

Cellular Networking Perspectives

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The Development of cdma2000 Standardsp. 1

Understanding CDMA technology is complicated by varying terminologies associated with different standards from different organizations, different technologies and different trade names. This article clearly describes the evolution of CDMA technology, associating the right words with the right concepts.

Optimal Routing, Part III: The Ultimate Solutionp. 3

None of the optimal routing solutions described in parts I and II of this article were totally satisfactory. This article describes what is needed to make optimal routing work well under all circumstances. The only problem is that no existing SS7 ISUP standards yet support the required messaging and switching capabilities.

TIA TR-45.1 Analog Cellular Air Interface Standardsp. 5

Analog cellular is still widely used, and incremental improvements to standards are still being pursued by TIA standards subcommittee TR-45.1.

Comments

We welcome comments on the format or contents of *Cellular Networking Perspectives*. We can be reached via email at:

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Next Issue: February 1st, 2001

The Development of cdma2000 Standards

By Clifton J. Barber
(Oki Network Technologies)
and Phil Brown (CISR, Inc.)

cdma2000 is one of the ITU-R IMT-2000 RTT (Radio Transmission Technology) candidates for so-called 3G, or third generation, wireless systems (with analog cellular representing the first generation, and digital cellular and PCS representing the second). It is designed to operate on 1.25 MHz RF (“narrowband”) channels, and is based upon the successful second generation cdmaOne™ air interface which has been deployed extensively throughout North and South America and Asia.

The development of standards for narrowband (1.25 MHz) CDMA began with the formation of the TIA TR-45.5 subcommittee in March 1992. TIA, which is a Standards Development Organization (SDO) for North America, managed the standards development activities for this technology until the end of 1998. In January 1999, 3GPP2 (Third Generation Partnership Project 2) was formed to harmonize the 3G requirements for — and development of — this technology on an international scale. The SDOs currently participating in 3GPP2 include ARIB and TTC (Japan), TIA (North America), TTA (Korea), and CWTS (China). 3GPP2 now generates all cdma2000 requirements and it controls most of the development of cdma2000 specifications (with the

exception of country-specific or regional capabilities). The intent of this partnership is that cdma2000 specifications are developed in 3GPP2, with all partner SDOs subsequently balloting them nationally. Resolution of SDO ballot comments will be handled within 3GPP2.

Complete information on 3GPP2, as well as a list of their published specifications, is currently available at:

www.3gpp2.org

The cdma2000 family of standards includes the following air interface versions: cdmaOne™ (as a backward compatibility mode), cdma2000, 1xEV-DO (Data Only), and 1xEV-DV (integrated Data and Voice, currently in development). The “1xEV” designation indicates an evolution of the 1x channel technology, where “1x” refers to the original 1.25 MHz channel bandwidth. This air interface evolution is depicted pictorially in Figure 1, summarized in Table 1, and detailed below.

cdmaOne™

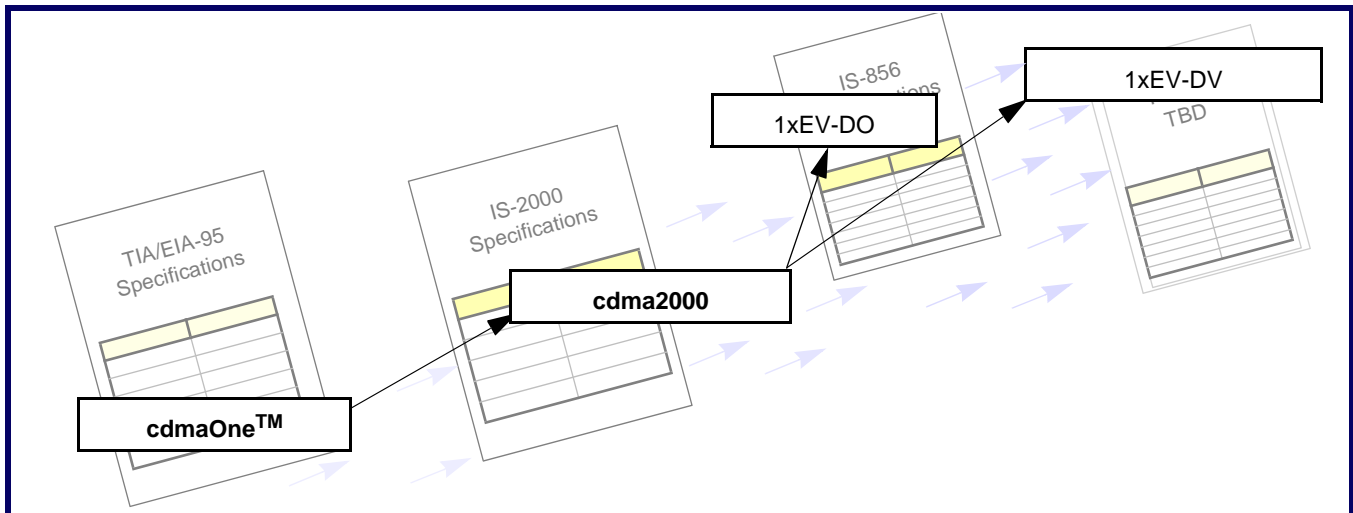
cdmaOne™ is a CDG (CDMA Development Group) trademark referring to the set of air interface standards developed by TIA during the period between 1992 and 1998, and published as TIA interim standards IS-95 and IS-95-A, and then as full American National Standard TIA/EIA-95-B. These standards represented the initial implementations of this CDMA technology, with bug fixes and minor enhancements representing the changes between the standards versions. These standards were supported by

