

REFLEX™ RULES !

**The Role of Pervasive
Low-Cost Networks and Devices
in the Future of Mobile Data Messaging**

A Sag Harbor Group White Paper

Copy #: _____

Confidentiality and Other Preliminaries

The information contained in this memorandum with respect to the ReFLEX™ technology and wireless messaging in general is being made available on a confidential basis by Sag Harbor Group. This memorandum should be read in conjunction with any additional information that has been included in the Appendix. The information contained herein has been obtained from sources that SHG believes to be reliable. However, SHG makes no representations or warranties expressed or implied as to its accuracy or completeness. Sag Harbor Group acknowledges the assistance and support of the ReFLEX™ Alliance, but all views expressed here are those of Sag Harbor Group.



SHG TEAM

JAMES S. HENRY
MANAGING DIRECTOR
SAG HARBOR GROUP

ED RESOR
SENIOR CONSULTANT

DAN BENDERLY
SENIOR CONSULTANT

SAG HARBOR GROUP
201 OFFICES AT WATER ST.
SAG HARBOR, NEW YORK 11963
631-725-5202
631-725-7994 (FAX)
JHENRY@SAGHARBOR.COM

Table of Contents

<u>SECTION</u>	<u>PAGE</u>
I. Executive Summary	5
II. Introduction – So What Became of the “Mobile Wireless Revolution”?	9
<i>1. Why Yet Another Wireless White Paper?.....</i>	<i>10</i>
<i>2. Great Expectations.....</i>	<i>10</i>
<i>3. Return to Earth.....</i>	<i>12</i>
III. DoCoMo’s Lessons	17
<i>1. Introduction - Japan’s Exceptionalism</i>	<i>18</i>
<i>2. Japan’s Mobile Internet Takeoff</i>	<i>18</i>
<i>3. Key Market Conditions for i-mode’s Success.....</i>	<i>19</i>
<i>4. The Rise of SMS Messaging.....</i>	<i>22</i>
<i>5. NTT DoCoMo’s Key Strategic Choices.....</i>	<i>28</i>
<i>6. Beyond i-mode → 3G’s Inevitability?.....</i>	<i>32</i>
<i>7. Implications for 3G’s Future Elsewhere.....</i>	<i>33</i>
<i>8. What Do Customers Really Want?.....</i>	<i>38</i>
<i>9. Key Implications, DoCoMo’s Experiment</i>	<i>40</i>
<i>10. Conclusion – DoCoMo’s Lessons.....</i>	<i>42</i>
IV. ReFLEX™’s Technology – Origins, Key Attributes, and Direction	43
<i>1. Introduction – Key Low-Speed Mobile Data Networks.....</i>	<i>44</i>
<i>2. ReFLEX™’s Origins</i>	<i>46</i>
<i>3. The First Launch – Mistakes and Roadblocks</i>	<i>47</i>
<i>4. ReFLEX™’s Original Technical Attributes</i>	<i>49</i>
<i>5. The Importance of Version 2.7, WCTP, and Other Developments.....</i>	<i>52</i>
<i>6. Summary – The Technical Foundations of ReFLEX™’s Revival.....</i>	<i>57</i>
V. ReFLEX’s Competitive Advantages	58
<i>1. Introduction -- ReFLEX’s Key Competitors.....</i>	<i>59</i>
<i>2. Mobitex™’s Origins, Decline and Revival.....</i>	<i>60</i>
<i>3. Mobitex™’s Strengths and Weaknesses.....</i>	<i>62</i>
<i>4. Summary - Mobitex™’ Vs. ReFLEX™</i>	<i>65</i>
<i>5. Applications “Fit” – Valuing Technical Attributes.....</i>	<i>68</i>
<i>6. The Other Data-Only Network Alternatives.....</i>	<i>69</i>
<i>7. 2.5G – A Threat to Everyone Else?.....</i>	<i>70</i>
<i>8. Summary – ReFLEX’s Competitive Advantages.....</i>	<i>78</i>
<i>9. Conclusion</i>	<i>80</i>
VI. Appendix A: Key Technical Features, ReFLEX™ Version 2.7.....	81
<i>1. Introduction</i>	<i>Error! Bookmark not defined.</i>
<i>2. Background Scanning.....</i>	<i>Error! Bookmark not defined.</i>
<i>3. Auto-Collapse – “Chat Mode”</i>	<i>Error! Bookmark not defined.</i>

4. *Broadcasting Maximum Inbound Message Lengths*.....**Error! Bookmark not defined.**

5. *Unscheduled Inbound Messaging*.....**Error! Bookmark not defined.**

VII. Appendix B: Detailed Comparisons, Key Data Networks..... 86

 1. *Network Comparison Charts*..... 87

 2. *Devices Comparison, ReFLEX[™], Mobitex[™] and DataTAC[™], 2001*..... 93

 3. *Network Cost Comparisons*..... 94

 4. *Applications Fit – Technology Requirements per Application Type (Illustrative)*..... 95

VIII. Appendix C: Glossary of Technical Terms 96

Executive Summary

This study examines the future of mobile data messaging (MDM) in general, and the ReFLEX™ family of low-speed two-way MDM technologies in particular.

ReFLEX™ is today's market share leader in US two-way MDM. It is now on the verge of a major new network upgrade, Version 2.7, and a new series of devices and applications development platforms. So the time is ripe to take a close look at the implications of all these improvements for ReFLEX™'s comparative performance and cost.

This is also a good time to pause and catch our breaths in the worldwide mobile Internet revolution, and pay close attention to some key messages that this so-called "revolution" has been trying to send us. Among the most important are the following:

1. What customers – especially enterprise customers -- really want from mobile data is easy to describe: (1) reliable (2) low cost (3) easy-to-use (4) secure (5) pervasive (6) interoperable MDM. What they *don't want* is what the global cellular voice industry is now desperately trying to sell them – costly upgrades to complex new handsets, the ability to watch video and surf at lighting speed on their cell phones and PDAs, and the poor service quality and costly network expansions associated with realizing this vision.

□ MDM has the chameleon-like property of being disguised by local market conditions. In Japan it takes the form of "i-mode;" in Europe, of person-to-person SMS; in the US, of two-way wireless data-only networks like ReFLEX™, Mobitex™, DataTAC™ and CDPD. Brought to light and aggregated, however the global evidence clearly shows that if there is one killer application for mobile wireless data, it is messaging – email, chat, and information broadcasting – not Web surfing, shopping, or mobile multimedia. (Chapter III.)

□ Unfortunately, if the global cellular industry has its way, what the world might get would be a very expensive two-step upgrade of all existing cellular networks and handsets – first to so-called "2.5G" in the next 2-3 years, and then to even higher-fixed cost 3G networks. Fortunately, under the strain of current economic conditions, this "vision" is now receiving much more critical scrutiny, especially in the US.

□ While 2.5G networks are supposed to offer major improvements for wireless data users over existing circuit-switched data services – including "always on" capability, higher data rates, and lower usage costs – on closer inspection, most of these advantages turn out to be highly questionable, especially for enterprise MDM applications. (Chapter V.)

□ 3G networks, if they are ever built at all, would turn out to be even more dubious, the "HDTV" of wireless networking. They are a costly, ill-conceived kluge of the mobile Videophone, the PocketPC, pay-per-view, and MP3, with little to offer to enterprise customers who just want affordable, reliable, and ubiquitous MDM applications *now*. (Chapter III.)

□ In general, our analysis of low-speed networks, i-mode, SMS, and 2.5G and 3G networks leads us to be deeply skeptical about what has really become ***the central value proposition*** behind the ***\$350 billion+*** 2.5 G and 3G cellular network and handset upgrades now going on around the world. For almost all mission-critical enterprise MDM applications that we can think of, these upgrades will provide virtually *no* discernable improvements in application performance. Indeed, to the extent that enterprises are seduced to adopt the data solutions offered by the cellular voice industry, actual MDM application performance is likely to suffer, even while the total costs of application ownership soar.

2. ReFLEX™’s supporters in the MDM industry are about to deliver a bundle of exciting new network, device and platform capabilities that will sharply improve its performance and costs significantly.

□ A close look at ReFLEX™’s history shows that during its first launch in 1995-2000, its success was limited by a combination of factors, including (1) non-interoperable networks; (2) a shortage of network capacity; (3) the limited number of low-cost, capable devices that it supported; (4) the absence of a standard, “open” applications development platform; and (5) confusion among service providers and network vendors about what ReFLEX™’s core value proposition really was. (Chapter IV.)

□ With this year’s release of ReFLEX™ 2.7, its new WCTP applications platform, the introduction of new low-cost devices, and other improvements, all these technical obstacles will now be overcome. Assuming that ReFLEX™’s service providers are able to relaunch their two-way services, they should now have a very solid technical platform for growth, and millions of enterprise and individual customers to convert to simple, low-cost MDM applications. (Chapter IV.)

□ Compared with other low-speed data networks like Mobitex™, DataTAC™, and CDPD, ReFLEX™’s new capabilities will provide a wide range of crucial technical and economic advantages. (Chapter V.) Among the most important capabilities are:

1. A huge increase in network capacity, on the order of 3-5 times current capacity;
2. Greater support for unparalleled wide-area coverage, in-building penetration, and reliable message delivery;
3. Interoperability and roaming among all ReFLEX™ networks, including those in Canada and Mexico;
4. Significant improvements in latency, enabling applications like instant messaging and real-time transactions;
5. Support for a variety of new low-cost, higher-performance devices,

- 6. A much more flexible, easy-to-use applications development platform, with support for “open systems” languages, development tools like XML and J2ME, and other leading wireless middleware platforms;
- 7. Stronger support for applications that require message broadcasting/simulcasting.

□ Relative to new “2.5 G” network technologies like GPRS and CDMA2000, for the foreseeable future, ReFLEX™ is also likely to offer several key advantages for “mission-critical” MDM applications, including

- 1. Much more reliable messaging, based on superior coverage and in-building penetration;
- 2. Interoperable networks, including support for user-focused, device- and network-agnostic data services;
- 3. Support for much lower-cost, more flexible devices;
- 4. Much better support for specific applications, including information broadcasting, store-and-forward messaging, and low-cost chat;
- 5. Tremendous nation-wide network capacity, supporting very competitive service costs for messaging, and much lower total costs of ownership, especially for enterprise applications. (Chapter V.)

3. Overall, therefore, we are optimistic about the future of low-speed MDM networks in general and ReFLEX™ in particular – assuming that its leading service operators can solve their pressing business problems.

□ The objective of this white paper was not to review the business and financial conditions of ReFLEX™’s main network service providers, Arch Wireless, Skytel/MCI, and Weblink Wireless. Obviously they have their work cut out for them. They must restructure the one-way paging industry’s legacy debts, aggressively invest in and promote ReFLEX™’s new capabilities, develop new channel partners for wireless applications and solutions, recruit new enterprise customers, and much more effectively together, in order to realize ReFLEX™’s new potential. This will not be easy, especially given the current economic environment.

□ However, assuming that the industry can restructure, this network’s reliable, low-cost services should be around for a very long time to come. As these service providers proceed to roll out V.2.7, new devices, and other capabilities over the next few months, we believe that ReFLEX™ deserves a close look from enterprise customers, solutions providers, and investors.



II. Introduction – So What Became of the “Mobile Wireless Revolution”?

1. Why Yet Another Wireless White Paper?

The wireless industry is notorious for burying its hapless customers in a blizzard of conflicting claims and shifting predictions about the capabilities of rival networks, devices, application development platforms, and protocols. Just when it seems that one storm has lifted, another blinding flurry arrives and the trail disappears again.

In the midst of all this confusion, it is important to keep an eye on fundamentals. This white paper starts from the little-regarded fact that, *at least in the US market*, two-way wireless data networks that are based on *the ReFLEX™ platform now account for more wireless data messaging and subscribers than all of the other data networks combined*.

Furthermore, ReFLEX™ is now on the brink of a major new network upgrade, Version 2.7. Its US service providers are also about to offer a whole new generation of messaging devices with outstanding designs and very competitive price/performance. Finally, on the applications development front, ReFLEX™ will soon be able to deliver much more powerful, scalable wireless solutions to enterprise customers as well as to the mass market.

All told, as these initiatives come together over the next few months, this amounts to nothing less than a *relaunch* of the ReFLEX™ platform, as *the* state-of-the-art, low-cost, reliable, easy-to-design and-deploy, pervasive platform for mobile data messaging (MDM) applications. The rest of this white paper is devoted to telling this story, which we regard as one of the (unintentionally) best-kept secrets in the wireless industry today.

2. Great Expectations

At the outset, it will be useful to examine what became of the so-called “mobile wireless revolution” that was so widely predicted just a short while ago, to see what can be learned from the way things actually turned out.

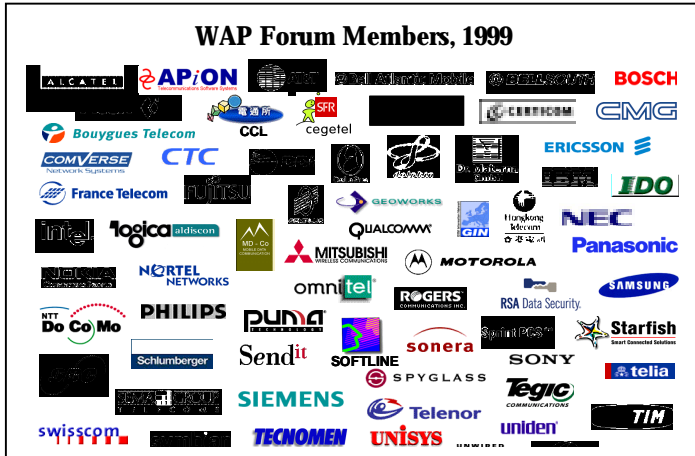
The global wireless industry started this decade with extraordinary expectations. As late as Fall 2000, a wide variety of industry observers were still trumpeting the notion that mobile wireless technology would soon bring the benefits of Internet access and mobile messaging to hundreds of millions of users around the globe. The expectation was that this might easily dwarf the PC Revolution of the 1980s and even the Internet Revolution of the late 1990s.

These great expectations were partly based on the “tulip craze” mentality that prevailed in global capital markets in the late 1990s. But they were also based on assumptions about the wireless industry that have since turned out to be wildly optimistic. For example:

- **Greatly Improved Cellular Data Networks and Devices.** Industry observers were bullish about the pace of technical progress in wireless networks and devices. They expected that the so-called 2.5 and 3G cellular data technologies would arrive quickly, delivering

significant advances in bandwidth, capacity, and reliability. Conversely, traditional low-speed, “data-only” network technologies like ReFLEX™, Datatac™, CDPD, and Mobitex™ were viewed as mature technologies that were headed for history’s dust bin.

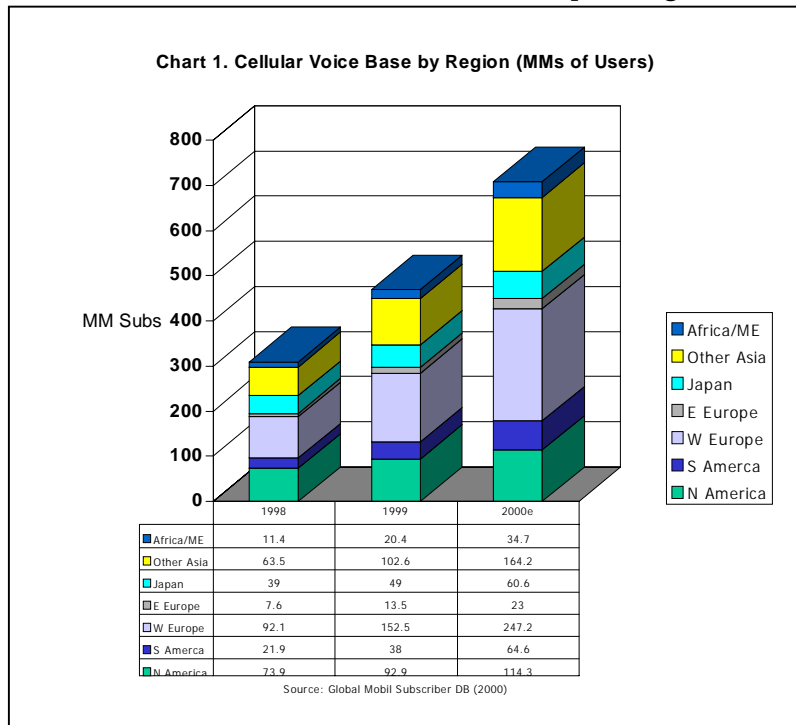
Investments in Spectrum and Network Capacity. Many observers also expected that wireless network operators would easily raise the hundreds of billions of capital required to purchase spectrum for these new networks and build them out.¹



Improved Wireless Software. Industry analysts also contemplated the widespread adoption of new mobile wireless standards like WAP and Bluetooth, new wireless “middleware” platforms, and mobile-friendly operating systems like Sun Microsystems’s J2ME, Qualcomm’s BREW, the Palm OS, Microsoft’s WinCE and Stinger, and Symbian’s EPOC. All these capabilities would be supported by

an increasingly global community of wireless solutions providers.

Innovative Wireless Data Applications / Solutions. It was also expected that all these new wireless hardware, software, and application capabilities would quickly lead to a rich assortment of applications and solutions, in both the consumer and enterprise segments of the market. The most exciting applications fall into two categories – (1) person-to-person messaging, including Internet messaging, corporate e:mail, corporate employee systems communications (including applications like sales force automation, field service logistics, and wireless access to corporate applications), and location-based “m:commerce;” and (2) device-to-device applications, including telemetry, inventory management, and meter reading.



Pervasive Adoption. Finally, the expectation was that all these new solutions and services, combined with lower device costs and faster networks, would finally lead to a global takeoff for wireless data, a natural sequel to the rapid growth of voice-based cellular services.² (See **Charts 1 and 2.**)

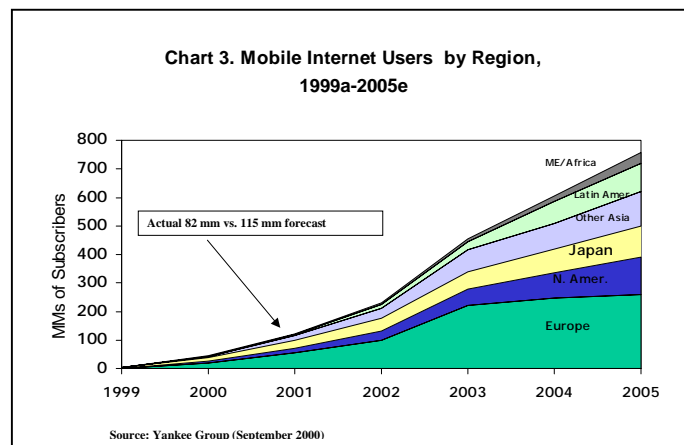
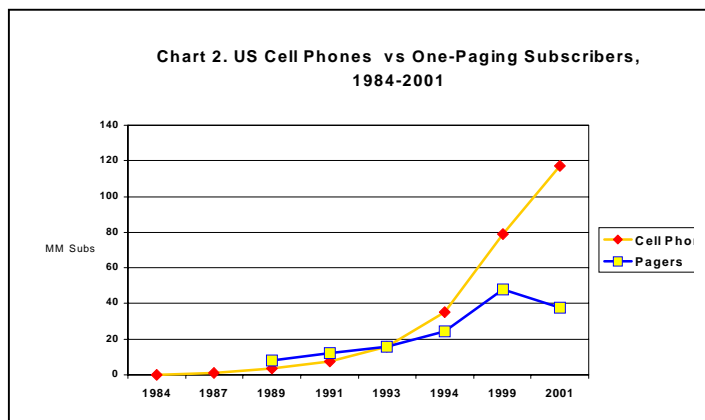
Hundreds of millions of new subscribers would supposedly sign up for mobile wireless Internet connections as early as 2002. (For just one example of many such forecasts, see **Chart 3.**)³ This would dwarf the number of PCs used to provide Internet connectivity, bring applications like email and browsing to vast new audiences, and change the balance of forces in the cellular, PC software, hardware, and network equipment.

3. Return to Earth

From the standpoint of all these great expectations, the last year has been a sobering experience. For example:

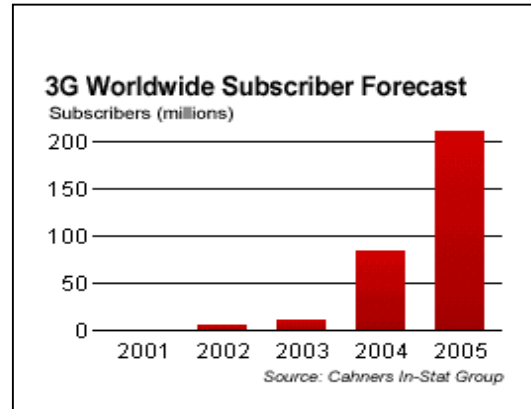
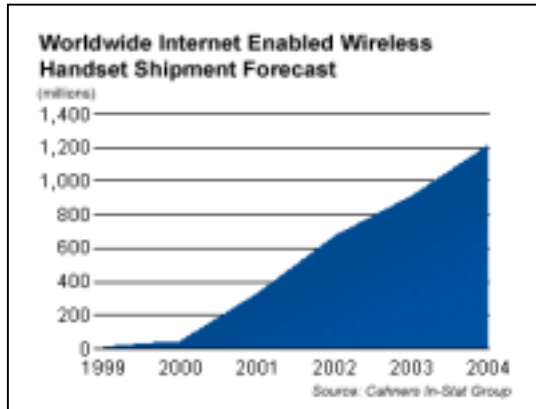
Missing in Action – New Networks and Devices That Work. In Europe, Japan and the US, the deployment of new 2.5G and 3G networks have been seriously delayed. In the US, 3G is even farther behind, because adequate spectrum for it has not yet been identified, much less licensed. There have also been serious delays on the 2.5G and 3G device side. Meanwhile, several mobile data startups, like Metricom’s Richochet, tried to deploy new high-speed networks, and simply ran out of money before they found enough customers.⁴

Network Capacity Slowdown. Except for a handful of special cases like Korea, Finland and Japan, the pace of investment in new high-speed networks by cellular service providers has also slowed substantially. This is partly because European cellular operators, among the earliest adopters of 3G technology, got involved in spectrum bidding wars that cost more than \$125 billion. And they will still have to spend another \$100 billion in order to



build out these new networks, and the additional costs required for the development of applications and content. Especially in the US, this capacity expansion problem has been further aggravated by the spectrum issues noted above, and by the fact that network vendors have not been able to agree on a standard upgrade path to 3G networks.⁵

● **Conflicting Protocols, Disappointing Software.** Meanwhile, the hoped-for convergence of wireless application developers around a common set of standards,



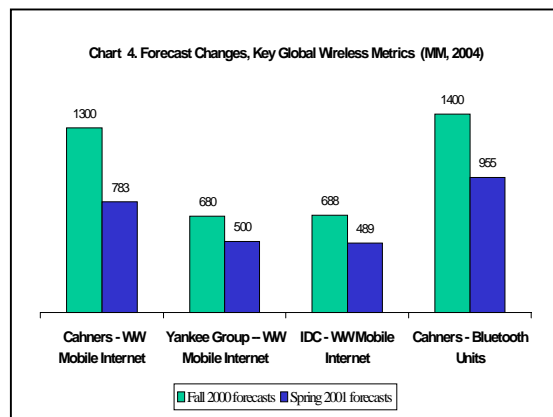
Two examples – Mobile Wireless Irrational Exuberance, Circa Early 2000

middleware, and operating systems is also missing. The WAP Forum, in particular, turned out to be a fiasco,⁶ a thinly-veiled attempt by its some of its founders to generate royalties and content tolls. WAP's Release 1.0 yielded applications that were painfully slow, hard to develop or use, expensive, and "seldom on."⁷ Not surprisingly, as one study of US corporate users of WAP phones recently reported, 85-90 percent of them quickly abandoned the phones' Internet and data messaging capabilities entirely.⁸ The Forum's "walled garden" approach to content hosting -- with carriers charging content providers hefty fees in order to get access to their subscribers -- also discouraged application development.⁹ For the subscriber, the result is a kind of applications ghost town, where the few applications that actually work would probably work better by way of voice calls!

Overall, as summarized in **Table 1**, the WAP Forum's approach could scarcely have been more **un-Web-like**.

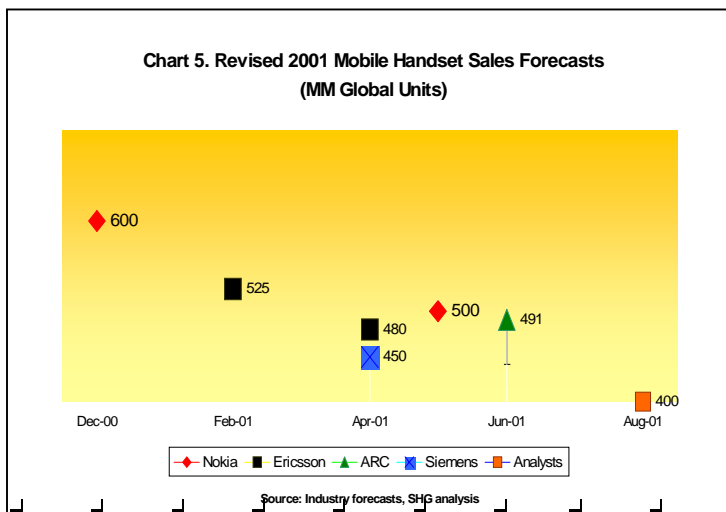
Table 1. Web vs. WAP Strategies to Internet Service Development	
Web Approach	WAP Approach
❑ Low marginal costs of use – often flat rates, declining capacity costs	❑ Per minute pricing -- \$.20 per minute or more
❑ Standard, interoperable open systems (3WC protocols)	❑ Closed/ proprietary protocol elements
❑ Relatively easy to use	❑ Hard to use (screens, keyboards)
❑ Easy to access (dial up everywhere; interoperable networks)	❑ Hard to access (carrier coverage limitations; non-interoperable networks)
❑ Easy to develop for (low cost/ standard application languages – HTML, XML, etc.)	❑ Hard to develop (need to learn WML)
❑ Open access -- content providers	❑ Closed “garden,” with access tolls and content rent
Source: SHG interviews and analysis	
© SHG 2001	

Meanwhile, the more robust micro-operating systems that are designed to provide local processing power on mobile devices, like Sun’s J2ME, have been slow to enter the market, partly just because they have been waiting for new devices and networks. And there has been little agreement on “middleware” standards, either. At least count there were more than 30 rival wireless middleware vendors.¹⁰



Prosaic Solutions, Sluggish Adoption.

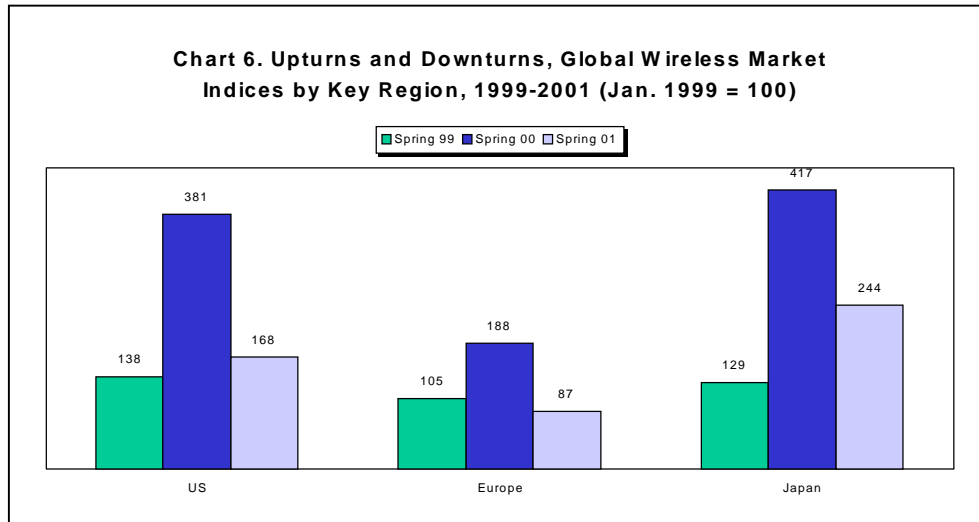
Given these constraints on networks, devices, and software, it is not really surprising that in most major markets other than Japan, the actual adoption of wireless Internet access has been modest -- less than 3 million users in the US and 5.9 million in Europe by the end of 2000, and only 25 million by the end of 2001. This compares with more than 29 million users very active Web phone users – almost all non-WAP -- in Japan by yearend 2000. Furthermore, most of these so-called “users” rarely use their Web phones to access the Internet or do



email.¹¹ Outside Japan, the volume of “m-commerce,”¹² location-based services,¹³ and mobile advertising services is tiny, and the number of truly exciting wireless data applications deployed so far by enterprise customers is also trivial.

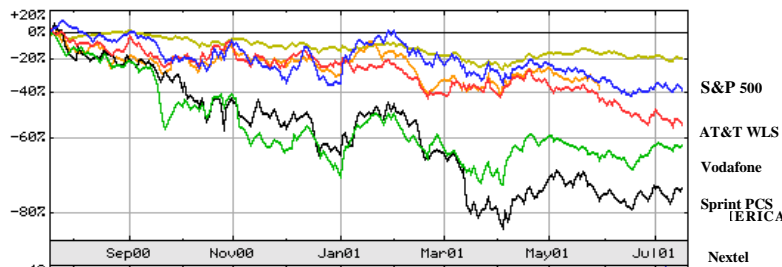
Accordingly, as shown in **Charts 4 and 5**, the latest estimates by leading industry forecasters for key indicators like the adoption of mobile Internet services, Bluetooth-enabled devices, and mobile handset sales are well below the projections that were made only just last Fall. Of course wireless industry analysts have also been known to make incredible underestimates of industry.¹⁴ But the uniformity of these recent overestimates is striking.

Not surprisingly, given this underperformance, market valuations for the global cellular industry as a whole have suffered sharp declines this year. (**Charts 6, 7, and 8**). The gloomy trends were especially hurtful to “pure play” mobile wireless data companies and solutions providers,¹⁵ as well as private-equity valuations in the wireless arena.¹⁶



Overall, it would be easy to conclude – as many analysts and investors already have – that the outlook for wireless data is just plain bleak. However, we will argue here that this, too, is an overreaction, and that all these clouds do have some silver linings, if we look closely enough.

Chart 8. Stock Price Changes, Leading Cellular Wireless Companies, 2000-1



To sharpen our vision, we'll begin with what might seem to be a complete detour – a visit to Japan, a market that has (1) more Web phones than anywhere else, (2) almost no low-speed, two-way, data-only networks of any kind; and (3) investment in 3G networks already under way.

If the case for low-speed data networks can stand up to this combination of circumstances, it can probably survive anywhere.



1. Introduction - Japan's Exceptionalism

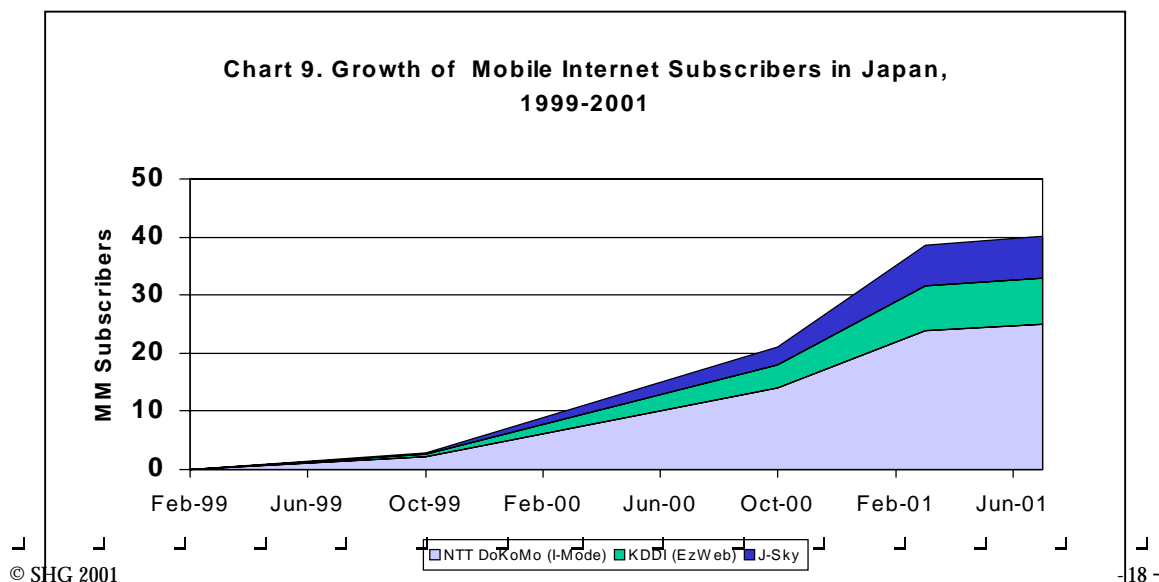
It is important for us to understand Japan's recent experience with mobile data, because it is by far the most important exception to the negative patterns described above. It is in fact *the only real* success story that champions of cellular data can point to, when they argue for the inevitable triumph of 2.5 and 3G technology over lower-speed networks. This chapter takes a close look at what has really been going on with mobile wireless in Japan, and argues that, beneath the surface, it actually supports the case for the long-term viability of lower-speed MDM networks, at least in the US.¹⁷

2. Japan's Mobile Internet Takeoff

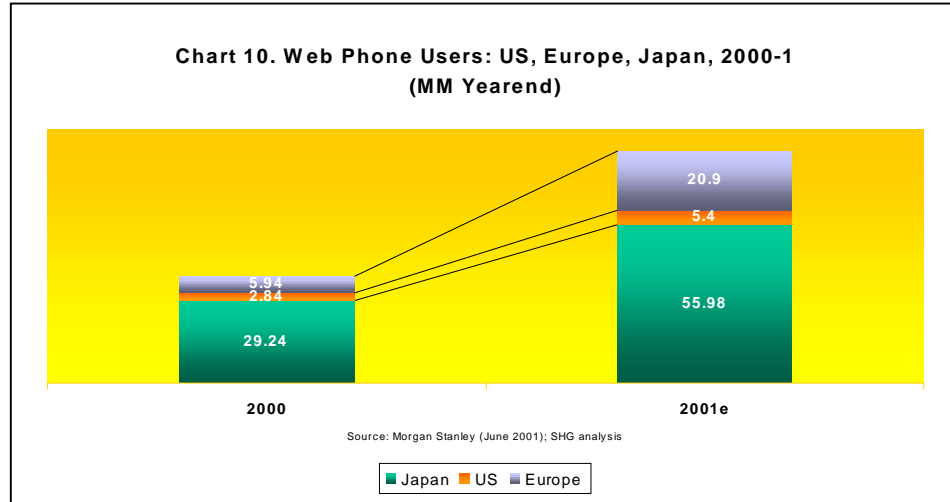
Japan's success to date with the mobile Internet has indeed been dramatic. From a standing start in February 1999, by July 2001 there were more than 40.3 million Japanese subscribers – 31 percent of the country's entire adult population – who were using Web-enabled cell phones to send messages and access the Internet on the fly.

This growth was spearheaded by NTT DoCoMo, which now commands about 62 percent of Japan's mobile Internet market. By yearend 2001 DoCoMo will have at least 32 million mobile Internet subscribers, and Japan as a whole will have more than 56 million,¹⁸ *twice* the number in North America and Europe *combined*, and two-thirds of the world's total. (See **Charts 9 and 10.**)

This year DoCoMo¹⁹ – more formally, the “NTT Mobile Communications Network,” which is two-thirds owned by NTT -- will generate more than \$2.8 billion of revenue from its “i-mode” mobile Internet service. This makes it NTT's most profitable business unit, accounting for *more than* 100 percent of NTT's net profit.²⁰ In less than three years DoCoMo has transformed itself into the world's largest and most innovative mobile data service provider.²¹ This is quite an achievement for a state-owned company that started out in 1959 as a maritime radio services provider, moved on to one-way paging in the 1960s and bulky executive car phones in the 1970s, and as recent as 1995, officially expressed doubts that more than 10 million cell phones would ever be sold in Japan. It is also quite an achievement for a country whose capacity for growth and innovation have recently been



widely questioned.



