The Economic Importance of WRC Agenda Item 1.5 to Countries Worldwide

Carolyn A. Kahn

The MITRE Corporation
202 Burlington Road
Bedford, Massachusetts 01730

Abstract: Aeronautical telemetry (ATM) spectrum is vital to flight testing and safety of aerospace vehicles. The amount of spectrum available for aeronautical telemetering is inadequate today, and demand is growing exponentially. This paper discusses the economic importance of sufficient ATM spectrum access and why countries should care about 2007 World Radio Conference Agenda Item 1.5, which proposes spectrum augmentation for wideband ATM in the 3 to 30 Gigahertz band.

Keywords: Bandwidth, Economic, Spectrum, Telemetry, World Radio Conference

1. Introduction

The flight test community faces a crisis in that insufficient spectrum is available to support telemetering requirements. Aeronautical telemetry (ATM) is used to transmit real-time data during flight tests, and the availability of such data is integral to the productivity and safety of live flight test programs. Sufficient telemetry spectrum access is critical to maintaining rigorous system testing and meeting flight test requirements. It is thus integrally related to the production of ever-more efficient and safe aircraft.

The extraordinary growth in the complexity of modern aircraft components and avionics has led to an exponential increase in the number of measurements that must be obtained during flight testing. The flight test program for the Boeing 707 involved measurements of a total of 300 data points when it was tested in the late 1950s. Flight testing for a more recent wide-body airliner (the Boeing 777) in service around the world today involved measurements of 40,000 data points [1]. Further exacerbating the spectrum problem, twenty-two percent of the bandwidth available for telemetry in the U.S. in 1980 has already been reallocated to consumer applications [2]. In many other countries, ATM spectrum losses have been worse. The exponential growth in data requirements, along with reduced supply, has led to an increasing ATM spectrum shortfall, with consequences for manufacturers as well as air carriers and their customers.

Technology and regulatory solutions are being developed to help offset the spectrum shortfall. Technology research initiatives offer the prospect of increasing bandwidth efficiency and, if they reach their intended capability, may partially offset telemetry spectrum demand until more spectrum access may be secured. For example, the Integrated Network Enhanced Telemetry (iNET) project is designing a wireless network to supplement point-to-point telemetry capabilities. A regulatory solution is currently proposed before the International Telecommunication Union as Agenda Item 1.5 of the 2007 World Radio Conference (WRC). This proposal calls for wideband ATM spectrum augmentation in the 3-30 Gigahertz band. This Agenda Item is of major importance for air transportation.

2. Economic Implications of WRC Outcome

There are economic implications associated with the potential outcomes of Agenda Item 1.5. Darrell Ernst, Carolyn Kahn, and David Portigal of The MITRE Corporation built a model to examine ATM spectrum supply and demand and to assess the economic importance of adequate access to ATM spectrum. Section 2.1 describes the model, and Section 2.2 summarizes its results.

2.1 Economic Model

The study team defined probable future scenarios at a test range complex, projected demand and supply of ATM spectrum, and modeled the economic impacts of spectrum shortfalls. Potential future scenarios vary from no spectrum allocation change to significantly increased allocation of ATM spectrum to meet needs over the next twenty years. In each case, technology development plays an important role. The team defined six future scenarios of ATM spectrum supply, the baseline being the 215 Megahertz (MHz) of currently available spectrum in the U.S. and five alternatives reflecting WRC decision outcomes ranging from 0 to 650 MHz of spectrum augmentation. The six scenarios used for analyzing economic impact also define additional influences including the use of additional and new test resources and test impacts due to spectrum shortfall.

Six future scenarios are shown in Table 1.

Roll-Up of Model Elements			
Scenarios	**Spectrum Augmentation**	**Additional Test Resources**	**New Test Resources**
Baseline	0	No	No
WRC 0	0	Yes	Yes
WRC 60	60	Yes	Yes
WRC 200	200	Yes	No
WRC 425	425	Yes	No
WRC 650	650	Yes	No

Table 1: Model Elements

Additional test resources refer to augmentation of test resources at existing ranges, while new test resources refer to the establishment of completely new test facilities. In addition to these elements, an inadequate testing factor incorporates test impacts of inadequate ATM spectrum access. Insufficient spectrum access may force flight test programs to accept lower caliber testing. Assuming flight test programs currently accept their maximum threshold of ATM spectrum shortage, the inadequate testing factor is applied in those years where the spectrum shortfall is greater than that experienced today.