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Figure 1: cdma2000 Air Interface Technology Evolution



ancillary data standards which added the capabilities for data transmissions of approximately 9.6 kbps or 14.4 kbps (with packet data speeds up to 115 kbps supported by 95-B).

cdma2000

The IS-2000 air interface standards were the initial release based on the cdma2000 RTT document. These standards are published in six separate volumes as noted in Table 1. IS-2000 Release 0 was developed by the TIA and published in August, 1999. Release A (December, 1999) and Release B (publication estimated for 1Q2001) were developed in 3GPP2. These standards provide enhanced data transmission capabilities up to 144 kbps (1x) and 1 Mbps (3x, see below), on both the forward and reverse links, by combining a low-rate fundamental channel with a high-rate supplemental channel. The performance improvement (relative to cdmaOne™) is provided by a combination of enhanced modulation and channel coding techniques. In addition, these standards support a 3x mode combining three 1x channels to support even higher levels of performance. The 3x mode was the first attempt at harmonization with W-CDMA (Wideband CDMA).

W-CDMA gets its name from its 3.84 MHz RF channel width versus $3 * 1.2288 \text{ MHz} = 3.6864 \text{ MHz}$ for cdma2000. It is a competing IMT-2000 RTT technology developed by 3GPP and

is intended as an evolutionary path for GSM system operators.

1xEV-DO

The 1xEV-DO air interface specification, formally entitled “High-Speed Data Enhancements for cdma2000 1x-Data Only”, was completed by 3GPP2 this year as C.S0024 and was also published by TIA as IS-856. However, some network support issues for it are still being finalized. This standard specifies a data-only channel, and it is based in large part on the HDR (High Data Rate) system first proposed by Qualcomm. This standard allows peak data rates up to 2 Mbps on the forward link and 144 kbps on the reverse link in a stationary environment. Average data rates are specified as 600 kbps on the forward link and 144 kbps on the reverse link. 1xEV-DO was developed as an interim solution to allow high-speed data support on a data-only channel until a complete integrated solution could be developed.

1xEV-DV

The 1xEV-DV air interface specification, formally entitled “High-Speed Data Enhancements for cdma2000 1x-Integrated Voice and Data”, is currently under development in 3GPP2. TSG-C, the air interface technical specification group of 3GPP2, is currently in a technology assessment mode as they are evaluating seven candidate framework proposals to serve as the basis for this specification. TSG-C is scheduled to

complete its evaluations sometime before mid-year, and publication of the 1xEV-DV specification is projected for 3Q2001. The 1xEV-DV specification is intended to support peak data rates up to 2.4 Mbps on the forward channel and 2 Mbps on the reverse channel, system wide average data rates of up to 600 kbps on both forward and reverse links, and to provide up to twice the voice traffic capacity. The 1xEV-DV channel is also intended to be able to support cdmaOne™ and IS-2000 mobiles.

Ancillary Standards

There are several ancillary standards which complete the cdma2000 family. The cdma2000 family of vocoders includes an 8 kbps QCELP vocoder (TIA/EIA-96), a 13 kbps QCELP vocoder (IS-733), an 8 kbps EVRC (enhanced variable rate codec) vocoder (IS-127), and a new low-rate SMV (selectable mode vocoder) which is expected to be published by 3Q2001.

