs are monitored. The models are often pushed into spins and various control inputs are tested to determine the optimum controls for the quickest recovery. Other studies explore the use of various control system types and arrangements to increase aviation safety under adverse conditions. Among these are tests where one or more control surfaces are disabled and the ability of the remaining controls to overcome this condition is explored. This work has been instrumental in defining the aircraft handling characteristics for stall departure and spin recovery in major military and civil aircraft of the last sixty years.

NASA flight test and research operations are performed by the Dryden Flight Research Center (DFRC), Langley Research Center (LaRC), and Wallops Flight Facility (WFF). Operations vary in both scope and time. Aircraft, which include models, may fly at altitudes from a few feet up to altitudes on the order of 5000 ft and ranges may extend from an immediate locale out to a range of several hundred miles. Missions might last from minutes, to hours, to days. Frequency of missions is dependent upon scheduling with competing missions at the test centers.

DFRC maintains three (3) frequency assignments at 1804.5 MHz for flight research activities at Edwards AFB, CA. Two of these are relatively narrowband (50 kHz and 300 kHz) for transmission of telecommand to aircraft; while one provides wider bandwidth (1 to 5 MHz) for reception of data and video from aircraft.

LaRC maintains seven (7) frequency assignments at 1780.5, 1804.5, 1820, and 1835.5 MHz for flight test and research activities in the Hampton/Wallops, VA area. These support narrowband emissions (400 kHz and 700 KHz) for telecommand and wider bandwidths (4 to 25 MHz) for reception of data and video.

WFF maintains two frequency assignments at 1800 and 1820 MHz with 12 MHz bandwidth for reception of video from UAVs.

The primary objective of the NASA Balloon Program is to provide high altitude scientific balloon platforms for scientific and technological investigations. These investigations include fundamental scientific discoveries that contribute to understanding of the Earth, the solar system, and the universe. Scientific balloons also provide a platform for the demonstration of promising new instrument and spacecraft technologies.

NASA balloon missions are operated by the Wallops Flight facility (WFF) from launch sites in Palestine, TX and Fort Sumner NM. These balloons will routinely fly above 100,000 feet, for some missions flying above 150,000 feet. They are supported by telemetry receive sites at the launch site locations, as well as by a telemetry receive site in Winslow AZ. WFF maintains five (5) frequency assignments at 1786, 1801, 1816, 1831, and 1845 MHz, requiring bandwidths of 10 megahertz, for obtaining video and scientific data from the balloons.

Balloon operations vary in their time and frequency of use. Shorter missions may last between 2 hours to 3 days and may occur 15 to 20 times per year. Longer duration missions, lasting up to several weeks, may occur several times (2 to 4) times per year. Finally, extended duration missions, up to 100 days, may occur once or twice per year.

A summary of NASA frequency assignments in 1755-1850 MHz, based upon information in the Government Master File, is given in Table 1.

**Table 1: NASA GMF Assignments – 1755-1850 MHz**

SERIAL NUMBER	FREQUENCY IN MHZ	EMISSION	TYPE OF OPERATION	CENTER	TRANSMITTER STATE	TRANSMITTER LOCATION	RECEIVER STATE	GEOGRAPHICAL AREA LOCATION	TYPE OF ASSIGNMENT	OPERATIONAL DETAILS (GMF)	COMMERCIAL OR NON-RF AVAILABLE?
NASA940205	1804.500000	1M00F3D 3M00F3D 5M00F3D	AIR TO GROUND TELEMETRY	DFRC	CA	AIRCRAFT	CA	EDWARDS AFB, CA	REGIONAL	AIR-TO-GROUND PCM/FM TLM DOWNLINK	NO
NASA900149	1804.500000	300K00F9D	UAS, UAV, RPV	DFRC	CA	EDWARDS	CA	EDWARDS AFB, CA	REGIONAL	SUPPORTS REMOTE PILOTED VEHICLE TELEMETRY OPERATIONS	NO
NASA990018	1804.500000	50K00F9D	UAS, UAV, RPV	DFRC	CA	EDWARDS	CA	EDWARDS AFB, CA	REGIONAL	SUPPORTS REMOTE PILOTED VEHICLE TELEMETRY OPERATIONS. OPERATES UNTIL RPV IS ABOVE RADIO HORIZON FOR ABSOLUTE CONTROL	NO
NASA840033	1763.000000	4M00G9D	SHUTTLE PAYLOAD INTERROGATOR	JSC	SPACE	SPACE	SPACE	SPACE (LEO)	WORLDWIDE	NSTS PAYLOAD INTERROGATOR. MULTIPLE FREQUENCIES AT 1763-1840 UTILIZED DUE TO VARYING PAYLOAD SPECTRUM REQUIREMENTS	NO
NASA940130	1780.500000	25M00F9W	UAS, UAV, RPV	LARC	VA	HAMPTON	US	VA, MD, DE, NC	REGIONAL	UPLINK TRANSMISSION TO PROVIDE DATA, VIDEO AND COMMAND TO RESEARCH AIRCRAFT. AIRCRAFT OPERATIONS IN FOLLOWING STATES NC,VA,MD,DE. GROUND TO AIR TRANSMISSION ONLY.	NO
NASA760222	1804.500000	400K00F9D	UAS, UAV, RPV	LARC	VA	HAMPTON	VA	HAMPTON/WALLOPS, VA	REGIONAL	GROUND-TO-AIR TELECOMMAND FOR VARIOUS FLIGHT PROGRAMS INCLUDING UAVS	NO
NASA940173	1804.500000	400K00F9D	UAS, UAV, RPV	LARC	VA	WALLOPS ISLAND	VA	HAMPTON/WALLOPS, VA	REGIONAL		
NASA900122	1820.000000	17M00F8W	UAS, UAV, RPV	LARC	VA	AIRCRAFT	VA	HAMPTON/WALLOPS, VA		SUPPORTS VARIOUS FLIGHT PROJECTS INCLUDING REDUCED SCALE AND UAVS. TYPICAL 15 MINUTES OPERATION WITH AVERAGE OF 10 PER MONTH.	NO

