U.S. Department
of Transportation
Federal Highway
Administration

Broadband Wireless in the ITS Domain

Overview **June 2001**

Companies, agencies, and individuals are increasingly seeking "anywhere" voice, data, and video services; consequently, the demand for high-speed (or broadband) wireless communications is growing. Developing nearly as fast as the demand for these services is the desire to integrate them so that multiple communications resources are not required.

Broadband Wireless, Integrated Services, and Their Application to ITS is a recent publication from the US Department of Transportation's Intelligent Transportation Systems (ITS) Joint Program Office (JPO). The report introduces some of the newer broadband wireless communications alternatives and describes how they could be used to provide high-speed connections between fixed, transportable, and mobile facilities. It also describes the new integrated service technologies – devices used to bundle voice, data, and video services for transmission over a single link. In this case, it's a broadband wireless link.

Together, the new broadband wireless and integrated service technologies can be used to provide efficient, cost-effective, and flexible multi-service provisioning. This brief overview presents the concept and summarizes the aforementioned report (June 2000). In a second phase, prototyping was conducted to demonstrate the potential of this concept. The phase II report will be available at the end of the calendar year (2001).

The Concept

Consider the ability to support real-time voice, data, and video for the following operations:

- Back-up communications between traffic management centers
- Temporary communications between transit management centers and special event coordinators and/or portable kiosks
- Emergency communications between incident management centers and public safety units in the field

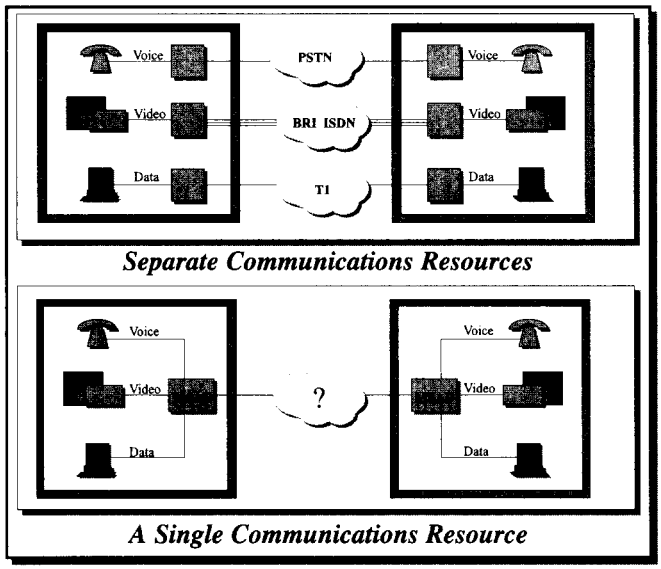
These are not exactly novel ideas, but consider the ability to establish such communication nearly "anywhere", and to permanently provide <u>all</u> these types of service with a system that has a return-on-investment (ROI) on the order of months.

This idea represents the basis for applying newer broadband wireless technologies to the integrated service platform. The general concept involves two aspects: integrating the services, and providing the wireless connectivity.

❶ Integrating Services

Typically, several types of equipment and different transmission facilities must be patched together in order to construct an integrated service network (e.g., voice over a PSTN, data services over T1, and video teleconferencing over ISDN). Each of these services requires separate communications resources – separate equipment, separate transmission facilities, etc.

Alternatively, one can build an integrated platform by bundling services for transmission over a single facility. This bundling can be accomplish by a relatively new type of equipment – a Multi-Service Access Device (MSAD), or Integrated Access Device (IAD).



Aside from the obvious savings from bundling services, an integrated service platform requires less technical support, less maintenance, and less administration. It also eases the network management function.

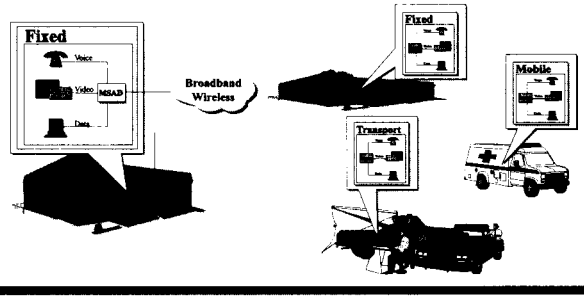
❷ Wireless Connectivity

Several companies now use wireline communications (e.g., fiber optics) to support an integrated service platform. However, we consider the wireless alternative. Wireless communication offers the flexibility to enable the "anywhere" concept.

