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by

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ABSTRACT This article discusses the development process associated with mobile communications. Through a comparison of ground mobile communications and satellite mobile communications, it points out the necessity of developing satellite mobile communications. Through a comparison of synchronous orbit and low orbit mobile communications and a comparison of single beams and multiple beams, a course of development is put forward for satellite mobile communications suited to China's actual economic strength and satellite technology level. Besides participating in a pan national satellite mobile communications system to resolve partial international mobile communications, we should go down the path of developing synchronous orbit, multiple beam satellite mobile communications.

SUBJECT TERMS Mobile service satellite communications Analysis China

1 INTRODUCTION

Satellite mobile communications is a very rich and attractive new field in satellite communications. It will open up a new era in globel personal communications. In conjunction with this, it very, very greatly promotes the development of society's "informationizing". It possesses important significance with regard to such developments as economic and military. In conjuction with this, it possesses very high commercial value. As a result, it is drawing serious attention from a good number of nations day by day. One after the other, development plans are drawn up and companies are set up to carry out technological development. An international competitive upsurge is just in the midst of appearing. This article compares ground mobile communications and satellite mobile communications. It compares synchronous satellites and nonsynchronous satellites. In conjunction with that, it carries out a comprehensive analysis with regard to the use of new technologies associated with satellite mobile communications, probing into routes and directions associated with China's satellite mobile communications development.

2 DEVELOPMENT AND COMPARISON OF SATELLITE MOBILE COMMUNICATIONS AND GROUND MOBILE COMMUNICAITONS

2.1 Development of Ground Mobile Communications

In the 1970's, Bell Telephone Laboratories put forward the concept and theory associated with cellular systems. In 1979, on the basis of this theory, AMPS (ADVANCDE MOBILE PHONE SYSTEM) service was implemented as well as comprehensive testing of system performance. In conjunction with this, it was put into commercial use.

The initial steps in China's mobile communications were relatively late. In the early 1980's, China designed its own small capacity 8 frequency channel public mobile telephone system. It began to be put into use in Shanghai. Such large cities as Beijing, Guangzhou, Shanghai, and so on, are just in the midst of turning their hands to the construction and use of cellular type public mobile communications networks associated with program controled switching technology and microprocessor control. Moreover, public wireless paging service began in the early 1980's and developed rapidly after that.

2.2 Development of Satellite Mobile Communications Systems

Satellite mobile communications systems refer to moving objects, such as vehicles, ships, aircraft, individual people, and so on, making use of satellites to carry out communications services. It is an extremely lively realm of newly developed satellite communications. The development of it will open up a new era in global personal communications. /25

As far as making use of geostationary satellites to carry out mobile communications is concerned, first uses were made for military purposes. In the 1970's, it expanded into civilian uses. The international maritime satellite organization set up the world's first global mobile communications satellite system. In conjunction with this, it developed toward land and air mobile communications service.

In the last few years, a number of companies in the world have put forward, one after the other, the utilizing of low orbit satellite groups to organize networks, realizing satellite mobile communications systems with global coverage. Frequency bands for which option is made for usage are UHF and L frequency bands.

2.3 Fiber Optic Communications

In the last few years, the development of fiber optic communications has been extremely fast. In large and medium cities as well as regions of population concentrations, fiber optic communications add regional mobile communications, causing the quality of communications, capacity, and sensitivity to all achieve extremely large increases. However, in such frontier regions as mines, forest areas, and so on, there are geographical limitations in all cases, and there is no way to lay fiber optics or, from the angle of economics, it is considered not to be appropriate to lay fiber optics, and cellular network areas are set up. At the present time, mobile communications have still not been decided on.