NASA092004	1835.500000	10M00F9D	UAS, UAV, RPV	LARC	VA	BLACKSTONE AAF	VA	BLACKSTONE, VA	REGIONAL	USED IN SUPPORT OF AIRSTAR PROJECT	NO
NASA900123	1835.500000	700K00F2D 4M00F2D	UAS, UAV, RPV	LARC	VA	HAMPTON	VA	HAMPTON/WALLOPS, VA	REGIONAL	SUPPORTS SCALED MODEL AIRCRAFT RESEARCH. USED FOR REMOTE PILOT CONTROL AIRBORNE PLATFORMS.	NO
NASA940174	1835.500000	700K00F2D 4M00F2D	UAS, UAV, RPV	LARC	VA	WALLOPS ISLAND	VA	HAMPTON/WALLOPS, VA	REGIONAL		
NASA092514	1800.000000	12M00F3F	UAS, UAV, RPV	WFF	VA	WALLOPS ISLAND	VA	WALLOPS, VA	REGIONAL	VIDEO DOWNLINK FROM UNMANNED AERIAL VEHICLE FLYING UP TO 4500 FT (ALTITUDE) AND EAST OF 753114W LONGITUDE.	NO
NASA092515	1820.000000	12M00F3F	UAS, UAV, RPV	WFF	VA	WALLOPS ISLAND	VA	WALLOPS, VA	REGIONAL		
NASA102558	1786.000000	10M00F3F	AIR TO GROUND TELEMETRY	WFF	USA	BALLOON	AZ. NM, TX	AZ. NM, TX	REGIONAL	FOR DOWNLINK OF VIDEO/DATA FROM SCIENTIFIC BALLOON. FLIGHTS LAST FROM 1 TO 36 HOURS. PAYLOAD RESPONDS TO ON/OFF COMMANDS.	NO
NASA102559	1801.000000	10M00F3F	AIR TO GROUND TELEMETRY	WFF	USA	BALLOON	AZ. NM, TX	AZ. NM, TX	REGIONAL		
NASA102560	1816.000000	10M00F3F	AIR TO GROUND TELEMETRY	WFF	USA	BALLOON	AZ. NM, TX	AZ. NM, TX	REGIONAL		
NASA102561	1831.000000	10M00F3F	AIR TO GROUND TELEMETRY	WFF	USA	BALLOON	AZ. NM, TX	AZ. NM, TX	REGIONAL		
NASA102562	1845.000000	10M00F3F	AIR TO GROUND TELEMETRY	WFF	USA	BALLOON	AZ. NM, TX	AZ. NM, TX	REGIONAL		

## Question 2 -- Draft Response

2. Comparable Band Evaluation - For each comparable spectrum band and for each type of operation, provide the following:
  - 2.1. Technical Considerations
    - 2.1.1. Any limitations on performance, attributable to technical or technology shortcomings.
    - 2.1.2. The technical solutions required to overcome such limitations
    - 2.1.3. The state of availability and maturity of the technology necessary.
    - 2.1.4. Mitigation options available
    - 2.1.5. The preferred technical solution to overcome any performance limitations related to technology and the reasons why
  - 2.2. Operational Considerations
    - 2.2.1. Any limitations on performance, imposed by the presence of incumbents, e.g. systems employed in band, # of assignments, location, time of operation, gross characterization of the system's frequency of use, etc.
    - 2.2.2. The extent to which these limits impact mission effectiveness
    - 2.2.3. Mitigation options available
    - 2.2.4. The preferred solution for overcoming limits on performance brought on by the operational environment and the reasons why.
  - 2.3. The extent to which other constraints impede relocation (e.g., necessary allocation changes) to a comparable band and proposed remedies.
  - 2.4. A gross estimate of the time required to transition out of the 1755-1850 MHz band to a comparable band
    - 2.4.1. Less than 10 years?
    - 2.4.2. 10-15 years?
    - 2.4.3. Greater than 15 years?
  - 2.5. A gross estimate of the cost to transition out of the 1755-1850 MHz band to a comparable band
    - 2.5.1. Less than \$0.5B?
    - 2.5.2. \$0.5B - \$1.5B?
    - 2.5.3. \$1.5B - \$2.5B?
    - 2.5.4. \$2.5B - \$5.0B?
    - 2.5.5. Greater than \$5B?
  - 2.6. A ranking of each comparable spectrum in priority order, from the highest to lowest, for each type of operation and system type
  - 2.7. For each comparable band(s) for each type of operation discuss and provide the rationale for selection or non-selection.

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NASA has considered the bands listed by NTIA for potential relocation from the 1755-1850 MHz band of NASA UAS//UAV/RPV and Air-to-Ground Telemetry operations. These include 225-328.6 MHz, 335.4-380 MHz, 1350-1390 MHz, 1435-1525 MHz, 1675-1695 MHz, 2025-2110 MHz, 2200-2300 MHz, and 2360-2395 MHz.

In addition, NASA has also considered the 4400-4940 MHz, 5091-5250 MHz and 5925-6700 MHz bands that were recently allocated by WRC-07 for Aeronautical Mobile Telemetry. WRC-07 made these allocations because of crowding in existing bands allocated for the service. NASA believes the new bands hold great potential to relieve pressures for telemetry spectrum, but there currently exist several impediments to their use. First, although the international allocations for the bands exist, there are no domestic allocations. The use of the bands under the international allocations is limited to use for flight testing by aircraft stations. Thus there is no specific provision for uplink command and control. (The 4400-4940 MHz band does have a primary Mobile service allocation, in both the international and domestic allocation tables, which could support command and control.) With regard to 5091-5250 MHz, spectrum was allocated by WRC-07 for aeronautical telemetry at 5091-5150 MHz for Region 2 via FN 5.444B and at 5150-5250 MHz for Region 1 via FN 5.446C. Aeronautical telemetry operations in the United States at 5150-5250 MHz would be in derogation of the international Table of Frequency Allocations, undertaken under Article 4.4 of the international Radio Regulations. Finally, the bands are also allocated to other services, which impose difficult coordination processes. NASA recommends that NTIA urge the FCC to complete its domestic implementation of the WRC-07 allocations so that the new bands become available for use in the United States. NASA also recommends that NTIA initiate the appropriate steps to secure international and domestic allocations that would permit use of the band 4400-4940 MHz in the ground-to-air direction so that it can be used for command and control of airborne vehicles.

