



U.S. Department  
of Transportation

**Federal Aviation  
Administration**

Office of the Administrator

800 Independence Ave., S.W.  
Washington, D.C. 20591

April 29, 2016

The Honorable John Thune  
Chairman, Committee on Commerce, Science,  
and Transportation  
United States Senate  
Washington, DC 20510

Dear Mr. Chairman:

The FAA Modernization and Reform Act of 2012, Section 820, requested the Federal Aviation Administration to provide a report to Congress on the aeronautical telemetry needs of civil aviation over the next decade, and the potential impact of the introduction of a new radio service operating at the same spectrum as aeronautical mobile telemetry service.

Enclosed please find our report.

Identical letters have been sent to Chairman Shuster, Senator Nelson, and Congressman DeFazio.

Sincerely,

A handwritten signature in black ink, appearing to read "Michael P. Huerta", with a circled number "1" at the end of the signature.

Michael P. Huerta  
Administrator

Enclosure



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800 Independence Ave., S.W.  
Washington, D.C. 20591

April 29, 2016

The Honorable Bill Nelson  
Committee on Commerce, Science,  
and Transportation  
United States Senate  
Washington, DC 20510

Dear Senator Nelson:

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The Honorable Bill Shuster  
Chairman, Committee on Transportation  
and Infrastructure  
House of Representatives  
Washington, DC 20515

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April 29, 2016

The Honorable Peter DeFazio  
Committee on Transportation  
and Infrastructure  
House of Representatives  
Washington, DC 20515

Dear Congressman DeFazio:

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**REPORT TO  
CONGRESS ON  
AERONAUTICAL  
MOBILE  
TELEMETRY**

Carolyn A. Kahn

July 2014

Document No: MP120385

McLean, VA

**MITRE**

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## Introduction

This Report has been prepared in response to Section 820 of the Federal Aviation Administration (FAA) Modernization and Reform Act of 2012, Pub. L. 112-95. Section 820 directs the Administrator of the FAA, in consultation with other agencies, to complete a report for Congress on Aeronautical Mobile Telemetry (AMT), referred to commonly as flight test telemetry. In particular, Section 820 calls for identification of: (1) the current and anticipated need by civil aviation, including equipment manufacturers, for flight test telemetry services; and (2) the potential impact to the aerospace industry of the introduction of a new radio service operating in the same spectrum as AMT. The full text is included in Appendix I. This report has been coordinated with NTIA (Commerce) and the Federal Communications Commission (FCC).

The Report is organized as follows. First, it defines AMT. Second, it discusses the aerospace industry and its significance for the United States. Third, it identifies aviation needs for AMT services. Fourth, it identifies the impact if a new radio service were to operate in the spectrum allocated to AMT.

## What Is Aeronautical Mobile Telemetry?

AMT is the wireless transmission and reception of data during flight tests. Data on the health and performance of an aircraft or missile under test is transmitted to ground-based equipment; the data is monitored by engineers on a real-time basis. Many different parameters are measured. These include stresses on wings and control surfaces, engine temperatures, and fluid pressures, to name just a few. Figure 1 below illustrates the use of AMT during flight testing.

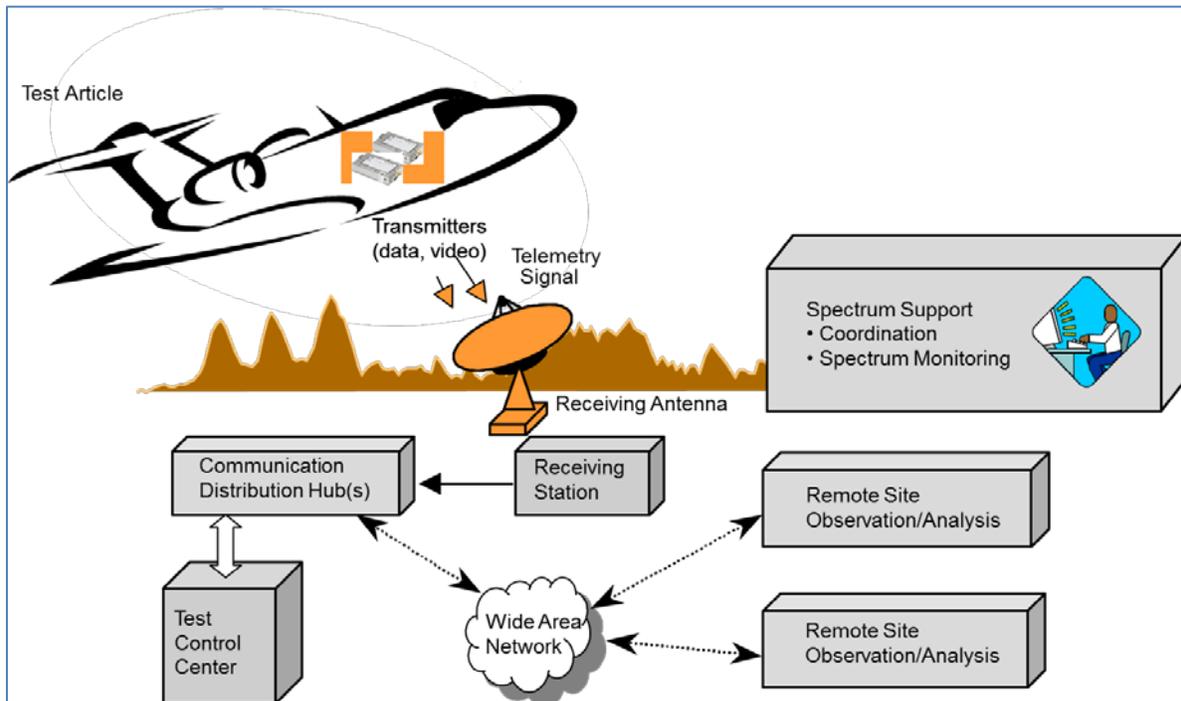


Figure 1. AMT in Flight Test

From the days of the Wright brothers, advances in aerospace engineering have depended largely upon tests conducted under actual flight conditions. First becoming widespread in the 1950s, AMT enables real-time access to engineering data. This access is crucial to monitor hazardous trends exceeding aircraft limitations, and to safely and incrementally progress to higher risk flight test points.<sup>1</sup> Higher speeds, altitudes, and performance requirements, and increasingly complex and integrated systems, added to the need for critical, thorough, and instantaneous test data. Displaying and analyzing data in real-time allows flight testers to monitor critical parameters and mitigate risks in order to conduct safe, effective, and efficient missions.