2.4 Comparison of Satellite Mobile Communications and Ground Mobile Communications

Ground public mobile communications which have developed relatively fast are cellular telephones and call forwarding devices. Due to the fact that there are limits on the effective ranges of mobile subscriber transmission stations (circles of 5-15km radius), in order to cover subscriber wandering areas, it is necessary to set up enormous relay networks. As a result, investment costs are large. Monthly rental fees are high. It is only possible to concentrate on large cities or busy areas on the two sides of highways. It is not possible to resolve the problems of mobile communications in the whole country or the whole world. This is particularly the case in China's border regions. It is difficult to spread cellular telephones to large farming villages or even medium and small cities. Due to the fact that communications ranges are broad, satellite mobile communications are the optimum choice for resolving pan national and even global mobile communications. The initial investment may be comparatively large. The decisive factor is the number of subscribers. Following along with improvements in satellite technology, batches of subscriber devices will grow, in the end, lowering user initial installation costs and monthly rental fees, thus entering into a positive cycle. A comparison of satellite and ground mobile communications is shown in Table 1.

Table 1 Comparison of Satellite Mobile Communications and Ground Mobile Communications

Catagory	Satellite Mobile Communications	Ground Mobile Communications
Communications Range	Long	Short
Coverage Range	A Nation, A Region, Even Up to Global	Local Region
Frequency Band	UHF, Ku, Ka, L	SW, L, UHF
Frequency Complex Utilization Rate	High	High
Communications Capacity	Large	Large
Communications Quality	Good	Good (Somewhat Worse Than the Quality Making Use of Short Wave)
For Communications in Regions Undeveloped Economically and in Communications	Effective	Ineffective
One Time Investment (Covering the Whole Country or the Whole World)	Large	Even Larger
Level of Universality	In Development and Application Phase	Comparatively Universal in Large and Medium Cities
Ease of Connection to Ordinary Telephone Networks	Easy	Easy

2.5 Relationships Linking Satellite Mobile Communication and Satellite Navigation and Positioning Technology

Mobile communications and navigational positioning are primarily services for mobile users. Navigation is mobile users acquiring their own position and speed information from navigation systems, guiding their own courses. Positioning, by contrast, is letting a third party know the mobile subscriber's position. In/26 this type of situation, mobile subscribers who possess navigation systems, need to have mobile communications working together. When mobile subscribers possessing inertial navigation systems require making use of difference methods in order to increase measurement precisions, mobile communications are even more indispensable. Moreover, it is generally mobile subscribers who make use of inertial navigation who always need to report status to command agencies and receive command control.

Users who need mobile communications often are also ones who require inertial navigation and positioning. Moreover, there are a number of mobile communications systems--such as, the "Iridium" system itself--which then require knowing the position coordinates associated with mobile users (even if the accuracy is rough). Only then is it possible, on the basis of positions where wandering users are located at that time, to set up call processes. As a result, with regard to users who require inertial navigation and positioning, and, at the same time, also require mobile communications--besides designs which take navigational receivers (for example, GPS/Glonass) and mobile communications user devices and connect them together at the same time--have a need to probe into the taking of precision navigation and positioning as well as mobile communications and combining them together into one system. Dual satellite positioning systems, indeed, simultaneously possess functions in these two areas. However, their designs at the present time are only capable of bidirectional transmission of brief data. They are still not able to transmit speech. This is their fly in the ointment. International civil aviation organizations have proposed making use of autonomous satellite inertial navigation and positioning systems as well as independent satellite mobile communications designs to form "Automatic Dependent Surveillance Systems". European NAVSAT designs are just in the midst of attempting to resolve this problem (both passive positioning and bidirectional communications, both the use of synchronous orbits and the use of large elliptical orbits with large angles of inclination).

3 CHARACTERISTICS OF TECHNICAL REQUIREMENTS ASSOCIATED WITH SATELLITE MOBILE COMMUNICATION USER DEVICES

Following along with ceaseless development in satellite communications technology, high frequency radiated powers which it is possible to provide on satellites have grown larger and larger. Antenna dimensions which can be supplied on satellites have also gotten larger and larger. Gains have gotten higher and higher. Moreover, as far at the development of multiple beam and satellite switching technology is concerned, it is possible to resolve very well contradictions associated with increasing antennas gains and guaranteeing adequate beam coverage ranges. In conjunction with this, it is possible to improve frequency spectrum complex utilization rates.