While communication can not literally be established "anywhere", it can be established in many different locations. The coverage, as well as mobility and other performance parameters, depend on the specific wireless technology. Each presents different ways to connect fixed, transportable, and/or mobile subsystems.

Broadband wireless refers to those communications technologies that use larger (or broader) portions of the radio frequency (RF) spectrum. This spectrum is needed to achieve higher data rates, which are in turn required to adequately provide for the integrated services. For the purpose of this effort, and to limit the scope of the task, broadband refers to those technologies that can support bi-directional data rates of at least 384 kbps.

MSADs efficiently integrate services, and broadband wireless provides high-speed and flexible connectivity. Together, these technologies can provide more services, between more locations, with less cost. And these trends will continue as the technologies develop.



Markets and Applications

The last decade has seen enormous growth in wireless communications. According to the consulting firm *Ernst & Young*, by 2008 wireless will surpass wireline as the dominant method of telecommunications worldwide[1]. While voice services were the driving factor this past decade, the next decade's growth will be fueled by the demand for high-speed data and video services. This will subsequently increase the demand for broadband wireless.

Federal Communications Commission (FCC) Chairman William Kennard recently expressed that the "focus" of many of the Commission's policies is to create more wireless spectrum so that carriers can develop broadband services. A recent report from telecommunications research consulting company *The Strategis Group* predicts that fixed broadband wireless revenues will increase at a 418% compound annual rate over the next five years.

In addition, most telecommunications companies and local exchange carriers are beginning to offer **integrated** voice, data, and video services – a trend being fueled by not only the growing demands for Internet access and multimedia, but also the decreasing revenue from voice-only services. Analysts predict that these "bundled" services will soon become a major source of revenue for the large carriers.

Why is this market information relevant? It indicates the level of private sector interest and the level of government support. Both impact development of broadband wireless and integrated service technologies, which subsequently impacts the ways in which one can support ITS.

In addition to the general applications of these technologies (e.g., mobile and thin-client computing, interactive video and video teleconferencing, Internet/intranet access and virtual private networking), the report presents specific transportation-related applications. Some currently use broadband wireless. Others do not, but could.

Within the framework of the National ITS Architecture, broadband wireless and integrated service technologies provide a viable means for exchanging information between many different ITS subsystems.

- For **Center-Center** communications, this would involve traffic video feeds, analog and digital voice services, LAN extension (for exchange of documents, imagery, etc.). It might also include newer applications such as IP-based video teleconferencing and real-time multimedia collaboration.
- For **Center-Traveler** communications, this exchange would involve multimedia ATIS (e.g., real-time voice, data, and video for traffic reporting, yellow pages information, and/or emergency assistance).
- For **Center-Roadside** or **Center-Vehicle** (transportable) communications, it would involve similar voice, data, and video services for emergency roadside assistance, remote medical triage, etc.

With different system designs, similar applications can be supported directly between vehicle, roadside, and/or traveler subsystems (i.e., without a center facility).

[1] "The 3G Force", http://www.redherring.com/mag/issue69/news-threegee.html (December 2000)

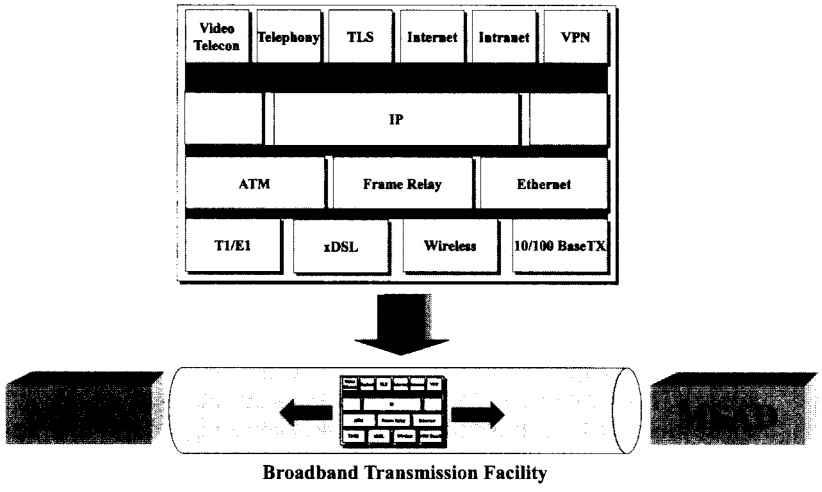
Integrated Service Platforms and the Multi-Service Access Device (MSAD)

The ability to integrate services is no longer limited to the major carriers and their complex networks. With the MSAD, bundled services can now be afforded by the smaller provider as well, whether commercial provider, private company, or public agency.