U.S. aerospace companies depend heavily on AMT services to reduce both risks and costs. Although AMT is not well known inasmuch as it serves a specialized technical purpose typically not seen by the general population, it is an important enabler for the aerospace industry. Indeed, AMT is in the *critical path* for U.S. aerospace manufacturers in delivering new products, and is a key asset to aerospace research and development (R&D), test and evaluation, and certification by the FAA.

## The Significance of the Aerospace Industry

The aerospace industry plays a vital role in the U.S. economy and national security. The U.S. aerospace industry has long been the world's leader in developing new aircraft and flight capabilities. New aircraft are a major export of the U.S. economy, contributing significantly to the balance of trade with many countries. The aviation industry is a major source of economic development and facilitates domestic and international trade. It not only contributes fundamentally to the way we live, work, travel, and communicate, but also inspires technological advancement and continuing innovation.<sup>2</sup>

For over 50 years, the aerospace industry has generated a net annual surplus in the U.S. balance of trade—the largest of any manufacturing sector.<sup>3</sup> According to the most recent data available, the industry has a positive trade balance of \$44.1 billion. The industry is the largest net exporter and one of the largest contributors to U.S. gross exports at \$89.6 billion. Of these exports, \$31.6 billion are foreign military sales.<sup>4</sup> It exports 42% of all aerospace production and 72% of civil aircraft and component production.<sup>5</sup>

Figure 2 is a color-coded display of recipients of U.S. aerospace exports in 2011. Top-tier export markets are highlighted in blue and second-tier recipients are highlighted in green. The standout feature of this map is the scale and scope of U.S. aerospace exports.<sup>6</sup> Also notable is the strong presence of the U.S. aerospace industry in Asia, by far the most rapidly growing market for new aircraft.

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<sup>1</sup> F.N. Stoliker (editor), "Introduction to Flight Test Engineering," North Atlantic Treaty Organisation, Research and Technology Organisation, Flight Test Techniques Series, vol. 14, July 2005.

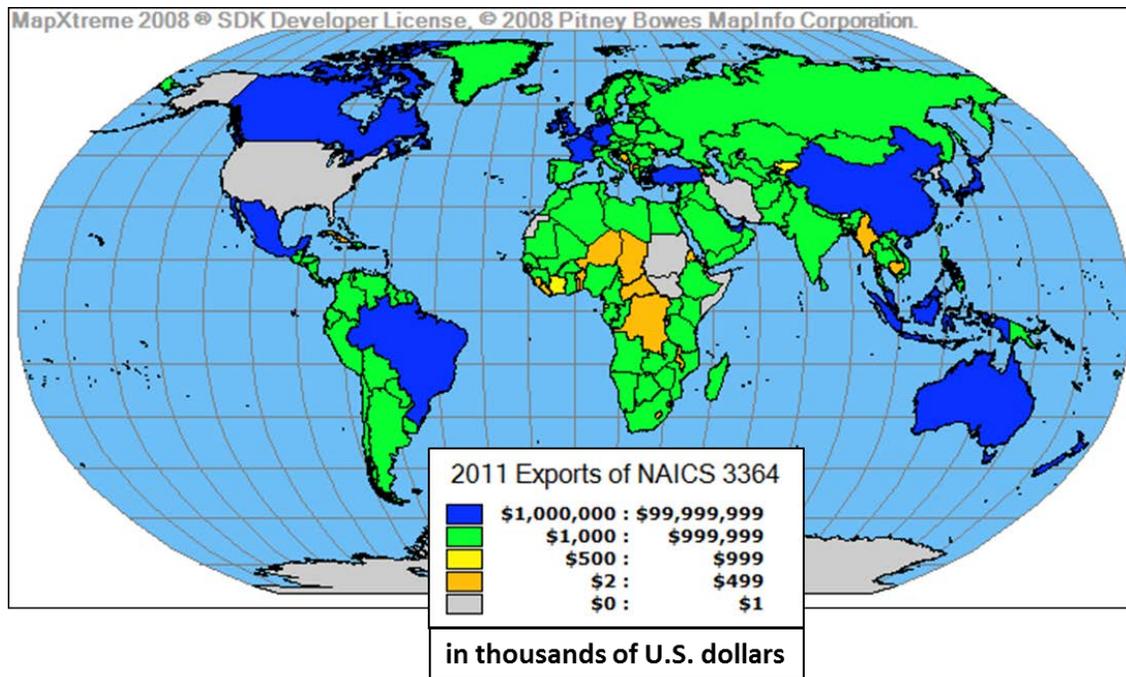
<sup>2</sup> "The Aerospace and Defense Industry in the U.S.," Deloitte, March 2012 ("Deloitte 2012").

<sup>3</sup> W. A. Chadwick, Jr., B. W. Ellis, B. G. R. E. Mansfield, Jr. and R. Materna, *Aerospace Industry Report 2011*, Arlington, VA: Aerospace Industries Association of America, Inc. and Embry-Riddle Aeronautical University, 2011 ("Chadwick, Jr., et al. 2011").

<sup>4</sup> Deloitte 2012.

<sup>5</sup> "The Aerospace Industry in the United States," SelectUSA.

<sup>6</sup> TradeStats Express, International Trade Administration, U.S. Department of Commerce. Product of MapXtreme 2008, SDK Developer License, Pitney Bowes MapInfo Corporation, 2012. See also Chadwick, Jr., et al. 2011. Note that North American Industry Classification System (NAICS) 3364 represents aerospace product and parts manufacturing.



