other applicants for that spectrum,[46] or, if strictly applied among those willing to conform to the coding and power limitations, it would compromise the maximum capacity of each individual system sharing the band to the point where the already high cost systems would become prohibitively more expensive.

Under the present L/S-Band RDSS-type of spectrum sharing multiple entry by the several pending applicants, all forced to operate at reduced power and thus at less than full capacity, is certain only to increase the effective cost per circuit for each system, increase the ultimate price to the end user, and possibly jeopardize the viability of one or more of the competing applicants. In effect, the Commission would struggle with trading a reduction in the maximum total capacity theoretically available using the allocated bandwidth in favor of licensing two, three or even four different licensee/providers -- all at high cost, and no one of which would have enough capacity to offer a sufficiently low cost, high volume service to meet the emerging needs of the latter half of this decade, let alone of the early twenty-first century.

CELSAT submits that the following proposal would both satisfy the Commission's duty to get the most out of the scarce spectrum resource, while also balancing the public interest goals of meeting user needs through a competitive alternative where feasible.

CELSAT proposes that the Commission acknowledge the tremendous space segment capacity, lower cost, and superior spectral efficiency attainable under HPCN, and then adopt the one

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[46] E.g., Motorola's IRIDIUM system.

licensee per HPCN allocation approach urged above. It should the encourage the HPCN licensees to offer rights to transponder capacity on HPCN satellites on an Indefeasible Right-of-Use or IRU-like basis to other qualified providers.[47] The IRU-holders would, of course, receive the same nationwide coverage and the benefits of all the functionalities inherent to the HPCN system, plus any additional ones they might choose to design into it and offer (provided that they remain technically compatible).[48] In other words, there should be one satellite system constructed and operated in the new HPCN band, but once launched, a predetermined amount of digital capacity on that system could be permanently and

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[47] An Indefeasible Right of Use, or IRU is an established industry convention for defining structured joint relationships in common facilities by multiple parties. It is used particularly in the context of international cable or satellite communications facilities. Historically, an IRU interest usually related to a specific or even discretely identifiable portion of the facility, such as a designated transponder on the satellite. However, it can also refer to a specific unit of capacity, appropriate to the medium or facility involved including undersea fiber cable. For purposes of **CELSAT**'s proposal, "IRU-like" is intended to refer to the transfer of all rights of use to a discrete amount of usable satellite system capacity, to be expressed in units most relevant to the digital nature of the system technology.

For purposes of simplifying the discussion of the concept, the petition expresses IRU capacity in terms of equivalent VG circuits (e.g., 18% of 60,900 total circuits or about 10,000 VG IRU circuits.) Ultimately, however, and in the interest of assuring that the IRU-holder has maximum flexibility to use the available capacity and digital bandwidth to its fullest capacity, the IRU-like allotment might be more appropriately expressed in other suitable and measurable units, such as some of the power capacity.

[48] For many of the same reasons dictating that there must be only one HPCN licensee, **CELSAT** cannot suggest that corresponding capacity on the ground-segment system be offered on an IRU-like basis. The reasons are primarily technical and also have to do with the more limited individual capacity of each ground cell vis-a-vis the comparatively larger capacity of the space-cells and space-segment as a whole.

However, inasmuch as spread spectrum CDMA compatibility and power control will be inherent and common to the personal/mobile terminals of both the HPCN and the IRU-holder subscribers, the latter users will enjoy full access to the ground segment services offered over the HPCN, and vice-versa. Thus, details of potential overlapping service use by the different groups of customers will simply have to be worked out through common billing/revenue sharing agreements, etc.

unconditionally surrendered to the IRU purchaser(s) for whatever compatible services they choose and are licensed to offer.

On the surface this proposal resembles the consortium approach which the Commission adopted in the context of the AMSC MSS Licensing Order, Id., but only to the extent that it proposes a single licensee and that multiple parties might, in effect, become involved in pooling resources to construct and launch the satellites. But in significant respects **CELSAT**'s proposed "pseudo sharing" is both a different and improved approach.

First, under the IRU-like scheme, the other "participants" will not be constrained artificially to offer the same services, or serve the same geographic or end-user markets as the master HPCN licensee offers. An IRU-holder might choose, for example, to sell exclusively to the public safety market sector, or specialize in only compressed video applications. In contrast, the AMSC consortium solution served only the interests of the consortium members in that, while they all now get to participate in the market for mobile satellite services, the consortium approach abandoned both competition and service diversity. **CELSAT**'s approach still offers both.