3. Key Market Conditions for i-mode's Success

Among the key factors responsible for Japan's exceptional adoption of Web phone services are the following:

Cell Phone Penetration. To begin with, in the last decade Japan quickly attained high cell phone penetration -- 77 percent of households, compared with less than half of US households.²² In May 2000 the number of mobile phones in Japan actually surpassed the number of wire line phones.²³ By 2004 cell phone penetration is expected to reach 95 percent.

This high cell phone penetration rate has been driven by several special market conditions, including the relatively high cost of wire-line telephone services in dense urban areas,²⁴ NTT's continued monopoly over wired local access, the use of metered billing for wired phone calls, the prevalence of public transportation and long commuting times,²⁵ the early adoption of "calling-party-pays" rules for pricing, and most important, the existence of high-quality, densely-sited national cellular networks that offer a very reliable alternative to wired service. Since most new cell phones that have shipped since 2000 have been Internet-enabled, this automatically provided a strong foundation for the mobile Internet.

Ironically, in the early 1980s Japan had been known for its *low* cell phone penetration. The very same NTT that is now the hero of our story had systematically overpriced analog phones, even requiring customers to lease them! In December 1988, Japan's Ministry of Posts finally understood that NTT's monopoly over wireline services created a conflict of interest with services, and ended its mobile wireless monopoly. The cell phone market really took off after April 1994, when pricing and services were more fully deregulated.

● **PC, Internet, and Broadband Penetration.** Another key factor behind Japan's recent mobile Internet surge is its relative *backwardness* in PC and wired Internet use. Partly just because the Japanese language has a difficult time with Qwerty keyboards, and double-byte compatibility came late to US operating systems, PC penetration in Japan has always lagged US levels. As of yearend 2000, just 38 percent of Japan's 46 million households had PCs,²⁶ compared with 63 percent of US households.²⁷ US Internet access from wired home PCs is, accordingly, also sharply higher.²⁸ Only 19 percent of Japanese households have wired PC connections,²⁹ compared with 57 percent of US households.³⁰ Americans also use their PC Internet connections much more intensively than Japanese or Europeans.³¹ This also reflects the fact that dial-up connections in Japan are relatively expensive, compared with the unmetered dial access available in the US.³² The share of US workers with wired connections at the office is also higher.³³

Finally, compared to the US, broadband Internet access is also relatively scarce in Japan. As of 2001, just 5 percent of Japan's Internet users have broadband access³⁴ at home or at work, compared with 31 percent of US Internet users.³⁵ Indeed, at home, less than 4 percent of Japanese households now have broadband connections, compared with 14.1 percent in the US and 3.3 percent in Europe.³⁶ While NTT made a commitment in 1994 to provide fiber to all Japanese homes by 2010, for at least the next five years this broadband gap is expected to persist.³⁷

Given these special conditions, it is not surprising that there are now more than 40 million Web phones in Japan, twice the number of wired PC connections, and that this number is expected to double to 75-80 million in the next three years.³⁸ These services already generate more than \$3 billion a year of revenue for Japan's three leading mobile operators.

Of course we should remember that Internet devices are not the same as *Internet use*. One recent analysis of Internet use in Japan found that PCs accounted for more than 93 percent of all *Internet use*, while mobile phones accounted for just 3 percent.³⁹ This is a key point for our analysis, because it turns out that most of what i-modes subscribers are actually doing with their Web phones is not "browsing" or higher-speed Internet applications, but low-speed MDM.

● **Two-Way Data Networks and Wireless Handhelds.** Two other factors that help to explain the rise of Web phones in Japan are the shortage of two-way data-only networks and the relatively small size of the domestic PDA market.

A. Two-Way Data Networks in Japan

Unlike the US, Japan never built nation-wide data-only networks like ReFLEX,TM Mobitex,TM DataTAC,TM or CDPD. This was not for want of one-way paging. One-way paging was first introduced in 1968, and by 1997 there were more than 10 million subscribers. Nearly sixty percent of them were served by a state-of-the-art national FLEXTM network that was owned by NTT DoCoMo.⁴⁰ But one-way paging in Japan stalled at roughly 8 percent penetration in the mid-1990s,⁴¹ half the US rate and well below the 25-30 percent levels achieved in other Asian markets like Korea and Hong Kong. This was partly due to stiff competition from the "personal handyphone," a popular low-cost mobile

phone that first appeared in 1995. Meanwhile, for its cellular voice services, NTT decided in the mid 1990s to go with its own proprietary standard, a variant of Japan's native "Personal Digital Cellular" (PDC) technology. When faced with the question of what to do about two-way data services, and whether or not to upgrade its FLEX™ network to ReFLEX™, DoCoMo later decided to go with i-mode, a digital packet-switched service that ran over PDC at 9.6 kbps. It launched i-mode in February 1999.

As for other two-way data networks, CDPD was not an option, because CDPD was an upgrade to US-developed AMPS analog cellular networks. One other local DataTAC 5000 network, at 450 MHz, was built in Tokyo in 1997, but the company performed poorly and was acquired by DoCoMo in 1998. No Mobitex™ network was ever built, partly because of frequency issues.⁴² In mid-2000, Glenayre finally sold a ReFLEX™ network to a paging company in Tokyo for telemetry applications.⁴³

B. PDAs/ Handhelds



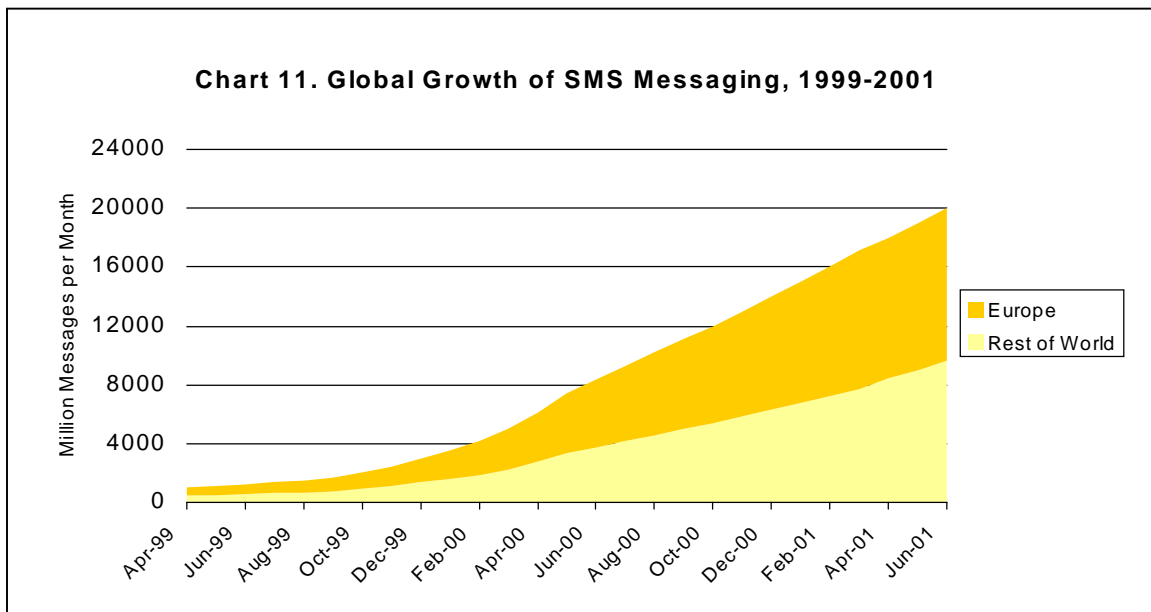
Given the paucity of low-speed data-only networks and low PC penetration,⁴⁴ it is not surprising the Japan's domestic PDA/handheld market is also small. As of 2001, there are less than 2 million PDAs in Japan, none of which are wireless.⁴⁵ This compares with about 7 million PDAs in the US, including a million that are wireless.⁴⁶

Recent market surveys indicate that Japanese users might actually prefer PDAs over Web phones or even PCs for purposes of Internet messaging.⁴⁷ But cellular service providers like NTT DoCoMo – and handset vendors like

Nokia, Motorola, Ericsson, and Samsung -- have a built-in bias toward devices that combine voice and data. Responding to the increasing demand for PDA form factors in Japan, however, Toshiba, NEC, and Sharp recently announced that they will produce new PDAs with slots for wireless modems.⁴⁸

4. The Rise of SMS Messaging

Another basic condition for i-mode's takeoff in Japan is that it offered a substitute for the short-message service (SMS) messaging that has proved so successful in Europe and some other Asian markets. SMS, yet another low-speed two-way MDM technology, operates in the signaling/ control channel of circuit-switched cellular networks, and was originally intended to provide voicemail notification to cell phone users. In the last decade, especially in



Europe and Asia, mobile operators have used it to provide a very simple, cheap way to send short (< 160 characters) text messages.

The results have been phenomenal, at least outside the US. As of July 2001, more than 20 billion SMS message per month were being sent by the world's 553 million GSM phone subscribers. Monthly SMS use now averages more than 35 messages per user in Europe, and up to 240 per user in some Asian markets! ⁴⁹ (See **Chart 11.**) While SMS's imminent demise had been predicted for years, a variety of new SMS technologies and services on the horizon are likely to permit this growth to continue for some time. ⁵⁰

SMS messaging has been a real boon to cellular operators. Depending on the market, they receive an average of \$.06 per SMS message. In terms of data throughput, this is more than \$5.80 per MB, several hundred times the price *per unit of data* for a minute of voice traffic! ⁵¹ SMS now accounts for 7-10 percent of operator revenues in Europe, ⁵² and several report even better results. ⁵³ While new SMS services like chat boards, subscriptions to "push" news services, and handset personalization are growing, the key point is that 98 percent of this traffic is just plain two-way person-to-person messaging. ⁵⁴

So here we have yet another success story for simple two-way mobile data messaging, and another striking contrast to the "WAP flop." It occurred *despite* SMS's numerous technical shortcomings. These include high latency, unreliability, ⁵⁵ limited in-building penetration (by

definition, no better than cellular voice service), short message lengths, no email attachments, no graphics, an inflexible applications development platform, limited content, and the cell phone's awkward numerical keypad. In fact, if we were *trying to design* a technically-limited messaging platform, it would be hard to design one more limited than SMS.

Despite these technical limitations, SMS has exceeded the cellular industry's wildest dreams, in terms of sheer numbers of users, traffic volume, and profitability. Again, we believe that this is for two simple reasons: (1) SMS (outside the US) followed the Web model for service development, and (2) it gives users what they really want (...all together now..!):

**(1) Reliable (2) Low cost (3) Easy-to-use (4) Secure (5) Pervasive (6) Interoperable
Mobile Data Messaging.**

A. Why SMS in Europe?

But why did SMS take off in Europe, and not Japan or the US? As in Japan, Europeans quickly became heavy users of cell phones, partly because landlines were relatively expensive and population density was high, permitting the efficient build-out of high-quality cellular systems.

Furthermore, beginning in the early 1980s, Europe's Conference of European Postal and Telecommunications Administration, and its successor, the European Telecommunications Standards Institute, promulgated the GSM standard for 2G digital cellular service, mandating it for all Western European service providers.⁵⁶ It also provided that customers would be charged per message sent, not per minute of use, and that "calling party pays" would also be implemented.⁵⁷

Contrary to the conventional wisdom, ETSI implemented this in Europe, not out of some bureaucratic desire to impose uniformity or do economic planning, but because Europe's *prior* experience with analog cellular systems had been sheer chaos. Unlike the US, where the AMPS standard was adopted by all cellular operators, Europe had ended up with nine rival analog systems, none of which could talk to each other!⁵⁸

In adopting the GSM standard, ETSI not only encouraged cell phone use to take off in Europe. It also managed to stumble on the Web model. This provided the industry with a simple, interoperable messaging standard and business model that permitted text messages to be sent or received cheaply by cellular subscribers across all GSM networks.⁵⁹ The adoption of this low cost messaging model, in turn, helped drive the growth of person-to-person SMS messaging in Europe through the roof.

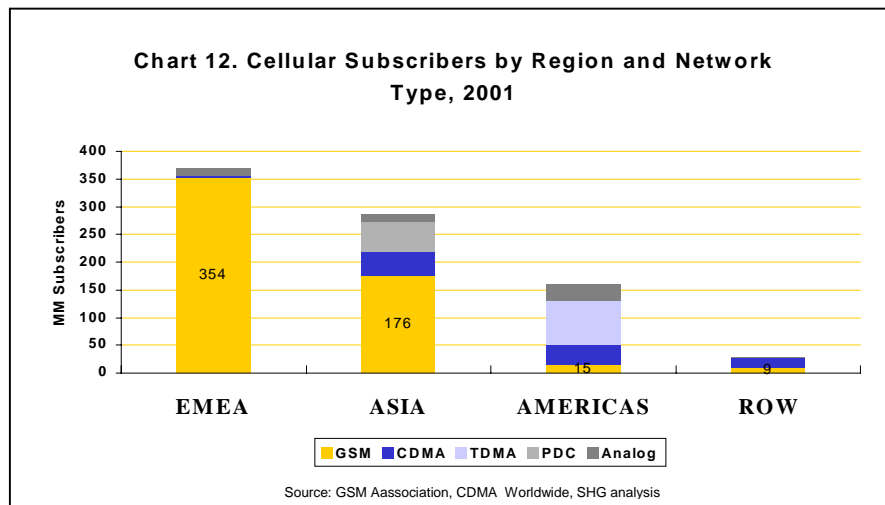
The ironic thing, of course, is that SMS was introduced by many of the very same regulators, network equipment vendors, and service providers who later played a leadership role in the WAP Forum. But unlike WAP, SMS was introduced almost as a boring afterthought, and *inadvertently* endowed with many of the same features that made the

Web so successful – low marginal costs, interoperability, pervasiveness, and even comparative ease of use (at least to the European teenagers one sees hammering away at cell phone keypads with pens and other blunt instruments.)

B. Why Only Limited Two-Way Data in Europe?

At the same time, two-way mobile data networks never got much traction in Europe. The Europeans developed their own standards for digital one-way paging,⁶⁰ in opposition to Motorola’s FLEX™ standard,⁶¹ which became the de factor digital one-way standard elsewhere by the mid-1990s. Since there was no FLEX™ base in Europe, ReFLEX™ was not an option. The “calling party pays” rule also severely hurt the paging industry.⁶² CDPD was not an option, because it was precluded by the GSM standard. While Mobitex™ public networks were built in the UK, the Netherlands, Belgium, Sweden, and Finland in the early 1990s, this was long before Internet email and wireless PDAs, and the networks didn’t interoperate. Mobitex™ in Europe has recently experienced a surge, following in the footsteps of the US, but it is still relatively small.⁶³ One DataTAC™ 6000 network was deployed by DeTeMobil⁶⁴ in Germany, but it was not focused on the mobile Internet or enterprise messaging.

So SMS provided Europe with an i-mode equivalent for simple two-way messaging. Its success there has also been echoed in many other countries where the GSM standard prevails. (See **Chart 12**.)



C. Why No SMS or Two-Way Data in Japan?

Meanwhile, back in Japan, for a variety of reasons neither SMS nor two-way data-only networks ever took off. First, the conditions that led to the success of SMS in Europe were absent. When it was choosing a 2G network in the mid-1990s, NT&T DoCoMo preferred to use its own local PDC technology rather than GSM. And NTT’s two competitors, KDDI

and Japan Telecom, went with a combination of PDC and CDMAOne networks. While all these networks support SMS messaging, unlike GSM, they are not interoperable.

Later, when i-mode was introduced in 1999, DoCoMo decided to play a role similar to that of ETSI. It permitted users to send and receive e-mails from any other Web phone users, whether or not they were i-mode subscribers. Combined with DoCoMo's 60 percent share of the cell phone market, this insured interoperability.

D. Why Limited SMS and Cellular Data in the US?

As for the US, neither SMS nor i-mode-like cellular messaging ever became dominant, because there was not a dominant national cellular operator, nor a government regulator like ETSI willing to impose a uniform cellular standard and sensible rules like "calling party pays." In contrast to Europe and Japan, in the late 1980s the FCC – with vocal support from equipment vendors like Lucent, Motorola, and Qualcomm – decided to leave digital cellular network standards up to the so-called "free market."

This *laissez-faire* approach to wireless networks was of course a striking contrast to the rigorous – wildly successful, in retrospect -- standards that the Internet's founding fathers, including academic institutions and the US Government, adopted for wired networks at the very same time. In a sense, the FCC's approach was rather like leaving the choice of railroad gauges, highway dimensions, Internet routers, or central office switch design up to local communities. The result was an alphabet soup of conflicting, proprietary cellular networks that – relative to Europe and Japan -- generally provide limited coverage and poor service, to this day. These include the original AMPS system, TDMA/IS-136 (AT&T Wireless, Cingular Wireless), CDMA (Verizon, Quest, Sprint PCS), GSM (Voicestream), and iDEN (Nextel). Each of these networks has very different performance characteristics and upgrade paths.

Later on we will examine the profound implications that the resulting potpourri will have for the adoption of 3G mobile wireless in the US – for better or worse, in the words of the Charlie Parker song, "Gonna Be a Long Time Coming..." But for purposes of understanding the fate of SMS and cellular data messaging in the US, the key result was that the *laissez faire* approach fundamentally undermined interoperability, which was so important to the growth of data messaging in both Europe and Japan.

In the US, unlike Europe, SMS messages simply can't be sent from subscribers on one cellular network to those on another. On the other hand, in the US the wired Internet is also more readily available. The result is that even though SMS messages in Europe and I-mode messages in Japan have higher unit prices than SMS messages in the US,⁶⁵ US cell phone users only send an average of less than 1 message a month, compared with 35-40 in Europe and Japan. (See **Table 3** below.) If US cell phone users want to send text messages to each other, they are forced to choose between non-interoperable SMS, cumbersome WAP, and a hard place.

For our purpose another key result of the US approach to telecommunication regulation was that it left the door wide open to two-way mobile data-only networks. On the one hand, as

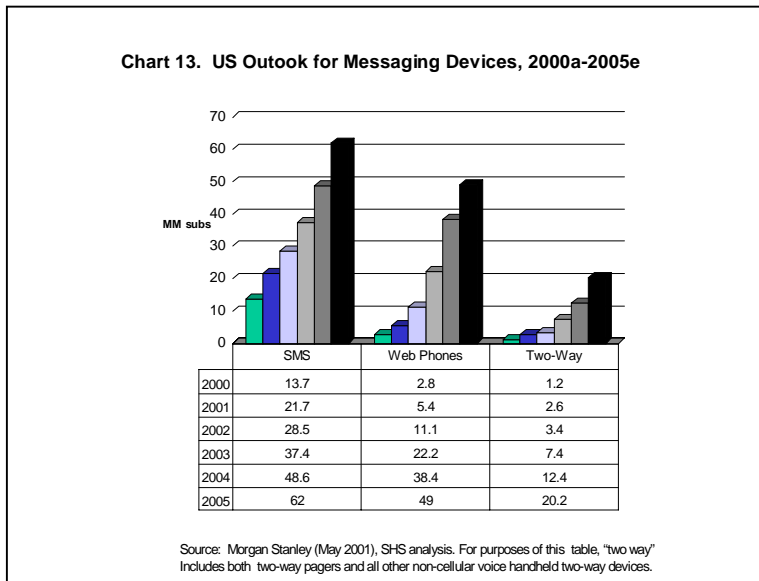


we've just seen, SMS messaging was crippled. On the other hand, for years cellular service simply wasn't very good, nationwide service was impossible because of disparate standards and sheer geographic area, and the difficulties created for paging by "calling party pays" were absent.

So today the US plays host – *in addition to four* different digital cellular network standards – to all the low-speed data-only networks known to man. These include three nationwide ReFLEX™ networks, a nationwide Mobitex™ network, two semi-national and five regional CDPD networks, and two nationwide DataTAC™ networks. (See **Table 2.**)

Table 2. Two Way Data Networks by Market, 2001			
	Japan	US	Europe
ReFLEX™	1 (Tokyo) – telemetry	3 national	0
Mobitex™	0	1 nationwide	5 national
DataTAC™	0	2 (1 national)	1 local (Germany)
CDPD	0	5 regional, 2 semi-national	0
GSM SMS	0	2 providers	All
Other SMS	3 interoperable	8 non interoperable	-
Internet messaging	i-mode/ interoperable	WAP (limited)	WAP (limited)
Source: SHG analysis			© SHG 2001

Of course since SMS messaging and, increasingly, Web phone capability, are built into all digital cell phones whether they are used or not,⁶⁶ if we simply look at the number of subscribers in the US market, we might get the impression that data-only networks are being overwhelmed by cellular data alternatives. (See **Chart 13.**) However, in terms of actual two way messaging, this is grossly misleading. As one recent comparison of US versus European SMS messaging showed, the intensity with which cell phones are actually used for



digital cell phones whether they are used or not,⁶⁶ if we simply look at the number of subscribers in the US market, we might get the impression that data-only networks are being overwhelmed by cellular data alternatives. (See **Chart 13.**) However, in terms of actual two way messaging, this is grossly misleading. As one recent comparison of US versus European SMS messaging showed, the intensity with which cell phones are actually used for

messaging is sharply lower in the US.⁶⁷

The good news for low-speed data-only network providers is that even in terms of subscriber headcounts, the latest forecasts agree that there is a robust future for non-voice networks. For example, if we group two-way pagers with wireless handhelds, one recent estimate is that there will be at least 20 million two-way data-only subscribers in the US by

2004.⁶⁸ Furthermore, we will argue here that if network operators fully exploit the opportunities presented by new platforms like ReFLEX™ 2.7, new devices, application platforms, channel partners, and interoperability, this number could actually be much higher.

Summary – Market Conditions for Success: DoCoMo, SMS, and Two-Way Data
Table 3 below summarizes the most important market structure factors behind DoCoMo's success, contrasting the US, Europe, and Japan.

Table 3. Key Market Structure Conditions for DoCoMo's Success			
	Japan	USA	Europe
Cell Phone Penetration	High	Moderate	High
"Calling Party Pays"	Yes	No	Yes
National Cellular Network Coverage	Good (9.3 cell sites/ 100 sq miles)	Poor (2.3 cell sites/ 100 sq. m.)	Excellent (20-40 cell sites/100 sq miles)
Wireline Costs	High/ Metered calls, shared business phones	Low/flat rates	High/ metered rates
Standards	3 digital standards (pdc, cdma, gsm)	3 digital standards (cdma, tdma, gsm)	One digital standard (GSM), all countries
Industry structure	PTT (NTT DoCoMo) - >60% share + 2 competitors	10 national carriers + regionals	2-5 carriers per country (
Wired Internet Access	Low	High	Mod
PC Penetration	Low	High	Mod
Wireline Cost	See Above	See Above	See Above
Broadband	Very Low	Mod/ Growing	Very Low
2-Way Data Networks	Very Limited	Mod-High	Very Low
PDA Penetration	Low	High	Low-Mod
One-Way Paging Penetration	Low	High	Low
Network Interoperability	Not Applicable	NO	Limited Mobitex use for roaming
Two-Way Data Networks/ Service Provider	Few (1 ReFLEX™ operator for telemetry (Tokyo)	7+ nationwide providers (ReFLEX™ - 3; Mobitex™ -1; CDPD-2; DataTAC™.1)	5 Mobitex™ local country networks; SMS preferred for messaging
SMS/ Internet Messaging	High (DoCoMo Standard)	Low	High
Technology	i-mode; CSC SMS on other networks	SMS - CSCD control channels	SMS- CSCD control channel (GSM standard)
Net. Interoperability?	Yes	NO	Yes
Messages/User/Mo.	100+	0-1	35+
Source: SHG interviews and analysis		© SHG 2001	

5. NTT DoCoMo's Key Strategic Choices

In addition to all these influences on market structure, DoCoMo's success was also aided by a series of adroit strategic choices. Among the most important were the following:



● A Blooming Garden With Low Walls.

To begin with, NTT DoCoMo's relatively open approach to content delivery and pricing encouraged the proliferation of Web phone content. Rather than set up a "walled garden" that was off limits to non-subscribers or content suppliers that didn't rent space, DoCoMo adopted a tiered content production and distribution model. This permitted anyone to develop and sell content for i-mode subscribers without fees, while giving some marketing preferences to official content partners. DoCoMo also started out by convincing leading companies in key industries – for example, Sumitomo in banking – to develop content. And it also deployed a team of 60 developers to work with outside content providers, at no cost to them.⁶⁹

The result is that there are now more than 750 "official" I-mode content sites. In exchange for 9 percent of their revenues, DoCoMo pre-positions their urls⁷⁰ on new handsets and allows them to sell "push" content to i-mode subscribers, who pay for the services on their phone bills. In addition, because of the open nature of the development platform (see below), there are also now about 45,000 unofficial sites, offering some 1200 other applications, including online TV schedules, sports scores, personal banking, gambling, horoscopes, anonymous "pen pal" dating services, wireless stock trading (now about 15 percent of all Japanese retail stock trading), "Hello Kitty" comics, and the ability to track daily basal temperatures for women who want to get pregnant. This compares with WAP's 2000 sites in the entire world.⁷¹ Subscribers to "push" content – about 80 percent of all users⁷² -- pay an extra \$2.50 per site per month. According to DoCoMo, these site subscription revenues now average more than \$40 million per month.⁷³

While initially DoCoMo followed the AOL "high wall" model and didn't permit its content providers to be accessed by competitors' subscribers, by 2001 this policy had changed – KDDI's 8 million mobile Web users and J-Telecom's 7.4 million can now access i-mode Web content, and vice versa.

The overall result is a medium that offers a compelling combination of mobile messaging, entertainment, and business services, a strong fit to Japan's "hima tsubusi"⁷⁴ urban commuting culture.

● Great Marketing and Strategic Pricing.

The explosive growth of i-mode's service was also partly due to NTT DoCoMo's basic product marketing strategy. This was to drive market penetration and traffic with a combination of (1) cool new handsets (which DoCoMo designed itself, subcontracted to device manufacturers, and sold through retail channels under its own logo), (2) the open content platform model described above, which was easy to develop for and generous to outside developers, and (3) an aggressive pricing

strategy. DoCoMo started off by making its basic devices dirt cheap – the lowest cost handset is only 1 yen. i-mode’s service pricing model is to charge only for packets actually sent, rather than airtime, at \$2.50 per month plus \$.02 per kilobyte for the basic service, plus \$2.50 per month per “push” site subscription. Compared with data services in the US, this is relatively expensive *per marginal kilobyte*, but on a per message basis it looks cheap – just \$.01 for a short message and 4 cents for a longer email.⁷⁵ Compared to the high cost of wired Internet access in Japan, this is very competitive. The average DoCoMo subscriber spends only about \$20 per month, less than half the cost of wired Internet service.⁷⁶

● **A Reliable National Network.** The fact that NTT DoCoMo’s digital packet-switched network provides national coverage, good penetration, and is “always on” has also helped to stimulate both demand and supply.

● **“Good Enough” Open Technology.** Another key reason why DoCoMo was able to quickly garner so much third-party content was its adroit choice of a development platform for wireless applications. Rather than use WAP, it opted for cHTML, a protocol that was rooted in the open HTML 2.0 standard. The protocol specification had been developed by Access, a Tokyo software company. With NTT’s encouragement, in 1998 Access offered it to the 3WC, the Internet’s global standards body, to make the language/ protocol an open standard. This “open” approach has had several key advantages.

- o First, even though cHTML is not XML, it is very good at what it does. From day one in February 1999 cHTML was able to access any website written in HTML, supporting features like colored screens with up to 256 colors, animated gifs, MIDI ring-tone downloads, and multi-user gaming, even at 9.6 kbps. Meanwhile, the WAP Forum, which started two years earlier, lost time trying to introduce a whole new set of proprietary networking protocols as well as a new web-page language, WML. Until WAP 2.0 ships later this year, it will have nothing comparable.

- o Second, cHTML was easier to learn than WML, requiring HTML developers only to learn a few new external tags. Unlike cHTML, WML isn’t backwards-compatible with HTML, and there are very few WML development tools available.⁷⁷

- o Third, i-mode devices talked directly to standard Web servers. WAP devices, on the other hand, speak only to WAP gateways, not directly to the Internet. As one developer has noted, WAP is not really Internet access – “It is access to some data that may also be on the Internet.” These WAP gateways are expensive carrier-run servers that translate Web content and control user access to selected Web sites.⁷⁸ In practice, this means that even though i-mode’s packet-switched version of the PDC network only runs at 9.6 kbps, while its WAP-based competitors run at 14.4 kbps on CDMAOne or circuit-switched PDC networks, i-mode often performs faster and more securely.⁷⁹

- o Fourth, while NTT’s cHTML is now an open standard, WAP really isn’t, at least not yet. Among other things, this exposes service providers and customers to risks of patent infringement or licensing charges. While the WAP Forum has always claimed to be developing “open” software, the fact is that there could already be some patented “booby traps” contained within its specification.⁸⁰ Already, two Forum members have been litigating

over rival patent claims, and pressing enterprise customers and carriers for royalties.⁸¹ In December 2000 the 3WC, i-mode supporters, and the WAP Forum agreed to unite around a common standard based on XHTML-Basic, which would help to resolve these issues, but the agreement has not yet been implemented. DoCoMo has actually been eager to see the long-delayed WAP 2.0 completed and deployed, because it has to rely on it for i-mode services that it launches in Europe or the US.⁸²

● **Beyond the Browser – Support for Java™-Based Applications.** Building on these foundations, as an extension to cHTML-based services, in January 2001 DoCoMo launched its “i-appli” (Internet application) version of i-mode. This supports a new series of Web phones that are enabled with Java 2 Platform Micro Edition (J2ME™), the mobile version of Sun Microsystem’s cross-platform application development language.⁸³ The main benefit of running Java on mobile devices is that, unlike browser-based services like WAP or i-mode, Java permits applications to be downloaded and run locally. This eliminates the need to be connected to a Web site in order to run games or other applications. Java also supports better graphics, sound, and agent-based applications, where information – like weather, stock quotes, corporate sales data --- can be automatically updated, depending on event-driven triggers. Java also provides better end-to-end security for mobile applications, because it supports SSL encryption and provides byte code verification.

Of course J2ME™ is just one of several competing micro-operating systems that have been designed to run on mobile devices.⁸⁴ And DoCoMo’s experiment with Java has hardly been glitch-free.⁸⁵ However, J2ME’s DoCoMo launch has already given it a head-start over rival mobile OS candidates like EPOC and Qualcomm’s BREW™, which have yet to appear on devices in any quantity. In less than three months, DoCoMo has already acquired 4 million i-appli users, who are now downloading applications from at least 38 Java-enabled websites. By the end of this year this figure is expected to approach 7 million J2ME™ users in Japan alone.⁸⁶

Furthermore, while i-mode was originally positioned as a consumer service, the security and robustness offered by J2ME™ is also encouraging Japanese enterprises to deploy new wireless solutions, including corporate e:mail and database access, field sales automation, and inventory management. Sun Microsystem’s Japanese office reports that many Japanese corporations are now experimenting with J2ME™ front ends on DoCoMo handsets, to provide secure access to corporate databases and email.⁸⁷ Not to be outdone, in June 2001 KDDI also started its “ezplus” Java-based service, using handsets from Hitachi and Casio, and providing downloadable applications from 32 new content sites.⁸⁸ Meanwhile, hedging its bets a little on mobile operating systems, NTT DoCoMo has also formed an alliance with Microsoft to market new mobile data services to business customers.⁸⁹

● **The Real Key → Mobile Data Messaging.** Together, all these cHTML and Java-enabled platform advantages have helped give NTT a commanding lead over its domestic WAP-based competitors. They have also helped to provide DoCoMo with credibility as a technology partner, in its efforts to expand its global relationships with players like AOL,⁹⁰ Microsoft, AT&T Wireless, KPN, Telecom Italia, and Telefonica.⁹¹

However, if we examine closely where most of DoCoMo's actual i-mode success has come from, in terms of *traffic, revenue, profit, and customer satisfaction*, at least *two-thirds* of it has little to do with all the prolific Web content, much less DoCoMo's choice of Web phones as a delivery vehicle.

Rather, we would argue that DoCoMo's distinctive value proposition has really been *its ability to provide reliable, easy to use, secure, "fast enough" two-way mobile data messaging to millions of users, at lower costs than the available alternatives, with excellent geographic coverage.*

For example:

- o One recent study of i-mode users showed that 42 percent were using it mainly for e:mail, 37 percent for voicemail, and just 21 percent for receiving Web content.⁹² Another recent analysis reported that 78 percent of time spent on i-mode is accounted for by voice (40 percent) or email (38 percent) communication, and just 22 percent by surfing.⁹³
- o Other studies have concluded that "email accounts for nearly half of i-mode traffic," that the average i-mode users sends more than 100 messages a month, and that "e:mail is the killer app on i-mode."⁹⁴
- o When i-mode subscribers are asked why they subscribed in the first place, 82 percent say their key reason was to get email, which is much less expensive and more convenient than using a wired ISP. Only 28 percent subscribed to use i-mode for browsing.⁹⁵
- o Finally, in July 2001 it was reported that the latest data on i-mode's "ARPU's" had DoCoMo a little worried, because they indicated that users might actually be *substituting* e:mail for mobile voice calls, *reducing* ARPU's.⁹⁶ If this bears out, it would have serious implications for DoCoMo and other 3G supporters, which have always assumed that data traffic would supplement voice revenue, not undermine it.⁹⁷ Indeed, 3G business cases usually have to assume steep increase in ARPU's over the next decade, to pay for the heavy initial investments required in 3G networks, while making up for declining voice revenue.⁹⁸

The success of DoCoMo's e:mail platform is even more striking, when we recall that all its messaging traffic is being generated on a 9.6 kbps (maximum) network from devices with tiny screens, numeric keypads, and relatively short battery lives that were initially designed for voice,⁹⁹ that i-mode permits no e:mail attachments, and that it is limited to less than 500 single-byte characters or 250 double-byte characters.

In our view, this is the key lesson of the DoCoMo experience. Effectively, NTT DoCoMo has used its market dominance wisely, creating a defacto "open" national standard for messaging that provides low-cost, pervasive, interoperable services among all wireless *and wired* users. The resulting "messaging commons," combined with strong marketing and some nifty content, has permitted Japan's MDM market to soar.

6. Beyond i-mode → 3G's Inevitability?

Even while building these solid low-speed foundations, DoCoMo has also been moving aggressively to launch 3G services, which it promises will *eventually* provide up to 384 kbps (actually 384 kbps for downlink speed, and 64kbps for the uplink) of shared bandwidth.¹⁰⁰ In late May 2001 it piloted its "Freedom of Mobile Access" (FOMA) W-CDMA service in Tokyo, offering video phones that deliver 64 kbps of shared bandwidth in both directions, with working prototypes of new services like mobile video calls and MP3 downloads. The prototype service and handsets have so far received mixed reviews, but of course it is still very early.¹⁰¹

NTT DoCoMo's initial pricing for this service is less than one-sixth that of ordinary i-mode *per incremental kilobyte*. Whether or not this is a compelling value proposition depends on the application. For applications like e:mail the implied prices per unit of value – per message, video call, download, or still image -- are compelling, but for multimedia applications they are still pretty rich. For example, as shown in **Table 4** below, incremental e:mail on the i-mode network costs about \$.11 cents, but only \$.02 cents on FOMA. Even on FOMA, however, one minute of compressed video costs about **\$19**, and a 30-second video call **\$9.50**.

Clearly DoCoMo's 3G profit model needs work. Who do they imagine will pay such prices? And who will bear the fixed costs of \$760 handsets and the 3X increase in the number of base stations that may be required?¹⁰² Recall the other key factors in i-mode's initial success – easy to use, easy to develop content for, profit sharing on content, and simple messaging. How easy will it be to produce and sell multimedia content for FOMA? Furthermore, what kind of multimedia do people really want on their mobile phones, anyway? What are the compelling new services that will raise ARPUs sufficiently over the next decade to replace declining voice revenues and cover 3G's incremental costs?