At the present time, satellite fixed communications, by opting for the use of international communications ground stations associated with antennas 20m or over, have already spread out to international communications. The development of VSAT technology makes antenna diameters go from around 3m (C wave band) to null points of several meters (Ku, Ka wave bands). Moreover, domestic trunk line communications also have expanded out further to communications associated with various specialized networks--farm villages and border regions sparcely served by communications channels. Their characteristics are small volume, light weight, large capacity, and low cost. It is possible to install them on the roofs of buildings. They are easily moved. They save on communications lines connecting satellite ground stations to users.

In economic terms, they make a good number of medium and large enterprises capable of reception.

Following along with further stengthening of satellite useful load capabilities, there have been further reductions in the size of user device antennas. With hemispheric wave coverage, there is no need for satellite alignment and tracking. User device volume, mass, and price have dropped to a large extent, thereby making entry into the realms of mobile communications and individual global communications even more convenient. Moreover, large increases in the numbers of users have also further lowered costs and rental fees of user devices.

3.1 Ship Borne Stations

Due to the needs of oceanic shipping for navigational safety and communications over broad ranges of ocean, it is permissible on ships to install relatively expensive meter range diameter tracking antennas. As a result, ship borne satellite mobile communications achieved development first. As far as hemispheric coverage waves associated with satellite borne low ERIP are concerned, only three to four geostationary satellites are required, and it is possible to realize global mobile communications. This the key element associated with the early success achieved by Inmarsat[1] satellite communications. In essence, it was an extremely scattered form of global mobile communications. China has over 3000 oceanic steam ships. At the present time, there are only 101 A model units of maritime satellite user stations. Following along with requirements of international maritime organizations, Chinese ocean going ships must, from now on, bring in applications of Inmarsat channels. However, there are large numbers of coastal fishing boats, passenger and cargo steamers, and inland river steamers which should, by contrast, be brought into the catagory of domestic mobile communications.

Inmarsat has aggressive tendencies toward aviation mobile communications and land mobile communications development. Miniaturized C reference stations which transmit data at code speeds of 600kbit/s suit the current satellite levels. B/M stations developed in association with second generation satellites have the ability to provide small numbers of stations which can be moved by hand, satisfying the requirements of voice communications.

However, third generation satellites increase partial beam functions. They are only capable of satisfying part of the requirements of busy regions. But, large amounts of concentrated beam coverage, by contrast, enters into the catagory of domestic mobile communications. Inmarsat's advantage rests on /27 the foundation of maritime satellite communications. It is capable of seizing the aviation and land mobile communications market ahead of time.

3.2 Airborne Stations

Committees on the future of flight of international aviation organizations propose that, from now on, aircraft navigation and communications make use of satellites for the most part. In conjunction with this, the two will be taken and combine applications to form automatic dependent surveillance systems, thus perfecting aerial traffic management functions. For the sake of the safety of civilian aviation, there is a requirement for aviation mobile communications to monopolize 1645.5 - 1656.5MHz associated with the L wave band to act as up link and down link wave bands. Minimum data rates required by aviation communications are 600bit/s. In conjunction with this, there is a requirement to be able to gradually realize voice communications.

Before the realization of aviation mobile communications satellites by various nations in the future, the optimum path is the application of the Inmarsat system. First of all, realizing low data rate communications and carrying out tests of airborne phase array antennas, antenna gains are increased to around 12dB. It is possible to realize voice communications. On the basis of analysis, as far as this type of system is concerned, even though it is a bit expensive, installed in aircraft on international routes, it is still acceptable in economic terms.

At the present time, China has over 100 civil aviation aircraft. By the year 2000, this could approximately double. On international routes, renting Inmarsat is relatively easy to realize. However, with respect to satellite communications problems associated with large numbers of domestic flight routes as well as aircraft with other uses, domestic satellite mobile communications integration should be taken into consideration.

3.3 Vehicle Borne Stations

Vehicle borne stations basically belong to satellite mobile communications associated with low speed movements. The volumes and masses which are acceptable in them, make it so that they are only able to opt for the use of nondirectional antennas and/or simple phase control array antennas. Moreover, their prices must be much lower than the prices of motor vehicles. Within large cities, cellular telephones are the main competitive opponent. However, mobile communications of a pan national scope, by contrast, cannot help but be satellite communications. The masking problems which this type of station suffers from vegetation and buildings are worthy of attention.