Forecasts of future telemetry demand are based on current usage, statistical analysis of historic test range data, projections of test demand associated with new complex aeronautical development programs, and recent and planned technology developments. The Bandwidth Demand Model (BDM) consists of two components. The first component is the estimate of average day-to-day demand as a result of routine flight test operations. This demand constitutes the large majority of spectrum usage at the test range complex. The second component of the demand estimate is referred to as "max user" and represents an estimate of the bandwidth needed to support a major new project.

The study analyzed a total of 17 scenarios – the six cases of ATM spectrum supply plus 11 cases of ATM spectrum demand – to examine results under varying assumptions. Demand scenarios vary inputs into the BDM, including the number of simultaneous user operations on a range, the effects of growth in the number of simultaneous operations or users, the fraction of spectrum expected to be used for iNet, the expected reduction in the amount of data a vehicle needs to send using iNet as compared to other methods, the multiplier used to vary the maximum user data as a percent of the original estimate, and the option of incorporating technology concepts beyond current research initiatives. The team then performed a gap analysis, which forecasts and compares ATM spectrum requirements, or demand, and available spectrum supply at a range complex. *Gap* is defined as the demand of ATM spectrum above and beyond the given supply. It specifies the spectrum shortfall, or amount by which spectrum is insufficient for flight testing on an annual (non-cumulative) basis. The gap analysis provides an important input into the economic model. The gap is estimated by comparing the baseline demand, both with and without the potential benefit of iNET, to the six supply scenarios – baseline supply, WRC 0, WRC 60, WRC 200, WRC 425, and WRC 650. Figure 1 shows the gap analysis with iNet, and Figure 2 shows it without iNet [3].

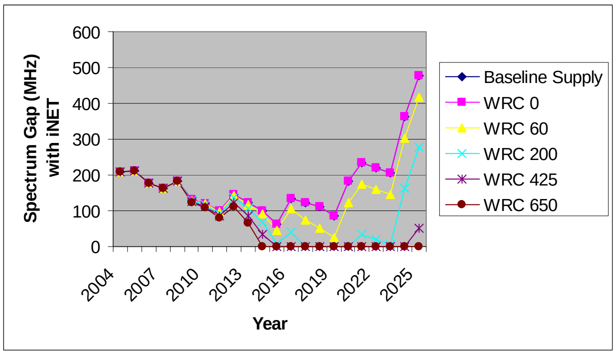

Figure 1: Gap Analysis with iNet

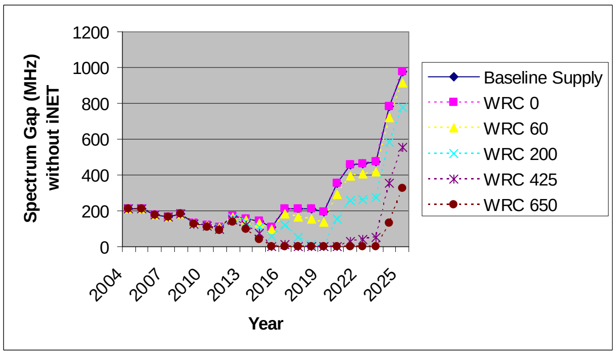

Figure 2: Gap Analysis without iNet

The model then estimates the economic implications of that gap. Based on actual data from test ranges, expert interviews, and several previous reports, the model estimates various component costs represented in each scenario. These include costs associated with test delays, technology investment, additional or new test range resources, and inadequate testing.

An unplanned test delay can cost a program $1 million to $3 million for a large test and about $50 thousand for a small test [3]. In some locations, commercial aerospace companies cannot conduct flight testing due to lack of ATM spectrum [4]. Programs incur significant costs – an estimated $60 million a year on a test range today – when tests must be delayed due to telemetry spectrum shortages.

