3. TRANSACTION PROCESSING

Transaction processing is a rudimentary data tool in which the information is either logical (i.e., true/false in-service/out-of-service) or alphanumeric. The transactions generally occur between two unique entities and are quite short in duration. As such the channel access technology tends to be packet oriented as opposed to circuit oriented. Examples which fall into this category include automatic caller identification, user status, vehicle location, order entry and database inquiry.

Transaction processing usage will increase significantly over the next decade as more users avail themselves of the efficiencies these services can provide. Diverse occupations from parking "meter maids" (number of unpaid tickets), to elevator service technicians (parts availability and service history) and from long haul truckers (location and status) to railroad yard managers (car location and availability) will utilize the benefits these data systems can provide. While these transactions are highly spectrally efficient, the future volume of these services will require significantly more spectrum than is currently available.

4. FAX

Facsimile as defined here is a mobile version of the service prevalent today over the land line network. The information being transmitted is generally contained on single sheets of paper as a black and white image and the primary content is alphanumeric. The resolution and

quality of the received information is modest. The user interface for reception could be either a printer or some type of display terminal. Landline usage has skyrocketed over the past five years and this trend will evolve to the wireless world. Government and industry will demand the significant efficiencies these services can bring. Again, spectrum requirements for this critical communications tool will be significant.

5. SNAPSHOT

The snapshot is a communications tool which goes beyond facsimile. It provides much higher resolution, gray scale and/or color, and could contain a much higher proportion of non-alphanumeric information. Examples of snapshot service would include the transmission of a photograph (mugshot) of a criminal suspect to a police officer in the field or the transmission of a picture of a crime scene from the field to laboratory technicians. In this latter case, the input device could be some type of a video snapshot camera with a data interface to the communication system. However, we should not limit our snapshot thinking to purely visual applications. The combination of sensor technology and powerful microcomputers could yield the "chemical snapshot" of a potentially hazardous material. This snapshot could be compared against a database of known materials to provide near instantaneous recommendations to field personnel concerning appropriate action to take.

6. DECISION MAKING

This tool is a data service which distinguishes itself from

transaction processing in the amounts of information that are required and how the information is used. This service generally involves significantly larger data transactions than occur in transaction processing described above, and usually involves combining and/or manipulating information by the end user. Examples of such applications include an insurance salesman who would aggregate potential customer information at a remote location and pair it with statistical information drawn from a database to provide an analysis and quotation for an insurance policy. When the quote is accepted, the salesman could electronically "write" the policy, and place the policy in force immediately. Alternately, an engineer could consult a remote product or system database, propose significant technical changes and receive an immediate response on the viability of these changes.

Decision making usage will increase through the decade as access tools and database applications become more readily available. Spectrum requirements for such transactions will be significant, growing with the creativity of end users who will "invent" their own applications.

7. SLOW VIDEO

This communications tool will provide high resolution color images at modest frame rates (i.e., approximately one frame per second). It is envisioned that this service would provide information either on a real time basis or a convenience store and forward basis. In the first case, emergency medical technicians could provide visual information of patient injuries to a doctor specializing in certain types of trauma. For this application, there is a requirement for both high resolution and color;

however, a scan rate of approximately one frame per second is quite adequate. In the case of convenience store and forward applications, an insurance adjuster could provide a visual, voice annotated record of a disaster. Since the information is required expeditiously, but not immediately, it could be packetized and forwarded through the system when there are lulls in the higher priority traffic. This approach might provide the information within tens of minutes rather than at the end of the day and relieve the travel burden for insurance field personnel at the end of the day.

8. PICTURE PHONE

This service would provide a color video image of the individual being communicated with within a telephone-type service. The content of the image would be restricted to human faces and the scan rates would be consistent with the minimum amount of motion that would occur in the image. This type of communication service could be used to enhance normal voice telephone particularly where visual identification is desirable. The shy or reluctant user could have the ability to restrict the use of his or her image when appropriate. The penetration rate of such a service will, again, start slowly, but gather significant momentum by the end of the decade. Spectrum allocations must be available to meet this demand.