3.4 Hand Held Devices

This is a higher form of requirement on satellite mobile communications. User devices are only able to opt for the use of low gain nondirectional antennas. Moreover, masses can only be a few kilograms. Hand held devices belong to the realm of individual mobile communications. That they require a drop in price goes without saying. In general cases, hand held telephones must operate outdoors. This can create quite a few inconvenient situations. Hand held paging devices, by contrast, can operate indoors.

3.5 Transportable Stations and Fixed or Semifixed Stations in Regions with Few Roads

In principle, this type of station belongs to fixed satellite communications. It permits directional antenna operation. The dimensions and masses of moveable station antennas as well as user devices should be smaller than VSAT. However, compared to mobile communications, the relaxation of requirements is, by contrast, much more. Moreover, as far as areas with few roads are concerned, in principle, it is possible to make use of VSAT to realize communications tasks. As a result, this type of station should not be the primary service object associated with mobile communications. In areas where it has already been determined to realize satellite mobile communications, and mobile user equipment prices and rental fees are cheaper than VSAT, this type of user requirement can be met by mobile communications.

4 STATIONARY ORBIT AND LOW ORBIT SATELLITE MOBILE COMMUNICATION COMPARISON

Satellite mobile communications are divided into the two large categories of stationary orbit and low orbit. As far as which orbit China's mobile communications should opt for the use of is concerned, there is a need to carry out analyses and comparisions in numerous areas.

4.1 The Area of Power Transmission and Consumption /28

With respect to satellites, using power P, effective range R, and, in conjunction with that, using beam solid angle Ω radiation, the flux density Ψ which arrives at user locations on the surface of the earth (power on unit surface area) is

$$\Psi = P/(R2\ \Omega) = P/M$$

With regard to conical beams

$$\Omega=4\pi \sin^2(\theta/4) \quad (1)$$

In this, M=R2Ω is the satellite beam coverage area. θ is beam width angle.

Assuming that user antenna area is Ae and all the additional consumption is L, then, user received power S is

S=PAe/(ML)

or

P=SML/Ae

When signals are transmited to n users, overall satellite transmission power is

$$P_\Sigma=nSML/A_e=nP$$

The explanation for this is that, when the required reception signal power S is fixed and the number of users is fixed, the total transmission power which is required, 2 , and M/Ae form a direct proportion, that is, the ratio of beam coverage spherical surface area and user antenna surface area forms a direct proportion. However, there is no relationship with effective range (that is also nothing else than that there is no direct relationship with orbital altitude). If M makes use of m individual beam coverage, then, the total radiated power is also capable of dropping to be the original 1/m. However, within m beams, the total number of users is maintained invariable. At this time, the total transmission power is

$$P_\Sigma=nSML/(mA_e)=(n/m)P \quad (2)$$

It is already known that the gain of antennas on satellites is

G=4πAsη/λ2=4πη/Ω

Ω=λ2/As

or

$$D_s=2\lambda/\sqrt{\pi\Omega} \quad (3)$$

In this, λ is wave length. As is transmission antenna area on satellites. Ds diameter of antennas on satellites. η is antenna efficiency.

On the basis of the formulae described above, analyses and comparisions are carried out with regard to low orbit mobile communications systems (using the "Iridium" system [2] to act as an example) and geosynchronous satellite systems. Calculation parameters are set out in Table 2.

Table 2 Comparision of Low Orbits and Synchronous Satellite Orbits

(1) 高 度 H/km	(2) 点波束数	(M/m)/ dBm^2	L/dB	P/W	Ω/rad^2	θ/(°)	D_s/m
767.1	1	132.39	17	4.43	3.287	123.03	0.12
	37	117.54	16	0.115	0.1074	21.22	0.65
35 786	1	130.10	13	1.04	6.91×10^{-3}	5.4	2.55
	37	115.24	15	0.054	2.[illegible]59 × 10^{-4}	1.0	14
	8	121.89	15	0.25	1.045×10^{-3}	2.1	6.54

(3) 注：对各种状况

Key: (1) Altitude (2) Beam Number (3) Note: With regard to various types of configurations, S=-165.46dBW, λ = 0.187 tm, Ae = 0.00056m2 (Changing it into a decibel value, it is -22.52dBm2) .