With regard to the bands needed for UAS/UAV/RPV, there are two functions that require consideration. First, there is a command and control function, which normally employs relatively narrowband emissions (e.g., 400 kHz, 700 kHz) for uplink to the airborne vehicle. Second, there is a data communications function, which normally employs relatively wide band channels (e.g., 3 MHz, 10 MHz) for downlink from the airborne vehicle. These functions do not necessarily have to occur in the same frequency band.

It appears that the best option for satisfying NASA's Aeronautical Telemetry and UAS/UAV/RPV operations would be to utilize the 5091-5250 MHz and the 4400-4940 MHz bands respectively, taking into account the considerations discussed above (development of an allocation for the United States for aeronautical telemetry). A second option for telemetry would be to utilize 4400-4940 MHz; this could be implemented in the near term by approval of frequency assignments under the Mobile service allocation. An alternative to use of these new aeronautical telemetry bands would be to squeeze assignments for NASA applications into the 1435-1525 MHz and 2360-2395 MHz bands. This approach might suffice for balloon operations by WFF and some testing by LaRC, but will likely not be suitable for research at DFRC due to heavy use of these bands for flight testing at Edwards AFB. Finally, the possibility of using 2025-2110 MHz for narrowband telecommand is an option for further study.

A band by band discussion for the Air To Ground Telemetry and UAS/UAV/RPV categories defined by NTIA is given in the following pages and summarized in Tables 2a and 2b.

### Air to Ground Telemetry

### 1350-1390 MHz

There is no current availability of commercial off the shelf equipment, transmitters and receivers, for airborne telemetry.

The band is only 40 MHz wide. There is an existing MOBILE service allocation in the band, but G27 limits it to military use. It is also allocated to FIXED service and RADIOLOCATION service, and there is known heavy radar use. Band allocations also include primary ARNS(5.334) and secondary srs/eess (passive)(5.339); and airborne telemetry is also not desirable in the band due to a desire to protect radio astronomy (US342).

The 1370-1390 portion of this band is still on the list of hi-priority bands NTIA is considering for commercial wireless broadband (ranked #4).

### 1435-1525 MHz

Commercial off the shelf equipment, transmitters and receivers, for airborne telemetry exist. The band is currently used by NASA (14 assignments) for flight test telemetry and balloon data communications and poses no technology problems.

The band is currently allocated exclusively for MOBILE (aeronautical telemetry), permitting associated telecommand. The band is known to be heavily used by Federal and non-Federal entities, and does not appear to have capacity for significant additional use. However, it might support several additional assignments for NASA's balloon and flight testing and research programs.

### 2025-2110 MHz

There is no current availability of commercial off the shelf equipment, transmitters and receivers, for airborne telemetry.

There is an existing MOBILE allocation but it is non-Government only, along with a non-Government FIXED allocation that supports Broadcast Auxiliary (ENG) use. US393 allows some federal mobile service but only for military use on a secondary basis at 6 military sites with no aeronautical mobile permitted.

The other primary allocations are for Government Space Operations Service/Earth Exploration Satellite Service/Space Research Service (E-s)(s-s). The band is heavily used by NASA satellite Uplinks and TDRS forward links (total 226 NASA assignments), which would impose constraints on protecting telemetry ground station receivers and airborne telecommand receivers from hi-power satellite NASA earth station uplinks. (US346 effectively makes the SOS,EESS, SRS operations secondary to ENG and already constrains the deployment of SOS/EESS/SRS earth stations.) This is an important band



internationally for SOS/EESS/SRS operations and NASA has a number of international agreements for cross-support.

#### 2200-2300 MHz

There is current availability of commercial off the shelf equipment, transmitters and receivers, for airborne telemetry.

There is primary allocation for federal MOBILE service, including aeronautical telemetry for unmanned aircraft. The other primary allocations are for Government Fixed Service and Government Space Operations Service/Earth Exploration Satellite Service/Space Research Service (s-E)(s-s).

The band is heavily used by NASA satellite downlinks (there are 18 receive sites in the United States, including Guam) and TDRS return links, (total 233 NASA assignments). There would be constraints on protecting earth station receivers and TDRS return links from airborne telemetry transmissions.

#### 2360-2395 MHz

There is current availability of commercial off the shelf equipment, transmitters and receivers, for airborne telemetry.

There is a Primary allocation for MOBILE (limited to aeronautical telemetry and telecommand by US276) as well as a primary Government allocation to RADIOLOCATION. NASA is already using the band for balloon/sounding rocket telemetry (13 assignments). The band is known to be heavily used by Federal and non-Federal entities, and does not appear to have capacity for significant additional use. . However, it might support several additional assignments for NASA's balloon program.

#### 4400-4940 MHz

There is limited availability of commercial off the shelf equipment, transmitters and receivers for airborne telemetry (some manufacturers are beginning to offer equipment but it is more expensive than L-band/S-band equipment). Telemetry links at the 5 GHz spectrum range will require higher power transmitters for a given line-of-sight distance due to higher propagation losses.

This is a new band for aeronautical telemetry, allocated by WRC-07 via FN 5.440A; there is no US allocation. Although there is no current US allocation specifically for aeronautical telemetry; there is an international allocation in the band for the Mobile service and a national allocation in the band for the Government mobile service. Resolution 416 does place certain EIRP limits on the aircraft transmissions.

This band appears to be a primary candidate for implementation of additional aeronautical telemetry spectrum in the United States and accommodation of telemetry

operations moved from 1755-1850 MHz. Additionally, this band appears to be a candidate for telecommand operations because the band already has an existing MS allocation.

#### 5091-5250 MHz

There is limited availability of commercial off the shelf equipment, transmitters and receivers, for airborne telemetry (some manufacturers are beginning to offer equipment but it is more expensive than L-band/S-band equipment). Telemetry links at the 5 GHz spectrum range will require higher power transmitters for a given line-of-sight distance due to higher propagation losses.