These eight types of communications tools afford the flexibility and efficiency necessary to increase real-time decision making capability and productivity. Technology can provide these tools to the "Smart Worker of the Future" if adequate spectrum is made available and an appropriate

regulatory framework supporting best fit solutions is adopted. From the user's perspective, spectrum allocations and accompanying regulation must support the following capabilities in employing the tools emerging technologies can offer:

-System tailoring to unique and specialized needs;

-Integrated information, messaging and voice communications;

-Support for both individuals and their dynamically changing work groups;

-Communications optimized to the users location;

-Accommodation of changing and presently unforeseen applications and;

-Provision of best fit solutions at the most economical cost.

However, just as today, no one solution will meet all users' needs. Multiple solutions will be required to provide the range of coverage, features and cost demanded by U.S. business, governmental agencies and consumers. A full range of new products and services are being created for a variety of private and public systems. These systems will offer expanded capabilities, including the eight communications tools discussed above. While multiple systems will be necessary to meet these requirements, new technologies will enable interoperability between various private and public systems as user needs dictate.

Though total flexibility may be attractive from a regulatory standpoint, the basic structure which has been used for mobile spectrum allocations in the U.S. has contributed greatly to the success of mobile telecommunications. Amalgamating all requirements into one relatively undefined block will significantly complicate the standards process,

thereby delaying introduction of these important wireless services to the public. Under such a scenario, products will necessarily be more complex and expensive and the requirement to meet all needs in one package will necessitate design compromises not to the users' benefit.

Historically, private land mobile users and manufacturers have been able to quickly respond to new spectrum allocations with innovative products and systems, in contrast to public allocations where the licensing and standard setting process inherently are significantly more complex. For example, at 800 MHz, private systems were available and operating more than five years before public cellular systems.

VII. CONCLUSION

Spectrum availability, not technology is the stumbling block that must be overcome to realize leadership for Emerging Technologies such as PCS in the U.S. market. Motorola is committed to developing communications technologies and products needed by U.S. businesses, governmental agencies and the public at large. We trust the Commission is equally committed to making available sufficient spectrum allocations and appropriate regulations without delay, especially since the important communications requirements of incumbent fixed users can be reaccommodated in alternative bands with no loss of reliability.

Just as today, no one system will meet all users needs. As the Commission takes the next step to define a regulatory structure for PCS service in the emerging technology bands, service specific allocations for private individual, private shared, and public systems will be required. This mix of services better meets the broad range of user needs and

provides competitive alternatives that drive each service to deliver the best possible solution at the lowest cost. Also, use of a service specific plan simplifies the standards process allowing faster product introduction.

CERTIFICATE OF SERVICE

I, Kelle Gardner, of Motorola Inc., do hereby certify that on this 8th day of June, 1992, a copy of the foregoing Comments was sent to each of the following by first class mail, except where hand delivery is noted (*):

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APPENDIX A

GLOBAL STATUS OF CELLULAR

The World Report '92

By Shawn P. Steward, editorial assistant

Look here for the cellular status of the world.

Take a trip around the world. The customs, the food and the languages vary widely. However, one thing that is becoming increasingly similar around the globe is the availability of cellular service. Each year we march closer to our goal of worldwide cellular service. Now, *Cellular Business* highlights this advancement with the expanded World Report. Most of the information for this report was provided courtesy of the U.S. Department of Commerce Office of Telecommunications. This year, start-up dates, the number of subscribers and the system suppliers were added to the list. So turn the pages, travel from Algeria to Zambia and discover the details of cellular's push to blanket the Earth.

If you have any information to update this report, please contact Shawn Steward, editorial assistant of *Cellular Business*; P.O. Box 12901, Overland Park, KS 66282-2901; 913-967-1790.

WORLD CELLULAR MARKET BY SYSTEM TYPE

System Type	Number of Subscribers	Percent of Total Subscribers	Number of Countries
AMPS	8,174,448	59.4	42
TACS	2,214,860	16.1	21
NMT 900	906,650	6.6	9
NMT 450	892,600	6.5	24
Other 800	860,960	6.3	1
Other 450	711,190	5.2	11
Total	13,760,708	100	108

Some countries are counted more than once if they have multiple systems of different types.

UNDER CONSTRUCTION		UNDER STUDY	
Bangladesh	India	Bulgaria	Romania
Botswana	Kenya	Ecuador	Tonga
Colombia	Nigeria	Iran	Vietnam
Ghana	Paraguay	Laos	Zambia
Greece	Poland	Panama	

These countries are building or studying cellular systems.