MSADs can support:

- Dial tone (POTS, PSTN access, FAX)
- Corporate PBX or key system access
- High-speed Internet access
- Corporate intranet access and virtual private networking (VPN)
- Video teleconferencing
- Collaborative multimedia

These devices combine the functions of various communications equipment that would typically be needed to construct a multi-service network. This includes: routers, bridges, channel/digital service units (CSU/DSU), digital access cross-connect systems (DACS), private branch exchanges (PBX), DSL access multiplexers (DSLAM), asynchronous transfer mode (ATM) switches, subscriber management devices, etc.



Mutiple Traffic Types over a Single Transmission Facility

The integrated functions allow the MSAD to combine multiple traffic types, effectively separating services from transmission technologies. The integrated traffic may be an ATM or Frame Relay virtual circuit, an IP/Ethernet flow, etc., but it rides over a single transmission facility. This could be an existing T1 or DSL connection. Alternatively, it might be one of the newer broadband wireless technologies.

The resulting integrated service platforms are practical alternatives to traditional multi-service networks. By using broadband wireless to support these platforms, one adds the benefits of mobility and rapid deployment.

Broadband Wireless Technologies

The aforementioned report reviews many of the newer wireless technologies. Some are relatively inexpensive and use unlicensed spectrum; others require more expensive implementations that depend on licensed spectrum. The coverage, architecture, mobility, and various performance parameters will depend on the specific technology.

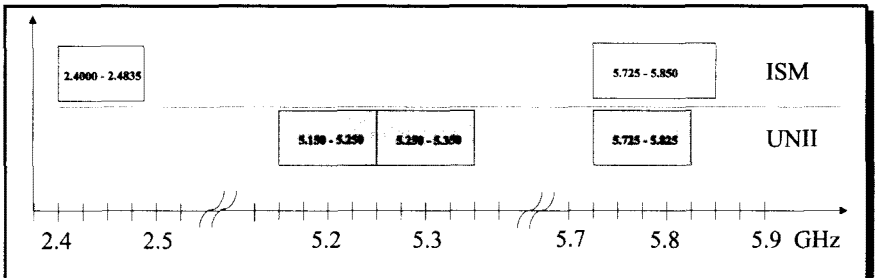
For each wireless technology or service, the report addresses issues such as:

- Spectrum and licensing (if applicable)
- Architecture
- Performance (e.g., data rates)
- Standards
- Existing products, services, and/or systems

It also provides additional information regarding costs, security, related technical innovations, system enhancements, like/similar technologies, etc.

Unlicensed Spectrum Technologies

Most of the unlicensed spectrum technologies presented in the report were designed to operate under Part 15 of the FCC rules and regulations. There are several Part 15 frequency bands in which to operate, but discussions are limited to the 2.4 GHz and 5.8 GHz industrial, scientific, and medical (ISM) bands and the new 5.3 GHz and 5.8 GHz Unlicensed National Information Infrastructure (UNII) bands. Most development in broadband wireless is occurring in these areas.



2.4 GHz ISM, and 5 GHz & UNII Bands

Of those technologies using 2.4 GHz ISM, the following are reviewed:

- Wireless Local Area Network (WLAN) Technologies: One standard currently underpins much of the development in this market – **IEEE 802.11b**. The **OpenAir** WLAN standard is also addressed.
- Other Wireless Networking Standards: **Bluetooth**, a technology providing basis for a new IEEE 802.15 personal area network (PAN) standard, is discussed briefly. The **HomeRF** standard is also addressed.
- Proprietary Wireless Networking: There are several proprietary networking technologies that operate at 2.4 GHz. Service providers offering wireless "last mile" connectivity have now formed the largest market for such equipment.