Table 4. NTT DoCoMo's Initial 3G FOMA Pricing vs. I-mode by Application				
IP Application:	Plain Old E: Mail	Video Phone Call	Video Download	Still Picture
Compression	-	MPEG4(?)	MPEG4	JPG
Duration	.025 sec	30 sec	1 minute	.5 sec
File size	25k	3MB (?)	6 MB	50 k
MB/sec	.1	.1	.1	.1
Price/ packet: - i-mode: - FOMA:	300 yen/ n + .3 yen 05 yen (n = Σ packets)	300 yen/ n + .3 yen 05 yen (n = Σ packets)	300 yen/ n + .3 yen 05 yen (n = Σ packets)	300 yen / n + .3 yen 05 yen (n = Σ packets)
Cost per Marginal MB - I Mode: - FOMA:	\$18.96 \$3.19	\$18.96 \$3.19	\$18.96 \$3.19	\$18.96 \$3.19
i-mode cost	\$.11 per message	Not feasible	\$113.77	\$.95 per still image
FOMA cost	\$.02 per message	\$9.48 (?)	\$18.96	\$.16 per still image
Source: NTT DoCoMo (2001); SHG interviews and analysis				© SHG 2001

Despite all these fundamental questions about the 3G business model, and the fact that DoCoMo delayed FOMA's commercial launch from April 2001 until October 2001 and nationwide service until 2002, NTT is still predicting that there will be at least 150,000 FOMA customers by yearend 2001, and millions more in 2002.¹⁰³ When it launches the service this fall, DoCoMo will become the world's first 3G service provider -- other than BT/Manx Telecom on the Isle of Man -- to deliver on the ITU's *15-year-old* 3G vision. Its competitors are watching closely. KDDI, for example, has already announced that it will upgrade to a CDMA2000 network next year, and J-Telecom has also said that it will launch a 3G network sometime in 2002.¹⁰⁴

7. Implications for 3G's Future Elsewhere

Earlier we saw that much of DoCoMo's success has really been based on low-speed mobile data messaging -- and more fundamentally, on giving customers what they really want with, with simple, but reliable technology. Does DoCoMo's early adoption of 3G undermine this analysis? If mobile messaging and content at 9.6 kbps have proved so successful, why is DoCoMo moving so fast with these new services?

□ **DoCoMo's Exceptionalism.** To begin with, there are just as many special background conditions at work on DoCoMo's 3G strategy as there were on its i-mode strategy.

- First, precisely because it has been so successful with i-mode, DoCoMo is facing an acute shortage of network capacity on its 2G PDC network. It has to expand in the next 6-9 months, and it is exploring both 2.5G and 3G alternatives to do so.¹⁰⁵
- Second, from DoCoMo's standpoint, 3G's economics are *artificially attractive* for one simple reason. *Unlike* cellular operators in Europe, the US, and elsewhere, DoCoMo and the two other Japanese cellular operators got all their 3G spectrum – two-by-20 MHz bands per carrier -- *for free*.

By comparison, Germany's 14-day marathon auction in early 2000 raised \$46 billion for six two-by-10 MHz band 3G licenses. The UK's April 2000 auction raised \$35 billion for just five licenses. As discussed below, in the US the 3G spectrum auction has been put off until September 2002 at the earliest, and if it does occur it will probably not match these inflated prices. But the costs of clearing the necessary US spectrum of other incumbents could be huge, and will mostly be born by bidders. (See below.) All told, once again, Japan may be the exception that proves the rule.

- Third, even with these 3G spectrum subsidies, DoCoMo appears to be hedging its bets. Even while testing 3G, it is also upgrading many of its 2G PDC base stations to a local 2.5 G equivalent, doubling the number of simultaneous sessions they can handle.¹⁰⁶ Perhaps in light of its recent experience with video phones, DoCoMo may also be backing off positioning its 3G services as radically-different. According to a senior marketing executive, i-mode services on 3G will look “exactly the same” as on i-mode.¹⁰⁷

□ **Comparative Advantages – Wired and Fixed Wireless Broadband Alternative.** As we have seen, DoCoMo's services strategy has been heavily influenced by the laws of comparative advantage. This is also the case with 3G. It turns that the case for 3G in the US is much more problematic than for 3G in Japan, just because of local market conditions.

- **Un-Wired Tokyo vs. Wired New York.** In the case of broadband, as noted earlier, Japan's deployment of wired Internet broadband service to the home and office is well behind that in the US, and the associated markets for multimedia accessories like PC cameras and speakers are also relatively small.¹⁰⁸ Early wired broadband adopters in the US market are also already concentrated in major cities like New York, Los Angeles, and San Francisco, otherwise the preferred candidates for 3G wireless. Since 3G networks like W-CDMA require up to three times as many cell sites and base stations per unit of area as 2G, this could be a severe barrier to 3G in the US.¹⁰⁹
- **Urban Density and High Cost Build-Outs.** The US population density is also much lower than that in Japan or Europe. So is the share of the population living in urban areas.¹¹⁰ The average cell site density for 2G cellular operators in the US is just 2.3 sites per 100 square mile, compared with 9.4 in Japan, 20 in the UK, and 30 in Germany.¹¹¹ It has also taken more than twenty years for 91 percent of the US population to have competitive choices among at least three cellular voice operators¹¹² -- and as we'll examine in Chapter V, the cellular network technology with the largest US footprint only covers about 43 percent of the US population. Even apart from any other issues, this makes the task of providing national competitive 3G coverage – or for that matter, 2.5

G coverage – in the US a daunting one. Nor does it encourage us to believe that most residential or corporate buyers will face serious competition among rival 3G or 2.5 G cellular service providers in their local markets any time soon. This fact alone considerably strengthens the long-term prospects for low-speed data-only networks in the US.

- **Fixed Wireless's Prospects in the US.** While *fixed* wireless ISPs have not made a huge dent in the US market so far,¹¹³ its prospects might actually be about improve. This is because of a combination of unsatisfied demand for broadband, dissatisfaction with wired alternatives (especially DSL), significant recent improvements in fixed wireless technology,¹¹⁴ and the fact that several leading IXCs are now considering the deployment of nationwide fixed wireless access to the residential and small business markets.¹¹⁵

This is important to us for several reasons. First, 3G networks require a great deal of spectrum.¹¹⁶ For example, W-CDMA, the preferred 3G upgrade for GSM networks, requires up to 5MHz for carrier channel spacing, compared with just 200 KHz for 2G GSM service, 30 KHz for plain old TDMA/AMPS, and 1.25 MHz for CDMA2000, the “2.5G” upgrade offered by Qualcomm. (See **Table 5** below.)

In Japan, NTT's dominant role in both the market *and the* government helped it push regulators, as well as network vendors and handset manufacturers, quickly down the 3G path, avoiding Europe's expensive spectrum auctions. In the US, the fact that 3G needs so much spectrum is somewhat relieved by the fact that the FCC – unlike European regulators – has not mandated that 3G networks only be built with new 3G spectrum.¹¹⁷ However, the FCC has not yet licensed the additional 160 MHz needed to provide national 3G services, and there are many obstacles to doing so.¹¹⁸

First, the FCC has recently experienced a costly reversal of its attempt to re-license spectrum in the 1900 MHz band that carriers like Verizon were hoping to use for 3G.¹¹⁹ Second, there are serious potential conflicts with fixed wireless service providers like Sprint and MCI/Worldcom.¹²⁰ Third, unlike modern Japan, the US has an influential military and the most politically-influential TV broadcasting networks in the world.¹²¹ 3G also faces a serious spectrum conflict with these two powerful incumbents.¹²²

Finally, to the extent that fixed wireless does succeed in the US, it might also significantly erode the demand for 3G. For example, 3G's maximum bandwidth in the stationary mode, 2 Mbps, is far exceeded by that already delivered by 802.11b technology today, and there are schemes afoot to deploy nationwide networks of “Wi-Fi” hotspots that might well could limit the need for high-speed mobile devices.¹²³

Table 5. Key Parameters, Leading Proposed 2.5G and 3G Network Systems							
	“2.5G” Systems			“3G” Systems			
Network System:	GPRS	CDMA2000 1x	DoCoMo PDC 2	UWC-136/EDGE	CDMA-2000 3X Ev	TD-CDMA	W-CDMA
Upgrade from:	GSM/TDMA	CDMAOne, TDMA, GSM	DoCoMo PDC 1	GPRS or GSM	CDMA2000 1x		GPRS/GSM
Key supporters	GSM Association, European telecoms,	CDMA Association, US telecoms	NTT				GSM Association, European telecoms,
Key Vendors	Nokia, Ericsson	Qualcomm (technology),	?	?	Qualcomm (technology), ?		Lucent,Nokia, Nortel,
Early Adopters	Most European telecoms; Nextel, Bell South, AT&T	SK Telcom KDDI Verizon Sprint PCS Quest	NTT DoCoMo?	None	None		NTT DoComo (10/01) BT/Manz
Carrier Spacing	?	1.25 MHz	?	200kHz – 1.6MHz ¹²⁴	3.75 MHz	5 Hz (nominal)	5 MHz +- n*.2 MHz
Data rates supported	Up to 115 Kbps	153.6 Kbps	?	144Kbps – 384 Kbps	461 Kbps	Car: 144 Kbps Walking: 384 Kbps Indoors: 2 Mbps	Car: 144 Kbps Walking: 384 Kbps Indoors: 2 Mbps
Access techniques	?	CDMA	?	TDMA	CDMA	TDMA/CDMA	CDMA
Modulation	?	QPSK/BPSK	?	GMSK 8-PSK	QPSK/BPSK	QPSK	HPSK
Duplex method	?	FDD	?	FDD	FDD	TDD	FDD
Estimated average network cost/MB ¹²⁵	\$.104 -\$.415	\$.059 - \$.089	?	?	\$.022-\$.033	?	\$.017- \$.069

Source: FCC(2001); NTIA (2001); GSM Association; CDG.org; SHG interviews and analysis © SHG 2001

□ **Other 3G Supply-Side Problems -- Spectrum, Networks, Handsets, and Technology.** There are also many other serious supply-side obstacles for 3G to overcome, especially in the US.

- 3G has recently encountered several technical snafus, notably the problem of designing handsets that are “multimode” – capable of running on 2G as well as 3G -- while maintaining adequate battery life. The longer it takes to deploy 3G, of course, the more important multi-mode capability will be.
- Another possible vicious cycle is the shortage of multimedia content and applications developers. There are exceptions, like Sony, Nintendo, and Sega, but Japanese and European content applications and multimedia content often don't translate very well to US audiences. So this will be an issue even if 3G networks and services perform well elsewhere.
- These technical snafus have already been responsible for significant delays in 3G services. As noted, in April 2001 NTT DoCoMo slipped its commercial release of the FOMA service significantly, and indicated that it would not deliver nationwide service in Japan until sometime in 2002. Even then, its bandwidth will probably only be 64kbps. In July 2001, Vodafone, the UK cellular operator, delayed its 3G service to 2003, blaming a shortage of multimode handsets.
- Even apart from the spectrum issues discussed earlier, because the US is such a potpourri of different digital networks, with many more carriers and vaster areas, it will take much longer to establish nationwide 3G services. Even sympathetic observers have recently picked the year 2007 as the earliest that this could happen.¹²⁶

□ **Other Recent Experiments -- High-Speed Mobile Wireless.** It is still not clear just how great the demand really is for high-speed mobile wireless data in the US, or even Japan and Europe. There have been several other recent attempts to launch high-speed wireless data services in the US with technologies other than cellular data, at speeds comparable to those of 3G's first release.¹²⁷ Several of these efforts – notably Metricom's Ricochet -- have failed.¹²⁸ In general, the failures occurred, not because of weak technology, but because service providers tried to pursue expensive network build-outs without a clear enough value proposition to attract sufficient customers.¹²⁹

There is also a host of development work going on with high-speed fixed wireless, as well as RF and optical local area networks. In the US, the focus has been on using 802.11b or Bluetooth technologies in the unlicensed 2.4GHz or 5.6-5.8GHz frequency ranges. While cell phones might be enabled with these technologies, the objective has been to provide “last 100 meters” access at speeds up to 11 Mb/s or more to PC laptops and PDAs. Companies like Texas Instruments and Spectrix are also developing wireless optical LANs with much higher data rates and more security, at speeds up to 100 Mb/s or more, and other companies are pursuing even higher-speed “ultra-wide bandwidth” solutions.¹³⁰ Service providers are also entering the fray – for example, one well-known national retailer has begun to deploy wireless LANs in its stores, allowing patrons to surf while they sip.

Unfortunately for the 3G industry, if a distributed network of local WLANs, connected to the Internet, ever took off, it might provide one more reason why high-speed mobile networks won't ever prosper, at least in the US. It would be easy to network all these local POPs with high speed fiber or fixed wireless connections, confining high-speed wireless to what it arguably does best anyway – the last few meters.¹³¹

□ **A Brief History Lesson – AT&T's Videophone Debacle.** AT&T's Bell Labs had been pushing the concept of sending video over ordinary phone lines ever since it successfully delivered a one-way image of President Herbert Hoover over a phone line to New York in 1930. By 1964, after years of work, AT&T was ready to demonstrate a prototype "PicturePhone" system at the New York World's Fair. The system worked, but it cost about \$500,000, and the price of a 3 minute video call was \$16.

Furthermore, as one report on the PicturePhone at the time concluded, "Most people did not like the PicturePhone. They were not comfortable with the idea of being seen during a phone conversation. However, the system's designers at Bell Labs were convinced that the PicturePhone was viable and could find a market."

Despite this feedback, over the next two decades Bell Labs continued development of the phone, and in January 1992 it launched a new version that was designed for the home, the "Videophone." Robert Kavner, the AT&T Group Executive in charge of the commercial launch, stated at the time, "This is the way people want to communicate. The time is right. The price is right. The technology is right."

Evidently, however, Mr. Kavner was wrong. The phone, which was priced for \$1000 and cost \$1500, only sold about 5000 units. The project cost the company more than \$ 1 billion. The phone was pulled off the market in 1994. The key reason? AT&T's "You Will" mentality. As AT&T's corporate historian later concluded, "It is still not entirely clear that people really want to be seen when on the telephone. This was not a question that was really studied before the introduction." (Emphasis added.)

8. What Do Customers Really Want?

We refer to this issue generically as the "Videophone problem," or the "You Will" problem, because we believe that at least in the US, the 3G industry may be about to repeat, on a much grander scale, the same kind of *hubris-driven* disaster that AT&T experienced with its failed PicturePhone/Videophone experiments in the 1960s and the 1990s. (See the sidebar.)¹³²

In general, even in Europe and Japan, there is still little public awareness about what 3G even is.¹³³ Nor have we been able to find, in the enormous 3G technical literature, a single piece of market research that looks closely at what potential business and residential customers really want to do with high-speed mobile wireless. In fact, so far as we can tell, this SHG white paper is the first critical look at this question.

This may be for a very good reason. For if customers were really asked about 3G services and prices, we believe they might well express serious doubts about their willingness to pay higher and higher ARPUs for high-speed mobile services that have such unclear value, especially in "high-wired" markets like the US.

□ **Mobile Videophones...for Consumers?** In the US market, many customers are having a hard enough time just making ordinary voice calls over

their cell phones safely while driving, much less while trying to download videos or receive voice calls.

While DSL and cable broadband services have problems, they are improving, as are fixed wireless broadband options. And while PCs are certainly highly imperfect devices, even multimedia fanatics must wonder whether mobile phones with tiny screens, speakers,

memories, on-board processing, and earpieces will ever be able to compete with the bandwidth, storage, processing power, software, integration with peripherals (printers, PDAs, MP3 players, etc.), input devices (keyboards, mice, microphones), power supplies (“infinite” battery life, at least for desktops), high-resolution monitors, powerful speakers, network integration, and overall ease of use that are routinely offered by wired *or wireless* PCs.

AT&T's PicturePhone (1964)



Of course, every so often, we *might* all enjoy the idea of being able to shop while walking down the street or chewing gum, send visual greetings to friends or enemies while on the move, download a brand new MP3 or short film while rushing to catch a plane, or check out the map of a new neighborhood while driving through it.

But how much are we really willing to pay for such frivolities, and how frequently will we use them? Will it

really add up to the incremental **\$164 billion** of new multimedia service revenues per year that the UMTS Forum, a leading 3G advocate, has recently claimed that 3G networks will produce by 2010?¹³⁴

□ **Mobile Videophones.... for Enterprises?** We also suspect that if anyone bothered to ask potential enterprise customers about it, they would quickly discover that such customers have even greater doubts about the value of 3G applications, especially in the US. Most large companies already have high-speed WANs, videoconference centers, and Web collaboration tools, and are moving toward even much faster wired access and backbone technologies like 10GigE.¹³⁵

Furthermore, while several startups are pursuing two-way video business applications for 3G cell phones,¹³⁶ the business value of being able to stream video to mobile phones is just not clear. Apart from, say, providing live TV coverage from the runway on Hainan Island, there is simply not that much *time-critical* video that has to be collected and distributed on the spot.

AT&T's Videophone (1992)



For remote presentations, wire-line distribution is more reliable. Nor are there vast libraries of business training videos that just can't wait until we return to the office. The very thought of employees running around the corporate office with live mobile video terminals in their pockets is positively scary, from a security standpoint. Finally, as other observers have noted recently, from a service provider's

viewpoint, the notion of dedicating network capacity that could easily handle more than 700 voice calls to just one video download seems like a high opportunity cost,¹³⁷ unless we're talking about midnight surfers.

Of course running large enterprises often requires the collaboration of large teams. But unless we are talking about the US Army invading Iraq or Panama, they are not likely to be highly mobile. Ordinarily, if project teams need remote collaboration, it is easiest to do so over the Web, using conferencing platforms like Interwise, WebEX, or Groove, desktop videoconferencing, or room-based Picturitel systems, rather than mobile videophones.

Indeed, desktop video conferencing and Web collaboration both started to take off in the late 1990s, driven by broadband, falling equipment costs, and better standards.¹³⁸



However, after two decades, the entire US videoconferencing and Web conferencing equipment and services market is still less than \$3-4 billion a year. As we saw earlier, there are also moves afoot to focus high-speed broadband wireless on the last few yards.¹³⁹ It seems unlikely that the market for real-time video conferencing will accelerate dramatically just because we can now make movies while we drive.

9. Key Implications, DoCoMo's Experiment

So what have we learned from this brief detour to Tokyo, Europe and 3G Fantasyland? How is it relevant to the future of low-speed data networks?

In any important new market where there is rapid technical change and substantial uncertainty about the future, we find that customer decisions about which technologies to adopt are often based, not on cold clear technical details, but on popular perceptions. These include the latest industry buzz about "the next big thing," conventional wisdom

about precisely how many units will be sold in China five years from now, and the latest brave pronouncements from industry giants about their wonderful upcoming releases, only a few months away. The graveyard is littered with the dusty bones of companies that may or may not have had vastly superior technologies, but undoubtedly did not realize soon enough just how much influence such subjective perceptions, the clear articulation of value propositions, and raw marketing





have on corporate investments in technology.

This is not really surprising. All truly important technologies are never quite finished, so it is hard to characterize them individually, much less to compare them. The incompleteness means that they are really *belief systems*, requiring a high degree of commitment from their sponsors and developers. It is no accident that engineers from rival companies can often never agree about anything. This is not just because technology is hard to pin down and compare, but also because at some level its protagonists have to act on conviction rather than pure reason.

Given this subjectivity, we believe that the best place to start in all technology assessments is with a deep understanding of *the historical development of particular markets and customer requirements*. The last thing the wireless world needs right now is yet another round of mindless forecasts, yet another technically-oriented “white paper” that starts and finishes with a one-sided comparison of Ts and Cs. We will present ample technology comparisons in Chapters IV and V below. But we hope that now they will be grounded on a more fundamental understanding of what customers really want from mobile wireless.

The last two years have taught us some expensive lessons about what customers really want. The Japanese and European experiences, in particular, reveal several things.

- *Simple low-speed mobile messaging* accounts for a huge share of non-voice Japan’s so-called Web phone traffic. Simple low-speed mobile messaging, not mobile Web browsing, entertainment, or information distribution, appear to be the killer mobile application.
- Japan turned to Web phones in droves mainly because other wired and wireless alternatives for data messaging were not available – just as Europeans turned to SMS messaging, and Americans turned to data-only networks.
- Given a choice, many users in all regions might well prefer to do *most of their* messaging and Web services on *non-phone* devices. We may never know – the history of telecommunications is that voice services preempted data services very early on, and we continue to pay the price for the biases that result. At the very least, from the standpoint of what has become our mantra -- reliable, low-cost, easy-to-use, secure, pervasive, interoperable mobile messaging -- it is clear that Web phones, much less the mobile VideoPhones of the future, leave a great deal to be desired.

□ The Japanese experience also shows that, given an open-standards platform and a business model that rewards content creation, low-speed networks can be “good enough” for most messaging, and even for many Web browsing and information retrieval applications. In other words, the open Web model, not the WAP model, should be our guidepost, as we endeavor to make mobile wireless services more popular.¹⁴⁰

□ On the other hand, the global wireless industry is now embarked on a costly worldwide push toward 3G technology, and our hero, NT&T DoCoMo, for reasons of its own, is leading the way. This is unfortunate, because as we’ve seen, Japan’s own experience raises serious questions about the *phone-centric*, bandwidth-hungry, capital- and spectrum-intensive, technically risky, proprietary, and vendor-driven strategy that the industry is now pursuing. It is this “You Will” mentality, spawned in boardrooms and backrooms without a single customer in the room, that accounts for many of our recent setbacks with wireless data.

This story is hardly unique. We find similar *supply-side hubris* in the history of AT&T’s Videophone, RCA’s Videodisc, France’s Minitel, Sony’s Betamax, the Concorde, nuclear power, and many other examples. But in most of those cases the impacts were local, limited to a few companies or at most a single country. Here, we are dealing with the future of global communications. It would seem to be in order that we pay more attention to what customers really want, before defaulting to the industry’s *blind faith* in “newer, faster” networks.

10. Conclusion – DoCoMo’s Lessons

Despite the global wireless industry’s diminished expectations, DoCoMo’s experience shows us that there is still much to be excited about. The “revolution” that has been so greatly over-predicted may eventually arrive. But if customers were given a voice, we suspect that it would have quite a different character from the “high-bandwidth/ cell-phone based/ mobile browsing” model that many have been pursuing.

In our view, the way forward now is to focus on mobile data messaging. From this perspective, it turns out that, at least in the US, conventional low-speed networks like ReFLEX™ have much more vitality than is widely believed. Like most important technologies, these networks are not nearly as “mature” as they seem. As we’ll see in the following chapter, ReFLEX™, in particular, will soon be revitalized with new network capabilities, devices, applications, and middleware support that will substantially enhance its performance and competitiveness.



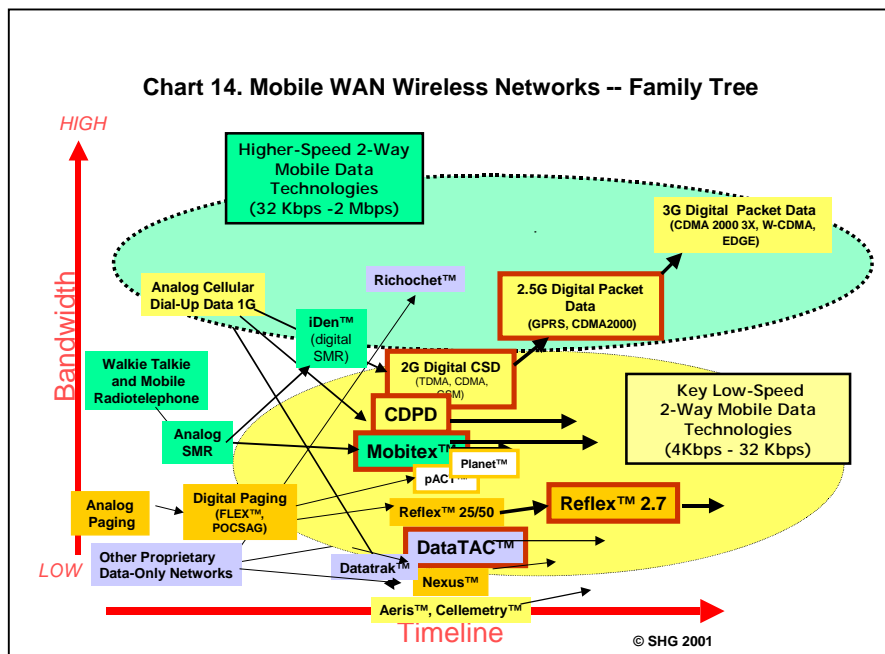
IV. ReFLEX™'s Technology – Origins,
Key Attributes, and Direction

1. Introduction – Key Low-Speed Mobile Data Networks

The argument so far has been an extended way of encouraging customers and application developers to take their minds off vendor daydreams about the high-speed networks of the future, and focus on the incredible value that can be delivered with today’s low-speed MDM networks, right here and now.

As we’ve argued, beneath the surface, the world’s most successful wireless data services to date in Japan and Europe have succeeded precisely because they delivered reliable, affordable MDM data speeds that may look “slow” by comparison to broadband, but are more than enough to get the job done, especially for enterprise applications. In addition to the “mobile Videophone” analogy, there is also the case of the “Lamborghini SUV.” Italian race car makers can easily produce cars that can hit 220 mph in 6 seconds, but this is not very helpful to those of us who have to battle rush hour traffic and unforgiving cops on the way to work every morning. We just want to get there reliably, securely and at reasonable cost.

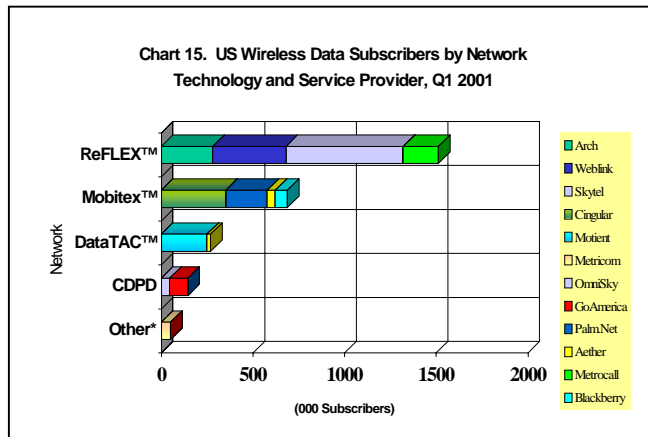
So at this point we will direct the reader’s attention to a narrower question. What are the



most important low-speed MDM technologies to consider, and how do these network technologies compare?

As summarized in **Chart 14**, the two-way mobile wireless “family tree” can be divided into three branches. First, there are technologies like Cellular Digital Packet Data (“CDPD”),¹⁴¹ digital circuit-switched data (“DCSD”), analog control channel (sponsored by telemetry players like Aeris and Cellemetry), and 2.5- and 3G digital packet-switched cellular data that are rooted in cellular voice technology. Second, there are technologies like Motorola’s

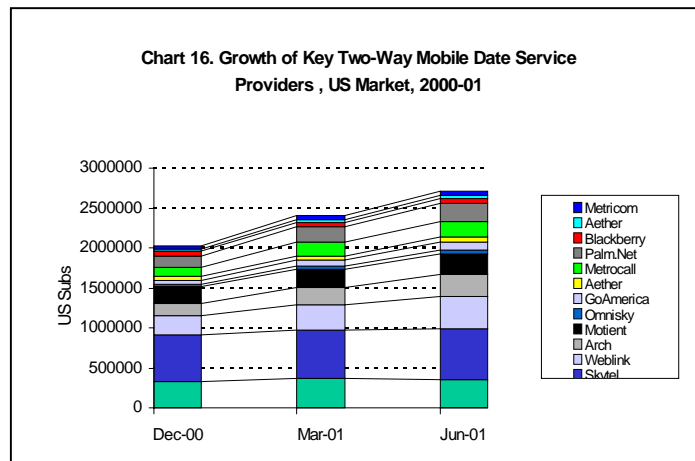
ReFLEX™, Nexus™, GWcom's Planet™,¹⁴² and AT&T Wireless/ Ericsson's pACT™¹⁴³ that had their roots in one-way paging networks. Third, there are a wide variety of other proprietary two-way networks that have diverse roots, like Ericsson's Mobitex™, Motorola's DataTAC™, Nexus™, and Siemen's DataTrak™.



For our purposes here, the key competitors to focus on are those networks that have either already achieved substantial subscriber bases in the US *person-to-person* MDM

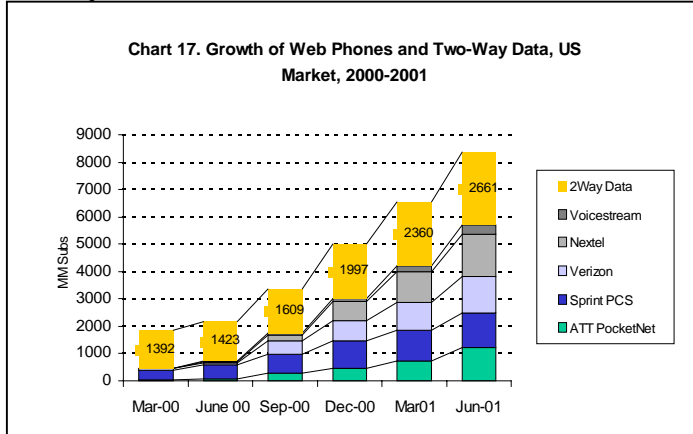
market,¹⁴⁴ or are 2.5 G technologies like CDMA2000 or GPRS that may become important competition in the next 2-3 years. As noted in **Chart 15**, in 2001, from this angle the key US data-only networks are ReFLEX™, Mobitex™, CDPD, and DataTAC™, with Metricom's hapless Ricochet™ bringing up the rear.

All told, these data-only networks now account for nearly 2.7 million subscribers in the US,¹⁴⁵ growing at more than 15 percent per quarter. (See **Chart 16**.) It is especially interesting to note the leading role played by ReFLEX™-based service providers in this story. During the first half of 2001 their subscriber base has increased by forty-five percent, and they now account for over sixty percent of all two-way data network subscribers in the US. Until now, Cingular Interactive (on Mobitex™) and Motient (on DataTAC™) have received more attention. This is partly just because they began operations several years before ReFLEX™, and supported popular devices like Palm™ VIIi and the RIM Blackberry™. It is also because ReFLEX™'s carriers were associated with one-way paging and its financial difficulties, were viewed as competing among themselves on different networks (e.g., Skytel's ReFLEX™ 50 network vs. Arch/Weblink's ReFLEX™ 25), and perhaps also because they paid less attention to marketing. Whatever the reasons, one key theme of this chapter is that this is all about to change – in particular, the ReFLEX™ providers are all now uniting behind a common platform, Version 2.7, with many advantages.



If we compare these figures on two-way subscribers with the nation's 117 million cellular voice subscribers,¹⁴⁶ or even the 5.8 million cellular subscribers who now have circuit-switched "WAP" services, at first glance the two-way data numbers look modest. (See **Chart 17**.) However, as noted in Chapter III, the actual use of WAP phones for data messaging

is very low, while data network subscribers use their devices an average of more than twice a each day.¹⁴⁷



Furthermore, for the foreseeable future, data networks like ReFLEX™ will also be quite competitive with the services offered by cellular operators, in network coverage, reliability, devices, and cost.

Finally, there are now more than 37 million one-way paging subscribers in the US, two-thirds of whom are the customers of

Arch, Weblink, and Skytel, ReFLEX™’s three nationwide service providers.¹⁴⁸ Many of them could easily become two-way data customers, assuming that there is adequate network capacity. And as we’ll see below, one of Version 2.7’s most important features is its capacity. Combined with new low-cost, more powerful devices, applications and content, and other new capabilities, we believe this will provide a strong technical foundation for ReFLEX™’s continued growth.¹⁴⁹

2. ReFLEX™’s Origins

It is helpful to review ReFLEX™’s origins and evolution, in order to understand its current architecture and comparative advantages, and how some of its key early barriers to growth are now being overcome.

In June 1993 Motorola took the paging world by storm with the announcement of its new FLEX™ binary protocol for one-way digital paging. Compared with its two other key rivals at the time, POCSAG¹⁵⁰ and ERMES,¹⁵¹ FLEX™ was much more efficient, with higher data rates, a more flexible range of data rates¹⁵² --- hence the name -- better error correction and reliability, and greater network capacity. For the global paging industry at the time, which was growing by leaps and bounds and was running out of capacity, this was a godsend.¹⁵³ Skytel launched the first commercial FLEX™ service in the US in March 1995.¹⁵⁴ By 1999 it had been adopted by 229 carriers in 47 countries, and became the official paging standard in China, India, Japan, Korea, and Russia. By then, the peak of the one-way paging market, 18 of the top 20 US operators were using FLEX™, accounting for more than half of the country’s 48 million one-way subscribers.

FLEX™’s success provided solid foundations for ReFLEX™, which Motorola released in September 1994.¹⁵⁵ To the FLEX™ industry, ReFLEX™ was positioned as a way to further expand network capacity, allowing devices to register their locations and avoid the need to broadcast to all geographic regions at once.¹⁵⁶ ReFLEX™ was also the world’s first two-way paging platform,¹⁵⁷ designed to take advantage of the FCC’s 1994 decision to auction 2 MHz of spectrum in the 900-941 MHz band for what it called “narrowband personal communication (N-PCS) services.”¹⁵⁸ Most of these licenses went to the corporate

on as resellers for the three US ReFLEX™ networks. But only a few other ReFLEX™ networks were built, mainly in Canada and Mexico.

The one-way paging contraction has meant hard times and corporate reorganizations for most paging operators in the last few years. By 2001, Skytel had been acquired by MCI/Worldcom, PageNet's network and licenses by Arch Wireless, and PageMart became Weblink Wireless and filed for bankruptcy protection. When the dust settled, these three ReFLEX™ operators ended up with networks that now serve more than 1.6 million two-way subscribers, more than any other US MDM network.¹⁷³ Despite this, all three have continued to struggle with profitability, as they cross the chasm from one-way to two-way services. Meanwhile, ReFLEX™'s original technology partners, Motorola and Glenayre, have both basically decided to exit the business of providing ReFLEX™ network equipment and devices.¹⁷⁴ So the three leading service providers are faced with having to support ReFLEX™'s continued technical development, including new devices and applications.

Ironically, we believe that this might actually turn out to be a good thing. The need to provide customers with devices and applications that actually deliver real value, to focus on their true competitors, and to rely on more responsive suppliers for software and hardware, may be just what the ReFLEX™ alliance needs to survive. After all, it is not unprecedented for service providers to take a lead role in designing their services, devices, network technologies, and applications – that is what AT&T did for decades with telephony, and it is also precisely what DoCoMo did with i-mode in Japan. In fact, one can make a case that, at least for communications, the separation of specialized “engineering/network” companies from service providers has been detrimental. But that is a larger issue. For our purposes, while the jury is by no means in, we believe that important progress is already being made toward the goal of removing all the key obstacles to ReFLEX™'s revitalization described above.

With this background, let's now look closer at ReFLEX™'s current network architecture and the role that Version 2.7 and other pending technology improvements will play in this revitalization.

4. ReFLEX™'s Original Technical Attributes

As noted, ReFLEX™ was originally designed as an upgrade to FLEX™'s one-way paging infrastructure, extending its core advantages -- high network capacity, low systems capacity cost, wide-area coverage, reliable message delivery, long battery life, and easy upgrades. These roots continue to determine many of ReFLEX™'s most important characteristics.

● **Great Battery Life.** ReFLEX™ adopted FLEX™'s frame structure and synchronous digital messaging protocol, which were already very efficient. This means that ReFLEX™ devices offer unparalleled battery life – one month or more on a single AA battery.

● **Signal Fade and Error Correction.** ReFLEX™ uses FLEX™'s protection against signal fading, which can withstand up to 10 ms of signal fade at all speeds and still accurately

decode information. ReFLEX™'s error correction mechanisms -- checksum validations and positive end-of-message control -- are also very robust. This is especially important for reliable WAN messaging and information distribution applications.

● **Rapid Two-Way Messaging and Delivery Confirmation.** From one angle, what ReFLEX™'s designers basically did was to take a successful one-way paging network and add a separate return channel on paired licensed frequencies. This provided a very efficient system for delivering short asynchronous two-way messages, including immediate message delivery confirmation -- a feature that to this day is still not provided by ordinary wired Internet email.¹⁷⁵

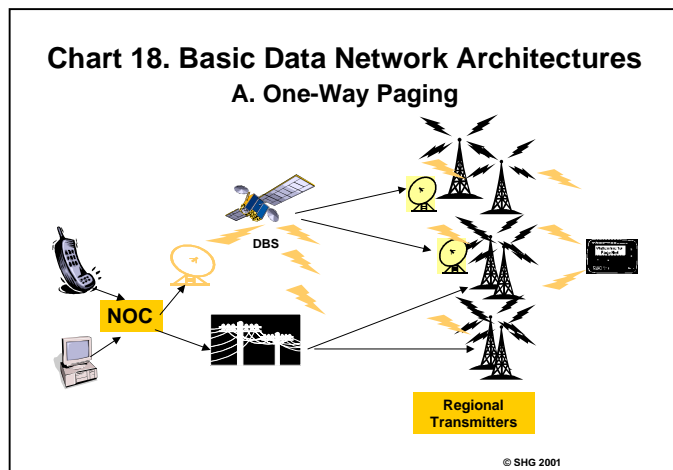
● **Frequency Re-Use and Store-and-Forward Messaging.** The return channel also permitted frequency re-use and an increase in overall network capacity, by using the return path to identify where the user devices were located, then channeling messages only to that area.¹⁷⁶ If devices were out of range, ReFLEX™ also automatically stores messages until the devices return to coverage.