Second, **CELSAT** believes that it is important that the HPCN satellite licensee have considerable latitude ultimately to determine such matters as whether, and if so, how much and for what price IRU capacity should be offered to others. The Commission, however, should retain ultimate control over the IRU-holder(s) by:

> (1) prescreening IRU candidates before they purchase IRU capacity, such as by requiring the filing and approval of Form 430-type information;

(2) licensing IRU-holders as separate mixed-use MSS/RDSS service providers;[49] and

(3) imposing whatever conditions or other common carrier requirements deemed necessary.

With certain necessary technical and operations-based exceptions to be established by the HPCN licensee, licensed IRU-holders would neither be constrained by nor accountable to the HPCN licensee, but would have relatively free and unfettered use of the IRU capacity that they purchased.

E. Other Miscellaneous Rule Provisions and Policies

In general, in addition to the relatively specific rules and new policies proposed above, **CELSAT** expects that the Commission will choose to apply the applicable provisions of Part 25, Satellite Communications, and the positions reflected in its more recent and contemporary orders addressing these and other related mobile satellite provisions and policies. Also, it is to be expected that relevant provisions and policies adopted in the context of general Public Mobile Services and reflected in Part 22 of the Commission's rules should also be made applicable. **CELSAT** proposes that the identification of specific subparts and sections from other established rules of the Commission should be left to general comment and reply process once the rule making proceeding is established.

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[49] As discussed above, because it will not be technically feasible similarly to share the ground-cell subbands, IRU-holder(s) will be limited to providing predominately space-based services over the space-cell capacity. However, because the terminals used by their end users will CDMA and frequency compatible, such customers of IRU-services will also be able to use the ground-based services offered by the HPCN licensee. Again, details of compensation, billing, arrangements, etc., will have to be worked out between the HPCN licensee and the IRU-holder(s).

As for the licensing procedure, although **CELSAT** has applied contemporaneously for a Pioneers Preference for an HPCN license, in general applicant's for an HPCN licensee should be determined on the basis of the current comparative hearing process.

CONCLUSION

For the foregoing reasons, **CELSAT** respectfully asks the Commission to institute a rule making to do the following:

- Allocate at least one of either Band A or Band B for use with a *hybrid personal communications network* on an exclusive and primary basis;
- Adopt a policy of awarding an HPCN license on a nationwide basis to no more than one operator per HPCN allocation;
- Adopt guidelines for defining an HPCN along the lines proposed herein;
- Adopt a rule permitting a liberal, relatively unconstrained variety of personal/mobile digital voice, data, video, position determination and other services to be offered over HPCN systems;
- Adopt a policy and related rules which would permit an HPCN licensee to sell outright, on an IRU-like basis, usable capacity on the HPCN space-components for compatible MSS/RDSS services;
- Adopt a relaxation of the relevant satellite PFD limits by at least 6 dB; and
- Adopt such other rules and policies necessary to the processes of HPCN authorization, deployment, operation, service provisioning, and termination of such HPCN systems and services.
- Reopen the RDSs L/S-Band for receipt of additional applications of the HPCN design.

Alternatively, the Commission should amend its Notice of Proposed Rulemaking relative to the proceedings underway in RMs - 7771. -7773, - 7805, and -7806 to expand its scope to include the above matters, and reopen the proceedings for further comment.

Respectfully submitted,
CELSAT, INC.

By: _____
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CELSAT's Attorney

February 6, 1992

EXHIBIT -- 1

The washington Post

BUSINESS

BY FRANK JOHNSTON—THE WASHINGTON POST

Real estate agent T.J. Murphy talks to a client on his cellular phone while his pager goes off. Both products are results of increased industry competition.

Phone Firms Propelled Into Future

10 Years After the Bell Breakup Order, Competition Fuels Technology Boom

WHAT"S WRONG WITH THIS PICTURE?

EXHIBIT -- 2

EXHIBIT 2

PROPOSED AMENDMENTS TO PARTS 2, 22, & 25 OF THE COMMISSION'S RULES

CELSAT proposes the following amendments, modifications and other changes to Parts 2, and 25 of the Commission's Rules. Additional changes to Part 22, Public Mobile Services, might be required for purposes of the *HYBRID COMMUNICATIONS NETWORK SERVICES* proposed herein, but **CELSAT** is not, at this time, recommending any specific changes to provisions in Part 22.