This is a new band for aeronautical telemetry, allocated by WRC-07 at 5091-5150 MHz for Region 2 via FN 5.444B and at 5150-5250 MHz for Region 1 via FN 5.446C. If international FN 5.444B is adopted into the US Table, it only allows transmissions from aircraft in the air-to-ground direction (i.e., no telecommand/uplinks in the band), in accordance with ITU Res 418 (WRC07). Aeronautical telemetry operations at 5150-5250 MHz would be in derogation of the international Table of Frequency Allocations, undertaken under Article 4.4 of the international Radio Regulations.

FN 5.444B also allows AM(R)S in the band for airport surface applications and aeronautical security transmissions which will require coordination for airborne telemetry users operating near airports. FN5.444A allocates 5091-5150 MHz to the fixed-satellite service (Earth-to-space) on a primary basis for NGSO MSS feeder links. It is used for Globalstar MSS feederlinks, which would constrain the number of airborne telemetry transmitters (and telecommand transmitters) so as not to interfere with Globalstar satellite receivers. Resolution 418 places certain PFD limits on the aircraft transmissions to protect FSS satellite receivers and terrestrial services.

The band is also allocated to MLS (5.444) and AMS(R)S (5.367); however there is no longer MLS in US and currently there is no AMS(R)S system.

This band might be useful for airborne telemetry.

#### 5925-6700 MHz

There is no current availability of commercial off the shelf equipment, transmitters and receivers, for airborne telemetry. Telemetry links at the 6 GHz spectrum range will require higher power transmitters for a given line-of-sight distance due to higher propagation losses.

This is a new band for aeronautical telemetry, allocated by WRC-07 via FN 5.457C; there is no US allocation. If international FN 5.457C is adopted into the US Table, ITU Res 416 (WRC07) only allows transmissions from aircraft in the air-to-ground direction (i.e., no telecommand/uplinks in the band). Resolution 416 also places certain EIRP limits on the aircraft transmissions.

The band is also allocated to the Fixed Satellite (Earth-to-Space) and Fixed services; these are heavily used by commercial entities in the US and coordination would be difficult.

## UAS/UAV/RPV

### 225-328.6 MHz

There is current availability of commercial off the shelf equipment, transmitters and receivers, for airborne telemetry in 215-320 MHz. Also, there is no availability of wide channels to support high data rate aeronautical telemetry and video. Large antennas would be required for high data rate aeronautical telemetry and video in this band. However, the band could be used for narrowband command and control.

There is a primary allocation for MOBILE service, but it is limited to military services (G27) and is likely already heavily used for military voice/data communications. The band is also allocated to FIXED service (limited to military by G27) and is likely heavily used for military fixed voice/data communications. There is also an allocation for Mobile Satellite Service in 235-322 MHz (for military use only, via G100) which could constrain airborne telemetry transmissions in order to protect MSS earth station receivers. Further, airborne telemetry transmissions are not desired in the 322-328.6 MHz portion due to a desire to protect radio astronomy (US342). Finally, the 242.95-243.05 MHz portion must be avoided since it is an emergency band for SAR/EPIRB/ELT .

### 335.4-380 MHz

There is no current availability of commercial off the shelf equipment, transmitters and receivers, for airborne telemetry. There is no availability of wide channels to support high data rate aeronautical telemetry and video. Large antennas would be required for high data rate aeronautical telemetry and video in this band. However, the band could be used for narrowband command and control.

There is a primary allocation for MOBILE service, but it is limited to military services (G27) and is likely already heavily used for military voice/data communications. The band is also allocated to FIXED service (limited to military by G27) and is likely heavily used for military fixed voice/data communications. There is also an allocation for Mobile Satellite Service in 335.4-380 MHz (for military use only, via G100) which could constrain airborne telemetry transmissions in order to protect MSS earth station receivers.

### 1350-1390 MHz

There is no current availability of commercial off the shelf equipment, transmitters and receivers, for airborne telemetry.

The band is only 40 MHz wide. There is an existing MOBILE service allocation in the band, but G27 limits it to military use. It is also allocated to FIXED service and RADIOLOCATION service, and there is known heavy radar use. Band allocations also include primary ARNS(5.334) and secondary srs/eess (passive)(5.339); and airborne

telemetry is also not desirable in the band due to a desire to protect radio astronomy (US342).

The 1370-1390 portion of this band is still on the list of hi-priority bands NTIA is considering for commercial wireless broadband (ranked #4).

#### 1435-1525 MHz

Commercial off the shelf equipment, transmitters and receivers, for airborne telemetry exist. The band is currently used by NASA (14 assignments) for flight test telemetry and balloon data communications and poses no technology problems.

The band is currently allocated exclusively for MOBILE (aeronautical telemetry), permitting associated telecommand. The band is known to be heavily used by Federal and non-Federal entities, and does not appear to have capacity for significant additional use. However, it might support several additional assignments for NASA's flight testing and research programs.

#### 1675-1695 MHz

There is no current availability of commercial off the shelf equipment, transmitters and receivers, for airborne telemetry. The band is only 20 MHz wide; and, therefore, not useful for wideband channels.

Currently there is no MOBILE service allocation; the band is allocated to METAIDS (radiosonde) and METSAT (s-E). Airborne telemetry transmissions would be constrained by the need to protect METSAT/METAID ground station receivers and also a need to protect radio astronomy in the adjacent band (US211).

NTIA has already recommended the adjacent spectrum at 1695-1710 MHz for commercial wireless broadband and might also seek 1675-1695 MHz for this purpose at a later date.

#### 2025-2110 MHz

There is no current availability of commercial off the shelf equipment, transmitters and receivers, for airborne telemetry.

There is an existing MOBILE allocation but it is non-Government only, along with a non-Government FIXED allocation that supports Broadcast Auxiliary (ENG) use. US393 allows some federal mobile service but only for military use on a secondary basis at 6 military sites with no aeronautical mobile permitted.