**Figure 2. Map of U.S. Aerospace Export Countries**

The growth of the civil aviation sector is closely tied to overall gross domestic product (GDP) growth. As GDP rises, demand for civil aviation products and services increases correspondingly. The sale of goods and services tied directly or indirectly to civil aviation constitutes \$1.3 trillion, or about 5.6% of national GDP.<sup>7</sup>

Passenger and freight traffic increased by 6.3% and 15.5%, respectively, from 2009 to 2010.<sup>8</sup> The FAA predicts that the U.S. commercial aviation industry will carry one billion passengers per year by 2024, assuming a moderate 2.5% average annual growth. Available seat miles, a general yardstick for how busy aviation is domestically and internationally, is projected to increase from 994 billion in 2012 to 1.5 trillion in 2025.<sup>9</sup>

According to a 2008 study by the Department of Commerce, aerospace exports “support more U.S. jobs than any other industry.”<sup>10</sup> Despite the recession, civil aviation has sustained nearly 12 million jobs, including many highly skilled, high technology positions.<sup>11</sup> U.S. aerospace and defense industry workers earn among the highest wages compared to other industries, i.e. eighty percent more than the average for all manufacturing workers and over twice as much as the average private sector worker.<sup>12</sup> According to one survey, eighty-six percent of Federal Communications Commission (FCC) telemetry spectrum licensees anticipate an increase in employment associated with aircraft development over the next

<sup>7</sup> “Civil Aviation Growth in the 21st Century,” AIA, September 2010 (“AIA 2010”).

<sup>8</sup> Chadwick, Jr., et al. 2011.

<sup>9</sup> “FAA Aerospace Forecast: Fiscal Years 2012-2032,” Federal Aviation Administration, U.S. Department of Transportation, 2012.

<sup>10</sup> Chadwick, Jr., et al. 2011.

<sup>11</sup> AIA 2010.

<sup>12</sup> Deloitte 2012.

three years.<sup>13</sup> U.S. aerospace and defense companies pay \$37.8 billion per year in wage and income taxes to federal and state treasuries, not including taxes paid by indirect industry employment, as a result of the \$324 billion in sales revenue they generate each year.<sup>14</sup>

The Presidential Commission on the Future of the United States Aerospace Industry concluded that “aerospace capabilities and the supporting defense industrial base are fundamental to U.S. economic and national security.” Consistent with this statement, the Commission specifically stressed the need for certification processes and airborne equipment innovations. The Commission issued an urgent call to action to the President and Congress to provide increased and sustained investment and to adopt policies that promote a healthy and growing U.S. aerospace industry.<sup>15</sup>

The federal government is involved in many aspects of the aerospace industry, including civil aviation transportation management, national security, space exploration, and R&D. The aerospace industry is inextricably linked to the defense sector, and AMT services can be difficult to parse between civil and military work. Aerospace manufacturers use many of the same locations, the same personnel, the same test range equipment, and the same spectrum, for civil and defense flight testing.<sup>16</sup> Civil aircraft are tested at government centers, and military aircraft are tested at civil centers, with the same resources used for both.

Over the next decade, the aerospace industry must address a new set of challenges, including economic uncertainty, oil price volatility, growing competition from new and emerging countries, improved efficiency, and environmental issues, among others. There is a persistent demand for civil aviation to recapitalize aging fleets with newer, more fuel-efficient aircraft, generating replacement demand on top of growth for fleet expansion.<sup>17</sup> As described below, AMT services help industry realize these objectives.

## **Aviation Needs for AMT Services**

The aerospace industry uses AMT services to improve flight test safety and efficiency.<sup>18</sup> Due to its vital importance, the demand for AMT data is increasing.

### **Flight Test Safety**

Flight testing must be conducted in order to secure airworthiness certification prior to aircraft delivery to the customer. FAA rules (Title 14 of the Code of Federal Regulations) require flight testing to ensure the airworthiness and safety of all new aircraft and new aircraft parts, or modifications to existing aircraft. Part 21 of the FAA rules identifies the requirements and procedures for obtaining type, production, and airworthiness certificates

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<sup>13</sup> “AFTRCC Survey Regarding Current and Anticipated Use of Aeronautical Mobile Telemetry Services,” Aerospace and Flight Test Radio Coordinating Council, Washington, DC: 2012 (“AFTRCC Survey 2012”). AFTRCC conducted the survey in connection with MITRE’s development of this report.

<sup>14</sup> Deloitte 2012.

<sup>15</sup> “Final Report of the Commission on the Future of the United States Aerospace Industry,” Commission on the Future of the United States Aerospace Industry, November 2002.

<sup>16</sup> Spectrum utilized by industry for AMT (1435-1525 and 2360-2390 MHz) is shared with government. Primary AMT access is permitted in these bands.

<sup>17</sup> AIA 2010.

<sup>18</sup> Without AMT services, flight tests would incur reduced safety, higher costs, and more schedule delays, negatively impacting the competitiveness of the U.S. aerospace industry.

and import and export approvals. It includes requirements for maintaining airworthiness over time as modifications are made to aircraft. Airworthiness standards are prescribed for: “normal,” utility, acrobatic, and commuter category airplanes (Part 23); transport category airplanes (Part 25); normal category rotorcraft (Part 27); transport category rotorcraft (Part 29); manned free balloons (Part 31); aircraft engines (Part 33); and propellers (Part 35).<sup>19</sup> A typical flight test program timeline is shown in Appendix II.

FAA rules do not prescribe the means by which the requisite data is to be collected. The aerospace industry has determined, however, that real-time telemetry is a very effective method for mitigating risks during flight testing. For example, AMT services reduce flight test risks for new and modified aircraft certification programs and for high risk flight tests as delineated in Appendix III. Additionally, the use of AMT is recommended by the FAA.<sup>20</sup>

During flight tests, aircraft are pushed to their maximum limits. So-called “flutter” tests stress the wings and control surfaces to the point where aerodynamic, elastic, and inertia forces can produce potentially violent oscillation.<sup>21</sup> These oscillations, or vibrations, can build with suddenness: Once begun, they are difficult, and sometimes impossible, to control. Likewise, envelope expansion testing, including stall, spin, and dive tests, requires that the aircraft be flown to the limits of its airspeed and load factor design capabilities. Another example, the pitch-roll coupling of higher performance aircraft, involves high-speed pullouts; these can create critical conditions not easily predicted by design engineers or recognized by a pilot. All of these tests are inherently dangerous to the pilot and persons on the ground. Even seemingly routine tests can involve significant risk to safety of life.