TOP 10 CELLULAR PENETRATION RATES

Country	Number of Subscribers	Percent of Population	Years in Service
1. Sweden	564,060	6.7	11
2. Finland	276,110	5.8	10
3. Norway	227,240	5.4	10.5
4. Iceland	12,240	5.1	6
5. Denmark	168,900	3.2	10.5
6. Hong Kong	168,420	3.0	8.5
7. Switzerland	164,080	2.9	4.5
8. Faeroe Islands	1,330	2.8	3.5
9. United States	7,557,148	2.6	8.5
10. Singapore	66,000	2.4	4

The Nordic countries lead the world in penetration rates.

COUNTRY	SYSTEM	START-UP	SUBSCRIBERS	OPERATORS	SUPPLIER(S)
Algeria	900-NMT	12/89	*	PTT	Nokia
Andorra (Spain)	450-NMT	7/90	380	STA	*
Anguilla	800-AMPS	*	*	Boatphone	*
Antigua	800-AMPS	*	*	Boatphone	*
Argentina	800-AMPS	11/89	20,000	CRM	Motorola
Australia	800-AMPS	2/87	330,230	Telecom Australia	Ericsson
Austria			total 103,620		
	450-NMT	11/84	63,920	PTT	Motorola
	900-TACS	7/90	39,700	PTT	Motorola
	900-GSM	1991	0	PTT	Siemens/Alcatel/ Kapsch/Schrack
Bahamas	800-AMPS	1988	*	BATELCO	Northern Telecom
Bahrain	900-TACS	9/86	6,240	Bahrain Telecom	NEC
	900-GSM	1994	0	*	
Bangladesh	*	1991	0	Hutchison	Motorola
Barbados	800-AMPS	1990	*	*	*
Barbuda	800-AMPS	*	*	Boatphone	*
Belgium	450-NMT	7/87	46,950	Belgian RTT	Bell/Nokia
Bermuda	800-AMPS	2/87	1,400	Bermuda Cellular	Northern Telecom
Bolivia	800-AMPS	1990	*	TCB	Motorola
Botswana	*	1992	0	Botswana Telecom	tendered
Brazil			total *		
	800-AMPS-A	1990	*	Telebrasilia	NEC
	800-AMPS-A	8/90	7,500	Telerj	Northern Telecom
	800-AMPS-B	1992	0	*	*
	800-AMPS-A	1992	0	Telepar	*
Brunei	800-AMPS	8/89	3,500	Jabatan Telecom	Motorola
Byelorussia	450	1991	0	US Commstruct	*
Canada			total 812,903		
	800-AMPS	7/85	*	Bell Cellular	Northern Telecom
	800-AMPS	1/86	*	Cantel	Ericsson
Cayman Islands	800-AMPS	1987	*	Cable & Wireless	Plexsys
Chile			total 21,500		
	800-AMPS	3/89	*	CTC Cellular	Ericsson/NEC
	800-AMPS	5/89	*	CIDCOM	NovAtel
	800-AMPS	6/91	*	Telecom Chile	Motorola
	800-AMPS	*	*	VTR Telecom	*
China			total 37,100		
	900-TACS	88/89	32,100	BTA SPTA Guangzhou PTT	Motorola Ericsson NovAtel
	450-NMT	1986	5,000	*	*
Colombia	*	1992	0	*	*
Costa Rica	800-AMPS	5/89	2,5000	Millicom	NovAtel
Curacao	800-AMPS	*	*	Setel	*
Cyprus	900-NMT	12/88	4,470	Cyprus Telecom Auth.	Ericsson
Czechoslovakia	450-NMT	10/91	*	Eurotel-Prague/Bratislava	Nokia
Denmark			total 168,900		
	450-NMT	1/82	51,730	PTT	Ericsson/Mobira/Radiosystem Sweden
	900-NMT	12/86	117,170	PTT	Ericsson/Philips/Radiosystem Sweden/Mitsubishi
	900-GSM	4/92	0	PTT	Ericsson
	900-GSM	3/92	0	Dansk Mobil	Nokia
Dominican Republic	800-AMPS	3/87	3,500	CODETEL	Motorola/AT&T
Ecuador	*	*	0	tendered	
Egypt			total 5,600		
	800	1979	2,600	ARENTO	Matsushita
	900-TACS	5/87	3,000	ARENTO	*
El Salvador	800-AMPS	1992	0	Telemovil El Salvador	Ericsson
Estonia	450-NMT	1/91	550	Eesti Mobile	Ericsson
Faeroe Islands	450-NMT	1/89	1,330	Foroya Lodtings	Ericsson
Finland			total 276,110		
	450-NMT	3/82	148,780	PTT	Ericsson/Mobira/Radiosystem Sweden/Mitsubishi

*Information unavailable as of press time.