Inadequate ATM spectrum access amplifies the need for investment in technology research and development. This offers the prospect of new methods to increase the efficiency of bandwidth utilization so real-time data can be transmitted as efficiently as possible. However, there is technical risk for technologies not yet proven, and research initiatives (such as iNet) that do not reach their intended capability will not improve bandwidth utilization.

Test programs that are not able to obtain the spectrum availability they need at their usual test facilities must find spectrum resources elsewhere. Use of additional test resources is only possible if there are alternative ranges available far enough away from existing ranges to allow for spectrum reuse. Reuse of the existing allocation at a sufficiently distant facility, if available, imposes additional cost. It may cost a flight program approximately $240 thousand to move a flight test, plus a flight test facility must pay on average about $900 thousand per antenna to accommodate the test vehicle [3]. If a facility does not yet exist, a country could hypothetically invest in a new range resource at an estimated $1.5 billion cost over a twenty-year period [3]. A new range resource would provide access to existing ATM spectrum through geographic separation. New test ranges are only possible at a huge expense, and in the present environment come with significant geographic, legal, environmental, political, and upfront investment hurdles.

Lack of ATM spectrum access may cause programs to reduce the number of test points collected during flight testing. This test point shedding may, in turn, lead to reduced quality of testing. At some point, failure to fully test results in catastrophes and fatalities. The inadequate testing factor that incorporates test impacts of inadequate ATM spectrum access is based on a case example and represents a cost of almost $1.6 billion per incident [3]. Costs to programs, development contractors, and the national economy can be huge when one also considers loss of competitive advantage from delay in marketing and sales of new commercial aircraft, or reduced military effectiveness from unavailability of more advanced aeronautic systems.

2.2 Results of Model

The economic model projects costs of inadequate ATM spectrum access. Costs are mitigated by decreasing testing delays, reducing inadequate testing, and/or lowering the need for test infrastructure enhancements. The first two can be accomplished through spectrum augmentation and/or the provision of new or additional test resources. The last can only be achieved with spectrum augmentation. The model does not incorporate the risk that new or additional test resources may not be available or possible. Legal, environmental, political, and large upfront investment hurdles may not be overcome. In the present environment, such test infrastructure enhancements are not a realistic option.

Figure 3 shows the source of the costs for the scenarios with iNET [3]. Results were computed for a twenty-year period, from 2005 to 2025. Even with iNET, the cost of inadequate ATM spectrum access is significant.

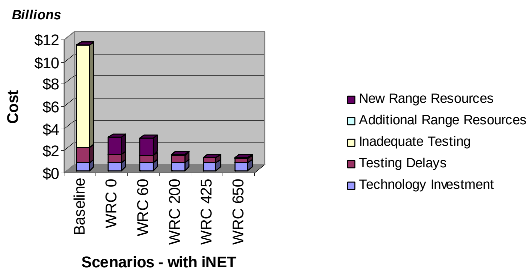

Figure 3: Source of Costs – with iNet

Figure 4 shows the cost breakdown for the scenarios without iNET [3]. Again, results were computed for a twenty-year period, from 2005 to 2025. Without iNET, costs are higher, and inadequate testing becomes a major cost factor in every scenario but WRC 650.

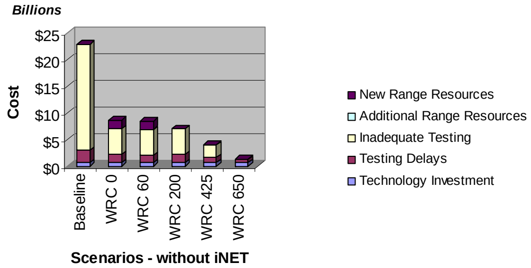

Figure 4: Source of Costs – without iNet

The results of the economic model are summarized in Table 2.