AMT allows controllers on the ground to monitor the performance of a test aircraft second-by-second, and warn the pilot to abort maneuvers that threaten a structural failure, out-of-control flight, or other system emergency. If an aircraft encounters an unsafe condition, or strays from a safe flight path, engineers can alert the pilot and advise him or her on possible corrective measures before personnel or property is endangered. In the unfortunate instance where an aircraft is lost during flight tests, real-time data captured by AMT helps in reconstructing the cause of the crash.

In one recent incident involving a new model business jet, abnormal vibrations were detected in the control surfaces during flutter tests. Ground engineers were made aware of the problem via real-time telemetry while the aircraft was performing a dive. They immediately warned the pilot to abort. Thereafter, many days of additional test flights were conducted where a multitude of test points were measured in order to isolate the cause. During these tests, a team of engineers on the ground carefully monitored the vibration data in real-time, and repeatedly found it necessary to warn the pilot to abort specific maneuvers. Such procedures were especially dangerous because the aircraft had to be flown aggressively enough for the vibrations to manifest, but not so aggressively that a catastrophic failure would result. Achieving this balance would not have been possible

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<sup>19</sup> 14 Code of Federal Regulations (CFR) Parts 1-35. See also “FAA-8083-30,” FAA.

<sup>20</sup> “Aircraft Certification Service Flight Test Risk Management Program,” Federal Aviation Administration, U.S. Department of Transportation, Order 4040.26B, Washington, DC, January 2012. The NASA/FAA Flight Test Safety Database includes the use of AMT as a risk mitigation measure.

<sup>21</sup> M. E. Kehoe, “A Historical Overview of Flight Flutter Testing,” NASA, Dryden Flight Research Center, Edwards, CA, October 1995.

without the continuous and uninterrupted reception of telemetry data from the aircraft. Ultimately, the cause was isolated, and the aircraft design modified. Subsequent testing verified that the modification had eliminated the problem.

In another example, technicians established contact with the test aircraft at an altitude of approximately 40,000 feet in the vicinity of Pittsburgh. Telemetry readouts immediately showed a problem: temperature parameters in certain equipment were dangerously above limits. Real-time AMT data alerted the ground crew to the imminent risk. Ground-based personnel were then able to warn the pilot and, together, they were able to take a series of corrective measures that ultimately succeeded in controlling the situation. AMT data was used throughout the flight to keep the pilot apprised of the aircraft's status.<sup>22</sup>

The essential contribution of AMT to flight test safety has been recognized repeatedly over the years by the FCC which, along with the National Telecommunications and Information Administration, regulates use of the radio frequency spectrum in the U.S. Because of the need to protect the safety of lives and property, the radio frequency bands used to transmit telemetry have been protected by regulators against incompatible uses. As the FCC has found,

“[I]nterference [to flight test telemetry] cannot be tolerated. For example, in the event of a crash the telemetry data may be the only means available to determine the cause of the crash. In this case, interference to the telemetry transmission could be disastrous.”<sup>23</sup>

In implementing this policy of carefully protecting AMT spectrum from potential interference, the FCC has refrained from approving additional spectrum uses that could threaten the reliability of flight test operations. As the FCC explained when it declined to approve a proposal to permit spectrum sharing between AMT and satellites used to broadcast audio programming:

“[F]light test, telemetry, and telecommand operations are vital to the U.S. aerospace industry to produce, deliver, and operate safe and efficient aircraft and space vehicles. Because the nature of the BSS [Broadcasting Satellite Service] (Sound) operations is 24 hour a day ... and the test and telemetry operations are in the proximity of many major metropolitan areas, we believe, as AFTRCC [Aerospace and Flight Test Radio Coordinating Council] asserts, that the BSS (Sound) transmissions will cause interference to these operations and threaten safety of life and property. Consequently, we do not believe it is feasible to share aeronautical mobile telemetering frequencies with BSS (Sound) or terrestrial broadcasting systems.”<sup>24</sup>

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<sup>22</sup> B. Rymer, Retired, Head, Range Instrumentation, Atlantic Ranges and Facilities, Naval Air Warfare Center-Aircraft Division, Patuxent River, MD: Telephone conversation, June 2012.

<sup>23</sup> Amendment of the Frequency Allocation and Aviation Services Rules (Parts 2 and 87) to Provide Frequencies for Use by Commercial Space Launch Vehicles, 5 FCC Rcd 493, 495, 1990; accord In the Matter of Petition to Amend Part 87 of the Commission's Rules to Allot VHF Aeronautical Frequencies for the Coordination of Air Show Events, Order, DA 90-957, 5 FCC Rcd 4641, 4642, 1990.

<sup>24</sup> Second Notice of Inquiry in Gen. Docket No. 89-554, In the Matter of An Inquiry Relating to Preparation for the International Telecommunication Union World Administrative Radio Conference for Dealing with Frequency Allocations in Certain Parts of the Spectrum, FCC 90-316, 5 FCC Rcd 6046, 6060, para. 101, 1990.

## Flight Test Efficiency

AMT enables more efficient flight testing operations, providing significant financial benefits and enhancing global competitiveness. By means of AMT, aerospace manufacturers are able to shorten test cycles by conducting more analysis and evaluation in real-time. Aircraft which successfully complete one set of test points can be cleared to advance to the next set of test points in the same flight, materially enhancing the efficiency of the flight test process.

Commercial test programs may require integration with existing and other new avionic and data systems. Advances in aerodynamics, fuels, and other technologies create a more challenging test environment that requires larger amounts of test data as well as additional spectral bandwidth to determine if the system can perform as intended.

## Data Rate Growth

Section 820 (1) of the FAA Modernization and Reform Act requires the identification of the current and anticipated need for AMT services. The demand for AMT services is rapidly growing for two reasons: an increase in the number of flight tests conducted to ensure the safety and efficiency of the aircraft, and an increase in the number and scope of test points monitored during each flight test.