AMENDMENTS TO PART 2, FREQUENCY ALLOCATIONS, ETC.

The Commission should amend Part 2, Section 2.106, Table of Frequency Allocations, as follows:

For United States Table, Non-Government Use, modify at least one or the other allocation (Band A or Band B), to allow these frequency pairs to be used for "*Hybrid Personal Communications Networks (HPCN)*" on an exclusive, primary basis:

- Band A -- 2,110 to 2,129 MHz and 2,410 to 2428 MHZ
- Band B -- 1,610 to 1,625.5 MHz and 2,483.5 to 2500 MHz

Similarly, amend this table to permit the use of the bands at 19.7-20.2 GHz and 29.5-30.0 GHz for Mobile Satellite (HPCN) on a co-primary basis.'

With respect to Band A, above, the Commission should, alternatively, adopt the modifications to the Table of

Frequencies for 2110-2200 MHz and 2390-2450 MHz as being proposed by the U.S. Delegation at WARC 92, in its entirety, including the proposed changes to all footnotes as shown in the attachments EXH. A-1, A-2 and A-3 hereto. Moreover, the Commission should adopt these changes for domestic purposes irrespective of the outcome of the U.S. Delegation's efforts at WARC 92.

Finally, footnotes US 306, and NG 147 should be modified to reflect a reference to HPCN.

AMENDMENTS TO PART 25, SATELLITE COMMUNICATIONS:

Subpart A, Section 25.103 *Definitions.*

This subpart should be amended to include the following new definitions:

Definition:

Hybrid Personal Communications Network. The term Hybrid Personal Communications Network ("HPCN") refers to an integrated combination of high capacity, very spectrally efficient (at least 1000 5 kbps space channels/MHz) space- and ground-cellular systems capable of:

a. Satellite personal/mobile communications and position determination service coverage over the continental United States

b. Ground cellular personal/mobile and position determination service coverage within space cells

c. Space/ground communications in compatible spread spectrum CDMA format with forward error correction (FEC) encoding

d. Transparent and integrated transfer of communications from cell-to-cell and between space/ground-cell types

e. A wide range of personal/mobile digital communications and position determination services, including high speed bit rates

f. Such communications capability must be able to

g. Dynamically redistributing portions of the subbands within of the allocated spectrum and other resources alternately between space and ground segments as needed to accommodate changing load and service requirements.

Definition:

Hybrid Personal Communications Network Services. Permitted HPCN services include any digital one-way or two-way communications of voice, data, video, image or position determination information originated or terminated over a hybrid personal communications network to or from either a portable, mobile, or special-purpose fixed terminal or transceiver operated at low power with unswitched low gain antenna for either point-to-point or point-to-multipoint personal, business, commercial or public safety purposes over land, air or water.

Power Flux Density Limits:

RR 2556 and 2557 in Appendix 28 of the Radio Regulations, as applied to HPCn, should be changed to allow new permitted flux density limits (d) in any 4-kHz band to conforming to the following expressions and at the following arrival angles:

-148 + 0.5(d-5) dBW/sq-m/4-kHz for d between 5 and 25 degrees;

-138 dBW/sq-m/4-kHz for d between 25 and 90 degrees.

Subpart B: Licensing Provisions

Section 25.141 (a) should be amended to permit the licensing of *Hybrid Personal Communications Network* systems meeting the definition proposed above. Such licenses should be considered on a one per HPCN band pair allocation, and extend nationwide. Mutually exclusive applications should be evaluated and an exclusive license granted on the basis of the Commission's comparative hearing process. Section 25.141 (d), *Permissible Communications*, should be amended to allow for the provision of

services of the type defined above. Section 25.141(f) should be amended to reflect the use of HPCN band pair allocations on an exclusive, primary use basis nationwide.

* * * * *

RECOMMENDED U.S. PROPOSALS

MHz
2110 - 2120

	Region 1	Region 2	Region 3
MOD	~~1710~~ 2110 - ~~2290~~ 2120	~~1710~~ 2110 - ~~2290~~ 2120	
	FIXED MOBILE-SATELLITE (Space-to-Earth) SPACE RESEARCH (Earth-to-space) (Deep Space) Mobile	FIXED MOBILE-SATELLITE (Space-to-Earth) MOBILE SPACE RESEARCH (Earth-to-space) (Deep Space)	
	~~722~~ 743A ~~744~~ ~~746~~ ~~747~~ ~~748~~ ~~750~~	~~722~~ ~~744~~ ~~745~~ ~~746~~ ~~747~~ ~~748~~ ~~749~~ ~~750~~	

SUP 748

SUP 749

Reason:

1. To provide additional allocations for the mobile-satellite service to permit flexibility to provide for the developing requirements for this service. To elevate the space research, space operation, and earth exploration-satellite service to primary status to facilitate the coordination of these services.