The other primary allocations are for Government Space Operations Service/Earth Exploration Satellite Service/Space Research Service (E-s)(s-s). The band is heavily used by NASA satellite Uplinks and TDRS forward links (total 226 NASA assignments), which would impose constraints on protecting telemetry ground station receivers and airborne telecommand receivers from hi-power satellite NASA earth station uplinks. (US346 effectively makes the SOS,EESS, SRS operations secondary to ENG and already constrains the deployment of SOS/EESS/SRS earth stations.) This is an important band internationally for SOS/EESS/SRS operations and NASA has a number of international agreements for cross-support.

This band might be useful for command and control of test aircraft.

#### 2200-2300 MHz

There is current availability of commercial off the shelf equipment, transmitters and receivers, for airborne telemetry.

There is primary allocation for federal MOBILE service, including aeronautical telemetry for unmanned aircraft. The other primary allocations are for Government Fixed Service and Government Space Operations Service/Earth Exploration Satellite Service/Space Research Service (s-E)(s-s).

The band is heavily used by NASA satellite downlink receive sites (there are 18 receive sites in the United States including Guam) and TDRS return links (total 233 NASA assignments). There would be constraints on protecting earth station receivers and TDRS return links from airborne telemetry transmissions.

#### 2360-2395 MHz

There is current availability of commercial off the shelf equipment, transmitters and receivers, for airborne telemetry.

There is a Primary allocation for MOBILE (limited to aeronautical telemetry and telecommand by US276) as well as a primary Government allocation to RADIOLOCATION. NASA is already using the band for balloon/sounding rocket telemetry (13 assignments). The band is known to be heavily used by Federal and non-Federal entities, and does not appear to have capacity for significant additional use. However, it might support several additional assignments for NASA's flight testing and research programs.

#### 4400-4940 MHz

There is limited availability of commercial off the shelf equipment, transmitters and receivers, for airborne telemetry (some manufacturers are beginning to offer equipment but more expensive than L-band/S-band equipment). Telemetry links at the 5 GHz

spectrum range will require higher power transmitters for a given line-of-sight distance due to higher propagation losses.

This is a new band for aeronautical telemetry, allocated by WRC-07 via FN 5.440A; there is no US allocation. Although there is no current US allocation specifically for aeronautical telemetry, there is an international allocation in the band for the Mobile service and a national allocation in the band for the Government mobile service. If international FN 5.440A is adopted into the US Table, ITU Res 416 (WRC07) only allows transmissions from aircraft in the air-to-ground direction (i.e., no telecommand/uplinks in the band). Therefore, a US specific allocation would be required (along the lines of US276, which was implemented for the 2360-2395 MHz band). Resolution 416 also places certain EIRP limits on the aircraft transmissions.

This band appears to be a primary candidate for implementation of additional aeronautical telemetry spectrum in the United States and accommodation of telemetry operations moved from 1755-1850 MHz.

#### 5091-5250 MHz

There is limited availability of commercial off the shelf equipment, transmitters and receivers, for airborne telemetry (some manufacturers are beginning to offer equipment but more expensive than L-band/S-band equipment). Telemetry links at the 5 GHz spectrum range will require higher power transmitters for a given line-of-sight distance due to higher propagation losses.

This is a new band for aeronautical telemetry, allocated by WRC-07 at 5091-5150 MHz for Region 2 via FN 5.444B and at 5150-5250 MHz for Region 1 via FN 5.446C. If international FN 5.444B is adopted into the US Table, it only allows transmissions from aircraft in the air-to-ground direction (i.e., no telecommand/uplinks in the band), in accordance with ITU Res 418 (WRC07). Aeronautical telemetry operations at 5150-5250 MHz would be in derogation of the international Table of Frequency Allocations, undertaken under Article 4.4 of the international Radio Regulations. A US specific allocation would be required, pending action to obtain appropriate changes to the International Table.

FN 5.444B also allows AM(R)S in the band for airport surface applications and aeronautical security transmissions which will require coordination for airborne telemetry users operating near airports. FN5.444A allocates 5091-5150 MHz to the fixed-satellite service (Earth-to-space) on a primary basis for NGSO MSS feeder links. It is used for Globalstar MSS feederlinks, which would constrain the number of airborne telemetry transmitters (and telecommand transmitters) so as not to interfere with Globalstar satellite receivers. Resolution 418 places certain PFD limits on the aircraft transmissions to protect FSS satellite receivers and terrestrial services.

The band is also allocated to MLS (5.444) and AMS(R)S (5.367); however there is no longer MLS in US and currently there is no AMS(R)S system.

This band might be useful for airborne telemetry.

#### 5925-6700 MHz

There is no current availability of commercial off the shelf equipment, transmitters and receivers, for airborne telemetry. Telemetry links at the 6 GHz spectrum range will require higher power transmitters for a given line-of-sight distance due to higher propagation losses.

This is a new band for aeronautical telemetry, allocated by WRC-07 via FN 5.457C; there is no US allocation. Even if international FN 5.457C is adopted into the US Table, ITU Res 416 (WRC07) only allows transmissions from aircraft in the air-to-ground direction (i.e., no telecommand/uplinks in the band). Resolution 416 also places certain EIRP limits on the aircraft transmissions.

The band is also allocated to the Fixed Satellite (Earth-to-Space) and Fixed services; these are heavily used by commercial entities in the US and coordination would be difficult.