The Aerospace and Flight Test Radio Coordinating Council (AFTRCC), a 58-year old association of major aerospace manufacturers and their suppliers, recently conducted a survey of its members and entities holding FCC licenses for telemetry spectrum. The survey focused on the current and anticipated need for AMT services.<sup>25</sup> Respondents reported a growth in the number of flight tests conducted over the past three years of as much as 465%, and an average reported growth of 190%.<sup>26</sup>

The amount of information that must be transferred from the aircraft to the ground using AMT spectrum during each flight test has grown significantly each decade and is expected to continue to do so. Measurement growth is being witnessed for all measurement types. The number of test measurements is growing with increased requirements to: fly at higher altitudes and faster speeds, transmit high-definition video, and accelerate test programs.

A 2004 technical study concluded that the amount of data required to be telemetered from aircraft test points has roughly doubled every three to five years since 1972 and shows no sign of abating.<sup>27</sup> For example, Boeing has reported that the FAA certification process for the Boeing 707 aircraft in 1954 included the electronic monitoring of 300 data channels. By 1995, certification for the Boeing 777 aircraft included the monitoring of approximately 64,000 individual data channels. The flight testing required to certify the Boeing 787 in 2011 exceeded 200,000 individual data channels.<sup>28</sup>

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<sup>25</sup> Survey data is presented in aggregate form only, and/or with company-identifying information redacted, in order to protect proprietary information.

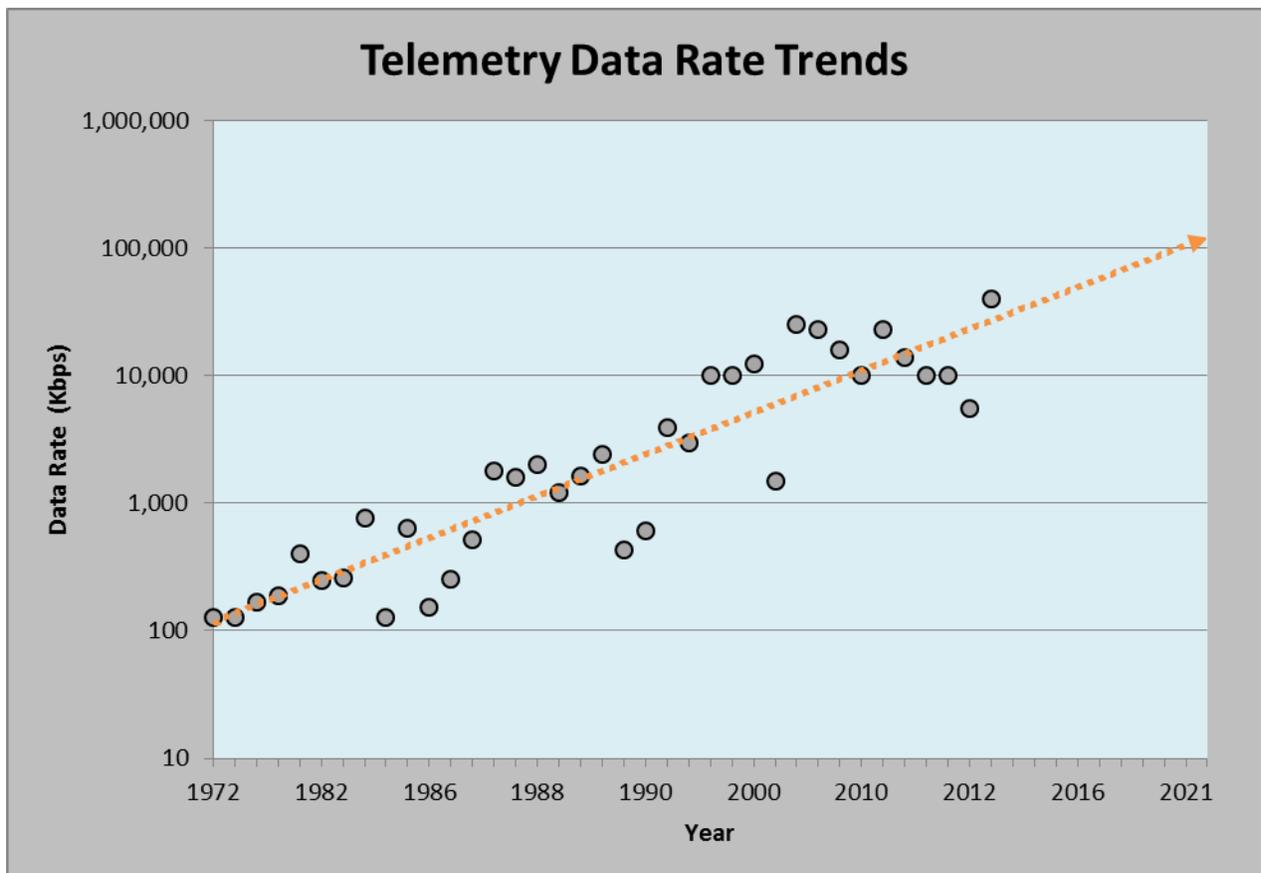
<sup>26</sup> AFTRCC Survey 2012.

<sup>27</sup> D. Ernst, Y. Hoh and D. Portigal, "The Growth of Data Rates for Aeronautical Telemetry and the Implications for the Radio Spectrum," McLean, VA: The MITRE Corporation, 2004.

<sup>28</sup> Comments of The Boeing Company, In the Matter of Amendment of Part 27 of the Commission's Rules to Govern the Operation of Wireless Communications Services in the 2.3 GHz Band, WT Docket No. 07-293, Establishment of Rules and Policies for the Digital Audio Radio Satellite Service in the 2310-2360 MHz Frequency Band, IB Docket No. 95-91, GEN Docket No. 90-357, RM No. 8610, 2010.

The frequency and precision of measurements have also increased, with current tests requiring over 400 test samples per second that output up to 32 bits per sample. Test aircraft now routinely collect data at a rate of Gigabits per second, but can only transmit 5-15 Megabits per second (Mbps) of data through AMT due to bandwidth limitations.<sup>29</sup> Therefore, flight test controllers are forced to transmit only the most critical aircraft safety data being collected, typically 5-15 Mbps of the 400-plus Mbps of data being recorded onboard the aircraft.<sup>30</sup>

Figure 3 shows estimated AMT data rate trends over time, including both historic (1972-2012) and projected (2013-2022) data rates measured by kilobits per second (Kbps).<sup>31</sup> The dotted line illustrates a notional trend of data rate growth.