2. Deletion of footnotes 722, 744, 745, and 746; and the suppression of footnotes 747, 748, 749, and 750 in the various bands is a consequence of the primary allocation to the space research, space operation, and earth exploration-satellite services under the new proposed band limits. The time period for RR 749 has expired.

RECOMMENDED U.S. PROPOSALS

MHz
2120 - 2200

	Allocation to Services		
	Region 1	Region 2	Region 3
MOD	~~1710~~ 2120 - ~~2290~~ 2130 FIXED Mobile MOBILE-SATELLITE (space-to-Earth) ~~722~~ 743A ~~744~~ ~~746~~ ~~747~~ ~~748~~ ~~750~~	~~1710~~ 2120 - ~~2290~~ 2130 FIXED MOBILE MOBILE-SATELLITE (space-to-Earth) ~~722~~ ~~744~~ ~~745~~ ~~746~~ ~~747~~ ~~748~~ ~~749~~ ~~750~~	
MOD	~~1710~~ 2130 - ~~2290~~ 2160 FIXED Mobile ~~722~~ 743A ~~744~~ ~~746~~ ~~747~~ ~~748~~ ~~750~~	~~1710~~ 2130 - ~~2290~~ 2160 FIXED MOBILE ~~722~~ ~~744~~ ~~745~~ ~~746~~ ~~747~~ ~~748~~ ~~749~~ ~~750~~	
MOD	~~1710~~ 2160 - ~~2290~~ 2180 FIXED Mobile MOBILE-SATELLITE (space-to-Earth) ~~722~~ 743A ~~744~~ ~~746~~ ~~747~~ ~~748~~ ~~750~~	~~1710~~ 2160 - ~~2290~~ 2180 FIXED MOBILE MOBILE-SATELLITE (space-to-Earth) ~~744~~ ~~745~~ ~~746~~ ~~747~~ ~~748~~ ~~750~~	
MOD	~~1710~~ 2180 - ~~2290~~ 2200 FIXED Mobile ~~722~~ 743A ~~744~~ ~~746~~ ~~747~~ ~~748~~ ~~750~~	~~1710~~ 2180 - ~~2290~~ 2200 FIXED MOBILE ~~722~~ ~~744~~ ~~745~~ ~~746~~ ~~747~~ ~~748~~ ~~749~~ ~~750~~	

Reason:

To provide additional allocations for the mobile-satellite service.

MHz
2390 - 2450

	Allocation to Services		
	Region 1	Region 2	Region 3
MOD	~~2300~~ 2390 - ~~2450~~ 2430 Fixed 752A ~~FIXED~~ Amateur Mobile Radiolocation MOBILE-SATELLITE (Earth-to-space) 664 743A 752	~~2300~~ 2390 - ~~2450~~ 2430 Fixed 752A ~~FIXED~~ Mobile 752C ~~MOBILE~~ ~~RADIOLOCATION~~ Radiolocation 752B Amateur MOBILE-SATELLITE (Earth-to-space) 664 ~~751~~ 752	
	~~2300~~ 2430 - 2450 FIXED Amateur Mobile Radiolocation 664 743A 752	~~2300~~ 2430 - 2450 FIXED MOBILE RADIOLOCATION Amateur 664 MOD 751 752	

ADD 752A The fixed service may continue to operate in a specific service area in the band 2390 - 2430 MHz on a primary basis until 1 January 1997 or until a mobile-satellite service (Earth-to-space) has been brought into use in such a manner as to affect or be affected by the fixed service in that service area, whichever is later.

ADD 752B The radiolocation service may continue to operate in a specific service area in the band 2390 - 2430 MHz on a primary basis until 1 January 1997 or until a mobile-satellite service (Earth-to-space) has been brought into use in such a manner as to affect or be affected by the radiolocation service in that service area, whichever is later.