● **Integration With Other Data Networks.** Partly because of its roots, ReFLEX™'s protocol is able to operate concurrently with most other existing paging protocols around the world. A ReFLEX system can also run in time-share mode, permitting service providers to run more than one protocol on the same network.

● **Architecture -- Pros and Cons of Alternative Designs.**

A. Cellular Networks. Most two-way data networks (e.g., Mobitex™, Ricochet™, and 2.5 G) are designed as cellular systems, with each base station dedicated to serving specific non-overlapping geographic areas ("cells.") In theory this makes better use of spectrum, because it is only used where devices are actually located. But this doesn't come for free. It requires the network to keep track of device locations, providing

capacity as needed in particular cells. Cellular architectures are also less expensive to modify, once enough base stations have been installed to cover a certain geographic service area. If more capacity is needed in a given area, new base stations can be added locally. Non-cellular networks, including one-way paging networks, require capacity to be added everywhere at once. But once again, this advantage doesn't come for free -- cellular systems generally also have significantly higher fixed costs of coverage, and a much higher infrastructure cost per customer served at full capacity.¹⁷⁷

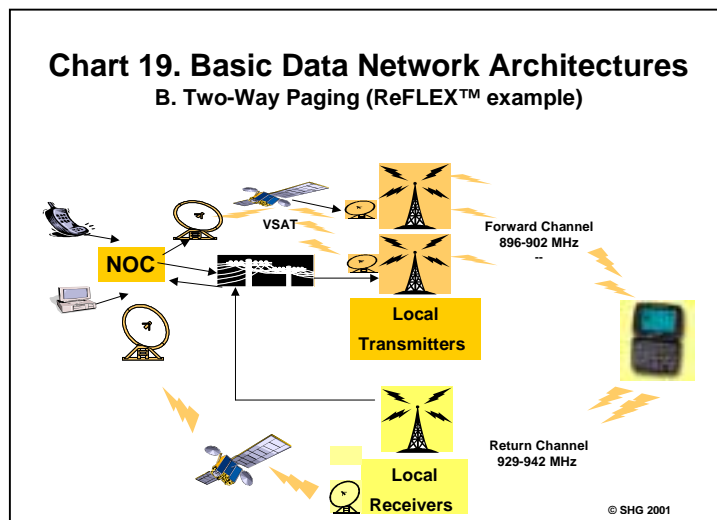


B. ReFLEX™'s Network.

In conventional one-way paging systems, the network acts as one big cell, multi-casting all messages throughout the system. Outbound messages are collected at a network operations center, relayed by satellites or wireline to paging transmitters across the country, and multicast by all transmitters at once to all devices. Unlike a cellular system, the traditional paging network has no idea where any given device is. All messages are sent over every transmitter to every endpoint device.¹⁷⁸ (See **Charts 18 and 19.**)

Device Simplicity. The essential non-cellular design has advantages that ReFLEX™ has inherited. It simplifies device design, lowers device costs, and reduces messaging overhead -- since the network doesn't have to manage complex handoffs among cells, there are fewer administrative transmissions and receptions, and longer battery life and simpler components, compared with cellular networks.

Capacity Cost. While the *incremental cost of expanding* a paging network has historically been higher on the margin, as noted above, the initial cost of covering a given area is much lower. As we'll see below, ReFLEX™ Version 2.7 directly address this incremental capacity cost issues, provides a one-time 3-5X capacity increase at virtually zero incremental cost, and brings it on a par with existing cellular low-speed networks.



In-Building Penetration/ Reliability. The fact that ReFLEX™ signals are broadcast to devices from multiple transmitters at once – properties known as “simulcast” on transmission and “macro-diversity” on reception – also means far better in-building penetration and reliability, as compared with cellular systems.

- o “Simulcast on transmit” means that individual ReFLEX™ devices receive transmissions from more than one transmitter at once. This increases the probability of receiving messages correctly, raising the effective link budgets for transmissions significantly.

- o “Macrodiversity on receive” means that multiple receivers “hear” any messages sent from a device, boosting the probability of error-free reception. This increases the effective link budgets on receive.¹⁷⁹

Greater reliability also means improved network efficiency, because busy-hour delays are minimized, cutting the need for retransmissions. The reduction in retransmissions has a significant effect on network delays, especially in the busy hour. In addition, ReFLEX™'s

network design also permits flexible transmission rates. The network can reduce transmission rates on receive where coverage capacity needs are low, so coverage can be provided by fewer base stations. Depending on a carrier's capacity requirements, the protocol supports inbound data rates at 800, 1600, or 6400 bits per second, allowing increased coverage at lower data rates in low-traffic areas, while retaining higher speed transmissions in high-demand locations.

ReFLEX™'s original design also included many other advantageous features.

- *High Power.* ReFLEX™ uses GPS timing signals to synchronize transmission and avoid interference from adjacent transmitters. Transmitters can use greater power than in cellular systems – up to twenty times more powerful. The result is a lower signal-to-noise ratios, better coverage, more reliable communications, and better in-building penetration.
- *Multiple carriers.* With ReFLEX™'s use of linear transmitters, multiple carriers can be carried on a single transmitter, reducing the cost of incremental capacity additions. These additional carriers, which can be dedicated to data payloads (e.g., without network control overhead), can be added simply by reprogramming the transmitters. Smart antennas can also be used to improve reception or capacity where it is too expensive to add receivers.
- *Non-symmetrical Capacity Increases.* ReFLEX™ permits transmit and receive paths to be sized separately, and receivers to be added independently. In a cellular system, inbound and outbound capacity are usually only adjustable in fixed proportions.

5. The Importance of Version 2.7, WCTP, and Other Developments

All of the attributes just described are already available from ReFLEX™'s current protocol, Version 2.6. However, Version 2.7, the first upgrade of ReFLEX™'s protocol in three years, will be deployed by all leading ReFLEX™ service providers in the next six months.

Furthermore, a consortium of ReFLEX™ service providers and technology vendors is also working hard on a new interface for wireless networks, the Wireless Communications Transfer Protocol (WCTP), an XML-based applications interface for ReFLEX™ networks.¹⁸⁰ This will be delivered in the same time frame as Version 2.7.

Finally, several device manufacturers are also about to deliver a variety of new low-cost designs for ReFLEX™-based PDAs, "cradles" and other devices that will work with Version 2.7 networks.

While there is still plenty of work to be done on all these developments, we believe that there is enough industry momentum behind them to justify "plausible speculation" about the advantages they will bring. It turns out that these benefits will be very substantial. The following are the most important ones for potential customers and development partners:

(1) Increased Capacity. A significant one-time increase in network capacity, at almost no cost, for all existing ReFLEX™ networks.

(2) More Flexible, Lower-Cost Capacity. Increased flexibility in capacity expansions, and lower incremental capacity costs.

(3) Much Lower Latency. A dramatic reduction in perceived latency over the network, enabling ReFLEX™ to support “near-real-time” applications like instant messaging, financial transactions and wireless POS.

(4) Interoperability and Roaming – “One Big Network.” The ability of new Version 2.7 compliant devices, applications, and subscribers to interoperate and roam across all ReFLEX™ networks, assuming that carriers implement the appropriate roaming agreements and interconnections.

Chart 20. Key ReFLEX™ v. 2.7 Technical Features and Benefits

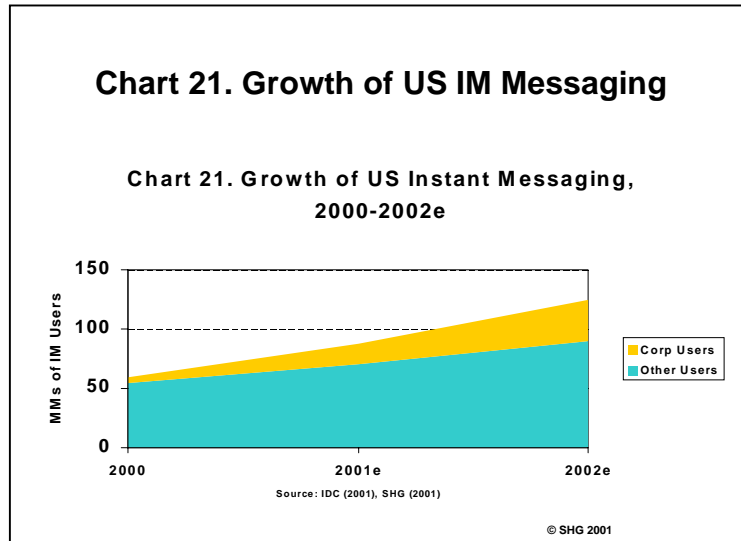
Benefits Features	Increased Network Capacity	More Flexible Capacity/ Coverage Expansion	Lower Latency/ Instant Messaging	Roaming/ Inter-Operability	Open-Systems Application Development
Background Scanning	√	√		√	
Auto-Collapse – “Chat Mode”			√		
Broadcasting Max. Inbound Message Length	√	√	√		
Harmonizing ReFLEX™ Variants	√	√		√	
Unscheduled Inbound Messaging			√		√
WCTP				√	√

© SHG 2001

(5) An Open-Systems Application Platform. Much more powerful, easier-to-develop applications, based on an open-systems based platform that already has strong support in the global Internet and software development community.

(6) New Low-Cost/ “Open” Devices. As noted, there will be a much broader selection of new devices for Version 2.7 networks. These will not only deliver lower costs, but also support much more powerful applications enablers, like J2ME.

● **Lower Latency/ Quasi-Real-Time Applications.** As noted in **Chart 21**, instant data messaging is one of the fastest-growing communications applications in the US, yet another



example of the success of simple messaging technology. The use of IM by corporate enterprises is projected to grow even faster, driven by its low cost, ease of use, and the proliferation of Web conferencing.¹⁸² So far almost all this IM activity is among wired PCs -- AOL is now the leading IM provider, with more than 33 million IM or ICQ¹⁸³ users. But there is also tremendous interest in providing wireless data users with IM capability. And

mobile data devices are also increasingly being used for other applications that demand quasi-real-time communication, including wireless point-of-sale, multi-player games and stock trading.

Unfortunately, all such “quasi-real-time” applications face the issue of latency, the speed with which wireless devices set up and complete communication with other devices on the network. This is not a bandwidth issue, but a question of network signaling and control. ReFLEX™’s latency has historically been relatively high, on the order of 30-60 seconds or more, because of its approach to conserving battery life and scheduling inbound messaging.¹⁸⁴ As described in more detail in Appendix A, however, several new features in Version 2.7 – including “auto-collapse,” chat mode, broadcasting maximum inbound message length, and unscheduled inbound messaging – promise to reduce ReFLEX™’s latency by more than 75 percent, from 30-60 seconds down to 5-15, or even less under certain circumstances.¹⁸⁵ Assuming it also follows through with V.2.7-compliant endpoint devices, this should permit ReFLEX™ to compete very effectively for real-time applications.

● **Interoperability and Roaming – “One Big Network”**

When Version 2.7 is fully deployed, from the user’s perspective there will no longer be any difference between ReFLEX™ 25 and ReFLEX™ 50. Applications and devices that are V. 2.7-compatible will work seamlessly on all networks. Assuming that ReFLEX™ operators can reach agreements, it should also be easy to roam transparently across all these networks, sharing capacity and coverage. In addition to facilitating interoperable services, roaming, and shared economies in applications development, this should also result in more efficient use of the combined network capacity.

Given that, as we’ve seen, ReFLEX™ operators already have the largest collection of two-way MDM customers in the US, and that Version 2.7 will provide capacity for at least

three-four times this customer base, this should also help to attract even more device manufacturers, application developers, and solution providers.

● **Finally! -- An “Open-Systems” Application Platform**

In addition to V. 2.7, there are also several other important supply-side developments that should help to strengthen ReFLEX™’s competitive prospects. One involves an effort to make ReFLEX™’s application development environment easier to use and more accessible. Following in the footsteps of the approach taken by leading wireless players like RIM and Palm, several ReFLEX™ operators formed a consortium, under the auspices of the Personal Communications Industry Association, to develop an “open systems” gateway for ReFLEX™ networks.¹⁸⁶

This “Wireless Communications Transfer Protocol”(WCTP)¹⁸⁷ provides an additional gateway (in addition to an SMTP¹⁸⁸ gateway) between ReFLEX™ networks and the outside world, using standard Internet protocols like XML and HTTP. Applications can treat ReFLEX™ devices as ordinary Internet nodes, with WCTP handling all the gory requirements of interfacing with the network.

This approach offers several key advantages:

- WCTP permits developers to create applications without having to know all the intricacies of ReFLEX™ networks. Any developer with a basic understanding of XML should be able to create applications quickly and cheaply.
- Once WCTP-compliant applications are written, they should work on all ReFLEX™ networks. WCTP can also provide an interface to other wireless data networks, including SMS. This provides more ways for ReFLEX™ applications to reaching other MDM users. Since applications are written in standard code, they will also be portable to non-ReFLEX™ networks.¹⁸⁹
- WCTP is a more efficient user of network capacity than naked TCP/IP, which was designed primarily for wired networks.¹⁹⁰

Overall, WCTP should open up ReFLEX™ to a much wider community of solutions providers and application developers. In a sense, therefore, the addition of all this new “development capacity” is just as important as the additional network capacity that V. 2.7 delivers.

● **Application-Specific Latency.** Another helpful development for mobile wireless applications is that the new ReFLEX™ V. 2.7 protocol allows for an adjustable mix of multiple access protocols on the return channel, and application-specific latency. For example, capacity can be reserved for contention multiple access for minimum latency or maximum capacity. Even for a given device, some applications can use the lower-latency allocation while others use the higher-capacity allocation. This feature is unique to ReFLEX™.

● **New Devices – With Support for J2ME !** As noted earlier, one key constraint on ReFLEX™’s success has been the shortage of really exciting, customizable MDM devices. This obstacle, too, is about to give way. Without revealing any trade secrets, a whole new family of V. 2.7-compliant mobile devices are now in the pipeline, for delivery in the next 3-6 months. Some are aimed mainly at simple, low-cost two-way messaging, which was initially targeted by Motorola’s T900 – for this segment, ReFLEX™ provides a unique advantage, because of its ability to handle very low-cost endpoint devices. Others include cradles for leading brand-name PDAs and new integrated wireless PDAs that will offer “industry standard” operating systems and cross-platform operating systems like Sun Microsystems’ “J2ME™”, the important enabler for wireless messaging in the enterprise segment that we examined in Chapter III.¹⁹¹

6. Summary – The Technical Foundations of ReFLEX™’s Revival

All told, the innovations just described should be able to overcome all the key obstacles to success that ReFLEX™ encountered during its first launch in the mid-1990s, including inflexible capacity, non-interoperable networks, “closed” approaches to hardware and software, a shortage of devices, and perhaps most important, a lack of clarity about ReFLEX™’s real value proposition.



The only cloud that still lingers is the continued plight of one-way paging operators. However, as noted earlier, we believe that this could actually be an **opportunity** for today’s ReFLEX™-based service providers. If they move quickly, and apply some of their newfound capacity, pricing flexibility, improved devices, and capabilities like “instant messaging,” they may be able to convert a significant share of one-way paging customers to two-way services.

At the same time, we’ve seen that ReFLEX™ has many compelling performance advantages even before we get to V. 2.7 and the other innovations. These include attributes like low cost, reliability, battery life, coverage, and building penetration that are inherent in ReFLEX™’s architecture. Combined with the exciting developments now in the works, plus some creative marketing, we believe that there is a major opportunity to relaunch ReFLEX™ as the leading technology in the US MDM market.

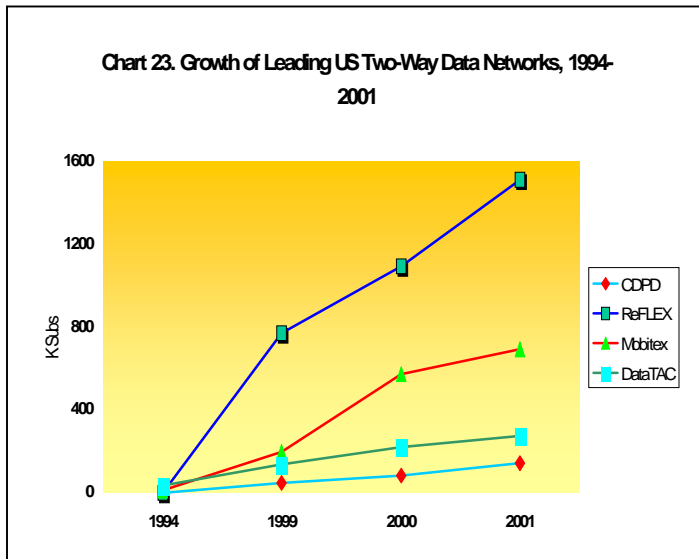
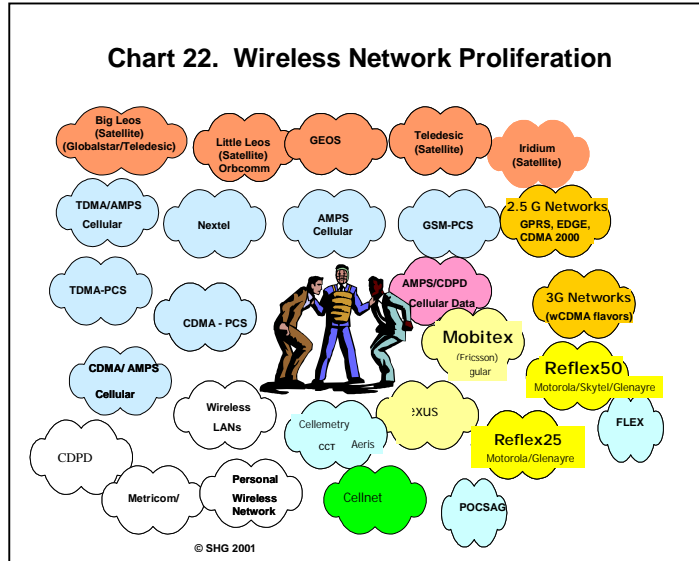
Of course the wonderful thing about capitalism is that no matter how good *or bad* you are in absolute terms, it does not matter very much at the teller’s window unless you can also beat the competition. Chapter V. examines how ReFLEX™ stacks up against to its most important competitors, now and in the future.



V. ReFLEX™'s Competitive Advantages

1. Introduction -- ReFLEX™'s Key Competitors

Now that we've covered ReFLEX™'s technology in some detail, we can proceed to examine how it stacks up against its most important rivals. In the last twenty years there has been a striking proliferation of wireless data networks (see **Chart 22**), driven by supply-side factors like the availability of more powerful microprocessors, new spectrum allocations, and increasingly clever engineering, and, on the demand side, by a seemingly insatiable demand for mobile communications.¹⁹² This proliferation complicates our mission – how can we possibly evaluate all the alternatives?



Of course we've already dealt with the hapless world of circuit-switched WAP and the elusive 3G "vision" in Chapter III. Those analyses will serve as bookends for this chapter. Here, we'll focus on those competitors that have either already achieved the greatest market success, or are about to be introduced by major US cellular operators. As shown in **Chart 23**, the key data-only competitors include Cingular's Mobitex™ network, Motient's DataTAC™ network, and CDPD, which is offered by AT&T

Wireless and several other cellular operators. We'll concentrate on Mobitex™, which almost half has many subscribers as ReFLEX™, relatively high ARPUs, strong technical foundation and global industry support. After all, if the "new ReFLEX™" can master Mobitex™ on performance and costs, it should also be able to handle the others.

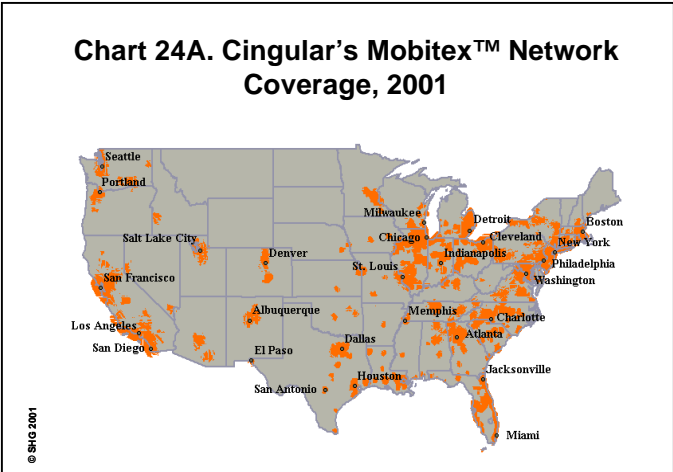
The following section takes a detailed look at Mobitex™, focusing on the factors behind its revival and its comparative advantages. For DataTAC™ and CDPD, we've provided thumbnail sketches, and they are also included in the detailed tables on network performance and costs in Appendix B. We'll also look at the pros and cons of the two

leading so-called 2.5G candidates, GPRS and CDMA 2000.¹⁹³ Finally, we'll draw some conclusions about ReFLEX™'s longer-term competitive prospects.

2. Mobitex™'s Origins, Decline and Revival

Like ReFLEX™, Mobitex™ also went through a long period of stagnation after its first launch, and then a sharp revival. Understanding the conditions that made this possible will also help us understand ReFLEX™, which has also experienced a long maturation period. Mobitex™'s history also illustrates another central theme of this paper – being able to deliver reliable, low-cost, user-friendly, and pervasive, even if somewhat “slow” -- mobile data services can be a *sufficient* condition for competitive success.

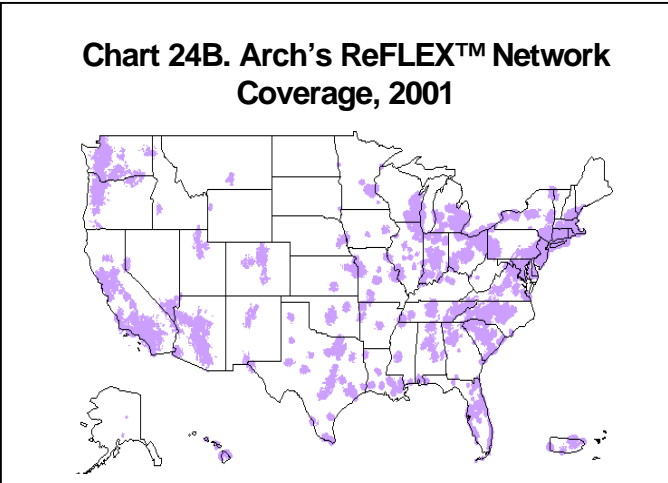
Mobitex™ was originally developed by Eritel, an Ericsson subsidiary, for Sweden's National Communications Authority in the early 1980s. Announced in 1984, the first commercial version was launched in Sweden in 1986, used by Telia, the local phone company, to manage field service calls. In the late 1980s Mobitex™ was brought to Canada by Rogers Cantel in 1988 and to the US by a New York startup, RAM Broadcasting Corp., in 1989.



¹⁹⁴ Over the next decade, 27 more Mobitex™ networks were built in 19 other countries, mainly in northern Europe and a handful of Asian countries.¹⁹⁵

In the US, Mobitex™'s expansion was accelerated by BellSouth's 1992 decision to acquire 49 percent of

RAM Mobile Data,¹⁹⁶ and its October 1997 decision to buy control of RAM. At that time, Mobitex™ appeared to offer the lowest latency and a clear path toward a cellular data future. Over the next three years, BSWD invested more than \$300 million to build a nationwide hierarchical network that grew from 840 base stations and 40 regional switches in 1994 to 1200 base stations in 1996, 1900 in 2000, and more than 2500 in 2001.¹⁹⁷ All told, according to Cingular Wireless (Bell South Wireless Data's new parent),¹⁹⁸ the network now covers about 93 percent of the US “urban business” population, including 200 million people in 492 metropolitan areas.¹⁹⁹ Of course the US population is



now about 276 million, so from Mobitex™'s total population coverage ratio is about 72 percent. (See **Chart 24A.**) ReFLEX™ networks, in contrast, now cover more than 95 percent of the US population. (See **Chart 24B.**)

Despite all this investment, for its first decade Mobitex™ suffered from an acute shortage of customers. As of 1994, RAM only had about 12,000 subscribers, 5000 fewer than Motorola's Ardis'/ DataTAC™ network, and as of 1998, just 125,000, for a network that had been designed to handle over a million.²⁰⁰

This slow takeoff was due to several factors:

- For most of the decade two-way messaging on Mobitex™ was a high-cost, low-performance novelty. Before Internet messaging and the PDA booms of the late 1990s, there was a dearth of low-cost messaging devices and services. Users had to make do with expensive, hefty external modems or PCMIA modems on bulky, slot- and battery-constrained laptops.²⁰¹ Nifty devices like RIM's Interactive Pager and the Palm VII did not appear until late 1998.²⁰²
- These devices and their service plans were also pretty pricey, until the price cuts of the last two years.²⁰³
- Since the Mobitex™ network didn't support native IP, even when it arrived, Palm VII's "Web clipping" service received terrible WAP-like reviews.²⁰⁴
- The Mobitex™ network didn't interoperate with the other data-only networks. Furthermore, before the Internet took off, mobile access was much more cumbersome. Connecting one's corporate email system to the Mobitex™ gateway required a dedicated X.25 connection, which few businesses could afford.
- Nor were there many convenient development platforms around to facilitate application development. For mission-critical applications, customers also found Mobitex™'s coverage and in-building penetration lacking. For example, when UPS and Fedex considered using Mobitex™ (or DataTAC™) for heavy-duty package tracking in 1993-94, they decided to build custom solutions instead.²⁰⁵

What apparently did *not* hurt Mobitex™ was its relatively low data rate. Indeed, the current (second) release of its software, which dates from 1992, claims a maximum throughput of just 8 kbps. And even this is overstated -- the effective maximum shared data rate is actually only about 4.5kbps,²⁰⁶ and in practice most users average just *1.2 to 2 kbps* on Mobitex™!²⁰⁷ Despite this network sloth, it turns out that this is *perfectly fine* for the great bulk of two-way and email messaging -- especially the 99 percent that is less than 10kb per message and lacks file attachments.

What users *were* aware of was latency, the amount of time it takes for a response to be received from the network, once a message is sent. And here Mobitex™ established a strong track record, with latency of just 5-15 seconds under most conditions. As we will see below, ReFLEX™'s new capabilities in this area mean that it will now be able to overcome one of Mobitex™'s most important historical advantages.

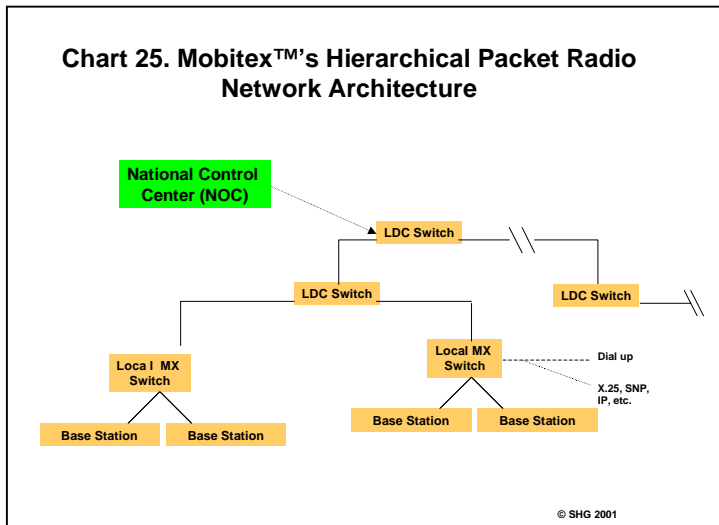
Accordingly, as “cool,” easy-to-use devices, more competitive service pricing, better applications platforms, and just plain better marketing especially by RIM, became available for Mobitex™-based services after 1998, its subscriber base began to take off, more than tripling from 200,000 in 1999 to 570,000 in 2000 and 690,000 by mid-2001.²⁰⁸ Furthermore, many of these were low-churn, high-ARPU business and professional customers. Overall, Mobitex™ is clearly ReFLEX™’s most important data-only network competitor, with very high levels of performance and customer satisfaction.

3. Mobitex™’s Strengths and Weaknesses

Mobitex™ is described by its supporters as an “open,” global network protocol that is available royalty-free to all members of the Mobitex™ Operators Association. But the protocol’s copy write is owned exclusively by Ericsson, which carefully controls its distribution and modification. As noted, the most recent version, V.2, dates from 1992. V. 3 which is supposed to offer better building penetration and adaptive rate coding that boosts data rates up to a 16-32 kbps, is long overdue. As we saw above, average throughput is usually well below such maximums. Furthermore, given Ericsson’s recent economic troubles and its decision – like Motorola -- to focus on its cellular businesses, Mobitex™ operators are not holding their breathe for this third release.

A. Mobitex™’s Network Architecture

From a technical standpoint, Mobitex™ is a nationwide, trunked packet-data mobile radio network, with a hierarchical cellular architecture. This is a fancy way of saying that the network has base stations, regional and national message switches, and a national control center that are all connected by a private wireline data backbone. (See **Chart 25.**)



The basic network was designed for licensed public and private operators in two basic flavors.²⁰⁹ In the Americas it operates in the 896-901 Mhz (handset) and 935-940 Mhz (base station) bands, just above cellular services, where RAM Mobile Data acquired about 200 frequencies in the 1990s, each capable of 8 kbps, with 12.5 KHz channel spacing, and about 500-750 KHz of spectrum in all, depending on the region. (Note: ReFLEX™

has 2 MHz). In Europe and Asia the network operates at 415-430 Mhz, with a poorer selection of devices and applications.²¹⁰ This global split has undermined the potential global economies that Mobitex™ might have obtained from deploying common interfaces and devices. It seems to reflect regional differences in regulatory regimes rather than Ericsson’s strategy.

Another key interesting feature of Mobitex™'s global picture is there tends to be only one nationwide public operator per country. This means that national roaming is automatic. It also means that competition has had to come from non-Mobitex™ networks – an unpleasant surprise for some customers. In Europe, where there are Mobitex™ networks in 11 countries, international roaming has been established, but there are no international roaming agreements among the Canadian, US, or South American networks.

B. Key Mobitex™ Attributes

From the standpoint of network performance and economics, Mobitex™ has the following key features:

□ **Packet Switching.** Like DataTAC™, ReFLEX™, the 2.5G networks, and the Internet itself, Mobitex™ is a digital packet-switched network. This means that it is “connectionless, - - unlike, say, a phone call, there is no end-to-end session. Instead, messages are aggregated into short bursts of digital data -- “packets” – with their own identifiers. The packets can be sent out over the network in any order. Each packet is routed to the common destination, where they are reassembled in order. In Mobitex™'s case each packet (“MPAK”) holds up to 512 bytes of data, a half-page of text.

Compared with networks like 2G WAP or circuit-switched CDPD,²¹¹ this packetized approach has several advantages, especially for short messages, the bread and butter of mobile messaging.

- It shares spectrum more efficiently among multiple users, allowing perhaps 10-50 times more subscribers per channel.
- Because of continuous connectivity, it permits low latency – less than 5-15 seconds per roundtrip message. As noted earlier, this is very useful in applications like wireless POS, OLTP,²¹² instant messaging, and interactive gaming that require quasi-real-time messaging.
- Packetization also enables message “push,” where senders or host computers can initiate messages. This allows devices to be, at least in theory,²¹³ “always on,” without tying up any network capacity.

□ **Hierarchical Structure.** Another distinctive feature is Mobitex™'s hierarchical structure. This means that messages are routed only to the lowest nodes common to both senders and receivers. This means that messages are automatically localized, avoiding the need for redundant wide-area distribution and wasted spectrum. Sophisticated “shortest path” routing algorithms are also used when messages have to cross multiple switches. Specific error correction mechanisms like link-level data checking and forward error correction are also employed at each level of the hierarchy to improve reliability. Meanwhile, billing information and administrative data gets passed to the system's highest level, Cingular's Network Control Center in Woodbridge, New Jersey.

□ **Cellular Architecture.** Each Mobitex™ base station serves just one local radio cell up to 30 kilometers in diameter, providing “last mile” connections to all devices in the cell. As

noted, Mobitex™ channels are 12.5 KHz wide, and each cell supports 10 to 30 channels.²¹⁴ As subscribers move across cells, their frequency-agile Mobitex™ radio modems, which operate on Cingular's several hundred allotted frequencies, stay connected to the network, switching to the best channels and base stations available. Like ReFLEX™, this automatic registration permits transparent roaming, as well as store-and-forward messaging, when users lose coverage or turn off their devices.

❑ **No Macrodiversity/ Simulcasting.** Unlike ReFLEX™, Mobitex™ users are never communicating with more than one base station at a time. This explains why ReFLEX™ has much better in-building penetration.TM Mobitex™'s distributed architecture is also not well-suited to applications that require simultaneous broadcasting to all users. Like other cellular systems, Mobitex™ is unable to deliver a single message simultaneously to multiple destinations – an important feature for applications like advertising, information services, or group chat.

❑ **Very Low Data Rate.** Compared with, say, DataTAC™, whose channel bandwidth is 25 KHz and has a maximum throughput of 19.2 kbps,²¹⁵ Mobitex™'s narrower 12.5 KHz channel is partly responsible for its 8kbps maximum data rate.

❑ **High Initial Coverage Costs.** From a network economics standpoint, Mobitex™'s cellular structure, plus the fact that all its network software and hardware still come from just one supplier, account for the fact that it has the highest initial coverage cost of any data-only network.²¹⁶ As we'll see, this is at least 1.5-2x the costs of DataTAC™, CDPD, or ReFLEX™.

❑ **Lower Incremental Capacity Costs.** On the other hand, Mobitex™'s modular design also features relatively low *incremental* capacity costs, because it is able to add base stations and subdivide channels selectively wherever traffic demands it. As we noted in Chapter IV, until V. 2.7, ReFLEX suffered from “indivisibility” -- network capacity had to be added (almost) everywhere to be useful anywhere. (With V. 2.7, ReFLEX™ actually pulls ahead of Mobitex™ in this category. See below.)

❑ **Protocol Support.** Mobitex™ really shows its age and heritage when we examine its support for transport protocols. Born in the pre-Internet heyday of ISO and CCITT standards and IBM-dominated networking, it supports a multitude of aging protocols like IBM's SNA,²¹⁷ X.25, MTP/1, and the X.24 CCITT standard for public packet-switched data networks. On the other hand, what it doesn't support very well is native TCP/IP, which has long since come to dominate the WAN world. For users, this means that gateways like Palm.Net and the RIM Blackberry server are required to support ordinary POP3 or IMAP Internet messaging and, especially, secure access to corporate email.²¹⁸ This considerably adds to expense and hassle. The only good news is that most of the other data-only networks are in the same boat – only CDPD provides native IP support.

❑ **Security – “Buyer Beware.”** Mobitex™'s key sponsors, Ericsson and Cingular, have long been outspoken in their assertions that it is a “relatively secure” mobile network,²¹⁹ a claim that is often repeated in the press.²²⁰ Indeed, unencrypted Mobitex™ applications are widely used by police forces, emergency services, and even wireless POS services, especially in Europe and Canada. However, while there are some aspects of Mobitex™'s algorithms

that make snooping challenging, ²²¹ detailed protocols for scanning and decoding unencrypted Mobitex™ traffic have in fact been freely available on Usenet groups since at least 1997, and the equipment required is easily within reach of any “RadioShack amateur.”²²²

The fundamental fact is for ALL wireless data WANs and LANs, is that for the serious hacker, unencrypted traffic provides *virtually no* security. If security is a real concern, the only answer is end-to-end encryption at application layer – as is increasingly recognized by most Mobitex™ and ReFLEX™ service providers, and recently emphasized by successful attacks on wireless networks.²²³ Both Palm and RIM have recognized this in designing their gateway services that run on Cingular’s network. Unfortunately, this requires mobile devices with more powerful CPUs and real operating systems. This helps to explain the increasingly powerful processors on the latest Palm and RIM devices, and the growing interest in micro-operating systems like J2ME, BREW, and Symbian.²²⁴

□ **Device, Application Platforms, Middleware Tools, and Industry Support.** Strictly speaking, devices, applications platforms, and middleware are not network properties, but Cingular’s Mobitex™ network certainly owes a great deal of its success to the fact that technology vendors like Palm, RIM, Handspring, and Aether are developing devices, middleware tools, and applications for it.²²⁵ This has provided Cingular with a great deal of joint sales/marketing as well as technical support. The continuing strong support of Ericsson, Mobitex™’s original network vendor, has also helped, as has the fact that Cingular has very wealthy RBOC (“Regional Bell Operating Company”) parents. These factors alone go a long way to explain why Mobitex™ is ReFLEX™’s strongest data-only competitor, and the other ReFLEX™ competitors are far behind.