**Figure 3. Estimated AMT Data Rate Trends**

As a result of the growth in measured data, U.S. aerospace companies are delivering the most technologically and economically advanced commercial airplanes in the history of aviation. However, limited bandwidth affects the efficiency, effectiveness, and ultimately

<sup>29</sup> The AMT community has increased the spectrum efficiency of AMT transmitters by more than 125 percent in recent years. With continuing investment in the development of networking and other technologies, the community seeks further improvements in efficiency. See D. Ernst, C. Kahn, D. Portugal, "The Economic Importance of Telemetry Spectrum," The MITRE Corporation, McLean, VA, 2007.

<sup>30</sup> See Spectrum Requirement for Aeronautical Mobile Telemetry, United States of America, Document 88/143-E at 2 (31 March 2005) ("Document 8B/143-E").

<sup>31</sup> T. Hill, Quasonix, a developer and manufacturer of AMT equipment, 2012; D. Hinton, "Spectrum Stewardship," ITEA, Las Vegas, NV, 2011.

the safety of flight testing. Respondents reported that bandwidth availability is constraining the collection of greater quantities of data.<sup>32</sup> As one telemetry engineer noted, “lack of available spectrum is literally the limiting factor for telemetered data on [the] program.” Another company indicated that “today’s telemetry streams are forcibly limited by available frequency bandwidth allocations.”<sup>33</sup> Therefore, the aerospace industry utilizes the available radio frequency spectrum extensively and as efficiently as possible given its requirements.

## Impact of New Radio Service in AMT Spectrum

Section 820 (2) of the FAA Modernization and Reform Act calls for identification of the potential impact to the aerospace industry from the introduction of a new radio service that operates in the same spectrum allocated to AMT services. A specific response necessarily requires identification of the “new radio service” that would be introduced in the AMT spectrum. With one unique exception discussed below, there is currently no such identification. Nevertheless, some general observations can be made.

The impact of a new radio service in AMT spectrum depends on the location, time, and power used by the new service as well as its ability to coordinate with AMT flight test operations. Any new service or user in the same frequency band used for AMT operations must guarantee it will not cause harmful interference to the receive dish that is tracking and obtaining data from the test aircraft. The industry standard for determining interference is International Telecommunications Union - Radiocommunication Sector (ITU-R) Recommendation ITU-R M. 1459. If a new user wishes to share spectrum resources with the aerospace industry, it must show that its operations will not interfere with the receiver’s sensitivity and cause harmful interference to critical flight test operations in accordance with Recommendation M.1459.<sup>34</sup>

AMT systems are highly susceptible to interference. Aircraft undergoing tests can be as much as 200 miles away from the flight test center’s AMT receive facilities which include large, dish-type antennas, such as those shown in Appendix IV. During flight, the telemetry signals are often weak and subject to severe fluctuations.<sup>35</sup> To detect telemetry signals at these distances, tracking systems are designed to be extraordinarily sensitive, requiring very high-gain directional antennas, which also renders them vulnerable to interference.<sup>36</sup>

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<sup>32</sup> This is true even with the use of sophisticated modulation techniques such as shaped-offset quadrature phase-shift keying (SOQPSK). The AMT community utilizes on-board recording systems, where appropriate, but the amount of data that must be telemetered for safety and economic reasons continues to increase proportionally with the increasing data rates needed for testing modern, highly complex aircraft.

<sup>33</sup> AFTRCC Survey 2012. As a consequence of the growth in measured data, the U.S. successfully sought access to additional spectrum for AMT at the 2007 World Radiocommunication Conference (WRC). This spectrum supplements, and cannot replace, the two principal AMT bands referenced previously (see note 16). Flight testing requires certain data for the protection of the aircraft crews, the test vehicles themselves, and people and property on the ground under the flight path. This data must be transmitted in protected radio bands to minimize the chance of interference/interruption to this critical safety information. The spectrum that was acquired at WRC is not exclusive to telemetry. It is shared with other users.

<sup>34</sup> AMT ground stations use special electronics and extremely large (hence sensitive) parabolic dish, tracking antennas. Due to these and other factors, AMT ground stations are 600 to 6,000 times more vulnerable to interference than broadband wireless antennas. This extreme sensitivity to interference is captured in the protection levels given by Rec. M.1459.

<sup>35</sup> “Flight Testing and Telemetry: An Overview,” AFTRCC, 2011.

<sup>36</sup> High-gain antennas can detect weak signals at large distances.

Flight tests have demonstrated that interfering signals as low as 1 milliwatt (mW) from transceivers located miles away from AMT receive antennas will create harmful interference and loss of data.<sup>37</sup> Such loss of data puts the safety of the pilot, the aircraft, and persons on the ground at risk.

Flight test centers and associated receive antennas are located throughout the United States. They are frequently co-located with aerospace manufacturing plants and include AMT antennas as well as a host of other resources. Although testing is concentrated in the Midwest and Southwest, other important facilities are located on the East Coast, in the Pacific Northwest, and in the Southeast. Important commercial aircraft test centers include, for example, Wichita, Kansas; Dallas-Fort Worth, Texas; Seattle, Washington; Savannah, Georgia; and Southern California. In addition, receive antennas are located on mobile vehicles in order to enable testing over large distances, often required by FAA and Department of Defense (DoD) regulatory requirements.