COUNTRY	SYSTEM	START-UP	SUBSCRIBERS	OPERATORS	SUPPLIER(S)
Finland (cont.)	900-NMT	12/86	127,330	PTT	Ericsson/Mobira/ Radiosystem Sweden
	900-GSM	1991	0	PTT	Ericsson/Orbitel
	900-GMS	1991	0	Radiolinja	Nokia/Simens/Philips
France			total 276,110		
	200-400	11/85	273,000	France Telecom	Matra/Alcatel
	450-NMT	4/89	79,000	Ligne SFR	Mobria/Alcatel
	900-GSM	1991	0	*	ECR 900
Germany	450-C	5/86	469,280	DB Telekom	Siemens/Alcatel
	900-GSM	1991	0	DB Telekom	SMCS 900/ECR 900
	900-GSM	1991	0	Mannesman Mobilfunk	Ericsson/Siemens
Ghana	900-TACS	9/91	0	Millicom	Motorola
Greece	900	1992	0	Hellenic Telecom Org.	*
Grenada	*	*	*	Grentel Boatphone	*
Guatemala	800-AMPS	1990	800	Millicom	Motorola
Hong Kong			total 168,420		
	900-ETACS	9/89	39,200	Pacific Link	Ericsson
	900-TACS	1/84	53,000	CSL	NEC
	800-AMPS	6/85	40,220	Hutchison	Motorola
	900-TACS	1/89	36,000	Hutchison	Motorola
Hungary	450-NMT	10/90	5,630	Hungarian Cellular	Ericsson
	900-TACS	1991	0	Contel	*
Iceland	450-NMT	7/86	12,240	PTT	Ericsson/Radiosystem Sweden
India	900-TACS	*	0	ONCG, DOT	tendered
Indonesia			total 22,100		
	450-NMT	1982	15,000	PT Telecom	Ericsson
	900	1985	5,500	*	*
	800-AMPS	11/91	*	Perumtel	Motorola
	800-AMPS	8/91	1,600	Perumtel	Motorola
Iran	*	92/93	0	Iranian PTT	*
Ireland	900-TACS	12/85	29,080	Telecom Eireann	Ericsson
Israel	800-AMPS	3/86	21,350	Motorola Tadiran	Motorola
Italy			total 496,220		
	450-RTMS	9/85	82,530	SIP	Italtel
	900-ETACS	5/90	413,690	SIP	Ericsson/Italtel
	900-GSM	1991	0	SIP	Matra/Telettra/Orbitel/ Marconi/Italtel/Alcatel
Jamaica	*	*	0	Jamaica Telephone	*
Japan	800-900		total 1,089,160		
	NTT	12/79	668,000	NTT	NEC
	NTT	12/88	192,960	Nippon Idou	NEC/Motorola
	JTAC	4/89	228,200	Daini Denden	Motorola
	JTAC	10/91	*	Nippon Idou	Motorola
	*(digital)	1993	0	Tuka Cellular	*
	*(digital)	1993	0	Tokyo Digital Phone	*
	*(digital)	1993	0	Kansai Cellular	*
Kenya	900-TACS	1990	*	*	NEC
Korea	800-AMPS	4/84	143,800	Korea Mobile Telecom	Motorola/AT&T
Kuwait	900-ETACS	9/86	0	Kuwait MTSC	NEC/Ericsson
	900-GSM	1994	0	*	*
Laos	800-AMPS	1/92	0	PTT	*
Latvia	450-NMT	1991	0	PTT	*
Lebanon	*	*	0	Spacetel	*
Lithuania	450-NMT	1991	0	PTT/Millicom	*
Luxembourg	450-NMT	8/85	830	PTT	Ericsson
Macao	900-TACS	11/88	3,900	*	Ericsson
Malaysia			total 129,060		
	450-NMT	3/85	69,000	Jabatan Telekom	Ericsson/Radiosystem Sweden
	900-ETACS	8/89	60,060	Celcom	Ericsson
	800-AMPS	*	0	STM/PTT	*
Malta	900-ETACS	7/90	1,800	Telemalta	Ericsson
Mauritius	900-ETACS	6/89	700	Comvik/Emtel/Millicom	NovAtel
Mexico	800-AMPS	1990	110,000	TELMEX/SOS/ regional companies	Ericsson/Motorola/ Northern Telecom
Morocco	450-NMT	1988	1,000	ONPT	Ericsson
Netherlands	450-NMT	1/85	28,800	PTT	Ericsson/Philips
	900-NMT	1/89	80,650	PTT	Mobira/Radiosystem Sweden