4. Summary - Mobitex™ Vs. ReFLEX™

Charts 26 and 27 (A-C) in Appendix B provides more details on technical and economic comparisons among all these networks. As shown there, when ReFLEX™ is compared toe-to-toe with Mobitex™ on performance, economics, and industry support, it compares extraordinarily well – especially for a network technology that almost no one outside the paging industry has ever heard of.

In particular:

□ **Technical Advantages.** *Even before Version 2.7*, ReFLEX™ clearly *outperforms* Mobitex™ on many critical technical attributes, including

1. Date Rate. ReFLEX™ averages at least **twice** the actual throughput of the Mobitex™ network. This also translates into greater capacity for each coverage zone.

2. Wide-area Coverage. ReFLEX™’s national coverage is nearly a third greater than Mobitex™’s.²²⁶ This is a decisive advantage for ReFLEX™ in applications that require reliable reachability, especially where access is needed outside core urban areas. (See the coverage maps in **Appendix B**, the coverage estimates provided in **Chart 26**, and **Chart 32** below.)

3. **In-building Penetration.** This is also a decisive advantage for ReFLEX™, especially where urgent/ emergency messaging is required.

4. **Broadcasting.** This ReFLEX™ advantage has recently been put to work in an application for Gemstar, TV Guide's owner. Gemstar will be using Arch's ReFLEX™ network to broadcast TV programming information to thousands of new TV sets that are to be manufactured with built-in ReFLEX™ modems.²²⁷ The application also leverages ReFLEX™'s two-way capability by permitting viewers to order pay-per-view and merchandise.

5. **Reliability/ Reachability.** This is a combination of battery life, coverage, in-building penetration, and the availability of portable devices. When these attributes are considered jointly, ReFLEX™ has an even more dominant advantage over Mobitex™ than when they are considered separately, in terms of the percentage of successfully completed messages within a given latency range.

6. **Low-Cost Devices/ Long Battery Life.** As discussed, ReFLEX™ has much longer-battery-life devices at price points that Mobitex™ can't come close to.

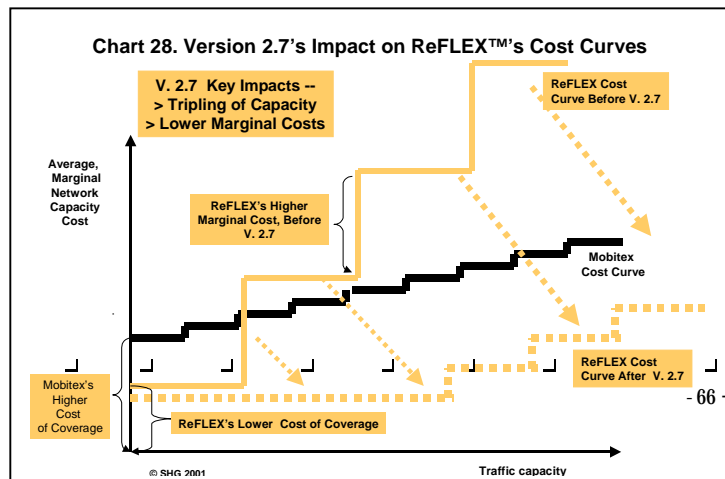
7. **Latency.** Prior to V. 2.7, as noted, Mobitex™ had a clear advantage over ReFLEX™ on latency. But V. 2.7 appears to have eliminated this differential, to the point where both systems now achieve 5-15 second latencies under normal conditions.

8. **Security.** Unless devices support end-to-end encryption, both ReFLEX™ and Mobitex™ are vulnerable to security problems from determined hackers. This may or may not be a serious concern, depending on the application.

□ **Economic Advantages.** The economic advantages of a given network depend on a combination of (1) device cost, availability, and functionality, (2) network capital and operating costs, and (3) the cost and quality of application development. From this angle, Mobitex™ has an early lead in devices, based on its successful relationships with Palm and RIM. It also has the edge in proven enterprise applications, wireless applications developers, and middleware support.

However, if ReFLEX™'s supporters can move quickly enough to take advantage of V. 2.7 and WCTP, these could easily become fleeting advantages. As summarized in **Chart 28**, ReFLEX™ networks now have several very important economic cards to play.

○ **A One-Time "Free" Increase in Network Capacity.** First, as discussed in Chapter IV, V. 2.7 will deliver a huge one-time increase in network capacity, at zero marginal cost. In the short run some ReFLEX™ operators will also be able to take advantage of



surplus network equipment, left over from other ReFLEX™ operators like ConXus, and the merger of Arch, PageNet, and MobileCom. Finally, ReFLEX™ operators in the US now own more spectrum – 2 MHz! – than all other data-only operators combined. In particular, an Arch/Weblink combination might deliver unsurpassed national coverage and capacity. All this near-term capacity should permit ReFLEX™ operators to grow their user base significantly, and perhaps experiment with pricing models that go after Mobitex™’s relatively high fixed costs.

- **Lower Long-Term Marginal Capacity Costs.** As noted in Chapter IV, V. 2.7 will also sharply reduce Mobitex™’s advantage with respect to incremental capacity costs, to the point where ReFLEX™ and Mobitex™’s incremental capacity costs will become almost identical. (See **Appendix B, Table 2**, for an estimate of comparative incremental costs per MB delivered, and **Chart 28** for the economic consequences.)
- **Harvesting Opportunities.** Once again, as noted in Chapter IV, ReFLEX™ operators not only have 1.6 million two-way customers, two-and-a-half as many as Mobitex™, and already growing at a faster rate. The ReFLEX™ operators also have more than 30 million one-way customers who might be converted to two-way. Given the excess capacity in ReFLEX™ networks, this becomes a question of devices, applications, support costs, and sheer marketing – the ability to explain to one-way customers why it makes more sense for them to trade in their one-way pagers for dependable, low cost MDM devices rather than switch to cell phones or other devices that are less reliable and cost more to own.
- **Channel Power.** Assuming that this harvesting proceeds briskly, ReFLEX™ might soon be sitting on a two-way customer base at least four times its current size. This should catch the eye of even more leading two-way device manufacturers, middleware providers, and perhaps a network vendor or two. This should help to overcome ReFLEX™’s current disadvantage in industry support.
- **ReFLEX™’s Device Advantages/ Device Proliferation.** When V. 2.7 is fully installed, its new capacity should also help light a fire under ReFLEX™’s advantages with respect to devices. For example, since ReFLEX™ transmitters are relatively low power – just 0.25-1.0W, compared with Mobitex™’s and DataTAC™’s 2W transmitters -- they generate less heat and interference, permitting less expensive components to be used. As noted, ReFLEX™ devices also have superior battery life because an advanced sleep cycle is designed into the protocol.

This means that new ReFLEX™ devices should have *much* lower unit costs, even before we take into account the scale effects of a large subscriber base. As noted in Chapter IV, and detailed in Appendix B, several device OEMs like Korea’s Standard Telecom (using the “Nixxo” brand) and Fine Telecom (“the Telica” brand), and Belgium’s Advantra²²⁸ have already understood this potential, and licensed the ReFLEX™ protocol from Motorola. They are working on V 2.7-compliant MDM devices, several of which have price points below \$100 retail. Meanwhile, at the high end, as noted in Chapter IV, there are also other new PDA-like devices in the pipeline that support the Palm OS and J2ME. These will enable ReFLEX™ to compete more effectively in the enterprise applications market.

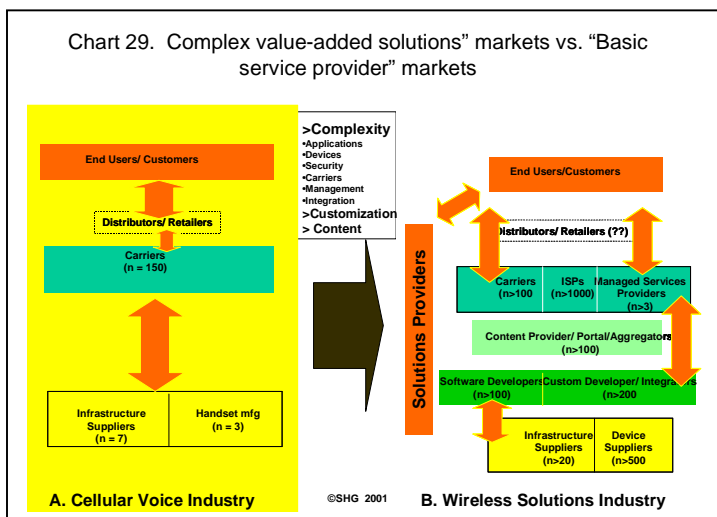
Overall, this marks a striking reversal of Motorola’s earlier policy of keeping ReFLEX™ device development closed and proprietary, and will help catalyze the V.2.7 launch.

□ **Industry Support.** Our last item for comparison has to do with industry support, the degree to which customers can count on a supply chain of solutions developers, software vendors, network equipment vendors, device OEMs, and service providers to help them deploy and support first-rate useful mobile solutions. As summarized in **Chart 26** (Appendix B), Mobitex™ has been leading in this category, with support from vendors like RIM and Palm, solution providers like Aether, and Ericsson, its original parent. It also has a leading national service provider, Cingular Wireless, that generates more than \$1.2 billion a quarter of EBITDA from its cellular/PCS voice services, and has two wealthy RBOCs as parents.

In contrast, two of the three ReFLEX™ operators are facing near-term financial reorganizations, and the strategic intent of the third, MCI/Worldcom’s Skytel, is not clear. Quite frankly, no matter how technically advanced ReFLEX™ V.2.7 may be, customers and channel partners are likely to examine the whole “supply chain” that supports a network, not just its technical merits.

In short, we believe that ReFLEX™’s new capabilities, including V. 2.7, provides the technical foundations for a strong rebound. But the most important challenges that ReFLEX™ faces are not technical. Indeed, one key lesson from Mobitex™ is that a very mature technology was able to revive itself largely because it combined solid technical foundations with strong partnering, marketing, and financial skills. Fortunately, it appears that a growing number of device manufacturers, applications developers, and middleware companies are beginning to take an interest in ReFLEX™’s potential.

5. Applications “Fit” – Valuing Technical Attributes



Of course the value of technical attributes like latency, coverage, and throughput depends on their role in particular applications, and this varies a great deal. See, for example, Appendix B’s **Table 3**, which summarizes the role of different attributes in various wireless data applications. For our purposes this means that there is no “absolute” answer to the question, “Is ReFLEX™ “better” than Mobitex™?” The answer

depends on the mix of applications that are demanded by a particular market.

In general, for applications like field sales, vehicle location, or wireless distribution of an electronic TV guide, ReFLEX™’s solid advantages in coverage, building penetration, and simulcasting might take the lead. ReFLEX™ has a very strong mix of attributes and cost that – assuming stronger channel partners and devices – should be able to satisfy a wide variety of MDM application requirements. If markets are diverse enough, however, there may actually be plenty of room for *both* ReFLEX™ and Mobitex™, with service providers shifting their focus from “selling airtime” to “providing solutions.”

Indeed, as described in **Chart 29**, there is a clear trend toward the emergence of a “wireless solutions” industry. This reflects the increasing number of complex wireless *and* wired networking alternatives that customers now face. It also reflects the fact that designing solutions increasingly requires the integration of many different disciplines, from network security and systems integration to network design and the knowledge of specific CRM or SFA applications.

This trend is especially important to service providers for data-only networks like ReFLEX™ and Mobitex™ to understand. This is not only because the market demands that they think about solutions in a more network-agnostic way, but also because – as we’ll see below – they may soon be forced by “common enemies” to regard themselves more as allies than as antagonists.

6. The Other Data-Only Network Alternatives

Chart 30A. Other Key Two-Way Wireless Data-Only Networks

Technology	Basics
Mobitex™	<ul style="list-style-type: none"> •20-year old 8 kbps two way technology •Packet-switched cellular network structure •Ericsson - lead network vendor • Devices by RIM, Palm, Novatel, etc. •US nationwide coverage - Cingular (Bell South) •690, 000 US users, 2001 • Networks in 21 countries
Cellular Digital Packet Data (CDPD)	<ul style="list-style-type: none"> •Packet-switched or circuit-switched data over analog AMPs, TDMA and CDMA cellular networks -- up to 19.2 kbps max. but 4.8kbps ave. •146,000 US users, 2001 •US, Mexico, and Venezuela technology •Leading US providers - AT&T Wireless, Verizon •Not all metro areas covered
Datatac™	<ul style="list-style-type: none"> •Data-only mobile wireless network -- up to 19.2 kbps •272,000 US users, 2001 •Origins in IBM/Motorola Ardis network for field service •Motient is only leading service provider in US (Datatac 4000 tech) • Outside US, in Asia and Europe at 400 Mhz, 9.6 kbps max • Devices - RIM, Korea, Motorola

© SHG 2001

Earlier we argued that surviving a face-off with Mobitex™ was a sufficient condition for ReFLEX™ to dominate its other data-only competitors, as briefly described in **Chart 30 (A and B)**. As shown in Appendix B, this does indeed turn out to be the case, although each network excels at some features, reflecting their peculiar histories.²²⁹ In general, if ReFLEX™ is able to overcome the industry support issues noted above with respect to Mobitex™, it will also

easily handle these less formidable competitors.

The other data-only networks also provide more evidence for what we will call *the “copper cable”/“DC-3”* hypothesis. This is the notion that even mature low-speed data

Chart 30B - Other Data-Only Networks

Technology	Basics
Circuit-switched data (CSD)	<ul style="list-style-type: none"> •Dial-up access over cellular networks (analog, CDMA, GSM); (Sprint sends digitally) •9.6 kbps (analog) - 14.4kbps usual max (but Sprint PCS +Blue Nite, or Broadcloud booster service →56kbps) •5.2 million US users, 2001 ---> but low intensity use •Providers - all US cellular operators •Pricey (\$30 connector + \$150 modem +\$7/mo surcharge +airtime) •Devices - PC cables for cell phones; special CDMA devices for telemetry

networking technologies can find a new lease on life if their supporters are willing to focus on real customer needs. In the case of copper cable, the 100-year old dialup phone system provides a low-cost, reliable, global, easy-to-use network that anyone can access with just a phone or modem. It is not about to disappear just because someone has discovered how to send gigabits of data per second over optical fiber or Terabeam™ lasers. Nor did the DC-3, first produced by McDonnell Douglas for American Airlines in June 1936, disappear just because of jet planes. Of 10,629 DC-3s ever produced, several hundred are still in operation.²³⁰ Meanwhile, McDonnell Douglas has gone the way of all flesh. In the case of ReFLEX™, Mobitex™, and DataTAC™, we suspect that they may also outlive some of the engineering-centric, customer-phobic organizations that created them.

7. 2.5G – A Threat to Everyone Else?

Of course the notion that US data-only networks only need to worry about each other begs the question of what cellular operators companies have in store with respect to higher speed data



Chart 32. "Higher-Speed" Cellular Wireless Data Alternatives

Network	Basics
CDMA 2000	<ul style="list-style-type: none"> Qualcomm's upgrade to CDMA networks...packetized voice and data, initially 144kbps max →384 kbps eventually (...for what?..) Already commercial in Korea Industry support - Lucent, Nortel, Qualcomm (patents), Ericsson, Samsung, Hyundai, NEC, Lucky Goldstar, Motorola, Nokia (terminals) Initial upgrade also doubles voice capacity →econ., but costlier than GPRS US Rollout Q4 2001(?) – Sprint PCS, Verizon Initially - coverage in selected metro centers only Limited device availability Carrier focus on mass-market, horizontal applications
GPRS	<ul style="list-style-type: none"> IP packet data upgrade to GSM, TDMA networks Doesn't packetize voice...uses part of voice network for packet data 55 operators, 20 countries so far US – Voicestream nationwide by 12/20 (for \$50 mm)...then ATTW, Cingular Limited devices so far –\$500, battery life "Always-on" is a theory, given low coverage Throughput – 115kbps max/ shared, 15-20kbps actual Voice channel cannibalization problem for data business.....high opp. costs, most apps Supported by major network equip vendors (Motorola, Ericsson, Nokia, etc.)

© SHG 2001

networks, beyond their dismal experiments with WAP and circuit-switched data. As outlined in **Chart 31**, the two most interesting candidates are the so-called "2.5 G cousins," GPRS and CDMA2000, both of which are digital packet-switched upgrades to existing cellular networks. There is already a huge technical literature on these prospective networks, and we won't repeat that here. For the interested reader, **Chart 28** in **Appendix B** and **Appendix Table 2** summarize their key

technical attributes and potential relative costs. Given the fact that these networks are only just now being deployed, our assessments are necessarily somewhat tentative. But as usual, some things can be said.

❑ **Perpetuating Network Divisions.** To begin with, it is important to understand that these 2.5G upgrades will perpetuate the deep divisions that already exist among rival 2G cellular networks in the US. Originally the idea was that they were interim upgrades on the way to a "grand reunion" of TDMA, CDMA, and GSM networks under the 3G/ wCDMA/

UMTS banner. (See Motorola's version of this roadmap in **Chart 33**.) However, as we saw in Chapter III, 3G's timing and economics are in now in doubt. So the 2.5G upgrades are beginning to look more like longer-term destinations than bridges.

A. GPRS

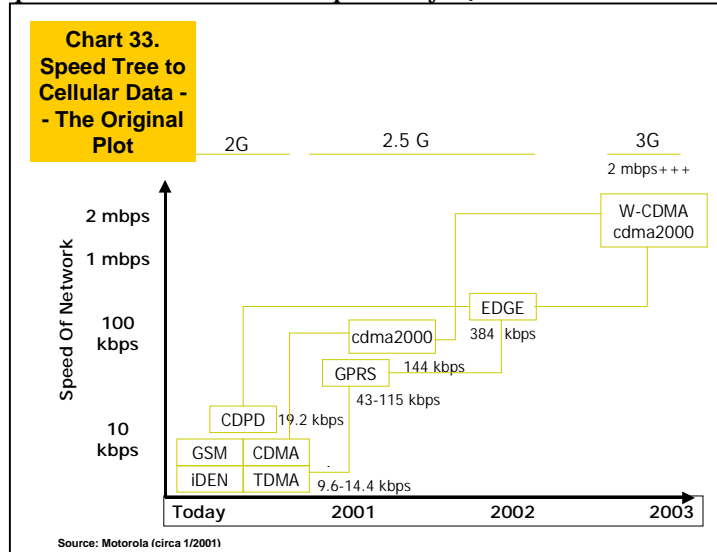
After five years of standards work by ETSI,²³¹ in the late 1990s the GSM Forum proclaimed GPRS – “General Packet Radio Service” – as the next big thing for the world's 535 GSM cellular operators, a digital packet-switched overlay to their existing networks. In theory, GPRS offers multiple advantages. First, it is supposed to be able to provide higher data rates, with maximum throughput up to 171.2 kbps, enough to support applications like video and audio streaming as well as Web browsing and email.²³² Second, unlike a circuit-switched network, but like i-mode, GPRS is supposedly “always on,” avoiding the horrible latency – “WAP wait” – associated with surfing on 2G networks, and supporting real-time applications like chat. Third, since GPRS is packet-switched, like i-mode, users will only be charged for data packets actually delivered, rather than airtime. Fourth, once WAP 2.0 is deployed, GPRS will support all the nice colors and graphics that i-mode already delivers. Fifth, for 2G GSM networks, upgrading to GPRS is supposed to be relatively easy and inexpensive.²³³ Finally, for 3G believers, the promise is that eventually there can also be a smooth transition from GPRS to whatever variant of EDGE, wCDMA, UMTS, or “whatever...”

In Europe, where the GSM camp includes almost everyone, this argument has been widely accepted. BT Cellnet launched the world's first GPRS data network in June 2000. At last count GPRS was being piloted by at least 59 European operators in 18 countries, including 15 of the top 20. Worldwide, there are now another 88 GPRS pilots in more than 30 other countries – including 13 in China alone. So far, full-scale deployments have been limited by factors like a shortage of working GPRS handsets. (See below.) Even so, and despite this year's depressed cell phone market, Motorola, the market leader in GPRS handsets, expects to sell 5 million this year, and twice that many in 2002.²³⁴ This is consistent with a global installed base for GPRS on the order of 20-30 million by the end of 2002.²³⁵ While this is a tiny fraction of the global 400-450 million cell phone market, it is obviously a key growth segment for the wireless data market, especially outside the US.

In the US and Canada, where until recently there were only a handful of small GSM operators, Voicestream/Omnipoint (now owned by Deutsche Telecom) had already started upgrading its GSM network in late 2000. But the real boost for GPRS' US prospects came when Cingular Wireless and AT&T Wireless announced plans to essentially double-upgrade their TDMA networks, first to GSM, and then to GPRS, and both launched commercial service in Seattle this summer. Depending on how their pilots go, these two carriers could offer GPRS on most of the POPs by the end of 2002.²³⁶

B. CDMA2000 1XRTT

Meanwhile, the other key faction in the US cellular industry is following the Qualcomm-designated route to 2.5G, so-called “CDMA2000 1xRTT.” This camp, which includes Sprint PCS, Verizon, and probably Quest, Nextel, and Alltel, has been slower to do trials,



partly because CDMA2000 1xRTT is a more expensive upgrade than GPRS.²³⁷ Around the world, there are also far fewer CDMA networks, though 1xRTT has already been launched by SK Telcom and LG Telcom in Korea,²³⁸ with Japan’s KDDI also launching in next year. In the US, Sprint PCS is the 1xRTT frontrunner, with plans to deploy in “late 2001.” Apart from the fact that its upgrade costs and maximum data rate – 144 kbps – are slightly higher, CDMA2000

1xRTT offers the same nominal advantages as GPRS.

C. Beneath the 2.5G Hype

At first glance, then, both these new networks appear to be formidable potential competitors for all low-speed data networks, including ReFLEX™. However, before we concede too quickly, we need to remember our history lessons, especially the cases of i-mode and SMS in Chapter III, ReFLEX™ in Chapter IV and Mobitex™ in Chapter V.

As we saw there, competitive success in MDM depends less upon raw speed, cool colors, or fancy multi-purpose designs than on a network’s ability to offer *attributes that customers really find useful*. In the case of MDM, for many applications these include reliability (a joint product of coverage, interoperability, battery life, error correction, and in-building penetration); easy-to-use devices and applications platforms; a prolific applications development channel; and affordable costs. From this standpoint, we believe that at last for the foreseeable future, 2.5 G networks will have some major gaps.

□ **“Always-On – Not.”** One key implication of 2.5G’s “forked road” to 3G is that at least in the US, there will *not* be a reliable, low-cost, interoperable nationwide 2.5G network with great coverage and in-building penetration in place to compete with data-only networks any time soon. Furthermore, it is unlikely that there will ever be a truly nationwide 2.5G network, due to the “territorial imperatives” of these competing technologies.

As shown in **Chart 34**, all the US cellular networks that are about to be upgraded to 2.5G have serious coverage problems. To begin with, Cingular Wireless and AT&T Wireless's TDMA networks *together* only cover about 6 percent of the country's area and 38 percent of its population, compared with ReFLEX™'s 95 percent. Recent estimates also

Chart 34. Low-Speed Data and Cellular Voice Networks -- Coverage and Throughput

		US Coverage		Max Speed (KBS)*	
		POPS	Geography	Now	Future
Dedicated Data	REFLEX	95%	30%	6.4	56.0 (V.3?)
	DATATAC	79%	25%	4.8	19.2 (50% now)
	MOBITEX	72%	23%	8.0	16-32.0
	CDPD	55%	17%	19.2	19.2
Voice & Data	TDMA	38%	6%	9.6	115.0
	GSM	43%	7%	9.6	115.0
	CDMA	63%	10%	14.4	144.0
	iDEN	66%	21%	9.6	19.2

Source: The Strategis Group, Credit Suisse/First Boston, Bear Stearns, Motorola

indicate that to provide adequate data rates and in-building penetration, GPRS networks may require at least 2.5 times as many base stations as GSM, especially in urban areas.²³⁹

Given the fact that they are competing vigorously with each other for voice customers (viz. the rival pilots by Cingular and AT&T in Seattle!), it is also doubtful that these networks will ever have roaming agreements that permit them to share network capacity and coverage, even within the same families of cellular networks. (CDMA2000,GSM/GPRS). Nor have these US network operators yet determined whether their handsets will be permitted to receive messages from 2.5G-enabled PDAs that run on other people's networks.²⁴⁰

Even apart from the fact that it will take time for these operators to upgrade their networks to 2.5G, the result is likely to resemble the Balkanized situation that still plagues the US SMS market. Given the low average density of the US market, and the increased number of base stations required to insure reception for GPRS and especially for CDMA2000, it is also unlikely that these networks will soon be able to match the in-building penetration of low-speed data networks like ReFLEX™. In short, chances are that for quite some time, many suburban or rural areas will lack adequate coverage, many urban centers will lack adequate penetration and highly variable data rates, and everyone will lack fully-interoperable data services.

❑ **Birthing Pains/ Complex Devices.** These are new, untested networks, and they are experiencing many birthing problems. For example, as noted above, there is a shortage of affordable handsets for both 2.5G networks.²⁴¹

One problem has been that WAP 2.0, needed to match i-mode's color graphics and animation and support 2.5G's higher speeds, security, and xHTML-based applications, was only released on July 31, 2001, three years after WAP 1.0. Another problem has been to make handsets with acceptable battery life and "multi-mode" capability – backwards compatibility with 2G networks. US GSM operators face special challenges in this regard, because they run at 1900 MHz, compared with 900 MHz/ 1800 MHz elsewhere.²⁴² Devices designed for Europe won't work here unless they are specifically made with multimode capability, which is much



Motorola's Accompli 008 for GPRS



more costly. Most 2.5G handset vendors have also felt compelled to stuff their devices with new features like PDA keyboards, calendaring and scheduling, color, pen recognition systems, multimedia sound and graphics, games, and even MP3 players, on top of regular voice handsets.²⁴³ Packing all this functionality into integrated mobile devices is not only difficult but expensive, so it is not surprising that most first-generation 2.5G handsets are likely to command at least \$200-\$400 retail price tags in the US, even after carrier subsidies.²⁴⁴

Longer-term, the real issue is not whether or not there is *any* market for these conglomerate devices. After all, even WAP 1.0 phones sold 5 million units in the US, though most of them have probably never been used for browsing. For us the real issue is whether these 2.5G devices will command such an overwhelming share of the market that they will crowd out lower-speed MDM devices entirely, just as 2G devices undermined the one-way paging market. We suspect that, especially for enterprise applications, it will quite some time before 2.5G devices can match the reliability, cost, simplicity, battery life, specificity and manageability of data-only network devices.

□ **Theoretical Vs. Actual Speeds.** As noted above, in addition to “always on,” another crucial part of the 2.5G value proposition is much higher data rates – the comparison is often made to ISDN-BRI with two B channels, which delivers 128 kbps. Here again, however, the actual average rates experienced by subscribers is likely to be much less than the cellular operators are advertising.

In the case of GPRS, for example, the 171.2kbps data rate often cited is a theoretical maximum for *a single user who is permitted to take command of all eight timeslots* on the GSM network, *without error correction*. First, adding error correction, vital for wireless communication, drops this to about 115 kbps. And no network operator in his right mind will provide more than 1-2 slots on uplink and up to 4 on downlink to any GPRS data user, because of the high opportunity costs of voice traffic – in fact today’s GPRS handsets don’t even support it. That cuts the maximum to 50-60 kbps for downlinks and 15-30 kbps for uplinks. Third, 2.5G data capacity is not dedicated, but is shared with all other users on the network, including voice traffic. In dense urban areas, especially, data rates could vary significantly by time of day.

So the actual data rates experienced by GPRS subscribers, especially in urban areas, is likely to average *just 10-20 kbps* – not much more than is already available on a reliable, wide-area basis from “low speed” data networks! As one recent analysis of GPRS concluded, “The actual bandwidth is nowhere near the theoretical value...In reality, users can hardly expect data rates greater than those provided by analog modems.”²⁴⁵ Consistent with this, operators and device vendors who are launching GPRS services and devices have been careful to use “best efforts” language in the fine print, promising speeds “up to” maximums in the 20 – 54 kbps range, and making no commitments about actual data rates.²⁴⁶

□ **Pricing and Costs.** The other key advantage that was promised for 2.5 G networks was that services would be cheaper, because users would be charged only for data volumes, not airtime. Indeed, the price plans announced for GPRS by AT&T Wireless, Cingular, and Vodafone do provide for “megabyte-based” pricing, based on the number of Kb of data sent or received per month, with some plans also pricing the number of messages sent.²⁴⁸

CHART 35. SELECTED GPRS SERVICE PRICING, 2001

	Cingular GPRS A	Cingular GPRS B	AT&T	Vodafone
Price per month	\$14.99	\$21.99	\$50	\$11
Included MB per month	0.5	0.5	1	1
Price per incremental KB	\$0.07	\$0.07	\$0.03	\$0.05
Price per incremental message	\$0.10	\$0.10	-	-
Voice minutes included	0	0	400	0
Imputed voice value	0	0	\$40	0
Net price per MB	\$29.98	\$43.98	\$10.00	\$11.00
Cost per message (100/month)	\$0.15	\$0.22	\$0.10	\$0.11
Cost per message (Heavy user)*	\$0.36	\$0.32	\$0.12	\$0.20

*Heavy user: averages 18.7 messages received, 8.3 sent per day, per Gallup

Source: corporate websites. Gallup Poll (7/2001). SHG analysis

These initial plans are difficult to compare without assuming specific use patterns, but in general they imply prices on the order of \$10 to \$44 per MB of data, and \$.10 to \$.36 per message, depending on usage volume.²⁴⁹ (See **Chart 35**.) On a *per MB basis* this still looks pretty pricey -- even without airtime charges, it would cost users at least \$5-\$12 to handle a typical day's worth of Internet email messages received and sent,²⁵⁰ or a handful of .jpg files.²⁵¹ For mobile surfers, every page view's worth of Web browsing costs 2-7 cents, somewhat higher than the average cost per page view for wired analog modem surfing, but not off the mark, considering the value of mobility.²⁵² However, it is still not clear how much surfing US mobile users will really want to do, even at these improved prices, given the continuing dearth of compelling i-mode-like mobile content in the US. And users who really want to download music videos to their MP3-ready mobile devices at affordable prices may just have to wait for 3G's vast new networks. Of course by then they may no longer be teenagers.

As noted in the charts in Appendix VI, these price levels per MB are also still well above the marginal costs of ReFLEX™ and other low-speed networks. While some analysts have recently argued that in some long run, all networks will compete with each other on a price-per – MB basis, we fundamentally disagree. For the foreseeable future, especially for messaging customers, the fact is that there are simply many other elements of value beside raw data throughput. Nevertheless, even on this basis, the per-MB prices used by the 2.5 G operators leaves plenty of room for low-speed networks like ReFLEX™ to compete.²⁵³

More important for MDM customers are average and marginal message prices. The unit prices implied by the new 2.5 G pricing plans vary greatly with customer usage, but in general, the plans are a marked improvement over circuit-switched data. However, they are still struggling to get unit message prices below 10 cents, and are often several times that.²⁵⁴ At least for these initial plans, given the fact that two-way data networks like ReFLEX™ have much less message overhead, they can easily match these price levels, especially given their capacity increases.²⁵⁵

Overall, therefore, at least for the 2.5G pricing plans announced so far, it appears that the main pricing benefits will be realized by mobile surfers, not MDM users. And even those

VI. Appendix A: Key Technical Features,
ReFLEX™ Version 2.7

1. Introduction

The following Appendix takes a closer look at the most important new features in Version 2.7 of the ReFLEX™ protocol, including background scanning, auto-collapse (“Chat Mode”), flexible control of the maximum inbound message length, unscheduled inbound messaging, and the harmonization of ReFLEX™ variants. It also briefly examines the efforts of the WCTP consortium to develop a new XML-based Internet gateway standard for wireless messaging.

In examining the benefits of these new features, it is important to understand that there is not a simple one-for-one alignment between the new features and their benefits. As summarized in **Chart 15** above, several new features affect more than one benefit, like increased capacity or lower latency, while several benefits are the product of more than one new feature. The overall result is truly a case of “the whole being greater than the sum of its parts.”

2. Background Scanning

One key driving force behind ReFLEX™, as noted in Chapter IV, is the capacity enhancements achieved through *background scanning*.

Mobile devices would start searching for a new channel only when they had completely lost touch with the current control, in previous version of ReFLEX™, even if other channels had stronger signals. This meant that there was significant time between losing one channel and acquiring a new channel, called “sub-zone drag”, during which time the device would not receive messages. This behavior means that the usual strategy of increasing network capacity by using smaller and smaller sub-zones has a negative impact on the subscriber.

In Version 2.7, devices periodically scan for neighboring control channels in the background, without interrupting normal operations. If the device finds a better channel, in terms of significantly better signal strength or higher priority, it can request a transfer. This is usually done using “make before break”, a concept similar to the soft hand-off used in PCS Phone networks, where registration with a new channel is completed before communication with the old channel is broken. Normally, this means that a device will always be registered with the network, and capable of receiving messages.²⁶⁷ This permits mobile devices to move quickly and efficiently across service areas with different control channels.

This change alone has a profound impact on ReFLEX™ networks by allowing cellular-like functionality, while retaining the superior coverage and reliability offered by simulcast and macro-diversity.

Sub-Zoning Currently, ReFLEX™ operators have divided their networks into zones that consist of many transmitters and receivers. Background scanning allows the operators, through simple software reconfiguration, to sub-divide these zones and achieving significant

frequency re-use, multiplying network capacities several-fold. A sub-zone can be as small as a single transmitter and receiver²⁶⁸, but there is a limit to the effectiveness of sub-zoning in wide area coverage. To maintain the superior coverage advantages of simulcasting and macrodiversity, primary zones for public networks typically include the number of transmitters required to cover significant metropolitan geographic boundaries.²⁶⁹ There are cases for secondary zones that benefit from being as small as one transmitter site. This will allow ReFLEX™ operators who adopt Version 2.7 to multiply their national network capacities more than three times their current limitations, with very little additional capital expenditure.

“Hot Spot” Capacity Increases. Background scanning also helps ReFLEX™ operators to add network capacity precisely where it is needed. ReFLEX™ has long had the ability to handle multiple outbound and inbound channels within a single sub-zone. Version 2.7 enables ReFLEX™ operators to add additional outbound and inbound channels only to those sub-zones where the traffic load warrants, and balance devices and traffic across those channels. For carriers using linear transmitters and controllers, additional outbound channels can be added with minimal capital expenditures. Operators can even overlay additional sub-zones that completely overlap existing geographical coverage.

Campus Coverage. The background scanning feature of the ReFLEX™ protocol allows operators to create special, dedicated networks to cover specific areas, such as corporate or academic campuses, amusement parks or ski slopes. Devices can be programmed to register when they are in range of this special, private zone, and utilize a public network otherwise. The resulting private network, or campus, consisting of both outbound and inbound channel(s), permits only authorized users to register. In fact, devices not associated with the private network will not even recognize the campus exists. The campus can transmit specialized private information relevant only to the specific private network without creating any traffic on the wide area public network. At the same time, it can provide the private network subscribers with the same coverage enjoyed by the subscribers of the wide area network.

The 'background scanning' enhancement to Version 2.7 of the ReFLEX™ protocol is one of its most important features. It allows the network operators to make dramatic increases in network capacity with minimal additional investment, while maintaining a high level of customer service. This translates into lower cost and better performance for subscribers.

3. Auto-Collapse – “Chat Mode”

ReFLEX™ was initially designed to deliver low-cost mobile data, using small, inexpensive devices that worked continuously for weeks on a single battery. One key design element employed to achieve this is called “collapse.”²⁷⁰ Collapse provides the ability for the system to let a device 'sleep' for periods of time. A collapse value of two, for example, allows a receiver to be “available”, listening for its address, for only a quarter of the normal time. The device saves energy by sleeping through the remainder of the time.