With iNET						
Scenarios	Total Cost for Analysis Period (2005-2025)	Year 2025 Cost	Annual Benefit (in Year 2025)	Year 2025 Gap (After Supplments)	New Range Resources	Spectrum Augmentation
Baseline	$11,316,203,864	$2,676,147,341	$0	476	No	0
WRC 0	$3,033,043,408	$176,359,275	$2,499,788,066	131	Yes - 1	0
WRC 60	$2,945,998,280	$149,399,838	$2,526,747,503	101	Yes -1	60
WRC 200	$1,433,722,130	$182,794,972	$2,493,352,369	138	No	200
WRC 425	$1,188,637,679	$81,697,084	$2,594,450,258	26	No	425
WRC 650	$1,137,500,126	$58,586,020	$2,617,561,321	0	No	650

Without iNET						
Scenarios	Total Cost for Analysis Period (2005-2025)	Year 2025 Cost	Annual Benefit (in Year 2025)	Year 2025 Gap (After Supplments)	New Range Resources	Spectrum Augmentation
Baseline	$22,885,760,198	$2,894,061,314	$0	977	No	0
WRC 0	$8,660,052,563	$2,811,538,828	$82,522,486	381	Yes - 1	0
WRC 60	$8,483,120,642	$2,784,579,391	$109,481,923	351	Yes -1	60
WRC 200	$7,094,639,064	$2,817,974,525	$76,086,789	389	No	200
WRC 425	$4,075,861,150	$2,716,876,637	$177,184,678	276	No	425
WRC 650	$1,380,718,261	$205,573,202	$2,688,488,112	164	No	650

Table 2: Summary Results of Economic Model

These results show the projected cost of inadequate ATM spectrum access over the twenty year period (2005-2025), the annual cost in year 2025, the annual benefit (namely cost savings) achieved in year 2025 from any spectrum augmentation, and the year 2025 gap (after range supplements) for each given scenario. The annual benefit is derived by comparing the Year 2025 cost of a given scenario to that of the baseline scenario. This "benefit" is a result of potential bandwidth efficiency improvements from technology investments, test infrastructure enhancements, and any spectrum augmentation as defined in each particular scenario. Table 2 also displays whether or not the scenario includes the provision of new range resources. Insufficient access to ATM spectrum will cost an estimated $11.3 billion with iNET, or $22.9 billion without iNET, over the next twenty years without spectrum augmentation or new range resources. WRC spectrum augmentation of 650 MHz with iNET would provide an annual benefit of $2.6 billion and is the only scenario in which projected requirements are met in the base case over the next twenty years [3].

This study and its resulting economic model point to substantial cost impacts associated with ATM spectrum shortfall. Operational and scheduling setbacks for flight testers, seen daily at test ranges, result in millions of dollars of added cost to the development or modification of aeronautical systems. The increasing complexity of these systems – driving the need for more extensive testing integrated with more test assets, advanced testing techniques with greater utilization of real-time video and high data rates, and shorter development cycles – are conclusively leading to an exponential growth in the demand for telemetry. While technology advances may mitigate some of the bandwidth shortfall, it is clear that spectrum augmentation is critical to closing the gap and reducing the costs identified in this study. It is important that the telemetry user and provider community protect and defend spectrum to ensure its future availability for aeronautical telemetering. The future use of spectrum must be carefully planned so it can adequately support commercial and government flight test missions. The WRC decision on telemetry spectrum augmentation is critical and will determine the nature of flight testing and impacts to this community far into the future.

3. Indirect Costs

In addition to direct costs, aerospace companies also realize indirect costs from lack of ATM spectrum access. In the competitive industry, a product line's time-to-market is crucial. Any delay in getting a product to market may postpone some sales while other sales may be lost to the competition. According to an aerospace company study, time-to-market impacts further multiply costs by a factor of ten [3].

In addition to lost sales to the aerospace company, time-to-market delays affect airports that need to invest in infrastructure modifications to efficiently accommodate a new aircraft. For example, Johannesburg's OR Tambo International Airport invested 100 million rand (about $14 million) to modify its runways and taxiways to accommodate the Airbus A380 [5]. As a result of a delay, these newly built airport facilities sit unused generating no income while still incurring loan payment, maintenance and depreciation cost obligations until the new aircraft reaches the market. Local communities, therefore, may incur added costs as a result of flight test delays.

Flight testing is an expensive undertaking. It can represent as much as 15 percent of the cost of developing a new aircraft [1]. Flight test programs typically last months or even years, and involve hundreds of workers. With flight test costs representing such a significant portion of the total cost for new aircraft, the undue costs described in this paper can have a devastating effect on aerospace companies which, in turn, are passed to the purchasing/leasing airlines. It is expected that carriers will, in turn, seek to recover the added costs in the form of higher fares – to the detriment of the traveling public and their nations.