In considering any potential additional use of AMT spectrum for other communications services, significant consideration must be given to the substantial costs and hazards that can result for aircraft manufacturers in the event that harmful interference does occur during a flight test operation. As discussed in previous sections of this Report, an interruption in AMT data transmissions can risk the integrity of the test aircraft, the safety of the flight crew, and life and property on the ground. Harmful interference involving AMT spectrum also adversely affects productivity. Data drop-outs require that test maneuvers, or entire missions, be re-flown, delaying the aircraft's certification and increasing costs. Certification delays impact payment schedules and can negatively influence the economic standing of an aircraft manufacturer. Such delays can put U.S. companies at a competitive disadvantage in the global marketplace. For defense programs, delays can also adversely affect acquisition program costs and schedules, and national security.<sup>38</sup>

As reported by the AFTRCC survey, for some test programs even one delayed or canceled test can cost millions of dollars. Total development can cost billions of dollars for major programs. One respondent noted that system design and development costs for one of its programs averages \$4.6 million per day. If AMT services were not available and the program had to be extended, costs would be much higher. Furthermore, depending on the persistence of interference, test delays can lead to program delays which, in turn, can impact time-to-market, and may result in contract penalties and defaults. Such schedule slippages can lead to reduced competitiveness and potential loss of sales. As one company put it, "there is a point where schedules cannot be met, program delays become inevitable, development costs soar, [and] the competitive edge and sales are reduced[...]."<sup>39</sup>

The tight competition and high development costs of the aerospace industry make time-to-market crucial: It can literally make or break a program, according to aerospace companies. Multiple companies reported that the use of telemetry cuts the time to

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<sup>37</sup> See Exhibit A to Reply Comments of Aerospace and Flight Test Radio Coordinating Council, filed November 4, 2009 in FCC ET Docket No. 08-59. For the FCC's decision in this Docket, see. In the Matter of Amendment of the Commission's Rules to Provide Spectrum for the Operation of Medical Body Area Networks, First Report and Order and Further Notice of Proposed Rulemaking, FCC 12-54, 27 FCC Rcd 6422 (2012) ("MBANs 2012").

<sup>38</sup> "Protection of Flight Test Spectrum," AFTRCC, Wichita, KS, 2012.

<sup>39</sup> AFTRCC Survey 2012.

complete flight testing certification efforts in half, thereby greatly accelerating time-to-market and significantly improving the manufacturer's competitiveness.<sup>40</sup>

Due to the demanding environment required for safe flight testing, AMT services require unique spectrum characteristics. AMT must have interference-free spectrum with specific signal propagation requirements, including the ability to receive signals from as much as 200 miles with a very high degree of reliability.<sup>41</sup> Hence, the spectrum allocated for aircraft testing, i.e. safety of flight, has long been on the basis of exclusive allocation that is also classified as "Restricted" from non-licensed devices.<sup>42</sup>

As noted before, the aerospace industry chiefly uses two bands for aircraft flight testing, 1435-1525 Megahertz (MHz) and 2360-2390 MHz. Both bands are primarily allocated for flight test purposes, and are shared by industry and government.<sup>43</sup> The first of the two is allocated on an exclusive basis for flight testing. The second band is shared but, as discussed below, the band conditions provide proper protection for flight test safety communications despite the expected introduction of another unique type of system.

Specifically, with the support of AFTRCC and the DoD, the FCC recently approved a novel sharing arrangement for AMT and a type of very low power (1mW) medical device in the 2360-2390 MHz band. Health care facilities will be able to employ the devices to transmit patient measurements wirelessly, but strictly inside the medical facility. The devices will allow patients to walk about within the building without being connected by wires or carrying bulky recorders. All hospitals must register their usage and be coordinated with AFTRCC before being allowed to operate in the 2360 to 2390 MHz band.<sup>44</sup>

This type of technology, and these types of restrictions, would not be practical for most other users because they typically operate at high power levels, and are used ubiquitously. However, each service must be evaluated based on its own particular operating characteristics for compatibility with AMT.<sup>45</sup>

## Conclusion

Civil aviation and equipment manufacturers rely on AMT services to collect data required by the FAA to certify airworthiness and safety. AMT services save lives and aircraft every day. Absent careful analysis, coordination, and conditions, introduction of a new radio service in AMT spectrum would likely cause interference, potentially compromising flight safety and U.S. industry competitiveness.

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<sup>40</sup> Ibid.

<sup>41</sup> In technical terms, requirements include a long slant range of 200 miles, low angles (i.e., near the horizon; high multipath), and data transmission with bit error rates of less than 1 error in every 10<sup>6</sup> bits.

<sup>42</sup> 47 CFR Section 15.205.

<sup>43</sup> Government users include the Department of Commerce, DoD, Department of Energy, and NASA.

<sup>44</sup> MBANs 2012. Broadcast networks have been allowed to use AMT spectrum on a coordinated, special temporary authority basis typically limited to a few days at a time, when and where there is not a risk of harmful interference to AMT.

<sup>45</sup> Work is being done under the auspices of the Commerce Spectrum Management Advisory Committee (CSMAC) to evaluate the sharing potential for a variety of government systems, including AMT, with fourth generation (4G) carrier long-term evolution (LTE) technology. That work is not yet completed.

The continued availability of interference-free flight test telemetry services is essential if the U.S aerospace industry is to remain the world's leader in aircraft design, safety, and productivity.

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## **Appendix I: Section 820 of the FAA Modernization and Reform Act of 2012, Public Law 112-95**

### **SEC. 820. STUDY OF AERONAUTICAL MOBILE TELEMETRY.**

Not later than 180 days after the date of enactment of this Act, the Administrator of the Federal Aviation Administration, in consultation with other Federal agencies, shall submit to the Committee on Commerce, Science, and Transportation of the Senate and the Committee on Science, Space, and Technology and the Committee on Energy and Commerce of the House of Representatives a report that identifies—

- (1) the current and anticipated, with respect to the next decade, need by civil aviation, including equipment manufacturers, for aeronautical mobile telemetry services; and
- (2) the potential impact to the aerospace industry of the introduction of a new radio service that operates in the same spectrum allocated to the aeronautical mobile telemetry service.

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## Appendix II: Flight Testing Program Development Timeline

Aircraft manufacturers conduct critical testing necessary to validate new and derivative aircraft to meet certification requirements of the FAA and international and foreign aeronautical regulatory agencies. A typical flight test program timeline is shown below.<sup>46</sup>

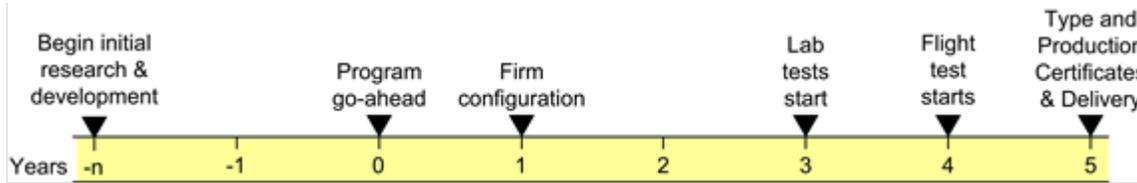


Figure 4. Flight Testing Program Development Timeline (in Years)

<sup>46</sup> "The Importance of Protecting Flight Test Telemetry Spectrum for the Aviation Industry and National Defense," July 2011.