The trade-off made for the sake of battery saving was increased message latency, since the device would only receive messages every 7.5 seconds (= 4 x 1.875 seconds, the standard ReFLEX™ frame length), using a collapse value of two. If a device needed to send a message, it requested a time allocation, and then waited for the next scheduled time slot to wake up and receive its transmit time information. Then the receiver would fall asleep again until its next scheduled wake-up, when it would receive a message acknowledgement. This implies a time lag of more than 15 seconds, for a collapse value of two, from the time the user presses “send” until the acknowledgment receipt. For higher collapse values (used to obtain even longer battery life), the perceived wait could be much longer, on the order of 30-60 seconds or more.

In ReFLEX™ version 2.7, these long latencies no longer exist because of a new feature called “auto-collapse.” In auto-collapse mode, the device receiver stays awake after most messaging events, for a device specified time, to look for any further messaging data. This is typically 30 seconds. Compared with the example above, this could allow an acknowledgement to be received just 5.625 seconds after “send” is pushed, regardless of the collapse value. This reduces latency by about two-thirds, and even more for higher collapse values.

Additionally, Version 2.7 enables users, or applications, to initiate a “chat mode,” in which the device automatically wakes up in every frame to look for messages, for four minutes. In this mode, messages can theoretically be sent in every frame, with latency between devices reduced to less than five seconds.²⁷¹ In practice, perceived latency on public networks will probably be a little longer. The reduced message latency of 'chat mode' on public networks will be similar to that now achieved by Mobitex or Datatac networks. When combining this feature with background scanning, which allows private networks, the latency will actually be faster than what is now achieved with other mobile data networks, often achieving the aforementioned 5.625 seconds.

This new “chat mode” could be very important for ReFLEX™'s future. Not only does it improve the performance of existing applications by greatly reducing latency associated with sending longer messages, but it also allows new real-time-critical applications to be deployed on ReFLEX™ networks, including instant messaging, wireless POS, and financial transactions.

4. Broadcasting Maximum Inbound Message Lengths

In Version 2.7, the network broadcasts, every minute, the maximum inbound message length that it will accept. This feature can be dynamically set for each zone and control channel, meaning that ReFLEX™ operators can manage inbound traffic to avoid network congestion during peak usage times, while allowing larger, more rapid transfers when the network is lightly loaded. This new more efficient way of managing network traffic will also help to reduce perceived latency, and increase the effective network capacity.

This feature also has the added benefit of relieving device manufacturers of the need to program fixed message length limits into their devices, and the burden of managing varying device configurations among the carriers. Manufacturers can now more easily make devices that will work across all ReFLEX™ networks.

5. Unscheduled Inbound Messaging

In a Version 2.6 ReFLEX™ network, inbound channels are divided into two separate logical channels: (1) a “control” channel, randomly accessed using shared ALOHA slots, and (2) the “data” channel, which is allocated by the network to specific devices that request inbound capacity. The conventional procedure for device-initiated inbound messaging is as follows:

- The device sends an allocation request over the control channel using a shared ALOHA slot;
- The network responds by sending a command to the device indicating which time slots in the “data channel” it has been allocated;
- The device sends the inbound message in the allocated timeslots in the "data channel".

This scheduling mechanism has tremendous advantages in terms of system capacity. The scheduled data channel has virtually no collisions, and can be loaded to more than 80% before any significant congestion is detectable. By comparison, a randomly accessed ALOHA only network, similar to TCP/IP, can be no more than 30 percent utilized before significant delays and congestion become apparent. ReFLEX™ networks utilize both protocol types to improve both capacity and availability for the network. The cost of this extra capacity is a small additional message latency, due to the time required for the allocation of timeslots for transmission of messages in the scheduled data channel.

ReFLEX™ Version 2.7²⁷² permits what are called ALOHA inbound messages, where in the case of short inbound messages of less than 223 bytes, the device can access this channel and immediately send, without having to wait for timeslot allocation. This further reduces latency at a very small cost to overall network capacity. This feature works in combination with the inherent ALOHA reuse of ReFLEX™ networks. ALOHA reuse allows messages from different receivers in the same sub-zone, to be accepted when they arrive at that same time, if they are uncorrupted.



VII. Appendix B: Detailed Comparisons,
Key Data Networks

1. Network Comparison Charts

Chart 26. Summary, Mobitex™ vs. ReFLEX™
A. Technical "Speeds and Feeds"

Key Attributes	Mobitex™ V.2	ReFLEX™ 2.7	Comments
Frequency band	896-902 MHz TX 935-941 RX	896-902 MHz 929-932, 940-941 MHz	
US Spectrum Allocated	500-750 KHz (depending on region)	>2 MHz	ReFLEX advantage -- capacity, pricing potential
Maximum data speed, single user	8.0 kbps	1.6-6.4 kbps down, .8- 9.6 kbps up	ReFLEX™ 2.7 unifies platform Mobitex v.3 -->32 Kbps ReFLEX™ v. 3.0 --> 56 kbps
Typical throughput, single user	1.2-2 kbps	3.2 kbps down 4.8 kbps up	ReFLEX™ adv.
Symmetrical data rates?	Yes	No	ReFLEX™ adv. -- more efficient network
RF Channel spacing	12.5 KHz	12.5 KHz in; 10KHz or 12.5 KHz out	R v 2.7 allows channel subdiv. And reuse
Channel Access	FDMA	TDMA (reverse channel) "TDMA-like" (forward ch.)	
Multi-user access	Dynamic S-Aloha	Aloha + scheduling (see App A.)	
Full or half duplex	Half	Half	
Packet length	Up to 512 bytes (MPAKs)	924 bytes	
Modulation Method	GMSK	4FSK-NRZ	
Native Protocols	Proprietary --- gateway support for TCP/IP	FLEX™Suite	Neither support native TCP/IP yet
Other transport protocols supported (gateways)	SNA, X.25, MTP/1, x.24 CCITT, SMTP	WCTP, SMTP	

© SHG 2001

Chart 26. Summary, Mobitex™ vs. ReFLEX™ B. Other Technical Performance Factors

Key Attributes	Mobitex™ V.2 Performance	ReFLEX™2.7 Performance	Comments
Reliable Reachability	Very Good	Excellent	Overall ReFLEX™adv.
-- Geographic coverage	High for metro enterprises/ 72% US pop	Very high - 95% US pop	Big ReFLEX™ adv.
-- Store-and-forward	Yes	Yes	Equivalent
-- In-Building penetration	Moderate	High	Big ReFLEX™ adv., most areas
-- Other reliability enhancements	None	Simulcast, Macrodiversity	ReFLEX™ adv.
Messaging modes	Best on latency	Best on broadcast	Application dependent
-- "Always on"/ "push" notification	Yes (except Palm VII)	Yes	Equiv.
-- Broadcast/ simulcast	No	Yes	Big ReFLEX™ adv.
-- Latency (min. / typical seconds)	<5 - 15 sec.	<5-15 sec	Equivalent
Other technical factors	Slight security adv.	Slight battery life adv.	Roughly equivalent
--Battery saving	Sleep cycle	Very high - sleep cycle, collapse	ReFLEX™ adv.
-- Typical battery life	Single AA, 1-2 weeks	Single AA, 2-4 weeks	ReFLEX™ adv.
--Data compression	Yes	Yes	
-- Native security	Moderate	Low	Slight Mobitex™ adv.
--End to end encryption?	Via 3rd party apps	Via 3rd party apps	Both can do if needed

© SHG 2001

Chart 26. Summary, Mobitex™ vs ReFLEX™
C. Economic and Industry Factors

Key Attributes	Mobitex™ V.2	ReFLEX™ 2.7	Comments
Device Economics			M lead shrinking
-- Device Selection	RIM 950/ 957, Palm VII	Advantra, Nixxo, Fine Telecom, Glenayre(2.6), Mot (2.6), Novatel (Palm cradle)	M advantage may be shrinking
-- Device Cost	Mod-High	Low-Mod	R advantage
-- Device Capability	Good (J2ME - Rim, Palm)	Improving	R catching up
Network Economics			R strong cost advantage
-- Fixed Costs, Coverage	Very high - Ericsson pricing, cellular structure	Low, for upgrades to FLEX™ networks -- high elsewhere	Only relevant to new networks
- Marginal Cost, New Capacity	Low- Mod (Cellular)	Higher before 2.7, similar with it	R2.7 narrows M lead
Marginal cost, Current Capacity	High- capacity constrained	"Zero" with 2.7 (up to 3-4 x subscriber base)	Tremendous R advantage
-- Operating Costs	Mod (trunking network)	Low- Moderate	Similar
Application Economics			M Lead, R potential
-- Application/ Middleware Development Tools	Multiple 3rd party vendors	WCTP, Agea, Outr.Net	M advantage -- R catching up
-- Proven Applications	Extensive	Limited so far	M advantage - key R need
--- Developer Channel	Extensive (Aether, etc.)	WCTP should help	M advantage - key R need
Other Industry Factors			M lead/ R potential catchup
-- Device Vendor Support	RIM, Palm, Handspring, Nomadic, etc.	Motorola (2.6), Advantra, Fine, Nixxo, Glenayre	R playing catch up
-- Network Vendor Support	Ericsson	Sonik, TGA	Big M lead
-- Service providers	1 (US), 28 non US	3 (US), 5 non US	R consolidation issues
-- Installed Base/ Growth	+ .690mm, US - 45%/yr +.400mm, non US	1.5 mm, US ---+90%/yr	Strong R. lead in US

© SHG 2001

Chart 27. Summary, Other Key Data Networks
A. Technical “Speeds and Feeds”

Key Attributes	CDPD	DataTAC™ /ARDIS	GPRS	CDMA2000™ (1xRTT)
Frequency band	824-849 MHz TX 868-894.4 MHz RX (AMPS networks)	855.8375 MHz	1900 MHz (GSM PCS networks, US)	1900 MHz (CDMA PCS Networks, US)
US Spectrum Allocated	NA (shared with AMPS)	125-600 KHz (varies by region)	NA (shared w PCS)	Na (shared with CDMA cellular)
Maximum data speed, single user	19.2 kbps (shared)	4.8 - 19.2 kbps, depending on protocol, equipment	38 -115 (shared)	144
Typical throughput, single user	0-9.6 (variable)	2.4 -8 kbps (4.39 kbps ave.)	7.2-14.4 kbps	60-72 kbps
Symmetrical data rates?	Yes	Yes	No	Yes
RF Channel spacing	30 KHz	25 KHz	1.25 Mhz	4-5Mhz
Channel Access	FDMA	FDMA	TDMA	CDMA
Multi-user access	DSMA	DSMA	?	CDMA-SS
Full or half duplex	Full	Half	Full	Full
Packet length	24-928 (128 ave.)	Up to 256	?	?
Modulation Method	GMSK	FSK,-4FSK	?	?
Native Protocols	TCP/IP	Proprietary (native Control Protocol 1.2)	TCP/IP	TCP/IP
Other transport protocols supported (gateways)	Multiple	TCP/IP, multiple	Multiple	Multiple

© SHG 2001

Chart 27. Summary, Other Key Data Networks
B. Other Technical Performance Factors

Key Attributes	CDPD	DataTAC™	GPRS	CDMA2000™
Reliable Reachability	Poorest choice	Good	Emerging	Emerging
-- Geographic coverage	Spotty (55% of US) - 25 top MSAs No interoperability among 7 CDPD operators	Mod (">427 SMSAs, 79% of US pop, >90% of US businesses") >50% have 19.2k	43% US Pop - TDMA/GSM base National rollout by AWS, 2001-2?	Sprint PCS, Verizon deploying 2002? US Pop 63% (CDMA)
-- Store-and-forward	Yes	Yes	Yes	Yes
-- In-Building penetration	Low	Mod (same or better than Mob)	Mod	Mod
-- Other reliability enhancements	None/ lots of delays in receipt	Simultcast, macrodiversity	None	None
Messaging modes				
-- "Always on"/ "push" notification	No	Yes	Yes (where coverage)	Yes (where coverage)
- -Broadcast/ simulcast	IP multicasting	No	No	No
-- Latency (min. / typical seconds)	Variable	Varies widely (<6 sec/ 20 sec)	<1 sec	<1
Other technical factors				
--Battery saving	None	Sleep cycle	Sleep cycle	Sleep cycle
-- Typical battery life	Low?	Single AA, <1 week (poor R850 batt life)	?	?
--Data compression	Yes	Yes	Yes	Yes
-- Native security	Very poor (bbone)	Low	?	?
--End to end encryption?	Yes (3rd party)	Yes (3rd party)	Yes (3rd party)	Yes(3rd party)

© SHG 2001




**Chart 27. Summary, Other Key Data Networks
C. Economic and Industry Factors**

Key Attributes	CDPD	DataTAC™	GPRS	CDMA2000™
Device Economics				
-- Device Selection	Cradles (Novatel, Raven, Airlink)	RIM 850, Palm (cradel for Palm V)	Shortage of devices that work (Motorola)	Early - shortage of devices that work
-- Device Cost	Mod	Mod-High	High, initially	High, initially
-- Device Capability	Limited	Good	Not quite ready	Not quite ready
Network Economics				
-- Fixed Costs, Coverage	Low -- add on to existing AMPS network	Higher than ReFLEX™ / but no networks	Low cost upgrade to GSM networks, but "opp cost."	Low cost upgrade to CDMAOne nets
- Marginal Cost, New Capacity	High	Higher than ReFLEX™	Low - but opp cost	Very low
Marginal cost, Current Capacity	High - "Capacity Did Prove Deficient"	Moderate	NA	NA
-- Operating Costs	Mod	Mod	Limited experience	Limited experience
Application Economics				
-- Application/ Middleware Development Tools	Limited	IBM , Aether middleware	NA	NA
-- Proven Applications	Some	IBM field sales (13k)	NA	NA
--- Developer Channel	Limited	Aether, ISPs, IBM	NA	NA
Other Industry Factors				
-- Device/ Vendor Support	Limited	RIM , WaveTek	Motorola, Ericsson	Kyocera, Ericsson, Motorola, etc.
-- Network Vendor Support	CDPD Forum	Vert. Integrated ?	Lucent, Nortel, Ericsson, etc.	Qualcomm, Nortel, etc.
-- Service providers, channel partners	AWE, Verizon, 5 RBOCs	Motient (US); Aether, Metrocall, Skytel,	AWE, Voicestream (US), many Euro. GSM	Sprint PCS, Verizon, Qwest
-- Installed Base	.146 K (US only)	.272mm (US), Canada 7 others (was 17)	NA	NA

© SHG 2001

2. Devices Comparison, ReFLEX™, Mobitex™ and DataTAC™, 2001

Appendix Table 1. Two-Way Network Devices Comparison © SHG 2001

© SHG 2001	Existing ReFLEX Devices				New ReFLEX Devices			Mobitex, Datatac Devices	
Product	T900	Timeport P935	Advantra AR1800	Glenayre ActiveLink	Fine Telecom	Nixxo	Sled for Palm m100	RM 850™ and RM 950™	RM 857™ and RM 957™
Model									
Availability	Now	Now	Now	Now	Q2 02	Q1 02	Q2 02	Now	Now
Retail Price	\$100 - \$125	\$350	\$70	\$450	\$70-80	\$120-\$130	\$225-\$275	\$350	\$500
Protocol	R 2.6	R 2.6	R 2.7	R 2.6	R 2.7	R 2.7	R 2.7	800 MHz DataTAC® networks (RM 850) 900 MHz Mobitex networks (RM 950)	800 MHz DataTAC® networks (RM 857) 900 MHz Mobitex networks (RM 957)
Dimensions	3.189 X 2.146 X 0.902 inches	3.75 X 2.85 X 1.2 inches	7.9 CM x 5.4CM x 2.2 CM	3.8 x 2.3 x 1.5	8cm x 5.5cm x 2.2cm	2.953 X 2.559 X 0.866 inches	Palm m100	2.5 x 3.5 x 0.93 inches (LxW xD)	4.6 x 3.1 x 0.70 inches (LxW xD)
Weight	3.86 ounces	6.7 ounces		3.5 oz.	110 gr	110 g	Palm m100	< 5 oz.	5.3 oz
Battery Type	1 AA Alkaline	1 NIMH	1 AA	2 AA	TBD	Rechargeable Batt.(Lithion 560mAh)	3.6v Lithium Ion or Lithium Polymer rechargeable	One AA alkaline or rechargeable AA NIMH (RM 850) One AA alkaline	Internal rechargeable Lithium
Battery Life	3 weeks	Over 1 week	2 mos	3 weeks	TBD	Over 7 days	7 days	3 weeks	1 week
Text Entry	31 keys	49 keys + NavDisc	Virtual keyboard	Stylis- Attaches to Handspring Visorsbt	Lit QWERTY keyboard	33 + 4 Keys EL Backlighting	Stylis	Optimized keyboard + Thumb-operated trackwheel	Optimized keyboard + Thumb-operated trackwheel
Display Screen	Optimax EL Electra Light Display 4 Line X 20Char.	EL Backlighting 9 Lines X 29Char.	4 lines x 20 char	Visor screen	4 lines by 20 characters with backlight	EL Backlighting 7 Line X 23Char. 160 * 120 pixels	Standard Palm touchscreen monochrome display with backlight. 160x160 pixels. Palm V	User-selectable 6 or 8 line display	User-selectable 16 or 20 line display
Graphic	No	Yes	Now		No	Yes	Yes	Yes	Yes
Microprocessor	???	Motrola Dragonball???(?? MHz)	?	Yes	???	PD703017 (16M IP)	Motrola DragonballVZ (33MHz)	32-bit Intel 386™ processor	32-bit Intel 386™ processor
Programmable	No	Yes	No	Yes	No	No	Yes	Yes	Yes
OS	N/A	Wisdom OS 4.0	?	Palm OS 3.5	N/A	N/A	Palm OS 4.0	RM Proprietary	RM Proprietary
OTA Function	No	Yes		No	???	Yes		???	???
Total Memory	128K	4.5MB	512K	8 meg	???	512K	8 megabyte RAM with 8 megabyte flash memory	4 MB flash memory plus 512 Kbytes SRAM	5 MB flash memory plus 512 Kbytes SRAM
Instant Messaging			No	No	Yes/TBD	Yes/TBD	Yes/TBD		
Available Memory for	100K	2MB	?	8 meg	100K	475K	TBS		
Applications	Messaging	Messaging + Integrated PM applications (Address Book, Calendar, etc.)	?	Messaging + Integrated PM applications (Address Book	Messaging	Messaging	Messaging + Standard Palm PM applications (address book, calendar	Integrated email/organizer software	Integrated email/organizer software
Notification				Vibrate or Audible		Vibrate or on-screen		Tone, vibrate or on-screen	Tone, vibrate, on-screen or LED

3. Network Cost Comparisons

Appendix Table 2. Comparative Network Capital Costs -- Coverage, Capacity Expansions, and Opportunity Costs						
© SHG 2001	Mobitex 900				GSM GPRS 900	CDMA 2000
	ReFlex 25	MHz.	Datatac 4000	GDPD 800 MHz.	MHz.	800 MHz.
COVERAGE COSTS						
Coverage Cost per Cell or Sub-Zone Extension	\$100,000	\$100,000	\$100,000	\$100,000	\$100,000	\$250,000
City Center with in Building Coverage						
Coverage Radius in kilometers	\$8	\$2	\$2	\$2	\$2	\$2
Area of Cell	\$201	\$13	\$13	\$13	\$10	\$13
Cost per Sq. Km.	\$497	\$7,958	\$7,958	\$7,958	\$9,623	\$19,894
Suburban with in Building Coverage						
Coverage Radius in kilometers	\$13	\$5	\$5	\$4	\$4	\$4
Area of Cell	\$515	\$72	\$72	\$41	\$41	\$41
Cost per Sq. Km.	\$194	\$1,382	\$1,382	\$2,456	\$2,456	\$6,140
Suburban and Rural with Street Level Coverage						
Coverage Radius in kilometers	\$19	\$12	\$12	\$14	\$14	\$14
Area of Cell	\$1,158	\$452	\$452	\$616	\$616	\$616
Cost per Sq. Km.	\$86	\$221	\$221	\$162	\$162	\$406
Costs for Adding Traffic Capacity						
Cost of Additional Equipment at existing location(s)	\$60,000	\$40,000	\$40,000	\$20,000	\$14,000	\$104,000
Portion of capacity used for data	100%	100%	100%	100%	50%	17%
Costs of Equipment used at one Base Station	\$60,000	\$30,000	\$40,000	\$20,000	\$7,000	\$17,680
Cost of Equipment to Add Capacity	\$60,000	\$30,000	\$40,000	\$20,000	\$7,000	\$17,680
Capacity Added kb/s	\$26	\$8	19.2/4.8	\$19	\$57	\$160
Usable Information Capacity Added kb/s	\$13	\$4	\$6	\$6	\$29	\$144
Capital cost \$/Additional kb/s Information Capacity	\$4,688	\$7,500	\$6,667	\$3,333	\$246	\$123
Busy Hour Capacity in kBytes per Base Station	\$5,760	\$1,800	\$2,700	\$2,700	\$12,825	\$64,800
Capital Cost per Kbyte per Hour	\$10	\$17	\$15	\$7	\$1	\$0
Cost per Megabyte Delivered	\$1.54	\$2.47	\$2.20	\$1.10	\$0.08	\$0.04
y Cost per Megabyte Delivered for Voice/Data Networks						
Voice channels used for data capability	\$0.51				\$3.50	\$9.00
Minutes of voice revenue lost per Megabyte delivered					\$16.37	\$8.33
Estimated net revenue per minute					\$0.07	\$0.07
Opportunity cost per Megabyte delivered	\$0.00	\$0.00	\$0.00	\$0.00	\$1.15	\$0.58
TOTAL COSTS PER MB DELIVERED	\$1.54	\$2.47	\$2.20	\$1.10	\$1.23	\$0.62

4. Applications Fit – Technology Requirements per Application Type (Illustrative)

Appendix Table 3. “Applications Fit” -- Technical Requirements Per Application

Application Requirements	Stolen Vehicle Recovery, Personal Security	Telemetry, Alarm Reporting, SCADA, Asset Tracking	Point of Sale, ATM Machines	Field Force Automation	Interactive Messaging, Mobile Commerce	Internet Access	Mobile V-Conferenc e
1. Latency requirement: maximum tolerable, typical	MEDIUM	MEDIUM	LOW	MEDIUM	LOW -MEDIUM	MEDIUM	LOW
2. Throughput per active user required in the network busy hour (kiloBytes) either direction [assumptions]	< 0.01 kB	< 0.01 kB	1.8 kB [6 x 0.3 kB]	1.8 kB [3 x 0.6 kB]	1 kB [4 X 1.0 kB]	200 kB	10,000 kB
3. Area coverage	HIGH	HIGH -MEDIUM	MEDIUM	HIGH	HIGH	MEDIUM	MEDIUM
4. Building penetration	HIGH	HIGH -MEDIUM	HIGH	HIGH - MEDIUM	HIGH	HIGH	MEDIUM
5. Battery conservation	LOW	HIGH -LOW [depends on power availability]	LOW	HIGH	HIGH	HIGH	LOW
6. Always on	HIGH	HIGH	HIGH	HIGH	HIGH	MEDIUM	LOW
7. Portability and Battery Life	LOW	LOW	LOW	HIGH	HIGH	MEDIUM	LOW
8. Is location information required.	HIGH	SOMETIMES	NO	SOMETIMES	BENEFICIAL	NO	NO
9. Does the terminal need to be hidden	YES	NO	NO	NO	NO	NO	NO
10. Does QoS have to be controlled?	NO	NO	YES	YES	YES	NO	YES



VIII. Appendix C:
Glossary of Technical Terms²⁷³

<u>TERM</u>	<u>DEFINITION</u>
Alias	<i>An address or username linked to a person or subscriber.</i>
Analog	<i>Analog refers to a representation of a quantity that varies over any continuous range of values. Analog signals can be thought of as pure in nature and not processed. Values are exact, but error correction is not easy.</i>
Baud	<i>After French engineer Jean-Maurice-Emile Baudot, (1845-1903), who did pioneering work on early teleprinters. Initially used to measure the transmission speed of telegraph, the baud rate is used today to measure a data transmission speed with a modem. The number of voltage or frequency transitions per second. At low speeds only, baud may be equal to bits per second. The measure of how frequently sound changes on a phone line. This used to be the measure of speed of modems because they worked by brute force and actually made a sound for each bit of information. Now, modems work on a more sophisticated level. A 14.4 Kbps modem actually uses 2400 baud, but can transmit 14.4 Kbps.</i>
Bit Rate	<i>The bits per second used to encode audio data in an MP3 or other compressed audio file, in kilobits per second (kbps). Higher bit rates typically mean better sound quality. Typically, bit rates range between 96-256, but any rate is possible</i>
Broadband	<i>This refers to the transfer of multiple signals over a single medium. In slang terms, it is any Internet connection that allows for higher transfer speeds than an analog modem, most often applied to cable modem access. However, it is sometimes used to refer to DSL, satellite and wireless Internet services as well.</i>
Byte	<i>8 bits. Think of it as a string of 1s and 0s that represents a number from 0 to 255. For example '01100101' is one byte of information.</i>
Bps	<i>A measure of how fast some device communicates, usually in thousands of bytes per second (KBps) or millions of bytes per second (MBps). See also bits per second. With a capital B, you are talking Bytes, which is equal to bits * 8</i>
CDMA	<i>Code-Division Multiple Access. Digital cellular technology using spread-spectrum techniques. Unlike GSM and TDMA, CDMA does not assign a specific frequency to each user. Instead, every channel is more efficient using the full available spectrum. This is a 2G digital wireless technology that allows multiple calls to share a radio</i>

extranet provides various levels of accessibility to outsiders. Access to an extranet is usually based on a valid username and password.

Federal Communications Commission (FCC)	<i>These are the people in the government who decide what's legal and illegal to broadcast, including what frequencies are allowed to be used by whom.</i>
Firewall	<i>System designed to prevent unauthorized access to or from a private network. Firewalls can be implemented in both hardware and software, or a combination of both. Firewalls are frequently used to prevent unauthorized Internet users from accessing private networks connected to the Internet, especially intranets. All messages entering or leaving the intranet pass through the firewall, which examines each message and blocks those that do not meet the specified security criteria.</i>
Gateway	<i>Combination of hardware and software that links two different types of networks. Gateways between e-mail systems, for example, allow users on different e-mail systems to exchange messages.</i>
Gb	<i>Gigabit (Gb) - This refers to approximately 1 billion bits. More exactly, it is 2³⁰ or 1,073,741,824 bits.</i>
GB	<i>Gigabyte; 2 to the 30th power (1,073,741,824) bytes. One gigabyte is equal to 1,024 megabytes.</i>
GPRS	<i>General Packet Radio Service. A digital packet switched data network that runs over GSM networks, and is capable of theoretical data rates up to 171.2 kbps.</i>
Group Messaging	<i>Ability to send same message to several people.</i>
GSM	<i>Global Standard of Mobile Communication. Currently the leading digital cellular technology. GSM systems use narrowband TDMA, which allows eight simultaneous calls on the same radio frequency.</i>
HTML	<i>HyperText Markup Language - a standard language made for typesetting, used for creating documents on the World Wide Web. Included in the language are provisions for including pictures and links to other pages.</i>
HTTPS	<i>Secure HyperText Transfer Protocol - a secure means of transferring data over using the HTTP protocol. Typically, HTTP data is sent over TCP/IP port 80, but HTTPS data is sent over port 443. This standard was developed by Netscape for secure transactions, and uses 40-bit encryption. . The HTTPS standard supports certificates. A web server operator must get a digital certificate from third party certificate provider that ensures that the web server in question is valid. This certificate gets installed on the web server, and verifies for a period of a year that that server is a proper secure server.</i>

ICQ *An easy-to-use online instant messaging program developed by Mirabilis LTD. Pronounced as separate letters, so that it sounds like "I-Seek-You," ICQ is similar to America OnLine's popular Buddy List and Instant Messenger programs. It is used as a conferencing tool by individuals on the Net to chat, e-mail, perform file transfers, play computer games, and more.*

IM *Instant Messaging. Type of communication service enabling a user to create a private chat room with another individual*

IMAP *Short for Internet Message Access Protocol, a protocol for retrieving e-mail messages. The latest version, IMAP4, is similar to POP3 but supports some additional features. For example, with IMAP4, you can search through your e-mail messages for keywords while the messages are still on mail server. You can then choose which messages to download to your machine. IMAP was developed at Stanford University in 1986.*

i-Mode *The digital packet-based low-speed (9.6 kbps) Web browsing and mobile messaging platform deployed in Japan by NTT DoCoMo in February 1999.*

Interface(s) *A method of connection between two separate entities. For example, a graphical user interface (GUI) is the part of a program that connects the human user to the computer functions. Interfaces can also connect programs and devices.*

Intranet *A network operating like the World Wide Web but having access restricted to a limited group of authorized users (as employees of a company).*

ISDN *Integrated Services Digital Network - a digital line that is often used to connect to the Internet. It generally come in two flavors: one is a 56 Kbps version, which in actuality only uses half of the ISDN line's bandwidth; the other is the 128 Kbps version, which uses both the 56 Kbps channels on the line. However, that's only 112 Kbps--the other 16 Kbps are an 8 Kbps back channel of each line.*

IP *Internet Protocol - a connectionless communications protocol that forms part of the basis for the TCP/IP protocol suite. It is a fast protocol, but it has no mechanism for sequencing or error conditions. Error packets are simply lost. IP will basically just move datagrams.*

IPSEC *IP Secure - This is the IETF standard "secure IP" transport. Typically, IPSEC is used in branch-VPN tunnels between routed*

	<i>LAN segments, but it's destined to become the method for securing IP traffic over IPv6.</i>
IPv6	<i>IPv6 (Internet Protocol version 6) - This is the current version of the IP protocol that features a 128-bit addressing scheme, as opposed to the 32-bit addressing scheme of IPv4, supporting a much higher number of addresses. It also features other improvements over IPv4, such as support for multicast and anycast addressing.</i>
ISP	<i>Internet Service Provider.</i>
JVM	<i>Java Virtual Machine - a program that runs under an operating system and interprets Java programs. The Java Virtual Machine ideally will not allow any harm to come to the computer because it has no control of the operating system, and acts as if it is a separate computer. Thus, if a malicious Java program were to crash the Java Virtual Machine, the operating system would remain stable. Another advantage of this mechanism is that different OS's can have their own Java Virtual Machines that should act identically. Thus, Java should be able to be run across different platforms easily with no code change</i>
Kilobits	<i>1024 bits (2¹⁰ bits)</i>
Kilobits per second	<i>A measure of data transfer. A 14.4 Kbps modem transfers data at about 1.8 kilobytes per second or about 100 KB per minute.</i>
Kilobyte	<i>1024 bytes (2¹⁰ bytes)</i>
LAN	<i>Local Area Network.</i>
Latency	<i>The amount of time required for a message to be sent from a two-way wireless device, and the first byte of the response received. (Since the time required for receipt of the entire message varies with the size of the message, this definition controls for message size.)</i>
Mobitex™	<i>A two-way low speed packet data network introduced by Ericsson in 1983.</i>
Mbit	<i>Megabit (Mbit) - Roughly one million bits. Exactly 1,048,576 bits (that's 2²⁰ bits).</i>
Mbps	<i>Megabits per second - aka Mbps. This is a measure of throughput roughly in millions of bits per second. More exactly, that is 2²⁰ (1,048,576) bits per second.</i>
MB	<i>Megabyte - Roughly one million bytes. Exactly 1,048,576 bytes (that's 1024 x 1024, or 2²⁰).</i>
MHz	<i>Megahertz (MHz) - One million hertz.</i>
Numeric Pager	<i>A wireless device that allows a person to receive a phone number.</i>
Online	<i>Connected to the Internet.</i>

Packet	<i>A collection of information. It's often used to refer to the chunks of information sent over computer networks.</i>
PCS	<i>A set of digital cellular technologies being deployed in the U.S.(1)</i>
Peer to Peer (P2P)	<i>A method of distributing files over a network. Using P2P client software, a client can receive files from another client. Some P2P file distribution systems require a centralized database of available files (such as Napster), while other distribution systems like Gnutella are decentralized.</i>
PKI	<i>Public Key Infrastructure. - This is the infrastructure needed to support public key encryption. It requires a certificate authority to issue and verify the public keys, a registration authority that verifies the identity of a person or organization before a key is issued, a certificate directory of the public keys and a certificate management system. Public key encryption can be used to verify an identity or to encrypt data or messages.</i>
POP (email)	<i>Short for Post Office Protocol, a protocol used to retrieve e-mail from a mail server. Most e-mail applications (sometimes called an e-mail client) use the POP protocol, although some can use the newer IMAP (Internet Message Access Protocol).</i> <i>There are two versions of POP. The first, called POP2, became a standard in the mid-80's and requires SMTP to send messages. The newer version, POP3, can be used with or without SMTP.</i>
POP (access)	<i>Short for Point of Presence, a telephone number that gives you dial-up access. Internet Service Providers (ISPs) generally provide many POPs so that users can make a local call to gain Internet access.</i>
PDA	<i>Personal Digital Assistant. Handheld device combining computing, telephone/fax, and networking features. Some PDAs can function as a cellular phone, fax sender, and personal organizer. Unlike portable computers, most PDAs are pen-based, using a stylus rather than a keyboard for input. Some PDAs can also react to voice input by using voice recognition technologies.</i>
QoS	<i>Quality of Service -- an effort to provide different prioritization levels for different types of traffic over a network. Various methods are used to achieve quality of service, including the RSVP protocol. For example, streaming video may have a higher priority than ICMP traffic, as the consequences of interrupting streaming video are more obvious than slowing down ICMP traffic.</i>
RF	<i>Radio Frequency -- the range or frequencies between 10 kilocycles per second to 300,000 megacycles per second in which radio waves can be transmitted. It can also refer to a frequency used for a specific radio station.</i>
ReFLEX™	<i>A two way low-speed paging overlay network introduced by Motorola in 1994.</i>

Response Time	<i>Length of time it takes to send/receive text messages.</i>
Routers	<i>A device that connects any number of LANs.</i>
Scalable	<i>Applications or systems that are able to scale to large amounts of users. For example, a database that completely locks out every other user when someone is using it is NOT scalable. The computer system that runs ATM and bank transactions must be highly scalable. Scalable</i>
Security	<i>Refers to techniques for ensuring that data stored in a computer cannot be read or compromised. Most security measures involve data encryption and passwords. Data encryption is the translation of data into a form that is unintelligible without a deciphering mechanism. A password is a secret word or phrase that gives a user access to a particular program or system.</i>
SLA	<i>Service Level Agreement s a promise of maintaining a consistent level of data transfer over a network. Every ISP typically has a SLA that states the promise of data availability that the ISP will provide for their customer. Usually SLAs are only given to business customers that pay more for their connections than home users. Thus, business connections are typically more reliable and also cost more. SLAs are important for companies that can lose millions of dollars when their customers cannot access their web servers.</i>
Sleep mode	<i>The placement of a computing device into an inoperable mode where less power is consumed by shutting down unnecessary devices, but leaving all data in RAM. Typically, you return from sleep mode by using the keyboard or mouse and devices are switched back on. Sleep mode in its early incarnations was very problematic in some PCs and would often crash programs and operating systems that were not completely compatible with the sleep mode capable by the PCs BIOS.</i>
SMS	<i>Short Messaging Service. Transmission of short text messages to and from a mobile phone, wireless device or IP address. A method of sending text messages that are 160 characters in length or shorter over a mobile phone. More and more mobile phones are supporting the sending and receiving of SMS messages.</i>
SMTP	<i>SMTP Short for Simple Mail Transfer Protocol, a protocol for sending e-mail messages between servers. Most e-mail systems that send mail over the Internet use SMTP to send messages from one server to another; the messages can then be retrieved with an e-mail client using either POP or IMAP. In addition, SMTP is generally used to send messages from a mail client to a mail server. This is why you need to specify both the POP or IMAP server and the SMTP server when you configure your e-mail application. The main limitations of SMTP are that it is limited to 7 bit ASCII data, handles limited message lengths, has to rely on MIME for attachments, and often has inconsistent format translation. It uses TCP/IP port 25 and allows for file attachments.</i> <i>Systems Network Architecture - an IBM architecture for enterprise</i>

SNA	<i>computing systems. IBM has created a complete suite of programs to work on their proprietary hardware for enterprise computing.</i>
Spamming	<i>Electronic junk mail or junk newsgroup postings</i>
SSL	<i>Secure Sockets Layer -- a protocol specified by Netscape that allows for "secure" passage of data. It uses public key encryption, including digital certificates and digital signatures, to pass data between a browser and a server. It is an open standard and is supported by Netscape's Navigator and Microsoft's Internet Explorer.</i>
Switches	<i>Network device that filters and forwards packets between LAN segments. Switches operate at the data link layer (layer 2) and therefore support any packet protocol.</i>
2G	<i>2nd Generation Wireless - wireless technology used in the 1990s, and still in use in the year 2000 and later. It features digital encoding of voice and 3G features are slowly being added to form a sort of 2.5G version of digital wireless. Here today, perhaps gone tomorrow.</i>
2.5G	<i>A second generation wireless technology (2G) with incomplete third generation (3G) technology added to it. Imperfect, but infinitely cheaper than 3G.</i>
3G	<i>3rd Generation Wireless) - This refers to the phase of cellular wireless communications that promises 2Mbps+ wireless data transfer speeds, full roaming throughout Japan, US and Europe, as well as enhanced multimedia capabilities and a standard features set including cellular voice, e-mail, paging, and Web functionality. Synonyms include "white elephant" and "HDTV."</i>
TDMA	<i>Time Division Multiple Access. Technology for delivering digital wireless service using time division multiplexing. TDMA works by dividing a radio frequency into time slots and then allocating slots to multiple calls. In this way, a single frequency can support multiple, simultaneous data channels. TDMA is used by the GSM digital cellular system.</i>
Text Messaging	<i>Alphanumeric message delivered to a wireless device.</i>
Text Pager	<i>A wireless device that allows a person to receive a text message or numeric message.</i>
Thin Client	<i>A desktop application</i>
Transmission Control Protocol (TCP)	<i>Technology standard and format by which voice and data traffic is handled and delivered over the Internet.</i>
Trunk	<i>A communication channel between two points. It usually refers to large-bandwidth telephone channels between switching centers that handle many simultaneous voice and data signals.</i>
Ultra Wide Band	<i>An RF technology, now in development for commercial applications, that uses short high energy bursts of radio frequency energy, generating waveforms that can deliver extremely high data</i>

rates – up to 1000 MB/s -- high resolution, and precision location detection. They also have the interesting property that they use very little spectrum, and are immune to multipath cancellation. The FCC is now examining the impact of UWB network deployment on interference with other applications, such as GPS and aircraft tracking. Intel currently has a 60 person research group devoted to UWB applications.