Technologies using either the 5 GHz ISM and UNII bands include:

- WLAN Technologies: The 802.11b standard has put wireless LANs on a rough parity with wireline Ethernet. However, new 5 GHz WLAN technologies will offer even better performance with data rates exceeding 50 Mbps and quality-of-service (QoS) features that can adequately support isochronous services such as voice and video. The report focuses on **IEEE 802.11a** and the **four HIPERLAN** standards.
- Proprietary Wireless Networking: The 5 GHz unlicensed spectrum is primarily used for outdoor long-range systems (i.e., miles not feet). While not many operational systems currently use this spectrum, proprietary technologies constitute the most rapidly evolving type of equipment in these bands.

In addition to Part 15 devices, two other unlicensed broadband technologies are introduced: free space optics and ulta-wideband (UWB) radio.

- **Free space optics** have been around for years, but most were used for point-to-point systems and were not particularly designed for distributed networks. However, advancements in optical systems (e.g. multiplexing techniques, optical switching, automatic tracking, and power control) have significantly improved wireless optical networking.
- **UWB** radio is currently an experimental technology for short-range radar applications. However, UWB-based communications equipment, such as that used for local area networking, might be in the foreseeable future.

2.4 GHz ISM Band			
IEEE 802.11b	1 - 11 Mbps	~300 - 400 ft	2-20+ mi
OpenAir	0.8 - 1.6 Mbps	~300 - 400 ft	3-20+ mi
HomeRF	1-2 Mbps	~100 ft	-
Bluetooth	< 0.5 Mbps	~ 30 ft	-
Proprietary Technologies	~ 1 - 11 Mbps	~100 - 500 ft	2-20+ mi
5 GHz ISM and/or UNII Bands			
IEEE 802.11a	6 - 54 Mbps	~200 ft	35+ mi
HIPERLAN I	24 Mbps	~200 ft	35+ mi
HIPERLAN II	6 - 54 Mbps	~200 ft	35+ mi
HIPERAccess	~20 Mbps	-	-
Proprietary Technologies	6 - 100+ Mbps	-	35+ mi
Free Space Optics	155 - 1000 Mbps	-	0.1 - 1.25 mi
Ultra Wideband (UWB) Radio	20 - 100 Mbps	?	?

[1] Nominal maximum indoor ranges
[2] Using supplemental antenna systems

Unlicensed Spectrum Technologies

Note: Table does not represent all the unlicensed spectrum technologies addressed in the report; nor is it completely indicative of the technologies' potential.

Licensed Spectrum Technologies

As indicated by the billions of dollars spent in recent auctions, licensed spectrum technologies are expected to become a valuable commodity. Many of the new broadband services/technologies are reviewed, including:

- Local Multipoint Distribution Service (**LMDS**): LMDS is a high-speed, wireless networking technology/service that operates in the 28-31 GHz range.
- Multichannel Multipoint Distribution Service (**MMDS**): MMDS is a 2-3 GHz technology/service to provide wide-area, high-speed, wireless networking.
- Wireless Communication Service (**WCS**) and General Wireless Communication Service (**GWCS**): WCS and GWCS are 2 and 5 GHz technologies/services, respectively, that may be used for fixed or mobile communication.
- Broadband Personal Communication Service (**Broadband PCS**): Broadband PCS systems operate within both the 1900 MHz PCS bands and the 800 MHz digital cellular bands. Emphasis is placed on use of the PCS spectrum. The report also address both fixed and mobile systems, including second generation (**2G**), enhanced second generation (**2.5G**), and third generation (**3G**) PCS.
- Satellite Services: Satellite systems provide the means to extend services to underdeveloped urban areas as well as the suburban and rural markets. The report introduces the **Teledesic** and **SkyBridge** broadband LEO systems, as well as a new broadband GEO system called **SkyDSL**.
- Digital Television (DTV): **DTV** is unique to the study. It's the only technology reviewed that's intended for broadcast only communication. However, the technology offers public safety and transportation agencies an effective (and possibly inexpensive) means of disseminating broadband multimedia.