Other ancillary standards include SMS (Short Message Service, published as TIA/EIA-637), OTASP and OTAPA (Over The Air Service Provisioning and Parameter Administration, published as TIA/EIA-683), circuit/fax and packet data services (IS-99 and IS-657, recently withdrawn and replaced by IS-707), R-UIM (Removable User Identity Module, published as IS-820), position location (IS-801), and streaming video service (currently under development).

Table 1: IS-2000 Air Interface Summary

	cdmaOne™	cdma 2000		
		IS-2000	1xEV-DO	1xEV-DV
TIA Documents	TIA/EIA-95	IS-2000.1 through IS-2000.6	IS-856	<i>tbd</i>
3GPP2 Documents	n/a	C.S0001 through C.S0006	C.S0024	<i>tbd</i>
Development Dates	1992-1998	1999	2000	2000-2001
Media Options	Voice + Data	Voice + Data	Data Only	Voice + Data
Data Rate - Peak/Best Case	14.4 kbps (circuit/fax), 115 kbps (packet)	144 kbps (1x), 1 Mbps (3x)	2 Mbps - Fwd 144 kbps - Rev	2.4 Mbps - Fwd 2 Mbps - Rev
Mobile Stations Supported (Backward Compatibility)	cdmaOne™	cdmaOne™, IS-2000	1xEV-DO	cdmaOne™, IS-2000, 1xEV-DV

4G CDMA?

Finally, with all this activity, it is reasonable to wonder: Will there be a cdma2000 4G? 3GPP2 has recently committed to the development of an All-IP (Internet Protocol) Network. While this network will support a Legacy Domain for backward compatibility with the TIA/EIA-41 network, the cdma2000 4G system will undoubtedly be based on the 3GPP2 All-IP Multimedia Domain implemented on a 1xEV-DV air interface. A wide range of new features and services will then be developed based on this platform

About the Authors:

Clif Barber is the Secretary for TIA TR-45.5 as well as for 3GPP2 TSG-C, TSG-S, and the All-IP Ad Hoc. Phil Brown is the Chairman of TIA TR-45.5 WG1 and 3GPP2 TSG-C WG1. Mr. Brown is a consultant who currently represents Ericsson in TR-45.5 and 3GPP2. Together, they have almost 15 years of experience in the development of cdma2000 standards.

Optimal Routing, Part III: The Ultimate Solution

The first two parts of our article on Optimal Routing (November and December, 2000) described some partial solutions, but did not describe all that is needed to make it work even when the caller is using a landline phone, when the mobile is ported and when call forwarding is considered.

The closest solution is based on SS7 ISUP Release-to-Pivot (RTP). It is, however, deficient in certain call forwarding cases, because the connection to the home MSC is released prematurely. A slight modification, which we call Conditional Release to Pivot (cRTP), maintains the trunk to the Home MSC until either the roaming mobile answers, or until call forwarding occurs. It is important to note that this solution is not yet under development by any standards organizations.

Conditional Release-to-Pivot (cRTP)

There is a period of time during a call to a roaming mobile when it is not known whether the call will be completed to the mobile or forwarded under the control of the home system. Figure 2 illustrates how cRTP can provide Optimal Routing

while allowing for this period of uncertainty.