4. Importance of Aerospace and Air Transport Industries to National Economies

The aerospace industry, and its air carrier partners, are vital contributors to national economies. "Flag-carrier" national and regional airlines, and their domestic owners, provide air service to and within their own country. A symbol of national pride, these carriers represent a vital aspect of the national infrastructure, particularly for developing countries [6].

The air transport industry generates 29 million jobs globally. Aviation provides the only worldwide transportation system which makes it essential for business and tourism. It transports close to 2 billion passengers annually and 40% of interregional exports of goods by value. Approximately 40% of international tourists travel by air. Aviation's global economic impact is estimated at $2.96 trillion, equivalent to 8% of world Gross Domestic Product (GDP). About 25% of all companies' sales are dependent on air transport, and 70% of businesses report that serving a bigger market is a key benefit of air transport. The world's 900 airlines have a fleet of nearly 22,000 aircraft. They serve about 1,670 airports through a route network managed by around 160 air navigation service providers. The air transport industry is a net contributor to national treasuries through taxation [7].

There are also social benefits. Air transport broadens the public's leisure and cultural experiences via a wide range of affordable access to destinations across the globe. It improves living standards and alleviates poverty through tourism. Aviation often serves as the only means of transportation to remote areas promoting social inclusion. It also facilitates the delivery of emergency and humanitarian aid relief and swift delivery of medical supplies and organs for transplantation [7].

Substantially increasing the cost of a capital-intensive business, such as air transport, will cause economic ripple effects. Higher costs incurred by carriers will be passed on to air travelers and shippers. At some point, the increased marginal cost will suppress demand as consumers rethink, for example, the cost of travel to one country as compared to other options.

Furthermore, the delayed launch of new aerospace products will require extended use of legacy vehicles. Older, less efficient aircraft nearing the end of their useful lives must undergo more frequent and more extensive maintenance in order to keep them in service. Moreover, fuel costs account for approximately 25% of an airline's operating expenses, providing another incentive to replace older aircraft with new, more fuel-efficient models. These aircraft will have to be kept in service longer at increasing cost to air carriers [7].

Similarly, carriers counting on the availability of added capacity to meet increased demand on certain routes will not have the new aircraft available to satisfy that demand, and will thereby suffer the opportunity cost of lost revenue.

5. Concluding Remarks

Support for ATM spectrum augmentation, as proposed by WRC Agenda Item 1.5, will redound to the benefit of countries worldwide. A determination by WRC that spectrum in the specified bands is suitable for flight test telemetry will provide the relief required. This augmentation will thus avoid imminent major, costly delays in flight testing – delays and costs which could have long-term adverse effects for national air carriers, their governments, and the people they serve.

6. Acknowledgement

The author would like to acknowledge the contributions of Francis Dello Russo, Darrell Ernst, Edward Gonzalez, Ken Keane, and David Portigal to this paper.

7. References

[1] Keane, Ken, "The Importance of WRC Agenda Item 1.5 to the Nations of the Americas," 2007.

[2] Ernst, Darrell, Yan-Shek Hoh, and David Portigal, "Projected Growth of Spectrum Requirements for Aeronautical Telemetering," The MITRE Corporation, March 2004.

[3] Ernst, Darrell E., Carolyn A. Kahn, and David L. Portigal, "The Economic Importance of Adequate Aeronautical Telemetry Spectrum," The MITRE Corporation, February 2007.

[4] Aerospace and Flight Test Coordinating Council.

[5] "S. Africa Ready to Welcome Superjumbo A380," People's Daily Online cites Business Day newspaper.

[6] "State Aid to Airlines," International Chamber of Commerce, Commission on Air Transport, June 1995.

[7] International Air Transport Association.

8. Glossary

ATM: Aeronautical Telemetry Spectrum

BDM: Bandwidth Demand Model

GDP: Gross Domestic Product

iNet: Integrated Network Enhanced Telemetry

MHz: Megahertz

WRC: World Radio Conference