(1) S Calculations

S is the voice signal power received. In forward error correction code (FEC), opting for the use of a constraining length of K=7, efficiency η = 3/4. During Weitebi (phonetic) decoding and soft determination, the required Eb/No = 3.6dB.

b is voice code speed. Option is made for the use of compressed voice at 4.8kbit/s. Down link transmission opts for the use of time division multichannel TDM systems. After giving consideration to encryption efficiency, data rates should be selected at 6kbit/s. When consideration is again given to demodulation on satellites and switching between beams, option is made for the use of digital speech interpolation technology (DSI). When users are not talking, data is not transmited. Average code speed can be reduced by half. Therefore, selection is made of b=3kbit/s or b=34.77dBbit/s. When user reception terminal equivalent noise temperature is T=300K, /29

$$No=KT=-203.83dBW$$

$$S=Eb/No+b+No=-165.46dBW$$

(2) Calculation of M/m

Iridium system orbital altitide is H=767.1km. Mimimum angle of elevation associated with user antenna operations is E=10°. Because the geocentric tension angle associated with disk coverage is 2α=36.96°, it is thus possible to solve for satellite beam angle θ=123.03°. The corresponding Ω=3.287rad2 . Beam edge slant range R=2297.6km. In accordance with M=R2Ω, it is possible to solve for results. M/m is calculated in accordance with beam solid angle bisection. However, consideration is given to beam congruence being 0.827 in order to facilitate making comparisions. Assuming that geosynchronous satellite coverage areas are the same as the "Iridium" system, the geocentric tension angle $2\alpha=36.96°$. Coverage area diameter is D=4110km. The center of the circle is 104°E longitude, 34°N latitude. This just covers the land portion of China. Assuming satellites to be placed in space above the equator at 104°E longitude, the satellite angle of elevation for the center of the circle is E=50.48°. As a result, the area of the coverage region is

$$M=(\pi/4D2x\sin E = 130.1dBm2)$$

(3) Calculations of Ae

Mobile subscriber antennas should possess upper hemisphere beams, $\Omega=2\pi$. Gain $G=4\pi/\Omega\approx2$. When frequencies are 1.6GHz,

$$Ae=\lambda2/\Omega\approx5.595x10-3m2$$

(4) Calculations of L

As far as feeder line losses associated with antennas on satellites are concerned, when there are single beams, they are 1dB. When there are multiple beams, they are 3dB. Low orbit satellite system operating angle of elevation E is 10°. Assuming that a medium vegetation masking margin is 12dB, synchronous satellite operating angles of elevation $E\geq27°$. There is only a need to consider medium vegetation masking margin as 8dB. Besides this--with regard to low orbit satellite systems--due to the fact that bisected beams are not advantageous to outer ring coverage, carrying out optimization design, it is possible to improve outer ring beam gains to approximately 3dB. This should be deducted in L.

(5) Calculations of P

In formula (2), assume n=1. Results clearly show that, as far as both low orbits and high orbits are concerned--when 37 beams are used--the average power which is accounted for by each speech channel on satellites roughly approaches between 0.05-0.1W. Although results for synchronous satellites have a slight advantage, the antenna diameters, however, require 14m. Beam width is 1°. Technical difficulties are increased severly. With synchronous satellites adjusted for the use of eight beams, each speech channel requires a power of 0.25W. Antenna diameter is 6.54m. Beam width is 2.1°. This is close to the paramters of the North American mobile satellite communications system (MSAT). Satellite antennas opt for the use of ground beacon tracking technology. It is possible to maintain precisions of ±0.1° (3σ).

With regard to the calculation of communications channels--in accordance with reciprocity theorems--the results described above are basically suitable for use. However, certain corrections are necessary. The noise temperature on board satellites is 500K. This is raised 2.63dB from the 300K of the ground. Up links are not capable of opting for the use of digital speech interpolation technologies. There is no improvement on the average code speed of 3dB. If differences in up and down link frequencies are ignored, up link power should increase 5.63dB, that is, the mean continuous wave power associated with each user device channel should be 3.7 fold of the down link.