**Table 2a:**

**Type of NASA Operation: Air to Ground Telemetry**

**Rank Legend: Acceptable (Further Study)**



**May Be Useful (Further Study)**



**Unacceptable (No Further Study)**



Target Band	Technical Considerations	Operational Considerations	Cost	Time	Rank	Remarks
1350-1390	<ul style="list-style-type: none"> <li>Non availability of COTS airborne TLM txs and rxs</li> </ul>	<ul style="list-style-type: none"> <li>Only 40 MHz available</li> <li>Heavy radar use</li> <li>There is an existing MOBILE service allocation, but G27 limits it to military use</li> <li>Band is also allocated to FIXED service and RADIOLOCATION service including primary ARNS(5.334) and secondary srs/eess (passive)(5.339)</li> <li>Airborne TLM xmission also not desired in the band due to desire to protect radio astronomy (US342)</li> <li>Reject for balloon program due to Fort Sumner launch range proximity to VLA in Socorro</li> </ul>	Less than \$0.5B	<10 years		<ul style="list-style-type: none"> <li>Target band for (5) other 1755 ops types</li> <li>The 1370-1390 portion of this band is still on the list of (6) hi-priority bands NTIA is considering for commercial wireless broadband (WiBB).</li> </ul>
1435-1525	<ul style="list-style-type: none"> <li>COTS txs &amp; rxs</li> <li>Already being used by NASA (14 assignments) for flight test telemetry and balloon data comm</li> </ul>	<ul style="list-style-type: none"> <li>Exclusive allocation for MOBILE (aero TLM and associated telecommand)</li> <li>Band is already heavily used for aero TLM; extremely difficult to support additional traffic</li> <li>Extremely heavy use for testing at Edwards AFB eliminates use by DFRC, but might be useful for WFF balloon program and LaRC research programs</li> </ul>	Less than \$0.5B	<10 years		<ul style="list-style-type: none"> <li>Target band for (6) other 1755 ops types</li> <li>Recommended by WFF for balloon ops and by LaRC for flight test</li> </ul>
2025-2110	<ul style="list-style-type: none"> <li>Non availability of COTS airborne TLM txs and ground rxs</li> </ul>	<ul style="list-style-type: none"> <li>There is existing MOBILE allocation but non-Fed only; US393 allows some fed mobile service (no aero mobile) but only to military on a secondary basis and only at 6 military sites</li> <li>Band is also allocated to FIXED (nonFed only) and toSOS/EESS/SRS (E-s)(s-s) Fed only</li> <li>Heavily used by NASA satellite ULs and forward links (total 226 NASA assmnts): hence constraints on protecting TLM ground station rxs and airborne telecommand rxs from hi-power satellite NASA earth station ULs including new DoD ULs; and, protecting TDRS forward links from mobile operations.</li> </ul>	Less than \$0.5B	<10 years		<ul style="list-style-type: none"> <li>Target band for (7) other 1755 ops types</li> <li>DoD has indicated they may move all their 1755 ops to this band including SGLS ULs</li> <li>If Federal systems migrate into the band from 1755-1850, NASA can request that NTIA modify US346 which now effectively makes the SOS,EESS,SRS UL ops secondary to ENG and constrains the deployment of SOS/EESS/SRS earth stations.</li> </ul>

2200-2300	<ul style="list-style-type: none"> <li>• COTS txs &amp; rxs</li> </ul>	<ul style="list-style-type: none"> <li>• Other primary allocations besides MOBILE (ie SOS/EESS/SRS (s-E)(s-s) and FIXED</li> <li>• Heavily used by NASA satellite DL receive sites (18 located in the US, including Guam ) and return links with a total of more than 230 freq assmnts) hence constraints on protecting earth station rxs from airborne TLM xmissions and protecting TDRS return links from mobile operations.</li> <li>• Band is already heavily used; extremely difficult to support additional traffic</li> <li>• Reject for balloon program due to Fort Sumner launch range proximity to Goldstone DSN station and White Sands TDRSS station</li> </ul>	Less than \$0.5B	<10 years		<ul style="list-style-type: none"> <li>• Target band for (6) other 1755 ops types</li> </ul>
2360-2395	<ul style="list-style-type: none"> <li>• COTS txs &amp; rxs available</li> <li>• NASA already using it for balloon/sounding rocket TLM (13 assmts)</li> </ul>	<ul style="list-style-type: none"> <li>• Primary Allocations limited to MOBILE (limited to aero TLM and telecommand US276) and RADIOLOCATION</li> <li>• Band is already heavily used for aero TLM; extremely difficult to support additional traffic</li> </ul>	Less than \$0.5B	<10 years		<ul style="list-style-type: none"> <li>• Target band for (5) other 1755 ops types but if DoD moves most of their ops to 2025-2110 instead then may not be that crowded.</li> <li>• Recommended by WFF for balloon ops</li> </ul>
4400-4940	<ul style="list-style-type: none"> <li>• Limited availability of COTS airborne TLM txs and ground rxs ( some manufacturers are beginning to offer equipment but more expensive than L-band/S-band equipment• 5 GHz telemetry links will require higher power txs for a given LOS range due to higher propagation losses</li> </ul>	<ul style="list-style-type: none"> <li>• Current US Table primary allocation for Govt mobile.</li> <li>• No current US Table aero mobile telemetry allocation. New band for aero telemetry if WRC-2007 aero mobile service international allocation, FN 5.440A, is adopted into US Table – but there are constraints imposed on aero TLM use</li> <li>• FN 5.440A under ITU Res 416 (WRC07) places certain EIRP limits on the aircraft xmissions.</li> <li>• Existing MS application</li> </ul>	Less than \$0.5B	<10 years		

5091-5250	<ul style="list-style-type: none"> <li>Limited availability of COTS airborne TLM txs and ground rxs</li> <li>5 GHz telemetry links will require higher power txs for a given LOS range due to higher propagation losses</li> </ul>	<ul style="list-style-type: none"> <li>No current US Table aero mobile telemetry allocation. New band for aero telemetry if WRC-2007 aero mobile service international allocation, FN 5.444B, is adopted into US Table – but there are constraints imposed on aero TLM use</li> <li>FN 5.444B under ITU Res 418 (WRC07) places certain PFD and EIRP limits on the aircraft xmissions to protect FSS satellite rxs and ARNS/AM(R)S rxs. FN 5.444B also allows AM(R)S in the band for airport surface WiMax comm. systems and aeronautical security xmissions which will require coordination with airborne TLM users operating near airports</li> <li>Allocated to ARNS (MLS 5.444) and AMS(R)S (5.367) (however there is no longer MLS in US and currently no AMS(R)S system)</li> <li>5091-5150 MHz is also allocated to the fixed-satellite service (Earth-to-space) on a primary basis (5.444A) for NGSO MSS feeder links (ie Globalstar feederlinks) which would constrain the number of airborne TLM txs (and telecommand txs) so as not to interfere with Globalstar satellite receivers</li> <li>No international Region 2 allocation for aero telemetry; but allocation elsewhere, also governed by ITU Res 418</li> <li>FCC Rules permit Unlicensed National Information Infrastructure (U-NII) devices at 5150-5250 MHz</li> </ul>	Less than \$0.5B	<10 years	
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5925-6700	<ul style="list-style-type: none"> <li>• Non availability of COTS airborne TLM txs and ground rx's</li> <li>• 6 GHz telemetry links will require higher power txs for a given LOS range due to higher propagation losses</li> </ul>	<ul style="list-style-type: none"> <li>• No US TABLE aero mobile telemetry allocation. New band for aero telemetry if WRC-2007 aero mobile service international allocation, FN 5.457C, is adopted into US Table – but there are constraints imposed on aero TLM use</li> <li>• FN 5.457C under ITU Res 416 (WRC07) places certain EIRP limits on the aircraft xmissions.</li> <li>• Band is also allocated for Fixed Satellite (EtoS) and Fixed services; heavily used by commercial entities in the US</li> </ul>	Less than \$0.5B	<10 years	
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**Table 2b**