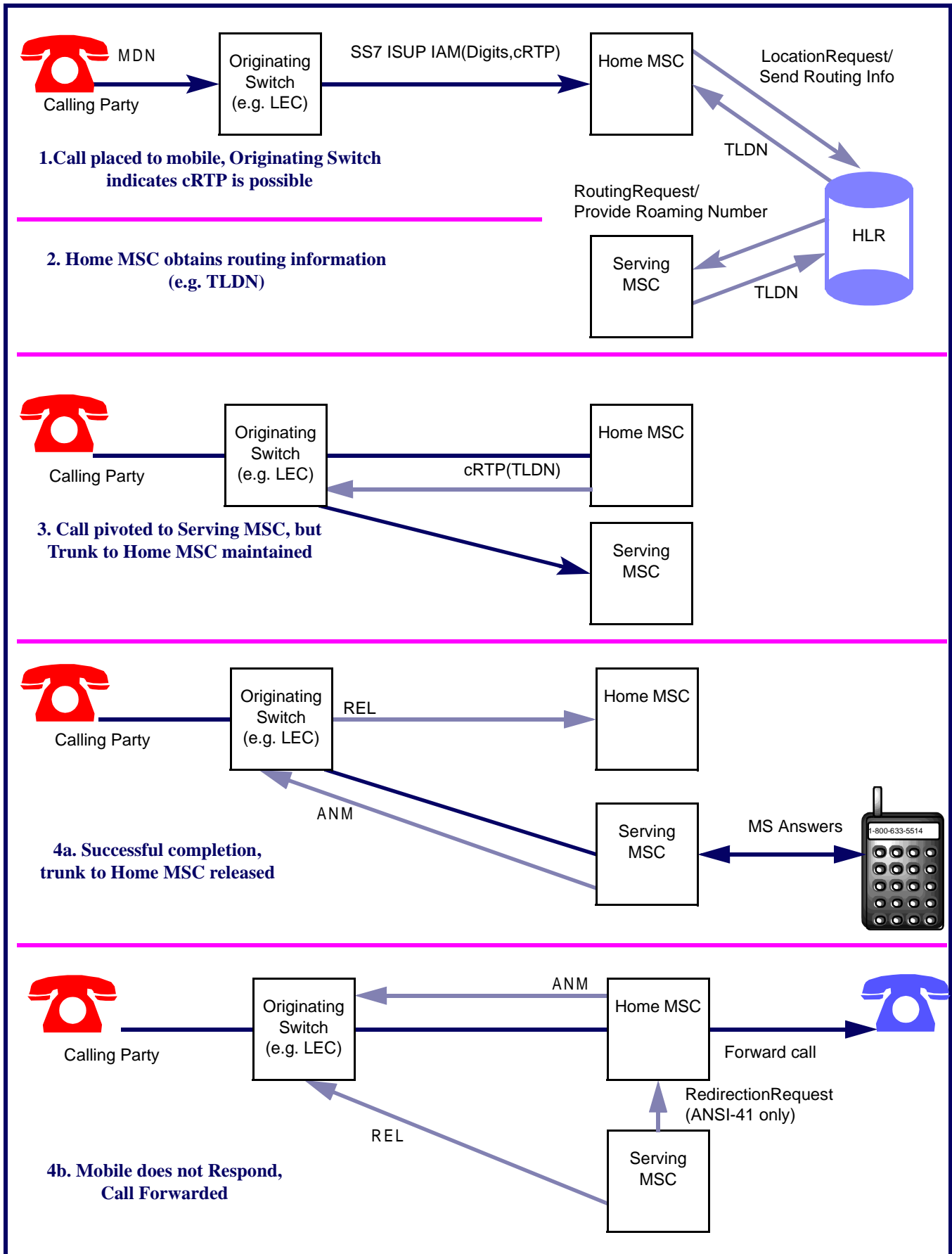
Steps 1 and 2 of this figure show normal call establishment to the Home MSC. At Step 3, however, while a route is established to the Serving MSC, the route to the Home MSC is still maintained (although it is not part of the voice path). This requires a new message that we have named cRTP.

Once a three-way call path is established, two different possibilities open up. Step 4a illustrates that, if the mobile answers (resulting in an ISUP ANM to the Originating Switch), the trunk to the Home MSC can be released normally and the Serving MSC will continue with the call for the roamer.

If the mobile does not respond to a page, if it is busy or if it does not answer after being paged, the mobile may be redirected to a call-forward busy/no-answer number, as shown in Step 4b. The Serving MSC sends an ISUP REL message to the Originating Switch at about the same time it sends an ANSI-41 RedirectionRequest to the Home MSC, which will then query the HLR for the forward-to number.

This type of call processing is not yet possible with GSM systems; forwarding would have to occur from the Serving MSC back to the Home MSC, and this would negate the benefits of optimal routing.

Figure 2: Optimal Routing using Conditional Release-to-Pivot (cRTP)



TIA TR-45.1

Analog Cellular

Air Interface Standards



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- Note: 1. IS- Interim Standard, TSB- Telecommunications Systems Bulletin, PN- Project Number, SP- ANSI Standards Proposal.
 2. Bold Type indicates a modification since the previous publication of this information.
 3. Published TIA standards can be obtained from TIA at www.tiaonline.org/standards/search_n_order.cfm.

Thanks to Bob Slocum (Ericsson) for his assistance compiling the information in this table.