URL	<i>Uniform Resource Locator. Global address of documents and other resources on the World Wide Web. The first part of the address indicates what protocol to use, and the second part specifies the IP address or the domain name where the resource is located.</i>
Username	<i>Unique address for the receiver that corresponds directly to a personal identifier.</i>
Virtual Private Network	<i>See VPN.</i>
VPN	<i>Virtual Private Network. Network constructed by using public wires to connect nodes. VPN systems use encryption and other security mechanisms to ensure that only authorized users can access the network and that the data cannot be intercepted.</i>
WAP	<i>Wireless Access Protocol.</i>
WCDMA	<i>Wideband CDMA -- a 3G standard that increases the throughput of data transmission of CDMA by using a wider 5 MHz carrier than standard CDMA which uses a 200 KHz carrier. WCDMA allows for data transfer rates as high as 2 Mbps.</i>
Web Enabled	<i>Able to receive internet content, communication or data.</i>
Windows CE	<i>A version of the Windows operating system designed for small devices such as PDAs (or handheld PCs in the Microsoft vernacular). The Windows CE graphical user interface (GUI) is similar to Windows 95.</i>
Wireless Transmission Protocol	<i>See Transmission Protocol.</i>
WML	<i>Wireless Markup Language (formerly HDML) – part of the Wireless Application Protocol (WAP) and it allows text portions of Web content to be separated from graphical content for display on wireless devices.</i>
Web	<i>A particular means of communicating text, graphics, and other multimedia objects over the Internet. Web servers on the Internet are set to respond to particular requests sent on TCP/IP port 80 by sending HTML documents to the requester. The requester must use a browser to receive this data. Think of the Internet as a 100-lane highway, and the Web as one of those lanes. Of course, traffic in the Web lane is probably very high compared to traffic in most other lanes.</i>
W3C	<i>World Wide Web Consortium -- an industry group created to design and promote standards to increase the functionality of the</i>

Web. The W3C was initially established in collaboration with CERN, the creators of the World Wide Web. You can reach the W3C at <http://www.w3.org>.

X.25

A packet-switching service that connects remote terminals to host systems. X.25 has higher overhead than Frame Relay, but has been around longer and is better supported. X.25 predates the OSI model.

XML

Extensible Markup Language (XML) - XML is a standard created by the W3C. It is a language with many similarities to HTML. What XML adds is the ability to define custom tags, such as , and define the meaning of those tags within the XML document itself. XML will become more and more common as more browsers and Web servers support the XML standard.



ENDNOTES

¹ See, for example, Rick Perera, IDG News Service, May 18, 2001: “ At this time a year ago, Europe was abuzz over the plans of high-flying telecommunication operators to roll out 3G (third generation) wireless networks, with their promise of high-speed data transmission and nifty multimedia functions. Today those same companies are limping financially. Having shelled out billions of dollars for UMTS (Universal Mobile Telecommunications System) licenses in major European markets, they face problems raising the money needed to build those networks One idea making the rounds is that multiple operators could share the same infrastructure. There's no reason four companies, for example, should build four separate sets of transmission networks in a given country. Why not build fewer base stations, masts, and antennas, as long as there's enough capacity to handle everyone's customers?”

² One Fall 2000 forecast by Cahners In-Stat was widely reported to predict that there would be more than 1.3 billion mobile Internet users by 2004. A closer reading of the forecasts shows that this figure double-counted 607 million predicted SMS users and 783 million wireless Web subscribers, but the latter figure was still more than 40 times the yearend 2000 worldwide total. In the U.S., for example, the number of wireless phone users grew from 340,000 in 1984 to 16 million in 1993, and then soared, to more than 79 million in 1999 and more than 100 million by yearend 2000. Global adoption was even more explosive, with more than 55 million by 1993 and 650 million worldwide cellular wireless users by yearend 2000. Data from Wireless Survey Results, Cellular Telecommunications Industry Association (CTIA), December 2000. GSM Association, www.gsmworld.com, July 2000.

³ At the peak of all the excitement in mid-2000, there were a flurry of wild-eyed forecasts , often based on nothing more than sheer optimism. In addition to this September 2000 forecast by the Yankee Group, which forecast nearly 700 million mobile Internet users by 2004, there were also forecasts by Ovum (2000) – 407 million wireless users by 2004; ARC (2000) – 803 million users by 2005; and Mobile Lifestreams – 400 million mobile Internet users by 2004. One of the most widely misquoted estimates was Cahners In-Stat, in

¹⁶ Venture capital is reported to have funded just 39 wireless deals, for a total of \$500 million in the first quarter of 2001, compared with 73 deals totaling \$1.4 billion during the first quarter of 2000. Red Herring, June 2001.

¹⁷ See, for example, ComputerWorld, 3/22/2001: “US Wireless Industry Eyeing Japan’s I-mode Success.”

¹⁸ Total Telecom, 7/16/2001, figures for June 30, 2001 NTT DoCoMo subscribers and market share. Morgan Stanley Japan Telecom report, June 2001. Since I mode subscriptions and phones are sold together through retailers, and subscriptions only cost about \$2.40 per month, there may be a gap between the actual number of I mode users and the number of subscribers. eMarketer, “I-mode: subscribers, users, and the area between,” estimates that about 20 percent of i-mode subscribers may not actually use the service. However, the growth in actual traffic and subscribers is still dramatic.

¹⁹ “DoCoMo” is a brand name, similar to the phrase for “anywhere” in Japanese.

²⁰ Morgan Stanley (6/2001) projects that DoCoMo will account for 796 billion yen of recurring profit this year, more than 100 percent of NTT’s operating profit (given its breakeven status in the wireline business and its large losses on its investments in Verio, a hosting company).

²¹ Consistent with this, as implied in **Chart 6**, relative market valuations for Japan’s leading wireless data providers like NTT, Japan Telecom, and KDDI have actually increased in the last year, compared with those of wireless service providers in the US and Europe, despite Japan’s continued economic woes. From May 7, 2001 to July 21, DoCoMo’s share price fell by 37 percent, mainly because of concerns about its overseas investments like KPN, the Java handset recall, its delay of I-mode entry in Europe, and the delay of its new 3G service.

²² By June 30, 2001, there were 63.39 million cellular subscribers in Japan, a 50 percent population penetration ratio, and a 77% household penetration ratio. Total Telecom, 7/16/2001, SHG analysis. US cell phone household penetration is for yearend 2000, a relatively high 51% estimate from Dataquest (12/21/2000). Merrill Lynch Research (6/2000) reported that US cell phone population penetration was 24 percent; the comparable figure for Japan is about 60 percent. Wired (June 2001) says that US cell phone penetration is only about 40 percent.

²³ www.editorand publisher.com, June 7, 2000.

²⁴ It costs about \$700 to have a new wired phone installed in Japan, compared with only \$60 wireless phone activation fees.

²⁵ An October 2000 survey showed that more than 25 percent of Japanese commuters to work or school spend at least an hour each way per day, compared with less than 8 percent in North America and six percent in Europe, and that more than 60 percent of Japanese commuters use public transportation, compared with just 16 percent in North America and 23 percent in Europe. Cars, on the other hand, were used by 71 percent of North American commuters and 58 percent of European commuters, but just 24 percent of Japanese commuters. Schauweckers’ Guide to Japan, November 2000. While cell phones can obviously be used in cars as well as on trains and buses, the relatively long commute times have helped to encourage cell phone/ handyphone adoption in Japan.

²⁶ ACNielsen (Japan), July 2000 survey – 38.2 percent of Japanese households had PCs.

²⁷ There is wide variation in statistics on PC penetration, Internet penetration, and broadband penetration by country, but there is general agreement on the overall relative patterns. Gartner Dataquest reported as of January 2001 that US PC penetration was “over 63 percent” (The Wall Street Journal, 1/19/2001). Arbitron, June 5, 2000, reported that on a survey of 50 US cities with an average PC penetration of 54 percent. The US appears to have passed Japan’s current level of PC penetration back in 1997. Dataquest, reported in The Washington Post, 2/11/1999.

²⁸ “Wired” includes dial-up, ISDN, cable modem, and DSL connections.

²⁹ Japan’s Ministry of Post and Telecommunications reported in June 2001 that as of the end of March 2001, there were about 17.25 million dial-up Internet users, 785,000 cable modem subscribers, and 112,000 DSL users. In addition, there are about another 1.25 million ISDN users not included in these figures. All told, assuming that the ISDN users have been omitted from the dial up users, this amounts to about 19.5 percent wired Internet penetration. Of these, about 9 million are from homes. ACNielsen, 2/2000, reported that about 45 percent of households with PCs in Japan had Internet connections. It gave a lower number, 8.7 million, for the number of PCs at home. Other measures of Internet penetration in Japan are consistent with these estimates, though there is substantial variation in the absolute measures used. For example, eMarketer (May 2001) estimates that as of yearend 2000, there were 17.7 million “Internet users” over the age of 14 in Japan, for a population penetration rate of 19.7 percent. Morgan Stanley, which used a broader measure

for all age groups, estimated that there were 29 million Internet users, while Nielsen/NetRatings estimated 28.3 million. See eMarketer, *The eJapan Report*, May 2001. All reports agreed that Japan's Internet penetration rate was relatively low – compared with, say, the US (63%), Singapore (41%) Australia (31.7%), and South Korea (21%). If our thesis is correct, these countries should all also have lower cell phone penetration rates than Japan (77%) – and indeed, it appears they do: US (52%), Singapore (70%), Australia, (69%), and South Korea (58 %). For the US, see *The Pew Foundation Internet Report*, January 2001, which reported that in December 2000, 56 percent of Americans, and 52 percent of US households, had Internet access. Arbitron, June 2001, reported that “nearly 60 percent” of Americans had Internet access. Forrester (quote in *The Wall Street Journal*, July 16, 2001, p. B1), reports that 63 percent of US households have PCs and 57 percent have Internet connections. Gartner Dataquest has predicted that 75 percent of Americans will be online by 2004, while Strategy Analytics has predicted that the figure will be 91 percent. As usual, all such forecasts should be taken with a grain of salt, but the overall pattern of very high US wireline Internet penetration is consistent.

³⁰ See Forrester, *supra*. Web access in both countries is stratified by income group – among those with incomes greater than \$75,000 a year, Internet penetration rises to more than 83 percent in the US. UPI, July 17, 2001.

³¹ Measure of average hours per month online vary significantly by survey, but they all agree that Americans spend at last 50-100 percent per month more time online now than Japanese or Europeans. See Media Matrix (April 13, 2001); Nielson NetRatings, June 2001, which showed that the average Japanese Internet users spent 9 hours per month online, compared with 35 hours for Canadians, 7 hours for Germans, and 6 hours for residents of the UK.

³² See eMarketer, *The eJapan Report*, May 2001, 38, which compares the cost of 40 hours per month of Internet use in Japan (\$49) with the US (\$35).

³³ Nielson/NetRatings, July 2001, reports that in July 2001, about 43 million office workers, or 32 percent of the US employed labor force, had Internet connections at work. Wall Street Journal, July 16, 2001, B1. For Japan, the figure is about 27 percent. A.C.Nielson, February 2000, found that 11.8 million Japanese workers had PC connections at work.

³⁴ By cable modem, optical fiber, fixed wireless, ISDN, or DSL connections.

³⁵ For the US numbers, see Arbitron, “Broadband Revolution Part Two,” June 21 2001. See also the June 2001 report by Japan's Ministry of Post and Telecommunications, *supra*.

³⁶ Gartner estimates for yearend 2001. Data on household broadband penetration in the US and Europe are from *Strategy Analytics* (6/12/2001). The most recent actual estimates for Japan are from the Ministry of Post and Telecommunications' most recent data on DSL and cable modems for March 31, 2001, which showed just 790,000 cable modem users and 120,000 DSL users. In addition, there are also ISDN users and some fixed wireless users. The government's target for broadband is to have 30 million users by 2005.

³⁷ *Strategy Analytics*, 6/12/2001, forecasts US broadband household penetration in 2005 at “greater than 50 percent,” compared with about 25 percent in Europe and 14 percent in Japan. Gartner is more bullish about Japanese broadband, predicting 30 percent broadband penetration by 2005.

³⁸ eMarketer, *The eJapan Report*, May 2005, 17. As noted above, the total number of Web phone subscribers in Japan passed the 40 million mark in July 2001. As of March 2001 there were about 18 million wired PC connections to the Internet in Japan. Of course the total amount of *Internet activity* by wired versus wireless devices is not necessarily proportionate to the number of devices.

³⁹ Ministry of Public Management, Home Affairs, Posts, and Telecommunications, 2000, cited in *The eJapan Report*, *supra*, 44.

⁴⁰ As of January 1997, there were 10.3 million one-way paging customers in Japan, a population penetration rate of 8.2 percent. The number of one-way customers was already falling – a year earlier, it had stood at 10.8 million. Compared with other Asian countries like Korea (30 percent) and Taiwan (17 percent), the penetration rate for one-way paging was relatively low. *Asian Technology Information Program*, August 1997. NTT DoComocom accounted for about 58 percent of subscribers at this point, and used a nation-wide FLEX network.

⁴¹ Earlier we saw that about 31% of the country's 130 million adults, or 40.3 million, have cell phones. Only about 10.4 million, or about 8 percent, had pagers.

⁴² As developed for the US market, both ReFLEX™ and Mobitex™ required frequencies in the 900 MHz “narrowband PCS” range, which the US FCC licensed to US paging companies in 1994. These nationwide

frequencies were not available in Japan. The 450 MHz spectrum that was available had very poor in-building penetration – critical to Japan’s densely-populated urban markets.

⁴³ The \$6.3 million ReFLEX™ network was sold to Tokyo Web Link Inc, partly owned by Japan Telecom, a leading NTT competitor.

⁴⁴ In the US market many PDAs have been sold as an adjunct to desktop PCs.

⁴⁵ ComputerChannel, 5.10.2001, reported annual sales of 912,000 PDAs in Japan, a 20 percent increase over 2000. It forecast 2.1 million units sold for 2005, but also admitted that PDAs faced sharp competition from Web phones in the Japanese market.

⁴⁶ Yankee Group, 2001; SHG analysis of Cingular, Omniskey, and GoAmerica PDA wireless subscribers.

⁴⁷ A recent survey of 1480 respondents by the Nikkei Business Daily reported that 39 percent preferred PDAs as Internet terminal devices, compared with 27 percent for Web phones and 25 percent for PCs. (Reported in Wireless Industry News, 5/25.2001).

⁴⁸ Industry Standard, July 19 2001. Reuters, August 22, 2001, reported that Sharp announced it would make so-called “3G PDAs” for NTT DoCoMo.

⁴⁹ GSM Association, July 2001. In the Philippines, where SMS messaging has become a very low cost alternative to voice calls, about 5 million cell phone users send an average of 40 million SMS messages *per day*, or 240 messages per month!

⁵⁰ IDC, “Mobile Data Services,” *op.cit.*, May 2001, estimates that SMS traffic in Europe will continue to grow by nearly 19 percent a year in Western Europe through the year 2004, and then start to decline, presumably because of 3G services. As noted below in this white paper, we have serious doubts about the 3G’s adoption rate and economic viability, and would be quite willing to bet that SMS, on the other hand, will have its useful life prolonged by new technologies like T9 intelligent text and chat boards, and the adoption of prepaid billing models, and the growth of handset personalization services.

⁵¹ Assuming a 132 character message, and 128 bit packets, an SMS message is the equivalent of about \$.058 cents per Kb. This is about 291 times the price per kb of a one minute \$.10 voice call. See Morgan Stanley (May 2001), *op. cit.*

⁵² IDC, Mobile Data Services, *op.cit.*, May 2001.

⁵³ Vodafone D2 says that SMS messaging alone now accounts for 16 percent of its revenue, while Sonera reports an 11 percent revenue share. Both have marketed new SMS services like information push and mobile handset personalization, and now have higher ARPUs than their competitors

⁵⁴ See IDC, Mobile Data Services and Applications: Forecast and Analysis, 2000-2005. (www.idc.com, May, 2001),

⁵⁵ SMS latency and unpredictability arises from delays that are inherent in its queuing model, and fundamentally, the fact that it has to compete with voice traffic. It relies on the cellular network’s control channel for capacity. One recent US study by Mspect Inc. reported on the results of sending 30,000 sample SMS messages on six different US cellular networks. It found that an average of 13 percent of the messages sent took more than ten minutes to arrive, and that the fraction of messages received within 30 seconds varied significantly by network , from a low of 46 percent to 98 percent. See Computer World, June 20, 2001.

⁵⁶ At first, the Group Speciale Mobile GSM) standard, later the Global System for Mobile Communications – (GSM, minus the C).

⁵⁷ This meant that message recipients would not be charged for person-to-person messages. however, subscribers who sign up to receive news services are indeed billed for SMS messages received, on a prepaid basis. But not the recipients of messages sent by others.

⁵⁸ These included the Nordic Mobile Telephone System, Germany’s Total Access Communication System, France’s RadioComm2000, Italy’s RTMI/RTMS, and several others.

⁵⁹ Unlike cellular operators in the US, Europe’s operators provide third-party SMS hubs for internetworking traffic across individual networks. This is precisely the basic Internet’s model. It provides a striking contrast to the Balkanized structure of non-interoperable cellular and wireless data network that exists in the US.

⁶⁰ The British Post Office’s POCsAG standard, and the ERMES standard fostered by ETSI.

⁶¹ European paging operators were required to deploy ERMES networks, and not allowed to use the FLEX standard, even though ERMES devices were significantly more expensive and less diverse. Operators in the UK and some other European countries were finally allowed to deploy FLEX networks in 1998, but at that point it was a desperation move to try to salvage something from the dying European paging industry.

⁶² Given the absence of calling-party-pays in the US, for example, before the introduction of digital cell phones with caller i.d., cell phone users often carried both pagers and cell phones to help them control their phone bills. The European paging industry tried to adopt its own sender-pays rules in response. But while this created a short-term surge in pager sales, it did not help the long-term condition of the European paging industry. This may have been also partly due to the high rates (greater than \$1 per message) that were charged to maintain ARPU levels.

⁶³ As of July 2001, for example, the UK's Mobitex™ operator Transcomm PLC, which bought RAM Mobile Data's UK subsidiary in December 2000, claimed 30,000 customers.

⁶⁴ A subsidiary of Deutsche Telecom

⁶⁵ For example, BT's price per SMS message sent is about \$.12, compared with \$.02 for Verizon.

⁶⁶ In the US in 2000, about 40 percent of the 40 million new cell phones shipped were Web-enabled. Naviglobe, 3.28.2001.

⁶⁷ This study reported that 58 percent of wireless subscribers in Europe were using SMS messaging, compared with just 11 percent in the US. Wireless Week, May 28, 2001.

⁶⁸ Morgan Stanley, "Wireless Data: State of the Nation," op.cit.; our analysis. See also Strategis Group, "State of the U.S. Paging and Advanced Messaging Industry," March 2001, 40

⁶⁹ Communications Weekly International, July 16, 2001.

⁷⁰ Uniform Resource Locator. See Glossary.

⁷¹ See www.gelon.net.

⁷² Red Herring, "Wireless A La Mode, June 12, 2000.

⁷³ Takeshi Natsumo, Gateway Business Developer, DoCoMo, Communications Week International, July 26, 2001.

⁷⁴ "Hima tsubushi" – killing time – is a pervasive feature of Japan's long commutes and crowded facilities.

⁷⁵ As of June 2001, I-mode was charging .3 yen per incremental packet. With 128 bytes per packet, and 126.3 yen per dollar, this implies a price per megabyte of \$18.56. Even I-mode's new 3G FOMA service, launched in pilot mode in June and is being priced more aggressively to attract users, will charge .05 yen per byte, or \$3 per MB. For comparison's sake, ReFLEX™ service providers offer plans that are the equivalent of about \$4.50 per MB for heavy use. Current packet-switched data services offered by AT&T Wireless vary from \$5.50 to \$46 per MB; Verizon's are much lower, at \$2.40 to \$5.50 per MB. SMS services, when looked at this way, are astronomically expensive – from \$10 to \$110 per MB in the US, and from \$60 to \$130 per MB in Europe. Of course most customers have not been taught to think in terms of how much they pay per MB of data; they are accustomed to think in terms of minutes of use, for cellular networks, or cost per message. In some time frame, as networks migrate to packet-based digital, and services become more fungible, the assumption made by some analysts is that customers and competitors will both become much more aware of these per-MB price differentials. For the sake of comparison, the price per MB equivalent for a minute of voice traffic, assuming \$.10/minute and an 8 kbps codec, is only about \$.20 per MB – less than 1/300th of what carriers are effectively earning per MB with SMS messaging. See Morgan Stanley, "Wireless Data Services – The State of the Union." (May 2001.)

⁷⁶ Communications Week International, July 16, 2001; eJapan Report, May 2001, op.cit.

⁷⁷ Both WML and WMLScript have to be learned from scratch, and are very different from HTML. Ordinary HTML pages have to be completely rewritten in WML to be available to wireless devices for WAP services.

⁷⁸ Though it made the client-side WAP browsers free, OpenWave, formerly Phone.com/ Software.com, proposed to charge carriers a license for its WAP gateway of \$20 per potential subscriber per year, whether or not they actually subscribed to Web services. In July 2000 Geoworks, a San Francisco-based software company that has fought a patent battle with OpenWave over the WAP Gateway, starting seeking \$20, 000 per server from major corporations that were using WAP phones.

⁷⁹ NTT DoCoMo's I mode service was launched on a digital packet-switched variant of a PDC/ P TDMA network at 800 Mhz, delivering 9.6 kbps. KDDI, one leading competitor, offered its "au" service with WAP on a CDMAOne network, at 14.4 kbps. Japan Telecom, the other leading competitor, offers WAP-based services at 14.4 kbps on a circuit-switched PDC network. For a discussion of WAP's security vulnerabilities, which were inherent in the gateway model, see R. Khare, op.cit. The WAP Forum claims to have fixed these security deficiencies in Release 2.0, due this month. With respect to circuit-switched networks, one of I-modes core advantages, despite its slower nominal throughput, is the fact that it is "always on."

┌ ┌ ┌ ┌ ┌ ┌ ┌ ┌ ┌ ┌ ┌ ┌ ┌ ┌ ┌ ┌

⁸⁰ For a discussion, see Banan, op.cit. At least nine members of the WAP Forum have made declarations of “intellectual property rights” that may be covered by the WAP Forum’s standards, including Motorola, Nokia, Phone.com, Entrust, Geoworks, NEC, Diversinet, and an individual named Behouz Vezuan, a Fin who claims to be the “inventor” of WAP.

⁸¹ See the discussion of the Openwave v. Geoworks litigation, supra in footnote 36.

⁸² In January 2001 NTT DoCoMo, Telecom Italia, and KPN Mobile announced that they would be launching i-mode services this year in Europe in the Netherlands, Belgium, and Italy over new GPRS networks. However, in July 2001, they delayed this to “some time in 2002,” because GPRS handsets are still scarce, and WAP 2.0 has still not been delivered.

⁸³ The I-appli service was launched on January 26, 2001, but Java-enabled phones from NEC and Sony were not available until the end of March. That makes the growth of this service even more dramatic.

⁸⁴ Strictly speaking, Java and j2ME are not an “operating systems; “indeed, Sun Microsystems makes a great deal out of the claim that Java runs across all other devices and operating systems, and is “OS agnostic.” Still, especially in the mobile world, it is viewed as competing with other mobile operating systems like Symbian’s EPOC, supported by Nokia, Motorola, and Ericsson for GSM phones; Microsoft’s Stinger, now about to be launched into service on Samsung-based phones by Telefonica and Australia’s Telstra; the Palm OS, now running on CDMA2000 phones from Kyocera and Samsung, and being brought into service by Sprint PCS, and Qualcomm’s BREW, about to appear on Samsung and Kyocera CDMA phones for new service with Verizon and KDDI. So far J2ME has the market lead among cellular operators because of its relationship with NTT DoCoMo. KDDI and J-Phone are also looking at introducing Java phones, as are FarEastTone in Taiwan and SmartTone in Hong Kong. In late 2001 it will also become available on new Motorola phones available from Nextel in the US, with Java phones also planned for introduction by Sprint PCS and Bell South. In Europe, Telefonica in Spain, One 2 One in the UK, But Java’s lead may eventually be challenged, mainly by GSM’s use of EPOC.

⁸⁵ In February 2001 DoCoMo had to recall 230,000 Java-enabled handsets because of operating problems, and again in May 2001 it had to recall 420,000 Java-enabled Panasonic 503i handsets. The problems were quickly fixed, and Java handset sales have continued to grow at more than 4 percent a month.

⁸⁶ Japan Internet Report, 7/2001.

⁸⁷ Interview with Sun-Japan executive, Communications Week, July 16,2001.

⁸⁸ KDDI website, 6.14.2001.

⁸⁹ The 505- joint venture, Mobimagic, was formed in mid-1999 between NTT Mobile Communications and Microsoft. NTT has also been expanding its relationship with Microsoft in other areas – for example, in March 2001 the two companies announced a deal whereby NTT would host the forthcoming “Xbox” on broadband for online gaming -- to Sony’s surprise.

⁹⁰ In May 2001 NTT invested in AOL Japan, and AOL and NTT DoCoMo announced an agreement that would permit AOL users to get their AOL email on I-mode. Cnet, May 21, 2001.

⁹¹ In August 2000, AOL adopted cHTML as its worldwide standard for wireless services, partnering with DoCoMo to help it develop services outside Japan for its 32 million customers. Since 23 million of these AOL customers reside in the US (as of June 2001), the implementation of this agreement obviously depends on NTT DoCoMo’s ability to work with US service providers, like AT&T Wireless and perhaps dedicated Java-enabled network providers as well. As of July 2001, NTT has acquired 15 percent of KPN, 16 percent of AT&T Wireless, 20 percent of KG Telecom in Taiwan, 20 percent of Hutchinson 3G in the UK, and 14.5 percent of SK Telecom in Korea. This year DoCoMo also announced plans to migrate I-mode services to Europe and the US, though some of these plans have been delayed. See footnote 44 above.

⁹² TNS Interactive (2001).

⁹³ InfoComm Research (2000), reported in eJapan Report, eMarketer (May 2001), 59.

⁹⁴ O’Reilly XML.com, September 20, 2000; CommWeb, April 16, 2001.

⁹⁵ Supra.

⁹⁶ Morgan Stanley Japan Telecom Report, July 21, 2001.

⁹⁷ DoCoMo had previously asserted that I-mode actually boosted cellular voice traffic per users by about 10 percent See CommWeb, April 16, 2001.

⁹⁸ See, for example, the recent analysis by Spectrum Strategy (July 2001), “3G Madness – Time for Moderation,” which argued that even IF it cost \$10 billion of fixed cost to deploy a 3G network (assuming just \$3 billion to build the network, \$6.3 billion to buy the license, and another \$.700 billion to launch and market services), such an investment might be able to avoid bankruptcy (note: though not be very

┌ ┌ ┌ ┌ ┌ ┌ ┌ ┌ ┌ ┌ ┌ ┌ ┌ ┌ ┌ ┌

of the fixed wireless customers were businesses; we don't have a breakout for the DSL and cable modem customer bases, but we suspect that they were overwhelmingly residential. eMarketer, *op.cit.*, predicted an installed base for fixed wireless in the US of just 3.86 million subscribers, compared to 16-20 million cable modem users, by 2003. Strategis Group, May 2001, predicted just 2.4 million users in the US by 2003 and 5.4 million by 2005. Interestingly, it also foresaw an \$8.6 billion market in Europe, where wired broadband is farther behind. These forecasts were made without taking into the account the possibility of the Sprint Broadband nationwide service discussed below. Some possible revivals by players at other frequencies like the unlicensed 60 MHz band (e-Xpedient) and the 28GHz-39GHz LMDS bands in the US has also been reported.

¹¹⁴ For example, the development new non-line of site technologies, "smart antennas," and low-cost ASICs that will considerably reduce the cost of both receivers and base stations. Together, these technology developments may make it possible to deploy integrated receivers in homes and businesses without external antennas, at less than \$300 per home, in the price range of DSL and cable modems, and also permit the service to be deployed mainly by self-provisioning. Together, this would significantly enhance the economics of fixed wireless access. Typical fixed wireless services would include bi-directional bandwidth of 384 kbps to 12 Mbps or more, depending on base station deployments and whether the spectrum used is licensed or unlicensed. Typical multipoint services have offered up to 1-2 Mbps of shared bandwidth, bi-directionally. Most US service providers to date have used unlicensed spread spectrum at 2.4 GHz. For example WorkNet, a fixed wireless ISP that launched service in 2000, was able to deliver stable Internet connections at 2 – 4.4 Mbps to business customers in the 2.4 GHz band.

¹¹⁵ Among the leading fixed wireless technology alternatives are Spike Broadband, Soma Networks, and ArrayNet. SHG industry interviews, July 2001. One motive for IXCs like Sprint, Worldcom, and AT&T, as well as RBOCs like Verizon that are going national to offer fixed wireless is to compete with the broadband access strategies of RBOCs (DSL) and AT&T Broadband (cablemodem). Another reason may be to do an "end run" around RBOC access charges, assuming that telephone services can be provided over fixed wireless access.

¹¹⁶ Otherwise known as IMT-2000 systems, after the standards that govern them.

¹¹⁷ This difference in policy is also due to variations in local market influences. Europe's leading 3G network vendors, Alcatel, Siemens, Nokia and Ericsson, have a strong interest in preserving their significant GSM customer franchise. Because 3G technology is late and expensive to deploy, many GSM networks have been looking for alternatives. Technically speaking, CDMA2000, US-based Qualcomm's technology, can also be configured as an upgrade to GSM or TDMA networks. However, it requires more bandwidth – 1.25 Mhz, vs. 200 kHz on the GSM circuit switched network – than GPRS, the European vendors' preferred alternative. The "only new spectrum for 3G" rule effectively makes it difficult for European operators to reuse their existing GSM spectrum for CDMA2000. For a given level of projected demand for 3G services, this reduces the supply of spectrum frequency on the market, and guarantees that Europe's regulators received higher bids for 3G licenses.

¹¹⁸ Estimate by Gary Rhodes, former Assistant Secretary of Commerce, Nov. 15, 2000. Adding this to the roughly 189 MHz of existing spectrum available for 3G in the US, the total would come to about 349 MHz. This compares with the 300 MHz that Japanese regulators have reserved for it, 395 MHz in Germany, and 364 MHz in UK. See FCC (March 2001), *op.cit.*

¹¹⁹ In January 2001, the FCC reauctoned about \$16.9 billion of 1900 MHz spectrum, about \$15.8 billion of which it had previously auctioned to NextWave Communications, which failed to meet payment conditions. In May 2001 NextWave successfully sued the FCC, getting the auction overturned. Winners of the second auction, like Verizon, were counting on it to provide them with the additional spectrum required for 3G. The matter is now on appeal, and the parties are bargaining.

¹²⁰ The most important licensed-spectrum versions of fixed wireless in the US occupy frequencies that are also important to 3G. For example, MMDS fixed wireless service is located in the 2.5- 2.69 MHz band. As of June 2001, Sprint had acquired MMDS licenses in 90 US markets covering 30 million households, and had filed new license applications for 45 more, while MCI/Worldcom had licenses in 78 markets and was seeking them in 30 others. US Federal Communications Commission, "Spectrum Study of the 2500-2690 Mhz Band," (Washington, D.C., March 30, 2001) One recent FCC study indicated that it could cost up to \$19 billion and take ten years to clear this 2.5-2.69 Ghz band of MMDS carriers – even apart from new services they may be launching.

See BWCS Consulting, July 30, 2001. This might cut significantly into 3G traffic, since WLAN access is already 5-6 times faster than 3G.

¹³² See the brief history of the videophone written by the US Air Force Communications Agency, Office of the Historian. Interview with Sheldon Hochreiser, AT&T Corporate Historian, September 15, 2000, CNN.

¹³³ See Total Telecom, "UMTS: What's That?," July 18 2001.

¹³⁴ See Universal Mobile Telecommunications System (UMTS) Forum, The UMTS Third Generation System – Structuring the Service Revenues Opportunities. (Report No. 9), September 2000, www.umts-forum.org, p.2.

¹³⁵ Gigabit Ethernet, now being deployed for business users in leading metropolitan markets by companies like Yipes, can provide data rates up to 10Gbps. See, for example, The Yankee Group "Metro GigE Providers," April, 2001.

¹³⁶ See, for example, PacketVideo and GPIX, two companies that are now developing two-way video streaming applications for wireless devices.

¹³⁷ With voice coders running at 8 kbps, and a video application requiring 800 kbps or more, the video has to generate at least 100 times the revenue per minute as the voice call in order to justify the carrier's opportunity cost. As noted above, 1 minute of video could easily require 6Mb of bandwidth, or 700-800 times the bandwidth of a 1 minute voice call.

¹³⁸ See Richard Dalton, "The Year of Desktop Videoconferencing," Byte, December 27, 2000. In 1999, the worldwide market for ISDN room-based videoconferencing units was just 93,600.

¹³⁹ There has also recently been progress toward making *black-and-white* videoconferencing available over both wired and low-speed (9.6 kbps or less) wireless connections. See the description of Microsoft's new Portrait low-speed wireless video product, USA Today, August 8, 2001.

¹⁴⁰ One key implication of this for supporters of two-way data networks, including ReFLEX™ and Mobitex™, is that they should also consider making them more interoperable. See below.

¹⁴¹ Cellular Digital Packet Data.

¹⁴² Gwcom's Planet™ is yet another paging-based two way data network. Gwcom, a US-based company with a strong focus on China, raised venture money in 2000 to launch services in China, and then turned to a focus on the wireless ASP market.

¹⁴³ The first version of "Personal Air Communications Technology," a purported ReFLEX™ competitor, was released by AT&T Wireless, Ericsson, Pacific Communication Sciences, and other pACT™ alliance partners in October 1995 about 2 years behind ReFLEX™, aimed at the narrowband PCS market in the US. Despite purported advantages over ReFLEX™ like location detection, spectral efficiency, and symmetrical send and receive speeds, it never got any adoption.