ADD 752C The mobile service may continue to operate in a specific service area in the band 2390 - 2430 MHz on a primary basis until 1 January 1997 or until a mobile-satellite service (Earth-to-space) has been brought into use in such a manner as to affect or be affected by the mobile service in that service area, whichever is later.

Reason:

These proposals are to provide allocations for the mobile-satellite service (Earth-to-space). These allocations will permit flexibility to provide for the developing requirements for this service.

APPENDIX -- A

APPENDIX A

CELSTAR SYSTEM OVERVIEW

The following is a brief overview of some of the relevant CELSTAR HPCN technical considerations. These are not intended to be thorough or complete in any respect. For more information one should refer to the additional Appendices B-E to this Petition for Rulemaking, as well as **CELSAT's** HPCN application.

CELSTAR HYBRID CONCEPT

The **CELSTAR** system is designed to set a new standard of service, cost effectiveness, and spectral efficiency in the mobile satellite service. The system will provide full 100% geographic coverage (voice, data, picture, compressed video and position location) for mobile and PCN users anywhere within the contiguous United States, covering rural as well as metropolitan areas. Full communications coverage without position determination will also be available in Hawaii, Alaska, and the Virgin Islands. The concept promises significant spectrum management advances in terms of maximum spectral utilization efficiency as well as minimum interference generation and susceptibility.

The key to the ability to provide this range of service and economy is a satellite system architecture which is fully complementary to and integrated with a new ground based cellular system. Together they form a fully compatible, complementary hybrid space/ground cellular network seamlessly operating in the same frequency band. The basic modulation and multiple access protocol of the **CELSTAR** system is designed to fit exactly the emerging standards of the CDMA ground cellular system, but it will operate in a new frequency band. High density metropolitan areas will thus be served mostly by **CELSTAR**'s ground based cellular nodes, architecturally similar to present practice. Rural areas, where ground cellular service is not economical, will be served in the **CELSTAR** system by a network of "super-cells" defined by the ground footprints of a high gain, multi feed satellite. Both

utilize the same basic user handheld "shirt pocket" unit. Making full use of today's state-of-the-art in very large satellite multi-beam antenna design technology, such super cells are ellipses with dimensions that vary with the satellite/ground geometry and with carrier frequency. The axes of such ellipses are typically on the order of 200 x 400 miles and the entire US is covered with an array in excess of 100 such satellite super-cells operating in either the S-Band or L/S-Band.

CELSAT is specifically requesting a license to operate in either (but not both) of the following frequency bands:

Band A: 2.10 GHz to 2.129 GHz and 2.428 GHz

Band B: 1.611 GHz to 1.625 GHz and 2.4835 GHz to 2.500 GHz

If the Commission makes an allocation in Band A, there will be 112 satellite cells; if in Band B, 149 satellite cells.

The overall **CELSTAR** HPCN system consists of the following parts

<u>User Element</u>

User Antenna

Near Omnidirectional

User transponder

Common, SS CDMA Waveform;
Advanced voice digital Coding/Decoding technology;
Forward Error Correction Coding/Decoding;
2-Way, rx signal-sensing, tx power level control;
Flexible support for other variable rate data services;
Position determination and presentation.

<u>Ground Element</u>

Ground nodes (cell-sites)

Existing cellular telephone technology transposed to requested carrier frequency bands, plus Spread Spectrum CDMA waveform and addressing, and advanced digital voice encoding and FEC.

Multilateration position determination.

Satellite Element

- Satellite
  - Geosynchronous orbit
  - State-of-the-art large (20 meter diameter) UHF, multi-beam, imaging antenna
  - Extraordinary circuit capacity by virtue of high antenna power gain and large frequency reuse factor
  - Multiple (20) K-Band backhaul links
  - 2-Way, signal-sensing tx power level control
  - Multilateration position determination
- Satellite hubs
  - Ground entry points to the PSTN or other network.

Network Control

- Maintain log of each subscriber's current call(s) address(s), and location.
- Coordinates optimal allocation between ground and satellite resources.
- Coordinates transitions between cells, whether satellite ground or mixed. Coordinates ground/satellite resources and relays radio position determination requests.

A key objective of the design is to build toward the ultimate capability of transparent, effortless transition between ground and satellite relay resources as a user roams freely between areas covered by both ground and satellite nodes, and areas covered only by satellite nodes.