First Generation: Basic Analog

Standard	Description	Status
EIA/TIA-553	Analog air interface	Published 09/89
IS-19-B	Mobile minimum performance standards	Published 06/88
IS-20-A	Base station minimum performance standards	Published 06/88
IS-3-A,B,C,D	Original analog air interface standards (see EIA/TIA-553-0)	Rescinded 09/89
TSB-16	Assignment of access overload classes	Published 03/85
TSB-35	Cellular mobile receiver dynamic range	Published 04/92
TSB-39	Message type assignment for extended protocol	Published 03/93

Second Generation: NAMPS, In-Building, Residential, Authentication

Standard	Description	Status
TIA/EIA-89	Elevate IS-89 to ANSI standard	Development
TIA/EIA-90	Elevate IS-90 to ANSI standard	Development
IS-88	Narrowband (3:1) analog air interface ("NAMPS")	Published 02/93 Being rescinded
IS-89	IS-88 base station performance standards	Published 02/93
IS-90	IS-88 mobile performance standards	Published 02/93
IS-91	Analog air interface (including "NAMPS" and authentication)	Published 10/94
IS-94	In-building analog air interface ("CAPS")	Published 05/94 Rescinded 10/00
IS-680	Residential ("cordless") interface between Wireless Residential Extension (WRE) and PSTN	Published 05/96
TSB-70	Cross reference for FSK control channel	Published 12/95 Rescinded 09/99
TSB-83-A	Additional modem options for IS-680 ("cordless")	Published 04/97

Third Generation: Isolation of "Core" Control Channel Capabilities

Standard	Description	Status
TIA/EIA-553-A	Analog air interface (including authentication, alert/flash with info, abbrev. alert, message waiting indicator and protocol capability indicator (PCI))	Published 11/99
TIA/EIA-690	Mobile minimum performance standards (previously IS-19-C).	In press
TIA/EIA-712	Base station minimum performance standards (prev. IS-20-A)	Published 09/97
TSB-16-A	Assignment of access overload classes	Ballot

TSB-39-A	Message type assignment for extended protocol (analog, TDMA and CDMA standards)	Published 10/94
TSB-70-A	Updated version of TSB-70 cross reference	Published 09/99
TSB-71	IS-94 enhancements and issues	Published 10/95

Fourth Generation: Advanced Capabilities

Standard	Project	Description	Status
TIA/EIA-691	SP-3665	Enhanced analog ANSI version of IS-91-A (w/o Wireless Residential Extension)	Published 11/99
IS-91-A	PN-3476	Revised IS-91 air interface (including IS-94 functionality and sleep mode)	Published 11/99
IS-91-B	SP-3666	Revised version of IS-91 (including IMSI, OTA, priority access, 911, cryptosync and Expanded ESN)	Project cancelled
IS-713	PN-3668	1900 MHz upbanded AMPS (based on IS-91-A)	Published 11/99
IS-788	PN-4205	Portable wireless phone to vehicle interface - Connector	Published 06/99
IS-788-A	PN-4660	IS-788 including IDB (ITS Data Bus)	In press
IS-789	PN-4207	Portable wireless phone to vehicle interface - Electrical Interface	Published 07/99
IS-789-A	PN-4629	Modification to IS-789 to support SAE J2366 ITS Data Bus (IDB)	Published 04/00
IS-790	PN-4208	Portable wireless phone to vehicle interface - Latch	Published 03/00
IS-791	PN-4209	Portable wireless phone to vehicle interface - Test Specifications	Project cancelled
IS-798	PN-4527	Portable wireless phone to vehicle interface: Mounting Envelope	In press
IS-816	PN-4630	IDB message set definition for IS-789	In press
IS-817	PN-4662	Geo-location for analog cellular phones	In press
IS-817-1	PN-4862	Geo-location for analog cellular phones, Addendum 1	Development
IS-822	SP-4560	"+" (Plus Code) dialing for international calling from analog cellular phones and Enhanced 911	Development
IS-xxx	PN-4204	Portable wireless phone to vehicle interface - Architecture	Project cancelled
TSB-119	PN-4559	"Intelligent Retry" for improved access to emergency calling (formerly scheduled to be IS-821)	In press
TSB-121	PN-4558	Interface between wireless phone and Telephony Device for the Deaf (TDD) - 2.5 mm jack	Ballot 01/01
	PN-4373	Analog Air Interface Support of Expanded ESN (56 bit ESNX)	On hold
	PN-4375	Analog Air Interface Support of International Mobile Station Identity (IMSI)	Project cancelled