¹⁴⁴ Note that this omits low-speed two-way data- only networks that are used primarily for telemetry, or device to device applications. These include the Nexus™ and DataTrak™ networks, as well as the analog control channel Aeris™ and Cellemetry™ technologies. Note also that an unidentified portion of the two-way data subscribers reported in Chart 11 may be telemetry subscribers – for example, MCI/Worldcom's Skytel™ network is reported to have a large number of telemetry endpoints in service.

¹⁴⁵ As of July 2001.

¹⁴⁶ Red Herring, July 16, 2001.

¹⁴⁷ See above, footnote 8.

¹⁴⁸ Strategis Group, "State of the U.S. Paging and Advanced Messaging Industry, 2001," March 2001, 37. As of yearend 2000, the country's 37.64 million one-way paging subscribers were divided among service providers as follows: Arch – 35 percent; Weblink Wireless (direct) – 5 percent; Verizon (resale of Weblink's ReFLEX™ network – 8 percent; Metrocall (resale of Weblink Wireless's ReFLEX™ network – 16 percent; Skytel – 3 percent; all others – 33 percent. Thus directly or indirectly, the national networks run by Arch and Weblink account for about 64 percent of all one-way paging subscribers. This represents a major two-way conversion opportunity, as discussed below.

¹⁴⁹ See footnote 61 above.

¹⁵⁰ "POCSAG," the "Post Office Code Standardization Advisory Group" standard paging protocol, was a digital code introduced by a group of international engineers working with the British Post Office in 1976-81, and was adopted by the ITU as an international standard in 1981. By the late 1980s it accounted for a majority of the world's pagers, and still is the predominant standard in some markets, notably in Asia. The Golay Sequential Code (GSC), named after the legendary MJ Golay, who published his famous half-page article on error correction in 1946, was another digital code introduced by Motorola in 1983., but it was

slower than POCSAG and never achieved much market success. Standard Golay paging receivers operated at just 300/600 bits/second, while POCSAG ran at 512/1200/2400 bits per second, with 2400 bps in a 12.5 KHz channel. Motorola was an early leader in the production of both POCSAG and Golay pagers.

¹⁵¹ “ERMES,” the Enhanced, or European, Radio Messaging System, a constant 6250 bit/second one way paging system, was an ETSI-backed European standard for digital one-way paging that supposed to do for paging what GSM did for cellular telephony in Europe. It was introduced in 1990, offering more capacity than POCSAG and better roaming capability. Commercial ERMES systems were adopted in France, Finland and Sweden in 1994, and several other countries, mainly in Europe and the Middle East. But as noted in Chapter III, most of the European paging operators were severely hurt by “calling party pays,” and were never very successful. As noted in Chapter III, paging had a difficult time competing in Europe, especially after the introduction of “calling party pays” rules for cellular telephones and the success of the GSM standard.

¹⁵² From 1.6 kbps to 6.4 kbps.

¹⁵³ While POCSAG accounted for a dominant share of numeric pagers through the mid-1990s, it was increasingly unable to deal with capacity and reliability problems created by the dramatic growth of the paging market. It basically suffered from three problems. First, its data rate was relatively slow – only 2400 bps per 12.5 KHz of paging spectrum. This lowered its system capacity by requiring more time to transmit a given amount of information. Second, its protocol was relatively inefficient, with lots of messaging overhead for preamble messages and synchronization words. Third, it had little fade protection, which meant frequent retransmissions, especially in mobile applications. FLEX™ was conveniently designed to be overlaid on to POCSAG, GOLAY and ERMES systems on the same RF channel, side by side – for example, FLEX™ 1600bps could operate in conjunction with a POCSAG 1200bps systems software upgrade to the paging terminal and FLEX™ pagers. FLEX™’s key advantages included first and foremost higher speeds (6400 bps in a 12.5KHz channel for paging, at the FCC’s specified 929-932MHz band, vs. POCSAG’s 2400 bps maximum), and much better error correction. Higher speeds, plus lower latency, in turn, meant more users per channel. -- a FLEX™ 4200 system had at least 4-5 times the network capacity as a POCSAG 2400 system, for numeric paging, supporting up to 600,000 pagers per channel, compared with POCSAG’s 120,000. Mats Frisk, Ericsson Review No. 1, (1997), “Personal Air communications technology,” 5. FLEX™ also offered longer battery life, due to the fact that it was a fully synchronous paging code, allowing the endpoint device to engage only when a message was available, whereas POCSAG’s was asynchronous, requiring a startup preamble signal to let the system know that a message was coming. FLEX™ also supported more than 5 billion addresses, whereas POCSAG only supported 2 million. Finally, FLEX™) also had much better fade protection, because it provided for data interleaving. ReFLEX™ later built on all these FLEX™ advantages.

¹⁵⁴ Skytel at the time was a subsidiary of MTEL, based in Jackson, Mississippi. MTEL was acquired by Bell South Wireless. See below.

¹⁵⁵ At the PCS’94 Conference, September 1994. See Motorola Press Release, “Motorola Conducts Industry’s First Public Demonstration of Two-Way Paging at PCS ’94,” September 22, 1994. www.motorola.com/MIMS/MSPG/Press/PR19980109_6301.html.

¹⁵⁶ See below. It also enhanced capacity by permitting channel layering and sub-zoning.

¹⁵⁷ While there had been earlier designs for two-way messaging, Motorola had the clear lead in two-way *licensed* paging networks. Nexus Telecommunications Systems had developed a two way system that used a return channel in the unlicensed 900 Mhz band.

¹⁵⁸ The N-PCS spectrum was licensed in blocks of up to 50 KHz. The FCC’s first auction, in July 1994, raised an unprecedented \$614 million, for eleven 10-year nationwide N-PCS licenses.

¹⁵⁹ These are Skytel, Arch Wireless, and Weblink Wireless. Skytel appeared at the 1994 auction as the National Wireless Network, owned by Destineer, a subsidiary of MTEL, which had been awarded a Pioneer Preference by the FCC in 1992, giving it narrowband PCS spectrum before the auctions. Microsoft also helped to finance MTEL/ Skytel network. Skytel was later sold to MCI/Worldcom in October 1999. NWN acquired one of the 50/ 50khz paired national licenses. Arch Wireless bought the Paging Network Inc., of Plano Texas, acquiring two paired 50/50KHz and one unpaired 50 KHz national N-PCS licenses, out of the 11 national licenses auctioned in July 1994. Arch acquired PageNet’s assets in 2000. Weblink Wireless was known as PageMart until December 1999. At the July 1994 FCC N-PCS, PageMart acquired one of the 50/12.5 KHz national licenses. Note that Craig McCaw’s KDM Messaging Co., later sold to AT&T, and Airtouch also acquired three national N-PCS licenses, but never fully used them.

occurred in 1998. Faced with the fundamental fact that few operators in world were upgrading their FLEX™ networks to ReFLEX™, GlenAyre, in turn, decided to exit the ReFLEX™ network business in May 2001. Motorola continues to make devices for the network, and to license the ReFLEX™ protocol to other manufacturers. Glenayre and Motorola are both doing some development work on Version 2.7 of the ReFLEX™ protocols

¹⁷⁵ Internet email that relies on the SMTP protocol is delivered on a “best efforts” basis, with no automatic provision for delivery confirmation. Senders may at best request delivery confirmation, but delivery times can be highly variable, and confirmation is optional on the part of the recipient.

¹⁷⁶ This means that after locating a device, the network sends messages for it only to the transmitters in its locality. ReFLEX™’s architecture provides for inbound receiver to receive the reverse channel messages from the pagers. It receives on 929-942 MHz and transmits at 896-902 MHz. ReFLEX25 transmitted at 800, 1600, or 6400 bps, and received at 1600, 3200 or 6400 bps. ReFLEX 50 transmitted at 9600 bps.

¹⁷⁷ Estimates vary for this, but some indicate that cellular systems may have as much as forty times the infrastructure cost per customer at full capacity as ReFLEX™.

¹⁷⁸ See Appendix A for more details on frequency reuse and sub-zoning.

¹⁷⁹ Link budgets on receive are increased significantly by macrodiversity on receive.

¹⁸⁰ The WCTP consortium includes Arch, Metrocall, Skytel, Weblink Wireless, Motorola, Glenayre, Verizon Wireless, RTS Wireless (now part of Aether), and Mobilesys. See www.wctp.org.

¹⁸¹ Roaming and interoperability may bring some additional effective increases in capacity to ReFLEX™ network, by way of more efficient sharing of capacity across geographic regions.

¹⁸² For examples, see www.interwise.com and www.groove.net.

¹⁸³ Another “free” popular instant messaging client developed by Mirabilis, and subsequently acquired by AOL.

¹⁸⁴ See Appendix A for more details.

¹⁸⁵ “Latency” is defined here and in the glossary as the amount of time it takes for a user to send a message and receive back the first byte of the response from the network. This varies greatly, depending on specific conditions, and whether it is operating in a LAN or a WAN environment. For a WAN environment, V. 2.7 is expected to reduce “normal” latency to 7.3 seconds (1.9 inbound, 5.4 outbound) to 13.9 seconds (3.8 inbound, 10.1 outbound). For an “OASIS LAN” situation, in a corporate campus situation for example, latency may be reduced to as little as 3.5-7.2 seconds. Interviews with Arch Wireless engineers, July-August 2001.

¹⁸⁶ Arch Wireless, WebLink Wireless, SkyTel, Metrocall, Motorola, Glenayre, TGA, Verizon Wireless, RTS Wireless and MobileSys.

¹⁸⁷ www.wctp.org.

¹⁸⁸ Simple Mail Transfer Protocol, oldest and simplest Internet protocol. See the Glossary.

¹⁸⁹ For WCTP to provide access to other networks, this would require someone to develop a WCTP gateway to those networks.

¹⁹⁰ For example, there is no need to send an entire IP address over the air – the gateway can do a translation between standard IP addressing and a much shorter network-specific addressing. Other issues include TCP/IP’s methods of stepping data rates up and down, which are completely inappropriate for wireless networks.

¹⁹¹ Sun’s Java Two Micro-Edition™ offers a write-once, run anywhere cross-platform application OS that is designed to provide local processing power. See the discussion of J2ME above in Chapter III.

¹⁹² Among the many proprietary, special purpose two-way data networks that we will NOT examine closely here are Nexus™, Geotek™, Teletrak™, Qualcomm’s Omnitrac™, Siemens/Securicor’s Datatrak™, Nextel’s SMR data (based on Motorola’s MIR technology), other mobile data services over SMR (Racom, Southern Company, Chadmoore), Metricom’s Ricochet™ (an unlicensed spread spectrum technology operating in the ISM band), and RadioMail (really a gateway service).

¹⁹³ See Chart 10 for some of those two-way data networks that we will NOT be examining. These include Metricom’s Ricochet™, Siemen’s Datatrak™, the low-speed analog control channel technologies used by Aeris and Cellemetry, and Nexus™. While SMS is also available in the US, and is a theoretical competitor, as noted in Chapter III, its current utilization is very limited because of interoperability issues, so we’ve also decided to omit it from the short list of serious competitors. See also Chart 13 for the growth of digital CSD, compared with the leading data-only networks.

¹⁹⁴ In North America, the first Mobitex™ network was launched in Nova Scotia by Rogers Cantel in 1988. Rogers Cantel, a subsidiary of Rogers Communications, only expanded its Mobitex™ network to nationwide coverage in Canada by July 1998. RAM Broadcasting Corp. was formed that same year in New York. The US network only commenced operations in 1991, however.

¹⁹⁵ As of 2001, there are public Mobitex™ networks in 14 countries, including the US, Canada, the UK, Venezuela, Chile, Korea, Singapore, Indonesia, Australia, Turkey, Belgium, the Netherlands, Finland, and two in Sweden. There are also private Mobitex™ networks in 8 countries, including Austria (n=6), Denmark, France, Germany, Italy, Poland, Nigeria, and Australia. There are plans to build new Mobitex™ networks in Brazil and China. Of 29 Mobitex™ public and private networks that have been built, northern Europe accounts for 16 of them. (Austria alone has 6, Sweden 2).

¹⁹⁶ RAM Mobile Data was a subsidiary of RAM Broadcasting Corp., New York. BellSouth Corp. took a 49% stake in 1992. In October 1997, it acquired 100 % of RAM Broadcasting Corp. Before the acquisition, RAM Mobile Data, in partnership with Bell South International, also launched Mobitex™-based joint ventures in the Netherlands, the UK, Belgium, and Singapore. The Bell South/RAM Mobile Data JV launched in the Netherlands in 1993, the UK in 1994, and Belgium and Singapore in 1995.

¹⁹⁷ Canada's Mobitex™ network also grew to 900 base stations during this period. By comparison, Arch Wireless now also has about 2500 ReFLEX™ base stations in the US, and will be adding another 700-800 by yearend 2001.

¹⁹⁸ Cingular Wireless is a privately-held joint venture of SBC and BellSouth Corp, formed in April 2000. The business unit formerly know as Bell South Wireless Data, owner of what used to be RAM Broadcasting and RAM Mobile Data, is now a Cingular subsidiary.

¹⁹⁹ Data from Cingular web site; www.cs.berkeley.edu, "A Short History of Wireless Data," (1996).

²⁰⁰ These are yearend subscriber numbers.

²⁰¹ RAM arranged with Intel to produce the Intel Wireless PC/MIA Modem for Mobitex™ in 1995, but it sold few units. Ericsson GE Communications, a JV, produced the Modidem AT wireless external modem, and Motorola also produced a bulky Mobitex modem in the early 1990s.

²⁰² The Palm VII was announced by Palm in December 1998, but did not appear in commercial quantities until May 1999, at a relatively expensive list price of \$599. Early reviews were mixed, especially noting its inability to serve as a paging like notification device because it was not "always on," because it couldn't receive corporate email or do unfettered Web browsing, and because the wireless services on Bell South Cingular and Motient were initially quite expensive. PC Magazine, October 6, 1999; Wired, May 21, 1999. Research In Motion's original 900 series Inter@ctive Pager, a two-way product with a Qwerty keyboard that it first produced for RAM Mobile Data under contract in December 1997, was upgraded to the 950, a smaller, device with more memory (4 MB of flash, 512 Kbytes of SRAM), a 2 watt transmitter, a 32-bit Intel386™ processor, better battery life, a thumb roller wheel that operated similar to a PC mouse, and a clear LCD display (with backlighting and a 6-8 line display) in 1998. It began shipping to BellSouth customers in August 1998 and to Rogers Cantel in September 1998. Despite its commitment to ReFLEX™, PageNET also began reselling the BellSouth RIM-based service in March 1999. That same month, RIM also signed a contract to deliver an equivalent version, the RIM 850 Inter@active Pager, available to American Mobile Satellite Corp. (later Motient, as of April 2000) for the Ardis DataTAC™ network that it had acquired from Motorola in March 1998. It delivered the devices in May 1999, and this time Skytel, another supposed member of the ReFLEX™ alliance, agreed to resell the American Mobile/Motient service on the RIM 850. RIM's even more popular "Blackberry" devices for these two networks – the RIM 957 for Mobitex and the 857 for Ardis/DataTAC™ -- was announced in January 1999, but did not start shipping in quantity until mid-year, as its Blackberry Enterprise Server software became available.

²⁰³ RAM Mobile Data's initial messaging charges were incredibly expensive -- \$135 per user per month for unlimited messaging, with \$25 and \$75 packages available that put stiff ceilings on usage. "Speedy Wireless Nets," Network Computing, June 20, 1998, 38. Under Bell South/Cingular, prices finally fall. For example, the monthly service plan prices for the RIM messaging monthly plans were reduced by about 40 percent from 1999 to 2001. As of 1999, Bell South's unlimited service plan for the RIM 950 Inter@active Pager was \$99.95 a month, stepping down to a minimum of 25,000 characters per month for \$24.95. By August 2001 it was charging \$59.95 for unlimited service, a forty percent reduction, and its entry level price was \$9.95 for 15,000 character, a 34 % per bit reduction. Cingular only introduced an unlimited service plan for the Palm VII in mid-2000.

²⁰⁴ See for example "Palm VII: A Definite Lemon," Wired, May 21, 1999.

²⁰⁵ UPS rejected both RAM Mobile Data and Ardis in February 1993, in favor of a custom circuit-switched cellular system that it deployed in conjunction with Southwest Bell, GTE, and PacBell. The loss of this potential 200,000 endpoint system was a major disappointment for RAM. Motorola designed and manufactured the custom endpoint devices that UPS deployed on this network, which used cellular modems to interface with UPS's own packet-switched network.

²⁰⁶ The Mobitex™ packet-based radio protocol groups data in packets of up to 512 byte packets, and the maximum message takes 907 ms. So the effective data rate is $4.516 \text{ kbps} = 512 \times (8 \text{ kbps}/907 \text{ bps})$.

²⁰⁷ See the network service test reported in Network Computing, July 10, 2000, which concluded that the typical Cingular Mobitex™ network user would average just 2 kbps in actual throughput. See also Pete Edmundson, RIM, "Security Issues in Wireless Environments," Wireless Internet for E Commerce Conference, April 28, 2000, which reports that since the 8 kbps is shared bandwidth, Mobitex users average just 1.2 kbps.

²⁰⁸ These are yearend subscriber estimates for 1999 and 2000. Of the 688,400 Mobitex™-based customers as of July 2001, about 225,000 were using Palm.Net, 65,000 sold by RIM's Blackberry service, 353,000 were sold by Cingular, and about 45,000 were sold by Aether, a wireless solutions company.

²⁰⁹ About 14 of the 29 Mobitex™ networks in the world today are private networks, for individual companies or members-only associations.

²¹⁰ China is reportedly also considering a new Mobitex™ in the 800 MHz range.

²¹¹ CDPD can also be packet switched.

²¹² Online transaction processing applications – for example, credit card processing.

²¹³ For reasons not clear, the designers of the original Palm VII lost sight of this vital paging-like Mobitex™ capability, requiring the user to take action, raise his aerial and essentially contact the network in order to receive any messages. RIM, in contrast, built pager-like always-on capability into all its devices. Palm is now reported to be working on a "RIM killer" that will mimic this always-on feature.

²¹⁴ With 5 percent concurrency, this implies about 1500-2000 concurrent users per Mobitex™ base station.

²¹⁵ DataTAC™'s original protocol, still in use for close to half its network, only runs at a maximum of 4.8 kbps.

²¹⁶ This is the costs of establishing coverage in any large service area, apart from spectrum costs.

²¹⁷ IBM's legendary Systems Network Architecture, of Sears Roebuck fame – perhaps the most lucrative proprietary protocol in history.

²¹⁸ Regular POP3 mail, for example, has to be forwarded to a user's Palm.net account.

²¹⁹ See for example the 1997 claim by Bell South Wireless Data: "Mobitex protocol provides a high level of security. Data transmissions over a wireless packet switched network are much more difficult to capture than voice transmissions over a cellular voice network. Unlike conversations in the cellular environment, which are continuous and easily monitored by unsophisticated eavesdroppers, messages in a packet switched environment are sent in bursts. "Reading" such messages is only possible if the RF interface can be de-scrambled, a process requiring a level of personnel skill and software sophistication that is prohibitive. In addition, Mobitex is compatible with customer selected security packages, thus enabling the user to choose additional security for select messages." See "The Inherent Insecurity of Data Over Mobitex Wireless Packet Data Networks," March 14, 1997, aron@geocities.com, rec.radio.scanner newsgroup.

²²⁰ See, for example, Alison Campbell, "Mobitex vs. GPRS," m-CommerceWorld.com, July 2001: "Mobitex is also said to be an extremely secure network, a primary requirement for trading exchanges. It is one of the only networks in the UK used by the Police and emergency services without encryption (although encryption can be built in)."

²²¹ For example, the combination of frequency agile modems, bit interleaving, and data scrambling built into the Mobitex™ protocols. They send data over the airlink in short bursts at up to 8 kbps using Gaussian Minimum Shift Keying (GMSK) modulation, which is encoded and interleaved for error correction, then scrambled. For efficient channel access, Mobitex™ also uses a TDMA method with a modified slotted Aloha channel access algorithm, which also complicates monitoring.

²²² See "The Inherent Insecurity of Data Over Mobitex Wireless Packet Data Networks," March 14, 1997, aron@geocities.com, rec.radio.scanner newsgroup.

²²³ ReFLEX™'s RC4 encryption does comply with the National Institute of Health's guidelines for health care data privacy. Basically it amounts to using RC4 to generate secret keys, which all protected wireless devices and network access points (base stations) share in common. But RC4 – the most widely used secret key cipher in software applications – has recently been shown to be vulnerable to attack, especially in a

wireless context where attackers are able to scoop up lots of encrypted data for analysis. For a recent example of an attack on 802.11b's security protocol, which also relies heavily on RC4, see AT&T Labs Technical Report TD-4ZCPZZ, "Using the Fluhrer, Mantin,, and Shamir Attack to Break WEP," August 6, 2001.

²²⁴ For example, Palm.Net uses Certicom's Elliptic Curve Cryptography for end-to-end encryption for the Palm VII services that it offers on Mobitex™.

²²⁵ Other device hardware manufacturers for the Mobitex™ network include Maxon, Nomadic, CNI, and Ericsson itself. Middleware providers including RIM, Palm, Cingular, Nettech, Mobix, Infowave, and Aether.

²²⁶ Our estimate is that ReFLEX™'s national coverage is about 95% of the US population, compared with Mobitex™'s 72 percent. Both networks also provide national coverage in Canada, the US's largest trading partner. ReFLEX™ also provides it in Mexico, the second largest US trading partner.

²²⁷ The Gemstar TV Guide application was announced on June 4, 2001. Advantra will supply the modems, and Thomson will manufacture the TV sets.

²²⁸ The former Phillips Electronics subsidiary, now owned by Punch International.

²²⁹ For example, CDPD – "Cellular Digital Packet Data+ -- has very low capacity expansion costs, because it is an overlay network that rides on existing AMPS cellular systems. It is also a full-duplex transfer mode system, unlike Mobitex™, DataTAC™ or ReFLEX™, allowing its modems to talk and listen at the same time, which reduces latency. It is also capable of relatively high throughput, at least when voice traffic permits it, at speeds up to 19.2 kbps, and provides native IP support, unlike all the others. Unfortunately coverage is lousy, there is no interoperability among the 7 US carriers that offer CDPD services, there's a shortage of low-cost devices for it, and it has also managed to earn the moniker, "Capacity Did Prove Deficient." Its strengths and weaknesses partly reflect the fact that it was developed in the early 1990s by a coalition of analog cellular operators (plus IBM, which holds the patents!) that was concerned about generating higher ARPUs from excess capacity in their voice systems.

Motient's DataTAC 4000 network also has pretty good coverage, and about half of the US business population is capable of providing a shared maximum throughput of 19.2 kbps, in the 70-odd cities where it has implemented its "Radio Data Link Access Protocol." It is also pretty good at in-building penetration. On the other hand, its slotted "Digital Sense Multiple Access" (DSMA) protocol reportedly has serious problems with latency because of the way base stations and mobile devices register with each other. Ardis's strengths and weaknesses also reflect its origins. The US Ardis DataTAC™ 4000 network that is now owned by Motient, had its roots in a proprietary data-only network that built for IBM's field sales force in 1983 by Motorola, and was jointly owned by the two companies until 1994. IBM remains the largest customer to this day, but Motorola and IBM parted ways on their wireless data JV in 1994, when Motorola bought out Big Blue for \$100 million. In 1997 it sold the network to what was then the American Mobile Satellite Corp, which changed its name to more catchy but perhaps less meaningful "Motient" in 2000.

²³⁰ See www.boeing.com/companyoffices/history. Boeing acquired McDonnell Douglas, the DC-3's creator, in 1997.

²³¹ ETSI's GPRS standards effort for GSM networks started in 1994. In the words of one participant, it followed the "standard telecommunication model – four years to write the standard, followed by years of implementation, after which we see if it works."

²³² The GSM Forum had been supported a higher-speed circuit-switched technology called HSCSD until roughly 1998, when it lost ground to GPRS, largely because GSM finally realized the value of a packet-switched network for data – viz, the Internet example.

²³³ For example, one early report indicated that it only cost Voicestream about \$50 million upgrade its US GSM network. It turns out that this was probably a serious understatement, because it assumed that Voicestream could provide adequate GPRS coverage with its existing GSM base stations, while in fact it may require at least 2-3 times as many base stations to get adequate data rates and building penetration. ETSI, SMG2, 2001. In any case, Voicestream's required investments will probably be much lower than those required of AT&T Wireless and Cingular Wireless to upgrade their TDMA networks to GSM and then add GPRS -- much less Verizon and Sprint PCS, since CDMA2000 requires even more investment in new base stations and perhaps more spectrum. From the standpoint of total system economics, the investment cost of replacing non-2.5G handsets will also be substantial – at least equal to the cost of the

network upgrades. It is appropriate to include “handset capital” (as well as application capital) in the accounting, when we consider the cost-benefits of upgrading to 2.5G – after all, consumers (or investors) will ultimately have to foot the whole bill.

²³⁴ WAP.com, August 22, 2001.

²³⁵ Dresdner Kleinwort Benson, 2001 estimate

²³⁶ In July 2001 AT&T Wireless launched a GPRS pilot in Seattle, offering Motorola’s new Timeport 7382i phone, with plans to upgrade 40 percent of its POPs to GPRS this year, and the rest scheduled for 2002. The AT&T Wireless GPRS pilot started in Seattle on July 17, 2001. In August 2001, Cingular also launched a Seattle GPRS pilot.

²³⁷ For some carriers it also requires more spectrum. Unlike GPRS, however, the CDMA2000 upgrade supposedly pays for itself very quickly, not necessarily because of increased data traffic, but because it automatically doubles the voice channel capacity of a carrier’s CDMAOne cellular voice network.

²³⁸ SKTecom launched its CDMA2000 platform in December 2000. LG Telcom followed suit in June 2001.

²³⁹ ETSI, Special Mobile Group 2, 2001.

²⁴⁰ This is referred to as the “mobile termination” issue. Given the fact that GPRS customers will be paying for their services based on data received rather than airtime, the cellular operators argue that permitting handsets to remain “open” could leave customers vulnerable to junk mail. On the other hand, it would also permit them to receive data from services that don’t pass through the “walled gardens” run by the operators.

²⁴¹ Our friends at Motorola delivered the first GPRS handset, the Timeport 260, for the European market in March 2000. That was widely panned, but Motorola has generally been very aggressive with GPRS, and now has at least six GPRS handset models in the market, than any other vendor. Ericsson followed in June 2000 with the R520, but it was withdrawn for battery life problems in April 2001. In June 2001 it launched the T39. Siemens has also recently produced a GPRS handset, the S45. Conspicuously late in joining the GPRS bandwagon has been the overall cellular handset market leader, Nokia, which apparently bet very heavily on a rapid transition to 3G, and is playing catch-up. It reportedly plans to introduce the 8390 GPRS phone in the US by yearend 2001. Until then, Motorola will be a dominant player on GPRS handsets. The shortage of handsets has already held up GPRS commercial launches. For example, in August 2001 Sweden’s Tele2 pushed back its GPRS launch to later in the fall.

²⁴² As of July 2001, the GPRS handset shortage had become a real problem for European operators. Only Motorola had one commercially available; Ericsson’s T39, finally delivered in June 2001 after delays, is still not available in commercial quantities.

²⁴³ An alternative tack, taken by vendors like RIM, Compaq (iPaq), and Palm, is to start with basic PDAs, add card slots for 2.5G modems, and deliver voice through headsets. This may prove more successful.

²⁴⁴ AT&T Wireless’ price for the Motorola Timeport 7382i GPRS phone in its Seattle trial is \$199.99, but this is a subsidized rate.

²⁴⁵ Some software companies, indeed, have identified this relatively slow unadjusted performance as an opportunity to offer middleware that boosts 2.5G performance. See, for example, the analysis provided of GPRS speed issues by www.firsthop.com, White Paper on GPRS, August 2001.

²⁴⁶ For example, Novatel’s new GPRS modem, to ship this fall, supports speeds “up to 53.6 kbps.” In Europe, where GPRS services have been tariffed for some time, no operator is offering a service greater than 40 kbps (T-D1 in Germany), most are in the 20-28 kbps range (Viag – 26.8kbps; E-Plus – 20 kbps; D2 Vodafone – 28 kbps), and all use “up to” language to qualify these services.

²⁴⁷ The reader may be surprised to find that the GSM Forum’s own website has really quite critical things to say about GPRS, for example, relative to the “next big thing,” which it takes to be EDGE or wCDMA. For example, one white paper on the site makes the point that GPRS’s modulation scheme, GFSK, is decidedly inferior to EDGE’s 8PSK scheme, resulting in lower bit See GSMworld.com.

²⁴⁸ For example, AT&T Wireless’s GPRS trial, started in July 2001, offered 1 MB of data sent or received plus 400 voice minutes for \$50 per month, plus incremental data for 3 cents per kilobyte, plus \$199.95 for the phone. Cingular’s pricing for its Seattle trial of its GPRS-based “wireless Internet Express” service started at \$14.99 for up to 100 messages or 500 Kb per month, increasing to \$21.99 for up to 500 messages per month, plus 10 cents per additional message and 7 cents per additional kilobyte.

²⁴⁹ We have examined two usage patterns in providing the estimates for Chart 35. One pattern assumes that a user stays within the limits of his monthly data allocation – typically 500KB for all these plans – and sends 100 messages a month. At the other extreme, we assume, based on data from a Gallup Poll of US email users taken on July 24, 2001, that users reflect the average behavior of the 72% of American adults who

now get email at both home and at work, and that they now try to use their GPRS wireless for all their monthly email traffic. According to this poll, these users now average about 18.7 messages received per day, of about 6 kb each, and send about 8.3 messages per day. The resulting estimates show their average costs per message if they converted all this messaging activity to wireless GPRS devices, and did no further browsing. The resulting estimates show that for heavy messaging, the AT&T and Vodafone plans are much cheaper. But all of these plans result in average costs per data message no less than ten cents, now about the average cost of a minute of voice service, and in most cases much higher.

It should be noted that two-way wireless data usage patterns are very similar to these average email users -- in July, 2001, the median Arch two-way customer was sending or receiving an average of 18 messages per day. On the other hand, a sample of 1086 users among PageNet's November 2000 Mobitex™ subscribers showed that they averaged just 123.Kb of messages per month. We would expect two-way data customers to have much shorter average message lengths than email users, so perhaps these data are not inconsistent.

²⁵⁰ Gallup Poll of email use, July 24, 2001, supra, implies average total Internet email traffic per user per day for employees who also have email at home of 174 kb per day, compared with the .5MB *per month* provided by these GPRS pricing plans. The \$5-\$12 range cited in the text as an average cost for one day's email assumes is based on the assumption that this use is after the first .5MB are exhausted.

²⁵¹ Assuming an average per .jpg file of 50 KB.

²⁵² This assumes that each wireless page view equals about 1 kb of data, so that these plans provide up to 500 page view per month. This obviously can vary a great deal, depending on Web content and WAP's translation capabilities. According the Nielsen/NetRatings (July 2001), the average US internet user that month did 33 sessions per month, visited 21 sites per session, and viewed 36 pages per session, for a total of 1188 page views per user per month. Assuming that the median user still surfed for \$19.95 over an analog modem, this implies a cost per page view -- ignoring the value of email, chat, and other web services -- of about 1.7 cents, somewhat below the average price per page view implied by the initial GRPS pricing models.

²⁵³ See, for example, Morgan Stanley (June 2001), op. cit.

²⁵⁴ For example, above the initial 500 KB offered by AT&T, incremental KBs cost 3 cents. Assuming that messages average 6 KB each, this implies a marginal cost per message of 18 cents.

²⁵⁵ For example, one basic Arch Wireless plan offers 200,000 characters per month for \$40, and typical discounts for corporate accounts are at least 20-30 percent lower. Because of ReFLEX™'s greater payload efficiency, each message only averages about .5 kilobytes or less, so this equates to about 400 messages per month, at an average cost of \$.10 per message. An alternative Arch plan provides unlimited messaging for \$60 per month.. Even before corporate discounts, for the heavy users discussed above who use wireless devices for all their messaging, this implies an average cost per message of just 7.4 cents, compared with the \$.12-\$.36 unit message prices for GRPS shown in Chart 35.

²⁵⁶ This may be another advantage of wireless data-only devices. At least 85 percent of those who have cell phones try to use them while driving, leading to accidents as often as drunken driving. A 1997 New England Journal of Medicine study showed that drivers are four times more likely to have automobile accidents while using cellular phones, and that the risk was the same when drivers used "hands-free" phones. US case law has already held that employers can liable for employees who have accidents because of their use of company-provided cell phones, whether or not the phones are being used for business or personal calls. See Ford & Harrison, Management Update, December 1999.(Vol. 22, No.1): "If cellular phones are provided by a company or if cellular phone use is a necessary component of a job, employers can be liable for problems created by employees' use of cell phones while driving. Employers can incur liability whether or not the call is personal or business related. Now, at least one lawsuit indicates that employers should consider banning their employees from talking on cellular telephones while driving." See Roberts v. Smith Barney (ED Pa., No. 97-CV-2727, 2/12/99). There is now a nationwide wave of state legislation on cell phone use while driving, including a recent New York State law that banned the use of handheld phones while driving. Federal legislation has also been propose, though the cellular operators are lobbying fiercely against it. See "Drive Talking: Cell Phone Debate Set to Heat Up," The New York Times, September 2, 2001.

²⁵⁷ Pete Blackstone, CEO, PlanetFeedback.com, April 24, 2001.

²⁵⁸ WitSound View, Survey of Customer Satisfaction Among Leading Wireless Carriers, March 2001.

²⁵⁹ Forbes Magazine, “Cell Hell: Why Wireless Service is a Mess and What You Can Do About It,” September 17, 2001, 114-117.

²⁶⁰ Michael Uhm, Spectrum Signal Processing, August 2001.

²⁶¹ See, for example, Vodafone’s July 20, 2001, announcement that it was delaying the European roll-out of 3G services until 2003. On August 22, 2001, the first 3G-related bankruptcy occurred – Broadband Mobile, jointly owned by Italy’s Enitel and Finland’s Sonera, announced that it would be unable to build out the 3G licenses it won in Norway, Germany, and Italy, and filed for bankruptcy.

²⁶² See, for example, Christopher Stern, “Demand for Broadband Cooling,” The Washington Post, August 29, 2001.

²⁶³ Cynthia Brumfield, Broadband Intelligence Inc., quoted in The Washington Post, *supra*.

²⁶⁴ The early history of the PC is instructive in this regard. Until there were compelling applications for the IBM PC – Lotus 123’s easy to use spreadsheet in particular – its early sales, especially to business customers, were sluggish. Only after Lotus 123 was launched in the fall of 1980 did IBM PC sales really take off.

²⁶⁵ Cf. the nuclear power industry in the 1950s and 1960s, which also spent hundreds of billions on power plants around the globe, many of which are now mothballed, and which at one point even contemplated building nuclear-powered cars, airplanes, ships, and toasters! The nuclear industry analogy also turns out to be at least somewhat similar on safety grounds – while the jury is still out on the long-term effects of cell phone electromagnetic emissions, there is no question, as noted above, that vehicle accident rates are much higher because of them. Indeed, even allowing for the risk of catastrophic accidents like Chernobyl that obviously don’t apply to the cellular industry, it is likely that there have been far more casualties due to cell phone-induced driving accidents than to nuclear power accidents.

²⁶⁶ See, for example, messagemachines.com.

²⁶⁷ It is also possible to configure a “Break before Make”, in which the device would break from its old zone before requesting registration in the new zone. This would typically happen in the case of a pager roaming between network providers, rather than changing zones within a single network.

²⁶⁸ See “Campus Coverage” below.

²⁶⁹ “Hot spot” zones can be smaller, however -- see “Hot Spot Coverage” below.

²⁷⁰ See “ReFLEX Wireless Data Technology”, published by WebLink Wireless in August 2000, for a more complete description.

²⁷¹ To achieve this would also require all the other components of the network to work this quickly. In many current ReFLEX networks, the transmit controllers work-ahead up to 4 seconds. To achieve a lower latency, these controllers would need to be upgraded.

²⁷² This feature may not appear until Version 2.7.2, due in early 2002.

²⁷³ Compiled from general sources, including geek.com, crosstouch.com, and webopedia.com