**Type of NASA Operation: UAS/UAV/RPV (includes both air-to-ground telemetry and ground-to-air telecommand)**

**Rank Legend: Acceptable (Further Study)  May Be Useful (Further Study)  Unacceptable (No Further Study)**

Target Band	Technical Considerations	Operational Considerations	Cost	Time	Rank	Remarks
225-328.6	<ul style="list-style-type: none"> <li>COTS airborne TLM txs and ground TLM rx's in 215-320 portion</li> <li>Large antennas required for HDR aero TLM and video</li> <li>Channelized to narrowband</li> </ul>	<ul style="list-style-type: none"> <li>MOBILE service limited to military services (G27) and likely already heavily used for military voice/data comm.</li> <li>The 242.95-243.05 must be avoided since it is an emergency band for SAR/EPIRB/ELT</li> <li>Also allocated to FIXED service (limited to military by G27) so likely heavily used for military fixed voice/data com and MSS in 235-322 (for military use only via G100) which could constrain airborne TLM txs in order to protect MSS earth station rx's</li> <li>Airborne TLM xmission also not desired in the 322-328.6 portion due to desire to protect radio astronomy (US342)</li> <li>May be useful for narrowband command and control</li> </ul>	Less than \$0.5B	<10 years		<ul style="list-style-type: none"> <li>Target band for (3) other 1755 ops types</li> <li>Recommended by DFRC for C2</li> </ul>
335.4-380	<ul style="list-style-type: none"> <li>Non availability of COTS airborne TLM txs and ground rx's</li> <li>Large antennas required for HDR TLM and video</li> <li>Channelized to narrowband</li> </ul>	<ul style="list-style-type: none"> <li>MOBILE service limited to military services (G27) and likely heavily used for military voice/data comm</li> <li>Also allocated to FIXED service (limited to military by G27) so likely heavily used for military fixed voice/data com and MSS (military) (G100) which could constrain airborne TLM txs in order to protect MSS earth station rx's</li> <li>Flight Termination Systems will be moved into this band</li> <li>May be useful for narrowband command and control</li> </ul>	Less than \$0.5B	<10 years		<ul style="list-style-type: none"> <li>Target band for (3) other 1755 ops types</li> <li>Recommended by DFRC for C2</li> </ul>
1350-1390	<ul style="list-style-type: none"> <li>Non availability of COTS airborne TLM txs and rx's</li> </ul>	<ul style="list-style-type: none"> <li>Only 40 MHz available</li> <li>Heavy radar use</li> <li>There is an existing MOBILE service allocation, but G27 limits it to military use</li> <li>Band is also allocated to FIXED service and RADIOLOCATION service including primary ARNS(5.334) and secondary srs/eess (passive)(5.339)</li> <li>Airborne TLM xmission also not desired in the band due to desire to protect radio astronomy (US342)</li> </ul>	Less than \$0.5B	<10 years		<ul style="list-style-type: none"> <li>Target band for (5) other types of 1755 ops types</li> <li>The 1370-1390 portion of this band is still on the list of (6) hi-priority bands NTIA is considering for commercial wireless broadband (WiBB)</li> </ul>
1435-1525	<ul style="list-style-type: none"> <li>COTS txs &amp; rx's</li> <li>Already being used by NASA (14 assignments) for flight test telemetry and balloon data comm</li> </ul>	<ul style="list-style-type: none"> <li>Exclusive allocation for MOBILE (aero TLM and associated telecommand)</li> <li>Band is already heavily used for aero TLM; extremely difficult to support additional traffic</li> <li>Extremely heavy use for testing at Edwards AFB eliminates use by DFRC, but might be useful for WFF balloon program and LaRC research programs</li> </ul>	Less than \$0.5B	<10 years		<ul style="list-style-type: none"> <li>Target band for (6) other 1755 ops types</li> </ul>