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## Appendix III: Typical Examples of High Risk Flight Tests

These are typical examples only, provided here for general guidance. The actual risk category must be evaluated on a case-by-case basis and it may be different from these examples depending on actual project-specific circumstances.<sup>47</sup>

### High Risk

- Stall characteristics:
  - Aft cg accelerated stalls with rapidly changing dynamic conditions.
  - On airplanes equipped with unproved pusher systems that are masking potential deep stalls.
  - High altitude stalls on airplanes with potential engine flameout problems.
  - With critical ice shapes.
- High speed tests above  $V_{ne}/V_{MO}/M_{MO}$ .
- $V_{MCA}$  tests at low altitude; particularly dynamic  $V_{MCA}$ .
- Flight control malfunction testing during takeoff and landing phases of flight, and asymmetric deployment of roll controls at high speeds.
- Ice shape testing, especially during the takeoff phase where special procedures are required.
- Maximum energy RTOs where wheel/brake fires are a possibility.
- Actual  $V_1$  fuel cuts for takeoff performance.
- Autopilot malfunction tests at low altitudes.
- WAT limited takeoffs with actual engine cuts.
- $V_{MU}$  test at low thrust to weight ratios.
- $V_{mcg}$  tests.
- Nose-wheel steering malfunction tests.
- Spin testing.
- Lateral-directional testing on aircraft that can achieve extremely large sideslip angles.
- Dynamic lateral stability testing (Dutch rolls) on airplanes that are extremely unstable under certain conditions.
- In-flight thrust reverser deployments.
- Systems installation (with unproved design aspects) where FHA has identified catastrophic events.

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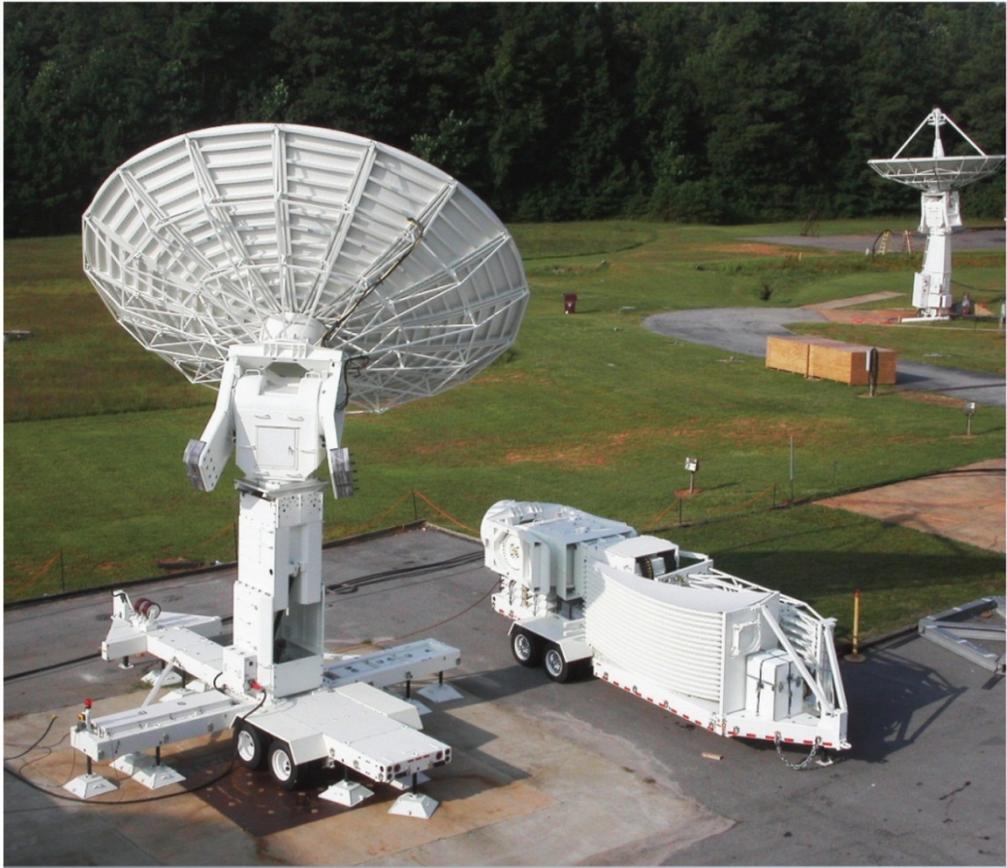
<sup>47</sup> FAA Order 4040.26B

- Stall characteristics on Restricted Category airplanes with asymmetric wing store configurations.
- H/V envelope determination.
- Helicopter low speed testing.
- Autorotation.
- PIO Testing.
- Max Crosswind Landings.

## **Appendix IV: Example AMT System Antennas [Source: ViaSat, Inc.]<sup>48</sup>**

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<sup>48</sup> "L- and S-band Range Telemetry Systems," ViaSat, Inc.



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## Appendix IV: Acronyms

4G	Fourth Generation
AFTRCC	Aerospace and Flight Test Radio Coordinating Council
AIA	Aerospace Industries Association
AMT	Aeronautical Mobile Telemetry
CSMAC	Commerce Spectrum Management Advisory Committee
DoD	Department of Defense
FAA	Federal Aviation Administration
FCC	Federal Communications Commission
GDP	Gross Domestic Product
ITU-R	International Telecommunications Union-Radiocommunication
Kbps	Kilobits per Second
LTE	Long-Term Evolution
Mbps	Megabits per Second
MHz	Megahertz
mW	Milliwatt
NASA	National Aeronautics and Space Administration
PIO	Pilot-Induced Oscillation
R&D	Research and Development
SOQPSK	Shaped-Offset Quadrature Phase-Shift Keying
U.S.	United States
WAT	Weight, Altitude, Temperature
WRC	World Radiocommunication Conference

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