GENERAL SATELLITE ELEMENT

The satellite operates at geosynchronous orbit. The mobile link UHF satellite antenna is an imaging feed antenna, that is the feed plane structure is in the image plane of the antenna and comprises an (diffraction limited) image of the ground coverage area, such as the United States (See Figures 1 and 2). The individual feed elements will consist of either isolated (e.g. cupped, half-wave or shorter) dipoles or crossed feeds depending on further testing.

The individual beam footprints of the state-of-the-art large, mobile link, multi-beam imaging antenna define a multiplicity (112 in Band A or 149 in Band B) of satellite cells on

the surface of the coverage area. Within each cell and between cells, all satellite link users use the same band for transmitting and a second band for receiving. The antenna pattern is such that this results in an effective total interference level from all users outside of any given cell of about 1.8 times that from the users of the same cell alone.

The satellite to ground hub or "backhaul" links are frequency multiplexed, with as many as 10 satellite cells served by a single backhaul link and ground station. This makes possible a flexible tradeoff between the number of ground stations to be built and distance and cost of regional landline circuits. The satellite backhaul (K-Band) antenna have significantly wider beams than those serving the critical UHF mobile links. Therefore, the satellite backhaul radiation is in effect "broadcast" over all the 10 cells comprising a "backhaul cluster". Thus, with the same backhaul broadcast one can serve one ground station or many throughout the service area of the "backhaul cluster". The preference will vary from locality to locality, depending on local landline economics.

Generally, the multiple (10 or less) cells served by a single backhaul link will be contiguous, forming a "backhaul cluster". However, it is also possible, at modest K-Band RF power cost, to provide special metropolitan multiplexes that serve a number of discontiguous metropolitan areas. Thus for example, it is possible to tie New York, Los Angeles, Chicago, Houston, Philadelphia, etc. together on a single metropolitan bus. The primary mobile service for these areas would be from the much smaller ground cells and nodes. Optionally, however, the CELSAT user in Los Angeles could select satellite links (by his/her dialed prefix code) for direct (via satellite) connection to, say, a New York destination, bypassing long distance landline charges. It is envisioned that only one such "metropolitan bus" would be provided.

TRANSCEIVER

A typical a voice signal can be traced inbound from a mobile user through the various processing stages in Figure 3 to the

designated ground hub (The process of placing, designating and initiating the call will be dealt with later.)

The analog voice waveform is first encoded using a state-of-the-art voice vector encoding algorithm. As discussed above, the numerical examples will be based upon 4.8 kbps CELP encoding which is expected to be practical in ASIC well within four years. Initial implementation prior to such time will use 8 kbps. It is one of the very important features of SS-CDMA, however, that the long term impact of such an interim design change is minimal. Whenever improved voice encoder performance becomes available it can be incorporated compatibly into the SS-CDMA multiplex, alongside the older standard, without sudden obsolescence of the older user units. The more favorable call rate economics may then be expected to encourage a gradual obsolescence or upgrading of the less efficient older user units. The ensuing capacity and power budget analysis are computed for the 4.8 kbps encoding.

The 4800 bps digital voice bit stream is digitally multiplexed with a 200 bps order wire and control functional data stream. These data are used for supervisory and power control. The resulting 5000 bps composite baseband is then FEC (Forward Error Correction) encoded.

The baseline for the present design calculations is convolutional, rate 1/3, K=7 encoding, with Viterbi 3-bit soft-decision decoding. This can be implemented in multi-sourced, single chip, off-the-shelf Application Specific Integrated Circuitry ("ASIP"), which also includes full duplex interleaver/scrambler/descrambler, error rate monitoring, and phase and bit synchronization. Error rate performance is 1 in 105 bit errors at Eb/No = 4.0 dB. It is anticipated that this field will also expand in the next two years, particularly in the direction of low-rate coding. This is particularly applicable to the present CDMA approach since as discussed above, unlike FDMA or TDMA systems, the additional coding gain may be achieved with no loss of processing gain or channel capacity. Consequently the baseline coding is regarded as a conservative place-holder with high

probability of further coding gains becoming practical within the next two years.

The signal is next spread spectrum modulated according to the unique transmit PRN sequence assigned to the particular subscriber. Taking account of time-shift options, the period of the basic PRN spreading code is long enough that there are an effectively unlimited number of such codes so they may be permanently assigned and serve as unique access keys for each subscriber mobile unit. In order to take advantage of time-shift address coding in this way, the user must have a fairly accurate time base. This is accomplished by requiring each user initially to synchronize to a pilot time reference broadcast from each ground and satellite node. With transit time delay compensation this initial course synch system will provide absolute time at the user within about 2 msec, independent of user position within any given satellite cell. The PRN sequence will be at a maximum chip frequency consistent with the location assignment, typically, 1 to 1.3 Mbps in the baseline design.