1675-1695	<ul style="list-style-type: none"> <li>• Non availability of COTS airborne TLM txs and ground rx</li> </ul>	<ul style="list-style-type: none"> <li>• This is a METAIDS/METSAT downlink band and appears to be lightly used by other agencies including NASA (1 NASA assignment)</li> <li>• Currently there is no MOBILE service allocation – band is allocated to METAIDS(radiosonde) and METSAT (s-E)</li> <li>• Airborne TLM xmissions would be constrained by the need to protect METSAT/METAID ground station rxs and also radio astronomy in adjacent band (US211)</li> <li>• Only 20 MHz; not useful for wideband channels</li> </ul>	Less than \$0.5B	<10 years	<ul style="list-style-type: none"> <li>• Target band for (3) other 1755 ops types</li> <li>• NTIA has already recommended the adjacent 1695-1710 for commercial WiBB and may seek 1675-1695 for commercial WiBB at a later date</li> </ul>
2025-2110	<ul style="list-style-type: none"> <li>• Non availability of COTS airborne TLM txs and ground rx</li> </ul>	<ul style="list-style-type: none"> <li>• There is existing MOBILE allocation but non-Fed only; US393 allows some fed mobile service (no aero mobile) but only to military on a secondary basis and only at 6 military sites</li> <li>• Band is also allocated to FIXED (nonFed only) and toSOS/EESS/SRS (E-s)(s-s) Fed only</li> <li>• Heavily used by NASA satellite ULs and forward links (total 226 NASA assmnts): hence constraints on protecting TLM ground station rxs and airborne telecommand rxs from hi-power satellite NASA earth station ULs including new DoD ULs; and, protecting TDRS forward links from mobile operations.</li> <li>• May be useful for command and control</li> </ul>	Less than \$0.5B	<10 years	<ul style="list-style-type: none"> <li>• Target band for (7) other 1755 ops types</li> <li>• DoD has indicated they may move all their 1755 ops to this band including SGLS ULs</li> <li>• If Federal systems migrate into the band from 1755-1850, NASA can request that NTIA modify US346 which now effectively makes the SOS,EESS,SRS UL ops secondary to ENG and constrains the deployment of SOS/EESS/SRS earth stations.</li> <li>• Recommended by DFRC for C2</li> </ul>
2200-2300	<ul style="list-style-type: none"> <li>• COTS txs &amp; rx</li> </ul>	<ul style="list-style-type: none"> <li>• Other primary allocations besides MOBILE (ie SOS/EESS/SRS (s-E)(s-s) and FIXED</li> <li>• Heavily used by NASA satellite DL receive sites (18 located in the US, including Guam ) and return links with a total of more than 230 freq assmnts) hence constraints on protecting earth station rxs from airborne TLM xmissions and protecting TDRS return links from mobile operations.</li> <li>• Band is already heavily used; extremely difficult to support additional traffic</li> </ul>	Less than \$0.5B	<10 years	<ul style="list-style-type: none"> <li>• Target band for (6) other 1755 ops types</li> </ul>
2360-2395	<ul style="list-style-type: none"> <li>• COTS txs &amp; rx available</li> <li>• NASA already using it for balloon/sounding rocket TLM (13 assignments)</li> </ul>	<ul style="list-style-type: none"> <li>• Primary Allocations limited to MOBILE (limited to aero TLM and telecommand US276) and RADIOLOCATION</li> <li>• Band is already heavily used for aero TLM; extremely difficult to support additional traffic</li> </ul>	Less than \$0.5B	<10 years	<ul style="list-style-type: none"> <li>• Target band for (5) other 1755 ops types but if DoD moves most of their ops to 2025-2110 instead then may not be that crowded.</li> </ul>
4400-4940	<ul style="list-style-type: none"> <li>• Limited availability of COTS airborne TLM txs and ground rx (some manufacturers are beginning to offer equipment but more expensive than L-band/S-band equipment</li> <li>• 5 GHz telemetry links will require higher power txs for a given LOS range due to higher propagation losses</li> </ul>	<ul style="list-style-type: none"> <li>• Current US Table primary allocation for Govt Mobile</li> <li>• No current US Table aero mobile telemetry allocation. New band for aero telemetry if WRC-2007 aero mobile service international allocation, FN 5.440A, is adopted into US Table – but there are constraints imposed on aero TLM use</li> <li>• FN 5.440A under ITU Res 416 (WRC07) only allows transmissions from aircraft in the air-to-ground direction (ie no telecommand/uplinks in the band). Res 416 also places certain EIRP limits on the aircraft xmissions.</li> <li>• Existing MS allocation could be used for telecommand.</li> </ul>	Less than \$0.5B	<10 years *Utilizing Mobile service allocation	<ul style="list-style-type: none"> <li>• Recommended by DFRC for C2 and ATM</li> </ul>

5091-5250	<ul style="list-style-type: none"> <li>Limited availability of COTS airborne TLM txs and ground rxs (some manufacturers are beginning to offer equipment but more expensive than L-band/S-band equipment)</li> <li>5 GHz telemetry links will require higher power txs for a given LOS range due to higher propagation losses</li> </ul>	<ul style="list-style-type: none"> <li>No current US Table aero mobile telemetry allocation. New band for aero telemetry if WRC-2007 aero mobile service international allocation, FN 5.444B, is adopted into US Table – but there are constraints imposed on aero TLM use</li> <li>FN 5.444B under ITU Res 418 (WRC07) only allows transmissions from aircraft in the air-to-ground direction (ie no telecommand/uplinks in the band). Res 418 also places certain PFD and EIRP limits on the aircraft xmissions to protect FSS satellite rxs and ARNS/AM(R)S rxs. FN 5.444B also allows AM(R)S in the band for airport surface WiMax comm. systems and aeronautical security xmissions which will require coordination with airborne TLM users operating near airports</li> <li>Allocated to ARNS (MLS 5.444) and AMS(R)S (5.367) (however there is no longer MLS in US and currently no AMS(R)S system)</li> <li>5091-5150 MHz is also allocated to the fixed-satellite service (Earth-to-space) on a primary basis (5.444A) for NGSO MSS feeder links (ie Globalstar feederlinks) which would constrain the number of airborne TLM txs (and telecommand txs) so as not to interfere with Globalstar satellite receivers</li> <li>No international Region 2 allocation for aero telemetry; but allocation elsewhere, also governed by ITU Res 418</li> <li>FCC Rules permit Unlicensed National Information Infrastructure (U-NII) devices at 5150-5250 MHz</li> </ul>	Less than \$0.5B	10-15 years	
5925-6700	<ul style="list-style-type: none"> <li>Non availability of COTS airborne TLM txs and ground rxs</li> <li>6 GHz telemetry links will require higher power txs for a given LOS range due to higher propagation losses</li> </ul>	<ul style="list-style-type: none"> <li>No US TABLE aero mobile telemetry allocation. New band for aero telemetry if WRC-2007 aero mobile service international allocation, FN 5.457C, is adopted into US Table – but there are constraints imposed on aero TLM use</li> <li>FN 5.457C under ITU Res 416 (WRC07) only allows transmissions from aircraft in the air-to-ground direction (ie no telecommand/uplinks in the band). Res 416 also places certain EIRP limits on the aircraft xmissions.</li> <li>Band is also allocated for Fixed Satellite (EtoS) and Fixed services; heavily used by commercial entities in the US</li> </ul>	Less than \$0.5B	<10 years	