4.2 Economic Comparisons

Resolving that domestic coverage of China only requires one geostationary satellite, basic band data is switched between beams on the satellite. User angles of elevation are greater than 27°. However, low orbit satellites, by contrast, require 40-80 satellites in order to maintain unbroken communications. Elevation angles of user terminal operations are capable of dropping to 10°. Basic band information needs to be simultaneously switched between beams and between satellites. Resolving domestic coverage by the use of geostationary satellites, is comparatively economical in terms of funds.

4.3 Continuity of World Ranges

Geostationary satellites are capable of going through international network methods to resolve global communications. In conjunction with this, it is possible, on the basis of user /30 distribution densities and user characteristics in different regions, to determine coverage ranges and ERIP values associated with each satellite. For example, the ships of maritime regions are scattered and few. Moreover, G/T values on ships or aircraft are relatively high. It is possible to make use of wide beam coverage. As far as the ground is concerned, it is possible to opt for the use of tracking antennas in order to increase gains. Moreover, in areas where population is dense, it is then possible, in accordance with terrain requirements, to design multiple beam coverage. Thus, it is possible to save on satellite energy.

As far as stationary satellite global netting is concerned, time delays are, generally, comparatively large. Going through direct switching of data on satellites, it is possible to make appropriate improvements.

4.4 Satellite Mobile Communications Frequency Bands and Beam Selection

From formulae (1), (2), and (3), it is possible to further derive

$$P=(SLM/m)\times(1/A_e)=(SLR^2\Omega_s/m)\times(\Omega_e/\lambda^2)$$
$$=SLR^2\times\Omega_e/A_s \quad (4)$$

In this, S and L are constant values. When orbits and required coverage areas are determined (This location still takes China's land coverage area as the required subject), R and Ω are also constant values. In expressions, the symbol subscript "s" refers to satellite. "e" refers to earth station.

(1) Hand Held Device User Terminals

As far as the requirement for user device antenna hemispherical coverage is concerned, azimuths are omnidirectional. $\Omega e=2\pi$. Antenna equivalent parabolic surface diameter De≤0.1m. At this time, operating wave length $\lambda e \leq 0.221$m or operating frequency fe ≥ 1357MHz. This is close to selecting satellite mobile communications frequency fe = 1600MHz, λe = 0.1875m, and De ==0.0844m.

With respect to low orbit satellites associated with H=767.1km--due to numbers of satellites being numerous--there is a need to opt for the use of inexpensive small satellite technology. Assuming satellite borne antenna diameter Ds=0.65m and m=31.03, beam coverage efficiencies are only calculated as being 0.827. Therefore, 37 beams are selected as being appropriate.

With regard to stationary satellites--due to the requirement for coverage beams to be narrow and in accordance with the technological possibilities--option is made for the use of large antennas. It is possible to imagine three types of situations. In the first type, Ds=2.5m. This type of antenna has no need to opt for the use of developing technology. It is comparatively easy to realize. As far as the second type is concerned, Ds=6.0m. This type of antenna requires opting for the use of developing technology. Moreover, there is a need for beam widths larger than 2°. At this time, there is only a requirement for 0.1° beam alignment precisions. In technological terms, this is possible to realize. With respect to the third case, Ds=20m. This requires very high large antenna technology. Table 3 gives calculation results.

Table 3 Geostationary Satellite Beam Width

D_s/m	2.5	6	20
m/波束数 (1)	1	7	75
(Ω_s/m)/rad^2	6.912×10^{-3}	1.194×10^{-3}	1.114×10^{-4}
θ_s/(°)	5.37	2.23	0.682

Key: (1) Beam Number

In accordance with present technological levels, opting for the use of antennas around 6m is appropriate.

(2) Rough Tracking Stations which Can Be Transported or Carried on Vehicles

At this time, user device antennas are capable of roughly aligning on satellites. All that is required is θe≥5°. Neither manual alignment on satellites nor rough satellite tracking on vehicles will give rise to difficulties. It is thus possible to manually move equipment to fixed points for installation or carry out antenna tracking on vehicles. Equivalent antenna parabolic surface diameter of De=0.4m is appropriate. This type of communications system fits between fixed communications and mobile communications. It is relatively appropriate for stationary satellite communications systems. However, with regard to low orbit satellites, there are difficulties in tracking and alignment.