*Information unavailable as of press time.

COUNTRY	SYSTEM	START-UP	SUBSCRIBERS	OPERATORS	SUPPLIER(S)
Netherlands (cont.)	900-GSM	1991	0	PTT	ECR 900
Netherlands Antilles	800-AMPS	*	*	Boatphone	*
New Zealand	800-AMPS	8/87	62,700	Telecom Cellular	Ericsson
	900-TACS	6/92	0	Bell South	*
Nigeria	900-TACS	1990	*	*	Ericsson
Norway			total 227,240		
	450-NMT	11/81	147,340	Telemobil/PTT	Ericsson/Mitsubishi
	900-NMT	12/86	79,900	Telemobil/PTT	Ericsson/Mitsubishi
	900-GSM	1991	0	Telemobil/PTT	Ericsson/Mobira/Radiosystem Sweden/Mitsubishi
	900-GSM	9/92	0	Netcom	*
Oman	450-NMT	5/85	3,300	PTT	Ericsson
Pakistan			total 4,770		
	800-AMPS	11/90	3,340	Paktel	Ericsson
	800-AMPS	12/90	1,430	Pakcom	Ericsson
Panama	*	1992	0	INTEL	*
Paraguay	800-AMPS	1992	0	Telecel	*
Peru	800-AMPS	4/90	4,700	Telemovil/Cell. Intl.	NovAtel
	800-AMPS	7/91	*	CPT	*
Philippines			total 33,000		
	800-AMPS	5/87	32,000	Piltel	NEC
	800-AMPS	1/90	1,000	Extelcom	AT&T
	800-AMPS	2/91	*	Islacom	Motorola
Poland	450-NMT	1991	*	PTT	*
Portugal	450-C	1/89	10,450	CTT	Siemens
	900-GSM	1992	0	Telecel	*
Puerto Rico	800-AMPS	*	*	PR Telephone/Warren Oil	*
Qatar	*	1982	3,300	*	*
	900-GSM	1994	0	*	*
Russia	450-NMT	6/91	0	LCNA/US West	Nokia/Ericsson
	450-NMT	12/91	*	MCC	Ericsson
Samoa (American)	800-AMPS	1987	450	*	Motorola
Saudi Arabia	450	9/81	18,000	Saudi Telecom	Philips/Ericsson
Singapore			total 66,000		
	800-AMPS	8/88	63,000	Singapore Telecom	NEC
	900-ETACS	6/91	3,000	Singapore Telecom	Ericsson
	900-GSM	1993	0	*	*
South Africa	450-C	5/86	8,790	PTT	Siemens
Spain			total 91,890		
	450-NMT	11/82	65,170	CTNE	Ericsson
	900-TACS	1990	26,720	CTNE	Motorola
	900-GSM	1991	0	CTNE	Ericsson/Motorola
Sri Lanka	900-ETACS	7/89	1,900	Celltel Lanka	Motorola
St. Kitts/Nevis	800-AMPS	1989	*	Boatphone	Plexsys
St. Lucia/ St. Vincent/ Grenadines	800-AMPS	*	*	Boatphone	*
St. Maarten	800-AMPS	1989	*	E. Caribbean Cellular	*
St. Martin/ Bartholemy	800-AMPS	9/91	*	St. Martin Mobiles	Plexsys
Sweden			total 564,060		
	450-NMT	10/81	247,010	Televerket	Ericsson/Mobira/Radiosystem Sweden
	450	8/81	17,000	Comvik	*
	900-NMT	12/86	300,050	Televerket	Ericsson/Mobira/Radiosystem Sweden/Mitsubishi
	900-GSM	1992	0	Televerket	Ericsson
	900-GSM	1992	0	Comvik	Motorola/Siemens
	900-GSM	9/92	0	NordicTel	Nokia
Switzerland	900-NMT	9/87	164,080	PTT	Ericsson
Taiwan	800-AMPS	1989	168,000	DGT	Ericsson
Thailand			total 124,600		
	450-NMT	7/86	43,000	TOT	Ericsson/Nokia/Radiosystem Sweden
	800-AMPS	2/87	45,000	CAT	Motorola

*Information unavailable as of press time.