The individual spread signal is now amplified by a variable gain amplifier to a level calculated in the power control unit to return a fixed signal level to the ground hub. This calculation is based upon the observed received signal level as an indicator of the current path loss. If the path level variations were static, this would result in effectively perfect compensation. For dynamic variations which occur primarily in the vicinity of the mobile, such as going behind a tree or building, the downcoming path perturbation information is generally less than a microsecond (1000 feet) late when it reaches the mobile receiver, and may be another microsecond late by the time the precompensated signal reencounters the obstruction on the return path to the hub. So for the inbound (mobile-to-hub path, very fast -- almost perfect -- path compensation is achieved. For the outbound (hub-to-mobile) path on the other hand, the sensing signal is 1/4 second late by the time it arrives at the ground hub and another 1/4 second late by the time the pre-compensated signal reencounters the obstruction near

the mobile on the outbound path. Thus, for the outbound path (hub-to-mobile) it is only the slow path variation components, less than about 1 Hz, that are effectively compensated by this system.

Finally, the spread-Spectrum signal is fed to the omnidirectional mobile antenna and radiated to the satellite.

SATELLITE

The satellite operates at geosynchronous orbit. The mobile link UHF satellite antenna is an imaging feed antenna; that is, the feed plane structure is in the image plane of the antenna and comprises an (diffraction limited) image of the ground coverage area. See Figure 2. The individual feed elements may consist of isolated, e.g. cupped, half-wave or shorter dipoles or cross feeds.

The satellite transponder consists of a multiplicity of full-duplex, linear, non-processing constant-gain, frequency translating, bent-pipe repeaters. One such repeater is assigned to each backhaul multiplex group (up to 15 such repeaters). provision is incorporated for switch-in standby spares. Each cell's composite uplink signal uses the same frequency allocation. The transponder structure is modularized to provide a flexible trunking structure. The signals from all the N, ($N \leq 10$), satellite cells within a "cluster" are frequency multiplexed into a single composite K-Band backhaul signal occupying N times the bandwidth of an individual UHF mobile link channel. The composite signal is then split into M parts, amplified, and beamed to satellite hubs in M ($M \leq N$), of the cluster cells. This general configuration supports a number of particular configurations which may be best adapted depending on regional landline long distance rate structure, frequency allocation, subscriber population, and other factors. Thus, for a low density rural area one may utilize an N-to-1 ($N=1$, $M=1$) cluster configuration of M contiguous cells served by a single common satellite ground node with N limited by available bandwidth. A megalopolitan, largely suburban cell with near capacity subscription but not served by ground cellular nodes might call for

such a 1-to-1 configuration (M=N=1). In order to provide high-value long distance service between metropolitan areas, already or best covered for local calling by ground cellular technology, an N-to-N configuration would provide an "inter-metropolitan bus" which would tie together all occupants of such N satellite cells as if in a single local calling region.

GROUND HUB

The ground hub consists of a number of independently assigned and operating linear transceivers just like that at the mobile. One of these is assigned to each active mobile link. The demodulating and deprocessing operations follow on a one-to-one inverse basis the corresponding processing and modulation operations described for the transceiver.

CELSTAR's USE OF CDMA

Key to several of the advances in the proposed system is the use of Spread Spectrum Code-Division-Multiple-Access (SS CDMA).

In a Frequency Division Multiple Access (FDMA) cellular system, as under the present standard, there is a minimum cluster size, N, required to insure sufficient geometrical separation between co-channel users to avoid unacceptable co-channel interference. This cluster size ranges typically from 7 to 14 or more cells depending on propagation topography. The significance of this from a spectral utilization efficiency stand point is that for a given total system allocation bandwidth, the bandwidth that can be used in any one cell, and therefore the number of channels that can be accommodated in a cell, is inversely proportional to N. For example, with N=7, only one seventh of the total system allocation bandwidth can be utilized in each cell.

By contrast, in the **CELSTAR** SS CDMA system the actual cluster number is 1; i.e., each cell uses the full channel bandwidth. Other users in or near the same cell interfere, but not fatally as would be the case in a FDMA system. Rather, the total received power of all such co-band users interferes as random noise,