Local Multipoint Distribution Service (LMDS)	~ 155 Mbps	~ 3.5 mi
Multichannel Multipoint Distribution Service (MMDS)	~ 37 Mbps	~ 30 mi
Wireless Communication Service (WCS)	~ 30 Mbps	~ 30 mi
General Wireless Communication Service (GWCS)	~ 30 Mbps	~ 30 mi
Broadband Personal Communication Service (Broadband PCS)		
Mobile Systems	0.144 - 2.048 Mbps*	~ 3 - 5 mi
Fixed Systems	~ 2+ Mbps	~ 3 - 7 mi
Satellite Service		
Teledesic	2 - 64 Mbps	global
SkyBridge	2 - 100 Mbps	global
SkyDSL	0.500 Mbps	North America
Digital Television (DTV) Alternative	19 Mbps	1 - 30 mi

Licensed Spectrum Technologies

Note: Table does not represent all the licensed spectrum technologies/services addressed in the report; nor is it completely indicative of the technologies' potential.

Summary

The JPO's initial study of broadband wireless and integrated service technologies is being conducted in two phases: an initial research effort, and a supplemental phase to develop a concept prototype. This overview summarizes the first phase of the study. The phase II report ***Broadband Wireless, Integrated Services, and Their Application to ITS: Prototyping*** will be available at the end of the calendar year (2001).

Phase I: Researching Broadband Wireless and the Integrated Service Platform

With significant advances in capacity and reliability, broadband wireless technologies now offer strong alternatives to wireline solutions. They also support the "anywhere" aspect of multimedia service provisioning. And as opposed to conventional broadband wireless, most are (or will soon be) more widely available, offer greater flexibility (i.e., better coverage for more users), offer better performance (e.g., larger data rates, enhanced quality-of-service), and are less expensive.

Additionally, most wireless systems are usually deployed in less time and with less cost than wireline alternatives – whether by public or private service provider. Some are also capable of rapid deployment (within days or even hours) in emergency situations.

In the initial phase, over fifty new broadband wireless technologies were reviewed. However, by the time the report is published and distributed, many changes will have occurred, and new technologies will have emerged. The industry is extremely dynamic and must be followed continuously.

The transition to integrated services is also underway, and with the development of the MSAD, this capability is no longer restricted to the major carriers. In relatively inexpensive fashion, the MSAD can bundle voice, data, and video services for transmission over a single link. MSADs efficiently integrate the services; broadband wireless provides the high-speed and flexible connectivity.

For ITS, these technologies present several ways to rapidly exchange information between fixed, transportable, and mobile units, supporting any number of applications. Broadband wireless has already begun to appear in the transportation and public safety domains, particularly traveler information, traffic management, emergency/incident management, and law-enforcement. As ITS develops, the numbers and types of transportation-related applications will grow. The ability to support these applications with the developing broadband wireless and integrated service technologies could provide significant technical and financial benefits.

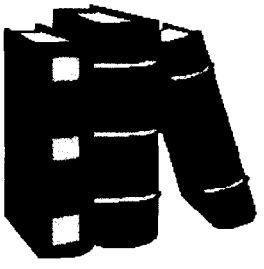
Phase II: Concept Prototyping

During the second phase of this effort, a prototype was established to demonstrate the concept. While we focus on the technical capabilities and performance of the prototype, we also address the potential financial benefits.

Laboratory testing is complete, and field-testing has begun. Hosting the field effort are the New York State Thruway Authority (NYSTA) and the New York Department of Transportation (NYDOT). From a technical perspective, the agencies presented an ideal scenario. In addition, this particular scenario addresses institutional matters, such as interagency service provisioning. Further detail of the prototype design and functionality, the test location and facilities, and the demonstration and evaluation process will be provided in the Phase II report.

Resources and Contacts

To learn more about broadband wireless, integrated services, and the application of these technologies to Intelligent Transportation Systems, refer to the following resources and contacts.



Broadband Wireless, Integrated Services, and Their Application to ITS, Biesecker, Keith, Mitretek Systems, June 2000.

ITS Electronic Data Library (EDL)

http://www.itsdocs.fhwa.dot.gov/jpodocs/repts_te/@5_01!.pdf

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16. Abstract

This document introduces some of the newer broadband wireless communications technologies and describes how they could be used for high-speed connectivity between fixed, transportable, and mobile systems. We also describe the new integrated service technologies – devices used to bundle voice, data, and video services for transmission over a single link. In the case of this effort, it's a broadband wireless link.

Together, broadband wireless and integrated service technologies can be used to provide efficient, cost effective, and flexible multi-service provisioning. We introduce this concept and discuss its potential for Intelligent Transportation Systems (ITS).

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