COUNTRY	SYSTEM	START-UP	SUBSCRIBERS	OPERATORS	SUPPLIER(S)
Thailand (cont.)	800-AMPS	9/91	3,600	TAC	Motorola
	900-NMT	10/90	33,000	Advanced Info	Nokia
	900-GSM	1994	0	*	*
Tonga	*	1993	0	*	*
Trinidad/Tobago	800-AMPS	12/91	*	TSTT	*
Tunisia	450-NMT	4/85	1,000	PTT	Ericsson
Turkey	450-NMT	10/86	43,310	PTT	Mobira
	900-GSM	1993	0	*	*
United Arab Emirates	900-TACS	3/89	26,070	Etisalat	Ericsson
	900-GSM	1994	0	*	*
United Kingdom			total 1,205,000		
	900-TACS,	1/85	525,000	Cellnet	Motorola
	ETACS	12/87	608,000	Vodaphone	Ericsson
	900-GSM	1991	0	Cellnet	Motorola/Nokia
	900-GSM	1991	0	Vodaphone	Ericsson/Orbitel
United States	800-AMPS	10/83	7,557,148	A- and B-system operators	Motorola/AT&T/NEC/ Ericsson/Astronet/ Northern Telecom
Uruguay	800-AMPS	1991	0	Abiatar	*
Venezuela	800-AMPS	1988	8,000	CANTV	Ericsson
	800-AMPS	1991	0	Telcel	Motorola
Vietnam	*	1993	0	*	*
Virgin Islands (British)	800-AMPS	12/86	120	CCT Boatphone	Plexsys
Yugoslavia	450-NMT	6/90	*	Zagreb PTT	Ericsson/Radiosystem AB
Zaire	800-AMPS	5/88	*	Telecel	Motorola/Plexsys
	800-AMPS	*	0	Express Communications	*
Zambia	*	*	0	Cellular Systems	Motorola

*Information unavailable as of press time.

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- Motorola 8000/9000/ultraclassic
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- GE pocketfone and Ericsson Hot Line
- Audiovox Minivox
- Mitsubishi 3000/DiamondTel 99X
- Technophone 205A/TP2

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APPENDIX B

RELIABILITY COMPARISONS FOR 2 AND 6 GHZ

Technical Aspects of Reaccommodation

Question:

What are the technical implications of reaccommodation of an existing point-to-point microwave link in the 2 GHz band to another frequency band, in particular, the 6 GHz band?

Reaccommodation should attempt to maintain overall system performance as perceived by the user. In a microwave link this usually means maintaining both equipment availability and path availability. Cost to reaccommodate is not considered in this analysis.

Equipment Availability

Equipment availability can be maintained by using equipment with a similar MTBF (mean time between failures) and a similar MTTR (mean time to repair). If the existing radios are "protected", that is, they have redundant modules waiting in standby mode, the new radios must also be protected in order to have approximately the same perceived equipment "unavailability". Unavailability is the fractional downtime of a system. For equipment,

$$\text{Unavailability (equipment)} = \text{MTTR}/(\text{MTTR} + \text{MTBF})$$

Path Availability

Path availability can be maintained through careful link design. Since going to a higher frequency channel reduces the ground clearance required to maintain line of sight, usually additional repeater sites or major changes in the tower or site buildings are not needed. A higher frequency increases free space path loss between isotropic antennas, but antenna gain also increases, for a given diameter dish. Higher frequency also implies more outage due to multipath fading, for a given fade margin on the link. All these factors tend to cancel out somewhat so that performance on a line of sight path is not very frequency dependent in the range 1 to 10 GHz. Above 10 GHz, rain attenuation cannot be neglected, and rain induced outages usually dominate above 15 GHz. Extremely good availability cannot be achieved at 18 or 23 GHz except on very short paths.