On the basis of A=λ2/Ω, Ω=4πxsin2(vθ/4), it is possible to solve for $\lambda_{min}=\sqrt{A_e\Omega_{min}}=\pi D_e \sin$ (θemin/4)=0.02741m. The corresponding fmax=10.94GHz.

From formula (4) and Ωs/m=λ2/As, it is possible to obtain /31

$$P=SLR^2\lambda^2/(A_eA_s) \qquad (5)$$

In order to reduce P values--under contitions where As is determined--one ought, as much as possible, to select permissible minimum values of λ_{min}, that is, λ=0.2741m, f=10.94GHz. It is already known that Ωs=6.912x10-3rad2. At this time, As = mλ2/Ωs=0.1087xm(m2), thus Ds=0.372 $\sqrt{m}$.

If one selects m=37 (should multiply by coverage coefficient 0.827), then, Ds=2.058m.

This type of multiple beam Ku wave band transportable station or tracking capable station can be brought into Ku wave band VSAT fixed communications systems. It has communications data rates which are much higher than hand held devices.

5 PRELIMINARY ANALYSIS OF DEVELOPMENT PATHS FOR CHINESE SATELLITE MOBILE COMMUNICATIONS

According to an analysis of early user requirements, by the year 2000, China will have approximately 80 thousand satellite mobile communications users. Among these, 90% are communications domestic in scope. 10% are international communications. On the basis of the technical analysis above, we put forward the following preliminary points of view.

1) China should develop geostationary satellite type domestic and peripheral region mobile communications systems in order to satisfy the requirements of the 90% of domestic mobile communications. In conjunction with this, attention can also be paid to the scarceness of roads in the border regions for communications. When necessary, it is also possible to pay attention at the same time to domestic navigation and positioning operations. If 72 thousand users make use of dometsic mobile communications satellites--figuring on 9 hours each day, telephoning 3 times, and each call being 5 min--calculating that the use of one stationary satellite provides 2400 channels, it is possible to satisfy domestic requirements. Opting for the use of

5.5m to 6.5m diameter antennas on satellites, the forming of 6-8 approximately 2.5 degree beams in order to resolve coverage of the national territory will be smaller in scale than the North American mobile satellite communications system[3]. Moreover, the investment of the latter in each satellite is less than 100 million U.S. dollars. Each user station unit is 4000 U.S. dollars. Space band utilization fees are 2 U.S. dollars/min.

2) Systems should opt for the use of satellite demodulation technology as well as data switching technology. With the addition of forward error correction, option is made for the use of acoustic code devices as well as the addition of digital speech interpolation technology on down link channels. Opting for the use of these technologies, it is possible to make user antennas get smaller.

With regard to cirrocumulus encryption/soft decision Weitebi (phonetic) decryption--due to the error correction capabilities being very strong--it is, therefore, a very effective type of forward error correction method with respect to digital satellite systems with limited power. (2,1,7) cirrocumulus encryption/soft decision Weitebi (phonetic) decrytion generally are capable of carrying encryption and decryption gains of 3-4dB.

Speech compression encryption very, very greatly reduces transmission code speeds to 4.8kbit/s, causing communications capacity to expand 13 fold or achieving 11dB gains.

Digital speech interpolation technology is capable of making communications capacities expand 2-2.5 fold or achieve 3-4dB gains.

3) With regard to international mobile communications systems--for example, the "Iridium" system--it is possible to rent their channels on a limited basis, mainly solving the problem of China's 10% of international mobile communications. The subscriber products can strive step by step for their own supply.

4) When developing Ku frequency band multiple beam VSAT communications systems, it is possible to combine the development of transportable or vehicle borne tracking type user device mobile communications systems.

5) China's dual satellite radiopositioning system (RDSS) makes use of two satellites. They operate in the L/S frequency bands. Making use of single beam coverage of China's national territory, it is possible to satisfy requirements associated with navigation, positioning, as well as brief, low data rate transmission mobile communications.

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