Examples

The effects of reaccommodation of 2 GHz links on 6 GHz can be illustrated by some examples. Typical performance of analog FDM-FM radios will be assumed.

Example 1: A Typical Path

Path length of 40 km (24.4 mi.) over average terrain

At 1.9 GHz:

Antennas:	8 foot diameter, 31.1 dBi gain
Cables:	7/8" air coax, 200 feet, 3.6 dB loss
Tx power:	+34 dBm
Rx sens.:	-82 dBm

This yields

Path Loss:	130.0 dB	
Fade Margin:	40.0 dB	
Unavailability:	1.79 E -6	56 seconds per year (path)

At 6.6 GHz:

Antennas:	8 foot diameter, 42.0 dBi gain
Cables:	Elliptical waveguide, 200 feet, 3.4 dB loss
Tx power:	+30 dBm
Rx sens.:	-81 dBm

This yields

Path Loss:	140.8 dB	
Fade Margin:	45.6 dB	
Unavailability:	1.75 E -6	55 seconds per year (path)

Compare this to equipment unavailability at 1.9 GHz or 6.6 GHz (radios only, protected configuration, hot standby):

MTTR:	4 hours (typical)	
MTBF:	300,000 hours (one protected terminal)	
Unavailability:	2.66 E-5	841 seconds per year (link)

Note that equipment outage will last about 4 hours but will occur on a protected link only once every 17 years on average.

Path outage on the other hand occurs randomly throughout the year, with a greater tendency toward fading during hot, humid, calm nights. Average outage duration with a 40 dB fade margin is a few seconds.

Example 2: A Long Path

Path length of 63 km (39 mi.) over average terrain

At 1.9 GHz:

Antennas:	8 foot diameter, 31.1 dBi gain
Cables:	7/8" air coax, 200 feet, 3.6 dB loss
Tx power:	+34 dBm
Rx sens.:	-82 dBm

This yields

Path Loss:	134.0 dB
Fade Margin:	35.9 dB
Unavailability:	1.82 E -5 574 seconds per year (path)

At 6.6 GHz:

Antennas:	8 foot diameter, 42.0 dBi gain
Cables:	Elliptical waveguide, 200 feet, 3.4 dB loss
Tx power:	+30 dBm
Rx sens.:	-81 dBm

This yields

Path Loss:	144.8 dB
Fade Margin:	42.1 dB
Unavailability:	1.51 E -5 477 seconds per year (path)

Longer paths than this one are rare. This is due in part to the fact that long paths require high antennas for line of sight, due to earth curvature. This implies mountain-top site locations or very tall towers with long feedline runs and associated losses. In addition, for analog radio systems, a 35 dB fade margin is necessary to maintain a 60 dB S/N on the voice channels when there is no fading. (This S/N degrades smoothly to 30 dB as signals fade to Rx sensitivity.) Maintaining high fade margin as path length increases is difficult.

For a long path like this, the outage time, or the time that the link is faded and unavailable, may be somewhat excessive for certain applications, but 6 GHz is no worse than 2 GHz.

Example 3: A Short Path

Path length of 10 km (6.1 mi.) over average terrain

At 1.9 GHz:

Antennas:	8 foot diameter, 31.1 dBi gain
Cables:	7/8" air coax, 200 feet, 3.6 dB loss
Tx power:	+24 dBm
Rx sens.:	-82 dBm

This yields

Path Loss:	118.0 dB	
Fade Margin:	42.0 dB	
Unavailability:	1.8 E -8	0.6 seconds per year (path)

At 6.6 GHz:

Antennas:	8 foot diameter, 42.0 dBi gain
Cables:	Elliptical waveguide, 200 feet, 3.4 dB loss
Tx power:	+13 dBm
Rx sens.:	-81 dBm

This yields

Path Loss:	128.8 dB	
Fade Margin:	40.6 dB	
Unavailability:	8.6 E -8	2.7 seconds per year (path)

Many paths are short like this one.

The path outage is almost zero in both cases.

Notice that the transmitter power had to be reduced. This is an FCC regulation and applies to paths shorter than 17 km (10 miles). See FCC Part 94, under 94.79.

Comments

As can be seen from these three examples, most 2 GHz point-to-point radio links should be able to be moved to 6 GHz while maintaining equivalent path availability.